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Office of Land and Emergency Management
Office of Superfund Remediation and
Technology Innovation

Optimization Review Report

Saunders Supply Company Superfund Site
Suffolk County, Virginia
EPA Region 3

FINAL – August 2016

www.clu-in.org/optimization | https://www.epa.gov/superfund/cleanup-optimization-superfund-sites

Prepared for United States Environmental Protection Agency

Prepared by ICF International

EXECUTIVE SUMMARY

Optimization Background

U.S. Environmental Protection Agency defines optimization as the following:

> "*Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply some other approaches to identify opportunities for greater efficiency and effectiveness. Contractors, states, tribes, the public, and PRPs are also encouraged to put forth opportunities for the Agency to consider.*"[1]

An optimization review considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness, and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization reviews.

An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Remedy effectiveness
- Cost reduction
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent review, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPP).

Site-Specific Background

The Saunders Supply Company Superfund Site (Saunders site) is located in Suffolk County, Virginia, in EPA Region 3, and is a 7-1/3 acre former wood treating plant. The site was added to the National

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[1] U.S. Environmental Protection Agency. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

Priorities List (NPL) on October 4, 1989. A Record of Decision (ROD) was signed in September 1991. A ROD Amendment was signed in September 1996. The source areas included wastewater ponds, treatment areas, and burn pits located on the Saunders property and were remediated by removing liquids and contaminated soil. Primary contaminants are currently pentachlorophenol (PCP), arsenic, and chromium in groundwater. The site is in the operation and maintenance (O&M) phase and uses a groundwater pump and treat (P&T) system to control migration of the contaminants and remove contaminant mass from the aquifer. The P&T system is intended to be operated until cleanup goals are achieved.

Summary of Conceptual Site Model and Key Findings
The subsurface geology at the Saunders site can be divided into three basic units: an uppermost unit of fine- to medium-grained sand that extends to a depth of approximately 12 feet across most of the site (this unit is identified as the Columbia aquifer); a fine-grained green-gray clayey confining unit approximately 2 to 7 feet in thickness is located beneath the uppermost sandy unit; and an approximately 55 foot thick gray silt and sandy silt unit is located beneath the green-gray clayey unit (this unit is identified as the Yorktown aquifer or Yorktown Confining Unit). The Columbia and the Yorktown aquifers are the two hydrostratigraphic units identified at the site and are separated by the fine-grained clayey unit. The water table occurs in the Columbia aquifer and the depth to water varies across the site but averages about 10 feet below ground surface (bgs) (CDM, 2006b). No nearby residential wells tap the Columbia aquifer. The Columbia aquifer intersects Godwin's Millpond, a surface water supply for the Chuckatuck area of Suffolk. An intermittent stream is located on the western edge of the property and discharges to Godwin's Millpond. The Kelly irrigation well, located approximately 300 feet from the Saunders property line, likely withdrew water from the Yorktown aquifer when it was operational.

Groundwater in the Columbia aquifer and upper Yorktown Confining Unit contains concentrations of PCP, arsenic, and chromium above U.S. EPA Maximum Contaminant Levels (MCLs). Four extraction wells capture contaminated groundwater and provide hydraulic control, however the volume of water captured and the mass of contaminants removed is low. The system began operating as part of a time critical removal action in 1988 and is currently operated and maintained by the Commonwealth of Virginia.

The optimization review team identified uncertainties about the extent of contamination near the sources and downgradient as a data gap in the CSM. The interaction of the shallow groundwater and the intermittent stream and Godwin's Millpond is also a data gap in the CSM. The site team determined that the current treatment system is adequate in meeting discharge criteria, however, the remedy has not succeeded in reducing contaminant concentrations in the aquifer and reaching groundwater cleanup levels (MCLs). Therefore, the optimization review team agrees that a revised strategy must be implemented that also focuses on contaminant mass removal and aquifer restoration. The current optimization review of the site is intended to improve recovery of PCP, arsenic, and chromium from the contaminated aquifer at the site.

Summary of Recommendations
Recommendations are provided to improve understanding of the site conditions by addressing data gaps in the CSM and improve effectiveness of the existing remedial system. The optimization review team also provided recommendations for alternative technologies to accelerate the removal of contaminants. The recommendations in these areas are as follows:

Remedy effectiveness –
Recommendations to improve the effectiveness of the proposed remedy include a sequenced approach to improve the capacity and mass removal rate of the current remedy and consideration of other treatment technologies to enhance the mass removal. Recommendations also include developing completion strategies for plume control and containment, aquifer restoration, and any new mass reduction

technologies that may be implemented. Developing and observing these criteria will help avoid operating long-term remedies longer than necessary.

The optimization review team recommends additional characterization of the source and downgradient plume areas to better understand the distribution of contaminants so that improvements to the groundwater treatment system can maximize the removal of contaminants from high concentration areas. As part of the characterization, the interaction of the groundwater with the intermittent stream and Godwin's Millpond will help ensure the groundwater system effectively captures contaminants throughout the site. The optimization review team also recommends updating the capture zone analysis to determine whether containment is adequate based on the current day plume configuration and extraction well pumping rates, or if improvements to the extraction system are necessary.

The optimization review team recommends confirming that the RAOs are consistent with current site conditions and exposed populations because the current RAOs are based on site conditions before 1991. Potential exposure points could include recently installed private wells (if present), Godwin's Millpond, and the Kelly irrigation well.

A groundwater performance monitoring plan is recommended to confirm control of the plume and the performance of the P&T system.

Cost reduction –
Recommendations to characterize the source and downgradient areas are anticipated to reduce costs over the lifetime of the project. Additional costs associated with sampling are estimated at $125,000; however costs are anticipated to be offset by more efficient contaminant mass removal and a shorter operation life time for the P&T remedy.

Recommendations for improving extraction well pumping rates and increasing treatment system capacity are also anticipated to reduce life-cycle costs. Remedy performance monitoring along with establishing remedy operation completion criteria for each remedy component can ensure that the performance monitoring procedures remain relevant to the remedy as it continues to operate into the future.

Technical improvement –
Technical improvements for the existing remedy are anticipated to result from additional site characterization (to optimize placement of extraction wells), additional maintenance and replacement of system components, consideration of combined treatment technologies, and remedy performance monitoring. Prioritizing increased mass removal is anticipated to provide the maximum improvement in the long-term performance of the P&T system.

Site closure –
Recommendations that are anticipated to shorten the time to attain cleanup goals include additional source area characterization, increasing the mass removal rate of contaminants with the existing system or supplemental technologies, and implementing remedy performance monitoring.

Environmental footprint reduction –
Due to the relatively small environmental footprint of the current P&T system, no specific recommendations have been identified for green remediation or environmental footprint reduction. However, several of the other optimization recommendations have the potential to reduce the remedy footprint by either streamlining the treatment process or reducing the likelihood of operating a remedy component past the point of measureable benefit in achieving the RAOs. Additionally, implementation of the recommendations could result in achievement of restoration in a shorter time frame, and thus reducing the remedy's overall environmental footprint.

NOTICE AND DISCLAIMER

Work described herein was performed by ICF International (ICF) for the U.S. Environmental Protection Agency. Work conducted by ICF, including preparation of this report, was performed under Task Order 0008 of EPA contract EP-W-14-001 with ICF Incorporated, LLC. The report was approved for release as an EPA document, following the Agency's administrative and expert review process.

This optimization review is an independent study funded by the EPA that focuses on remedy effectiveness, cost reduction, site closure, technical improvements, and environmental footprint reduction. Detailed consideration of EPA policy was not part of the scope of work for this review. This report does not impose legally-binding requirements, confer legal rights, impose legal obligations, implement any statutory or regulatory provisions, or change or substitute for any statutory or regulatory provisions. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Recommendations are based on an independent evaluation of existing site information, represent the technical views of the optimization review team, and are intended to help the site team identify opportunities for improvements in the current site remediation strategy. These recommendations do not constitute requirements for future action; rather, they are provided for consideration by the EPA Region and other site stakeholders.

While certain recommendations may provide specific details to consider during implementation, these recommendations are not meant to supersede other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP); nor are they intended to override applicable or relevant and appropriate requirements (ARARs). Further analysis of recommendations, including review of EPA policy may be needed prior to implementation.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization practices from site assessment to site completion implemented by the United States Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (OSRTI)[2]. The project contacts are as follows:

Organization	Key Contact	Contact Information
EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Kirby Biggs Edward Gilbert Matthew Jefferson Amanda Van Epps	EPA OSRTI Technology Innovation and Field Services Division (TIFSD) 2777 Crystal Drive Arlington, VA 22202 biggs.kirby@epa.gov phone: 703-823-3081 gilbert.edward@epa.gov phone: 703-603-8883 jefferson.matthew@epa.gov phone: 703-603-8892 vanepps.amanda@epa.gov phone: 703-603-8855
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The national optimization strategy includes a system for tracking consideration and implementation of the optimization recommendations, and, for some sites, includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and EPA OSRTI.[2]

[2] U.S. Environmental Protection Agency. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CSM	Conceptual site model
COC	Contaminant of concern
DNAPL	Dense non-aqueous phase liquid
DPT	Direct-push technology
DQO	Data quality objective
DSITMS	Direct Sampling Ion Trap Mass Spectroscopy
EA	Environmental Alliance, Inc.
E&E	Ecology & Environment
EPA	U.S. Environmental Protection Agency
FS	Feasibility study
ft	feet
GAC	Granular activated carbon
GC/MS	Gas chromatograph/mass spectrometry
gpm	gallons per minute
HRSC	High Resolution Site Characterization
HQ	Headquarters
ICF	ICF International
ITRC	Interstate Technology and Regulatory Council
lb	pound
LIF	Laser Induced Fluorescence
LTM	Long-term Monitoring
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
MIP	Membrane Interface Probe
MW	Monitoring well
NPL	National Priorities List
O&F	Operational and Functional
O&M	Operation and Maintenance
OSRTI	Office of Superfund Remediation and Technology Innovation
PCP	Pentachlorophenol
PDB	Passive diffusion bag
P&T	Pump and treat
PV	photovoltaics
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAO	Remedial action objective
RD	Remedial design
RI	Remedial investigation
ROD	Record of Decision
RPM	Remedial Project Manager
SVOC	Semi-volatile organic compound
TIFSD	Technology Innovation and Field Services Division
µg/L	micrograms per liter
VDEQ	Virginia Department of Environmental Quality

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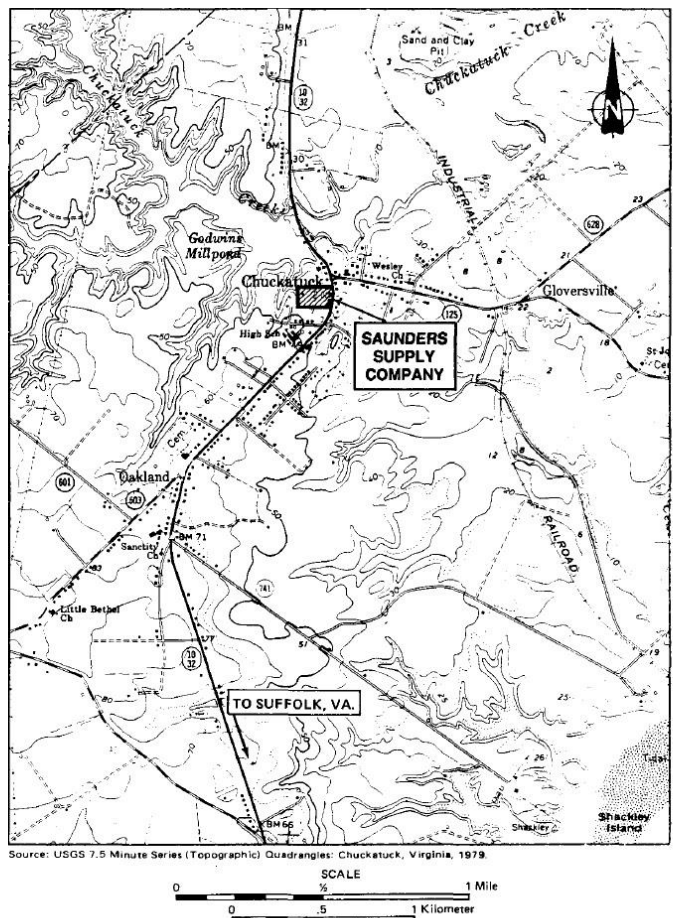
APPENDICES

1.0 OBJECTIVES OF OPTIMIZATION REVIEW

For more than a decade, the Office of Superfund Remediation and Technology Innovation (OSRTI) has provided technical support to the EPA regional offices through the use of independent (third party) optimization reviews at Superfund sites. The Saunders Supply Company Superfund Site (Saunders site) was nominated for an optimization review at the request of the Region 3 Remedial Project Manager (RPM) in September 2015. The current optimization review of the site is intended to improve recovery of pentachlorophenol (PCP), arsenic, and chromium from the contaminated aquifer at the site. The existing groundwater pump and treat (P&T) system began operation in 1998 and is currently operated and maintained by the Commonwealth of Virginia.

