Record of Decision

Remediation of Groundwater at the Maryland Square Tetrachloroethylene (PCE) Site

Clark County, Nevada

March 31, 2015

Prepared by:

Nevada Division of Environmental Protection

PART I THE DECLARATION

1.1 Site Name and Location

Maryland Square Tetrachloroethylene (PCE) Site
Clark County, Nevada, NDEP Facility ID H-000086 Former Maryland Square Shopping Center
3661 S. Maryland Parkway
Las Vegas, Nevada
APN 162-15-602-009

1.2 Statement of Basis and Purpose

This decision document presents the Selected Remedy for cleanup of PCE-contaminated groundwater at the Maryland Square PCE Site (Figure 1-1). This decision is based on the administrative record file for Nevada Division of Environmental Protection (NDEP) Facility ID H-000086. The NDEP is the lead agency overseeing cleanup of this site.

1.3 Assessment of Site

The response action selected in this Record of Decision (ROD) is necessary to protect public health and the environment from hazardous substances historically released into the environment, where contaminants from the site may present an imminent and substantial endangerment to public health or welfare.

1.4 Description of Selected Remedy

This remedial action for groundwater at the Maryland Square PCE Site addresses the need to protect human health and the environment by containing and remediating the PCE-contaminated groundwater. Groundwater extraction and above-ground treatment will be used to hydraulically contain and remediate PCE-contaminated groundwater at the "East Treatment Area," which is immediately upgradient of the residential neighborhood. In addition, several treatment technologies to remove or destroy contaminant mass will be deployed immediately downgradient from the historical release point (former Al Phillips the Cleaner at the former Maryland Square Shopping Center). PCE-contaminated soil in the source area at the site of the former dry cleaners was cleaned up in September 2011.

The Selected Remedy includes the following actions:

1. Use pumping wells and groundwater extraction to hydraulically contain PCE-contaminated groundwater upgradient of the residential neighborhood
2. Perform above-ground treatment of extracted groundwater prior to release or reinjection
3. Install and implement destructive or removal technologies to reduce the main mass of PCE, which lies across the street and downgradient of the source area; selected technologies include the following:
    a. In situ chemical oxidation (ISCO)
    b. Air sparging and vapor extraction (AS/VE)

Additional on-going actions at the site include the following:

1. Annual/semi-annual/quarterly sampling and monitoring of groundwater wells
2. Annual indoor air sampling
3. Maintenance of vapor-mitigation systems installed in homes where concentrations of PCE in indoor air exceeded the NDEP's interim-action level of 32 micrograms per cubic meter ($\mu g/m^3$).
4. Installation of vapor-mitigation systems in additional homes, as needed, based on analytical data for PCE in indoor-air samples collected during annual monitoring
5. Monitoring the terminus of the PCE plume in groundwater to evaluate for potential migration farther downgradient

Additional high-resolution characterization will likely be performed in the proposed treatment areas.

1.5 Statutory Determinations

The Selected Remedy attains the mandates of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section 121 and to the extent practicable, the National Contingency Plan (NCP). Specifically, the remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable to the remedial action (unless justified by a waiver), is cost-effective, and employs permanent solutions to the maximum extent possible.

This remedy also satisfies the preference in CERCLA for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

This remedy may leave residual contaminants in groundwater above levels that allow for unlimited use and unrestricted exposure. It will take more than five years to attain remedial action objectives and cleanup levels, so a remedy review will be conducted within five years of completion of the physical construction of the remedy to ensure that the remedy is, or will be, sufficiently protective of human health and the environment.

1.6 Certification Checklist for ROD Data

The following information is included in the Decision Summary Section of this ROD. Additional information can be found in the administrative record file for this site (http://ndep.nv.gov/pce/foia.htm).

1. Site-related contaminants, PCE and its degradation products (trichloroethylene [TCE]; 1,2-cis dichloroethylene [1,2-cis DCE]; and vinyl chloride) and their respective health-based concentrations for all media of interest; in this case, groundwater and vapor (i.e., indoor air)

2. Screening-level human health risk assessment (HHRA) for exposure to site-related contaminants in groundwater and vapor phase

3. Cleanup levels established for the site-related contaminants and the basis for these levels

4. How source materials constituting principal threats are addressed

5. Current and reasonably anticipated future uses of affected and potentially affected properties

6. Current and potential future beneficial uses of groundwater as described in the screening-level HHRA and ROD

7. Potential uses of groundwater that will be available at the site as a result of implementing and completing the Selected Remedy

8. Estimated capital; operation and maintenance (O&M); and total present-value costs, discount rate, and the number of years over which the remedy cost estimates are projected and

9. Key factors that led to selecting the remedy

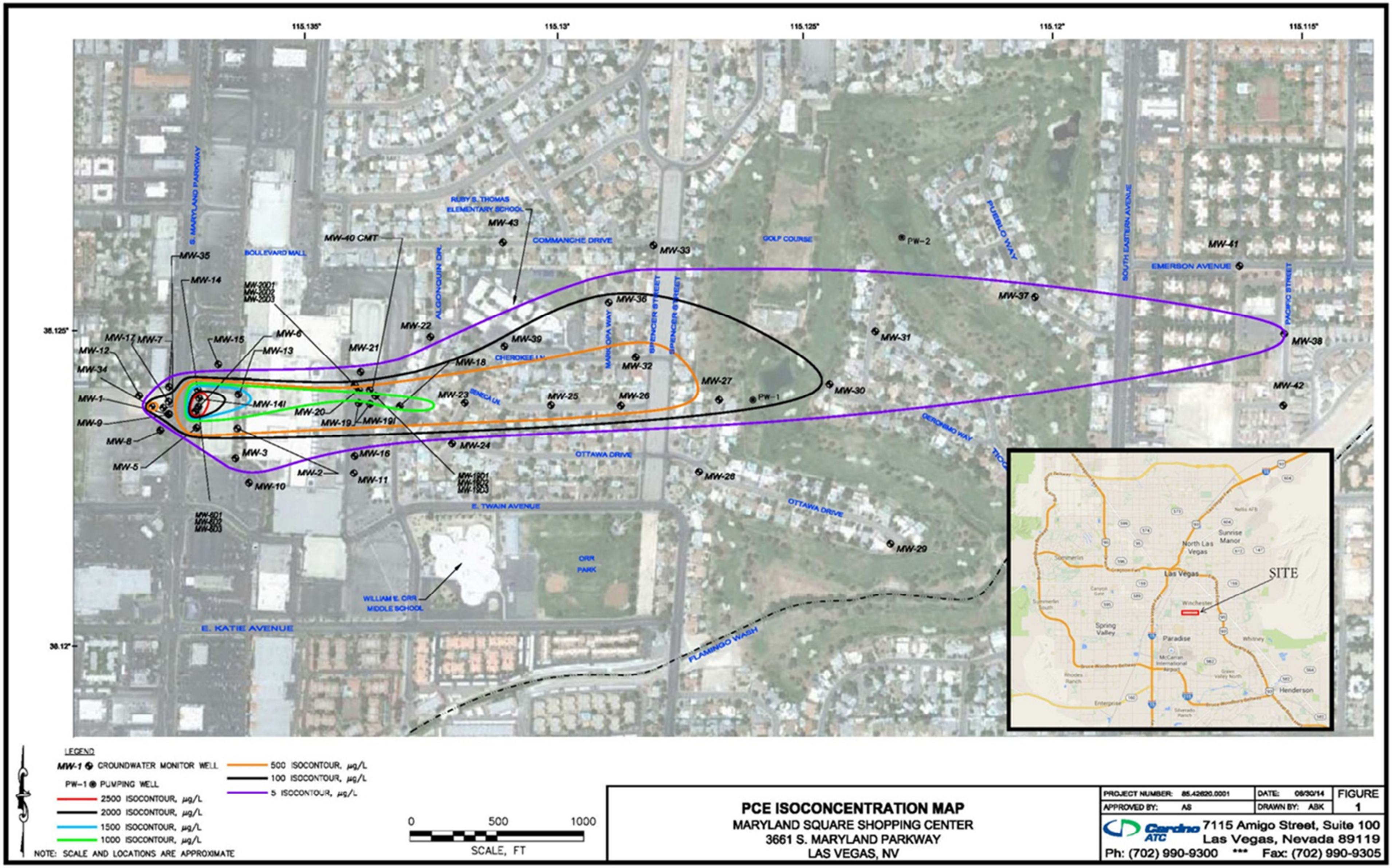
1.7 Authorizing Signature

4/6/15

Colleen Cripps, Ph.D., Administrator
Nevada Division of Environmental Protection

Date

Figure 1-1. Maryland Square PCE Site: PCE Plume in Groundwater and Location Map (inset)



PART II THE DECISION SUMMARY

1.0 Site Name, Location, and Description

The source for the Maryland Square PCE Site is the former dry cleaner in the former Maryland Square Shopping Center located at 3661 South Maryland Parkway, Las Vegas in Clark County, Nevada. The parent parcel for the former shopping center is located on the northwest corner of Maryland Parkway and Twain Avenue, and lies within the Southeast ¼ of the Northeast ¼ of Section 15, Township 21 South, and Range 61 East. This parcel is designated as assessor's parcel number (APN) 162-15-602-009 and is a 6.57-acre tract of land.

The site of the former Maryland Square Shopping Center is zoned commercial and currently consists of an empty, graded dirt lot, with grading performed following excavation and treatment of PCE-contaminated source soils in September 2011. Properties surrounding the former Maryland Square Shopping Center consist primarily of commercial developments, as well as some residential areas to the north. The Boulevard Mall lies directly east of the source area, across South Maryland Parkway. A residential neighborhood and a golf course are located east of the Boulevard Mall.

The plume of PCE-contaminated groundwater extends more than 6,000 feet downgradient (to the east) and is approximately 400 to 1,200 feet wide, as defined by the 5 micrograms per liter (µg/L) boundary. Drilling and multi-depth sampling indicates the zone of shallow, PCE-contaminated groundwater is about 60 to 70 feet thick (i.e., the zone of PCE-contaminated groundwater extends from the water table to 80 or 90 feet below ground surface). Vertical hydraulic gradients are mixed and variable, with these gradients sometimes indicating upward flow and sometimes indicating downward flow.

The NDEP is the lead agency providing regulatory oversight for the Maryland Square PCE Site and the NDEP Facility ID number for the site is H-000086. The source of cleanup monies is an enforcement settlement with the potentially responsible parties (PRPs).

2.0 Site History and Enforcement Actions

The source of groundwater contamination was the release of PCE to the ground from spills inside of the former Al Phillips the Cleaner and from drain lines beneath the dry cleaners, which was located in the former Maryland Square Shopping Center at 3661 S. Maryland Parkway, Las Vegas, Nevada. Contaminated source-area soils were excavated in late 2011; however, a significant mass of PCE was already within groundwater, with the main mass of contaminants migrating downgradient. The area of highest concentrations appears to now reside beneath a parking lot, just across the street and downgradient from the former dry cleaners (see Figure 1-1).

2.1 Site History

The source area for the Maryland Square PCE Site is located at 3661 South Maryland Parkway in Las Vegas, Nevada. The source area is the location of a former dry cleaner (Al Phillips the Cleaner) that was contained within the former Maryland Square Shopping Center. Al Phillips the Cleaner operated at the site from 1969 through 2000.

Records obtained during legal actions revealed at least one large spill of PCE in 1982. An estimated 100 gallons of pure-phase PCE was spilled inside the dry cleaners, with some portion of that spill going down the drain and through the concrete floor. Additional spills were noted as resulting from filter changes and from button clean-outs of the dry cleaning equipment. This scenario of releases was reflected in the distribution of PCE-contaminated soils beneath the former building that housed the dry cleaners.

During excavation of source-area soils, an additional area of contaminated soil was found in an area that would have corresponded to the area out the back door of the former dry cleaners. This may be related to disposal of PCE-contaminated waters out the back door or outside storage of used filters and containers that held PCE.

2.2 Previous Investigations and Enforcement Activities

The initial spill report for PCE in groundwater was reported to the NDEP in November 2000. The contamination was discovered during environmental investigations being performed for a property transaction. A soil boring installed during the initial environmental investigation at the former shopping center was converted into a monitoring well (MW-1). Analysis of the groundwater sample collected from MW-1 found 2,300 µg/L (or parts per billion, ppb) of PCE in groundwater. This concentration of PCE exceeded Nevada's action level of 5 µg/L, as defined in NAC445A.2273.5(1)(c), which adopts the primary maximum contamination level (MCL) of 5 µg/L for PCE in drinking water, as defined by the U.S. Environmental Protection Agency (USEPA).

From 2000 through 2004, additional soil borings and monitoring wells were installed at the former Maryland Square Shopping Center and to the east on the Boulevard Mall property in an attempt to find the eastern extent of the PCE plume. In February, the parent company (DCI) of the former dry cleaners accepted responsibility for the PCE contamination and assumed control of assessment activities, using URS to perform additional characterization and groundwater monitoring.

In March 2005, after not finding the eastern extent of the PCE plume on mall property, URS installed five monitoring wells within the residential neighborhood east of the Boulevard Mall. Concentrations of PCE exceeded the action level (5 µg/L) in groundwater samples collected from three of these five wells, with the highest concentration at 1,430 µg/L. In 2006, two additional wells were installed farther east in the neighborhood, and groundwater samples from the wells confirmed the presence of the PCE plume in groundwater beneath the neighborhood.

Following the discovery and confirmation of the PCE plume in the neighborhood in 2005/2006, in early 2007 the NDEP performed vapor transport modeling using the analytical data from groundwater samples collected from wells within the neighborhood. The results of modeling indicated the potential for unacceptable level of PCE vapors in indoor air, via the process of vapor intrusion. In response to a NDEP requirement to sample soil gas for PCE, URS conducted a soil vapor study in March 2007. These soil-gas data confirmed the presence of PCE vapors in unsaturated soils above the contaminated groundwater.

Approximately 16 months after discovery and confirmation of PCE-contaminated groundwater in the neighborhood, and less than 6 months after confirming PCE vapors in soil gas within the neighborhood, the NDEP performed a public outreach (August 27, 2007), mailing notification letters to approximately 200 residents, issuing a press release, and providing a dedicated website and call-in line for residents. While continuing cleanup negotiations with the responsible parties, the NDEP conducted indoor-air sampling of 97 homes and 2 schools.

The dry cleaner's parent company (DCI) declared bankruptcy in July 2008, and a new consultant, on behalf of the Trust (owners of the former Maryland Square Shopping Center), resumed quarterly monitoring as required by the NDEP. The NDEP then began cleanup negotiations with the former property owner to obtain money for cleanup. On May 4, 2009, following 11 months of negotiations between NDEP and the property owner, the Nevada Office of Attorney General Filed a Complaint in U.S. District Court, District of Nevada, against all PRPs for the Maryland Square PCE Site. This complaint requested injunctive relief (cleanup of contaminated soil and groundwater) and cost recovery for state funds expended on indoor air sampling, home mitigation, and other work. The NDEP complaint is available at: http://www.ndep.nv.gov/pce/record/2009_05_04_marylandsquare_ndep_complaint.pdf.

Based on revisions to a one-page outline that NDEP provided to the Court in July 2010, the NDEP worked with citizen plaintiff's attorneys to finalize a revised version of the injunction. On December 27, 2010, the U.S District Court issued a Permanent Injunction that dictated the requirements for remediation of source-area soils and PCE-contaminated groundwater across the site, including selection and implementation of cleanup in a manner not inconsistent with the National Contingency Plan (NCP). The injunction also decreed that groundwater monitoring should continue based on the schedule previously defined by the NDEP.

Starting in late August 2011, cleanup of source-area soils was initiated. More than 4,000 tons of soil was excavated and approximately 20 tons shipped for treatment and disposal to a Resource Conservation and Recovery Act (RCRA) Subtitle C landfill in Beatty, Nevada. A total of 2,290 tons was shipped for thermal treatment and recycling. Following excavation and treatment of the pit floor with an oxidant (potassium permanganate), the excavation was back-filled and re-graded in October 2011.

Pilot testing for groundwater remedies was performed in 2013. Testing focused on ISCO, using potassium permanganate in one test and peroxide-activated ozone injections in another test. Pumping tests were also performed at several locations, in parking lots downgradient of the source ("West Treatment Area") and immediately upgradient of the neighborhood ("East Treatment Area"). A pilot test for AS/VE was proposed, but a thick layer of caliche across the water table in the East Treatment Area may have made it difficult for the vapor extraction to capture fugitive PCE vapors generated by the air sparging. Because the pilot testing in the East Treatment Area was within a hundred feet or so from the residential neighborhood, the NDEP did not want to risk production of uncaptured fugitive vapors so close to the homes. Therefore, the AS/VE pilot test was not performed. Use of AS/VE in the West Treatment Area is less of a concern because the area is in a parking lot surrounded by commercial buildings, and the caliche zone is not as thick or extensive as it is in the East Treatment Area.

As of the date of this ROD, there are 59 monitoring wells (some of which include nested and multi-depth wells) located across the site. The site spans more than 6,000 feet in length, from the source area to the terminus of the plume east of Eastern Avenue, as defined by the 5 µg/L boundary. Wells across the site are sampled quarterly, semi-annually, or annually, depending on location and concentration. Indoor air sampling is performed annually.

