FINAL

Five-Year Review Report

Second Five-Year Review Report

for

Frontier Hard Chrome Superfund Site

City of Vancouver

Clark County, Washington

January 2013

PREPARED BY

United States Army Corps of Engineers

Seattle District

Seattle, Washington

Approved by: Cami Grandinetti

Date: 1/29/13

Cami Grandinetti

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Executive Summary

The Frontier Hard Chrome Superfund Site is located in the city of Vancouver in Clark County, Washington. In 1975, the City of Vancouver determined that chromium in the wastewater from the Frontier Hard Chrome (FHC) facility was interfering with the operation of its new secondary treatment system. FHC was directed to cease discharge to the sewer system until an appropriate wastewater treatment system could be installed to remove chromium from wastewater discharges at the site. In 1976, the Washington State Department of Ecology (WDOE) gave the FHC facility a wastewater disposal permit for discharge of chromium-contaminated wastewater to an on-site dry well. The permit also contained a schedule for the installation of an appropriate treatment system for the FHC wastewater stream. Several extensions of the permit and schedule were granted as the deadlines were passed without compliance. In 1982, WDOE found FHC in violation of the Washington State Dangerous Waste Act for illegally disposing of hazardous wastes. In 1983, WDOE prohibited the use of the dry well for chromium waste disposal. FHC was also required to prepare a plan for the investigation of groundwater, but closed down all operations at the site without undertaking the investigation. In March of 1983, the U.S. Environmental Protection Agency (EPA) and WDOE signed a Cooperative Agreement to investigate wastes.

The Frontier Hard Chrome Superfund Site was listed on the National Priorities List (NPL) in September of 1983. A remedial investigation was completed during the summer of 1987, and a feasibility study was completed in October of 1987. In December 1987, a Record of Decision (ROD) was signed for Operable Unit (OU) #1 (soils/source control) which included excavation of contaminated soils, on-site treatment of excavated materials by chemical stabilization, and replacement of treated materials. In July 1988, a ROD was signed for OU #2 (groundwater) which included a groundwater extraction and treatment system. Neither remedy was implemented. Evaluation of the soils remedy by EPA after the ROD for OU #1 was issued revealed that the chosen stabilization method was ineffective at preventing the leaching of hexavalent chromium from site soils. Groundwater monitoring conducted after the ROD for OU #2 was issued indicated that the contaminated groundwater plume was decreasing in size as downgradient industrial supply wells were taken off line.

Since the original RODs were issued, EPA continued to monitor groundwater and soils, and evaluated new, innovative cleanup technologies to address persistently high concentrations in soils and groundwater at the FHC site. In May 2000, EPA finalized a Focused Feasibility Study (FFS), which identified and evaluated several new and innovative technologies for addressing the contamination at the site. One of the promising *in situ* treatment technologies identified in the FFS, *In Situ* Redox Manipulation (ISRM), was evaluated further in a bench scale study in February 2001. In August 2001, EPA selected a final remedy for the site soils and groundwater through a ROD Amendment, which included *in situ* source area/soil treatment, *in situ* groundwater treatment, and institutional controls and monitoring.

Remedy installation was completed in September 2003. An ISRM Wall was installed to reduce hexavalent chromium levels in groundwater downgradient of the source area. Treatment of hexavalent chromium in the source area soil and groundwater was completed by using *in situ* soil mixing equipment to mix the proprietary reducing agent into the subsurface soils and groundwater. Institutional controls using the State of Washington well construction codes and an Agreement and Covenant Not to Sue between the developer and EPA prevent well construction in the contaminated aquifer. Monitoring has occurred since the remedy construction was completed. Groundwater monitoring and operation and maintenance of the monitoring well network are conducted by WDOE.

Cleanup standards were met for the OU #1 upon completion of the remedial action. Since then, the focus of monitoring has been chromium in groundwater.

Groundwater chromium concentrations were greater than the cleanup level in 2007 and 2008 for monitoring well B87-8. This well is down gradient of the ISRM wall and contained chromium concentrations above the cleanup level prior to installation of the wall. The concentration of total chromium in B87-8 for 2009, 2010, and 2011 decreased below the cleanup level (50 µg/L) to 3 µg/L. Continued groundwater monitoring should take place for B87-8 and down gradient.

The monitoring program is working as designed. Future redevelopment of the FHC site may physically impact the current monitoring network.

ARARs, toxicity assumptions and exposure pathways have not changed since the first five-year review. No other information has called into question the protectiveness of the remedy.

When considering the site as a whole, the assessment of this second five-year review found that the remedy was constructed in accordance with the requirements of the 2001 Amendment to the Records of Decision. Exposure pathways have been eliminated through the implementation of the remedy and institutional controls. Therefore, the remedy continues to be protective of human health and the environment.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Frontier Hard Chrome, Inc.		
EPA ID: WAD053614988		
Region: 10	**State:** WA	**City/County:** Vancouver/Clark County

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes

REVIEW STATUS
Lead agency: EPA **If "Other Federal Agency" was selected above, enter Agency name:** Click here to enter text.
Author name (Federal or State Project Manager): Claire Hong and (as of 11/20/12) Joe Wallace
Author affiliation: USEPA
Review period: January 2008 – January 2013
Date of site inspection: 10/16/2012
Type of review: Policy
Review number: 2
Triggering action date: 01/29/2008
Due date *(five years after triggering action date)*: 01/29/2013

Five-Year Review Summary Form (continued)

Issues/Recommendations
OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU 1: Soils/Source Area
OU 2: Groundwater

Protectiveness Statement(s)		
Operable Unit: #1 **Soils/Source Area**	***Protectiveness Determination:*** **Protective**	***Addendum Due Date (if applicable):*** **Click here to enter date.**
Protectiveness Statement: The remedy at OU 1 (soils/source area) is protective of human health and the environment and exposure pathways that could result in unacceptable risks have been eliminated as a result of soils/source area remedial action.		
Operable Unit: #2 **Groundwater**	***Protectiveness Determination:*** **Protective**	***Addendum Due Date (if applicable):*** **Click here to enter date.**
Protectiveness Statement: The remedy at OU 2 (groundwater) is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled through remedial action and institutional controls.		

Site wide Protectiveness Statement (if applicable)	
Protectiveness Determination: Protective	*Addendum Due Date (if applicable):* Click here to enter date.
Protectiveness Statement: Because the remedial actions at both OUs are protective, the site is protective of human health and the environment.	

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List of Abbreviations

AMSL	Above Mean Sea Level
ARAR	Applicable, Relevant and Appropriate Requirement
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Cleanup, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of Concern
Corps	U.S. Army Corps of Engineers
cm/s	Centimeters per Second
DO	Dissolved oxygen
EPA	U.S. Environmental Protection Agency
FFS	Focused Feasibility Study
FS	Feasibility Study
ft	Feet
FYR	Five-year review
ISRM	*In Situ* Redox Manipulation
LTMO	Long-Term Monitoring Optimization
MAROS	Monitoring and Remediation Optimization System
MCL	Maximum Contaminant Level
mg/kg	Milligrams per Kilogram
MSL	Mean Sea Level
MTCA	Model Toxics Control Act
mV	Millivolts
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NPL	National Priorities List
ORP	Oxidation-reduction potential
OU	Operable Unit
PCE	Perchloroethylene
RAO	Remedial Action Objective
RCW	Revised Code of Washington
RI	Remedial Investigation

ROD	Record of Decision
RPM	Remedial Project Manager
SWCAA	Southwest Clean Air Agency
TCA	Trichloroethane
TCE	Trichloroethylene
µg/L	Micrograms per Liter
USACE	U.S. Army Corps of Engineers
USC	United States Code
VOC	Volatile Organic Compounds
WAC	Washington Administrative Code

List of Abbreviations

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1. Introduction

This is the second five-year review (FYR) for the Frontier Hard Chrome Superfund Site (FHC) in Vancouver, Washington (EPA ID: WAD053614988). The start of construction of the remedy described in the 2001 Record of Decision (ROD) Amendment triggered the first FYR. The triggering action for this review is the previous FYR dated January 29, 2008. The first FYR was required because there were hazardous substances, pollutants, or contaminants remaining at the site after the installation of the remedy. Although the selected remedy is not expected to leave contaminants on site above unlimited use and unrestricted exposure levels when completed, this FYR is required by U.S. Environmental Protection Agency (EPA) policy to confirm that cleanup levels continue to be met, and to ensure that institutional controls remain effective until they are no longer necessary.

The EPA conducted this FYR of the remedy implemented at the site. This review was conducted by the EPA Project Manager for the period from January 2008 through January 2013. This report documents the results of the review.

1.1. Purpose

The purpose of this five-year review is to determine whether the remedy at the Frontier Hard Chrome Superfund Site is protective of human health and the environment. This report describes the methods, findings, and conclusions of this five-year review. In addition, this five-year review report identifies issues found at the Frontier Hard Chrome Superfund Site during the review process, if any, and recommendations to address them.

1.2. Authority

The U.S. Environmental Protection Agency (EPA) prepared this five-year review pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) §121 and the National Contingency Plan (NCP). CERCLA §121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

EPA interpreted this requirement further in the National Contingency Plan (NCP); 40 Code of Federal Regulations (CFR) §300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or*

contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

EPA Region 10 and the U.S. Army Corps Engineers (USACE) conducted this FYR of the remedial actions implemented at the Frontier Hard Chrome Superfund site in Vancouver, Washington. EPA is the lead agency for developing and implementing the remedy for the FHC site. The USACE provided technical assistance to EPA in the process of completing of this five-year review. This review was conducted from August 2012 through October 2012.

2. Site Chronology

Table 1. Chronology of Site Events

Event	Date
City of Vancouver determined that chromium in the wastewater from FHC was interfering with the operation of its new secondary treatment system. FHC directed to cease discharge to the sewer system until an appropriate wastewater treatment system could be installed to remove chromium from wastewater discharges at the site.	1975
WDOE gave the FHC facility a wastewater disposal permit for discharge of chromium-contaminated wastewater to an on-site dry well. The permit also contained a schedule for the installation of an appropriate treatment system for the FHC wastewater stream.	1976
Several extensions of the permit and schedule were granted as the deadlines were passed without compliance	1976-1981
WDOE found FHC in violation of the Washington State Dangerous Waste Act for illegally disposing of hazardous wastes.	1982
WDOE prohibits use of dry well for chromium waste disposal. FHC was also required to prepare a plan for the investigation of groundwater. FHC closed down all operations at the site without undertaking the investigation.	1983
EPA and WDOE sign Cooperative Agreement to investigate wastes. WDOE had the lead for the site until it was listed on the NPL.	March 1983
The site was listed on the NPL.	September 1983
Remedial Investigation (RI) conducted.	Fall 1984 – Summer 1987
Feasibility Study (FS) was completed.	October 1987

Event	Date
Record of Decision (ROD) for OU 1 (soils/source control) selected excavation of contaminated soils, on-site treatment of excavated materials by chemical stabilization, and replacement of treated materials.	December 1987
Remedial design start for OU 1. Evaluation of the soils remedy by EPA after the ROD was issued revealed that the chosen stabilization method was ineffective at preventing the leaching of hexavalent chromium from site soils.	April 1988
ROD for OU 2 (groundwater) selected a groundwater extraction and treatment system. Groundwater monitoring conducted after the ROD was issued indicated that the contaminated groundwater plume was decreasing in size as down-gradient industrial supply wells located at FHC were taken off line.	July 1988
WDOE conducted an interim removal action by removing approximately 160 cubic yards of chromium-contaminated surface soil on the property adjacent to and east of the FHC site.	1994
EPA finalized a Focused Feasibility Study (FFS) which indentified and evaluated new and innovative technologies. One of those technologies was *In Situ* Redox Manipulation (ISRM).	May 2000
ISRM evaluated further in bench scale test	February 2001
EPA issued a Proposed Plan for cleanup of both soils and groundwater that identified in situ treatment using reducing compounds as the preferred alternative.	June 2001
Amendment to the RODs for OU 1 and OU 2 selected ISRM	August 2001
EPA issued Remedial Design Scope of Work	October 2001
ISRM Wall design completed	December 2002
Phase 1 Building Demolition began and completed	January – February 2003
Source Area Treatment design completed	February 2003
ISRM Wall Installation began and completed	April – August 2003
Phase 2 Building Demolition began and completed	May 2003
Source Area Treatment began and completed	August 2003
Preliminary Close Out Report signed; site achieved construction completion status.	September 2003
Kelly Development LLC and EPA sign Agreement and Covenant Not To Sue	July 2004
WDOE resumes lead for site during Operation and Maintenance phase	Fall 2004
Survey of wells impacted by development south of the site completed	November 2007

Event	Date
Long Term Monitoring Optimization Study assessed the groundwater monitoring network	December 2007
Previous five-year review	01/29/2008
Monitoring recommendations from LTMO study adopted	June 2008

3. Background

3.1. Physical Characteristics

The Frontier Hard Chrome (FHC) Superfund Site is located in the southwestern part of the State of Washington, in the City of Vancouver (Figure 3-1). The address of the site is 113 Y Street, Vancouver, Washington.