The site is located in Suffolk County Virginia, in EPA Region 3, and is a 7-1/3 acre former wood treating plant (Figure 1). The site was added to the National Priorities List (NPL) on October 4, 1989, and activities under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) have been ongoing since this time. Remedial Investigation (RI) (E&E, 1991) and Feasibility Study (FS) (EPA, 1991a) reports for the site were finalized in May 1991 and a Record of Decision (ROD) (EPA, 1991b) was signed in September 1991. A ROD Amendment (EPA, 1996) was signed in September 1996. The site is currently in the operation and maintenance (O&M) phase.

Figure 1: Site Location *(Excerpt from Figure 1-1 of May 1991 RI [E&E, 1991]. A full size version of this figure is provided in Appendix B.)*



Source: USGS 7.5 Minute Series (Topographic) Quadrangles: Chuckatuck, Virginia, 1979.

An optimization review team (described below) was assembled and met with regulatory stakeholders and consultants at the site to observe site conditions, review site data and remediation goals, and discuss the technical aspects of the existing remedy and its performance toward achieving remediation goals. The optimization review team also reviewed site documents provided by EPA Region 3 and Virginia Department of Environmental Quality (VDEQ). This report summarizes the findings and recommendations of the optimization review team.

Objectives of this cleanup-stage optimization review include:

- Review of conceptual site model (CSM)
- Review of Remedial Action Objectives (RAO)
- Review of ongoing remedies and associated costs
- Provide recommendations for:
  - CSM improvements
  - Remedy improvements
  - Prioritization and sequencing of the remedy components
  - Performance monitoring metrics in support of completion for each remedy component

2.0 OPTIMIZATION REVIEW TEAM

The optimization review team consisted of the independent, third-party participants listed in Table 1. The optimization review team collaborated with representatives of EPA Headquarters (HQ) (OSRTI), EPA Region 3, VDEQ, and Environmental Alliance, Inc. (EA), the current groundwater treatment system O&M contractor for VDEQ.

The independent, third-party optimization review team consisted of the following individuals:

Table 1: Optimization Review Team

Name	Organization	Phone	Email
Kirby Biggs	EPA HQ OSRTI	703-823-3081	biggs.kirby@epa.gov
Edward Gilbert	EPA HQ OSRTI	703-603-8883	gilbert.edward@epa.gov
Matthew Jefferson	EPA HQ OSRTI	703-603-8892	jefferson.matthew.epa.gov
Kevin Palaia	ICF International	617-250-4271	kevin.palaia@icfi.com
Jim Rice	ICF International	617-250-4280	james.rice@icfi.com

The individuals listed in Table 2 also contributed to the optimization review process:

Table 2: Other Optimization Review Contributors

Name	Organization	Title/Party	Present for Site Visit/Site Meeting
Lisa Denmark	EPA Region 3	RPM	Yes
Nathan Doyle	EPA Region 3	Region 3 Hydrogeologist	Yes
Karen Doran	VDEQ	CERCLA Program Manager	Yes
Amanda Van Epps	EPA HQ OSRTI	Environmental Engineer	No
Jim Cutler	VDEQ	State RPM	Yes
Matt Richardson	VDEQ	Previously with EA, managed treatment system at the site	Yes
Jimmy Mackey	EA	Groundwater Treatment System Operator	Yes
Aaron Siegel	EA	Groundwater Treatment System Operator	Yes

A site visit followed by a meeting occurred on December 1, 2015. Documents reviewed during the optimization review process are listed in Appendix A.

2.1 Quality Assurance

This optimization review used existing environmental data to interpret the CSM, evaluate potential future remedy performance, and make recommendations to improve the remedy. The quality of the existing data was evaluated by the optimization review team before use. The evaluation for data quality included a brief review of 1) how the data were collected and managed (where practical, the site QAPP was considered), 2) whether various data sets are consistent with each other, and 3) whether and to what extent the data can be used in the optimization review. Data that were of suspect quality were either not used as part of the optimization review or were used with the quality concerns noted. Where appropriate, this report provides recommendations to improve data quality.

3.0 REMEDIAL ACTION OBJECTIVES AND SELECTED REMEDIES

The Saunders site is the location of a former wood treating plant. Wood treating operations ceased in July 1991, but the site is still an active lumber yard. Between 1964 and 1984, a mixture of pentachlorophenol (PCP) and fuel oil was used for wood preservation, with chromated copper arsenate added in 1974. Onsite surface and subsurface soils, wastewater ponds, concrete pads, and storm sewer pipelines contained elevated levels of PCP, arsenic, and chromium. The groundwater in the shallow Columbia aquifer is contaminated with arsenic, chromium, and PCP. The aquifer intersects Godwin's Millpond, which is part of a water supply source for approximately 30,000 people in Suffolk, Virginia. The current CSM is described in documents including the ROD (EPA, 1991b), ROD Amendment (EPA, 1996), RI (E&E, 1991), FS (EPA, 1991a), and the Third Five Year Review (EPA, 2014) listed in Appendix A. A summary of the CSM components relevant to remedial design (RD) and remedial action (RA) is provided below.

3.1 Remedial Action Objectives and Affected Media

The basis for remedial action at the Saunders site was onsite soil contamination, wastewater ponds, storm sewers, and groundwater contamination exceeding human health risk levels and Virginia Groundwater Standards as a result of historic wood treating operations. A risk-based cleanup standard for PCP in soil, the principal contaminant, was set at 1.46 milligram per kilogram (mg/kg), corresponding to a 10^{-6} risk level.

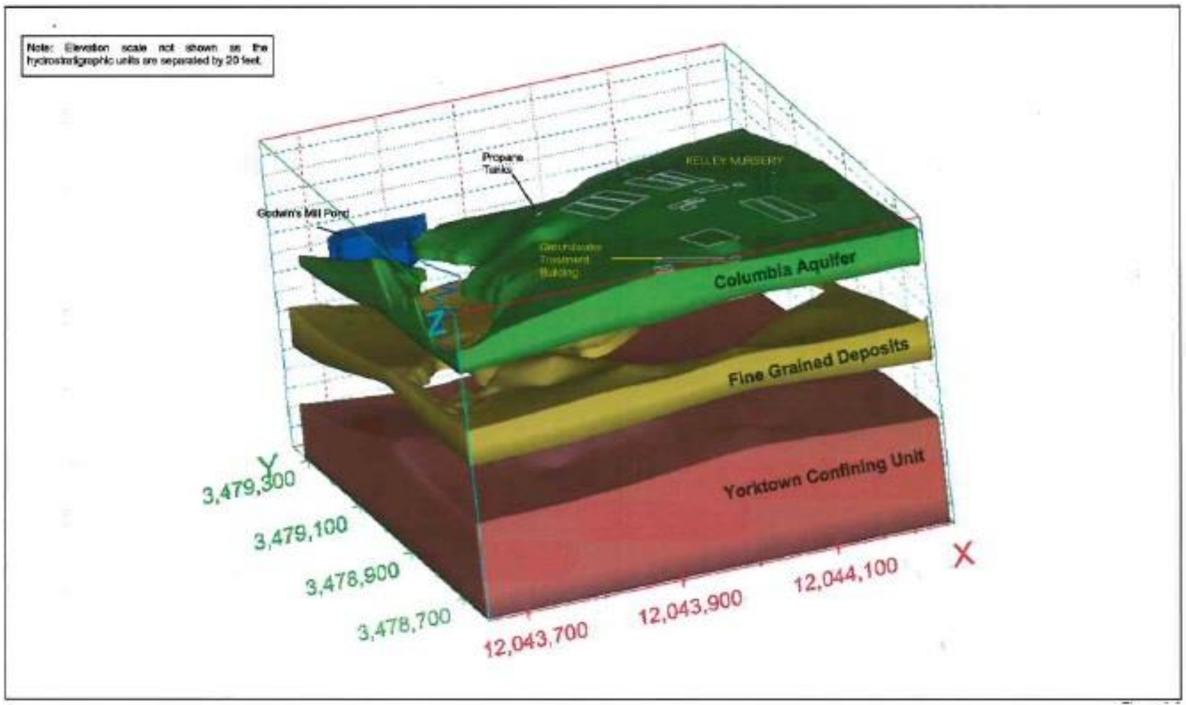
RAOs for groundwater were not specifically listed as such in the ROD. However, they can be inferred from the major components of the remedy as summarized in the ROD and later defined in a ROD Amendment. The 1991 ROD identified groundwater monitoring as the preferred remedial action for groundwater and stipulated that if monitoring results indicate concentrations of PCP greater than the maximum contaminant level (MCL) of 1.0 microgram/liter (μg/L) at the boundary of the plume, verification sampling would be conducted, and active groundwater restoration may be implemented. Groundwater would also be monitored for arsenic and chromium but no action levels for these components were set in the ROD. The primary focus of this optimization review is the groundwater remedy, therefore the remainder of this report will only focus on remedies associated with the groundwater media and potential sources of continued groundwater contamination.

The subsurface geology at the Saunders site can be divided into three basic units, which are illustrated in Figure 2 and in the cross sections presented in Appendix B.

- An uppermost unit of primarily fine- to medium-grained sand with some isolated silts and clay. This uppermost unit extends to a depth of approximately 12 feet across most of the site. This unit is identified as the Columbia aquifer on the cross sections.
- A fine-grained green-gray clayey unit approximately 2 to 7 feet in thickness is located beneath the uppermost sandy unit. This unit is identified as the confining clay on the cross sections.
- A gray silt and sandy silt unit is located beneath the green-gray clayey unit. This unit is approximately 55 feet thick in the site area and is identified as the Yorktown aquifer or Yorktown Confining Unit on the cross sections.

The Columbia and the Yorktown aquifers are the two hydrostratigraphic units identified at the site and are separated by the fine-grained clayey unit. The water table occurs in the Columbia aquifer and the depth to water varies across the site but averages about 10 feet below ground surface (bgs) (CDM, 2006b). No nearby residential wells tap the Columbia aquifer (E&E, 1991). The Columbia aquifer intersects Godwin's Millpond, a surface water supply for the Chuckatuck area of Suffolk. The deeper Yorktown aquifer was not penetrated in any site borings, but is believed to be present at more than 75 feet bgs. The Kelly irrigation well, located approximately 300 feet from the Saunders property line, likely withdrew water from the Yorktown aquifer when it was operational (E&E, 1991). No documentation was identified that definitively identifies the closure process and current status of the Kelly irrigation well. The nearest residential well is located approximately 3,000 feet from the site and draws water from 566 feet bgs (E&E, 1991).

Figure 2: Site Stratigraphy Showing the Upper Water Bearing Unit (Columbia aquifer) and Godwin's Millpond. *(Figure is an excerpt of Figure 4-1 from December 2006 Hydrogeological Analysis Report [CDM, 2006b]. A full size version of the figure is provided in Appendix B.)*



Godwin's Millpond, also referred to as Crumps Millpond, is located approximately 700 feet north of the Saunders property line. Godwin's Millpond is one of the water sources for the City of Suffolk. According to the site team, approximately 1.7 million gallons per day are reportedly withdrawn from Godwin's Millpond and stored in a series of water supply lakes located ½ mile north of the site. The water supply serves a population of approximately 30,000. An intermittent stream is located on the western edge of the property and discharges to Godwin's Millpond. Numerous seeps originating in the Columbia aquifer are present on the east side of the incised stream valley, and discharge to the stream.

The primary site contaminant, pentachlorophenol (PCP) is a semivolatile organic compound (SVOC) that is denser than water, has low solubility in water and tends to partition to soil particles. During site operations, PCP was dissolved in fuel carrier oil to facilitate penetration into the wood. The RI (E&E, 1991) postulated that the petroleum hydrocarbons initially increased the mobility of PCP in groundwater, but were subsequently degraded, leaving low concentrations of PCP in groundwater. Elevated concentrations of diesel and other fuel constituents were not detected during the RI. PCP is not likely to be found as free phase in the downgradient portion of the plume. These characteristics present challenges in investigation and remedy selection, as reflected in the discussion below. Figures 6 and 7 in Appendix B show the contaminant concentrations in the deep and shallow zones from the April 2015 sampling event.

Table 3 shows the groundwater contaminants of concern (COCs) and cleanup goals based on federal MCLs.

Table 3: Contaminants of Concern for Groundwater and MCLs

Constituent Name	Affected Media	MCL
PCP	Columbia Aquifer and Yorktown Aquifer	1 µg/L
Arsenic		10 µg/L
Chromium		100 µg/L

Note: µg/L = micrograms per liter; PCP = pentachlorophenol

Table 4 summarizes the affected and potentially affected media along with potential exposure and migration pathways. Table 5 lists RAOs for the site, as presented in the latest five-year review.