3.0 Community Participation

On August 27, 2007, the NDEP mailed notification and information packages to residents in an area of homes east of the Boulevard Mall. The information provided a description of the contamination and the potential for vapor intrusion to affect indoor air in the homes, along with an offer to sample the indoor air. The NDEP met with residents in their homes to discuss the matter and answer any questions about the contaminated groundwater and the upcoming indoor-air sampling.

Also in August 2007, the NDEP sent out a press release, set up a resident call-in line, and set up a website for the Maryland Square PCE Site. The website includes the entire administrative record (all documents and letters as pdf files), a background document, a frequently asked questions (FAQ) document, and links to other information sources, as well as contact information for the NDEP (http://ndep.nv.gov/pce/maryland_square.htm).

In February, 2008, the NDEP mailed out notification and information packets for an additional area of the neighborhood when the plume was found to be located several hundred feet north of where the plume boundary was anticipated. Again, NDEP staff conducted in-home meetings with residents to answer their questions. An "***Information Update – Indoor Air Issue***" in fact-sheet form was also mailed out to residents in Spring 2008.

A ***Fact Sheet*** on the current status of site investigation and remediation was released in October 2011. A **Community Meeting** was held in Las Vegas on October 26, 2011 to describe the cleanup of source-area soils and present the path forward for cleanup of groundwater; residents were notified of the meeting via mail and door-to-door flyers. The Final ***Community Involvement Plan*** was released on May 2, 2012.

On October 15, 2014, the ***Proposed Plan for Cleanup of Groundwater*** was released, along with a ***Proposed Plan Fact Sheet*** announcing the release of the Proposed Plan and soliciting comments on the Plan. The Fact Sheet was mailed out to nearly 800 residents and businesses in the general area of the Maryland Square PCE Plume, and also served as the announcement for the Community Meeting on the Proposed Plan.

The **Community Meeting** to present the Proposed Plan was held in Las Vegas, Nevada on November 19, 2014, at a community center not far from the affected neighborhood. At this meeting, the County Commissioner spoke briefly, and NDEP representatives gave slide presentations and answered questions about the Maryland Square PCE Site and the remedial alternatives proposed for cleanup of groundwater. One verbal comment on the Selected Remedy and two written comments on other site-related issues were received at the meeting. No other specific comments on the proposed remedy or objections concerning the preferred remedial alternative were raised at the meeting.

The NDEP received a comment letter from the plaintiff's attorney's environmental expert and two comment forms filled out by participants at the Community Meeting. The NDEP did not receive any additional written comments from the community during the remainder of the 90-day public comment period for the Proposed Plan (October 15, 2014 through January 13, 2015). All comments received are addressed in the Responsiveness Summary in Part III of this ROD.

4.0 Scope and Role of Operable Unit or Response Action

The Maryland Square PCE Site consists of a plume of PCE-contaminated groundwater in the shallow groundwater (the Las Vegas Aquitard). Depth to shallow groundwater is from 10 to more than 25 feet below ground surface across the site. Contaminated soil in the source area was removed and treated in September and October 2011; however, a mass of highly contaminated (as much as 10,000 μg/L PCE) groundwater had already migrated offsite by the time the onsite contamination was discovered in 2000. The main mass of PCE currently underlies the West Treatment Area, which is near-downgradient from the former dry cleaners. Because the main mass lies beneath the West Treatment Area, remediation of the groundwater in that area will be the most cost-effective location for remedy implementation.

The overall plan for site cleanup includes the following:

- Cleanup of source-area soil (completed by October, 2011)
- Containment of the PCE plume upgradient of the residential neighborhood ("pump and treat" component of the proposed remedy)
- Removal of PCE mass from groundwater (destruction and removal component of the proposed remedy)
- Continued monitoring of groundwater across the site

- Annual indoor-air sampling of homes overlying areas overlying the plume where PCE concentrations exceed 100 µg/L (indoor-air sampling is voluntary and performed at no cost to the property owner)
- Installation of vapor-mitigation systems in homes where PCE concentrations exceed the interim-action level of 32 µg/m3 for residential indoor air (acceptance of a system is voluntary and system is installed at no cost to the property owner)

Remediation of site groundwater is being performed under the regulatory authority of the State of Nevada, and pursuant to the Permanent Injunction, issued by U.S. District Court, District of Nevada, Case No. 2:08-cv-01618 RCJ (GWF)

5.0 Site Characteristics

The Maryland Square PCE Site includes contaminated soil and groundwater at the site of the former dry cleaners, as well as an offsite plume of PCE-contaminated groundwater. The dry cleaner operated at the Maryland Square site from 1969 through 2000. The exact dates of all spills are not known; however, at least one major spill in 1982 was estimated at 100 gallons of PCE, and some minor spills have been described by former workers at the former dry cleaners. The shopping center was demolished in mid-2006. Following cleanup of the source area by the excavation and removal of PCE-contaminated soils in the fall of 2011, the property was re-graded and is currently an empty dirt lot.

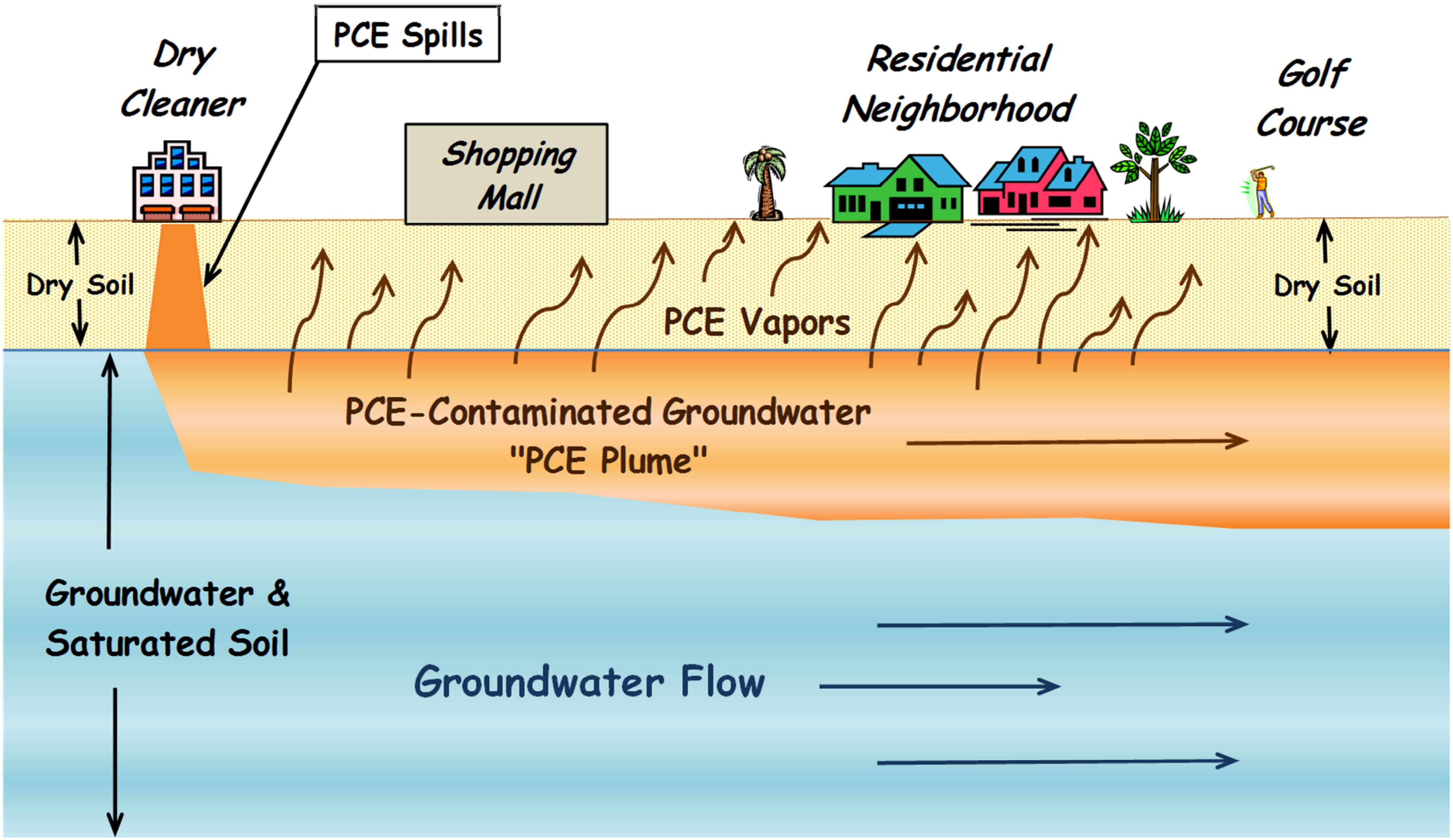
5.1 Conceptual Site Model

The conceptual site model (CSM) is based on the inhalation exposure pathway, wherein indoor air is contaminated with PCE vapors emanating from PCE-contaminated groundwater (Figure 5-1). Residents are exposed when they breathe the contaminated indoor air. Vapor intrusion has been confirmed at the site by sampling of soil gas and indoor air. There is also the potential for exposure via ingestion, if actively used domestic wells intercept the plume. The latter exposure scenario assumes that groundwater wells are completed in the shallow groundwater system hosting the Maryland Square PCE plume, and that the water is used as an untreated drinking water source. This latter scenario is unlikely to occur throughout most of the plume, because homes are on a city water system throughout the neighborhood and drilling of new domestic wells is generally prohibited in Las Vegas.

The deeper drinking-water aquifers underlying the Maryland Square PCE Site have not been affected by the PCE plume. The vertical hydraulic conductivity is significantly lower than (1/100th) the horizontal hydraulic conductivity; this means the dissolved-phase PCE plume migrates laterally rather than vertically. Additionally, a thick heterogeneous sequence of interbedded clays, silts, silty sands, caliche, and gravels overlies the drinking-water aquifer.

Site conditions indicate that it is highly unlikely that contaminants in the plume will migrate vertically downward to the water-supply aquifer at 300 to 500 feet below the ground surface. Studies of the chemical composition and extent of contamination across aquitards and aquifers in the basin show that areas of contaminated shallow groundwater have not affected the deep water-supply aquifer (Leising, 2004). Dissolved-phase PCE is neutrally buoyant, so barring any strong downward hydraulic gradient, downward migration of the plume is unlikely. Pure-phase PCE, which is classified as a "dense non-aqueous-phase liquid" (DNAPL) because it has a higher specific gravity than water and can migrate downward due to density differences, has not been found at the Maryland Square PCE site.

Figure 5-1. Conceptual Site Model showing Cross-sectional Representation of Source, Migration Pathways, and Receptors.



Results of contaminant-transport modeling using calculations and a simple analytical model are consistent with what is known about the site geology, geochemistry, and hydrogeology. That is, the PCE is not degrading via reductive dechlorination, the migration of PCE is only slightly retarded (due to low organic-carbon content of site soils), and some fraction of the PCE migrates more quickly through more transmissive zones such as sand channels or stringers, while the bulk of PCE migrates slowly through fine-grained materials.

The 14-compartment model for DNAPLs (Sale & Newell, 2011) suggests the Maryland Square PCE plume is a mature plume, with secondary sources (i.e., fine-grained soils saturated with PCE) serving to sustain the dissolved-phase plume. Slow release of PCE stored in fine-grained, low-conductivity materials can sustain a plume long after the primary source (free pure-phase DNAPL) is depleted.

Although the shallow groundwater in the Las Vegas Valley is of poor quality and not generally used for drinking water or other beneficial purposes, contamination of this groundwater with volatile chemicals is a concern for several reasons. Samples of soil gas and indoor air have confirmed that PCE vapors emanating from the contaminant plume have travelled through vadose-zone soils and up into homes overlying the plume. Concentrations of PCE in samples of groundwater collected from monitoring wells within the residential neighborhood have been as high as 3,500 µg/L.

Vapor intrusion is the process by which contaminant vapors enter into, and accumulate within, the indoor air of homes and other buildings. Exposure occurs when occupants breathe the contaminated indoor air. Analytical results from testing indoor air in more than 100 homes have found potentially unacceptable levels of PCE in indoor air in some of the homes. However, the only homes found to be adversely affected overlie groundwater with more than 100 µg/L PCE (i.e., homes outside of the 100 µg/L PCE contour in groundwater do not appear to be adversely affected by intrusion of PCE vapors).

5.2 Overview of Site

Size: The site encompasses the source area and the area underlain by the PCE plume in groundwater (see Figure 1-1). As defined at the 5 µg/L boundary, the plume extends more than 6,000 feet downgradient, from the source area at the former dry cleaners to well MW-38. Monitoring well MW-38 is located on Pacific Street, east of Eastern Avenue and about 400 feet south of the intersection of Emerson Avenue. The width of the PCE plume varies, ranging from 400 to about 1,200 feet, depending on location. The plume traverses beneath a large shopping mall east of the source area, and then enters a residential neighborhood about 1,300 downgradient of the source. About 3,400 feet downgradient, the plume passes beneath a golf course, where the centerline of the plume intersects an old (installed in 1961), deep-screened irrigation well. The shallow plume does not extend down to the depth of the screened interval of the deep well, but minor amounts of PCE-contaminated water have entered into the irrigation well casing by way of leakage past a failed surface seal, down the well annulus and through breaches in the steel casing. In 2004, 5.6 µg/L PCE was measured in the irrigation well.

The plume continues due east under more homes on the east side of the golf course, crosses under Eastern Avenue, and extends about 1,000 feet east of Eastern to the 5 µg/L contour. Depth to shallow groundwater ranges from about 10 feet to approximately 25 feet below ground surface (bgs) across the length of the plume. The zone of PCE-contaminated groundwater appears to reside in the upper 60 or 70 feet of the shallow groundwater system. A deeper water-supply aquifer is present at 300 feet or more in depth; intervening layers of silts, sands, and a thick sequence of clays likely impede downward migration of the dissolved-phase PCE. Unlike pure-phase PCE, which is denser than water and will migrate downward, dissolved-phase PCE is neutrally buoyant and should not tend to migrate vertically unless there is a strong downward gradient. Results from aquifer tests were used to conclude that horizontal hydraulic conductivity at the site is about 100 times greater than vertical hydraulic conductivity.

<u>Geographical and Topographical Information</u>: The hydraulic gradient generally follows the topography, which slopes gently toward the east. Land surface of the old alluvial fan setting is slightly undulating with ephemeral channels now covered over by homes, roads, commercial buildings and other developments. Flamingo Wash, which lies south of the plume, remains a main drainage channel that carries significant flow volume during heavy rain events. Portions of the wash are concrete-lined, especially through the more urban areas of Las Vegas. The wash meanders in an east-northeasterly direction. At present, the 5 µg/L boundary likely does not extend to the Wash, although it is possible that the distal portion of the plume is still migrating eastward with groundwater flow. Flamingo Wash is tributary to the Las Vegas Wash, with the intersection with Las Vegas Wash approximately 5 miles downgradient from the former dry cleaners at the former Maryland Square Shopping Center.

5.3 Surface and Subsurface Features

The area, which consists of alluvial-fan deposits crossed by ephemeral channels, was developed in the 1960s and 1970s as the City of Las Vegas grew. Boulevard Mall opened in 1968, making it the oldest mall in Las Vegas. The Las Vegas National Golf Course and surrounding homes were built from the early 1960s (the course was completed in 1961, as the "Stardust Country Club"). Most of the homes in the Paradise Palms neighborhood were built in the 1960s and 1970s, and include both custom-built and tract homes, but nearly all construction is slab on grade.

The Flamingo Wash, which is located south of the plume, was highly modified in the 1970s and was developed primarily as part of the flood conveyance system in the rapidly urbanizing area. From its origin as an ephemeral desert wash that existed prior to the 1950's, the Flamingo Wash is now driven hydrologically by urban run-off and treated water from upstream water-treatment facilities. The Flamingo Wash trends northeast and lies across the projected path of the PCE plume approximately 8,000 feet downgradient of the former dry cleaners.

5.4 Sampling Strategy

The initial spill report for PCE in groundwater was reported to NDEP in November 2000. The contamination was discovered during environmental investigations being performed for a property transaction. A soil boring installed during the initial investigation at the former shopping center was converted into a monitoring well (MW-1). Analysis of the groundwater sample collected from MW-1 found 2,300 µg/L PCE in groundwater. This concentration of PCE exceeded Nevada's action level of 5 µg/L, as defined in NAC 445A.2273.5(1)(c), which adopts the primary MCL of 5 µg/L for PCE in drinking water as the state action level.

From 2000 through 2004, additional soil borings and monitoring wells were installed at the former Maryland Square Shopping Center and to the east of S. Maryland Parkway in an attempt to find the eastern extent of the PCE plume. In February, the parent company (DCI) of the former dry cleaners accepted responsibility for the PCE contamination and assumed control of assessment activities, using URS to perform additional characterization and groundwater monitoring.

In March 2005, after not finding the eastern extent of the PCE plume, URS installed five monitoring wells within the residential neighborhood east of the Boulevard Mall. Concentrations of PCE exceeded the action level (5 µg/L) in groundwater samples collected from three of these five wells, with the highest concentration at 1,430 µg/L. In 2006, two additional wells were installed farther east in the neighborhood, and groundwater samples from the wells confirmed the presence of the PCE plume in groundwater beneath the neighborhood.

