Central Truckee Meadows Remediation District Program

WASHOE COUNTY COMMUNITY SERVICES DEPARTMENT

Central Truckee Meadows Remediation District Program

2010 Annual Groundwater Monitoring Report

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LIST OF ACRONYMS AND ABBREVIATIONS

AMEC	AMEC Geomatrix, Inc.
AMSL	above mean sea level
ASG	active soil gas
ASR	aquifer storage and recovery
BCC	Washoe County Board of Commissioners
BESST	Best Environmental Subsurface Sampling Technologies, Inc.
bgs	below ground surface
cfs	cubic feet per second
County	County of Washoe
CSB	Crystal Springs Barrier
CSD	Washoe County Community Services Department
CTM	central Truckee Meadows
CTMRD	Central Truckee Meadows Remediation District
DNAPL	dense non-aqueous phase liquid
DQI	data quality indicators
DQO	data quality objectives
DR	Downtown Reno
DS	Downtown Sparks
DWR	Washoe County Department of Water Resources
ES	East Sparks
ESA	environmental site assessment
EPA	United States Environmental Protection Agency

ER	El Rancho
GD	Greenbrae Drive
GMP	Groundwater Monitoring Plan
g/d	grams per day
gpm	gallons per minute
HGC	Hydro Geo Chem, Inc.
HMA	high mass area
HWB	Harvard Way Barrier
J	Joule
K	hydraulic conductivity
Kh	horizontal hydraulic conductivity
Kv	vertical hydraulic conductivity
LCS	laboratory control sample
LNAPL	light non-aqueous phase liquid
m	meters
Ma	millions years before present
MCL	maximum contaminant level
MG	million gallons
MG/yr	million gallons per year
mg/L	milligrams per liter
MK	Mill/Kietzke
MS	matrix spike
MSD	matrix spike duplicate

MTBE	methyl tert-butyl ether
NCDC	National Climate Data Center
NELAP	National Environmental Laboratory Accreditation Program
ND	not detected
NDEP	State of Nevada Division of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NTUs	Nephelometric Turbidity Units
PAI	Pezzonella Associates, Inc.
PCAs	Potentially Contributory Activities
PCE	tetrachloroethene/tetrachloroethylene
PID	photo-ionization detector
PSA	Potential Source Area
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RMP	Remediation Management Plan
SMP	Sewer Monitoring Program
SMPL	Sparks Marina Park Lake
SOP	Standard Operating Procedures
SPPCo	Sierra Pacific Power Company
SR	South Reno
SS/FS	Sparks Solvent/Fuel Site
TCA	trichloroethane

TCE	trichloroethene/trichloroethylene
TMG	The Moss Group
TMWA	Truckee Meadows Water Authority
µs/cm	microsiemens per centimeter
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
USGS	United States Geological Survey
UST	underground storage tank
VA	Victorian Avenue
VBS	Verdi Basin Sediments
VLFZ	Virginia Lake Fault Zone
VOCs	volatile organic compounds

1. INTRODUCTION

This 2010 Annual Report summarizes the methods, results and findings of the 2010 first through fourth quarter (2010 Q1 to Q4) monitoring events conducted as part of the Groundwater Monitoring Plan (GMP) in support of the Central Truckee Meadows Remediation District program. The report also presents the most current understanding of groundwater flow and contaminant transport in the central Truckee Meadows (the "Conceptual Model"), an inventory of data gaps in that understanding, and a summary of planned and recommended activities to address those data gaps. The work was performed pursuant to the contract agreement between Washoe County and Kennedy/Jenks Consultants dated January 12, 2010 and Purchase Order No. 5500012207 from Washoe County dated January 26, 2010. The location of the Study Area is presented in **Figure 1.1**. **Figure 1.1** also presents an overview of physical features in the Study Area. **Figure 1.2** shows the distribution of the eight contamination plumes that are the subject of this monitoring program.

It should be noted that in 2012, the Washoe County Department of Water Resources (DWR) was combined with four other departments to create the Community Services Department (CSD). This change is reflected in the citation for this report. However, because this report refers to data collected and evaluated by DWR prior to that change, the term DWR is retained in the body of the text.

1.1 Groundwater Monitoring Plan Background

In the 1980's, the United States Environmental Protection Agency (EPA) began requiring municipal water systems to initiate monitoring for tetrachloroethene (PCE), a possible human carcinogen. PCE is a chlorinated organic solvent also known as perchloroethylene, tetrachloroethylene, or PERC that has been used extensively since the 1940's in chemical manufacturing and as a cleaner or degreaser. It has also been used in a variety of commercial/industrial operations including dry cleaning, auto repair and service stations, paint and machine shops, and chemical manufacturing. PCE use has declined since the late 1980's, with dry cleaning and chemical manufacturing being the principal uses of PCE today.

In 1987, water from municipal supply wells in the Reno/Sparks area was first tested for PCE. At that time PCE was detected in concentrations exceeding proposed drinking water standards in two of these wells. Three additional wells reached concentrations exceeding drinking water standards by the mid-1990s. Groundwater wells in the central Truckee Meadows (CTM) need to meet the water demands of the area when the Truckee River has poor water quality or low flow conditions, and are vital components in the local water supply system. The State of Nevada Division of Environmental Protection (NDEP) completed studies in 1994 (Westec/SRK, 1994) concluding that PCE contamination of groundwater in the CTM was widespread and probably originated over time from numerous possible sources. Many of the possible sources were considered to be associated with businesses that have been out of operation for many years.

In 1995, the Nevada Legislature passed Senate Bill 489, providing the Washoe County Board of Commissioners (BCC) with the authority to create a district for the remediation of a groundwater contamination condition identified by the District Health Officer and by the NDEP Administrator. The Central Truckee Meadows Remediation District (CTMRD) program was created in response to the PCE contaminated groundwater in the CTM. The CTMRD program provides a mechanism to mitigate the PCE-impacted groundwater and also provides liability protection to innocent property owners. The Washoe County Department of Water Resources (DWR) is charged with administering the CTMRD program on behalf of the BCC. In 1997, the Nevada State Legislature amended the Nevada Revised Statutes with the addition of NRS 540A.250 through 285 to include a mechanism to fund the CTMRD program. Beginning in July 1998 (the Washoe County 1998-1999 fiscal year), a “Remediation District fee” was added to property tax bills for water-using parcels served by water purveyors with wells located within the affected area.

A large portion of the collected remediation fees have been used for installation and operation of PCE treatment facilities for five municipal water supply wells. Additionally, these funds have been used for the development of the Remediation Management Plan (RMP), which by state statute (NRS 540A.260) must accommodate “any action which is reasonable and economically feasible in the event of the release or threat of release of any hazardous substance which may affect the water quality in this state.” The RMP was developed (CDM, 2002) and approved by the BCC in October 2002 and by NDEP in April 2003. The RMP defines the processes and procedures utilized to investigate and remediate PCE contamination within the CTM, an essential element of which is groundwater monitoring. Groundwater monitoring provides the information used to characterize and evaluate the contaminant impacts to groundwater as well as to help identify potential sources of the PCE contamination. In order to effectively monitor the widespread groundwater contamination by PCE in the CTM, DWR (now CSD) developed a Groundwater Monitoring Plan (GMP) (Intera, 2004). The GMP describes the process for monitoring PCE and other related volatile organic compounds (VOCs) in groundwater in the CTM. The GMP was implemented by DWR beginning in December 2003, at which time the first, regularly scheduled, quarterly groundwater monitoring event was conducted.

1.2 Groundwater Monitoring Plan Objectives

The following were the GMP objectives for 2010.

- Verify data quality and work with the contracted analytical laboratory to ensure that the data generated meet program objectives as specified in the Quality Assurance Project Plan (QAPP, contained in Intera, 2004).
- Collect monthly water level data.

- Use these data to assess the lateral groundwater gradient direction over the course of the year.
- Assess lateral and vertical gradients and potential groundwater flow over the course of the year.
- Assess water level trends and patterns over time for key wells, (e.g., using hydrographs).

- Collect and analyze groundwater samples to assess the horizontal and vertical distribution of PCE in the CTM.
  - Characterize the distribution of PCE in each plume.
  - Evaluate short and longer term PCE concentration trends and patterns in key wells in each plume area to assess contaminant migration patterns and trends.
- Evaluate the GMP data generated in 2010 to gain a better understanding of PCE sources, pathways and threats to receptors in the CTM and prepare an updated conceptual model, including the following specific tasks.
  - Describe known potential PCE contamination sources in each plume area and their relationship to recognized groundwater contamination.
  - Evaluate the distribution of vertical hydraulic flow gradients in the CTM and how the gradient may change during the course of a year.
  - Evaluate the potential for vertical migration of PCE.
    - Interpret lateral and vertical groundwater flow patterns and pathways for PCE transport in light of hydraulic gradients, PCE concentration distribution, and hydrostratigraphy;
  - Assess the potential for concentrations in impacted municipal water supply (i.e. “receptor”) wells to change, and the potential that contamination will migrate to other municipal water supply wells that are not yet impacted.
- Identify data gaps to the understanding of PCE occurrence and migration in the CTM.
- Provide recommendations for activities to address data gaps.

1.3 Report Organization

The remainder of this report is organized as follows:

Section 2 includes an overview of the physical, geologic and hydrogeologic setting of the CTM.

Section 3 summarizes the field methods, the data collected, and the laboratory analyses performed for the 2010 groundwater monitoring program.

Section 4 discusses the data quality assurance evaluations conducted for the 2010 GMP.

Section 5 presents the GMP data collected in 2010 and includes 1) regional-scale GMP data evaluations, 2) a summary of pertinent non-GMP investigations performed by the CTMRD program, and 3) subregion-specific GMP data evaluations that:

- Characterize observed behavior and interrelationships between principal data elements including hydrogeology, groundwater gradient and flow direction, potential PCE sources, PCE distribution, and PCE receptors or potential receptors; and
- Provide an update of the conceptual models of PCE occurrence and transport for each PCE plume identified in the CTM.

Section 6 discusses data gaps identified as a result of the data evaluation, presents recommendations for additional activities that could be undertaken to address the data gaps, and identifies planned activities to address data gaps.

Section 7 includes a list of references cited in the report.

2. CENTRAL TRUCKEE MEADOWS REGIONAL SETTING

2.1 Physical Setting

The Truckee Meadows is a topographic basin bounded by the Virginia Range and Pah Rah mountains to the east, the Carson Range to the west, Steamboat Hills to the south, and the Peavine Mountain to the north. A predominant feature in the Truckee Meadows basin is the Truckee River, which flows across the basin from west to east. Other tributary drainages flow into the Truckee River from the north or the south. The most significant tributary to the Truckee River in the Truckee Meadows is Steamboat Creek. Steamboat Creek flows from Washoe Lake, located south of the Truckee Meadows, and collects tributary flows from Galena Creek, Whites Creek, Thomas Creek, and agricultural return flows before joining the Truckee River at the eastern margin of the CTM.

The Truckee Meadows is in the rain shadow of the Sierra Nevada. Precipitation in the Truckee Meadows basin ranges from approximately 6 to 10 inches per year. According to information provided by the National Oceanic and Atmospheric Administration (NOAA, 2011), the average annual precipitation in Reno (at the airport, station ID RNO) during the period from 1938 through 2010 was 7.31 inches per year, with a range of 1.6 to 13.2 inches per year. In the higher elevations of the Carson Range, which bound the Truckee Meadows to the west, average annual precipitation is on the order of 40 inches per year (H. Klieforth, 1983). Measured precipitation at the Truckee River Ranger Station (station ID TKE, located at a longitude of -120 10 23, latitude of 39 19 59 and an elevation of 5823 feet above mean sea level [AMSL]) has ranged from 16.04 inches to 54.56 inches per year (from 1904 through 2010), with an annual average of 31.47 inches through 2010 (DRI, 2009 and CDWR, 2011). In 2010, measured precipitation at this station was 36.54 inches (CDWR, 2011). Precipitation that falls in the Carson Range and drains to the Truckee Meadows is a significant source of potential recharge to the CTM (either as mountain front recharge or as recharge originating from surface water features such as the Truckee River and its tributaries).

The Study Area is located in the central portion of the Truckee Meadows as shown on **Figure 1.1**, and includes the core Reno/Sparks urban areas, suburban residential and commercial development, and peripheral undeveloped and/or agricultural land. The Reno/Sparks metropolitan area has the third greatest concentration of people in Nevada; only Las Vegas/North Las Vegas and Henderson rank higher (US Census Bureau, 2011).

The Reno/Sparks metropolitan commercial and industrial districts exist to a large part in and along the Truckee River corridor. Downtown Reno is located both south and north of the Truckee River in the northwestern portion of the Truckee Meadows. Older commercial establishments as well as the historical railroad switching yards and railway corridors lie just east of downtown Reno and west of U.S. Highway 395. Older commercial establishments exist along Virginia Street, both north and south of the Truckee River. Another older commercial and industrial area is located north of the Truckee River in

Sparks, east of Reno. This area includes the Sparks Solvent/Fuel Site (SS/FS), the Sparks railroad yard, and numerous other industrial facilities whose operations date prior to 1970. More recent development of additional industrial land uses has expanded to the east of Reno-Tahoe International Airport and east of McCarran Boulevard in Sparks.

2.2 Geology

Five principal rock types comprise the geologic framework for the Truckee Meadows Basin. In order of decreasing age, these include:

- Late Paleozoic to Mesozoic metavolcanic and metasedimentary rocks;
- Mesozoic (Cretaceous) Sierran plutonic rocks;
- Tertiary (Miocene) andesitic volcanic rocks;
- Tertiary (Miocene-Pliocene [Neogene]) fluvial and deltaic/lacustrine sedimentary rocks (*e.g.,* Verdi Basin Sediments, described below); and
- Quaternary (Pleistocene) glacial outwash and (modern) fluvial and alluvial deposits.

2.2.1 Bedrock

Metamorphic, plutonic, and volcanic rocks comprise the bedrock that forms the mountains surrounding the Truckee Meadows, the low hills along the margins of the basin, and the basement beneath the younger sedimentary basin fill. These rock types are considered generally impermeable, except for the secondary permeability that has developed with fracturing. Granite outcrops are commonly fractured and jointed, and some fractures are mineralized, indicating groundwater flow at depth in the past. A deeply weathered surface on the plutonic rocks is evident where exposures exist (such as along Somersett Parkway in suburban northwest Reno). Volcanic rocks are not present as continuous deposits, but rather occur as local accumulations up to hundreds of feet in thickness, probably as a function of proximity to Miocene volcanic centers. Portions of the Miocene volcanic rocks are considered to be contemporaneous with the oldest part of the overlying Tertiary sediments, although locally the volcanics unconformably underlie younger parts of the sedimentary section along a buttress unconformity on the east flank of the Carson Range (Trexler and Cashman, 2006). Based on the groundwater model developed by McDonald Morrissey Associates (MMA, 1993) for water resource management, depth to bedrock in the central and south Truckee Meadows basins had previously been characterized as greater than 3,000 feet and 2,500 feet, respectively. A more recent reassessment of the Truckee Meadows based on gravity, surface mapping, and drill hole data (Widmer et al., 2007, Widmer, 2005 and 2007) indicates that the Truckee Meadows basin configuration is more complex than had been previously thought and that basin fill is generally thinner and bedrock depths generally shallower than had been represented by McDonald Morrissey Associates.

2.2.2 Sedimentary Deposits

Sedimentary deposits in the Truckee Meadows basin consist of moderately consolidated to unconsolidated alluvial, fluvial, deltaic, lacustrine, and glacial materials. These materials are exposed in outcrop along the western margins of, and as fill within, the Truckee Meadows basin. These sedimentary deposits range in age from Tertiary to modern and have typically been subdivided into the following two principal categories proposed by Cohen and Loeltz (1964):

- Moderately to poorly consolidated sediments of Miocene to Pliocene (Tertiary) age; and
- Unconsolidated sediments of Pleistocene (Quaternary) to modern age.

Tertiary Deposits

Interbedded fluvial, deltaic, and lacustrine sediments exposed in the west and northwest parts of the basin comprise what Cohen and Loeltz (1964) referred to as the “Truckee Formation”. These sediments include massive to thinly bedded siltstone, silty sandstone, sandy conglomerate, diatomite, and diatomaceous silt- and sandstone. In the Truckee Meadows basin, these materials have historically been characterized as less permeable than the overlying Pleistocene to modern sediments, even though distinguishing between them within the basin itself can be difficult and quantitative hydraulic properties from where the Tertiary materials have been distinguished to date are rare. More recent investigations (Trexler and Cashman, 2006) have described the Tertiary sedimentary rocks that occur in the vicinity of the modern Truckee Meadows basin as the “Verdi Basin Sediments” (VBS) based on exposures in and around Verdi, Nevada, west of Reno. The VBS are representative of Tertiary sediments deposited in paleo-basins (such as the Verdi basin) that were subsequently exhumed along the Sierra Nevada – Basin and Range transition zone east of the modern Sierra crest. These Tertiary sedimentary systems are considered to be sensitive indicators of local relief, the type of bedrock exposed to erosion, the nature and rate of subsidence, and drainage-basin configuration during the Neogene paleo-basin formation.

Quaternary Deposits

These younger sediments are comprised of Quaternary glacial outwash and modern fluvial and alluvial deposits. The deposits consist of varying proportions of silt, sand, and gravel that are complexly inter-bedded and inter-layered. Lenses of clay and clayey materials have also been observed. From Verdi to west Reno, glacial outwash sediments form significant surficial deposits, primarily as mainstream terraces, along the Truckee River corridor. These poorly consolidated gravels and sands were deposited by the Quaternary Truckee River system when it carried melt water and sediment from alpine glaciers in the Sierra. From west to central Reno, the VBS probably form a more significant part of the Truckee

Meadows basin fill compared to Quaternary deposits. In this area, Quaternary sediments are deposited on an angular unconformity with the underlying Tertiary sediments (Trexler and Cashman, 2006).

Glacial terraces along the Truckee River in west Reno have been correlated with four glacial stages in the high Sierra that range in age from as old as 1 Ma (or less) to as young as 11,000 years (Birkeland, 1968; Phillips et al., 1996; Yount and LaPointe, 1997; Howle, 2000). The Hobart is the oldest and highest outwash terrace, and its identification in the Reno area most problematic. The Donner Lake and Tahoe terrace systems are well developed west of Reno. The youngest outwash terrace, Tioga, has only locally been described in the Reno/Sparks area and is thought to be part of, buried by, or possibly reworked by modern fluvial deposition. There are also higher, and presumed older, terrace surfaces along the Truckee Meadows valley margins; these have not yet been studied or correlated to glacial deposits in the Sierra.

The glacial outwash deposits dip eastward at progressively shallower angles from west Reno to central Reno (Birkeland, 1968). The eastward dip direction of the glacial deposits (or reworked glacial deposits) is consistent with the Quaternary deposits becoming thicker within the Truckee Meadows basin than in the surficial exposures west of Reno along the Truckee River corridor. Up to 200 feet (approximately 60 meters) of fluvial gravel and sand have been exposed in gravel quarries in the Reno area beneath the modern floodplain (Bell, pers. comm. 2006). Outwash debris is described to have traversed the Truckee Meadows basin and continued down the Truckee River canyon as far as present day Mustang (Birkeland, 1968). Workers in the area envision an alluvial fan of glacial outwash constructed from a point source in west Reno near where the present day Truckee River comes out of the canyon. This fan is not evident in modern topography because it has been tilted gently east and buried by the modern floodplain. The Quaternary to modern glacio-fluvial sedimentary system may dominate the upper part of basin fill, especially in the north half of the Truckee Meadows basin. In summary, the glacial outwash section (or reworked material derived from it) may form a wedge of coarse sediment in the Truckee Meadows basin that thickens to the east.

2.2.3 Structural Development of Basin

Trexler and Cashman (2006) have described the structural development of the Central Truckee Meadows basin. The following summary was distilled from their work.

The sedimentary record in the vicinity of the Truckee Meadows basin contains good evidence for deformational episodes both early and late in the Neogene paleo-basin history, and for no significant tectonism between about 10.5 Ma and 2 or 2.5 Ma. There is no direct evidence for the orientation or sense of faulting associated with basin initiation, but the apparently fault-derived granitic-clast breccias near the base of the section suggest significant local topographic relief and therefore probably dip-slip faulting. In addition, complex fault geometries and kinematic evidence of reactivation suggest that at least some of the post-depositional faulting reactivated pre-existing fault surfaces. In particular, the steeply dipping fault surfaces with generally north strikes tend to exhibit oblique-slip motion (see below), which may indicate that these are controlled by the orientation of older surfaces which were reactivated in a new stress field. There are no fault-derived breccias throughout the rest of the Tertiary section and sediment compositions indicate intermediate volcanic rocks in the source area, rather than the underlying Sierran granitic rocks. The uplift, incision, and high-energy fluvial system at the end of the Tertiary record indicate renewed tectonism, and the faults that offset the Tertiary section are a direct record of post-depositional deformation that represents the onset of the development of the Truckee Meadows basin.

Since the end of Neogene deposition, the Tertiary section has been tilted eastward and folded into a broad, east-plunging syncline. The map pattern of the Tertiary section (older rocks exposed farther to the west) reflects this overall east dip. Bedding dips are not systematically steeper in the older part of the section, so all of the tilting appears to post-date deposition. The exception to this might be the youngest Tertiary rocks (the “Gravels of Reno”, exposed along West Fourth Street, generally west of McCarran) and the glacial outwash terraces (see below). In addition to the general east dip there is a broad synform in the Tertiary rocks west of Reno, recording uplift of the Carson Range (to the south) and Peavine Mountain (to the north) relative to the Truckee River corridor. These data indicate that the Tertiary sediments can be expected to dip east into the Truckee Meadows basin.

Pervasive small-scale faults, comprising several fault sets, cut the Tertiary section; most appear to have formed after the section was tilted. Although the major fault sets record primarily strike-slip motion, they were (at least in part) active simultaneously, and together accommodate generally east-west extension. A detailed analysis of the pervasive minor faults in the VBS diatomite exposure in the road and railroad cuts on West Fourth Street (generally west of McCarran) provides insight into the styles and relative ages of post-depositional faulting. It reveals three main fault sets as follows.

- A set of moderately to gently northwest-dipping, down-to-the-northwest normal faults is the oldest fault set in the diatomite exposures along West Fourth Street. These faults record extension, and may be in part synchronous with the tilting (although their strikes are oblique, rather than perpendicular, to the tilt direction). These faults were cut by the later faults and were not reactivated during the later faulting.

- North-to northwest-striking, steeply dipping faults exhibit dextral to dextral-normal oblique slip. Bedding, already sub-parallel to these faults, records significant drag folding near the larger faults. This drag folding results in bedding strike parallel to fault strike, and means that slip magnitude determinations using offset marker beds give minimum values, and probably greatly underestimate the total slip.

- Northeast-to east-northeast-striking, steeply dipping faults have sinistral or sinistral-normal oblique slip. They are commonly the most recent faults, but exhibit mutually cross-cutting relationships with dextral faults in several places, indicating that the two sets were, at least in part, active simultaneously. Most of the larger-offset faults in the West Fourth Street exposure belong to this set.

Deformation apparently continued on into the Quaternary. Birkeland (1968a) proposed that the Truckee Meadows basin has subsided asymmetrically during the Quaternary, such that the east part of the basin dropped more than the west, tilting the basin fill to the east. He based this interpretation on the observation that successively older glacial outwash terraces in west Reno and Verdi are tilted more steeply than the modern river gradient, and the glacial terraces are buried at their eastern ends by modern alluvium.

Gravity studies (Widmer et al., 2007; Widmer, 2005 and 2007) combined with borehole data have contributed to a three-dimensional, high-resolution depth-to-basement model of the Truckee Meadows basin. This gravity-based model indicates that the Truckee Meadows basin is not a simple, fault-bounded basin as is typical in the Basin and Range Province. Rather, the basin floor is irregular and defines four sub-basins that may result from a combination of pre-Neogene paleo-topography and post-Neogene displacement along geologic structures. Some of the linear gravity gradient features have the same orientation as post-Neogene structures described (Trexler and Cashman, 2006) in exposures along Somersett Parkway (in northwest Reno) and the small-scale fault sets (described above) observed in the VBS diatomite exposed along West Fourth Street. The majority of these faults appear to have formed after the eastward tilt of the offset beds, and are therefore considered younger than 2.5 Ma.

2.2.4 Potential Groundwater Flow Barriers

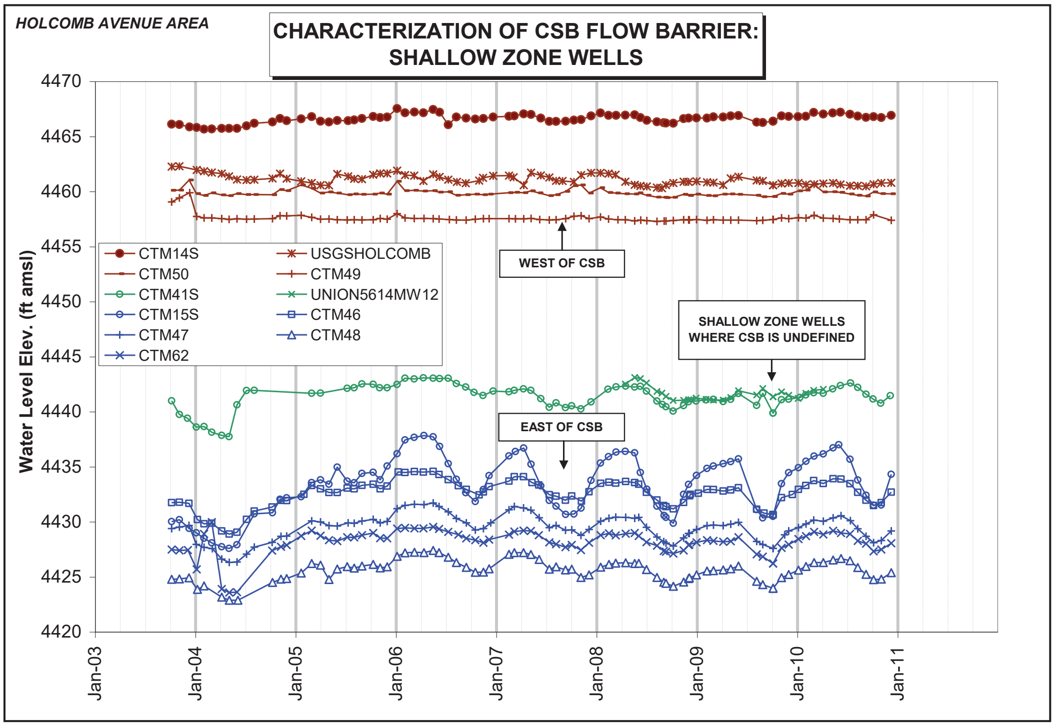
Two hydrogeologic features presently recognized in the central Truckee Meadows, the Virginia Lake Fault Zone (VLFZ) and the Harvard Way Barrier (HWB) reflect the potential influence of post-Neogene faulting (or other abrupt lateral changes in hydrologic properties) as partial flow barriers to groundwater flow. Each is described below.

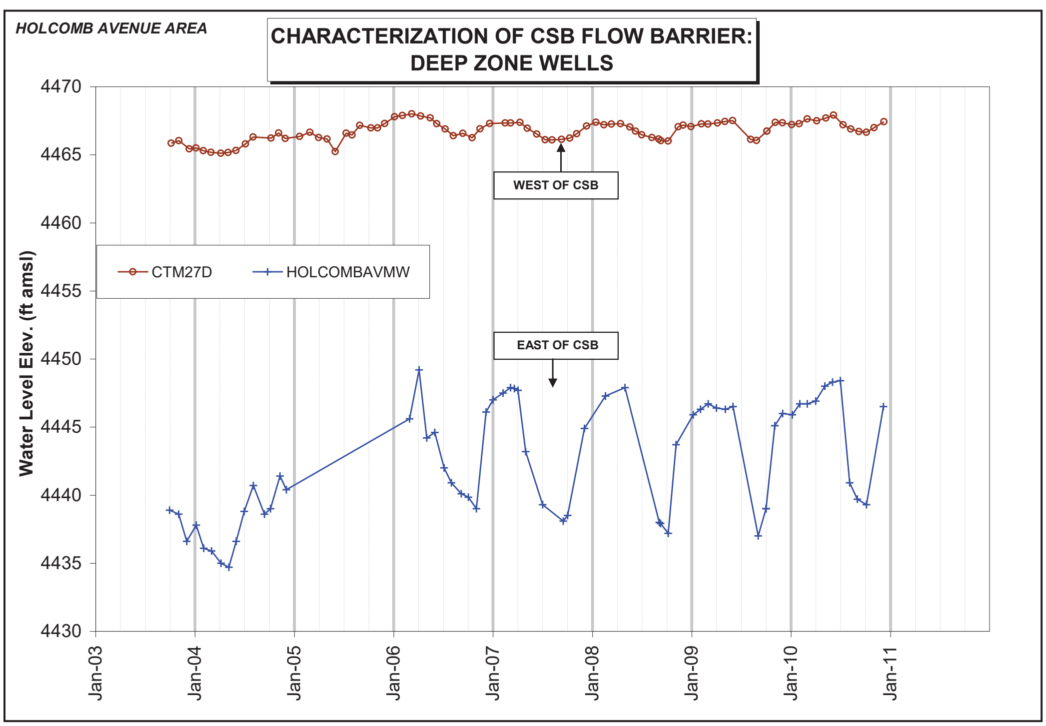
Virginia Lake Fault Zone

Evaluation of potentiometric surface maps has identified a step in the shallow and deep zone groundwater levels across a north trending fault system that has been termed the Virginia Lake Fault Zone (VLFZ, **Figure 1.1**) (Widmer et al., 2007). This fault system is herein represented by a subparallel series of mapped faults (represented by Bonham and Bingler, 1973; Bonham and Rodgers, 1983) that extend north from the Moana geothermal area (near the intersection of Plumas Street and Manzanita Lane) through the Virginia Lake area, and continue as far north as Ryland Avenue where they are buried by Holocene alluvial deposits. Gravity data (Widmer, 2005) suggest that the VLFZ is the surface reflection of a major structural zone that transects the area from the Moana geothermal area northward through the Reno city center and beyond (to the University of Nevada Reno campus). This structural zone is interpreted to bound the east side of a Quaternary sub-basin (the west Reno sub-basin) within the Truckee Meadows and comprise of a system of north-striking, predominantly west-side-down normal faults. The steepening of water level contours across the VLFZ is interpreted to reflect the influence of one or more partial flow barriers caused by steeply dipping zones of lower permeability associated with the fault system. Contracted steepening of the lateral gradient is observed in two areas that are inferred to be related to the VLFZ; the area along Holcomb Avenue (between Capitol Hill Avenue and East Taylor) and the area near Wells Avenue in the vicinity of the Truckee River (**Figures 5.2** through **5.9**). In the area along Holcomb Avenue a partial flow barrier herein called the Crystal Springs Barrier (CSB) is defined by monitoring well water level data and is described as follows.

The Crystal Springs Barrier (CSB) is defined by a step in groundwater levels that exists along the eastern margin of the VLFZ, in the vicinity of and sub-parallel to Holcomb Avenue. This contracted steepening of the lateral gradient exists between pairs of monitoring wells (CTM14S and CTM15S, and CTM49 and CTM47) and is observed in both shallow zone and deep zone monitoring well data from the area. Based on shallow zone well data, the CSB coincides with the easternmost mapped fault (as defined by Bonham and Bingler, 1973) along this portion of the VLFZ. Shallow zone and deep zone hydrographs (as shown below) from wells on either side of the CSB exhibit:

- Water levels that are generally 20 to 30 feet deeper east of the VLFZ compared to within the VLFZ and west of the CSB; and
- Longer term trends and annually recurring water level patterns east of the VLFZ that are significantly larger in magnitude compared to within the VLFZ and west of the CSB. East of the VLFZ, longer term average annual water level increases (observed between 2003 and 2006) and recurring water level changes (between 2006 and 2010) correspond to decreased annual pumping volumes and annual patterns in municipal water supply well pumping respectively. Within the VLFZ and west of the CSB, water levels exhibit very little long term change in average annual water level elevation and markedly smaller changes (<2 feet) that do not define an obvious recurring pattern.

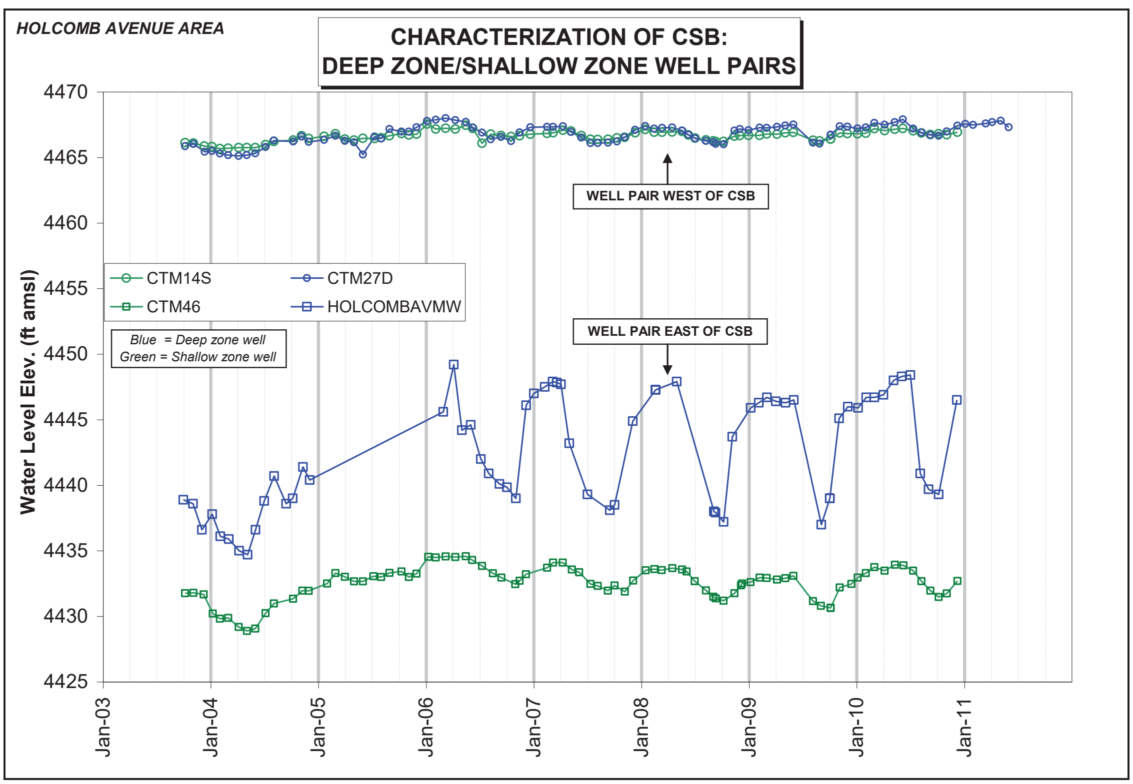

HOLCOMB AVENUE AREA
CHARACTERIZATION OF CSB FLOW BARRIER:
SHALLOW ZONE WELLS
Water Level Elev. (ft amsl)
4470
4465
4460
4455
4450
4445
4440
4435
4430
4425
4420
CTM14S
CTM50
CTM41S
CTM15S
CTM47
CTM62
USGSHOLCOMB
CTM49
UNION5614MW12
CTM46
CTM48
WEST OF CSB
SHALLOW ZONE WELLS WHERE CSB IS UNDEFINED
EAST OF CSB
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11


HOLCOMB AVENUE AREA
CHARACTERIZATION OF CSB FLOW BARRIER:
DEEP ZONE WELLS
Water Level Elev. (ft amsl)
4470
4465
4460
4455
4450
4445
4440
4435
4430
CTM27D
HOLCOMBAVMW
WEST OF CSB
EAST OF CSB
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11

The notably muted hydrodynamics within the VLFZ and west of the CSB compared to east of the VLFZ is interpreted to indicate that groundwater within the VLFZ is at least partly isolated from the regional aquifer system.

It should be noted that two shallow zone wells (CTM41S and UNION5614MW2) in southern part of the Holcomb Avenue area exhibit water level elevation and hydrodynamics that are somewhere between the ranges described above for either hydrographs within or east of the VLFZ (see first hydrograph above). These wells are located in a portion of the VLFZ where limited data do not define a groundwater step and the persistence of the CSB is not established.

In addition to the distinctly different hydrograph characteristics recognized on either side of the CSB (as described above), vertical gradient data also define relatively distinct hydrologic characteristics that are consistent with the occurrence of a partial flow barrier. East of the VLFZ, shallow zone/deep zone well pair CTM46/HOLCOMBAVMW shows a persistent upward vertical gradient (in the range of 0.02 to 0.05) Within the VLFZ and west of the CSB, well pair CTM14S/CTM27D exhibits an order of magnitude smaller gradient (in the range of -0.001 to 0.005) that generally fluctuates from upward to downward during any given year (as shown on the hydrograph below).



In previous GMP annual reports, the VLFZ has been projected to extend to the Truckee River where a similar groundwater step exists between shallow zone wells CORWSSMW1 and WMMW1 (now abandoned) and between deep zone wells CTM8D and MORRILL. However, with the addition of a new well cluster (CTM102/CTM101/CTM100) in 2009, the steepened lateral gradient previously indicated (on quarterly water level contour maps) to be continuous along the projection from the CSB to the Truckee River is no longer obvious. Therefore the persistence of the CSB (or other flow barriers associated with the VLFZ) is not well established northward to the Truckee River and represents a data gap. Currently, the steepened lateral gradient observed near Wells Avenue in the vicinity of the Truckee River is (as in previous annual reports) tentatively attributed to the VLFZ, but this partial flow barrier is not considered to be continuous with the CSB.

Harvard Way Barrier

A similar step in the deep zone potentiometric surface is observed between well CTM33D and CORBETT (**Figures 5.3, 5.5, 5.7** and **5.9**), and has been termed the Harvard Way Barrier (HWB) (**Figure 1.1**). Unlike the VLFZ, this feature is not obviously associated with a gravity anomaly and there are no surface expressions of the feature. Thus, it is not clear at this point in time whether the HWB is associated with a fault or with a lateral change in material properties (such as an abrupt facies change). Either possibility could result in the observed water level and gradient changes. The step in deep zone water levels has only been observed at two transects. In the area between CTM33D and CORBETT, there is a lack of a co-located step in the overlying shallow zone. This results in distinctly different vertical gradient characteristics on either side of the HWB. On the west side, vertical gradients are persistently upward. On the east side, they are seasonally reversing with an upward vertical gradient during non-pumping periods and a downward gradient during pumping periods (see **Figure 5.10**). To the north of this transect, deep zone potentiometric maps indicate a similar step between well clusters CTM102/CTM101/CTM100 and CTM9S/CTM104/CTM103/CTM10D (**Figures 5.3**, **5.5**, **5.7**, and **5.9**), particularly during periods of sustained pumping. Aquifer test and vertical hydraulic gradient data discussed in the 2009 GMP Annual Report (WorleyParsons, 2013) indicate distinctly different hydraulic behavior at these well clusters, respectively, that supports the interpretation that the HWB extends in a northwesterly orientation between the well cluster locations.

The importance of potential barriers with regard to their influence on groundwater flow and contaminant transport in the CTM is being increasingly recognized. Ongoing work may result in the refinement of the extent and continuity of the HWB and flow barriers associated with the VLFZ. It may also result in the identification of additional hydraulic barriers and/or faults.

2.3 Hydrogeology

From a hydrogeologic perspective, the sedimentary deposits or “basin fill” in the CTM have traditionally been subdivided into two categories (MMA, 1993; CDM, 2002). The “Truckee Formation” (which has, to date, been defined as older and much less permeable materials) and the Quaternary “alluvium” (which has been defined as younger, less consolidated, and more permeable materials). The Quaternary alluvium, as so defined, has also historically been subdivided into the "younger" and "older" alluvium (Cohen and Loeltz, 1964).

As applied to the CTM, the Truckee Formation label is now recognized as a misnomer that has been loosely applied in the past to the Tertiary sedimentary rocks in the vicinity. These Tertiary rocks are now collectively called the VBS, based in large part on the work of Trexler and Cashman (2006) (see **Section 2.2.2**). The Quaternary sediments are some of the principal aquifer materials through which groundwater readily flows in the central Truckee Meadows and within which many municipal water supply wells have been completed (particularly in central and west Reno and along the Truckee River corridor). While the Quaternary sediments include some of the most transmissive materials known within the Truckee Meadows, some productive municipal water supply wells are now considered to also have been completed in the VBS. The near surface occurrence of transmissive materials like the Quaternary alluvium can provide pathways through which contaminants (such as PCE) released at the surface can migrate. Along the Truckee River corridor, the potential for long-term down-cutting through and reworking of older sediments is also likely to have a significant influence on the potential vertical movement of groundwater and contaminants such as PCE.

As presented in the RMP (CDM, 2002), the geophysical logging and short term transient monitoring performed during the initial Work Plan Development and Implementation Phase of the CTMRD program suggested a large ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity (k_h/k_v) in the sediments within the CTM basin. The RMP suggested that this apparent vertical anisotropy was caused by alternating high and low energy depositional environments that can be typical in valley fill deposits. Such dynamic depositional environments often result in discontinuous and interlayered coarser grained and finer grained materials, the accumulation of which in turn can result in significant vertical anisotropy. However, the heterogeneity of these deposits can also result in a lack of lateral continuity of any lower permeability materials, so that significant vertical groundwater flow is locally possible.

In the bedrock materials in the CTM basin, the hydraulic conductivity has always been represented to be low even though there are very limited data to substantiate this. If that is indeed the case, the amount of water contributed from the bedrock into the CTM basin would be relatively small.

2.3.1 Groundwater Flow

Groundwater moves beneath the land surface from areas of higher hydraulic head to areas of lower hydraulic head. Within the central Truckee Meadows, groundwater generally flows from west to east from the proximity of the Carson Range of the Sierra Nevada toward the gap between the Pah Rah and Virginia Ranges through which the Truckee River leaves the basin (**Figure 1.1**). Locally, the direction of groundwater flow can be influenced by well pumping, underground injection of water for aquifer storage and recovery, by the infiltration of water from the Truckee River and other surface water features, and by hydraulic flow barriers associated with geological features such as possible faults or lateral changes in lithology.

The groundwater flow direction at the water table generally parallels the Truckee River. Shallow groundwater locally shows evidence of the influence of recharge from the river. This is apparent in downtown Reno (in part, based on water quality and PCE distribution) and along the stretch of the river between the VLFZ and E. McCarran Blvd (based on inflections in the water level elevation contours). These features are shown on **Figures 5.2**, **5.4**, **5.6**, **5.8** and described in **Section 5**. Groundwater in the deeper portions of the aquifer also generally moves from west to east, but is locally strongly influenced by pumping in those parts of the basin where municipal water supply wells are located and routinely used.

The general character of the vertical gradient in the basin is that relatively strong downward gradients can be induced during periods of groundwater pumping (typically in summer and fall, during peak water demand). During periods of little or no groundwater pumping (e.g., winter and spring), downward vertical gradients are reduced in magnitude and can locally reverse and become upward. In general, more persistent downward vertical gradients occur in the western portion of the basin and along the river corridor while more persistent upward gradients can occur in the eastern parts of the basin and in areas away from the river and the influence of groundwater pumping. Specifically, downward gradients are present in much of downtown Reno and along the river from Keystone Avenue to E. McCarran Blvd. This is shown on **Figure 5.10** and described in **Section 5**. The area of greatest groundwater level difference, and greatest magnitude downward vertical gradient is along the river corridor east of the VLFZ and occurs during periods of sustained pumping in the central part of the basin. These features are more fully discussed in the subsections below.

Until recently, groundwater flow in the central Truckee Meadows has historically been characterized in terms of a two aquifer system. The shallow aquifer, representing the unconfined aquifer, was defined as extending from the water table to the base of a regional aquitard (including the aquitard). The underlying deep aquifer was defined as the confined or semi-confined aquifer present below the regional aquitard, and separated from the shallow aquifer by that regional aquitard. Given the heterogeneous nature of the CTM basin fill, the lateral continuity of lower permeability layers such as what might comprise a regional aquitard can be difficult to establish, but finer grained materials are commonly within the interval between what have been referred to as the shallow aquifer and the deep aquifer.

More recently it has become apparent that in many parts of the CTM a discrete sequence of finer grained materials that can effectively function as an aquitard cannot be identified. In these areas, distinguishing between the shallow and deep aquifers becomes somewhat more arbitrary. This indicates that a regional aquitard does not exist in the CTM and that the Truckee Meadows aquifer system is best represented by a single, three-dimensional, complex aquifer. In this case, the shallow zone (rather than a discrete shallow aquifer) extends from the water table and includes the unconfined portion of the complex aquifer and any local potentially confining interval that may exist beneath the unconfined portion of the aquifer. The shallow zone typically extends in depth to about 90 to 150 feet bgs. Deeper groundwater producing intervals within the complex aquifer have a tendency to exhibit semi-confined characteristics. The deep zone (rather than a discrete deep aquifer) now refers to the semi-confined to anisotropic unconfined portions of the complex aquifer that are present at depths typically greater than about 150 feet bgs.

Shallow Zone

Since the implementation of the GMP in 2003 Q4, groundwater in the CTM has been consistently shown (Intera, 2006a; WorleyParsons, 2008, 2010, 2011, 2013) to generally move from west to east in the shallow zone. A contracted steepening of the lateral groundwater flow gradient is consistently observed between the HIGH and MORRILL municipal water supply wells in the north, and between pairs of monitoring wells to the south (CTM49 and CTM50, and CTM14S and CTM15S), thus forming a north-south trend. Steepening of the water table gradient along these two transects is interpreted to be caused by the VLFZ acting as a hydraulic barrier that partly impedes lateral groundwater movement. East and west of this apparent zone of lower permeability, the water table groundwater contour lines are more widely spaced indicating relatively higher permeability materials. With the addition of well cluster CTM100/CTM101/CTM102 in 2009, the steepened lateral gradient previously observed to be laterally persistent (in both the shallow zone and deep zone piezometric contouring) between the two transects is less apparent and the lateral continuity of the partial flow barrier(s) associated with the VLFZ is therefore not well established.

In the western portion of the CTM (along the Truckee River corridor and west of the VLFZ), the groundwater elevations lie at or just below the nearby river surface elevations (stages), suggesting a direct interconnection exists between surface water and shallow zone groundwater. Historically, evidence for groundwater discharge along the river corridor in the area west of the VLFZ and upgradient of the RENOHIGH well has also been observed (Cooley et al., 1971; Stephens, 1971).

In the central portion of the CTM (along the Truckee River corridor and east of the VLFZ), groundwater elevations are about 30 feet lower than the corresponding river stages. Contours of shallow groundwater elevations are deflected downstream as they cross the river, which suggests infiltration along a losing reach of the river. Continuing east, groundwater contours are deflected upstream and indicate groundwater movement toward what becomes a gaining reach of the Truckee River in the area east of E. McCarran Blvd. and the gap between the Pah Rah and Virginia Ranges where the river leaves the basin. The low-lying areas along the eastern margins of the CTM (near the base of the Pah Rah and Virginia Ranges) are where the water table is most likely to intercept the ground surface and produce the springs and wetlands that have historically been common in those areas.

Additional information would be needed to better characterize the relationship between the Truckee River and shallow zone groundwater, and the influence of the river on lateral and vertical groundwater flow. Based on an evaluation of transducer data collected in 2008, many data sets from shallow zone monitoring wells examined within about 300 feet of the Truckee River showed some degree of groundwater – surface water interaction (WorleyParsons, 2011). The evidence for interaction is more pronounced in wells west of the VLFZ, where groundwater levels are shallower and a more direct connection between the river and shallow groundwater has been inferred. East of the VLFZ, where groundwater levels are deeper, an unsaturated zone apparently exists between the river and the water table. This unsaturated interval represents a hydraulic disconnect between the river and the aquifer system below. As such, recharge from the river to the aquifer system moves downward through the unsaturated zone before it reaches the water table. This means that changes in either river stage or the water table elevation will not affect the vertical hydraulic gradient that would otherwise influence the rate of recharge beneath the river. However, changes in river stage will increase the cross-sectional area of any perched, saturated material beside and beneath the river, such that the quantity of river leakage will increase with an increase in river stage. This increase in the quantity of river leakage with increasing stage is reflected in a muted response in groundwater levels that increase as that leakage reaches the water table. Transducer data collected in 2008 from shallow zone monitoring wells more than 300 feet from the Truckee River showed virtually no response to changes in river stage but did show a response to pumping. Based on this pattern of response from the 2008 data, any direct influence on shallow zone groundwater levels by surface waters of the Truckee River is a function of both the degree of hydraulic connection between the groundwater and the river, and lateral proximity to the river.

Deep Zone

Groundwater in the deep zone also generally moves from west to east. Review of quarterly deep zone groundwater elevation maps generated as part of the GMP to date show changes in deep zone water level elevation contours that occur in response to pumping of the municipal water supply wells. The largest area of depressed deep zone groundwater levels typically develops in the eastern portions of the Downtown Reno and South Reno plume areas (east of the VLFZ and HWB) and causes groundwater from an apparently large portion of the deep zone to be drawn toward the municipal water supply wells in this area (see **Figure 5.7**). Other periodic and more localized cones of depression occur in the deep zone around other, more isolated or hydraulically less influential, municipal water supply wells in other parts of the basin. These also occur in response to groundwater pumping. The depression of deep zone water level elevation is most prominent during sustained periods of basinwide pumping that typically occur in the summer and fall when community water demand is highest. This is particularly evident starting in 2006 when year-around operation of PCE-treated wells ceased and demand-based (typically summer and fall) operation was initiated. Water level elevations near these wells generally remain relatively depressed beyond the end of the pumping period, but recover to pre-pumping levels within 4 to 6 months. This seasonal recovery to pre-pumping levels is consistent with an aquifer system that has generally had sufficient recharge capacity to replace annual municipal water supply pumping demands in the CTM basin.

As is observed in the shallow zone, hydraulic flow barriers associated with the VLFZ also influences groundwater in the deep zone. An offset in the deep zone potentiometric surface similarly occurs at the HWB. At the HWB, the lack of observed offset or increased gradient in the shallow zone water levels results in a vertical gradient reversal across the HWB during periods of sustained pumping. A persistent upward gradient is present west of the HWB, while the gradient generally changes from downward during seasonal summer and fall pumping to upward by the end of an extended period of non-pumping on the east side. Hydrodynamics observed during a long duration aquifer test at CORBETT and MILL (WorleyParsons, 2012) indicate similar differences in hydraulic characteristics exist between well clusters CTM102/CTM101/CTM100 and CTM9S/CTM104/CTM103/CTM12D that are interpreted to indicate that the HWB has a northwest orientation and extends to the north as far as Mill Street. However the actual nature of, continuity and lateral extent of the hydraulic influence of the HWB have yet to be fully determined.

Vertical Groundwater Flow

Groundwater elevation contour maps for the shallow and deep zones generated since the implementation of the GMP show distinct differences between the water table (i.e., the shallow zone) and the groundwater producing parts of the aquifer system (i.e., the deep zone). Of particular interest is the nature and distribution of water level responses in the shallow zone to pumping from the deep zone. A general lack of spatial coincidence between the observed and typically subdued or attenuated shallow zone water table responses and the deep zone pumping locations suggests that local vertical hydraulic separation is present between some of the water bearing intervals in the shallow zone and deep zone. A subdued or apparently missing shallow zone water level response to deep zone pumping could also result from being hydraulically connected to a recharge source (such as the Truckee River) that can readily recharge the shallow zone and mask any drawdown response in the shallow zone to pumping from the deep zone.

These two alternative processes (local hydraulic separation or relatively rapid recharge of the deep zone from the Truckee River through the shallow zone) and the potential interrelationship between the Truckee River and the shallow zone require further evaluation. Groundwater in the shallow zone generally flows across the CTM to the east toward lower groundwater elevations. However, shallow zone groundwater would also have a vertical flow component, moving from the water table into the deep zone, when there is a downward vertical gradient (i.e., where the water level elevation in the shallow zone is higher than in the deep zone) and there is a conduit or pathway along which groundwater movement can take place. The degree to which vertical flow might occur is controlled by the permeability and continuity of the geologic materials along potential vertical pathways between the water table (i.e., shallow zone) and the deep zone and the magnitude of the vertical gradient. The potential for vertical flow would decrease where the downward vertical gradient is small and/or where geologic materials between water bearing zones have low hydraulic conductivity and are laterally continuous (resulting in a local hydraulic barrier or aquitard). Thus, the vertical component of groundwater flow could be significant where the groundwater elevation difference is large and/or the permeability of the geologic materials between the water table and deeper portions of the aquifer is uniform and relatively high or where finer grained lower permeability layers are discontinuous or absent (as a result of erosion, such as along the Truckee River corridor, or as a result of dynamic and heterogeneous depositional processes). Vertical groundwater flow can also occur where a well passes through a finer grained interval or barrier and is screened both above and below the barrier, thereby acting as a local conduit.

2.3.2 Overview of Central Truckee Meadows Contaminant Hydrogeology

Of the suite of VOCs monitored as part of the CTMRD program GMP, PCE has been shown to be the most widespread groundwater contaminant in the central Truckee Meadows. Plotting and contouring the PCE concentrations observed in shallow and deep zone monitoring wells has identified discrete three dimensional volumes, or plumes, of PCE contamination (the individual plumes are defined below). The shape and location of the PCE plumes within the central Truckee Meadows are defined by the existing wells in the groundwater monitoring network. Plume extents and shapes are subject to change if plumes migrate in response to groundwater movement or if greater spatial definition is provided through the addition of new monitoring wells in important parts of the basin. PCE plumes tend to be elongate parallel to the direction of groundwater flow. The longitudinal plume axes appear to be inclined and are interpreted to plunge from shallow zone sources to deep zone receptors.

Since the horizontal component of groundwater flow in the CTM is generally from west to east, high local PCE concentrations (hot spots) typically at the western ends of the shallow zone portions of the plumes are considered indicative of proximity to a probable source of PCE (i.e., the proximal ends of the plumes). Local, high concentrations of PCE have also been observed in the deep zone (plume cores) which may be the result of heterogeneous distribution of PCE in the complex aquifer or a consequence of the plume being defined based on data from multiple wells constructed at different total depths and having varying screen lengths. Possible explanations for the apparently heterogeneous distribution of PCE in the complex aquifer include the following:

- preferential pathway(s) for PCE migration between shallow zone sources and the deep zones of the aquifer system;
- more robust dissolved PCE concentrations that have detached and migrated to more distal points along the plume axis from historical source areas; and,
- unidentified PCE source areas that have contributed to the observed deep zone PCE concentrations along as yet unrecognized migration pathways.

There had been a tendency (as documented in the 2006 GMP Annual Report [WorleyParsons, 2008a] and 2007 GMP Annual Report [WorleyParsons, 2010]) in the past for the PCE plumes to be designated as shallow zone or deep zone plumes. However, as discussed in the Hydrogeology section (**Section 2.3**), the sediments that comprise the water-bearing strata in the CTM are heterogeneous, and there is not a distinct, laterally continuous, aquitard that effectively separates what are referred to as the shallow zone and deep zone, nor is there a single discrete and laterally continuous water bearing interval in the deep zone of the aquifer system. This is compounded by the fact that the completion depths and screened interval lengths of the monitoring wells in the GMP network are variable with a number of the wells being utilized for monitoring that were not originally installed for characterizing the vertical extent of the PCE plumes. As a result, the designation of the shallow zone and deep zone plumes is a simplified representation of a more complex aquifer system within which the PCE is distributed three dimensionally. In an effort to convey evolving conceptual models and to more accurately represent vertically continuous distribution of PCE in the complex aquifer system, the plume designations have been updated accordingly. The conceptual models will continue to evolve as specific contaminated regions are investigated.

Since 2008, several of the PCE plumes have been redefined to reflect those that are considered to be vertically continuous across the shallow zone and deep zone. The eight currently identified plumes are named as follows: South Reno, Downtown Reno, Mill/Kietzke, Victorian Avenue, Downtown Sparks, East Sparks, El Rancho, and Joule. A basemap identifying the plume locations and designations discussed in this report is shown on **Figure 1.2**. Each plume is described below.

The **South Reno** plume is considered to be a single laterally and vertically continuous (i.e. "complex") plume that includes:

1) The Vassar Street hot spot (where the presence of local persistently higher PCE concentration suggests a probable PCE source);

2) The East Plumb Lane hot spot (where the presence of local persistently higher PCE concentration suggests a probable PCE source);

3) The shallow zone portions of the plume that extend laterally from the upgradient hot spots in the downgradient direction; and

4) The deep zone portion of the plume that has impacted the CORBETT municipal water supply well and is interpreted to be the downgradient and deeper (in the hydrostratigraphic section) continuation of the shallow zone portions of the plume.

The **Downtown Reno** plume is considered to be a single laterally and vertically continuous (i.e. "complex") plume that includes:

1) The shallow zone West Fourth Street hot spot (where the presence of locally persistent higher PCE concentration suggests a probable PCE source);

2) The shallow zone portion of the plume that extends laterally from the upgradient West Fourth Street hot spot in the downgradient direction; and,

3) The deep zone portion of the plume that has impacted the HIGH, MORRILL, 4TH, KIETZKE, and MILL municipal water supply wells and is considered to be the downgradient and deeper (in the hydrostratigraphic section) continuation of the shallow zone portion of the plume.

The **Mill/Kietzke** and **East Sparks** plumes are, based on the existing data, currently characterized as shallow zone only plumes that are spatially associated with PCE hot spots and possible PCE sources. Further evaluation and possible refinement of plume conceptual models along with assessment of existing data gaps would be needed in order to more thoroughly characterize the nature and extent of these plumes, and to make a determination of any associated deep zone impacts.

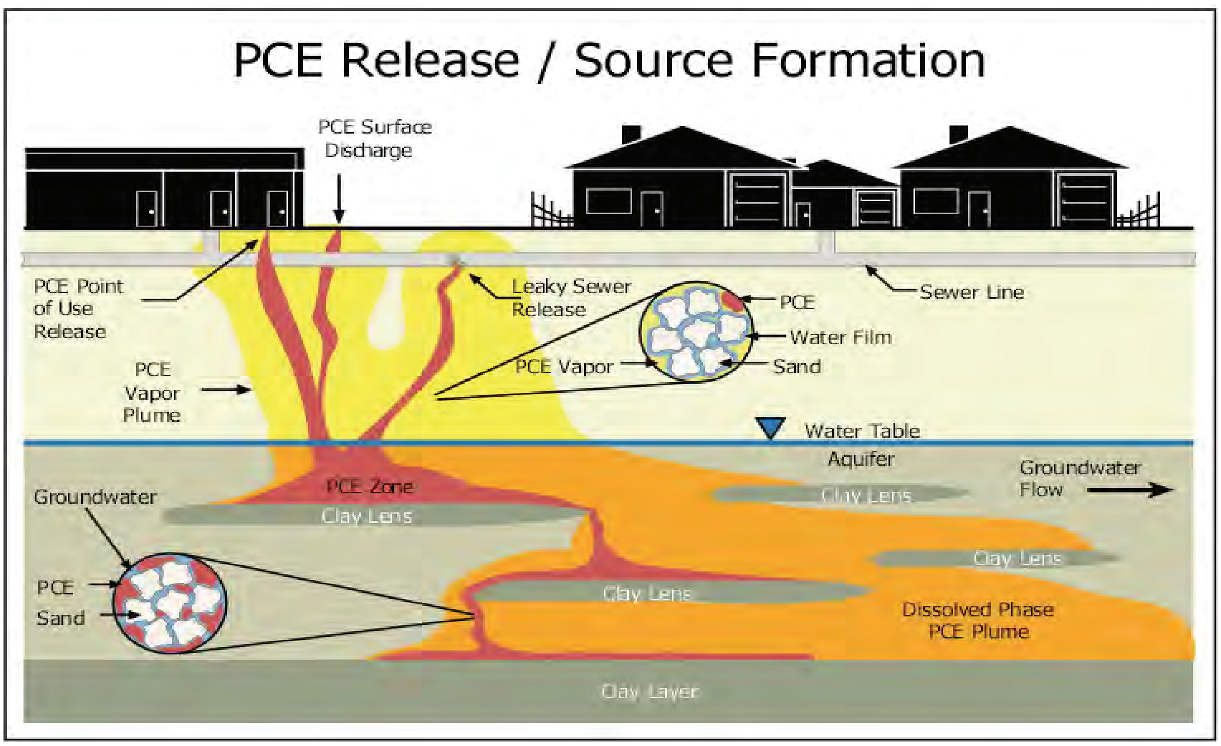
The **Victorian Avenue** and **Downtown Sparks** plumes continue to be designated as separate and distinct shallow zone and deep zone, respectively, plumes. Existing data suggest that multiple and distinct hot spots are contributing to the Victorian Avenue plume. Further evaluation and possible refinement of plume conceptual models and assessment of existing data gaps would be needed in order to more thoroughly characterize the nature and extent of these plumes before a determination of potential sources, possible vertical continuity, hydraulic connection, and/or genetic relationship between the Victorian Avenue and Downtown Sparks plumes can be made.

The **El Rancho** plume is currently only defined in the deep zone based on PCE that has only been observed in the EL RANCHO municipal water supply well and in a nearby well cluster consisting of two deep zone monitoring wells. An investigation was initiated in 2009 to characterize the nature and extent of the plume, as well as to identify possible PCE sources for the contamination that has impacted this well.

The **Joule** plume is a more recently defined complex plume where in 2009, PCE was detected in two adjacent monitoring wells (shallow zone well CTM87 and deep zone well BELFAST) located to the east of the Reno-Tahoe International Airport. As currently defined, the Joule plume is upgradient from the HV5 municipal water supply well which has had VOC impacts in the past (intermittent PCE at concentrations ranging up to 2.3 µg/L between 1992 and 2005). Starting in 2009 Q2, the Joule plume was defined to formally incorporate this area of PCE contamination into the GMP evaluation process.

The **Greenbrae Drive** plume, discussed in previous annual reports through 2008, is no longer defined by existing wells and is currently interpreted to have migrated beyond the existing DWR monitoring well network. In late 2008, owners for the Greenbrae Plaza NDEP Corrective Action Site located northwest of the Greenbrae Drive and 4th Street received a No Further Action letter from NDEP (DWR, 2009). Therefore, the Greenbrae Drive plume is no longer described in GMP annual reports. However, groundwater level data and groundwater quality samples continue to be collected and laboratory analytical data continue to be analyzed for VOCs from the wells located in this region.

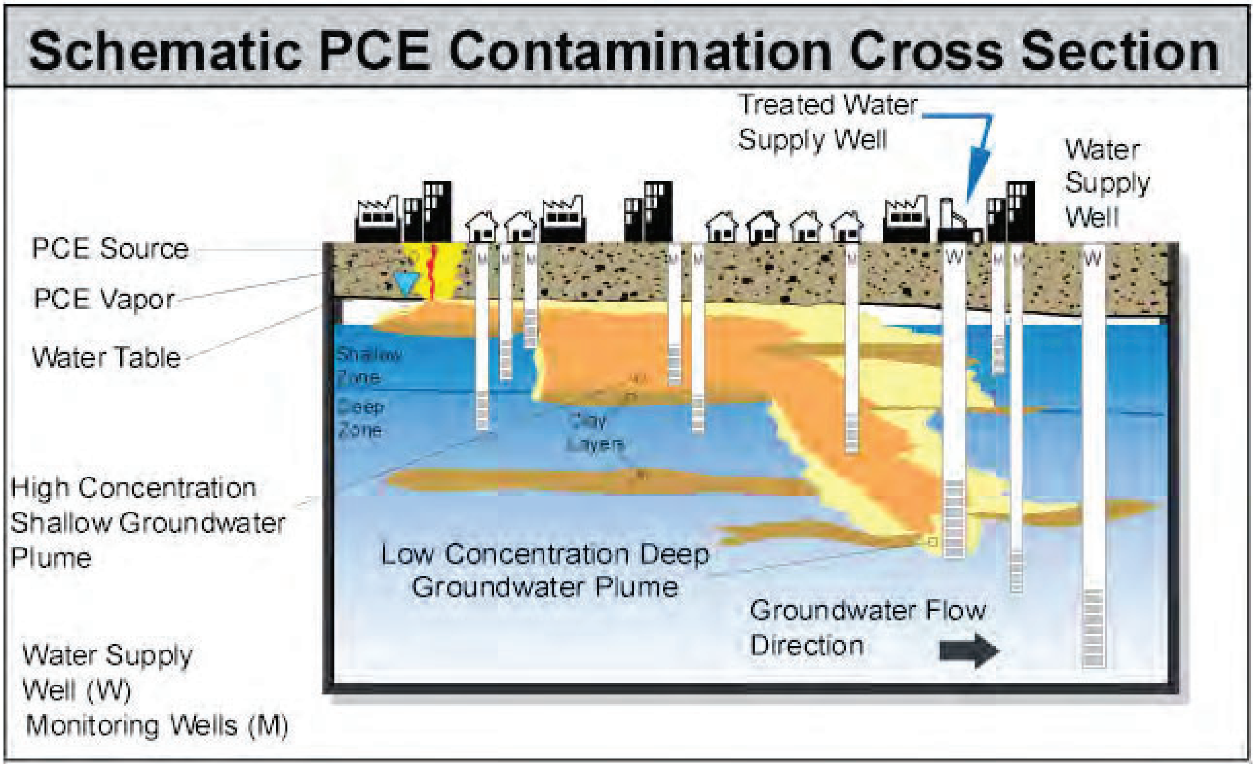
The schematic below shows how a PCE release can impact subsurface materials and groundwater.



Pure PCE is denser than water (by approximately 1.6 times) and has a low aqueous solubility. Given these properties, PCE is characterized as a dense nonaqueous-phase liquid (DNAPL) which tends to sink in water when present as a free phase. Even though the solubility of PCE is relatively low, the maximum concentration of dissolved PCE that can be present in associated groundwater is approximately 200,000 micrograms per liter (µg/L, NIOSH, 1994). This is almost five orders of magnitude greater than the drinking water maximum contaminant level (MCL) of 5 µg/L.

All PCE that occurs in the subsurface environment is associated with human activity and, by extension, originates at or near the land surface. Shallow zone plumes form when PCE releases at or near the ground surface encounter groundwater. Releases to the environment can occur in response to improper storage (e.g., leaking containers without secondary containment), use, disposal (e.g., into a leaking sanitary sewer system or by surface disposal), or accidental discharge. Once released to the subsurface, the PCE drains downward under gravitational forces. Because the density of PCE is greater than that of water, it will continue to drain downward if a sufficient volume is released. As PCE migrates through soils and geologic materials, some of it is typically trapped in the pore spaces of the sediment through which it passes, leaving behind a trail of residual PCE. If the migrating PCE encounters a hydraulic barrier, such as a competent finer grained layer or lens (silt or clay), it will tend to collect and form a pool. If the release continues, the PCE will spread out along the top of the barrier and continue to migrate laterally until it encounters the edge of the barrier or a conduit through the barrier where it will resume migrating vertically downward. Migration of PCE continues until the volume released becomes insufficient to drive further movement.

Groundwater that comes in contact with PCE dissolves some of it, forming a dissolved-phase PCE plume that effectively moves with the groundwater, developing plumes of PCE contamination such as those we observe in the CTM today (as shown on the conceptual figure above). While there is no laterally continuous barrier to vertical flow separating the shallow zone from the deep zone in the CTM, there are multiple discontinuous lower permeability layers that provide varying levels of at least local impedance to vertical groundwater flow and contaminant transport. PCE contamination in the shallow zone can ultimately become deep zone PCE contamination as a result of the vertical movement of either PCE as a DNAPL or dissolved phase PCE-contaminated groundwater. Deep zone contamination can in turn impact and be captured by municipal water supply wells. This conceptual understanding is shown graphically in the figure below.


Schematic PCE Contamination Cross Section
Treated Water Supply Well
Water Supply Well
PCE Source
PCE Vapor
Water Table
Shallow Zone
Deep Zone
Clay Layers
High Concentration Shallow Groundwater Plume
Low Concentration Deep Groundwater Plume
Groundwater Flow Direction
Water Supply Well (W)
Monitoring Wells (M)

3. 2010 SUMMARY OF GROUNDWATER MONITORING

3.1 Scope of Work

Two types of field data collection activities generally occur during a given GMP year; routine and non-routine activities. Routine activities include the recurring systematic data collection activities that are an explicit part of the GMP and include monthly groundwater level monitoring and quarterly water quality monitoring. Non-routine activities include data collection associated with other field activities such as potential source area investigations, new well construction, aquifer testing, borehole or well water quality and flow profiling, or high resolution groundwater level monitoring. These activities can occur at any time during the year and while not specifically defined in the GMP, may provide data that are integral to meeting GMP objectives.

Monthly groundwater level monitoring is conducted at all accessible wells in the monitoring well network. Wellhead monitoring for organic vapor emissions (using a photo-ionization detector [PID]), low density non-aqueous phase liquids (LNAPL) monitoring, and well condition assessment are performed in conjunction with groundwater level measurement at each well. These data are maintained in the CTMRD program database and support the groundwater elevation analyses presented in subsequent sections of this report.

Quarterly water quality monitoring is generally performed during the last month of a given quarter. The first (Q1) and third (Q3) quarter, included 155 and 211 scheduled wells respectively. These larger sampling events are scheduled to coincide with the period prior to and during the end of seasonal municipal groundwater pumping in the CTM (Q1 and Q3 respectively). The smaller second (Q2) and fourth (Q4) quarter sampling events included 118 and 121 scheduled wells, respectively, and provide temporal resolution necessary to monitor PCE concentration trends and to identify and characterize dynamic processes that might influence PCE distribution and movement taking place within or near the identified plumes in the CTM. In addition to quarterly; semi-annually; and annually scheduled wells, other wells may be opportunistically sampled including pumping municipal water supply wells; newly identified wells; or otherwise unscheduled wells as appropriate.

Low flow purge and sampling is the primary sample collection method that has been used for CTMRD program GMP sampling. Alternative sample collection methods that have or can be employed include: grab sampling (quasi-steady state high-flow discharge sampling, 3-well volume high-flow purge/sampling, purge/bail sampling); minimum purge sampling; passive diffusion bag sampling; and, depth-discrete grab sampling (using Hydrasleeves™ or passive diffusion bags) where logistics warrant or require. These alternative methods are used at a relatively small number of wells. Grab sampling methods are commonly used at municipal, irrigation, and industrial wells that, because of the high pumping rates and long screened intervals, cannot be effectively sampled using low-flow sampling methods. Minimum purge methods (using Hydrasleeves™ or passive diffusion bags) are commonly used for either very low yield wells where low-flow purge rates are not sustainable or wells with long screen intervals where field parameter stability attainment can be problematic under low-flow conditions. Depth-discrete sampling methods (arrays of samples collected at multiple depth intervals) are commonly used to characterize vertical PCE concentration distribution across longer-screened wells. In certain instances, several sampling methods may be employed at the same well. This can occur when a new sampling method replaces a sample method that had been previously used at a given well. In that instance, paired sets of samples are collected using both methods so that the results can be compared to recognize and minimize any potential method-related bias during the transition.

Field water quality measurements and laboratory analyses for groundwater sampled as part of the GMP include:

- Field parameters; and
- Volatile organic compounds (VOCs).

Field parameters are measured using a multi-parameter meter with electrodes placed in an enclosed flow-through cell. Measured parameters include pH, specific conductance, temperature, dissolved oxygen, turbidity, and oxidation-reduction potential. These parameters are monitored at all wells where low-flow purging is performed. The final, stabilized measurement values are compiled and included in the CTMRD program groundwater quality database as a means for tracking spatial and temporal water quality variability with respect to these parameters.

VOCs are analyzed in groundwater collected from every monitoring well sampled during a given quarter using USEPA method 8260B for all target analytes listed in the GMP QAPP (Intera, 2004).

Unless otherwise specified in this section, recurring field activities were performed in accordance with the Standard Operating Procedures (SOPs) and Quality Assurance Project Plan (QAPP) defined in the Groundwater Monitoring Plan (Intera, 2004).

During 2010, other non-routine data collection activities included:

- Ongoing potential source area investigations; and
- Vertical flow and water quality profiling of MILL, ELRANCHO, and 4TH PCE-impacted municipal water supply wells

The mechanistic aspects of these field activities are described below in **Section 3.3.3**. Data evaluation associated with these activities are either incorporated into the Data Evaluation section (**Section 5**) of this report where appropriate, or will be completed as a separate report and summarized in future annual reports as they become available.

3.2 Groundwater Monitoring Program Changes

3.2.1 Field Activity SOP Changes

Since the implementation of the GMP beginning in late 2003, modifications to the standard operating procedures (SOPs) for several field activities have taken place. These modifications have improved the efficiency, effectiveness, data quality or logistical safety of the program and have been documented in the subsequent GMP Annual Reports (Intera, 2006a; WorleyParsons, 2008, 2010, 2011, 2012). During the 2010 GMP, additional modifications were implemented and the sampling frequency of existing network wells was periodically revised. These modifications are summarized below. Detailed information concerning well-specific sampling frequency changes are listed in the 2010 Quarterly Reports (Kennedy Jenks, 2010a, 2010b, 2010c, 2011a).

- Beginning in 2010 Q1, 35 wells were transitioned from a semi-annual to an annual schedule. These wells were downgraded based on consistent PCE concentration non-detects in prior GMP sampling.
- Beginning in 2010 Q1, six wells were transitioned from a quarterly to an annual sampling schedule. These wells were downgraded based on consistent PCE concentration non-detects in prior GMP sampling.
- Beginning in 2010 Q1, eight wells were transitioned from quarterly to a semi-annual schedule. These wells were downgraded based on a relatively short history of PCE concentration non-detects in prior GMP sampling.
- Beginning in 2010 Q1, eight wells were transitioned from an interim quarterly to a quarterly schedule. These wells consist of new wells that were constructed in 2009.
- Beginning in 2010 Q1, LONGLEYLANE1 municipal water supply well was transitioned from a quarterly schedule to an opportunistic-monthly schedule. LONGLEYLANE1 is more effectively sampled on an opportunistic schedule during periods when it is pumped.
- During 2010 Q1, six wells were eliminated from the GMP. Five of these wells were eliminated due to safety issues associated with sampling logistics. One well was abandoned by the owner.
- In 2010 Q2, three wells were eliminated from the GMP because they were abandoned by the owner.
- In 2010 Q3 and Q4, there were no sample frequency changes.
- Beginning in 2010 Q4, Hydrasleeves™ were designated the preferred sampling device (over bailers or passive diffusion bags) for collecting samples at low yield wells; monitoring wells with long screen intervals; and for depth-discrete grab sampling.

3.2.2 Changes to Data Quality and Records Management

Beginning in 2010 Q3, analytical reporting limits were reduced for PCE and TCE from 1.0 µg/L to 0.50 µg/L. Otherwise there were no other changes to data quality and records management procedures during 2010.

3.3 Data Collection

3.3.1 Groundwater Level Monitoring

During 2010, DWR staff performed monthly water level monitoring with the objective of collecting a sufficient density of temporal data to characterize seasonal groundwater level dynamics and to provide monthly "snapshots" of groundwater levels in the CTM. The table below provides a summary of data collection activities associated with groundwater level monitoring for 2010. Groundwater level data are provided on data CDs included with the respective 2010 Q1, Q2, Q3 and Q4 Groundwater Monitoring Reports (Kennedy Jenks, 2010a, 2010b, 2010c, and 2011).

Summary Statistics for 2010 Groundwater Level Monitoring

2010 Q1	**JANUARY**	**FEBRUARY**	**MARCH**
MONITORED WELLS/WELLS SCHEDULED FOR MONITORING	*202/202*	*201/202*	*197/197*
OPPORTUNISTICALLY MONITORED WELLS	0	0	0
MONITORING WELLS MEASURED BY OTHERS	65	69	69
TOTAL # MONITORED WELLS	267	270	266
2010 Q2	**APRIL**	**MAY**	**JUNE**
MONITORED WELLS/WELLS SCHEDULED FOR MONITORING	*197/197*	*194/194*	*194/194*
OPPORTUNISTICALLY MONITORED WELLS	0	0	0
MONITORING WELLS MEASURED BY OTHERS	69	69	69
TOTAL # MONITORED WELLS	266	263	263
2010 Q3	**JULY**	**AUGUST**	**SEPTEMBER**
MONITORED WELLS/WELLS SCHEDULED FOR MONITORING	*194/194*	*192/194*	*190/194*
OPPORTUNISTICALLY MONITORED WELLS	0	0	0
MONITORING WELLS MEASURED BY OTHERS	69	69	69
TOTAL # MONITORED WELLS	263	261	259
2010 Q4	**OCTOBER**	**NOVEMBER**	**DECEMBER**
MONITORED WELLS/WELLS SCHEDULED FOR MONITORING	*188/194*	*190/194*	*193/194*
OPPORTUNISTICALLY MONITORED WELLS	0	0	0
MONITORING WELLS MEASURED BY OTHERS	68	68	68
TOTAL # MONITORED WELLS	256	258	261

3.3.2 Water Quality Monitoring

DWR staff performed the 2010 water quality monitoring as summarized below. Sample-specific details, including a list of wells sampled, corresponding sample ID, date/time of sampling, sample method/device used, and any special circumstances encountered during sampling are provided on the data CDs included with the respective 2010 Q1, Q2, Q3 and Q4 Groundwater Monitoring Reports (Kennedy Jenks, 2010a, 2010b, 2010c, and 2011).

2010 Q1 Activities

DWR staff performed the 2010 Q1 water quality monitoring between January 4, 2010 and March 25, 2010. The event included sampling at 155 scheduled wells. Two wells (ELRANCHOMWD and ELRANCHOMWS) were sampled opportunistically in early January and again during routine quarterly monitoring.

2010 Q2 Activities

DWR staff performed the 2010 Q2 water quality monitoring between April 2, 2010 and July 1, 2010. A total of 118 monitoring wells were sampled, including 108 scheduled wells and 10 opportunistically sampled wells (including CORBETT, HV3, LAKESIDE, LONGLEY, LONGLEYLANE1, MILL, MORRILL, and VIEW municipal water supply wells; and monitoring well USGSWCYARD twice).

2010 Q3 Activities

DWR staff performed the 2010 Q3 water quality monitoring between July 6, 2010 and September 30, 2010. A total of 211 wells were sampled, including 195 scheduled wells and 16 opportunistically sampled wells (including 21ST, 4TH, CORBETT, ELRANCHO, HIGH, HV3, HV5, KIETZKE, LAKESIDE, LONGLEY, LONGLEYLANE1, MILL, MORRILL, PECKHAM, SIERRAPLAZA, and VIEW municipal water supply wells).

2010 Q4 Activities

DWR staff performed the 2010 Q4 water quality monitoring between October 5, 2010 and December 23, 2010. A total of 121 wells were sampled, including 109 scheduled wells and 12 opportunistically sampled wells (including HV3, HV5, MILL, KIETZKE, HIGH, MORRILL, 4TH and ELRANCHO municipal water supply wells; and ELRANCHOMWS, ELRANCHOMWD, 4THMWS and 4THMWD monitoring wells).

The table below provides a summary of the 2010 Q1, Q2, Q3 and Q4 sampling events. Additional details are presented within the 2010 Q1, Q2, Q3 and Q4 Groundwater Monitoring Reports (Kennedy Jenks, 2010a, 2010b, 2010c, and 2011).

TABLE 3.5 - 2010 Water Quality Sampling Summary

	# INDIVIDUAL WELLS SAMPLED				# SAMPLES COLLECTED [1]							
	2010 Q1	2010 Q2	2010 Q3	2010 Q4	2010 Q1		2010 Q2		2010 Q3		2010 Q4	
					VOC	FIELD PARAMETERS	VOC	FIELD PARAMETERS	VOC	FIELD PARAMETERS	VOC	FIELD PARAMETERS
WELLS SAMPLED:					**GROUNDWATER SAMPLES:**							
SCHEDULED	155	108	195	109	158	130	109	102	198	169	110	102
NOT SCHEDULED	0	10	16	12	2	0	12	3	88	1	90	0
NOT SAMPLED	0	0	0	0								
TOTAL GROUNDWATER	**155**	**118**	**211**	**121**	**160[2]**	**130**	**121[2]**	**105**	**286[2]**	**170**	**200[2]**	**102**
QA/QC SAMPLES:												
FIELD DUPLICATES					11	10	7	7	18	10	13	8
EQUIPMENT					5	0	3	0	6	0	3	0
FIELD BLANKS					0	0	0	0	0	0	0	0
TRIP BLANKS					21	0	17	0	40	0	30	0
TOTAL QA/QC:					**37**		**27**	**7**	**64**	**10**	**46**	**8**
TOTAL SAMPLES:					**197**	**140**	**148**	**112**	**350**	**180**	**246**	**110**

[1] Total number of samples collected may include additional samples for purposes not directly associated with quarterly monitoring. These may include those for comparison of sampling methods, assessment of vertical distribution or PCE, etc.

[2] Total number of samples collected may exceed total number of individual wells sampled. This may be caused by multiple sampling at certain wells for assessment of vertical distribution of PCE, high frequency time-series sampling during aquifer testing, sample results verification, opportunistic monthly sampling at municipal water supply wells, etc.

[3] One or more equipment blank samples were collected from the reverse-osmosis decontamination system. Equipment blank requirements (1 per 20 groundwater samples) apply to samples collected using portable bladder and Rediflo2 pumps (a total of 45 samples in 2010 Q1, 28 samples in 2010 Q2, 64 samples in 2010 Q3 and 26 samples in 2010 Q4).

3.3.3 Other Data Collection Activities

Potential Source Area Investigations

During 2010 ongoing potential source area (PSA) investigations have continued at four areas identified by DWR where specific sources that may have contributed or that are contributing to recognized shallow zone plumes are likely to exist. These areas include the upgradient shallow zone portions of the following plumes:

- Victorian Avenue plume;
- Mill/Kietzke plume;
- South Reno plume; and
- Downtown Reno plume.

Potential source area (PSA) investigations in these areas were initiated in order to:

- Characterize the magnitude and extent of shallow subsurface contamination in the PSA;
- Identify sources that may have contributed to or that may be contributing to the contamination;
- Assess the threat posed by that source to groundwater; and
- Provide information to support a cost-benefit assessment of possible PCE source mitigation.

2010 data collection activities at these PSA's included the completion of passive soil gas surveys at the West Fourth Street PSA and an initial phase of active soil gas sampling at the Mill/Kietzke PSA. Although PSA investigations are not specifically part of the GMP, any pertinent new information obtained in the course of these investigations will be summarized in the appropriate subregion data evaluation discussion.

Vertical Flow and Water Quality Profiling of Impacted Production Wells

Vertical flow and water quality profiling of PCE-impacted municipal water supply wells (when considered along with well construction details, land use history, basin hydrostratigraphy) provide critical and detailed information on the flow of contaminated groundwater into these wells. This information will:

- Help define potential well-specific solutions for mitigating the PCE impacts to that particular well;
- Help focus efforts on the specific parts of the basin most likely to be contributing contaminated groundwater to the impacted interval(s) of each well;

- Provide vertical contaminant distribution information that will help vector back to potential source areas and inform ongoing potential source area investigations; and

- Supplement existing information (generated by the GMP and by the ongoing potential source area investigations) and contribute to the decision-making process as to how to most cost effectively mitigate PCE contamination in those parts of the aquifer contributing groundwater to the impacted wells.

Vertical flow and water quality profiling was implemented at MILL municipal water supply well during October 2010, and at ELRANCHO and 4TH municipal water supply wells during December 2010. The results from those activities will be evaluated in separate reports (in preparation) and discussed in the appropriate subregion data evaluation section of the next appropriate GMP Annual Report.

3.4 Laboratory Methods and Results

The following table summarizes the analyses performed on samples collected during 2010 monitoring events. All samples collected were submitted to Alpha Analytical of Sparks, Nevada. This laboratory is certified by the State of Nevada for analysis of waste water and drinking water under the Clean Water, Safe Drinking Water and Resource Conservation and Recovery Acts. Alpha also holds certification under the National Environmental Laboratory Accreditation Program (NELAP). Complete analytical results are tabulated on the data CDs included with the 2010 Q1, Q2, Q3 and Q4 Groundwater Monitoring Reports (Kennedy Jenks, 2010a, 2010b, 2010c, and 2011). PCE analytical data are posted and contoured on **Figures 5.2** through **5.9**.

Summary of 2010 Laboratory Analytical Program

		Number of Field Samples Analyzed
Event	Number and Type of QA/QC Data Packages	VOCs EPA 8260B (# Normal / # Other)
2010 Q1	26 Level II / 3 Level IV	160 / 40
2010 Q2	18 Level II / 2 Level IV	123 / 29
2010 Q3	40 Level II / 4 Level IV	286 / 67
2010 Q4	31 Level II / 4 Level IV	242 / 55
	Total	**811 / 191**

Notes:

QA/QC	Quality Assurance/Quality Control
Level II	Level II laboratory package including sample results, method blanks, laboratory control spike, matrix spike/matrix spike duplicate and surrogate summary data.
Level IV	Level IV laboratory package including all Modified Level II data and calibration, instrument tune, internal standards, interference check and serial dilution/post-digestion spike data.
Normal	Representative field sample
Other	Duplicate representative field sample, equipment blank, trip blank, or wastewater characterization samples

Total number of samples reviewed for QA/QC data quality exceeds total number of samples listed in Table 3.5 by 61 samples that include R.O. check samples and other non-GMP samples collected in association with vertical water quality profiling at MILL, ELRANCHO, and 4TH municipal water supply wells.

4. 2010 SUMMARY OF DATA QUALITY ASSURANCE REVIEW

This section summarizes the 2010 laboratory data quality assurance/quality control (QA/QC) data review and validation. The objectives, requirements and procedures of the QA/QC program for the GMP are outlined in detail in the QAPP. Details regarding the 2010 QA/QC program and data validation results are presented in the respective 2010 Q1, Q2, Q3 and Q4 Groundwater Monitoring Reports (Kennedy Jenks, 2010a, 2010b, 2010c, and 2011). During the QA/QC data review and validation, data generated from the implementation of the 2010 field and analytical programs were assessed for conformance with the following Data Quality Indicators (DQIs) defined in the QAPP (Intera, 2004):

- Accuracy;
- Precision;
- Representativeness;
- Comparability; and
- Completeness.

Data review included assessment of laboratory data deliverables and QA/QC samples (blank, spike and duplicate samples) for conformance with project data quality objectives (DQOs). Data validation included review of Level IV laboratory QA/QC packages to assess the conformance of instrument calibration, instrument tune, internal standards, interference checks, serial dilutions and post-digestion spikes with program DQOs.

Data that failed to meet program DQOs based on the data review and validation were flagged to identify the limitations to their reliability or usefulness. Data flags were entered into the project database and are included in the electronic tables on the data CDs in the respective 2010 Q1, Q2, Q3 and Q4 Groundwater Monitoring Reports (Kennedy Jenks, 2010a, 2010b, 2010c, and 2011). No corrective actions were identified as a result of quarterly data review and validation. Although the QA/QC program encompasses all data collected for the project, the subsequent sections focus only on data related to the detection and quantification of target analytes defined in the QAPP.

The results of data that failed to meet program DQOs based on quarterly data review and validation for target analytes are summarized in the table below. Listed constituents for the each sample identified in the table were flagged as estimated values.

Summary of 2010 Qualified Results

Quarter	Constituent	Sample ID	Concentration (µg/L)	Acceptance Criteria Violated	Result Qualified
2010 Q1	1,2-Dichloroethane	GW-ARCO2137M3-M-032510	< 10	Values are estimated due to reporting limit exceeding maximum contaminant level.	Yes
	Tetrachloroethene		< 10		
	Carbon tetrachloride		< 10		
	Vinyl chloride		< 10		
	Dichloromethane		< 40		
	1,1-Dichloroethene		< 10		
	Trichloroethene		< 10		
	1,1,2,2-Tetrachloroethane		< 10		
2010 Q2	None				
2010 Q3	Bromodichloromethane	GW-4THMWS-G2-071510	1.1	Relative Percent Difference (RPD) for this analyte, between this original sample and its duplicate, exceed 30%	Yes
	Chloroform		4.3		
	Bromodichloromethane	GW-1A-G1-071510	2.3		
	Chloroform		8.5		
2010 Q4	Bromoform	GW-4TH-G-120310 GW-4THMWS-G1-120310 GW-4THMWS-G2-120310 GW-4THMWS-G3-120310 GW-4THMWS-G4-120310 GW-4THMWS-G5-120310 GW-4THMWD-G1-120310 GW-4THMWD-G2-120310 GW-4THMWD-G3-120310 GW-4THMWD-G4-120310 GW-4THMWD-G5-120310 GW-4THMWD-G6-120310 GW-1C-G1-120310	All < 1.0 (Reporting Limit)	Bromoform has a %Recovery for Lab Control Spike, and % Recovery for both Matrix Spike (MS) and Matrix Spike Duplicate (MSD) below laboratory control limits. Although not detected in any samples in this work order, Bromoform has previously been detected at wells 4THMWS, 4THMWD, and 4TH where these samples were collected.	Yes
	Toluene	GW-CTM111-M-120710 GW-CTM113-L-120710	390 < 1.0 (Reporting Limit)	Toluene has a % Recovery for both MS and MSD below laboratory control limits and a RPD outside 30% acceptance criteria. Toluene has previously been detected at wells CTM111 and CTM113 where these samples were collected.	Yes

Additional details regarding the QA/QC data review and validation procedures are presented in the 2010 Q1, Q2, Q3 and Q4 Groundwater Monitoring Reports (Kennedy Jenks, 2010a, 2010b, 2010c, and 2011). These reports also include a data CD with summary tables presenting additional information regarding any QA/QC deficiencies that were identified and data flags that were applied, as well as a complete listing of laboratory analytical data and water level measurement data.

In all four 2010 sampling events, the 95% completeness DQI was met, which is the percentage of the valid analytical results produced divided by the number initially requested. In fact, no data were deemed invalid and rejected for the entire 2010 GMP analytical data set. In addition, during each 2010 quarterly sampling event only 0.1% of the data (27 values out of 26,763 groundwater constituent analyses) were qualified as estimated as a consequence of being outside of specified acceptance criteria. Qualified data are still usable although the resultant estimated values may be less accurate than non-qualified results. As a result of the 2010 data quality assurance review, performed as outlined in QAPP, the 2010 analytical data meet CTMRD program DQOs.

5. 2010 GMP DATA EVALUATION

The following subsections describe the GMP data evaluation based on hydrogeologic information, groundwater elevation data and PCE concentration data collected in the CTM since 2003 Q4 (when systematic groundwater monitoring conducted as part of the GMP began) through 2010. Sections are summarized as follows:

- **Sections 5.1 and 5.2** provide a regional perspective to the GMP groundwater level and PCE concentration data, respectively;
- **Section 5.3** summarizes regional data for groundwater sources and sinks that are tracked by the GMP;
- **Section 5.4** provides a brief summary of other regional-scale evaluations that, in 2010, includes the GMP well network review and the reassessment of key wells;
- Following these generally regional-scale data evaluations, **Section 5.5** provides an overview of the subregion-specific format utilized for presenting water level and PCE concentration data in the foregoing subregion discussions; and
- **Sections 5.6** through **5.12** present and discuss the specific data pertinent to the seven individual subregions that have been defined and are described below. The individual PCE plumes described in **Section 2.3.2** are discussed in the context of these individual subregions.

The subregions for each plume have been delineated such that they include the potential source(s) (or source area) for the plume as well as any receptor (or potential receptor) municipal water supply well(s) that has been (or could be) impacted by the plume. These subregions have been created in order to focus the analysis on discrete portions of the basin where cause, effect, and impact relationships are apparent (based on the existing data). The delineation of subregions also facilitates data evaluation and the presentation of results.

Each subregion that has been defined is a three-dimensional volume of the CTM basin that contains (where present and/or pertinent):

- Upgradient wells that have not been impacted by PCE and therefore define the upgradient extent of contaminated groundwater in the subregion;
- Wells that have been impacted by PCE and therefore define the lateral and vertical extent of contaminated groundwater (i.e. the plume) in the subregion;

- Potential PCE sources or source areas where the plume is likely to have originated and where releases of PCE may still be taking place or residual high concentrations of PCE in the subsurface may still contribute to groundwater contamination;
- Receptor or potential receptor municipal water supply wells that are or could be impacted by the plume; and,
- Downgradient wells that have not been impacted by the plume and therefore provide an 'early warning' capability in the event the plume would move in that direction.

Each subregion may contain:

- A vertically continuous PCE plume that has been identified in BOTH the shallow and deep zones (South Reno, Downtown Reno, and Joule);
- Distinct shallow zone PCE plumes (Mill/Kietzke and East Sparks);
- Shallow and deep zone PCE plumes whose hydraulic interconnection is undefined (Victorian Avenue and Downtown Sparks); or
- Deep zone plumes that are not yet sufficiently defined to associate with a specific potential shallow zone source area (El Rancho).

The hydrogeologic data from each of the subregions are used to develop and assess evolving conceptual models that are utilized to explain plume behavior and identify the drivers for PCE migration, contribute to identifying sources of the PCE contamination in the CTM, and contribute to the understanding of PCE migration pathways and identifying the potential risks to receptors. The boundaries of each subregion are intended to entirely encompass the currently defined extent of a plume, its potential source areas, and any actual or nearby potential receptor wells. The lateral boundaries of the subregions define rectangles that are typically elongated in the west to east direction as shown on **Figure 5.1**.

The seven three-dimensional subregions that contain the eight designated PCE plumes are as follows:

- **South Reno Subregion** containing the South Reno plume
- **Downtown Reno Subregion** containing the Downtown Reno plume
- **Mill/Kietzke Subregion** containing the Mill/Kietzke plume
- **Downtown Sparks Subregion** containing the Victorian Avenue and Downtown Sparks plumes
- **East Sparks Subregion** containing the East Sparks plume complex
- **El Rancho Subregion** containing the El Rancho plume
- **Joule Subregion** containing the Joule plume

Therefore, the eight plumes will be discussed in the context of these seven subregions.

5.1 Regional Groundwater Levels

5.1.1 Potentiometric Surface Data

Potentiometric surface maps for the shallow zones and deep zones during 2010 are presented in **Figures 5.2** through **5.9**. These figures illustrate the lateral groundwater flow directions and gradients for each quarter during 2010. As has been observed in previous years, the predominant natural flow direction was from west to east with local strong influences from municipal pumping that (as discussed in **Section 2.3.1)** results in deep zone groundwater cones of depression in the vicinity of pumped wells. Two deep zone groundwater depressions became apparent in Q2 in the vicinity of the CORBETT and VIEW municipal water supply wells where seasonal municipal water supply pumping commenced in May. In Q3, a coalescing groundwater depression was apparent in the vicinity of MORRILL, KIETZKE, MILL, CORBETT and VIEW that extended to the northeast to include 4TH and ELRANCHO, while a depression around LONGLEYLANE1 also became apparent. Groundwater flow in the deep zone was toward these wells and became most extensive in Q3, coinciding with peak municipal pumping periods during the summer and early fall.

A corresponding, but less pronounced decrease in shallow zone groundwater elevations was apparent in the general vicinity of VIEW and ELRANCHO in Q2 that expanded and increased in magnitude during Q3. Also during Q3, shallow zone groundwater elevation decreases became apparent in the area in the vicinity of MORRILL, KIETZKE, and MILL extending south of MORRILL and MILL to the area near Vassar Street between Virginia Street and U.S 395. The formation of shallow zone groundwater depressions in response to deep zone pumping from municipal water supply wells indicates that the shallow zone and deep zone are hydraulically connected in these areas and that shallow zone flow has an increased downward component in response to deep zone pumping. In Q4, groundwater depressions that were evident in the shallow and deep zones began to rebound except around 4TH where pumping commenced during Q4. With the exception of this area near 4TH, the groundwater flow returned to a predominantly west to east direction throughout the CTM. This coincides with the cessation of municipal well pumping (that corresponds to peak seasonal demand) and the resumption of generally natural gradient conditions.

5.1.2 Quarterly Shallow Zone/Deep Zone Water Level Differences

Maps showing the vertical groundwater elevation difference between the shallow and deep zones during 2010 (**Figure 5.10**) reflect the changes discussed above. These water level difference maps, or “color flood maps” are prepared based on the water level grid developed from contoured deep zone groundwater level elevation data minus the water level grid developed from contoured shallow zone groundwater level elevation data. These grids are comprised of point data developed from interpolating the groundwater elevation contours across the CTM. A positive grid difference reflects a net upward gradient and is indicated in green on the color-flood maps. A negative grid difference reflects a net downward gradient and is indicated in red. The calculated water level difference area includes a perimeter that extends 1,000 feet outward beyond where routinely gauged shallow and deep zone well networks coincide. Areas outside this perimeter are excluded from the groundwater level difference calculation, and are represented on the figure as uncolored areas of insufficient well coverage.

The color flood maps identify the vertical gradient distribution across the CTM. The potential movement of groundwater in the CTM would likely occur in a direction (upward or downward) consistent with the vertical gradient direction. Downward gradients are evident in a west to east corridor generally along the Truckee River (and are persistent in the portion of the corridor west of and proximal to the projection of the VLFZ). The areas of downward gradient become more pronounced, expand and extend east of the VLFZ and south of the river into the area of the deep zone cones of depression (discussed above in **Section 5.1.1**) during Q2 and Q3. Downward relative gradients are at their greatest magnitude and extent during Q3 (at the end of seasonal groundwater pumping from the deep zone). In Q4 they persist but decrease in both magnitude and extent.

The groundwater depressions that form in Q2 and expand laterally in Q3 create a sharp boundary between areas of upward and downward gradient. This boundary occurs along a projection from the area west of CORBETT roughly 7,000 feet northwestward towards MORRILL. The vertical gradient on either side of this northwesterly trending feature is characterized on the color flood maps by a persistent upward gradient on the southwest side and a seasonally reversing gradient (downward during pumping periods; upward during periods of more natural groundwater flow) on the northeast side. The boundary coincides with the HWB and is interpreted to reflect the influence of the HWB as a partial barrier to lateral groundwater flow in the deep zone.

The Truckee River can affect groundwater levels by potentially providing recharge to the aquifer in the upstream areas of the CTM (areas of downward gradient) and receiving discharge from the aquifer in the downstream areas (areas of upward gradient). The amount of groundwater recharge and discharge that would occur in areas where the aquifer is hydraulically connected to the river would vary in response to changing vertical gradients (caused by fluctuations in groundwater elevation and/or river stage).

5.1.3 Cumulative Annual Water Level Changes

In the previous 2008 and 2009 Annual Reports (WorleyParsons, 2011; WorleyParsons, 2012), drawdown response was evaluated using the calculated difference between annual maximum and minimum groundwater levels for each shallow zone and each deep zone well as a means of approximating the cumulative drawdown associated with municipal groundwater pumping. Starting in 2010, this methodology is revised to more directly represent the time period when cumulative water level changes correspond to pumping and non-pumping periods. **Figures 5.11** and **5.12** plot deep zone and shallow zone contour maps (respectively) of the cumulative water level change for the period from September

2009 to April 2010 when community-wide water demand typically decreases and pumping at municipal water supply wells generally has ceased or is at a minimum. **Figures 5.13** and **5.14** plot similar water level change contours for the period from April 2010 to September 2010 when water demand typically increases and municipal water supply well pumping peaks. Data utilized for each map are calculated on a well-by-well basis by subtracting each well's water levels at the start of the represented period from that well's corresponding water level at the end of the period. The calculated change for shallow zone and deep zone wells are then contoured and depicted on respective maps as positive isopleths for water level increases (indicating recovery) and defined by shades of blue, and negative isopleths for water level decreases (indicating drawdown) and defined by shades of red. It has previously been recognized (from review of hydrographs and transducer data) (WorleyParsons, 2011) that deep zone pumping is the primary driver for recurring annual water level fluctuations in a significant portion of the CTM basin. This section discusses features depicted by the respective deep zone and shallow zone maps for each period that are influenced by deep zone pumping or other potential seasonal groundwater fluxes.

Cumulative Water Level Changes during the Non-Pumping Period

September to April generally represents a period when pumping decreases and injection for artificial storage and recovery occurs at a limited number of municipal water supply wells in the CTM basin. This is the general case for the period between September 2009 and April 2010, where net municipal water supply extraction (pumping minus injection) for the CTM was 73.7 MG compared to 2098.4 MG during the previous pumping season (April through September 2009). The mapped contours on **Figures 5.11** and **5.12** provide a means of depicting cumulative recovery observed to occur across the CTM basin that coincides with fall and winter when pumping volume is typically low.

Figure 5.11 depicts the distribution of cumulative water level change for the deep zone during the non-pumping period and draws attention to several areas of note.

- In the area around MILL, KIETZKE, 4TH, MORRILL, ELRANCHO, and VIEW the highest magnitude cumulative water level increase (in the range of 20 to 40 feet) occurs and is attributable to recovery from the prior year's cumulative pumping at these wells.

- Proximal to TERMINAL, 10 feet or more of recovery occurs. TERMINAL was neither pumped nor injected during 2009 or 2010. The water level increases at TERMINAL are considered to be attributable to recovery associated with cumulative pumping, - primarily at wells constructed at similar depths (greater than 300 feet bgs) and similar hydrostratigraphic packages as TERMINAL. These include MILL, KIETZKE, MORRILL, 4TH, and perhaps VIEW.

- In the area west of the VLFZ where:

  - Proximal to HIGH, a relatively localized area of water level increase (greater than 20 feet) occurs and is attributable to recovery from pumping at HIGH.

  - Proximal to GLENHARE and HUNTERLAKE, an area of increased water level (in the range of 10 feet or more) occurs that is attributed to injection for ASR. Net injection of 52 MG occurred at these wells during the September 2009 to April 2010 period.

- Proximal to POPLAR1, POPLAR2, and SPARKS more than 10 feet of recovery occurs. Water level increases at deep zone wells in this area are likely attributable to recovery associated with the prior year's cumulative pumping at other nearby municipal water supply wells. No pumping occurred at these wells prior to the period represented by the map.

- In the southern part of the mapped area proximal to HUFFAKER, HOLCOMB, and LONGLEY an increase in water levels of approximately 10 feet occurs. This increase is inferred to be the result of a combination of recovery from the prior year's pumping at LONGLEY and from injection during 2010 at HOLCOMB.

- Over the extent of the mapped area, water levels during the non-pumping season exhibit an increase everywhere except in the far northwestern and far northeastern edge of the mapped area.

Figure 5.12 depicts the corresponding map for the shallow zone and draws attention to several areas of potential interest. As is observed in the deep zone cumulative water level change map for this period, discrete areas of water level increases and water level decreases are also evident, but are significantly smaller in magnitude. There is general spatial correlation between higher magnitude deep zone recovery and shallow zone recovery; however several areas of shallow zone water level change are notable for their different configuration.

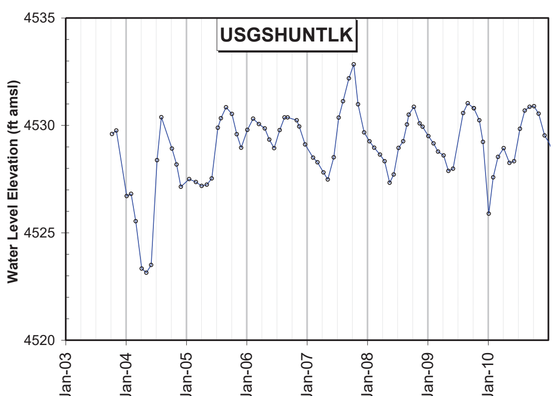
- In the area around the MILL, KIETZKE, 4TH and MORRILL wells, and extending to the south along and east of the VLFZ, the highest magnitude cumulative increase (commonly between 5 and 10 feet) occurs. This area generally coincides with the location of the highest magnitude cumulative recovery for the deep zone. However it has a different configuration to the west where its extent more closely correlates with the mapped position of the VLFZ.

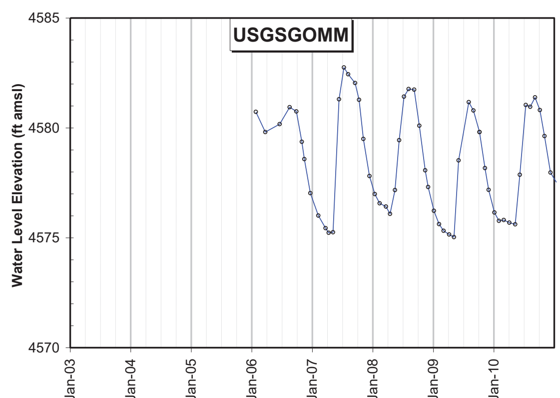
- In the area west of the VLFZ where:

  - Proximal but north of HIGH, a local area of higher magnitude cumulative water level increase (in the range of 4 feet) corresponds to the location of CTM6S.

- Throughout most of the remainder of the area there is low cumulative water level change (generally less than 1 foot) that includes wells that appear to respond primarily to river stage, such as MW7NS, RPDWM6, and COR10 (WorleyParsons, 2011).

- At the far west edge of the mapped area, water levels apparently decrease by as much as 4 feet. The decreasing water levels at the few wells in this area exhibit a recurring annual pattern that is opposite of the majority of wells in the CTM basin. This pattern may reflect fluctuation of groundwater recharge caused by irrigation or surface water infiltration (e.g., from nearby irrigation ditches) that occur during the spring through summer and diminish during the winter (see hydrographs of the two westernmost wells below).





- In the area north and east of Virginia Lake, between the VLFZ and the HWB, there is an area of relatively low (generally < 3 feet and locally < 1 foot) water level increase.

- East of US 395, shallow zone cumulative water level change is generally low and predominantly exhibits an increase (in a range between 0 and 2 ft).

- South of South McCarran Blvd and west of US 395, shallow zone water levels increase by as much as 10 feet. The two monitoring wells in this area have hydrographs indicating seasonal fluctuations that correlate to pumping and injection at LAKESIDE municipal water supply well. Both monitoring wells are constructed in bedrock.

Cumulative Water Level Changes during the Pumping Period

April to September generally represents a period of the year when basinwide pumping occurs as a result of increased demand for community-wide water supply. This is the general case for the period between April 2010 and September 2010 where net pumping in the basin was 2053 MG compared to 73.7 MG during the previous non-pumping season (from September 2009 through April 2010). The mapped contours on **Figures 5.13** and **5.14** provide a means of depicting cumulative drawdown observed to occur across the CTM basin that coincides with the spring and summer when pumping volume is high.

Figure 5.13 depicts the distribution of cumulative water level changes for the deep zone during the pumping season and draws attention to several areas of note.

- In the area around MILL, KIETZKE, 4TH, MORRILL, ELRANCHO, and VIEW the highest magnitude cumulative water level drawdown (in the range of 30 to 60 feet) occurs and is attributed to sustained pumping at these wells. For the period between April and September a combined volume of 999.7 MG was pumped from these wells. This represents roughly 50% of the total basin-wide pumping volume (2089 MG) during that period.

- Proximal to TERMINAL and CORBETT, drawdown in the range of 20 to 30 feet occurs and is attributed to a combination of pumping at CORBETT (274.6 MG) and enhanced drawdown at TERMINAL (where no pumping occurred in 2010). Enhanced drawdown at TERMINAL (represented by a water level decrease of 40.7 feet) is attributed to cumulative pumping at deep municipal water supply wells (including MILL, KIETZKE, MORRILL, 4TH, and perhaps VIEW) that are constructed to depths exceeding 300 feet bgs and are considered to be screened across (and hydraulically connected to) some the same hydrostratigraphic packages where TERMINAL is constructed (screened interval - 330 to 665 feet bgs).

- In the area west of the VLFZ where:

    - Proximal to HUNTERLAKE and GLENHARE, seasonal water level decreases on the order of 10 feet are attributed the cessation of injection for ASR at both wells in April. No pumping occurred at these wells during the 2010 pumping season.

    - Proximal to HIGH, deep zone drawdown is relatively small in magnitude, and decreases to less than 5 feet at distances of 1,000 feet or more from the well in the south and west directions. At MW10ND (1,400 ft south) and CTM30D (1,200 feet west) drawdown is 2.65 and 4.91 feet respectively. The relatively small magnitude and extend of drawdown in the vicinity of HIGH is notably different than the more widespread drawdown in the vicinity of MILL, KIETZKE, 4TH, MORRILL, ELRANCHO, and MILL.

- Deep zone drawdown is generally lower west of the VLFZ than east of the VLFZ.
    - West of the VLFZ, level decreases are more localized in proximity to a municipal water supply well. Results are consistent with deep zone drawdown west of the VLFZ that is at least partly mitigated by enhanced vertical hydraulic connections and a local source of recharge. This is consistent with evidence provided in previous annual reports

(WorleyParsons, 2010, 2011) for a possible hydraulic connection between the Truckee River and groundwater west of the VLFZ.

  - East of the VLFZ, the relatively larger volume of pumping (compared to west of the VLFZ) is a likely contributing influence on the more widespread distribution of drawdown. Results also suggest that the deep zone drawdown east of the VLFZ may be enhanced as a consequence of the VLFZ effectively impeding subsurface flow sufficiently to limit groundwater inflow from the west into the area east VLFZ. This is consistent with evidence provided in previous annual reports (WorleyParsons, 2010, 2011) that the Truckee River is disconnected from groundwater (and unavailable to directly mitigate deep zone drawdown) east of the VLFZ.

- In the south and east parts of the CTM (including east of Rock Boulevard and south of the Reno-Tahoe International Airport) deep zone drawdown is typically less than 10 feet and includes areas where limited municipal water supply well pumping occurred during 2010.

Figure 5.14 depicts the distribution of cumulative water level change for the corresponding shallow zone map. As is observed in the deep zone cumulative water level change map for this period, discrete areas with seasonal increases or decreases are also evident, but are smaller in magnitude compared to the deep zone water level changes. There is general spatial correlation between higher magnitude deep zone drawdown and shallow zone drawdown; however several areas of shallow zone drawdown are notable for their different configuration.

- In the area around the MILL, KIETZKE, 4TH and MORRILL wells, and extending to the south along and east of the VLFZ, a relatively widespread area of high magnitude cumulative drawdown (commonly between 5 and 10 feet) occurs. The general extent of this area is nearly identical to the area defined by **Figure 5.12** depicting shallow zone recovery. Both maps are consistent with the shallow zone east of the VLFZ having enhanced vertical hydraulic communication in an area that partially coincides with the deep zone area with highest magnitude water level change. The western extent of this area of high magnitude annual fluctuation coincides with the mapped location of the VLFZ and suggests that this partial flow barrier inhibits the influence of pumping at municipal water supply wells located east of the VLFZ on shallow zone drawdown and recovery to the west of the VLFZ.

- In the area west of the VLFZ where:

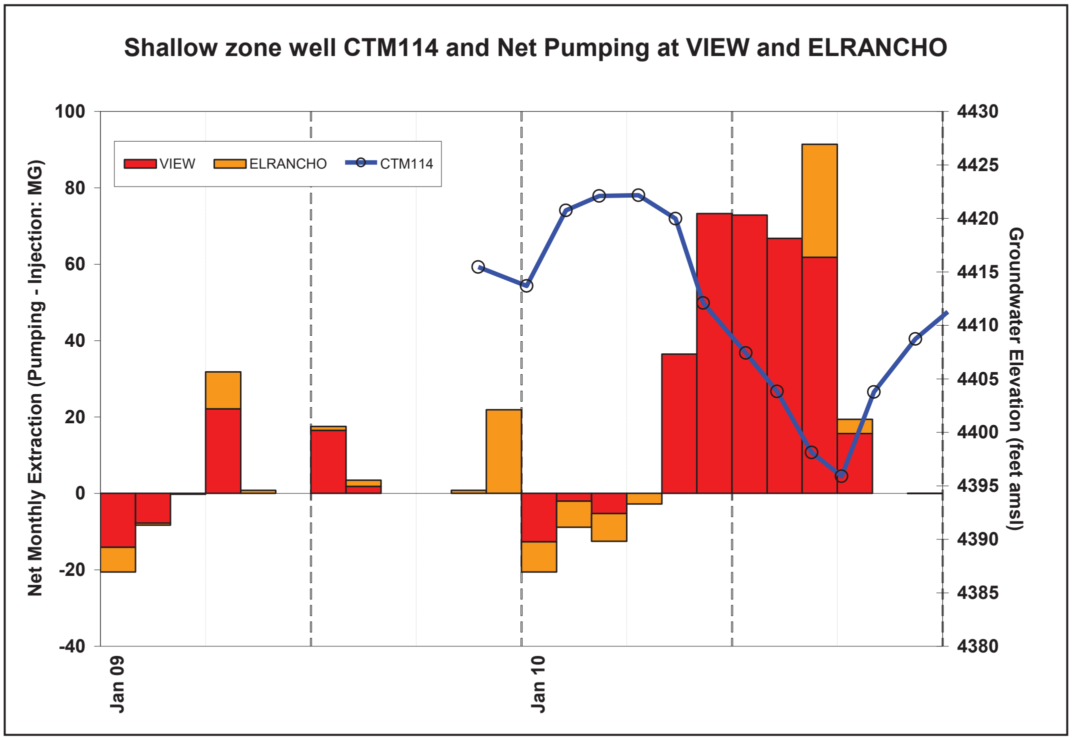
  - Proximal to the HIGH municipal water supply well there is an area of higher magnitude cumulative drawdown (> 3 feet) localized in the vicinity of CTM6S.

  - Throughout the most of remainder of the area, there is low cumulative drawdown (generally < 1 feet). During 2010 the area of low seasonal drawdown generally includes the entire downtown Reno area west of the VLFZ. In previous annual reports (WorleyParsons, 2011; 2012), this area of low cumulative drawdown is suggested to be partly influenced by the Truckee River (where the connection between the river and the water table would mitigate any shallow zone drawdown response) and by decreased pumping over the period since 2008. For the group of municipal water supply wells located west of the downtown Reno area (including RENOHIGH, GLENHARE, SWOPE, and HUNTERLAKE), pumping has decreased from 308.4 MG (in 2008), to 137.2 MG (in 2009), to no pumping during 2010.

  - At the far west edge of the mapped area water levels apparently increase by as much as 5 feet. The increasing water levels at the few wells in this area exhibit a recurring pattern that is opposite of the majority of wells in the CTM basin and may reflect increases as a result of increased groundwater recharge caused by the onset of irrigation or by increased surface water infiltration (from nearby ditches that are operated seasonally) during the late spring and summer months (see previous hydrographs above).

- North and east of Virginia Lake, between the VLFZ and the Harvard Way Barrier, there is another area of low cumulative annual shallow zone drawdown (generally ≤ 2 feet, and locally < 1 foot). It is possible that the VLFZ and HWB influence vertical gradients and mitigate shallow zone drawdown in this area. It is also possible that the drawdown response is lower as a consequence the relatively distal location of this area from regional pumping.

- In the El Rancho area, north of Interstate 80 and east of US 395, the highest magnitude cumulative shallow zone drawdown (between 5 and 20 feet) occurs. This area is proximal to VIEW and ELRANCHO where between April and September 2010, 326.7 MG and 29.6 MG of groundwater were pumped, respectively. The large magnitude drawdown and apparent correlation between drawdown and pumping at VIEW and ELRANCHO suggest a relatively direct hydraulic connection between deeper pumped portions of the aquifer and shallow part of the aquifer in this area (see hydrograph for shallow zone well CTM114 below).



- In the Downtown Sparks area and eastward, shallow zone cumulative water level decreases are of low magnitude (typically < 3 ft) and there are local areas with water level increases. In 2009, a similar distribution of low drawdown was interpreted to be the result of lower annual pumping at wells in this area; the area's distance from the Truckee River; and a relatively weaker hydraulic connection between the shallow zone and the deep zone (WorleyParsons, 20112). In 2010, no seasonal pumping occurred in this area at GALLETTI, GREG, POPLAR1, POPLAR2, SPARKS, or STANFORD and only 10.2 MG was pumped from 21ST.

- South of South McCarran Blvd and west of US 395, shallow zone water level drawdown of as much as 10 feet occurs. Water levels from the two monitoring wells that define this area exhibit seasonal fluctuations that correlate to pumping and injection at LAKESIDE municipal water supply well (located approximately 450 feet northwest of the southernmost of the two wells). Both monitoring wells are constructed in bedrock.

5.2 Regional PCE Distribution

PCE concentrations observed during 2010 in shallow and deep zone wells are contoured in **Figures 5.2** through **5.9**. The lateral and vertical extents of the South Reno, Downtown Reno, Mill/Kietzke, Victorian Avenue, Downtown Sparks, El Rancho, East Sparks, and Joule plumes (as defined by the existing monitoring well network) are relatively unchanged in 2010 compared to 2009 and to previous years as documented in prior GMP reports (Intera, 2006a; Worley Parsons, 2008, 2010, 2011, 2013). It should be noted that plume outlines were modified for the Victorian Avenue and Downtown Sparks plumes in 2009 as a consequence of reassigning several monitoring wells (from deep zone to shallow zone as discussed in the 2008 Annual Report; WorleyParsons, 2011). It should also be noted that starting in 2008 Q4, PCE data used to defined the East Sparks plume complex (previously designated the Wolverine Way-SS/FS plume) are combined with PCE data (generated on behalf of the Vista Canyon Group by Camp, Dresser, and McKee) from the adjacent SS/FS. Finally, it should be noted that apparent changes to the defined lateral and vertical extent of the South Reno, Downtown Reno, and Joule complex plumes occurred in 2009 as a result of the improved resolution capability provided by 30 new wells constructed during late 2008 and early 2009 as part of the Phase 3 well program (as described in the 2009 Annual Report; WorleyParsons, 2013). However in all of these instances, modifications or changes to plume outlines are due solely to either well zone reassignment or to improved plume resolution associated with the addition of new data points and do not reflect changes in plume dynamics.

Starting in 2010 Q3, analytical reporting limits for PCE (and TCE) have been lowered from 1.0 µg/L to 0.50 µg/L. The increased capacity to detect lower concentrations of PCE (along with the concurrent lowering of the PCE contour interval utilized to define plume outlines from 0.625 to 0.50 µg/L (on **Figures 5.2** through **5.9**) has resulted in slight modifications to the plume outline for the Victorian Avenue plume; the deep zone portion of the South Reno plume; and to the outline of PCE contamination upgradient (west) of the Mill/Kietzke plume (see **Figure 1.2** for currently defined plume outlines). They are described as follows.

- At the Victorian Avenue plume, the lower reporting limit defines the shallow zone plume to extend roughly 1,500 feet further to the south than previously defined (and now includes CTM77 and CTM78 near the POPLAR1 and POPLAR2 municipal water supply wells).
- In the area west of the Mill/Kietzke plume, with the detection of sub-1 µg/L PCE concentration at shallow zone well CTM104, the previously isolated zone of contamination at CTM102 is shown to be laterally contiguous with the Mill/Kietzke plume. In this instance, PCE contamination at shallow zone well CTM102, deep zone well CTM101, and shallow zone well CTM104 is considered to either be part of the Downtown Reno plume or to originate from a source that is distinct from the source area for the Mill/Kietzke plume.
- At the South Reno complex plume, the detection of PCE at deep zone well CTM95 (0.75 µg/L) defines the western outline of the deep zone portion of this plume to extend roughly 2,000 feet west of its previously defined outline. CTM95 (screened interval – 80 to 90 feet bgs) is relatively shallow but has been tentatively designated a deep zone well based on the relatively large magnitude upward vertical gradient exhibited between it and shallow zone well CTM96 (and

part of well cluster CTM96/CTM95/CTM94). Results from this well are consistent with the shallow zone PCE contamination recognized at CTM96 (screened interval – 41 to 46 feet bgs) extending into the uppermost portion of the deep zone at this location.

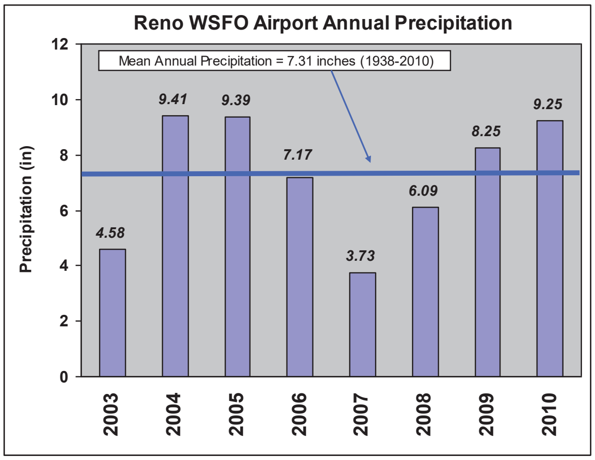
The lateral extents of the shallow zone portion of the Joule plume changed from 2009 to 2010 as a result of the first-time detection of PCE in the range of 1 µg/L at shallow zone well CTM86. The shallow zone portion of the plume is now defined to extend for at least 1,200 feet in a northeast direction from its previous defined outline around single shallow zone well CTM87.

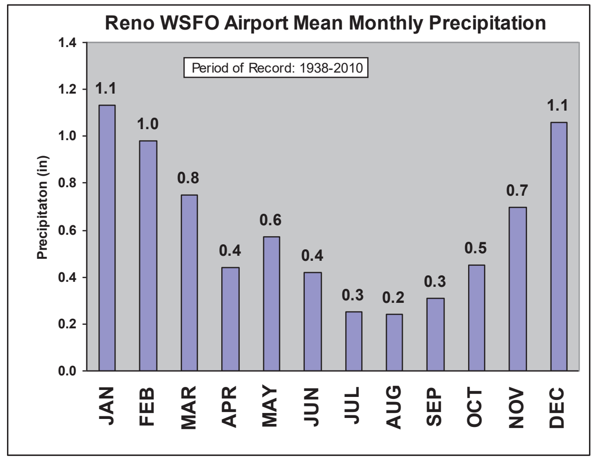
The distribution of PCE within the context of the seven subregions will be discussed further in **Sections 5.6** through **5.12**.

5.3 Regional Groundwater Source and Sinks

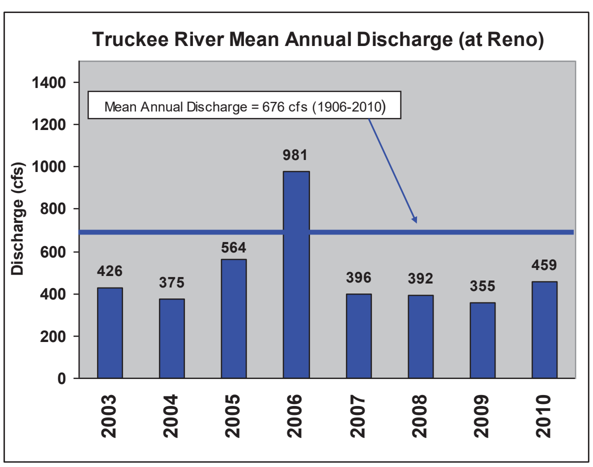
Potential sources of aquifer recharge that contribute to the CTM alluvial basin water budget include; mountain front recharge along the margins of the alluvial aquifer; recharge from the Truckee River; deep zone well injection for aquifer storage and recovery (ASR); groundwater inflow across basin boundaries; infiltration from creeks, ditches and other surface water features; infiltration from irrigation, leaking distribution and wastewater collection systems; and, infiltration from precipitation. Summary statistics including annual precipitation, annual Truckee River flow, and annual municipal water supply well injection are provided below.

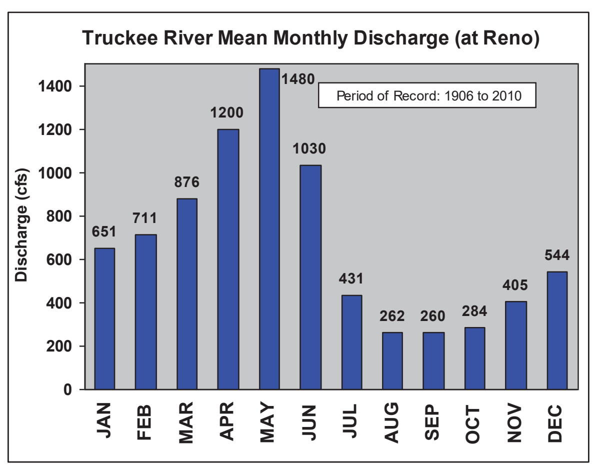
Annual precipitation as measured at the Reno airport (RNO gage) was 9.25 inches in calendar year 2010 (NOAA, 2011) and was above the long term average of 7.31 inches (1937 – 2010; NOAA, 2011). Annual records indicate precipitation in the CTM basin has increased each year since 2007, when annual precipitation attained a GMP period minimum at 3.73 inches. Mean monthly precipitation for the period from 1938 to 2010 show a seasonal pattern where precipitation is generally greatest in magnitude during the winter and smallest during the summer. No effort is made as part of the GMP to estimate groundwater recharge associated with precipitation.





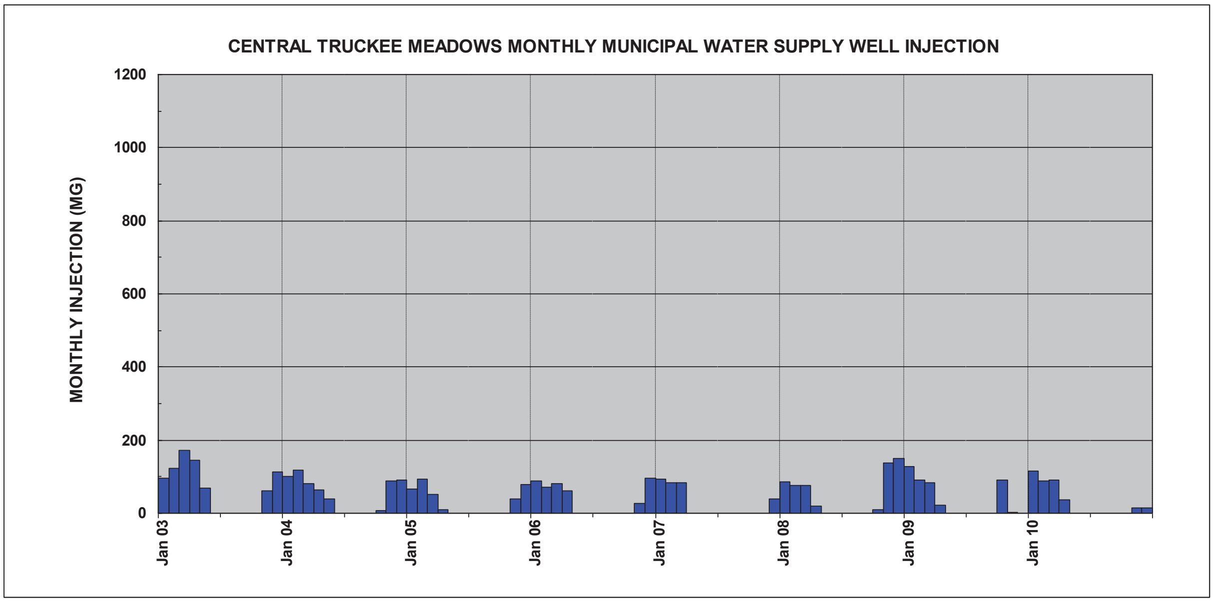
Mean annual Truckee River discharge as measured at the Reno Gage was 458.7 cubic feet per second (CFS) during 2010 and was below the long term average annual discharge of 676 cfs (1906 to 2010; USGS, 2011). Annual records for the GMP period of record starting in 2003 indicate mean annual Truckee River flow in the CTM basin has been similar (ranging between 355 and 564 cfs) during each year except in 2006 when flows were significantly larger and averaged 981 cfs. Mean monthly discharge data (for the period from 1906 to 2010) show a seasonal pattern where flow is generally at a minimum in late summer, increases starting in fall and continues to increase during the winter through the spring runoff period before flows begin to decrease in the late spring or early summer. No effort is made as part of the GMP to estimate groundwater recharge or discharge associated with river flow.





Well injection for artificial storage and recovery (ASR) has routinely occurred in the CTM basin since 1999 and is typically conducted between November and May. Eleven municipal water supply wells have historically been utilized for ASR. During 2010, annual ASR injection was 363.9 million gallons (MG) and was less than the average annual injection volume (472.4 MG) since the start of the GMP period in 2003.

The annual recharge from ASR activities has decreased during the past three years (559.7 MG in 2008; 417.9 MG in 2009; 363.9 MG in 2010) as depicted in the table below.

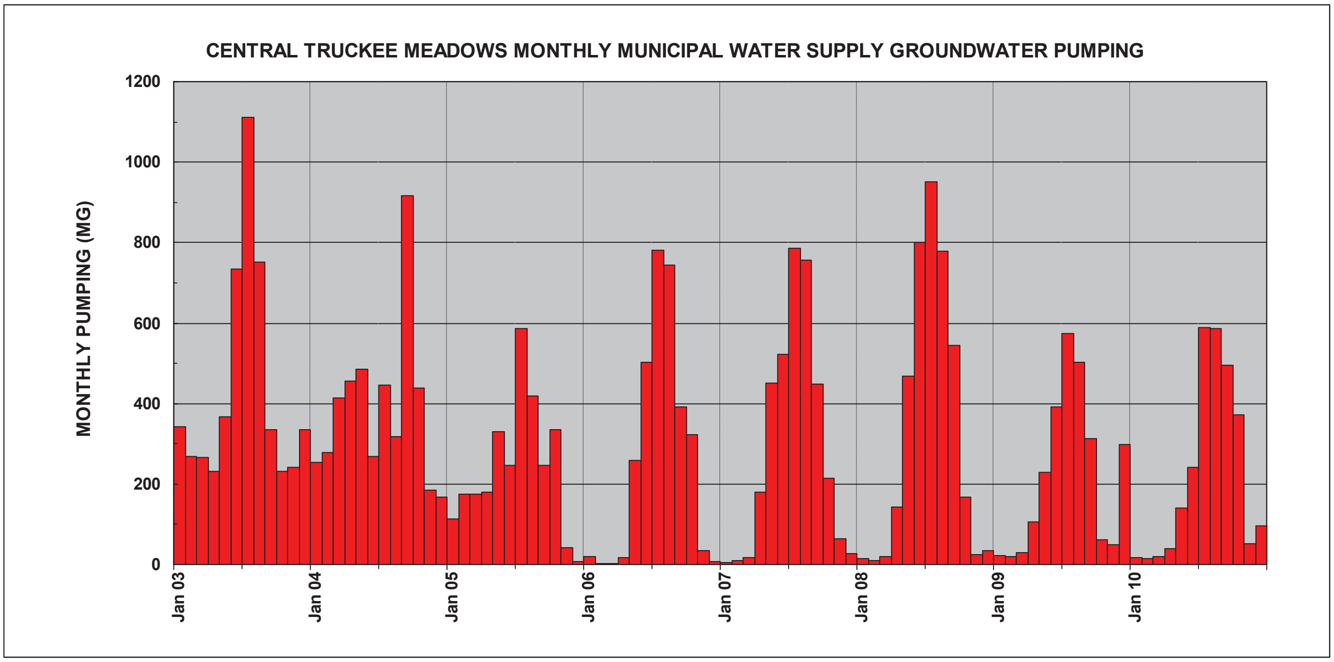


Groundwater sinks in the CTM basin include groundwater discharge to the Truckee River; pumping from municipal water supply wells; pumping from domestic, commercial, and other wells; groundwater discharge to creeks, sloughs, or drainage ditches; evaporation from surface water features connected to the aquifer system; and evapotranspiration in parts of the basin where the water table is sufficiently shallow. With the exception of municipal water supply pumping, these groundwater sinks are not routinely estimated or quantified as part of the GMP. Summary statistics for annual municipal water supply well pumping are provided below.

On average, annual municipal water supply pumping in the CTM basin provides approximately 10-15% of the community-wide water demand with the bulk of the remaining demand being supplied by the Truckee River (TMWA, 2011). Prior to 2006, pumping operations occurred more or less year-around, with pumping continuing into the fall and winter at PCE-treated wells (HIGH, MORRILL, KIETZKE, MILL, and CORBETT). In the winter of 2005-2006 (starting in early November 2005), the PCE-treated wells were shut down for the winter. These wells were restarted in the spring of 2006 and have since been operated in accordance with a pumping schedule that is based on meeting peak water demand. Pumping is typically conducted between May and October.

A total of 32 TMWA and DWR municipal water supply wells have been utilized for municipal water supply pumping since the start of the GMP period in 2003. During 2010, annual pumping was 2,662.4

MG and was less than the average annual pumping volume (3,560.8 MG) since the start of the GMP period of record in 2003. The 2010 pumping was similar to the pumping volume of 2,601.0 MG in 2009.



Central Truckee Meadows Annual Pumping and Injection (in millions of gallons)			
	Pumping	Injection	Net Annual Extraction
2003	5,215.0	(782.3)	4,432.7
2004	4,627.2	(591.6)	4,035.6
2005	2,856.9	(338.1)	2,518.8
2006	3,086.6	(426.1)	2,660.5
2007	3,479.6	(299.2)	3,180.4
2008	3,958.0	(559.7)	3,398.3
2009	2,601.0	(417.9)	2,183.1
2010	2,662.4	(363.9)	2,298.4

5.4 Other Evaluations

5.4.1 Well Network Review and Key Well Identification

During 2010, DWR initiated an assessment of the GMP well network with the objective of evaluating individual wells within each subregion in terms of:

- Defining individual monitoring well function as defined by each well's capacity to provide data needed to meet GMP objectives;
- Determining individual monitoring well value in terms of relative importance to the GMP; and
- Redefining key wells based on well function and value with regard to providing critical data needed to assess key plume or groundwater-flow characteristics and dynamics.

This process included a subregion-by-subregion evaluation of individual well hydrographs and PCE time series data in the following stepwise manner:

- Each well within a subregion was characterized based on its location relative to
    - the associated plume in that subregion (including location relative to critical parts of the plume such as hot spots, plume axis, areas of high plume mass –or plume cores, etc.);
    - features that are potential influences on hydrodynamic or PCE plume behavior (such as flow barriers, or groundwater sources and sinks); and
    - Potentially Contributory Activities (PCAs).
- All subregion wells were grouped based on similarity of monthly groundwater elevation hydrograph characteristics including water level trends, patterns, and fluctuation magnitudes. Each grouping was characterized and described in terms of those characteristics.
- PCE time series data for each individual well were characterized based on apparent trends, patterns, and any recognized interrelationship between PCE concentration and water level data as distinguished by PCE time series-hydrograph plots of quarterly PCE concentration and monthly groundwater elevation data.
- Based on the water level and PCE concentration assessments described above, an integrated function for each well was described in terms of the well's capacity to provide data needed for plume characterization/dynamics and/or for groundwater flow characterization/hydrodynamics.
- These narrative descriptions were then compiled in **well review spreadsheets** and utilized to establish each well's primary function and relative value with regard to the well's capacity to assess PCE plume and groundwater flow characteristics and dynamics.

- Finally key wells were selected utilizing a **key well decision matrix table** to evaluate each well within the currently defined subregions based on its capacity to assess one or more of 16 critical or "Key Well" functions. These key well functions are defined based on the following more general GMP assessment elements:
  - PCE source vectoring;
  - Characterizing PCE source areas and source area mass flux contribution;
  - Assessing PCE mass flux/plume dynamics (particularly along plume axis, core, and downgradient plume extent);
  - Assessing of risk to receptors;
  - Evaluating Pumping Plan effectiveness. The Pumping Plan prescribes a mutually agreed-to pumping schedule at the five PCE-treated wells operated by TMWA and is designed to substantially contribute to remedying the condition of PCE contamination (Pumping Plan Agreement, 2009); and
  - Defining plume migration pathways (particularly near flow barriers, groundwater sources or sinks, or potential areas of enhanced vertical flow).

Based on this process, 81 monitoring or municipal water supply wells were defined as key wells for 2010. These key wells include 54 of the 64 previously defined 2009 key well list. Wells that were eliminated include CTM1S, CTM4D, CTM19S, CTM46, CTM50, CTM60, CTM64, CTM69, CTM74, and MW1ND. These wells were either considered redundant or did not meet any of the key well functions as defined by this process. The majority of former key wells that were eliminated are wells that are hydraulically upgradient of any associated PCE plume. While these upgradient wells are important for defining plume extent; rather than key wells, they function as detection monitoring points for potential contributing upgradient sources or to define changes in hydrodynamics that would potentially cause changes in PCE plume distribution. Twenty-seven wells were added to the list in 2010. Twenty of these are Phase 3 wells constructed in 2009 and include CTM5, CTM80, CTM81, CTM83 through CTM87, CTM93, CTM95 through CTM99, CTM101 through CTM103, and CTM105 through CTM107. The remaining 7 added wells include 4THMWD, COR12A, CTM31S, HV5, SSFSMW205, SSFSMW207, and TERMINAL. **Key well decision matrix tables** and **well review spreadsheets** summarizing well function and an assessment of their value to the GMP are provided for each key well for each subregion in **Appendix 5.1**.

During previous years, a subset of specified well clusters was designated as key well clusters. During 2010, all well clusters positioned within any currently defined subregion are considered important and are therefore the term key well cluster is no longer used. This modification is in recognition of the inherent importance of well clusters for characterizing source to receptor migration pathways and for tracking the vertical component of PCE dynamics and groundwater flow.

5.4.2 High and Morrill Aquifer Test Analyses

DWR collaborated with Hydro Geo Chem, Inc. (HGC) in preparing a report (HGC, 2009) summarizing the results of two long-duration aquifer tests: one conducted at the HIGH municipal water supply well in spring 2006 and the second at the MORRILL municipal water supply well in spring 2007. For the HIGH aquifer test, HIGH was pumped at an average rate of 1475 gallons per minute (GPM) for 10 days while water levels were recorded at 16 observation wells distributed across the Downtown Reno Subregion. For the MORRILL aquifer text, MORRILL was pumped at an average rate of 1431 GPM for 10 days while water levels were recorded at 21 observation wells also distributed across the Downtown Reno Subregion. Specific results from the tests' analysis are discussed as part of the Downtown Reno Subregion data evaluation in the pertinent subsections of **Section 5.7**.

5.5 Subregion-specific Data

The specific hydrostratigraphy, water level data, groundwater sources and sinks, potential PCE sources, PCE concentration and distribution, possible trends and patterns in water level and PCE concentration data, and groundwater receptors are described in each subregion as part of the following subsections of the report. Figures and tables used for these subregion evaluations are summarized below. The approach for the subsequent subregion evaluations are based on using the available data and known features of each subregion to guide the discussions so that topics relevant to the individual subregions and objectives of the GMP are emphasized.

5.5.1 Groundwater Levels

In the subregion-specific sections (**Sections 5.6** through **5.12**) of this report, potentiometric surface maps, vertical groundwater elevation difference maps, and vertical gradient data are used to assess lateral and vertical hydraulic gradient and groundwater flow based on data collected during 2010. **Figures 5.2** through **5.14** depict these data and are used for groundwater level data evaluation in the subregion-specific sections that follow. Each figure has been discussed in previous parts of **Section 5** and is briefly described below.

Figures 5.2 through **5.9** provide quarterly potentiometric water level surface contours for the shallow zone and deep zone during 2010. These figures illustrate the lateral groundwater flow directions and gradients for each quarter during 2010.

Figure 5.10 presents the quarterly vertical groundwater elevation difference color-flood map for each quarter of 2010. These maps are prepared based on the water level grid developed from contoured deep zone groundwater level elevation data minus the water level grid developed from contoured shallow zone groundwater level elevation data (as described previously in **Section 5.2**). These grids are comprised of point data developed from interpolating the groundwater elevation contours across the

CTM. A positive grid difference reflects a net upward gradient and is indicated in green on the color-flood maps. A negative grid difference reflects a net downward gradient and is indicated in red.

Figures 5.11 through **5.14** are bi-annual cumulative groundwater level change maps for the shallow zone and deep zone. These maps are prepared by calculating the groundwater level elevation difference for each shallow zone well and each deep zone well during two periods: the non-pumping period that commonly occurs between September and April when community-wide water demand is low and routine sustained pumping does not occur; and the pumping period that commonly occurs between April and September when increased demand is met by sustained pumping that is relatively widespread in the CTM basin. For each period, a separate shallow zone and deep zone cumulative groundwater level change map is depicted.

5.5.2 PCE Concentrations

This subregion-specific sections of this report characterize the distribution and quarterly changes in PCE concentration in wells from each subregion in the CTM using a compilation of 2010 quarterly PCE concentration data and contours (as depicted in **Figures 5.2** through **5.9**) and PCE time series graphs for key wells and well clusters (**Graphs 5.1** through **5.7**)**.**

Key wells for each subregion are defined based on the well's capacity to provide data needed for plume characterization/dynamics and/or for groundwater flow characterization/hydrodynamics. Key wells that facilitate plume analysis provide information that characterizes PCE concentration distribution and dynamics in critical parts of the plume including:

- Proximal to potential sources;
- Along axial or mid-plume locations; and,
- Near the leading edge of the plume.

Key wells can also function as sentry wells to protect municipal water supply wells; verification wells to track the effectiveness of PCE containment by the pumping plan; or be receptor wells (municipal water supply wells that are impacted by PCE). Key wells in the context of hydrodynamics are considered representative of distinct hydrodynamic regimes (such as groundwater conditions on either side of a potential hydraulic barrier (such as the VLFZ) or representative of distinct portions of a PCE plume (to assist in evaluating plume dynamics in response to lateral or vertical groundwater gradients). Well clusters are comprised of wells completed at different depths (e.g., shallow zone and deep zone monitoring wells) located in close proximity and constructed to evaluate the potential for vertical groundwater flow and PCE distribution and movement between the shallow zone and deep zone. Key wells and well clusters for each subregion are listed in **Tables 5.1** and **5.2,** respectively and are depicted on **Figure 5.15**.

The PCE data for key wells are summarized in **Tables 5.3** and **5.4**, and further described in the appropriate subsequent subregion-specific report sections (**Sections 5.6** through **5.12**).

Table 5.3 presents the PCE concentration statistics (including minimum, maximum, mean, standard deviation, and coefficient of variation) for key and other important wells over the GMP period of record. **Table 5.4** presents the 2010 quarterly PCE concentration data and highlights potentially significant PCE concentration changes observed in the key wells (and in any other wells considered to have notable results). Any quarterly result that represents a new GMP minimum PCE concentration is indicated in green. A result that represents a new PCE maximum concentration is indicated in red. A result that exhibits a statistically significant change compared to the previous most recent sample is indicated in magenta. A statistically significant PCE concentration change is defined as any quarter-to-quarter (or quarter to most recent previous) PCE concentration change that exceeds two times the standard deviation of the PCE concentration data for the well for the period since the implementation of the GMP (2003 Q4). This is an empirical criterion that flags any relatively large short term change in PCE. As shown in **Table 5.4**, PCE concentrations changes in 13 wells meet this criterion. The PCE trend listed in **Table 5.4** is the Mann-Kendall trend analysis of data from 2003 Q4 to 2010 Q4 (herein referred to as the GMP period). The last column on **Table 5.4** entitled "Notable Results" identifies any well noted during quarterly data evaluation whose results are considered to be potentially important, either because they are inconsistent with the existing conceptual model, they identify data gaps, or they otherwise identify an item that could be addressed and thereby contribute to meeting GMP objectives. These potentially important results are described in detail in the appropriate subregion.

PCE time-series plots and water level hydrographs were created for each key well and for select well clusters to evaluate possible patterns, trends and correlations in water level and PCE concentration data and to support the conceptual model analysis. The key well graphs are presented in **Graphs 5.1a** through **5.7a** and the well cluster graphs are presented in **Graphs 5.1b** through **5.7b**. In these graphs, vertical gridlines represent the beginning of each quarter. Spiky, single measurement water level values (where present) indicate possible inconsistencies or errors in the data. The possible patterns, trends, and correlations are discussed in the subregion-specific data evaluation subsections of this report. The interpretations of the graphs are discussed further in the corresponding subregion-specific conceptual model discussion of this report as appropriate.

5.5.3 Other Data

Data on potential PCE sources are provided on **Figures 5.16**, **5.19**, **5.22**, **5.24**, **5.28**, and **5.30** and include the identification of:

- Former or current NDEP PCE Corrective Action Sites;
- Other sites where evidence of PCE in the subsurface environment has been previously documented;

- SMP Sites, where DWR (in collaboration with the City of Sparks and Reno) has detected PCE in wastewater samples collected as part of the Sewer Monitoring Program (SMP) — a program that monitors PCE in the wastewater collection system serving any active or recently active drycleaners in the CTM;
- PCE high mass areas, where DWR has delineated elevated PCE mass in the vadose zone as part of a Potential Source Area (PSA) investigation; and
- Potentially Contributing Activities (PCAs) that include existing and former potentially PCE-using businesses (herein defined to include dry cleaners, auto repair shops, auto paint and body shops, chemical manufacturers, and paint shops) where the improper use, and/or disposal of PCE could potentially result in releases to the environment and could cause impacts to groundwater.

The presence of a PCA does not necessarily mean that PCE is or was used at that location or that an environmental release of PCE has occurred or will occur.

5.6 South Reno Subregion

The South Reno Subregion encompasses a plume that has originated from at least two separate sources near the shallow zone Vassar Street and East Plumb Lane hot spots. The contamination has, in recent years, moved laterally to the east under natural conditions and vertically downward in response to municipal well pumping. As a result, the originally separate plumes (now represented by these hot spots) have subsequently combined into a larger single plume. This single contiguous plume extends laterally and vertically across multiple water bearing zones in the complex aquifer system. Accordingly, the South Reno plume is characterized as a “complex” plume. This larger plume extends downgradient from the hot spots and into the deep zone. Receptors or potential receptors include (with multiple screens that span the intervals shown in parentheses):

- CORBETT (180-280 feet bgs), a receptor for the South Reno plume
- TERMINAL (330-665 feet bgs), a potential receptor for the South Reno plume as well as the, Downtown Reno and Mill/Kietzke plumes

The South Reno plume originates east of the Virginia Lake Fault Zone (VLFZ) and west of the Harvard Way Barrier (HWB). Between the VLFZ and the HWB, the South Reno plume is interpreted to occur primarily in the shallow zone of the aquifer system. East of the HWB, downward PCE mass movement has resulted in impacts to CORBETT. The downgradient extent of the plume is undefined to the east, but extends at least 1,300 feet east of CORBETT. **Figure 5.16** depicts pertinent features in the South Reno Subregion that are described in the following subsections.

5.6.1 Hydrogeology

No new hydrogeologic data were acquired in the South Reno Subregion in 2010. Consequently, the following description is taken largely from the 2009 GMP Annual Report (WorleyParsons, 2013).

As discussed in **Section 2.2.4**, two geologic features occur in this subregion (**Figures 5.16**) that act, at least locally, as partial barriers to groundwater flow. The westernmost feature is called the Virginia Lake Fault Zone (VLFZ). The easternmost feature is called the Harvard Way Barrier (HWB).

The VLFZ passes through the South Reno Subregion into the Downtown Reno Subregion where it is inferred to be present west of MORRILL. DWR borehole information suggests that structural displacement across the VLFZ (in the vicinity of CTM14S and CTM15S) is on the order of 50 feet in the shallow subsurface. Water level data from wells in the vicinity of the VLFZ define a contracted steepening of the lateral hydraulic gradient. This steepening in the gradient locally coincides with the eastern margin of the VLFZ where it is referred to as the Crystal Springs Barrier (CSB).

The HWB was originally (WorleyParsons, 2007) identified based on a sharp west-to-east steepening of the hydraulic gradient along a deep zone well transect between CTM33D and CORBETT. As discussed in the 2009 GMP annual report (WorleyParsons, 2012), the HWB is currently interpreted to persist to the northwest and pass between well clusters CTM102/CTM101/CTM100 and CTM9S/CTM104/CTM103/CTM10D (located north of and outside the South Reno Subregion).

The following description of hydrostratigraphy in the South Reno Subregion is subdivided into what are considered to be three distinct areas:

1) West of the CSB and within the VLFZ;

2) Between the VLFZ and the HWB; and,

3) East of the HWB.

In previous GMP annual reports, the westernmost part of the South Reno Subregion was represented as being west of the VLFZ, with the VLFZ being represented as a relatively narrow linear feature coinciding with steepening of the lateral hydraulic gradient. As discussed in **Section 2.2.4**, the VLFZ is currently represented as a corridor that includes multiple post-Neogene faults. The multiple faults in the basin fill material are considered the near-surface manifestation of a deep seated bedrock structure that has been interpreted (based on gravity data by Widmer, 2005) as a down-to-the-west normal fault. That portion of the South Reno Subregion that had been described in previous GMP annual reports as being west of the VLFZ is now represented as being west of the CSB and within the VLFZ (**Figure 5.16**).

In general, the hydrostratigraphy in the South Reno Subregion is interpreted to have an apparent flat to gentle dip to the east. West of the HWB, the deep zone is characterized based on data from a limited number of wells. East of the HWB, the deep zone is characterized based on a larger number of wells.

The characterization of hydrostratigraphy is presented in terms of vertical sequences of geological materials that, while variable, are more generally similar (with respect to acting as either a conduit or impediment to groundwater movement) within a given interval and distinct from the overlying and underlying intervals. Where these sequences are laterally continuous, they are defined as distinct hydrostratigraphic packages (herein termed packages), that while internally heterogeneous, are recognizable from well to well and can extend across any given subregion. Hydrogeologic descriptions are consistent with and based principally on cross-sections prepared by DWR.

West of the CSB and within the VLFZ (described from top to bottom):

The following description is based primarily on deep zone borings CTM27D and CRYSTALSPG2 (located at the former Crystal Springs Water Company, 901 S. Center Street). These monitoring wells are considered to be located within the VLFZ corridor that that extends along the western edge of the subregion from Virginia Lake north toward the intersection of Holcomb Avenue and Ryland Avenue. The sequences described below have not been designated as hydrostratigraphic packages because the limited number of wells in this part of the subregion does not allow confirmation of the lateral continuity of these sequences in this area.

- A generally coarser upper sequence (comprised of poorly sorted sandy/silty gravel to gravelly sand with lesser silt) that extends from land surface to approximately 150 to 190 feet bgs. Based on shallow zone wells CTM49, CTM50, CRYSTALMW1, CRYSTALMW2, CRYSTALMW3 and USGSHOLCOMB, the uppermost 30 feet of this sequence includes relatively thin interlayers of silt, sandy silt, silty sand, and silty gravel.

- Below approximately 190 feet bgs (based on CRYSTALSPG2), a sequence of relatively finer material (ranging from silt to sand with lesser gravel) extends to a depth of at least 270 feet bgs.

Between the VLFZ and the HWB (described from top to bottom):

The following description is based on multiple shallow zone borings no deeper than 56 feet bgs and on lithology logs from deep zone wells CTM92, CTM94, CTM95, CTM33D, and PEPPERMILL4. These data have been used to define the following packages:

- Package A. Generally coarser grained material (comprise of poorly sorted silty/gravelly sand to sandy gravel) extends to approximately 120 to 150 feet bgs. This package includes distinct cobble-rich intervals and minor thin finer (silt and clay) intervals. Package A has relatively high intra-package heterogeneity that could contribute to locally semi-confining conditions.

- Package A includes the following characteristics near the plume hot spots:
  - Near the Vassar Street hot spot (in CTM46, CTM47, CTM48, and CTM62; to approximately 56 feet bgs) coarser material (sand with gravel, gravel with subordinate fines, gravel and cobbles) predominates with minor thin intervals of finer material (sandy clay, silt, sandy silt, silty sand, fine sand,).
  - Near the East Plumb Lane hot spot (in CTM16S, CTM51, CTM52, CTM53, and USGSLISTON; to 42 feet bgs) coarser material (sandy gravel to clayey gravel, sand, and gravelly to silty sand) is interlayered with finer material (sandy clay, silt, silty sand).
  - The near surface material at each hotspot is similar to what occurs near the surface west of the CSB and within the VLFZ.
- Package B(c). Beneath shallow zone Package A is a package of uncertain thickness that consists of generally coarser grained material (including sandy gravel to gravelly sand, and silty gravel) with limited finer grained lenses and interlayers (silty clay, silt, and silty sand). The transition from Package A to underlying deep zone Package B(c) is defined at CTM33D by the presence of a 10 foot thick, finer grained interlayer at a depth of 153 ft bgs. The coarser grained materials in Package B(c) can effectively transmit water. While there has not been a substantial thickness of finer grained material identified in this depth interval in this subregion (causing Package B(c) and the underlying deep zone Package C to be indistinguishable here), the finer grained lenses or interlayers in B(c) have lower hydraulic conductivity and would be expected to contribute to locally impeding vertical groundwater movement through this sequence and between the shallow zone (i.e. Package A) and the underlying deep zone. Package B(c) and underlying deep zone Package C have a total combined thickness of approximately 100 feet in this area.
- Package C. A package of uncertain thickness that consists of generally coarser grained material (sandy gravel, silty gravel with cobbles) with limited finer grained lenses and interlayers (silty clay, silt, and silty sand). The coarser grained materials in this package can effectively transmit water. There has not been a significant thickness of finer grained material identified above this depth interval in this subregion (resulting in Package C and overlying Package B(c) being indistinguishable here and comprising a total combined thickness of up to 100 feet).
- Package D. A package of predominantly finer grained material (silt to silty sand) that extends from 210 feet bgs to at least 255 feet bgs at the bottom of CTM94.
- Based on the lithologic log from PEPPERMILL4 (located approximately 500 feet south of the southern subregion boundary) there are alternating sequences of predominantly finer and coarser materials that corresponds in part to Package D. These sequences are described as follows:

  - Relatively finer material (clayey sand with gravel) from approximately 200 to 430 feet bgs. This interval may be equivalent to Package D and to comparable material at CTM94.
  - Thickly interlayered coarser and finer material (sandy gravel with cobbles to gravely sand to clayey sand) that occurs from approximately 430 to 580 feet bgs.
  - Finer material (silty sand with local clay) from approximately 580 to 1130 feet bgs.
  - Bedrock (andesitic volcanic rock) beginning at approximately 1,130 feet bgs.
  - These sequences have not been designated as hydrostratigraphic packages. No attempt has yet been made to establish their hydrostratigraphic context due to the small amount of related data and limited bearing on issues pertinent to the CTMRD program.

East of the HWB (described from top to bottom):

- Package A. A predominantly coarser material (poorly sorted silty gravelly sand, to sandy gravel with cobbles) with lesser fines (interlayered silt and clay) from ground surface to a depth of approximately 160 feet bgs (in CORBETT, CTM17D, CTM97, CTM98 and TERMINAL). This is considered equivalent to Package A defined between the VLFZ and the HWB and potentially equivalent to the material in the near-surface west of the CSB and within the VLFZ.

- Package B(c). A generally coarser grained package (comprised of silty gravel to gravelly silt, gravel, and gravelly sand) with limited finer grain lenses and interlayers (silt and silty clay). Coarser interlayers (with low matrix fines) are considered to be permeable and (based on spinner log data at CORBETT) are capable of producing significant groundwater. The transition from Package A to B(c) is defined by the presence of a 10 to 20 foot thick, finer grained interlayer starting at a depth of 163 feet bgs at CORBETT. While there has not been a significant thickness of finer grained material identified in this depth interval in this subregion (causing Package B(c) and the underlying deep zone Package C to be indistinguishable here), the finer grained lenses or interlayers in B(c) have lower hydraulic conductivity and would be expected to contribute to locally impeding vertical groundwater movement through this sequence and from the shallow zone (i.e. Package A) into the underlying deep zone. Package B(c) and the underlying Package C have a total combined thickness of approximately 100 feet in this area. CORBETT is entirely screened across Package B(c) and C (screened interval -180 to 280 feet bgs). Package B(c) is defined on both sides of the HWB, but based on limited well data, is interpreted to have greater vertical heterogeneity (consisting of more diverse and thinner interlayers of different material types) east of the HWB.

- Package C. A package of uncertain thickness that consists of generally coarser grained material (sandy gravel, silty gravel with cobbles) with limited finer grained lenses and interlayers (silty clay, silt, and silty sand). The coarser grained materials in this package can effectively transmit water. There has not been a significant thickness of finer grained material identified above this depth interval in this subregion (causing Package C and overlying Package B(c) to be indistinguishable here). Package C and overlying Package B(c) comprise a total combined thickness of approximately 100 feet.

- Package D. A generally finer package (consisting of interlayered silty clay to silty sand and sand) with local coarser interlayers (silty to sandy gravel). As designated, this package includes thick (up to 35 feet) silty interlayers that have the potential to at least locally impede vertical groundwater flow. At TERMINAL, Package D is defined between 280 and 405 feet bgs. The uppermost screened interval (330 to 355 feet bgs) at TERMINAL is constructed in a relatively coarser water-producing portion of this package. MILL (located roughly 1,750 feet northwest of TERMINAL) is the closest well that completely penetrates this package as defined. Like TERMINAL, the uppermost screened interval of MILL (326 to 346 feet bgs) is constructed across a water-producing portion of Package D. Package D is defined on both sides of the HWB.

- Package sequence E, F, G. At depths greater than 405 feet bgs, the hydrostratigraphy near TERMINAL consists of generally coarser grained material (including gravelly sand, gravel, and sand) alternating with interlayers of finer grained material (including silty sand, silt, and clay). The coarser materials tend to be groundwater producing. The upper 170 feet of this package is interpreted to be comprised of thicker intervals of coarser material that are similar to groundwater producing intervals in the upper part of same combined package defined to the north of the subregion at HIGH, MORRILL, MILL and potentially KIETZKE. Below the upper 170 feet of the package, finer grained interlayers become more prevalent, and less groundwater is interpreted to be produced. This interpretation is corroborated by spinner log data from HIGH, MORRILL, and MILL for the correlative package sequence. Roughly 280 feet of this package sequence is penetrated by TERMINAL. TERMINAL has screened intervals in the package sequence between 405 and 665 feet bgs.

- The gravity-based cross section (D-D'; Widmer, 2005; 2007) that extends through the area near TERMINAL estimates the depth to bedrock to be approximately 1,150 feet bgs. If that estimate is accurate, approximately 500 feet of basin-fill material is present below the lowermost screened interval at TERMINAL.

Hydrostratigraphic data on either side of the HWB are consistent with an aquifer system that is heterogeneous and anisotropic. Based on the available lithologic data, local finer interlayers or lenses exist and contribute to anisotropy in the aquifer system. However, there is no evidence for a laterally continuous layer between the water table (Package A) and the PCE-impacted groundwater producing intervals (Packages B(c) and C) at CORBETT that would act as an aquitard.

5.6.2 Groundwater Level Data

The 2010 quarterly potentiometric surface maps (that include the South Reno Subregion) are presented in **Figures 5.2** through **5.9**, and are the basis for estimating lateral gradients. Regional groundwater level difference maps (**Figure 5.10**), cumulative groundwater level change maps (**Figures 5.11** through **5.14**), and water level data at well clusters (**Graphs 5.1b**) provide the basis for characterizing vertical hydraulic gradients for this subregion.

During 2010, water levels in the South Reno Subregion responded, as has consistently been observed in recent years, to municipal pumping. This water level response is most significant in the deep zone, but is also evident in the shallow zone. The distribution and magnitude of water level responses affects both lateral and vertical gradients in the subregion. Municipal pumping is an important influence on both groundwater hydrodynamics and PCE distribution.

Lateral Gradients

Shallow Zone

The lateral groundwater flow direction and hydraulic gradient in the shallow zone across this subregion remained relatively consistent during 2010 and was similar to what has been observed since the GMP began. The flow direction is generally from west to east. A local exception to this flow direction exists northeast of the East Plumb Lane hot spot, where the hydraulic gradient is to the northeast between CTM51/CTM53 and USGSLISTON then changes to the east-northeast toward CTM96 and CTM93. The area where this exception occurs can increase in extent in response to sustained deep zone pumping (such as what has been typically observed by the end of Q3 since 2006). The expansion of this area reflects increased drawdown at CTM93 and CTM96 that occurs during Q3 in response to cumulative pumping at MILL, CORBETT, KIETZKE, and other municipal water supply wells east of the HWB.

For 2010, lateral gradients in the shallow zone are described as follows:

- West of the CSB and within the VLFZ, the lateral gradient is not well constrained. Based on the quarterly water level contour maps, the gradient in this area is on the order of 0.007.
- Across the eastern margin of the VLFZ (i.e. across the CSB), the gradient steepens to approximately 0.03 to 0.04 between CTM50 and CTM47.
- East of the VLFZ the gradient is approximately 0.006 from the Vassar Street hot spot to CTM96 and approximately 0.007 from the East Plumb Lane hot spot towards USGSLISTON. The gradient flattens to approximately 0.003 (increasing to 0.004 in Q3) between both CTM96 and USGSWOOSTER and between USGSLISTON and USGSWOOSTER.

- East of the HWB, the gradient is approximately 0.003 (or less) to the east. The shallow zone gradient does not appear to be influenced by the HWB.

Deep Zone

The flow direction and gradient in the deep zone can vary depending on if and where deep zone pumping is taking place. This observed interrelationship between deep zone gradients and pumping in 2010 is similar to what has been observed since the GMP began. West of the HWB, gradients tend to be consistent and are only nominally influenced by pumping. East of the HWB, cones of depression develop around pumping wells including CORBETT, TERMINAL, MILL, MORRILL, and KIETZKE and influence the deep zone gradient in the South Reno Subregion. Since 2006, a coalescing cone of depression that develops around CORBETT, MILL, MORRILL, and KIETZKE in Q2 and Q3 has caused similar gradient patterns, magnitudes, and directions from 2006 through 2010.

- In 2010 Q1, when no pumping is taking place and water levels are closest to natural groundwater conditions, groundwater flow is generally from west to east. Under these conditions, the lateral deep zone gradient is as follows:
    - West of the CSB and within the VLFZ, the lateral gradient is not well constrained. Based on the quarterly water level contour maps, the gradient in this area is on the order of 0.007.
    - Across the eastern margin of the VLFZ (i.e. near the CSB) the gradient steepens to 0.010 between CTM27D and HOLCOMBAVMW.
    - East of the VLFZ, the gradient decreases to approximately 0.005 between the VLFZ and HWB (i.e. at CTM33D).
    - Across the HWB, the gradient steepens to 0.02 east of CTM33D.
    - East of the HWB, the gradient decreases to 0.003 (or less) near CORBETT and extending to the east margin of the subregion.
- In 2010 Q2, deep zone water levels respond strongly to pumping at CORBETT. The response defines a cone of depression centered on CORBETT. East of the HWB, groundwater flow converges toward CORBETT with a gradient of at least 0.05 (between CTM33D and CTM17D). The groundwater flow direction and gradient west of the HWB were relatively unchanged at this time and comparable to what was observed during Q1.

- In Q3, deep zone water levels respond strongly to cumulative pumping at CORBETT and MILL, and to a lesser extent at HIGH, MORRILL, and KIETZKE. A large coalesced cone of depression develops around these wells. This affects flow directions and gradients in the South Reno Subregion and in the area to the north. East of the HWB, deep zone groundwater flow in the

South Reno Subregion is towards the northeast with a lateral gradient of 0.02 or more. West of the HWB, the groundwater flow direction and gradient remains relatively unchanged.

- In Q4, the groundwater flow direction and gradient were similar to what was observed in Q1. This indicates recovery toward natural conditions after pumping stopped in late Q3 - early Q4.

Vertical Gradients

Vertical gradient is described for each of the 3 distinct hydrogeologic areas defined in **Section 5.7.1**.

West of the CSB and within the VLFZ

Similar to what has been observed since the start of the GMP, a nominally upward vertical gradient persists west of the CSB and within the VLFZ during periods when little to no deep zone pumping occurs (e.g. winter and spring since 2006). During periods of sustained municipal water supply pumping (e.g. summer through early fall since 2006), deep zone water levels are weakly affected and the magnitude of the upward gradient is reduced and can reverse, becoming downward. Based on water level data for well cluster CTM14S/CTM27D, the vertical gradient during 2010 is described as follows:

- In Q1 and Q2, there was a persistent upward gradient that ranged to a maximum of 0.005 in 2010 Q2.
- In Q3, the upward vertical gradient decreased, becoming downward (-0.0003) by September.
- In Q4, the downward gradient reached a minimum of -0.001 in October, coinciding with the last month of sustained pumping to meet peak demand. By the end of Q4, the vertical gradient resumed an upward direction.

The maximum cumulative drawdown observed in shallow zone and deep zone wells was 1.84 feet (in CTM41S) and 1.26 feet (in CTM27D), respectively.

Between the VLFZ and the HWB

As observed since the start of the GMP, a persistent, year-around upward vertical gradient occurs between the VLFZ and the HWB. The upward gradient is nominally influenced by municipal water supply pumping, decreasing in magnitude during periods of sustained deep zone pumping. Based on data from CTM96/CTM94 and CTM93/CTM33D (the shallowest and deepest wells in their respective clusters), the vertical gradient during 2010 is described as follows:

- The vertical gradient was upward during every month.

- The upward gradient ranged in magnitude from a minimum of 0.091 (in October and November in CTM96/CTM94) to a maximum of 0.130 (in December in CTM93/CTM33D).

- The magnitude of upward gradient is influenced by deep zone pumping with the smallest upward gradients occurring in early Q4 during the end of sustained municipal water supply pumping. Transducer water level measurements collected in 2009 (for the CORBETT-MILL composite aquifer test [WCDWR and HGC, 2013; WorleyParsons, 2013]) suggest that pumping at HIGH is the principal influence on deep zone water level response west of the HWB. These data show a lack of measurable deep zone drawdown west of the HWB from pumping at water supply wells CORBETT or MILL located on the opposite side of the HWB.

The maximum cumulative drawdown between the VLFZ and the HWB was 5.50 feet in the shallow zone (at CTM15S) and 9.10 feet in the deep zone (at HOLCOMBAVMW).

East of the HWB

A relatively strong downward gradient occurs in this area in response to sustained deep zone pumping. When little or no pumping occurs, the magnitude of the downward vertical gradient is reduced and can reverse to become locally upward. The changes in vertical gradient east of the HWB in 2010 are similar to what has been observed in this area since late 2005. The change from a persistent downward gradient east of the HWB prior to late 2005, to a variable, reversing gradient is interpreted to reflect the change from year-around deep zone pumping to demand-based pumping at PCE-treated wells starting in 2006. The addition of well cluster CTM99/CTM98/CTM97 in 2009 has provided greater vertical gradient resolution that shows that:

- When CORBETT pumps, the vertical gradient converges toward the deep zone Packages (B(c) and C) where CORBETT is screened; and

- When MILL or TERMINAL is pumped, the vertical gradient is downward toward the lower deep zone packages (D and E, F, G) where TERMINAL is constructed, regardless of whether CORBETT is pumping.

Based on data from well clusters CTM99/CTM98/CTM97, USGSWOOSTER/CTM17D, and CTM18S/CTM107, the vertical gradient in 2010 is characterized as follows:

- In Q1 an upward gradient occurred east of the HWB. For example, the vertical gradient was 0.005 at CTM99/CTM98/CTM97.

- In Q2 the vertical gradient changed from upward to convergent toward the shallower deep zone where CTM98 and CORBETT are constructed. Gradient data at CTM99/CTM98/CTM97 exhibit a downward gradient of -0.044 between CTM99/CTM98 and an upward gradient of 0.062

between CTM98/CTM97. This change is coincident with the start of pumping at CORBETT on May 14.

- In Q3, the vertical gradient changed from convergent toward Packages B(c) and C (where CTM98 and CORBETT have screened intervals) to downward toward Package D (where deeper wells CTM97 and TERMINAL have screened intervals). The gradient at CTM99/CTM98/CTM97 was -0.061. This change is coincident with the start of pumping at MILL on June 30.

- In Q4, the consistent downward gradient changed to nominally convergent toward Package B(c) and C (CTM98 and CORBETT). The downward gradient from the shallow zone decreased to -0.004 between CTM99/CTM98, and reversed to 0.005 between deep zone wells CTM98/97. These changes occur after the end of pumping at CORBETT and MILL on October 7 and reflect recovery, and the gradual return to an upward gradient 3 or 4 months after sustained pumping stops. The maximum cumulative drawdown east of the HWB was 2.92 feet in the shallow zone (at CTM99) and 43.30 feet in the deep zone (at TERMINAL, which was not pumped in 2010).

5.6.3 Groundwater Sources and Sinks

Potential sources of recharge that could contribute to the South Reno Subregion water budget include mountain front recharge, groundwater inflow, infiltration from ditches and surface water features, infiltration from leaking water distribution and wastewater collection systems, infiltration from irrigation, infiltration from storm water run-off, and infiltration from direct precipitation. All of these recharge processes are likely to take place in the South Reno Subregion except mountain front recharge. No effort is made as part of the GMP to estimate recharge associated with these potential groundwater sources. Precipitation data for the GMP period is presented in **Section 5.3**. Annual precipitation was 9.25 inches in 2010. This is an increase over 2009 (8.25 inches), and above the historical annual average (7.31 in/year) for the period of record (1937 through 2010; NOAA, 2011).

Groundwater sinks in or near the South Reno Subregion include deep zone pumping from the CORBETT, TERMINAL, and MILL municipal water supply wells. The 2010 combined annual pumping from these wells was 503.9 MG. Since 2006, CORBETT and MILL (which were operated on a generally year-around basis prior to 2006) have been operated to meet peak water demand that typically occurs during the summer and fall. TERMINAL has only been utilized on a limited basis since 2005 and was not pumped in 2010. Cumulative annual pumping in the South Reno Subregion was greatest in 2003 and 2004 and decreased between 2005 and 2008. Starting in 2009, pumping generally increased, but remained nominally below the average annual pumping volume (of 557 MG) for the GMP period. The combined pumping at CORBETT, MILL, and TERMINAL (when it is operated) is interpreted to be the principal influence on groundwater flow dynamics in the South Reno Subregion, east of the HWB. This is based on:

- The lack of other recognized dynamic sources or sinks of similar magnitude (such as surface water features or groundwater injection) that could influence how groundwater moves across the subregion; and
- The direct influence of deep zone pumping on 1) deep zone lateral gradients that converge toward pumping wells and 2) vertical gradients that change from upward under non-pumping conditions to downward (or converging toward the upper part of the deep zone), when one or more of CORBETT, MILL, and TERMINAL is pumped (as described in **Section 5.1.2).**

The following tables present a summary of the 2010 groundwater pumping history and production, and a compilation of annual pumping volumes for these wells since the inception of the GMP.

Well Name	Pumping Start Date (2010)	Pumping End Date (2010)	2010 Groundwater Production (MG)	2010 Pumping Pattern
CORBETT	May 14	Oct 7	286.4	Continuous
TERMINAL	No pumping	No pumping	0.0	No pumping
MILL	June 30	Oct 7	217.5	Continuous

South Reno Subregion and Vicinity Annual Municipal Water Supply Well Pumping History (in millions of gallons)

Year	Wells			Annual totals
	CORBETT	TERMINAL	MILL	
2003	444.7	141.8	107.8	694.3
2004	437.6	1.7	454.5	893.8
2005	149.1	89.9	235.8	474.8
2006	192.2	0.0	298.8	491
2007	150.4	12.2	223.3	385.9
2008	150.8	43.3	253.1	447.2
2009	248.5	9.7	308.6	566.8
2010	286.4	0.0	217.5	503.9

5.6.4 Data on Potential PCE Sources

Numerous PCAs have been identified in the South Reno Subregion **(see Figure 5.16)**. Several are located near the Vassar Street and E. Plumb Lane hot spots. These PCAs include former or existing dry cleaners and auto repair shops. PCAs are generally more common along or near S. Virginia Street and Wells Avenue where commercial and industrial land use activities have had a longer history.

As summarized in the 2007 GMP annual report (WorleyParsons, 2010) environmental releases of PCE were identified near PCAs during CTMRD program activities in 2001 and 2002 (Kleinfelder, 2003). The following updated summaries are provided for potential PCE sources for the South Reno plume.

- **Vassar Street hot spot**. The North Alley (upgradient from CTM48) and South Alley (near CTM62) potential release sites are near the Vassar Street hot spot. These release sites were evaluated and discussed in Kleinfelder (2003). This general area includes five former dry cleaners. There have been no corrective actions involving PCE or other chlorinated solvents in this area; therefore, there has been no site-specific investigation or monitoring. The most recent active dry cleaner in this area (Champion Laundry Center) stopped dry cleaning operations in 2008. DWR (in collaboration with the City of Reno) has been collecting wastewater samples as part of the Sewer Monitoring Program (SMP) since 2005. The SMP is intended to monitor the wastewater collection system serving active (or recently active) drycleaners and to verify compliance with wastewater discharge regulations that were revised in 2005. Wastewater samples collected in this subregion through 2010 are summarized in the table below. The most recent PCE detection in wastewater near the Champion Laundry Center was 54 µg/L in 2008. PCE in wastewater from the sewer line at this location has been below the reporting limit of 5 µg/L in 2009 and 2010.

- **East Plumb Lane hot spot.** Plumb Lane Plaza is an active NDEP Corrective Action Site located immediately upgradient from the East Plumb Lane hot spot. Rainbow Cleaners operated in this shopping center (at 499 E. Plumb Lane) from 1986 until 2006. Prior to the initiation of corrective action at this site, PCE had been detected in wastewater samples collected along Wrondel Way at concentrations up to 480 µg/L in 2001 (Kleinfelder, 2003). The sewer line along Wrondel Way originates near Plumb Lane Plaza. Subsequent investigations identified sewer line defects and PCE impacted soil, soil vapor, and groundwater spatially associated with the sewer line. Wastewater monitoring of the Rainbow Cleaners site was discontinued in 2008. PCE was not detected in the three wastewater samples collected during the two year period after the facility closed.

  In June, 2009 NDEP issued a **Finding of Alleged Violation** and **Order** (NDEP, 2009) requesting that the Rainbow Cleaners site property owner provide the NDEP with a work plan and schedule for additional investigations including the:

  - Collection and analysis of active soil gas samples, soil samples, and groundwater samples along the entire western side of the building where Rainbow Cleaners had been located;
  - Installation of two up-gradient groundwater monitoring wells; and,

- Installation of paired multi-depth groundwater monitoring wells at three separate down-gradient locations.

In early 2010, four temporary on-site soil gas borings were installed and sampled. The highest levels of PCE (120 µg/Kg in soil [at SVP-1] and 760 mg/m^3 in soil gas [at SVP-2]) were detected near the former Rainbow Cleaners site (MGA, 2010). As of December 2010, the on-site investigations requested by NDEP had been initiated and quarterly monitoring of existing groundwater wells have continued, but the planned new wells had not been installed (DWR, 2011).

- **Holcomb source site.** As summarized in WorleyParsons (2010) work conducted by Kleinfelder (2003) detected PCE in wastewater and in impacted soil immediately adjacent to an active dry cleaner. This dry cleaner (Bob's Cleaners) is located near CTM49. According to City of Reno, Environmental Control (Ryan Bird, personal communication) Bob's Cleaners uses hydrocarbon solvent and has been using alternative solvents (other than PCE) since 2003. Wastewater sampling detected a single occurrence (12 µg/L in 2007) of PCE in the sewer line serving this area. The Holcomb source site is upgradient from the Vassar Street hot spot and west of the CSB. PCE at this location is not currently considered to be associated with the South Reno plume.

- **Orchard Plaza PCE/SMP site.** Orchard Plaza is a NDEP Corrective Action Site located approximately 2,200 feet west and south of the East Plumb Lane hot spot. An environmental site assessment (ESA) conducted by The Moss Group (TMG) in association with an active dry cleaner (Star Cleaners) at this location resulted in the identification of groundwater contaminated by PCE exceeding the MCL (TMG, 2008a). The maximum groundwater PCE concentration observed in direct push samples collected as part of the ESA was 6.9 µg/L (on 9/5/2008 from boring B-1). This was reported to NDEP, resulting in the initiation of the ongoing corrective action. Subsequent passive soil gas sampling identified an area of high PCE mass (up to 480.53 µg) in the alley behind the dry cleaner (TMG, 2008b). Follow-up active soil gas sampling in the area of high mass identified PCE concentrations in the range of 62 to 69 mg/m^3 (TMG, 2009). In 2010, three groundwater monitoring wells were installed and of quarterly groundwater monitoring was initiated at the site. Maximum groundwater PCE concentration observed in the 3 wells was 10 µg/L (at MW-1). Wastewater samples collected from the lateral originating from Star Cleaners have intermittently contained PCE and TCE at concentrations as high as 720 µg/L and 7,100 µg/L, respectively (on 10/25/2010).

- **Former Artist Cleaners PCE site.** The former Artist Cleaners site is located 4,000 feet south of the East Plumb Lane hot spot on the northeast corner of Gentry Way and Wrondel Way (outside of the South Reno Subregion). This former dry cleaner site is the subject of an ongoing NDEP

Corrective Action. In 2007, an environmental site assessment conducted by Pezzonella Associates, Inc. (PAI) identified on-site PCE contaminated groundwater at a concentration of 90 µg/L (MGA, 2008). Since that time, further investigation, site characterization, and quarterly groundwater monitoring by McGinley and Associates (MGA) has identified PCE in soil at up to 34 µg/Kg (MGA, 2008) and PCE in groundwater at up to 300 µg/L (MGA, 2011). Quarterly groundwater samples from December 2010 define PCE contamination above the MCL both on- and off-site (MGA, 2011). As of the end of 2010, seven monitoring wells (six on-site and one off-site) are sampled quarterly. Water level contours indicate that PCE contamination at this site would migrate in an easterly direction and would not impact the South Reno Subregion.

- **Lakeside Plaza SMP site.** Wastewater samples collected downstream from Lakeside Cleaners through early 2007 identified PCE up to 950 µg/L (on 10/11/2006). Wastewater samples collected at this location from 2007 through 2009 were below the reporting limit. During 2010, PCE was detected in wastewater at concentrations up to 250 µg/L (on 10/25/2010). There are presently no data to indicate a PCE release to the environment at this location.

South Reno SMP Sampling Results Summary

Sample Location	Bobs (1)		Champion (2)		Rainbow (2)		Lakeside(2)		Star(1)	
	Sample Date	PCE (µg/L)	Sample Date	PCE (µg/L)	Sample Date	PCE (µg/L)	Sample Date	PCE (µg/L)	Sample Date	PCE (µg/L)
	12/12/00	103.6			12/06/00	302				
	12/21/00	21.2								
	01/03/01	<1	01/09/01	51.3	01/03/01	41.8				
	01/18/01	34.8	02/01/01	14.9	01/11/01	24.2				
	02/01/01	53.1	02/13/01	450	01/18/01	45.8				
	02/13/01	79	03/01/01	2600	01/30/01	64.8				
	08/16/01	<1			02/13/01	62				
					08/16/01	120				
	10/24/05	<1	10/25/05	<1	10/24/05	2.5	10/25/05	8.9	10/25/05	<5
			10/25/05	1.3						
	04/04/06	<1	04/06/06	<1	04/04/06	2.3	04/04/06	4.8	04/04/06	130
									07/28/06	<5
	10/11/06	<1	10/12/06	<2	10/10/06	2.3	10/11/06	950	10/11/06	26
							01/10/07	49	01/10/07	11
	04/24/07	<20	04/24/07	<20	04/23/07	<5	04/23/07	<5	04/23/07	<5
							07/19/07	<5		
	10/02/07	12	10/02/07	<5	10/01/07	<5	10/02/07	<5	10/02/07	10
	04/21/08	<5	04/21/08	14	04/21/08	<5	04/21/08	<5	04/21/08	<5
	10/14/08	<5	10/13/08	54			10/13/08	<5	10/13/08	220
									01/27/09	<5
	04/30/09	<5	04/27/09	<5			04/30/09	<5	04/30/09	18
									07/14/09	5.5
	11/02/09	<5	10/28/09	<5			11/02/09	<5	11/02/09	<5
	04/30/10	<5	04/28/10	<5			04/30/10	5.1	04/30/10	<5
							07/21/10	<5	07/21/10	<5
	10/26/10	<5	10/25/10	<5			10/25/10	250	10/25/10	720

(1) samples collected from the site lateral where it enters the main
(2) samples collected from main at first manhole downstream from site lateral

The Vassar Street-East Plumb Lane Potential Source Area (PSA) was delineated in 2008 to encompass the area (see **Figure 5.16**) that includes the Vassar Street and East Plumb Lane hot spots where persistent and elevated shallow zone groundwater PCE concentrations have been present over time. The PSA includes PCAs and possible residual subsurface PCE sources that could have contributed to or that may be contributing to the South Reno plume. While elevated concentrations of PCE have been identified in near surface soil, soil gas, and groundwater in this PSA, the location and nature of any specific sources has yet to be determined. In 2008, DWR received Board of County Commissioners approval to initiate a PSA investigation in order to:

- Characterize the magnitude and extent of shallow subsurface contamination in the PSA;
- Identify sources that may have contributed to or that may be contributing to the contamination;

- Assess the threat posed by that source to groundwater; and,
- Provide information to support a cost-benefit assessment of possible PCE source mitigation.

In 2009, phase 1 of a passive soil gas survey (PSG) was initiated as part of the Vassar/East Plumb PSA investigation. Phase 1 results identified five discrete PCE high mass areas (HMAs), shown on **Figure 5.16**. These include:

- The Wonder HMA – near the intersection between Wonder Street and Holcomb Avenue and coincident with the Holcomb source site (described previously);
- The Arroyo HMA – between Vassar and East Pueblo Streets and between Haskell and Locust Streets that is proximal to the Vassar Street hot spot, and includes the North Alley and South Alley release sites (described previously);
- The Wrondel HMA – between Cassaza Drive and along East Plumb Lane and between Kirman and Yori Avenue that corresponds to the East Plumb Lane hot spot;
- The Cassaza HMA – along Holcomb Avenue (between Colorado River Boulevard and East Plumb Lane) that had not been previously recognized as an area of potential concern; and
- The Cadillac HMA – along Virginia Street (between Cadillac Place and Hillcrest Drive) that coincides with the Orchard Plaza PCE/SMP site (described previously).

In November 2009, a phase 2 PSG survey including 180 GORE™ modules was conducted to provide better spatial resolution of the Wonder, Arroyo, and Cassaza HMAs.

In early 2010, the DWR contract with Hydro Geo Chem Inc. was terminated. As a consequence, no further work was done in this PSA in 2010.

5.6.5 PCE Concentration and Distribution Data

The South Reno plume occurs in the area that extends east from near Virginia Street to beyond US 395, and north from near East Plumb Lane to north of Vassar Street. Pertinent features in the South Reno Subregion are shown on **Figure 5.16**. Quarterly 2010 PCE concentrations are shown for the shallow zone and deep zone on **Figures 5.2** through **5.9**.

The PCE distribution in the South Reno plume (based on monitoring well data) remained essentially unchanged in 2010 (compared to 2009). PCE in shallow zone well CTM99 and in deep zone wells CTM98 and CTM106 indicate that both shallow zone and deep zone PCE contamination occurs east of US 395 and that the maximum downgradient plume extent remains undefined.

Shallow Zone

The upgradient shallow zone extent of the South Reno plume is generally delineated by PCE near or below the reporting limit (0.50 µg/L) in CTM15S, CTM49, CTM41S, and CTM60.

As described in **Section 5.6.4**, the PCE plume extends eastward from hot spots (indicated by wells CTM62 and CTM52) that are located near PCAs and HMAs (which represent possible sources). During 2010:

- PCE in the Vassar Street hot spot (represented by CTM62) ranged from 34 to 74 µg/L; and,
- PCE in the East Plumb Lane hot spot (as represented by CTM52) ranged from 12 to 14 µg/L.

Downgradient from these hot spots, the shallow zone PCE concentration generally decreases with increasing distance (to the east). An exception to this occurs near CORBETT, where PCE in both USGSWOOSTER and CTM99 was higher than what was observed in the nearest upgradient well (CTM93). The relatively higher PCE concentration in USGSWOOSTER and CTM99 could:

- Be a detached shallow zone plume core that has migrated east from one of the upgradient hot spots;
- Be a new hot spot that has originated from a nearby and previously unrecognized contributing source; or,
- Indicate that USGSWOOSTER and CTM99 are closer to and more representative of groundwater conditions near the shallow zone plume axis than nearby upgradient well CTM93.

Until the locally higher PCE in USGSWOOSTER and CTM99 is better understood, this area will be referred to as the “Condor Way hot spot”.

The downgradient extent of PCE in the shallow zone extends beyond US 395 at least to CTM99 and is currently undefined. The crossgradient extent of shallow zone contamination is also not well defined. East of the HWB the shallow zone plume has a width that extends from south of USGSWOOSTER to north of CTM18S. CTM18S is located where the shallow zone portion of the South Reno plume and the Mill/Kietzke plume potentially overlap and or could be locally contiguous. Water quality data (WorleyParsons, 2011) indicate that the pre-2006 Mill/Kietzke plume (characterized by PCE, with MTBE and 1,1,1-TCA) is distinct from the pre-2006 South Reno plume (characterized by PCE only). The absence of MTBE and 1,1,1- TCA at CTM18S in circa-2006 data is interpreted to indicate that this well is completed in the South Reno plume. Since 2006, MTBE and 1,1,1-TCA have not been detected in the Mill/Kietzke plume and the previously distinct water quality characteristics are no longer evident. CTM18S is also interpreted to be located along a groundwater flowpath that (during either a pumping or natural flow regime) is more consistent with a source to the west or southwest.

The vertical extent of the South Reno plume is undefined at the East Plumb Lane and Vassar Street hot spots where PCE contamination is present at the local maximum well depth of 56 feet bgs. Approximately 2,000 feet downgradient from the Vassar Street hot spot, PCE in well cluster CTM96/CTM95/CTM94 defines the vertical extent of contamination to be from near the water table (up to 4.4 µg/L at approximately 22 feet bgs in CTM96) to approximately 90 feet bgs (based on a single PCE detection of 0.75 µg/L at CTM95 in 2010 Q3). Further east, at well cluster CTM93/CTM92/CTM33D (just west of the HWB), PCE contamination extends from the shallow zone into the deep zone to a depth of 180 feet bgs. PCE at this well cluster is highest in the shallow zone (up to 5.7 µg/L in CTM93), and decreases in concentration with depth in the deep zone (up to 3.6 µg/L and 1.8 µg/L , respectively, in CTM92 and CTM33D). East of the HWB, PCE also extends into the deep zone, but has higher concentration in deep zone wells (e.g. CTM17D and CORBETT) compared to shallow zone wells (e.g. USGSWOOSTER and CTM99).

