RECORD OF DECISION

WATSON JOHNSON LANDFILL SUPERFUND SITE

RICHLAND TOWNSHIP, BUCKS COUNTY, PENNSYLVANIA

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 3, PHILADELPHIA, PENNSYLVANIA
August 2009

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WATSON JOHNSON LANDFILL SUPERFUND SITE

RICHLAND TOWNSHIP, BUCKS COUNTY, PENNSYLVANIA

RECORD OF DECISION
WATSON JOHNSON LANDFILL
SUPERFUND SITE

DECLARATION

Site Name and Location

Watson Johnson Landfill Superfund Site
Richland Township, Bucks County, Pennsylvania
CERCLIS ID Number PAD980706824

Statement of Basis and Purpose

This decision document presents the selected remedial action for the Watson Johnson Landfill Superfund Site ("Site") located in Richland Township, Bucks County, Pennsylvania, (see Figure 1) which was chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act 42 USC §§ 9601 et seq., as amended, ("CERCLA"), and the National Oil and Hazardous Substances Pollution Contingency Plan ("NCP"), 40 C.F.R. Part 300. This decision document explains the factual and legal basis for selecting the remedial action for this Site. The information considered or relied upon in making this decision is contained in the Administrative Record for this Site.

The Pennsylvania Department of Environment Protection ("PADEP") concurred with the selected remedy in a letter dated July 24, 2009.

Assessment of the Site

The response action selected in this Record of Decision ("ROD") is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

Description of the Remedy

The remedial action described here comprises a comprehensive remedy for the Site. Landfill operations conducted at the Site have resulted in residual contamination, mainly of volatile organic compounds ("VOCs"), in groundwater. A presumptive remedy approach was taken by the U.S. Environmental Protection Agency ("EPA") with regard to the landfill.

The contamination within the groundwater is not considered to be a principal threat waste. The contaminant plume emanates from the landfill and has migrated in the general direction of groundwater flow to the south, toward a Quakertown, Pennsylvania neighborhood, and also to a lesser extent toward the southwest. VOCs were detected within the Quakertown neighborhood residential wells and a Quakertown Borough water

supply well located downgradient from the Site. The Quakertown neighborhood was placed on public water supply in 2005/2006 during an EPA Removal Action, thereby eliminating exposure to the contaminated groundwater by residential well users. Also, the Borough supply wells are currently being treated by an air-stripper system to remove the chlorinated solvents when the wells are in operation.

There are elevated levels of several metals in soils and sediments adjacent to the landfill and in soils located within the Tohickon Creek flood plain. EPA determined that these metals may pose a risk to ecological receptors.

The selected remedy consists of:

1. Installation of a multi-layer cap cover system for the landfill area including a storm water management system and a vertical and horizontal landfill gas management system.

2. Ecological area remediation.

3. In-situ chemical oxidation of the VOC contamination in the groundwater.

4. Enhanced bioremediation to encourage the natural biological degradation process to further remediate the VOC contamination in groundwater.

5. Groundwater monitoring to ensure effectiveness of the groundwater remedy.

6. Institutional controls to protect the integrity of the remedy including the monitoring wells, injection wells, cap cover system and any groundwater cleanup process itself. This latter will include preventing the pumping of groundwater that could interfere with the cleanup. Institutional Controls are also needed to prevent dermal contact with and consumption of groundwater that exceeds the performance standards. An Institutional Control Implementation and Assurance Plan ("ICIAP") will be developed for the Site during the remedial design to ensure appropriate institutional controls are drafted, implemented and monitored.

Statutory Determinations

The selected remedial action is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable.

This remedy also 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). The groundwater remedy includes treatment using in-situ chemical oxidation and enhanced bioremediation to remediate the contaminated groundwater.

Because the Site remedy results in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

Data Certification Checklist

The following information is included in the Decision Summary of this ROD. Additional information can be found in the Administrative Record for this Site.

ROD CERTIFICATION CHECKLIST	
Information	Location/Page Number
Chemicals of concern and respective concentrations	Section 5.2, p.8 and Tables 1-6
Baseline risk	Section 7.0, p. 17
Clean-up levels and the basis for these levels	Section 8.0, p. 30 and Tables 13-15
How source materials constituting principal threat are addressed	Section 7.1.6, p. 28
Current and reasonably anticipated future land use assumptions and potential future beneficial uses of groundwater	Section 6.0, p. 16 Section 11.4, p. 59
Potential future land and groundwater use that will be available at the Site as a result of the selected remedy	Section 11.4, p. 59
Estimated capital, annual operation and maintenance, and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected	Section 11.3, p. 59 and Tables 19 and 20
Key factors that led to selecting the remedy	Section 11.1, p. 52

Dennis D. Carney for

Kathryn A. Hodgkiss, Acting Director
Hazardous Site Cleanup Division
EPA Region III

8/14/09
Date

II. DECISION SUMMARY

WATSON JOHNSON LANDFILL
SUPERFUND SITE

RICHLAND TOWNSHIP, BUCKS COUNTY, PENNSYLVANIA

1.0 SITE NAME, LOCATION AND DESCRIPTION

The Watson Johnson Landfill Superfund Site is located in Richland Township, Bucks County, Pennsylvania (Figure 1). The Site is located approximately 0.75 miles north of Quakertown and lies northeast of Tohicken Creek (Figure 2).

The Site is approximately 32 acres in area, and contains a 20.4 acre inactive and unlined landfill. The landfill was in operation from the late 1950's until the early 1970's, when it was shut down by court order. The landfill was never permitted to accept waste. Both household and industrial wastes were disposed of at the landfill. The Comprehensive Environmental Response, Compensation, and Liability Information System ("CERCLIS") identification number for this Site is PAD980706824.

The U.S. Environmental Protection Agency ("EPA") is the lead agency for Site activities and the Pennsylvania Department of Environmental Protection ("PADEP") is the support agency.

This action addresses the landfill area and the contamination in the groundwater throughout the Site. This action is a comprehensive remedy for the Site, and EPA does not anticipate the need to select any additional remedial actions (Records of Decision).

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The EPA Region III Site Assessment Technical Assistance ("SATA") team conducted field investigations at the Site from 1998 through 1999. SATA collected samples from on-site soils, adjacent wetlands, the Tohickon Creek, and from on-site groundwater monitoring wells and nearby residential and municipal wells.

Hazardous substances detected in the soils of the landfill during the Site Investigation ("SI") included volatile organic compounds ("VOCs"), semi-volatile organic compounds ("SVOCs"), polychlorinated biphenyls ("PCBs"), and metals. Site monitoring well results also showed elevated levels of tetrachloroethene ("PCE") and trichloroethene ("TCE") in groundwater. These compounds were also found in the samples collected from the Quakertown Borough water supply wells QT-10 and QT-17. The municipal wells are approximately 3/4 of a mile south of the Site (Figure 3). The SI concluded that the PCE and TCE contamination of the municipal wells was attributable to the Site. This conclusion was determined from the following: (1) general groundwater flow off-site is south-southwest (toward the municipal wells); (2) PCE and TCE were found in Site monitoring wells, and PCE was found in a drum buried on Site; (3) PCE and TCE were found in a municipal well down gradient from the Site; and (4) neither PCE nor TCE were found in background wells. Production water from the municipal well is currently being treated by an air stripper to remove contamination prior to distribution.

During the SI, low levels of PCE were also detected in several off-site residential wells. The PCE is believed to be Site-related. Elevated levels of arsenic were also detected in several residential wells. The SI concluded that there were two potential possibilities for

the elevated levels of arsenic. The first is based on the fact that pyrite has been documented to be present in rocks underlying the area. Pyrite minerals, specifically arsenopyrite, contain arsenic, and this is a common source of natural levels of arsenic in the groundwater. The second possibility is that the iron sulfate in the pyrite would form a weak acid and dissolve the pyrite found naturally in the soil, thereby increasing the natural levels of arsenic found in the groundwater. Further study was performed during the Remedial Investigation ("RI") which confirmed that the actual cause of the elevated levels of arsenic in groundwater was naturally occurring pyrite based on the statistical background elevation of arsenic in monitoring wells, the random distribution of elevated arsenic in groundwater and the presence of pyritic crystals observed to be present in monitoring well MW21D.

During the SI, elevated levels of metals (mercury, chromium, aluminum, iron and manganese) and PCBs were detected in sediment samples collected from wetlands adjacent to the landfill.

This Site was proposed for the National Priorities List on June 14, 2001 and formally added to the list on September 13, 2001.

A contaminant plume emanates from the landfill and has migrated in the general direction of groundwater flow to the south, toward a Quakertown neighborhood, and also toward the southwest. The VOCs were detected within the Quakertown neighborhood residential wells and a Quakertown Borough water supply well located downgradient from the Site. The Quakertown neighborhood was placed on public water supply in 2005/2006 during an EPA Removal Action, thereby eliminating exposure to the contaminated groundwater by residential well users.

3.0 COMMUNITY PARTICIPATION

The Watson Johnson Landfill Remedial Investigation, Feasibility Study, and Baseline Risk Assessment, and other Administrative Record documents relating to the Site, were made available to the public. They are located in the Administrative Record, which was available at the following locations:

Administrative Records Room
US EPA Region III
1650 Arch Street
Philadelphia, PA 19103
(215) 814-3157

And:

James A. Michener Library
Bucks County Free Library System
401 West Mill Street
Quakertown, PA 18951
Phone: 215-535-3306

The Administrative Record can also be viewed at http://www.epa.gov/arweb, or at the Administrative Record link on the sidebar of the U.S. EPA Region 3 Hazardous Site Cleanup Division Homepage at http://www.epa.gov/reg3hscd.

The notice of availability of these documents was published in the *Daily Intelligencer*, a Bucks County newspaper, on September 5, 2008 and in the *North Penn Reporter* on March 5, 2009. In addition, EPA delivered a fact sheet summarizing the Agency's preferred remedial alternative for the Site to residences and businesses near the Site in September 2008.

From September 8, 2008 to October 7, 2008 EPA took public comment on the remedial alternatives presented in the Feasibility Study, the Proposed Plan and the other documents contained within the Administrative Record for the Site. On September 25, 2008, EPA held a public meeting to discuss the Proposed Plan and accept comments. A transcript of this meeting is included in the Administrative Record. EPA held a public comment period from March 9, 2009 to April 7, 2009 on the Proposed Plan. The summary of significant comments received from the public and EPA's responses are included in the Responsiveness Summary, which is a part of this Record of Decision.

4.0 SCOPE AND ROLE

The actions selected by EPA in this document constitute a comprehensive approach for addressing all of the environmental problems at the Site. EPA expects that the removal actions taken at the Site to date and the remedial action selected by EPA in this document will address the risks posed by the Site. The action selected by EPA at this time and the actions already completed are expected to be the final actions necessary to address the risks from the contamination at the Site.

5.0 SITE CHARACTERISTICS

5.1 Surface Features, Soil and Geology, Hydrogeology, And Surface Hydrogeology

5.1.1 Surface Features and Resources

The Watson Johnson Landfill Site encompasses the approximate area shown in Figure 2. The approximate boundaries of the Site are the southern edges of Richlandtown Borough to the north, Heller Road and Tohickon Creek to the west, Richlandtown Pike to the east, and Tochickon Avenue to the south. An unnamed tributary flowing south to Tohickon Creek lies directly east of the Site, and forms a divide between two topographic tendencies within the Site. East of the tributary, the general topography slopes gently from northwest to southeast. West of the tributary, the general topography slopes gently from the east-northeast to west-southwest, toward Tohickon Creek.

The land surface in the vicinity of the landfill is relatively flat, sloping gently to the west-southwest toward Tohickon Creek. The landfill itself is mounded, relative to surrounding grades, having a relatively flat but irregular topographic surface. In addition, a mounded berm is located on the south perimeter of the landfill and portions of the east perimeter adjacent to the residential properties. A mounded berm was also identified along what is estimated to be the property line between the landfill property and the property owned by Jolly Gardner Products, Inc. The Frontier Woods division of Jolly Gardner Products, Inc. operates a composting facility on this adjacent property ("Frontier Woods").

Land use in the vicinity of the Site is approximately 50% residential, 10% commercial, 5% agricultural, and 35% wooded and/or wetland. The Site is currently not in use and has unrestricted access (no fence). The landfill is bordered by agricultural properties to the north and south. Woodlands and wetlands are located southwest of the Site, extending from the landfill to Tohickon Creek. The composting facility lies to the west and a residential housing subdivision, Heather Valley/Richland Farms, borders the landfill to the east.

The residents in the Watson Johnson Landfill Site area are either on public or private water supply. Three public water suppliers serve the general area: 1) Richlandtown Borough Water Department; 2) Richland Township Water Authority ("RTWA"); and 3) Quakertown Borough Water Department ("QBWD").

The RTWA supplies water to the Heather Valley/Richland Farms subdivision located on the east side of the landfill property and provides water to the Walnut Bank Farms, a subdivision located southwest of the landfill property. A RTWA supply well is located directly north of Walnut Bank Farms and may be used by the RTWA in the near future.

The Richlandtown Borough Water Department services home in the Richlandtown Borough, located north of the Site.

The QBWD supplies water to a population of approximately 14,000, including the entire Borough and limited portions of Richland and Milford Townships, using 10 supply wells. The majority of the residents on public water south of the landfill are served by QBWD. Two QBWD wells, a shallow well and a deep well, are located south-southwest of the landfill property and are designated QT10/17 (Figure 3). Due to the historical detection of TCE in these wells, the QBWD uses an air-stripper treatment system to remove VOCs from these wells prior to distribution.

Approximately 270 homes are known to have private drinking water wells. Most of these homes are located along Richlandtown Pike, East Pumping Station Road, a neighborhood located north of East Pumping Station Road and portions of Heller Road. Directly south of the landfill property, portions of a Quakertown neighborhood located on the south side of the Tohickon Creek were also supplied by private drinking water wells. However, due to the presence of VOCs in their drinking water source, these homes were placed on public service by an EPA Removal Action conducted in 2005/2006.

5.1.2 Soil and Geology

The Watson Johnson Landfill property consists of soils that are generally reddish brown silty clay/clayey silt. The soils extend to a depth of 3 to 7 feet (near the landfill), where weathered and fractured bedrock of the Brunswick Group is encountered. The surface soils have been determined to have a low permeability, as evidenced by saturated soils and pools of water lying on the surface.

Soil types have been mapped by the Soil Conservation Service. The soil types are mainly composed of the following types:

- AbA and AbB: Abbottstown Silt Loam: The Abbottstown series consists of deep, somewhat poorly drained soils, nearly level to sloping soils in uplands. They formed in loamy material weathered from red and brown shale and sandstone.
- Bo: Bowmansville Silt Loam: The Bowmansville series consists of deep, poorly drained, nearly level soils on the floodplain. Most areas are along small meandering streams. Soils are formed in loamy alluvium that is washed from upland soils underlain by red and brown shale and sandstone. Runoff is slow, and the hazard of erosion is slight.
- CwA: Culleoka-Weikert Silt Loam: The Culleoka series consists of moderately deep, well-drained soils, gently sloping to moderately steep soils on uplands. The Culleoka-Weikert series is composed of shale and silt loams. These soils are mostly used for crops, but the level of drought tolerance limits their use for cultivated crops.
- RIA and RIB: Reaville Channery Silt Loam: Reaville soils are moderately deep, moderately well to somewhat poorly drained soils with slow permeability. RIA and RIB differ only in the slope of the soils. RIA soils have 0-3% slope. RIB soils have 3-8% slope.
- UdB: Urban Land Chester Complex: This complex is composed of 60% Urban Land, 35% Chester soil, and 5% included soils.

The Site is located within the Triassic Lowland Section of the Piedmont Physiographic Province, also known as the Newark Basin. The Piedmont Physiographic Province is composed of non-marine, sedimentary rocks. The Piedmont Province is underlain by dense, almost impermeable bedrock that yields water primarily from secondary porosity and permeability provided by fractures. The Newark Basin contains three principal stratigraphic units. These are the Stockton Formation, Lockatong Formation, and the Brunswick Formation.

The Watson Johnson Landfill Site is specifically underlain by the Brunswick Group and is mostly composed of red and gray, silty mudstone and shales forming a Van Houten cycle. These cycles are made up of thick cyclic repetitions of black to gray shale grading up into massive gray, silty mudstones. Van Houten cycles in the lower most part of the Brunswick Group include the Graters and Perkasie Members, which contain thick black shales that are distinctive across the length of the Newark Basin. These laminated shales are characteristically pyritic. Pyrite is an isometric mineral and is commonly found as

striated cubes or in pyritohedrons. Joints in the Brunswick Formation are common and tend to be partially or completely filled with calcite and quartz.

A series of diabase dikes and sills are found in the area, with the closest units located approximately 1.5 miles to the west, north and east of the Site. These intrusives have altered the Brunswick Formation to hornfels, which are fine grained and more resistant to erosion than the shale within the Brunswick. The shale typically exhibits low relief terrain with broad shallow valleys.

Strike and dip measurements in the immediate area surrounding the landfill property show a northward trending strike with dip of 20 degrees toward the northwest and west. Some strike and dip orientations in the region are reversed (especially in the immediate vicinity of the diabase structures), likely caused by post depositional tectonism with which the diabase dikes are associated. Drainage patterns and stream reaches exhibit an orientation similar to the underlying structure.

5.1.3 Hydrogeology

Groundwater beneath the Site and surrounding area occurs within the unconsolidated overburden and also within the underlying bedrock. Shallow groundwater flows through the unconsolidated deposit generally follows the topographic gradient, while the direction of groundwater flow through the bedrock formation is expected to be southward along the bedding plane fractures toward the Tohickon Creek.

The saturated portion of the Brunswick Formation forms the Brunswick Group Aquifer. Groundwater within this aquifer is found in the primary and secondary fracture porosity of the bedrock. Groundwater flow is dominated by the fracture porosity. Types of fracture porosity consist of vertical joints, bedding fractures and large scale vertical fractures.

Vertical joints form perpendicular to bed surfaces and are the most numerous types of fractures. These joints tend to be vertically limited and confined to the more brittle sedimentary units. Joints are important to the vertical movement of groundwater. However, the restricted areal and vertical extent of these joints limits their importance to the regional groundwater flow system.

More significant to the regional flow network are bedding plane fractures. These fractures develop along zones of weakness that occur at the contacts between differing rock types. Bedding plane fractures may be continuous over large areas and are significant in number. Bedding plane fractures dominate the groundwater flow system because of their consistent orientation, significant number, and wide scale distribution.

Large scale vertical fractures that extend to significant depth and cut large sections of rock strata are also present. These large scale vertical fractures are the least widespread of the fracture types. Wells drilled through these fractures may have anomalously high yield, because these fractures may connect many bedding plane fractures and joints.

Large scale vertical fractures may be expressed at the surface by linear topographic features. They may also be expressed as linear stream segments, where they act as major groundwater discharge pathways.

The siltstone, sandstone, and conglomerate units may also contain the primary porosity or intergranular pore space. Intergranular porosity tends to be more important to groundwater storage than to groundwater flow due to the relatively low permeability of the primary porosity.

Water used for drinking water in the Site area is obtained from wells installed within the Brunswick Group. Wells located in the Quakertown area typically exhibit higher yields than those in other areas. The greater yields are likely associated with high intensity fracturing from diabase intrusives in the area. However, yields can be sporadic over relatively short distances, especially farther from the intrusive zones, depending upon the secondary porosity conditions.

5.1.4 Surface Hydrogeology

The Watson Johnson Landfill Site is situated in the Middle Delaware-Musconetcong Watershed that straddles the Pennsylvania/New Jersey borders. This watershed basin includes parts of six counties in New Jersey and three counties in Pennsylvania, including Bucks County. Watersheds upstream of the Site include the Crosswicks-Neshaminy and Schuykill while downstream is the Delaware Bay Watershed.

Quakertown Borough lies in a basin drained by five main streams. Morgan Run and Beaver Run generally flow northeast, Licking flows to the east and Loux Creek flows southwest. The main drainage source for the Site is the Tohickon Creek, which drains the area north of Quakertown, including the Site. (Figures 2 & 3)

Tohickon Creek flows south approximately 1,500 feet west of the landfill property and then bends and flows southeast toward an area just north of Quakertown, where it passes approximately 2,500 feet south of the landfill. Tohickon Creek is generally shallow (2.0 to 4.0 feet deep), rocky, flows slowly and tends to flood after large rain events. A small unnamed tributary flowing south to Tohickon Creek lies directly east of the Site.

Isolated wetlands and surface ponds exist on the southern, eastern and western portions of the landfill. Wetlands adjacent to the landfill to the south are part of a larger wetland area located south of Frontier Woods on the southwestern border. This contiguous wetland area drains into the Tohickon Creek. Given the topography and hydrogeology, it is likely that isolated wetlands and ponds were connected to this larger wetland/creek system prior to creation of the landfill.

Surface water runoff from the northeast portion of the landfill flows into a small pond located just outside the landfill boundary to the northeast. The runoff from the southern portion of the landfill flows into a broad swale and a series of small ponds located on the landfill boundary. There are a series of shallow ponds and forested wetlands located outside the landfill boundary that receive runoff from the northwest. This forested

wetland area flows into a broad swale along the western landfill boundary. The runoff from the western portion of the landfill also flows into this broad swale. The swales just outside the western and southern limits of the landfill converge at the southwestern corner. They continue to flow through a poorly defined series of ditches and depressions across the Tohickon floodplain and eventually into the Tohickon Creek. The pond to the northeast of the landfill appears isolated and currently has no outlet.

The National Wetlands Inventory ("NWI") classifies the majority of the Site as Upland. Two wetland areas are present at the Site according to NWI, both of which are classified as Palustrine Open Water. Other wetlands are present in the vicinity of the Site with the majority of these defined as Palustrine and located within the 100-year floodplain of the Tohickon Creek. Additional wetlands do exist on the southern, eastern and western portions of the landfill. Wetlands adjacent to the landfill to the south are part of a larger wetland area located south of Frontier Woods. This contiguous wetland area drains into Tohickon Creek.

5.2 Nature and Extent of Contamination

EPA initiated the Remedial Investigation/Feasibility Study ("RI/FS") for the landfill portion of the Site as well as the groundwater aquifer in September 2001. The objectives of the RI were generally to characterize Site conditions, determine the nature and extent of contamination, and assess risks to human health and the environment related to the groundwater. EPA utilized a presumptive remedy approach for the landfill portion of the Site. This approach supports the application of cleanup techniques shown to be effective in the past to cleanup similar sites. The 1993 Presumptive Remedy Guidance Document identifies containment (specifically a landfill cap) as the presumptive remedy for landfill waste.

The RI confirmed that bedrock groundwater at the Site is contaminated with chlorinated solvents including PCE, TCE, cis-1,2-dichloroethylene (cis-1,2-DCE), and vinyl chloride. The contaminant plume emanates from the landfill and has migrated in the general direction of groundwater flow to the south, toward a Quakertown neighborhood, and also to a lesser extent toward the southwest. The chlorinated solvents were detected within the Quakertown neighborhood residential wells and a Quakertown Borough water supply well located downgradient from the landfill. The Quakertown neighborhood was placed on public water supply in 2005/2006 during an EPA Removal Action, thereby eliminating exposure to the contaminated groundwater by residential well users. Also, the Borough supply wells are currently being treated by an air-stripper system to remove the chlorinated solvents prior to distribution.

The RI also confirmed the presence of elevated levels of several metals in soils and sediments adjacent to the landfill and in soils located within the Tohickon Creek flood plain. EPA determined that these metals may pose a risk to ecological receptors.

The investigation findings are summarized below regarding the nature and extent of contamination:

5.2.1 Landfill

- The area of the landfill is approximately 20.4 acres and is essentially located within the landfill property line. The landfill mass is generally situated directly on a fractured shale bedrock surface, indicating that overburden soils were removed during landfilling operations. Overburden soil along the perimeter of the landfill mass ranged from 3.0 to 6.5 feet thick. The average thickness of the waste is 10.5 feet, and the volume of the landfill mass is estimated to be approximately 346,000 cubic yards. The landfill waste encountered during the RI generally consisted of household waste.

- Methane was not detected within the shallow subsurface of the landfill or its perimeter. Given the age of the landfill, lack of methane, and low levels of carbon dioxide, it appears that the landfill is within its last phase of gas generation (i.e., reduced to no gas production). Based on the landfill soil gas survey performed, it was concluded that there is no off-site migration of methane.

- Wetlands exist on the southern, eastern and western perimeters of the landfill. It appears that historic landfill operations may have encroached into pre-existing forested wetlands in the western areas of the landfill.

- A geophysical survey was performed across the landfill to identify anomalies. The source metals within the anomaly areas ranged from car parts, fencing, and scrap metal to an intact automobile. Some crushed and empty smaller metal containers were encountered in some of the test pits performed during the RI, as well as some small container lids and a few 55-gallon drum lids. In addition, one crushed and empty 5-gallon drum was encountered and several crushed and empty 30-gallon drums. No VOCs were detected during screening of the debris or during the entire anomaly area test pit investigation. No labeling or markings were distinguishable on crushed drums and/or lids.

- The amount of freestanding leachate, present within the waste mass, is estimated to be approximately 11 to 15 million gallons. Except for several seeps, it does not appear that an appreciable amount of leachate is discharging off-site. However, due to the high leachate levels observed within the landfill mass, leachate will continue to migrate into the groundwater, especially since the waste is situated directly over fractured bedrock. The leachate is very weak and the RI did not identify an impact to groundwater from the leachate. The large volume of leachate in the landfill is due to the lack of a landfill cover, which has resulted in infiltration of precipitation.

- The leachate collected from shallow wells located within the landfill waste is a very weak or low strength leachate as compared to typical landfill leachate. Major groundwater VOC contaminants of concern ("COCs"), such as PCE, TCE, and vinyl chloride, were not detected in leachate samples. Low levels of several

other VOCs, SVOCs, and pesticides were detected in the shallow leachate wells. In addition, slightly elevated levels of metals were also detected in the leachate.

- Low flow leachate seeps were observed discharging from the landfill mass on the western and southern perimeters. The seeps are located adjacent to drainage swales and ponds located on the southern and western perimeters of the landfill Site. The drainage swales converge at the southwest corner of the property, and continue to flow through a poorly defined series of ditches and depressions across the Tohickon Creek flood plain and eventually into the Tohickon Creek. Given the presence of the drainage swales, and the series of ditches and depressions, EPA has concluded that a pathway exists for the continued migration of leachate contaminants to surface water. Low level organics (less than Risk Based Concentrations ("RBCs")) were detected in surface water and sediment around the landfill. Elevated levels of inorganics (barium, manganese, and thallium) were detected in surrounding surface water. In addition, inorganic levels in sediments on the western and southern perimeter of the landfill may be a potential ecological risk. It is not known if the contamination is a result of leachate seeps, historic practices at the landfill, or surface water runoff.

5.2.2 Groundwater

- Groundwater was encountered within the Brunswick Formation. Pumping rates in on-site wells range from less than 5 gallons per minute ("gpm") to more than 100 gpm. The geologic units at the Site are generally oriented north-south. These units dip to the west. Rock units found beneath the landfill are found at increasing depth in wells drilled further to the west. The rock units encountered directly underneath the landfill have been eroded to the east and are not present in wells drilled east of the landfill. In order to help interpret and describe the geology at the Site the rock stratigraphy encountered in the monitoring wells has been divided into three units. Unit 1 includes the rocks that are found at the surface west of the landfill. Unit 2 includes rocks that lie directly underneath the landfill. Unit 3 includes rocks found at the surface east of the landfill. A well drilled west of the landfill would encounter Unit 1, 2 and 3 with increasing depth. A well drilled in the landfill would encounter Unit 2 and 3. A well drilled east of the landfill would encounter only Unit 3. Unit 2 was further subdivided with increasing depth into Units 2A, Unit 2B, and Unit 2C. Figure 4 is a Stratigraphic Cross-Section that illustrates how the rock units in the different monitoring wells relate to each other.

- Most of the Site groundwater contamination is found in Unit 2A and Unit 2B. Residential wells drilled in the Quakertown neighborhood mostly encounter Unit 2A. Unit 2A is also partially found in the Quakertown Borough well QT10 and the Richland Township well TW-2.

- The general groundwater flow direction at the Site is from the landfill southward toward the Tohickon Creek groundwater discharge areas. The flow directions in

both the shallow and deep portions of the aquifer are similar. Although the Tohickon Creek is a general groundwater discharge area, not all of the groundwater in the area discharges to this surface water body. There is a component of groundwater flow under the creek south of the landfill property, as evidenced by the groundwater flow data and the presence of contamination in wells located on the south side of Tohickon Creek.

- A contaminant plume consisting of PCE, TCE, cis-1,2-DCE, and vinyl chloride exists at the Site. The plume emanates from the landfill in the vicinity of MW03 and MW04, and moves in the general direction of groundwater flow southward toward the Quakertown neighborhood. This flow direction is also similar to the orientation of the geologic units at the Site. The landfill is considered to be the source of the solvent plume. PCE, TCE, Cis-1,2-DCE, and vinyl chloride all were detected above their respective Maximum Contaminant Levels ("MCLs") in Site monitoring wells. These contaminants were detected in both the shallow and deeper portions of the aquifer.

- The TCE and cis-1,2-DCE plumes extend south to the Quakertown neighborhood, which is located on the south side of Tohickon Creek. Low levels of PCE and vinyl chloride (<1microgram/ liter (ug/L)) also extend south to the Quakertown neighborhood. PCE and vinyl chloride were not detected in the Quakertown neighborhood monitoring wells (MW11 and MW13). Both were detected within the Quakertown neighborhood residential wells at less than 1 ug/L. The contaminant plume appears to be steady state and stable, indicating that the plume is no longer expanding. Any future pumping at wells QT-10/17 would probably alter the rate, and possibly the depth, of contaminant migration. Extensive pumping of Richland Township well TW-2 could change the migration of contaminants to a more southwesterly direction.

- Groundwater contamination is primarily found in wells screened in stratigraphic Unit 2, which outcrops at the landfill property. Monitoring wells located downgradient from the landfill, which exhibited high yield conditions during drilling and a higher fracture density, contained the higher contaminant concentrations within the shallow aquifer.

- The concentrations and distribution of breakdown product cis-1,2-DCE and vinyl chloride indicate that some biologic degradation is occurring, especially in the vicinity of the landfill.

- A wide variety of inorganics were detected in groundwater within the study area. Seven metals were detected at concentrations exceeding RBC screening values, including arsenic, cyanide, barium, chromium, manganese, vanadium, and boron. A statistical background evaluation of monitoring well groundwater data conducted as part of the human health risk assessment concluded that, except for boron, all the above-listed metals (cyanide, arsenic, barium, chromium, manganese, and vanadium) had concentrations similar to those detected at

background locations. This evaluation indicates, for the most part, that the presence of inorganics in the groundwater is influenced by natural or anthropogenic sources, rather than Site-specific sources.

- Although arsenic was considered statistically similar to background concentrations, arsenic was a potential contaminant of concern in the study area. The distribution of arsenic in monitoring wells appears random, with no obvious concentration gradient trends coinciding with observed groundwater flow direction. Based on the background evaluation of arsenic, the random distribution of elevated arsenic in groundwater, and the presence of pyritic crystals observed to be present in the Brunswick Formation (i.e., as observed in monitoring well MW21D), it appears that the elevated levels of arsenic in the Site study area are related to natural minerals in the bedrock rather than related directly to the Site.

- With the exception of Quakertown Borough well QT10, VOCs were either not detected or were estimated to be at low concentrations in Quakertown Borough water supply wells located south of the landfill. (The location of the additional Quakertown Borough wells that were sampled can be seen in Figure 3-7 of the Remedial Investigation Report). Site COCs (TCE, PCE and cis-1,2-DCE) were detected in well QT10, which is located directly south of the landfill, adjacent to the Quakertown neighborhood, and within the Site groundwater contamination plume. Arsenic was detected at concentrations exceeding the MCL. Iron was detected above secondary maximum contaminant levels ("SMCLs"). Iron concentrations in all the sampled water supply wells were below the RBC value for groundwater. Manganese levels in QT10, QT12 and QT13 exceeded both the RBC and SMCL value for groundwater. Wells QT12 and QT13 are located to the southwest of well QT10 outside of the current Site area.

- Based on the analytical results of the water supply wells and monitoring well data, it is evident that water supply well QT10 has been impacted by Site COCs (TCE, PCE and cis-1,2-DCE). Although it appears that QT17 is not impacted by Site COCs, if operated frequently, it is possible that water pumped from this deeper well could also be impacted by Site COCs. Both QT10 and QT17 are situated in the same stratigraphic unit (Unit 2) as monitoring wells containing Site COCs. The combined flow of QT10/17 is currently treated by an air-stripper system (to remove VOCs) operated by the Quakertown Borough Water Department. The flow is also treated (green sand filters) to ensure metals are within required regulatory limits. The Water Department has stated that wells QT10/17 are low-yielding wells and are infrequently used. Figure 3 depicts the locations of the above Quakertown wells.

5.2.3 Residential Wells

- Approximately 270 residential wells were identified as located within the Watson Johnson Landfill study area. Approximately 160 homeowners of the 270 properties identified in the WJL study area gave EPA permission to sample their wells. Volatile organic compounds PCE, TCE, cis-1,2-DCE and vinyl chloride were detected in residential wells located in the Quakertown neighborhood at levels consistent with the solvent plume identified by the Site monitoring well results. TCE was detected in excess of its MCL in 11 residential wells in this neighborhood. Based on Site monitoring and residential well data, and groundwater flow, it is apparent that the Site solvent plume has impacted many of the residential wells located in the Quakertown neighborhood. An EPA Removal Action which provided a public water supply to the residential well users was conducted in the Quakertown neighborhood in 2005/2006.

- A wide variety of inorganics were detected in residential wells within the Site study area. Aluminum, iron and manganese were detected in select wells at concentrations exceeding SMCLs. Aluminum detections are not considered to be Site-related given their infrequent detection throughout the study area, as well as the fact that there are low detections (<RBC) of aluminum encountered in Site groundwater monitoring wells. Iron and manganese are common in the groundwater in the Brunswick Formation. Due to their random distribution in residential wells, and based on groundwater monitoring well results, the elevated levels of iron and manganese detected in area residential wells are also not considered Site-related.

- Lead was detected in 10 residential wells at concentrations exceeding EPA's action level. Based on their random distribution, and based on groundwater monitoring well results, the elevated levels of lead in residential wells are not considered Site-related. Rather, the elevated levels of lead in residential wells are probably due to associated plumbing or piping fixtures.

- Arsenic was detected in 119 of the 128 residential wells sampled in the study area, with concentrations ranging from 1 to 41 ug/L. Thirty of these wells had concentrations of arsenic in excess of EPA's MCL (10 ug/L) for arsenic, including those located up- and side-gradient of the landfill. Based on the statistical background evaluation of arsenic in monitoring wells, the random distribution of elevated arsenic in groundwater (monitoring wells and residential wells), and the presence of pyritic crystals observed to be present in the Brunswick (i.e., as observed in monitoring well MW21D), the elevated levels of arsenic in the Site study area are considered naturally occurring and are not Site-related.

- A pump test performed in 1988 by Walnut Bank Farm, Inc. at the Richland Township well TW-2 (see Figure 3) indicated that pumping of TW-2 could influence Site monitoring wells, including those located within the Site solvent

plume. Prolonged pumping could potentially effect the direction of existing groundwater flow patterns, and alter the current shape of the solvent plume. Such pumping could interfere with implementing a groundwater remedy by increasing the cost or decreasing the effectiveness of the remedy.

5.2.4 Surface Soil

- Polycyclic aromatic hydrocarbons (PAHs) and pesticides/PCBs were detected at very low levels in several surface soil samples. Detected at three locations, benzo(a)pyrene was the only organic compound detected above human health screening criteria.

- Eight heavy metals were detected in surface soil at concentrations exceeding human health screening criteria. Based on its statistical evaluation of background sample data, EPA concluded that all these heavy metals except arsenic (i.e., aluminum, cadmium, chromium, iron, manganese, thallium, and vanadium) have similar concentrations to those detected at background locations.

- With the possible exception of benzo(a)pyrene and arsenic, it appears that historical runoff from the landfill has not resulted in elevated concentrations of analytes in downgradient areas beyond those that are otherwise present as a result of natural or anthropogenic sources.

- Mercury is a potential ecological contaminant of concern ("COC") at a surface soil location on the northeast perimeter of the landfill and in the Tohickon Creek floodplain southwest of the landfill.

5.2.5 Surface Water

- Several surface water samples taken in the swales/ponds around the landfill had low level detections of a variety of volatile and semi-volatile organic compounds. None of the organics detected exceeds any human health screening criteria. It should be noted that organics were detected at sample locations located on the western and southern perimeter of the landfill, adjacent to potential landfill seep areas. Organic compounds were not detected in any of the downgradient samples collected from Tohickon Creek. It should also be noted that PCE, TCE, cis-1,2-DCE and vinyl chloride, which are Site groundwater COCs, were not detected in any of the surface water samples.

- Seven heavy metals were detected at elevated concentrations in surface water in ponds surrounding the landfill and in downgradient locations along Tohickon Creek. A statistical background evaluation of the surface water conducted by EPA as part of the human health risk assessment concluded that chromium, iron and lead had concentrations similar to those detected at background locations. Both barium and manganese had concentrations greater than those detected at background locations.

5.2.6 Sediment

- The sediment sampling results indicate that there were widespread detections of low levels of organic compounds (VOCs, SVOCs, pesticides and PCBs) within the study area. None of the organics detected exceeded human health screening criteria. Most of the organic detections were from sediment locations in ponds and swales located around the landfill area. However, some were detected within Tohickon Creek sediments. Notable Tohickon Creek detections include TCE and cis-1,2-DCE, detected in an area along Tohickon Creek within the area of the Site groundwater plume (including TCE and cis-1,2-DCE). The detection of TCE in sediment could be related to groundwater discharge to the creek, but could also be related to a laboratory measurement error. Organic compounds were not detected in downgradient surface water samples located along Tohickon Creek.

- Four heavy metals were detected at elevated concentrations (>RBCs) in sediments of ponds surrounding the landfill and in downgradient locations along Tohickon Creek. A statistical background evaluation of sediments conducted by EPA as part of the human health risk assessment concluded that these inorganic analytes (arsenic, iron, manganese, and thallium) had concentrations similar to those detected at background locations.

- The only Contaminants of Potential Concern ("COPCs") identified for sediments in ponds/swales along the western and southern perimeter of the landfill are cadmium, copper, lead, manganese, selenium and zinc; these were identified based on potential ecological risk considerations.

5.2.7 Vapor Intrusion

- The Quakertown neighborhood is situated near the downgradient edge of the groundwater contaminant plume area. Volatile organic contaminants in groundwater (PCE, TCE, cis-1,2-DCE, vinyl chloride) can emit vapor from the groundwater. This vapor can then migrate through the unsaturated zone and into a resident's basement or crawl space. This process is known as vapor intrusion. Since PCE, TCE, vinyl chloride, and benzene were detected in soil vapor samples in the Quakertown neighborhood at levels greater than screening values listed for target shallow soil gas concentrations in EPA's *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (EPA 2002d), these contaminants have been designated as soil vapor COPCs by EPA.

- PCE, TCE and vinyl chloride concentrations in soil vapor could potentially be a result of contaminants in groundwater originating from the Site. However, it should be noted that these concentrations could also be a result of other unrelated sources (i.e., historical industrial activities in the area, improper disposal of chemicals by residents, etc.) The widespread detections of benzene in soil vapor could also be a result of groundwater contamination; however, it is more likely a result of "non-site related" petroleum hydrocarbon contamination of subsurface soils (e.g., residential use and disposal of gasoline or motor oil). Site bedrock

groundwater COPCs (i.e., PCE, TCE, cis-1,2-DCE, vinyl chloride and benzene) were not detected in overburden groundwater near Tohickon Creek. Regardless of origination, the vapor intrusion pathway was evaluated for homes in and around the Quakertown neighborhood located over the existing groundwater plume.

5.3 Conceptual Site Model

A Conceptual Site Model ("CSM"), developed by EPA, diagrams contaminant sources, contaminant release mechanisms and migration routes, exposure pathways, and potential human and ecological receptors. It documents what is known about human and environmental exposure under current and potential future Site conditions. The risk assessment and selected remedial action for this Site are based on the CSM.

The CSM for this Site integrates and summarizes the information concerning sources, migration pathways, and exposure routes into a combination of exposure pathways. The Conceptual Site Model for Human Health (see Figure 5) identifies the key potential release mechanisms, transport media, exposure points, exposure media, exposure routes, and potential receptors.

The CSM for the Watson Johnson Landfill identified several key release mechanisms for the Site. The release mechanisms investigated included soil and surface water runoff, leachate seepage to surface water and groundwater and vapor intrusion into basements and low-lying living areas from groundwater. These release mechanisms provided potential exposure scenarios which EPA assessed for risk. The exposure routes included human ingestion, inhalation and dermal contact with groundwater, inhalation of soil vapors, ingestion and dermal contact with leachate and ingestion and dermal contact with sediment, surface soil and surface water. The selection of exposure pathways is also presented in Table 1.

A CSM for ecological exposure was developed for the WJL Site (Figure 6). The CSM identified the key habitats of concern to be evaluated as upland forest habitat, bottomland hardwood forest habitat, open water/marsh complex habitat, open water/riverine habitats and open water/pond habitat. The relationship of the measurement endpoints to the assessment endpoints are identified in the CSM. The assessment endpoints include soil invertebrate community, vermivore community, benthic invertebrate community and aquatic community.

6.0 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

The Watson Johnson Landfill property encompasses approximately 20.2 acres. The land use within the Site area is approximately 50% residential, 10% commercial, 5% agricultural, and 35% wooded and/or wetland. The landfill is currently not in use and has unrestricted access (no fence). The landfill is bordered by agricultural properties to the north and south. Woodlands and wetlands are located southwest of the landfill, extending from the landfill to Tohickon Creek. A composting facility lies to the west and a residential housing subdivision, Heather Valley/Richland Farms, borders the landfill to

the east. Future land use is anticipated to be consistent with the current land use. Restrictions for development of the landfill property will be included as an institutional control and a fence will be placed around the landfill to protect the engineered remedy.

The aquifer at the Site is designated by Pennsylvania as a Class IIA aquifer, a drinking water aquifer. The residents in the Watson Johnson Landfill Site area are either on public or private water supply. Three public water suppliers serve the general area: 1) Richlandtown Borough Water Department; 2) Richland Township Water Authority ("RTWA"), and; 3) Quakertown Borough Water Department ("QBWD").

7.0 SUMMARY OF SITE RISKS

The findings of the RI were used to evaluate potential risks to human health and the environment from chronic exposure to contaminants of concern at the Watson Johnson Landfill Superfund Site. A Baseline Human Health Risk Assessment was conducted in order to estimate the probability and magnitude of potential adverse human health effects from exposure to Site contaminants, assuming no further response actions were taken at the Site. A screening level ecological risk assessment was conducted to identify the potential of the Site contaminants to adversely affect ecological resources in the absence of further response actions at the Site. The risk assessments provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the selected remedial action at the Site.

This section of the ROD summarizes the results of both the baseline human health risk assessment and the ecological risk assessment.

7.1 Summary of Human Health Risk Assessment

The Human Health Risk Assessment ("HHRA") estimates what risks the Site would pose if no additional actions were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the HHRA for this Site.

The HRRA considered the effects of exposure to different media at the Site. The HRRA consisted of a four step process: (1) the identification of chemicals of potential concern ("COPCs"), i.e., those that have the potential to cause adverse health effects; (2) an exposure assessment, which identified actual and potential exposure pathways, potentially exposed populations, and the magnitude of possible exposure; (3) a toxicity assessment, which identified the adverse health effects associated with exposure to each COPC and the relationship between the extent of exposure and the likelihood or severity of adverse effects; and (4) a risk characterization, which integrated the three previous steps to summarize the potential and actual risks posed by hazardous substances at the Site, including carcinogenic and non-carcinogenic risks. A summary of these components of the human health risk assessment, which support the need for remedial action, is discussed below.

7.1.1 Contaminants of Concern

Contaminants at the Watson Johnson Landfill Superfund Site were identified from samples of soil, groundwater, surface water, and sediment. Many contaminants (including VOCs, SVOCs, PAHs, PCBs and inorganics) were detected in these media. A screening of contaminants was conducted in which the maximum detected concentrations were compared to risk-based screening levels (i.e., EPA Region 3 Risk Based Concentrations). Through this process, contaminants were selected as COPCs for the Site.

Not every COPC was detected or selected at every exposure area or in every environmental medium sampled at the Site. Consequently, potential health risks and hazards are characterized based on the selected COPCs for each relevant medium at each identified exposure area.

Tables 2 through 6 present a summary of the contaminants of concern ("COPC") and the exposure point concentration for each of the COCs in each media. The tables include the arithmetic mean for each COC, the 95% Upper Confidence Level ("UCL") distribution, the maximum concentration and the exposure point concentration ("EPC").

7.1.2 Exposure Assessment

Potential human health effects associated with exposure to the COPCs were estimated quantitatively or qualitatively through the evaluation of several actual or potential exposure pathways (See Attachment 1: Exposure Parameters). These pathways were developed to reflect the potential for exposure to hazardous substances at the Site. Local climate, geology, soils, groundwater, and surface water conditions at the Site, as well as local population statistics, land, and water use, were evaluated to assess the risks to present and potential future populations working or otherwise spending time at the Site.

The exposure assessment estimates the total intake of COPCs that the key receptor groups are expected to receive over various exposure periods. The evaluation of the residential receptors, a conservative exposure scenario, is appropriate for the Watson Johnson Landfill since residential properties are located nearby and within the Site. Residents are expected to be exposed to contaminants for longer periods of time than receptors, such as industrial workers or recreational visitors. In addition, the residential evaluation incorporates a quantitative assessment of a child receptor.

The assessment of pathways by which human receptors may be exposed to COPCs at the Site includes an examination of existing (current) exposure routes as well as those that may reasonably be expected to occur in the future. The determination of exposure routes is made by a careful examination of the current extent of affected media and the results of the fate and transport assessment for predicting contaminant migration pathways and estimating exposure point concentrations. The potential exposure routes for human receptors at the Site include ingestion, dermal absorption, and inhalation pathways.

The HHRA studied several exposure pathways and routes for the Watson Johnson Landfill including:

- Indoor Air Vapor Intrusion Exposure Pathway – Current exposure to chemicals in groundwater migrating into basements and low-lying living areas was evaluated to determine the impact to indoor air quality.
- Groundwater Exposure Pathway – Potential future exposure to chemicals in groundwater was evaluated through ingestion and inhalation exposure routes for the future resident. A child receptor was assumed to bathe, but not shower, and was evaluated for incidental ingestion of and dermal contact with groundwater while bathing; an adult receptor was assumed to shower, but not bathe, and was evaluated for exposure to groundwater via inhalation of volatile COPCs while showering.
- Surface Water Exposure Pathway – Current/Future exposure to chemicals in surface water bodies surrounding the Site while wading or during other outdoor activities was evaluated through ingestion and dermal exposure routes for the resident adult and child.
- Sediment Exposure Pathway – Current/Future exposure to chemicals in sediments surrounding the Site while wading or during other outdoor activities was evaluated through ingestion and dermal routes for the resident adult and child.
- Soil Exposure Pathway – Current/Future exposure to chemicals in soil was evaluated through ingestion and dermal routes for the resident adult and child. In addition, inhalation of soil particulates derived from the Site was also evaluated for the resident adult and child.

7.1.3 Toxicity Assessment

The purpose of the toxicity assessment is to identify the types of adverse health effects that a COPC may potentially cause and to define the relationship between the dose of a compound and the likelihood and magnitude of an adverse effect. Adverse effects are characterized by the EPA as carcinogenic or non-carcinogenic. Dose-response relationships are defined by the EPA for oral and inhalation exposures. Oral dose-response values were used to derive appropriate dermal toxicity values.

The dose-response assessment evaluated the available toxicity information and quantitatively described the relationship between the level of exposure (either from animal or human epidemiological studies) and the occurrence of an adverse health effect. This relationship is described by a cancer slope factor ("CSF") or unit risk factor ("URF") for carcinogens and a reference dose ("RfD") or reference concentration ("RfC") for systemic toxicants, collectively called toxicity values.