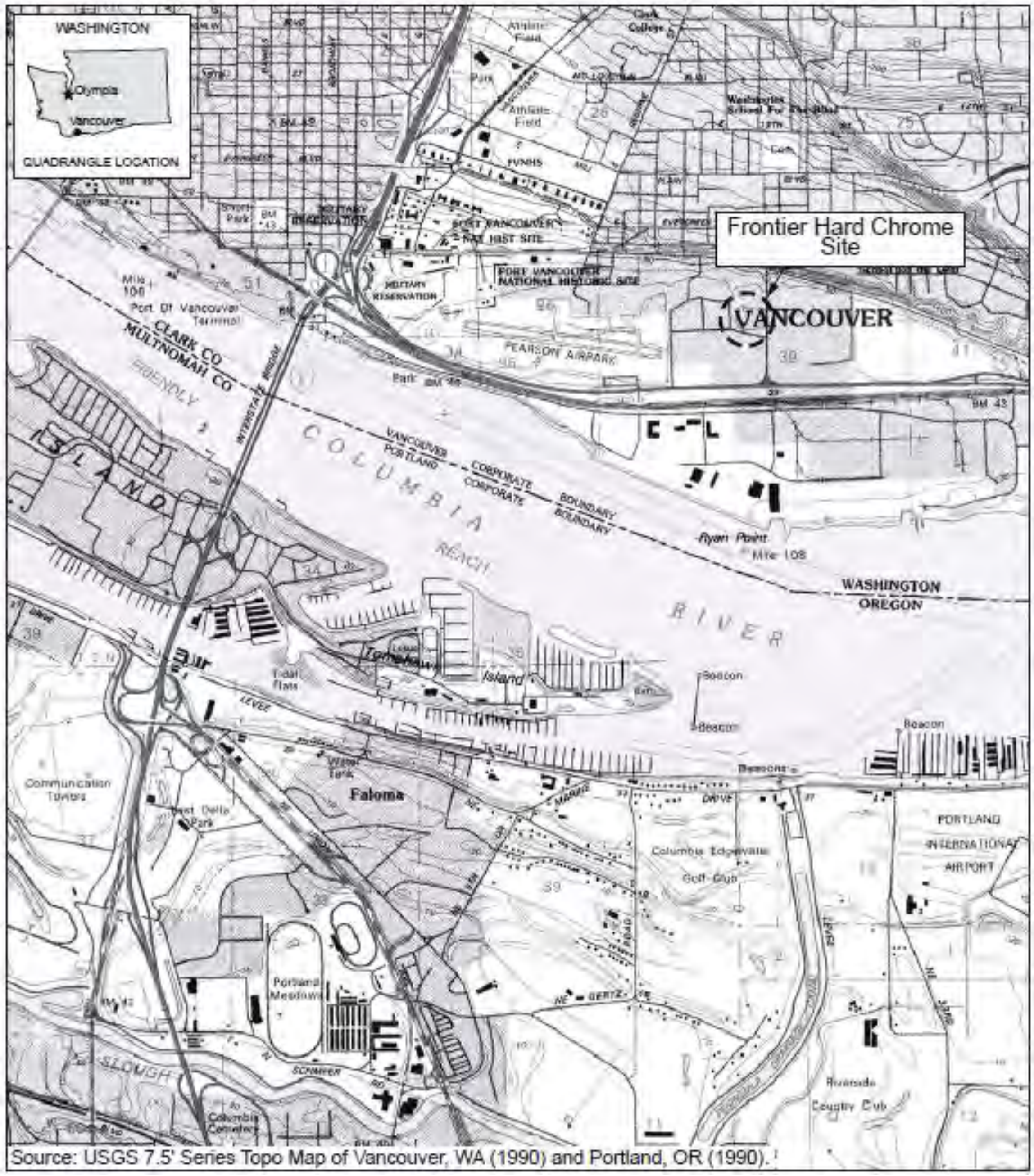


Figure 3-1. Frontier Hard Chrome vicinity map

The FHC site is located on a former floodplain about 0.5 miles north of the Columbia River at an elevation of approximately 30 feet above mean sea level. A short distance north of the site (north of 5th Street), a bluff rises to an elevation of approximately 160 feet. The FHC site covers approximately half an acre and is bordered to the east by Grand Avenue and to the west by Y Street.

3.1.1. Site Geology

The FHC Site is underlain by five geologic units: fill, alluvial unit, glacial flood deposits, sedimentary rocks of the Troutdale formation, and Columbia River Basalts. The upper two units are of interest to this FYR and are described below.

- Fill Unit. Before its development, the site was part of a gently undulating, swampy, alluvial floodplain terrace along the Columbia River. Starting in the 1940's, the surface was modified by grading and placement of up to 20 feet of fill for local industrial developments. Fill materials consist of both hydraulic fill (silt and sand) and construction fill and ranges from 12 to 20 feet thick.

- Alluvial Unit. The alluvial unit is highly heterogeneous and anisotropic and is approximately 70 feet thick. It consists of a clayey silt subunit and a sand and gravel subunit. The clayey silt subunit directly underlies the fill unit across most of the site. This unit is typically 3 to 7 feet thick, but thins to the north and is absent along the northern margin of the floodplain. Underlying the clayey silt unit is a sand and gravel subunit that resulted from overbank deposition during Columbia River flooding. Three types of deposits are present within the sand and gravel subunit: 1) poorly sorted deposits of silty sandy gravel to silty gravelly sand, 2) moderate to well-sorted deposits of coarse sandy gravel to gravelly sand, and 3) very dense deposits of sandy silt to silty sand. These deposits display variation in particle size distribution and degree of sorting and, in general, are interbedded and discontinuous.

3.1.2. Hydrogeology

The uppermost hydrogeologic unit consists of perched groundwater in the fill unit. The fill unit is generally unsaturated, but locally perched water is present (USEPA, 2001). The dry well used by FHC to discharge chromium-contaminated wastewater was open at the base of the fill unit. Groundwater in the perched aquifer is generally recharged from precipitation by direct infiltration and by stormwater dry wells and roof drains. Separating the fill unit from the alluvial unit is the 3- to 7-foot thick, discontinuous, clayey silt subunit of alluvial unit.

Underlying the clayey silt unit is the alluvial aquifer. The alluvial aquifer is a sand-and-gravel unit beginning 15 to 20 feet below ground surface (bgs). The upper portion of the alluvial unit was subdivided in the RI into two water-bearing zones based on the presence of a discontinuous silty sand or sandy silt zone at a depth of 25 to 35 feet bgs. The upper zone has been referred to as the "A" zone or "A" aquifer, and the lower zone has been designated "B" zone or "B" aquifer. The silt zone, when present, varies from 1 to 3 feet in thickness and appears to be discontinuous. The silt zone was recognized by an increase in drilling resistance and little or no groundwater entering the drill casing as the boring encountered this unit. Although this layer may be a local semi-confining unit, evidence suggests this unit is not a significant hydraulic barrier within the alluvial aquifer. Figure 3-2 illustrates the general hydrostratigraphy inferred to be locally present in the FHC Site area.

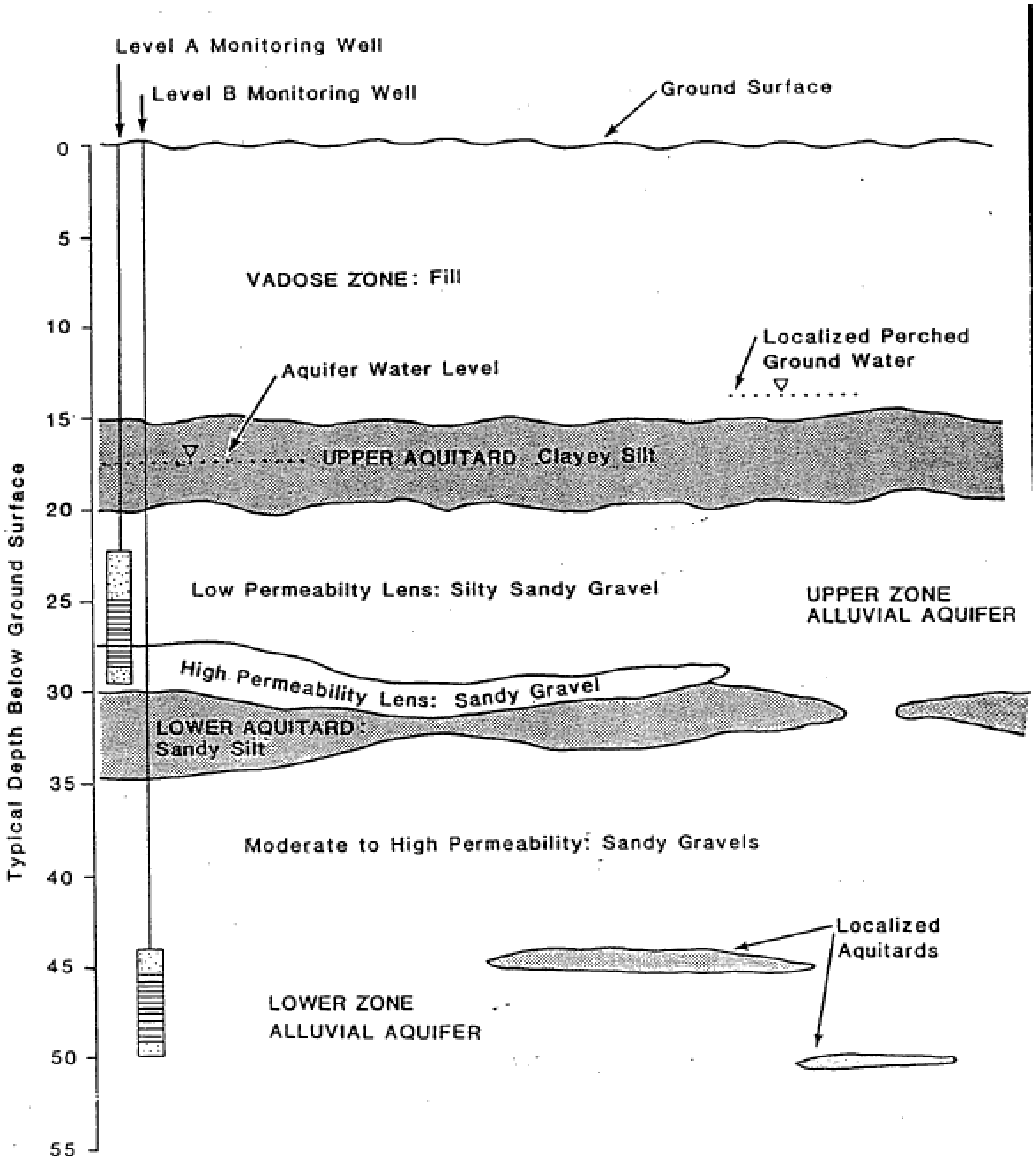


Figure 3-2.General hydrostratigraphy present locally in FHC site area

The groundwater potentiometric surface generally slopes very shallowly to the south in the vicinity of the FHC site. Recharge to the alluvial aquifer system occurs north of the site along the northern margin of the floodplain from another hydraulically connected alluvial aquifer and from direct infiltration of precipitation. Groundwater discharges to the Columbia River. Seasonal fluctuations in the river stage exert a strong influence on water levels and the hydraulic gradients within the alluvial aquifer system.

As noted in the Focused Feasibility Study (FFS), groundwater flow is approximately 0.5 to 5 feet per day toward the Columbia River. The hydraulic gradient averages 0.00015 ft/ft. Since the alluvial aquifer is hydraulically connected to the Columbia River, groundwater levels in the alluvial aquifer appear to be controlled primarily by the stage of the river. During high river stages, groundwater flow away from the river has been recorded. There is no distinct vertical gradient between the "A" and "B" zone wells. The hydraulic conductivity of the alluvial aquifer averages 5 x 10^{-1} cm/s, as measured by slug tests, grain size analysis, and pumping tests.

3.2. *Land and Resource Use*

Two chrome platers operated on the site. Pioneer Plating operated from 1958 to 1970. The business was taken over by FHC and operated from 1970 to 1983.

Land use in the FHC area is primarily industrial, with some manufacturing and commercial uses. Land ownership in the area is predominantly private, with the exception of Pearson Air Park, which is publicly owned. Before the 2008 FYR, major redevelopment of the area, including the construction of a large grocery store, occurred immediately south of the FHC site. Residential and commercial development south of the site along the Columbia River has occurred, though minimal redevelopment has occurred since the last FYR.

The groundwater in the greater area is generally used for drinking water, but existing drinking water wells have not been affected by chromium-contaminated groundwater, nor is it expected that it will be in the future. At the time of the 2001 ROD Amendment, the water supplies used in the area included two City of Vancouver municipal supply wells approximately one mile southwest of the site and an irrigation well located about 1,000 feet to the east. Those wells were sampled and found not to be affected. In addition, groundwater modeling completed in the Feasibility Study (FS) indicated very little chance of the contamination spreading to these wells and reaching the Columbia River. As was determined at the time of the 2001 ROD Amendment and at the time of this review, there are no active supply wells in the contaminated aquifer.

3.3. *History of Contamination*

During the operation of Pioneer Plating and the initial operation of FHC, chromium plating wastes were discharged to the sanitary sewer system. In 1975, the City of Vancouver determined that chromium in the wastewater from FHC was interfering with the operation of its new secondary treatment system. FHC was directed by the city and the Washington State Department of Ecology (WDOE) to cease discharge to the sewer system until an appropriate wastewater treatment system could be installed to remove chromium from wastewater discharges at the site.

In 1976, WDOE gave the FHC facility a wastewater disposal permit for discharged of chromium-contaminated wastewater to an on-site dry well. The permit also contained a schedule for the installation of an appropriate treatment system for the FHC wastewater stream. Between 1976 and 1981, several extensions of the permit and schedule were granted as the deadlines were passed without compliance.

In 1982, WDOE found FHC in violation of the Washington State Dangerous Waste Act for the illegal disposal of hazardous wastes. WDOE also discovered that an industrial supply well about one quarter mile southwest of the FHC site was contaminated with chromium at more than twice the federal drinking water standard. FHC's wastewater permit was again modified with a new compliance date. FHC again did not comply with the permit requirements for economic reasons, and in December 1982, the site was proposed for inclusion on the National Priorities List under CERCLA. The listing was finalized in September 1983.

In 1983, WDOE ordered FHC to stop discharge of chromium plating wastes to the dry well. FHC was also required to prepare a plan for the investigation of groundwater. At that time, FHC closed down all operations at the site. The company did not undertake the investigation.

3.4. Initial response

In March 1983, EPA and WDOE signed a Cooperative Agreement which gave WDOE the lead for the investigation of the FHC site under CERCLA. WDOE began the investigation in the fall of 1984. The Remedial Investigation (RI) led to a Feasibility Study (FS), the purpose of which was to determine a cost-effective remedial action at the FHC site. The FS was completed in October 1987.

Based on surface soil sample analyses for total chromium conducted during the RI, WDOE completed a removal action in 1994 to reduce the threat of direct exposure and further impacts to groundwater from the most heavily contaminated surface soils. This action consisted of excavation of surface soil with chromium concentrations exceeding 210 mg/kg from the easternmost portion of the site. The area of excavation was subsequently backfilled with clean material and has been developed. Development consisted of the construction of a commercial office building and adjacent parking.