New maxima, minima, or statistically significant changes in PCE concentration at key (or other important) shallow zone wells for the South Reno plume are highlighted on **Table 5.4.** These include PCE concentration dynamics that potentially result from plume dynamics that are either inconsistent with the conceptual model or that could represent an increased threat and therefore constitute a potentially significant data gap. The identification and assessment of significant data gaps more effectively contributes to meeting GMP objectives. Potentially important results during 2010 are summarized below.

- New PCE concentration minima (for the GMP period) were established in:
  - CTM51 (3.9 µg/L in 2010 Q2); and
  - CTM52 (12 µg/L in 2010 Q2 and Q4).

CTM51 and CTM52 have historically been used to define the East Plumb Lane hot spot. The PCE minima observed in these wells during 2010 are consistent with long term decreasing PCE concentration trends and suggest either a decreasing source contribution near these wells or groundwater with decreased PCE encroaching on these wells. It should be noted that PCE in nearby shallow zone well CTM53 (20 µg/L in 2009 Q4 and 21 µg/L in 2010 Q1) was higher than what was concurrently observed in CTM51 and CTM52. This indicates a possible short term change in plume behavior near the East Plumb Lane hot spot. The transient PCE increase at CTM53 (in 2009 Q4 and 2010 Q1) did not persist through 2010 when PCE concentrations subsequently decreased to 9.7, 9.8, and 9.2 µg/L (for Q2, Q3, and Q4, respectively).

In 2010 Q3, PCE was reported at CTM45 (0.67 µg/L), located 2,000 feet south of the East Plumb Lane hot spot. This may be a simple consequence of having lowered the reporting limit for PCE from 1.0 µg/L to 0.50 µg/L starting in Q3. The PCE at CTM45 (located on Linden Avenue, east of S. Virginia Street), is considered distinct from the South Reno plume. CTM45 occurs in an area where PCE was previously detected in wastewater (1,200 µg/L) and in soil vapor (2.1 mg/m^3) during a targeted sewer line investigation (Kleinfelder, 2003). There is presently no evidence to suggest that PCE at CTM45 is more than an isolated occurrence that corresponds to a relatively localized PCE impact recognized (delineated by passive soil gas and active soil gas samples) by Kleinfelder (2003).

Deep Zone

The deep zone PCE distribution in the South Reno Plume is presently defined by seven wells (CTM95, CTM33D, CTM92, CTM17D, CTM98, CTM106 and CORBETT). Most of these wells are located (**Figure 5.16**) in a relatively small area near CORBETT. Accordingly, the extent of deep zone contamination is not well characterized. PCE at CTM106 and CTM98 indicate that deep zone contamination extends east of US 395 and is not delineated in the downgradient direction.

West of the HWB

PCE was detected in deep zone well CTM95 in the first sampling event after the laboratory reporting limit had been lowered from 1 µg/L to 0.50 µg/L (in 2010 Q3, at a concentration of 0.76 µg/L). This indicates that the low level deep zone PCE contamination extends at least 2,000 feet upgradient from the CTM93/CTM92/CTM33D well cluster.

- The apparently larger deep zone footprint delineated by CTM95 is a consequence of higher resolution provided by the lower laboratory reporting limit. There is no way of knowing if low level contamination (below the 1.0 µg/L reporting limit) was present at this location prior to 2010. The low concentration and relatively shallow well construction at CTM95 (screened interval - 80 to 90 feet bgs) suggest that the vertical extent of PCE contamination at this location is not substantially deeper than 90 feet bgs.

- The relatively low PCE concentration (consistently below 2 µg/L) at CTM33D is consistent with a relatively small PCE mass in the deep zone west of the HWB that does not extend significantly deeper than 180 feet bgs in this part of the basin.

East of the HWB

PCE concentration at CORBETT and CTM17D is generally higher than at the other deep zone wells in this plume. This indicates a plume core of higher PCE mass in the deep zone proximal to CORBETT.

- During 2010, PCE in CORBETT averaged 19.4 µg/L (based on 5 monthly samples collected in Q2 and Q3).

- During 2010, PCE in CTM17D varied between 5.4 and 12 µg/L. The lowest annual PCE is observed when CORBETT is pumping (e.g. Q2 and Q3 in 2010) and the highest annual PCE is observed under natural groundwater flow conditions prior to any municipal well pumping (e.g. Q1). This is consistent with what has been observed previously.

- PCE contaminated groundwater east of the HWB is present in all deep zone wells screened over the depth interval between 125 and 280 feet bgs.

- Depth discrete groundwater samples (collected while drilling CTM97) indicate that contamination extends to more than 285 feet but less than 319 feet bgs (at the CTM97 location, 1,300 feet east of CORBETT). During 2010, PCE concentrations at adjacent cluster well CTM98 varied from 7.4 to 10 µg/L.

- CTM106 is located near where the South Reno, Downtown Reno, and Mill/Kietzke plumes overlap and where the PCE distribution is not well defined. During 2010, PCE in CTM106 varied from 4.4 to 6.5 µg/L. Based on prevailing groundwater flow directions and on water quality characteristics at co-located shallow zone well CTM18S (WorleyParsons, 2011), groundwater at CTM106 (where only PCE has been observed) is interpreted to be constructed in the deep zone portion of the South Reno plume rather than the Downtown Reno plume (where TCE is also present) or the Mill/Kietzke plume (where MTBE and 1,1,1-TCA were diagnostic co-contaminants prior to 2006, but were not detected in shallow zone well pair CTM18S during that time).

- TERMINAL is approximately 1,500 feet east-northeast, generally downgradient of, and screened deeper (from 330 to 665 feet bgs) than CORBETT. TERMINAL is not regularly operated or sampled. The most recent sample from TERMINAL was collected in 2008 Q2. The most recent PCE detection (0.51 µg/L) occurred in September 2004. The potential threat to TERMINAL from contamination at CORBETT (or contamination in the Downtown Reno or Mill/Kietzke plumes) has yet to be evaluated.

Potentially significant PCE concentration changes at key (or other important) deep zone wells for the South Reno Plume are highlighted on **Table 5.4**. None of these changes were determined to be inconsistent with the current conceptual model or to indicate the potential for an increased threat to either groundwater or to potential receptors.

5.6.6 Trends and Patterns in Water Levels and PCE Concentrations in Key Wells

Trends and patterns in key well water level and PCE concentration data are identified and evaluated in this section. The key wells in the South Reno Subregion are listed in **Table 5.1** (and depicted on **Figure 5.15**) and include:

- Shallow zone wells - CTM49, CTM48, CTM62, CTM96, CTM51, CTM52, USGSLISTON, CTM93, USGSWOOSTER, CTM99, and CTM18S; and,

- Deep zone wells - CTM95, CTM33D, CTM17D, CTM97, CTM98, CTM106, CORBETT, and TERMINAL.

Water level hydrograph/PCE concentration time series graphs for these wells are included in **Graphs 5.1a**. Selected graphs are also presented in the following discussion to help illustrate what has been identified. Throughout the report PCE time series data are plotted as red lines and water levels are plotted as blue lines. **Table 5.4** summarizes PCE concentration and trend information for key (or other important) wells. Based on the well network review (as described in **Section 5.4.1**), the following wells have been removed or added to the 2010 key well list.

- CTM46 was removed because it is upgradient from the Vassar Street hot spot. While this well helps delineate the South Reno plume, it does not meet the key well criteria defined in **Section 5.4.1**.
- CTM50 was removed because it is upgradient from the Holcomb Avenue source site, within the VLFZ, and hydrogeologically isolated from that portion of the aquifer system where the South Reno plume is located. This well does not meet any of the key well criteria defined in **Section 5.4.1**.
- Shallow zone wells CTM96, CTM93, CTM99 and deep zone wells CTM95, CTM97, CTM98, and TERMINAL were added to the key well list for the South Reno Subregion.
    - All these wells (except TERMINAL) are new and were constructed in late 2008 or 2009. The rationale behind adding these new wells to the key well list are provided in **Appendix 5.1**.
    - TERMINAL provides data that helps in the evaluation of the PCE capture at CORBETT and MILL and the performance of the pumping plan.

Water Levels

The average annual water levels in the South Reno Subregion generally:

- Decreases or is relatively unchanged between 2003 Q4 and 2004 Q2;
- Increases between 2004 Q2 and 2006 Q2;
- Decreases or is relatively unchanged between 2006 Q2 and 2009 Q4; and,
- Increases in 2010 compared to 2009.

In most wells, a pattern of alternating annual water level minima and maxima (i.e. recurring annual fluctuation) is superimposed on the longer term trends. The wells that exhibit the largest magnitude longer term trends also tend to be those wells with the largest recurring annual fluctuations. These include deep zone wells and (to a lesser degree) shallow zone wells that are more influenced by deep zone pumping.

As described in WorleyParsons (2010, 2011, 2013), the evaluation of water level data has shown that key wells can be subdivided into separate groups where each group has water level trends and patterns that are distinct from the other groups. These groups have been updated based on the revised key wells in 2010 (as described in **Section 5.4.1**), with two new groups (group E and group F) added. The water level trend and pattern characteristics for each of these groups are discussed below.

Shallow Zone Wells

Group A consists of shallow zone well CTM49. This well has a similar hydrograph to CTM50 (a former key well) and USGSHOLCOMB and lacks any discernible longer term water level trends. CTM49 exhibits generally short duration and small magnitude (on the order of 1 foot or less) water level fluctuations. Recurring fluctuations are evident as small increases during Q4 or Q1, followed by decreases back to approximately 4457.5 feet amsl. This is observed from 2004 through 2006, and again in 2008 and 2010. This pattern (in particular the Q1 increase) is not evident in the 2007 or 2009 data. These short duration increases or 'spikes' in water level appear to coincide with winter precipitation events. The location of this well(within the VLFZ) and the long term, relatively stable hydrograph is consistent with an interpretation that this well is effectively isolated from many of the dynamic processes that influence the portions of the complex aquifer system where PCE is a concern.

Group B includes shallow zone wells CTM48, CTM62, CTM96, CTM93, USGSLISTON, USGSWOOSTER, CTM99, and CTM18S. USGSLISTON had been previously in Group C but was moved into this group because the larger magnitude water level fluctuations make it more similar to Group B wells. These wells exhibit longer term decreasing and increasing trends in average annual water level (on the order of 4 to 6 feet) along with a pattern of regular recurring annual fluctuations (on the order of 2 feet or more). Fluctuations are more obvious from 2006 on, with water level minima that typically occur in late Q3 or early Q4. The timing and duration of these fluctuations generally coincides with of municipal well pumping (with some drawdown and recovery response time lag). Data are not available to resolve which municipal water supply wells cause the annual fluctuation observed at these wells.

Group C includes shallow zone wells CTM51 and CTM52. These wells also exhibit longer term decreasing and increasing trends in average annual water level but of a smaller magnitude (on the order of 2 to 3 feet) than what is observed in the Group B wells. Recurring annual water level fluctuations are also evident, but the fluctuations are small (on the order of 1 foot) and less distinct, particularly in 2007 and 2009. Fluctuations at CTM51 and CTM52 are muted and have a larger lag (1-2 months) between annual maxima/minima and seasonal pumping, compared to other shallow zone well groups in the area between the VLFZ and the HWB. These observations suggest a weaker or less direct hydraulic connection between the East Plumb Lane hot spot (where CTM51 and CTM52 are located) and larger scale hydrodynamic drivers in the CTM basin. Shallow zone water level contours (**Figures 5.2**, **5.4**, **5.6**, and **5.8**) define a persistent deflection in shallow zone potentiometric surface north of CTM51 and

CTM52. This indicates a divergence (ranging from easterly to north-northeasterly) in the groundwater flow direction. This divergence may result from a local hydrogeologic discontinuity or some other variation in hydraulic properties in that area.

Deep Zone Wells

Group D includes deep zone wells CTM17D, CTM98, CTM97, and CTM106. CTM17D is the only one of these wells with a data set representing the entire GMP period (starting in 2003 Q4). The characterization of Group D wells is therefore based largely on data from CTM17D. Group D wells (i.e. CTM17D) exhibit both longer term decreasing and increasing trends in average annual water levels and recurring annual fluctuations. The longer term changes (on the order of 10 to 15 feet) and recurring annual fluctuations (on the order of between 10 to 30 feet or more) that occur in response to municipal water supply well pumping are greater in magnitude than what is observed in shallow zone wells in the South Reno Subregion. The recurring fluctuations (based on CTM17D) are more distinct starting in 2006 and coincide with the change from year-around to demand-based municipal water supply well pumping at PCE-treated wells in the CTM. Group D wells are interpreted to exhibit water level dynamics that are primarily influenced by pumping at CORBETT and MILL (based on results from the CORBETT-MILL composite aquifer test [WCDWR and HGC, in prep.]).

Group E includes deep zone wells CTM95 and CTM33D, located west of the HWB.. CTM33D had previously been included in Group B. However the more distinct, recurring annual water level fluctuation (compared to Group B wells) combined with a greater similarity to CTM95 distinguish these wells and provide the rationale for establishing a new well group. CTM33D is the only well in Group E with a data set for the entire GMP period. CTM33D exhibits longer term decreasing and increasing water level trends (on the order of 5 feet) that are similar to that observed in shallow zone Group B wells. The recurring annual fluctuations (on the order of 3 to 5 feet) at Group E wells reflect a response to pumping at HIGH and/or MORRILL, but not CORBETT or MILL (based on results from the 2009 CORBETT-MILL composite aquifer test [WCDWR and HGC, in prep.]). This makes Group E wells distinct compared to other well groups in the subregion. **Group F** consists of the TERMINAL municipal water supply well. TERMINAL exhibits sporadic, large magnitude water level fluctuations that directly reflect periodic pumping at the well (in 2005, 2007, and 2008). Excluding short-duration periods when TERMINAL is pumped, water level responses exhibit a long term increasing trend in average annual water level (in the range of 25 feet) between 2004 and 2006. Since 2006 average annual water levels have remained relatively consistent. However, recurring annual water level fluctuations overprint and are of larger magnitude than long term trends making any more subtle longer term trends starting in 2006 difficult to resolve. Annual fluctuations (excluding periods of pumping at the well) range between 30 and 50 feet and principally reflect the influence of pumping at MILL (based on observed drawdown responses during the CORBETT-MILL composite aquifer test [WCDWR and HGC, in prep]).

CORBETT municipal water supply well exhibits water level trends and patterns that are dominated by its own pumping schedule and is therefore no longer included in the defined hydrograph groups.

Overall, the recurring water level minima (where present) are typically observed (since 2006) in late Q3/early Q4 for both shallow zone wells and deep zone wells, and corresponds to the end of sustained pumping to meet water demand in late summer or early fall. In general:

- Shallow zone wells within the VLFZ (Group A) are relatively isolated from the dynamic influences that affect the aquifer system.
- Shallow zone wells east of the VLFZ (Group B and C) exhibit varying degrees of influence from basin-wide municipal water supply pumping. Water level responses are generally smaller in magnitude compared to deep zone responses in the subregion,
- Deep zone wells east of the VLFZ and west of the HWB (Group E) respond more directly to pumping at HIGH and/or MORRILL.
- Deep zone wells east of the HWB (Groups D and F) respond more directly to pumping at CORBETT, MILL, and to a lesser degree, other municipal water supply wells to the east.

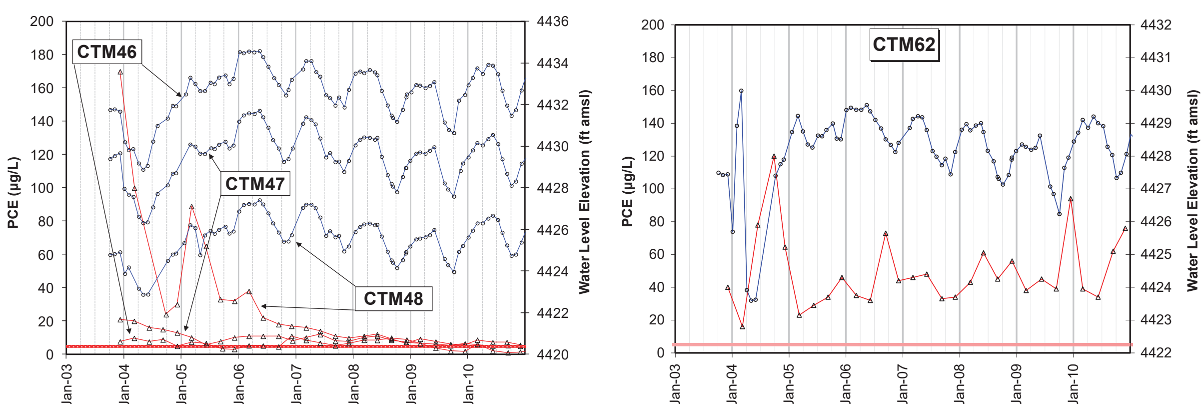
PCE Concentration

PCE concentration dynamics can vary in individual wells (See **Table 5.4** and **Graphs 5.1a**). These variations reflect possible trends (as defined statistically using the Mann-Kendall test or qualitatively based on visual inspection of PCE time-series graphs) and/or patterns and interrelationships with changes in water level. These trends, patterns, and/or other concentration dynamics can provide context to source term contribution and plume behavior. Concentration dynamics for individual key (or important) wells are discussed below.

Shallow Zone Wells, Vassar Hot Spot and Vicinity (West of HWB)

- CTM49 (screened interval - 5 to 25 feet bgs):
    - PCE in CTM49 defines no Mann-Kendall trend over the GMP period..
    - There is no obvious recurring pattern of consistent interrelationship between PCE concentration and water level elevation.
    - The PCE maximum (36 µg/L) for this well occurred in 2006 Q2.
    - The highest PCE concentration during 2010 was 0.94 µg/L in Q3.
    - PCE was below the laboratory reporting limit until 2005 Q1.
    - Three transient spikes in PCE concentration occur in 2005 Q3, 2006 Q2, and 2007 Q3.

- After 2007 Q3, PCE concentration is low or below the laboratory reporting limit (<1 µg/L in 8 of 12 quarterly samples).CTM48 (screened interval - 30 to 50 feet bgs):
  - PCE exhibits a decreasing Mann-Kendall trend over the GMP period. PCE concentration has consistently decreased year-over-year since 2006, with PCE concentration reaching a new minimum (5.6 µg/L) in 2010 Q4.
  - PCE concentration positively correlates with water level changes. The more obviously correlated changes are observed between 2003 Q4 and 2006 Q1 and become less evident afterwards. This diminished interrelationship is interpreted to be a consequence of decreasing PCE concentration and a much lower transient variability in PCE concentration.
  - The PCE maximum (170 µg/L) in this well was observed in 2003 Q4.
  - The highest PCE concentration during 2010 was 8.7 µg/L in Q1.
  - Prior to 2008, CTM48 defined the northern part of the Vassar Street hot spot. Since 2008, PCE in CTM48 has decreased to a similar in magnitude as what is observed in CTM46 and CTM47 (located upgradient from CTM48, see hydrograph below) and is no longer within the hot spot. The decreasing trend at CTM48 could indicate that either a decreasing source contribution from the area upgradient of CTM48 (between CTM46 and CTM47) or that a less contaminated part of the plume is moving through CTM48.



*PCE time series are red lines, water level hydrographs are blue lines.

- CTM62 (screened interval - 31 to 56 feet bgs):
  - PCE exhibits no statistically defined increasing or decreasing long term trend. Qualitatively however, PCE generally increases over the GMP period (see graph above).

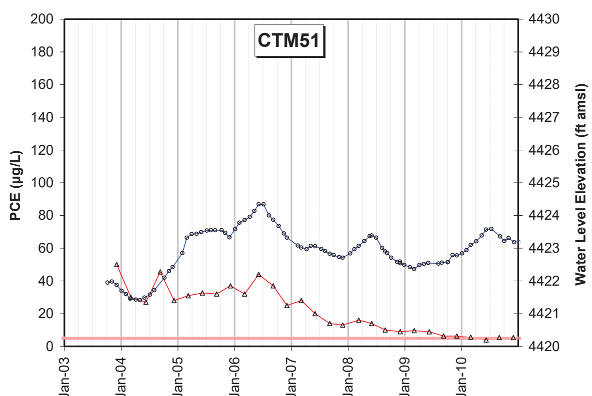
  - Relatively large transient changes in PCE concentration have been observed in this well. There is an intermittent pattern where PCE increases to an annual maximum in Q3 or Q4 when water levels are either near an annual minimum or are recovering.
  - PCE in this well is consistently higher in magnitude than in nearby upgradient wells (CTM46 and CTM47).
  - A PCE maximum (120 µg/L) occurred in this well in 2004 Q4.
  - The highest PCE concentration during 2010 was 76 µg/L in Q4.
  - The data from CTM62 are consistent with episodic, ongoing PCE contribution to groundwater nearby. The spiky nature of the time-series data is consistent with either transient releases from a residual source or with recurring releases to the environment near this well. The lower concentrations at upgradient well CTM46 suggests a source contribution that is either in the area between CTM46 and CTM62, or is upgradient of CTM62 and along a flowpath positioned south of CTM46.

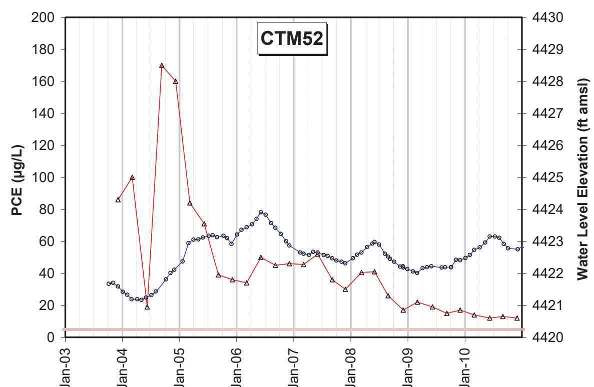
Shallow Zone Wells, East Plumb Lane Hot Spot and Vicinity (West of HWB)

- CTM51 (screened interval - 10 to 30 feet bgs):
  - PCE exhibits a decreasing Mann-Kendall trend for the GMP period. PCE is relatively stable between 2003 Q4 and 2006 Q4, then exhibits relatively consistently decreases, culminating in a new minimum in 2010.
  - There is no obvious recurring pattern in the PCE data and no consistent interrelationship between the PCE and water level changes.
  - A PCE maximum (63 µg/L) was observed in this well prior to the implementation of the GMP, in 2003 Q2.
  - The highest PCE observed during 2010 was 5.6 µg/L in Q1.
  - The period of decreasing PCE begins roughly 2 quarters after dry cleaning stopped at Rainbow Cleaners (the dry cleaning facility associated with the Plumb Lane Plaza PCE corrective action site) in December, 2005. This decreasing trend also coincides with the change from an increasing (prior to 2006 Q2) to a decreasing water level trend (after 2006 Q2) in this well. The relatively consistent concentration decreases after 2006 suggest either a decreasing PCE source contribution or a change in contamination migration pathway where less contaminated parts of the plume have been moving towards this well since late 2006.

- CTM52 (screened interval - 12 to 22 feet bgs):
  - PCE exhibits a decreasing Mann-Kendall trend for the GMP period.

- There is a marked PCE decrease between 2004 Q3 and 2005 Q3 that corresponds with a relatively rapid increase in water level. This correspondence may be coincidental. After this sharp decrease, the longer term decreasing PCE concentration rate is similar to that observed in CTM51.
- There are no other interrelationship between changes in PCE concentration and changes in water level.
- The PCE maximum (170 µg/L) was observed in this well in 2004 Q3.
- The highest PCE concentration during 2010 was 14 µg/L in Q1.
- CTM52 generally has exhibited the highest PCE concentration in the East Plumb Lane hot spot. The decreasing PCE trend in this well is consistent with either a decreasing PCE source contribution or a change in the contaminant migration pathway in the vicinity of this well. The decreasing PCE trend for this well in PCE concentration begins in late 2004 roughly one year before dry cleaning stopped at Rainbow Cleaners (the dry cleaning facility associated with the Plumb Lane Plaza PCE corrective action site).





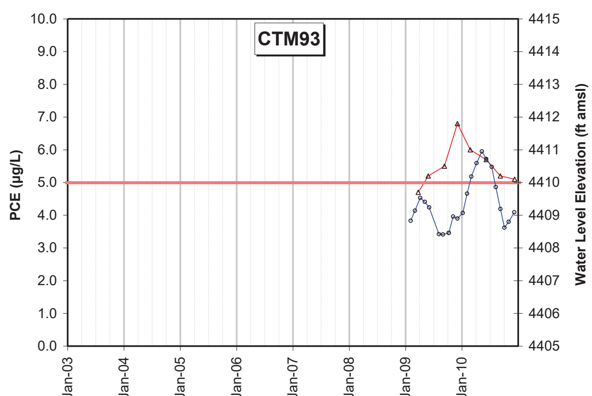
Shallow Zone Wells – Downgradient of Hot Spots

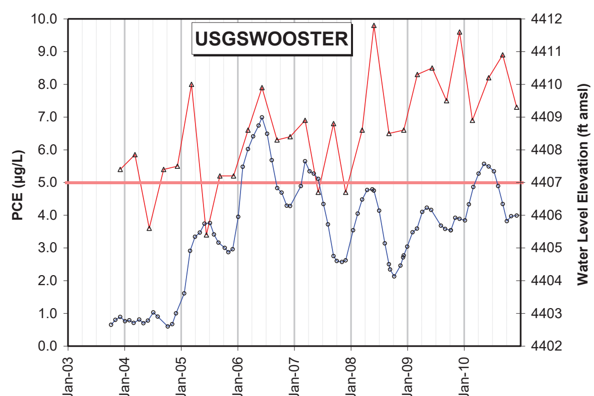
- USGSLISTON (screened interval - 28.5 to 38.5 feet bgs):
  - With the addition of the 2010 data, PCE in USGSLISTON presently exhibits a decreasing Mann-Kendall trend for the GMP period. Prior to 2010, PCE in this well defined no Mann-Kendall trend. From a qualitative perspective, decreasing (but variable) PCE is generally observed after 2006 Q4. Prior to that time, generally increasing (but also variable) PCE was observed in this well.
  - Beginning in 2006, there is evidence of a recurring pattern where annual PCE maxima correspond with decreasing water levels and where annual PCE minima correspond with either increasing water levels or water level minima that precede increasing water levels.
  - The PCE maximum (38 µg/L) was observed in this well in 2006 Q3.

- The highest PCE concentration during 2010 was 14 µg/L in Q3.
- PCE was detected at this well at 20 µg/L in a sample collected by the U.S. Geological Survey on July 27,1994 (USGS, 2013), shortly after the well was constructed.
- USGSLISTION is located approximately 850 feet to the northeast, and downgradient of hot spot well CTM52. During 2010 Q3 and Q4, PCE concentrations at USGSLISTON were roughly the same as PCE concentrations at CTM51 and CTM52. The similar concentrations suggest that the East Plumb Lane hot spot is becoming less distinct with time as a consequence of long term decreasing concentration at wells that define it.

- CTM96 (screened interval – 41 to 46 feet bgs):
  - PCE exhibits a decreasing Mann-Kendall trend over the two year period of record for the well (using 8 quarterly data values from 2009 Q1 through 2010 Q4).
  - There is no obvious pattern or interrelationship between PCE and water level based on the two year period of record for this well.
  - A PCE concentration maximum of 4.4 µg/L was observed in this well in 2009 Q2.
  - The highest PCE observed in 2010 was 3.1 µg/L in Q2 and Q3.
  - CTM96 is considered to be downgradient from the Vassar Street hot spot. However PCE data do not currently exhibit any transient increases (similar to CTM62) that would be attributable to the recurring transient concentration at the Vassar Street hot spot. This may result from CTM96 being along a different flow path or there not being a long enough monitoring record for the transient changes observed upgradient to be seen at this location.
- CTM93 (screened interval – 45 to 50 feet bgs):
  - PCE data define no Mann-Kendall trend (based on the 8 quarterly data points from 2009 Q1 to 2010 Q4).
  - There is no evidence at this time for any consistent pattern or interrelationship between PCE and water level data.
  - The PCE maximum in this well (4.4 µg/L) occurred in 2009 Q1.
  - The highest PCE in 2010 was 3.1 µg/L in both Q2 and Q3.
  - CTM93 is located in the area where PCE originating from the Vassar Street hot spot could commingle with PCE originating from the East Plumb Lane hot spot. However, the position of CTM93 relative to the contaminant migration pathways from either hot spot is presently uncertain due to the lack of other nearby wells to the north or south in the plume. The position of CTM93 relative to plume migration pathways may be of future potential importance in terms of defining downgradient PCE mass flux, PCE center of mass, and relative PCE contribution from the two hot spots.

- USGSWOOSTER (screened interval - 34 to 39 feet bgs):
  - PCE data exhibits an increasing Mann-Kendall trend for the GMP period.
  - There is no obvious recurring pattern in the PCE data and no consistent interrelationship between changes in PCE and changes in water level.
  - The PCE maximum in this well (9.8 µg/L) was observed in 2008 Q2.
  - The highest PCE during 2010 was 8.9 µg/L in Q3.
  - The higher PCE at USGSWOOSTER (and CTM99, as described below) than at upgradient well CTM93 is consistent with USGSWOOSTER being either:
  - Located closer to the shallow zone plume axis than CTM93;
  - Within a detached plume core that has migrated downgradient from the source, past CTM93; or,
  - Proximal to and downgradient from a local, currently unrecognized, contributing PCE source.
  - Until the locally higher PCE in USGSWOOSTER (and CTM99) is better understood, the area encompassed by these wells will be referred to as the “Condor Way hot spot”.





- CTM99 (screened interval – 35 to 40 feet bgs):
  - PCE exhibits a decreasing Mann-Kendall trend (based on the 8 quarterly samples collected from 2009 Q1 to 2010 Q4).
  - There is no obvious pattern in the PCE data and no consistent interrelationship between changes in PCE and changes in water level.
  - The PCE maximum in this well (9.4 µg/L) was observed in 2009 Q2.
  - The highest PCE during 2010 was 8.9 µg/L in Q2.

- The locally higher PCE in CTM99 and USGSWOOSTER is referred to as the "Condor Way hot spot".

- CTM18S (screened interval – 14.5 to 34.5 feet bgs):
  - PCE exhibits a decreasing Mann-Kendall trend for the GMP period.
  - An inverse relationship between changes in PCE and changes in water level is evident prior to 2006.
  - Beginning in 2006, changes in PCE have an intermittent positive correlation with water level changes.
  - The PCE maximum in this well (8.1 µg/L) was observed in 2004 Q1.
  - The highest PCE during 2010 was 1.6 µg/L in Q1.

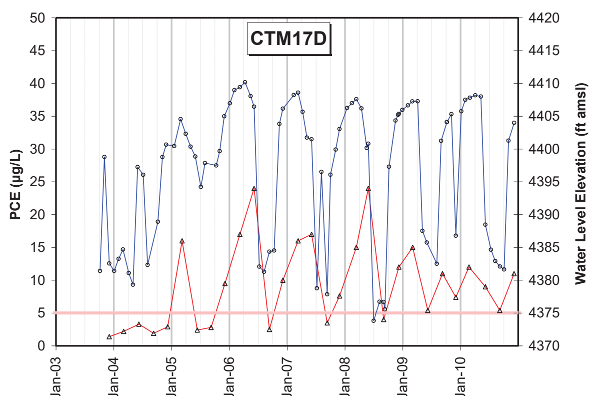
Deep Zone Wells (Monitoring)

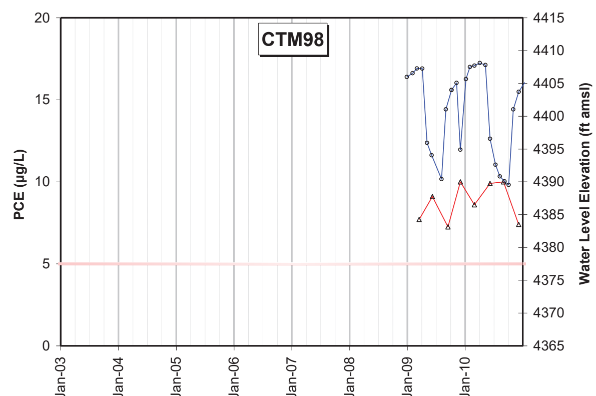
- CTM95 (screened interval – 80 to 90 feet bgs):
  - PCE was first reported in this well in 2010 Q3 at a concentration of 0.75 µg/L (after the project analytical reporting limit for PCE was reduced from 1.0 µg/L to 0.50 µg/L beginning that quarter).
  - The occurrence of PCE at this well provides better resolution to the vertical and lateral extent the plume west of the HWB. The low concentration and relatively shallow depth of this deep zone well indicate that the South Reno plume is localized in the upper 90 feet of the subsurface at this location.
- CTM33D (screened interval - 178.5 to 198.5 feet bgs):
  - With the inclusion of 2010 results, PCE exhibits an increasing Mann-Kendall trend for the first time during the GMP period. PCE data has previously defined no trend.
  - There is no obvious pattern or consistent long term interrelationship between the PCE and water level data.
  - The PCE maximum (1.8 µg/L) for this well was observed in 2009 Q4 and again in 2010 Q2.
- CTM17D (screened interval - 179 to 199 feet bgs):
  - PCE exhibits an increasing Mann-Kendall trend for the GMP period.
  - There is a strong positive correlation between changes in PCE concentration and changes in water level in this well.
  - The PCE maximum in this well (24 µg/L) was observed in 2006 Q2.
  - The highest PCE during 2010 was 12 µg/L in Q1.

  - The correlation between water level drawdown and transient decreases in PCE concentration is consistent with the more concentrated portion of the plume moving away from CTM17D and toward CORBETT in response to pumping at CORBETT. The relatively large range in annual PCE concentration fluctuation require a locally steep PCE concentration gradient near the well and is consistent with this well being in proximity to a plume margin.

- CTM98 (screened interval – 239 to 254 feet bgs):

  - PCE exhibits no Mann-Kendall trend over the two year period of record for the well that started in 2009 Q1.
  - The existing data suggest a weak interrelationship where annual PCE maxima coincide with water level decreases that occur during sustained periods of pumping. Annual PCE minima coincide with water level increases.
  - The PCE maximum for this well (10.0 µg/L) was observed in 2009 Q4 and again in 2010 Q3.





- CTM97 (screened interval – 319 to 329 feet bgs):

  - PCE has been consistently below the laboratory reporting limit since the well was first completed and sampled in 2009 Q1. Accordingly, the existing PCE data do not define any trends and/or patterns, or any interrelationships between changes in PCE and changes in water level.
  - CTM97 has been constructed in the same hydrostratigraphic interval as the upper screened interval at TERMINAL and is intended to serve as a sentinel well. Results to date are consistent with the South Reno plume being shallower in the aquifer system than the top of CTM97 (and therefore TERMINAL).

- CTM106 (screened interval – 125.5 to 135.5 feet bgs):

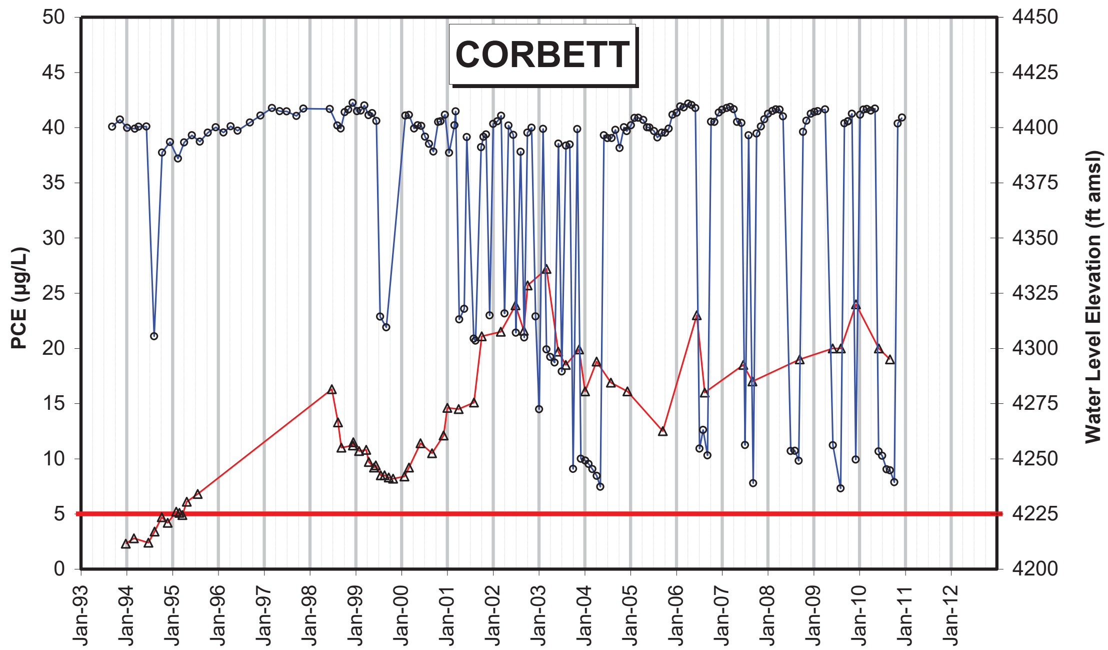
  - PCE exhibits no Mann-Kendall trend over the two year period of record.

- The existing data suggest a possible interrelationship between annual PCE maxima and decreasing water levels in response to sustained pumping.
- The PCE maximum for this well (7.6 µg/L) was observed in both 2009 Q2 and 2009 Q4.
- The highest PCE in 2010 was 6.6 µg/L in Q1.

Deep Zone Wells (Municipal Supply Wells)

Identifying and evaluating possible PCE and water level patterns, trends, and interrelationships in the municipal water supply wells can be problematic. The water quality data typically collected from these wells is intended to be representative of groundwater from the aquifer in a given well under steady state pumping conditions. Water quality samples have generally only been collected from these wells while they are being pumped. Accordingly, the groundwater elevation data from these wells are indicative of the aquifer under pumping conditions. Since 2006, municipal water supply wells are typically sampled opportunistically on a monthly basis during sustained pumping periods (typically late spring through early fall).

- CORBETT municipal water supply well (screened interval - 180 to 280 feet bgs):
  - GMP PCE data exhibit an increasing Mann-Kendall trend. The combined DWR and TMWA data (see graph below) also exhibit a long term increasing trend that extends from 1993 to 2010.
  - Municipal water supply well data are typically collected during pumping periods and are consequently not the most effective for defining patterns or interrelationships between PCE and water level data.
  - PCE concentration has ranged from 12 to 24 µg/L.
  - The GMP maximum of 24 µg/L occurred in 2009 Q4. The overall maximum of 27.2 µg/L was observed based on a TMWA compliance sample collected in 2003 Q1.
  - The highest PCE concentration during 2010 was 22 µg/L in Q3.
  - Time series samples collected during periods of sustained pumping exhibit decreasing PCE concentration as more groundwater is extracted. This suggests that increased pumping at CORBETT could mitigate the long term increasing trend observed at this well.
  - PCE first impacted CORBETT in 1993, shortly after the well was constructed. This indicates that PCE had migrated downward into the deep zone prior to pumping at CORBETT.



- TERMINAL municipal water supply well (multiple screened intervals - 330 to 665 feet bgs):
  - TERMINAL is located downgradient of CORBETT and MILL and was added as a key well because it functions both in a self-sentry capacity and to verify the effectiveness of PCE capture at CORBETT and MILL.
  - Sampling by TMWA detected PCE in TERMINAL at a concentration of 0.51 µg/L in September 2004.
  - PCE was not above the laboratory reporting limit in the 2 samples collected from the well in 2007 (Q3) and 2008 (Q2).
  - Data from TERMINAL are sparse reflecting the infrequent use of this well. .
  - While low concentration PCE has been intermittently detected at TERMINAL, there is no indication that the South Reno plume has impacted the portions of the aquifer system where TERMINAL is constructed (330 to 665 feet bgs). Existing cross sections suggest that impacts to TERMINAL are more likely associated with the Downtown Reno plume.

5.6.7 Receptors

CORBETT and TERMINAL are receptor (CORBETT) or potential receptor (TERMINAL) wells for the South Reno plume.

PCE at CORBETT first exceeded the MCL in 1995 and this has been fitted with PCE treatment equipment and operated accordingly since July 1998. CORBETT is operated to meet municipal water supply and to provide remedial benefit by capturing and/or providing hydraulic containment for the South Reno plume. The pumping plan agreement (Pumping Plan) between Washoe County and TMWA prescribes a mutually agreed-to pumping schedule at CORBETT and the other four PCE-treated wells operated by TMWA that is designed to substantially contribute to remedying the condition of PCE contamination (Pumping Plan Agreement, 2009). CORBETT has met or exceeded the annual pumping volume threshold of 150 MG prescribed by the Pumping Plan every year. The groundwater treatment history at CORBETT is summarized in the following table.

South Reno Subregion PCE Well Treatment History

Calendar Year	CORBETT		
	PCE (µg/L) [1]	Water treated (million gallons)	PCE removed (pounds)
1996			
1997			
1998	12.7	50.7	5.3
1999	9.4	222.2	17.3
2000	10.8	192.3	17.3
2001	16.3	440.2	59.9
2002	22.3	338.5	63.0
2003	21.8	444.7	80.8
2004	17.0	437.6	62.0
2005	17.6	149.1	21.9
2006	18.0	192.2	28.9
2007	17.1	150.4	21.5
2008	22.5	150.8	28.3
2009	21.4	248.3	49.6
2010	19.4	286.4	49.2
TOTALS		3303.5	505.0

(1) Weighted annual average, based on (pre-2005) SPPCo/TMWA compliance data or (post-2005) on DWR GMP data

The data provided in this table suggest that after 2002, higher annual pumping rates correlate to decreases in average annual PCE. This interrelationship suggests that when CORBETT is pumped at an annual rate of more than 200 MG, PCE concentration stabilizes or decreases. As shown on the table, PCE concentration peaked in 2002 and began to decrease until 2005 when annual pumping rates were reduced to less than 200 MG. Between 2005 and 2008 PCE increased while annual pumping remained below 200 MG. In 2009 and 2010, PCE resumed a decreasing trend when annual pumping was increased above 200 MG. These data suggest that maintaining higher pumping rates (than the prescribed 150 MG/yr) at CORBETT could have an increased remedial benefit in terms of plume stabilization and recession.

TERMINAL is approximately 1,500 feet east-northeast of CORBETT. TERMINAL is completed across a deeper interval (and in what are considered different hydrostratigraphic packages) than CORBETT. TERMINAL is downgradient of CORBETT and MILL and can help evaluate the effectiveness of PCE capture and containment (as part of the pumping plan) at both of these wells. While low level PCE contamination has been occasionally detected at TERMINAL, there is no indication that the South Reno plume has impacted the deeper portions of the aquifer system where TERMINAL is constructed (330 to 665 feet bgs).

5.6.8 South Reno Conceptual Model

The South Reno complex plume has multiple potential sources spatially associated with two separate hot spots in the shallow zone, and one impacted receptor in the deep zone. The plume is interpreted to originate from sources located east of the VLFZ, extend laterally to the east across the HWB, and impact both the shallow zone and deep zone portions of the aquifer system on the east side of the HWB. The South Reno Subregion conceptual model presented in the following is based on the data presented in **Sections 5.6.1** through **5.6.7**.

Figure 5.17 shows a plan view schematic of pertinent features described in this section. In addition, **Figures 5.18A** and **5.18B** are schematic vertical cross sections (replicated from the 2009 Annual Report [WorleyParsons, 2013]) representing the hydrostratigraphic conceptual model, and PCE distribution and potential migration pathways for PCE in the South Reno plume, respectively. These sections transect the Vassar Street hot spot, project through the CORBETT municipal water supply well, and extend past the TERMINAL municipal supply well. The schematic sections were prepared based on data available through 2009; however they are consistent with newer data and are used here to support the 2010 conceptual model discussion.

Hydrogeology

As depicted on **Figure 5.17** and **Figure 5.18A**, the South Reno Subregion is transected by two generally north-trending geologic features that act, at least locally, as partial barriers to horizontal groundwater flow; the VLFZ and the HWB. The VLFZ is located west of the South Reno plume and is interpreted to extend in a northerly direction from the vicinity of Virginia Lake to the west of the Vassar Street hot spot and along the western border of the South Reno Subregion. The eastern margin of the VLFZ is locally defined by the CSB, a flow barrier that extends along the east side of Holcomb Avenue (as depicted on **Figure 5.17**). The VLFZ acts as local partial barrier to flow in both the shallow zone and deep zone. The HWB is located east of the VLFZ, between CTM33D and CORBETT, and is interpreted to extend in a northwesterly direction beyond the South Reno Subregion. The HWB is only recognized as a partial flow barrier in the deep zone (and has no recognized influence on flow in the shallow zone). The nature and extent of the HWB and the geologic circumstances that have resulted in this partial flow barrier have not yet been fully determined.

The hydrostratigraphy in the South Reno Subregion is nearly flat-lying or has a relatively gentle apparent dip towards the east. Hydrostratigraphy is generally defined by sequences of unconsolidated alluvial material that alternate between predominantly coarser grained material (gravel, sandy gravel, gravelly sand with cobbles and boulders with varying amounts of matrix fines and local interlayers of finer grained sand, silt and clay) and predominantly finer grained material (silty sand, silt, and clay with local interlayers of coarser grained gravel, gravelly sand, and sand). Where these sequences have relatively consistent characteristics and lateral continuity, they have been defined as hydrostratigraphic packages that are considered likely to exert an influence on groundwater flow and contaminant movement. These packages are shown and described on **Figure 5.18A**.

As determined based on borehole lithology and depicted on **Figure 5.18A**, both the coarser and finer grained hydrostratigraphic packages have significant intra-package heterogeneity. This results in an aquifer system that is characterized by a high degree of anisotropy that is likely to contain local areas of enhanced vertical flow and other areas where vertical flow is relatively impeded. In general this is corroborated by water level patterns. Both shallow zone and deep zone wells have similar water level patterns that coincide with deep zone pumping patterns. However, shallow zone drawdown in response to deep zone pumping is consistently smaller than what is observed in the deep zone. Shallow zone drawdown also has a non-uniform distribution relative to distance from the pumping well. This general response pattern is interpreted to reflect the influence of intra-package variability combined with the relatively distinct characteristics of the hydrostratigraphic packages. As a result the aquifer system exhibits behavior consistent with hydrologic characteristics that can range from a heterogeneous and anisotropic unconfined system to a leaky confined system (even in the absence of a mappable aquitard).

It is important to note the following.

- Shallow zone hydrostratigraphic packages (Packages A and B(c)) are predominantly coarser grained, but contain finer grained material as local interlayers and lenses that can act as local impediments to vertical flow. These finer grained intervals often have relatively thin vertical dimension that suggests their lateral continuity and effectiveness as potential aquitards are limited. Where a lower proportion of finer grained intervals exist, potential for enhanced vertical flow and PCE migration from the shallow zone into the deep zone is expected to be greater.

- The deep zone hydrostratigraphic package (Package D) that underlies the South Reno plume in the vicinity of CORBETT and TERMINAL is a relatively thick (100 to 130 feet thick) interval of generally finer grained material. This package may represent an impediment to vertical flow and PCE transport between the PCE-impacted groundwater-producing packages at CORBETT and the deeper unimpacted groundwater-producing package sequence at TERMINAL. This package is interpreted to have some protective capacity to mitigate impacts to TERMINAL from the South Reno plume.

Lateral Groundwater Movement

Lateral groundwater movement in both the shallow zone and deep zone is to the east under natural conditions. The predominant lateral gradient (particularly east of the HWB in the deep zone) steepens in response to municipal water supply well pumping (particularly at CORBETT, MILL, and TERMINAL). During times of pumping, the local deep zone gradient can converge on an individual operating well or on a group of operating wells (i.e. a coalescing cone of depression). Since 2006, the effects of municipal water supply well pumping have been evident primarily during the summer and into the early fall. Lateral groundwater movement also appears to be influenced by the VLFZ and the HWB. A steepening of the horizontal gradient occurs locally in both the shallow and deep zones in association with the VLFZ. A steepening of the deep zone potentiometric surface only occurs in association with the HWB. The HWB is interpreted to trend in a northwesterly direction across the South Reno Subregion and to act as a barrier to lateral groundwater flow only in the deep zone.

Vertical Groundwater Movement

The potential vertical groundwater movement and downward PCE migration (as indicated by the direction and magnitude of the vertical gradient) varies both spatially and temporally across the South Reno Subregion. Vertical hydraulic communication is indicated by shallow zone drawdown that occurs during deep zone pumping. Vertical gradient data define distinct areas having different vertical hydrodynamics that reflect their location relative to flow barriers and to groundwater sources or sinks (particularly municipal water supply wells).

West of the CSB and within the VLFZ

- A relatively small upward vertical gradient occurs during periods of little to no pumping (e.g. winter and spring –Q4 and Q1). During periods of sustained pumping (e.g. summer through early fall –Q2 and Q3) the vertical gradient is reduced in magnitude and commonly reverses (becoming nominally downward). The small annual water level fluctuations (generally less than 2 ft) in both the shallow zone and deep zone suggest that the area west of the CSB and within the VLFZ is hydraulically isolated from the effects of municipal water supply well pumping..

Between the VLFZ and the HWB

- There is an upward vertical gradient from the deep zone to the shallow zone that persists throughout the year. This is consistent with a potential for upward groundwater flow from the deep zone to shallow zone of the aquifer system. This is also consistent with a limited potential for downward PCE movement from the shallow zone into the deep zone of the aquifer system.

- Lateral groundwater flow in the deep zone appears to be significantly impeded by the HWB, as indicated by the relatively limited drawdown response in observation wells west of the HWB to municipal water supply pumping (e.g., at CORBETT, TERMINAL, or MILL) on the opposite side (east) of the HWB. The HWB is interpreted to contribute to the upward vertical gradient that persists between the VLFZ and the HWB.

- The distinct deep zone response west of the HWB to pumping at HIGH and/or MORRILL (as described in the 2009 Annual Report [WorleyParsons, 2013]) indicates direct hydraulic communication between this area and pumping to the north of the area. This is in contrast to the limited response here to pumping at CORBETT and MILL. These observations indicate that groundwater flow in the area between the VLFZ and the HWB is more strongly influenced by pumping at HIGH and/or MORRILL than by pumping at CORBETT, MILL, and TERMINAL (or other wells located east of the HWB).

- There is vertical hydraulic communication between the shallow zone and deep zone of the aquifer system on the west side of the HWB. This is based on shallow zone drawdown that coincides with deep zone pumping. However, the persistent upward vertical gradient limits downward groundwater flow (or vertical PCE migration) potential in this area.

East of the HWB

- The vertical gradient direction is dependent on pumping conditions. An upward gradient exists under non-pumping conditions and a downward gradient exists under pumping conditions.

- Prior to 2006, PCE-treated municipal water supply wells were commonly pumped year-round and a downward vertical gradient (and potential for downward flow) was persistent. Since 2006, municipal water supply well pumping has been based on peak water demand (typically in Q2 and Q3). Under this pumping scenario, an upward gradient is typically observed during Q1 and a downward gradient develops during Q2 and Q3 (particularly in response to pumping at CORBETT, MILL, and TERMINAL). By the end of Q4, the downward gradient typically reverses and an upward gradient persists into Q1 of the subsequent year.

- There is vertical hydraulic communication between the shallow zone and deep zone east of the HWB. This is based on the shallow zone drawdown response to deep zone pumping and the presence of PCE in the deep zone. However, the magnitude of shallow zone drawdown is significantly less than the corresponding deep zone drawdown. This is interpreted to result from vertical heterogeneity and vertical anisotropy rather than from a continuous aquitard.

- The shallow zone drawdown response to deep zone pumping is not uniformly distributed. This is interpreted to reflect heterogeneity that can result in local preferential pathways or conduits where downward vertical flow in response to pumping is relatively enhanced. Based on the distribution of PCE contamination, downward PCE migration is interpreted to occur somewhere in the area east of the HWB and upgradient (west) of CORBETT. However there is currently a lack of data points in that area to define specific shallow zone to deep zone pathways.

Potential PCE Sources

Numerous PCAs have been identified in the subregion and represent potential PCE sources. Potential PCE source areas have been identified as a result of the work conducted to date in the vicinity of the Vassar Street and East Plumb Lane hot spots (see **Figure 5.16**).

The area near the Vassar Street hot spot includes:

- Multiple historical potential PCE-using businesses;

- At least two potential PCE release sites (the North Alley Source Site and the South Alley Source Site) (Kleinfelder, 2003); and

- The Champion SMP site where PCE-containing wastewater was identified in sanitary sewer lines downgradient from a now former PCE-using facility.

The area around the East Plumb Lane hot spot includes:

- A limited number of historical potential PCE-using businesses;

- PCE-impacts to soil vapor, soil, and groundwater proximal to a former PCE-using facility and near the sanitary sewer line downgradient from that business;

- The Rainbow SMP site where PCE-containing wastewater was identified in sanitary sewer lines downgradient from a former PCE-using facility; and

- The Plumb Lane Plaza NDEP PCE corrective action project site.

For both the Vassar Street and East Plumb Lane hot spots, these features are consistent with multiple potential sources that could include site-specific releases and/or "distributed sources" (that might occur when exfiltration of PCE from the sanitary sewer occurs at more than one location downstream from a facility that has discharged PCE-containing wastewater).

DWR's ongoing Vassar/East Plumb potential source area (PSA) investigation has identified five PCE high mass areas (HMAs). Each HMA is proximal to one or more previously identified PCAs. Results indicate that:

- The Wrondel HMA is spatially associated with the East Plumb Lane hot spot and has a limited areal extent. This is consistent with the potential source for that hot spot occurring within a relatively small and well-defined area.
- The Arroyo HMA is spatially associated with the Vassar Street hot spot. This HMA is more complex and has a relatively large extent. These characteristics are consistent with multiple potential contributing sources in the area proximal to and upgradient from the Vassar Street hot spot.
- The Wonder HMA has a limited areal extent that is coincident with previous soil and groundwater data (Kleinfelder, 2003). These data suggest that impacts associated with the Holcomb source site are limited in extent.
- The Cadillac HMA is spatially associated with the Orchard Plaza Corrective Action site.
- The Cassaza HMA represents previously unrecognized PCE impacts in an area where numerous former or current potential PCE-using businesses have been identified.

While no work was conducted in the Vassar/East Plumb PSA during 2010, future work will assess these high mass areas.

PCE Plume Formation and Distribution

The shallow zone portion of the South Reno plume originates from at least two sources that occur in the vicinity of the Vassar Street hot spot and the East Plumb Lane hot spot, respectively. Both hot spots are spatially associated with PCA's and PCE impacts to soil, soil vapor, and groundwater. In the vicinity of the Vassar Street hot spot, the plume extends from near South Virginia Street laterally and downgradient toward the east. In the vicinity of the East Plumb Lane hot spot, the plume extends from near Wrondel and East Plumb Lane downgradient to the east-northeast. PCE distribution relative to these hot spots is consistent with the prevailing lateral hydraulic gradient. PCE contamination originating from the vicinity of these hot spots is interpreted to extend downgradient and become contiguous in the area between the hot spots and the HWB. PCE contamination extends across the HWB where the shallow zone portion of the plume extends eastward beyond US 395 (at CTM18S and

CTM99). The leading edge of the plume is undefined to the east. The crossgradient plume extent in the shallow zone is undefined to the north and south, but is interpreted to generally extend from East Plumb Lane northward beyond Vassar Street, as depicted on **Figure 5.17.** There is a zone of relatively elevated shallow zone PCE concentration identified as the "Condor Way" hot spot (near USGSWOOSTER and CTM99, and east of the HWB) that may either be a third plume hot spot (with local sources) or a shallow zone plume core that has detached from an upgradient source (see **Figure 5.18B**).

The deep zone portion of the plume extends from near CTM33D (west of the HWB) eastward past US 395 at least to CTM98 (east of the HWB). The northern extent potentially overlaps with the Downtown Reno plume to the north of CTM106. The southern deep zone extent is interpreted to be under the influence of CORBETT since there is a lack of municipal water supply wells south of CORBETT. This suggests that the deep zone contamination is not likely to extend appreciably south of CORBETT.

The complex plume extends vertically from the water table near the hot spots into the deep zone east of the HWB. As depicted on **Figure 5.18B**, the plume is interpreted to remain primarily in the shallow zone near and downgradient from the hotspots (in an area where the vertical gradient is persistently upward). Approaching the HWB, PCE contamination extends into the deep zone to a depth of 180 feet bgs. Across and east of the HWB, the plume extends to a depth of more than 285 feet but less than 319 feet bgs. This vertical distribution indicates significant downward movement of PCE near and, more specifically, east of the HWB.

Data suggest that the source term contributing to the plume may be decreasing near both the Vassar Street and East Plumb Lane hot spots. There is a long term decreasing trend in PCE concentration at wells (CTM51, CTM52, and CTM48) that help define the hot spots. This would be consistent with the local PCE centers of mass migrating downgradient from these hot spots.

Data also suggest that a plume core has detached from source areas west of the HWB and migrated into the deep zone near CORBETT. This is illustrated as Alternative B in **Figure 5.18B** and is indicated by:

- The long term increasing trend in PCE concentration at downgradient, deep zone wells (CORBETT and CTM17D); and
- The higher PCE concentration in the deep zone east of the HWB compared to shallow zone concentration upgradient and west of the HWB.

A conceptual model alternative (shown as Alternative A in **Figure 5.18B)** recognizes that local PCE sources (east of the HWB as reflected by the Condor Way hot spot) could also be contributing to the impacts at CORBETT.

At least a part of the southern plume margin is interpreted to be captured or contained by pumping at CORBETT. This is indicated by sympathetic changes in water level and PCE concentration at CTM17D that suggest a causal relationship to pumping at CORBETT where:

- Falling water level and decreased PCE concentration indicates that the plume margin moves away from CTM17D toward Corbett under sustained pumping conditions; and
- Increased PCE (and water level) indicates that the plume margin shifts closer to CTM17D when CORBETT is not pumped.

The long term increasing PCE trend at CTM17D indicates that a higher concentration part of the plume (e.g., a deep zone plume core) has moved into that part of the aquifer system where CTM17D is screened, and that the plume margin has also moved further beyond CTM17D during both non-pumping and pumping conditions.

Other water level and PCE concentration interrelationships recognized at deep zone wells (including CTM98 and CTM106) near CORBETT are interpreted to indicate that the plume extends beyond where these wells are constructed. This is indicated by:

- Higher PCE concentration that can be observed when water levels are low; and
- An intermittently inverse correlation between pumping and PCE concentration.

This behavior is consistent with a more concentrated part of the plume existing beyond these monitoring wells during non-pumping conditions. Implications are that recent pumping at CORBETT has been less than effective in providing plume capture in those areas.

PCE Migration Mechanisms and Pathways

The South Reno plume is considered to be continuous from the shallow zone hot spots to the deep zone where it impacts CORBETT. The conceptual model for the South Reno complex plume showing PCE distribution and potential migration pathways is illustrated in **Figure 5.17** and **Figure 5.18B**.

The shallow zone Vassar Street and East Plumb Lane hot spots are located near the upgradient margin of the South Reno plume and are spatially associated with nearby PCAs. These hot spots are interpreted to be located near sources of PCE that have contributed and which may still be contributing PCE to groundwater. These once local and isolated PCE plumes migrated laterally over time and eventually combined in the down gradient area to the east. PCE groundwater contamination between these plume hot spots and the HWB is kept shallow by an upward vertical gradient. The shallow zone PCE is interpreted to continue to migrate east and then move vertically downward (particularly east of the HWB) into the deep zone portion of the aquifer system in response to gradients induced by municipal water supply well pumping. When little or no pumping occurs, shallow zone and deep zone contamination can continue to migrate to the east, beyond CORBETT (as indicated by PCE at the

CTM97/CTM98/CTM99 well cluster). Recognizing that the PCE impacts to CORBETT first occurred in 1993 (immediately after the well was constructed), the PCE contamination to that portion of the aquifer system and a driver for downward migration in the South Reno Subregion predates CORBETT. The pre-CORBETT groundwater flow direction was likely to have been:

- Laterally from west to east (similar to present day conditions); and
- Vertically downward when MILL, TERMINAL, and other municipal water supply wells were pumped.

Therefore, PCE contamination is interpreted to have migrated from one or more of the plume hot spots west of the HWB into that portion of the aquifer system where CORBETT is completed for a potentially significant period of time prior to 1993. Dry cleaning activity near the East Plumb Lane hot spot began in 1986. Dry cleaning activity near the Vassar Street hot spot began in 1946.

Threats to Receptors

PCE concentration in the CORBETT municipal water supply well could continue to increase in the future based on the increasing PCE concentration trends observed in nearby shallow zone and deep zone monitoring wells (USGSWOOSTER and CTM17D). This long term increasing PCE concentration trend at CORBETT can potentially be mitigated by increased pumping at CORBETT and using the existing treatment equipment. This is suggested by the following observations:

- Pumping at CORBETT over the course of the peak demand season results in decreased wellhead PCE concentrations at CORBETT; and
- When CORBETT is pumped at annual volumes that exceed 200 MG, average PCE concentration at CORBETT can exhibit a decreasing trend.

Based on PCE concentrations at well clusters CTM99/CTM98/CTM97 and CTM18S/CTM106, it is evident that the South Reno plume extends beyond CORBETT to the east. If not captured or contained by pumping at CORBETT, the South Reno plume could potentially impact TERMINAL or other downgradient municipal water supply wells (including PEZZI, HV3, HV5, or LONGLEYLANE1; which are farther away but shallower than TERMINAL). TERMINAL is also a potential receptor for the Downtown Reno and Mill/Kietzke plumes. While TERMINAL has recently only been used in a limited capacity, the threat to this well will increase if it is operated more and/or if CORBETT is operated less.

5.6.9 Summary

The South Reno plume is a complex plume that occurs predominantly in the shallow zone west of the HWB and in both the shallow zone and deep zone east of the HWB. PCE in the shallow zone has moved downward into the deep zone where it has impacted the CORBETT municipal water supply well. PCE has originated from sources near to the Vassar Street and East Plumb Lane plume hot spots, and potentially from other (as yet undefined and unsubstantiated) sources west of the HWB. The plume center of mass may be moving east (toward CORBETT) based on the long term decreasing PCE concentration trends at several hot spot wells and the long term increasing PCE concentration trend at CORBETT.

West of the HWB, PCE migration from the hot spots occurs primarily through lateral movement. A persistent upward hydraulic gradient limits downward PCE migration until the plume reaches or goes beyond the HWB. Deep zone pumping from either HIGH and/or MORRILL influence water levels west of the HWB, but does not eliminate the persistent upward vertical gradient in that area. Therefore municipal well pumping is not currently considered to influence the South Reno plume west of the HWB. The HWB acts as a partial barrier to deep zone groundwater flow. However, it has a limited influence on shallow zone flow and PCE migration. East of the HWB, a stronger response to deep zone pumping (resulting in a downward gradient) is evident and the extent and magnitude of deep zone PCE impacts increase significantly. This is interpreted to result from PCE migration that is lateral under natural conditions or downward when municipal water supply well pumping is taking place east of the HWB.

The South Reno plume extends to the east and downgradient of CORBETT. In the event that this PCE contamination has migrated beyond the CORBETT capture zone, it could pose a threat to TERMINAL and/or other downgradient water supply wells (PEZZI, HV3, HV5, and LONGLEYLANE1). It will be important to review the CORBETT capture zone and to assess the effectiveness of capture and containment of the South Reno by operating CORBETT in accordance with the current pumping plan target (150 million gallons per year). TERMINAL is also a potential receptor for the Downtown Reno and Mill/Kietzke plumes. The threat to TERMINAL from any of these plumes may increase if TERMINAL is operated more regularly in the future.

5.7 Downtown Reno Subregion

The Downtown Reno Subregion encompasses a complex, vertically continuous plume that extends from a hot spot in the shallow zone (at depths generally less than 50 feet bgs) located in the vicinity of West Fourth and Ralston Streets, and plunges to increasing depths in the downgradient direction to the east. From west to east, this plume is interpreted to have impacted the following municipal water supply wells (with the multiple screens that span the interval shown in parentheses):

- HIGH (131-511 feet bgs)
- MORRILL (178-578 feet bgs)
- 4TH (176-480 feet bgs)
- KIETZKE (233-498 feet bgs)
- MILL (326-640 feet bgs)

North of the Truckee River the Downtown Reno plume is present in both the shallow zone and deep zone. South of the Truckee River, the Downtown Reno plume has only been recognized in the deep zone of the aquifer system. In the southeastern part of the subregion, the Mill/Kietzke plume is located in the shallow zone (to a maximum defined depth of approximately 97 feet bgs) above the deep zone Downtown Reno plume (present at a minimum depth of approximately 290 feet bgs). No data are available at this time to substantiate a physical connection between the Mill/Kietzke plume and the Downtown Reno plume. The southeastern extent of the Downtown Reno plume is currently undefined given that PCE contamination exists in the deep zone 1,600 feet beyond the MILL municipal water supply well.

5.7.1 Hydrogeology

Two geologic features occur in this subregion (**Figures 5.19**) that act, at least locally, as partial barriers to groundwater flow. These features, called the Virginia Lake Fault Zone (VLFZ) and the Harvard Way Barrier (HWB), have been discussed previously in **Section 2.2.4** and are described below.

The westernmost partial flow barrier recognized in the subregion is currently attributed to the VLFZ, and is defined in the deep zone between MORRILL and HIGH and in the shallow zone between CORWSSMW2 and WMMW3. This barrier causes groundwater elevation to drop by approximately 40 ft from west to east (comparing shallow zone water level in CTM7S and CORWMMW2 to WMMW3). The barrier is also evident based on aquifer tests at HIGH and MORRILL (HGC, 2010) that show negligible water level response across the barrier during pumping at either HIGH (west of the barrier) or MORRILL (east of the barrier). These results indicate a limited hydraulic connection between deep zone water producing intervals across the barrier. As discussed in **Section 2.2.4**, this report refines the representation of the VLFZ, which is now depicted as a corridor that includes multiple post-Neogene faults. The multiple faults in basin fill material may be the near-surface manifestation of a deep seated structure that has been interpreted (based on gravity data by Widmer, 2005) as a down-to–the-west normal fault. While the gravity data indicate that this deep seated structure transects the Downtown Reno Subregion and continues to the north, surface faults near and north of the Truckee River have not been identified in the area. This imparts significant uncertainty to locating and characterizing the VLFZ in the Downtown Reno Subregion. As in previous GMP annual reports (WorleyParsons, 2011, 2013), the partial flow barrier identified west of MORRILL is interpreted to be related to the VLFZ. However, this interpretation is subject to revision in light of new information.

The second partial barrier, the HWB, is interpreted to project from the area west of CORBETT into the southern portion of the Downtown Reno Subregion between well clusters CTM102/CTM101/CTM100 and CTM9S/CTM104/CTM103/CTM10D. This is based on contrasting water level hydrodynamics on either side of the HWB (as described in **Sections 2.2.4**). West of the HWB, monitoring well clusters exhibit a generally persistent upward vertical gradient and deep zone wells show an obvious response to pumping at HIGH and/or MORRILL. East of the HWB, well clusters exhibit a reversing vertical gradient where the natural upward gradient changes to a downward gradient during periods of sustained municipal water supply pumping and deep zone wells exhibit an obvious response to CORBETT and/or MILL. The northern extent of the HWB is not presently defined beyond Mill Street, but projects northward toward the area between MORRILL and HIGH were the VLFZ is tentatively defined to occur.

No new lithologic data were acquired for the Downtown Reno Subregion in 2010. Consequently the following hydrostratigraphic description is largely taken from the 2009 GMP Annual Report (WorleyParsons, 2013). In general, the stratigraphy dips gently to the east with an apparent dip of less than 2 degrees.

In the Downtown Reno Subregion evidence for lateral continuity of discrete specific lithologic intervals is limited, but lateral continuity of packages is apparent (based on correlation of driller's, geologist's, and geophysical logs), particularly proximal to, and east of the VLFZ. The hydrostratigraphic packages in the vicinity of the projected location of the VLFZ are characterized by anisotropy (interlayered coarser and finer grained materials). There are fewer deep zone wells (and associated data) west of the VLFZ. Accordingly, the deep zone hydrostratigraphy is better characterized on the east side of the VLFZ (where more data are available).

The hydrostratigraphy of the Downtown Reno Subregion is described below for the areas:

1) West of the VLFZ; and,

2) East of the VLFZ.

West of the VLFZ

From near MORRILL to the vicinity of CTM30D (on Evans Ave near Second Street) and described from top to bottom:

- Package A. A generally coarser grained sequence (consisting of interlayered silty gravel and silty sand to bouldery gravel) extends from land surface to approximately 50 to 80 feet bgs. Gravelly interlayers commonly contain cobbles and boulders.
- Package B(f). Generally finer grained material (consisting of interlayered silty clay, silt, silty sand and lesser gravelly sand) that is from 50 to 100 feet thick overall. This package appears to thin and become generally coarser to the west. Package B(f) is interpreted to locally comprise a lower hydraulic conductivity sequence that separates the overlying shallow zone from the underlying deep zone in this portion of the basin.

The deep zone hydrostratigraphic packages in this area are described below.

- Package C. Coarser grained, gravel-dominated material (consisting of interlayered gravel, gravelly sand, and lesser sand) that is approximately 30 to 50 feet thick. Gravelly interlayers commonly contain cobbles and boulders.

- Package D. A generally finer grained package (consisting predominantly of interlayered clay, gravelly clay and silty sand) with generally thinner coarser grained interlayers and lenses (including sand and gravel). This package contains relatively thick (up to 30 feet) finer grained material that may act as local confining layers at depths between approximately 200 and 250 feet bgs. Existing well data do not indicate that these potentially confining layers are laterally persistent. Package D has a thickness of approximately 80 to 100 feet.

- Package sequence E, F, G. A relatively thick (approximately 320 feet thick) package of generally coarser grained material (comprised predominantly of interlayered clayey gravel, gravel, sand, and gravely sand) alternating with interlayers of finer grained material (including gravelly clay, silt, and silty sand). Package sequence E, F, G is where most of the HIGH well screen intervals are located. This package is indicated to have a significantly larger component of gravelly material in its upper 120 feet that, at HIGH, contributes substantially more groundwater to corresponding screened intervals than deeper screened intervals (based on flow profiling [AMEC, 2009]). Near the VLFZ, lithology and geophysical logs indicate that below the upper 120 feet, finer grained interlayers become more prevalent, and less groundwater is interpreted to be produced. Away from the VLFZ, the package sequence is poorly defined but is inferred to transition into coarser grained material (i.e. gravel dominated) to the west. The individual packages in this sequence are described (see **Section 5.10.1** of this report) in the eastern part of the basin based largely on data from STANFORD.

- Package V. A sequence of interlayered finer grained materials (consisting of sand and clay, sandy clay, silt, sandy silt, and silty sand with local gravelly interlayers) of undetermined total thickness (i.e., the sequence extends beyond the deepest available boring log [from HIGH at 753 feet total depth]).

West of CTM30D (on Evans Ave near Second Street) and described from top to bottom:

- Package Sequence A, B, C, D. Generally coarser grained material (comprised of thicker layers of sandy gravel and gravelly sand with varying proportions of matrix fines) and thinner layers of finer grained material (silty sand to sandy clay) that are commonly 5-10 feet thick, but ranging up to 20 feet. The individual packages (A, B, C, and D or their stratigraphic equivalent) defined to the east (for example at HIGH) are considered indistinguishable west of CTM30D. This is due to a relative lack of finer grained material and absence of the generally finer grained hydrostratigraphic packages (B(f) and D) that otherwise punctuate this sequence. This westward transition to predominantly coarser grained material may be due to sediment reworking in the river corridor, facies changes, and/or pinching out of finer grained sequences. Package sequence A, B, C, D extends to at least 200 feet bgs (the deepest boring) in the area.

The shallow zone/deep zone boundary is defined as occurring within this package sequence at a depth between 130 and 180 feet bgs, based on the depths to the first groundwater-producing interval in municipal water supply wells (HIGH, RENOHIGH, GLENHARE, and HUNTERLAKE) near the area.

East of the VLFZ:

- Package A. Generally coarser grained material (consisting of interlayered silty gravel to bouldery gravel) with local finer grained lenses and interlayers (consisting of silt to silty clay). Gravelly interlayers commonly contain cobbles and boulders. This interval is similar to the near surface material described west of the VLFZ and exists across the majority of the area east of the VLFZ where (based on borehole data) it thickens to the southeast, and extends from land surface to approximately 50 to 100 feet bgs.

- Package B(f). Generally finer grained material (consisting predominantly of interlayered silty clay, silt, gravelly silt, silty sand) with lesser coarser grained interlayers and lenses (sand to gravelly sand). The material in this package generally becomes finer to the east and includes a 20-foot thick clay interval in the KIETZKE well that may function as a locally confining layer. Package B(f) thickens from approximately 50 feet thick in the vicinity of the VLFZ to approximately 150 feet at KIETZKE. Southeast of MORRILL, it transitions laterally into coarser grained Package B(c).

- Package B(c). Generally coarser grained material (comprised of gravel, gravelly sand, and silty gravel with cobbles) with limited interlayers and lenses of finer grained material (silty clay, silt, and silty sand). Package B(c) occurs southeast of MORRILL where it is in the same stratigraphic position (between Package A and C) as B(f). While there has not been a significant thickness of finer grained material identified in this package in this subregion (causing Package B(c) and the underlying deep zone Package C to be indistinguishable here), the finer grained lenses or interlayers have lower hydraulic conductivity and would be expected to locally impede vertical groundwater movement through this sequence and from the shallow zone (i.e. Package A) into the underlying deep zone (Package C). Package B(c) and the underlying deep zone Package C have a total combined thickness of approximately 150 feet in the subregion.

The deep zone hydrostratigraphic packages east of the VLFZ are described below.

- Package C. Generally coarser grained material (comprised predominantly of cobbly to silty gravel) that corresponds to the upper screen in MORRILL and in KIETZKE. The package has relatively abundant matrix fines that are interpreted to locally restrict groundwater flow (based on dynamic flow profiling at MORRILL [AMEC, 2009]). Package C ranges between 25 and 40 feet thick where is distinguishable as a discrete package. Southeast of MORRILL (at CTM10D, MILL, and CTM107), there has not been a substantial thickness of finer grained material identified above this package resulting in Package C and overlying package B(c) being indistinguishable here and comprising of a total combined thickness of up to 150 feet.

- Package D. Generally finer grained material (comprised of interlayered silt, silty clay, silty sand, and sand with local, generally thinner layers of sand to sandy gravel). Package D is 90 feet thick at MORRILL and thickens to approximately 120 feet at MILL. The coarser grained interlayers are interpreted to correspond to relatively productive groundwater producing screened intervals in MORRILL and MILL (based on dynamic flow profiling at MORRILL [AMEC, 2009] and spinner logging at MILL [TMWA, 2003]). The finer grained materials in this interval could potentially function as local confining layers.

- Package sequence E, F, G. A relatively thick, generally coarser grained sequence of packages characterized by alternating coarser grained material (comprised predominantly of sand and gravel to gravelly sand) and finer grained material (silty sand, silt and/or clay layers and streaks). This package sequence is 290 feet thick at MORRILL. At MILL it extends from 370 feet bgs to beyond the bottom of MILL at 660 feet bgs. At least two-thirds of the cumulative screened interval length of MILL (as well as MORRILL, KIETZKE, and TERMINAL) is constructed in coarser grained materials within this package sequence. This package sequence has a significantly greater proportion of permeable gravelly material in the upper 120 feet so that at MILL and MORRILL the upper portion contributes substantially more groundwater than deeper screened intervals (based on flow profiling at MILL and MORRILL [TMWA, 2003; AMEC, 2009; BESST, 2011]). The individual packages in this sequence are described (see **Section 5.10.1** of this report) in the eastern part of the basin based largely on data from STANFORD.

- Package V. Generally finer grained material (comprised predominantly of clay, sandy clay, silt and silty sand with lesser gravelly interlayers) that extends beyond the total depth (667 feet bgs) of the deepest boreholes in the area. The data indicate a greater proportion of finer grained material and a generally lower-energy environment than the superjacent package. Due to the absence of deeper data, this package is of unverified thickness. At HIGH, (located on the west side of the VLFZ) a 180 foot thick interval of this material was penetrated from 575 to the bottom of the boring at 753 feet bgs.

- A gravity-based geologic cross section (D-D', Widmer, 2005; Widmer, 2007) interprets the depth to bedrock at MILL to be approximately 820 feet. If that is accurate, approximately 180 feet of sedimentary basin-fill are present beneath the lowermost screened interval at MILL.

Hydrostratigraphic data on either side of the VLFZ are consistent with an aquifer system that is heterogeneous and anisotropic. Based on the available lithologic data, local finer interlayers or lenses exist and contribute to anisotropy in the aquifer system. These data also indicate overall coarsening of aquifer material to the west of the VLFZ, in the downtown Reno area and continuing westward along the Truckee River corridor. Results from aquifer testing at HIGH and MORRILL (HGC, 2009) indicate that the aquifer system is represented reasonably well by either a leaky confined or anisotropic unconfined aquifer system model.

5.7.2 Groundwater Level Data

The 2010 quarterly potentiometric surface contour maps are presented in **Figures 5.2** through **5.9**. These maps include the Downtown Reno Subregion and are the basis for characterizing lateral hydraulic gradients in this area. Regional groundwater level difference maps (**Figure 5.10**) and cumulative groundwater level change maps (**Figures 5.11** through **5.14**), combined with well cluster water level data (**Graphs 5.2b**), provide the basis for characterizing vertical hydraulic gradients for the Downtown Reno Subregion.

Lateral Gradients

Shallow Zone

Lateral groundwater flow north of the Truckee River in the shallow zone portion of the plume (**Figures 5.2, 5.4, 5.6 and 5.8**) was generally to the east-northeast during 2010. The observed lateral gradient magnitude is in the range of between 0.005 and 0.006 in all four quarters. The groundwater flow direction and gradient observed in 2010 are similar to what has been observed in this portion of the subregion since the beginning of the GMP.

Lateral groundwater flow in the shallow zone south of the Truckee River was generally to the east-southeast in 2010. The lateral gradient magnitude exhibits nominal apparent seasonal variability during the year, changing from a minimum of 0.010 in Q1 to a maximum of 0.011 in Q3. This variation in lateral gradient correlates to municipal water supply well pumping that peaked in Q3 (**Graph 5.8**). The groundwater flow direction and gradient observed in the subregion during 2010 is similar to what has been observed in previous years since the GMP began. The lateral gradient in the shallow zone south of the Truckee River (where the subregion is interpreted to be transected by both the VLFZ and the HWB) is approximately 50 percent greater than the lateral gradient in the shallow zone north of the river (which is largely west of the projected VLFZ). Neither the VLFZ nor the HWB have been identified on the north side of the Truckee River, but both are interpreted to be present south of the Truckee River. Based on the location of relatively steeper lateral gradients that coincide with the area between the projected locations of the VLFZ and the HWB, both features potentially exert an influence on the shallow zone gradient in the Downtown Reno Subregion on the south side of the Truckee River (where the lateral gradients were computed). These data suggest that the HWB transitions northward from a flow barrier that influences only the deep zone in the South Reno Subregion to a flow barrier that extends across the deep zone and into the shallow zone in the Downtown Reno Subregion.

Deep Zone

Lateral groundwater flow in the deep zone of the Downtown Reno Subregion west of the VLFZ (**Figures 5.3, 5.5, 5.7 and 5.9**) was generally to the east-southeast throughout 2010. The lateral gradient in this portion of the subregion was approximately 0.005 throughout 2010. The groundwater flow direction and gradient observed in the deep zone in this area during 2010 are similar to what has been observed since the GMP began.

During 2010, lateral groundwater flow in the deep zone east of the VLFZ was to the east in Q1 and Q2, convergent on municipal water supply wells in Q3, and returned to a more easterly direction in Q4. The lateral gradient magnitude varied during the year, from a minimum of 0.008 in Q1 to a maximum of roughly 0.02 in Q3, during the period of peak pumping. In Q3, lateral gradients were recognized to steepen to the east of well cluster CTM102/CTM101/CTM100 and coalescing cones of depression were observed (see **Figure 5.7**) east of the HWB and VLFZ in response to sustained pumping at MORRILL, 4TH, KIETZKE, VIEW, and MILL. This is consistent with a greater influence of deep zone pumping on the aquifer system east of the HWB and VLFZ compared to west of these partial flow barriers. The groundwater flow directions and gradients observed in the deep zone in this area during 2010 are generally similar to what has been observed in previous years, where flow direction and gradient magnitude are significantly influenced by deep zone municipal water supply well pumping.

Vertical Gradients

West of the VLFZ

There were spatially and temporally variable vertical gradients in the Downtown Reno Subregion in the area west of the VLFZ (**Figure 5.10**) during 2010. Shallow zone-deep zone well clusters in the downtown Reno area near the Truckee River generally indicate a relatively persistent downward gradient direction over the time interval since the GMP began. A consistent downward vertical gradient (with a magnitude of -0.03 to -0.04) has been observed at the MW2NS/MW1ND well cluster (see **Graphs 5.2b**). This well cluster is located just upgradient of the West Fourth Street hot spot, and may be representative of vertical gradient conditions in this near-source area. In contrast, the CTM3S/CTM4D well cluster indicates a continuous upward gradient throughout the GMP period with the exception of 2006 Q3. CTM3S/CTM4D (**Graphs 5.2b**) is the farthest well cluster from the Truckee River on the north side. Well cluster CTM6S/CTM80/CTM79 (**Graphs 5.2b**) is also distinct in that the data indicate a generally upward gradient between the deepest (CTM79) and shallowest wells (CTM6S), but a downward gradient between the shallowest (CTM6S) and mid-depth well (CTM80). The downward gradient between CTM6S and CTM80 becomes greatest in magnitude when HIGH is pumping. This well cluster is located 1,400 feet north of HIGH and reflects vertical gradient conditions more indicative of a relatively direct hydraulic connection between screened interval where HIGH produces the majority of its water (245 to 335 feet bgs [AMEC, 2009]) and the shallower interval where CTM80 is constructed (115 to 130 feet bgs). The relatively large drawdown exhibited at shallow zone well CTM6S in response to municipal water supply well pumping is consistent with this interpretation. Results from the HIGH aquifer test (HGC, 2009) indicating vertical conductivity estimates in the range of 1 ft/day from data at CTM6S are also consistent with this interpretation. These data suggest that the shallow zone in the vicinity of CTM6S may be an area of enhanced vertical groundwater flow (and potentially enhanced vertical migration of PCE). The gradients observed in 2010 are similar to what has been observed in previous years during the GMP period.

East of the VLFZ

There were spatially and temporally variable vertical gradients in the Downtown Reno Subregion, east of the VLFZ (**Figure 5.10**) during 2010. In Q1, the vertical gradient was nominal and downward immediately east of the VLFZ along the Truckee River corridor. At the same time the vertical gradient was upward in the rest of the area east of the VLFZ and away from the river. The Q1 period coincides with the time when little or no groundwater pumping occurred. A steeper downward gradient was observed during Q2 and Q3 east of the VLFZ. This coincides with the time when sustained groundwater pumping was taking place in this part of the basin. In Q4, a downward gradient is observed to persist, but is generally reduced in magnitude and extent, reflecting recovery and the decreased groundwater pumping in the fall. The continued pumping at 4TH and ELRANCHO into December is likely to have contributed to the persistence of a downward gradient in this area during Q4. The gradients observed in 2010 are similar to what has been observed in previous years during the GMP period.

In 2010 Q1 and Q2, a consistently upward gradient reached a maximum of 0.018 (between the shallowest and deepest wells CTM9S and CTM10D) at the CTM9S/CTM104/CTM103/CTM10D well cluster. The gradient between CTM9S and CTM10D became downward in Q3 with the magnitude reaching approximately -0.17. By the end of Q3, the vertical gradient is downward across most of the subregion (coinciding with peak groundwater production for the year, **Graph 5.8**). In Q4, the downward gradient at CTM9S/CTM10D continued but was smaller in magnitude (decreasing to approximately -0.02).

The gradient in the vicinity of well cluster CTM102/CTM101/CTM100 (located approximately 1,700 feet west of CTM9S and CTM10D) exhibits notably different behavior compared to what was observed at well pair CTM9S/CTM10D. For shallow zone/deep zone well pair CTM102/CTM100 the vertical gradient is upward during all quarters except Q3. In Q1 and Q2 the gradient was upward with a magnitude in the range of approximately 0.05. In Q3, the gradient reversed to slightly downward with a maximum magnitude of -0.002 before returning to an upward gradient in Q4 with a similar magnitude (0.05) as observed in Q1 and Q2. Well pair CTM102/CTM100 exhibits a pattern of predominantly upward gradient that not significantly influenced by pumping at MILL, KIETZKE, or CORBETT. This pattern is more similar to what is observed on the west side of the HWB in the South Reno Subregion and is consistent with the interpretation that the HWB exists in the area between well clusters CTM102/CTM100 and CTM9S/CTM10D.

Results from the High and Morrill aquifer test (HGC, 2009) provide further insight into the groundwater flow response in the Downtown Reno Subregion, particularly in terms of how pumping in the deep zone influences vertical gradient, water level responses, and groundwater flow on either side of the VLFZ. As described in the HGC report, aquifer test results are interpreted to indicate the following.

- Vertical hydraulic connections and the potential for vertical groundwater flow and downward PCE transport exist on both sides of the VLFZ flow barrier, but is suggested to be locally greater on the west side of the VLFZ, particularly near CTM6S and MW6ND where vertical conductivity estimates are in the range of 1 foot/day.
- Vertical flow is influenced by:
    - The connection between groundwater and the Truckee River on the west side of the VLFZ and a potential for pumping-induced recharge in the area near the HIGH municipal water supply well. This is evidenced by a flattening of the drawdown response at HIGH with time that is consistent with a source of recharge. River recharge is also supported by the lack of drawdown response to pumping at water table wells next to the river on the west side of the VLFZ compared to obvious response to pumping at water table

wells more distal from the river. This is consistent with the river acting as a constant head boundary that mitigates drawdown; and

- The spatial variability of aquifer properties and the presence of vertical conduits between the water table in the shallow zone and the deep zone of the aquifer system resulting from the non-uniform distribution of materials within the aquifer system. This is based on the non-uniform distribution of shallow zone drawdown observed during the test that indicates areas of locally enhanced vertical connections proximal to CTM6S and MW6ND where drawdown is greater.

- Both horizontal and vertical hydraulic conductivity estimates have a larger range and higher magnitude west of the VLFZ (Kh = 16 to 224 ft/day and Kv = 7 X 10-2 to 3 ft/day) compared to east of the VLFZ (Kh = 11 to 37 ft/day and Kv = 6 X 10-3 to 8 X 10-2 ft/day).

5.7.3 Groundwater Sources and Sinks

Potential sources of aquifer recharge that could contribute to the Downtown Reno Subregion water budget include; mountain front recharge along the western extent of the alluvial aquifer; recharge from the Truckee River; deep zone well injection for aquifer storage and recovery; infiltration from ditches and other surface water features; infiltration from irrigation, leaking distribution and wastewater collection systems; and, infiltration from precipitation. All of these recharge processes are likely to occur within the Downtown Reno Subregion with the probable exception of mountain front recharge. Artificial recharge (injection) for the VIEW, 4TH, GALLETTI and 21ST municipal water supply wells totaled approximately 86.4 MG in 2010. Recharge at these wells occurred only during 2010 Q1 and Q2.

Downtown Reno Subregion Annual Artificial Recharge History (in millions of gallons)

Year	Wells				Annual Totals
	4TH	21ST	GALLETTI	VIEW	
1999	0.0	0.0	0.0	106.5	106.5
2000	12.6	20.0	26.5	158.3	217.4
2001	147.1	65.8	77.8	141.0	431.7
2002	100.6	62.7	76.1	84.6	324.0
2003	49.5	84.2	85.4	115.0	334.1
2004	45.4	56.1	71.2	195.0	367.7
2005	26.6	35.2	38.7	85.9	186.4
2006	36.7	49.1	56.9	65.7	208.4
2007	29.4	35.0	48.7	58.4	171.5
2008	52.1	50.2	73.2	94.9	270.4
2009	34.8	37.7	57.5	22.1	152.1
2010	23.2	29.7	13.5	20.0	86.4

Average precipitation was 9.25 inches in 2010, an increase compared to the 8.25 inches in 2009, and above the historical average (7.31 in/year) precipitation year (NOAA, 2011). Truckee River flows were higher in 2010 compared to the previous three years. Mean annual Truckee River discharge as measured at the Reno Gage was 459.9 cubic feet per second (CFS) during 2010, compared to 354.9, 392.3, and 396.1 cfs in 2009, 2008, and 2007 respectively. However, 2010 discharge was below the long term average annual discharge of 676 cfs (1906 to 2010; USGS, 2011). Precipitation and Truckee River discharge for the GMP period are summarized in **Section 5.3**.

Groundwater sinks in the Downtown Reno Subregion include the HIGH, MORRILL, KIETZKE, 4TH, VIEW, MILL, GALLETTI and 21ST municipal water supply wells. The 2010 combined pumping for these wells was approximately 1,524.7 MG. The majority of this pumping occurred in Q2 and Q3 with the five largest groundwater producers in 2010 (HIGH, MORRILL, KIETZKE, MILL, and VIEW) pumping between April and November. Cumulative pumping for 2010 was larger compared to 2009 (1524.7 compared to 1170.1 MG) as a result of substantially more pumping at VIEW and 4TH.

A consideration in interpreting the 2010 water level data presented in this report is that the operational pumping pattern for the five PCE treated wells in the CTM changed in late 2005. In the early November 2005, the HIGH, MORRILL, KIETZKE, MILL, and CORBETT wells (which had been operated on a more or less year-round basis up to that time) were shut down for the winter. These wells were restarted in the spring of 2006 and have been operated to meet peak water demands in accordance with a seasonal pumping schedule that has been in effect since that time.

The following tables summarize 2010 pumping and annual groundwater production for these wells.

Well Name	Pumping Start Date (2010)	Pumping End Date (2010)	2010 Groundwater Production (MG)	2010 Pumping Pattern
HIGH	July 1	Nov 1	244.7	Continuous
MORRILL	June 30	Nov 1	232.9	Continuous
KIETZKE	July 7	Nov 1	350.2	Continuous
4TH	July 10	Dec 23	142.5	Intermittent/Pumped
VIEW	April 17	Oct 8	326.7	Continuous
MILL	June 30	Oct 7	217.5	Continuous
GALLETTI	No pumping	No pumping	0.0	No pumping
21ST	July 11	Aug 25	10.2	Intermittent

Downtown Reno Subregion Annual Municipal Water Supply Well Pumping History (in millions of gallons)

Year	Wells								Annual Totals
	HIGH	MORRILL	KIETZKE	MILL	4TH	21ST	GALLETTI	VIEW	
2003	606.4	526.5	818.1	107.8	129.6	146.7	205.5	64.3	2604.9
2004	447.2	391.5	735.0	454.5	66.4	109.7	125.0	84.4	2413.7
2005	210.3	254.7	348.1	235.8	45.4	88.8	115.4	57.2	1355.7
2006	342.8	288.9	471.2	298.8	59.4	99.5	127.1	57.6	1745.3
2007	360.8	293.0	459.9	223.3	74.1	90.4	510.2	59.6	2071.3
2008	279.9	268.0	475.2	253.1	24.7	24.7	73.4	167.8	1566.6
2009	257.3	218.9	318.9	308.6	3.3	22.6	0.1	40.4	1170.1
2010	244.7	232.9	350.2	217.5	*142.5*	10.2	0.0	326.7	1524.7
2010 pumping at 4TH includes groundwater pumped to waste during 3 periods: July-Aug (for TMWA's vertical wellbore profiling)), Oct.-Nov. (for aerated water extraction), and Dec. (for DWR's BESST wellbore profiling)									

5.7.4 Data on Potential PCE Sources

A large number of PCAs have been identified in the Downtown Reno Subregion (**Figure 5.19**); with the majority being former or existing dry cleaners and auto repair shops. They are scattered throughout the subregion with a high density of occurrence in the historical commercial and industrial corridor along West Fourth Street in the southern and eastern portions of the present shallow zone plume area. The available PCA data only include a limited amount of site-specific soil and/or groundwater information that is insufficient for identifying specific potential sources for the Downtown Reno plume.

A potential PCE source area within the Downtown Reno Subregion (**Figure 5.19**) is spatially associated with the PCE hot spot in shallow zone groundwater. The shallow zone plume maximum concentration is typically observed in well CTM28S or nearby well QUIKMRTMW18C near the intersection of West Fourth and Ralston Streets. This area of higher PCE concentration has been called the West Fourth Street hot spot. There are several existing and historical PCAs in this immediate vicinity and upgradient of this hot spot. The area between CTM28S and upgradient well CTM1S has the potential to contain one or more PCE release sites, but the presence and/or location of such a release site has not yet been confirmed by soil, soil vapor or groundwater monitoring data.

A description of potential PCE sources in the Downtown Reno Subregion was provided in WorleyParsons (2010) and is updated and summarized below.

- The four former NDEP Corrective Action Sites in or immediately adjacent to the Downtown Reno Subregion (**Figure 5.19**) as presented in McGinley and Associates (McGinley, 2002) includes:

    - **Project C Construction Site**. The Project C Pump Test/Dewater System NDEP site is located east (downgradient) of the West Fourth Street hot spot (at CTM28S) [**Figure 5.19**]. The peak PCE concentration detected in groundwater at the Project C site was 240 µg/L in October 1993.
    - **Keystone Square Site.** Elevated concentrations of PCE were detected in groundwater monitoring wells at the Keystone shopping center, located approximately 500 feet upgradient from CTM1S and approximately 2,000 feet west (upgradient) from the West Fourth Street hot spot at CTM28S (**Figure 5.19**). Parcel 5 at this site is a former dry cleaning establishment (Society Cleaners). PCE was detected in soil at concentration up to 9,200 µg/Kg near an underground storage tank. The peak PCE concentration detected in groundwater at this site was 111 µg/L in October 1996.
    - **Downtown Reno VOC Site.** The boundaries of the Downtown Reno VOC site (see Appendix K.1 of McGinley, 2002) was defined based on the initial investigation of PCE contamination in the Reno area conducted in the early 1990's on behalf of NDEP in response to the recognition that municipal water supply wells had been impacted by PCE (Westec/SRK, 1994). The peak PCE concentration detected in groundwater during the Downtown Reno VOC site investigation was 480 µg/L in July 1993. This was observed in a monitoring well for the service station at the northwest corner of Fourth and Ralston Streets (near CTM28S, which has consistently defined the location of the West Fourth Street hot spot).
    - **Sierra Chemical Site.** This site is located immediately east of Renown Medical Center (**Figure 5.19**) near the northeast corner of the Downtown Reno Subregion. Sierra Chemical had PCE concentration of up to 1,100 micrograms per kilogram (µg/kg) identified in soil beneath two different underground storage tanks (USTs) between 1988 and 1990.

The results of a sewer sampling investigation (DWR, 2002) conducted in the western portion of the plume were discussed by GeoTrans (2002). Out of 18 locations sampled up to that time, PCE was detected in a single wastewater sample collected upgradient of the plume hot spot, about midway between wells CTM1S and CTM28S. Sewer sampling has been conducted on a routine basis since late 2005 as part of the Sewer Monitoring Program (SMP) conducted by DWR in coordination with Reno and Sparks. The SMP includes the Mikado Cleaners, and the current and former Society Cleaners locations within this subregion. All sewer sampling results associated with these locations through 2010 have been below laboratory reporting limits.

In 2008, the West Fourth Street Potential Source Area (PSA) was delineated to encompass the area (see **Figure 5.19**) that includes the West Fourth Street hot spot and other PCAs that are potentially contributing or could have contributed to the Downtown Reno plume. DWR received Board approval to initiate a PSA investigation in order to:

- Characterize the magnitude and extent of shallow subsurface contamination in the PSA;
- Identify specific sources that may have contributed or may be contributing to the contamination;
- Assess the threat posed by that source to groundwater; and,
- Provide information to support a cost-benefit assessment of possible PCE source mitigation.

Over the period between February 2009 and October 2010, a passive soil gas (PSG) survey consisting of three phases (Gore, 2009b, 2010b, 2011) have defined the following PCE HMAs (as shown on **Figure 5.19**):

- The Keystone Place HMA – along Keystone Place near the intersection with West Second Street;
- The West Fifth HMA - along the West Fifth Street between Keystone Avenue and Washington Street;
- The Ralston and Commercial Row HMA – near Ralston Street between West Second Street and West Fourth Street;
- The North Virginia HMA – along North Virginia Street between West Fifth and West Seventh Streets;
- The East Sixth and Record HMA – between Evans Street and Valley Road, and between East Fifth and East Eighth Streets.

The next phase of the PSA investigation will consist of completing additional PSG surveys to define the northern margin of the East Sixth and Record HMA. It is anticipated that a follow-up program consisting of semi-permanent active soil gas (ASG) and groundwater monitoring wells will be implemented in 2012.

5.7.5 PCE Concentration and Distribution Data

The Downtown Reno plume occurs in an area that extends east from approximately Washington Street to east of US 395, and south from approximately Interstate 80 to roughly 1,000 feet southeast of Mill Street. The extent of the Downtown Reno plume (as defined by existing wells) remains unchanged since the previous year. From its upgradient extent west of shallow zone CTM28S, to its presently defined downgradient extent; the Downtown Reno plume has a 12,000 foot northwest to southeast dimension. Shallow zone PCE principally occurs north of the Truckee River and west of the VLFZ. Deep zone PCE occurs downgradient of the West Fourth Street hot spot and extends east and southeast beyond PCE-impacted KIETZKE and MILL municipal water supply wells. Its downgradient extent is undefined to the southeast of MILL, beyond CTM107.

Quarterly PCE concentrations during 2010 are depicted for the shallow zone and deep zone on **Figures 5.2** through **5.9**.

Shallow Zone

The shallow zone portion of the Downtown Reno plume extends eastward, from the upgradient extent delineated to the west by CTM1S, to or beyond well CTM37S to the northeast (**Figure 5.19** and **5.20**). Persistent low PCE concentration (in the range of 2 to 3 µg/L in 2010) in CTM37S suggests that this well is near the northeastern extent of the shallow zone portion of this plume. The southeastern extent of the shallow zone plume is delineated by CORWSSMW1 north of the Truckee River, and by CTM7S immediately south of the river. The southern extent of the plume occurs on the north side of the Truckee River and is delineated by wells including MW2NS, RETRACB14, and COR10. In 2010 a single shallow zone detection of PCE (1.1 µg/L) occurred south of the Truckee River at RPDMW6 located approximately 200 feet from the river and less than 20 feet east of HIGH municipal water supply well. With the exception of RPDMW6, shallow zone detections in this area south of the Truckee River have not been observed during the GMP period. The shallow zone portion of the plume is delineated to the north by CTM40S.

The area near wells CTM28 and QUIKMRTMW18C (**Figure 5.19**) continues to represent the plume hot spot. As previously mentioned in **Section 5.7.4**, existing and historical PCE-using businesses are located in proximity to this hot spot and are suggested to be possible contributing sources. Passive soil gas survey results define a PCE high mass area (the West Fifth HMA) upgradient of the hot spot. During 2010, PCE in the West Fourth Street hot spot ranged from 25 to 78 µg/L (in CTM28). During 2010, PCE in CTM5 (located roughly 850 feet north of CTM28S) ranged from 28 to 34 µg/L. These data suggest that the upgradient portion of the shallow zone plume is relatively wide in the north-south dimension. This may reflect the presence of multiple, spatially distinct sources and/or a distributed source. Alternatively the apparent width of plume may result from divergent shallow zone groundwater flow associated with a locally observed groundwater mound (see **Figures 5.2, 5.4, 5.6,** and **5.8**) in the vicinity of the West Fourth Street hot spot.

Other areas where shallow zone PCE may be associated with or contribute to the Downtown Reno plume include PCE at CTM2S and at CTM102. CTM2S has detected PCE as high as 22 µg/L (2008 Q1) during the GMP period. This contamination is currently only observed at CTM2S and the extent is therefore undefined. CTM102 defines an area of shallow zone PCE, where in 2010 PCE concentration ranged from 8.5 to 10 µg/L. CTM102 is part of well cluster CTM102/CTM101/CTM100 located south of the Truckee River. PCE at this location is also present in associated deep zone well CTM101 (screened interval – 156 to 166 feet bgs) with similar concentrations (ranging from 6.5 to 8.8 µg/L) as those in the shallow zone well. However no PCE has been detected in the deepest well CTM100 (screened interval – 254 to 264 feet bgs). The occurrence of PCE in both the shallow and the deep zone at CTM102 and CTM101 is inconsistent with the conceptual model that the Downtown Reno plume occurs only in the deep zone south of the Truckee River. This represents a data gap. One possible explanation for PCE at CTM102 is that this area of contamination has a separate, potentially distinct source. Another explanation is that the shallow zone portion of the Downtown Reno plume locally extends south of the Truckee River to CTM102 across the area where there is a lack of shallow zone observation wells. New maxima, minima, or statistically significant PCE concentration changes at key (or other important) shallow zone wells for the Downtown Reno plume are highlighted on **Table 5.4**. Potentially important results for 2010 are summarized below.

- A new PCE concentration maximum for the GMP period was established in:
    - COR12A (36 µg/L in 2010 Q2).

COR12A defines a local area of elevated PCE that may represent a plume hot spot and result from a nearby source. The new PCE maximum is consistent with an increasing PCE concentration trend defined by the Mann-Kendall test over the GMP period of record. The PCE concentration time series data for COR12A exhibit sporadic, recurring fluctuations with no obvious pattern or interrelationship with water level data. The apparently limited extent of PCE in the downgradient direction suggests that PCE contamination at COR12A may be localized. However, the lack of nearby downgradient shallow zone wells and a potential influence from the Truckee River may preclude coming to any substantial conclusions based on the limited existing data.

Deep Zone

The deep zone portion of the Downtown Reno plume has impacted multiple receptors that are up to 10,000 feet downgradient from the shallow zone hot spot and potential source areas. However, there are a limited number of existing monitoring wells that are screened in the deeper portions of the shallow zone and shallower portions of the deep zone (between 60 and 125 feet bgs) in this subregion to fully delineate the vertical distribution of PCE between the source areas and the receptors. The three dimensional continuity of the plume is indicated by the increasing PCE concentration in successive deep zone wells (MW6ND, CTM30D, and MW8ND) downgradient from the hot spot compared to the decreasing PCE in the corresponding shallow zone wells at or near each of these deep zone wells. Downward vertical gradients in the area where PCE increases are observed in the deep zone are consistent with a vertically plunging plume originating near the hot spot and migrating downward to the east-southeast.

The upgradient extent of the Downtown Reno plume in the deep zone is delineated by the lack of PCE in MW1ND, MW3ND, and CTM4D. The westernmost deep zone well where PCE occurs is MW6ND located approximately 1,400 feet southeast of the West Fourth Street hot spot. From MW6ND, the deep zone portion of the plume extends downgradient to the east and southeast where the leading edge of the plume extends beyond PCE-impacted 4TH, KIETZKE, and MILL municipal water supply wells. The eastern extent of the plume is delineated by VIEW and well cluster CTM84/CTM83/CTM82. However, TCE is consistently detected at CTM83 (ranging from 2.6 to 3.1 µg/L in 2010) and CTM84 (ranging from 6.3 to 8.1 µg/L in 2010) indicating the potential for a distinct zone of TCE contamination that extends beyond the PCE-rich portion of the plume in that area. The southeastern plume extent of the plume is undefined beyond MILL, where PCE occurs in deep zone well CTM107 located 1,600 feet southeast of MILL.

The crossgradient (north-south) extent of the plume is relatively poorly defined by the available well network. Deep zone PCE is delineated as far north as East Fifth Street at well cluster CTM6S/CTM80/CTM79 where low PCE concentration in deep zone well CTM80 (in the range of 1 µg/L) indicate proximity to the plume margin. Further east the plume margin extends north of CTM81 and 4TH and is not defined. The southern plume margin extends to the south of Mill Street, beyond COURTHOUSE, MW10ND, well cluster CTM102/CTM101/CTM100 and well cluster CTM11S/CTM105/CTM12D.

The vertical extent of the plume is largely undefined in the upgradient portion of the plume. PCE is not detected above the reporting limit in the deep zone at MW1ND, MW3ND, or CTM4D and is therefore vertically delineated at these locations. At MW6ND (1,400 feet southeast of the West Fourth Street hot spot), PCE extends to at least 186 feet bgs. Further downgradient, dynamic vertical profiling at HIGH and MORRILL (AMEC, 2009; WorleyParsons, 2011b) indicate that the vertical extent of the plume in the vicinity of these municipal supply wells (and on either side of the VLFZ) reaches depths in the range of approximately 350 feet bgs.

The vertical extent of the plume near eastern margin of the plume is suggested to exist at depths of at least 350 ft in the vicinity of KIETZKE (based on the PCE detection from a discrete depth sample at 355 ft bgs during the drilling of CTM82). At MILL the plume is interpreted to be at least 200 feet thick, and to extend to a depth of 450 feet bgs or greater (based on the screened interval distribution at MILL and on PCE concentration distribution in nearby monitoring wells CTM103, CTM107, and CTM10D).

A plume core is recognized in the deep zone west of the VLFZ and in the vicinity of HIGH, that is defined by relatively higher PCE concentrations at CTM30D, CTM137, MW8ND, and CTM8D. Hydrogeologic cross sections constructed by DWR indicate that this plume core (the Western plume core) extends from the West Fourth Street hot spot into the deep zone towards PCE-impacted HIGH municipal water supply well. Another deep zone plume core (the Eastern plume core) is evident in the vicinity of MILL as defined by higher PCE concentration at CTM10D and MILL.

New maxima, minima, or statistically significant changes in PCE concentration at key deep zone wells for the Downtown Reno plume are highlighted on **Table 5.4**.

Potentially important results are summarized below.

- New PCE concentration maxima were established in:
    - 4THMWS (3.6 in 2010 Q3 and 4.1 in 2010 Q4); and
    - 4THMWD (0.67 µg/L in 2010 Q4).

4THMWS and 4THMWD are located roughly 50 feet south of the 4TH municipal water supply well. 4THMWS (screened interval - 180 to 300 feet bgs) coincides with the upper screened intervals at 4TH. 4THMWD (screened interval - 330 to 480 feet bgs) coincides with the lower screened intervals at 4TH. PCE concentration data at 4THMWS exhibit a recurring seasonal pattern (over the period between 2004 and 2010) where PCE concentration has a negative correlation to seasonal groundwater elevation changes caused by pumping and injection at 4TH. The associated samples were collected during periods of sustained pumping when groundwater is more likely to represent ambient aquifer conditions. The new PCE concentration maxima indicate a potentially increasing threat to 4TH. It is noted that TCE is also present in this well, reaching a new maximum concentration of 14 µg/L in 2010 Q3.

The PCE detection of 0.67 µg/L in 4THMWD is the first detection of PCE at this well since it was originally sampled in 2004. While this first time detection may result from a lower reporting limit (reduced from 1.0 µg/L to 0.50 µg/L starting in 2010 Q3), the result is also important because it suggests that PCE extends vertically to at least 330 feet bgs in the area near 4TH.

- A new PCE concentration minimum was established in:
    - CTM10D (38 µg/L in 2010 Q1 and 37 µg/L in 2010 Q2).

CTM10D is in the Downtown Reno plume eastern core, located upgradient of the MILL municipal water supply well. PCE concentration data exhibit a long term decreasing trend since 2004 Q2 when PCE concentrations spiked to 270 µg/L. The continued decrease in PCE concentration to new minima is potentially an indicator for future decreasing PCE concentration at MILL. PCE concentration data at MILL continue to exhibit an increasing long term trend. However, PCE concentration has recently decreased from a maximum of 60 µg/L in 2009 Q4 to between 44 and 51 µg/L during 2010.

- Potentially important statistically significant quarterly PCE concentration changes were established in:

- COURTHOUSE (where PCE concentration increased from 3.3 to 4.6 µg/L between 2010 Q2 and 2010 Q3); and
- MORRILL (where PCE increased from 9.1 µg/L in 2009 Q3 to 13 µg/L in 2010 Q2)

COURTHOUSE is located in the upgradient (southwestern) deep zone part of the Downtown Reno plume and has two relatively long, separate screen intervals (136 to 221 feet bgs and 307 to 340 feet bgs). Two samples are routinely collected from the well; one in the shallow screened interval (at 177 feet bgs) and one in the deep screened interval (at 332 feet bgs). Results from these two samples are averaged to define the quarterly PCE result for this well. Increases in the averaged PCE concentration are consistent with a long term increasing trend at this well and represent increased PCE mass movement in the portion of the plume where COURTHOUSE is constructed. The PCE concentration in each individual sample (from the different depths in this well) indicate that PCE concentration in the shallower screened interval (ranging from 4.4 to 6.6 µg/L) is roughly twice that in the deeper screened interval (ranging from 2.2 to 2.8 µg/L). Water level data from COURTHOUSE and nearby shallow zone well COR10 (located approximately 300 feet to the east) indicate a persistent downward gradient in this area. Based on these findings, it is possible that the COURTHOUSE wellbore acts as a local conduit for PCE contamination to enter the well though the shallower screened interval and move down the wellbore and exit the well through the deeper screened intervals. This would result in PCE mass moving from a relatively more impacted portion of the aquifer system to a less impacted portion of the aquifer system. As a result of that potential risk scenario, the COURTHOUSE well is scheduled for abandonment in 2011.

MORRILL is a PCE-impacted receptor for the Downtown Reno plume. The significant increase in PCE concentration between 2009 Q3 (at the end of seasonal pumping in 2009) to 2010 Q2 (at the beginning of seasonal pumping in 2010) is consistent with an intermittent tendency for PCE to exhibit higher concentrations at the start of the pumping season then decrease with sustained pumping. This tendency is potentially important because it suggests that an increasing proportion of cleaner groundwater is drawn into MORRILL the longer it is pumped. This scenario is consistent with MORRILL being located near a plume margin or the well capturing a source of clean recharge (effectively diluting the PCE contaminated groundwater in the well) during sustained pumping. Vertical depth-discrete water quality and flow profiling results using data collected after 3 months of sustained pumping at MORRILL (2009 BESST dynamic profile data; AMEC, 2009) indicate the highest concentration of PCE, chloroform, chloride, and nitrate enters the well at the shallowest screened interval. The shallow occurrence and co-location PCE contamination and other anthropogenic indicators are not consistent with capture of a source of clean recharge; -at least not in a downward vertical direction. Moreover these results are more consistent with the plume margin being near the well. Further assessment of the correlation between pumping and PCE concentration is required to verify any causal relationship.

5.7.6 Trends and Patterns in Water Levels and PCE Concentrations in Key Wells

Trends and patterns in key well water level and PCE concentration data are identified and evaluated in this section. The key wells in the South Reno Subregion are listed in **Table 5.1** (and depicted on **Figure 5.15)** and include:

- Shallow zone wells - CTM28S, CTM5, COR12A, COR8A, RETRACP2, CTM3S, CTM31S, CTM6S, CTM37S, and CTM102; and
- Deep zone wells - MW6ND, COURTHOUSE, CTM30D, CTM137, MW8ND, MW10ND, CTM8D, CTM22D, CTM83, CTM84, CTM101, CTM103, CTM10D, CTM12D, CTM107, CTM80, CTM81, 4THMWD, 4THMWS. 4TH, HIGH, MORRILL, KIETZKE, and MILL.

Water level hydrograph/PCE concentration time series graphs for these wells are plotted on **Graphs 5.2a**. Select graphs are embedded in the following text to illustrate trends or patterns discussed below. **Table 5.4** summarizes PCE concentration and trend information for key (or other important) wells. Changes to the original set of key wells were made in 2010 based on DWR's ongoing well network review (as described in **Section 5.4.1**). For 2010, the following wells have been removed or added to the 2010 key well list.

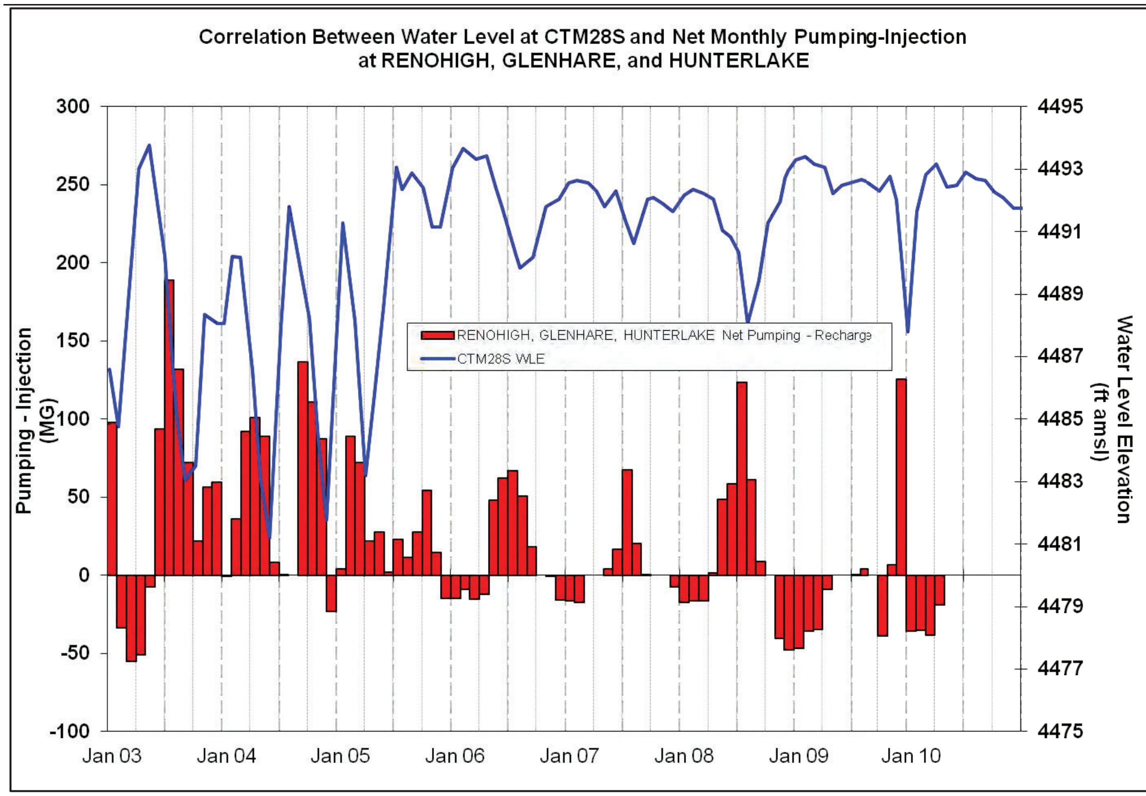
- CTM1S was removed because it is upgradient of the West Fourth Street hot spot. While the well helps delineate the upgradient extent of the Downtown Reno plume, the relatively low PCE concentration indicates that the well is upgradient from the potential source area for the hot spot. This well does not meet any of the key well criteria defined in **Section 5.4.1**.
- MW1ND and CTM4D were removed because PCE have never been detected above the reporting limit at either well. These wells do not meet any of the key well criteria defined in **Section 5.4.1**.
- Shallow zone wells COR12A and CTM102 and deep zone wells CTM83, CTM84, CTM101, CTM103, CTM107, CTM80, CTM81, and 4THMWD were added to the key well list for the Downtown Reno Subregion.
    - COR12A defines a local area of elevated PCE that may represent a plume hot spot and result from a nearby source.
    - CTM102, CTM83, CTM84, CTM101, CTM103, CTM107, CTM80, and CTM81 are new and were constructed in late 2008 or 2009. The rationale for adding these to the key well list are provided in **Appendix 5.1**.
    - 4THMWD was added because it provides (along with 4THMWS) an assessment of the vertical distribution of PCE near PCE and TCE-impacted 4TH municipal water supply well.

Water Levels

Shallow Zone Wells

Water level data from most shallow zone key wells exhibit generally increasing average annual water level elevation between the inception of the GMP (2003 Q4) and 2006. Between 2006 and 2010 average annual water levels exhibit more gradual changes that may either increase or decrease in any given well. These longer-term trends are can be superimposed by recurring, alternating water level minima and maxima that occur with varying timing. Based on the water level data through 2010 for the shallow zone key wells, these wells are subdivided into five separate groups, each having water level fluctuations and/or patterns over time that are more similar to the other wells within that group and distinct from the wells in the other groups. These five well groups represent a change from the four groups initially defined in the 2007 annual report (WorleyParsons, 2010) and described in the 2008 and 2009 annual reports (WorleyParsons, 2011 and 2013, respectively). The revised well groups are based on a larger period of record and also reflect the revised set of key wells (as discussed in **Section 5.4.1**). The revised water level hydrograph groups are discussed separately below.

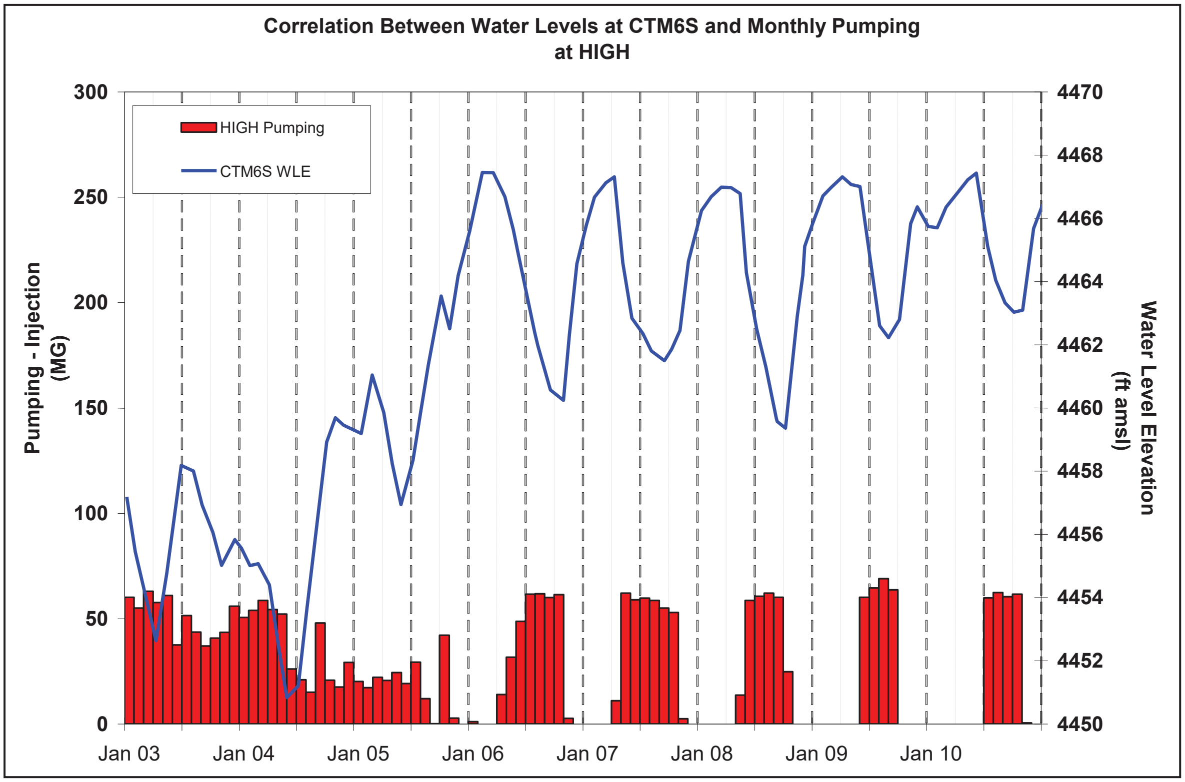
Group A is comprised of key well CTM28S. This well exhibits a hydrograph similar to wells located nearby and to the southwest (including CTM2S, MW2NS, CTM1S, RETRACB13, CTM59 and RETRACMWE). Water level data define a "step increase" of approximately 6 feet in average annual water level in mid to late 2005. Between 2006 and 2008, average annual water levels have a relatively flat to slightly decreasing trend (of less than 2 feet) that is followed by an increased average annual water level (on the order of 1 foot per year) in 2009 and 2010. These longer term trends negatively correlate to annual net pumping volumes at west Reno municipal water supply wells (HIGH, RENOHIGH, SWOPE, GLENHARE, and HUNTERLAKE –as defined as the "west Reno wells" in the 2008 Annual Report [WorleyParsons, 2010). Moreover, group A wells have the most obvious correlation to pumping at RENOHIGH, GLENHARE, and HUNTERLAKE. SWOPE may also influence water levels at CTM28S, but the lack of sustained pumping at SWOPE limits that assessment. Recurring water level fluctuations in CTM28S, prior to mid to late 2005, appear to take place twice a year (i.e. two increases and two decreases per year) and are on the order of 3 to 9 feet. Beginning in 2006, the recurring water level fluctuations take place once a year (i.e. one increase and one decrease per year) and are smaller in magnitude (1 to 6 feet). Like the longer term trends, the timing and magnitude of seasonal water level fluctuations coincide with timing and magnitude of net pumping at RENOHIGH, GLENHARE, and HUNTERLAKE (as depicted on the graph below). This relationship is consistent with Group A wells being strongly influenced by pumping and injection at these three municipal water supply wells.



Group B is comprised of CTM3S, CTM5, and CTM31S. These wells exhibit a "step increase" of roughly 2 feet in approximate average annual water level beginning in mid to late 2005. The water level changes in these wells prior to mid-2005 are sporadic or irregular and on the order of 1 to 3 feet. After 2005, the recurring water level fluctuations generally take place once a year (i.e. one increase and one decrease per year) and are on the order of 1 to 4 feet. The timing and duration of these fluctuations coincide with those exhibited by Group A wells but are generally smaller in magnitude. The similarities in trends and patterns in Group B wells compared to Group A indicate that Group B water levels are also influenced by pumping at the RENOHIGH, GLENHARE, and HUNTERLAKE municipal water supply wells.

Group C is comprised of COR8A and COR12A. These wells exhibit an average annual water level interpreted to include a small (less than 2 foot per year) increasing trend between 2003 Q4 and the end of 2005, followed by a generally consistent average annual water level through 2010. The water level variations prior to mid to late 2005 are sporadic or irregular and on the order of 0.5 to 2 feet. Beginning in 2006, the water level variations are more muted and are on the order of 1 foot or less. The timing and duration of the variations prior to the end of 2005 do not appear to coincide with any particular event or process (such as municipal well pumping). The timing and duration of some of the variations from 2006 through 2009 appear to coincide with municipal water supply well pumping. Impacts associated with dewatering (NPDES permit NV0021598) at the nearby Harrah's Casino are also a likely influence these water levels. The proximity to (and hydraulic connection with) the Truckee River likely plays a role in the relatively small water level changes exhibited over the GMP period in these wells.

Group D is comprised of CTM6S, CTM37S, and CTM102. These wells exhibit a relatively consistent increasing trend in approximate average annual water level from 2004 through 2006 Q1. The increase in water level over that period ranges from 4 to 10 feet. Starting in 2006, average annual water levels remain relatively constant. Long term trends are superimposed by recurring annual fluctuations in water level. From 2006 through 2010, these water level variations take place once a year (i.e. one increase and one decrease per year) and are on the order of 4 to 8 feet. Water level minima occur in late Q3 or early Q4 during each year since 2006 and coincide with the late stages of summertime municipal well pumping to meet peak demand. Group D wells exhibit a notably different seasonal pattern compared to other shallow zone wells located further to the west (Groups A, B, C). This pattern coincides more closely to pumping patterns at HIGH (as depicted below), suggesting a relatively better hydraulic connection to pumping in the west central part of the Downtown Reno Subregion than to pumping further to the west (at RENOHIGH, GLENHARE, HUNTERLAKE, and SWOPE) or to potential groundwater sources like the Truckee River. CTM6S is of particular note because the relatively large magnitude recurring annual fluctuation exhibited in this well suggests a particularly direct hydraulic connection between the shallow zone in the vicinity of CTM6S and deep zone pumping. Results from the HIGH and MORRILL aquifer test (HGC, 2009; discussed previously) support the same conclusion.



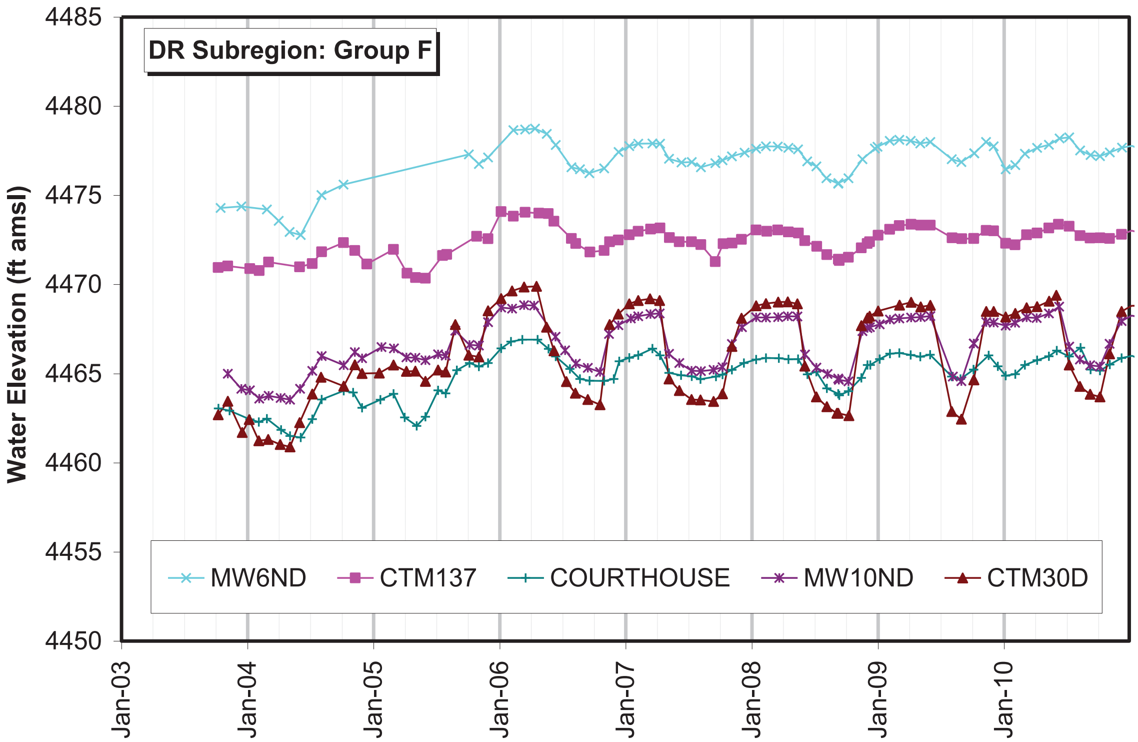
Group E is comprised of key well RETRACP2. This well exhibits a longer term increasing average annual water level on the order of 3 feet from 2004 through 2006 followed by a relatively consistent average annual water level between 2006 and 2010. RETRACP2 exhibits water level increases in 2006 Q1 through 2006 Q2 and in 2008 Q1 that correlate to increased Truckee River discharge during those periods. Starting in 2006 recurring fluctuations in water level take place roughly once a year with annual minima generally occurring in early Q4, coinciding with or lagging after the end of peak water demand when groundwater pumping is highest. Annual fluctuations are in the range of one to two feet.

The timing of recurring water level declines shown in shallow zone key well hydrographs generally coincide with pumping at municipal water supply wells. This is particularly the case for Group A and B wells (to pumping at RENOHIGH, GLENHARE, HUNTERLAKE, and potentially SWOPE) and Group D wells (to HIGH).

Deep Zone Wells

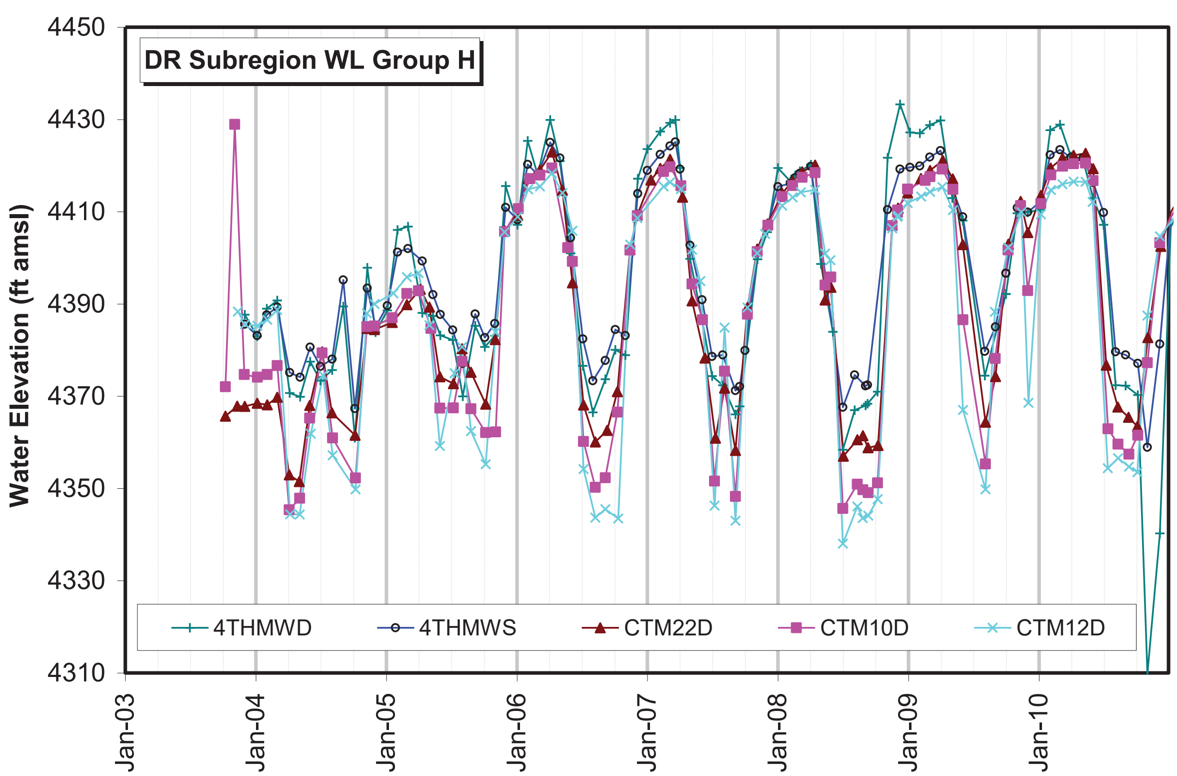
Water level data from most deep zone key wells exhibit generally increasing average annual water level elevation between the inception of the GMP (2003 Q4) and 2006. Between 2006 and 2010 average annual water levels exhibit more gradual changes that may either increase or decrease for any given well. Longer term changes are commonly superimposed by recurring, alternating water level minima and maxima that occur in response to varying influences. The water level data for the deep zone wells indicate that they can be subdivided into four separate groups, each having water level fluctuations and/or patterns over time that are more similar to the other wells within that group and distinct from wells in other groups. These water level hydrograph groups, revised and updated through 2010, are discussed separately below.

Group F is comprised of deep zone wells COURTHOUSE, CTM137, CTM30D, MW6ND, and MW10ND. These wells exhibit a gradual increasing trend in approximate average annual water level between 2004 and 2006. This increase in water level is approximately 4 to 6 feet. From 2006 through 2009, average annual water levels remain relatively similar. These longer term trends are superimposed by recurring fluctuations in water level. These fluctuations are characterized by relatively spiky changes prior to 2006, becoming more cyclical with a muted recurring annual decrease/increase (on the order of 2 to 6 feet). The decreases coincide with the period of high seasonal water demand when groundwater pumping is at its highest. The annual decreases in water level that coincide with periods of groundwater pumping are more distinct in 2006 through 2010. It is noted that CTM137, COURTHOUSE, and MW6ND have similar annual patterns that, compared to CTM30D and MW10ND, are more muted and exhibit a degree of correlation to pumping at RENOHIGH, GLENHARE, and HUNTERLAKE. These differences suggest that Group F represents a hybrid group where CTM137, COURTHOUSE, and MW6ND are potentially more influenced by pumping at RENOHIGH, GLENHARE, and HUNTERLAKE; and CTM30D and MW10ND have relatively larger magnitude, more distinct seasonal fluctuations that coincide more closely with pumping operations at HIGH.



Group G is comprised of deep zone wells CTM8D, CTM80, CTM101, and MW8ND. Of these wells only CTM8D and MW8ND have water level data for entire GMP period. Based on their hydrographs, Group G wells exhibit a gradual increasing trend in approximate average annual water level between 2004 and 2006. The increase in water level is approximately 10 to 30 feet. From 2006 through 2010, average annual water levels remain relatively the same or decrease slightly (on the order of less than 5 feet). These longer term trends are superimposed by recurring fluctuations in water level. Prior to 2006, these are characterized by sharp, relatively short duration transient fluctuations of 5 to 15 feet. Beginning in 2006 and continuing through 2010, these recurring fluctuations occur as annual decreasing/increasing cycles, with the decreases coinciding with the period of peak groundwater pumping associated with high summer-time water demand. These annual decreasing/increasing cycles are characterized by generally larger sharp seasonal fluctuations of 10 to 40 feet. It is noted that the pattern of water level fluctuation observed in wells CTM30D and MW10ND (in Group F) is consistently similar to the pattern observed in Group G wells, but the magnitude of fluctuations in CTM30D and MW10ND is smaller.

Group H is comprised of deep zone wells 4THMWD, 4THMWS, CTM10D, CTM22D, and CTM12D. These wells exhibit an increasing trend in approximate average annual water level between 2004 and 2006. This increase in water level is approximately 20 to 30 feet. From 2006 through 2010, average annual water levels remain relatively similar or decrease slightly (on the order of 5 feet or less). These longer term trends are superimposed by recurring sharp fluctuations in water level. Prior to 2006, these fluctuations are characterized by an annual decrease/increase cycle (on the order of 20 to 40 feet) that is typically accompanied by minor short-duration increases (on the order of 10 to 20 feet) in water level that for CTM10D, CTM22D, and CTM12D usually occur near the middle of the major decrease period. Beginning in 2006, the major annual decrease/increase cycle gets larger in magnitude (on the order of 60 to 80 feet). Also beginning in 2006, the minor short duration increases in water level during the major decrease period are no longer evident. The major decrease/increase cycles occur on an annual basis with the major decreases coinciding with the period of high seasonal water demand when groundwater pumping is at its highest. This pattern continues to be evident through 2010. Wells 4THMWD and 4THMWS exhibit relatively short-duration patterns that are different from other wells in this group and apparently coincide with pumping/injection patterns at 4TH municipal water supply well (located roughly 50 ft to the north). CTM10D, CTM22D, and CTM12D exhibit short-duration fluctuations that coincide more closely with MILL, KIETZKE, and/or MORRILL pumping patterns. The relatively large magnitude longer term increasing water levels prior to 2006 and the annual fluctuations exhibited by Group H wells are considered to be the influence of the placement of these wells proximal to and at depths that coincide with screened intervals at municipal water supply wells in this part of the CTM basin.



Group I is comprised of deep zone wells CTM81, CTM83, CTM84, CTM103, and CTM107. These wells were all constructed in late 2008 or early 2009 and therefore have a relatively short period of record. Data are of insufficient duration to establish longer term water level trends, but the average annual water level elevation for 2009 and 2010 are relatively similar. Recurring seasonal water level fluctuations in the range of 15 to 40 feet occur and coincide with seasonal pumping patterns. Group I wells have similar annual water level fluctuation patterns as Group H wells but are of significantly lower magnitude.

Municipal water supply wells HIGH, MORRILL, 4TH, KIETZKE, and MILL exhibit water level trends and patterns that generally are dominated by their own respective pumping and recharge schedule and are therefore not included in the defined hydrograph groups. All generally exhibit an increase in average annual water level between 2004 and 2006 (in the range of 50 to 100 feet) followed by a relatively consistent average annual water level from 2006 through 2010. Recurring seasonal water levels are apparent starting in 2006 and continuing through 2010. These seasonal patterns are in direct response to the change to seasonal pumping initiated in 2006 at these and other municipal water supply wells in the CTM basin.

PCE Concentration

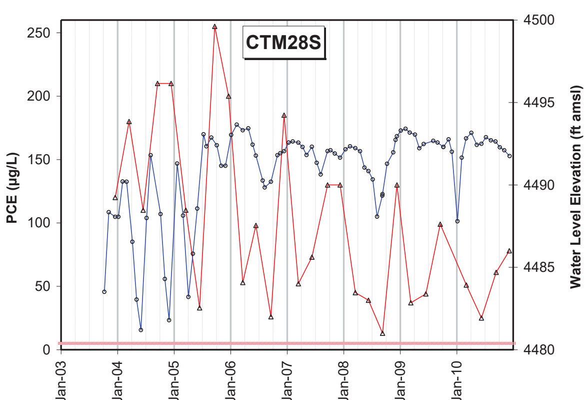
Long term PCE concentration trends (**Table 5.4**) and possible patterns and interrelationships between PCE concentration and groundwater elevation (as illustrated on **Graphs 5.2a**) were initially presented in the 2007 GMP Annual Report (WorleyParsons, 2010) and are updated for all key wells in the Downtown Reno Subregion through 2010 below.

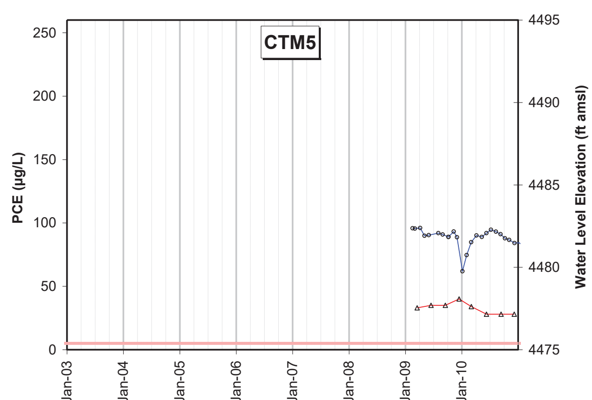
Shallow Zone Wells, West Fourth Street Hot Spot and Vicinity

- CTM28S (screened interval - 23.5 to 43.5 feet bgs):
  - PCE data from CTM28S exhibit a decreasing Mann-Kendall trend over the GMP period.
  - Relatively large transient changes in PCE concentration are observed in this well over the GMP period. PCE concentration exhibit a pattern of recurrent increases in Q3 or Q4 and decreases in Q1 (respectively, compared to the previous sample). This recurring pattern does not correlate with water level changes and a causal relationship has not been established.
  - The maximum PCE concentration in this well (255 µg/L) occurred in 2005 Q3.
  - The highest PCE concentration observed in 2010 was 78 µg/L in Q4.
  - CTM28S defines the West Fourth Street hot spot. The transient, spiky PCE concentration data are consistent with recurring PCE contribution to groundwater nearby. The decreasing long term PCE trend could indicate that either there is a decreasing source contribution from the upgradient area, or that the plume migration

pathway is changing and a less contaminated part of the plume is moving through CTM28S.

- CTM5 (screened interval – 74 to 84 feet bgs):
  - PCE data from CTM5 exhibit a decreasing Mann-Kendall trend over the period since it was constructed in 2009 Q1.
  - The two-year period of record is not sufficiently long to define any seasonal pattern or interrelationship between PCE data and water level data.
  - The maximum PCE concentration in this well (40 µg/L) occurred in 2009 Q4 and coincides with a short-duration decrease in water level at the well that correlates to pumping (111.4 MG) at RENOHIGH, GLENHARE, and HUNTERLAKE.
  - The highest PCE concentration observed in 2010 was 34 µg/L in Q1.
  - CTM5 is approximately 850 feet north of CTM28S. The occurrence of relatively high PCE concentration at CTM5 and CTM28S suggest that the upgradient portion of the shallow zone plume is relatively wide in the north-south dimension. This could reflect the presence of multiple, spatially distinct sources and/or a distributed source. Alternatively the width of plume may result from divergent shallow zone groundwater flow that could be associated with a groundwater mound (see Figures 5.2, 5.4, 5.6, and 5.8) locally observed in the vicinity of the West Fourth Street hot spot.





Shallow Zone Wells, - Downgradient of Hot Spot

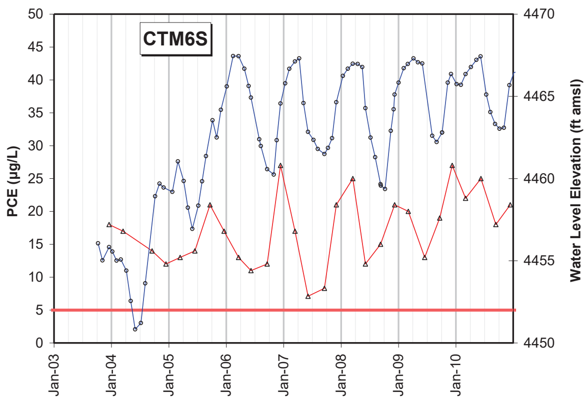
- COR12A (screened interval – 10 to 40 feet bgs):
  - PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
  - PCE concentration generally exhibits a spiky pattern with no consistent recurrence and no apparent interrelationship between PCE data and water level data. Sporadic PCE concentration changes are most apparent starting in 2008 with successive PCE concentration spikes (both maxima and minima) increasing through 2010.

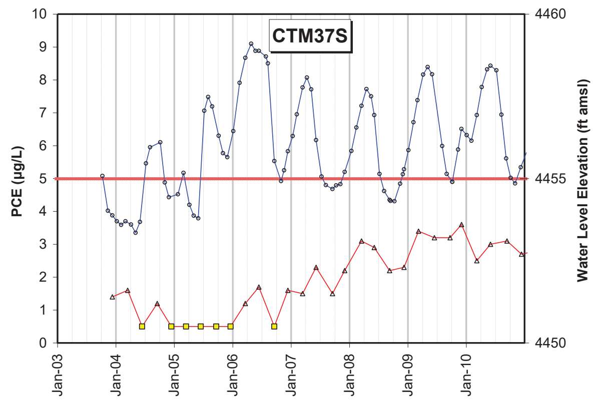
  - In 2010 a new GMP PCE maximum concentration in this well of 36 µg/L was reached in Q2.
  - The local high, concentration (compared to nearby wells) and sporadic, fluctuating PCE concentration are consistent with a potential local contributing PCE source near this well. Dewatering activities at the nearby Harrah's facility is a likely influence on this zone of contamination.

- COR8A (screened interval - 10 to 45 feet bgs):
  - PCE data exhibit a decreasing Mann-Kendall trend for the GMP period.
  - While PCE data between 2006 and 2008 show some evidence for increasing concentration when water level increases, there is no recurring pattern or consistently recognized interrelationship between PCE data and water level data.
  - The PCE maximum concentration in this well (16 µg/L) occurred in 2005 Q1 and again in 2005 Q3.
  - The highest PCE concentration observed in 2010 was 8.1 µg/L in Q3.
- RETRACP2 (screened interval - 20 to 40 feet bgs):
  - PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
  - The PCE concentration in this well (sampled on a semi-annual basis) was below the laboratory reporting limit prior to 2006 Q3. The appearance of PCE in this well coincides with both a general increase in groundwater level elevation that occurred in mid to late 2005 and the change to seasonal pumping at PCE-treated wells that began in 2006.
  - In 2010 Q3 a new GMP PCE maximum concentration in this well (2.2 µg/L) was reached.
- CTM3S (screened interval - 30.5 to 50.5 feet bgs):
  - PCE data exhibit no statistically defined increasing or decreasing Mann-Kendall trend for the GMP period.
  - Since 2006, PCE concentration exhibits an apparent interrelationship with water level elevation where PCE maxima coincide with periods of lower water level elevations that generally correlate to pumping at RENOHIGH, GLENHARE, and HUNTERLAKE.
  - The PCE maximum concentration in this well (36 µg/L) occurred in 2003 Q4.
  - The highest PCE concentration observed in 2010 was 19 µg/L in Q4.

- CTM31S (screened interval – 31.5 to 50.5)
    - PCE data exhibit an increasing Mann-Kendall trend over the GMP period. However, inspection of the PCE time-series graph indicates that PCE data exhibit increasing PCE concentration between 2003 Q4 and 2008 Q2 followed by a generally decreasing concentration between 2008 Q2 and 2010 Q4.
    - Intermittent PCE concentration spikes in 2006 Q2 and 2008 Q2 correlate to decreasing water levels. Otherwise there is no apparent recurring PCE concentration pattern or interrelationship between PCE data and water level data.
    - The PCE maximum concentration in this well (22 µg/L) occurred in 2008 Q2.
    - The highest PCE concentration observed in 2010 was 14 µg/L in Q1 and in Q3.
- CTM6S (screened interval - 23 to 43 feet bgs):
    - With the inclusion of the 2010 data, PCE concentration from CTM6S exhibits an increasing Mann-Kendall trend for the first time during the GMP period.
    - PCE concentration data exhibit an apparent short term decreasing trend (through 2005 Q1) that gives way to annually recurring, generally increasing maxima and minima. PCE concentration maxima are evident in 2005 Q3, 2006 Q4, 2007 Q4 (increasing further in 2008 Q1), 2008 Q4, and 2009 Q4. Recurring PCE maximum generally coincide with increasing water levels that tend to occur in Q4 after the cessation of municipal water supply pumping during Q2 and Q3 to meet peak demand.
    - The GMP PCE maximum concentration in this well (27 µg/L) occurred in 2006 Q4 and was equaled in 2009 Q4.
    - The highest PCE concentration observed in 2010 was 25 µg/L in Q2.
- CTM37S (screened interval - 25.5 to 45.5 feet bgs):
    - PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
    - The PCE concentration in this well was below the laboratory reporting limit for 6 of 9 quarters prior to 2006 Q1, and has been above the laboratory reporting limit for 15 of 16 quarters since. This change is coincident with both a general increase in groundwater level elevation that occurred in mid to late 2005 and the change to demand-based pumping at PCE-treated wells that began in 2006.
    - PCE concentration exhibit a weak pattern where annual PCE maxima are commonly observed when groundwater elevations are increasing or are near annual highs. PCE minima generally coincide with periods of pumping, occurring when groundwater elevations are decreasing or are at or near annual lows. The GMP PCE maximum concentration in this well (3.6 µg/L) occurred in 2009 Q4.
    - The highest PCE concentration observed in 2010 was 3.1 µg/L in Q3.

  - One possible explanation for the overall increasing long term trend and correlation between PCE concentration and changes in pumping operations is that the downgradient portion of the plume is nominally expanding as a consequence of operational changes in pumping at PCE-treated wells.





- CTM102 (screened interval – 96 to 106 feet bgs):
  - PCE data define no Mann-Kendall trend during the two year sampling period at this well starting in 2009 Q1.
  - The limited PCE concentration data exhibit a pattern where annual maxima occur in Q2 or Q3 when water level elevation is decreasing and annual maxima occur in Q4 after pumping during peak water demand has ceased and water levels are recovering.
  - In 2010 Q3, a new GMP PCE concentration maximum in this well (10 µg/L) was reached.
  - One possible explanation for the apparently isolated shallow zone PCE at CTM102 is that this area of contamination originates from a separate, distinct source. An alternative explanation is that the shallow zone portion of the Downtown Reno plume locally extends south of the Truckee River to CTM102, across the area where there is a lack of shallow zone observation wells.

Deep Zone Wells (Monitoring Wells)

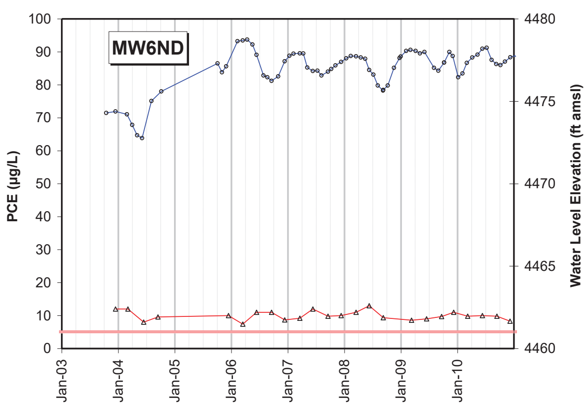
- MW6ND (screened interval - 182 to 192 feet bgs):
  - PCE data define no Mann-Kendall trend during the GMP period.
  - MW6ND was not accessible from 2004 Q4 through 2005 Q3; therefore no data were obtained from this well during that time. After 2005 Q3, there is a recurring pattern where increases in PCE concentration (with maxima in Q2 or Q3) occur when groundwater elevations are either decreasing or are at annual lows. This pattern is less well defined in 2009 and 2010 when PCE concentrations are more stable and groundwater elevations exhibit smaller seasonal decreases.

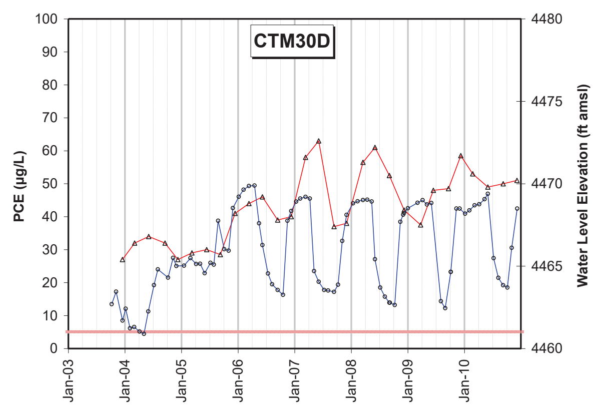
  - The PCE maximum concentration in this well (13 µg/L) was detected in 2008 Q2.
  - The highest PCE concentration observed in 2010 was 10 µg/L in Q2.

- COURTHOUSE (screened interval - 156 to 360 feet bgs):
  - PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
  - An apparent shorter term decreasing trend (through 2005 Q2) is followed by a recurring pattern where annual PCE concentration maxima occur in Q2 or Q3 and coincide with decreasing water levels or annual water level minima. The appearance of this possible pattern takes place after a general increase in groundwater level was observed in mid to late 2005. It also occurs after the pattern of recurring annual groundwater level fluctuations becomes more obvious as a result of the change to demand-based pumping at PCE treated municipal water supply wells in this subregion.
  - The PCE data from COURTHOUSE represent the average of two samples collected at two different depths (177 and 332 feet bgs respectively) across the well's long screened interval. PCE concentration in the upper sample is consistently higher (on the order of 2 times higher) than concentration in the lower screen.
  - The GMP PCE maximum (composite) concentration was reached in this well (5.0 µg/L) in 2009 Q3. The PCE concentration in the upper sampled depth during 2009 Q3 was 7.4 µg/L.
  - The highest PCE concentration observed in 2010 was 4.6 in Q3.
  - Downward vertical gradients that are prevalent in this portion of the Downtown Reno Subregion have the potential to induce downward vertical flow within the wellbore. If this is the case, the PCE concentration results from the upper portion of the screened interval (at 177 feet bgs) may be more representative of actual plume concentrations and results from the lower portion of the screened interval may reflect local wellbore conditions caused by downward vertical flow of PCE-contaminated groundwater entering at the upper screened interval and exiting at the lower screened interval. As a result of the recognized potential for cross contamination caused by wellbore flow, the COURTHOUSE well is scheduled for abandonment in 2011.
- MW10ND (screened interval - 187 to 197 feet bgs):
  - With the incorporation of 2010 data, PCE concentration data from MW10ND that previously defined an increasing Mann-Kendall trend now show no statistically defined increasing or decreasing trend for the GMP period.
  - Beginning in late 2005, there is an apparent inverse relationship between PCE concentration and groundwater elevation. Recurring annual PCE concentration minima during Q1 or Q2 generally correspond to recurring annual groundwater elevation highs. This timing and the recurrence of this relationship correlates to pumping-induced water level changes.

  - The PCE maximum concentration in this well (24 µg/L) occurred in 2007 Q4.
  - The highest PCE concentration observed in 2010 was 16 µg/L in Q3 and in Q4.

- CTM30D (screened interval - 131.5 to 151.5 feet bgs):
  - PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
  - Between 2005 Q4 through 2008, short term increases in PCE concentration generally correlate with increased groundwater levels. These annual fluctuations are generally larger in magnitude and overprint the long term trend at this well. Starting in 2009, no consistent interrelationship between PCE concentration and water level data is observed.
  - The PCE maximum concentration in this well (63 µg/L) occurred in 2007 Q2.
  - The highest PCE concentration observed in 2010 was 35 µg/L in Q1.





- CTM137 (screened interval - 120 to 125 feet bgs):
  - PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
  - The PCE concentration in this well increases regularly in Q2 during all seven years of the GMP period. After 2006, this increase generally occurs after an annual water level maximum, when groundwater level elevation is decreasing in this well. In 2010, relatively small annual groundwater level elevation fluctuations occurred and PCE concentrations were relatively stable.
  - The PCE maximum concentration in this well (150 µg/L) occurred in 2007 Q2.
  - The highest PCE concentration observed in 2010 was 130 µg/L in Q2, Q3, and Q4.

- MW8ND (screened interval - 176 to 186 feet bgs):

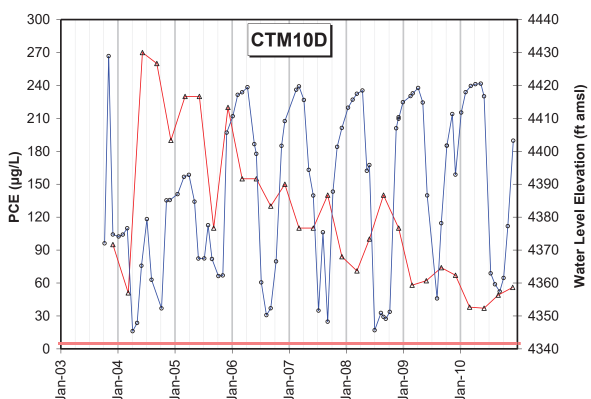
- PCE data define no Mann-Kendall trend for the period starting in 2006 Q4. This well was inaccessible for water quality sampling prior to 2006 Q4.
- The PCE concentration data prior to 2010 decreases slightly during times when water level elevations are decreasing. The correlation is not observed in 2010.
- The PCE maximum concentration in this well (48.5 µg/L) occurred in 2007 Q4.
- The highest PCE concentration observed in 2010 was 36 µg/L in Q1.

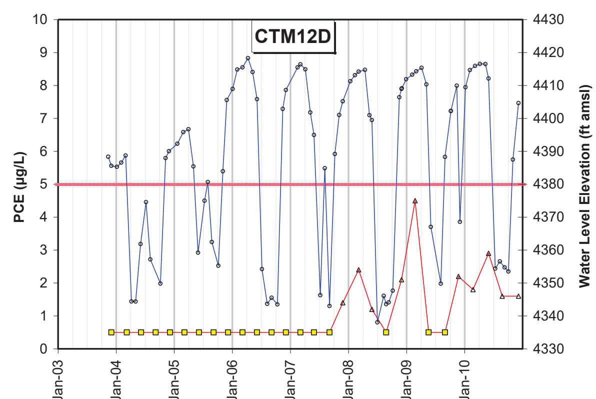
- CTM8D (screened interval - 240.5 to 260.5 feet bgs):
  - PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
  - There are recurring changes in PCE concentration beginning in 2005 but these changes do not appear to occur on a regular or consistent basis or show a consistent interrelationship with groundwater level elevation.
  - A PCE maximum concentration was observed in this well (56 µg/L) in 2008 Q2.
  - The highest PCE concentration observed during 2010 was 46 µg/L in Q2.
- CTM22D (screened interval - 231.5 to 251.5 feet bgs):
  - PCE data exhibit an increasing Mann-Kendall trend. Starting in 2007, this increasing trend is not obvious and PCE concentrations exhibit a relatively stable average annual concentration.
  - After 2005, there is a recurring pattern where annual PCE concentration minima occur in Q1 and correlate to annual groundwater level elevation maxima (or near maxima).
  - The PCE maximum concentration in this well (30 µg/L) occurred in 2007 Q4.
  - The highest PCE concentration observed during 2010 was 23 µg/L in Q2 and in Q3.
- CTM83 (screened interval - 266 to 286 feet bgs):
  - PCE has not been detected above the reporting limit in CTM83 for the two year sampling period starting in 2009 Q1.
  - TCE has been detected in this well up to a maximum concentration of 3.6 µg/L in 2009 Q1.
  - The highest TCE concentration observed in CTM83 during 2010 was 3.1 µg/L in Q1 and Q4.
  - Based on the occurrence of TCE without PCE, contamination at this location is interpreted to originate from a distinct and different source compared to the source(s) that contribute to the PCE-rich part of the Downtown Reno plume.
- CTM84 (screened interval - 156 to 176 feet bgs):

- PCE has not been detected above the reporting limit in CTM83 for the two year sampling period starting in 2009 Q1.
- TCE has been detected in this well up to a maximum concentration of 11 µg/L in 2012 Q4.
- Similar to well pair CTM83, the TCE-rich contamination at this location is interpreted to originate from a different and distinct source compared to the PCE-rich portion of the Downtown Reno plume.

- CTM101 (screened interval – 156 to 166 feet bgs):
  - PCE data define no Mann-Kendall trend for the two years of sampling starting in 2009 Q1.
  - The limited PCE concentration data exhibit no apparent recurring pattern and no interrelationship with water level elevation.
  - The PCE maximum concentration in this well (11 µg/L) occurred in 2009 Q1.
  - The highest PCE concentration observed during 2010 was 8.8 µg/L in Q1.
- CTM103 (screened interval – 195 to 205 feet bgs):
  - PCE data define no Mann-Kendall trend for the two years of sampling starting in 2009 Q1.
  - The limited PCE concentration data exhibit an apparent recurring pattern where annual PCE concentration maxima occur in Q2 and correlate to decreasing groundwater level elevation. PCE minima correlate to increasing groundwater level elevation and occur in Q3 or Q4.
  - The PCE maximum concentration in this well (38 µg/L) occurred in 2009 Q2 and was equaled in 2010 Q2 (note that the graphed value is lower as a result of averaging a duplicate sample with the original sample).
- CTM10D (screened interval - 326.5 to 346 feet bgs):
  - PCE data exhibit a decreasing Mann-Kendall trend for the GMP period.
  - There are changes in PCE concentration, most notably a dramatic increase in 2004 Q2, but these changes do not occur on a regular or consistent basis, or show a consistent interrelationship to groundwater level elevation.
  - The PCE maximum concentration in this well (270 µg/L) occurred in 2004 Q2.
  - The highest PCE concentration observed during 2010 was 56 µg/L in Q4.
  - CTM10D is located roughly 2,200 feet northwest (upgradient) of MILL and is interpreted to provide an indicator of locally decreasing PCE mass movement toward MILL.
- CTM12D (screened interval - 326 to 346 feet bgs):

- PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
- PCE was not detected above the laboratory reporting limit in this well until 2007 Q4.
- Beginning in 2008, a recurring pattern exists where PCE concentration increases correlate to groundwater elevation increases and PCE minima generally coincide with decreasing groundwater elevation or annual groundwater elevation minima. CTM12D is located roughly 400 feet south of MILL municipal water supply well. The PCE maximum concentration in this well (4.5 µg/L) occurred in 2009 Q1.
- The highest PCE concentration observed during 2010 was 2.9 µg/L in Q2.
- Groundwater elevations at CTM12D respond strongly to pumping at MILL and the correlation between decreasing water level and decreasing PCE concentration suggest a causal relationship where a local portion of the Downtown Reno plume margin is drawn towards MILL during periods of sustained pumping.

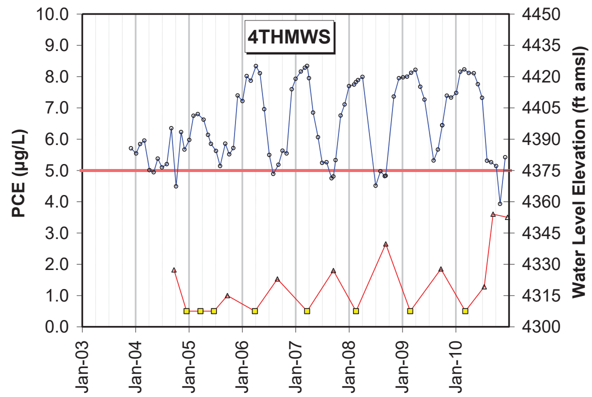




- CTM107 (screened interval – 276 to 296 feet bgs):
  - PCE data defined no Mann-Kendall trend for the two years of sampling starting in 2009 Q1.
  - The limited PCE concentration data exhibit a possible pattern where annual PCE concentration minima occur in Q1 and correlate to groundwater level elevation maxima.
  - The PCE maximum concentration in this well (21 µg/L) occurred in 2009 Q3.
  - The highest PCE concentration observed during 2010 was 19 µg/L in Q2.
  - Contamination at this location has an undefined potential to escape capture at MILL. CTM107 is located approximately 1,600 feet southeast of MILL and is constructed in a different and shallower hydrostratigraphic Package (C) compared to MILL (D and E, F, G)
- CTM80 (screened interval – 115 to 130 feet bgs):
  - PCE data define no Mann-Kendall trend for the two years of sampling since 2009 Q1.

  - Detected PCE concentrations at or near 1 µg/L has occurred in this well in three of 8 samples collected since the well was constructed.
  - The PCE maximum concentration in this well (1.1 µg/L) occurred in 2009 Q4.
  - The highest PCE concentration observed during 2010 was 0.97 µg/L in Q3.
  - The generally low PCE concentration at this well is consistent with a location near the bottom of the plume. Results suggest that the Downtown Reno plume plunges to the south between CTM80 and HIGH.
- CTM81 (screened interval – 175 to 195 feet bgs):):
  - PCE data define no Mann-Kendall trend for the two years of sampling starting in 2009 Q1.
  - The limited PCE concentration data exhibit no apparent seasonal pattern or interrelationship between PCE data and water level data.
  - The PCE maximum concentration in this well (7.6 µg/L) occurred in 2009 Q4.
  - The highest PCE concentration observed during 2010 was 7.3 µg/L in Q3.
  - TCE also occurs in CTM81 and reached a maximum of 3.4 µg/L in 2009 Q2.
  - The highest TCE concentration observed during 2010 was 2.2 µg/L in Q3.
- 4THMWS (screened interval - 180 to 300 feet bgs):
  - PCE data exhibit an increasing Mann-Kendall trend for the GMP period.
  - This well is located approximately 100 feet from 4TH municipal water supply well and is part of a well pair with 4THMWD.
  - Prior results exhibit a recurring pattern where PCE detections from semi-annual sampling occur in Q3 and non-detections occur in Q1. This pattern is a direct result of artificial recharge injection that occurs at 4TH during the winter season and pumping that occurs during the summer. Q1 sample non-detects represent water quality of the injection water. Q3 samples likely represent a combination of groundwater and injection water depending on the volume of water extracted during the pumping season compared to the volume of water injected during previous injection cycles. The most representative samples of groundwater occur at the end of the pumping season.
  - Current data are consistent with the higher PCE and TCE concentrations occurring within the vertical interval where 4THMWS is screened compared to the deeper interval where 4THMWD is screened (see description below).
  - Given the proximity to 4TH (that is used for artificial storage and recovery with treated surface water), characterizing the water quality and water level data from 4THMWS in a hydrogeological context is problematic. However the overall long term increasing PCE trend along with TCE concentration that exceeds the MCL may indicate a potential increased threat to 4TH.

- Maximum PCE and TCE concentrations of 4.1 µg/L (2010 Q4) and 14 µg/L (2010 Q3), respectively, were reached in 2010.



- 4THMWD (screened interval – 330 to 480 feet bgs):
  - Prior to 2010 Q4, PCE was not detected above the reporting limit in this well in semi-annual sampling between 2003 Q4 and 2010 Q3. The first PCE detection occurred in 2010 Q4.
  - This well is located roughly 100 feet from 4TH municipal water supply well and is part of a well pair with 4THMWS (described above).
  - In 2010 Q4, PCE and TCE concentrations of 0.67 µg/L and 1.3 µg/L, respectively, occurred in this well (as represented by the average result of a set of composite of vertical depth-discrete samples collected across the well screen). These samples were collected during a period of sustained pumping at nearby 4TH municipal water supply well.
  - Given the proximity to 4TH municipal water supply well (that is used for artificial storage and recovery with treated surface water), characterizing the water quality and water level data from 4THMWD in a hydrogeological context is problematic.
  - Prior to 2010 Q3, PCE concentration in the range of 0.50 and 1.0 µg/L would not have been recognized as a result of the higher laboratory reporting limit of 1 µg/L used between 2004 Q3 and 2010 Q2.
  - Recent results are consistent with low levels of PCE and TCE existing to depth of at least 330 ft bgs (the top of the 4THMWD well screen) in this area.

Deep Zone Wells (Municipal Supply Wells)

Identifying and evaluating possible PCE and water level patterns, trends, and interrelationships in the municipal water supply wells can be problematic. The water quality data typically collected from these wells is intended to be representative of groundwater from the aquifer in a given well under steady state pumping conditions. Water quality samples have generally only been collected from these wells while they are being pumped. Accordingly, the groundwater elevation data from these wells are indicative of the aquifer under pumping conditions. Since 2006, municipal water supply wells are typically sampled opportunistically on a monthly basis during sustained pumping periods (typically late spring through early fall).

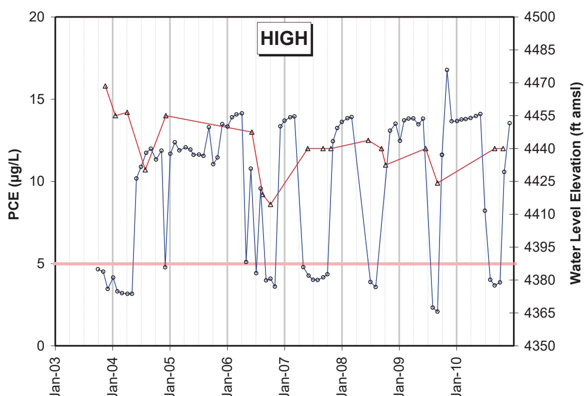
PCE concentration trends and patterns observed in zone municipal supply wells are described below.

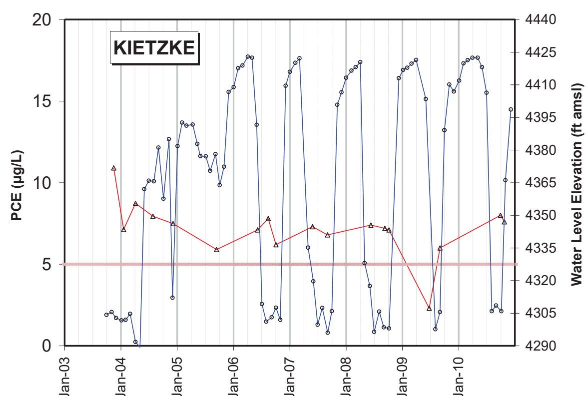
- 4TH (screened interval - 176 to 480 feet bgs):
  - PCE data from 4TH exhibit a decreasing Mann-Kendall trend for the GMP period. However visual inspection of the PCE time-series graph (Graphs 5.2a) for the well indicate no obvious trend. Statistical results for 4TH are likely biased by the small number of PCE detections (4) and by the influence of implementing a reduced reporting limit (from 1.0 to 0.50 µg/L) starting in 2010 Q3.
  - 4TH has typically been used for artificial recharge during the winter season since 2000. As a result, characterizing the PCE and water level data from 4TH in a hydrogeological context is problematic.
  - The limited distribution of PCE concentration data from 4TH shows no evidence of a recurring pattern.
  - PCE concentration during the GMP has ranged from below the reporting limit to a maximum of 1.3 µg/L (in 2004 Q4).
  - The highest PCE concentration observed in this well during 2010 was 0.73 µg/L in Q4.
  - TCE concentration is commonly higher than PCE concentration in this well. The maximum TCE concentration (3.2 µg/L) for the GMP period occurred in 2004 Q4.
- HIGH (screened interval - 133 to 511 feet bgs):
  - PCE data for HIGH exhibit a decreasing Mann-Kendall trend for the GMP period.
  - The PCE concentration in HIGH appears to decrease slightly during periods of sustained pumping.
  - HIGH was not sampled by DWR between 2004 Q4 and 2006 Q2. PCE concentration during the GMP period has ranged from 8.6 to 15.8 µg/L.
  - The highest PCE concentration observed in this well during 2010 was 12 µg/L in Q2 and Q3.
- MORRILL (screened interval - 178 to 578 feet bgs):
  - PCE data exhibit a decreasing Mann-Kendall trend for the GMP period.

- During every year except 2007, the PCE concentration in MORRILL decreases slightly during sustained pumping.
- PCE concentration during the GMP has ranged from 8.3 to 14.3 µg/L.
- The highest PCE concentration observed in this well during 2010 was 13 µg/L in Q2.

- KIETZKE (screened interval - 233 to 498 feet bgs):

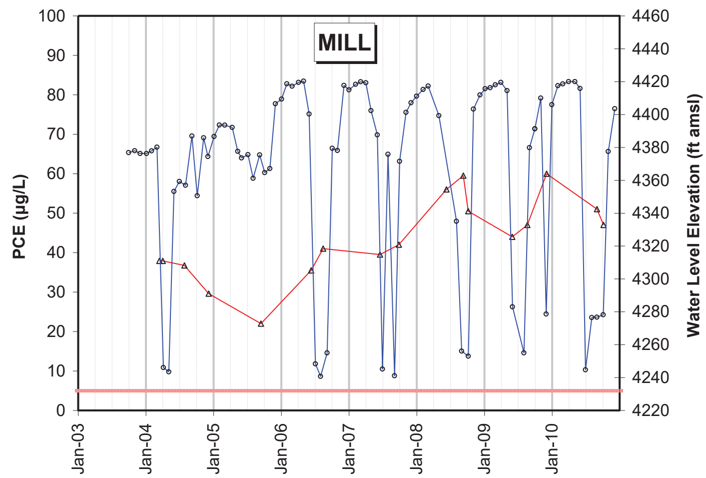
  - PCE data exhibit a decreasing Mann-Kendall trend for the GMP period.
  - The limited distribution of PCE concentration data over any given year is insufficient to define a recurring pattern.
  - PCE concentration during the GMP has ranged from 2.3 to 10.9 µg/L.
  - The PCE concentration minimum of 2.3 µg/L occurred in 2009 Q2 on the first day of seasonal pumping at the well. This minimum value is suspect and is not considered representative of typical pumping groundwater conditions.
  - The highest PCE concentration observed in this well during 2010 was 8.0 µg/L in Q3.





- MILL (screened interval - 326 to 640 feet bgs):

  - PCE data at MILL exhibit an increasing Mann-Kendall trend for the GMP period.
  - PCE concentrations in this well show no apparent recurring pattern.
  - Between 2004 Q1 and 2005 Q3 PCE concentration data indicate an apparent decrease in concentration to a GMP minimum of 22 µg/L in 2005 Q3. Starting in 2005 Q3, PCE concentration in the well increased to a maximum concentration of 60 µg/L in 2008 Q3 that was equaled in 2009 Q4.
  - The highest PCE concentration observed in this well during 2010 was 50.5 µg/L in Q3.



5.7.7 Receptors

The Downtown Reno plume is interpreted to have impacted the HIGH, MORRILL, KIETZKE, 4TH, and MILL municipal water supply wells. Groundwater pumped from these wells has contained PCE at concentrations ranging from 8.6 to 15.8 µg/L (HIGH), 8.3 to 14.1 µg/L (MORRILL), 2.3 to 10.9 µg/L (KIETZKE), below the laboratory reporting limit to 1.3 µg/L (4TH) and 22 to 60 µg/L (MILL) since the start of the GMP period. Groundwater pumped from these wells in 2010 contained PCE that averaged 11.3 µg/L (HIGH), 10.4 µg/L (MORRILL), 7.1 µg/L (KIETZKE), 49.2 µg/L (MILL), and <1.0 µg/L (4TH) based on volume weighted annual averages calculated by DWR. These wells (except 4TH) are equipped with wellhead treatment systems for PCE. They are operated for municipal water supply and, in accordance with the CTMRD program Pumping Plan (SPPCo, 2000; Intera, 2006b), to capture and contain the Downtown Reno plume thereby protecting the resource and other downgradient wells. In 2010, the net volume of water pumped from these wells was approximately 245, 232, 350, 218, and 119.2 MG respectively. The groundwater treatment history for the wells fitted with PCE treatment equipment is summarized in the table below.

Downtown Reno Subregion PCE Well Treatment History

Calendar Year	HIGH			MORRILL			KIETZKE			MILL		
	PCE (µg/L) (1)	water treated (million gallons)	PCE removed (pounds)	PCE (µg/L) (1)	water treated (million gallons)	PCE removed (pounds)	PCE (µg/L) (1)	water treated (million gallons)	PCE removed (pounds)	PCE (µg/L) (1)	water treated (million gallons)	PCE removed (pounds)
1996	20.2	419.5	70.6	27.7	362.5	83.7						
1997	17.6	273.8	40.2	19.7	463.3	76.0				14.1	2.5	0.3
1998	17.1	179.4	25.6	18.1	451.3	68.3	11.4	80.6	7.7	14.1	0.01	0.001
1999	16.5	429.7	59.1	16.3	278.7	37.9	8.4	349.4	24.4	15.9	195.9	26.0
2000	17.0	235.4	33.3	19.9	273.8	45.3	10.2	340.5	28.8	17.9	277.0	41.4
2001	20.0	398.9	66.5	19.0	521.3	82.7	9.2	472.4	36.1	23.2	347.9	67.3
2002	17.4	520.0	75.4	15.8	462.2	60.7	8.2	482.3	33.1	31.4	389.8	102.1
2003	16.5	606.4	83.6	17.3	526.5	76.1	8.8	818.1	60.2	33.0	107.8	29.7
2004	13.2	447.2	49.3	13.5	391.5	44.2	7.8	735.0	48.0	33.7	454.5	127.8
2005	12.7	210.3	22.2	12.0	254.7	25.4	8.2	348.1	23.9	35.7	235.8	70.1
2006	10.4	342.8	29.8	11.3	288.9	27.3	7.1	471.2	27.9	39.6	298.8	98.6
2007	11.5	360.8	34.7	10.6	293.0	25.9	7.0	459.9	26.7	39.5	223.3	73.5
2008	12.6	280.0	29.3	11.7	268.0	26.1	7.5	475.2	29.8	55.4	253.0	116.8
2009	11.1	257.3	23.9	9.6	218.9	17.5	6.7	318.9	17.7	49.6	308.6	127.5
2010	11.3	244.7	23.1	10.4	232.9	20.1	7.1	350.2	20.9	49.2	217.5	89.3
TOTALS		**5206.2**	**666.7**		**5287.5**	**717.1**		**5702.0**	**385.1**		**3312.3**	**970.4**

(1) Weighted annual average, based on (pre-2005) SPPCo/TMWA compliance data or (post-2005) on DWR GMP data

Migration of PCE mass in the shallow zone of the Downtown Reno plume is likely to be influenced by the downward vertical gradient induced by pumping at the HIGH and MORRILL wells and also the apparent boundary effect of the Truckee River. The shallow zone plume may be diluted by or be intercepted by the river. Alternatively a substantial portion of the shallow zone plume may migrate vertically downward into the deep zone of the aquifer system in response to the downward gradient in the area before crossing beneath the river. The operation of HIGH and MORRILL promotes this downward migration and is considered to enhance the containment of the Downtown Reno plume. Therefore the continued operation of these wells is a key component of the Pumping Plan (SPPCo, 2000; Intera, 2006b), intended to maximize containment of known PCE plumes by wells currently fitted with PCE treatment equipment. Further evaluation would be required (as discussed below) to determine whether the shallow portion of the Downtown Reno plume would migrate laterally and impact other downgradient wells if the HIGH and MORRILL wells were not operated routinely. It should be noted that PCE concentration at easternmost defined portion of the shallow zone plume at CTM37S indicates a long term increasing trend in PCE. While concentrations remain low (in the range of 2 to 3 µg/L), the overall increasing trend suggest a nominal expansion to the leading edge of the shallow zone plume.

The areal extent of the Downtown Reno plume in the deep zone during 2010 is essentially the same as was defined in 2009. Additional monitoring wells constructed in the Downtown Reno Subregion in late 2008 and early 2009 continue to constrain the downgradient extent of PCE to the east of KIETZKE (at CTM84/CTM83/CTM83) and characterize PCE contamination to the east of MILL (at CTM107) where the downgradient extent of PCE is undefined. Any changes in apparent areal extent of the plume outline during the GMP period have been largely a result improved plume resolution created by the addition of these new monitoring wells. Otherwise the actual areal extent of the Downtown Reno plume does not appear to have substantially changed over the time since the first plume maps were created in 2003 Q4. The similarity in plume geometry over time is largely attributed to the hydraulic control created by operation of the receptor wells equipped with PCE treatment systems. Most of the Downtown Reno plume is estimated (Intera, 2006b) to be captured by pumping of the HIGH, MORRILL, KIETZKE, and MILL wells - assuming they are operated in accordance with the pumping plan. Therefore, PCE contamination in the Downtown Reno plume is less likely to migrate downgradient and impact other wells as long as the net volumes defined in the pumping plan are regularly attained. If the current receptor wells were to shut down or to regularly not meet pumping plan targets, the Downtown Reno plume could potentially migrate toward and eventually impact the VIEW, GALLETTI, 21ST, POPLAR2, POPLAR1, GREG, TERMINAL, PEZZI, HV3, and HV5 municipal water supply wells.

The Pumping Plan analysis (Intera, 2006b), estimates that 10% of the Downtown Reno plume is NOT captured by the receptor wells listed above and could be moving further downgradient (i.e., further east). Of potential concern in this regard include the following areas where PCE or TCE concentration results from wells indicate an undefined extent of contamination that may require further evaluation to verify hydraulic control:

- **East of KIETZKE municipal water supply well.** The detection of TCE in deep zone wells a CTM83 (screened interval – 266 to 286 feet bgs) and CTM84 (screened interval – 156 to 176 feet bgs) at concentrations up to 3.1 and 11 µg/L, respectively. These wells are part of a well cluster located 1,950 ft southeast of KIETZKE and equidistant (northwest) from GALLETTI. GALLETTI has had intermittent detections of TCE in the range of 0.50 to 1.0 µg/L since as early as 2001. The most recent TCE detection at GALLETTI was from a TMWA compliance sample that returned 0.54 µg/L in September 2008.

- **Southeast of MILL municipal water supply well.** The detection of PCE in CTM107 (screened interval - 276 to 296 feet bgs) at concentrations up to 21 µg/L. This well is located 1,600 feet southeast of MILL. CTM107 is screened 30 feet shallower and in an apparently distinct hydrostratigraphic package compared to the shallowest screened interval at MILL (screened interval – 326 to 640 feet bgs). During 2010 MILL pumped 217.5 MG and did not meet the pumping plan target of 250 MG.

5.7.8 Downtown Reno Conceptual Model

The Downtown Reno plume is a complex plume with sources associated with contamination in the shallow zone, and receptors in the deep zone. Based on the PCE distribution, the complex plume is interpreted to have crossed the VLFZ and the HWB and has impacted a 350-foot vertical thickness of geologic material. The Downtown Reno Subregion conceptual model that follows is based on the data presented in **Sections 5.7.1** through **5.7.7**. **Figure 5.20** shows a schematic plan map with conceptual model features that are described in this section. **Figures 5.21A** and **5.21B** show schematic cross sections (updated from the 2009 Annual Report; WorleyParsons, 2012) of the hydrostratigraphic conceptual model, and the plume distribution/potential migration pathways for the Downtown Reno Subregion. These sections transect the West Fourth Street hot spot, project through the area near HIGH and MORRILL municipal supply wells, then change orientation and project though and extend past the MILL municipal water supply well (see **Figure 5.19**; schematic line ds-ds'/cs-cs').

Hydrogeology

The Downtown Reno Subregion is a least partly transected by the VLFZ (a system of faults with an overall down-to-the-west offset). On the eastern margin of this fault zone is a semi-permeable barrier to groundwater flow that causes a groundwater elevation drop (in both the deep zone and shallow zone) of approximately 40 ft from west to east in the area between the HIGH and MORRILL municipal water supply wells. West of the VLFZ, the water table is in apparent hydraulic connection with the Truckee River. East of the VLFZ the water table is at least locally deeper than and disconnected from the Truckee River. The HWB, another semi-permeable flow barrier is interpreted to extend into the Downtown Reno Subregion from the South Reno Subregion, and project in a northwesterly direction between well clusters CTM102/CTM101/CTM100 and CTM9S/CTM104/CTM103/CTM10D. Unlike in the South Reno Subregion, where the HWB influences only deep zone groundwater flow —steepened lateral gradients in both the shallow and deep zone indicate that the HWB acts as a partial flow barrier in the shallow zone and deep zone where it projects into the southern part of the Downtown Reno Subregion. Moreover, the northern extent of the HWB and therefore its influence on hydrogeology, groundwater flow, and plume migration in the Downtown Reno Subregion are as yet poorly defined.

The hydrostratigraphy on either side of the VLFZ is generally characterized by vertical anisotropy that is a consequence of heterogeneity (interlayering of laterally discontinuous layers and lenses, of relatively coarser and/or relatively finer grained materials). Lithologic data (as described in **Section 5.7.1** and shown on the schematic cross section depicted in **Figure 5.21A**) define multiple vertically distinct, apparently laterally continuous packages of predominantly coarser grained material, interlayered with relatively finer grained material. The coarser grained hydrostratigraphic packages are comprised of vertically discrete water producing sequences that typically correspond to the depth intervals where the screens in the municipal water supply wells have been constructed. These transmissive and water producing packages are often separated by sequences comprised of generally finer grained materials that can act, at least locally, as an impediment to vertical groundwater movement (i.e. to act as an aquitard).

While there appears to be general consistency in the hydrostratigraphy across the VLFZ, lithologic data indicate that the materials become generally coarser and there is a decrease in finer grained interlayers with increasing distance to the west of the VLFZ. This suggests that vertical heterogeneity is lower and the potential for downward vertical groundwater flow and contaminant movement is greater in the western portion of the subregion. To the east of MW6ND, multiple, discrete hydrostratigraphic packages have been identified in the interval between the land surface to beyond the depth of the deepest well in the subregion (MILL, with a total depth of 660 feet bgs). This indicates that the vertical anisotropy is higher in the area east of MW6ND and that downward vertical groundwater flow and contaminant movement across hydrostratigraphic packages is relatively impeded eastward from MW6ND and in the vicinity of the VLFZ. To the east of the VLFZ, (southeast of MORRILL towards CTM10D) a relatively shallow finer-grained hydrostratigraphic package (Package B(f)) that may represent a locally semi-confining layer, transitions into predominantly coarser grained material (Package B(c)). This transition provides the potential for enhanced vertical flow in the area near CTM10D and to the southeast towards MILL.

Lateral Groundwater Movement

Lateral groundwater flow in the shallow zone is generally from west to east on both sides of the VLFZ and roughly parallel to the Truckee River.

The shallow zone gradient on the west side of the VLFZ exhibits less variability than is typically observed east of the VLFZ. During the late summer and early fall, the shallow zone gradient across the VLFZ steepens and the water level elevation on the east side of the VLFZ decreases in response to municipal water supply well pumping (which is more significant east of the VLFZ). This enhanced shallow zone response to deep zone pumping becomes even more pronounced in the area between MORRILL, KIETZKE, and MILL and in the Mill/Kietzke Subregion (see discussion in **Section 5.8.2**).

Lateral groundwater flow in the deep zone is also generally to the east under natural conditions but is observed to vary in direction and magnitude in response to municipal water supply well pumping. A prominent depression of deep zone groundwater levels occurs east of the VLFZ and the HWB (where numerous municipal water supply wells are located) during periods of sustained municipal water supply well pumping. Since 2006, this pumping has taken place during peak water demand (generally in Q2 and Q3). This sustained period of pumping causes a coalescing deep zone cone of depression during the summer and fall in the eastern portion of the Downtown Reno Subregion. The development of this cone of depression coincides with sustained pumping at MORRILL, KIETZKE, 4TH, VIEW and MILL and affects both gradient direction and magnitude. Typically groundwater flow in the deep zone becomes convergent toward each of these wells as the demand-based pumping begins (typically during Q2). As pumping continues, the individual cones of depression that form around each of these wells expand, interfering with those of the other pumping wells and eventually coalesce into a large composite cone of depression in the deep zone of the aquifer system. When the municipal water supply wells are turned off at the end of peak demand (which has generally taken place between late Q3 and early Q4 since 2006), deep zone lateral groundwater flow resumes a predominantly eastward direction, and, by the end of Q1, water levels have recovered to pre-pumping conditions. Such a pumping-driven pattern has been observed since 2006, with the return to the natural gradient and recovery to pre-pumping levels occurring prior to the next annual pumping season.

The relatively low annual drawdown (in both the shallow zone and deep zone wells) west of the VLFZ is interpreted to reflect:

- That the Truckee River is connected with the water table west of the VLFZ;
- A significant vertical hydraulic connection between the shallow zone and deep zone; and
- Pumping-induced drawdown near the Truckee River that is mitigated by recharge from the river.

The relatively high seasonal drawdown (in both the shallow zone and deep zone wells) east of the VLFZ is interpreted to reflect:

- Separation between the Truckee River and the water table east of the VLFZ;
- Increased vertical anisotropy (compared to west of the VLFZ) but with local areas of enhanced vertical flow;
- Pumping-induced drawdown that is not significantly mitigated by recharge from the Truckee River; and
- The partial flow barrier effect of both the VLFZ and the northern extension of the HWB.