Table 4: Affected or Potentially Affected Media on Site

Medium	Location	Composition	Potential Exposure / Migration Pathways
Columbia Aquifer	Approximately 8 feet of saturated material beginning at 2 to 12 feet bgs	fine to coarse sand with some clay	• Direct exposure by excavation • Discharge to Godwin's Millpond and subsequent municipal use • Discharge to unnamed intermittent stream west of site
Yorktown Confining Unit	20 to 76 feet bgs	predominantly silt with shells, some sandy silt and clay	• Discharge to deeper Yorktown aquifer – primary public water supply
Surface Water	Intermittent stream on west side of site; Godwin's Millpond is 700 feet downgradient of the Saunders Property line	sandy bottom stream bed; pond is a Cypress swamp with mucky organic sediments	• Seeps on stream bank may discharge into stream, and into Godwin's Millpond • Godwin's Millpond is a municipal drinking water source

Table 5: Remedial Action Objectives as Described in the Record of Decision

Medium	Remedial Action Objective
Soils	Eliminating direct contact with the contaminated surface and subsurface soil, storm sewer sediments, and the wastewater pond sediments by excavating and treating those wastes prior to disposing in an approved off-site facility.
Concrete Pads	Reducing contaminant levels in the concrete pads by testing to determine whether they are characteristic hazardous waste, scarification and treatment of the top one inch of the pads if they are a characteristic waste, removal of any residual soil, and off-site disposal of the remaining portion of the pads.
Wastewater Pond	Eliminating direct contact with the water in the wastewater pond by treating and discharging of the water a determined during the remedial design (RD).
Storm Sewer	Reducing the contaminant levels in the existing concrete storm sewer by cleaning and slip-lining the sewer.

Medium	Remedial Action Objective
Groundwater	Evaluate the protectiveness of the remedial action through groundwater monitoring and implement institutional controls to prevent further migration of the PCP plume and use of the Columbia and Yorktown aquifers as a source of potable water.
Groundwater (from ROD Amendment)	Continue to operate and maintain the system to collect and treat groundwater to prevent further migration of the contamination and until PCP cleanup levels have reached the MCL of 1 µg/L.

3.2 Selected Remedies

The ROD initially identified soils and sediments in the wastewater ponds as the primary threat to human health and selected soil removal, treatment, and offsite disposal as the remedy. Remedial alternatives did not include long-term groundwater treatment because it was believed that the contaminated groundwater was limited to on-site and mass reduction of contaminant through soil excavation would reduce groundwater concentrations (EPA, 1991b). The 1991 ROD included only monitoring of groundwater, but was amended in 1996 to add a P&T system to control the migration of contaminants off-site towards Godwin's Millpond. Table 6 lists the components of the selected remedy in the order presented in the ROD Amendment (EPA, 1996).

Table 6: Remedy Components Documented in the ROD Amendment

Remedy Component	Target Medium	Description
Excavation, Treatment, and Disposal of Pond Sediments	Pond Sediment	Excavation and offsite incineration and disposal of the K001 sediments (wood treatment sludge) from the wastewater pond and the former earthen separation pond.
Excavation, Treatment, and Disposal, of Soil and Sewer Sediments	Soils and Storm Sewer Sediment	Excavation and offsite incineration and disposal of the Site soils and the sediments from the storm sewer.
Groundwater	Columbia Aquifer and Yorktown Aquifer	Operation and maintenance of the groundwater collection and treatment system constructed under EPA's time critical removal action to prevent further migration of Site contaminants and achieve PCP cleanup levels of 1 µg/L; includes treatment of the groundwater collected during the dewatering process prior to excavating the soil. Treatment may be either onsite or offsite.
Concrete Pad	Concrete Pad	Removal of the top one inch of the stained areas of the concrete pad, solidification and offsite disposal of the removed material, and removal of the concrete pad in the area requiring soil excavation with onsite disposal.
Cleaning and Lining of the Storm Sewer	Storm Sewer Sediment	The existing 8-inch concrete storm sewer will be cleaned of all debris and sediment and lined with a flexible high-density polyethylene pipe (the sewer was inspected with a closed circuit television camera during the remedial design).
Groundwater Monitoring	Columbia Aquifer and Yorktown Aquifer	Groundwater monitoring will be performed for thirty years to ascertain that the remedy is protective of human health and the environment.

Remedy Component	Target Medium	Description
Institutional Controls	Columbia Aquifer and Yorktown Aquifer	Institutional controls will be implemented to restrict access to the contaminated groundwater under the Site and to prevent movement of the PCP offsite. The institutional controls include deed restrictions on the Site to prohibit using either the Columbia aquifer or the Yorktown aquifer as a source of groundwater and restrictions on offsite groundwater extraction.

3.3 Current Completion Strategy

The ROD and ROD Amendment (EPA 1991b, 1996) set forth short-term expectations that the exposure to contaminated groundwater will be prevented, that plume migration will be controlled, and that source area soil will be remediated (including excavation and removal of any principal threat wastes). The ROD Amendment also sets the long-term expectation that the groundwater remedy will require less than 10 years to restore the aquifers. The Fund-lead remedy was transferred to the Commonwealth of Virginia in July 2009, 10 years after the P&T system was determined to be operational and functional (O&F).

4.0 DATA GAPS

This section presents key data gaps in site characterization and a review of the current remedial strategy based on discussions during the optimization review meeting and document review.

4.1 Data Gaps in Characterization

During the site meeting and document review, several key data gaps and uncertainties in the Saunders Supply Site CSM were identified. Table 7 prioritizes data gaps identified that may reduce the effectiveness of remedial actions.

Table 7: Identified Data Gaps

Medium	Data Gap	Implications
Groundwater – source area	Unknown distribution and mass of PCP in source area	Source area contaminant mass may act as a long term continuing source to downgradient areas.
Groundwater	Extent of contamination	The extent of contamination in the down gradient and cross-gradient areas west of the recovery wells is not well understood and may not be effectively captured and removed by the existing groundwater extraction and treatment system.
Groundwater	Potential for groundwater leakage from Columbia to Yorktown through irrigation well	Contaminants in the Columbia aquifer may be moving through the Kelly irrigation well into lower aquifer if the well was not properly sealed.
Surface Water	The interaction of the groundwater and surface water among the aquifers, intermittent stream, and Godwin's Millpond is not well understood.	Potential for groundwater discharge from Columbia and upper Yorktown to intermittent stream and Godwin's Millpond.

4.2 Review of Current Remedial Strategy

The optimization review team and site team discussed the current strategy for groundwater cleanup at the site. The existing P&T system was installed during 1998 as part of a time critical removal action to collect and treat the groundwater to prevent further migration of the contamination, but the 1996 ROD Amendment indicated that the system would be operated until groundwater cleanup levels were achieved. In its 18 years of operation, the P&T system has not effectively reduced groundwater concentrations in the aquifer. The remedy currently includes four extraction wells, three located along the axis of the plume (RW-1, RW-3, and RW-4) and one in the former wood treatment area (RW-5) (see Figures 2 and 4 in Appendix B). The extraction system delivers groundwater to the treatment building to remove contaminants (PCP, arsenic, and chromium) prior to effluent discharge to the storm drain located along Godwin Boulevard (State Route 10/32). The sequence of groundwater treatment is currently as follows:

- Groundwater is mixed with a solution of sodium carbonate in reaction tank T-1 and mixed with air from an air compressor to allow for the precipitation of iron and other heavy metals.
- Water flows from the reaction tank to the settling tank (T-2), which collects precipitated iron and other solids that settle.
- Water flows through four bag filters to remove solids.

- Two granular activated carbon (GAC) vessels arranged in two series (C1 and C2) are used to remove PCP.
- Effluent from the GAC units is collected in a holding tank (T-3) prior to its discharge to the storm drain.

While the current treatment system is adequate in meeting discharge criteria, the remedy has not succeeded in reducing contaminant concentrations in the aquifer and reaching groundwater cleanup levels (MCLs). Therefore, the optimization review team agrees that a revised strategy must be implemented that focuses on contaminant mass removal and aquifer restoration. The current remedy is not removing contaminant mass at a rate that would allow the site to reach completion in a reasonable timeframe. As such, a revised remedial approach is necessary that involves a combination of: additional source area and plume characterization, a better understanding of groundwater/surface water interactions, improved remedy effectiveness, P&T system refinements, additional remedy performance monitoring, and well-defined remedy operation completion criteria.

5.0 FINDINGS AND RECOMMENDATIONS

The findings and recommendations provided by the optimization review team address the site characterization data gaps identified in Section 4.1 and the remedial strategy data gaps in Section 4.2. Recommendations are provided for site characterization, remedial action objectives, remedy effectiveness, performance monitoring, and the development of remedy completion criteria.

Relative to the ROD, the recommended strategy ensures effectiveness of groundwater containment, raises the priority of mass removal to facilitate groundwater restoration, and emphasizes performance monitoring and timely shutdown of remedy components. Collectively, the recommendations help fill critical data gaps and satisfy the RAOs in a cost-efficient manner.

5.1 Recommendations to Characterize the Site for Remedy Refinement

The optimization review team assigns a high priority to source area characterization because aquifer restoration will be difficult and lengthy unless sufficient contaminant mass is located and removed. The optimization review team recommends a more comprehensive evaluation of the contaminant mass distribution and transport pathways to improve mass removal efficiency.

The primary source of PCP and metals contamination was contaminated soil and wastewater ponds located on north end of the Saunders property. These known sources were removed but more information on the current distribution of PCP and metals contamination in the source area as well as portions of the downgradient extent of contamination would be beneficial in order to determine if additional source remediation is necessary.

Benefits of Implementing Section 5.1 Recommendations

- High resolution site characterization of groundwater will help focus remedial activities on areas that will improve mass removal.
- Characterization of contaminant mass in place provides a basis for performance monitoring of ongoing and potential new remedial activities.

Recommendation 5.1.1: Delineate current extent of potential source and groundwater contamination at the source area

Finding: Contaminants are present in, and migrate through, the permeable sands of the Columbia aquifer, as evidenced by the downgradient concentrations of PCP in shallow monitoring wells. Recovery well RW-5, located near the former source area, accounts for most of the annual contaminant mass removal which indicates that the groundwater in the area has a high contaminant load. During the RI, PCP concentrations between 10,000 μg/L and 19,000 μg/L were detected in the source area. Elevated concentrations of carrier oil constituents were not detected, suggesting that the petroleum hydrocarbons initially increased the mobility of PCP in groundwater, but were subsequently degraded (E&E, 1991). PCP may be held in the fine grained sands and silts of the Columbia aquifer and upper part of the Yorktown Confining Unit immediately underlying the Columbia and act as a continuing source. Understanding the total contaminant mass and distribution in the source area is necessary to refine the remedy and develop performance monitoring criteria.

The site team stated that during the installation of recovery well RW-5 in 2010, an investigation was performed and soil and/or groundwater samples were collected. Unfortunately, the optimization review team was unable to locate this documentation.

Recommendations: The optimization review team recommends PCP and metals characterization of the source area for both the Columbia aquifer and the Yorktown Confining Unit. The objective would be to characterize the distribution of the mass in the aquifer and develop an estimate of the contaminant mass remaining in the subsurface.

The optimization review team recommends using EPA's strategic sampling strategy of high resolution site characterization (HRSC) in the source area. Transect-based HRSC investigations will better define the more highly contaminated plume core in relation to the less contaminated dissolved phase plume when oriented accurately in their geologic settings.

HRSC data will help accurately depict the footprint of subsurface contamination in order to apply targeted actions, should they be deemed to be necessary. The optimization review team recommends initiating the HRSC in the vicinity of RW-5 on the Saunders property using an east-west oriented transects near the Former Wastewater Pond source area and Former Wood Treating Process Area. Real time data, combined with site action levels, can be used to identify the western edge of the transect. If data support further characterization, parallel transects can be made further north, within the Kelly property. A second location for an east-west HRSC transect is recommended on the Kelly property between the fence and MW-7S/8D to characterize the Conical Burn Pit source area and Former Wood Treating Process Area. In each of these locations, discrete soil and groundwater samples should be collected for PCP, arsenic, and chromium analysis in the Columbia and upper Yorktown Confining Unit to assess contaminant mass and transport. The approximate location of these transects is shown in Figure 6 in Appendix B.

On-site field laboratory with gas chromatograph/mass spectrometry (GC/MS) capability could be used for analysis of PCP, but may be costly for a small field program. Analysis of arsenic and chromium would require an off-site laboratory.

The optimization review team also recommends collecting high resolution data of aquifer properties near the Former Wastewater Pond, Conical Burn Pit, and Former Wood Treating Process Area (hydrostratigraphic sampling) to obtain relative permeability data in order to define potential areas of contaminant storage and better understand the differences in flow characteristics of the Columbia and Yorktown Confining Unit. Hydraulic conductivity data will support contaminant transport analysis and mass removal remedy evaluation.

Based on discussions during the optimization review, the optimization review team estimates that additional investigation of the source area with onsite laboratory analysis for PCP and offsite laboratory analysis for arsenic and chromium would cost approximately $50,000, if performed in conjunction with other site investigation work recommended in this optimization.

Recommendation 5.1.2: Delineate current extent of contamination in groundwater in the western portion of the downgradient plume area for both the Columbia aquifer and the Yorktown Confining Unit

Finding: Groundwater flow at the site is generally to the north with a slight westerly component. Groundwater from the Columbia aquifer breaks out in seeps on the eastern bank of the unnamed intermittent stream. Monitoring wells MW-9S and MW-10D are the only groundwater monitoring points on the west side of the plume. Over the last five years of monitoring, concentrations of PCP have varied between non-detect (<0.1 µg/L) and 11.9 µg/L in these wells with no apparent upward or downward trend. Samples from the deep well (MW-10D) exceed the MCL of 1 µg/L more often than the shallow well (MW-9S).