Toxicity values were obtained from the a hierarchy of sources consistent with guidance of the EPA Office of Superfund Remediation and Technology Innovation ("OSRTI") (EPA, 2003).

The criteria used to evaluate the potential for non-carcinogenic health effects are generally referred to as Reference Doses ("RfDs"). The term RfD was developed by EPA to refer to a daily intake of a chemical to which an individual can be exposed without any expectation of non-carcinogenic adverse health effects occurring (e.g., organ damage, biochemical alterations, birth defects). Other acceptable doses may exist for some chemicals that have been developed by the scientific community and are reported in the literature. However, these criteria are used for constituents that the EPA has not yet evaluated.

A summary of the cancer and non-cancer toxicity data relevant to the COPCs in the HRRA for the Watson Johnson Landfill Superfund Site is presented in Tables 7 through 10. Brief toxicity profiles for the COPCs for the Site can be found in Attachment 2: Toxicity Profiles.

7.1.4 Risk Characterization

Risk characterization integrates the results of the exposure and toxicity assessments to derive quantitative estimates and qualitative summaries of the potential cancer risk and non-cancer hazards that may occur due to exposure to contaminants at the Site.

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$Risk = CDI \times SF$$

Where: Risk = a unitless probability (e.g., $2x10^{-5}$) of an individual's developing cancer
CDI = chronic daily intake averaged over 70 years (mg/kg-day)
SF = slope factor, expressed as $(mg/kg\text{-}day)^{-1}$

These risks are probabilities that usually are expressed in scientific notation (e.g., $1x10^{-6}$). An excess lifetime cancer risk of $1x10^{-6}$ indicates that an individual experiencing the reasonable maximum exposure estimate has a 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 such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for Site-related exposures is 10^{-4} to 10^{-6}.

The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified time period with a reference dose (RfD) derived for a similar exposure period. An RfD represents a toxicity level that is not expected to cause any deleterious effect to an exposed individual. The ratio of exposure to toxicity is called a hazard quotient ("HQ"). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non-carcinogenic effects from that chemical are unlikely. The Hazard Index ("HI") is generated by adding the HQs for all chemical(s) of

concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI≤1 indicates that, based on the sum of all HQs from different contaminants, for all complete exposure pathways, exposure routes, and across all target organs, toxic non-carcinogenic effects from all contaminants are not likely. An HI>1 indicates that Site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ=CDI/RfD

Where: CDI = Chronic daily intake
RfD = reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Soil Vapor Intrusion

Current receptors for vapor intrusion include residents living in and around the Quakertown neighborhood, south of the landfill property, who live in homes located over the existing groundwater plume. VOCs in groundwater may migrate from shallow groundwater through soils into basements or low-lying living spaces. Exposure to COCs in groundwater via vapor intrusion to indoor air was evaluated as a potentially complete exposure pathway for the current adult and child resident receptors living in or around the Quakertown residential area. Thirty (30) soil gas samples were collected from the vicinity of ten (10) homes in the Quakertown neighborhood in May 2004 as suggested as an evaluation method in EPA's *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (EPA 2002d). The maximum detected concentrations of COCs in soil gas were screened against the lower of either ten (10) times the Region 3 Risk-Based Concentrations for ambient air or the target shallow soil gas concentrations from Table 2c of EPA's draft vapor intrusion guidance referenced immediately above. If the soil gas concentration exceeded its screening value, the chemical was then evaluated using the Johnson & Ettinger model, as recommended in the draft guidance. The Johnson & Ettinger model was run with Site-specific data and the conservative indoor air exchange rate of 0.25 air changes per hour. This replicates a situation in which the home is tightly sealed against outdoor air, such as during winter conditions.

A Hazard Index (HI) of 0.0089 (as estimated for the child resident) and a cancer risk of 1E-06 (as estimated for a lifetime (adult + child)) were calculated, with inhalation (indoor vapor intrusion) exposure accounting for all of the cancer risk. The non-cancer hazard for the current residential receptor is below the target threshold of 1; the cancer risk for the current resident (adult + child) is equal to the risk management point of departure of 1E-06. Therefore, the current off-site risk due to vapor intrusion into basements or low-lying living spaces is at or below EPA's threshold levels.

Groundwater

If in the future the groundwater solvent plume expands such that drinking water wells in off-site areas (which are not currently impacted) become impacted or should a future resident install a drinking water well within the contaminated portion of the plume, residential receptors could be exposed to COPCs in groundwater via direct contact pathways. Future residential receptors were quantitatively evaluated for exposure to groundwater via direct contact (i.e., ingestion, dermal contact [child bathing], and inhalation [adult showering]). VOCs were assessed for inhalation exposures using the EPA shower model based on the model developed by Foster and Chrostowski (1987).

A HI of 25 (as estimated for a child resident) was calculated for the future residential receptor, which exceeds the target threshold of 1. The ingestion route contributed the majority of the non-cancer hazard (route-specific HI = 22); specifically the Hazard Quotients (HQs) calculated for ingestion of TCE (HQ = 12), manganese (HQ = 5.7), and arsenic (HQ = 3.2). The dermal route contributed a route-specific HI of 2.5. Target organs with HI greater than 1 included the liver, kidney, nervous system, hematopoietic, and developmental endpoints.

The cancer risk for future hypothetical ingestion and direct contact with the on-site plume represents a probability of 1.3E-03, with the ingestion pathway accounting for the majority of the excess risk. Risk drivers in groundwater include TCE, PCE, vinyl chloride, bis(2-ethylhexyl)phthalate (BEHP) and arsenic.

EPA concluded that, based on the cancer and non-cancer results of the Risk Assessment for future use of the Site groundwater, a remedial action should be taken to clean up the contamination. Both the cancer and non-cancer risk for the future groundwater exposure pathway are outside of EPA's acceptable range.

Surface Soil, Surface Water and Sediment

Off-site surface soils, sediments, and shallow surface water bodies (including seeps, runoff, upland wooded areas, wetlands, and Tohickon Creek) may be impacted by COPCs. Nearby residents may be exposed to COPCs during outdoor activities as well as via the inhalation of particulates/dusts derived from the contaminated area. Residential receptors were evaluated for the following exposure scenarios: (1) incidental ingestion of and dermal contact with surface water and sediment and (2) incidental ingestion of and dermal contact with surface soil and inhalation of particulates derived from surface soil.

A HI of 7.3 (as estimated for the child resident) was calculated for the current/future residential receptor, which exceeds the target threshold of 1, with exposure to surface soil accounting for the majority of the non-cancer hazard (media-specific HI = 6.6). Non-cancer HIs for both surface water and sediment were below the target threshold of 1. Target organ indices for the child resident hazards were liver HI = 2.8 (as estimated for the child resident, attributed to soil iron); kidney HI = 1.4 (the target organ for barium, cadmium and vanadium); and nervous system HI = 2.0 (the target organ for aluminum and manganese). Cancer risk for soil exposures was 2.2E-5 (driven by arsenic) for the

lifetime resident (adult + child) which lies within the cancer risk management range of 1E-6 to 1E-4. The cancer risk estimates for surface water and sediment were 2.3E-7 and 2.7E-7, respectively, which are both below the acceptable risk level point of departure of 1E-6.

The noncancer HI for the current/future residential receptor (as estimated for the child receptor) exceeds the target threshold of 1; in addition, the target organ-specific HIs for several chemicals also exceed the threshold of 1 as indicated above. However, the chemicals that contributed the majority of the excess risk (i.e., aluminum, iron, cadmium, manganese, and vanadium in surface soil) are naturally occurring inorganics; concentrations of these inorganics were below background levels in Site surface soils.

Based on the results of the risk assessment, no further action would be warranted to address COPCs in off-site surface water and sediment if the decision as to whether to take a remedial action were based solely on human health concerns. Although exposure to surface soil did result in a non-cancer hazard that exceeds the threshold of 1, the majority of the hazard is attributable to inorganic chemicals (i.e., aluminum, cadmium, chromium, iron, manganese, thallium and vanadium) which are present at concentrations at background levels with the notable exception of arsenic in surface soil (mentioned below as part of uncertainty analysis). The carcinogenic risk was within the risk management range, with arsenic in surface soil being the main contributor to the carcinogenic risk.

Presented in Table 11 is the Summary of Receptor Risks and Hazards for COPCs. The Risk Assessment Summary Table is presented as Table 12 for all the media, receptors and timeframes assessed in the HRRA for the Watson Johnson Landfill Site. The Table provides both the carcinogenic and non-carcinogenic risk for each contaminant identified as a risk driver. The risk drivers will become the Contaminants of Concern ("COCs"). Information regarding the statistical analysis of background levels can be found in Attachment F in Volume 2 of the final Remedial Investigation (Human Health Risk Assessment) for the Watson Johnson Landfill Superfund Site.

7.1.5 Uncertainty in Risk Characterization

Risk assessment provides a systematic means of organizing, analyzing and presenting information on the nature and magnitude of risks posed by chemical exposures. Uncertainties are present in all risk assessments because of the quality of available data and the need to make assumptions and develop inferences based on incomplete information about existing conditions and future circumstances. The goal of an uncertainty analysis in a risk assessment is to provide to the appropriate decision makers (i.e., risk managers) a wide range of information about risk assessment assumptions, their uncertainty and variability, and the effect of uncertainty and variability on the estimate of risk. Risk estimates presented herein are single-point estimates of risk rather than probabilistic estimates. Therefore, it is important to specify the uncertainties inherent in the risk assessment in order to place the risk estimates in proper perspective.

One of the greatest sources of uncertainty in the Human Health Risk Assessment for the Site is the inclusion of naturally occurring inorganic chemicals. As noted above, the current/future resident receptor is subject to cancer risk and HI values in excess of the 1E-6 point of departure and the target non-cancer threshold of 1.0. Surface soil ingestion accounts for the majority of risk/hazard associated with this receptor/timeframe scenario. A statistical evaluation of background concentrations in surface soil concluded that, except for arsenic, all the inorganic COPCs (aluminum, cadmium, chromium, iron, manganese, thallium, and vanadium) had concentrations similar to background levels. Further investigation revealed that the arsenic concentration detected at one sample location contained an elevated concentration of arsenic relative to other samples collected during the RI. This soil sample was collected some distance south of the landfill in the wooded flood plain, and may be considered a potential outlier. If this soil sample is considered an outlier, and not included in the statistical background evaluation, arsenic concentrations in surface soil at the Site would be similar to concentrations detected at background locations; therefore, it was determined that the risk associated with exposure to arsenic in surface soil is not attributable to landfill activities.

Below is a brief discussion of the major uncertainties associated with the HHRA.

Selection of COPCs

- Various types of data qualifiers are attached to analytical data by either the laboratory conducting the analyses or by the person performing the data validation. A common data qualifier in data packages is the "J" qualifier. Data qualified with a J are estimated concentrations reported below the sample quantitation limit or are estimated because quality assurance parameters were out of range. In this HRRA, all data qualified with a J were used the same way as positive data that did not have the qualifier.

- Sometimes, a level of bias is associated with the J-qualified data, indicating whether the concentration is biased high or low. Other times, the level of bias is unknown. The use of J-qualified data as the reported concentration may result in either an under or over estimation of the actual concentration.

- The data set for a particular chemical generally will contain some samples with positive results and other with non-detect results. For non-detect samples, the chemical may be present at a concentration just below the reported detection limit, or it may not be present in the sample at all. In this HHRA, if a chemical was reported as a non-detect in a sample, it was assumed to be present at one-half the detection limit for that sample. This may result in either an under or over estimation of the actual concentration.

- Because all chemicals with appropriate screening values, and at least one detection, were evaluated without any being removed based on low detection frequency some chemicals may have been inappropriately selected as COPCs, which would result in a more conservative estimate of Site-related risk. For

example, bis(2-ethylhexyl)phthalate ("BEHP"), a plasticizer easily introduced as a sample contaminant, was included as a COPC in groundwater based on detection frequency of 3 percent (2 of 63 samples). All other 61 samples were "B" qualified and reported at one-half the sample quantitation limit of 10 µg/L. The Region 3 carcinogenic risk-based screening value for tap water of 4.3 µg/L was used as the screening value for BEHP. One sample exceeded the MCL for BEHPof 6 µg/L. Subsequently, BEHP was identified as a risk driver through ingestion/dermal contact in the future resident scenario. This inclusion results in an overestimation of risk.

- The inclusion of boron as a groundwater COPC was based on the maximum detected value of 1,070 µg/L, which seems to be an outlier because it was the only detection above the Region 3 noncancer screening value of 730 µg/L. The inclusion of boron as a COPC in this HHRA did not significantly affect the risk estimates for future residential groundwater exposures; however, it does result in some overestimation of Site-related risk.

- Naturally occurring inorganics are present in the soil, surface water, sediments, and groundwater. Because elevated levels of arsenic were reported in the various media present at the Site, it is important to note that these concentrations may be the result of naturally occurring geologic formations. The inclusion of arsenic in the estimate of Site risk may overestimate Superfund Site-related risks. It is a conservative approach that was deemed appropriate at the time of the HHRA.

- The vapor intrusion exposure pathway for residential exposure was evaluated using the Upper Confidence Limit 95 ("UCL95") of all the modeled infinite indoor air concentrations. The infinite indoor air concentrations were modeled from soil gas samples using the EPA vapor intrusion model (EPA 2000) based on the Johnson and Ettinger model (1991). Using the UCL95 for the exposure point concentration is appropriate for an average exposure to all soil gas concentrations over time. However, if a residence were present in the vicinity of a single soil gas sampling location, then it would be more appropriate to evaluate residential exposure to that single soil gas sampling location. Therefore, a sensitivity analysis was conducted to estimate residential adult and child carcinogenic risks and non-carcinogenic hazards from exposure to individual soil gas sample locations. Only one soil gas sample location had estimated carcinogenic risks greater than 10^{-6}, but within the risk management range of 10^{-4} to 10^{-6}. No non-carcinogenic hazards were greater than one.

- An uncertainty in the risk assessment exists for the potential future indoor scenario for an area located southwest of the landfill property that is currently uninhabited. The soil gas data collected for use in the Johnson and Ettinger model to estimate indoor air concentrations could not be used due to the depth to groundwater in that area. Even though risks could not be estimated for this scenario, the available soil gas data suggest that risks would be negligible because no COPC concentration exceeds screening values in this area.

- Statistical tests were used to evaluate whether there are statistically significant differences between the concentrations of chemicals on Site and reference (or background) area or media. In this HHRA, inorganics in surface soil, sediment, groundwater, and surface water were evaluated to facilitate the selection of COCs.

- Arsenic and thallium in surface water could not be evaluated because the background data sets were nondetect. All other inorganics in the evaluation were not considered significantly greater than background at the Site: however, as a conservative measure no COPCs were eliminated from risk calculations based on background comparisons.

- COPCs were selected based on comparison to a toxicity screening value. Chemicals lacking an EPA Region 3 RBC or target soil gas concentration were not retained as COPCs due to lack of a toxicity screening value. Although exclusion from quantitative evaluation may result in an underestimation of risk, the chemicals not retained were either infrequently detected or detected in limited media; therefore, an underestimation based on their exclusion would be minor.

Exposure Assessment

- Exposure assumptions directly influence calculated intake values. In general, conservative exposure assumptions were made when calculating intake values for the reasonable maximum exposure scenario. The assumptions included the selection of exposure routes and scenarios and the exposure input factors used to estimate exposure doses. In most cases, these uncertainties contributed to the overestimation of actual exposure. Cancer risk and noncancer hazards are likely overestimated.

- The selection of the residential receptor (adult/child) for quantitative evaluation serves as a more conservative estimation of risks relative to other potentially exposed receptors. Exposure parameters employed in this scenario represent virtually continuous exposure over the lifetime of the receptor and are more conservative upper-bound estimates for all other potential receptors. Using these receptors may result in an overestimation of the Site-related risks relative to other potential receptors.

- Lead was only a COPC in surface water. The intermittent nature of exposure to lead-containing surface water at a concentration below the chronic tap water RBC did not warrant modeling, since the model assumes lead exposure at a steady state. Further evaluation of surface water lead data set showed a high degree of skewness. The presumptive remedy for landfills will eliminate landfill leachate to surface water and also eliminate the landfill-generated surface water runoff. This is a minor data gap.

Toxicity Assessment

- Cancer slope factors are developed assuming there is no safe level of exposure to any chemical proven or suspected to cause cancer. This approach implies that exposure to even a single molecule of a chemical may be associated with a finite risk, however small. The assumption is that even if relatively large doses of a pollutant were required to cause cancer in laboratory animals, these exposure doses can be linearly extrapolated downward many orders of magnitude to estimate cancer slope factors for humans. A significant uncertainty for the carcinogens is whether cancer slope factors accurately reflect carcinogenic potency of these chemicals at low-exposure concentrations. The calculated cancer slope factors are used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a carcinogen. Therefore, the cancer slope factors developed by EPA are generally conservative and represent the upper-bound limit of the carcinogenic potency of each chemical. The actual risk posed by each chemical in humans is unknown, but it is likely to be lower than the calculated risk and may even be as low as zero. The conclusion is that these toxicity assumptions typically result in an overestimation of carcinogenic risk.

- The assumption that all carcinogens can cause cancer in humans is conservative. Only those chemicals EPA classifies as Group A are unequivocally considered human carcinogens. The other three classes are probable (Groups B1 and B2) and possible (Group C) human carcinogens. All probable carcinogens were given the same weight in the toxicity assessment (and consequently in the estimation of risk) as known human carcinogens. This assumption most likely overestimates actual carcinogenic risk to humans.

- In the development of reference doses ("RfDs"), it is assumed that a threshold dose exists below which there is no potential for adverse health effects to the most sensitive individuals in the population. In general, the calculated RfD is likely to be overly protective, and its use probably results in a moderate to high overestimation (approximately equates to an order of magnitude) of the potential for non-carcinogenic risk.

- A lack of toxicity factors for some COPCs may underestimate the risks. The lack of inhalation toxicity factors for some inorganics may result in an underestimation of the soil inhalation pathway, specifically, the inhalation of particles/dust.

- There are chemical-specific uncertainties associated with toxicity values that can result in an over or under estimation of risk.

- In the absence of quantitative information on the synergistic and antagonistic effects of COPCs, cancer risk probabilities for each receptor were assumed to be additive across all media and exposure routes. Therefore, the target risks used to screen for COPCs were sufficiently low (at the 1 in 1 million threshold) to allow

for additivity. The use of an additive approach to calculate cancer risks may have resulted in an over or under estimation of potential risk.

- For non-cancer effects, HIs were calculated for all exposure pathways for each receptor, and were segregated by target organ or primary effect. This approach is consistent with Risk Assessment Guidance for Superfund ("RAGS"), and is intended to model a more realistic approach to cumulative toxicity.

7.1.6 Principal Threat Waste

EPA characterizes waste on-site as either principal threat waste or low-level threat waste. The concept of principal threat waste and low-level threat waste, as developed by EPA in the NCP, is applied on a site-specific basis when characterizing source material. "Source material" is defined as material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or that act as a source for direct exposure. Principal threat wastes are those source materials considered to be highly toxic or highly mobile, which would present a significant risk to human health or the environment should exposure occur.

The RI confirmed that there are no principal threat wastes associated with the Watson Johnson Landfill Superfund Site.

7.2 Summary of Ecological Risk Assessment

A Screening Level Ecological Risk Assessment ("SLERA") was performed for the Watson Johnson Landfill Superfund Site. The methodology used in the SLERA was consistent with the latest guidance from EPA as described in the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* ("ERAGS")(EPA, 1997). The SLERA is designed to be a conservative assessment. The SLERA is not designed nor intended to provide definitive estimates of actual risk or to generate cleanup goals, and in general it does not use site-specific assumptions. Rather, the purpose of a SLERA is to assess the need and, if necessary, the level of effort required to conduct a detailed or "baseline" ecological risk assessment for a particular site or facility.

The SLERA indicated that risks to ecological receptors may exist from Site-related metals. The erosion of landfill materials and the seepage of contaminated leachate from the landfill were the major contaminant migration routes that affect ecological receptors.

The following preliminary conclusions are provided regarding ecological contaminants of potential concern:

Surface Soil

Mercury exceeded the maximum background level at a single surface soil location (SS15), located on the northeast perimeter of the landfill (see Figure 7).

Surface soil locations SS24, SS25, SS29 and SS31 located within the Tohickon Creek Floodplain have concentrations exceeding screening benchmarks for manganese, mercury, and thallium. (It should be noted that manganese and thallium had concentrations similar to those detected at background locations. As a result, the only ecological COPC within the flood plain area is mercury at surface soil locations SS29 and SS31). Mercury was slightly elevated (low concentration, J-qualified) at these two isolated areas.

Sediment

Cadmium, copper, lead, manganese, selenium and zinc are considered COPCs. Found along the western drainage area of the landfill, these contaminants exceed maximum background levels and are slightly below or at probable effect levels for benthic organisms. The probable effects level is the level, or concentration, of a contaminant to which, if a receptor is exposed, such exposure is likely to cause an adverse effect. These same contaminants are found to exceed background and are at or slightly above probable effect levels for benthic organisms in the ponds/swales along the southern perimeter of the landfill.

7.3 Conclusion of Risk Assessments

EPA has concluded that hypothetical future potential exposure to groundwater by direct contact for a residential (adult/child) receptor would result in a non-cancer hazard that exceeds the target threshold of 1 and a cancer probability that would exceed the upper bound of the cancer risk management range (10^{-4}). A non-cancer hazard of 25 and a cancer risk estimate of 1.3×10^{-3} were estimated for the future resident receptor. Ingestion of groundwater accounted for the majority of the risk. Arsenic, BEHP, TCE, PCE, and vinyl chloride were identified as risk drivers for the estimate of non-cancer hazard and/or cancer risk. The primary target organs for the risk drivers, excluding risk drivers at background levels, are liver, kidney and developmental endpoints. Arsenic concentrations in groundwater were determined to be within background levels.

Exposure to volatile COPCs in groundwater via vapor intrusion to indoor air resulted in a non-cancer hazard below the target threshold of 1 and a cancer risk probability equal to the point of departure (10^{-6}).

Exposure to surface water, sediment and surface soil for the current/future resident (adult/child) resulted in a non-cancer hazard above the threshold of 1 and a cancer risk probability that exceeds the point of departure (10^{-6}). The cancer risk is within the risk management range of 10^{-4} to 10^{-6}. Exposure to surface soil via the ingestion pathway contributed the majority of the non-cancer hazard and the cancer risk. Risk drivers included inorganics that were determined to be within background levels. Surface water and sediment exposures were below the non-cancer target threshold of 1 and the cancer risk probability was below the point of departure.

EPA has concluded that the SLERA was unable to definitively demonstrate negligible risk to ecological receptors exposed to contaminated media at the Site. A number of

contaminants detected in sediment and surface soil represent a potential adverse risk to ecological receptors. The evaluation of the preliminary assessment endpoints identified preliminary COPCs for direct and food chain exposure in each medium for each habitat.

The remedial action selected in this Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

8.0 REMEDIAL ACTION OBJECTIVES

Based on the information relating to the types of contaminants, environmental media of concern, and potential exposure pathways, Remedial Action Objectives ("RAOs") were developed to aid in the development and screening of remediation alternatives. EPA has established the following RAOs to mitigate and/or prevent existing and future potential threats to human health and the environment.

RAOs for the Landfill

The RI was performed assuming a presumptive remedy for the landfill. Since a presumptive remedy was assumed for the landfill, Site specific characterization of the landfill subsurface (soil, waste and leachate), surface soil, and leachate seeps, including evaluation of their human health risk (including dermal, ingestion, and air borne particulate) and their ecological risk, was not performed. Capping of the landfill will address any potential human health or ecological risks associated with the landfill.

Presumptive remedial action objectives for risks associated with the landfill include:

- Prevention of direct contact with landfill contaminants and wastes.
- Reduction of the infiltration of precipitation into the waste material to reduce the quantity of leachate produced and subsequent migration of leachate into bedrock groundwater.
- Prevention of erosion and surface water runoff to prevent off-site migration of landfill contaminants.
- Prevention of off-site migration of landfill seeps to prevent off-site migration of landfill contaminants.

RAOs for Surface Soil

Arsenic is a human health COC. There were also many other metals that increased the risk; however, they were determined to be at background levels. One sample location (SS27) contained an elevated concentration of arsenic (14.5 mg/kg) relative to other samples collected during the RI and relative to the RBC for arsenic, which is 0.43 mg/kg. Because this soil sample (SS27) was collected some distance south of the landfill in the wooded floodplain it was not included in the statistical background evaluation. (Refer to Figure 7 for surface soil sample locations.) This soil sample was collected some distance

south of the landfill in the wooded flood plain, and may be considered a potential outlier. If this soil sample is considered an outlier, and not included in the statistical background evaluation, arsenic concentrations in off-site surface soil at the Site would be similar to concentrations detected at background locations. EPA has concluded that the risk associated with exposure to arsenic in surface soil is not attributable to landfill activities and was not included in Site RAOs.

Mercury is an ecological COC in surface soil in the Upland Forest Area. Mercury exceeded the maximum level classified as a background level at a single surface soil location (SS15), located on the northeast perimeter of the landfill. Surface soil locations SS24, SS25, SS29 and SS31 (in the Tohickon Creek Flood plain) have concentrations exceeding screening benchmarks for three ecological COPCs—manganese, mercury, and thallium. Manganese and thallium had concentrations similar to those detected at background locations. As a result, the only ecological COC within the flood plain area is mercury at surface soil locations SS29 and SS31. Mercury was slightly elevated (low concentration, J-qualified) at these two isolated areas.

EPA concluded that surface soil containing ecologically elevated mercury levels on the northeast perimeter of the landfill (SS15 area) and within isolated areas of the Tohickon Creek flood plain (SS29 and SS31 areas) should be further delineated and characterized during a pre-remedial design investigation. This investigation will include further sampling and analysis of the surface soil areas of concern.

RAOs for risks associated with the surface soil include:

- Mitigation of surface soil contamination to address risk to ecological receptors.
- Restoration of surface soil quality.

The remediation levels and cleanup actions for mercury in surface soil are as follows:

TABLE 13: REMEDIATION LEVELS AND CLEANUP ACTIONS FOR SURFACE SOIL

Mercury in Soil (mg/kg)	Spatial Extent	Action to be taken
Less than 0.073	N/A	No Action
0.073 (Probable Food Chain Effects) and less than 1.0 (Probable Direct Effects)	Spatially weighted average concentration across the 6 acre floodplain exceeds 0.073 but is less than 1.0	Determination of Site-specific bioavailability: (1) contaminants are less than 75% bioavailable then utilize in situ treatment to reduce bioavailability (compost soil amendment) with vegetative stabilization to minimize erosion or (2) contaminants are greater than 75% bioavailable then remove and revegetate.
1.0 (Probable Direct Effects) or greater	Any hot spot	Remove, revegetate

The above levels are based on the threshold concentrations of contaminants of concern identified in the ecological risk assessment. Ecological risks at the Site can occur through direct exposure to contaminants in soil (dermal absorption/ingestion) or through food-chain exposure (i.e., ingestion of prey which has accumulated contaminants).

RAOs for Sediment

Cadmium, copper, lead, manganese, selenium and zinc found in sediment samples along the western drainage area of the landfill exceed background maximum levels and are slightly below or at probable effects levels for benthic organisms. These same contaminants are located in ponds and swales along the southern perimeter of the landfill where they exceed background maximums and are at or above probable effects levels for benthic organisms. Refer to Figure 8 for sediment sample locations. The EPA concluded that the risks associated with areas immediately surrounding the landfill area will either be eliminated or significantly reduced with implementation of the landfill presumptive remedy, i.e., capping the landfill. For example, contaminated sediments along the southern and western perimeter of the landfill, if required based on the pre-design sampling, would be removed and placed below the landfill cap during remediation. These areas most likely will be subsequently used as stormwater management features (e.g., detention ponds, drainage channels, etc.) as part of the presumptive remedy. If wetland areas are disturbed during sediment removal, their restoration will need to be planned during the remedial design of Site stormwater management features. Confirmatory sampling would be performed during the remedial action to ensure affected sediments have been properly removed from these areas.

RAOs for risks associated with the sediment include:

- Mitigation of contaminated sediments to address risk to ecological receptors.
- Mitigation of impacted wetlands.
- Restoration of sediment quality.

Cleanup Levels for the sediments as described above are as follows:

TABLE 14: CLEANUP LEVELS FOR SEDIMENT

Cleanup Levels	Sediment (mg/kg)					
	Cadmium	Copper	Lead	Manganese	Selenium	Zinc
Probable Direct Effects	4.98	149	128	1100	20*	459
* Probable effect level not determined; no effect *10 uncertainty factor						

The sediment cleanup levels are based on the probable effects concentrations of contaminants of concern identified in the ecological risk assessment. Ecological risks at the Site occur through direct exposure to contaminants in soil (dermal absorption/ingestion) or through food-chain exposure (i.e., ingestion of prey that has accumulated contaminants).

RAOs for Groundwater

TCE, PCE, vinyl chloride, and BEHP are human health COCs. Although cis-1,2-DCE does not drive the risk at the Site (i.e., levels resulted in a non-cancer hazard value of less than 1.0), it is considered a Site COC because it has been historically detected in groundwater above the MCL of 70 ug/L, was detected at low levels in landfill leachate, and is a TCE degradation product. Several metals also contribute to the risk; however, they were determined to be at background levels (e.g., arsenic and manganese).

Figure 9 depicts the extent of the total VOC COC plume (total concentration of Site COCs: PCE, TCE, cis-1,2-DCE and vinyl chloride). Even though groundwater data indicate that the landfill is the source of the solvent plume present at the Site, PCE, TCE, and vinyl chloride were not detected in leachate samples collected from the landfill shallow leachate well locations. The fact these contaminants were not detected in leachate samples could suggest that the original chlorinated solvent source in the landfill, which historically caused the bedrock groundwater to become contaminated, may no longer be present; i.e., the source may have been "flushed-out" by the large quantities of precipitation infiltration over the last 30 years, or may have been completely transformed and degraded by biological activity within the landfill.

The VOC plume emanates from the landfill and migrates in the general direction of groundwater flow to the south, toward the Quakertown neighborhood (Figure 9). VOCs were detected within residential wells, whose depths ranged from 30 feet to 465 feet with an average of 138 feet, in the Quakertown neighborhood and a Quakertown Borough water supply well (QT10), confirming a groundwater exposure pathway. QT10 and some of the residential wells in the Quakertown neighborhood are open or screened within stratigraphic Unit 2, which is the same stratigraphic unit found outcropping at the landfill.

Remedial action objectives for human health risks associated with the groundwater include:

- Prevention of exposure to contaminated groundwater in the future.
- Prevention of further migration of the contaminant plume.
- Restoration of groundwater quality throughout the plume to primary drinking water standards.

The primary objective for the groundwater is to restore the aquifer to beneficial use. The remedial cleanup levels for groundwater contaminants of concern are as follows:

TABLE 15: PRELIMINARY REMEDIAL CLEANUP LEVELS FOR GROUNDWATER

GROUNDWATER COCS	MCL (ug/L)
TCE	5
PCE	5
Cis-1,2-DCE	70
Vinyl Chloride	2
BEHP	6

Because groundwater which meets the MCLs for individual contaminants may not meet the risk-based standards (1.0E-04) and HI less than or equal to 1) cumulatively, if multiple contaminants are present, determination of meeting the "protection of human health and the environment" RAO will be performance-based. When preliminary cleanup standards have been attained (MCLs), EPA will evaluate post-Record of Decision (ROD) data from the periodic groundwater monitoring and develop a trend analysis and risk assessment. The risk assessment will be based on an assessment of the cumulative risk across all applicable exposure routes for all COCs remaining in groundwater following achievement of the MCLs. The remediation of groundwater at the Site will continue until the risk-based cleanup standards (1.0E-04 and HI less than or equal to 1) are achieved.

9.0 SUMMARY OF REMEDIAL ALTERNATIVES

9.1 Remedial Alternatives Common Elements

During the Feasibility Study, various alternatives to cleanup contamination at the Site were developed. EPA evaluated a number of alternatives, described in detail below, to determine which cleanup methods would be best for both the landfill area and the groundwater. EPA's selected alternative for the landfill is LF Alternative 3 (see page 38) and for the groundwater is GW Alternative 6 (see page 43). Further information may be obtained from the Administrative Record.

Each alternative, except the "No Action" alternative, contains some common elements that were considered in the evaluation process.

Landfill Alternatives

Common Elements. Several of the Landfill Alternatives share the following common elements: (1) Institutional Controls and Engineering Controls and (2) Ecological Areas of Concern:

1. Institutional and Engineering Controls

Alternatives 2 through 5 include construction of a perimeter chain-link fence and placement of institutional controls (e.g., land development restrictions). Construction of the fence and placement of institutional controls on the property would prevent direct contact with landfill contaminants and wastes and would also protect the remedy. Institutional controls would prohibit and/or regulate future on-site development and protect the integrity of the landfill cap. An Institutional Control Implementation and Assurance Plan will be developed for the Site to outline appropriate institutional controls, and to identify appropriate mechanisms to implement and monitor the controls to ensure they are viable. None of these alternatives relies exclusively on institutional controls to achieve protectiveness. The chain-link-fence would be placed along the perimeter of the landfill property and would enclose the engineered remedy (i.e, cap and some stormwater management features).

2. Ecological Areas of Concern

The Multi-layer Cap and Soil Cap alternatives (LF Alternatives 3 and 4) each include an element which defines how off-site surface soil and sediments that are of ecological concern would be addressed. Figure 10 depicts areas of ecological concern at the Site identified in the RI. A description of this element common to LF Alternatives 3 and 4 follows:

Pre-design sampling would be conducted to further identify areas of elevated contamination in surface soils, based on the areas of concern identified in the RI. If mercury levels are found to be less than 0.073 mg/kg no actions will be taken. If mercury levels are found to be between 0.073 mg/kg and 1.0 mg/kg in the Site surface soils during

the pre-design sampling within the 6-acre floodplain, then additional sampling and analysis (which may include, but need not be limited to, toxicity bioassay and potential bioaccumulative studies) would be conducted. These additional studies would be conducted to further characterize and delineate areas of ecological concern and to further evaluate their potential impact to ecological receptors. Mercury levels in the surface soil equal to or greater than 1.0 mg/kg would be removed and the area would be backfilled and revegetated. Once the additional characterization and delineation efforts have been completed, EPA will determine the final locations for remediating Site surface soil ecological areas of concern in accordance with the remediation levels and cleanup actions set forth in Table 13.

The contaminated sediments in ponds/swales along the western and southern perimeter of the landfill would be excavated based on the cleanup levels for sediment set forth in Table 14 and consolidated below the landfill cover/cap. These areas most likely will be subsequently used as stormwater management features (e.g., detention ponds, drainage channels, etc.) as part of the presumptive remedy. Restoration of wetland areas disturbed during sediment removal would be incorporated into the final design of the stormwater management features at the Site. The remedy must comply with the standards set forth in Executive Order 11990 (federal Wetlands). No activity that adversely affects wetlands shall be permitted if a practicable alternative that has less effect is available. If there is no other practicable alternative, impacts must be minimized and/or mitigated. The total area of the ecological areas of concern to be addressed is 3 ¼-acres. This is comprised of approximately 1¼ -acres (sediment) at landfill swale locations, ¼-acre (surface soil) at the SS15 location, and approximately 1¾ -acres (surface soil) within the Tohickon Creek flood plain.

Groundwater Alternatives

Common Elements. Groundwater (GW) Alternatives 2 through 6 have common elements that include long-term monitoring of groundwater conditions and contaminant concentrations and movement while controlling the potential future risks through institutional controls. A brief description of these common elements follows:

Long-Term Groundwater Monitoring

Long-term monitoring of VOCs will be necessary to evaluate changes in water quality in the future, over time and distance. The monitoring program would be designed such that the concentration and movement of the contaminant plume could be determined. Many of the existing Site wells would be used to monitor the groundwater plume. In addition, a few additional wells (some shallow and deep nested pairs) might need to be installed to provide adequate monitoring of the plume as it advances hydraulically downgradient. These additional wells would likely be located at the southern boundary of the plume, within the Quakertown neighborhood (the exact number and locations to be determined during the RD). Easements, access agreements or other legal means of gaining access would be needed to install additional monitoring wells.

Institutional Controls

Temporary institution controls, such as land use and/or well permit restrictions, are necessary to:

- Prevent the installation of drinking water supply wells in the area where the groundwater contamination levels exceed MCLs and the risk-based performance standards, thus minimizing the potential for future exposure to contaminated groundwater.

- Prevent potential migration of the VOC plume if possibly caused by off-site pumping.

An Institutional Control Implementation and Assurance Plan will be developed for the Site to outline appropriate institutional controls, and to identify appropriate mechanisms to implement and monitor the controls to ensure they are viable. None of the alternatives rely exclusively on institutional controls to achieve protectiveness.

9.2 Remedial Alternatives

This section describes the remedial alternatives that EPA considered. Note that the Total Present Worth Cost for each alternative was calculated using a 7% discount rate and an Operations and Maintenance ("O&M") period of 30 years (unless mentioned otherwise). This time period was used as a basis for comparison.

Landfill Alternatives

A summary description of each of the Site landfill remedial alternatives follows:

LF ALTERNATIVE 1: No Action

Estimated Capital Cost: *$0*

Estimated Annual O&M Cost: *$0*

Estimated Present Worth Cost: *$0*

LF Alternative 1 constitutes a no-action alternative for the Site. Under the no-action alternative, no additional remedial measures would be implemented at the Site to address the landfill. As required by the NCP, this alternative is considered in the detailed analysis as a baseline to which the other landfill containment alternatives are compared.

LF ALTERNATIVE 2: Institutional/ Engineering Controls

Estimated Capital Cost: *$292,000*

Estimated Annual O&M Cost: *$14,000*

Estimated Present Worth Cost: *$466,000*

LF Alternative 2 includes the common element of institutional and engineering controls (previously described). No other remedial activities would be performed.

LF ALTERNATIVE 3: Multi-layer Cap

Estimated Capital Cost: *$8,215,000*

Estimated Annual O&M Cost: *$42,000*

Estimated Present Worth Cost: *$8,737,000*

LF Alternative 3 addresses the remedial objectives of the WJL Site and contains the following remedial components:

- Landfill Capping: Single-barrier multi-layer cap cover system, grading, stormwater management system, and a vertical and horizontal landfill gas management system.
- Ecological Areas of Concern: Pre-design sampling of ecological areas of concern to further delineate contamination. If required, surface soil would be excavated or stabilized depending on spatial extent and/or Site-specific bioavailability; sediment would be excavated. Excavated soils or sediments from areas not in the landfill cap area will be consolidated under the landfill cap.
- Institutional/Engineering Controls: To prevent direct contact with the landfill contaminants and wastes and to protect the engineered remedy.
- Long-Term Monitoring: Preventative inspections and maintenance.

Containment of the Site landfill through use of a multi-layer cap (i.e., soil and geosynthetic layers) cover system would minimize the amount of leachate generation and prevent exposure to landfill contaminants. A typical cross-section of a multi-layer soil/ geosynthetic cap cover system is depicted on Figure 11 and includes (from surface to top of waste) a vegetative cover, erosion layer, cover soil layer, geosynthetic drainage layer, geomembrane (hydraulic barrier), geosynthetic gas venting layer, and a landfill bedding layer. The multi-layer cap meets the requirements of both federal and state applicable or relevant and appropriate requirements. The cap would extend approximately 5 feet beyond the limits of waste. All waste located outside the landfill property would be removed/consolidated to within and below the Site cap. Regrading of the Site prior to placement of the cap would occur to allow for maximum slopes of 33% (3H:1V) where existing grades are not adequate for proper Site drainage and gas venting. Existing grades would be essentially maintained for the remainder of the Site except for what is required to establish a smooth uniformly graded and well-draining surface. Stormwater management controls, such as perimeter drainage swales and detention ponds, would be incorporated into the design. Overall grades at the Site, once the multi-layer cap has been constructed, will generally lie three feet higher (i.e., three foot cap thickness) than current Site grades. Trees and shrubs will be planted on the eastern perimeter of the landfill to provide a screen with the Heather Valley/Richland Farms residential neighborhood. The

new trees/shrubs would replace the existing trees/shrubs that would be cleared in order to construct the cap and perimeter drainage channels.

Landfill gas would be managed using a gas venting layer within the cap, gas vents to vent landfill gas collected within the cap venting layer, and perimeter gas monitoring wells to monitor landfill gas to ensure that the gas is not migrating off-site.

LF Alternative 3 includes the common element (previously described) that includes investigating areas of ecological concern, excavating confirmed contaminated sediments in ponds/swales along the western, southern and/or northeastern perimeter of the landfill, and consolidating them below the landfill cap/cover and either excavating or stabilizing in place confirmed surface soils contamination based on spatial extent and/or Site-specific bioavailability. LF Alternative 3 also includes the common element (previously described) of institutional/engineering controls.

Operation and maintenance activities for the landfill cap would include Site inspections, mowing, Site maintenance on an as-needed basis (e.g., revegetation, erosion repair, sediment removal, etc), and landfill gas monitoring (gas vents and monitoring wells).

LF ALTERNATIVE 4: Soil Cap

Estimated Capital Cost: *$6,744,000*

Estimated Annual O&M Cost: *$42,000*

Estimated Present Worth Cost: *$7,266,000*

Except for the type of landfill cap, LF Alternative 4 is identical to LF Alternative 3 (e.g., stormwater management, landfill gas management, excavation of contaminated sediments, further identification and removal or in place stabilization of select soil areas of ecological concern, institutional/engineering controls, and landfill cap operation and maintenance). The various components of a typical soil cap are (from surface to top of waste) a vegetative cover, erosion layer, infiltration layer (i.e., a low permeability barrier soil layer), geosynthetic gas venting layer, and a landfill bedding layer.

LF ALTERNATIVE 5: Soil Cover (limited action)

Estimated Capital Cost: *$2,829,000*

Estimated Annual O&M Cost: *$34,000*

Estimated Present Worth Cost: *$3,251,000*

LF Alternative 5 provides a soil cover across the landfill surface. This alternative provides a minimal landfill containment option and, unlike LF Alternatives 3 and 4, does not provide stormwater management (swales and ponds) or landfill gas management, and also does not include removal and consolidation of ecological areas of concern below the cover. The landfill surface would not be regraded for this alternative. However, this

alternative would include institutional/engineering controls and long-term monitoring (preventative maintenance and inspections).

A typical cross-section of a soil cover system includes (from surface to top of waste) a vegetative cover, erosion layer, and a landfill bedding area.

Groundwater Alternatives

A summary description for each of the Site groundwater remedial alternatives follows:

GW ALTERNATIVE 1: No Action

Estimated Capital Cost: *$0*

Estimated Annual O&M Cost: *$0*

Estimated Present Worth Cost: *$0*

The No Action alternative does not utilize additional remedial technologies to reduce contaminant mobility, toxicity, or volume. Contaminants are allowed to attenuate strictly by natural process, with no monitoring. The No Action alternative was retained for consideration as a potential alternative at the Site as required by the NCP for comparative purposes with other remedial alternatives.

GW ALTERNATIVE 2: Limited Action (Groundwater Monitoring and Institutional Controls)

Estimated Capital Cost: *$103,000*

Estimated Annual O&M Cost: *$94,000*

Estimated Present Worth Cost: *$1,270,000*

GW Alternative 2 includes the common element of long-term groundwater monitoring and institutional controls (previously described). No other remediation activities would be performed.

GW ALTERNATIVE 3: Groundwater Extraction, Pre-treatment and Discharge to POTW

Estimated Capital Cost: *$3,547,000*

Estimated Annual O&M Cost: *$1,239,000*

Estimated Present Worth Cost: *$18,922,000*

GW Alternative 3 includes the active pumping of groundwater from new groundwater extraction wells, pre-treatment of the extracted groundwater, and discharging the water to the area sewer system for treatment at the Borough of Quakertown Wastewater Treatment

Plant (QWTP). GW Alternative 3 would include pumping and treating current contaminated groundwater to meet relevant and appropriate MCLs and the risk range standards selected for this Site (1.0E-04 and HI less than of equal to 1).

Extraction and Treatment System

GW Alternative 3 involves the extraction of groundwater from a series of new wells to control the plume and prevent continued migration of contaminants toward Tohickon Creek and the Quakertown neighborhood. Based on an assessment of the overall hydrogeology of the Site (characterized during the RI), it has been assumed for costing purposes that a series of five new extraction wells would be installed to a depth of approximately 100 feet, each being pumped in the range of 30 to 40 gallons per minute. Conceptually, the pretreatment facility is located at the southwest corner, just off the landfill property line. This location was chosen for the conceptual design so that the facility would not be visible to the public. However, this location may require easements, access agreements or other legal means of gaining access. The conceptual layout of the extractions wells focuses on the higher COC concentration areas of the Site plume. The actual number, location, and depth of wells, as well as pumping requirements, would be initially determined during remedial design and finalized during the remedial action.

After pretreatment for metals and VOCs, the water would be pumped to the local sewer system which is operated by the Bucks County Water and Sewer Authority ("BCWSA"). The closest sewer line is an 8-inch line located within one hundred feet of the southeast boundary of the landfill property. According to the BCSWA there is adequate capacity in the sewer lines, however, use of this line would require QWTP to acquire additional capacity rights.

One or more presumptive technologies (chemical precipitation, ion exchange, or adsorption) would be used for treating contaminants in the extracted groundwater prior to discharge at the Publically Owned Treatment Works ("POTW"). Typically, the various components of the treatment system would include an equalization tank, metals removal system consisting of a filter and chemical precipitation system, liquid phase carbon units for VOC removal, and a sludge thickening and dewatering system in a manner consistent with EPA's presumptive remedies guidance document (EPA, 1996). The actual technologies and sequence of technologies used for the treatment system would be determined during remedial design. The sludge generated by the treatment system would be transported and disposed of at an off-site location in accordance with all applicable federal, state, and local regulations in effect at the time.

For costing purposes, it has been assumed that quarterly sampling of the treatment system would be required in accordance with discharge requirements.

Easements

Easements may be needed from landowners for placement of the treatment plant (if placed off the landfill property) and to install pipe lines from extraction wells to the treatment plant, and from the treatment plant to the sewer discharge point.

GW Alternative 3 includes the common elements (previously described) of long-term groundwater monitoring and institutional controls.

GW ALTERNATIVE 4: Groundwater Extraction, Treatment and Discharge to Tohickon Creek

Estimated Capital Cost: *$1,740,000*

Estimated Annual O&M Cost: *$389,000 (Years 1-10)*

$374,000 (Years 11-30)

Estimated Present Worth Cost: *$6,487,000*

GW Alternative 4 is essentially the same as GW Alternative 3, except that treated groundwater would be discharged to Tohickon Creek (instead of to a POTW), either directly via a forcemain, or indirectly via a drainage swale. Discharge of treated groundwater would meet substantive National Pollution Discharge Elimination System ("NPDES") requirements.

Once extracted (as described in GW Alternative 3), the groundwater would be conveyed through underground piping to an on-site treatment plant. The treatment components for this alternative would utilize the technologies described in GW Alternative 3. The actual components and sequence of technologies used for the treatment system would be determined during remedial design. The sludge generated by the treatment system would be transported and disposed of at an off-site location in accordance with all applicable federal, state, and local regulations in effect at the time.

GW ALTERNATIVE 5: In Situ Chemical Oxidation and Groundwater Monitoring

Estimated Capital Cost: *$2,715,000*

Estimated Annual O&M Cost: *$94,000*

Estimated Present Worth Cost: *$3,882,000*

GW Alternative 5 includes in situ chemical oxidation ("ISCO") by injecting permanganate into the bedrock groundwater to destroy COCs in place. GW Alternative 5 also includes the common elements of long-term groundwater monitoring and institutional controls.

GW Alternative 5 delivers permanganate, an oxidant, to bedrock fractures to contact and react with Site contaminants, which would either be completely oxidized to carbon dioxide or converted to innocuous compounds commonly found in nature. Permanganate reacts rapidly with the non-aromatic double bonds in chlorinated ethenes such as PCE, TCE, and vinyl chloride, which are groundwater COCs at the Site. Injected permanganate will migrate through fractures via advection and dispersion, and it will also diffuse into the primary porosity (non-fractured portion) of the bedrock matrix. Diffusion

of permanganate into the bedrock matrix provides a means to treat otherwise inaccessible VOCs that have also diffused into the bedrock matrix.