Vertical Groundwater Movement

In a large part of the area west of the VLFZ, the vertical hydraulic gradient between the shallow zone and deep zone is almost continuously downward-directed throughout the year. This is particularly the case near the Truckee River and extending north of the river to West Fourth Street. Considering the location of the West Fourth Street hot spot, the presence of a vertical hydraulic connection or conduit in this area would allow for enhanced downward groundwater flow and downward PCE mass movement from the potential source area. Aquifer test results (HGC, 2009; and summarized in **Section 5.7.2**) indicate potentially enhanced shallow zone/deep zone hydraulic connections (or conduits) may exist in the vicinity of MW6ND and CTM6S. This is consistent with what has been observed in this part of the plume.

In the area east of the VLFZ and the HWB, the vertical gradient is strongly influenced by municipal water supply well pumping. When no wells are or have recently been pumping, the vertical gradient in this area is typically upward. When wells are pumping or have recently been pumped for a sustained period, the gradient is typically downward. In the presence of a vertical hydraulic connection or conduit, this condition would allow for enhanced downward groundwater flow and downward PCE mass movement, and is consistent with what has been observed in this part of the plume.

Data suggest that the Truckee River contributes locally to downward vertical gradients and to recharge. Downward gradients are persistent throughout the year in areas (near the river) west of the VLFZ where the river is hydraulically connected to shallow zone groundwater. Pumping from municipal water supply wells, while transient, accentuates downward vertical gradients by creating deep zone cones of depression that can also lower the water table. This effect would induce additional recharge from the river in areas where shallow zone drawdown encroaches on places where the river and the water table are hydraulically connected.

Downward vertical gradients west of the VLFZ and upward vertical gradients east of the VLFZ may have been present in the CTM before significant groundwater development and municipal water supply well pumping was initiated in the basin in 1960 (CDM, 2002; Volume 2, Appendix D, specifically Figures 3-5 and 3-6). The onset of significant municipal water supply well pumping would have changed the pre-existing hydrodynamics and associated recharge distribution. Decreased water levels in the deep zone and ensuing increase in the downward vertical gradient would have taken advantage of any hydraulic connection to the shallow zone and, where the shallow zone is in hydraulic connection to the river, induced river recharge in parts of the basin where there would have been little if any potential for it to take place previously. Specific conductance data from shallow zone groundwater near the river (WorleyParsons, 2010) are consistent with the concept that the river provides recharge to shallow zone groundwater**.** A change in hydrodynamics and the distribution of recharge components (particularly an increase in recharge from the Truckee River to the shallow zone in areas where PCE contamination was present) in response to municipal water supply well pumping beginning around 1960 is likely to have and to have had a strong influence on PCE distribution and potential migration pathways since that time. The presence of both a shallow zone groundwater source (the Truckee River) and deep zone sinks (municipal water supply wells) combine to potentially drive PCE mass migration from source to receptor in the Downtown Reno plume.

Potential PCE Sources

Multiple PCE sources are likely to have contributed to the Downtown Reno complex plume. These sources are interpreted to have been located in the general area along the commercial and industrial corridor that is/was (historically) present along West Fourth Street. Sources could include specific points of use (such as the former Society Cleaners Corrective Action site, where the nature and extent of the PCE contamination detected in the late 1990's was apparently not determined before "no further action status" was issued by NDEP) or include one or more "distributed" sources that might occur as a result of exfiltration of PCE-containing wastewater over a large area downstream from the discharging facility. The multiple source/distributed source interpretation is based on:

- The abundance of PCAs that are or have been located in this general area;
- The relatively large width of the shallow zone plume; and
- The relatively large distances between PCE-contaminated shallow zone wells in this area.

This interpretation is consistent with the general conclusions reached in the initial assessment (WESTEC/SRK, 1994) of the PCE problem in the downtown Reno area sponsored by NDEP. The general area between hot spot well CTM28S and wells CTM5, CTM1S and CTM2S is a logical location for one or more possible specific PCE release locations.

PSA investigations are ongoing in the Downtown Reno Subregion. These investigations have the objective to identify, delineate, and if feasible, remediate specific releases or residual sources in this general area that may have contributed and may continue to contribute PCE to the Downtown Reno plume. Results from passive soil gas surveys indicate a total of five PCE high mass areas in the West Fourth Street PSA and are consistent with the multiple source interpretation. One of the five PCE high mass areas (West Fifth Street high mass area) partially coincides with the West Fourth Street hot spot.

While the magnitude of PCE concentrations detected to date in existing shallow zone wells are not indicative of the presence of DNAPL, persistently elevated PCE concentrations have been present in this area over an approximately 20-year period. This suggests that PCE sources (either robust residual sources from historical releases [which could include localized areas with residual DNAPL], or recurring ongoing releases) potentially continue to contribute PCE contamination to the groundwater in the downtown Reno area.

PCE sources in or near the plume hot spot may be experiencing decreasing release rates in recent years. Evidence that supports the concept of a decreasing source term includes:

- The decreasing PCE concentrations in wells that define or are near the hot spot;
- The decreasing PCE concentration trends in proximal downgradient receptor wells (such as HIGH and MORRILL); and

- The increasing PCE concentrations in distal deep zone monitoring wells and downgradient receptor wells (such as MILL).

PCE Plume Formation and Distribution

The shallow zone portion of the Downtown Reno plume extends northward from the Truckee River to Interstate 80 and eastward from Keystone Avenue to the VLFZ and potentially beyond. The shallow zone plume margin coincides with the Truckee River along its southern edge. This may be caused by dilution or hydraulic control of the plume by surface water infiltrating into the shallow zone from the river. It may also reflect the plunge of PCE contamination from the shallow zone into the deep zone as it migrates:

1) beneath the river (to the east and southeast);
2) along gently dipping hydrostratigraphic packages; and
3) towards deep zone municipal water supply wells.

The shallow zone portion of the plume plunges to the east-southeast and contamination impacts the deep zone 1,600 feet east of the West Fourth Street hot spot. Further east, PCE is present in both shallow zone wells and deep zone wells, but higher concentration in the deep zone indicate that the plume core plunges into the deep zone in the area approximately 3,000 feet east (in the vicinity of CTM30D) of the West Fourth Street hot spot.

The deep zone portion of the plume extends north from East Taylor Street to Fifth Street and beyond Fourth Street, and east from near Keystone Avenue to US-395 (at CTM82/CTM83/CTM84) and beyond Matley Lane (at CTM107).

The deep zone portion of the Downtown Reno plume reaches approximately 2,500 feet wide (from north to south) west of the VLFZ, and spreads transversely in the downgradient portion of the plume, becoming approximately 5,500 feet wide between the 4TH and MILL receptor wells. The width of the plume may be caused in part by having multiple and/or distributed sources and also by the combined drawdown and competing capture influence of multiple downgradient pumping wells (including receptor and potential receptor wells).

The vertical dimensions of the complex plume extends from near the water table in the vicinity of the West Fourth Street hot spot to deep zone portions of the aquifer system, potentially as deep as 450 feet or more. The schematic cross section of the Downtown Reno complex plume (**Figure 5.21B**) summarizes data that indicates that the Downtown Reno plume extends to an estimated vertical depth of approximately 350 feet bgs in the area where it crosses beneath the Truckee River. The contaminant distribution appears to favor coarser grained strata that have an apparent dip to the southeast. Therefore potential exists for the plume to extend to greater depths in the area around MILL, where the same hydrostratigraphic packages with similar coarser grained strata extend to depths of at least 450 feet bgs.

PCE Migration Mechanisms and Pathways

The projection of high PCE concentration from the shallow zone, near multiple potential sources, downgradient and into the deep zone is consistent with significant downward vertical PCE mass flux. This results in an elongated plume core that extends from the shallow zone hotspot into the deep zone. If PCE data from the hot spot (as high as 260 µg/L in CTM28S in September 2005 and at 78 µg/L in December 2010) are generally representative, the concentration in such a plunging plume core could be 260 µg/L or higher. Data that support the concept of a plunging plume core include:

- The relative lack of vertical anisotropy and a persistent downward gradient in the source area that would foster initial downward PCE contaminant movement;
- Hydrostratigraphic data that indicates hydrostratigraphic packages downgradient of the source area have an apparent dip to the southeast and favor a similar contaminant distribution.
- The spatial relationships between PCE concentration data for CTM28S and deep zone wells CTM30D, MW8ND, and CTM137 (completed at different depths and potentially aligned with the groundwater gradient and general dip direction of hydrostratigraphic materials);
- The PCE concentration (observed through 2010) in shallow zone wells downgradient of the Downtown Reno plume hot spot (and towards PCE impacted municipal water supply wells) that is typically lower than subjacent deep zone wells over the same time period.
- The coincidence of intervals of higher PCE mass flux and higher groundwater flow at both HIGH and MORRILL municipal water supply wells ((AMEC, 2009) that suggest that greater PCE mass flux tends to occur in more transmissive strata during periods of pumping.

The temporal relationships between longer term PCE concentration trends at hot spot well CTM28S (long term decreasing) compared to downgradient deep zone wells CTM30D, CTM137 and CTM8D (long term increasing) are consistent with the PCE center of mass moving from the hot spot to the deep zone downgradient of the hot spot. Once PCE has impacted the deep zone of the aquifer system, lateral PCE mass movement is interpreted to occur primarily within the more transmissive hydrostratigraphic packages. As reported in the 2009 Annual Report (WP, 2013) this is corroborated by dynamic water quality and flow profiling at HIGH and MORRILL (AMEC, 2009). PCE present in these more transmissive packages have increased potential for rapid movement and high flux rates (for both groundwater and PCE) in response to municipal water supply well pumping.

PCE movement into and distribution within the deep zone is interpreted to be strongly influenced by municipal water supply well pumping. The deep zone portion of the Downtown Reno plume is intercepted by pumping at HIGH, MORRILL, KIETZKE, and MILL. HIGH and MORRILL are partly cross-gradient to the groundwater flow direction and have captured 16% and 13% of the total PCE mass removed by these four PCE-treated wells since 2006 (when pumping plan operations were changed from year-around pumping to demand-based pumping to optimize the effectiveness of PCE capture and containment and to meet TMWA's operational constraints). The plume extends downgradient, where an additional 14% of the total mass removed since 2006 was captured by KIETZKE. The plume continues to the east-southeast where an additional 57% of the total mass removed since 2006 was captured by MILL.

HIGH is intercepting PCE mass which would (assuming a decreasing source term) positively influence concentrations at both MORRILL and KIETZKE. These three wells all have long term decreasing PCE concentration trends that are consistent with a decreasing source term in upgradient source areas. All are also located proximal to the Truckee River, which could be providing a local source of recharge to dilute the PCE concentration in groundwater captured by these wells. The higher mass removal and increasing PCE concentration at MILL could reflect the lack of mitigating circumstances (because of its distance from the river) but also could be caused by either a detached plume core or by impacts associated with releases from other sources within the MILL capture zone (see **Figure 5.21B** for conceptual model alternatives).

Threats to Receptors

While the location and outline or "footprint" of the Downtown Reno plume has generally been stable (has not changed significantly) since 2003 Q4, PCE concentration in the receptor wells impacted by this plume has varied over time. PCE in HIGH and MORRILL has exhibited a deceasing trend through 2010. PCE in KIETZKE has also exhibited a decreasing concentration, but at a slower rate. PCE in 4TH exhibits no apparent trend (likely as a consequence of injection for ASR). However, PCE concentration in the downgradient portion of the plume south of the Truckee River has been increasing, as observed at MILL. The long term decreasing PCE trend at CTM10D (upgradient of MILL) and the increasing PCE concentration at MILL and CTM12D (downgradient of MILL) suggest more dynamic PCE mass movement in the southeast part of the plume than in the northern and central parts of the plume. PCE concentration at MILL (49.2 µg/L in 2010) is more than 4 times higher than at any other well used to capture and contain the Downtown Reno plume. The substantially higher PCE concentration at MILL makes pumping MILL critical to the capture and containment of a significant mass of the Downtown Reno plume. This is demonstrated by the fact that between 2006 and 2010, MILL removed more PCE mass (101.14 pounds) than the combined PCE mass (76.1 pounds) removed at HIGH, MORRILL, and KIETZKE. During 2010 pumping at MILL (217.5 MG) did not meet the annual pumping volume threshold (250 MG) defined in the pumping plan schedule.

In addition to these considerations, sampling results from downgradient wells indicate that:

- TCE concentrations (up to 11 µg/L in 2010) at well CTM84 suggest a potential future threat to GALLETTI municipal supply well, particularly if pumping at downgradient wells (for example GALLETTI or 21ST) was increased significantly compared to pumping at KIETZKE and/or 4TH.

- PCE (up to 19 µg/L in 2010) at CTM107 occurs downgradient of, and in a shallower hydrostratigraphic package compared to the screened interval at MILL. In the event that PCE contamination in this well is outside the MILL capture zone, downgradient wells could potentially be impacted at some time in the future.

Future threats to receptor and potential receptor wells spatially associated with the Downtown Reno complex plume include the potential for increased PCE and TCE concentration in 4TH (and potentially downgradient in GALLETTI or VIEW) requiring a response plan or action to maintain well viability. In the event that the plume moves (or has moved) beyond MILL, other downgradient wells (such as TERMINAL, GREG, PEZZI, HV3, or HV5) may potentially be impacted by PCE originating in the Downtown Reno Subregion.

5.7.9 Summary

The Downtown Reno PCE plume is characterized as a complex plume that occurs in both the shallow zone and deep zone of the aquifer system west of the VLFZ and north of the Truckee River, and is recognized principally in the deep zone of the aquifer system downgradient (east) of the VLFZ. Consistent downward vertical hydraulic gradients in the vicinity of the West Fourth Street hot spot allow PCE to migrate to depths greater than 180 feet within lateral distances of less than 2,000 feet from the hot spot. This results in a plunging plume that extends into in the deep zone west of the VLFZ and north of the Truckee River. Once PCE has reached the deep zone of the aquifer system and crosses partial flow barriers associated with the VLFZ and the HWB, it can then readily move along groundwater-producing hydrostratigraphic packages toward receptor wells including MORRILL, 4TH, KIETZKE and MILL.

Two groundwater flow regimes are defined in the Downtown Reno Subregion. West of the partial flow barrier (attributed to the VLFZ) that projects between HIGH and MORRILL, the water table is shallower; horizontal hydraulic gradients are lower; and there is greater influence from the Truckee River on both shallow zone and deep zone groundwater. East of this barrier, the water table is deeper and Truckee River appears to be disconnected from the groundwater system. Drawdown in response to municipal water supply well pumping is substantial in both shallow and deep zones, and horizontal hydraulic gradients are 2.5 to 5 times higher east of the barrier than west of the barrier, which allows for faster PCE movement to the east, assuming comparable hydraulic conductivities.

Both shallow zone and deep zone wells exhibit drawdown in response to municipal water supply well pumping, indicating vertical hydraulic communication and supporting the interpretation that the shallow zone and deep zone are both parts of a single complex aquifer system. This is further supported by the presence of the complex, vertically and laterally continuous PCE plume in this part of the basin. This continuity is apparent on both the east and west sides of the flow barrier attributed to the VLFZ between HIGH and MORRILL. This indicates that while the feature does impede groundwater flow, the PCE plume does cross the zone. Once across the partial flow barrier, PCE migrates along transmissive hydrostratigraphic packages moving east to southeastward to receptor wells under the high hydraulic gradients that occur in response to municipal supply pumping.

Multiple PCE sources are likely to have contributed to the Downtown Reno complex plume. These sources are interpreted to have been located in the general area along the commercial and industrial corridor that is/was (historically) present along West Fourth Street. Initial results from PSA investigations are consistent with the multiple source interpretation. Persistently elevated PCE concentration in potential source areas suggests that PCE sources (either robust residual sources from historical releases [which could include localized areas with residual DNAPL], or recurring, ongoing releases) potentially continue to contribute PCE contamination to the groundwater in the downtown Reno area.

While the extents of the plume are generally stable, the PCE center of mass appears to be moving to the southeast based on continued increases in PCE concentration in MILL. The increasing PCE concentration at MILL could be caused by a detached plume core or by impacts associated with releases from other unidentified (downgradient) sources (see **Figure 5.21B** for conceptual model alternatives).

PCE contamination extends at least 1,600 feet downgradient of MILL. In the event that the plume moves (or has moved) beyond the MILL capture zone, other downgradient wells (i.e. TERMINAL, GREG, HV3, HV5, and PEZZI [used for construction water supply]) may potentially be impacted by PCE originating in the Downtown Reno Subregion. Defining the effectiveness of capture and containment of the Downtown Reno plume east of MILL remains a significant data gap for assessing threat to receptors and pumping plan effectiveness. In addition, future potential threats to other receptor and potential receptor wells include PCE and TCE impacts at 4TH (and potentially VIEW and GALLETTI) if KIETZKE does not effectively capture or contain the northeastern margin of the Downtown Reno plume.

5.8 Mill/Kietzke Subregion

The Mill/Kietzke Subregion encompasses a plume that (based on the existing data) is delineated only within the shallow zone. The shallow zone Mill/Kietzke plume overlies the deep zone Downtown Reno plume (which is present in deeper water-bearing portions of the aquifer system in this area). The Mill/Kietzke plume is interpreted to have originated from multiple and distinct sources. These sources could include either residual sources or ongoing discharges that continue to contribute PCE to the Mill/Kietzke plume.

No data are available at this time to substantiate a physical connection between the Mill/Kietzke plume and the Downtown Reno plume or the contribution of PCE mass from the Mill/Kietzke plume to the MILL municipal water supply well. Potential receptors for the Mill/Kietzke plume include (with multiple screens that span the intervals shown in parentheses):

- MILL (326-640 feet bgs), a receptor to the Downtown Reno plume
- CORBETT (180-280 feet bgs), a receptor to the South Reno plume
- TERMINAL (330-665 feet bgs), also a potential receptor to the Downtown Reno and South Reno plumes

HV3, HV5, and PEZZI (located over 6,000 feet downgradient from the Mill/Kietzke plume as presently defined) are also potential receptors. The northwestern (upgradient), eastern (cross and downgradient), and southeastern (downgradient) extents of the Mill/Kietzke plume are presently uncertain given the distribution of existing monitoring wells.

5.8.1 Hydrogeology

The following description is largely taken from the 2009 GMP Annual Report (WorleyParsons, 2012). This description of hydrostratigraphy is presented in terms of hydrostratigraphic packages.

The hydrostratigraphy is interpreted to dip to the southeast at a low angle (approximately 2 degrees). The shallow zone hydrostratigraphic packages in the Mill/Kietzke Subregion consist of (from top to bottom) the following:

- Package A. Generally coarser grained material (comprised of bouldery to cobbly gravel, sandy gravel, and silty gravel with thinner silt and sand layers and/or lenses) extends from the land surface to approximately 70 to 100 feet bgs. Cobble to boulder-sized clasts exist in many of the gravelly interlayers and are characteristic of this package. The amount of matrix fines generally increases with depth in this package, with a greater proportion of silty gravel being common in the basal 30 to 40 feet in the Mill/Kietzke Subregion. Package A is interpreted to be continuous across the subregion. The water table occurs in this package and varies from approximately 30 to 45 feet bgs (depending on location and time of year).

- Package B(c). Beneath Package A (beginning at approximately 70 to 100 feet bgs) is a package of uncertain thickness that consists of generally coarser grained material (sandy gravel, silty gravel with cobbles) with limited finer grained lenses and interlayers (silty clay, silt, and silty sand). The coarser grained materials in this package can effectively transmit water. While there has not been a significant thickness of finer grained material identified in this depth interval in this subregion (causing Package B(c) and the underlying deep zone Package C to be indistinguishable here), the finer grained lenses or interlayers have lower hydraulic conductivity and are expected to locally impede vertical groundwater movement through this sequence and from the shallow zone (i.e. Packages A and B(c)) into the underlying deep zone (Package C). Package B(c) and the underlying deep zone Package C have a total combined thickness of approximately 150 feet in the subregion.

The deep zone hydrostratigraphic packages (which occur deeper in the aquifer system than the Mill/Kietzke plume and which underlie the Mill/Kietzke Subregion at depth) are described (from top to bottom) below. Note that the indicated thicknesses and the corresponding top and bottom depths can vary across the area being described. The descriptions are generally representative of the area near MILL.

- Package C. A package of uncertain thickness that consists of generally coarser grained material (sandy gravel, silty gravel with cobbles) with limited finer grained lenses and interlayers (silty clay, silt, and silty sand). The coarser grained materials in this package can effectively transmit water. There has not been a significant thickness of finer grained material identified above this depth interval in this subregion (resulting in Package C and the overlying shallow zone Package B(c) being indistinguishable here). However finer grained lenses or interlayers in this package have lower hydraulic conductivity and can locally impede vertical groundwater movement through the package. Package C and the overlying shallow zone Package B(c) have a total combined thickness of approximately 150 feet in this area.

- Package D. A 120-foot thick, generally finer grained package with discrete layers or lenses of finer grained material (clayey silt, sandy silt, and silty sand) interlayered with lesser coarser grained material (sand with local intervals of gravel to gravelly sand). Package D occurs between 250 and 370 feet bgs at MILL. Based on roto-sonic core at CTM10D, CTM12D, and CTM107 the majority of this package is comprised of lower permeability silt to silty sand and is interpreted to be continuous across the Mill/Kietzke Subregion. The finer grained interlayers within this package have the potential to locally impede vertical groundwater flow. Interlayers of sand and relatively clean gravel also exist in the package. One such sand and gravel interlayer is present near the center of Package D and corresponds to a groundwater producing zone (confirmed by spinner logging [TMWA, 2003] and vertical flow profiling [BESST, 2011] at MILL) in the upper screened interval at MILL (326 to 345 feet bgs). MORRILL, KIETZKE, and TERMINAL are also interpreted to have screened intervals completed in this package.

- Package sequence E, F, G. A relatively thick, generally coarser grained sequence of packages characterized by alternating coarser grained material (comprised predominantly of sand and gravel to gravelly sand) and finer grained material (silty sand, silt and/or clay layers and streaks). This package sequence is 290 feet thick at MORRILL. At MILL it extends from 370 feet bgs to beyond the bottom of MILL at 660 feet bgs. At least two-thirds of the cumulative screened interval length of MILL (as well as MORRILL, KIETZKE, and TERMINAL) is constructed in coarser grained materials within this package sequence. This package sequence has a significantly greater proportion of permeable gravelly material in the upper 120 feet so that the upper portion generally contributes substantially more groundwater than deeper screened intervals (based on flow profiling at MILL and MORRILL [TMWA, 2003; AMEC, 2009; BESST, 2011]). The individual packages in this sequence are described (see **Section 5.10.1** of this report) in the eastern part of the basin based largely on data from STANFORD.

- A gravity-based cross section (D-D'; Widmer, 2005; 2007) that extends through MILL, interprets the depth to bedrock at MILL to be approximately 820 feet. If that is accurate, approximately 180 feet of sedimentary basin-fill are present beneath the lowermost screened interval at MILL.

Hydrostratigraphic data in the Mill/Kietzke Subregion are consistent with an aquifer system that is heterogeneous and anisotropic. Based on the available lithologic data, local finer interlayers or lenses exist and contribute to anisotropy in the aquifer system. However, there is no evidence for a laterally continuous layer between the water table (Package A) and groundwater producing intervals at MILL that would act as an aquitard.

5.8.2 Groundwater Level Data

Shallow zone potentiometric maps are presented as **Figures 5.2**, **5.4**, **5.6**, and **5.8**. These maps include the Mill/Kietzke Subregion and are the basis for characterizing lateral hydraulic gradients in this area. Quarterly regional groundwater level difference between the shallow zone and deep zone (**Figure 5.10**) and cumulative groundwater level change (**Figures 5.11** through **5.14**) in the shallow zone and deep zone, combined with well cluster groundwater level data (**Graphs 5.3b**) provide the basis for characterizing vertical hydraulic gradients that influence the Mill/Kietzke Subregion.

Lateral Gradients

Quarterly potentiometric maps show that shallow zone lateral groundwater flow was generally to the southeast during 2010. This is consistent with the gradient that has been observed in this subregion since the GMP began.

- In Q1 and Q2, the southeasterly gradient has a magnitude of 0.0017 and 0.0018, respectively.
- In Q3, the lateral gradient reverses to the northwest and has a magnitude of 0.0001.
- In Q4, the southeasterly gradient is re-established and has a magnitude of 0.0008.

The groundwater flow direction patterns and gradient magnitudes in 2010 are similar to what has been observed in this subregion in previous years. The shallow zone flow direction is to the southeast when little or no deep zone pumping is taking place. The gradient flattens and forms a shallow zone cone of depression to the west and northwest of MILL during peak periods of deep zone municipal water supply pumping.

Vertical Gradients

During 2010, a downward vertical gradient is present between the shallow zone and deep zone during periods of sustained deep zone pumping (during the summer and early fall). When little or no deep zone pumping is taking place (during late fall through spring), the magnitude of the downward gradient is reduced and locally reverses (becoming upward).

- In Q1, an upward vertical gradient (approximately 0.02) is observed at well pair CTM11S/CTM12D (**Figure 5.23**).
- The upward gradient at this location persists through Q2, but decreases in magnitude (to approximately 0.007 by June).
- A downward gradient is present at this well pair during Q3 (approximately -0.17 in September).
- This downward gradient persists through Q4, but decreases in magnitude to -0.008.

Similar vertical gradient changes are observed at the other shallow zone/deep zone well clusters (CTM39S/CTM107 and CTM9S/CTM10D) in this subregion during 2010. This pattern of vertical gradient direction changes has been observed in this subregion since 2006. The strongest and most extensive downward gradient develops in this subregion when widespread and sustained municipal water supply well pumping is taking place. An upward gradient is re-established within 2 to 3 months after deep zone pumping stops. Cumulative Mill/Kietzke shallow zone water level drawdown in response to deep zone pumping ranged from 3.34 feet (at CTM39S) to 12.84 feet (at CTM104) during 2010.

5.8.3 Groundwater Sources and Sinks

Potential recharge sources that could contribute to the Mill/Kietzke Subregion water budget include mountain front recharge, groundwater inflow, recharge along or near the Truckee River corridor (or other surface water features), artificial recharge for aquifer storage and recovery (ASR), infiltration from leaking water distribution and wastewater collection systems, infiltration from irrigation, infiltration from storm water run-off, and infiltration from direct precipitation. All of these recharge processes are likely to occur within or near the Mill/Kietzke Subregion except mountain front recharge.

Precipitation and Truckee River flows for the GMP period are presented in **Section 5.3**. Annual precipitation was 9.25 inches in 2010. This is an increase over 2009 (8.25 inches), and above the historical annual average (7.31 in/year) for the period of record (1937 through 2010; NOAA, 2011). Mean annual Truckee River discharge (at the Reno Gage) was 459.9 cubic feet per second (cfs) during 2010. This is an increase over 2009 (354.9 cfs), but below the historical average annual discharge of 676 cfs for the period of record (1906 to 2010; USGS, 2011). As described in the 2008 and 2009 CTMRD GMP Annual Reports (WorleyParsons, 2011; WorleyParsons, 2012), the Truckee River has the potential to lose water to the aquifer system where it transects the Mill/Kietzke Subregion. The river elevation in this area is approximately 4,424 feet AMSL and the corresponding maximum groundwater elevation is at least 10 feet below the river (as observed at shallow zone wells 21STMWS and CTM39S; 1,000 feet north and 1,500 feet south of the river, respectively; with maximum water levels at 4,413 and 4409 feet AMSL, respectively, during 2010). No effort is made as part of the GMP at this point to estimate potential groundwater recharge associated with precipitation or with infiltration from the Truckee River.

Deep zone artificial recharge for ASR is typically conducted between November and March. Injection at GALLETTI and 21ST (completed in the underlying Downtown Reno Subregion, near the northeast corner of the Mill/Kietzke Subregion) totaled approximately 43.2 MG in 2010 compared to 95.2 MG in 2009. Annual injection using these wells is summarized below. Injection in 2010 was less than the annual average volume (104.6 MG) for the time period since 2000. The potential influence of this deep zone recharge on the overlying Mill/Kietzke Subregion shallow zone has not yet been evaluated. If there is vertical groundwater movement between the Mill/Kietzke Subregion and the underlying Downtown Reno Subregion, the water budgets for these subregions will be interdependent.

Mill/Kietzke Subregion Vicinity Artificial Recharge History (in millions of gallons)			
Year	**Wells**		**Annual Totals**
	21ST	**GALLETTI**	
1999	0.0	0.0	0.0
2000	20.0	26.5	46.5
2001	65.8	77.8	143.6
2002	62.7	76.1	138.8
2003	84.2	85.4	169.6
2004	56.1	71.2	127.3
2005	35.2	38.7	73.9
2006	49.1	56.9	106.0
2007	35.0	48.7	83.7
2008	50.2	73.2	123.4
2009	37.7	57.5	95.2
2010	29.7	13.5	43.2

Groundwater sinks in or near the Mill/Kietzke Subregion include shallow zone evaporation from the Aqua Range (a surface water feature at the Grand Sierra Resort), and deep zone groundwater extraction from the MILL, KIETZKE, GALLETTI, and 21ST municipal water supply wells. Annual groundwater flux from the Aqua Range is estimated to be on the order of 29 to 54 MG (WorleyParsons, 2010). The 2010 deep zone groundwater extraction was approximately 578.0 MG. Groundwater extraction during 2010 was the lowest since the inception of the GMP (in 2003). Decreased pumping in 2010 is primarily a result of less pumping at MILL. Pumping during 2010 at MILL (217.5 MG) was also less than the 254 MG annual pumping volume defined in the current Pumping Plan (Pumping Plan Agreement, 2009) to achieve plume capture and containment.

The tables below define the 2010 groundwater production conditions and summarize the annual pumping by these wells during the time since the inception of the GMP.

Well Name	2010 Pumping Start Date	2010 Pumping End Date	2010 Groundwater Production (MG)	2010 Pumping Pattern
MILL	June 30	Oct 7	217.5	Continuous
KIETZKE	July 7	Nov 1	350.2	Continuous
GALLETTI	No pumping	No pumping	0.0	No pumping
21ST	July 11	Aug 25	10.2	Intermittent

Mill/Kietzke Subregion Vicinity Municipal Water Supply Well Pumping History (in millions of gallons)					
Year	Wells				Annual Totals
	MILL	KIETZKE	21ST	GALLETTI	
2003	107.8	818.1	146.7	205.5	1278.1
2004	454.5	735.0	109.7	125.0	1424.2
2005	235.8	348.1	88.8	115.4	788.1
2006	298.8	471.2	99.5	127.1	996.6
2007	223.3	459.9	90.4	510.2	1283.8
2008	253.1	475.2	24.7	73.4	826.4
2009	308.6	318.9	22.6	0.1	650.2
2010	217.5	350.2	10.2	0.0	578.0

5.8.4 Data on Potential PCE Sources

Potentially contributory activities (PCAs) have been identified near the Mill/Kietzke plume (as shown on **Figure 5.22**). Numerous existing and historical potential PCE-using businesses (such as auto repair shops, dry cleaners, and auto body repair and paint shops) are or have been in the vicinity of the Mill Street and Kietzke Lane intersection. Environmental releases and PCE impacts discussed in previous reports are summarized (and updated as appropriate) below.

- Of the 28 PCAs identified by McGinley and Associates (2002) in the vicinity of the Mill/Kietzke plume, a reported PCE release is only documented at the former Sierra Chemical Site (**Figure 5.22**). The Sierra Chemical Site is located in the extreme northwest corner of the Mill/Kietzke Subregion. PCE in soil as high as 1,100 micrograms per kilogram (µg/kg) was identified beneath two different underground storage tanks (USTs) between 1988 and 1990.

- PCE impacts were identified in three separate areas during a targeted sewer line investigation (Kleinfelder, 2003). These impacts occur near sanitary sewer lines in which transient PCE discharges had been detected in 2001 and 2002. These three areas were defined (Kleinfelder, 2003) as:

  - Kietzke Lane impacted area (along Kietzke Lane between Prosperity Street and Mill Street) is located close to the Kietzke hot spot and well ARCO6018MW11.
  - Prosperity Street impacted area (near the intersection of Prosperity Street and Sunshine Lane) is immediately adjacent to an active drycleaner, the Prosperity hot spot, and well CTM13S. Wastewater samples (collected since 2001, and since 2005 as part of the

Sewer Monitoring Program [SMP] conducted in collaboration with city of Reno Environmental Control and tabulated below) downstream from this facility continue to indicate the recurring presence of PCE (as high as 34,000 µg/L in 2001 and up to 26 µg/L in 2010).

- Golden Lane impacted area (near the intersection of Prosperity Street and Golden Lane) is close to well CTM42 (which has only had one detection; 1 µg/L in 2006 Q4).

Mill/Kietzke SMP Sampling Results Summary

Sample Location	Prosperity (1)		Prosperity (2)		JJ's Cleaners (3)	
	Sample Date	PCE (µg/L)	Sample Date	PCE (µg/L)	Sample Date	PCE (µg/L)
			12/06/00	34.5		
			12/21/00	28		
			01/03/01	265.2		
	01/09/01	38.2	01/09/01	169.2		
	01/18/01	10	01/18/01	816		
	01/30/01	59.9	01/30/01	456		
	02/01/01	15.6	02/01/01	689.7		
	02/13/01	9100	02/13/01	34000		
	02/16/01	6.2	02/16/01	16		
	02/16/01	23	02/16/01	52		
	03/01/01	40	03/01/01	48		
	03/01/01	130	03/01/01	180		
	08/16/01	34				
	10/17/05	470				
	10/25/05	44				
	04/04/06	54				
	04/04/06	50				
	07/28/06	6.9				
	10/13/06	14				
	1/10/07	25				
	4/25/07	40				
	10/3/07	170				
	10/3/07	180				
					12/17/07	440
					2/20/08	5.1
					4/22/08	<5
					7/16/08	150
					10/15/08	160
					1/27/09	<5
					4/27/09	6.2
					7/14/09	26
					10/28/09	<5
					04/28/10	<5
					07/21/10	26
					10/25/10	5.5

(1) sample collected from main at first manhole downstream from site lateral
(2) sample collected from main at second manhole downstream from site lateral
(3) sample collected from same location as (1) after change in ownership

The Mill/Kietzke Potential Source Area (PSA) was delineated in 2008 to encompass the area (see **Figure 5.22**) where persistent and relatively elevated shallow zone groundwater PCE concentrations have been present over time. This PSA includes PCAs and possible residual subsurface PCE sources that may have contributed to or that may be contributing to the Mill/Kietzke plume. In 2008, DWR received Board of County Commissioners approval to initiate a PSA investigation in order to:

- Characterize the magnitude and extent of shallow subsurface contamination in the PSA;
- Identify sources that may have contributed to or that may be contributing to the contamination;
- Assess the threat posed by that source to groundwater; and,
- Provide information to support a cost-benefit assessment of possible PCE source mitigation.

The Mill/Kietzke PSA investigation was initiated in 2008 and results through 2010 are summarized below.

In 2009, a two-phase passive soil gas (PSG) survey (Gore, 2009b; 2009c; Kleinfelder, 2010) identified four PCE high mass areas (HMAs, identified on **Figure 5.22**):

- The Kietzke Lane HMA – along Kietzke Lane (between Mill Street and Prosperity Lane) that corresponds to the Kietzke impacted area identified in 2003;
- The Prosperity Lane HMA – along Prosperity Lane (between Sunshine Lane and Golden Lane) that corresponds to the Prosperity impacted area identified in 2003;
- The Golden Lane HMA – along Golden Lane (between Mill Street and Zinc Street) that had not been previously recognized; and
- The Sunshine Lane HMA – along Sunshine Lane (between Mill Street and Prosperity Lane) that had not been previously recognized.

Active soil gas (ASG) samples were collected from existing groundwater monitoring wells screened across the water table (ARCO6018MW8, ARCO6018MW11, and ARCO6018MW12) in the PSA in 2010. The ASG results (Kleinfelder, 2010) suggest sympathetic spatial correlation between ASG concentration, the proximal PCE mass indicated by the PSG survey, and the groundwater PCE concentration from the same well. PSG and ASG sampling results from 2003 and 2009-2010 and the wastewater sampling results from 2001 through 2010 indicate that PCE discharges to the waste water collection system and PCE in the environment have been persistent for a relatively long period of time.

The results from the Mill/Kietzke PSA investigation through 2010 have identified four HMAs that represent potential PCE sources. Preliminary ASG sampling using existing suitably constructed groundwater monitoring wells has indicated that subsurface vapor concentrations do pose a potential threat to groundwater. Considering the thickness of the vadose zone and the significant seasonal shallow zone water level fluctuation, additional subsurface vapor data will be required to assess the extent and magnitude of the subsurface vapor concentrations and to substantiate the threat to groundwater. A series of dedicated active soil gas wells will be installed in 2011 as part of this effort.

5.8.5 PCE Concentration and Distribution Data

The Mill/Kietzke plume extends south and east from the recognized hot spots. The plume, as presently defined, is elongated from NW to SE and located within the area bounded in the northwest by the intersection of Lewis Street and Gould Street and in the southeast by the intersection of Terminal Way and Vassar Street (**Figure 5.22)**.

The PCE plume extends from the hot spots (indicated by wells CTM13S and ARCO6018MW11) toward the southeast to CTM39S and CTM38D (and potentially beyond)**.** The Mill/Kietzke plume is delineated to the west (by CTM9S and CTM104, CTM37D, and ARCO6018MW8) and in the northeast (by CTM42). The southeast (downgradient) and northwest extents of the plume are not delineated by existing wells.

The maximum vertical extent of the Mill/Kietzke plume has not been specifically delineated (neither near the plume hot spots nor near the furthest downgradient wells). PCE contamination is present at the maximum depth of investigation in the furthest downgradient shallow zone wells (at 95 feet bgs in CTM38D and at 97 feet bgs in CTM105). PCE has been consistently higher in the deeper well in each downgradient shallow zone well pair. PCE is higher in CTM105 in the CTM11S/CTM105 well pair and higher in CTM38D in the CTM39S/CTM38D well pair. Depth discrete groundwater samples were collected at 35, 85, 135, 165, 195, 225, 255, 285, 315, and 355 ft bgs during the drilling of well CTM107 (which was subsequently screened from 276-296 ft bgs and which is co-located with CTM39S and CTM38D near the downgradient extent of the plume). PCE was found in samples collected from 85, 135, 165, and 285 feet bgs at a concentration of up to 3.1 µg/L (in the sample from 135 ft bgs). All other depth discrete samples were non-detect with respect to PCE. The depth discrete sample collected during drilling at 285 ft bgs (coincident with the screened interval) contained 2.5 µg/L PCE (subsequent groundwater samples from this well have had PCE concentrations as high as 19 µg/L [in 2010 Q4]). While the depth discrete data from the CTM107 borehole have a lower pedigree and cannot presently be verified by monitoring well data, they are consistent with the downgradient well pair data. They are also consistent with the Mill/Kietzke plume either plunging to the southeast or there being preferential pathways between deeper portions of the aquifer system in that area and the upgradient plume sources and/or hot spots.

Potentially significant PCE concentration dynamics in key or important Mill/Kietzke plume wells observed during 2010 are highlighted in **Table 5.4**. These include concentration changes in CTM13S, ARCO6018MW12, CTM63, ARCO6018MW12, ARCO6018MW16, CTM11S, CTM105, and CTM38D.

Potentially important results during 2010 are summarized below.

- New PCE concentration maxima (for the GMP period) were established in:
    - ARCO6018MW12 (27 µg/L in 2010 Q1 and 44 µg/L in 2010 Q2); and

  - ARCO6018MW16 (17 µg/L in 2010 Q3).

The GMP PCE concentration maximum at ARCO6018MW12 occurs after successive new maxima during each of the three previous years (9.1 µg/L in 2007 Q1, 16 µg/L in 2008 Q2, and 23 µg/L in 2009 Q4). It should be noted however that the PCE maximum for this well was observed prior to GMP implementation (235.1 µg/L in September, 2000).

- New PCE concentration minima were established in:
  - CTM38D (3.3 µg/L in 2010 Q2 followed by 2.4 µg/L in Q4).
- Potentially important short term PCE concentration changes (not resulting in a new maximum or minimum) occurred in:
  - CTM63 (increased from 22 to 75 µg/L between 2010 Q1 and Q2);
  - ARCO6018MW16 (increased from 1.6 to 5.7 to 16 µg/L from 2010 Q1 to Q3, then decreased to 6.1 µg/L in Q4); and
  - CTM11S (increased from 0.65 to 3.6 µg/L between 2010 Q3 and Q4).

The wells with either new PCE maxima or important short term PCE concentration increases in 2010 are downgradient from the Mill/Kietzke plume hot spots and proximal to or upgradient from MILL. In the 2007 and 2008 GMP annual reports (WorleyParsons, 2010; WorleyParsons, 2011), some Mill/Kietzke key wells (including ARCO6018MW11, CTM64, CTM63, and ARCO6018MW12) were identified as exhibiting short duration transient increases in PCE concentration over one or two quarterly sample events. These increases occur when the shallow zone groundwater elevation is at or near the annual maximum (between Q4 and Q2). This transient behavior, with corresponding increases in PCE concentration, is evident in 2010 in ARCO6018MW11, CTM63, and ARCO6018MW12. The transient increase in PCE groundwater concentration associated with increased water level suggest the potential for short-term increases in PCE contribution from one or more nearby sources in the smear zone or vadose zone.

5.8.6 Trends and Patterns in Water Levels and PCE Concentrations in Key Wells

PCE concentration and groundwater elevations observed in key wells located in the Mill/Kietzke Subregion are plotted on **Graphs 5.3a**. As noted in **Section 5.8.5**, the ten key wells in this subregion (listed in **Table 5.1** and depicted on **Figure 5.22**) include CTM13S, ARCO6018MW11, CTM63, ARCO6018MW12, ARCO6018MW16, CTM11S, CTM105, and CTM38D. The patterns and trends shown on **Graphs 5.3a** are described below. Selected graphs are embedded in the following text to help illustrate important points. Table 5.4 summarizes PCE concentration and PCE concentration and trend information for the key (or other important) wells. The list of key/important wells was modified in 2010 (see **Section 5.4.1**). For the Mill/Kietzke Subregion, modifications to the key/important well list included removing CTM39S and CTM64 and adding CTM105.

Water Levels

The groundwater level data exhibit a trend of increasing average annual water level elevation from late 2003 through early 2006. The increase in water level elevation that occurred in each well over that time ranges from approximately 10 to 16 feet. Beginning in early 2006 and lasting through 2008, a decrease in average annual water level elevation (of approximately 4 to 10 feet) occurs. Beginning in 2009, the average annual water levels increase relative to 2008 and continue to do so through 2010. This indicates a change from a decreasing to increasing longer term trend. However, this most recent longer term increasing trend is less dramatic than the increase that occurred from 2003 to 2006. These longer term trends are superimposed by annually recurring water level minima and maxima in each well. The annual fluctuations range from 4 to 12 feet. Groundwater elevation maxima typically occur during Q1 or Q2 and minima typically occur during Q3 or Q4.

Based on a review and reassessment of water level data through 2010, the Mill/Kietzke key wells have been divided into two groups that are somewhat different from the groupings that were defined previously (Worley Parsons, 2011). It should be noted that all the Mill/Kietzke key wells exhibit very similar behavior in terms of both longer term trends and shorter term dynamics. The rationale behind these revised groupings is discussed below.

Group A includes CTM13S, ARCO6018MW11, CTM63, and ARCO6018MW12. These wells exhibit a gradual increase of roughly 11 feet in approximate average annual water level between 2003 Q4 and early 2006. From 2006 through 2008 a gradual decrease of approximately 4 feet in average annual water level occurs. Starting in 2008, the decreasing trend that began in 2006 ends and average annual water levels increase approximately 2 feet between 2008 and 2010. Recurring annual water level fluctuations are observed and, since 2006, have been on the order of 5 to 10 feet. Annual water level minima generally coincide with peak municipal well pumping.

Group B includes ARCO6018MW16, CTM11S, CTM105, and CTM38D. These wells exhibit similar behavior to the Group A wells but the water level changes in the Group B wells are generally smaller in magnitude. Group B wells exhibit a gradual increase of roughly 8 feet in approximate average annual water level between 2003 Q4 and early 2006. From 2006 through 2008 a gradual decrease of approximately 3 feet in average annual water level occurs. Starting in 2008, average annual water levels increase by approximately 2 feet. Recurring annual water level fluctuations since 2006 are on the order of 3 to 6 feet.

Water level patterns and trends in all the Mill/Kietzke key wells are similar over the GMP period of record. Annual water level fluctuations that can range to 12 feet or more reflect a relatively large response to pumping compared to other shallow zone areas in the CTM. Water level decreases coincide with periods of sustained pumping that, after 2005, occur during peak annual water demand in late spring (Q2) through early fall (Q3). Water level recovery typically occurs from Q4 through Q1. Water levels in Group A and B wells both exhibit a generally increasing trend between 2003 Q4 and 2006, a generally decreasing trend between 2006 and 2008, and an increasing average annual water levels from 2008 through 2010 (**Graphs 5.3a**). The increased water levels through 2010 are interpreted to result from decreased deep zone pumping (826.4 MG in 2008, 650.2 MG in 2009, 578.0 MG in 2010) by municipal water supply wells near the Mill/Kietzke Subregion. This increase is also interpreted to result from deep zone pumping that stopped earlier in 2009 (when pumping stopped in August and September) than it did in 2008 (when pumping stopped in September and October).

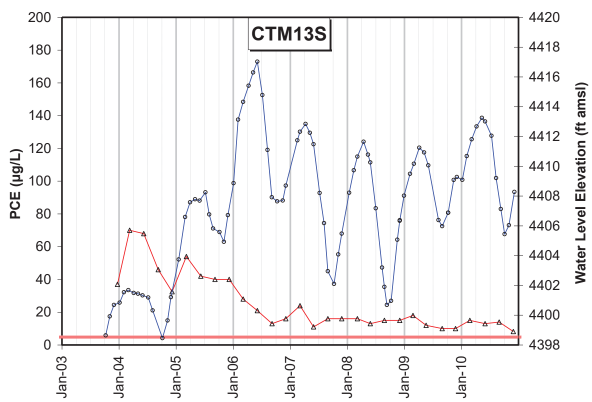
Group A wells are distinguished from Group B wells by their relatively larger magnitude range of annual water level fluctuations and trends. These characteristics are consistent with Group A wells being more directly affected by the deep zone pumping stresses that influence shallow zone water level behavior in the Mill/Kietzke Subregion.

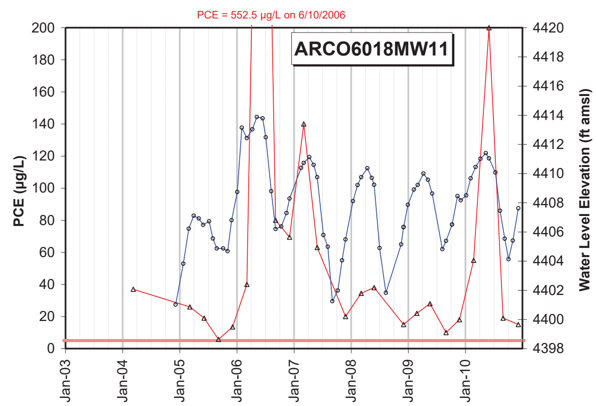
PCE Concentrations

PCE concentration trends and patterns (**Table 5.4** and **Graphs 5.3a**) observed in Mill/Kietzke key wells are described below.

- CTM13S (screened interval - 35.5 to 55.5 feet bgs):
  - PCE concentration in CTM13S exhibits a decreasing Mann-Kendall trend for the GMP period.
  - An inverse relationship exists between average annual water level elevation and PCE concentration prior to 2006.
  - This inverse relationship is not apparent after 2006. This may indicate that PCE concentration in this well becomes independent from water level.
  - There is no evidence for inter-related short-term changes in PCE concentration and short-term changes in water level.
  - The PCE maximum in this well (70.0 µg/L) occurred in 2004 Q1.
  - The highest PCE concentration during 2010 was 15 µg/L in Q1.
  - The decreasing PCE concentration trend is consistent with either a decreasing source term (assuming proximity to a source) that is independent of water level elevation OR a less concentrated portion of the plume having moved from the upgradient direction towards this well over the GMP period.
- ARCO6018MW11 (screened interval - 28 to 53.5 feet bgs):
  - PCE exhibits no Mann-Kendall trend over the GMP period.
  - PCE concentration exhibits recurring transient increases: 1,108 µg/L in March 2000 (prior to the GMP); 553 µg/L in 2004 Q1; and, 200 µg/L in 2010 Q2.

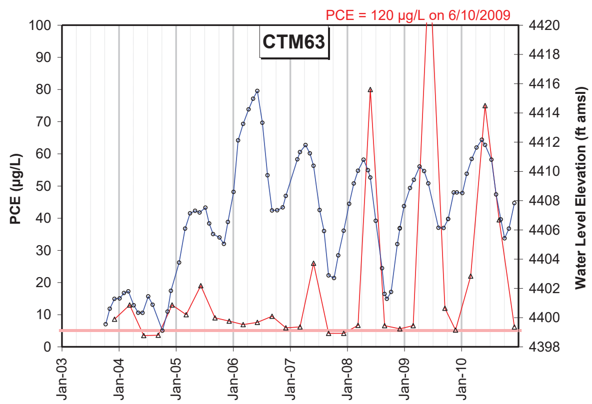
- These transient PCE increases are followed by a longer term decreasing PCE concentration trend that includes short duration increases in PCE that correlate with annual water level increases. These transient increases occur at about the same time as when water level elevation exceeds 4410 feet AMSL. The recurring transient PCE increases followed by a decay pattern is consistent with a residual source in the vadose zone or smear zone that episodically contributes PCE to groundwater when groundwater rises (given the positive correlation with groundwater elevation fluctuations) OR with recurring releases to the environment in the vicinity of this well.

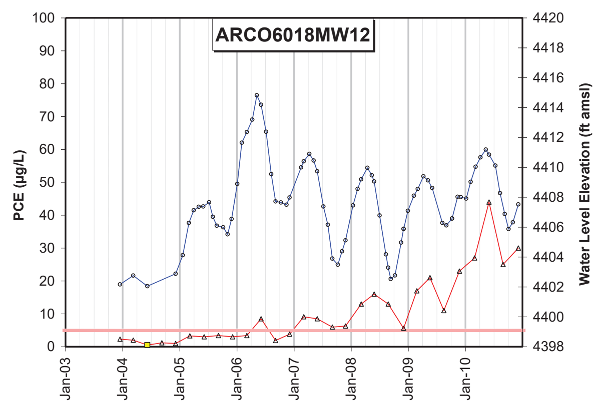




- CTM63 (screened interval - 36 to 56 feet bgs):
  - PCE data define no Mann-Kendall trend over the GMP period.
  - PCE in this well exhibits a recurring spiky pattern that positively correlates with annual water level maxima.
  - Relatively low PCE concentration levels through 2007 were followed by significant increases in 2008 and 2009.
  - The PCE maximum concentration in this well (120 µg/L) occurred in 2009 Q2. The highest PCE concentration observed during 2010 was 75 µg/L in Q2.
  - The recurring spiky pattern in PCE concentration is consistent with groundwater encountering a source of PCE in the vadose zone or smear zone (and correlating with annual water level maxima in this well beginning in 2007) that was less accessible to groundwater before that time OR groundwater with increased PCE encroaching on this well beginning in 2007.
- ARCO6018MW12 (screened interval - 28 to 53.5 feet bgs):
  - PCE exhibits an increasing Mann-Kendall trend over the GMP period.
  - The PCE and water level data are positively correlated. The recurring pattern observed in ARCO6018MW12 is generally similar to (but less dynamic) what is observed at CTM63.

- PCE data define two separate and distinct periods when elevated concentrations were present in groundwater at this location: up to 235.1 µg/L in September 2000 (prior to the GMP); and 45 µg/L in 2010 Q2.
- The relatively consistent long-term trend is consistent with a location further from a PCE source as compared to ARCO6018MW11 and CTM63.



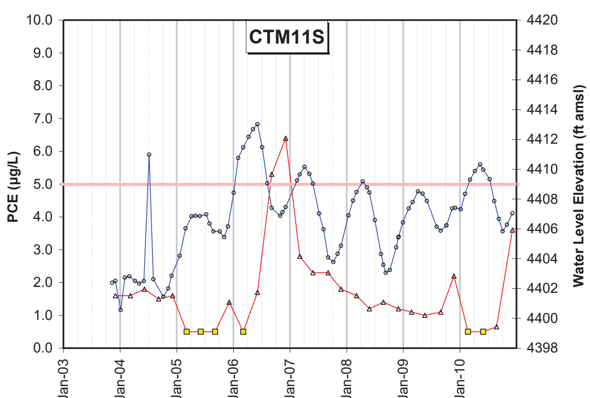


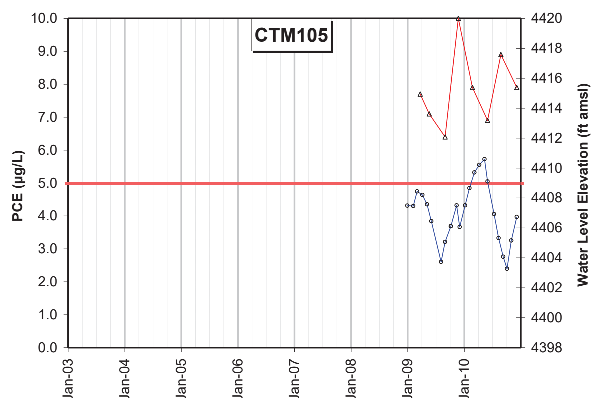
- ARCO6018MW16 (screened interval - 17 to 42 feet bgs):
  - PCE exhibits an increasing Mann-Kendall trend.
  - There is no evidence at this time for any consistent interrelationship between water level changes and PCE concentration in this well.
  - PCE was consistently below 1.4 µg/L prior to 2007.
  - PCE data define two separate and distinct periods when elevated PCE concentrations were present in groundwater at this location: a short period during 2007 Q2 and Q3 when PCE increased to 6.9 µg/L; followed by a period of relatively stable and lower concentration (approximately 2-3 µg/L) until 2010 when PCE increased to a maximum of 17 µg/L in Q3.
  - The separate PCE increases in this well could be downgradient effects of the transient PCE increases observed at ARCO6018MW11 and/or ARCO6018MW12.
- CTM11S (screened interval 25 to 45 feet bgs):
  - PCE data define no Mann-Kendall trend.
  - There is some evidence for an inverse short term interrelationship between decreasing water level and increasing PCE concentration in this well.
  - PCE data define three separate and distinct periods when elevated PCE was present in groundwater at this location: prior to 2005 when PCE reached a maximum of 9.8 µg/L (in 2001 Q2); a period during 2006 and 2007 when PCE increased to 6.4 µg/L (in 2006

Q4); followed by generally decreasing concentration until 2010 when PCE increased to 3.6 µg/L in Q4.

- The PCE time series for CTM11S is similar to what is observed at ARCO6018MW16. The separate PCE increases in CTM11S could be downgradient effects of the transient PCE increases observed at ARCO6018MW11 and/or ARCO6018MW12.

- CTM105 (screened interval – 89 to 97 feet bgs):
  - PCE data define no Mann-Kendall trend.
  - There is no obvious recurring pattern or consistent interrelationship between PCE concentration and water level elevation based on the two year period of record for this well.
  - The PCE maximum concentration in this well (10 µg/L) occurred in 2009 Q4. The highest PCE concentration observed during 2010 was 8.9 µg/L in Q3.
  - The higher PCE concentration at this well (compared to shallower cluster well CTM11S) is interpreted to indicate that the plume axis is deeper than the water table at this location.





- CTM38D (screened interval - 75 to 95 feet bgs):
  - PCE shows a decreasing Mann-Kendall trend.
  - Prior to 2010, PCE concentration and water level data are positively correlated and annual PCE maxima occur during periods of high groundwater elevation. In 2010, no positive correlation between PCE concentration and water level is evident.
  - PCE reached a maximum of 55 µg/L (in June 2001, soon after the well was constructed) before generally declining over the subsequent period of record. The highest PCE concentration observed during 2010 was 3.7 µg/L in Q1.
  - In contrast to most of the other wells in this subregion, CTM38D does not exhibit any indication for transient increases that could be attributable to recurring releases or

submergence of sources in the smear zone. The CTM38D time series shows a generally steady decrease from an initially high concentration and no apparent direct affects from the transient increases observed in upgradient wells (based on the data to date). This may result from CTM38D being located along a different flow path or there not having been a long enough period of record for the transient changes observed in the upgradient wells to manifest at this location.

The transient and episodic PCE concentrations present in multiple wells in this subregion are indicative of: 1) either residual sources in the smear zone or vadose zone that contribute PCE to groundwater when water levels rise; or 2) recurring releases from active or recently active PCE users.

5.8.7 Receptors

The potential receptor wells for the Mill/Kietzke plume include MILL, CORBETT, TERMINAL, HV3, HV5, and PEZZI. The definition of the downgradient lateral and vertical extent of the Mill/Kietzke plume is limited to the existing wells (located between the well cluster on Gould Street [CTM9S/CTM104] and the well cluster on Matley Lane near Mill Street [CTM39S/CTM38D/CTM107]). There are presently no monitoring wells that clearly delineate the downgradient extent of the plume.

It is not presently known if any municipal water supply wells have been impacted by the Mill/Kietzke plume. The current interpretation is that PCE impacts to the MILL and TERMINAL wells result from the Downtown Reno plume. The current interpretation is that the PCE impacts to the CORBETT well result from the South Reno plume. Considering the relatively high historical PCE concentration in CTM38D, a specific concern is that this plume extends further to the east and/or southeast and poses a threat to downgradient municipal water supply wells. These wells include HV3, HV5, and PEZZI. This threat is tempered somewhat by the fact that these wells are more than 6,000 feet downgradient from the presently defined leading edge of the Mill/Kietzke plume.

5.8.8 Mill/Kietzke Conceptual Model

The Mill/Kietzke plume is presently defined to exist only in the shallow zone and is interpreted to have formed from multiple sources. The plume is interpreted to have moved laterally to the southeast and to plunge in that direction. The impacts extend to depths of at least 56 feet in hot spot wells and to at least 97 feet near the downgradient extent of the plume. The Mill/Kietzke plume occurs at a shallower depth in the CTM aquifer system than the underlying deep zone Downtown Reno plume and there is presently no evidence to indicate that the Mill/Kietzke and Downtown Reno plumes are physically contiguous.

This Mill/Kietzke Subregion conceptual model discussion is based on the data presented in **Sections 5.8.1 through 5.8.7**. **Figure 5.23** is a schematic plan map that shows pertinent aspects of the subregion conceptual model. **Figures 5.21A** and **5.21B** are cross sections (updated from WorleyParsons, 2013) that schematically represent the hydrostratigraphy, the PCE distribution, and the potential plume migration pathways in and near this subregion. The southeastern-most (i.e. right hand side of the page) portion of these sections transects the Mill/Kietzke Subregion from northwest to southeast (passing through ARCO6018MW11 and near the MILL municipal supply well) to beyond the well cluster at CTM39S/CTM38D/CTM107D and the approximate downgradient extent of the Mill/Kietzke plume (see **Figure 5.22**; schematic line cs-cs').

Hydrogeology

Lithologic data define multiple, vertically distinct, laterally continuous hydrostratigraphic packages. The predominant material in the Mill/Kietzke Subregion is coarser grained. This generally coarser grained material (represented as Package A in **Figure 5.21A)** is characterized by cobbles and boulders (with sand and gravel) present at or near the land surface. Package A is immediately underlain by other hydrostratigraphic packages that, in this area, also consist of generally coarser grained material (sandy gravel, silty gravel with cobbles) with lesser amounts of interlayered finer grained material (silty clay, silt, and silty sand). The two packages (B(c) and C) immediately below A are indistinguishable from each other based on existing data. Packages B(c) and C occur from approximately 100 to 250 feet bgs. At depths greater than 250 feet bgs, Package D (a 120 foot thick sequence of generally finer grained material) is characterized by relatively thick layers and/or lenses of clayey silt to silty sand with one or more discrete sand and gravel intervals. The finer grained materials in Packages B(c), C, or D could act (as individual interlayers or by contributing to the anisotropy) to impede downward groundwater flow and contaminant transport on a local scale. The Mill/Kietzke plume is currently interpreted to occur in Package A and Package B(c).

In general, the Mill/Kietzke shallow zone and underlying Downtown Reno deep zone have similar groundwater flow patterns with both responding significantly to deep zone pumping. The observed differences in shallow zone and deep zone flow characteristics in this area result from lower vertical K than horizontal K (i.e. anisotropy of hydraulic conductivity) across the aquifer system. This anisotropy is interpreted to result from the lithologic variability (e.g., interlayering of finer and coarser grained materials) that is characteristic of the hydrostratigraphic packages in the CTM basin. Anisotropy is interpreted to be more significant in packages that are either highly heterogeneous (such as Packages B(c) and C) or in packages that contain a greater proportion of finer grained material (such as Package D). While these packages have potential for increased anisotropy, they do not include discrete mappable aquitards. Based on this characterization, the overall behavior in the Mill/Kietzke Subregion is consistent with a heterogeneous unconfined aquifer system.

Lateral Groundwater Movement

Natural shallow zone groundwater flow is toward the southeast. During times of sustained municipal water supply well pumping (which has commonly taken place in Q2 and Q3 since 2006) the shallow zone gradient flattens and forms a cone of depression induced by deep zone pumping. The implication of these dynamics is that deep zone pumping has the potential to influence lateral migration of the Mill/Kietzke plume. The development of a shallow zone cone of depression would draw contamination that has moved to the southeast back towards the northwest, reducing the rate of southeastward plume migration toward downgradient potential receptors.

Vertical Groundwater Movement

An upward vertical gradient exists between the Mill/Kietzke shallow zone and Downtown Reno deep zone when deep zone municipal water supply wells in the area are not pumping. A downward gradient develops in response to sustained deep zone municipal water supply well pumping. Over the course of the peak summer and fall water demand period, as much as 15 feet of associated shallow zone drawdown can occur. This indicates that there is at least local vertical hydraulic communication between the shallow zone and the underlying deep zone in or near the Mill/Kietzke Subregion. Differences in the magnitude of the shallow zone water level responses are interpreted to indicate that there is spatial variability in the hydraulic connection between the shallow zone and deep zone in this part of the CTM basin. Based on the generally larger shallow zone responses in wells located in the northern (CTM64, CTM13S, and CTM63, see **Section 5.8.6**) and western (CTM9S and CTM104) parts of the subregion, a more effective vertical hydraulic connection is indicated to be present in the northwest portion of the Mill/Kietzke Subregion.

A widespread shallow zone drawdown response to deep zone municipal pumping is considered evidence for vertical hydraulic communication between the shallow zone and deep zone and further evidence against an effective aquitard in this subregion. The rapid and generally concurrent response to deep zone pumping in both the shallow zone and deep zone is also interpreted to indicate generally good vertical hydraulic communication and to indicate against an effective intervening aquitard.

Evidence indicates that enhanced downward groundwater flow and PCE migration could potentially occur in the northwest part of the subregion. While no specific vertical conduits have yet been identified, this part of the subregion is where the cone of depression develops in the shallow zone in response to deep zone pumping.

Potential PCE Sources

Several PCAs have been identified the area north of Mill Street (**Figure 5.22**) and multiple potential PCE sources are indicated as a result of the work conducted to date. Key observations include:

- Transient high concentrations of PCE in the wastewater collection system (from 2000 through 2010);
- The presence of PCE in soil, soil vapor, and groundwater potentially associated with sewer line defects;

- Two persistent and distinct groundwater plume PCE concentration hot spots are located near the Kietzke Lane and Prosperity Street impacted areas;

- Recurring transient PCE increases in groundwater monitoring wells (e.g. ARCO6018MW11 and CTM63) suggest that either robust residual sources are periodically contributing PCE to groundwater or that ongoing discharges are occurring;

- A former corrective action site (Sierra Chemical) in the northwest corner of the Mill/Kietzke Subregion may have contributed PCE to groundwater (although PSG data do not indicate that to be the case);

- The ongoing Mill/Kietzke PSA investigation has identified four PCE high mass areas that represent potential contributing sources and are in part proximal to previously identified impacted areas; and

- Active soil gas sampling of three existing groundwater monitoring wells corroborate the high PCE mass defined by PSG surveys and indicate subsurface PCE vapor concentration that would result in groundwater concentrations that exceed the MCL.

These observations indicate that multiple sources exist and that multiple releases have occurred and contributed to the Mill/Kietzke plume. Based on wastewater sampling results from 2001 through 2010 and PSG results from 2003 and 2009-2010, elevated PCE has been present in this area for a relatively long period of time. This suggests that robust PCE sources are present in the subregion. Considering the thickness of the vadose zone in this area, the recurring transient increases in groundwater PCE concentration, and the significant fluctuations in water level that are observed, these sources could include either residual sources or ongoing discharges that continue to contribute PCE to the Mill/Kietzke plume.

Plume Formation and Distribution

The Mill/Kietzke plume is interpreted to originate from sources near upgradient hot spots (near CTM13S and ARCO6018MW11) and extend downgradient to the southeast at least as far as CTM38D and CTM39S. High PCE concentrations (1,108 µg/L at ARCO6018MW11; 70 µg/L at CTM13S) observed at these hot spots in the early 2000's indicates proximity to impacts from pre-existing PCE releases.

The occurrence and recurrence of high PCE concentrations in the plume hot spots (at monitoring wells ARCO6018MW11 and CTM63; which are proximal to PCAs, potential residual sources indicated by PCE high mass areas, and releases identified by Kleinfelder [2003]) is interpreted to indicate that PCE has been repeatedly released to groundwater from multiple sources since at least 1999. PCE contaminated groundwater then moves laterally to the southeast under the natural gradient. The presence of PCE in the deepest shallow zone well (CTM38D) located in the downgradient portion of the plume indicates that contaminated groundwater is also moving vertically downward into deeper portions of the shallow zone as it moves to the southeast (although the discrete transient concentration changes seen in upgradient wells are not recognized in CTM38D).

The lack of monitoring wells completed in the vertical interval between 100 and 270 feet bgs within the present outline of the Mill/Kietzke plume precludes delineating the vertical extent of the plume. Depth discrete sampling results (during drilling at CTM107) indicate that PCE contamination could exist as deep as from 85 to 165 feet bgs in the downgradient portion of the plume. While these results have not been verified, if they are accurate, they indicate that the Mill/Kietzke plume could have a substantial vertical thickness in the downgradient direction. Under this scenario, a relative large proportion of the Mill/Kietzke plume mass could have migrated, and could continue to be migrating to the southeast beyond MILL.

PCE Migration Mechanisms and Pathways

PCE in the Mill/Kietzke plume is interpreted to have originated or to be originating from multiple sources near the land surface or in the subsurface above the water table. The plume extends from multiple near source hot spots laterally to the southeast with a downward component in that direction.

Multiple sources are suggested by land use history and the near surface distribution of PCE mass defined by PSG data. This is corroborated by PCE data in shallow zone groundwater. The decreasing trend in CTM13S suggests a decreasing PCE source term contributing to that portion of the aquifer system where this well is completed. Conversely, transient and highly variable PCE in ARCO6018MW11 and CTM63 suggest recurring releases of PCE to groundwater from either residual sources or recurring releases. Evidence for transient releases of PCE is also observed in downgradient wells including ARCO6018MW12, ARCO6018MW16, and CTM11S. A correlation between PCE concentration and water level increases in ARCO6018MW11 suggests a possible relationship to a residual source in either the smear zone or vadose zone that contributes PCE to groundwater when the water table rises.

Relatively finer grained materials in hydrostratigraphic Packages B(c), C, and/or D (at depths between 100 and 360 feet bgs (as observed in MILL; **Figure 5.21A**) could contribute to vertical anisotropy that inhibits downward groundwater flow and PCE migration. An upward vertical gradient, present when municipal water supply wells are not pumping, would allow lateral groundwater flow and PCE migration along the predominant lateral gradient to the southeast. A downward vertical gradient, present when municipal water supply wells are pumping would create a potential for downward groundwater flow and PCE migration that would take advantage of any preferential pathways that are present in areas of reduced anisotropy. The significant shallow zone response to deep zone pumping in the northwest part of the Mill/Kietzke Subregion and apparent plunge of the Mill/Kietzke plume to the southeast indicate the potential for reduced anisotropy or presence of preferential pathways in those areas.

The formation of a shallow zone cone of depression in response to deep zone pumping is interpreted to draw contamination back towards the northwest providing further opportunity for PCE contamination to take advantage of vertical preferential pathways in the northwest part of the subregion. This cone of depression intermittently occurs in Q3 and has a northwesterly-directed magnitude that is similar to or less than the natural southeast gradient (that occurs during Q1, Q2, and Q4). The similar gradient magnitude, but relatively shorter duration of the cone of depression compared to the natural gradient indicates that the Mill/Kietzke plume has a net southeasterly migration. This supports the interpretation that the Mill/Kietzke plume is not entirely contained by deep zone pumping and at least a portion of the plume migrates to the southeast beyond MILL.

The possibility for a PCE contribution from the shallow zone Mill/Kietzke plume into the deep zone beneath the Mill/Kietzke Subregion cannot be ruled out at this time. While the principal PCE impacts to the MILL municipal water supply well are presently interpreted to originate from the deep zone Downtown Reno plume, the Mill/Kietzke plume could potentially contribute PCE to the deep zone and to MILL. This possibility is based on the recognition of a strong downward vertical gradient that develops during periods of deep zone pumping, the vertical shallow zone – deep zone hydraulic connection indicated by 15 feet of shallow zone drawdown, and the a shallow zone cone of depression that can develop in response to deep zone pumping.

Threats to Receptors

Recognizing that the vertical extent of the Mill/Kietzke plume has not been defined, MILL may be, or could become a receptor for this plume.

If the PCE migration pathway in this subregion is predominantly lateral and to the southeast, other municipal water supply wells are potential receptors for the Mill/Kietzke plume. Relatively nearby municipal water supply wells (such as TERMINAL, or perhaps CORBETT) could be impacted by this plume should it extend to the south and find vertical conduits that would allow PCE to reach those well screens. The likelihood of PCE impacts at TERMINAL or CORBETT by the Mill/Kietzke plume would increase if MILL were pumped less and TERMINAL and/or CORBETT were pumped more. Relatively distant but shallower municipal water supply wells (such as HV3, HV5, and PEZZI) could be impacted by this plume should it migrate to the east-southeast.

5.8.9 Summary

Multiple persistent and robust PCE sources in the Mill/Kietzke Subregion are interpreted to have contributed to and continue to contribute to the shallow zone Mill/Kietzke plume. This plume has migrated along the natural gradient to the southeast beyond the MILL municipal water supply well. Shallow zone drawdown response to deep zone municipal well pumping indicates that there is vertical communication between the shallow zone and deep zone in this general area. Deep zone municipal well pumping therefore provides a mechanism to drive downward movement of PCE assuming that a conduit is present or that enough time has elapsed. The larger shallow zone response to deep zone pumping in the northwest part of the Mill/Kietzke Subregion and apparent plunge of the Mill/Kietzke plume to the southeast indicate the potential for reduced anisotropy or presence of preferential pathways in those areas. However, a lack of wells screened in the interval between 100 and 270 feet bgs below the Mill/Kietzke plume footprint means that the vertical extent of the plume is undefined and that specific vertical PCE migration pathways (between the shallow zone and the deep zone in this area) cannot be delineated or confirmed.

PCE in the Mill/Kietzke plume poses a possible threat to potential receptors to the south and to the southeast. PCE from the Mill/Kietzke plume can also potentially be contributing to impacts to the MILL municipal water supply well.

5.9 Downtown Sparks Subregion

The Downtown Sparks Subregion encompasses PCE contamination that is principally within the lower portion of the shallow zone (i.e. the Victorian Avenue plume) but also within the deep zone (i.e. the Downtown Sparks plume) where it has impacted the SPARKS and POPLAR2 municipal water supply wells. A potential connection between the shallow zone contamination and the deep zone contamination is evident but not well defined. The Victorian Avenue plume is interpreted to have originated from multiple and distinct local sources along or near the Victorian Avenue corridor and may actually consist of multiple small plumes that have coalesced or may be in the process of doing so. The Downtown Sparks plume potentially represents PCE contamination originating as part of the Victorian Avenue plume that has moved vertically downward into the deep zone. Alternatively, the Downtown Sparks plume may have a distal upgradient origin that is unrelated to the Victorian Avenue plume source or sources. Receptors and potential receptors for these plumes include (with multiple screens that span the intervals shown in parentheses):

- SPARKS (150-272 feet bgs), a receptor to the Downtown Sparks and/or the Victorian Avenue plume;
- POPLAR2 (146-286 feet bgs), a receptor to the Downtown Sparks plume;
- POPLAR1 (453-645 feet bgs), a potential receptor to the Downtown Sparks plume; and,
- GREG (110-260 feet bgs), a potential receptor to the Downtown Sparks plume.

The extents of these plumes (particularly the deep zone Downtown Sparks plume) are presently not well defined.

5.9.1 Hydrogeology

The hydrogeology of the Downtown Sparks Subregion has been previously described (WorleyParsons, 2010, 2011, and 2013) based on working hydrogeologic sections prepared by DWR. Considering that no new hydrogeologic data were acquired for the Downtown Sparks Subregion in 2010, the following descriptions are based on the same information described in the 2009 GMP Annual Report (WorleyParsons, 2013) and from more recent cross section interpretation and construction by DWR. In general, the stratigraphy is flat-lying. The shallow zone hydrogeology in the Downtown Sparks Subregion can be generally described (from top to bottom) as follows:

- Package A. Predominantly coarser grained material (comprised of silty to sandy gravel, gravelly sand, silty sand with gravel) and lesser relatively thin, finer grained interlayers. Cobbles are common in more gravelly intervals. This package has a relatively wide range of matrix fines in both the lateral and vertical dimension that are interpreted to cause significant heterogeneity in hydraulic properties. The package extends from land surface to approximately 60 to 90 feet bgs. The water table surface occurs in Package A and generally varies from 15 to 20 feet bgs.

- Package B(f). Predominantly finer grained material (comprised of interlayered silty sand to silt or clay) with lesser coarser grained interlayers and lenses (sand and gravelly sand). The package is relatively highly interlayered. Package B(f) ranges from 140 feet thick near the east margin of the subregion and thins to 50 feet near the west boundary of the subregion (at VIEW). This package is considered to have lower vertical hydraulic conductivity than the super- and subjacent packages and accordingly has a greater potential to locally impede vertical groundwater flow. The base of Package B(f) is therefore interpreted to represent the separation between the shallow zone and the underlying deep zone. Package B(f) transitions to coarser grained Package B(c) laterally to the south at GALLETTI, 21ST, and GREG.

The hydrostratigraphy of the underlying deep zone is described (from top to bottom) below.

- Package B(c). Generally coarser grained material (comprised of sand and gravel) with finer grained interlayers and lenses (silt, sandy clay, or clay). The package has a moderate degree of interlayering and relatively high vertical variability that increases from west to east across the subregion. Package B(c) is interpreted to transition into finer grained Package B(f) from west to east and from south to north in the Downtown Sparks Subregion. Package B(c) and subjacent Package C, which is also comprised of generally coarser grained material (see below), are indistinguishable in the subregion. The combined thickness of B(c) and C ranges between 50 feet at MITCHELLTW to 180 feet at GREG (located approximately 700 feet south of this subregion). Package B(c) includes multiple transmissive, water-producing layers and corresponds to screened intervals in SPARKS, GALLETTI, 21ST, GREG, and potentially POPLAR2. Upper screened intervals in the VIEW and ELRANCHO are also interpreted to occur in this package.

- Package C: Generally coarser grained material (sandy gravel, silty gravel with cobbles) with limited finer grained lenses and interlayers (silty clay, silt, and silty sand). Package C underlies Package B(c) across the central, western and southern parts of the subregion (where it is indistinguishable from B(c), and the combined thickness of B(c) and C ranges between 50 and 180 feet). Package C underlies Package B(f) near the eastern boundary of this area where it can be defined as a distinct package and has a thickness of approximately 40 feet.

- Package D. Predominantly finer grained material (comprised of interlayers of clay, silt, and silty sand) with some coarser grained interlayers (sand, and gravel). Electric log profiles at VIEW and SPARKS distinguish this package as having thicker intervals with relatively lower resistivity compared to super- and subjacent packages. These low resistivity intervals are interpreted to represent relatively thick interlayers of finer grained material that have the potential to locally impede vertical groundwater flow. VIEW and ELRANCHO are interpreted to have screened intervals constructed in coarser grained interlayers within this package. Package D ranges from 50 to 100 feet thick in the subregion.

- Package sequence E, F, G. A sequence of packages that alternates between coarser grained material including gravel, gravelly sand, and sand, and finer grained material including silty sand, silt, and clay. Individual Packages E, F, and G (tentatively defined to the east in the East Sparks Subregion) are not currently distinguished in this subregion. Based on limited data for deeper parts of the subregion (at VIEW and POPLAR1) Package sequence E, F, G has a thickness of approximately 200 feet in the area. Lithologic logs and the distribution of screened intervals at VIEW and POPLAR1 suggest that a larger proportion of transmissive interlayers occur in the upper 100 feet of the package sequence compared to deeper parts. VIEW, ELRANCHO, and potentially POPLAR1 have significant thicknesses of screened intervals in the coarser interlayers within this package.

- Package V. Predominantly finer grained material (comprised of relatively thick layers of silty sand and clay) with lesser intervals gravelly sand. This package is only partially penetrated at VIEW. The relatively uniform geophysical properties in the vertical dimension as demonstrated by the VIEW E-log profile, and the markedly lower resistivity values for this interval, suggest that the package has generally uniform material properties and is significantly finer grained than other currently defined packages. No municipal water supply wells are screened in this package.

Gravity data interpretation (Widmer, 2005) estimates the depth to bedrock at approximately 650 feet near SPARKS and 750 feet near POPLAR1.

5.9.2 Groundwater Level Data

Quarterly potentiometric maps are presented in **Figures 5.2** through **5.9**. These maps include the Downtown Sparks Subregion and are the basis for characterizing lateral hydraulic gradients in the area. Groundwater level difference maps (**Figure 5.10**), cumulative groundwater level change data (**Figures 5.11** through **5.14**) and well cluster data (**Graphs 5.4b**) are the basis for characterizing vertical hydraulic gradients for the Downtown Sparks Subregion.

Lateral Gradients

Potentiometric maps for shallow and deep zone indicate that lateral groundwater flow in the Downtown Sparks Subregion was generally to the east-southeast in 2010. The lateral gradient direction and magnitude in 2010 varied with depth and as a function of the time of year.

Shallow Zone

The groundwater flow direction in the shallow zone was consistently to the east-southeast, generally parallel to the Truckee River, with a gradient of approximately 0.002 to 0.004 throughout 2010. The same shallow zone flow direction and similar gradient has been observed since the GMP was implemented in 2003. The water table elevation in the Downtown Sparks Subregion was generally comparable in 2010 to 2009 and averaged approximately 4,408 feet AMSL at CTM65 (corresponding to an approximate depth to water of 14.5 feet bgs).

Deep Zone

The groundwater flow gradient in the deep zone varies both temporally and spatially across the subregion depending on if and where deep zone pumping is taking place.

- In the western part of the subregion, the groundwater flow direction and gradient changed from generally to the east at approximately 0.001 in 2010 Q1 to nearly flat and locally to the west in Q2, Q3, and Q4, when a prominent cone of depression developed (starting at VIEW in Q2; coalescing around VIEW, KIETZKE, MILL, and MORRILL in Q3; and being locally observed at 4TH in Q4) west of the Downtown Sparks Subregion. This is similar to what has been observed in previous years when the lateral groundwater gradient in the deep zone flattens or reverses direction toward the west during periods of sustained pumping at wells located west of the subregion in the central part of the CTM basin.

- In the central and eastern part of the subregion, the gradient was consistently to the east-southeast with a magnitude in the range of 0.001 during 2010. In previous years when SPARKS, POPLAR1, and/or POPLAR2 were routinely used during peak demand periods in the summer and fall, a cone of depression developed and was centered on these wells during Q2 and Q3 causing the lateral gradient to converge toward the pumping wells. In contrast, no pumping occurred at these wells and no measurable cone of depression was observed in 2010

Vertical Gradients

Similar to what has been observed since the start of the GMP, the vertical gradient between the shallow zone and deep zone in the Downtown Sparks Subregion varies in direction and magnitude principally as a function of pumping operations. A relatively strong downward vertical gradient is induced during periods of sustained municipal water supply well pumping (typically in summer and fall). During periods when little no groundwater pumping occurs (typically in winter and spring) the magnitude of the downward vertical gradient is reduced or even reversed.

- In 2010 Q1, an upward vertical gradient was observed throughout the majority of Downtown Sparks Subregion (**Figure 5.10**) and was approximately 0.03 (based on data from well pair CTM65/CTM68).
- In Q2, a downward vertical gradient developed and persisted through Q4 with a maximum magnitude in the range of -0.10 (based on well pair CTM65/CTM68).

In the previous GMP annual reports (WorleyParsons, 2011 and 2013), it was observed that downward flow potential could be dominant as a consequence of regional pumping in the CTM basin even during years when limited pumping occurs at wells in the Downtown Sparks Subregion. During 2010, this was observed to be the case. The downward gradient starting in 2010 Q2 and persisting through Q4 coincides with regional pumping at nearby wells including VIEW, 21ST, ELRANCHO, and more distal wells including 4TH, KIETZKE, and MILL. Given that the average downward vertical gradient (-0.64) during and after summertime pumping was larger than the average upward gradient (0.03) after recovery in the winter, and that downward gradients existed approximately 75% of the time during 2010, the potential for downward flow predominated in the subregion even though no pumping occurred at SPARKS, POPLAR2, and POPLAR1.

There is vertical hydraulic communication between the shallow zone and deep zone in the Downtown Sparks Subregion based on the widespread shallow zone water level response to deep zone pumping when SPARKS, POPLAR1, and POPLAR2 are pumped for a sustained period. This is observed in all shallow zone key wells (see hydrographs for CTM65, CTM66, CTM67, and CTM68: **Graphs 5.4a**) between 2004 and 2008 when pumping occurred at one or more of these municipal water supply wells. The relatively small shallow zone drawdown response compared to the significantly larger deep zone response (see well cluster hydrographs, **Graphs 5.4b**) is interpreted to result from vertical anisotropy. Hydro Geo Chem, Inc. (2005) analyzed data from short duration aquifer tests and developed vertical hydraulic conductivity values for the materials in the shallow zone that ranged between 0.012 and 0.65 feet/day. Corresponding horizontal hydraulic conductivity values ranged from 0.64 and 8.2 feet/day near the water table and from 13.1 to 35.3 feet/day at depths coinciding with the municipal water supply well screens. These results indicate that the aquifer is anisotropic.

Similar to 2009, the 2010 water level data in the Downtown Sparks Subregion indicate relatively little shallow zone response to regional pumping. This is in contrast to the more obvious, widespread shallow zone drawdown observed in the area between 2004 and 2008 when SPARKS, POPLAR1, and/or POPLAR2 were routinely pumped (see well cluster hydrographs, **Graphs 5.4b**). This suggests that while regional pumping induces downward vertical gradients, local pumping at SPARKS, POPLAR1, and POPLAR2 has a much stronger influence on potential vertical movement of groundwater in the subregion. Observed maximum water level change for 2010 was 2.75 feet (CTM71) and 20.95 feet (CTM68) in the shallow zone and deep zone respectively.

5.9.3 Groundwater Sources and Sinks

Potential sources of recharge that could contribute to the Downtown Sparks Subregion water budget include mountain front recharge, groundwater inflow, deep zone well injection for aquifer storage and recovery, recharge along or near the Truckee River corridor (or other surface water features), infiltration from leaking water distribution and wastewater collection systems, infiltration from irrigation, and infiltration from direct precipitation. All of these recharge processes are likely to take place in the Downtown Sparks Subregion except mountain front recharge.

Precipitation and Truckee River flows for the GMP period are presented in **Section 5.3**. Average precipitation was 9.25 inches in 2010. This is an increase compared to 2009 (8.25 inches) and above the historical annual average (7.31 in/year) for the period of record (1937 through 2010; NOAA, 2011). Mean annual discharge for the Truckee River in 2010 (at the Reno gage) was 459.9 cfs. This is an increase compared to 2009 (354.9 cfs), but below the historical average annual discharge of 676 cfs for the period of record (1906 to 2010; USGS, 2011). As described in the 2008 and 2009 CTMRD GMP annual reports, the Truckee River has the potential to lose water to the aquifer in the Downtown Sparks Subregion given that the elevation of the river in this area is approximately 4,424 feet AMSL and the corresponding maximum groundwater elevation is at least 10 feet below the river (as observed at shallow zone well 21STMWS; located 1,000 feet north of the river; with maximum water level at 4,413 feet AMSL). No effort is made as part of the GMP to estimate potential groundwater recharge associated with precipitation or with mean annual river discharge.

Deep zone artificial recharge for ASR is typically conducted between November and March. In 2010 injection at SPARKS, POPLAR2, VIEW, GALLETTI and 21ST totaled approximately 65.6 MG compared to 125.5 MG in 2009. Injection in 2010 was the lowest since the inception of the GMP. Annual injection using these well is summarized below.

Downtown Sparks Annual Artificial Recharge History (in millions of gallons)						
Year	**Wells**					**Annual Totals**
	SPARKS	**21ST**	**POPLAR 2**	**GALLETTI**	**VIEW**	
2003	0.0	84.2	3.1	85.4	115.0	287.7
2004	0.0	56.1	14.4	71.2	195.0	336.6
2005	0.0	35.2	12.1	38.7	85.9	172.0
2006	0.0	49.1	0.8	56.9	65.7	172.4
2007	0.0	35.0	0.0	48.7	58.4	142.1
2008	6.2	50.2	0.0	73.2	94.9	224.5
2009	6.0	37.7	2.2	57.5	22.1	125.5
2010	1.5	29.7	0.9	13.5	20.0	65.6

Groundwater sinks in or near the Downtown Sparks Subregion include deep zone extraction from the SPARKS, POPLAR1, POPLAR2, 21ST, GALLETTI, and VIEW municipal water supply wells. The 2010 groundwater extraction was 336.9 MG. This occurred principally at VIEW with a smaller volume extracted at 21ST. In 2010, the groundwater extraction was more than in 2009 (80.1 MG), but was less than the average annual extraction (503.3 MG) for the GMP period. The 2010 Groundwater production conditions and annual pumping by these wells are summarized below.

Well Name	Pumping Start Date (2010)	Pumping End Date (2010)	2010 Groundwater Production (MG)	2010 Pumping Pattern
SPARKS	No pumping	No pumping	0.0	No pumping
POPLAR2	No pumping	No pumping	0.0	No pumping
POPLAR1	No Pumping	No Pumping	0.0	No Pumping
VIEW	May 17	October 8	326.7	Continuous
GALLETTI	No pumping	No pumping	0.0	No pumping
21ST	July 11	Aug 7	10.2	Intermittent

Downtown Sparks Subregion Annual Municipal Water Supply Well Pumping History (in millions of gallons)

Year	Wells						Annual Totals
	GALLETTI	21ST	VIEW	POPLAR1	POPLAR2	SPARKS	
2003	205.5	146.7	64.3	147.9	98.6	26.6	760.5
2004	125.0	109.7	84.4	20.7	66.9	0	432.3
2005	115.4	88.8	57.2	92.3	59.7	10.9	433.1
2006	127.1	99.5	57.6	0.0	63.7	7.1	382.7
2007	510.2	90.4	59.6	18.4	126.5	30.8	858.9
2008	73.4	24.7	167.8	67.3	286.9	93.8	742.2
2009	0.1	22.6	40.4	17.0	0.0	0.0	80.1
2010	0.0	10.2	326.7	0.0	0.0	0.0	336.9

As shown in the tables above, there have been substantial differences in the amount and location of recharge and pumping in this subregion during any given year, and particularly in the past two years. These differences have the potential to influence the hydrodynamics in the subregion and the potential movement of PCE mass in the affected areas. Similar to 2009, there was relatively limited pumping at SPARKS, POPLAR2, POPLAR1, 21ST, and GALLETTI compared to previous years. Unlike 2009, where the annual injection volume was larger than the annual pumped volume for these wells (as a group), there was a return to net extraction (i.e., pumping volume exceeded injection volume) in 2010. Except for 2009, there has always been a net removal of groundwater from these wells as a group in any given year.

Beginning in 1996 there has also been groundwater extraction and injection associated with the J.A. Nugget Tower 2 dewatering treatment system. This system effectively acts to redistribute water within the shallow zone of the aquifer system. The point of extraction is located approximately 700 feet due east of the SPARKS municipal water supply well and approximately 400 feet northeast of CTM70. The “injection point” is an infiltration gallery located approximately 365 feet west northwest of SPARKS and approximately 220 feet due east of CTM69. The extraction and injection rate for this system is relatively small and has varied over time from approximately 4 gpm to approximately 55 gpm. The highest rates occur during the winter/spring months when the water table is typically shallower than other periods of the year.

5.9.4 Data on Potential PCE Sources

Several PCAs (**Figure 5.24**) have been identified in or near the Downtown Sparks Subregion. These include numerous former or existing auto repair shops, dry cleaners, auto body repair and paint shops, and railroad maintenance facilities. Additional PCAs including current or former NDEP Corrective Action sites have been described in previous annual reports and are summarized below.

- **Harrah's Auto Collection PCE site**. This former Corrective Action site is located east of and downgradient from the Victorian Avenue and Downtown Sparks plumes and currently is not considered to have contributed to either of these plumes. The Harrah's site is described in the corresponding section for the East Sparks Subregion.

The J.A. Nugget, Tower 2 site is also shown on **Figure 5.24** as a PCE project site. As described in **Section 5.9.3**, this is a groundwater dewatering project where a relatively small amount of groundwater is extracted, treated, and injected into an infiltration gallery located east of the SPARKS municipal water supply well. As such, this project is not associated with a corrective action site or a PCE source release.

The Downtown Sparks PSA was delineated in 2008 to encompass the area (see **Figure 5.24**) where persistent and elevated shallow zone PCE concentrations have been observed. The PSA includes PCAs and possible residual subsurface sources that may have contributed to or that may be contributing to the Victorian Avenue and Downtown Sparks plumes. In 2008, DWR initiated the PSA investigation in order to:

- Characterize the magnitude and extent of shallow subsurface contamination in the PSA;
- Identify sources that may have contributed to or that may be contributing to the contamination;
- Assess the threat posed by that source (or sources) to groundwater; and
- Provide information to support a cost-benefit assessment of possible PCE source mitigation.

Results of the Downtown Sparks PSA investigation through 2010 are summarized below.

In 2008 and 2009, a three-phase passive soil gas (PSG) survey (Gore, 2008; 2009e, 2009f) identified five PCE HMAs (shown on **Figure 5.24**):

- The Prater/Sullivan HMA - along Prater Way (on either side of the intersection between Prater Way and Sullivan Lane);
- The 19th and Rice HMA – along Rice Street (between 18th and 20th Streets and between Prater Way and C Street);
- The 20th and A Street HMA – at the intersection of 20th and A Streets;
- The 16th Street HMA – along and east of 16th Street (between Victorian Avenue and C Street); and

- The 15th and Prater HMA – along and east of 15th Street (between Prater Way and E Street).

During early 2010, DWR's contract with the consulting firm performing the field work for the Downtown Sparks PSA investigation was terminated. As a consequence, further evaluation of this PSA was placed on hold.

5.9.5 PCE Concentration and Distribution Data

The shallow zone Victorian Avenue plume, as delineated by existing monitoring wells, overlaps with the outline of the deep zone Downtown Sparks plume. The current PCE distribution data indicate potential for a hydraulic connection and vertical continuity between the shallow zone and deep zone contamination, particularly in the vicinity of SPARKS. Whether or not deep zone contamination originates from the shallow zone Victorian Avenue plume, particularly at POPLAR2, has not been determined. **Figure 5.24** depicts both the Victorian Avenue and Downtown Sparks plume outlines and includes 2010 Q3 PCE concentration results.

Shallow Zone

Based on the existing monitoring well distribution, the shallow zone plume underlies the area bounded by A Street to the north, near Pittman Avenue to the south, 18th Street to the west and 13th Street to the east (**Figure 5.24**). The minimum western and eastern extents of the shallow zone contamination are defined by the NDOT and CTM70 wells, respectively. The southern extent of the shallow zone contamination is defined by LEGENDS (which typically only exhibits PCE contamination during Q1 each year), CTM77, and CTM78 (which have both had detections that are in the range of 0.50 and 1.0 µg/L during 2010). However, there are no wells beyond LEGENDS or NDOT to define the western extent of contamination. The northern extent of shallow zone contamination is delineated in part by the lack of PCE (results below the laboratory reporting limit) in wells ARCO2137M3 (screened 8.2 to 18.25 feet bgs) and CTM71 (screened 18 to 53 feet bgs). It is possible that PCE contamination exists beneath these two shallow-screened wells.

Based on the screened interval depths, PCE contamination is interpreted to occur primarily in the lower portion of the shallow zone (in the 60 to 120 feet bgs depth interval), in the area west and northwest of the SPARKS municipal water supply well. Monitoring wells in this area with screened intervals shallower than 50 feet bgs typically have PCE concentration below 1 µg/L. These include CTM69, CTM71, and CTM65. Wells CTM69 (screened 20 to 50 feet bgs) and CTM65 (screened 20 to 40 feet bgs) are otherwise within the apparent "footprint" of the shallow zone contamination, but are inferred to be completed near or above the plume margin.

To the east and southeast of SPARKS, PCE contamination occurs at a shallower depth and suggests a separate and distinct source from the source or sources that have contributed to the western part of the shallow zone plume. At CTM70 (screened from 19.5 to 49.5 feet bgs) PCE contaminated groundwater occurs downgradient from similarly constructed wells (CTM69, CTM71, and CTM69) with no PCE contamination. This indicates that multiple sources are likely to have contributed to the shallow zone PCE contamination in this subregion.

PCE detected in shallow zone wells CTM77 (screened 20-50 feet bgs) and CTM78 (screened 20-50 feet bgs) near POPLAR2 in 2010 Q3 was less than 1.0 µg/L. These detections (and the depiction of a larger plume extent to the south in 2010 Q3) are at least partly the consequence of better resolution provided by using a lower laboratory reporting limit starting in 2010 Q3 (0.5 µg/L from 1.0 µg/L). However, prior detections have also been observed at these wells (near the previous reporting limit of 1.0 µg/L). These combined results indicate that intermittent, low-level PCE contamination, (in the range of 1.0 µg/L or less), is likely to have existed in the shallow zone near POPLAR2 since the inception of the GMP. The shallow zone PCE contamination near POPLAR2 is considered to have an undefined and possibly different source compared to PCE contamination near SPARKS. This interpretation is based on the cross gradient position of this PCE contamination relative to shallow zone contamination near SPARKS.

New PCE concentration maxima, new minima, or statistically significant PCE concentration changes at key (or other important) shallow zone wells for the Downtown Sparks Subregion are highlighted on **Table 5.4.** Of the wells on **Table 5.4** with highlighted results, none of the PCE concentration changes in shallow zone wells were identified as important or notable (i.e., having changes in PCE concentration that potentially indicate a change in plume dynamics that could result in an increased threat and therefore constitute a significant data gap) during quarterly data assessment. This indicates that 2010 shallow zone PCE concentrations were relatively consistent with what has been observed since the start of the GMP. PCE concentration trends and patterns for the shallow zone wells are described in **Section 5.9.6**.

Deep Zone

The deep zone contamination is presently not well delineated because of the relatively few deep zone wells in the subregion. Deep zone PCE contamination observed at SPARKS municipal water supply well may be contiguous with shallow zone contamination and, if so indicates a local hydraulic connection between the shallow zone and deep zone in that area.

Based on the existing monitoring well distribution, the deep zone plume is interpreted to be elongated in a north-south direction. The presently defined plume has minimum extents corresponding to the area bounded by Victorian Avenue to the north, Glendale Avenue to the south, Rock Boulevard to the west and 14th Street to the east (**Figure 5.24**). Deep zone contamination is present in:

- CTM75 (screened 148 – 168 feet bgs);
- POPLAR2 (screened 146 – 286 feet bgs); and
- SPARKS (screened 150 – 272 feet bgs);

- But not in nearby CTM68 (screened 166 – 186 feet bgs).

This suggests that the heterogeneity has an influence on the distribution of PCE in the deep zone plume, particularly near SPARKS. Base on available data, it cannot be determined whether the deep zone contamination is contiguous between POPLAR2 and SPARKS.

Potentially significant changes in PCE concentrations at key (or other important) deep zone wells for the Downtown Sparks Subregion are highlighted on **Table 5.4**. None of the PCE concentration changes in deep zone wells in the Downtown Sparks Subregion were identified as important or notable (i.e., having changes in PCE concentration that potentially indicate a change in plume dynamics that could result in an increased threat and therefore constitute a significant data gap) during quarterly data assessment. This indicates that 2010 deep zone PCE concentrations were relatively consistent with what has been observed since the start of the GMP. PCE concentration trends and patterns in deep zone wells are described in **Section 5.9.6**.

5.9.6 Trends and Patterns in Water Levels and PCE Concentrations in Key Wells

Trends and patterns in water level and PCE concentration data observed in key wells for the Downtown Sparks Subregion are evaluated in this section. The key wells in this subregion are listed in **Table 5.1** (and depicted on **Figure 5.15**) and include:

- Shallow zone wells CTM65, CTM66, CTM67, and CTM70; and
- Deep zone wells CTM68 (near SPARKS), SPARKS, CTM75 (near POPLAR2), and POPLAR2.

Water level hydrograph/PCE concentration time series graphs for these wells are included in **Graphs 5.4a**. Time series groundwater elevations for key well clusters are plotted on **Graphs 5.4b**. **Table 5.4** summarizes PCE concentration and trend information for key (or other important) wells. Based on the well network review (as described in **Section 5.4.1** and detailed in **Appendix 5.1**), the following wells have been removed from the 2010 key well list.

- CTM68 was removed because it is constructed beneath the shallow zone Victorian Avenue plume and no PCE detections have been observed at this well since 2004. While this well helps delineate the bottom of the Victorian Avenue shallow zone plume, it does not meet the key well criteria as defined in **Section 5.4.1**.
- CTM74 was removed because it is constructed above the deep zone Downtown Sparks plume and no PCE detections have been observed at this well since it was installed in 2003. This well helps delineate the top of the Downtown Sparks plume but does not meet the key well criteria as defined in **Section 5.4.1**.

Water Levels

Shallow Zone Wells

The water level data from the shallow zone wells exhibit a longer term trend of generally increasing average annual water level elevation (in the range of 2 to 6 feet) between late 2003 and 2006 followed by a more gradual decreasing trend between 2006 and **2008 (in the** range of 1 to 3 feet). Beginning in 2008, average annual water levels increase through 2010 (in the range of 1 to 3 feet). These longer term trends are superimposed by recurring, fluctuating water level minima and maxima that coincide with periods of recovery and drawdown associated with municipal water supply pumping. Prior to 2009, fluctuations in these shallow zone wells had a regular recurrence (ranging between 2 and 8 feet) that correlates to pumping at POPLAR2, SPARKS, and potentially GALLETTI. Starting in 2009, annual fluctuations became relatively muted with no obvious pattern. This change corresponds to the lack of sustained pumping at POPLAR2, SPARKS, and GALLETTI during 2009 and 2010.

The trends and patterns observed in the water level data for the shallow zone key wells CTM65, CTM66, CTM67, and CTM70 indicate that these wells can be subdivided into two somewhat similar but separate groups. Each of these groups has water level variations and/or patterns that are more similar to the other wells within their group and distinct from the wells in the other group. Group A wells are distinct from Group B wells because (although their hydrographs have similar shape) Group A wells exhibit larger long term change and larger magnitude annual fluctuations than Group B wells. This is likely a reflection of Group A wells having a more direct hydraulic connection to deep zone pumping because of their deeper screen depths compared to Group B wells. The shallow zone water level hydrograph groups (based on the data shown on **Graphs 5.4a**) are discussed below.

Group A is comprised of CTM66 and CTM67. These wells are screened deeper and have greater response to municipal well pumping than the Group B wells. These wells exhibit a gradual increase of roughly 4 to 6 feet in approximate average annual water level between 2003 Q4 and 2006 Q2. Between 2006 and 2008, average annual water levels gradually decreased approximately 2 to 3 feet. Between 2004 and 2008, recurring water level fluctuations were observed once a year on the order of 6 to 8 feet. The timing of these fluctuations generally coincides with peak municipal well pumping (occurring in Q3 each year). During 2009 and 2010, these wells exhibited increasing water levels (in the range of 1 to 2 feet) and nominal fluctuation. The lack of recurring annual fluctuation in 2009 and 2010 correlates to the lack of sustained pumping at municipal wells in or near the Downtown Sparks Subregion. In 2010, water levels reached the maximum for the year in Q1 and Q2 and decreased by more than 1 foot in Q3 and Q4. The late season declines could represent a lagged drawdown the correlates to regional pumping that occurred from Q2 through early Q4.

Group B is comprised of CTM65 and CTM70. These wells exhibit a gradual increase of roughly 3 feet in approximate average annual water level between 2003 Q4 and 2006 Q2 followed by a gradual decrease of approximately 1 to 2 feet until the end of 2008. In 2009, the average annual water level increased by 1 to 2 feet. Prior to 2009, recurring water level fluctuations are observed once a year and are on the order of 2 to 4 feet. The timing of these variations generally coincides with peak municipal well pumping (occurring in Q3 each year). The absence of fluctuation in 2009 correlates to the lack of sustained pumping at municipal wells in or near the Downtown Sparks Subregion. In 2010, water levels reached the maximum for the year in Q1 and Q2 and decreased approximately 1 foot in Q3 and Q4. As with Group A wells, the late season declines could represent a lagged drawdown the correlates to regional pumping that occurred from Q2 through early Q4.

Water levels in all shallow zone key wells exhibit a longer term trend where peak elevations (for the GMP period) were attained in 2006 Q2. This is followed by a decreasing trend in water level until 2009. The water level peak corresponds with a period of greater than average annual precipitation in both 2005 and 2006. Also beginning in 2005, there was a drop in groundwater production in the CTM and a change to seasonal operation for the five PCE treated wells (changed from year-round pumping which occurred through 2004). Prior to 2005 annual municipal pumping in the CTM was approximately 5,000 MG/year (as high as 5,588 MG in 2001). In 2005 annual municipal pumping was 2,857 MG and has been less than 4,000 MG/year since 2004.

A similar pattern in water-level elevation fluctuation is exhibited in data from all of the shallow zone key wells. Prior to 2009, a recurring annual water level pattern is characterized by rising groundwater levels in the winter and spring (observed during Q4 and Q1), and falling groundwater levels in the summer and fall (observed during Q2 and Q3). This pattern coincides with the pumping of the POPLAR2 and SPARKS wells (and the other municipal water supply wells in the CTM) that typically occurred during summer months. During 2009 and 2010, the general increase in water levels and the absence of the annual water level pattern (observed in prior years) are consistent with the lack of sustained pumping at municipal water supply wells in the Downtown Sparks Subregion.

Deep Zone Wells

The water level data from the deep zone wells also exhibit a longer term trend of generally increasing water level elevation between late 2003 and 2006 (in the range of 10 to 15 feet). Average annual deep zone water level elevation (based on the data from these wells) was generally stable from 2006 through 2008. During 2009, deep zone wells exhibit an increase in average annual water level and leveled off in 2010. These longer term trends are superimposed by recurring, annual fluctuations in water level that regularly occur in these wells. While the magnitude of these fluctuations can range between 15 and 50 (or more) feet, the maxima regularly occur during Q1 or Q2 and the minima typically occur during Q3. The similarity in patterns (based on the data shown on **Graphs 5.4a**) observed in the water level data for the deep zone key wells CTM68 and CTM75 indicate that they belong in one group. This group is discussed below.

Group A as defined in the 2007 GMP Annual Report (WorleyParsons, 2010) consisted of CTM67 and CTM74. These wells have since been reclassified as shallow zone wells and are discussed accordingly in this report. The former Group B is herein renamed Group C to avoid confusion with shallow zone Group B discussed above. There is no longer a Group A comprised of deep zone wells in the Downtown Sparks Subregion.

Group C is comprised of CTM68 and CTM75. These wells exhibit a gradual increase of roughly 10 to 12 feet in approximate average annual water level between 2003 Q4 and 2006 followed by stable or gradually decreasing water levels through 2008. Recurring water level fluctuations are observed once a year and are typically on the order of 50 feet (or more) when either SPARKS or POPLAR2 is pumped. The timing of water level decreases generally coincide with municipal well pumping (typically occurring in Q2 and Q3 each year). During 2009 and 2010, these wells exhibit water level fluctuations of significantly smaller magnitude during municipal well pumping (in the range of 12 to 15 feet) compared to previous years. These annual fluctuations represent deep zone drawdown attributed to regional pumping and have a substantially smaller magnitude that reflects the lack of sustained pumping at SPARKS and POPLAR2 municipal water supply wells during 2009 and 2010.

A common pattern in water level elevation change is exhibited in data from both of the deep zone key wells. These recurring water level fluctuations are similar to patterns recognized in shallow zone wells and are characterized by rising groundwater levels in the winter and spring (observed during Q4 and Q1), and falling groundwater levels in the summer and fall (observed during Q2 and Q3). This pattern coincides with pumping of the POPLAR2 and SPARKS wells (and the other municipal water supply wells in the CTM) that typically occurs during summer months. During 2009 and 2010, the relatively smaller magnitude fluctuation in deep zone water levels and absence of fluctuation in shallow zone wells are the result of less sustained pumping at SPARKS and POLPAR2. The observed (but smaller) recurring decrease in water levels observed in 2009 and 2010 is interpreted to reflect regional pumping that began in Q2 and peaked in Q3.

PCE Concentration

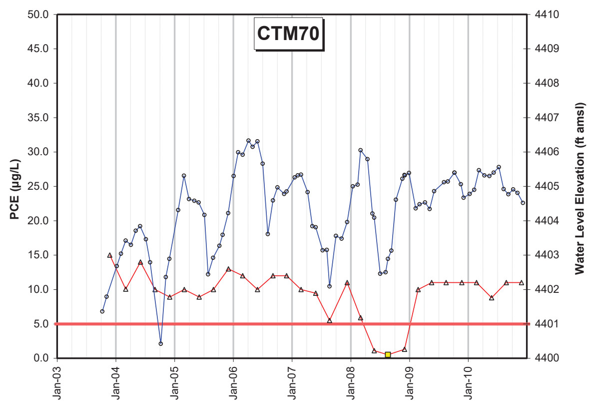
PCE concentration trends and patterns (**Table 5.4** and **Graphs 5.4a**) observed in the shallow zone and deep zone key wells are described below.

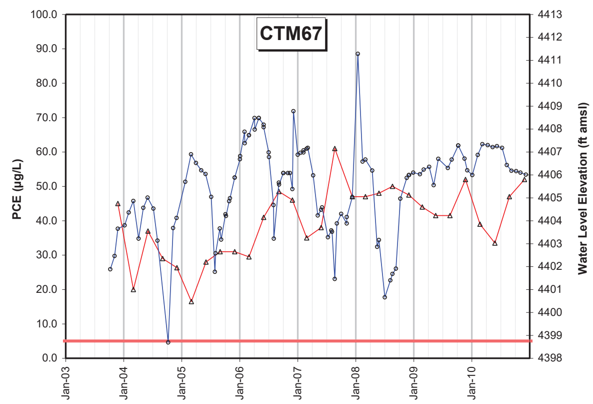
Shallow Zone Wells

- CTM65 (screened interval - 20 to 40 feet bgs):
    - PCE concentration defines no Mann-Kendall trend over the GMP period.

  - PCE concentration variations exhibit no obvious recurring pattern or interrelationship with changes in water levels.
  - PCE was not detected in this well above the laboratory reporting limit for the first 10 quarters of sampling (from 2003 Q4 through 2006 Q1). Between 2006 Q2 and 2007 Q2, a pulse of PCE contamination was observed at CTM65 where PCE was reported at concentrations up to 1.5 µg/L. Since 2007 Q2, PCE has only been detected above the laboratory reporting limit in 2010 Q3 at 1.0 µg/L.
  - The pulse of elevated PCE groundwater detected at CTM69 potentially moved downgradient and was encountered at CTM65 roughly one quarter later.
  - The PCE maximum (1.5 µg/L) in this well was observed in 2006 Q3.
- CTM66 (screened interval - 60 to 80 feet bgs):
  - PCE exhibits a decreasing Mann-Kendall trend over the GMP period.
  - Before 2009, there is some evidence to suggest a pattern in which a weak and possibly delayed increase in PCE concentration occurs after there has been an increase in water level elevation. Since 2009, there has not been an obvious correlation between PCE concentrations and water level changes.
  - The PCE maximum (9.5 µg/L) in this well occurred in 2004 Q2.
  - The highest PCE concentration observed in 2010 was 4.2 µg/L in Q3.
- CTM70 (screened interval - 19.5 to 49.5 feet bgs):
  - PCE defines no Mann-Kendall trend over the GMP period.
  - A positive correlation between PCE concentration and water level existed at this well until 2009. Since 2009, there has not been an obvious correlation between PCE concentrations and water level changes. The time series graph shows a relatively consistent PCE concentration during 2009 and 2010.
  - The PCE maximum (15 µg/L) in this well occurred in 2003 Q4.
  - The highest PCE concentration observed in 2010 was 11 µg/L in Q1, Q3, and Q4
  - The higher PCE concentration at CTM70 compared to upgradient shallow zone wells (CTM65, CTM69 and CTM71) is consistent with a distinct local source.
- CTM67 (screened interval - 101.5 to 111.5 feet bgs):
  - PCE exhibits an increasing Mann-Kendall trend over the GMP period.
  - There is evidence of a recurring pattern where PCE concentration inversely correlates to water levels. PCE decreases early each year when water level is high, then increases as water level decreases. Since 2007, this pattern still exists but is less obvious because water levels have had smaller annual fluctuations.

- The PCE maximum at this well occurred in 2007 Q3 (61 µg/L).
- The highest PCE concentration observed in 2010 was 52 µg/L in Q4.





Deep Zone Wells (Monitoring)

PCE concentration trends and patterns observed in the key deep zone wells are described below.

- CTM75 (screened interval - 148 to 168 feet bgs):
  - PCE defines no Mann-Kendall trend over the GMP period.
  - There is a positive correlation between PCE concentration and groundwater level. PCE concentration generally reaches an annual maximum in Q1 when water level is high and reaches an annual minimum when water level is low during periods of pumping. This interrelationship between water levels and PCE suggests that a local plume margin exists near the CTM75 screen interval and that during periods of pumping at POPLAR2, the plume is drawn away from CTM75 and potentially toward POPLAR2.
  - The PCE maximum (8.9 µg/L) in this well occurred in 2009 Q1.
  - The highest PCE concentration observed in 2010 was 5.3 µg/L in Q1 and Q2.
- CTM68 (screened interval - 166 to 186 feet bgs):
  - PCE concentration has been below the reporting limit for every quarter except in 2004 Q2 when PCE was reported at 0.71 µg/L.

Deep Zone Wells (Municipal Supply Wells)

Identifying and evaluating possible PCE and water level trends, patterns, and interrelationships in the municipal water supply wells can be problematic. The GMP water quality data are typically collected at water supply wells only during periods of pumping, and are intended to represent groundwater from the aquifer under steady state pumping conditions. Therefore PCE data do not represent a distribution of data that defines any recurring pattern or long term interrelationship between PCE data and water level for a given well. PCE concentration trends observed in deep zone municipal supply wells are described below.

- POPLAR2 (screened interval - 146 to 286 feet bgs):
    - The limited data set (11 data points) exhibits a decreasing Mann-Kendall trend over the GMP period. However, PCE concentration has increased since PCE was initially detected in 1987 (when the first sample was collected).
    - POPLAR2 is periodically used as an artificial recharge well. Therefore, PCE concentration trends and changes can be influenced by the water quality of injection water.
    - The PCE maximum at this well occurred after a brief pumping period in 2003 Q4 (6.8 µg/L). However, PCE concentration has been as high as 8.4 µg/L (2004 Q2) during the early stages of pumping.
    - No samples were collected at POPLAR2 in 2009 or 2010.
    - Based on high frequency (1 hour or less) time series samples (TMWA data provided to DWR) collected in 2004, PCE concentration is typically highest when the well is first pumped, decreases to below the MCL less than 5 hours, and stabilizes at approximately 2 µg/L or less after sustained pumping of a week or more.
    - The pattern where higher PCE concentrations occur at the onset of pumping that decrease and stabilize over a period of sustained pumping is consistent with either:
        - Cross contamination along the wellbore when POPLAR2 is not being pumped and a downward vertical gradient exists. In this scenario, PCE contamination originating from the upper part of the POPLAR2 well screen would move down the well in response to the downward gradient in the well, and would exit into the lower parts of the aquifer system; or
        - Lateral migration of PCE contamination beyond POPLAR2 when the well is not being pumped. In this scenario, PCE contamination would migrate laterally past the well and the plume would extend beyond the well in the downgradient direction.

    Under either scenario, a greater proportion of PCE contaminated water is drawn into the well during the early time when pumping commences. This results in higher PCE concentration for a period of time until the part of the contamination that migrated either vertically down or laterally past the well (during the period of non-pumping) is captured. After that period of time the PCE concentration stabilizes at a lower level that is more representative of the aquifer system under sustained pumping.

- SPARKS (screened interval - 150 to 272 feet bgs):
  - The limited data set (6 data points) defined no Mann-Kendall trend over the GMP period. However, PCE concentration has increased since PCE was initially detected in 1987 (when the first sample was collected).
  - SPARKS is periodically used as an artificial recharge injection well. Therefore, PCE concentration trends and changes can be influenced by the water quality of injection water.
  - The PCE maximum (6.1 µg/L) for the GMP at this well (after a brief period of pumping) occurred in 2003 Q4. An overall PCE concentration maximum of 20.7 µg/L was observed (2004 Q2) in a sample collected during the initial minutes of pumping by TMWA.
  - PCE concentrations were approximately 1 µg/L after sustained pumping in 2008.
  - No samples were collected at SPARKS in 2009 or 2010.
  - SPARKS was observed to have a similar short-term trend as POPLAR2 where PCE concentration was typically highest when the well is first pumped, decreased to below the MCL in less than 5 hours, and stabilized at approximately 2 µg/L or less after sustained pumping of a day or more. At SPARKS, this phenomenon was investigated (HGC, 2004) and interpreted to be the result of downward migration of PCE contamination in the well bore that: 1) originated either from a leak in the well casing, or from the upper part of the well screen, 2) moved down the well in response to a predominantly downward gradient across the screened intervals, and 3) exited into deeper parts of the aquifer. As pumping commenced (after a sustained period of non-pumping), PCE contaminated water that had cross-contaminated the aquifer system across the well screen was drawn back into the well, resulting in higher PCE concentrations during the first few hours of pumping. After several hours of pumping, the cross-contamination was extracted, and groundwater that is more representative of the aquifer system was extracted. As a result of the HGC investigation the well casing was repaired, potentially mitigating this issue.

5.9.7 Receptors

Shallow Zone Plume

SPARKS and POPLAR2 are receptors, or potential receptors for the Victorian Avenue shallow zone plume complex. However, data are not presently available to unequivocally determine whether the recognized PCE impacts at either of these municipal water supply wells are associated with shallow zone PCE attributed to the Victorian Avenue plume. The current interpretation is that at least a portion of the PCE impacts to SPARKS are attributed to local downward migration of the Victorian Avenue plume into the deep zone near SPARKS. This interpretation is based on the occurrence of highest PCE concentration (recognized at CTM67) in the area proximal to SPARKS and at a depth near the bottom of the shallow zone. The presence of a lower permeability interval acting as an impediment or partial impediment to vertical flow and transport may explain why PCE has not yet been detected in CTM68 (the deep zone well near CTM67, screened at the same depth as the upper screened interval at SPARKS). This condition (the presence of lower permeability material preventing significant downward PCE migration) may explain why PCE contamination at SPARKS has remained at relatively low concentration (generally less than 2 µg/L since 1987). .

Based on the shallow zone distribution of PCE near SPARKS, the identification of five PCE HMAs north and west of SPARKS (recognized during the Downtown Sparks PSA investigation), and groundwater modeling results by HGC (2005), PCE impacting SPARKS is considered to have originated predominantly from a shallow source or sources located proximal to that well.

It is not known whether any of the PCE impact at POPLAR2 is associated with the Victorian Avenue plume. Current interpretation is that the PCE impact observed at CTM75 and POPLAR2 are associated with the Downtown Sparks deep zone plume, which may or may not be contiguous with, and may or may not have similar contributing source areas as the Victorian Avenue plume. Based on the deep zone occurrence and behavior of PCE at CTM75, HGC (2005) concluded that the PCE contamination occurs at depths within the upper screened interval of POPLAR2. HGC also concluded that PCE contamination impacting the POPLAR2 well is more likely to have originated from distal sources, located upgradient and to the northwest, based on groundwater modeling. Travel time calculations and particle tracking analyses (HGC, 2005) suggested that distal upgradient sources could include PCAs that are up to 5,400 feet to the northwest of POPLAR2. The five PCE HMAs (discussed in **Section 5.9.4**) identified to the north and northwest of SPARKS are in this area and will be assessed as part of the Downtown Sparks PSA for their potential to contribute or to have contributed to PCE contamination that impacts SPARKS and POPLAR2.

POPLAR1 and GREG are potential receptors for both the Victorian Avenue and the Downtown Sparks plumes. Neither well has had recognized PCE impacts in the past. POPLAR1 is constructed deeper than either SPARKS or POPLAR2. Additional pumping at POPLAR1 would increase the potential threat to this well by increasing downward vertical gradients and provide a stronger driver for vertical flow toward POPLAR1. Similarly, additional pumping at GREG would increase the potential for PCE contamination from the downgradient portion of the Downtown Sparks plume to be drawn toward GREG. Since the plume is not delineated on the south or east margin, the threat posed to GREG is not well defined.

PCE at SPARKS has been detected since the well was first sampled in 1987. Concentrations have nominally increased since that time, ranging between 0.3 and 2 µg/L (during periods of sustained pumping). No samples were collected at SPARKS in 2009 or 2010. The gradual, but increasing PCE concentration at SPARKS, combined with the increasing PCE concentration trend at nearby shallow zone well CTM67, indicate a potentially increasing threat to the viability of SPARKS.

PCE at POPLAR2 has also been detected since the well was first sampled in 1987. Concentrations have nominally increased since that time. Prior to 1993, PCE averaged less than 1 µg/L. More recently (2007 and 2008), PCE concentration was in the range of 1.7 to 2.0 µg/L. No samples were collected at POPLAR2 in 2009 or 2010. The gradual, but increasing PCE concentrations during the past 20 years indicate a potentially increasing threat to POPLAR2.

5.9.8 Downtown Sparks Conceptual Model

The Downtown Sparks Subregion contains:

- Shallow zone contamination (Victorian Avenue plume) that potentially is contiguous with deep zone contamination in the immediate vicinity of and impacting the upper screened intervals at SPARKS; and
- Deep zone contamination (Downtown Sparks plume) at POPLAR2 that may or may not be contiguous with the deep zone contamination at SPARKS, and may not originate from the same source(s) as the shallow zone Victorian Avenue plume.

The Victorian Avenue plume is likely to have originated from multiple and distinct local sources (based on multiple and distinct hot spots that are laterally and vertically separated). The contamination from these multiple sources has potentially coalesced (or may be in the process of doing so) into a single plume in response to pumping at SPARKS and possibly at POPLAR2.

The Downtown Sparks plume has been suggested to have originated from a more distant and potentially distinct source (HGC, 2005). However, the Victorian Avenue shallow zone and Downtown Sparks deep zone plumes have partly overlapping outlines, and there is evidence for (at least local) vertical hydraulic communication between the shallow zone and deep zone in this subregion (based on the shallow zone water level response to deep zone municipal well pumping). Therefore, it has yet to be verified that these two plumes (as currently defined) are separate and distinct. The Downtown Sparks Subregion conceptual model that follows is based on the data presented in **Section 5.9.1** through **Section 5.9.7**.

Figure 5.25 shows a plan view schematic of pertinent aspects of the subregion conceptual model. . **Figures 5.26A and 5.26B** are schematic vertical cross sections representing the hydrostratigraphic conceptual model, and the PCE distribution and potential migration pathways for the Victorian Avenue plume.

Hydrogeology

The hydrostratigraphy consists of interlayered coarser and finer grained unconsolidated alluvial materials. Finer grained materials, considered to have generally lower vertical hydraulic conductivity, occur between approximately 120 to 165 feet bgs and are interpreted to locally impede vertical groundwater and PCE contamination movement from near the water table (i.e. the shallow zone) to the water bearing intervals in the underlying deep zone. Lateral continuity of these finer grained interlayers is unlikely considering the different depths where these materials occur within this interval. In the absence of a continuous and mappable aquitard layer, with the occurrence of the relatively small shallow zone drawdown response to deep zone pumping, the aquifer system in this subregion is considered to be heterogeneous and reflect behavior that is consistent with either an anisotropic unconfined or leaky confined aquifer system.

There are no known structural features (faults, or other possible flow barriers) that would potentially play a significant role in groundwater flow and contaminant movement in the Downtown Sparks Subregion.

Lateral Groundwater Movement

The shallow zone and deep zone have similar groundwater flow directions under natural (non-pumping and non-recharge) conditions. Water levels in both respond to deep zone pumping. However, the shallow zone response to pumping is significantly smaller than what is observed in the deep zone wells. As a consequence, lateral gradients are relatively uniform in magnitude and direction in the shallow zone, and are dynamic in both magnitude and direction in the deep zone. Groundwater flow in the shallow zone is consistently to the east-southeast, generally parallel to the Truckee River. Groundwater flow in the deep zone is also generally to the east-southeast during periods when no pumping occurs in or near the subregion. The deep zone gradient can flatten or even change to a westerly direction when a cone of depression develops in the central portion of the basin (to the west of the subregion) as a result of regional municipal water supply well pumping that normally occurs in that area during summer months. Likewise, the deep zone gradient can converge toward any given pumping well in the subregion (including SPARKS, POPLAR1, and POPLAR2) when they operate over a sustained period.

Vertical Groundwater Movement

The vertical gradient between the shallow zone and deep zone in the Downtown Sparks Subregion varies in direction and magnitude during the year. The observed vertical gradient is upward at times when no groundwater pumping occurs in the CTM. The gradient is downward when sustained pumping in the CTM is taking place and persists for several months after pumping has stopped. Upward gradient conditions typically occur in Q1 and Q4 when municipal water supply pumping is minimal, while downward conditions are typical in Q2 and Q3 when pumping increases. The significantly greater magnitude of the downward vertical gradient during pumping conditions compared to the upward gradient during non-pumping conditions indicates an overall net downward flow potential occurs in this subregion.

There is evidence for vertical hydraulic communication between the shallow zone and deep zone in the Downtown Sparks Subregion, at least locally, based on the shallow zone water level response (to deep zone municipal pumping) and on the occurrence of higher PCE concentrations in the lower part of the shallow zone near SPARKS (that indicates downward migration of contaminated groundwater). Spatial variability in drawdown response is interpreted to be the result of a combination of vertical anisotropy, differences in hydraulic properties of the hydrostratigraphic packages defined in the subregion, and the existence of local zones of enhanced hydraulic connection where downward groundwater flow and PCE migration are enhanced.

Potential PCE Sources

Multiple PCE sources are considered to have contributed and potentially continue to contribute to the Victorian Avenue and Downtown Sparks plumes. Multiple sources are interpreted to exist based on:

- Numerous PCAs located in the vicinity of, and upgradient (to the north and northwest) of the plumes;
- The heterogeneous distribution of PCE in groundwater, both in the vertical and lateral dimension; and
- The identification of 5 HMAs in this area (**Figure 5.24**).

Further work as part of the Downtown Sparks PSA investigation will characterize the nature of potential sources associated with the HMAs and assess the threat posed by those sources to ongoing groundwater contamination.

Plume Formation and Distribution

Based on the existing monitoring well network, shallow zone PCE contamination has been recognized in close proximity to both SPARKS and POPLAR2. The shallow zone plume extends over a distance of approximately 1,700 feet in both a west-to-east and south-to-north directions. The plume extent has not been defined in either the upgradient or downgradient directions, so actual lateral dimensions of the shallow zone contamination plume are unknown. The shallow zone plume occurs at highest concentrations in the lower portion of the shallow zone (approximately in the 60 to 110 foot depth interval) and in the vicinity of SPARKS. An inferred distinct source of PCE has contributed to the higher concentration, more shallow contamination intercepted by CTM70 to the east of SPARKS. Low-level shallow zone PCE contamination near POPLAR2 (at CTM77 and CTM78) is also considered to have a distinct source based on its crossgradient location from the PCE contamination near SPARKS.

The only deep zone well with detectable PCE in the vicinity of SPARKS is the SPARKS well itself. At least a portion of this contamination is interpreted to originate from the Victorian Avenue shallow zone plume that is locally drawn down into the upper part of the deep zone by SPARKS pumping. Based on the absence of PCE in CTM68 (screened from 166 to 186 feet bgs) located 140 feet west (upgradient) of

SPARKS, the deep zone portion of this plume is not well developed in this area. It is also possible that the Downtown Sparks deep zone plume also impacts SPARKS and occurs at a depth greater than CTM68.

PCE contamination in the deep zone near POPLAR2 occurs in the interval between 146 and 286 feet bgs (the depth interval containing the CTM75 and POPLAR2 well screens). While it is recognized that there are limited deep zone data points in the area, the Downtown Sparks plume is currently represented as being continuous across the area between POPLAR2 and SPARKS.

PCE Migration Mechanisms and Pathways

PCE in the Downtown Sparks Subregion is interpreted to be migrating:

- Vertically downward from nearby shallow zone sources and impacting SPARKS (completed in the deep zone); and
- Laterally in the deep zone from upgradient sources (that may or may not be the same sources of the Victorian Avenue plume) and impacting POPLAR2.

Downward vertical gradients during sustained pumping periods at municipal supply wells (typically Q2 and Q3) would facilitate downward vertical flow and PCE movement. Relatively finer grained geological materials recognized in the interval between approximately 120 and 165 feet bgs (as observed in SPARKS, POPLAR2, CTM68, and CTM75) potentially act as local impediments to downward vertical flow and PCE migration from shallow zone sources and/or areas of contamination. Lateral groundwater flow is considered the primary PCE migration mechanism during times when the municipal water supply wells in the area are not pumping (and when a downward vertical gradient does not exist). Upward vertical gradients during non-pumping conditions (typically in Q4 and Q1) combined with the natural lateral gradient would potentially contribute to PCE migration toward the east-southeast during those time periods.

The primary PCE migration pathway to the impacted SPARKS municipal water supply well is interpreted to be downward vertical migration of local shallow zone contamination into the deep zone in response to deep zone pumping. Downward PCE migration is likely to be the greatest when SPARKS and/or POPLAR2 are pumped.

The primary PCE migration pathway to the impacted POPLAR2 municipal water supply well is interpreted to be lateral migration of deep zone contamination that originated upgradient to the west/northwest (including the area that potentially contributes contamination to the shallow zone Victorian Avenue plume). Estimates based on travel time calculations and particle tracking analyses indicate that the contamination potentially could have traveled up to 5,400 feet in the deep zone before impacting POPLAR2 and could include PCE from as far away as the Downtown Reno plume.

Threats to Receptors

Existing data indicate that the SPARKS municipal water supply well is a receptor for the shallow zone Victorian Avenue plume and POPLAR2 is a receptor for the Downtown Sparks plume. However, there is uncertainty regarding the nature and extent of the deep zone Downtown Sparks plume and whether the deep zone contamination at POPLAR2 is contiguous with the contamination at SPARKS. Depending on the magnitude and extent of the Victorian Avenue plume and the Downtown Sparks plume, both pose a potential threat to the viability of SPARKS and POPLAR2. Nominally higher PCE concentrations in recent years, compared to PCE concentrations first observed at both wells in 1987 suggest a gradual increase in PCE mass in the vicinity of both wells.

Other municipal water supply wells such as GREG and POPLAR1 represent potential receptors for the Downtown Sparks plume. Recognizing that the magnitude and extent of contamination has not been defined, the threat to these potential receptors is also an important consideration.

5.9.9 Summary

Multiple sources in the Downtown Sparks Subregion have contributed to a localized shallow zone PCE plume along Victorian Avenue (the Victorian Avenue plume) that is interpreted to have been drawn vertically downward into the deep zone and impacted the SPARKS municipal water supply well. Shallow zone drawdown in response to municipal well pumping indicates that there is vertical communication between the shallow zone and deep zone in this area. Thus, municipal well pumping provides a mechanism for downward movement of PCE. It is possible that deep zone contamination (the Downtown Sparks plume) originated as far as 5,400 feet upgradient (northwest) of POPLAR2 and has moved laterally in the deep zone to impact POPLAR2. It is also possible that shallow zone PCE associated with the Victorian Avenue plume has migrated downward and contributed to impacts at POPLAR2. PCE from the incompletely defined Downtown Sparks plume has the potential to migrate and impact other potential receptors such as GREG (laterally downgradient) and POPLAR1 (deeper than POPLAR2).

5.10 East Sparks Subregion Data

The East Sparks Subregion encompasses the East Sparks plume complex which, as currently delineated, contains PCE contaminated groundwater limited to the shallow zone. This plume complex potentially originated from multiple and distinct local sources that include potential release sites at the Sparks Solvent Fuel Site (SS/FS), an ongoing corrective action site. These multiple potential sources (and perhaps other nearby potential sources), combined with the influences of remediation operations at the SS/FS, have resulted in PCE contamination that is interpreted to be segmented and discontinuous. The vertical dimension of the plume is not well defined since there are no deep zone wells in the plume area. The southern portion of the plume complex is located downgradient from a former PCE correction action site (the Harrah's Auto Collection site). This site may have also contributed and may continue to contribute contamination to the East Sparks plume complex.

The potential receptors to the East Sparks plume complex include six presently unused municipal water supply wells and Sparks Marina Park Lake (SMPL). The municipal water supply wells (with screens that span the intervals in parentheses) are:

- PRATERWAY (140-310 feet bgs)
- DILWORTH (180-370 feet bgs)
- STANFORD (also identified as NICHOLS, 215-650 feet bgs)
- MITCHELLTW (a test well, 158-408 feet bgs)
- SPARKSHIGH (140-330 feet bgs)
- SPARKSUMCTW (a test well, 117-427 feet bgs)

While currently not in operation, these wells eventually will be brought online at a date that depends on future groundwater supply demands on the TMWA municipal water supply system.

5.10.1 Hydrogeology

The following hydrogeologic description for the East Sparks Subregion is based on the southwest to northeast oriented cross-section f-f' (**Figure 5.27A**) developed by DWR. This cross section is based on principally on borehole data from GREG (an operating municipal water supply well) and STANFORD. GREG is approximately 1,000 feet southwest of the subregion while STANFORD is in the middle of the subregion. Additional borehole data for relatively shallow screened wells SSFSMW204, SSFSDWC302A, and VICTORIANMW were also used to develop the cross section. Like for other subregions, the characterization of hydrostratigraphy is presented in terms of hydrostratigraphic packages (herein termed packages), that while internally heterogeneous, are recognizable from well to well and can extend across any given subregion. The hydrostratigraphic packages are described (from top to bottom) as follows:

- Package A: Generally coarser grained material (comprised of silty to sandy gravel and gravelly sand), with lesser, relatively thin interlayers or lenses of finer grained material (silty sand and silt). Cobbles are common in the more gravelly intervals. This package has a relatively wide range of matrix fines in both the lateral and vertical dimension that potentially cause significant heterogeneity in hydraulic properties. The package is interpreted to extend across the entire subregion. Thickness increases slightly from west to east and ranges from between 75 feet near the west edge of the subregion to 110 feet at the SMPL. In the northern part of the subregion Package A can be thinner and is 60 feet thick at PRATERWAY. The water table exists in this package.

- Package B(f): Generally finer grained material (comprised of interlayered silty sand to silt or clay) with lesser sand and gravelly sand. Lateral variability exists, and is characterized by changes in the thickness and frequency of finer grained interlayers and lenses across the subregion. Discrete finer grained horizons are generally discontinuous (on the scale of 100s of feet) based on lithologic data from close-spaced roto-sonic boring data at the SS/FS site (CDM, 2008). This lateral variability is interpreted to influence the potential for vertical groundwater flow from the water table into deeper groundwater producing portions of the complex aquifer system. Package B(f) is interpreted to coarsen from STANFORD to the southwest and transition into generally coarser grained Package B(c) at GREG. This package is not defined in the east half of the subregion (where no lithologic data exist) and is difficult to extend to the north toward PRATERWAY and SPARKSUMCTW where limited data suggest that Package B(f) does not exist as a distinct package. Anisotropy is considered to be generally high but the potential for vertical groundwater flow is expected to be enhanced wherever more permeable layers are vertically juxtaposed (and therefore a conduit exists). This package can contain low permeable layers that constitute locally confining intervals that hydraulically separate the shallow zone from the deep zone. The package thickness ranges from approximately 50 feet at VIEW (in the Downtown Sparks Subregion) to greater than 140 feet at SSFSDWC303 (at the SS/FS). Thickness also increases from approximately 70 feet at MITCHELLTW, 105 feet at DILWORTH, and 120 feet at STANFORD. Package B(f) occurs beneath Package A and is interpreted to extent to a depth of approximately 210 feet bgs in the vicinity of the East Sparks plume complex.

The hydrostratigraphy of the underlying deep zone is described (from top to bottom) below. Package thicknesses can vary and are not be consistent throughout the subregion.

- Package B(c): Generally coarser grained material (comprised of gravel and gravelly sand) with thinner interlayers and lenses of sand and silty or clayey material. This package is relatively poorly characterized within the East Sparks Subregion because of its limited extent and the lack of deep zone lithologic data. It is currently defined only in the southwest and northwest parts of the subregion where is occurs in the same stratigraphic position (between Package A and Package C) as B(f). Based on its distribution across most of the Downtown Sparks Subregion, it is interpreted to be continuous along or near the mutually overlapping borders between the Downtown Sparks and East Sparks Subregion. While there has not been a significant thickness of finer grained material identified in this package in this subregion (causing Package B(c) and the underlying deep zone Package C to be indistinguishable here), the finer grained lenses or interlayers have lower hydraulic conductivity and would be expected to locally impede vertical groundwater movement through this sequence and from the shallow zone (i.e. Package A) into the underlying deep zone (Package C).

- Package C: Predominantly coarser grained gravelly material comprised of gravel, gravelly sand, and lesser sand. Gravel intervals can contain cobbles and boulders. The package is considered to have relatively low lateral variability and have the potential to transmit appreciable groundwater throughout its defined extent in the subregion. The package is considered to be laterally extensive. Anisotropy is expected to be relatively low due to the coarser grained character and relatively low number of interlayers in the package. Anisotropy may increase to the northwest from STANFORD to DILWORTH where increased finer grained intervals are identified in lithologic and geophysical logs. Package C thickness is approximately 30 feet at DILWORTH and 40 feet at STANFORD**.** At GREG, Package C is not distinguished from Package B(c) where the two packages comprise a total combined thickness of approximately 190 feet.

- Package D: Generally finer grained material (comprised of interlayered clay, silt, silty sand), and limited interlayers and lenses of coarser grained material (sand with lesser gravel layers). This package has a moderate to high degree of interlayering. Package D is defined at STANFORD, MITCHELLTW, DILWORTH, and GREG. The package is considered to be laterally extensive but has not been characterized in the northern portions of the subregion. Permeability in this package is considered to be relatively low with anisotropy expected to be high as a result of the significant proportion of finer grained interlayers considered to impede vertical flow. Thickness increases from northwest to southeast and is approximately 45 feet at MITCHELLTW, 70 feet at DILWORTH, and 80 feet at STANFORD. Based on an interpreted thickness of 105 feet at GREG, thickness may increase from north to south across the subregion.

- Package E: Generally coarser grained material (comprised of gravel, gravelly sand and sand) alternating with intervals of finer grained material (including sandy clay and clay). Permeability is considered to be relatively high within the coarser grained portions of the package. Anisotropy is expected to be moderate to high as a result of the alternating pattern of interlayered coarser and finer grained material that characterizes this package.

- Package F: Generally finer grained material (comprised of clay and sandy clay) with interlayers of coarser material (sand and gravel). The package is only identified at STANFORD and GREG. Thickness is approximately 75 feet at STANFORD and 70 feet at GREG.

- Package G: Generally coarser grained material considered to include gravel, gravelly sand and sand alternating with intervals of finer grained material described as gray clay or sandy clay. The package is only recognized at STANFORD and GREG. Thickness is at least 115 feet at STANFORD and 70 feet at GREG.

5.10.2 Groundwater Level Data

The 2010 regional potentiometric surface maps including the East Sparks Subregion are presented in **Figures 5.2** through **5.9**. These maps were used to characterize the lateral gradients in the subregion. Groundwater level difference maps (**Figure 5.10**), cumulative groundwater level change data (**Figures 5.11** through **5.14**) and well cluster data (**Graphs 5.5b**) are the basis for characterizing vertical hydraulic gradients for the East Sparks Subregion. The lateral and vertical gradient directions and magnitudes have been influenced over time by changes in various sources and sinks in or near the subregion. Mechanisms that have impacted gradients include groundwater dewatering operations at Helms Pit, groundwater pumping at STANFORD, remediation pumping at the SS/FS, and Truckee River flow (and the resulting stage height). Gradients resulting from each of these mechanisms are discussed below.

Lateral Gradients

Water level data from the late 1950s and early 1960s (USGS, 1964), presumably representing both shallow and deep zone wells, indicate that the lateral groundwater gradient was to the east/southeast with a magnitude of approximately 0.0025 prior to initiation of dewatering operations at Helms Pit in 1967. This general gradient direction and magnitude has been derived from a relatively small number of water level data points (USGS, 1964). STANFORD pumped from July 1961 through January 1967 (averaging 273.3 million gallons per year) and potentially resulted in a lateral gradient toward this well. STANFORD has only pumped a total of 78 million gallons since 1967 according to TMWA municipal water supply well pumping records. Before 1967, the lateral gradient direction could have been more southerly (toward the Truckee River) in the subregion during periods when STANFORD was not pumping and the Truckee River was a gaining and not a losing reach.

Dewatering occurred at Helms Pit from 1967 until the pit filled with flood water (creating the SMPL) in January 1997. The base of the pit is estimated to be 100 feet bgs. This pit depth indicates that dewatering operations potentially maintained the water level at 100 feet bgs and would have resulted in a lateral gradient direction toward the pit with the gradient magnitude being greater near the pit.

Pumping to maintain a constant lake level has continued at SMPL since 1997. This pumping has resulted in a shallow zone groundwater gradient direction to the east-southeast (toward the lake) over the GMP period through 2010. The observed shallow zone lateral gradient magnitude was relatively constant during the year and was 0.0030 during all four quarters in the vicinity of the plume footprint. The groundwater flow direction and gradient magnitude in 2010 were similar to previous years.

The lateral groundwater flow direction in the deep zone to the north of the SS/FS was to the southeast in 2010, based on a relatively few number of data points. The observed deep zone lateral gradient magnitude exhibited minimal variation during the year ranging from 0.0020 in Q1, 0.0011 in Q2, 0.0009 in Q3, and 0.0016 in Q4. This direction and magnitude is also consistent with previous years.

The stable lateral gradients since 1997 are potentially the result of:

- The lack of municipal water supply pumping in the subregion;
- The constant lake level at SMPL (maintained by pumping at the lake); and
- The relatively continuous groundwater extraction rate at remediation wells constructed in the shallow zone at the SS/FS.

Vertical Gradients

The vertical gradient between the shallow zone and the deep zone varies with time of year and location in the East Sparks Subregion (**Figure 5.10** and **Graphs 5.5b**). Water level data indicate that the gradient in the western portion of the subregion is more influenced by municipal water supply well pumping. Here, the gradient generally reverses from a natural upward gradient (in Q1), to downward during periods of sustained regional pumping to the west (typically in late Q2 and Q3), and returns to an upward gradient after regional pumping ends (in Q4). In contrast, the northern and eastern portions of the subregion are further from and therefore less influenced by regional pumping. In this area the vertical gradient remains upward throughout the year. This spatial and temporal pattern is consistent with the gradients observed since the GMP was implemented.

In 2010, the vertical gradients were as follows:

- In the western portion of the subregion (based on USGSDILWORTH/DILWORTH well pair):
  - Upward during Q1 and Q2 reaching a maximum of 0.0145;
  - Downward in Q3 and early Q4, reaching a minimum of -0.010; and
  - Becoming nominally downward by late Q4 (-0.0005).
- In the northern and eastern portion of the subregion (based on PRATERWAYMW/PRATERWAY):
  - Upward throughout the year, reaching a maximum of 0.056 in Q2 and a minimum of 0.026 in Q4.

As previously discussed, no deep zone wells exist within the footprint of the East Sparks plume complex. However, water level data (CDM, 2011a) for several shallow zone wells pairs indicate a persistent downward gradient between the upper portion and lower portions of the shallow zone. In the western part of the SS/FS (at MW228/DWC302A), the vertical gradient was downward (-0.0167) in June 2010 and downward (-0.0088) in December 2010. Further east, (at MW-TC-3/DWC311), the vertical gradient was downward (-0.0404) in June 2010 and also downward (-0.0437) in December 2010. Cumulative annual drawdown (**Figure 5.12**) in shallow zone wells ranged from approximately 0.5 feet to 2 feet in 2010. Cumulative annual drawdown in deep zone wells ranged from approximately 4 to 6 feet.

5.10.3 Groundwater Sources and Sinks

Potential sources of recharge that could contribute to the East Sparks Subregion include mountain front recharge, groundwater inflow, deep zone well injection for aquifer storage and recovery, recharge along or near the Truckee River corridor (or other surface water features), infiltration from leaking water distribution and wastewater collection systems, infiltration from irrigation, and infiltration from direct precipitation. All of these recharge processes are potentially occur in or near the East Sparks Subregion with the exception of mountain front recharge.

Average precipitation for the greater Reno area was 9.25 inches in 2010 compared to 8.25 inches in 2009, and above the historical average (7.31 in/year) precipitation year (NOAA, 2011). No effort is made as part of the GMP to estimate potential groundwater recharge associated with precipitation or mean annual river discharge. Data for artificial recharge of nearby municipal water supply wells (i.e., SPARKS, POPLAR2, GREG, VIEW, and ELRANCHO) are provided in the Downtown Sparks Subregion Data Evaluation section (**Section 5.10.3**) of this report.

Groundwater sinks in the East Sparks Subregion include pumping at remedial extraction wells at the SS/FS and groundwater discharge (through evaporation and discharge into the Truckee River) at SMPL. Groundwater extraction at the SS/FS (CDM, 2011b) and estimated groundwater discharge from the SMPL are provided in the following tables.

SS/FS Annual Remediation Groundwater Pumping History

Year	Average Pumping rate (GPM)	Monthly Average[1] (MG)	Annual Totals (MG)
2002	931.2	40.8	489.8
2003	902.8	39.6	474.8
2004	886.9	38.9	466.5
2005	866.6	38.0	455.8
2006	834.6	36.6	439.0
2007	804.0	35.2	422.9
2008	723.4	31.7	380.5
2009	721.6	31.6	379.5
2010	715.8	31.4	372.1

[1](assuming uniform monthly pumping rate each quarter)

Sparks Marina Park Lake Approximate Annual Discharge (in millions of gallons)			
Year			**Annual totals**
	DISCHARGE	**EVAPORATION**	
2002	576.8	124	700.8
2003	626.2	124	750.2
2004	525.2	124	649.2
2005	495.7	124	619.7
2006	693.6	124	817.6
2007	536.5	124	660.5
2008	776.7	124	900.7
2009	771.0	124	895.0
2010	876.4	124	1000.4

The hydrodynamics and water budget in this subregion are also likely to be influenced by regional municipal water supply well pumping at wells located to the west. This influence is evident in the vertical gradient dynamics (that reverse from upward to downward) in the west part of East Sparks Subregion caused by sustained pumping at nearby municipal supply wells. The following table provides a summary of municipal water supply well pumping that has taken place in or near the East Sparks Subregion. The only significant deep zone pumping that has occurred in the subregion was during the STANFORD pumping test in 2007. Deep zone pumping in this general part of the basin was relatively high in 2003 and 2008 (annual totals exceeding 400 MG), and relatively low in 2006 (less than 100 MG), 2009 (66.9 MG), and 2010 (65.9 MG).

East Sparks Subregion Vicinity Annual Municipal Water Supply Well Pumping History (in millions of gallons)							
Year	**Wells**						**Annual Totals**
	POPLAR1	**POPLAR2**	**GREG**	**SPARKS**	**STANFORD**	**ELRANCHO**	
2003	147.9	98.5	152.0	26.5	0.0	75.0	499.9
2004	20.7	67.0	89.9	0	0.0	25.7	203.3
2005	92.4	59.9	86.3	10.9	0.0	8.8	258.3
2006	0.0	63.7	0.8	7.2	0.0	28.2	99.9
2007	18.4	126.5	14.4	30.7	29.4	23.0	242.4
2008	67.3	286.9	53.5	93.8	0.0	28.3	529.8
2009	17.0	0.0	14.1	0.0	0.0	35.8	66.9
2010	0.0	0.0	12.4	0.0	0.0	53.5	65.9

5.10.4 Data on Potential PCE Sources

A number of PCAs have been identified in the vicinity of the East Sparks plume complex. These include former or existing automotive repair shops, auto paint shops, paint shops, chemical manufacturers, a railroad maintenance yard, and a dry cleaner.

As described in the 2009 GMP Annual Report (WorleyParsons, 2013), one ongoing and one former PCE-related NDEP corrective action site are located within the East Sparks Subregion. Summary information for these and other PCAs are summarized and updated below. No other previous solvent-related corrective action sites have been identified in this subregion.

- **The Sparks Solvent/Fuel Site (SS/FS)**. This ongoing corrective action site is located directly north of well SSFSMW204 (**Figure 5.24)**. The maximum PCE and TCE concentrations detected in groundwater beneath the site were 3,400 µg/L in 1992 and 1,500 µg/L in 1991, respectively. Investigation, monitoring, and remediation have been ongoing through 2010 at the SS/FS to address petroleum hydrocarbon, MTBE and chlorinated solvent contamination. Multiple extraction wells operate full time at this site and the total volume of groundwater treated in 2010 was 372.1 million gallons. The amount of PCE and TCE removed during remediation at the SS/FS is summarized in the table below (from CDM 2011b). The 2010 Q4 groundwater quality data from the SS/FS site (CDM, 2011a) are presented and discussed in conjunction with DWR 2010 Q4 data from the surrounding area in **Section 5.10.5**.

SS/FS Annual Solvent Mass Removal			
Year	**Water Treated (MG)**	**PCE Removed (pounds)**	**TCE Removed (pounds)**
2002	489.8	36.5	10.2
2003	474.8	31.0	8.9
2004	466.5	26.5	7.6
2005	455.8	24.8	7.1
2006	439.0	24.8	6.5
2007	422.9	25.6	6.4
2008	380.5	21.7	5.7
2009	379.5	21.1	5.3
2010	372.1	19.8	5.1

- **Harrah's Automobile Collection Site**. This is a former NDEP corrective action site located in the vicinity of Icehouse Avenue and west of SSFSMW204 (**Figure 5.24**). The following summary is derived from McGinley (2002):

- In 1988, PCE was detected in groundwater beneath the site at a concentration of 30 µg/L near the former plating shop.
- Additional monitoring wells were installed downgradient of the former plating shop and a maximum PCE concentration of 2,000 µg/L (in MW-4) was detected in 1995.
- In November 1996, soil vapor extraction and air sparging was conducted in close proximity to well MW-4.
- In July 1997, in-situ oxidation was used to remediate groundwater in close proximity to well MW-6 (Appendix 2-figure of the McGinley report).
- On September 3, 1997, PCE was detected in the farthest downgradient well MW-6 at a concentration 15 µg/L.
- On September 29, 1997, the NDEP issued a no further action letter.
- Information pertaining to the mass of PCE removed via remediation was not available in NDEP files. The extent and magnitude of the PCE plume was not established prior to no further action status being granted at this site.

- Wastewater sampling has been conducted as part of the SMP from 2005 through 2010 at the two active dry cleaners located in the southwestern (Coit) and northeastern (Silver State) parts of the subregion. The results of the SMP sampling are summarized in the table below. PCE has only been detected in one SMP sample collected downstream from Coit (13 µg/L, on 9/9/2005).

East Sparks Subregion SMP Sampling Results Summary

Sample Location	Coit (1)		Silver State (1)	
	Sample Date	PCE (µg/L)	Sample Date	PCE (µg/L)
	08/23/05	<1	08/23/05	<1
	09/09/05	13	09/08/05	<1
	04/12/06	<1	04/12/06	<1
	10/16/06	<5	10/16/06	<2
	04/30/07	<5	04/30/07	<5
	10/05/07	<5	10/05/07	<5
	04/11/08	<5	04/11/08	<5
	10/17/08	<5	10/17/08	<5
	04/13/09	<5	04/13/09	<5
	10/12/09	<5	10/12/09	<5
	04/23/10	<5	04/23/10	<5
	10/05/10	<5	10/05/10	<5

(1) sample collected from main at first manhole downstream from site lateral

5.10.5 PCE Concentration and Distribution Data

The East Sparks plume complex outline is represented in **Figure 5.24**. The segmented plume outlines were derived from PCE concentration data generated by CDM as part of the SS/FS site monitoring program in 2010 Q4 and DWR data collected in 2010 Q3. It should be noted that the segmented plume outlines are similar in shape compared to the previously contoured outlines derived for the 2008 and 2009 GMP Annual Reports (WorleyParsons, 2011 and 2013). The East Sparks plume complex occurs within an area extending east from Dermody Way/Pyramid Way to the SMPL and north from approximately Glendale Avenue to Victorian Avenue. The upgradient (west) extent is delineated by results below the laboratory reporting limit in well CTM19S. Through 2010, the downgradient extent of the PCE plume is undefined given that the plume extends to SMPL and is present in downgradient wells (DWC-312 at 4.6 µg/L, and MW-238 at 3.5 µg/L) located adjacent to SMPL. The northern extent of the plume is defined by wells MW-203, DWC-306, MW-TC-1, MW-234, MW-UMW-1, and MW-236. The southern extent of the plume lies beyond impacted wells SSFSMW204, SSFSMW205, and SSFSMW212 and is undefined.

SS/FS data include PCE concentration results from more than 70 monitoring wells at the site. Screen interval lengths for these monitoring wells range from approximately 10 to 120 feet (i.e., all screened in the shallow zone). Based on the combined monitoring well data, the East Sparks plume complex consists of disconnected plumes to the west and a coalesced plume in the downgradient direction to the east. The maximum PCE concentration in 2010 (Q4) for samples collected by DWR was at SSFSMW204 (35 µg/L). This well is screened from 13 to 53 feet bgs and is in the southwest portion of the subregion. The maximum concentration for samples collected by CDM in 2010 (Q4) was at DWC-315 (75 µg/L). This well is screened from 70 to 90 feet bgs and is located approximately 2,400 feet east of SSFSMW204. Also in 2010, PCE contamination was detected at 7.8 µg/L in MW-TO-4 (screened interval - 15 to 40 feet bgs) and at 11 µg/L in DWC-302 (screened interval - 92.5 to 102.5 feet bgs). Both of these wells are located on the SS/FS site within areas of relatively higher PCE concentration that have been represented as plume hot spots in previous GMP Annual Reports.

PCE has been observed in monitoring wells to a maximum depth of 119.5 feet bgs (in extraction well M2). Through 2010, there are no monitoring wells screened deeper than 119.5 feet bgs to define the vertical extent of PCE contamination in the shallow zone or to assess the potential for PCE contamination in the underlying deep zone. In 2010 Q4, PCE concentration results for well pairs indicate that concentration is greater with depth, as shown in the following table.

East Sparks Subregion Well Pair PCE Concentration Distribution (2010 Q4 data)			
Well Pair	**Well ID**	**PCE Concentration (µg/L)**	**Screened Interval (feet bgs)**
1	MW-228	ND	7-27
	DWC-302	11	92.5-102.5
2	MW-224	4.2	7-30
	DWC-305	11	70-90
3	MW-241	ND	6-36
	DWC-315	75	70-90
4	MW-239	ND	21-41
	M5	3.6	13.5-93.5
5	MW-225	ND	7-30
	DWC-310	9.2	77-97
6	MW-237	ND	5-25
	DWC-312	4.6	74.5-94.5

Potentially important PCE concentration changes at key shallow zone wells for the East Sparks plume are shown on **Table 5.4** and summarized below. Shallow zone key wells include SSFSMW204, SSFSMW205, SSFSMW207, and SSFSMW212.

- No new PCE concentration maxima for the GMP period of record were established at any of these key wells.
- A new PCE concentration minimum was established in 2010 Q3 at SSFSMW204 (3.8 µg/L). In 2010, PCE concentration at this well varied by almost an order of magnitude (3.8 µg/L to 34, 5 µg/L). Spikey, transient PCE concentration fluctuations are typical for this well. These large magnitude changes are consistent with either contamination near this well having heterogeneous PCE concentration, or with intermittent, recurring PCE contribution from a nearby residual or ongoing source.
- No new significant changes for the GMP period of record were established at any of these key wells.

5.10.6 Trends and Patterns in Water Levels and PCE Concentrations in Key Wells

Trends and patterns in key well water level and PCE concentration data are identified and evaluated in this section. The key wells for the East Sparks Subregion include shallow zone wells SSFSMW204, SSFSMW205, SSFSMW207, and SSFSMW212 (shown on **Figure 5.24**).

Water level hydrograph and PCE concentration time series graphs for these wells are plotted on **Graphs 5.5a**. Select graphs are embedded in the following text to illustrate trends or patterns discussed below. **Table 5.4** summarizes PCE concentration and trend information for key (or other important) wells. For 2010, the following wells have been removed or added to the 2010 key well list.

- CTM19S was removed because it is upgradient of the plume. While the well delineates an upgradient margin of the East Sparks plume complex, it does not meet any of the key well criteria defined in **Section 5.4.1**.

- SSFSMW205 and SSFSMW207 were added to the key well list because, in combination with key wells SSFSMW204 and SSFSMW212, they may help define plume dynamics influenced by planned changes in SSFS remediation pumping and by future municipal water supply pumping at the six currently unused water supply wells in the subregion.

Water Levels

The water level trends and patterns are similar in these four key wells. Average annual water level increased from 2004 to 2006 (increasing by 2 to 3 feet), then decreased from 2006 through 2010 (by 3 to 6 feet) Prior to 2009, a pattern of annual fluctuations with lows typically in Q3 or Q4 and highs in Q1 or Q2 is superimposed on the increasing and decreasing annual trends. This pattern coincides with peak pumping at regional municipal water supply wells in the basin. This pattern is better developed in SSFSMW204 which is farther west and closer to municipal water supply wells (including GREG, POPLAR1, POPLAR2, and SPARKS) and least developed at SSFSMW212 to the east. Starting in 2009, this pattern is not obvious compared to previous years, and potentially reflects the substantially lower pumping (described in **Section 5.10.3**) at municipal water supply wells located west of the subregion in 2009 and 2010.

PCE Concentrations

PCE concentration trends and patterns observed in the key wells are summarized below.

- SSFSMW204 (screened interval - 13 to 53 feet bgs):
    - PCE defines no Mann-Kendall trend over the GMP period.
    - Generally, there is a positive correlation between changes in PCE concentration and annual fluctuations in water levels at this well. PCE concentration exhibits a spikey pattern with annual maxima typically occurring in either Q1 or Q4 when water levels are increasing or relatively high and annual minima occurring when water levels are decreasing or relatively low.
    - The PCE maximum (89.5 µg/L) for this well occurred in 2007 Q1.
    - The highest PCE concentration in 2010 was 34.5 µg/L in Q1.

  - The spiky nature of the time-series data for SSFSMW204 is consistent with either consistent with either 1) contamination near this well having heterogeneous PCE concentrations that shift into and out of the well, or 2) intermittent, recurring PCE contribution from a nearby residual source or ongoing release.

- SSFSMW205 (screened interval - 18 to 58 feet bgs):
  - PCE exhibits a decreasing Mann-Kendall trend for the GMP period.
  - There is no recurring pattern in PCE data and no obvious interrelation between PCE and water level changes at this well.
  - The PCE maximum (11 µg/L) for this well occurred in 2004 Q1.
  - The highest PCE concentration in 2010 was 4.8 µg/L in Q1.
  - The PCE concentration trends and patterns at SSFSMW205 are dissimilar to upgradient well SSFSMW204, suggesting that they are on different flowpaths and cannot be used to estimate travel time in this part of the plume.
- SSFSMW212 (screened interval - 18.8 to 59.4 feet bgs):
  - PCE defines no Mann-Kendall trend over the GMP period.
  - There is no recurring pattern in PCE data and no obvious interrelation between PCE and water level changes at this well.
  - The PCE maximum (8.7 µg/L) for this well occurred in 2006 Q2.
  - The highest PCE concentration in 2010 was 5.9 µg/L in Q3.
  - PCE concentration has been relatively stable to gradually decreasing, ranging between 3.6 and 8.7 µg/L, over the GMP period.
- SSFSMW207 (screened interval – 17 to 62 feet bgs):
  - PCE exhibits an increasing Mann-Kendall trend over for the GMP period.
  - There is no recurring pattern in PCE data and no obvious interrelation between PCE and water level changes at this well.
  - The PCE maximum (3.5 µg/L) for this well occurred in 2004 Q1.
  - The highest PCE concentration in 2010 was 3.0 µg/L in Q3.
  - PCE concentration has been relatively stable, ranging between 1.6 and 3.5 µg/L, over the GMP period.

5.10.7 Receptors

There are presently no municipal water supply wells operating in the vicinity of the East Sparks plume complex. The current potential receptor is surface water in the SMPL. The closest municipal water supply well to the plume is STANFORD, located approximately 1,600 feet north of the nearest portion plume footprint. STANFORD is one of six unequipped municipal water supply wells (including DILWORTH, MITCHELLTW, PRATERWAY, SPARKSHIGH, and SPARKSUMCTW) located north, northeast, and northwest of the East Sparks plume complex with a combined capacity of up to 12,000 gpm (DWR, 2008). These wells would have a significant influence on the hydrodynamics in the subregion and would become potential receptors for the East Sparks plume complex they were brought online and pumped on a regular basis. A limited amount of sampling has occurred at these wells. STANFORD was most recently sampled in 2007 Q4 and PCE was not detected in this well above the laboratory reporting limit (1.0 µg/L). PRATERWAY, DILWORTH and SPARKSHIGH were most recently sampled in 2005 Q3 and PCE was not detected above the laboratory reporting limit (1.0 µg/L).

5.10.8 East Sparks Conceptual Model

The East Sparks Subregion includes segmented and potentially discontinuous PCE contaminated groundwater defined only in the shallow zone. However, no deep zone wells exist within the defined plume footprint to delineate the vertical extent PCE contamination. Based on available data, the plume complex extends to the east over a 5,000 foot length (from its western extent) in the downgradient direction to the area near the Sparks Marina Park Lake (SMPL). The plume complex is located south and east of six currently non-operating municipal water supply wells. These wells would become potential receptors should they pump on a regular basis.

One PCA (the SS/FS) has been identified as contributing PCE to the plume complex. Remediation to address chlorinated solvent contamination (PCE and TCE) has been underway at this site since the 1990s. Remediation activities include groundwater extraction and treatment in the central and eastern portions of the site. These remediation activities potentially have contributed to the segmented and potentially discontinuous nature of solvent contamination in this subregion. Other separate PCAs (including the Harrah's Auto Collection former corrective action site) exist in the subregion and could also have contributed to the segmented nature of contamination in the subregion. The SS/FS is located in the west portion of the subregion and is described in **Section 5.10.5** and shown on **Figure 5.24**. Harrah's Auto Collection is in the southwest part of the subregion (**Figure 5.24**).

This East Sparks Subregion conceptual model discussion is based on the data presented in **Sections 5.10.1 through 5.10.7**. **Figure 5.25** is a schematic plan map that shows pertinent aspects of the subregion conceptual model. **Figures 5.27A** and **5.27B** are cross sections (updated from WorleyParsons, 2013) that schematically represent the hydrostratigraphy, the PCE distribution, and the potential plume migration pathways in and near this subregion (see **Figure 5.24** for the location of the cross section line fs-fs').

Hydrogeology

Hydrostratigraphy is nearly flat-lying or has a nominal dip toward the east. The hydrostratigraphy is defined by multiple vertically distinct, laterally continuous hydrostratigraphic packages of unconsolidated alluvial material. Generally coarser grained material (comprised of gravel, sandy to silty gravel with varying amounts of matrix fines and local interlayers of finer grained sand and silt; represented as Package A) exists from ground surface to approximately 90 feet bgs. Underlying Package A is a generally finer grained material (comprised of sand and fine sand with discontinuous interlayers and lenses of silt or clay; represented as Package B(f)) that extends from approximately 90 to 210 feet bgs. Package A and B(f) comprise the shallow zone portion of the aquifer system in the part of the subregion where the East Sparks plume is defined. Beneath the shallow zone, deep zone hydrostratigraphy is comprised of sediments that alternate between coarser grained (groundwater-transmitting) and finer grained less permeable hydrostratigraphic packages. These packages are shown and described on **Figure 5.26A**.

While finer grained material in Package B(f) could impede vertical groundwater (and PCE) movement locally, there is no indication that this package represents a laterally continuous aquitard. Drawdown in shallow zone wells observed during regional municipal pumping and the STANFORD aquifer test provides direct evidence for local hydraulic communication between the shallow zone (in or above B(f)) and the deep zone. However, shallow zone drawdown is consistently smaller than what is observed in the deep zone. Shallow zone drawdown also has a non-uniform distribution relative to distance from the pumping well. These responses are considered to reflect the combined influence of local intra-package variation and the relatively distinct characteristics of hydrostratigraphic packages. As a result, in the absence of a mappable aquitard layer, the aquifer system has material properties and exhibits heterogeneous behavior that reflects hydrologic characteristics that can range from a heterogeneous and anisotropic unconfined to a leaky confined aquifer system.

Lateral Groundwater Movement

The general shallow zone flow direction is toward the east-southeast. Accordingly, the principal direction for potential PCE movement is expected to be to the east-southeast along with groundwater flow. Limited deep zone water level data (to the north of the SS/FS) indicate that the lateral ground water gradient (and the potential direction of PCE movement) in the deep zone is also to the east-southeast.

The lateral gradients in this portion of the CTM are likely to have changed over the past 50 years. Prior to the operations at Helms Pit (in 1967), the lateral gradient in the subregion could have been more southerly, toward the Truckee River, particularly during any period when the river was a gaining reach in the eastern part of the CTM. Historical pumping at STANFORD (in the early 1960s) would also have influenced gradients, resulting in local groundwater flow toward this well. After 1967, when dewatering operations began at the Helms Pit, the lateral gradient was likely toward the pit. When the pit was flooded (in 1997) the lateral gradient direction continued toward the pit (in an east-southeast direction), but is likely to have had a decreased magnitude (given that pumping at the SMPL has continued to maintain a higher and constant water level at the lake).

The historical variations in lateral gradient direction, combined with remediation pumping activities conducted at different locations with the SS/FS (since 1995) and the distribution of PCAs, would have contributed to the laterally discontinuous and segmented distribution of PCE contamination recognized in the subregion.

Vertical Groundwater Movement

Based on vertical gradient data from water level difference maps and wells pairs in the subregion, a downward vertical gradient occurs in the western portion of the subregion during periods of regional municipal water supply well pumping (typically in Q2 and Q3) that takes place to the west of the subregion. A shallow zone response to municipal pumping is also observed in the western portion of the subregion indicating vertical communication between the shallow zone and deep zone. The eastern portion of the subregion is further from operating municipal water supply wells and the vertical gradient remains upward throughout the year. However, the shallow zone response and downward vertical gradient recognized during the STANFORD aquifer test indicate that pumping at this well and the five other planned municipal wells (DILWORTH, PRATERWAY, SPARKSHIGH, MITCHELLTW, and, SPARKSUMCTW), located in and near the subregion, would have a significant influence on the direction and rate of groundwater flow and potential contaminant transport once they are placed in operation.

Similar to lateral gradients in the East Sparks Subregion, the vertical gradients in this subregion are likely to have changed significantly over the last 50 years. Prior to the operations at Helms Pit (in 1967) and municipal pumping in the CTM (in the 1960s), the vertical gradient in the subregion was most likely upward; similar to the currently observed natural gradient (observed during non-pumping periods). Historical pumping at STANFORD (from 1961 to 1966) would have resulted in a downward gradient in the vicinity of this well. After 1967, when dewatering operations began at the Helms Pit, the vertical gradient was likely convergent toward the base elevation of the pit; with a downward gradient between the water table and lower portion of the shallow zone, and an upward gradient between the deep zone and lower portion of the shallow zone. After the pit was flooded (in 1997), the downward vertical gradient between the water table and lower portion of the shallow zone is likely to have continued until the present, as a result of remediation pumping at SS/FS.

Potential PCE Sources

The SS/FS corrective action site has been identified as contributing PCE contamination to the East Sparks plume complex. One former corrective action site (Harrah's Auto Collection) is located upgradient (west) of the south portion of the plume complex and potentially could have (and may still be) contributing PCE contamination to this portion of the plume, based on relatively high PCE concentrations identified in groundwater at this site. Other PCAs including auto repair shops, dry cleaners, railroad maintenance facilities, and chemical manufacturing facilities have been identified in or near the East Sparks subregion.

Plume Formation and Distribution

The East Sparks plume complex includes laterally discontinuous PCE contamination that extends from the western part of the subregion (near MW-TO-4 and SSFSMW204) to the east toward SMPL. The horizontally segmented nature of PCE contamination is potentially the result of:

- The different lateral and vertical gradients directions and magnitudes that has existed over the past 50 years in the subregion;
- Groundwater remediation pumping conducted at different locations within the SS/FS; and
- The different locations of the active (SS/FS) and former (Harrah's Auto Collection) corrective action sites and other PCAs within the subregion.

PCE concentration data (as discussed in **Section 5.10.5**) indicate that PCE contamination has migrated downward, being more concentrated in the deeper screened well in well pairs located in the central and downgradient part of the plume. However, the vertical extent of groundwater contamination in the subregion is unknown since no wells are screened in the deep zone within the plume footprint. PCE has been detected in the deepest shallow zone monitoring wells installed to date (approximately 120 feet bgs).

Through 2010 Q4, there are no consistent trends in PCE concentration at the four key wells in the East Sparks Subregion. PCE concentration at upgradient well SSFSMW204 exhibits transient increases and the highest concentrations of any well monitored by DWR in the subregion. These results suggest that SSFSMW204 is more proximal to a contributing source area. PCE results at downgradient wells SSFSMW205, SSFSMW212, and SSFSMW207 are generally lower than SSFSMW204 and have substantially more uniform concentration over time. These results are consistent with these wells being more distal from a contributing source.

PCE Migration Mechanisms and Pathways

The predominantly upward vertical gradients (except for the western part of the subregion) and lack of operating municipal water supply wells in the subregion promote predominantly lateral migration of PCE within the shallow zone toward the east-southeast. The natural tendency toward east-southeast movement would be locally influenced by pump and treat activities at the SS/FS. These circumstances result in what is interpreted to be a relatively low potential for downward groundwater flow and PCE migration from the shallow zone (the portion of the aquifer system above approximately 210 feet bgs) into the deep zone under current hydrodynamic conditions. However, the vertical extent of PCE is currently undefined due to the lack of monitoring wells completed at depths greater than 120 feet bgs within the plume.

If the vertical extent of PCE is actually limited to approximately 120 feet bgs, this may be due to:

- The predominantly upward vertical gradient between the shallow zone and deep zone in this area; and/or,
- The vertical heterogeneity in hydrostratigraphic Package B(f) caused by the presence of finer grained interlayers between approximately 90 to 210 feet bgs, which would impede downward vertical groundwater flow and PCE migration.

There is the potential for PCE contamination to migrate below 120 feet bgs based on:

- A recognized downward hydraulic gradient in the west part of the subregion when municipal water supply wells to the west are pumping;
- Measurable shallow zone drawdown in response to deep zone pumping (as observed during the STANFORD aquifer test and during other municipal pumping to the west). Shallow zone water level responses in wells SSFSMW202, LINCOLNWAYMW, PRATERWAYMW, and SSFSDWC302A during the STANFORD well aquifer test indicate local vertical communication between the shallow zone and deep zone; and
- Higher PCE concentration detected in deeper shallow zone wells throughout the East Sparks plume complex.

The occurrence of higher PCE contamination in the lower portion of the shallow zone is interpreted to be the result of the combined effects of dewatering activities at Helms Pit prior to 1997 and the largely continuous groundwater pumping from the plume complex by SS/FS extraction wells (with screened intervals that extent to depths of up to 120 feet bgs). Both activities would facilitate downward vertical migration of PCE from near the water table to deeper parts of the shallow zone.

Threats to Receptors

Currently, no municipal water supply wells are operating near the East Sparks plume complex. However, if the STANFORD, DILWORTH, PRATERWAY, SPARKSHIGH, MITCHELLTW, and SPARKSUMCTW municipal water supply wells are put into production, the local hydrodynamics in the subregion would change.

Pumping at these wells could draw the contamination laterally to the north and vertically downward, creating a potential threat to these wells.

5.10.9 Summary

One or more sources (the SS/FS active correction action site and potentially the Harrah's Auto Collection former corrective action site) have contributed to a shallow zone plume that extends for approximately 5,000 feet in the downgradient direction from near Dermody Way (on the west) to the SMPL. The East Sparks plume complex is incompletely defined but includes the area downgradient of both the SS/FS site and f the Harrah's Auto Collection site. . Past and current groundwater gradients could have moved PCE contamination from the SS/FS to the southern portion of the plume complex. The groundwater gradients could also have moved PCE contamination from the Harrah's site (and possibly other PCAs) to southern portions of the plume complex.

Pumping at municipal water supply wells (SPARKS, POPLAR1, and POPLAR2) located to the west potentially creates a downward gradient that influences at least the western portion of this subregion. The shallow zone drawdown response observed during the STANFORD pumping test also indicates that there is vertical communication between the shallow zone and deep zone in the subregion. A downward vertical gradient is also observed between wells screened in the upper part of the shallow zone and the deeper part of the shallow zone at the SS/FS. These conditions indicate that a downward PCE migration potential exists and the plume complex either is or will move to deeper portions of the aquifer as long as the downward potential remains. Lithologic data indicate that finer grained material is not laterally extensive and an aquitard separating the shallow zone from the deep zone does not exist across the subregion.

Significant changes will occur to the hydrodynamics in the subregion once the six additional municipal water supply wells (STANFORD, DILWORTH, PRATERWAY, SPARKSHIGH, SPARKSUMCTW, and MITCHELLTW) begin operating. Operating these wells will provide a mechanism for lateral movement to the north and additional vertical downward movement potential. SMPL continues to be a potential receptor for PCE contamination in the East Sparks plume complex.

5.11 El Rancho Subregion

The El Rancho Subregion is intended to encompass the plume that has impacted the ELRANCHO municipal water supply well. To date, this plume has an undefined extent and magnitude with PCE contamination only having been detected in ELRANCHO and in the two monitoring wells located within 50 feet of ELRANCHO (all completed in the deep zone). The most significant PCE impacts occur in the aquifer system interval where the upper screen of ELRANCHO is located. PCE contamination has not been detected in the eight monitoring wells upgradient (i.e. to the west and northwest) of ELRANCHO

(**Figure 5.28 and 5.29**). PCE contamination has not been identified at depths less than 143 feet bgs (although there are no wells shallower than that proximal to or north of ELRANCHO).

Receptors of the El Rancho plume include (with multiple screens that span the interval in parentheses):

- ELRANCHO (143-360 feet bgs)

Potential receptors of the El Rancho plume include:

- VIEW (148-518 feet bgs);
- SPARKS (150-272 feet bgs), also a receptor to the Victorian Avenue and/or the Downtown Sparks plumes;
- SPARKSHIGH (140-330 feet bgs), an unequipped well; and,
- MITCHELLTW (158-408 feet bgs), an unequipped well.

5.11.1 Hydrogeology

The El Rancho Subregion is located near the northern margin of the CTM basin. Tertiary volcanic bedrock is exposed along the northern subregion boundary. The bedrock-basin fill surface contact is approximately 4,000 feet north of ELRANCHO. Bedrock elevation data (from borehole logs for CTM108, CTM111, CTM113, ELRANCHO, and several domestic wells) indicate that the bedrock surface has an apparent dip of approximately 10 degrees to the south. The overlying basin fill thickens to the south and east across the subregion. A subsurface bedrock high, identified based on geophysical data (DWR, 2007), is located approximately 5,000 feet west of ELRANCHO. From ELRANCHO, stratigraphy is interpreted to dip generally to the east at approximately 1 to 2 degrees.

The following description of hydrostratigraphy is presented in terms of hydrostratigraphic packages. The description is based largely on lithologic, geophysical and spinner logs for the ELRANCHO, VIEW, and MITCHELLTW municipal water supply and test wells, and on lithologic logs for the monitoring wells in the subregion. Other logs for nearby municipal water supply wells (i.e., SPARKS, SPARKSHIGH, POPLAR1, and GALLETTI) were also considered. The hydrostratigraphic packages are described (from top to bottom) as follows:

- Package A. Primarily coarser grained material (consisting of interlayered silty gravelly sand to sandy gravel with notable cobbly intervals) that extends from land surface to 40 to 60 feet bgs throughout the subregion. The water table generally occurs in this package. The depth to water varies from approximately 18 to 54 feet bgs (depending on location and time of year).

- Package B(f). Generally finer grained material (consisting predominantly of interlayered silty clay, silt, gravelly silt, silty sand) with lesser coarser grained interlayers (sand to gravelly sand). This package is approximately 90 feet thick at ELRANCHO and is distinguishable to the east and south where it is of similar thickness at MITCHELLTW and VIEW (4,500 feet east and 2,200 feet south of ELRANCHO respectively). This generally finer grained package is considered to have lower vertical hydraulic conductivity than the super- and subjacent packages and is interpreted to have the potential to locally impede vertical groundwater flow. The base of this finer grained package is therefore interpreted to represent the separation between the shallow zone and the underlying deep zone. This package is not recognized to the west and northwest of ELRANCHO.

The hydrostratigraphy of the underlying deep zone is described (from top to bottom) below.

- Package B(c). Generally coarser grained material (comprised of sand and gravel) with interlayers of silt, sandy clay, or clay. The package has a moderate degree of interlaying and correspondingly higher vertical variability. Package B(c) and subjacent Package C, which is also comprised of coarser grained material (see below), are indistinguishable in the subregion. The combined thickness of B(c) and C ranges from 50 feet at MITCHELLTW, to 70 feet at ELRANCHO, and 135 feet at VIEW. The package includes multiple, coarser grained water-producing layers that correspond to the upper screened interval in ELRANCHO and VIEW. SPARKS, GALLETTI, 21ST, GREG, and potentially POPLAR2 are considered to be entirely screened in this package.

- Package C. Generally coarser grained material (including gravel, silty gravel and gravelly sand). Package C underlies Package B(c) across the southeast part of the subregion proximal to ELRANCHO and to the south and east of the subregion. This package is not recognized to the west and northwest of ELRANCHO.

- Package D. Generally finer grained material (comprised of interlayered silt, silty clay, silty sand, and sand) with local, generally thinner layers of coarser grained material (sand to sandy gravel). This package is approximately 90 feet thick at ELRANCHO and extends to the east and south, decreasing in thickness to approximately 40 feet at MITCHELLTW. The middle screen of ELRANCHO (250 feet to 260 feet bgs) is constructed in a coarser grained interval in this package. This package is not recognized to the west and northwest of ELRANCHO.

- Package E. Generally coarser grained material (comprised predominantly of sand and gravel to gravelly sand) with lesser thin finer grained layers or streaks (of silt and/or clay) layers or streaks. This package is approximately 75 feet thick at ELRANCHO and extends to the east and south, increasing in thickness to approximately 110 feet at MITCHELLTW. The lower screen of ELRANCHO (300 feet to 360 feet bgs) is constructed in this package. Spinner logging (TMWA, 2003) and preliminary results from BESST well profiling (conducted in December 2010) at

ELRANCHO indicate that Package E is relatively more transmissive at this location and is the most significant groundwater producing interval in ELRANCHO. This package is recognized to the south, east, and to the west (at CTM 111) of ELRANCHO.

- Bedrock occurs at approximately 425 feet bgs in ELRANCHO; at 243 feet bgs in CTM108; and at 265 feet bgs in CTM113. The depth to bedrock is greater than 633 feet bgs (the boring depth) at VIEW (approximately 2,200 feet south of ELRANCHO).

It should be noted that except for Package A, the packages defined at ELRANCHO (and to the east and southeast of ELRANCHO) become indistinct in the west and northwest part of the El Rancho Subregion (at wells CTM108 through CTM115). The hydrostratigraphy in this area has yet to be placed into the context of hydrostratigraphic packages. The area to the west and northwest of ELRANCHO is comprised of a sequence of coarser and finer grained material that is in the same vertical position as Packages B(f), B(c), C, and D located at ELRANCHO and to the east and southeast. Thickness of this sequence is approximately 250 feet or less. This stratigraphy cannot be segregated into the distinct packages found to the south and east of ELRANCHO because the coarser and finer grained lenses or inter-layers are intermixed throughout the vertical thickness. This basin-fill material may be the result of deposition originating at separate sources such as bedrock which outcrops to the north and a fluvial source to the south. The sequence is vertically and laterally more heterogeneous than the corresponding packages at ELRANCHO, being generally coarser than B(f) and D, but finer than B(c) and C. There is substantially better vertical hydraulic communication across this sequence than across laterally correlative packages B(f), B(c), C and D to the south and east. This is based on water level data from shallow zone wells (constructed shallower than 100 feet bgs) that indicate a greater response to deep zone pumping in the area underlain by this sequence compared to other parts of the CTM basin.

5.11.2 Groundwater Level Data

Potentiometric surface maps are presented in **Figures 5.2** through **5.9**. These maps include the El Rancho Subregion and are the basis for characterizing lateral gradients. Quarterly groundwater level difference between the shallow zone and deep zone (**Figure 5.10**) and cumulative groundwater level change (**Figure 5.11** through **5.14**) in the shallow zone and deep zone, combined with the well cluster groundwater level data (**Graphs 5.6b**) provide the basis for characterizing vertical hydraulic gradients for the subregion.

Water level data have been collected under natural, pumping, and/or artificial recharge conditions. Artificial recharge (when recharge at municipal water supply wells can influence water levels) can occur in late fall through spring (Q4 into early Q2) and pumping (when deep zone municipal water supply well pumping can influence water levels) typically occurs in the summer and early fall (Q2 and Q3). Natural conditions (when pumping or artificial recharge stresses are not impacting water levels) commonly occurs in late spring (Q2). The gradients observed in this subregion are described below.

Lateral Gradients

Prior to 2010, quarterly groundwater level contour maps that depicted contours in the El Rancho Subregion were created using data that were largely outside the subregion boundaries. Based on these pre-2010 contour maps, the shallow zone flow direction was indicated to be toward the southeast throughout the year, while deep zone flow direction was to the southeast in Q1 and Q4 and changed to a south direction in Q2 and Q3. The installation of eight new monitoring wells in the subregion in 2009 Q4 provide better gradient resolution as described below.

Shallow Zone

The lateral groundwater flow direction and hydraulic gradient exhibit variability caused by the operation of municipal water supply wells ELRANCHO and VIEW.

- During 2010 Q1, recharge occurred at ELRANCHO and VIEW and the lateral gradient (**Figure 5.2**) was approximately 0.004 to the southeast.
- Recharge activities at these wells stopped in late Q1 (VIEW) and early Q2 (ELRANCHO) and pumping did not start until mid Q2 (VIEW) and late Q3 (ELRANCHO). The lateral gradient during Q2 was approximately 0.004 to the southeast (**Figure 5.4**). While this gradient may approximate natural conditions, it represents a period immediately after more than three months of artificial recharge that is complicated by concurrent pumping at VIEW.
- During 2010 Q3 and Q4, pumping occurred at VIEW (for approximately five months) and at ELRANCHO (for approximately seven weeks total over two separate periods). The lateral gradient during this time was 0.015 to the southeast (from CTM115 toward ELRANCHO). The potentiometric maps (**Figure 5.6** and **Figure 5.8**) show a cone of depression forming in the shallow zone near ELRANCHO in Q3 and a lateral gradient toward ELRANCHO through Q4.

Deep Zone

The groundwater flow direction and gradient in the deep zone also exhibits variability caused by municipal water supply well operation.

- During 2010 Q1, recharge occurred at ELRANCHO and VIEW and the lateral gradient was approximately 0.003 to the southeast. Groundwater mounding may occur near ELRANCHO and VIEW during recharge but it is not evident on the 2010 Q1 deep zone potentiometric map (**Figure 5.3**).
- Recharge activities at these wells stopped in late Q1 (VIEW) and early Q2 (ELRANCHO) and pumping did not start until mid Q2 (VIEW) and late Q3 (ELRANCHO). The lateral gradient in Q2 (based on June data, as shown in **Figure 5.5**) was approximately 0.002 to the southeast. While

this gradient may approximate natural conditions, it represents a period immediately after more than three months of artificial recharge that is complicated by concurrent pumping at VIEW.

- During 2010 Q3 and Q4, pumping occurred at VIEW (over a roughly five month period) and ELRANCHO (pumping for roughly seven weeks total over two discontinuous periods between September and December) with the lateral gradient increasing to 0.015 and shifting to the south. The potentiometric maps (Figure 5.7 and Figure 5.9) show a cone of depression forming with the gradient converging on ELRANCHO and VIEW. The deep zone cone of depression is greater in magnitude and larger in extent than the concurrent shallow zone cone of depression.

Vertical Gradient

Prior to 2010, there was insufficient well data distribution to characterize quarterly vertical gradients between the shallow zone and deep zone in this subregion. For 2010, the vertical gradient between the shallow zone and deep zone was calculated using groundwater elevation data for the new cluster wells (installed in 2009 Q4) located to the west and northwest of ELRANCHO. The following bullets describe the vertical gradient calculated between the shallowest and deepest well at each of the three well clusters in the subregion during 2010. Negative numbers indicate a downward vertical gradient and positive numbers indicate an upward vertical gradient.

- The vertical gradient at CTM115/CTM108 was:
    - -0.009 in Q1;
    - -0.039 in Q2;
    - -0.227 in Q3; and,
    - -0.114 in Q4
- The vertical gradient at CTM112/CTM111 was:
    - 0.004 in Q1;
    - -0.012 in Q2;
    - -0.122 in Q3; and,
    - -0.047 in Q4.
- The vertical gradient at CTM114/CTM113 was:
    - 0.009 in Q1;
    - -0.009 in Q2;
    - -0.144 in Q3; and,
    - -0.058 in Q4.

The gradient data indicate that either an upward or slightly downward gradient occurs during recharge (Q1 in 2010), and a downward gradient exists the rest of the time (Q2 through Q4 in 2010). The maximum downward gradient occurs in Q3 and coincides with sustained pumping at VIEW and ELRANCHO. The maximum cumulative shallow zone drawdown was approximately 26 feet (in both CTM112 and CTM114) as of early October 2010. This cumulative shallow zone drawdown is approximately 50% of the concurrent deep zone drawdown in this subregion. The cumulative shallow zone drawdown observed in the El Rancho Subregion is almost twice as much as what has been observed in other parts of the CTM basin. This indicates a better vertical hydraulic connection in the El Rancho Subregion (or at least the northwestern portion thereof) compared to the other GMP subregions.

5.11.3 Groundwater Source and Sinks

Potential sources of recharge that could contribute to the El Rancho Subregion water budget include mountain front recharge, groundwater inflow, deep zone well injection for aquifer storage and recovery, infiltration from the lakes at Paradise Park (or other surface water features), infiltration from leaking water distribution and wastewater collection systems, infiltration from irrigation, and infiltration from direct precipitation. All of these recharge processes are likely to occur in the El Rancho Subregion.

Potentially significant local sources of recharge include artificial recharge at ELRANCHO and VIEW, and surface water infiltration from the lakes at Paradise Park. The recharge specifics for ELRANCHO and VIEW for 2010 and the annual recharge history over the course of the GMP are included in the tables below. VIEW is included because it is relatively close (1,200 feet) to the southern subregion boundary and (as will be shown) has a significant influence on this area. The 2010 recharge volume for ELRANCHO of 24.7 MG was more than 2009 but less than 5 of the previous 6 years before 2009. The 2010 recharge volume for VIEW of 20 MG was slightly less than 2009 but significantly less than the previous 6 years before 2009. The combined 2010 recharge volume for ELRANCHO and VIEW was more than 2009 but significantly less than the previous 6 years.

