ENGINEERING EVALUATION/COST ANALYSIS

PROPERTIES IMMEDIATELY ADJACENT TO MARINA CLIFFS/NORTHWESTERN BARREL SITE SOUTH MILWAUKEE, WISCONSIN

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EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) Report has been prepared by Conestoga-Rovers & Associates (CRA), on behalf of the Marina Cliffs/Northwestern Barrel Site Performing Parties (Performing Parties). This EE/CA Report has been prepared pursuant to the requirements of an Administrative Order by Consent (AOC) Docket No. V-W-02-C-703 issued by the United States Environmental Protection Agency (USEPA) for the properties immediately adjacent to the Marina Cliffs/Northwestern Barrel Site (Site) in South Milwaukee, Wisconsin. The AOC was signed by USEPA on July 5, 2002.

The AOC directed the Performing Parties to implement EE/CA investigation activities at the residential properties located immediately west of the Site as well as the right-of-way owned by the City of South Milwaukee located immediately south of the Site (herein referred to collectively as the "Properties"). The AOC also directed the Performing Parties to complete a risk analysis of the exposure potential for residents on or near these Properties as well as construction/utility workers working at these Properties, and to develop and submit an EE/CA Report following completion of these EE/CA activities.

This EE/CA Report presents the basis for and results of EE/CA investigation activities completed on the Properties between 2002 and 2005, a Streamlined Risk Evaluation (SRE) of the analytical data collected, and identification and evaluation of Removal Action alternatives.

The Performing Parties conducted initial EE/CA investigation activities on the Properties in 2002 and 2003 under a USEPA-approved EE/CA Work Plan. Based on the analytical results for samples collected during the initial EE/CA investigation activities, it was determined that:

- TCL PCBs and/or lead were coincidently detected in shallow soils at concentrations exceeding USEPA's self-implementing (40 CFR Part §761.61.a) PCB residential cleanup level of 1 mg/kg and/or the lead IEUBK screening level of 400 mg/kg along the eastern boundary of the Marina Cliffs Condominium property, commencing near the southeast corner of Building No. 3, extending northward, east of Building No. 1, then westerly along the northern side of Building No. 1, extending onto the southeast corner of the Bay Heights Condominium property. Lead was also detected at a concentration exceeding its IEUBK screening level of 400 mg/kg at one location on the City of South Milwaukee Right-of-Way; and
- Four specific VOCs (benzene, ethylbenzene, PCE, and TCE) were detected above their respective VOC risk-based Region IX PRGs for an industrial worker in three discrete areas on the Marina Cliffs Condominium property: between Building Nos. 1 and 2; north of Building No. 2; and north of Building No. 4.

On January 8, 2004, representatives of the Performing Parties met with USEPA to discuss the analytical results for soil samples collected during the above referenced EE/CA sampling activities.

As a result of this meeting, a Time-Critical Removal Action was implemented by the Performing Parties on the Properties between May and July 2004. The Time-Critical Removal Action consisted of the excavation and off-Site disposal of all lead-impacted soils above its IEUBK screening level of 400 mg/kg and PCB-impacted soil above USEPA's self-implementing (40 CFR Part §761.61.a) PCB residential cleanup level of 1 mg/kg (ppm). The removal of all lead- and PCB-impacted soil was verified prior to backfilling by the performance of verification sampling conducted during excavation activities. There was a total of 1,359 cubic yards of impacted soils excavated and disposed of off Site.

During the January 8, 2004 meeting, there was also discussion pertaining to the VOC-impacted subsurface soils that exceeded VOC risk-based Region IX PRGs under a future construction/utility worker exposure scenario and potential Removal Action technologies to be evaluated in the EE/CA Report. The Performing Parties proposed that In Situ Chemical Oxidation (ISCO) be considered a viable Removal Action technology in the EE/CA Report to treat the VOC-impacted subsurface soils. USEPA indicated it would require additional information on the effectiveness of ISCO to treat the VOC-impacted soils.

Following this meeting, the Performing Parties conducted additional EE/CA investigation activities on the Properties in 2004 and 2005 under a USEPA-approved EE/CA Work Plan Addendum. A full-scale ISCO pilot study was conducted using the BIOX® technology in the three discrete areas with subsurface soils that exceeded VOC risk-based Region IX PRGs under a future construction/utility worker exposure scenario. Subsequent post-ISCO pilot study soil sampling indicated that BIOX® injection was effective in reducing VOC concentrations in the soils when applied at 3-foot injection point grid spacing.

Based on the analytical results for samples collected during the initial and additional EE/CA investigation activities and during the Time-Critical Removal Action, it was determined that:

- Following the excavation activities, all remaining lead and TCL PCB concentrations on the Properties are below USEPA's self-implementing (40 CFR Part §761.61.a) PCB residential cleanup level of 1 mg/kg and/or the lead IEUBK screening level of 400 mg/kg; and
- Following the implementation of the ISCO pilot study and the excavation activities, VOC impacts still remain in two discrete areas on the Marina Cliffs Condominium property: between Building Nos. 1 and 2; and north of Building No. 4. However, the pilot study has

demonstrated that the ISCO technology is effective in reducing VOC concentrations when implemented using the tighter grid spacing of 3-foot centers.

Subsequent to this additional work, an SRE was completed. Consistent with the AOC, the SRE was a focused assessment of estimated current and future risks to human health associated with potential exposure to chemical concentrations under the following two potential exposure pathways:

- Potential current / future residential exposure to soils, garden produce and indoor air; and
- Potential future hypothetical construction / utility worker exposure to soils and groundwater.

USEPA policy, as specified in the NCP (1990), has established that an upper limit excess cancer risk falling below or within the range of 1E-06 to 1E-04 is acceptable. In addition, 40 CFR Part 300.430 (f)(2) specifies that for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 1E-04 and 1E-06 using information on the relationship between dose and response. USEPA does, however, determine the acceptable risk level based on a site-by-site basis, taking into account a full engineering and cost analysis for the site. It is generally USEPA's goal to use a 1E-06 risk level as the point of departure for determining remediation goals when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure.

As part of the SRE, it was determined that many Contaminants of Potential Concern (COPC), which contributed to the estimated cumulative lifetime cancer risks and cumulative non-cancer hazard indices, were determined to be present in soils at levels below background, and therefore, are non-Properties-related. These non-Properties-related COPCs included arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b) fluoranthene, dibenz(a,h) anthracene, indeno(1,2,3-cd)pyrene. In addition, COPCs that contributed significantly to the estimated cumulative lifetime cancer risks and cumulative non-cancer hazard indices in indoor air include carbon tetrachloride, chloroform, and dichlorodifluoromethane. These COPCs were also determined to be non-Properties-related.

The estimated cumulative lifetime cancer risks and cumulative non-cancer hazard indices for the exposure scenarios are summarized below:

Exposure Scenario	Including Non-Properties-Related Constituents		Excluding Non-Properties-Related Constituents	
	RME Risk	RME Hazard	RME Risk	RME Hazard
Current/Future Residential				
Unit 1J (provisional TCE RfD and CSF)	1.2E-04	2.3	4.5E-05	1.5
Unit 1J (withdrawn TCE RfD and CSF)	8.9E-05	2.2	1.2E-05	1.4
Unit 2A[1]	8.8E-05	4.9	1.1E-05	1.4
Unit 3J[2]	7.6E-05	1.7	5.7E-06	1.4
Unit 4A (provisional TCE RfD and CSF)	1.1E-04	2.1	4.0E-05	1.4
Unit 4A (withdrawn TCE RfD and CSF)	8.4E-05	2.1	9.7E-06	1.4
Future Construction/Utility Worker				
(provisional TCE RfD and CSF)	1.8E-04	7.4	1.8E-04	7.4
(withdrawn TCE RfD and CSF)	4.0E-05	5.0	4.0E-05	5.0

As summarized above, when excluding non-Properties-related constituents, the estimated cumulative reasonable maximum exposure (RME) lifetime cancer risks for the current/future residential scenario for the individual units assessed are within the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals. Similarly, when excluding non-Properties-related constituents, the estimated cumulative RME non-cancer hazard indices for the current/future residential scenario are just slightly above 1.0, the level of potential concern.

As summarized above, the estimated cumulative RME lifetime cancer risks for the future construction/utility worker scenario are within or slightly above the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established by the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals. Similarly, the estimated cumulative RME non-cancer hazard indices for the future construction/utility worker scenario are well above 1.0, the level of potential concern. Both the estimated cumulative RME lifetime cancer risks and cumulative RME non-cancer hazard indices are associated with the presence of elevated concentrations of benzene, PCE, TCE and vinyl chloride in subsurface soils. As such, exclusion of non-Properties-related constituents does not reduce either the estimated cumulative RME lifetime cancer risks or the cumulative RME non-cancer hazard indices under the future construction/utility worker scenario.

Based on the estimated cumulative lifetime cancer risks and cumulative non-cancer hazard indices for the future construction/utility worker scenario, the SRE concluded that Non-Time-Critical Removal Action activities were considered necessary to address subsurface

[1] TCE not a contaminant of potential concern since it was not detected.

[2] TCE not a contaminant of potential concern since it was not detected.

soils that exceed acceptable risk-based VOC concentrations for future construction/utility workers to be protective of human health and the environment.

Consistent with EE/CA guidelines, the scope of removal activities and Removal Action Objectives (RAOs) were then established to ensure protection of human health and the environment. The specific RAO established for the Properties, based on the current and reasonably foreseeable land use of the Properties, the SRE conclusions, ARARs, and TBCs is:

- Treatment or removal of VOC-impacted soils to a depth of 10 feet below ground surface to meet acceptable VOC risk-based concentrations [i.e., the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990)] for future construction/utility workers.

Based on the RAO established, potential Removal Action technologies were identified and evaluated. The following four Removal Action alternatives were then assembled from the candidate technologies and were subjected to a comparative evaluation based on effectiveness in meeting the RAO, implementability, and cost:

- Alternative 1 - No Action;
- Alternative 2 – Monitored Natural Attenuation, Institutional Controls, and Drain Tile Depressurization Systems;
- Alternative 3 - Excavation/Off-Site Disposal, Institutional Controls, and Drain Tile Depressurization Systems; and
- Alternative 4- In situ Chemical Oxidation (ISCO), Institutional Controls, and Drain Tile Depressurization Systems.

Based on the comparative analysis, it was determined that Alternatives 2, 3, and 4 would all be protective of human health and the environment. Alternative 2 would be would be the least disruptive to the property owners in the short term, but would require periodic soil sampling over a period of approximately 30 years to monitor the natural attenuation of VOCs in the subsurface soils. Both Alternatives 3 and 4 include additional active remediation in the short term, and would meet acceptable risk-based VOCs concentrations in soils within 3 months of implementation. Alternative 3 would be very difficult to implement because of the proximity of impacted soils to underground utilities and to foundation walls, whereas Alternative 4 has been implemented at the Properties as part of the full-scale ISCO pilot study. Alternative 3 would be approximately three times more expensive to implement than either Alternative 2 or Alternative 4.

USEPA will select the final Removal Action alternative to be implemented at the Properties.

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1.0 INTRODUCTION

This Engineering Evaluation/Cost Analysis (EE/CA) Report has been prepared by Conestoga-Rovers & Associates (CRA), on behalf of the Marina Cliffs/Northwestern Barrel Site Performing Parties (Performing Parties). This EE/CA Report has been prepared pursuant to the requirements of an Administrative Order by Consent (AOC) Docket No. V-W-02-C-703 issued by the United States Environmental Protection Agency (USEPA) for the properties immediately adjacent to the Marina Cliffs/Northwestern Barrel Site (Site) in South Milwaukee, Wisconsin. The AOC was signed by USEPA on July 5, 2002.

The AOC directed the Performing Parties to implement EE/CA activities at the properties immediately adjacent to the Marina Cliffs/Northwestern Barrel Site consistent with the USEPA-approved EE/CA Scope of Work which was provided as Attachment C to the AOC. The AOC directed the Performing Parties to develop and submit an EE/CA Work Plan detailing the additional sampling activities that would be completed to further define the extent of potential contamination at the residential properties located immediately west of the Site as well as the right-of-way owned by the City of South Milwaukee located immediately south of the Site (herein referred to collectively as the "Properties"). The AOC also directed the Performing Parties to complete a risk analysis of the exposure potential for residents on or near these Properties as well as construction/utility workers working at these Properties, and to develop and submit an EE/CA Report following completion of these EE/CA activities.

The EE/CA Work Plan (CRA, 2002) was submitted to USEPA for approval under cover dated July 19, 2002 and was conditionally approved by USEPA in a letter dated September 17, 2002. Conditional approval was granted by USEPA for all of the proposed EE/CA Work Plan sampling activities with the exception of the proposed indoor air, ambient air, and soil gas sampling. USEPA approval of these activities was delayed pending USEPA's review and approval of an Amendment to the USEPA-approved Quality Assurance Project Plan (QAPP). USEPA provided approval of the QAPP Amendment on October 24, 2002. Sampling activities, specified in the USEPA-approved EE/CA Work Plan, were completed at the Properties between October 2002 and March 2003.

Based on the analytical results for soils samples collected during the EE/CA sampling activities performed between October 2002 and March 2003, it was determined that:

- TCL PCBs and/or lead were coincidently detected in shallow soils at concentrations exceeding USEPA's self-implementing (40 CFR Part §761.61.a) PCB residential

cleanup level of 1 mg/kg and/or the lead IEUBK screening level of 400 mg/kg along the eastern boundary of the Marina Cliffs Condominium property, commencing near the southeast corner of Building No. 3, extending northward, east of Building No. 1, then westerly along the northern side of Building No. 1, extending onto the southeast corner of the Bay Heights Condominium property. Lead was also detected at a concentration exceeding its IEUBK screening level of 400 mg/kg at one location on the City of South Milwaukee Right-of-Way; and

- Four specific VOCs (benzene, ethylbenzene, PCE, and TCE) were detected above their respective VOC risk-based Region IX PRGs for an industrial worker in three discrete areas on the Marina Cliffs Condominium property: between Building Nos. 1 and 2; north of Building No. 2; and north of Building No. 4.

On January 8, 2004, representatives of the Performing Parties met with USEPA to discuss the analytical results for soil samples collected during the EE/CA sampling activities.

During the meeting, the Performing Parties requested USEPA to consider the implementation of a Time-Critical Removal Action for the Pb- and PCB-impacted shallow soils on the Properties since they represented a potential current exposure to residents. The Performing Parties proposed excavation and off-Site disposal for the Pb- and PCB-impacted shallow soils. USEPA agreed with this approach, subject to USEPA meeting with the Marina Cliffs and Bay Heights condominium associations, since the proposed Time-Critical Removal Action was consistent with the Removal Action implemented on the Site and there was a potential current exposure pathway to residents.

USEPA and Performing Parties' representatives met with the condominium associations on February 12 and April 5, 2004 to discuss the proposed Time-Critical Removal Action activities and responded to comments from individual residents on the Properties. Subsequently, USEPA approved a Time-Critical Removal Action Work Plan prepared by the Performing Parties and issued an AOC with the Performing Parties on May 4, 2004 (No. V-W-04-C-787) for performance of that Time-Critical Removal Action.

Time-Critical Removal Action activities commenced on the Properties in May 2004 and were completed in July 2004. The Time-Critical Removal Action included the excavation and off-Site disposal of all impacted soils with lead concentrations above the IEUBK screening level of 400 mg/kg and with PCB concentrations above USEPA's self-implementing PCB residential cleanup level of 1 mg/kg. The removal of all lead- and PCB-impacted soil was verified prior to backfilling by the performance of

verification sampling conducted during excavation activities. There was a total of 1,359 cubic yards of impacted soils excavated and disposed of off Site. The Time-Critical Removal Action activities conducted at the Properties are summarized in the Time-Critical Removal Action Report submitted to USEPA under cover dated August 22, 2005 (CRA, 2005a).

During the January 8, 2004 meeting, there was also discussion pertaining to the VOC-impacted subsurface soils that exceeded VOC risk-based Region IX PRGs (screening values) under a future construction/utility worker exposure scenario and potential Removal Action technologies to be evaluated in the EE/CA Report. The Performing Parties proposed that In Situ Chemical Oxidation (ISCO) be considered a viable Removal Action technology in the EE/CA Report to treat the VOC-impacted subsurface soils. USEPA indicated they would require additional information on the effectiveness of ISCO to treat the VOC-impacted soils. Thus, the Performing Parties proposed to conduct additional EE/CA investigation activities to provide USEPA with the additional information requested.

A draft Work Plan Addendum was prepared and submitted to USEPA and WDNR on April 1, 2004. USEPA provided verbal approval on a portion of the draft Work Plan Addendum on April 2, 2004 in order to allow chemical oxidation bench-scale treatability study activities to commence. USEPA provided written comments on the draft Work Plan Addendum in June 2004. The Work Plan Addendum was revised and resubmitted to USEPA under cover dated September 30, 2004 (CRA, 2004b). The Work Plan Addendum incorporated appropriate revisions based on USEPA's June 2004 comments and included the results of the bench-scale treatability study, which had been completed. Subsequent to attending two meetings with the Marina Cliffs Condominium Association on October 4 and 14, 2004, to review and discuss the Work Plan Addendum, USEPA approved the September 30, 2004 Work Plan Addendum, with revisions (i.e., Figure 3.4) based on comments received from the residents. The additional EE/CA investigation activities were completed at the Properties between October 2004 and October 2005. These additional investigation activities included the completion of a full-scale ISCO pilot study at the Properties in November/December 2004.

A Streamlined Risk Evaluation (SRE) of the analytical data collected during the EE/CA sampling activities at the Properties was subsequently completed and is presented herein. The SRE is a focused assessment of potential current and future risks to human health associated with chemical concentrations in surface soil, subsurface soil, indoor air, and groundwater at the Properties. The SRE is comprised of a Site Characterization, Identification of Chemicals of Potential Concern, Exposure Assessment, Toxicity Assessment, and Risk Characterization. The SRE process applies several theoretical

assumptions to determine a numerical expression of both carcinogenic and non-carcinogenic risk to human health. The SRE characterizes potential carcinogenic effects in terms of probabilities that an individual would develop cancer over a lifetime based on an exposure period to hazardous constituents related to the Properties. The potential for non-carcinogenic effects is evaluated by comparing an estimated daily intake level from potential exposures to a reference dose which is defined as the intake level at which a receptor can be exposed daily over their entire lifetime without experiencing appreciable adverse health effects. The results of the evaluation of carcinogens and non-carcinogens were then compared to acceptable levels developed by USEPA. Based on the results of the SRE, it was concluded that Non-Time-Critical Removal Action activities, in response to VOC concentrations in subsurface soils at the Properties, are required to be protective of human health and the environment.

Consistent with EE/CA guidelines, the scope of additional removal activities and Removal Action Objectives (RAOs) were then established to ensure protection of human health and the environment. Based on the RAOs established, potential Removal Action technologies were identified and evaluated. Removal action alternatives were then assembled from candidate technologies and subjected to an evaluation based on effectiveness in meeting the RAOs, implementability, and cost. Finally, a comparative evaluation of the Removal Action alternatives is presented in this EE/CA Report. Based on this comparative analysis, the USEPA will select the final Removal Action alternative to be implemented at the Properties.

This EE/CA Report has been prepared consistent with the USEPA-approved EE/CA Work Plan (CRA, 2002) and the USEPA-approved EE/CA Work Plan Addendum (CRA, 2004b), as well as applicable laws, regulations, and USEPA policy as specified in USEPA's Office of Emergency and Remedial Response guidance document titled "Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA" dated August 1993 (USEPA Guidance Document). This Guidance Document provides information on the procedures and activities that the USEPA uses in conducting Non-Time-Critical Removal Actions under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

2.0 SITE CHARACTERIZATION

2.1 SITE DESCRIPTION AND BACKGROUND

2.1.1 LOCATION

The Site and the Properties are located on the shoreline of Lake Michigan in the city of South Milwaukee, Wisconsin (NW ¼, NW ¼, Section 13, Township 5N, Range 22E) near the intersection of Marina Road and Fifth Avenue. The locations of the Site (latitude 42°53'59" N, longitude 87°50'55" W) and the Properties are shown on Figure 2.1.

Generally, the Site and the Properties are bounded to the east by Lake Michigan; to the west by Fifth Avenue; to the north by the South Milwaukee Wastewater Treatment Plant; and to the south by Marina Road and apartments located along Marina Road. A plan of the existing conditions of the Site and the Properties is presented on Figure 2.2.

Northwestern Barrel Company's barrel reconditioning operations were conducted on an approximately 18-acre parcel of property. USEPA initially defined the Site to include only the eastern portion of the property, which consists of roughly 13 acres of the original 18 acres occupied by the Northwestern Barrel Company. The original Site definition excluded the residential properties located immediately west of the Site as well as the right-of-way owned by the City of South Milwaukee located immediately south of the Site. The 13-acre portion of the property (i.e., Site) included the ravine, lake bluff, and upland areas and was the focus of Time-Critical and Non-Time-Critical Removal Actions conducted pursuant to the 1995 and 1998 Unilateral Administrative Orders (Nos. V-W-95-C-313 and V-W-98-C-486) and the 2001 AOC (No. V-W-01-C-630).

The remaining 5 acres including the residential properties located immediately west of the Site as well as the right-of-way owned by the City of South Milwaukee located immediately south of the Site (the "Properties") were the focus of Time-Critical Removal Actions recently completed at the Properties in 2004 pursuant to AOC No. V-W-04-C-787 and Non-Time-Critical Removal Actions, including this EE/CA Report, which have been completed pursuant to the AOC No. V-W-02-C-703.

2.1.2 SETTING

The Site is municipally zoned for residential occupancy. Land use of the properties located immediately west of the Site is residential and land use of the property located immediately south of the Site is a right-of-way owned by the City of South Milwaukee.

Land use in the surrounding area is residential consisting of mostly homes, apartment and condominium buildings. The South Milwaukee Wastewater Treatment Plant is located immediately north of the Site and the Properties. Residences are serviced with a municipal water supply that utilizes Lake Michigan as a source of drinking water.

General stratigraphy in the vicinity of the Site and the Properties is characterized as approximately 150 feet of silty clay glacial drift overlying Silurian dolostone bedrock. The drift was deposited during the Woodfordian substage of the Wisconsinan glaciation. The principal stratigraphic unit in the vicinity of the Site and the Properties is silty clay till of the Oak Creek formation. The silty clay till has a very low permeability, which acts as an aquitard limiting the potential for downward groundwater migration.

The climate in southeastern Wisconsin is temperate with seasonal changes in temperature and precipitation. The average annual rainfall is approximately 32 inches per year with over half of the precipitation falling between May and September. The ground is generally snow covered and frozen from December through February and the mean annual temperature of the area is 50°F.

2.1.3 HISTORY

Prior to 1941, the Site and the Properties had been operated as a leather treatment/ tanning facility by the Pfister & Vogel Leather Company. The Northwestern Barrel Company operated a barrel reconditioning facility on the Site and the Properties from approximately 1941 until 1964. Northwestern Barrel Company reconditioned both steel and wood barrels. Used barrels were received from a wide variety of companies for cleaning and reconditioning. The operations included handling, washing, and refurbishing of drums and barrels. The residuals from these operations were disposed of in disposal pits on the Site[3]. Northwestern Barrel Company then sold the reconditioned drums.

Trilla Cooperage purchased the barrel operation in 1964 and continued to store barrels and drums there until late in the year, when it moved the barrel operation to Oak Creek, Wisconsin. U.S. Equities, a real estate developer, purchased the property in 1965. The Estate of Nicholas Demos owned the property from 1968 to 1972, and Northern Trust Company (co-executor of the estate) held the title to and operated the property. Unicare Development Corporation bought the property in 1972, and then sold the Site to Towne

[3] Historical contamination on the Site, primarily VOCs, PCBs, and Pb present in disposal pit sludge or near surface soils have been remediated through a series of Time-Critical Removal Actions as documented in the Supplemental Work Plan for the Site (CRA, 2005b).

Realty in 1982. The residential properties located immediately west of the Site are currently privately owned and the right-of-way located immediately south of the Site was conveyed by Towne Realty to the City of South Milwaukee in April 1994.

2.2 PREVIOUS INVESTIGATIONS – 1996 TO 1999

The following subsections summarize previous surface and subsurface soil investigation activities conducted at the Properties prior to implementation of the EE/CA investigation activities in 2002.

A summary of investigative analytical samples collected on the Properties during these previous investigative activities and discussed in this EE/CA, including the date of sample collection, depth, and analysis type is provided in Table D.1, Appendix D. Surface soil analytical results are presented in Tables D.2 and D.6, Appendix D and subsurface soil analytical results are presented in Tables D.3 and D.7, Appendix D. The soils analytical data presented in Tables D.2 and D.3, Appendix D are considered representative of current Properties' conditions. The soils analytical data presented in Tables D.6 and D.7, Appendix D are not considered representative of current Properties' conditions since the samples were collected from soils that were either excavated during Time-Critical Removal Actions completed at the Properties in 2004 (see Section 2.4.2) or were treated during the full-scale ISCO pilot study completed at the Properties in 2004 (see Section 2.4.3.3).

2.2.1 PERFORMING PARTIES BACKGROUND SURFACE SOIL SAMPLING - 1996

In accordance with the USEPA-approved Non-Time-Critical Site-Wide Evaluation Work Plan dated October 1996 (CRA, 1996), the Performing Parties conducted background surface soil sampling in the vicinity of the Site and the Properties in November 1996 at four locations (SS-B-01 through SS-B-04). In December 2000, as part of the Site EE/CA investigation, the Performing Parties collected one additional background surface soil sample (JW-164). This additional sample was collected in accordance with the USEPA-approved Addendum EE/CA Work Plan, dated September 2000 (CRA, 2000).

All background surface soil samples were collected from a depth of 0 to 0.5 feet below ground surface (bgs) and were analyzed for the full Target Compound List/Target Analyte (TCL/TAL) parameter list. These data were previously incorporated into the

Site EE/CA Report (CRA, 2004a). The locations for these background surface soil samples are shown on Figure 2.3.

2.2.2 WDHFS SURFACE SOIL SAMPLING - 1997

The Wisconsin Department of Health and Family Services (WDHFS) collected a total of 28 surface soil samples from the Properties and the Site on July 11, 1997. Of the 28 surface soil samples collected, 19 were collected from the Properties (SM-SS-01, -02, -04, -06 through -08, -09A, -09B, -14 through -23, and -27), eight were collected from the Site (SM-SS-05, -10 through -13, and -24 through -26), and one was scraped from a pair of boots (SM-SS-03). All surface soil samples from the Properties were collected from a depth of 0 to 4 inches bgs and were analyzed for lead. The locations of the WDHFS surface soil samples collected from the Properties are shown on Figure 2.3.

The analytical data for the 19 surface soil samples collected by WDHFS on the Properties in 1997 were summarized and evaluated in a letter dated July 22, 1997 from WDHFS to the South Milwaukee Health Department. The WDHFS concluded, based on the analytical results, the concentrations of lead detected in the surface soil samples ranged from 16 to 112 mg/kg and were not a health hazard.

2.2.3 PERFORMING PARTIES SURFACE/SUBSURFACE SOIL SAMPLING - 1998

Investigation activities were initially completed at the Properties by the Performing Parties in March and June/July 1998 as part of the Non-Time-Critical Site-Wide Evaluation investigation activities.

Between March 9, 1998 and March 17, 1998, Non-Time-Critical Site-Wide Evaluation investigation field activities were conducted at the Properties in accordance with the USEPA-approved Addendum to Non-Time-Critical Site-Wide Evaluation Work Plan, dated January 26, 1998. The analytical results of the additional Non-Time-Critical Site-Wide Evaluation investigation activities were summarized by CRA on behalf of the Performing Parties in a Technical Memorandum to USEPA dated May 8, 1998.

As discussed in the May 8, 1998 Technical Memorandum, a total of 12 surface soil samples (SS-1 through SS-11 and SS-13) were collected on the Properties and on the Site in the vicinity of the Properties. The surface soil samples were all collected from a depth of 0.5 to 1.0 feet bgs and were analyzed for the full TCL/TAL parameter list. Of the 12

surface soil samples collected, 11 were collected on the Properties (SS-1 through SS-11), and one was completed on the Site (SS-13). The locations of the surface soil samples collected from the Properties are shown on Figure 2.3 and the data are discussed in Section 2.3.9.

As also discussed in the May 8, 1998 Technical Memorandum, a total of 11 boreholes (BH-1 through BH-11) were completed on the Properties and on the Site in the vicinity of the Properties. The boreholes ranged in depth from 10 to 14 feet bgs. In accordance with the USEPA-approved Addendum, a sample of non-native soil (i.e., backfill) was collected from each borehole and analyzed for TCL Polychlorinated Biphenyls (PCBs) and lead. A second sample was collected at each borehole from the upper 2 feet of the underlying native silty clay till and was analyzed for the full TCL/TAL parameter list. In addition, a third sample was collected at each borehole from a depth of approximately 5 feet below the top of the native silty clay till and was analyzed for TCL PCBs and lead. Two additional subsurface soil samples were collected at borehole BH-5 and one additional subsurface soil sample was collected at borehole BH-10 and was analyzed for the full TCL/TAL parameter list. Of the 11 boreholes completed, five were completed on the Properties (BH-2, BH-4, BH-5, BH-7, and BH-8), five were completed on the Site in the vicinity of the Properties (BH-1, BH-3, BH-6, BH-9, and BH-11), and one was completed south of Marina Road (BH-10). The locations of the boreholes completed on the Properties are shown on Figure 2.3 and data are discussed in Section 2.3.9.