GW Alternative 5 includes the in-situ chemical oxidation of the groundwater plume area with total VOC contaminant concentrations greater than 100 ppb VOCs, natural degradation of contaminant levels less than 100 ppb total VOCs and long-term groundwater monitoring to evaluate the attenuation of VOCs remaining after the ISCO injection process. The groundwater monitoring results would be used to determine if additional injections would be required to meet the cleanup standards. In general, GW Alternative 5 includes:

- Installation of new monitoring wells to further characterize the plume area greater than 100 ug/L of total VOCs.

- Permanganate Injection: Installation of ISCO injection wells. The wells will be installed in a phased approach in order to verify or modify well placement based on the results of initial injections. Based on the pilot test performed at the Site, and for cost estimating purposes, it has been assumed that 80,850 pounds ("lbs") of potassium permanganate will be injected into the fractured bedrock system (based on 22 wells, 2,450 lbs potassium permanganate per well per injection, average 1.5 injections per well).

- ISCO Monitoring: Monitor influence of permanganate injections until the permanganate is depleted from reaction with the VOCs. This is expected to take a period of two to three months. The ISCO monitoring will evaluate the areas of oxidant distribution, potential VOC concentration rebound, and aquifer conditions for anaerobic dehalogenation.

The scope of the ISCO alternative developed for the FS was for planning and costing purposes. The actual number of wells, and sequencing of injections, will initially be determined during the remedial design phase and finalized during the remedial action.

GW ALTERNATIVE 6: In Situ Chemical Oxidation, with Enhanced Bioremediation and Groundwater Monitoring

Estimated Capital Cost: *$3,732,000*

Estimated Annual O&M Cost: *$114,000*

Estimated Present Worth Cost: *$4,771,000*

GW Alternative 6 is identical to GW Alternative 5 (ISCO injection, institutional controls, and groundwater monitoring); however, it also includes enhanced bioremediation to encourage effective biological degradation processes. Enhanced bioremediation would be utilized to further restore groundwater to the clean-up levels. Figure 12 shows the conceptual layout of GW Alternative 6.

Based on the results of a bioremediation evaluation (See Appendix E of the FS), there were only moderate amounts of microbes present in each of the wells analyzed. Dehalococcoides, microbes that biologically degrade certain COCs, were detected in low concentrations. A food source for the microbes (e.g., carbon and electron donor such as emulsified edible oil) would be required to enhance natural attenuation. The edible oil amendment stimulates the growth of the microbe population and enhances the anaerobic biodegradation of chlorinated solvents. Other potential sources of carbon and electron donors could also be used. The actual food source and microbes used to remediate groundwater would be determined during remedial design.

The following presents a summary of the components of GW Alternative 6:

- In Situ Chemical Oxidation Using Permanganate (as described in GW Alternative 5).

- A pilot test would initially be performed after the ISCO injections to evaluate the effectiveness of the bioremediation remedy for full-scale implementation. The actual quantities, areas of injections, and the number of injection phases would be determined initially during the pilot test phase, as well as after initial injection phases and monitoring. The scope described below for enhanced bioremediation is for cost estimating purposes.

- Enhanced bioremediation at the Site would include addition of carbon and electron donor to the fractured bedrock system. Changes in microbial population and contaminant levels would be monitored. The need for the injection of additional microbes to enhance remediation at the Site would be made based on the results of the initial monitoring. For purposes of this evaluation, non-toxic edible oil and microbes would be delivered into groundwater monitoring and injection wells (installed as part of the ISCO delivery system), as well as existing Site wells. For full-scale implementation, a 60-foot saturated thickness has been assumed, and injections would occur in approximately 14 injection/monitoring wells. Based on the above injection area (assumed to be the area shown in Figure 12 for the ISCO portion of the remedy), it has been estimated that approximately 10,700 lbs. of edible oil and 470 liters of Dehalococcoides organisms would be required at the Site. It has been assumed that injections would occur in three phases with monitoring of the dechlorination process (e.g., VOCs, ethane, and ethene, TOC, water quality parameters, etc.) and presence of dechlorinating Dehalococcoides organisms between injection phases.

10.0 EVALUATION OF ALTERNATIVES

The remedial alternatives described above were evaluated in detail to determine which would best meet the requirements of CERCLA, as amended, and the NCP, and achieve the remedial action objectives identified in section 8.0 of this ROD. EPA uses the nine criteria set forth in the NCP, 40 C.F.R. § 300.430(e)(9)(iii), to evaluate remedial alternatives. The first two criteria are threshold criteria: (1) overall protection of human health and the environment; and (2) compliance with applicable or relevant and appropriate requirements ("ARARs"). The selected remedy must meet both of these

threshold criteria, except when an ARAR waiver is invoked. The next five criteria are the primary balancing criteria: (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility or volume through treatment; (5) short-term effectiveness; (6) implementability; and (7) cost. The remaining two criteria are referred to as modifying criteria and are taken into account after public comment is received on the Proposed Remedial Action Plan: (8) state acceptance and (9) community acceptance.

The following discussion summarizes the evaluation of the remedial alternatives developed for the Site against the nine evaluation criteria.

Overall Protection of Human Health and the Environment

A primary requirement of CERCLA is that the selected remedial action be protective of human health and the environment. A remedy is protective if it reduces, to acceptable levels, current and potential risks associated with each exposure pathway at a site.

Landfill Alternatives

LF Alternative 1 (No Action) would not provide any protection of human health and the environment. Carcinogenic and non-carcinogenic risks exceeding EPA's target risk ranges would remain for current and future use. Because LF Alternative 1 does not satisfy the threshold criterion of protectiveness, it will not be considered further in this analysis.

LF Alternative 2 (Institutional/Engineering Controls) provides minimal protection of human health and the environment. The risk from direct contact with soil would be reduced due to the fence around the landfill perimeter. Off-Site migration of landfill contaminants and infiltration of precipitation into waste material would still occur.

LF Alternative 3 (Multi-layer cap) would attain all the landfill RAOs. This Alternative would provide the best protection of human health. LF Alternative 3, with further investigation, excavation, and/or stabilization of select areas of ecological concern, provides protection of the environment for all areas of ecological concern.

LF Alternatives 4 (Soil cap) would not meet all the RAOs for the landfill. This Alternative would provide protection of human health, but there is still a potential for seeps to migrate through the soil cap and for infiltration of precipitation into the waste and eventually into the groundwater, which could exacerbate efforts to cleanup the groundwater by increasing the contaminants flushing into the groundwater. LF Alternative 4 also provides protection of the environment for all areas of ecological concern.

LF Alternative 5 (Soil cover) would provide a small amount of protection of human health. There is still a potential for off-site migration of contaminants and infiltration of precipitation into the waste, and there is no remediation of ecological areas of concern.

Groundwater Alternatives

GW Alternative 1 (No Action) would not provide any protection of human health and the environment due to exposure to contaminated groundwater. Carcinogenic and non-carcinogenic risks exceeding EPA's target risk ranges would remain for future groundwater use and migration of the contaminant plume would not be controlled. Because GW Alternative 1 does not satisfy the threshold criterion of protectiveness, it will not be considered further in this analysis.

GW Alternative 2 (Limited Action) would provide no further remedial action at the Site, but would provide control of exposure to groundwater through institutional controls. Carcinogenic and non-carcinogenic risks exceeding EPA's target risk ranges would remain for future groundwater use and migration of the contaminant plume would not be controlled. GW Alternative 2 would be protective as long as the institutional controls remained in place.

GW Alternatives 3 and 4 (Groundwater Extraction and Treatment) would provide protection of human health and the environment by restoring the aquifer to beneficial use by the extraction and treatment of contaminated groundwater.

GW Alternative 5 (In-Situ Chemical Oxidation) would provide protection of human health and the environment through in-situ destruction of contaminants in the area where total VOCs are greater than 100 ug/L and natural degradation processes in areas where total VOCs are less than 100 ug/L.

GW Alternative 6 (In-Situ Chemical Oxidation and Enhanced Bioremediation) would provide protection of human health and the environment through destruction of contaminants in the area where total VOCs are greater than 100 ug/L and enhanced natural degradation processes in areas where total VOCs are less than 100 ug/L, similar to GW Alternative 5. The use of enhanced bioremediation after the In-Situ injections would accelerate the degradation process, causing this Alternative to reach MCLs and the selected risk-based standards throughout the plume more quickly than Alternative 5.

Compliance with ARARs

This criterion addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements ("ARARs") of federal and state environmental and facility siting laws and/or whether a remedy will provide grounds for invoking a waiver.

Any cleanup alternative selected by EPA must comply with all applicable or relevant and appropriate federal and state environmental and facility-siting requirements or, under certain conditions, include a waiver of one or more ARARs. Applicable requirements are those substantive environmental standards, requirements, criteria, or limitations promulgated under federal or state law that are legally applicable to the Remedial Action to be implemented at a site. Relevant and appropriate requirements, while not being directly applicable, address problems or situations sufficiently similar to those

encountered at a site such that their use is well-suited to the particular site. EPA is not waiving any ARARs for this Site.

Landfill Alternatives

LF Alternative 2 would not meet some of the substantive ARARs triggered by this remedial action. For instance, the Pennsylvania Land Recycling and Environmental Standards Act, 35 P.S. § 6026.101, *et seq.*, ("Act 2") mercury standard for soil would not be met. The subsections of the Pennsylvania regulations for solid waste landfills that have been determined by EPA to be relevant and appropriate would not be met by this alternative. Because LF Alternative 2 does not satisfy the threshold criterion of compliance with ARARs, it will not be considered further in this analysis.

LF Alternative 3 is the only alternative that would meet the relevant and appropriate portions of 25 PA Code Chapter 273. These regulations, which establish requirements for solid waste landfills, are not applicable to the Watson Johnson Landfill because of the time period during which waste was disposed of at the facility. However, due to similarities in the media (soil and sediment) affected, the purpose of the requirements and the substances regulated by the requirements, EPA has determined that numerous subsections of these regulations are relevant and appropriate to the landfill portion of the remedy. These specific subsections are identified in Table 16. EPA has determined that the leachate does not pose a threat to human health or the environment based on the levels of contaminants identified in the leachate. Therefore, the portions of Pennsylvania's solid waste landfill regulations that deal with leachate are neither relevant nor appropriate to this Site.

LF Alternatives 3 and 4 are similar in that each would meet the Pennsylvania Act 2 Land Recycling and Environmental Remediation Standards Act Section 301(a)(2); 25 PA Code 250.201, 201(a) and (b) and 250.302 (a) and (b), including the Statewide Health Standards for mercury. These alternatives would also meet the applicable portions of 40 CFR 122.26 and 122.44(h)(iv)(4), which contain substantive requirements for stormwater discharges from the landfill. The difference between LF Alternatives 3 and 4 is that LF Alternative 4 does not meet the relevant and appropriate portions of 25 PA Code Chapter 273.

LF Alternative 5 would not meet the substantive ARARs triggered for closure of a solid waste landfill. This Alternative does not include any actions for the ecological areas of concern and would not meet the substantive ARARs associated with these areas. Because LF Alternative 5 does not satisfy the threshold criterion of compliance with ARARs, it will not be considered further in this analysis.

During construction, LF Alternatives 3 and 4 would meet the applicable requirements for fugitive particulate matter, ambient air quality standards for particulate matter and air quality standards. Erosion and sediment control will comply with the ARARs for such activities.

Groundwater Alternatives

The Maximum Contaminant Levels ("MCLs") for public drinking water supplies established under the Safe Drinking Water Act ("SDWA") 42 U.S.C. § 300(f), *et seq.*, are considered to be relevant and appropriate standards for groundwater cleanup under the Superfund program. Groundwater contamination levels at the Site exceed the MCLs for various contaminants. Pennsylvania's Statewide Health Standards for groundwater are no more stringent than the federal MCL and therefore are not ARARs for this particular Site. GW Alternative 3 (groundwater extraction, pre-treatment and discharge to a POTW) and GW Alternative 4 (groundwater extraction, treatment and discharge to Tohicken Creek) would be designed so that groundwater concentrations meet the ARARs over time. Alternative 5 (in-situ chemical oxidation) and Alternative 6 (in-situ chemical oxidation and enhanced bioremediation) would also meet these requirements over time, but these alternatives are predicted to result in a faster reduction in contamination and to meet MCLs sooner than Alternatives 3 and 4. Alternative 6 is predicted to meet MCLs in approximately 15 years.

GW Alternative 2 would not meet the in-situ groundwater cleanup levels, i.e., the MCLs from the Safe Drinking Water Act, which have been determined to be relevant and appropriate. Because GW Alternative 2 does not satisfy the threshold criterion of compliance with ARARs, it will not be considered further in this analysis.

GW Alternatives 3 through 6 would meet the relevant and appropriate portions of PA Code Chapter 273. These regulations, which establish (among other things) requirements for groundwater related to solid waste landfills, are not applicable to Watson Johnson Landfill because of the time period during which waste was disposed of at the facility. However, due to similarities in the medium (groundwater) affected, the purpose of the requirements and the substances regulated by the requirements, EPA has determined that numerous subsections of these regulations are relevant and appropriate to the groundwater portion of the remedy.

Alternative 4 would achieve compliance with the ARARs for groundwater as well as those for discharge to the nearby surface water.

Alternatives 3 and 4 would be designed to meet the federal wetlands requirements of federal Executive Order 11990, for all activities that would affect wetlands. These alternatives would also be designed to meet the relevant and appropriate sections of the Pennsylvania Flood Plain Management Act which regulates earth moving activities within a 100-year flood plain.

Alternatives 5 and 6 would meet the substantive standards of the applicable requirements of the Underground Injection Control Program, 40 CFR Part 144, for injecting both the chemical oxidant and the bioremediation microbes.

All the alternatives that require construction would meet the substantive standards of the applicable regulations for discharge of stormwater, erosion and sediment control, water well drillers, and conservation of water resources.

A complete list of ARARs for the selected remedy for the Site is presented in Table 16. Table 17 presents the ARARs for all the Landfill Alternatives and Table 18 present the ARARs for all the Groundwater Alternatives.

Long-term Effectiveness and Permanence

This criterion considers the ability of an alternative to maintain protection of human health and the environment over time. The evaluation takes into account the residual risk remaining from untreated waste at the conclusion of remedial activities, as well as the adequacy and reliability of containment systems and institutional controls.

Landfill Alternatives

LF Alternative 3 would be the most successful at meeting the objective of long-term effectiveness and permanence. A multi-layer cap would reduce the infiltration of stormwater into the waste mass and subsequent generation of leachate. Regular inspection, monitoring and maintenance would ensure the cap's integrity, performance and long-term reliability.

LF Alternative 4 would not be as effective in the long-term as LF Alternative 3 because the soil cap would not be as effective at eliminating infiltration of precipitation and might allow seeps to migrate through the cap.

Groundwater Alternatives

GW Alternatives 3 and 4 (Groundwater Extraction and Treatment) would offer long-term effectiveness in controlling the contaminant plume by the continuous operation of the pump and treat system. However, the long-term effectiveness of extracting all the contamination in the fractured bedrock geology and treating the contamination may be limited.

GW Alternative 5 (In-Situ Chemical Oxidation) and GW Alternative 6 (In-Situ Chemical Oxidation and Enhanced Bioremediation) would provide long-term effectiveness and permanence through in-situ destruction of contaminants in the area where total VOCs are greater than 100 ug/L. GW Alternative 5 includes the use of natural degradation processes to reduce groundwater contamination in areas where total VOCs are less than 100 ug/L, whereas GW Alternative 6 proposes to enhance the natural biodegradation processes to reduce the contamination to below cleanup levels.

Reduction of Toxicity, Mobility or Volume of Contaminants through Treatment

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of the hazardous substances as their principal element. This preference is satisfied when treatment is used to reduce the principal threats at a site.

Landfill Alternatives

LF Alternative 3 (Multi-layer cap) and LF Alternative 4 (Soil cap) would provide no reduction of toxicity, mobility or volume of the landfill contaminants through treatment.

Groundwater Alternatives

GW Alternatives 3 and 4 (Groundwater Extraction and Treatment) would reduce the contaminant toxicity and volume over the long-term.

GW Alternative 5 (In-Situ Chemical Oxidation) would significantly reduce the contaminant toxicity and volume in the short-term. GW Alternative 6 (In-Situ Chemical Oxidation with Enhanced Bioremediation) would provide significant reduction of the contaminant toxicity and volume in the short-term and would provide additional reduction in the long-term due to the enhanced bioremediation action included in the Alternative.

Short-term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial action objectives are met. It considers risk to the community and on-site workers and available mitigation measures, as well as the time frame for attainment of the response objectives.

Landfill Alternatives

The short-term effectiveness for LF Alternatives 3 and 4 are the same. The risk to the community and the environment during implementation would be minimal. The biggest impact to the community would be noise and dust during construction and the removal of the natural visual barrier between the community and the landfill. The implementation of these alternatives would subject workers to minimal risk. It is estimated that the construction of both of these alternatives would take approximately 12 to 18 months to implement, once construction was initiated.

Groundwater Alternatives

GW Alternatives 3 and 4 would result in minimal risks to workers, the community, or the environment during implementation of these alternatives. It is estimated that it would take 12 to 18 months to complete the construction of these treatment facilities, once construction began.

GW Alternatives 5 and 6 would also result in minimal risks to workers, the community, or the environment during implementation of these alternatives. It is estimated that GW Alternative 5 would take approximately 6 to 9 months to construct and the in-situ

injections would occur over an 18 to 24 month period. GW Alternative 6 would take a similar amount of time to construct. GW Alternative 6 would also have an in-situ chemical oxidation injection phase lasting 18 to 24 months and would be followed by the enhanced bioremediation which could require injections over a three to five year period.

Implementability

The evaluation of alternatives under this criterion considers the technical and administrative feasibility of implementing an alternative and the availability of services and materials required during implementation.

Landfill Alternatives

Both LF Alternatives 3 and 4 can be readily implemented. Both cap systems are common landfill remedies that can be readily engineered and constructed. Construction of perimeter drainage swales may be challenging because construction on the residential properties would require temporary easements or other legal means of gaining access.

Groundwater Alternatives

The groundwater extraction and treatment facility, as required in GW Alternatives 3 and 4, can be readily engineered and constructed. Both alternatives would require easements, access agreements or other legal means of gaining access to install the wells, treatment facility and associated piping.

The components and systems associated with GW Alternatives 5 and 6 could be readily engineered and constructed. Although the design of this type of system is specialized, there are numerous engineering firms that are capable of performing this work. Both alternatives would require easements, access agreements or other legal means of gaining access to install monitoring and injection wells.

Cost

The Alternative Cost Summary Table (see Table 19) summarizes the capital, annual operation and maintenance ("O&M"), and total present worth costs for each alternative. Capital costs include engineering design, construction, construction management, administration, and contingency. Annual O&M costs include the estimated annual operation and maintenance costs of the remedy throughout the life of the project. In order to best compare the varying costs of the different alternatives, a present worth analysis was performed. This analysis included the present worth of annual O&M costs with a discount rate of 7% over the life of the project (estimated to be 30 years for comparison purposes except for GW Alternative 6, which is estimated to be 15 years) and the one-time capital costs. Table 20 is a detailed cost estimate for the Selected Remedy.

LF Alternative 3 is the most expensive landfill alternative at a Present Worth Cost of $8,737,000, and it also is the only alternative that meets all the ARARs. LF Alternative 4 is the next expensive alternative at a Present Worth Cost of $7,266,000, but it does not

meet the relevant and appropriate portions of 25 PA Code Chapter 273. The remaining LF alternatives are less expensive, but they do not meet all of the ARARs and they do not address ecological concerns.

GW Alternative 2 is the least expensive groundwater alternative but it does not provide remediation of the contamination. GW Alternatives 3 and 4 provide remediation using extraction of the groundwater, treatment and discharge. These alternatives are the most expensive groundwater alternatives, with GW Alternative 3 being at least four times more expensive than GW Alternatives 5 and 6. GW Alternative 6 is approximately $1,000,000 more expensive than GW Alternative 5 but should meet the cleanup standards in 15 years instead of 30 years.

State Acceptance

PADEP has reviewed a draft of the Record of Decision and comments from the public, and concurred with the selected remedy in a letter dated July 24, 2009.

Community Acceptance

From September 8, 2008 through October 7, 2008, EPA took public comment on the remedial alternatives presented in the Feasibility Study and the Proposed Plan and the other documents contained within the Administrative Record for the Site. On September 25, 2008, EPA held a public meeting to discuss the Proposed Plan and accept comments. A transcript of this meeting is included in the Administrative Record. From March 9, 2009 to April 7, 2009, EPA held a public comment period on the Proposed Plan for the Site. The summary of significant comments received from the public and EPA's responses are included in the Responsiveness Summary, which is a part of this Record of Decision.

11.0 SELECTED REMEDY

Following review and consideration of the information in the Administrative Record, the requirements of CERCLA and the NCP, and public comments, EPA has selected the following as the remedy for the Watson Johnson Landfill Superfund Site: LF Alternative 3, Multi-layer Cap and GW Alternative 6, In Situ Chemical Oxidation, with Enhanced Bioremediation and Groundwater Monitoring.

11.1 Summary of the Rationale for the Selected Remedy

EPA's selected alternatives meet the threshold criteria of overall protection of human health and the environment and compliance with ARARs. Based on the information currently available, EPA (the lead agency) has determined that Alternatives LF 3 and GW 6 provide the best balance of advantages among the alternatives, when evaluating them using the balancing criteria.

EPA's selected alternative for the landfill:

1) will be protective of both human health and the environment;

2) will meet federal and state ARARs;

3) can be easily implemented in a relatively short timeframe; and

4) will provide long-term effectiveness and permanence.

EPA's selected alternative for the groundwater:

1) will be protective of both human health and the environment;

2) will meet federal and state ARARs;

3) will reduce toxicity and volume of groundwater contaminants through treatment;

4) will be effective in the short-term; and

5) will reach cleanup levels sooner than other alternatives.

Overall, EPA's selected alternatives satisfy the statutory requirements of CERCLA §121 and the NCP by being protective of human health and the environment; complying with ARARs; being cost-effective; and utilizing permanent solutions and alternative treatment technologies to the maximum extent practicable. The groundwater alternative satisfies the preference for treatment as a principal element. The selected remedy is the best balance of the nine evaluation criteria.

11.2 Description of the Selected Remedy and Performance Standards

Based on the comparison of the nine criteria, EPA's selected alternative for the Landfill is Alternative 3 and for the Groundwater is Alternative 6. The total present worth cost of EPA's selected remedy is $13,508,000. In addition to the common elements described on pages 35-37, the major components of the Selected Remedy (as discussed in detail on pages 38 and 43) are:

1. Installation of a multi-layer cap cover system for the landfill area including a storm water management system and a vertical and horizontal landfill gas management system.

2. Ecological area remediation.

3. In-situ chemical oxidation of the VOC contamination in the groundwater.

4. Enhanced bioremediation to encourage the natural biological degradation process to further remediate the VOC contamination in groundwater.

5. Groundwater monitoring to ensure effectiveness of the groundwater remedy.

6. Institutional controls to protect the integrity of the remedy including the monitoring wells, injection wells, cap cover system and any groundwater cleanup process itself. This latter will include preventing the pumping of groundwater that could interfere with the cleanup. Institutional Controls are also needed to prevent dermal contact with and consumption of groundwater that exceeds the performance standards. An Institutional Control Implementation and Assurance Plan ("ICIAP") will be developed for the Site during the remedial design to ensure appropriate institutional controls are drafted, implemented and monitored.

The selected remedy shall meet all applicable or relevant and appropriate requirements contained in Table 16.

11.2.1 Installation of a Multi-layer Cap Cover System for the Landfill Area

Prevent the exposure to landfill contaminants and minimize the amount of leachate generated by using a multi-layer cap. The design of the cap system shall include stormwater management and a vertical and horizontal gas management system.

Performance Standards for a Multi-layer Cap Cover System

1. Prevent exposure to landfill contaminants by installing a multi-layer cap cover system. The cap shall include (from surface to top of waste) a vegetative cover, erosion layer, cover soil layer, geosynthetic drainage layer, geomembrane (hydraulic barrier), geosynthetic gas venting layer, and a landfill bedding layer. The multi-layer cap meets the applicable or relevant and appropriate landfill requirements. Relevant and appropriate requirements include 25 PA Code Sections 273.292(e); 273.234(a)(1)(i) and (ii), (a)(2) and (3), (c), (d), (e), (f), and (g); 273.235(a) and (c); and 273.236(a) and (b).

2. All waste located outside the landfill property would be removed/consolidated to within and below the Site cap. Regrading of the Site prior to placement of the cap would occur to allow for maximum slopes of 33% (3H:1V) where existing grades are not adequate for proper Site drainage and gas venting. Existing grades would be essentially maintained for the remainder of the Site except for what is required to establish a smooth uniformly graded and well-draining surface. The applicable portions of the Pennsylvania Air Quality Standards, 25 PA Code Chapter 123.31, shall be met during grading of the landfill waste.

3. Stormwater management controls, such as perimeter drainage swales and detention ponds, would be incorporated into the design. The stormwater management controls shall meet the applicable requirements of the Pennsylvania Water Quality Standards 25 PA Code, Chapter 93 and the applicable requirements of 40 CFR 122.26 and 40 CFR 122.44(h)(iv)(4), Discharge of Stormwater.

4. Trees and shrubs will be planted on the eastern perimeter of the landfill to provide a screen with the Heather Valley/Richland Farms residential neighborhood. The new trees/shrubs would replace the existing trees/shrubs that would be cleared in order to construct the cap and perimeter drainage channel.

5. The vegetative cover will be planted with a native mix seed to reduce the need for mowing and maintenance.

6. Landfill gas would be managed using a gas venting layer within the cap, gas vents to vent landfill gas collected within the cap venting layer, and perimeter gas monitoring wells to monitor landfill gas to ensure that the gas is not migrating off-site.

7. Operate and maintain the cap cover system to ensure the integrity of the engineered remedy.

8. The following applicable requirements shall be met during construction: Fugitive Particulate Matter, 25 PA Code Chapters 123.1 and 123.3; Ambient Air Quality Standards for Particulate Matter, 25 PA Code Chapters 131.2 and 131.3; and, Erosion and Sediment Control, 25 PA Code Chapters 102.4, 102.11 and 102.22.

11.2.2 Conduct Ecological Area Remediation

Conduct ecological area remediation for both surface soil and sediment. Pre-design sampling would be conducted to further identify areas of elevated contamination in surface soils and sediments, based on the areas of concern identified in the RI.

In surface soils, if mercury levels are found to be less than 0.073 mg/kg, no actions will be taken. If mercury levels are found to be between 0.073 mg/kg and 1.0 mg/kg in the Site surface soils during the pre-design sampling within the 6-acre floodplain, then additional sampling and analysis (which may include, but need not be limited to, toxicity bioassay and potential bioaccumulative studies) would be conducted. These additional studies would be conducted to further characterize and delineate areas of ecological concern and to further evaluate their potential impact to ecological receptors. Mercury levels in the surface soil equal to or greater than 1.0 mg/kg would be removed and the area would be revegetated. Once the additional characterization and delineation efforts have been completed, EPA will determine the final locations for remediating Site surface soil ecological areas of concern in accordance with the remediation levels and cleanup actions set forth in Table 13.

The contaminated sediments in ponds/swales along the western and southern perimeter of the landfill would be excavated based on the cleanup levels for sediment set forth in Table 14 and consolidated below the landfill cover/cap. These areas most likely will be subsequently used as stormwater management features (e.g., detention ponds, drainage channels, etc.) as part of the selected remedy. Restoration of wetland areas disturbed during sediment removal would be incorporated into the final design of the stormwater management features at the Site. The total area of the ecological areas of concern to be

addressed is 3 ¼-acres, consisting of approximately 1¼ -acres (sediment) at landfill swale locations, ¼-acre (surface soil) at the SS15 location, and approximately 1¾ -acres (surface soil) within the Tohickon Creek flood plain.

Performance Standards for Ecological Area Remediation

1. Performance of the remediation of Site surface soil ecological areas of concern shall be in accordance with the remediation levels and cleanup actions set forth in Table 13 of this ROD. The surface soil remediation shall be in accordance with the relevant and appropriate requirements of Pennsylvania Act 2, The Land Recycling and Environmental Standards Act, Section 301(a)(2); 25 PA Code §§ 250.201, 201(a) and (b) and 250.302(a) and (b).

2. Performance of the remediation of Site sediment ecological areas of concern shall be in accordance with the remediation levels and cleanup actions set forth in Table 14 of this ROD.

3. All remediation of Site ecological areas of concern shall be in accordance with the federal wetlands requirements in Executive Order 11990.

11.2.3 Perform In-Situ Chemical Oxidation of Contaminated Groundwater

Perform in-situ chemical oxidation of contaminated groundwater.

Performance Standards for In-Situ Chemical Oxidation of Contaminated Groundwater

1. Install new monitoring wells to further characterize the plume area greater than 100 µg/L of total VOCs and injection wells for the injection of the chemical oxidant. The wells shall be installed in accordance with the applicable substantive portions of the Water Well Drillers License Act, 17 PA Code Chapter 47.

2. Inject a chemical oxidant, determined during design, into the wells in the plume area containing greater than 100 µg/L of total VOCs. Injection shall be conducted in accordance with the substantive requirements of the applicable portions of the Underground Injection Control Program (40 CFR Part 144).

3. Monitor groundwater throughout entire plume area to determine the influence of the injections. The monitoring program will evaluate the oxidant distribution, VOC concentration and rebound, and aquifer conditions for anaerobic dehalogenation. Adjust injection program if required. The monitoring program shall be developed in accordance with the relevant and appropriate portions of the Municipal Solid Waste Landfill: Groundwater Requirements, 25 PA Code §§ 273.282; 273.283; 273.284 and 273.322 (e) and (f).

4. Discontinue the in-situ chemical oxidation when EPA determines that cleanup standards are met or that the chemical oxidation is no longer effective in treating the contamination. The in-situ chemical oxidation will be considered no longer effective when the average concentration in the treatment area of total VOCs is less than 100 ppb. When this level is reached, the remediation would then proceed to enhanced bioremediation.

11.2.4 Perform Enhanced Bioremediation of Contaminated Groundwater

Perform enhanced bioremediation of the contaminated groundwater after the in-situ chemical oxidation has met its treatment objectives.

Performance Standards for Enhanced Bioremediation of Contaminated Groundwater

1. A pilot test shall be conducted to evaluate the bioremediation remedy for full-scale design. The actual quantities, areas of injections, and the number of injection phases shall be determined during design of the bioremediation phase of the remedy and again after the initial injection phase and monitoring.

2. Enhanced bioremediation shall include addition of carbon and electron donors into the fractured bedrock in the area of groundwater contamination. An assessment of the need to inject additional microbes into the area will be determined based on the results of the initial monitoring. Injection shall be conducted in accordance with the substantive requirements of the applicable portions of the Underground Injection Control Program (40 CFR Part 144).

3. Monitor groundwater plume to determine the influence of the enhanced bioremediation on the groundwater contamination. The monitoring program shall evaluate the groundwater compared to the cleanup criteria specified in Section 8 of this ROD and Table 15. The monitoring program shall be developed in accordance with the relevant and appropriate portions of the Municipal Solid Waste Landfill: Groundwater Requirements, 25 PA Code§§ 273.282; 273.283; 273.284 and 273.322 (e) and (f).

11.2.5 Monitor Groundwater to Ensure the Effectiveness of the Remedy

Collect and analyze data from the groundwater within and surrounding the contaminant plume using existing and new monitoring wells to determine whether the groundwater treatment remedy is operating effectively. Develop a groundwater monitoring plan for the Site.

Performance Standards for Monitoring Groundwater to Ensure the Effectiveness of the Remedy

1. Collect and analyze groundwater samples for Site contaminants from multiple locations and monitor water levels in the wells; the specific locations and frequency of sampling shall be as determined in the Operations and Maintenance Monitoring Plan, which will be updated as necessary.

2. Update the monitoring plan every five years, coinciding with EPA's five year reviews, unless EPA develops an alternate schedule.

11.2.6 Land and Groundwater Use Restrictions for the Site and Surrounding Area (as appropriate)

An Institutional Control Implementation and Assurance Plan ("ICIAP") shall be developed during the remedial design to address institutional controls, including land and groundwater use restrictions, for the Site. The requirements for institutional controls contained in this ROD are based on current, reasonably anticipated uses of the Site and areas in the vicinity of the Site. The purpose of the institutional controls shall be to prevent exposure to unacceptable risks associated with the groundwater during implementation of the remedy and with the remaining Site-related contaminants in the landfill after remedy implementation and to protect the components of the selected remedy. The required Institutional Controls may include property use controls (such as easements and restrictive covenants) and governmental controls (such as zoning ordinances and local permits). The ICIAP shall identify parties responsible (i.e., federal, State or local authorities or private entities) for implementation, enforcement, and monitoring and long-term assurance of each institutional control including costs, both short-term and long-term, and methods to fund the costs and responsibilities for each step. The ICIAP shall include maps, which shall describe coordinates of the restricted areas depicting all areas that do not allow unlimited use/unrestricted exposure and areas where ICs have been implemented along with a schedule for implementation of the remaining ICs. The maps and information about the ICs shall be made available to the public. In addition, the ICIAP shall identify reporting requirements associated with each institutional control which shall include at a minimum an annual review of the status and effectiveness of the institutional controls and whether each institutional control is still appropriate.

Performance Standards for Land and Groundwater Use Restrictions for the Site and Surrounding Area

1. Maintain and protect the integrity of the engineered remedy including, but not limited to, the landfill cap and storm water management features, monitoring wells and injection wells. The ICs regarding wells would be removed when wells are permanently removed.

2. Prohibit exposure to contaminated groundwater. Use of and/or contact with contaminated groundwater at the Site, via ingestion, vapor inhalation or dermal

contact, shall be prohibited to avoid unacceptable exposure to contaminants in groundwater. When cleanup standards listed in section 8 and Table 15 have been met, the institutional controls to prohibit groundwater use would be removed.

11.3 Summary of the Estimated Remedy Costs

The estimated present worth costs of the selected remedies is $13,508,000. See Table 20 for a detailed cost summary.

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the selected remedial action. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Minor changes may be documented in the form of a memorandum in the Administrative Record. Changes that are significant, but not fundamental, may be documented in an Explanation of Significant Differences. Any fundamental changes would be documented in a ROD amendment.

11.4 Expected Outcomes of the Selected Remedy

This section presents the expected outcomes of the selected remedy in terms of resulting land and groundwater uses and risk reduction achieved as a result of the response actions. The completion and maintenance of the landfill cover system will eliminate the potential risk of residents being exposed to contaminated soil.

The groundwater remedies to be put in place at the Site are expected to remediate the groundwater. The treatment of the groundwater shall remediate the groundwater to meet MCLs. The groundwater remedy will continue until the cleanup standards are met and the excess lifetime cancer risk for use of the groundwater, as drinking water, is below 1.0E-04 and the Hazard Index is reduced to 1. The groundwater remedy is expected to take approximately 15 years to reach the cleanup standards.

The selected remedy is expected to eliminate the ecological risk at the Site. Soil excavation and/or soil stabilization along with the landfill cover system and groundwater treatment at the Site should result in the improvement of ecological conditions in the area.

The selected remedy will restrict any use of the landfill area in ways that could interfere with any of the engineered components of the cover system. Groundwater use restrictions will prevent exposure to contaminated groundwater. Land use restrictions in the area of groundwater contamination will include restrictions to protect the groundwater wells and injection wells. After the cleanup standards listed in section 8 and Table 15 have been met for the groundwater the institutional controls to prohibit groundwater use and to protect the monitoring and injection wells would be removed.

12.0 STATUTORY DETERMINATIONS

Under Section 121 of CERCLA, 42 U.S.C. § 9621, selected remedies must protect human health and the environment, comply with ARARs, be cost-effective and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Additionally, CERCLA includes a preference for remedies that use treatment to significantly and permanently reduce the volume, toxicity or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy for the Watson Johnson Landfill Superfund Site meets these statutory requirements.

12.1 Protection of Human Health and the Environment

The selected remedy will protect human health and the environment by eliminating or mitigating exposure or the potential for exposure to Site-related contaminants through the installation of a landfill cover system and the remediation of the groundwater contamination. The selected remedy will provide protection of the environment for all areas of ecological concern through further investigation, excavation, and/or stabilization of select areas of ecological concern. The in-situ chemical oxidation and enhanced bioremediation will provide treatment for the contaminated groundwater which will reduce the volume and toxicity of the contamination. The groundwater remedy will remediate the groundwater to cleanup standards.

12.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy will attain all applicable or relevant and appropriate requirements, which are identified as a performance standard in Section 11.2 and specified in Table 16 of this ROD.

12.3 Cost Effectiveness

The selected remedy is cost effective in that: (1) it eliminates or mitigates the risks posed by the contaminants at the Site; (2) it meets all requirements of CERCLA and the NCP; and (3) its overall effectiveness in meeting the remedial action objectives is proportional to its cost. The landfill alternative is the most costly of the alternatives considered but it is the only alternative that meets all the State and federal ARARs. The groundwater alternative is one of the lower cost alternatives considered, yet it ranks highest in terms of long-term effectiveness and permanence; reduction in toxicity, mobility or volume; and short-term effectiveness, as compared to the other alternatives.

12.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy utilizes long-term solutions and treatment technologies to the maximum extent practicable through the use of in-situ chemical oxidation and enhanced bioremediation to clean up the groundwater. Of those alternatives that are protective of human health and the environment and comply with ARARs, EPA has determined that the remedy provides the best balance of advantages and disadvantages, in terms of long-

term effectiveness and permanence, reduction in toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and cost, while also considering the statutory preference for treatment as a principal element, and State and community acceptance.

12.5 Preference for Treatment as a Principal Element

The selected remedy will meet the statutory preference for treatment as a principal element, since it treats the groundwater contamination present at the Site. The in-situ chemical oxidation portion of the groundwater remedy has been successfully used at the Site during the pilot test.

12.6 Five-Year Review Requirements

Because the Site remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted every five years to ensure that the remedy is, or will be, protective of human health and the environment pursuant to CERCLA Section 121 (c) and the NCP, 40 C.F.R. § 300.430(f)(5)(iii)(C). The first review will be conducted within five years of the initiation of remedial action at the Site and will continue every five years after that.

13.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The public comments did not result in any significant or fundamental changes in the selected remedy from the alternatives proposed in the Proposed Plan.

The cost of Landfill Alternatives 3 and 4 were incorrectly quoted in the Proposed Plan for the Watson Johnson Landfill Superfund Site. In the Proposed Plan the cost for the ecological areas of concern did not include all relevant areas. The Capital Cost for Alternative 3 was stated as $7,736,000 in the Proposed Plan on page 18, but it should have been stated as $8, 215,000. The Capital Cost for Alternative 4 was stated as $6,265,000 in the Proposed Plan on page 20, but it should have been stated as $6,774,000. The correct costs were included in Table 6 of the Proposed Plan.

The cost of Groundwater Alternative 4 was incorrectly quoted in the Proposed Plan for the Watson Johnson Landfill Superfund Site. On page 23 of the Proposed Plan, the O&M Cost for GW Alternative 4 was incorrectly stated as $391,000 per year. The correct O&M costs are $389,000 for Years 1-10 and $374,000 for Years 11-30. The correct costs were included in Table 6 of the Proposed Plan.

III. RESPONSIVENESS SUMMARY

WATSON JOHNSON LANDFILL
SUPERFUND SITE

RICHLAND TOWNSHIP, BUCKS COUNTY, PENNSYLVANIA

WATSON JOHNSON LANDFILL SUPERFUND SITE,
RICHLAND TOWNSHIP, BUCKS COUNTY, PENNSYLVANIA

RESPONSIVENESS SUMMARY

This Responsiveness Summary documents public participation in the remedy selection process for the Watson Johnson Superfund Site. It contains a summary of the significant comments received by EPA on the Proposed Plan for the Site and EPA's responses to those comments.

A. Summary of Significant Comments from the Public Meeting on September 25, 2008 and EPA's Responses

EPA held a Public Meeting on September 25, 2008 to accept public comment on EPA's Proposed Plan for the Watson Johnson Landfill Superfund Site. The significant comments received regarding the plan for OU3 are summarized here, along with EPA's responses to these comments. The entire transcript of the meeting, including all comments received and EPA's responses, is included in the publicly available portion of the Administrative Record for anyone who wants to view them.

1. **Comment:** How deep is the landfill waste currently? Why can't the waste be excavated and removed?

Response to comment: The top surface of the landfill waste can be found at the surface to about two feet deep depending on location. The average thickness of the waste is 10.5 feet. The landfill area is 20.4 acres. Excavating the waste and removing to another place does not meet the EPA's evaluation criteria for remedial alternatives. EPA's presumptive remedy for a municipal waste landfill is containment, which a multi-layer cap cover system provides.

2. **Comment:** How high is the fence going to be?

Response to comment: Since the cap cover system has not yet been designed for the Watson Johnson Landfill, the height of the fence is not known at this time. In similar situations, the fences often have been eight feet in height.

3. **Comment:** Originally did they do the testing on the wrong site?

Response to comment: EPA's Site Assessment Team originally tested the wrong side of the street prior to the Site being listed on the National Priorities List. The data used to develop the selected remedy were from the correct Site.

4. **Comment:** Is there a concern that the contaminants will leak out the sides of the cap? Will the groundwater get into the waste from below?

Response to comment: The cap will be designed to encapsulate the waste. The cap and the stormwater management features will be constructed to provide additional protection around all sides of the waste. The cap is impermeable, so rainwater will not be able to penetrate the cap or waste. The groundwater begins below the bottom of the waste. The groundwater will not come in contact with the waste.

5. **Comment:** How much time will the residents have to prepare before the remedial action construction begins?

Response to comment: After the Remedial Design is completed, an Informational Meeting will be held to inform the residents of the design plan and schedule for implementation. During the process, EPA will send fact sheets to update the residents. It is hard to estimate the timeframe at this stage of the process.

6. **Comment:** Will the landfill be flat?

Response to comment: The landfill cap has not been designed at this time, but it is anticipated that the final shape of the landfill will be somewhat similar to its current shape, in that it will be relatively flat. However, some grading of the landfill will be performed to allow rain water to properly drain off the landfill cap. When the cap is complete landfill elevations will increase by approximately three feet.

7. **Comment:** What are Institutional Controls?

Response to comment: Institutional controls are legal means to place restrictions on a property and/or environmental media to ensure protectiveness of human health or the environment.

8. **Comment:** Will you install additional groundwater monitoring wells? Have you noticed the plume moving?

Response to comment: Additional groundwater monitoring wells may be installed as part of the groundwater remedy. This decision will be made during the remedial design of the in-situ chemical oxidation and enhanced bioremediation system. EPA sampled the existing monitoring wells in 2008 and has determined that the plume has not significantly migrated since the completion of the Remedial Investigation in May 2006.

9. **Comment:** Will the cap cover the entire property?

Response to comment: The property on which the landfill is located is approximately 32 acres in area, and contains a 20.4 acre inactive and unlined landfill. The cap will extend further than just 20.4 acres, but it is hard to determine how much further it will extend until the remedial design is complete.

10. **Comment:** Was there a multi-million dollar settlement to pay for the cleanup?

Response to comment: The U.S has reached an agreement with W.R. Grace, a Potentially Responsible Party for the Watson Johnson Landfill Superfund Site. The settlement occurred in the context of bankruptcy and covers numerous Sites throughout the country. A portion of the settlement, $50,000, will be put into a Special Account and be available for use at the Watson Johnson Landfill Superfund Site.

B. Written Comments from the Public

As with the comments from the Public Meeting, this Responsiveness Summary focuses on comments received from local residents that are significant. The full text of the residents comments and EPA's initial response is included in the publicly available portion of the Administrative Record. The responses below are EPA's final responses.

1. **Comment:** Who needs to approve this proposal?

Response to Comment: After reviewing comments received from the public, including during the public comment period, and taking into consideration the position of the Pennsylvania Department of Environmental Protection ("PADEP"), EPA is issuing today a Record of Decision which documents the selection of the remedy for this Site. The decision regarding the selection is delegated to the Division Director, Hazardous Sites Cleanup Division, Region 3, EPA.

2. **Comment:** What type of fence would be put up around the perimeter? Would I see it from my house?

Response to Comment: The landfill cap has not been designed, but usually it is accompanied by a chain link fence that is 8 feet high. EPA is sensitive to not making the Site an eyesore to the residents who live near the landfill. Landscaping will accompany the fence and hopefully in time will provide a visual barrier to block the fence. Since there is not a design for the landfill it cannot be determined at this time whether or not you would be able to see the fence.

3. **Comment:** If not approved and no further action is taken, are there potential health risks?

Response to Comment: There are potential risks associated with not taking an action. The landfill risks are from ingesting (eating), dermal (touching) and inhalation (breathing) the waste and landfill soils, which no one is currently doing. The groundwater risks are from ingesting the contaminated groundwater. Homes and businesses at risk were connected by EPA to public drinking water. Although EPA is not aware of anyone currently involved in actions that would put them at risk, EPA wants to ensure this remains the case by capping the landfill and remediating the groundwater.

4. **Comment:** As a resident of Heather Valley I am concerned about noise, smell and view from the Old Castle mulch yard on Pumping Station Road. I know that there have been several complaints filed with the township from residents of

Walnut Bank Farm on Heller Rd regarding my same concerns. Once the trees are removed we will have no barrier between our development and the mulch yard. Has this or will this be taken into consideration for the residents of Heather Valley?

Response to Comment: The landfill cap has not been designed, therefore, it is hard to estimate how many trees and which trees will need to be removed. All the trees and shrubs that are within the cap area will need to be removed. EPA does not want to remove all the trees on the perimeter of the cap and will landscape in conjunction with the cap. This comment will be taken into consideration during the design of the cap. The design and information regarding the cleanup plans will be shared with the community prior to the start of the work.

5. **Comment:** From your previous experience in dealing with this type of clean up, what could this do to our property value?

Response to Comment: Real estate values are hard to predict.