Well	Recharge Start Date (2010)	Recharge End Date (2010)	2010 Recharge (MG)	2010 Recharge Pattern
ELRANCHO	January 5	April 14	24.7	Continuous
VIEW	January 7	February 10	11.6	Continuous
	February 24	April 14	8.4	Continuous

El Rancho Subregion Vicinity Annual Artificial Recharge History (in millions of gallons)			
Year	Wells		Annual Total
	ELRANCHO	VIEW	
2003	83.1	115.0	198.1
2004	45.3	195.0	240.3
2005	31,9	85.9	117.8
2006	33.5	65.7	99.2
2007	20.3	58.4	78.7
2008	38.8	94.9	133.7
2009	7.30	22.1	29.1
2010	24.7	20.0	44.7

The four lakes at Paradise Park have the potential to interact with the aquifer system in the El Rancho Subregion. These lakes are located to the west and northwest of ELRANCHO with the nearest lake being approximately 300 feet from ELRANCHO. The eastern two lakes (those closest to ELRANCHO) have engineered liners (CFA, 1996; Harding Lawson Associates, 1998) while the western two lakes are unlined (City of Reno, 2010). The eastern lakes were lined because decreasing lake levels in the early 1990s were attributed to pumping of ELRANCHO and/or decreased flows into the lakes (Harding Lawson Associates, 1995). As shown in the table below, the 2010 shallow zone groundwater elevation maxima are lower than the approximate lake bottom elevations. This indicates that, during 2010, there was potential for infiltration from the lakes into the aquifer system. Considering that regional groundwater maxima occurred in 2006 and those levels were 2 to 4 feet higher than 2010 levels – these ponds COULD have been groundwater sinks in 2006 under circumstances where the actual lake levels were close to the bottom of the lakes.

El Rancho Subregion Shallow Zone Groundwater and Paradise Park Lake Bottom Elevations (ft AMSL)			
Well	Maximum 2010 Groundwater	Nearest Lake Bottom	Elevation Difference[(2)]
CTM110	4424.17	4429	4.83
CTM115	4426.13	4429	2.87
CTM112	4422.86	4429	6.14
CTM114	4422.15	4423.5	1.35

(1) Lake bottom elevations from CFA, 1996, and Harding Lawson Associates, 1998
(2) Positive elevation difference indicates groundwater is lower than the lake bottom

Annual precipitation measured at the Reno-Tahoe International Airport (RNO gage) was 9.25 inches in calendar year 2010. This is an increase from 8.25 inches in 2009, and is also above the historical annual average of 7.31 in/year (1937 to 2010; NOAA, 2011). Precipitation data for the GMP period are summarized in **Section 5.3**.

Groundwater sinks include ELRANCHO, VIEW, and approximately 10 domestic wells in the general area. VIEW is considered to be a sink in the El Rancho Subregion because of the influence it has on water levels as observed at monitoring wells in the subregion. The operational specifics for ELRANCHO and VIEW in 2010 and a summary of annual pumping for the GMP period are presented below.

Well	2010 Pumping Start Date	2010 Pumping End Date	2010 Groundwater Production (MG)	2010 Pumping Pattern
ELRANCHO	September 3	October 4	33.3	Continuous
	December 7	December 21	20.2	Continuous
VIEW	May 17	October 8	326.7	Continuous

El Rancho Subregion Vicinity Annual Municipal Water Supply Well Pumping History (in millions of gallons)			
Year	**Wells**		**Annual Total**
	ELRANCHO	**VIEW**	
2003	75.0	64.3	139.3
2004	25.7	75.8	101.5
2005	8.8	57.2	66.0
2006	28.2	57.6	85.8
2007	23.0	59.6	82.6
2008	28.3	167.7	196.0
2009	35.8	40.4	76.2
2010	53.5	326.7	380.2

The 2010 pumping volume for ELRANCHO (53.5 MG) was the most since 2003 (75.0 MG). The 2010 pumping volume for ELRANCHO plus VIEW (380.2 MG) was the most since before the beginning of the GMP (e.g. 548.8 MG were pumped from ELRANCHO and VIEW in 1996).

In both 2009 and 2010, there was net groundwater extraction at ELRANCHO. During each of these years, extraction exceeded injection by 28.8 MG. However, over the GMP period (2003-2010), injection has been greater than extraction in 5 out of 8 years. Over the GMP period there has been net recharge at ELRANCHO (with recharge exceeding extraction by 6.3 MG).

In both 2009 and 2010, there was also net groundwater extraction at VIEW. In 2009, extraction exceeded injection by 18.3 MG; in 2010, extraction exceeded injection by 306.7 MG. Over the GMP period (2003-2010), groundwater extraction has been greater than injection in 4 out of 8 years. Over the GMP period there has been net groundwater extraction at VIEW (with extraction exceeding recharge by 192.3 MG).

5.11.4 Data on Potential PCE Sources

Several PCAs have been identified in the area upgradient from ELRANCHO (**Figure 5.28**). These PCAs include auto repair shops, former dry cleaners, and one active dry cleaner

Wastewater sampling downstream from active dry cleaning facilities has been conducted in coordination with the cities of Reno and Sparks as part of the Sewer Monitoring Program (SMP) since late 2005. The SMP includes Sparks Cleaners, located in the northeastern portion of the El Rancho Subregion at the intersection of El Rancho Drive and Greenbrae Drive. SMP results from this location are provided in the table below. PCE has not been detected in any samples collected downstream from this location through 2010.

El Rancho Subregion SMP Sampling Results Summary

Sample Location	Sparks Cleaners [1]	
	Sample Date	PCE (µg/L)
	8/23/2005	<1
	9/8/2005	<1
	4/12/2006	<1
	10/16/2006	<2
	4/30/2007	<5
	10/5/2007	<5
	4/11/2008	<5
	10/17/2008	<5
	4/13/2009	<5
	10/12/2009	<5
	4/23/2010	<5
	10/05/2010	<5

[1] Samples collected from first manhole downstream from where site lateral enters the sewer main

DWR has defined the El Rancho Subregion to include the area where PCE sources that have contributed to or that are contributing to the El Rancho plume are likely to be located (based on plume extent, groundwater flow direction, gradient, capture zone, etc.). However, the plume is not well defined and data to identify sources that may have contributed to the El Rancho plume are limited at this time. No regulatory corrective actions associated with PCE releases have occurred in the subregion or upgradient area. Specific source(s) for the PCE contamination that has impacted the ELRANCHO well have yet to be identified. Accordingly, the subregion boundary is approximate and any ongoing release(s) or residual source(s) have yet to be identified and assessed.

5.11.5 PCE Concentration and Distribution Data

The occurrence of PCE contamination attributed to the El Rancho plume is presently limited to three deep zone wells: ELRANCHO, ELRANCHOMWD, and ELRANCHOMWS. These wells are all located within 50 feet of each other. Shallow zone PCE contamination has not yet been detected. Shallow zone PCE contamination does not exist in the area naturally upgradient from ELRANCHO (to the west and northwest) where PCE is below the reporting limit in shallow zone wells CTM110, CTM112, CTM114, and CTM115. To date, there are no nearby shallow zone wells to the north, east, or south of ELRANCHO. The lateral extent of deep zone PCE contamination is only partially delineated (to the west and northwest of ELRANCHO) where PCE is below the reporting limit in deep zone wells CTM108, CTM109, CTM111, and CTM113. There are presently no nearby deep zone wells to the north, east, or south of ELRANCHO.

At ELRANCHO (which has been in operation since 1993), PCE was first detected in October 2004. Since that time, PCE at ELRANCHO has been detected intermittently, with a maximum concentration of 3.1 µg/L occurring in 2008 Q3

PCE was present in time-series samples collected at ELRANCHO during the 18-day ELRANCHO constant discharge aquifer test that took place in 2009. The PCE concentration in those samples decreased relatively uniformly from 2.8 µg/L (at the start of the test) to 0.96 µg/L (by the end of the test).

Data collected prior to 2009 suggested that PCE contamination in ELRANCHO occurred only in the deepest screened interval (300 to 360 feet bgs). This interpretation was based on PCE being present in monitoring well ELRANCHOMWD (screened interval - 300 to 360 feet bgs). PCE had not been detected in ELRANCHOMWS (screened interval - 130 to 200 feet bgs) prior to 2009. Data collected in 2009 and 2010 show that (when ELRANCHO is pumped in a sustained manner):

- The PCE concentration increases in ELRANCHOMWS; while at the same time
- The PCE concentration decreases in both ELRANCHO and ELRANCHOMWD.

These observations were made as continued pumping purged artificial recharge water from the aquifer, allowing ambient groundwater to flow into the well. This behavior is interpreted to indicate that:

1) PCE contamination is entering ELRANCHO through the upper screen (the same interval screened by ELRANCHOMWS);

2) PCE contamination is not above the MCL or widespread in that portion of the aquifer system where the lower screen of ELRANCHO is completed (300 to 360 ft bgs, the same interval screened by ELRANCHOMWD); and,

3) The PCE detected in the pre-2009 samples from ELRANCHOMWD resulted from:

- The downward vertical gradient; and,
- Well construction details that allow PCE contaminated groundwater to enter the well through the upper screen at ELRANCHO and to flow vertically downward through the wellbore and/or gravel pack.

The typical gradient conditions and well construction allow PCE contamination to use the well as a conduit and impact the deeper part of the aquifer system by exiting through the lower well screen. This results in impacts to that portion of the aquifer system (where nearby ELRANCHOMWD is completed) during periods when ELRANCHO is not pumping.

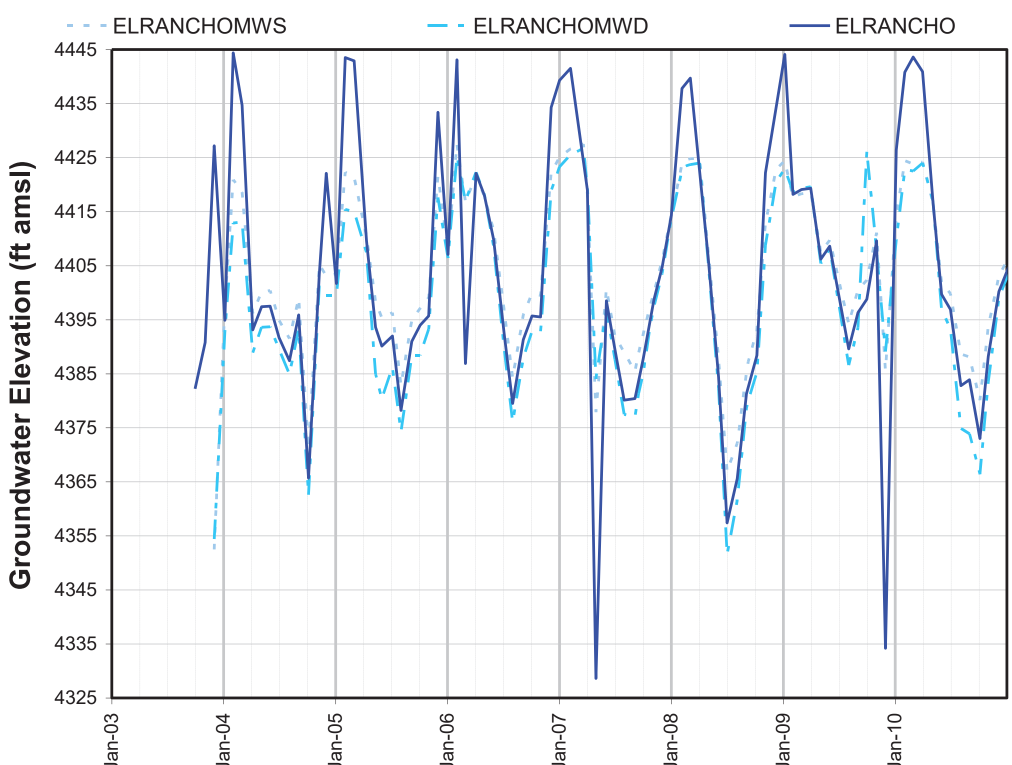
A time-series of depth-discrete samples were collected from ELRANCHOMWS and ELRANCHOMWD in 2010 during a period of sustained pumping at ELRANCHO. The time-series results from ELRANCHOMWS show that PCE concentration increases as pumping proceeds. The depth-discrete results from ELRANCHOMWS show that PCE is consistently at the highest relative concentration at a depth between approximately 140 and 180 feet bgs in this well (reaching a maximum of 6 µg/L by the end of the time-series). PCE in ELRANCHOMWD was below the reporting limit (< 0.50 µg/L) in all the time-series of depth-discrete samples collected during the sustained pumping period. These results are interpreted to indicate that the PCE contamination (in the immediate vicinity of ELRANCHO) occurs in the interval between 132 and 188 feet bgs. PCE contamination at ELRANCHO may also extend to depths shallower than 132 feet bgs but there are presently no wells to assess that possibility.

5.11.6 Trends and Patterns in Water Levels and PCE Concentrations in Key Wells

Trends and patterns observed in water level and PCE concentration data from key wells of the El Rancho Subregion are considered and evaluated in this section. The key wells in this subregion are listed in **Table 5.1** and depicted in **Figure 5.28**. The key wells in this subregion are all deep zone wells and include ELRANCHO, ELRANCHOMWD, and ELRANCHOMWS. Water level hydrograph/time series PCE concentration graphs for these wells are depicted as **Graphs 5.6a** and **5.6b**. Selected graphs are also embedded in the following text to illustrate any trends and/or patterns discussed. **Table 5.4** contains summary information on PCE concentration changes and trends for the key wells.

Water Levels

Water-level elevation changes observed in all three wells are similar and principally reflect drawdown and recovery associated with pumping at ELRANCHO and/or VIEW. Annual water level fluctuations are characterized by changes that include rising groundwater levels during recovery and recharge, and falling groundwater levels during pumping. Drawdown responses during pumping (which typically occurs in Q2 and Q3) are approximately 60 feet in ELRANCHO and approximately 40 feet in both ELRANCHOMWS and ELRANCHOMWD. Water level increases coincide with artificial recharge at ELRANCHO and/or VIEW that typically occurs in Q4 and Q1 (and sometimes into Q2).



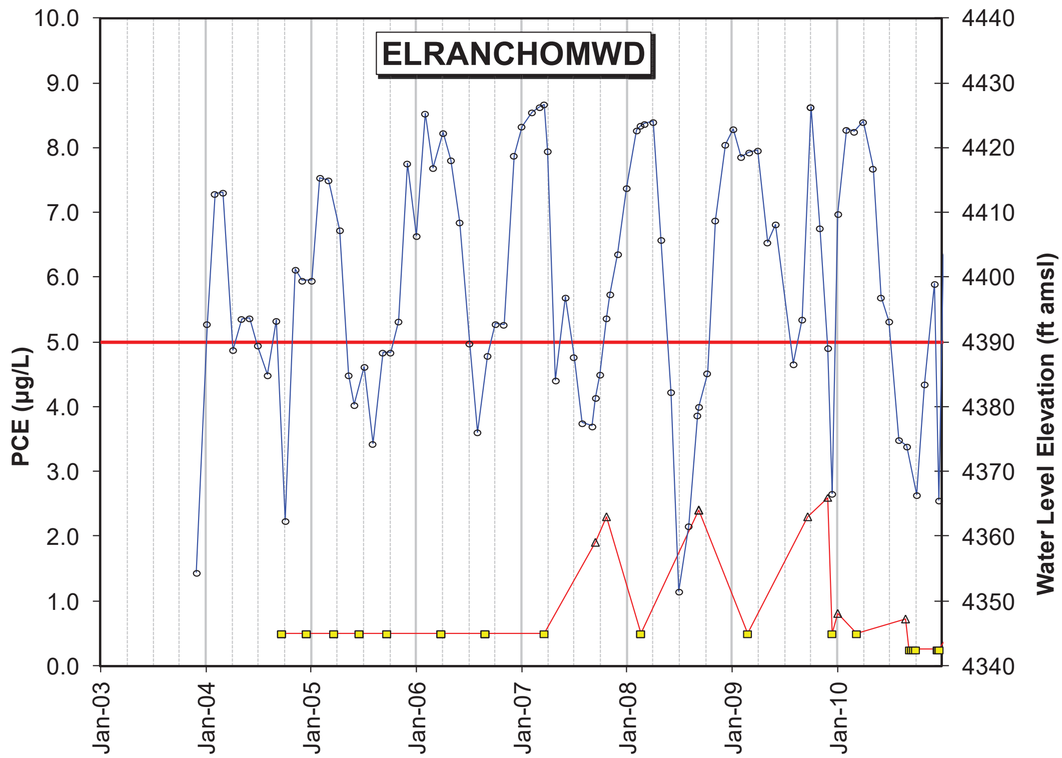
PCE Concentrations

The PCE concentration (**Table 5.4** and **Graphs 5.6a** and **5.6b**) observed in the key wells is described below.

- ELRANCHOMWD (screened interval – 300 to 360 feet bgs):

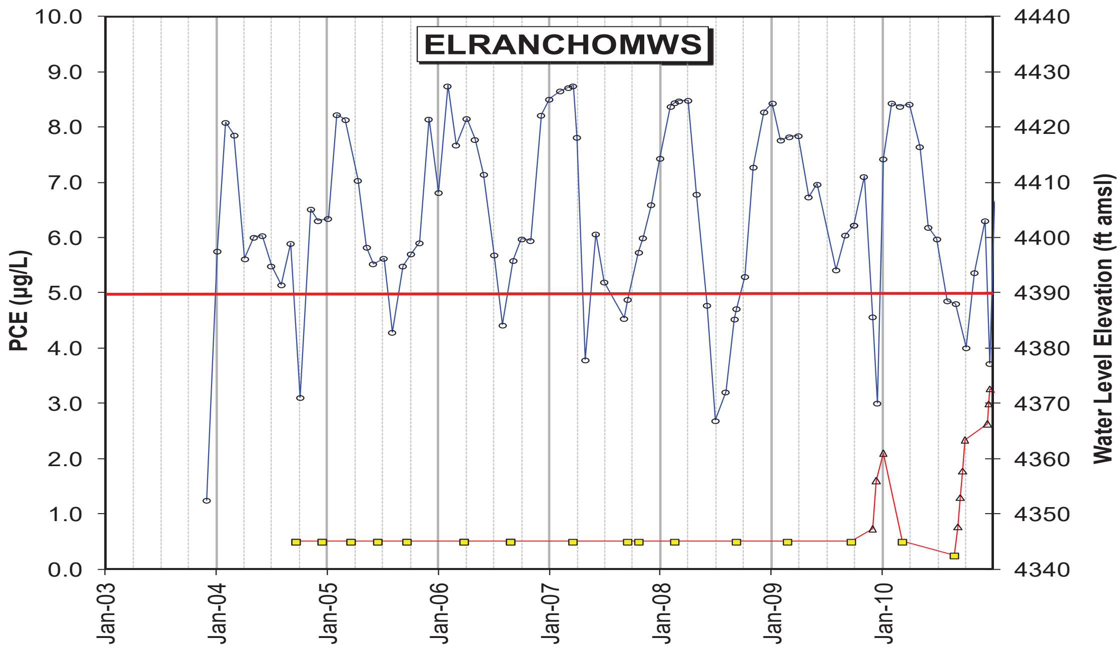
- PCE was first detected (1.9 µg/L) in 2007 Q3;
- PCE concentrations have fluctuated episodically from below the laboratory reporting limit to a maximum of 2.6 µg/L between 2007 Q3 and 2009 Q4;
- PCE concentration decreased from 2.6 µg/L (at the beginning of the ELRANCHO aquifer test in 2009 Q4) to 0.8 µg/L (two weeks after the test ended); and,
- PCE data in for the time-series of depth-discrete samples collected during sustained pumping in September and December 2010 were below the reporting limit for the entire sampling period.

These PCE concentration data are depicted in the graph below. The first appearance and episodic occurrence of PCE in this well is interpreted to result from a combination of natural conditions, well construction details, and the way in which ELRANCHO is typically operated. Recharge (using treated surface water) typically occurs at ELRANCHO in the late fall through late spring. Recharge has occurred at ELRANCHO every year from 2000 through 2010. The PCE results below the laboratory reporting limits from ELRANCHOMWD in 2007 Q1, 2008 Q1, and 2009 Q1 are therefore interpreted to have been influenced (diluted) by recharge water. Under pumping conditions, recharge water is removed from the aquifer. The 2007 Q3, 2007 Q4, 2008 Q3, and 2009 Q4 results of 1.9 µg/L, 2.3 µg/L, 2.4 µg/L, and 2.6 µg/L respectively, are interpreted to be the contaminated groundwater present in the well after the recharge water has been purged. The PCE contamination in ELRANCHOMWD (the same interval of the aquifer system where the lower screen of ELRANCHO is constructed) is interpreted to result from the downward movement of contaminated groundwater (present in the aquifer where the upper screened interval of ELRANCHO is located) through the wellbore and/or filter pack into the lower portion of the aquifer in response to the natural downward vertical gradient. The decrease in PCE concentration in ELRANCHOMWD in response to continued pumping (typically to below the reporting limit) is interpreted to reflect the ambient groundwater present in the lower portion of the aquifer system after: 1) recharge water has been purged; and, 2) contaminated water that has moved downward through the wellbore and/or filter pack has been purged.

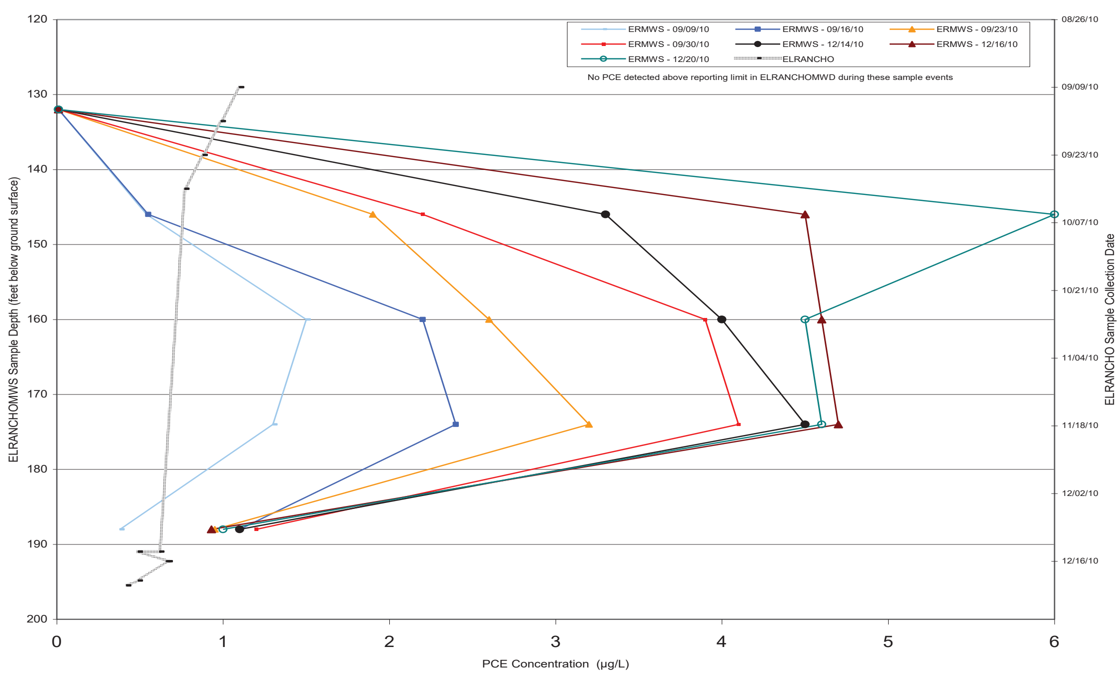


- ELRANCHOMWS (screened interval – 130 to 200 feet bgs):
  - PCE was below the laboratory reporting limit from 2004 Q3 to 2009 Q4;
  - PCE was first detected in 2009 Q4 during the 18-day aquifer test at ELRANCHO (It should be noted that the initial detection of PCE coincided with the laboratory reporting limit being lowered from 1.0 µg/L to 0.5 µg/L in 2009 Q4);
    - PCE concentration increased from: 0.72 µg/L (just before aquifer test began); to 1.6 µg/L (14 days after pumping began); and, to 2.1 µg/L (17 days after the pumping test ended);
  - PCE data from the time-series of depth-discrete samples collected during sustained pumping (in September and December 2010;
    - Increased in concentration as sustained pumping progressed;
    - Consistently exhibited the highest concentrations in samples collected between approximately 140 feet and 180 feet bgs; and
    - Reached a maximum concentration (6 µg/L) in the sample collected from 146 feet bgs at the end of sustained pumping.

These changes are depicted in the two graphs below. As was observed in ELRANCHOMWD, the PCE concentration in ELRANCHOMWS is influenced by recharge at ELRANCHO (when PCE concentration is observed to decrease). Under sustained pumping, the PCE concentration in ELRANCHOMWS increases. This behavior is in direct contrast to what occurs at ELRANCHOMWD. The PCE data collected from ELRANCHOMWS through the start of the aquifer test in 2009 Q4 (including the 0.72 µg/L sample from November 30, 2009) are interpreted to have been affected by recharge. The increased PCE present in ELRANCHOMWS after sustained pumping are interpreted to represent ambient groundwater from that portion of the aquifer system where ELRANCHOMWS and the upper part of ELRANCHO are screened.

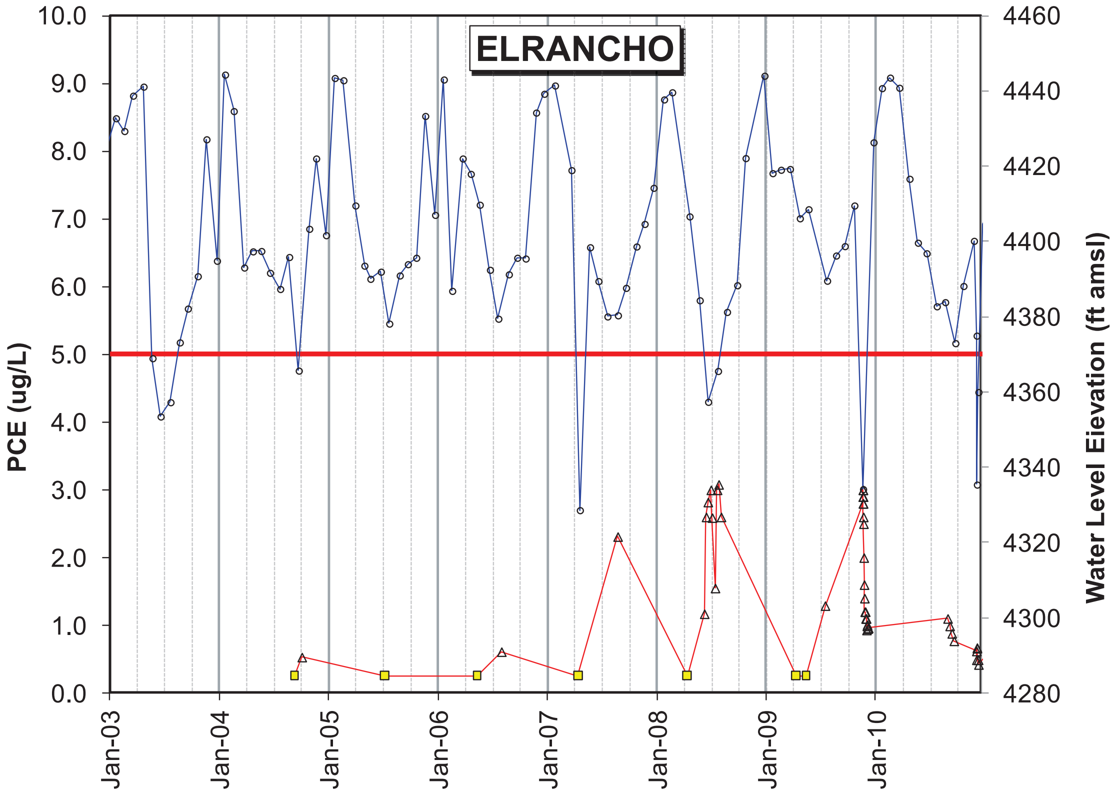


PCE Concentration Results For ELRANCHOMWS Depth-Discrete Time Series and ELRANCHO Wellhead Sampling in 2010



ELRANCHO (3 screened intervals – 143 to 208 feet bgs, 250 to 260 feet bgs, and 300 to 360 feet bgs):

- PCE data defines no Mann-Kendall trend during the GMP period
- PCE was first detected in this well in 2004 in TMWA compliance sampling. Based on the combined TMWA compliance sampling and GMP sampling results (shown on graph below), PCE has fluctuated episodically from below the laboratory reporting limit to a maximum of 3.08 µg/L (in 2008 Q3).
- Artificial recharge at ELRANCHO is considered to have a significant influence on PCE concentration in ELRANCHO. Results indicate that non-detections occur during the initial stages of pumping when injection water is present in the aquifer. Higher concentration results occur as sustained pumping continues and substantially all purged injection water in the vicinity of the well is removed, and a greater proportion of ambient groundwater is pumped.
- Without the influence of injection water, PCE concentration decreases during periods of sustained pumping. This concentration decrease is interpreted to be a consequence of wellbore cross contamination during non-pumping/non-recharging periods. Under this scenario: PCE contamination enters the well through the upper screened interval (143-208 ft bgs), moves downward through the wellbore and/or filter pack, and out of the lower screened interval into a deeper portion of the aquifer in response to the natural downward vertical gradient during non-pumping periods. This is interpreted to result in local impacts to an otherwise uncontaminated portion of the aquifer system. The decrease in PCE concentration in ELRANCHO in response to continued pumping is interpreted to result from: 1) the purging of contaminated water from the aquifer were the lower screen is constructed (which also yields more groundwater); and, 2) the greater production of uncontaminated water that comes from the lower screened interval of the well that effectively dilutes the contaminated groundwater produced through the upper screened interval.



5.11.7 Receptors

The El Rancho municipal water supply well is the receptor for the El Rancho plume. VIEW is the nearest potential receptor for contamination present in this subregion. While the magnitude and extent of the El Rancho plume has yet to be determined, other potential receptors are located downgradient from the El Rancho Subregion. These include SPARKS (an operational municipal water supply well that has been impacted by PCE to levels below the MCL), and SPARKSHIGH and MITCHELLTW (presently unequipped wells that are planned for future use).

5.11.8 El Rancho Conceptual Model

The magnitude and extent of the El Rancho plume is presently undefined. Groundwater contamination has, to date, only been identified in the upper portion of the deep zone of the aquifer system in a very localized part of the subregion. Groundwater hydrodynamics and PCE distribution are strongly influenced by the operation and construction of the ELRANCHO well. Shallow zone contamination and evidence for sources of the El Rancho plume have not yet been identified. This El Rancho Subregion conceptual model discussion is based on the data presented in **Sections 5.11.1** through **5.11.8**. **Figure 5.29** is a schematic plan view map that shows pertinent aspects of the subregion conceptual model.

Hydrogeology

Lithologic data define multiple, vertically distinct, laterally continuous hydrostratigraphic packages at ELRANCHO and to the east/southeast of that well. Northwest (and by inference to the north) of ELRANCHO, the lithologic conditions and hydrostratigraphy change from what is defined at ELRANCHO. The upper-most package (Package A) is interpreted to be continuous from ELRANCHO to the west and northwest. Deeper Package E is interpreted to only be continuous to the west, is present at CTM111, and is underlain by bedrock in the El Rancho Subregion. Between these two packages, Packages B(f), B(c), C, and D are not distinguishable to the west and northwest of ELRANCHO. This is interpreted to reflect a general coarsening of the basin-fill materials to the west and northwest of ELRANCHO and a lack of materials otherwise characteristic of Packages B(f) and D in that part of the basin. This may be caused by relative proximity to exposed bedrock or the lack of the depositional mechanism(s) for source materials that would have produced Packages B(f) and D in that area. The contamination in the upper screened interval at ELRANCHO is currently interpreted to be in Packages B(c) and C.

The relatively coarser and finer grained hydrostratigraphic packages also have potentially significant intra-package heterogeneity. This can result in some areas where vertical flow potential is enhanced and other areas where vertical flow potential is likely to be reduced or impeded. This variability is perhaps best reflected by the distribution of the relatively finer grained Package B(f). Package B(f) is present at ELRANCHO (and to the south and east of ELRANCHO) but absent to the west and northwest of ELRANCHO. This contributes to the present interpretation that the aquifer system in the El Rancho Subregion can (depending on the local conditions) exhibit behavior that reflects either a heterogeneous unconfined aquifer system (to the northwest and west of ELRANCHO) or a leaky confined aquifer system (to the south and east of ELRANCHO).

Lateral Groundwater Movement

Shallow zone and deep zone groundwater gradients are from northwest to southeast under natural conditions. Both shallow zone and deep zone gradients change in response to deep zone pumping but shallow zone responses are consistently less than deep zone responses. Under deep zone pumping conditions, the shallow zone gradient converges on ELRANCHO and the deep zone gradient converges on an area that includes both ELRANCHO and VIEW. While it is clear that pumping at ELRANCHO and VIEW influences the flow gradients in this subregion, pumping at other municipal water supply wells may also influence groundwater gradients in the El Rancho Subregion but that influence has not yet been evaluated. Any influence that deep zone artificial recharge might have on shallow zone and deep zone lateral gradients has not been established. Artificial recharge locally increases water levels near ELRANCHO and VIEW during recharge periods at these wells.

Vertical Groundwater Movement

The vertical gradient varies spatially and temporally in the El Rancho Subregion. Water level data indicate that the vertical gradient is downward during both natural and pumping conditions. The limited existing data indicate that the vertical gradient is upward at the cluster wells to the west and northwest (except for a slight downward gradient at CTM108/CTM115, the well pair farthest from ELRANCHO) during winter recharge periods.

During sustained pumping periods, the significant shallow zone drawdown indicates that there is better vertical hydraulic connection in the northern part of the El Rancho Subregion compared to other areas of the CTM basin. The responses in the northern part of the El Rancho Subregion indicate a high downward groundwater flow and vertical PCE migration potential in that area.

Potential PCE Sources

The PCE source(s) that caused or that are contributing to the El Rancho plume are currently undefined. DWR has defined the El Rancho potential source area (PSA) as the area where sources that may have contributed or that are contributing to the El Rancho plume (which has impacted ELRANCHO) are most likely to occur based on existing data. A potential source area investigation to identify, characterize, and potentially remediate those sources is underway. PCE contamination has not been detected in wells to the west and northwest of ELRANCHO. It is currently considered unlikely that PCAs in that direction are contributing to the contamination at ELRANCHO.

PCE Plume Formation and Distribution

The magnitude and extent of the El Rancho plume is presently undefined. The lateral extent of the plume is partially defined by wells located west and northwest of ELRANCHO. The lateral plume extent is undefined to the north, east, and south of ELRANCHO.

The vertical plume extent is also undefined. Data indicate that the plume extends no deeper than 188 feet bgs in the vicinity of ELRANCHO. Additional data are needed between the upper screen in ELRANCHO and the water table to better define the vertical and lateral extent of the plume.

PCE Migration Mechanisms and Pathways

The El Rancho plume has only been identified in the upper portion of the deep zone in the immediate vicinity of ELRANCHO. The extent of the plume is undefined. The point(s) of origin for the plume in or near the shallow zone has (have) not been identified. Potential shallow zone-deep zone migration pathways are similarly undefined. The presence of good vertical hydraulic communication to the west and northwest of ELRANCHO suggests the potential for a vertical migration pathway in that area. Comparable hydrostratigraphic conditions (and the potential for a vertical migration pathway) are inferred to also exist to the north and northeast of ELRANCHO.

A downward vertical gradient exists in the subregion during natural and pumping conditions. A downward vertical gradient would, in the presence of conduits, allow PCE movement from the near-surface environment toward the production well screen. The shallow zone response to sustained deep zone pumping indicates that municipal water supply well pumping could be an effective mechanism to cause downward PCE migration from the shallow subsurface into the deep zone and toward the upper screened interval at ELRANCHO. This migration pathway is interpreted to have resulted in the PCE impacts to ELRANCHO.

Threats to Receptors

ELRANCHO is currently the receptor for the poorly-defined El Rancho plume. VIEW is the nearest potential receptor (approximately 2,200 feet south of ELRANCHO) that could be impacted by the El Rancho plume based on water level responses to VIEW during pumping conditions.

Other potential receptors include:

- SPARKSHIGH (unequipped well approximately 4,100 feet northeast of ELRANCHO)
- MITCHELLTW (unequipped well approximately 4,500 feet east of ELRANCHO)
- SPARKS (equipped well approximately 4,900 feet southeast of ELRANCHO, also a receptor to the Victorian Avenue and possibly the Downtown Sparks plumes)

These potential receptors are east-northeast to southeast (generally downgradient) from ELRANCHO and the potential location of the El Rancho plume. The El Rancho plume needs to be better defined and characterized in order to effectively assess the potential threats to both ELRANCHO and these other wells.

5.11.9 Summary

The magnitude and extent (lateral and vertical) of the El Rancho plume has not been defined. PCE has not been detected to the west and northwest of ELRANCHO, indicating that the plume does not extend in that direction. The location and nature of the source(s) of PCE contamination that have contributed or that are contributing to the El Rancho plume is (are) unknown. Any source(s) is (are) currently considered likely to be located to the north and/or northeast of ELRANCHO.

Known PCE contamination occurs in deep zone wells (ELRANCHO, ELRANCHOMWS, and ELRANCHOMWD) located within 50 feet of each other. The PCE contamination intersected by those wells is highest in concentration where the upper screened interval of ELRANCHO is completed. This relatively shallow occurrence suggests that the source for the plume is relatively close. The observed shallow zone water level response to deep zone pumping indicates that there is an enhanced connection between the shallow zone and the deep zone to the west and northwest of ELRANCHO (compared to other parts of the CTM basin). These conditions are inferred to also exist to the north and northeast of ELRANCHO. This enhanced vertical communication and a downward gradient under natural and pumping conditions would facilitate PCE migration from the north and northeast toward ELRANCHO.

PCE in ELRANCHOMWD is interpreted to be caused by the details of the ELRANCHO well construction and the downward vertical gradient that predominates in the subregion. PCE in ELRANCHOMWD (and the deeper screened interval of ELRANCHO) is caused by downward movement of contaminated water from the upper screened interval of the production well and is not considered representative of that portion of the aquifer system away from the well.

Gradients under natural and pumping conditions indicate that the El Rancho plume can potentially migrate to the south and east toward potential receptors. Potential receptors to the El Rancho plume include VIEW, SPARKSHIGH, MITCHELLTW, and SPARKS (also a receptor to the Victorian Avenue plume and potential receptor to the Downtown Sparks plume).

5.12 Joule Subregion

The Joule Subregion is intended to encompass a complex plume that has impacted both the shallow zone and the deep zone in an area southwest of and in the vicinity of the HV5 municipal water supply well. The source or sources for the Joule plume are as yet undefined, but at least one contributing source is considered likely to exist west of CTM87, the shallowest and most upgradient impacted well. The complex plume is not well characterized or delineated in either the lateral or vertical dimension due to the relatively few number of monitoring wells in the subregion. Currently, two shallow-zone and one deep-zone monitoring wells delineate the plume. These wells define a zone of contamination that occurs within an area that is approximately 1,300 feet (south-to-north) by 1,300 feet (west-to-east). PCE extends from the water table to a depth of at least 114 feet bgs.

Potential receptors for the Joule plume include (with screen interval in parentheses):

- HV5 (68-138 feet bgs) —with historical PCE impacts (less than 3 µg/L) between 1992 and 2005, but with a lack of PCE impacts since that time.
- HV3 (105-191 feet bgs)

PEZZI (214-548 feet bgs) is a construction (non-municipal) water supply well and would be considered a potential receptor if it were converted to a municipal water supply well.

PCE was periodically observed at HV5 between 1992 and 2005, but it is not known whether these historical PCE impacts originated from the same source or sources as the Joule plume, or are otherwise unrelated to the current PCE contamination in the subregion. PCE was also observed at CTM20S and

USGSAG (in the north part of the subregion) between 1999 and 2005. PCE in these wells is considered to have originated from a distinct and different source that may no longer pose a threat to groundwater. **Figure 5.30** depicts pertinent features in the Joule Subregion that are described in the following subsections.

5.12.1 Hydrogeology

The following description of hydrogeology of the Joule Subregion is based primarily on a working hydrogeologic cross-section prepared by DWR. The section is derived from the lithologic logs for monitoring wells CTM85, CTM86, CTM87, and from lithologic and geophysical logs for monitoring well HV5M and the municipal supply well HV5. The lithologic log for PEZZI provides additional hydrogeologic information in the northwest portion of the subregion. Due to the limited data, hydrostratigraphic packages have not been defined for the Joule Subregion.

The hydrostratigraphy of the Joule Subregion is described (from top to bottom) as follows:

- Generally coarser grained material (composed principally of sandy to silty gravel and gravelly sand) occurs from the ground surface to approximately 80 feet bgs. These sediments may be correlative to Package A (defined in other subregions), however the occurrence of cobbles and boulders that are diagnostic of Package A are not as prevalent here. This interval contains local finer grained interlayers of lenses composed of silty sand to silty clay that have thicknesses of 5 to 10 feet but do not correlate from well-to-well across the subregion. The upper 12 feet of screened interval at HV5 occurs in the bottom of this sequence.

- Generally coarser grained material (composed of sandy gravel to sand) interlayered with thin silt lenses or layers occur from 80 to 135 feet bgs. The geophysical E-log for HV5M (located approximately 25 feet north of HV5) defines a single low resistivity interval that is interpreted as finer grained material at the top of this sequence from 80 to 93 feet bgs. This finer grained interlayer is interpreted to extend laterally to CTM85 (located approximately 650 feet southwest of HV5). This local finer grained layer, along with the other shallower, finer grained lenses and interlayers, are interpreted to be comprised of lower hydraulic conductivity material that collectively contribute to impeding vertical flow from near the water table (i.e., the shallow zone) into the underlying groundwater-producing strata (i.e., the deep zone) in the area near HV5. There is no similarly characterized finer grained material identified further to the southwest in the vicinity of deep zone well BELFAST where PCE has been detected. The screened interval for HV5 extends across the entire thickness of this sequence, ending at 138 feet bgs.

- From approximately 135 to 200 feet bgs is a heterogeneous assemblage of finer grained material (comprised of interlayered silt, silty sand), interlayered with coarser grained material (gravelly sand to silty sand with gravel). The E-log profile for HV5M indicates that this interval has an overall lower resistivity than the superjacent coarser grained interval and contains local lower resistivity interlayers or lenses that correlate to finer grained silt or clay intervals in the lithologic description. These finer grained interlayers have the potential to inhibit vertical flow.

- From approximately 200 to 256 feet bgs, the lithologic data at HV5M consists of generally finer grained material (comprised of interlayered sand and silt) with minor gravel. The E-log profile from HV5M shows an overall decline in resistivity that suggests this interval is comprised of generally finer grained material compared to overlying intervals.

- Similarities in the PEZZI (located in the northwest portion of the Joule Subregion) and HV5M E-logs indicate that correlative intervals are slightly thicker or exist at greater depth in the vicinity of PEZZI. The PEZZI E-log indicates that the generally finer grained interval starting at 200 feet bgs in HV5M (described above) potentially starts at 264 feet bgs at PEZZI and extends to a depth of 338 feet bgs. Beneath this interval, the lithologic log for PEZZI indicates that interlayered sand, gravel, sandy clay, and clay extend from 338 to 563 feet bgs. All screened intervals except one (214 to 266 feet bgs) occurred within potentially more permeable zones in this deeper interval. However, all screens except for this uppermost screen have been plugged because of sand production and elevated arsenic concentrations found in deeper portions of the well.

Hydrostratigraphic data, as described above, are consistent with an aquifer system that is heterogeneous and anisotropic. Available data, suggest that local finer grained interlayers or lenses exist in the upper 100 feet of the land surface that contribute to anisotropy in the shallow zone aquifer system. There is no evidence for a laterally continuous aquitard between the water table and groundwater producing intervals. The relatively shallow depth of screened intervals at HV3 (screened interval – 105 to 191 feet bgs) and HV5 (screened interval – 68 to 138 feet bgs) increase the potential for PCE contamination to migrate to a depth that would impact these wells.

5.12.2 Groundwater Level Data

Potentiometric surface maps for the Joule Subregion are presented in **Figures 5.2** through **5.9**. These maps are the basis for characterizing lateral groundwater gradients for the subregion. Groundwater level difference color-flood maps comparing the shallow zone with the deep zone for the Joule Subregion (**Figure 5.10)**, cumulative groundwater level change data (**Figures 5.11** through **5.14**) and well cluster data (**Graphs 5.7b**) are the basis for characterizing vertical hydraulic gradients for the Joule Subregion.

In 2010, the water table is generally between 5 and 13 feet bgs across the subregion based on monthly measurements at shallow wells CTM20S, USGSAG, GLOBALMW1, CTM86, and CTM87.

Lateral Gradients

Shallow Zone

Quarterly shallow zone water level contour maps that include the Joule Subregion indicate that the shallow zone lateral groundwater flow direction was generally to the southeast in 2010. Based on regional contouring, the observed lateral gradient varied from 0.001 to 0.004 from the south to the north across the subregion, with gradient magnitude being generally steeper near the Truckee River. The observed flow direction and gradients are relatively uniform for all four quarters of 2010 and are similar to those observed in previous years.

The influence of the river on the groundwater system has not been determined. However, the steeper lateral gradient magnitude proximal to the river combined with water level contours that deflect away from the river suggest the river to be a losing reach across the subregion. River impacts on the groundwater system will be addressed (as appropriate) as the Joule Subregion investigation continues.

Deep Zone

Lateral groundwater flow direction in the deep zone was also generally to the southeast in 2010. Based on regional contouring, the observed lateral gradient varied from 0.002 to 0.005 from north to south across the subregion. The observed deep zone flow direction and gradients are relatively uniform for all quarters of 2010 and are similar to those observed in previous years.

Cones of depression associated with municipal water supply well pumping are not depicted on deep zone quarterly water level maps in the Joule Subregion since the start of the GMP. However, they are expected to occur during periods when HV3 and HV5 are pumped. The absence of expected cones of depression is the result of a lack of appropriate deep zone water level data near these pumping wells.

Vertical Gradients

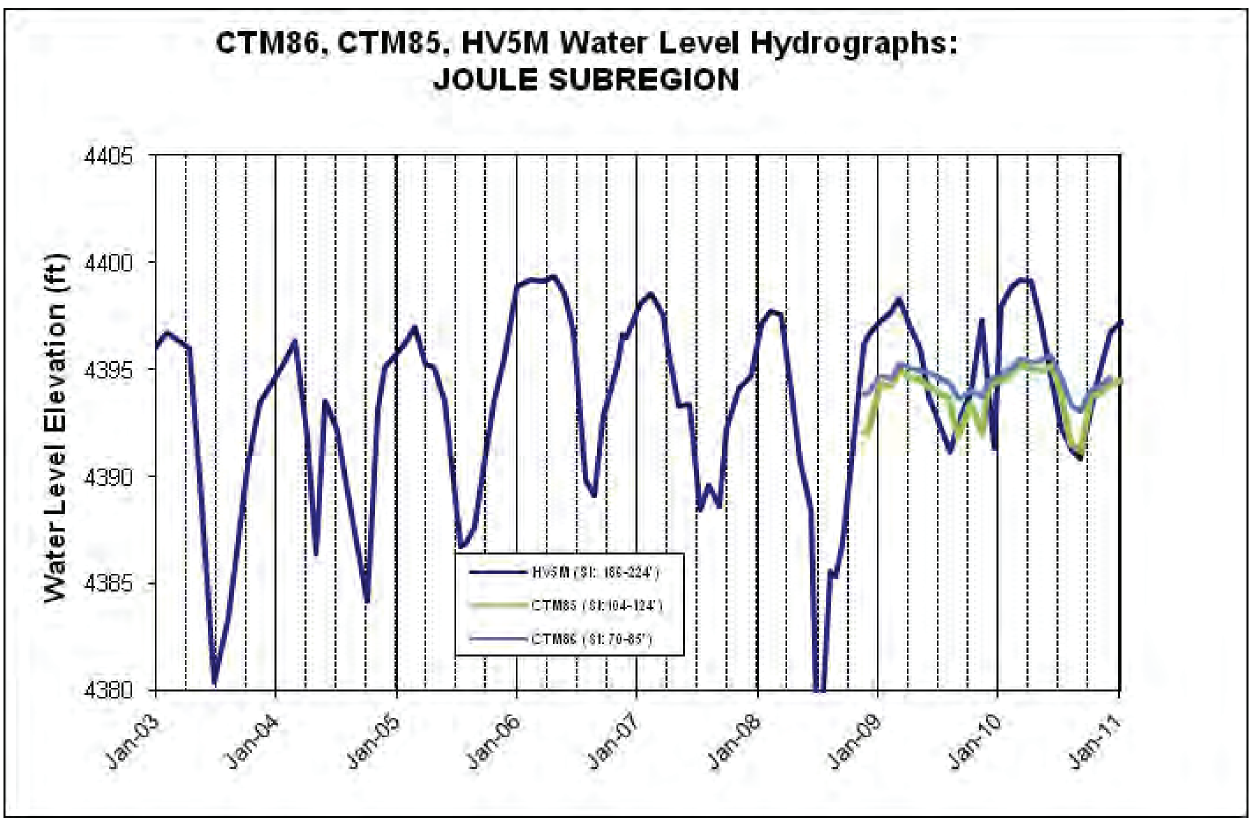
During 2010, a persistent downward vertical gradient is present between the shallow zone and the upper portions of the deep zone. Based on water level measurements at well pair CTM86/CTM85 (screened interval - 70 to 85 feet bgs and - 104 to 124 feet bgs, respectively), quarterly vertical gradients have had a downward magnitude of:

- -0.009 in Q1;
- -0.015 in Q2;
- -0.050 in Q3; and
- -0.010 in Q4.

The increasing downward gradient during Q2 and Q3 reflect the influence of pumping at HV3 and HV5. A nominal downward gradient between the shallow zone and the deep zone in Q1 increases in magnitude in Q2 and Q3 as HV3 and HV5 were pumped more frequently. By the end of Q4, after pumping at HV3 had stopped and HV5 was pumped less frequently, the downward gradient returns to a nominally downward gradient that is similar in magnitude to Q1.

Water levels at HV5M (screened interval – 186 to 224 feet bgs), located approximately 650 feet northeast of well pair CTM86/CTM85 show a different pattern (see graph below) that indicates an upward gradient exists in the deeper parts of the complex aquifer during non-pumping conditions (typically during Q4 and Q1) that reverses to downward during pumping periods (typically Q2 and Q3). These data indicate that, during non-pumping periods, the vertical gradient can converge toward the upper part of the deep zone. During periods of sustained regional pumping, this convergent gradient can change to a consistently downward gradient from the water table to the lower part of the deep zone.

Maximum cumulative water level drawdown in the Joule Subregion in response to deep zone pumping was approximately 2 feet in the shallow zone (at CTM87) and 8 feet in the deep zone (at HV5M) during 2010.



5.12.3 Groundwater Sources and Sinks

Potential sources of groundwater recharge to the water budget include mountain front recharge, infiltration from the Truckee River, infiltration form irrigation ditches, infiltration from leaking water distribution and wastewater collection systems, infiltration from irrigation, and infiltration from direct precipitation. All of these processes are likely to occur in the Joule Subregion with the exception of mountain front recharge.

Average precipitation was 9.25 inches in 2010, an increase compared to the 8.25 inches in 2009, and above the historical average (7.31 in/year) precipitation year (NOAA, 2011). Truckee River flows were higher in 2010 compared to the previous three years. Mean annual Truckee River discharge as measured at the Reno Gage was 459.9 cubic feet per second (CFS) during 2010, compared to 354.9, 392.3, and 396.1 cfs in 2009, 2008, and 2007 respectively. However, 2010 discharge was below the long term average annual discharge of 676 cfs (1906 to 2010; USGS, 2011). Precipitation and Truckee River discharge for the GMP period are summarized in **Section 5.3**.

The Pioneer Ditch traverses in a west to east direction across the northern portion of the subregion and represents a potential groundwater source in the Joule Subregion. This ditch is utilized to supply flood irrigation water to agricultural land along the south side of the Truckee River during the growing season (typically April through September).

Groundwater sinks in the Joule Subregion include groundwater outflow, municipal pumping at HV3 and HV5, construction-related pumping at PEZZI, groundwater discharge to the Yori drain, and potentially groundwater discharge to the Truckee River. Pumping operations and annual pumping history for municipal supply wells in or near the Joule Subregion are summarized in the tables below. GREG is included in the tables because of its proximity to the northern boundary of the subregion. No records are available from construction-related pumping at deep zone well PEZZI, but the pumped volume utilized for construction purposes is expected to be negligible relative to the volume pumped from municipal water supply wells HV3 and HV5. HV4 municipal water supply well, approximately 30 feet south of the Truckee River, is screened entirely in the shallow zone (screened interval – 10 to 70 feet bgs). This well is interpreted to derive its water from the Truckee River and is not included here because it is not considered to have any significant impact the groundwater system in this subregion.

Well Name	Pumping Start Date (2010)	Pumping End Date (2010)	2010 Groundwater	2010 Pumping Pattern
HV3	April 20	Nov 4	215.5	Intermittent
HV5	Jan 1	Dec 31	57.1	Intermittent
GREG		No Pumping		

Joule Subregion Annual Municipal Water Supply Well Monthly Pumping History (in millions of gallons)				
Year	Wells			Annual Totals
	HV3	HV5	GREG	
2003	134.7	72.5	152.1	359.3
2004	179.7	92.5	89.8	362.0
2005	159.5	49.5	86.3	295.3
2006	56.8	91.3	0.8	148.9
2007	0.0	79.1	14.4	93.5
2008	113.4	92.9	53.5	259.8
2009	192.5	67.2	14.1	273.8
2010	215.5	57.1	0	272.6

No effort is made as part of the GMP to estimate groundwater sinks associated with potential groundwater discharge to the Yori Drain or potentially to the Truckee River. Shallow zone groundwater contours for each quarter in 2010 (**Figures 5.2, 5.4, 5.6,** and **5.8**) indicate that the Truckee River in the Joule Subregion is a principally a losing reach, but transitions to a gaining reach the vicinity or east of where East McCarran Boulevard crosses the river. Additional data would be needed to make a more definitive assessment of the position of the Truckee River's transition from a losing to a gaining reach in this part of the CTM basin.

5.12.4 Data on Potential PCE Sources

PCAs identified in the Joule Subregion include numerous former and existing automotive repair shops, auto paint shops, paint shops, and a chemical manufacturer (**Figure 5.30)**. No current or former NDEP corrective action sites are identified within the Joule Subregion. Of the presently identified PCA's, one former chemical manufacturer and one former paint shop are upgradient of the currently defined plume. There are also several current or former auto repair and auto paint shops located upgradient and in the vicinity of the historically impacted monitoring wells CTM20S and USGSAG, which in turn, are located near and upgradient from the HV3 municipal supply well. In addition, five current fleet service facilities exist within the subregion. The specific source(s) impacting the shallow zone and deep zone in the Joule Subregion is unknown.

5.12.5 PCE Concentration and Distribution Data

The Joule complex plume is currently defined by PCE detections in shallow zone monitoring wells CTM86 (first detections in 2010) and CTM87, and deep zone well BELFAST. CTM87 and BELFAST are approximately 560 feet apart and located along Joule Street near its intersection with Edison Way

(**Figure 5.30**). CTM86 is approximately 1,300 feet northeast of these two wells. The first detections at CTM86 (three detections ranging from 1.0 to 1.3 µg/L) were observed during 2010 and increase the previously defined extent of the plume to the northeast. The current plume footprint occurs in an approximate 1,300 foot west-to-east by 1,300 foot north-to-south area.

The lateral plume extent is not delineated (by the presence of wells without PCE contamination) to the northwest, west, south, or east and could be more extensive in those directions. The plume margin is currently constrained only to the northeast by shallow zone well GLOBALMW1 (screened interval - 7 to 17 feet bgs).

The vertical plume extent is delineated from near the water table at upgradient shallow zone well CTM87 , to a depth of at least 114 feet bgs at BELFAST, located approximately 560 feet downgradient from CTM87. To the north, at well pair CTM86/CTM85, PCE has not been detected at deep zone well CTM85 indicating that the base of the plume at this location is shallower than 104 feet bgs.

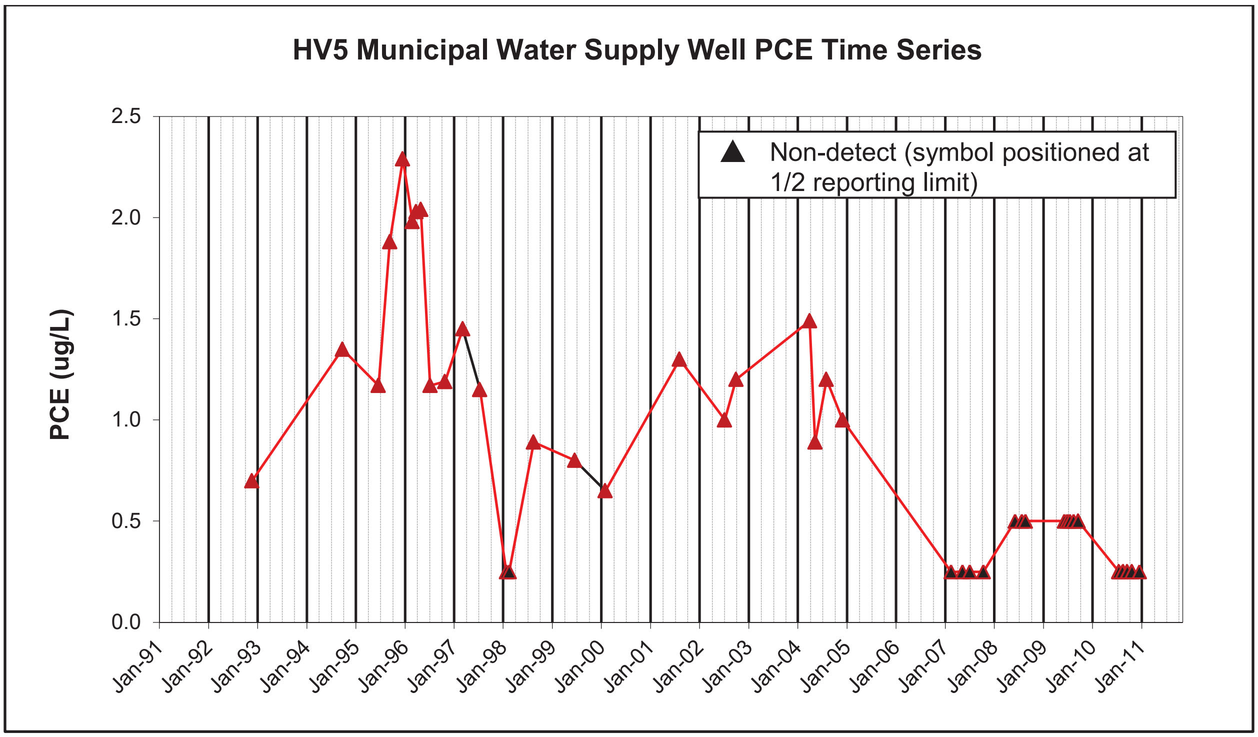
PCE concentrations at all three of the PCE-impacted monitoring wells have been below the MCL (5 µg/L) since samples have been collected. Deep zone well BELFAST has the longest history of water quality data (covering the entire GMP period). PCE was first detected at BELFAST in 2007 Q1 and has remained relatively stable ranging between 1.3 and 2.4 µg/L from 2007 through 2010. PCE concentration in shallow zone well CTM87 has a shorter period of record but has a similar range of concentrations as BELFAST, ranging between 2.0 and 3.0 µg/L from 2009 (after it was installed) through 2010. PCE in shallow zone well CTM86 was detected for the first time in 2010 and ranged between <1.0 and 1.3 µg/L.

Other PCE contamination has been recognized in the Joule Subregion in the past and includes an area of former contamination north of the current Joule plume footprint. This contamination was observed, between Mill Street and the Truckee River, in shallow zone wells CTM20S and USGSAG.

- At CTM20S, a single PCE detection (2.2 µg/L) occurred in 2001.
- At USGSAG, located approximately 650 feet southeast of CTM20S, PCE contamination was detected in six of 10 samples collected between 1999 (in the first sample collected at this well) and 2005. PCE concentration at this well ranged from a maximum of 20.6 µg/L (in 2000 Q2) and decreased to 2.1 µg/L in 2005 Q2. Since 2005, no PCE has been detected in USGSAG.

This area of former contamination is located cross gradient from the Joule plume footprint and is considered to have originated from a distinct and different source. Several PCAs have been identified in the vicinity. The lack of PCE detections since 2005 suggest that the contamination observed in this area has migrated beyond the well network.

It should also be noted that PCE impacted the HV5 municipal water supply well over the period between 1992 (when the well was constructed) and 2005 (see hydrograph below). PCE concentration during this period ranged up to 2.3 µg/L. Since 2005, PCE concentration has remained below the reporting limit (which was lowered to 0.5 µg/L in 2010 Q3). The distinctly different timing (1992 to 2005) of impacts at HV5 compared to the timing (2007 through 2010) of impacts at deep zone well BELFAST suggest the possibility of separate origins for the historical impacts at HV5 and the currently defined Joule plume.



5.12.6 Trends and Patterns in Water Levels and PCE Concentrations in Key Wells

PCE concentrations and groundwater level elevations measured in key wells (**Figure 5.30**) in the Joule Subregion are plotted on **Graph 5.7a**. Changes to the original set of key wells were made in 2010 based on DWR's ongoing well network review (as described in **Section 5.4.1**). In 2010, shallow zone key wells include CTM86 and CTM87 and deep zone key wells include BELFAST and CTM85. For 2010:

- Shallow zone wells CTM86 and CTM87 and deep zone well CTM85 are new wells constructed in late 2008 or 2009. The rationale for adding these to the key well list are provided in **Appendix 5.1**.

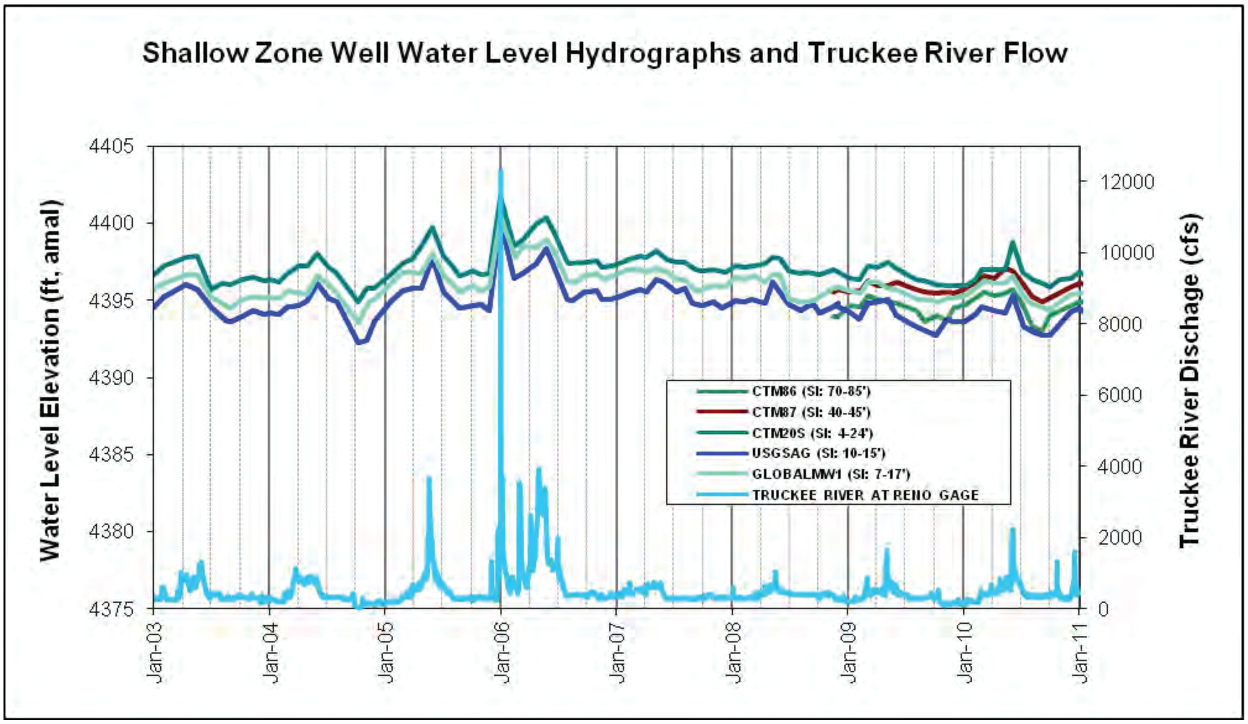
Patterns and longer term trends involving groundwater levels as shown on **Graphs 5.7a** are described below. Select graphs are embedded in the following text to illustrate certain trends or patterns.

Groundwater elevations for certain non-key wells are included in the descriptions below because the newer key wells in this subregion have only two years of monthly water level measurements.

Water Levels

Shallow Zone

Water levels for shallow zone monitoring wells including key wells CTM86 and CTM87, along with CTM20S, USGSAG, and GLOBALMW1 (all shown on graph below) are generally similar. Based on the non-key wells that have data over the entire GMP period, the shallow zone exhibits an overall increase in average annual water levels of approximately 1 to 3 feet between 2003 Q4 and early 2006. This increase occurred during a period when annual average precipitation and annual average Truckee River discharge also increased. Between 2006 and the end of 2010, average annual water levels decreased by approximately 5 feet. This decrease corresponds to decreasing Truckee River discharge and precipitation (between 2006 and 2007) and to increasing pumping volumes in the subregion (from 2008 through 2010). A distinct pattern of water level fluctuations is overprinted on the longer term trends. Water levels are highest during or shortly after periods of increased Truckee River discharge as shown on the graph below. These increases in water level are more abrupt and greatest in magnitude (up to approximately 5 feet) during the largest magnitude increases in river discharge. Water levels are typically lowest in Q3 or early Q4 and correspond to the combination of lower Truckee River stage and the cumulative impact of regional pumping that generally occurs during the summer as a result of increased community-wide water demand. Shallow zone water levels exhibit annual water fluctuations of approximately 1 to 5 feet.



Deep Zone

Water level trends and patterns from deep zone key wells BELFAST and CTM85 are similar over the two year period where data exist for both. The BELFAST hydrograph covers the entire GMP period and is therefore used to represent deep zone water level trends and patterns in the Joule Subregion. Average annual water levels exhibit a gradual increase of roughly 2 to 3 feet between 2003 Q4 and 2006 followed by a slight decreasing trend of approximately 2 feet through 2009. Average annual water levels in 2009 and 2010 were similar. Recurring water level fluctuations are observed annually and are on the order of 1 to 3 feet. The timing and duration of water level decreases (in Q2 and Q3) generally coincide with peak pumping periods.

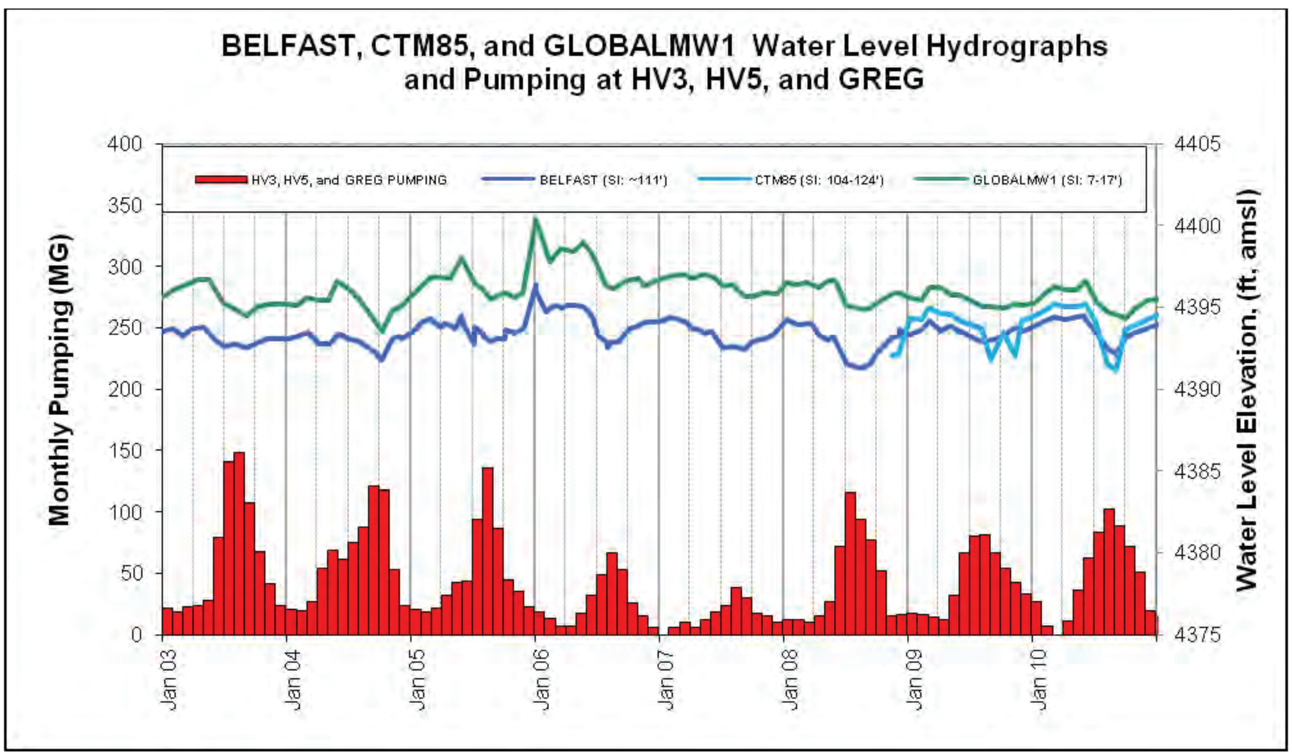
For comparison purposes, hydrographs for deep zone wells BELFAST and CTM85 are shown in the graph below, together with the hydrograph for shallow zone well GLOBALMW1, and cumulative monthly pumping for HV3, HV5, and GREG municipal water supply wells. The graph illustrates that:

- Shallow zone and deep zone wells in the Joule Subregion tend to exhibit an overall similar pattern (in terms of timing and magnitude of change) that reflects the influence of both the Truckee River and municipal water supply pumping.

- Responses to the Truckee River (for example the water level spike in January 2006; see previous graph with corresponding Truckee River flow) are of greater magnitude in the shallow zone; whereas

- Responses to pumping (for example drawdown in 2006, 2007, and 2008) are of greater magnitude in the deep zone.

The finding that groundwater in the shallow zone and the upper portion of the deep zone are each influenced by both the Truckee River and pumping indicates that there is good hydraulic communication between the shallow zone (near the water table) and deep zone (to depths of at least 114 feet bgs) in the Joule Subregion. The nominally smaller drawdown response to pumping observed in the shallow zone compared to the deep zone indicates that the aquifer system behaves in an anisotropic manner. The smaller magnitude river response in the deep zone compared to the shallow zone indicate a similar anisotropic behavior.



PCE Concentrations

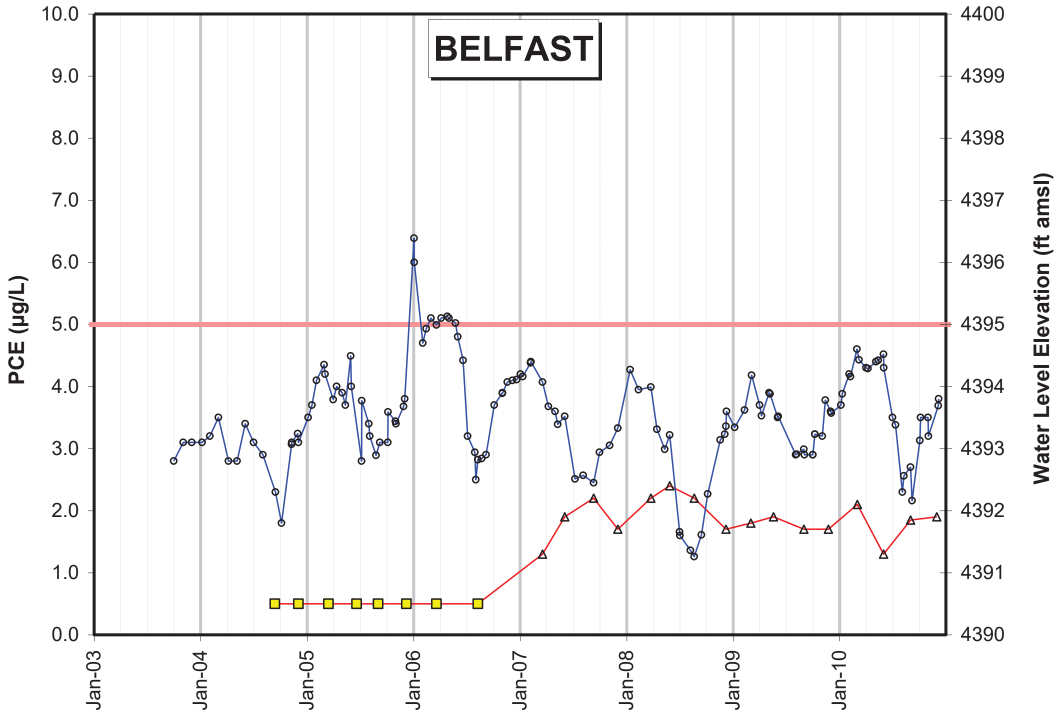
PCE concentration trends and patterns observed in the key wells are summarized below.

Shallow Zone

- CTM87 (screened interval - 40 to 45 feet bgs):
  - PCE data define no Mann-Kendall trend based eight samples collected since the well was constructed in late 2008.
  - Additional data are needed to define any recurring pattern or potential interrelationship between water level and PCE concentration.
  - PCE concentration has ranged between 2.0 to 2.7 µg/L.
- CTM86 (screened interval - 70 to 85 feet bgs):
  - PCE exhibits an increasing Mann-Kendall trend based on eight samples collected since the well was constructed in late 2008.
  - Additional data are needed to define any recurring pattern or interrelationship between water level and PCE concentration.
  - PCE concentration has ranged from less than the reporting limit (1.0 µg/L) to 1.3 µg/L.

Deep Zone

- BELFAST (screened interval – open at 114 feet bgs):
  - PCE exhibits an increasing Mann-Kendall trend over the GMP period.
  - This increasing trend is defined by a period where no PCE was detected between 2003 Q4 and 2006 Q3 followed by a period between 2007 Q1 through 2010 where PCE detections have been relatively uniform, ranging between 1.0 and 2.4 µg/L.
  - PCE data exhibits no obvious recurring pattern or interrelationship water level changes.
  - The PCE impact at BELFAST occurs after the PCE impact (between 1992 and 2005) observed at HV5 ceased. This is potentially consistent with two distinct sources (and/or releases) of PCE contamination in the area.



5.12.7 Receptors

HV5 has been an historical receptor (last detection in 2005) to PCE contamination that may be attributable to the Joule plume. HV3 is a potential receptor.

HV5 is located approximately 1,600 feet northeast of BELFAST and is cross gradient from the currently defined portion of the Joule complex plume (based on regional water level contours). PCE time series data for HV5 is provided in **Section 5.12.5**. At HV5, PCE was initially detected in November 1992, immediately after completion of the well. From 1992 through 2005, PCE was detected in 17 of 23 samples and had a maximum concentration of 2.29 µg/L (in December 1995). There is no record of sampling at HV5 in 2006. Since 2007 (through 2010), PCE has not been detected at HV5 in 21 samples.

HV3 is located more than 2,000 feet northeast of the northern defined extent of the Joule plume. PCE has never been detected in HV3 (15 samples between 1991 and 2004, 14 samples between 2008 and 2010). HV3 occurs in an area where PCE (from what is considered a separate and distinct point of origin compared to the Joule plume) was observed in shallow zone monitoring wells CTM20S and USGSAG. PCE at these nearby monitoring wells has not been observed since 2005.

PEZZI is also located in the Joule Subregion but is currently only used for construction water supply. While there are no plans to change the use of PEZZI, the well could represent a potential receptor if it is converted to a municipal water supply well.

5.12.8 Joule Subregion Conceptual Model

The Joule complex plume is presently characterized by PCE detections in two shallow zone wells and one deep zone well. As such, the magnitude and extent of the plume in currently undefined. Groundwater contamination presently attributed to the Joule complex plume exists within a 1,300 by 1,300 foot area that is proximal to the HV5 municipal water supply well. PCE occurs in the upgradient part of the plume footprint at depths as shallow as 40 feet bgs, suggesting that a nearby source or sources occur northwest of CTM87. However, no specific sources have yet been identified. PCE contamination extends into the upper portion of deep zone to a depth of at least 114 feet bgs.

The Joule Subregion conceptual model is based on the data presented in **Sections 5.12.1 through 5.12.7. Figure 5.31** is a plan view schematic that shows the pertinent aspects of the subregion conceptual model.

Hydrogeology

Lithologic data indicate that the stratigraphy is flat-lying. There is lateral and vertical variability in lithology that includes coarser grained material (sand and gravel) that transmit water, alternating with thin (10 feet or less) interlayers and lenses of finer grained material (silt and clay) that locally could act to impede vertical groundwater movement. Based on the current assessment, finer grained interlayers are not laterally or vertically extensive in the subregion. However, additional evaluation is needed to better characterize the continuity of lithologic material and to define hydrostratigraphic packages in the subregion**.**

Lateral Groundwater Movement

The shallow zone gradient is consistently toward the southeast, and does not change substantially in magnitude over the course of the year. The hydraulic gradient generally diverges away from the Truckee River in the north portion of the subregion. Water level data also indicate that the shallow zone groundwater responds to changes in river stage. These characteristics indicate that there is relatively good hydraulic communication between the shallow zone and the Truckee River and are consistent with the river being a source of recharge in the area. Water level data also indicate that the shallow zone responds to pumping. This indicates that there is a vertical hydraulic connection between the shallow zone and deep zone in the Joule Subregion.

Based on quarterly water level contouring, the deep zone gradient is depicted as generally similar to the shallow zone gradient, and is consistently toward the southeast with a magnitude that is similar to that observed in the shallow zone. Cones of depression are inferred to develop and cause convergent flow toward supply wells in the subregion when they are pumped. However, the influence of pumping on deep zone water level contours is not evident in quarterly water level contours due to the limited distribution of deep zone data points near municipal water supply wells in the subregion.

Vertical Groundwater Movement

Groundwater level data indicate that a downward vertical gradient generally exists between the shallow zone and the upper portion of the deep zone throughout the year. This downward gradient is relatively small during low or non-pumping conditions (typically during periods in Q1 and Q2) and increases in magnitude during pumping conditions (typically during periods in Q3 and Q4). This behavior indicates that the potential for downward groundwater flow and PCE migration exists year-around, but is enhanced by periods of sustained pumping. Downward gradients that occur during non-pumping periods support the interpretation that the Truckee River acts as a source for recharge in the shallow zone.

Potential PCE Sources

Several PCAs have been identified in the Joule Subregion but the specific source or sources of PCE contamination impacting the shallow and deep zones are as yet undefined. Multiple sources are considered likely in the subregion based on:

- The difference in timing (prior to 2005) and location of PCE contamination at CTM20S and USGSAG compared to PCE contamination associated with the Joule plume; and
- The difference in timing (occurring prior to 2005) of PCE contamination at HV5 compared to PCE contamination at BELFAST (occurring after 2007).

At least one potential source for the presently defined Joule plume could occur relatively close to, and northwest of CTM87 based on the shallow occurrence of PCE contamination and the generally northwest-to-southeast lateral gradient in the vicinity of this well.

Plume Formation and Distribution

The magnitude and extent of the Joule plume are presently undefined. Current PCE impacts at two shallow zone wells and one deep zone well define a plume footprint (based on PCE contouring) that covers an area of approximately 1,300 feet by 1,300 feet. However, the plume extent is not delineated west, east, and south of these three wells. The lateral groundwater gradient in the subregion indicates that shallow zone PCE contamination would migrate from the northwest (upgradient) of the currently defined plume footprint and is therefore likely to extend in that direction.

The vertical extent of the plume is also undefined. Present data indicate that the plume extends to a depth of at least 114 feet bgs in the southern part of its footprint. To the north (at CTM85), the plume is interpreted to extend no deeper than 124 feet.

PCE impacts have been recognized at the HV5 municipal water supply well in the past (between 1992 and 2005). These impacts could be related to the present Joule plume (i.e., originating from the same source or sources) or they could have had a separate and distinct origin. The distinctly different timing (2007 through 2010) of PCE impacts at deep zone well BELFAST compared to the timing (1992 to 2005) of impacts at HV5 are more consistent with separate origins. For either scenario, the more recent impacts observed at BELFAST are an indicator of an increased potential threat at HV5.

PCE Migration Mechanisms and Pathways

PCE in the Joule complex plume is interpreted to have originated or be originating from one or more sources upgradient and to the west or northwest of the current plume footprint.

Hydrostratigraphy is characterized by flat-lying intervals of generally coarser grained material with interlayers and lenses of finer grained material. Material properties are consistent with aquifer behavior that would reflect a heterogeneous unconfined aquifer system. The finer grained interlayers and lenses are interpreted to locally inhibit downward movement of groundwater and PCE contamination. However, no laterally continuous layer has been identified that could act as an aquitard between the water table and groundwater producing intervals in the subregion.

There is a relatively persistent downward vertical gradient between the shallow zone and the deep zone that increases in magnitude during pumping conditions, and provides the driver for downward PCE movement. Water supply wells that influence the vertical gradient in the subregion include HV5, HV3, PEZZI (which pumps a relatively small volume of water), and possibly GREG. There is a recognized drawdown response at shallow zone wells to municipal water supply well pumping that indicates a hydraulic connection between the shallow zone and the deep zone groundwater producing intervals. The relatively shallow depth of HV3 and HV5 (screened intervals - 105 to 191 feet bgs and - 68 to 138 feet bgs, respectively) means that PCE need only migrate 60 to 100 feet below the water table to reach groundwater producing intervals where these wells are constructed. The occurrence of PCE in shallow zone well CTM85 (screened interval – 70 to 85 feet bgs) and deep zone well BELFAST (open below 114 feet bgs) indicate that PCE has moved downward to depths that coincide with these nearby water supply wells.

Threats to Receptors

HV3 and HV5 are potential receptors for the Joule plume. The threat to either of these potential receptors depends on the plume distribution and magnitude, which are incompletely defined. HV5 has been a historical receptor for PCE contamination in the subregion. However, it is not known whether the pre-2005 PCE impacts at HV5 have any relationship to the presently defined Joule plume. The current existence of PCE at the same depth as, and in the upgradient vicinity of HV5 suggests a relatively higher potential threat to HV5 by the Joule plume. The crossgradient location of HV3 from the presently defined plume suggests a relatively lower potential threat to this well at this time. PEZZI (a construction water supply well) would become a potential receptor if it were converted to a municipal water supply well and pumped more routinely.

5.12.9 Summary

The Joule PCE plume is a complex plume that occurs in the shallow and deep zones to the southwest of municipal water supply well HV5. A downward vertical gradient exists between the shallow zone and the upper portion of the deep zone (where HV3 and HV5 are constructed) during both pumping and non-pumping conditions. This downward vertical gradient combined with the absence of any laterally extensive aquitard has allowed PCE to migrate to a depth of at least 114 feet bgs. Vertical hydraulic communication between the shallow zone and the deep zone is evident and the potential for downward PCE movement is enhanced by pumping at HV3, HV5, PEZZI, and possibly GREG.

The overall magnitude and extent of the Joule complex plume is unknown, being defined at two shallow zone wells and one deep zone well. The source(s) of PCE contamination are also unknown. The relatively uniform northwest-to-southeast shallow zone groundwater flow direction and the shallow occurrence of PCE at CTM87 suggests that at least a portion of the plume originates from an area to the west or northwest of plume footprint.

HV5 is the closest potential receptor for the Joule complex plume. Historical PCE impacts at HV5 may or may not be associated with the Joule plume. HV3 is also potential receptor depending on the magnitude and extent of the Joule plume to the north of its presently defined footprint. PEZZI would also be a potential receptor for PCE contamination if the well were converted for use as municipal water supply well and were pumped more routinely.

6. DATA GAPS

Significant data gaps identified during implementation of the GMP to date are discussed in the following sections. A discussion of general data gaps is presented in **Section 6.1**, followed by additional individual sections that discuss subregion-specific data gaps. Where appropriate, recommendations for addressing specific data gaps are included.

6.1 General Data Gaps

General Data Gap 1 – Potential Limitations Imposed by the Existing Monitoring Well Network

The GMP is being implemented in a large area (of more than 16 square miles). Some of the monitoring wells utilized in the GMP were installed during reconnaissance level assessment of PCE in the CTM or were installed for purposes not directly associated with PCE contamination of groundwater (and have been opportunistically incorporated into the CTMRD program monitoring network).

Because of this, existing wells can be:

- By necessity, widely and/or non-uniformly distributed (both horizontally and vertically);
- Completed with a wide range of screened interval lengths; and,
- Completed with screened intervals that are hydrostratigraphically non-specific.

Because of these factors, wells in the existing monitoring well network are not always optimally located, designed, and/or constructed for monitoring:

- The extent and potential migration of the multiple PCE plumes that have been recognized; or
- The pathways along which PCE could migrate from potential sources, through a complex hydrogeologic environment, toward existing and/or potential receptors.

Vertical movement has been shown to be an extremely important component of both groundwater flow and contaminant transport of PCE in the CTM. The migration of PCE (which is chemically stable and persistent under typical conditions in the CTM) from sources at or near the ground surface to receptor wells in the deep zone of the aquifer system allows this contaminant to act as a chemical "tracer". Behaving as a tracer means that the present distribution of PCE is a direct result of the lateral and vertical groundwater flow (and accompanying PCE movement) that has taken place to date in the CTM. Adding to the existing monitoring well network in certain important areas would reduce the uncertainty relative to the present PCE distribution and potential PCE migration pathways from recognized potential source areas, plume hot spots, or known plume cores toward receptor or potential receptor wells. Alternatively, other types of data collection activities (as described below) could be more cost effective (than additional monitoring wells) at providing key information to support plume management and mitigation decision-making.

Recommendations to address limitations posed by the existing monitoring well network include:

- Perform additional vertical discrete water quality and flow profiling to identify specific stratigraphic intervals within individual water supply wells that provide significant PCE mass to those wells. Vertical profiling results (as demonstrated by investigations at HIGH and MORRILL, and described in the 2009 GMP annual report (WorleyParsons, 2013), provide valuable information that help project those PCE-impacted intervals back toward the ground surface or to where they are in communication with the shallow zone. These results can be used as a means to identify possible source areas and/or conduits for that PCE mass. In turn, these results help narrow down the areas where additional monitoring wells would most effectively contribute to GMP objectives and augment the current monitoring well network. In 2010, vertical profile data were collected at ELRANCHO, 4TH, and MILL. These data will be analyzed with results to be provided in the 2011 annual report. Other municipal water supply wells where vertical profiling should be considered include the PCE-impacted CORBETT, KIETZKE, and POPLAR2. The decision to conduct profiling at one or more of these wells should be based on defining how the vertical profile data at each well supports specific plume management or mitigation decisions.

- Prepare and use additional detailed hydrogeologic cross sections to identify regions where additional stratigraphic detail and plume characterization are required. Update hydrogeologic cross sections based on new information as it comes available. Construct additional monitoring wells (if necessary) at locations based on data gaps identified through the process. The following additional/updated cross sections are recommended:

    - Two sections through the ELRANCHO municipal water supply well; one oriented from west to east (including CTM112/CTM113-ELRANCHO-MITCHELLTW-DILWORTH-STANFORD) and one from north to south (including the bedrock/basin fill contact to ELRANCHO-VIEW-MENTALHEALTH-GALLETTI). These sections will help define migration pathways and potential source areas for PCE that impacts ELRANCHO.

    - One north to south section between MILL and TERMINAL to help define the distribution of, potential hydrostratigraphic influences on, and the relative potential threat to TERMINAL posed by the Downtown Reno, Mill/Kietzke, and South Reno plumes in the area where all 3 plumes apparently overlap.

- Improve efficiency of GMP by defining and implementing a monitoring optimization process (optimize for specific wells, sampling frequency, list of analytes; eliminate redundant data collection sites). In 2010, each well within every subregion was assessed to define its function and value in the context of the GMP objectives. Key wells were redefined based on this evaluation. The next step in the process will include developing and implementing a process for defining which specific wells should be monitored, which wells are redundant and should be eliminated from the GMP well network, and how frequently individual wells that remain in the network should be monitored.

General Data Gap 2 – PCE Sources

Many current and historical PCAs (i.e. potentially contributory activities or potential PCE-using businesses) have been identified in the CTM, but few PCE releases have been reported, few specific PCE sources have been identified, and even fewer PCE sources are being or have been investigated and/or remediated to date. A relatively small number of PCE-related regulatory corrective actions have been undertaken or are underway at specific potential sources. Most of those have yet to be completed.

The persistent nature of and generally stable PCE concentration in the CTM groundwater plumes defined by GMP data suggest they originate from relatively robust contaminant sources; however, these sources have (for the most part) yet to be identified and/or mitigated. Potential source area investigations conducted by the CTMRD program are underway at several areas where PCE hot spots and/or a relatively high density of PCAs are known to exist in the upgradient portions of groundwater plumes in the CTM. Specifically, PSA investigations are ongoing in the South Reno, Downtown Reno, Mill/Kietzke, and Downtown Sparks Subregions. At the Mill/Kietzke PSA, 12 active soil gas monitoring wells are planned to determine whether PCE concentration in soil vapor is high enough to pose a threat to groundwater. For the other three PSAs, PSG surveys have been completed (or nearly completed) and PCE high mass areas have been characterized and defined. Similar to the Mill/Kietzke PSA investigation, the second phase of investigation will be developed at each of these PSAs to assess the threat posed by individual PCE high mass areas to continued contamination of groundwater.

It is unlikely that there are, as of yet, undiscovered major PCE plumes in the CTM. However, it is possible that additional, as of yet unidentified, sources and/or plume hot spots may exist. This data gap is most pertinent where shallow zone plumes have been identified and most significant where these shallow zone plumes are upgradient from unprotected municipal water supply wells (i.e. those wells without wellhead treatment for PCE).

Recommendations:

- Continue to consider the results from PSA investigations and the GMP together in context of how their combined results influence CTMRD program priorities and actions. Combined results should be considered with regard to whether and how near-source groundwater contamination is related to PCE high mass areas in the soil vapor. Maintaining an awareness of any interrelationships will benefit both projects and will help develop more robust hydrogeologic and contaminant conceptual models for PCE source areas in the CTM.
- Implement a PSA investigation in the area north of ELRANCHO to define the potential source(s) for PCE that impacts the upper screened interval of the ELRANCHO municipal water supply well. Conduct a relatively small scale PSG survey in the vicinity of the two PCE-using businesses that have or are currently operating in that area. Based on those results, follow up with additional PSG surveys to provide the appropriate resolution of any identified PCE high mass areas. Consider other follow-up activities based on the combined results of PSG surveys and the ongoing El Rancho Impacted Well Investigation.

- Prioritize and conduct PSG surveys at other hot spots and locations where upgradient shallow zone PCE contamination poses a potential threat to groundwater or to unprotected municipal water supply wells. Consider PSG surveys at the Condor Way hot spot (defined by wells USGSWOOSTER and CTM99) and in the Joule Subregion, in the area proximal to PCE contamination identified at shallow zone wells CTM87 and CTM85.

General Data Gap 3 –Hydrogeologic Framework and Conceptual Model

The understanding of subsurface hydrostratigraphy and the influence it has on groundwater flow and PCE migration in the CTM is still being developed. Systematic evaluation of the CTM hydrostratigraphy and aquifer test data is ongoing. This work is being conducted using existing lithological and aquifer test data in conjunction with the development of a geological conceptual model that that is consistent with geologic, hydrologic, and contaminant distribution/dynamics data. This conceptual model may eventually support a numerical groundwater flow and transport model of the CTM. The systematic evaluation of the CTM hydrostratigraphy and aquifer test data is also being done to form a basis for identifying and addressing key hydrostratigraphic data gaps. The schematic cross sections provided in this annual report are part of this effort. The following recommendations would help resolve some of the key data gaps in this regard:

- Review the set of currently completed hydrostratigraphic cross sections to formally document and determine whether criteria used to define and distinguish individual hydrostratigraphic packages is appropriately data driven and consistent. Hydrostratigraphic packages are intended to be utilized to distinguish between laterally continuous, principal water-bearing sequences and similarly continuous sequences that are impediments to groundwater flow and PCE migration in the CTM. As improvements to the understanding of the hydrogeology and hydrodynamics in the CTM are made, the need exists to reassess whether hydrostratigraphic packages as currently defined, consistently and appropriately represent the hydrogeologic conditions across the CTM basin.

- Continue to make progress identifying and characterizing those areas within the CTM where vertical movement of groundwater (and contaminants) is relatively enhanced and movement from the shallow to deep zone occurs. Specifically, continue to conduct and analyze long duration aquifer tests that characterize aquifer system behavior, and can help to identify locations where vertical groundwater flow (and potential PCE migration) is either relatively enhanced or impeded;

- Characterize the detailed hydrostratigraphy and possible lithologic controls on PCE movement in and around potential contaminant source areas. Data collected as part of each PSA investigation could be incorporated into individual, high-resolution hydrostratigraphic conceptual models for potential source areas, once they are determined to pose a threat to groundwater; and

- Continue to characterize the detailed hydrostratigraphy, vertical PCE distribution, and possible lithologic controls on PCE movement in the vicinity of PCE-impacted municipal water supply wells. A part of this recommendation could include conducting additional vertical profiling at PCE-impacted CORBETT, KIETZKE, and POPLAR2 municipal water supply wells.

Addressing these data gaps, incrementally and/or on a recurring basis would result in a geologic model that more accurately represents the hydrogeology of the CTM and will more effectively support a groundwater flow and contaminant transport model with improved predictive capabilities. It will also help identify those areas with an enhanced hydraulic connection between the shallow zone (where PCE originates) and the deep zone (where municipal water supply wells are completed) within the CTM complex aquifer. These areas are where there is a resultant greater risk to the local groundwater supply from PCE contamination.

General Data Gap 4 – Subsurface Faults and/or Lithologic Discontinuities

The location, nature, and hydrogeologic properties of known, probable, and/or possible subsurface faults and/or lithologic discontinuities are presently poorly constrained in the CTM. The apparent importance of these features (*e.g.*, the VLFZ and the HWB) as influences on groundwater flow in both the shallow zone and the deep zone is becoming increasingly evident. Features that influence water movement are also likely to influence PCE movement and distribution. The VLFZ and HWB, where recognized, can act as partial barriers to groundwater movement. The location of these hydraulic flow barriers is constrained in a limited number of locations where water level data from wells that are relatively close to each other define local deviations in the gradient or flow direction. Data gaps associated with known, probable, and possible hydraulic flow barriers that have been identified to date include the following:

- The location, geologic character, and hydraulic properties of the VLFZ are poorly constrained and incompletely understood.
    - Based on the existing data, the VLFZ is a north-trending zone within which multiple discrete structural features are recognized at the surface and are present over a finite width. Where currently defined, the VLFZ could be continuous or comprised of multiple, discontinuous segments. The continuity and location of features that act as flow barriers within the VLFZ is not well characterized or defined.
    - The presence and location potential flow barriers associated with the VLFZ are locally undefined in the following key areas:
        - the CTM north of the Truckee River; and
        - the area between the Truckee River and the northern extent of the South Reno Subregion.
    - Data to determine the location and to define the characteristics of the VLFZ with depth are presently unavailable.
    - The hydraulic properties of the VLFZ and how they might vary laterally and vertically is presently unknown. The lack of groundwater discharge at the land surface on the west side of the VLFZ indicates that the VLFZ is at least locally permeable to groundwater flow. The presence of apparently stable PCE plumes that cross the VLFZ and are

continuous in the third dimension indicates that the VLFZ is also at least locally permeable to PCE migration. The fact that pumping stresses do not appear to be effectively transmitted across the VLFZ during aquifer tests using the HIGH and MORRILL wells (located on either side of the VLFZ) could reflect both the influence of the VLFZ and a contributing influence by rapid recharge from the Truckee River. It is also possible that the length of the pumping tests and the limited distribution of observation points are not appropriate to accurately characterize the magnitude and distribution of pumping stresses transmitted across the VLFZ.

- The Downtown Reno plume crosses the area where the VLFZ and Truckee River intersect. While the VLFZ and the Truckee River are recognized as having significant influence on groundwater in the CTM, the potential interaction of the VLFZ with groundwater, the PCE plume, and the Truckee River is not well understood.

- The location of the HWB is poorly constrained, and the geologic character and hydraulic properties of this feature are not well understood.
    - Based on the existing data, it is not possible to determine whether the HWB is a single linear structural feature or a zone of some finite width within which multiple discrete structural features are present. It is also not possible to determine if the HWB is continuous or discontinuous and comprised of multiple individual segments.
    - The HWB is interpreted to be oriented in a northwest direction based on its location along two well transects (between CTM33D and CORBETT/CTM17D and between CTM102/CTM101/CTM100 and CTM9S/CTM104/CTM103/CTM10D) where the presence of this potential hydraulic flow barrier is recognized. The HWB could potentially extend both to the south and north of these transects where data to constrain its orientation and lateral extent are lacking. The northern extent of the HWB is of particular pertinence because of its possible influence on the migration of the Downtown Reno plume. The finding that the HWB projects towards the Truckee River, into the same area where the VLFZ is interpreted to exist, casts uncertainty on the relative influences of these two features on the Downtown Reno plume.
    - The hydraulic properties of the HWB have not been characterized and the specific influence this potential flow barrier may have on groundwater flow and contaminant transport in the shallow and deep zones is poorly understood. Data indicates that the HWB contributes to the presence of the upward vertical gradient that has been observed in the deep zone in at least part of the South Reno Subregion. However the extent to which this effect persists west of the HWB has not be determined.
    - Data indicates that the HWB acts as a flow barrier in the deep zone but not in the shallow zone between CTM33D and CORBETT. Other data along the northern projection of the HWB are unavailable to characterize the nature of the HWB with depth.

Recommendations include:

- The location and continuity of the VLFZ and the HWB could be mapped based on the distribution of water level responses to pumping at different production wells. This could be conducted by deploying the appropriate array of transducers in the vicinity of the VLFZ and HWB and monitoring water levels on a long term basis. The distribution of water level responses to individual pumping wells would then be captured during unique periods of pumping at individual wells that occur as a consequence of annual variations in pumping operations. The distribution of water level response to each pumping well would define "hydrogeologic provinces" where hydraulic connections exist (recognized by relatively large magnitude and similar water level response behavior to pumping) or discontinuities where flow barriers occur (recognized by a significantly muted or lack of water level response to pumping).
- Additional pumping tests using appropriately located pumping and observation wells could be used to substantiate the location and hydraulic properties of currently recognized hydraulic flow barriers (such as the VLFZ and the HWB) along with other, yet to be recognized barriers. Specifically:
    - High stress pumping tests (long duration and high flow rate) should be conducted in those key areas where there is a high degree of uncertainty in terms of how groundwater and contaminant movement is being influenced by:
        - Potential barriers to lateral and/or vertical groundwater flow and PCE movement; or,
        - Areas with good vertical hydraulic communication between the shallow zone and deep zone.
    - Data from these tests can be incorporated into the subregion conceptual models and CTM groundwater flow and transport model to improve the understanding in these key areas. At present such high priority data are lacking in the vicinity of the following municipal water supply wells:
        - RENOHIGH;
        - POPLAR #2; and
        - HV5.

General Data Gap 5 – Groundwater Flow and Recharge

Groundwater flow and contaminant transport are influenced both by recharge and by municipal water supply well pumping. The effects of and interaction between these factors has been seasonal in nature since 2006. While the qualitative understanding of these influences has been improved substantially based on the 2006 through 2010 GMP data analysis, the relative importance and quantitative effect of recharge by surface features such as the Truckee River and by artificial recharge using municipal water supply wells is not well understood.

Data (see **Section 2.3.1 and 5.7.2**) suggest that there is a significant source of shallow zone recharge that allows recovery in the underlying deep zone and replaces groundwater that is removed by sustained pumping of municipal water supply wells during periods of peak water demand. This is indicated by generally steady state conditions defined by relatively stable position of average annual water level contours in both the shallow zone and deep zone observed across the CTM since 2006. An obvious local recharge source is the Truckee River. Existing data suggest that in some areas shallow zone recharge has the potential to occur more readily and at higher rates than in others.

For example, in some areas where there is a hydraulic connection between the Truckee River and the groundwater, little to no shallow zone response to deep zone pumping has been observed. Such a muted shallow zone response is particularly evident in the area west of the VLFZ, in the upgradient footprint of the Downtown Reno plume. This muted shallow zone response could reflect the influence of recharge from the Truckee River (and other surface water features such as irrigation ditches in the vicinity of downtown Reno). Elsewhere, a muted shallow zone response could reflect local differences in hydrostratigraphy and/or the effect caused by hydraulic barriers (such as the VLFZ, HWB, or other as of yet unrecognized barriers). In some areas, an existing shallow zone response could simply be unrecognized given the limitations of the existing shallow zone monitoring network and/or lack of high resolution transducer data.

Artificial recharge can also have a potentially significant local effect on groundwater levels and therefore can affect vertical and lateral groundwater flow patterns. However, the potential influence of artificial recharge on PCE distribution and plume containment and/or capture has not been evaluated and is not well understood at this time.

Recommendations to address these data gaps include:

- Developing a process for using a combination of high resolution transducer water level data and water quality data (with an appropriate distribution with regard to the recharge source) to help quantify the relative importance of Truckee River recharge and artificial recharge on groundwater flow and PCE migration..
- Developing a process for using water quality data from municipal water supply wells near the Truckee River (including RENOHIGH, HIGH, MORRILL, KIETZKE, GALLETTI, and GREG) to quantify whether and how much Truckee River recharge is drawn into these wells during periods of pumping. This would help better define how pumping influences Truckee River recharge. This would contribute to a better understanding of how the interrelationship between pumping and Truckee River recharge influences groundwater flow and PCE migration.

Both recommendations would support the development of an updated groundwater flow and transport model of the CTM.

6.2 South Reno Subregion Data Gaps

- PCE sources may be present in one or more of the five PCE high mass areas (HMAs) defined in the Vassar/East Plumb potential source area (PSA). However, the assessment of these HMAs has not proceeded to the point where any ongoing threats to groundwater can be substantiated. An important goal of the GMP is to inform the PSA investigation by using groundwater information to characterize potential residual sources (location, size, age, etc.).

- **Recommendation:** Continue the ongoing assessment of GMP data near the Vassar Street hot spot in conjunction with and to support the PSA investigation at the Casazza HMA. Utilize PCE time series and hydrograph data for monitoring wells within or near the hot spot, along with groundwater flow direction data, and other water quality (VOC and field parameter) data to characterize potential sources in the PSA in the context of:
    - Source location(s) relative to the hot spot
    - Source term characteristics (decreasing, increasing, stable, etc.)
    - Water quality forensics that might distinguish different sources
    - Apparent release characteristics (i.e., ongoing or active discharge, residual source [in vadose zone, smear zone, or below water table] etc.)
    - Potential age of initial release(s) based on travel times required for contamination to migrate from the hot spot to CORBETT and on the occurrence of PCE at CORBETT in 1993.
- **Recommendation:** Active soil gas (ASG) and groundwater monitoring wells are planned for 2013 to further characterize and assess the three HMAs (Casazza, Arroyo, and Wonder) that are not spatially associated with active NDEP Corrective Action sites (Wrondel and Cadillac). ASG well locations will be based on the 2009/2010 passive soil gas survey (PSG) results. The data from these wells will be evaluated in the context of the available hydrogeologic and water quality data for the PSA. Nested groundwater monitoring wells may be installed if warranted based on ASG results. The objective of the ASG wells will be to determine if soil vapor concentration are high enough to pose a threat to groundwater. Activities will be designed to provide data to address the following goals:
    - Evaluate subsurface PCE vapor concentrations;
    - If vapor concentrations exceed the threat threshold, estimate the total mass of PCE in the vadose zone; and
    - Evaluate the location and nature of the PCE vapor source (e.g., residual PCE mass in vadose zone or off-gassing groundwater).

The PSA monitoring locations will be sampled quarterly.

- The Condor Way hot spot may result from PCE sources on the east side of the HWB. Substantiating and eliminating any source that may cause this hot spot is directly related to the goal of mitigating PCE threats to groundwater.

  - **Recommendation**: Conduct a passive soil gas survey (PSG) in the area that extends west from Harvard Way to Terminal Way, and north from East Plumb Lane to Vassar Street. The survey will be designed to identify PCE high mass areas spatially associated with the Condor Way hot spot.
  - **Recommendation**: Assess the PCE vapor concentration in any identified HMAs to determine whether they pose a threat to groundwater.

- There remains a limited understanding of the location, geologic characteristics, and hydraulic properties of HWB. The influence of this feature on groundwater flow and PCE distribution is potentially significant, but presently not well understood. An improved characterization of where and how PCE moves across the HWB will contribute to defining the South Reno plume dimensions and PCE mass, assessing plume dynamics, and estimating PCE travel time from source to receptor.

  - **Recommendation:** Complete the analysis of the 2009 CORBETT-MILL aquifer test data to better define the location, extent (lateral and vertical), characteristics, and continuity of HWB. Use observation well data to identify areas where:
    - Measurable responses indicate that hydraulic continuity (and enhanced flow) exists across the projection of the HWB; and
    - The lack of response indicates that the HWB exists and impedes groundwater flow (and PCE migration).
  - **Recommendation:** Conduct sequential pumping at HIGH and MORRILL (where HIGH is pumped for at least 10 days prior to pumping at MORRILL) while collecting near-continuous water level measurements at monitoring wells in the area between the HWB and VLFZ. Use data to help identify the principal hydrodynamic influences in that area. This will help determine whether pumping operations at HIGH or MORRILL could cause unintended changes in either the lateral or vertical migration of the South Reno plume. Also, and in conjunction with other GMP data, the information will help resolve the continuity and characteristics of the HWB and the VLFZ beyond where they are currently defined. This will help determine whether the flow barrier located between HIGH and MORRILL is 1) associated with the VLFZ (as currently defined); 2) the northern extension of the HWB; or 3) may constitute the convergence of both these features.

- Potential PCE migration pathways, on either side of the HWB, are presently incompletely characterized. West of the HWB, limited data suggest that an upward gradient exists and the plume migrates laterally and occurs principally in the shallow zone. However, it is not known whether the upward vertical gradient persisted prior to the GMP. East of the HWB, downward gradients can exist and the limited evidence for finer grained material that would act as an effective aquitard is interpreted to indicate that downward groundwater flow and PCE movement occurs once PCE has migrated across the HWB. However specific locations where this can occur (or has occurred) have not been identified and hydraulic properties that control the pathway and rate of migration have not been established. An improved understanding of PCE migration pathways will inform efforts to define the plume dimensions. In addition, results can be used to help establish plume metrics that 1) track PCE source contributions and 2) assess whether the plume is expanding, stable, or shrinking in size.

- **Recommendation:** Complete the evaluation of the CORBETT-MILL aquifer test to better define potential lateral PCE migration pathways across the HWB and vertical migration pathways east of the HWB. Define these potential pathways based on the location of observation wells where relatively larger water level responses to pumping indicate areas of hydraulic continuity. Use these results to verify and refine the conceptual model for PCE migration from sources west of the HWB to PCE-impacted CORBETT. Apply hydraulic parameters from the test to estimate PCE travel time from hot spots to CORBETT.
- **Recommendation:** Assess vertical gradient data west of the HWB for the potential that downward gradients could have occurred in the past (as a consequence of historically greater pumping volumes) and could have acted as a driver for downward PCE migration on the west side of the HWB at some time prior to the GMP period. Specifically, use water level gradient data at well clusters HOLCOMBAVMW/CTM48, CTM96/CTM95/CTM94, and CTM93/CTM92/CTM33D to define whether vertical gradients were downward during periods of higher historical pumping such as occurred between 2001 and 2004. If upward gradients have persisted since the 1930's, (when PCE was first used as a commercial product), then PCE is not likely to have had an opportunity to migrate downward. Verification of historically persistent upward gradients west of the HWB means that the South Reno plume thickness can be determined with a greater degree of certainty in the upgradient portion of the plume.
- **Recommendation:** Track and incorporate monitoring data (as it becomes available) from the ongoing Plumb Lane Plaza Corrective Action Site investigation located in the vicinity of the East Plumb Lane hot spot. PCE results from planned well pairs (expected to be constructed in 2011) will help define plume thickness in the vicinity of the East Plumb Lane hot spot.

- The degree of plume capture/containment of the South Reno plume by CORBETT has not been confirmed. PCE data at shallow zone well CTM99 and deep zone well CTM98 indicate that the South Reno plume extends at least 1,300 feet downgradient of CORBETT, and the maximum extent remains undefined in that direction. A better definition of the CORBETT capture zone will help determine whether increased pumping is needed to improve capture and containment of the plume.

- **Recommendation:** Complete the analysis of the CORBETT-MILL aquifer test to help establish hydraulic parameter estimates that can be used to better define the capture zone at CORBETT.
- **Recommendation:** Conduct a capture zone analysis for CORBETT. Use standard steady state methods (USEPA, 2008) to provide estimates of the maximum expected downgradient and crossgradient capture within the groundwater-producing hydrostratigraphic packages. Assess whether the deep zone PCE contamination at CTM98 and CTM106 is being captured at the current Pumping Plan target volume of 150 MG/yr, or whether increased pumping at CORBETT is needed to improve capture and containment.
- **Recommendation:** If capture is not indicated at CTM98 and CTM106, work with TMWA to increase pumping at CORBETT.

- The potential for the South Reno plume to impact TERMINAL has not been evaluated.
  - **Recommendation:** Complete the evaluation of the CORBETT-MILL aquifer test to better define the hydraulic properties (and potential for vertical communication) for the interval that separates the PCE-impacted hydrostratigraphic package where CORBETT is completed and deeper strata where TERMINAL is completed.
  - **Recommendation:** Participate in TMWA's planned 2011 water quality and flow profiling program at TERMINAL to better define vertical distribution of groundwater flow and whether measurable PCE mass currently impacts the well. Data will help define TERMINAL's potential as a receptor for the South Reno (and Downtown Reno, or Mill/Kietzke) plume.
  - **Recommendation:** Based on results from the above, work with TMWA to minimize downward gradients at TERMINAL by developing a pumping strategy where CORBETT is pumped whenever MILL and/or TERMINAL are pumped.

- Groundwater velocity, potential PCE travel time, and the lateral flow direction for the South Reno plume downgradient of CORBETT has not been evaluated. Consequently, if the plume is not captured or contained by pumping at CORBETT, a threat to potential downgradient receptors exists that has not been evaluated.
  - **Recommendation:** Utilize quarterly water level contour maps to evaluate groundwater flowpaths and identify the most likely potential downgradient receptors.
  - **Recommendation:** Combine hydraulic parameter estimates from the CORBETT-MILL aquifer test analysis and from previous slug tests to estimate travel times for the South Reno plume to reach the most likely potential receptor(s).
  - **Recommendation:** If pumping at CORBETT is increased to improve capture and containment (as discussed above), assess the influence of increased pumping on mitigating the threat to downgradient potential receptors by re-assessing capture/containment and re-evaluating travel times.

6.3 Downtown Reno Subregion Data Gaps

- PCE sources are considered likely to occur within one or more of the five PCE high mass areas (HMAs) defined in the West Fourth Street potential source area (PSA) by the 2009/2010 passive soil gas survey. However, individual sources have yet to be specifically identified or characterized with regard to their potential to contribute to groundwater contamination.
    - **Recommendation:** One additional passive soil gas survey is planned along the northern margin of the East Sixth and Record HMA to define the extent of that area to the north.
    - **Recommendation:** Follow-up work (also as part of the PSA) is planned to install active soil gas and groundwater monitoring wells that will be used to characterize and quantify PCE concentration in the vadose zone at each of the five high mass areas. Initial work will focus on the West Fifth HMA, where one well cluster (comprised of two active soil gas, one smear zone, and one groundwater monitoring well) is planned on Washington Street, west of CTM28S. Additional locations will be based on the PSG results and in the context of the available hydrogeologic and water quality data for the PSA. The objective of this work will be to define locations where soil vapor concentration (originating from potential sources) is high enough to pose a continuing threat to groundwater contamination in the Downtown Reno Subregion.
- The Downtown Reno eastern plume core is interpreted to have a significant impact at MILL. The capture of this higher concentration portion of the plume is critical to effectiveness of the Pumping Plan. This plume core is partially defined to the northwest of MILL at CTM10D. The plume core could either represent a detached higher concentration part of the Downtown Reno plume or it could originate from a separate contributing source south of the river. Determining whether this plume core is a detached part of the Downtown Reno plume or is from a separate source has implications with regard to both effective plume management by pumping at MILL and identifying a previously unrecognized source that could be mitigated near its point of origin.
    - **Recommendation:** Use the vertical PCE concentration and mass distribution data from BESST dynamic profiling at MILL (performed in 2010) to characterize the hydrostratigraphic position of the eastern plume core at MILL. Compare these results to the hydrostratigraphic position of the plume core as characterized at CTM10D. Incorporate the BESST data into the Downtown Reno plume cross section interpretation. Use the updated cross section to corroborate or revise the conceptual model for the plume core (i.e., formation, distribution, migration pathway, etc.).
    - **Recommendation:** Complete the analysis of the long duration CORBETT-MILL sequential composite aquifer test (performed in 2009) to help establish hydraulic parameter estimates and the degree of lateral and vertical hydraulic communication between MILL and the area encompassing the eastern plume core.

- **Recommendation:** Assuming that the plume core represents a detached portion of the Downtown Reno plume, use available water quality and hydrologic data to estimate when the high and increasing PCE concentration at MILL (interpreted to be attributable to the eastern plume core) is projected to peak and PCE concentration should start to decrease. Base this on:
  - The groundwater velocity required for peak PCE concentrations that were observed at MORRILL in 1994 Q4 to migrate to CTM10D in 2004 Q2; and
  - Travel time estimates for peak concentration observed at CTM10D to migrate to MILL based on Darcy's law calculations using available groundwater gradient data, hydraulic conductivity, and porosity estimates.

  If these calculations are consistent with PCE concentration data observed at MILL to date, use results as a predictive tool to support the management of pumping operations at MILL. If calculations are not consistent with the available PCE data, the detached plume alternative would be considered a less likely explanation for the plume core
- **Recommendation:** Assess whether the BESST dynamic profiling data at MILL exhibit a distinct "water quality signature" in shallower portions of the well screen compared to deeper portions. A distinct signature (including characteristic PCE: TCE ratios, inorganics concentrations, and metals concentrations, etc.) in the upper screened interval at MILL would support the concept of a distinct source located south of the river. Possible sources could include a currently unrecognized source(s) upgradient (northwest) from CTM10D or source(s) associated with the Mill/Kietzke plume.
- **Recommendation:** If BESST data are more consistent with a separate source, and if other recommended assessments (described above) do not support the detached plume concept, conduct a PSG survey in the area south of the Truckee River to Mill Street, and east of the HWB to Gould Street. Use results to define PCE HMAs that would reflect possible contributing sources to the Downtown Reno plume.

- The degree of downgradient plume capture/containment by MILL and KIETZKE has not been confirmed. Specifically, the capture zones of MILL and KIETZKE need to be better defined. The Pumping Plan Analysis (Intera, 2006b) indicates that a small portion of the Downtown Reno plume may not be captured by MILL or KIETZKE. Monitoring well data indicate that TCE-rich contamination extends beyond KIETZKE and that PCE and TCE contamination extends beyond MILL.
  - **Recommendation:** Complete the analysis of the CORBETT-MILL aquifer test to establish hydraulic parameter estimates that can be used to better define the capture zones at MILL and KIETZKE.
  - **Recommendation:** Conduct-capture zone analyses for both KIETZKE and MILL. Use standard steady state methods (USEPA, 2008) to provide estimates of the maximum expected downgradient and crossgradient capture within the groundwater-producing

hydrostratigraphic packages. Use these estimates to assess whether groundwater contamination observed at CTM107 (located 1,300 feet downgradient of MILL) and at 4TH and well cluster CTM84/CTM83/CTM82 (located 1,500 feet crossgradient and 1,850 feet downgradient of KIETZKE, respectively) are being captured at the current Pumping Plan target volumes, or whether increased pumping at either MILL or KIETZKE is needed to improve capture and containment.

  - **Recommendation:** If capture is not indicated at either KIETZKE or MILL, work with TMWA to increase pumping at these wells as appropriate.

- Groundwater velocity, potential PCE or TCE travel time, and the lateral flow direction for the Downtown Reno plume downgradient of MILL and KIETZKE have not been evaluated. Consequently, if the plume is not captured or contained by pumping at either of these wells, a threat to potential downgradient receptors exists that has not been evaluated.

  - **Recommendation:** Update the hydrostratigraphic cross section between KIETZKE and GALLETTI to assess distribution of PCE and TCE contamination downgradient of KIETZKE. Use this cross section to help define potential threat to GALLETTI.
  - **Recommendation:** Use quarterly water level contour maps to evaluate whether the TCE-contaminated zone east of KIETZKE at CTM84/CTM83/CTM82 is migrating towards GALLETTI. If it is, use hydraulic parameter estimates from the MORRILL aquifer test analysis and the CORBETT-MILL aquifer test analysis to estimate travel time for TCE contamination to reach GALLETTI.
  - **Recommendation:** Continue to monitor TCE concentration at GALLETTI to track for increases that would indicate an increased threat to the viability of this well.
  - **Recommendation:** Use water level contour maps to evaluate the groundwater flowpath of PCE contamination downgradient from MILL. Use this assessment combined with the hydrostratigraphic position of the plume at MILL (relative to downgradient municipal water supply wells) to identify the most likely downgradient potential receptor.

- There is a limited definition of potential threat posed by PCE and TCE contamination to the viability of 4TH.

  - **Recommendation:** Use PCE and TCE vertical distribution and mass flux data from BESST dynamic profiling at 4TH to:
    - Define the thickness and vertical position of the PCE and TCE contamination.
    - Define the hydrostratigraphic controls on contamination.
    - Determine whether PCE and TCE are comingled (and behave similarly), or occur in distinct and different vertical positions (and behave differently) in the aquifer system; and.

- Evaluate whether PCE and TCE data suggest distinct and different releases, source area locations, and/or flow pathways for the TCE-rich contamination compared to the PCE-rich part of the Downtown Reno plume.

  - **Recommendation:** Construct a west-to-east cross section from CTM6S through 4TH to VIEW. Incorporate BESST water quality and flow profiling data at 4TH into cross section. Use PCE concentration time series data at wells upgradient from 4TH to assess whether long term PCE trends indicate an increasing or decreasing threat to 4TH in the future.
  - **Recommendation:** Based on the assessment activities recommended above, update the subregion conceptual model to consider the implications of TCE contamination and the potential for a separate, distinct origin for the TCE-rich portion of the Downtown Reno plume. Assess how the behavior of the TCE-rich portion of the plume informs the conceptual model of the Downtown Reno plume.

- There is an undefined potential threat to RENOHIGH from the Downtown Reno plume. Water levels in the vicinity of the West Fourth Street hot spot are measurably influenced by pumping from RENOHIGH, GLENHARE, and HUNTERLAKE municipal water supply wells. This means that pumping at these wells may have a significant influence on the PCE distribution and movement of the Downtown Reno plume. However, it is not presently known whether PCE impacts observed at RENOHIGH are from the Downtown Reno plume.

  - **Recommendation:** Conduct a long duration aquifer test at RENOHIGH to characterize the aquifer system and help determine whether and where hydraulic connections exist between the Downtown Reno plume and RENOHIGH. Evaluate the potential for pumping to induce portions of the Downtown Reno plume to migrate towards and impact RENOHIGH.

- There is a limited understanding of the location, geologic characteristics, and hydraulic properties of the VLFZ and HWB partial flow barriers. Their influence on groundwater flow, PCE transport, and PCE contaminant distribution is potentially significant, but presently not well understood. A key data gap concerns whether the higher concentration PCE (eastern plume core) that impacts MILL has migrated through these structures or has a distinct and separate contributing source located east of the structures.

  - **Recommendation:** Conduct sequential pumping at HIGH and MORRILL (where HIGH is pumped for at least 10 days prior to pumping at MORRILL) while collecting near-continuous water level measurements at monitoring wells in the area between the HWB and VLFZ. Use data to help resolve hydrodynamic properties, lateral hydraulic continuity, and flow barrier characteristics in the area between the HWB and the VLFZ. This will better define the northern projection of the HWB and determine whether the flow barrier identified between HIGH and MORRILL is 1) associated with the VLFZ (as is currently depicted); 2) the northern extension of the HWB; or 3) is at the convergence of both features.

6.4 Mill / Kietzke Subregion Data Gaps

- PCE sources may be present in one or more of the four PCE high mass areas (HMAs) defined in the Mill/Kietzke PSA. However, the assessment of these potential sources has yet to reach the point where any ongoing threats to groundwater can be substantiated. There is a continuing need to inform the PSA investigation by using groundwater information to help characterize potential sources (in terms of location, release characteristics, size, age, etc.).
  - **Recommendation:** Continue the ongoing assessment of GMP data in the Mill/Kietzke PSA in conjunction with and to support the PSA investigation. Utilize PCE time series and hydrograph data for monitoring wells within the Mill/Kietzke plume, along with groundwater flow direction data, and other water quality (VOC and field parameter) data to characterize potential sources in the PSA in the context of:
    - Source location(s) relative to the hot spots
    - Source term characteristics (based on decreasing, increasing, stable PCE trends for monitoring wells in or near hot spots and HMAs)
    - Water quality forensics that might distinguish different sources
    - Release characteristics (i.e., ongoing or active discharge, residual source in vadose zone, smear zone, or below water table, etc.) as inferred by long term PCE trends, interrelationships between PCE concentration and water levels, and other PCE concentration changes that may reflect how PCE is transmitted from a source to the groundwater
    - Potential age of initial release(s) based on travel time estimates from hot spots to the downgradient extent of plume
  - **Recommendation:** Twelve active soil gas (ASG) monitoring sites are planned (as part of the PSA investigation) to quantitatively define PCE concentration in soil vapor at each of the four HMAs defined in the subregion. Each well will be constructed at approximately 10 to 15 feet bgs. Six will be constructed in the Kietzke Lane HMA, two in the Prosperity Lane HMA, three in the Sunshine Lane HMA, and one in the Golden Lane HMA. These sites will be sampled quarterly, as part of the PSA investigation, to assess whether PCE in soil vapor at each HMA occurs at concentrations that pose a threat to groundwater.
- The position of the Kietzke Lane HMA indicates that there is one or more potential sources northwest and west of the Kietzke and Prosperity hot spots (as defined by wells ARCO6018MW11 and CTM13S, respectively) that may be a candidate for source remediation. Additional characterization data will be needed to determine whether a remedial investigation at this HMA is warranted. Characterization criteria include 1) determining if the concentration and mass of PCE in the vadose zone indicates a threat to groundwater that warrants remediation and 2) defining the extent, center of mass, and vapor source.

- **Recommendation:** Based on results from sampling at planned ASG monitoring sites (see recommendation above), three pairs of nested of ASG wells and one nested pair of groundwater monitoring wells are planned (as part of the PSA investigation).
  - Three nested pairs of ASG wells will be placed along Kietzke Lane, north of Mill Street. These nested ASG wells will coincide with locations of previously installed ASG well but will be constructed at approximately 20 to 25 feet bgs and 30 to 35 feet bgs, respectively. These nested wells will provide vertical PCE distribution data required to help characterize the vertical extent of the vapor plume, estimate the PCE mass, and define concentration gradients that will contribute to determining where PCE center of mass is and where the source or sources are located. These sites will be sampled quarterly as part of the PSA investigation.
  - One nested pair of groundwater wells will be located, roughly 400 feet north of ARCO6018MW11, near the center of the Kietzke Lane HMA (as defined by PSG data). The deeper well will be constructed below the minimum water level elevation observed at CTM13S and ARCO6018MW11. The other will be constructed within the "smear" zone (the interval between the typical annual maximum and minimum water table fluctuation). The groundwater wells will be co-located with an appropriate ASG monitoring site to help characterize the upgradient extent of the groundwater plume and to establish any link that may exist between PCE in the vadose zone and PCE-contaminated groundwater beneath the Kietzke HMA. These sites will be sampled quarterly for groundwater as part of both the PSA investigation and the GMP.

- There is an unknown potential for MILL to capture or contain a portion of the plume. If the plume is partially captured and/or contained by MILL, the threat to other potential receptors can be mitigated by the pumping operations at MILL. If the plume is not contained by MILL, the threat to downgradient potential receptors is an important concern. In either scenario, determining whether and how much of the Mill/Kietzke plume is captured by MILL is necessary to assess key plume metrics that include: plume volume, PCE mass and center of mass, PCE mass removal (at MILL), and source term contribution. These metrics will become particularly important tools to measure source remediation effectiveness, if and when it is implemented.
  - **Recommendation:** Use BESST water quality profile data from MILL to assess whether MILL captures a portion of the Mill/Kietzke plume. If the Mill/Kietzke plume is captured by MILL, it would principally be drawn into the uppermost MILL screened interval. Therefore if capture is occurring, water quality parameters (such as the PCE:TCE ratio, inorganics concentration, and metals concentration) at the upper screen would potentially have a distinct water quality signature (compared to deeper screened intervals) that is more similar to water quality characteristics of the Mill/Kietzke plume than the Downtown Reno plume.

Water quality data from ARCO6018MW11 and CTM13S (for Mill/Kietzke plume) and from 2009 BESST results at MORRILL and HIGH (for Downtown Reno plume) will be used as end-member signatures to make this assessment.

- **Recommendation:** Use water level contours to assess the influence of pumping at MILL on the containment of the Mill/Kietzke plume. Evaluate the dynamics and distribution of lateral hydraulic gradients in the plume footprint to estimate the net lateral hydraulic gradient for a typical year when MILL is operated during peak demand and meets the current Pumping Plan target (150 MG/yr). A net lateral gradient toward the northwest (where a shallow zone cone of depression has been observed to develop during pumping) would indicate some degree of containment. A net lateral gradient toward the south or southeast (along the natural gradient) would indicate some degree of escape. Apply a similar process to evaluate whether increased pumping at MILL (and the longer duration of a shallow zone cone of depression) would influence the net lateral gradient and plume containment. Use this assessment to consider whether/how pumping operations at MILL can be used to more effectively contain the plume.

- The bottom of the Mill/Kietzke plume is not defined in the upgradient part of the plume. As a result, vertical plume distribution data needed to verify vertical plume pathways, define plume metrics (plume volume, mass, stability), and to support estimating source term contribution/mass flux is lacking,

  - **Recommendation:** After the PSA investigation has defined specific contributing sources, install monitoring well clusters along the downgradient flowpath from those sources. Wells should be installed at depths that are based on PCE concentration results from depth-discrete sampling during drilling. Initial borings should extend to at least 200 feet bgs. If the bottom of the plume is deeper than 120 feet bgs, construct three wells in PCE-bearing transmissive intervals in the plume. If the plume is shallower than 120 feet bgs, construct two wells above the bottom of the plume and one well beneath the plume. These wells would also serve as performance wells for any future remediation activity in the Mill/Kietzke PSA.

- Groundwater velocity, PCE travel time, and the likely downgradient lateral flowpath of the Mill/Kietzke plume has not been evaluated. Therefore the mostly likely potential downgradient receptor(s) has not been identified and travel time to downgradient potential receptors is undefined.

  - **Recommendation:** Use quarterly water level contour maps to evaluate groundwater flowpaths in the shallow zone and define most likely downgradient potential receptors. Combine hydraulic parameter estimates from the 2009 CORBETT-MILL aquifer test analysis (to be completed in 2012) and from available slug test results to estimate travel time from the Mill/Kietzke hot spots to potential receptors.

- The size, PCE concentration distribution, and PCE mass magnitude of the plume requires further definition in order to better assess the threat to downgradient potential receptors. Monitoring wells CTM39S and CTM38D indicate that the Mill/Kietzke plume extends downgradient of MILL, beyond US 395, and remains undelineated. Discrete depth grab sampling at co-located well CTM107 indicate that PCE potentially extends deeper than CTM38D (screened interval – 75 to 95 feet bgs).

    - **Recommendation:** If other recommended activities indicate that the threat to downgradient receptors is a significant concern, construct one monitoring well cluster east of cluster wells CTM39S/CTM38D/CTM10D and along the downgradient flowpath (as determined by quarterly water level contour maps) of the Mill/Kietzke plume. The well cluster should be positioned at the predicted location of the leading edge of the plume based on PCE travel time estimates and the likely age for source release(s). Three wells should be constructed at depths that are based on depth-discrete sampling during drilling. The deepest boring should extend to 260 feet bgs to test the groundwater-producing hydrostratigraphic packages where downgradient potential receptors HV3, HV5, and PEZZI are screened. Construct the three wells in separate transmissive intervals where PCE is most concentrated. If no PCE is detected, construct three wells with screens distributed between 50 and 250 feet bgs and positioned in the most transmissive intervals. Use results to support the assessment of potential threats posed by the plume to downgradient receptors including PEZZI, HV3, and HV5. If no PCE is detected, these wells will function to verify downgradient plume stability and act as sentinel wells.

6.5 Downtown Sparks Subregion Data Gaps

- PCE sources for the shallow zone Victorian Avenue plume are likely to occur within one or more of the five PCE HMAs defined by the 2008/2009 passive soil gas survey. However, individual sources have yet to be identified or characterized with regard to their potential to contribute to groundwater contamination.

    - **Recommendation:** Approximately 12 active soil gas monitoring wells are planned to quantitatively define PCE concentrations at the five HMAs in the subregion. Each well will be constructed to approximately 10 to 15 feet bgs (depth to water is approximately 15 feet bgs in the area). These sites will be sampled quarterly, as part of the PSA investigation, to assess whether PCE in soil vapor at each HMA occurs at concentrations that pose a threat to groundwater.

- The groundwater and PCE contamination migration pathways from source(s) to PCE-impacted POPLAR2 are not known. PCE contamination at POPLAR2 may originate from distinctly different sources compared to PCE contamination at SPARKS. Alternatively, PCE at both POPLAR2 and SPARKS may be part of the same plume and originate from the same source(s).

  - **Recommendation:** Perform a long duration constant discharge pumping test at POPLAR2. Evaluate the water level data collected at area monitoring wells to determine how deep zone pumping influences horizontal and vertical groundwater (and potential PCE contamination) movement in the area. Identify areas where deep zone pumping influences the water levels to help define potential conduits for lateral and vertical migration of groundwater and PCE migration. Analyze well responses to estimate aquifer properties and their distribution.

- The hydrostratigraphy in the area between SPARKS and POPLAR2 is poorly defined. Defining the relationship and lateral continuity between hydrostratigraphic packages recognized at SPARKS and the hydrostratigraphy at POPLAR2 will help define whether potential PCE migration pathways exist between the Victorian Avenue plume (at SPARKS) and the Downtown Sparks plume (at POPLAR2).

  - **Recommendation:** Construct a north-south hydrostratigraphic cross section between SPARKS and POPLAR2 using lithology, aquifer test (from POPLAR2 and SPARKS tests), spinner logs, and borehole geophysics data to characterize the material characteristics and continuity of hydrostratigraphic packages across the area. Use results from this cross section to help assess whether potential pathways exist between PCE-impacted hydrostratigraphic packages at SPARKS and POPLAR2.

- The vertical distribution of PCE contamination that impacts POPLAR2 is incompletely defined. POPLAR2 has four screen intervals between 146 and 286 feet bgs. PCE data from CTM75, constructed at the same depth as the upper screened interval, indicate that contamination impacts the upper 20 feet of the POPLAR2 well screen, but there are no data to define PCE distribution beneath that interval. A more complete understanding of the vertical distribution of PCE across the well screens is needed to help define the vertical extent of and hydrostratigraphic controls on the Downtown Sparks plume. This information could be used for source vectoring (i.e., shallower, thinner plume – nearer source; deeper, thicker plume –more distal source) and would help resolve whether the Downtown Sparks plume is spatially or genetically associated with the relatively shallow, nearby Victorian Avenue plume or originates from a different, more distal source.

  - **Recommendation:** Utilize existing data (including spinner logs, PCE concentration data, aquifer test results, and groundwater gradient data) and the recommended north-south hydrostratigraphic cross section through POPLAR2 (see above) to help determine the most likely distribution of PCE contamination in and near POPLAR2. If this assessment is inconclusive, consider performing BESST dynamic profiling at POPLAR2 to quantitatively define the vertical distribution of PCE concentration at the well.

- The origin of the higher PCE contamination recognized to the east of SPARKS at CTM70 is undefined. This area of higher PCE concentration (compared to lower concentration in upgradient shallow zone wells) suggests the potential for a distinct source in the vicinity of CTM70 that may contribute contamination to SPARKS and possibly POPLAR2.

- **Recommendation:** Perform a PSG survey around CTM70 that extends along public right-of-way south and east of the well. Use results to identify HMAs that may reflect sources that have contributed to or that may be contributing to the contamination. Follow-up with additional PSG surveys or with the installation of ASG wells as appropriate.

- The threat to downgradient potential receptor GREG resulting from contamination near SPARKS and POPLAR2 is poorly defined and needs further assessment.

  - **Recommendation:** Monitor the water level in GREG during the planned POPLAR2 aquifer test to assess the potential communication and hydrostratigraphic connection between these two municipal water supply wells. Good communication observed during the pumping test would indicate a greater potential for PCE to migrate from the SPARKS/POPLAR2 area to GREG. Poor hydraulic communication would suggest that GREG is not a likely potential receptor to contamination from the SPARKS/POPLAR2 area.
  - **Recommendation:** If results from the POPLAR2 aquifer test indicate that GREG is a likely potential receptor (based on a good hydraulic connection between POPLAR2 and GREG, and the appropriate hydraulic gradient from POPLAR2 towards GREG), complete a travel time analysis (using hydrologic parameters estimated from the POPLAR2 aquifer test) to estimate the time required for PCE to migrate from the SPARKS/POPLAR2 area to GREG. Based on these results, determine what, if any, further investigations are warranted to assess the threat to GREG.

6.6 East Sparks Subregion Data Gaps

The active SS/FS corrective action site and the former Harrah's Auto Collection corrective action site are both in the East Sparks Subregion. These sites have (in the case of the SS/FS) or potentially have (in the case of Harrah's Auto Collection) contributed to the PCE contamination observed in this subregion. Future investigations and activities to manage and mitigate PCE contamination in the subregion are the responsibility of the party or parties responsible for PCE contamination contributing to the East Sparks plume complex. Data gaps pertaining to those investigations and activities should be addressed by the parties responsible for PCE contamination in the subregion. Only data gaps pertaining specifically to the CTMRD program are described below.

- The SS/FS has been identified as a source area that has contributed PCE contamination to the East Sparks plume complex. To date, no other PCAs have been defined as contributors to the plume (PCE contamination was also identified at the Harrah's Auto Collection former corrective action site in the past, however, the extent and magnitude of that contamination were not determined). The current CTMRD contaminant boundary includes the SS/FS site, Harrah's Auto Collection site, and other parcels in the vicinity of the SS/FS. Parcels in the vicinity of the SS/FS should not be included within the CTMRD contaminant boundary if it is determined that the SS/FS corrective action site (or any other non-legacy site) is the source area for the East Sparks plume.

- **Recommendation:** Evaluate historical and current groundwater and PCE concentration data, groundwater pumping records, and SMPL discharge information to define the groundwater gradients that have and continue to influence groundwater and PCE contamination movement in the area. Assess groundwater gradients and PCE contamination distribution to identify the potential source area(s) and contamination movement direction(s) from those areas that contributed (and may continue to contribute) to the East Sparks plume complex.
- **Recommendation:** Initiate communication with NDEP to discuss future actions and investigations at or near the SS/FS. A key objective is to define a path forward to determine the source(s) and responsible party (or parties) for PCE contamination in the southern part of the plume footprint. Once this determination is made, DWR will adjust the contaminant boundary (as appropriate) to remove parcels impacted by PCE from non-legacy source sites. This would include the parcels impacted by the SS/FS corrective action site or any other non-legacy source sites that are determined to contribute or have contributed to the plume complex.

- The East Sparks plume complex poses an as yet undefined potential threat to six TMWA municipal water supply wells that are located to the north of the SS/FS site and are planned for future operation.
  - **Recommendation:** GMP monitoring activities should continue at a level that contributes to the assessment of the potential threat to the six TMWA municipal water supply wells. A reduced number of existing groundwater monitoring wells (potentially four to six wells) should continue to be monitored to provide sufficient information about the subregion hydrodynamics, PCE concentration, PCE distribution, and PCE migration over time.
- The scheduled start-up date(s) for the six TMWA municipal water supply wells is unknown. Consequently, the timing of any change to the subregion hydrodynamics that potentially would increase the threat to potential receptors is also unknown.
  - **Recommendation:** Continue routine communication with TMWA personnel to maintain an awareness of any operational changes to municipal water supply well pumping that would change the hydrodynamics in the subregion.
  - **Recommendation:** Continue communication with NDEP to ensure that monitoring by responsible or potentially responsible parties conducting investigations in the subregion appropriately reduces the threat and protects the viability of the six municipal water supply wells.

6.7 El Rancho Subregion Data Gaps

- The plume magnitude and extent are undefined. As a result, the nature of the threat to ELRANCHO and downgradient potential receptors is not well understood. The threat to the viability of ELRANCHO, the threat to potential receptors, and the options for plume management and mitigation are dependent upon the size and magnitude of the plume.

  The available water quality data indicate that the PCE impacts to ELRANCHO occur predominantly in the upper screened interval (143-208 feet bgs). This relatively shallow depth of PCE contamination is consistent with a relatively nearby source or sources. Based on the lack of PCE in cluster wells to the west and northwest of ELRANCHO, the PCE impacting ELRANCHO is considered more likely to originate to the north and/or or northeast of the production well. This is also supported by water level data from area monitoring wells that suggest that the capture zone resulting from pumping at ELRANCHO (and potentially VIEW) could extend to the north/northeast rather than to the west as suggested by the original capture zone simulation used by TMWA.

  - **Recommendation:** Conduct a passive soil gas (PSG) survey in the area near and downgradient from two PCAs identified to the northeast of ELRANCHO. Use results to help define the plume extent by identifying PCE high mass areas (HMAs) where elevated PCE contamination in soil vapor may identify potential source areas for the plume.
  - **Recommendation:** Complete a capture zone analysis that includes recent data (gradient direction and magnitude, and aquifer parameters) from the new cluster wells. Simulate pumping at both ELRANCHO and VIEW. Use results to better define the capture zone footprint within which PCE contamination impacting ELRANCHO would likely originate.
  - **Recommendation:** Use results from the PSG survey, capture zone analysis, and the known locations of PCAs to define locations for two or more groundwater monitoring wells (or well pairs). Locate the wells within the simulated capture zone footprint and proximal to any identified HMAs and/or downgradient from PCAs. Position the wells along potentially different flow paths between ELRANCHO and possible source areas. Locate screen intervals between the water table and the upper screen of ELRANCHO. Position screen intervals in coarser grained, more transmissive material, based on maximum PCE concentration results from discrete depth sampling during drilling, or on maximum photo-ionization detector measurements during field screening of drill cuttings.
  - **Recommandation:** Estimated travel times from potential source areas or HMAs to potential receptors if the PSG survey and PCE concentration at new wells suggest a threat to potential downgradient receptors (including SPARKSHIGH, MITCHELL, and VIEW). Based on these results, determine what, if any, further investigations are warranted to assess the threat to most likely downgradient potential receptors.

   - **Recommendation**: Construct active soil gas (ASG) monitoring wells in the vicinity of any HMAs identified during the PSG survey. Sample the ASG wells on a quarterly basis to quantify and assess whether the PCE concentration in soil vapor occurs at a concentration that poses a threat to groundwater. Each ASG well should be constructed approximately 10-15 feet bgs.

- The influence of pumping at nearby municipal supply wells (i.e., POPLAR2, SPARKS, and 4TH) on groundwater and PCE contamination movement in the El Rancho Subregion is incompletely characterized. Based on the preliminary assessment of the El Rancho aquifer test, deep zone water levels in the El Rancho Subregion are influenced by pumping at POPLAR2. This suggests that regional pumping is potentially a contributing driver for lateral and vertical groundwater and PCE contamination migration.

   - **Recommendation:** Compare historical pumping data for POPLAR2, SPARKS, and 4TH with water level data for monitoring wells in the subregion. Assess whether hydraulic gradient direction and magnitude in the El Rancho Subregion are influenced by the pumping at one or more of these production wells. Incorporate this information into the conceptual model, to assess how the distribution of PCE could be influence by pumping at these municipal water supply wells.

6.8 Joule Subregion Data Gaps

- The individual source(s) for the Joule complex plume have yet to be identified or characterized with regard to their potential to contribute to groundwater contamination. The occurrence of shallow zone PCE at CTM87 and CTM85 are consistent with one or more sources in west-central part of the subregion. Defining potential sources would contribute toward assessing source remediation options and potentially help define the upgradient extent of the plume.

   - **Recommendation:** Complete a PSG survey in the area from west to east between Rock Blvd. and Edison Way and from north to south between the Truckee River and Energy Way. Use results to identify PCE high mass areas (HMAs) near the land surface that have the potential to correspond with contributing sources to the Joule plume.

- The lateral and vertical extent and the continuity of hydrostratigraphic packages are not defined in the subregion. Identifying hydrostratigraphic packages and characterizing their influence on groundwater flow will help define potential PCE migration pathways from source to receptor (HV5) and potential receptors (HV3, and PEZZI).

   - **Recommendation:** Construct a northwest-southeast hydrostratigraphic cross section between GREG and HV5 (through PEZZI) using available lithologic, geophysical, aquifer test, and spinner log data to characterize hydrostratigraphy in terms of:

      - The spatial distribution of material characteristics;
      - The continuity of hydrostratigraphic sequences; and

        - The definition of hydrostratigraphic packages in the subregion.

- The influence of pumping at HV5 on groundwater flow and PCE migration is undefined. This information is needed to characterize PCE migration pathways from the shallow zone to deep zone and to help assess the threat posed by the Joule plume to HV5.

    - **Recommendation:** Complete an extended (10 to 14 days) pumping test at HV5 to determine the influence HV5 has on the lateral and vertical gradients, and to characterize the vertical communication between the shallow zone and deep zone. Evaluate PCE distribution data in conjunction with hydraulic gradient and water level response data to identify possible PCE migration pathways.

    - **Recommendation:** Conduct a capture zone analysis incorporating hydraulic parameter estimates from the HV5 aquifer test. Use either analytical solution software or numerical modeling software capable of simulating anisotropy, multiple aquifer layers, transient conditions, and short time steps (of one month or less to accommodate intermittent pumping). Estimate the HV5 capture zone and perform travel time/particle tracking simulations to assess groundwater flowpaths toward HV5.

- The plume extent and magnitude is undefined. As a result, the threat to receptors/potential receptors cannot be determined. Presently, the plume is delineated by PCE contamination in two shallow zone wells and one deep zone well located to the southwest of HV5.

    - **Recommendation:** Update the Joule plume conceptual model by incorporating the results from the proposed PSG survey, the HV5 aquifer test and capture zone analysis, and the hydrostratigraphic assessment of the aquifer system (see recommendations above). Use combined results (and resultant conceptual model) to delineate the potential lateral and vertical distribution of PCE contamination that would occur if PCE has migrated and continues to migrate:

        - From PCE HMAs (defined by PSG results);
        - Along hydraulically connected pathways (defined by hydrostratigraphic packages and by any conduits recognized by the HV5 aquifer test analysis); and
        - Toward HV5.

- The threat to HV3 is undefined. The historically observed groundwater PCE contamination located north of Mill Street (at CTM20S and USGSAG) could reflect a nearby source that may still pose a threat to the groundwater (and to HV3). The Joule plume may also pose a threat to HV3.

    - **Recommendation:** Use results from proposed PSG survey (recommended above) to identify HMAs that have the potential to correspond to contributing sources in the area north of Mill Street and along Edison Way where numerous PCAs have existed.

    - **Recommendation:** Continue collecting annual groundwater samples from shallow zone wells CTM20S and USGSAG to verify that PCE no longer exists in the immediate vicinity of

HV3. Continue collecting samples at HV3 (on a monthly basis when pumping) to monitor for future PCE impacts.

- **Recommendation:** Correlate the hydrostratigraphy at HV3 with the hydrostratigraphy as defined by the working cross section between CTM87 and HV5 and the proposed cross section between GREG and HV5. Substantiate of refute the potential threat to HV3 from the Joule plume by determining whether HV3 is hydraulically connected with the same hydrostratigraphic packages where the Joule plume is known to exist.

6.9 Planned Activities

The following activities are currently planned or underway to address the above data gaps.

- DWR is preparing additional and updating existing hydrostratigraphic cross sections for the designated subregions as new data becomes available. The set of currently completed hydrostratigraphic cross sections will be reviewed to formally document and define whether criteria used to distinguish individual hydrostratigraphic packages is objective, data driven and consistent. Data from these cross sections will continue to be used to update the subregional conceptual models. They will also be used to identify potentially significant data gaps that either suggests a potential increased threat (to groundwater or a potential receptor) or an inconsistency in the conceptual model.

- DWR plans to thoroughly analyze previous aquifer test data collected at ELRANCHO, CORBETT, and MILL. These tests were conducted in 2009 and 2010 to better understand the hydraulic connection between the shallow zone and deep zone, the influence of potential flow barriers on groundwater flow and PCE transport, and the potential pathways along which PCE contamination originating near the ground surface is being transported into groundwater-producing intervals in the deep zone. Results will also provide estimates of hydraulic parameters that will then be used to calculate PCE travel times from source to receptor, or from plume to potential receptor.

- DWR plans to conduct long duration aquifer tests at RENOHIGH and POPLAR2.
  - The RENOHIGH test has the objective of assessing whether pumping at RENOHIGH could have unintended influences on PCE migration in the Downtown Reno plume. It also will support the assessment of whether RENOHIGH has been or could be impacted by the Downtown Reno plume if it is more routinely pumped.
  - The POPLAR2 test has the objective of identifying the area influenced by pumping at POPLAR2. Results of the test will support the assessment of extent and magnitude of the deep zone contamination that impact POPLAR2. It will also support determining whether

PCE impacts at POPLAR2 originate from the shallow zone Victorian Avenue plume or from a distinct and different source.

- DWR plans to complete the analysis of discrete depth groundwater flow and PCE concentration dynamic vertical profiling at ELRANCHO, 4TH, and MILL. The results will help define the vertical distribution of contamination at each well, the hydrostratigraphic controls on contamination, and (in conjunction with hydrostratigraphic cross sections) will provide key information on potential migration pathways from possible source areas in the shallow zone to the groundwater-producing hydrostratigraphic packages in the deep zone.
- DWR plans to continue to implement a monitoring well network optimization program. The next step in the process will be optimizing the water quality monitoring network. This will include developing objective criteria and implementing a process for defining which specific wells should be monitored, which wells are redundant and should be eliminated from the GMP well network, and how frequently individual wells that remain in the network should be monitored.
- DWR plans to continue the PSA investigation into the potential sources for the Downtown Reno plume during 2011. This will include completing PSG surveys to better resolve one of the five PCE high mass areas recognized in the PSA by previous PSG surveys. It will also include defining locations for active soil gas monitoring wells that will be used to quantify PCE concentration at each of the five high mass areas. The objective of future active soil gas monitoring will focus on defining locations where soil vapor concentration (originating from potential sources) is high enough to pose a continuing threat to groundwater contamination in the Downtown Reno Subregion.
- DWR plans to continue the PSA investigation into the potential sources for the Mill/Kietzke plume during 2011. This will include construction 12 semi-permanent active soil gas (ASG) monitoring sites (as part of the PSA investigation) to quantitatively define PCE concentration in soil vapor at each of the four high mass areas. The objective of future active soil gas monitoring will focus on defining locations where soil vapor concentration (originating from potential sources) is high enough to pose a continuing threat to groundwater contamination. Follow-up activities will include construction of three nested pairs of ASG wells and one nested pair of groundwater monitoring wells at the Kietzke HMA. The objective of this additional work is to characterize the lateral and vertical extent of the PCE vapor plume at the Kietzke HMA. Results of this follow-up work will support estimating PCE mass and center of mass, and identifying the location of any potential residual sources or ongoing releases associated with the Kietzke HMA.
- DWR will continue PSA investigations at the Vassar-East Plumb PSA and the Downtown Sparks PSA after it hires one or more new contractors to replace the contractor that was formerly managing these programs. This is planned to occur in 2012 or 2013.
- DWR will initiate a PSA investigation in the El Rancho Subregion in 2011. This will include completing a PSG survey to identify high mass areas in the vicinity and upgradient from ELRANCHO.

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Tables

Central Truckee Meadows Remediation District Program

Table 5.1

2010 Key Wells
Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Wells
South Reno	Shallow Zone	CTM49
		CTM48
		CTM62
		CTM96
		CTM51
		CTM52
		USGSLISTON
		CTM93
		USGSWOOSTER
		CTM99
		CTM18S
	Deep Zone	CTM95
		CTM33D
		CTM17D
		CTM97
		CTM98
		CTM106
		CORBETT
		TERMINAL
Downtown Reno	Shallow Zone	CTM28S
		CTM5
		COR12A
		COR8A
		RETRACP2
		CTM3S
		CTM31S
		CTM6S
		CTM37S
		CTM102
	Deep Zone	MW6ND
		COURTHOUSE
		MW10ND
		CTM30D
		CTM137
		MW8ND
		CTM8D
		CTM22D
		CTM83
		CTM84
		CTM101
		CTM103
		CTM10D
		CTM12D
		CTM107
		CTM80
		CTM81
		4THMWD
		4THMWS
		4TH
		HIGH
		MORRILL
		KIETZKE
		MILL

Subregion	Shallow Zone/ Deep Zone Designation	Wells
Mill/Kietzke	Shallow Zone Only	CTM13S
		ARCO6018MW11
		CTM63
		ARCO6018MW12
		ARCO6018MW16
		CTM11S
		CTM105
		CTM38D
Downtown Sparks	Shallow Zone	CTM65
		CTM66
		CTM70
		CTM67
	Deep Zone	CTM68
		SPARKS
		CTM75
		POPLAR2
East Sparks	Shallow Zone Only	SSFSMW204
		SSFSMW205
		SSFSMW207
		SSFSMW212
El Rancho	Deep Zone Only	ELRANCHOMWS
		ELRANCHOMWD
		ELRANCHO
Joule	Shallow Zone	CTM87
		CTM86
	Deep Zone	BELFAST
		CTM85
		HV5

Central Truckee Meadows Remediation District Program

Table 5.2
2010 Subregion Well Clusters
Washoe County Department of Water Resources

Subregion	Well Clusters
South Reno	CTM14S/CTM27D
	CTM46/HOLCOMBAVMW
	CTM96/CTM95/CTM94
	CTM93/CTM92/CTM33D
	USGSWOOSTER/CTM17D
	CTM18S/CTM106
	CTM99/CTM98/CTM97
Downtown Reno	CTM3S/CTM4D
	CTM6S/CTM80/CTM79
	MW2NS/MW1ND
	MW4NS/MW3ND
	MW9NS/MW10ND
	MW7NS/MW8ND
	CTM7S/CTM8D
	CTM102/CTM101/CTM100
	CTM84/CTM83/CTM82
Mill/Kietzke and Downtown Reno	CTM9S/CTM104/CTM103/CTM10D
	CTM11S/CTM105/CTM12D
	ARCO6018MW16/MILL
	CTM39S/CTM38D/CTM107
Downtown Sparks	CTM72/CTM73/CTM74/CTM75/POPLAR2/POPLAR1
	CTM65/CTM66/CTM67/CTM68/SPARKS
	21STMWS/21STMWD
East Sparks	USGSDILWORTH/DILWORTH
	PRATERWAYMW/PRATERWAY
El Rancho	CTM115/CTM110/CTM109/CTM108
	CTM114/CTM113
	CTM112/CTM111
	ELRANCHOMWS/ELRANCHOMWD/ELRANCHO
Joule	CTM86/CTM85

Central Truckee Meadows Remediation District Program

Table 5.3

PCE Statistics for Key Wells and Other Wells with Notable PCE Results, GMP Period of Record (2003 Q4 through 2010 Q4)
Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Well ID	Location of Well Relative to Associated Plume	GMP Period of Record PCE Concentration Statistics				
				Minimum PCE (µg/L)	Maximum PCE (µg/L)	PCE Mean (µg/L)	PCE Standard Deviation (µg/L)	PCE Coefficient of Variation
South Reno	Shallow Zone	CTM49	Northwest of Vassar St. Hot Spot	< 0.5	36	3.5	7.1	2.00
South Reno	Shallow Zone	CTM48	North Flank of Vassar St. Hot Spot (former Hot Spot well)	5.6	170	28.5	37.3	1.31
South Reno	Shallow Zone	CTM62	Vassar St. Hot Spot	16	120	48.9	21.9	0.45
South Reno	Shallow Zone	CTM96**	Downgradient of Vassar St. Hot Spot	2.8	4.4	3.5	0.5	0.16
South Reno	Shallow Zone	CTM51	E. Plumb Ln. Hot Spot	3.9	50	21.8	14.1	0.65
South Reno	Shallow Zone	CTM52	E. Plumb Ln. Hot Spot	12	170	45.5	40.0	0.88
South Reno	Shallow Zone	USGSLISTON	Downgradient of E. Plumb Ln. Hot Spot	6.6	38	16.2	7.9	0.49
South Reno	Shallow Zone	CTM93**	Downgradient of E. Plumb Ln. Hot Spot	4.7	6.8	5.5	0.7	0.12
South Reno	Shallow Zone	USGSWOOSTER	Downgradient of Vassar St. and E. Plumb Ln. Hot Spots. Commingled part of SR plume. Potentially impacted by local contributing source	3.4	9.8	6.6	1.7	0.25
South Reno	Shallow Zone	CTM99**	Downgradient of Vassar St. and E. Plumb Ln. Hot Spots. Commingled part of SR plume. Potentially impacted by local contributing source	7.1	9.4	8.5	0.8	0.10
South Reno	Shallow Zone	CTM18S	Downgradient of Vassar St. Hot Spot. Downgradient plume extent is undefined to the east	1.1	8.1	2.3	1.6	0.67
South Reno	Deep Zone	CTM95**	Downgradient of Vassar St. Hot Spot. Potentially defines bottom of SR Plume	< 1.0	0.8	0.5	0.1	0.19
South Reno	Deep Zone	CTM33D	Upgradient (West) of SR Plume Core	< 1.0	1.8	1.3	0.4	0.27
South Reno	Deep Zone	CTM17D	SR Plume Core	1.4	24	9.2	6.6	0.71
South Reno	Deep Zone	CTM97**	East of SR Plume Core. Screened deeper than bottom of SR plume. Screen depth coincides with shallowest screened interval of TERMINAL municipal supply well.	< 0.5	< 1.0	NA	NA	NA
South Reno	Deep Zone	CTM98**	East of SR Plume Core. Plume extent is undefined to the east. Screen depth coincides with portion of CORBETT screened interval	7.1	10	8.7	1.2	0.14
South Reno	Deep Zone	CTM106**	Downgradient of Vassar St. Hot Spot. Plume extent is undefined to the east and at depth	4.4	7.6	6.4	1.0	0.16
South Reno	Deep Zone	CORBETT	SR Deep Zone Plume Core-Receptor	13	26	19.2	3.4	0.18
South Reno	Deep Zone	TERMINAL	Potential SR or DR Plume Receptor/Historically PCE-impacted	< 1.0	< 1.0	NA	NA	NA

Central Truckee Meadows Remediation District Program

Table 5.3

PCE Statistics for Key Wells and Other Wells with Notable PCE Results, GMP Period of Record (2003 Q4 through 2010 Q4)
Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Well ID	Location of Well Relative to Associated Plume	GMP Period of Record PCE Concentration Statistics				
				Minimum PCE (µg/L)	Maximum PCE (µg/L)	PCE Mean (µg/L)	PCE Standard Deviation	PCE Coefficient of Variation
Downtown Reno	Shallow Zone	CTM28S	West Fourth St. Hot Spot	13	260	100.5	68.1	0.68
Downtown Reno	Shallow Zone	CTM5**	North Flank of West Fourth St. Hot Spot	28	40	32.6	4.3	0.13
Downtown Reno	Shallow Zone	COR12A	Potential Local Hot Spot	< 1.0	36	12.9	10.2	0.79
Downtown Reno	Shallow Zone	COR8A	Downgradient (Southeast) of West Fourth St. Hot Spot. Adjacent to or part of local hot spot at COR12A	6.9	16	10.3	2.9	0.28
Downtown Reno	Shallow Zone	RETRACP2	Downgradient (Southeast) of West Fourth St. Hot Spot. Near southeastern extent of shallow zone DR plume	< 1.0	2.2	1.0	0.6	0.56
Downtown Reno	Shallow Zone	CTM3S	Downgradient (Northeast) of West Fourth St. Hot Spot	6.0	36	13.9	7.7	0.55
Downtown Reno	Shallow Zone	CTM31S	Downgradient (Northeast) of West Fourth St. Hot Spot. Near northern extent of shallow zone DR plume	8.6	22	14.1	3.2	0.23
Downtown Reno	Shallow Zone	CTM6S	Downgradient (East) of West Fourth St. Hot Spot. Potentially near shallow zone DR plume axis or centerline	7.1	27	17.2	5.3	0.31
Downtown Reno	Shallow Zone	CTM37S	Downgradient (East) of West Fourth St. Hot Spot. Near eastern extent of shallow zone DR plume	< 1.0	3.6	1.9	1.1	0.55
Downtown Reno	Shallow Zone	CTM102**	Southeast of Shallow Zone DR Plume. PCE defined by single well but is likely contiguous with deep zone DR Plume. PCE distribution not well defined	6.6	10	8.3	1.1	0.13
Downtown Reno	Deep Zone	MW6ND	Upgradient (West) of Western Core of DR Plume. Furthest upgradient deep zone well in DR Plume	7.4	13	10.1	1.5	0.15
Downtown Reno	Deep Zone	COURTHOUSE	Southwest of Western Core of DR Plume. Plume extent undefined to south	3.0	5.0	3.9	0.6	0.14
Downtown Reno	Deep Zone	MW10ND	Lateral (South) Flank of Western Core of DR Plume. Plume extent undefined to south	5.2	24	12.5	5.0	0.40
Downtown Reno	Deep Zone	CTM30D	Western Core of DR Plume	27	63	43.1	10.8	0.25
Downtown Reno	Deep Zone	CTM137	Western Core of DR Plume	59	150	97.1	27.2	0.28
Downtown Reno	Deep Zone	MW8ND*	Western Core of DR Plume	27	48	36.5	5.8	0.16
Downtown Reno	Deep Zone	CTM8D	Western Core of DR Plume	25	56	38.4	8.5	0.22
Downtown Reno	Deep Zone	CTM22D	Downgradient of Western Core of DR Plume	12	30	20.3	4.2	0.21
Downtown Reno	Deep Zone	CTM83**	Downgradient (East) of DR Plume. Impacted by TCE	< 0.5	< 1.0	NA	NA	NA
Downtown Reno	Deep Zone	CTM84**	Downgradient (East) of DR Plume. Impacted by TCE	< 0.5	< 1.0	NA	NA	NA
Downtown Reno	Deep Zone	CTM101**	Upgradient (West) of Eastern Core of DR Plume. In area where PCE distribution is not well defined.	6.5	11	8.6	1.3	0.14
Downtown Reno	Deep Zone	CTM103**	Eastern Core of DR Plume. Screened at shallower depth than screened interval of PCE-impacted MILL municipal water supply well	22	38	28.4	6.1	0.21

Central Truckee Meadows Remediation District Program

Table 5.3

PCE Statistics for Key Wells and Other Wells with Notable PCE Results, GMP Period of Record (2003 Q4 through 2010 Q4)
Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Well ID	Location of Well Relative to Associated Plume	GMP Period of Record PCE Concentration Statistics				
				Minimum PCE	Maximum PCE	PCE Mean	PCE Standard Deviation	PCE Coefficient of Variation
				(µg/L)				
Downtown Reno (cont.)	Deep Zone	CTM10D	Eastern Core of DR Plume. Screen depth coincides with upper screened interval of PCE-impacted MILL municipal water supply well	37	270	122.8	68.3	0.56
		CTM12D	East of Eastern Core of DR Plume. Screen depth coincides with upper screened interval of PCE-impacted MILL municipal water supply well.	< 1.0	4.5	1.1	1.0	0.91
		CTM107**	Southeastern Part of DR Plume. Plume extent is undefined to the east and south.	14	21	17.6	2.2	0.12
		CTM80**	Northern Part of DR Plume in the Deep Zone. Potentially near bottom of DR plume	< 1.0	1.1	0.7	0.3	0.38
		CTM81**	Northeast Part of DR Plume. Sentry for 4TH municipal water supply well	5.2	7.6	6.7	0.8	0.12
		4THMWD	Downgradient (Northeastern) Part of DR Plume. Screen depth coincides with lower screened intervals at PCE-impacted 4TH municipal water supply well	< 0.5	0.7	0.5	0.1	0.16
		4THMWS	Downgradient (Northeastern) Part of DR Plume. Screen depth coincides with upper screened intervals at PCE-impacted 4TH municipal water supply well	< 1.0	4.1	1.4	1.2	0.86
		4TH	DR Plume Receptor	< 0.5	1.3	0.7	0.3	0.49
		HIGH	DR Plume Receptor	8.6	15.8	12.5	1.8	0.15
		MORRILL	DR Plume Receptor	8.3	14.3	11.8	1.9	0.16
		KIETZKE	DR Plume Receptor	2.3	10.9	7.4	1.7	0.23
		MILL	Eastern Plume Core/DR Plume Receptor	22	61	44.0	10.5	0.24
Mill/Kietzke	Shallow Zone	CTM13S	MK Plume Hot Spot	8.2	70	24.4	16.9	0.69
		ARCO6018MW11	MK Plume Hot Spot	10	850	79.7	173.9	2.18
		CTM63	East Flank of MK Plume Hot Spot	3.2	120	18.7	27.1	1.45
		ARCO6018MW12	Downgradient (Southeast) Flank of MK Hot Spot	< 1.0	44	10.8	10.7	0.99
		ARCO6018MW16	Downgradient of MK Plume Hot Spot	< 1.0	17	2.7	3.4	1.24
		CTM11S	Downgradient of MK Plume Hot Spot	< 1.0	6.4	1.7	1.4	0.79
		CTM105**	Downgradient of MK Plume Hot Spot	6.4	10	7.9	1.2	0.15
		CTM38D	Downgradient of MK Plume Hot Spot. Downgradient extent of MK plume is undefined to the east and south.	2.4	17	8.2	4.5	0.55
Downtown Sparks	Shallow Zone	CTM65	West of Hot Spot defined by CTM70. Defines top of VA plume	< 0.5	1.5	0.7	0.4	0.53
		CTM66	West of Hot Spot defined by CTM70	2.7	7.1	4.4	1.2	0.28
		CTM70	CTM70 Hot Spot	< 1.0	17	9.7	3.8	0.39
		CTM67	VA Plume Core	23	62	41.6	9.8	0.24

Central Truckee Meadows Remediation District Program

Table 5.3

PCE Statistics for Key Wells and Other Wells with Notable PCE Results, GMP Period of Record (2003 Q4 through 2010 Q4)
Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Well ID	Location of Well Relative to Associated Plume	GMP Period of Record PCE Concentration Statistics: Minimum PCE	Maximum PCE	PCE Mean	PCE Standard Deviation	PCE Coefficient of Variation
				(µg/L)				
Downtown Sparks (cont.)	Deep Zone	CTM68	Sentry Well for SPARKS Municipal Water Supply Well. Deeper than	< 0.5	0.7	0.5	0.1	0.16
		SPARKS	VA and/or DS Plume Receptor	< 1.0	6.4	2.4	2.5	1.04
		CTM75	Sentry Well for POPLAR2 Municipal Water Supply Well. Screen depth coincides with upper screened interval at PCE-impacted POPLAR2 municipal water supply well	< 1.0	8.9	3.0	2.6	0.87
		POPLAR2	DS Plume Receptor	< 1.0	6.8	2.9	1.9	0.65
East Sparks	Shallow Zone	SSFSMW204	Wolverine Way Hot Spot	3.8	89	30.5	20.5	0.67
		SSFSMW205	Downgradient of Wolverine Way Hot Spot	3.9	11	6.3	1.9	0.31
		SSFSMW207	Downgradient of Wolverine Way Hot Spot	1.6	3.5	2.6	0.5	0.18
		SSFSMW212	Downgradient of Wolverine Way Hot Spot	3.0	8.7	5.9	1.4	0.23
El Rancho	Deep Zone	ELRANCHOMWS	Adjacent to PCE-impacted ELRANCHO Municipal Water Supply Well. Screen depth coincides with upper screened interval at ELRANCHO	< 1.0	3.3	0.9	0.8	0.92
		ELRANCHOMWD	Adjacent to PCE-impacted ELRANCHO Municipal Water Supply Well. Screen depth coincides with lower screened interval at ELRANCHO	< 0.5	2.6	1.0	0.8	0.85
		ELRANCHO	ER Plume Receptor	< 1.0	1.1	0.8	0.3	0.34
Joule	Shallow Zone	CTM87**	Westernmost Well in J Plume	2.0	3.0	2.5	0.3	0.14
		CTM86**	Northeasternmost Well in J Plume. Screen depth coincides with upper sceened interval of HV5 municipal water supply well	< 1.0	1.3	0.7	0.3	0.46
	Deep Zone	BELFAST	J Plume Interior. PCE distribution in area is poorly defined	< 1.0	2.4	1.4	0.7	0.50
		CTM85**	Screen depth is potentially deeper than J Plume. Screen depth coincides with middle part of sceened interval of HV5 municipal water supply well	< 0.5	< 1.0	NA	NA	NA
		HV5	Potential Receptor/Historically PCE-impacted	< 0.5	< 1.0	NA	NA	NA
Outside Subregion	Shallow Zone	UNRAGMW25N***	Outside of Any Designated Plume. PCE defined by single well	< 1.0	9.8	3.1	2.9	0.95

EXPLANATION:

(yellow) = High standard deviation equals values >50.
(light blue) = High coefficient of variation equals values >1.
* = Well MW8ND was inaccessible for sampling as part of the GMP prior to 2006 Q4.
** = New monitoring wells CTM5, CTM79 - CTM107 have data sets that start in 2009 Q1
*** = UNRAGMW25N is not a Key Well but has 2010 PCE concentration results that are notable and potentially significant

SR = South Reno
DR = Downtown Reno
MK = Mill / Kietzke
DS = Downtown Sparks
ES = East Sparks
ER = El Rancho
J =Joule

Notes:

Descriptions of **Location of Well Relative to Plume** are defined based on interpretation of plume outline, location of hot spots, or plume cores, and on interpretation of ambient lateral groundwater flow directions derived from water level contouring.

The standard deviation is a measure of variability of a data set.

The coefficient of variation is a normalized measure of variability of a data set. It is defined as the ratio of the standard deviation to the mean.

Statistics for wells where PCE concentration has not been detected above the reporting limit are not applicable and are note by "NA"

Central Truckee Meadows Remediation District Program

Table 5.4

Comparison of PCE Concentrations in Key Wells and Other Wells with Notable PCE Results, 2010 Q1 through 2010 Q4
Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Well ID	Location of Well Relative to Associated Plume	2010 PCE Concentrations (µg/L) Q1	Q2	Q3	Q4	PCE Trend From 2003 Q4 to 2010 Q4	Notable Results
South Reno	Shallow Zone	CTM49	Northwest of Vassar St. Hot Spot	< 1.0	< 1.0	0.94	<0.5	NO TREND	
		CTM48	North Flank of Vassar St. Hot Spot (former Hot Spot well)	8.7	7.2	7.3	5.6	DECREASING	
		CTM62	Vassar St. Hot Spot	39	34	63	74	NO TREND	
		CTM96	Downgradient of Vassar St. Hot Spot	3.0	3.1	3.1	2.8	DECREASING	
		CTM51	E. Plumb Ln. Hot Spot	5.6	3.9	5.4	5.4	DECREASING	X
		CTM52	E. Plumb Ln. Hot Spot	14	12	13	12	DECREASING	X
		USGSLISTON	Downgradient of E. Plumb Ln. Hot Spot	9.0	7.8	14	12	DECREASING	
		CTM93	Downgradient of E. Plumb Ln. Hot Spot	6.0	5.7	5.2	5.1	NO TREND	
		USGSWOOSTER	Downgradient of Vassar St. and E. Plumb Ln. Hot Spots. Commingled part of SR plume. Potentially impacted by local contributing source	6.9	8.2	8.9	7.3	INCREASING	
		CTM99	Downgradient of Vassar St. and E. Plumb Ln. Hot Spots. Commingled part of SR plume. Potentially impacted by local contributing source	7.4	8.9	8.7	7.1	DECREASING	
		CTM18S	Downgradient of Vassar St. Hot Spot. Downgradient plume extent is undefined to the east	1.6	1.2	1.4	1.5	DECREASING	
	Deep Zone	CTM95	Downgradient of Vassar St. Hot Spot. Potentially defines bottom of SR Plume	< 1.0	NS	0.75	NS	NP	
		CTM33D	Upgradient (West) of SR Plume Core	1.7	1.8	1.6	1.5	INCREASING	
		CTM17D	SR Plume Core	12	9	5.4	11	INCREASING	
		CTM97	East of SR Plume Core. Screened deeper than bottom of SR plume. Screen depth coincides with shallowest screened interval of TERMINAL municipal supply well.	< 1.0	< 1.0	<0.5	<0.5	NP	
		CTM98	East of SR Plume Core. Plume extent is undefined to the east. Screen depth coincides with portion of CORBETT screened interval	8.6	9.9	10	7.4	NO TREND	
		CTM106	Downgradient of Vassar St. Hot Spot. Plume extent is undefined to the east and at depth	6.6	4.4	6.5	5.7	NO TREND	
		CORBETT	SR Deep Zone Plume Core-Receptor	NS	20	22	NS	INCREASING	
		TERMINAL	Potential SR or DR Plume Receptor/Historically PCE-impacted	NS	NS	NS	NS	NP	

Central Truckee Meadows Remediation District Program

Table 5.4

Comparison of PCE Concentrations in Key Wells and Other Wells with Notable PCE Results, 2010 Q1 through 2010 Q4

Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Well ID	Location of Well Relative to Associated Plume	2010 PCE Concentrations (µg/L) Q1	Q2	Q3	Q4	PCE Trend From 2003 Q4 to 2010 Q4	Notable Results
Downtown Reno	Shallow Zone	CTM28S	West Fourth St. Hot Spot	51	25	61	78	DECREASING	
		CTM5	North Flank of West Fourth St. Hot Spot	34	28	28	28	DECREASING	
		COR12A	Potential Local Hot Spot	16	36	22	10	INCREASING	X
		COR8A	Downgradient (Southeast) of West Fourth St. Hot Spot. Adjacent to or part of local hot spot at COR12A	7.5	7.8	8.1	6.9	DECREASING	
		RETRACP2	Downgradient (Southeast) of West Fourth St. Hot Spot. Near southeastern extent of shallow zone DR plume	1.3	NS	2.2	NS	INCREASING	
		CTM3S	Downgradient (Northeast) of West Fourth St. Hot Spot	8.0	9	10	19	NO TREND	
		CTM31S	Downgradient (Northeast) of West Fourth St. Hot Spot. Near northern extent of shallow zone DR plume	14	12	14	13	INCREASING	
		CTM6S	Downgradient (East) of West Fourth St. Hot Spot. Potentially near shallow zone DR plume axis or centerline	22	25	18	21	INCREASING	
		CTM37S	Downgradient (East) of West Fourth St. Hot Spot. Near eastern extent of shallow zone DR plume	2.5	3	3.1	2.7	INCREASING	
		CTM102	Southeast of Shallow Zone DR Plume. PCE defined by single well but is likely contiguous with deep zone DR Plume. PCE distribution not well defined	8.9	8.8	10	8.5	NO TREND	
	Deep Zone	MW6ND	Upgradient (West) of Western Core of DR Plume. Furthest upgradient deep zone well in DR Plume	9.8	10	9.8	8.3	NO TREND	
		COURTHOUSE	Southwest of Western Core of DR Plume. Plume extent undefined to south	3.9	3.3	4.6	4.5	INCREASING	X
		MW10ND	Lateral (South) Flank of Western Core of DR Plume. Plume extent undefined to south	9.2	6.5	16	16	NO TREND	
		CTM30D	Western Core of DR Plume	53	49	50	51	INCREASING	
		CTM137	Western Core of DR Plume	120	130	130	130	INCREASING	
		MW8ND	Western Core of DR Plume	36	29	35	35	NO TREND	
		CTM8D	Western Core of DR Plume	44	46	41	41	INCREASING	
		CTM22D	Downgradient of Western Core of DR Plume	17	23	23	21	INCREASING	
		CTM83	Downgradient (East) of DR Plume. Impacted by TCE	< 1.0	< 1.0	<0.5	<0.5	NP	
		CTM84	Downgradient (East) of DR Plume. Impacted by TCE	< 1.0	< 1.0	<0.5	<0.5	NP	
		CTM101	Upgradient (West) of Eastern Core of DR Plume. In area where PCE distribution is not well defined.	8.8	8.6	8.5	6.5	NO TREND	
		CTM103	Eastern Core of DR Plume. Screened at shallower depth than screened interval of PCE-impacted MILL municipal water supply well	25	38	29	23	NO TREND	

Central Truckee Meadows Remediation District Program

Table 5.4

Comparison of PCE Concentrations in Key Wells and Other Wells with Notable PCE Results, 2010 Q1 through 2010 Q4

Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Well ID	Location of Well Relative to Associated Plume	2010 PCE Concentrations (µg/L) Q1	Q2	Q3	Q4	PCE Trend From 2003 Q4 to 2010 Q4	Notable Results
Downtown Reno (cont.)	Deep Zone	CTM10D	Eastern Core of DR Plume. Screen depth coincides with upper screened interval of PCE-impacted MILL municipal water supply well	38	37	49	56	DECREASING	X
		CTM12D	East of Eastern Core of DR Plume. Screen depth coincides with upper screened interval of PCE-impacted MILL municipal water supply well.	1.8	2.9	1.6	1.6	INCREASING	
		CTM107	Southeastern Part of DR Plume. Plume extent is undefined to the east and south.	14	16	18	19	NO TREND	
		CTM80	Northern Part of DR Plume in the Deep Zone. Potentially near bottom of DR plume	< 1.0	< 1.0	0.97	0.9	NO TREND	
		CTM81	Northeast Part of DR Plume. Sentry for 4TH municipal water supply well	7.3	5.8	7.3	6.6	NO TREND	
		4THMWD	Downgradient (Northeastern) Part of DR Plume. Screen depth coincides with lower screened intervals at PCE-impacted 4TH municipal water supply well	< 1.0	NS	<0.5	0.67	NP	X
		4THMWS	Downgradient (Northeastern) Part of DR Plume. Screen depth coincides with upper screened intervals at PCE-impacted 4TH municipal water supply well	< 1.0	NS	3.6	4.1	INCREASING	X
		4TH	DR Plume Receptor	NS	NS	<0.5	0.73	DECREASING	
		HIGH	DR Plume Receptor	NS	NS	8.3	12	DECREASING	
		MORRILL	DR Plume Receptor	NS	13.0	9.5	9.9	DECREASING	X
		KIETZKE	DR Plume Receptor	NS	NS	8	7.6	DECREASING	
		MILL	Eastern Plume Core/DR Plume Receptor	NS	NS	50.5	47	INCREASING	
Mill/Kietzke	Shallow Zone	CTM13S	MK Plume Hot Spot	15	13	14	8.2	DECREASING	
		ARCO6018MW11	MK Plume Hot Spot	55	200	19	15	NO TREND	
		CTM63	East Flank of MK Plume Hot Spot	22	75	37	6.2	NO TREND	X
		ARCO6018MW12	Downgradient (Southeast) Flank of MK Hot Spot	27	44	25	30	INCREASING	X
		ARCO6018MW16	Downgradient of MK Plume Hot Spot	1.6	5.7	17	6.1	INCREASING	X
		CTM11S	Downgradient of MK Plume Hot Spot	< 1.0	< 1.0	0.65	3.6	NO TREND	X
		CTM105	Downgradient of MK Plume Hot Spot	7.9	6.9	8.9	7.9	NO TREND	
		CTM38D	Downgradient of MK Plume Hot Spot. Downgradient extent of MK plume is undefined to the east and south.	3.7	3.3	3.3	2.4	DECREASING	X
Downtown Sparks		CTM65	West of Hot Spot defined by CTM70. Defines top of VA plume	< 1.0	< 1.0	1.0	<0.5	NO TREND	
		CTM66	West of Hot Spot defined by CTM70	3.6	2.8	4.2	2.7	DECREASING	
		CTM70	CTM70 Hot Spot	11	8.8	11	11	NO TREND	
		CTM67	VA Plume Core	39	34	47	52	INCREASING	

Central Truckee Meadows Remediation District Program

Table 5.4

Comparison of PCE Concentrations in Key Wells and Other Wells with Notable PCE Results, 2010 Q1 through 2010 Q4
Washoe County Department of Water Resources

Subregion	Shallow Zone/ Deep Zone Designation	Well ID	Location of Well Relative to Associated Plume	2010 PCE Concentrations (µg/L) Q1	Q2	Q3	Q4	PCE Trend From 2003 Q4 to 2010 Q4	Notable Results
Downtown Sparks (cont.)	Deep Zone	CTM68	Sentry Well for SPARKS Municipal Water Supply Well. Deeper than VA plume	< 1.0	< 1.0	<0.5	<0.5	NP	
		SPARKS	VA and/or DS Plume Receptor	NS	NS	NS	NS	NO TREND	
		CTM75	Sentry Well for POPLAR2 Municipal Water Supply Well. Screen depth coincides with upper screened interval at PCE-impacted POPLAR2 municipal water supply well	5.3	5.3	1.6	0.97	NO TREND	
		POPLAR2	DS Plume Receptor	NS	NS	NS	NS	DECREASING	
East Sparks	Shallow Zone	SSFSMW204	Wolverine Way Hot Spot	35	9.8	3.8	20	NO TREND	X
		SSFSMW205	Downgradient of Wolverine Way Hot Spot	4.8	4.7	4.2	4.1	DECREASING	
		SSFSMW207	Downgradient of Wolverine Way Hot Spot	2.9	2.2	3	2.9	INCREASING	
		SSFSMW212	Downgradient of Wolverine Way Hot Spot	5.9	5.4	4.4	3.6	NO TREND	
El Rancho	Deep Zone	ELRANCHOMWS	Adjacent to PCE-impacted ELRANCHO Municipal Water Supply Well. Screen depth coincides with upper screened interval at ELRANCHO	2.1	NS	2.3	3.3	INCREASING	X
		ELRANCHOMWD	Adjacent to PCE-impacted ELRANCHO Municipal Water Supply Well. Screen depth coincides with lower screened interval at ELRANCHO	< 1.0	NS	0.72	<0.5	NO TREND	
		ELRANCHO	ER Plume Receptor	NS	NS	1.1	0.67	NO TREND	X
Joule	Shallow Zone	CTM87	Westernmost Well in J Plume	2.7	2.1	2.4	2.7	NO TREND	
		CTM86	Northeasternmost Well in J Plume. Screen depth coincides with upper sceened interval of HV5 municipal water supply well	1.0	< 1.0	1.3	1.1	INCREASING	X
	Deep Zone	BELFAST	J Plume Interior. PCE distribution in area is poorly defined	2.1	1.3	1.6	1.9	INCREASING	
		CTM85	Screen depth is potentially deeper than J Plume. Screen depth coincides with middle part of sceened interval of HV5 municipal water supply well	< 1.0	< 1.0	<0.5	<0.5	NP	
		HV5	Potential Receptor/Historically PCE-impacted	NS	NS	<0.5	<0.5	NP	
Outside Subregion	Shallow Zone	UNRAGMW25N	Outside of Any Designated Plume. PCE defined by single well	9.8	6.6	5.2	2.1	NA	X

EXPLANATION:

NS = Not sampled
NA = Not avaliable or not applicable
NP = Not performed because data set either includes less than 4 samples or has less than 3 PCE detections
(green) = New PCE concentration minimum
(red) = New PCE concentration maximum
(pink) = Significant PCE concentration change as defined by change between successive quarterly samples that is larger than two standard deviations
<1.0 = PCE was not detected above the specified reporting limit
J = Estimated value
JP = Analytical results are considered an estimate because field parameters failed to meet established stability guidelines.
JF =Analytical results are considered an estimate because field protocol were not followed.

SR = South Reno
DR = Downtown Reno
MK = Mill / Kietzke
DS = Downtown Sparks
ES = East Sparks
ER = El Rancho
J =Joule

Notes:

Descriptions of **Location of Well Relative to Plume** are defined based on interpretation of plume outline, location of hot spots, or plume cores, and on interpretation of ambient lateral groundwater flow directions derived from water level contouring.

Mann-Kendall Trend (Increasing, Decreasing, or No Trend) is defined based on available data during the period between 2003 Q4 and 2010 Q4. "No trend" indicates that the null hypothesis (no increasing or decreasing trend) can not be statistically rejected at the >80% confidence level. It does not indicate stable PCE concentrations.

POPLAR2 and SPARKS were not sampled in 2010.

Figures

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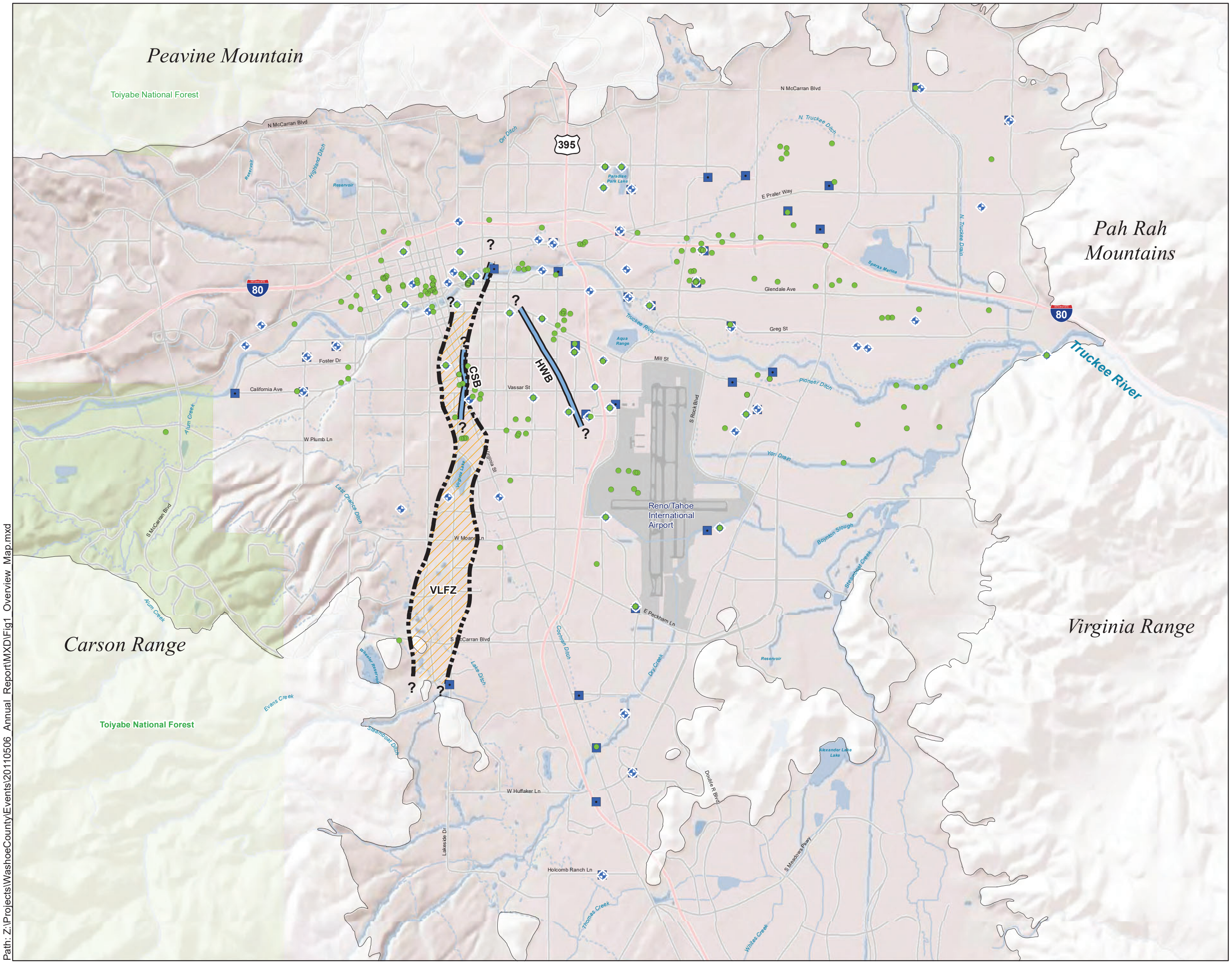


EXPLANATION

- Shallow Zone Monitoring Well
- Deep Zone Monitoring Well
- Deep Zone Municipal Water Supply Well
- Virginia Lake Fault Zone (VLFZ)
- Partial Flow Barrier
- Highway
- Streets
- Creeks/Rivers/Slough
- Ditch/Drain/Canal
- Water Bodies
- Basin Fill/Bedrock Boundary

Notes: 1) The positions of some overlapping well symbols are adjusted slightly to enhance well recognition at this map scale.
2) Municipal water supply wells include some wells that are currently in production and some wells that are planned for future production.
3) Base Map Image © 2009 ESRI.