In response to the elevated concentrations of VOCs detected in subsurface soil samples collected at borehole BH-5 (see Section 2.3.9), a second Addendum to the USEPA-approved Non-Time-Critical Site-Wide Evaluation Work Plan was prepared by CRA on behalf of the Performing Parties and submitted to USEPA/WDNR under cover dated May 29, 1998. The USEPA approved the second Addendum to the USEPA-approved Non-Time-Critical Site-Wide Evaluation Work Plan in a letter to CRA dated June 10, 1998.

Between June 29, 1998 and July 1, 1998, additional Non-Time-Critical Site-Wide Evaluation investigation field activities were conducted at the Properties in accordance with the USEPA-approved Addendum to Non-Time-Critical Site-Wide Evaluation Work Plan, dated May 29, 1998. The analytical results of the additional Non-Time-Critical Site-Wide Evaluation investigation activities were summarized by CRA on behalf of the Performing Parties in the August 1998 Monthly Progress Report for the Site, dated September 10, 1998.

As discussed in the August 1998 Monthly Progress Report, the surface soil sample (SS-12) and the borehole (BH-12) that were not completed as part of the sampling program in March 1998, due to access issues, were collected during this sampling event. The surface soil sample and the borehole subsurface soil samples were collected consistent with the protocols adhered to in March 1998. All soil samples were analyzed for the full TCL/TAL parameter list. The locations of surface soil sample SS-12 and borehole BH-12 are shown on Figure 2.3 and the data are discussed in Section 2.3.9.

As also discussed in the August 1998 Monthly Progress Report, a total of 11 additional boreholes (BH-13 through BH-23) were completed on the Properties. Boreholes BH-13 through BH-21 and BH-23 were completed in the vicinity of BH-5. Borehole BH-22 was completed near the northeast corner of Building 4 on the Marina Cliffs Condominium property. Boreholes BH-13 through BH-21 and BH-23 ranged in depth from 18 to 20 feet bgs and borehole BH-22 was completed to depth of 10 feet bgs. In accordance with the USEPA-approved Addendum, a minimum of three subsurface soil samples were collected from all boreholes and were analyzed for TCL VOCs. One sample collected from borehole BH-14 and one sample collected from borehole BH-22 were also analyzed for the full TCL/TAL parameter list and one sample from borehole BH-19 and BH-20 were also analyzed for TCL Semivolatile Organic Compounds (SVOCs). All subsurface soil samples were selected from depth intervals determined by CRA's representative in consultation with USEPA's representative based on an evaluation of the PID headspace analyses at each borehole. The locations of the boreholes completed on the Properties are shown on Figure 2.3 and the data are discussed in Section 2.3.9.

A health evaluation of the analytical data collected in March and June/July 1998 was completed by the Wisconsin Department of Health and Family Services (WDHFS) and summarized in a letter to USEPA dated November 3, 1998. In the letter, WDHFS concluded that concentrations detected in the surface soils were not a health hazard and that VOC concentrations detected in the subsurface soils between Marina Cliffs Condominium Building Nos. 1 and 2 were not a direct contact health hazard. However, WDHFS recommended that additional investigation activities (i.e., indoor air sampling, soil gas sampling, and subsurface soil sampling) be completed between Marina Cliffs Condominium Building Nos. 1 and 2 and in the vicinity of borehole BH-22 between Marina Cliffs Condominium Building Nos. 3 and 4.

2.2.4 MARINA CLIFFS CONDOMINIUM ASSOCIATION SURFACE/ SUBSURFACE SOIL SAMPLING - 1999

In December 1999, surface and subsurface soil samples were collected by Thresher & Son, Inc., on behalf of the Marina Cliffs Condominium Association, at the Marina Cliffs Condominium property. Samples were collected from three locations (MCB-1 through MCB-3). At each location, samples were collected from 0 to 1 foot bgs, 1 to 2 feet bgs, and 3 to 4 feet bgs. All samples were analyzed for PCBs and lead. The sample locations are shown on Figure 2.3 and the data are discussed in Section 2.3.9.

2.3 EE/CA WORK PLAN INVESTIGATION ACTIVITIES – 2002/2003

2.3.1 GENERAL

Based on the results of the previous investigations conducted at the Properties from 1996 through 1999, USEPA signed an EE/CA Approval Memorandum on August 15, 2000, which documented the need to collect additional information necessary to conduct an EE/CA investigation for the Properties. A number of meetings and discussions were subsequently held between representatives of USEPA, WDNR, WDHFS, and the Performing Parties to discuss the scope of the EE/CA investigation activities to be completed at the Properties. The final Scope of Work for the EE/CA investigation activities was submitted by CRA, on behalf of the Performing Parties, under cover dated March 1, 2002. The final Scope of Work for the EE/CA investigation was approved by USEPA and was included as Attachment C to the AOC issued by USEPA for the Properties. The AOC was signed by USEPA on July 5, 2002.

The AOC directed the Performing Parties to develop and submit an EE/CA Work Plan detailing the additional sampling activities that would be completed to further define the extent of potential contamination at the Properties, consistent with the USEPA-approved EE/CA Scope of Work. The EE/CA Work Plan (CRA, 2002) was submitted to USEPA for approval under cover dated July 19, 2002, and was conditionally approved by USEPA in a letter dated September 17, 2002. Conditional approval was granted by USEPA for all of the proposed EE/CA Work Plan sampling activities with the exception of the proposed indoor air, ambient air, and soil gas sampling. USEPA approval of these activities was delayed pending USEPA's review and approval of an Amendment to the USEPA-approved Quality Assurance Project Plan (QAPP). USEPA provided approval of the QAPP Amendment on October 24, 2002.

Subsequent finalizing the Scope of Work for the EE/CA investigation activities in March 2002 and prior to issuance of the AOC in July 2002, six boreholes (BH-36 through BH-41) were advanced and soil samples were collected south of Marina Cliffs Condominium Building Nos. 3 and 4 on March 19, 2002. These boreholes were completed in response to a request received from the Marina Cliffs Condominium Association. These activities were completed prior to the effective date of the AOC for the EE/CA to allow completion of surface water drainage modification activities in this area in the spring of 2002 by the Marina Cliffs Condominium Association. However, as agreed with USEPA, these activities and the analytical data collected were used to replace those activities proposed for this area in the USEPA-approved EE/CA Scope of Work and have been incorporated into the discussion of EE/CA investigation activities discussed in Sections 2.3.2 and 2.3.3.

The following subsections summarize surface soil, subsurface soil, groundwater, soil gas, indoor air and background ambient air investigation activities conducted as part of the EE/CA investigation activities completed at the Properties in 2002 and 2003. All activities were completed in accordance with the USEPA-approved EE/CA Work Plan.

A summary of investigative analytical samples collected on the Properties during these EE/CA investigative activities and discussed in this EE/CA, including the date of sample collection, depth, and analysis type is provided in Table D.1, Appendix D. Surface soil analytical results are presented in Tables D.2 and D.6, Appendix D and subsurface soil analytical results are presented in Tables D.3 and D.7, Appendix D. Groundwater analytical results are presented in Table D.4, Appendix D and soil gas, indoor air, and background ambient air analytical results are presented in Table D.5, Appendix D. The soils analytical data presented in Tables D.2 and D.3, Appendix D are considered representative of current Properties' conditions. The soils analytical data presented in Tables D.6 and D.7, Appendix D are not considered representative of current Properties' conditions since the samples were collected from soils that were either excavated during Time-Critical Removal Actions completed at the Properties in 2004 (see Section 2.4.2) or were treated during the full-scale ISCO pilot study completed at the Properties in 2004 (see Section 2.4.3.3).

2.3.2 SURFACE SOIL SAMPLING AND LABORATORY ANALYSES

2.3.2.1 GENERAL

In accordance with the USEPA-approved EE/CA Work Plan, surface soil samples were collected on a uniform grid across the condominium properties located immediately

west of the Site and from selected locations from the City of South Milwaukee right-of-way. These surface soil samples were collected to supplement the existing analytical database for surface soil samples collected during previous investigation activities at the Properties.

Surface soil samples were collected from a total of 45 locations, as discussed below. The final locations for all surface soil samples were determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of conditions encountered. Surface soil samples were collected from boreholes BH-36 through BH-41 on March 19, 2002 and from all other locations from October 7, 2002 through December 3, 2002.

All surface soil samples, with the exception of two locations, were collected from 0.0 to 0.5 feet bgs. Surface soil samples were collected at location BH-38 from 1.0 to 3.0 feet bgs and at location BH-50 from 1.0 to 2.0 feet bgs. All surficial soil samples were collected using direct push or stainless steel trowel sampling techniques. The surface soil samples were examined by CRA's project geologist and described in accordance with the Unified Soil Classification System (USCS). All surface soil sampling locations were surveyed for horizontal and vertical control using the previously established grid coordinate system and geodetic datum. The surface soil sample locations are shown on Figure 2.3.

2.3.2.2 GRID LOCATIONS

Initially, a uniform 75-foot grid was established across the condominium properties and surface soil samples were collected from 33 locations (BH-36 through BH-39, BH-41 through BH-50, BH-55, BH-60 through BH-64, BH-66, BH-67, BH-76, BH-77, BH-79 through BH-81, and BH-83 through BH-88). The samples were submitted to Severn Trent Laboratories (STL) of North Canton, Ohio, for laboratory analyses of TCL SVOCs and PCBs, and TAL inorganics. In addition, a select number of surface soil samples were submitted to STL for laboratory analyses of TCL pesticides.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

These data, in conjunction with the existing analytical data collected during previous investigations, were used to assess the distribution of surface soil TCL SVOCs, PCBs,

pesticides and TAL inorganics concentrations across the condominium properties. These data are discussed in Section 2.3.9.

2.3.2.3 RIGHT-OF-WAY AREA DELINEATION LOCATIONS

Surface soil samples were also collected from six locations (BH-89 through BH-93 and BH-95) in the City of South Milwaukee right-of-way. The samples from locations BH-89 through BH-93 were submitted to STL for laboratory analyses of TCL PCBs and lead. The sample from location BH-95 was submitted to STL for laboratory analyses of TCL SVOCs, PCBs, pesticides, and TAL inorganics.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

These data, in conjunction with the existing analytical data collected during previous investigations, were used to assess the distribution of surface soil TCL PCBs and lead concentrations in the City of South Milwaukee right-of-way. These data are discussed in Section 2.3.9.

2.3.2.4 DRAINAGE SWALE LOCATIONS

Following completion of surface water drainage modification activities south of Marina Cliffs Condominium Building Nos. 3 and 4 by the Marina Cliff Condominium Association in 2002, USEPA requested and the Performing Parties agreed to collect confirmatory surface soil samples from the disturbed areas. Therefore, additional surface soil samples were collected from six locations (BH-96 through BH-101) south of Marina Cliffs Condominium Building Nos. 3 and 4 and were submitted to STL for laboratory analyses of TCL PCBs and lead. These data are discussed in Section 2.3.9.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

2.3.3 SUBSURFACE SOIL SAMPLING AND LABORATORY ANALYSES

2.3.3.1 GENERAL

In accordance with the USEPA-approved EE/CA Work Plan, subsurface soil samples were collected from boreholes on a uniform grid across the condominium properties from two locations from the City of South Milwaukee right-of-way, and from selected additional locations across the condominium properties. These subsurface soil samples were collected to supplement the existing analytical database for subsurface soil samples collected during previous investigation activities at the Properties.

Subsurface soil samples were collected from a total of 54 borehole locations, as discussed below. The final locations for all boreholes were determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of conditions encountered. Subsurface soil samples were collected from boreholes BH-36 through BH-41 on March 19, 2002 and from boreholes BH-42 though BH-95 from October 7, 2002 through October 16, 2002.

All boreholes were advanced using direct-push techniques and continuous soil sampling. All subsurface soils were examined by CRA's project geologist and described in accordance with the USCS. All subsurface soil samples were screened over the entire length of the borehole with a PID for the presence of volatile organics and samples were selected from depth intervals determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of conditions encountered. All selected subsurface soil samples were submitted under chain-of-custody to STL for laboratory analyses. All boreholes were surveyed for horizontal and vertical control using the previously established grid coordinate system and geodetic datum. A summary of the PID headspace analyses, soil description, and the subsurface soil samples selected for laboratory analyses at each borehole location is summarized in the stratigraphic and instrumentation logs provided in Appendix A. The borehole locations are shown on Figure 2.3.

2.3.3.2 GRID LOCATIONS

Initially, a uniform 75-foot grid was established across the condominium properties and subsurface soil samples were collected at 37 borehole locations (BH-36, BH-37, BH-39 through BH-55, BH-61, BH-62, BH-65 through BH-67, BH-75 through BH-78, and BH-80

through BH-88). Subsurface soil samples were also collected from the City of South Milwaukee right-of-way at two locations (BH-89 and BH-95).

Subsurface soil samples were collected from the 37 borehole locations across the condominium properties as follows:

- One subsurface soil sample was selected from each borehole and was submitted to STL for laboratory analyses of TCL SVOC, TCL PCBs, and TAL inorganics;
- A select number of subsurface soil samples were submitted to STL for laboratory analyses of TCL pesticides; and
- Subsurface soil samples were also submitted to STL for laboratory analyses of TCL VOCs if screening with a PID indicated the presence of VOCs.

One subsurface soil sample was selected from the each of the two borehole locations completed on the City of South Milwaukee right-of-way and were submitted to STL for laboratory analyses of TCL SVOC, TCL PCBs, and TAL inorganics.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

These data, in conjunction with the existing analytical data from previous investigations, were used to assess the distribution of TCL VOCs, SVOCs, PCBs, pesticide, and TAL inorganic subsurface soil concentrations at the Properties. These data are discussed in Section 2.3.9.

2.3.3.3 DELINEATION LOCATIONS – BUILDING NOS. 3 AND 4 AREA

Subsurface soil samples were collected from six borehole locations (BH-56 through BH-60 and BH-69) near borehole BH-22 in the vicinity of Marina Cliffs Condominium Building Nos. 3 and 4. Two to three subsurface soil samples were selected from each of the six borehole locations and were submitted to STL for laboratory analysis of TCL VOCs.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed

and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

These data, in conjunction with the existing analytical data from previous investigations, were used to assess the distribution of TCL VOCs in the vicinity of borehole BH-22. These data are discussed in Section 2.3.9.

2.3.3.4 DELINEATION LOCATIONS – BUILDING NOS. 1 AND 3 AREA

Subsurface soil samples were collected from four borehole locations (BH-68 and BH-70 through BH-72) east of Marina Cliffs Condominium Building Nos. 1 and 3. Two subsurface soil samples were selected from each of the four borehole locations and were submitted to STL for laboratory analysis of TCL PCBs and lead.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

These data, in conjunction with the existing analytical data from previous investigations, were used to assess the distribution of TCL PCBs and lead subsurface soil concentrations east of Marina Cliffs Condominium Building Nos. 1 and 3. These data are discussed in Section 2.3.9.

2.3.3.5 DELINEATION LOCATIONS – BUILDING NOS. 1 AND 2 AREA

Subsurface soil samples were collected from two borehole locations (BH-63 and BH-64) north of Marina Cliffs Condominium Building No. 1 and from three borehole locations (BH-73, BH-74, and BH-94) adjacent to Marina Cliffs Condominium Building No. 2. One subsurface soil sample was selected from each of the two borehole locations completed north of Marina Cliffs Condominium Building No. 1 and were submitted to STL for laboratory analyses of TCL SVOC, TCL PCBs, and TAL inorganics. Two subsurface soil samples were selected from each of the three borehole locations completed adjacent to Marina Cliffs Condominium Building No. 2 were submitted to STL for laboratory analysis of TCL VOCs.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

The data collected from boreholes BH-63 and BH-64, in conjunction with the existing analytical data from previous investigations, were used to assess the distribution of TCL PCBs subsurface soil concentrations north of Marina Cliffs Condominium Building No. 1. The data collected from boreholes BH-73, BH-74, and BH-94, in conjunction with the existing analytical data from previous investigations, were used to assess the distribution of TCL VOCs subsurface soil concentrations in the vicinity of Marina Cliffs Condominium Building No. 2. These data are discussed in Section 2.3.9.

2.3.4 MONITORING WELL INSTALLATIONS

A total of three groundwater monitoring wells (MW-8 through MW-10) were installed on the Properties in October 2002 at the locations shown on Figure 2.3. The final monitoring well locations were determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of conditions encountered. Each of these locations was selected based on a review of the existing surface soil and subsurface soil analytical data and an evaluation of the locations that have the highest potential for groundwater contamination (i.e., in the immediate vicinity of potential groundwater contaminant source areas).

Nested monitoring wells MW-8 and MW-9 were completed between Building Nos. 1 and 2 of the Marina Cliffs Condominium property. Monitoring well MW-10 was completed immediately north of Building No. 1 of the Marina Cliffs Condominium property. Monitoring wells MW-8 and MW-10 were installed to monitor the groundwater in the uppermost water-bearing hydrogeologic unit. Monitoring well MW-9 was installed adjacent to MW-8 to monitor the groundwater in the deeper portion of the uppermost water-bearing hydrogeologic unit. The final screened intervals of the monitoring wells were determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of stratigraphy and hydrogeological conditions encountered at each monitoring well location. The final screened interval elevations for all monitoring wells, including those on the Site and the Properties, are summarized in Table 2.1.

The boreholes for each of the monitoring wells were advanced using hollow-stem augering techniques and continuous soil sampling into the basal till unit underlying the Properties. The subsurface soils were examined by CRA's project geologist and described in accordance with the USCS. The subsurface soil samples were screened for VOCs over the entire length of the borehole with a PID. Each monitoring well was constructed of 2-inch diameter PVC riser pipe with a 10-foot length of slotted PVC well screen. A clean quartz sand pack was placed around the screen and extended to approximately 2 feet above the top of the screen. A hydraulic seal of bentonite pellets was placed above the sand pack and a protective casing and concrete collar was installed at the ground surface.

Each of the monitoring wells was surveyed for horizontal and vertical control using the grid coordinate system and geodetic datum previously established at the Site. The stratigraphy encountered and the construction details for each monitoring well are summarized in the stratigraphic and instrumentation logs provided in Appendix A.

2.3.5 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was performed in October 2002 and March 2003 at the three new monitoring wells (MW-8, MW-9, and MW-10) on the Properties as well as at the existing monitoring wells (MW-1 through MW-7) on the Site, prior to completion of each groundwater sampling round. These data were used to verify groundwater flow direction and determine groundwater gradients. Static groundwater elevations were obtained by measuring the distance from the top of the monitoring well riser to the top of the water column using an electronic water level meter. A summary of the static groundwater elevations measured in the monitoring wells is provided in Table 2.1. Groundwater elevation contours based on the static groundwater elevations measured during the October 2002 and March 2003 are provided on Figures 2.4 and 2.5, respectively.

2.3.6 GROUNDWATER SAMPLING AND LABORATORY ANALYSES

Two rounds of groundwater samples were collected from the three new monitoring wells (MW-8, MW-9, and MW-10) on the Properties and from existing monitoring wells (MW-4, MW-5, and MW-6) on the Site in accordance with the USEPA-approved July 19, 2002 EE/CA Work Plan. Groundwater samples were collected from each monitoring well in October 2002 and March 2003 and submitted to STL for laboratory analyses for the full TCL/TAL parameter list.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

These data were used to assess the presence and distribution of TCL VOCs, SVOCs, PCBs, pesticides, and TAL inorganics in groundwater at the Properties. These data are discussed in Section 2.3.9.

2.3.7 SOIL GAS PROBE INSTALLATION

A total of four soil gas probes (GP-1 through GP-4) were completed at the locations shown on Figure 2.3. The final gas probe locations were determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of conditions encountered. Each of these locations was selected based on a review of the existing surface soil and subsurface soil analytical data referenced above and an evaluation of the locations which have the highest potential for soil gas concentrations (i.e., in the immediate vicinity of potential contaminant source areas).

Soil gas probes GP-1, GP-2, and GP-3 were completed between Building Nos. 1 and 2 on the Marina Cliffs Condominium property. Soil gas probe GP-4 was completed north of Building No. 4 on the Marina Cliffs Condominium property. The final screened intervals of the gas probes were determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of stratigraphy and hydrogeological conditions encountered at each gas probe location.

The borehole for each gas probe was advanced to a depth of approximately 10 feet bgs using hollow-stem augering techniques and continuous soil sampling. The subsurface soils were examined by CRA's project geologist and described in accordance with the Unified Soil Classification System. The subsurface soil samples were screened for VOCs over the entire length of the borehole with a PID. Each gas probe was constructed of 1-inch diameter PVC riser pipe with a 5-foot length of slotted PVC well screen. A clean quartz sand pack was placed around the screen. A hydraulic seal of bentonite pellets was placed above the sand pack and a protective casing and concrete collar was installed at the ground surface.

The stratigraphy encountered and the construction details for each gas probe are summarized in the stratigraphic and instrumentation logs provided in Appendix A. Each of the gas probes was surveyed for horizontal and vertical control using the previously established grid coordinate system and geodetic datum.

2.3.8 SOIL GAS/INDOOR AIR/AMBIENT AIR SAMPLING AND ANALYSES

Two rounds of soil gas samples were collected from three of the new soil gas probes (GP-2, GP-3, and GP-4). Perched groundwater was encountered above the screened interval of GP-1 during both monitoring rounds and as a result, soil gas samples were not collected from this gas probe. Grab samples from each probe were collected using Summa canister sampling techniques. The two rounds of soil gas samples were collected during periods of both frozen ground (February 2003) and unfrozen ground conditions (December 2002). Soil gas samples were submitted to STL for laboratory analysis of TCL VOCs.

Concurrent with each of the soil gas sampling rounds, indoor air samples were collected from the basements of four units at the Marina Cliff Condominiums (i.e., Units 1J, 2A, 3J, and 4A) as well as background locations using Summa canister sampling techniques. The indoor air/ambient air samples were collected over a 4-hour interval. During collection of the indoor air sample at Unit 3J in December 2002, equipment problems were encountered in the field during sample collection when the flow regulator on the Summa canister malfunctioned. As a result, the integrity of this one sample is questionable and it has not been used in the SRE.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

These data were used to assess the distribution of TCL VOCs in soil gas, in indoor air, and in background ambient air at the Properties. These data are discussed in Section 2.3.9.

2.3.9 NATURE AND EXTENT OF CONTAMINATION

This subsection presents a summary of the nature and extent of contamination on the Properties based on the data collected during previous investigations conducted on the Properties from 1997 through 1999 and the EE/CA investigation activities conducted on the Properties in 2002 and 2003.

2.3.9.1 SURFACE SOILS

As part of the EE/CA investigation activities conducted at the Properties in 2002 and 2003 and during the previous investigations conducted at the Properties from 1997 through 1999, the following surface samples were collected:

- 19 surface soil samples were collected by WDHFS in 1997 and analyzed for lead (see Section 2.2.2);
- 14 surface soils samples, not including duplicate or split samples, were collected by the Performing Parties in 1998 and were analyzed for either the full TCL/TAL parameter list or for TCL PCBs and lead (see Section 2.2.3);
- 6 surface soil samples were collected by Thresher & Son, Inc. on behalf of the Marina Cliffs Condominium Association in 1999 and were analyzed for PCBs and lead (see Section 2.2.4); and
- 45 surface soil samples, not including duplicate or split samples, were collected by the Performing Parties in 2002 and were analyzed for either TCL SVOCs, PCBs, pesticides, and TAL inorganics, for TCL SVOCs, PCBs, and TAL inorganics or for TCL PCBs and lead (see Section 2.3.2).

The analytical data for the surface soil samples collected from the Properties indicated that TCL VOC, TCL SVOC, TCL pesticides, and TAL inorganics were detected infrequently and/or at low concentrations at the majority of surface soil sampling locations, with the exception of TCL PCB/lead within one area on the Marina Cliffs Condominium property and Bay Heights Condominium property and within one area on City of South Milwaukee Right-of-Way.

TCL PCBs were coincidently detected at elevated concentrations on the southeast corner of the Bay Heights Condominium property (BH-49) and along the northwest corner of Building No. 1 on the Marina Cliffs Condominium property (BH-14 and MCB-3). The elevated concentrations of PCBs ranged from 1.6 mg/kg at BH-14 to 22 mg/kg at MCB-3. Lead was also detected at higher concentrations in this area but did not exceed

the IEUBK screening level of 400 mg/kg; the maximum lead concentration detected was 205 mg/kg at BH-14. Additionally, TCL PCBs were also detected at elevated concentrations in shallow soils (1 to 2 feet depth) in MCB-1 and MCB-2 at 3.6 and 12 mg/kg; lead concentrations at these locations ranged from 240 to 390 mg/kg. The surface samples at these locations (0 to 1 foot) did not have elevated PCBs or lead concentrations.

Lead was also detected at one location (BH-89) on City of South Milwaukee Right-of-Way at an elevated concentration of 803 mg/kg. The areas on the Properties with surface soils that exceeded USEPA's self-implementing (40 CFR Part §761.61.a) PCB residential cleanup level of 1 mg/kg (ppm) and/or exceeded the lead IEUBK screening level of 400 mg/kg are shown on Figure 2.6.

2.3.9.2 SUBSURFACE SOILS

As part of the EE/CA investigation activities conducted at the Properties in 2002 and 2003 and during the previous investigations conducted at the Properties from 1997 through 1999 the following subsurface samples were collected:

- 51 subsurface soils samples, not including duplicate or split samples, were collected by the Performing Parties in 1998 and were analyzed for the either the full TCL/TAL parameter list, for TCL VOCs, or for TCL PCBs and lead (see Section 2.2.3);
- 3 subsurface soil samples were collected by Thresher & Son, Inc. on behalf of the Marina Cliffs Condominium Association in 1999 and were analyzed for PCBs and lead (see Section 2.2.4); and
- 82 subsurface soil samples, not including duplicate or split samples, were collected by the Performing Parties in 2002 and were analyzed for either the full TCL/TAL parameter list, for TCL SVOCs, PCBs, pesticides, and TAL inorganics, for TCL SVOCs, PCBs, and TAL inorganics, for TCL VOCs, or for TCL PCBs and lead (see Section 2.3.3).

The analytical data for the subsurface soil samples collected from the Properties indicated that TCL VOC, TCL SVOC, TCL pesticides, and TAL inorganics were detected infrequently and/or at low concentrations at the majority of subsurface soil sampling locations, with the exception of TCL PCB/lead within one area of the Marina Cliffs Condominium property and the Bay Heights Condominium property and TCL VOCs at three discrete areas of the Marina Cliffs Condominium property.

TCL PCBs and lead were coincidently detected at elevated concentrations along the eastern boundary of the Marina Cliffs Condominium property, commencing near the southeast corner of Building No. 3, extending northward, east of Building No. 1, then westerly along the northern side of Building No. 1. The elevated concentrations of PCBs and lead were primarily detected at the depth interval of 2 to 4 feet bgs (MCB-1, MCB-2, BH-7, BH-53, BH-66, BH-67, BH-70, and BH-71), extending to a maximum depth of 8 feet bgs at the southeast of Building No. 3 (BH-72). The elevated concentrations of PCBs ranged from 2.5 to 340 mg/kg and the elevated concentrations of lead ranged from 330 was 1,050 mg/kg. The areas on the Properties with subsurface soils that exceeded USEPA's self-implementing (40 CFR Part §761.61.a) PCB residential cleanup level of 1 mg/kg (ppm) and/or exceeded the lead IEUBK screening level of 400 mg/kg are shown on Figure 2.6.

The following four specific VOCs were detected in three discrete areas on the Marina Cliffs Condominium property at concentrations above their respective VOC risk-based Region IX PRGs for an industrial worker: benzene; ethylbenzene; PCE; and TCE. These four VOCs were detected above their respective VOC risk-based Region IX PRGs for an industrial worker[4] in 3 boreholes, 2 boreholes, 6 boreholes, and 12 boreholes, respectively. These four VOCs were detected at elevated concentrations in the following three discrete areas on the Marina Cliffs Condominium property: between Building Nos. 1 and 2; north of Building No. 2; and north of Building No. 4. The elevated VOCs were detected at depths ranging from approximately 2 to 14 feet bgs. The majority of the VOC impacts were detected in the 10 to 14 feet range bgs, with the exception of shallower impacts of TCE at BH-13, BH-22, BH-58 and BH-66, and ethylbenzene at BH-62 and BH-94. The areas on the Marina Cliffs Condominium property with subsurface soils that exceeded VOC risk-based Region IX PRGs for an industrial worker are shown on Figure 2.6.