Several well screens, including MW-8D and MW-12D, appear to intersect both the Columbia and upper portion of the Yorktown Confining Unit. Groundwater samples collected from these wells likely originate from the most permeable flow zones in the Columbia, and may not reflect the conditions in the Yorktown Confining Unit. Wells that intersect both hydrostratigraphic units should be abandoned and may need to be replaced with wells with shorter well screens in discrete units, using the results of the HRSC described in this recommendation.

Recommendations: The optimization review team recommends applying an HRSC approach for characterizing the extent of contamination to the south and north of MW-9S and MW-10D well pair to better understand the extent of contamination and the nature of contaminant transport between the Columba aquifer and the upper Yorktown Confining Unit.

Direct-push HRSC methods can be used to identify the edge of the groundwater plume exceeding MCLs and to select the locations and depths for shallow and deep well screens for new permanent monitoring wells. Samples at the proposed new location should show low to non-detect levels of PCP and metals in both the shallow and deep zones. The new well locations should be sampled at the same frequency as all other monitoring wells to confirm delineation of the plume.

The optimization review team also recommends HRSC of the downgradient plume area (see Figure 6 in Appendix B) to support estimation of contaminant mass, build a detailed conceptual model of the plume, and evaluate the effectiveness of potential refinements to the remedy described below in Recommendation 5.3. Boring logs from continuous direct-push technology (DPT) profiling of the Columbia aquifer during the 2005 Deep Groundwater Investigation (CDM, 2005) shows thick layers of sand locally broken by lenses of fat clay. The 10-foot well screens in the existing monitoring wells, and the 15 foot screens in the existing recovery wells expose large sections of the Columbia aquifer and lesser parts of the upper Yorktown Confining Unit, and may contain stratified flow zones separated by less permeable zones. Contaminant flow may be concentrated in thin permeable zones and the existing screens may not provide fine enough resolution to focus removal on the preferential transport zones for PCP and metals. High resolution groundwater contaminant and hydraulic profiling can be used to increase the vertical resolution of contaminant distribution.

Based on discussions during the optimization review, the optimization review team estimates that additional investigation of the downgradient plume area would cost approximately $50,000 if this work is performed in conjunction with the source area characterization described in Recommendation 5.1.1. The annual cost for monitoring new wells installed following the recommended characterization (assumed to be two well pairs, or four wells) would be approximately $3,600 per year.

Recommendation 5.1.3: Better characterization of groundwater, stream, and Godwin's Millpond interaction

Finding: Godwin's Millpond is the downgradient discharge point for groundwater from the Columbia aquifer and the small amount of flow that may come from the Yorktown Confining Unit. Godwin's Millpond is also the discharge point for surface water from the intermittent stream, including any seepage from the Columbia aquifer breakouts observed in the stream bank. Only one deep monitoring well (MW-19D) adjacent to Godwin's Millpond is currently sampled to assess potential contaminant migration into the pond. According to the site team, approximately 1.7 million gallons of water per day are withdrawn from Godwin's Millpond to supply drinking water for the City of Suffolk, Virginia. The optimization review team found no information on the hydrologic effects of these large water supply withdrawals on contaminant movement and believes that additional hydrologic and chemical characterization is needed to ensure plume migration remedial objectives will continue to be met.

Recommendations: Specifically, the optimization review team recommends:

- Installing a shallow monitoring well screened in the Columbia aquifer to characterize groundwater quality at the downgradient discharge location near Godwin's Millpond. This new shallow well would complement the existing deep monitoring well MW-19D and serve as an additional sentinel well. The HRSC data from the additional characterization described in Recommendations 5.1.1 and 5.1.2 should be used to assist in determining the screened interval depth of the new well.
- Characterizing the location, flow, and contaminant content of seeps along the banks of the intermittent stream to determine the amount and chemical nature of groundwater from the Columbia aquifer entering the stream. Thermal imaging is a potential method to map the location of seeps. Placement of piezometers in the stream bed and adjacent areas to develop groundwater flow nets can also be used detect discharge points. Direct sampling of seeps with larger flow rates may be possible; otherwise pore-water sampling devices may be required. Passive diffusion bag (PDB) samplers are not likely to be effective for PCP.
- Determining if withdrawal of water from Godwin's Millpond affects the groundwater flow direction or rate. Extracting large quantities of water from the downgradient aquifer could accelerate groundwater flow and draw contaminants further downgradient, towards the pond. The optimization review team found no documentation on the rate or frequency of extraction, the location of the extraction point, or the hydrologic effects of extraction on the Saunders site conditions. This information may be available from county or city offices. If the data are not available, hydrologic modeling should be used to estimate the effects of pumping.

Based on discussions during the optimization review, the optimization review team estimates that additional investigation of the groundwater, stream, and Godwin's Millpond interaction would cost approximately $20,000 (excluding hydrologic modeling). Installation of a shallow well would cost approximately $5,000 and add $500 per year to annual monitoring costs.

5.2 Recommendations to Confirm Exposure Assumptions

Finding: The RAOs for the site are based on exposure assumptions and associated data collected prior to 1991.

Recommendations: It should be confirmed that the RAOs are consistent with current site conditions and exposed populations. The optimization review team supports the following activities to ensure future actions are aligned with RAOs that reflect current conditions and exposures:

- Confirm and document that no on-site or off-site private wells (drinking or irrigation) have been installed since the previous survey in 1991.
- Verify and document the closure of the Kelly irrigation well and that it is not acting as a potential vertical conduit for transfer of contaminants from the Columbia aquifer to lower hydrostratigraphic units.
- Include city sampling data in the annual site O&M and Monitoring reports to confirm that Godwin's Millpond is free of site-related contamination.

Benefits of Implementing Section 5.2 Recommendations

- Confirming the exposure assumptions will help ensure the optimization recommendations address current conditions.

Based on discussions during the optimization review, the optimization review team estimates that verification of the items above would cost approximately $5,000, and revision to the sampling and reporting to incorporate city sampling data would cost approximately $500 per year.

5.3 Recommendations for Improving Remedy Effectiveness

<u>Finding:</u> The current remedy is designed to contain groundwater so that it does not migrate to the public drinking water supply (Godwin's Millpond) along with reducing concentrations of PCP in the underlying aquifers. The capture zone analysis presented in the 2006 Hydrologic Analysis Report (CDM, 2006b), prepared prior to the installation of RW-5, concluded that the majority of the PCP plume and all of the arsenic plume are within the capture zone, but elevated chromium concentrations at MW-9S may not be within the capture zone (Figure 4-5 in Appendix B). The lack of current groundwater data south and west of MW-9 raises uncertainty of the extent of the complete capture of the plume in the area.

Over the last three years, a small mass of COCs has been removed by the P&T system (see Table 8, from annual O&M reports). Prior to 2012, COC mass removal rates were similar; the total quantity of PCP removed from all of the wells through the December 2007 quarterly monitoring event is 0.64 lbs (CDM, 2007). Based on this removal rate, it would likely take decades to reach MCLs and site closure.

Benefits of Implementing Section 5.3 Recommendations

- Improving the extraction rate of the existing pumping system would increase mass removal while ensuring groundwater containment.
- Updating the CSM with high resolution data will provide a better target for focused remedial activities.
- Applying a combined remedy approach will increase mass removal and reduce time to site closure.
- Without additional mass removal, the current system is not expected to reach cleanup goals for many decades, if it can be achieved at all.

Table 8: Contaminant Mass Removed 2012 - 2015

Year	Mass of PCP Removed (lb)	Mass of Arsenic Removed (lb)	Mass of Chromium Removed (lb)
2012-2013	0.011	0.003	0.0025
2013-2014	0.06	0.006	0.007
2014-2015	1.142	0.0117	0.0049
Total	**1.213**	**0.0207**	**0.0144**

<u>Recommendations:</u> The optimization review team supports a sequenced approach to improve the effectiveness of the current remedy and consideration of other treatment technologies to enhance the mass removal.

- Following the additional characterization described in Section 5.1, perform an updated capture zone analysis to evaluate if the current groundwater P&T system is effectively capturing the lateral and vertical extent of contamination. The prior capture zone analysis (CDM, 2006b) was completed before the installation of extraction well RW-5 and may not be representative of current plume conditions and extraction well pumping rates.
- If the updated capture zone analysis indicates that the current P&T system is not adequately containing the contaminant plume, improve the extraction rate and treatment system capacity of the current groundwater P&T system (as described in Recommendations 5.4.1 and 5.4.2) to ensure adequate plume containment and to maximize contaminant mass removal.
- Update the CSM to reflect the current distribution and mass of contaminants in the source area and downgradient area using HRSC characterization data.
- Update the CSM to reflect findings of the hydrologic characterization including the relationship of the groundwater, intermittent stream, and Godwin's Millpond.

- Evaluate potential in-situ technologies to supplement the existing groundwater extraction system that will improve the mass removal rate of PCP and metals.
    - Using HRSC data, identify the highest concentration areas for source treatment.
    - In Situ Chemical Oxidation (permanganate or persulfate) and In Situ Enhanced Bioremediation have shown to be successful in reducing PCP mass at other wood treating sites over relatively short periods. Site-specific testing of these technologies would be required to determine the most effective treatment for the site conditions, and to assess whether the in-situ technologies would have any unintended consequences on the remedy, such as mobilizing metals into the groundwater.
- Use a combined remedy approach to reduce contaminant mass while continuing to provide containment. For example, continue to use the existing P&T system to provide plume control and containment, while conducting targeted in-situ treatment of high concentration zones within the source area to reduce contaminant mass.

Costs for improvements to the treatment system are addressed in Recommendations 5.4.1 and 5.4.2. Costs for updating the CSM with additional characterization data are addressed in Recommendations 5.1.1, 5.1.2, and 5.1.3. Updating the capture zone analysis is estimated to cost approximately $10,000. Evaluating potential options for enhancing the existing system performance is estimated to cost approximately $30,000. The optimization review team cannot estimate the cost of applying additional remedies at the site until the further site characterization is conducted.

5.4 Recommendations for Current Extraction and Treatment System Improvements

Benefits of Implementing Section 5.4 Recommendations

- Improve hydraulic control/ containment of plume
- Increase contaminant mass removal and shorten time to site closure

The additional site characterization recommendations presented in Section 5.1, if implemented, are likely to take some time. Therefore, to ensure that adequate containment of the contaminant plume is achieved during this timeframe, the remedy should continue to include operation of the P&T system. Many of the system improvements presented below (including extraction well redevelopment) are a standard component of an effective O&M program, and as such, should be implemented regardless of whether the other recommendations are implemented. However, other specific recommendation presented below (including the replacement or relocation of extraction wells) should be determined only after additional characterization and an updated capture zone analysis have been completed.

Recommendation 5.4.1: Improve extraction well pumping rates to increase plume capture and maximize contaminant mass removal

Finding: Over the last several years, the extraction system has had a total combined pumping rate (from all four extraction wells, RW-1, RW-2, RW-4, and RW-5) of less than approximately 0.75 gallons per minute (gpm). The total volume extracted during the last few years is summarized in Table 9.

Table 9: Groundwater Extracted by P&T System from 2012 to 2015

Period	Gallons Extracted/ Year	Gallons/Month	Gallons/Minute
July 2014 - June 2015	391,002	32,584	0.74
July 2013 - June 2014	85,972	7,164	0.16
July 2012 - June 2013	135,224	11,269	0.26

Data tables presented in the 2005 O&M and Monitoring Report (CDM, 2006a) indicate that combined flow rates from four wells during the 1998 to 2005 timeframe ranged from approximately 25,000 to 80,000 gallons per month (or approximately 0.57 to 1.82 gpm), significantly higher than current rates.

Extraction well RW-5, the newest well, was installed in January 2010 in an effort to increase the recovery of PCP near the former wood treating process area. Since its installation, RW-5 has consistently accounted for the greatest volume of pumping (ranging from 39- to 87-percent of the total) and the highest rate of contaminant mass removal of all four wells. The extraction well located the farthest downgradient at the edge of the plume, RW-4, has accounted for the second highest volume (ranging from 4- to 32-percent of the total). The other two extraction wells, RW-1 and RW-2, have had the lowest pumping rates and have accounted for generally less than 5- to 15-percent of the total pumping.

Extraction pumps are routinely cleaned (every month or every other month) by system operators to prevent iron-scale buildup and fouling of the impellers. However, despite the procedures outlined in the 2003 O&M Manual (CDM, 2003), routine extraction well redevelopment has not been performed, at least not since 2009 when VDEQ assumed responsibility of O&M activities. The reduced yields that have been observed from extraction wells are likely due to iron fouling of the well screens and the gravel pack surrounding the well. In this case, while the pump will produce at the desired rate, more frequent pump shut downs will occur due to triggering low water level conditions, thus lowering the overall volume of water produced from the well.

In addition to fouling and clogging of the extraction wells themselves, iron-scale has also likely reduced the effective diameter of the piping that conveys water from the well to the treatment system building. Iron-scale buildup in this piping may also be limiting the amount of water that can be pumped to and treated by the system.

Recommendations: The updated capture zone analysis described in Recommendation 5.3 should be evaluated to determine whether containment is adequate based on current day plume configuration and extraction well pumping rates. If it is not, the optimization review team recommends improving the effectiveness of the extraction system. In order to maintain adequate plume capture and maximize contaminant mass removal, the following activities should be completed.