In December 2000, in conjunction with a drainage project on the adjacent Grand Avenue, the City of Vancouver extended a tight-lined drain pipe with road drains and catch basins up 1st Street (directly to the south of the FHC site) to the intersection with Y Street (directly to the west of the FHC site). The extension was designed to handle all water flowing south on Y Street (which had previously entered the FHC site from 1st Street). The extension was provided in conjunction with an EPA Removal Action to provided drainage of surface water away from the FHC site, preventing further infiltration of surface water through contaminated soils on site.

3.5. *Basis for Taking Remedial Action*

Six hazardous substances were identified in the RI to be present in one or more media (groundwater, soil, and building debris) at concentrations of potential concern to human health and the environment. These substances are chromium, nickel, lead, perchloroethylene (PCE), trichloroethylene (TCE), and trichloroethane (TCA). During the 1999 groundwater investigation activities, PCE and TCE were detected in 23 and 24 of the shallower zone (Zone A) groundwater samples. Only three PCE concentrations and only one TCE concentration exceeded the federal maximum contaminant level (MCL) for those contaminants. Volatile organic compounds (VOCs) were not considered further for remedial actions because 1) concentrations have been extremely low and few detections have exceeded the respective MCL criteria, 2) VOCs in groundwater have historically been an area-wide issue, not specific to FHC, and 3) the presence of VOCs is not directly linked to past activities at FHC. Nickel and lead were also found in soils at the facility; EPA believes that the VOCs measured upgradient of the historical FHC Site may be coming from the former Cascade Manufacturing facility. Nickel at the site did not exceed the 10^{-7} cancer risk for long-term airborne exposures. Lead also presented minimal risk at the site in that it did not exceed and were not expected to exceed National Ambient Air Quality Standards (NAAQS). Though the levels of exposure were not zero, the additional risk imposed by nickel and lead in dust was negligible.

High levels of hexavalent chromium posed significant exposure risks from soil, groundwater, and building debris. The primary exposure route of concern for human health risk was the ingestion of groundwater containing hexavalent chromium. Releases from FHC operations contained reported total chromium concentrations as high as 300,000 µg/L. At the time the contaminated groundwater was first detected, a groundwater plume exceeding Washington State groundwater cleanup standards for chromium (50 µg/L) extended approximately 1,600 feet southwest from the facility.

4. Remedial Actions

4.1. *Regulatory actions*

EPA issued separate RODs for the soils/source control operable unit, OU 1 (December 1987) and the groundwater operable unit, OU 2 (July 1988). The December 1987 ROD called for the removal, stabilization, and replacement of 7,400 cubic yards of soil – or all soils with total chromium concentrations greater than 550 mg/kg (this number was based on a site specific leachate test for protection of groundwater). The July 1988 ROD called for the extraction of groundwater from the area of greatest contamination (levels of total chromium in excess of 50,000 µg/L) via extraction wells and treatment of extracted water. Neither of these remedies was implemented. Evaluation of the soils remedy by EPA after the 1987 ROD was issued revealed that the chosen stabilization method was ineffective at preventing the leaching of hexavalent chromium from site soils. Groundwater monitoring conducted after the 1988 ROD was issued indicated that the contaminated groundwater plume was decreasing in size as down-gradient industrial supply wells were taken off line.

Since the original RODs were issued, EPA continued to monitor groundwater and soils, and evaluated new, innovative cleanup technologies to address persistently high concentrations in soils and groundwater at the FHC site. In May 2000, EPA finalized a FFS, which identified and evaluated several new and innovative technologies for addressing the contamination at the site. One of the promising *in situ* treatment technologies identified in the FFS, *In Situ* Redox Manipulation (ISRM), was evaluated further in a bench scale study in February 2001.

In June 2001, EPA issued a Proposed Plan for cleanup of both soils and groundwater that identified *in situ* treatment using reducing compounds as the preferred alternative. In August 2001, EPA selected a final remedy for the site soils and groundwater through a ROD Amendment, which included *in situ* source area/soil treatment, *in situ* groundwater treatment, and institutional controls and monitoring.

4.2. Remedial action objectives

Generally, Remedial Action Objectives (RAOs) identify exposure routes, receptors, chemicals of concern (COC), and a human health or environmental cleanup objective. The 2001 Amendment to the ROD included the following RAOs for the FHC site:

For Groundwater:

1. Restore all hexavalent chromium-contaminated groundwater to groundwater cleanup standards (Model Toxics Control Act (MTCA) A standard, 50 µg/L)

2. Prevent ingestion of hexavalent chromium-contaminated groundwater above state groundwater cleanup standards (MTCA A standard, 50 µg/L)

3. Prevent chromium-contaminated groundwater from seeping into the Columbia River above chronic state standards for the protection of fresh water aquatic organisms (WAC 173-201A-240, 10.5 µg/L)

For Soils:

1. Prevent hexavalent chromium in soils from serving as an uncontrolled, ongoing source of contamination to groundwater

2. Prevent current and future exposure to soil contaminated with chromium above state standards for unrestricted future use (19 mg/kg [MTCA A] for hexavalent chromium and 80,000 mg/kg [MTCA B] for trivalent chromium).

Cleanup goals for the site outlined in the ROD Amendment include the reduction of total chromium concentration in groundwater to less than 50 µg/L. Additionally, the State Chronic Surface Water criteria of 10.5 µg/L for hexavalent chromium is applicable to prevent contaminated groundwater from seeping into the Columbia River for the protection of freshwater aquatic organisms. For soils, the 2001

ROD Amendment specified that hexavalent chromium be less than 19 mg/kg (MTCA A) and trivalent chromium be less than 80,000 mg/kg (MTCA B).

4.3. Remedy description

The soils at the Frontier Hard Chrome Superfund Site and the groundwater beneath the site extending beyond the southern boundary of the Frontier Hard Chrome property are contaminated with hexavalent chromium, which is highly mobile and toxic. The selected remedy addressed the contamination through in-situ reduction of hexavalent chromium to trivalent chromium, which is generally immobile and non-toxic. Chromium reduction occurred through the injection, or mixing, of reducing agents into contaminated soils and groundwater at the site.

The following are major components of the selected remedy, as outlined in the 2001 ROD Amendment:

<u>Contain Highly-Contaminated Groundwater</u>

> "Containment of the most heavily contaminated groundwater at the site, or groundwater "hot spot" will involve the delivery, through injection or augering/injection, of reducing compounds on the down-gradient side of the soils source area, into the groundwater and soils. The compounds delivered to the area will reduce the naturally occurring iron, thereby creating an *in situ* treatment barrier which reacts directly with the chromium in groundwater. As chromium-contaminated groundwater moving down-gradient passes through the permeable reactive zone, the hexavalent chromium in the groundwater is reduced to trivalent chromium, which is insoluble, and non-mobile. This *In Situ* Redox Manipulation (ISRM) barrier will be in place prior to treatment of the soils source area and the groundwater plume "hot spot" in order to 1) provide containment of the groundwater "hot spot" as quickly as possible, 2) provide added protection during the *in situ* treatment of the soils source area and the groundwater "hot spot" to prevent hexavalent chromium from moving down-gradient; and 3) provide long-term protection against future leaching of hexavalent chromium, should it occur. Reducing compounds will either be injected through a series of wells, or augered/injected into the groundwater. Recharge of the ISRM barrier is not anticipated because the soils source area up-gradient of the ISRM barrier will also be treated as described below. It is unlikely that residual concentrations of hexavalent chromium in the soils source area, should they exist after treatment, will pose a problem beyond the predicted 30 year life of the ISRM barrier."

<u>*In Situ* Treatment of Source Area Soils and Groundwater "Hot Spot"</u>

> "*In situ* treatment of the soils source area and the groundwater "hot spot" will involve the delivery of reducing compounds directly to site soils exceeding 19 mg/kg hexavalent chromium (soils source area) and contaminated groundwater with concentrations of hexavalent chromium exceeding 5,000 µg/L by augering/injecting or through injection wells. Augering/injection is the most likely method of delivery given the cost savings and

> the thorough mixing of reductant with soils the augering provides. After treatment of soils exceeding 19 mg/kg and groundwater exceeding 5,000 µg/L, compaction of augered soils will be provided to allow for future use of the property to the extent practicable."

Institutional Controls and Monitoring

> "Once the source area for soils (exceeding 19 mg/kg hexavalent chromium) and groundwater (exceeding 5,000 µg/L hexavalent chromium) have been treated, remaining groundwater exceeding the state groundwater cleanup standard of 50 µg(L (MTCA Method A, total chromium) is expected to disperse and dilute. Regular monitoring of down-gradient groundwater to ensure dilution and dispersion of affected groundwater outside of the source area will be conducted until all remaining groundwater meets state standards for groundwater cleanup. Institutional controls and monitoring will be implemented to protect human health and the environment during the time required for dispersion and dilution to reduce chromium concentrations in plume areas outside of the "hot spot". In addition to the state and local institutional controls already in place, other institutional controls to be considered include placing notices and restrictions on property deeds that serve to prevent access to contaminated groundwater or future activities that threaten to remobilize chromium in site soils. Property owners would ensure that any future property transfers would include appropriate deed restrictions. Monitoring of existing wells will also be needed to track the concentrations in groundwater over time."

4.4. Remedy implementation

Remedy implementation began in January 2003 with Phase I building demolition. The ISRM Wall was installed between April and August 2003. Phase II building demolition occurred in May 2003. Source area treatment was initiated and completed in August 2003. The site achieved construction completion status when the Preliminary Close Out Report was signed on September 22, 2003.

Building Demolition

The buildings housing FHC facilities were demolished and removed. A significant amount of the building material was heavily contaminated by chromium, and subsequently disposed of off-site. Areas were pre-excavated to a depth of approximately 20 feet to remove buried debris prior to treatment. Large debris in fill material was also removed.

In Situ Redox Manipulation (ISRM) Treatment Wall

An ISRM Wall was installed to reduce hexavalent chromium levels in groundwater downgradient of the source area. Eight pairs of injection wells were installed during ISRM Wall installation. Each pair of wells included a deep well (screened from 28 to 33 ft bgs) and a shallow well (screened from 23 to 28 ft bgs). Each well pair was injected with 5,700 gallons of sodium dithionite reagent. The reagent was mixed with water prior to injection such that a total of approximately 40,000 gallons were injected into each well pair. Based on monitoring during installation, no significant gaps in the treatment zone were present; installation of the ISRM Treatment Wall met performance requirements. The treatment wall is approximately 240 feet long and greater than 33 feet deep. The treatment zone extends from approximately 22 ft bgs to the bottom of the wall. The exact bottom of the treatment zone is not known due to potential sinking of the reagent, but it is likely to be significantly deeper than the 33 foot installation depth.

Source Area Treatment

Treatment of hexavalent chromium in the source area soil and groundwater was completed by using *in situ* soil mixing equipment to mix the proprietary reducing agent into the subsurface soils and groundwater. Treatment depths varied from 20 to 33 feet bgs.

The Remedial Action Report noted that fifty-three groundwater confirmation samples were collected from the treated areas (additional samples were also collected during startup optimization testing). These samples were collected to confirm treatment requirements were met. Only one area had to be retreated due to failure of treatment criteria. The area was retreated and resampled. Hexavalent chromium was not detected in the area after retreatment. Overall, the technology performed as required.

At the end of site work, 28 surface soil samples were also collected along the perimeter of the exclusion zone and along both sides of Y Street and 1st Street. These samples were collected to ensure no contaminated soil was tracked offsite that could pose a human health risk. All individual soil samples outside the site boundary contained less than 2,000 mg/kg trivalent chromium and 19 mg/kg hexavalent chromium, which are the MTCA cleanup levels for unrestricted land use. These data indicated that soil outside the work area had not been adversely impacted with chromium.