A summary of the detected concentrations for the four specific VOCs, and their respective VOC risk-based Region IX PRGs for an industrial worker is presented in Table 2.2. The distribution of these four specific VOCs in the subsurface soils is presented on Figure 2.7.

4 The Region IX PRGs were revised on October 1, 2004.

2.3.9.3 GROUNDWATER

As discussed in Section 2.3.6, the following groundwater samples were collected by the Performing Parties as part of the EE/CA investigation activities conducted at the Properties in 2002 and 2003:

- Two rounds of groundwater samples were collected from the three monitoring wells installed on the Marina Cliffs Condominium property (MW-8, MW-9, and MW-10) and were analyzed for the full TCL/TAL parameter list; and
- Two rounds of groundwater samples were collected from three Site monitoring wells (MW-4, MW-5, and MW-6) and were analyzed for the full TCL/TAL parameter list.

The groundwater analytical results for samples collected from monitoring wells (MW-4, MW-5, and MW-6) on the Site, which do not form part of the database for this EE/CA, are presented and discussed in the Supplemental Work Plan for the Site (CRA, 2005b).

The analytical data for monitoring wells MW-8, MW-9, and MW-10 indicated that TCL VOC, TCL SVOC, TCL pesticides/PCBs, and TAL inorganics were detected infrequently and at low concentrations. The only notable detections were isolated detections of vinyl chloride at concentrations of 4.1 mg/L and 21 mg/L in monitoring well MW-8 during the October 2002 and March 2003 monitoring events, respectively.

It should be noted that vinyl chloride was not detected in the deeper portion of the uppermost water-bearing hydrogeologic unit at nested monitoring well MW-9 or in downgradient monitoring well MW-10 during either of the October 2002 and March 2003 monitoring events. It should also be noted that monitoring well MW-8 is located within one of the VOC-impacted subsurface soil areas at the Properties, adjacent to BH-17, in which PCE and TCE were present at elevated concentrations. Vinyl chloride is a degradation product of these two VOCs; therefore, its presence is directly attributed to the VOC-impacted soils in this area.

2.3.9.4 SOIL GAS/INDOOR AIR

As discussed in Section 2.3.8, the following soil gas, indoor air and background ambient air samples were collected by the Performing Parties as part of the EE/CA investigation activities conducted at the Properties in 2002 and 2003:

- Two rounds of soil gas samples were collected from three soil gas probes installed on the Marina Cliffs Condominium property (GP-2, GP-3, and GP-4) and were analyzed for full TCL VOCs; and
- Two rounds of indoor air samples were collected from the basements of four units on the Marina Cliffs Condominium property (Units 1J, 2A, 3J, and 4A) as well as from two background locations and were analyzed for TCL VOCs.

The analytical data for the soil gas samples indicated the presence of specific VOCs that were also detected in subsurface soil samples in adjacent boreholes (i.e., PCE, TCE, vinyl chloride, benzene, ethylbenzene, and xylene).

The analytical data for the indoor air samples indicated the presence of eight VOCs above their respective generic screening levels (USEPA, 2002a). Five of these eight VOCs (i.e., PCE, TCE, vinyl chloride, ethylbenzene and benzene) were also detected in soil gas samples and subsurface soil samples. The three other VOCs detected in the indoor air samples are not considered to be Properties-related (carbon tetrachloride, chloroform, and dichlorodifluoromethane). The analytical data for the indoor air is further discussed in Section 2.6.6.3.

The analytical data for the background ambient air samples also indicated the presence of various VOCs, including benzene, ethylbenzene, and xylenes.

2.4 TIME-CRITICAL REMOVAL ACTION AND ADDITIONAL EE/CA INVESTIGATION ACTIVITIES

2.4.1 GENERAL

Based on the analytical results for soil samples collected during the EE/CA investigation conducted at the Properties in 2002 and 2003 and the previous investigations conducted at the Properties from 1997 through 1999, it was determined that:

- TCL PCBs and/or lead were coincidently detected in shallow soils at concentrations exceeding USEPA's self-implementing (40 CFR Part §761.61.a) PCB residential cleanup level of 1 mg/kg and/or the lead IEUBK screening level of 400 mg/kg along the eastern boundary of the Marina Cliffs Condominium property, commencing near the southeast corner of Building No. 3, extending northward, east of Building No. 1, then westerly along the northern side of Building No. 1, extending onto the southeast corner of the Bay Heights Condominium property. Lead was also detected

at a concentration exceeding its IEUBK screening level of 400 mg/kg at one location on the City of South Milwaukee Right-of-Way; and

- Four specific VOCs (benzene, ethylbenzene, PCE, and TCE) were detected above their respective VOC risk-based Region IX PRGs for an industrial worker in three discrete areas on the Marina Cliffs Condominium property: between Building Nos. 1 and 2; north of Building No. 2; and north of Building No. 4.

On January 8, 2004, representatives of the Performing Parties met with USEPA to discuss the analytical results for soil samples collected during the EE/CA investigation.

As a result of this meeting, a Time-Critical Removal Action was implemented by the Performing Parties on the Properties between May and July 2004. The Time-Critical Removal Action consisted of the excavation and off-Site disposal of all lead-impacted soils above its IEUBK screening level of 400 mg/kg and PCB-impacted soil above USEPA's self-implementing (40 CFR Part §761.61.a) PCB residential cleanup level of 1 mg/kg. The removal of all lead- and PCB-impacted soil was verified prior to backfilling by the performance of verification sampling conducted during excavation activities. A summary of the Time-Critical Removal Action activities, including the verification sampling activities, is provided in Section 2.4.2.

During the January 8, 2004 meeting, there was also discussion pertaining to the VOC-impacted subsurface soils that exceeded VOC risk-based Region IX PRGs under a future construction/utility worker exposure scenario and potential Removal Action technologies to be evaluated in the EE/CA Report. The Performing Parties proposed that ISCO be considered a viable Removal Action technology in the EE/CA Report to treat the VOC-impacted subsurface soils. USEPA indicated they would require additional information on the effectiveness of ISCO to treat the VOC-impacted soils.

Following this meeting, the Performing Parties conducted additional EE/CA investigation activities on the Properties in 2004 and 2005 under a USEPA-approved EE/CA Work Plan Addendum (CRA, 2004b). The additional EE/CA investigation activities, completed at the Properties in 2004 and 2005, are discussed in Section 2.4.3.

2.4.2 TIME-CRITICAL REMOVAL ACTION - 2004

As discussed in Section 2.4.1, the Time-Critical Removal Action completed on the Properties between May 2004 and July 2004 included the excavation and off-Site disposal of all impacted soils with lead concentrations above the IEUBK screening level of 400 mg/kg and with PCB concentrations above USEPA's self-implementing PCB

residential cleanup level of 1 mg/kg. There was a total of 1,359 cubic yards of impacted soils excavated and disposed of off Site. The extent of PCB- and lead-impacted soils that were excavated as part of the Time-Critical Removal Action is illustrated on Figure 2.8. The excavations were subsequently backfilled to ground surface following receipt of the final verification analytical data confirming that all lead and TCL PCB concentrations were below the cleanup criteria of 400 mg/kg and 1 mg/kg, respectively. A detailed description of the Time-Critical Removal Action activities is presented in the Time-Critical Removal Action Report (CRA, 2005a).

Prior to backfilling the excavated areas, verification soil samples were collected at an approximate 25-foot grid interval from the base and sidewalls of the excavations at the Properties. The final locations for all verification soil samples were determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of conditions encountered at the base and sidewalls of the excavations.

All verification soil samples were collected using stainless steel trowel sampling techniques and were examined by CRA's project geologist and described in accordance with the USCS. All verification soil sampling locations were surveyed for horizontal and vertical control using the previously established grid coordinate system and geodetic datum. All verification soil samples collected at the Properties were submitted under chain-of-custody to STL for lead and TCL PCB analyses.

The analytical data reports provided by the laboratory have previously been provided to USEPA in the Time-Critical Removal Action Report (CRA, 2005a). The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports were also previously provided to USEPA in the Time-Critical Removal Action Report (CRA, 2005a).

A summary of the final verification soil samples including 15 surface (i.e., <2.0 feet bgs) and 48 subsurface samples (i.e., >2.0 feet bgs) which were collected from the Properties as part of the Time-Critical Removal Action activities is provided in Table D.1, Appendix D. The locations of the final verification soil samples collected from the Properties as part of the Time-Critical Removal Action activities are shown on Figures 2.8 and 2.9. The analytical results for the 15 surface (i.e., <2.0 feet bgs) and 48 subsurface (i.e., >2.0 feet bgs) final verification soil samples collected from the Properties as part of the Time-Critical Removal Action activities are presented in Tables D.2 and D.3, Appendix D, respectively.

Based on the results of the verification data, all remaining lead and TCL PCB concentrations on the Properties are below the cleanup criteria of 400 ppm and 1 ppm, respectively. The maximum remaining concentrations of lead and TCL PCB in surface soils (<2.0 feet bgs) are 132 ppm (BH91, 0 to 0.5 feet bgs) and 0.68 ppm (BH-62, 0 to 0.5 feet bgs), respectively. The maximum remaining concentrations of lead and TCL PCBs in subsurface soils (>2.0 feet bgs) are 339 ppm (BH68, 2.0 to 4.0 feet bgs) and 0.89 ppm (BH-14, 2.0 to 4.0 feet bgs), respectively.

Concurrent with the implementation of the Time-Critical Removal Action completed on the Properties in 2004, an area of VOC-impacted soils was excavated in the vicinity of MW-6, located in the southwest corner of the Site. The soils were identified during the Site EE/CA to exhibit elevated concentrations of TCE. During excavation in this area, verification soil samples were collected and analyzed for VOCs. Based on these verification data, the excavation was extended northwest to the southern property boundary of the Marina Cliffs Condominium property, and south to the north side of Marina Road. Based on the verification data collected during excavation activities, TCE was identified in subsurface soils along a portion of the above described excavation limits abutting these Properties at concentrations exceeding its risk-based Region IX PRG for an industrial worker. As such, it was determined there was potential that VOCs exceeding risk-based Region IX PRGs for an industrial worker extended onto the Marina Cliffs Condominium property, south of Building No. 3, and under the north side of Marina Road, south of the Site.

2.4.3 EE/CA WORK PLAN ADDENDUM INVESTIGATION ACTIVITIES – 2004/2005

2.4.3.1 GENERAL

As discussed in Section 2.4.1, the Performing Parties conducted additional EE/CA investigation activities in 2004 and 2005, including the performance of a full-scale ISCO pilot study on the Marina Cliffs Condominium property. The additional EE/CA investigation activities were based on the data collected during previous investigations conducted on the Properties from 1997 through 1999, the previous EE/CA investigation activities conducted on the Properties in 2002 and 2003 and the previous Time-Critical Removal Action activities conducted on and adjacent to the Properties in 2004. All activities were completed in accordance with the USEPA-approved EE/CA Work Plan Addendum, dated September 30, 2004 (CRA, 2004b).

The additional EE/CA investigation activities completed on the Properties are summarized in Sections 2.4.3.2 and 2.4.3.3 and the results of these activities are discussed in Sections 2.4.3.4 through 2.4.3.6.

2.4.3.2 ADDITIONAL EE/CA INVESTIGATION ACTIVITIES

Based on the nature and extent of VOC-impacted soils on the Properties and in response to USEPA's request that additional information on the effectiveness of ISCO to treat the VOC-impacted soils be collected, the following additional EE/CA investigation activities were completed at the Properties in 2004 and 2005:

- Performance of subsurface soil sampling to delineate the extent of potential VOC-impacted soils that may be present on the Marina Cliffs Condominium Corporation property, south of Building No. 3 and along the north side of Marina Road (October/November 2004);
- Installation of depressurization systems in the four Marina Cliffs Condominium buildings, north of Marina Road, as a precautionary measure during the ISCO pilot study (October 2004);
- Performance of a full-scale ISCO pilot study on the Properties in November and December 2004;
- Performance of one additional indoor air sampling event in Building No. 1 as a precautionary measure when treating the soils during the ISCO pilot study (November 2004);
- Performance of subsurface soil sampling in the areas treated during the ISCO pilot study to evaluate the effectiveness of the ISCO. Subsurface soil samples were collected at the Properties in February 2005 and May 2005; and
- Performance of indoor air sampling prior to and subsequent to performing the ISCO pilot study. Indoor air sampling events were performed in the four Marina Cliffs Condominium buildings, north of Marina Road in October 2004, February 2005, and October 2005.

The following subsections summarize the full-scale ISCO pilot study, subsurface soil, groundwater, soil gas, indoor air, and background ambient air investigation activities as part of the additional EE/CA investigation activities completed at the Properties in 2004 and 2005. All activities were completed in accordance with the USEPA-approved EE/CA Work Plan Addendum (CRA, 2004b).

A summary of investigative analytical samples collected on the Properties during these additional EE/CA activities and discussed in this EE/CA, including the date of sample collection, depth, and analysis type is provided in Table D.1, Appendix D. Subsurface soil analytical results are presented in Tables D.3 and D.7, Appendix D. Groundwater analytical results are presented in Table D.4, Appendix D and soil gas, indoor air, and background ambient air analytical results are presented in Table D.5, Appendix D. The soils analytical data presented in Table D.3, Appendix D are considered representative of current Properties' conditions. The soils analytical data presented in Table D.7, Appendix D are not considered representative of current Properties' conditions since the samples were collected from soils that were either excavated during Time-Critical Removal Actions completed at the Properties in 2004 (see Section 2.4.2) or were treated during the full-scale ISCO pilot study completed at the Properties in 2004 (see Section 2.4.3.3).

2.4.3.3 FULL-SCALE ISCO PILOT STUDY

This subsection presents a summary of the full-scale ISCO pilot study activities performed on the Marina Cliffs Condominium property in 2004. An evaluation of its effectiveness to reduce VOC concentrations in subsurface soils on the Properties is presented in Section 2.4.3.4.4.

Initially, a chemical oxidation bench-scale treatability study was performed on representative subsurface soil samples collected from the Properties. The details and results of the bench-scale treatability study were presented in the USEPA-approved EE/CA Work Plan Addendum (CRA, 2004b).

Based upon the results of the bench-scale treatability study (see Section 3.2.6 of EE/CA Work Plan Addendum), it was recommended that the ISCO pilot study be completed using the BIOX® technology. The BIOX® technology is a proprietary technology owned by BMS, Inc (BMS). The BIOX® technology combines chemical oxidation with enhanced biodegradation. The chemical oxidation component of the BIOX® process is based on Fenton's-type reactions. A full description of the BIOX® technology is provided in the EE/CA Work Plan Addendum.

The ISCO pilot study was completed in November and December 2004 at the three discrete areas on the Marina Cliffs Condominium property with elevated concentrations of VOCs in the subsurface soils (i.e., full-scale pilot study). The full-scale ISCO pilot study was completed using the BIOX® technology by BMS, under the supervision of a CRA representative. A summary of the BIOX® injection activities, including number of

injection points, volume of soil treated, and volume of BIOX® injection fluids injected are provided in the summary report prepared by BMS, dated January 20, 2005, a copy of which is provided in Appendix I. Also provided in Appendix I are copies of CRA's weekly summary reports submitted to USEPA and WDNR during performance of the pilot study.

The horizontal and vertical extent of VOC-impacted soils treated and the injection point grid spacing used during treatment are illustrated on Figure 2.10. As summarized in the BMS summary report, there were a total of 1,079 injection points completed to treat approximately 4,471 cubic yards of VOC-impacted soils with 22,676 gallons of BIOX® remedial fluids. As shown on Figure 2.10, certain areas were treated using 3-foot injection point grid spacing and other areas were treated using 4-foot injection point grid spacing.

Prior to implementation of full-scale ISCO pilot study, drain tile depressurization systems were installed by KMB Radon Reduction (KMB), under the supervision of a CRA representative. Drain tile depressurization systems were installed in Buildings No. 1 through 4 on the Marina Cliffs Condominium properties. The sumps in each building were also sealed in accordance with the protocols provided in the USEPA-approved EE/CA Work Plan Addendum. The drain tile depressurizations systems were installed as a precautionary measure to prevent or minimize potential migration of impacted soil gas to indoor air during the implementation of the pilot study. As discussed in the EE/CA Work Plan Addendum, the systems should continue to operate continuously, at no cost to the residents, until the Removal Action activities for the soils are completed.

Also, as part of the full-scale ISCO pilot study, groundwater, soil gas, and indoor air sampling and analyses were performed immediately prior to and subsequent to the pilot study. As discussed in the EE/CA Work Plan Addendum, the groundwater data were collected to determine any impact the BIOX® injection may have on groundwater. As also discussed in the EE/CA Work Plan Addendum, the soil gas and indoor air data were collected to assess the effectiveness of the ISCO in reducing soil gas concentrations in subsurface soils, and to ensure that concentrations of VOCs in indoor air remained at or below acceptable levels. The groundwater sampling activities and the analytical results are discussed and presented in Section 2.4.3.5 and the soil gas and indoor air sampling activities and analytical results are discussed and presented in Section 2.4.3.6.

2.4.3.4 SUBSURFACE SOIL SAMPLING AND LABORATORY ANALYSES

In accordance with the USEPA-approved EE/CA Work Plan Addendum, subsurface soil samples were collected on the Properties in October 2004 and November 2004 prior to the completion of the full-scale ISCO pilot study at the Properties. A total of 35 subsurface soil samples were collected from a total of 16 borehole locations (i.e., BH-102 to BH-113, and BH-118 to BH-121) to further ascertain the horizontal and vertical extent of the VOC-impacted subsurface soils that exceeded VOC risk-based Region IX PRGs for an industrial worker. These borehole locations are shown on Figure 2.9.

In addition, subsurface soil samples were also collected on the Properties in February 2005 and May 2005 following the completion of the full-scale ISCO pilot study at the Properties. A total of 38 subsurface soil samples were collected from a total of 15 borehole locations (i.e., BH-5, BH-13, BH-15, BH-16, BH-17, BH-18, BH-22, BH-50, BH-56 to BH-60, BH-62, and BH-94) to evaluate the effectiveness of the full-scale ISCO pilot study to reduce VOC concentrations at the Properties. These borehole locations were previously sampled during investigation activities performed on the Properties in 1998 (see Section 2.2.3) and in 2002 (see Section 2.3.3). These borehole locations are shown on both Figures 2.3 and 2.9.

All boreholes were advanced using direct-push techniques and continuous soil sampling. All subsurface soils were examined by CRA's project geologist and described in accordance with the USCS. All subsurface soil samples were screened over the entire length of the borehole with a PID for the presence of volatile organics and samples were selected from depth intervals determined by CRA's project geologist in consultation with the USEPA representative based on an evaluation of conditions encountered. All selected subsurface soil samples were submitted under chain-of-custody to STL for laboratory analyses of VOCs with the exception of total heterotrophic plate counts (THPC), which were submitted under chain-of-custody to CRA's treatability study laboratory in Niagara Falls, New York. All boreholes were surveyed for horizontal and vertical control using the previously established grid coordinate system and geodetic datum. A summary of the PID headspace analyses, soil description, and the subsurface soil samples selected for laboratory analyses at each borehole location is summarized in the stratigraphic and instrumentation logs provided in Appendix A.

2.4.3.4.1 DELINEATION LOCATIONS - NORTH OF MARINA ROAD

Two subsurface soil samples were selected from six borehole locations (BH-102 through BH-107) completed along the north side of Marina Road and were submitted for

laboratory analysis of TCL VOCs. These data were used to assess whether there were TCE-impacted soils in this area along the north side of Marina Road (see Section 2.4.2).

The VOC analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The VOC analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

The analytical data for the subsurface soil samples collected along the north side of Marina Road indicated that TCL VOCs were detected infrequently and/or at very low concentrations at all of the locations sampled. These data confirmed that there are no TCE-impacted soils in this area.

2.4.3.4.2 DELINEATION LOCATIONS - SOUTH OF BUILDING NO. 3

Two subsurface soil samples were selected from four borehole locations (BH-108 through BH-111) and one subsurface soil sample was selected from another borehole location (BH-112) completed along south of Building No. 3 on the Marina Cliffs Condominium property and were submitted for laboratory analysis of TCL VOCs. These data were used to assess whether there were TCE-impacted soils in this area of the Marina Cliffs Condominium property (see Section 2.4.2).

The VOC analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The VOC analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

The analytical data for the subsurface soil samples collected along south of Building No. 3 on the Marina Cliffs Condominium property indicated that TCL VOCs were detected infrequently and/or at very low concentrations at all of the locations sampled. These data confirmed that there are no TCE-impacted soils in this area of the Properties.

2.4.3.4.3 DELINEATION LOCATIONS – BETWEEN BUILDINGS NOS. 2 AND 4

Two subsurface soil samples were selected from 5 borehole locations (BH-113 and BH-118 through BH-121) completed on the Marina Cliffs Condominium property, between the areas to be treated during the full-scale ISCO pilot study, and were submitted for laboratory analysis of TCL VOCs. These data were used to confirm that the areas treated during the full-scale ISCO pilot study were not connected at depth (see Section 3.4.3.3).

The VOC analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The VOC analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

The analytical data for the subsurface soil samples collected on the Marina Cliffs Condominium property, between the areas to be treated during the full-scale ISCO pilot study indicated that TCL VOCs were detected infrequently and/or at very low concentrations at four of the locations sampled (BH-118 through BH-121). An elevated level of benzene (34,000 µg/kg) was detected in BH-113 at a depth of 14 to 16 feet bgs; defining the extent of VOC-impacted soils north of Building No. 4. These data confirmed that the areas to be treated during the full-scale ISCO pilot study data were not connected at depth.

2.4.3.4.4 ISCO EVALUATION LOCATIONS

Subsequent to completion of the full-scale ISCO pilot study, subsurface soil samples were collected from 15 borehole locations (i.e., BH-5, BH-13, BH-15, BH-16, BH-17, BH-18, BH-22, BH-50, BH-56 to BH-60, BH-62, and BH-94) within the areas that were treated, and were submitted for laboratory analysis of TCL VOCs. Samples for VOC analyses were initially collected in February 2005, approximately 1 month after the ISCO injection activities were completed and selected locations were resampled for VOC analyses in May 2005, approximately 4 months after the ISCO injection activities were completed. In addition, samples from the above referenced boreholes were also collected and submitted for THPC in February 2005. These data were used to evaluate the effectiveness of the BIOX® technology to reduce VOCs in subsurface soils to acceptable risk-based concentrations for future construction/utility workers.

The VOC analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The VOC analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B. The THPC data are summarized in a memorandum provided in Appendix C.

Based on the post-ISCO investigation activities, the following five specific VOCs were detected in the treated areas at concentrations above their respective VOC risk-based Region IX PRGs for an industrial worker: benzene; PCE; TCE; vinyl chloride; and xylene (total). All other VOCs were either not detected or were detected at concentrations below their respective VOC risk-based Region IX PRGs for an industrial worker.

A summary of the detected concentrations for the five specific VOCs, and their respective VOC risk-based Region IX PRGs for an industrial worker is presented in Table 2.3. The distribution of these five specific VOCs in the subsurface soils is presented on Figure 2.11.

Based on a review of Table 2.3 and Figure 2.11, benzene, PCE, TCE, vinyl chloride, and xylene (total) were detected above their respective VOC risk-based Region IX PRGs for an industrial worker[5] in 3 boreholes, 7 boreholes, 9 boreholes, 2 boreholes, and 1 borehole, respectively. A comparison of these five specific VOCs and their concentrations in the soils for pre-ISCO pilot study and post-ISCO pilot study is provided in Table 2.4. It should be noted that vinyl chloride was not detected above its Region IX PRG for an industrial worker prior to completing the ISCO pilot study. Vinyl chloride is a degradation product of PCE and TCE. The two boreholes (BH-15 and BH-17) where vinyl chloride was detected in the post-ISCO samples are located in an area that was treated on a 3-foot injection point spacing during the pilot study and experienced significant reductions in PCE and TCE concentrations as a result of the pilot study (see Table 2.4).

Further review of the data provided in Table 2.4 indicates that when the BIOX® injection was performed on a 3-foot injection point grid spacing (see Figure 2.10 and Table 2.4), it achieved some success reducing the concentrations of VOCs that exceeded Region IX PRGs for an industrial worker. However, when the BIOX® injection was performed on a 4-foot injection point grid spacing (see Figure 2.10 and Table 2.4), it did not indicate any success reducing the concentrations of VOCs that exceeded Region IX PRGs for an industrial worker.

5 The Region IX PRGs were revised on October 1, 2004.

Based on the data summarized in Table 2.3 and presented on Figure 2.11, there are two remaining discrete areas on the Marina Cliffs Condominium Corporation property with elevated concentrations of VOCs. These two areas are described as follows:

- Between Building Nos. 1 and 2 at five borehole locations (BH-5, BH-13, BH-15, BH-16, and BH-17) at depths ranging from 8 to 14 feet bgs; and
- North of Building No. 4 at eight borehole locations (BH-22, BH-50, BH-56, BH-57, BH-58, BH-59, BH-60, and BH-113) at depths ranging from 4 to 16 feet bgs.

2.4.3.5 GROUNDWATER SAMPLING AND LABORATORY ANALYSES

Two rounds of groundwater samples were collected from monitoring well MW-8 in October 2004 and February 2005 immediately prior to and following the completion of the full-scale ISCO pilot study on the Properties. Groundwater samples were collected from the monitoring well and submitted for laboratory analyses for VOCs, iron (total and dissolved), Dissolved Organic Carbon (DOC), pH, and THPC.

All groundwater samples were collected using low flow purging techniques and submitted under chain-of-custody to STL for laboratory analyses with the exception of samples collected for THPC which were submitted under chain-of-custody to CRA's treatability study laboratory in Niagara Falls, New York.

The VOC analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also presented in Appendix B. The THPC data are summarized in a memorandum provided in Appendix C.

The post-ISCO pilot study VOC data for monitoring well MW-8 indicates that cis-1,2-dichloroethene (C12DCE) was the only VOC detected, at a concentration (1.2 µg/L), well below its MCL of 70 µg/L. As discussed previously in Section 2.3.6, vinyl chloride was previously detected in monitoring well MW-8 at concentrations of 4.1 µg/L and 21 µg/L during the October 2002 and March 2003 monitoring events, respectively, but was not detected in the sample collected from this well subsequent to completing the pilot study. It should be noted that C12DCE is a degradation product of TCE. Therefore, the detection of C12DCE in this well is directly attributed to the degradation of VOC-impacted soils in this area. This is supported by the THPC data for

the groundwater samples collected from monitoring well MW-8 which indicates the presence of higher TCE degrading bacteria in the post-ISCO pilot study data compared to the pre-ISCO pilot study data (see Appendix C).

Based on the groundwater data collected as part of the full-scale ISCO pilot test, the BIOX® injection had a positive impact on the groundwater in the areas treated.

2.4.3.6 SOIL GAS/INDOOR AIR/AMBIENT AIR SAMPLING AND ANALYSES

One round of soil gas samples were collected from three of the soil gas probes (GP-2, GP-3, and GP-4) in October 2004 prior to the completion of the full-scale ISCO pilot study at the Properties. Two rounds of soil gas samples were collected from three of the soil gas probes (GP-2, GP-3, and GP-4) in February 2005 (frozen) and May 2005 (unfrozen) following the completion of the full-scale ISCO pilot study on the Properties. Perched groundwater was encountered above the screened interval of GP-1 during all of the monitoring rounds and as a result, soil gas samples were not collected from this gas probe. Grab samples from each probe were collected using Summa canister sampling techniques and were submitted to STL for laboratory analysis of VOCs.

In addition, indoor air samples were collected from the basements of four units at the Marina Cliff Condominiums (i.e., Units 1J, 2A, 3J, and 4A) as well as background locations using Summa canister sampling techniques in October 2004 prior to the completion of the full-scale ISCO pilot study at the Properties. An indoor air sample was also collected from the basement of Unit 1J at the Marina Cliff Condominiums using Summa canister sampling techniques in November 2004 during the completion of the full-scale ISCO pilot study at the Properties. Two rounds of indoor air samples were also collected from the basements of four units at the Marina Cliff Condominiums (i.e., Units 1J, 2A, 3J, and 4A) as well as background locations using Summa canister sampling techniques in February 2005 and October 2005 following the completion of the full-scale ISCO pilot study at the Properties. An additional indoor air sample was also collected from the basement of Unit 3B at the Marina Cliff Condominiums using Summa canister sampling techniques in October 2005. The indoor air / ambient air samples were collected over an 8-hour interval and were submitted to STL for laboratory analysis of VOCs.

The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements

stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also presented in Appendix B.

A review of the soil gas data for samples collected as part of the full-scale ISCO pilot study (see Table D.5, Appendix D) indicates that soil gas concentrations were generally lower in post-ISCO pilot study samples (i.e., GP-2 and GP-3) where 3-foot injection point grid spacing was used and showed no reductions in post-ISCO pilot study samples (i.e., GP-4) where 4-foot injection point grid spacing was used.