TABLE 1
SELECTION OF EXPOSURE PATHWAYS
WATSON JOHNSON LANDFILL

Scenario Number	Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
1A	Current	Groundwater	Air	Air in basements or low-lying living spaces	Resident	Child	Inhalation	Quant	Potential for compounds to volatilize from shallow groundwater and seep into a basement or low lying living space Soil gas data collected from 10 residences in the Quakertown Residential Area (south neighborhood) were used in modeling of air concentrations. No actual indoor air monitoring data are proposed to be collected to evaluate this scenario.
1B				Quakertown Residential Area		Adult	Inhalation	Quant	
1C						Child/Adult	Inhalation	Quant	Lifetime cancer risk evaluation for inhalation
1D				Air in basements or low-lying living spaces	Resident	Child	Inhalation	None	Only very low concentrations of COPCs were detected in this general area (i.e., most are only slightly above quantitation limits), and therefore would be considered negligible. In addition, the site COPC plume does not appear to impact this area. Therefore, this pathway is not proposed to be evaluated as part of the risk assessment.
1E				Richland Township Pike Residential Area		Adult	Inhalation	None	
1F						Child/Adult	Inhalation	None	
2A	Future	Groundwater	Groundwater	Tap Water/Drinking	Resident	Child	Ingestion	Quant	Groundwater impacted by COPCs Exposure can occur from current residential water wells and public supply wells impacted in the future by groundwater migration, or new residential wells and public supply wells installed in the Site Plume. RI monitoring well data from the landfill and down and side gradient areas are to be used for this scenario. Applicable wells include: MW-02D, MW-03S/D, MW-04S/D, MW-05S/D, MW-06S/D, MW-07S/D, MW-08S/D, MW-18D1/D2, MW-09S/D, MW-10S/D, MW-11S/D, MW-12S/D, MW-13S/I/D, MW-14S/D, two Frontier Woods Wells FW-01, FW-03, and new wells MW-19S/D, and MW-20S/D. It is assumed that a child bathes and an adult showers.
2B							Dermal	Quant	
2C						Adult	Ingestion	Quant	
2D							Dermal	None	The risks/hazards from dermal exposure by adults during showering are negligible when compared to ingestion or inhalation. Therefore, no evaluation of the adult dermal pathway is proposed for tapwater medium.
2E						Adult/Child	Ingestion	Quant	Lifetime cancer risk evaluation for tap water ingestion and dermal.
2F							Dermal	Quant	
2G					Industrial Worker	Adult	Ingestion	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
2H							Dermal	None	The risks/hazards from dermal exposure by industrial workers during hand washing (which is the expected exposure scenario, although showering is also possible, but less probable given little heavy industry in the area) are negligible when compared to ingestion. Therefore, no evaluation of the commercial worker dermal pathway is proposed for tap water medium.
2I							Inhalation	Qual	The risks/hazards from inhalation exposure by industrial workers during hand washing or showering are considered to be negligible when compared to ingestion. Therefore, only a qualitative evaluation of this scenario is proposed for the tap water medium.
2J			Air	Water vapors at showerhead	Resident	Child	Inhalation	None	Children are assumed not to shower. No complete inhalation pathway
2K						Adult	Inhalation	Quant	See the rationale for Future Groundwater Groundwater Tap Water/Drinking Resident Adult Scenario (Site Plume) as it also applies to the adult inhalation scenario
2L				Air in basements or low-lying living spaces	Resident	Child	Inhalation	Qual	Potential for compounds to volatilize from shallow groundwater and seep into a basement or low lying living space. Soil gas data from locations in the vicinity of MW-09S and MW-19S were collected. COPCs were not detected in excess of screening criteria. In addition, this area lies within a potenital wetlands and/or flood plain area, and has a groundwater depth of approximately 3 feet and has shallow bedrock (no basements would be constructed). Therefore, development of dwellings in the MW-09S and MW-19S area would not be likely. However, to address the future offsite receptors, these scenarios will be evaluated qualitatively based on a comparison to the current resident and will be discussed in the text of the HHRA Report.
2M						Adult	Inhalation	Qual	
2N						Child/Adult	Inhalation	Qual	

TABLE 1
SELECTION OF EXPOSURE PATHWAYS
WATSON JOHNSON LANDFILL

Scenario Number	Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
3A	Current/Future	Surface Water	Surface Water	Wading, outdoor activities in off-site water bodies receiving runoff/discharge from the landfill site Off-site areas	Resident	Child	Ingestion	Quant	Water bodies in the vicinity, including Tohickon Creek, and seeps, runoff, and wetlands, may be impacted by COPC. Residents may be exposed during outdoor activities. No swimming or fishing is expected in these water bodies because of their limited depth and width. The data set to be used for this assessment includes all the surface water data collected from all water bodies outside the landfill perimeter (21 samples). Surface water data from within the landfill perimeter are not proposed to be used as part of the risk assessment, as the presumptive remedy approach does not warrant quantitative risk assessment of the source areas.
3B							Dermal	Quant	
3C						Adult	Ingestion	Quant	
3D							Dermal	Quant	
3E						Child/Adult	Ingestion	Quant	Lifetime cancer risk evaluation for surface water exposure
3F							Dermal	Quant	
3G					Other Worker	Adult	Ingestion	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
3H							Dermal	Qual	
3I					Other Recreational Person	Adult	Ingestion	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
3J							Dermal	Qual	
3K						Adolescents (teens)	Ingestion	Qual	
3L							Dermal	Qual	
3M				Wading, outdoor activities in on-site water bodies Landfill area - on-site surface water	Other Worker	Adult	Ingestion	None	Under the presumptive remedy approach (see footnote (a)), all surface water and leachate generated at the site (including seeps, runoff, and wetlands) will be addressed as part of the remedy. Since this pathway will be eliminated in the future by the remedial action, no risk analysis is proposed.
3N							Dermal	None	
3O					Other Recreational Person	Adult	Ingestion	None	
3P							Dermal	None	
3Q						Adolescents (teens)	Ingestion	None	
3R							Dermal	None	
4A	Current/Future	Sediment	Sediment	Wading, outdoor activities in the off-site water bodies receiving runoff/drainage from the landfill site Off-site areas	Resident	Child	Ingestion	Quant	Water bodies in the vicinity, including Tohickon Creek, may be impacted by COPC. Residents may be exposed during outdoor activities. The data set for sediment evaluation includes all sediment data collected from water bodies outside the landfill perimeter (27 sediment locations).
4B							Dermal	Quant	
4C						Adult	Ingestion	Quant	
4D							Dermal	Quant	
4E						Child/Adult	Ingestion	Quant	Lifetime cancer risk evaluation for sediment exposure
4F							Dermal	Quant	
4G					Other Worker	Adult	Ingestion	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
4H							Dermal	Qual	
4I					Other Recreational Person	Adult	Ingestion	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
4J							Dermal	Qual	
4K						Adolescents (teens)	Ingestion	Qual	
4L							Dermal	Qual	
4M				Wading, outdoor activities in the water bodies located on the landfill Landfill area - on-site sediment	Other Worker	Adult	Ingestion	None	Under the presumptive remedy approach (see footnote (a)), all on-site sediments will be addressed as part of the remedy. Since this pathway will be eliminated in the future by the remedial action, no risk analysis is proposed.
4N							Dermal	None	
4O					Other Recreational Person	Adult	Ingestion	None	
4P							Dermal	None	
4Q						Adolescents (teens)	Ingestion	None	
4R							Dermal	None	
5A	Current/Future	Surface Soil	Surface Soil	Surface soil, outdoor activities Off-site areas outside the landfill perimeter	Resident	Child	Ingestion	Quant	Surface soils outside the landfill may be impacted by COPC. Residents may be exposed during outdoor activities. The data set for this evaluation includes 16 surface soil samples collected from the areas outside the landfill perimeter.
5B							Dermal	Quant	
5C						Adult	Ingestion	Quant	
5D							Dermal	Quant	
5E						Child/Adult	Ingestion	Quant	Lifetime cancer risk evaluation for surface soil exposure
5F							Dermal	Quant	

TABLE 1
SELECTION OF EXPOSURE PATHWAYS
WATSON JOHNSON LANDFILL

Scenario Number	Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
5G	Current/Future	Surface Soil	Surface Soil	Surface soil, outdoor activities	Other Worker	Adult	Ingestion	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
5H				Off-site areas outside the landfill perimeter			Dermal	Qual	
5I					Other Recreational Person	Adult	Ingestion	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
5J							Dermal	Qual	
5K						Adolescents (teens)	Ingestion	Qual	
5L							Dermal	Qual	
5M				Surface soil, outdoor activities	Other Worker	Adult	Ingestion	None	Under the presumptive remedy approach (see footnote (a), all on-site surface soils will be capped as part of the remedy. Since this pathway will be eliminated in the future by the remedial action, no risk analysis is proposed
5N				Landfill area - on-site areas			Dermal	None	
5O					Other Recreational Person	Adult	Ingestion	None	
5P							Dermal	None	
5Q						Adolescents (teens)	Ingestion	None	
5R							Dermal	None	
5S			Particulate	Particulates in air from surface soil are available during outdoor activities	Resident	Child	Inhalation	Quant	Surface soils may be impacted by COPC. Residents may be exposed during outdoor activities.
5T				Off-site areas outside the landfill perimeter		Adult	Inhalation	Quant	
5U						Child/Adult	Inhalation	Quant	Lifetime cancer risk evaluation for particulate exposure
5V					Other Worker	Adult	Inhalation	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
5W					Other Recreational Person	Adult	Inhalation	Qual	This scenario will be evaluated qualitatively based on a comparison to the Residential scenario and will be discussed in the text of the HHRA Report.
5X						Adolescents (teens)	Inhalation	Qual	
5Y				Exposure population may be exposed to particulates in the air during outdoor activities	Other Worker	Adult	Inhalation	None	Under the presumptive remedy approach (see footnote (a)), all on-site surface soils will be capped as part of the remedy. Since this pathway will be eliminated in the future by the remedial action, no risk analysis is proposed.
5Z				Landfill area - on-site areas	Other Recreational Person	Adult	Inhalation	None	
5AA						Adolescents (teens)	Inhalation	None	
6A	Current/Future	Subsurface Soil	Vapor	Volatiles in the air from subsurface soil are available for exposure during outdoor activities	Resident	Child	Inhalation	None	It was assumed that VOCs are not present in surface soils. There are also no VOCs in subsurface soil in off-site areas as there are no known off-site source areas. Landfill gas emissions to be addressed by presumptive remedy. Therefore, no risk analysis of this pathway is proposed.
6B				Off-site areas outside the landfill perimeter		Adult	Inhalation	None	
6C						Child/Adult	Inhalation	None	
6D					Other Worker	Adult	Inhalation	None	
6E					Other Recreational Person	Adult	Inhalation	None	
6F						Adolescents (teens)	Inhalation	None	
6G				Exposure population may be exposed to volatiles in the air emanating from the subsurface soil during outdoor activities	Other Worker	Adult	Inhalation	None	Under the presumptive remedy approach, all subsurface soil vapor emissions will be addressed as part of the remedy. Since this pathway is eliminated in the future by the remedial action, no risk analysis is proposed.
6H					Other Recreational Person	Adult	Inhalation	None	
6I				Landfill area - on-site areas		Adolescents (teens)	Inhalation	None	
7A	Current/Future	Air	Vapor	Exposure to landfill gases during outdoor activities	Other Worker	Adult	Inhalation	None	Under the presumptive remedy approach, all landfill gases (including methane), will be managed as part of the remedy Since this pathway will be eliminated in the future by the remedial action, no risk analysis is proposed.
7B					Other Recreational Person	Adult	Inhalation	None	
7C				Landfill area - on-site areas		Adolescents (teens)	Inhalation	None	

(a) See the following references for streamlined risk assessment guidance for presumptive remedy landfill sites: EPA 540/F-96/017 (January 1997) - Landfill Presumptive Remedy Saves Time and Cost; Publication 9203.1-021 (April 1992) - Presumptive Remedies for Municipal Landfill Sites; EPA/540/P-91/001 (February 1991) - Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites; EPA Publication 9203.1-02I (February 1993) Presumptive Remedies for Municipal Landfill Sites.

TABLE 2
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
GROUNDWATER
WATSON JOHNSON LANDFILL

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tapwater/Drinking

CAS Number	Chemical	Minimum Concentration (1)	Min Q	Maximum Concentration (1)	Max Q	Units	Location of Maximum Concentration	Detection Frequency	Minimum Detection Limit	Maximum Detection Limit	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
106467	1,4-Dichlorobenzene	2	J	2	J	ug/L	MW07S	2/63	10	10	2	NA	0.47C	75	MCL	Y	ASL
67641	Acetone	2	J	7	J	ug/L	MW05D	3/63	10	10	7	NA	550N	None	None	N	BSL
7429905	Aluminum	10.4	J	11.6	J	ug/L	MW11S	2/63	3.2	8.3	11.6	NA	3700N	50	SMCL	N	BSL
7440382	Arsenic	3	J	67.8		ug/L	MW07S	28/63	2.4	3.6	67.8	NA	0.045C	10	MCL	Y	ASL
7440393	Barium	14.4	J	501		ug/L	MW07S	60/63	NA	NA	501	NA	260N	2000	MCL	Y	ASL
71432	Benzene	1	J	1	J	ug/L	MW07S	2/63	10	10	1	NA	0.34C	5	MCL	Y	ASL
85687	Benzyl Butyl Phthalate	3	J	3	J	ug/L	MW12S	1/63	10	10	3	NA	730N	None	None	N	BSL
319857	beta-BHC	0.05		0.076	J	ug/L	MW03S	2/63	0.05	0.05	0.076	NA	0.037C	None	None	Y	ASL
117817	Bis(2-Ethylhexyl)phthalate	1	J	7	J	ug/L	MW12S	2/63	10	10	7	NA	4.8C	6	MCL	Y	ASL
7440428	Boron	54		1070		ug/L	MW13D	37/48	50	100	1070	NA	730N	None	None	Y	ASL
7440439	Cadmium	0.3	J	0.71	J	ug/L	FW03	9/63	0.3	1.2	0.71	NA	1.8N	5	MCL	N	BSL
7440702	Calcium	6150	J	126000		ug/L	MW07S	63/63	NA	NA	126000	NA	NUT	None	None	N	NUT
108907	Chlorobenzene	2	J	8	J	ug/L	MW07S	7/63	10	10	8	NA	11N	100	MCL	N	BSL
75003	Chloroethane	1	J	3	J	ug/L	MW06S	2/63	10	10	3	NA	3.6C	None	None	N	BSL
7440473	Chromium total	0.45	J	18.4		ug/L	MW18D2	8/63	0.4	0.68	18.4	NA	11N	100	MCL	Y	ASL
156592	Cis-1, 2-Dichloroethylene	1	J	210		ug/L	MW03S	19/63	10	10	210	NA	6.1N	70	MCL	Y	ASL
7440484	Cobalt	1.7	J	2.5	J	ug/L	MW06S	4/63	3.6	1.6	2.5	NA	73N	None	None	N	BSL
7440508	Copper	0.92	J	2.2	J	ug/L	MW04D	3/63	0.5	1.2	2.2	NA	150N	1300	MCL	N	BSL
151508	Cyanide	2.2	J	138		ug/L	MW06S	12/63	2.0	3.8	138	NA	73N	200	MCL	Y	ASL
84742	Di-N-Butyl Phthalate	13		13		ug/L	MW12S	1/63	10	10	13	NA	370N	None	None	N	BSL
206440	Fluoranthene	1	J	1	J	ug/L	FW03 Dup	1/63	10	10	1	NA	150N	None	None	N	BSL
1305371	Iron	39	J	854		ug/L	MW07D	15/63	2.4	12.9	854	NA	1100N	300	SMCL	N	BSL
7439954	Magnesium	4250	J	65200		ug/L	MW07S	63/63	NA	NA	65200	NA	NUT	None	None	N	NUT
7439965	Manganese	2.3	J	2300		ug/L	MW07S	46/63	0.1	0.81	2300	NA	73N	50	SMCL	Y	ASL
7439976	Mercury	0.043	J	0.049	J	ug/L	MW06D	2/63	0.02	0.04	0.049	NA	1.1N	2	MCL	N	BSL
7440020	Nickel	1.1	J	17.7	J	ug/L	MW03S Dup	18/63	1.1	2.8	17.7	NA	73N	None	None	N	BSL
850018	Phenanthrene	1	J	3	J	ug/L	FW03 Dup	4/63	10	10	3	NA	NTX	None	None	N	NTX
7440097	Potassium	218	J	15600		ug/L	MW10D	60/63	7.1	30.5	15600	NA	NUT	None	None	N	NUT
7782492	Selenium	4.3	J	5.8	J	ug/L	MW10S	4/63	1.9	13.2	5.8	NA	18N	50	MCL	N	BSL
7440235	Sodium	9510	J	50700	J	ug/L	MW14S	63/63	NA	NA	50700	NA	NUT	None	None	N	NUT
127184	Tetrachloroethylene	3	J	76		ug/L	MW03S Dup	6/63	10	10	76	NA	0.1C	5	MCL	Y	ASL
79016	Trichloroethylene	1	J	240		ug/L	MW04S Dup	20/63	10	10	240	NA	0.026C	5	MCL	Y	ASL
7440622	Vanadium	0.43	J	4.1	J	ug/L	MW10S	23/63	0.4	1.1	4.1	NA	3.7N	None	None	Y	ASL
75014	Vinyl Chloride	1	J	29		ug/L	MW03S	5/63	10	10	29	NA	0.015C	2	MCL	Y	ASL

(1) Minimum/maximum detected concentration in groundwater monitoring well samples.
(2) Maximum concentration used for screening.
(3) Refer to supporting information for background discussion.
(4) All compounds were screened against the Risk-Based Concentration (RBC) Table, U.S. EPA Region 3, October 2004 for tap water (cancer benchmark=1E-06, HQ=0.1).
(5) Rationale Codes:
Selection Reasoning: No Toxicity Information (NTX); Above Screening Level (ASL)
Deletion Reasoning: Below Screening Level (BSL); Essential Nutrient (NUT)

Definitions:
C = Carcinogenic
COPC = Chemical of Potential Concern
MCL = Federal Maximum Contaminant Level
N = Non-Carcinogenic
NA = Not Applicable
Q = Data Qualifier
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
No code = Confirmed identification as defined in the Glossary of Data Qualifier Codes.

TABLE 2
EXPOSURE POINT CONCENTRATION SUMMARY
GROUNDWATER
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Medium:	Groundwater
Exposure Medium	Groundwater

Exposure Point	Chemical	Units	Arithmetic Mean	UCL95 (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale[a]
Tap Water from future well installed in the site plume[b]	1,4-Dichlorobenzene	ug/L	4.90E+00	5.01E+00 NP	2.00E+00 J	2.00E+00	ug/L	Max Conc.	(2)
	Arsenic	ug/L	9.42E+00	1.18E+01 LN	6.76E+01	1.18E+01	ug/L	UCL95	(4)
	Barium	ug/L	1.57E+02	1.78E+02 N	5.01E+02	1.78E+02	ug/L	UCL95	(1)
	Benzene	ug/L	4.87E+00	5.01E+00 NP	1.00E+00 J	1.00E+00	ug/L	Max Conc.	(2)
	beta-BHC	ug/L	2.62E-02	2.79E-02 NP	7.50E-02 J	2.79E-02	ug/L	UCL95	(2)
	Bis(2-Ethylhexyl)phthalate	ug/L	4.96E+00	5.08E+00 NP	7.00E+00 J	5.08E+00	ug/L	UCL95	(2)
	Boron	ug/L	1.80E+02	3.06E+02 NP	1.07E+03	3.06E+02	ug/L	UCL95	(3)
	Chromium Total	ug/L	9.50E-01	2.30E+00 NP	1.84E+01	2.30E+00	ug/L	UCL95	(3)
	Cis-1,2-Dichloroethylene	ug/L	1.11E+01	2.70E+01 NP	2.10E+02	2.70E+01	ug/L	UCL95	(3)
	Cyanide	ug/L	4.40E+00	1.38E+01 NP	1.38E+02	1.38E+01	ug/L	UCL95	(3)
	Manganese	ug/L	2.01E+02	1.38E+03 LN	2.30E+03	1.38E+03	ug/L	UCL95	(6)
	Tetrachloroethylene	ug/L	6.48E+00	1.17E+01 NP	7.60E+01	1.17E+01	ug/L	UCL95	(3)
	Trichloroethylene	ug/L	1.64E+01	4.50E+01 NP	2.40E+02	4.50E+01	ug/L	UCL95	(5)
	Vanadium	ug/L	8.22E-01	1.19E+00 NP	4.10E+00 J	1.19E+00	ug/L	UCL95	(3)
	Vinyl Chloride	ug/L	5.31E+00	6.07E+00 NP	2.90E+01	6.07E+00	ug/L	UCL95	(2)

Notes:

a The lesser of the UCL95 and maximum detected concentration was used as the exposure point concentration (EPC) as determined by ProUCL (EPA 2004). One-half the reporting limit was used as a proxy for non-detect values.

b As noted in Table 1, the groundwater samples included in the quantitative assessment are RI monitoring well data from the landfill and down- and side-gradient areas; applicable wells include MW-02D, MW-03S/D, MW-04S/D, MW-05S/D, MW-06S/D, MW-07S/D, MW-08S/D, MW-18D1/D2, MW-09S/D, MW-10S/D, MW-11S/D, MW-12S/D, MW-13S/I/D, MW-14S/D, two Frontier Woods Wells FW-01, FW-03, and new wells MW-19S/D and MW-20S/D.

c If the maximum detected concentration was found in a sample that has two results (both an original and a duplicate sample), then the higher of the two results is shown. Note, however, that the average of the two values is used in the statistical evaluation (e.g., UCL95 determination).

UCL95	One-sided 95 percent upper confidence limit of the mean
J	Estimated concentration
LN	Lognormal distribution confirmed using the Shapiro-Wilk W test (alpha = 0.05).
MVUE	Minimum variance unbiased estimator
N	Normal distribution confirmed using the Shapiro-Wilk W test (alpha = 0.05)
NP	Non-parametric distribution (alpha = 0.05)
RAGS	Risk Assessment Guidance for Superfund
ug/L	microgram per liter
(1)	UCL95 calculated using the Student's-t UCL method.
(2)	UCL95 calculated using the Modified-t UCL method.
(3)	UCL95 calculated using the 95% Chebyshev (Mean, SD) method.
(4)	UCL95 calculated using the H-UCL method.
(5)	UCL95 calculated using the 97.5% Chebyshev (Mean, SD) method.
(6)	UCL95 calculated using the 97.5% Chebyshev (MVUE) UCL method.

References:

EPA. 2004. ProUCL Version 3.0. EPA Statistical Program Package. April. Available online at http://www.epa.gov/nerlesd1/tsc/form.htm

TABLE 3
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SURFACE WATER
WATSON JOHNSON LANDFILL

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Wading, outdoor activities in off-site water bodies receiving runoff/discharge from the landfill site

CAS Number	Chemical	Minimum Concentration (1)	Min Q	Maximum Concentration (1)	Max Q	Units	Location of Maximum Concentration	Detection Frequency	Minimum Detection Limit	Maximum Detection Limit	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
75343	1,1-Dichloroethane	2	J	3	J	ug/L	SW17	2/21	10	10	3	NA	800N	NA	NA	N	BSL
541731	1,3-Dichlorobenzene	1	J	1	J	ug/L	SW02	1/21	10	10	1	NA	18N	NA	NA	N	BSL
106445	4-Methylphenol (P-Cresol)	3	J	3	J	ug/L	SW17	1/21	10	50	3	NA	180N	NA	NA	N	BSL
7429905	Aluminum	235	J	11900	J	ug/L	SW18	19/21	NA	NA	11900	NA	37000N	NA	NA	N	BSL
7440360	Antimony	13.4	J	13.4	J	ug/L	SW18	1/21	1.5	60	13.4	NA	15N	NA	NA	N	BSL
7440382	Arsenic	2.4	[]	8.7	J	ug/L	SW31	2/21	1.7	15	8.7	NA	0.45C	NA	NA	Y	ASL
7440393	Barium	17.9	J	9770	J	ug/L	SW17	21/21	NA	NA	9770	NA	2600N	NA	NA	Y	ASL
100527	Benzaldehyde	1	J	1	J	ug/L	SW17	1/21	10	50	1	NA	3700N	NA	NA	N	BSL
71432	Benzene	1	J	1	J	ug/L	SW17	1/21	10	10	1	NA	3.4C	NA	NA	N	BSL
7440417	Beryllium	0.39	J	0.39	J	ug/L	SW18	1/21	5	5	0.39	NA	73N	NA	NA	N	BSL
319857	beta BHC	0.058	J	0.076	J	ug/L	SW16	2/21	0.05	0.05	0.076	NA	0.37C	NA	NA	N	BSL
117817	Bis(2-Ethylhexyl) Phthalate	1	J	2	J	ug/L	SW17	2/21	10	50	2	NA	48C	NA	NA	N	BSL
7440428	Boron	21		339		ug/L	SW16	16/16	NA	NA	339	NA	7300N	NA	NA	N	BSL
7440439	Cadmium	0.46	J	6.3		ug/L	SW18	4/21	5	5	6.3	NA	18N	NA	NA	N	BSL
7440702	Calcium	5160		236000		ug/L	SW17	21/21	NA	NA	236000	NA	NUT	NA	NA	N	NUT
108907	Chlorobenzene	2	J	3	J	ug/L	SW17/18	4/21	10	10	3	NA	110N	NA	NA	N	BSL
75003	Chloroethane	1	J	3	J	ug/L	SW17	3/21	10	10	3	NA	36C	NA	NA	N	BSL
7440473	Chromium total	0.9	J	377		ug/L	SW17	12/21	0.9	10	377	NA	110N	NA	NA	Y	ASL
7440484	Cobalt	0.37	J	18.6	J	ug/L	SW17	8/21	2	50	18.6	NA	730N	NA	NA	N	BSL
7440508	Copper	1.5	J	245		ug/L	SW17	17/21	25	25	245	NA	1500N	NA	NA	N	BSL
1309371	Iron	340		1290000		ug/L	SW17	21/21	NA	NA	1290000	NA	11000N	NA	NA	Y	ASL
7439921	Lead	3.6	K	272		ug/L	SW17	9/21	10	10	272	NA	15	15	EPA	Y	ASL
7439954	Magnesium	1540	J	44800		ug/L	SW01	21/21	NA	NA	44800	NA	NUT	NA	NA	N	NUT
7439965	Manganese	52.6		8450		ug/L	SW01	21/21	NA	NA	8450	NA	730N	NA	NA	Y	ASL
7439976	Mercury	0.06	J	0.44		ug/L	SW17	4/21	0.2	0.2	0.44	NA	11N	NA	NA	N	BSL
7440020	Nickel	3.3	J	55.3		ug/L	SW02	8/21	1	40	55.3	NA	730N	NA	NA	N	BSL
86306	N-Nitrosodiphenylamine	1	J	1	J	ug/L	SW17/18	2/21	10	50	1	NA	140C	NA	NA	N	BSL
108952	Phenol	5	J	5	J	ug/L	SW17	1/21	10	50	5	NA	11000N	NA	NA	N	BSL
7440097	Potassium	1520	J	30300	J	ug/L	SW31	21/21	NA	NA	30300	NA	NUT	NA	NA	N	NUT
7782492	Selenium	2.3	L[]	3.2	L[]	ug/L	SW01	2/21	1.9	35	3.2	NA	180N	NA	NA	N	BSL
7440224	Silver	2.6	J	2.6	J	ug/L	SW17	1/21	0.5	10	2.6	NA	180N	NA	NA	N	BSL
7440235	Sodium	1230	[]	19200		ug/L	SW01	19/21	NA	NA	19200	NA	NUT	NA	NA	N	NUT
7440280	Thallium	4.8	J	36.7		ug/L	SW17	6/21	3	25	36.7	NA	2.6N	NA	NA	Y	ASL
7440622	Vanadium	0.63	J	28.3	J	ug/L	SW18	15/21	1.7	50	28.3	NA	37N	NA	NA	N	BSL
7440666	Zinc	4.4	J	547		ug/L	SW02	14/21	60	60	547	NA	11000N	NA	NA	N	BSL

(1) Minimum/maximum detected concentration based on off-site surface water samples.
(2) Maximum concentration used for screening.
(3) Refer to supporting information for background discussion.
Background values derived from statistical analysis.
(4) All compounds were screened against the Risk-Based Concentration (RBC) Table, U.S. EPA Region 3, October 2004 for tap water (cancer benchmark=1E-05; HQ=1). Lead was screened against the U.S. EPA action level of 15 ug/L.
(5) Rationale Codes:
Selection Reasoning: Above Screening Level (ASL)
Deletion Reasoning: Below Screening Level (BSL)
Essential Nutrient (NUT)

Definitions:
C = Carcinogenic
COPC = Chemical of Potential Concern
N = Non-Carcinogenic
NA = Not Applicable
Q = Data Qualifier

HQ = Hazard quotient
J = Estimated Value
L = Analyte present. Reported value may be biased low.
[] = Analyte present. As values approach the IDL the quantitation may not be accurate.
No code = Confirmed identification as defined in the Glossary of Data Qualifier Codes.

TABLE 3
EXPOSURE POINT CONCENTRATION SUMMARY
SURFACE WATER
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Point	Chemical	Units	Arithmetic Mean	UCL95 (Distribution)		Maximum Concentration (Qualifier)[b]		Exposure Point Concentration			
								Value	Units	Statistic	Rationale[a]
Surface Water, outdoor activities	Arsenic	ug/L	5.75E+00	8.59E+00	NP	8.70E+00	J	8.59E+00	ug/L	UCL95	(2)
	Barium	ug/L	6.24E+02	5.20E+03	NP	9.77E+03	J	5.20E+03	ug/L	UCL95	(1)
	Chromium Total	ug/L	2.20E+01	1.99E+02	NP	3.77E+02		1.99E+02	ug/L	UCL95	(1)
	Iron	ug/L	7.33E+04	6.81E+05	NP	1.29E+06		6.81E+05	ug/L	UCL95	(1)
	Lead	ug/L	2.26E+01	1.49E+02	NP	2.72E+02		1.49E+02	ug/L	UCL95	(1)
	Manganese	ug/L	1.13E+03	1.92E+03	G	8.45E+03		1.92E+03	ug/L	UCL95	(3)
	Thallium	ug/L	1.07E+01	1.76E+01	NP	3.67E+01		1.76E+01	ug/L	UCL95	(2)

Notes:

a The lesser of the UCL95 and maximum detected concentration was used as the exposure point concentration (EPC) as determined by ProUCL (EPA 2004). One-half the reporting limit was used as a proxy for non-detect values.

b If the maximum detected concentration was found in a sample that has two results (both an original and a duplicate sample), then the higher of the two results is shown. Note, however, that the average of the two values is used in the statistical evaluation (e.g., UCL95 determination).

UCL95	One-sided 95 percent upper confidence limit of the mean
G	Gamma distribution confirmed (alpha = 0.05).
J	Estimated concentration
NP	Non-parametric distribution (alpha = 0.05)
RAGS	Risk Assessment Guidance for Superfund
ug/L	microgram per liter
(1)	UCL95 calculated using the 99% Chebyshev (Mean, SD) method.
(2)	UCL95 calculated using the 95% Chebyshev (Mean, SD) method.
(3)	UCL95 calculated using the Approximate Gamma method.

References:

EPA. 2004. ProUCL Version 3.0. EPA Statistical Program Package. April. Available online at http://www.epa.gov/nerlesd1/tsc/form.htm

TABLE 4
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SEDIMENT
WATSON JOHNSON LANDFILL

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Wading, outdoor activities in off-site water bodies receiving runoff/drainage from the landfill site

CAS Number	Chemical	Minimum Concentration (1)	Min Q	Maximum Concentration (1)	Max Q	Units	Location of Maximum Concentration	Detection Frequency	Minimum Detection Limit	Maximum Detection Limit	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
75343	1,1-Dichloroethane	8	J	8	J	ug/kg	SD170 (Dup of SD17)	1/27	11	53	8	NA	7800000N	NA	NA	N	BSL
95501	1,2-Dichlorobenzene	3	J	22	J	ug/kg	SD02	4/27	11	53	22	NA	7000000N	NA	NA	N	BSL
106467	1,4-Dichlorobenzene	3	J	140		ug/kg	SD02	7/27	11	53	140	NA	270000C	NA	NA	N	BSL
91587	2-Chloronaphthalene	220	J	220	J	ug/kg	SD02	1/27	410	1700	220	NA	6300000N	NA	NA	N	BSL
106445	4-Methylphenol (P-Cresol)	79	J	1200		ug/kg	SD24	4/27	410	1700	1200	NA	3900000N	NA	NA	N	BSL
67641	Acetone	17	J	670	J	ug/kg	SD32	18/27	32	53	670	NA	7800000N	NA	NA	N	BSL
319846	alpha BHC	12		12		ug/kg	SD02	1/27	2.1	8.8	12	NA	1500C	NA	NA	N	BSL
57749	alpha-Chlordane	2.8	J	87		ug/kg	SD18S	3/27	2.1	7.9	87	NA	180000C	NA	NA	N	BSL
7429905	Aluminum	3250		32500		mg/kg	SD15D	27/27	NA	NA	32500	NA	76000N	NA	NA	N	BSL
120127	Anthracene	110	J	110	J	ug/kg	SD170 (Dup of SD17)	1/27	410	1700	110	NA	23000000N	NA	NA	N	BSL
7440360	Antimony	0.76	J	23	UJ	mg/kg	SD07	5/26	0.61	45.1	23	NA	31N	NA	NA	N	BSL
7440382	Arsenic	0.96	J	9.1	J	mg/kg	SD02	21/27	1.7	3	9.1	NA	4.3C	NA	NA	Y	ASL
7440393	Barium	70.5		635		mg/kg	SD32	27/27	NA	NA	635	NA	5500N	NA	NA	N	BSL
100527	Benzaldehyde	83	J	1000	J	ug/kg	SD02	12/27	410	1700	1000	NA	7800000N	NA	NA	N	BSL
71432	Benzene	2	J	6	J	ug/kg	SD02	3/27	11	53	6	NA	120000C	NA	NA	N	BSL
56553	Benzo(a)anthracene	340	J	340	J	ug/kg	SD170 (Dup of SD17)	1/27	410	1700	340	NA	8700C	NA	NA	N	BSL
50328	Benzo(a)pyrene	130	J	200	J	ug/kg	SD220 (Dup of SD22)	2/27	410	1700	200	NA	870C	NA	NA	N	BSL
205992	Benzo(b)fluoranthene	25	J	880	J	ug/kg	SD170 (Dup of SD17)	6/27	410	1700	880	NA	8700C	NA	NA	N	BSL
207089	Benzo(k)fluoranthene	220	J	260	J	ug/kg	SD170 (Dup of SD17)	1/27	410	1700	260	NA	87000C	NA	NA	N	BSL
85687	Benzyl Butyl Phthalate	69	J	78	J	ug/kg	SD03	2/27	410	1700	78	NA	16000000N	NA	NA	N	BSL
7440417	Beryllium	0.09	J	1.1	J	mg/kg	SD19D	25/27	0.16	0.39	1.1	NA	160N	NA	NA	N	BSL
319857	beta BHC	1.8	J	3.4	J	ug/kg	SD02	2/27	2.1	17	3.4	NA	3500C	NA	NA	N	BSL
33213659	beta Endosulfan	0.25	J	0.25	J	ug/kg	SD03	1/27	3.6	17	0.25	NA	470N	NA	NA	N	BSL
117817	BIS(2-Ethylhexyl) Phthalate	62	J	1200	J	ug/kg	SD18S	13/27	NA	NA	1200	NA	460000C	NA	NA	N	BSL
7440439	Cadmium	0.15	J	13.4		mg/kg	SD02	19/27	0.21	1.8	13.4	NA	39N	NA	NA	N	BSL
7440702	Calcium	625	J	51900		mg/kg	SD18S	27/27	NA	NA	51900	NA	NUT	NA	NA	N	NUT
105602	Caprolactam	40	J	40	J	ug/kg	SD10	1/27	410	1700	40	NA	39000000N	NA	NA	N	BSL
86748	Carbazole	110	J	110	J	ug/kg	SD170 (Dup of SD17)	1/27	410	1700	110	NA	320000C	NA	NA	N	BSL
75150	Carbon Disulfide	2	J	91		ug/kg	SD12S	22/27	14	53	91	NA	7800000N	NA	NA	N	BSL
108907	Chlorobenzene	3	J	110		ug/kg	SD02	5/27	11	53	110	NA	1600000N	NA	NA	N	BSL
75003	Chloroethane	6	J	6	J	ug/kg	SD170 (Dup of SD17)	1/27	11	53	6	NA	2200000C	NA	NA	N	SSL
74873	Chloromethane	53		53		ug/kg	SD32	1/27	11	53	53	NA	NTX	NA	NA	N	NTX, IFD
7440473	Chromium, Total	9.4	J	87.8		mg/kg	SD32	27/27	NA	NA	87.8	NA	230N	NA	NA	N	BSL
218019	Chrysene	23	J	690	J	ug/kg	SD170 (Dup of SD17)	5/27	410	1700	690	NA	870000C	NA	NA	N	BSL
156594	CIS-1,2-Dichloroethylene	25		25		ug/kg	SD21	1/27	11	53	25	NA	780000N	NA	NA	N	BSL
7440484	Cobalt	3.4	B	21.7		mg/kg	SD14D	26/27	1	1	21.7	NA	1600N	NA	NA	N	BSL
7440508	Copper	11.7		192		mg/kg	SD32	27/27	NA	NA	192	NA	3100N	NA	NA	N	BSL
151508	Cyanide	0.04	J	0.19	J	mg/kg	SD25	4/17	NA	NA	0.19	NA	3900N	NA	NA	N	BSL
110827	Cyclohexane	10	J	10	J	ug/kg	SD02	1/27	11	53	10	NA	NTX	NA	NA	N	NTX, IFD
60571	Dieldrin	0.57	J	11	J	ug/kg	SD18S	11/27	4	15	11	NA	400C	NA	NA	N	BSL
84662	Diethyl Phthalate	82	J	82	J	ug/kg	SD02	1/27	410	1700	82	NA	63000000N	NA	NA	N	BSL
84742	DI-N-Butyl Phthalate	150	J	150	J	ug/kg	SD24	1/27	410	1700	150	NA	7800000N	NA	NA	N	BSL
1031078	Endosulfan sulfate	0.46	J	0.46	J	ug/kg	SD04	1/27	4	17	0.46	NA	470N	NA	NA	N	BSL
72208	Endrin	0.32	J	2.7	J	ug/kg	SD08	7/27	4	17	2.7	NA	23000N	NA	NA	N	BSL
7421934	Endrin aldehyde	0.25	J	1.7	J	ug/kg	SD02	4/27	4	17	1.7	NA	23000N	NA	NA	N	BSL
206440	Fluoranthene	25	J	1400		ug/kg	SD170 (Dup of SD17)	7/27	410	1700	1400	NA	3100000N	NA	NA	N	BSL
58899	gamma BHC (Lindane)	0.23	J	0.71	J	ug/kg	SD02	2/27	2.1	520	0.71	NA	4900C	NA	NA	N	BSL
57749	gamma-Chlordane	4.1	J	78		ug/kg	SD18S	2/27	2.1	7.9	78	NA	18000C	NA	NA	N	BSL
76448	Heptachlor	5.7		5.7	J	ug/kg	SD16	1/27	2.1	8.8	5.7	NA	1400C	NA	NA	N	BSL
1024573	Heptachlor epoxide	0.27		2.6	J	ug/kg	SD08	10/27	2.1	8.8	2.6	NA	700C	NA	NA	N	BSL
193395	Indeno(1,2,3-C,D)Pyrene	31	J	94	J	ug/kg	SD220 (Dup of SD22)	2/27	410	1700	94	NA	8700C	NA	NA	N	BSL
1309371	Iron	10600		376000		mg/kg	SD32	27/27	NA	NA	376000	NA	23000N	NA	NA	Y	ASL

TABLE 4
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SEDIMENT
WATSON JOHNSON LANDFILL

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Wading, outdoor activities in off-site water bodies receiving runoff/drainage from the landfill site

CAS Number	Chemical	Minimum Concentration (1)	Min Q	Maximum Concentration (1)	Max Q	Units	Location of Maximum Concentration	Detection Frequency	Minimum Detection Limit	Maximum Detection Limit	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
98828	Isopropylbenzene (Cumene)	9	J	9	J	ug/kg	SD02	1/27	11	53	9	NA	7800000N	NA	NA	N	BSL
7439921	Lead	13.3		123		mg/kg	SD32	27/27	NA	NA	123	NA	400	NA	NA	N	BSL
7439954	Magnesium	1240	J	8020		mg/kg	SD19D	27/27	NA	NA	8020	NA	NUT	NA	NA	N	NUT
7439965	Manganese	76.2		5080		mg/kg	SD32	27/27	NA	NA	5080	NA	1600N	NA	NA	Y	ASL
7439976	Mercury	0.061	J	0.54		mg/kg	SD32	8/27	0.099	0.54	0.54	NA	23N	NA	NA	N	BSL
79209	Methyl Acetate	2	J	360		ug/kg	SD32	10/27	11	53	360	NA	78000000N	NA	NA	N	BSL
78933	Methyl Ethyl Ketone	10	J	250	J	ug/kg	SD32	17/27	26	53	250	NA	47000000N	NA	NA	N	BSL
108872	Methylcyclohexane	6	J	6	J	ug/kg	SD02	1/27	11	53	6	NA	NTX	NA	NA	N	NTX, IFD
75092	Methylene Chloride	6	J	15	J	ug/kg	SD18S	7/27	NA	NA	15	NA	850000C	NA	NA	N	BSL
7440020	Nickel	9.5	J	47		mg/kg	SD32	27/27	NA	NA	47	NA	1600N	NA	NA	N	BSL
86306	N-Nitrosodiphenylamine	130	J	520	J	ug/kg	SD18S	3/27	410	1700	520	NA	1300000C	NA	NA	N	BSL
72548	P,P-DDD	0.54		350		ug/kg	SD18S	12/27	4	15	350	NA	27000C	NA	NA	N	BSL
72559	P,P-DDE	1.9		39	J	ug/kg	SD18S	14/27	4	15	39	NA	19000C	NA	NA	N	BSL
50293	P,P-DDT	0.55		12	J	ug/kg	SD02	9/27	4	17	12	NA	19000C	NA	NA	N	BSL
53469219	PCB-1242 (Arochlor 1242)	350	J	350	J	ug/kg	SD02	1/27	40	170	350	NA	3200C	NA	NA	N	BSL
12672296	PCB-1248 (Arochlor 1248)	20	J	220	J	ug/kg	SD08	5/27	40	170	220	NA	3200C	NA	NA	N	BSL
11097691	PCB-1254 (Arochlor 1254)	23	J	210	J	ug/kg	SD08	7/27	40	170	210	NA	3200C	NA	NA	N	BSL
11096825	PCB-1260 (Arochlor 1260)	100		100		ug/kg	SD08	1/27	40	170	100	NA	3200C	NA	NA	N	BSL
85018	Phenanthrene	31	J	500	J	ug/kg	SD170 (Dup of SD17)	2/27	410	1700	500	NA	2300000N	NA	NA	N	BSL
7440097	Potassium	423	J[]	2890		mg/kg	SD19D	27/27	NA	NA	2890	NA	NUT	NA	NA	N	NUT
129000	Pyrene	34	J	1100		ug/kg	SD170 (Dup of SD17)	14/27	420	1750	1100	NA	2300000N	NA	NA	N	BSL
7782492	Selenium	1.4	[]	9		mg/kg	SD08	11/26	5	26.3	9	NA	390N	NA	NA	N	BSL
7440224	Siver	1.8	J	1.8	J	mg/kg	SD32	1/27	0.2	6	1.8	NA	390N	NA	NA	N	BSL
7440235	Sodium	551	K[]	1870	K[]	mg/kg	SD02	10/27	NA	NA	1870	NA	NUT	NA	NA	N	NUT
7440280	Thallium	0.83	J	18.9		mg/kg	SD32	11/27	1.2	15.1	18.9	NA	5.5N	NA	NA	Y	ASL
108883	Toluene	1	J	18	J	ug/kg	SD24	15/27	13	53	18	NA	16000000N	NA	NA	N	BSL
79016	Trichloroethylene (TCE)	50		50		ug/kg	SD21	1/27	11	53	50	NA	16000C	NA	NA	N	BSL
7440622	Vanadium	11.9	[]	63		mg/kg	SD15D	26/27	17.7	17.7	63	NA	78N	NA	NA	N	BSL
7440666	Zinc	33.6		668		mg/kg	SD08	27/27	NA	NA	668	NA	23000N	NA	NA	N	BSL

(1) Minimum/maximum detected concentration based on off-site sediment samples
(2) Maximum concentration used for screening
(3) Refer to supporting information for background discussion
Background values derived from statistical analysis
(4) All compounds were screened against the Risk-Based Concentration (RBC) Table, U.S. EPA Region 3, October 2004 for residential soil (cancer benchmark=1E-05; HQ=1). Lead was screened against the U.S. EPA action level of 400 mg/Kg.
(5) Rationale Codes:
Selection Reasoning: Above Screening Level (ASL)
Deletion Reasoning: Below Screening Level (BSL)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Infrequent Detection (IFD)

Definitions:
C = Carcinogenic
COPC = Chemical of Potential Concern
N = Non-Carcinogenic
NA = Not Applicable
Q = Data Qualifier

J = Estimated Value
L = Analyte present. Reported value may be biased low.
K = Analyte present. Reported value may be biased high. Actual value value is expected to be lower
[] = Analyte present. As values approach the IDL the quantitation may not be accurate.
No code = Confirmed identification as defined in the Glossary of Data Qualifier Codes.

TABLE 4
EXPOSURE POINT CONCENTRATION SUMMARY
SEDIMENT
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Point	Chemical	Units	Arithmetic Mean	UCL95 (Distribution)		Maximum Concentration (Qualifier) [b]		Exposure Point Concentration			
								Value	Units	Statistic	Rationale[a]
Wading, outdoor activities in off-site waterbodies receiving runoff/drainage from the landfill site.	Arsenic	ug/kg	3.60E+03	4.28E+03	G	9.10E+03	[]	4.28E+03	ug/kg	UCL95	(1)
	Iron	ug/kg	5.51E+07	1.20E+08	NP	3.76E+08		1.20E+08	ug/kg	UCL95	(3)
	Manganese	ug/kg	9.75E+05	1.45E+06	LN	5.08E+06		1.45E+06	ug/kg	UCL95	(2)
	Thallium	ug/kg	2.54E+03	3.60E+03	LN	1.89E+04		3.60E+03	ug/kg	UCL95	(2)

Notes:

a The lesser of the UCL95 and maximum detected concentration was used as the exposure point concentration (EPC) as determined by ProUCL (EPA 2004). One-half the reporting limit was used as a proxy value for non-detect values.

b If the maximum detected concentration was found in a sample that has two results (both an original and a duplicate sample), then the higher of the two results is shown. Note, however, that the average of the two values is used in the statistical evaluation (e.g., UCL95 determination).

UCL95	One-sided 95 percent upper confidence limit of the mean
[]	Analyte present. As values approach the IDL the quantitation may not be accurate.
G	Gamma distribution confirmed (alpha = 0.05).
LN	Lognormal distribution confirmed using the Shapiro-Wilk W test (alpha = 0.05).
NP	Non-parametric distribution (alpha = 0.05)
RAGS	Risk Assessment Guidance for Superfund
ug/kg	microgram per kilogram
(1)	UCL95 calculated using the Approximate Gamma method.
(2)	UCL95 calculated using the H-UCL method.
(3)	UCL95 calculated using the 95% Chebyshev (Mean, SD) method.