- Redevelop all four existing extraction wells. Redevelopment can be accomplished using a mechanical surge and pump method. If fouling and clogging are significant, chemical redevelopment methods (for example, muriatic acid) may be necessary. Continuously reevaluate extraction well pumping rates and perform routine extraction well redevelopment to sustain higher yields.
- If extraction well redevelopment efforts do not improve yields, abandon and replace the under-performing extraction wells with new extraction wells. Prior to replacing existing extraction wells in their current position, consider relocating the new wells to areas with higher observed contaminant concentrations based on the additional characterization activities suggested in Recommendation 5.1.1 to improve mass removal. Consider the use of horizontal extraction wells if the characterization (Recommendations 5.1.1 and 5.1.2) identifies favorable conditions such as continuous elongated areas of elevated groundwater concentrations.
- Replace piping that conveys pumped water from the extraction well vaults to the treatment system building.

The optimization review team estimates that the extraction well redevelopment, extraction well replacement, and pipe replacement would cost approximately $35,000, and an increase of approximately $5,000 per year in routine O&M.

Recommendation 5.4.2: Improve treatment system capacity

Finding: At its current pumping rates, the treatment system is effectively reducing contaminant concentrations to below required discharge limits for PCP, arsenic, and chromium. While many of the system components are original (including reaction tank T-1, settling tank T-2, bag filters, and holding tank T-3), they continue to perform adequately. The GAC canisters and their associated tubing/piping were replaced in June 2015 and are in excellent condition. Three dual-media filters that were part of the originally constructed treatment system are no longer in use, and have been replaced by bag filters, which are in good condition and operate effectively.

However, like the extraction wells, many of the treatment system components and related piping are operating below their design flow rates and have not been maintained to allow for maximum flow, if needed. Based on operator observations, there is significant iron-scale build up inside the piping between several components of the system. Additionally, there is significant sedimentation and sludge buildup in the soda ash reaction tank (T-1), the settling tank (T-2), and possibly the effluent holding tank (T-3). If the extraction well redevelopment and replacement efforts discussed in Recommendations 5.4.1 are successful, it is possible that additional treatment capacity will be needed to meet the increased flow rates.

Recommendations: In order to improve the treatment system capacity, the optimization review team recommends completing the following activities.

- Evaluate the degree of iron-scale buildup in treatment system manifolds and piping and replace any piping that is heavily scaled.
- Evaluate the degree of scaling and fouling of flow meters, sensors, and valves. Clean or replace impacted meters, sensors, and values.
- Implement routine maintenance program to flush and clean lines, meters, sensors, and valves to minimize future scaling.
- Gauge depth of sedimentation in the soda ash reaction tank (T-1), the settling tank (T-2), and holding tank (T-3). If excessive accumulation of sedimentation and sludge is present, test and dispose of sediment and sludge using a properly licensed waste handler.

The optimization review team estimates that the treatment system improvements would cost approximately $20,000, and an increase of approximately $2,500 per year in routine O&M.

5.5 Recommendations for Remedy Performance Monitoring

Recommendation 5.5.1: Update remedy performance monitoring

Benefits of Implementing Section 5.5 Recommendations

- Cost-effective monitoring program and performance metrics to optimize remedy operation and shutdown remedy components in a timely manner.

Finding: Based on a recommendation from a 2005 optimization review of the Saunders site (EPA, 2005), the frequency of monitoring well and treatment system sampling was reduced to semi-annual and quarterly, respectively. Given the current pumping and mass removal rates of the system, this frequency is adequate. Additionally, the current annual O&M and monitoring reports provide an adequate assessment of various remedy performance metrics, including: groundwater elevation contour maps to assess hydraulic control and capture of the plume in the shallow and deep aquifers; contaminant concentration data and associated trend plots to assess overall aquifer restoration; calculations to evaluate contaminant removal efficiencies of the treatment system; and mass recovery and removal calculations to assess overall aquifer restoration. These data should continue to be collected and reported.

<u>Recommendations:</u> To ensure that the performance monitoring procedures remain relevant to the remedy as it continues to operate into the future, the optimization review team recommends completing the following activities.

- Update the O&M Manual. The O&M Manual being used by the site operator was developed in 2003, and several changes to the monitoring and O&M program have been made since then, including sampling frequency reduction, discontinued use of the media filters, and installation of new GAC canisters. Additional updates should be made to reflect any new updates to the remedy based on recommendations implemented as a result of this optimization review. Having an up-to-date O&M Manual will ensure that the proper performance monitoring will be conducted into the future to adequately assess remedy progress and ultimate site closure.
- Include concentration contour plots for PCP, arsenic, and chromium for the shallow and deep intervals of the aquifer in the annual O&M and monitoring reports to better illustrates the plume footprint. These figures will allow for a more robust assessment of plume capture as well as concentration trends over time.
- Collect quarterly effluent samples after the second GAC canister to ensure that the treated water being discharged to the storm drain located along Godwin Boulevard (State Route 10/32) meets required discharge limits. These data will also be helpful in evaluating potential contaminant breakthrough in the GAC canisters, particularly if flow and mass removal rates improve as a result of other implemented recommendations from in this report.

Additional recommended remedy performance metrics include:

- Estimate total sorbed mass in the source area and compare with mass removal by P&T, or other selected remedies.
- Statistical trend tests should be performed for groundwater data and included in five-year reviews. Trend tests can be performed for datasets with four or more sampling events. A non-parametric test for trend, such as the Mann-Kendall test, is recommended to track groundwater response to remedial actions. Semi-annual to annual sampling will generate datasets of sufficient size to develop trends. Historical concentration data can be mined to determine the variability and confidence intervals around concentration estimates.
- A mass discharge or mass flux approach to assessing remedial performance can be effective in demonstrating plume control and reduction in total mass (Farhat, Newell et al. 2006; ITRC 2010). Initial mass estimates can be made using new site characterization data collected as part of Recommendation 5.1.1 and 5.1.2. Mass flux calculations can be performed during the five-year review process and compared with pre-remedy estimates to evaluate the efficacy of source treatment.
- Many software and analytical tools are available to evaluate trends and mass distribution in groundwater plumes. Recommendations provided above are intended to guide discussion of more specific remedy performance evaluation tools and methods. Each remedy and remedy stage should have detailed data quality objectives (DQOs), data management strategies, and a data analysis plan when the remedies are designed and implemented.

Updating the O&M Manual and preparing the necessary data sets and calculation systems for mass and statistical analysis will require an initial cost of approximately $13,000. The incremental costs for the additional recommended remedy performance monitoring activities are estimated to be $7,000 per year.

Remedy performance monitoring involves using routine groundwater sampling results from existing and recommended new wells, and the analyses described above.

5.6 Recommendation for Establishing Remedy Operation Completion Criteria

Benefits of Implementing Section 5.6 Recommendations
• Criteria to help avoid operating long-term remedies longer than necessary.

Findings: Establishing remedy operation completion criteria, or performance metrics, for each remedy component can help reduce the risk of operating a remedy past the point of effectiveness. Completion criteria are remedy-specific recommendations developed to evaluate the cost and benefit of continued operation of each remedy component.

Recommendations: Completion criteria for each remedy component should be developed by the site team. The optimization review team provides the following suggestions by remedy component for consideration by the site team.

- P&T system for plume control and containment
  - The completion criterion for a specific extraction zone (such as source area and downgradient plume) for the P&T hydraulic control component could be based on the PCP, arsenic, and chromium concentrations and mass discharge at that extraction zone, relative to a predetermined threshold below which unacceptable plume migration will not occur.
- P&T system for aquifer restoration
  - The completion criterion for the P&T aquifer restoration component could be based on observable decreasing PCP, arsenic, and chromium concentration trends at monitoring wells within the source area and the downgradient plume, and a decreasing plume footprint over time. The data from each monitoring well should be evaluated to confirm that PCP, arsenic, and chromium concentrations are reduced to below the MCL cleanup goals. Existing EPA guidance and tools that might be used to develop or evaluate such completion criteria include:
    - Groundwater Road Map (http://semspub.epa.gov/src/document/HQ/174480),
    - Groundwater Remedy Completion Strategy (http://semspub.epa.gov/src/document/HQ/100000021), and Groundwater Statistics Tool (http://semspub.epa.gov/src/document/HQ/174595 and https://semspub.epa.gov/work/HQ/189718.pdf.
- Alternative (non-P&T) remedy, if deemed necessary based on additional characterization and delineation of the source area and downgradient plume. Completion criterion for an alternative remedy could include several possibilities, depending largely on the specific technology that is implemented. These could include: a contaminant mass removal and reduction rates in the target treatment zone that is small relative to the initial mass removal rate at a start-up of the alternative remedy; a mass removal rate relative to the current mass flux from the source area to the dissolved plume; or concentration trends in monitoring wells located within the target treatment area.

Additional study by the site team would be needed to help define reasonable completion criteria for the various remedy components to help avoid unnecessary operation of these remedies. Changes to the remedy would likely require a remedy modification, such as an ESD or amended ROD, as determined by lead agency.

5.7 Recommendations for Green Remediation and Environmental Footprint Reduction

Findings: The current P&T system is a relatively small operation that does not require a significant amount of electrical power to operate. The four extraction wells use ½ horsepower submersible pumps that operate intermittently, and the pumps within the treatment system (chemical feed pump, transfer pumps, effluent pump) also operate intermittently in a batch treatment process. Additionally, site operators indicate that very little water is used to support O&M of the system. In fact, treated effluent is typically used for routine maintenance activities, such as cleaning pumps and flow meters, cleaning the bag filters, and backwashing the GAC canisters.

The P&T system operator indicated that a renewable energy vendor visited the site in the recent past to evaluate the feasibility of installing solar photovoltaics (PV) to power the P&T system. However, given the relatively low electricity demand of the P&T system, the capital and operating cost of the solar PV system outweighed the potential benefits that it might provide to the site. Therefore, this alternative renewable energy source was not implemented.

Recommendations: Due to the relatively small environmental footprint of the current P&T system, no specific recommendations have been provided for green remediation or environmental footprint reduction. However, several of the above optimization recommendations have the potential to reduce the remedy footprint by either streamlining the treatment process or reducing the likelihood of operating a remedy component past the point of measureable benefit in achieving the RAOs. Additionally, implementation of the recommendations could result in achievement of restoration in a shorter time frame, and thus reducing the remedies overall environmental footprint.

Table 10: Recommendation Summary

Recommendation	Remedy Effectiveness	Cost Reduction	Technical Improvement	Site Closure	Environmental Footprint Reduction	Capital Cost	Change in Annual Cost
5.1.1: Delineate current extent of potential source and groundwater contamination at the source area.	X	X	X			$50,000	N/A
5.1.2: Delineate current extent of contamination in groundwater in the western portion of the downgradient plume area for both the Columbia aquifer and the Yorktown Confining Unit	X	X	X			$50,000	$3,600
5.1.3: Better characterization of groundwater, stream, and Godwin's Millpond interaction	X	X	X			$25,000	$500
5.2 Confirm Exposure Assumptions				X		$5,000	$500
5.3 Improving Remedy Effectiveness	X	X	X	X		$40,000	N/A
5.4.1 Improve extraction well pumping rates to increase plume capture and maximize contaminant mass removal	X		X	X		$35,000	$5,000
5.4.2 Improve treatment system capacity	X		X	X		$20,000	$2,500
5.5.1 Update Remedy Performance Monitoring	X	X	X	X		$13,000	$7,000
5.6: Establishing Remedy Operation Completion Criteria	X			X	X	N/A	N/A