In early 2007, the NDEP performed vapor transport modeling using the analytical data for wells within the neighborhood. The results of modeling indicated the potential for unacceptable level of PCE vapors in indoor air, via the process of vapor intrusion. In response to a NDEP requirement to sample soil gas for PCE, URS conducted a soil vapor study in March 2007. Soil borings were installed along three transects across the inferred extent of the PCE plume; one transect in the eastern parking lot of the Boulevard Mall, and two within the residential neighborhood to the east of the Boulevard Mall. Soil gas samples were collected at multiple depths within each boring. The concentrations of PCE in soil vapor samples ranged from not detected to 170,000 $\mu g/m^3$, with the maximum concentration measured for a vapor sample collected at 20 feet bgs from boring SVB-14.

The dry cleaner's parent company (DCI) declared bankruptcy in July 2008, and URS discontinued work at the site. Converse Consultants, on behalf of the Trust, resumed quarterly monitoring as required by the NDEP. Converse continued with monitoring until July 2010, when field activities and responsibilities were transferred from Converse to Tetra Tech EM Inc. (Tetra Tech) during the second quarter of 2010. Groundwater monitoring protocol and procedures used by Converse and accepted by NDEP were continued to maintain data consistency.

On December 27, 2010, the U.S District Court issued a Permanent Injunction that dictated the schedule for remediation of source-area soils and PCE-contaminated groundwater across the site. The injunction also decreed that groundwater monitoring should continue based on the schedule previously defined by the NDEP. Responsibilities for groundwater monitoring and sampling were transferred from Tetra Tech to Cardno ATC in the fourth quarter of 2011. Tetra Tech continued to provide the Trust with support for indoor air testing and performed field pilot testing for groundwater remedies in early 2013. Pilot testing focused on use of injected oxidants to promote chemical oxidation of the PCE.

As of the date of this ROD, there are 59 monitoring wells (some of which include nested and multi-depth wells) located across the site. The site spans approximately 6,000 feet in length, from the source area to the terminus of the plume, as defined by the 5 µg/L boundary. Wells are sampled quarterly, semi-annually, or annually, depending on location and concentration.

5.5 Known Sources of Groundwater Contamination

The source of the PCE contamination was the former Al Phillips the Cleaner, which was located in the former Maryland Square Shopping Center at 3661 S. Maryland Parkway, Las Vegas, Nevada. The former shopping center was located on the northwest corner of Maryland Parkway and East Twain Avenue. This parcel is APN 162-15-602-004.

The dry cleaner operated at the Maryland Square site from 1969 through 2000. The exact dates of all spills are not known; however, at least one major spill in 1982 was estimated at 100 gallons of PCE, and some minor spills have been described by former workers at the former dry cleaners. The shopping center was demolished in mid-2006. Following cleanup of the source area by the excavation and removal of PCE-contaminated soils in the fall of 2011, the property was re-graded and is currently an empty dirt lot.

5.6 Types of Contaminants and Affected Media

PCE is the main contaminant at the site, with minor amounts of related TCE. No other site-related contaminants exceed action levels. The effects of PCE on human health depend upon the length and frequency of the exposure, in addition to the concentration. Based on testing of lab animals, PCE is believed to be a "possible to probable" carcinogen. TCE may cause harmful effects on the nervous system, liver, respiratory system, kidneys, blood, immune system, heart, and body weight, and there is some evidence that it causes liver cancer and malignant lymphoma (a blood cancer). Some studies suggest exposure to TCE during pregnancy is associated with low birth weight and heart defects.

TCE is a breakdown product of PCE, as well as a minor contaminant in pure commercial PCE. At the Maryland Square PCE Site, the percentage of TCE in samples containing more than 1,000 µg/L PCE is generally ranges from 0.1 to 0.8 percent, suggesting its presence may be an impurity in the original PCE solvent rather than as a result of in situ degradation of PCE. Complete reductive dechlorination of PCE requires reducing conditions (about -240 millivolts [mV]); this value for the oxidation-reduction potential (ORP) occurs only in one well (MW-10), which was the site of a small gasoline release decades ago. Elsewhere across the plume, ORP values are too high for complete reductive dechlorination to occur.

Both PCE and TCE are termed "DNAPLs" because they are only slightly soluble in water and have higher densities than water. Consequently, both will migrate downward when present as pure-phase liquids; however, the dissolved phase is neutrally buoyant. Both PCE and TCE sorb to aquifer materials, especially organic carbon, which retards migration of these solvents. PCE and TCE can sorb to fine-grained aquifer materials, which then themselves, can back-diffuse into groundwater, creating a persistent secondary source of contamination (Sale and Newell, 2011).

- PCE in Soil
  PCE-contaminated soil at the former dry cleaners was cleaned up in September 2011. The site was excavated nearly down to groundwater (about 18 feet below ground surface), and the base of the excavation was treated with an oxidant (potassium permanganate, $KMnO_4$ to promote chemical destruction of residual PCE prior to backfilling. The excavation was backfilled with clean soil and re-grading of the site was completed in October 2011.

- PCE in Soil Gas
  Samples of soil gas collected at multiple depths at several locations across the plume showed concentrations of PCE as high as 170,000 µg/m^3 west of the neighborhood and as much as 46,000 µg/m^3 in shallow soil gas within the residential neighborhood. The NDEP performed vapor-transport monitoring using the data from soil-gas samples. The results from NDEP's modeling, prompted the NDEP to offer indoor air sampling to residents whose homes were potentially affected by PCE vapors emanating from groundwater.

- PCE in Groundwater
  Concentrations of PCE detected in groundwater samples collected from wells across the site range from not detected at 0.05 µg/L to 10,000 µg/L (MW-14I). Currently, there are 15 wells (out of 59) that contain concentrations of PCE greater than 1,000 µg/L, and the plume, as defined by the 5 ppb contour, extends more than 6,000 feet downgradient from the source area.

5.7 Location of Contaminated Media and Potential Routes of Contaminant Migration

PCE was released to soil at the site of the former dry cleaners. Some PCE was retained in unsaturated soil; some of the PCE migrated into groundwater as DNAPL (100-gallon spill) and dissolved-phase PCE (minor spills). DNAPLs migrate vertically under density-driven flow, all the while partitioning into groundwater as dissolved-phase PCE. Some DNAPL becomes trapped in soil due to capillary pressures, capture in dead-end pores, and sorption. PCE also volatilizes into soil gas. Both dissolution and volatilization are driven by the process of chemical equilibrium.

5.7.1 PCE-Contaminated Soil

Contaminated soils at the site of the former dry cleaners were excavated and treated in 2011. The excavation extended down to just above the water table. Oxidant solution was sprayed on the floor of the excavation to treat residual PCE in soil. Based on the age of the site, it is reasonable to assume that PCE sorbed into fine-grained saturated soils will continue to sustain the dissolved-phase plume by back-diffusion of PCE into groundwater.

5.7.2 PCE-Contaminated Soil Gas

PCE evaporates from DNAPL into air and from liquid into air. In subsurface soil, air-filled pores represent “soil gas.” PCE vapors in soil gas can migrate in any direction (i.e., are not constrained by the hydraulic gradient of groundwater) along the most transmissive pathways. PCE vapors in soil gas can travel by diffusion, and contaminate groundwater or can be transported into overlying buildings by advection if caught in the vacuum envelope of the building. Predicting the distribution of contaminated soil gas is difficult and is best pictured as a “patchy fog” emanating from the surface of the PCE-contaminated groundwater.

5.7.3 PCE-Contaminated Groundwater

PCE spilled at the former dry cleaners migrated down through the soil and into groundwater, where it ultimately formed a plume of PCE-contaminated groundwater that now extends more than 6,000 feet downgradient, as defined by the 5 µg/L isoconcentration contour (see Figure 1-1). The largest mass of PCE, however, remains just downgradient of the source area, apparently retained in fine-grained soils. The highest concentration of dissolved PCE (10,000 µg/L) was measured in a sample from well MW-14I, directly across the street and approximately 120 feet downgradient from the former dry cleaners. Data from 59 monitoring wells installed across the site and screened at different depths (though most are screened across the water table) describe a dissolved-phase PCE plume that is more than 6,000 feet long, about 1,000 feet wide and approximately 70 to 80 feet thick.

The plume is contained within the shallow portion of a basin-wide aquitard (Las Vegas Wash Aquitard) that consists of a heterogeneous package of sandy, silty, and clayey sediments, with lenses and layers of gravels and caliche. The thickness of the aquitard is estimated to be from 50 to 450 feet, and it regionally overlies and confines the Las Vegas Springs Aquifer (Leising, 2004). The quality of groundwater in the shallow zone is poor and the water has no widespread beneficial use. Some old domestic wells that tap into the shallow groundwater are shown in a database maintained by the Nevada Division of Water Resources (DWR), but none are within the known extent of the plume, and it is unknown if any are still actively used.

6.0 Current and Potential Future Site and Resource Uses

The Maryland Square PCE Site is located in an urbanized area that was developed in the 1960s and 1970s, as Las Vegas expanded out across the desert. Properties surrounding the former Maryland Square Shopping Center consist primarily of commercial developments, as well as some residential areas. The site of the former shopping center is a level dirt lot; future commercial development of the site seems likely.

The Boulevard Mall lies directly east of the source area, across South Maryland Parkway. A residential neighborhood (Paradise Palms) and a golf course (Las Vegas National Golf Course) are located east of The Boulevard Mall. In 1965, the golf course and nearby homes lay surrounded by desert, south of the main part of the city. Even as late as 1973, undeveloped desert lay to the south of the Paradise Palms residential neighborhood

Reasonably anticipated future uses of properties across the site are likely to remain commercial and residential. The main recreational area within the site is the golf course, which may remain as a golf course or be developed as a new residential area.

Shallow groundwater is of such poor quality and productivity that it is unlikely to be put to beneficial uses. The amount of water contained in the shallow zone is partially sustained by irrigation of lawns and vegetation. As water conservation increases and more lawns are converted to xeriscape or artificial lawns, water levels in the shallow zone may drop. The effect of a declining water table on the contamination is uncertain.

7.0 Summary of Site Risks

A screening-level HHRA was performed and described in the ***Final Corrective Action Report for Groundwater*** (August 12, 2013). The primary objective of the HHRA was to evaluate whether site contaminants pose a current or potential risk to human health, in the absence of remediation. Risk is one of the factors that the NDEP considers in deciding whether to take actions on a site. For the Maryland Square PCE Site, the NDEP's decision to take action is based principally on the presence of contamination in groundwater at concentrations that produce unacceptable levels of PCE vapors that enter into homes overlying the plume, as well as evidence that contamination will continue to migrate into areas of groundwater that are presently clean or less contaminated.

Corrective action objectives defined in the Corrective Action Report are based on reducing risk and include the following:

1. Protect human health by reducing inhalation exposure to PCE and daughter products emanating from groundwater containing PCE concentrations above the site-specific remediation goal for protection of indoor air.
2. Remediate shallow groundwater where PCE concentrations exceed the site-specific remediation goal for groundwater.
3. Take appropriate action to assure that the drinking water standards for PCE and its degradation products are not exceeded in domestic wells identified within the 5 μg/L boundary of the plume, and an exemption under NAC 445A.227525(2) can be provided.

7.1 Summary of HHRA

As described in Risk Assessment Guidance for Superfund (RAGS) (USEPA 1989), this summary of health risk includes sections on identifying contaminants of concern, exposure assessment, toxicity assessment, and risk characterization.

7.1.1 Identifying Contaminants of Concern

The contaminants driving the need for remedial action (risk drivers) are identified based on the data collected during investigations conducted at the site between 2000 and 2013. Analytical data are available for groundwater samples collected from more than 50 monitoring wells, as well as data for a number of soil-gas samples and soil borings. PCE is the primary risk driver, followed by TCE, which was detected only sporadically. No other site-related chemicals were detected at concentrations that exceeded action levels. Table 7-1 provides a summary of contaminant concentrations in groundwater and indoor air.

Table 7-1. Range of Contaminant Concentrations in Groundwater and Indoor Air

Chemical	Groundwater Upgradient of Neighborhood		Groundwater in Neighborhood		Indoor Air	
	Min (µg/L)	Max (µg/L)	Min (µg/L)	Max (µg/L)	Min (µg/m3)	Max (µg/m3)
Tetrachloroethylene	<0.5	10,000	<0.5	3,500	<0.23	110
Trichloroethylene	<0.5	51	<0.5	5.2	<0.17	9.4
cis-1,2 dichloroethylene	<0.5	23	<0.5	nd	<0.15	nd
Vinyl chloride	<0.5	nd	<0.5	nd	<0.05	0.075

µg/L - Micrograms per liter

µg/m^3 - Micrograms per cubic meter

nd - Not detected (variable reporting limits)

7.1.2 Exposure Assessment

Exposure refers to the potential contact of an individual (receptor) with a chemical. Exposure assessment is the determination or estimation of the magnitude, frequency, duration, and route of potential exposure. This section briefly summarizes the potentially exposed populations, the exposure pathways evaluated, and the exposure quantification from the screening-level HHRA performed for the Maryland Square PCE Site. A complete discussion of all the scenarios and exposure pathways is presented in the Corrective Action Report (Tetra Tech, 2013) and is summarized in the following discussion.

- Inhalation of contaminant vapors in indoor air. The risk-based CSM describes the primary exposure pathway presented by intrusion of contaminant vapors into home overlying the PCE plume. The conditions that exacerbate vapor intrusion at this site include the high concentrations of PCE (as much as 3,500 µg/L) in the plume underlying the residential neighborhood; the shallow depth of groundwater (as shallow as 8 feet bgs) beneath the homes; the presence of generally dry sandy and silty soils in the neighborhood; the age and construction (slab-on-grade) of homes; the warm temperature of groundwater (approximately 25^{o}C on average), which promotes increased volatilization of PCE; and long duration of residence for a number of the homeowners, some of whom bought the homes when new in the late 1960s and early 1970s.

- Ingestion, dermal contact, and inhalation of groundwater contaminants for domestic usage. Another possible exposure pathway is the ingestion of PCE-contaminated groundwater; however, all residents in the Paradise Palms neighborhood are on the city water-supply system. The only potential for ingestion appears to be the possible presence of domestic wells in an area east of Eastern Avenue, near the terminus of the plume.

The vapor intrusion pathway is unique in that each home poses its own exposure area; there is no “averaging” of risk. Adjacent homes may be vastly different with respect to the extent and severity of vapor intrusion. Home-specific factors such as the heating and cooling system, slab condition, and architecture, along with behaviors of the residents, can greatly affect the extent to which vapor intrusion occurs in a single home.

Samples of indoor air have been collected from more than 100 homes within the neighborhood. Despite the coverage, some potentially affected homes have not been sampled (indoor air sampling is voluntary); this means that indoor air in a hypothetical “worst-case” home may have not been sampled. To account for homes that have not been sampled, the highest concentrations of PCE and TCE measured in indoor air were assumed for the “worst-case” analysis, which represents a conservative estimate of potential risk. There are at least 30 homes in the area of concern that have not been sampled.

7.1.3 Toxicity Assessment

The USEPA has classified PCE as likely to be carcinogenic to humans by all routes of exposure based on suggestive evidence in epidemiological studies and conclusive evidence in rats (mononuclear cell leukemia) and mice (increased incidence of liver tumors). The International Agency for Research on Cancer (IARC) has classified PCE as probably carcinogenic to humans (Group 2A). The USEPA has characterized TCE as “carcinogenic in humans by all routes of exposure.” This conclusion is based on convincing evidence of a causal association between TCE exposure in humans and kidney cancer. In addition to being a human carcinogen (TCE) or probable human carcinogen (PCE), both chemicals have toxicity data indicating their potential for adverse noncarcinogenic health effects. See USEPA for more information on health effects of PCE and TCE: http://www.epa.gov/iris/subst/0106.htm http://www.epa.gov/IRIS/subst/0199.htm

Tetrachloroethylene. The acute toxicity data for inhalation exposure of humans to PCE vapors show irritation of the upper respiratory tract and eyes, kidney dysfunction, and at lower concentrations, neurological effects, such as reversible mood and behavioral changes, impairment of coordination, dizziness, headache, sleepiness, and unconsciousness. The major effects from chronic inhalation exposure to PCE vapors are neurological effects, including sensory symptoms such as headaches, impairments in cognitive and motor neurobehavioral functioning and color vision decrements. For more information, see: http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showQuickView&substance_nmbr=0106

Trichloroethylene. Central nervous system effects are the primary effects noted from acute inhalation exposure to TCE in humans, with symptoms including sleepiness, fatigue, headache, confusion, and feelings of euphoria. Effects on the liver, kidneys, gastrointestinal system, and skin have also been noted. Chronic exposure to TCE by inhalation affects the human central nervous system. Case reports of intermediate and chronic occupational exposures included effects such as dizziness, headache, sleepiness, nausea, confusion, blurred vision, facial numbness, and weakness. Effects to the liver, kidneys, and immune and endocrine systems have also been seen in humans exposed to trichloroethylene occupationally or from contaminated drinking water. In addition, the USEPA derived a candidate reference dose (RfC) of 1.97 μg/m^3 (0.37 ppb) based on cardiac developmental effects observed in offspring of pregnant rats exposed to TCE (USEPA, 2011). There is medium confidence in the key cardiac developmental toxicity study and moderate-to-high confidence both in the hazard and the candidate reference values for developmental effects from exposure to TCE. For more information, see: http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showQuickView&substance_nmbr=0199).