N

0 2,500 5,000

Scale: Feet

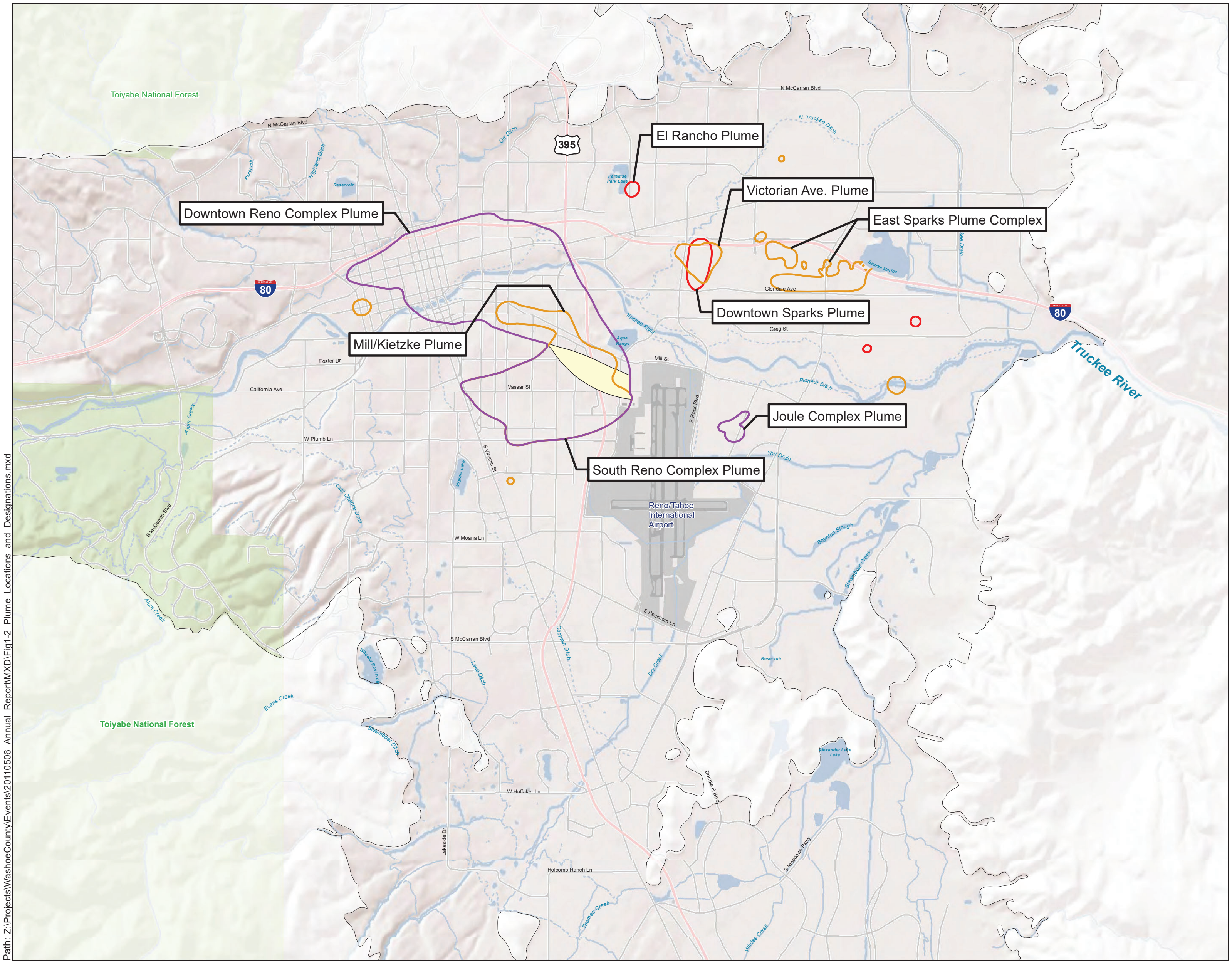
Kennedy/Jenks Consultants

Washoe County DWR
Reno, Nevada

GMP Overview Map

K/J 1083007*00
August 2012

Figure 1.1



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EXPLANATION

- Shallow/Deep Zone Contamination Outline
- Shallow Zone Contamination Outline
- Deep Zone Contamination Outline
- Area of Potential Deep Zone (Downtown Reno and South Reno Complex Plume) and Shallow Zone (Mill/Kietzke Plume and South Reno Complex Plume) Plume Overlap
- Highway
- Streets
- Creeks/Rivers/Slough
- Ditch/Drain/Canal
- Water Bodies
- Basin Fill/Bedrock Boundary

Notes: 1) Plume outlines are based on 0.50 µg/L PCE contours using 2010 Q3 PCE concentration data (see Figures 5.6 and 5.7).
2) Base Map Image © 2009 ESRI

N

0 2,500 5,000

Scale: Feet

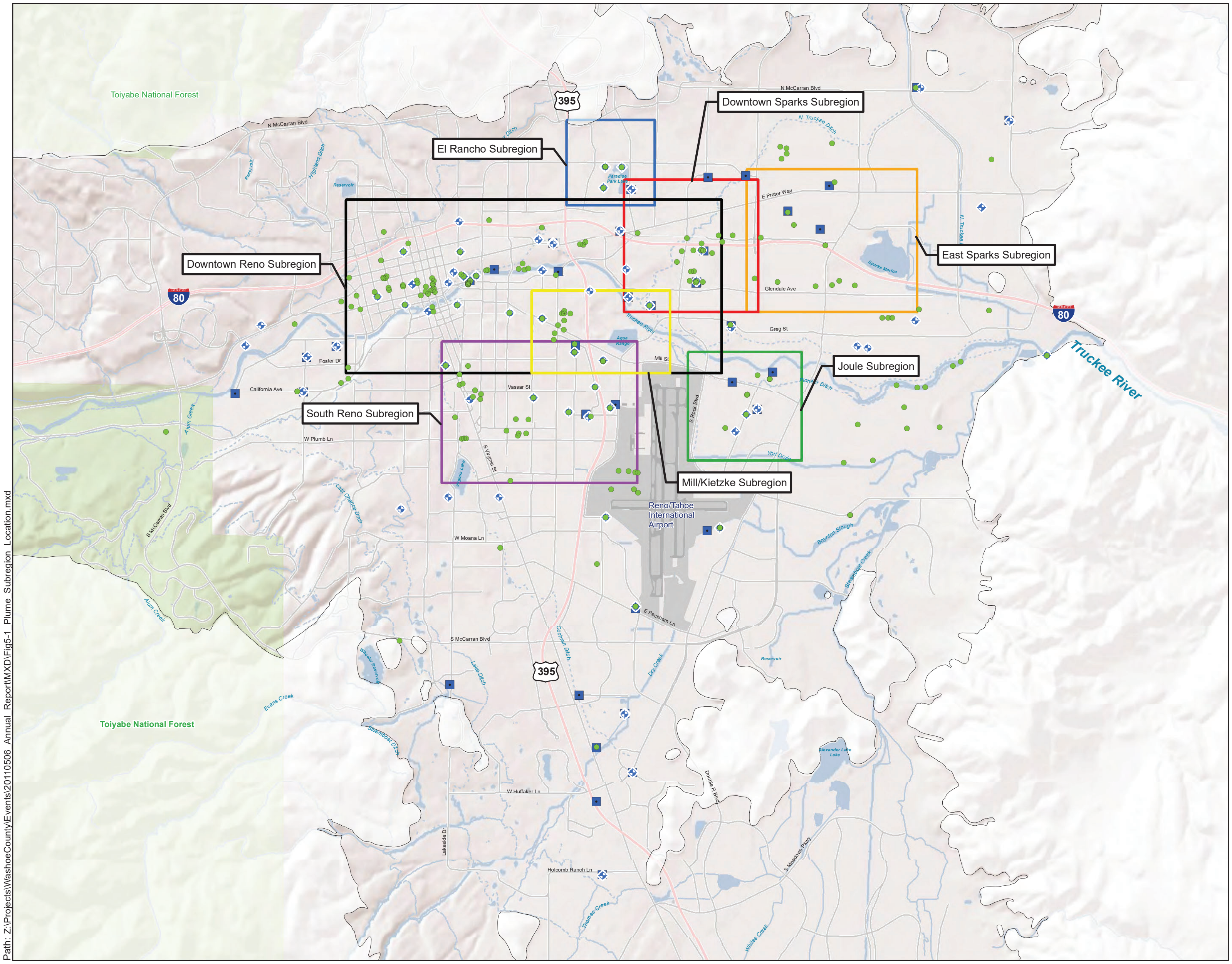
Kennedy/Jenks Consultants

Washoe County DWR
Reno, Nevada

PCE Plume Locations and Designations

K/J 1083007*00
August 2011

Figure 1.2



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EXPLANATION

- Shallow Zone Monitoring Well
- Deep Zone Monitoring Well
- Deep Zone Municipal Water Supply Well
- Highway
- Streets
- Creeks/Rivers/Slough
- Ditch/Drain/Canal
- Water Bodies
- Basin Fill/Bedrock Boundary

Notes: 1) The positions of some overlapping well symbols are adjusted slightly to enhance well recognition at this map scale.
2) Municipal water supply wells include some wells that are currently in production and some wells that are planned for future production.
3) Base Map Image: © 2009 ESRI.

N

0 2,500 5,000

Scale: Feet

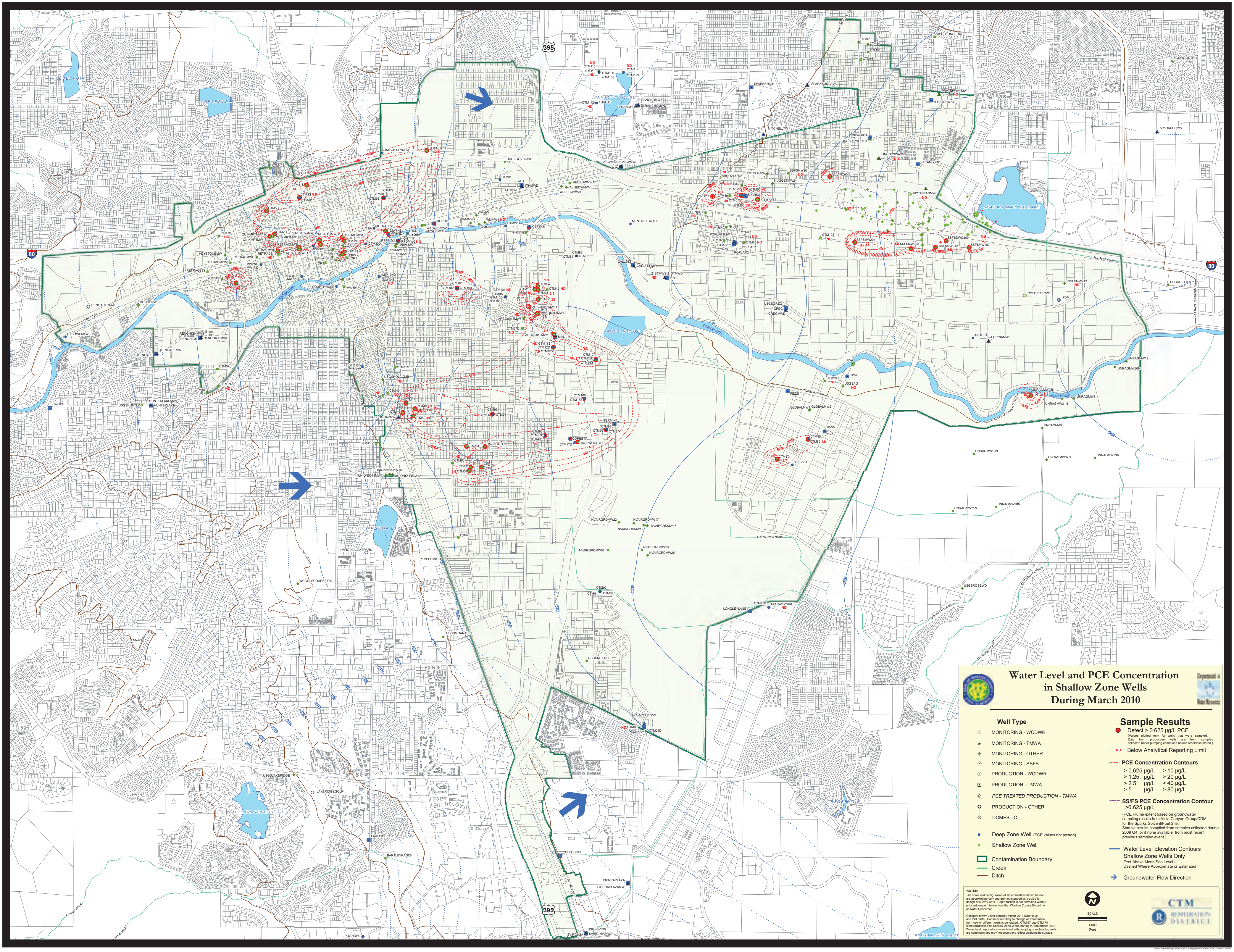
Kennedy/Jenks Consultants

Washoe County DWR
Reno, Nevada

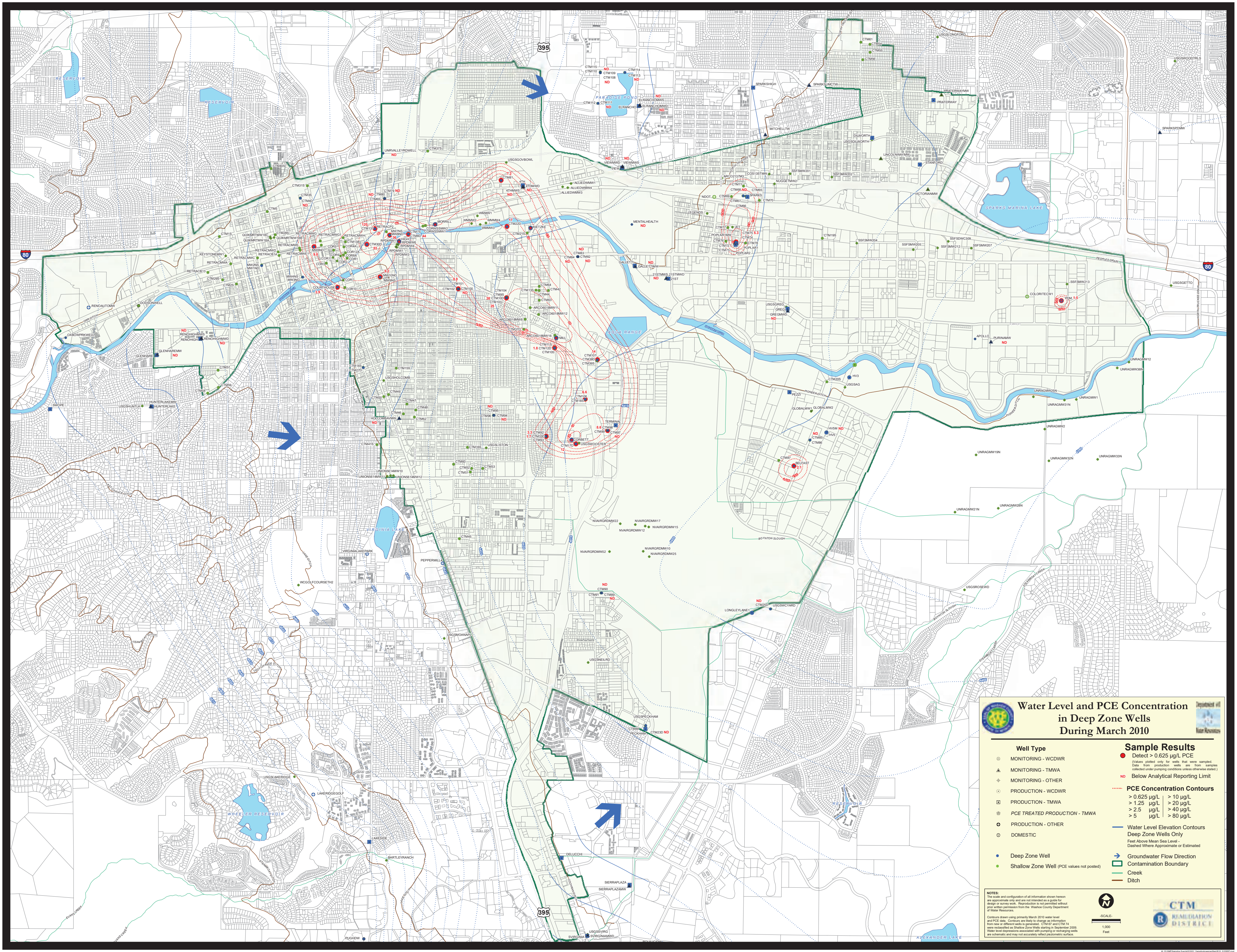
Subregion Locations and Designations

K/J 1083007*00
August 2011

Figure 5.1



Water Level and PCE Concentration in Shallow Zone Wells During March 2010
Well Type
MONITORING - WCDWR
MONITORING - TMWA
MONITORING - OTHER
MONITORING - SSFS
PRODUCTION - WCDWR
PRODUCTION - TMWA
PCE TREATED PRODUCTION - TMWA
PRODUCTION - OTHER
DOMESTIC
Deep Zone Well (PCE values not posted)
Shallow Zone Well
Contamination Boundary
Creek
Ditch
Sample Results
Detect > 0.625 µg/L PCE
(Values plotted only for wells that were sampled. Data from production wells are from samples collected under pumping conditions unless otherwise stated.)
ND Below Analytical Reporting Limit
PCE Concentration Contours
> 0.625 µg/L
> 1.25 µg/L
> 2.5 µg/L
> 5 µg/L
> 10 µg/L
> 20 µg/L
> 40 µg/L
> 80 µg/L
SS/FS PCE Concentration Contour >0.625 µg/L
(PCE Plume extent based on groundwater sampling results from Vista Canyon Group/CDM for the Sparks Solvent/Fuel Site. Sample results compiled from samples collected during 2009 Q4, or if none available, from most recent previous sampled event.)
Water Level Elevation Contours Shallow Zone Wells Only
Feet Above Mean Sea Level - Dashed Where Approximate or Estimated
Groundwater Flow Direction
NOTES:
The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.
Contours drawn using primarily March 2010 water level and PCE data. Contours are likely to change as information from new or different wells is generated. CTM 67 and CTM 74 were reclassified as Shallow Zone Wells starting in September 2009. Water level depressions associated with pumping or recharging wells are schematic and may not accurately reflect piezometric surface.
-SCALE-
1,000 Feet
CTM REMEDIATION DISTRICT



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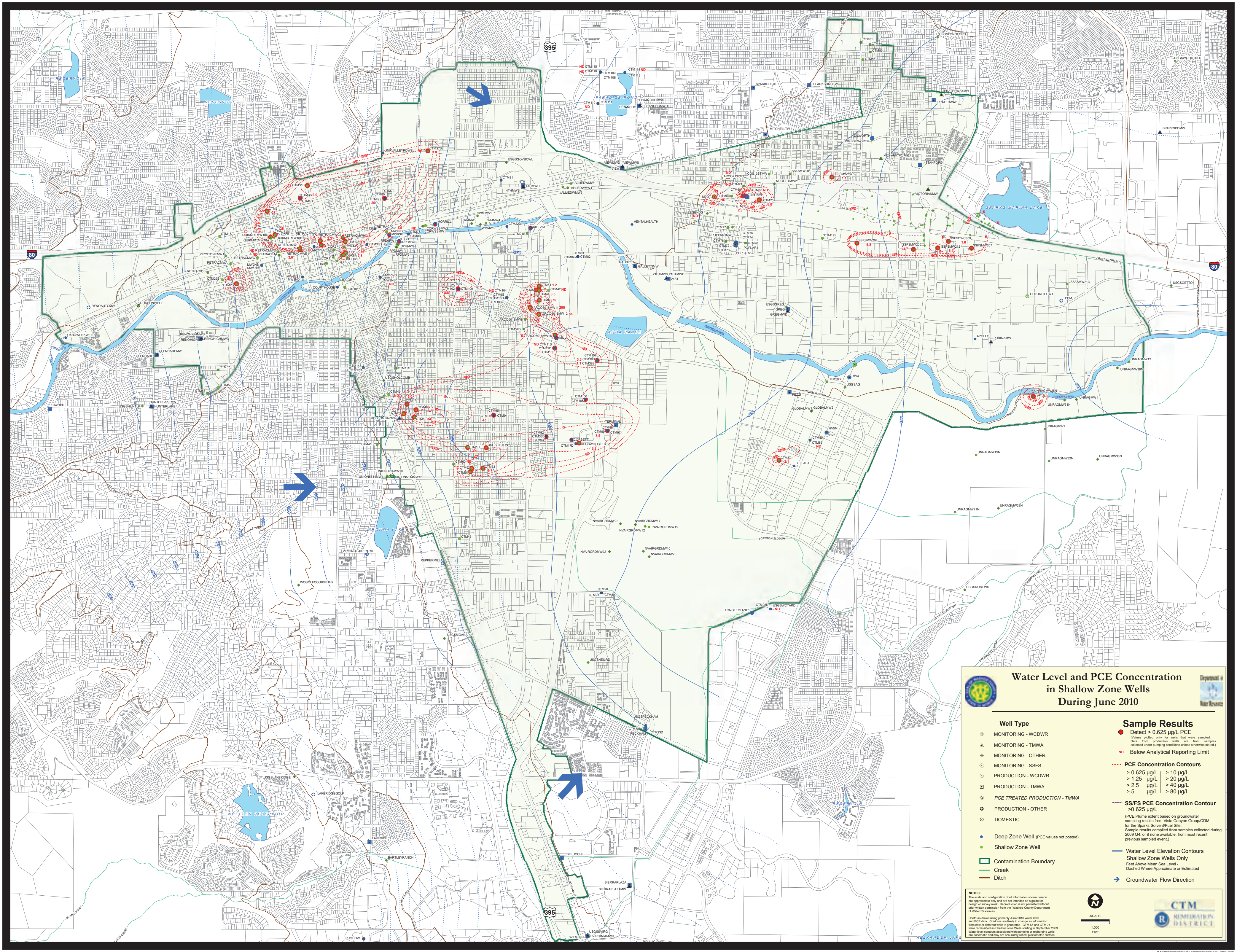
Water Level and PCE Concentration
in Shallow Zone Wells
During June 2010
Well Type
MONITORING - WCDWR
MONITORING - TMWA
MONITORING - OTHER
MONITORING - SSFS
PRODUCTION - WCDWR
PRODUCTION - TMWA
PCE TREATED PRODUCTION - TMWA
PRODUCTION - OTHER
DOMESTIC
Deep Zone Well (PCE values not posted)
Shallow Zone Well
Contamination Boundary
Creek
Ditch
Sample Results
Detect > 0.625 µg/L PCE
(Values plotted only for wells that were sampled. Data from production wells are from samples collected under pumping conditions unless otherwise stated.)
ND Below Analytical Reporting Limit
PCE Concentration Contours
> 0.625 µg/L > 10 µg/L
> 1.25 µg/L > 20 µg/L
> 2.5 µg/L > 40 µg/L
> 5 µg/L > 80 µg/L
SS/FS PCE Concentration Contour
>0.625 µg/L
(PCE Plume extent based on groundwater sampling results from Vista Canyon Group/CDM for the Sparks Solvent/Fuel Site. Sample results compiled from samples collected during 2009 Q4, or if none available, from most recent previous sampled event.)
Water Level Elevation Contours
Shallow Zone Wells Only
Feet Above Mean Sea Level -
Dashed Where Approximate or Estimated
Groundwater Flow Direction
NOTES:
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Contours drawn using primarily June 2010 water level and PCE data. Contours are likely to change as information from new or different wells is generated. CTM 67 and CTM 74 were reclassified as Shallow Zone Wells starting in September 2009. Water level contours associated with pumping or recharging wells are schematic and may not accurately reflect piezometric surface.
-SCALE-
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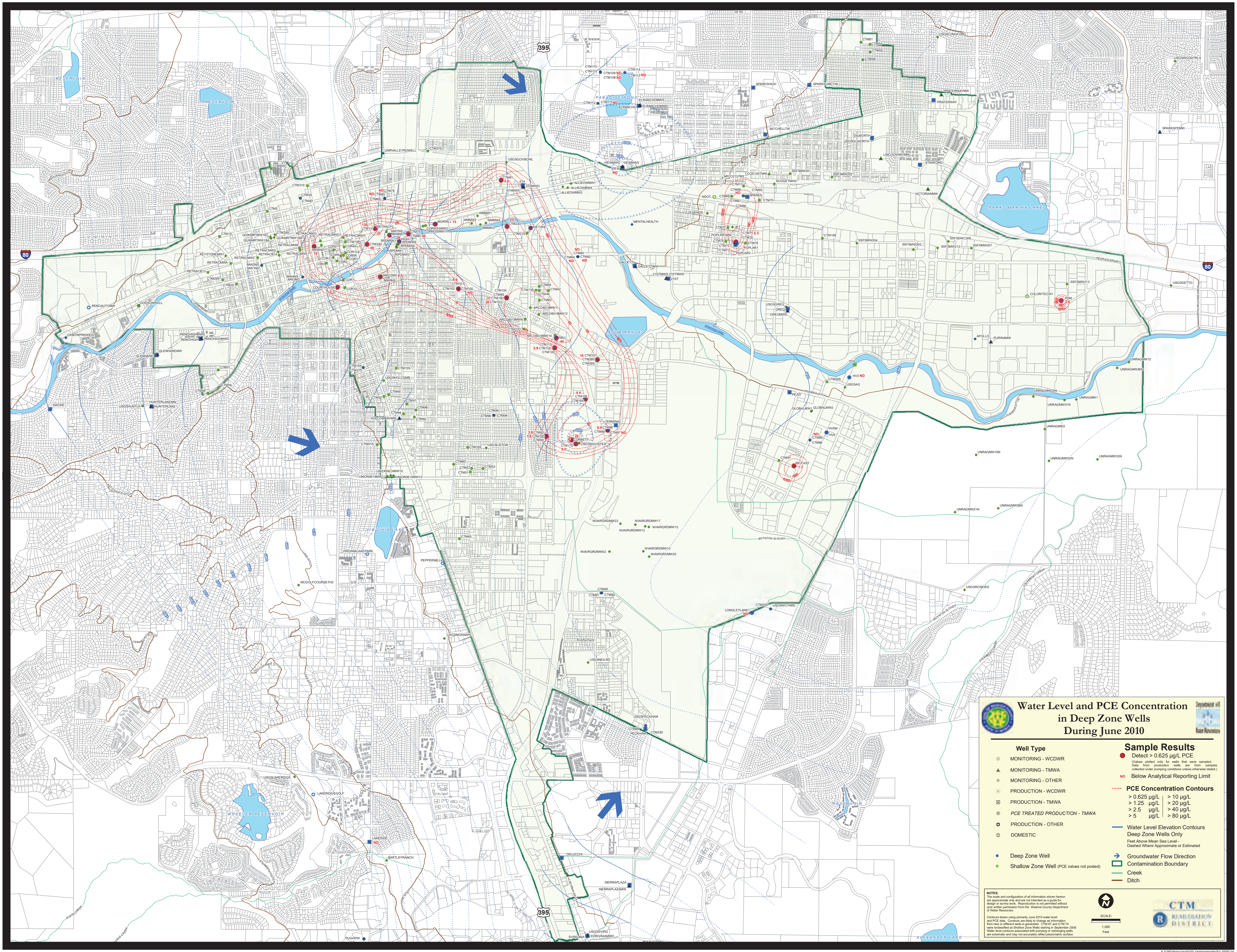
Feet
CTM
REMEDIATION DISTRICT
SPARKS MARINA LAKE
VIRGINIA LAKE
WHEELER RESERVOIR
AQUA RANGE
PARADISE POND
ALEXANDER LAKE



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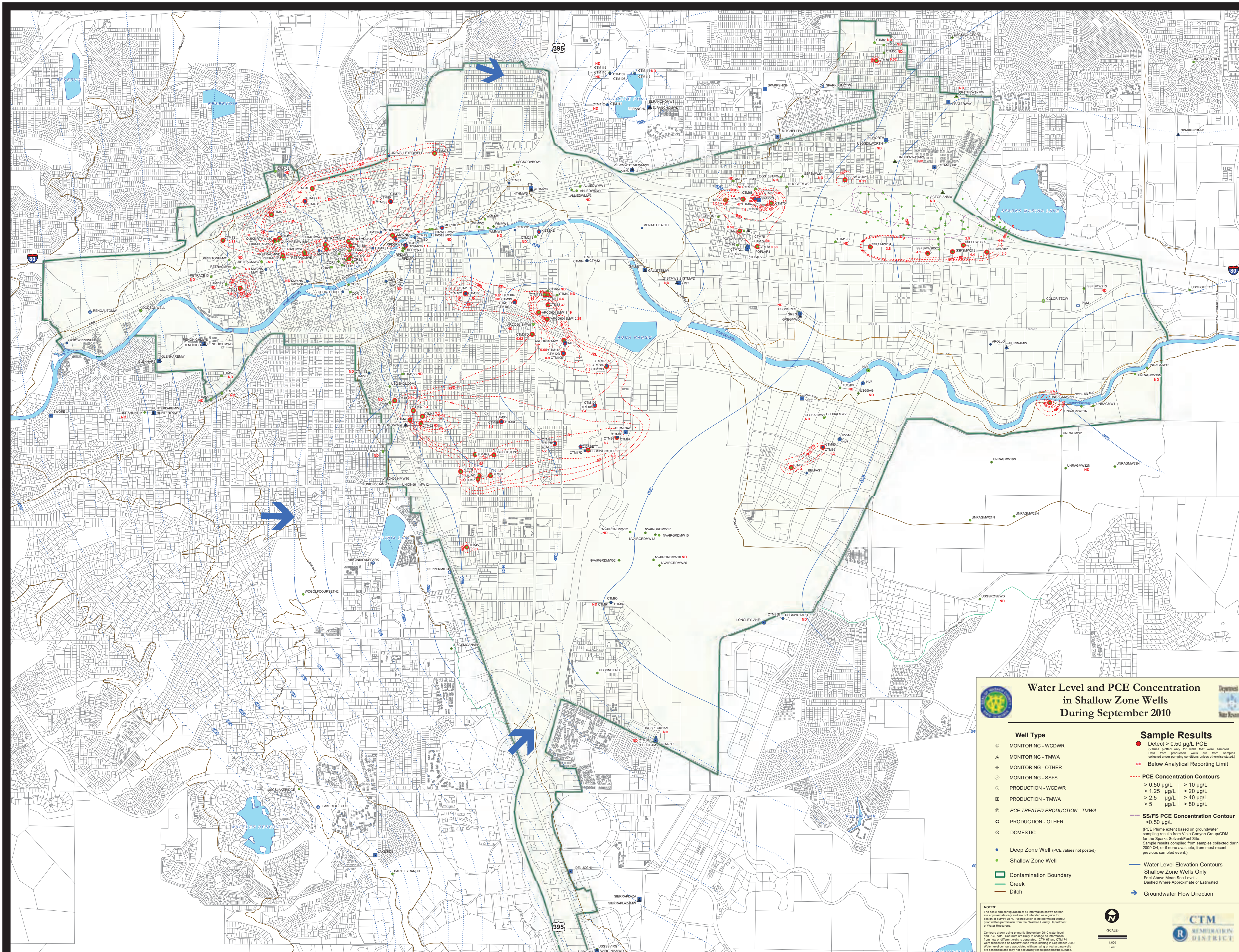
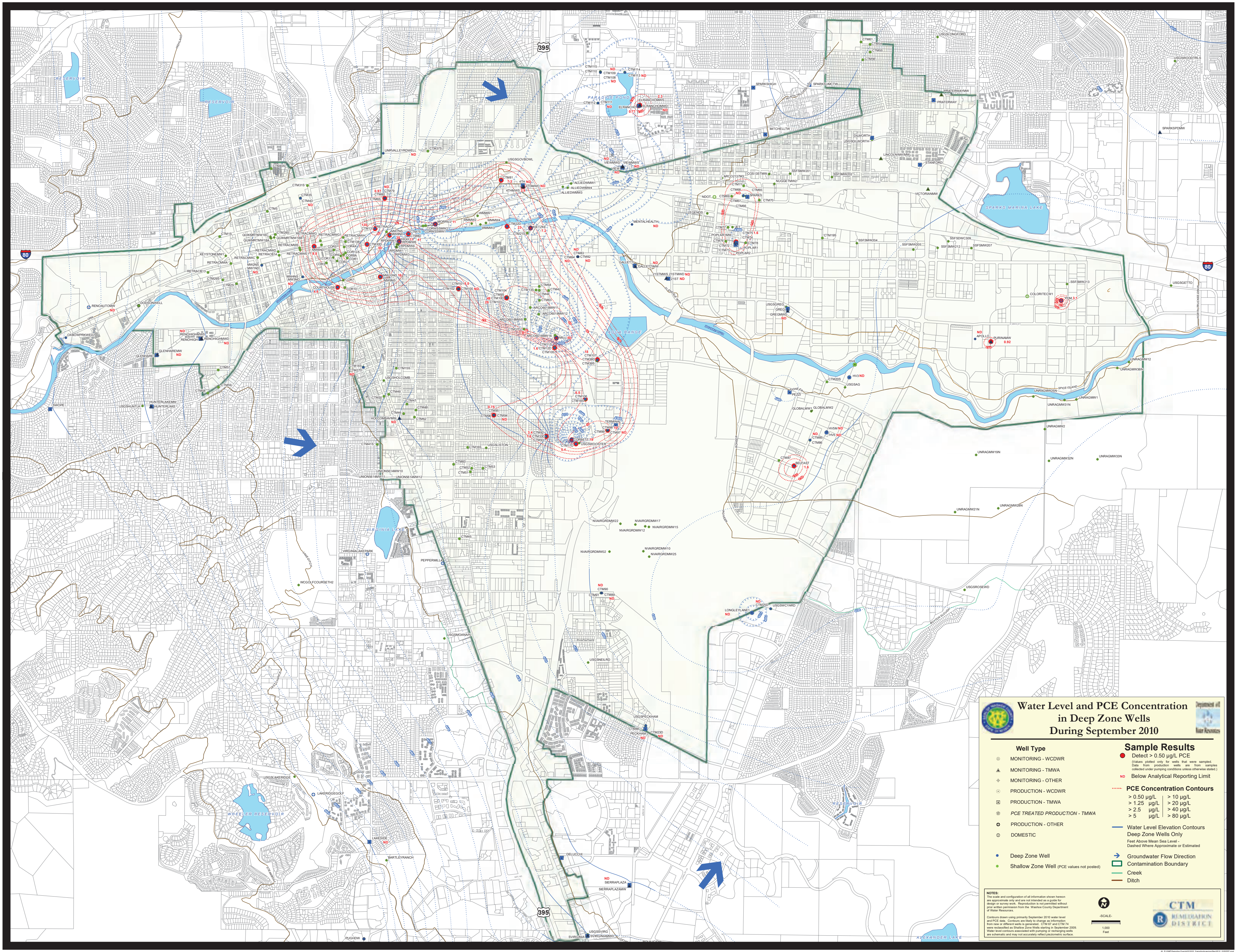
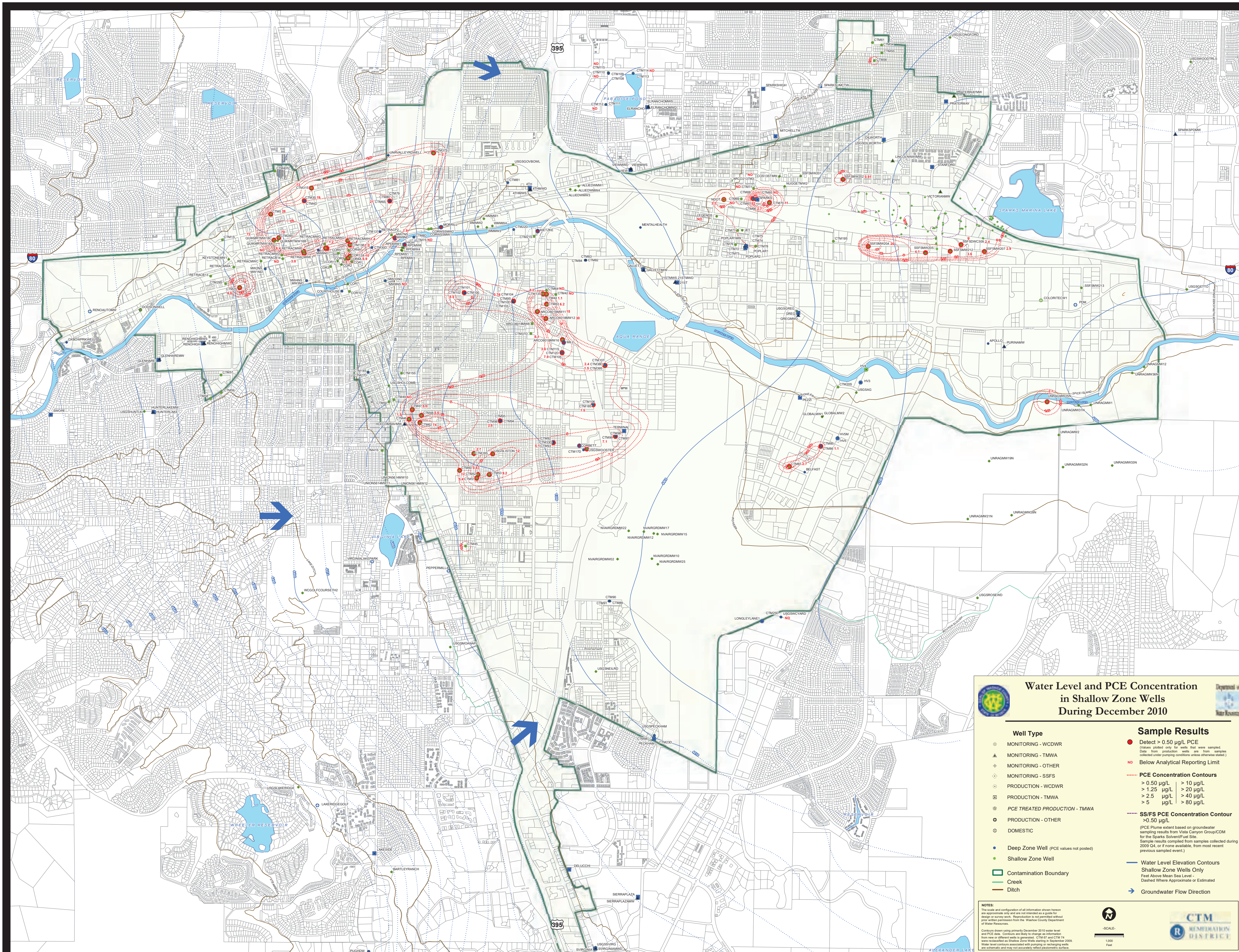


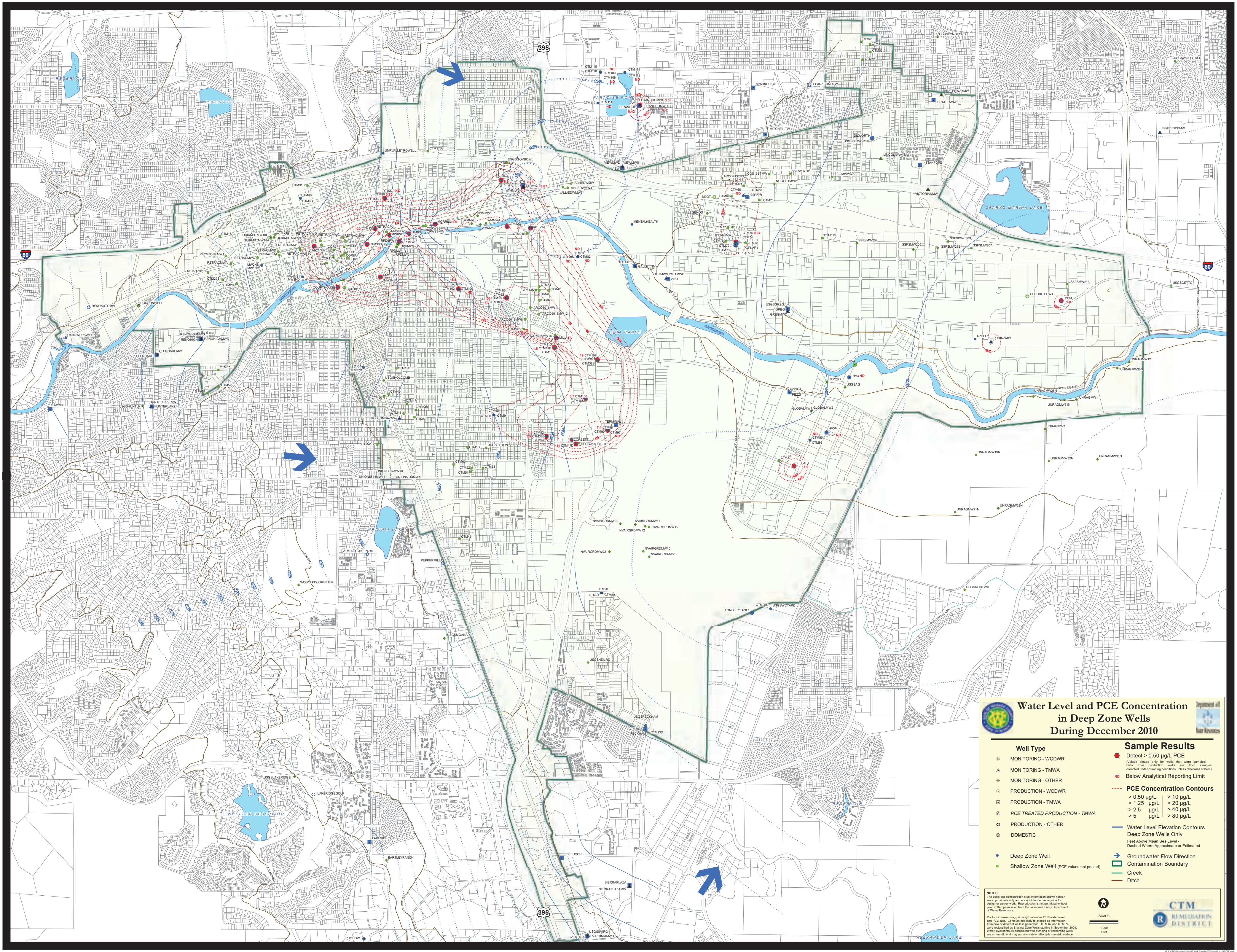
Water Level and PCE Concentration in Shallow Zone Wells During September 2010
Well Type
MONITORING - WCDWR
MONITORING - TMWA
MONITORING - OTHER
MONITORING - SSFS
PRODUCTION - WCDWR
PRODUCTION - TMWA
PCE TREATED PRODUCTION - TMWA
PRODUCTION - OTHER
DOMESTIC
Deep Zone Well (PCE values not posted)
Shallow Zone Well
Contamination Boundary
Creek
Ditch
Sample Results
Detect > 0.50 µg/L PCE
(Values plotted only for wells that were sampled. Data from production wells are from samples collected under pumping conditions unless otherwise stated.)
ND Below Analytical Reporting Limit
PCE Concentration Contours
> 0.50 µg/L
> 1.25 µg/L
> 2.5 µg/L
> 5 µg/L
> 10 µg/L
> 20 µg/L
> 40 µg/L
> 80 µg/L
SS/FS PCE Concentration Contour
>0.50 µg/L
(PCE Plume extent based on groundwater sampling results from Vista Canyon Group/CDM for the Sparks Solvent/Fuel Site. Sample results compiled from samples collected during 2009 Q4, or if none available, from most recent previous sampled event.)
Water Level Elevation Contours
Shallow Zone Wells Only
Feet Above Mean Sea Level -
Dashed Where Approximate or Estimated
Groundwater Flow Direction
NOTES:
The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.
Contours drawn using primarily September 2010 water level and PCE data. Contours are likely to change as information from new or different wells is generated. CTM 67 and CTM 74 were reclassified as Shallow Zone Wells starting in September 2009. Water level contours associated with pumping or recharging wells are schematic and may not accurately reflect piezometric surface.
-SCALE-
1,000
Feet
CTM
REMEDIATION DISTRICT



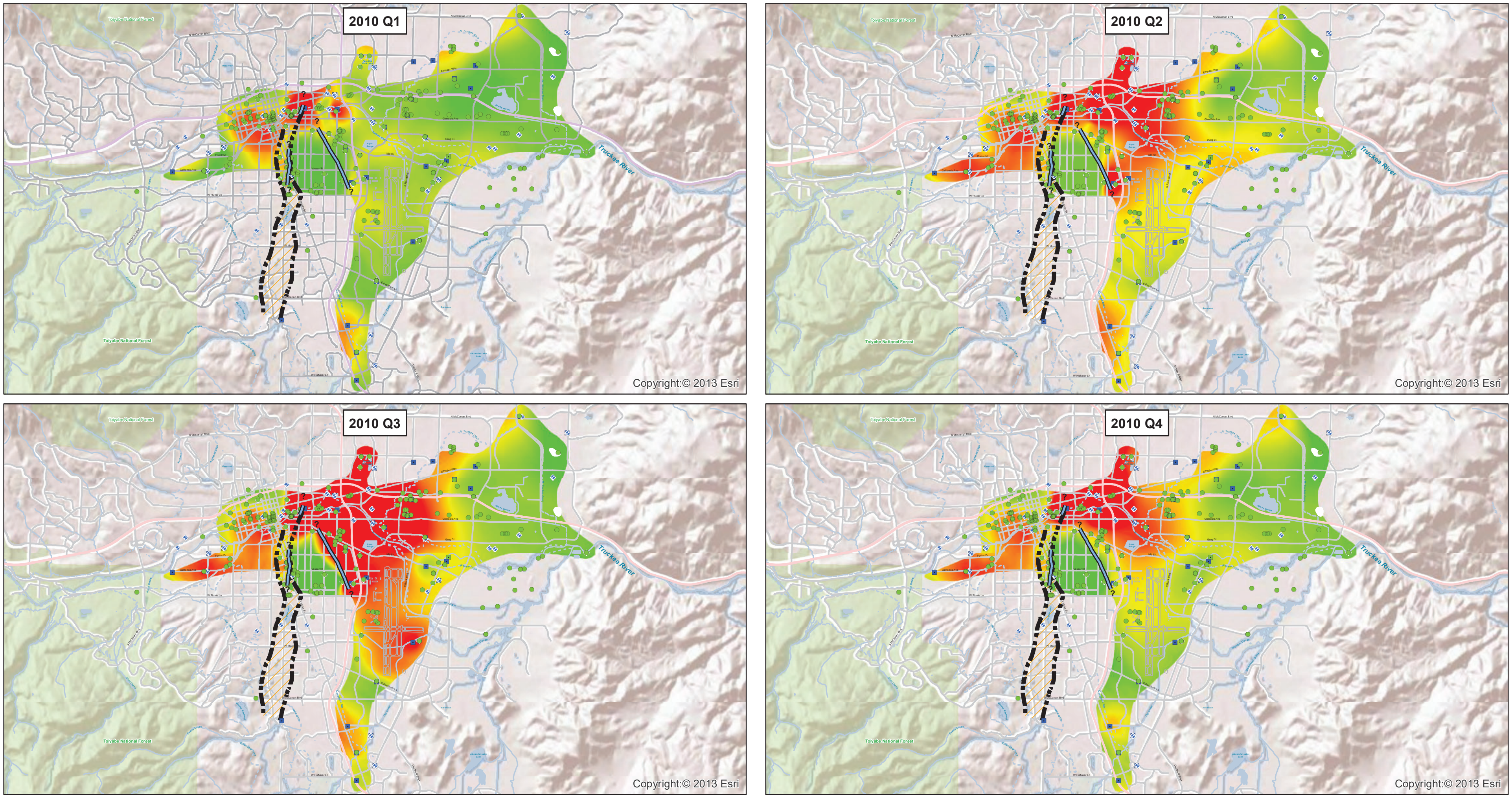
Water Level and PCE Concentration in Deep Zone Wells During September 2010
Well Type
MONITORING - WCDWR
MONITORING - TMWA
MONITORING - OTHER
PRODUCTION - WCDWR
PRODUCTION - TMWA
PCE TREATED PRODUCTION - TMWA
PRODUCTION - OTHER
DOMESTIC
Deep Zone Well
Shallow Zone Well (PCE values not posted)
Sample Results
Detect > 0.50 µg/L PCE
(Values plotted only for wells that were sampled. Data from production wells are from samples collected under pumping conditions unless otherwise stated.)
ND Below Analytical Reporting Limit
PCE Concentration Contours
> 0.50 µg/L
> 1.25 µg/L
> 2.5 µg/L
> 5 µg/L
> 10 µg/L
> 20 µg/L
> 40 µg/L
> 80 µg/L
Water Level Elevation Contours Deep Zone Wells Only
Feet Above Mean Sea Level - Dashed Where Approximate or Estimated
Groundwater Flow Direction
Contamination Boundary
Creek
Ditch
NOTES:
The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.
Contours drawn using primarily September 2010 water level and PCE data. Contours are likely to change as information from new or different wells is generated. CTM 67 and CTM 74 were reclassified as Shallow Zone Wells starting in September 2009. Water level contours associated with pumping or recharging wells are schematic and may not accurately reflect piezometric surface.
-SCALE-
1,000 Feet
CTM REMEDIATION DISTRICT
SPARKS MARINA LAKE
VIRGINIA LAKE
WHEELER RESERVOIR
ALEXANDER LAKE
395
80



JH_R:\GMP\Sampling Events\2010Q4_Sampling\GIS\mxd\2010_Q4SHALLOW.mxd



JH_R:\GMP\Sampling Events\2010Q4_Sampling\GIS\mxd\2010_Q4DEEP.mxd



Path: Z:\Projects\WashoeCounty\Events\20110506_Annual_Report\MXD\Fig5-10_WL_Difference.mxd

Legend

- Shallow Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Municipal Water Supply Well
- Deep Zone Municipal Water Supply Well
- Virginia Lake Fault Zone (VLFZ)
- Partial Flow Barrier
- Highway
- Streets
- Creeks/Rivers/Slough
- Ditch/Drain/Canal
- Water Bodies

Water Level Difference

High: > 10 ft.

Low : < -10 ft.

Note: 1) 2010 water level difference in the **alluvial aquifer** system is calculated by subtracting the contoured water level elevation in the shallow zone from the contoured water level elevation in the deep zone.
2) Map accuracy is variable and is the least accurate in areas where water-level data in either shallow or deep zones are absent, or widely distributed.
3) The small uncolored areas in the eastern part of the basin that are covered by the water level difference overlay are bedrock outcrops.
4) The positions of some overlapping well symbols are adjusted slightly to enhance well recognition at this map scale.
5) Municipal water supply wells include some wells that are currently in production and some wells that are planned for future production.
6) Base Map Image: © 2009 ESRI.

N

0 5,000 10,000

Scale: Feet

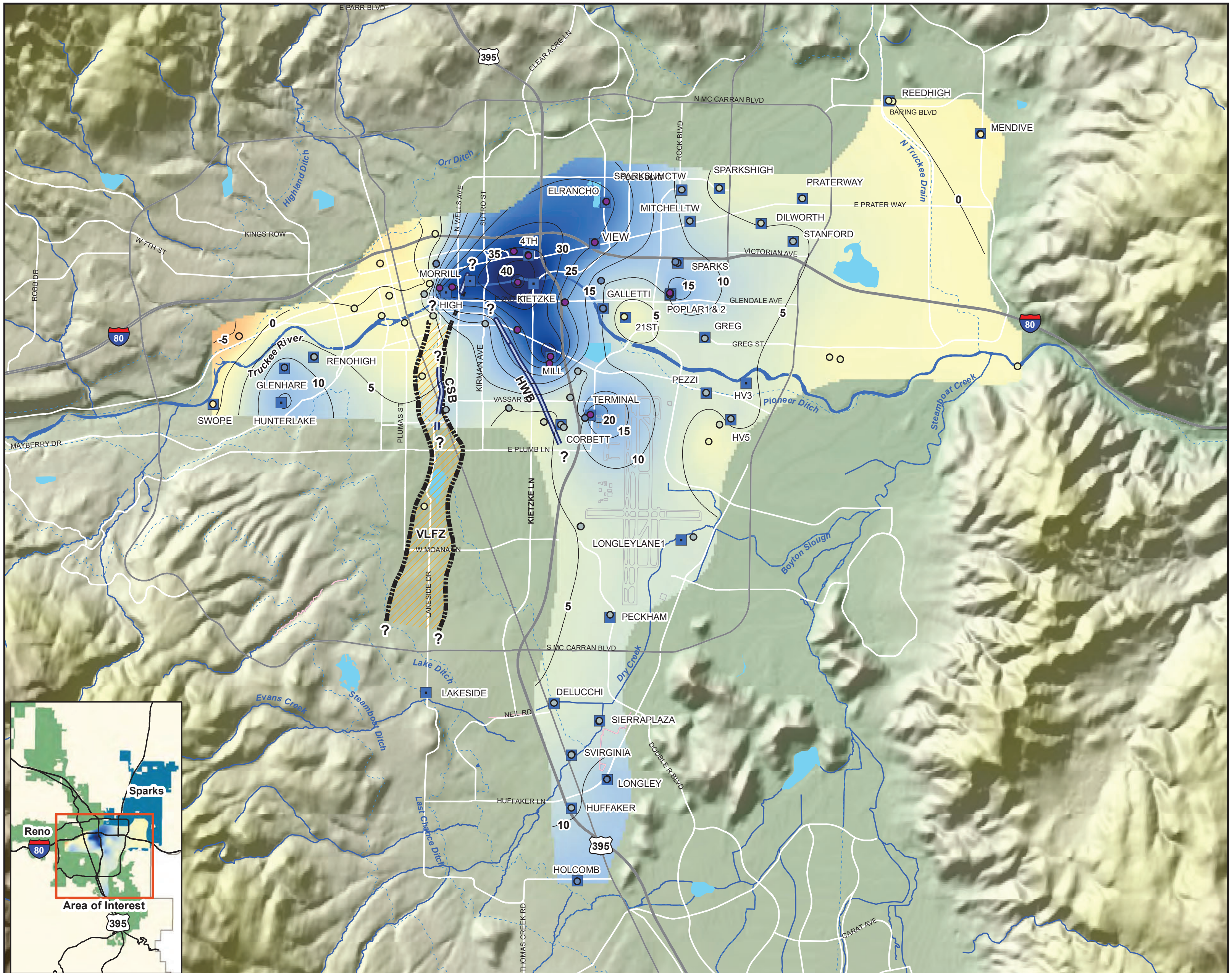
Kennedy/Jenks Consultants

Washoe County DWR
Reno, Nevada

2010 Quarterly Groundwater Level Difference Maps

K/J 1083007*00
November 2013

Figure 5.10



Cumulative Deep Zone Water Level Change 2010 Non Pumping Period September 2009 - April 2010

Municipal Water Supply Well (Not Utilized for Contouring)

Deep Zone Monitoring Well Utilized for Contouring

Cumulative Change (Feet)

Greater Than 20.0	0 to -2.50
+15.0 to +20.0	-2.50 to -5.0
+10.0 to +15.0	-5.0 to -10.0
+5.0 to +10.0	-10.0 to -15.0
+2.50 to +5.0	-15.0 to -20.0
0 to +2.50	Less Than - 20

Cumulative water level change calculated for each well by subtracting water level elevation in April 2010 from corresponding water level elevation in September 2009 for the same well.

Water Level Change (Feet)

Increase > 40

No Change

Decrease < -40

Virginia Lake Fault Zone (VLFZ)

Partial Flow Barrier

Ditch/Canal/Drain

Rivers/Creeks/Slough

Water Bodies

Department of Water Resources

Central Truckee Meadows Remediation District Program

June, 2013

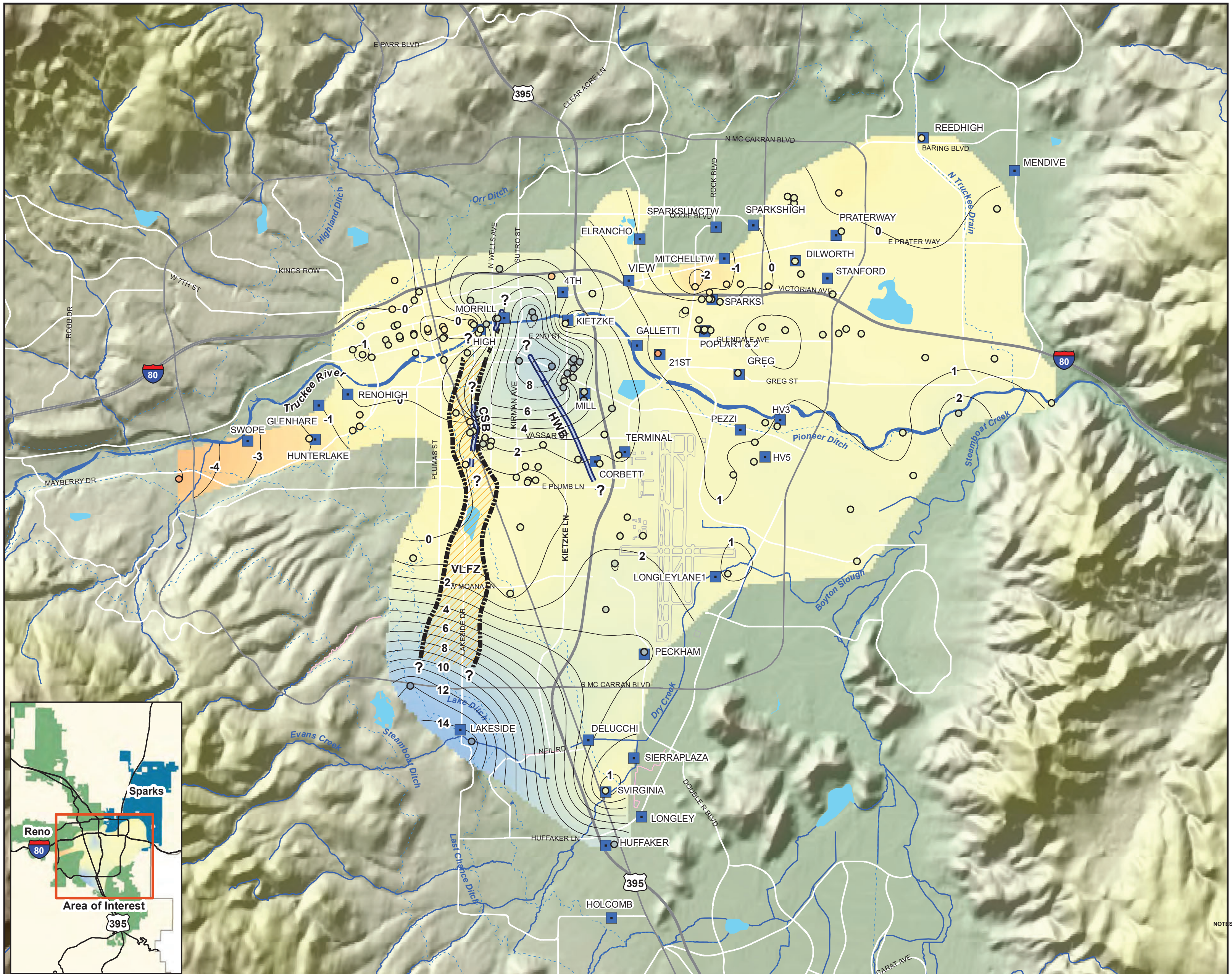
NOTE: The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.

1 inch = 5,000 feet

0 0.5 1 Miles

Figure 5.11

BThomas R:\GMP\GISDATA\2010_Annual_Report\Cumulative_Water_Level_Change\MXD\Cumulative_wat_level_change_Deep_Zone_Sept2009_April2010.mxd (6/26/2013)



Cumulative Shallow Zone Water Level Change 2010 Non Pumping Period September 2009 - April 2010

Municipal Water Supply Well (Not Utilized for Contouring)

Shallow Zone Monitoring Well Utilized for Contouring

Cumulative Change (Feet)

Greater Than 20.0	0 to -2.50
+15.0 to +20.0	-2.50 to -5.0
+10.0 to +15.0	-5.0 to -10.0
+5.0 to +10.0	-10.0 to -15.0
+2.50 to +5.0	-15.0 to -20.0
0 to +2.50	Less Than - 20

Cumulative water level change calculated for each well by subtracting water level elevation in April 2010 from corresponding water level elevation in September 2009 for the same well.

Water Level Change (Feet)

Increase > 40

No Change

Decrease < -40

Virginia Lake Fault Zone (VLFZ)

Partial Flow Barrier

Ditch/Canal/Drain

Rivers/Creeks/Slough

Water Bodies

Department of Water Resources

Central Truckee Meadows Remediation District Program

June, 2013

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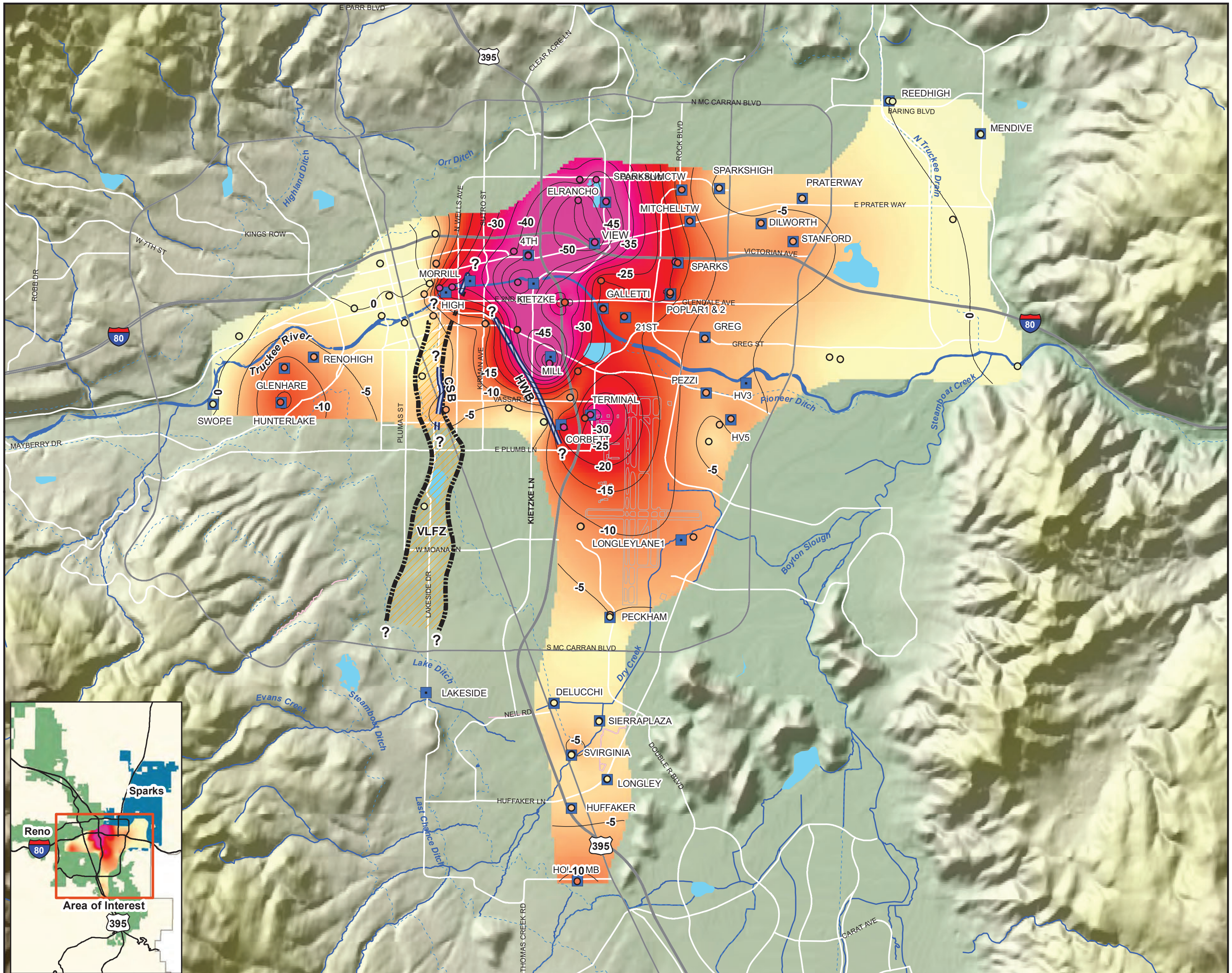
NOTES:

1 inch = 5,000 feet

0 0.5 1 Miles

Figure 5.12

BThomas R:\GMP\GISDATA\2010_Annual_Report\Cumulative_Water_Level_Change\MXD\Cumulative_wat_level_change_Shallow_Zone_Sept2009_April2010.mxd (6/26/2013)



Cumulative Deep Zone Water Level Change 2010 Pumping Period April 2010 - September 2010

- Municipal Water Supply Well (Not Utilized for Contouring)
- Deep Zone Monitoring Well Utilized for Contouring

Cumulative Change (Feet)

Greater Than 20.0	0 to -2.50
+15.0 to +20.0	-2.50 to -5.0
+10.0 to +15.0	-5.0 to -10.0
+5.0 to +10.0	-10.0 to -15.0
+2.50 to +5.0	-15.0 to -20.0
0 to +2.50	Less Than - 20

Cumulative water level change calculated for each well by subtracting water level elevation in September 2010 from corresponding water level elevation in April 2010 for the same well.

Water Level Change (Feet)

Increase > 40
No Change
Decrease < -40

- Virginia Lake Fault Zone (VLFZ)
- Partial Flow Barrier
- Ditch/Canal/Drain
- Rivers/Creeks/Slough
- Water Bodies

Department of Water Resources
Central Truckee Meadows Remediation District Program

June, 2013

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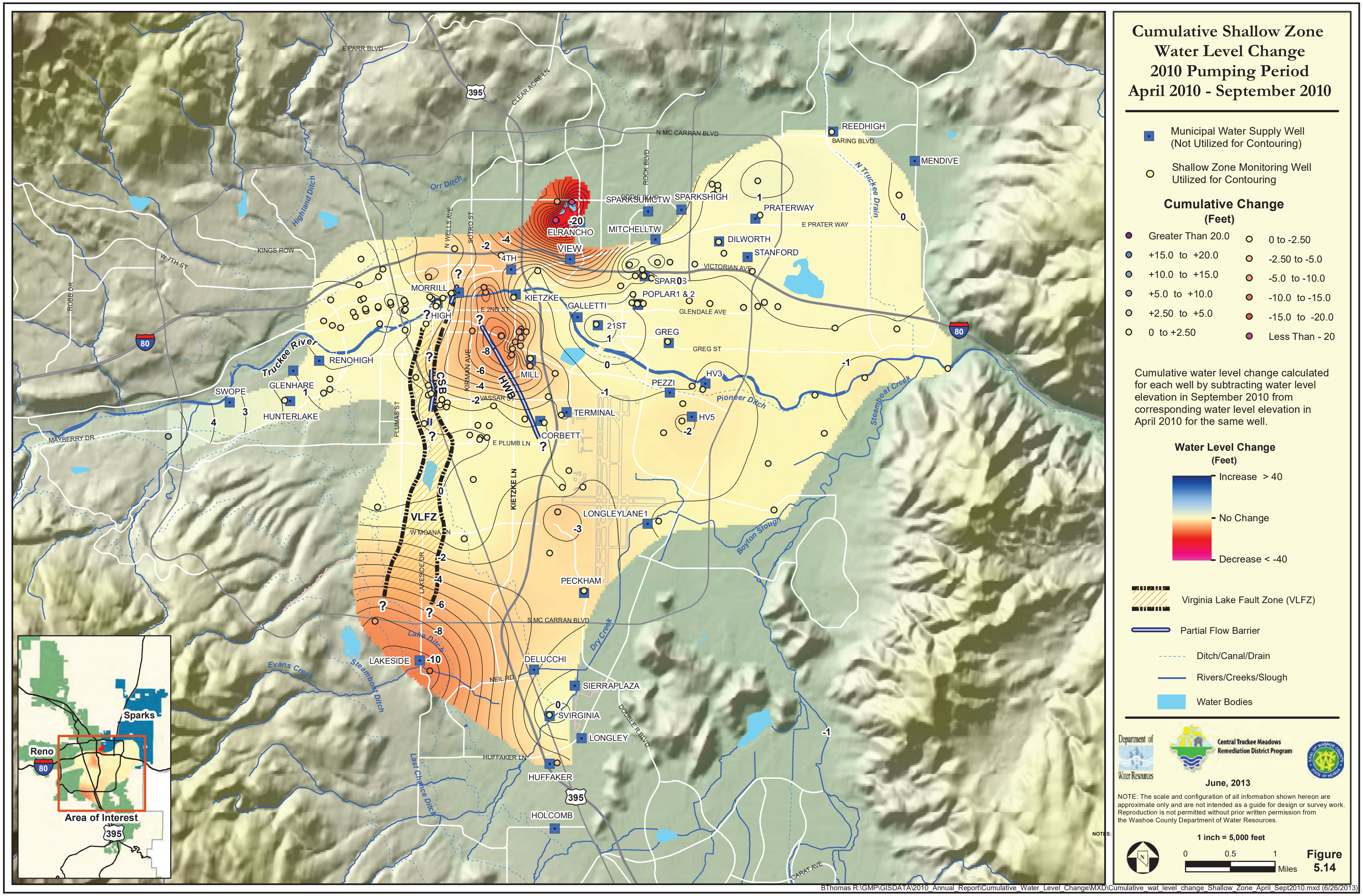
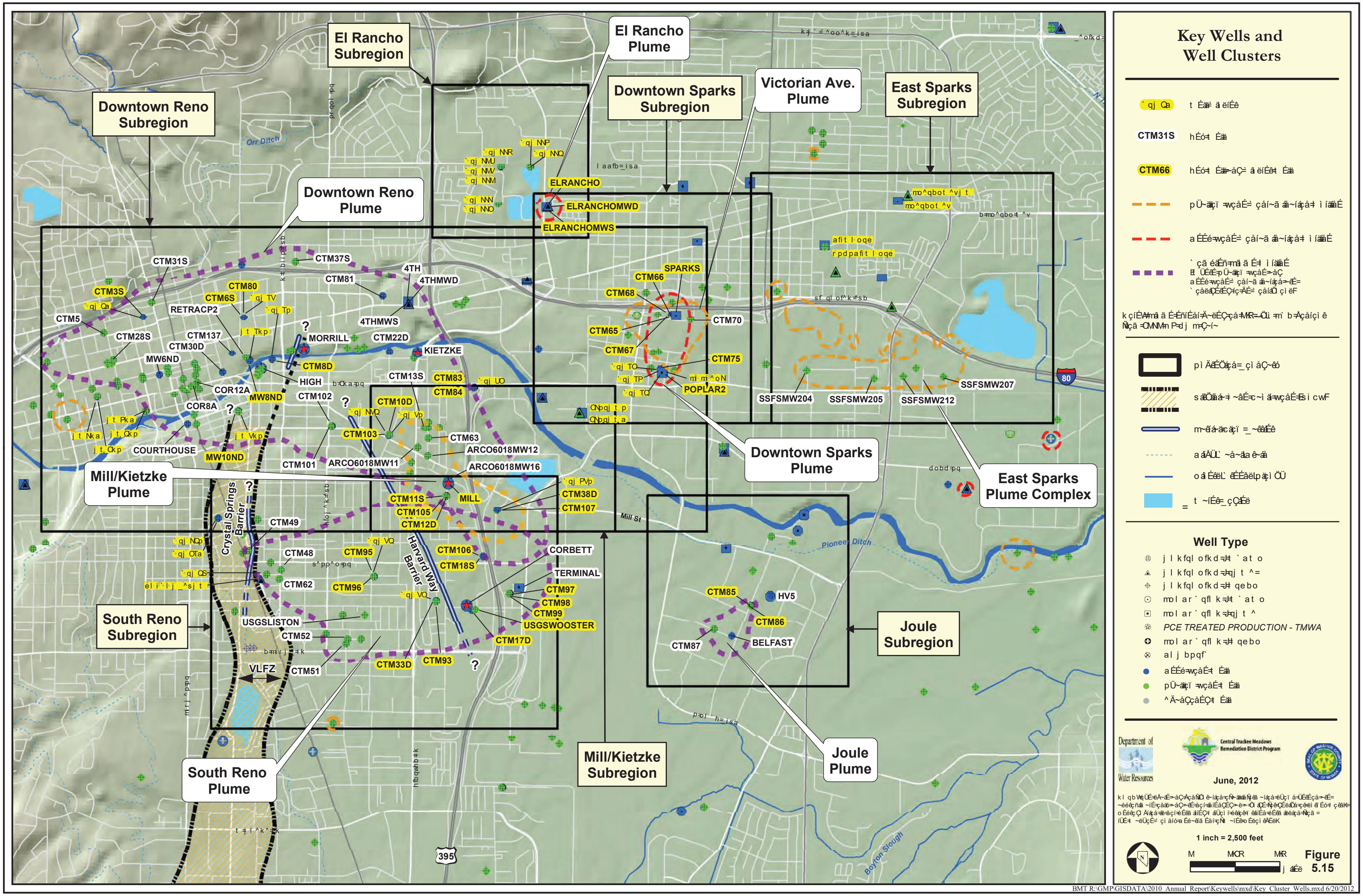
1 inch = 5,000 feet

0 0.5 1 Miles

Figure 5.13

BThomas R:\GMP\GISDATA\2010_Annual_Report\Cumulative_Water_Level_Change\MXD\Cumulative_wat_level_change_Deep_Zone_April_Sept2010.mxd (6/26/2013)


Cumulative Shallow Zone
Water Level Change
2010 Pumping Period
April 2010 - September 2010
Municipal Water Supply Well (Not Utilized for Contouring)
Shallow Zone Monitoring Well Utilized for Contouring
Cumulative Change
(Feet)
Greater Than 20.0
+15.0 to +20.0
+10.0 to +15.0
+5.0 to +10.0
+2.50 to +5.0
0 to +2.50
0 to -2.50
-2.50 to -5.0
-5.0 to -10.0
-10.0 to -15.0
-15.0 to -20.0
Less Than - 20
Cumulative water level change calculated for each well by subtracting water level elevation in September 2010 from corresponding water level elevation in April 2010 for the same well.
Water Level Change
(Feet)
Increase > 40
No Change
Decrease < -40
Virginia Lake Fault Zone (VLFZ)
Partial Flow Barrier
Ditch/Canal/Drain
Rivers/Creeks/Slough
Water Bodies
Department of Water Resources
Central Truckee Meadows Remediation District Program
June, 2013
NOTE: The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.
1 inch = 5,000 feet
0 0.5 1 Miles
Figure 5.14
Sparks
Reno
Area of Interest
REEDHIGH
MENDIVE
SPARKSHIGH
PRATERWAY
DILWORTH
STANFORD
MITCHELLTW
ELRANCHO
VIEW
4TH
MORRILL
KIETZKE
GALLETTI
21ST
POPLAR1 & 2
GREG
HIGH
RENOHIGH
GLENHARE
SWOPE
HUNTERLAKE
MILL
HV3
PEZZI
TERMINAL
HV5
CORBETT
LONGLEYLANE1
VLFZ
CSB
HMB
PECKHAM
LAKESIDE
DELUCCHI
SIERRAPLAZA
SVIRGINIA
LONGLEY
HUFFAKER
HOLCOMB
Truckee River
Steamboat Creek
Pioneer Ditch
Boynton Slough
Dry Creek
Evans Creek
Steamboat Ditch
Last Chance Ditch
Lake Ditch
Orr Ditch
Highland Ditch
N Truckee Drain
BThomas R:\GMP\GISDATA\2010_Annual_Report\Cumulative_Water_Level_Change\MXD\Cumulative_wat_level_change_Shallow_Zone_April_Sept2010.mxd (6/26/2013)



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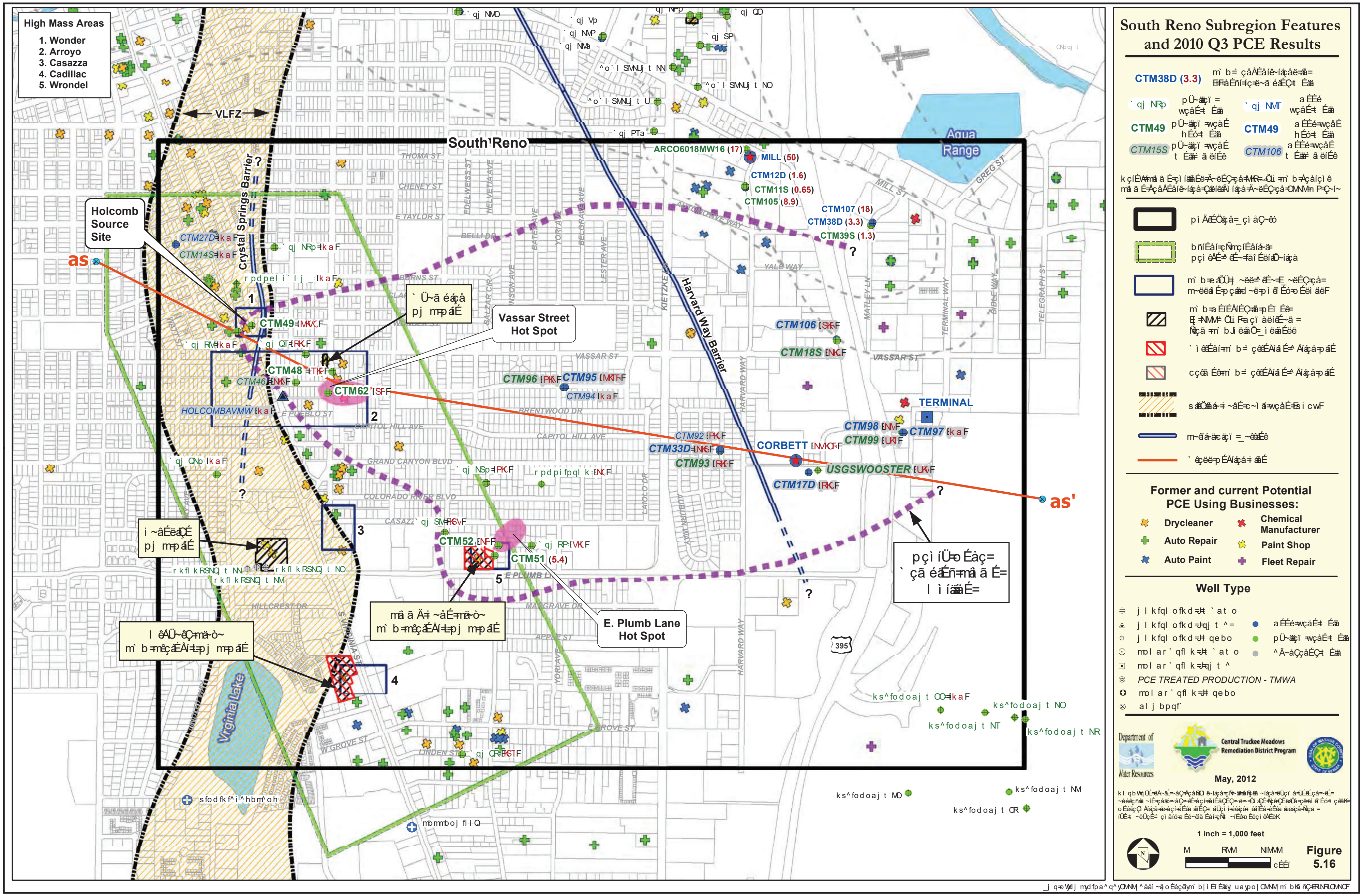
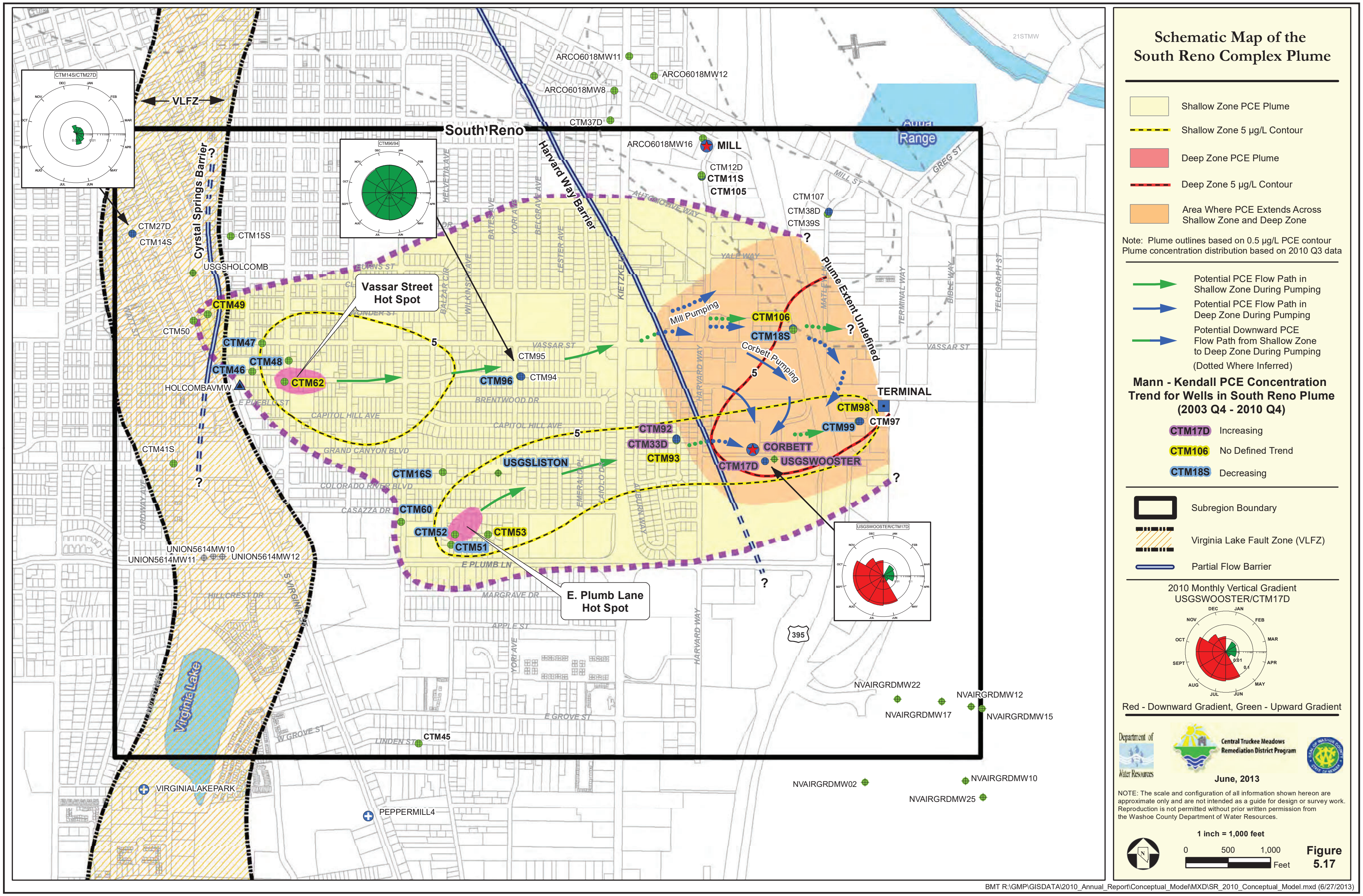
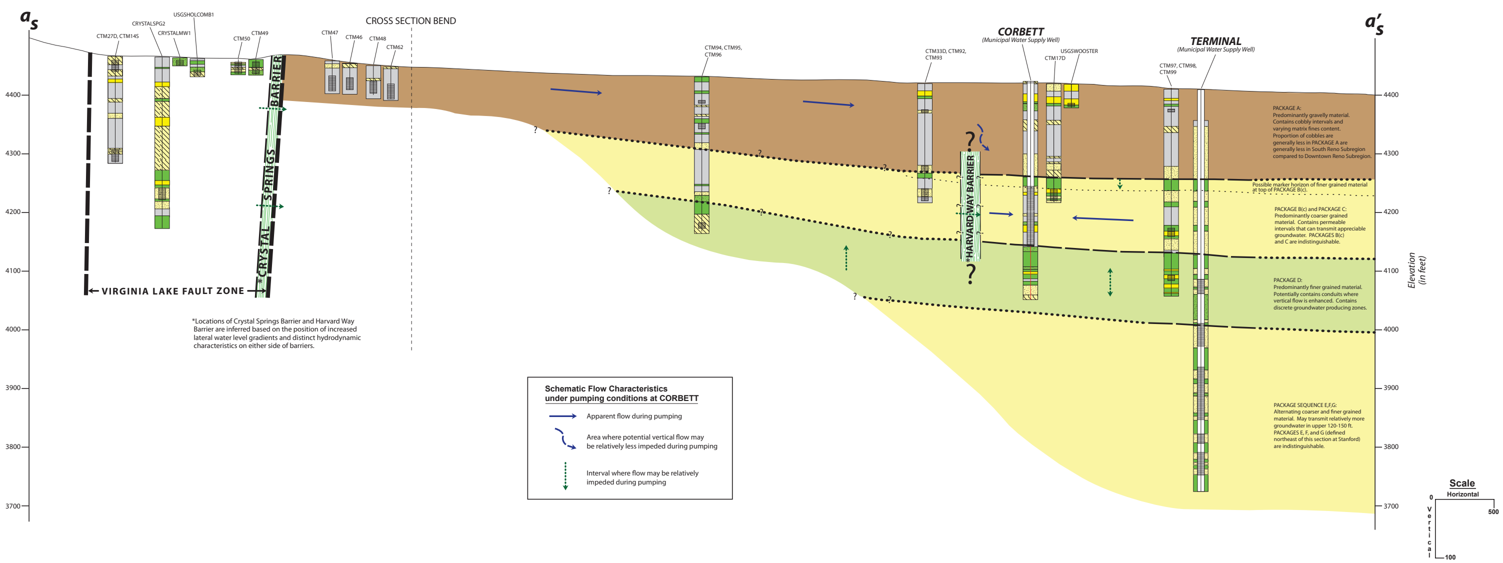


South Reno Subregion Features and 2010 Q3 PCE Results
High Mass Areas
1. Wonder
2. Arroyo
3. Casazza
4. Cadillac
5. Wrondel
VLFZ
South Reno
Holcomb Source Site
Crystal Springs Barrier
Harvard Way Barrier
Vassar Street Hot Spot
E. Plumb Lane Hot Spot
Agua Range
Virginia Lake
CTM38D (3.3)
CTM49
CTM15S
CTM106
CTM27D
CTM14S
CTM49
CTM48
CTM46
CTM62
HOLCOMBAVMW
CTM52
CTM51 (5.4)
CTM96
CTM95
CTM94
CTM106
CTM18S
CTM92
CTM33D
CTM93
CORBETT
USGSWOOSTER
CTM17D
CTM98
CTM99
CTM97
TERMINAL
ARCO6018MW16 (17)
MILL (50)
CTM12D (1.6)
CTM11S (0.65)
CTM105 (8.9)
CTM107 (18)
CTM38D (3.3)
CTM39S (1.3)
PCE TREATED PRODUCTION - TMWA
Former and current Potential PCE Using Businesses:
Drycleaner
Chemical Manufacturer
Auto Repair
Paint Shop
Auto Paint
Fleet Repair
Well Type
Central Truckee Meadows Remediation District Program
Department of Water Resources
May, 2012
1 inch = 1,000 feet
Figure 5.16

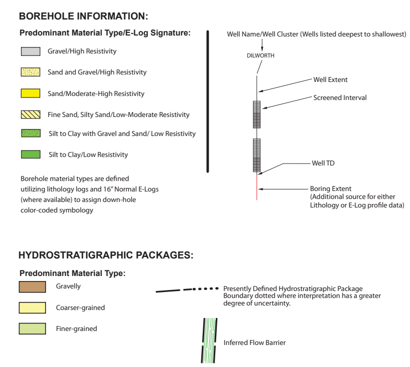

Schematic Map of the
South Reno Complex Plume
Shallow Zone PCE Plume
Shallow Zone 5 µg/L Contour
Deep Zone PCE Plume
Deep Zone 5 µg/L Contour
Area Where PCE Extends Across Shallow Zone and Deep Zone
Note: Plume outlines based on 0.5 µg/L PCE contour
Plume concentration distribution based on 2010 Q3 data
Potential PCE Flow Path in Shallow Zone During Pumping
Potential PCE Flow Path in Deep Zone During Pumping
Potential Downward PCE Flow Path from Shallow Zone to Deep Zone During Pumping
(Dotted Where Inferred)
Mann - Kendall PCE Concentration Trend for Wells in South Reno Plume (2003 Q4 - 2010 Q4)
CTM17D Increasing
CTM106 No Defined Trend
CTM18S Decreasing
Subregion Boundary
Virginia Lake Fault Zone (VLFZ)
Partial Flow Barrier
2010 Monthly Vertical Gradient
USGSWOOSTER/CTM17D
Red - Downward Gradient, Green - Upward Gradient
Department of Water Resources
Central Truckee Meadows Remediation District Program
June, 2013
NOTE: The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.
1 inch = 1,000 feet
0 500 1,000
Feet
Figure
5.17
South Reno
VLFZ
Cyrstal Springs Barrier
Harvard Way Barrier
Plume Extent Undefined
Vassar Street
Hot Spot
E. Plumb Lane
Hot Spot
MILL
TERMINAL
CORBETT
Mill Pumping
Corbett Pumping
Virginia Lake
ARCO6018MW11
ARCO6018MW12
ARCO6018MW8
CTM37D
ARCO6018MW16
CTM12D
CTM11S
CTM105
CTM107
CTM38D
CTM39S
CTM27D
CTM14S
CTM15S
USGSHOLCOMB
CTM49
CTM50
CTM47
CTM48
CTM46
HOLCOMBAVMW
CTM62
CTM95
CTM96
CTM94
CTM106
CTM18S
CTM98
CTM97
CTM99
CTM92
CTM33D
CTM93
CTM17D
USGSWOOSTER
CTM41S
CTM16S
USGSLISTON
CTM60
CTM52
CTM51
CTM53
UNION5614MW10
UNION5614MW11
UNION5614MW12
CTM45
VIRGINIALAKEPARK
PEPPERMILL4
NVAIRGRDMW22
NVAIRGRDMW12
NVAIRGRDMW17
NVAIRGRDMW15
NVAIRGRDMW02
NVAIRGRDMW10
NVAIRGRDMW25
Aqua Range
395
BMT R:\GMP\GISDATA\2010_Annual_Report\Conceptual_Model\MXD\SR_2010_Conceptual_Model.mxd (6/27/2013)



Central Truckee Meadows Remediation District Program

Department of Water Resources

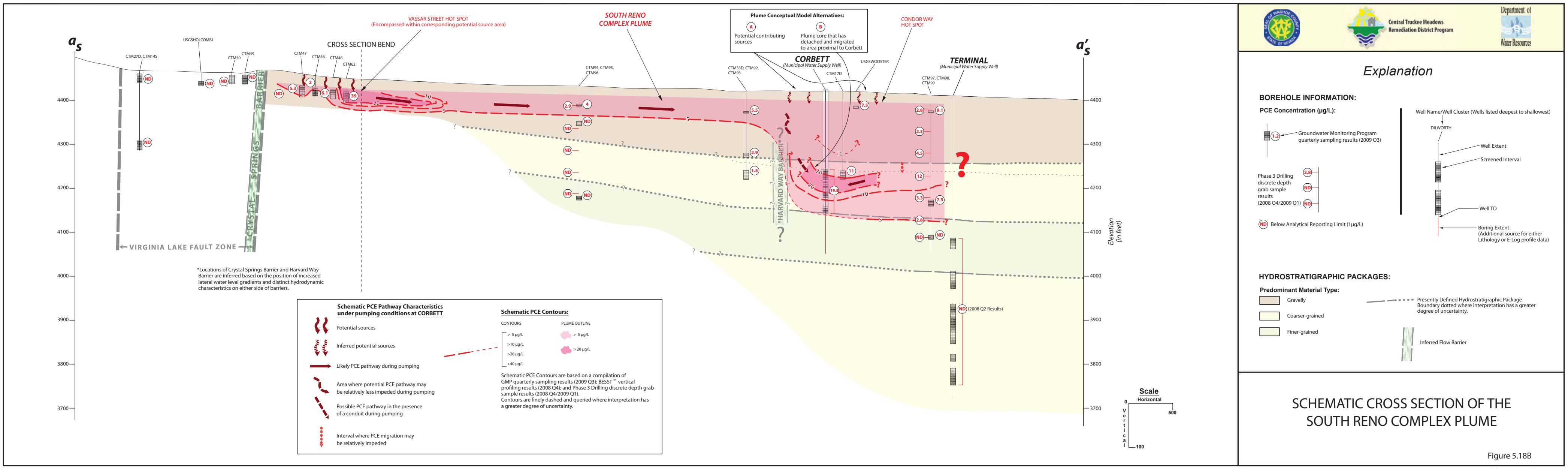
Explanation



SCHEMATIC CROSS SECTION OF THE HYDROSTRATIGRAPHIC CONCEPTUAL MODEL FOR THE SOUTH RENO SUBREGION

Figure 5.18A

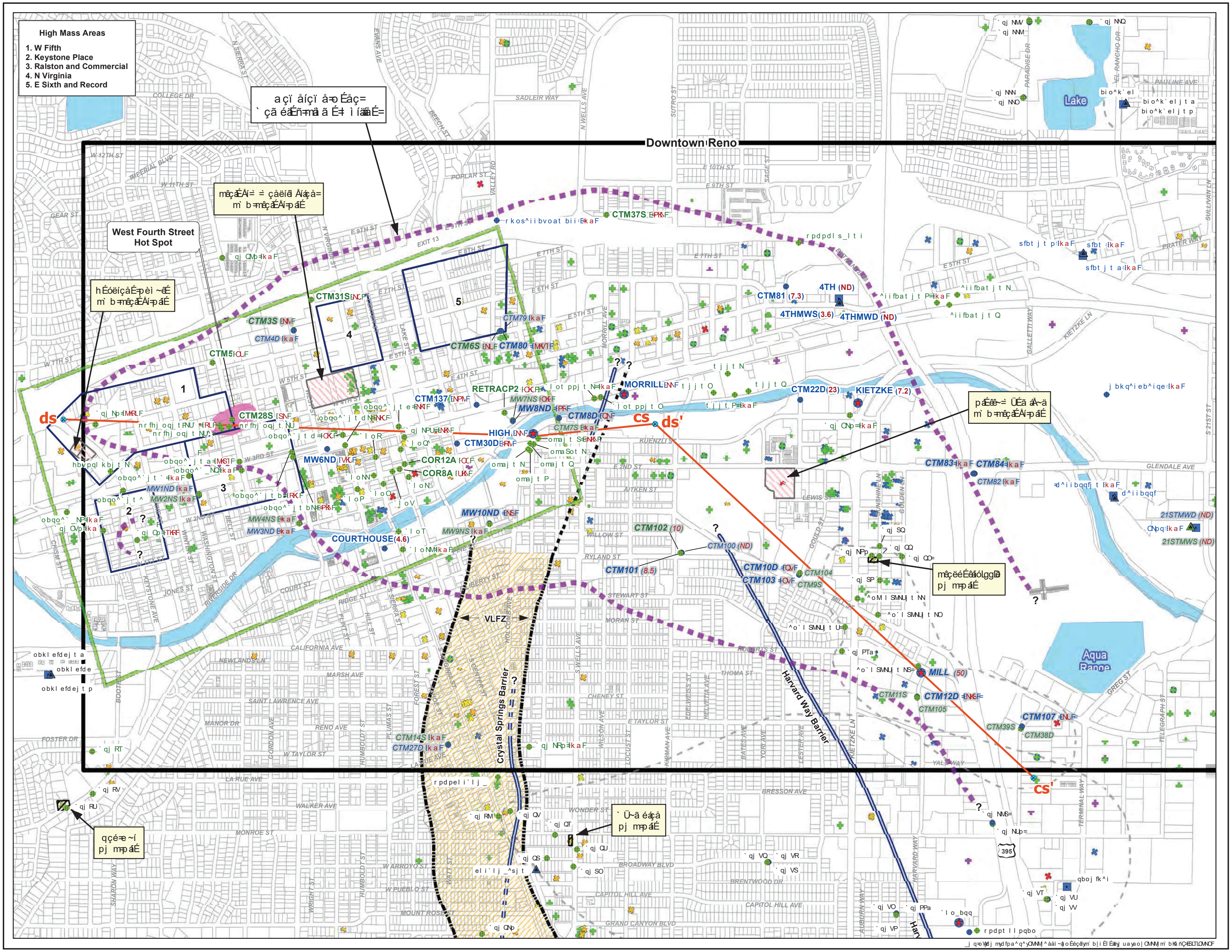
JH_R:\GMP\GISDATA\CROSS_SECTION\drafts_xsections\south_reno_2010.ai



SCHEMATIC CROSS SECTION OF THE SOUTH RENO COMPLEX PLUME

Figure 5.18B

JH_R:\GMP\GISDATA\CROSS_SECTION\drafts_xsections\south_reno_2010.ai



Downtown Reno Subregion Features and 2010 Q3 PCE Results

CTM38D (3.3)

CTM49

CTM15S

CTM49

CTM106

Former and current Potential PCE Using Businesses:

- Drycleaner
- Auto Repair
- Auto Paint
- Chemical Manufacturer
- Paint Shop
- Fleet Repair

Well Type

PCE TREATED PRODUCTION - TMWA

Central Truckee Meadows Remediation District Program

June, 2012

1 inch = 1,000 feet

Figure 5.19

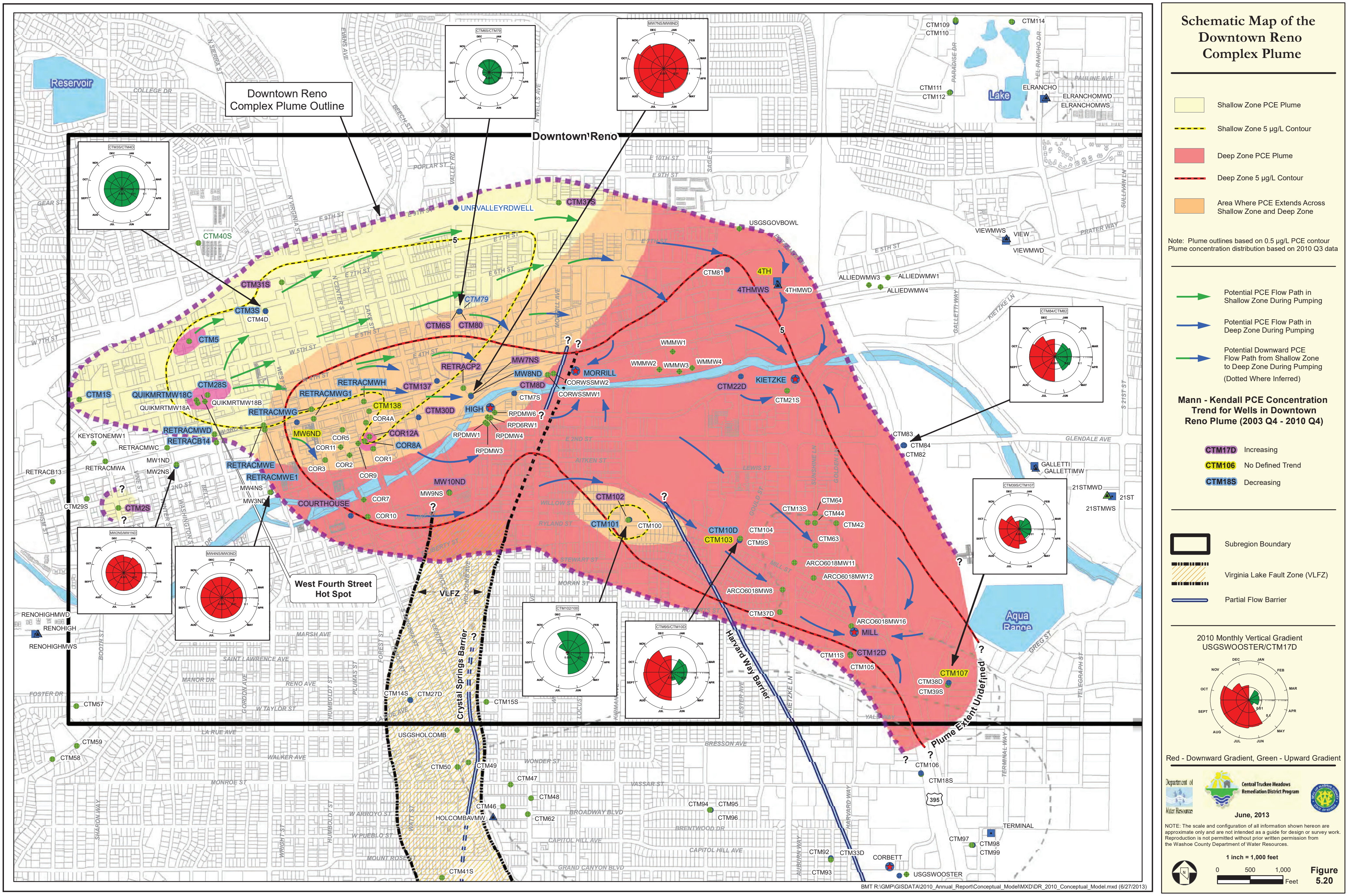
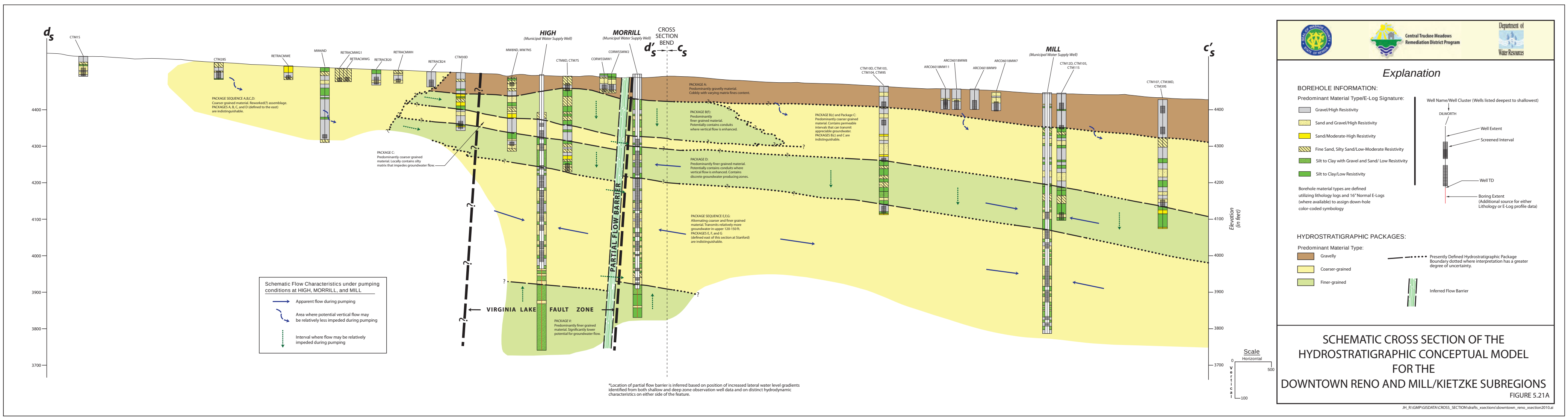
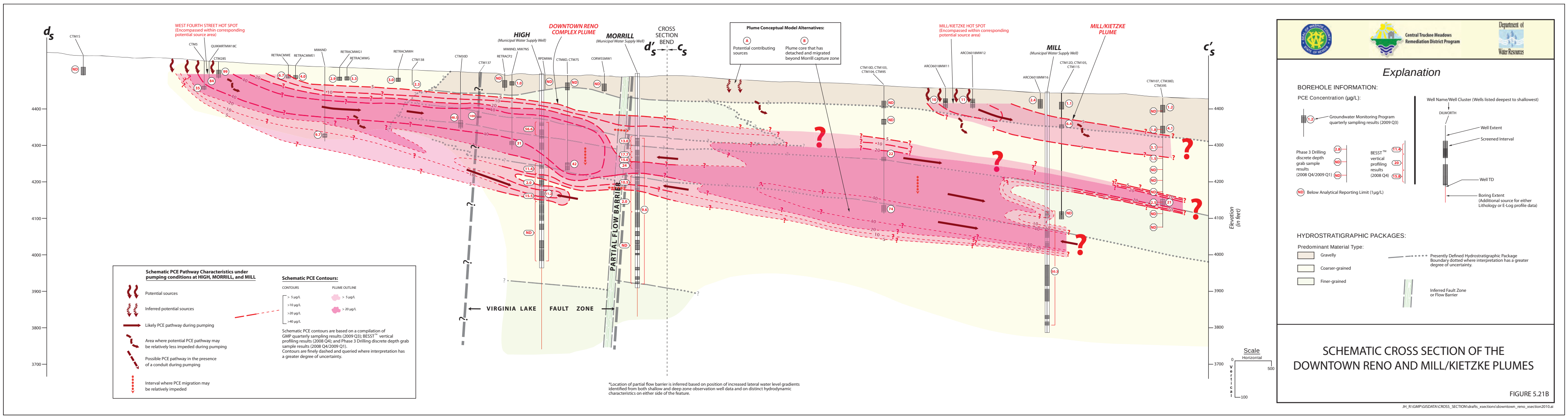

Schematic Map of the Downtown Reno Complex Plume
Shallow Zone PCE Plume
Shallow Zone 5 µg/L Contour
Deep Zone PCE Plume
Deep Zone 5 µg/L Contour
Area Where PCE Extends Across Shallow Zone and Deep Zone
Note: Plume outlines based on 0.5 µg/L PCE contour
Plume concentration distribution based on 2010 Q3 data
Potential PCE Flow Path in Shallow Zone During Pumping
Potential PCE Flow Path in Deep Zone During Pumping
Potential Downward PCE Flow Path from Shallow Zone to Deep Zone During Pumping
(Dotted Where Inferred)
Mann - Kendall PCE Concentration Trend for Wells in Downtown Reno Plume (2003 Q4 - 2010 Q4)
CTM17D Increasing
CTM106 No Defined Trend
CTM18S Decreasing
Subregion Boundary
Virginia Lake Fault Zone (VLFZ)
Partial Flow Barrier
2010 Monthly Vertical Gradient USGSWOOSTER/CTM17D
Red - Downward Gradient, Green - Upward Gradient
Department of Water Resources
Central Truckee Meadows Remediation District Program
June, 2013
NOTE: The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.
1 inch = 1,000 feet
0 500 1,000 Feet
Downtown Reno Complex Plume Outline
Downtown Reno
West Fourth Street Hot Spot
Reservoir
Lake
Aqua Range
VLFZ
Crystal Springs Barrier
Harvard Way Barrier
Plume Extent Undefined
BMT R:\GMP\GISDATA\2010_Annual_Report\Conceptual_Model\MXD\DR_2010_Conceptual_Model.mxd (6/27/2013)

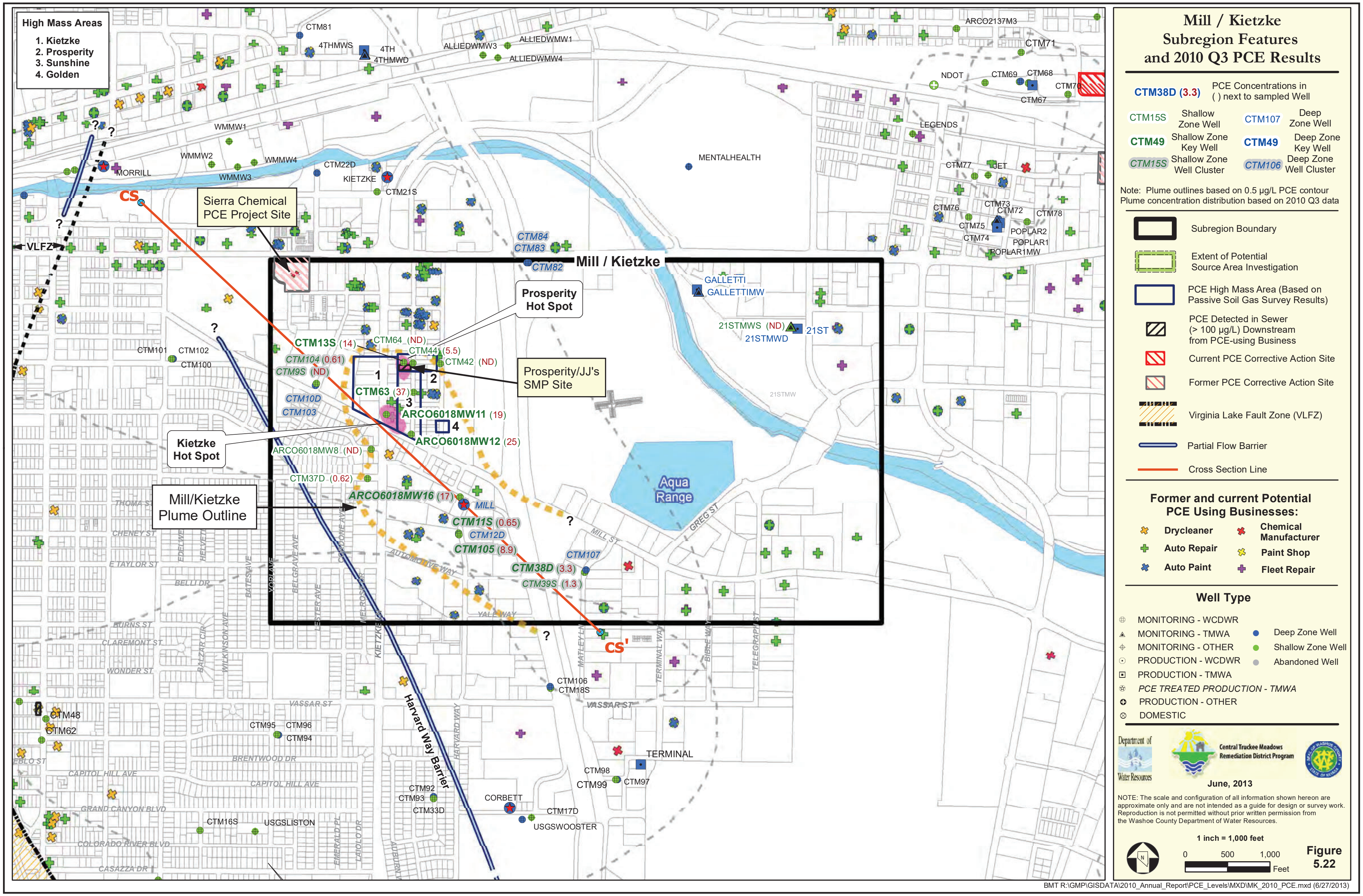
Figure 5.20



SCHEMATIC CROSS SECTION OF THE HYDROSTRATIGRAPHIC CONCEPTUAL MODEL FOR THE DOWNTOWN RENO AND MILL/KIETZKE SUBREGIONS

FIGURE 5.21A


WEST FOURTH STREET HOT SPOT (Encompassed within corresponding potential source area)
HIGH (Municipal Water Supply Well)
DOWNTOWN RENO COMPLEX PLUME
MORRILL (Municipal Water Supply Well)
CROSS SECTION BEND
Plume Conceptual Model Alternatives:
A Potential contributing sources
B Plume core that has detached and migrated beyond Morrill capture zone
MILL/KIETZKE HOT SPOT (Encompassed within corresponding potential source area)
MILL (Municipal Water Supply Well)
MILL/KIETZKE PLUME
PARTIAL FLOW BARRIER
VIRGINIA LAKE FAULT ZONE
Elevation (in feet)
Schematic PCE Pathway Characteristics under pumping conditions at HIGH, MORRILL, and MILL
Potential sources
Inferred potential sources
Likely PCE pathway during pumping
Area where potential PCE pathway may be relatively less impeded during pumping
Possible PCE pathway in the presence of a conduit during pumping
Interval where PCE migration may be relatively impeded
Schematic PCE Contours:
CONTOURS
> 5 µg/L
>10 µg/L
>20 µg/L
>40 µg/L
PLUME OUTLINE
> 5 µg/L
> 20 µg/L
Schematic PCE contours are based on a compilation of GMP quarterly sampling results (2009 Q3); BESST™ vertical profiling results (2008 Q4); and Phase 3 Drilling discrete depth grab sample results (2008 Q4/2009 Q1).
Contours are finely dashed and queried where interpretation has a greater degree of uncertainty.
*Location of partial flow barrier is inferred based on position of increased lateral water level gradients identified from both shallow and deep zone observation well data and on distinct hydrodynamic characteristics on either side of the feature.
Scale
Horizontal
500
Vertical
100
Central Truckee Meadows Remediation District Program
Department of Water Resources
Explanation
BOREHOLE INFORMATION:
PCE Concentration (µg/L):
Groundwater Monitoring Program quarterly sampling results (2009 Q3)
Phase 3 Drilling discrete depth grab sample results (2008 Q4/2009 Q1)
BESST™ vertical profiling results (2008 Q4)
ND Below Analytical Reporting Limit (1µg/L)
Well Name/Well Cluster (Wells listed deepest to shallowest)
DILWORTH
Well Extent
Screened Interval
Well TD
Boring Extent (Additional source for either Lithology or E-Log profile data)
HYDROSTRATIGRAPHIC PACKAGES:
Predominant Material Type:
Gravelly
Coarser-grained
Finer-grained
Presently Defined Hydrostratigraphic Package Boundary dotted where interpretation has a greater degree of uncertainty.
Inferred Fault Zone or Flow Barrier
SCHEMATIC CROSS SECTION OF THE DOWNTOWN RENO AND MILL/KIETZKE PLUMES
FIGURE 5.21B
JH_R:\GMP\GISDATA\CROSS_SECTION\drafts_xsections\downtown_reno_xsection2010.ai


Mill / Kietzke Subregion Features and 2010 Q3 PCE Results
CTM38D (3.3) PCE Concentrations in ( ) next to sampled Well
CTM15S Shallow Zone Well
CTM107 Deep Zone Well
CTM49 Shallow Zone Key Well
CTM49 Deep Zone Key Well
CTM15S Shallow Zone Well Cluster
CTM106 Deep Zone Well Cluster
Note: Plume outlines based on 0.5 µg/L PCE contour
Plume concentration distribution based on 2010 Q3 data
Subregion Boundary
Extent of Potential Source Area Investigation
PCE High Mass Area (Based on Passive Soil Gas Survey Results)
PCE Detected in Sewer (> 100 µg/L) Downstream from PCE-using Business
Current PCE Corrective Action Site
Former PCE Corrective Action Site
Virginia Lake Fault Zone (VLFZ)
Partial Flow Barrier
Cross Section Line
Former and current Potential PCE Using Businesses:
Drycleaner
Chemical Manufacturer
Auto Repair
Paint Shop
Auto Paint
Fleet Repair
Well Type
MONITORING - WCDWR
MONITORING - TMWA
MONITORING - OTHER
PRODUCTION - WCDWR
PRODUCTION - TMWA
PCE TREATED PRODUCTION - TMWA
PRODUCTION - OTHER
DOMESTIC
Deep Zone Well
Shallow Zone Well
Abandoned Well
Department of Water Resources
Central Truckee Meadows Remediation District Program
June, 2013
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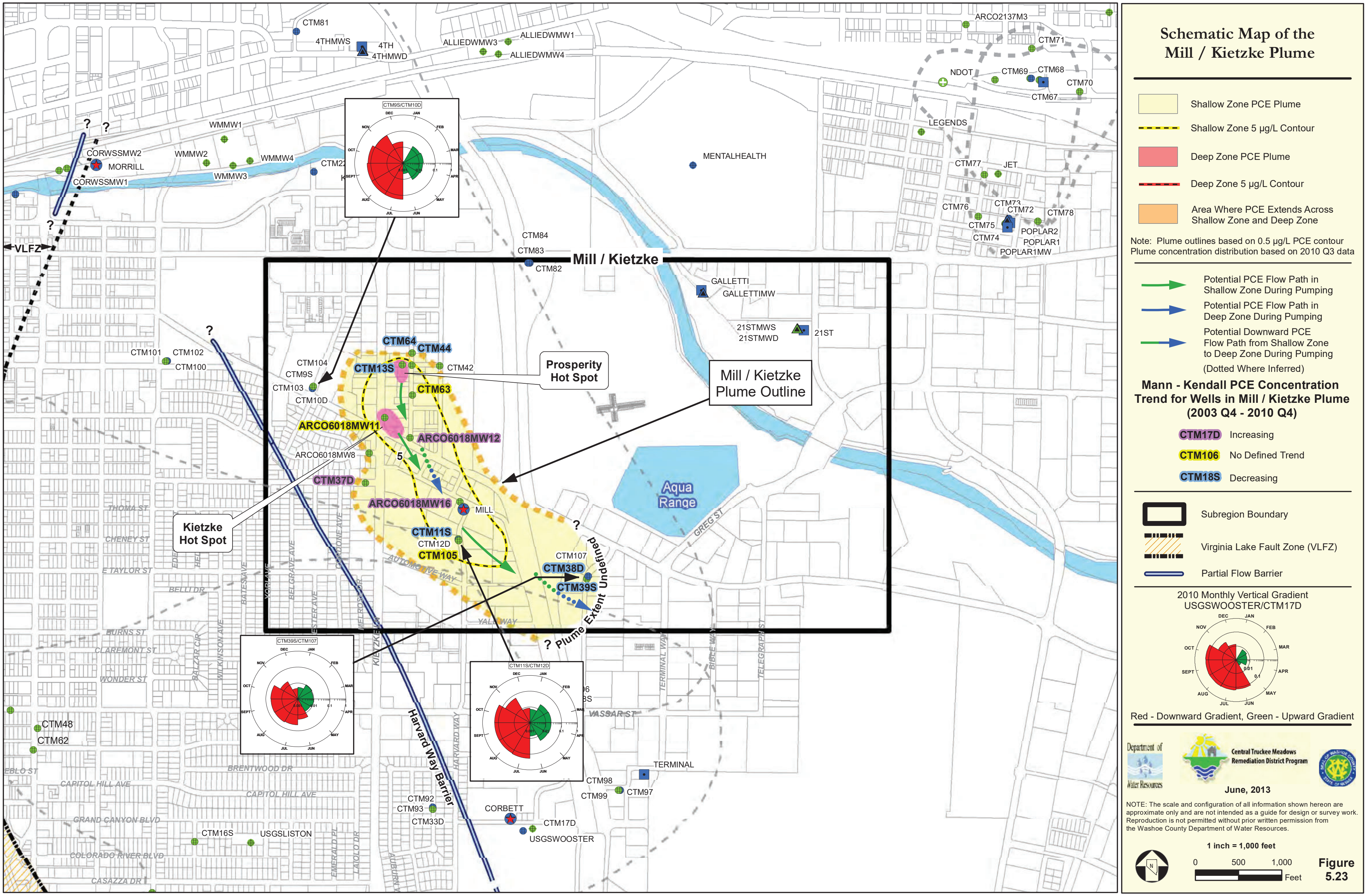
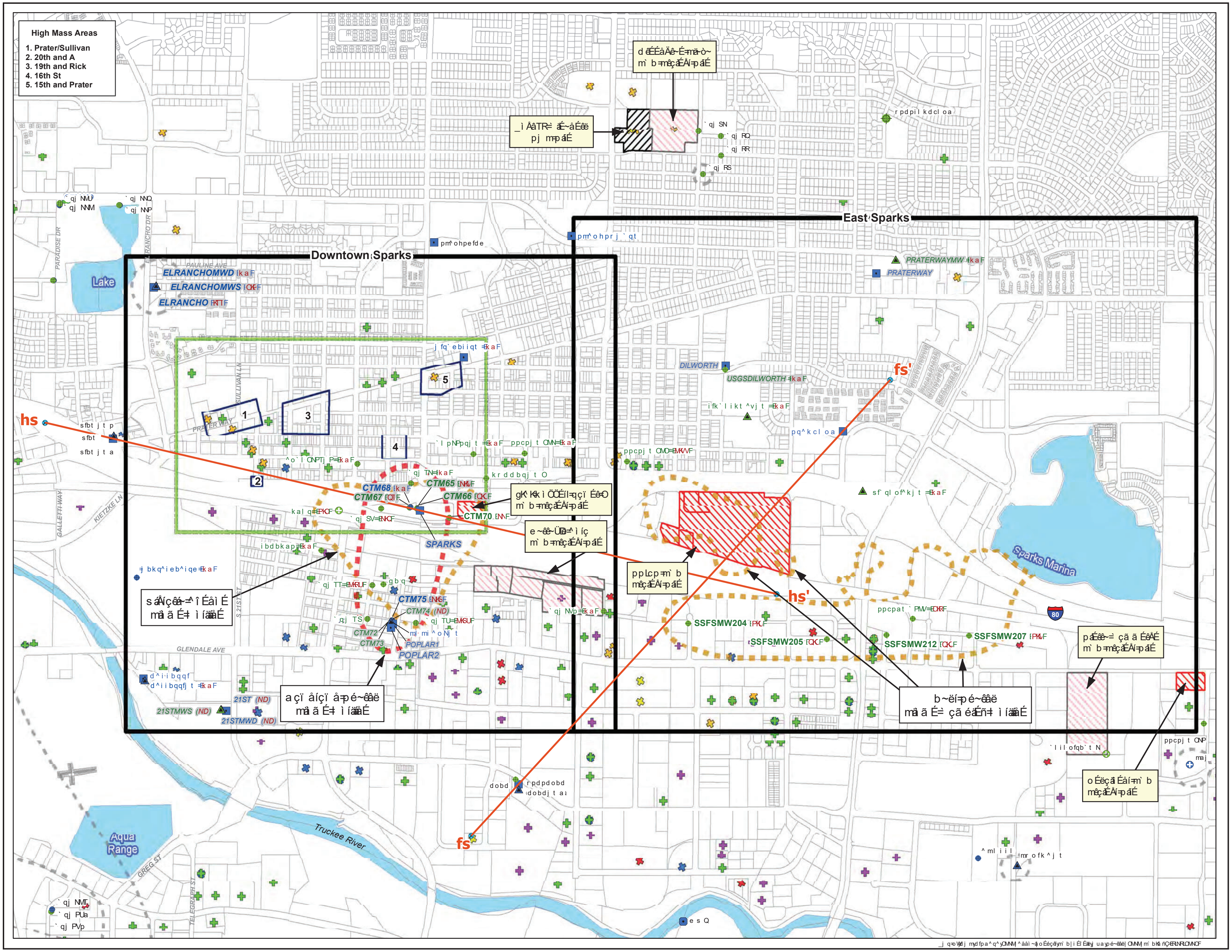
1 inch = 1,000 feet
0 500 1,000 Feet
Figure 5.22
High Mass Areas
1. Kietzke
2. Prosperity
3. Sunshine
4. Golden
Mill / Kietzke
Sierra Chemical PCE Project Site
Prosperity Hot Spot
Prosperity/JJ's SMP Site
Kietzke Hot Spot
Mill/Kietzke Plume Outline
Aqua Range
Harvard Way Barrier
VLFZ
CS
CS'
CTM13S (14)
CTM64 (ND)
CTM44 (5.5)
CTM42 (ND)
CTM104 (0.61)
CTM9S (ND)
CTM63 (37)
CTM10D
CTM103
ARCO6018MW11 (19)
ARCO6018MW12 (25)
ARCO6018MW8 (ND)
CTM37D (0.62)
ARCO6018MW16 (17)
MILL
CTM11S (0.65)
CTM12D
CTM105 (8.9)
CTM107
CTM38D (3.3)
CTM39S (1.3)
21STMWS (ND)
21STMWD
21ST
GALLETTI
GALLETTIMW
CTM84
CTM83
CTM82
MENTALHEALTH
KIETZKE
CTM21S
CTM22D
MORRILL
WMMW1
WMMW2
WMMW3
WMMW4
CTM81
4THMWS
4TH
4THMWD
ALLIEDWMW3
ALLIEDWMW1
ALLIEDWMW4
ARCO2137M3
CTM71
NDOT
CTM69
CTM68
CTM70
CTM67
LEGENDS
CTM77
JET
CTM76
CTM73
CTM72
CTM78
CTM75
CTM74
POPLAR2
POPLAR1
POPLAR1MW
CTM101
CTM102
CTM100
CTM106
CTM18S
CTM48
CTM62
CTM95
CTM96
CTM94
TERMINAL
CTM98
CTM99
CTM97
CTM92
CTM93
CTM33D
CORBETT
CTM17D
USGSWOOSTER
CTM16S
USGSLISTON
MILL ST
GREG ST
VASSAR ST
YALE WAY
AUTOMOTIVE WAY
HARVARD WAY
TERMINAL WAY
BIBLE WAY
TELEGRAPH ST
MATLEY LN
KIETZKE LN
MELROSE DR
BRENTWOOD DR
CAPITOL HILL AVE
GRAND CANYON BLVD
COLORADO RIVER BLVD
CASAZZA DR
WONDER ST
CLAREMONT ST
BURNS ST
BELLI DR
E TAYLOR ST
CHENEY ST
THOMA ST
BMT R:\GMP\GISDATA\2010_Annual_Report\PCE_Levels\MXD\MK_2010_PCE.mxd (6/27/2013)



BMT R:\GMP\GISDATA\2010_Annual_Report\Conceptual_Model\MXD\MK_2010_Conceptual_Model.mxd (6/27/2013)



Downtown & East Sparks Subregion Features and 2010 Q3 PCE Results

CTM38D (3.3)

CTM49

CTM15S

CTM49

CTM106

Former and current Potential PCE Using Businesses:

- Drycleaner
- Auto Repair
- Auto Paint
- Chemical Manufacturer
- Paint Shop
- Fleet Repair

Well Type

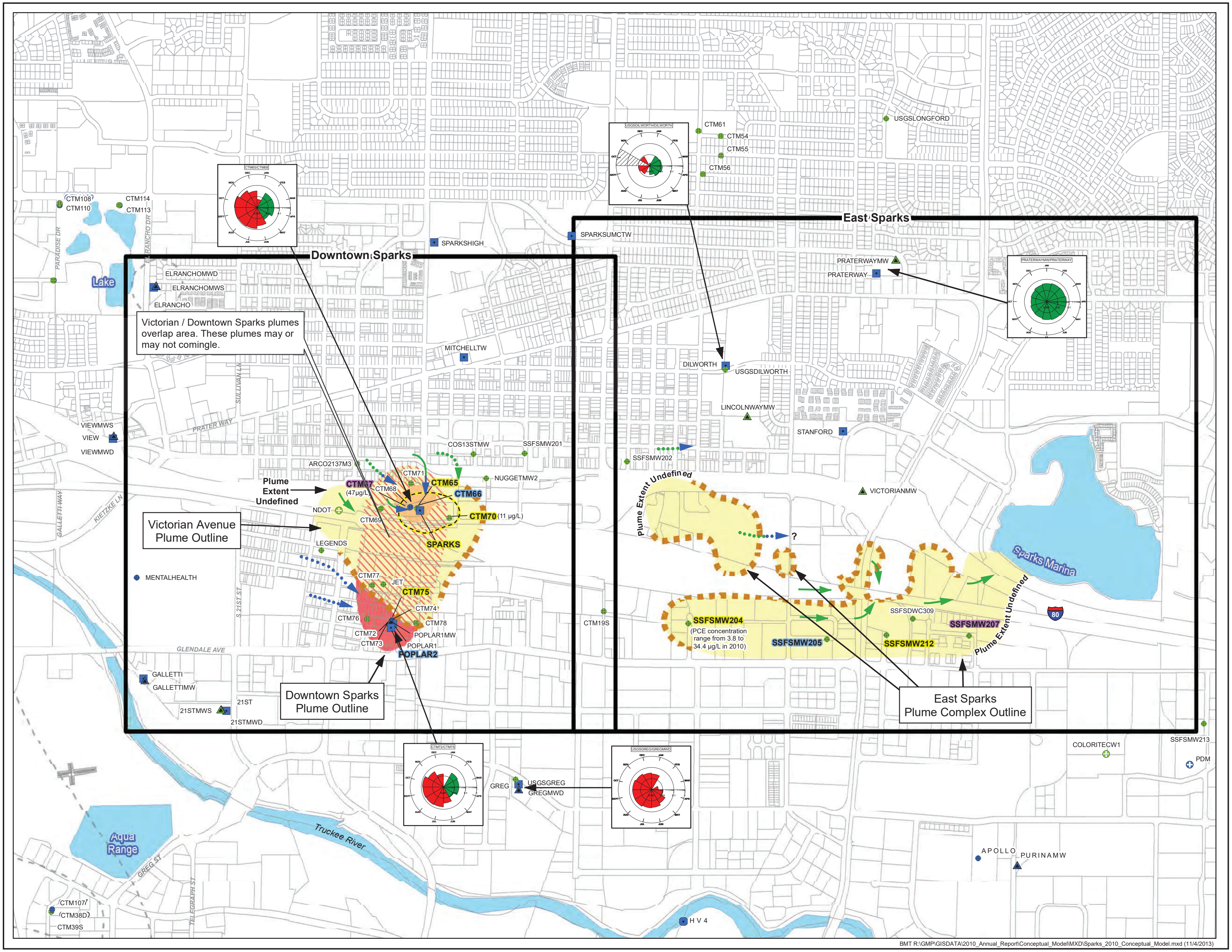
- PCE TREATED PRODUCTION - TMWA

Central Truckee Meadows Remediation District Program

May, 2012

1 inch = 1,000 feet

Figure 5.24



Schematic Map of the Victorian Avenue and Downtown Sparks Plume and East Sparks Plume Complex

- Shallow Zone PCE Plume
- Shallow Zone 5 µg/L Contour
- Deep Zone PCE Plume
- Deep Zone 5 µg/L Contour
- Area Where PCE Extends Across Shallow Zone and Deep Zone

Note: Plume outlines based on 0.5 µg/L PCE contour. Plume concentration distribution based on 2010 Q3 data

- Potential PCE Flow Path in Shallow Zone During Pumping
- Potential PCE Flow Path in Deep Zone During Pumping
- Potential Downward PCE Flow Path from Shallow Zone to Deep Zone During Pumping (Dotted Where Inferred)

Mann - Kendall PCE Concentration Trend for Wells in Victorian Avenue and Downtown Sparks Plume and the East Sparks Plume Complex (2003 Q4 - 2010 Q4)

- CTM17D Increasing
- CTM106 No Defined Trend
- CTM18S Decreasing

- Subregion Boundary
- Virginia Lake Fault Zone (VLFZ)
- Partial Flow Barrier

2010 Monthly Vertical Gradient USGSWOOSTER/CTM17D

Red - Downward Gradient, Green - Upward Gradient

Department of Water Resources

Central Truckee Meadows Remediation District Program

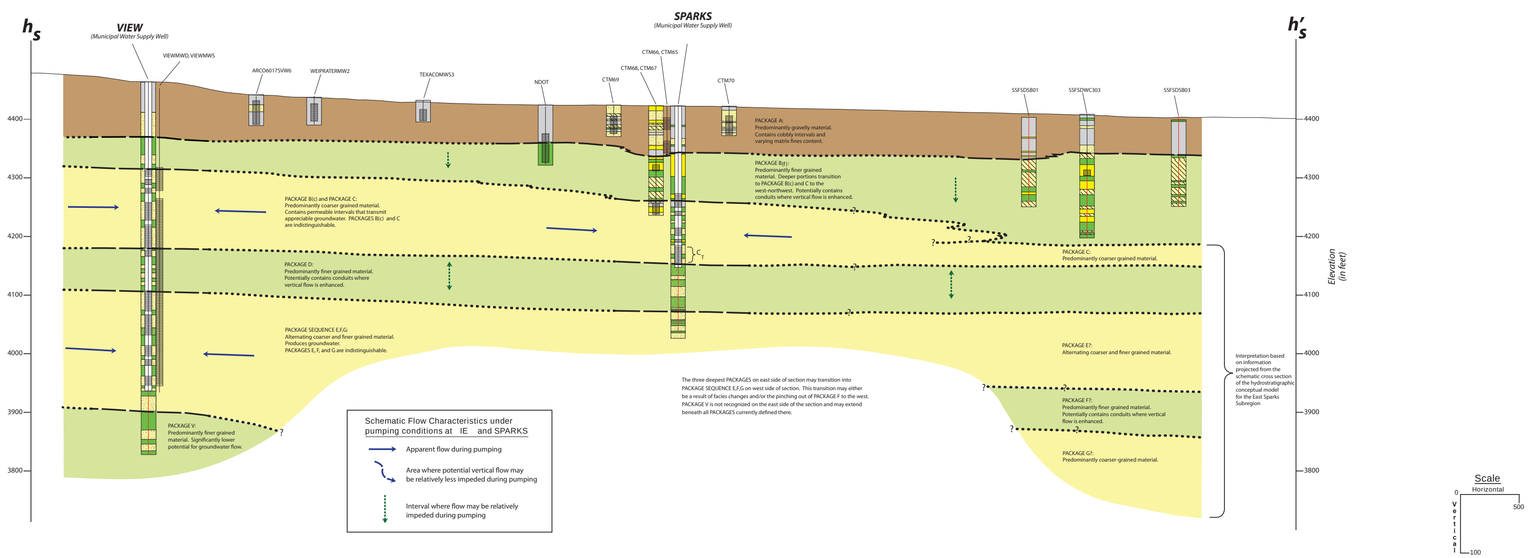
November, 2013

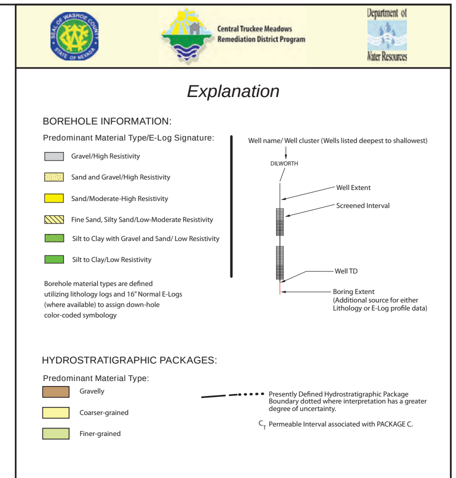
NOTE: The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.

1 inch = 1,000 feet

0 500 1,000 Feet

Figure 5.25

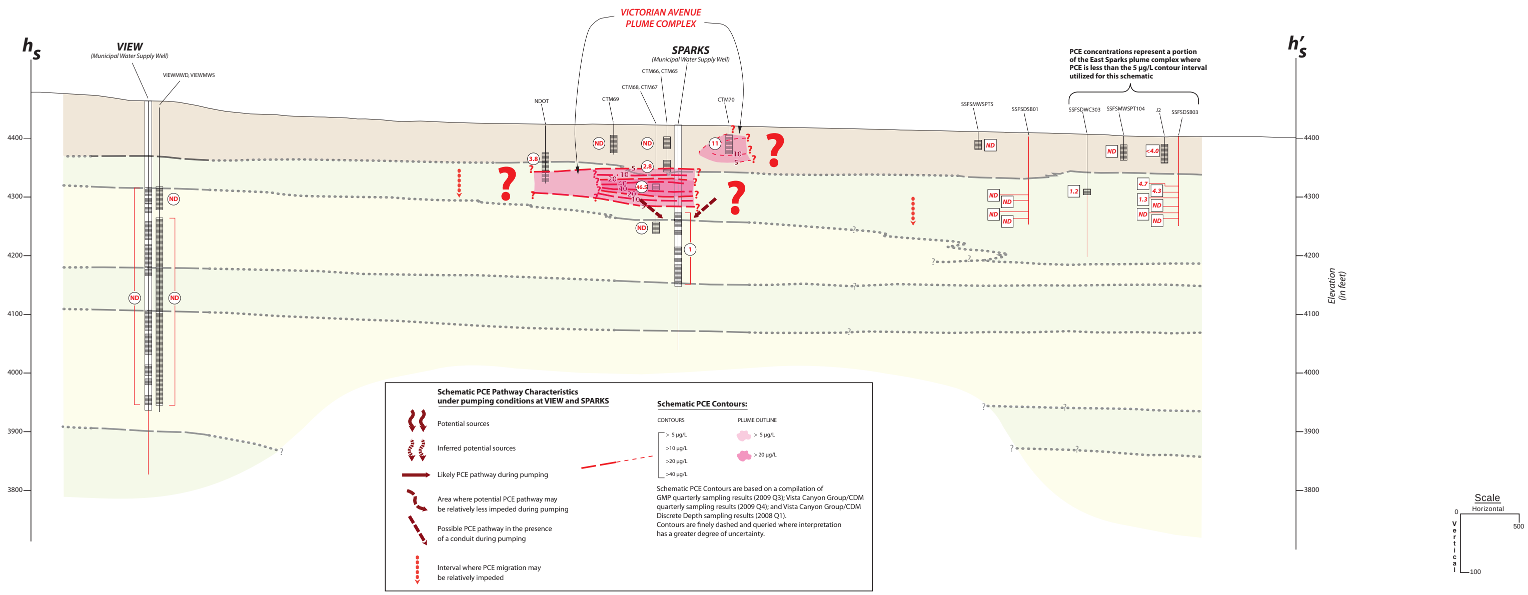




SCHEMATIC CROSS SECTION OF THE HYDROSTRATIGRAPHIC CONCEPTUAL MODEL FOR THE DOWNTOWN SPARKS SUBREGION

FIGURE 5.26A

JH_R:\GMP\GISDATA\CROSS_SECTION\downtown_sparks.ai



Central Truckee Meadows Remediation District Program

Department of Water Resources

Explanation

BOREHOLE INFORMATION:

PCE Concentration (µg/L):

- 1.2 — Groundwater Monitoring Program quarterly sampling results (2009 Q3)
- ND — Vista Canyon Group/CDM quarterly sampling results (2009 Q4)
- 4.7 / ND / 2.1 — Vista Canyon Group/CDM results from discrete depth sampling results (2008 Q1)
- ND — Below Analytical Reporting Limit (1µg/L)

Well name/ Well cluster (Wells listed deepest to shallowest)

DILWORTH

- Well Extent
- Screened Interval
- Well TD
- Boring Extent (Additional source for either Lithology or E-Log profile data)

HYDROSTRATIGRAPHIC PACKAGES:

Predominant Material Type:

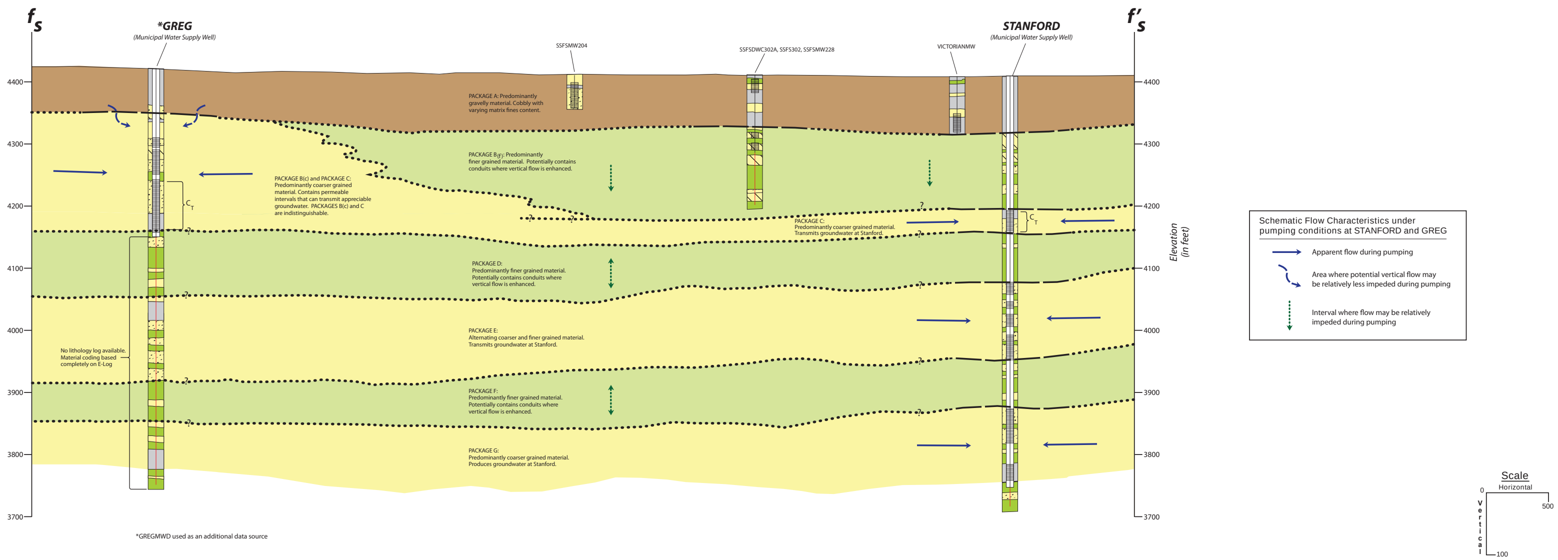
- Gravelly
- Coarser-grained
- Finer-grained

Presently Defined Hydrostratigraphic Package Boundary dotted where interpretation has a greater degree of uncertainty.

SCHEMATIC CROSS SECTION OF THE VICTORIAN AVENUE PLUME COMPLEX

FIGURE 5.26B

JH_R:\GMP\GISDATA\CROSS_SECTION\downtown_sparks.ai



Central Truckee Meadows Remediation District Program

Department of Water Resources

Explanation

BOREHOLE INFORMATION:

Predominant Material Type/E-Log Signature:

- Gravel/High Resistivity
- Sand and Gravel/High Resistivity
- Sand/Moderate-High Resistivity
- Fine Sand, Silty Sand/Low-Moderate Resistivity
- Silt to Clay/Low Resistivity

Borehole material types are defined utilizing lithology logs and 16" Normal E-Logs (where available) to assign down-hole color-coded symbology

Well name/ Well cluster (Wells listed deepest to shallowest)

DILWORTH

Well Extent

Screened Interval

Well TD

Boring Extent (Additional source for either Lithology or E-Log profile data)

HYDROSTRATIGRAPHIC PACKAGES:

Predominant Material Type:

- Gravelly
- Coarser-grained
- Finer-grained

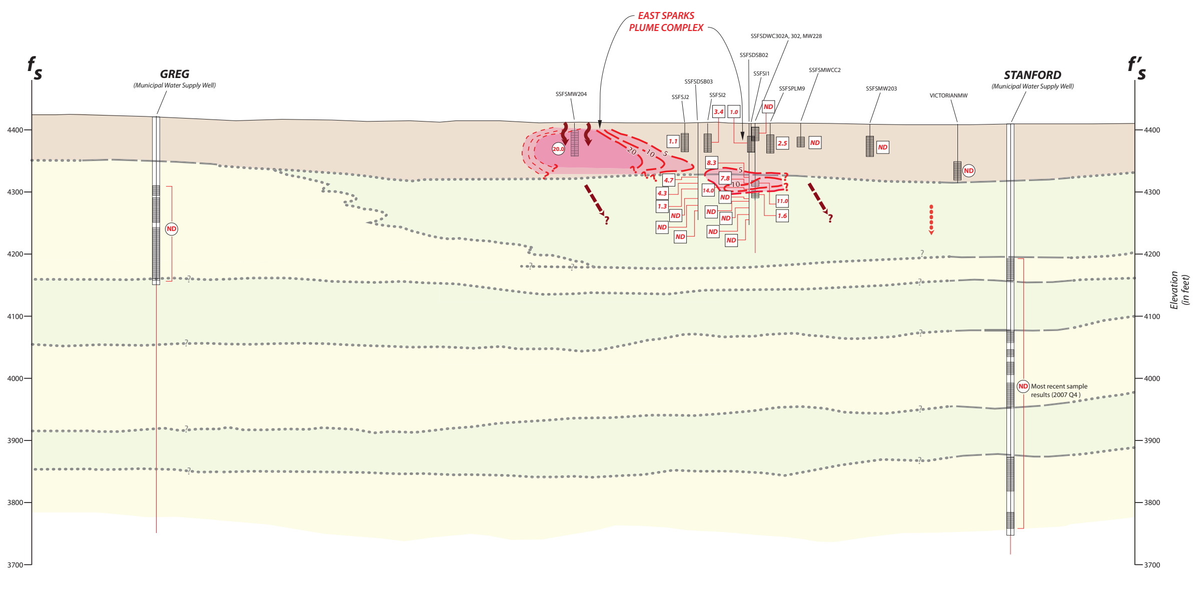
Presently Defined Hydrostratigraphic Package Boundary dotted where interpretation has a greater degree of uncertainty.

C_T Permeable Interval associated with PACKAGE C.

SCHEMATIC OF THE HYDROSTRATIGRAPHIC CONCEPTUAL MODEL FOR THE EAST SPARKS SUBREGION

FIGURE 5.27A

JH_R:\GMP\GISDATA\CROSS_SECTION\R:\GMP\GISDATA\CROSS_SECTION\drafts_xsections\eastsparks_xsection.ai



Schematic PCE Pathway Characteristics under pumping conditions at STANFORD and GREG

- Potential sources
- Inferred potential sources
- Likely PCE pathway during pumping
- Area where potential PCE pathway may be relatively less impeded during pumping
- Possible PCE pathway in the presence of a conduit during pumping
- Interval where PCE migration may be relatively impeded

Current PCE pathway likely to be from west to east (into the section) and controlled by the prevailing groundwater gradient.

Schematic PCE Contours:

CONTOURS
- > 5 µg/L
- >10 µg/L
- >20 µg/L
- >40 µg/L

PLUME OUTLINE
- > 5 µg/L
- > 20 µg/L

Schematic PCE Contours are based on a compilation of GMP quarterly sampling results (2010 Q4); Vista Canyon Group/CDM quarterly sampling results (2010 Q4); and Vista Canyon Group/CDM Discrete Depth sampling results (2008 Q1).
Contours are finely dashed and queried where interpretation has a greater degree of uncertainty.

Scale
Horizontal 0 — 500
Vertical 0 — 100

Central Truckee Meadows Remediation District Program

Department of Water Resources

Explanation

BOREHOLE INFORMATION:

PCE Concentration (µg/L):

- (1.2) Groundwater Monitoring Program quarterly sampling results (2009 Q3)
- ND Vista Canyon Group/CDM quarterly sampling results (2009 Q4)
- 4.7 / ND / 2.1 Vista Canyon Group/CDM results from discrete depth sampling results (2008 Q1)
- (ND) Below Analytical Reporting Limit (1µg/L)

Well name/ Well cluster (Wells listed deepest to shallowest)
DILWORTH
- Well Extent
- Screened Interval
- Well TD
- Boring Extent (Additional source for either Lithology or E-Log profile data)

HYDROSTRATIGRAPHIC PACKAGES:

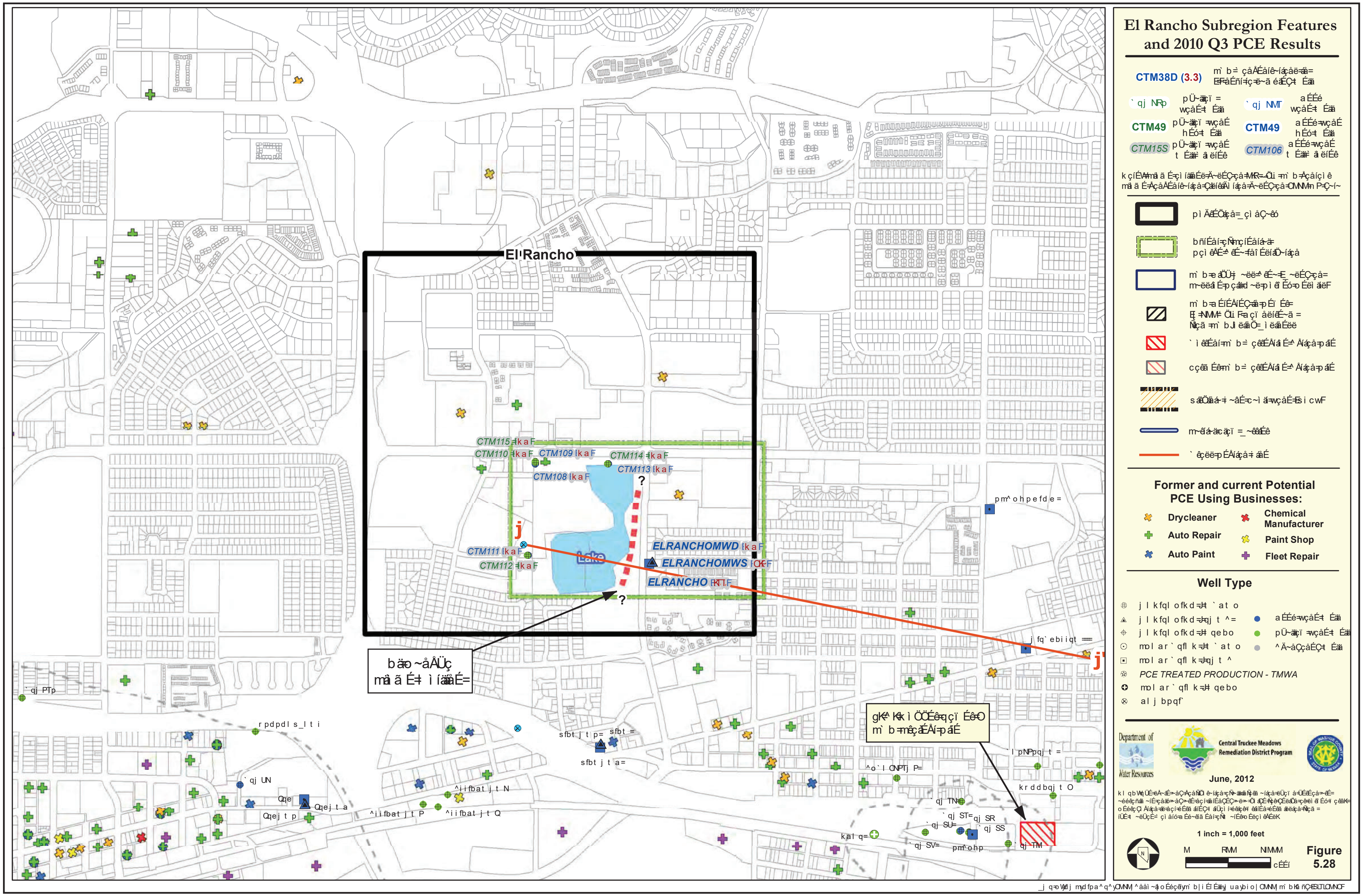
Predominant Material Type:
- Gravelly
- Coarser-grained
- Finer-grained

Presently Defined Hydrostratigraphic Package Boundary dotted where interpretation has a greater degree of uncertainty.

C_T Transmissive Interval associated with PACKAGE C.

SCHEMATIC CROSS SECTION OF THE EAST SPARKS PLUME COMPLEX

FIGURE 5.27B


El Rancho Subregion Features and 2010 Q3 PCE Results
CTM38D (3.3)
CTM49
CTM15S
CTM106
Former and current Potential PCE Using Businesses:
Drycleaner
Auto Repair
Auto Paint
Chemical Manufacturer
Paint Shop
Fleet Repair
Well Type
PCE TREATED PRODUCTION - TMWA
Central Truckee Meadows Remediation District Program
June, 2012
1 inch = 1,000 feet
Figure 5.28
El Rancho
Lake
CTM115
CTM110
CTM109
CTM114
CTM113
CTM108
CTM111
CTM112
ELRANCHOMWD
ELRANCHOMWS
ELRANCHO

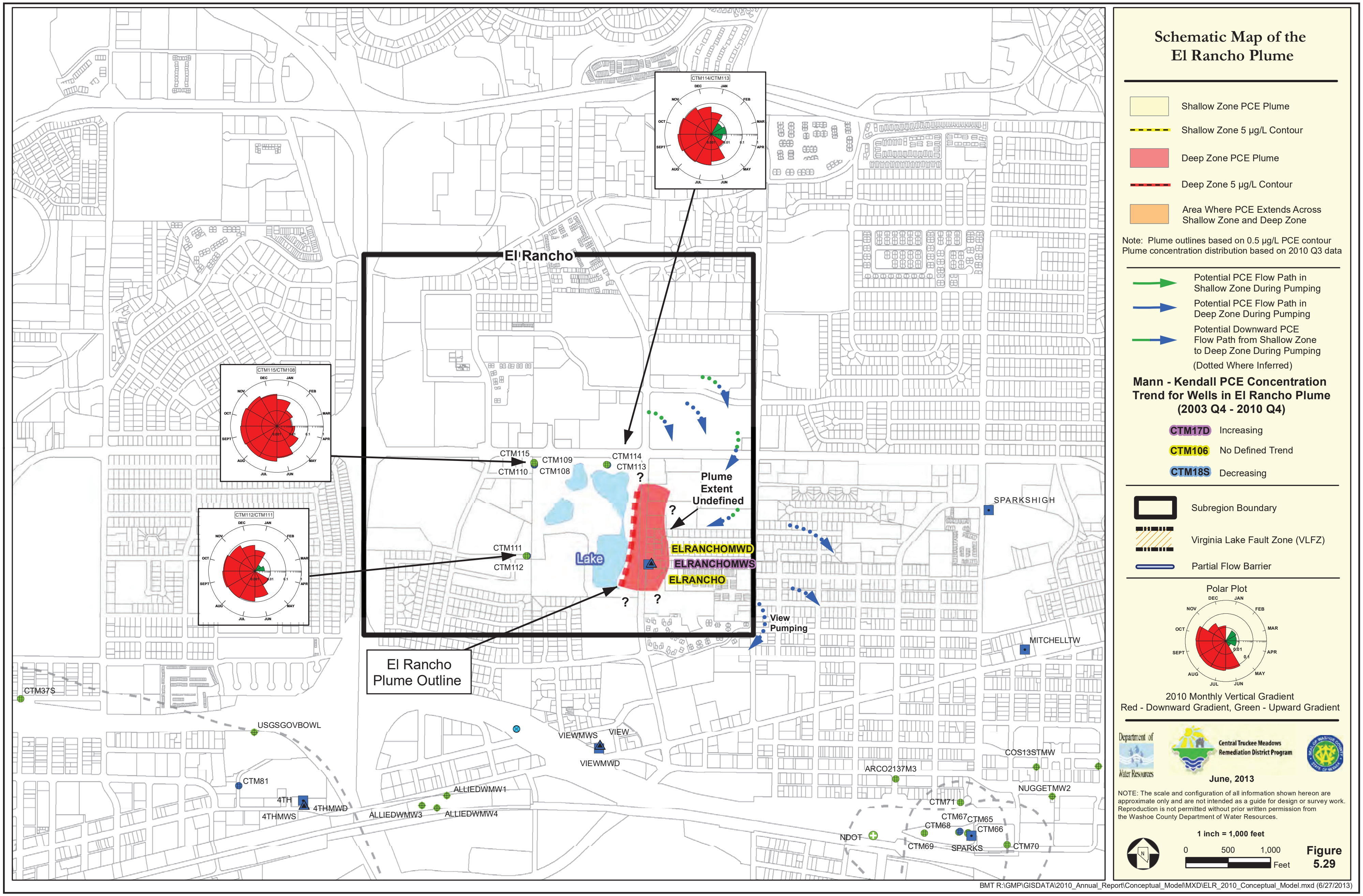
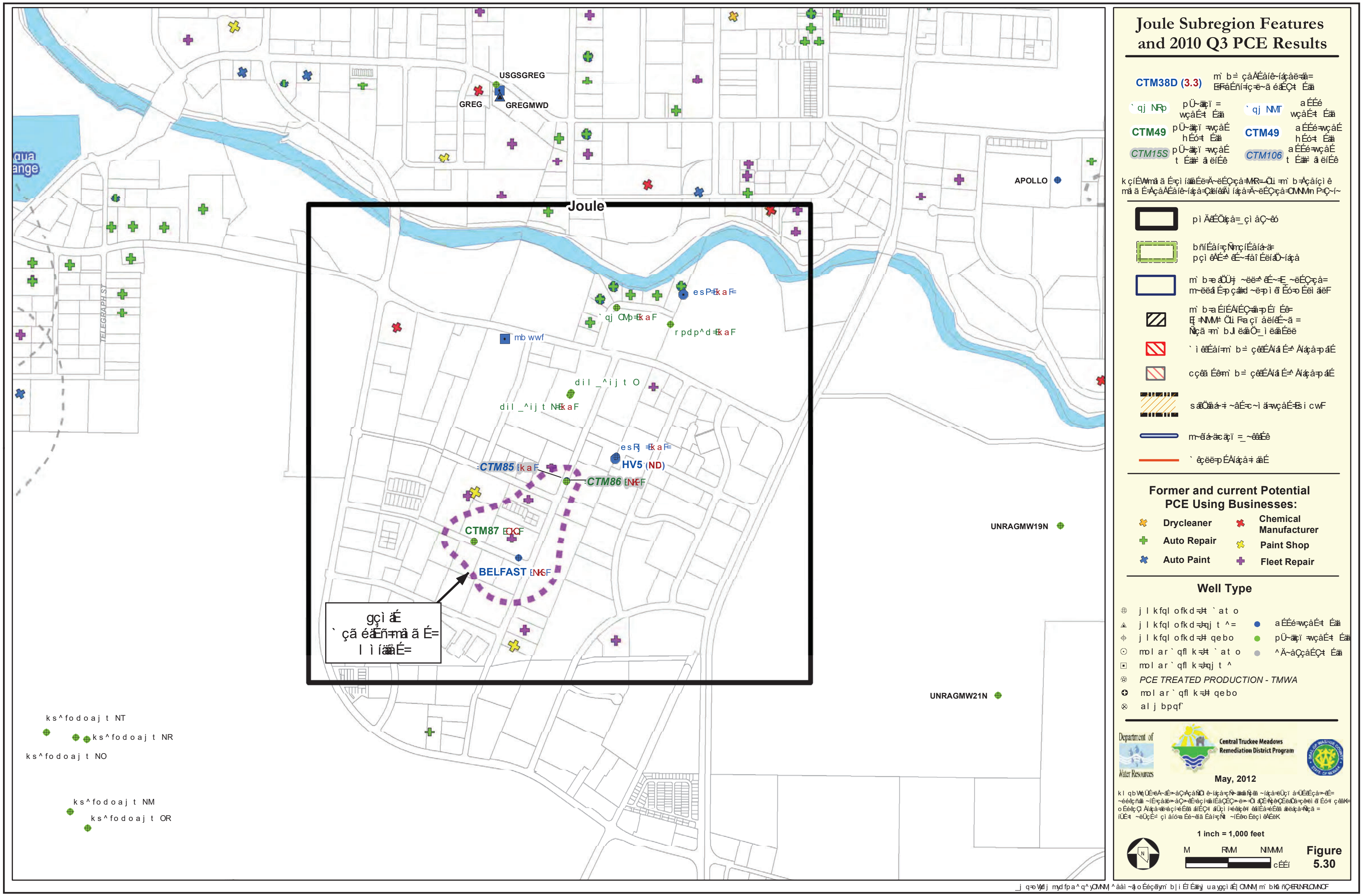
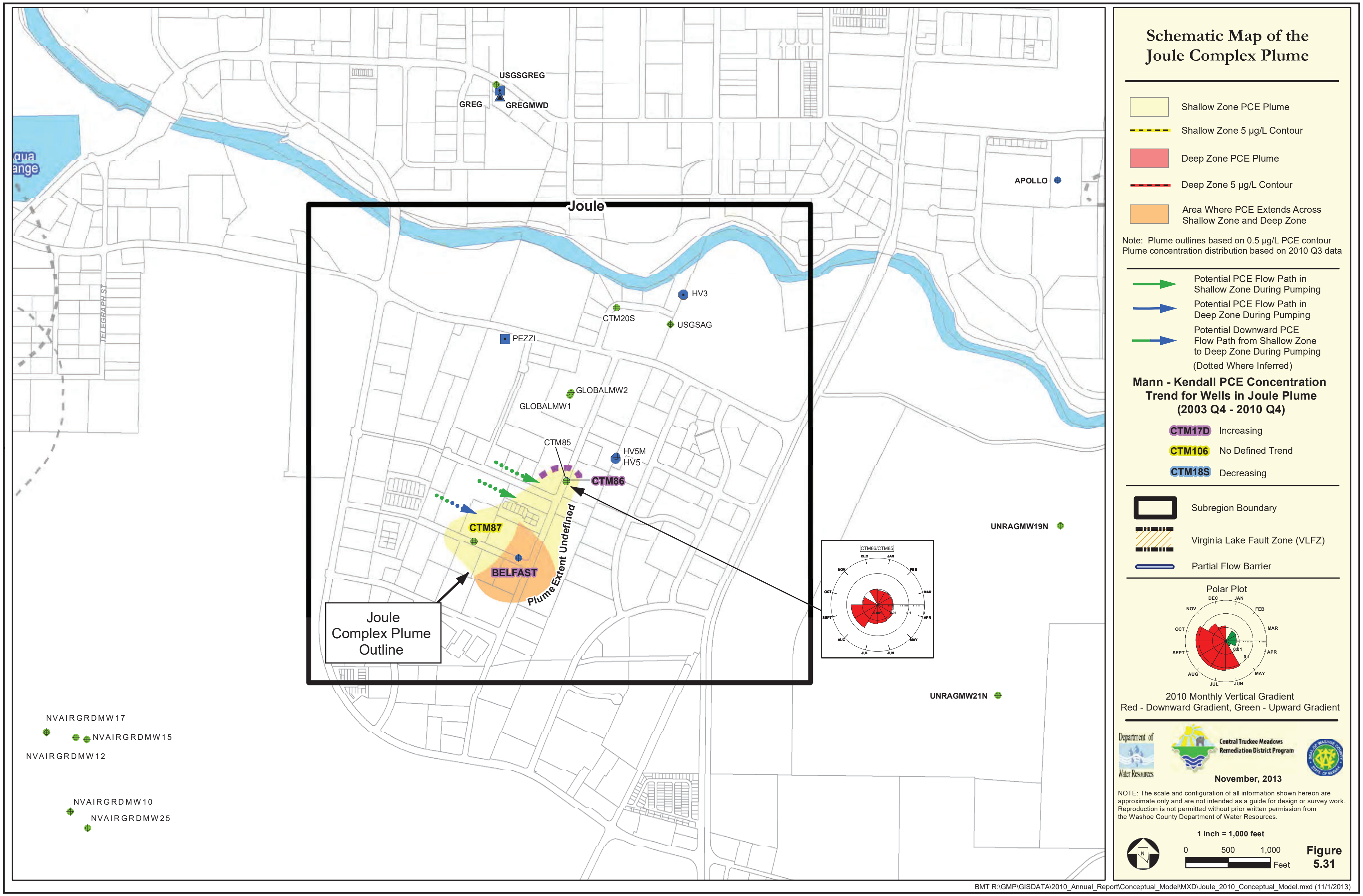

Schematic Map of the El Rancho Plume
Shallow Zone PCE Plume
Shallow Zone 5 µg/L Contour
Deep Zone PCE Plume
Deep Zone 5 µg/L Contour
Area Where PCE Extends Across Shallow Zone and Deep Zone
Note: Plume outlines based on 0.5 µg/L PCE contour
Plume concentration distribution based on 2010 Q3 data
Potential PCE Flow Path in Shallow Zone During Pumping
Potential PCE Flow Path in Deep Zone During Pumping
Potential Downward PCE Flow Path from Shallow Zone to Deep Zone During Pumping
(Dotted Where Inferred)
Mann - Kendall PCE Concentration Trend for Wells in El Rancho Plume (2003 Q4 - 2010 Q4)
CTM17D Increasing
CTM106 No Defined Trend
CTM18S Decreasing
Subregion Boundary
Virginia Lake Fault Zone (VLFZ)
Partial Flow Barrier
Polar Plot
2010 Monthly Vertical Gradient
Red - Downward Gradient, Green - Upward Gradient
Department of Water Resources
Central Truckee Meadows Remediation District Program
June, 2013
NOTE: The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.
1 inch = 1,000 feet
0 500 1,000
Feet
El Rancho
El Rancho Plume Outline
Plume Extent Undefined
View Pumping
Lake
CTM114/CTM113
CTM115/CTM108
CTM112/CTM111
CTM115
CTM110
CTM109
CTM108
CTM114
CTM113
CTM111
CTM112
ELRANCHOMWD
ELRANCHOMWS
ELRANCHO
SPARKSHIGH
MITCHELLTW
CTM37S
USGSGOVBOWL
VIEWMWS
VIEW
VIEWMWD
CTM81
4TH
4THMWD
4THMWS
ALLIEDWMW1
ALLIEDWMW3
ALLIEDWMW4
COS13STMW
ARCO2137M3
NUGGETMW2
CTM71
CTM67
CTM65
CTM68
CTM66
NDOT
CTM69
SPARKS
CTM70
BMT R:\GMP\GISDATA\2010_Annual_Report\Conceptual_Model\MXD\ELR_2010_Conceptual_Model.mxd (6/27/2013)

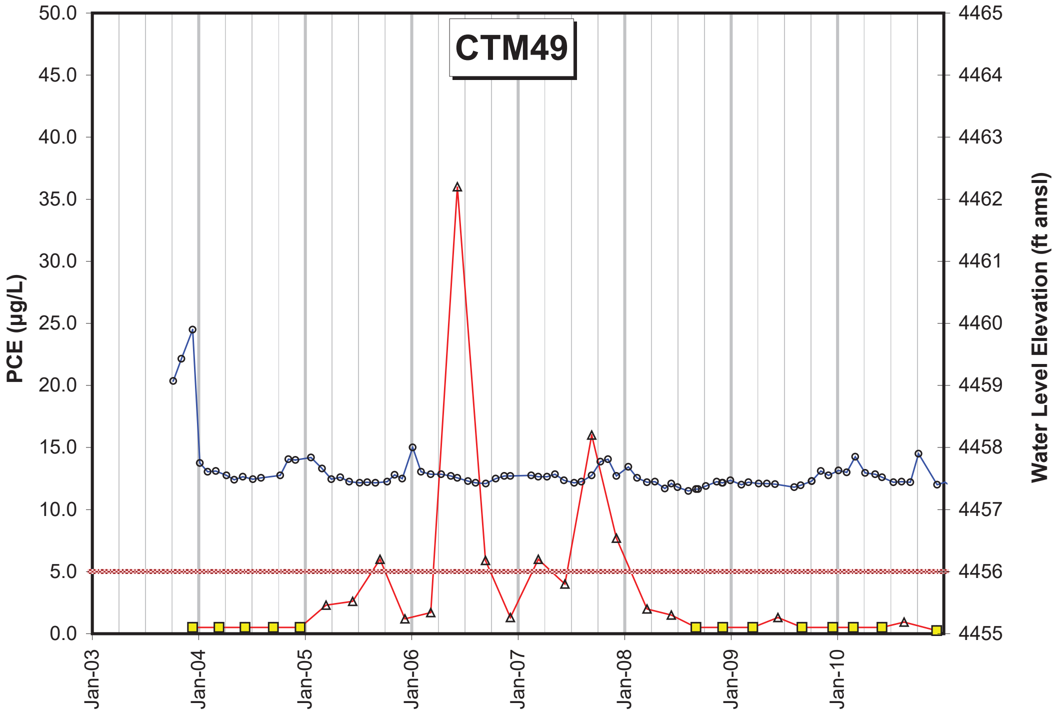
Figure 5.29

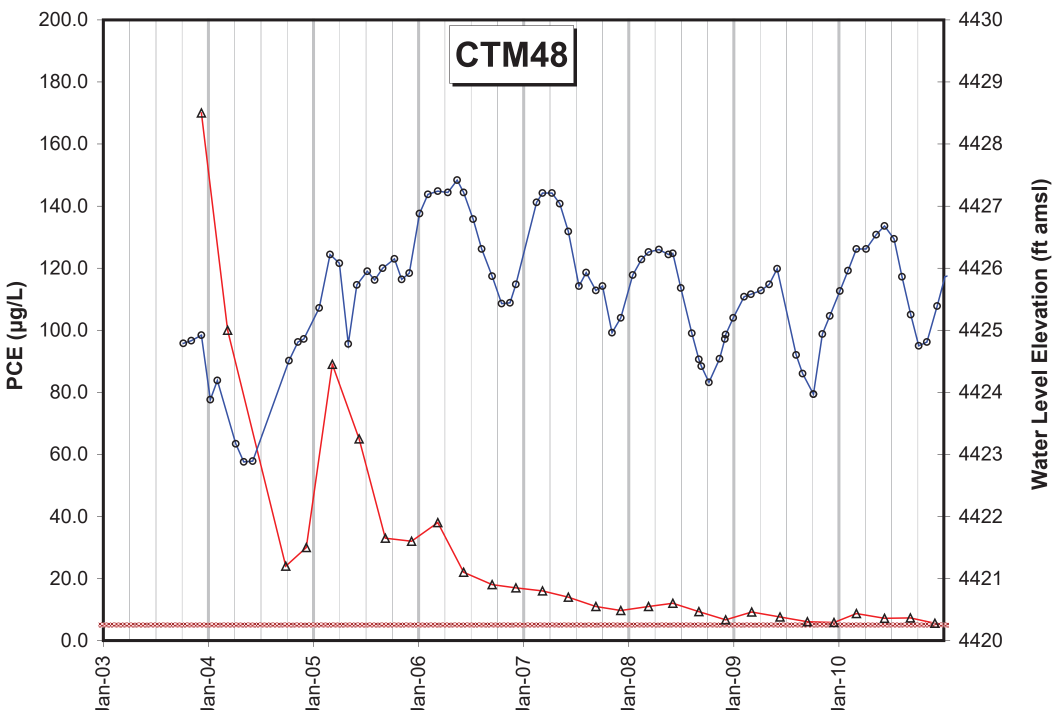

Joule Subregion Features and 2010 Q3 PCE Results
CTM38D (3.3)
CTM49
CTM15S
CTM106
Former and current Potential PCE Using Businesses:
Drycleaner
Chemical Manufacturer
Auto Repair
Paint Shop
Auto Paint
Fleet Repair
Well Type
PCE TREATED PRODUCTION - TMWA
Central Truckee Meadows Remediation District Program
May, 2012
1 inch = 1,000 feet
USGSGREG
GREG
GREGMWD
APOLLO
Joule
TELEGRAPH ST
CTM85
CTM86
HV5 (ND)
CTM87
BELFAST
UNRAGMW19N
UNRAGMW21N
Figure 5.30

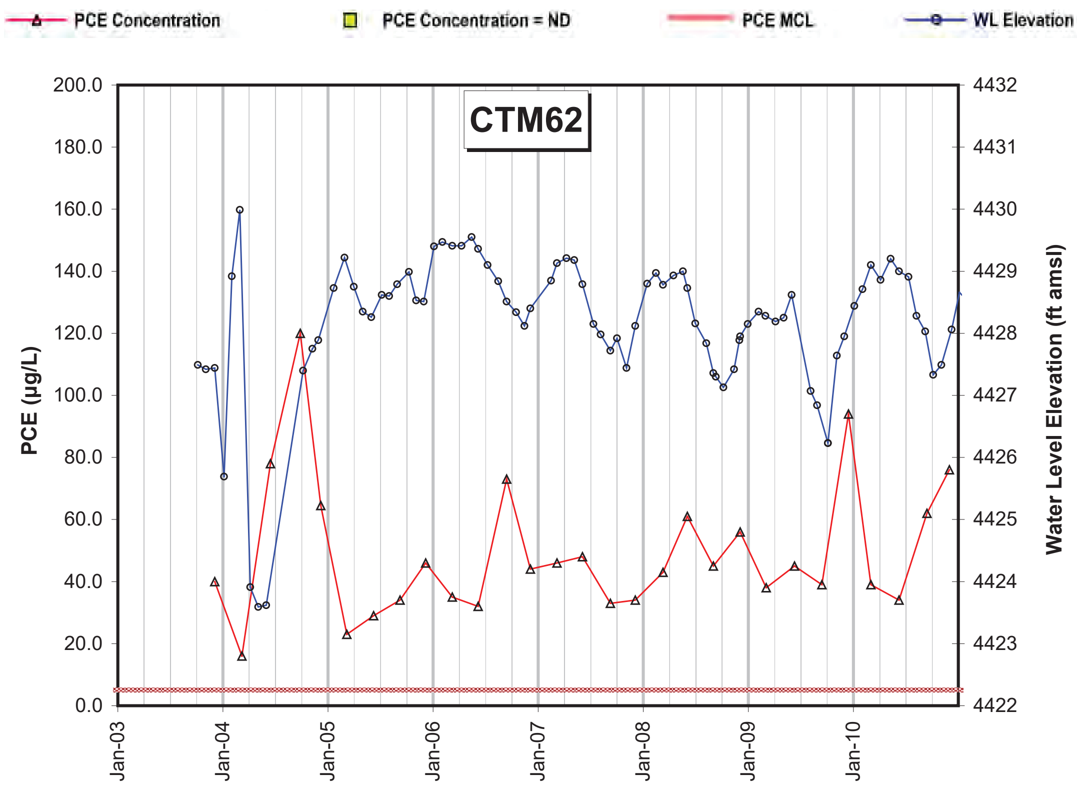

Schematic Map of the Joule Complex Plume
Shallow Zone PCE Plume
Shallow Zone 5 µg/L Contour
Deep Zone PCE Plume
Deep Zone 5 µg/L Contour
Area Where PCE Extends Across Shallow Zone and Deep Zone
Note: Plume outlines based on 0.5 µg/L PCE contour
Plume concentration distribution based on 2010 Q3 data
Potential PCE Flow Path in Shallow Zone During Pumping
Potential PCE Flow Path in Deep Zone During Pumping
Potential Downward PCE Flow Path from Shallow Zone to Deep Zone During Pumping
(Dotted Where Inferred)
Mann - Kendall PCE Concentration Trend for Wells in Joule Plume (2003 Q4 - 2010 Q4)
CTM17D Increasing
CTM106 No Defined Trend
CTM18S Decreasing
Subregion Boundary
Virginia Lake Fault Zone (VLFZ)
Partial Flow Barrier
Polar Plot
2010 Monthly Vertical Gradient
Red - Downward Gradient, Green - Upward Gradient
Department of Water Resources
Central Truckee Meadows Remediation District Program
November, 2013
NOTE: The scale and configuration of all information shown hereon are approximate only and are not intended as a guide for design or survey work. Reproduction is not permitted without prior written permission from the Washoe County Department of Water Resources.
1 inch = 1,000 feet
0 500 1,000 Feet
Figure 5.31
Joule
USGSGREG
GREG
GREGMWD
Aqua Range
TELEGRAPH ST
APOLLO
HV3
CTM20S
USGSAG
PEZZI
GLOBALMW2
GLOBALMW1
CTM85
HV5M
HV5
CTM86
CTM87
BELFAST
Plume Extent Undefined
Joule Complex Plume Outline
CTM86/CTM85
UNRAGMW19N
UNRAGMW21N
NVAIRGRDMW17
NVAIRGRDMW15
NVAIRGRDMW12
NVAIRGRDMW10
NVAIRGRDMW25
BMT R:\GMP\GISDATA\2010_Annual_Report\Conceptual_Model\MXD\Joule_2010_Conceptual_Model.mxd (11/1/2013)

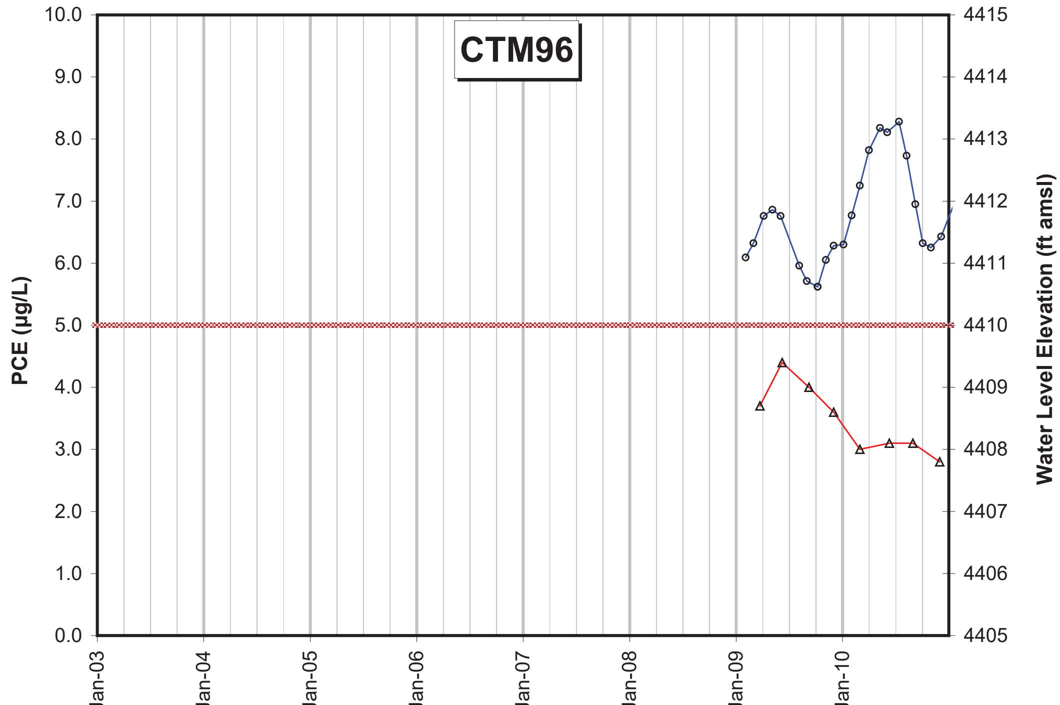
Graphs

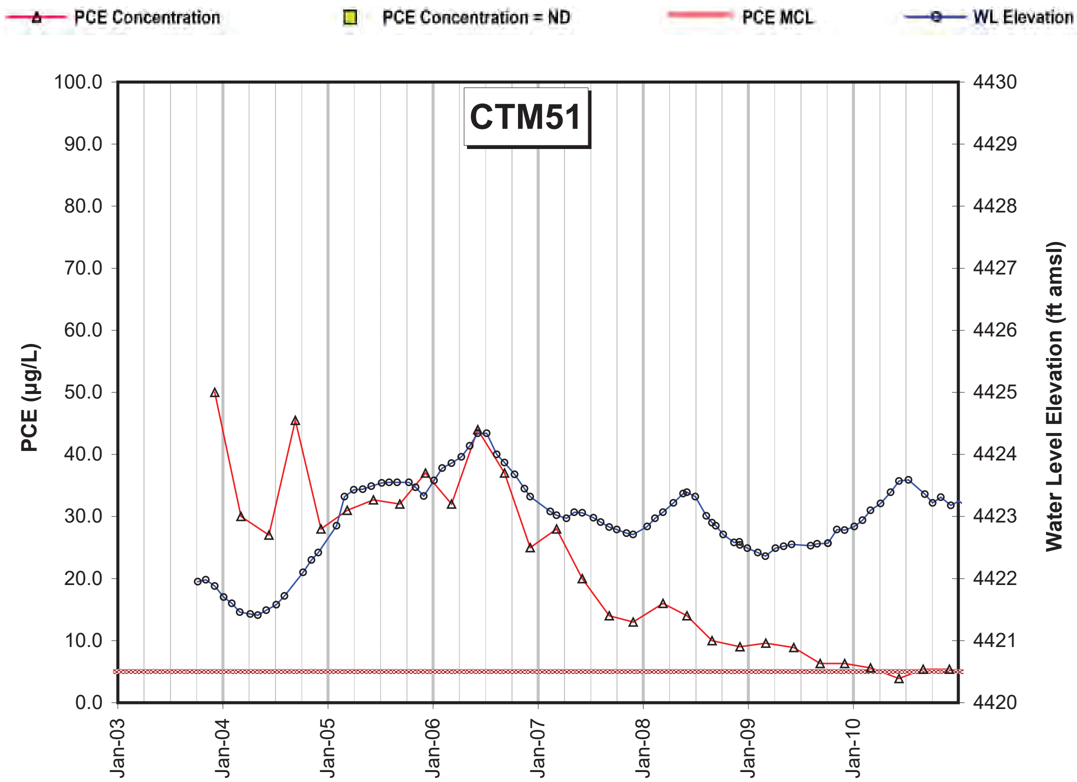
PCE Concentration | PCE Concentration = ND | PCE MCL | WL Elevation

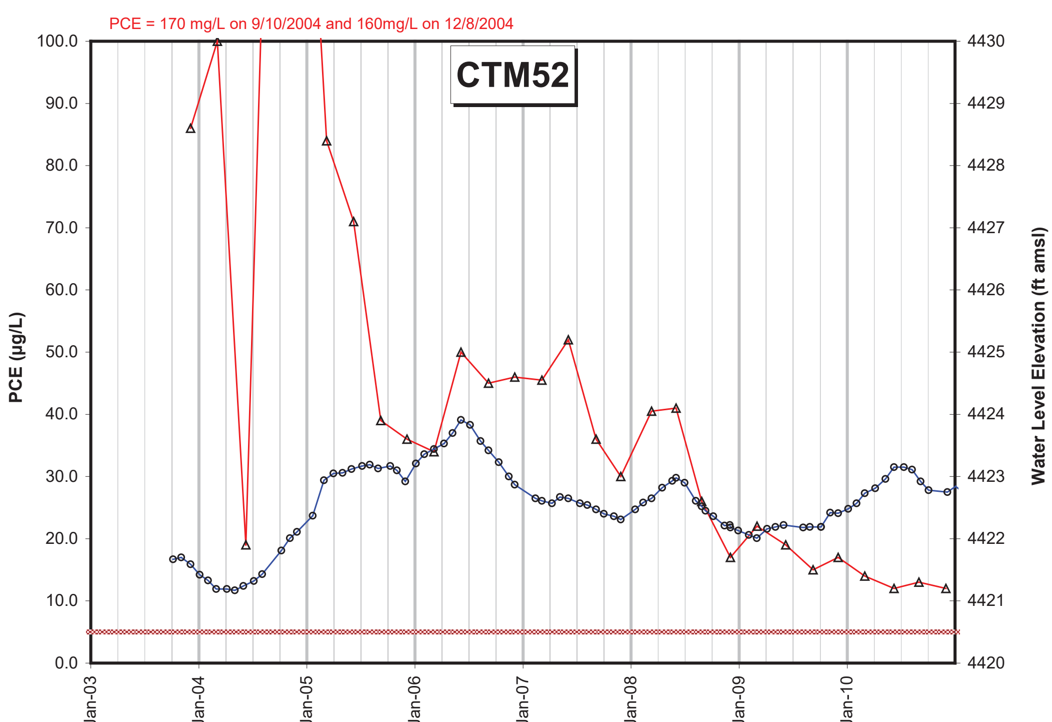


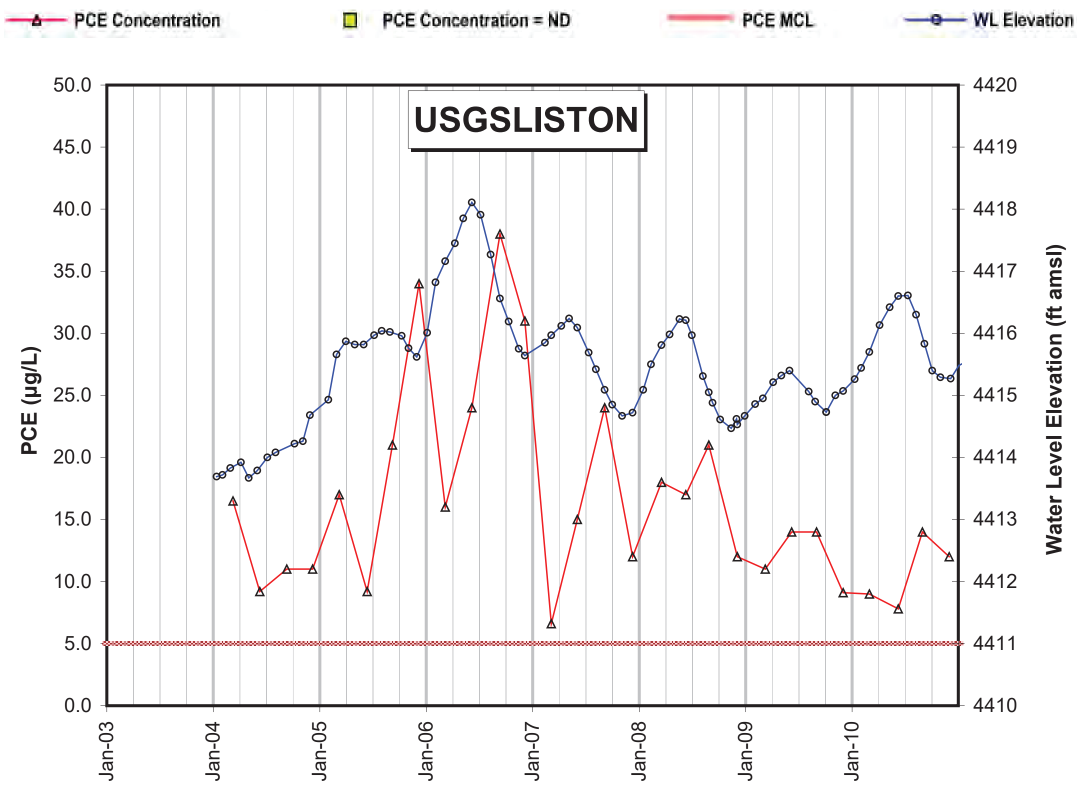


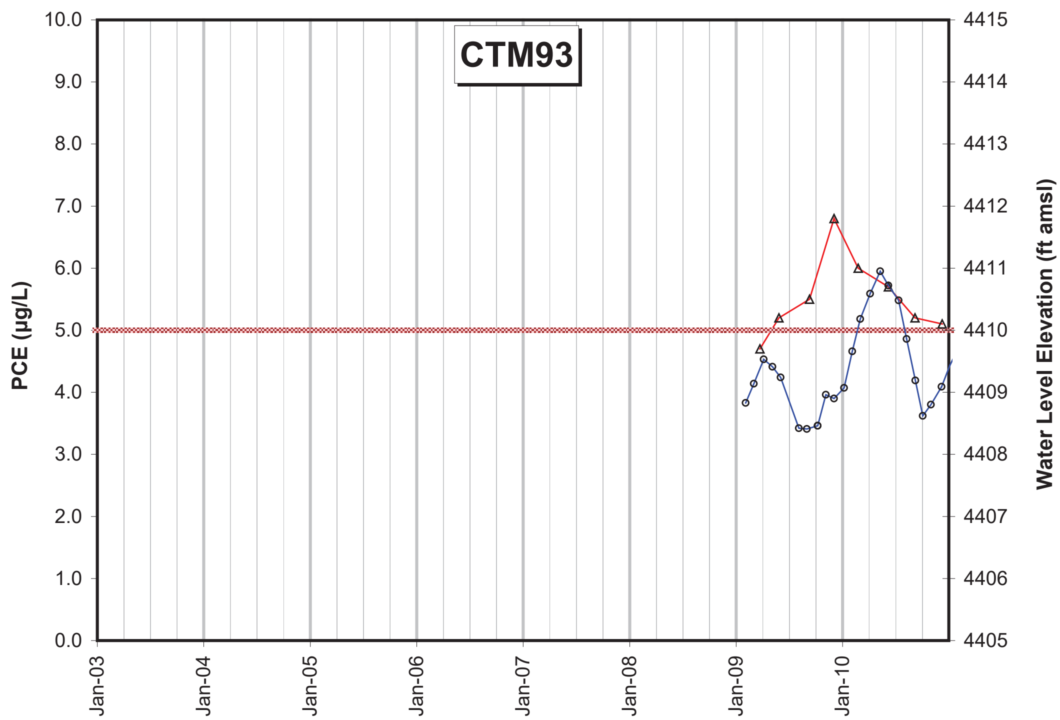

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM62
PCE (µg/L)
Water Level Elevation (ft amsl)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
4432
4431
4430
4429
4428
4427
4426
4425
4424
4423
4422
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