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

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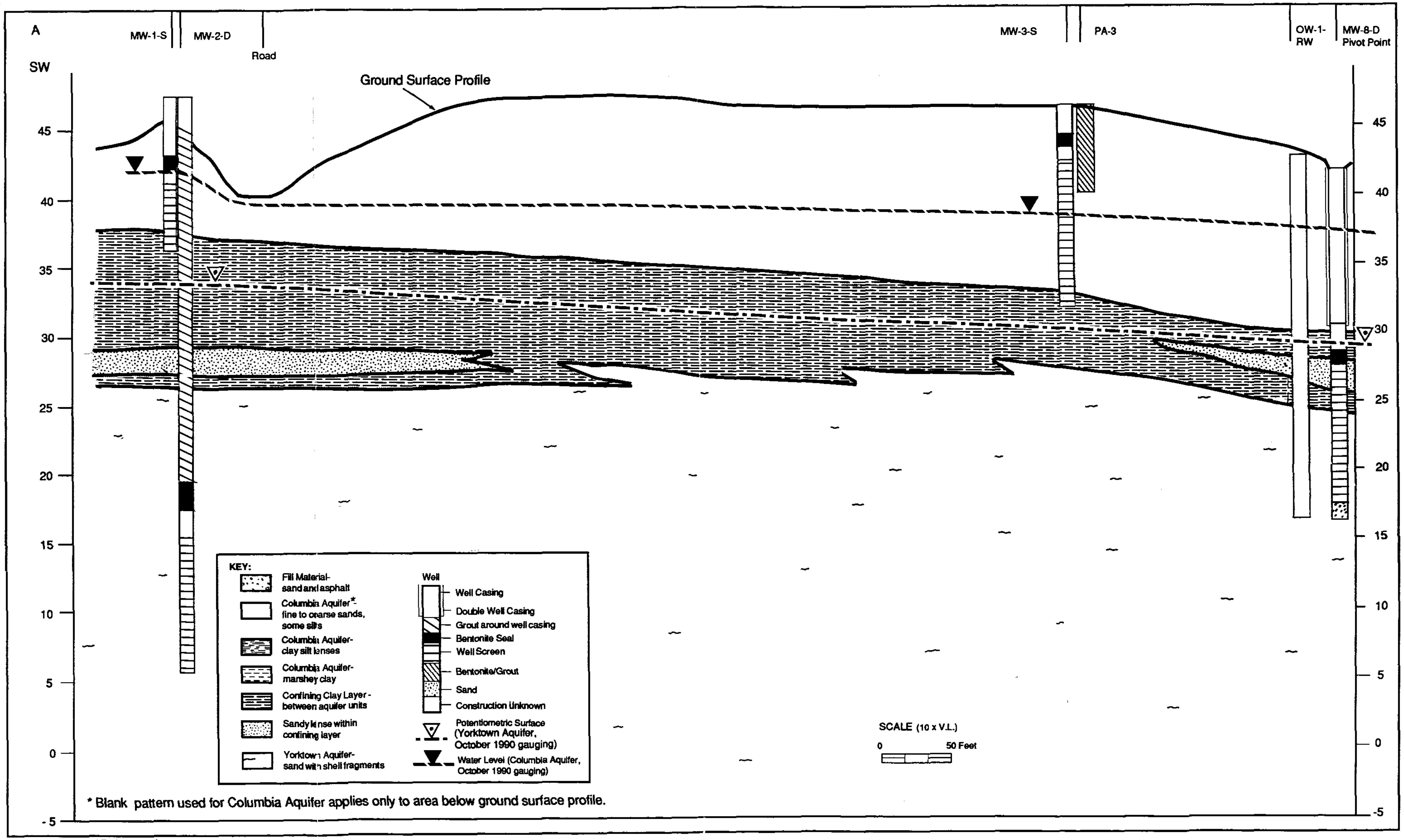
APPENDIX B

SUPPORTING FIGURES FROM EXISTING DOCUMENTS

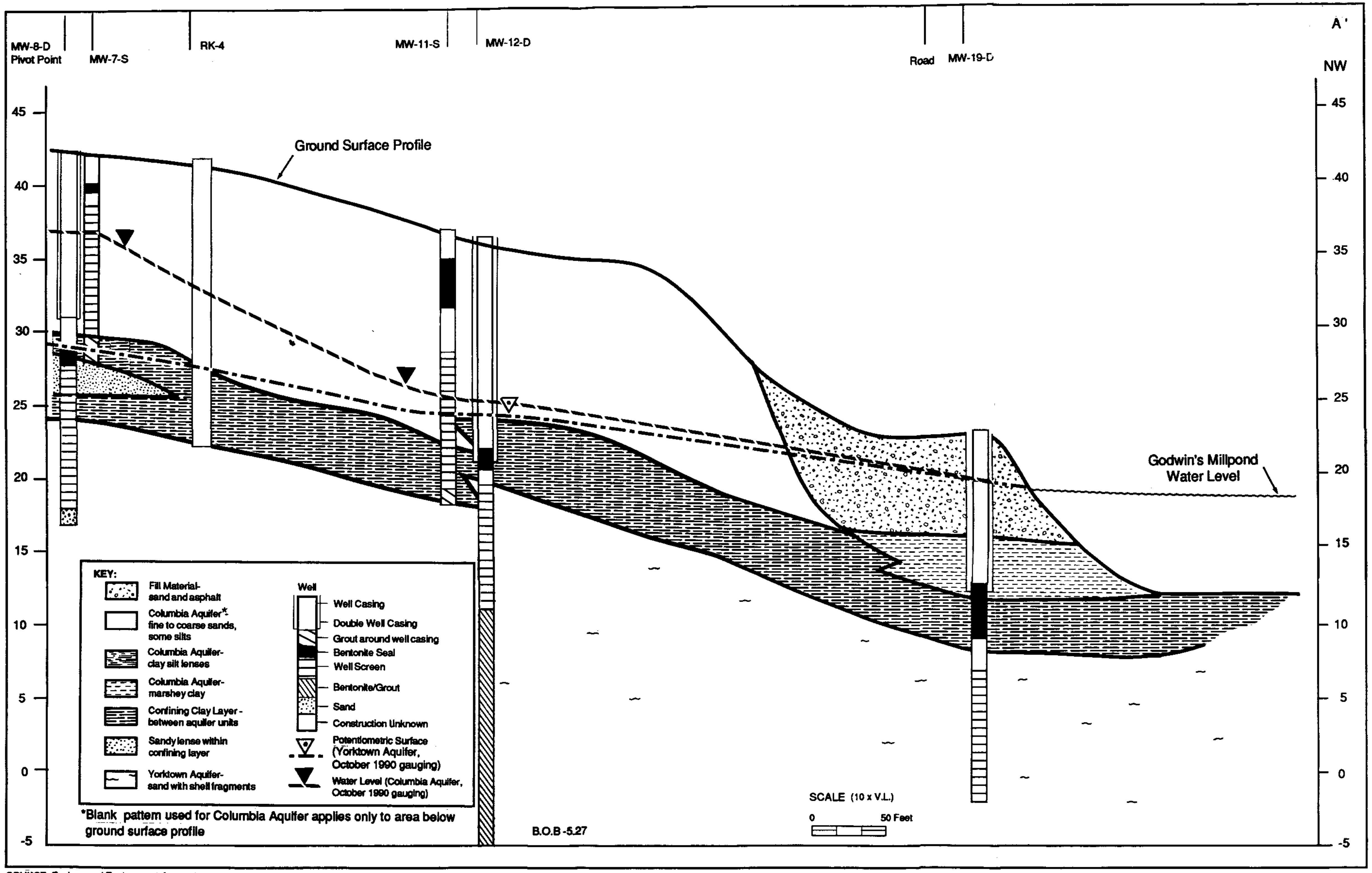
SOURCE: Ecology and Environment, Inc. 1991.

Figure 4-1
CROSS SECTION LOCATIONS



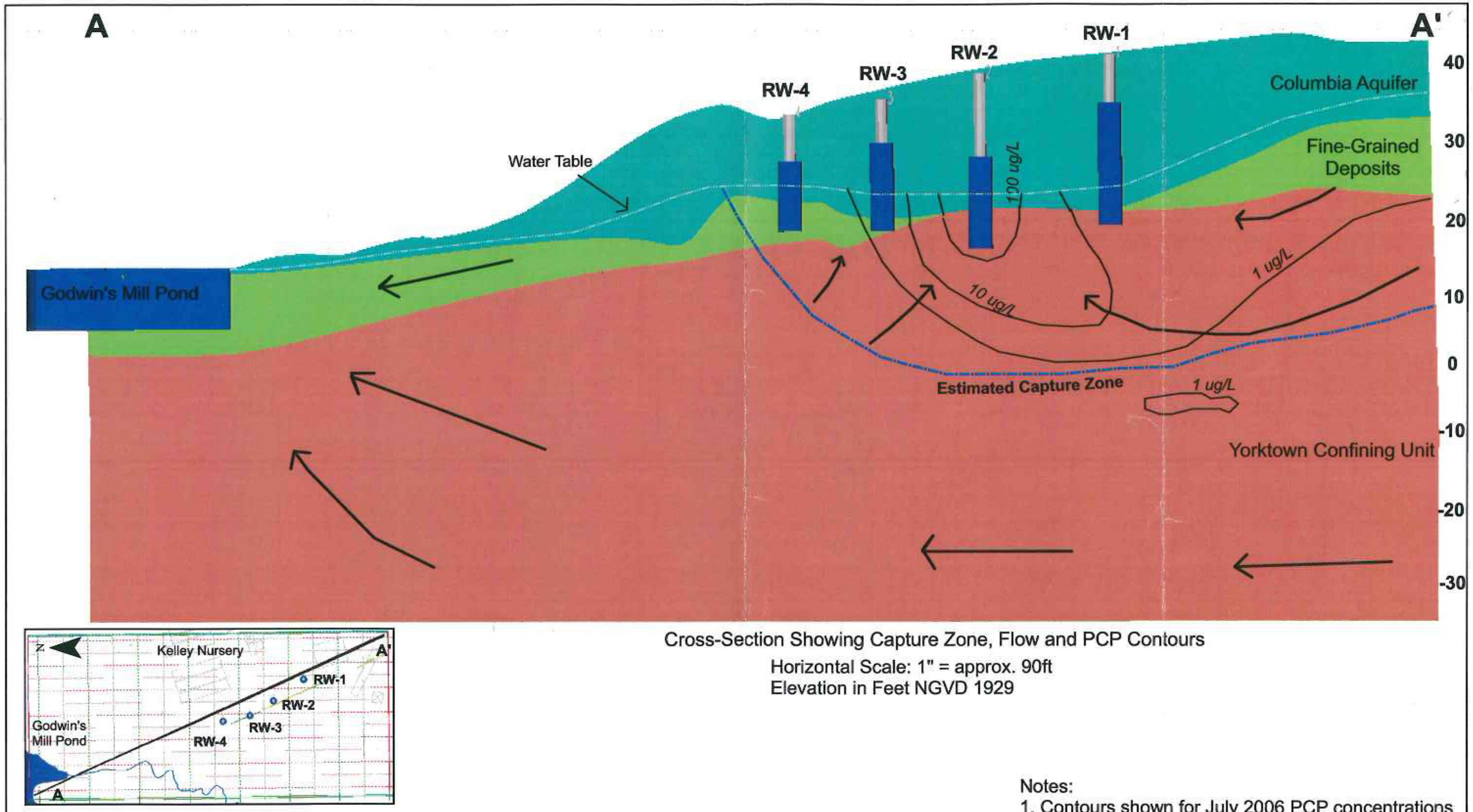
SOURCE: Ecology and Environment, Inc. 1991.

Figure 4-2a
CROSS SECTION A TO A'
PAGE 1 OF 2



SOURCE: Ecology and Environment, Inc. 1991.