Institutional Controls and Monitoring

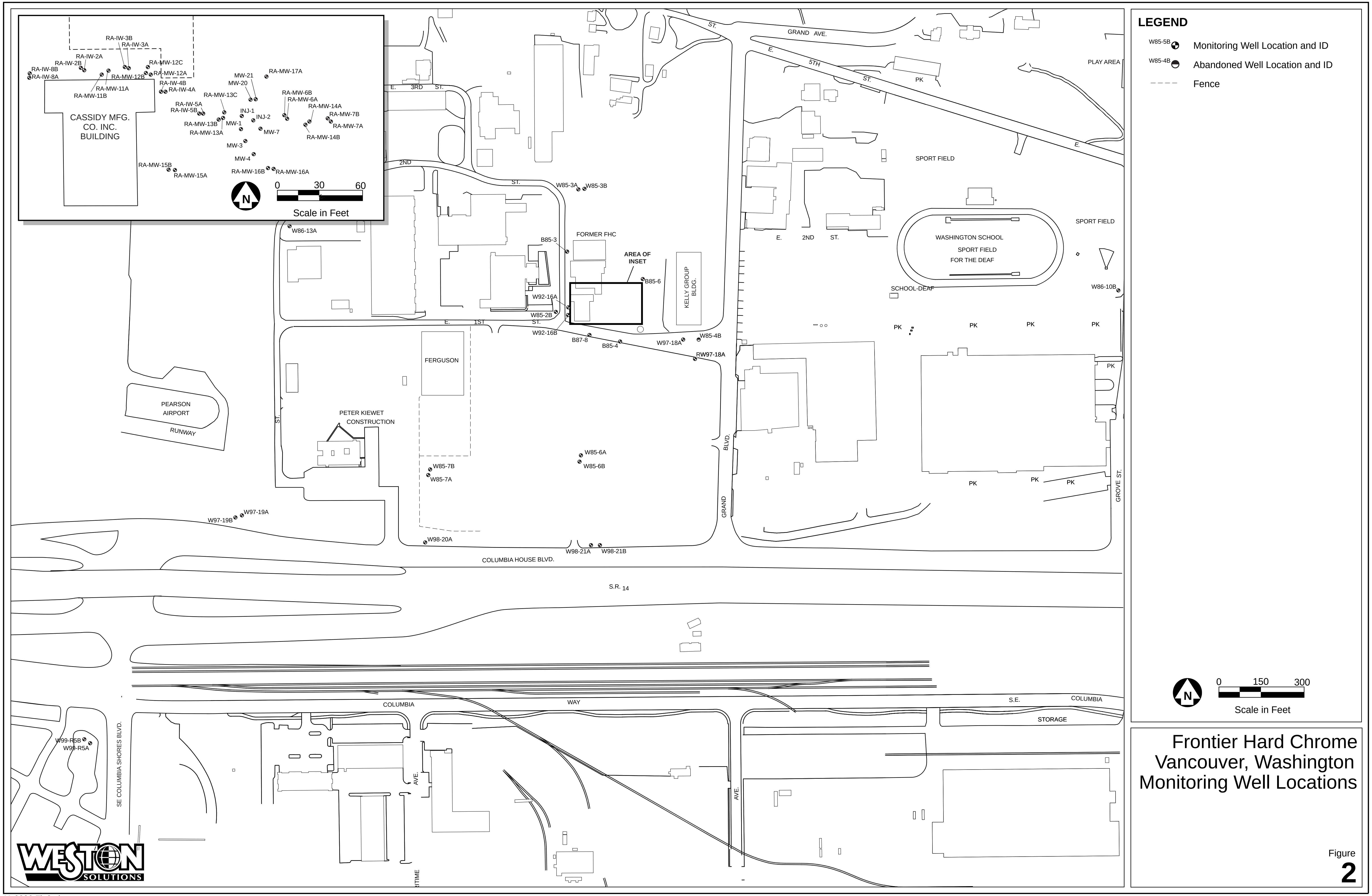
On July 17th, 2004, EPA entered into an Agreement and Covenant Not to Sue with Kelly Development LLC, the owners of the FHC site. The agreement includes numerous institutional controls such as prohibition against drilling wells and groundwater use. The specific provisions regarding institutional controls are included in Appendix B. The Agreement and Covenant Not to Sue also requires Kelly Development LLC to “ensure that assignees, successors in interest, lessees, and sublessees of the Property shall provide the same access and cooperation, including compliance with Institutional Controls.” In addition, Title 173, Chapter 160 of the Washington Administrative Code (WAC) establishes minimum standards for well construction and maintenance. WAC 173-160-171 mandates that wells shall not be located within certain minimum distances of known or potential sources of contamination, such as landfills, industrial lagoons, and hazardous waste sites.

The original Long-Term Monitoring Plan consisted of sampling two groups of wells over five years for a series of twelve sampling events. The first group of wells selected for monitoring the ISRM barrier wall consists of eighteen wells located within or near the wall. The second group of wells selected for monitoring the long-term attenuation of chromium consists of sixteen wells, primarily located downgradient of the FHC site. Sampling events were conducted approximately quarterly for two years, semi-annually for the following two years, and annually for the next year. Additional sampling events were completed under individual authorization/contracts. The sampling frequency and number of wells sampled were altered in June 2008 as a result of the Long-Term Monitoring Optimization (LTMO) study performed by EPA. The number of wells was reduced to 22 and the sampling frequency was changed to annual.

4.5. Systems operations/Operations & Maintenance

4.5.1. Systems operations/O&M requirements

The remedy was determined to be operational and functional on September 30, 2004. In the fall of 2004, the State of Washington assumed responsibility for Operation and Maintenance of the Site. The remedy selected for the Site was an *in situ* treatment; a passive remedy. Groundwater monitoring and protection of the monitoring network are currently the main operation and maintenance activities taking place at the site. Figure 4-1 shows the location of the monitoring wells.



11-0026 Fig2.ai

Figure 4-1. Monitoring Well Locations at the FHC Site

4.5.2. Systems operations/O&M operational summary

Sampling events performed for the EPA were conducted approximately quarterly for the first year after completion of the remedial action. Planned sampling events were completed in February, April, and August 2004. The sampling event performed the week of 16 August 2004 concluded monitoring for approximately one year after the remedial action was completed.

In September/October 2004, monitoring of the FHC site was turned over to the WDOE. Sampling of the site groundwater for WDOE occurred in May 2005 and again in December 2005. In February 2006, WDOE amended Weston's contract to perform 6 additional rounds of monitoring to be done quarterly: March 2006, June 2006, September 2006, December 2006, March 2007, and June 2007.

In July 2007, additional funding was provided by WDOE for an additional 8 quarters of groundwater monitoring. These additional 8 quarters of monitoring were scheduled for September 2007, December 2007, March 2008, June 2008, September 2008, December 2008, March 2009, and June 2009.

In the summer and fall of 2007, EPA conducted a LTMO study to assess monitoring requirements at the FHC site. In June 2008 and as a result of the LTMO study, ten wells were deleted from the monitoring program and the remaining rounds of sampling, with the exception of one round to be completed in September 2008, were removed. Sampling in September 2009, September 2010, and September 2011 was completed under individual Authorization/Contracts. Monitoring is likely to continue in this manner in the future.

4.5.3 Summary of costs of system operations/O&M effectiveness

Collecting and analyzing total chromium concentrations in groundwater is the main activity at the site. The 2001 ROD Amendment anticipated 15 years of post remedy monitoring at the site. Differences in monitoring frequency and other activities at the site (well protection, surveying, installation and abandonment) resulted in annual system operations/O&M costs that varied considerably. System operations/O&M costs were substantially lower in the years after the LTMO Study recommendations were implemented.

Table 2. Annual System Operations/O&M Costs

Year	Total System Operations/O&M Costs
2005	$33,520
2006	$83,930
2007	$48,082
2008	$9,140
2009	$10,000
2010	$12,250
2011	$13,850

5. Progress Since the Last Five-Year Review

5.1. Protectiveness statements from last review

The following protectiveness statement was presented for the overall Frontier Hard Chrome Superfund Site in the 2008 Five-Year Review Report:

> "When considering the site as a whole, the assessment of this five-year review found that the remedy was constructed in accordance with the requirements of the 2001 Amendment to the Records of Decision and that the remedy is functioning as designed. All immediate threats have been addressed. Current monitoring data indicate that the remedy is functioning as required to achieve groundwater cleanup goals. Because the remedial actions at all operable units are protective, the site is protective of human health and the environment."

The protectiveness statement for the Source Area/Soils OU in the 2008 Five-Year Review was:

> "Operable Unit #1 focuses on soils. EPA finds that for OU #1, the remedy was constructed in accordance with the requirements of the 2001 Amendment to the Records of Decision and that the remedy is functioning as designed. The cleanup levels have been met. We anticipate that OU #1 will be designated as fit for unlimited use and unrestricted exposure at the time of site closure."

The protectiveness statement for the Groundwater OU in the 2008 Five-Year Review was:

> "Operable Unit #2 addresses groundwater. EPA finds that for OU #2, the remedy was constructed in accordance with the requirements of the 2001 Amendment to the Records of Decision and that the remedy is functioning as designed. All immediate threats have been addressed. Current monitoring data indicate that the remedy is functioning as required to achieve groundwater cleanup goals. Groundwater monitoring and statistical analyses will be conducted to confirm that the remedy is functioning as required. We anticipate that OU #2 will be designated for unlimited use and unrestricted exposure at the time of closure."

5.2. Status of recommendations and follow-up actions from last review and results of implemented actions

All follow-up actions have been completed as outlined below.

Recommendation 1: "Redevelopment of the Area may endanger the monitoring network. The Washington State Department of Ecology must provide close oversight and communication with the developers over the next 1 to 2 years."

Status: The WDOE site manager has been in contact with the developer regarding future plans for development on or near the FHC site. Little redevelopment has occurred since the first FYR.

Recommendation 2: "Survey existing monitoring wells that were physically impacted by the development south of the Frontier Hard Chrome site."

Status: New casing elevations for the 12 wells affected by mall construction were surveyed by Minister-Glaeser Surveying, Inc. on November 30, 2007 (prior to the milestone date of 9/30/2008). These elevations were first provided in Table 4 and Appendix C of the Event 13 Long-Term Monitoring Report. This table and appendix are provided in Appendix C of this report.

Recommendation 3: "Ensure proper abandonment of monitoring well W97-18A and installation of a suitable replacement."

Status: The Event 14 Long Term Monitoring Report is the only monitoring report to explicitly mention the replacement of well W97-18A. It states "Replacement Well W97-18A located on the other side of the roadway in the flower garden had still not been developed. Efforts to use this well to determine water levels rather than the original well (due to safety issues) were not successful. Soft sediment was found in the well." This shows that the replacement well was installed before the milestone date (12/31/2008), though it had not been properly developed at the time of sampling (September 2008). The same monitoring report also indicates that the original well W97-18A had a newly constructed monument and was withstanding road traffic without damage. The well is not mentioned in subsequent monitoring reports, but figures in those reports indicate that the original well W97-18A was being used to determine water levels and take samples rather than the replacement well. Since the original well W97-18A is again serving its original purpose, there is no need to abandon it.

Recommendation 4: "Adopt groundwater monitoring frequency recommendations from the LTMO study."

Status: Recommendations from the LTMO study for the FHC were adopted effective June 16, 2008 (prior to the milestone date of 12/31/2008) as stated in the memorandum titled Modification of Monitoring Frequency at Frontier Hard Chrome Based on Long-Term Monitoring Optimization Study (Appendix D).

Recommendation 5: "Notify State of potential impacts of the former Cascade Manufacturing facility on Perchloroethylene (PCE) concentrations at FHC."

Status: The WDOE site manager was notified prior to the milestone date (2008) and is aware of the issue.

6. Five-Year Review Process

6.1. *Administrative Components*

The team lead for the Frontier Hard Chrome Superfund Site Five-Year Review is Joe Wallace, the EPA Remedial Project Manager (RPM). The review team included the following personnel from EPA Region 10 and the USACE Seattle District: Joe Wallace (EPA Region 10), Marlowe Laubach (chemical engineer), Sharon Gelinas (geologist), and Aaron King (environmental engineer). On 2 August 2012, EPA held a scoping meeting (teleconference) with the review team to discuss the Site and items of interest as they related to the protectiveness of the remedy currently in-place. A review schedule was established that consisted of the following:

- Community notification and involvement
- Document review
- Data collection and review
- Site inspection
- Local interviews, and
- Five-year review report development and review.

6.2. *Community Involvement*

A public notice announcing the five-year review for the Site was published in The Columbian on Friday, September 14th, 2012. The notice provided a brief background of the Site, explained the reason for the five-year review, and invited the community to submit comments and questions regarding remedy performance via a toll-free phone number or by contacting the RPM directly. A copy of the public notice is provided in Appendix E. Additionally, EPA sent postcard notifications to over seventy-five potentially interested parties. EPA was not contacted as a result of these advertisements. The five-year review report will be made available to the public once it has been finalized. The report will be available in the EPA Records Center and the Vancouver Community Library.

6.3. *Document review*

This five-year review consisted of a review of relevant, site-related documents including RODs for each OU, the Amendment to the RODs, monitoring reports, and recent monitoring data. A complete list of the documents reviewed can be found in Appendix A.

6.4. *Data Review*

The FHC site was divided into two Operable Units: soils and groundwater. The soils OU was extensively monitored during the remedial action, which consisted of demolition of the buildings, excavation of large materials, and augering in of reductant. Cleanup standards were met for the soils OU as noted previously in Section 4.4, so the focus of monitoring has been chromium in groundwater.

Groundwater Flow Direction and Gradients

Groundwater elevations, flow directions, and gradients were determined during each groundwater monitoring event. Groundwater elevations from monitoring events since the first five-year review (Events 12 and 14-17) indicate a southerly groundwater flow direction from the FHC site toward the Columbia River (Table 3). Groundwater elevation measurements during Event 13 were inconsistent with previous rounds of monitoring. Two wells (B85-3 and W98-21A) had unusual water levels that were not consistent with surrounding wells. This may have been due to an error in measurement, an error in the surveyed casing elevation, or just an anomaly associated with surface construction activities occurring at the time. Site groundwater elevations appeared to be mounded under the construction area with lower levels present to the north (W85-3A) and south (W99-R5A). These anomalies may also have been associated with the record rainfall that occurred in the area in the week previous to sampling. Therefore, flow direction, gradient, and velocity were not determined for this round. However, previous monitoring events (e.g. Events 1, 3, 7, 10) have shown that groundwater can also flow toward the site from the Columbia River. Flow toward the site from the Columbia River occurs during periods of high river stage (Table 3).

Table 3. Groundwater Flow Direction, Gradient, and Seepage Velocity for Each Monitoring Event

Monitoring Event	Date	Columbia River Elevation (ft AMSL)	Flow Direction	Gradient (ft/ft)	Groundwater Seepage Velocity (ft/day)[a]
1	2-Feb-04	12.05	Northerly- from Columbia River toward FHC site	0.000104	1.64
2	5-Apr-04	5.55	Southerly- from FHC site toward Columbia River	0.000062	0.98
3	17-Aug-04	Data Unavailable	Northerly- from Columbia River toward FHC site	0.000085	1.35
4	3-May-05	6.24	Southerly- from FHC site toward Columbia River	0.000029	0.46
5	15-Dec-05	5.28	Southerly- from FHC site toward Columbia River	0.000021	0.33
6	9-Mar-06	6.90	Southerly- from FHC site toward Columbia River	0.00015	2.38
7	13-Jun-06	12.34	Northerly- from Columbia River toward the FHC site	0.00005	0.79
8	28-Sep-06	4.07	Southerly- from FHC site toward Columbia River	0.00003	0.48
9	5-Dec-06	6.76	Southerly- from FHC site toward Columbia	0.00005	0.79

			River		
10	1-Apr-07	10.02	Northerly- from Columbia River toward FHC site	0.00008	1.27
11	7-Jun-07	7.52	Southerly- from FHC site toward Columbia River	0.0003	4.75
12	20-Sep-07	2.75	Southerly-from FHC site toward Columbia River	0.00005	0.79
13[b]	13-Dec-07	5.55	--	--	--
14	23-Sep-08	3.04	Southerly- from FHC site toward Columbia River	0.00002	3.17
15	14-Sep-09	3.46	Southerly-from FHC site toward Columbia River	0.00004	0.63
16	13-Sep-10	2.80 - 3.49	Southerly- from FHC site toward Columbia River	0.00007	1.11
17	12-Sep-11	4.86	Southerly- from FHC site toward Columbia River	0.0002	3.17

[a] Hydraulic conductivity of 1,900 ft/day and porosity of 0.12 used to estimate seepage velocity (Battelle, 2004).
[b] Elevation measurements in Event 13 were inconsistent with previous measurements, so flow direction, gradient, and velocity were not determined.