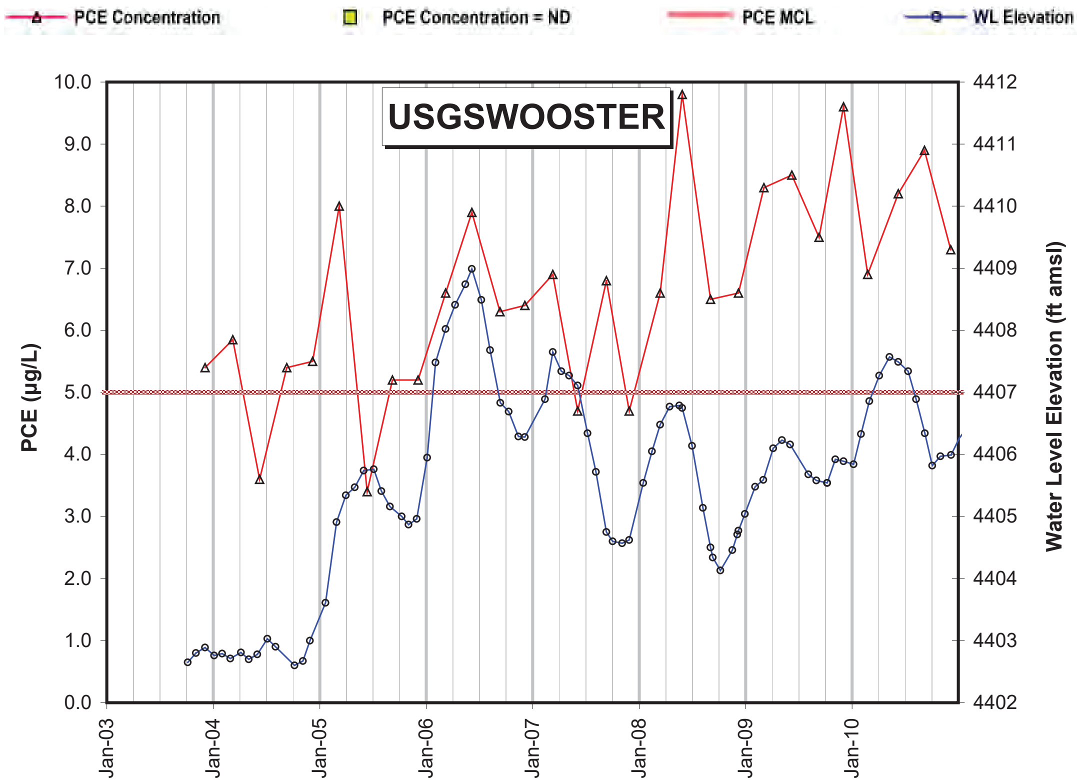

CTM96
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4415
4414
4413
4412
4411
4410
4409
4408
4407
4406
4405
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

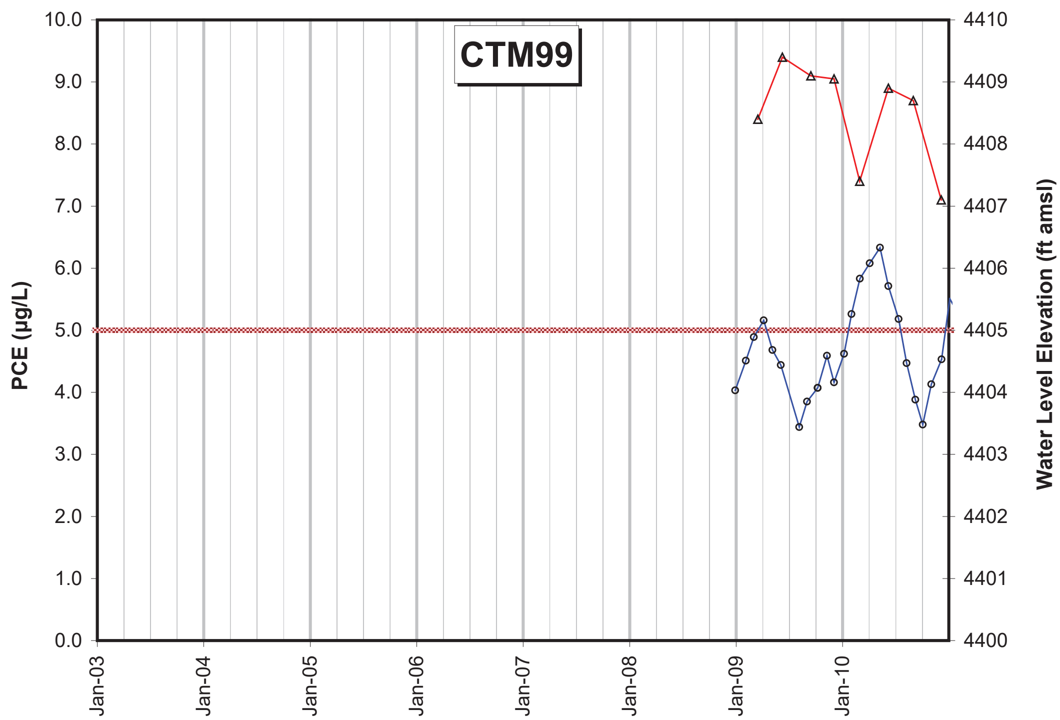

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM51
PCE (µg/L)
Water Level Elevation (ft amsl)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4430
4429
4428
4427
4426
4425
4424
4423
4422
4421
4420
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

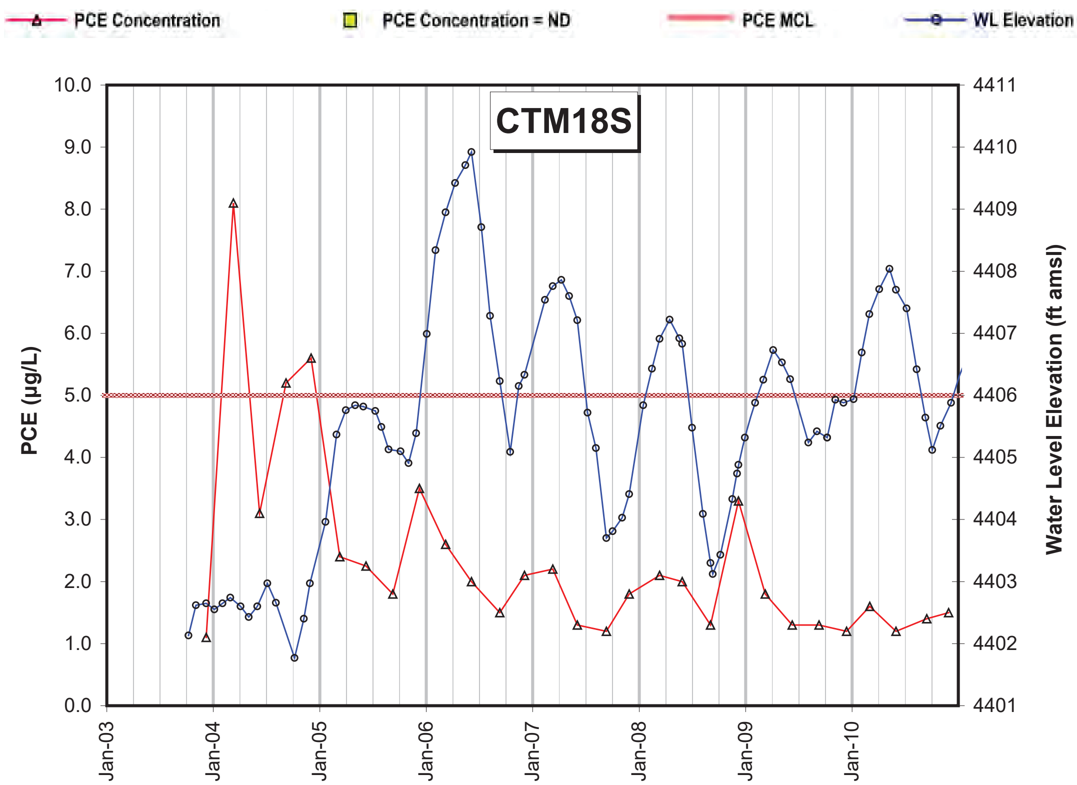

PCE = 170 mg/L on 9/10/2004 and 160mg/L on 12/8/2004
CTM52
PCE (µg/L)
Water Level Elevation (ft amsl)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4430
4429
4428
4427
4426
4425
4424
4423
4422
4421
4420
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

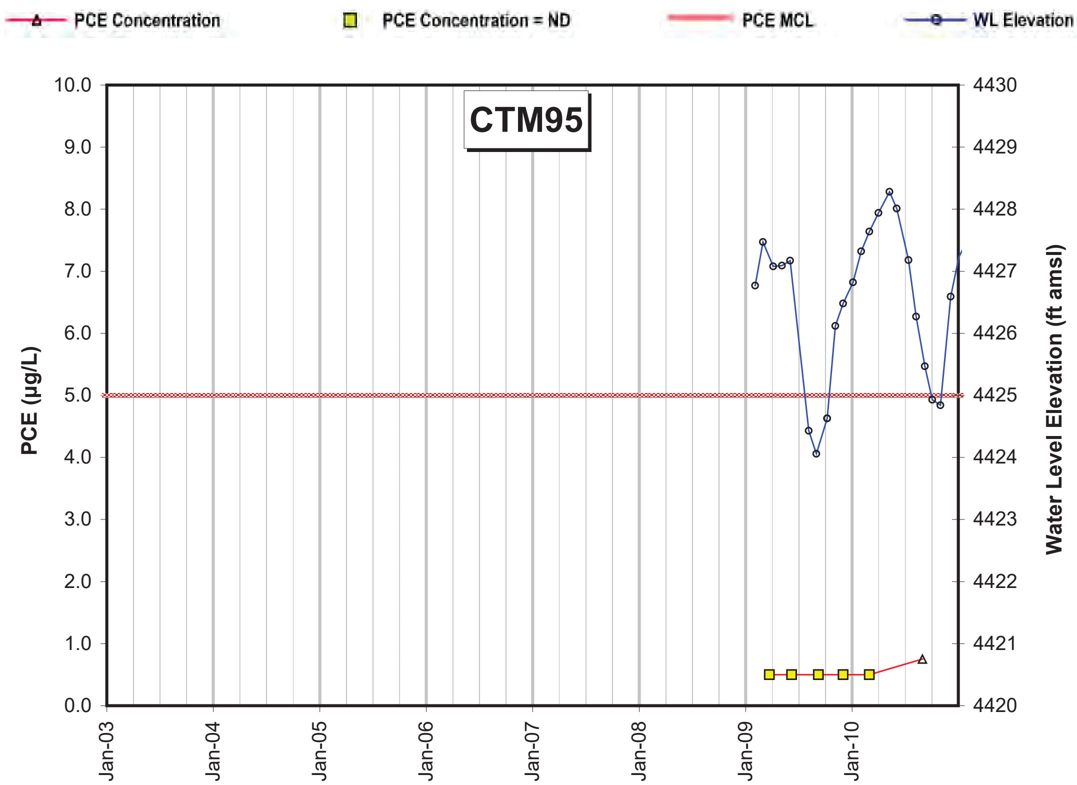

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
USGSLISTON
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4420
4419
4418
4417
4416
4415
4414
4413
4412
4411
4410
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

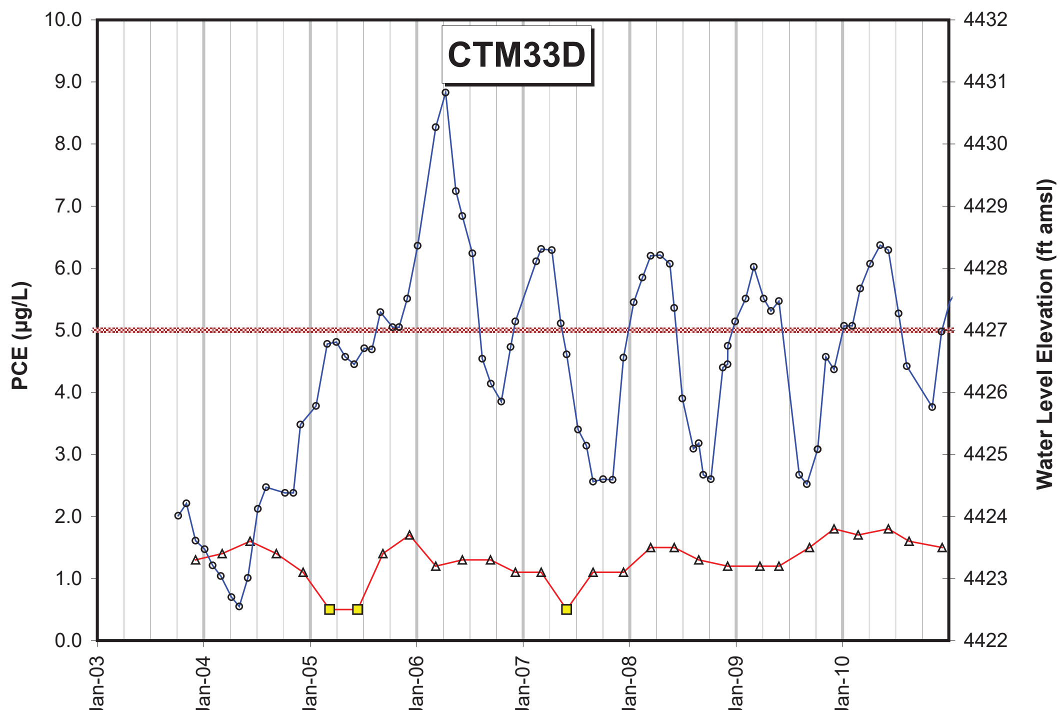

CTM93
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4415
4414
4413
4412
4411
4410
4409
4408
4407
4406
4405
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
USGSWOOSTER
PCE (µg/L)
Water Level Elevation (ft amsl)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
4402
4403
4404
4405
4406
4407
4408
4409
4410
4411
4412
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

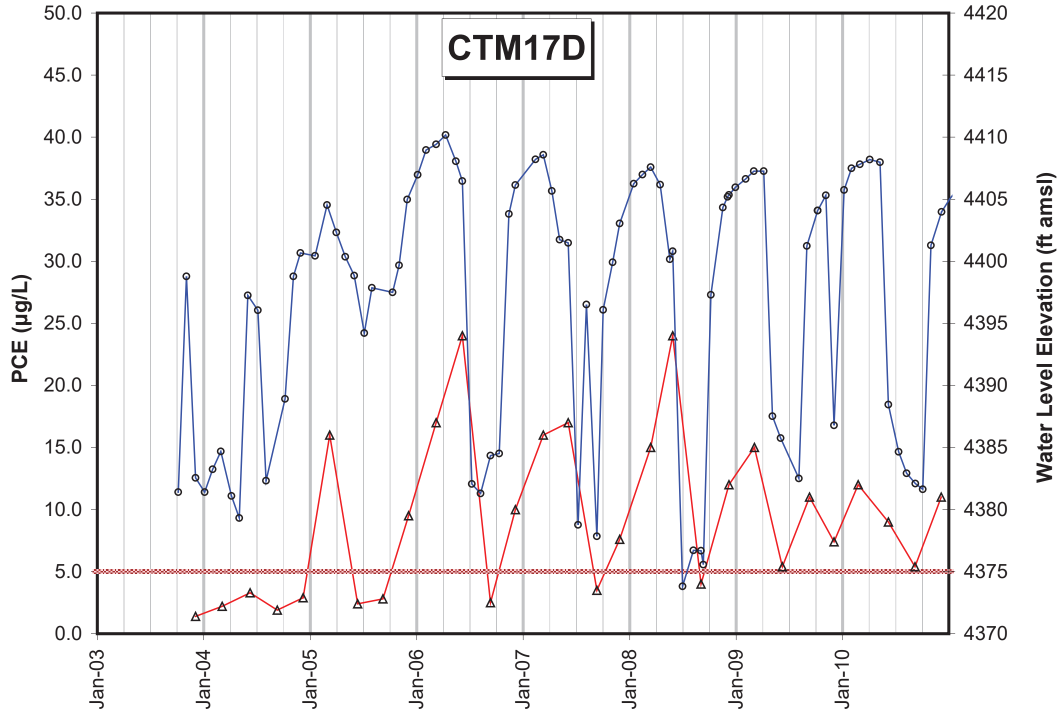

CTM99
PCE (µg/L)
Water Level Elevation (ft amsl)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
4400
4401
4402
4403
4404
4405
4406
4407
4408
4409
4410
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

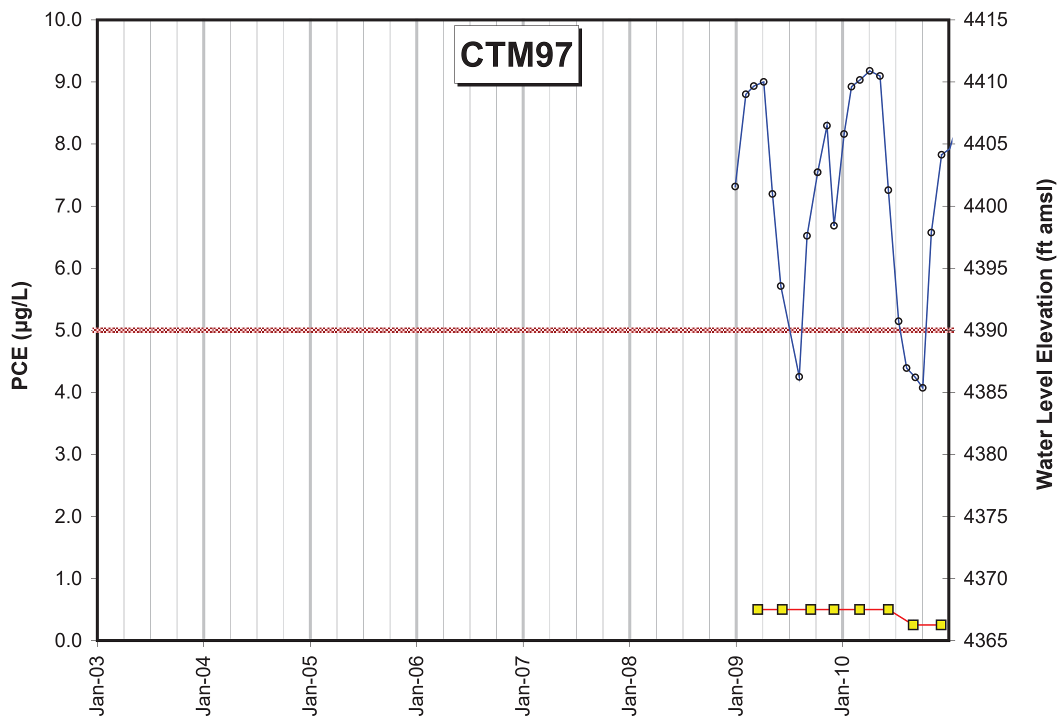

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM18S
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4411
4410
4409
4408
4407
4406
4405
4404
4403
4402
4401
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

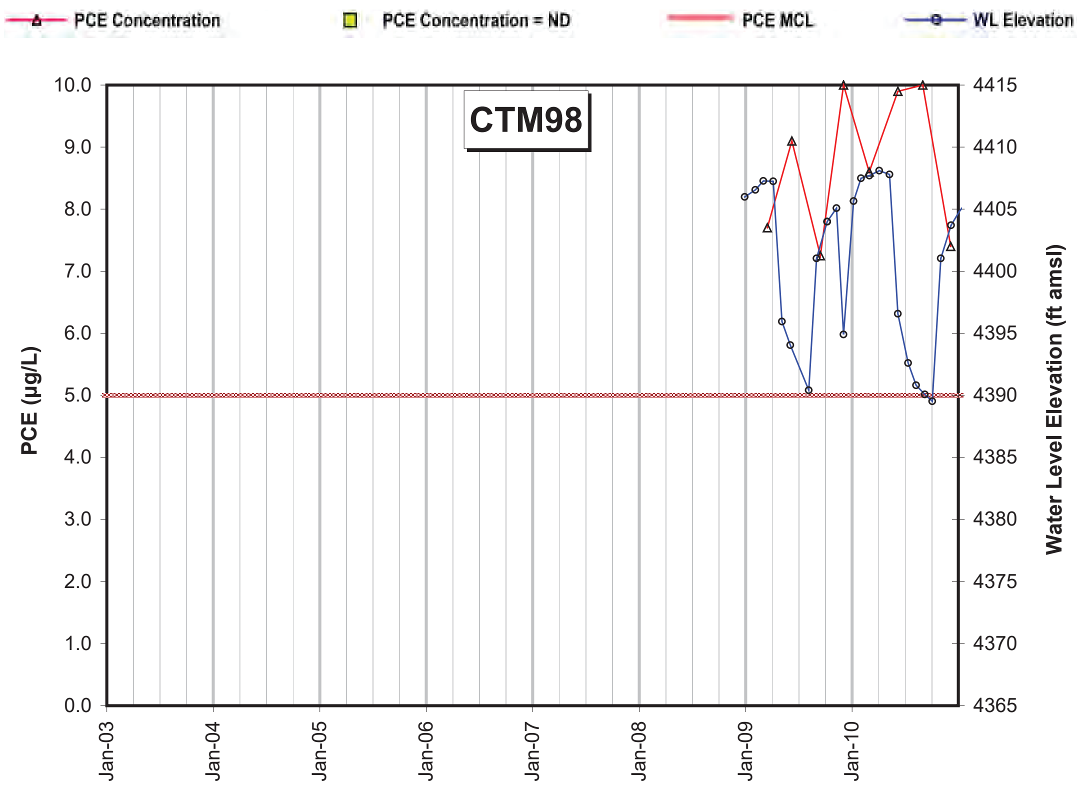

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM95
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4430
4429
4428
4427
4426
4425
4424
4423
4422
4421
4420
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

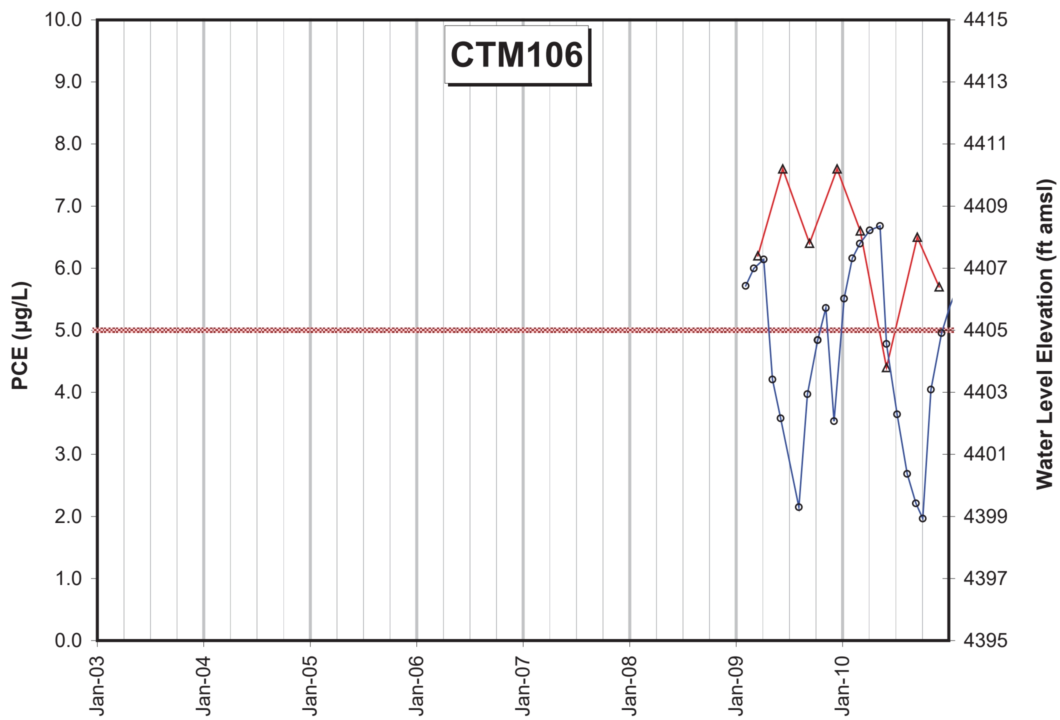

CTM33D
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4432
4431
4430
4429
4428
4427
4426
4425
4424
4423
4422
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

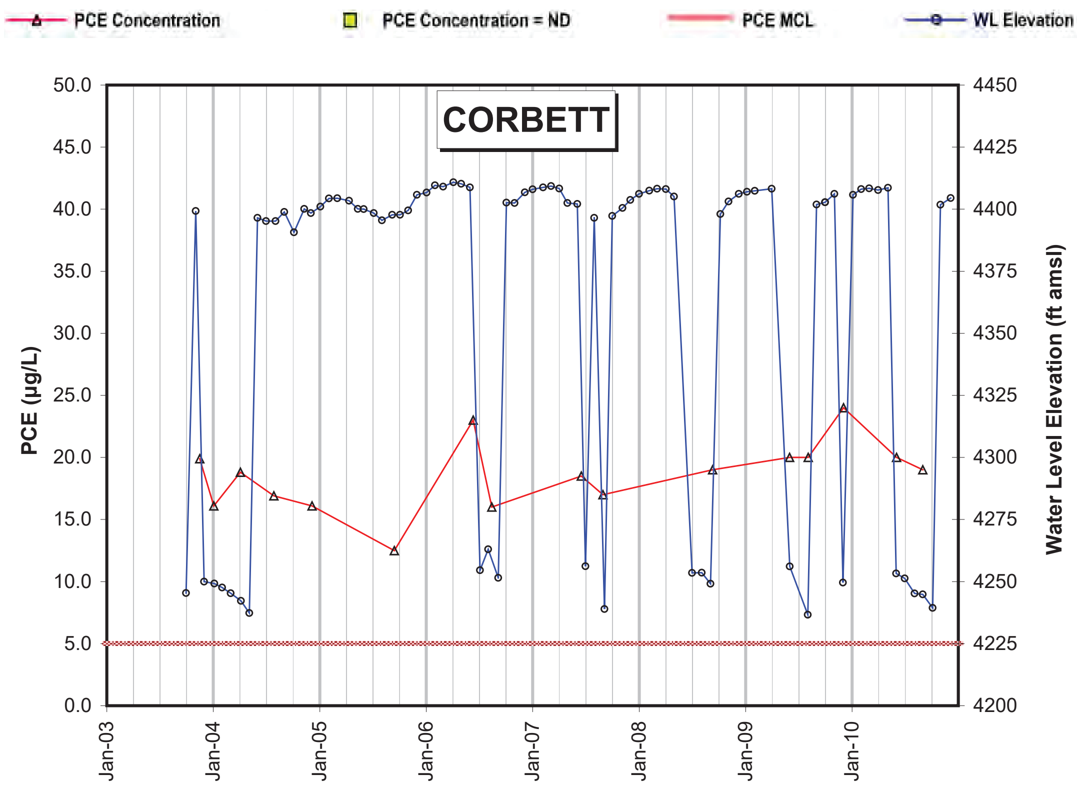
PCE Concentration | PCE Concentration = ND | PCE MCL | WL Elevation

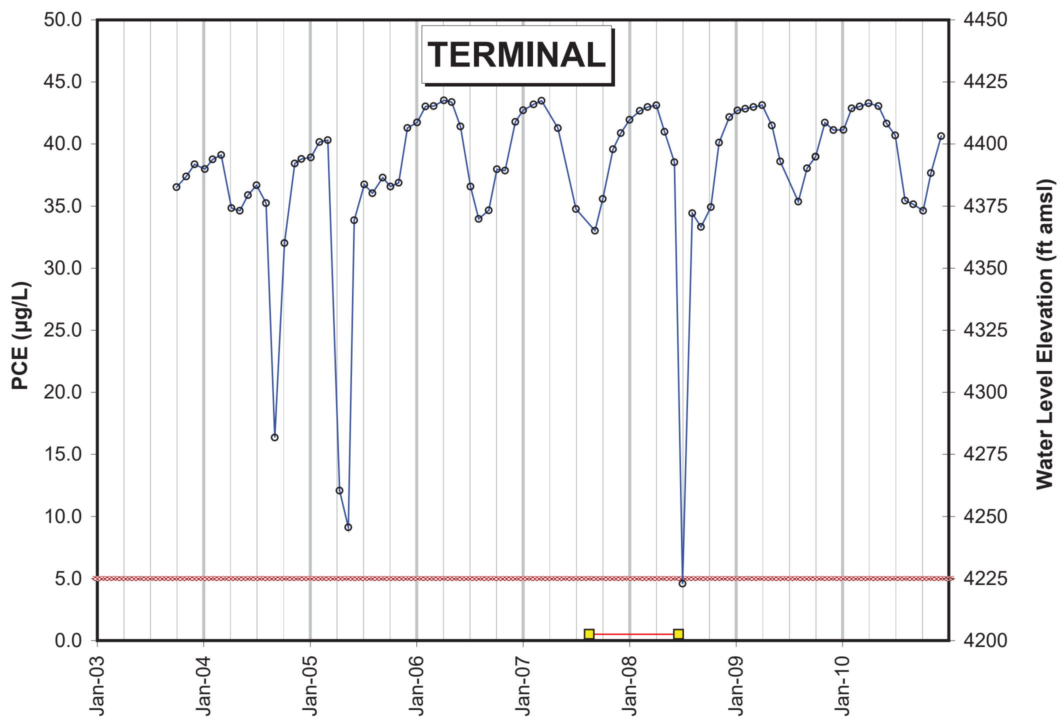





PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM98
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4415
4410
4405
4400
4395
4390
4385
4380
4375
4370
4365
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

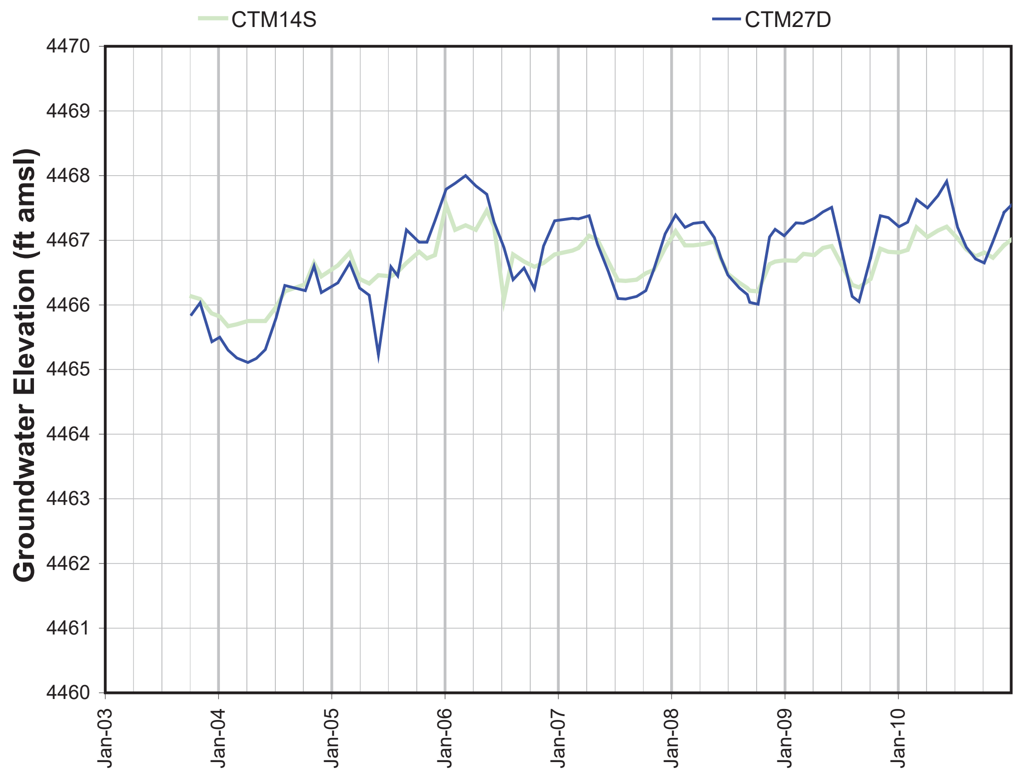

CTM106
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4415
4413
4411
4409
4407
4405
4403
4401
4399
4397
4395
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

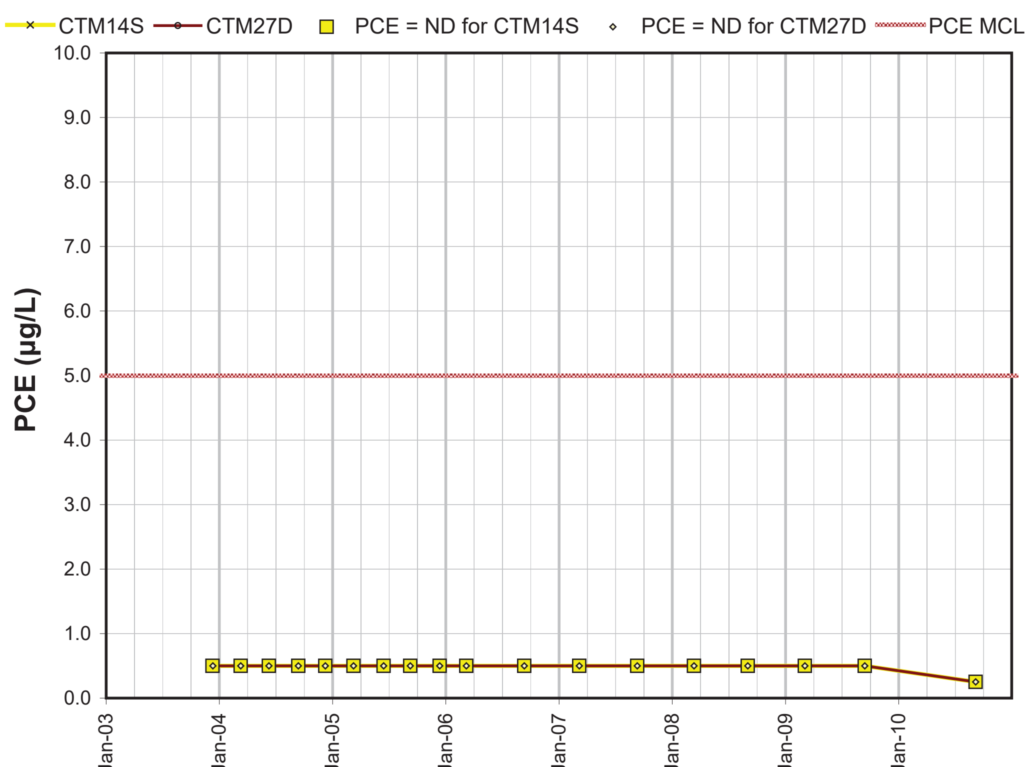




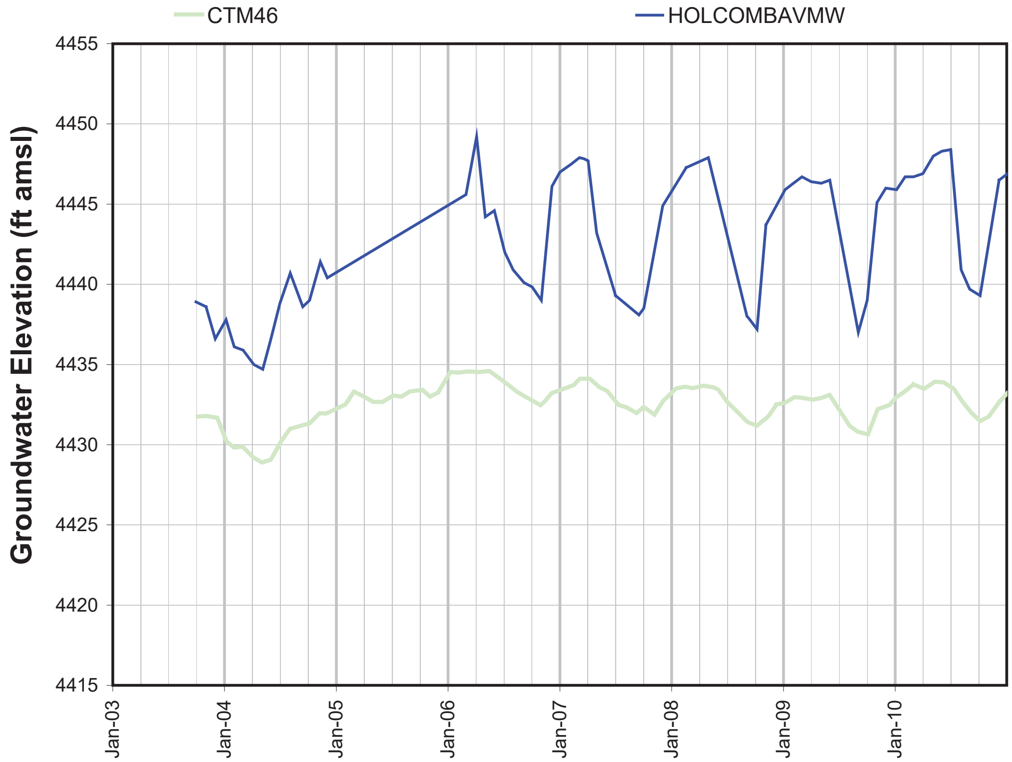
CTM REMEDIATION DISTRICT
Washoe County

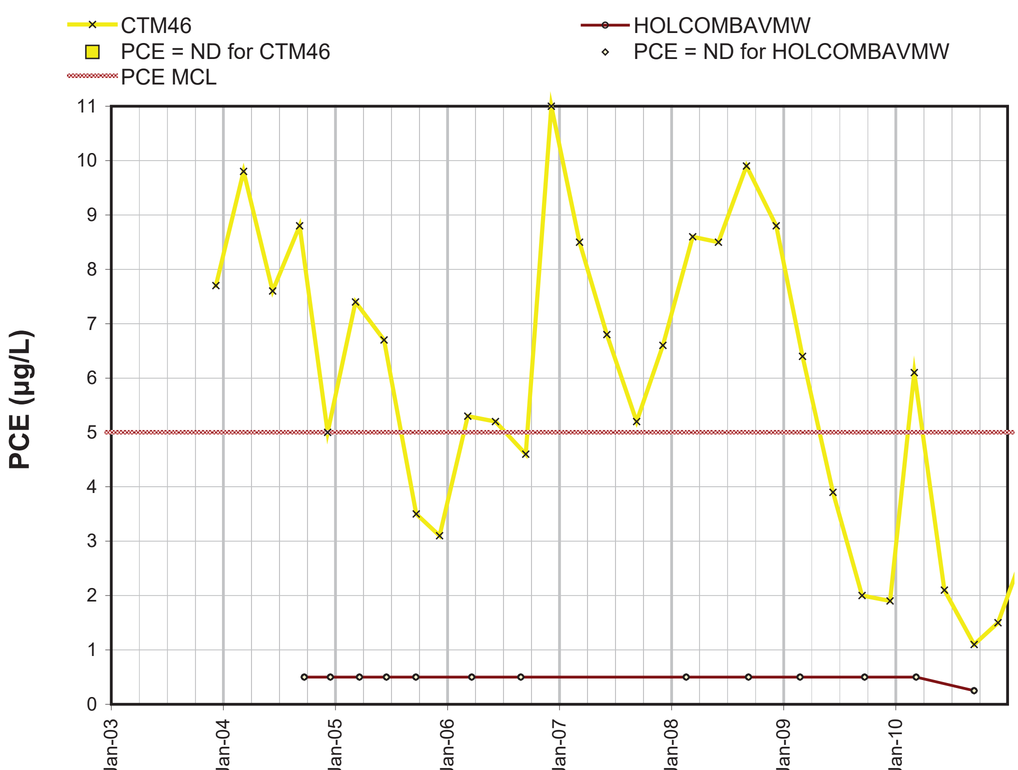
CTM14S / CTM27D



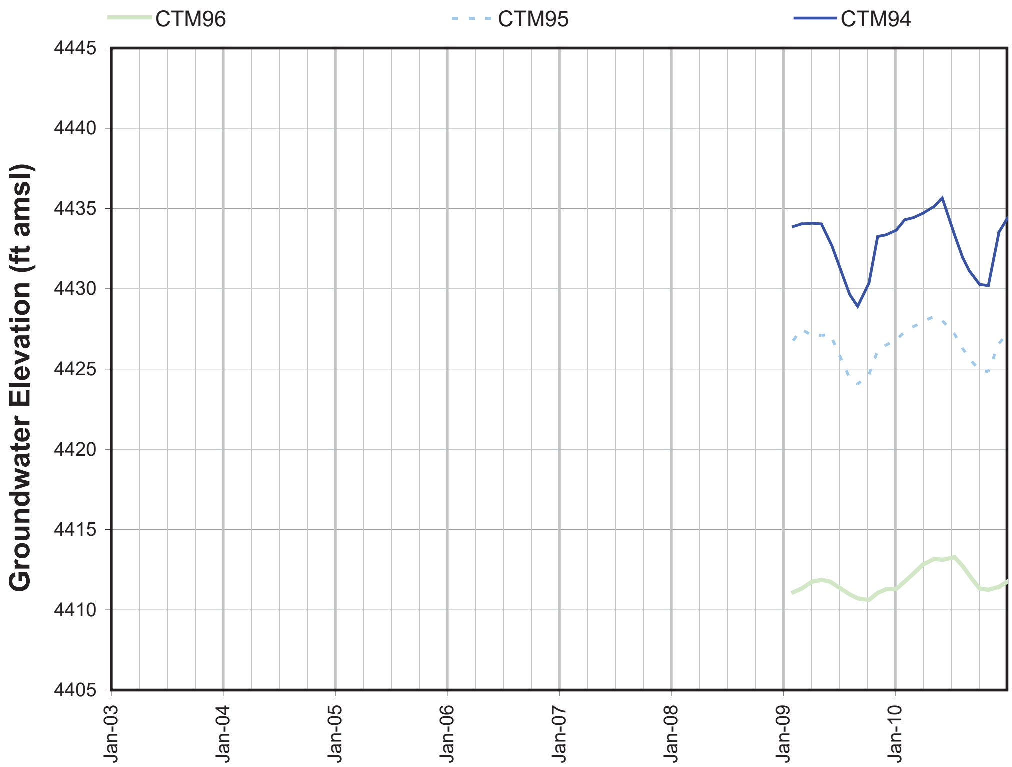


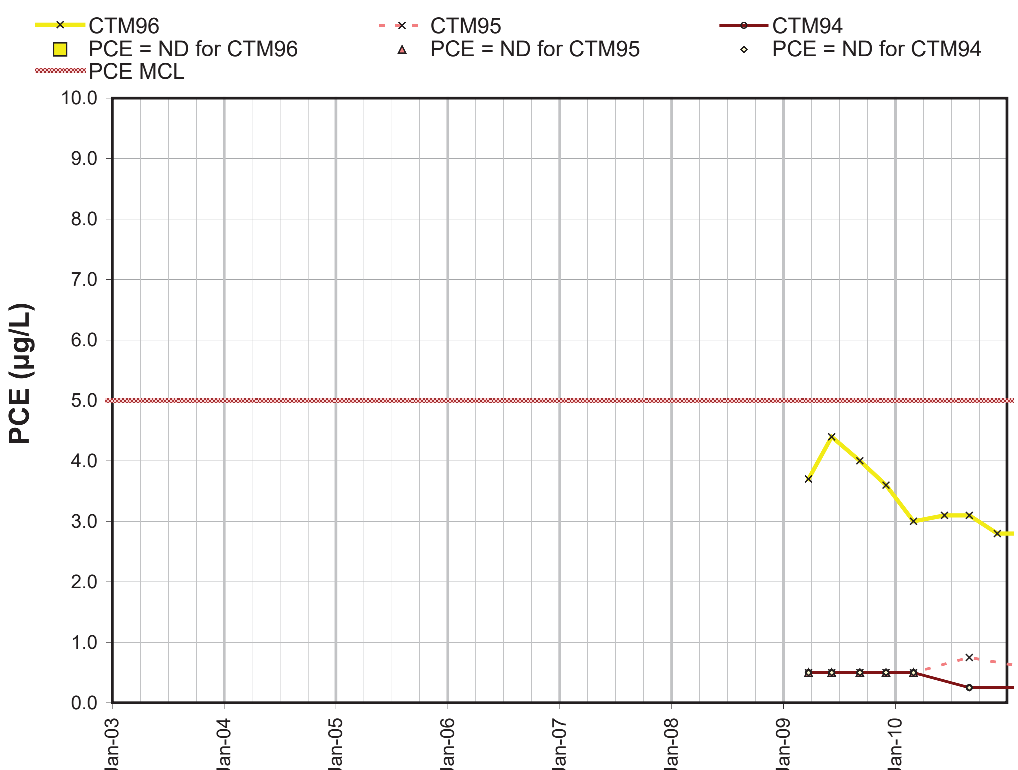
CTM46 / HOLCOMBAVMW



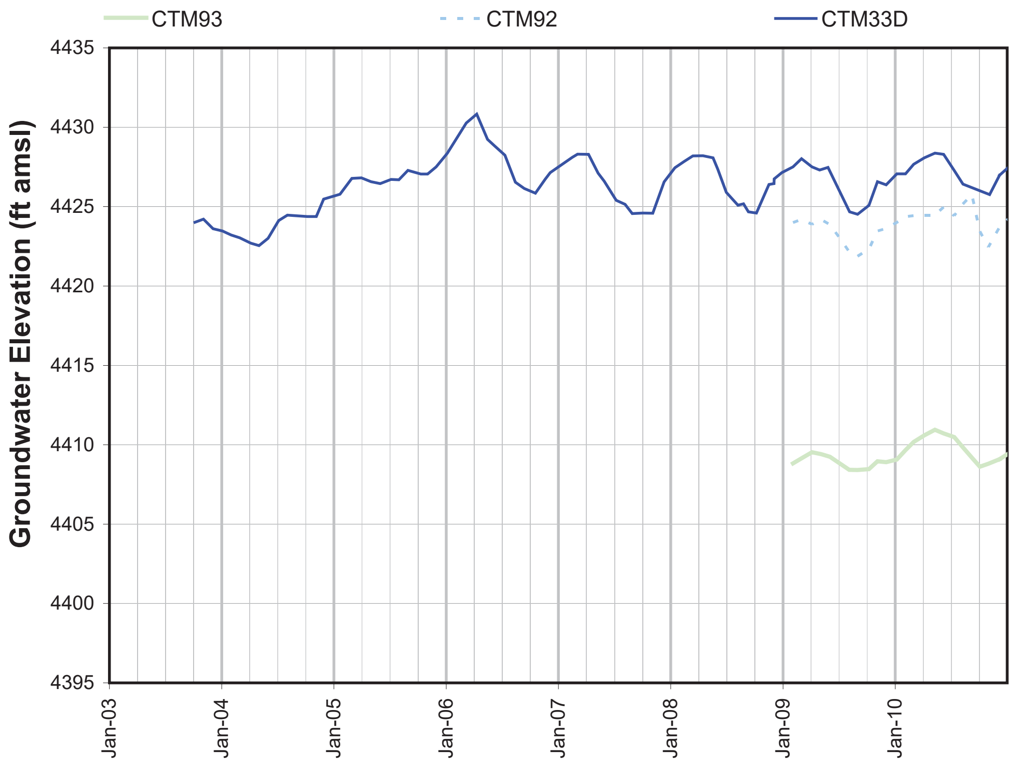


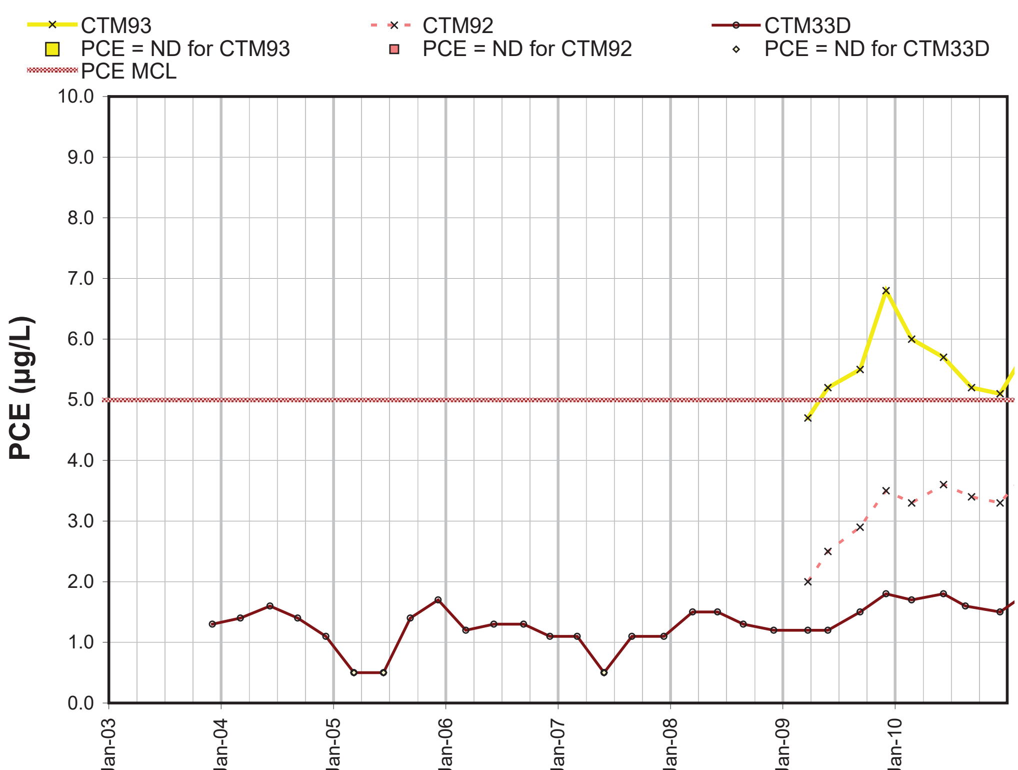
CTM96 / CTM95 / CTM94



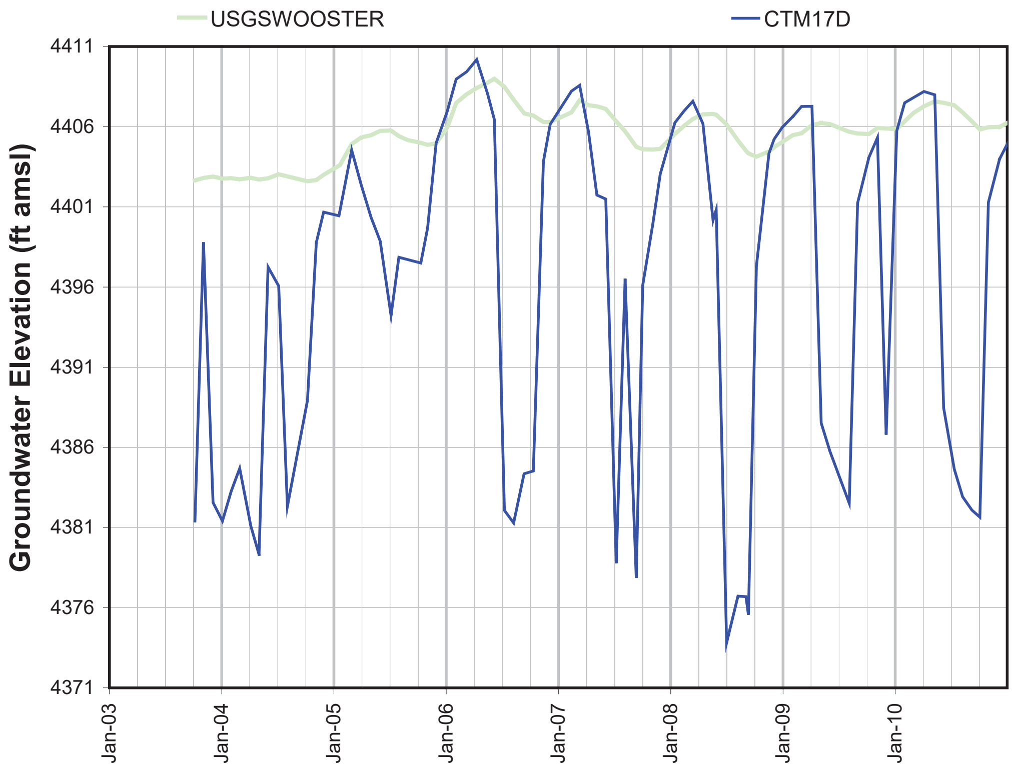


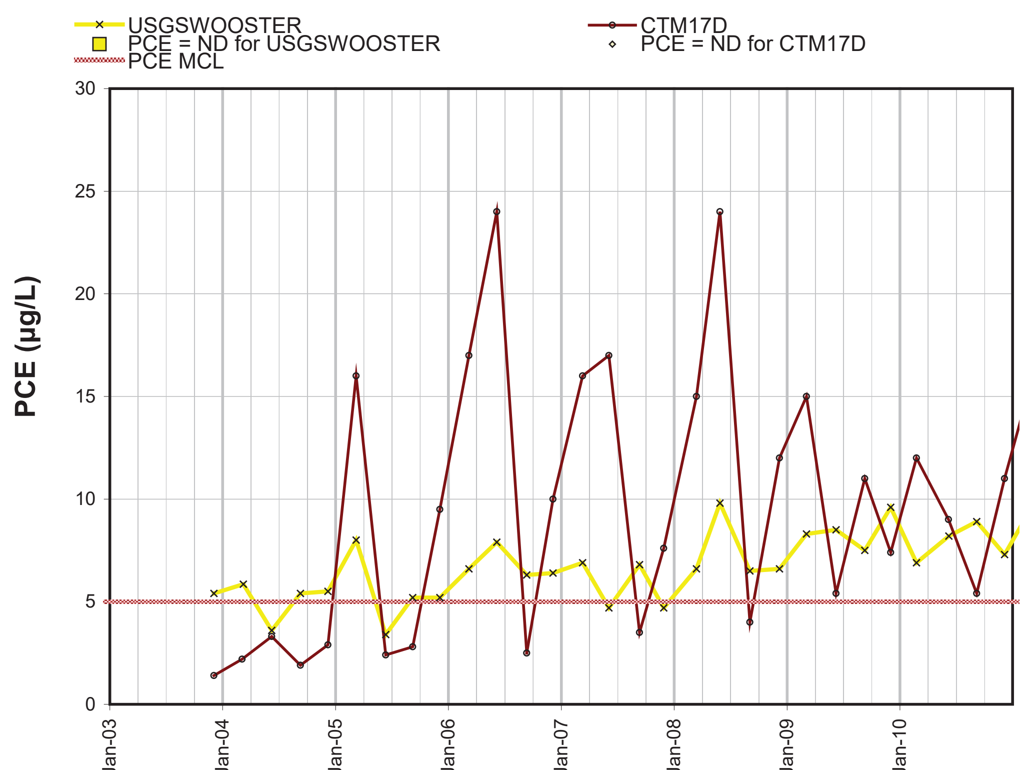
CTM93 / CTM92 / CTM33D



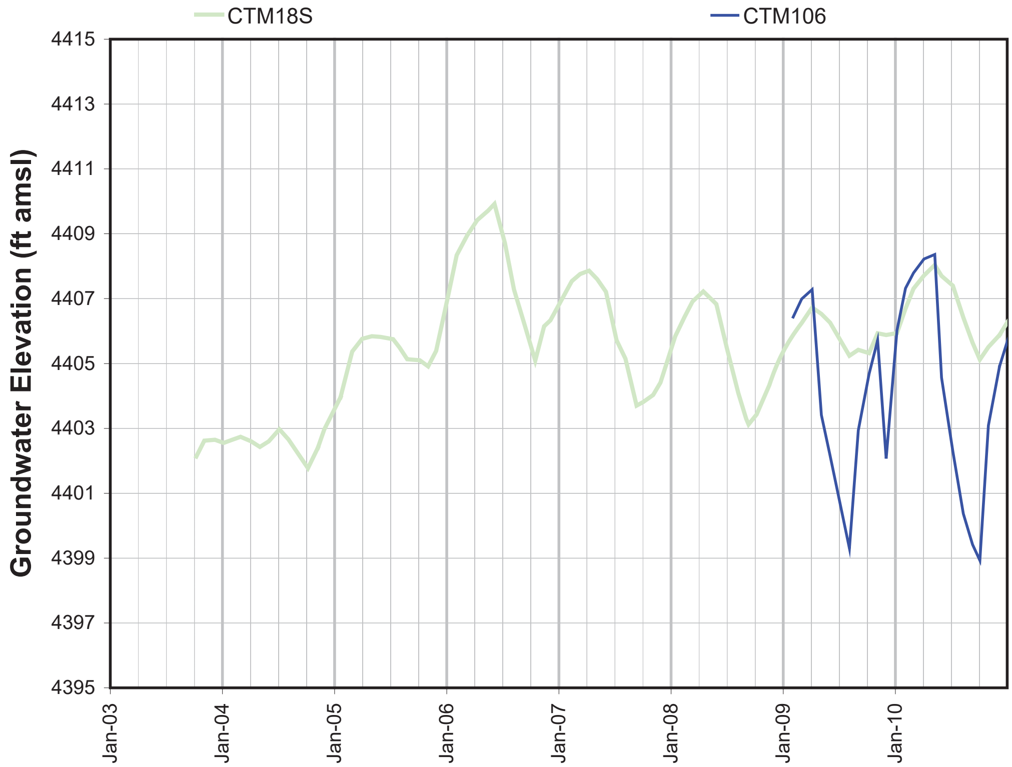


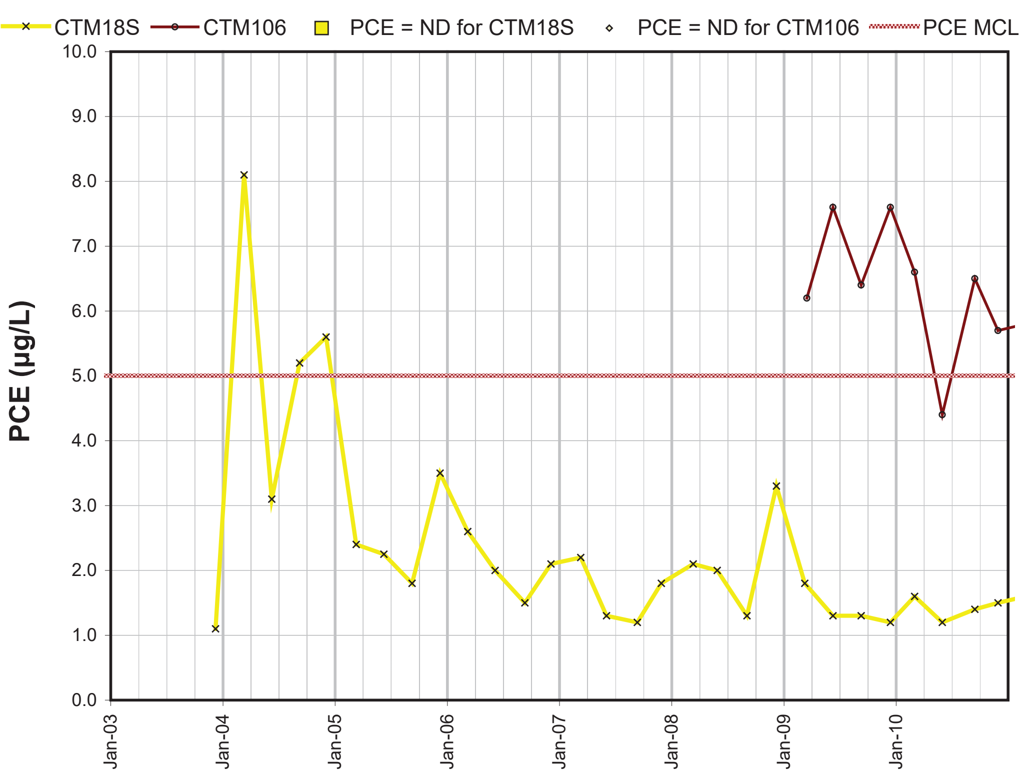
USGSWOOSTER / CTM17D



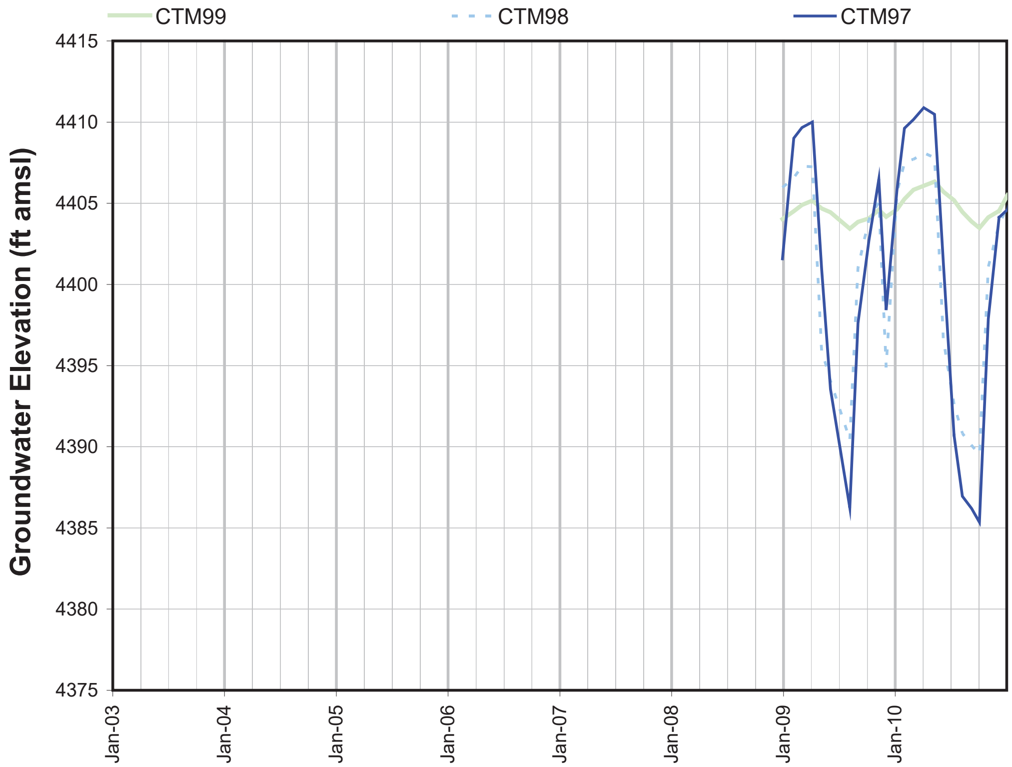


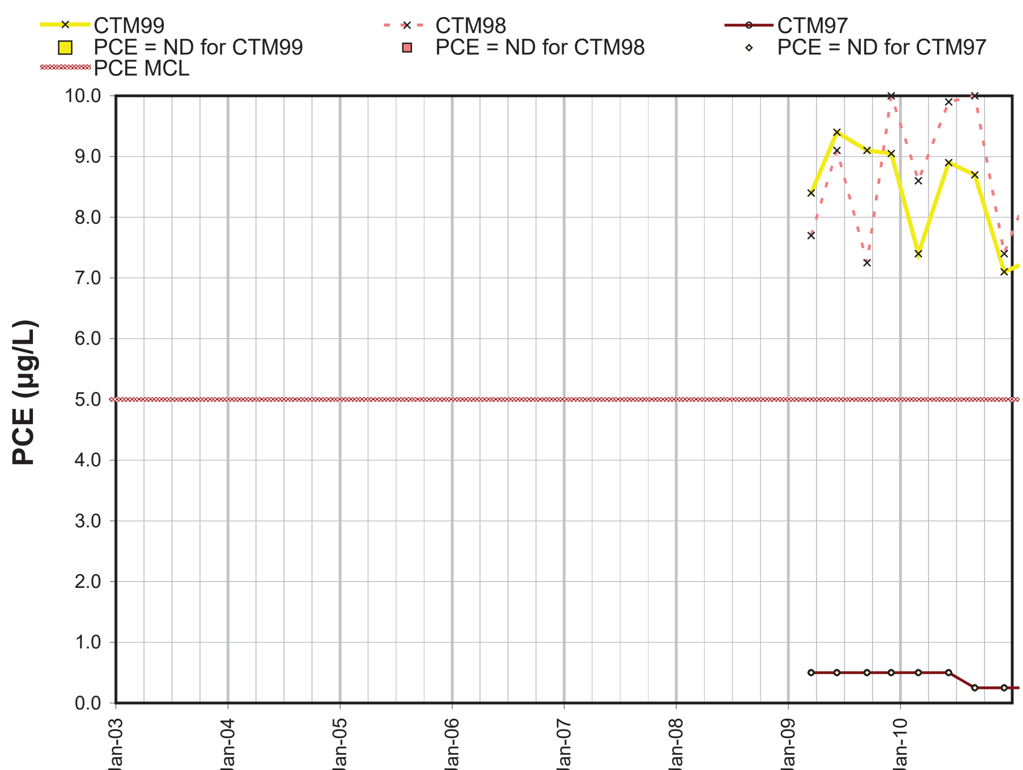
CTM18S / CTM106



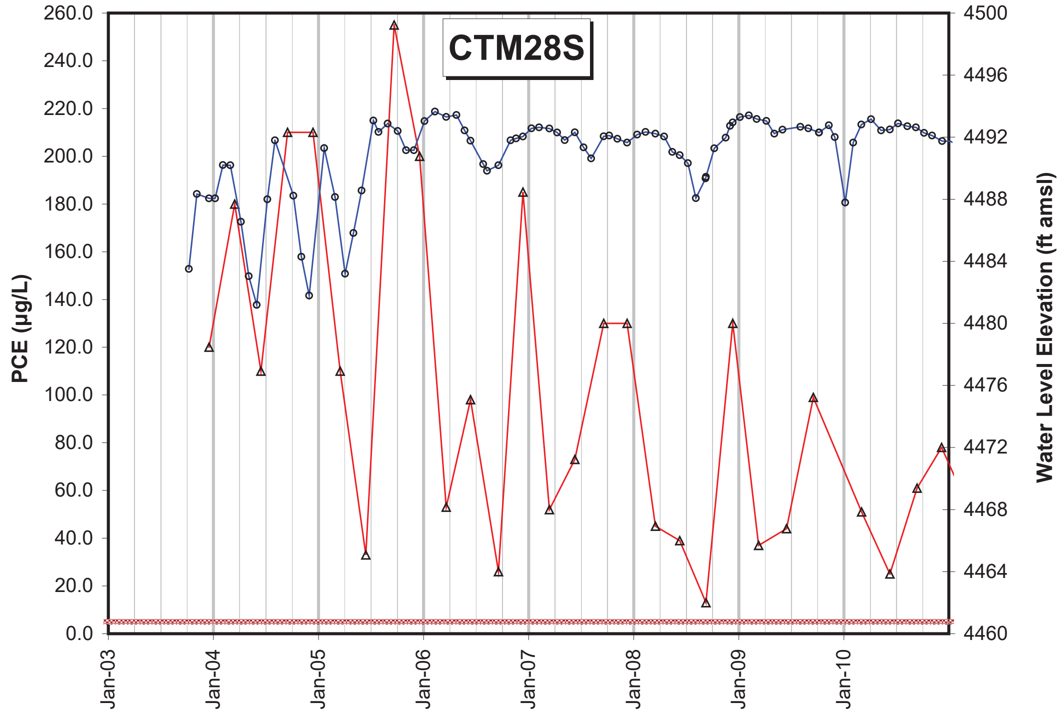


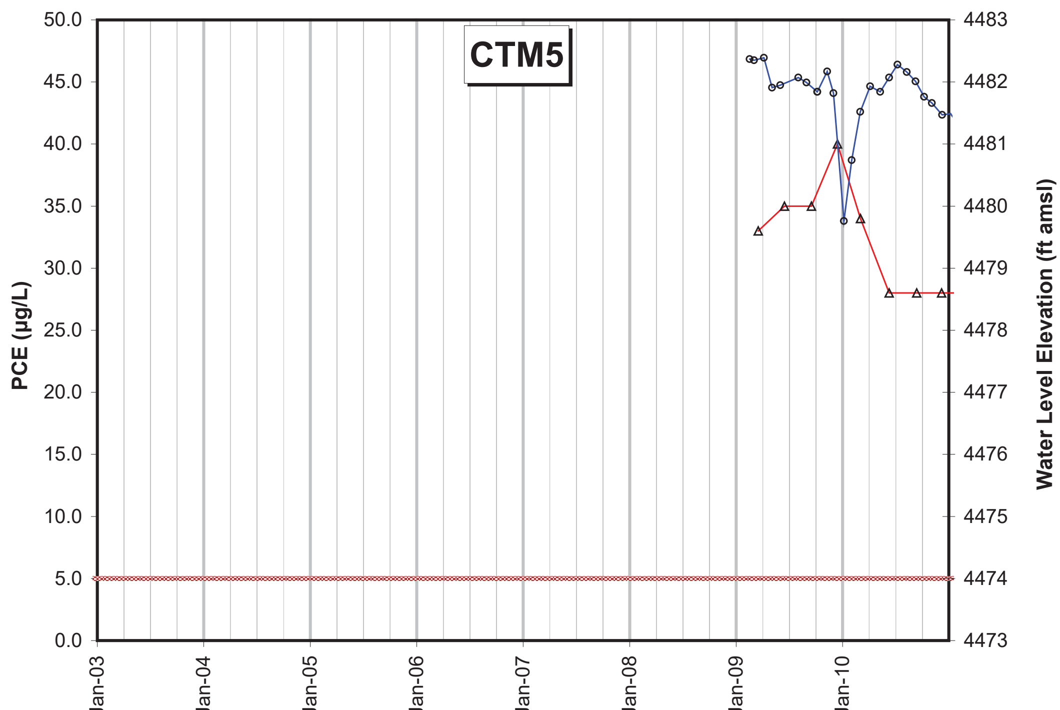
CTM99 / CTM98 / CTM97

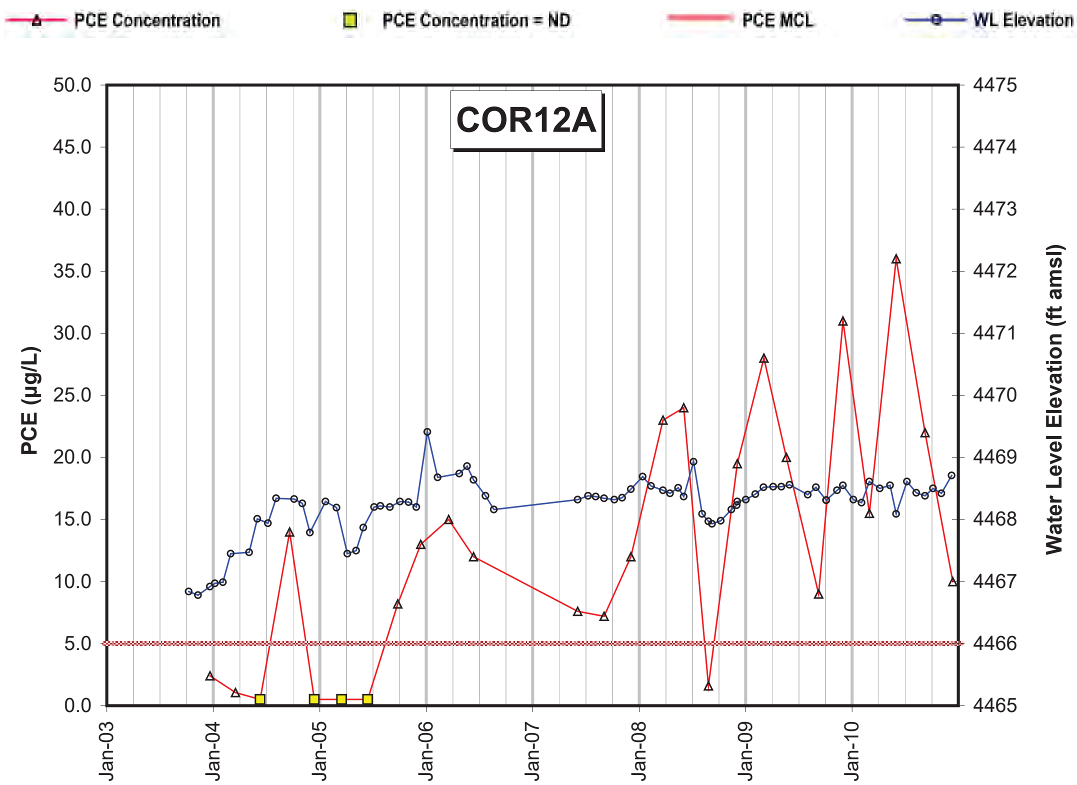


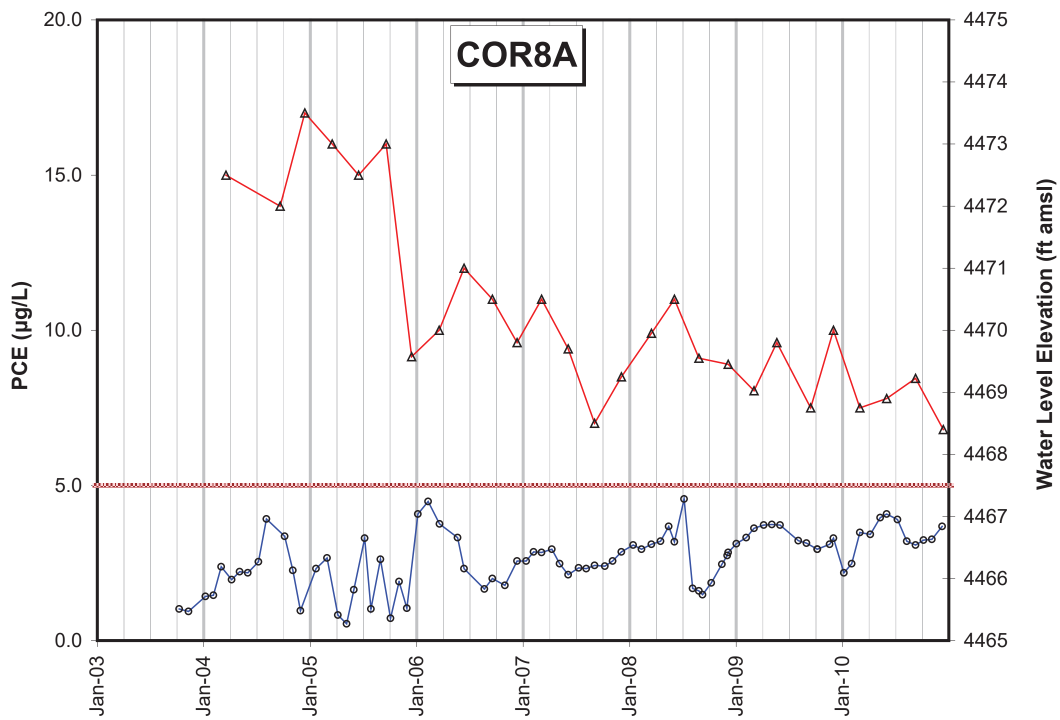


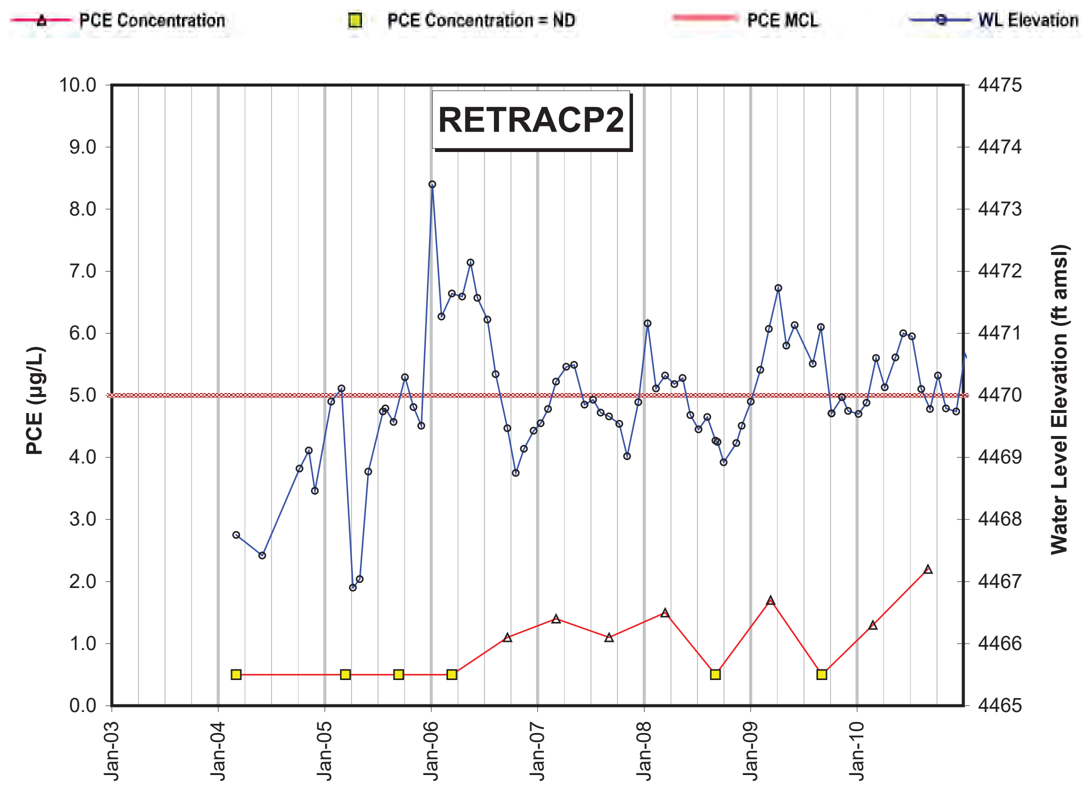
PCE Concentration   PCE Concentration = ND   PCE MCL   WL Elevation

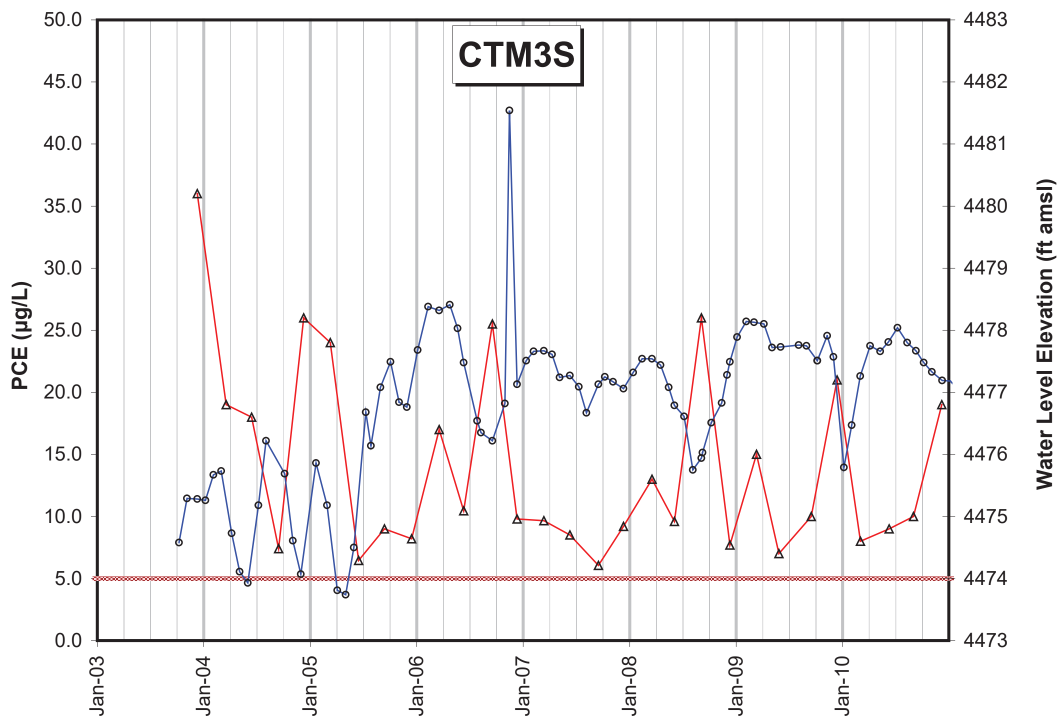


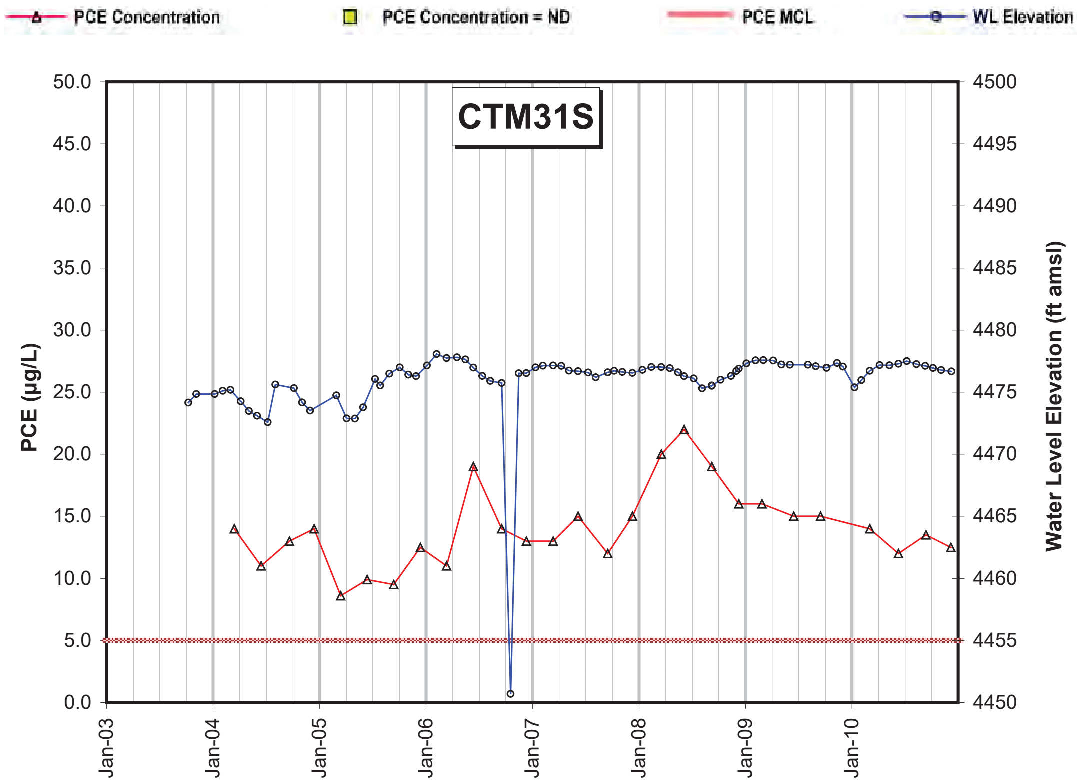


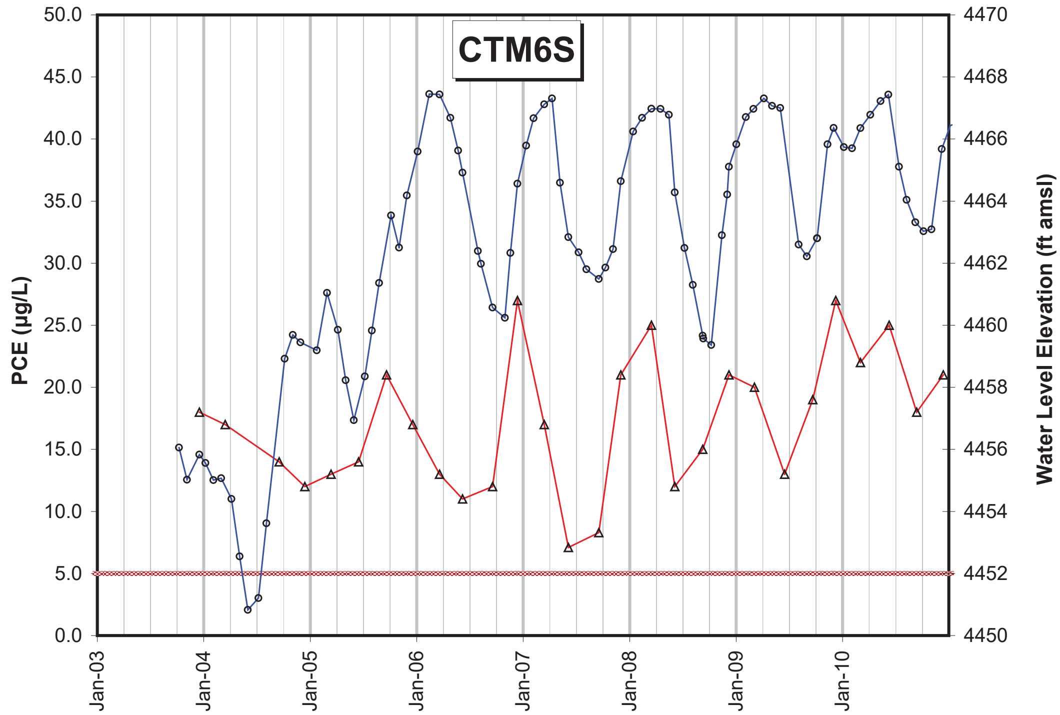

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
COR12A
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4475
4474
4473
4472
4471
4470
4469
4468
4467
4466
4465
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


COR8A
PCE (µg/L)
Water Level Elevation (ft amsl)
20.0
15.0
10.0
5.0
0.0
4475
4474
4473
4472
4471
4470
4469
4468
4467
4466
4465
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

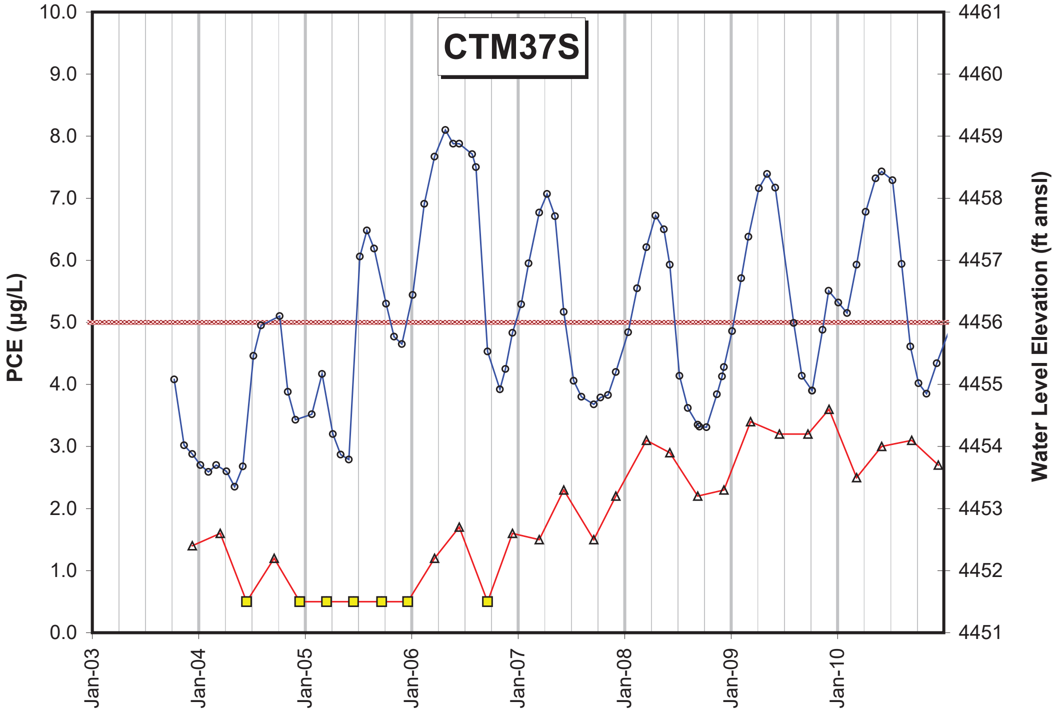

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
RETRACP2
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4475
4474
4473
4472
4471
4470
4469
4468
4467
4466
4465
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

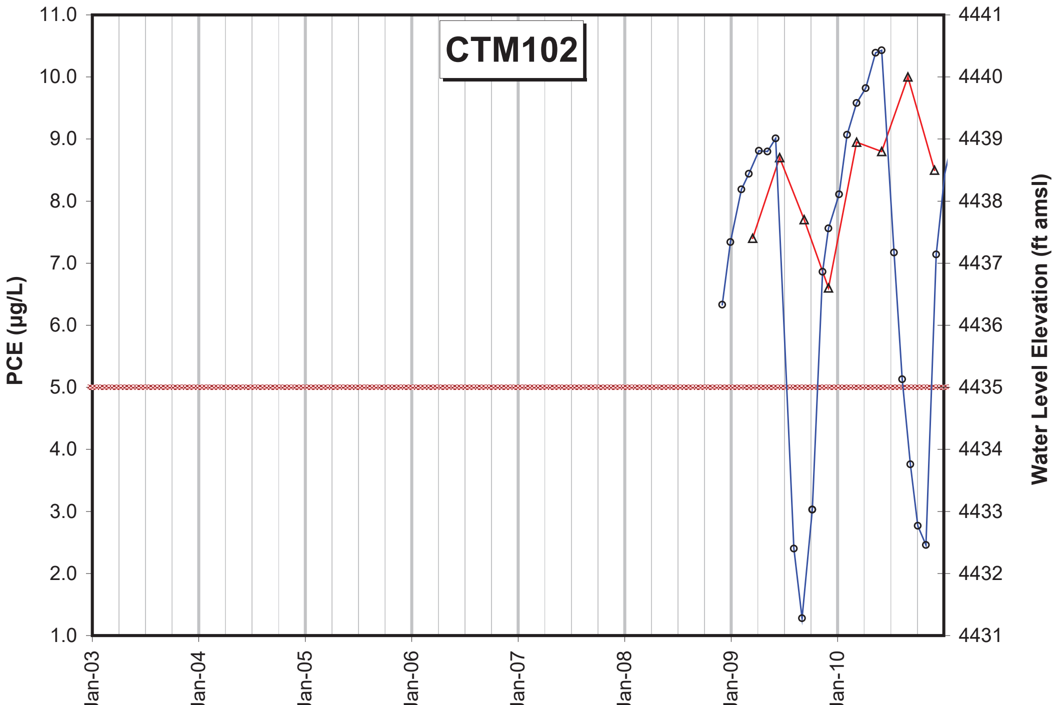

CTM3S
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4483
4482
4481
4480
4479
4478
4477
4476
4475
4474
4473
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

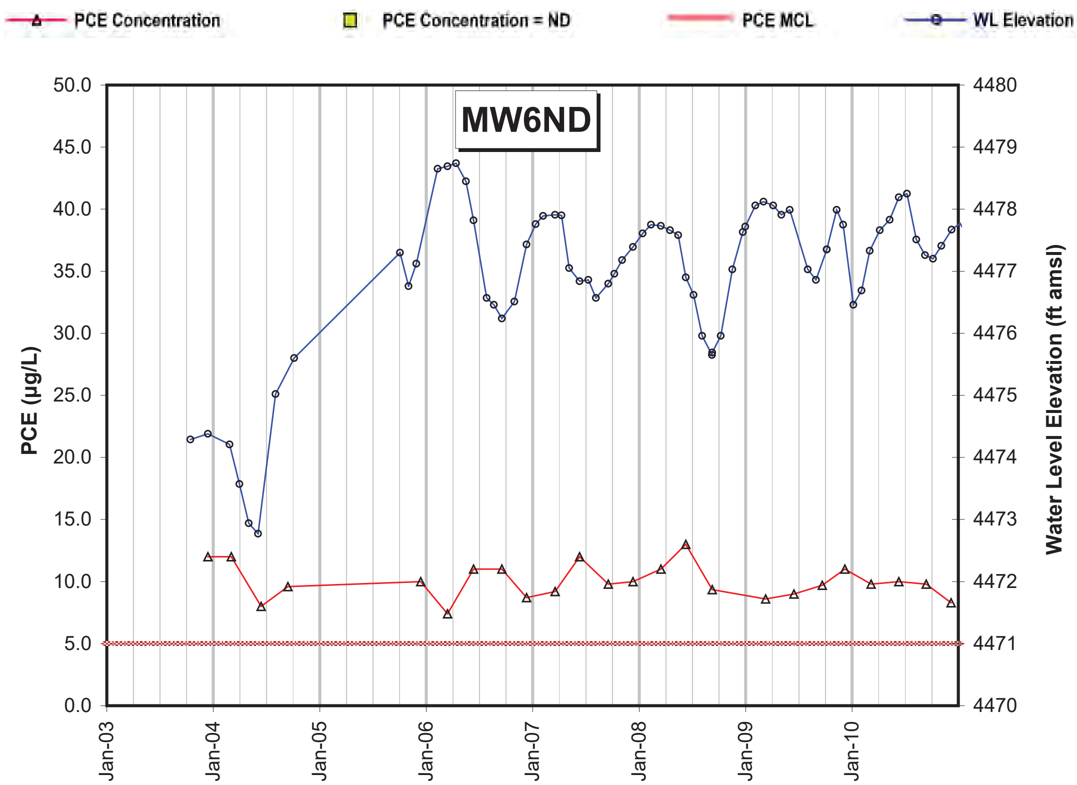

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM31S
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4500
4495
4490
4485
4480
4475
4470
4465
4460
4455
4450
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

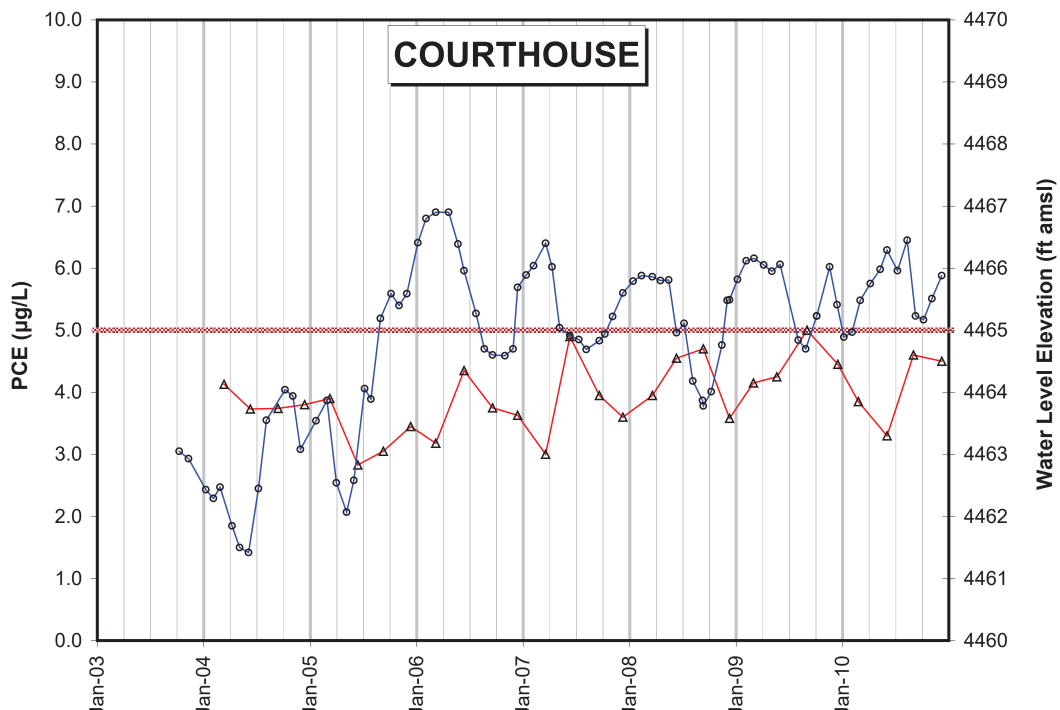

CTM6S
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4470
4468
4466
4464
4462
4460
4458
4456
4454
4452
4450
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

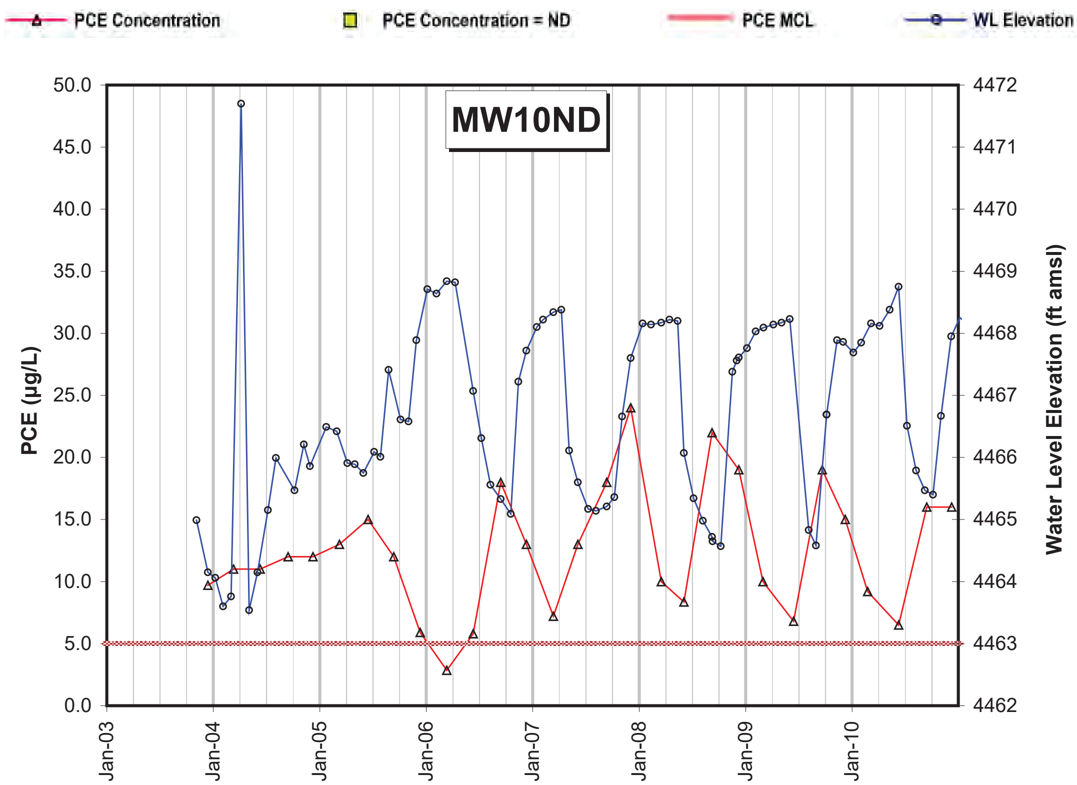
PCE Concentration | PCE Concentration = ND | PCE MCL | WL Elevation

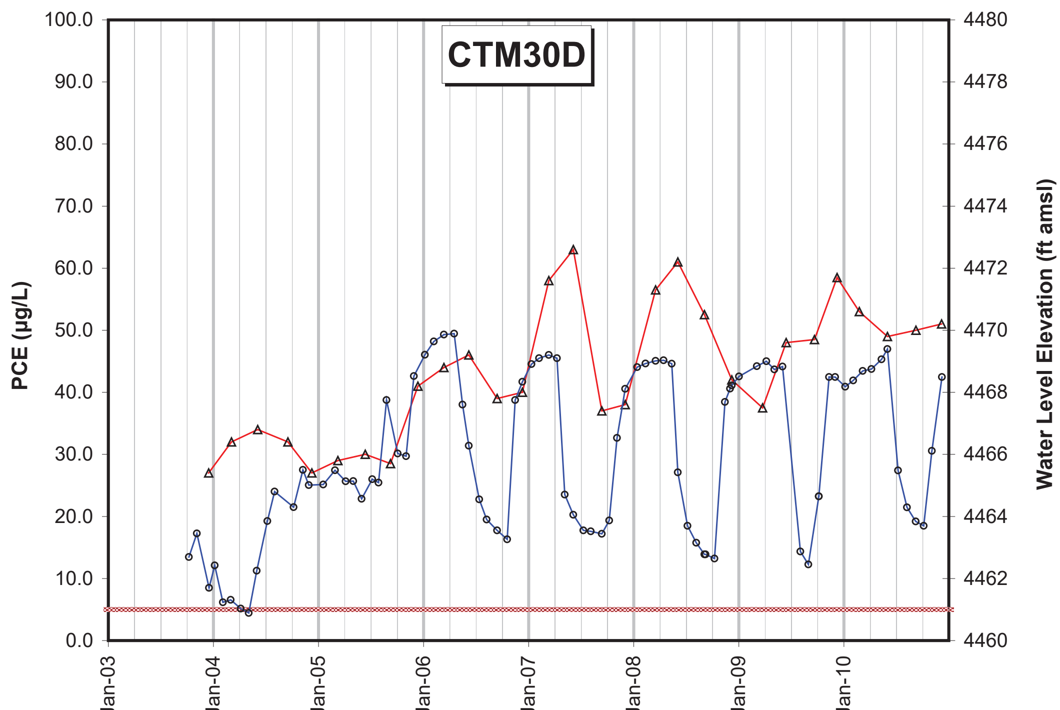


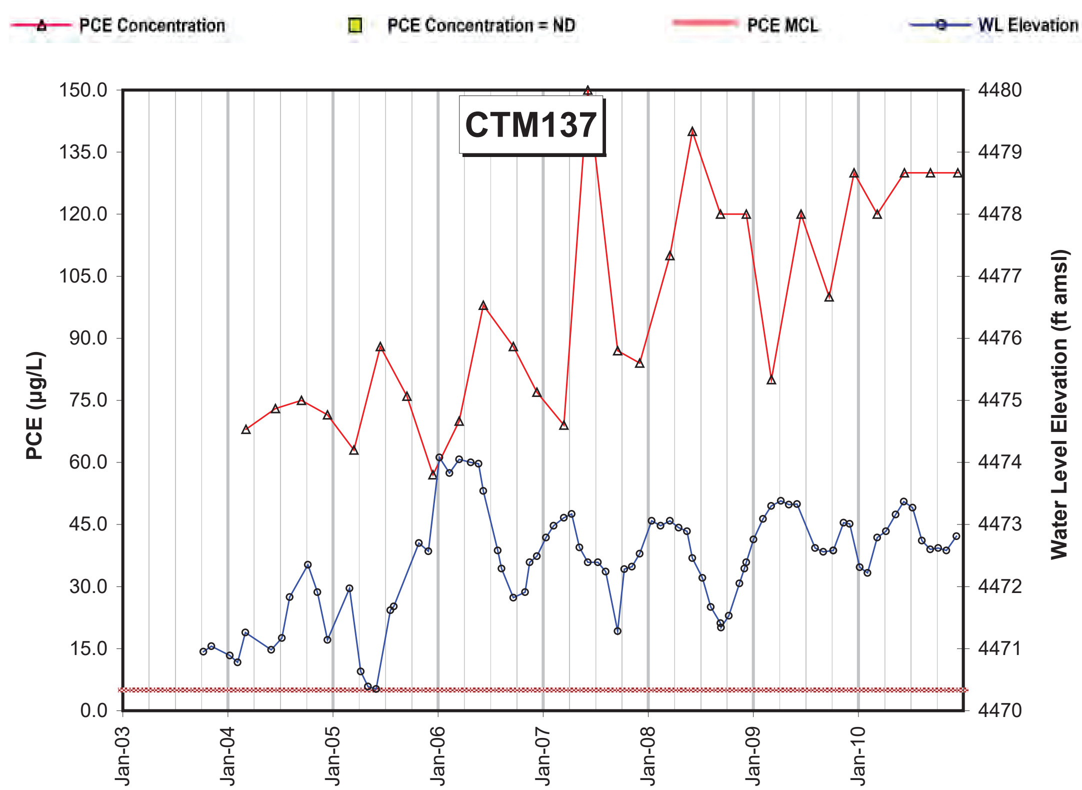


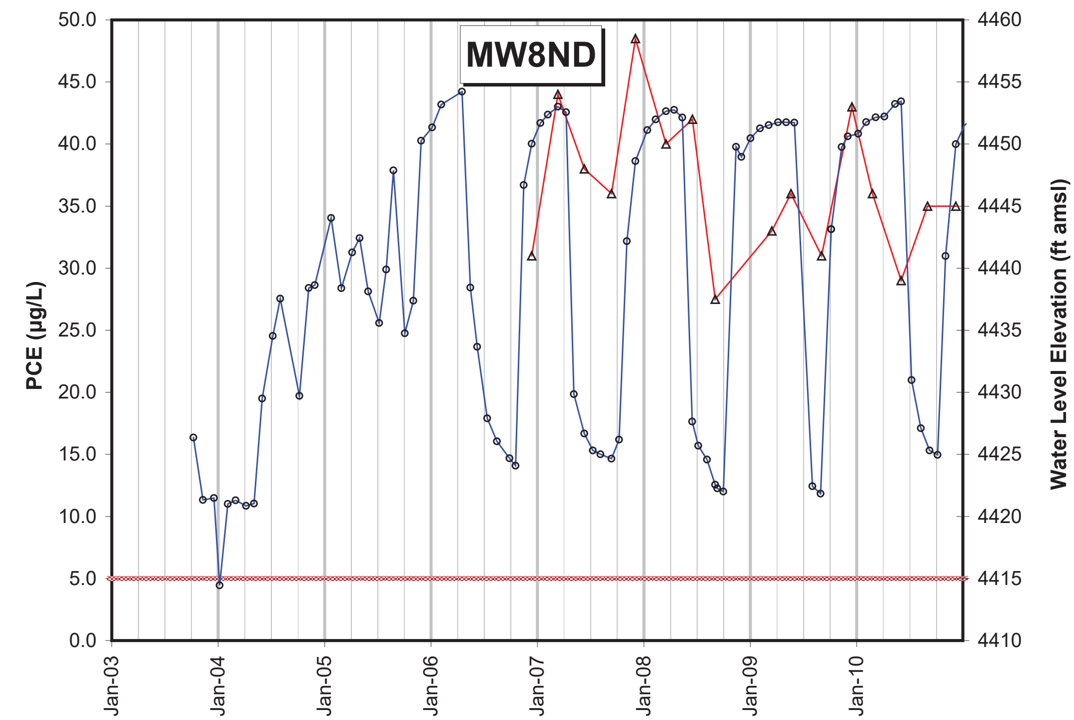

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
MW6ND
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4480
4479
4478
4477
4476
4475
4474
4473
4472
4471
4470
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

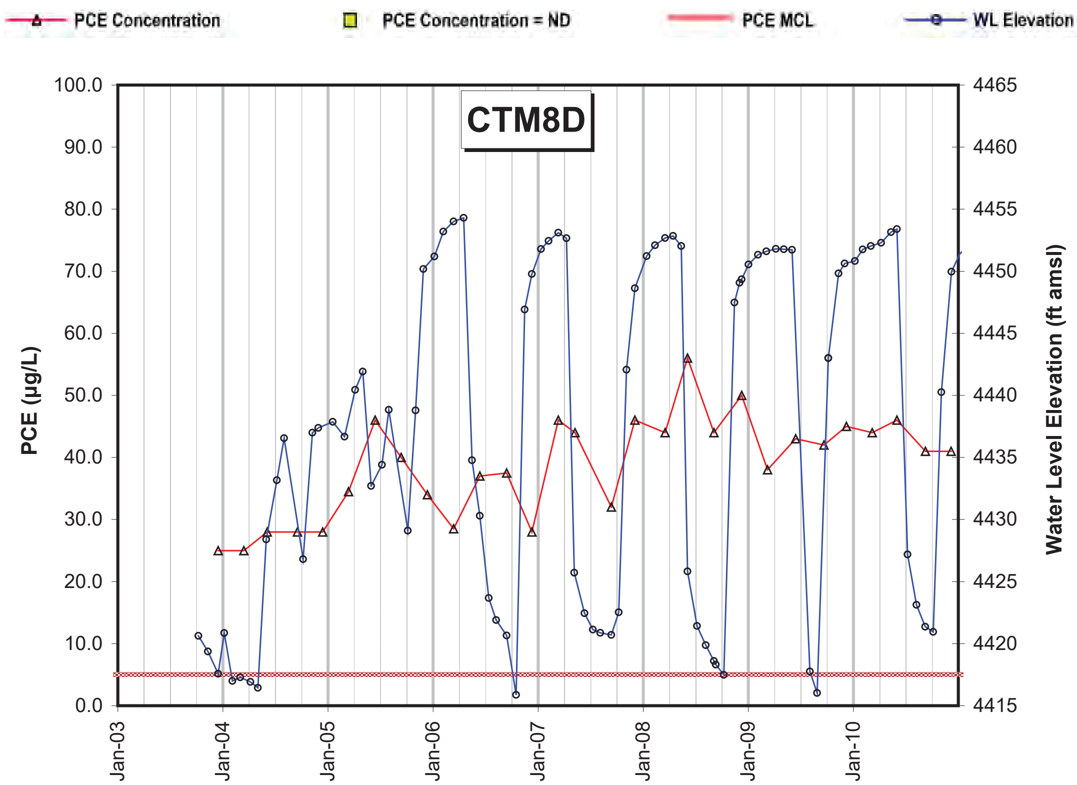

COURTHOUSE
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4470
4469
4468
4467
4466
4465
4464
4463
4462
4461
4460
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

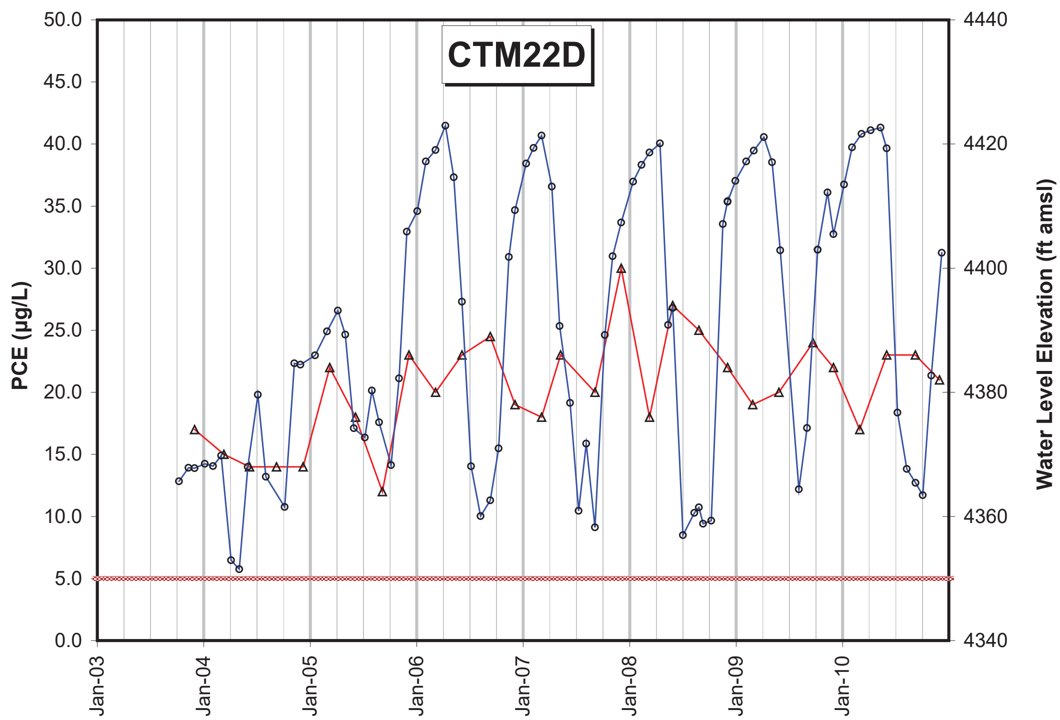

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
MW10ND
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4472
4471
4470
4469
4468
4467
4466
4465
4464
4463
4462
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

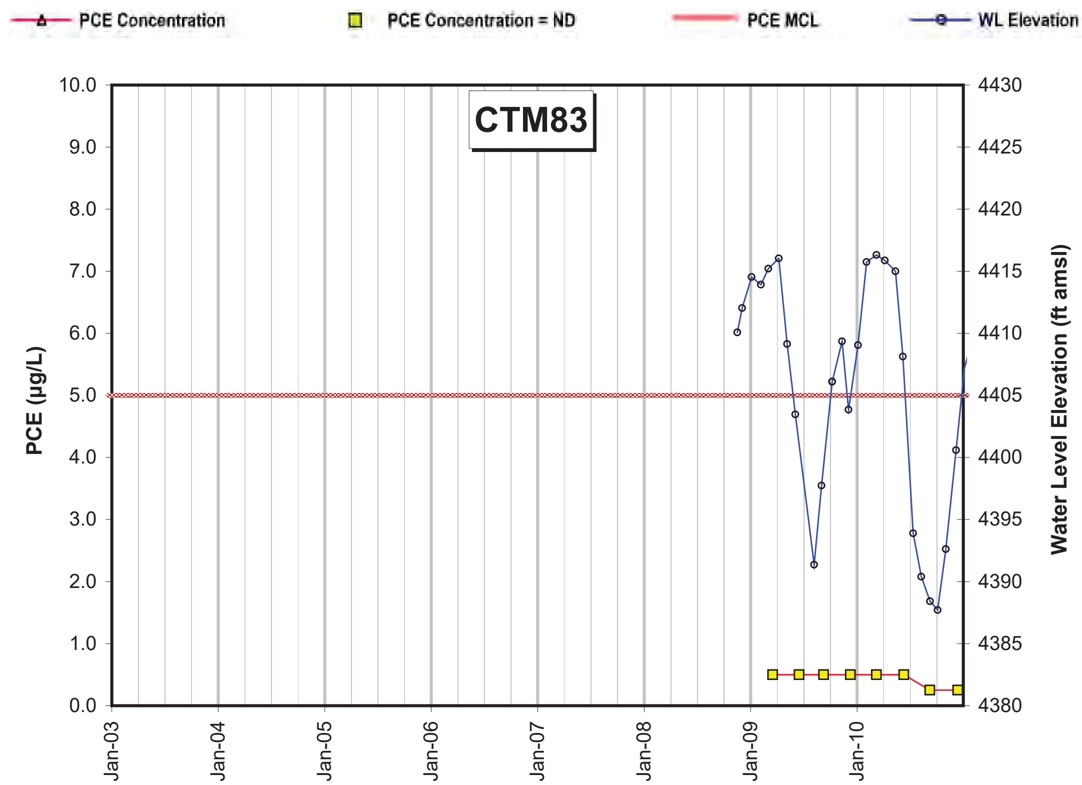

CTM30D
PCE (µg/L)
Water Level Elevation (ft amsl)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4480
4478
4476
4474
4472
4470
4468
4466
4464
4462
4460
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

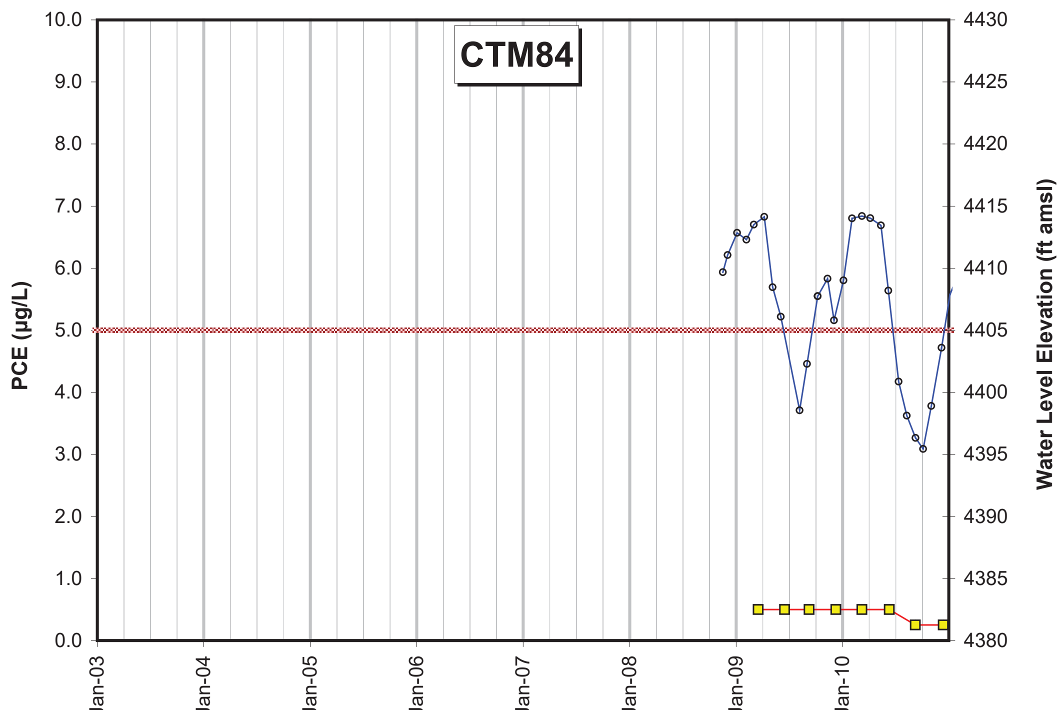

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM137
PCE (µg/L)
Water Level Elevation (ft amsl)
150.0
135.0
120.0
105.0
90.0
75.0
60.0
45.0
30.0
15.0
0.0
4480
4479
4478
4477
4476
4475
4474
4473
4472
4471
4470
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

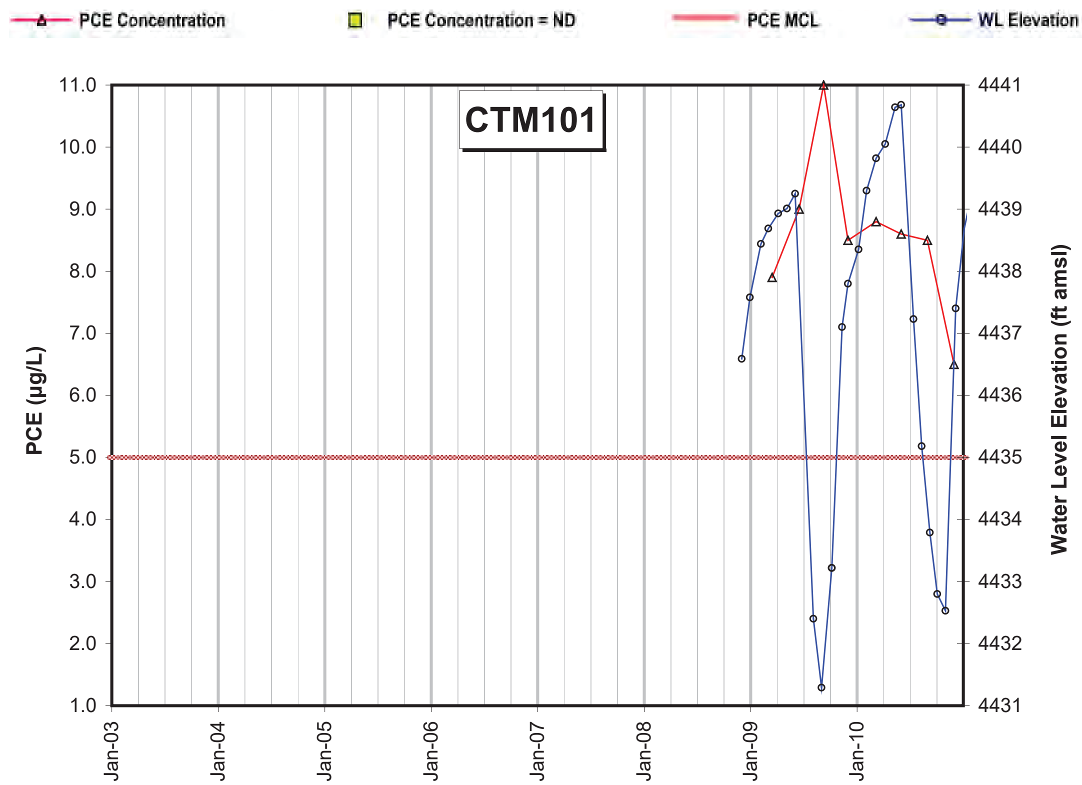

MW8ND
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4460
4455
4450
4445
4440
4435
4430
4425
4420
4415
4410
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

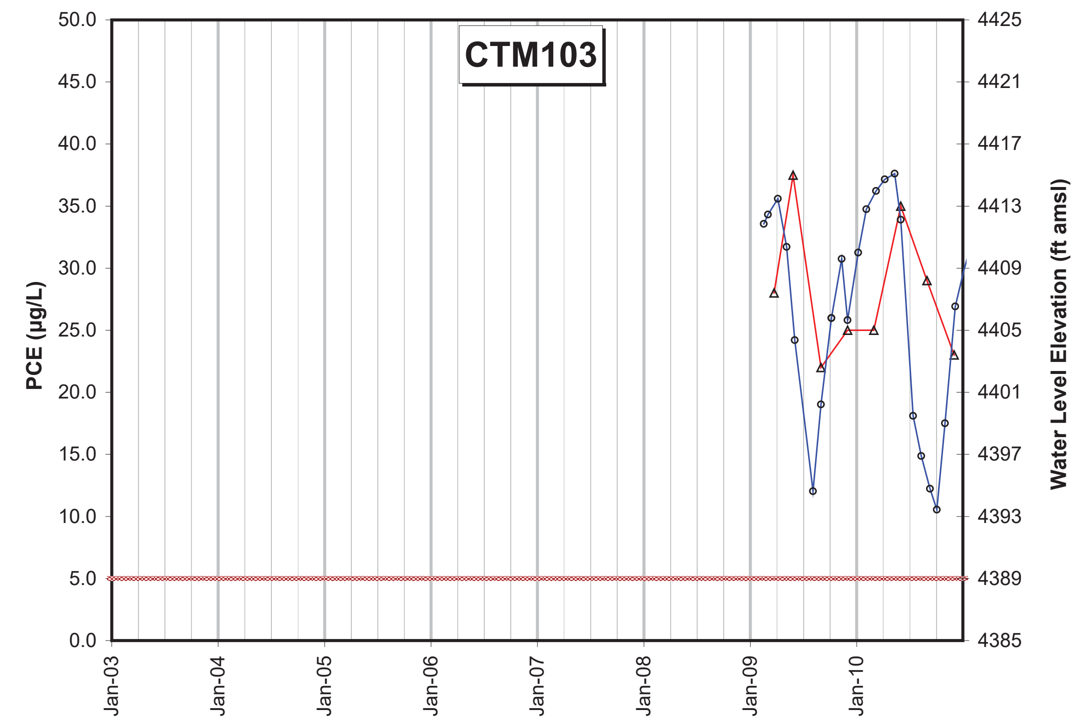

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM8D
PCE (µg/L)
Water Level Elevation (ft amsl)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4465
4460
4455
4450
4445
4440
4435
4430
4425
4420
4415
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

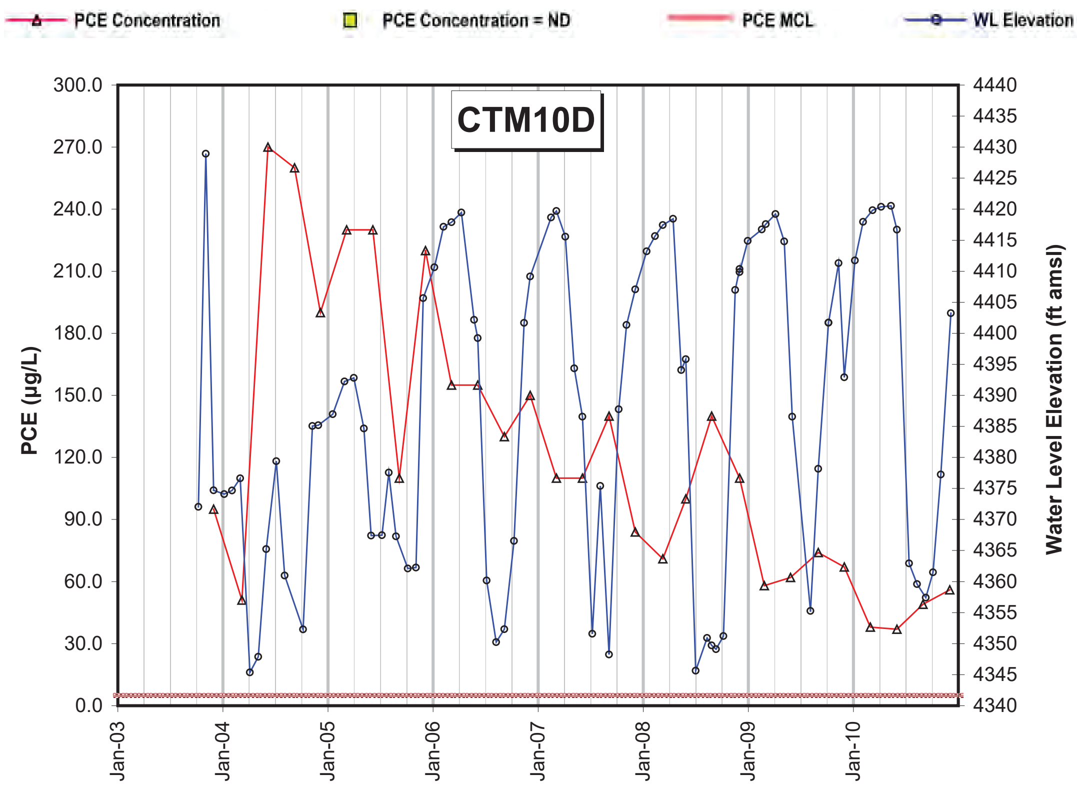

CTM22D
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4440
4420
4400
4380
4360
4340
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

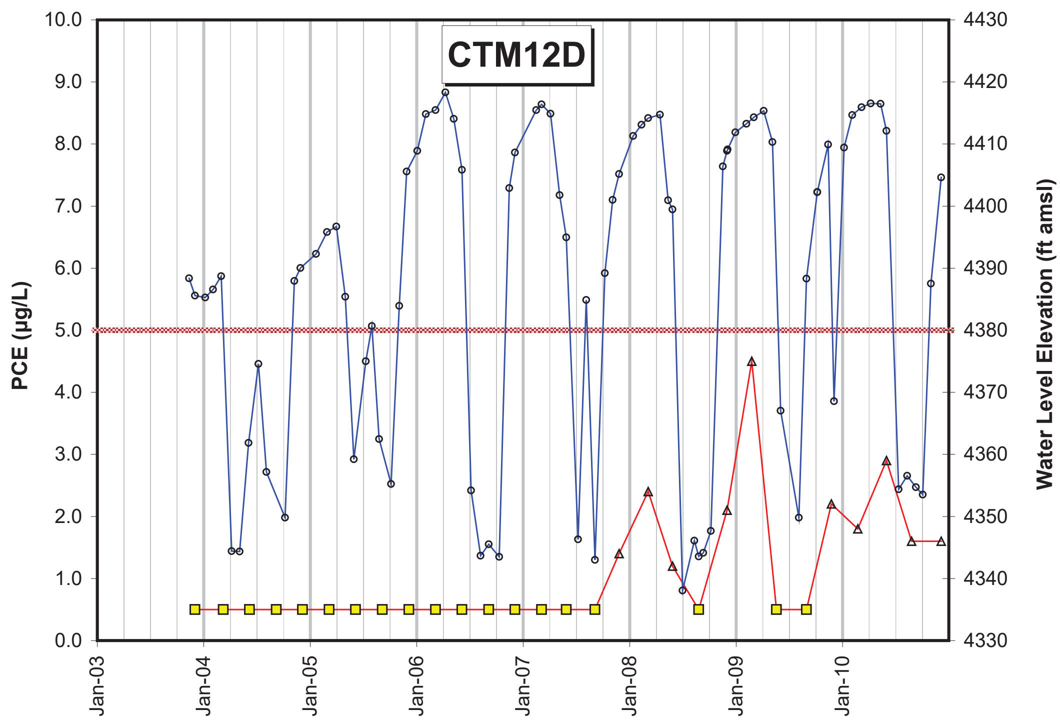

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM83
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4430
4425
4420
4415
4410
4405
4400
4395
4390
4385
4380
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


CTM84
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4430
4425
4420
4415
4410
4405
4400
4395
4390
4385
4380
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM101
PCE (µg/L)
Water Level Elevation (ft amsl)
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
4441
4440
4439
4438
4437
4436
4435
4434
4433
4432
4431
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

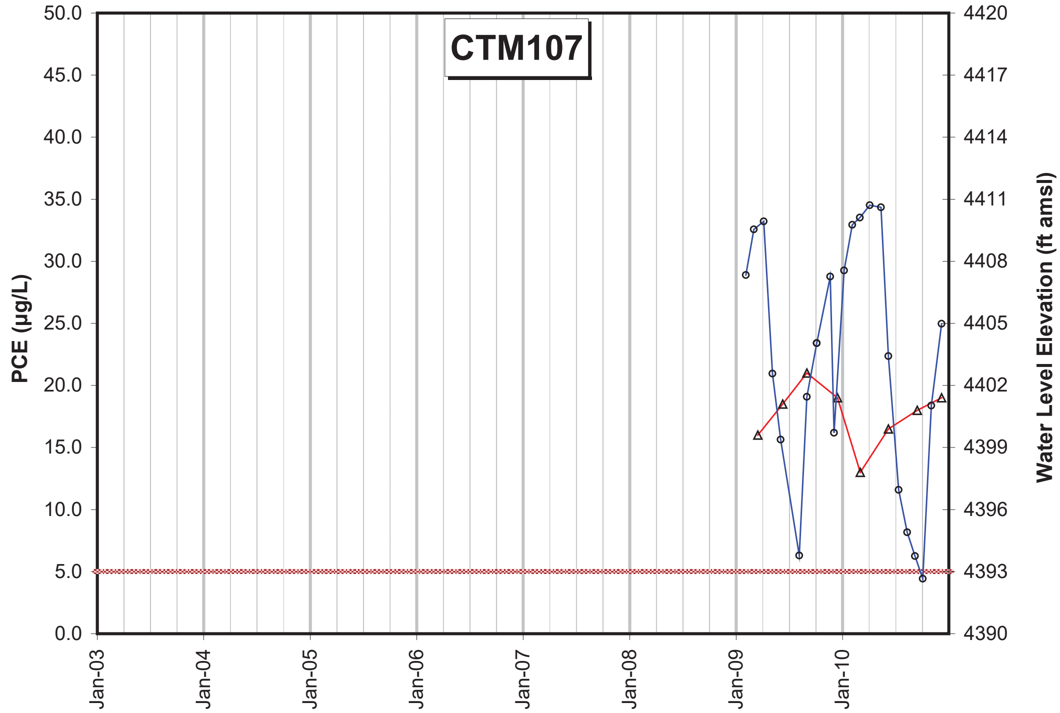

CTM103
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4425
4421
4417
4413
4409
4405
4401
4397
4393
4389
4385
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

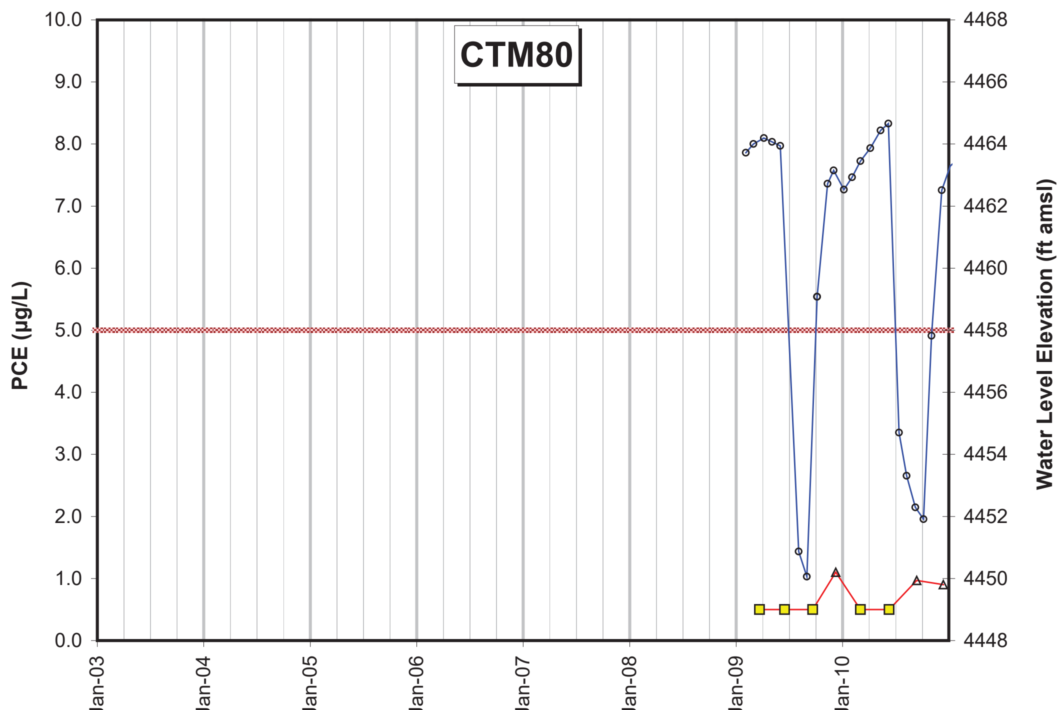


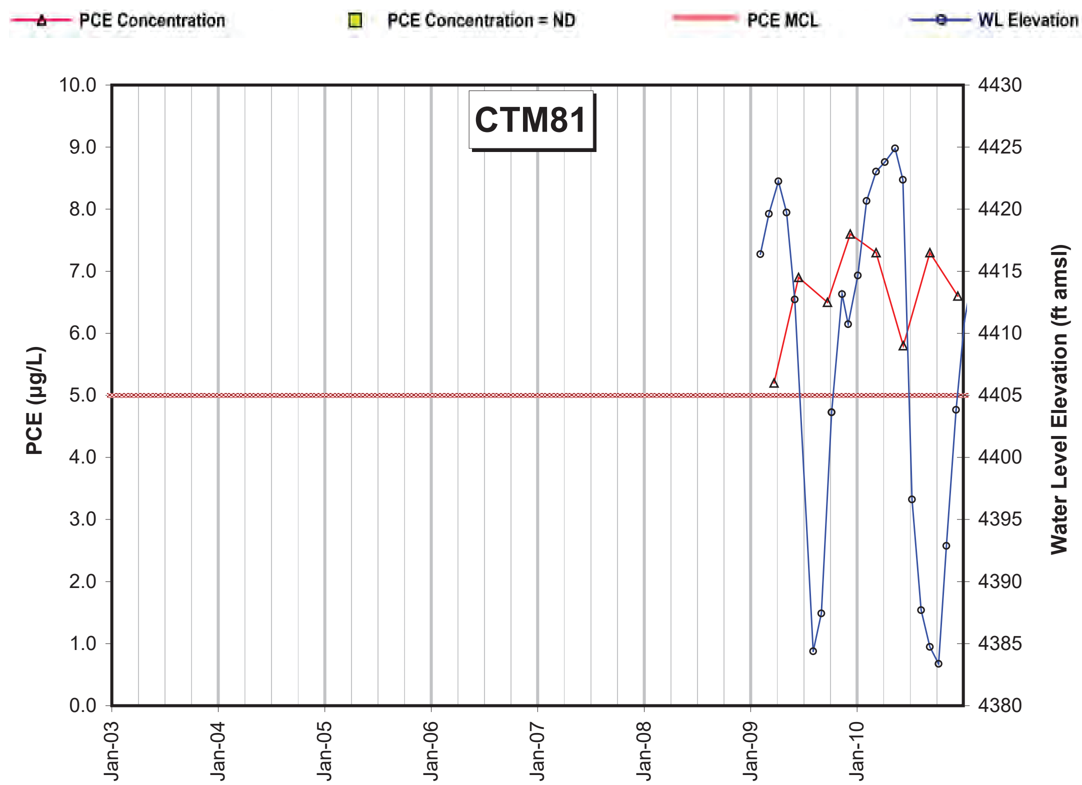


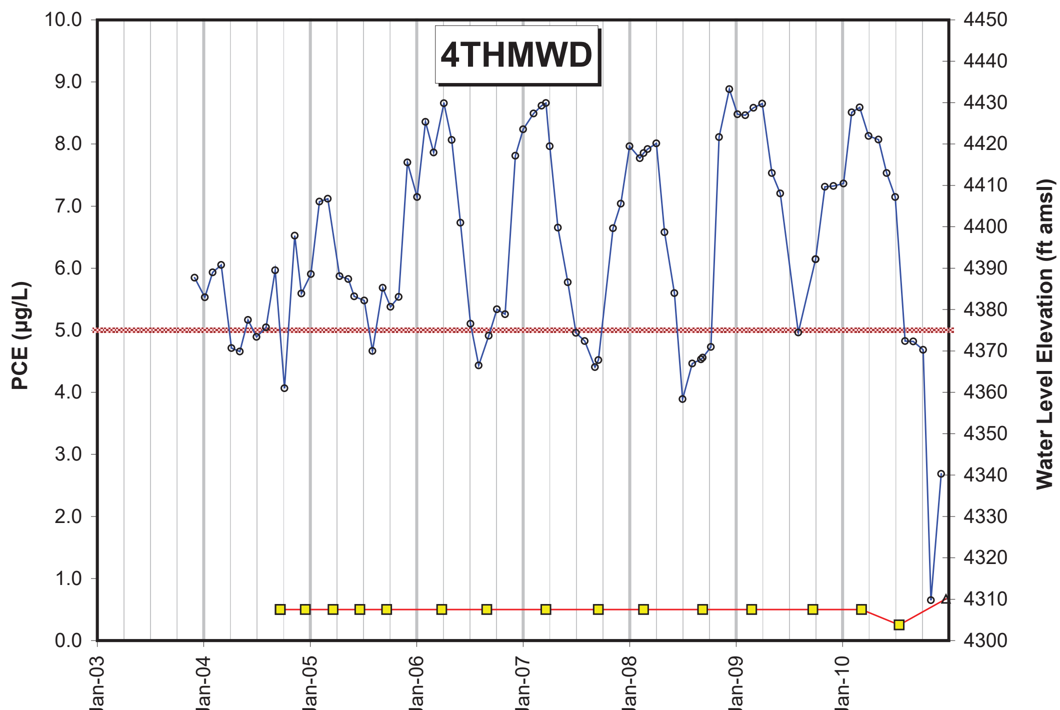
Washoe County

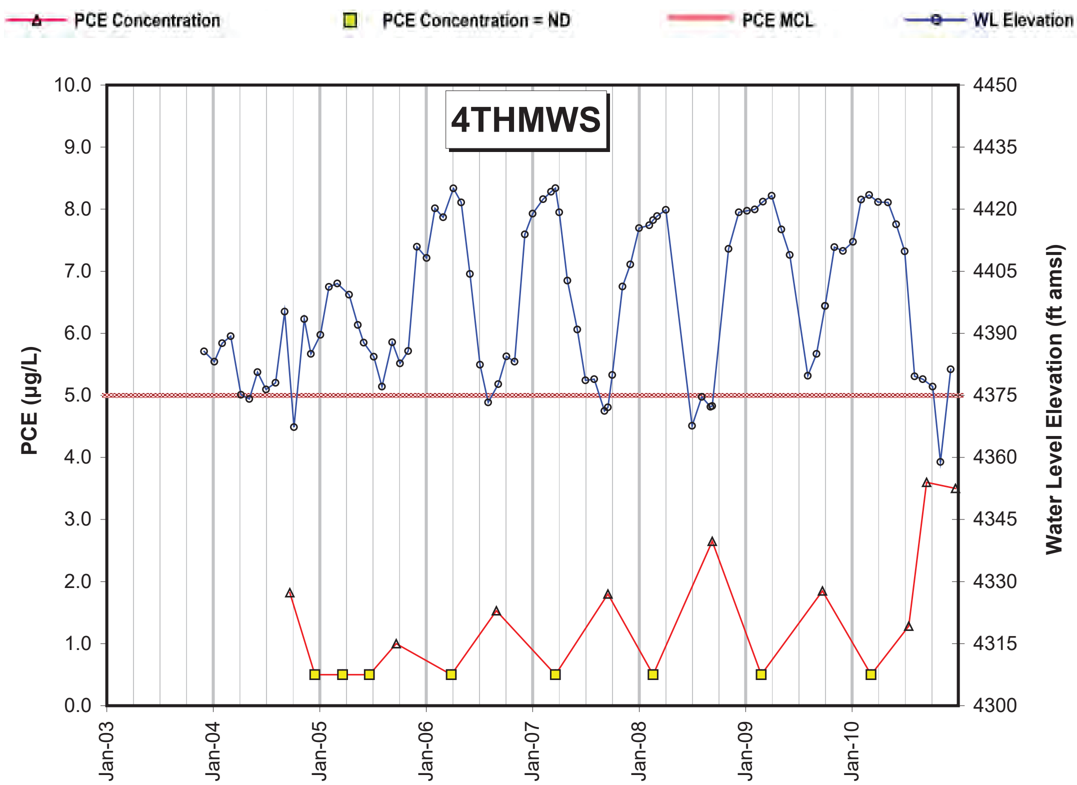
PCE Concentration | PCE Concentration = ND | PCE MCL | WL Elevation

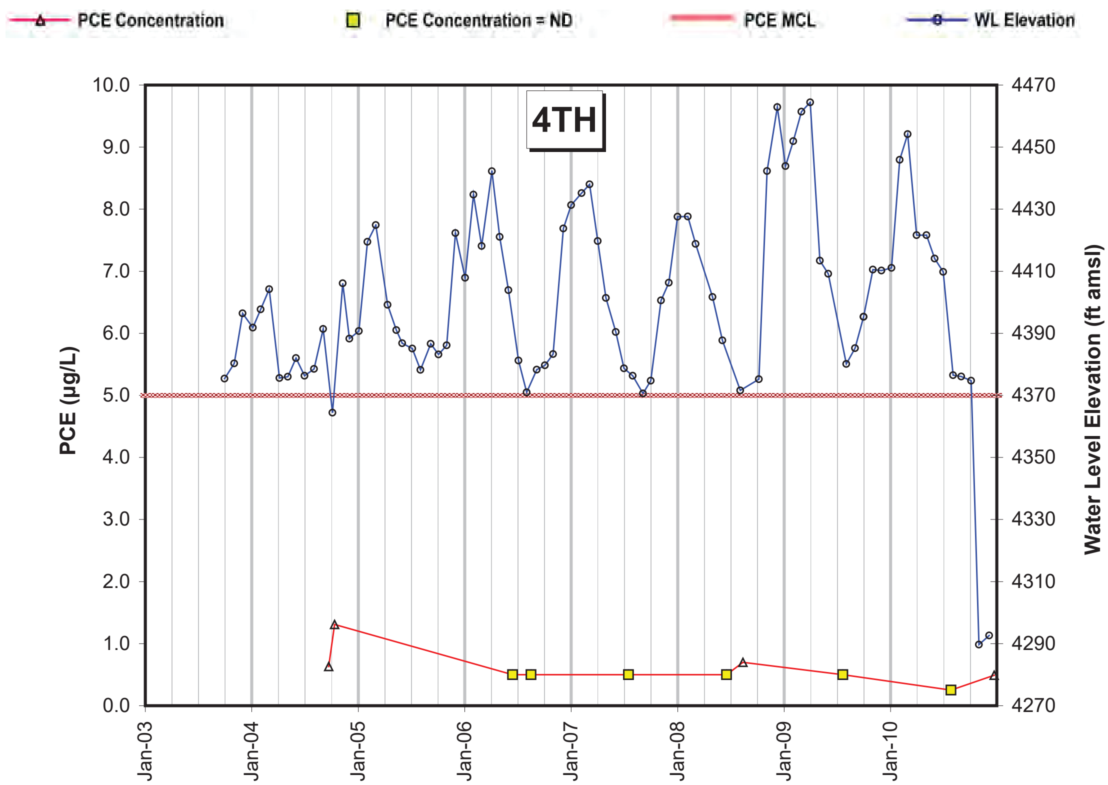


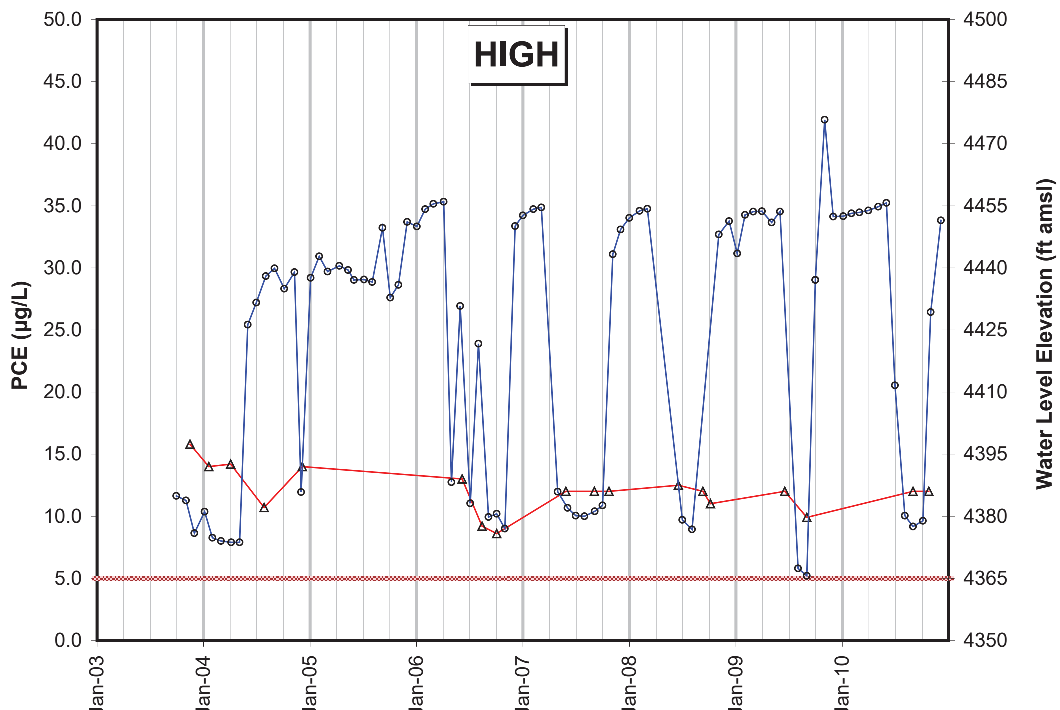


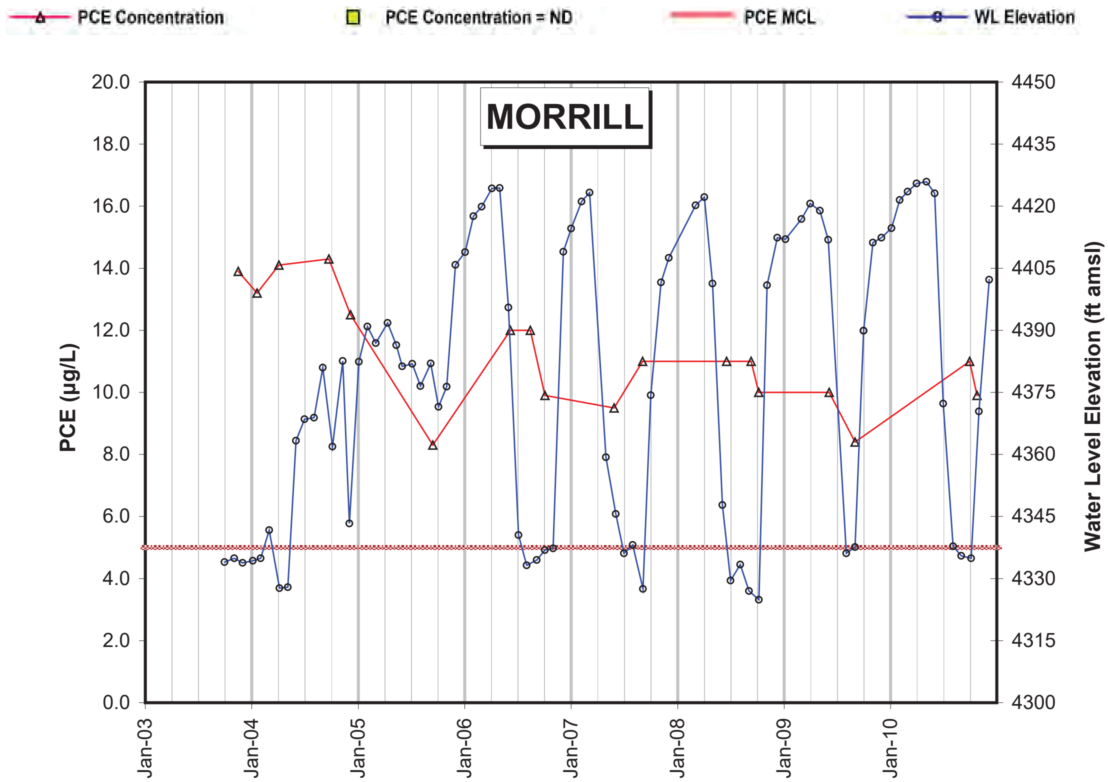

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
CTM81
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4430
4425
4420
4415
4410
4405
4400
4395
4390
4385
4380
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

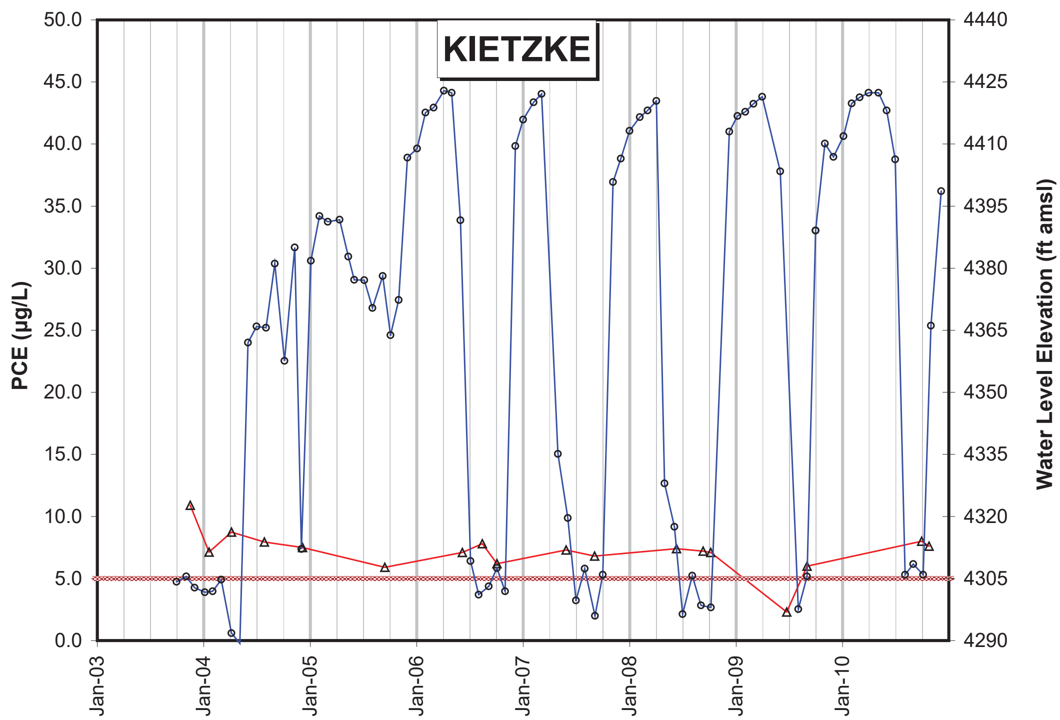

4THMWD
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4450
4440
4430
4420
4410
4400
4390
4380
4370
4360
4350
4340
4330
4320
4310
4300
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

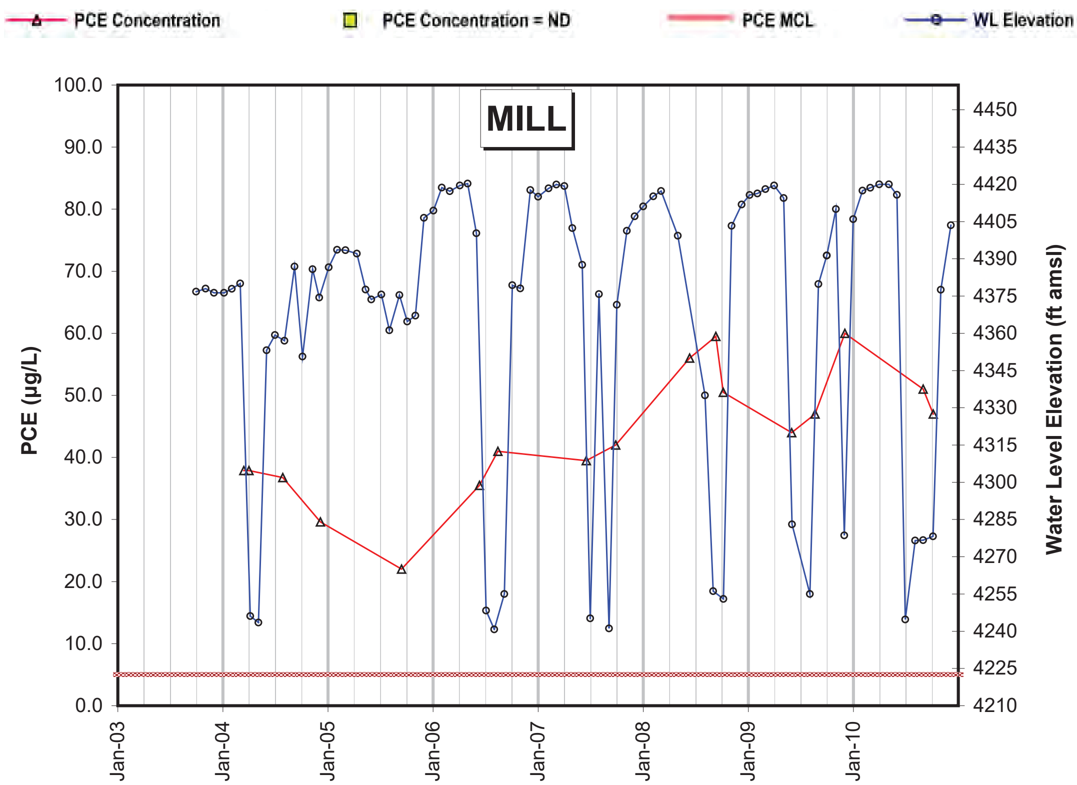

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
4THMWS
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4450
4435
4420
4405
4390
4375
4360
4345
4330
4315
4300
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
4TH
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4470
4450
4430
4410
4390
4370
4350
4330
4310
4290
4270
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

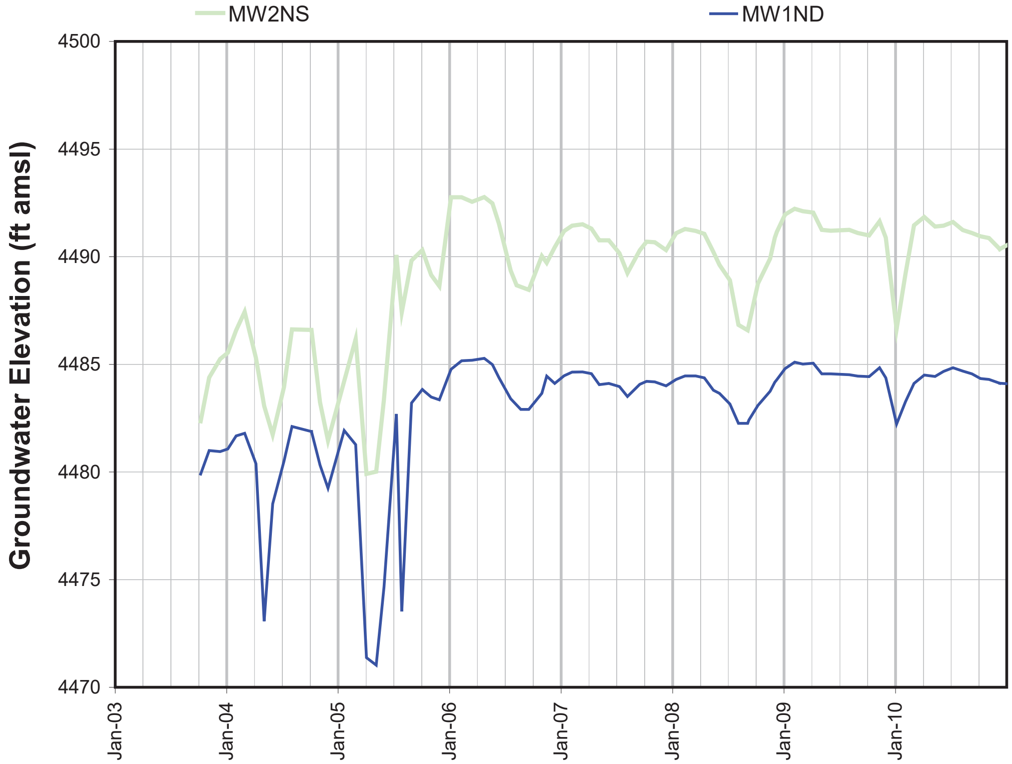

HIGH
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4500
4485
4470
4455
4440
4425
4410
4395
4380
4365
4350
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

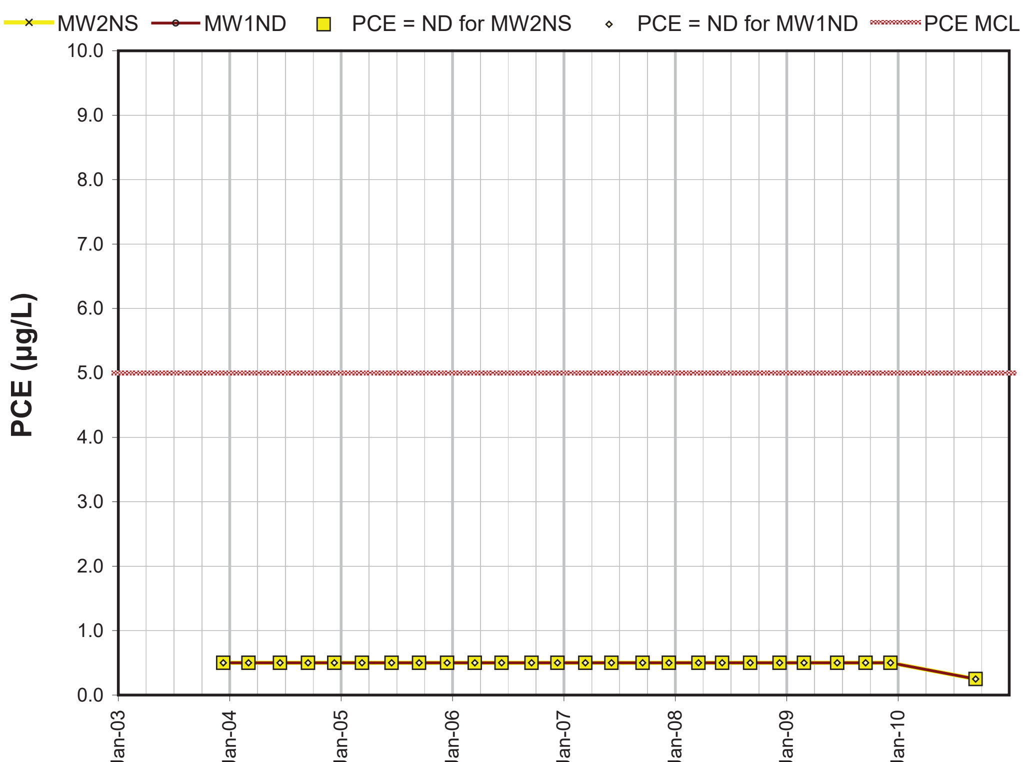

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
MORRILL
PCE (µg/L)
Water Level Elevation (ft amsl)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4450
4435
4420
4405
4390
4375
4360
4345
4330
4315
4300
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


KIETZKE
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4440
4425
4410
4395
4380
4365
4350
4335
4320
4305
4290
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

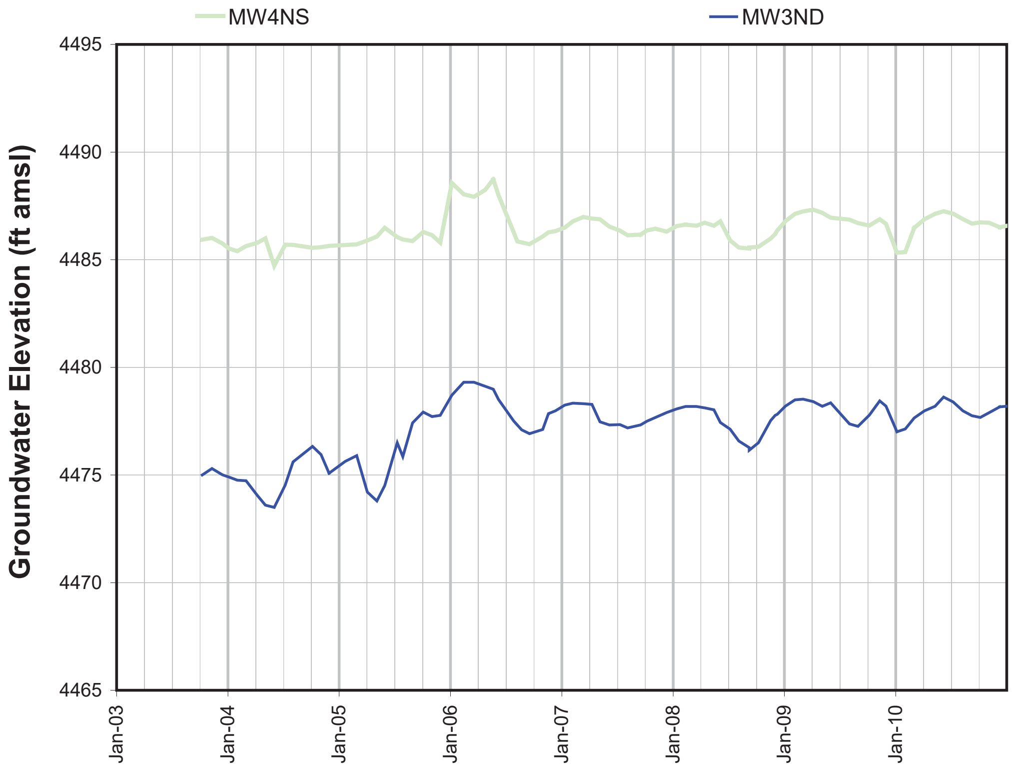

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
MILL
PCE (µg/L)
Water Level Elevation (ft amsl)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4450
4435
4420
4405
4390
4375
4360
4345
4330
4315
4300
4285
4270
4255
4240
4225
4210
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

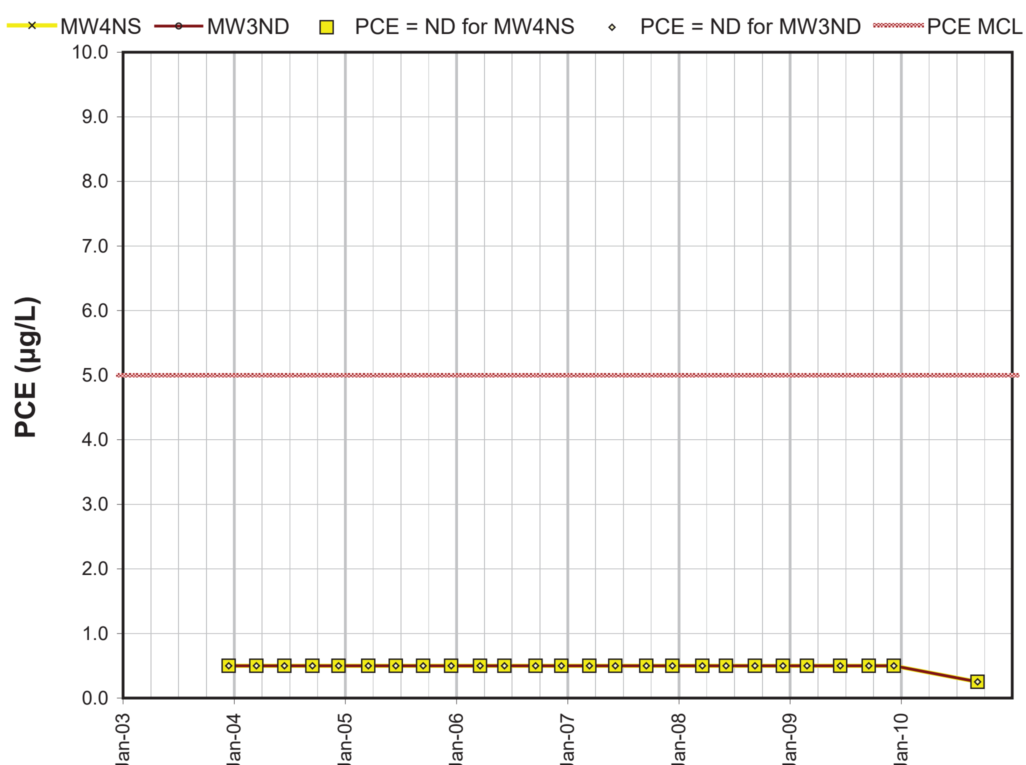
MW2NS / MW1ND


MW2NS
MW1ND
Groundwater Elevation (ft amsl)
4500
4495
4490
4485
4480
4475
4470
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

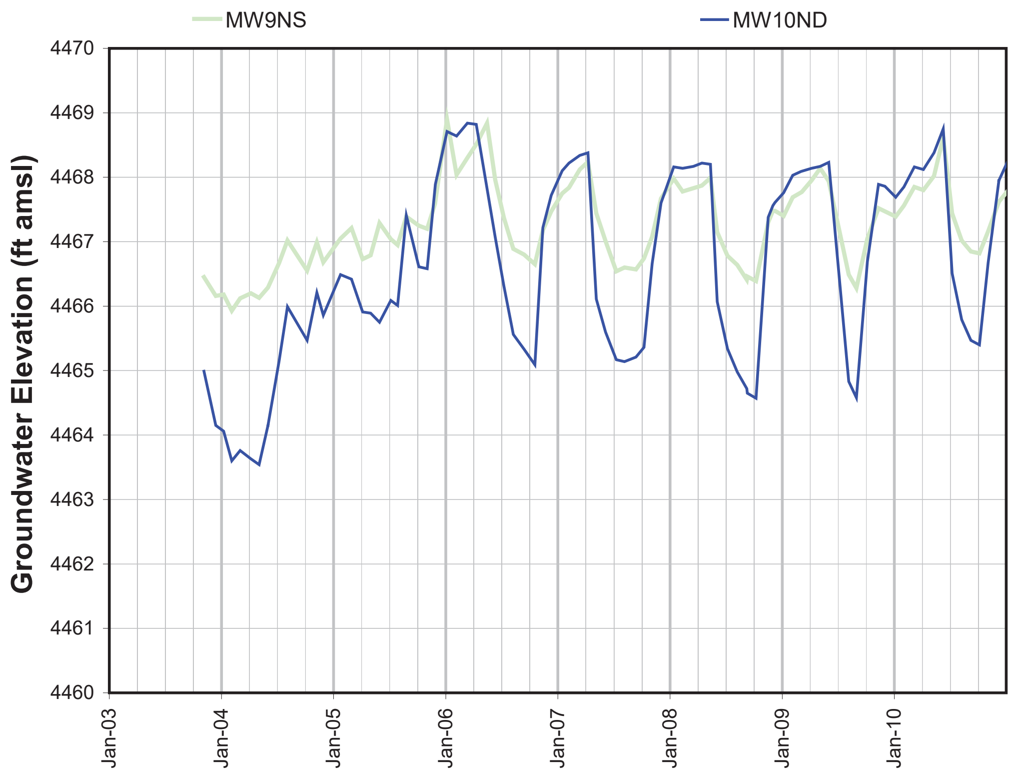

MW2NS
MW1ND
PCE = ND for MW2NS
PCE = ND for MW1ND
PCE MCL
PCE (µg/L)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

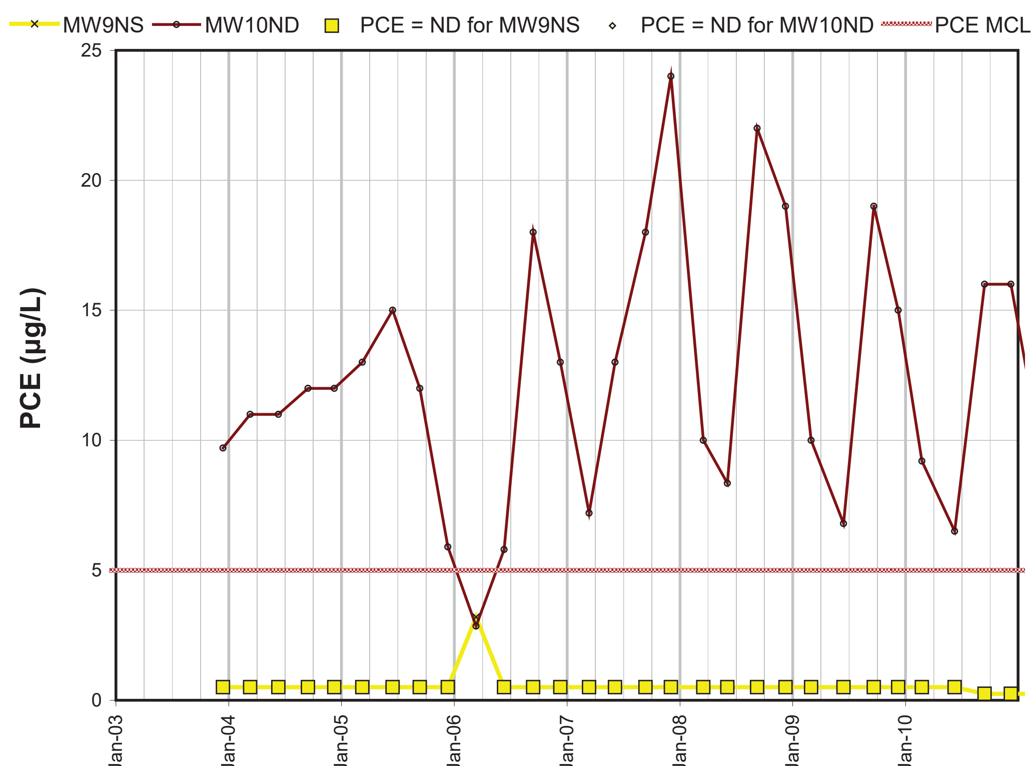
MW4NS / MW3ND


MW4NS
MW3ND
Groundwater Elevation (ft amsl)
4495
4490
4485
4480
4475
4470
4465
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

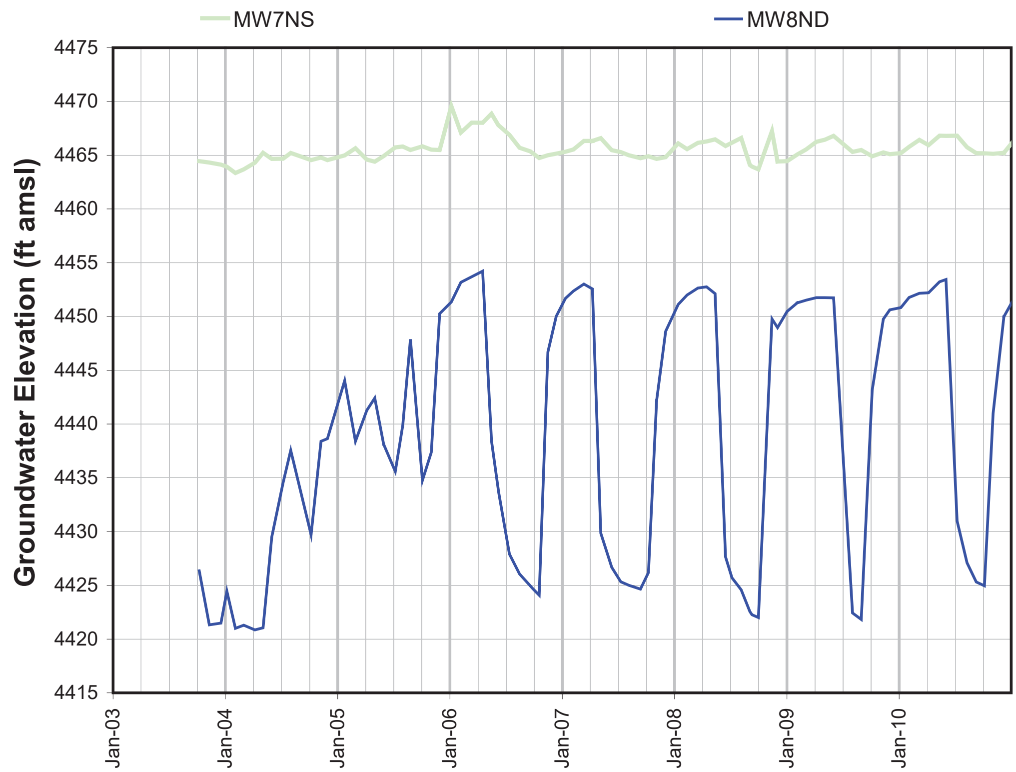

MW4NS
MW3ND
PCE = ND for MW4NS
PCE = ND for MW3ND
PCE MCL
PCE (µg/L)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

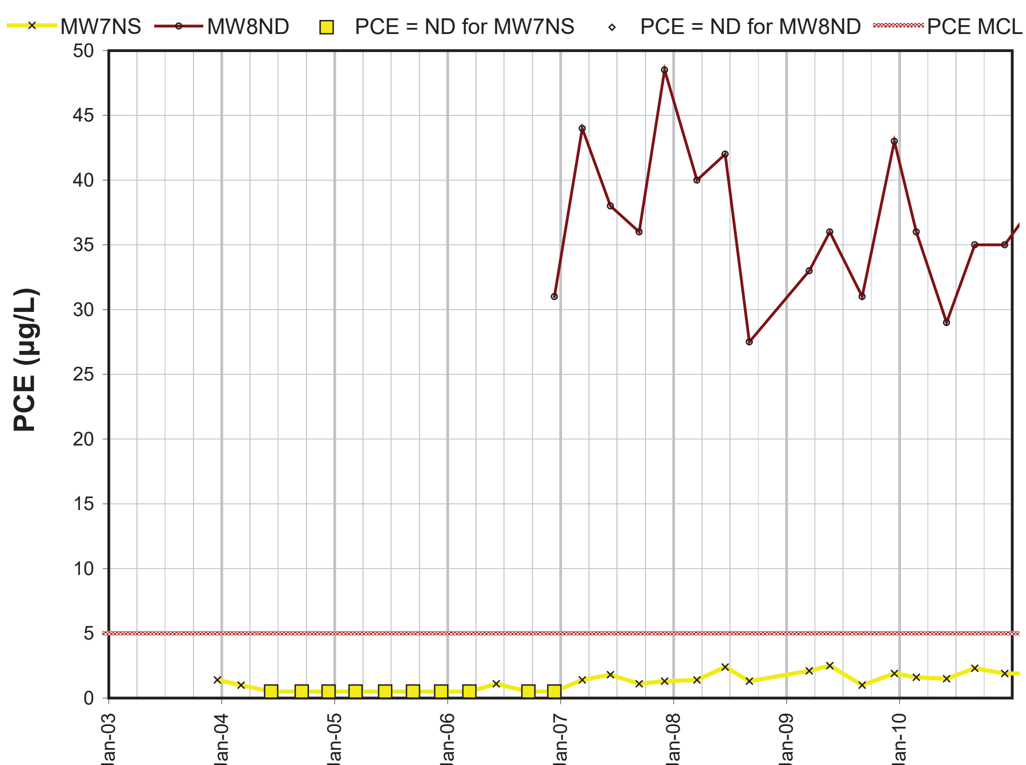
MW9NS / MW10ND



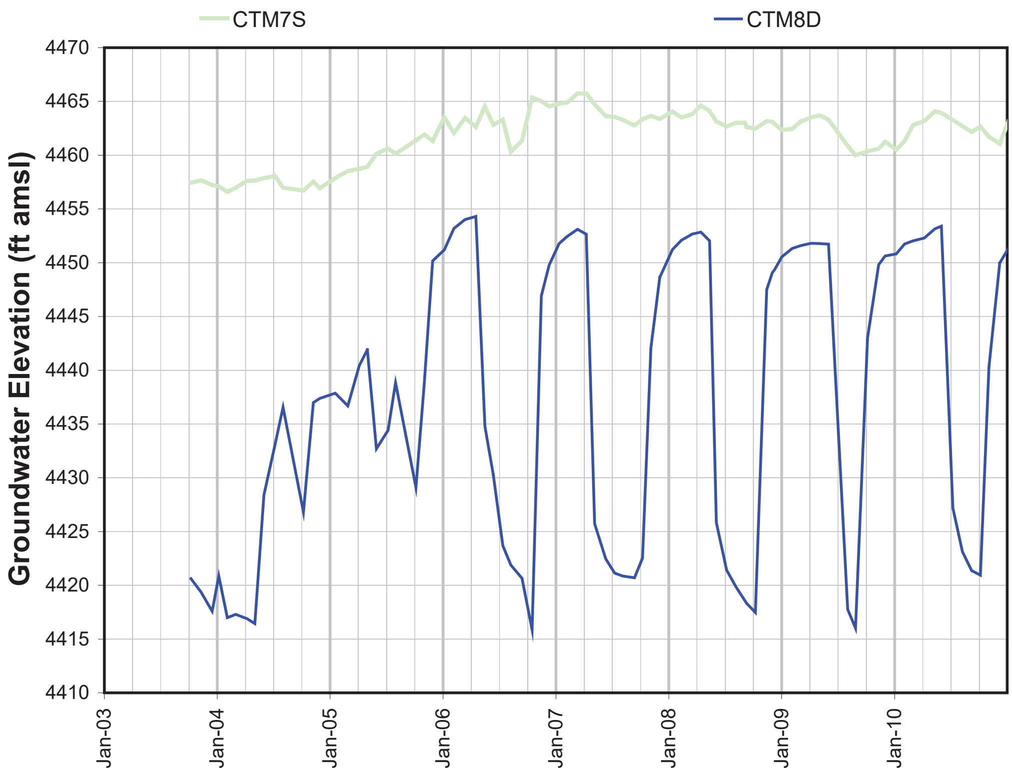


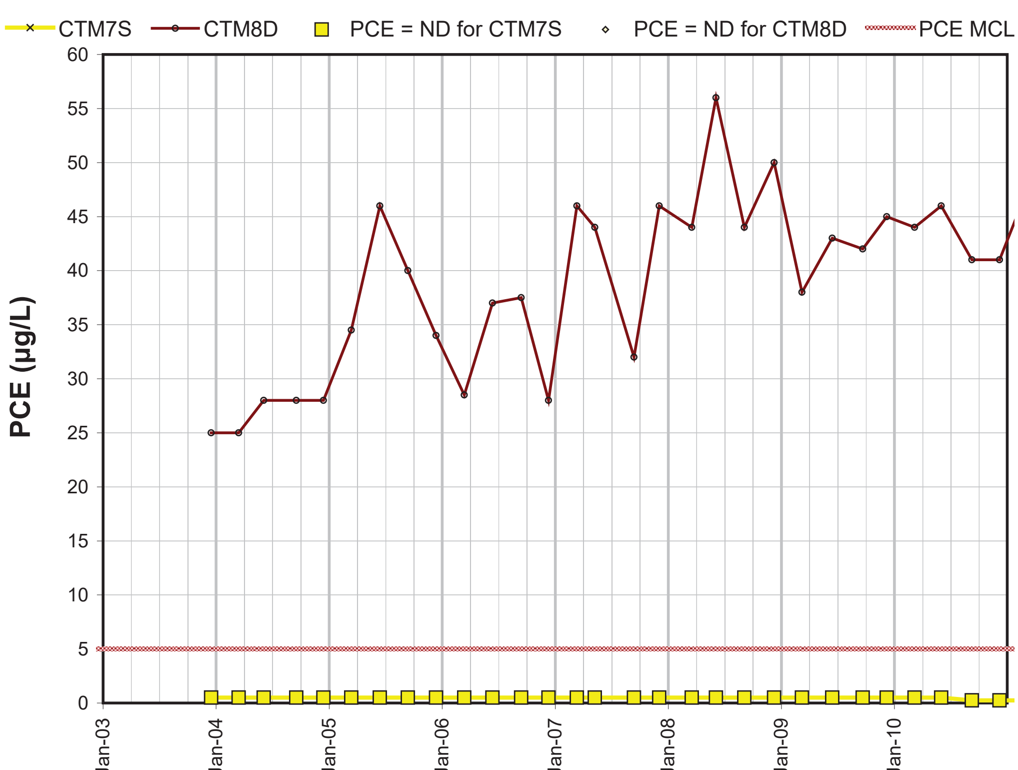
MW7NS / MW8ND


MW7NS
MW8ND
Groundwater Elevation (ft amsl)
4475
4470
4465
4460
4455
4450
4445
4440
4435
4430
4425
4420
4415
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

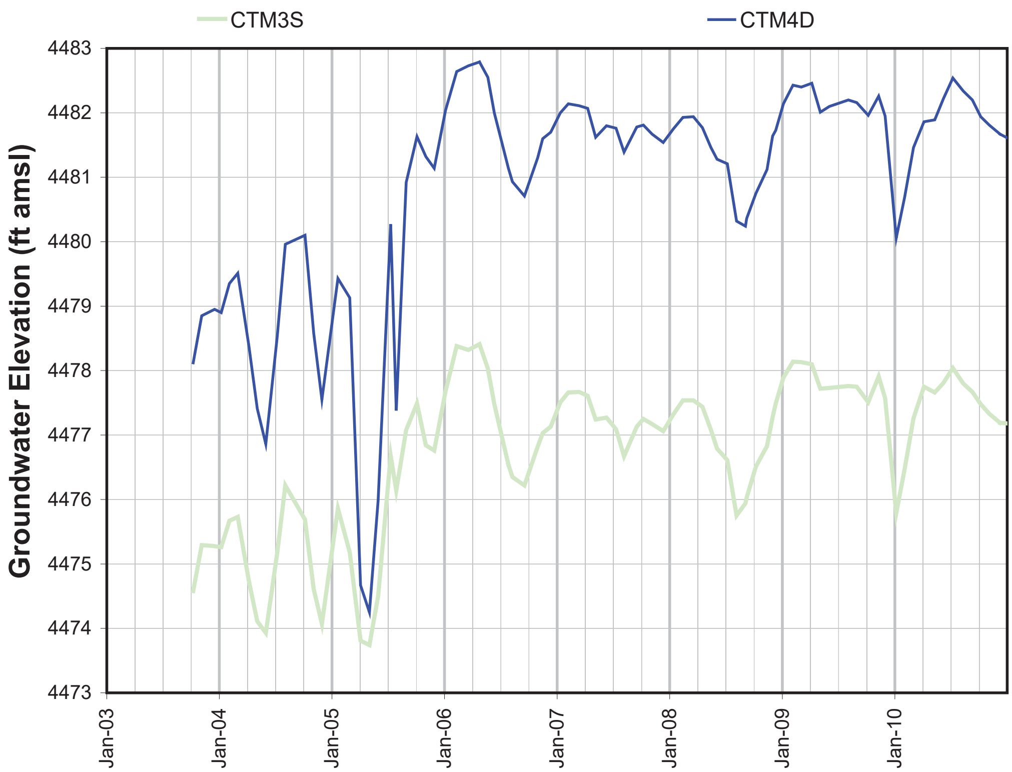

MW7NS
MW8ND
PCE = ND for MW7NS
PCE = ND for MW8ND
PCE MCL
PCE (µg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