The preliminary numerical remediation standard for PCE in shallow groundwater is 5.0 μg/L, the MCL promulgated under the Safe Drinking Water Act. The preliminary numerical remediation standard for PCE in indoor air is the concentration associated with a 10^{-6} carcinogenic risk as published in USEPA Region IX Regional Screening Levels (RSL) for indoor air in a residential scenario. When the ***Corrective Action Plan for Groundwater*** was written, this concentration was 0.41 μg/m^3, but has since changed to 9.4 μg/m^3. The concentration equivalent to a noncarcinogenic hazard index (HI) of 1 also changed from 276 to 42 μg/m^3 (USEPA 2012). Table 7-2 summarizes the toxicity information for site-related contaminants.

Table 7-2. Toxicity and Chemical-Specific Information

Chemical of Concern	CAS Number	IUR ($\mu g/m^3$)$^{-1}$ (IRIS)	Carcinogenic Screening Level TR=1.0E-6 ($\mu g/m^3$)	Carcinogenic Classification	RfCi (mg/m^3) (IRIS)	Noncarcinogenic Screening Level HI=1 ($\mu g/m^3$)	RFCi Uncertainty Factor	Target Organ
Tetrachloroethylene	127-18-4	2.60E-07	9.40E+00	Likely Carcinogenic to Humans	4.00E-02	4.20E+01	1000	Nervous System
Trichloroethylene	79-01-6	4.10E-06	4.30E-01	Carcinogenic to Humans	2.00E-03	2.10E+00	100	Liver, Kidney, Nervous System
Vinyl Chloride	75-01-4	4.40E-06	1.60E-01	Carcinogenic to Humans	1.00E-01	1.00E+02	30	Liver

Notes:

$\mu g/m^3$	Micrograms per cubic meter
mg/m^3	Milligrams per cubic meter
CAS	Chemical Abstract Services
HI	Hazard Index
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
RfCi	Reference Concentration - inhalation

7.1.4 Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to contaminants. These risks are probabilities that are expressed in scientific notation (e.g., 1E-06). An excess lifetime cancer risk of 1E-06 indicates that an individual has a one in one million (1 in 1,000,000) chance of developing cancer as a result of site-related exposure. This is referred to as an “excess lifetime cancer risk” because it would be in addition to the risks of cancer individuals face from other causes. The chance of an individual developing cancer from all other causes has been estimated to be as high as 1 in 3. The USEPA’s generally acceptable risk range for site-related exposures is 1E-04 to 1E-06 (in effect, 1 in 10,000 to 1 in a 1,000,000). An excess lifetime cancer risk greater than 1 in 10,000 (1E-04) is the point at which action is generally required at a site (USEPA 1991a).

The potential for noncarcinogenic effects is evaluated by comparing an exposure level, over a specified time period, with a reference dose (RfD), based on an average daily exposure or dose. The ratio of the dose to the RfD is referred to as the hazard quotient (HQ). An HQ less than one indicates that a receptor’s dose is less than the RfD and that adverse toxic noncarcinogenic effects from exposure to that chemical are unlikely. The sum of all of the chemical and route-specific HQs is called the hazard index (HI). An HI less than one indicates that noncarcinogenic effects from all the contaminants are unlikely. Table 7-3 provides estimates for cancer and non-cancer risks.

Indoor Air Pathway. The indoor air risks for the hypothetical resident were based on actual data obtained from indoor air. More than 100 different homes have been sampled, and some have been sampled multiple times since the indoor air sampling program began in 2007. The risks for the hypothetical residential receptor were calculated to be three in one hundred thousand (3E-05), as a result of inhalation exposure to PCE and TCE in indoor air, using current toxicity data. The cumulative exposure to PCE and TCE vapors in indoor air has an estimated HI value of 7, which exceeds the acceptable HI value of 1 or less and indicates a potential for adverse health effects (noncarcinogenic effects). One additional note on TCE, which was detected in 15 of the 40 homes sampled in 2014 (0.054 to 0.71 $\mu g/m^3$): Recent experimental data suggest that fetal heart deformation may result from maternal exposure to PCE during the early weeks of pregnancy. As a result, the NDEP has set the site-specific remediation goal for TCE at 2 $\mu g/m^3$ for residential indoor air.

Ingestion Pathway. Exposure to PCE and TCE through ingestion of untreated groundwater has not been documented at the Maryland Square PCE Site because all homes and businesses in the area are on the city water system. The DWR database shows one possible well at the 5 µg/L contour, located at 3887 Pacific, but there is no DWR well log or installation date available for that well. Another well at 3859 Pacific was abandoned on June 14, 2010. Based on a search of the DWR database, no other domestic or irrigation wells are known to be located near the plume or in the inferred immediate path of the plume.

Table 7-3. Estimated Cancer Risk and Non-cancer Hazard, using Maximum Concentrations

Chemical	Maximum Indoor Air ($\mu g/m^3$)	Cancer RSL ($\mu g/m^3$)	Non-Cancer RSL ($\mu g/m^3$)	Estimated Excess Cancer Risk	Estimated Non-Cancer Hazard
Tetrachloroethylene	110	9.4	42	1.20E-05	2.6
Trichloroethylene	9.4	0.43	2.1	2.20E-05	4.5
Vinyl chloride	0.075	0.16	100	4.70E-07	0.0008
Cumulative Cancer Risk and Non-Cancer Hazard				3.00E-05	7

$\mu g/m^3$ - Micrograms per cubic meter

Human health responses to PCE, TCE, or any other type of contaminant exposure are not entirely based on the concentration and time period of exposure, however. Individual differences among the exposed population also play a role in the human health response. Individual traits including, but not limited to, differences in age, sex, diet, health status, family history of disease, and personal lifestyle choices can impact individual sensitivity to exposure and the severity of response.

Nearly every step in the HHRA process requires numerous assumptions, all of which contribute to uncertainty in the risk evaluation. In the absence of empirical or site-specific data, assumptions are developed based on best estimates of data quality, exposure parameters, and dose-response relationships. Overall, conservative measures were used to address the uncertainties in the HHRA; thus, the HHRA is expected to overestimate actual risks to receptors in the area of concern for vapor intrusion into homes.

7.2 Summary of Ecological Risk Assessment

An assessment of risk to ecological receptors was not performed for the Maryland Square PCE Site because there are no known completed exposure pathways for such receptors. Source-area soils were cleaned up in 2011, and groundwater does not daylight anywhere at the Site.

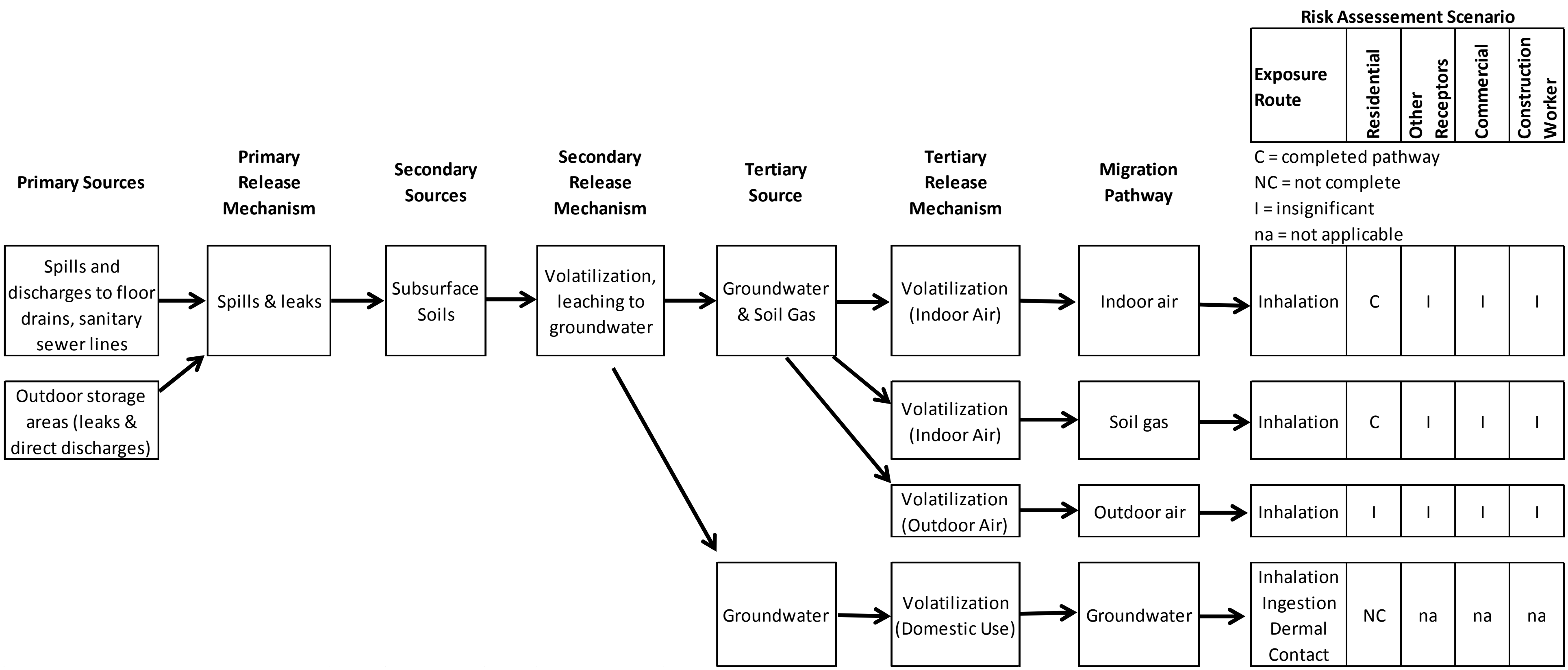
7.3 Conclusion of Risk Assessment

The principal contaminant of concern is PCE in groundwater, with TCE contributing a minor amount to overall risk. Exposure occurs through intrusion of PCE vapors into homes overlying the contaminant plume in groundwater, wherein residents inhale the contaminated indoor air. Figure 7-1 provides a CSM of exposure pathways.

Mitigation systems have been installed in homes where PCE concentrations exceeded the NDEP's interim-action level (32 $\mu g/m^3$) for residential indoor air. The interim-action level was based on USEPA risk-based numbers from 2004; these were the data available in 2006-2007, when the NDEP was evaluating the site for vapor intrusion potential. The value of 32 $\mu g/m^3$ was based on a 1E-04 carcinogenic risk level and exposure to sensitive populations. In December of 2012, the USEPA released a revised toxicity and hazard assessment for PCE, wherein the 1.0E-04 carcinogenic risk level was raised to 400 $\mu g/m^3$, but the hazard index was lowered from 276 µg/m3 to 42 $\mu g/m^3$. According to USEPA Air Toxics Web Site (http://www.epa.gov/ttn/atw/hlthef/tet-ethy.html), the NDEP's interim-action level of 32 $\mu g/m^3$ now represents an excess carcinogenic risk of 8.0E-06 and a hazard index of 0.8.

None of the houses included in the quantitative evaluation had an estimated potential cancer risk exceeding the USEPA's current 1.0E-04 action level (USEPA, 2012); however, only the post-mitigation data were used for the homes with systems installed. Twenty-two of the 45 houses evaluated had estimated potential cancer risk within the risk management range (1.0E-06 to 1.0E-04; currently, 4 to 400 $\mu g/m^3$); however, none the estimated risks exceeded 5.0E-06, and nine houses were equivalent to the low end of the range at 1.0E-06. Twenty-three houses had estimated potential cancer risks of less than 1.0E-06. These houses are considered to have negligible cancer risk from exposure to PCE vapors in indoor air.

Figure 7-1. Risk-Based Conceptual Site Model showing Sources, Migration Pathways, and Receptors.



8.0 Remedial Action Objectives

The overall objective of the groundwater cleanup is to protect human health and the environment by reducing concentrations of PCE in groundwater and minimizing exposure of receptors to affected media. This objective requires the development and implementation of suitable and effective cleanup technologies. Until the cleanup of groundwater is achieved, interim actions (i.e., home mitigation systems) will continue. To accomplish the overall objective, the following remedial action objectives (RAOs) have been established:

<u>Indoor Air</u>

1. Protect human health by reducing inhalation exposure to PCE and daughter products emanating from groundwater and ensuring that concentrations of PCE in indoor air are less than the site-specific remediation goals of 9.4 μg/m^3 for PCE and 2.0 μg/m^3 for TCE.

<u>Groundwater</u>

2. Remediate shallow groundwater until concentrations of PCE in groundwater are determined to be adequately protective of indoor air by achieving goals for PCE and TCE in indoor air (RAO 1). The NDEP has established a site-specific remediation goal of 100 μg/L PCE for groundwater. If the site-specific remediation goal for PCE in indoor air is achieved while PCE concentrations remain above the 100 μg/L goal for groundwater, the 100 μg/L goal may be revised upward, as long as protection of indoor air is well demonstrated and well documented, meaning that results from the annual indoor-air testing confirm that the RAOs for indoor air have been consistently achieved in all homes.
3. Execute appropriate action to ensure PCE does not exceed water quality standard of 5 μg/L as defined in NAC 445A.22735 in domestic water-supply wells, and to protect water quality from further degradation.

The RAOs were formed based on the following:

- Reasonably anticipated land-use scenarios used in the HHRA that include continuation of residential use and the possibility of future residential development on the golf course property
- The shallow PCE-contaminated groundwater may pose a continuing threat to areas of clean groundwater, and, potentially, the deeper water-supply aquifer
- The screening-level HHRA identified PCE as driving the risk and need for remedial action for long-term protection of human health.

9.0 Description of Alternatives

Remedies were developed to address shallow groundwater contaminated with the dry cleaning chemical, PCE. The NDEP evaluated five remedial alternatives.

<u>Alternatives for Cleanup of Groundwater</u>

Alternative 1 – No Further Action Alternative

Alternative 2 – Enhanced Bioremediation for In Situ Treatment of Target Areas

Alternative 3 – Permeable Reactive Barrier (PRB) using Zero-Valent Iron (ZVI)

Alternative 4 – In Situ Chemical Oxidation (ISCO) of Entire Plume

Alternative 5 (Selected Remedy) – Groundwater Extraction and Treatment (East Area), with Air Sparging and Vapor Extraction (AS/VE), ISCO with Recirculation of Groundwater, or other technologies (West Area)

9.1 Description of Alternatives for Groundwater and Components of the Remedy

Exposure to contaminants at the Maryland Square PCE Site occurs through inhalation of contaminant vapors that have accumulated in homes via the vapor intrusion pathway. The contaminant vapors emanate from the contaminated groundwater. PCE is the main chemical of concern at the site; however, degradation products and impurities in the original dry cleaning solvent may include TCE, DCE, and vinyl chloride. Based on data collected in more than 100 homes, elevated concentrations of PCE vapors in indoor air appear restricted to homes overlying or adjacent to the 100 µg/L boundary for PCE in groundwater. Without remediation of groundwater, unacceptable levels of intrusion of PCE vapors into homes will continue unless mitigation systems are installed and continue to run in all potentially affected homes. Alternatives are summarized in Table 9-1.

9.1.1 Alternative 1 – No Action

In accordance with the NCP, a no action alternative must be evaluated to serve as a basis for comparison with other remedial alternatives. Under this remedial action, no action is undertaken toward cleanup or reducing the risk to human health. There is no capital cost or operation and maintenance cost associated with this alternative. Because this alternative is not protective of human health and the environment and does not comply with regulatory action levels, this alternative is not further evaluated.

9.1.2 Alternative 2 – Enhanced Bioremediation

Treatment Components: Enhanced Bioremediation involves the establishment (and maintenance) of suitable geochemical conditions in groundwater necessary to sustain populations of bacteria that perform dechlorination of PCE under anaerobic conditions. (Such conditions may also establish abiotic dechlorination on mineral surfaces.) Anaerobic dechlorination by microbes is a step-wise process that progressively strips chlorine atoms from the carbon framework of PCE (C_2Cl_4) to form TCE (C_2Cl_3H), then DCE ($C_2Cl_2H_2$), then vinyl chloride ($C_2Cl_1H_3$), then ethene (C_2CH_4), and ultimately, carbon dioxide (CO_2) and water.

Institutional Control Components: The Maryland Square PCE Site covers mainly privately owned property, both residential and commercial. The only possible type of institutional control is to restrict the drilling of wells within the plume. Due to the urbanized nature of the area, the widespread (and required) use of city-supplied water, and the generally poor quality of the shallow groundwater, it is unlikely that additional controls on drilling are needed.

Monitoring Components: This remedy will require continued monitoring of groundwater quality as sampled in monitoring wells across the site. Analysis of PCE and other site-related contaminants in groundwater, and annual sampling of indoor air will be part of all alternatives. Alternative 2 may also require periodic analysis of microbial communities.

Required O&M: Where conditions are suitable for sustainment of anaerobic bacteria, the O&M requirements for this alternative would be minimal. However, in a strongly aerobic system, such as the one found across much of the Maryland Square PCE Site, it would be difficult to create and sustain suitable anaerobic conditions. The high concentrations of electron acceptors (O_2, nitrate, sulfate, ferric iron) and the buffering capacity present in the shallow groundwater system would require constant adjustment to attain and maintain the Eh range suitable for complete reductive dechlorination (~-240 mV).