A review of the indoor air data for samples collected as part of the full-scale ISCO pilot study indicates that concentrations of VOCs in indoor air samples collected during and subsequent to performing the pilot study were consistent with samples collected prior to performing the pilot test.

2.5 ANALYTICAL DATA SUMMARY

2.5.1 GENERAL

The following subsections provide a summary of the hydrogeology and the soil, groundwater, soil gas, indoor air, and ambient air analytical data that were collected at the Properties from 2002 through 2005 in accordance with the USEPA-approved EE/CA Work Plan and EE/CA Work Plan Addendum, and the data that were collected during the previous investigations. The analytical data reports provided by the laboratory and the completed chain-of-custody forms, for the investigation work preformed by the Performing Parties, are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also provided in Appendix B.

In addition, these data were supplemented, as appropriate, with the previous hydraulic and geotechnical data that were collected during EE/CA investigations at the Site between December 4, 2000 and May 4, 2001. Given the close proximity of the Site, these previously collected data are considered representative of hydrogeological conditions at the Properties and have been incorporated into the following sections, as appropriate. A complete summary of these previous hydraulic and geotechnical data was provided in the Site EE/CA Report (CRA, 2003).

2.5.2 HYDROGEOLOGY

The overburden at the Properties is consistent with the Site (i.e., silty clay till of the Oak Creek formation). As discussed in the Site EE/CA Report (CRA, 2003), the silty clay till at the Site is relatively impermeable with a calculated mean bulk hydraulic conductivity of approximately 1.2×10^{-5} cm/s and measured mean triaxial (vertical) permeability of approximately 9.1×10^{-8} cm/s.

Examination of the groundwater elevation contours measured in October 2002 and March 2003, provided on Figures 2.4 and 2.5, respectively, indicates that horizontal groundwater flow beneath the Properties follows the topography and trends to the Site, which in turn trends to the ravine and Lake Michigan. As part of the Site EE/CA investigation (CRA, 2003), no seeps were observed in the ravine or Lake Michigan bluff areas, and it was concluded in the Site EE/CA Report that groundwater discharge from the Site to surface water is very limited.

Examination of Figures 2.4 and 2.5 also indicates that the horizontal gradient across the Properties is flatter than the horizontal hydraulic gradient across the Site. This is due to the fact that these properties are further removed from the ravine and Lake Michigan. The horizontal gradient for the Properties was calculated to be approximately 0.03. Using a horizontal hydraulic gradient of 0.03, a horizontal hydraulic conductivity of 1.0×10^{-5} cm/s, and a representative porosity of 0.3, the horizontal groundwater flow velocity beneath the Properties is calculated to be approximately 1.0 foot/year.

As discussed in Section 2.3.4, monitoring wells MW-8 and MW-9 were installed immediately adjacent to each other. The monitored interval for each well is summarized in Table 2.1. Examination of Table 2.1 indicates that the vertical gradient in the upper 50 feet of the silty clay till (i.e., extent of investigation) is approximately 0.4 downward. Using a vertical hydraulic gradient of 0.4, a vertical hydraulic conductivity of 1.0×10^{-7} cm/s, and a representative porosity of 0.3, the vertical groundwater flow velocity beneath the Properties is calculated to be approximately 0.15 feet/year.

2.5.3 SURFACE SOIL CONCENTRATIONS

Examination of Table D.2, Appendix D indicates that all remaining TCL VOC, TCL SVOC, TCL pesticides/PCBs, and TAL inorganics were detected infrequently and/or at low concentrations similar to background at all surface soil sampling locations.

As discussed in Section 2.4.2, all elevated concentrations of lead and TCL PCB concentrations were excavated as part of the Time-Critical Removal Action activities performed on the Properties in 2004.

Based on the results of the verification data collected during the Time-Critical Removal Action activities, all remaining lead and TCL PCB concentrations on the Properties are below the cleanup criteria of 400 ppm and 1 ppm, respectively. The maximum remaining concentrations of lead and TCL PCB in surface soils (<2.0 feet bgs) are 132 ppm (BH91, 0 to 0.5 feet bgs) and 0.68 ppm (BH-62, 0 to 0.5 feet bgs), respectively. The maximum remaining concentrations of lead and TCL PCB in subsurface soils (>2.0 feet bgs) are 339 ppm (BH68, 2.0 to 4.0 feet bgs) and 0.89 ppm (BH-14, 2.0 to 4.0 feet bgs), respectively.

2.5.4 SUBSURFACE SURFACE SOIL CONCENTRATIONS

Examination of Table D.3, Appendix D indicates that all remaining TCL VOC, TCL SVOC, TCL pesticides, and TAL inorganics were detected infrequently and/or at low concentrations at the majority of subsurface soil sampling locations, with the exception of TCL VOCs at two discrete areas of the Properties.

TCL VOCs were detected at elevated concentrations (i.e., above VOC risk-based Region IX PRGs for an industrial worker) in two discrete areas of the Marina Cliffs Condominiums:

- Between Building Nos. 1 and 2 at five borehole locations (BH-5, BH-13, BH-15, BH-16, and BH-17) at depths ranging from 8 to 14 feet bgs; and
- North of Building No. 4 at eight borehole locations (BH-22, BH-50, BH-56, BH-57, BH-58, BH-59, BH-60, and BH-113) at depths ranging from 4 to 16 feet bgs.

The two discrete areas and corresponding VOC concentrations in subsurface soils are shown on Figure 2.11.

2.5.5 GROUNDWATER CONCENTRATIONS

Examination of Table D.4, Appendix D indicates that TCL VOC, TCL SVOC, TCL pesticides/PCBs, and TAL inorganics groundwater concentrations were detected infrequently and at low concentrations at monitoring wells MW-8, MW-9, and MW-10 at the Properties.

The post-ISCO pilot study VOC data for monitoring well MW-8 indicates that cis-1,2-dichloroethene (C12DCE) was the only VOC detected, and at a concentration (1.2 µg/L) well below its MCL of 70 µg/L. As discussed previously in Section 2.3.6, vinyl chloride was previously detected in monitoring well MW-8 at concentrations of 4.1 µg/L and 21 µg/L during the October 2002 and March 2003 monitoring events, respectively, but was not detected in the sample collected from this well subsequent to completing the pilot study. It should be noted that both C12DCE and vinyl chloride are degradation products of TCE. Therefore, the detection of these two VOCs in this well is directly attributed to the degradation of VOC-impacted soils in this area. This is supported by the THPC data for the groundwater samples collected from monitoring well MW-8 which indicates the presence of higher TCE degrading bacteria in the post-ISCO pilot study data compared to the pre-ISCO pilot study data (see Appendix C).

As discussed in Section 2.1.2, residences are serviced with municipal water and groundwater is not used as a drinking water source.

2.5.6 SOIL GAS/INDOOR AIR/BACKGROUND AMBIENT AIR CONCENTRATIONS

Examination of Table D.5, Appendix D indicates that TCL VOCs were detected in the soil gas, indoor air, and background ambient air samples.

The analytical data for the soil gas samples indicated the presence of specific VOCs consistent with VOCs detected in subsurface soil samples in adjacent boreholes (i.e., PCE, TCE, vinyl chloride, benzene, ethylbenzene, and xylene). The analytical data for the indoor air samples indicated the presence of eight VOCs above their respective generic screening levels (USEPA, 2002a). Five of these eight VOCs (i.e., PCE, TCE, vinyl chloride, ethylbenzene, and benzene) were also detected in soil gas samples and subsurface soil samples. The analytical data for the background ambient air samples also indicated the presence of various VOCs, including benzene, ethylbenzene, and xylenes.

A review of the soil gas data for samples collected as part of the full-scale ISCO pilot study indicates that soil gas concentrations were generally lower in post-ISCO pilot study samples (i.e., GP-2 and GP-3) where 3-foot injection point grid spacing was used and were not lower in post-ISCO pilot study samples (i.e., GP-4) where 4-foot injection point grid spacing was used.

A review of the indoor air data for samples collected as part of the full-scale ISCO pilot study indicates that concentrations of VOCs in indoor air samples collected during and subsequent to performing the pilot study were consistent with samples collected prior to performing the pilot test.

2.6 STREAMLINED RISK EVALUATION

2.6.1 INTRODUCTION

A Streamlined Risk Evaluation (SRE) was conducted in accordance with the USEPA guidance document entitled "Guidance on Conducting Non-Critical Removal Actions Under CERCLA" (EPA, 1993). The SRE followed the general procedures and protocols specified in the USEPA document entitled "Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual" (EPA, 1989). Additional USEPA risk assessment guidance used to conduct the SRE included:

- RAGS Supplemental Guidance, Calculating Exposure Point Concentrations at Hazardous Waste Site, OSWER 9285.6-10, December 2002.
- RAGS Supplemental Guidance, Standard Default Exposure Factors, USEPA OSWER Directive 9285.6-03, March 25, 1991;
- RAGS Part E, Supplemental Guidance for Dermal Risk Assessment, USEPA Final, July 2004;
- USEPA Exposure Factors Handbook, EPA/600/P-95/002Fa, August 1997; and
- Other applicable USEPA guidance, criteria, and reference documents referenced throughout this section.

2.6.1.1 SCOPE AND ORGANIZATION OF THE SRE

The SRE focused on an evaluation of potential current and future risks to human health associated with chemical concentrations in surface soil, subsurface soil, groundwater, and indoor air. This evaluation was based on known or anticipated future human activity patterns at the Properties. The SRE incorporates the following major components:

- Site Characterization - An examination of the present use and condition of the Properties, in addition to known or anticipated future human activity, was

completed. This information was used to determine the potential exposure scenarios evaluated in the SRE.

- Identification of Chemicals of Potential Concern (COPC) - The presence, distribution, concentration, and toxicity of chemical concentrations in surface soil, subsurface soil, groundwater, and indoor air were evaluated to identify those chemicals which are most likely to pose the majority of the potential health risk at the Properties.
- Exposure Assessment - Potential exposure pathways were assessed to identify receptors and routes of exposure, and to determine how and in what media the COPCs could potentially come in contact with the receptors. Estimation of the exposure point concentrations and the daily chemical intake for receptors was also conducted.
- Toxicity Assessment - Toxicity factors and data for the COPCs were identified and used to evaluate the potential health effects associated with exposure to the COPCs.
- Risk Characterization - The potential carcinogenic and non-carcinogenic risks were calculated for each potential exposure scenario based on the data for the COPCs identified in the exposure and toxicity assessments. An evaluation of the uncertainties associated with this characterization was also completed.

The SRE process applied several theoretical assumptions to determine a numerical expression of both carcinogenic and non-carcinogenic risk to human health. The SRE characterized potential carcinogenic effects in terms of probabilities that an individual would develop cancer over a lifetime based on an exposure period to hazardous constituents related to the Site. The potential for non-carcinogenic effects was evaluated by comparing an estimated daily intake level from potential exposures to a reference dose which is defined as the intake level at which a receptor can be exposed daily over their entire lifetime without experiencing appreciable adverse health effects. USEPA guidelines also require that the estimates of potential carcinogenic risk and non-carcinogenic hazard be based on the reasonable maximum exposure (RME), which is defined as the maximum exposure that is reasonably expected to occur at a site. The results of the carcinogen and non-carcinogen evaluation were then compared to acceptable levels developed by USEPA.

2.6.2 SITE CHARACTERIZATION

2.6.2.1 SITE DESCRIPTION

Background information including a description of the Properties was previously presented in Section 2.1. The following information was considered in the SRE:

- The Properties include the residential properties located immediately west of the Site as well as the right-of-way owned by the City of South Milwaukee located immediately south of the Site. The Properties are approximately 5 acres in size.
- The Properties are generally bounded to the east by the Site and Lake Michigan; to the west by Fifth Avenue; to the north by the South Milwaukee Wastewater Treatment Plant, and to the south by apartments located on Marina Road.
- The Properties are municipally zoned for residential land use.
- Land use in the vicinity of the Properties is primarily residential and the Properties are bordered to the south and the west by residential areas consisting of mostly apartment and condominium buildings.
- Residences on the Properties are serviced with a municipal water supply that utilizes Lake Michigan as a source of drinking water.
- The surface topography of the Properties is generally flat. The adjacent Site slopes gently to the northeast towards a ravine that runs in a west-east direction towards Lake Michigan. The Site's upland elevation is approximately 60 feet above Lake Michigan and its eastern boundary slopes steeply (approximately 15 to 20 percent) towards a sand beach adjacent to Lake Michigan.
- A ravine is located adjacent to the northern boundary of the Site and.

2.6.2.2 ANALYTICAL DATA

As discussed in Sections 2.3 and 2.4, the surface soil, subsurface soil, groundwater, soil gas, indoor air, and background ambient air samples, collected in accordance with the applicable USEPA-approved Work Plans, were submitted under chain-of-custody to STL for laboratory analyses. The analytical data reports provided by the laboratory and the completed chain-of-custody forms are provided in Appendix B. The analytical data were assessed and validated by CRA's project chemist for conformance with the requirements stipulated in the analytical methods and generally accepted laboratory practices. The data assessment and validation reports are also presented in Appendix B.

The analytical data tables for all media samples and parameters analyzed, that form part of the database for this EE/CA, are provided in Appendix D. As a result of the Time-Critical Removal Action and full-scale ISCO Pilot Studies conducted at the Properties in 2004, certain surface and subsurface soil samples collected prior to implementation of the Time-Critical Removal Action activities and the full-scale ISCO pilot study at the Properties in 2004 were in areas that were either excavated or treated and are either no

longer present or are not representative of current soil conditions. As discussed in Section 2.4, the soils in these areas were resampled, and only the most current soil sample from a location that was excavated or treated is used in the SRE. Also, as discussed in Section 2.4, additional soil gas, ambient air, and indoor air samples were collected as part of the full-scale ISCO pilot study. Based on discussions with USEPA, the SRE evaluated the indoor air samples collected during the initial EE/CA investigation activities in October 2002 and March 2003.

Table D.1 of Appendix D provides a summary of all samples collected from the Properties that form part of the database for this EE/CA. Tables D.2 and D.3 of Appendix D provide a summary of the surface soil and subsurface soil analytical results, respectively, that are considered representative of current soil conditions. Table D.4 of Appendix D provides a summary of the groundwater analytical results and Table D.5 of Appendix D provides a summary of the soil gas, indoor air, and background ambient air, respectively. These validated analytical data, with the exception of one indoor air sample collected from Unit 3A in December 2002 (see Section 2.3.8) and the indoor air samples collected as part of the full-scale ISCO pilot study were used quantitatively in this SRE. Tables D.6 and D.7 of Appendix D provides a summary of surface soil and subsurface soil analytical results, respectively, that are not considered representative of current soil conditions (i.e., no longer exist or were treated as part of the ISCO pilot study).

To characterize potential health risk to potential human receptors under current/future residential conditions, the surface soil data collected from 0.0 to 2.0 feet bgs and the indoor air data collected from the basement of four individual residential units were evaluated in this SRE (i.e., each individual unit evaluated separately). The surface soil data set was chosen based on the fact the Properties are already fully developed with existing residential units constructed. Therefore, it is very unlikely under the current/future residential scenario that exposure to soils at depths greater than 2.0 feet bgs would occur. The existing indoor air data set was chosen since it conservatively (i.e., worst-case exposure conditions) represents the current/future indoor air quality in the individual residential units. Groundwater was not used to characterize potential health risk to potential human receptors under the current/future residential scenario because, as summarized above, residences on the Properties are serviced with a municipal water supply that utilizes Lake Michigan as a source of drinking water. Tables D.2 and D.5 of Appendix D, provide a summary of the surface soil and indoor air analytical results, respectively.

To characterize potential health risk to potential human receptors under potential future construction/utility worker conditions, a soil data set consisting of both the surface soil

data as well as subsurface soil data to a depth of 10 feet bgs (herein referred to as "future soil data set") and the groundwater data collected from the Properties were evaluated in this SRE. Recognizing that future construction / utility work will likely occur at the Properties, a depth of 10 feet bgs was conservatively assumed as a maximum depth of potential future soil excavation. It was also assumed that during potential future construction / utility excavation that groundwater might be encountered due to its depth below ground surface at the Properties (i.e., approximately 8 feet bgs). Under this assumption, all surface soil and subsurface soil data collected to a depth of 10 feet bgs, that form part of the database for this EE / CA, were conservatively assumed to characterize future surface soil conditions and existing groundwater data collected were conservatively assumed to characterize future groundwater conditions. Tables D.2 and D.3 of Appendix D, provide a summary of the surface and subsurface soil analytical results, respectively, and Table D.4 of Appendix D, provides a summary of groundwater analytical results.

2.6.2.3 EXPOSURE PATHWAYS

The SRE focused on an evaluation of potential current and future risks to human health associated with chemical concentrations in surface soil, subsurface soil, indoor air, and groundwater. This evaluation was based on known or anticipated future human activity patterns at the Properties. Chemical concentrations in surface soil, subsurface soil, and groundwater also have the potential to migrate to other media, such as ambient air, to which identified receptors may also be exposed. These secondary exposure pathways were also evaluated in the SRE, as appropriate. A summary of the exposure pathways selected for evaluation in the SRE is provided in Table E.1.0 of Appendix E. In accordance with the risk assessment guidance, the approach used in determining the various exposure scenarios was conservative, and, as such, may have resulted in the exaggeration of stated exposures, as well as higher risk and hazard estimates than are likely to actually occur.

For example, the basements in four residential units on the Marina Cliffs sampled for indoor air during the EE / CA investigation are not occupied as living quarters. Thus, applying the current indoor air concentrations measured in the basements over a lifetime of exposure is overly conservative. Also, there are no community gardens or individual gardens on the Marina Cliffs Condominium property in the vicinity of the VOC-impacted soils. Therefore, the potential exposure pathway due to ingestion of home grown produce over a lifetime is similarly overly conservative.

2.6.3 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

Identification of the COPCs was completed to identify those chemicals that are most likely to pose the majority of the potential health risk at the Properties.

Analytical data for each detected chemical in the current soil, current indoor air, future soil, and future groundwater data sets were evaluated to determine detection frequencies, minimum and maximum detected concentrations, and the sampling location of the maximum detected concentration. Additionally, an appropriate screening value was identified, where possible, for each chemical in each of the data sets. The chemical data from the data sets were evaluated to determine which chemicals were present at concentrations above the respective screening value and/or which were present at a frequency and concentration that would indicate they might be Properties-related chemicals. All chemicals that were determined to be present at concentrations above their respective screening concentrations were considered COPCs.

The identification of COPCs in soil and indoor air did not include an evaluation of the detected chemicals to the Properties-specific background soil and ambient air data collected. Chemicals detected in soil and indoor air were considered COPCs even though the detected concentrations may be within Properties-specific background ranges. Rather, an evaluation of the risk associated with the COPCs versus the risk associated with the COPCs that were detected within Properties-specific background ranges was completed as part of the risk characterization as discussed in Section 2.6.6.7.

Screening values are used to provide a preliminary indication of chemicals that may pose a threat to human health. Screening values are based on standard, conservative and health protective exposure assumptions related to land use activities, which are considered protective of humans, including sensitive groups, over a lifetime. Chemical concentrations detected above their respective screening values do not necessarily indicate that a potential health impact is occurring, or even likely to occur. Rather, the exceedances of a screening value suggest that further evaluation of the potential risk posed by the chemical is warranted.

For groundwater, available Maximum Contaminant Levels (MCLs) were initially applied in the SRE for screening levels (WDNR, 2005). Where MCLs did not exist for groundwater parameters and in the absence of available soil screening values from USEPA Region V, human health-based screening values available from USEPA Region IX (USEPA, 2004a) were applied in the SRE to identify groundwater and soil COPCs. USEPA IX has derived risk-based concentrations for several different types of media and land uses that can be used to screen chemical data.

Recognizing that the Properties are fully developed for residential land use and that land use in the vicinity of the Properties is primarily residential, the USEPA Region IX screening values for residential land use were applied in the SRE for the current / future residential scenario. Also, recognizing that the Properties could be subject to future construction / utility work, the USEPA Region IX screening values for an industrial worker were applied in the SRE for the future construction / utility worker scenario.

For chromium in soil, the screening value for total chromium, and not the hexavalent form (Cr6), was applied in the COPC identification process. The rationale for this decision is based on data collected in March 1998 as part of the Time-Critical Removal Action for the Site. Four locations at the Site that had exhibited the highest detected concentrations of total chromium during previous (November / December 1996) Non-Time-Critical Site-Wide Evaluation data were resampled and analyzed for both total chromium Cr3 and Cr6. The total and hexavalent chromium results for the four sampling locations are summarized below:

Sample Location	***Total Chromium Concentration (mg/kg)***	***Hexavalent Chromium Concentration (mg/kg)***
HS-BP-01 / CR-1	284	ND(1.6)
HS-BP-02 / CR-2	585	ND(1.8)
SS-C-07 / CR-3	728	ND(1.2)
SS-RND-23 / CR-4	1,620	2.6

As indicated by these data, Cr6 was detected in only one of four samples, and in the one sample it was detected, it was present at a ratio of 1:622 of Cr6:Cr3. These data were submitted to USEPA in June 1998, and the subsequent Time-Critical Removal Action at the Site was performed on the basis that chromium was present only as trivalent chromium. In addition, subsequent addenda that were prepared for further Non-Time-Critical Removal Action investigation activities were based on total chromium analyses. Thus, for the purposes of this SRE, it is appropriate to consider that chromium is present in soils predominantly in the trivalent form.

In the absence of indoor air screening values from USEPA Region V, human health-based screening values available from USEPA Office of Solid Waste (USEPA, 2002a) were applied in the SRE to identify indoor air COPCs. The USEPA Office of Solid Waste has derived risk-based concentrations for indoor air, primarily for residential settings that can be used to screen chemical data. Recognizing that the Properties are

fully developed for residential purposes, the USEPA screening values for residential land use were applied in the SRE.

A chemical was identified as a COPC in a media data set if its maximum detected concentration exceeded its respective screening value. If the maximum detected concentration of a chemical was less than its respective screening value, then that chemical was not identified as a COPC. The results of the COPC selection process for each media data set evaluated in the SRE are summarized in the following subsections.

2.6.3.1 COPCs IN CURRENT/FUTURE SURFACE SOIL DATA SET

Table E.2.1 of Appendix E, presents the summary of the occurrence, distribution, and selection of COPCs for the surface soil data set used to evaluate the current/future residential condition. Surface soil COPCs were identified by comparing each chemical's maximum detected concentration to its respective screening level as described in Section 2.6.3. Parameters reported in surface soil (including all locations) with a maximum detected concentration in exceedance of their respective screening value, and thus identified as COPCs, were benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, aroclor-1254, arsenic, iron, and manganese.

2.6.3.2 COPCs IN CURRENT/FUTURE INDOOR AIR DATA SET

Tables E.2.2.A through E.2.2.D of Appendix E, present the summary of the occurrence, distribution, and selection of COPCs for the indoor air data set used to evaluate the current/future residential condition for each of the four individual residential units. Indoor air COPCs were identified by comparing each chemical's maximum detected concentration to its respective screening level as described in Section 2.6.3. Parameters reported in indoor air with a maximum detected concentration in exceedance of their respective screening value (and thus identified as COPCs) were benzene, carbon tetrachloride, chloroform (trichloromethane), dichlorodifluoromethane (CFC-12), ethylbenzene, tetrachloroethene, trichloroethene, and vinyl chloride, as appropriate for each individual unit.

2.6.3.3 COPCs IN FUTURE SOIL DATA SET

Table E.2.3 of Appendix E presents the summary of the occurrence, distribution, and selection of COPCs for the future soil data set (i.e., soil samples to a depth of 10 feet bgs including surface soils) used to evaluate the future construction / utility worker condition. Future soils COPCs were identified by comparing each chemical's maximum detected concentration to its respective screening level as described in Section 2.6.3. Parameters reported in the future soil data set with a maximum detected concentration in exceedance of their respective screening value, and thus identified as COPCs, were benzene, tetrachloroethene, trichloroethene, vinyl chloride, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, aroclor-1254, and arsenic.

2.6.3.4 COPCs IN FUTURE GROUNDWATER DATA SET

Table E.2.4 of Appendix E presents the summary of the occurrence, distribution, and selection of COPCs for the future groundwater data set used to evaluate the future construction / utility worker condition. The future groundwater data set consisted of groundwater data from MW-8, MW-9, and MW-10, as these locations are representative of the groundwater immediately under the Properties. Groundwater COPCs were identified by comparing each chemical's maximum detected concentration to its respective drinking water screening level. To be conservative, screening values protective of drinking water were applied in the SRE even though it has been determined that the groundwater drinking water exposure pathway is not complete at the Properties and that the only potential exposure would be to a construction / utility worker. Parameters reported in the future groundwater data set with a maximum detected concentration in exceedance of their respective screening value (and thus identified as COPCs), were 2-hexanone, chloroethane, vinyl chloride, bis(2-ethylhexyl)phthalate, iron, manganese, and thallium.

2.6.3.5 COPCs IN CURRENT/FUTURE AMBIENT AIR DATA SETS

Chemicals detected in surface soils on the Properties have the potential to migrate to ambient air as volatiles or by adsorption to airborne soil particulates. Therefore, COPCs identified for the current soil data set were conservatively identified as COPCs in ambient air under the current / future residential condition (i.e., airborne particulates) and COPCs identified for the future soil data set were also conservatively identified as COPCs in ambient air under the future construction / utility worker condition.

2.6.4 EXPOSURE ASSESSMENT

2.6.4.1 POTENTIAL PATHWAYS OF HUMAN EXPOSURE

To determine whether an exposure to COPCs remaining in a medium exists, the environmental and human components that lead to human exposure must be evaluated.

An exposure pathway consists of four necessary elements:

- A source and mechanism of chemical release to the environment;
- An environmental transport medium;
- A point of potential human contact within the impacted medium (exposure point); and
- A human exposure route (ingestion, dermal contact, or inhalation) at the contact point.

Exposure pathways are classified as complete, potential, or incomplete. For an exposure pathway to be complete, the aforementioned four elements must be present, which indicates that the exposure is occurring or is expected to occur in the future. Potential exposure pathways have one element temporarily missing, which indicates that the exposure pathway may be complete in the future. Incomplete exposure pathways have one or more elements missing which, within reason, will never be present. Table E.1.0 of Appendix E presents a summary of the complete and potentially complete exposure pathways selected for evaluation in the SRE. Both complete current and future potential exposures were considered for evaluation in the SRE.

Exposure pathways evaluated in the SRE include direct contact to COPCs in soil through incidental ingestion, dermal contact, and inhalation of airborne contaminants. As discussed previously in Section 2.6.2.2, surface soil data collected from 0 to 2.0 feet bgs were used to characterize potential health risk to receptors under the current / future residential condition. Soil data collected from 0 to 10 feet bgs were used to characterize potential health risk to receptors under the future construction / utility worker condition.

An exposure pathway also evaluated in the SRE includes inhalation of indoor air COPCs. Indoor air data collected were used to characterize potential health risk to receptors under current / future residential condition.

There is no complete direct contact exposure to groundwater under the current/future residential condition. Drinking water is currently supplied to residents through a piped municipal water system; a situation that is anticipated to continue into the foreseeable future. As such, neither a current nor a future groundwater drinking water exposure was evaluated in the SRE for the residential condition. However, there is a potential complete direct exposure to groundwater under the future construction/utility worker condition. It is recognized that a construction/utility worker might intercept groundwater while excavating into the soils. Therefore, groundwater data collected from the Properties were used to characterize potential health risk to receptors under future construction/utility worker conditions. It should be noted, however, that groundwater direct contact was characterized only for future dermal exposure to groundwater COPCs at the point of excavation. It was assumed that little or no incidental ingestion of groundwater occurs and thus, the oral groundwater exposure pathway was not included. Also, it was assumed that, due to the extremely low concentrations of VOCs detected in the groundwater on the Properties, that volatilization of VOCs from the groundwater would be insignificant.

2.6.4.2 POTENTIALLY EXPOSED POPULATIONS

Residents

Under the current (and foreseeable future) condition, the Properties are fully developed as residential. As such, a current child and adult residential exposure to soils and indoor air was evaluated in the SRE. Exposure is assumed to occur through the incidental ingestion, dermal, and inhalation exposure routes.

In addition, garden produce may be homegrown in the backyards of the residential properties. Thus, an exposure to COPCs taken up in homegrown garden produce was also evaluated for a child and adult residential receptor.

Construction/Utility Worker

Under the future condition, it is recognized that a construction/utility worker might excavate into the soils at the Properties and potentially be exposed to soils and/or groundwater since there are underground utilities present in the areas of VOC-impacted subsurface soil on the Marina Cliffs Condominium property. As such, a future construction/utility worker exposure to soils and groundwater was evaluated in the SRE. Exposure is assumed to occur through the incidental ingestion, dermal, and

inhalation exposure routes for soils and through the dermal exposure route for groundwater.