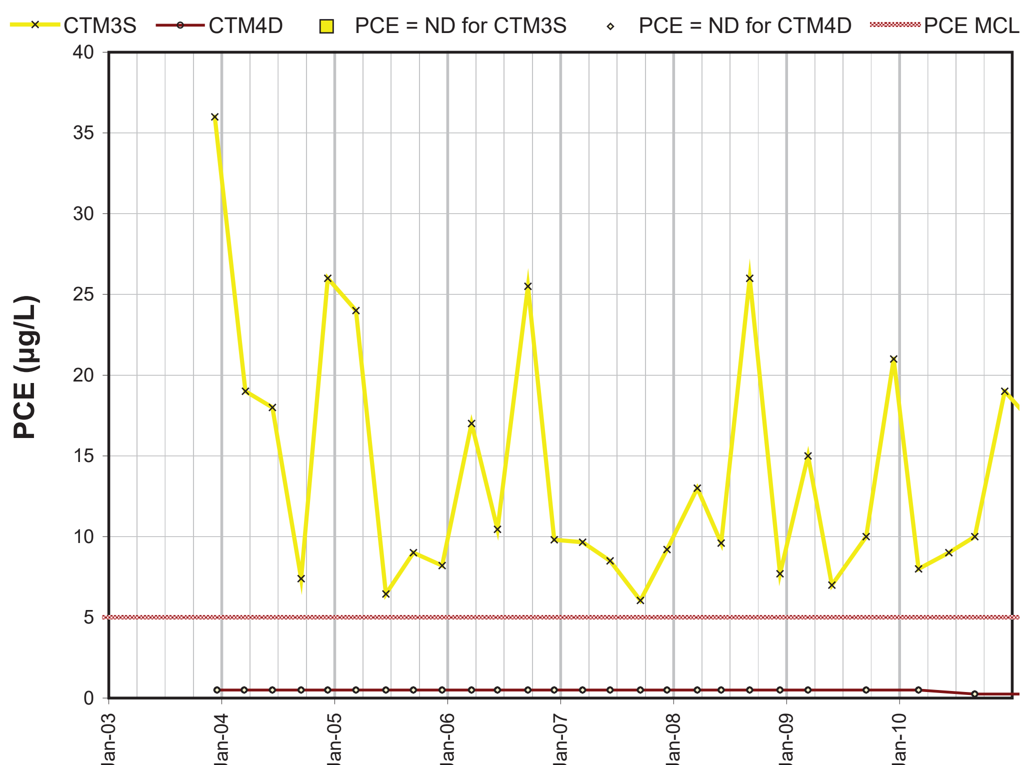
CTM7S / CTM8D


CTM7S
CTM8D
Groundwater Elevation (ft amsl)
4470
4465
4460
4455
4450
4445
4440
4435
4430
4425
4420
4415
4410
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

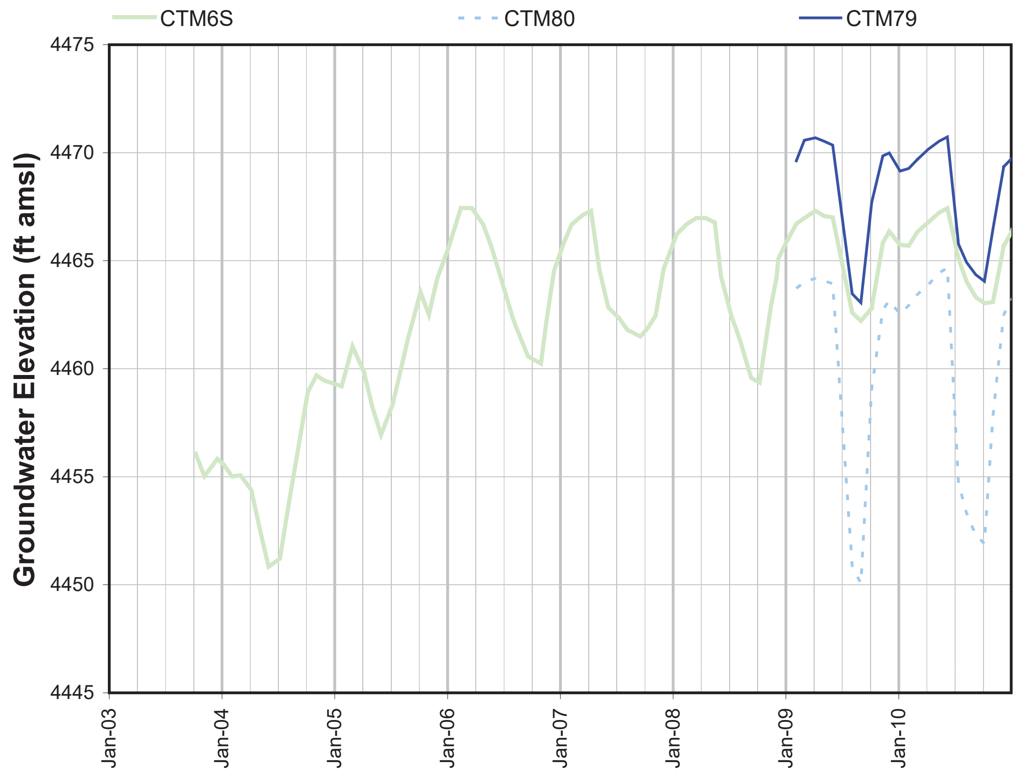

CTM7S
CTM8D
PCE = ND for CTM7S
PCE = ND for CTM8D
PCE MCL
PCE (µg/L)
60
55
50
45
40
35
30
25
20
15
10
5
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

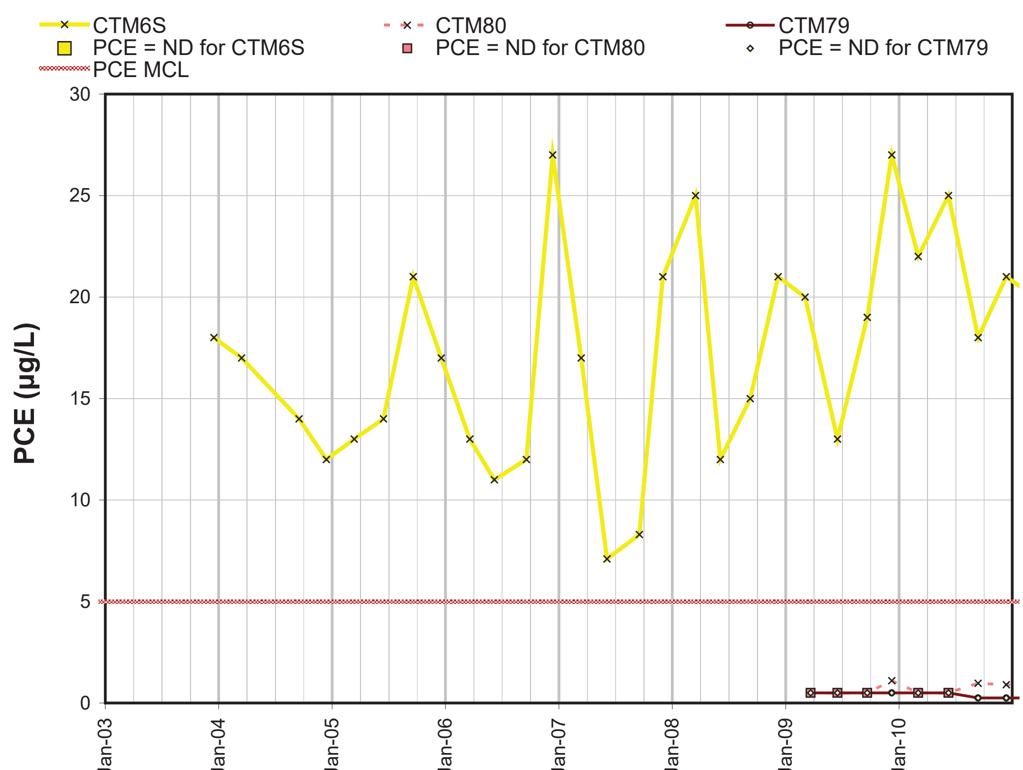
CTM3S / CTM4D


CTM3S
CTM4D
Groundwater Elevation (ft amsl)
4483
4482
4481
4480
4479
4478
4477
4476
4475
4474
4473
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

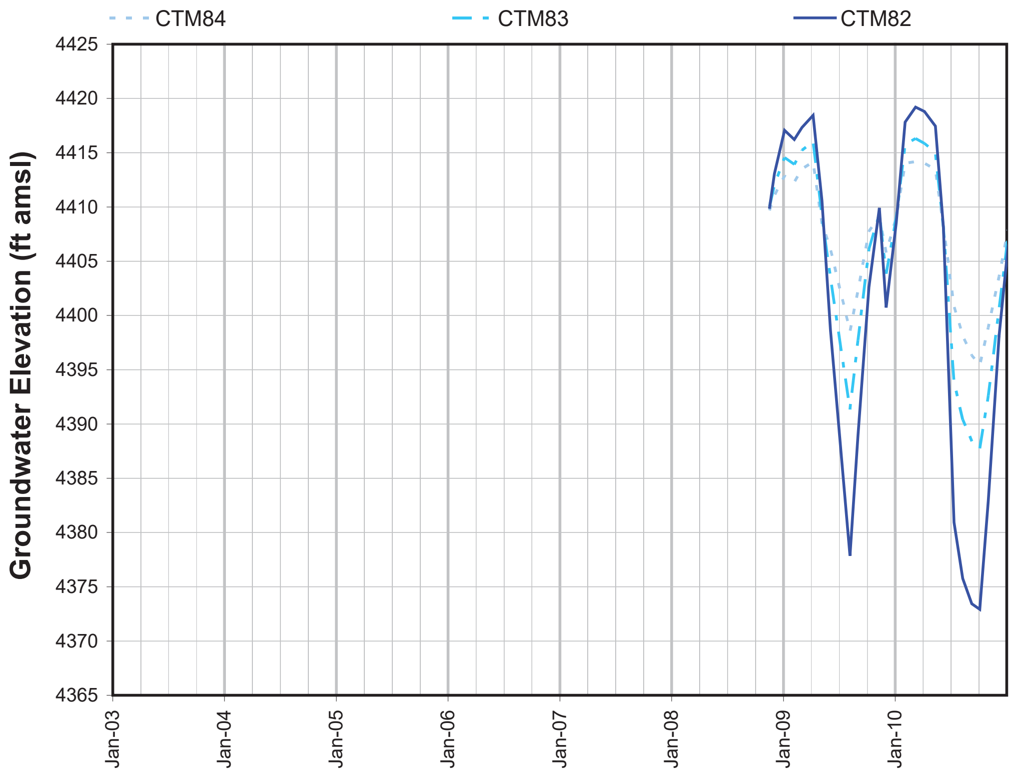

CTM3S
CTM4D
PCE = ND for CTM3S
PCE = ND for CTM4D
PCE MCL
PCE (µg/L)
40
35
30
25
20
15
10
5
0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

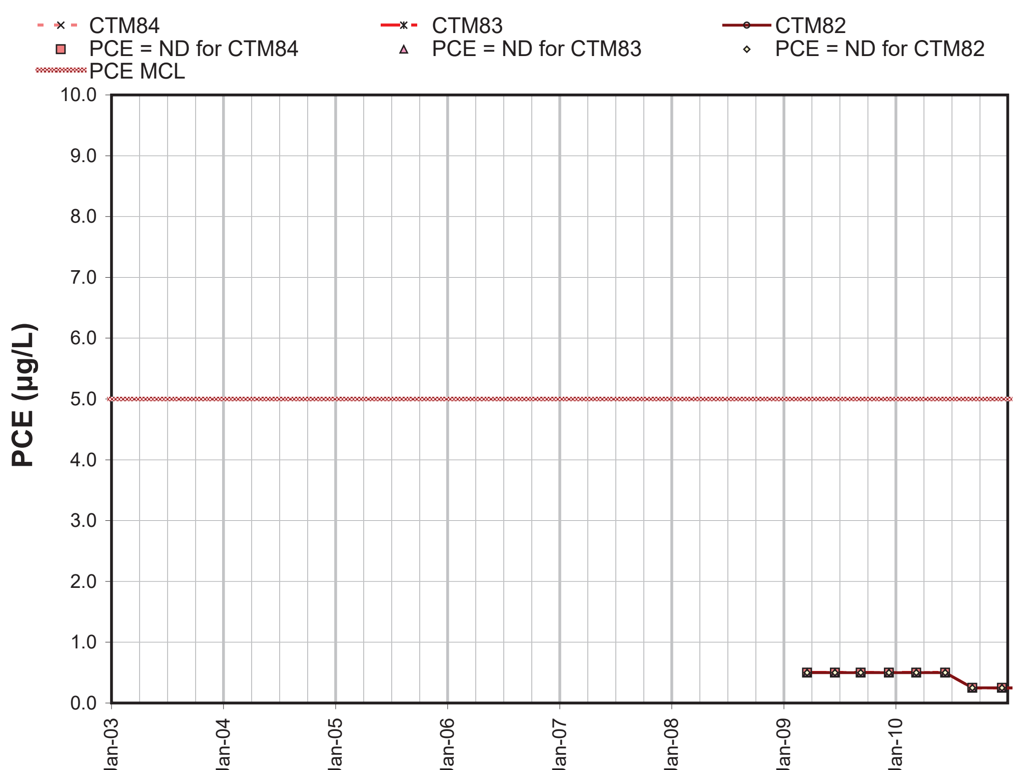
CTM6S / CTM80 / CTM79



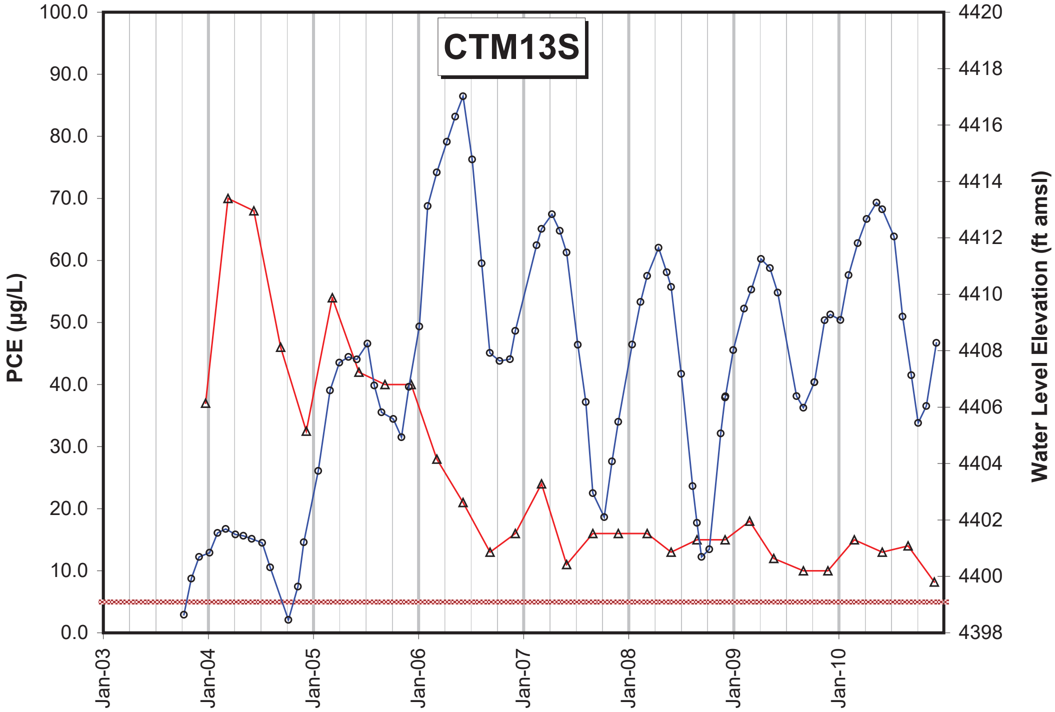


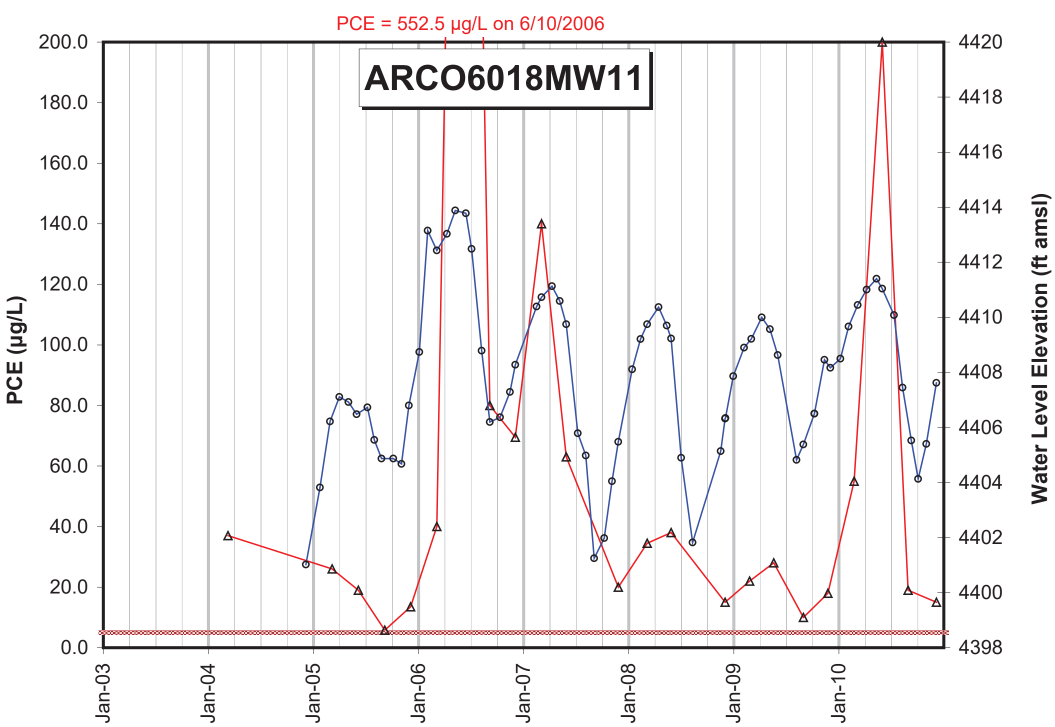
CTM84 / CTM83 / CTM82

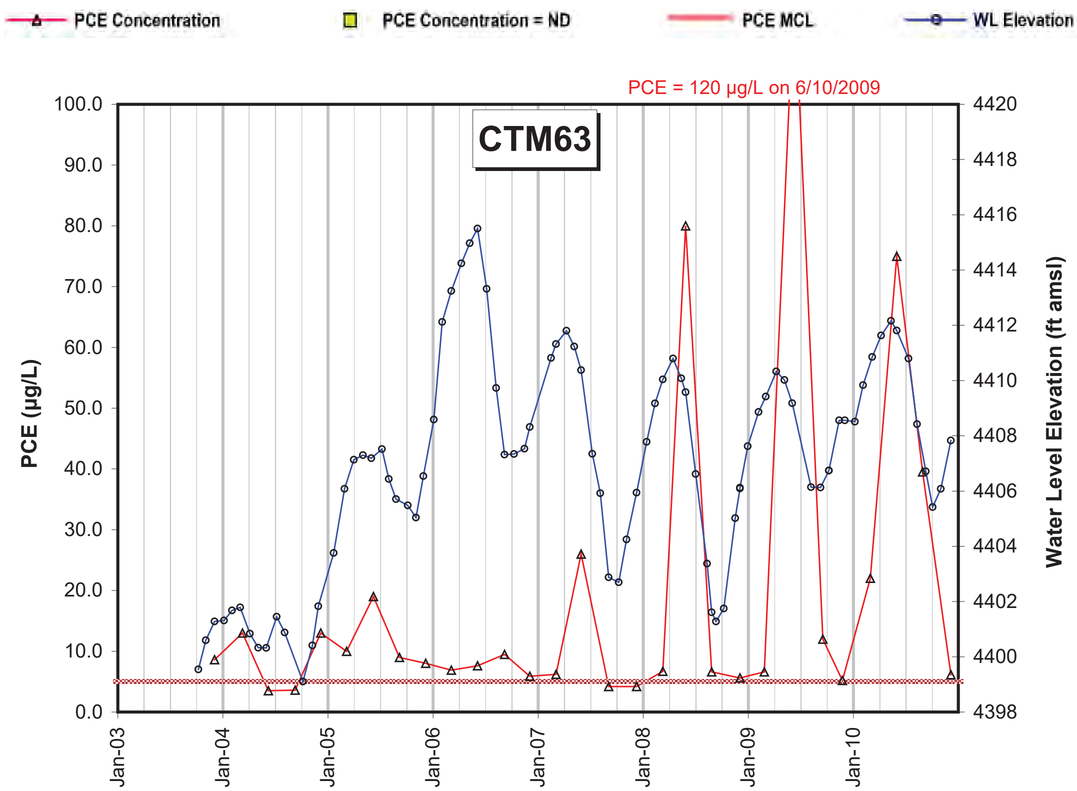


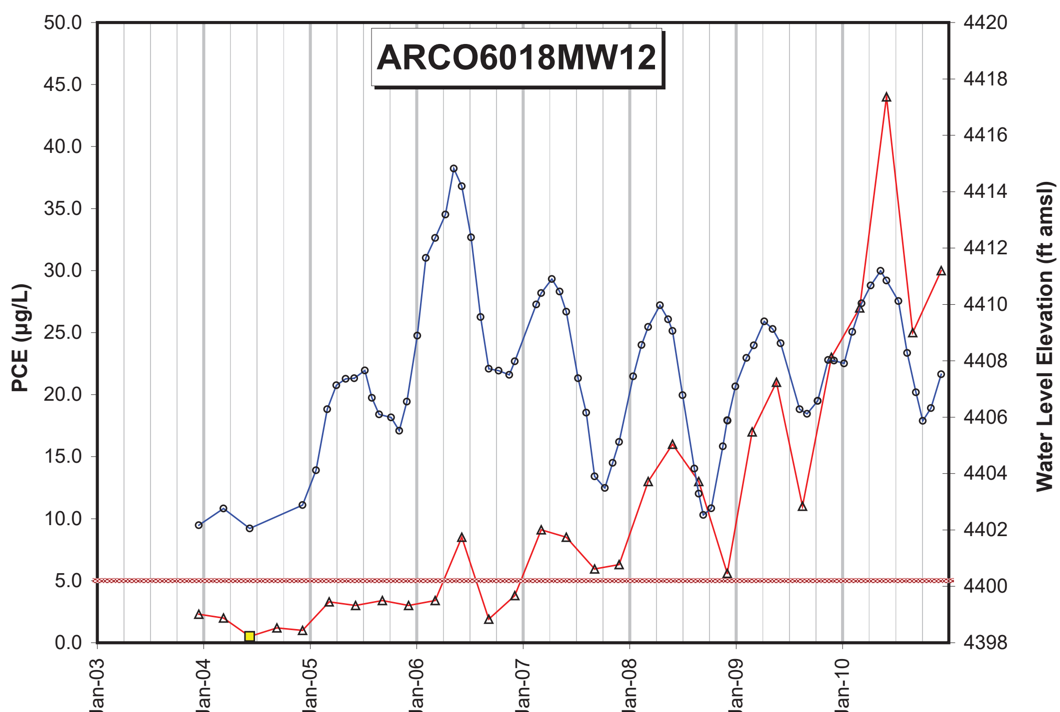


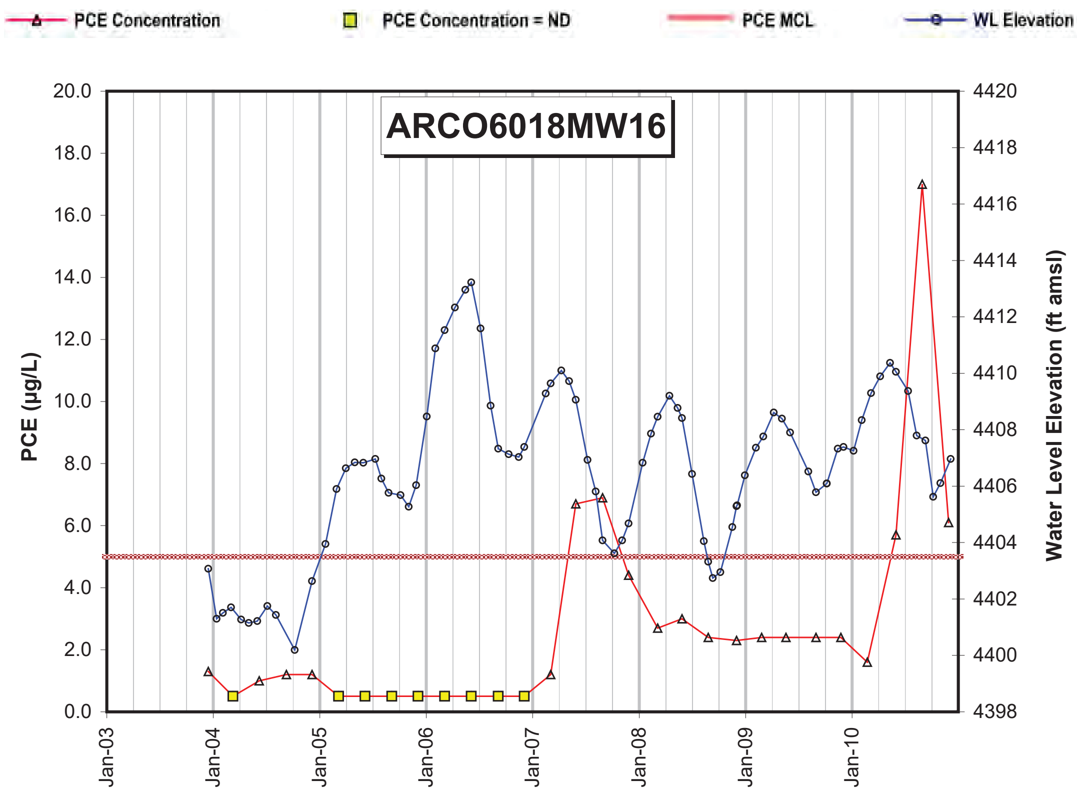
PCE Concentration   PCE Concentration = ND   PCE MCL   WL Elevation

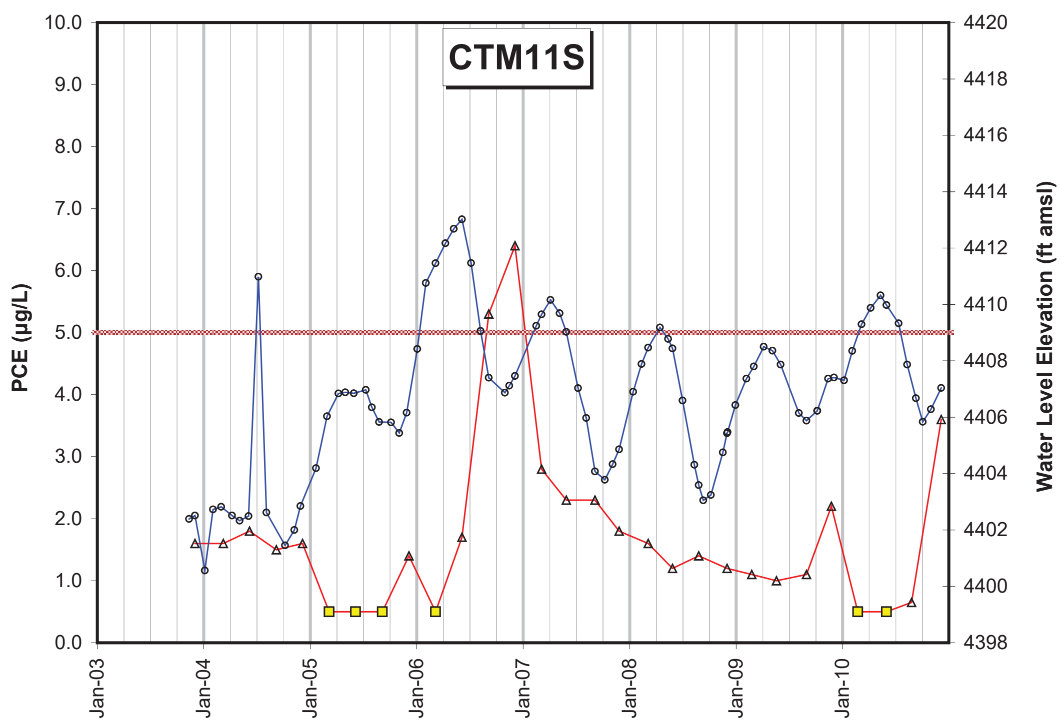




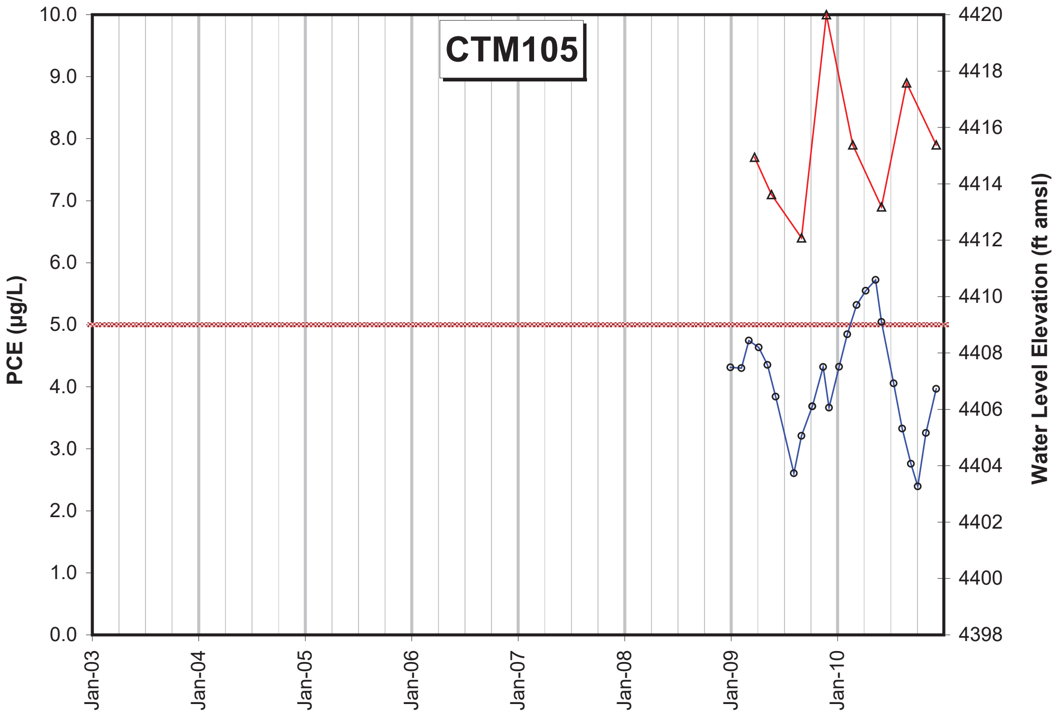

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
PCE = 120 µg/L on 6/10/2009
CTM63
PCE (µg/L)
Water Level Elevation (ft amsl)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4420
4418
4416
4414
4412
4410
4408
4406
4404
4402
4400
4398
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

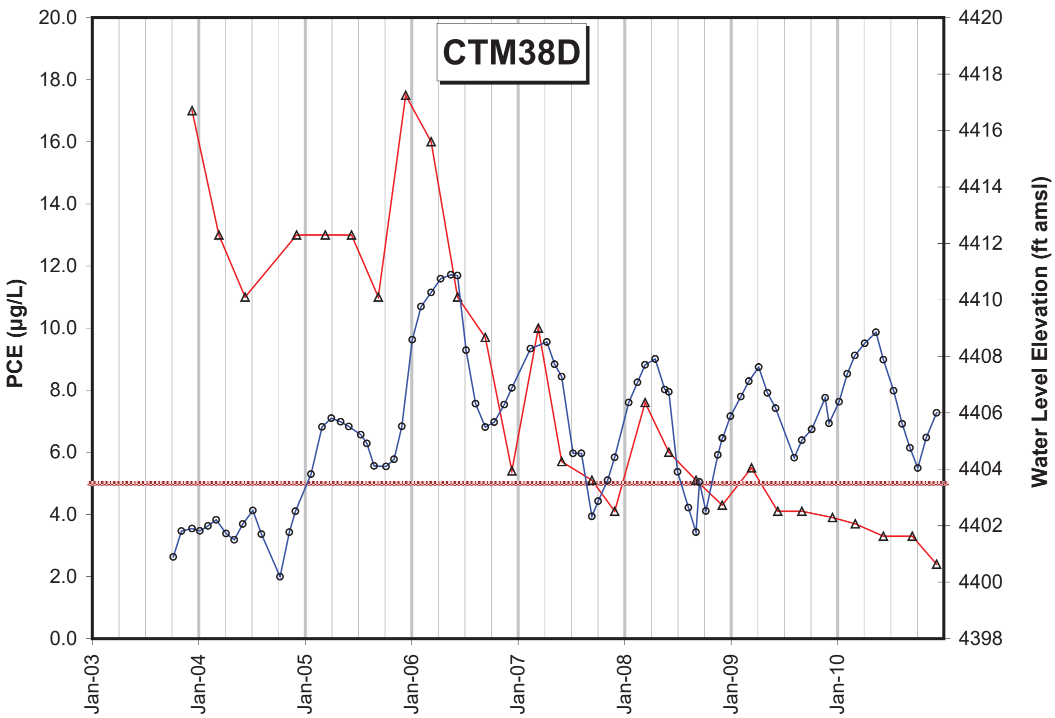

ARCO6018MW12
PCE (µg/L)
Water Level Elevation (ft amsl)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4420
4418
4416
4414
4412
4410
4408
4406
4404
4402
4400
4398
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
ARCO6018MW16
PCE (µg/L)
Water Level Elevation (ft amsl)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4420
4418
4416
4414
4412
4410
4408
4406
4404
4402
4400
4398
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

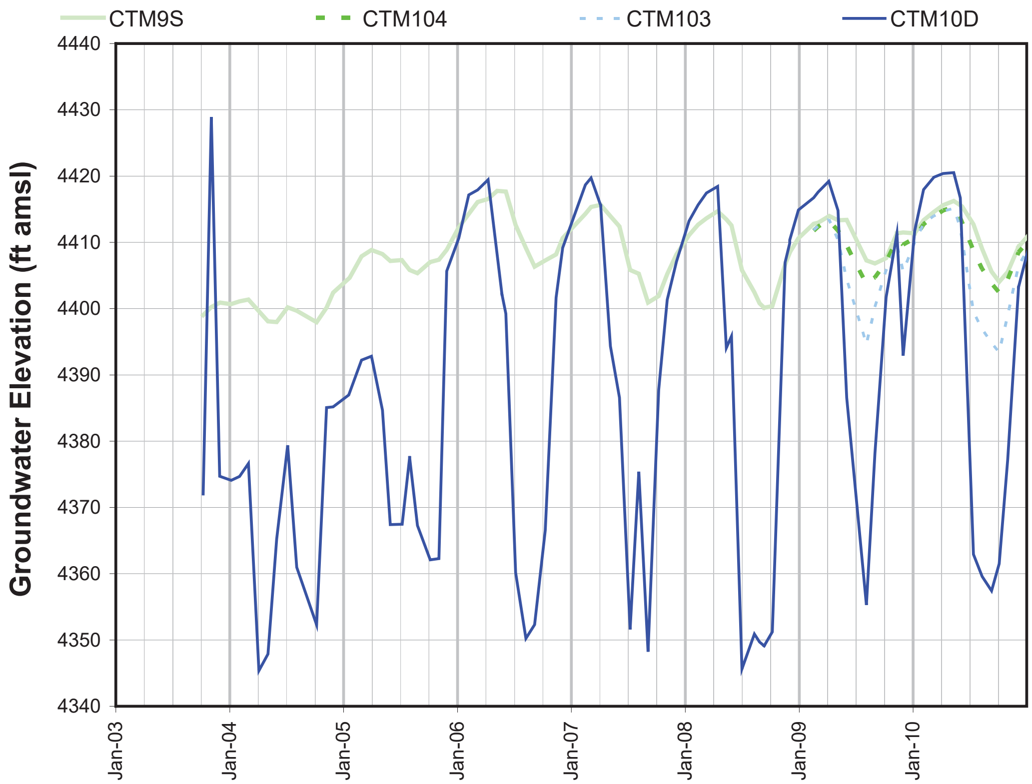

CTM11S
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4420
4418
4416
4414
4412
4410
4408
4406
4404
4402
4400
4398
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

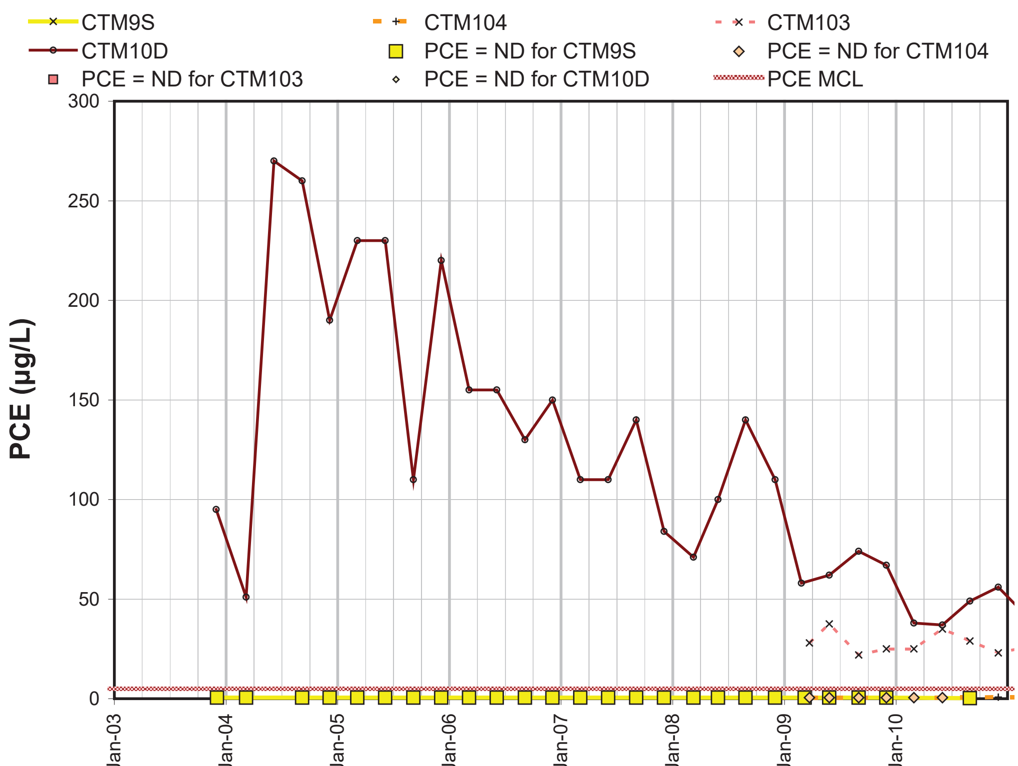
PCE Concentration | PCE Concentration = ND | PCE MCL | WL Elevation





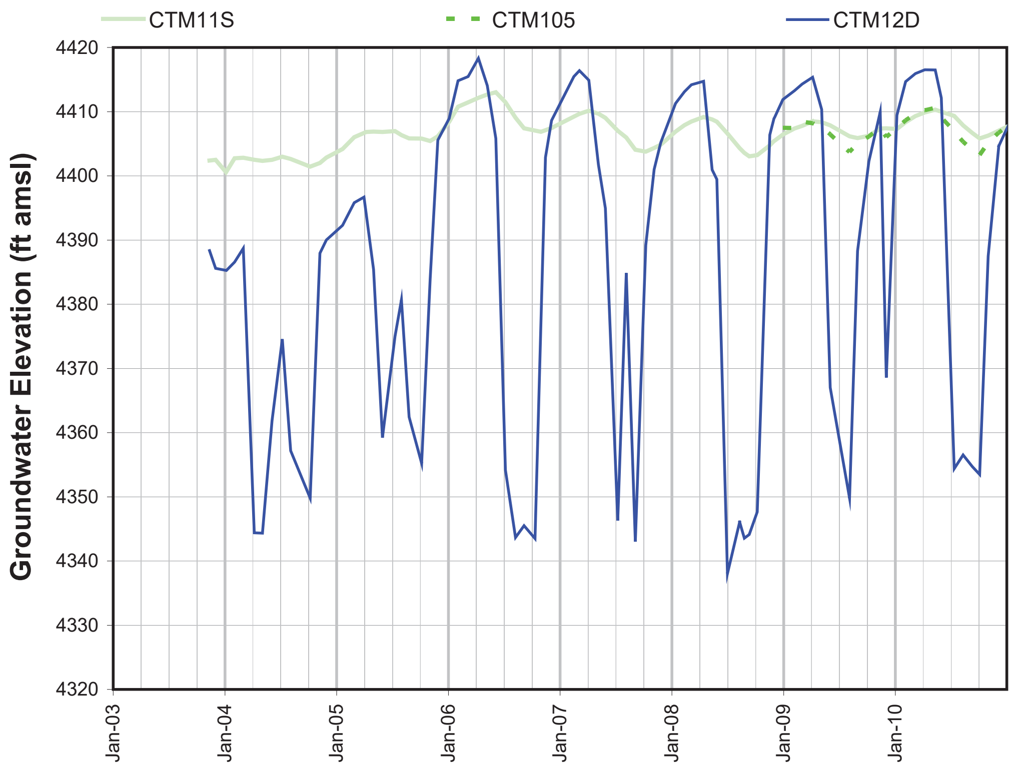
CTM9S / CTM104 / CTM103 / CTM10D

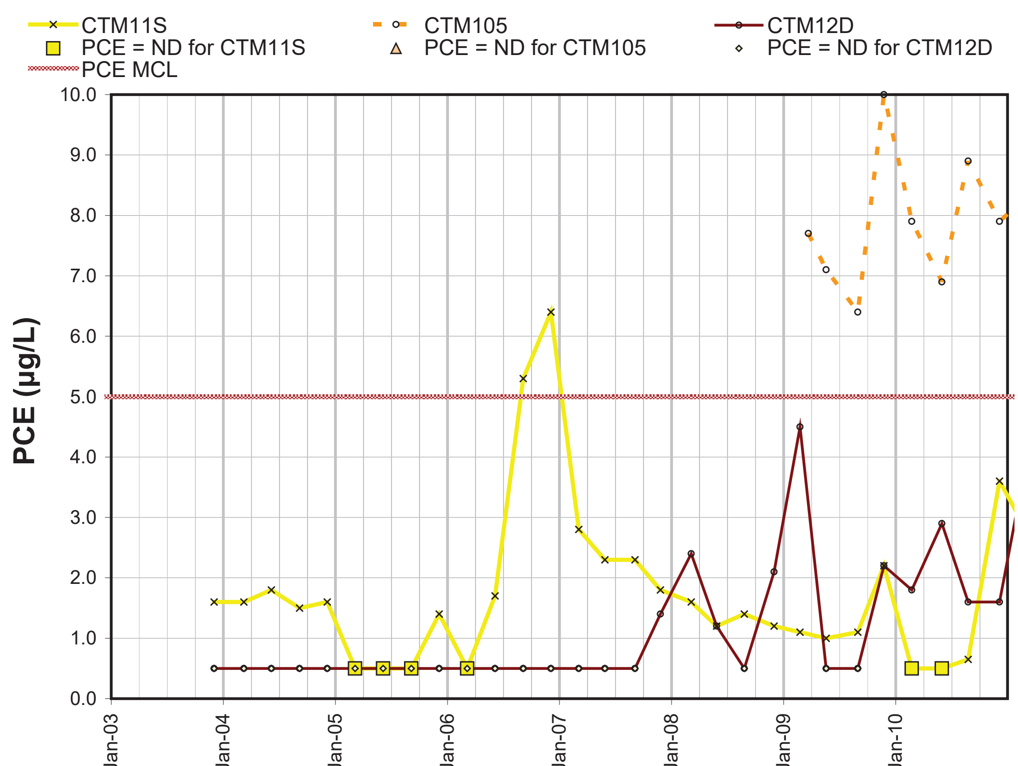




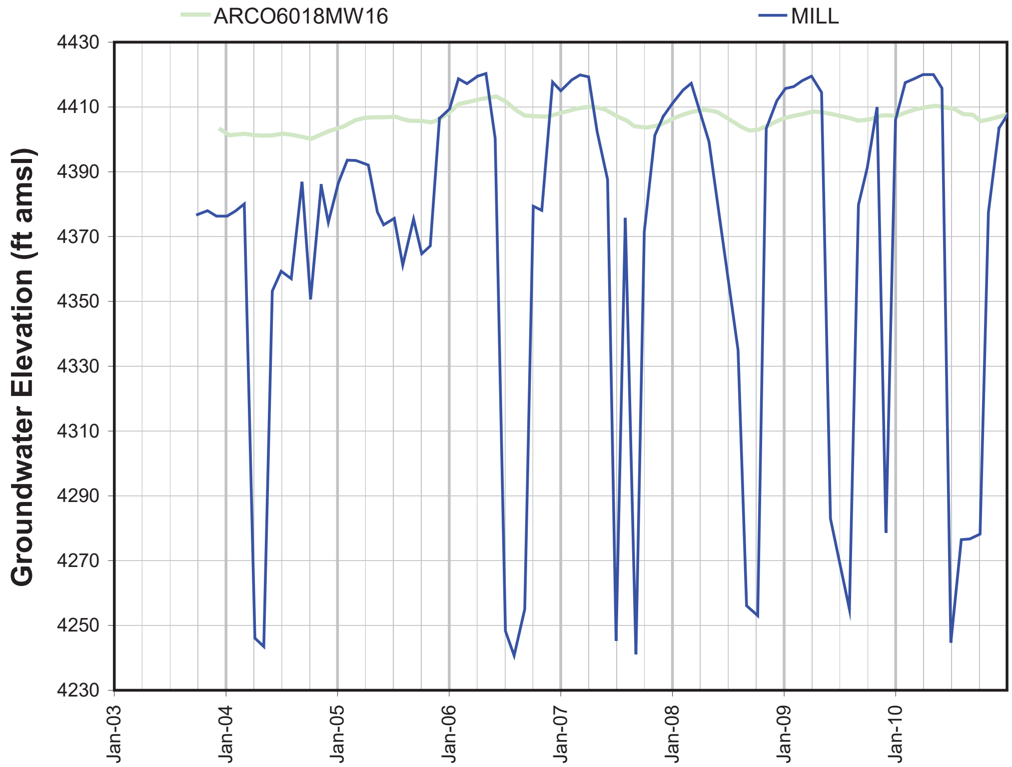
CTM REMEDIATION DISTRICT
Washoe County

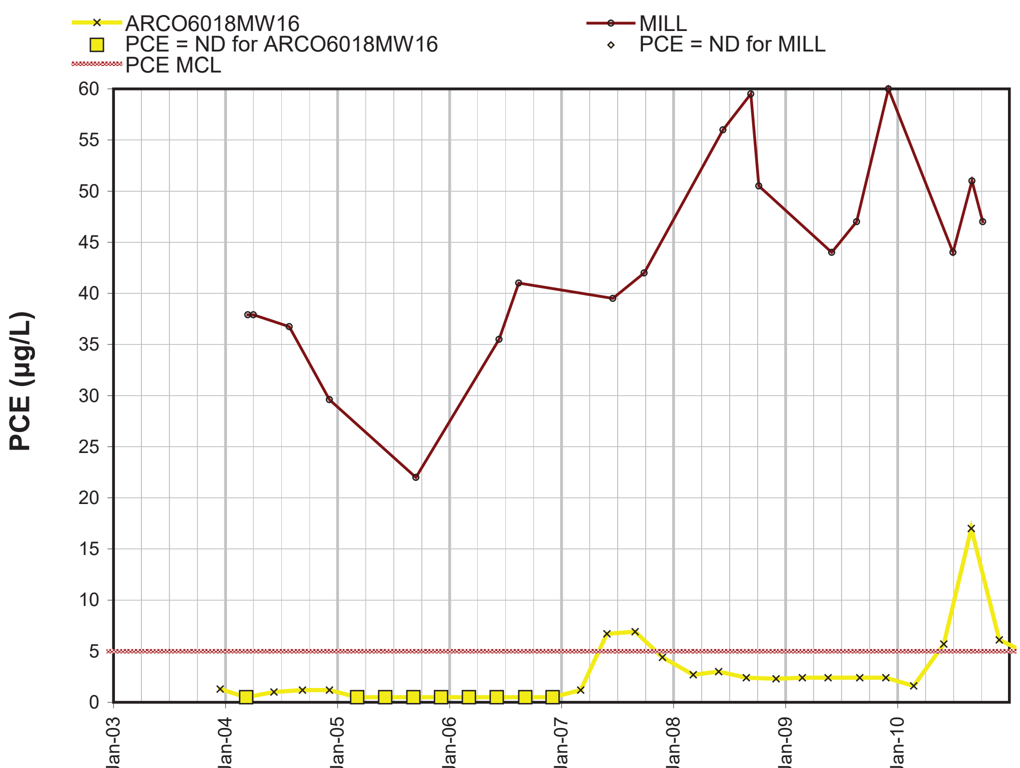
CTM11S / CTM105 / CTM12D





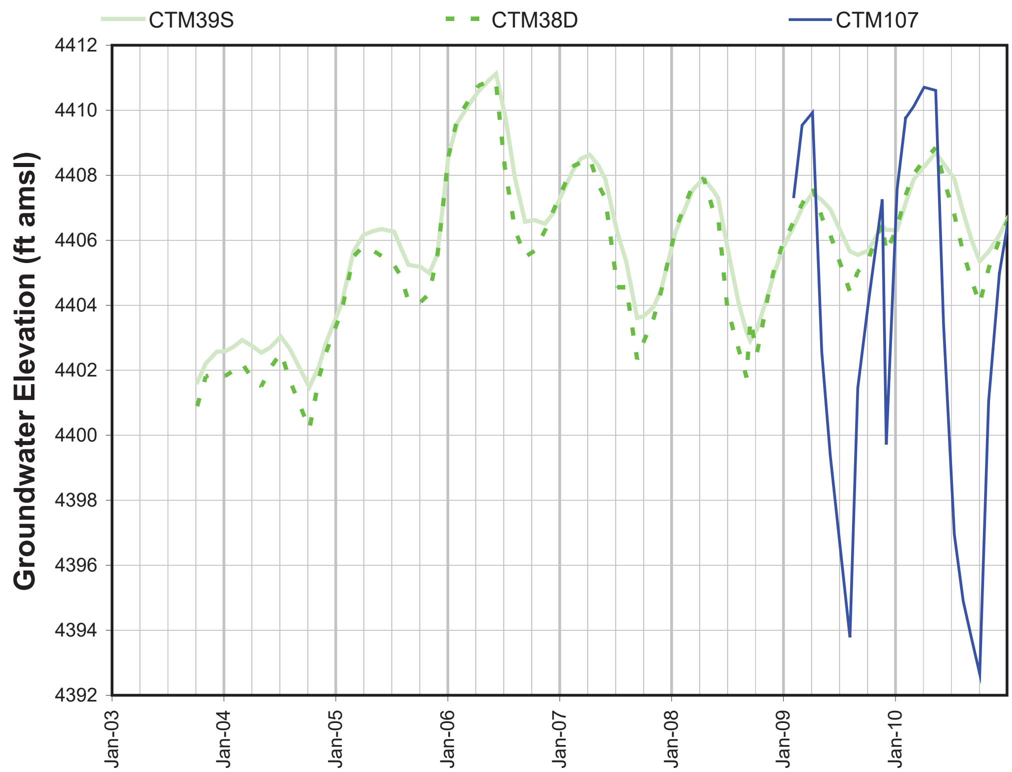
ARCO6018MW16 / MILL

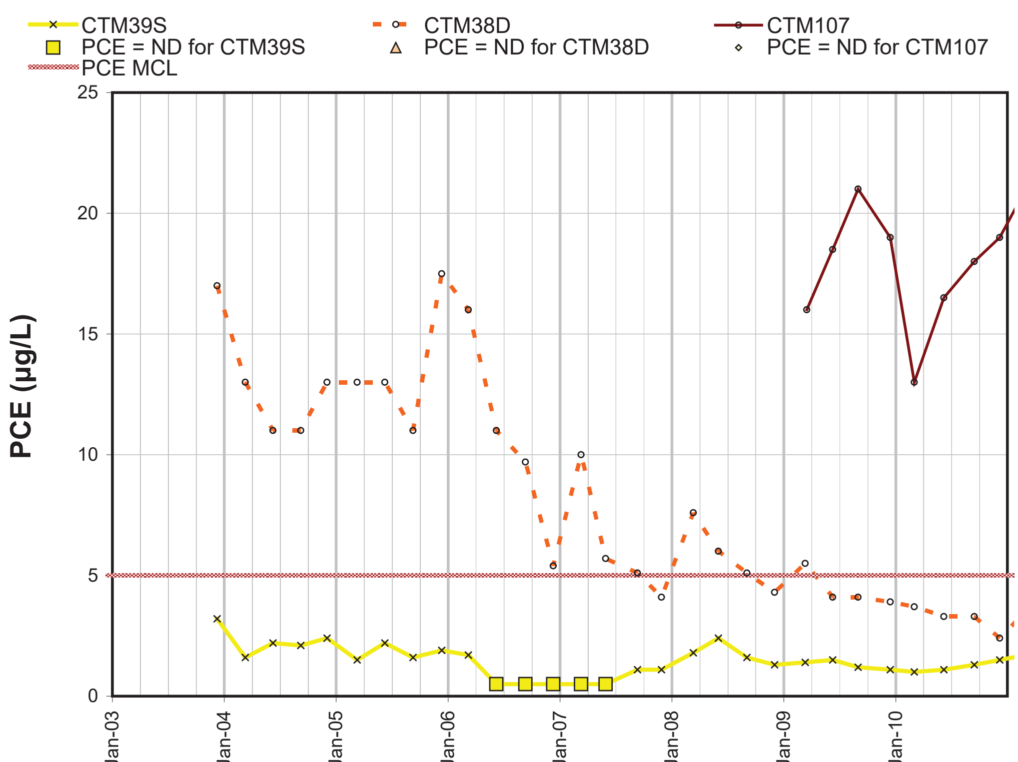




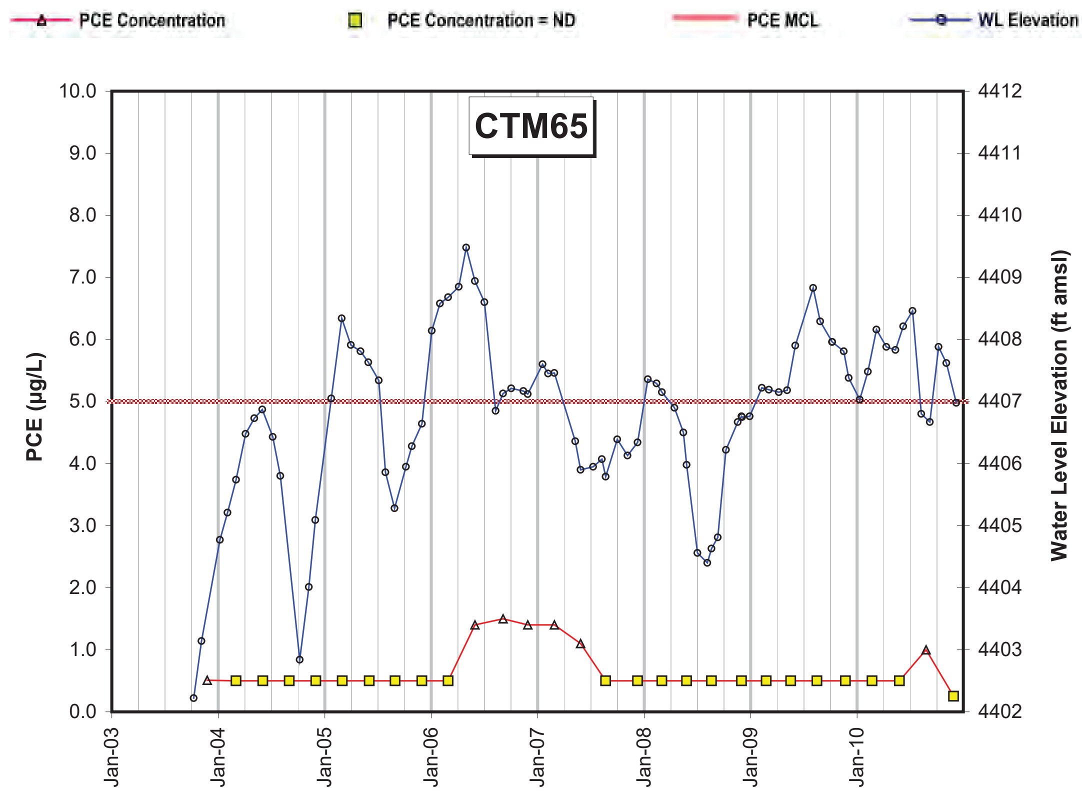
CTM REMEDIATION DISTRICT
Washoe County

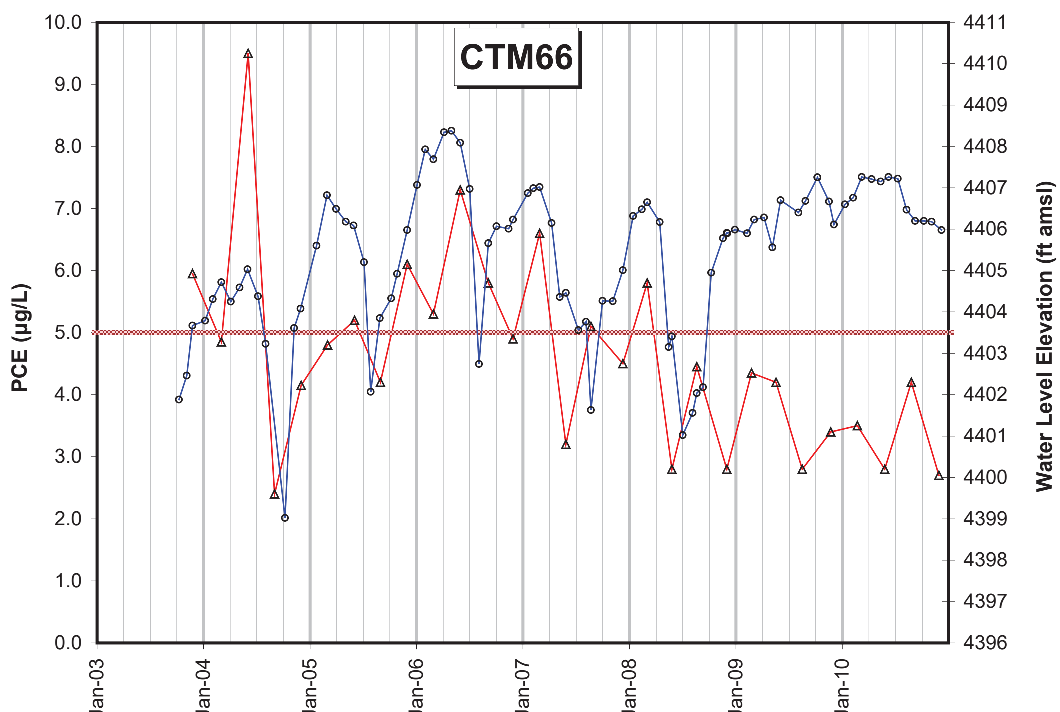
CTM39S / CTM38D / CTM107



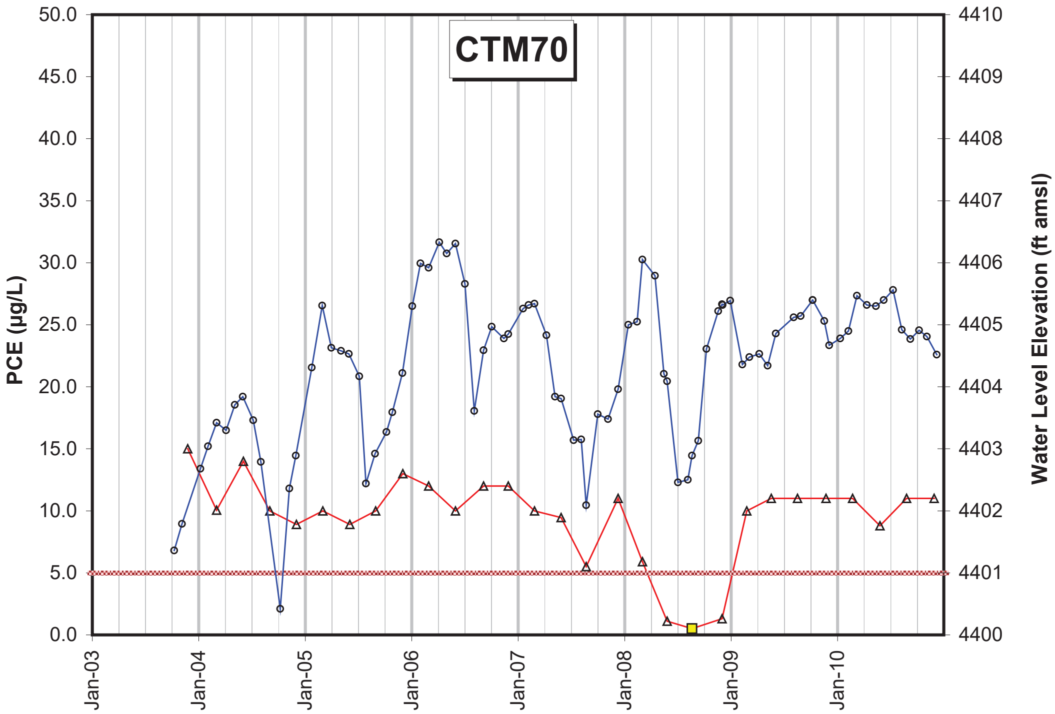


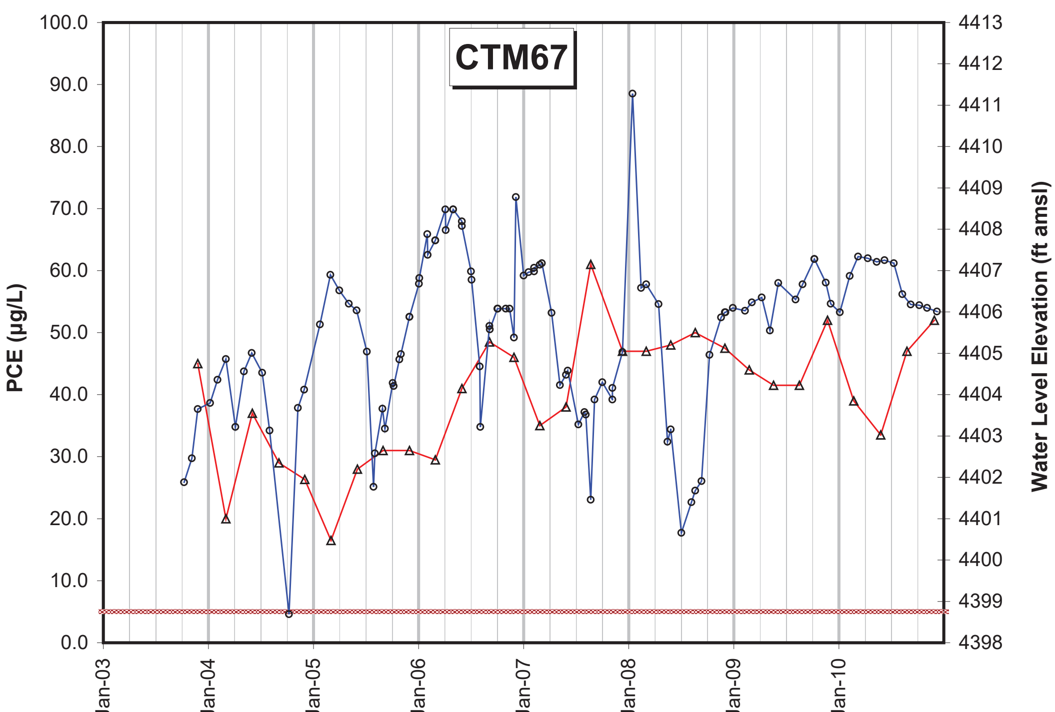
Central Truckee Meadows Remediation District Program
Groundwater Monitoring Plan 2010 Annual Report
GRAPHS 5.4a –PCE Time-Series and Water Level Hydrographs Charts, Downtown Spark Subregion
Shallow Zone Key Wells

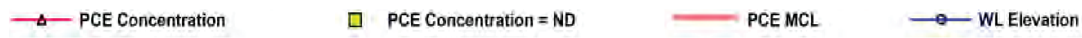


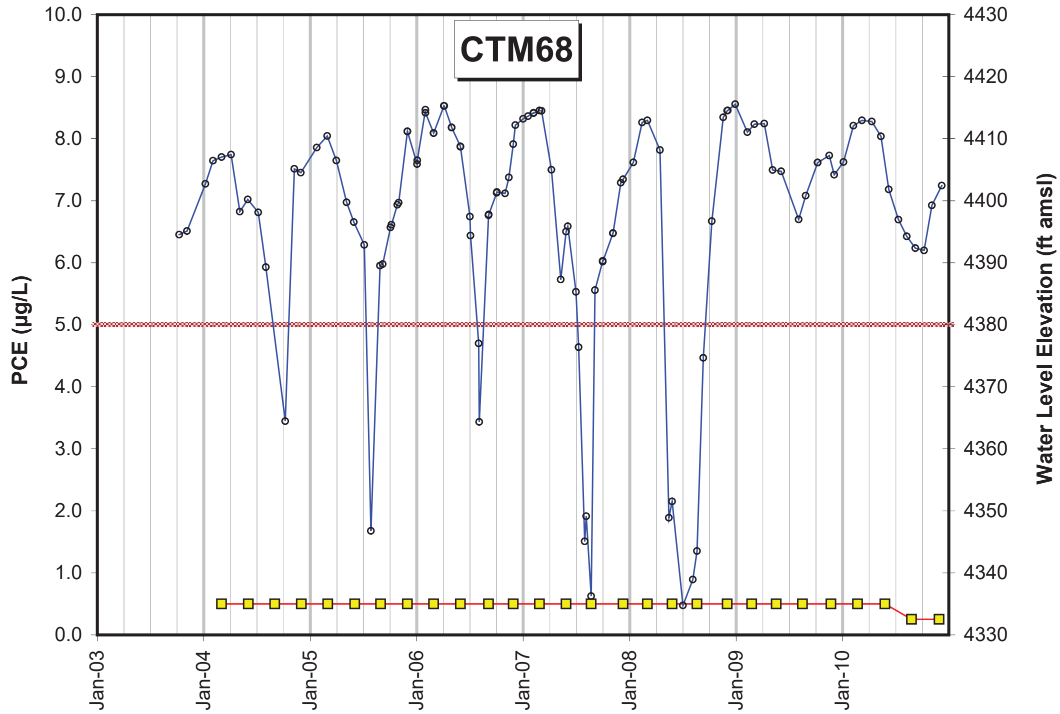


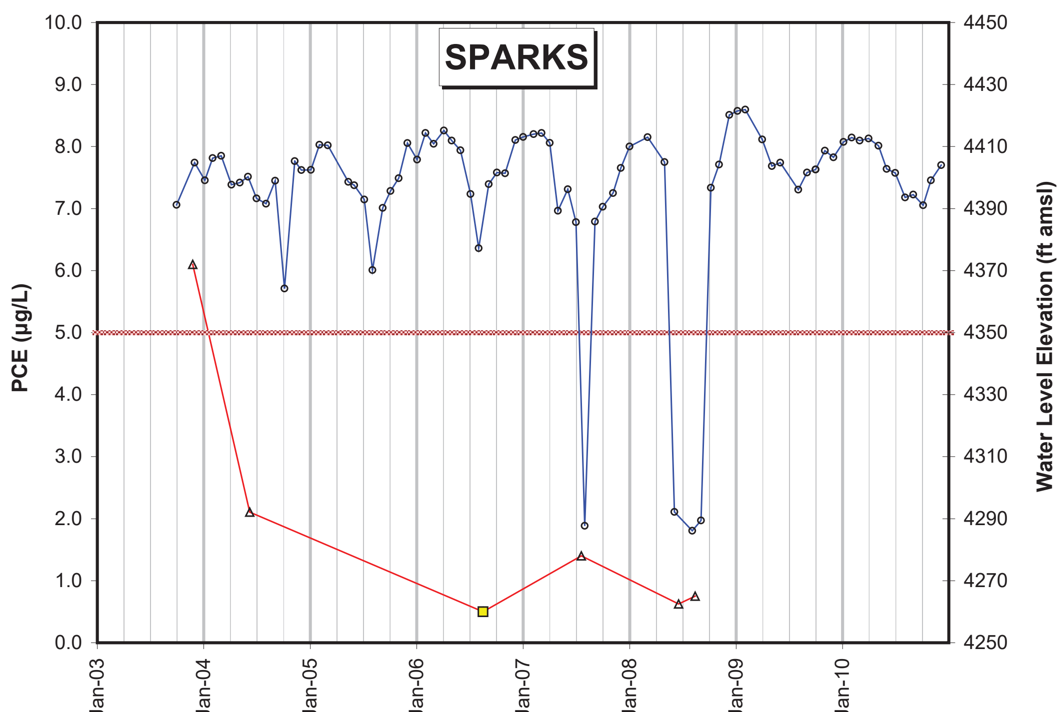
PCE Concentration | PCE Concentration = ND | PCE MCL | WL Elevation



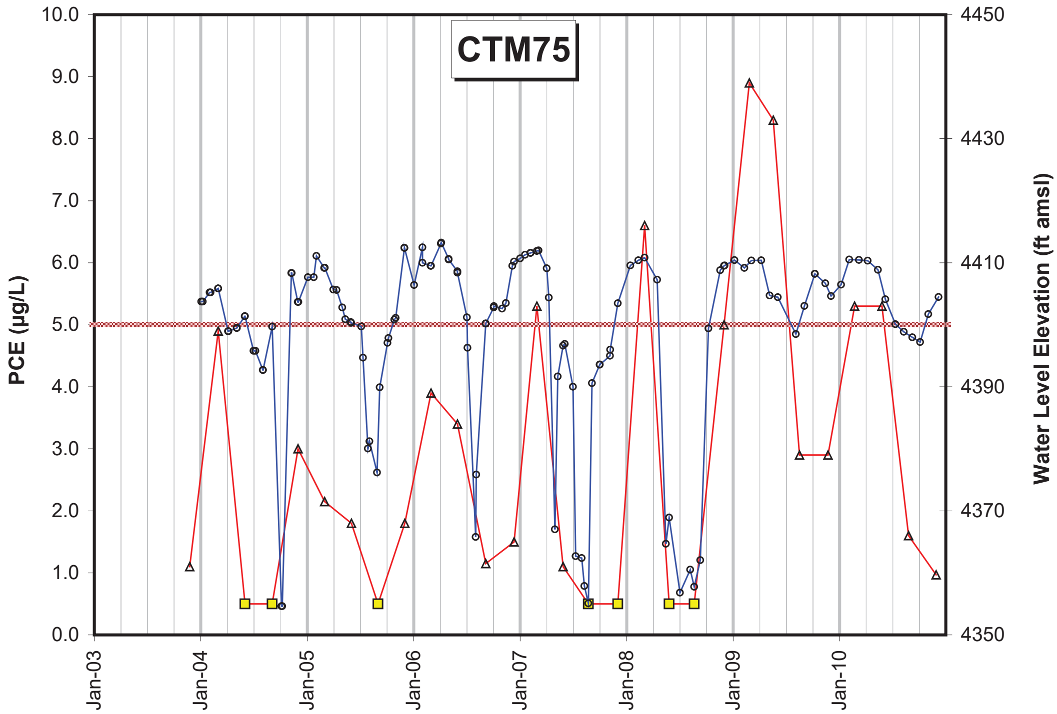


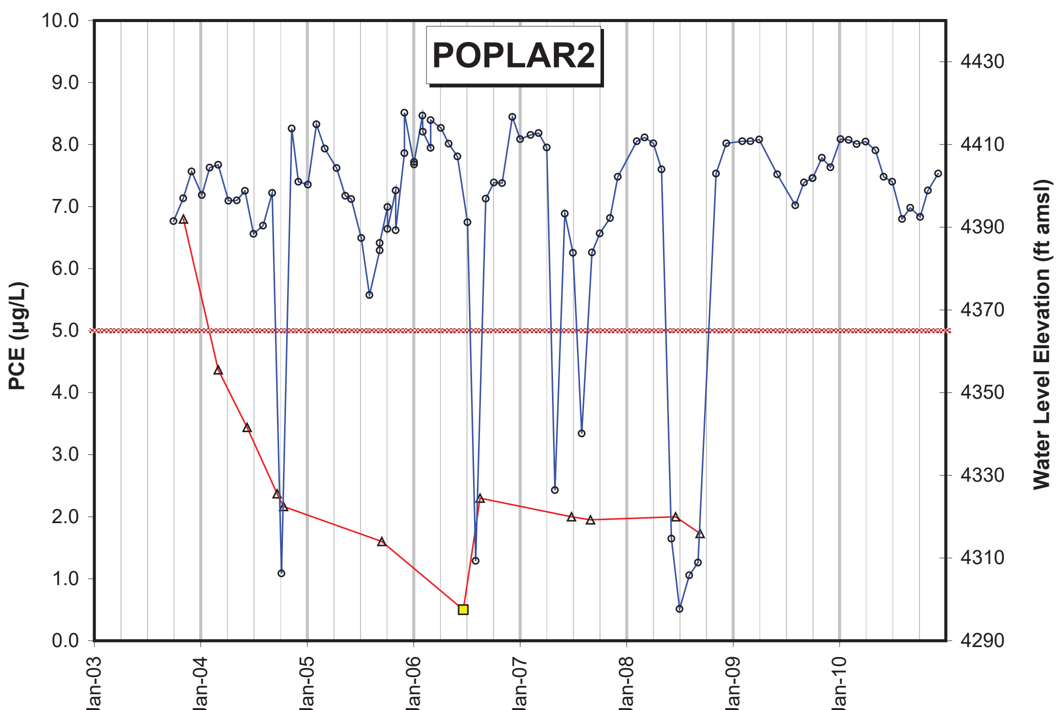

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation


CTM68
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4430
4420
4410
4400
4390
4380
4370
4360
4350
4340
4330
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

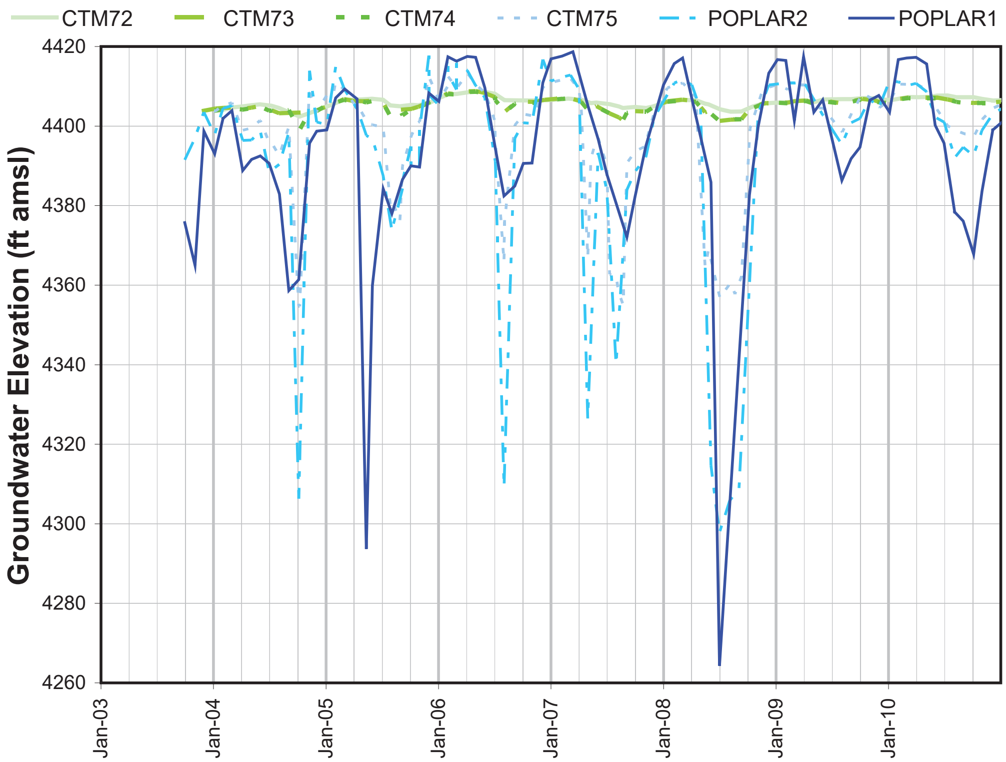

SPARKS
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4450
4430
4410
4390
4370
4350
4330
4310
4290
4270
4250
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

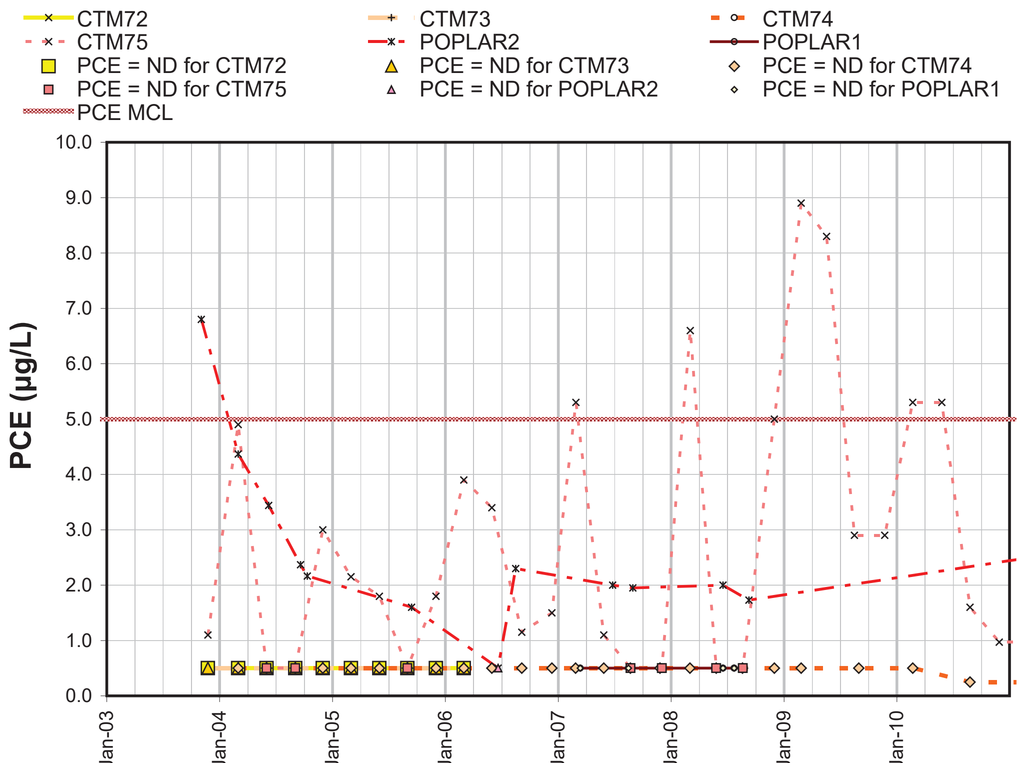

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation


CTM75
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4450
4430
4410
4390
4370
4350
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

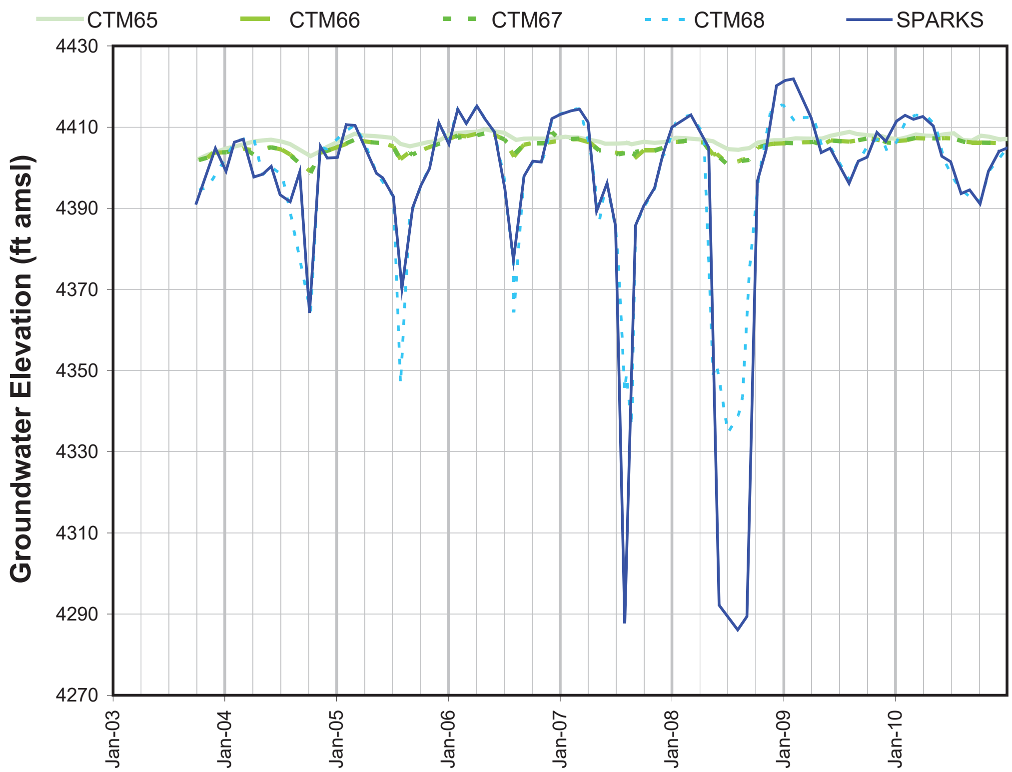

POPLAR2
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4430
4410
4390
4370
4350
4330
4310
4290
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

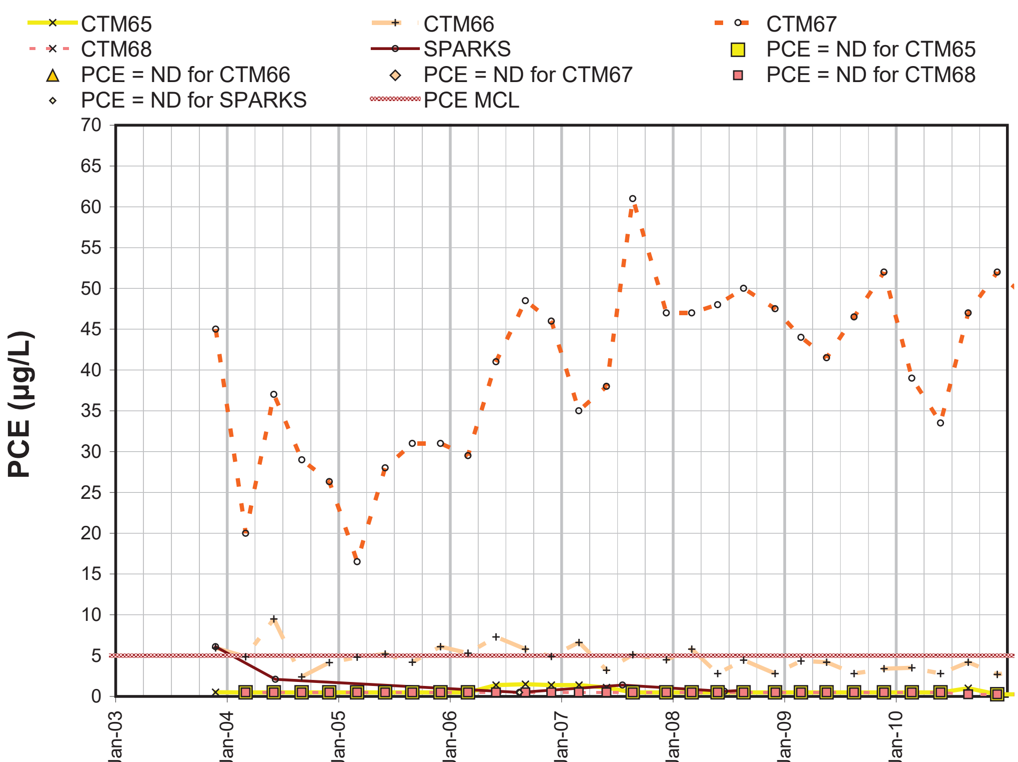
CTM72 / CTM73 / CTM74 / CTM75 / POPLAR2 / POPLAR1





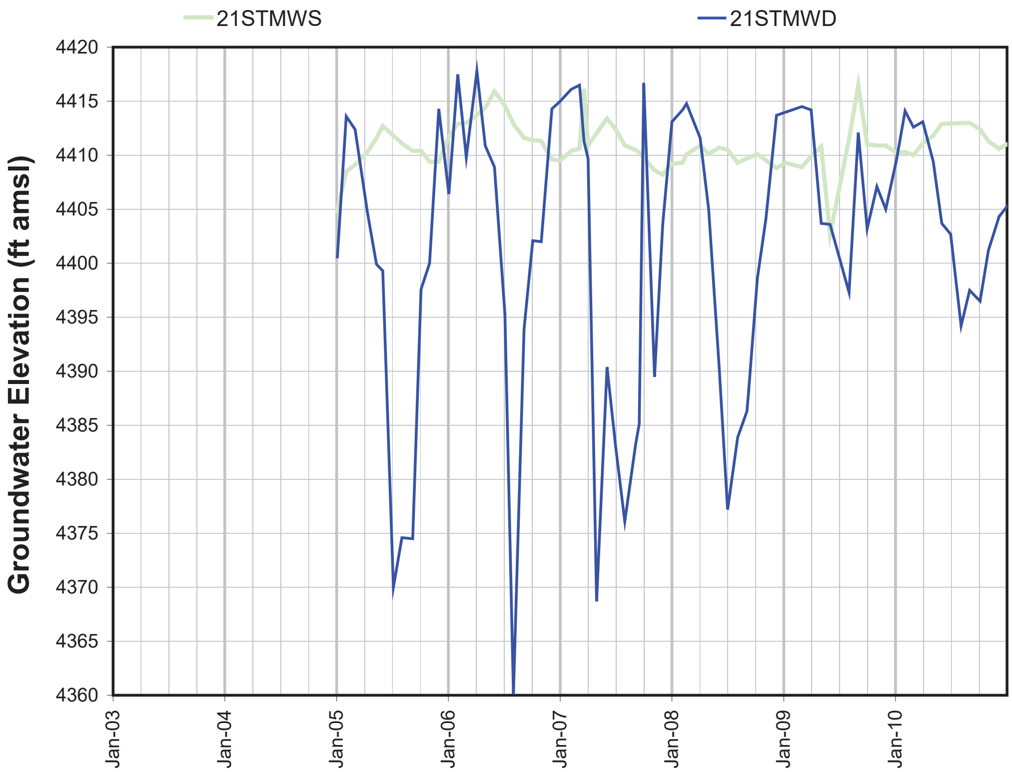
CTM65 / CTM66 / CTM67 / CTM68 / SPARKS

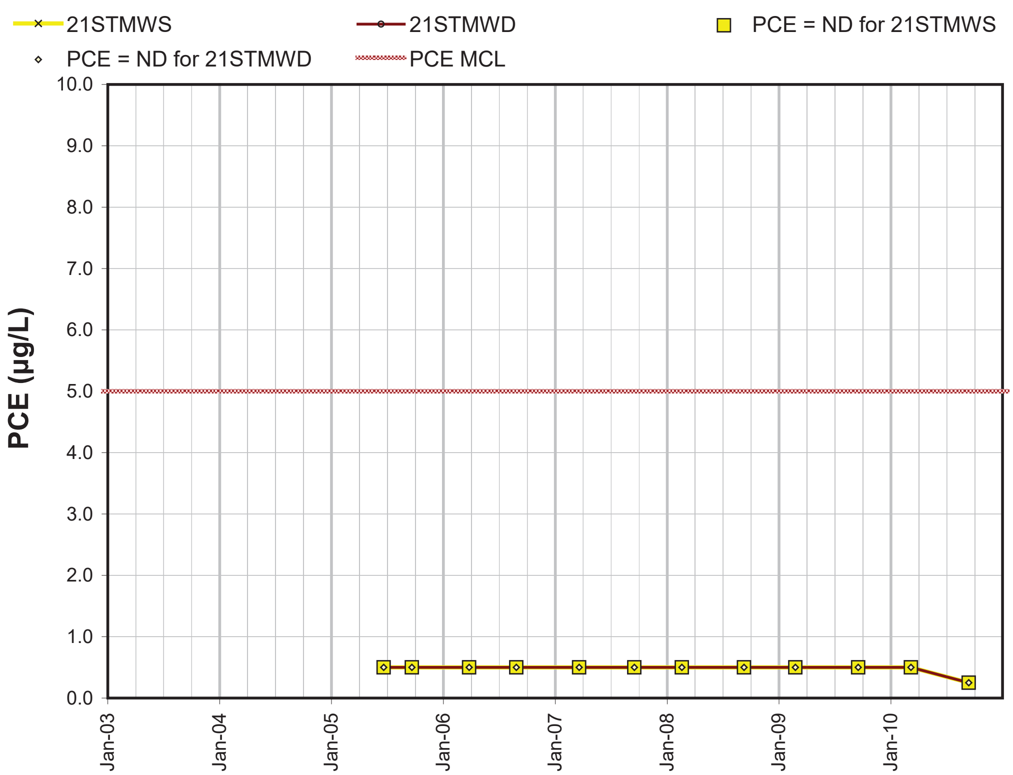




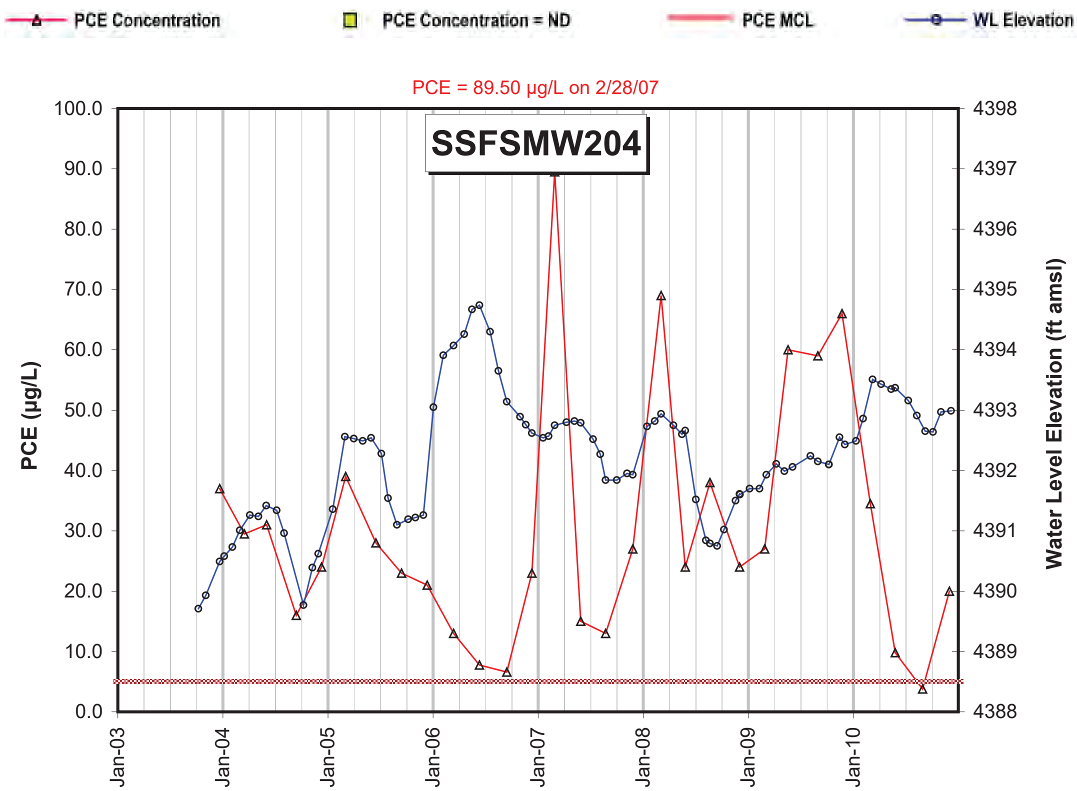
CTM Remediation District
Washoe County

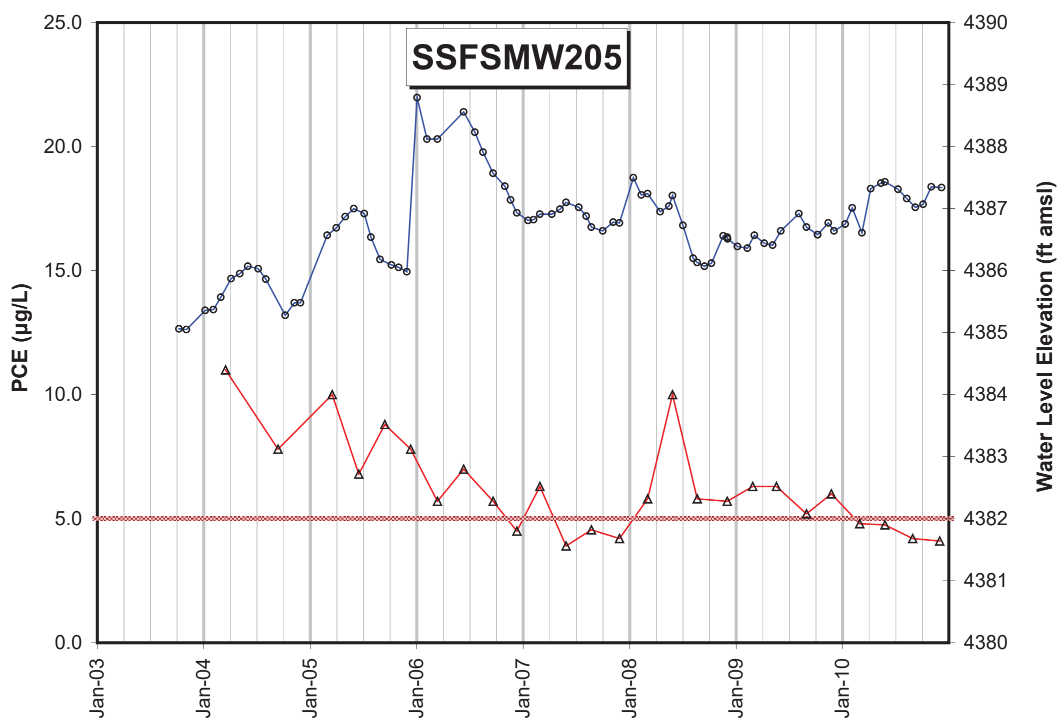
21STMWS / 21STMWD



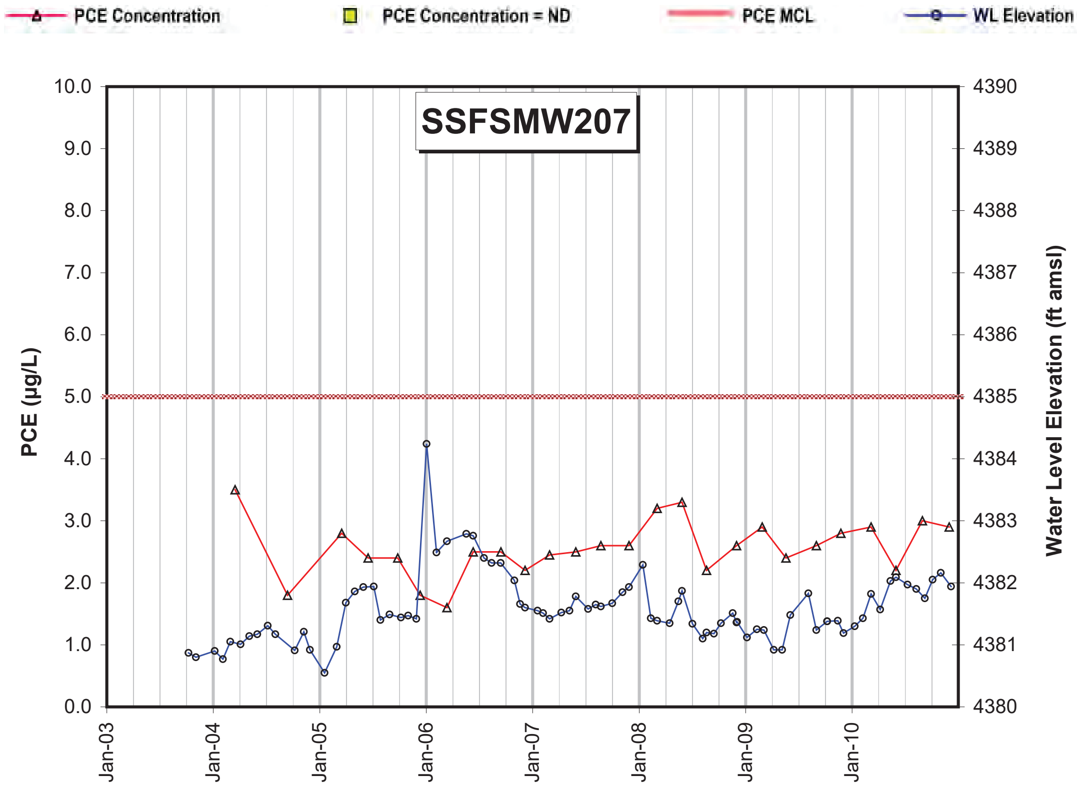


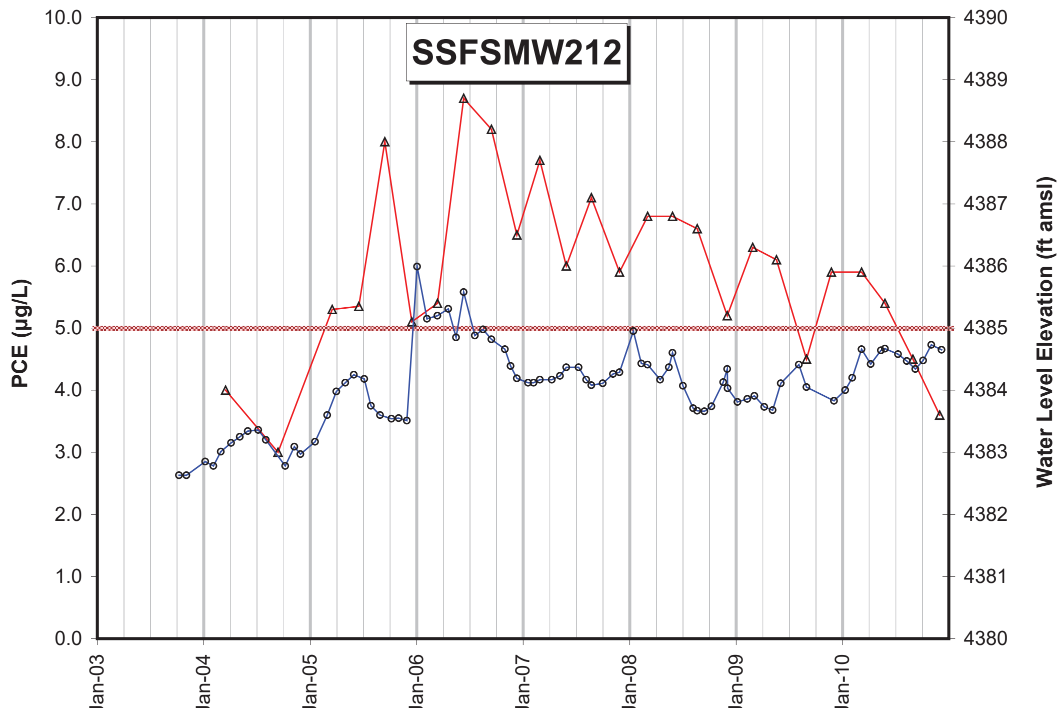
GRAPHS 5.5a – PCE Time-Series and Water Level Hydrograph Charts, East Sparks Subregion Shallow Zone Key Wells



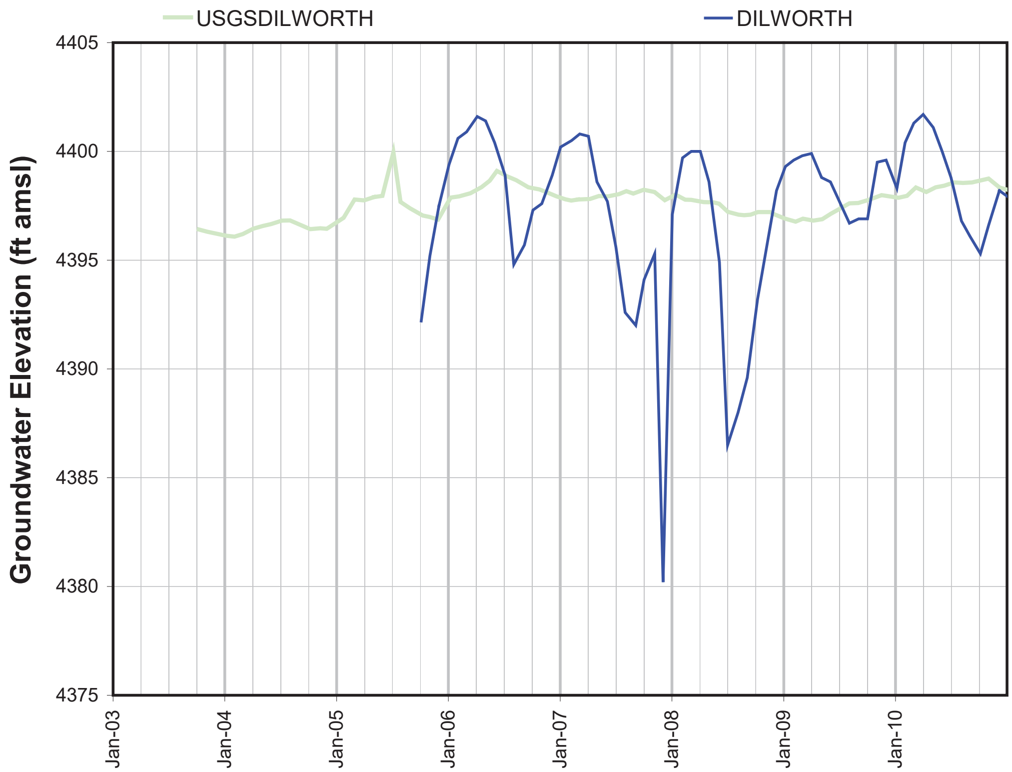


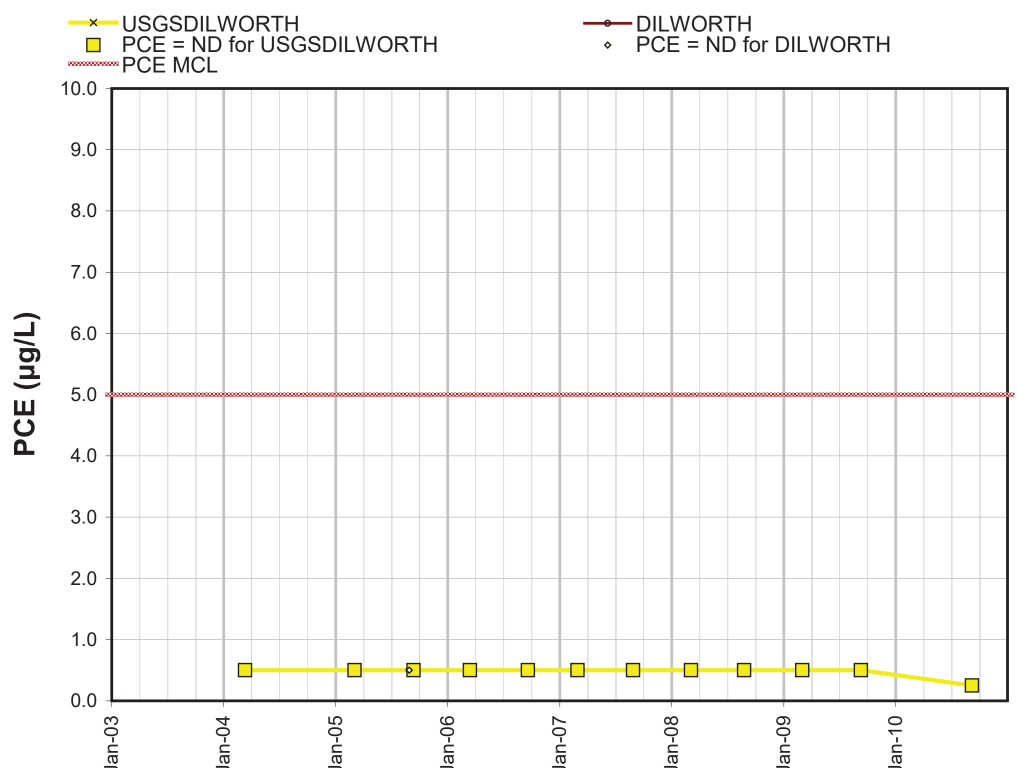
CTM REMEDIATION DISTRICT
Washoe County


PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
SSFSMW207
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4390
4389
4388
4387
4386
4385
4384
4383
4382
4381
4380
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

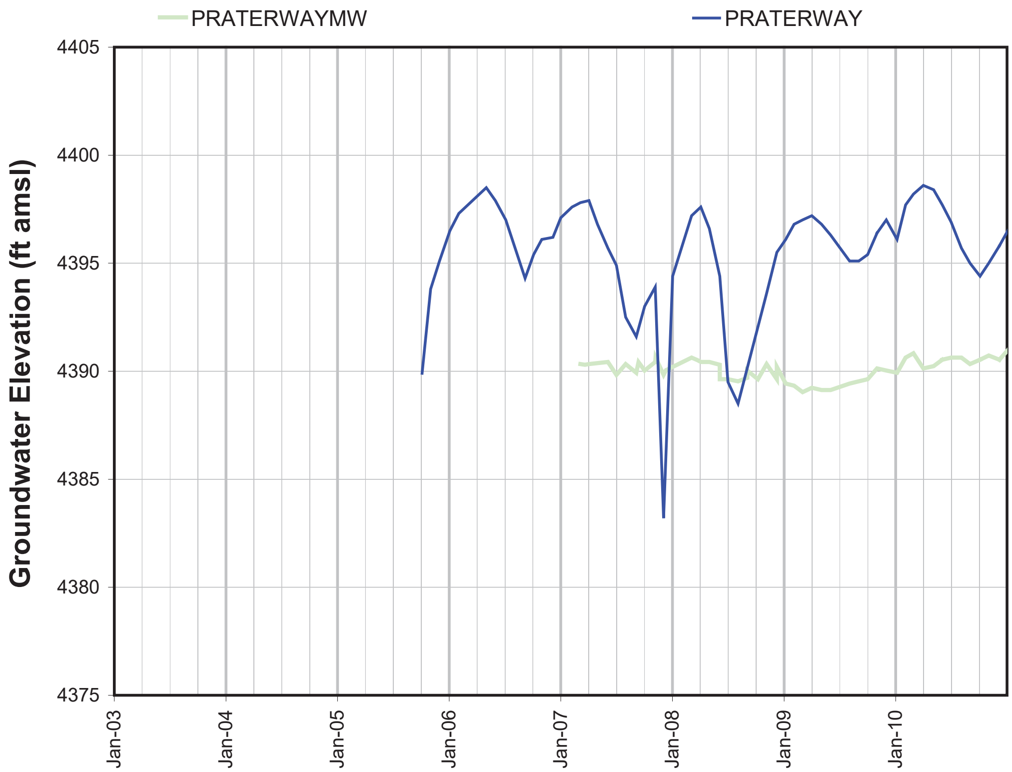

SSFSMW212
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4390
4389
4388
4387
4386
4385
4384
4383
4382
4381
4380
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

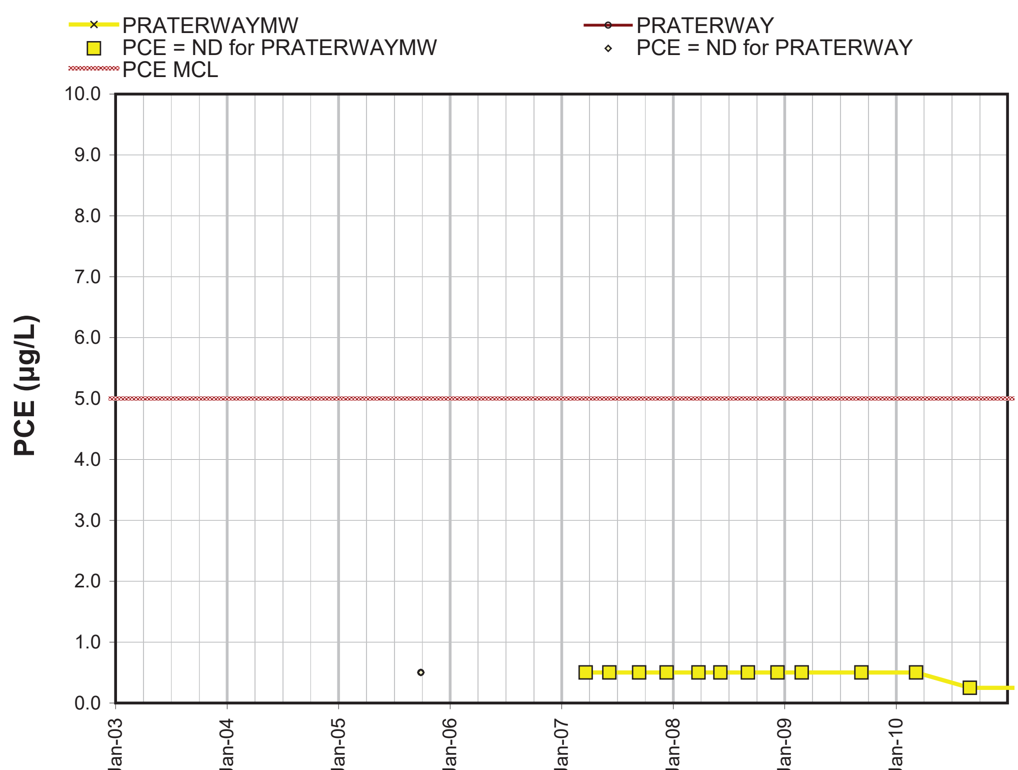
USGSDILWORTH / DILWORTH



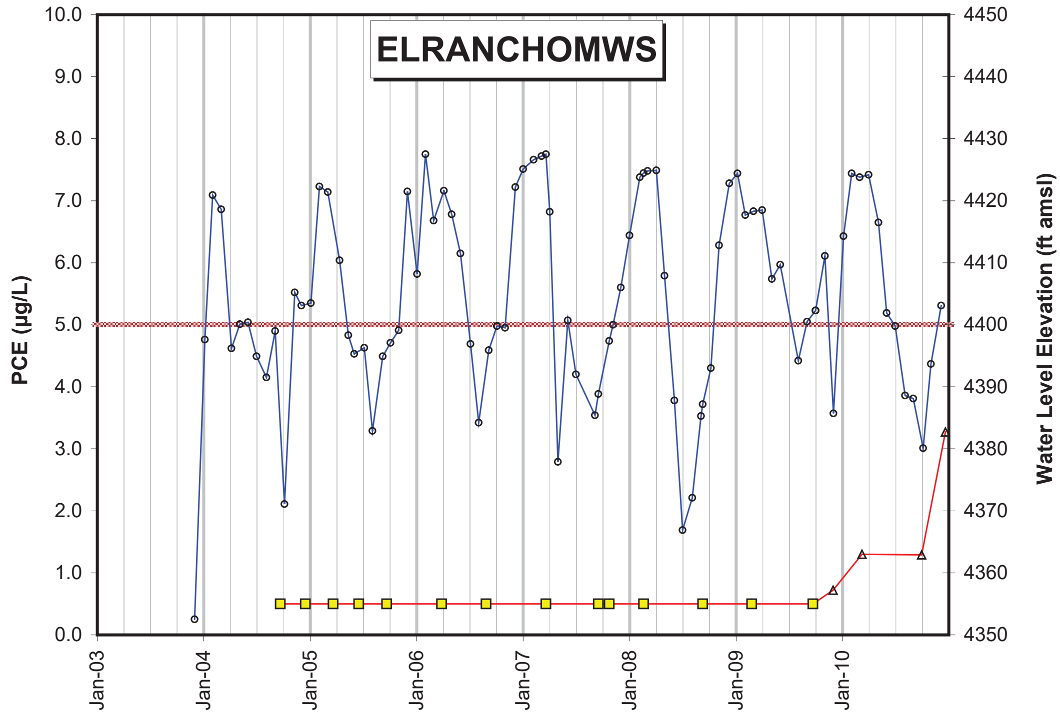


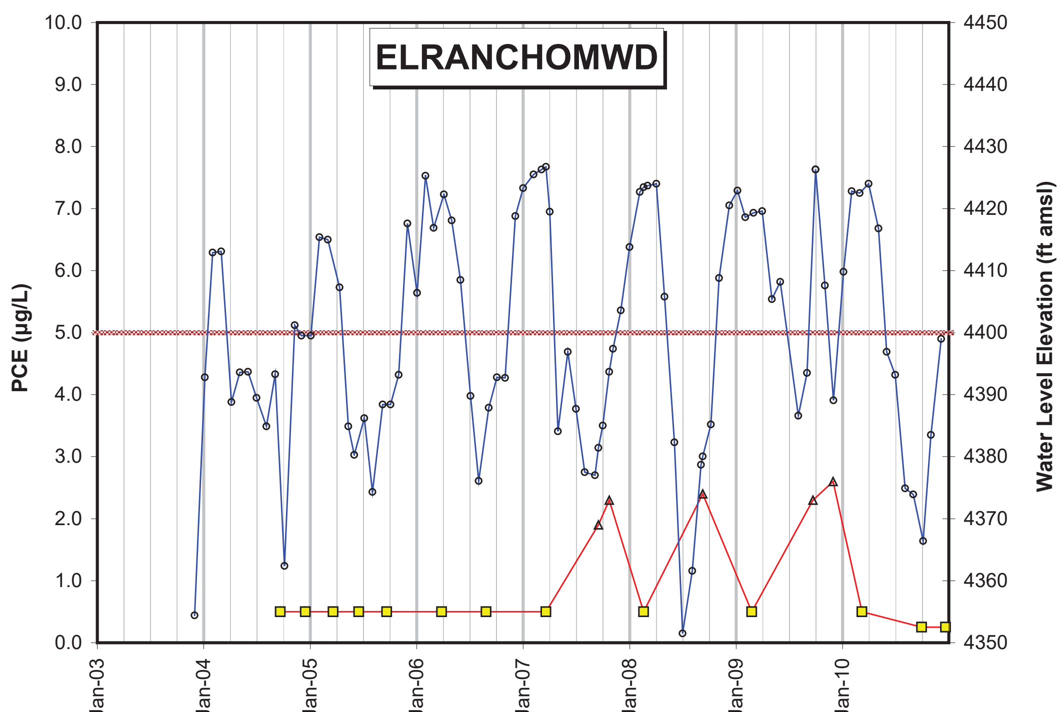
PRATERWAYMW / PRATERWAY



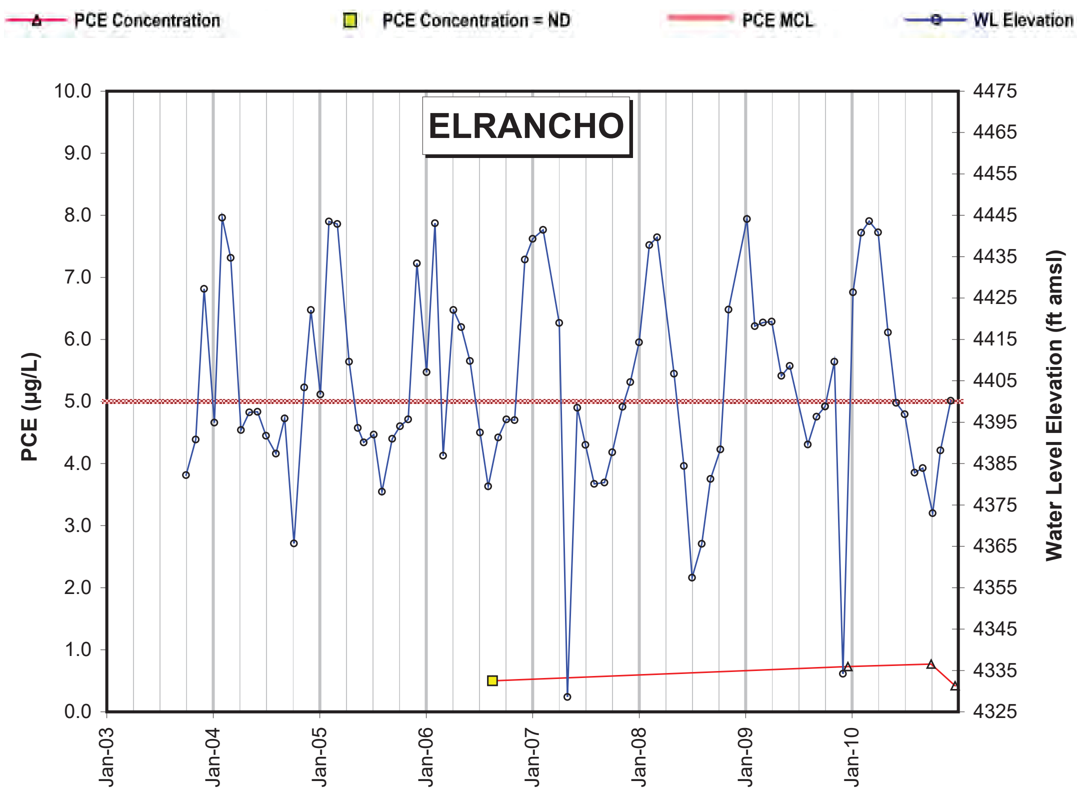



PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation

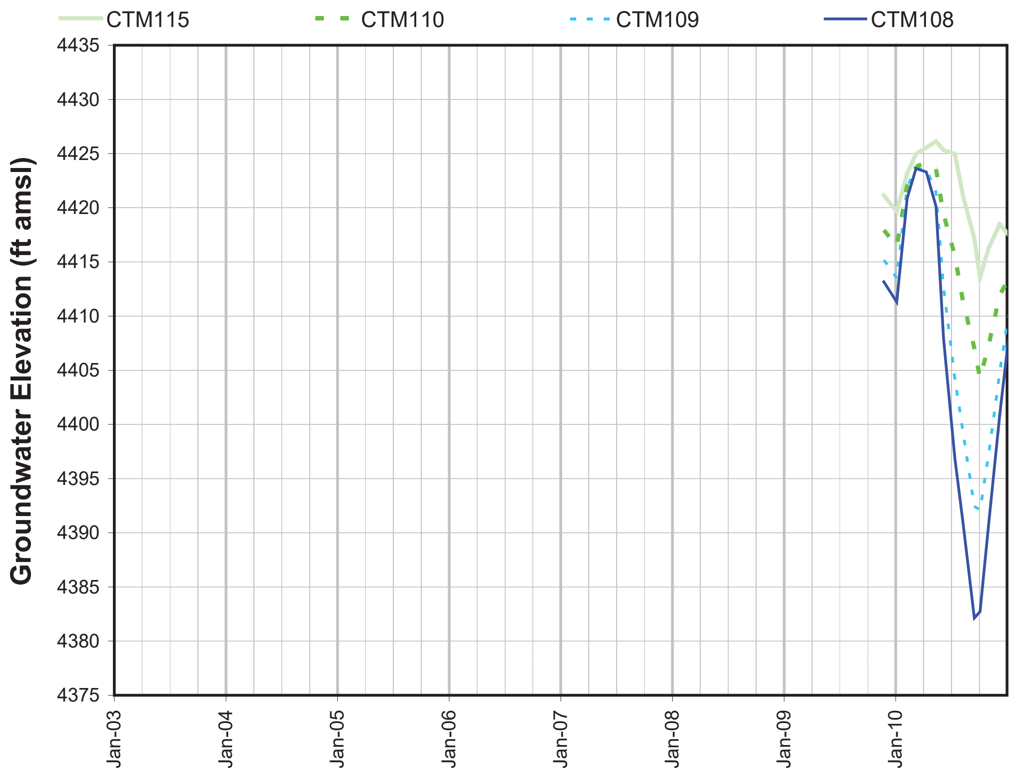

ELRANCHOMWS
PCE (µg/L)
Water Level Elevation (ft amsl)
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

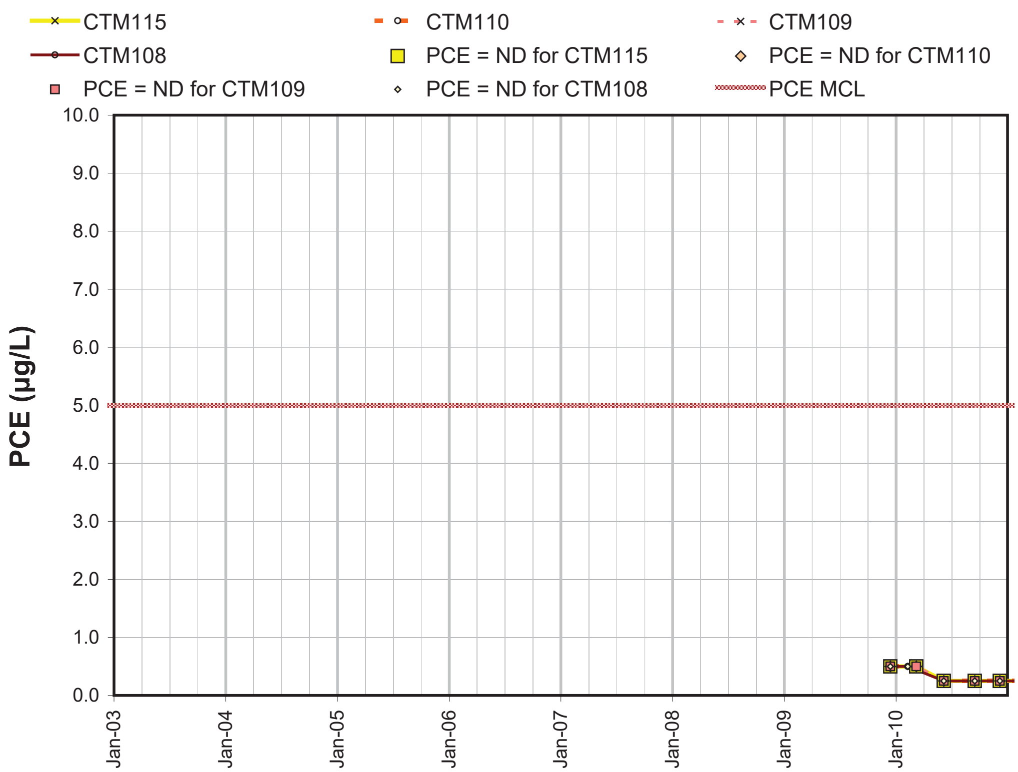

ELRANCHOMWD
PCE (µg/L)
Water Level Elevation (ft amsl)
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

GRAPHS 5.6a – PCE Time-Series and Water Level Hydrograph Charts, El Rancho Subregion Municipal Water Supply Wells

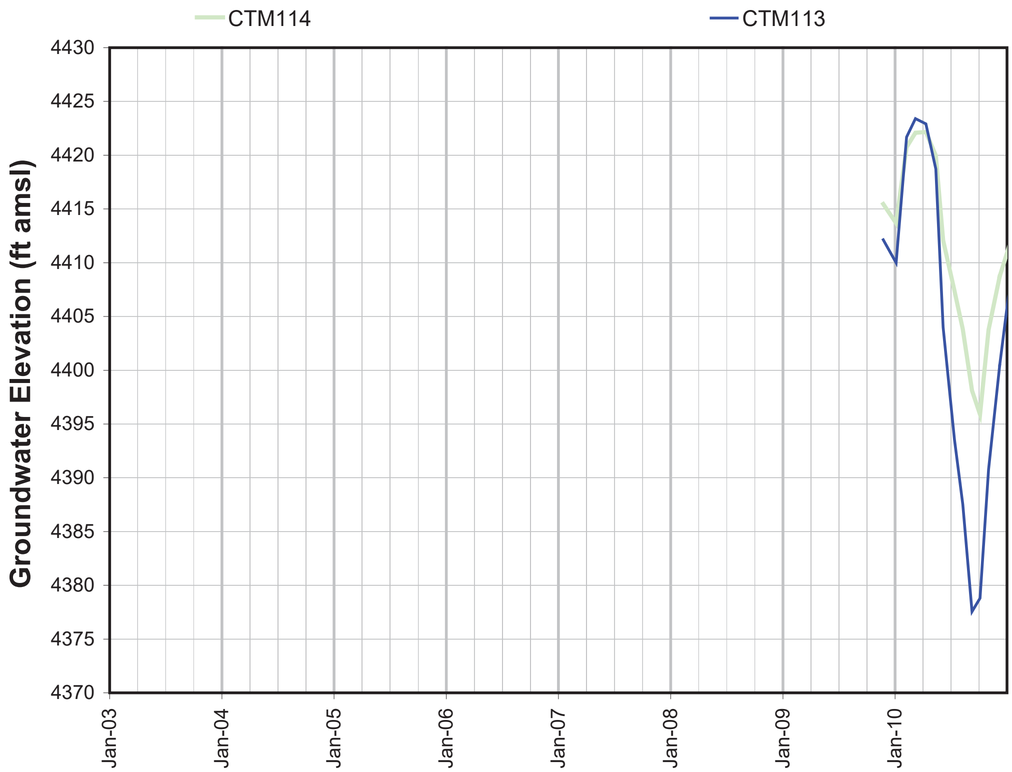


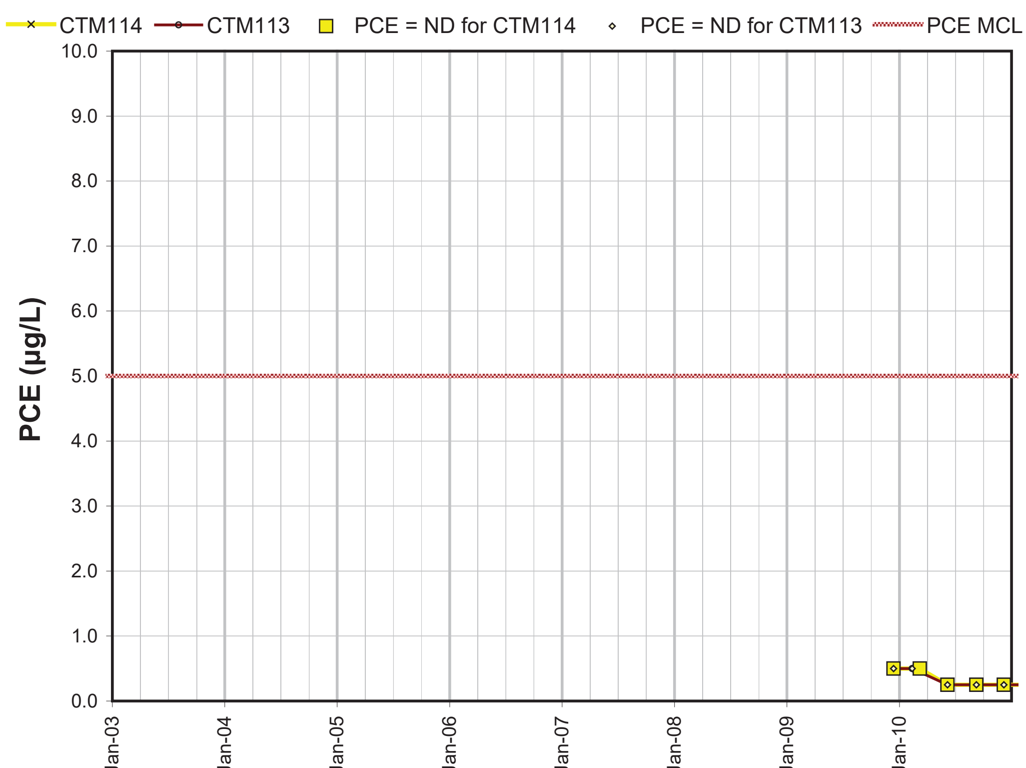
CTM115 / CTM110 / CTM109 / CTM108



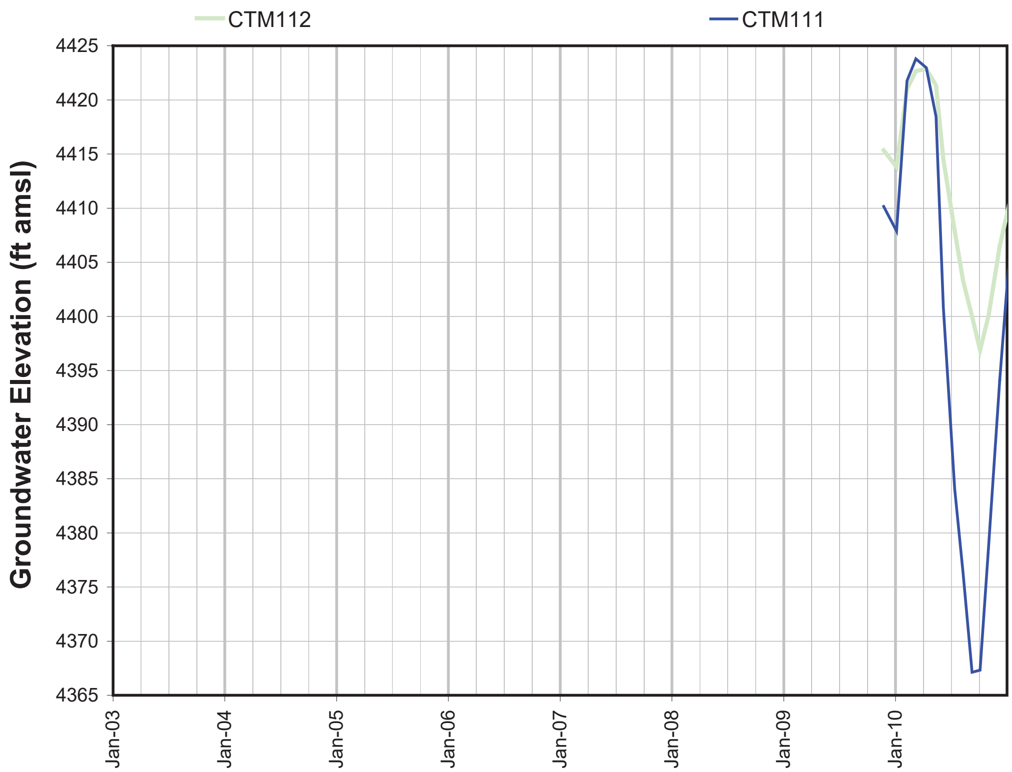


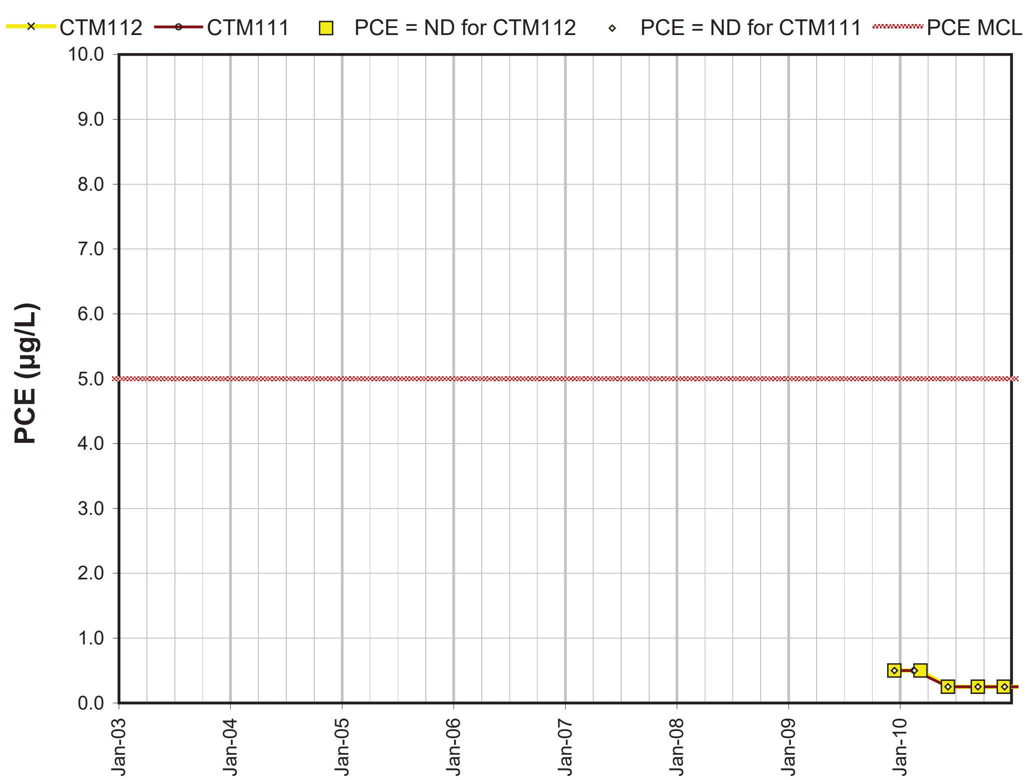
CTM114 / CTM113



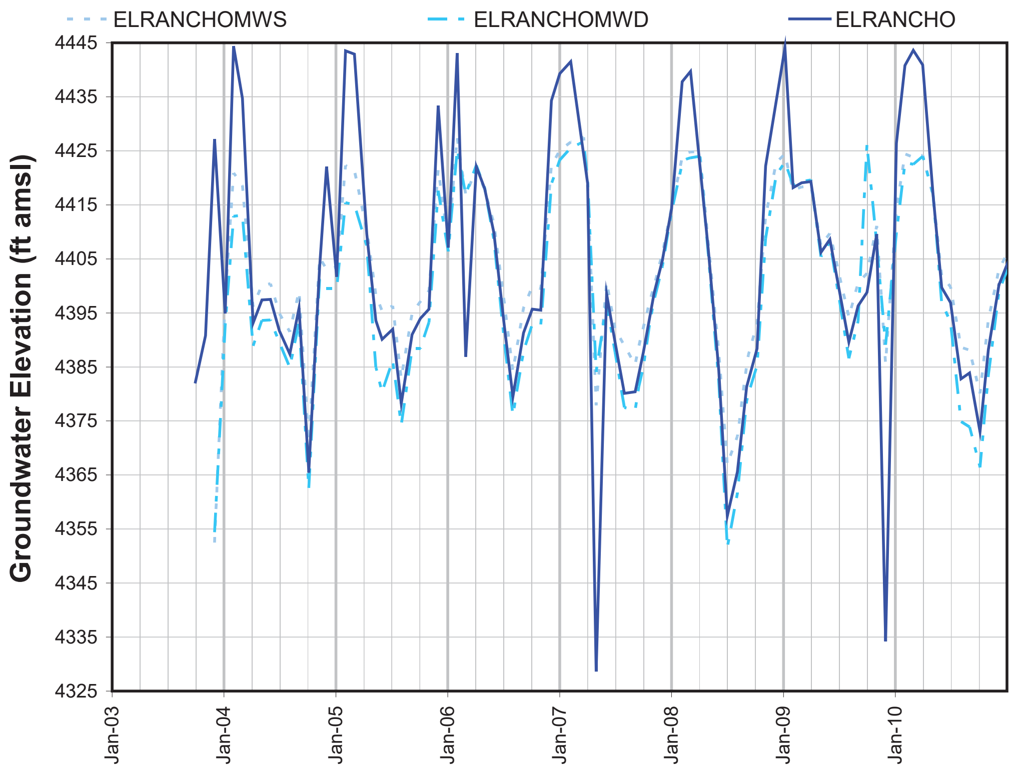


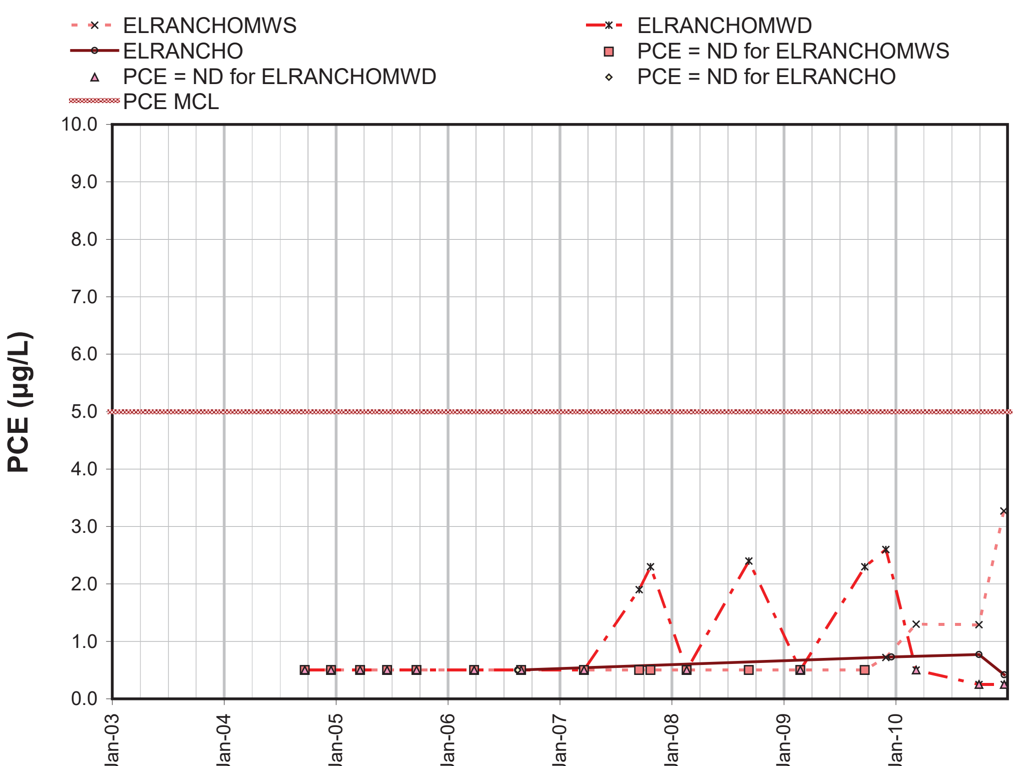
CTM112 / CTM111



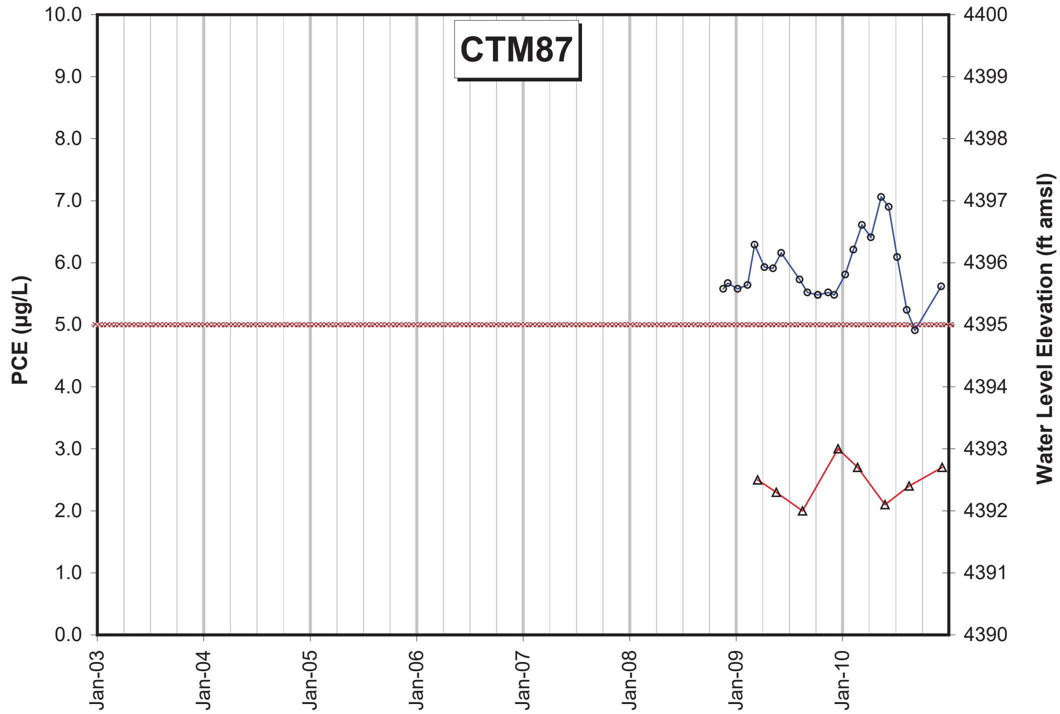


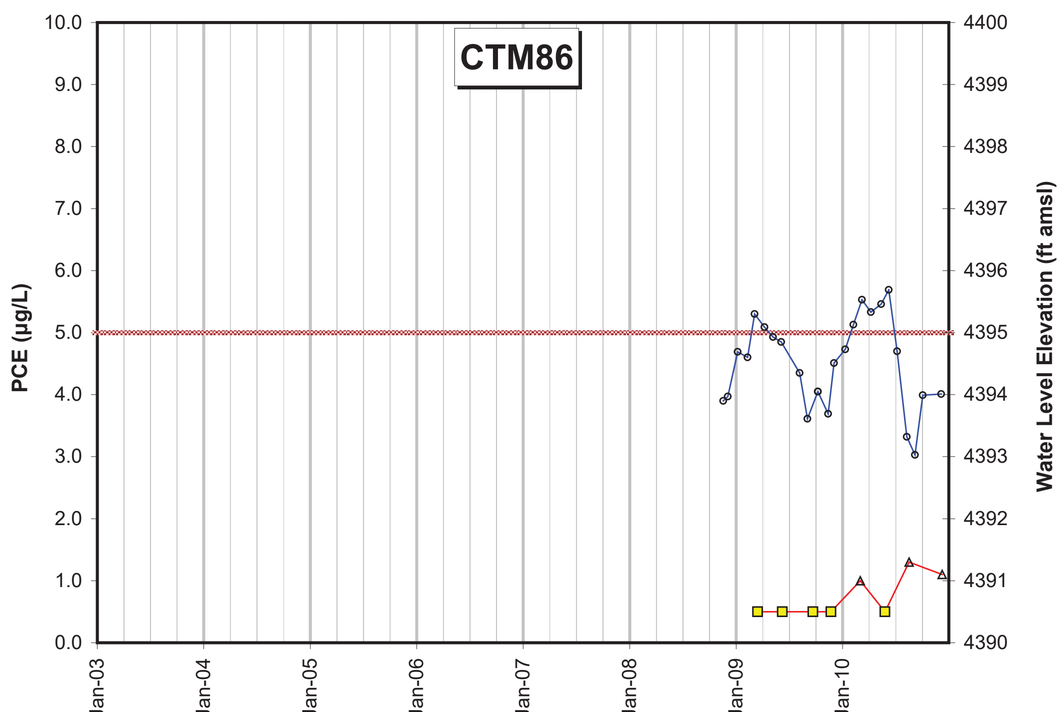
ELRANCHOMWS / ELRANCHOMWD / ELRANCHO

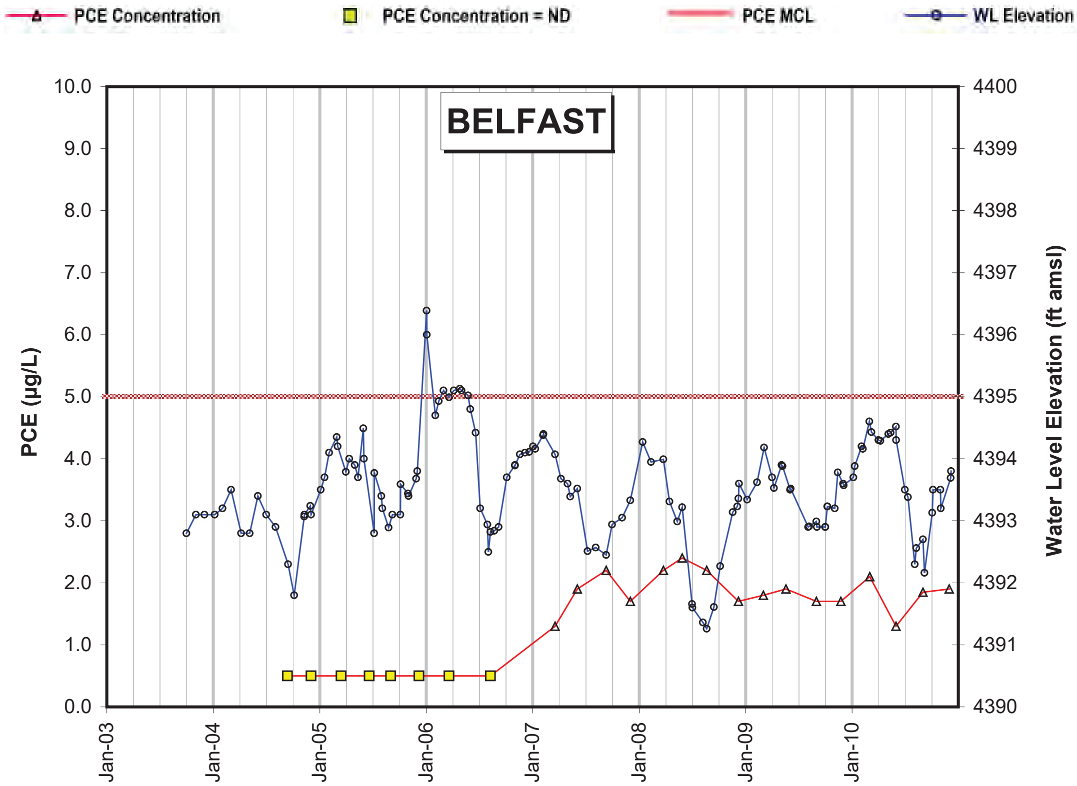


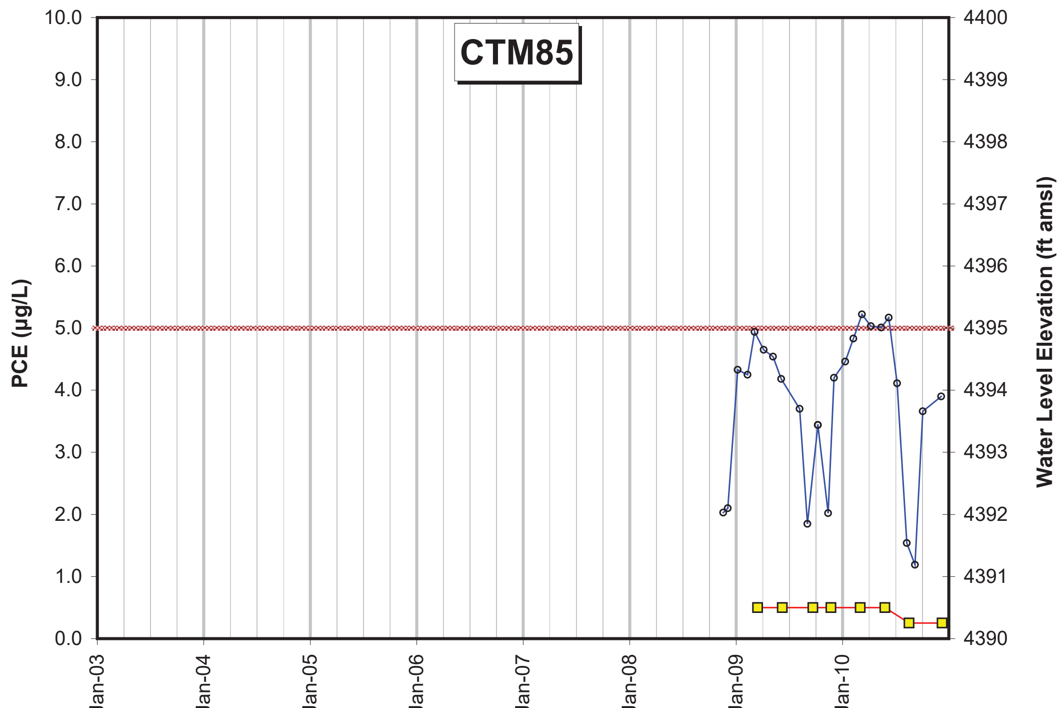


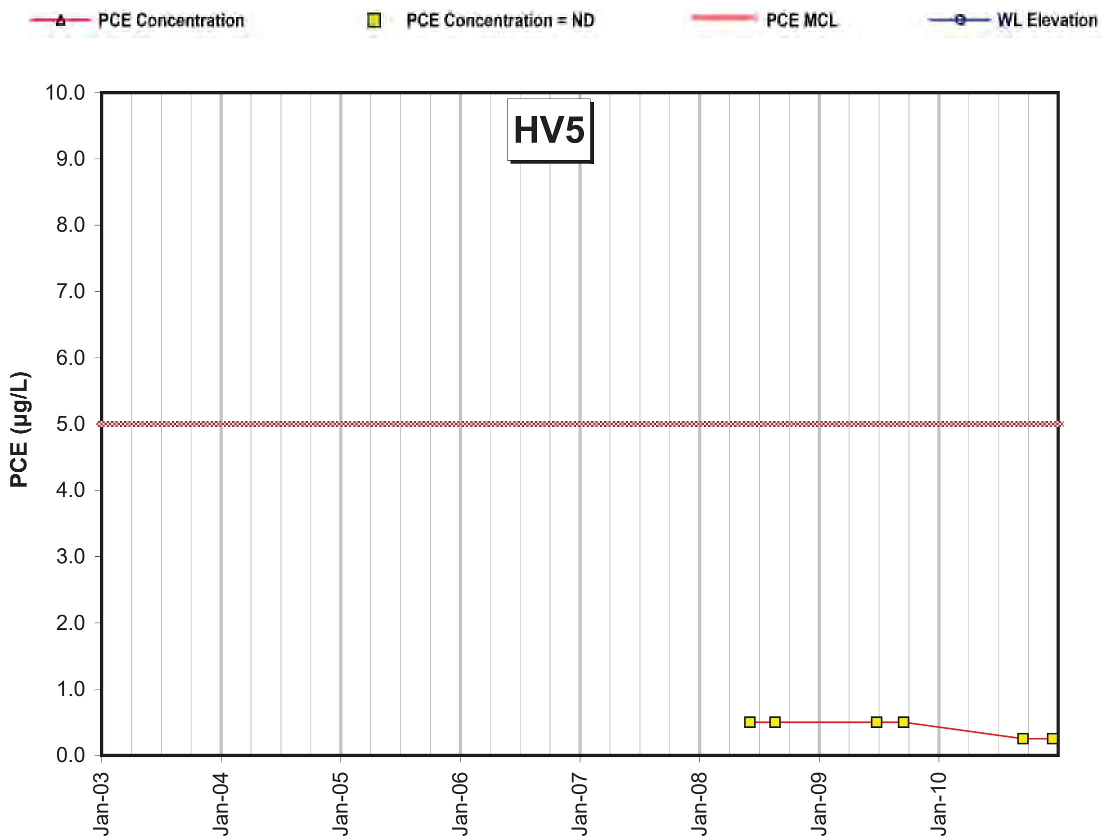
PCE Concentration   PCE Concentration = ND   PCE MCL   WL Elevation



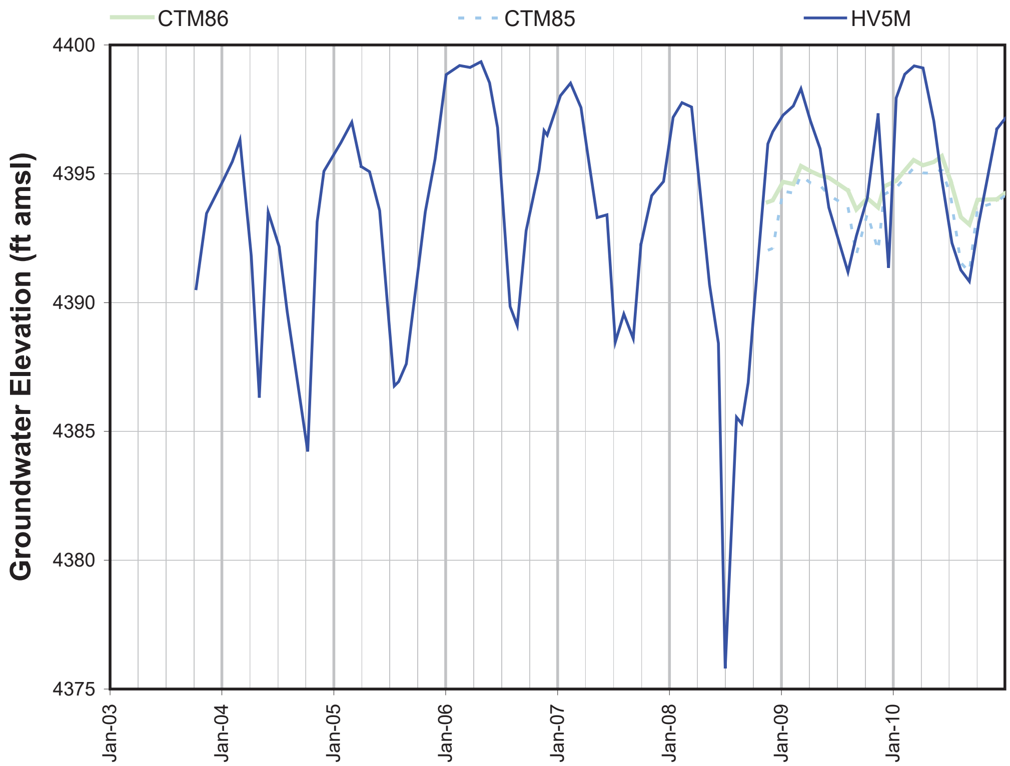


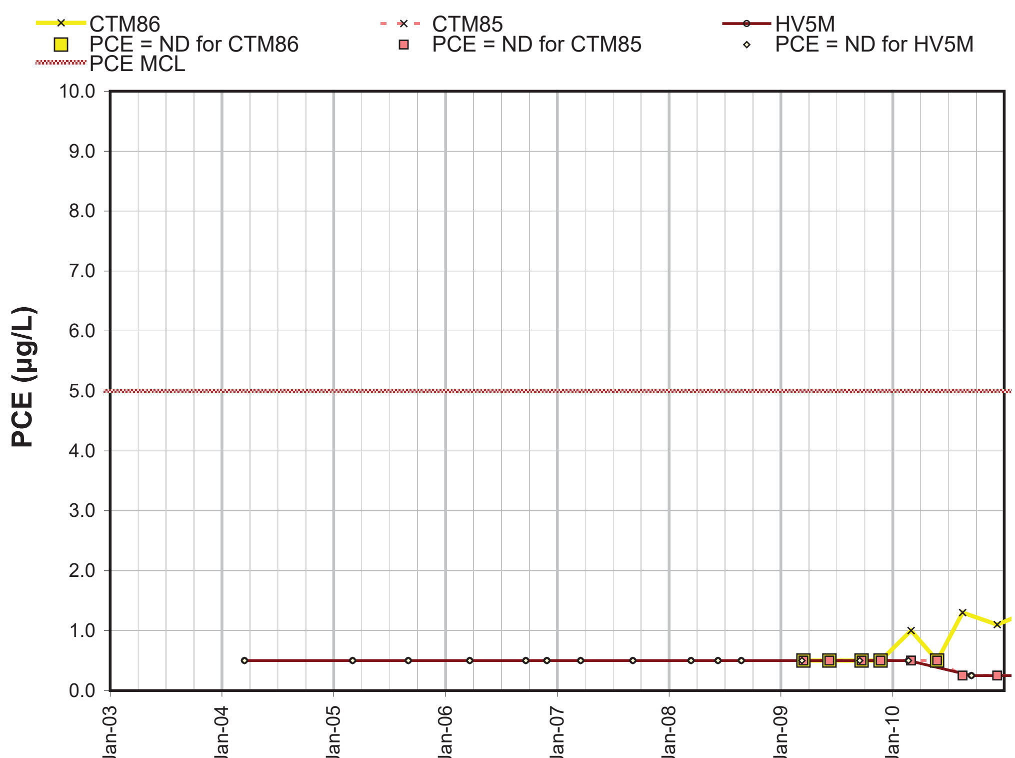

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
BELFAST
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4400
4399
4398
4397
4396
4395
4394
4393
4392
4391
4390
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10


CTM85
PCE (µg/L)
Water Level Elevation (ft amsl)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4400
4399
4398
4397
4396
4395
4394
4393
4392
4391
4390
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

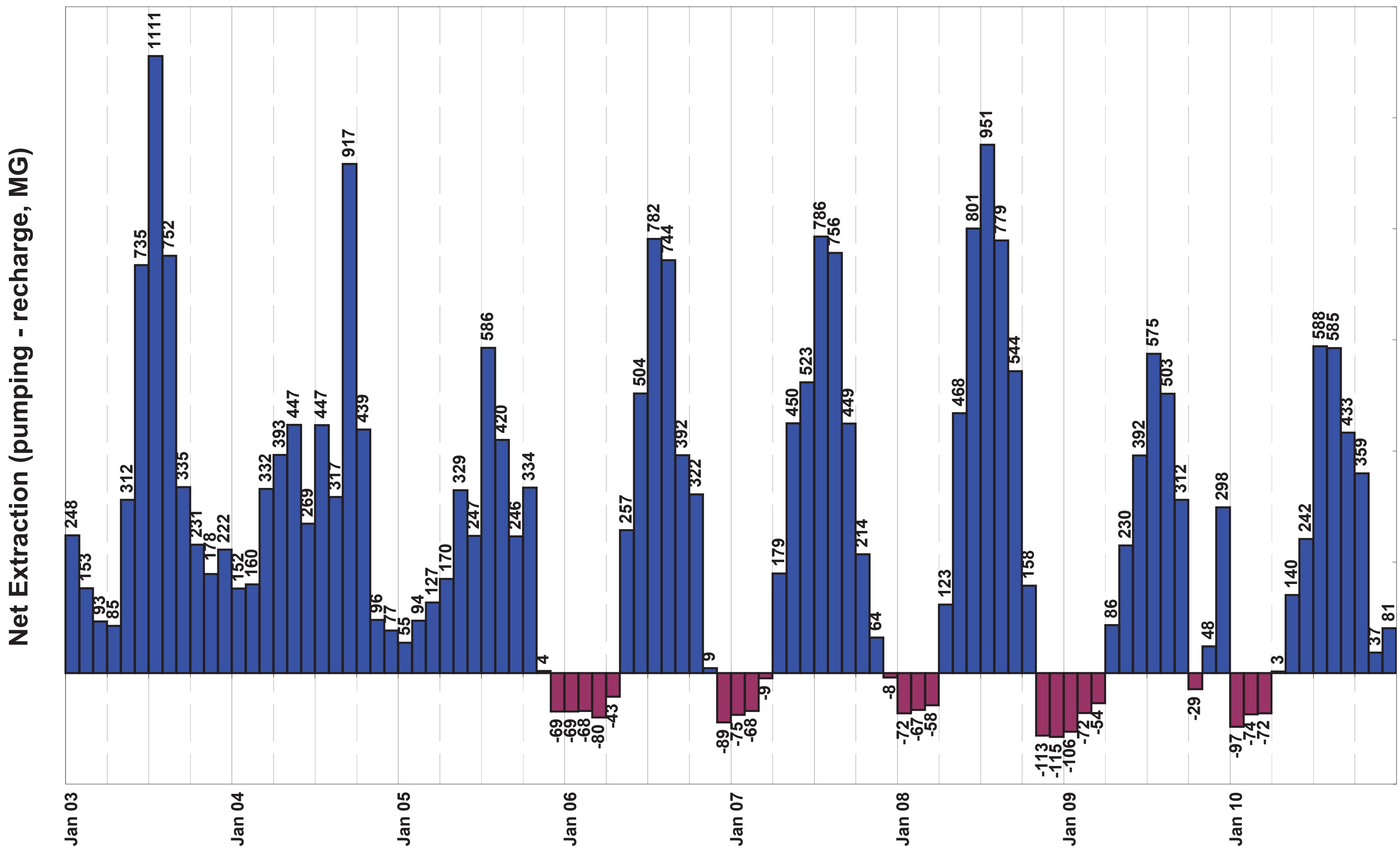

PCE Concentration
PCE Concentration = ND
PCE MCL
WL Elevation
HV5
PCE (µg/L)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

CTM86 / CTM85 / HV5M





Graph 5.8: CENTRAL TRUCKEE MEADOWS MUNICIPAL WATER SUPPLY NET MONTHLY GROUNDWATER PRODUCTION - 2003 through 2010



Appendix 5.1

SO TH RENO S BREGION KEY ELL DECISION MATRI

	WATER QUALITY FUNCTION:											WATER LEVEL FUNCTION:					CLUSTER FUNCTION:		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture assessment	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume migration across low arrier assessment	Plume migration dri er assessment	ertical low/plume migration assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
E				X			X		X		X	X	X	X		X			
CTM14S															[2]	[2]		X	X
CTM15S															X				
CTM16S										X									
				X							X	[2]	[2]	[2]		[2]	X	X	X
					R(CTM106)	R(CTM10)			X		X			[2]		[2]			X
CTM27D															[2]	[2]		X	X
										[2]	X	[2]	[2]	[2]	[2]	[2]	X	X	X
CTM41S																			
CTM45																			
										[2]	[2]			[2]		[2]		X	X
CTM47																			
		(SR Sa)	X								X								
		(SRHA)								X	X	X			X	X			
		(SREPL)	X								X								
		(SREPL)	X								X				X	X			
CTM53										X									
		(SR S)	X								X				X	X			
CTM89															[2]	[2]		[3]	[3]
CTM90															[2]	[2]		[3]	[3]
CTM91															[2]	[2]		[3]	[3]
			[2]								[2]	[2]	[2]	[2]	[2]	[2]	X	X	X
											X	[2]	[2]	[2]	[2]	[2]	X	X	X
											[2]			[2]	[2]	[2]	X	X	X
											X			[2]	[2]	[2]	X	X	X
											X			[2]	[2]	[2]	X	X	X
											X		[2]	[2]	[2]	[2]	X	X	X
											X		[2]	[2]	[2]	[2]	X	X	X
		X	X						X		X		[2]	[2]	[2]	[2]	X	X	X
									X		X			[2]		[2]			X
HOLCOMBAVMW														[2]	[2]	[2]	X	X	X
TERMINAL									X		X			X	X	X			
USGSHOLCOMB																			
											X				X	X			
E		X	X			X			X		X	[2]	[2]	[2]		[2]	X	X	X

Notes:

2010 KEY WELL

2010 WELL CLUSTER MEMBER

tali 2009 Key Wells

R(CTM105) = Redundant with well identified in parenthesis

X(SRHA) = Potential local source in South Reno Subregion at Holcomb Source Area

X(SRVSa) = Potential local source "a" in South Reno Subregion at Vassar Street hot spot

X(SRVSb) = Potential local source "b" in South Reno Subregion at Vassar Street hot spot

X(SREPL) = Potential local source in South Reno Subregion at East Plumb Lane hot spot

1 Potential individual sources are identified by subregion, hot spot, and local source alpha descriptors as appropriate. See notes for descriptions.

2 Water quality and/or water levels should be assessed relative to well's role as part of a well cluster.

3 Wells are outside of South Reno Subregion but represent important wells for assessing area-wide hydrodynamics.

SO TH RENO S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
CORBETT	PCE MASS REMO AL AND CAPT RE	RECEPTOR: PCE data define mass removal quantities and a long-term increasing PCE concentration trend in the deep zone portion of the SR complex plume. Data suggest CORBETT is capturing a portion of the plume that either represents a plume core (that has migrated downgradient from currently defined hot spots), or has other source contributions that contribute to the higher mass in the deep zone at CORBETT than is currently defined in the upgradient, shallow zone portions of the plume. Water level data are a direct function of pumping at the well.	KEY ELL Defines PCE mass removal and assesses effectiveness of pump and treat activities on removal and capture of SR complex plume.	HIGH: KEY WELL	Currently long-term increasing trends have no apparent correlation to upgradient decreasing PCE trends. Future assessments should consider the potential for either an unidentified additional PCE source or a plume core that has migrated to the area proximal to CORBETT. If concentrations continue to increase over the next 2 or more years, a source area investigation should be considered in the region east of the HWB, proximal to CORBETT.
CTM1 S	SPATIAL BACKGRO ND MONITORING	PCE non-detects and other water quality data at CTM14S provide background groundwater characterization for area upgradient of SR shallow zone plume, west of the VLFZ. Water levels characterize area west of the VLFZ and provide vertical gradient characterization (with CTM27D).	Not a ey well Provides background water quality west of the VLFZ.	LIMITED: Upgradient background water quality.	None. Continued monitoring to verify uncontaminated background water quality.
CTM15S	SPATIAL BACKGRO ND MONITORING	PCE non-detects at CTM15S constrains crossgradient (north) extent of SR shallow zone plume complex. The generally good hydraulic connection indicated by seasonal water level fluctuations and the potential closer hydraulic communication between CTM15S and production well pumping to the north (compared to the east) is important in context of the apparent influence the HWB (as a partial flow barrier) has on the groundwater hydrodynamics. Well functions to characterize hydrodynamics that may be critical to defining regional flow characteristics. Higher frequency monitoring (with transducer) should be considered.	Not a ey well Constrains northern extent of SR shallow zone plume complex and is over 1,500 ft upgradient of currently defined plume outlines. Well should continue to be monitored annually for PCE to verify plume status in this area and monitor for potential future emerging trends. Potentially Important well for characterizing hydrodynamics across and east of VLFZ.	MODERATE: Primary value is for long-term assessment of hydrodynamics east of VLFZ.	Deploy transducer in well to verify which pumping wells influence water level response at this well. Data would potentially indicate projection and position of VLFZ/HWB to the north in the area near HIGH and MORRILL.
CTM1 S	SPATIAL PL ME MONITORING	PCE data partially characterizes the SR shallow zone plume interior downgradient (north) from the E. Plumb Ln. hot spot. The step decrease in PCE concentration between 2005Q1 and 2006Q1 has similarities to, but lags by 2 quarters, a marked PCE decrease at CTM52. This similarity is consistent with either 1) migration of a pulse of PCE or 2) similar interrelationships between PCE and water level changes at both wells. PCE and water level contouring are consistent with CTM16S being proximal to but not on the SR shallow zone plume axis. PCE data identify this well as an important location for characterizing potential seasonal patterns and/or plume migration/travel time. The PCE decrease (described above) at CTM16S has similarities to a spike and subsequent decline at USGSLISTON between 2006Q3 and 2007Q1 (roughly a year later) and may indicate CTM16S provides an early indicator of downgradient plume changes. Hydrograph shows seasonal patterns consistent with the HWB representing a partial flow barrier (showing an interrelationship between water levels and overall municipal water supply pumping, but not specifically to CORBETT pumping).	Not a ey well Helps define off-axis plume interior of SR shallow zone plume, north of E. Plumb Ln. hot spot. Represents an important well for to assessing plume extent and stability. Water levels at CTM16S and USGSLISTON are nearly identical and should continue to be tracked and assessed with regard to interrelationships with pumping.	HIGH: Characterizes an area of dynamic PCE concentrations in SR plume interior that may provide help assess plume dynamics and stability.	Continued monitoring and comparison with CTM53, USGSLISTON, CTM92 for patterns that may indicate travel time/mass flux dynamics.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
CTM1 D	P MPING PLAN PERFORMANCE ASSESSMENT PL ME CORE DYNAMICS	PCE data characterize the potential margin of the SR deep zone plume core proximal to CORBETT (receptor). Correlation between PCE concentrations and pumping at CORBETT are consistent with the well functioning to define a relatively sharp PCE concentration gradient near the well screen that migrates seasonally in response to pumping. Part of a well cluster with USGSWOOSTER that provides a key location for assessing vertical PCE distribution and vertical gradient near CORBETT.	KEY ELL Provides partial assessment of capture capabilities at CORBETT. Assesses plume core dynamics associated with pumping at CORBETT (receptor). Part of a cluster that provides key vertical PCE distribution and vertical gradient data.	HIGH: KEY WELL	PCE data at this well exhibit a strong interrelationship with pumping at CORBETT. This correlation should be evaluated to determine its potential significance. PCE distribution in the deep zone are poorly constrained, particularly transverse (N-S) to ambient flow direction. Consider an additional well cluster north-northwest of CORBETT to help define lateral extent of PCE east of HWB.
CTM1 S	DISTAL (LATERAL) PL ME DYNAMICS (potentially redundant w/CTM10)	PCE data characterize plume interior in SR shallow zone plume. Located in a region that has limited well distribution that poorly characterize PCE distribution in the upgradient, downgradient, and vertical directions. Part of a well cluster with CTM106 that provides a key location for assessing vertical PCE distribution and vertical gradient. Data indicates plume concentrations are higher in CTM106 (screen interval: 125.5-135.5 ft bgs) than at CTM18S (screen interval: 14.5-35.5 ft bgs).	KEY ELL Helps assess plume dynamics in unconstrained downgradient portion of SR complex plume where plume capture is uncertain. Part of a cluster that provides vertical PCE distribution and vertical gradient data.	HIGH: KEY WELL	PCE concentrations should be monitored closely for potentially increasing trends that would suggest plume expansion in this distal portion of the plume. The capture of this portion of the SR plume is uncertain and is significant increases in PCE concentrations occur at this well, additional downgradient wells should be considered..
CTM D	SPATIAL BACKGRO ND MONITORING	PCE non-detects and other water quality data at CTM27D provide background groundwater characterization for area upgradient of SR deep zone plume west of the VLFZ. Water levels characterize deep zone in area west of the VLFZ and provide vertical gradient characterization (with CTM14S).	Not a ey well CTM27D provides background ambient water quality west of the VLFZ.	LIMITED: Upgradient background water quality.	None
CTM D	SPATIAL PL ME MONITORING	PCE data at CTM33D help define the upgradient (west) SR deep zone plume outline and is part of a well cluster with CTM92 and CTM93 that provides a key location for assessing vertical PCE distribution and vertical gradient west of the HWB. Important location along or near SR complex plume axis between E. Plumb Ln. hotspot and Corbett well. Characterization of migration pathway for low level PCE is problematic due to persistent upward hydraulic gradient. Water levels provide deep zone characterization west of HWB in Middle block and are consistent with HWB as a partial flow barrier. Transducer data during the CORBETT-MILL aquifer test are consistent with the deep zone of the complex aquifer system having more direct response to pumping at MORRILL (or less likely HIGH) than pumping at either CORBETT or MILL.	KEY ELL Helps define upgradient (west) SR deep zone plume outline. Water levels help assess hydrodynamics west of the HWB in the Middle block. Part of a cluster that provides key vertical PCE distribution and vertical gradient data.	HIGH: Demonstrates presence of PCE at a depth inconsistent with hydraulic gradients in the area. Assesses	Develop list of potential alternative explanations for PCE in this well (e.g. vertical PCE migration at distal location where there is a downward vertical gradient, an upgradient DNAPL source, etc.). Consider construction of additional well clusters upgradient from this well but more proximal to E. Plumb Ln. and (at a lower priority) Vassar Street hot spots to assess potential for vertical PCE migration nearer to potential source areas.

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CTM 1S	SPATIAL BACKGRO ND MONITORING	PCE non-detects at CTM41S constrain the upgradient (west) extent of SR shallow zone plume and provide background groundwater characterization west of the VLFZ. Water levels characterize shallow zone in area west of the VLFZ. Proximity to Cochran ditch may impact water levels and potentially water quality (depending on integrity of ditch). Water level patterns (particularly prior to 2005) suggest a hydrodynamic response to a source or sink unrelated to regional pumping that is more discrete and of larger magnitude in CTM41S than other wells to the east and north. The timing of this response is consistent with a groundwater source between May and September or a groundwater sink between September and May. If response is cause be ditch leakage CTM41S functions to monitor that dynamic.	Not a ey well CTM41S provides upgradient background water quality west of the VLFZ. Water level patterns suggest a hydrodynamic response to a source or sink unrelated to regional pumping and should continue to be monitored monthly (or more frequently) to better define patterns and assess significance of hydrodynamic response.	LIMITED: Upgradient background water quality. Water level data may be an indicator of local groundwater source or sink.	Maintain transducer in well to monitor hydrograph patterns to characterize seasonal fluctuations. Obtain ditch records as available for Cochran Ditch between 2001 - current to correlate with water level patterns.
CTM 5	SPATIAL BACKGRO ND MONITORING	PCE non-detects at CTM45 constrain cross- or upgradient extent of SR shallow zone plume. Well functions to verify uncontaminated status of area upgradient of location where several PCAs exist. Water levels are generally redundant with water level data at wells in the E. Plumb Ln. hot spot and therefore are primarily useful to define quarterly water level contours and lateral gradient.	Not a ey well Well monitors an unimpacted area where multiple PCAs exist, located 2,000 ft cross-gradient (south) from the E. Plumb Ln. hotspot. Water levels are generally redundant with other SR-2 wells but help for regional water level contouring and lateral gradient information.	LIMITED: Monitors area where multiple PCA's exist, but PCE has not been detected.	None. Continued monitoring for evidence of PCE contamination/release.
CTM	SPATIAL PL ME MONITORING	PCE data characterize the upgradient (west) portion of the Vassar Street hot spot. PCE concentrations have ranged between 1.9 to 10 µg/L and have shown apparent short-term increases and decreases with no apparent longer-term trend. The similar magnitude PCE concentrations exhibited at CTM46 compared to CTM47 and CTM48 suggest that they all currently monitor the margins in the Vassar Street hot spot area. Part of a key well pair (with HOLCOMBAVMW -open at ~385 ft) that provides general vertical gradient characterization. Otherwise, has similar hydrograph characteristics compared to CTM62. Water level data are of value primarily for defining water level contours and local lateral gradient.	Not a ey well Helps delineate upgradient (west) outline of SR shallow zone plume and define the Vassar Street hot spot. Provides important data to assess hot spot extent and plume stability. CTM46 represents part of a well cluster with HOLCOMBAVMW that provides vertical gradient characterization.	HIGH: Characterizes hot spot PCE distribution near Vassar Street hot spot.	Consider an additional upgradient monitoring well to determine whether PCE in CTM46 and CTM47 is associated with Vassar Street hot spot or, alternatively, represents PCE from a different, upgradient source.
CTM	SPATAL PL ME MONITORING	PCE data at CTM47 characterizes the upgradient/crossgradient (northwest) portion of the Vassar Street hot spot. Unlike CTM46, that is also upgradient of the Vassar Street hot spot, PCE data exhibit a relatively consistent decreasing long-term trend that may correlate to a similar decreasing trend at hot spot well CTM48. Prior to 2007Q1, CTM47, had substantially lower PCE concentrations than CTM48. Starting in 2007Q1 PCE similar magnitude concentrations at CTM47 and CTM48 are consistent with negligible contributions of PCE from a potential source between the wells. Well has similar hydrograph characteristics compared to CTM62. Water level data are of value primarily for defining water level contours and local lateral gradient.	Not a ey well Helps delineate up- or crossgradient (northwest) outline of SR shallow zone plume and characterize PCE distribution near the Vassar Street hot spot. Provides important data to assess hot spot extent and plume stability.	HIGH: Characterizes hot spot PCE distribution near Vassar Street hot spot.	Consider an additional upgradient monitoring well to determine whether PCE in CTM46 and CTM47 is associated with Vassar Street hot spot or, alternatively, represents PCE from a different, upgradient source.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
CTM	MASS FL /SO RCE ASSESSMENT	CTM48 (prior to 2007Q4) defines this location as formerly part of the Vassar Street hotspot. Decreasing PCE concentrations suggest that PCE mass flux in the hot spot near CTM48 has diminished. However, this well currently functions to characterize continued long-term trends and monitor for possible increases in PCE mass contribution from the source area. Well has similar hydrograph characteristics compared to CTM62. Water level data are of value primarily for defining water level contours, local gradient, and interrelationships between water level and PCE concentrations.	KEY ELL Pro ides assessment o mass lu /source characterization in area that was pre iously considered to contain a local source, ut whose contri utions ha e diminished CTM has e hi ited high concentrations (up to 1 0 µg/L) and a history o relati ely spi y time series data that pre iously de ined part o the assar Street hot spot More recent PCE concentrations ha e een steadily decreasing to concentrations more similar to other near y (upgradient) non-hot spot wells	HIGH: KEY WELL	Consider an additional upgradient monitoring well to determine whether current lower level PCE at CTM48 is associated with Vassar Street hot spot or, alternatively, represents PCE from a different, upgradient source.
CTM	MASS FL /SO RCE ASSESSMENT	PCE data at CTM49 characterize and monitor an intermittent, potentially short-term and local source. Water level data apparently characterize the water table in or adjacent to the VLFZ, being muted and having a relatively flat trend that suggests poor hydraulic connection to regional hydrodynamics. Small water level spikes suggest water levels respond to a local source (potentially a leaking stormdrain near CTM50).	KEY ELL Provides assessment of potential mass flux/source characterization from likely nearby local (and relatively small) residual or intermittent source. Water levels characterize VLFZ hydrodynamics and have apparent poor connection to regional hydrodynamics.	HIGH: KEY WELL	Deploy transducer in well (or CTM50) to verify potential impact of stormdrain on water levels and potentially help define any interrelationship between PCE and water level data. Based on shallow depth to water and absence of PCE at upgradient well CTM50, source is likely to be in immediate vicinity of well and of relatively small magnitude. As a result, additional characterization in the area is probably not warranted. Well should continue to be monitored for potential additional pulses of PCE contamination.
CTM50	SPATIAL BACKGRO ND MONITORING	PCE non-detects at CTM50 constrain upgradient (west) extent of local hot spot defined by CTM49. Water level data apparently characterize the water table in or adjacent to the VLFZ, being muted and having a relatively flat trend that suggests poor connection to regional hydrodynamics. Small water level spikes suggest water levels respond to a local source (potentially a leaking stormdrain near CTM50).	Not a ey well Potentially provides background water quality but may be impacted by leaking stormdrain. Water levels redundant with CTM49.	LIMITED: Well constrains upgradient extent of PCE detected at CTM49. Data pedigree may be compromised by construction adjacent to stormdrain. Several PCA's are identified upgradient.	Deploy transducer in well (or CTM49) to verify potential impact of stormdrain on water levels. If verified consider elimination of well from water level network.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
CTM51	MASS FL /SO RCE ASSESSMENT	CTM51 previously helped define the E. Plumb Ln. hot spot. Of supporting value to hot spot well CTM52. The more recent decreasing PCE trends recognized at CTM51 are similar to, but concentrations are measurably lower than those at CTM52. The water level hydrograph is nearly identical to CTM52. CTM51 (10-30 ft bgs) is constructed over a larger interval than CTM52 (12-22 ft bgs) and may, as a consequence, characterize a somewhat different vertical proportion of the plume near the water table. The longer screen may be at least partly responsible for the differences in PCE concentrations at CTM51 compared to CTM52. The potential relationship between higher PCE and low water levels at CTM52 is not as apparent here.	KEY ELL Previously part of E. Plumb Ln. hot spot. Well continues to provide assessment of potential mass flux at or near the hot spot/source area. CTM51 is useful to compare to and verify observations in CTM52. Differences in PCE concentration at CTM51 compared to CTM52 may partly reflect position relative to source or difference in screen length. CTM52 is considered to more optimally assess local source and mass flux to groundwater from source(s) at the E. Plumb Ln. hotspot.	HIGH: KEY WELL	None. Continued monitoring and verification of decreasing PCE trend in hotspot. Periodically compare to CTM52 to verify similarity in patterns/trends and relative concentrations.
CTM5	MASS FL /SO RCE ASSESSMENT	CTM52 helps define E. Plumb Ln. hot spot and functions as an important source area monitoring site for characterizing long-term PCE contribution from the E. Plumb Ln. hotspot. The relatively spiky, higher PCE concentrations between 2003Q4 and 2005Q3 may be symptomatic of either an active discharge source or the result of historically low water levels followed by a marked increase in water level during that period. The sharp transition to lower, stable to decreasing concentrations after 2005Q3 may be the consequence of 1) the elimination of an active source, 2) the migration of a higher concentration PCE pulse past the well, or 3) an interrelationship between PCE concentration and the marked increasing water levels in the well between 2004Q2 and 2005Q3 (such as by dilution/dispersion). The long-term decreasing PCE concentration trend recognized at CTM52 (best represented after 2008Q2) should be monitored to assess whether there is a sustained decline in PCE mass contribution from this hotspot or whether the decreasing PCE concentration trend is a function of shorter-term hydrodynamics (i.e., generally higher water levels) that could reverse with a change in stresses to the groundwater system (pumping, precipitation, etc.). The recognized association between rapidly increasing water levels (from a historical minima) and the cessation of spiky, higher PCE concentrations should be monitored for by continued monthly collection of water levels to assess whether this association represents a meaningful water level-PCE interrelationship. Correlation between pumping dynamics and relatively small water level changes should be further assessed to verify role of pumping on groundwater flow in region.	KEY ELL Defines E. Plumb Ln. hot spot. Provides key assessment of mass flux to groundwater and source area assessment at the E. Plumb Ln. hot spot.	HIGH: KEY WELL	Periodically compare PCE time series to other wells along this segment of SR shallow zone plume axis to assess for PCE concentration dynamics, mass flux, and travel time indicators. PCE concentrations have shown a short-term decreasing trend since 2008Q2 that suggest a diminishing PCE flux. PCE should be monitored closely for increasing PCE concentrations or spikes that may be an indicator of increased mass flux associated with water level minimums and/or rapidly increasing water levels, or additional PCE releases.
CTM5	SITE-SPECIFIC PL ME DYNAMICS	CTM53 helps define the plume interior downgradient or crossgradient (east) from the E. Plumb Ln. hot spot. Recent marked increases in PCE 2009Q3 to 2010Q1 indicate that the plume migration is dynamic. The potential correlation of higher PCE during periods of higher water levels apparent prior to 2009 is not apparent during these recent PCE increases. The well functions to characterize PCE concentration dynamics that are poorly understood and represent a data gap that needs to be monitored and assessed.	Important ut not a ey well Helps define SR shallow zone plume interior and characterize PCE distribution near E. Plumb Ln. hot spot. Provides important data for assessing recent (2009/2010) PCE dynamics proximal to hot spot.	HIGH: Characterizes hot spot PCE distribution near E. Plumb Ln. hot spot. Recent (2009/2010) PCE concentration increases at CTM53 characterize plume dynamics that are unexplained and potentially of significance.	Monitor PCE concentrations quarterly to track unexplained increasing concentration PCE dynamics at well. Consider the potential for plume core migration through this site or the movement of the plume axis towards this well.

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CTM 0	SPATIAL PL ME MONITORING	CTM60 functions to provide partial definition of the up- or crossgradient (west) plume outline in the vicinity of the E Plumb Lane hotspot. Relatively stable, low to non-detect PCE concentrations (maximum historical GMP value = 1.9 µg/L) suggest a relatively low sampling frequency is needed to monitor plume extent here. Like other wells near E Plumb Lane hotspot (CTM51, CTM52, CTM16S) , highest PCE concentrations occur during earlier part of GMP record. Water levels are redundant with CTM52 (key well) and therefore are primarily useful to define quarterly water level contours and lateral gradient.	Not a ey well Helps define up- or crossgradient outline of SR shallow zone plume upgradient/crossgradient of E. Plumb Ln, hot spot. Provides important data to assess hot spot extent and plume stability.	HIGH: Characterizes hot spot PCE distribution near E. Plumb Ln. hot spot.	Continued monitoring to verify extent of hot spot and plume stability. If PCE concentrations increase significantly also consider the possibility of an additional upgradient source contribution.
CTM	MASS FL /SO RCE ASSESSMENT	CTM62 helps define the Vassar Street hot spot and potential source area upgradient of the well. Order of magnitude higher PCE concentrations compared with upgradient well CTM47, proximity to PCA's, and nearby PCE detections in soil vapor and soil are consistent with a source area in the vicinity of the well. The generally flat to slightly increasing PCE trend (since a spike of 120 µg/L in 2004Q2) suggests that a continued source/residual source exists near this well. The spiky pattern and potential (albeit poor) correlation between marked changes in water levels and PCE spikes are consistent with a residual PCE source that contributes more PCE to the groundwater when water levels are dynamic, and particularly when water levels rise. Alternatively, PCE spikes may be a result of other undefined changes in mass flux or plume dynamics. Water level data at this well are important for characterizing hydrodynamics and interrelationships between water level and PCE concentration in the Vassar Street hot spot.	KEY ELL De ines assar Street hot spot Pro ides assessment o mass lu /source characterization or a local apparently continuing source CTM has e hi ited high PCE concentrations (1 0 µg/L ma imum) and a history o relati ely spi y PCE time series data that has had a sta le or slightly increasing trend with time	HIGH: KEY WELL	Consider focused source area investigation in upgradient area proximal to CTM62.
CTM	AREA-SPECIFIC HYDRODYNAMICS ASSESSMENT	PCE non-detects at CTM89 verify uncontaminated groundwater conditions southwest of the Reno-Tahoe International Airport and upgradient of LONGLEYLANE1 municipal supply well. Water level data provide important information on area of influence of CORBETT based on clear drawdown response. Part of a well cluster with CTM90 and CTM91 that provides a key location to monitor for PCE and characterize vertical gradient in the area upgradient (west) of LONGLEYLANE1 .	Not a ey well: Provides sentry capacity for LONGLEYLANE1. Part of a cluster that helps assess vertical gradient distal from a currently defined plume.	MODERATE: Part of a well cluster that can provide assessment of area-specific hydrodynamics. Value as sentinel well is limited by its distance (roughly 5,400 ft west) from and uncertain capture zone of potential receptor LONGLEYLANE1. Location downgradient of numerous PCAs, including Artist Cleaners PCE Project Site, make well cluster useful for long-term monitoring.	None. Continued monitoring for potential PCE contamination from upgradient PCAs. Assess well cluster water level data annually to assess hydrodynamics in area.