References:

EPA. 2004. ProUCL Version 3.0. EPA Statistical Program Package. April. Available online at http://www.epa.gov/nerlesd1/tsc/form.htm

TABLE 5
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SURFACE SOIL
WATSON JOHNSON LANDFILL

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Surface soil, outdoor activities, off-site areas outside the landfill perimeter

CAS Number	Chemical	Minimum Concentration (1)	Min Q	Maximum Concentration (1)	Max Q	Units	Location of Maximum Concentration	Detection Frequency	Minimum Detection Limit	Maximum Detection Limit	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
57749	alpha-Chlordane	19	J	19	J	ug/kg	SS15	1/16	2.1	3.8	19	NA	1600C	NA	NA	N	BSL
7429905	Aluminum	12900		35100		mg/kg	SS220 (Dup of SS20)	16/16	NA	NA	35100	NA	7800N	NA	NA	Y	ASL
7440360	Antimony	0.72	J	0.95	L[]	mg/kg	SS15	3/15	11.1	23.9	0.95	NA	3.1N	NA	NA	N	BSL
7440382	Arsenic	2.3	J	14.5		mg/kg	SS27	16/16	NA	NA	14.5	NA	0.43C	NA	NA	Y	ASL
7440393	Barium	46.3	[]	447		mg/kg	SS22	16/16	NA	NA	447	NA	550N	NA	NA	N	BSL
100527	Benzaldehyde	51	J	160	J	ug/kg	SS15	4/16	410	680	160	NA	780000N	NA	NA	N	BSL
56553	Benzo(a)anthracene	92	J	92	J	ug/kg	SS12	1/16	410	750	92	NA	870C	NA	NA	N	BSL
50328	Benzo(a)pyrene	100	J	110	J	ug/kg	SS18	3/16	410	750	110	NA	87C	NA	NA	Y	ASL
205992	Benzo(b)fluoranthene	78	J	95	J	ug/kg	SS12	2/16	410	750	95	NA	870C	NA	NA	N	BSL
19124	Benzo(g,h,i)perylene	53	J	69	J	ug/kg	SS12	2/16	410	750	69	NA	230000N	NA	NA	N	BSL
207089	Benzo(k)fluoranthene	150	J	150	J	ug/kg	SS12	1/16	410	750	150	NA	8700C	NA	NA	N	BSL
7440417	Beryllium	0.44	J	1.6		mg/kg	SS220 (Dup of SS20)	16/16	NA	NA	1.6	NA	16N	NA	NA	N	BSL
117817	Bis(2-Ethylhexyl) Phthalate	97	J	230	J	ug/kg	SS23	6/16	490	710	230	NA	46000C	NA	NA	N	BSL
7440439	Cadmium	0.1	J	5.1		mg/kg	SS23	15/16	NA	NA	5.1	NA	3.9N	NA	NA	Y	ASL
7440702	Calcium	276	J	12100		mg/kg	SS29	16/16	NA	NA	12100	NA	NUT	NA	NA	N	NUT
7440473	Chromium, Total	15.7		48.2		mg/kg	SS31	16/16	NA	NA	48.2	NA	23N	NA	NA	Y	ASL
218019	Chrysene	140	J	510	J	ug/kg	SS15	2/16	410	750	510	NA	87000C	NA	NA	N	BSL
7440484	Cobalt	2.9	J	21.2		mg/kg	SS220 (Dup of SS20)	16/16	NA	NA	21.2	NA	160N	NA	NA	N	BSL
7440508	Copper	8.7		76.3		mg/kg	SS220 (Dup of SS20)	16/16	NA	NA	76.3	NA	310N	NA	NA	N	BSL
151508	Cyanide	0.13	J	0.33	J	mg/kg	SS27	6/14	NA	NA	0.33	NA	390N	NA	NA	N	BSL
60571	Dieldrin	0.92	J	12	J	ug/kg	SS15	2/16	4.1	7.4	12	NA	40C	NA	NA	N	BSL
72208	Endrin	12	J	12	J	ug/kg	SS15	1/16	4.1	7.4	12	NA	2300N	NA	NA	N	BSL
7421934	Endrin aldehyde	1.9	J	14	J	ug/kg	SS15	2/16	4.1	7.4	14	NA	2300N	NA	NA	N	BSL
53494705	Endrin ketone	9.1	J	9.1	J	ug/kg	SS15	1/16	4.1	7.4	9.1	NA	2300N	NA	NA	N	BSL
206440	Fluoranthene	240	J	240	J	ug/kg	SS12	1/16	410	750	240	NA	310000N	NA	NA	N	BSL
58899	GAMMA BHC (LINDANE)	0.16	J	0.16	J	ug/kg	SS12	1/16	2.1	3.8	0.16	NA	490C	NA	NA	N	BSL
1024573	Heptachlor epoxide	3	J	3	J	ug/kg	SS15	1/16	2.1	3.8	3	NA	70C	NA	NA	N	BSL
193395	Indeno(1,2,3-C,D)Pyrene	70	J	70	J	ug/kg	SS12	1/16	410	750	70	NA	870C	NA	NA	N	BSL
1309371	Iron	8090		129000	J	mg/kg	SS23	16/16	NA	NA	129000	NA	2300N	NA	NA	Y	ASL
7439921	Lead	20.3		115		mg/kg	SS12	16/16	NA	NA	115	NA	400	400	EPA	N	BSL
7439954	Magnesium	1130	J	7720		mg/kg	SS220 (Dup of SS20)	16/16	NA	NA	7720	NA	NUT	NA	NA	N	NUT
7439965	Manganese	37.1	L	2920		mg/kg	SS12	16/16	NA	NA	2920	NA	160N	NA	NA	Y	ASL
7439976	Mercury	0.054	J	1.4		mg/kg	SS15	10/16	0.16	0.16	1.4	NA	2.3N	NA	NA	N	BSL
72435	Methoxychlor	24	J	24	J	ug/kg	SS21	1/16	21	38	24	NA	39000N	NA	NA	N	BSL
7440020	Nickel	7.6	J	35.3		mg/kg	SS220 (Dup of SS20)	16/16	NA	NA	35.3	NA	160N	NA	NA	N	BSL
72548	P,P-DDD	24	J	24	J	ug/kg	SS15	1/16	4.1	7.4	24	NA	2700C	NA	NA	N	BSL
72559	P,P-DDE	3.9	J	36	J	ug/kg	SS15	7/16	4.5	6.8	36	NA	1900C	NA	NA	N	BSL
50293	P,P-DDT	2.1	J	170		ug/kg	SS15	5/16	4.5	7.4	170	NA	1900C	NA	NA	N	BSL
85018	Phenanthrene	140	J	140	J	ug/kg	SS12	1/16	410	750	140	NA	230000N	NA	NA	N	BSL
7440097	Potassium	442	[]	2620		mg/kg	SS21	16/16	NA	NA	2620	NA	NUT	NA	NA	N	NUT
129000	Pyrene	110	J	210	J	ug/kg	SS12	3/16	410	750	210	NA	230000N	NA	NA	N	BSL
7782492	Selenium	4.7	J	4.7	J	mg/kg	SS23	1/12	6.5	13.9	4.7	NA	39N	NA	NA	N	BSL
7440224	Siver	0.16	[]	1.1	[]	mg/kg	SS15	2/16	1.6	2.7	1.1	NA	39N	NA	NA	N	BSL
7440235	Sodium	435	K[]	459	K[]	mg/kg	SS12	2/16	NA	NA	459	NA	NUT	NA	NA	N	NUT
7440280	Thallium	0.51	J	3.4	J	mg/kg	SS23	11/16	0.91	1.2	3.4	NA	0.55N	NA	NA	Y	ASL
7440622	Vanadium	25.2		68.8		mg/kg	SS220 (Dup of SS20)	16/16	NA	NA	68.8	NA	7.8N	NA	NA	Y	ASL
7440666	Zinc	29.9		310		mg/kg	SS23	16/16	NA	NA	310	NA	2300N	NA	NA	N	BSL

(1) Minimum/maximum detected concentration based on surface soil samples.
(2) Maximum concentration used for screening.
(3) Refer to supporting information for background discussion.
Background values derived from statistical analysis.
(4) All compounds were screened against the Risk-Based Concentration (RBC) Table, U.S. EPA Region 3, October 2004 for residential soil (cancer benchmark=1E-06; HQ=0.1). Lead was screened against the U.S. EPA action level of 400 mg/kg.
(5) Rationale Codes:
Selection Reasoning: Above Screening Level (ASL)
Deletion Reasoning: Below Screening Level (BSL)
Essential Nutrient (NUT)

Definitions:
C = Carcinogenic
COPC = Chemical of Potential Concern
N = Non-Carcinogenic
NA = Not Applicable
Q = Data Qualifier

J = Estimated Value
L = Analyte present. Reported value may be biased low.
K = Analyte present. Reported value may be biased high. Actual value value is expected to be lower.
[] = Analyte present. As values approach the IDL the quantitation may not be accurate.
No code = Confirmed identification as defined in the Glossary of Data Qualifier Codes.

TABLE 5
EXPOSURE POINT CONCENTRATION SUMMARY
SURFACE SOIL
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Medium:	Surface Soil
Exposure Medium:	Surface Soil

Exposure Point	Chemical	Units	Arithmetic Mean	UCL95 (Distribution)		Maximum Concentration (Qualifier) [b]		Exposure Point Concentration			
								Value	Units	Statistic	Rationale[a]
Surface Soil, outdoor activities	Aluminum	ug/kg	1.86E+07	2.05E+07	N	3.51E+07		2.05E+07	ug/kg	UCL95	(1)
	Arsenic	ug/kg	6.16E+03	7.61E+03	G	1.45E+04		7.61E+03	ug/kg	UCL95	(3)
	Benzo(a)pyrene	ug/kg	2.39E+02	2.75E+02	N	1.10E+02	J	1.10E+02	ug/kg	Max Conc.	(1)
	Cadmiun	ug/kg	8.16E+02	1.32E+03	G	5.10E+03		1.32E+03	ug/kg	UCL95	(3)
	Chromium Total	ug/kg	2.67E+04	3.02E+04	N	4.82E+04		3.02E+04	ug/kg	UCL95	(1)
	Iron	ug/kg	2.79E+07	5.82E+07	NP	1.29E+08	J	5.82E+07	ug/kg	UCL95	(2)
	Manganese	ug/kg	8.87E+05	1.32E+06	G	2.92E+06		1.32E+06	ug/kg	UCL95	(3)
	Thallium	ug/kg	1.58E+03	2.02E+03	N	3.40E+03	J	2.02E+03	ug/kg	UCL95	(1)
	Vanadium	ug/kg	4.32E+04	4.81E+04	N	6.88E+04		4.81E+04	ug/kg	UCL95	(1)

Notes:

a The lesser of the UCL95 and maximum detected concentration was used as the exposure point concentration (EPC) as determined by ProUCL (EPA 2004). One-half the reporting limit was used as a proxy for non-detect values.

b *If the maximum detected concentration was found in a sample that has two results (both an original and a duplicate sample), then the higher of the two results is shown. Note, however,* that the average of the two values is used in the statistical evaluation (e.g., UCL95 determination).

UCL95	One-sided 95 percent upper confidence limit of the mean
G	Gamma distribution confirmed (alpha = 0.05).
J	Estimated concentration
N	Normal distribution confirmed using the Shapiro-Wilk W test (alpha = 0.05).
NP	Non-parametric distribution (alpha = 0.05)
RAGS	Risk Assessment Guidance for Superfund
ug/kg	microgram per kilogram
(1)	UCL95 calculated using the Student's-t UCL method.
(2)	UCL95 calculated using the 95% Chebyshev (Mean, SD) method.
(3)	UCL95 calculated using the Approximate Gamma method.

References:

EPA. 2004. ProUCL Version 3.0. EPA Statistical Program Package. April. Available online at http://www.epa.gov/nerlesd1/tsc/form.htm

TABLE 6
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
INDOOR AIR
WATSON JOHNSON LANDFILL

Scenario Timeframe: Current
Medium: Groundwater
Exposure Medium: Air
Exposure Point: Air in basements or low-lying living spaces, Quakertown residential

CAS Number	Chemical	Minimum Concentration (1)	Min Q	Maximum Concentration (1)	Max Q	Units	Location of Maximum Concentration	Detection Frequency	Minimum Detection Limit	Maximum Detection Limit	Concentration Used for Screening (2)	Background Value	Screening Toxicity Value (N/C) (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
79345	1,1,2,2-Tetrachloroethane	8.4		8.4		ug/m3	SV01	1/30	6.9	6.9	8.4	NA	0.31C	NA	NA	N	NGWCOPC
79005	1,1,2-Trichloroethane	22		22		ug/m3	SV06	1/30	5.5	5.5	22	NA	1.1C	NA	NA	N	NGWCOPC
75343	1,1-Dichloroethane	0.95	J	0.95	J	ug/m3	SV06	1/30	4.0	4.0	0.95	NA	500N	NA	NA	N	BSL
120821	1,2,4-Trichlorobenzene	1.7	J	1.7	J	ug/m3	SV11	1/30	7.4	7.4	1.7	NA	3.7N	NA	NA	N	BSL
95636	1,2,4-Trimethylbenzene	1.1	J	36		ug/m3	SV04	23/30	4.9	4.9	36	NA	6N	NA	NA	N	NGWCOPC
107062	1,2-Dichloroethane	1.3	J	8.4		ug/m3	SV06	2/30	4.0	4.0	8.4	NA	0.69C	NA	NA	N	NGWCOPC
108678	1,3,5-Trimethylbenzene	1	J	9.3		ug/m3	SV04	12/30	4.9	4.9	9.3	NA	6N	NA	NA	N	NGWCOPC
78933	2-Butanone (methyl ethyl ketone)	2.9	J	290	J	ug/m3	SV04	29/30	2.9	2.9	290	NA	1000N	NA	NA	N	BSL
591786	2-Hexanone (methyl butyl ketone)	0.98	J	53	J	ug/m3	SV04	24/30	4.1	4.1	53	NA	NTX	NA	NA	N	NTX
622968	4-Ethyl toluene	1	J	14		ug/m3	SV04	16/30	4.9	4.9	14	NA	NTX	NA	NA	N	NTX
108101	4-Methyl-2-pentanone (methyl isobutyl ketone)	0.9	J	82		ug/m3	SV04	18/30	4.1	4.1	82	NA	80N	NA	NA	N	NGWCOPC
67641	Acetone	76	J	1600		ug/m3	SV03	26/30	2.4	2.4	1600	NA	350N	NA	NA	N	NGWCOPC
71432	Benzene	0.8	J	69	J	ug/m3	SV01	27/30	3.2	3.2	69	NA	2.3C	NA	NA	Y	ASL
75150	Carbon Disulfide	0.85	J	190	J	ug/m3	SV04	22/30	3.1	3.1	190	NA	700N	NA	NA	N	BSL
108907	Chlorobenzene	2.4	J	7.7		ug/m3	SV01	2/30	4.6	4.6	7.7	NA	60N	NA	NA	N	BSL
67663	Chloroform	1	J	1.8	J	ug/m3	SV06	4/30	4.9	4.9	1.8	NA	0.77C	NA	NA	N	NGWCOPC
74873	Chloromethane (Methyl Chloride)	0.75	J	20		ug/m3	SV04	23/30	3.5	3.5	20	NA	24C	NA	NA	N	BSL
75718	Dichlorodifluoromethane (Freon 12)	2.3	J	4.9	J	ug/m3	SV08	25/30	4.9	4.9	4.9	NA	180N	NA	NA	N	BSL
100414	Ethylbenzene	0.99	J	16		ug/m3	SV01	21/30	4.3	4.3	16	NA	22C	NA	NA	N	BSL
1330207	m,p-Xylene	2	J	43		ug/m3	SV04	23/30	8.7	8.7	43	NA	110N	NA	NA	N	BSL
1634044	Methyl t-butyl ether	0.83	J	9.1		ug/m3	SV08	7/30	3.6	3.6	9.1	NA	16C	NA	NA	N	BSL
75092	Methylene Chloride	1	J	1100	J	ug/m3	SV01	7/30	3.5	3.5	1100	NA	38C	NA	NA	N	NGWCOPC
1330207	o-Xylene	0.89	J	15		ug/m3	SV04	18/30	4.3	4.3	15	NA	110N	NA	NA	N	BSL
100425	Styrene	0.86	J	7.2		ug/m3	SV04	13/30	4.3	4.3	7.2	NA	1000N	NA	NA	N	BSL
127184	Tetrachloroethene	1.4	J	320	J	ug/m3	SV01	15/30	6.8	6.8	320	NA	3.1C	NA	NA	Y	ASL
108883	Toluene	1.6	J	87	J	ug/m3	SV01	24/30	3.8	3.8	87	NA	400N	NA	NA	N	BSL
79016	Trichloroethene	4.3	J	4.3	J	ug/m3	SV01	1/30	5.4	5.4	4.3	NA	0.16C	NA	NA	Y	ASL
75694	Trichlorofluoromethane (Freon 11)	1.2	J	110		ug/m3	SV08	23/30	5.6	5.6	110	NA	730N	NA	NA	N	BSL
108054	Vinyl acetate	3	J	42		ug/m3	SV01	21/30	3.5	3.5	42	NA	200N	NA	NA	N	BSL
75014	Vinyl Chloride	2.2	J	2.8		ug/m3	SV04	2/30	2.6	2.6	2.8	NA	0.72C	NA	NA	Y	ASL

(1) Minimum/maximum detected concentration based on subsurface soil vapor samples.
(2) Maximum concentration used for screening.
(3) Screening level based on the lower screening value of either 1) RBC x 10 attenuation factor, or 2) Target Shallow Soil Gas Concentration, based on *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils, Table 2c*
(4) Rationale Codes:
Selection Reasoning: Above Screening Level (ASL)
Deletion Reasoning: Below Screening Level (BSL)
No Toxicity Information (NTX)
Not a Site Groundwater Contaminant of Concern (NGWCOPC)

Definitions:
C = Carcinogenic
COPC = Chemical of Potential Concern
N = Non-Carcinogenic
NA = Not Applicable
Q = Data Qualifier
J = Estimated Value
No code = Confirmed identification as defined in the Glossary of Data Qualifier Codes.

TABLE 6
EXPOSURE POINT CONCENTRATION SUMMARY
INDOOR AIR
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current
Medium:	Indoor Air
Exposure Medium:	Indoor Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	UCL95 (Distribution)	Maximum Concentration (Qualifier)[c]		Exposure Point Concentration		
							Value	Units	Rationale[a]
95% UCL Infinite Indoor Air Concentration	Benzene	ug / m^3	N/A	6.89E-02	6.90E+01	J	6.89E-02	ug / m^3	a
	Tetrachloroethene	ug / m^3	N/A	9.44E-02	3.20E+02	J	9.44E-02	ug / m^3	a
	Trichloroethene	ug / m^3	N/A	4.55E-03	4.35E+00	J	4.55E-03	ug / m^3	a
	Vinyl Chloride	ug / m^3	N/A	2.44E-03	2.80E+00		2.44E-03	ug / m^3	a

Notes:

a The infinite indoor air concentrations were modeled from detected concentrations of analytes in soil gas samples SV01 through SV06 and SV08 through SV11 using the EPA's Johnson & Ettinger Advanced Soil-Gas Model Version 2.0 (EPA 2003). The UCL95 of the modeled infinite indoor air concentrations was calculated using ProUCL (EPA 2004).

b The maximum chemical-specific infinite indoor air concentrations are from two different locations (i.e., SV01 and SV04) as indicated in Table 2.5, with the majority of the maxima occurring at SV01 Thus, risks will be estimated using the concentrations from SV01 to evaluate a worst-case scenario evaluation in the uncertainty analysis. Location SV01 has the maximum concentration for benzene, tetrachloroethene, and trichloroethene but vinyl chloride was not detected and therefore will not be included in the worst-case scenario evaluation.

UCL95	One-sided 95 percent upper confidence limit of the mean
N/A	Not applicable (not calculated)
RAGS	Risk Assessment Guidance for Superfund
ug / m^3	Microgram per cubic meter

References:

EPA. 2003. EPA's Johnson & Ettinger Advanced Soil Gas Model, Version 2.0. February. Available online at http://www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm

EPA. 2004. ProUCL Version 3.0. EPA Statistical Program Package. April. Available online at http://www.epa.gov/nerlesd1/tsc/form.htm

TABLE 7

NONCANCER TOXICITY DATA --- ORAL/DERMAL

WATSON JOHNSON LANDFILL

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal	Absorbed RfD for Dermal		Primary Target Organ(s)/Effect(s)	Combined Uncertainty/Modifying Factors	RfD.Target Organ(s)	
		Value	Units	(1) (2)	Value	Units	(3)		Source(s)	Date(s) (MM/DD/YYYY)
1,4-Dichlorobenzene	Chronic	3.0E-02	mg/kg-day	100%	3.0E-02	mg/kg-day	Blood/Liver	--	NCEA	10/20/2004
Aluminium	Chronic	1.0E+00	mg/kg-day	100%	1.0E+00	mg/kg-day	CNS/Developmental	--	PPRTV	6/28/2004
Arsenic	Chronic	3.0E-04	mg/kg-day	100%	3.0E-04	mg/kg-day	Skin/Vasular Effects	3	IRIS	1/10/2005
Barium	Chronic	7.0E-02	mg/kg-day	7%	4.9E-03	mg/kg-day	Kidney	3	IRIS	1/10/2005
Benzene	Chronic	4.0E-03	mg/kg-day	100%	4.0E-03	mg/kg-day	Blood	300	IRIS	8/11/2004
Benzo(a)pyrene	Chronic	--	--	--	--	--	--	--	--	--
beta-BHC	Chronic	--	--	--	--	--	--	--	--	1/18/2005
Bis(2-Ethylhexyl)phthalate	Chronic	2.0E-02	mg/kg-day	100%	2.0E-02	mg/kg-day	Liver	1,000	IRIS	1/10/2005
Boron	Chronic	2.0E-01	mg/kg-day	100%	2.0E-01	mg/kg-day	Developmental	66	IRIS	1/10/2005
Cadmium (water)	Chronic	5.0E-04	mg/kg-day	5%	2.5E-05	mg/kg-day	Kidney	10	IRIS	1/10/2005
Cadmium (food)	Chronic	1.0E-03	mg/kg-day	2.5%	2.5E-05	mg/kg-day	Kidney	10	IRIS	1/10/2005
Chromium (total) [b]	Chronic	3.0E-03	mg/kg-day	2.5%	7.5E-05	mg/kg-day	NOAEL	300	IRIS	1/11/2005
Cis-1, 2-Dichloroethylene	Chronic	1.0E-02	mg/kg-day	100%	1.0E-02	mg/kg-day	Blood	3,000	PPRTV	6/28/2004
Cyanide	Chronic	2.0E-02	mg/kg-day	100%	2.0E-02	mg/kg-day	CNS	100	IRIS	1/10/2005
Iron	Chronic	3.0E-01	mg/kg-day	100%	3.0E-01	mg/kg-day	Liver	1	NCEA	10/20/2004
Lead	Chronic	--	--	--	--	--	--	--	--	1/11/2005
Manganese	Chronic	2.0E-02	mg/kg-day	4%	8.0E-04	mg/kg-day	CNS	1	IRIS	1/10/2005
Tetrachloroethylene	Chronic	1.0E-02	mg/kg-day	100%	1.0E-02	mg/kg-day	Liver	1,000	IRIS	1/10/2005
Thallium	Chronic	8.0E-05	mg/kg-day	100%	8.0E-05	mg/kg-day	Blood	3,000	IRIS	1/10/2005
Trichloroethylene	Chronic	3.0E-04	mg/kg-day	100%	3.0E-04	mg/kg-day	Liver/Kidney/Fetus	3,000	NCEA	10/20/2004
Vanadium	Chronic	1.0E-03	mg/kg-day	2.6%	2.6E-05	mg/kg-day	Kidney	--	NCEA	10/20/2004
Vinyl chloride (adult)	Chronic	3.0E-03	mg/kg-day	100%	3.0E-03	mg/kg-day	Liver	30	IRIS	1/10/2005

Notes:

a The trichloroethene values are draft NCEA provisional values subject to change. Significant peer review comments on the *Trichloroethene Health Risk Assessment: Synthesis and Characterization* document (External Review Draft, August 2001) are being addressed by EPA NCEA prior to finalizing the peer-reviewed values.

b As a conservative measure, total chromium was assumed to be the more toxic hexavalent chromium. Although the RfD is based on a NOAEL, if cumulative noncancer effects require a target organ breakdown (by virtue of the HI exceeding 1 for all COPCs), potential target organs listed in IRIS (such as gastrointestical effects, fetotoxicity, dermatitis and reproductive effects for chromium VI and liver/spleen and reproductive effects for chromium III) will be evaluated, as appropriate.

Definitions:

-- Not available; not applicable

COPC Chemical of potential concern

EPA U.S. Environmental Protection Agency

IRIS EPA Integrated Risk Information System (EPA 2005)

mg/kg-day Milligram per kilogram per day

NCEA EPA National Center for Exposure Assessment provisional value. Not all original NCEA source papers are publicly available; R3 RBC table (EPA 2004c) was used as secondary source.

NOAEL No Adverse Affect Effect Level

PPRTV EPA Provisional Peer-Reviewed Toxicity Value (EPA 2004a) no longer publicly available; R3 RBC table (EPA 2004c) was used as secondary source.

(1) Absorption efficiencies were taken from the RAGS Part E dermal guidance document (EPA 2004b).

(2) Per EPA's dermal guidance (EPA 2004b), organic and inorganic COPCs without ABSGI values listed in Exhibit 4-1 of EPA 2004b were assigned an ABSGI value of 100%. Per EPA's dermal guidance (EPA 2004b), COPCs with ABS_{GI} values of greater than 50% in Exhibit 4-1 of EPA 2004b were assigned an ABS_{GI} value of 100%. Note that when a range of ABSGI values was presented in Exhibit 4-1 of EPA 2004b, the lowest number in the range was used, which was the most conservative approach.

(3) Target organ information for trichloroethene (March 1993) obtained from the Risk Assessment Information System (RAIS), U.S. Department of Energy (DOE), Office of Environmental Manangement. Available online at http://risk.lsd.ornl.gov/tox/rap_toxp.shtml.

TABLE 7

NONCANCER TOXICITY DATA — ORAL/DERMAL

WATSON JOHNSON LANDFILL

References:

EPA 2004a. EPA Provisional Peer-Reviewed Toxicity Value (PPRTV). Available online at http://hhpprtv.ornl.gov/pprtv.shtml.

EPA 2004b. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. 20460, EPA/540/R-99/005, OSWER 9285.7-02EP, PB99-963312, September. Available online at http://www.epa.gov/superfund/programs/risk/ragse/index.htm.

EPA 2004c. "EPA Region 3 Risk-based Concentration (RBC) Table." Online address: http://www.epa.gov/reg3hwmd/risk/human/index.htm. Last updated October 8, 2004.

EPA 2005. Integrated Risk Information System. Available online at http://www.epa.gov/iris/index.html. Accessed January.

TABLE 8

NONCANCER TOXICITY DATA --- INHALATION

WATSON JOHNSON LANDFILL

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
1,4-Dichlorobenzene	Chronic	8.0E-01	mg/m^3	2.3E-01	mg/kg-day	Liver	100	IRIS	1/10/2005
Aluminium	Chronic	3.5E-03	mg/m^3	1.0E-03	mg/kg-day	CNS	--	PPRTV	6/28/2004
Arsenic	Chronic	--	--	--	--	--	--	--	1/10/2005
Barium	Chronic	5.0E-04	mg/m^3	1.4E-04	mg/kg-day	Fetotoxicity	1,000	HEAST	10/20/2004
Benzene	Chronic	3.0E-02	mg/m^3	8.6E-03	mg/kg-day	Blood	300	IRIS	1/10/2005
Benzo(a)pyrene	Chronic	--	--	--	--	--	--	--	--
beta-BHC	Chronic	--	--	--	--	--	--	--	1/10/2005
Bis(2-Ethylhexyl)phthalate	Chronic	--	--	--	--	--	--	--	1/10/2005
Boron	Chronic	5.7E-03	mg/m^3	1.6E-03	mg/kg-day	Developmental	--	HEAST	10/20/2004
Cadmium	Chronic	2.0E-04	mg/m^3	5.7E-05	mg/kg-day	Kidney	30	NCEA	1/10/2005
Chromium (total) [b]	Chronic	8.0E-06	mg/m^3	2.3E-06	mg/kg-day	Lungs	90	IRIS	1/10/2005
Cis-1, 2-Dichloroethylene	Chronic	--	--	--	--	--	--	--	1/13/2004
Cyanide	Chronic	--	--	--	--	--	--	--	1/10/2005
Iron	Chronic	--	--	--	--	--	--	--	1/10/2005
Lead	Chronic	--	--	--	--	--	--	--	1/10/2005
Manganese	Chronic	5.0E-05	mg/m^3	1.4E-05	mg/kg-day	CNS	1,000	IRIS	1/10/2005
Tetrachloroethylene	Chronic	4.9E-01	mg/m^3	1.4E-01	mg/kg-day	CNS/Liver/Kidney	100	NCEA	10/20/2004
Thallium	Chronic	--	--	--	--	--	--	--	1/11/2005
Trichloroethylene	Chronic	4.0E-02	mg/m^3	1.1E-02	mg/kg-day	CNS/Liver/Endocrine Sys.	1,000	NCEA	10/20/2004
Vanadium	Chronic	--	--	--	--	--	--	--	1/11/2005
Vinyl chloride	Chronic	1.0E-01	mg/m^3	2.9E-02	mg/kg-day	Liver	30	IRIS	1/11/2005

Notes:

a The trichloroethene values are draft NCEA provisional values subject to change. Significant peer review comments on the *Trichloroethene Health Risk Assessment: Synthesis and Characterization* document (External Review Draft, August 2001) are being addressed by EPA NCEA prior to finalizing the peer-reviewed values.

b As a conservative measure, total chromium was assumed to be the more toxic hexavalent chromium.

Definitions:

--	Not available; not applicable
COPC	Chemical of potential concern
EPA	U.S. Environmental Protection Agency
IRIS	EPA Integrated Risk Information System (EPA 2005)
mg/kg-day	Milligram per kilogram per day
mg/m^3	Milligram per cubic meter

TABLE 8

NONCANCER TOXICITY DATA --- INHALATION

WATSON JOHNSON LANDFILL

NCEA	EPA National Center for Exposure Assessment provisional value. Not all original papers are publicly available; R3 RBC table (EPA 2004b) was used as secondary source.
PPRTV	EPA Provisional Peer-Reviewed Toxicity Value (EPA 2004a) no longer publicly available; R3 RBC table (EPA 2004b) was used as secondary source.
R3-N	Source of toxicity value listed as "NCEA" in the EPA Region 3 RBC Table (EPA 2004b).
RTR	Route-to-route extrapolation was used for this analyte (see oral noncancer reference dose)

References:

EPA 1997. Health Effects Assessment Summary Tables (HEAST) FY 1997 Update, United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, 9200.6-303 (97-1), EPA/540/R-97/036, PB97-921199, July 31.

EPA 2004a. EPA Provisional Peer-Reviewed Toxicity Value (PPRTV). Available online at http://hhpprtv.ornl.gov/pprtv.shtml.

EPA 2004b. "EPA Region 3 Risk-based Concentration (RBC) Table." Online address: http://www.epa.gov/reg3hwmd/risk/human/index.htm. Last updated October 8, 2004.

EPA 2005. Integrated Risk Information System. Available online at http://www.epa.gov/iris/index.html. Accessed January.

TABLE 9

CANCER TOXICITY DATA — ORAL/DERMAL

WATSON JOHNSON LANDFILL

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal	Absorbed Cancer Slope Factor for Dermal		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units	(1) (2)	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
1,4-Dichlorobenzene	2.4E-02	$(mg/kg\text{-}day)^{-1}$	100%	2.4E-02	$(mg/kg\text{-}day)^{-1}$	C	HEAST	10/20/2004
Aluminium	--	--	--	--	--	--	--	1/11/2005
Arsenic	1.5E+00	$(mg/kg\text{-}day)^{-1}$	100%	1.5E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/11/2005
Barium	--	--	--	--	--	D	IRIS	1/11/2005
Benzene [a]	5.5E-02	$(mg/kg\text{-}day)^{-1}$	100%	5.5E-02	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/10/2005
Benzo(a)pyrene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	100%	7.3E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/10/2005
beta-BHC	1.8E+00	$(mg/kg\text{-}day)^{-1}$	100%	1.8E+00	$(mg/kg\text{-}day)^{-1}$	C	IRIS	1/10/2005
Bis(2-Ethylhexyl)phthalate	1.4E-02	$(mg/kg\text{-}day)^{-1}$	100%	1.4E-02	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/10/2005
Boron	--	--	--	--	--	--	--	1/10/2005
Cadmium	--	--	--	--	--	B1	IRIS	1/10/2005
Chromium (total) [c]	--	--	--	--	--	D	IRIS	1/10/2005
Cis-1, 2-Dichloroethylene	--	--	--	--	--	D	IRIS	1/10/2005
Cyanide	--	--	--	--	--	D	IRIS	1/11/2005
Iron	--	--	--	--	--	--	--	1/11/2005
Lead	--	--	--	--	--	B2	IRIS	1/11/2005
Manganese	--	--	--	--	--	D	IRIS	1/11/2005
Tetrachloroethylene	5.4E-01	(mg/kg-day)-1	100%	5.4E-01	(mg/kg-day)-1	--	R3-O	4/14/2004
Thallium	--	--	--	--	--	--	--	1/11/2005
Trichloroethylene	4.0E-01	$(mg/kg\text{-}day)^{-1}$	100%	4.0E-01	$(mg/kg\text{-}day)^{-1}$	B1	NCEA	10/20/2004
Vanadium	--	--	--	--	--	--	--	1/11/2005
Vinyl chloride (early life)	1.4E+00	$(mg/kg\text{-}day)^{-1}$	100%	1.4E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/11/2005
Vinyl chloride (adult)	7.2E-01	$(mg/kg\text{-}day)^{-1}$	100%	7.2E-01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/11/2005

Notes:

a The high range oral cancer slope factor for benzene (EPA 2004a) is listed.

b The trichloroethene values are draft NCEA provisional values subject to change. Significant peer review comments on the *Trichloroethene Health Risk Assessment: Synthesis and Characterization* document (External Review Draft, August 2001) are being addressed by EPA NCEA prior to finalizing the peer-reviewed values.

c As a conservative measure, total chromium was assumed to be the more toxic hexavalent chromium.

Definitions:

-- Not available; not applicable

EPA U.S. Environmental Protection Agency

IRIS EPA Integrated Risk Information System (EPA 2005)

NCEA EPA National Center for Exposure Assessment provisional value. Not all original NCEA source papers were available; R3 was used as secondary source.

EPA Region 3

R3-O Source of toxicity value listed as "Other" in the EPA Region 3 Risk-based Screening Concentration (RBC) Table (EPA 2004b).

$(mg/kg\text{-}day)^{-1}$ 1/milligram per kilogram per day

TABLE 9

CANCER TOXICITY DATA --- ORAL/DERMAL

WATSON JOHNSON LANDFILL

(1) Absorption efficiencies were taken from the EPA dermal guidance document (EPA 2004c).

(2) Per EPA dermal guidance document (EPA 2004a), organic and inorganic COPCs without ABSGI values listed in Exhibit 4-1 of EPA 2004a were assigned an ABSGI value of 100%, and COPCs with ABS_{GI} values of greater than 50% in Exhibit 4-1 of EPA 2004a were assigned an ABS_{GI} value of 100%. Note that when a range of ABS_{GI} values was presented in Exhibit 4-1 of EPA 2004a, the lowest number in the range was used, which was the most conservative approach.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

EPA 2004a. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. 20460, EPA/540/R-99/005, OSWER 9285.7-02EP, PB99-963312, September. Available online at http://www.epa.gov/superfund/programs/risk/ragse/index.htm.

EPA 2004b. "EPA Region 3 Risk-based Concentration (RBC) Table." Online address: http://www.epa.gov/reg3hwmd/risk/human/index.htm. Last updated October 8, 2004.

EPA 2005. Integrated Risk Information System. Available online at http://www.epa.gov/iris/index.html. Accessed January.

TABLE 10

CANCER TOXICITY DATA --- INHALATION

WATSON JOHNSON LANDFILL

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
1,4-Dichlorobenzene	6.3E-06	$(ug/m^3)^{-1}$	2.2E-02	$(mg/kg\text{-}day)^{-1}$	C	NCEA	10/20/2004
Aluminium	--	--	--	--	--	--	1/11/2005
Arsenic	4.3E-03	$(ug/m^3)^{-1}$	1.5E+01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/11/2005
Barium	--	--	--	--	D	IRIS	1/11/2005
Benzene [a]	7.8E-06	$(ug/m^3)^{-1}$	2.7E-02	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/11/2005
Benzo(a)pyrene	--	--	3.1E+00	$(mg/kg\text{-}day)^{-1}$	B2	NCEA	1/11/2005
Beta-BHC	5.3E-04	$(ug/m^3)^{-1}$	1.9E+00	$(mg/kg\text{-}day)^{-1}$	C	IRIS	1/11/2005
Bis(2-Ethylhexyl)phthalate	--	--	1.4E-02	$(mg/kg\text{-}day)^{-1}$	B2	NCEA	10/20/2004
Boron	--	--	--	--	--	--	1/11/2005
Cadmium (water)	1.8E-03	$(ug/m^3)^{-1}$	6.3E+00	$(mg/kg\text{-}day)^{-1}$	B1	IRIS	1/11/2005
Chromium (total) [c]	1.2E-02	$(ug/m^3)^{-1}$	4.2E+01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/11/2005
Cis-1, 2-Dichloroethylene	--	--	--	--	D	--	1/11/2005
Cyanide	--	--	--	--	D	IRIS	1/11/2005
Iron	--	--	--	--	--	--	1/11/2005
Lead	--	--	--	--	B2	IRIS	1/11/2005
Manganese	--	--	--	--	D	IRIS	1/11/2005
Tetrachloroethylene	5.7E-06	$(ug/m^3)^{-1}$	2.0E-02	(mg/kg-day)-1	--	R3-O	4/14/2004
Thallium	--	--	--	--	--	--	1/11/2005
Trichloroethylene	1.1E-04	$(ug/m^3)^{-1}$	4.0E-01	$(mg/kg\text{-}day)^{-1}$	B1	NCEA	10/20/2004
Vanadium	--	--	--	--	--	--	1/11/2005
Vinyl chloride (early life)	8.6E-06	$(ug/m^3)^{-1}$	3.0E-02	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/12/2005
Vinyl chloride (adult)	4.4E-06	$(ug/m^3)^{-1}$	1.5E-02	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/11/2005

Notes:

a The high range unit risk factor (EPA 2004a) is listed.

b The trichloroethene values are draft NCEA provisional values subject to change. Significant peer review comments on the *Trichloroethene Health Risk Assessment: Synthesis and Characterization* document (External Review Draft, August 2001) are being addressed by EPA NCEA prior to finalizing the peer-reviewed values.

Definitions:

--	Not available; not applicable
COPC	Chemical of potential concern
EPA	U.S. Environmental Protection Agency
IRIS	EPA Integrated Risk Information System (EPA 2005)
NCEA	EPA National Center for Exposure Assessment provisional value. Not all original NCEA source papers were available; R3 was used as secondary source.

TABLE 10

CANCER TOXICITY DATA --- INHALATION

WATSON JOHNSON LANDFILL

c As a conservative measure, total chromium was assumed to be the more toxic hexavalent chromium

R3	EPA Region 3
RTR	Route-to-route extrapolation was used for this analyte (see oral cancer slope factor)
R3-O	Source of toxicity value listed as "Other" in the EPA Region 3 Risk-based Screening Concentration (RBC) Table (EPA 2004).
$(ug/m^3)^{-1}$	1/microgram per cubic meter
$(mg/kg\text{-}day)^{-1}$	1/milligram per kilogram per day

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

EPA 2004. "EPA Region 3 Risk-based Concentration (RBC) Table." Online address: http://www.epa.gov/reg3hwmd/risk/human/index.htm. Last updated October 8, 2004.

EPA 2005. Integrated Risk Information System. Available online at http://www.epa.gov/iris/index.html. Accessed January.

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT ADULT RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Air	Indoor Air Vapor Intrusion(a)	Benzene	--	1.8E-07	--	--	1.8E-07	Vascular/Blood	--	2.2E-03	--	2.2E-03
			Tetrachloroethylene	--	1.8E-07	--	--	1.8E-07	CNS/Liver/Kidney	--	1.8E-04	--	1.8E-04
			Trichloroethylene	--	1.7E-07	--	--	1.7E-07	CNS/Liver/Endocrine Sys	--	1.1E-04	--	1.1E-04
			Vinyl Chloride	--	3.5E-09	--	--	3.5E-09	Liver	--	2.3E-05	--	2.3E-05
			Chemical Total	--	5.3E-07	--	--	5.3E-07		--	2.5E-03	--	2.5E-03
		Exposure Point Total						5.3E-07					2.5E-03
	Exposure Medium Total							5.3E-07					2.5E-03
Medium Total								5.3E-07					2.5E-03
Receptor Total							Receptor Risk Total	5.3E-07				Receptor HI Total	2.5E-03

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

(a) See Attachment C for determination of the modeled indoor air EPCs.

Total Organ 1 (Vascular/Blood) HI Across All Media =	--
Total Organ 2 (Central Nervous System) HI Across All Media =	***2.4E-03***
Total Organ 3 (Developmental) HI Across All Media =	--
Total Organ 4 (Endocrine System) HI Across All Media =	***1.8E-04***
Total Organ 5 (Kidney) HI Across All Media =	***2.2E-03***
Total Organ 6 (Liver) HI Across All Media =	***2.5E-03***
Total Organ 7 (No Observed Adverse Effects) HI Across All Media =	--
Total Organ 8 (Lungs) HI Across All Media =	--

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: FUTURE ADULT RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap (Oral)	1,4-Dichlorobenzene	4.5E-07	--	--	--	4.5E-07	Vascular/Blood/Liver	1.8E-03	--	--	1.8E-03
			Arsenic*	1.7E-04	--	--	--	1.7E-04	Vascular/Blood	1.1E+00	--	--	1.1E+00
			Barium*	--	--	--	--	--	Kidney	7.0E-02	--	--	7.0E-02
			Benzene	5.2E-07	--	--	--	5.2E-07	Vascular/Blood	6.8E-03	--	--	6.8E-03
			beta-BHC	4.7E-07	--	--	--	4.7E-07	--	--	--	--	--
			Bis(2-Ethylhexyl)phthalate	6.7E-07	--	--	--	6.7E-07	Liver	7.0E-03	--	--	7.0E-03
			Boron	--	--	--	--	--	Developmental	4.2E-02	--	--	4.2E-02
			Chromium*	--	--	--	--	--	NOAEL	2.1E-02	--	--	2.1E-02
			Cis-1, 2-Dichloroethylene	--	--	--	--	--	Vascular/Blood	7.4E-02	--	--	7.4E-02
			Cyanide*	--	--	--	--	--	CNS	1.9E-02	--	--	1.9E-02
			Manganese*	--	--	--	--	--	CNS	1.9E+00	--	--	1.9E+00
			Tetrachloroethylene	5.9E-05	--	--	--	5.9E-05	Liver	3.2E-02	--	--	3.2E-02
			Trichloroethylene	1.7E-04	--	--	--	1.7E-04	Liver/Kidney/Developmental	4.1E+00	--	--	4.1E+00
			Vanadium*	--	--	--	--	--	Kidney	3.3E-02	--	--	3.3E-02
			Vinyl Chloride	4.1E-05	--	--	--	4.1E-05	Liver	5.5E-02	--	--	5.5E-02
			Chemical Total	4.4E-04	--	--	--	4.4E-04		7.4E+00	--	--	7.4E+00
		Exposure Point Total						4.4E-04					7.4E+00
		Tap (Inhalation during Showering)	1,4-Dichlorobenzene	--	2.4E-07	--	--	2.4E-07	Liver	--	1.4E-04	--	1.4E-04
			Benzene	--	2.1E-07	--	--	2.1E-07	Vascular/Blood	--	2.6E-03	--	2.6E-03
			Cis-1, 2-Dichloroethylene	--	--	--	--	--	--	--	--	--	--
			Tetrachloroethylene	--	1.3E-06	--	--	1.3E-06	CNS/Liver/Kidney	--	1.4E-03	--	1.4E-03
			Trichloroethylene	--	1.1E-04	--	--	1.1E-04	CNS/Liver/Endocrine Sys.	--	7.1E-02	--	7.1E-02
			Vinyl Chloride	--	8.3E-07	--	--	8.3E-07	Liver	--	5.5E-03	--	5.5E-03
			Chemical Total	--	1.1E-04	--	--	1.1E-04		--	8.0E-02	--	8.0E-02
		Exposure Point Total						1.1E-04					8.0E-02
	Exposure Medium Total							5.5E-04					7.5E+00
Medium Total								5.5E-04					7.5E+00
Receptor Total							Receptor Risk Total	5.5E-04				Receptor HI Total	7.5E+00

Notes:

--	Not available or not applicable
BHC	Hexachlorocyclohexane
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
NOAEL	No Observed Adverse Effects Level
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***1.2E+00***
Total Organ 2 (Central Nervous System) HI Across All Media =	***2.0E+00***
Total Organ 3 (Developmental) HI Across All Media =	***4.1E+00***
Total Organ 4 (Endocrine System) HI Across All Media =	***7.1E-02***
Total Organ 5 (Kidney) HI Across All Media =	***4.2E+00***
Total Organ 6 (Liver) HI Across All Media =	***4.3E+00***
Total Organ 7 (No Observed Adverse Effects) HI Across All Media =	***2.1E-02***

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT/FUTURE ADULT RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Surface Soil	Aluminum*	--	--	--	--	--	CNS/Developmental	2 8E-02	--	1.1E-03	2.9E-02
			Arsenic	5 4E-06	--	6.4E-07	--	6.0E-06	Vascular/Blood	3.5E-02	--	4.2E-03	3.9E-02
			Benzo(a)pyrene	3.8E-07	--	2.3E-07	--	6 0E-07	--	--	--	--	--
			Cadmium*	--	--	--	--	--	Kidney	3.6E-03	--	2.9E-04	3.9E-03
			Chromium*	--	--	--	--	--	NOAEL	1.4E-02	--	2.2E-02	3 6E-02
			Iron*	--	--	--	--	--	Liver	2.7E-01	--	1.1E-02	2.8E-01
			Manganese*	--	--	--	--	--	CNS	9.1E-02	--	9.0E-02	1.8E-01
			Thallium*	--	--	--	--	--	Vascular/Blood	3.5E-02	--	1.4E-03	3.6E-02
			Vanadium*	--	--	--	--	--	Kidney	6.6E-02	--	1.0E-01	1.7E-01
			Chemical Total	5.7E-06	--	8.7E-07	--	6.6E-06		5.4E-01	--	2 3E-01	7.7E-01
		Exposure Point Total						6.6E-06					7.7E-01
	Exposure Medium Total							6.6E-06					7.7E-01
	Air	Outdoor Air (Particulates)	Aluminum*	--	--	--	--	--	CNS	--	4.2E-03	--	4.2E-03
			Arsenic	--	8.1E-09	--	--	8.1E-09	--	--	--	--	--
			Benzo(a)pyrene	--	2.4E-11	--	--	2.4E-11	--	--	--	--	--
			Cadmium*	--	5.9E-10	--	--	5.9E-10	Kidney	--	4.8E-06	--	4.8E-06
			Chromium*	--	9.0E-08	--	--	9.0E-08	Lungs	--	2.7E-03	--	2.7E-03
			Iron*	--	--	--	--	--	--	--	--	--	--
			Manganese*	--	--	--	--	--	CNS	--	1 9E-02	--	1.9E-02
			Thallium*	--	--	--	--	--	--	--	--	--	--
			Vanadium*	--	--	--	--	--	--	--	--	--	--
			Chemical Total	--	9.9E-08	--	--	9.9E-08		--	2.6E-02	--	2.6E-02
		Exposure Point Total						9.9E-08					2.6E-02
	Exposure Medium Total							9.9E-08					2.6E-02
Medium Total								6 7E-06					7.9E-01

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT/FUTURE ADULT RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	Sediment	Arsenic*	3.7E-08	--	6.5E-08	--	1.0E-07	Vascular/Blood	2.4E-04	--	4.2E-04	6.6E-04
			Iron*	--	--	--	--	--	Liver	6.8E-03	--	4.0E-03	1.1E-02
			Manganese*	--	--	--	--	--	CNS	1.2E-03	--	1.8E-02	1.9E-02
			Thallium*	--	--	--	--	--	Vascular/Blood	7.6E-04	--	4.5E-04	1.2E-03
			Chemical Total	3.7E-08	--	6.5E-08	--	1.0E-07		9.0E-03	--	2.3E-02	3.2E-02
		Exposure Point Total						1.0E-07					3.2E-02
	Exposure Medium Total							1.0E-07					3.2E-02
Medium Total								1.0E-07					3.2E-02
Surface Water	Surface Water	Surface Water	Arsenic(a)	3.7E-08	--	1.1E-07	--	1.5E-07	Vascular/Blood	2.4E-04	--	7.1E-04	9.5E-04
			Barium	--	--	--	--	--	Kidney	6.3E-04	--	2.6E-02	2.7E-02
			Chromium*	--	--	--	--	--	NOAEL	5.6E-04	--	1.3E-01	1.3E-01
			Iron*	--	--	--	--	--	Liver	1.9E-02	--	5.6E-02	7.5E-02
			Lead*	--	--	--	--	--	--	--	--	--	--
			Manganese	--	--	--	--	--	CNS	8.1E-04	--	5.9E-02	6.0E-02
			Thallium(a)	--	--	--	--	--	Vascular/Blood	1.9E-03	--	5.4E-03	7.3E-03
			Chemical Total	3.7E-08	--	1.1E-07	--	1.5E-07		2.3E-02	--	2.6E-01	3.0E-01
		Exposure Point Total						1.5E-07					3.0E-01
	Exposure Medium Total							1.5E-07					3.0E-01
Medium Total								1.5E-07					3.0E-01
Receptor Total							Receptor Risk Total	7.0E-06				Receptor HI Total	1.1E+00

Notes:

--	Not available or not applicable
BHC	Hexachlorocyclohexane
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
NOAEL	No Observed Adverse Effects Level
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***9.4E-02***
Total Organ 2 (Central Nervous System) HI Across All Media =	***2.9E-01***
Total Organ 3 (Developmental) HI Across All Media =	***2.9E-02***
Total Organ 4 (Endocrine System) HI Across All Media =	--
Total Organ 5 (Kidney) HI Across All Media =	***2.0E-01***
Total Organ 6 (Liver) HI Across All Media =	***3.7E-01***
Total Organ 7 (No Observed Adverse Effects) HI Across All Media =	***1.3E-01***
Total Organ 8 (Lungs) HI Across All Media =	***2.7E-03***

(a) Statistical background comparisons could not be performed because these COPCs were not detected in background samples. See Attachment E for more detail on statistical methods.