Groundwater Chemistry

Groundwater data from 2003-2011 were reviewed (see Appendix A for documents reviewed) and are presented in Appendix F and G. This data consists of total chromium and conventional parameters (water temperature, conductivity, dissolved oxygen, pH, oxidation-reduction potential, sulfur, and sulfate).

Total chromium data were compared against performance criteria provided in the 2001 ROD Amendment for the groundwater OU. Of the 22 wells analyzed here, only well B87-8 exceeded the cleanup standard in any of the monitoring events over the last 5 years. Monitoring well B87-8 experienced a total chromium concentration (dissolved fraction) greater than the 50 µg/L cleanup standard in the September 2007 (53.3 µg/L), December 2007 (56.9 µg/L), and September 2008 (119 µg/L monitoring events (Appendix F). The chromium concentration decreased to 40.5 µg/L in September 2009 and has been less than 3 µg/L since September 2010. In response to the cleanup level exceedences in September and December 2007 from well B87-8, hexavalent chromium was also measured in samples from B87-8 in subsequent sampling events (Events 14-17). The sample during the

September 2008 (Event 14) sampling event was analyzed for both total and hexavalent chromium. Total chromium measured 119 µg/L and hexavalent chromium measured 120 µg/L. Events 15, 16, and 17 had no detection of hexavalent chromium in B87-8 at the reporting limit of greater than 50 µg/L. The oxidation-reduction potential, pH, and other conventional parameters during this time of increased chromium concentrations were not outside of the normal ranges for this well (Appendix G). This short-term increase in chromium concentrations at B87-8 followed by a rapid decrease suggests the presence of a slug of contaminated groundwater moving downgradient. Due to the relatively low seepage velocity at the site and the effects of dilution and dispersion, concentrations are expected to decrease over time. Assuming the prevalent groundwater flow is in a southerly direction toward well W85-6A and using Table 3 and the estimated range of groundwater seepage velocity (high of 4.75 ft/day to low of 0.33 ft/day), the estimated arrival time at W85-6A is between 5 months and 6 years. Based on the average seepage velocity (1.5 ft/day), the slug could be observed in well W85-6A in 1.3 years, depending on the size of the slug and the flow direction. Even then, the chromium concentrations in the slug may have decreased below the cleanup goal due to dispersion, dilution, and/or continued chromium precipitation.

Chromium concentrations in monitoring wells W99-R5A and W99-R5B, the wells nearest to the Columbia River (approximately 1,500 feet from the river), have been below the chronic state standard for the protection of freshwater aquatic organisms (10.0 µg/L; WAC 173-201A-240) since February 2004 when long-term monitoring began (Appendix F).

Statistical trend analyses were performed for total chromium for the 22 monitoring wells using data from 2003-2011 using the same methodology as in the LTMO report. The Monitoring and Remediation Optimization System (MAROS) was used to perform Mann-Kendall (M-K) and linear regression (LR) trend analyses. The MAROS tool was also used to identify monitoring wells that have statistically achieved site cleanup goals with greater than 80% statistical power, and also those wells that have attained cleanup goals using the Sequential T-test method (EPA, 1992), which is a more rigorous statistical test than the 80% statistical power evaluation. MAROS assumes either a normal or lognormal distribution in the calculations; the reliability of t-tests may be questionable if the data do not have normal distributions. Additional information about these calculations and their use can be found in the MAROS User's Guide version 2.2 (Air Force Center for Environmental Excellence, 2006) or the LTMO Report. Non-detect values were left at the reporting limit. Analytical results for total chromium were used in the analysis as a conservative surrogate for assessing the concentration of soluble hexavalent chromium. Use of total chromium results will over-predict soluble chromium concentrations, making this a conservative trend analysis. Table 4 presents a summary of this analysis. More detailed MAROS output is provided in Appendix H for 2003-2011.

Table 4. Statistical Trends and Individual Well Cleanup Status for 2003-2011

Well Name	Mann-Kendall Trend[1]	Linear Regression Trend[1]	Statistically Below Cleanup Level >80% Power[2, 3]	Sequential T-test Result[2, 4]
B85-3	D	PD	YES	Attained
B85-4	D	D	YES	

B87-8	NT	PD	NO	
RA-MW-12A	D	D	NO	
RA-MW-12B	D	D	YES	Attained
RA-MW-12C	S	S	YES	Attained
RA-MW-15A	NT	NT	YES	Attained
RA-MW-15B	D	D	YES	
RA-MW-16A	D	D	YES	Attained
RA-MW-16B	NT	PD	YES	
RA-MW-17A	D	S	YES	Attained
W85-6A	S	PD	YES	Attained
W85-6B	D	D	YES	Attained
W92-16A	D	PD	YES	Attained
W92-16B	NT	NT	YES	Attained
W97-18A	D	NT	YES	
W97-19A	D	D	YES	Attained
W97-19B	D	D	YES	Attained
W98-21A	S	S	YES	Attained
W98-21B	PD	PD	YES	
W99-R5A	NT	NT	YES	
W99-R5B	D	D	YES	Attained

Notes

1. D = Decreasing, PD = Probably Decreasing, S = Stable, PI = Probably Increasing, I = Increasing, NT = No Trend, ND = well has all non-detect results
2. Results for Lognormal Distribution Assumption are presented. Results of Normal Distribution Assumption may be different.
3. YES indicates the mean concentration is significantly below the cleanup goal (50 µg/L). NO indicates the mean concentration is below the cleanup goal but not statistically significant because the existence of large data variability prevents the test from resulting in significance.
4. Attained indicates the mean concentration is significantly below the cleanup goal, and has achieved the target level of 0.8 (50 µg/L) = 40 µg/L with statistical significance using the sequential t-test. The program default for determining the target level is 80% of the cleanup goal.

Trend analyses for all data (2003-2011) indicate that chromium is not increasing in any of the 22 monitoring wells. All but two monitoring wells are statistically below 50 µg/L with >80% power.

Conventional parameters dissolved oxygen (DO) and oxidation-reduction potential (ORP) were evaluated to assess the groundwater chemistry in the source zone (Appendix H). DO concentrations measured in ISRM wall wells RA-MW-12A, RA-MW-12B, and RA-MW-12C were low over this FYR period, ranging from 0 to 1.96 mg/L. Similarly, ORP was very low, ranging from -396 to -154 mV. DO concentrations and ORP measurements indicate the wall remained reductive over this FYR period, which is necessary for the treatment of hexavalent chromium.

With the exception of the ISRM wall wells and wells B85-3, B87-8, RA-MW-15A, and RA-MW-17A, ORP in all wells increased substantially from Event 16 (September 2010) to Event 17 (September 2011). ORP ranged from 21 to 220 mV in Event 16 and from 315 to 609 mV in Event 17; Event 17 ORP measurements represent historical highs for all but the excepted wells. However, some wells (e.g., B85-4, W92-16A, W97-18A, W99-R5A, W99-R5B) did not show substantial increases in DO concentrations that would be expected with substantial increases in ORP; DO continues to show reducing conditions in most wells. This may indicate errant DO or ORP values in Event 17. Even if the comparatively high ORP levels are accurate, solid trivalent chromium (e.g. chromium (III) oxide or Cr_2O_3) was still thermodynamically favorable in wells sampled during Event 17 (Figure 6-1); all pH and ORP conditions during Event 17 (Appendix G) fall within the Cr_2O_3 stability region. Therefore, oxidation and subsequent dissolution of trivalent chromium solids is unlikely in any well based on current geochemical conditions.

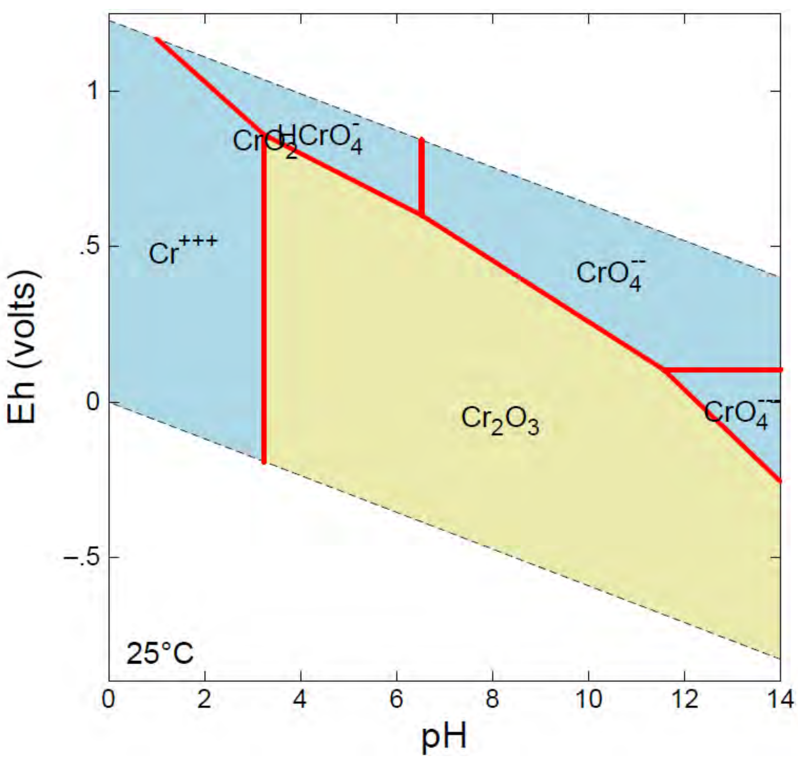


Figure 6-1. Pourbaix diagram for chromium. Prepared using Geochemist's Workbench Essentials version 8. Temperature = 25°C, Pressure = 1.013 bars, Chromium activity = 10^{-6}.

6.5. Site Inspection

The site was inspected on Thursday, October 18th, 2012. The site inspection was conducted by Bernie Zavala (EPA, Hydrogeologist), Claire Hong (EPA), Guy Barrett (WDOE, Site Manager), Mohsen

Kourehdar (WDOE), Sharon Gelinas (USACE, Hydrogeologist), and Aaron King (USACE, Environmental Engineer).

The Site Inspection Report is presented in Appendix J.

6.6. Institutional Controls

USACE confirmed that the Agreement and Covenant Not to Sue is still on file at the Clark County Recorder's Office (as of 13 September 2012, Appendix B). No new domestic, industrial, or irrigation wells have been installed within one mile of the site and no one is known to be drinking or contacting affected groundwater. Contact with contaminated soils has been eliminated by contaminated soil removal and in situ treatment and is further prohibited by requirements to test any disturbed Site soils prior to excavation or storage and the prohibition of human exposure to any Site soils containing hazardous substances.

6.7. Interviews

A questionnaire was sent to WDOE. The purpose of the interview was to document the perceived status of the FHC site and any perceived problems or successes with the remedy components implemented to date. In general, WDOE felt informed about the progress at the site. WDOE feels the remedy continues to be protective of human health and the environment, and is looking forward to project closeout in the future. No concerns were raised. The full questionnaire responses are presented in Appendix K.

7. Technical Assessment

7.1. Question A

Is the remedy functioning as intended by the decision documents?

Yes, the remedy is functioning as intended by the decision documents as described below.

Remedial Action Performance

The remedy has been fully implemented in accordance with the amended ROD and remedial action objectives, and the State has the lead for operation and maintenance, which consists primarily of periodic groundwater monitoring.

Source Area Soils OU 1

Cleanup levels have been met for OU 1. Soils in the source area were treated until chromium levels were lower than the required state standards during the Remedial Action and soils outside the work area were not been adversely impacted by chromium as a result of cleanup activities.

Groundwater OU

All but one of the wells demonstrated compliance with the cleanup standard over this FYR period. Total chromium in three samples from well B87-8 exceeded the cleanup standard (50 µg/L) in 2007 and 2008. Total chromium in B87-8 has been below the cleanup goal since 2009 and concentrations in the next downgradient well W85-6A have been below the cleanup goal since 2004. This short-term increase followed by a rapid decrease may indicate the presence of a slow-moving slug of groundwater with total chromium concentrations above the standard, but the next downgradient well (W85-6A) has been below the cleanup goal since 2004; the expected range of arrival times of this slug at well W85-6A is 5 months to six years from 2008 based on the seepage velocity from Table 3. Chromium concentrations are expected to decrease over time due to dispersion, dilution, and/or continued redox change to trivalent chromium.

No other wells exceeded the cleanup standard (50 µg/L) at any time during the second FYR period and no wells during the most recent sampling event exceeded the total chromium cleanup standard. Chromium-contaminated water has never exceeded the chronic state standards for the protection of fresh water aquatic organisms (10 µg/L) in the two wells closest to the Columbia River.

DO concentrations in Event 17 generally did not increase substantially like ORP, indicating the potential for instrument malfunction or calibration error of either the DO or ORP probe during this Event.

In general, most monitoring wells showed decreasing, probably decreasing, or stable trends (with values below the cleanup goal of 50 µg/L) for the overall time period of 2003-2011. All but two monitoring wells are statistically below 50 µg/L with >80% power.

System operations/O&M

The monitoring system is working as designed. Groundwater monitoring samples have been obtained annually with no problems since the first FYR.

Cost of system operations/O&M

The costs from the last five years reflect minimal O&M for this site. Continued monitoring will result in additional costs, though annual monitoring costs could be expected to remain roughly the same if all of the current wells remain a part of the monitoring program.

Opportunities for optimization

An easy and inexpensive means to check errant DO or ORP (one or the other) values in future events would be to also measure ferrous iron in the field, which completes a trio of field parameters that indicate the extent of reducing conditions in groundwater. Adding ferrous iron to the conventional parameters measured would increase the reliability of the field geochemical parameter result interpretation.