2.6.4.3 EXPOSURE POINT CONCENTRATIONS

Two estimates of exposure are used in the risk assessment process: (i) the mean or central tendency (CT) exposure; and (ii) the reasonable maximum exposure (RME). The mean exposure scenario uses the CT value and represents probable exposure conditions. The RME scenario places a statistical upper bound on the true mean to provide a more conservative assessment. The determinations of the CT exposure and RME are statistically based and dependent on the probability distribution of the observed data. As well, the presence of censored data (non-detected results) influences the statistical methods used to determine the CT and RME values.

Appendix F presents the procedures used to determine the CT and RME exposure point concentrations for the COPCs identified for the Properties. A number of guidance documents were consulted in developing the statistical methodologies including USEPA (1989b), USEPA (1997b), USEPA (2002b), USEPA (2004b), and USEPA (2006).

The arithmetic mean, the maximum detected concentration, and the CT and RME concentration for each COPC identified in the data sets are presented in the following table in Appendix E:

- Table E.3.1 for current / future residential surface soil data set;
- Tables E.3.2.A to E.3.2.D for the current / future individual residential indoor air data sets for Units 1J, 2A, 3J, and 4A, respectively;
- Table E.3.3 for the future construction / utility worker soil data set; and
- Table E.3.4 for the future construction / utility worker groundwater data set.

Exposure to COPCs in ambient air was estimated using the COPCs CT or RME exposure point concentration in soil and using a particulate emission factor (PEF) for non-volatile COPCs and a volatilization factor (VF) for volatile COPCs, consistent with equations presented in USEPA (2002c). Appendix H presents the ambient air emission model / calculations used to estimate the ambient air concentrations from soil and groundwater during the construction / utility excavation activities.

2.6.4.4 QUANTIFICATION OF EXPOSURE

For each exposure scenario, two levels of assumptions are presented. The Mean or CT assumptions represent the average or central tendency value for the assumptions approximating the average expected exposure conditions. The RME assumptions, which are more conservative, approximate the reasonable maximum exposure. The RME assumptions are generally based on the 90th or the 95th percentile confidence level for exposure assumptions such as the exposure duration and the ingestion rate.

To quantify exposures, potential exposure scenarios were developed using guidance provided in various USEPA documents as referenced. In some instances, where USEPA guidance does not present the necessary assumptions, and where Property-specific exposure information was not available, professional judgment was used to develop conservative and health protective exposure assumptions.

2.6.4.4.1 GENERIC ESTIMATION OF INTAKE

To quantify exposures or intakes of COPCs, the following general equation is applied:

$$\text{Intake} = \frac{CM \times ER \times EF \times ED \times CF}{AT \times BW}$$

where:

Intake = Average daily intake of chemical (mg/kg/day)

CM = Concentration of COPC in specific media (i.e., mg/kg for soil)

ER = Exposure rate (i.e., mg/day for soil ingestion)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

CF = Conversion Factors as needed (kg/mg)

BW = Body weight of receptor (kg)

AT = Averaging time (days)

The exposure assumptions applied for the specific exposure scenarios evaluated in the SRE are presented in the following sections.

2.6.4.4.2 RESIDENTIAL SOIL EXPOSURE - CURRENT/FUTURE CONDITION

A soil exposure scenario for a combined child and adult resident exposure was developed for the Properties under current/future conditions. Exposure to COPCs in soil was assumed to occur through inadvertent ingestion of soil, generally due to hand-to-mouth contact, dermal absorption of chemicals on soiled skin, and the inhalation of chemicals adsorbed to airborne dust or present as vapor that originated from a soil source. The chemical intake, and resulting carcinogenic risk or non-carcinogenic hazard, for each exposure route is calculated separately. Table E.4.1 of Appendix E presents a summary of the conservative and health-protective assumptions that were used to calculate the residential exposure to COPCs in surface soils, as appropriate. The exposure assumptions are described as follows:

- The exposure point concentrations are the 95 percent UCL of the mean or the maximum detected concentration, whichever is lower, for both the CT and RME exposure scenarios.
- The inadvertent soil ingestion rates for the child and adult are 200 mg/day and 100 mg/day, respectively, for both the CT and RME (USEPA, 1991).
- The oral absorption efficiency following ingestion is assumed to be 100 percent for all COPCs.
- The conversion factor is 0.000001 kg/mg.
- The exposed skin surface area for the child and adult are 2,800 cm^2/day and 5,700 cm^2/day, respectively, for both the CT and RME based on USEPA (2004c) recommended values. The exposed skin surface area for the child is based on assumed exposure to the head, hands, forearms, and lower legs and feet. The exposed skin surface area for the adult is based on assumed exposure to the head, hands, forearms, and lower legs.
- The soil-to-skin adherence factors for the child are 0.04 mg/cm^2 (CT) and 0.2 mg/cm^2 (RME) based USEPA (2004c) recommended values. The soil-to-skin adherence factors for the adult are 0.01 mg/cm^2 (CT) and 0.07 mg/cm^2 (RME) based USEPA (2004c) recommended values.
- The dermal absorption factor is chemical-specific. Where chemical-specific information is not available, the recommended USEPA (2004c or 1995) generic default dermal absorption factors for semi-volatiles of 10 percent or 0.1, and for inorganics of 1 percent or 0.01 were used.
- The inhalation rates for the child and adult are 8.3 m^3/day and 15 m^3/day, respectively, for the CT and RME (USEPA, 1997a).

- The particulate emission factor of 9.20E+08 m^3/kg was estimated based on a 5-acre source area in Zone V (Minneapolis) using equations 4-5 and Exhibit D-2 from USEPA (2002c).
- The exposure frequency for both the child and adult residents is 350 days/year for the CT and RME (USEPA, 1989b).
- The exposure duration for the RME is a combined 30-year exposure consisting of 6 years as a child and 24 years as an adult. The exposure duration for the CT is a combined 9-year exposure consisting of 6 years as a child and 3 years as an adult (USEPA, 1991).
- The body weights of the child and adult are 15 kg and 70 kg, respectively, for both the CT and RME (USEPA, 1991).
- The carcinogenic averaging time is 70 years times 365 days/year or 25,550 days. The averaging time for non-carcinogens is 365 times the exposure duration (ED).

2.6.4.4.3 RESIDENTIAL HOMEGROWN GARDEN PRODUCE EXPOSURE - CURRENT/FUTURE CONDITION

A homegrown garden produce consumption scenario for a combined child and adult residential exposure was conservatively developed for current/future conditions. Exposure to COPCs in soil was assumed to occur after root uptake into produce grown in a backyard garden. Two different types of produce were considered: i) aboveground produce such as tomatoes, and ii) below ground produce such as carrots. A 25 percent factor is applied for the amount of produce consumed that comes from the backyard garden and is contaminated, versus the amount of produce consumed that comes from a market or store that is not contaminated. Produce consumption rates for both above ground and below ground produce are then applied for children and adults to determine the COPC intake. Table E.4.1 of Appendix E includes a summary of the conservative and health-protective assumptions that were used to calculate the homegrown produce consumption exposure. The exposure assumptions are described as follows:

- The exposure point concentrations are the 95 percent UCL of the mean or the maximum detected concentration, whichever is lower, for both the CT and RME exposure scenarios.
- The above ground produce concentration in mg/kg dry weight (DW) is calculated by multiplying the soil concentration by a chemical-specific plant-soil uptake factor according to USEPA (2005a).

- The below ground produce concentration in mg/kg dry weight (DW) is calculated by multiplying the soil concentration by a chemical-specific plant-soil uptake factor and a correction factor according to USEPA (2005a).
- The child and adult consumption rates for above ground produce are 0.00077 kg/kg-day DW and 0.00032 kg/kg-day DW, respectively, as specified by USEPA (2005a).
- The child and adult consumption rates for below ground produce are 0.00023 kg/kg-day DW and 0.00014 kg/kg-day DW, respectively, as specified by USEPA (2005a).
- The fraction of produce consumed that is assumed to be contaminated is 25 percent based on professional judgment.
- The plant-soil uptake factors for above ground produce are chemical specific and are listed in Table E.4.1 of Appendix E according to USEPA (1998).
- The plant-soil uptake factors for below ground produce are chemical specific and are presented in the Companion Database available at www.epa.gov/epaoswer/hazwaste/combust/riskrol.htm#volume1 USEPA (2005a).
- The correction factor for below ground produce uptake is 0.01 for COPCs with a log Kow greater than 4, and is 1.0 for COPCs with a log Kow less than 4, as recommended by USEPA (2005a).
- The exposure duration for the RME is a combined 30-year exposure consisting of 6 years as a child and 24 years as an adult. The exposure duration for the CT is a combined 9-year exposure consisting of 6 years as a child and 3 years as an adult (USEPA, 1989b).
- The carcinogenic averaging time is 70 years. The averaging time for non-carcinogens equals the exposure duration.

2.6.4.4.4 RESIDENTIAL INDOOR AIR EXPOSURE - CURRENT/FUTURE CONDITION

An indoor air exposure scenario for a combined child and adult residential exposure was developed for the Properties under current/future conditions. Exposure to COPCs in indoor air was assumed to occur through inhalation of chemicals present as vapor within a residential unit. The basement indoor air concentrations represent the worst-case exposure concentrations, as the air concentration will become diluted/attenuated as the air migrates to the upper levels of the residential properties. The chemical intake, and resulting carcinogenic risk or non-carcinogenic hazard, for each exposure route is calculated separately. Table E.4.2 of Appendix E present a summary

of the conservative and health-protective assumptions that were used to calculate the residential exposure to COPCs in indoor air, as appropriate. The exposure assumptions are described as follows:

- The exposure point concentrations are the 95 percent UCL of the mean or the maximum detected concentrations, whichever is lower, for both the CT and RME exposure scenarios.
- The inhalation rates for the child and adult are 8.3 m^3/day and 15 m^3/day, respectively, for the CT and RME (USEPA, 1997a).
- The exposure frequency for both the child and adult residents is 350 days/year for the CT and RME (USEPA, 1991).
- The exposure duration for the RME is a combined 30-year exposure consisting of 6 years as a child and 24 years as an adult. The exposure duration for the CT is a combined 9-year exposure consisting of 6 years as a child and 3 years as an adult (USEPA, 1991).
- The body weights of the child and adult are 15 kg and 70 kg, respectively, for the CT and RME (USEPA, 1991).
- The carcinogenic averaging time is 70 years times 365 days/year or 25,550 days. The averaging time for non-carcinogens is 365 times the exposure duration (ED).

2.6.4.4.5 CONSTRUCTION/UTILITY WORKER SOIL EXPOSURE - FUTURE CONDITION

A soil exposure scenario for an adult construction/utility worker exposure was developed for the Properties under future conditions. Exposure to COPCs in soil was assumed to occur through inadvertent ingestion of soil, generally due to hand-to-mouth contact, and dermal absorption of chemicals on soiled skin. The chemical intake, and resulting carcinogenic risk or non-carcinogenic hazard, for each exposure route is calculated separately. Table E.4.3 of Appendix E presents a summary of the conservative and health-protective assumptions that were used to calculate the residential exposure to COPCs in the future soil data set, as appropriate. The exposure assumptions are described as follows:

- The exposure point concentrations are the 95 percent UCL of the mean or the maximum detected concentrations, whichever is lower, for both the CT and RME exposure scenarios.

- The inadvertent soil ingestion rate for the adult construction / utility worker is 330 mg / day, for both the CT and RME (USEPA, 2002c).
- The oral absorption efficiency following ingestion is assumed to be 100 percent for all COPCs.
- The conversion factor is 0.000001 kg / mg.
- The exposed skin surface area for the construction / utility worker is 3,300 cm^2 / day for both the CT and RME based on USEPA (2002c) recommended values. The exposed skin surface area for the construction / utility worker is based on assumed exposure to the head, hands, forearms, and lower legs.
- The soil-to-skin adherence factors for the construction / utility worker are 0.1 mg / cm^2 (CT) and 0.3 mg / cm^2 (RME) based USEPA (2002c) recommended values.
- The dermal absorption factor is chemical-specific. Where chemical-specific information is not available, the recommended USEPA (2004b or 1995) generic default dermal absorption factors for volatiles of 0.05 percent or 0.0005, semi-volatiles of 10 percent or 0.1, and for inorganics of 1 percent or 0.01 were used.
- The inhalation rate for the construction / utility worker is 20 m^3 / day for both the CT and RME (USEPA, 1997a).
- The exposure frequency for construction / utility worker is 5 days / year for the CT and 10 days / year for the RME. This is based on professional judgment and is consistent with construction / utility worker exposure at the Properties.
- The exposure duration for the construction / utility workers for both the CT and the RME is 1 year. This is based on professional judgment and is consistent with construction / utility worker exposure at the Properties.
- The body weight of the construction / utility worker is 70 kg for both the CT and RME (USEPA, 1991).
- The carcinogenic averaging time is 70 years times 365 days / year or 25,550 days. The averaging time for non-carcinogens is 365 times the exposure duration (ED).

2.6.4.4.6 CONSTRUCTION/UTILITY WORKER AMBIENT AIR EXPOSURE - FUTURE CONDITION

A soil-to-ambient air exposure scenario for an adult construction / utility worker was developed for the Properties under future conditions. It was assumed that chemicals detected in soil may become airborne adsorbed to particulates during excavation activities. The future soil data set was used to conservatively model particulate air emissions within an excavation area for the potential future construction / utility worker

exposure (see Appendix H). This scenario assumes construction / utility worker exposure through inhalation. The chemical intake, and resulting carcinogenic risk or non-carcinogenic hazard, for each exposure route is calculated separately. Table E.4.3 of Appendix E presents a summary of the conservative and health-protective assumptions that were used to calculate the residential exposure to COPCs in the future soil data set, as appropriate. The exposure assumptions are described as follows:

- The exposure point concentration was the 95 percent UCL or the maximum detected concentration, whichever was lower, for both CT and RME exposure scenarios. Note that RME soil results from the future soil data set were used as the initial inputs for air modeling, as described in Appendix H, in order to derive ambient air exposure point concentrations for the soil-to-ambient air exposure pathway. The RME point concentrations represent maximum 8-hour ground level concentration estimates;
- The exposure frequency for construction / utility worker is 5 days / year for the CT and 10 days / year for the RME. This is based on professional judgment and is consistent with construction / utility worker exposure at the Properties.
- The exposure duration for the construction / utility workers for both the CT and the RME is 1 year. This is based on professional judgment and is consistent with construction / utility worker exposure at the Properties.
- The body weight of the construction / utility worker is 70 kg for both the CT and RME (USEPA, 1991).
- The carcinogenic averaging time is 70 years times 365 days / year or 25,550 days. The averaging time for non-carcinogens is 365 times the exposure duration (ED).

2.6.4.4.7 CONSTRUCTION/UTILITY WORKER GROUNDWATER EXPOSURE - FUTURE CONDITION

A groundwater exposure scenario for an adult construction / utility worker exposure was developed for the Properties under future conditions. Exposure to COPCs in groundwater was assumed to occur through dermal absorption of chemicals on soiled skin. Inadvertent ingestion of groundwater, generally due to hand-to-mouth contact, and inhalation of chemicals as vapor were not considered to be significant exposure pathways due to the low probability of ingesting groundwater during construction activities and due to the very low concentrations of VOCs in the groundwater versus the higher concentrations in the soils. The chemical intake, and resulting carcinogenic risk or non-carcinogenic hazard, for the dermal exposure route is calculated separately. Table E.4.4 of Appendix E presents a summary of the conservative and health-protective assumptions that were used to calculate the residential exposure to COPCs in the future

groundwater data set, as appropriate. The exposure assumptions are described as follows:

- The exposure point concentrations are the 95 percent UCL of the mean or the maximum detected concentration, whichever is lower, for both the CT and RME exposure scenarios.
- The exposed skin surface area for the construction / utility worker is 3,300 cm^2 for both the CT and RME based on USEPA (2002c) recommended values. The exposed skin surface area for the construction / utility worker is based on assumed exposure to the head, hands, forearms, and lower legs.
- The permeability constant following COPC dermal exposure is chemical specific as taken from USEPA (2004b).
- The conversion factor is 0.001 L / m^3.
- The exposure time for construction / utility worker is 2 hours / day for both the CT and RME. This is based on professional judgment and is consistent with construction / utility worker exposure to groundwater at the Properties
- The exposure frequency for construction / utility worker is 5 days / year for the CT and 10 days / year for the RME. This is based on professional judgment and is consistent with construction / utility worker exposure to groundwater at the Properties.
- The exposure duration for the construction / utility workers for both the CT and the RME is 1 year. This is based on professional judgment and is consistent with construction / utility worker exposure to groundwater at the Properties.
- The body weight of the construction / utility worker is 70 kg for both the CT and RME (USEPA, 1991).
- The carcinogenic averaging time is 70 years times 365 days / year or 25,550 days. The averaging time for non-carcinogens is 365 times the exposure duration (ED).

2.6.5 TOXICITY ASSESSMENT

The health criteria for non-carcinogenic substances suspected of causing chronic effects, are usually expressed as chronic intake levels or reference doses (RfDs) in units of mg / kg-day below which no adverse effects are expected. In contrast with the underlying toxicological model used by USEPA to assess carcinogenic risk, which assumes no threshold, the non-carcinogenic dose-response model postulates a "threshold". In other words, there is a level of exposure to a chemical below which virtually no effects are expected.

In this risk assessment, chronic RfDs are used as the toxicity values to estimate non-carcinogenic health effects. A chronic RfD is defined as an estimate (with uncertainty spanning an order of magnitude or greater) of a daily exposure level for the human population, including sensitive sub-populations that is likely to be without an appreciable risk of deleterious effects during a lifetime. Uncertainty factors have been incorporated into the RfDs to account for extrapolations from animal data, the quality of the data, and to protect sensitive sub-populations. The RfD is usually based on the highest dose level administered to laboratory animals that did not cause observable adverse effects after chronic (usually lifetime) exposure, which is referred to as the No Observed Adverse Effect Level (NOAEL). The NOAEL is then divided by an uncertainty (safety) factor, and sometimes an additional modifying factor, to obtain the RfD. In general, an uncertainty factor of 10 is used to account for interspecies variation and another factor of 10 to account for sensitive human populations. Additional factors of 10 are included in the uncertainty factor if the RfD is based on the Lowest-Observed Adverse Effect Level (LOAEL) instead of the NOAEL, or data inadequacies such as an experiment that includes a less than lifetime exposure.

Table E.5.1 of Appendix E presents the non-cancer toxicity data used in the SRE to estimate human health effects for the oral and dermal exposure routes. Table E.5.2 of Appendix E presents the non-cancer toxicity data used in the SRE to estimate human health effects for the inhalation exposure route.

A Cancer Slope Factor (CSF) is applied to estimate the potential risk of cancer from exposure to carcinogenic chemicals. The CSF is expressed in units of $[mg/kg/day]^{-1}$ and when multiplied by the lifetime average daily dose expressed in units of mg/kg/day will provide an estimate of the probability that the dose will cause cancer during the lifetime of the exposed individual. This increased cancer risk is expressed by terms such as 1E-06 or 1×10^{-6}. This is a hypothetical estimate of the upper limit of risk based on very conservative and/or health-protective assumptions and statistical evaluations of data from animal experiments or from epidemiological studies. To state that a chemical exposure causes a 1E-06 added upper limit risk of cancer means that if 1,000,000 people are exposed, one additional incident of cancer is expected to occur in the population. From an individual perspective, a 1.0E-06 increased cancer risk equates to a one-in-a-million chance of developing cancer over a lifetime. The calculations and assumptions yield an upper limit estimate, which indicates that no more than one case is expected and, in fact, there may be no additional cases of cancer. USEPA policy, as specified in the NCP (1990), has established that an upper limit cancer risk falling below or within the range of 1E-06 to 1E-04 is acceptable. In addition, 40 CFR Part 300.430 (f)(2) specifies that for known or suspected carcinogens, acceptable exposure levels are

generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 1E-04 and 1E-06 using information on the relationship between dose and response. USEPA does, however, determine the acceptable risk level on a site-by-site basis, taking into account a full engineering and cost analysis for the site. It is generally USEPA's goal to use a 1E-06 risk level as the point of departure for determining remediation goals when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure. Since USEPA CSFs represent 95 percent upper confidence levels (UCLs), the calculated risks are 95 percent upper bound estimates. Thus, actual risks associated with exposure to a potential carcinogen are not likely to exceed the risks estimated using CSFs, but may in fact be lower.

Known or suspect human carcinogens are evaluated and identified by the Carcinogen Assessment Group with USEPA's Weight-of-Evidence classification for carcinogenicity. The COPCs for the Properties are classified utilizing USEPA's system. The USEPA classification is based on an evaluation of the likelihood that the agent is a human carcinogen. The evidence is characterized separately for human and animal studies as follows:

Group A Known Human Carcinogen (sufficient evidence of carcinogenicity in humans);

Group B Probable Human Carcinogen (Group B1 - limited evidence of carcinogenicity in humans; and Group B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans);

Group C Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data);

Group D Not Classifiable as to Human Carcinogenicity (inadequate or no evidence); and

Group E Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in animal studies).

Table E.6.1 of Appendix E presents the cancer toxicity data used in the SRE to estimate the risk of cancer for the oral and dermal exposure routes. Table E.6.2 of Appendix E, presents the cancer toxicity data used in the SRE to estimate the risk of cancer for the inhalation exposure route.

As indicated in Tables E.5.1, E.5.2, E.6.1, and E.6.2, as discussed with USEPA, there are two toxicity values (USEPA, 1999 and 2004a) presented and assessed for TCE in this SRE. The USEPA has withdrawn the toxicity values for trichloroethene due to

uncertainty in chemical modes of action, problems relating high-dose animal experiments to low-dose human effects and inconsistencies between human epidemiological data. To that end, the dose response data for TCE is currently under re-evaluation by USEPA and the National Academy of Sciences. In the absence of a USEPA-sanctioned value, the current USEPA National Center for Environmental Assessment (NCEA) value was used. The use of provisional values from the USEPA sources specified above will lead to added uncertainty in the risk assessment process, beyond that found by selecting conservative default exposure assumptions. A number of State EPA Agencies (including California EPA) have rejected the USEPA slope factor as being scientifically flawed, and have developed their own to reduce the uncertainty in the risk estimates. Due to this uncertainty, risk estimates are provided for TCE using both the current provisional non-cancer risk reference dose and cancer risk toxicity factors, as well as the factors previously listed (but then withdrawn) by USEPA. In this way, the full range of potential risk has been quantified for TCE.

2.6.5.1 ADJUSTMENT OF DERMAL TOXICITY FACTORS

USEPA verified toxicity factors are typically based on administered dose. Therefore, to characterize risk from the dermal exposure pathway, adjustment of the oral toxicity factor to represent an absorbed dose rather than administered dose is necessary. This adjustment accounts for the absorption efficiency in the "critical study" which forms the basis of the RfD of CSF. For example, in the case where oral absorption in the critical study is essentially complete (i.e., 100 percent), the absorbed dose is equivalent to the administered dose, and therefore no toxicity adjustment is necessary (USEPA, 2004c). When gastrointestinal (GI) absorption of a chemical in the critical study is poor (i.e., 1 percent), the absorbed dose is much smaller than the administered dose, and therefore toxicity factors based on the absorbed dose must be adjusted for the difference in the absorbed dose relative to the administered dose.

The magnitude of toxicity factor adjustment is inversely proportional to the absorption fraction in the critical study. Thus, when the absorption efficiency in the critical study is high, the absorbed dose approaches the administered dose resulting in little difference in a toxicity factor derived from either the absorbed or administered dose. As absorption efficiency in the critical study decreases, the difference between the absorbed dose and the administered dose increases. At some point, a toxicity factor based on absorbed rather than administered dose needs to account for this difference in dose. A cutoff of 50 percent GI absorption is recommended to reflect the intrinsic variability in the analysis of absorption studies. This cutoff level obviates the need to make comparatively small adjustments in the toxicity value that would otherwise impart on

the process a level of accuracy that is not supported by the scientific literature (USEPA, 2004c). Oral to dermal adjustment factors applied in the SRE are presented in Tables E.5.1 and E.6.1 of Appendix E.

2.6.6 RISK CHARACTERIZATION

The risk characterization step of the SRE combines the information presented in the exposure assessment and the toxicity assessment to derive an expression of health risk. Both carcinogenic risks and non-carcinogenic hazards are estimated for each COPC for each evaluated exposure scenario based on the calculated COPC bodily intake and the applicable toxicity factor. The estimated carcinogenic risk is calculated using the following formula:

Risk = Intake x CSF

where:

Risk = the estimated upper bound risk of additional cancer in a population exposed to the estimated chemical intake for the exposure duration averaged over a lifetime.

Intake = the lifetime average daily dose (LADD) of a chemical calculated by applying the exposure assumptions derived for each exposure scenarios (expressed as mg/kg/day). The LADD represents the daily dose received over the exposure duration averaged over the individuals expected lifetime of 70 years.

CSF = Cancer Slope Factor represents the potential for carcinogenic response based on a theoretical model. This factor is expressed as 1/(mg/kg/day).

Exposure situations may involve the potential exposure to more than one carcinogen. To assess the potential for carcinogenic effects posed by exposure to multiple carcinogens, it is assumed in the absence of information on synergistic or antagonistic effects that carcinogenic risks are additive. Potential risks estimated for the Properties were characterized by comparison to an acceptable risk range of 1E-06 to 1E-04. USEPA policy, as specified in the NCP (1990), has established that an upper limit cancer risk falling below or within the range of 1E-06 to 1E-04 is acceptable. USEPA does, however, determine the acceptable risk level on a site-by-site basis, taking into account a full engineering and cost analysis for the site. It is generally USEPA's goal to use a 1E-06 risk level as the point of departure for determining remediation goals when ARARs are not

available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure.

The hazard of non-carcinogenic adverse effects from exposure to a chemical is expressed as the Hazard Quotient (HQ) and is calculated as follows:

$$\text{Hazard Quotient (HQ)} = \frac{\text{Intake}}{\text{RfD}}$$

where:

Hazard Quotient = the relationship between the calculated daily intake of a chemical and a reference dose that is not expected to cause adverse effects from a lifetime exposure.

Intake = the chronic average daily dose (CADD) of a chemical calculated by applying the exposure assumptions derived for each exposure scenario (expressed as mg/kg/day). The intake represents the average daily dose for the expected period of exposure.

RfD = Reference Dose represents the daily chemical intake level that is based on experimental study and/or human experience and is believed to not cause an adverse effect from even a lifetime of exposure.

It should be noted that the non-cancer hazard assessment is based only on the child exposure because the child is the most sensitive potential receptor sub-group. The Hazard Index (HI) for an exposure situation is the sum of the Hazard Quotients estimated for the individual COPCs. An HI below 1.0 is considered health protective for a lifetime exposure and is therefore not an exposure of concern. If the HI exceeds 1.0 it may be appropriate to reevaluate the toxicity of the individual COPCs to determine if individual chemicals have the same or differing toxicological endpoints that would support conclusions that the HQs should or should not be added.

2.6.6.1 SOIL EXPOSURE FOR CURRENT/FUTURE RESIDENTS

The calculated CT and RME non-cancer hazard indices and the calculated lifetime cancer risks for residential exposure to soils under current/future conditions through incidental ingestion, dermal contact, and inhalation are presented in Tables E.7.1.CT and E.7.1.RME and Tables E.8.1.CT and E.8.1.RME, respectively, Appendix E. The total calculated hazard indices and the total calculated lifetime cancer risks for the ingestion, dermal, and inhalation exposure routes combined are summarized below:

Exposure Scenario	Including Non-Properties-Related Constituents		Including Non-Properties-Related Constituents	
	CT Risk	CT Hazard	RME Risk	RME Hazard
Current/Future Residential Surface Soils (via Ingestion, Dermal, and Inhalation)	3.1E-05	1.4	5.2E-05	1.5

The estimated hazard indices are slightly above 1.0, the level of potential concern. However, the estimated lifetime cancer risks fall within the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals.

A COPC that contributes to the estimated hazard indices and estimated cancer risks is arsenic, which was determined to be present in the Properties' soils at levels below background, and therefore, is not Properties related (refer to Section 2.6.6.7). Other COPCs that contribute to the estimated cancer risks include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd) pyrene, which were also determined to be present in the Properties' soils at levels below background and, therefore, are not Properties related (refer to Section 2.6.6.7). Removing these non-Properties-related constituents, the total calculated hazard indices and the total calculated lifetime cancer risks for the ingestion, dermal, and inhalation exposure routes are summarized below:

Exposure Scenario	Excluding Non-Properties-Related Constituents		Excluding Non-Properties-Related Constituents	
	CT Risk	CT Hazard	RME Risk	RME Hazard
Current/Future Residential Surface Soils (via Ingestion, Dermal, and Inhalation)	2.4E-07	1.1	4.4E-07	1.2

The estimated HIs are at or slightly above 1.0, the level of potential concern. The estimated lifetime cancer risks are below the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and below the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals.