Table 9-1 .Comparative Analysis of Alternatives

Comparison Criteria	**Alternative 1** No Further Action	**Alternative 2** Enhanced In Situ Biologic (ISB) Treatment	**Alternative 3** Permeable Reactive Barrier (PRB) using Zero-Valent Iron (ZVI)	**Alternative 4** In Situ Chemical Oxidation (ISCO) of the Entire Plume	**Alternative 5** Hydraulic Containment and Treatment (P&T) (East Treatment Area), plus ISCO with Recirculation and AS/VE in West Treatment Area	Comparative Analysis Summary
Threshold Criteria						
1) Overall Protection of Human Health and the Environment	Fails	Likely Fails	Likely Meets	Likely Meets	Meets	**Alt 2** (ISB) is not compatible with site geochemistry. **Alt 3** (PRB using ZVI) would be extremely difficult to implement to 80 feet in depth, as well as being subject to occlusion of porosity due to mineral precipitation. **Alt 4** (ISCO of Entire Plume) appears to destroy PCE under site conditions; however, uncontrolled migration and displacement of contamination are concerns, along with safety issues for implementing in neighborhood. **Alt 5** (ISCO with Recirculation and AS/VE in West Treatment Area, along with hydraulic containment (P&T) in East Treatment Area, is believed to be the best option to safely provide protection of human health and the environment.
2) Achieving Action Levels*	Fails	Likely Fails	Likely Meets	Likely Meets	Meets	**Alt 2** (ISB) and **Alt 3** (PRB using ZVI) depend on reducing conditions and are not likely to perform successfully over the long term due to groundwater geochemistry, so these remedies are not expected to achieve and maintain remediation goals. Performance of **Alt 4** is difficult to determine due to potential for displacement of contamination. **Alt 5** (P&T in in East Treatment Area, plus ISCO with Recirculation & AS/VE in West Treatment Area) is considered likely to achieve remediation goals within a reasonable timeframe
Primary Balancing Criteria						
3) Long-term Effectiveness	0	2	1	3	4	**Alt 2** (ISB) and **Alt 3** (PRB using ZVI) are anticipated to have low long-term effectiveness due to incompatibility with site geochemistry and the resulting difficulty in achieving and maintaining reducing conditions. The long-term effectiveness of **Alt 4** (ISCO) is unknown because of difficulty discerning between efficacy and displacement. **Alt 5** (P&T plus ISCO and AS/VE) should remain effective over the long-term.
4) Reduction of Toxicity, Mobility and Volume	0	3	2	1	4	**Alt 2** (ISB) and **Alt 3** (PRB using ZVI) are expected to produce only a small decrease in contaminant volume. **Alt 2** may increase toxicity by production of more-toxic degradation products as a result of incomplete reductive dechlorination of PCE. **Alt 4** (ISCO across the entire plume) may decrease volume and toxicity, but without active recirculation wells may increase mobility by displacing the contamination into previously clean areas of depths. **Alt 5** (P&T, plus ISCO with recirculation and AS/VE) should effectively reduce the mobility, toxicity and volume of contaminants.
5) Short-term Impact	0	2	1	0	3	Implementing enhanced ISB (**Alt 2**) on mall property would likely have minimal short-term disruption to the residential neighborhood, but may be slow to ineffective in achieving remediation goals. A PRB with ZVI (**Alt 3**) would have moderate negative short-term impact during construction and moderate to low effectiveness in the short term. Implementing ISCO on Mall property would have a low to moderate short-term impact, depending on the oxidant used; however, ISCO throughout the plume (**Alt 4**) would have a high negative impact on the neighborhood. Installing a series of pumping wells just upgradient of the neighborhood, along with conducting ISCO and AS/VE downgradient of the source area (**Alt 5**)would likely have moderate negative short-term impact during construction and optimization, but hydraulic containment with reinjection of treated water may provide the fastest short-term effectiveness to achieve remediation goals in the neighborhood.
6) Implementability	0	3	1	0	3	Implementing enhanced ISB (**Alt 2**) is theoretically easy, but achieving and maintaining reducing conditions will likely be difficult due to geochemical conditions at the site. Installing a PRB (**Alt 3**) to 80 feet deep would be difficult to highly impracticable. Implementing ISCO across the entire plume (**Alt 4**) would be feasible on mall property, but difficult and intrusive in the neighborhood due to the necessity of drilling hundreds of injection points. Installing a series of pumping wells just upgradient of the neighborhood, along with conducting ISCO and AS/VE downgradient of the source area (**Alt 5**) should be feasible to implement, although optimal placement of well screens would likely require more detailed characterization in the treatment areas.
7) Cost	0	4	3	1	2	Costs for all alternatives are estimated based on known site conditions. The highest costs are likely to be for **Alt 4** (ISCO across entire plume), **Alt 5** (P&T with AS/VE and ISCO with Recirculation) and **Alt 3** (PRB with ZVI).
Modifying Criterion						
8) Community Acceptance	0	0	0	0	3	No negative community feedback on the selected remedy was received during 90-day comment period on the Proposed Plan

*Note: The remediation goal (100 µg/L) for PCE in groundwater under the residential neighborhood protective of indoor air is 20 times higher than the MCL (5 µg/L); the goals for PCE (9.4 µg/m^3) and TCE (2 µg/m^3) in indoor air reflect the latest risk information from the U.S. EPA.

	Worst Option				**Best Option**
TOTALS =	0	14	8	5	19

Expected Outcomes: If strongly reducing conditions (-240 mV) could be attained and sustained across the site, this remedy would be effective in destroying PCE and its chlorinated degradation products. However, given the geochemical conditions in the shallow groundwater system, it is unlikely that conditions conducive to biotic reductive dechlorination could be developed and sustained at the Maryland Square PCE Site. Addition of a bacterial culture would likely be required to avoid long lag periods before such microbial populations could develop sufficiently. Bioreactors would have to deal with sulfide toxicity, whereby the waste products of the microorganisms eventually become toxic to the microbes themselves. This can eliminate or reduce all microbial activity or cause these microbes to be replaced by other bacteria that will not dechlorinate PCE. Partial dechlorination of PCE can generate even-more toxic products, such as TCE and vinyl chloride.

9.1.3 Alternative 3 – Permeable Reactive Barrier using Zero-Valent Iron

Treatment Components: A PRB is a constructed zone of reactive material, such as zero-valent iron (ZVI,) that extends below the water table to passively intercept and treat contaminated groundwater. PRBs can be installed as permanent or semi-permanent units. The most commonly used PRB configuration is that of a continuous trench in which the treatment material is backfilled. The trench is perpendicular to groundwater flow and intersects the groundwater plume.

Institutional Control Components: The Maryland Square PCE Site covers mainly privately owned property, both residential and commercial. The only possible type of institutional control is to restrict the drilling of wells within the plume. Due to the urbanized nature of the area, the widespread (and required) use of city-supplied water, and the generally poor quality of the shallow groundwater, it is unlikely that additional controls on well drilling are needed.

Monitoring Components: This remedy will require continued monitoring of groundwater quality as sampled in monitoring wells across the site. Analysis of PCE and other site-related contaminants in groundwater, and annual sampling of indoor air will be part of all alternatives. Frequent monitoring of PRB conductivity and health may be required at this site.

Required O&M: Once installed, a PRB is a low-maintenance remedy; however, under the geochemical conditions at this site, the high concentrations of TDS and, in particular, sulfate, may substantially decrease the life-span of a PRB. A PRB can become disabled due to precipitation of sulfide minerals within the porous wall of the PRB. After hydraulic conductivity through the PRB is diminished, groundwater flow (and contaminant transport) may divert around and beneath the PRB wall. Frequent monitoring of PRB conductivity and reactivity may be required at this site.

Expected Outcomes: Use of PRBs with ZVI has been shown to be effective in intercepting and treating chlorinated solvent plumes at some sites. A PRB employing ZVI installed upgradient of the residential neighborhood would theoretically achieve threshold criteria; however, the site conditions are likely to preclude effective long-term functioning of this technology. Under the geochemical conditions at the Maryland Square PCE Site the ZVI could be subject to premature passivation (i.e., loss of its catalytic properties) due to the naturally high concentrations of total dissolved solids in site groundwater. The concentrations of naturally occurring constituents are in ranges known to diminish the longevity of ZVI-based PRBs, due to mineral precipitation and other surface-coating reactions .

It is not known how quickly the ZVI in the PRB would suffer passivation and breakthrough. Before passivation occurred, PCE could be at least partially dechlorinated by ZVI-mediated reactions. Long-term effectiveness and permanence are questionable for the reasons discussed above. It is questionable if this technology could provide long-term effectiveness due to site geochemistry, which could likely lead to failure of the remedy in the longer term, even if initial results showed decreased concentrations of PCE downgradient of the PRB.

9.1.4 Alternative 4 – In Situ Chemical Oxidation across the Entire Plume

Treatment Components: A chemical oxidation reaction involves the breaking of chemical bonds. ISCO is a class of remediation technologies in which PCE and other contaminants are degraded in place by oxidants delivered to the subsurface. Successful implementation of this technology requires an effective means for dispersing the oxidizing chemicals throughout the contaminated groundwater. Complete and rapid treatment may be inhibited by a lack of direct contact between oxidant and contaminant. This contract problem is especially true for highly heterogeneous soils with low-permeability lenses and layers. To employ ISCO across the entire plume would involve drilling numerous injection wells and thorough characterization of every treatment area. Oxidants could be mixed on site, but safety and access issues may affect the ability to conduct ISCO everywhere across the plume within the neighborhood.

Institutional Control Components: The Maryland Square PCE Site covers mainly privately owned property, both residential and commercial. The only possible type of institutional control is to restrict the drilling of wells within the plume. Due to the urbanized nature of the area, the widespread (and required) use of city-supplied water, and the generally poor quality of the shallow groundwater, it is unlikely that additional controls on well drilling are needed.

Monitoring Components: This remedy will require continued monitoring of groundwater quality as sampled in monitoring wells across the site. Analysis of PCE and other site-related contaminants in groundwater, and annual sampling of indoor air will be part of all alternatives.

Required O&M: Conducting ISCO within the residential area would likely encounter numerous problems related to infrastructure and access, as well as the noise and disruption of traffic flow throughout the neighborhood. There are also safety issues related to the chemical oxidant itself and the migration of the oxidizing solution into other areas. Although the data from the pilot test indicated that concentrations of PCE and its daughter products were almost completely destroyed by the oxidant, the effects of dilution and displacement after injecting the chemical oxidant were not calculated or evaluated in the ***Corrective Action Report for Groundwater***. O&M would consists of maintaining the injection points, monitoring, and repeating oxidant injections across the plume, as deemed necessary based on monitoring data.

Expected Outcomes: . Laboratory tests have demonstrated that chemical oxidants destroy PCE; however, in the field, it can be difficult to predict and direct the migration of oxidants and contaminants. The presence of heterogeneous soils and clay layers exacerbates the difficulty in controlling and predicting migration of contaminants and oxidants. Unless injection of oxidant solutions into groundwater is paired with extraction of groundwater, the potential for uncontrolled migration is too high to recommend use in a residential area.

The issue of displacement also can make it difficult to accurately gauge the effectiveness of the ISCO treatment in reducing the toxicity, mobility or volume of the PCE. That is, it is difficult to determine if decreasing concentrations measured in some observation wells are the result of chemical destruction of the PCE or simply displacement of PCE-contaminated groundwater. Depending on sampling locations observed, post-injection declines might reflect the displacement of contaminated water rather than actual contaminant mass destruction. Any area where oxidants are injected needs to have a comprehensive monitoring well system in place. Monitoring should start before oxidant injection and continue at least a year after.

9.1.5 Selected Remedy – Hydraulic Containment and Mass Removal/Destruction

Treatment Components: This alternative consists of two treatment areas: In the East Treatment Area, just upgradient of the residential neighborhood, pumping wells will provide hydraulic containment that will greatly reduce the flow of PCE-contaminated groundwater into the residential neighborhood; in the West Treatment Area, one or more technologies will be used to destroy or remove contaminants in the main mass of the plume. These methods include AS/VE and ISCO with extraction wells for recirculation of injected oxidant (to minimize displacement). Other treatment technologies may be proposed, but would require convincing demonstration of effectiveness under site conditions.

Institutional Control Components: The Maryland Square PCE Site covers mainly privately owned property, both residential and commercial. The only possible type of institutional control is to restrict the drilling of wells within the plume. Due to the urbanized nature of the area, the widespread (and required) use of city-supplied water, and the generally poor quality of the shallow groundwater, it is unlikely that additional controls on well drilling are needed.

Monitoring Components: This remedy will require continued monitoring of groundwater quality as sampled in monitoring wells across the site. Analysis of PCE and other site-related contaminants in groundwater, and annual sampling of indoor air will be part of all alternatives.

Required O&M: This remedy requires significant O&M. Blowers for AS/VE system must be maintained, along with any off-gas treatment system. Monitoring of system gauges must be performed to assess system efficacy and make adjustments as needed to optimize the system. If ISCO is used in the West Treatment Area, then injection points must be maintained and periodic injections made. The pump and treat system has a lot of mechanical parts and also requires continued O&M. Pumps, aboveground treatment systems and reinjection equipment must all be maintained.

Expected Outcomes: Remediation of groundwater using extraction and aboveground treatment ("pump and treat") remains a dependable technology for cleanup of groundwater that is more than 50 feet below ground surface. Pumping of the shallow groundwater to depress the water table has been used to dewater subterranean parking garages and other structures in the Las Vegas area. There is every reason to think that properly designed pumping wells should be able to depress the water table in the East Treatment Area, thereby achieving hydraulic containment of the contaminated groundwater.

Successful and cost-effective use of this technology requires (1) detailed characterization of the geology, hydrology, and chemistry; (2) removal of source terms, if possible; (3) initial design for plume containment and source remediation; (4) detailed monitoring of the remediation; (5) active ongoing reevaluation of the operating well field, including redesign as appropriate (dynamic management); (6) reinjection of treated groundwater to speed the flushing of contaminants. Using a variety of techniques can dramatically reduce the time required to achieve remediation goals and thus the cost of groundwater remediation.

The expectation is that concentrations of PCE within the neighborhood will begin to decrease as hydraulic containment prevents downgradient migration of additional PCE. Reduction in concentrations is expected to be a gradual process that will take a number of years. In addition to routine O&M, the system will be reassessed after 5 years of operation to determine what, if any, changes are needed. Pump and treat is a process of physical removal of contaminants.

Treatment in the West Treatment Area is focused on actually destroying the PCE or removing PCE via a natural process (volatilization) that is enhanced through the use of air injection and vacuum capture of PCE vapors. Combined, the extraction and destruction are expected to reduce concentrations of PCE in groundwater.

9.2 Common Elements and Distinguishing Features of Each Alternative

All of the alternatives require maintaining the protective elements already in place at the Site until groundwater cleanup levels are achieved. These common elements include long-term sampling and analysis of groundwater, in order to monitor contaminant concentrations across the site. Another common element is the use of institutional controls to prevent installation of drinking water or irrigation wells within the footprint of the PCE plume. Additionally, all alternatives require maintenance of home mitigation systems (such as system adjustment and fan replacement), along with annual testing of indoor air for homes located on or within the estimated 100 µg/L boundary of the plume

All of the remedial alternatives would require a five-year review. The five-year reviews of the remedy would be conducted until the RAOs for groundwater and indoor air are achieved. If the site-specific remediation goal for PCE in indoor air is achieved while PCE concentrations remain above the 100 µg/L goal for groundwater, the 100 µg/L goal may be revised upward, as long as protection of indoor air is well demonstrated and well documented.

10.0 Comparative Analysis of Alternatives

The evaluation of each alternative is used as a method to compare and contrast the remedial alternatives and assess the advantages and disadvantages of each by looking at a number of important factors. The expectations for remedy selection are listed in the Code of Federal Regulations at 40 CFR § 300.430 (a)(1)(iii).

Alternatives were evaluated in the Proposed Plan by the NDEP using the nine criteria described in Section 121(b) of CERCLA. For an alternative to be an acceptable remedy it must, at a minimum, satisfy the statutory requirements of two threshold criteria: 1) Overall protection of human health and the environment, and 2) Compliance with regulatory requirements. The “No Action” (Alternative 1) is the only retained alternative that does not satisfy these threshold criteria. Therefore, this alternative will not be further evaluated in the comparative analysis.

Threshold criteria are requirements that each alternative must meet in order to be eligible for further evaluation and selection. Primary balancing criteria are used to weigh major trade-offs among alternatives. In the final balancing of trade-offs between alternatives, the modifying criterion (community acceptance) is of equal importance to the primary balancing criteria. Each remedial alternative was evaluated in the Proposed Plan according to the threshold and primary balancing criteria. Table 10-1 provides a summary of the evaluation of alternatives.

10.1 Overall Protection of Human Health and the Environment

This threshold criterion addresses whether each alternative provides adequate protection of human health and the environment and describes how health risks are eliminated, reduced, or controlled, through treatment, engineering controls, or institutional controls.

Alternatives 3 and 4, along with the Selected Remedy, have the potential to be protective by reducing contaminant concentrations, but only the Selected Remedy is likely to achieve remediation goals in the long term. Alternative 4 and the Selected Remedy, both of which include use of in situ treatments are expected to expedite the destruction of PCE and TCE in groundwater. Regarding plume containment, the Selected Remedy, which includes use of extraction, treatment, and reinjection of groundwater, or “pump-and-treat” response action, would be more effective in containing the plume than the other alternatives.