Implementation of institutional controls

The Agreement and Covenant Not to Sue, WAC minimum standards for well construction, and other institutional controls have been successful in preventing the installation of wells and groundwater used in the contaminated area. Soil deed restrictions, as listed in the Agreement (Appendix B), may no longer be needed since all soil is below cleanup standards, as reported in the Remedial Action Report. As of 13 September 2012, the Agreement and Covenant Not to Sue for the FHC site was still on file at the Clark County Recorder's Office. Also, WDOE has been in contact with the developer regarding future development on or near the site.

7.2. Question B

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

Changes in standards

As outlined in the 2001 ROD Amendment, the remedy was designed and implemented to comply with all action- and chemical-specific ARARs identified therein (Appendix L). No location-specific ARARs were identified in the 2001 ROD Amendment. The chemical-specific ARARs are the only ones currently applicable to the FHC site, though action-specific ARARs may be applicable to future activities at the site. WAC 173-201A-240 lists a slightly different value for the chronic state standard for the protection of freshwater aquatic organisms (10.0 µg/L) than the previous FYR (10.5 µg/L). Chromium concentrations in monitoring wells W99-R5A and W99-R5B, the wells nearest to the Columbia River (approximately 1,500 feet from the river), have been below the 10.0 µg/L (WAC 173-201A-240) since February 2004 when long-term monitoring began (Appendix F). Therefore, this change does not affect the protectiveness of the remedy. There were no other changes in chemical-specific ARARs that affect the protectiveness of the remedy. A more complete evaluation and discussion of all ARARs identified in the 2001 ROD Amendment is provided in Appendix L.

Changes in exposure pathways

Six exposure pathways were considered in the remedy design: Groundwater Pathway, Groundwater discharges to the Columbia River, Airborne Pathway, Surface Water Pathway, Dermal Contact Pathway and Incidental Ingestion Pathway.

<u>Groundwater Pathway</u>: Modeling results for a 70-year scenario suggested little impact to domestic or municipal water wells; the maximum predicted probability of exceeding the MCL for chromium was 5%. However, a hypothetical well within or near the groundwater plume would be severely impacted by high chromium concentrations in the contaminated plume.

<u>Groundwater discharges to the Columbia River</u>: The concentration of chromium in the groundwater was predicted by flow simulation model to rarely exceed the State standard for chronic surface water for chromium due to dilution of the contaminated plume as groundwater migrates to and enters the river.

<u>Airborne Pathway</u>: The 95th percentile excess cancer risk for chromium did not exceed the 10^{-7} level on-site or the 10^{-8} level off-site.

Surface Water Pathway: At the time of the 2001 ROD Amendment, insufficient data were available to conduct a detailed assessment of the human health and environmental risk due to surface water transport. Groundwater modeling determined there was negligible risk due to the low concentrations of chromium detected in groundwater near the river and predicted dilution as it migrates and enters the river. Storm water impacts to surface waters have been eliminated by the interception and rerouting of run on from up gradient sources, and the removal and treatment of contaminated site soils.

Dermal Pathway: As a result of the removal of the most contaminated soils and materials from the site, the in situ treatment of the remaining soils, and the institutional controls prohibiting drilling wells and groundwater use, the potential for actionable risk resulting from dermal contact with contaminated soils or groundwater is very unlikely.

Incidental Ingestion Pathway: Worst-case scenarios for chromium ingestion via on-site soils or acute consumption of blackberries grown on-site exceed allowable daily intake (ADI) values for chromium for children. However, in both of these cases, other exposures – notably inhaled dusts- might be of greater concern to children with access to the site.

These exposure pathways from the 2001 ROD Amendment have not changed. There are no private, municipal, or industrial supply wells in operation within the contaminated aquifer. Soils/source area treatment was completed successfully. Institutional controls are in place to prevent the installation of wells in the contaminated area. Chromium in soils was treated below the cleanup standards, as shown in the Remedial Action Report.

Changes in toxicity

The MTCA A cleanup level for chromium (50 μg/L) in groundwater is based on the concentration derived using Equation 720-1 for hexavalent chromium (WAC 173-340-720). The equation is risk-based; it uses the oral reference dose for chromium to calculate the chromium concentration that would result in a hazard quotient equal to unity.

EPA's Integrated Risk Information System (IRIS) database was reviewed to determine if toxicity values used by the Agency in risk assessments have been updated. The last significant revision to chromium related constituents (insoluble trivalent chromium salts and hexavalent chromium) in the IRIS database took place in September 1998. Toxicity values from EPA Region 9's 2004 Preliminary Remediation Goals (PRG) table and 2012 Regional Screening Levels (RSLs) table were also reviewed and are shown in Table 5 were also reviewed and for reference. Note that the oral reference doses for Chromium (III), insoluble salts and Chromium (VI) have not changed since 2004 and, therefore, have not changed since the first FYR or the time of remedy selection. As a result, the MTCA A cleanup level from chromium in groundwater has not changed since the first FYR. Inhalation toxicity values are included for completeness, though there is no discernible pathway for the inhalation of chromium from groundwater.

Table 5. Toxicity Values

Contaminant	Toxicity Values from 2004 Preliminary Remediation Goals[1]	Toxicity Values from 2012 EPA Regional Screening Levels[2]

Chromium (III), insoluble salts	Oral Rfd: 1.5 mg/kg-day	Oral Rfd: 1.5 mg/kg-day
Chromium (VI)	Oral Rfd: 3.0E-03 mg/kg-day Inhalation SF: 2.9E+02 kg-day/mg Inhalation Rfd: 2.2E-06 mg/kg-day	Oral Rfd: 3.0E-03 mg/kg-day Oral SF: 5.0E-01 kg-day/mg IUR: 8.4E-02 $\mu g/m^3$ Inhalation RfC: 1.0E-04 mg/m^3
Chromium Total	Inhalation SF: 4.2E+01 kg-day/mg	--

Notes
1. Toxicity values were not provided in the RODs or the ROD Amendment. Therefore this evaluation uses 2004 Preliminary Remedial Goals (PRGs) from EPA Region 9
2. New toxicity values from the April 2012 EPA Regional Screening Levels (RSLs).
SF = slope factor
Rfd = reference dose
RfC = reference concentration
IUR = inhalation unit risk

In September 2010, EPA released a draft IRIS assessment for hexavalent chromium, for the oral route of exposure only, for peer review and public comment. An independent expert peer review panel met in May 2011 to review the draft assessment. In their final report, the peer review panel urged EPA to consider the results of research that would soon be completed and peer-reviewed that could provide relevant scientific information that may inform the findings of the assessment. Based on the recommendations of the external peer review panel, EPA will consider the results of recently and soon to be completed peer-reviewed primary research on the chemical before finalizing the IRIS assessment. The oral assessment will be revised to address the peer review comments and combined with the inhalation assessment, which is currently in draft development. EPA anticipates that the draft assessment for hexavalent chromium (oral and inhalation) will be released for public comment and external peer review in 2013. Given the delay and uncertainty over future changes, this does not constitute new information which could call into question the protectiveness of the remedy at the Site and no changes to cleanup levels for this Site are appropriate or necessary at this time.

Changes in land and resource use

Land use in the FHC area is primarily industrial, with some manufacturing and commercial uses. Land use has not changed since the first FYR. Continued redevelopment of the area is expected in the future, and may impact the monitoring network. No new domestic, industrial, or irrigation wells have been installed within one mile of the site and no one is known to be drinking affected groundwater.

New contaminants and/or contaminant sources

There are no known new contaminants or contaminant sources associated with the FHC site.

7.3. Question C

Has any other information come to light that could call into question the protectiveness of the remedy?

There is no new information that could call into question the protectiveness of the remedy.

7.4. Technical Assessment Summary

Overall, the remedy is currently functioning as intended. Source area treatment reduced the concentration of chromium in soils below the cleanup goals for unlimited use; the RAOs for soils have been achieved. Institutional controls for groundwater prevent the construction of new wells in the contaminated portion of the aquifer, and, therefore, exposure to chromium-contaminated groundwater. Chromium-contaminated groundwater above chronic state standards for the protection of fresh water aquatic organisms (10 μg/L) has been prevented from seeping into the Columbia River. Annual O&M has been completed with no problems.

Twenty-one of the 22 wells demonstrated compliance with the cleanup level (50 μg/L) during this FYR period, but there is uncertainty regarding well B87-8. Groundwater with chromium concentrations greater than the cleanup level was observed downgradient from the ISRM wall in well B87-8 in three consecutive samples during in 2007 and 2008, potentially indicating the presence of a slow-moving slug of groundwater contaminated above the cleanup level (50 μg/L). The expectation is that chromium concentrations greater than the cleanup goal will continue to decrease as a result of dispersion, dilution and/or continued chromium precipitation. Oxidation and subsequent dissolution of trivalent chromium solids is unlikely based on current geochemical conditions. In order to deal with the uncertainty with well B87-8, modifications to the monitoring program are recommended as outlined in Sections 8 and 9.

Exposure assumptions, toxicity data, RAOs, cleanup levels and other ARARs used at the time of remedy selection are still valid. There have been no changes in ARARs and toxicity data since the selection of the remedy. There have been no changes in exposure pathways. The principal exposure pathway for hexavalent chromium in soils is through ingestion and dermal contact. This pathway has been eliminated by source zone treatment. The principal exposure pathway for hexavalent chromium in groundwater is through ingestion and dermal contact. This pathway has been eliminated by the institutional controls.

There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedy. Land use has not changed since the first FYR, but redevelopment in the area is expected to continue in the future; this may physically impact the monitoring network.

8. Issues

There were no issues identified that affect either current or future protectiveness of the site. The following is a list of issues that were identified as a result of uncertainties remaining at the site.

1. Groundwater chromium concentrations were greater than the cleanup level in 2007 and 2008 for monitoring well B87-8. This well is downgradient of the ISRM wall and concentrations of chromium were above the cleanup level prior to the installation of the wall. The concentration of total chromium in well B87-8 for 2009, 2010, and 2011 decreased below the cleanup level (50

µg/L) to 3 µg/L. This is a key location for monitoring the performance of the ISRM wall and the source control down gradient of the FHC building

2. DO concentrations in Event 17 generally did not increase substantially like ORP, indicating the potential for instrument malfunction or calibration error of either the DO or ORP probe during this Event.

3. Future redevelopment of the FHC site may impact the existing monitoring wells.

4. Begin the process to statistically test the groundwater monitoring data to determine whether or not the cleanup level for chromium has been attained.

5. Improve groundwater interpretations presented in future monitoring reports.

9. Recommendations and Follow-up Actions

Recommendations and follow-up actions for the issues that do not affect current or future protectiveness presented in Section 8 are given below.

1. Continue monitoring in well B87-8 and downgradient monitoring wells. The sampling frequency for B87-8 should increase to semi-annual for three years, and both hexavalent and total chromium must be analyzed. The current reporting level for total chromium is adequate, but the reporting level for hexavalent chromium is too high at 50 µg/L and should be changed to 5 µg/L.

2. In future monitoring events at appropriate locations, measure DO by a field test kit using a Winkler titration method; also, measure ferrous iron in the field using a test kit. Both of these methods would increase the reliability of the field geochemical interpretation.

3. Continue to be in close contact with the developer regarding redevelopment activities and the protection of the monitoring network.

4. Select the appropriate statistical test and perform the evaluation prior to the next five year review. Make recommendations regarding site closure.

5. Include contours on groundwater elevation maps in future monitoring reports. Also remove contours from the plume maps. These maps appear to indicate large plumes of chromium contaminated groundwater. However, chromium concentrations have not been higher than the cleanup level in any well since the September 2008 sampling event.

10. Protectiveness Statements

OU 1 Soils/Source Area

The remedy at OU 1 (soils/source area) is protective of human health and the environment and exposure pathways that could result in unacceptable risks have been eliminated as a result of soils/source area remedial action.

OU 2 Groundwater

The remedy at OU 2 (groundwater) is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled through remedial action and institutional controls.

Site-wide

Because the remedial actions at both OUs are protective, the site is protective of human health and the environment.

11. Next Review

The next five-year review for the Frontier Hard Chrome Superfund Site is required by 29 January 2018, five years from the date of this review.

12. References

Air Force Center for Environmental Excellence. 2006. Monitoring and Remediation Optimization System (MAROS) Software Version 2.2 User's Guide. March 2006.

Battelle. 2004. In Situ Redox Manipulation Permeable Reactive Barrier Emplacement: Final Report. Frontier Hard Chrome Superfund Site, Vancouver, WA. January 2004.

EPA. 2001. Comprehensive Five-Year Review Guidance. June 2001.

EPA. 1992. Methods for Evaluating the Attainment of Cleanup Standards Volume 2: Groundwater. July 1992.

Petersen, M.D., Frankel, A.D., Harmsen, S.C., Mueller, C.S., Haller, K.M., Wheeler, R.L., Wesson, R.L., Zeng, Y., Boyd, O.S., Perkins, D.M., Luco, N., Field, E.H., Wills, C.J. and Rukstales, K.S. 2008. Seismic-Hazard Maps for the Conterminous United States, 2008. USGS Scientific Investigations Map 3195.

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Appendix A: List of Documents Reviewed

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List of Documents Reviewed

These documents were reviewed as part of this Five-Year Review:

EPA. 2008. Five-Year Review Report for Frontier Hard Chrome Superfund Site, City of Vancouver, Clark County, Washington. EPA Region 10. January 2008.

EPA, 2007. Groundwater Monitoring Network Optimization Frontier Hard Chrome Superfund Site, Vancouver, Washington. December 2007.

EPA, 2003. Preliminary Close Out Report Frontier Hard Chrome Vancouver, Washington. September 2003.

EPA. 2001. EPA Superfund Record of Decision Amendment: Frontier Hard Chrome, Inc. EPA ID: WAD053614988 OU 01, 02, Vancouver, Washington. August 2001.

EPA. 1988. EPA Superfund Record of Decision: Frontier Hard Chrome, Inc. EPA ID: WAD053614988 OU 02, Vancouver, Washington. July 1988.

EPA. 1987. EPA Superfund Record of Decision: Frontier Hard Chrome, Inc. EPA ID: WAD053614988 OU 01, Vancouver, Washington. December 1987.