2.6.6.2 HOMEGROWN GARDEN PRODUCE EXPOSURE FOR CURRENT/FUTURE RESIDENTS

The calculated CT and RME non-cancer hazard indices and the calculated lifetime cancer risks for residential exposure to homegrown garden produce under current/future conditions are presented in Tables E.7.2.CT and E.7.2.RME, and Tables E.8.2.CT and E.8.2.RME, respectively, Appendix E. The total calculated hazard indices and the total calculated lifetime cancer risks for the produce consumption exposure route are summarized below:

Exposure Scenario	*Including Non-Properties-Related Constituents*		*Including Non-Properties-Related Constituents*	
	CT Risk	***CT Hazard***	***RME Risk***	***RME Hazard***
Current/Future Residential Homegrown Garden Produce (via Ingestion)	3.7E-06	2.7E-02	1.0E-05	2.7E-02

The estimated HIs are below 1.0, the level of potential concern. The estimated lifetime cancer risks fall within the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and slightly above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals.

Arsenic contributes to the estimated hazard indices and the estimated cancer risks, but was determined to be present in soils at levels below background and, therefore, is not Properties related (refer to Section 2.6.6.7). Other COPCs contributing to the estimated cancer risks include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene, which were also determined to be present in soils at levels below background and, therefore, are not Properties related (refer to Section 2.6.6.7). Removing these non-Properties-related constituents, the total calculated hazard indices and the total calculated lifetime cancer risks for the produce consumption exposure route are summarized below:

Exposure Scenario	*Excluding Non-Properties-Related Constituents*		*Excluding Non-Properties-Related Constituents*	
	CT Risk	***CT Hazard***	***RME Risk***	***RME Hazard***
Current/Future Residential Homegrown Garden Produce (via Ingestion)	2.8E-08	6.0E-03	7.7E-08	6.0E-03

The estimated HIs are below 1.0, the level of potential concern. The estimated lifetime cancer risks are below the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and below above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals.

2.6.6.3 INDOOR AIR EXPOSURE FOR CURRENT/FUTURE RESIDENTS

As discussed with USEPA, each condominium unit sampled during the EE/CA investigation activities in October 2002 and March 2003 were assessed individually in this SRE. Therefore, the calculated CT and RME non-cancer hazard indices and lifetime cancer risks for residential exposure to indoor air under current/future conditions are respectively presented in Appendix E as follows:

- Unit 1J – Tables E.7.3.A.CT, E.7.3.A.RME, E.8.3.A.CT, and E.8.3.A.RME;
- Unit 2A – Tables E.7.3.B.CT, E.7.3.B.RME, E.8.3.B.CT, and E.8.3.B.RME;
- Unit 3J – Tables E.7.3.C.CT, E.7.3.C.RME, E.8.3.C.CT, and E.8.3.C.RME; and
- Unit 4A – Tables E.7.3.D.CT, E.7.3.D.RME, E.8.3.D.CT, and E.8.3.D.RME.

The total calculated hazard indices and the total calculated lifetime cancer risks for the indoor air inhalation exposure route for the individual units are summarized below:

	Including Non-Properties-Related Constituents		***Including Non-Properties-Related Constituents***	
Exposure Scenario	***CT Risk***	***CT Hazard***	***RME Risk***	***RME Hazard***
Current/Future Residential				
Unit 1J (provisional TCE RfD and CSF)	2.8E-05	0.72	5.9E-05	0.72
Unit 1J (withdrawn TCE RfD and CSF)	1.2E-05	0.68	2.7E-05	0.68
Unit 2A[6]	1.2E-05	3.40	2.6E-05	3.40
Unit 3J[7]	6.4E-06	0.14	1.4E-05	0.14
Unit 4A (provisional TCE RfD and CSF)	2.4E-05	0.60	5.2E-05	0.60
Unit 4A (withdrawn TCE RfD and CSF)	1.0E-05	0.57	2.2E-05	0.57

6 TCE not a contaminant of potential concern since it was not detected.
7 TCE not a contaminant of potential concern since it was not detected.

With the exception of Unit 2A, the estimated HIs are all below 1.0, the level of potential concern. The estimated lifetime cancer risks for all the individual units fall within the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals.

COPCs that contribute to the estimated hazard indices and the estimated cancer risk include carbon tetrachloride, chloroform, and dichlorodifluoromethane, which were determined to be non-Properties-related (refer to Section 2.6.6.7). Removing these non-Properties-related constituents, the total calculated hazard indices and the total calculated lifetime cancer risks for the indoor air inhalation exposure route for the individual units are summarized below:

	Excluding Non-Properties-Related Constituents		***Excluding Non-Properties-Related Constituents***	
Exposure Scenario	***CT Risk***	***CT Hazard***	***RME Risk***	***RME Hazard***
Current/Future Residential				
Unit 1J (provisional TCE RfD and CSF)	2.1E-05	0.22	4.4E-05	0.22
Unit 1J (withdrawn TCE RfD and CSF)	5.6E-06	0.18	1.2E-05	0.18
Unit 2A[8]	5.1E-06	0.19	1.1E-05	0.19
Unit 3J[9]	2.7E-06	0.11	5.7E-06	0.11
Unit 4A (provisional TCE RfD and CSF)	1.8E-05	0.18	3.9E-05	0.18
Unit 4A (withdrawn TCE RfD and CSF)	4.3E-06	0.14	9.2E-06	0.14

The estimated hazard indices for all the individual units are all below 1.0, the level of potential concern when the non-Properties-related constituents are removed. The estimated lifetime cancer risks for all the individual units fall within the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals.

As recommended by USEPA (USEPA, 2002a), the potential presence of background indoor air VOCs should be carefully considered as detected VOCs may represent typical concentrations in a building from sources (i.e., consumer products, building materials, etc.) not related to impacted soil or groundwater. Given the variability in background

8 TCE not a contaminant of potential concern since it was not detected.

9 TCE not a contaminant of potential concern since it was not detected.

concentrations in buildings, studies of representative indoor air background VOCs are preferred by USEPA. A recent study completed for the Colorado Department of Public Health and Environment (CDPHE) (Foster et al., 2002), measured background VOC concentrations in nearly 100 residences. Indoor air concentrations observed for the Properties were compared to the typical concentrations from this study. As presented in Table D.5 of Appendix D, TCE was detected at concentrations greater than both the typical log arithmetic mean (0.15 µg/m^3) and 95 UCL (0.21 µg/m^3) for Units 1J (0.70 µg/m^3 in December 2002) and 4A (0.64 µg/m^3). VC was also detected at Unit 1J at concentrations greater than both the typical log arithmetic mean (0.01 µg/m^3) and 95 UCL concentrations (0.01 µg/m^3) during February 2003 (0.86 µg/m^3) and December 2002 (0.36 µg/m^3). Benzene was not detected in the indoor air samples at concentrations greater than the typical log arithmetic mean or 95 UCL concentrations. Individual-point comparisons against these mean-based typical values are not conclusive, since half of the individual points in the "typical" survey would be expected to be above the mean value (for a symmetric distribution of concentrations). However, these TCE and VC concentrations may be elevated with respect to conditions found in the typical representative conditions.

Estimation of indoor air concentrations modeled using the maximum soil gas concentration at GP-2 and the Johnson and Ettinger (J&E) Model (1991) as implemented by the USEPA (2004d), and conservative default silty clay soil properties, resulted in indoor air concentrations in Unit 1J well below the maximum measured indoor air concentrations. This conservative J&E modeling exercise indicates that sources (i.e., background) other than the impacted soil are contributing to the measured indoor air concentrations.

As discussed above, indoor air quality can be affected by the presence of constituents brought in to a house, such as construction materials, carpets, and furnishings. These constituents are known as "background" indoor air constituents. Common background indoor air constituents include TCE, PCE, vinyl chloride, formaldehyde, acetone and gasoline constituents (benzene, toluene, ethyl benzene, etc.). Activities such as painting, paint stripping, arts and crafts hobbies, re-carpeting, and decorating can contribute significantly to background indoor air constituents. Even tap water can contribute to background indoor air because tap water chlorination, used to kill bacteria, leads to volatile chlorinated organic compounds, like chloroform and bromodichloromethane that have a potentially high risk when inhaled. Using the USEPA's risk assessment process for residential exposure, the risks from background indoor air can easily be above 1.0E-5, and are commonly in the range of 1.0E-06 to 1.0E-05. For example, in an urban area, benzene background indoor air is commonly 1 to 5 µg/m^3, leading to a risk of approximately 4.0E-06 to 2.0E-05. For houses with attached garages benzene can be at

an average of 15 µg/m^3 with risk as high as 5.0E-05. Inhalation risks of 1.0E-06 to 1.0E-05 are common for tap water chlorination byproducts. If risks from a number of background indoor air constituents are combined, the cumulative background risk from indoor air can be significant.

2.6.6.4 SOIL EXPOSURE FOR FUTURE CONSTRUCTION/UTILITY WORKERS

The calculated CT and RME non-cancer hazard indices and the calculated lifetime cancer risks for construction/utility worker exposure to soils under hypothetical future conditions through incidental ingestion, dermal contact, and inhalation are presented in Tables E.7.4.CT and E.7.4.RME, and E.8.4.CT and E.8.4.RME, respectively, Appendix E. The total calculated hazard indices and the total calculated lifetime cancer risks for the ingestion, dermal, and inhalation exposure routes combined are summarized below:

Exposure Scenario	*Including Non-Properties-Related Constituents*		*Including Non-Properties-Related Constituents*	
	CT Risk	***CT Hazard***	***RME Risk***	***RME Hazard***
Future Construction/Utility Worker				
Surface and Subsurface Soil (via Ingestion, Dermal and Inhalation) (provisional TCE RfD and CSF)	8.8E-05	3.7	1.8E-04	7.4
Surface and Subsurface Soil (via Ingestion, Dermal and Inhalation) (withdrawn TCE RfD and CSF)	2.0E-05	2.5	4.0E-05	5.0

The estimated hazard indices are above 1.0, the level of potential concern. However, the estimated lifetime cancer risks are within or slightly above the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals. The COPCs resulting in the majority of the estimated hazard indices are benzene, PCE, TCE (current provisional RfD), and vinyl chloride, primarily through the potential inhalation exposure route. As such, exclusion of non-Properties-related constituents does not reduce either the estimated cumulative RME lifetime cancer risks or the cumulative RME non-cancer hazard indices under the future construction/utility worker scenario (see Tables E.8.4.CT and E.8.4.RME of Appendix E).

As discussed in Appendix H, the VOC emissions, and ultimately the estimated non-cancer hazard indices and lifetime cancer risks from potential construction/utility

worker exposure, were calculated using an overly conservative USEPA default excavation rate. Based on current Site knowledge, a realistic, but still conservative assumption for excavation rate would reduce both the estimated non-cancer hazard indices and lifetime cancer risks significantly (CRA, 2006).

2.6.6.5 GROUND WATER EXPOSURE FOR FUTURE CONSTRUCTION/UTILITY WORKERS

The calculated CT and RME non-cancer hazard indices and the calculated lifetime cancer risks for construction/utility worker exposure to groundwater under the hypothetical future condition through dermal exposure are presented in Tables E.7.5.CT and E.7.5.RME, and E.8.5.CT and E.8.5.RME, respectively, Appendix E. The total calculated hazard indices and the total calculated lifetime cancer risks for the dermal, exposure route is summarized below:

Exposure Scenario	*Including Properties-Related Constituents*		*Including Non-Properties-Related Constituents*	
	CT Risk	***CT Hazard***	***RME Risk***	***RME Hazard***
Future Construction/Utility Worker Groundwater (via Dermal)	1.0E-09	1.0E-03	2.1E-09	1.8E-03

The estimated HIs are well below 1.0, the level of potential concern. The estimated lifetime cancer risks are well below the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and well below the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals. All COPCs are considered Properties' related.

2.6.6.6 SUMMATION OF INCREMENTAL CANCER RISK AND NON-CANCER HAZARD

A given population or receptor group may be exposed to a chemical from several exposure routes and from more than one exposure pathway. The purpose of this section is to identify the risks associated with a population that may be exposed to COPCs through a combination of exposure pathways.

A. Current/Future Residential Conditions

The calculated CT and RME cumulative lifetime cancer risks and the calculated non-cancer hazard indices for current/future residents that may be exposed to the Properties' surface soils, homegrown garden produce, and indoor air are respectively presented in Appendix E as follows:

- Unit 1J - Tables E.9.1.A.CT and E.9.1.A.RME;
- Unit 2A - Tables E.9.1.B.CT and E.9.1.B.RME;
- Unit 3J - Tables E.9.1.C.CT and E.9.1.C.RME; and
- Unit 4A - Tables E.9.1.D.CT and E.9.1.D.RME.

The total calculated cumulative lifetime cancer risks and the total calculated cumulative non-cancer hazard indices for the current/future residents that may be exposed to the Properties' surface soils, homegrown garden produce, and indoor air are summarized below:

	Including Non-Properties-Related Constituents		***Including Non-Properties-Related Constituents***	
Exposure Scenario	***CT Risk***	***CT Hazard***	***RME Risk***	***RME Hazard***
Current/Future Residential				
Unit 1J (provisional TCE RfD and CSF)	6.2E-05	2.1	1.2E-04	2.2
Unit 1J (withdrawn TCE RfD and CSF)	4.7E-05	2.1	8.9E-05	2.2
Unit 2A[10]	4.7E-05	4.8	8.8E-05	4.9
Unit 3J[11]	4.1E-05	1.5	7.6E-05	1.7
Unit 4A (provisional TCE RfD and CSF)	5.9E-05	2.0	1.1E-04	2.1
Unit 4A (withdrawn TCE RfD and CSF)	4.5E-05	1.9	8.4E-05	2.1

The estimated cumulative lifetime cancer risks for current/future residents are within and slightly above the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals. The estimated cumulative non-cancer hazard indices for current/future residents are above 1.0, the level of potential concern.

10 TCE not a contaminant of potential concern since it was not detected.
11 TCE not a contaminant of potential concern since it was not detected.

COPCs that contribute significantly to the estimated cumulative lifetime cancer risks and non-cancer hazard indices in soils and homegrown produce include arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and in indoor air include carbon tetrachloride, chloroform, and dichlorodifluoromethane. All of these COPCs were determined to be non-Properties-related (refer to Section 2.6.6.7). Removing these non-Properties-related constituents, the cumulative calculated lifetime cancer risks and the cumulative calculated non-cancer hazard indices for the current/future residents that may be exposed to the Properties' surface soils, homegrown garden produce, and indoor air are summarized below:

	Excluding Non-Properties-Related Constituents		***Excluding Non-Properties-Related Constituents***	
Exposure Scenario	***CT Risk***	***CT Hazard***	***RME Risk***	***RME Hazard***
Current/Future Residential				
Unit 1J (provisional TCE RfD and CSF)	2.1E-05	1.4	4.5E-05	1.5
Unit 1J (withdrawn TCE RfD and CSF)	5.9E-06	1.3	1.2E-05	1.4
Unit 2A[12]	5.4E-06	1.3	1.1E-05	1.4
Unit 3J[13]	2.9E-06	1.2	5.7E-06	1.4
Unit 4A (provisional TCE RfD and CSF)	1.9E-05	1.3	4.0E-05	1.4
Unit 4A (withdrawn TCE RfD and CSF)	4.6E-06	1.3	9.7E-06	1.4

The estimated cumulative lifetime cancer risks for current/future residents are within the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals. Review of the estimated cancer risks in Tables E.9.1.A through E.9.1.D of Appendix E, indicates that when non-Properties-related constituents are removed, more than 90 percent of the estimated cancer risks for the individual units are associated with potential exposure to indoor air. As discussed in Section 2.6.6.3, sources other than the impacted soil are contributing to the measured indoor air concentrations.

The estimated cumulative non-cancer hazard indices for current/future residents are slightly above 1.0, the level of potential concern. Review of the estimated hazard indices in Tables E.9.1.A through E.9.1.D of Appendix E, indicates that iron and manganese

12 TCE not a contaminant of potential concern since it was not detected.

13 TCE not a contaminant of potential concern since it was not detected.

contribute approximately 56 percent and 23 percent, respectively, of the cumulative hazard index value of 1.5. As discussed in Section 2.6.6.7, over 90 percent of the HI based on exposure to iron and manganese in the soil is attributed to the background soil concentrations.

B. Future Construction / Utility Worker Conditions

The calculated CT and RME cumulative lifetime cancer risks and the cumulative non-cancer hazard indices for future hypothetical construction / utility workers that may be exposed to the Properties' future soils data set (i.e., 0 to 10 feet bgs) and groundwater are presented in Tables E.9.2.CT and E.9.2.RME of Appendix E. The total calculated cumulative lifetime cancer risks and the total calculated non-cancer hazard indices for the future hypothetical construction / utility workers that may be exposed to the Properties' surface and subsurface soils and groundwater are summarized below:

Exposure Scenario	***Including Non-Properties-Related Constituents***		***Including Non-Properties-Related Constituents***	
	CT Risk	***CT Hazard***	***RME Risk***	***RME Hazard***
Future Construction/Utility Worker				
Surface and Subsurface Soil and Groundwater (provisional TCE RfD and CSF)	8.8E-05	3.7	1.8E-04	7.4
Surface and Subsurface Soil and Groundwater (withdrawn TCE RfD and CSF)	2.0E-05	2.5	4.0E-05	5.0

The estimated cumulative lifetime cancer risks for future construction / utility workers are within or only slightly above the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990), and above the 1.0E-06 risk level generally used by USEPA as the point of departure for determining remediation goals. The estimated cumulative non-cancer hazard indices for future construction / utility workers are above 1.0, the level of potential concern.

Review of the estimated cumulative lifetime cancer risks and estimated cumulative non-cancer hazard indices in Tables E.9.2.CT and E.9.2.RME of Appendix E indicates that greater that 99.99 percent of the estimated cancer risks and hazard indices are due to direct exposure to the soil, and less than 0.01 percent due to direct exposure to groundwater. The COPCs resulting in the majority of the estimated cumulative lifetime cancer risks and estimated cumulative non-cancer hazard indices in the soil are benzene, PCE, TCE, and vinyl chloride, primarily through the potential inhalation exposure route.

As such, exclusion of non-Properties-related constituents does not reduce either the estimated cumulative RME lifetime cancer risks or the cumulative RME non-cancer hazard indices under the future construction/utility worker scenario.

As noted in Section 2.6.6.4, the VOC emissions, and ultimately the estimated cumulative lifetime cancer risks and estimated cumulative non-cancer hazard indices for future hypothetical construction/utility worker exposure, were calculated using an overly conservative USEPA default excavation rate. Based on current Site knowledge, a realistic, but still conservative assumption for excavation rate would reduce both the estimated lifetime cancer risks and non-cancer hazard indices significantly (CRA, 2006).

2.6.6.7 RISK CONTRIBUTION FROM BACKGROUND COPC LEVELS

When all COPCs are included, both the current/future residential condition and the future construction/utility worker condition for the Properties in general exhibited total cumulative lifetime cancer risks and total cumulative non-cancer hazard indices that exceeded the acceptable cancer risk and hazard target levels.

The COPCs resulting in the majority of the estimated cancer risks and hazard indices in the soil under the future hypothetical construction/utility worker condition were benzene, PCE, TCE, and vinyl chloride, primarily through the potential inhalation exposure route. These COPCs are related to the Properties.

The COPCs resulting in a significant portion of the estimated cancer risks and hazard indices in the soil under the current/future residential condition were based on exposure to arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno (1,2,3-cd)pyrene in surface soil, and to carbon tetrachloride, chloroform, and dichlorodifluoromethane in indoor air.

As such, it is appropriate to include an analysis in the SRE that involves a comparison of COPC levels detected in Properties soils versus background soils for naturally occurring inorganics to determine if the analytes contributing to the estimated cancer risks and hazard indices under the current/future residential condition are related to the Properties. Table E.10.1, provided in Appendix E, presents the occurrence and distribution of detected chemicals in background soils. The background data set consists of five surface soil samples and is considered to represent background soil conditions in the vicinity of the Properties.

A statistical analysis was conducted of the concentrations of the inorganic COPCs in Properties soils versus background surface soils. Two types of comparisons of Properties vs. background concentrations (for inorganics) were performed. The first were group-based comparisons (i.e., Wilcoxon rank sum (WRS) test and the quantile test). The second were point-based comparisons that looked for individual data pints with concentrations elevated above those expected to be found in background soils (i.e., using Upper Tolerance Limits (UTLs).

Statistical methodologies that compare two groups of data typically perform significance tests based on the mean or median values of each group. The null hypothesis tested is that there is no difference in mean or median concentration between groups. If the observed difference is greater than can be explained by random chance, then the result is declared to be statistically significant. Considering any comparison of the Properties data versus background data, the alternative hypothesis of interest would be that Properties' COPC concentrations are above background. Medians for the Properties' and background data sets were statistically compared using the WRS test. For the quantile test, the upper "tails" of the distributions (Properties vs. background), rather than the medians, are compared to establish whether evidence exists identifying a disproportionate number of high concentrations occurring in the Properties dataset relative to background (for a one-tailed test). All inorganic parameters above risk screening values (refer to Appendix E.2 tables) were found to be consistent with background conditions using both these group-based comparisons (WRS and Quantile tests). A description of uncertainties associated with these analyses is presented in Section 2.6.6.8.6.

It is possible that individual data points may have concentrations above background conditions. To evaluate the individual Properties data for values above background conditions, the background data set was used to generate UTLs. These UTLs represent upper concentration limits (with 95 percent confidence) on the 95th percentile of all background soils. Thus, it is expected that if additional background soil samples were collected, at least 19 out of 20 samples would be below the UTL value. Hence, if a Properties data point is above the background UTL, it is reasonable to assume that it is above background conditions. Table E.10.2, Appendix E, presents the calculated background UTLs and the Properties inorganics data exceeding the UTLs. Arsenic had two samples in the current/future residential condition surface soils set and one single sample in the future construction/utility worker condition future soils set exceeding the background UTL. Since the current/future residential condition surface soils set consisted of 39 individual points and the future construction/utility worker condition future soils set consisted of 92 individual points, finding one or two points above the background UTL is not unexpected since up to 1 in 20 results may be above the UTL by

random chance and, therefore, these sample exceedances for arsenic should not be considered to be above background conditions. However, iron and manganese had higher frequencies of sampling results points above their respective background UTLs. These exceedances are not considered to be due to random chance, and are considered to be above background conditions. For purposes of this SRE, these two COPCs were concluded to be Properties-related constituents.

The abundance of metals within soil is determined in part by the element content of the bedrock or other deposits from which the material originated. Therefore, detectable levels in background soils (as was the case with the background soil samples collected for the Properties' evaluation) is a result of the regional geology. The background levels of arsenic, iron, and manganese have then contributed to the cancer risks and non-cancer hazard indices calculated for the Properties. The background arsenic soil concentration is 5.88 µg/kg (Table E.10.2) which is above the RME concentration of arsenic in surface soil (5.65 µg/kg; Table E.3.1) and soil (5.6 µg/kg; Table E.3.3). Therefore, the cancer risks and non-cancer hazard indices calculated due to arsenic in the soil is reflective of background concentrations. The iron and manganese background soil concentrations of 16,960 µg/kg and 606 µg/kg, respectively, contribute approximately 90 percent and 92 percent of the iron and manganese RME soil concentrations (18,900 µg/kg and 660 µg/kg; Table E.3.1). Therefore, over 90 percent of the non-cancer hazard indices calculated based on exposure to iron and manganese in the soil can be attributed to the background soil concentrations.

PAHs are ubiquitous in the environment, often found at detectable levels in background soils, as was the case with the background soil samples collected for the Properties' evaluation. The arithmetic mean of detected levels of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd) pyrene in Properties' soils were 454 µg/kg, 512 µg/kg, 616 µg/kg, 220 µg/kg, and 344 µg/kg, respectively. These arithmetic mean levels for the Properties can be compared to detectable levels of PAHs in background sample JW-164 that was collected in December 2000 at a location approximately 300 feet west of the Site as determined in consultation with USEPA representatives. Comparison is made to this one background soil sample because of concerns that USEPA had with the relatively higher PAH levels in some of the other background samples. The concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd) pyrene in this background sample were 1,600 µg/kg, 510 µg/kg, 2,000 µg/kg, 280 µg/kg, and 540 µg/kg, respectively, which are each above the arithmetic mean level for the Properties with the exception of benzo(a)pyrene which is just slightly above background concentrations (512 µg/kg vs. 510 µg/kg). The Agency for Toxic Substances and Disease Registry (ATSDR, 1993) presents background urban soil

concentration ranges for benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene of 169 to 69,000 µg/kg, 165 to 220 µg/kg, and 15,000 to 62,000 µg/kg, respectively, which support the conclusion that the PAHs detected at the Properties and off the Properties are attributable to background conditions. Thus, the PAHs detected in Properties soils are likely not attributable to historic Site activities, but are representative of the ubiquitous nature of PAHs in urban areas. Thus, the inclusion of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h) anthracene, and indeno(1,2,3-cd)pyrene as COPCs in Properties' soil is inappropriate as these chemicals are likely not Properties related.

As discussed above, a significant portion of the estimated cancer risks and HIs under the current/future residential condition was also based on exposure to carbon tetrachloride, chloroform, and dichlorodifluoromethane in indoor air. A comparison of these three COPCs to the soil gas data (see Table D.5, Appendix D) and to the subsurface soil data (see Table D.3, Appendix D) indicates that three COPCs are not Properties related. None of these three COPCs were detected in the 66 subsurface soil samples and only one very low concentration of chloroform and dichlorodifluoromethane were detected in the eight soil gas samples. Thus, carbon tetrachloride, chloroform, and dichlorodifluoromethane detected in the Properties' indoor air are likely not attributable to historic Site activities and inclusion of these chemicals as COPCs in the Properties' indoor air is inappropriate.

As discussed in Section 2.6.6.6, exclusion of non-Properties-related constituents as COPCs in the risk estimate for the current/future residential condition reduces the cumulative lifetime cancer risks and HIs. The following table provides as comparison estimates with and without the non-Properties-related COPCs.

Exposure Scenario	*Including Non-Properties-Related Constituents*		*Excluding Non-Properties-Related Constituents*	
	RME Risk	***RME Hazard***	***RME Risk***	***RME Hazard***
Current/Future Residential				
Unit 1J (provisional TCE RfD and CSF)	1.2E-04	2.3	4.5E-05	1.5
Unit 1J (withdrawn TCE RfD and CSF)	8.9E-05	2.2	1.2E-05	1.4
Unit 2A[14]	8.8E-05	4.9	1.1E-05	1.4
Unit 3J[15]	7.6E-05	1.7	5.7E-06	1.4
Unit 4A (provisional TCE RfD and CSF)	1.1E-04	2.1	4.0E-05	1.4
Unit 4A (withdrawn TCE RfD and CSF)	8.4E-05	2.1	9.7E-06	1.4

As discussed in Section 2.6.6.6, under the future construction / utility worker scenario, COPCs resulting in the majority of the estimated cumulative lifetime cancer risks and estimated cumulative non-cancer hazard indices in the soil are benzene, PCE, TCE, and vinyl chloride, primarily through the potential inhalation exposure route. As such, exclusion of non-Properties-related constituents does not reduce either the estimated cumulative RME lifetime cancer risks or the cumulative RME non-cancer hazard indices under the future construction / utility worker scenario.

2.6.6.8 IDENTIFICATION OF UNCERTAINTY

Uncertainty is an element which presents itself at several junctions in the process. Every time an assumption is made, some level of uncertainty is introduced into the risk assessment. The purpose of the identification of uncertainty is to provide a discussion regarding the major uncertainties associated with the SRE and the final characterization of risk. Uncertainties identified in the SRE are discussed below in the following sections.

2.6.6.8.1 EXPOSURE SCENARIO ASSUMPTIONS

There is a level of uncertainty involved with any evaluation where multiple assumptions are made. The purpose of this section is to discuss the uncertainty associated with the primary exposure variables applied in the exposure scenario evaluation.

14 TCE not a contaminant of potential concern since it was not detected.

15 TCE not a contaminant of potential concern since it was not detected.

Because the assumptions used in the exposure scenarios are generally not based on objective test data, but are subjective estimates based on judgment and experience applied to the data available, the tendency is to select conservative, health-protective values to guard against under-estimating exposure (and associated risk). This leads to a general, inherent over-estimating in all assumptions. When more than one over-estimate of individual assumptions are included in the scenario equations, they are multiplied. This exaggerates the over-estimation of each assumption and overstates the total potential exposure to an even greater degree. The exposure scenarios evaluated in the SRE are, therefore, conservative in nature, thereby providing the necessary factor of safety that is protective of human health.

The intent of the SRE was to estimate the potential exposure point intakes for both the average (Mean or Central Tendency) and the reasonable maximum exposure (RME) exposure scenarios. In order to accomplish this goal, a series of standardized USEPA exposure assumptions were utilized when possible. In the absence of available USEPA guidance on exposure assumptions or where Site-specific information indicated otherwise, professional judgment was used to establish reasonable exposure assumptions that are reflective of Site-specific conditions or expectations.