Table 10-1. Comparison Criteria for Remedies

Comparison Criteria	Alternative 2 Biologically Enhanced in Situ Treatment (ISB)	Alternative 3 Permeable Reactive Barrier (PRB) using Zero-Valent Iron (ZVI)	Alternative 4 In Situ Chemical Oxidation (ISCO) of the Entire Plume	Alternative 5 Groundwater Extraction and Treatment in East Treatment Area, AS/VE or ISCO in West Treatment Area
Overall Protectiveness	May be protective under ideal geochemical conditions	May be protective under ideal geochemical conditions	Likely protective, but highly instrusive and may displace the plume vertically	Likely to be protective, with plume capture and contaminant mass removal
Achieving Cleanup Goals	Likely Fails	May Fail	May Fail	Likely Meets
Long-Term Effectiveness & Permanence	Long-term effectiveness contingent on maintaining ideal anaerobic conditions	Long-term effectiveness contingent on preventing mineral precipitation from reducing PRB permeability and reactivity	Long-term effectiveness contingent on ability of oxidant to come into physical contact with contaminants	Long-term effectiveness and permanence likely, assuming plume capture and mass destruction and removal
Reduction of Toxicity, Mobility and Volume	Capable of destroying mass under ideal geochemical conditions, but produces more-toxic degradation products if reaction incomplete	Capable of destroying mass under ideal geochemical and hydrogeologic conditions, but requires physical contact of contaminant molecules with ZVI	Capable of destroying mass under ideal geochemical conditions, but oxidant must come into physical contact with contaminants	Multi-component remedy should effectively reduce the mobility, toxicity and volume of contaminants
Short-Term Impact & Effectiveness	Likely to have minimal short-term disruption to the residents, but effectiveness is questionable, both short- and long-term	Likely to have short-term disruption to the residents; however, once in place, impacts would be minimal for a number of years. Could have acceptable short-term effectiveness	Would have high levels of disruption to residents; could have good short-term effectiveness if oxidant comes into physical contact with contaminants and does not push contaminated groundwater into previously clean areas	Likely to have short-term disruption (noise, dust) to the residents; however, once in place, impacts should be minimal. Effective reduction of PCE concentrations would likely take from 5 to 15 years
Implementability	Theoretically easy, but achieving and maintaining reducing conditions may be extremely difficult due to geochemical conditions at the site	Installing a ZVI PRB to 80 to 100 feet below ground would be difficult and highly impracticable	Implementing across the plume would be difficult and intrusive in the neighborhood due to the need to dril hundreds of injection points.	Installing pumping wells in East Treatment Area and AS/VE or ISCO (with recirculation) in West Treatment Area should be implementable
Present Worth Capital Cost ($1,000)	$550	$1,500	$1,000	$1,700
Annual O&M Cost ($1,000)	$575	$700	$800	$750
Total Present Worth Cost ($1,000): NPV 4%, 10 YR	$4,100	$6,000	$7,200	$6,800

Note: the site-specific remediation goal for PCE in groundwater under the residential neighborhood (100 µg/L) is protective of indoor air and is 20 times higher than the MCL of 5 µg/L; the remediation goals for PCE (9.4 $\mu g/m^3$) and TCE (2 $\mu g/m^3$) in indoor air reflect the latest risk information from the USEPA.

10.2 Compliance with Regulatory Requirements

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, unless such requirements are waived under CERCLA §121(d)(4).

The Maryland Square PCE Site is not a CERCLA site; however, the NDEP is performing this analysis of alternatives to be consistent with the CERCLA process. NAC 445A.22735(1)(b) establishes the action level for hazardous substances as the concentration equal to the MCL, "*established pursuant to the Safe Drinking Water Act, 42 U.S.C. §§ 300f et seq., and 40 C.F.R. Part 141, as those sections existed on October 3, 199*6." For PCE and TCE, the MCL is the same, 5 µg/L; for 1,2-cis-DCE and vinyl chloride (a degradation product of PCE) the MCL value are 70 and 2 µg/L, respectively.

The NDEP has determined that an alternative remediation goal of 100 µg/L for PCE in groundwater within the vapor intrusion "area of concern" is warranted, under an **exemption**, NAC 445A.22725(2)(a). The NDEP finds that an exemption is warranted because the remedial action objective is protection of indoor air; the source is identified and controlled, NAC 445A.22725(2)(a)(1); the magnitude and extent of the contamination of the groundwater is known, NAC 445A.22725(2)(a)(2); and data from most of the wells located in the plume within the neighborhood do show a trend of decreasing concentrations, and none of these wells show a trend of increasing concentrations, NAC 445A.22725(2)(a)(3). Additionally, groundwater contaminated by the PCE is not a source of drinking water in the affected area and is not likely to be a source of drinking water due to the poor quality (high TDS, nitrate, and sulfate) of the shallow groundwater; the latter make it economically impractical to render the water fit for human consumption, NAC 445A.22725(2)(c)(1).

The RAOs were established with the overall objective to protect human health and the environment by reducing concentrations of PCE in groundwater and minimizing exposure of receptors to affected media. This objective requires the development and implementation of suitable and effective cleanup technologies. Until the cleanup of groundwater is achieved, interim actions (i.e., home mitigation systems) will continue. To accomplish the overall objective, the following RAOs have been established:

For indoor air, the RAO is to protect human health by reducing inhalation exposure to PCE and daughter products emanating from groundwater and ensuring that concentrations of PCE in indoor air are less than the long-term goals of 9.4 µg/m^3 for PCE and 2.0 µg/m^3 for TCE. For groundwater, the RAOs are to remediate shallow groundwater where PCE concentrations exceed the site-specific remediation goal for groundwater (100 µg/L PCE) that is protective of indoor air, and to execute appropriate action to ensure PCE does not exceed water quality standard of 5 µg/L as defined in NAC 445A.22735 in domestic water-supply wells, and to protect water quality from further degradation.

Alternative 4 and the Selected Remedy would likely meet all the regulatory requirements (assuming an exemption and an alternative cleanup goal of 100 µg/L for PCE) and RAOs. These groundwater alternatives rely on hydraulic control or treatment to reduce toxicity and mobility of the site-related contaminants in groundwater. Alternative 5 would discharge treated groundwater to the aquifer or the local publicly owned treatment works (POTW). A permit would be necessary for off-site discharge of treated water to the POTW; treatment would comply with the local sewer discharge limitations and fee requirements.

10.3 Long-Term Effectiveness and Permanence

This criterion refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, after cleanup levels have been met. This criterion includes the consideration of residual risk that will remain on-site following remediation and the adequacy and reliability of controls.

Over the long-term, the Selected Remedy would provide an effective means of controlling the contaminant plume. The contamination in the groundwater would be permanently reduced because remedial action would continue until RAOs were met. Once RAOs are achieved, compliance monitoring would provide an early warning if contamination rebound were observed. If treated water is re-injected, care must be taken to prevent fouling and scaling of the injection wells over time.

The long-term effectiveness of Alternatives 2 and 3 is uncertain because of the geochemical characteristics of the shallow groundwater system. The Selected Remedy is the only remedy that includes a pump-and-treat component to hydraulically control the plume upgradient of the residential neighborhood.

10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This CERCLA criterion refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. Remedial actions that use active treatment to permanently and significantly reduce the toxicity, mobility, and volume of contamination satisfy this criterion.

Alternatives 2, 3 and 4, along with the Selected Remedy (Alternative 5), would reduce the toxicity, mobility, and volume of PCE through active treatment, if all functioned ideally. However, due to geochemical conditions at the site, Alternatives 2 and 3 may not be fully functional or may have a short active life-span. Alternative 4 may be effective in destroying PCE and TCE; however, it would be extremely disruptive throughout the neighborhood and would likely be the most costly alternative.

In addition to the pump-and-treat component of the Selected Remedy, it includes the use of in situ technologies which, if effective, would chemically react with, or volatilize and capture, the contaminants, thus reducing the volume and toxicity of these compounds in the groundwater. This would reduce the contamination load on the P&T treatment system. Because of the proven pump-and-treat component, the Selected Remedy is expected to be more effective in extracting and permanently removing site-related contaminants from the groundwater.

10.5 Short-Term Effectiveness

This criterion addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

Appreciable short-term results (i.e., in less than a year) are generally not associated with the extraction and above-ground treatment component of the Selected Remedy. However, reduction in mass and mobility of contamination is expected over time as groundwater is pumped and treated.

Implementation of the Selected Remedy may entail use of an oxidizing reagent for in situ oxidation of PCE and TCE in the high-mass area of the plume. Oxidation of the chlorinated solvents depends on physical contact between the oxidant and contaminant, but once in contact, oxidation should be rapid and effective. Recirculation wells are required to prevent displacement of contaminated groundwater into previously clean areas; a volume equal to the volume injected must be extracted. Also, in the short-term, because of increased mobility, concentrations of some metals may increase; this was seen for chromium and, to a lesser degree, arsenic following the ISCO pilot tests. The concentrations will eventually return to background levels.

Well construction must be completed so as not to create a conduit through which contaminants can migrate vertically. The recirculation wells for the Selected Remedy must be designed so as to provide adequate hydrologic control of the injected oxidizing solution. If groundwater recirculation zones are formed effectively upon implementation of the Selected Remedy, some short-term removal of contaminants may be expected. Initially, some increase in PCE concentrations may occur as PCE volatilizes and desorbs from the soil. Construction recirculation wells must be completed so as not to create a conduit through which contaminants can migrate vertically.

10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered. Implementation of all groundwater alternatives is technically feasible and all materials and services needed for implementation are readily and commercially available. However, installation of a PRB (Alternative 3) would require excavating a trench to 80 to 100 feet bgs, which would be technically challenging.

The extraction and treatment component of the Selected Remedy would result in the installation of wells and related conveyance piping, and the construction of an aboveground treatment plant. Coordination with the owners of commercial properties would be required to install treatment system components which may disrupt traffic. Reinjection of treated water would require coordination with the BWPC. NDEP's position is that reinjection of water with constituents at background levels would be acceptable, so long as the treated water is re-injected back into the same aquifer, not far from where it was extracted. Discharge of treated groundwater to the POTW may be acceptable if reinjection is not feasible or the discharge volume is small. Discharge limits would have to comply with off-site permit requirements in either case. Operation and maintenance of the system would include cleaning and replacement of well components, disposal and replacement of activated carbon, and maintenance of pumps, controls, and other equipment.

Implementation of Alternative 4 (ISCO across the plume) would additionally entail injecting a reagent into many injection points located across the neighborhood. For technical feasibility, care must be taken to inject the reagent such that there is adequate overlap of the radii of influence between consecutive injection points. The density of injection points would cause disruption of residents and traffic, and affect surface structures. Coordination with City and every affected resident would likely be required. A UIC permit is required to allow for injection of the reagents and water into the subsurface.

Some degree of disruption with ongoing commercial activities is expected with implementation of Alternatives 2, 3, and 4, as well as the Selected Remedy, because of the need to install additional wells and related structures, including conveyance piping and the construction of an aboveground treatment plant for the Selected Remedy. Coordination with the City of Las Vegas would be required to install treatment system components that may disrupt traffic (Alternatives 4 and the Selected Remedy). Any water discharges would need to be coordinated with the appropriate agencies. A soundproof building would be required to house blowers or other noisy equipment (Alternatives 4 and the Selected Remedy). The most difficulty could be keeping the treatment system, the wells, and the conveyance piping free of scale. Operation and maintenance of the system would also include cleaning and replacement of well components, disposal and replacement of activated carbon, and maintenance of pumps, controls, and other equipment.

10.7 Cost

Cost of each remedy is a rough estimate at this time. More detailed system design will allow more specific costs to be provided. Table 10-2 lists the capital, annual O&M, and total present worth cost estimates for the groundwater alternatives. The estimated present worth costs for the groundwater alternatives, not including the No Action alternative, range from a minimum of $ 3.1 million for Alternative 2 to $8.7 million for Alternative 4. All costs are based on a a 10-year duration for remedial action. Although the projected cost for implementing the Selected Remedy is shown to be higher than that for Alternatives 2 and 3, the following items should be taken into perspective for a fair comparison:

1) The use of in situ treatment in addition to the pump-and-treat action may expedite cleanup, to such a level that the overall cost of implementation of the Selected Remedy is less than Alternative 4.
2) It is possible that only one in situ treatment - oxidation or AS/VE, whichever is found to be more effective during treatability studies - will actually be used as part of the Selected Remedy.
3) The extent of in situ treatment (i.e., amount of material used, number of injection points, and frequency of applications) may be less than projected, such that the implementation cost for the Selected Remedy is less than estimated.

Table 10-2. Summary of General Information for Each Alternative

Alternative	10-Year Present Value Cost ($million)	Estimated Time to Achieve RAOs (years)
Alternative 2	$3.1 to $5.3	10+
Alternative 3	$4.6 to $7.6	10+
Alternative 4	$5.8 to $8.7	10+
Selected Remedy	$5.7 to $7.9	10+

10.8 Community Acceptance

During the public comment period for the Proposed Plan, three sets of written comments were received. Questions that were raised at the Public Meeting were addressed by NDEP staff during the question-and-answer session that followed the presentations. Residents had no significant issues or objections directed toward the Selected Remedy. The NDEP believes that the Selected Remedy addresses the comments received (see Part III, Responsiveness Summary).

11.0 Principal Threat Wastes

The NCP establishes the expectation that treatment be used to address the principal threats posed by a site wherever practical. The principal threat concept applies to the source materials at a site that are highly mobile and cannot be reliably controlled in place, or would present a significant risk to human health or the environment should exposure occur. A source material is material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air or act as a source for direct exposure. Soils at the site of the former dry cleaners have been cleaned up, so that source is no longer a concern.

According to the USEPA (1991), "source material" is defined as any material that "contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure." Based on this definition, **PCE-contaminated groundwater underlying the homes can be considered a principal threat waste at the Maryland Square PCE Site.** That is, the groundwater is a source of PCE vapors, which enter homes via vapor intrusion, and pose a potentially unacceptable risk to residents by way of the inhalation exposure pathway. Currently, engineering controls have been put in place (i.e., vapor-mitigation systems installed in homes) to reduce exposure to PCE vapors, and there is an annual air-monitoring program for homeowners.

12.0 Selected Remedy

The remedial action proposed for groundwater at the Maryland Square PCE Site addresses PCE-contaminated groundwater, which in turn, addresses the vapor intrusion pathway. The Selected Remedy for cleanup of groundwater contaminated with PCE and TCE will use a combination of technologies to achieve remedial goals and be protective of residential indoor air.

An ex situ treatment component, consisting of a groundwater extraction and treatment system, will be used for containment and remediation in the East Treatment Area, just upgradient of the residential neighborhood (Figure 12-1). This ex-situ treatment component may use presumptive technologies identified in Directive 9283.1-12 from the USEPA's Office of Solid Waste and Emergency Response (OSWER), because contaminants in groundwater are volatile, one of the presumptive technologies, which is granular activated charcoal (GAC) may be used for treating aqueous contaminants in the extracted ground water.

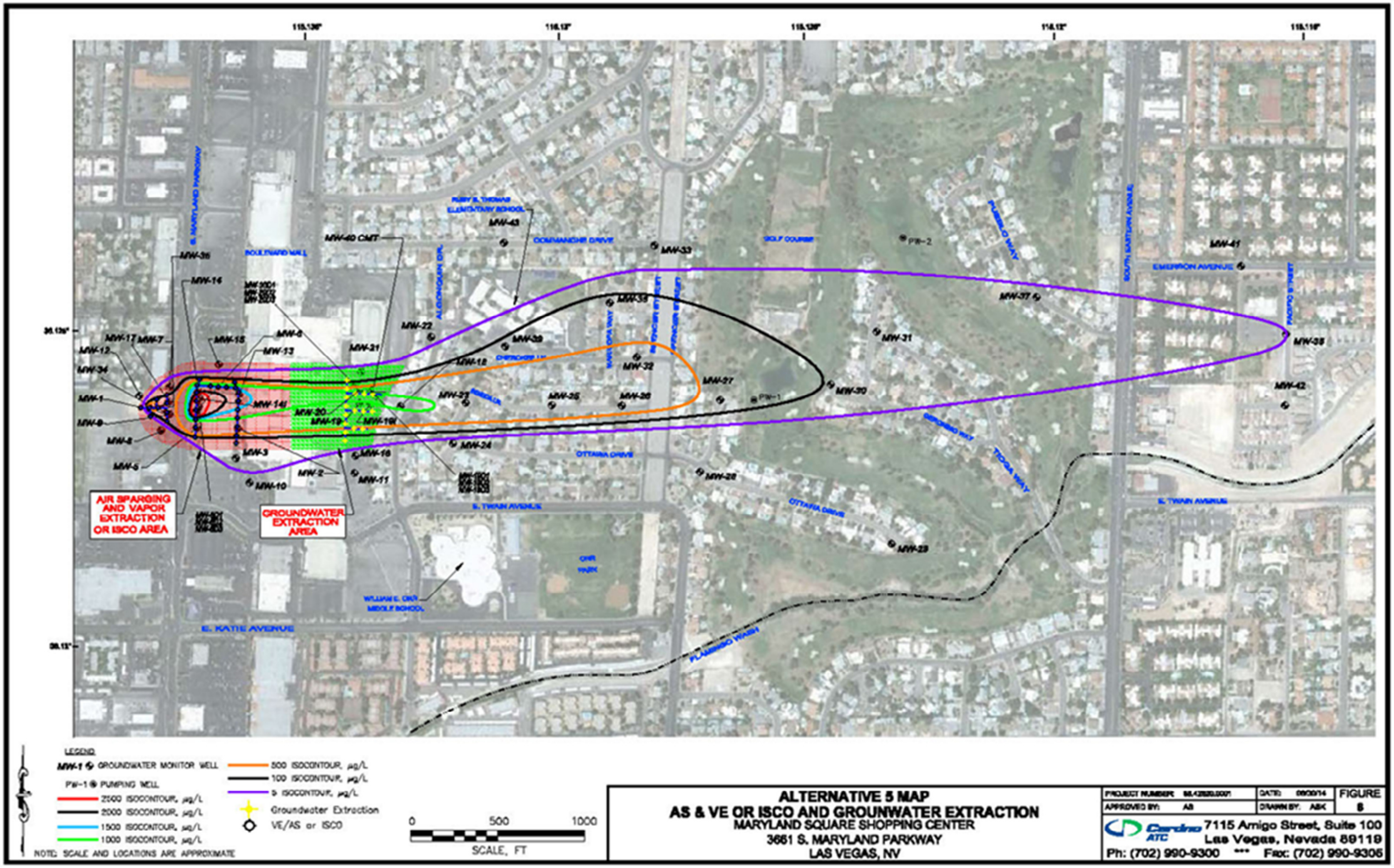
Either ISCO or AS/VE or both will also be considered to enhance the treatment of PCE and TCE in groundwater and to minimize the need for extraction and ex situ treatment. These technologies would be deployed in the West Treatment Area, just across the street and downgradient from the former dry cleaners.