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Air	Indoor Air Vapor Intrusion (b)	Benzene	--	1.6E-07	--	--	1.6E-07	Vascular/Blood	--	7.8E-03	--	7.8E-03
			Tetrachloroethylene	--	1.6E-07	--	--	1.6E-07	CNS/Liver/Kidney	--	6.5E-04	--	6.5E-04
			Trichloroethylene	--	1.5E-07	--	--	1.5E-07	CNS/Liver/Endocrine Sys.	--	3.8E-04	--	3.8E-04
			Vinyl Chloride (a)	--	4.1E-08	--	--	4.1E-08	Liver	--	8.3E-05	--	8.3E-05
			Chemical Total	--	5.0E-07	--	--	5.0E-07		--	8.9E-03	--	8.9E-03
		Exposure Point Total						5.0E-07					8.9E-03
	Exposure Medium Total							5.0E-07					8.9E-03
Medium Total								5.0E-07					8.9E-03
Receptor Total							Receptor Risk Total	5.0E-07				Receptor HI Total	8.9E-03

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***7.8E-03***
Total Organ 4 (Central Nervous System) HI Across All Media =	***1.0E-03***
Total Organ 6 (Developmental) HI Across All Media =	--
Total Organ 7 (Endocrine System) HI Across All Media =	***3.8E-04***
Total Organ 12 (Kidney) HI Across All Media =	***6.5E-04***
Total Organ 13 (Liver) HI Across All Media =	***1.1E-03***
Total Organ 14 (No Observed Adverse Effects) HI Across All Media =	--
Total Organ 21 (Lungs) HI Across All Media =	--

(a) Toxicity criteria and carcinogenic risk estimates for vinyl chloride were adjusted to comply with the EPA Region 3 memo on Derivation of Vinyl Chloride RBCs (EPA 2001).

(b) See Attachment C for determination of the modeled indoor air EPCs.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: FUTURE CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap (Oral/Dermal)	1,4-Dichlorobenzene	3.4E-07	--	1.7E-07	--	5.1E-07	Vascular/Blood/Liver	5.5E-03	--	2.8E-03	8.2E-03
			Arsenic*	1.3E-04	--	6.4E-07	--	1.3E-04	Vascular/Blood	3.2E+00	--	1.7E-02	3.3E+00
			Barium*	--	--	--	--	--	Kidney	2.1E-01	--	1.5E-02	2.2E-01
			Benzene	3.9E-07	--	4.6E-08	--	4.3E-07	Vascular/Blood	2.1E-02	--	2.4E-03	2.3E-02
			beta-BHC	3.5E-07	--	1.1E-07	--	4.6E-07	--	--	--	--	--
			Bis(2-Ethylhexyl)phthalate	5.0E-07	--	7.2E-07	--	1.2E-06	Liver	2.1E-02	--	3.0E-02	5.1E-02
			Boron	--	--	--	--	--	Developmental	1.3E-01	--	6.5E-04	1.3E-01
			Chromium*	--	--	--	--	--	NOAEL	6.3E-02	--	2.6E-02	8.9E-02
			Cis-1, 2-Dichloroethylene	--	--	--	--	--	Vascular/Blood	2.2E-01	--	1.5E-02	2.4E-01
			Cyanide*	--	--	--	--	--	CNS	5.7E-02	--	2.9E-04	5.7E-02
			Manganese*	--	--	--	--	--	CNS	5.7E+00	--	7.3E-01	6.4E+00
			Tetrachloroethylene	4.5E-05	--	2.0E-05	--	6.5E-05	Liver	9.7E-02	--	4.3E-02	1.4E-01
			Trichloroethylene	1.3E-04	--	1.6E-05	--	1.4E-04	Liver/Kidney/Developmental	1.2E+01	--	1.6E+00	1.4E+01
			Vanadium*	--	--	--	--	--	Kidney	9.8E-02	--	1.9E-02	1.2E-01
			Vinyl Chloride (a)	4.1E-04	--	1.7E-05	--	4.2E-04	Liver	1.7E-01	--	7.0E-03	1.7E-01
			Chemical Total	7.1E-04	--	5.5E-05	--	7.6E-04		2.2E+01	--	2.5E+00	2.5E+01
		Exposure Point Total						7.6E-04					2.5E+01
	Exposure Medium Total							7.6E-04					2.5E+01
Medium Total								7.6E-04					2.5E+01
Receptor Total							Receptor Risk Total	7.6E-04				Receptor HI Total	2.5E+01

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***3.5E+00***
Total Organ 2 (Central Nervous System) HI Across All Media =	***6.5E+00***
Total Organ 3 (Developmental) HI Across All Media =	***1.4E+01***
Total Organ 4 (Endocrine System) HI Across All Media =	--
Total Organ 5 (Kidney) HI Across All Media =	***1.4E+01***
Total Organ 6 (Liver) HI Across All Media =	***1.4E+01***
Total Organ 7 (No Observed Adverse Effects) HI Across All Media =	***8.9E-02***
Total Organ 8 (Lungs) HI Across All Media =	--

(a) Toxicity criteria and carcinogenic risk estimates for vinyl chloride were adjusted to comply with the EPA Region 3 memo on Derivation of Vinyl Chloride RBCs (EPA 2001).

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT/FUTURE CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Surface Soil	Aluminum*	–	–	–	–	–	CNS/Developmental	2.6E-01	–	7.3E-03	2.7E-01
			Arsenic	1.3E-05	–	1.1E-06	–	1.4E-05	Vascular/Blood	3.2E-01	–	2.7E-02	3.5E-01
			Benzo(a)pyrene	8.8E-07	–	3.7E-07	–	1.2E-06	–	–	–	–	–
			Cadmium*	–	–	–	–	–	Kidney	3.4E-02	–	1.9E-03	3.6E-02
			Chromium*	–	–	–	–	–	NOAEL	1.3E-01	–	1.4E-01	2.7E-01
			Iron*	–	–	–	–	–	Liver	2.5E+00	–	6.9E-02	2.6E+00
			Manganese*	–	–	–	–	–	CNS	8.4E-01	–	5.9E-01	1.4E+00
			Thallium*	–	–	–	–	–	Vascular/Blood	3.2E-01	–	9.1E-03	3.3E-01
			Vanadium*	–	–	–	–	–	Kidney	6.2E-01	–	6.6E-01	1.3E+00
			Chemical Total	1.3E-05	–	1.4E-06	–	1.5E-05		5.0E+00	–	1.5E+00	6.5E+00
		Exposure Point Total						1.5E-05					6.5E+00
	Exposure Medium Total							1.5E-05					6.5E+00
	Air	Outdoor Air (Particulates)	Aluminum*	–	–	–	–	–	CNS	–	1.5E-02	–	1.5E-02
			Arsenic	–	7.2E-09	–	–	7.2E-09	–	–	–	–	–
			Benzo(a)pyrene	–	2.1E-11	–	–	2.1E-11	–	–	–	–	–
			Cadmium*	–	5.2E-10	–	–	5.2E-10	Kidney	–	1.7E-05	–	1.7E-05
			Chromium*	–	8.0E-08	–	–	8.0E-08	Lungs	–	9.7E-03	–	9.7E-03
			Iron*	–	–	–	–	–	–	–	–	–	–
			Manganese*	–	–	–	–	–	CNS	–	6.8E-02	–	6.8E-02
			Thallium*	–	–	–	–	–	–	–	–	–	–
			Vanadium*	–	–	–	–	–	–	–	–	–	–
			Chemical Total	–	8.7E-08	–	–	8.7E-08		–	9.2E-02	–	9.2E-02
		Exposure Point Total						8.7E-08					9.2E-02
	Exposure Medium Total							8.7E-08					9.2E-02
Medium Total								1.5E-05					6.6E+00
Sediment	Sediment	Sediment	Arsenic*	8.7E-08	–	8.7E-08	–	1.7E-07	Vascular/Blood	2.3E-03	–	2.3E-03	4.5E-03
			Iron*	–	–	–	–	–	Liver	6.3E-02	–	2.1E-02	8.4E-02
			Manganese*	–	–	–	–	–	CNS	1.1E-02	–	9.6E-02	1.1E-01
			Thallium*	–	–	–	–	–	Blood	7.1E-03	–	2.4E-03	9.5E-03
			Chemical Total	8.7E-08	–	8.7E-08	–	1.7E-07		8.4E-02	–	1.2E-01	2.1E-01
		Exposure Point Total						1.7E-07					2.1E-01
	Exposure Medium Total							1.7E-07					2.1E-01
Medium Total								1.7E-07					2.1E-01

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT/FUTURE CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	Arsenic(a)	4.4E-08	–	3.9E-08	–	8.2E-08	Vascular/Blood	1.1E-03	–	1.0E-03	2.1E-03
			Barium	–	–	–	–	–	Kidney	2.9E-03	–	3.7E-02	4.0E-02
			Chromium*	–	–	–	–	–	NOAEL	2.6E-03	–	1.9E-01	1.9E-01
			Iron*	–	–	–	–	–	Liver	8.9E-02	–	8.0E-02	1.7E-01
			Lead*	–	–	–	–	–	–	–	–	–	–
			Manganese	–	–	–	–	–	CNS	3.8E-03	–	8.4E-02	8.8E-02
			Thallium(a)	–	–	–	–	–	Vascular/Blood	8.7E-03	–	7.7E-03	1.6E-02
			Chemical Total	4.4E-08	–	3.9E-08	–	8.2E-08		1.1E-01	–	4.0E-01	5.1E-01
		Exposure Point Total						8.2E-08					5.1E-01
	Exposure Medium Total							8.2E-08					5.1E-01
Medium Total								8.2E-08					5.1E-01
Receptor Total							Receptor Risk Total	1.5E-05				Receptor HI Total	7.3E+00

Notes:

–	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***7.2E-01***
Total Organ 4 (Central Nervous System) HI Across All Media =	***2.0E+00***
Total Organ 6 (Developmental) HI Across All Media =	***2.7E-01***
Total Organ 7 (Endocrine System) HI Across All Media =	--
Total Organ 12 (Kidney) HI Across All Media =	***1.4E+00***
Total Organ 13 (Liver) HI Across All Media =	***2.8E+00***
Total Organ 14 (No Observed Adverse Effects) HI Across All Media =	***4.6E-01***
Total Organ 21 (Lungs) HI Across All Media =	***9.7E-03***

(a) Statistical background comparisons could not be performed because these COPCs were not detected in background samples. See Attachment E of Appendix A.

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT LIFETIME RESIDENT (ADULT + CHILD)
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current
Receptor Population:	Resident
Receptor Age:	Lifetime (Adult + Child)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient[c]				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Air	Indoor Air Vapor Intrusion (b)	Benzene	--	3.4E-07	--	--	3.4E-07	Vascular/Blood	--	7.8E-03	--	7.8E-03
			Tetrachloroethylene	--	3.4E-07	--	--	3.4E-07	CNS/Liver/Kidney	--	6.5E-04	--	6.5E-04
			Trichloroethylene	--	3.2E-07	--	--	3.2E-07	CNS/Liver/Endocrine Sys.	--	3.8E-04	--	3.8E-04
			Vinyl Chloride (a)	--	4.5E-08	--	--	4.5E-08	Liver	--	8.3E-05	--	8.3E-05
			Chemical Total	--	1.0E-06	--	--	1.0E-06		--	8.9E-03	--	8.9E-03
		Exposure Point Total						1.0E-06					8.9E-03
	Exposure Medium Total							1.0E-06					8.9E-03
Medium Total								1.0E-06					8.9E-03
Receptor Total							Receptor Risk Total	1.0E-06				Receptor HI Total	8.9E-03

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***7.8E-03***
Total Organ 4 (Central Nervous System) HI Across All Media =	***1.0E-03***
Total Organ 6 (Developmental) HI Across All Media =	--
Total Organ 7 (Endocrine System) HI Across All Media =	***3.8E-04***
Total Organ 12 (Kidney) HI Across All Media =	***6.5E-04***
Total Organ 13 (Liver) HI Across All Media =	***1.1E-03***
Total Organ 14 (No Observed Adverse Effects) HI Across All Media =	--
Total Organ 21 (Lungs) HI Across All Media =	--

(a) Toxicity criteria and carcinogenic risk estimates for vinyl chloride were adjusted to comply with the EPA Region 3 memo on Derivation of Vinyl Chloride RBCs (EPA 2001).

(b) See Attachment C for determination of the modeled indoor air EPCs.

(c) Non-cancer hazards are calculated based on the child, as a child has higher non-cancer risk that an adult.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: FUTURE LIFETIME RESIDENT (ADULT + CHILD)
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime (Adult + Child)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient[b]				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap	1,4-Dichlorobenzene	7.9E-07	2.4E-07	1.7E-07	--	1.2E-06	Vascular/Blood/Liver	5.5E-03	--	2.8E-03	8.2E-03
		Inhalation during showering (adult)	Arsenic*	3.0E-04	--	6.4E-07	--	3.0E-04	Vascular/Blood	3.2E+00	--	1.7E-02	3.3E+00
		Dermal during bathing (child)	Barium*	--	--	--	--	--	Kidney	2.1E-01	--	1.5E-02	2.2E-01
			Benzene	9.1E-07	2.1E-07	4.6E-08	--	1.2E-06	Vascular/Blood	2.1E-02	--	2.4E-03	2.3E-02
			beta-BHC	8.2E-07	--	1.1E-07	--	9.3E-07	--	--	--	--	--
			Bis(2-Ethylhexyl)phthalate	1.2E-06	--	7.2E-07	--	1.9E-06	Liver	2.1E-02	--	3.0E-02	5.1E-02
			Boron	--	--	--	--	--	Developmental	1.3E-01	--	6.5E-04	1.3E-01
			Chromium*	--	--	--	--	--	NOAEL	6.3E-02	--	2.6E-02	8.9E-02
			Cis-1, 2-Dichloroethylene	--	--	--	--	--	Vascular/Blood	2.2E-01	--	1.5E-02	2.4E-01
			Cyanide*	--	--	--	--	--	CNS	5.7E-02	--	2.9E-04	5.7E-02
			Manganese*	--	--	--	--	--	CNS	5.7E+00	--	7.3E-01	6.4E+00
			Tetrachloroethylene	1.0E-04	1.3E-06	2.0E-05	--	1.3E-04	Liver	9.7E-02	--	4.3E-02	1.4E-01
			Trichloroethylene	3.0E-04	1.1E-04	1.6E-05	--	4.3E-04	Liver/Kidney/Developmental	1.2E+01	--	1.6E+00	1.4E+01
			Vanadium*	--	--	--	--	--	Kidney	9.8E-02	--	1.9E-02	1.2E-01
			Vinyl Chloride (a)	4.5E-04	8.3E-07	1.7E-05	--	4.7E-04	Liver	1.7E-01	--	7.0E-03	1.7E-01
			Chemical Total	1.2E-03	1.1E-04	5.5E-05	--	1.3E-03		2.2E+01	--	2.5E+00	2.5E+01
		Exposure Point Total						1.3E-03					2.5E+01
	Exposure Medium Total							1.3E-03					2.5E+01
Medium Total								1.3E-03					2.5E+01
Receptor Total							Receptor Risk Total	1.3E-03				Receptor HI Total	2.5E+01

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***3.5E+00***
Total Organ 2 (Central Nervous System) HI Across All Media =	***6.5E+00***
Total Organ 3 (Developmental) HI Across All Media =	***1.4E+01***
Total Organ 4 (Endocrine System) HI Across All Media =	--
Total Organ 5 (Kidney) HI Across All Media =	***1.4E+01***
Total Organ 6 (Liver) HI Across All Media =	***1.4E+01***
Total Organ 7 (No Observed Adverse Effects) HI Across All Media =	***8.9E-02***
Total Organ 8 (Lungs) HI Across All Media =	--

(a) Toxicity criteria and carcinogenic risk estimates for vinyl chloride were adjusted to comply with the EPA Region 3 memo on Derivation of Vinyl Chloride RBCs (EPA 2001).

(b) Non-cancer hazards are calculated based on the child, as a child has higher non-cancer risk that an adult.

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT/FUTURE LIFETIME RESIDENT (ADULT + CHILD)
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime (Adult + Child)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient[b]				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Surface Soil	Aluminum*	–	–	–	–	–	CNS/Developmental	2.6E-01	–	7.3E-03	2.7E-01
			Arsenic	1.8E-05	–	1.7E-06	–	2.0E-05	Vascular/Blood	3.2E-01	–	2.7E-02	3.5E-01
			Benzo(a)pyrene	1.3E-06	–	6.0E-07	–	1.9E-06	–	–	–	–	–
			Cadmium*	–	–	–	–	–	Kidney	3.4E-02	–	1.9E-03	3.6E-02
			Chromium*	–	–	–	–	–	NOAEL	1.3E-01	–	1.4E-01	2.7E-01
			Iron*	–	–	–	–	–	Liver	2.5E+00	–	6.9E-02	2.6E+00
			Manganese*	–	–	–	–	–	CNS	8.4E-01	–	5.9E-01	1.4E+00
			Thallium*	–	–	–	–	–	Vascular/Blood	3.2E-01	–	9.1E-03	3.3E-01
			Vanadium*	–	–	–	–	–	Kidney	6.2E-01	–	6.6E-01	1.3E+00
			Chemical Total	1.9E-05	–	2.3E-06	–	2.2E-05		5.0E+00	–	1.5E+00	6.5E+00
		Exposure Point Total						2.2E-05					6.5E+00
	Exposure Medium Total							2.2E-05					6.5E+00
	Air	Outdoor Air (Particulates)	Aluminum*	–	–	–	–	–	CNS	–	1.5E-02	–	1.5E-02
			Arsenic	–	1.5E-08	–	–	1.5E-08	–	–	–	–	–
			Benzo(a)pyrene	–	4.5E-11	–	–	4.5E-11	–	–	–	–	–
			Cadmium*	–	1.1E-09	–	–	1.1E-09	Kidney	–	1.7E-05	–	1.7E-05
			Chromium*	–	1.7E-07	–	–	1.7E-07	Lungs	–	9.7E-03	–	9.7E-03
			Iron*	–	–	–	–	–	–	–	–	–	–
			Manganese*	–	–	–	–	–	CNS	–	6.8E-02	–	6.8E-02
			Thallium*	–	–	–	–	–	–	–	–	–	–
			Vanadium*	–	–	–	–	–	–	–	–	–	–
			Chemical Total	–	1.9E-07	–	–	1.9E-07		–	9.2E-02	–	9.2E-02
		Exposure Point Total						1.9E-07					9.2E-02
	Exposure Medium Total							1.9E-07					9.2E-02
Medium Total								2.2E-05					6.6E+00
Sediment	Sediment	Sediment	Arsenic*	1.2E-07	–	1.5E-07	–	2.7E-07	Vascular/Blood	2.3E-03	–	2.3E-03	4.5E-03
			Iron*	–	–	–	–	–	Liver	6.3E-02	–	2.1E-02	8.4E-02
			Manganese*	–	–	–	–	–	CNS	1.1E-02	–	9.6E-02	1.1E-01
			Thallium*	–	–	–	–	–	Blood	7.1E-03	–	2.4E-03	9.5E-03
			Chemical Total	1.2E-07	–	1.5E-07	–	2.7E-07		8.4E-02	–	1.2E-01	2.1E-01
		Exposure Point Total						2.7E-07					2.1E-01
	Exposure Medium Total							2.7E-07					2.1E-01
Medium Total								2.7E-07					2.1E-01

TABLE 11
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS: CURRENT/FUTURE LIFETIME RESIDENT (ADULT + CHILD)
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime (Adult + Child)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient[b]				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Surface Water	Arsenic(a)	8.1E-08	–	1.5E-07	–	2.3E-07	Vascular/Blood	1.1E-03	–	1.0E-03	2.1E-03
			Barium	–	–	–	–	–	Kidney	2.9E-03	–	3.7E-02	4.0E-02
			Chromium*	–	–	–	–	–	NOAEL	2.6E-03	–	1.9E-01	1.9E-01
			Iron*	–	–	–	–	–	Liver	8.9E-02	–	8.0E-02	1.7E-01
			Lead*	–	–	–	–	–	–	–	–	–	–
			Manganese	–	–	–	–	–	CNS	3.8E-03	–	8.4E-02	8.8E-02
			Thallium(a)	–	–	–	–	–	Vascular/Blood	8.7E-03	–	7.7E-03	1.6E-02
			Chemical Total	8.1E-08	–	1.5E-07	–	2.3E-07		1.1E-01	–	4.0E-01	5.1E-01
		Exposure Point Total						2.3E-07					5.1E-01
	Exposure Medium Total							2.3E-07					5.1E-01
Medium Total								2.3E-07					5.1E-01
Receptor Total							Receptor Risk Total	2.2E-05				Receptor HI Total	7.3E+00

Notes:

–	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***7.2E-01***
Total Organ 4 (Central Nervous System) HI Across All Media =	***2.0E+00***
Total Organ 6 (Developmental) HI Across All Media =	***2.7E-01***
Total Organ 7 (Endocrine System) HI Across All Media =	--
Total Organ 12 (Kidney) HI Across All Media =	***1.4E+00***
Total Organ 13 (Liver) HI Across All Media =	***2.8E+00***
Total Organ 14 (No Observed Adverse Effects) HI Across All Media =	***4.6E-01***
Total Organ 21 (Lungs) HI Across All Media =	***9.7E-03***

(a) Statistical background comparisons could not be performed because these COPCs were not detected in background samples. See Attachment E of Appendix A.

(b) Non-cancer hazards are calculated based on the child, as a child has higher non-cancer risk that an adult.

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

References:

TABLE 12
RISK SUMMARY: CURRENT ADULT RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk (b)					Non-Carcinogenic Hazard Quotient (b)				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Air	Indoor Air Vapor Intrusion (a)		--	--	--	--	--	--	--	--	--	--
			Chemical Total	--	0.0E+00	--	--	0.0E+00		--	0.0E+00	--	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								0.0E+00					0.0E+00
Receptor Total							Receptor Risk Total	0.0E+00				Receptor HI Total	0.0E+00

Notes:

--	Not available or not applicable
BHC	Hexachlorocyclohexane
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
NOAEL	No Observed Adverse Effects Level
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

(a) See Attachment C for determination of the modeled indoor air EPCs.

(b) As shown in Table 7.1.RME, total risks did not exceed 1E-06 and total HI did not exceed 1 for the current adult receptor. Thus, no risk drivers were identified for inclusion in the RAGS Part D Table 10 for this receptor/timeframe combination.

TABLE 12
RISK SUMMARY: FUTURE ADULT RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap (Oral)	Arsenic*	1.7E-04	--	--	--	1.7E-04	Vascular/Blood	1.1E+00	--	--	1.1E+00
			Cis-1, 2-Dichloroethylene (b)	--	--	--	--	--	Vascular/Blood	7.4E-02	--	--	7.4E-02
			Manganese*	--	--	--	--	--	CNS	1.9E+00	--	--	1.9E+00
			Tetrachloroethylene	5.9E-05	--	--	--	5.9E-05	--	--	--	--	--
			Trichloroethylene	1.7E-04	--	--	--	1.7E-04	Liver/Kidney/Developmental	4.1E+00	--	--	4.1E+00
			Vinyl Chloride	4.1E-05	--	--	--	4.1E-05	--	--	--	--	--
			Chemical Total	4.4E-04	--	--	--	4.4E-04		7.2E+00	--	--	7.2E+00
		Exposure Point Total						4.4E-04					7.2E+00
		Tap (Inhalation during Showering)	Cis-1, 2-Dichloroethylene (b)	--	--	--	--	--	--	--	--	--	--
			Tetrachloroethylene	--	1.3E-06	--	--	1.3E-06	--	--	--	--	--
			Trichloroethylene	--	1.1E-04	--	--	1.1E-04	--	--	--	--	--
			Vinyl Chloride	--	8.3E-07	--	--	8.3E-07	--	--	--	--	--
			Chemical Total	--	1.1E-04	--	--	1.1E-04		--	0.0E+00	--	0.0E+00
		Exposure Point Total						1.1E-04					0.0E+00
	Exposure Medium Total							5.5E-04					7.2E+00
Medium Total								5.5E-04					7.2E+00
Receptor Total							Receptor Risk Total	5.5E-04				Receptor HI Total	7.2E+00

Notes:

--	Not available or not applicable
BHC	Hexachlorocyclohexane
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
NOAEL	No Observed Adverse Effects Level
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***1.2E+00***
Total Organ 2 (Central Nervous System) HI Across All Media =	***1.9E+00***
Total Organ 3 (Developmental) HI Across All Media =	***4.1E+00***
Total Organ 4 (Kidney) HI Across All Media =	***4.1E+00***
Total Organ 5 (Liver) HI Across All Media =	***4.1E+00***

(a) See Attachment C for determination of the modeled indoor air EPCs.

(b) Per EPA Region 3 request, TCE degradation products were included despite cancer risk and/or non-cancer hazard values below 1E-06 and 1, respectively.

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

TABLE 12
RISK SUMMARY: CURRENT/FUTURE ADULT RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Surface Soil	Arsenic	5.4E-06	--	6.4E-07	--	6.0E-06	--	--	--	--	--
			Chemical Total	5.4E-06	--	6.4E-07	--	6.0E-06		0.0E+00	--	0.0E+00	0.0E+00
		Exposure Point Total						6.0E-06					0.0E+00
	Exposure Medium Total							6.0E-06					0.0E+00
	Air	Outdoor Air (Particulates)		--	--	--	--	--	--	--	--	--	--
			Chemical Total	--	0.0E+00	--	--	0.0E+00		--	0.0E+00	--	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								6.0E-06					0.0E+00
Sediment	Sediment	Sediment		--	--	--	--	--	--	--	--	--	--
			Chemical Total	0.0E+00	--	0.0E+00	--	0.0E+00		0.0E+00	--	0.0E+00	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								0.0E+00					0.0E+00
Surface Water	Surface Water	Surface Water		--	--	--	--	--	--	--	--	--	--
			Chemical Total	0.0E+00	--	0.0E+00	--	0.0E+00		0.0E+00	--	0.0E+00	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								0.0E+00					0.0E+00
Receptor Total							Receptor Risk Total	6.0E-06				Receptor HI Total	0.0E+00

Notes:

--	Not available or not applicable
BHC	Hexachlorocyclohexane
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
NOAEL	No Observed Adverse Effects Level
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

TABLE 12
RISK SUMMARY: CURRENT CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk (b)					Non-Carcinogenic Hazard Quotient (b)				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Air	Indoor Air Vapor Intrusion (a)		–	–	–	–	–	–	–	–	–	–
			Chemical Total	–	0.0E+00	–	–	0.0E+00		–	0.0E+00	–	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								0.0E+00					0.0E+00
Receptor Total							Receptor Risk Total	0.0E+00				Receptor HI Total	0.0E+00

Notes:

–	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

(a) See Attachment C for determination of the modeled indoor air EPCs.

(b) As shown in Table 7.4.RME, total risks did not exceed 1E-06 and total HI did not exceed 1 for the current child receptor. Thus, no risk drivers were identified for inclusion in the RAGS Part D Table 10 for this receptor/timeframe combination.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 12
RISK SUMMARY: FUTURE CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap (Oral/Dermal)	Arsenic*	1.3E-04	--	6.4E-07	--	1.3E-04	Vascular/Blood	3.2E+00	--	1.7E-02	3.3E+00
			Bis(2-Ethylhexyl)phthalate	5.0E-07	--	7.2E-07	--	1.2E-06	--	--	--	--	--
			Cis-1, 2-Dichloroethylene (b)	--	--	--	--	--	Vascular/Blood	2.2E-01	--	1.5E-02	2.4E-01
			Manganese*	--	--	--	--	--	CNS	5.7E+00	--	7.3E-01	6.4E+00
			Tetrachloroethylene	4.5E-05	--	2.0E-05	--	6.5E-05	--	--	--	--	--
			Trichloroethylene	1.3E-04	--	1.6E-05	--	1.4E-04	Liver/Kidney/Developmental	1.2E+01	--	1.6E+00	1.4E+01
			Vinyl Chloride (a)	4.1E-04	--	1.7E-05	--	4.2E-04	Liver	1.7E-01	--	7.0E-03	1.7E-01
			Chemical Total	7.0E-04	--	5.5E-05	--	7.6E-04		2.2E+01	--	2.4E+00	2.4E+01
		Exposure Point Total						7.6E-04					2.4E+01
	Exposure Medium Total							7.6E-04					2.4E+01
Receptor Total							Receptor Risk Total	7.6E-04				Receptor HI Total	2.4E+01

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***3.3E+00***
Total Organ 2 (Central Nervous System) HI Across All Media =	***6.4E+00***
Total Organ 3 (Developmental) HI Across All Media =	***1.4E+01***
Total Organ 4 (Kidney) HI Across All Media =	***1.4E+01***
Total Organ 5 (Liver) HI Across All Media =	***1.4E+01***

(a) Toxicity criteria and carcinogenic risk estimates for vinyl chloride were adjusted to comply with the EPA Region 3 memo on Derivation of Vinyl Chloride RBCs (EPA 2001).

(b) Per EPA Region 3 request, TCE degradation products were included despite cancer risk and/or non-cancer hazard values below 1E-06 and 1.0, respectively.

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 12
RISK SUMMARY: CURRENT/FUTURE CHILD RESIDENT
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Surface Soil	Aluminum*	--	--	--	--	--	CNS/Developmental	2.6E-01	--	7.3E-03	2.7E-01
			Arsenic	1.3E-05	--	1.1E-06	--	1.4E-05	Vascular/Blood	3.2E-01	--	2.7E-02	3.5E-01
			Benzo(a)pyrene	8.8E-07	--	3.7E-07	--	1.2E-06	--	--	--	--	--
			Chromium*	--	--	--	--	--	NOAEL	1.3E-01	--	1.4E-01	2.7E-01
			Iron*	--	--	--	--	--	Liver	2.5E+00	--	6.9E-02	2.6E+00
			Manganese*	--	--	--	--	--	CNS	8.4E-01	--	5.9E-01	1.4E+00
			Vanadium*	--	--	--	--	--	Kidney	6.2E-01	--	6.6E-01	1.3E+00
			Chemical Total	1.3E-05	--	1.4E-06	--	1.5E-05		4.4E+00	--	1.5E+00	5.9E+00
		Exposure Point Total						1.5E-05					5.9E+00
	Exposure Medium Total							1.5E-05					5.9E+00
	Air	Outdoor Air (Particulates)		--	--	--	--	--	--	--	--	--	--
			Chemical Total	--	0.0E+00	--	--	0.0E+00		--	0.0E+00	--	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								1.5E-05					5.9E+00
Sediment	Sediment	Sediment		--	--	--	--	--	--	--	--	--	--
			Chemical Total	0.0E+00	--	0.0E+00	--	0.0E+00		0.0E+00	--	0.0E+00	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								0.0E+00					0.0E+00
Surface Water	Surface Water	Surface Water		--	--	--	--	--	--	--	--	--	--
			Chemical Total	0.0E+00	--	0.0E+00	--	0.0E+00		0.0E+00	--	0.0E+00	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								0.0E+00					0.0E+00
Receptor Total							Receptor Risk Total	1.5E-05				Receptor HI Total	5.9E+00

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***3.5E-01***
Total Organ 2 (Central Nervous System) HI Across All Media =	***1.7E+00***
Total Organ 4 (Kidney) HI Across All Media =	***1.3E+00***
Total Organ 5 (Liver) HI Across All Media =	***2.6E+00***
Total Organ 6 (Developmental) HI Across All Media =	***2.7E-01***
Total Organ 7 (NOAEL) HI Across All Media =	***2.7E-01***

(a) Toxicity criteria and carcinogenic risk estimates for vinyl chloride were adjusted to comply with the EPA Region 3 memo on Derivation of Vinyl Chloride RBCs (EPA 2001).

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 12
RISK SUMMARY: CURRENT LIFETIME RESIDENT (ADULT + CHILD)
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current
Receptor Population:	Resident
Receptor Age:	Lifetime (Adult + Child)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Air	Indoor Air Vapor Intrusion		--	--	--	--	--		--	--	--	--
			Chemical Total	--	0.0E+00	--	--	0.0E+00		--	0.0E+00	--	0.0E+00
		Exposure Point Total						0 0E+00					0 0E+00
	Exposure Medium Total							0 0E+00					0 0E+00
Medium Total								0.0E+00					0.0E+00
Receptor Total							Receptor Risk Total	0.0E+00				Receptor HI Total	0.0E+00

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 12
RISK SUMMARY: FUTURE LIFETIME RESIDENT (ADULT + CHILD)
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime (Adult + Child)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient[b]				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap											
		Inhalation during showering (adult)	Arsenic*	3.0E-04	--	6.4E-07	--	3.0E-04	Vascular/Blood	3.2E+00	--	1.7E-02	3.3E+00
		Dermal during bathing (child)	Benzene	9.1E-07	2.1E-07	4.6E-08	--	1.2E-06	--	--	--	--	--
			Bis(2-Ethylhexyl)phthalate	1.2E-06	--	7.2E-07	--	1.9E-06	--	--	--	--	--
			Cis-1, 2-Dichloroethylene	--	--	--	--	--	Vascular/Blood	2.2E-01	--	1.5E-02	2.4E-01
			Manganese*	--	--	--	--	--	CNS	5.7E+00	--	7.3E-01	6.4E+00
			Tetrachloroethylene	1.0E-04	1.3E-06	2.0E-05	--	1.3E-04	--	--	--	--	--
			Trichloroethylene	3.0E-04	1.1E-04	1.6E-05	--	4.3E-04	Liver/Kidney/Developmental	1.2E+01	--	1.6E+00	1.4E+01
			Vinyl Chloride (a)	4.5E-04	8.3E-07	1.7E-05	--	4.7E-04	Liver	1.7E-01	--	7.0E-03	1.7E-01
			Chemical Total	1.2E-03	1.1E-04	5.5E-05	--	1.3E-03		2.2E+01	--	2.4E+00	2.4E+01
		Exposure Point Total						1.3E-03					2.4E+01
	Exposure Medium Total							1.3E-03					2.4E+01
Medium Total								1.3E-03					2.4E+01
Receptor Total							Receptor Risk Total	1.3E-03				Receptor HI Total	2.4E+01

Notes:

--	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	***3.5E+00***
Total Organ 2 (Central Nervous System) HI Across All Media =	***6.4E+00***
Total Organ 3 (Developmental) HI Across All Media =	***1.4E+01***
Total Organ 4 (Endocrine System) HI Across All Media =	--
Total Organ 5 (Kidney) HI Across All Media =	***1.4E+01***
Total Organ 6 (Liver) HI Across All Media =	***1.4E+01***
Total Organ 7 (No Observed Adverse Effects) HI Across All Media =	--
Total Organ 8 (Lungs) HI Across All Media =	--

(a) Toxicity criteria and carcinogenic risk estimates for vinyl chloride were adjusted to comply with the EPA Region 3 memo on Derivation of Vinyl Chloride RBCs (EPA 2001).

(b) Non-cancer hazards are calculated based on the child, as a child has higher non-cancer risk that an adult.

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 12
RISK SUMMARY: CURRENT/FUTURE LIFETIME RESIDENT (ADULT + CHILD)
REASONABLE MAXIMUM EXPOSURE
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime (Adult + Child)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient[b]				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Surface Soil											
			Arsenic	1.8E-05	–	1.7E-06	–	2.0E-05	–	–	–	–	–
			Benzo(a)pyrene	1.3E-06	–	6.0E-07	–	1.9E-06	–	–	–	–	–
			Iron*	–	–	–	–	–	Liver	2.5E+00	–	6.9E-02	2.6E+00
			Manganese*	–	–	–	–	–	CNS	8.4E-01	–	5.9E-01	1.4E+00
			Vanadium*	–	–	–	–	–	Kidney	6.2E-01	–	6.6E-01	1.3E+00
			Chemical Total	1.9E-05	–	2.3E-06	–	2.2E-05		3.9E+00	–	1.3E+00	5.3E+00
		Exposure Point Total						2.2E-05					5.3E+00
	Exposure Medium Total							2.2E-05					5.3E+00
	Air	Outdoor Air (Particulates)		–	–	–	–	–	–	–	–	–	–
			Chemical Total	–	0.0E+00	–	–	0.0E+00		–	0.0E+00	–	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								2.2E-05					5.3E+00
Sediment	Sediment	Sediment		–	–	–	–	–	–	–	–	–	–
			Chemical Total	0.0E+00	–	0.0E+00	–	0.0E+00		0.0E+00	–	0.0E+00	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								0.0E+00					0.0E+00
Surface Water	Surface Water	Surface Water		–	–	–	–	–	–	–	–	–	–
			Chemical Total	0.0E+00	–	0.0E+00	–	0.0E+00		0.0E+00	–	0.0E+00	0.0E+00
		Exposure Point Total						0.0E+00					0.0E+00
	Exposure Medium Total							0.0E+00					0.0E+00
Medium Total								0.0E+00					0.0E+00
Receptor Total							Receptor Risk Total	2.2E-05				Receptor HI Total	5.3E+00

Notes:

–	Not available or not applicable
CNS	Central nervous system
EPA	U.S. Environmental Protection Agency
HI	Hazard index
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure

Total Organ 1 (Vascular/Blood) HI Across All Media =	–
Total Organ 4 (Central Nervous System) HI Across All Media =	***1.4E+00***
Total Organ 6 (Developmental) HI Across All Media =	–
Total Organ 7 (Endocrine System) HI Across All Media =	–
Total Organ 12 (Kidney) HI Across All Media =	***1.3E+00***
Total Organ 13 (Liver) HI Across All Media =	***2.6E+00***
Total Organ 14 (No Observed Adverse Effects) HI Across All Media =	–
Total Organ 21 (Lungs) HI Across All Media =	–

(a) Statistical background comparisons could not be performed because these COPCs were not detected in background samples. See Attachment E of Appendix A.

(b) Non-cancer hazards are calculated based on the child, as a child has higher non-cancer risk that an adult.

* denotes COPCs whose site EPC values were not determined to be significantly greater than background concentrations (p = 0.05). See Attachment E for more detail on statistical methods.

References:

EPA 2001. Memorandum Regarding Derivation of Vinyl Chloride RBCs. From Jennifer Hubbard, Toxicologist, EPA Region 3 Superfund Technical Support Section. To RBC Table Users. May 6.

TABLE 13: REMEDIATION LEVELS AND CLEANUP ACTIONS FOR SURFACE SOIL

Mercury in Soil (mg/kg)	Spatial Extent	Action to be taken
Less than 0.073	N/A	No Action
0.073 (Probable Food Chain Effects) and less than 1.0 (Probable Direct Effects)	Spatially weighted average concentration across the 6 acre floodplain exceeds 0.073 but is less than 1.0	Determination of Site-specific bioavailability: (1) contaminants are less than 75% bioavailable then utilize in situ treatment to reduce bioavailability (compost soil amendment) with vegetative stabilization to minimize erosion or (2) contaminants are greater than 75% bioavailable then remove and revegetate.
1.0 (Probable Direct Effects) or greater	Any hot spot	Remove, revegetate

TABLE 14: CLEANUP LEVELS FOR SEDIMENT

Cleanup Levels	Sediment (mg/kg)					
	Cadmium	Copper	Lead	Manganese	Selenium	Zinc
Probable Direct Effects	4.98	149	128	1100	20*	459
* Probable effect level not determined; no effect *10 uncertainty factor						

TABLE 15: PRELIMINARY REMEDIAL CLEANUP LEVELS FOR GROUNDWATER

GROUNDWATER COCS	MCL (ug/L)
TCE	5
PCE	5
Cis-1,2-DCE	70
Vinyl Chloride	2
BEHP	6

Table 16
Applicable or Relevant and Appropriate Requirements (ARARs)
For the Selected Remedy
For the
Watson Johnson Landfill

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
1. Pennsylvania Water Quality Standards	25 PA Code, Chapter 93	Applicable	Sets forth criteria for pollutants protect designated uses of water bodies.	Stormwater discharges from the Site to surface waters and wetlands must not cause a violation of these substantive standards.
2. Pennsylvania Flood Plain Management Act Regulations	25 PA Code Chapters 106.31-.32	Relevant and Appropriate	Standards relating to construction, earthmoving, filling and excavation within 100-year flood plain, wetlands and regulated water.	The substantive standards of subsections 106.31 and 106.32 are relevant and appropriate to alternatives involving earthmoving activities in the Tohickon Creek 100-year floodplain and associated wetlands, including cap construction and removal of soil/sediment in areas of ecological concern.
3. Municipal Solid Waste Landfills	25 PA Code Section 273.292(e); 273.234(a)(1)(i) and (ii), (a)(2) and (3), (c), (d), (e), (f), and (g) ; 273.235(a) and (c); and 273.236(a) and (b).	Relevant and Appropriate (not applicable because landfill did not accept waste in applicable time periods under Section 271.113)	Establishes requirements for municipal waste landfills	The substantive requirements of the specific subsections listed are relevant and appropriate to design, construction or maintenance of the cap.

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
4. Act 2 The Land Recycling and Environmental Remediation Standards Act	Section 301(a)(2); 25 PA Code 250.201, 201(a)and (b) and 250.302(a) and (b)	Relevant and Appropriate	Contains statewide health standard for mercury of 10mg/kg.	Mercury is present in surface soil above background levels. Under the facts and circumstances of this Site, the statewide health standard for mercury (10mg/kg) is relevant and appropriate for remedies involving soil cleanup.
5. Fugitive Particulate Matter	25 PA Code Chapter 123.1 and 123.2	Applicable	Establishes particulate matter requirements.	Substantive applicable standards apply to remedial actions.
6. Ambient Air Quality Standards for Particulate Matter	25 PA Code 131.2 and 131.3	Applicable	Establishes standards for particulate matter.	Substantive applicable standards apply to remedial actions.
7. Air Quality Standards	25 PA Code Chapter 123.31	Applicable	Establishes requirements to limit odor emissions.	Substantive requirements applicable during grading of the landfill waste mass.
8. Discharge of Storm Water	40 CFR 122.26 40 CFR 122.44(h)(iv)(4)	Applicable	Storm water from the Site would fall within the definition of storm water discharge associated with industrial activity (40 CFR 122.26((b)(12)) so the substantive requirements of these sections must be met.	Stormwater runoff from the site remediation may result in runoff to Tohickon Creek. Any such runoff must comply with the substantive requirements.

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
9. Erosion and Sediment Control	25 PA Code Chapters 102.4, 102.11 and 102.22.	Applicable	Requires preparation of an erosion and sediment control plan for activities involving land clearing, grading and other earth disturbances and establishes erosion and sediment control criteria. No plan will be submitted since this is a procedural requirement, but any applicable substantive standards shall be met.	Substantive, applicable requirements apply to construction activities at the Site which disturb the ground surface, including clearing, grading and excavation, to extent they are more stringent than federal requirements.
10. Safe Drinking Water Act: Maximum Contaminant Levels (MCLs)	40 CFR 141.61	Relevant and Appropriate	Under the Safe Drinking Water Act, MCLs are enforceable standards for public drinking water supply systems which have at least 15 service connections or are used by at least 25 persons. MCLs are relevant and appropriate requirements for groundwater cleanup.	Groundwater at the site is a potential future source of drinking water; therefore, the drinking water MCLs for carcinogens are to be met in the groundwater plume. The five MCLs for contaminants of concern at the Site are: Vinyl chloride: 2ug/l TCE: 5ug/l cis-1,2- Dichloroethylene: 70 ug/l PCE: 5 ug/l BEHP: 6 ug/l
11. Water Well Drillers License Act	17 PA Code Chapter 47	Applicable	Establishes requirements for the licensing of well drillers, prevention of pollution of underground waters, submittal of well construction records and well abandonment.	Only the substantive portions of these regulations apply to any monitoring, injection and/or recovery well installations.

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
12. Municipal Solid Waste Landfills: Groundwater Requirements.	25 PA Code 273.282 ; 273.283 ; 273.284 and 273.322(e) and (f)	Relevant and Appropriate (not applicable because landfill did not accept waste in applicable time periods under Section 271.113)	Establishes standards related to groundwater monitoring, including well casing requirements and sampling.	The substantive requirements of the specific subsections listed are relevant and appropriate to groundwater monitoring.
13. Underground Injection Control Program	40 CFR Part 144	Applicable	Establishes classes of injection wells and establishes requirements for the Underground Injection Control Program.	The applicable, substantive portions of these regulations apply to the in-situ portion of the remedy, which requires injection of an oxidant and the bioremediation microbes into the aquifer.

Table 17
Applicable or Relevant and Appropriate Requirements (ARARs)
For Landfill Alternatives
Watson Johnson Landfill

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
1. Pennsylvania Water Quality Standards	25 PA Code, Chapter 93	Applicable	Sets forth criteria for pollutants protect designated uses of water bodies.	Stormwater discharges from the Site to surface waters and wetlands must not cause a violation of these substantive standards.
2. Federal Wetlands Requirements	40 CFR Section 6.302(a)	Applicable	Sets forth federal requirements for carrying out provisions of Executive Order 11990 (Protection of Wetlands). No activity that adversely affects a wetland shall be permitted if a practicable alternative that has less effect is available. If there is no other practicable alternative, impacts must be minimized and/or mitigated.	The substantive standards of this regulation are applicable to all Site activities that could affect wetlands.
3. Pennsylvania Flood Plain Management Act Regulations	25 PA Code Chapters 106.31-.32	Relevant and Appropriate	Standards relating to construction, earthmoving, filling and excavation within 100-year flood plain, wetlands and regulated water.	The substantive standards of subsections 106.31 and 106.32 are relevant and appropriate to alternatives involving earthmoving activities in the Tohickon Creek 100-year floodplain and associated wetlands, including cap construction and removal of soil/sediment in areas of ecological concern.

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
4. Municipal Solid Waste Landfills	25 PA Code Section 273.292(e); 273.234(a)(1)(i) and (ii), (a)(2) and (3), (c), (d), (e), (f), and (g) ; 273.235(a) and (c); and 273.236(a) and (b).	Relevant and Appropriate (not applicable because landfill did not accept waste in applicable time periods under Section 271.113)	Establishes requirements for municipal waste landfills	The substantive requirements of the specific subsections listed are relevant and appropriate to design, construction or maintenance of the cap.
5.Act 2 The Land Recycling and Environmental Remediation Standards Act	Section 301(a)(2); 25 PA Code 250.201, 201(a)and (b) and 250.302(a) and (b)	Relevant and Appropriate	Contains statewide health standard for mercury of 10mg/kg.	Mercury is present in surface soil above background levels. Under the facts and circumstances of this Site, the statewide health standard for mercury (10mg/kg) is relevant and appropriate for remedies involving soil cleanup.
6. Fugitive Particulate Matter	25 PA Code Chapter 123.1 and 123.2	Applicable	Establishes particulate matter requirements.	Substantive applicable standards apply to remedial actions.
7. Ambient Air Quality Standards for Particulate Matter	25 PA Code 131.2 and 131.3	Applicable	Establishes standards for particulate matter.	Substantive applicable standards apply to remedial actions.
8. Air Quality Standards	25 PA Code Chapter 123.31	Applicable	Establishes requirements to limit odor emissions.	Substantive requirements applicable during grading of the landfill waste mass.

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
9. Discharge of Storm Water	40 CFR 122.26 40 CFR 122.44(h)(iv)(4)	Applicable	Storm water from the Site would fall within the definition of "storm water discharge associated with industrial activity" (40 CFR 122.26((b)(12)) so the substantive requirements of these sections must be met.	Stormwater runoff from the site remediation may result in runoff to Tohickon Creek. Any such runoff must comply with the substantive requirements.
10. Erosion and Sediment Control	25 PA Code Chapters 102.4, 102.11 and 102.22.	Applicable	Requires preparation of an erosion and sediment control plan for activities involving land clearing, grading and other earth disturbances and establishes erosion and sediment control criteria. No plan will be submitted since this is a procedural requirement, but any applicable substantive standards shall be met.	Substantive, applicable requirements apply to construction activities at the Site which disturb the ground surface, including clearing, grading and excavation, to extent they are more stringent than federal requirements.