The RME exposure scenario represents the maximum exposure that is reasonably expected to occur at a site. The RME exposure scenarios presented in this SRE were developed in conformance with the USEPA RAGS. The RME scenarios evaluated in the SRE were developed to estimate the maximum exposures that could be expected to occur under both current and future land use conditions. That does not mean the RME exposure is occurring or will occur in the future; in fact, the average or CT exposure is more likely to occur at the Site than is the RME.

The major uncertainties utilized in the SRE regarding the physical exposure scenarios are summarized as follows:

- The actual frequency of exposures related of the Properties' residents and potential construction / utility workers are unknown. As a result, USEPA default values and professional judgment were used to conservatively estimate exposure frequency, time, and duration, where appropriate.
- The utilization of present exposure point concentrations for future exposure scenarios is conservative due to the fact that source material is not being added to the Properties and that Properties-related constituent concentrations often decrease with time. Natural processes that can decrease environmental chemical concentrations include dilution by uncontaminated media, volatilization, particulate

emission, biodegradation, chemical degradation, and photodegradation. The use of steady-state contaminant concentrations can often overestimate future exposures.

- This SRE has assumed 100 percent absorption of chemicals that have been ingested. Actual absorption rates for ingested contaminants may vary from 5 to 100 percent, and absorbed chemical may not reach the toxic endpoint before being metabolized and/or excreted by the body. Therefore, assuming 100 percent bioavailability of COPCs may overestimate the associated risks.
- For most COPCs, the SRE assumed that 100 percent absorption occurs after inhalation. Actual lung absorption rates may vary based on individual COPC absorption rates. Thus, assumption of 100 percent lung absorption of COPCs overestimates the associated risks.
- Uncovered skin surface areas assumed for dermal exposures are likely overestimates for the construction/utility worker and even perhaps the residential exposure scenarios to soil. Most resident users would simply walk over the exposure areas without any appreciable dermal contact with soil. The risks and hazards estimated for the dermal exposure route are likely overstated.
- The excavation rate used to calculate the VOC emission concentrations under for the construction/utility worker. An overly conservative USEPA default excavation rate was assumed. Use of a realistic (but still conservative) Site-specific excavation rate would reduce both the risks and hazards significantly (CRA, 2006).

2.6.6.8.2 DOSE RESPONSE

One of the major uncertainties in the quantification of risk involves the application of toxicity information. Some of the uncertainties associated with the toxicity values are presented as follows:

- Chemicals may be assumed to be human carcinogens based on animal studies even when there is limited or no available evidence that the chemical is a human carcinogen. Such chemicals may not be carcinogenic in humans.
- CSFs are derived from study data on animals dosed with high concentrations and therefore may not be applicable to the evaluation of low concentration exposures. High levels of chemicals may override the detoxification or excretion capabilities and allow the chemical to impact the target cells.
- CSFs are developed in a conservative manner. The model used by USEPA makes a number of conservative assumptions, which may over estimate carcinogenic potency, by several orders of magnitude.

- RfDs are also established with conservative factors of safety in comparison to actual studies resulting in error. For example, it is assumed that all chemicals are more toxic for man than the test animals studied, while in fact the exact opposite may be true.
- The use of provisional TCE toxicity data versus the withdrawn toxicity data illustrates the range of possible risk and hazard associated with the compound toxicity data. The USEPA has not completed its review process, and has not issued a revised TCE CSF in IRIS. The value used in the SRE has not been through the USEPA's peer review process and could be reevaluated to include the mode of action of TCE and correct for the inclusion of controversial animal toxicity data associated responses at low doses.

2.6.6.8.3 THE THEORETICAL NATURE OF RISK ESTIMATES

As indicated previously, the results of a health risk assessment assigns a numerical value to the probability than an individual will develop cancer due to the exposure to a specific amount of chemical which is a known or suspected carcinogen. This numerical value is presented as an upper bound excess cancer risk such as 1.0E-06, or one additional cancer case in a million people exposed to the designated chemical concentration for the exposure duration averaged over their entire lifetime, assumed to be 70 years. The model that is applied to calculate this numerical risk is a combination of the exposure estimate and dose response values, and so will potentially include the uncertainty in each set of values. The true risk is expected to be lower than that calculated, and may quite reasonably be zero. Thus, risk estimates are overestimated by the risk assessment methodology itself. The Cancer Risk Model and the assumptions used to estimate exposure are considered protective of the most sensitive human population subsets.

2.6.6.8.4 SYNERGISTIC, ADDITIVE, AND ANTAGONISTIC EFFECTS

Receptor exposure to a mixture of chemicals can in some cases lead to synergistic, additive, or antagonistic health effects. Synergistic effects occur when chemicals interact in the receptor to cause an effect significantly greater than the sum of effects of the individual chemicals. There is no apparent biological reason to suspect that the COPCs identified at the Site will have synergistic effects. Potential synergistic effects were not evaluated in the SRE, and thus the estimated risks and hazards may be understated. Alternatively, chemicals may interact in the receptor in such a way as to cause an overall effect that is less than the sum of effects of the individual chemicals. These potential

antagonistic effects were not evaluated in the SRE, and thus the estimated risks and hazards may be overstated.

For the SRE it was assumed that carcinogenic and non-carcinogenic effects were additive, whereby individual chemical cancer risks and hazards were added to obtain a total risk and hazard estimate. For example, volatile organics, semi-volatile organics (e.g., PAHs), and inorganic chemicals were treated as if they all affect the receptor in a similar manner. Their potential carcinogenic risk and hazard ratios were then added. Although the carcinogenic risks and non-carcinogenic hazards for individual chemicals were summed, there is no basis to suspect their toxic effects are in fact cumulative. This suggests that the total risks and hazards estimated for the potential Site receptors may be higher than any actual health effects.

2.6.6.8.5 TOXICITY DATA GAPS

Toxicity data for some COPCs were not available from which to estimate potential risks and hazards to human receptors, due in some cases to a lack of available scientific study. Accordingly, the absence of toxicity data for some COPCs may result in an underestimation of the total risks and hazards for the particular exposure pathways where these COPCs were identified.

2.6.6.8.6 STATISTICAL COMPARISONS OF PROPERTIES TO BACKGROUND DATA

The statistical comparisons of Properties to background data performed are inherently subject to uncertainty, and thus inferences made based on these analyses need to be considered in the proper perspective. These uncertainties arise in both the group-based and point-based comparisons. In performing statistical tests, two types of errors may occur: (i) false positives, and (ii) false negatives. These errors are typically controlled by specifying acceptable limits on their rate of occurrence. The acceptable rate of false positive results is set by the confidence level used, and then acceptable rate of false negative results is set by the statistical power of the test. In USEPA guidance (USEPA, 2002c), 95 percent confidence is specified for calculating exposure point concentrations for the purposes of risk assessment. Thus, the false positive rate (1-confidence) is set to a maximum of 5 percent. For a specified confidence level, the statistical power achieved by a test is a function of the number of samples used, the observed variation (e.g., standard deviation), and the size of difference that is to be detected by the test (termed the "effect size"). In performing the Properties versus background comparisons,

the statistical power of the tests performed provide information quantifying the uncertainties associated with the test results.

Two types of comparisons of Properties versus background concentrations (for inorganics) were performed. The first were group-based comparisons (i.e., Wilcoxon rank sum (WRS) test and the quantile test). The second were point-based comparisons looked for individual data points with concentrations elevated above those expected to be found in background soils (using UTLs).

The group-based comparisons did not find statistically significant differences between parameter concentrations at the Properties versus concentrations in background soils. Using arsenic to represent the group of inorganic parameters considered (due to arsenic's toxicological significance and its relatively high degree of variability compared other parameter concentrations), post-hoc ("after-the-fact") statistical power analyses were performed to determine false negative rates. The soil (0 to 10 feet) data set for arsenic on the Properties consisted of 92 samples, having a mean of 5.1 mg/kg and standard deviation of 2.54 mg/kg. The background data set had five samples, with a mean and standard deviation of 5.88 and 1.69 mg/kg, respectively. The pooled standard deviation required for statistical power calculations was 2.51 mg/kg. Using the WRS test at a 95 percent confidence level, the approximate power achieved for the test to detect a difference of one standard deviation was 55 percent. The power improves to approximately 80 percent (a value commonly referred to as an analysis goal) for a difference of 1.36 standard deviations. Thus, there is a potential uncertainty in the range of 20 to 45 percent probability of a false negative in removing arsenic from the COPC list based on the background comparisons performed.

The point-based comparisons found a number of individual points above UTLs calculated using the background data set. The statistical power achieved for the comparison of a single data point to an UTL was not calculated, since tools for accomplishing this are not generally accessible. However, since the risk evaluation has not screened out any inorganic COPCs based on background concentrations, any uncertainty in this assessment errs on the side of conservatism (i.e., overestimating potential risks), even though the results of the group-based tests (above) indicate that overall mean inorganic parameter concentrations are not significantly above background conditions.

To summarize this discussion of statistical power and uncertainty in comparing Properties conditions to background, the power achieved by the various statistical tests used appears quite acceptable given the types of questions asked (i.e., is the Properties mean value elevated with respect to background, and are individual Properties

concentrations above background). The group-based comparisons have would have detected a true difference (Properties versus background) of approximately 1.2 standard deviations with 80 percent power. Individual point-based comparisons could have detected individual points elevated 1.7 standard deviations above the background mean with 80 percent power. Limits on the level of uncertainty achieved in these determinations are considered acceptable and, moreover, consistent with the overall level of uncertainty in the risk assessment.

2.6.7 SRE CONCLUSIONS

Based on the estimated cumulative lifetime cancer risks and HIs for the future construction / utility worker scenario, it is concluded that Non-Time-Critical Removal Action activities are required to be protective of human health and the environment.

Non-Time-Critical Removal Action activities are considered necessary to address the subsurface soils that exceed acceptable risk-based VOC concentrations for future construction / utility workers.

As a precautionary measure until the selected Removal Action is completed, it is recommended that the drain tile depressurization systems be maintained to minimize the potential for migration of impacted soil gas to indoor air.

3.0 IDENTIFICATION OF REMOVAL ACTION SCOPE AND OBJECTIVES

The following subsections present the Removal Action scope and Removal Action Objectives (RAOs) for the Properties, the Removal Action schedule, and potential applicable relevant and appropriate requirements (ARARs).

3.1 REMOVAL ACTION SCOPE

As required by Section 300.415(b)(4)(i) of the NCP, an EE/CA must be completed for all Non-Time-Critical Removal Actions. The goals of the EE/CA are to identify the objectives of the Non-Time-Critical Removal Action and to analyze the various alternatives that may be used to satisfy the objectives for cost, effectiveness, and implementation.

The overall goal of the Removal Action is to ensure the protection of human health and the environment. The general RAOs for the Properties, based on current and reasonably foreseeable land use of the Properties and the SRE conclusions are:

- Treatment or removal of VOC-impacted soils to a depth of 10 feet bgs to meet acceptable VOC risk-based concentrations to ensure protection of human health under the hypothetical future construction/utility worker scenario.

This general RAO satisfies the requirements for a long-term response because consideration of long-term effectiveness and controls is included. Therefore, the Removal Actions scoped and evaluated in this EE/CA will serve as the final response action for the Properties. Specific RAOs are presented in Section 3.4.

3.2 REMOVAL ACTION SCHEDULE

Completion of the Removal Action will commence after USEPA approves the EE/CA Report and selects the final response action for the Properties. Upon USEPA selection of the final Removal Action alternative, a Non-Time-Critical Action Work Plan (Work Plan), which details the Removal Action activities to be performed at the Properties, will be prepared and submitted for USEPA review and approval. Upon USEPA approval of the Work Plan, the selected Removal Action alternative will be implemented. The schedules for completing the various Removal Action alternatives are presented in Section 6.0.

3.3 POTENTIAL APPLICABLE RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

The ARARs are used in addition to contaminant characterization and risk assessment, to develop RAOs and to scope and formulate remedial action technologies and alternatives. ARARs are cleanup standards, control standards, or other substantive environmental limitations promulgated under federal or state law. The consideration of ARARs is made in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, (CERCLA) §121, 42 U.S.C. §9621. CERCLA only requires the consideration of substantive requirements. ARARs are defined below, pursuant to SARA.

Applicable Requirements

Applicable requirements are federal and state requirements such as cleanup standards, standards of control, and other environmental protection criteria or limitations that specifically address a hazardous substance, pollutant, contaminant, Removal Action, location, or other circumstance at a site.

Relevant and Appropriate Requirements

Relevant and appropriate requirements are those federal and state requirements that, while not directly applicable as defined above to the circumstances at a site, address problems or situations sufficiently similar to those encountered at a site that their use is well suited. The regulations provide specific criteria for determining whether a requirement is relevant and appropriate.

Other Requirements To Be Considered

This category contains other requirements and non-promulgated documents to be considered in the process of developing and screening removal alternatives. The To Be Considered (TBC) category includes federal and state non-regulatory requirements, such as guidance documents, advisories, or criteria. Non-promulgated advisories or guidance documents do not have the status of ARARs. However, if no ARARs for a contaminant or situation exist, guidance or advisories would be identified and used to ensure that a remedy is protective.

ARARs are categorized as follows:

- Chemical-specific requirements that define acceptable exposure limits and can, therefore, be used in establishing preliminary remediation goals;
- Location-specific requirements that may restrict activities within specific locations such as floodplains or wetlands; and
- Action-specific requirements that may establish controls or restrictions for specific treatment and disposal activities.

The potential federal and State of Wisconsin ARARs for the Properties are listed in Table 3.1.

The potential ARARs are divided into the following three categories defined in the revised NCP:

- Chemical-specific requirements;
- Action-specific requirements; and
- Location-specific requirements.

Chemical-specific ARARs are usually health- or risk-based requirements and are often expressed as numerical values that, when applied to site-specific conditions, establish the acceptable amount of a chemical that can be detected in or discharged to the environment. Action-specific ARARs are usually technology- or activity-based requirements triggered by the particular activities selected to accomplish a remedy, such as soil excavation (complete or partial removals), in situ treatment actions, air stripping, or other remedies. Location-specific ARARs are requirements that place restrictions on either the concentrations of hazardous substances or on the performance of activities solely because the activities are carried out in specific locations (such as wetlands flood plains, or historic places). Chemical-specific, action-specific, and location-specific ARARs and to be considered (TBCs) are discussed individually below.

Chemical-specific ARARs and TBCs: Chemical-specific ARARs include federal and state requirements that regulate contaminant levels in various media. TBCs include proposed regulations and policy or guidance documents. Consideration of ARARs and TBCs is important in developing RAOs that comply with regulatory requirements or guidance (as appropriate). Summaries of potential chemical-specific ARARs and TBCs for the Properties are presented in Table 3.1.

Action-specific ARARs: Action-specific ARARs are regulatory requirements that define acceptable treatment and disposal procedures. This group of requirements includes ARARs that are action-specific for the management of hazardous substances, such as Resource Conservation and Recovery Act (RCRA) regulations for facility closures, Clean Air Act (CAA) standards for air contaminant emission sources, and Clean Water Act (CWA) standards for effluent discharges to surface water bodies and pretreatment standards for discharges to publicly owned treatment works (POTW). Summaries of potential action-specific ARARs for the Properties are presented in Table 3.1.

Location-specific ARARs: Location-specific ARARs are requirements for contaminant concentrations or removal activities associated with a site's physical location. For example, federal and state ARARs exist for sites where removal activities would impact wetlands, flood plains, critical habitats, wilderness areas, fault zones, or areas of historic and/or archeological preservation areas. Summaries of potential location-specific ARARs for the Properties are presented in Table 3.1.

3.4 REMOVAL ACTION OBJECTIVES

The specific RAO for the Properties, based on the current and reasonably foreseeable land use of the Properties, the SRE conclusions, ARARs, and TBCs is:

- Treatment or removal of VOC-impacted soils to a depth of 10 feet bgs to meet acceptable VOC risk-based concentrations [i.e., the acceptable excess cancer risk range of 1.0E-06 to 1.0E-04, as established in the NCP (1990)] for future construction/utility workers.

As discussed in Section 3.1, the prevention or minimization of potential migration of impacted soil gas to indoor air should be maintained during the implementation of Removal Action activities.

3.5 PLANNED REMOVAL ACTION ACTIVITIES

Removal Action activities will be finalized after USEPA selects a remedy and after a public hearing on the selected remedy is held.

4.0 IDENTIFICATION AND DESCRIPTION OF REMOVAL ACTION TECHNOLOGIES AND ALTERNATIVES

As discussed in Section 3.1, the goals of the EE/CA are to identify the objective of the Non-Time-Critical Removal Action and to analyze the various alternatives that may be used to satisfy the objectives for cost, effectiveness, and implementation.

This section describes potential Removal Action technologies and identifies preferred technologies that are used to develop Removal Action alternatives presented in Section 5.0. USEPA's guidance for conducting Non-Time-Critical Removal Actions (USEPA, 1993a) states that based on available site-specific information, only the most qualified technologies that apply to the media (i.e., soils) or contamination source (i.e., VOCs) should be discussed in the EE/CA Report. Therefore, based on the nature and extent of contamination in soils at the Properties, the following remedy components are evaluated in this report:

- Monitored Natural Attenuation;
- In Situ Treatment:
  - Chemical Oxidation,
  - Enhanced Bioremediation, and
  - Soil Vapor Extraction;
- Excavation/Removal Activities; and
- Institutional Controls.

Based on the conclusions and recommendations of the SRE, all developed Removal Action alternatives will include the continued operation of the existing drain tile depressurization systems on the building sumps on the Marina Cliffs Condominium property adjacent to the areas of VOC-impacted subsurface soils. The drain tile depressurization systems draw air from the building sumps and perimeter footer drain piping and vent the sump system to the atmosphere. These systems should continue to operate during the implementation of the Removal Action.

In addition to the above remedy components, the "no action" scenario is also presented as a reference scenario in which the Properties' conditions remain as they are without any additional Removal Actions occurring. The remedy components are described in the following subsections.

4.1 NO ACTION

The "no action" scenario assumes that the Properties' conditions remain as they are without any Removal Action technologies being implemented. Given the Properties' conditions, "no action" is not appropriate for the Properties because it does not meet the RAOs discussed in Section 3.0. Without any action, there remains the potential of direct contact with contaminated soils under the future construction / utility worker scenario.

4.2 NATURAL ATTENUATION

Natural attenuation is a technology that relies on naturally occurring processes in the soils to achieve treatment. Natural attenuation is defined in the NCP to be naturally occurring processes that effectively reduce contaminant concentrations to levels that are protective of human health and the environment. Natural attenuation processes are classified as destructive and non-destructive. Destructive processes are chemical degradation (where organic compounds are chemically transformed to degradation products) and biological degradation (where the respiration of indigenous bacteria effectively transforms organic compounds to degradation products). Non-destructive processes include sorption, dispersion, dilution, and volatilization. In some cases it may be appropriate for natural attenuation to form part of an overall remedy or to be used as a final stage of remediation, following an initial phase of remediation. USEPA recognizes that natural attenuation can be a more cost effective and, therefore, a more appropriate alternative than active remediation. However, it is generally required that a long-term monitoring program be established, and that a contingency plan based on active remediation be developed.

This technology may be applicable to the VOC-impacted subsurface soils. Many of the VOCs in the impacted soils at the Properties are biodegradable by microorganisms indigenous to the subsurface environment. During biodegradation, microorganisms transform available nutrients into forms for energy and cell reproduction by facilitating the transfer of electrons from donors to receptors. This results in the oxidation of an electron donor and the reduction of an electron acceptor. Electron donors represent the primary substrate for cell respiration and may include naturally occurring organic carbon, petroleum hydrocarbons (e.g., BTEX compounds), and, to a limited extent, some less oxidized chlorinated aliphatic hydrocarbons (e.g., vinyl chloride) under specific conditions. Organic contaminants may undergo biodegradation through three different pathways: (1) use as an electron donor (primary growth substrate) where the transfer of electrons from donors (e.g., BTEX) provides energy to the microorganisms; (2) use as an electron acceptor (reductive dehalogenation) where a chlorine atom from a chlorinated

hydrocarbon is replaced by a hydrogen atom. In general, reductive dehalogenation occurs by sequential dechlorination of tetrachloroethene (PCE) to trichloroethene (TCE) to dichloroethene (DCE) to vinyl chloride (VC) to ethene; and degradation of chlorinated aliphatic hydrocarbon is catalyzed by an enzyme, or cofactor, that is fortuitously produced by the microorganisms for other purposes. The microorganisms directly transform the chlorinated hydrocarbon as they use dissolved organic carbon or BTEX compounds as a primary substrate for energy.

Natural Attenuation in the Unsaturated Zone

The recharge rate of infiltrating water through the unsaturated soils on the Properties would be on the order of 0.5 feet / year (typical of silt). Potential migration for organic contaminants through the unsaturated zone would be controlled by the recharge rate (equivalent to advective flow in the saturated zone) and the amount of organic carbon in the soils. The total organic carbon (TOC) in the overburden ranges from 0.8 to 2.8 percent, with an average of 1.7 percent. The high organic carbon in the overburden would result in a retardation coefficient for the contaminants due to adsorption of about 10. Therefore, migration of organic contaminants would be about 10 times slower than advective movement. The vertical movement of organic compounds through the unsaturated zone at the Properties would be on the order of 0.05 feet / year.

Natural Attenuation in the Saturated Zone

As discussed in Section 2.5.2, the horizontal and vertical advective groundwater flow velocities are very slow. The calculated horizontal and vertical advective groundwater flow velocities are 1.0 feet / year and 0.15 feet / year, respectively. The amount of organic carbon in the silty clay till is high. The TOC in the overburden ranges from 0.8 to 2.8 percent, with an average value of 1.7 percent. The high content of organic carbon in these soils results in adsorption of organic contaminants to the soils.

Essentially, the retardation coefficient of organic contaminants such as vinyl chloride would be on the order of 10. The horizontal and vertical contaminant flow velocities would be an order of magnitude lower than the advective groundwater flow velocities. Therefore, the horizontal and vertical contaminant flow velocities at the Properties would be on the order of 0.1 feet / year and 0.015 feet / year, respectively. The extremely slow movement of organic contaminants in the subsurface at the Properties would result in an increase in the rate of degradation of these compounds.

Therefore, adsorption coupled with degradation of organic compounds in the subsurface would be the dominant natural attenuation processes which would effectively destroy contaminants at the Properties.

As discussed above, natural attenuation of the VOC-impacted soils is a potentially viable technology, and with time will eventually achieve the specific RAO for these soils. This technology would be easy to implement (i.e., long-term monitoring program), would be cost-effective, and would not be disruptive to the current residents. However, due to the concentrations of VOCs that exist in the soils, and the length of time that the VOCs have already been present, it is estimated that it could take well in excess of 30 years to meet acceptable VOC risk-based concentrations for future construction / utility workers. Based on the timeframe required to remediate the soils under this technology, it would require implementation in conjunction with institutional controls until the VOC-impacted subsurface soils are remediated to acceptable risk-based concentrations for future construction / utility workers.

Natural attenuation will be retained as a technology component to be implemented in conjunction with other technologies, such as institutional controls, since it will not meet the specific RAO for these soils in a reasonable period of time.

4.3 IN SITU TREATMENT

In situ treatment actions involve the treatment of soils in place without soil removal (or handling). Immediate benefits, relative to soil removal methods, include reduced short-term worker and public exposure to contaminants below grade, less intrusion, and easier construction. Extended remedial time frames may be required to achieve the Removal Action objectives, combined with long-term performance monitoring activities.

Numerous in situ treatment technologies exist, consisting of biological, chemical, or physical treatment techniques. Three technologies applicable and proven for elevated VOCs in soils are biological, chemical oxidation, and soil vapor extraction (SVE). Often these options can be implemented independently or in combination.

The following subsections describe three technologies potentially applicable to the VOC-impacted soils at the Properties. A number of other in situ technologies exist that have not been considered due to no proven track record or eliminated due to technical implementation issues within developed areas.

4.3.1 ENHANCED BIOREMEDIATION

Similar to natural attenuation, enhanced bioremediation is a process in which indigenous or inoculated micro-organisms (e.g., fungi, bacteria, and other microbes) degrade organic compounds. The degradation processes are described above in Section 4.2.

Enhanced bioremediation of soils typically involves the percolation or injection of groundwater or uncontaminated water mixed with nutrients and saturated with dissolved oxygen. Shallow soil treatment is generally performed using infiltration galleries or spray irrigation, deeper soils are treated using injection wells or direct injection through temporary direct-push drilling equipment. The residential areas adjacent to the Properties may best be addressed using multiple injection points, shifting the application centers if multiple treatment applications are required. Given the lower soil permeability at the Properties and based on the results of the full-scale ISCO pilot test implemented at the Properties in 2004, a closely spaced network of injection points would be required (e.g., 3-foot centers).

Completion of an injection program throughout the areas of VOC-impacted soils would be conducted using direct-push-drilling techniques to insert the injection equipment and inoculate the soil regime with the selected compound. The Properties would best be addressed using multiple injection points where no features remain at the ground surface.

Compound injection using direct-push technology would be completed in a short time period (i.e., technique is fast), produce minimal cuttings for disposal, and minimize contaminant release to the atmosphere and surrounding community. Therefore, there would be minimum disruption to the residents. Repeat injections (if required) are easily performed in locations offset from initial injection points. This would maximize the contact area between the selected treatment compound and impacted soils.

Prior to implementation, treatability testing and field testing to determine the treatment effectiveness and extent of well influence / spacing would be required.

Due to the concentrations of VOCs that exist in the soils, it could take many years to meet acceptable risk-based VOC concentrations for future construction / utility workers. Thus, an enhanced bioremediation approach would result in a long-term Removal Action program. Based on the timeframe required to remediate the soils under this technology, it would require institutional controls until the VOC-impacted subsurface soils are remediated.

4.3.2 CHEMICAL OXIDATION

Chemical oxidation converts hazardous contaminants to non-hazardous, less toxic constituents that are more stable, less mobile, and / or inert. Oxidizing agents commonly used are ozone, sodium persulfate, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. This treatment process is non-selective and oxidizes all organics, including chlorinated solvents (applicable to VOCs). This technology can be used in applications where the effectiveness of bioremediation is limited by the range of contaminants or climatic conditions.

Chemical oxidation of soils typically involves the percolation or injection of the oxidant alone, oxidant mixed with a catalyst, or the oxidant mixed with an extract from the site.

As discussed in Section 2.4.3, a full-scale ISCO pilot study was completed using the BIOX® technology at the Properties in 2004. As discussed in Section 2.4.3, the VOC-impacted subsurface soils were treated via multiple injection points using temporary direct-push drilling injection equipment. Based on the results of the pilot test, a closely spaced network of injection points is required to effectively treat the soils (i.e., 3-foot centers).

Based on the results of the full-scale ISCO pilot study, chemical oxidation injection using direct-push technology would be completed in a short time period (i.e., technique is fast), produce minimal cuttings for disposal, and minimize contaminant release to the atmosphere and surrounding community. Therefore, there would be minimum disruption to the residents.

A chemical oxidation approach would result in a short-term Removal Action program (i.e., less than 3 months) to achieve acceptable risk-based VOC concentrations for future construction / utility workers.

4.3.3 SOIL VAPOR EXTRACTION (SVE)

A soil vapor extraction (SVE) system is an in situ unsaturated zone (vadose zone) soil remediation technology in which a vacuum is applied to the impacted soil area. The controlled flow of air removes VOCs from the soil media. The recovered soil gas may be treated to recover or destroy the contaminants, dependent upon local and state air discharge regulations.

An SVE system can be configured as horizontal wells for shallow applications, or in areas where the contamination geometry dictates a horizontal application. In the VOC-impacted areas at the Properties, the installation of a series of extraction wells would be effective given the chemistry at depth and areal extent of chemical presence. Given the lower soil permeability at the Properties and adjacent areas, a closely spaced network of extraction wells would be required (e.g., 10-foot centers or less).

Installation of an extraction well gallery throughout the areas of elevated VOCs would be completed using direct-push-drilling techniques to install and backfill the extraction wells to depth. Well installation using direct-push technology would be completed in a short time period (i.e., technique is fast), produce minimal cuttings for disposal, and minimize contaminant release to the atmosphere and surrounding community. Therefore, there would be minimum disruption to the residents during installation of the SVE system. Once the extraction well field was complete, a below-grade header system to convey soil vapors to a treatment area would be required. Vapor treatment may consist of activated carbon, catalytic oxidation, flameless thermal oxidation, or resin adsorption. Treatment would result in significant operation and maintenance (O&M) costs.

Prior to implementation, treatability testing and field testing to determine the treatment effectiveness and extent of well influence/spacing would be required. Given the lower permeability of the area soils (silts and clays), the effectiveness of an SVE system may be limited.

Due to the low permeability of the soils, it could take many years to meet acceptable risk-based VOC concentrations for future construction/utility workers. Thus, an SVE system approach would result in a long-term Removal Action program. Based on the timeframe required to remediate the soils under this technology, it would require institutional controls until the VOC-impacted subsurface soils are remediated.