Weston Solutions, Inc. 2011. Frontier Hard Chrome Long-Term Monitoring Report Event 17—September 2011, Vancouver, Washington. Prepared for Washington State Department of Ecology. December 2011.

Weston Solutions, Inc. 2010. Frontier Hard Chrome Long-Term Monitoring Report Event 16—September 2010, Vancouver, Washington. Prepared for Washington State Department of Ecology. December 2010.

Weston Solutions, Inc. 2009. Frontier Hard Chrome Long-Term Monitoring Report Event 15—September 2009, Vancouver, Washington. Prepared for Washington State Department of Ecology. December 2009.

Weston Solutions, Inc. 2008. Frontier Hard Chrome Long-Term Monitoring Report Event 14—September 2008, Vancouver, Washington. Prepared for Washington State Department of Ecology. December 2008.

Weston Solutions, Inc. 2007. Frontier Hard Chrome Long-Term Monitoring Report Event 13—December 2007, Vancouver, Washington. Prepared for Washington State Department of Ecology. February 2008.

Weston Solutions, Inc. 2007. Frontier Hard Chrome Long-Term Monitoring Report Event 12—September 2007 Vancouver, Washington. Prepared for Washington State Department of Ecology. November 2007.

Weston Solutions, Inc. 2007. Frontier Hard Chrome Long-Term Monitoring Report Event 11—June 2007 Vancouver, Washington. Prepared for Washington State Department of Ecology. August 2007.

Weston Solutions, Inc. 2007. Frontier Hard Chrome Long-Term Monitoring Report Event 10—March 2007 Vancouver, Washington. Prepared for Washington State Department of Ecology. May 2007.

Weston Solutions, Inc. 2007. Frontier Hard Chrome Long-Term Monitoring Report Event 9—December 2006 Vancouver, Washington. Prepared for Washington State Department of Ecology. January 2007.

Weston Solutions, Inc. 2006. Frontier Hard Chrome Long-Term Monitoring Report Event 8—September 2006 Vancouver, Washington. Prepared for Washington State Department of Ecology. November 2006.

Weston Solutions, Inc. 2006. Frontier Hard Chrome Long-Term Monitoring Report Event 7—June 2006 Vancouver, Washington. Prepared for Washington State Department of Ecology. July 2006.

Weston Solutions, Inc. 2006. Frontier Hard Chrome Long-Term Monitoring Report Event 6—March 2006 Vancouver, Washington. Prepared for Washington State Department of Ecology. April 2006.

Weston Solutions, Inc. 2006. Frontier Hard Chrome Long-Term Monitoring Report Event 5—December 2005 Vancouver, Washington. Prepared for Washington State Department of Ecology. February 2006.

Weston Solutions, Inc. 2005. Frontier Hard Chrome Long-Term Monitoring Report Event 4—May 2005 Vancouver, Washington. Prepared for Washington State Department of Ecology. July 2005.

Weston Solutions, Inc. 2004. Frontier Hard Chrome Long-Term Monitoring Report Event 3—August 2004 Vancouver, Washington. Prepared for Washington State Department of Ecology. December 2004.

Weston Solutions, Inc. 2004. Frontier Hard Chrome Long-Term Monitoring Report Event 2—April 2004 Vancouver, Washington. Prepared for Washington State Department of Ecology. June 2004.

Weston Solutions, Inc. 2004. Frontier Hard Chrome Long-Term Monitoring Report Event 1—February 2004 Vancouver, Washington. Prepared for Washington State Department of Ecology. May 2004.

Weston Solutions, Inc. 2003. Institutional Controls Plan Frontier Hard Chrome Vancouver, Washington. Prepared for EPA. December 2003.

Weston Solutions, Inc. 2003. Remedial Action Report Frontier Hard Chrome Superfund Site Vancouver, Washington. Prepared for EPA. December 2003.

Appendix B: Institutional Controls from the Agreement and Covenant not to Sue

4068766
Page: 1 of 3
10/19/2005 02:34P
JH KELLY LLC AGR 34.00 Clark County, WA

RETURN ADDRESS

Mark Fleischmer
821 3rd Ave.
Longview, WA 98632

Please print neatly or type information

Document Title(s)

Notice of Agreement & Institutional Controls

Reference Numbers(s) of related documents:

Additional Reference #'s on page ____

Grantor(s) (Last, First and Middle Initial)

Kelly Development LLC

Additional grantors on page ___

Grantee(s) (Last, First and Middle Initial)

MEH LLC

Additional grantees on page ___

Legal Description (abbreviated form: i.e. lot, block plat or section, township, range, quarter/quarter)

Lots 2 and 3 of Blurock Homestead Lots.

Additional legal is on page ___

Assessor's Property Tax Parcel/Account Number

033824-000 033825-000

Additional parcel #'s on page ___

The Auditor/Recorder will rely on the information provided on this form. The staff will not read the document to verify the accuracy or completeness of the indexing information provided herein.

I am requesting an emergency nonstandard recording for an additional fee as provided in RCW 36.18.010. I understand that the recording processing requirements may cover up or otherwise obscure some part of the text of the original document.

____

Signature of Requesting Party

When recorded, please return to:

Mark Fleischauer
821 Third Avenue
Longview, WA 98632

NOTICE OF AGREEMENT & INSTITUTIONAL CONTROLS

This Notice is filed to reflect the below prescribed information with respect to approximately 2.6 acres of real property comprised of portions of the former Frontier Hard Chrome site and the Richardson Metal Works, more formally described as:

A parcel of property in Lots 2 and 3 of Blurock Homestead Lots as recorded in Volume A of Plats at Page 43, Clark County, Washington records and lying in the Southeast quarter of the Southeast quarter of Section 26, Township 2 North, Range 1 East of the Willamette Meridian, Clark County, Washington, described as follows:

BEGINNING at the Southeast corner of said Lot 2;

THENCE North 00° 16' 21" East along the East line of said Lot 2 a distance of 385.78 feet;

THENCE North 89° 50' 31" West a distance of 336.60 feet to the East line of East Y Street as conveyed by deed recorded under Auditor's File No. G 546002 of Clark County records;

THENCE South 02° 02' 09" East along said East line a distance of 181.21 feet to the South line of that tract conveyed to Walter and Otto Neth by deed recorded under Auditor's File No. G 193751 of Clark County records;

THENCE North 87° 57' 51" East along said South line a distance of 138.49 feet to the West line of that tract conveyed to Walter and Otto Neth by deed recorded under Auditor's File No. 8411070063 of Clark County records;

THENCE South 00° 16' 21" West along said West line a distance of 181.40 feet to the South line of said Lot 2;

THENCE South 81° 19' 09" East along the South line of said Lot 2 a distance of 193.00 feet to the POINT OF BEGINNING.

(collectively, the "Property")

(1) The United States EPA selected an environmental remedy for the Property on August 30, 2001.

(2) The Property is subject to an Agreement and Covenant Not To Sue (Docket No. CERCLA-10-2003-0009) by and between Kelly Development LLC and the United States EPA.

(3) The Property is subject to Institutional Controls prescribed in the above-referenced Agreement and Covenant Not to Sue.

IN WITNESS WHEREOF, the Property owner has executed this Notice.

Date: July 17, 2004

Kelly Development LLC

Mark A. Fleischauer, Vice President

ACKNOWLEDGED AND AGREED:

MEH LLC (proposed purchaser of Property)

Mason M. Evans, Manager
Date: July 17, 2004

Recorders Note
No Notary Signature

Recorders Note
No Notary Seal

Settling Respondent shall comply with the following institutional controls at the Frontier Hard Chrome Site:

1. No installation of groundwater or dry wells on Site, exclusive of any storm water treatment and/or detention ponds required by regulatory bodies.

2. No use of groundwater from the Site.

3. Soil that is to be excavated for use or disposal off-Site must first be tested for hexavalent chromium and trivalent chromium. The use or disposal of such soil must comply with State and Federal regulations. EPA must be consulted prior to such excavation.

4. Soil that is to be excavated for use or storage on-Site must first be tested for hexavalent chromium and trivalent chromium. The use or disposal of such soil must comply with State and Federal regulations. EPA must be consulted prior to such excavation.

5. The controls outlined in (3) and (4) above shall not apply to shallow trenching conducted for purposes of installing utilities, footings, etc., when soils from such activities are returned to their original locations. Settling Respondent shall provide EPA with a diagram of proposed trenching activities prior to excavation.

6. Any disturbance of soil at the Site must be undertaken in a manner that prevents human exposure to any hazardous substances contained in the soil.

7. Any of the above institutional controls may be waived in writing by EPA should EPA determine that there may otherwise be a potentially acceptable level of risk of exposure to hazardous substances absent the particular institutional control.

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Institutional Controls from the Agreement and Covenant Not to Sue

The following Appendix shows two documents. The first is an unofficial copy of the Notice sent to the Clark County Recorder's Office to notify the County of the Agreement and Covenant Not to Sue and the property to which it pertains. This Notice contains the identities of parties involved (Kelly Development LLC and United States EPA) and the date which the Agreement was signed (July 17, 2004). The second is a list of the Institutional Controls outlined in the Agreement and Covenant Not to Sue.

Appendix C: 2007 Survey of Wells Impacted by Development South of FHC Site

Table 4—Frontier Hard Chrome—Event 13 Ground Water Elevations 13 December 2007

Well No.	Time	Casing Elevation (feet)	Depth to Water (feet)	Water level Elevation (AMSL)
W85-3A	910	26.40	19.75	6.65
W85-3B	913	26.77	20.12	6.65
W97-18A[1]	945	24.66	17.88	6.78
W97-18B[1]	956	25.64	18.86	6.78
B85-4[1]	939	25.13	18.32	6.81
B87-8[1]	934	25.80	19.03	6.77
W92-16B	922	25.51	18.86	6.65
W92-16A	921	25.62	18.95	6.67
B85-3[1]	930	25.97	18.21	7.76
W85-7A[1]	1032	26.22	19.48	6.74
W85-7B[1]	1036	26.41	20.32	6.09
W97-19A	1059	22.45[2]	15.79	6.66
W97-19B	1100	21.72[2]	15.15	6.57
W98-20A[1]	1050	26.62	19.87	6.75
W85-6A[1]	1006	25.90	19.15	6.75
W85-6B[1]	1007	25.85	19.11	6.74
W98-21B[1]	1020	27.05	20.28	6.77
W98-21A[1]	1016	27.00	21.49	5.51
W99-R5A	1112	32.26	25.56	6.70
W99-R5B	1114	32.33	25.62	6.71
USGS 14144700 (Stage height of the Columbia River corrected to NGVD 1929)				5.55

[1] Casing elevation surveyed by Minister-Glaeser Surveying Inc, on November 30, 2007.

[2] Two different elevation datum's have been used at Frontier Hard Chrome. Weston (12/03) Long-Term Monitoring plan has applied a correction factor (+3.76 feet) using the City of Vancouver's benchmark #108 located near FHC site.

-- Could not measure water level elevation due to construction activities in the area.

MONITORING WELL ASBUILT

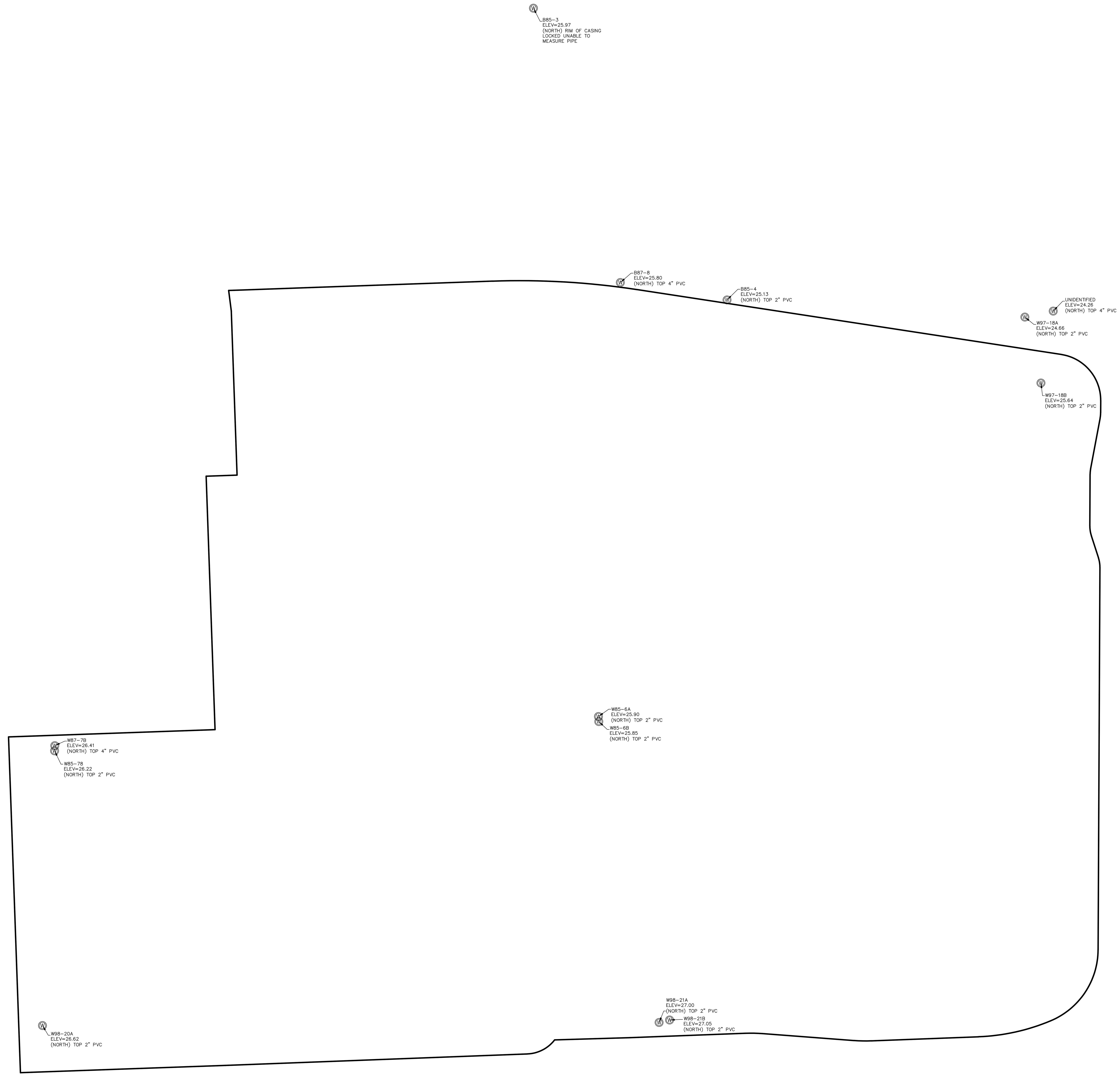
FOR

"GRAND CENTRAL"