The actual technologies and sequence of technologies used will be determined during remedial design (RD). Final selection of these technologies will be based on the outcome of treatability studies to be performed during the RD. The NDEP believes the Selected Remedy for cleanup of groundwater at the Maryland Square PCE Site meets the threshold criteria and provides the best balance of tradeoffs among the alternatives considered.

Part of the RD work will entail additional characterization of subsurface conditions in the treatment areas. The heterogeneous nature of the materials hosting the shallow groundwater means that additional characterization is needed for optimal design of any treatment system.

The NDEP expects the Selected Remedy to satisfy the statutory requirements of CERCLA Section 121(b): 1) protection of human health and the environment, 2) compliance with regulatory requirements, 3) cost effectiveness, 4) use of permanent solutions and alternative treatment technologies to the maximum extent practicable, and 5) use of treatment as a principle component. The Selected Remedy should achieve RAOs established under NAC 445A.22725(2)(a).

Figure 12-1. Map showing Treatment Areas for the Selected Remedy



12.1 Summary of the Rationale for the Selected Remedy

The principal factors considered in choosing the Selected Remedy for groundwater include the following:

1) Groundwater extraction provides an effective means of minimizing migration of the PCE plume
2) Reinjection of a portion of the treated ground water will enhance recovery of contaminants from the formation and will reduce the potential for migration of higher-concentration areas of the plume
3) Treatment of higher-concentration areas of the plume with ISCO, AS/VE, or both may expedite cleanup and reduce volume and toxicity of contaminants
4) Depending on the success of the treatment components, monitoring may become the only action needed within 5 to 15 years, if it can be demonstrated that contaminant concentrations in the PCE plume have stabilized at sufficiently reduced concentrations
5) The Selected Remedy will not require intrusive work in the residential neighborhood, although monitoring of groundwater and indoor air and installation of additional home-mitigation systems will continue until RAOs are achieved.

12.2 Description of the Selected Remedy

The Selected Remedy for cleanup of groundwater at the Maryland Square PCE Site combines several treatment technologies shown to be effective in reducing concentrations of PCE in shallow groundwater in other locations within the Las Vegas Valley. This alternative is recommended because it will achieve substantial risk reduction by reducing the mass of PCE near S. Maryland Parkway and preventing the continued flow of contaminated groundwater into the residential neighborhood.

The major elements of the Selected Remedy include the following:

- Construction of a groundwater extraction and treatment (also known as “pump and treat”) system for hydraulic containment of the PCE plume upgradient of the residential neighborhood (“East Treatment Area”)
- AS/VE or ISCO with directed recirculation of groundwater (that is, paired injection and extraction wells) in the area of highest PCE concentrations. This area of contaminated groundwater underlies a parking lot about 200 feet downgradient of the former dry cleaners (“West Treatment Area”)
- Continued monitoring of groundwater across the site
- Indoor air monitoring of qualifying homes in the residential neighborhood between the Boulevard Mall on the west and the Las Vegas National Golf Course on the east
- Maintenance of vapor-mitigation systems (i.e., subslab depressurization [SSD] systems) and installation of new vapor-mitigation systems in homes as needed, until such time that concentrations of PCE in the groundwater have declined to be sufficiently protective of residential indoor air via the vapor intrusion pathway

Remediation of groundwater using extraction and aboveground treatment (“pump and treat”) remains a dependable technology for cleanup and containment of deep (> 50 feet below ground surface) groundwater. Successful and cost-effective use of this technology requires (1) detailed characterization of the geology, hydrology, and chemistry; (2) removal of source areas, if possible; (3) initial design for plume containment and source remediation; (4) detailed monitoring of the remediation; (5) active ongoing reevaluation of the operating well field, including redesign as appropriate (dynamic management); (6) reinjection of treated groundwater to speed the flushing of contaminants. Techniques can dramatically reduce the time required to achieve cleanup goals and thus the cost of groundwater remediation.

This remedy combines at least two remedial technologies to achieve **containment** of the PCE-contaminated groundwater and **treatment** to reduce the mass of contaminants through treatment. **Hydraulic containment** of the PCE plume upgradient of the residential neighborhood would be achieved by installing a line of pumping wells to prevent contaminated groundwater from continuing to flow into the neighborhood. A series of extraction wells would be designed to intercept the PCE-contaminated groundwater upgradient of the neighborhood. Groundwater would be extracted, treated aboveground to remove the contaminants, and then re-injected as clean water to help reduce concentrations of PCE in the plume underlying the neighborhood. The reinjection should accelerate the time required to reduce concentrations of PCE to the point where home mitigation systems are no longer needed.

The other component of the remedy is **treatment** of the main mass of contaminated groundwater, which currently resides in an area just to the east of the former dry cleaner, in the West Treatment Area. This component may involve several different treatment technologies, with a preference for the following:

- AS/VE, where vapor extraction is used to capture fugitive vapors released from the groundwater by the sparging of air into the groundwater
- ISCO, with concurrent groundwater extraction (i.e., directed recirculation) to minimize displacement of contaminated groundwater into areas or zones that are currently unaffected by the PCE plume

Summary of the Selected Remedy

Based on information currently available, the NDEP believes the **Selected Remedy** meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria.

The NDEP expects the **Selected Remedy** to satisfy the following statutory requirements of CERCLA §121(b): 1) be protective of human health and the environment; 2) comply with site-specific remediation goals; 3) be cost-effective; 4) employ permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and 5) satisfy the preference for treatment as a principal element.

12.3 Summary of the Estimated Remedy Costs

Selected Remedy

Estimated First-Year Cost: $1,700,000
Estimated Annual Cost: $750,000
Estimated Present Worth: $5,700,000 to $7,900,000
Estimated Time to Completion: 10+ years

The estimated costs for the Selected Remedy are presented in Table 12-1. This table presents the subtotal capital and O&M costs associated with different components of the Selected Remedy, the subtotal discounted costs, and the total present worth costs for implementation of the remedy.

Table 12-1: Example Cost Details for Selected Remedy

Cost Description	Present Worth (Mean Value)*
Capital & Construction	$700,000
Site Assessment	$500,000
Operation & Maintenance	$3,500,000
Engineering & Reporting	$1,000,000
Monitoring	$1,100,000
TOTAL	$6,800,000

Note: These cost estimations represent a mid-point value in a hypothetical range of costs over a 10-year period. Costs are reflective of a conservative discount rate of 4% and inflation at 2.5% over a 10-year horizon.

<u>Uncertainty in Cost Estimates</u>

All assumptions used in calculating the cost estimates are listed in the table footnotes and as follows:

- A remedial-action start date of 2015 was assumed in the cost calculations; however, actual start date may be later.
- Overall duration of remedial action was assumed to be 10 years.
- A 4% discount rate and 2.5% inflation was used in the present-worth analysis.

The major sources of uncertainty in the cost estimates include the following:

- The number of extraction and injection wells.
- The number of injection points and the amount of chemical reagent needed.
- The amount of water that will be discharged.
- The extent and duration of monitoring.
- The design of all remedy components
- The resources needed for obtaining permits and access agreements
- The duration of remedial action.

The cost summary tables are based on the best available information regarding the anticipated scope of the remedial action. Changes in the cost elements are likely to occur as a result of the new information and data collected during the remedial design phase. Major changes may be documented in the form of a memorandum to the Administrative Record file, an Explanation of Significant Differences (ESD), or a ROD amendment. The projected cost is based on an order-of-magnitude engineering cost estimate that is expected to be within +50 or -30 percent of the actual project cost.

12.4 Expected Outcome of the Selected Remedy

Based on information currently available, the NDEP believes the **Selected Remedy** meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria.

The NDEP expects the **Selected Remedy** to satisfy the following statutory requirements of CERCLA §121(b): 1) be protective of human health and the environment; 2) comply with remediation goals; 3) be cost-effective; 4) employ permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and 5) satisfy the preference for treatment as a principal element.

The NDEP anticipates that achieving the initial site-specific remediation goal (100 µg/L) for PCE in groundwater beneath the neighborhood will be adequately protective of indoor air. If the site-specific remediation goal for PCE in indoor air (9.4 $\mu g/m^3$) is achieved while PCE concentrations remain above the 100 µg/L in groundwater, the 100 µg/L goal may be revised upward, as long as protection of indoor air is well demonstrated and well documented. Achievement of the goals could take from 5 to 15 years. Monitoring of the downgradient extent of the PCE plume in groundwater with respect to potentially active, domestic water-supply wells will ensure the 5 µg/L action level is not exceeded and an exemption under NAC 445A.22725(2) can be provided.

13.0 Statutory Determination

Under CERCLA §121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with statutory and regulatory requirements, are cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes.

13.1 Protection of the Human Health and the Environment

The Selected Remedy (pump-and-treat system, enhanced by upgradient treatment), will reduce concentrations of contaminants (primarily PCE) in groundwater, such that indoor air in overlying homes is sufficiently protected from unacceptable levels of vapor intrusion. Removal and treatment will also prevent the plume from migrating laterally and vertically. Treatment of groundwater will eliminate the threat of exposure via ingestion and inhalation of contaminated water by on-site and off-site human receptors. Absent mitigation or remediation, the cumulative excess carcinogenic risk from inhalation exposure to groundwater contaminants via the vapor intrusion pathway is estimated at 3.0E-05, with a non-carcinogenic HI of 7. The Selected Remedy for groundwater will reduce contamination to meet health-protective goals.

13.2 Compliance with Regulatory Requirements

Nevada has adopted by reference, USEPA action levels for hazardous substances. NAC 445A.22735(1)(b)states that "*The presence of a hazardous substance, hazardous waste or a regulated substance in groundwater at a level of concentration equal to the maximum contaminant level for that substance or waste established pursuant to the Safe Drinking Water Act, 42 U.S.C. §§ 300f et seq., and 40 C.F.R. Part 141, as those sections existed on October 3, 1996*." For PCE and TCE, this sets an action level (i.e., cleanup goal) of 5 µg/L for groundwater. Achieving this goal can be nearly impossible and certainly impracticable even under the best of conditions. However, Nevada's regulations permit an exemption that allows an alternative remediation goal to be established, as long as certain conditions are satisfied. NAC 445A.22725 specifies those conditions.

13.3 Cost Effectiveness

The selected technologies for cleanup of groundwater are cost-effective and present reasonable value. According to the NCP, a remedy is cost-effective if its costs are proportional to its overall effectiveness. The overall effectiveness of the Selected Remedy for groundwater was demonstrated in the comparative analysis of the alternatives. The Selected Remedy satisfies the threshold criteria (overall protectiveness and compliance with regulatory requirements), while scoring highly with respect to the three balancing criteria of long-term effectiveness, reduction in toxicity, mobility, and volume through treatment, and short-term effectiveness.

The Selected Remedy for groundwater includes possible use of an in situ technology combined with extraction and treatment. It is expected that use of ISCO and AS/VE will enhance destruction of PCE over the short-term. When compared to use of pump-and-treat alone, addition of in situ treatment may actually result in cost savings because of the expected reduction in the time required to achieve cleanup goals, as well as the lower amount of extraction and treatment required to reach these goals. For cost-estimating purposes, however, no reduction in time or effort was assumed. This led to higher projected capital costs for the Selected Remedy as compared to pump-and-treat alone. Because of the reduced extraction volume, the projected annual O&M costs were actually lower for the Selected Remedy. The NDEP believes that use of ISCO and AS/VE, in addition to pump-and-treat, is more cost-effective than use of stand-alone pump-and-treat, or conversely, use of stand-alone in situ treatment.

13.4 Use of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The NDEP believes that the Selected Remedy for cleanup of groundwater represents the maximum extent to which permanent and alternative solutions can be used in a practical manner at the Maryland Square PCE Site. The Selected Remedy for groundwater satisfies the threshold criteria of overall protection and compliance with statutory and regulatory requirements, while scoring competitively with respect to the five balancing criteria. An evaluation of the Selected Remedy with respect to the balancing and modifying criteria follows.

Selected Remedy for Groundwater

<u>Long-term Effectiveness and Permanence</u>:
This remedy combines several technologies to maximize effectiveness and permanence of the cleanup. Destruction of the mass of PCE in groundwater beneath the West Treatment Area (just east of the former dry cleaners), combined with containment and aboveground treatment of extracted PCE-contaminated groundwater in the eastern parking lot, will permanently reduce the mass of PCE in groundwater.

<u>Reduction of Toxicity, Mobility, or Volume through Treatment</u>:
The pump-and-treat portion of the remedy will provide hydraulic containment of PCE-contaminated groundwater and reduce the mass of PCE flowing into the residential neighborhood. Aboveground treatment, AS/VE, and ISCO or other technology will reduce the volume (mass) of PCE in groundwater.

<u>Short-term Effectiveness</u>:
The extraction wells will hydraulically contain the flow of PCE-contaminated groundwater.

Implementability:
Design and installation of remedy components are easy to implement using widely available drilling technology. Detailed characterization of treatment areas would be required for any of the remedies; better characterization leads to better design and better effectiveness of the remedy.

Costs:
Cost estimated for this alternative includes annual operating and maintenance expenses.

Community Acceptance:
The Selected Remedy avoids construction and disruption within the residential neighborhood. Installing wells and a pumping station in the East Treatment Area will entail some construction noise, but it should be temporary and minimal. Construction and drilling in the West Treatment Area will not disrupt any residential area and can be scheduled to minimize disruption of business operations.

The NDEP did not receive any negative comments on the Proposed Plan from community members. Residents will likely be accepting of any remedy that is effective and that does not disrupt the neighborhood.

13.5 Preference for Treatment as a Principal Element

This remedy satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment) (NCP §300.430(f)(5)(ii)(F)). Treatment is a major component of the Selected Remedy for groundwater. The Selected Remedy specifies two treatment areas within the PCE plume.

The remedy in the East Treatment Area will use a pump-and-treat system to hydraulically control the contaminant plume upgradient of the neighborhood, treat the extracted groundwater above-ground to remove or destroy the contaminants, and re-inject clean water to facilitate reduction of PCE concentrations in groundwater that underlies the neighborhood.

Meanwhile, in the West Treatment Area, the highest concentrations of PCE will be actively targeted by ISCO, AS/VE, or both.

13.6 Five-Year Review Requirements

This remedy may result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure. Because it will likely take longer than five years to attain RAOs and cleanup levels, a policy review will be conducted within five years of construction completion for the Maryland Square PCE Site to ensure that the remedy is, or will be, protective of human health and the environment.

14.0 Documentation of Significant Changes

The Proposed Plan for Cleanup of Groundwater at the Maryland Square PCE Site was released for public comment on October 15, 2014. The 90-day review period ended January 13, 2015. The Proposed Plan identified Alternative 5 – extraction and treatment in the East Treatment Area just upgradient of the residential neighborhood, with ISCO and AS/VE in the West Treatment Area – as the Preferred Alternative for groundwater remediation. The NDEP reviewed all written comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate. However, the remediation goal for TCE in indoor air was reduced from 6 $\mu g/m^3$ in the Proposed Plan to 2 $\mu g/m^3$ in the ROD.

PART III RESPONSIVENESS SUMMARY

1.0 Stakeholder Issues and NDEP Responses

Comment 1.1 – County Commissioner Chris G, written comment submitted at the Community Meeting, November 19, 2014. *If a home has been foreclosed on or just abandoned, what happens to testing and the* [home mitigation] *equipment? Are new owners informed? What are State regulations regarding notification? Case studies of other similar remedial technologies?*

NDEP Response to Comment 1.1
If a home is abandoned or foreclosed, the home mitigation system should remain in the home (much like other utilities would be; e.g., furnace, hot-water tank, etc.). However, the mitigation system requires electricity to operate the fan, so would not be operable until electrical service was re-established at the house.