Table 18
Applicable or Relevant and Appropriate Requirements
For Groundwater Alternatives
Watson Johnson Landfill

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
1. Safe Drinking Water Act: Maximum Contaminant Levels (MCLs)	40 CFR 141.61	Relevant and Appropriate	Under the Safe Drinking Water Act, MCLs are enforceable standards for public drinking water supply systems which have at least 15 service connections or are used by at least 25 persons. MCLs are relevant and appropriate requirements for groundwater cleanup.	Groundwater at the site is a potential future source of drinking water; therefore, the drinking water MCLs for carcinogens are to be met in the groundwater plume. The five MCLs for contaminants of concern at the Site are: Vinyl chloride: 2ug/l TCE: 5ug/l cis-1,2- Dichloroethylene: 70 ug/l PCE: 5 ug/l BEHP: 6 ug/l
2. Pennsylvania Water Quality Standards	25 PA Code, Chapter 93	Applicable	Sets forth criteria for pollutants that protect designated uses of water bodies.	These would be applicable to stormwater discharges from the Site to surface water or wetlands or to any discharges to surface water or wetlands from a treatment plant.
3. Pennsylvania Flood Plain Management Act	25 PA Code Chapters 106.31-.32	Relevant and Appropriate	Standards relating to construction, earthmoving, filling and excavation within 100-year flood plain, wetlands and regulated water.	The substantive standards of subsections 106.31 and 106.32 are relevant and appropriate to earthmoving activities in the Tohickon Creek 100-year flood plain and associated wetlands, if the treatment plant construction involves such activities.

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
4. Clean Water Act (CWA); National Pollutant Discharge Elimination System Requirements	33 U.S.C. Section 401, et seq. 40 CFR part 122	Applicable	Establishes effluent limitations for discharges to waters of the United States.	Any alternative involving a point source discharge must comply with the substantive portions of these requirements. No permit shall be required.
5. Pennsylvania National Pollutant Discharge Elimination System Requirements	25 PA Code Chapters 92 and 93; 25 PA Code Section 95.2	Applicable	Establishes effluent limitations for discharges to waters of Pennsylvania and establishes specific requirements for waste treatment projects.	Any alternative involving a point source discharge must comply with the substantive portions of these requirements if they are more stringent than the federal NPDES requirements. No permit shall be required.
6. Discharge of Storm Water	40 CFR 50.12	Applicable	Establishes requirements to control and manage stormwater runoff.	The standards applicable to construction activities would have to be met for alternatives involving a wastewater treatment plant.
7. Erosion and Sediment Control	25 PA Code Chapters 102.4, 102.11 and 102.22.	Applicable	Requires preparation of an erosion and sediment control plan for activities involving land clearing, grading and other earth disturbances and establishes erosion ans sediment control criteria. No plan will be submitted but any applicable substantive standards shall be met.	The standards applicable to construction activities would have to be met for alternatives involving a wastewater treatment plant.
8. Underground Injection Control Program	40 CFR Part 144	Applicable	Establishes classes of injection wells and establishes requirements for the Underground Injection Control Program.	The applicable, substantive portions of these regulations apply to the in-situ portion of the remedy, which requires injection of an oxidant and the bioremediation microbes into the aquifer.

ARAR	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARAR in the context of the Remedial Action Alternatives
9. Federal Wetlands Requirements	40 CFR 6.302(a)	Applicable	Sets forth federal requirements for carrying out provisions of Executive Order 11990 (Protection of Wetlands). No activity that adversely affects a wetland shall be permitted if a practicable alternative that has less effect is available. If there is no other practicable alternative, impacts must be minimized and/or mitigated.	The substantive standards of this regulation are applicable to all Site activities that could affect wetlands.
10. Water Well Drillers License Act	17 PA Code Chapter 47	Applicable	Establishes requirements for the licensing of well drillers, prevention of pollution of underground waters, submittal of well construction records and well abandonment.	Only the substantive portions of these regulations apply to any monitoring, injection and/or recovery well installations.
11. Conservation of Power and Water Resources	18 CFR 430	Applicable	Establishes requirements for the extraction and discharge of groundwater within the Delaware River Basin.	Any groundwater extraction system would comply with the substantive portions of the applicable provisions of these regulations.
12. Municipal Solid Waste Landfills: Groundwater Requirements.	25 PA Code 273.282 ; 273.283 ; 273.284 and 273.322(e) and f)	Relevant and Appropriate (not applicable because landfill did not accept waste in applicable time periods under Section 271.113)	Establishes standards related to groundwater monitoring, including well casing requirements and sampling.	The substantive requirements of the specific subsections listed are relevant and appropriate to groundwater monitoring.

TABLE 19
COST OF ALTERNATIVES
WATSON JOHNSON LANDFILL

Alternative	Capital Costs	Annual O&M	Total Present Worth
Landfill Alternatives			
LF 1 - No Action	$0	$0	$0
LF 2 - IC/Engineering Controls	$292,000	$14,000	$466,000
LF 3 – Multi-layer Cap	$8,215,000	$42,000	$8,737,000
LF 4 – Soil Cap	$6,774,000	$42,000	$7,266,000
LF 5 – Soil Cover	$2,829,000	$34,000	$3,251,000
Groundwater Alternatives			
GW 1 – No Action	$0	$0	$0
GW 2 – Limited Action	$103,000	$94,000	$1,270,000
GW 3 – Extraction, Pre-treatment, Discharge POTW	$3,547,000	$1,239,000	$18,922,000
GW 4 - Extraction, Treatment, Discharge Tohickon Creek	$1,740,000	$389,000 (Yrs 1-10) $374,000 (Yrs 11-30)	$6,487,000
GW 5 - ISCO	$2,715,000	$94,000	$3,882,000
GW 6 – ISCO and Enhanced Bioremediation	$3,732,000	$114,000 (15 years)	$4,771,000

TABLE 20
DETAILED COST SUMMARY OF SELECTED REMEDY
WATSON JOHNSON LANDFILL

LANDFILL

	Description	Quantity	Unit	Unit Cost	Cost
100	**Site Preparation**				
101	Mobilization/Demobilization	1	LS	$50,000	$50,000
102	Temporary facilities, trailers, signs, ..	1	LS	$20,000	$20,000
103	Sediment and Erosion Controls	1	LS	$55,000	$55,000
104	Project Plans	1	LS	$25,000	$25,000
105	Clearing	21	Acre	$2,000	$42,000
106	Stormwater Management Ponds/Swales	1	LS	$200,000	$200,000
107	General Site Regrading	10,000	CY	$6	$60,000
108	Subgrade Densification	21	Acre	$1,000	$21,000
109	Site Security	1	LS	$100,000	$100,000
200	**Ecological Areas of Concern**				
201	Submittals (Work Plan, HASP, QAPP, ...)	1	LS	$12,000	$12,000
202	Characterization and Delineation	1	LS	$75,000	$75,000
203	Sediment and Erosion Controls	1	LS	$20,000	$20,000
204	Clearing	1	LS	$25,000	$25,000
205	Excavate/Transport 12" of Contaminated Sed./Soil	6,400	CY	$15	$96,000
206	Confirmation Sampling	1	LS	$35,000	$35,000
207	Backfill with clean fill (SS15, SS29, SS31 area only)	4,370	CY	$25	$109,250
208	Topsoil and Vegetate	3.3	Acre	$22,000	$72,600
209	Access road (clearing, grading, geotextile, 1.5' stone)	1	LS	$40,000	$40,000
300	**Landfill Cap**				
301	12" Bedding Layer Installation (12" over 21 acres)	33,880	CY	$25	$847,000
302	Geocomposite Gas Venting Layer	25,410	SY	$5.00	$127,050
303	40 mil LDPE Geomembrane	101,640	SY	$4.50	$457,380
304	Geocomposite Drainage Layer	101,640	SY	$6.75	$686,070
305	18" Cover Soil Layer (18" over 21 acres)	50,820	CY	$25	$1,270,500
306	6" Topsoil	21	Acre	$19,000	$399,000
307	Vegetative Cover (Seeding/Mulch)	21	Acre	$2,200	$46,200
308	Cap Toe or Pipe Drains	1	LS	$75,000	$75,000
309	Anchor Trench	1	LS	$20,000	$20,000
400	**Landfill Gas Management**				
401	Gas Vents with Turbine Ventilators (9)	9	Each	$1,500	$13,500
402	Gas Monitoring Wells (3)	9	Each	$2,500	$22,500
500	**Other Costs**				
501	Clearing for Fence Line	1	LS	$5,000	$5,000
502	8' Chain-Link-Fence	4,500	LF	$35	$157,500
503	Vehicle Gates	2	LS	$2,500	$5,000
504	Personnel Gates	2	LS	$1,500	$3,000
505	Signs	2.0	LS	$1,000	$2,000
506	H&S and PPE	1	LS	$50,000	$50,000
507	Landscapping (Trees, shrubs on east perimeter)	1	LS	$75,000	$75,000
508	Balance of Work (Supv)	1	LS	$100,000	$100,000

TABLE 20
DETAILED COST SUMMARY OF SELECTED REMEDY
WATSON JOHNSON LANDFILL

LANDFILL

	Description	Quantity	Unit	Unit Cost	Cost
600	**Institutional Controls**				
601	Deed Restrictions	1	LS	$20,000	$20,000
	Construction Cost Subtotal (Rounded Up)				**$5,440,000**
	Contingency on Construction Capital Costs		%	25	$1,360,000
	Remedial Design & Permitting		%	15	$816,000
	Construction Management		%	11	$598,400
Total Construction Cost (Rounded Up)					**$8,215,000**
700	**Annual O&M Cost (30 Years)**				
701	Visual Inspections (Quarterly)	4	LS	$2,500	$10,000
702	Site Maintenance (Reveg., cover repair, etc.)	1	LS	$10,000	$10,000
703	Mowing (every 6 months)	2	LS	$2,000	$4,000
704	Landfill Gas Monitoring (quarterly)	4	LS	$2,000	$8,000
705	Administrative/Management	1	LS	$10,000	$10,000
	Total Annual O&M Cost				**$42,000**
Present Worth of Annual O&M Costs (7% discount rate for 30 years, rounded up)					**$522,000**
Total Present Worth of Landfill Alternative					**$8,737,000**

Notes:
- Backfill in Ecological Areas of Concern at SS15, SS29 and SS31 only. Western and southern swales will be used for SWM swales, therefore, backfill is not needed.

TABLE 20
DETAILED COST SUMMARY OF SELECTED REMEDY
WATSON JOHNSON LANDFILL

GROUNDWATER

	Description	Quantity	Unit	Unit Cost	Cost
100	**Site Preparation and Oxidant Procurement**				
101	Mobilization/Demobilization (ISCO)	1	LS	$75,000	$75,000
102	Subcontractor and Equipment Procurement	1	LS	$15,000	$15,000
103	Temporary facilities, trailers, signs, ...	1	LS	$15,000	$15,000
104	Temporary Access Roads (to well locations)	1	LS	$75,000	$75,000
105	Sediment and Erosion Controls	1	LS	$20,000	$20,000
106	Project Plans and Permits	1	LS	$20,000	$20,000
107	Site Security	1	LS	$10,000	$10,000
108	H&S and PPE	1	LS	$15,000	$15,000
109	Onsite Water Production Well	1	LS	$20,000	$20,000
110	Chemical Oxidant Procurement (22 wells, 2,450 lbsKMnO4 per well per injection, average 1.5 injections per well)	80,850	LB	$2.50	$202,125
200	**Pre-Injection Characterization and Well Installation**				
201	Well Driller Mobilization	1	LS	$5,000	$5,000
202	Drilling Water Handling/Treatment	1	LS	$25,000	$25,000
203	Well Installation (includes 8 new MWs in plume, 3 new MWs just outside of plume, and 2 ISCO injection wells near landfill.	13	EA	$17,000	$221,000
204	Borehole Geophysics, 13 wells	13	EA	$2,000	$26,000
205	Pre-Injection Sampling - New Wells	8	EA	$750	$6,000
206	Pre-Injection Sampling - Existing Wells	6	EA	$750	$4,500
207	Analyses (VOCs, select metals, water quality), non CLP	14	EA	$345	$4,830
208	Pre-Injection Data Analysis and Final Injection Design	1	LS	$20,000	$20,000
300	**Phase 1 ISCO Injection and Monitoring**				
301	Phase 1 Oxidant Injections (7 wells nearest landfill)	1	LS	$56,000	$56,000
302	Phase 1 Monitoring (14 wells, bi-weekly, over 3 months)	84	EA	$750	$63,000
303	Phase 1 Sampling (14 wells, monthly, over 3 months)	42	EA	$750	$31,500
304	Analyses (VOCs, select metals, water quality), non CLP	42	EA	$345	$14,490
305	Phase 1 Data Analysis and Modifications	1	LS	$20,000	$20,000
400	**Phase 2 ISCO Injection and Monitoring**				
401	Well Driller Mobilization	1	LS	$5,000	$5,000
402	Drilling Water Handling/Treatment	1	LS	$15,000	$15,000
403	Well Installation (includes 9 new ISCO injection wells down-gradient of landfill.	9	EA	$17,000	$153,000
404	Borehole Geophysics, 9 wells	9	EA	$2,000	$18,000
405	Phase 2 Oxidant Injections (Injections at 26 wells; 15 wells away from landfill and 11 wells needing supplemental injection)	1	LS	$208,000	$208,000
406	Phase 2 Monitoring (14 wells, bi-weekly, over 3 months)	84	EA	$750	$63,000
407	Phase 2 Sampling (14 wells, monthly, over 3 months)	42	EA	$750	$31,500
408	Analyses (VOCs, select metals, water quality), non CLP	42	EA	$345	$14,490
409	Phase 2 Data Analysis and Modifications	1	LS	$20,000	$20,000

TABLE 20
DETAILED COST SUMMARY OF SELECTED REMEDY
WATSON JOHNSON LANDFILL

GROUNDWATER

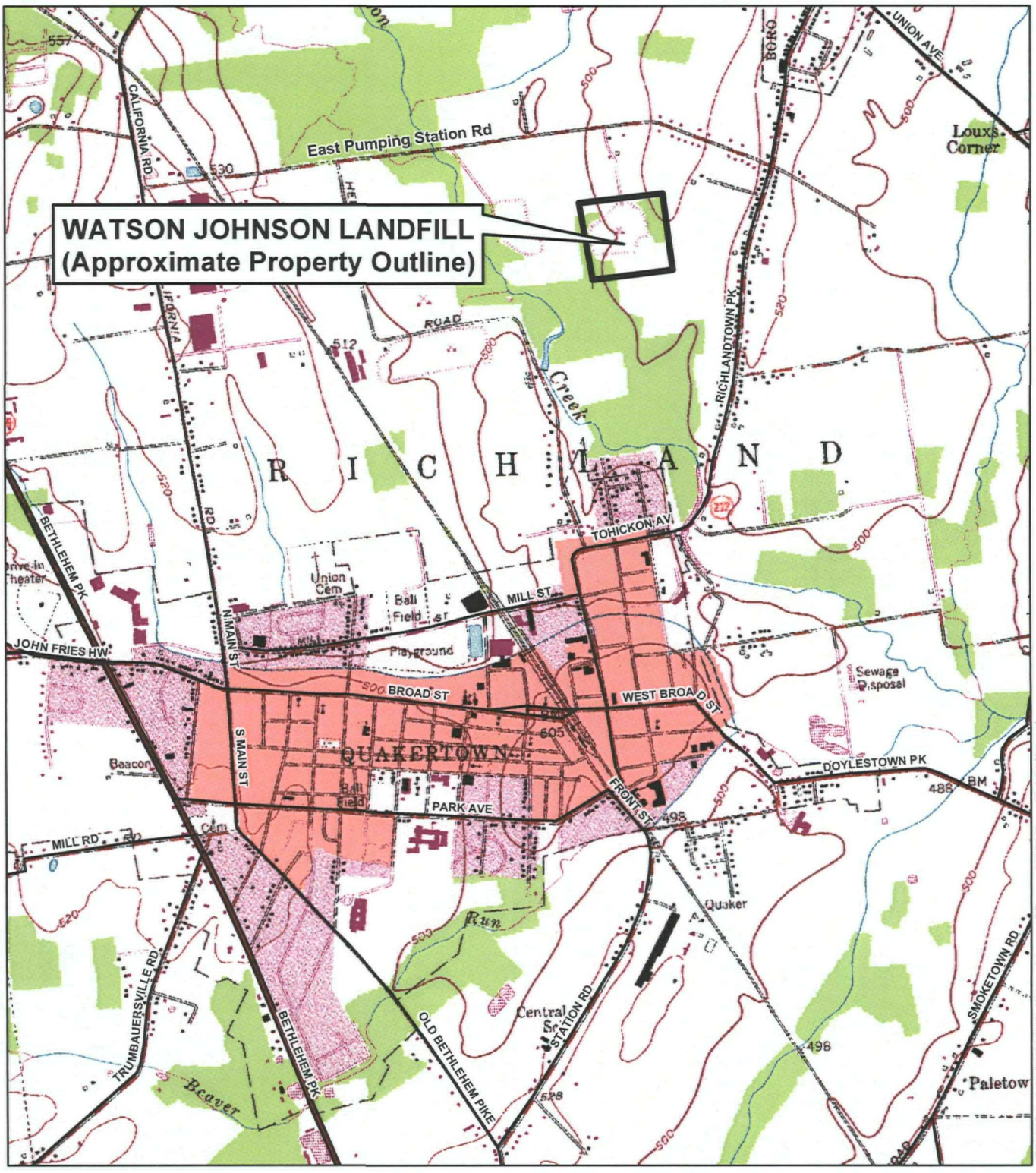
	Description	Quantity	Unit	Unit Cost	Cost
500	**Post-ISCO Remediation Monitoring and Reporting**				
501	Sampling (8 wells, quarterly, over 2 years)	64	EA	$750	$48,000
502	Analyses (VOCs, select metals, water quality), non CLP	64	EA	$345	$22,080
503	Quarterly Reporting (over two years), includes MNA evaluation	8	EA	$10,000	$80,000
504	Interim Remedial Action Report	1	LS	$20,000	$20,000
600	**Enhanced Bioremediation**				
601	Pilot Test	1	LS	$50,000	$50,000
602	Mobilization/Demobilization	1	LS	$20,000	$20,000
603	Project Plans and Permits	1	LS	$15,000	$15,000
604	Temporary facilities, trailers, signs, ...	1	LS	$15,000	$15,000
605	H&S and PPE	1	LS	$5,000	$5,000
606	Subcontractor and Equipment Procurement	1	LS	$15,000	$15,000
607	Electron Donor Procurement (EOS) and Transporation	10,700	LB	$3	$32,100
608	Microbes Procurement (KB-1) and Transporation	470	Liters	$300	$141,000
609	Electron Donor Injection (assumes 3 injections)	3	LS	$15,000	$45,000
610	Microbe Injection (assumes 3 injections)	3	LS	$15,000	$45,000
611	Post Injection Monitoring (14 wells, bi-weekly, over 2 months, 3 phases)	168	EA	$750	$126,000
612	Post Injection Sampling (14 wells, monthly, over 2 months, 3 phases), Performed concurrent with monitoring	84	EA	$250	$21,000
613	Analyses (VOCs, ethene/ethane, TOC, microbes, other), non-CLP	84	EA	$750	$63,000
614	Data Analysis and Modifications	1	LS	$20,000	$20,000
615	Interim Remedial Action Report	1	LS	$20,000	$20,000
700	**Contractor Project Management (10% of Above)** (not including cost of permanganate, EOS, and KB-1)	1	LS	$192,039	$192,039
800	**Down-Gradient Monitoring Well Installation**				
801	Mobilization/Demobilization	1	LS	$3,000	$3,000
802	New Well Installation	4	EA	$10,000	$40,000
900	**Institutional Controls**				
901	Deed Restrictions	1	LS	$25,000	$25,000
	Construction Cost Subtotal (Rounded Up)				**$2,556,000**
	Contingency on Construction Capital Costs		%	25	$639,000
	Remedial Design & Permitting		%	10	$255,600
	Construction Management		%	11	$281,160
Total Construction Cost (Rounded Up)					**$3,732,000**

TABLE 20
DETAILED COST SUMMARY OF SELECTED REMEDY
WATSON JOHNSON LANDFILL

GROUNDWATER

	Description	Quantity	Unit	Unit Cost	Cost
1000	**Annual O&M Cost (15 Years)**				
1001	Groundwater Monitoring (34 wells sampled semi-annually)	68	EA	$750	$51,000
1002	MW VOC and BEHP Analyses, and MNA parameters	68	EA	$775	$52,700
1003	Reporting/Administrative/Management	1	LS	$10,000	$10,000
	Total Annual O&M Cost (Rounded)				**$114,000**
	Present Worth of Annual O&M Costs (7% discount rate for 15 years, rounded up)				**$1,039,000**
	Total Present Worth of Groundwater Alternative				**$4,771,000**

Note 1. EOS is injected with a Dosatron D1520.
Note 2. KB-1 is injected under an argon blanket.
Note 3. For full-scale implementation, assume 14 existing monitoring well, 60 feet of saturated thickness for EOS and KB-1 application. (Budgeting purposes only)
Note 4. EOS and KB-1 costs and spatial application rates were obtained from Dajak, LLC

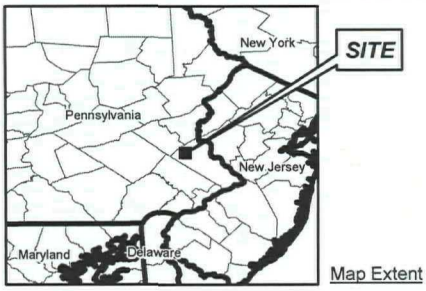


TETRA TECH, INC.

FIGURE 1
PROPERTY LOCATION MAP
WATSON JOHNSON LANDFILL
QUAKERTOWN, PA

AR302248

Aerial Photography by Land & Mapping, February 2002



Map Extent

0 500 1,000 2,000

Feet

N
W E
S

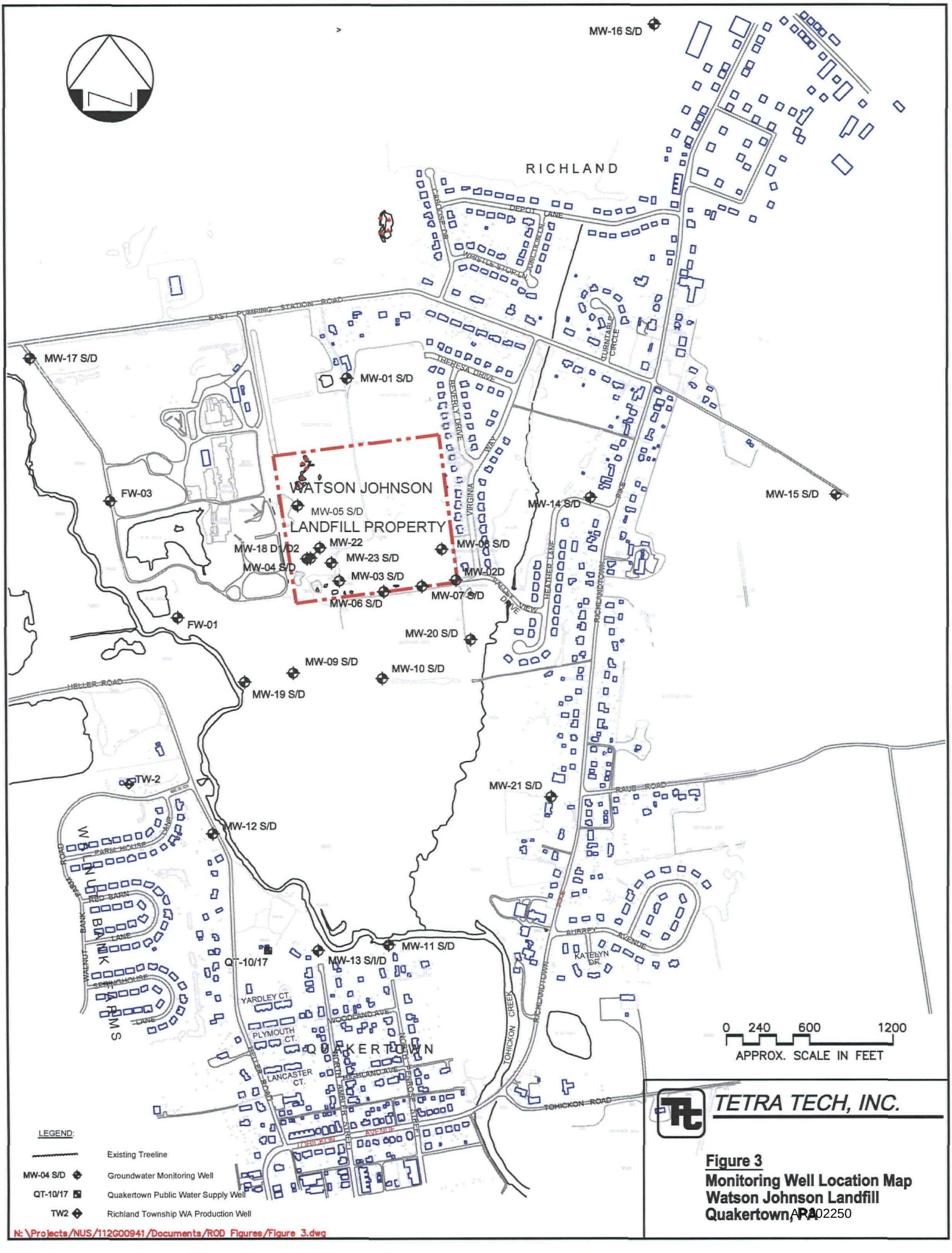
Legend

WJL Study Area

TETRA TECH, INC.

FIGURE 2
WJL STUDY AREA
WATSON JOHNSON LANDFILL
QUAKERTOWN, PA

AR302249



TETRA TECH, INC.

Figure 3
Monitoring Well Location Map
Watson Johnson Landfill
Quakertown, PA

AR302250

WEST

RPW

NOT SAMPLED

MW12

QT10

QT17

MW19

MW09

MW05

MW04

MW18

MW13

MW01

MW03

MW06

MW10

MW11

MW07

MW08

MW02

MW20

500'

400'

300'

200'

100'

0'

-100'

-200'

-300'

FEET ABOVE MARKER BED DATUM LINE

FEET BELOW MARKER BED DATUM LINE

MARKER BED DATUM LINE (SEE NOTE 6)

UNIT 2A

UNIT 2B

UNIT 2C

200

60

(-15)

(-110)

STRATIGRAPHIC UNIT 1

STRATIGRAPHIC UNIT 2

STRATIGRAPHIC UNIT 3

LEGEND

- WELLS WITH ANY DETECTIONS OF PCE
- WELLS WITH ANY DETECTIONS OF TCE
- WELLS WITH ANY DETECTIONS OF CIS 1, 2-DCE
- WELLS WITH ANY DETECTIONS OF VINYL CHLORIDE

TOP OF WELL

SCREEN INTERVAL

OPEN ROCK INTERVAL

TOTAL WELL DEPTH

VERTICAL SCALE: 1"=100'

NOTES:

1) FIGURE REPRESENTS APPROXIMATELY 2,020 FEET OF STRATIGRAPHIC SECTION IN BRUNSWICK FORMATION.
2) TOTAL WELL DEPTH SHOWN
3) SECTION ASSUMES NO MAJOR STRUCTURES THAT IMPACT OVERALL STRIKE AND DIP
4) STRATIGRAPHIC CROSS-SECTION DOES NOT DEPICT A TRUE REPRESENTATION OF THE VERTICAL DEPTH CHANGE BETWEEN WELLS. SEE RI FIGURES 4-19 THROUGH 4-24 FOR STRUCTURAL CROSS-SECTIONS WHICH DEPICT VERTICAL CORRELATION.
5) STRATIGRAPHIC UNITS: STRATIGRAPHIC UNIT 2 IS DEFINED AS THE ROCKS WHICH OUTCROP IN THE VICINITY OF THE LANDFILL. UNIT 1 IS DEFINED AS THE ROCKS STRATIGRAPHICALLY HIGHER (AND YOUNGER) THAN UNIT 2. UNIT 3 IS DEFINED AS THE ROCKS STRATIGRAPHICALLY LOWER (AND OLDER)THAN UNIT 2.
6) THE MARKER BED DATUM LINE SELECTION IS ARBITRARY AND INTENDED TO ALLOW FOR STRATIGRAPHIC CORRELATION BETWEEN ALL WELLS.
7) WELLS MW14, MW15, MW16, MW17 AND MW21 NOT SHOWN TO MAXIMIZE SCALE.

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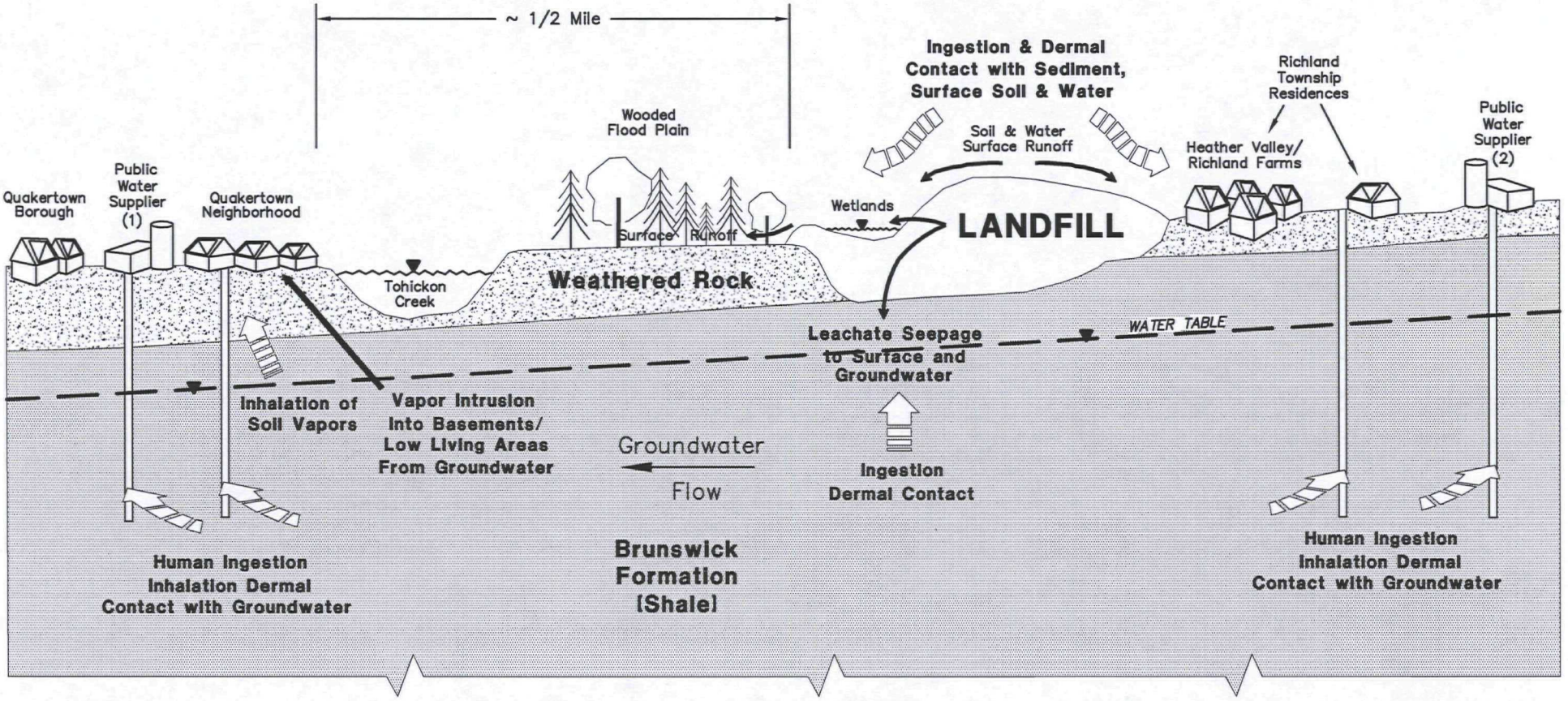
Figure 4
Stratigraphic Cross-Section with Solvent VOC's
Watson Johnson Landfill
Quakertown, Pennsylvania

South–Southwest

Conceptual Site Model for Human Health
Watson Johnson Landfill



Brunswick Formation (Shale) | Weathered Rock | Exposure Route | Release Mechanism

Note:

Public Water Supplier: (1) Quakertown Borough and Richland Township
(2) Quakertown Borough

Not To Scale

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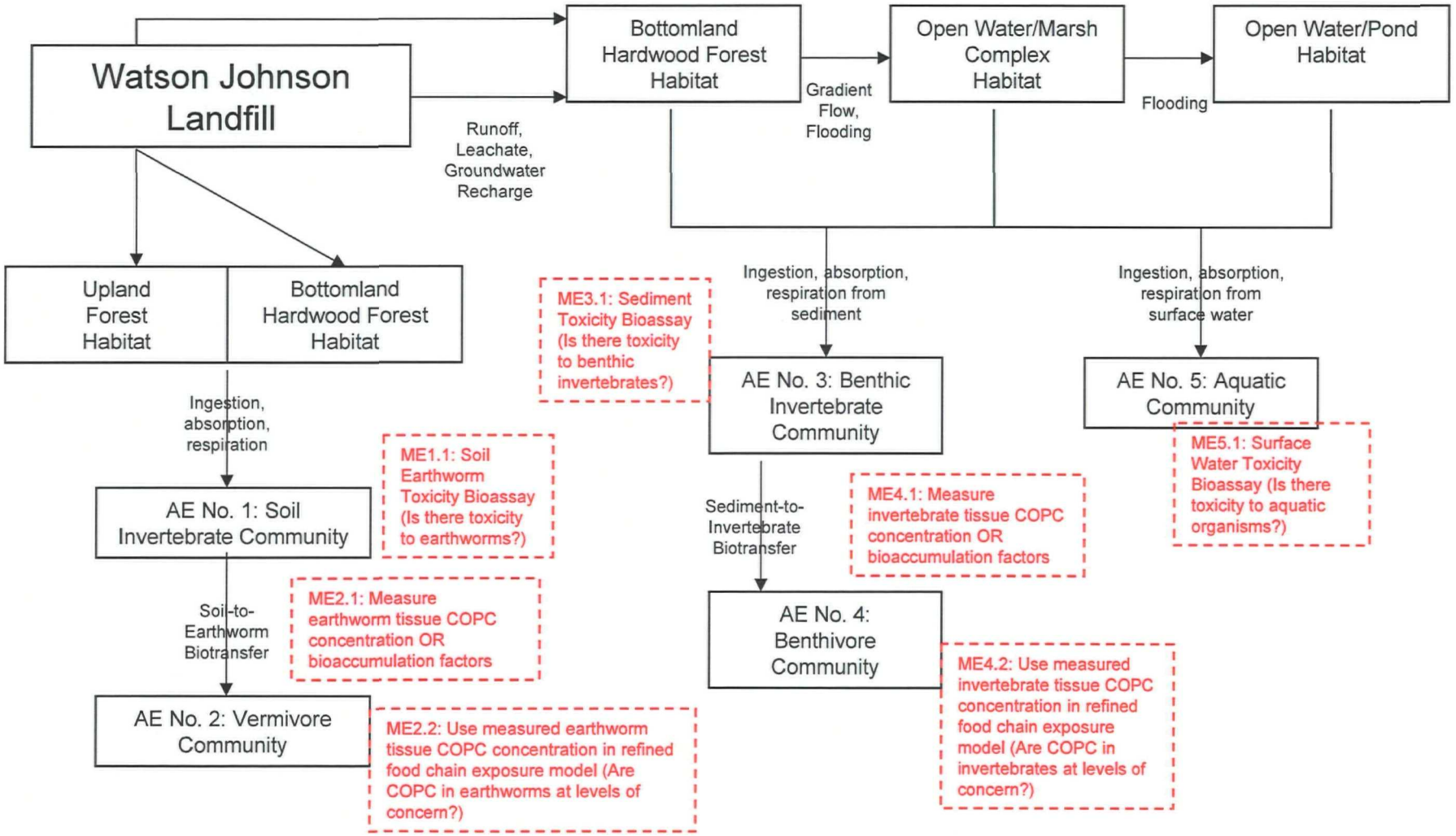
TETRA TECH, INC.

Figure 5
HHRA Conceptual Site Model
Watson Johnson Landfill
Quakertown, Pennsylvania

Figure 6
Conceptual Site Model
Baseline Ecological Risk Assessment Problem Formulation
Watson Johnson Landfill Superfund Site



Legend

- Off-Site Surface Soil Sample
- Interim Surface Soil Sample
- *Limits of Waste*
- Eco Areas of Concern

0 350 700 1,400
Feet

N
W E
S

TETRA TECH, INC.

Figure 7
Surface Soil Sample Locations
Watson Johnson Landfill
Quakertown, Pennsylvania

AR302254

Legend

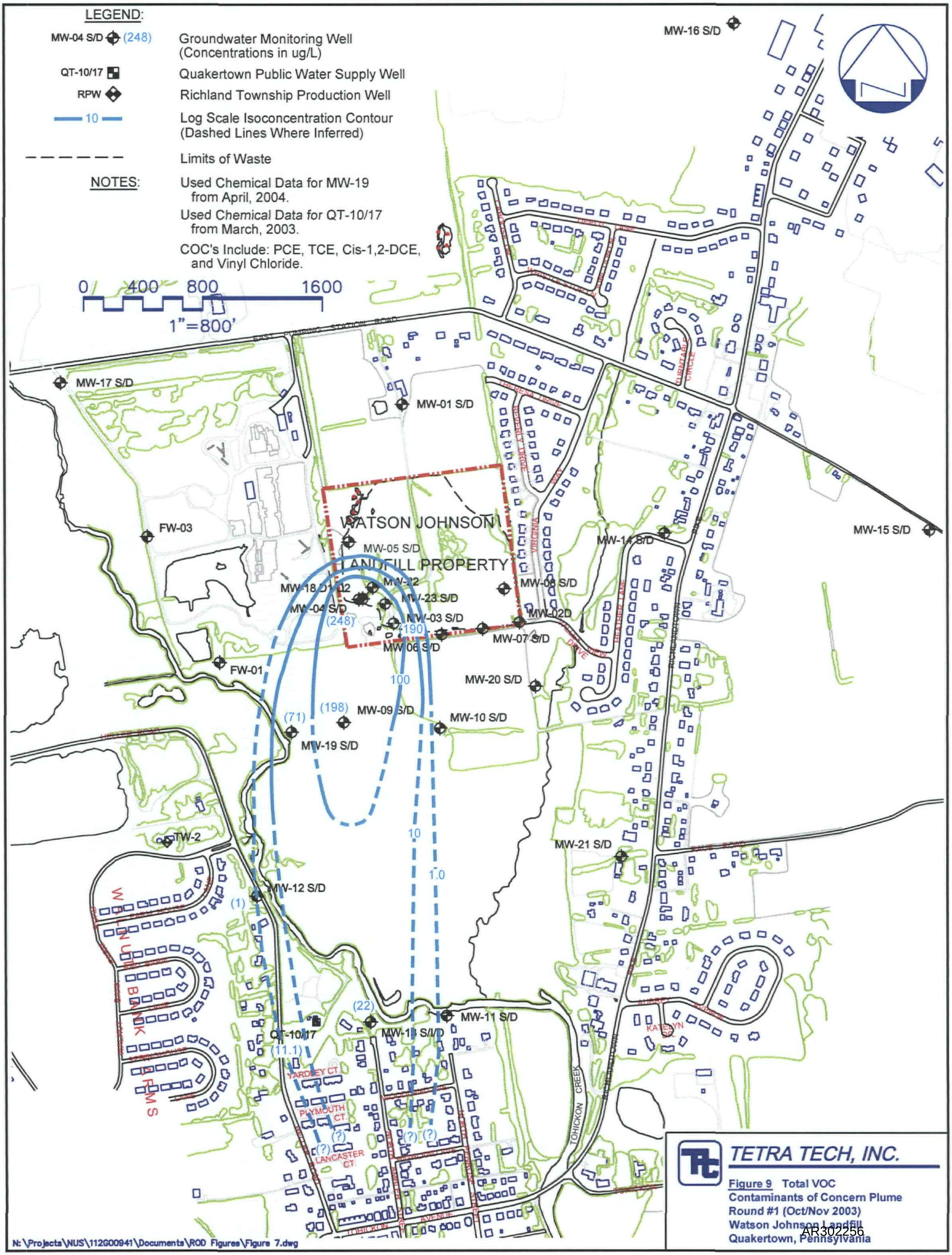
- Interim Sediment Sample
- Interim Co-located Surface Water and Sediment Sample
- Off-site Co-located Surface Water and Sediment Sample
- Off-site Surface Water Sample
- Limits of Waste
- Temperature and Flow Transects
- Eco Areas of Concern

0 300 600 1,200
Feet

N
W E
S

TETRA TECH, INC.

FIGURE 8
SURFACE WATER/SEDIMENT SAMPLE LOCATIONS
WATSON JOHNSON LANDFILL
QUAKERTOWN, PA



TETRA TECH, INC.

Figure 9 Total VOC Contaminants of Concern Plume Round #1 (Oct/Nov 2003) Watson Johnson Landfill Quakertown, Pennsylvania

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Legend

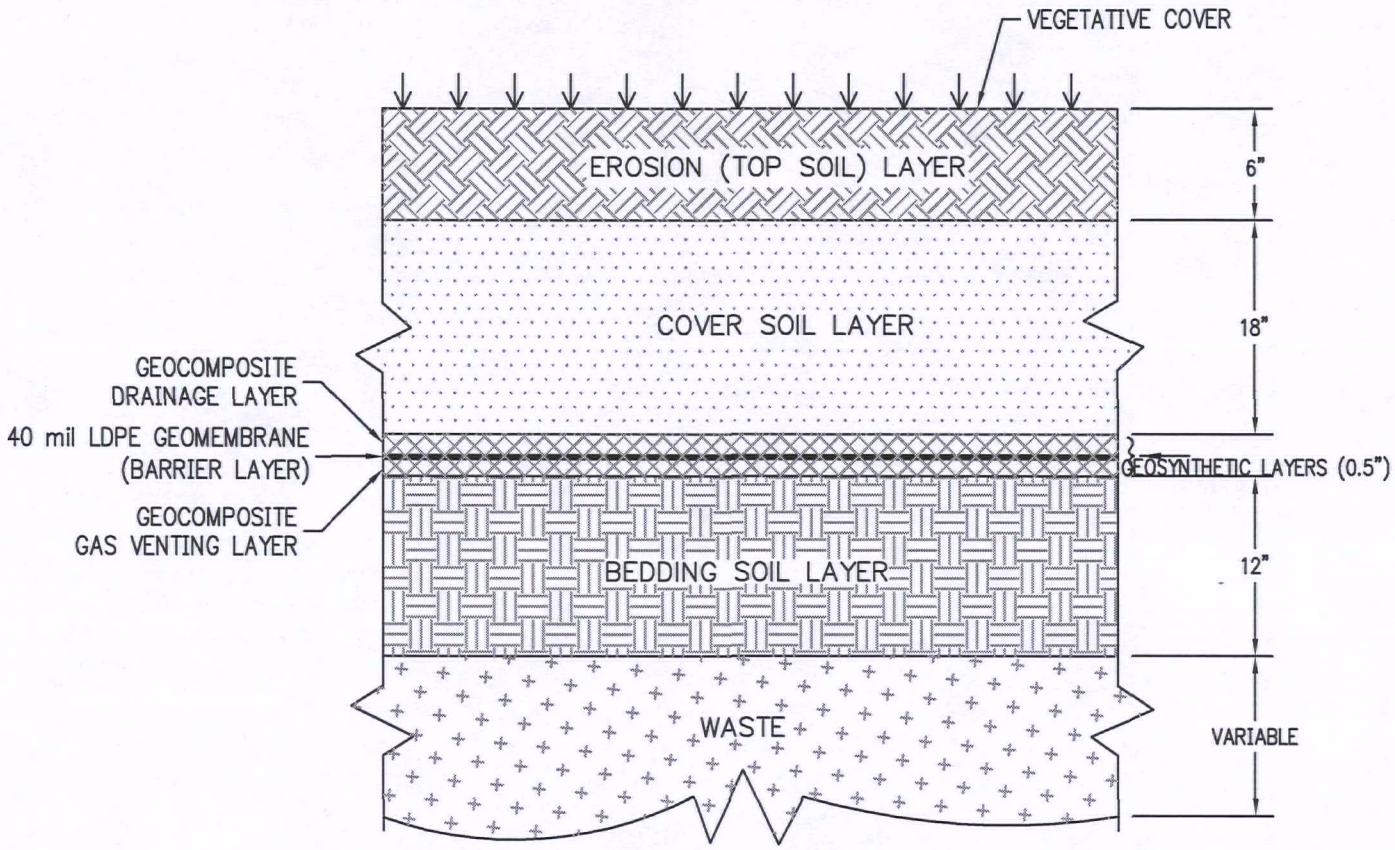
- Applicable Sediment Soil Sample
- Applicable Soil Sample
- Stormwater/Sediment
- Sediment only
- Ecological Areas of Concern (Assumed Extent)
- Limits of Waste

0 150 300 600
Feet

N
W E
S

TETRA TECH, INC.

Figure 10
Ecological Areas of Concern
Watson Johnson Landfill
Quakertown, Pennsylvania



MULTI-LAYER LANDFILL CAP

NOT TO SCALE

TETRA TECH, INC.