4.3.4 IN SITU TREATMENT SUMMARY

In situ treatment of VOC-impacted subsurface soils will meet the RAO for the subsurface soils, will minimize exposure concerns during construction, can be easily implemented, and has demonstrated success in reducing VOC concentrations during the pilot study. Based on the results of the full-scale ISCO pilot test it is estimated that one additional round of chemical oxidation injection, using the BIOX® technology, would be effective in meeting the specific RAO for these soils within approximately 3 months after

implementation. Both the enhanced bioremediation and SVE technologies would take many years to complete and would take significantly more effort to implement.

Based on the above, in situ chemical oxidation (BIOX®) of the VOC-impacted subsurface soils will be retained as a technology component for further evaluation consideration.

4.4 EXCAVATION/REMOVAL ACTIVITIES

Soil removal is a technology that would involve the excavation and removal of VOC-impacted subsurface (e.g., 4 to 10 feet bgs) soils at the Properties. Soil removal would be accomplished by the use of conventional excavation/soil handling equipment and structural support to prevent foundation failure or movement. Subsequent to soil removal, the VOC-impacted soils would be disposed of off Site in a permitted landfill. On-Site treatment of excavated soils is not an acceptable option due to potential emission of particulates and organic vapors and odor concerns, and the close proximity of the residential units. Following excavation of the VOC-impacted soil, the excavated areas would be backfilled with clean fill and restored to original conditions. Since all VOC-impacted subsurface soils that pose a potential risk to future construction/utility workers would be removed from the Properties, it would meet the specific RAO for these soils.

As discussed above, removal of the VOC-impacted subsurface soils is a viable technology, and will achieve the specific RAO for these soils in a relatively short period of time (approximately 3 months from implementation). This technology would, however, be technically difficult to implement, expensive, and very disruptive to nearby residents.

Real-time monitoring would be performed during excavation activities to evaluate both particulate and organic vapor emissions from the active excavation areas. Particulate releases due to excavation activities could be effectively managed by incorporating engineering controls (e.g., foaming compounds or water spray to wet the excavation face and excavated soils) to minimize or eliminate airborne particulates. However, due to the elevated VOC concentrations in the soils, and the close proximity of these soils to residential units, organic vapor emissions and associated odors during excavation activities would be difficult to control. Organic vapor releases and associated odors could be reduced during excavation activities by incorporating appropriate engineering controls (e.g., foaming compounds and/or minimizing the open excavation areas); however, these controls may not be sufficient to mitigate potential short-term risks to nearby residents. Also, significant structural concerns would exist in both excavation

areas, and foundation underpinning and lateral wall support during excavation would likely be required. Sheet piling in close proximity to these buildings would not be feasible due to vibration, shock, and noise issues. There are also numerous existing underground utilities (e.g., storm and sanitary sewers, telephone and electrical cables, gas lines) present in both excavation areas that would require support or temporary relocation during the soil removal activities. It is very likely that the residents immediately adjacent to the excavation areas would have to be temporarily relocated due to the health and safety and structural concerns and the potential disruption of utilities during excavation activities.

Notwithstanding the fact that this technology would be technically difficult to implement, expensive, and very disruptive to nearby residents, it will be retained as a technology component for further evaluation since it will meet the specific RAO for these soils in a short period of time.

4.5 INSTITUTIONAL CONTROLS

Institutional controls are actions that are administrative or peripheral in nature to the primary actions at a site. Institutional controls alone would not achieve the RAO for the Properties and would be required to be implemented in conjunction with other technologies to form effective response action alternatives.

Because the Properties are already zoned residential and are fully developed, and because VOCs will remain present in subsurface regardless of which other technology is implemented at the Properties, applicable institutional controls include imposing deed restrictions that would require appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

Institutional controls will be retained as a technology component to be implemented in conjunction with other technologies.

4.6 SUMMARY OF PREFERRED TECHNOLOGIES AND REMOVAL ACTION ALTERNATIVES

4.6.1 SUMMARY OF PREFERRED TECHNOLOGIES

Sections 4.1 through 4.5 summarize various technologies for consideration as components for Removal Action alternatives for VOC-impacted subsurface soils at the Properties. The following provides a summary of the technologies retained for development of Removal Action alternatives:

- No action (presented as a reference scenario);
- Monitored natural attenuation;
- In situ chemical oxidation;
- Excavation / removal; and
- Institutional controls including deed and building restrictions and public notification.

4.6.2 SUMMARY OF REMOVAL ACTION ALTERNATIVES

As discussed in Section 4.0, based on the conclusions and recommendations of the SRE, all developed Removal Action alternatives will include continued operation of the existing drain tile depressurization systems on the building sumps on the Marina Cliffs Condominium property adjacent to the areas of elevated VOC presence. The drain tile depressurization systems draw air from the building sumps and perimeter footer drain piping and vent the sump system to the atmosphere. These systems would continue to operate as a precautionary measure to prevent or minimize the potential migration of impacted soil gas to indoor air during the implementation of the Removal Action activities. As discussed in Section 4.5, because VOCs will remain present in subsurface regardless of which other technology is implemented at the Properties, institutional controls should be implemented imposing deed restrictions requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties. As such, the Removal Action alternatives assembled from the above candidate technologies are as follows:

- Alternative 1 - No Action;
- Alternative 2 - Monitored Natural Attenuation, Institutional Controls, and Drain Tile Depressurization Systems;

- Alternative 3 - Excavation / Off-Site Disposal, Institutional Controls, and Drain Tile Depressurization Systems; and
- Alternative 4 - In Situ Chemical Oxidation, Institutional Controls, and Drain Tile Depressurization Systems.

5.0 EVALUATION OF REMOVAL ACTION ALTERNATIVES

This section describes and evaluates four Removal Action alternatives (including the "No Action" alternative) for the Properties. The focused alternatives include only the technologies and process options that merit further evaluation based on the initial screening presented in Section 4.0. Each alternative has been developed to address the RAOs and to achieve the overall goal of protecting human health and the environment. As discussed in Section 4.6.2, the four alternatives developed for evaluation as Removal Action alternatives are:

- Alternative 1 - No Action;
- Alternative 2 - Monitored Natural Attenuation, Institutional Controls, and Drain Tile Depressurization Systems;
- Alternative 3 - Excavation / Off-Site Disposal, Institutional Controls, and Drain Tile Depressurization Systems; and
- Alternative 4 - In Situ Chemical Oxidation, Institutional Controls, and Drain Tile Depressurization Systems.

The components of the four Removal Action alternatives are summarized in Table 5.1.

The alternatives presented in this section are evaluated with respect to three broad criteria: (1) effectiveness, (2) implementability, and (3) cost. A discussion of these three broad criteria is presented below, followed by a description and evaluation of each alternative developed.

5.1 EVALUATION CRITERIA

The purpose of evaluating Removal Action alternatives based on three criteria is to ensure that each alternative developed would be effective in protecting human health and the environment, would be technically and administratively feasible, and would not be grossly excessive in cost compared to other alternatives that would result in an equal or greater degree of effectiveness. Evaluation based on these three broad criteria also helps to ensure that all alternatives considered achieve RAOs. Each criterion is discussed below.

5.1.1 EFFECTIVENESS

Effectiveness refers to the ability of an alternative to be protective and to achieve overall RAOs. Protectiveness refers to whether an alternative would be protective of workers during implementation (short term), would be protective of public health and the environment (long term), and would comply with ARARs. Each alternative is also evaluated to determine whether it would reduce the toxicity, mobility, or volume of contaminants through treatment.

5.1.2 IMPLEMENTABILITY

Implementability refers to the ease with which an alternative can be constructed, operated, and maintained. This criterion addresses both the technical and administrative feasibility of implementing the alternative relative to site remediation goals, permitting, and related requirements.

5.1.3 COST

Cost analysis is used to eliminate high-cost alternatives that provide essentially the same level of protection as less expensive ones. A comparative evaluation of the alternatives was conducted based on estimates of their current dollar costs. The cost breakdowns for Alternatives 1 through 4 are presented in Tables 5.2 to 5.5, respectively. The cost estimates are based on numerous assumptions and are expected to be revised as additional information from preconstruction activities becomes available.

5.2 EVALUATION OF ALTERNATIVES

A total of four Removal Action alternatives (including "No Action") were developed for the Properties. The components of the Removal Action alternatives are summarized in Table 5.1. Each alternative is described and evaluated below.

5.2.1 ALTERNATIVE 1: NO ACTION

The "No Action" alternative provides a reference against which other alternatives are evaluated. Under this alternative, no action would be taken to contain or remediate impacted soils at the Properties.

5.2.1.1 EFFECTIVENESS

As discussed in Section 4.2, natural attenuation, including degradation processes, of the VOC-impacted soils will eventually reduce VOCs in the subsurface soils to acceptable risk-based concentrations for future construction / utility workers over time (estimated to take well in excess of 30 years). During this time, however, without the implementation of appropriate institutional controls, future construction / utility workers could be exposed to unacceptable risk-based concentrations while repairing or constructing utility services. As such, this alternative does not meet the specific RAO for the Properties.

5.2.1.2 IMPLEMENTABILITY

This alternative would be easy to implement technically; however, it would be very difficult to implement administratively because lack of action would not meet the RAO for the Properties and thus, it would not be protective of human health and the environment.

5.2.1.3 COST

The cost for Alternative 1 is presented in Table 5.1. As indicated in Table 5.2, there are no costs are associated with this No Action Alternative.

5.2.2 ALTERNATIVE 2: MONITORED NATURAL ATTENUATION, INSTITUTIONAL CONTROLS AND DRAIN TILE DEPRESSURIZATION SYSTEMS

Alternative 2 would include the implementation of a MNA program to evaluate natural attenuation / degradation processes in VOC-impacted soils on the Properties, the implementation institutional controls, and the continued operation of the existing drain tile depressurizations systems in the Marina Cliffs Condominium Buildings Nos. 1 through 4. This alternative was developed to present an alternative that was least disruptive to residents and the community, yet provides controls to protect human health and the environment.

An MNA program to evaluate the reduction of VOCs in the soils would be implemented to monitor VOC-impacted soils at depth. Soil sampling would be conducted every 5 years (to coincide with USEPA's 5-year review) to evaluate VOC attenuation and degradation.

Institutional controls would be implemented imposing deed restrictions requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

Indoor air preventative measures would consist of the continued operation of the existing drain tile depressurization systems on the existing building sumps (five sumps total) within the Marina Cliffs Condominium Buildings Nos. 1 through 4. The drain tile depressurization systems would continue to draw air from the building sumps and perimeter footer drain piping and vent the sump system to the atmosphere. These systems are recommended to remain in place only as a precautionary measure to minimize the potential for migration of impacted soil gas to indoor air until the VOC-impacted soils at depth have been remediated to acceptable risk-based concentrations for future construction / utility workers.

5.2.2.1 EFFECTIVENESS

As discussed in Section 4.2, natural attenuation, including degradation processes, of the VOC-impacted soils will eventually reduce VOCs in the subsurface soils to acceptable risk-based concentrations for future construction / utility workers over time (estimated to take well in excess of 30 years). During this time, with the implementation of appropriate institutional controls, future construction / utility workers would not be exposed to unacceptable risk-based concentrations while repairing or constructing utility services. As such, this alternative meets the specific RAO for the Properties.

MNA sampling and analysis would show over time that the reduction of VOC concentrations in the subsurface soils is occurring. The long-term effectiveness of this alternative would be managed through the implementation of institutional controls requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

Over the long term, the potential for migration of impacted soil gas to indoor air would be minimized or prevented by the continued operation of the existing drain tile

depressurization systems. Annual indoor air monitoring would also be performed to ensure that the indoor air quality remains at acceptable risk-based concentrations until the VOC subsurface soils are remediated to acceptable risk-based concentrations for future construction / utility workers.

5.2.2.2 IMPLEMENTABILITY

Alternative 2 is technically easy to implement. Administratively, this alternative would require federal, state, local and residents acceptance with regard to leaving VOC-impacted soils in place above acceptable risk-based concentrations for future construction / utility workers and the implementation of deed restrictions on a residential property requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

5.2.2.3 COST

The cost for Alternative 2 is presented in Table 5.3. The cost estimate includes capital (direct and indirect) and annual monitoring costs. The capital costs are associated with implementing the institutional controls. O&M costs are associated with annual indoor air monitoring and reporting and with the continued operation of the existing drain tile depressurization systems. It is also expected that a significant MNA evaluation effort, including a soil sampling program, would be conducted every 5 years to coincide with USEPA's mandatory 5-year reviews. It is assumed that an extended period of monitoring would be required for at least 30 years. The total present worth cost for Alternative 2 is $380,000.

5.2.3 ALTERNATIVE 3: EXCAVATION/OFF-SITE DISPOSAL, INSTITUTIONAL CONTROLS AND DRAIN TILE DEPRESSURIZATION SYSTEMS

Alternative 3 would include the excavation and off-Site disposal of VOC-impacted subsurface soils, the implementation institutional controls, and the continued operation of the existing drain tile depressurizations systems in the Marina Cliffs Condominium Buildings Nos. 1 through 4.

This alternative would actively remediate the VOC-impacted subsurface soils to depths of 10 feet bgs to acceptable risk-based concentrations for future construction/utility workers. Conceptual limits of excavation for this alternative are shown on Figure 5.1 and are used for the cost estimating purposes in Section 5.2.3.3.

Institutional controls would be implemented imposing deed restrictions requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

Indoor air preventative measures would consist of the continued operation of the existing drain tile depressurization systems on the existing building sumps (five sumps total) within the Marina Cliffs Condominium Buildings Nos. 1 through 4. The drain tile depressurization systems would continue to draw air from the building sumps and perimeter footer drain piping and vent the sump system to the atmosphere. These systems would continue to operate as a precautionary measure to minimize the potential for migration of impacted soil gas to indoor air during implementation of the Removal Action activities.

5.2.3.1 EFFECTIVENESS

Alternative 3 would provide an immediate and effective (i.e., permanent) remediation of VOC-impacted subsurface soils to acceptable risk-based concentrations for future construction/utility workers. It is expected that VOC-impacted soils above acceptable risk-based concentrations would be excavated and disposed of off Site within approximately 3 months of implementation. Soil sampling and analysis would verify that the VOC-impacted areas have been remediated. Therefore, the RAO would be met for these soils in the short term. Short-term risks during excavation activities would be minimized by worker protection. Short-term risks to residents are discussed in Section 5.2.3.2.

Over the short term, during excavation activities, potential migration of impacted soil gas to indoor air would be minimized or prevented by the continued operation of the existing drain tile depressurization systems. Indoor air monitoring would also be performed immediately prior to, during, and subsequent to excavation activities, to ensure that the indoor air quality remains at acceptable risk-based concentrations.

5.2.3.2 IMPLEMENTABILITY

Alternative 3 would be very difficult and expensive to implement. Soil removal would be accomplished by the use of conventional excavation/soil handling equipment and structural support to prevent foundation failure or movement. However, since both areas of VOC-impacted soils are situated immediately adjacent to residential units and the VOC-impacted soils extend to depths of 10 feet bgs, construction complexities would exist. Due to the elevated VOC concentrations in the soils, and the close proximity of these soils to residential units, organic vapor emissions and odors during excavation and handling of the soils would be very difficult to control. Also, significant structural concerns would exist in both excavation areas, and foundation underpinning and lateral wall support during excavation would likely be required. Sheet piling in close proximity to these buildings would not be feasible due to vibration, shock, and noise issues. Existing utilities in these areas would also require support or temporary relocation during the soil removal activities. It is likely that residents immediately adjacent to the excavation areas would have to be temporarily relocated due to the disruption of utilities and structural, health, and safety concerns during excavation. Although possible, deep excavations in these areas would be technically difficult to implement and would be very disruptive to the residents.

Particulate releases from excavation activities could be effectively managed by incorporating engineering controls to minimize or eliminate airborne particulates. Real-time monitoring would be performed to evaluate both particulate organic vapor emissions from the active excavation areas. Foaming compounds or water spray to wet the excavation face and excavation soils are generally effective measures to control particulates and odors. Areas of elevated VOCs in soils may, however, pose a concern for both excavation workers and the general public. Foaming compounds, or minimizing the open excavation areas, may help to minimize or eliminate VOC releases during excavation activities. Once a complete or partial excavation is finished, the excavated areas would be backfilled and restored to original conditions.

Administratively, this alternative would require federal, state, local, and residents acceptance with regard to the implementation of deed restrictions on a residential property requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

5.2.3.3 COST

The cost for Alternative 3 is presented in Table 5.4. The cost estimate includes capital (direct and indirect) costs. There are no annual or 5-year periodic costs under this alternative. The capital costs are associated with construction activities (excavation / restoration works, soils disposal) and continued operation of the drain tile depressurization systems, soil sampling and analyses, and indoor air monitoring. Based on the limits of excavation shown on Figure 5.1, it is estimated that approximately 2,500 cubic yards of clean soil and approximately 2,500 cubic yards of VOC-impacted soils (both volumes include a 25 percent contingency) would require to be excavated. Based on concentrations of VOCs in the soils, all excavated VOC-impacted soils are assumed to be non-hazardous. Also, based on information from the Time-Critical Removal Action performed on the Properties in 2004, it is assumed that the soils exhibit a density of 1.6 tons per cubic yard. It is further assumed that all capital costs will be expended within a 3-month period. Based on the above estimates and assumptions the total present worth cost for Alternative 3 is $1,024,000.

5.2.4 ALTERNATIVE 4: IN SITU CHEMICAL OXIDATION, INSTITUTIONAL CONTROLS, AND DRAIN TILE DEPRESSURIZATION SYSTEMS

Alternative 4 would include in situ chemical oxidation of VOC-impacted soils to a depth of 10 feet bgs, the implementation institutional controls, and the continued operation of the existing drain tile depressurizations systems in the Marina Cliffs Condominium Buildings Nos. 1 through 4.

Based on the results of the full-scale ISCO pilot test conducted on the Properties in 2004, one additional round of BIOX® injection is expected to meet the specific RAO for the VOC-impacted subsurface soils. Conceptual limits of treatment for this alternative are shown on Figure 5.2 and are used for the cost estimating purposes in Section 5.2.4.3. Specifically, the additional round of BIOX® injection would be performed as follows:

- Injection performed in Areas 1 and 3 from 6 to 10 feet bgs and in Area 2 from 4 to 10 feet bgs;
- Injection pressures not to exceed 100 psi;
- Injection performed on 3-foot centers;
- BIOX® selected as the preferred treatment compound; and

- Soil monitoring performed approximately 1 month following the injection event to evaluate effectiveness.

This alternative would actively remediate the VOC-impacted subsurface soils to depths of 10 feet bgs to acceptable risk-based concentrations for future construction / utility workers.

Institutional controls would be implemented imposing deed restrictions requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

Indoor air preventative measures would consist of the continued operation of the existing drain tile depressurization systems on the existing building sumps (five sumps total) within the Marina Cliffs Condominium Buildings Nos. 1 through 4. The drain tile depressurization systems would continue to draw air from the building sumps and perimeter footer drain piping and vent the sump system to the atmosphere. These systems would continue to operate as a precautionary measure to minimize the potential for migration of impacted soil gas to indoor air during implementation of the Removal Action activities.

5.2.4.1 EFFECTIVENESS

It is expected that one additional round of BIOX® injection would reduce VOC-impacted subsurface soils to acceptable risk-based concentrations for future construction / utility workers within approximately 3months from commencement of injection activities. Soil sampling and analysis would verify that the VOC-impacted areas have been remediated. Therefore, the RAO would be met for these soils in the short term. Short-term risks during BIOX® injection activities would be minimized by worker protection. Short-term risks to residents would be minimized by implementing appropriate air monitoring and contingency measures.

Over the short term, during BIOX® injection activities, potential migration of impacted soil gas to indoor air would be minimized or prevented by the continued operation of the existing drain tile depressurization systems. Indoor air monitoring would also be performed immediately prior to, during, and subsequent to injection activities, to ensure that the indoor air quality remains at acceptable risk-based concentrations.

5.2.4.2 IMPLEMENTABILITY

Alternative 4 would be very easy to implement as it employs a proven technology (i.e., BIOX® chemical oxidation) that has already been implemented at the Properties as a pilot study.

Administratively, this alternative would require federal, state, local, and residents acceptance with regard to the implementation of deed restrictions on a residential property requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

5.2.4.3 COST

The cost for Alternative 4 is presented in Table 5.5. The cost estimate includes capital (direct and indirect) costs and are based on the costs incurred during implementation of the full-scale pilot study on the Properties in 2004. There are no annual or 5-year periodic costs under this alternative. The capital costs are associated with in situ chemical oxidation treatment, continued operation of the drain tile depressurization systems, soil sampling and analyses, and indoor air monitoring. It is assumed that all capital costs will be expended within a 3-month period. The total present worth cost for Alternative 4 is $322,000.

6.0 COMPARATIVE EVALUATION OF REMOVAL ACTION ALTERNATIVES

This section provides a comparative evaluation of the four Removal Action alternatives discussed in Section 5.0. The comparative evaluation considers the three evaluation criteria of effectiveness, implementability, and cost. This comparison is also summarized in Table 6.1. This comparison is followed by a discussion of the Removal Action schedule.

6.1 EFFECTIVENESS

The effectiveness of the Removal Action alternatives developed for the Properties is evaluated based on their overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; and short-term effectiveness. The ability of the alternatives to meet these criteria is compared below.

6.1.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 1 would not provide overall protection of human health and the environment under the future construction / utility worker scenario since no further action would be implemented. The potential risks posed by VOC-impacted subsurface soils at the Properties would remain.

Alternatives 2, 3, and 4 would all provide effective, immediate, and permanent protection of human health and the environment under the future construction / utility worker scenario, and thus would all meet the specific RAO for the Properties. Alternative 2 will take in excess of 30 years to meet acceptable risk-based concentrations for an industrial worker; whereas Alternatives 3 and 4 are expected to meet acceptable risk-based concentrations in the short term (i.e., within 3 months of commencement of Removal Action activities). Under all three alternatives, the drain tile depressurization systems would continue to operate as a precautionary measure to minimize the potential for migration of impacted soil gas to indoor during implementation of the Removal Action activities. All three alternatives would require long-term institutional controls to be implemented imposing deed restrictions requiring appropriate health and safety measures and a Soils Management Plan to be implemented during future intrusive activities in the VOC-impacted areas on the Properties.

6.1.2 COMPLIANCE WITH ARARs

There are chemical-specific ARARs for the VOC-impacted subsurface soils on the Properties. Potential chemical-specific ARARS or TBCs include VOC risk-based Region IX PRGs for an industrial worker and acceptable risk-based concentrations for future construction / utility workers.

Alternative 1 does not meet acceptable VOC risk-based concentrations for future construction / utility workers. Alternative 2 will meet acceptable VOC risk-based concentrations for future construction / utility workers over the long term (i.e., greater than 30 years) with the implementation of institutional controls. Both Alternatives 3 and 4 will meet acceptable VOC risk-based concentrations for future construction / utility workers in the short term (i.e., less than 3 months).

The potential federal action-specific ARARs for the Properties include:

- CERCLA / SARA 42 USC 9601 et. seq (40 CFR 300.68 (NCP) and 40 CFR 300.415 (NCP);
- RCRA Subtitle C (40 CFR 260-268) and Subtitle D (40 CFR 257);
- NPDES (40 CFR 122);
- Clean Air Act (relevant sections);
- National Primary and Secondary Ambient Air Quality Standards (relevant sections); and
- Worker Safety and Health Protection Occupational Safety and Health Association (OSHA).

The potential state action-specific ARARs for the Properties include:

- State General Solid Waste Management Requirements (NR 500);
- Environmental Monitoring for Landfills (NR 507);
- Remedial and Interim Action Design, Implementation, Operation, Maintenance and Monitoring Requirements (NR 724);
- Groundwater Monitoring Well Requirements (NR 141);
- Identification and Listing of Hazardous Waste (NR 605);
- Water Quality Standards for Surface Water (NR 102 through NR 106 and NR 207);
- Air Quality Standards (NR 445);

- Control of Organic Compound Emissions (NR 419);
- Categories and Classes of Point Sources and Effluent Limitations (NR 220);
- List of Toxic Pollutants (NR 215);
- Effluent Standards and Limitations (NR 217);
- Requirements or Environmental Insurance, Wisconsin Statute (Section 292.15 (2)(ae)3m);
- General Requirements (NR 700);
- Personnel Qualifications for Conducting Environmental Response Actions (NR 712);
- Public Information and Participation (NR 714);
- Management of Solid Wastes Excavated During Response Actions (NR 718);
- Standards for Selecting Remedial Actions (NR 722); and
- Case Closure (NR 726).

No location-specific ARARs are directly applicable to the Removal Action alternatives. No wetland, floodplain, or navigable waters are directly adjacent to the Properties.

6.1.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Long-term effectiveness and permanence refer to the extent to which the alternatives would reduce the magnitude of residual risk at a site and the adequacy and reliability of the controls that would ensure operation of the alternatives.

Alternative 1 would not provide long-term effectiveness or permanence at the Properties. Under Alternative 1, potential risks exist over the short and long term since there would not be any institutional controls implemented. Alternatives 2, 3, and 4 are all effective in reducing both human health and environmental risk and are permanent. Alternative 2 will achieve effectiveness and permanence over the long term (in excess of 30 years) and Alternatives 3 and 4 will achieve effectiveness and permanence within a very short time period (approximately 3 months). Alternatives 2, 3, and 4 would all be effective in preventing or minimizing the potential migration of impacted soil gas to indoor during remedial action implementation due to the continued operation of the existing drain tile depressurization systems.

6.1.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME

Under Alternatives 1 and 2, the toxicity, mobility, and volume of VOC-impacted subsurface soil would be reduced through natural attenuation over the long term. Under Alternatives 3 and 4, the toxicity, mobility, and volume of VOC-impacted subsurface soil would be reduced at the Properties through excavation and off-Site disposal, or through ISCO treatment.

6.1.5 SHORT-TERM EFFECTIVENESS

Alternatives 1 and 2 would not pose any short-term risk during their implementation and Alternative 4 would pose minimal short-term risk during its implementation. For example, a field crew might be exposed to contaminants during BIOX® injection activities, although these could be easily managed by implementation of worker protection.

There are significant short-term risks associated with Alternative 3. Due to the elevated VOC concentrations in the soils, and the close proximity of these soils to residential units, organic vapor emissions and odors during excavation and handling of the soils would be very difficult to control. Also, significant structural concerns would exist in both excavation areas, and foundation underpinning and lateral wall support during excavation would likely be required. Sheet piling in close proximity to these buildings would not be feasible due to vibration, shock, and noise issues. Existing utilities in these areas would also require support or temporary relocation during the soil removal activities. It is likely that residents immediately adjacent to the excavation areas would have to be temporarily relocated due to the disruption of utilities and structural, health, and safety concerns during excavation.

During the implementation of Alternatives 2, 3, or 4, potential short-term impacts due to potential migration of impacted soil gas to indoor air would be prevented or minimized by continued operation of the existing drain tile depressurization systems.

6.2 IMPLEMENTABILITY

Technical implementability refers to the extent to which a technology has been developed, its ease of construction, the frequency or complexity of its operation and maintenance, and the ability to monitor its effectiveness. Administrative implementability refers to the need to coordinate activities (including the issuance of

permits) with agencies or offices. The technical and administrative implementability of the three Removal Action alternatives developed for the Properties is compared below.

6.2.1 TECHNICAL IMPLEMENTABILITY

Alternatives 1 and 2 would require no technical implementation and would, therefore, be the easiest alternatives to implement. Alternatives 3 and 4 are proven technologies, commonly implemented. Alternatives 3 and 4 would both meet the RAO within 3 months of implementation, resulting in no future ongoing O&M or periodic inspection activities. As discussed in Section 6.1.5, Alternative 3 would be technically difficult to implement and would be very disruptive to the residents.

6.2.2 ADMINISTRATIVE IMPLEMENTABILITY

Although no permits would be necessary for Alternative 1, this alternative would be difficult to implement administratively because federal and state agencies and the community are not expected to agree to lack of action at the Properties. Alternatives 2, 3, and 4 would all require the implementation of long-term institutional controls; thus, they would have the same administrative implementability in that regard.

6.3 COST

The present worth costs for the alternatives are as follows:

- Alternative 1 $0;
- Alternative 2 $380,000;
- Alternative 3 $1,024,000; and
- Alternative 4 $322,000.

The cost to implement Alternative 2 is approximately three times higher than the cost to implement either Alternatives 2 or 4.

6.4 REMOVAL ACTION SCHEDULE

Removal action schedules for Alternatives 2 through 4 are presented on Figures 6.1 through 6.3, respectively. These timeframes are estimated and will vary depending on the Properties owners, regulatory environment, weather conditions, and Properties conditions. The schedules were developed with a milestone date for approval of this EE/CA report and selection of the final remedial actions as the start date.

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