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CTM 0	AREA-SPECIFIC HYDRODYNAMICS ASSESSMENT	PCE non-detects at CTM90 verify uncontaminated groundwater conditions southwest of the Reno-Tahoe International Airport and upgradient of LONGLEYLANE1 municipal supply well. Water level data provides important information on area of influence of the CORBETT based on clear drawdown response. Part of a well cluster with CTM89 and CTM91 that provides a key location to monitor for PCE and characterize vertical gradient in the area upgradient (west) of LONGLEYLANE1 .	Not a ey well: Provides distal sentry capacity for LONGLEYLANE1. Part of a cluster that helps assess vertical gradient distal from a currently defined plume.	MODERATE: Part of a well cluster that can provide assessment of area-specific hydrodynamics. Value as sentinel well is limited by its distance (roughly 5,400 ft west) from and uncertain capture zone of potential receptor LONGLEYLANE1. Location downgradient of numerous PCAs, including Artist Cleaners PCE Project Site, make well cluster useful for long-term monitoring.	None. Continued monitoring for evidence of PCE contamination from upgradient PCAs. Assess well cluster water level data annually to assess hydrodynamics in area.
CTM 1	AREA-SPECIFIC HYDRODYNAMICS ASSESSMENT	PCE non-detects at CTM91 verify uncontaminated groundwater conditions southwest of the Reno-Tahoe International Airport and upgradient of LONGLEYLANE1 municipal supply well. Water level data provides important information on area of influence of the CORBETT based on clear drawdown response. Part of a well cluster with CTM89 and CTM90 that provides a key location to monitor for PCE and characterize vertical gradient in the area upgradient (west) of LONGLEYLANE1 .	Not a ey well: Provides distal sentry capacity for LONGLEYLANE1. Part of a cluster that helps assess vertical gradient distal from a currently defined plume.	MODERATE: Part of a well cluster that can provide assessment of area-specific hydrodynamics. Value as sentinel well is limited by its distance (roughly 5,400 ft west) from and uncertain capture zone of potential receptor LONGLEYLANE1. Location downgradient of numerous PCA's, including Artist Cleaners PCE Project Site, make well cluster useful for long-term monitoring.	None. Continued monitoring for evidence of PCE contamination/release from upgradient PCAs. Assess well cluster water level data annually to assess hydrodynamics in area.
CTM	SPATIAL PL ME MONITORING	PCE data at CTM92 help define the upgradient (west) SR deep zone plume outline and is part of a well cluster with CTM33D and CTM93 that provides a key location for assessing vertical PCE distribution and vertical gradient west of the HWB. Provides similar function as CTM33D. See CTM33D integrated function for more detailed discussion.	Important ut not a ey well Helps define upgradient (west) SR deep zone plume outline. Water levels help assess hydrodynamics west of the HWB in the Middle block. Part of a cluster that provides key vertical PCE distribution and vertical gradient data.	HIGH: Demonstrates presence of PCE at a depth inconsistent with hydraulic gradients in the area (similar to CTM33D).	Develop list of potential alternative explanations for PCE in this well and CTM33D where vertical gradient is inconsistent with presence of PCE (e.g. downward PCE migration west of this well where vertical gradient is downward, upgradient DNAPL source, etc.). Consider construction of additional well clusters proximal to E. Plumb Ln. and (at a lower priority) Vassar Street hot spots to assess potential for vertical PCE migration nearer to potential source areas.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
CTM	MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT	PCE data at CTM93 characterize the plume interior and is potentially on plume axis of the commingled part of the SR shallow zone plume downgradient of the Vassar Street and E. Plumb Ln. hot spots. As a consequence of its likely position on or near the SR plume axis, well data may function to help characterize plume dynamics, travel time, and PCE mass flux. Water levels (both monthly and transducer data from CORBETT-MILL aquifer test) indicate that this well is the only well in the Middle block that distinctly responds to pumping at CORBETT. This finding is consistent with the HWB representing a partial flow barrier that does not extend to the shallow portion of the complex aquifer system. Part of a well cluster with CTM33D and CTM92 that provides a key location for assessing vertical PCE distribution and vertical gradient west of the HWB.	KEY ELL Characterizes plume interior and may be along plume axis of SR shallow zone plume. Water levels help assess hydrodynamics west of the HWB in the Middle block. Part of a cluster that provides key vertical PCE distribution and vertical gradient data.	HIGH: KEY WELL	Continued monitoring and comparison with CTM62, CTM52, USGSLISTON, CTM96, and USGSWOOSTER for patterns that may indicate travel time/mass flux dynamics.
CTM	SPATIAL BACKGRO ND MONITORING	Non-detects at CTM94 constrain the vertical and upgradient (west) extent of SR deep zone plume. CTM94 is part of a well cluster with CTM95 and CTM96 that provides a key location for assessing vertical PCE distribution and vertical gradient.	Important ut not a ey well Constrains vertical and upgradient extent of SR deep zone complex plume. Part of a cluster that provides key vertical PCE distribution and vertical gradient data.	MODERATE: Constrains vertical plume extent. Water levels characterize deep zone water levels in region of limited data distribution.	Evaluate available transducer data to verify interrelationships between pumping wells and water level response, and to verify HWB as a partial flow barrier.
CTM 5	MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT	Non-detects at CTM95 constrain the base of the SR shallow zone plume downgradient from the Vassar Street hot spot. CTM95 is part of a nested well cluster with CTM94 and CTM96 that provides a key location for assessing vertical PCE distribution and vertical gradient.	KEY ELL Constrains vertical extent of SR complex plume downgradient for Vassar Street hot spot. Part of a cluster that provides key vertical gradient and vertical PCE distribution data.	HIGH: KEY WELL	Continued monitoring to verify vertical plume extent and track any vertical plume dynamics that would suggest vertical plume expansion.
CTM	MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT	PCE data at CTM96 characterizes the SR shallow zone plume interior downgradient from the Vassar Street hot spot. CTM96 is part of a well cluster with CTM94 and CTM95 that provides a key location for assessing vertical PCE distribution and vertical gradient. May be located along plume axis and potentially help characterize plume travel time, mass flux, and long term trends along flow path from the Vassar Street hot spot.	KEY ELL Provides potential assessment of mass flux/plume dynamics/travel-time along axis/centerline of SR shallow zone plume downgradient of Vassar Street hot spot. Part of a cluster that assesses vertical PCE distribution and vertical gradient.	HIGH: KEY WELL	Continued monitoring and comparison with other shallow zone wells considered to be along the same flowpath (CTM62, CTM92, USGSWOOSTER, CTM99) for patterns that may indicate plume dynamics/travel time/mass flux.
CTM	RISK ASSESSMENT TO NIMPACTED RECEPTOR	PCE non-detects constrain the vertical extent of the SR deep zone plume between CORBETT and TERMINAL. Well functions as a sentinel for downward or lateral migration of PCE towards the upper screened interval at TERMINAL (potential receptor). Part of a well cluster with CTM98 and CTM99 that provides a key location for assessing vertical PCE distribution and vertical gradient.	KEY ELL Provides sentry capacity for TERMINAL. Part of a cluster that assesses vertical PCE distribution and vertical gradient.	HIGH: KEY WELL	Monitor for any detections of PCE in well that would indicate a risk to TERMINAL. Track TMWA's pumping schedule for TERMINAL so that if it becomes utilized more routinely, CTM97 is appropriately monitored.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
CTM	PL ME DYNAMICS DO NGRADIENT OF RECEPTOR OR CAPT RE ONE P MPING PLAN PERFORMANCE ASSESSMENT	PCE data help define current downgradient, but unconstrained outline of SR deep zone plume. Well is located downgradient (east) of CORBETT (receptor) and is screened at 239-254 ft bgs, within the same hydrostratigraphic package as the CORBETT screened interval (intermittent screens between 180- 280 ft bgs) and shallower than the upper screened interval at TERMINAL. Part of a well cluster with CTM98 and CTM99 that provides a key location for assessing vertical PCE distribution and vertical gradient in the area between CORBETT and TERMINAL.	KEY ELL Helps assess plume dynamics (and potentially plume stability) in unconstrained downgradient portion of SR complex plume where plume capture is uncertain. Well provides key data for assessment of effectiveness of CORBETT to capture SR complex plume because it is screened in the same hydrostratigraphic package as CORBETT. Part of a cluster that assesses vertical PCE distribution and vertical gradient.	HIGH: KEY WELL	Assess risk for PCE to migrate downgradient of CORBETT capture zone as part of pumping plan performance assessment.
CTM	PL ME CORE DYNAMICS PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE CAPT RE ONE	PCE data characterize the Condor Way shallow zone plume core/hot spot and define current downgradient (east), but unconstrained outline of SR shallow zone plume. Well is downgradient (east) of CORBETT (receptor). Higher PCE concentrations at USGSWOOSTER and CTM99 than upgradient at CTM93 are consistent with an additional potential source east of the HWB or the migration of higher concentrations of PCE from hot spots west of the HWB. Part of a well cluster with CTM98 and CTM99 that provides a key location for assessing vertical PCE distribution and vertical gradient in the area between CORBETT and TERMINAL.	KEY ELL Provides assessment of shallow zone Condor Way plume core dynamics (or potential hot spot) downgradient (east) of CORBETT. Provides furthest downgradient (east) monitoring location in the SR shallow zone plume, in portion of plume that may not be captured by CORBETT. Part of a cluster that assesses vertical PCE distribution and vertical gradient.	HIGH: KEY WELL	PCE trend should be monitored and compared to USGSWOOSTER and CTM93 to assess any interrelationships that may indicate whether a local source is likely. Shallow zone SR plume extent is unconstrained and additional downgradient wells should be considered to better define the lateral extent of the plume and its potential to impact other receptors.
CTM10	DISTAL (LATERAL) PL ME DYNAMICS PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE CAPT RE ONE	PCE data characterize plume interior the deep zone portion of SR complex plume. Located in a region that has limited well distribution and poorly characterized PCE distribution in the upgradient, downgradient, and vertical directions. Part of a well cluster with CTM18S that provides a key location for assessing vertical PCE distribution and vertical gradient. Data indicates plume concentrations are higher in CTM106 (screen interval: 125.5-135.5 ft bgs) than at CTM18S (screen interval: 14.5-35.5 ft bgs).	KEY ELL Helps assess plume dynamics (and potentially plume stability) in unconstrained downgradient portion of SR complex plume where plume capture is uncertain. Part of a cluster that provides assessment vertical PCE distribution and vertical gradient.	HIGH: KEY WELL	Plume extent is unconstrained at depth and downgradient of CTM106. The unconstrained dimensions of the plume and the potential for PCE at this location to be outside the capture zone of MILL and CORBETT are data gaps that could be assessed with a deep well at this location and/or additional wells along or east of Terminal Way.
HOLCOMBA M	SPATIAL BACKGRO ND MONITORING	The undefined well construction details at HOLCOMBAVMW render PCE non-detects at this well of marginal value. Water level data (indicating higher water levels compared to shallow zone, the warm temperature of water (at 380 ft bgs), and video-logging are consistent with the well being open at the bottom of the well in deeper portions of the aquifer. Well functions to provide deep zone water levels helpful to characterize vertical gradient direction (with nearby shallow zone well CTM46). Correlation between water level response and pumping at HIGH are consistent with a better hydraulic connection between where this well is constructed and the screened interval at HIGH. This suggests that no flow barrier exists between HIGH and HOLCOMBAVMW.	Not a ey well Characterizes direction of vertical gradient. Well construction details based on video-logging are consistent with the well being open at its TD and any screen being sealed by precipitate.	MODERATE: Primary value is for long-term water level characterization. Well has been monitored since 1981. Value is somewhat compromised by uncertain well construction details. Video logging indicates the any well screen is likely deep and closed off by precipitation. Well appears open at bottom.	Continued compilation of water level data provided by TMWA. Periodic assessment of interrelationship between pumping and water level response. Water levels at this well should be closely examined to assess whether its apparent better hydraulic connection to HIGH than other pumping wells helps define the position of either the VLFZ or HWB.

SO TH RENO S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
N AIRGRDM 0	SPATIAL BACKGRO ND MONITORING	PCE non-detects at all NVAIRGRDMW series wells verify uncontaminated groundwater conditions at the water table where these wells are constructed. Water level data are generally similar and redundant with NVAIRGRDMW10 and 22 but provide good spatial distribution for defining water level contours and local lateral gradient. These wells are shallow (screened above 17 ft bgs) and show muted hydrograph responses that correlate to the regional pumping pattern. This indicates that the water table in this location has some level of hydrodynamic communication with the regional complex aquifer system.	Not a ey well Useful for local water level characterization and regional water level contouring.	LIMITED: Characterizes background groundwater crossgradient and distal from SR complex plume.	None. Continue to monitor water levels for regional water level contouring.
N AIRGRDM 10	SPATIAL BACKGRO ND MONITORING	PCE non-detects at all NVAIRGRDMW series wells verify uncontaminated groundwater conditions at the water table where these wells are constructed. Water level data are generally similar and redundant with NVAIRGRDMW02 and 22 but provide good spatial distribution for defining water level contours and local lateral gradient. These wells are shallow (screened above 17 ft bgs) and show muted hydrograph responses that correlate to the regional pumping pattern. This indicates that the water table in this location has some level of hydrodynamic communication with the regional complex aquifer system.	Not a ey well Useful for local verification of uncontaminated conditions, local water level characterization, and regional contouring.	LIMITED: Characterizes background groundwater crossgradient and distal from SR complex plume.	This well is in the footprint of planned construction and will probably be eliminated from water level and water quality network. If so, NVAIRGRDMW02 could replace this well for water quality sampling going forward.
N AIRGRDM 1	SPATIAL BACKGRO ND MONITORING	Well is not currently monitored for PCE or water levels.	Not a ey well Well is not currently monitored. NVAIRGRDMW02, NVAIRGRDMW10, and NVAIRGRDMW22 provide adequate assessment/characterization data for the area.	LIMITED: Characterizes background groundwater crossgradient and distal from SR complex plume.	None. This well is currently not monitored and is redundant with NVARIGRDMW22.
N AIRGRDM 1	SPATIAL BACKGRO ND MONITORING	Well is not currently monitored for PCE or water levels.	Not a ey well Well is not currently monitored. NVAIRGRDMW02, NVAIRGRDMW10, and NVAIRGRDMW22 provide adequate assessment/characterization data for the area.	LIMITED: Characterizes background groundwater crossgradient and distal from SR complex plume.	None. This well is currently not monitored and is redundant with NVARIGRDMW22.
N AIRGRDM	SPATIAL BACKGRO ND MONITORING	PCE non-detects at all NVAIRGRDMW series wells verify uncontaminated groundwater conditions at the water table where these wells are constructed. Water level data are generally similar and redundant with NVAIRGRDMW02 and 10 but provide good spatial distribution for defining water level contours and local lateral gradient. These wells are shallow (screened above 17 ft bgs) and show muted hydrograph responses that correlate to the regional pumping pattern. This indicates that the water table in this location has some level of hydrodynamic communication with the regional complex aquifer system.	Not a ey well Useful for local verification of uncontaminated conditions in and upgradient of southwestern part of Reno-Tahoe International Airport property. Provides water level data for local water level characterization and regional water level contouring.	LIMITED: Characterizes background groundwater crossgradient and distal from SR complex plume. Prior to GMP, had a single PCE detection (1 µg/L).	None. The well should continue to be monitored annually for PCE to verify uncontaminated groundwater. Continue monitoring water levels for regional contouring.

SO TH RENO S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
TERMINAL	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	UNTREATED RECEPTOR/POTENTIAL RECEPTOR: Well is constructed in a deeper hydrostratigraphic package than CORBETT and has not exhibited PCE impacts (in limited sampling) since 2004. If well were utilized more routinely, the potential for downward (from the SR complex plume) or lateral (from the DR complex plume) migration of PCE would increase. Water level data show a more direct hydraulic communication with MILL than CORBETT. This is consistent with TERMINAL and MILL being screened across the same hydrostratigraphic package. Well has not been routinely pumped since 2005.	KEY ELL Works in a self-sentry capacity to assess potential migration of PCE into TERMINAL screened interval. Also helps to assess pumping plan performance, verifying that PCE has not migrated either vertically from the CORBETT screened interval to TERMINAL, or from the MILL area to TERMINAL	HIGH: KEY WELL	Well should be sampled opportunistically whenever it is pumped.
NION5 1 M 10	SPATIAL BACKGRO ND MONITORING	Well abandoned 5/2010	Not a ey well Abandoned 5/2010	ABANDONED	ABANDONED
NION5 1 M 11	SPATIAL BACKGRO ND MONITORING	Well abandoned 5/2010	Not a ey well Abandoned 5/2010	ABANDONED	ABANDONED
NION5 1 M 1	SPATIAL BACKGRO ND MONITORING	Well abandoned 5/2010	Not a ey well Abandoned 5/2010	ABANDONED	ABANDONED
SGSHOLCOMB	SPATIAL BACKGRO ND MONITORING	PCE non-detects at USGSHOLCOMB constrain crossgradient (north) extent of local hot spot defined by CTM49. Water level data apparently characterize the water table in or adjacent to the VLFZ, being muted and having a relatively flat trend that suggests poor hydraulic connection to regional hydrodynamics. Pumping associated with Crystal Springs commercial well should be compared with hydrograph to assess any potential response.	Not a ey well Potentially provides background water quality but may be impacted by leaking stormdrain. Water levels redundant with CTM49 and may also be impacted by Crystal Springs commercial water supply well.	LIMITED: Redundant with CTM49. Data pedigree may be compromised by location near Crystal Springs commercial water supply well and screen position in low permeability interval. Well constrains crossgradient (north) extent of PCE detected at CTM49. Several potential PCA's are identified upgradient.	Obtain Crystal Springs commercial well pumping history and determine any impacts it may have on water levels USGSHOLCOMB. Consider elimination of well from water level network.
SGSLISTON	MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT	USGSLISTON provides critical downgradient PCE concentration characterization along or near the axis of the E. Plumb Ln. segment of the SR shallow zone plume. Well provides long term PCE concentration patterns that potentially would help assess travel time and verify link between E. Plumb Ln. hotspot and contamination where USGSLISTON is constructed. The recent decreasing PCE concentration trend should be assessed for whether it reflects a real decrease in mass flux in the vicinity of this well or is a function of shorter-term hydrodynamics (i.e., changes in water levels) that may reverse with a change in stress (such as pumping, precipitation, etc.) to the groundwater system. PCE concentrations at USGSLISTON as early as 1999 (38.5 µg/L) indicate that the SR shallow zone plume has existed prior to that time. Water levels are similar to E. Plumb Ln hot spot wells , but have a larger magnitude, less muted pattern. This relationship suggests a more direct hydraulic connection with seasonal pumping than to the south.	KEY ELL Characterizes PCE and water level dynamics along SR shallow zone plume axis, downgradient from E. Plumb Ln. hot spot. PCE time series has the potential to assess plume dynamics, travel time, and PCE mass flux based on comparisons with CTM52 and CTM16S. Water level data are critical for continued assessment of the noted correlation between water level and PCE data.	HIGH: KEY WELL	Continued monitoring and comparison with CTM53, CTM16S, CTM92, USGSWOOSTER for patterns that may indicate travel time/mass flux dynamics.

SO TH RENO S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e/Primary ell alue	Follow-up Actions and Key Conditions to Monitor
SGS OOSTER	PL ME CORE DYNAMICS	PCE data characterize the Condor Way shallow zone plume core/hot spot proximal to CORBETT (receptor). Higher PCE concentrations at USGSWOOSTER and CTM99 than upgradient at CTM93 are consistent with an additional potential source east of the HWB or the migration of higher concentrations of PCE from hot spots west of the HWB. Part of a well cluster with CTM17D that provides a key location for assessing vertical PCE distribution and vertical gradient near CORBETT.	KEY ELL Provides assessment of shallow zone Condor Way plume core dynamics (or potential hot spot) proximal to CORBETT. Part of a cluster that assesses vertical PCE distribution and vertical gradient.	HIGH: KEY WELL	Increasing PCE concentration trend is consistent with a different, unidentified source for higher PCE at USGSWOOSTER. PCE trend should be monitored and compared to CTM93 and CTM99 to assess any interrelationships that may indicate whether a local source is indicated.

DO NTO N RENO S BREGION KEY ELL DECISION MATRI

	WATER QUALITY FUNCTION:											***WATER LEVEL FUNCTION:***					***CLUSTER FUNCTION:***		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume mass mo ement across low arrier assessment	Plume mass mo ement dri er assessment	ertical low/ ertical plume mass mo ement assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
					X				X		X		[2]	[2]	[2]	[2]	X	X	X
4THMWD					X				X		X		[2]	[2]	[2]	[2]	X	X	X
					X				X		X		[2]	[2]	[2]	[2]	X	X	X
ALLIEDWMW3																			
ALLIEDWMW4																			
COR1	ABANDONED																		
COR10																			
COR12A	[5]	X(DRa)									X		X[5]			X[5]			
COR2																			
COR3	ABANDONED																		
COR4A	ABANDONED																		
COR5	ABANDONED																		
	[5]	X(DRa)									X		X[5]			X[5]			
CORWSSMW1																			
CORWSSMW2																			
E					X						X								
												[2,6]		[2,6]	[2,6]	[2,6]	X	X	X
					X						X	[2,6]		[2,6]	[2,6]	[2,6]	X	X	X
					X						X	[2,6]		[2,6]	[2,6]	[2,6]	X	X	X
											X	[2,6]		[2,6]	[2,6]	[2,6]	X	X	X
				X			X				X			[2]		[2]	X	X	X
			X								X	[2,6]		[2,6]	[2,6]	[2,6]	X	X	X
						X					X		[2]	[2]		[2]	X	X	X
											X								
CTM138																			
CTM21S																			
				X							X		X			X			
		X(DRWFS)	X								X				X	X			
CTM29S																			
CTM2S																			
			X								X		X			X			
CTM31S			X								X								
			X						X		X								
											X				[2]		X	X	X
CTM40S																			
															[2]	[2]	X	X	X
		X(DRWFS)	X								X								
CTM57																			
CTM58																			

DO NTO N RENO S BREGION KEY ELL DECISION MATRI

	WATER QUALITY FUNCTION:											WATER LEVEL FUNCTION:					CLUSTER FUNCTION:		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume mass mo ement across low arrier assessment	Plume mass mo ement dri er assessment	ertical low/ ertical plume mass mo ement assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
CTM59																			
		X?									X				X, [2]	X, [2]	X	X	X
														[2]		[2]	X	X	X
CTM7S																	X	X	X
									X?		X			[2]		[2]	X	X	X
			X								X		X	X		X			
							[2]		[2]		[2]			[2]		[2]		X	X
							X		[2]		X			[2]		[2]		X	X
							X		[2]		X			[2]		[2]		X	X
											X	X	X			X	X	X	X
							X		X		X	X	X			X			
E E			X				X		X		X		X			X			
MENTALHEALTH																			
MILL			X	X			X		X		X		X	[2]	[2]	X		X	X
							X		X		X	X	X			X			
					X?						X		[2]	[2]		[2]	X	X	X
																		X	X
MW2NS																		X	X
MW3ND																		X	X
MW4NS																		X	X
											X					X			
MW7NS					R(RETRACP2)								[2]	[2]		[2]	X	X	X
											X		[2]	[2]		[2]	X	X	X
MW9NS													[2]	[2]		[2]	X	X	X
QUIKMRTMW18C	R(CTM28S)[4]	R(CTM28S)[4]	R(CTM28S)[4]											R(CTM28S)[4]					
RENOAUTOMW																			
RENOHIGH							[3]				[3]		[3]				[3]	[3]	[3]
RENOHIGHMWD							[3]				[3]		[3]				[3]	[3]	[3]
RENOHIGHMWS							[3]				[3]		[3]				[3]	[3]	[3]
RETRACB13																			
RETRACB14																			
RETRACMWA	ABANDONED																		
RETRACMWC																			
RETRACMWD																			
RETRACMWE																			
RETRACMWE1																			
RETRACMWG																			
RETRACMWG1																			
RETRACMWH																			
E											X		X			X			

DO NTO N RENO S BREGION KEY ELL DECISION MATRI

	WATER QUALITY FUNCTION:											WATER LEVEL FUNCTION:					CLUSTER FUNCTION:		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume mass mo ement across low arrier assessment	Plume mass mo ement dri er assessment	ertical low/ ertical plume mass mo ement assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
RPDMW3																			
RPDMW6													2						
UNRVALLEYRDWELL																			
USGSGOVBOWL																			
USGSHUNTLK																			
VIEW																			
VIEWMWD																			
VIEWMWS																			
WMMW1																			
WMMW3																			
WMMW5																			

Notes:

2010 KEY WELL

2010 WELL CLUSTER MEMBER

tali 2009 Key Wells

R(CTM105) = Redundant with well identified in parenthesis

X(DRWFS) = Potential local source in Downtown Reno Subregion at West Fourth St. hot spot

X(DRa) = Potential local source in Downtown Reno Subregion

1 Potential individual sources are identified by subregion, hot spot, and local source alpha descriptors as appropriate. See notes for descriptions.

2 Water quality and/or water levels should be assessed relative to well's role as part of a well cluster.

3 Wells are outside of Downtown Reno Subregion but represent important wells for assessing low level PCE contamination and potential risk to RENOHIGH municipal water supply well.

4 QUIKMRTMW18C has unknown screened interval compromising pedigree of results.

5 Water quality and water level data at COR8A and COR12A may be influenced by dewatering at Harrah's

6 Well may be proximal to extension of Harvard Way Barrier based on INSAR data and on difference in hydrograph patterns between Pickett Park wells (CTM100, CTM101, CTM102) and Gould wells (CTM9S, CTM103, CTM102, CTM10

DO NTO N RENO S BREGION ELL NET ORK RE IE

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE data at 4TH help define and assess impacts of PCE and TCE contamination at this municipal water supply well. PCE/TCE data poorly define the downgradient and relatively poorly constrained extent of the deep zone DR plume between 4TH and VIEW. The well represents a self-sentry monitoring point to assess and track PCE/TCE dynamics that would indicate the well's potential risk for future impacts at levels that would require treatment. The presence of TCE in this and other wells in the northeast part of the DR plume suggest a separate distinct source for this part of the plume, and to some extent provide vector information for that source. Water quality data are impacted by artificial recharge making identification of long term PCE/TCE trends (needed to identify future risk to this receptor) problematic.	KEY ELL: Represents a self-sentry well providing an assessment of potential risk for increasing PCE/TCE contamination to levels that would require treatment or other remedial strategies in order to utilize groundwater for municipal water supply.	HIGH: KEY WELL	A consistent effort directed towards sampling 4TH, 4THMWS, and 4THMWD after periods of extended pumping would provide more representative data from these wells. As a minimum PCE/TCE results should be assessed in the context of pumping/injection history at 4TH.
4THMWD	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE/TCE data poorly define the downgradient and relatively poorly constrained extent of the deep zone DR plume between 4TH and VIEW. PCE/TCE results collected after a period of extended pumping may provide vertical distribution information to assess impacts to the deeper portion of the 4TH screened interval. Recent depth discrete PCE data collected in this manner suggest low level concentrations of PCE/TCE exist at depths where this well is constructed (330-480 ft bgs). The identification of long term trends that would help predict future risk to 4TH may be problematic at this well because of impacts from artificial recharge at 4TH.	KEY ELL: Provides assessment of a less contaminated interval of the deep zone. Pedigree of water quality results need to account for injection/pumping history at 4TH and for potential vertical wellbore flow in 4TH (that may cause PCE/TCE to locally impact the interval where 4THMMWD is constructed).	HIGH: KEY WELL	A consistent effort directed towards sampling 4TH, 4THMWS, and 4THMWD after periods of extended pumping would provide more representative data from these wells. As a minimum PCE/TCE results should be assessed in the context of pumping/injection history at 4TH.
	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE/TCE data poorly define the downgradient and relatively poorly constrained extent of the deep zone DR plume between 4TH and VIEW. PCE/TCE results collected after a period of extended pumping may provide vertical distribution information to assess impacts to the shallower portion of the 4TH screened interval. Resent depth discrete PCE data collected in this manner are consistent with the highest PCE and TCE concentrations occurring in 4THMWS (screened interval: 180-300 ft bgs) compared to 4THMWD (screened interval 330-480 ft bgs). The identification of long term trends that would help predict future risk to 4TH may be problematic at this well because of impacts from artificial recharge at 4TH.	KEY ELL: Provides assessment of more contaminated interval of the deep zone where (based on spinner logging) most of the 4TH production is derived. Pedigree of water quality results need to account for injection/pumping history at 4TH.	HIGH: KEY WELL	A consistent effort directed towards sampling 4TH, 4THMWS, and 4THMWD after periods of extended pumping would provide more representative data from these wells. As a minimum PCE/TCE results should be assessed in the context of pumping/injection history at 4TH. Because of the high PCE/TCE concentrations where this well is constructed (consistent with the predominant mass of the plume existing in the interval where this well is constructed), it may provide more optimal water quality data to assess plume dynamics proximal to 4TH. Q3 sample results should be tracked for potential increasing trends that would indicate greater risk to 4TH.
ALLIEDWMW3	SPATIAL BACKGRO ND MONITORING	Non-detects at ALLIEDWMMW3 poorly constrain the lateral, downgradient (east) extent of the DR shallow zone plume. The well is greater than 4,000 ft downgradient of the currently defined plume outline. Water level data are not collected at this well because it is utilized as a vapor extraction well.	Not a Key ell: Well provides general characterization water quality to verify that the area where well is constructed is not contaminated.	MODERATE/LIMITED: Provides gross-scale plume geometry definition in the distal downgradient area outside the DR shallow zone plume extents.	None. Continued water quality monitoring for verification that groundwater is not impacted by PCE in this area.

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ALLIEDWMW4	SPATIAL BACKGRO ND MONITORING	This well is utilized only for water level data collection. It's hydrograph has similarities to shallow zone well to the west (WMMW3), south (CTM13S) and southeast (21STMWS) consistent with water level elevation being influenced by a composite of sources and sinks that control water levels in the area. Water level data are useful for general characterization of the area and for water level contouring and lateral gradients.	Not a Key ell Well provides general characterization water level elevation in the area.	LIMITED/MODERATE: Well should be maintained for general water level monitoring.	None. Continued water level monitoring for general characterization purposes.
COR1	ABANDONED	NA: Abandoned	NA: Abandoned	NA: Abandoned	NA: Abandoned
COR10	SPATIAL BACKGRO ND MONITORING	Non-detects at COR10 poorly constrain the lateral, crossgradient (south) extent of the DR shallow zone plume. The well is greater than 1,000 ft crossgradient of the currently defined plume outline. Its location on the opposite side (south) of the Truckee River from the DR shallow zone plume and relatively muted water level response that is consistent with a hydraulic connection to the river and suggest that the well characterizes Truckee River water that recharges the groundwater in this area. Low specific conductance measurements (in the range of 150-300 µS/cm at the well corroborate this interpretation.	Not a Key ell Provides local assessment of potential influence of the Truckee River on water quality and water levels and helps constrain extend of shallow zone plume south of downtown Reno.	MODERATE/LIMITED: Provides some level of plume geometry definition and limited plume expansion monitoring capabilities. May help assess Truckee River-groundwater hydrodynamics.	None. Water level elevation trends and patterns do not have a similar pattern to other wells considered to respond directly to Truckee River discharge, whereas water quality indicate river contribution. Well of limited value for plume assessment as a result of likely river influence.
COR12A	MASS FL /SO RCE ASSESSMENT	PCE data at COR12A along with COR8A help define a local zone of higher concentration PCE contamination. The spiky and apparently increasing trend since 2006 may either indicate a local source or hot spot, or it may reflect currently undefined local hydrodynamics that influence local plume dynamics. Quarterly water level contouring suggest that a small cone of depression exists in this area that may influence local hydrodynamics and plume dynamics.	KEY ELL: Helps assess plume dynamics and/or mass flux in local zone of PCE contamination.	HIGH: KEY WELL	Apparent increasing PCE trend since 2007 and contrasting pattern/trend compared to COR8A (located roughly 200 ft to SW) suggest a local source and or local hydrodynamics (e.g.., Harrah's dewatering) that affect concentrations. Should monitor RETRACP2, MW7NS, and RPDMW6 and consider whether increases recognized at these wells have any relationship to increases at COR12A.
COR2	N SED	NA: Unused	NA: Unused	NA: Unused	NA: Unused
COR3	ABANDONED	NA: Abandoned	NA: Abandoned	NA: Abandoned	NA: Abandoned
COR4A	ABANDONED	NA: Abandoned	NA: Abandoned	NA: Abandoned	NA: Abandoned
COR5	ABANDONED	NA: Abandoned	NA: Abandoned	NA: Abandoned	NA: Abandoned
	MASS FL /SO RCE ASSESSMENT	PCE data at COR8A along with COR12A help define a local zone of higher concentration PCE contamination. Unlike COR12A where PCE data exhibit a spiky apparently increasing trend, COR8A exhibits relatively stable to decreasing concentrations that have recently ranged between 10 and 6 µg/L between 2009 and 2010. The contrasting trends and patterns between COR8A and COR12A are not currently explained, but are consistent with a local zone higher PCE concentration in the area defined by the two wells. Quarterly water level contouring suggest that a small cone of depression exists in this area that may influence local hydrodynamics and plume dynamics.	KEY ELL: Helps assess plume dynamics and/or mass flux in local zone of PCE contamination.	HIGH: KEY WELL	The contrasting pattern/trend between COR8A and COR12A is unexplained but suggests either a local source and/or local hydrodynamics (e.g.. Harrah's dewatering). PCE concentrations at COR8A and COR12A should be tracked together to assess any as yet unidentified relationship.

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CORWSSMW1	SPATIAL BACKGRO ND MONITORING	Non-detects at CORWSSMW1 help constrain the lateral, downgradient (southeast) extent of the DR shallow zone plume along the north side of the Truckee River, west of the VLFZ/HWB flow barrier. PCE non-detects may be partly a result of either the river acting as a hydraulic barrier to shallow zone groundwater flow, dilution of plume by river recharge, or the result of the plume plunging beneath the interval where the well is constructed. Water level elevations exhibit a more direct response to seasonal pumping than to Truckee River flow dynamics. Water level responses may function to help assess the relative roles that the VLFZ/HWB partial flow barrier, pumping, and the Truckee River have on hydrodynamics in the area. The relatively higher specific conductance values (350-470 µS/cm) at this well suggest a smaller river contribution than wells with lower specific conductance including COR10 or MW9NS. This may be more consistent with the area where CORWSSMW1 is constructed being a gaining reach.	Not a Key well Helps constrain downgradient extent of shallow zone DR plume.	MODERATE: Provides plume geometry definition and plume expansion monitoring capabilities proximal to and north of the Truckee River.	Well represents a reasonably good monitoring site to assess for downgradient plume expansion. Any PCE detections at this well should trigger quarterly sampling and assessment of risk for lateral plume expansion in the shallow zone.
CORWSSMW2	SPATIAL BACKGRO ND MONITORING	CORWSSMW2 is redundant with CORWSSMW1.	Not a Key ell Redundant with CORWSSMW1	LIMITED: Redundant with CORWSSMW1	Consider abandoning well.
E	SITE SPECIFIC PL ME DYNAMICS	PCE data at COURTHOUSE help define plume dynamics in a poorly constrained upgradient portion in the deep zone of DR plume. The increasing longer-term PCE trend is consistent with a potentially expanding plume extent in this area. The well's two relatively long screen intervals (136-221; 307-340 ft bgs) compromise the pedigree of data from this well, rendering the actual position and concentration of the plume in this area poorly defined. The consistently higher PCE concentration and larger fluctuations in samples collected from the upper screen interval suggest the larger mass of the plume exists within this screen interval. Lower concentrations and more muted fluctuations from samples collected from the lower screen interval may represent either lower PCE concentration in the deeper parts of the plume, or downward vertical flow in the wellbore (and no actual contamination in the deeper screened interval). Water level data reflect a composite piezometric surface over the long screened intervals. However, the well provides one of the few deep zone wells in the area for assessing hydrodynamics.	KEY ELL: Helps define plume dynamics in a poorly constrained upgradient part of the deep zone DR plume.	HIGH: KEY WELL	This well should continue to be assessed for potentially increasing PCE that suggests plume expansion. Consideration to performing depth-discrete sampling under pumping conditions should be made to define the vertical position and concentration of the plume within the screened interval.
	SPATIAL BACKGRO ND MONITORING	PCE data at CTM100 help constrain the vertical extent of what may represent a shallow lobe of the DR plume or a distinct segment of contamination that may commingle with the DR plume. Water level data is of value for defining the potential projection of the HWB to the north-northwest between the CTM100/101/102 and CTM10D/103/104/9S well clusters.	Not a ey well Helps constrain the local vertical extent of the DR plume. As part of well cluster CTM100/101/102 is critical for assessing position and significance of HWB hydrodynamics in DR Subregion.	HIGH: Part of a well cluster that potential provides assessment of position and significance of HWB in DR Subregion.	As part of CORBETT-MILL aquifer test, need to evaluate hydrograph responses to assess hydrologic connections that may help project HWB to the north between CTM100/101/102 and CTM10D/103/104/9S. See also CTM101 discussion.
	SITE SPECIFIC PL ME DYNAMICS	PCE data at CTM101 help characterize and assess plume dynamics in what may represent a shallow lobe of the DR plume or a distinct segment of contamination that may commingle with the DR plume. Water level data is of value for defining the potential projection of the HWB to the north-northwest between the CTM100/101/102 and CTM10D/103/104/9S well clusters.	KEY ELL: Helps define plume dynamics in a poorly constrained potentially local zone of contamination. As part of well cluster CTM100/101/102, well is critical for assessing position and significance of HWB hydrodynamics in DR Subregion.	HIGH: KEY WELL	An additional well cluster positioned near the intersection of Kirman Ave. and E. Second St. is recommended to better define the DR plume in this region and to put both the PCE data and stratigraphy at CTM100/101/102 into better context. PCE data need to be monitored for emerging trends and patterns. Water levels need to be tracked to better define hydraulic connections between this well cluster and pumping wells (compared to well cluster CTM10D/1003/104/9S) to verify projection of HWB into the DR Subregion.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
	SITE SPECIFIC PL ME DYNAMICS	PCE data at CTM102 help characterize and assess plume dynamics in what may represent a shallow lobe of the DR plume or a distinct segment of contamination that may commingle with the DR plume. Water level data is of value for defining the potential projection of the HWB to the north-northwest between the CTM100/101/102 and CTM10D/103/104/9S well clusters.	KEY ELL: Helps define plume dynamics in a poorly constrained potentially local zone of contamination. As part of well cluster CTM100/101/102 is critical for assessing position and significance of HWB hydrodynamics in DR Subregion.	HIGH: KEY WELL	See CTM100 and CTM101 discussion.
	PL ME CORE MONITORING	PCE data at CTM103 help characterize and assess plume dynamics in the Eastern plume core having apparent significantly higher PCE mass than characterized in other portions of the deep zone DR plume. PCE concentration data at CTM103 (along with cluster well CTM10D) may provide information useful to predict travel time, PCE concentration, and mass flux between this well cluster and downgradient receptor MILL. Part of a well cluster with CTM10D, CTM102, and CTM9S that provides key location for assessing vertical PCE distribution and vertical gradient upgradient from MILL and in an area where strong seasonal water table response to pumping suggest enhanced potential for vertical flow and PCE migration.	KEY ELL Assesses plume dynamics, mass flux, and vertical PCE distribution in a plume core, or area of high PCE mass.	HIGH: Part of a well cluster that assesses plume dynamics, mass flux, and vertical PCE distribution in a plume core or area of high PCE mass.	See CTM10D and CTM100 discussion.
	PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE OF CAPT RE ONE P MPING PLAN PERFORMANCE ASSESSMENT	PCE data at CTM107 characterize and assess plume dynamics in the currently unconstrained downgradient outline of the DR deep zone plume southeast of MILL municipal water supply well. The well is shallower than, and potentially outside the capture zone of MILL making it important for assessing pumping plan performance and the potential for risk to unimpacted downgradient water supply wells (including GREG, PEZZI, HV3, and HV5). Part of a well cluster with CTM38D and CTM39S that provides a key location for assessing vertical PCE distribution and vertical gradient at the currently defined downgradient outline of both the Downtown Reno deep zone and Mill/Kietzke shallow zone plumes.	KEY ELL: Assesses potential migration of PCE in an unconstrained downgradient portion of the DR plume that has migrated east of MILL and as a result of being shallower than the MILL screened interval may not be captured by MILL pumping.	HIGH: KEY WELL	PCE contamination at this well is likely to be a shallower portion of the DR complex plume that may escape capture by MILL.PCE data need to be monitored for emerging trends and patterns that would help define plume dynamics. Water levels need to be tracked to better define hydraulic connections between this well cluster and pumping wells. Additional cross section and hydrograph assessment work needs to be performed to assess whether impacted interval at CTM107 is hydraulically connected with either 21st, GREG, PEZZI, or other potential downgradient receptors. Additional downgradient monitoring wells should be considered based on the outcome of that work.
	PL ME CORE DYNAMICS	PCE data help characterize the Eastern plume core, having apparently significantly higher PCE mass than characterized in other portions of the deep zone DR plume. The well functions to assess plume dynamics and mass flux in a zone of relatively high PCE mass. The longer term decreasing PCE trend are consistent with this mass migrating past the well. Increasing PCE trends at MILL suggest that this mass may have impacted and continue to impact portions of the aquifer where MILL is constructed. Hydrostratigraphic interpretations indicate that CTM10D is constructed in a correlative interval to upper screened intervals at MILL. The large water level responses at CTM10D that coincide with pumping at MILL and other PCE-treated wells in the area are consistent with a direct hydraulic connection between the interval where CTM10D is constructed and deep zone pumping. Part of a well cluster with CTM102, CTM103, and CTM9S that provides key location for assessing vertical PCE distribution and vertical gradient upgradient from MILL and in an area where strong seasonal water table response to pumping suggest enhanced potential for vertical flow and PCE migration.	KEY ELL Assesses plume dynamics, mass flux, and vertical PCE distribution in a plume core, or area of high PCE mass.	HIGH: KEY WELL	PCE concentration patterns and trends should be compared to MILL, and upgradient pumping wells MORRILL and HIGH to assess whether PCE data are consistent with a detached plume core migrating from the area near the VLFZ to MILL. PCE data at MILL should be tracked to determine whether the decreasing PCE trend at CTM10D is similarly identified at MILL consistent with the concept that the plume core is migrating past CTM10D and being captured by MILL.

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	P MPING PLAN PERFORMANCE MONITORING	PCE data characterize potential leading edge of a portion of the DR complex plume that coincides with the upper screen interval at MILL. Well functions as a local monitoring point to verify the effectiveness of PCE capture at MILL. Data are consistent with PCE migrating past MILL during seasonal periods of nonpumping and being captured by MILL during the pumping season. Water level data are consistent with a direct hydraulic connection to MILL and the surrounding PCE-treated wells in the subregion. Part of a well cluster with CTM11S and CTM105 that provides a key location for assessing vertical PCE distribution and vertical gradient proximal to MILL.	KEY ELL Characterizes distal part of a portion of the DR complex plume and helps to assess effectiveness of seasonal pumping to capture PCE in the upper screened interval at MILL. Part of a cluster that helps assess PCE distribution and vertical gradient in the MK and DR plumes.	HIGH: KEY WELL	PCE concentrations should continue to be monitored to verify that PCE concentrations remain at non-detect (or very low levels) by the end of pumping season. Continued long-term increasing PCE trends and/or the onset of year-around PCE detections occur at this well should be monitored and may represent risk indicators for less effective pumping plan performance.
	PL ME CORE DYNAMICS	PCE data help characterize a plume core (Downtown core), or more concentrated portion of the deep zone DR plume. The well functions to assess plume dynamics and mass flux in a zone of potentially higher PCE mass. The longer term increasing PCE trend are consistent with mass increasing at the well. Based on geologist logs, this well is constructed in a relatively finer-grained interval making both PCE and water level data potentially less meaningful compared to wells constructed in more permeable intervals within this portion of the aquifer, where greater mass flux may occur. Its relatively shallow position (screened interval: 120-125 ft bgs) and higher PCE concentration are consistent with the plume have higher PCE concentrations in the shallower portions of the deep zone, at least in the area around CTM137. The relatively finer-grained material represented in the screened interval at CTM137 suggest that high PCE at the well could represent residual concentrations that may be relatively less mobile compared to other portions of the DR plume.	KEY ELL Assesses plume dynamics and mass flux in an area of potential high PCE mass. Any assessment should account for the potential that PCE mass represented at CTM137 may be relatively lower as a result of the finer-grained (potentially lower permeability) interval where the well is constructed.	HIGH: KEY WELL	PCE results should be assessed in context with nearby deep zone monitoring wells CTM30D and MW8ND that are apparently in more permeable intervals and may be more representative of overall plume dynamics where more mass flux occurs.
CTM138	SPATIAL PL ME MONITORING	PCE data help characterize a portion of the plume interior between a potential local source at COR12A and the main segment of the shallow zone portion of the DR plume. The well functions to provide plume geometry definition and assess plume dynamics along the southern plume outline. General similarities in recurring seasonal patterns between this well and many of the other RETRAC series wells are consistent with an area-wide interrelationship between PCE and water level elevations at or near the water table where these wells are constructed.	Not a ey well Helps define DR shallow zone plume. Provides limited assessment of plume dynamics in a lower concentration portion of the plume.	MODERATE: Provides plume geometry definition and limited assessment of plume dynamics.	RETRAC paired wells and CTM138 should be assessed for determining whether sets of wells on either side of the trench are redundant. This evaluation suggests that the primary value of having these pairs is for providing a PCE concentration gradient useful for defining the plume outline along the south edge of the shallow zone DR plume.
CTM14S	SPATIAL BACKGRO ND MONITORING	See SR Subregion description	See SR Subregion description	See SR Subregion description	See SR Subregion description
	SPATIAL BACKGRO ND MONITORING	PCE data suggest that CTM1S is at or near the upgradient extent of the shallow zone DR plume. Intermittent low concentration PCE detections prior to 2007 suggest that concentrations in the area have potentially decreased of the GMP period of record. A more recent PCE detection of .58 µg/L utilizing a lower (0.50 µg/L) reporting limit in 2010Q3 is consistent with generally low level concentration PCE existing where the well is constructed. The well's position within the largest and highest magnitude passive soil gas PCE anomaly is consistent with the well being proximal to a potential source. Relatively low PCE concentrations suggest it is upgradient from any potential source. This well functions to constrain and potentially provide a vector towards a source between CTM1S and CTM28S.	Important ut not a ey well Acts in the capacity as a source vector towards CTM28S and locally constrains upgradient extent of W. Fourth St. hot spot/DR plume.	HIGH: Constrains upgradient extent of W. Fourth St. and DR plume	PSA investigation should consider constructing 2 wells; one at W. Fifth St. and Washington St., one at W. Fifth St. and Vine St. to help constrain the source area for the W. Fourth St. hot spot.

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CTM21S	SPATIAL BACKGRO ND MONITORING	Water level data, specific conductance measurements, and PCE non-detects at CTM21S are consistent with this well being constructed in a perched zone that is not representative of the general aquifer conditions in the area. If this interpretation is correct, the well has limited value and may misrepresent conditions in the shallow zone portion of the aquifer in the area where it is located.	Not a ey well Potentially provides local characterization of a perched zone.	LIMITED: The potential construction of well in perched zone limit its usefulness in characterizing/assessing the shallow zone portion of the area where it is constructed.	Consideration to replacing well with one that better represents aquifer conditions is warranted. One or more well clusters along Second St. would provide better shallow zone and deep zone coverage for the area.
	MASS FL /PL ME DYNAMICS/TRA EL TIME ASSESSMENT	PCE data characterize an area downgradient of the Downtown plume core and upgradient of the KIETZKE PCE-treated well. The well functions to assess plume dynamics and mass flux in a zone of potentially higher PCE mass. The apparent change in PCE data starting in 2006 from increasing PCE concentration to a more stable average annual PCE concentration coincides with a general increase in water levels and the onset of seasonal pumping at PCE-treated wells suggesting an interrelationship. Water level data are consistent with a direct hydraulic connection to the surrounding PCE-treated wells in the subregion.	KEY ELL Assesses plume dynamics and mass flux in an area of potential high PCE mass. May provide travel time information by comparing time series with downgradient well KIETZKE	HIGH: KEY WELL	PCE trends at CTM22D should be compared to those at KIETZKE to assess whether data can be utilized to assess travel time. Trends at KIETZKE and CTM22D should be tracked to determine CTM22D's capacity to predict PCE conditions at the receptor. Consideration to replacing CTM21S with a shallow zone well next to CTM22D should be made. To provide more representative vertical gradient information.
CTM27D	SPATIAL BACKGRO ND MONITORING	See SR Subregion description	See SR Subregion description	See SR Subregion description	See SR Subregion description
	MASS FL /SO RCE ASSESSMENT	CTM28S helps define the W. Fourth St. hot spot and functions as an important source area monitoring site for defining near source plume dynamics and potentially long-term PCE contribution (mass flux) from the hot spot. The spiky, recurring seasonal PCE concentration pattern are consistent with a potential interrelationship with seasonal hydrodynamics. This interrelationship may be caused by changes in mass flux, plume dynamics, or local wellbore dynamics (changing vertical gradients in wellbore). Water level data are best suited to characterize this well group and are consistent with better hydraulic communication between the deep zone pumping at RENOHIGH, HUNTERLAKE, and GLENHARE and the shallow zone where CTM28S is constructed. Shallow zone water level response to pumping at these wells is greater at CTM28S than elsewhere in the downtown Reno area suggesting a better vertical hydraulic connection in the area. Water level contouring identify a water level mound that encompasses the area proximal to CTM28S and is consistent with a source of recharge in the area that may impact plume concentration and flow dynamics.	KEY ELL: Helps assess plume dynamics and/or mass flux in W. Fourth St. hot spot.	HIGH: KEY WELL	PCE data need to be tracked to verify continued decreasing trend. If an emerging increasing trend develops, PSA investigation should be expedited. Additional monitoring wells should be considered (as part of the PSA investigation in the area) in the upgradient PSG hot spot and at other locations downgradient from that hot spot (but upgradient from CTM28S) to vector towards the source for the W. Fourth St. hot spot. A potential recharge source suggested by water level contours may be responsible for the relatively wide lateral plume dimension and should be looked into. Potential exists for an underground leaking ditch or drainage conduit to be impacting the hydrodynamics and plume distribution at the hot spot.
CTM29S	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the upgradient extent of the potentially local zone of PCE contamination at CTM2S and function to verify that no potential upgradient sources (from other PCA's) exist. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Defines upgradient extent of potentially local zone of contamination	MODERATE: Provides upgradient definition to local zone of contamination. Verifies that no potential contributing sources exist upgradient.	None. Continued monitoring to verify no impacts from upgradient PCAs.

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CTM2S	SITE SPECIFIC PL ME DYNAMICS	PCE data characterize and assess local zone of PCE contamination that is poorly constrained, particularly in the lateral and vertical downgradient dimensions. The relatively spiky and recent lower concentrations in the 5 to 10 µg/L range are consistent with a potentially nearby, but generally low mass source that may or may not be diminishing over time. The potential interrelationship between higher PCE concentrations and water levels may indicate that a residual source exists that is released when water levels are higher. Alternatively this interrelationship could be a function of the influence of local hydrodynamics changing plume or wellbore PCE dynamics. Water level data provide general characterization for defining lateral gradient and water level contouring.	Important ut not a ey well Provides assessment of local contamination dynamics and mass flux in a poorly constrained, but probably low mass zone of contamination.	HIGH: Assess dynamics and mass flux of poorly characterized, local zone of contamination.	PCE should be monitored for any potential spikes or emerging trends that would indicate increased, potentially significant PCE mass contribution to the groundwater from this potential locally sourced zone of contamination.
	PL ME CORE DYNAMICS	PCE data help characterize the Downtown plume core, or more concentrated portion of the deep zone DR plume. The well functions to assess plume dynamics and mass flux in a zone of potentially higher PCE mass. There is an apparent change in PCE concentration time-series data (starting in 2006) from stable PCE concentration with relatively small seasonal fluctuations, to a step increase to a higher but stable average annual PCE concentration with relatively large seasonal fluctuations. This change coincides with the onset of seasonal pumping at PCE-treated wells and suggest an interrelationship. Water level data are more consistent with a better hydraulic connection to HIGH than to municipal water supply wells located to the west.	KEY ELL Assesses plume dynamics and mass flux in an area of potential high PCE mass.	HIGH: KEY WELL	Longer-term PCE trends between CTM137, CTM30D, MW8ND, and CTM8D should be assessed together to help define the extent to which the Downtown plume core behaves as a single zone of higher PCE contamination with similar dynamics.
CTM31S	MASS FL /PL ME DYNAMICS/TRA EL TIME ASSESSMENT	PCE data at CTM31S characterize the shallow zone plume interior at the poorly constrained northern extent of the DR plume. Its position laterally downgradient from CTM5 suggest that PCE data may function to provide travel time information along the flowpath between CTM5 and CTM31S. The potential interrelationship between decreasing water levels and PCE concentration spikes suggest that local plume dynamics, wellbore flow dynamics, or mass flux are interrelated with intermittent seasonal pumping hydrodynamics. Water level data are similar to nearby well CTM3S and help define the area where pumping at RENOHIGH, GLENHARE, and HUNTERLAKE influence shallow zone hydrodynamics.	KEY ELL: Helps assess mass flux/plume dynamics/travel time downgradient of W. Fourth St. hot spot.	HIGH: KEY WELL	PCE concentrations at CTM31S should be compared to CTM5 to assess whether any characteristics that would provide travel time information emerge with additional sampling.
	DISTAL (LATERAL) PL ME DYNAMICS P MPING PLAN PERFORMANCE ASSESSMENT	PCE data at CTM37S help define the downgradient, unconstrained extent of the shallow zone DR plume. The longer term increasing PCE concentration trend and interrelationship between PCE concentration and water level minima both suggest that plume dynamics are influenced by hydrodynamics associated with seasonal pumping. This well functions to define plume dynamics in the unconstrained downgradient extent of the plume. Increasing PCE concentrations since 2006 are consistent with the plume expanding in the lateral downgradient direction. Consideration should be made as to whether the change to seasonal pumping negatively influences the effectiveness of plume capture the shallow portion of the DR plume. Water level data inversely correlate to pumping volume at HIGH (and other PCE-treated wells) both with respect to longer term trends and seasonal patterns. Water levels are important at this well for examining the interrelationship between PCE concentrations and water levels.	KEY ELL: Helps assess plume dynamics at unconstrained downgradient extent of shallow zone DR plume.	HIGH: KEY WELL	CTM37S should be tracked for plume expansion. Consideration as to whether shallow zone plume dynamics (increasing PCE concentrations) have changed as a result of implementation seasonal pumping at PCE-treated wells, should be examined at this well.

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	MASS FL /PL ME DYNAMICS/TRA EL TIME ASSESSMENT	PCE data at CTM3S characterize the shallow zone plume interior in the northern portion of the DR plume. Its position laterally downgradient from CTM5 suggest that (along with CTM31S) PCE data may function to provide travel time information along the flowpath between CTM5 and CTM3S. The potential interrelationship between lower water levels and PCE concentration spikes suggest that local plume dynamics, mass flux, or local wellbore flow dynamics are interrelated with intermittent seasonal pumping-related hydrodynamics. Water level data are similar to nearby well CTM31S and help define the area where pumping at RENOHIGH, GLENHARE, and HUNTERLAKE influence shallow zone hydrodynamics. Part of a well cluster with CTM4D that provides a key location for assessing vertical PCE distribution and the consistently upward vertical gradient in the northern part of the downtown Reno area.	KEY ELL: Helps assess mass flux/plume dynamics/travel time downgradient of W. Fourth St. hot spot.	HIGH: KEY WELL	PCE concentrations at CTM3S should be compared to CTM5 to assess whether any characteristics that would provide travel time information emerge with additional sampling.
CTM40S	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the lateral (north) extent of the shallow zone DR plume. The well's position is distal from any known PCAs making the likelihood of detecting PCE at this well unlikely. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Helps define DR shallow zone plume extents.	LIMITED: Provides ambient aquifer characterization	Consider discontinuing water quality monitoring and utilizing well for water level monitoring only.
	SPATIAL BACKGRO ND MONITORING	Part of a well cluster with CTM4D that provides a key location for assessing vertical PCE distribution and the consistently upward vertical gradient in the northern part of the downtown Reno area.	Not a ey well Part of a well cluster that assesses vertical PCE distribution and vertical gradient.	HIGH: Part of well cluster that assesses vertical PCE distribution and area of persistent upward gradient.	None. Continued annual water quality monitoring and monthly water level monitoring.
	MASS FL /SO RCE ASSESSMENT	CTM5 helps define the W. Fourth St. hot spot and functions as an important source area monitoring site for defining near source plume dynamics and potentially long-term PCE contribution (mass flux) from the hot spot. The currently limited set of data exhibits less spiky PCE concentrations compared to CTM28S. This may be a function of their respective position's relative to a source, or it may be a function of well construction. CTM5 is screened below the water table (74-84 ft bgs), while CTM28S is screened across the water table (23.5-43.5 ft bgs). Water level data are consistent with hydraulic communication between the deep zone pumping at RENOHIGH, HUNTERLAKE, and GLENHARE and the shallow zone where the well is constructed.	KEY ELL: Helps assess plume dynamics and/or mass flux in or near W. Fourth St. hot spot.	HIGH: KEY WELL	The greater depth of CTM5 (74-84 FT bgs) is consistent with any PCE source being sufficiently upgradient from the well to migrate vertically through roughly 30 ft of the water column. This and the lateral width of the plume as defined by CTM28S and CTM5 suggest either multiple sources or a relatively more upgradient position for a single source.
CTM57	SPATIAL BACKGRO ND MONITORING	CTM57 monitors for potential contamination associated with PCAs in the Booth St./California Ave. area. PCE non-detects are consistent with uncontaminated groundwater in the shallow zone portion of the aquifer where this well exists. Water level data provide general characterization for defining lateral gradient and water level contouring. The hydrograph for CTM57 is consistent with a hydraulic connection with the both the Truckee River and pumping from the nearby RENOHIGH, GLENHARE, and HUNTERLAKE wells.	Not a ey well Provide verification that no contamination has impacted groundwater from nearby PCAs.	MODERATE: Verification that groundwater remains uncontaminated in region of PCAs.	None. Continued annual water quality monitoring.
CTM58	SPATIAL BACKGRO ND MONITORING	CTM58 monitors for potential contamination associated with PCAs in the Booth St./California Ave. area. PCE non-detects are consistent with uncontaminated groundwater in the shallow zone portion of the aquifer where this well exists. Water level data provide general characterization for defining lateral gradient and water level contouring. Hydrographs for CTM58 and CTM59 are similar to CTM57, but exhibit less apparent influence from the Truckee River.	Not a ey well Provide verification that no contamination has impacted groundwater from nearby PCAs.	MODERATE: Verification that groundwater remains uncontaminated in region of PCAs.	None. Continued annual water quality monitoring.
CTM59	SPATIAL BACKGRO ND MONITORING	CTM59 monitors for potential contamination associated with PCAs in the Booth St./California Ave. area. PCE non-detects since 2005 Q2 are consistent with uncontaminated groundwater in the shallow zone portion of the aquifer where this well exists. Water level data provide general characterization for defining lateral gradient and water level contouring. Hydrographs for CTM58 and CTM59 are similar to CTM57, but exhibit less apparent influence from the Truckee River.	Not a ey well Provide verification that no contamination has impacted groundwater from nearby PCAs.	MODERATE: Verification that groundwater remains uncontaminated in region of PCAs.	None. Continued annual water quality monitoring.

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	ERTICAL PL ME MASS MO EMENT MASS FL /PL ME DYNAMICS/TRA EL TIME ASSESSMENT SO RCE ECTOR	PCE data at CTM6S help define the plume interior downgradient from the W. Fourth St. hot spot and potentially along the plume centerline. The recurring pattern of PCE concentration maxima and minima overprint and generally obscure any longer term trend that may exist at this well. The interrelationship between PCE concentration maxima and minima and water level increases and decreases respectively suggest that plume dynamics are influenced by hydrodynamics associated with seasonal pumping. This interrelationship may be the result of changes in mass flux, plume dynamics, or wellbore dynamics that are linked to hydrodynamics associated with seasonal pumping. The general spiky PCE behavior and the relatively high concentrations at CTM6S suggest the potential that a proximal contributing source influences PCE at this well. Water level data at CTM6S characterize this well group and are consistent with the shallow zone (where CTM6S is located) having a relatively greater hydraulic connection with pumping in the deep zone at PCE-treated wells (and particularly HIGH municipal water supply well based on HIGH-MORRILL aquifer test results).	KEY ELL: Helps assess plume dynamics along plume centerline and potentially associated with a contributing proximal source. Important for assessing potentially enhanced vertical PCE migration in an area of better vertical hydraulic connection.	HIGH: KEY WELL	CTM6S exhibits a strong, spiky interrelationship between PCE concentration and water level data that should be assessed for cause. These seasonal fluctuations are significantly larger than any long term trend that may exist and are an indicator of local heterogeneity in PCE concentration that may be caused by either plume/wellbore dynamics or mass flux dynamics (from a proximal source). The larger magnitude water level response that correlates to pumping at HIGH indicate that this well has greater vertical hydraulic connection to HIGH pumping. The data are consistent with significant PCE mass migrating vertically from CTM6S towards HIGH. This interpretation should be further examined.
	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the vertical extent of the DR plume to the shallow zone portion of the aquifer above where this well and CTM80 is constructed. Water level data from this well are critical to the assessment of vertical migration of PCE in the area because in combination with data from the other wells in the cluster, they indicate a more direct response in the shallow zone (CTM80 and CTM6S) to pumping at HIGH compared to the response in the deep zone (CTM79).	Not a ey well Helps verify shallow zone vertical extent of shallow zone DR plume. Part of a well cluster that assessed vertical PCE distribution and vertical gradient.	MODERATE: Part of a well cluster that provides assessment of vertical PCE distribution and hydrodynamics in an area of potentially enhance vertical groundwater flow.	
CTM7S	SPATIAL BACKGRO ND MONITORING	PCE non detects constrain lateral/downgradient extend of shallow zone DR plume. Water level data and specific conductance measurements (ranging from 150-485 µS/cm) are consistent with a connection between the Truckee River and where this well is constructed. PCE non-detects may be result of either the river acting as a hydraulic barrier to shallow zone groundwater flow, dilution of plume by river recharge, or the result of the plume plunging beneath the interval where the well is constructed. Water level data provide general characterization for defining lateral gradient and water level contouring. Part of a well cluster with CTM8D that provides a key location for assessing vertical PCE distribution and persistent downward vertical gradient proximal to the river and HIGH.	Not a ey well Helps constrain lateral/downgradient extent of shallow zone DR plume. Part of a well cluster that assessed vertical PCE distribution and vertical gradient.	HIGH: Part of a well cluster that provides assessment of vertical PCE distribution and hydrodynamics in an area where pumping, influence of the Truckee River, and a partial flow barrier apparently impact groundwater and plume migration.	Continued quarterly water quality and monthly water level sampling.
	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the vertical extent of the DR plume to the shallow zone portion of the aquifer above where the well is constructed (screened interval: 115-130 ft bgs). Water level data from this well are critical to the assessment of vertical migration of PCE in the area because in combination with data from the other wells in the cluster, they indicate a more direct response in the shallow zone (CTM80 and CTM6S) to pumping at HIGH compared to the response in the deep zone (CTM79).	KEY ELL Assesses vertical extent of DR plume in critical area where vertical flow and vertical PCE migration may be enhanced.	HIGH: Part of a well cluster that provides assessment of vertical PCE distribution and hydrodynamics in an area of potentially enhance vertical groundwater flow.	Data at this well cluster need to be assessed and placed into context with pumping stresses and hydrostratigraphic packages in the area. Currently available data is consistent with a potential conduit and appropriate gradients that would cause PCE to migrate downward (or along an inclined pathway) in response to pumping at PCE-treated wells (particularly HIGH).
	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE and TCE data assess an upgradient portion of contamination that is considered to impact 4TH. The well functions to assess plume dynamics and any potential increasing PCE/TCE trends that would indicate greater risk to 4TH municipal water supply well. TCE detections provide source vector information for a potentially distinct source in the northeastern segment of the DR plume. Water level data help define water level contours and dynamics west of 4TH particularly when 4TH is pumping.	KEY ELL Acts as a sentry to 4TH. Assesses plume dynamics that would provide early warning for increased risk at 4TH. Helps define and vector towards potentially distinct source characterized by PCE and TCE.	HIGH: KEY WELL	Continue to track PCE and TCE concentration dynamics at CTM81 to assess potential risk at 4TH.

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	P MPING PLAN PERFORMANCE MONITORING	PCE and TCE non-detections help to verify that either the DR plume does not extend to depths where this well is constructed (380-395 ft bgs) or that capture at 4TH and KIETZKE is effective at containing the deep zone DR plume at depths where the well is constructed . Water level data are consistent with a direct hydraulic connection to the surrounding PCE-treated wells in the subregion. Part of a well cluster with CTM82 and CTM84 that provides a key location for assessing vertical gradient in the area proximal to KIETZKE, GALLETTI, and the Truckee River.	KEY ELL Verifies effectiveness of pumping plan.	HIGH: KEY WELL	TCE concentrations at CTM84 (in well cluster that includes CTM82/83/84) are above the MCL and already suggest a potential risk to downgradient municipal supply wells GALLETTI and 21ST. An updated cross section through well cluster CTM82/83/84 from either KIETZKE to 21ST or from 4TH to 21ST should be constructed to put risk into hydrostratigraphic context.
	PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE OF CAPT RE ONE P MPING PLAN PERFORMANCE ASSESSMENT	TCE data at CTM83 help define and assess potential risk for TCE contamination to migrate beyond the capture zone of 4TH and KIETZKE and to impact downgradient potential receptors GALLETTI and 21ST. The presence of TCE in this and other wells in the northeast part of the DR plume suggest a separate distinct source for this segment of the plume, and to some extent provide vector information for this potentially distinct source. Part of a well cluster with CTM82 and CTM84 that provides a key location for assessing vertical gradient in the area proximal to KIETZKE, GALLETTI, and the Truckee River.	KEY ELL Assesses plume dynamics that would provide early warning for increased risk at GALLETTI and 21ST. Helps define and vector towards potentially distinct source characterized by PCE and TCE.	HIGH: KEY WELL	TCE concentrations at CTM84 (in well cluster that includes CTM82/83/84) are above the MCL and already suggest a potential risk to downgradient municipal supply wells GALLETTI and 21ST. An updated cross section through well cluster CTM82/83/84 from either KIETZKE to 21ST or from 4TH to 21ST should be constructed to put risk into hydrostratigraphic context.
	PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE OF CAPT RE ONE P MPING PLAN PERFORMANCE ASSESSMENT	TCE data at CTM84 help define and assess potential risk for TCE contamination to migrate beyond the capture zone of 4TH and KIETZKE and to impact downgradient potential receptors GALLETTI and 21ST. The presence of TCE in this and other wells in the northeast part of the DR plume suggest a separate distinct source for this segment of the plume, and to some extent provide vector information for this potentially distinct source. Part of a well cluster with CTM82 and CTM84 that provides a key location for assessing vertical gradient in the area proximal to KIETZKE, GALLETTI, and the Truckee River.	KEY ELL Assesses plume dynamics that would provide early warning for increased risk at GALLETTI and 21ST. Helps define and vector towards potentially distinct source characterized by PCE and TCE.	HIGH: KEY WELL	TCE concentrations at CTM84 (in well cluster that includes CTM82/83/84) are above the MCL and already suggest a potential risk to downgradient municipal supply wells GALLETTI and 21ST. An updated cross section through well cluster CTM82/83/84 from either KIETZKE to 21ST or from 4TH to 21ST should be constructed to put risk into hydrostratigraphic context.
	PL ME CORE DYNAMICS	PCE data help characterize the Downtown plume core, a more concentrated portion of the deep zone DR plume. The well functions to assess plume dynamics and mass flux in a zone of potentially higher PCE mass. PCE data are consistent with increasing longer-term PCE concentration and mass flux. Water level data are more consistent with a better hydraulic connection to HIGH than to other municipal water supply wells in the subregion. Aquifer testing results from pumping at HIGH and MORRILL (HGC, 2010) indicate that CTM8D and other deep wells to the west of CTM8D are positioned west of a partial flow barrier and respond more directly to HIGH than MORRILL . The significantly larger seasonal water level responses compared to CTM30D and MW10ND are consistent with its more proximal position relative to HIGH and to the flow barrier, but may also be caused by a separate flow barrier west of HIGH that mutes water levels on its opposite side (where CTM30D and MW10ND may be located). Part of a well cluster with CTM7S that provides a key location for assessing vertical PCE distribution and vertical gradient proximal to HIGH.	KEY ELL Assesses plume dynamics and mass flux in an area of potential high PCE mass.	HIGH: KEY WELL	Longer-term PCE trends between CTM137, CTM30D, MW8ND, and CTM8D should be assessed together to help define the extent to which the Western Plume Core behaves as a single zone of higher PCE contamination with similar dynamics.
	PCE MASS REMO AL AND CAPT RE	RECEPTOR: PCE data define mass removal and long-term PCE trends in the deep zone portion of the DR complex plume. HIGH has exhibited a long-term decreasing trend recognized over a period between 1995 to 2010. Well functions as a significant remediation and capture well for DR complex plume. Water levels are a direct function of pumping at the well.	KEY ELL Defines PCE mass removal and assesses effectiveness of pump and treat activities on removal and capture of a portion of the DR complex plume.	HIGH: KEY WELL	Review long-term PCE concentration trend and any potential relationships between change in pumping plan and mass removal. Compare trends at upgradient deep zone trends with trend at HIGH. Consider strategy to assess effectiveness of pumping plan for all PCE-treated wells. Assess whether during the pumping season PCE concentration have any relationship to pumping volume that would provide an assessment of seasonal pumping effectiveness.
E E	PCE MASS REMO AL AND CAPT RE	RECEPTOR: PCE data define mass removal and long-term PCE trends in the deep zone portion of the DR complex plume. The relatively stable PCE concentrations (at 6 - 8 μg/L) since the well was placed on treatment (1998) suggest relatively consistent or uniform capture/containment. Well functions as a significant remediation and capture well for DR complex plume. Water levels are a direct function of pumping at the well.	KEY ELL Defines PCE mass removal and assesses effectiveness of pump and treat activities on removal and capture of a portion of the DR complex plume.	HIGH: KEY WELL	Review long-term PCE concentration trend. Consider strategy to assess effectiveness of pumping plan for all PCE-treated wells. Assess whether during the pumping season PCE concentration have any relationship to pumping volume that would provide an assessment of seasonal pumping effectiveness.

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MENTALHEALTH	SPATIAL BACKGRO ND MONITORING	PCE non detects constrain PCE contamination in the deep zone, downgradient of the DR plume upgradient (west) of the DS Subregion. The well functions to locally constrain and verify that PCE contamination from the DR plume does not migrate east of and out of the capture zone of KIETZKE or 4TH. Water levels respond directly to pumping from nearby wells that exist to the north (VIEW), west (4TH and KIETZKE), south (GALLETTI and 21ST), and east (POPLAR1, POPLAR2, and SPARKS). As a result of the high number of pumping wells and an apparently relatively direct hydraulic connection within the deep zone, MENTALHEALTH water levels exhibit a relatively direct, large magnitude response to pumping.	Not a ey well Outside either the VA or DS plume extents.	MODERATE: Provides area-wide deep zone hydrodynamic assessment. Helps constrain extent of deep zone plume west of subregion.	None. Continued annual water quality and monthly water level monitoring.
MILL	PCE MASS REMO AL AND CAPT RE	RECEPTOR: PCE data define mass removal and long-term PCE trends in the deep zone portion of the DR complex plume. The long-term increasing PCE concentration trend between 1990 and 2009 indicate that this well functions as a key well for mass removal and capture. The apparent increasing PCE concentrations over the course of a pumping season should be verified. If verified they are consistent with this well capturing greater PCE mass, the longer it is pumped. This suggests that as the well's capture zone increases, its effectiveness as a remediation well increases. Water levels are a direct function of pumping at the well.	KEY ELL Defines PCE mass removal and assesses effectiveness of pump and treat activities on removal and capture of a portion of the DR complex plume.	HIGH: KEY WELL	Recent PCE concentration maxima (2008Q3 and 2009Q4) at MILL may correlate to upgradient maxima at MORRILL (in 1994Q3 and Q4) and CTM10D (in 2004Q2). If these maxima represent a single, discrete migrating plume core, that core traveled from MORRILL to CTM10D to MILL in a period of roughly 14 years with a travel time in the range of 1 to 1.4 ft/day. PCE concentrations at MILL should continue to be characterized to determine whether maximum concentrations have been reached and a decreasing trend similar to that observed at CTM10D emerges. Pumping schedule at this well should be reassessed. Consideration for greater volumes of pumping should be made to increase remediation and capture effectiveness at this well. The long-term increasing PCE concentration at MILL compared to the stable or decreasing trends at HIGH, MORRILL, and HIGH are consistent with the center of mass of the DR plume being south the Truckee River and the capture zones of HIGH, MORRILL, and KIETZKE.
	PCE MASS REMO AL AND CAPT RE	RECEPTOR: PCE data define mass removal and long-term PCE trends in the deep zone portion of the DR complex plume. Similar to HIGH, MORRILL has exhibited a long-term decreasing trend recognized over a period between 1995 to 2010. Well functions as a significant remediation and capture well for DR complex plume. Water levels are a direct function of pumping at the well.	KEY ELL Defines PCE mass removal and assesses effectiveness of pump and treat activities on removal and capture of a portion of the DR complex plume.	HIGH: KEY WELL	Recent PCE concentration maxima (2008Q3 and 2009Q4) at MILL may correlate to upgradient maxima at MORRILL (in 1994Q3 and Q4) and CTM10D (in 2004Q2). If these maxima represent a single, discrete migrating plume core, that core traveled from MORRILL to CTM10D to MILL in a period of roughly 14 years with a travel time in the range of 1 to 1.4 ft/day. PCE concentrations at MILL should continue to be characterized to determine whether maximum concentrations have been reached and a decreasing trend similar to that observed at CTM10D emerges.
	SITE SPECIFIC PL ME DYNAMICS	PCE data at MW10ND characterize the deep zone plume interior in the southern, laterally unconstrained portion of the DR plume. The well assesses plume dynamics in a relatively poorly characterized part of the plume. The potential interrelationship between higher water levels and PCE concentration minima suggest that local plume dynamics or vertical wellbore dynamics are interrelated with recurring seasonal hydrodynamics associated with pumping at PCE-treated wells (primarily HIGH). Part of a well cluster with MW9NS that provides a key location for assessing vertical PCE distribution and vertical gradient proximal to HIGH.	KEY ELL: Helps assess plume dynamics in a poorly characterized/constrained part of the deep zone DR plume.	HIGH: KEY WELL	The apparent interrelationship between PCE concentration and water levels is consistent with local PCE concentration heterogeneity that migrates into and out of the well screen in response to water level dynamics. This interrelationship could indicate either vertical or lateral plume dynamics, or it could be the result of vertical wellbore flow dynamics that are a function of well construction rather than any real plume dynamics. This well is a good candidate to assess causal relationships between PCE concentration and water level dynamics.

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	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the vertical, downgradient extent of the local zone of contamination defined at CTM2S and the lateral cross gradient extent of the deep zone DR plume. Water level data provide general characterization for defining lateral gradient and water level contouring. Part of a well cluster with MW2Ns that provides a key location for assessing vertical PCE distribution and vertical gradient in the downtown Reno area where a persistent downward gradient exits. The notably larger water level response in shallow zone well MW2NS compared to deep zone well MW1ND are consistent with a more direct hydraulic connection between the shallow zone and pumping at RENOHIGH, GLENHARE, and HUNTERLAKE and the deep zone as represented by MW2NS. This observation is not fully understood and requires further assessment.	Not a key well. Helps to constrain lateral/upgradient extent of deep zone PCE contamination in area. Provides potentially important, but poorly understood water level data to assess vertical hydrodynamics in the downtown Reno area.	HIGH: Part of a well cluster that characterizes potentially key vertical hydrodynamics.	Assess hydrodynamics at well pair during RENOHIGH aquifer test (performed in 2/2011) with objective of evaluating apparently unique vertical hydrodynamics where shallow zone well responds more directly to pumping than deep zone well.
MW2NS	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the lateral, downgradient extent of the local zone of contamination defined at CTM2S and the lateral crossgradient extent of the shallow zone DR plume. Water level data provide general characterization for defining lateral gradient and water level contouring. Part of a well cluster with MW1ND that provides a key location for assessing vertical PCE distribution and vertical gradient in the downtown Reno area where a persistent downward gradient exits. The notably larger water level response in shallow zone well MW2NS compared to deep zone well MW1ND are consistent with a more direct hydraulic connection between the shallow zone and pumping at RENOHIGH, GLENHARE, and HUNTERLAKE and the deep zone as represented by MW2NS. This observation is not fully understood and requires further assessment.	Not a ey well Helps to constrain lateral extent of shallow zone PCE contamination in area. Provides potentially important, but poorly understood water level data to assess vertical hydrodynamics in the downtown Reno area.	HIGH: Part of a well cluster that characterizes potentially key vertical hydrodynamics.	Assess hydrodynamics at well pair during RENOHIGH aquifer test with objective of evaluating apparently unique vertical hydrodynamics where shallow zone well apparently responds more directly to pumping than deep zone well.
MW3ND	SPATIAL BACKGRO ND MONITORING	PCE non-detects poorly constrain the lateral, crossgradient (south) extent of the deep zone DR plume. Water level data provide general characterization for defining lateral gradient and water level contouring. Part of a well cluster with MW4NS that provides a key location for assessing vertical PCE distribution and vertical gradient in the downtown Reno area where a persistent downward gradient exits.	Not a ey well Helps to constrain lateral extent of deep zone PCE contamination in area. Provides potentially important, but poorly understood water level data to assess vertical hydrodynamics in the downtown Reno area.	HIGH: Part of a well cluster that characterizes potentially key vertical hydrodynamics.	Assess hydrodynamics at well pair during RENOHIGH aquifer test with objective of evaluating vertical hydrodynamics and role of Truckee River in hydrodynamics during extended pumping at RENOHIGH.
MW4NS	SPATIAL BACKGRO ND MONITORING	PCE non-detects poorly constrain the lateral, crossgradient (south) extent of the shallow zone DR plume. Water level data provide general characterization for defining lateral gradient and water level contouring. Part of a well cluster with MW3ND that provides a key location for assessing vertical PCE distribution and vertical gradient in the downtown Reno area where a persistent downward gradient exits. The notably muted response and water level increases that coincide with high river discharge an MW4NS indicate a hydraulic connection to the Truckee River.	Not a ey well Helps to constrain lateral extent of shallow zone PCE contamination in area. Provides potentially important water level data to assess vertical hydrodynamics in the downtown Reno area.	HIGH: Part of a well cluster that characterizes potentially key vertical hydrodynamics.	Assess hydrodynamics at well pair during RENOHIGH aquifer test with objective of evaluating vertical hydrodynamics and role of Truckee River in hydrodynamics during extended pumping at RENOHIGH.
	SITE SPECIFIC PL ME DYNAMICS	MW6ND is the furthest upgradient PCE-impacted deep zone well in the DR plume. It functions to assess deep zone plume dynamics between the shallow zone hot spot (at CTM28S) and proximal parts of the deep zone DR plume. Presence of deep zone contamination at MW6ND is consistent with notable vertical PCE migration between the W. Fourth St. hot spot and this well. Relatively stable PCE concentrations are consistent with a uniform mass flux across the interval where the well is constructed. Water level data indicate that this well is influenced by municipal water supply pumping at RENOHIGH, GLENHARE, and HUNTERLAKE, and to a potentially lesser extent pumping at HIGH (or other PCE-treated wells).	KEY ELL Assesses plume dynamics and mass flux in an upgradient portion of the deep zone closer to the W. Fourth St. hot spot.	HIGH: KEY WELL	MW6ND should be monitored to assess whether decreasing PCE trends observed at CTM28S emerge at MW6ND.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
MW7NS	DISTAL (LATERAL) PL ME DYNAMICS (redundant with RETRACP)	MW7NS is generally redundant with RETRACP2 exhibiting a similar increasing PCE concentration trend that is recognized by PCE detections starting in 2006Q2 that coincides with the period after increasing water levels that culminate in a GMP period of record maximum in 2006Q1. PCE detections and the longer term increasing PCE concentrations also coincide with the onset of seasonal pumping at PCE-treated wells. Consideration should be made as to whether the change to seasonal pumping negatively influences the effectiveness of plume capture the shallow portion of the DR plume near this well. Water level data generally characterize this well group and appear to be influenced by the Truckee River and to a slight degree, seasonal pumping (at HIGH or other PCE-treated wells). The notably muted response and water level increases that coincide with high river discharge an MW7NS indicate a hydraulic connection to the Truckee River. Part of a well cluster with MW8ND that provides a key location for assessing vertical PCE distribution and vertical gradient proximal to HIGH where a persistent downward gradient exits.	Not a ey well Redundant with RETRACP2, but has value as part of a well cluster with MW8ND.	HIGH: Part of a well cluster that characterizes potentially key vertical hydrodynamics.	Track MW7NS, RPDMW6, and RETRACP2 for potential emerging increasing trends that may suggest plume expansion in this area and southward across the Truckee River.
	PL ME CORE DYNAMICS	PCE data help characterize a plume core (Downtown core), or more concentrated portion of the deep zone DR plume. The well functions to assess plume dynamics and mass flux in a zone of potentially higher PCE mass. PCE concentrations are consistent with seasonal fluctuations that tend to be larger than any longer-term trend that may exist at the well. Water level data are more consistent with a better hydraulic connection to HIGH than to municipal water supply wells located to the west. The significantly larger seasonal water level responses compared to CTM30D and MW10ND are consistent with its more proximal position relative to HIGH, but may also be caused by a separate flow barrier west of HIGH that mutes water levels on its opposite side (where CTM30D and MW10ND may be located).. Part of a well cluster with MW7NS that provides a key location for assessing vertical PCE distribution and vertical gradient proximal to HIGH.	KEY ELL Assesses plume dynamics and mass flux in an area of potential high PCE mass.	HIGH: KEY WELL	Longer-term PCE trends between CTM137, CTM30D, MW8ND, and CTM8D should be assessed together to help define the extent to which the Western Plume Core behaves as a single zone of higher PCE contamination with similar dynamics.
MW9NS	SPATIAL BACKGRO ND MONITORING	PCE non-detects help constrain lateral (south) extent of shallow zone DR plume. Water level data provide general characterization for defining lateral gradient and water level contouring. Part of a well cluster with MW10ND that provides a key location for assessing vertical PCE distribution and vertical gradient proximal to HIGH where a recurring seasonal pattern of alternating upward and downward gradients correlates to seasonal pumping at HIGH (and the other PCE treated wells).	Not a ey well Helps to constrain lateral and vertical extent of PCE contamination in area. Part of well cluster that provides potentially important water level data to assess vertical hydrodynamics in the downtown Reno area.	HIGH: Part of a well cluster that characterizes potentially key vertical hydrodynamics.	None. Continued quarterly water quality and monthly water level monitoring.
QUIKMRTMW18C	MASS FL /SO RCE ASSESSMENT (redundant with CTM S)	QUIKMRTMW18C is redundant with CTM28S in terms of both PCE concentrations and water levels.	Not a ey well Redundant with CTM28S for both water levels and PCE	LIMITED: Redundant with CTM28S	Redundant with CTM28S. Consider discontinuing water quality and water level monitoring at this well. Well may be of use for any remediation that may occur as a result of the PCA investigation outcome.
RENOAUTOMW	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide ambient groundwater conditions where a no indentified PCAs exist upgradient or proximal to well. It is however located on an auto wrecking yard. The well is utilized for commercial purposes compromising the ability to obtain high pedigree water quality and water level data.	Not a ey well Its position distal from the DR plume and the poor pedigree of data obtained at the well because of its intermittent use as a commercial well make the well of limited value.	LIMITED: Provides poor quality ambient aquifer characterization as a result of its active use.	Consider discontinuing water quality sampling. Water level monitoring should continue but data should be collected only when well if off and water levels are stable.
RENOHIGH	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	Low concentration intermittent PCE detections at RENOHIGH are consistent with PCE contamination that may either have a source proximal to the well (southwest of the DR Subregion) or it may be part of the DR plume that is captured by pumping at RENOHIGH. The well functions to in a self-sentry capacity and provides relatively qualitative PCE information that is compromised by its relatively long screen interval and injection.	Not a ey well Provides self sentry capability to monitor for increases in PCE concentration detected at well that would put well at risk.	HIGH: Acts as self-sentry. Injection at well needs to be considered when assessing water quality data.	Consider follow-up actions after RENOHIGH aquifer testing in 2/2011.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
RENOHIGHMWD	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	Low concentration PCE detections at RENOHIGHMWD are consistent with PCE contamination that impacts RENOHIGH existing in the deeper portions of the screened interval between 240-420 ft bgs. The well functions to provide relatively qualitative PCE information that is compromised by its relatively long screen interval and injection at RENOHIGH.	Not a ey well Provides sentry capability to monitors for increases in PCE concentration detected at well that would put RENOHIGH at risk.	MODERATE: Acts as sentry well for RENOHIGH. Injection at well needs to be considered when assessing water quality data.	Consider follow-up actions after RENOHIGH aquifer testing in 2/2011.
RENOHIGHMWS	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE non-detects at RENOHIGHMWD are consistent with PCE contamination that impacts RENOHIGH existing in the deeper portions of the screened interval deeper than the bottom of the well's screened interval at 230 ft bgs. The well functions to provide relatively qualitative PCE information that is compromised by its relatively long screen interval and injection at RENOHIGH.	Not a ey well Provides verification that PCE contamination has not impacted groundwater in shallower groundwater producing interval where RENOHIGH is constructed.	MODERATE: Acts as sentry well for RENOHIGH. Injection at well needs to be considered when assessing water quality data.	Consider follow-up actions after RENOHIGH aquifer testing in 2/2011.
RETRACB13	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the upgradient extent of PCE contamination in the downtown Reno area and provide ambient groundwater conditions west of the urban area. The well also helps monitor for PCE impacts from the PCAs along Dickerson Ave. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Monitors for potential impact from upgradient PCAs. Characterizes ambient groundwater conditions upgradient of DR plume.	MODERATE: Provides ambient groundwater characterization and monitors for impact from upgradient PCAs.	None. Continued annual water quality monitoring.
RETRACB14	SPATIAL PL ME MONITORING	PCE data help characterize and to a degree define the general plume extent along the southern outline of the shallow zone DR plume. The well functions to provide plume geometry definition and assess plume dynamics along the southern plume outline. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Provides plume geometry definition and a limited assessment of plume dynamics along southern/upgradient outline of shallow zone DR plume.	MODERATE: Provides plume geometry definition and limited assessment of plume dynamics.	RETRAC paired wells and CTM138 should be assessed for determining whether sets of wells on either side of the trench are redundant. Current evaluation suggests that the primary value of having these pairs is for providing a PCE concentration gradient useful for defining the plume outline along the south edge of the shallow zone DR plume.
RETRACMWA	ABANDONED	NA: Abandoned	NA: Abandoned	NA: Abandoned	NA: Abandoned
RETRACMWC	SPATIAL BACKGRO ND MONITORING	Non-detects at RETRACMWC help constrain the lateral, upgradient (southwest) extent of the DR shallow zone plume. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Locally constrains lateral, updgradient extent of shallow zone DR plume.	MODERATE: Provides plume geometry definition and limited verification that no upgradient sources exist.	None. Shallow depth of RETRAC series wells (all having bottom of screen at 35 ft bgs) render them less than optimal and limit their value.
RETRACMWD	SPATIAL PL ME MONITORING	PCE data help characterize the general plume extent along the southern outline of the shallow zone DR plume. The well functions to provide plume geometry definition and assess plume dynamics along the southern plume outline. General similarities in recurring seasonal patterns between this well and many of the other RETRAC series wells are consistent with an area wide interrelationship between PCE and water level elevations at or near the water table where these wells are constructed. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Provides plume geometry definition and a limited assessment of plume dynamics along southern outline of shallow zone DR plume.	MODERATE: Provides plume geometry definition and limited assessment of plume dynamics.	RETRAC paired wells and CTM138 should be assessed for determining whether sets of wells on either side of the trench are redundant. This evaluation suggests that the primary value of having these pairs is for providing a PCE concentration gradient useful for defining the plume outline along the south edge of the shallow zone DR plume.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
RETRACMWE	SPATIAL PL ME MONITORING	PCE data help characterize a portion of the plume interior along the southern outline of the shallow zone DR plume. The well functions to provide plume geometry definition and assess plume dynamics along the southern plume outline. General similarities in recurring seasonal patterns between this well and many of the other RETRAC series wells are consistent with an area wide interrelationship between PCE and water level elevations at or near the water table where these wells are constructed. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Provides plume geometry definition and a limited assessment of plume dynamics along southern outline of shallow zone DR plume.	MODERATE: Provides plume geometry definition and limited assessment of plume dynamics.	RETRAC paired wells and CTM138 should be assessed for determining whether sets of wells on either side of the trench are redundant. This evaluation suggests that the primary value of having these pairs is for providing a PCE concentration gradient useful for defining the plume outline along the south edge of the shallow zone DR plume.
RETRACMWE1	SPATIAL PL ME MONITORING	PCE data help characterize a portion of the plume interior along the southern outline of the shallow zone DR plume. The well functions to provide plume geometry definition and assess plume dynamics along the southern plume outline. General similarities in recurring seasonal patterns between this well and many of the other RETRAC series wells are consistent with an area wide interrelationship between PCE and water level elevations at or near the water table where these wells are constructed. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Provides plume geometry definition and a limited assessment of plume dynamics along southern outline of shallow zone DR plume. Redundant with RETRACMWE	LIMITED: Redundant with RETRACMWE but does provide PCE concentration gradient useful for contouring plume outline.	RETRAC paired wells and CTM138 should be assessed for determining whether sets of wells on either side of the trench are redundant. This evaluation suggests that the primary value of having these pairs is for providing a PCE concentration gradient useful for defining the plume outline along the south edge of the shallow zone DR plume.
RETRACMWG	SPATIAL PL ME MONITORING	PCE data help characterize a portion of the plume interior along the southern outline of the shallow zone DR plume. The well functions to provide plume geometry definition and assess plume dynamics along the southern plume outline. General similarities in recurring seasonal patterns between this well and many of the other RETRAC series wells are consistent with an area wide interrelationship between PCE and water level elevations at or near the water table where these wells are constructed. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Provides plume geometry definition and a limited assessment of plume dynamics along southern outline of shallow zone DR plume.	MODERATE: Provides plume geometry definition and limited assessment of plume dynamics.	RETRAC paired wells and CTM138 should be assessed for determining whether sets of wells on either side of the trench are redundant. This evaluation suggests that the primary value of having these pairs is for providing a PCE concentration gradient useful for defining the plume outline along the south edge of the shallow zone DR plume.
RETRACMWG1	SPATIAL PL ME MONITORING	PCE data help characterize a portion of the plume interior along the southern outline of the shallow zone DR plume. The well functions to provide plume geometry definition and assess plume dynamics along the southern plume outline. General similarities in recurring seasonal patterns between this well and many of the other RETRAC series wells are consistent with an area wide interrelationship between PCE and water level elevations at or near the water table where these wells are constructed. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Provides plume geometry definition and a limited assessment of plume dynamics along southern outline of shallow zone DR plume.	LIMITED: Redundant with RETRACMWG but does provide PCE concentration gradient useful for contouring plume outline.	RETRAC paired wells and CTM138 should be assessed for determining whether sets of wells on either side of the trench are redundant. This evaluation suggests that the primary value of having these pairs is for providing a PCE concentration gradient useful for defining the plume outline along the south edge of the shallow zone DR plume.
RETRACMWH	SPATIAL PL ME MONITORING	PCE data help characterize a portion of the plume interior along the southern outline of the shallow zone DR plume. The well functions to provide plume geometry definition and assess plume dynamics along the southern plume outline. General differences in seasonal patterns between this well and many of the other RETRAC series wells are unexplained. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Provides plume geometry definition and a limited assessment of plume dynamics along southern outline of shallow zone DR plume.	MODERATE: Provides PCE concentration gradient with CTM138 useful for contouring plume outline.	RETRAC paired wells and CTM138 should be assessed for determining whether sets of wells on either side of the trench are redundant. This evaluation suggests that the primary value of having these pairs is for providing a PCE concentration gradient useful for defining the plume outline along the south edge of the shallow zone DR plume.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
E	DISTAL (LATERAL) PL ME DYNAMICS	PCE data at RETRACP2 help define the southern lateral extent of the shallow zone DR plume on the north side of the Truckee River. The well functions to assess distal plume dynamics near the currently defined plume extent. PCE concentration detections since 2006 are consistent with the plume expanding in the lateral downgradient direction. Water level data provide general characterization for defining lateral gradient and water level contouring. Water level elevation data suggest hydraulic connection to the Truckee River and potentially to pumping at HIGH (or other PCE-treated wells).	KEY ELL: Helps assess plume dynamics at unconstrained crossgradient extent of shallow zone DR plume.	HIGH: KEY WELL	RETRACP2 should be tracked for plume expansion. Consideration as to whether shallow zone plume dynamics have changed as a result of seasonal pumping should be examined at this and other nearby wells.
RPDMW3	SPATIAL BACKGRO ND MONITORING	Water quality samples are not collected at RPDMW3. Water level data provide general characterization for defining lateral gradient and water level contouring. Water level data for RPDMW3 are similar to those at RPDMW6 but are on average 6 ft higher, show a smaller apparent response to higher Truckee River flow, and larger magnitude seasonal recurring patterns that may correlate to seasonal pumping. The influence of local remediation pumping at the Reno Police Department is not known, but may be responsible for the small-scale chatter in the hydrograph.	Not a ey well Provides potentially useful hydraulic information (compared with nearby shallow zone wells) that would help assess role of Truckee River in groundwater hydrodynamics that impact vertical and lateral PCE movement.	MODERATE: Potentially provides assessment of hydrodynamics that may control vertical/lateral PCE distribution/ migration.	The area between HIGH and MORRILL should be considered as a reasonable site to place a set of shallow zone wells in a transect across river. This transect would have the objective of characterizing this reach to determine 1) is the reach losing or gaining, 2) does the north side of the river behave hydrologically different than the south side of the river, 3) what is the water budget between the river and groundwater in this region.
RPDMW6	SPATIAL BACKGRO ND MONITORING	Two PCE detections (1.5 and 1.1 µg/L) at RPDWM6 are consistent with low levels of contamination existing, at least periodically where this well is constructed. These results suggest that shallow zone PCE is capable of migrating laterally beneath the river. Water level data provide general characterization for defining lateral gradient and water level contouring. Water level data for RPDMW6 are similar to those at RPDMW3 but are on average 6 ft lower, show a larger apparent response to higher Truckee River flow, and smaller magnitude seasonal recurring patterns that may correlate to seasonal pumping. These features are consistent with 1) a gaining river in this area, 2) a more direct hydraulic connection closer to the river, 3) hydraulic responses caused by pumping being more muted where the river has a more direct hydraulic connection to the aquifer. The influence of local remediation pumping at the Reno Police Department is not known, but may be responsible for the small-scale chatter in the hydrograph.	Potentially important ut not a ey well Detection of PCE is consistent with the interpretation that PCE can migrate laterally beneath the river in the shallow zone. Water level data may provide useful hydraulic information (compared with nearby shallow zone wells) that would help assess role of Truckee River in groundwater hydrodynamics that impact vertical and lateral PCE movement.	HIGH: Provides capacity to assess potential plume expansion across the river. Water level data provide information to assess hydrodynamics (and role of river and pumping) that may control vertical/lateral PCE distribution/migration.	The area between HIGH and MORRILL should be considered as a reasonable site to place a set of shallow zone wells in a transect across river. This transect would have the objective of characterizing this reach to determine 1) is the reach losing or gaining, 2) does the north side of the river behave hydrologically different than the south side of the river, 3) what is the water budget between the river and groundwater in this region.
UNRVALLEYRDWELL	SPATIAL BACKGRO ND MONITORING	PCE non-detects poorly constrain the northern extent of PCE in the DR plume where the well is located. The well is constructed with a screened interval that extends from the ground surface to its total depth of 211 ft bgs rendering both PCE or water level data of limited, qualitative value.	Not a ey well Provides qualitative PCE and water level data as result of long screened interval.	LIMITED: Provides qualitative plume extent and composite (shallow/deep) water level data as a result of long screen.	Discontinue monitoring at well.

DO NTO N RENO S BREGION ELL NET ORK RE IE

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
USGSGOVBOWL	NO F NCTION OR AL E	Well is of limited value because of it's construction on a baseball field where water level data are consistent with ball field irrigation having a direct and significant influence on water level elevations.	Not a ey well Data from well not representative of groundwater conditions.	LIMITED: Well's construction and location render data from well of no value to GMP	Discontinue monitoring at well.
USGSHUNTLK	SPATIAL BACKGRO ND MONITORING	PCE non-detects at USGSHUNTLK provide verification that no contamination exists in the shallow zone proximal to HUNTERLAKE municipal water supply well. There are no PCAs identified near or upgradient of well. Water level data provide general characterization for defining lateral gradient and water level contouring. The wells proximity to HUNTERLAKE make water levels potentially useful for characterizing vertical gradient and shallow zone response from pumping in the area where this well is constructed. However there is an apparent recurring seasonal pattern at USGSHUNTLK that is consistent with water levels having an interrelationship to irrigation. This interrelationship may limit the well's capacity to provide meaningful vertical gradient information. As a minimum any assessment should consider whether irrigation plays a local role at the water table in the area near USGSHUNTLK.	Not a ey well Potentially provides characterization vertical gradient in the region near HUNTERLAKE municipal water supply well.	MODERATE/LIMITED: Part of a well cluster that may provide an area-specific assessment of vertical flow dynamics.	Water level data at USGSHUNTLK should be assessed with HUNTERLAKEMW as a well pair to characterize vertical gradient in area near HUNTERLAKE municipal water supply well.
VIEW	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE non-detects at VIEW verify that PCE contamination has not impacted the groundwater producing interval at VIEW. The well functions as a self sentry location for potential future impacts and provides verification that the pumping plan is effective at capturing the northern part of the DR plume.	Not a ey well Provides verification that PCE contamination has not impacted groundwater in groundwater producing interval where VIEW is constructed.	HIGH: Acts as self-sentry and helps verify effectiveness of pumping plan. Injection at well needs to be considered when assessing water quality data.	VIEW should be evaluated in the context of where it fits into the hydrostratigraphic framework and hydrodynamics of the area between 4TH, ELRANCHO, SPARKS, and GALLETTI/21ST.
VIEWMWD	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE non-detects at VIEWMWD verify that PCE contamination has not impacted the deeper groundwater producing interval at VIEW. The well functions as a sentry location for potential future impacts and provides verification that the pumping plan is effective at capturing the northern part of the DR plume.	Not a ey well Provides verification that PCE contamination has not impacted groundwater in deeper groundwater producing interval where VIEW is constructed.	MODERATE: Has potential to provide more depth-specific water quality in the event that PCE impacts encroach on area.	None. Continued annual sampling (if possible after periods of extended pumping) and monthly water level monitoring.
VIEWMWS	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE non-detects at VIEWMWS verify that PCE contamination has not impacted the shallower groundwater producing interval at VIEW. The well functions as a sentry location for potential future impacts and provides verification that the pumping plan is effective at capturing the northern part of the DR plume.	Not a ey well Provides verification that PCE contamination has not impacted groundwater in shallower groundwater producing interval where VIEW is constructed.	MODERATE: Has potential to provide more depth-specific water quality in the event that PCE impacts encroach on area.	None. Continued annual sampling (if possible after periods of extended pumping) and monthly water level monitoring.
WMMW1	SPATIAL BACKGRO ND MONITORING	WMMW1 is not utilized to monitor water quality. Water level data provide general characterization for defining lateral gradient and water level contouring.	Not a ey well Useful for general water level characterization	LIMITED: Redundant with WMMW3, but does provide local lateral gradient and water level contouring data.	None. Continued water level monitoring for general characterization purposes.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
WMMW3	SPATIAL BACKGRO ND MONITORING	Occasional PCE detections in the 1 µg/L range are consistent with periodic low level contamination existing in the area where WMMW3 is constructed. More recent PCE non-detects poorly constrain the lateral extent of the shallow zone DR plume.	Not a ey well Helps to constrain lateral, downgradient extent of shallow zone DR plume. Periodic (pre-2007) PCE detections may indicate lateral extent of shallow zone DR plume is or has been further east than is currently defined on PCE contour maps.	MODERATE: Constrains downgradient extent of shallow zone DR plume. Provides useful water level data that assesses reach of Truckee River where water table is disconnected for river.	The occurrence of periodic PCE detections at this well make the downgradient extent of the shallow zone DR plume an relative uncertainty, particularly in light of the lack of additional monitoring wells located to the northwest of this well. At least one additional shallow zone well should be constructed 1,500 ft northwest of WMMW3 to better constrain the shallow zone DR plume extent and monitor plume stability at its leading edge.
WMMW5	ABANDONED	NA: Abandoned	NA: Abandoned	NA: Abandoned	NA: Abandoned

MILL/KIET KE KEY   ELL DECISION MATRI

	WATER QUALITY FUNCTION:											WATER LEVEL FUNCTION:					CLUSTER FUNCTION:		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture assessment	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume mass mo ement across low arrier assessment	Plume mass mo ement dri er assessment	ertical low/ ertical plume mass mo ement assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
		(MK)	X								X			X[4]	X	X			
		(MKd)	X								X								
											X		X		X	X		X	X
ARCO6018MW8																			
CTM9S												[2,4,5]		[4,5]		[5]		X	X
			R(CTM105)								X						X	X	X
		(MKa)	X								X								
CTM37D																			
					X						X						X	X	X
CTM39S			R(CTM38D)		R(CTM38D)	R(CTM38D)											X	X	X
CTM42																			
CTM44																			
		(MKc)	X								X								
												[2,5]		[4,5]		[5]	X	X	X
											X[3]						X	X	X

Notes:

2010 KEY WELL

2010 WELL CLUSTER MEMBER

tali 2009 Key Wells

R(CTM105) = Redundant with well identified in parenthesis

X(MKa) = Potential local source "a" in Mill/Kietzke Subregion

1 Potential individual sources are identified by subregion, hot spot, and local source alpha descriptors as appropriate. See notes for descriptions.

2 Well may be proximal (east) to extension of Harvard Way Barrier based on INSAR data and on difference in hydrograph patterns between these wells and CTM102 (at Pickett Park)

3 Well is constructed in a relatively less permeable interval compared to CTM11S and may be less representative of plume conditions.

4 Water levels should be assessed relative to general assessment of potential for enhanced vertical flow to MILL.

5 Water quality and/or water levels should be assessed relative to well's role as part of a well cluster.

R:\GMP\Reports\2010\Annual\Optimization Appendix\MK Optimization\MK_KeyWellMatrix.xls

J. Benedict
11/4/2013

MILL/KIET KE S BREGION NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
ARCO 01 M 11	MASS FL /SO RCE ASSESSMENT	PCE data at ARCO6018MW11 help to define the Mill/Kietzke hot spot and may be proximal to one of multiple potential sources that contribute to PCE in the Mill/Kietzke plume. Spiky high PCE concentrations, proximity to PCA's, and nearby detections in soil vapor and soil are consistent with a source area in the vicinity of the well. PCE spikes up to 850 µg/L (in 2006 Q2) have occurred at the well. In 2010 Q2, a spike (200 µg/L) occurred suggesting PCE source contributions continue in the vicinity of the well. The potential source type (active or residual) is not defined. However an apparent emerging relationship between higher water levels (above roughly 4411 ft amsl) and increased PCE concentration may be more consistent with a residual source that contributes PCE to the groundwater when water levels increase above a certain threshold. Water level data at this well are important for characterizing hydrodynamics and verifying the speculative interrelationships (described above) between water level and PCE concentration.	KEY ELL: Provides assessment of mass flux/source characterization for potentially local source in M/K hot spot.	HIGH: KEY WELL	The apparent interrelationship between high water levels (>4411 ft amsl) and PCE spikes suggest that a residual source exists in the vicinity of this well that contributes a larger PCE mass when water levels are high. This phenomenon should be tracked and the presence of residual contaminated soil near this well should be investigated as part of the M/K PSA investigation.
ARCO 01 M 1	MASS FL /SO RCE ASSESSMENT	PCE data at ARCO6018MW12 help define the downgradient (southeast) extent of the M/K hotspot, potentially on or near the plume centerline. This is the only well proximal to or in the M/K hotspot that has a statistically determined increasing trend making it a potentially critical well for tracking PCE dynamics immediately downgradient of the M/K hotspot. Some indication of travel time may come out of comparing PCE data at this well with downgradient well ARCO6018MW16. Both have increasing PCE trends, but the respective time series patterns and changes have no currently apparent similarities.	KEY ELL: Provides assessment of mass flux/source characterization for potentially local source in M/K hot spot.	HIGH: KEY WELL	The location of this well at the apparent downgradient margin of the currently defined M/K hot spot is consistent with the well being optimally located to assess the overall dynamics of the M/K hot spot (and combined multiple source contributions that are apparent upgradient of the well). PCE trends at this well may be an indicator for overall changes in PCE mass contributions at the M/K hot spot. That said, the overall similar PCE time series compared to CTM63 are consistent with a stronger influence at ARCO6018MW12 from the local source that impacts CTM63 than from other local sources in the M/K hotspot. PCE time series for this well needs to be assessed annually as a potential indicator of overall mass flux dynamics from the M/K hot spot. An additional, but deeper shallow zone monitoring well at this location (constructed at roughly 130-150 ft bgs) should be considered to assess the potential for vertical PCE migration that could plunge beneath the currently monitored part of the M/K plume and potentially impact MILL.
ARCO 01 M 1	MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT	PCE data at ARCO6018MW16 characterize the M/K plume interior potentially near its centerline, downgradient (southeast) of the M/K hot spot. Intermittent PCE detections with a spiky, apparent increasing trend may weakly correlate to the more consistent increasing PCE trend at upgradient ARCO6018MW12. Well may ultimately function to characterize travel time and plume dynamics, but correlation between PCE time series patterns at upgradient well ARCO6018MW12 (potentially along same flow line) have yet to be defined. Degree that PCE data represents concentrations along plume centerline is poorly defined by current well distribution. Part of a well pair with MILL that provides a key location for assessing vertical gradient proximal to MILL.	KEY ELL: Characterizes area downgradient of M/K hotspot. May help evaluate travel-time and overall plume dynamics.	HIGH: KEY WELL	ARCO6018MW16 may be positioned along a similar flowpath as ARCO6018MW12. PCE time series for these wells should be compared periodically to assess whether travel-time (based on characteristic patterns that may have a measurable time lag) can be estimated. This assessment may be partly confounded by the potentially plunging nature of the plume. Because both wells are screened across the water table, PCE concentrations that may have inter-relationships with water level fluctuations have the potential to further confound travel time assessment.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
ARCO 01 M	SPATIAL BACKGRO ND MONITORING	PCE data at ARCO6018MW8 constrain the lateral (west) extent M/K plume. Small magnitude PCE detections near 1 µg/L in 2003Q4 and 2004Q1 are consistent with the well being proximal to the plume extent (as defined by a <1.0 µg/L contour). Water level data are of value primarily for defining water level contours and local lateral gradient.	Not a ey well Helps constrain/define western plume extent.	MODERATE: Characterizes plume extent. Helps constrain/define lateral (west) plume extent.	None
CTM S	SPATIAL BACKGRO ND MONITORING	PCE non-detects at CTM9S constrain lateral (west) extent of Mill/Kietzke plume. Water level data characterize the water table and well is part of a 4-well cluster. Compared to deeper shallow zone well pair CTM104, water levels show a muted, smaller magnitude seasonal response with a potential lag. These characteristics are consistent with water levels functioning to characterize some level of decreased hydraulic connection (and impeded vertical flow) between CTM9S (screened interval: 40-60 ft bgs) CTM104 (screened interval: 87-97 ft bgs). Water level data at CTM9S and CTM104 define a persistent downward gradient that is generally larger in Q2 and Q3 during periods of decreasing water levels the correlate to seasonal pumping. CTM9S is part of a well cluster with CTM104, CTM103, and CTM10D that provides a key location for assessing vertical PCE distribution and vertical gradient. The relatively larger long-term and recurring seasonal changes in water levels at CTM9S compared to other water table wells in the subregion is consistent this well being in an area that has an enhanced vertical flow component.	Not a ey well Generally redundant with CTM104, but it does contribute to characterizing/assessing vertical gradient as part of key well cluster and constrains western lateral extent of M/K plume at water table.	BY ITSELF-LIMITED, B T POTENTIALLY IMPORTANT AS PART OF A KEY ELL CL STER: Well is essentially redundant with CTM104. But it has value as part of a key well cluster, providing vertical gradient information. Also provides a more representative water level at the water table (for contouring purposes) than CTM104.	CTM9S could be considered redundant and abandoned. However prior to eliminating this well, water level data for the key well cluster should be closely examined to assess the vertical distribution of hydraulic gradient in this very important part of the subregion. Vertical head difference maps and cumulative seasonal change maps both suggest that this well is positioned near an area of maximum shallow zone water level response to pumping, consistent with an area that has enhanced vertical flow. CTM9S and CTM104 water level data also characterize a persistent downward gradient at the water table that is consistent with a groundwater source at the water table (e.g.., lateral flux from river or vertical flux from leaking pipes or lawn irrigation).
CTM11S	PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE CAPT RE ONE MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT (Redundant w/CTM105)	PCE data at CTM11S characterize a shallower portion of the M/K plume interior, downgradient (southeast) of the M/K hot spot. PCE concentrations at CTM11S (screened interval: 25-45 ft bgs) are lower than paired-well CTM105 (screened interval: 87-97 ft bgs) consistent with a plunging plume; the plume center of mass being deeper than, and detached from the water table in this part of the plume compared to upgradient at the M/K hot spot where relatively high concentrations of PCE occur at the water table. Part of a well cluster with CTM105 and CTM12D that provides a key location for assessing vertical PCE distribution and vertical gradient proximal to MILL.	KEY ELL Provides assessment of plume dynamics in shallower part of M/K plume interior in area immediately downgradient of MILL municipal water supply well. May help assess mass flux/travel-time along plume centerline. Part of a cluster that provides data for assessment of PCE distribution and vertical gradient.	HIGH: KEY WELL	CTM11S may be positioned along a similar flowpath as ARCO6018MW16. PCE time series for these wells should be compared periodically to assess whether travel-time (based on characteristic patterns that may have a measurable time lag) can be estimated. This assessment may be partly confounded by the potentially plunging nature of the plume. Because both wells are screened across the water table, PCE concentrations that may have inter-relationships with water level fluctuations have the potential to further confound travel time assessment.
CTM1 S	MASS FL /SO RCE ASSESSMENT	PCE data at CTM13S help to define the Mill/Kietzke hot spot and may be proximal to one of multiple potential sources that contribute to PCE in the Mill/Kietzke plume. Its proximity to PCA's, and nearby detections in soil vapor and soil are consistent with a source area in the vicinity of the well. The decreasing PCE concentrations prior to 2006 Q2 and subsequent relatively stable PCE concentration (between 10 and 26 µg/L) are consistent with PCE mass flux that has diminished and become relatively stable. Similar to CTM44 and CTM64, the coincidence between notable decreasing PCE concentrations and longer-term increasing water levels between 2004 and 2006 may indicate an interrelationship. Water level data are important for characterizing lateral gradient and flow direction in the vicinity of the hot spot.	KEY ELL: Provides assessment of mass flux/source characterization for potentially local source in M/K hot spot.	HIGH: KEY WELL	The generally decreasing long-term and more recent stable PCE trend at this well suggest that PCE mass flux has diminished and more recently has become relatively constant from the potentially nearby source where CTM13S is located. Well should continue to be monitored for emerging increasing trends in PCE concentration that would indicate an increase in mass flux.

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ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CTM D	SPATIAL PL ME MONITORING	PCE data at CTM37D characterize the lateral (west) extent of the M/K plume. PCE detections that correlate to seasonal water level maxima may indicate that the M/K plume extent (as defined by a 1 µg/L reporting limit) either expands to the west or moves vertically upward into the screened interval during higher water levels that correlate to non-pumping periods. Alternatively changing wellbore gradients may influence PCE concentration patterns. Water level data are of value primarily for defining water level contours and local lateral gradient.	Not a ey well Helps constrain/define western plume extent.	MODERATE: Characterizes plume extent. Helps constrain/define lateral (west) plume extent.	Water levels at CTM37D have higher magnitude trends and seasonal fluctuations than most wells in the M/K region. The greater dynamic range of water levels is at least partly the consequence of the well's deeper screened interval compared to most other wells in the subregion that are screened across the water table. Consideration for this association should be accommodated when assessing water level contouring and flowpaths.
CTM D	PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE CAPT RE ONE MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT	PCE data at CTM38D characterize the currently defined downgradient (southeast), open-ended extent of the Mill/Kietzke plume. Potentially on or near the centerline of the Mill/Kietzke plume and may help characterize plume dynamics, travel time, and PCE mass flux. Part of a well cluster with CTM107 and CTM39S that provides a key location for assessing vertical PCE distribution and vertical gradient at the currently defined downgradient but unconstrained outline of both the Downtown Reno deep zone and Mill/Kietzke shallow zone plumes.	KEY ELL May help assess mass flux/plume dynamics/travel-time as a result of its position on or near plume centerline. Assesses shallow zone portion of the M/K plume that has migrated downgradient of and may not be captured by MILL. Part of a cluster that provides data for the assessment of vertical PCE distribution and vertical gradient.	HIGH: KEY WELL	CTM38D and CTM39S are the most downgradient wells along the M/K plume. WCDWR cross section construction and PCE vertical distribution data collected during well construction at CTM12D and CTM107 are consistent with at least a portion of the plume migrating past MILL and potentially continuing downgradient toward other receptors. Consideration should be made to better defining the likely downgradient PCE migration direction, then constructing additional monitoring wells to assessment potential migration pathways and risk to downgradient receptors. PCE time series should be periodically compared to upgradient wells CTM11S and CTM105 for similarities that would indicate wells lie along a flowpath and can be utilized to estimate travel time or mass flux.
CTM S	PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE CAPT RE ONE MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT (Redundant w/CTM D)	PCE data at CTM39S characterize the shallower (compared to paired well CTM38D), less concentrated portion of currently defined downgradient (southeast) open-ended extent of the Mill/Kietzke plume. Part of a well cluster with CTM107 and CTM38D that provides a key location for assessing vertical PCE distribution and vertical gradient at the currently defined downgradient but unconstrained outline of both the Downtown Reno deep zone and Mill/Kietzke shallow zone plumes.	Important ut not a ey well Generally redundant with CTM38D. Characterizes shallow zone portion of the M/K plume that has migrated downgradient of and may not be captured by MILL. Part of a key well cluster that provides data for the assessment of vertical PCE distribution and vertical gradient.	HIGH: Characterizes unconstrained part of plume. Open-ended, downgradient part of MK plume at the water table. Part of key well cluster that provides data for the assessment of plume geometry and hydrodynamics.	CTM38D and CTM39S are the most downgradient wells along the M/K plume. WCDWR cross section construction and PCE vertical distribution data collected during well construction at CTM12D and CTM107 are consistent with at least a portion of the plume migrating past MILL and potentially continuing downgradient to other receptors. Consideration should be made to better defining the likely downgradient PCE migration direction, then constructing additional monitoring wells to assessment potential migration pathways and risk to downgradient receptors. PCE time series should be periodically compared to upgradient wells CTM11S and CTM105 for similarities that would indicate wells lie along a flowpath and can be utilized to estimate travel time or mass flux.

MILL/KIET KE S BREGION NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CTM	SPATIAL BACKGRO ND MONITORING	PCE non-detects at CTM42 constrain the upgradient/lateral (east) extent of the M/K plume, east of the hot spot. Water level contouring are consistent with the well being in an upgradient location relative to the hot spot of the plume. Water level contours on the east side of the hot spot appear to be controlled by higher water levels along the Truckee River corridor (that are consistent with a losing reach in the area northeast of CTM42). Water level data are of value primarily for defining water level contours and local lateral gradient.	Not a ey well Helps constrain/define northeastern upgradient plume extent.	MODERATE: Characterizes plume extent. Helps constrain/define lateral (east) plume extent.	Potential exists for PCE contamination to migrate eastward toward CTM42 during periods when water level gradients change from their prevalent direction away from the river. This could occur either during periods when the river has undergone a period of relatively low flow or when the operation of MILL (that may induce a lateral gradient towards MILL) has undergone a sustained non-pumping period.
CTM	SPATIAL PL ME MONITORING	PCE data at CTM44 help to define the M/K hot spot on its northeastern margin. The similar time series, but smaller magnitude PCE concentrations compared to CTM13S are consistent with the well being in a more distal part of the same source contribution area as CTM13S. Similar to CTM13S and CTM64, the coincidence between notable decreasing PCE concentrations and longer-term increasing water levels between 2004 and 2006 may indicate an interrelationship. Water level data are of value primarily for defining water level contours and local lateral gradient.	Important ut not a ey well Helps define M/K hotspot. Generally behaves similar to CTM13S (in terms of both PCE time series and water level hydrograph), but has lower PCE concentrations.	HIGH: Helps define potential source area/hot spot extent.	CTM44 has both water level and PCE patterns and trends that are very similar to CTM13S. PCE concentrations are consistently lower that CTM13S and indicate a PCE source vector towards CTM13S. Similarity in PCE trends are consistent with an influence from the same source as that impacting CTM13S. Any change in time series patterns at CTM44 compared to CTM13S may indicate a change in plume dynamics or mass flux that could be symptomatic of either a difference source contribution or a change in flow patterns.
CTM	MASS FL /SO RCE ASSESSMENT	PCE data at CTM63 help to define the M/K hot spot. The correlation between the early part of seasonal decreasing water levels and PCE spikes are potentially significant and may indicate either an increase in PCE mass flux in response to water level changes or the migration of a shallow plume core into the well's screened interval as a result of head changes (either in the vertical or lateral dimension). Alternatively, changes in wellbore hydraulic gradient and vertical flow in the well could also cause this pattern. Water level data are needed to track the interrelationship between PCE-water level. Water level data are also important for characterizing lateral gradient and flow direction in the vicinity of the hot spot.	KEY ELL: Provides assessment of mass flux/source characterization for potentially local source in M/K hot spot.	HIGH: KEY WELL	The very similar but more spiky characteristic (and higher concentration maxima) in PCE time series data for CTM63 compared to ARCO6018MW12 is consistent with CTM63 being closer to a source that is also the primary influence on PCE concentrations monitored at ARCO6018MW12. The strong seasonality (spikes in Q2) is consistent with a relatively discrete zone of higher PCE contamination that either 1) seasonally migrates into the well screen interval (laterally or vertically), 2) exists in a portion of the well screen interval and seasonally influences sampling results due to a change in wellbore gradient, or 3) is caused by a seasonal increase in mass flux induced by seasonally higher water levels that mobilize residual PCE at a nearby source.
CTM	SPATIAL PL ME MONITORING	PCE data at CTM64 help define the upgradient (northern) margin of the M/K hot spot. The apparent decreasing trend and shape of the PCE concentration time series is similar to the time series at CTM13S and CTM44 suggesting that as a group, they monitor a portion of the plume where plume dynamics are influenced by the same processes. Similar to CTM13S and CTM44, the coincidence between notable decreasing PCE concentrations and longer-term increasing water levels between 2004 and 2006 may indicate an interrelationship. The apparent correlation between seasonal PCE maxima and either increasing or seasonal maxima water levels (beginning in 2007) may be caused by either seasonal mass flux dynamics, seasonal migration of plume across the well screen, or changes in wellbore gradient and vertical flow in the well.	Not a ey well Helps define northern plume outline.	MODERATE: Helps define potential source area/hot spot extent. Helps constrain/define lateral (north) plume extent.	CTM64 has both water level and PCE patterns and trends that are very similar to CTM13S. PCE concentrations are consistently lower than at CTM13S and indicate a PCE source vector towards CTM13S. Similarity in PCE trends are consistent with an influence from the same source as that impacting CTM13S. Any change in time series patterns at CTM64 compared to CTM13S may indicate a change in plume dynamics or mass flux that could be symptomatic of either a difference source contribution or a change in flow patterns.

MILL/KIET KE S BREGION NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CTM10	SPATIAL BACKGRO ND MONITORING	CTM104 has a similar function as CTM9S. It is roughly 50 ft deeper than CTM9S and is screened across an apparently more permeable interval (based on a smaller relative drawdown during low flow sampling). It helps constrain both the lateral extent (west) of the M/K plume and constrains the upper extent of deep zone PCE contamination monitored at CTM103 (screened interval: 195-205 ft bgs). CTM104 is part of a well cluster with CTM9S, CTM103, and CTM10D that provides a key location for assessing vertical PCE distribution and vertical gradient.	Important ut not a ey well Part of a key well cluster that provides vertical PCE distribution and gradient data.	HIGH: Part of key well cluster that helps define vertical plume geometry and hydrodynamics.	Well cluster CTM9S/104/103/10D should be compared to well cluster CTM102/101/100 to assess whether the HWB, or other flow barrier extends between these clusters. Also a recent (2010 Q3) low PCE concentration detection (.61 µg/L) at this well may indicate that contamination identified at deeper shallow zone well CTM102 (and shallower deep zone well CTM101) extends to (and beneath) CTM104. Additional well construction to the north of well cluster CTM100/101/102 and west of CTM92/104/103/12D need to be considered to better define the extend PCE contamination at deep shallow zone and shallow deep zone depths.
CTM105	PL ME DYNAMICS DO NGRADIENT OF RECEPTOR: POTENTIALLY O TSIDE CAPT RE ONE MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT	PCE data at CTM105 characterize a deeper portion of the M/K plume interior, downgradient (southeast) of the M/K hot spot. PCE concentrations at CTM105 (screened interval: 87-97 ft bgs) are higher than adjacent CTM11S (screened interval: 25-45 ft bgs) consistent with a plunging plume; the plume center of mass being deeper than, and detached from the water table in this part of the plume compared to the M/K hot spot where relatively high concentrations of PCE occur at the water table. Part of a well cluster with CTM11S and CTM12D that provides a key location for assessing vertical PCE distribution and vertical gradient proximal to MILL.	KEY ELL Provides assessment of mass flux/plume dynamics/travel-time in deeper part of M/K plume interior in area immediately downgradient of MILL municipal water supply well. Part of a key well cluster that provides vertical PCE distribution and vertical gradient data.	HIGH: KEY WELL	CTM105 may be positioned along a similar flowpath as ARCO6018MW16. PCE time series for these wells should be compared periodically to assess whether travel-time (based on characteristic patterns that may have a measurable time lag) can be estimated. This assessment may be partly confounded by the potentially plunging nature of the plume. Because ARCO6018MW16 is screened across the water table, PCE concentrations that may have inter-relationships with water level fluctuations have the potential to further confound travel time assessment.

DO NTO N SPARKS S BREGION KEY ELL DECISION MATRI

	WATER QUALITY FUNCTION:											WATER LEVEL FUNCTION:					CLUSTER FUNCTION:		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture assessment	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume mass mo ement across low arrier assessment	Plume mass mo ement dri er assessment	ertical low/ ertical plume mass mo ement assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
21ST															[2]	[2]		X	X
21STMW															[2]	[2]		X	X
21STMWD																			
21STMWS																			
ARCO2137M3																			
CTM19S																			
											X		[2]	[2]		[2]		X	X
											X		[2]	[2]		[2]		X	X
							X			X	X		[2]	[2]		[2]		X	X
										X	X		[2]	[2]		[2]		X	X
		(DSa)				X				X	X								
CTM71																			
CTM72															[2]	[2]		X	X
CTM73															[2]	[2]		X	X
														[2]	[2]	[2]	X	X	X
										X	X		[2]	[2]	[2]	[2]	X	X	X
CTM76																			
CTM77																			
CTM78																			
GALLETTI																			
GALLETTIMW																			
LEGENDS																			
MENTALHEALTH																			
MITCHELLTW																			
NDOT																			
POPLAR1																			
											X		[2]			[2]		X	X
											X		[2]			[2]		X	X
SPARKSHIGH																			
SSFSMW201																			

Notes:

2010 INDIVIDUAL KEY WELL

2010 WELL CLUSTER MEMBER

tali 2009 Key Wells

R(CTM105) = Redundant with well identified in parenthesis

X(DSa) = Potential local source "a" in Downtown Sparks Subregion

[1] Potential individual sources are identified by subregion descriptor and alpha modifier.

[2] Water quality and/or water levels should be assessed relative to well's role as part of a well cluster.

DO NTO N SPARKS S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
1ST	RISK ASSESSMENT TO POTENTIAL RECEPTOR P MPING PLAN PERFORMANCE ASSESSMENT	PCE data function to assess and monitor for risk of PCE impacts from upgradient M/K and DR plumes. Water level data generally function in a limited fashion for water level contouring.	Not a ey well Outside either the VA or DS plume extents.	HIGH: Well represents a self-sentry well and is a potential receptor for the DR plume. Also functions to verify pumping plan effectiveness.	Continued opportunistic monthly sampling during pumping periods. Track for any PCE/TCE detections that would indicate risk to receptor.
1STM	ABANDONED ELL	PCE data functioned to verify that no PCE contamination exists in the shallow zone proximal to GALLETTI or 21ST municipal supply wells. Water level data are consistent with the shallow zone being connected to the Truckee River. This well was abandoned in 2009Q3.	Not a ey well Abandoned	A andoned	Abandoned
1STM D	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE data function to assess and monitor for risk of PCE impacts to 21ST from upgradient M/K and DR plumes. Water level data generally function to track proximal pumping/injection response from 21ST, provide vertical gradient data (with 21STMWS), and provide data for quarterly water level contouring when 21ST is pumping.	Not a ey well Outside either the VA or DS plume extents.	MODERATE: Well represents a sentry well to 21ST. Provides vertical gradient data along with 21MWS	Continued general monitoring to track for any PCE/TCE detections that would indicate risk to receptor.
1STM S	SPATIAL BACKGRO ND MONITORING	PCE data functioned to verify that no PCE contamination exists in the shallow water table proximal to GALLETTI or 21ST municipal supply wells. Water level data are consistent with the shallow zone being connected to the Truckee River and generally define the shallow zone in this area as occurring along a losing reach of the river.	Not a ey well Outside either the VA or DS plume extents.	MODERATE: Provides vertical gradient data along with 21STMWD. Also characterizes Truckee River influence on shallow groundwater.	Continued general monitoring to verify background water quality.
ARCO 1 M	SPATIAL BACKGRO ND MONITORING	PCE data provide very limited value with respect to characterizing or assessing PCE contamination in the shallow zone DS Subregion. A single PCE detection in 2007Q3 suggest PCE exists or has existed in the area, but the pedigree of the well (very shallow and potentially impacted by leakage from the Truckee Ditch) is poor. Water level data apparent reflect leakage from the Truckee Ditch. Water levels otherwise provide limited value for water level contouring.	Not a ey well	LIMITED: Pedigree of well (shallow construction and location near Truckee Ditch) make PCE and water level data from well of poor quality.	Consider eliminating this well from water level and water quality sampling.

DO NTO N SPARKS S BREGION ELL NET ORK RE IE SPREADSHEET

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CTM 5	SITE-SPECIFIC PL ME DYNAMICS	PCE data provide shallow zone assessment of the VA plume. Low PCE concentrations that have not exceeded 1.5 µg/L (and have often been below the reporting limit) are consistent with this well being positioned above the more concentrated portions of the VA plume. The potential relationship between higher water levels and higher PCE concentrations suggest a hydrodynamic interrelationship that should be assessed further. Water levels are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1/POPLAR2 municipal water supply wells. Part of a well cluster including CTM65, 66, 67, 68 that provide vertical PCE distribution and vertical gradient near SPARKS.	KEY ELL: Helps assess vertical and lateral plume dynamics near the water table.	HIGH: Key Well	Continued monitoring to track shallow zone plume dynamics. Periodically compare to CTM69 and CTM71 to assess for similarities and indicators of area-wide plume dynamics that may help define plume behavior.
CTM	SITE-SPECIFIC PL ME DYNAMICS	PCE data assess the upper portions of the VA plume and is positioned above the VA plume core defined and characterized by CTM67. PCE concentrations are consistent with this well being constructed in a portion of the plume that is generally decreasing in concentration. The generally decreasing concentrations at CTM66 compared to the long term increasing PCE concentrations in the plume core at CTM67 suggest a vertical shifting of the plume and require further assessment in terms of vertical and lateral plume dynamics. Water levels for this well and the other deeper shallow zone wells have slightly larger magnitude long-term trends and larger seasonal fluctuations, compared to shallower near water table wells. This is consistent with these wells assessing hydrodynamics that are somewhat better connected to deep zone pumping/injection stresses than shallower near-water table wells. Part of a well cluster including CTM65, 66, 67, 68 that provide vertical PCE distribution and vertical gradient near SPARKS.	KEY ELL: Helps assess lateral and vertical plume dynamics shallower than the plume core monitored by CTM67.	HIGH: Key Well	Continue to compare PCE concentration dynamics between CTM66 and CTM67 to assess/verify vertical plume distribution and any vertical plume dynamics that may correlate to water level dynamics.
CTM	PL ME CORE DYNAMICS	PCE data assess plume dynamics in the VA plume core where it occurs roughly 40 ft above the upper screen of the SPARKS municipal supply well and is 300 ft west of SPARKS. PCE concentrations in CTM67 (screen interval: 101..5 -111.5 ft bgs) are the highest monitored in the area and have an increasing long-term trend through 2009. The increasing PCE trend at CTM67 compared to the decreasing trend at nearby shallower well CTM66 suggest a vertical shifting of the plume that should continue to be assessed. Water levels for this well and the other deeper shallow zone wells have slightly larger magnitude long-term trends and larger seasonal fluctuations, compared to shallower near water table wells. This is consistent with these wells assessing hydrodynamics that are somewhat better connected to deep zone pumping/injection stresses. Part of a well cluster including CTM65, 66, 67, 68 that provide vertical PCE distribution and vertical gradient near SPARKS.	KEY ELL: Assesses plume dynamics in a zone of high PCE mass, proximal to, and potentially impacting the uppermost screen in receptor (SPARKS).	HIGH: Key Well	Continue to compare PCE concentration dynamics between CTM66 and CTM67 to assess/verify vertical plume distribution and any vertical plume dynamics that may correlate to water level dynamics.
CTM	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE non-detects constrain the vertical extent of the VA plume in the area near SPARKS. The well functions as a sentinel for downward or lateral migration of PCE towards the upper screened intervals at SPARKS. Water levels show a relatively direct response to SPARKS when it pumps. Part of a well cluster including CTM65, 66, 67, 68 that provide vertical PCE distribution and vertical gradient near SPARKS.	KEY ELL: Monitors risk to receptor (SPARKS). Constrains lower vertical extent of VA plume.	HIGH: Key Well	Continued monitoring for PCE detections that would indicate increased risk to SPARKS. Any detection at this well would indicate increased downward migration of the VA plume and the potential for significantly greater PCE impacts at SPARKS.
CTM	SPATIAL PL ME MONITORING	PCE data provide shallow zone assessment of the VA plume. The low PCE concentrations that have not exceeded 1.9 µg/L and have more often been below the reporting limit consistent with this well being positioned above the more concentrated portions of the VA plume. The potential similarity between a low concentration PCE pulse at CTM69 and CTM65 (in 2006 and early 2007) suggest a similar relationship between PCE concentrations in the 2 wells that could be indicative of a pulse of PCE migrating across the area. Alternatively is may be related to the generally high water levels during that period. However, a similar pulse did not occur in 2009/10 during a similar higher period of water levels. Water levels characterize the VA-1 group and are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1/POPLAR2 municipal water supply wells.	Not a ey well Helps define shallow zone extent of VA plume	HIGH: Potential similar PCE concentration time series between CTM69 and CTM65 are suggested by current data and may indicate they either lie along the same flow path or PCE concentrations in both wells behave similarly to hydrodynamics.	Periodically compare to CTM65 and CTM71 to assess for similarities and indicators of area-wide plume dynamics that may help define plume behavior or travel time.

DO NTO N SPARKS S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CTM 0	SO RCE ECTOR MASS FL /SO RCE AREA ASSESSMENT	PCE data provide an assessment of plume dynamics in a potential local hot spot. The relationship between generally higher, spikier PCE concentrations at CTM70 compared to other nearby shallow zone wells (CTM65, CTM69, and CTM71) is consistent with this well functioning to assess a potentially more dynamic interval of PCE contamination that may either represent a shallow zone plume core, or a hot spot that is spatially associated with a PCE source. Water levels are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1/POPLAR2 municipal water supply wells.	KEY ELL: Assesses and tracks potential mass flux to groundwater and may help vector in on a PCE source.	HIGH: Key Well	Continued monitoring to track potential mass flux and plume dynamics from a possible source area proximal to this well.
CTM 1	SPATIAL PL ME MONITORING	PCE data assess the shallow zone where PCE contamination may exist but at concentrations near or less than 1.0 μg/L. Water levels are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1/POPLAR2 municipal water supply wells.	Not a ey well Helps define shallow zone extent of VA plume	MODERATE: Characterizes plume interior in region of very low PCE concentrations.	Periodically compare to CTM65 and CTM69 to assess for similarities and indicators of area-wide plume dynamics that may help define plume behavior or travel time.
CTM	SPATIAL BACKGRO ND MONITORING	PCE data assess the shallow zone where PCE contamination either does not occur may exist but at concentrations less than 1.0 μg/L. Water levels are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1 and POPLAR2 municipal water supply wells. Part of a well cluster including CTM72, 73, 74, 75 that provide vertical PCE distribution and vertical gradient near POPLAR1/POPLAR2.	Not a ey well	MODERATE: Characterizes plume interior in region of very low PCE concentrations.	Currently CTM72 is not monitored for PCE. Consider sampling at lower reporting limit in 2011 Q3.
CTM	SPATIAL BACKGRO ND MONITORING	PCE data assess the shallow zone where PCE contamination either does not occur may exist but at concentrations less than 1.0 μg/L. Water levels characterize the VA-2 group and are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1 and POPLAR2 municipal water supply wells. Water levels for this well and the other deeper shallow zone wells have slightly larger magnitude long-term trends and larger seasonal fluctuations, compared to shallower near water table wells. This is consistent with these wells assessing hydrodynamics that are somewhat better connected to deep zone pumping/injection stresses. Part of a well cluster including CTM72, 73, 74, 75 that provide vertical PCE distribution and vertical gradient near POPLAR1/POPLAR2.	Not a ey well	MODERATE: Characterizes plume interior in region of very low PCE concentrations.	Currently CTM73 is not monitored for PCE. Consider sampling at lower reporting limit in 2011 Q3.
CTM	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the upper vertical extent of the DS plume in the area near POPLAR2. The well functions to track any potential for shallower PCE contamination to migrate into the vicinity of POPLAR2. Water levels for this well and the other deeper shallow zone wells have slightly larger magnitude long-term trends and larger seasonal fluctuations, compared to shallower near water table wells. This is consistent with these wells assessing hydrodynamics that are somewhat better connected to deep zone pumping/injection stresses. Part of a well cluster including CTM72, 73, 74, 75 that provide vertical PCE distribution and vertical gradient near POPLAR1/POPLAR2.	Important ut not a ey well Constrains shallower vertical extent of DS plume in area near POPLAR2.	HIGH: Helps assess potential for PCE impacts shallower than contamination detected at CTM75.	Continued general monitoring to verify upper vertical extent of DS plume. PCE detections at this well would be a potential indicator of the migration of a vertically more extensive portion of the plume into the area.
CTM 5	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE data assess an apparent generally increasing PCE concentration trend as measured by recurring seasonal PCE maxima that may suggest increasing PCE impacts at POPLAR2. A seasonal pattern of PCE spikes during late stages of the non-pumping season and minimum concentrations during periods of pumping is consistent with PCE migrating either vertically or laterally out of the CTM75 screen interval during periods of pumping. Alternatively, the PCE concentration pattern may be the result of local vertical well-bore flow caused by vertical gradients across the well's screen. Under either scenario the data are consistent with a relatively heterogeneous, local interval of PCE contamination existing near where CTM75 is constructed. Water levels for this well respond more directly to pumping, particular from pumping at POPLAR2. Part of a well cluster including CTM72, 73, 74, 75 that provide vertical PCE distribution and vertical gradient near POPLAR1/POPLAR2.	KEY ELL: Acts in a sentry capacity to assess potential for increased PCE impacts to POPLAR2 and the need for treatment. Monitors plume dynamics in interval that impacts POPLAR2.	HIGH: Key Well	Continued monitoring to track plume dynamics and potentially increasing PCE concentrations that may impact POPLAR2.

DO NTO N SPARKS S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CTM	SPATIAL BACKGRO ND MONITORING	PCE data assess the shallow zone where PCE contamination either does not occur or may exist but at concentrations less than 1.0 µg/L. Water levels are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1/POPLAR2 municipal water supply wells.	Not a ey well	MODERATE: Characterizes plume interior in region of very low PCE concentrations.	Currently CTM76 is not monitored for PCE. Consider sampling at lower reporting limit in 2011 Q3.
CTM	SPATIAL PL ME MONITORING	PCE data assess the shallow zone where PCE contamination may exist but at concentrations near or less than 1.0 µg/L. Water levels are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1/POPLAR2 municipal water supply wells.	Not a ey well	MODERATE: Characterizes plume interior in region of very low PCE concentrations.	Continued general monitoring.
CTM	SPATIAL PL ME MONITORING	PCE data assess the shallow zone where PCE contamination may exist but at concentrations near or less than 1.0 µg/L. Water levels are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1/POPLAR2 municipal water supply wells.	Not a ey well	MODERATE: Characterizes plume interior in region of very low PCE concentrations.	Continued general monitoring.
GALLETTI	RISK ASSESSMENT TO POTENTIAL RECEPTOR P MPING PLAN PERFORMANCE ASSESSMENT	PCE data function to assess and monitor for risk of PCE impacts from upgradient M/K and DR plumes. TCE has been historically been detected at this well, intermittently in the 0.5 to 1.0 µg/L range. The most recent detection was in 2008Q3. These detections may indicate that part of the northern segment of the DR plume (characterized by TCE and PCE) may escape capture by KIETZKE and migrate into the GALLETTI capture zone.	Not a ey well Outside either the VA or DS plume extents.	HIGH: Well represents a self-sentry well and is a potential receptor for the DR plume. Also functions to verify pumping plan effectiveness.	Continued opportunistic monthly sampling during pumping periods. Track for any PCE/TCE detections that would indicate risk to receptor.
GALLETTIM	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE data function to assess and monitor for risk of PCE impacts from upgradient M/K and DR plumes. Water level data generally function to track proximal pumping/injection response from GALLETTI and provide data for quarterly water level contouring.	Not a ey well Outside either the VA or DS plume extents.	MODERATE: Well represents a sentry well to GALLETTI	Continued general monitoring. Track for any PCE/TCE detections that would indicate risk to receptor.
LEGENDS	SPATIAL PL ME MONITORING	PCE data assess intermittent PCE concentrations as measured by recurring seasonal PCE maxima during late stages of the non-pumping season and minimum concentrations during periods where area-wide pumping causes water levels to decrease. This pattern is consistent with PCE migrating either vertically or laterally out of the LEGENDS screen interval during periods of pumping. Alternatively, the PCE concentration pattern may be the result of local vertical well-bore flow caused by vertical gradients across the well's screen. Under either scenario the data are consistent with a relatively heterogeneous, discrete interval of PCE contamination existing near where LEGEND is constructed. Water levels for this well and the other deeper shallow zone wells have slightly larger magnitude long-term trends and larger seasonal fluctuations, compared to shallower near water table wells. This is consistent with these wells assessing hydrodynamics that are somewhat better connected to deep zone pumping/injection stresses.	Not a ey well Intermittent PCE detections are consistent with the existence of contamination where the well is constructed. But the recurring seasonal pattern of PCE spikes is, as yet unexplained.	MODERATE: Helps define plume geometry and dynamics	Consider assessment of recurring PCE concentration pattern at this well to determine whether patterns have any implications to plume dynamics or PCE concentration distribution in area around LEGENDS. Uncertain well construction make data from well of poor pedigree. PCE detections suggest the potential for a source for shallow zone contamination upgradient and to the west of LEGENDS. Consideration to expanding any source area investigation in that direction is warranted.
MENTALHEALTH	SPATIAL BACKGRO ND MONITORING	PCE non detects constrain PCE contamination in the deep zone, upgradient (west) of the DS Subregion. The well functions to locally constrain and verify that PCE contamination from the DR plume does not migrate east of and out of the capture zone of KIETZKE or 4TH. Water levels respond directly to pumping from nearby wells that exist to the north (VIEW), west (4TH and KIETZKE), south (GALLETTI and 21ST), and east (POPLAR1, POPLAR2, and SPARKS). As a result of the high number of pumping wells and an apparently relatively direct hydraulic connection within the deep zone, MENTALHEALTH water levels exhibit a relatively direct, large magnitude response to pumping.	Not a ey well Outside either the VA or DS plume extents.	MODERATE: Provides area-wide deep zone hydrodynamic assessment. Helps constrain extent of deep zone plume west of subregion.	Once well is utilized for water supply it should be monitored on a monthly basis (during pumping) similar to other municipal water supply wells.

DO NTO N SPARKS S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
MITCHELLT	SPATIAL BACKGRO ND MONITORING	Currently MITCHELLTW's primary function is to provide hydrodynamic assessment of the deep zone. It's hydrograph is very similar to SPARKSHIGH and to hydrographs of DILWORTH, PRATERWAY, and STANFORD (group ES-4 in the ES Subregion). The relatively large magnitude seasonal response in this well, and in other deeper deep zone wells is consistent with a relatively direct hydraulic connection between these wells and deep zone pumping. In the future, when MITCHELLTW is utilized as a municipal water supply well, it will function as a self sentry well to monitor for potential impacts from as yet undefined PCE.	Not a ey well Outside either the VA or DS plume extents.	MODERATE: Current value is restricted to assessing area-wide hydrodynamics	Once well is utilized for water supply it should be monitored on a monthly basis (during pumping) similar to other municipal water supply wells.
NDOT	SPATIAL PL ME MONITORING	PCE data define the current unconstrained upgradient (west) extent of the shallow zone VA plume. The pedigree of PCE results is compromised by sampling procedures that require collecting a grab sample from a wellhead leak and by uncertain pumping history at the well because of its intermittent seasonal use as an irrigation well. The consistent presence of PCE at concentrations in the range of 5 µg/L over the GMP period of record are consistent with this well characterizing a significant interval of contamination. Since the well is screened over a relatively long interval (50 - 100 ft bgs), it is not certain whether PCE monitored at the well originates in a narrower higher concentration interval, or a relatively thicker, but lower concentration interval. PCE characterized at this well may indicate that a contributing source for PCE contamination to the VA plume is from the west of NDOT. No water levels are collected at NDOT.	Important ut not a ey well PCE results are compromised by sampling pedigree, well construction, and its use as an irrigation well. But PCE concentrations at or above the MCL are consistent with the well assessing a relatively significant interval of PCE that may vector to a potential source to the west of the VA plume.	MODERATE: Defines western unconstrained extent of VA plume.	Although capture zone analysis performed under contract for DWR indicate the source areas for the VA plume are most likely to the northwest of its currently defined extent. PCE detections at NDOT suggest the potential for a source to the west. Consideration to expanding any source area investigation in that direction is warranted.
POPLAR1	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE non-detects establish that POPLAR1 has not been impacted by PCE. The well functions as a self sentry to verify its unimpacted condition.	Not a ey well Acts as a self-sentry for potential, but currently considered, unlikely PCE impacts.	HIGH: Well represents a self-sentry well and is a potential receptor.	POPLAR1 has no record of sampling since 2008. Additional sampling should be considered, at least annually to verify that no PCE impacts this well.
POPLAR	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE data provide an assessment of plume dynamics and monitoring for potential that PCE concentration trends that would indicate potential for PCE to exceed the MCL. Based on GMP data, PCE concentrations have remained relatively stable and consistently below 2.5 µg/L over the period between 2004Q3 and 2008Q3. However the longer-term increasing seasonal maximum concentrations apparent at sentry well CTM75 suggests the potential for increasing PCE in the area. Water levels are directly influenced by pumping at the well. When POPLAR2 is not pumping water levels respond to area-wide pumping similarly to other relatively shallower deep zone wells.	KEY ELL: Act in a self-sentry capacity to assess potential for increased PCE impacts and the need for treatment.	HIGH: Key Well	POPLAR2 has no record of sampling since 2008, but has shown a overall long term increase in PCE concentration from TMWA sampling between 1987 through 2008. Additional sampling is critical here to determine whether PCE impacting this well has continued to increase.
SPARKS	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE data provide an assessment of plume dynamics and monitoring for potential that PCE concentration trends that would indicate potential for PCE to exceed the MCL. Based on GMP data, PCE concentrations have remained consistently below 1.5 µg/L over the period between 2006Q3 and 2008Q3. Water levels are directly influenced by pumping at the well. When SPARKS is not pumping water levels respond to area-wide pumping similarly to other relatively shallower deep zone wells.	KEY ELL: Act in a self-sentry capacity to assess potential for increased PCE impacts and the need for treatment.	HIGH: Key Well	SPARKS has no record of sampling since 2008, but has shown a overall long term increase in PCE concentration from TMWA sampling between 1987 through 2008. Additional sampling is critical here to determine whether PCE impacting this well has continued to increase.
SPARKSHIGH	SPATIAL PL ME MONITORING	Currently SPARKSHIGH's primary function is to provide hydrodynamic assessment of the deep zone. It's hydrograph is very similar to MITCHELLTW and to hydrographs of DILWORTH, PRATERWAY, and STANFORD (group ES-4 in the ES Subregion). The relatively large magnitude seasonal response in this well, and in other deeper deep zone wells is consistent with a relatively direct hydraulic connection between these wells and deep zone pumping. In the future, when SPARKSHIGH is utilized as a municipal water supply well, it will function as a self sentry well to monitor for potential impacts from as yet undefined PCE.	Not a ey well Outside either the VA or DS plume extents.	MODERATE: Current value is restricted to assessing area-wide hydrodynamics	Once well is utilized for water supply it should be monitored on a monthly basis (during pumping) similar to other municipal water supply wells.

DO NTO N SPARKS S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
SSFSM 01	SPATIAL PL ME MONITORING	PCE non-detects function to constrain the northeastern extent of the VA plume. Water levels are generally similar to other near-water table wells in the area proximal to both the SPARKS and POPLAR1/POPLAR2 municipal water supply wells.	Not a ey well Outside either the VA or DS plume extents.	MODERATE: Constrains shallow portion of VA plume to the northeast	Continued general monitoring.

EAST SPARKS KEY   ELL DECISION MATRI

	WATER QUALITY FUNCTION:											WATER LEVEL FUNCTION:					CLUSTER FUNCTION:		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture assessment	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume mass mo ement across low arrier assessment	Plume mass mo ement dri er assessment	ertical low/ ertical plume mass mo ement assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
APOLLO																			
CTM54																			
CTM55																			
CTM56																			
CTM61																			
DILWORTH																		X	X
LINCOLNWAYMW																			
PRATERWAY																		X	X
PRATERWAYMW																		X	X
PURINAMW																			
SPARKSHIGH																			
SPARKSPDMW																			
SSFSDWC309																			
SSFSMW202																			
		(ES)									X				X	X			
SSFSMW205											X								
SSFSMW207					X						X								
											X				X	X			
SSFSMW213																			
STANFORD																			
USGSDILWORTH																		X	X
USGSLONGFORD																			
VICTORIANMW																			

Notes:

2010 INDIVIDUAL KEY WELL

2010 WELL CLUSTER MEMBER

tali 2009 Key Wells

R(CTM105) = Redundant with well identified in parenthesis

X(ESWW) = Potential local source in East Sparks Subregion at Wolverine Way hot spot

1 Potential individual sources are identified by subregion, hot spot, and local source alpha descriptors as appropriate. See notes for descriptions.

2 Water quality and/or water levels should be assessed relative to well's role as part of a key well cluster.

EAST SPARKS S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CTM1 S	SPATIAL BACKGRO ND MONITORING	PCE non-detects function to locally constrain and verify the upgradient extent of the WW hot spot.	Important ut not a ey well Important for verification of upgradient extent of WW hot spot.	HIGH: Provides upgradient plume definition. Constrains upgradient extent of WW hot spot.	Monitor for any detections that would suggest an additional upgradient source. Otherwise continue monitoring to verify upgradient plume definition.
DIL ORTH	F T RE M NICIPAL ATER S PPLY ELL: F T RE SITE FOR RISK ASSESSMENT TO POTENTIAL NIMPACTED RECEPTOR	Currently DILWORTH's primary function is to provide an assessment of deep zone hydrodynamics. Its hydrograph is more similar to PRATERWAY suggesting that both are constructed in a hydrodynamically connected interval where water levels have a relatively direct response to area-wide seasonal pumping. In the future, when DILWORTH is utilized as a municipal water supply well, it will function as a self-sentry well to monitor for potential impacts from either the ES plume or from the Greenbrae fugitive plume.	Not a ey well Part of a well cluster that is important to the hydrodynamic assessment in the eastern CTM. Represents potential receptor if utilized as a municipal water supply well.	MODERATE: Current value is restricted to assessing area-wide hydrodynamics.	Once well is utilized for water supply it should be monitored on a monthly basis (during pumping) similar to other municipal water supply wells.
LINCOLN AYM	SPATIAL BACKGRO ND MONITORING	PCE non-detects verify that LINCOLNWAYMW is constructed outside of any current PCE contamination. Water levels provide lateral gradient and water level contouring data. MTBE is detected at well and is an indicator of potential risk to future receptors.	Not a ey well	LIMITED: Current value is limited to providing lateral gradient and for water level contouring.	Continued general monitoring. Well becomes an important monitoring site once DILWORTH, PRATERWAY, and STANFORD are utilized for water supply. MTBE is detected in this well and should be assessed as potential risk to future receptors.
PRATER AY	F T RE M NICIPAL ATER S PPLY ELL: F T RE SITE FOR RISK ASSESSMENT TO POTENTIAL NIMPACTED RECEPTOR	Currently PRATERWAY's primary function is to provide an assessment of deep zone hydrodynamics. Its hydrograph is more similar to DILWORTH suggesting that both are constructed in a hydrodynamically connected interval where water levels have a relatively direct response to area-wide seasonal pumping. In the future, when PRATERWAY is utilized as a municipal water supply well, it will function as a self-sentry well to monitor for potential impacts from either the ES plume or from the Greenbrae fugitive plume.	Not a ey well Part of a well cluster that is important to the hydrodynamic assessment in the eastern CTM. Represents potential receptor if utilized as a municipal water supply well.	MODERATE: Current value is restricted to assessing area-wide hydrodynamics.	Once well is utilized for water supply it should be monitored on a monthly basis (during pumping) similar to other municipal water supply wells.
PRATER AYM	SPATIAL BACKGRO ND MONITORING	PCE non-detects verify that PRATERWAYMW is constructed outside of any current PCE contamination. Water levels provide lateral and vertical (with PRATERWAY) gradient, and water level contouring data.	Not a ey well Part of a well cluster that is important to the hydrodynamic assessment in the eastern CTM.	MODERATE: Current value is restricted to assessing area-wide hydrodynamics.	Continue to assess well cluster hydrodynamics. Well becomes an important monitoring site once DILWORTH, PRATERWAY, and STANFORD are utilized for water supply.

EAST SPARKS S BREGION   ELL NET   ORK RE IE   SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
SSFSD C 0	SPATIAL PL ME MONITORING	PCE data function to assess plume dynamics in the distal and deeper portions of the ES plume downgradient of the WW hot spot. The relatively low, generally stable/non-fluctuating PCE concentrations are consistent with the well being positioned in a relatively stable (non-dynamic) portion of the plume. This well is the deepest well monitored by DWR downgradient of the WW hot spot. The vertical extent of PCE is otherwise undefined in the area downgradient of the WW hot spot. Water level data function mainly to define lateral gradient and water level contours in the area.	Important ut not a ey well SSFSDWC309 demonstrates the relative stability of PCE concentrations in the distal portions of the ES plume where it is constructed.	MODERATE: Helps define plume geometry/dynamics in plume interior.	Continue to monitor to assess any changes in dynamics of potentially slightly increasing to relatively stable PCE concentrations. Water quality monitoring will become more critical if remediation pumping operations change at SS/FS.
SSFSM 0	SPATIAL PL ME MONITORING	Low concentration PCE detections at SSFSMW202 (in a relatively narrow range between 2.9 and <1.0 µg/L) are consistent with this well functioning to provide an verification of stable to decreasing PCE concentrations near the northern outline of the ES plume complex, in a potentially isolated segment of PCE contamination. The well functions to assess any potential change in plume dynamics that may occur in this area in response to potential changes in either hydrodynamics of mass flux in the area. Water level data provide lateral gradient and water level contouring data.	Not a ey well	MODERATE: Helps define plume geometry/dynamics along the northern part of the plume complex.	Continued general monitoring. Well becomes an important monitoring site once DILWORTH, PRATERWAY, and STANFORD are utilized for water supply.
SSFSM 0	MASS FL /SO RCE AREA ASSESSMENT	PCE data function to assess mass flux and potential source area dynamics spatially associated with the WW hot spot. The relatively high concentration and spiky characteristics of the PCE time series is consistent with the well being positioned near a source area where PCE concentrations are dynamic either as a result of changes in mass flux or currently undetermined hydrodynamics that affect the near-source plume position and therefore PCE concentration in the well.	KEY ELL: Provides assessment of mass flux/source characterization for the WW hot spot.	HIGH: Key Well	SSFSMW204's spiky, relatively higher PCE concentrations are consistent with the well being positioned proximal to a source. The determination of that source (Harrah's, SS/FS, or another as yet undefined release) and who is responsible for any potential remediation is currently undefined. The CTMRD program may not have a responsibility at this site. If that were determined, the responsibility and cost to remediate/monitor the area would not be part of the CTMRD program. Periodically compare time series with SSFSMW205, 207, 212 for evidence of similar, lagged patterns/characteristics that would indicate they are on a similar flowpath and that travel time can be estimated.
SSFSM 05	MASS FL /PL ME DYNAMICS/TRA EL TIME ASSESSMENT	PCE data function to assess plume dynamics in the plume interior downgradient from the WW hot spot. Data are consistent with an overall decrease in PCE concentration downgradient of the hot spot. This trend is inconsistent with PCE concentrations at hot spot well SSFSMW204. The well's position downgradient from hot spot well SSFSMW204 suggest that this well has the potential to provide an assessment of plume dynamics/travel time between the well and the hot spot, but a comparison between PCE time series of the two wells shows no obvious interrelationship. PCE concentration and long term apparent trends (since 2006Q2) are similar between this well and SSFSMW212 (excluding a spike in SSFSMW205 in 2008Q2) suggesting a level of redundancy between these two wells. Water level data function mainly to define lateral gradient and water level contours in the area. Differences between hydrograph for SSFSMW204 and 205 are consistent with a transition from water levels more influenced by pumping at 204 compared to water levels more influenced by Truckee River (or related surface water discharge dynamics) at 205.	KEY ELL SSFSMW205 has similarities and some redundancy with SSFSMW212 in terms of defining plume dynamics downgradient of WW hot spot.	HIGH: Key Well	Continued monitoring to track plume dynamics. Periodically compare time series with SSFSMW204, 207, 212 for evidence of similar, lagged patterns/characteristics that would indicate they are on a similar flowpath and that travel time can be estimated. Water quality monitoring will become more critical if remediation pumping operations change at SS/FS.

EAST SPARKS S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
SSFSM 0	MASS FL /PL ME DYNAMICS/TRA EL TIME ASSESSMENT	PCE data function to assess plume dynamics in the distal, unconstrained portion of the ES plume downgradient of the WW hot spot. The relatively low, generally stable/non-fluctuating PCE concentrations are consistent with the well being positioned in a relatively stable (non-dynamic) portion of the plume. Water level data function mainly to define lateral gradient and water level contours in the area.	KEY ELL Provides an assessment of plume dynamics in an unconstrained laterally downgradient part of the ES plume.	HIGH: Key Well.	Continued monitoring to track plume dynamics. Periodically compare time series with SSFSMW204, 205, 212 for evidence of similar, lagged patterns/characteristics that would indicate they are on a similar flowpath and that travel time can be estimated. Water quality monitoring will become more critical if remediation pumping operations change at SS/FS.
SSFSM 1	MASS FL /PL ME DYNAMICS/TRA EL TIME ASSESSMENT	PCE data function to assess plume dynamics in the plume interior downgradient from the WW hot spot. Data are consistent with more recent overall decrease in PCE concentration downgradient of the hot spot. This trend is inconsistent with PCE concentrations at hot spot well SSFSMW204. Historically PCE concentrations at this well have been relatively similar in magnitude to those as SSFSMW205. Starting in 2006Q2 apparent trends (excluding a spike in SSFSMW205 in 2008Q2) have also been similar. Water level data function mainly to define lateral gradient and water level contours in the area.	KEY ELL: Helps define plume dynamics downgradient of WW hot spot. Its role as a key well in prior years make it a better choice than SSFSMW205 (which provides a similar function).	HIGH: Key Well	Continued monitoring to track plume dynamics. Periodically compare time series with SSFSMW204, 205, 207 for evidence of similar, lagged patterns/characteristics that would indicate they are on a similar flowpath and that travel time can be estimated. Water quality monitoring will become more critical if remediation pumping operations change at SS/FS.
SSFSM 1	SPATIAL BACKGRO ND MONITORING	PCE non-detects function to locally verify that potential PCE contamination associated with the former Resolvent PCE Project Site has not impacted groundwater, at least in the location where the well is constructed. Water level data function mainly to define lateral gradient and water level contours in the area.	Not a ey well Monitors for potential release associated with the Resolvent PCE Project Site.	HIGH: Monitors for potential release associated with the Resolvent PCE Project Site.	Once on-site verification that PCE releases at Resolvent are not likely to have impacted groundwater, SSFSMW213 will have limited value as a water quality site. Until then, the well should be monitored at least semi-annually for PCE.
STANFORD	SPATIAL BACKGRO ND MONITORING	PCE non-detects verify that PCE contamination from either the Greenbrae fugitive plume or from the ES plume have not impacted the interval where STANFORD is constructed. However, the well is not regularly pumped and is therefore not regularly sampled (most recent available sample results in 2007Q4). Water level data are of long-term value, providing a general sense of the long-term trends in average annual water levels in this part of the basin. However the spiky nature of the hydrograph, caused by intermittent pumping for construction-related water, compromise the value of the historical water level data.	Not a ey well Represents potential receptor if utilized as a municipal water supply well.	MODERATE: Current value is restricted to assessing area-wide hydrodynamics.	Once well is utilized for water supply it should be monitored on a monthly basis (during pumping) similar to other municipal water supply wells.
SGSDIL ORTH	SPATIAL BACKGRO ND MONITORING	PCE non-detects verify that USGSDILWORTH is constructed outside of any current PCE contamination. Water levels provide lateral and vertical (with DILWORTH) gradient, and water level contouring data.	Not a ey well Part of a well cluster that is important to the hydrodynamic assessment in the eastern CTM.	MODERATE: Current value is restricted to assessing area-wide hydrodynamics.	Continued general monitoring.
ICTORIANM	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain the northern extent of the ES plume. PCE monitoring provides a verification site to assess the ES plume's lateral extent and verify that PCE does not migrate to the north. Water levels provide lateral gradient and water level contouring data.	Not a ey well Constrains northern extent of ES plume.	MODERATE: Provides assessment of stability of portion of northern extent of ES plume near STANFORD	Continued general monitoring. Well becomes an important monitoring site once STANFORD is utilized for water supply. MTBE is detected in this well and should be assessed as potential risk to future receptors.

EL RANCHO S BREGION KEY ELL DECISION MATRI

	WATER QUALITY FUNCTION:											***WATER LEVEL FUNCTION:***					***CLUSTER FUNCTION:***		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture assessment	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume mass mo ement across low arrier assessment	Plume mass mo ement dri er assessment	ertical low/ ertical plume mass mo ement assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
CTM108															2	2		X	X
CTM109															2	2		X	X
CTM110															2	2		X	X
CTM111															2	2		X	X
CTM112															2	2		X	X
CTM113															2	2		X	X
CTM114															2	2		X	X
CTM115															2	2		X	X
E											X			2	2	2	X	X	X
E											X			2	2	2	X	X	X
E											X			2	2	2	X	X	X

Notes:

2010 INDIVIDUAL KEY WELL

2010 WELL CLUSTER MEMBER

tali 2009 Key Wells

R(CTM105) = Redundant with well identified in parenthesis

[1] Potential individual sources are identified by subregion, hot spot, and local source alpha descriptors as appropriate. See notes for descriptions.

[2] Water quality and/or water levels should be assessed relative to well's role as part of a well cluster.

ELRANCHO S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CTM10	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide background water quality assessment for the area northwest of currently defined ER plume. In combination with other wells at Paradise Park (CTM108-115), data suggest that ER plume does not extend to the northwest of ELRANCHO municipal water supply well. Water level data from this and other wells at Paradise Park provide key vertical gradient and water level response information that provides an assessment of the relatively enhanced connection between the deep zone and shallow zone in this area. Water levels for well cluster that includes this well (CTM108/109/110/115) indicate incrementally greater seasonal response with depth for each successively deeper well. These results are more consistent with anisotropy across the interval rather than a single discrete confining layer.	Not an indi idual ey well Helps eliminate the area to the northwest of ELRANCHO as a likely location for or source area of the ER plume. Has value as part of a well cluster that assesses vertical groundwater flow dynamics in an area of enhanced vertical hydraulic communication.	HIGH: KEY WELL CLUSTER	CTM108-115 need to be monitored monthly for water levels and quarterly for water quality through 2011. At that point a reassessment of their value providing water quality or hydrodynamic information should be performed.
CTM10	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide background water quality assessment for the area northwest of currently defined ER plume. In combination with other wells at Paradise Park (CTM108-115), data suggest that ER plume does not extend to the northwest of ELRANCHO municipal water supply well. Water level data from this and other wells at Paradise Park provide key vertical gradient and water level response information that provides an assessment of the relatively enhanced connection between the deep zone and shallow zone in this area. Water levels for well cluster that includes this well (CTM108/109/110/115) indicate incrementally greater seasonal response with depth for each successively deeper well. These results are more consistent with anisotropy across the interval rather than a single discrete confining layer.	Not an indi idual ey well Helps eliminate the area to the northwest of ELRANCHO as a likely location for or source area of the ER plume. Has value as part of a well cluster that assesses vertical groundwater flow dynamics in an area of enhanced vertical hydraulic communication.	HIGH: KEY WELL CLUSTER	CTM108-115 need to be monitored monthly for water levels and quarterly for water quality through 2011. At that point a reassessment of their value providing water quality or hydrodynamic information should be performed.
CTM110	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide background water quality assessment for the area northwest of currently defined ER plume. In combination with other wells at Paradise Park (CTM108-115), data suggest that ER plume does not extend to the northwest of ELRANCHO municipal water supply well. Water level data from this and other wells at Paradise Park provide key vertical gradient and water level response information that provides an assessment of the relatively enhanced connection between the deep zone and shallow zone in this area. Water levels for well cluster that includes this well (CTM108/109/110/115) indicate incrementally greater seasonal response with depth for each successively deeper well. These results are more consistent with anisotropy across the interval rather than a single discrete confining layer.	Not an indi idual ey well Helps eliminate the area to the northwest of ELRANCHO as a likely location for or source area of the ER plume. Has value as part of a well cluster that assesses vertical groundwater flow dynamics in an area of enhanced vertical hydraulic communication.	HIGH: KEY WELL CLUSTER	CTM108-115 need to be monitored monthly for water levels and quarterly for water quality through 2011. At that point a reassessment of their value providing water quality or hydrodynamic information should be performed.
CTM111	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide background water quality assessment for the area northwest of currently defined ER plume. In combination with other wells at Paradise Park (CTM108-115), data suggest that ER plume does not extend to the northwest of ELRANCHO municipal water supply well. Water level data from this and other wells at Paradise Park provide key vertical gradient and water level response information that provides an assessment of the relatively enhanced connection between the deep zone and shallow zone in this area. Water levels for well cluster that includes this well (CTM111/112) indicate greater seasonal response in deep zone well CTM111 (screen interval: 321.7-351.7 ft bgs) compared to shallow zone well CTM112 (screen interval: 62.5-72.5 ft bgs). But the shallow zone response at CTM112 is relatively large (decreasing 23 ft) compared to the deep zone response at CTM112 (decreasing 56 ft) during the 2010 pumping season (March to September, 2010).	Not an indi idual ey well Helps eliminate the area to the northwest of ELRANCHO as a likely location for or source area of the ER plume. Has value as part of a well cluster that assesses vertical groundwater flow dynamics in an area of enhanced vertical hydraulic communication.	HIGH: KEY WELL CLUSTER	CTM108-115 need to be monitored monthly for water levels and quarterly for water quality through 2011. At that point a reassessment of their value providing water quality or hydrodynamic information should be performed.

ELRANCHO S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CTM11	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide background water quality assessment for the area northwest of currently defined ER plume. In combination with other wells at Paradise Park (CTM108-115), data suggest that ER plume does not extend to the northwest of ELRANCHO municipal water supply well. Water level data from this and other wells at Paradise Park provide key vertical gradient and water level response information that provides an assessment of the relatively enhanced connection between the deep zone and shallow zone in this area. Water levels for well cluster that includes this well (CTM111/112) indicate greater seasonal response in deep zone well CTM111 (screen interval: 321.7-351.7 ft bgs) compared to shallow zone well CTM112 (screen interval: 62.5-72.5 ft bgs). But the shallow zone response at CTM112 is relatively large (decreasing 23 ft) compared to the deep zone response at CTM112 (decreasing 56 ft) during the 2010 pumping season (March to September, 2010).	Not an indi idual ey well Helps eliminate the area to the northwest of ELRANCHO as a likely location for or source area of the ER plume. Has value as part of a well cluster that assesses vertical groundwater flow dynamics in an area of enhanced vertical hydraulic communication.	HIGH: KEY WELL CLUSTER	CTM108-115 need to be monitored monthly for water levels and quarterly for water quality through 2011. At that point a reassessment of their value providing water quality or hydrodynamic information should be performed.
CTM11	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide background water quality assessment for the area northwest of currently defined ER plume. In combination with other wells at Paradise Park (CTM108-115), data suggest that ER plume does not extend to the northwest of ELRANCHO municipal water supply well. Water level data from this and other wells at Paradise Park provide key vertical gradient and water level response information that provides an assessment of the relatively enhanced connection between the deep zone and shallow zone in this area. Water levels for well cluster that includes this well (CTM113/114) indicate greater seasonal response in deep zone well CTM113 (screen interval: 202.6-212.6 ft bgs) compared to shallow zone well CTM114 (screen interval: 62.5-67.5 ft bgs). But the shallow zone response at CTM114 is relatively large (decreasing 24 ft) compared to the deep zone response at CTM113 (decreasing 46 ft) during the 2010 pumping season (March to September, 2010).	Not an indi idual ey well Helps eliminate the area to the northwest of ELRANCHO as a likely location for or source area of the ER plume. Has value as part of a well cluster that assesses vertical groundwater flow dynamics in an area of enhanced vertical hydraulic communication.	HIGH: KEY WELL CLUSTER	CTM108-115 need to be monitored monthly for water levels and quarterly for water quality through 2011. At that point a reassessment of their value providing water quality or hydrodynamic information should be performed.
CTM11	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide background water quality assessment for the area northwest of currently defined ER plume. In combination with other wells at Paradise Park (CTM108-115), data suggest that ER plume does not extend to the northwest of ELRANCHO municipal water supply well. Water level data from this and other wells at Paradise Park provide key vertical gradient and water level response information that provides an assessment of the relatively enhanced connection between the deep zone and shallow zone in this area. Water levels for well cluster that includes this well (CTM113/114) indicate greater seasonal response in deep zone well CTM113 (screen interval: 202.6-212.6 ft bgs) compared to shallow zone well CTM114 (screen interval: 62.5-67.5 ft bgs). But the shallow zone response at CTM114 is relatively large (decreasing 24 ft) compared to the deep zone response at CTM113 (decreasing 46 ft) during the 2010 pumping season (March to September, 2010).	Not an indi idual ey well Helps eliminate the area to the northwest of ELRANCHO as a likely location for or source area of the ER plume. Has value as part of a well cluster that assesses vertical groundwater flow dynamics in an area of enhanced vertical hydraulic communication.	HIGH: KEY WELL CLUSTER	CTM108-115 need to be monitored monthly for water levels and quarterly for water quality through 2011. At that point a reassessment of their value providing water quality or hydrodynamic information should be performed.
CTM115	SPATIAL BACKGRO ND MONITORING	PCE non-detects provide background water quality assessment for the area northwest of currently defined ER plume. In combination with other wells at Paradise Park (CTM108-115), data suggest that ER plume does not extend to the northwest of ELRANCHO municipal water supply well. Water level data from this and other wells at Paradise Park provide key vertical gradient and water level response information that provides an assessment of the relatively enhanced connection between the deep zone and shallow zone in this area. Water levels for well cluster that includes this well (CTM108/109/110/115) indicate incrementally greater seasonal response with depth for each successively deeper well. These results are more consistent with anisotropy across the interval rather than a single discrete confining layer. The 2010 seasonal water level maximum at CTM115 is measurably higher than maxima at the other 3 wells in this cluster and suggest that recharge from Paradise Pond or the nearby drain feeding Paradise Pond has a relatively greater influence on this well than the other wells in the area. CTM115 is the only well in the ER Subregion constructed in package A. This may also play a role in its relatively higher seasonal maximum, its more muted seasonal response, and the apparent lag in its response to pumping during 2010 Q2.	Not an indi idual ey well Helps eliminate the area to the northwest of ELRANCHO as a likely location for or source area of the ER plume. Has value as part of a well cluster that assesses vertical groundwater flow dynamics in an area of enhanced vertical hydraulic communication.	HIGH: KEY WELL CLUSTER	CTM108-115 need to be monitored monthly for water levels and quarterly for water quality through 2011. At that point a reassessment of their value providing water quality or hydrodynamic information should be performed.

ELRANCHO S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
ELRANCHOM S	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	2010 depth discrete PCE data at ELRANCHOMWS indicate that a portion, if not all PCE contamination impacting ELRANCHO municipal water supply, comes from the interval where ELRANCHOMWS is screened (130-200 ft bgs). ELRANCHOMWS is currently the only monitoring well considered constructed across a contaminated portion of the aquifer that impacts ELRANCHO municipal water supply well. It functions to assess risk to ELRANCHO. However, its value is influenced by the degree that samples collected at the well are representative of actual groundwater conditions. PCE results are likely influenced by local conditions that result from injection at ELRANCHO. For example, the first detected PCE at ELRANCHOMWS in 2009Q4 may have been a consequence of sampling after a period of sustained pumping, thereby collecting a more representative sample of groundwater, than any actual change in groundwater quality. Water level data at ELRANCHOMWS, ELRANCHOMWD, and ELRANCHO provide local gradient data that help assess how groundwater flow caused by pumping and injection at ELRANCHO is distributed across the two producing intervals in the pumping well.	KEY ELL: Provides assessment capabilities of at least part of the deep zone PCE-contaminated interval that impacts ELRANCHO. Pedigree of samples needs to account for injection/pumping history at ELRANCHO.	HIGH: KEY WELL	A consistent effort directed towards sampling ELRANCHO, ELRANCHOMWS, and ELRANCHOMWD after periods of extended pumping would provide more representative data from these wells. As a minimum PCE results should be assessed in the context of pumping/injection history at ELRANCHO. Any assessment of plume dynamics or increased risk to ELRANCHO municipal water supply will be problematic as a result of ASR at ELRANCHO and potential local impacts from wellbore flow.
ELRANCHOM D	SPATIAL BACKGRO ND MONITORING	PCE data at ELRANCHOMWD is considered to be significantly impacted by local conditions resulting from the influence of nearby ELRANCHO municipal water supply well. PCE detections at the well may be partly the result of vertical wellbore movement in ELRANCHO that migrates into the ELRANCHOMWD interval. If this interpretation is correct then the well functions to monitor a deeper portion of the screened interval at ELRANCHO that is generally uncontaminated, but is locally impacted by PCE-contaminated water during periods of vertical wellbore flow at ELRANCHO. PCE results (and their pedigree) are also influenced by injection at ELRANCHO. Water level data at ELRANCHOMWS, ELRANCHOMWD, and ELRANCHO provide local gradient information that help assess how groundwater flow caused by pumping and injection at ELRANCHO is distributed across the two producing intervals in the pumping well.	KEY ELL: Provides assessment of a potentially uncontaminated portion of the deep zone aquifer where most of ELRANCHO production is derived. Pedigree of sampling results need to account for injection/pumping history at ELRANCHO and for the potential for vertical wellbore flow in ELRANCHO (that may cause PCE-contaminated groundwater to locally impact the interval where ELRANCHOMWD is constructed).	HIGH: Potentially helps verify that the deeper, more productive portion of aquifer is (and remains) uncontaminated.	A consistent effort directed towards sampling ELRANCHO, ELRANCHOMWS, and ELRANCHOMWD after periods of extended pumping would provide more representative data from these wells. As a minimum PCE results should be assessed in the context of pumping/injection history at ELRANCHO. Any assessment of plume dynamics or increased risk to ELRANCHO municipal water supply will be problematic as a result of ASR at ELRANCHO and potential local impacts from wellbore flow.
ELRANCHO	RISK ASSESSMENT TO RECEPTOR/POTENTIAL RECEPTOR	PCE data at ELRANCHO help define and assess impacts of PCE contamination at this municipal water supply well. The well represents a self-sentry monitoring point to assess and track PCE concentration dynamics that would indicate the well's potential risk for being impacted to a level where groundwater from the well would require treatment before it can be utilized for municipal water supply.	KEY ELL: Represents a self-sentry well providing an assessment of potential risk for increasing PCE contamination to levels that would require treatment or other remedial strategies in order to utilize groundwater for municipal water supply.	HIGH: KEY WELL	A consistent effort directed towards sampling ELRANCHO, ELRANCHOMWS, and ELRANCHOMWD after periods of extended pumping would provide more representative data from these wells. As a minimum PCE results should be assessed in the context of pumping/injection history at ELRANCHO. Any assessment of plume dynamics or increased risk to ELRANCHO municipal water supply will be problematic as a result of ASR at ELRANCHO and potential local impacts from wellbore flow.

O LE S BREGION KEY ELL DECISION MATRI

	WATER QUALITY FUNCTION:											WATER LEVEL FUNCTION:					CLUSTER FUNCTION:		
ELL ID	1				5					10	KEY ELL	L1	L	L	L	L KEY ELL	C 1	LC 1	ELL CL STER
	Mass lu /source assessment	PCE source ector[1]	Mass lu /plume dynamics/ tra el time	Plume core dynamics	Distal (lateral) plume dynamics	Plume dynamics downgradient o receptor or plume capture zone	Ris assessment to receptor/ potential receptor	PCE mass remo al and capture assessment	Pumping plan per ormance assessment	Site-speci ic plume dynamics		Plume mass mo ement across low arrier assessment	Plume mass mo ement dri er assessment	ertical low/ ertical plume mass mo ement assessment	Area-wide hydrodynamics assessment		ertical plume dynamics assessment	ertical hydrodynamics assessment	
E			X								X								
CTM20S																			
											X		2	2	X	X	X	X	X
											X		2	2	X	X	X	X	X
							X				X				X	X			
GLOBALMW1																			
HV3																			
HV4																			
HV5											X		2	2	3	3	3	3	3
HV5M													2	2	2	2	X	X	X
PEZZI																			
USGSAG																			

Notes:

2010 INDIVIDUAL KEY WELL

2010 WELL CLUSTER MEMBER

tali 2009 Key Wells

R(CTM105) = Redundant with well identified in parenthesis

1 Potential individual sources are identified by subregion, hot spot, and local source alpha descriptors as appropriate. See notes for descriptions.

2 Water quality and/or water levels should be assessed relative to well's role as part of a well cluster.

3 Municipal water supply wells HV5 and LONGLEYLANE1 do not, but should have transducer instrumentation connected to SCADA. Historical water levels have poor pedigree and are not in database.

O LE S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
BELFAST	RISK ASSESSMENT TO POTENTIAL RECEPTOR MASS FL /PL ME DYNAMICS/TRA EL-TIME ASSESSMENT	PCE data at BELFAST function to provide the most complete history of PCE contamination in the J complex plume. It is the only deep zone well constructed within the currently defined plume outline. While well construction pedigree is not optimal (no drill log available; DWR video logging indicates that the well is open at depth of 114 ft bgs), PCE data are considered to represent contamination at similar depths as a part of the screened interval at municipal water supply well HV5, making the well important as a potential sentinel well and to track long-term PCE trends until more data are collected at nearby (and better pedigreed) wells CTM85 and CTM86. The location of BELFAST in an apparent crossgradient position relative to HV5 compromises its capacity as a sentinel well, particularly if HV5 is not pumped consistently. To the extent that water levels are representative of the shallow part of the deep zone, the similarities of BELFAST's hydrograph to shallow zone well hydrographs in the J Subregion are consistent with a relatively good connection between the water table and the interval where BELFAST is constructed.	KEY ELL: Provides assessment of PCE dynamics in deep zone portion of J plume at a depth that coincides with part of the screened interval where municipal water supply well HV5 is constructed. May provide some level of sentry capacity, but its position relative to the HV5 capture zone (and/or the ambient gradient toward HV5) is uncertain.	HIGH: Key well	BELFAST has a relatively poor pedigree because no driller's log or construction records exist. The well has qualitative value because based on video logging it does monitor the shallower parts of the deep zone where potential receptor HV5 is constructed. PCE concentrations at BELFAST should be compared to concentration results at CTM85 to assess whether PCE patterns or trends at BELFAST are potential indicators of where BELFAST is positioned relative the HV5 capture zone. The step increase in PCE concentrations starting in 2007 (from non-detect to consistent, but low PCE concentrations between 1.3 and 2.4 µg/L) should be assessed for potential increased risk to HV5.
CTM 0S	SPATIAL BACKGRO ND MONITORING	PCE non-detects during the GMP period of record are consistent with this well being outside of any current area of PCE contamination. The single non-GMP historical PCE detection suggests that PCE contamination existed in this area prior to the GMP. Currently the well functions to monitor potential for the occurrence of contamination in the area upgradient of municipal supply well HV3 and proximal to several current and historical PCA's in the nearby small commercial complex on Edison Way.	Not a ey well	MODERATE: Verifies that no potential upgradient sources exist in part of aquifer where PCA's exit nearby or upgradient	As businesses close and land becomes open space for flood control, well may only have value as a water level monitoring site.
CT	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE non-detects are consistent with a decreasing PCE concentration gradient in the deep zone between BELFAST (with recent detections in the 1.3-2.4 µg/L range) and CTM85. CTM85 is considered to provide better sentinel capacity than BELFAST because of its more proximal position and its optimally positioned screened interval constructed in a relatively permeable interval located at an appropriate depth to coincide with the screened interval at HV5. PCE non-detects may suggest that the J plume (as currently defined by CTM87, CTM86, and BELFAST), is south of and outside the recent operational capture zone of HV5. However, this interpretation is conjectural because of the limited number of wells in the J Subregion to sufficiently characterize the area or the plume extents.	KEY ELL: Provides sentinel capacity for municipal water supply well HV5.	HIGH: Key well	CTM85 and CTM86 represents more optimally located sentinel wells for HV5 compared to BELFAST. Both should be monitored closely for any indication of PCE concentration changes, patterns, trends on a quarterly basis at least until the end of 2011. At that point, depending on PCE trends in the subregion, sampling frequency could be reassessed. Any PCE concentrations at either CTM85 or CTM86 that indicate an emerging increasing trend should be tracked for potential increased risk to HV5 municipal water supply well.

O LE S BREGION ELL NET ORK RE IE SPREADSHEET

ell ID	Primary ell Function	Integrated Function/ alue	Should well e a Key ell	Relati e ell alue	Follow-up Actions and Key Conditions to Monitor
CT	RISK ASSESSMENT TO POTENTIAL RECEPTOR	PCE data at CTM86 help define and track low level PCE concentrations (~< 1 µg/L) proximal to and at a depth that coincides with the upper portion of the screened interval at municipal water supply well HV5. CTM86, in combination with CTM85 provide sentinel capacity for the more transmissive (and potentially more "at-risk") portions of the aquifer where HV5 is constructed. Water level data in combination with CTM85 (and potentially HV5M) function to help assess vertical hydraulic communication in the area between HV5 and the currently defined J plume outline.	KEY ELL: Provides sentinel capacity for municipal water supply well HV5.	HIGH: Key well	CTM85 and CTM86 represents more optimally located sentinel wells for HV5 compared to BELFAST. Both should be monitored closely for any indication of PCE concentration changes, patterns, trends on a quarterly basis at least until the end of 2011. At that point, depending on PCE trends in the subregion, sampling frequency could be reassessed. Any PCE concentrations at either CTM85 or CTM86 that indicate an emerging increasing trend should be tracked for potential increased risk to HV5 municipal water supply well.
CT	SITE-SPECIFIC PL ME DYNAMICS	PCE data at CTM87 define one of two data points (along with CTM86) that defines the shallow zone portion of the J complex plume. It has value primarily in characterizing and potentially assessing plume dynamics in the area where the well is constructed. The lack of additional shallow zone wells, particularly north of CTM87 and west of CTM86, make it impossible to define the actual plume extent and therefore put PCE data in appropriate context. Water level data are of value primarily for contouring and lateral gradient definition.	KEY WELL: Provides assessment of PCE concentration dynamics in shallow zone. Currently only well constructed in shallow zone portion of plume as defined by .50 µg/L reporting limit.	HIGH: Key well	CTM87 is the furthest upgradient well in the J plume. It should continue to be monitored quarterly for the indefinite future. Additional shallow zone wells are needed to define the plume, particularly in the lateral dimension (to the north).
GLOBALM 1	SPATIAL BACKGRO ND MONITORING	PCE non-detects constrain northern extent of shallow zone portion of the J complex plume. Well functions to verify northern extent of shallow zone portion of J plume.	Not a ey well	MODERATE: Verifies that no potential upgradient sources exist in part of aquifer where PCA's exit nearby or upgradient	Continued general monitoring.
H	RISK ASSESSMENT TO POTENTIAL RECEPTOR	HV4 functions in a self-sentry capacity. Pre-GMP PCE detects at this well and at nearby shallow zone wells CTM20S and USGSAG and the presence of upgradient PCAs are consistent with relatively higher potential risk for PCE impacts at this well.	Not a ey well	MODERATE: Potential receptor in a part of aquifer where PCA's exist nearby or upgradient	Continued opportunistic monthly water quality monitoring. Consider deploying pressure transducer as part of SCADA system.
H	NO SIGNIFICANT F NCTION ITH REGARD TO GMP OB ECTI ES	HV3 has no significant value to the GMP. As a municipal water supply induction well, it is not considered a viable potential receptor.	Not a ey well	LIMITED: Induction well with limited value as a result of type of well construction.	Consider deploying pressure transducer as part of SCADA system to provide assessment capability of deep zone hydrodynamics.
H 5	RISK ASSESSMENT TO POTENTIAL RECEPTOR	HV5 functions in a self-sentry capacity. Pre-GMP PCE detects are consistent with either the J plume or another, different-sourced zone of PCE contamination having historical impacts at HV5. The presence of upgradient PCAs are also consistent with relatively higher potential risk for PCE impacts at this well.	KEY ELL: Potential receptor. Provides self-sentry capacity.	HIGH: Key well	Continued opportunistic monthly water quality monitoring. Consider deploying pressure transducer as part of SCADA system so vertical and lateral hydrodynamics in area could be better assessed utilizing HV5 water levels in conjunction with data from CTM85, CTM86, and HV5M. Any future PCE detections at well that suggest a potential increased risk at well should trigger an assessment of vertical distribution of PCE in well (BESST) as well as a focused source area investigation.

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H 5M	SPATIAL BACKGRO ND MONITORING	PCE non-detects at HV5M are consistent with the well being constructed outside of the J complex plume extent. The well is constructed significantly deeper than municipal water supply well HV5 making PCE data from this well of limited value for either plume assessment or for sentinel purposes. Water level data function to help assess vertical gradient dynamics in the subregion. These data combined with water levels at CTM85 and CTM86 suggest that vertical gradients may converge towards the part of the aquifer where HV5 is screened both during pumping and non-pumping periods, but additional data are needed to confirm this interpretation.	Not a ey well: Should be utilized as part of a Key Well cluster with CTM85 and CTM86.	MODERATE: Provides regional-scale hydrodynamics and assessment of vertical flow dynamics.	Consider adding this well to well cluster assessment with CTM85, CTM86, and HV5 (if SCADA is implemented at this well).
PE I	SPATIAL BACKGRO ND MONITORING	PCE non-detects are consistent with this well being unimpacted by PCE. Its construction deeper than and potentially upgradient of the J plume make this well of limited value for plume assessment. However this well does function to assess the potential for the migration of other upgradient PCE plumes including the SR, DR, and M/K plumes into this area. And as a potential receptor, it has value as a self-sentry site. Water levels provide valuable data to assess regional hydrodynamics in the deep zone portion of the aquifer in this area.	Not a ey well	MODERATE: Regional-scale hydrodynamics assessment. Acts in a self-sentry capacity for migration of upgradient contamination into area.	Continued opportunistic monthly water quality and water level monitoring.
SGSAG	SPATIAL BACKGRO ND MONITORING	PCE non-detects during the GMP period of record are consistent with this well being outside of any current area of PCE contamination. The multiple non-GMP historical PCE detections as high as 20.6 µg/L suggests that PCE contamination existed in this area prior to the GMP. Currently the well functions to monitor potential for the occurrence of contamination in the area crossgradient, but proximal to municipal supply well HV3 and downgradient to several current and historical PCA's in the nearby small commercial complex on Edison Way.	Not a ey well	MODERATE: Verifies that no potential upgradient sources exist in part of aquifer where PCA's exit nearby or upgradient.	As businesses close and land becomes open space for flood control, well may only have value as a water level monitoring site.