Figure 4-2b
CROSS SECTION A TO A'
PAGE 2 OF 2



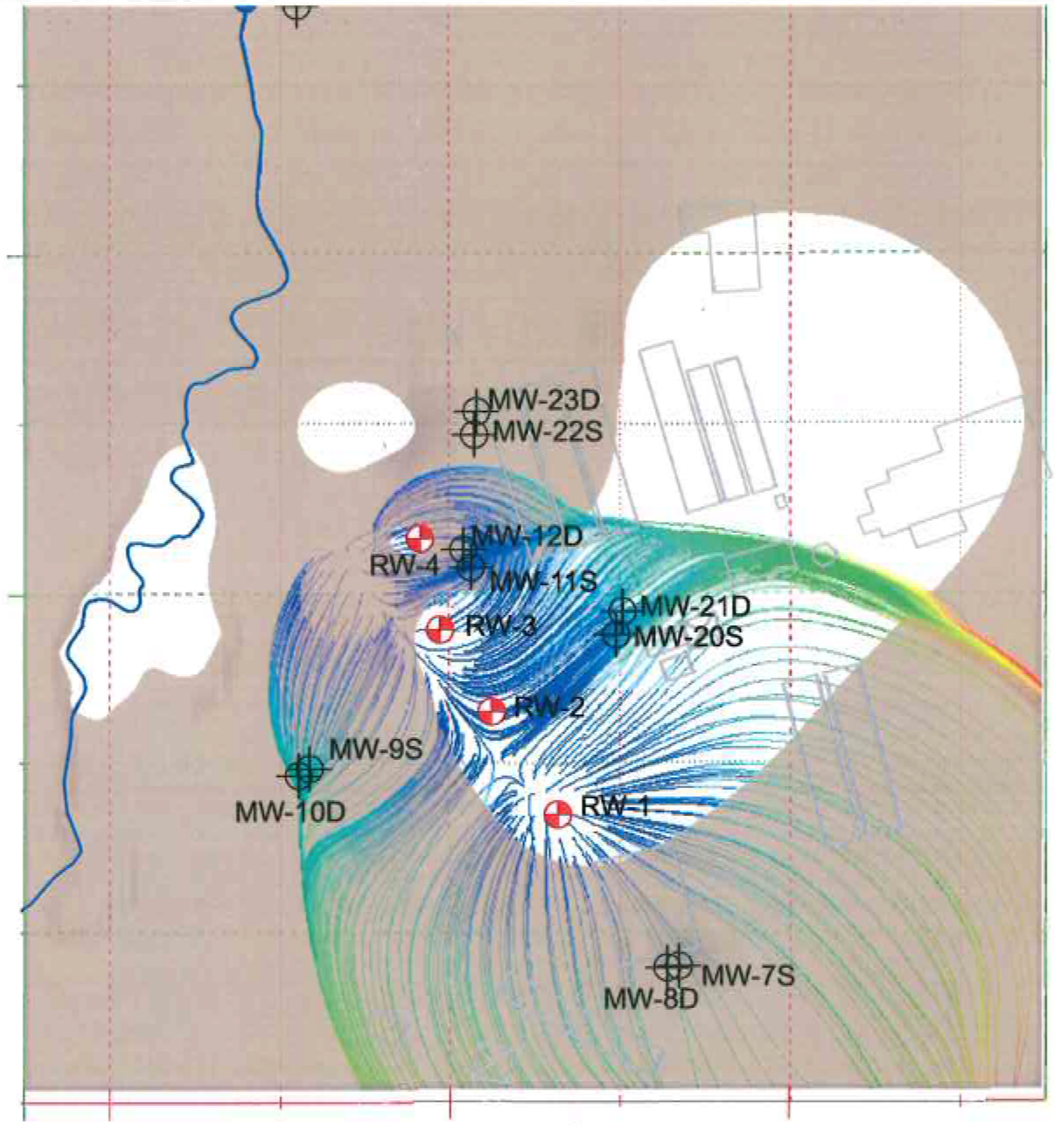
Cross-Section Location

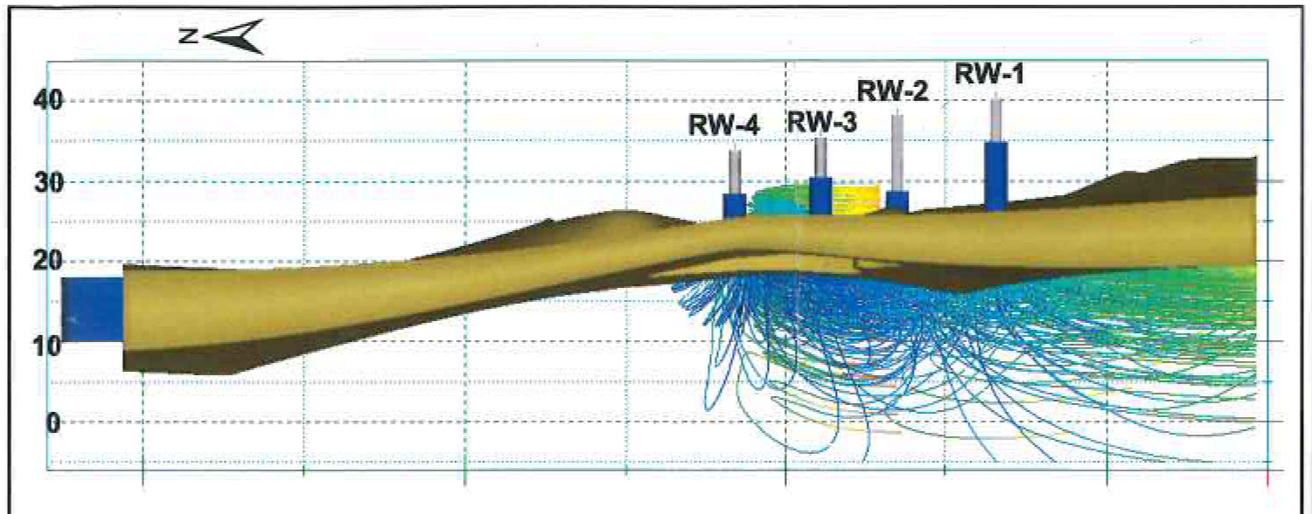
Cross-Section Showing Capture Zone, Flow and PCP Contours

Horizontal Scale: 1" = approx. 90ft
Elevation in Feet NGVD 1929

Notes:
1. Contours shown for July 2006 PCP concentrations
2. Vertical exaggeration = 5

F:\PROJECT_FILES_RAC_III\3233037_Saunders\GIS\Streamline Throughout 2.mxd





Profile View of Capture Zone
Vertical Exaggeration = 5

Legend

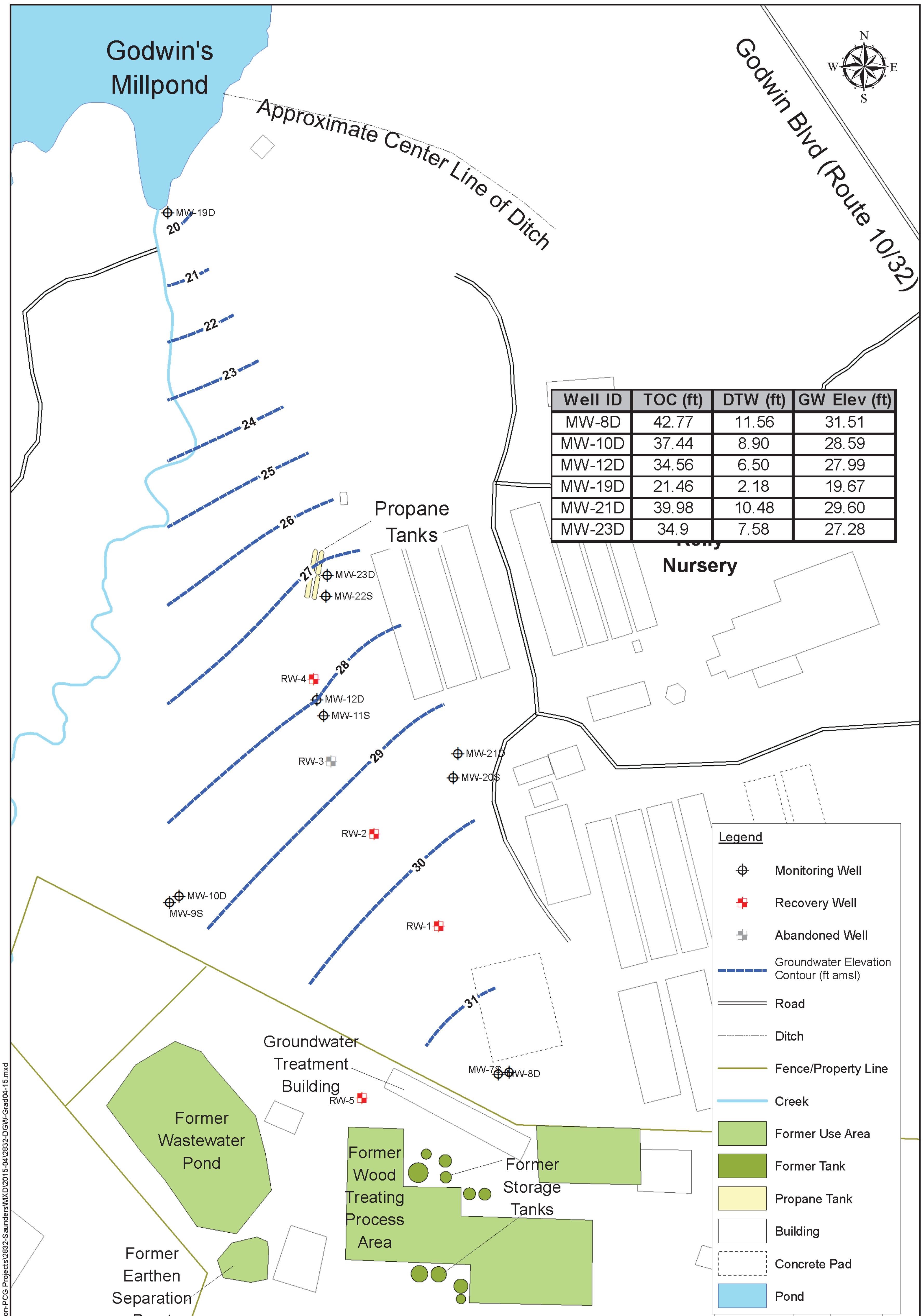
- Extraction Wells
- Monitoring Wells
- Buildings Onsite
- Stream

Note: Shaded Area Shows Lateral Extent of Fine-Grained Columbia Deposits

CDM

Saunders Supply Site
Chuckatuck, Virginia

Figure 4-5
Estimated Capture Zone
Using Three-Dimentional Visualization



Well ID	TOC (ft)	DTW (ft)	GW Elev (ft)
MW-8D	42.77	11.56	31.51
MW-10D	37.44	8.90	28.59
MW-12D	34.56	6.50	27.99
MW-19D	21.46	2.18	19.67
MW-21D	39.98	10.48	29.60
MW-23D	34.9	7.58	27.28

0 60 120
Feet

Source: Base map provided by CDM

Environmental Alliance, Inc.
8215 Hermitage Road - Henrico, Virginia 23228
Phone: (877) 234-1141 - Fax: (302) 234-1535

Saunders Supply Company
Superfund Site
Chuckatuck, Virginia

Groundwater Elevation Contour Map - Deep Zone - April 2015

DESIGNED BY:	DRAWN BY:	UPDATED BY:	FIGURE NO.:
MRR	SKJ	-- --	4
APPROVED BY:	PROJECT NO.: 2832	DATE: 6/19/2015	

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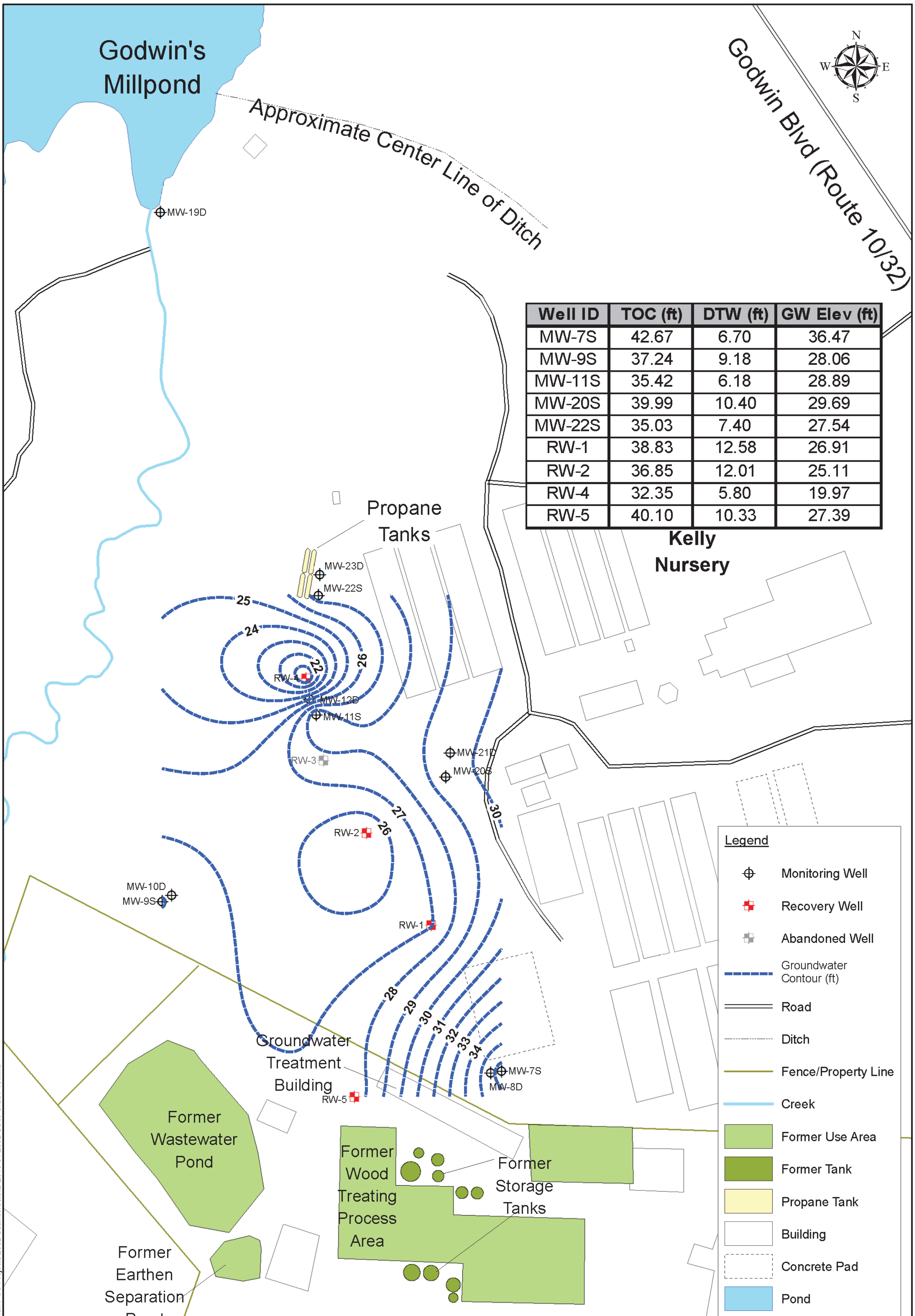

Well ID	TOC (ft)	DTW (ft)	GW Elev (ft)
MW-7S	42.67	6.70	36.47
MW-9S	37.24	9.18	28.06
MW-11S	35.42	6.18	28.89
MW-20S	39.99	10.40	29.69
MW-22S	35.03	7.40	27.54
RW-1	38.83	12.58	26.91
RW-2	36.85	12.01	25.11
RW-4	32.35	5.80	19.97
RW-5	40.10	10.33	27.39