Figure 11
Multi-Layer Landfill Cap
LF Alternative 3
Watson Johnson Landfill Site
Quakertown, Pennsylvania

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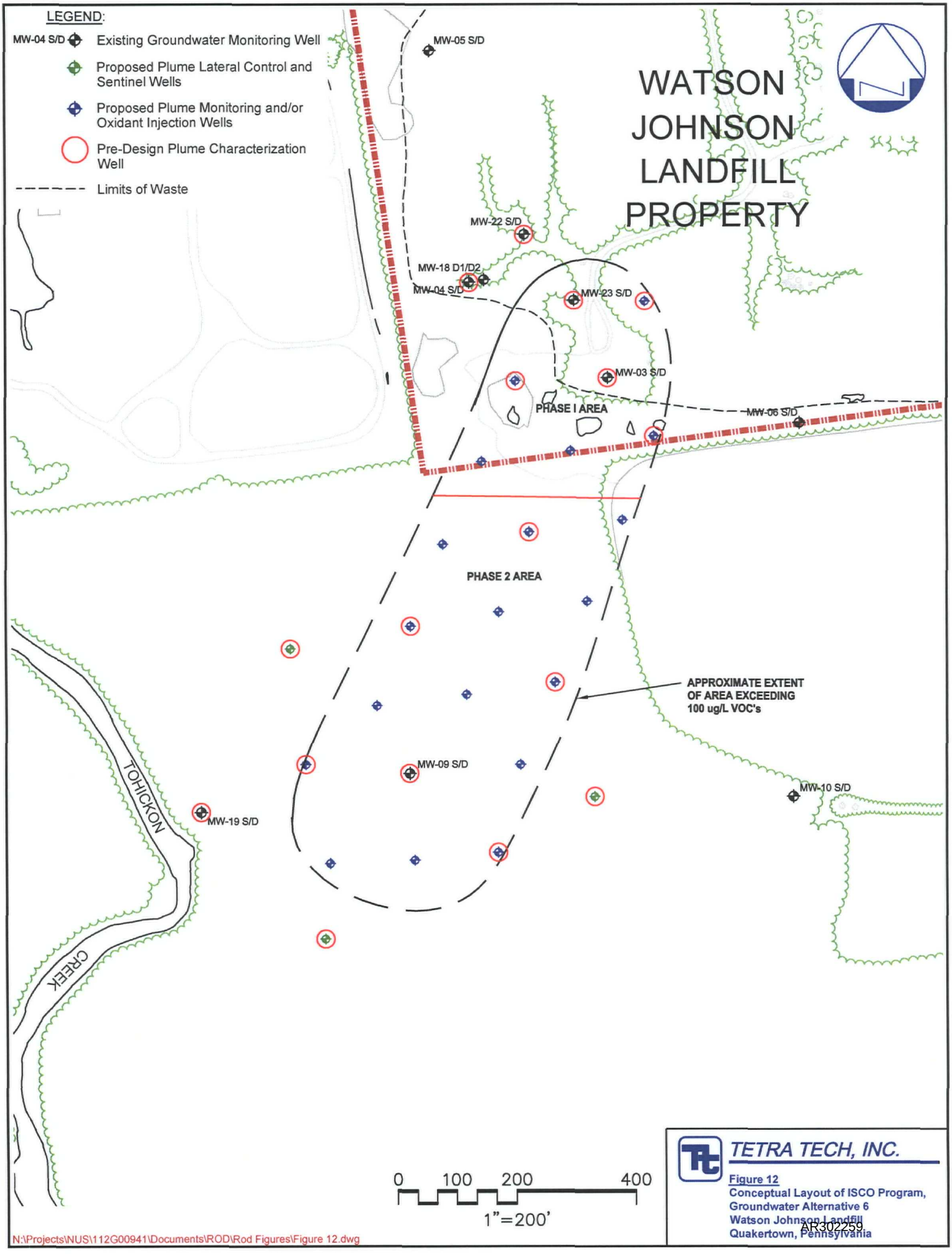
LEGEND:
MW-04 S/D
Existing Groundwater Monitoring Well
Proposed Plume Lateral Control and Sentinel Wells
Proposed Plume Monitoring and/or Oxidant Injection Wells
Pre-Design Plume Characterization Well
Limits of Waste
WATSON JOHNSON LANDFILL PROPERTY
MW-05 S/D
MW-22 S/D
MW-18 D1/D2
MW-04 S/D
MW-23 S/D
MW-03 S/D
PHASE I AREA
MW-06 S/D
PHASE 2 AREA
APPROXIMATE EXTENT OF AREA EXCEEDING 100 ug/L VOC's
MW-09 S/D
MW-10 S/D
MW-19 S/D
TOHICKON CREEK
0 100 200 400
1"=200'
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Figure 12
Conceptual Layout of ISCO Program,
Groundwater Alternative 6
Watson Johnson Landfill
Quakertown, Pennsylvania
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ATTACHMENT 1
VALUES USED FOR DAILY INTAKE CALCULATIONS
RME AND CTE PARAMETERS FOR SOIL AND SEDIMENT EXPOSURES
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Medium:	Soil and Sediment
Exposure Medium:	Soil and Sediment

Exposure Route	Receptor Population	Receptor Age	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name (1)
Ingestion (Soil)	Resident	Adult	CS	Chemical Concentration in Soil	mg/kg	EPC	See Table 3.4	EPC	See Table 3.4	Intake (mg/kg-day) = (CS x FI x IRS x EF x ED x MCF) / (BW x AT)
			IRS	Ingestion Rate - Soil	mg/day	100	EPA 1991	50	EPA 1991	
			FI	Fraction Ingested	unitless	1	Professional judgment	1	Professional judgment	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	
			MCF	Mass Conversion Factor	kg/mg	1E-06	Not applicable	1E-06	Not applicable	
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	
		Child	CS	Chemical Concentration in Soil	mg/kg	EPC	See Table 3.4	EPC	See Table 3.4	Intake (mg/kg-day) = (CS x FI x IRS x EF x ED x MCF) / (BW x AT)
			IRS	Ingestion Rate - Soil	mg/day	200	EPA 1991	100	EPA 1991	
			FI	Fraction Ingested	unitless	1	Professional judgment	1	Professional judgment	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	
			ED	Exposure Duration	years	6	EPA 1991	2	EPA 1991	
			MCF	Mass Conversion Factor	kg/mg	1E-06	Not applicable	1E-06	Not applicable	
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	
Dermal (Soil)	Resident	Adult	CS	Chemical Concentration in Soil	mg/kg	EPC	See Table 3.4	EPC	See Table 3.4	Intake (mg/kg-day) = (CS x ABS x SA x AF x EF x ED x MCF) / (BW x AT)
			ABS	Dermal Absorption Factor	unitless	Chemical-specific	EPA 2004	Chemical-specific	EPA 2004	
			SA	Exposed Skin Surface Area	cm^2	5,700	EPA 2004	5,700	EPA 2004	
			AF	Soil to Skin Adherence Factor	mg/cm^2	0.07	EPA 2004	0.01	EPA 2004	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	
			MCF	Mass Conversion Factor	kg/mg	1E-06	Not applicable	1E-06	Not applicable	
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	

ATTACHMENT 1
VALUES USED FOR DAILY INTAKE CALCULATIONS
RME AND CTE PARAMETERS FOR SOIL AND SEDIMENT EXPOSURES
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Medium:	Soil and Sediment
Exposure Medium:	Soil and Sediment

Exposure Route	Receptor Population	Receptor Age	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name (1)
Dermal (Soil)	Resident	Child	CS	Chemical Concentration in Soil	mg/kg	EPC	See Table 3.4	EPC	See Table 3.4	Intake (mg/kg-day) = (CS x ABS x SA x AF x EF x ED x MCF) / (BW x AT)
			ABS	Dermal Absorption Factor	unitless	Chemical-specific	EPA 2004	Chemical-specific	EPA 2004	
			SA	Exposed Skin Surface Area	cm^2	2,800	EPA 2004	2,800	EPA 2004	
			AF	Soil to Skin Adherence Factor	mg/cm^2	0.2	EPA 2004	0.04	EPA 2004	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	
			ED	Exposure Duration	years	6	EPA 1991	2	EPA 1991	
			MCF	Mass Conversion Factor	kg/mg	1E-06	Not applicable	1E-06	Not applicable	
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	
Inhalation Particulates (Soil)	Resident	Adult	CA	Chemical Concentration in Air	mg/m^3	Chemical-specific	Calculated from CS	Chemical-specific	Calculated from CS	Intake (mg/kg-day) = (CA x InhR x ET x EF x ED) / (BW x AT)
			InhR	Inhalation Rate	m^3/hour	0.83	EPA 1991	0.83	EPA 1991	
			ET	Exposure Time (3)	hours/day	24	EPA 1991	24	EPA 1991	where CA = CS / PEF for particulates, and
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	CA = CS / VF for volatiles
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	PEF = 1.32E+09 m^3/kg (EPA 2002c)
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	VF = Chemical-specific volatilization factor
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	
		Child (2)	CA	Chemical Concentration in Air	mg/m^3	Chemical-specific	Calculated from CS	Chemical-specific	Calculated from CS	Intake (mg/kg-day) = (CA x InhR x ET x EF x ED) / (BW x AT)
			InhR	Inhalation Rate	m^3/hour	0.63	EPA 1997	0.63	EPA 1997	
			ET	Exposure Time (3)	hours/day	24	EPA 1991	24	EPA 1991	where CA = CS / PEF for particulates, and
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	CA = CS / VF for volatiles
			ED	Exposure Duration	years	6	EPA 1991	2	EPA 1991	PEF = 1.32E+09 m^3/kg (EPA 2002c)
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	VF = Chemical-specific volatilization factor
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	

ATTACHMENT 1
VALUES USED FOR DAILY INTAKE CALCULATIONS
RME AND CTE PARAMETERS FOR SOIL AND SEDIMENT EXPOSURES
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Medium:	Soil and Sediment
Exposure Medium:	Soil and Sediment

Exposure Route	Receptor Population	Receptor Age	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name (1)
Ingestion (Sediment)	Resident	Adult	CS	Chemical Concentration in Sediment	mg/kg	EPC	See Table 3.3	EPC	See Table 3.3	Intake (mg/kg-day) = (CS x FI x IRS x ET x EF x ED x MCF) / (BW x AT)
			IRS	Ingestion Rate - Sediment	mg/day	100	Professional judgment	50	Professional judgment	
			FI	Fraction Ingested	unitless	1	Professional judgment	1	Professional judgment	
			ET	Exposure time (4)	unitless	0.083	Professional judgment	0.083	Professional judgment	
			EF	Exposure Frequency	days/year	52	Professional judgment	26	Professional judgment	
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	
			MCF	Mass Conversion Factor	kg/mg	1E-06	Not applicable	1E-06	Not applicable	
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	
		Child	CS	Chemical Concentration in Sediment	mg/kg	EPC	See Table 3.3	EPC	See Table 3.3	Intake (mg/kg-day) = (CS x FI x IRS x Etx EF x ED x MCF) / (BW x AT)
			IRS	Ingestion Rate - Sediment	mg/day	200	Professional judgment	100	Professional judgment	
			FI	Fraction Ingested	unitless	1	Professional judgment	1	Professional judgment	
			ET	Exposure time (4)	unitless	0.083	Professional judgment	0.083	Professional judgment	
			EF	Exposure Frequency	days/year	52	Professional judgment	26	Professional judgment	
			ED	Exposure Duration	years	6	EPA 1991	2	EPA 1991	
			MCF	Mass Conversion Factor	kg/mg	1E-06	Not applicable	1E-06	Not applicable	
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	
Dermal (Sediment)	Resident	Adult	CS	Chemical Concentration in Sediment	mg/kg	EPC	See Table 3.3	EPC	See Table 3.3	Intake (mg/kg-day) = (CS x ABS x SA x AF x EF x ED x MCF) / (BW x AT)
			ABS	Dermal Absorption Factor	unitless	Chemical-specific	EPA 2001	Chemical-specific	EPA 2001	
			SA	Exposed Skin Surface Area (*face, forearms, feet, lower legs,* and hands)	cm^2	6,075	*EPA 2004*	6,075	*EPA 2004*	
			AF	Soil to Skin Adherence Factor Soccer Players (moist conditions, 95th percentile adult) Exhibit C-3	mg/cm^2	0.08	EPA 2004	0.08	EPA 2004	
			EF	Exposure Frequency	days/year	52	Professional judgment	26	Professional judgment	
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	
			MCF	Mass Conversion Factor	kg/mg	1E-06	Not applicable	1E-06	Not applicable	
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	

ATTACHMENT 1
VALUES USED FOR DAILY INTAKE CALCULATIONS
RME AND CTE PARAMETERS FOR SOIL AND SEDIMENT EXPOSURES
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Medium:	Soil and Sediment
Exposure Medium:	Soil and Sediment

Exposure Route	Receptor Population	Receptor Age	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name (1)
Dermal (Sediment)	Resident	Child	CS	Chemical Concentration in Sediment	mg/kg	EPC	See Table 3.3	EPC	See Table 3.3	Intake (mg/kg-day) = (CS x ABS x SA x AF x EF x ED x MCF) / (BW x AT)
			ABS	Dermal Absorption Factor	unitless	Chemical-specific	EPA 2001	Chemical-specific	EPA 2001	
			SA	Exposed Skin Surface Area (face, hands, forearms, feet, and lower legs)	cm^2	1,850	EPA 1997	1,850	EPA 1997	
			AF	Soil to Skin Adherence Factor Soccer Player (95th percentile teen, moist conditions) Exhibit C-3	mg/cm^2	0.3	EPA 2004	0.3	EPA 2004	
			EF	Exposure Frequency	days/year	52	Professional judgment	26	Professional judgment	
			ED	Exposure Duration	years	6	EPA 1991	2	EPA 1991	
			MCF	Mass Conversion Factor	kg/mg	1E-06	Not applicable	1E-06	Not applicable	
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	

Notes:

(1) See Exposure Assessment text for discussion of the intake assumptions.

(2) While children's inhalation rates can be estimated, the toxicity factors applied in a risk assessment are based on chronic risks and not adjusted for a child's unique physiology.

(3) These exposure times for inhalation are shown to represent the total daily inhalation rate on an hourly basis; however, the actual outdoor activity where particles or vapors would be inhaled does not amount to round-the-clock exposure. In particular, for residential scenarios where exposure to indoor air is assumed, this will result in a conservative overestimate of risk, unless soil (vapor and particulate) and groundwater (indoor air and soil gas) pathways are characterized separately.

(4) The Exposure time (ET) for both the adult and child sediment exposure scenarios is 0.083 representing 2 hours/day multiplied by 1 day/24 hours

cm^2	Square centimeter
days/year	Days per year
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
hours/day	Hours per day
kg	Kilogram
kg/mg	Kilograms per milligram
mg/cm^2	Milligrams per square centimeter
mg/day	Milligrams per day
mg/kg	Milligrams per kilogram
mg/m^3	Milligrams per cubic meter
m^3/hour	Cubic meters per hour
m^3/kg	Cubic meters of air per kg soil (reduced from mg/m3-air per mg/kg-soil)
OERR	Office of Emergency and Remedial Response
PEF	Particulate emission factor
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable maximum exposure
CTE	Central tendency exposure

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ATTACHMENT 1
VALUES USED FOR DAILY INTAKE CALCULATIONS
RME AND CTE PARAMETERS FOR WATER EXPOSURES
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Medium:	Groundwater and Surface Water
Exposure Medium:	Groundwater and Surface Water

Exposure Route	Receptor Population	Receptor Age	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name (1)
Ingestion (Groundwater)	Resident	Adult	CW	Chemical Concentration in Groundwater	mg/L	EPC	See Table 3 1	EPC	See Table 3.1	Intake (mg/kg-day) = (CW x WC x EF x ED) / (BW x AT)
			WC	Water Consumption Rate	liters/day	2	EPA 1991	1 4	EPA 1989	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
				Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	
		Child	CW	Chemical Concentration in Groundwater	mg/L	EPC	See Table 3 1	EPC	See Table 3 1	Intake (mg/kg-day) = (CW x WC x EF x ED) / (BW x AT)
			WC	Water Consumption Rate	liters/day	1 29	EPA 1997	0 74	Professional judgment	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	
			ED	Exposure Duration	years	6	EPA 1991	2	EPA 1991	
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	
Dermal (Groundwater)		Child	DA event	Absorbed Dose Per Event	mg/cm^2-event	Chemical-specific	See Table 4.3	Chemical-specific	See Table 4.3	Intake (mg/kg-day) = DAevent x EF x ED x EV x SA / (BW x AT)
			SA	Surface Area	cm^2	6,600	EPA 2004	6,600	EPA 2004	
			EV	Event Frequency (4)	event/day	1 (1-hour bath)	EPA 2004	1 (0 33-hour bath)	EPA 2004	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	
			ED	Exposure Duration	years	6	EPA 1989	2	EPA 1989	
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	

ATTACHMENT 1
VALUES USED FOR DAILY INTAKE CALCULATIONS
RME AND CTE PARAMETERS FOR WATER EXPOSURES
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Medium	Groundwater and Surface Water
Exposure Medium	Groundwater and Surface Water

Exposure Route	Receptor Population	Receptor Age	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name (1)
Inhalation of Volatiles During Showering	Resident	Adult	CW_{Air}	Chemical Concentration of Groundwater in Air	mg/m^3	Chemical-specific	Foster and Chrostowski 1987	Chemical-specific	Foster and Chrostowski 1987	Intake (mg/kg-day) = (CW_{Air} x InhR x ET x EF x ED) / (BW x AT)
			InhR	Inhalation Rate	m^3/hour	0.83	EPA 1997	0.83	EPA 1997	
			*Dt	Total Time in Shower Room	minutes	60	EPA 1997	20	EPA 1997	Parameters designated with * are used to calculate CW_{Air}
			*Ds	Shower Time	minutes	30	EPA 2004	15	EPA 2004	
			*SV	Shower Room Volume	m^3	12	Professional judgment	12	Professional judgment	
			*ts	Droplet Drop Time	seconds	0.50	CPF Associates 2003	0.50	CPF Associates 2003	
			*FR	Shower Flow Rate	L/minute	10	Professional judgment	10	Professional judgment	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	
Ingestion (Surface water)	Resident	Adult	CW	Chemical Concentration in Groundwater	mg/L	EPC	See Table 3.2	EPC	See Table 3.2	Intake (mg/kg-day) = (CW x WC x FI x ET x EF x ED) / (BW x AT)
			WC	Water Consumption Rate	liters/day	0.05	EPA 1997	0.05	EPA 1997	
			EF	Exposure Frequency	days/year	52	Professional judgment	26	Professional judgment	
			FI	Fraction Ingested	unitless	1	Professional judgment	1	Professional judgment	
			ET	Exposure time (5)	unitless	0.083	Professional judgment	0.083	Professional judgment	
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
				Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	
		Child	CW	Chemical Concentration in Groundwater	mg/L	EPC	See Table 3.1	EPC	See Table 3.1	Intake (mg/kg-day) = (CW x WC x FI x ET x EF x ED) / (BW x AT)
			WC	Water Consumption Rate	liters/day	0.05	EPA 1997	0.05	EPA 1997	
			EF	Exposure Frequency	days/year	52	Professional judgment	26	Professional judgment	
			FI	Fraction Ingested	unitless	1	Professional judgment	1	Professional judgment	
			ET	Exposure time (5)	unitless	0.083	Professional judgment	0.083	Professional judgment	
			ED	Exposure Duration	years	6	EPA 1991	2	EPA 1991	
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	
Dermal (Surface water)	Resident	Adult	DAevent	Absorbed Dose Per Event	mg/cm^2-event	Chemical-specific	See Table 4.4	Chemical-specific	See Table 4.4	
			SA	Exposed Skin Surface Area (face, forearms, feet, lower legs, and hands)	cm^2	6,075	EPA 2004	6,075	EPA 2004	Intake (mg/kg-day) = DAevent x EF x ED x EV x SA / (BW x AT)
			EV	Event Frequency (4)	events/day	1 (2-hour event)	EPA 2004	1 (2-hour event)	EPA 2004	
			EF	Exposure Frequency	days/year	52	Professional judgment	26	Professional judgment	
			ED	Exposure Duration	years	24	EPA 1989	9	EPA 1991	

ATTACHMENT 1
VALUES USED FOR DAILY INTAKE CALCULATIONS
RME AND CTE PARAMETERS FOR WATER EXPOSURES
WATSON JOHNSON LANDFILL

Scenario Timeframe:	Future
Medium:	Groundwater and Surface Water
Exposure Medium:	Groundwater and Surface Water

Exposure Route	Receptor Population	Receptor Age	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name (1)
Dermal (Surface water)	Resident	Adult	BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	
		Child	DAevent	Absorbed Dose Per Event	mg/cm^2-event	Chemical-specific	See Table 4.4	Chemical-specific	See Table 4.4	
			SA	Exposed Skin Surface Area (face, hands, forearms, feet, and lower legs)	cm^2	1,850	EPA 1997	1,850	EPA 1997	
			EV	Event Frequency (4)	event/day	1 (2-hour event)	EPA 2004	1 (2-hour event)	EPA 2004	Intake (mg/kg-day) =
			EF	Exposure Frequency	days/year	52	Professional judgment	26	Professional judgment	DAevent x EF x ED x EV x SA
			ED	Exposure Duration	years	6	EPA 1989	2	EPA 1989	/ (BW x AT)
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	
Inhalation of Volatiles in Indoor Air	Resident	Adult	CA	Chemical Concentration in Air	mg/m^3	EPC	See Table 3.5	EPC	See Table 3.5	Intake (mg/kg-day) =
			InhR	Inhalation Rate	m^3/hour	0.83	EPA 1991	0.83	EPA 1991	(CA x InhR x ET x EF x ED) / (BW x AT)
			ET	Exposure Time (3)	hours/day	24	EPA 1991	24	EPA 1991	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	where CA has been modeled from CW and/or
			ED	Exposure Duration	years	24	EPA 1991	9	EPA 1991	soil gas data using the Johnson & Ettinger
			BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	model
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	8,760	EPA 1989	3,285	EPA 1989	
		Child (2)	CA	Chemical Concentration in Air	mg/m^3	EPC	See Table 3.5	EPC	See Table 3.5	Intake (mg/kg-day) =
			InhR	Inhalation Rate	m^3/hour	0.63	EPA 1997	0.63	EPA 1997	(CA x InhR x ET x EF x ED) / (BW x AT)
			ET	Exposure Time (3)	hours/day	24	EPA 1991	24	EPA 1991	
			EF	Exposure Frequency	days/year	350	EPA 1991	350	EPA 1991	where CA will be modeled from CW and/or
			ED	Exposure Duration	years	6	EPA 1991	2	EPA 1991	soil gas data using the Johnson & Ettinger
			BW	Body Weight	kg	15	EPA 1991	15	EPA 1991	model
			AT-C	Averaging Time - Cancer	days	25,550	EPA 1989	25,550	EPA 1989	
			AT-NC	Averaging Time - Noncancer	days	2,190	EPA 1989	730	EPA 1989	

Notes:

(1) See Exposure Assessment text for discussion of the intake assumptions

(2) While children's inhalation rates can be estimated, the toxicity factors applied in a risk assessment are based on chronic risks and not adjusted for a child's unique physiology

(3) These exposure times for inhalation are shown to represent the total daily inhalation rate on an hourly basis; however, because some outdoor activity is being assumed based on the inclusion of soil pathways and outdoor air inhalation, this will result in a conservative overestimate of risk, unless soil (vapor and particulate) and groundwater (indoor air and soil gas) pathways are characterized separately.

(4) The event frequency for dermal exposure to water is one event per day, with activity-specific exposure times noted in Tables 4.3 and 4.4 for calculation of DAevent

(5) The Exposure time (ET) for both the adult and child sediment exposure scenarios is 0.083 representing 2 hours/day multiplied by 1 day/24 hours

cm^2	Square centimeters	m^3/hour	Cubic meters per hour
cm/hr	Centimeters per hour	L/cm^3	Liters per cubic centimeter
days/year	Days per year	mg/kg-day	Milligrams per kilogram per day
DTSC	Department of Toxic Substances Control	mg/m^3	Milligrams per cubic meter
EPA	U.S. Environmental Protection Agency	mg/L	Milligrams per liter
EPC	Exposure Point Concentration	RAGS	Risk Assessment Guidance for Superfund
hours/day	Hours per day	RME	Reasonable maximum exposure
kg	Kilogram	CTE	Central tendency exposure
mg/cm^2-event	milligrams per squared centimeters		

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ATTACHMENT 1
CALCULATION OF DOSE ABSORBED PER EVENT (DERMAL EXPOSURE)
RME AND CTE PARAMETERS FOR GROUNDWATER EXPOSURES
WATSON JOHNSON LANDFILL

Chemicals of Potential Concern	EPC (1) (mg/cm^3)	K_p (cm/hr)	FA (unitless)	τ_{event} (hr/event)	t^* (hr)	B	RME t_{event} (hr/event)	Calculated RME DA_{event} (1) (mg/cm^2-event)	CTE t_{event} (hr/event)	Calculated CTE DA_{event} (1) (mg/cm^2-event)
1,4-Dichlorobenzene	2.0E-06	4.2E-02	1.0E+00	7.1E-01	1.7E+00	2.0E-01	1.0E+00	2.0E-07	3.3E-01	1.1E-07
Arsenic	1.2E-05	1.0E-03	--	--	--	--	1.0E+00	1.2E-08	3.3E-01	3.9E-09
Barium	1.8E-04	1.0E-03	--	--	--	--	1.0E+00	1.8E-07	3.3E-01	5.9E-08
Benzene	1.0E-06	1.5E-02	1.0E+00	2.9E-01	7.0E-01	1.0E-01	1.0E+00	2.3E-08	3.3E-01	1.4E-08
beta-BHC	2.8E-08	1.1E-02	9.0E-01	4.6E+00	1.1E+01	1.0E-01	1.0E+00	1.6E-09	3.3E-01	9.4E-10
Bis(2-Ethylhexyl)phthalate	5.1E-06	2.5E-02	1.0E+00	1.7E+01	4.0E+01	2.0E-01	1.0E+00	1.4E-06	3.3E-01	8.2E-07
Boron	3.1E-04	1.0E-03	--	--	--	--	1.0E+00	3.1E-07	3.3E-01	1.0E-07
Chromium Total	2.3E-06	2.0E-03	--	--	--	--	1.0E+00	4.6E-09	3.3E-01	1.5E-09
Cis-1, 2-Dichloroethylene (2)	2.7E-05	7.7E-03	1.0E+00	3.7E-01	8.9E-01	2.9E-02	1.0E+00	3.6E-07	3.3E-01	2.3E-07
Cyanide	1.4E-05	1.0E-03	--	--	--	--	1.0E+00	1.4E-08	3.3E-01	4.6E-09
Manganese	1.4E-03	1.0E-03	--	--	--	--	1.0E+00	1.4E-06	3.3E-01	4.6E-07
Tetrachloroethene	1.2E-05	3.3E-02	1.0E+00	9.1E-01	2.2E+00	2.0E-01	1.0E+00	1.0E-06	3.3E-01	5.9E-07
Trichloroethene	4.5E-05	1.2E-02	1.0E+00	5.8E-01	1.4E+00	1.0E-01	1.0E+00	1.1E-06	3.3E-01	6.5E-07
Vanadium	1.2E-06	1.0E-03	--	--	--	--	1.0E+00	1.2E-09	3.3E-01	3.9E-10
Vinyl Chloride	6.1E-06	5.6E-03	1.0E+00	2.4E-01	5.7E-01	1.7E-02	1.0E+00	5.0E-08	3.3E-01	2.8E-08

Notes:

(1) Dermal exposure from organics and inorganics during bathing were calculated using Equation 3.4 (inorganics) and Equation 3.2 and 3.3 (organics) of RAGS Part E (EPA 2004).

(2) The chemical-specific information for trans-1,2-dichloroethene was used as a surrogate for cis-1,2-dichloroethene.

(3) The chemical-specific information for gamma-BHC (lindane) was used as a surrogate for beta-BHC (beta-hexachlorocyclohexane).

Definitions:

--	Not applicable / not calculated	hr/event	Hour per event
B	Dimensionless permeability ratio	hr	Hour
beta-BHC	Beta-hexachlorocyclohexane	K_p	Dermal permeability coefficient of compound in water
cm/hr	Centimeters per hour	mg/cm^3	Milligram per cubic centimeter
mg/cm^2-event	Milligram per square centimeter per event	RAGS	Risk Assessment Guidance for Superfund
DA	Dose absorbed per event per area of skin exposed	RME	Reasonable Maximum Exposure
EPA	U.S. Environmental Protection Agency	τ_{event}	Lag time per event
EPC	Exposure point concentration	t_{event}	Event duration
FA	Fraction absorbed water		

Reference:

EPA. 2004. *RAGS, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).* Office of Emergency and Remedial Response. Washington, DC.

ATTACHMENT 1
CALCULATION OF DOSE ABSORBED PER EVENT (DERMAL EXPOSURE)
RME AND CTE PARAMETERS FOR SURFACE WATER EXPOSURES
WATSON JOHNSON LANDFILL

Chemicals of Potential Concern	EPC (1) (mg/cm^3)	K_p (cm/hr)	FA (unitless)	τ_{event} (hr/event)	t_{event} (hr/event)	Calculated RME and CTE DA_{event} (1) (mg/cm^2-event)
Arsenic	8.6E-06	1.0E-03	--	--	2.0E+00	1.7E-08
Barium	5.2E-03	1.0E-03	--	--	2.0E+00	1.0E-05
Chromium Total	2.0E-04	2.0E-03	--	--	2.0E+00	8.0E-07
Iron	6.8E-01	1.0E-03	--	--	2.0E+00	1.4E-03
Lead	1.5E-04	--	--	--	2.0E+00	(2)
Manganese	1.9E-03	1.0E-03	--	--	2.0E+00	3.8E-06
Thallium	1.8E-05	1.0E-03	--	--	2.0E+00	3.5E-08

Notes:

(1) Dermal exposure from inorganics were calculated using Equation 3.4 of RAGS Part E (EPA 2004).

(2) Because lead dermal absorption or ingestion from surface water would not result in a steady-state dose, lead modeling is not appropriate for the intermittent exposure reasonably predicted from surface water absorption. The presence of lead will be discussed qualitatively in the Uncertainty Assessment.

Definitions:

--	Not applicable / not calculated	hr/event	Hour per event
cm/hr	Centimeters per hour	K_p	Dermal permeability coefficient of compound in water
mg/cm^2-event	Milligram per square centimeter per event	mg/cm^3	Milligram per cubic centimeter
DA	Dose absorbed per event per area of skin exposed	RAGS	Risk Assessment Guidance for Superfund
EPA	U.S. Environmental Protection Agency	RME	Reasonable Maximum Exposure
EPC	Exposure point concentration	τ_{event}	Lag time per event
FA	Fraction absorbed water	t_{event}	Event duration

Reference:

EPA. 2004. *RAGS, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).* Office of Emergency and Remedial Response. Washington, DC.

ATTACHMENT 1
CHEMICAL-SPECIFIC PARAMETERS
WATSON JOHNSON LANDFILL

COPC	Kp (cm/hr)[a]
1,4-Dichlorobenzene	4.2E-02
1,2-Dichloroethylene (cis)	7.7E-03
Aluminum	1.0E-03
Arsenic	1.0E-03
Barium	1.0E-03
Benzene	1.5E-02
Benzo-a-pyrene	7.0E-01
beta-BHC	1.1E-02
Bis(2-Ethylhexyl)phthalate	2.5E-02
Boron	1.0E-03
Cadmium	1.0E-03
Chromium	1.0E-03
Cyanide	1.0E-03
Iron	1.0E-03
Lead	1.0E-03
Manganese	1.0E-03
Tetrachlorethylene	3.3E-02
Thallium	1.0E-03
Trichloroethylene	1.2E-02
Vanadium	1.0E-03
Vinyl chloride	5.6E-03

Notes;
ABS
cm/hr
H
Kp
m^3/kg
VF

[a] Kp values taken from Exhibit B-2 of EPA 2004. For inorganic chemicals lacking a Kp, a default value of 0.001 cm/hr was used (EPA 2004). For organic chemicals lacking a Kp, a default value of 1E-5 cm/hr (the Kp of water) was used.

ATTACHMENT 2
TOXICITY PROFILES
WATSON JOHNSON LANDFILL

Brief toxicity profiles for organic and inorganic COPCs detected in media at WJL are included in the following sections; the toxicity values used in the WJL HHRA are presented in Tables 5.1, 5.2, 6.1, and 6.2 of Attachment A.

When considering the toxicity of the COPCs at WJL, it should be noted that many of the inorganic chemicals detected at WJL are naturally occurring in the earth's crust. Although risks presented in this HHRA include all detected inorganics and do not distinguish between anthropogenic or naturally occurring background levels, some degree of risk attributable to inorganics may not be reflected in results from former landfill operations or Superfund contamination but rather background risk.

1,4-Dichlorobenzene

1,4-Dichlorobenzene, also referred to as para-dichlorobenzene, does not occur naturally and is a chemical used to control moths, molds, and mildew, and to deodorize restrooms and waste containers (ASTDR 2004). It also has applications in fumigants, insecticides, lacquers, paints, and seed disinfection products (ASTDR 2004). At room temperature, 1,4-dichlorobenzene is a white solid with a strong, pungent odor. When exposed to air, it slowly sublimates from a solid to a vapor (ASTDR 2004). Exposure to 1,4-dichlorobenzene generally results from inhalation of increased levels in indoor air or workplace air (ASTDR 2004). Extremely high exposures can cause dizziness, headaches, and liver problems. The Region 3 RBC tables reference an NCEA provisional oral RfD value for 1,4-dichlorobenzene of 0.03 mg/kg-day (EPA 2004d). The inhalation RfC (0.8 mg/m^3) is based on the critical effect of significantly increased liver weights of P1, parental male rats (EPA 2005a). The inhalation RfC is based on a subchronic NOAEL dose; an uncertainty factor of 100 was applied. 1,4-Dichlorobenzene is classified as a class C weight-of-evidence possible human carcinogen, based on an increase in liver tumors in mice administered 1,4-dichlorobenzene for 103 weeks (Risk Assessment Information System [RAIS] 2005). EPA's HEAST lists an oral SF of 0.024 mg/kg day (EPA 1997b). The NCEA PPRTV database lists a provisional inhalation SF of 0.022 $(mg/kg\text{-}day)^{-1}$ (EPA 2004d).

Arsenic

Arsenic is a naturally occurring element with widespread distribution. Arsenic is used in metallurgy to harden copper, lead, and alloys, in the manufacture of certain types of glass, and in medical applications. Because arsenic is present in many mineral ores, it is frequently concentrated near mining sites as a byproduct of smelting. Historically, inorganic and organic forms of arsenic were widely used as pesticides. Consequently, arsenic concentrations are frequently elevated in agricultural areas.

Human arsenic exposure occurs primarily through oral ingestion of both organic and inorganic forms of arsenic. The toxicity of inorganic arsenic (As) depends on its valence state (As^{-3}, As^{+3}, or As^{+5}), and also on the physical and chemical properties of the compound in which it occurs. Trivalent (As^{+3}) compounds are generally more toxic than pentavalent (As^{+5}) compounds, it is also thought that exposure conditions at hazardous waste sites favors the formation of the pentavalent form because of natural oxidation processes in the environment. Water-soluble arsenic is efficiently absorbed from the gastrointestinal tract. The primary target organs for arsenic are the skin (hyperpigmentation and hyperkeratosis) and vascular system. The prominent pathological effect is plantar and palmar hyperpigmentation and hyperkeratotic lesions (ATSDR 2000). Although these lesions in themselves do not pose a significant health concern, they may ultimately develop into malignant skin cancers and metastasize to other parts of the body. The oral RfD for arsenic is 0.0003 mg/kg-day based on pathological changes in skin as well as lesions in blood vessels and includes an uncertainty factor of 3 (EPA 2005a). EPA has not established an inhalation

RfC for arsenic. Arsenic is classified as a class A carcinogen. The basis for the classification is an increased lung cancer mortality observed in multiple human populations exposed through the inhalation route. An increased mortality observed in multiple internal organs (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water containing high concentration of inorganic arsenic. An oral SF of 1.5 $(mg/kg\text{-}day)^{-1}$ and an inhalation UR factor of 0.0043 $(\mu g/m^3)^{-1}$ have been established by EPA (EPA 2005a).

Barium

Barium is ubiquitous (ATSDR 1992), so its identification as a COPC in WJL groundwater and surface water is not surprising. Ingesting high levels of barium can cause problems with the kidneys, liver, heart, stomach, and other organs. The oral primary target organ for barium is the kidney (EPA 2005a). The soluble salts of barium, an alkaline earth metal, are toxic in mammalian systems. They are absorbed rapidly from the GI tract and are deposited in the muscles, lungs, and bone. The EPA reports a chronic oral RfD of 0.07 mg/kg-day based on a weight of evidence approach involving four studies (including human studies) (EPA 2005a). Barium is not considered to be a human carcinogen.

Benzene

Benzene is a highly volatile organic compound; as such, the primary route of exposure is inhalation. It is readily absorbed from the GI tract following oral ingestion because of its lipophilic nature. In contrast, dermal absorption of benzene is limited (EPA 2005a). Benzene is distributed to fatty tissues in the body and has an affinity for adipose and nervous tissue, bone marrow, liver, spleen, and blood. Benzene is metabolized in the liver primarily to phenol, which is subsequently excreted in the urine. Long-term exposure to benzene can result in central nervous system (CNS) and gastrointestinal effects; however, the primary pathological target is the bone marrow. Symptoms include anemia and thrombocytopenia as well as other hematologic abnormalities. Triggered by chronic benzene exposure, these hematologic abnormalities may progress to leukemia. Both the chronic oral RfD (0.004 mg/kg-day) and chronic inhalation RfC (0.03 mg/m^3) are based on a decreased lymphocyte count in an occupational study and include uncertainty factors of 300 (EPA 2005a). Benzene is classified as a class A weight-of-evidence carcinogen based on nonlymphocytic leukemia associated with occupational exposures and neoplasia in experimental animals (EPA 2005a). An oral SF of 0.055 $(mg/kg\text{-}day)^{-1}$ and an inhalation UR factor of 0.0000078 $(\mu g/m^3)^{-1}$ have been established by EPA (2005a).

Benzo(a)pyrene

BAP is a PAH that is commonly found in coal tar. It is readily absorbed following inhalation, oral, and dermal routes of administration (ATSDR 1995). Following inhalation exposure, BAP is rapidly distributed to several tissues followed by complex metabolism, which results in the formation of benzo(a)pyrene-7,8 diol-9,10-

epoxide. No data are available on the systemic (non-carcinogenic) effects of BAP in humans and neither a chronic oral RfD nor an RfC have been derived for BAP. BAP is classified as a class A weight-of-evidence carcinogen by inhalation (EPA 2005a). BAP has an oral SF of 7.3 $(mg/kg\text{-}day)^{-1}$ available through IRIS (EPA 2005a); a provisional inhalation SF of 3.1 $(mg/kg\text{-}day)^{-1}$, which is referenced from NCEA was identified in the Region 3 RBC tables (EPA 2004d).

beta-BHC (beta-HCH)

Hexachlorocyclohexane (HCH) exists as several isomers. The four major isomers are alpha-HCH , beta-HCH, gamma-HCH, and delta-HCH. Gamma-HCH is also commonly known as lindane. The toxicity of the isomers varies. With respect to acute exposure, gamma-HCH is the most toxic, followed by alpha-, delta-, and beta-HCH; however, with respect to chronic exposure, beta-HCH (beta-BHC) is the most toxic (ATSDR 2003). With chronic exposures, the increased toxicity of beta-BHC is thought to be due to its longer biological half-life and its accumulation in the body over time (ATSDR 2003). In humans, the most commonly reported effects associated with oral exposure to beta-BHC are neurological (ATSDR 2003). Most of the information is from case reports of acute HCH poisoning. No studies were located regarding neurological effects in humans following long-term ingestion of beta-BHC. There are no EPA established chronic oral RfD or chronic inhalation RfC values. Beta-BHC is classified as a class C weight-of-evidence carcinogen. An oral SF of 1.8 $(mg/kg\text{-}day)^{-1}$ and an inhalation UR factor of 0.00053 $(\mu g/m^3)^{-1}$ have been established by EPA (EPA 2005a).

bis(2-Ethylhexyl)phthalate

BEHP, also known as di(2-ethylhexyl)phthalate, is a colorless oily liquid that is extensively used as a plasticizer in a wide variety of industrial, domestic and medical products. It is rapidly absorbed primarily from the gastrointestinal tract (ATSDR 2002). The diester can also be absorbed through dermal and inhalation exposure. It is rapidly metabolized in the blood and tissues to the monoester, which can be excreted as a glucuronide conjugate or further hydrolyzed to phthalic acid and excreted. Animal studies have indicated that the primary target organs are the liver and kidneys. A chronic oral RfD of 0.02 mg/kg-day was calculated from a LOAEL based on increased relative liver weight in guinea pigs (EPA 2005a). A chronic inhalation RfC is not available. Based on EPA guidelines, BEHP was assigned to weight-of-evidence Group B2, probable human carcinogen, on the basis of an increased incidence of liver tumors in rats and mice. An oral SF of 0.014 $(mg/kg\text{-}day)^{-1}$ has been established (EPA 2005a). A provisional inhalation SF from NCEA (0.014 $[mg/kg\text{-}day]^{-1}$) was provided in the Region 3 RBC tables (EPA 2004d).

cis-1,2-Dichloroethylene

1,2-Dichloroethylene exists in two isomeric forms, cis-1,2-DCE and trans-1,2-dichloroethylene, that are colorless, volatile liquids with a slightly acrid odor. Although not used extensively in industry, 1,2-dichloroethylene is used in the production of other chlorinated solvents and as a solvent for dyes, perfumes, and lacquers. Humans are exposed to cis-1,2-DCE primarily by inhalation, but exposure can also occur by oral and dermal routes. Limited information exists on the absorption, distribution, and excretion of cis-1,2-DCE in either humans or animals. Also, information on the toxicity of cis-1,2-DCE in humans and animals is limited. Workers exposed to 1,2-dichloroethene have been reported to suffer from drowsiness, dizziness, nausea, fatigue, and eye irritation (ATSDR 1996). Acute inhalation animal studies of cis-1,2-DCE suggests that the liver is the primary target organ. Secondary target organs can include the central nervous system and lung. The EPA has established a PPRTV for the chronic oral RfD of 0.01 mg/kg-day derived using a NOAEL for decreased hematocrit and hemoglobin with combined uncertainty factors and modifying factors of 300 (EPA 2004b). A chronic inhalation RfC for cis-1,2-DCE has not been derived. The EPA has placed both cis-1,2-DCE and trans-1,2-dichloroethylene in weight-of-

evidence group D, not classifiable as to human carcinogenicity, based on the lack of human or animal carcinogenicity data. Oral and inhalation slope factors have not been calculated for these isomers.

Manganese

Manganese is an essential element in humans; however, it can cause toxic effects with prolonged exposure at high concentrations via the oral or inhalation routes. The National Research Council (NRC) recommends a dietary allowance of 2 to 5 milligrams per day (mg/day) as a "safe and adequate" intake of manganese for an adult human (NRC 1989 as cited in RAIS 2005). The primary target organ for manganese toxicity is the CNS. Symptoms include headache, insomnia, and disorientation. These symptoms progress with continued exposure, and the motor skill effects are often irreversible. Intestinal absorption has been estimated to be between 3 and 10 percent (4 percent was employed in this HHRA; see RAGS Part D standard Table 5.1 of Attachment A) of the amount of manganese ingested. The oral dietary RfD for manganese of 0.14 mg/kg-day accounts for intake from all sources (e.g., diet, soil, and water). The EPA's IRIS assessment for manganese recommends that the dietary contribution from the normal U.S. diet (an upper limit of 5 mg/day) be subtracted when evaluating non-food (such as drinking water or soil) exposures to manganese, leading to an RfD of 0.069 mg/kg-day for non-food items. The explanatory text in IRIS further recommends using a modifying factor of 3 when calculating risks associated with non-food sources due to a number of uncertainties that are discussed in the IRIS toxicity profile for manganese, leading to a RfD of 0.02 mg/kg-day. After an uncertainty factor of 1,000 is applied, an inhalation RfC of 0.00005 mg/m^3 was calculated from an abundance of occupational studies addressing neurological impairment (EPA 2005a). Manganese is assigned to weight of evidence Group D based on a lack of existing studies to assess its carcinogenicity.

Tetrachloroethylene (PCE)

PCE is used primarily as a solvent in industry, and less frequently in commercial dry cleaning operations (ATSDR 1997a). Exposure to the general population can occur via exposure to contaminated air, food, and water. PCE is rapidly absorbed by the lungs and the digestive tract but not through the skin (RAIS 2005). The primary target organ of PCE is the liver by both the oral and inhalation exposure routes. Chronic exposure can cause various effects such as respiratory tract irritation, headache, nausea, sleeplessness, abdominal pain, cirrhosis of the liver, hepatitis, and nephritis. Oral exposure to PCE is primarily through drinking contaminated groundwater. It readily volatilizes from water, therefore contaminated water is also a potential source of inhalation exposure. Relative to other routes of exposure, little PCE vapor is absorbed across the skin. The RfD for chronic oral exposure to PCE is 0.01 mg/kg-day and is based on the application of an uncertainty factor of 1,000 to a NOAEL addressing hepatotoxicity in mice (EPA 2005a). As a RfC for PCE was not available from EPA's IRIS, PPRTV, or in the HEAST tables, a provisional RfC of 0.14 mg/m^3, which included an uncertainty factor of 100, was provided by NCEA as cited in the Region 3 RBC tables (EPA 2004d). An oral SF of 0.054 mg/kg-day and inhalation SF of 0.02 mg/kg-day were obtained from the EPA Region 3 RBC table, where the reference to "other" (EPA 2004d) as a source is the California Environmental Protection Agency.

Trichloroethylene (TCE)

TCE is an industrial solvent used primarily in metal degreasing and cleaning operations. TCE can be absorbed through the lungs, mucous membranes, gastrointestinal tract, and the skin; therefore, exposure to TCE may occur via the inhalation, oral, or dermal routes. TCE is extensively metabolized in humans

with most of the absorbed dose excreted in urine (ATSDR 1997b). Human and animal data indicate TCE exposure can result in toxic effects on a number of organs including the liver, kidney, blood, skin, immune system, reproductive system, nervous system, and cardiovascular system. In the past, TCE was used as a human anesthetic. TCE has also been used by individuals who intentionally inhale it for its narcotic properties. Therefore, most of the information regarding the effects of TCE in humans comes from case studies and experiments describing effects of TCE after inhalation exposure. These studies indicate that the primary effect of exposure to TCE is on the CNS. Effects include headache, vertigo, fatigue, short-term memory loss, decreased word associations, CNS depression, and anesthesia. Much of the most recently available information on TCE was summarized by EPA in an external review draft *Trichloroethylene Health Risk Assessment: Synthesis and Characterization* (EPA 2001b). However, that review draft was the subject of some controversy, and does not yet represent agency policy. In particular, the external review draft discussed several SFs, with most between 0.02 and 0.4 $(mg/kg\text{-}day)^{-1}$. Several sources of uncertainty have been identified and quantified (EPA 2001b). EPA's external draft review slope factor range, 0.02 to 0.4 per $(mg/kg\text{-}day)^{-1}$, lies just above EPA's previous SF for TCE, 0.011 per $(mg/kg\text{-}day)^{-1}$. The upper bound of the SF range 0.4 $(mg/kg\text{-}day)^{-1}$ was used as the oral SF for this HHRA. Despite the existence of numerous studies, EPA noted that the database for developing a noncancer RfD or RfC is problematic. ATSDR (1997b) did not derive chronic-duration levels for TCE, viewing the chronic studies as limited by inadequate characterization of exposure, inadequate quantitation of results, or lack of endpoints suitable for deriving chronic levels (ATSDR 1997b). The EPA has established a provisional oral RfD of 0.0003 mg/kg-day, which is based on critical effects in the liver, kidney, and developing fetus (EPA 2004b). A provisional inhalation RfC of 0.04 mg/m^3 has been proposed and used in this HHRA based on critical effects in the CNS, liver, and endocrine system (EPA 2001b, 2004b).

Vinyl Chloride (VC)

VC is among the few chemicals that has been conclusively linked to human cancer, and thus is classified as a class A weight-of-evidence carcinogen. EPA recently studied VC in detail and established two sets of SFs for VC, considering lifetime (since birth) exposure as well as exposure only in adulthood. EPA established the oral SF of 0.72 $(mg/kg\text{-}day)^{-1}$ to account for continuous lifetime exposure during adulthood, based on use of the linearized multistage model, with a twofold increase to 1.4 per mg/kg-day to account for continuous lifetime exposure from birth (EPA 2005a). Among the specific types of cancer induced in the animal studies were statistically significant increases in liver angiosarcomas, neoplastic nodules, and hepatocellular carcinomas, and risk was calculated based on animals exhibiting any of these endpoints. EPA (2005a) notes that the oral UR (and SF) should not be used if the water concentration exceeds 105 µg/L, because above this concentration the slope factor may differ from that stated.

VC is also carcinogenic via inhalation. Metabolism of VC becomes nonlinear at high exposure concentrations; therefore, cumulative exposure is not sufficient for quantitating risk. Instead, animal studies were pharmacokinetically converted to human equivalents. The pharmacokinetic model employed by EPA was linear up to nearly 100 mg/m^3; the calculated equivalence factor was used to convert the risk from the inhalation experiments conducted in animals (in the units of the dose metric) to human risk values (EPA 2005a). The slope factor is thus based on the UCL95 on risk in female rats. Calculation of a SF is appropriate in this case, in spite of the use of a pharmacokinetic model, because VC metabolism is linear in humans in this exposure range (EPA 2005a). EPA (2005a) notes that the inhalation UR of 0.0000044 $(\mu g/m^3)^{-1}$ for continuous exposure during adulthood should not be used if the air concentration exceeds 104 $\mu g/m^3$, because above this concentration the slope factor may differ from that stated.

Noncancer effects of VC have also been studied. Preneoplastic liver cell polymorphism was found to be the critical noncancer effect upon which EPA based the oral RfD 0.003 mg/kg-day for oral VC exposure. A total uncertainty factor of 30 was applied to a NOAEL for cellular changes in the rat liver of 0.13 mg/kg-day. The same underlying chronic dietary study is the foundation for the inhalation RfC of 0.1 mg/m^3 (EPA 2005a). The EPA found the inhalation database for VC deficient in chronic inhalation studies from which a RfC could be derived, but determined that the mode of action is common to exposures from either route (liver toxicity), and found that pharmacokinetic models were adequate for route-to-route extrapolations. The critical effect, increases in the incidence of liver cell polymorphism and cysts, was reported in both oral studies (lifetime feeding studies) and inhalation studies (EPA 2005a). In addition, the existing inhalation studies report no direct effects at the portal of entry (i.e., the respiratory tract). Therefore, the same study NOAEL was used in the EPA RfC derivation for VC, and included the same uncertainty factor of 30.