The property ownership records are checked every year, prior to mailing out letters offering indoor air sampling to owners of potentially affected homes. So, if the owners had not been informed when they purchased the home (as required by Nevada laws governing real-estate transactions), they will find out when they receive the letter from the NDEP.

Nevada laws governing real-estate transactions are covered under statutes (NRS 113) and regulations (NAC 113). The Nevada Real Estate Division (NRED) is the agency that has as its mission, "to safeguard and promote public interest in real estate transactions by developing an informed public and a professional real estate industry. " http://red.state.nv.us/ The NDEP does not have regulatory authority over property transactions, per se.

The NRED has developed for the consumer a basic "Residential Disclosure Guide" for residential properties. This is the Nevada Legislature's attempt to inform the consumer of potential disclosure issues. This booklet contains information for the consumer - it is not designed to relieve the licensee or seller of any of his or her disclosure duties. (See: http://red.state.nv.us/forms/622.pdf Residential Disclosure Guide booklet, http://red.state.nv.us/publications/RDG_june2014.pdf Residential Disclosure Guide full text)

The NRED has also produced a reference guide as a legal resource guide for Nevada real estate licensees. This guide notes that "Licensee liability lies in inadequate disclosure. " http://red.state.nv.us/publications/law-reference/law_guide_files/lawguide2014.pdf Text under "Environmental Hazards" cautions that "Although the seller is required to disclose the presence of environmental hazards, a statement that the seller is not aware of a defect or hazard does not mean that it does not exist. It is the buyer's responsibility to be informed and take additional steps to further investigate. "

Comment 1.2 – Resident, written comment submitted at the Community Meeting, November 19, 2014. *I would like to have our house tested for PCE vapor. I would also like to find out the rate at which the PCE plume is moving east.*

NDEP Response to Comment 1.2
The NDEP recommends that you contact representatives for the responsible party (the Herman Kishner Trust) and request that they collect a sample of your indoor air. The Permanent Injunction issued by District Court on December 27, 2010 specifies only that the responsible party must provide indoor air sampling "…*for homes in the neighborhood that overlie the area of elevated PCE concentrations in groundwater, as defined by the 100 microgram per liter (µg/L) boundary of the plume*." Because your home lies outside of the 100 µg/L boundary, it has not been included in the indoor-air sampling program to date.

The rate of migration for a contaminant plume is typically evaluated through use of a statistical trend test. Such tests will indicate whether the contaminant concentrations within each well are increasing, decreasing, or stable (i.e., show no trend). There must be a minimum of four samples to perform a trend test. Since 2007, the NDEP has required statistical trend tests on all wells across the site.

Based on the location of your home, which is east of the Las Vegas National Golf Course, the 100 µg/L isoconcentration contour is estimated to be 200 to 300 feet west of your property. There are two groundwater monitoring wells in your area, MW-30 and MW-31. MW-27 is on the west side of the golf course, approximately 900 feet upgradient of your property. Results of the statistical testing indicates "no trend" for PCE concentrations in MW-27, a "probably decreasing" trend (at 93.8% confidence) for PCE concentrations in MW-30, and "no trend" for PCE concentrations in MW-31.

Results from the statistical analysis across the plume indicate that much of the plume is at a "steady state" condition; that is, it appears that it is no longer expanding, and higher concentrations of PCE are no longer moving downgradient. The only wells showing a trend of increasing concentrations are three wells near the source area (MW-5, MW-6, MW-6D3 and MW-7) and two wells near the pilot test area (MW-19D2 and MW-19D3). Well MW-41, east of Eastern Avenue showed an increase from 1.7 to 3.7 µg/L over five quarters; however, more data are needed to confirm this tentative trend.

So, the answer to your second question regarding the "rate at which the PCE plume is moving east" appears to be that the plume is no longer moving east (i.e., attenuation is equal to migration). Monitoring of groundwater will continue throughout development and implementation of the remedy to verify that the area of concern for indoor air (i.e., the area of homes within the 100 µg/L isoconcentration contour) is not changing.

Comment 1.3 – Resident, verbal comment at the Community Meeting, November 19, 2014.
The resident stated that they "*would like to see the State of Nevada move toward regulation or legislation to phase out PCE. It seems, from the database on the NDEP website, that virtually every dry cleaner in Las Vegas is leaking to some degree. At some point, we need to acknowledge that this is an old technology, an old chemistry, that we need to move away from*."

NDEP Response to Comment 1.3. Comment noted.

2.0 Technical and Legal Issues

Comment 2.1 – Peter Krasnoff Letter dated September 19, 2014
"The Proposed Plan identifies that long term indoor air remedial goals for the cleanup include PCE at 9.4 µg/m^3 and TCE at 6.0 µg/m^3. However, the Proposed Plan neither explains the bases for these remedial goals, nor addresses the short-term exposure threshold for protection of pregnant women.

In 2011, the USEPA published its Toxicological Review of Trichloroethylene in Support of the Integrated Risk Information System (IRIS). The USEP A concluded that "women in the first trimester of pregnancy are one of the most sensitive populations to TCE short-term inhalation exposure due to the potential for heart malformation for the developing fetus." To address the short-term exposure risk, USEP A "derived an inhalation RfC continuous inhalation exposure to TCE, which is 2 micrograms per cubic meter (2 µg/m^3)." Therefore, the Proposed Plan should be modified to address the short-term indoor air protection criteria for TCE."

NDEP Response to Comment 2.1

The remediation goal for TCE in indoor air has been modified to 2 µg/m^3 in the ROD (see Section 7.1.4), instead of the 6.0 µg/m^3 goal stated in the Proposed Plan

Comment 2.2 – Peter Krasnoff Letter dated September 19, 2014

"NDEP concludes in the Proposed Plan that a "well-designed groundwater extraction and above ground treatment system is a proven technology that will also prevent continued migration of PCE-contaminated groundwater into the neighborhood." However, a "well-designed" groundwater extraction system should consider Site-specific available information on the hydrogeology."

NDEP Response to Comment 2.2

The NDEP agrees that a well-designed groundwater extraction system should consider site-specific information on the geology and hydrogeology. Additional characterization in the proposed treatment area will allow refinement of the design.

Comment 2.3 – Peter Krasnoff Letter dated September 19, 2014

"NDEP concludes in the Proposed Plan that a "well-designed groundwater extraction and above ground treatment system is a proven technology that will also prevent continued migration of PCE-contaminated groundwater into the neighborhood." However, a "well-designed" groundwater extraction system should consider Site-specific available information on the hydrogeology.

As presented in the Final Corrective Action Report for Groundwater, in July and August 2012, Tetra Tech conducted pump tests west of the Boulevard Mall to "better evaluate the feasibility of groundwater extraction as a corrective action." The tests revealed that "wells screened in the shallow water-bearing zone would produce water at very low flow rates, making them impractical for use in groundwater extraction for hydraulic control of PCE mass removal." Tetra Tech's evaluations concluded that "wells screened in the shallow water-bearing zone would produce water at very low flow rates making the impractical for use in groundwater extraction. Given the low pumping rates and the associated small capture zones, groundwater extraction for hydraulic control or PCE mass removal would be challenging within the Boulevard Mall property."

Based on these findings, Tetra Tech concluded "groundwater extraction is not a recommended corrective action." In contrast to Tetra Tech's conclusion, and without supporting rationale, NDEP is recommending groundwater extraction as a primary component of the Proposed Plan. The Proposed Plan should be modified to explain how a groundwater extraction system will provide capture of the contaminated groundwater given the findings from Tetra Tech's investigations"

NDEP Response to Comment 2.3

Remediation of groundwater using extraction and aboveground treatment ("pump and treat") remains a dependable technology for cleanup of groundwater. Pumping of the shallow groundwater to depress the water table has been used to dewater subterranean parking garages and other structures in the Las

Vegas area. The former Sahara Hotel used a dewatering system to allow operation of a subgrade roller coaster; water levels have steadily risen at the site since the roller coaster and dewatering system were removed.

The NDEP believes that Tetra Tech's pumping test was not properly designed. Based on dewatering systems functioning properly at sites throughout Las Vegas, there is every reason to think that properly designed pumping wells should be able to depress the water table on the eastern side of the mall. Such a system should thereby achieve hydraulic containment of the contaminated groundwater.

Successful and cost-effective use of this technology requires (1) detailed characterization of the geology, hydrology, and chemistry; (2) removal of source terms, if possible; (3) initial design for plume containment and source remediation; (4) detailed monitoring of the remediation; (5) active ongoing reevaluation of the operating well field, including redesign as appropriate (dynamic management); (6) reinjection of treated groundwater to speed the flushing of contaminants. Techniques can dramatically reduce the time required to achieve cleanup goals and thus the cost of groundwater remediation.

"Pump and treat" is perceived by some to be ineffective in reducing contaminant concentrations to drinking water standards. This is due to the length of time required to remove low concentrations of contaminants; pump and treat typically suffers from a "law of diminishing returns" when concentrations approach drinking water standards. The NDEP understands this limitation, as it applies to drinking water standards. Because the water will not be used as drinking water, the alternative site-specific remediation goal (100 µg/L PCE in groundwater) is based on protection of indoor air rather than on achieving the drinking water standard for PCE (5 µg/L PCE). The higher goal of 100 µg/L PCE in groundwater is considered achievable.

<u>Comment 2.4 – Peter Krasnoff Letter dated September 19, 2014</u>

To "destroy" mass, NDEP has proposed the use of air sparging (AS) and vapor extraction (VE) as part of the Proposed Plan. However, NDEP does not address the noted limitations for implementing this technology at the Site.

Tetra Tech had identified ASNE as a potential remedial technology "pending proof of performance." However, during investigations at the Site, a low permeable caliche layer was encountered. Due to the low permeable zone, Tetra Tech had requested that NDEP approve that AS/VE testing "be dropped from the upcoming field work because unfavorable subsurface conditions, consisting of caliche layer below the water table that had been confirmed during vertical delineation work."

In evaluating the request to cancel the pilot test NDEP responded in August of2012:

> *"The NDEP agrees that trying to conduct air sparging beneath a laterally extensive and competent 2-foot thick layer of caliche is problematic ... the vapor extraction system ... may not be able to effectively capture the air sparged beneath the caliche. Therefore, sparging beneath the caliche may create fugitive vapors of PCE in the subsurface environment that are not adequately captured by the vapor extraction wells screened above the caliche layer. These fugitive vapors may pose a human health risk." [emphasis added]*

Based on these findings, Tetra Tech wrote in the Final Corrective Action Report for Groundwater, the "AS [air sparging] pilot test was eliminated after subsurface investigations within the pilot test area revealed layers of caliche and other fine-grained soils below the lowest observed water table. Caliche layers and clayey lenses are undesirable for AS with SVE."

Because of the encountered conditions, Tetra Tech concluded in 2012 that "AS was not a viable treatment option." Therefore, the Proposed Plan should be modified to explain how the occurrence of the caliche layer will not create problems for the implementation of AS/VE.

NDEP Response to Comment 2.4

The NDEP agreed not to perform AS in the eastern parking lot of the Boulevard Mall due to the proximity of the pilot test area to nearby homes (~100 feet away) and the presence of an apparently laterally continuous caliche layer near the water table. AS works by injecting air into a well that is screened at depth below the water table. The air bubbles capture PCE vapors and transport the PCE-laden vapors to the water table and then into soil gas of the unsaturated zone, where vacuum extraction wells suck up these vapors. However, on the eastern side of the mall property, the laterally extensive layer of caliche at the water table means that PCE-laden air bubbles cannot predictably escape across the water table to be captured by the adjacent VE wells. This may lead to fugitive vapors that travel unpredictably to areas outside of the influence of the VE wells. Because homes were so close (~100 feet) to pilot test area, the NDEP did not want to risk creating fugitive, uncaptured PCE vapors that could unpredictably migrate toward the nearby homes.

The proposed treatment area on the west side of the mall is surrounded by an extensive parking lot, S. Maryland Pkwy and commercial buildings. This treatment area is far removed from any homes, with the closest residences located more than 300 to 500 feet away. This makes fugitive vapors entering into homes much less of a concern than on the eastern side of the mall. Additionally, although there are caliche layers noted in some of the bore logs for wells in the western parking lot, the caliche does not appear to be as laterally extensive as in the pilot test area on the east side of the mall.

Properly designed AS/VE systems have proven an effective remedy at other dry cleaner sites in the Las Vegas area. With some additional characterization work in the proposed treatment area, there is no reason to think that AS/VE will not be an effective remedy for removing PCE mass. The bore log for MW-14 shows clayey sand, sandy clay and silty sand with gravel, but no caliche. MW-14I shows 15 feet of silty sand overlying caliche, below which silty sand dominates the lithology down to the total depth of 55 feet bgs. These logs suggest that caliche occurs as lenses rather than a laterally extensive layer. Gravels, sands, silty sands, and silts are all amenable to remediation using AS/VE. AS/VE is unlikely to be effective in fat clays.

Based on lithology and distance to residential receptors, the NDEP is comfortable that AS/VE will be an effective remedy in the proposed treatment area, where the greatest mass of PCE still resides. Text has been added to Section 2.3 of the ROD to describe the rationale for not performing the AS/VE pilot test in the East Treatment Area, and why use of AS/VE in the West Treatment Area is not of the same concern.

Comment 2.5 – Peter Krasnoff Letter dated September 19, 2014

The Proposed Plan also includes the use of ISCO with re-circulation wells for treatment of PCE-contaminated groundwater near Maryland Parkway. As part of the development of the Final Corrective Action Plan for Groundwater, Tetra Tech conducted pilot testing of ISCO. Although the results were favorable initially showing decreases in concentrations of PCE, sampling conducted of the deep-screened monitoring wells "increased from nondetect (0.50 to 0.68 µg/L) to 710 to 160 µg/L in one well."

As noted in the Proposed Plan, "although results were initially promising, data collected from 3 to 12 months after injections appeared to show that PCE-contaminated groundwater had been displaced into previously clean areas. These results suggested that any cleanup technology involving injection of treatment chemicals must be paired with groundwater withdrawal to minimize the displacement of contaminated groundwater."

NDEP has also concluded in the Proposed Plan that the effectiveness of the ISCO "is difficult to distinguish between destruction of PCE in groundwater and displacement of PCE-contaminated groundwater." Therefore, given the noted limitations on groundwater capture with extraction wells, the Proposed Plan should provide an explanation how groundwater extraction could prevent further displacement of PCE-contaminated groundwater to the deeper zone to control ISCO injections.

NDEP Response to Comment 2.5
The NDEP noted in the Proposed Plan that "*Although the ISCO pilot testing conducted on the eastern side of the Mall property appeared to result in displacement of contaminated groundwater into previously clean areas or zones, that testing did not incorporate extraction or recirculation wells. Theoretically, extraction of a volume of groundwater equal to the volume of injectate should minimize the amount of displacement of contaminated groundwater*." The key to any effective remedy is adequate characterization and a clear understanding of the site-specific lithology and hydrogeology in the proposed treatment area.

As noted in NDEP's response to Comment 2.3, pumping of the shallow groundwater to depress the water table has been used to dewater subterranean parking garages and other structures in the Las Vegas area. There is every reason to think that properly designed pumping wells should be able to depress the water table on the eastern side of the mall, thereby achieving hydraulic containment of the contaminated groundwater. The very fact that the deeper portion of the aquitard sampled by MW-19D3 (92 to 102 feet bgs) is hydraulically connected to the shallow zone where oxidants were injected (20,000 gallons from 20 to 60 feet bgs), means that applying controlled hydraulic head can move the groundwater in a vertical (as well as horizontal) direction.

Again, the key is adequate characterization and effective design. The pilot tests performed by Tetra Tech in 2012 were quite limited in scope and involved very extensive access negotiations between the Trust and the Boulevard Mall, which, at the time was under a third-party lawsuit from the Trust. The NDEP's approach is to carefully evaluate the design details of every facet of the remedy proposed for the Maryland Square PCE Site.

The NDEP recognizes the heterogeneous lithology of the geologic deposits at this site. Accordingly, as noted previously, adequate characterization is necessary for planning an effective remedy. This ROD is designed to implement the most cost-effective remedy while retaining some flexibility to adapt individual remedy components to the constraints of the site. Design and implementation of the remedy must necessarily be capable of adequately protecting human health and the environment.

Comment 2.6. Verbal comment at Community Meeting, November 19, 2014. Provided by Mr. Tom Douglas.
Mr. Douglas noted that although he liked the flexibility of different options in the Proposed Plan, he was concerned about the "pump and treat" component failing due to a lack of funds. He stated that he had seen sites where the pumping wells had "drawn in" the plume. Because the pumping wells at the Maryland Square site are proposed to be located just upgradient of the homes, he was concerned what would happen if the money ran out and the pumping ceased after drawing the plume closer to the homes. He said the funding needs to be there for ten years or longer; however long it takes to clean up the groundwater.

NDEP Response to Comment 2.6.
Full funding has been secured for the design, installation, and operation of the Selection Remedy. The funds secured are sufficient to cover conservative cost estimates for long-term operation. In addition, funding obtained by the NDEP is not a single fixed payment, and mechanisms are in place for continued funding should initial payments not be sufficient to achieve Remedial Action Objectives.

The Selected Remedy also includes continuation of the annual sampling program for indoor air and installation of home mitigation systems to control exposure from the vapor intrusion pathway until Remedial Action Objectives are met.