Source: Base map provided by CDM

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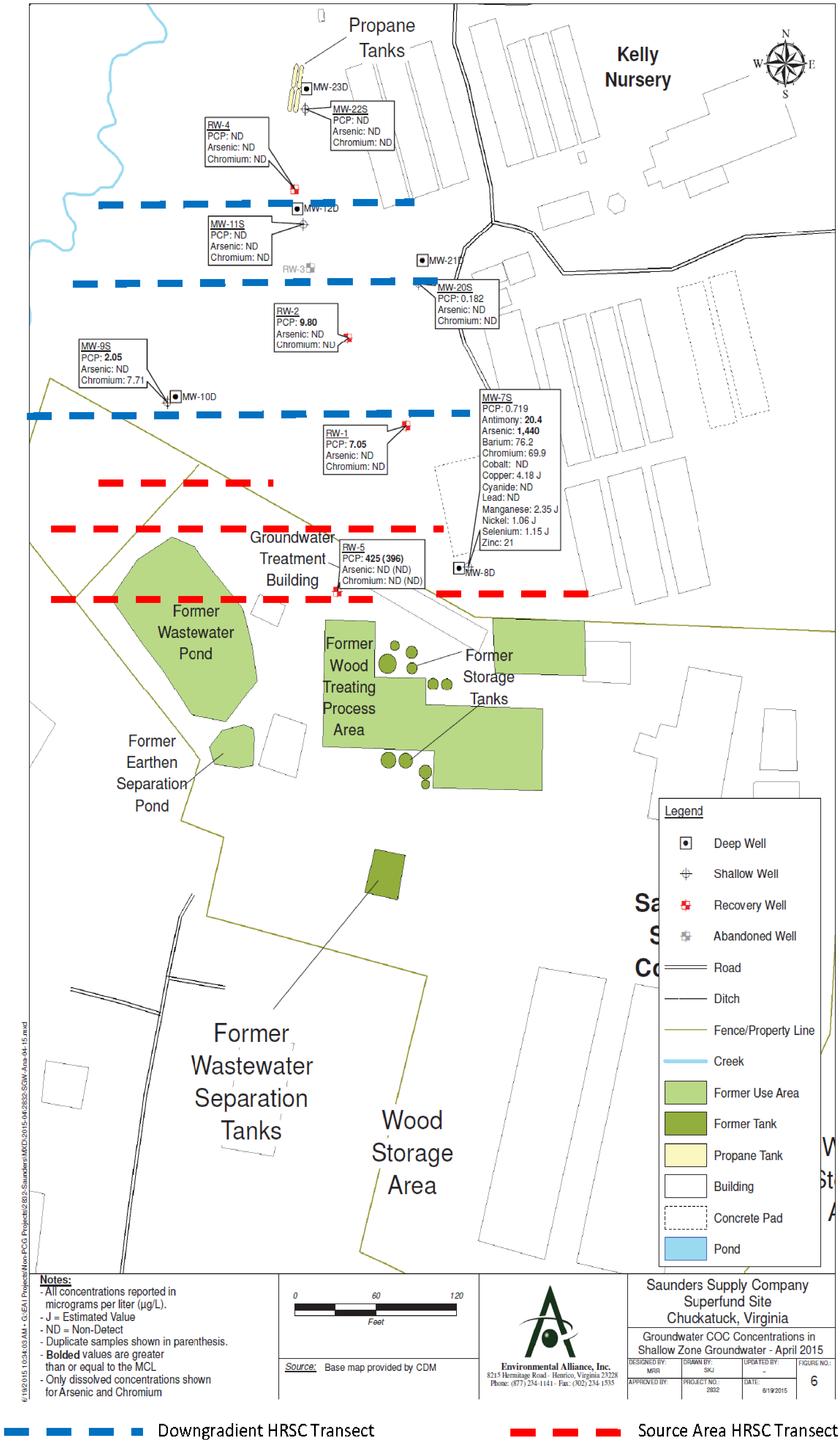
Chuckatuck, Virginia

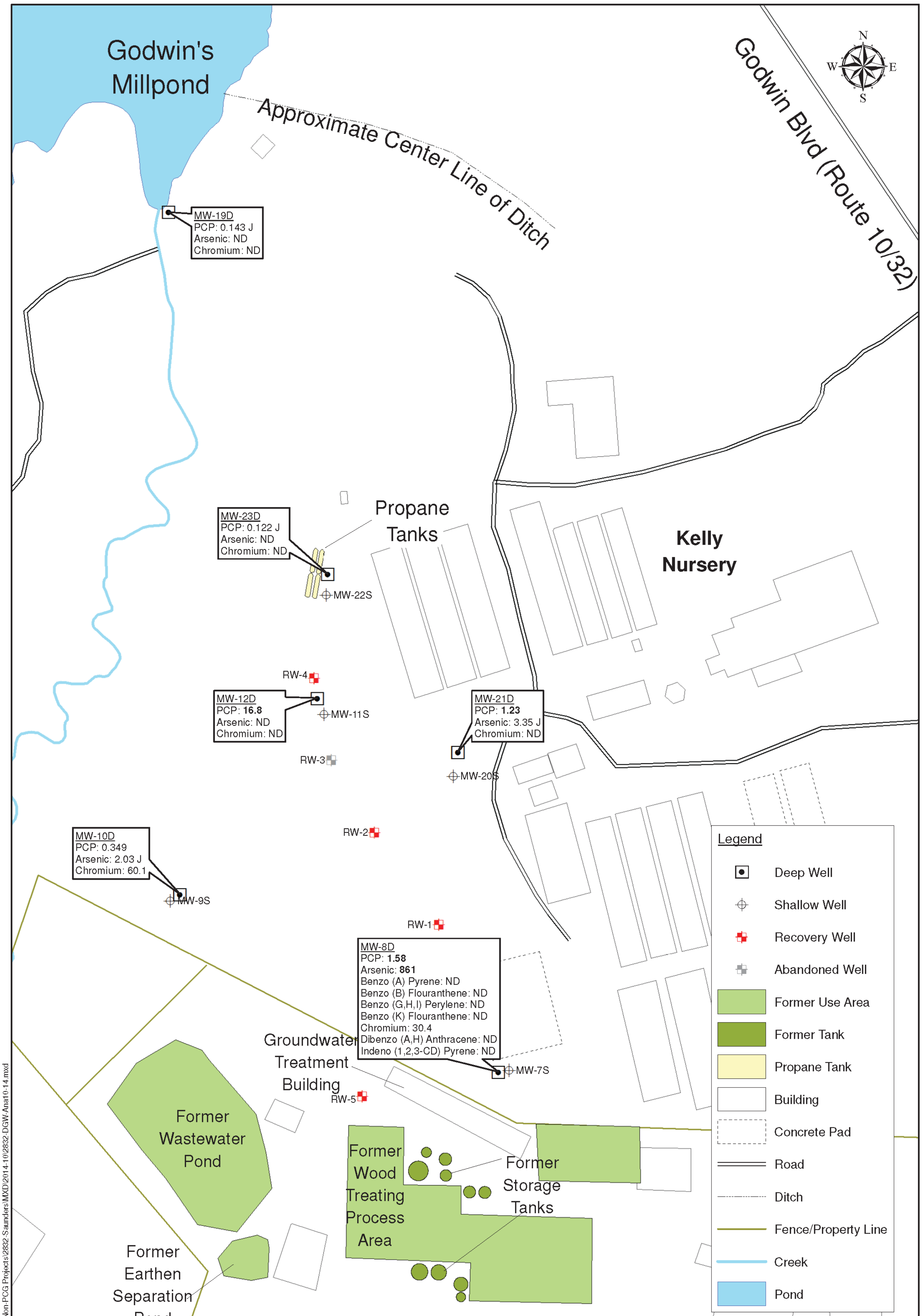
Groundwater Elevation Contour Map - Shallow Zone - April 2015

DESIGNED BY: MRR
DRAWN BY: SKJ
UPDATED BY: -- --
FIGURE NO.: 2
APPROVED BY:
PROJECT NO.: 2832
DATE: 6/19/2015

6/19/2015 10:57:31 AM - G:\EAI Projects\Non-PCG Projects\2832-Saunders\MXD\2015-04\2832-SGW-Grad4-15.mxd



Propane Tanks
Kelly Nursery
MW-23D
MW-22S
PCP: ND
Arsenic: ND
Chromium: ND
RW-4
PCP: ND
Arsenic: ND
Chromium: ND
MW-12D
MW-11S
PCP: ND
Arsenic: ND
Chromium: ND
RW-3
MW-21D
MW-20S
PCP: 0.182
Arsenic: ND
Chromium: ND
RW-2
PCP: 9.80
Arsenic: ND
Chromium: ND
MW-9S
PCP: 2.05
Arsenic: ND
Chromium: 7.71
MW-10D
MW-7S
PCP: 0.719
Antimony: 20.4
Arsenic: 1,440
Barium: 76.2
Chromium: 69.9
Cobalt: ND
Copper: 4.18 J
Cyanide: ND
Lead: ND
Manganese: 2.35 J
Nickel: 1.06 J
Selenium: 1.15 J
Zinc: 21
RW-1
PCP: 7.05
Arsenic: ND
Chromium: ND
Groundwater Treatment Building
RW-5
PCP: 425 (396)
Arsenic: ND (ND)
Chromium: ND (ND)
MW-8D
Former Wastewater Pond
Former Wood Treating Process Area
Former Storage Tanks
Former Earthen Separation Pond
Former Wastewater Separation Tanks
Wood Storage Area
Legend
Deep Well
Shallow Well
Recovery Well
Abandoned Well
Road
Ditch
Fence/Property Line
Creek
Former Use Area
Former Tank
Propane Tank
Building
Concrete Pad
Pond
Notes:
- All concentrations reported in micrograms per liter (µg/L).
- J = Estimated Value
- ND = Non-Detect
- Duplicate samples shown in parenthesis.
- Bolded values are greater than or equal to the MCL
- Only dissolved concentrations shown for Arsenic and Chromium
0 60 120
Feet
Source: Base map provided by CDM
Environmental Alliance, Inc.
Saunders Supply Company Superfund Site Chuckatuck, Virginia
Groundwater COC Concentrations in Shallow Zone Groundwater - April 2015
DESIGNED BY: MRR
DRAWN BY: SKJ
APPROVED BY:
PROJECT NO.: 2832
DATE: 6/19/2015
FIGURE NO.: 6
Downgradient HRSC Transect
Source Area HRSC Transect



Notes:
- All concentrations reported in micrograms per liter (µg/L).
- J = Estimated Value
- ND = Non-Detect
- Bolded values are greater than or equal to the MCL
- Only Dissolved concentrations shown for Arsenic and Chromium unless otherwise noted

0 60 120
Feet

Source: Base map provided by CDM

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Saunders Supply Company
Superfund Site
Chuckatuck, Virginia

Groundwater COC Concentrations in Deep Zone Groundwater - October 2014

DESIGNED BY: JSE	DRAWN BY: SKJ	UPDATED BY: -- --	FIGURE NO.: 7
APPROVED BY:	PROJECT NO.: 2832	DATE: 1/30/2015	

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APPENDIX C

SITE PHOTOGRAPHS

Photo 1. Treatment system building (December 1, 2015)

Photo 2. GAC, Soda Ash Reaction Tank (T-1), and Settling Tank (T-2) (December 1, 2015)

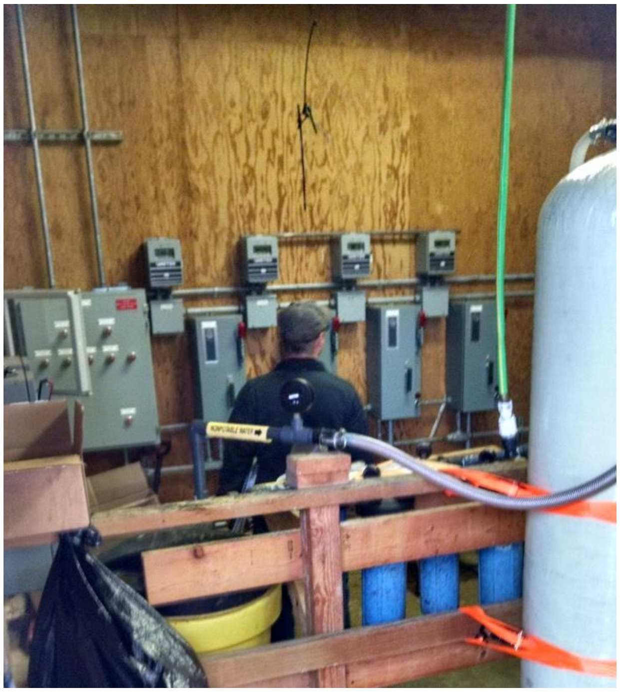

Photo 3. GAC, Extraction Well Control Panel, and Pump Level Indicators (December 1, 2015)

Photo 4. Extraction Well Influent Manifold and Flow Meters (December 1, 2015)

Photo 5. New Fiberglass GAC Canisters (December 1, 2015)

Photo 6. View Looking North from the Treatment System Building (December 1, 2015)

Photo 7. View along Western Edge of Site, Looking South (December 1, 2015)

Photo 8. Extraction Well RW-1 Vault (December 1, 2015)

Photo 9. View of Intermittent Stream along Western Edge of Site (December 1, 2015)

Photo 10. View of Drainage Ditch along Eastern Edge of Site (December 1, 2015)

Photo 11. View of Northern Portion of Site, Looking North (December 1, 2015)

Photo 12. View of Godwin's Millpond, Looking North (December 1, 2015)