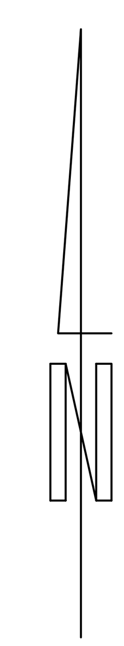
JOB NO.: 07-231
DATA COLLECT: 11-30-07
DRAWING DATE: 12-06-07

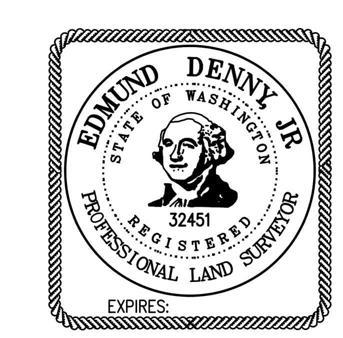
LEGEND:

Ⓦ INDICATES MONITORING WELL



BENCH MARK:
VERTICAL DATUM IS CITY OF VANCOUVER BENCH MARK 108, A BRASS DISC ON THE NORTHEAST CURB AT THE INTERSECTION OF E. 5TH STREET AND GRAND BOULEVARD. ELEVATION = 53.76 (NAVD 29)





50 25 0 50 75 100

SCALE 1 INCH = 50 FEET

MINISTER-GLAESER
SURVEYING INC.
2200 E. EVERGREEN BLVD.
VANCOUVER, WA 98661
(360) 694-3313

DRAWING FILE: 07231AB-MW2.DWG DRAWN BY: JAG PROJECT MGR: ED

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2007 Survey of Wells Impacted by Development South of FHC Site

New casing elevations for the 12 wells affected by mall construction were surveyed by Minister-Glaeser Surveying, Inc. on November 30, 2007 (prior to the milestone date of 9/30/2008). These elevations were first provided in Table 4 and Appendix C of the Event 13 Long-Term Monitoring Report, which are reproduced in this Appendix.

Appendix D: LTMO Study Recommendation Adoption Memorandum

FHCSF
19.4.1.1
9/3/2010

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL CLEANUP

September 3, 2010

MEMORANDUM

SUBJECT: Modification of Monitoring Frequency at Frontier Hard Chrome Based on Long-Term Monitoring Optimization Study

FROM: Claire Hong

TO: Frontier Hard Chrome Site File

In preparation for the Five Year Review for Frontier Hard Chrome, EPA conducted a long-term groundwater monitoring optimization study. Finalized in December 2007, The Frontier Hard Chrome Superfund Site: Groundwater monitoring Network Optimization, SDMS #1273104, recommended a change in the monitoring schedule for the wells at this site. Recommendations on which wells to monitor and the frequency were presented in Table 7, "Final Recommended Monitoring Network Frontier Hard Chrome," which is attached to this memorandum. Guy Barrett of the Washington State Department of Ecology is the primary site manager during Operations and Maintenance of the remedy at this site. Ecology is using these recommendations to monitor this site. Ecology modified their contract to meet these recommendations. The effective date of this change was June 16, 2008.

There is one well that is not being monitored based on the recommendations from the optimization study. That well is the replacement well for one that had been damaged during the redevelopment of the property to the south of Frontier Hard Chrome. During the development of the Grand Central retail complex, W97-18B was damaged. Ecology oversaw the development of the replacement well. Unfortunately, that well is not connected to the aquifer, so sampling is not possible.

TABLE 7
FINAL RECOMMENDED MONITORING NETWORK FRONTIER HARD CHROME

LONG-TERM MONITORING OPTIMIZATION
FRONTIER HARD CHROME SUPERFUND SITE
VANCOUVER, WASHINGTON

	Total Chromium					
WellName	Percent Detection	Mann Kendall Trend	Statistically Below Standard?	MAROS Redundancy Determination	Recommendation After Qualitative Review	Final Recommended Frequency
Zone A Wells						
B85-4	91%	D	√	√	Retain	Annual
RA-MW-11A	83%	D	√		**Exclude**	**Exclude**
RA-MW-12A	100%	NT			Retain	Annual
RA-MW-13A	83%	S	√		**Exclude**	**Exclude**
RA-MW-14A	75%	S	√	√	**Exclude**	**Exclude**
RA-MW-15A	92%	NT	√	√	Retain	Annual
RA-MW-16A	92%	D	√	√	Retain	Annual
RA-MW-17A	92%	S	√		Retain	Annual
W85-6A	89%	S	√	√	Retain	Annual
W85-7A	82%	S	√	√	**Exclude**	**Exclude**
W92-16A	64%	NT	√	√	Retain	Annual
W97-18A	55%	S	√		Retain	Annual
W97-19A	91%	PD	√		Retain	Annual
W98-20A	91%	S	√	√	**Exclude**	**Exclude**
W98-21A	91%	PD	√		Retain	Annual
W99-R5A	36%	NT	√		Retain	Annual
Zone B Wells						
B85-3	73%	NT	√		Retain	Annual
B87-8	100%	NT		√	Retain	Annual
RA-MW-11B	92%	D	√	√	**Exclude**	**Exclude**
RA-MW-12B	83%	D	√	√	Retain	Annual
RA-MW-12C	100%	S	√	√	Retain	Annual
RA-MW-13B	50%	NT	√		**Exclude**	**Exclude**
RA-MW-13C	91%	S	√	√	**Exclude**	**Exclude**
RA-MW-14B	75%	NT	√		**Exclude**	**Exclude**
RA-MW-15B	100%	NT			Retain	Annual
RA-MW-16B	100%	NT			Retain	Annual
W85-6B	89%	D	√	√	Retain	Annual
W85-7B	36%	D	√		**Exclude**	**Exclude**
W92-16B	100%	NT			Retain	Annual
W97-18B	73%	NT	√		Retain	Annual
W97-19B	82%	D	√		Retain	Annual
W98-21B	91%	D	√		Retain	Annual
W99-R5B	91%	D	√		Retain	Annual

Notes:

1. Mann Kendall Trends: D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; NT = No Trend; ND = well has all non-detect.
2. Mann-Kendall trends 2003 - 2007 are shown.
3. Statistically below standard based Student's T-Test with >80% statistical power for data between 2003-2007. Cleanup standard is Washington Ecology MTCA A = 50ug/L Total Chromium.
4. MAROS redundancy indicates well has low SF and high AR and CR.
5. Final Recommendation based on statistical as well as qualitative evaluation.

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LTMO Study Recommendation Adoption Memorandum

Recommendations from the LTMO study for the FHC were adopted effective June 16, 2008 (prior to the milestone date of 12/31/2008) as stated in the following memorandum titled Modification of Monitoring Frequency at Frontier Hard Chrome Based on Long-Term Monitoring Optimization Study.

Appendix E: Copy of Public Notice

Nation says goodbye to moonwalker Neil Armstrong

1,500 gather to praise astronaut, his legacy

WASHINGTON (AP) — The nation bid farewell Thursday to Neil Armstrong, the first man to take a giant leap onto the moon.

The pioneers of space, the powerful of the capital and the everyday public crowded into the Washington National Cathedral for a public interfaith memorial for the very private astronaut.

Armstrong, who died last month in Ohio at age 82, walked on the moon in July 1969.

"He's now slipped the bonds of Earth once again, but what a legacy he left," former Treasury Secretary John Snow told the gathering.

ANN HEISENFELT/Associated Press
The congregation stands at the National Cathedral in Washington on Thursday during the national memorial service for Neil Armstrong.

Apollo 11 crewmates Buzz Aldrin and Michael Collins, Mercury astronaut John Glenn, 18 other astronauts, three NASA chiefs, and about two dozen members of Congress were among the estimated 1,500 people that joined Armstrong's widow, Carol, and other family members in the cavernous cathedral.

Collins read a prayer tailored to Armstrong's accomplishments and humility. A moon rock that the Apollo 11 astronauts gave the church in 1974 is embedded in one of its stained glass windows.

"You have now shown once again the pathway to the stars," Eugene Cernan, the last man to walk on the moon said in a tribute to Armstrong. "As you soar through the heavens beyond even where eagles dare to go, you can now finally put out your hand and touch the face of God."

The service also included excerpts from a speech 50 years ago by John F. Kennedy in which he said America chose to send men to the moon by the end of the 1960s not because it was easy, but because it was hard. The scratchy recording of the young president said going to the moon was a goal that "will serve to organize and measure the best of our energies and skills, because that challenge is one that we're willing to accept, one we are unwilling to postpone."

Shortly after that speech in 1961 at Rice University, Armstrong, not yet an astronaut but always a gifted engineer, was already working on how to land a spaceship on the moon, NASA administrator Charles Bolden recalled. Snow talked of the 12-year-old Armstrong who built a wind tunnel. But most of Armstrong's friends and colleagues spent time remembering the humble Armstrong. Snow called him a "regular guy" and "the most reluctant of heroes."

Armstrong commanded the historic landing of the Apollo 11 spacecraft on the moon July 20, 1969. His first words after stepping onto the moon are etched in history books: "That's one small step for man, one giant leap for mankind."

Seattle is sun-splashed while Southwest deals with rain

Late summer often flips West's weather on head

By JACQUES BILLEAUD and CHRIS GRYGIEL
Associated Press

SEATTLE — Heavy rains and flooding in the Southwest? A near-record dry streak in Seattle?

The seemingly counterintuitive weather is not necessarily unusual for this time of year, but it's striking when compared with the usual opinions about the regions — overcast and rainy in the Northwest and sunny skies in the Southwest. But late summer is typically the sunniest, driest part of the year in Washington and Oregon, while the Southwest monsoon season stretches into September.

In the Pacific Northwest, high temperatures and bone-dry terrain have made for dangerous fire conditions, particularly in Washington. More than 1,600 firefighters labored Wednesday on seven large fire complexes in Eastern Washington that were fanned by high winds earlier this week.

JOHN LOCHER/Associated Press
University of Nevada-Las Vegas students walk through a flooded parking lot on campus Tuesday after thunderstorms drenched the area.

ELAINE THOMPSON/Associated Press
A beachgoer shades himself from the sun last month at Seattle's Alki Beach. The city has been on a surprising run of dry weather.

Meanwhile, intense summer thunderstorms that struck parts of the Southwest this week flooded homes and streets in the Las Vegas area, inundated mobile home parks in Southern California, stranded some Navajo Nation residents in Arizona, and broke a dike in southern Utah, leading to evacuations.

The conditions may be leaving residents reeling, but they're par for the course this time of year, experts say.

Arizona, for example, has seen much flooding in recent months, with normally dry washes rushing like rivers in parts of the state. Some residents might have the impression that this summer has been extremely wet because of the frequency of rain that they can see from their homes, said J.J. Broston, a science officer for the National Weather Service in Tucson.

But rain falls more diffusely across a region — and this year has been wet but not record-breaking, he said.

"For the most part, people are looking at rainfall from their own individual perspectives, and if it rains at their homes, they think it has been a wet monsoon (season)," Broston said. "From the Weather Service's perspective, we are looking at a larger area."

Rainfall levels in Arizona so far in the monsoon season that runs from June 15 through Sept. 30 have generally been just above average.

Metro Phoenix and surrounding areas have seen 2.35 inches this season, up from the average of 1.4 inches but nowhere near the record of 9.56 in 1984, according to the National Weather Service.

In southern Arizona, Tucson International Airport has recorded 5.97 inches of rain this season. That's a half-inch above the average so far in the season, but pales in comparison to the record of 13.84 inches in 1964.

In the Las Vegas area, heavy rains this week delayed flights and prompted helicopter rescues of some stranded motorists.

Crews on Wednesday planned to resume their search for a landscape worker who was possibly swept away during a downpour at an area golf course. Police said the man was last seen Tuesday afternoon; photos showed the backhoe he was using almost completely submerged in floodwaters.

More than 1.75 inches of rain was reported in downtown Las Vegas after Tuesday's showers. That puts the region on pace to exceed the 4.5 inches of rain it normally gets in a year.

Nation briefs *from news services*

CHICAGO

Teachers union leader 'optimistic' about talks

The city's public schools will stay closed for at least one more day, but leaders of the teachers union and the school district kept talking Thursday, with both sides saying they hoped to complete a deal soon to end the nearly weeklong strike.

"We are optimistic, but we are still hammering things out," said Karen Lewis, president of the Chicago Teachers Union.

Word of the progress in negotiations came less than a day after the school board offered a proposal to modify a system that would use student test scores to help evaluate teacher performance.

Under an old proposal, the union estimated that 6,000 teachers could lose their jobs within two years. An offer made late Wednesday included provisions that would have protected tenured teachers from dismissal in the first year of the evaluations. It also altered categories that teachers can be rated on and added an appeals process.

SYCAMORE, ILL.

Seattle man's defense rests in 1957 killing

The defense has rested its case on behalf of a Seattle man accused of killing a 7-year-old northern Illinois girl in 1957.

Attorneys for Jack McCullough, 72, rested their case after calling just a few witnesses over a few hours on Thursday. The judge recessed shortly after the defense finished and suggested he could rule today after closing arguments.

McCullough has pleaded not guilty to kidnapping and killing Maria Ridulph in Sycamore on Dec. 3, 1957.

McCullough was arrested in 2011 after his former girlfriend talked to investigators.

WASHINGTON

Death Valley, not Libya, recorded hottest temp

For exactly 90 years, it was thought El Azizia, Libya, had recorded the world's hottest temperature, a blistering 136 degrees on Sept. 13, 1922. Not so.

A team of atmospheric scientists has concluded the reading is bogus after a comprehensive review.

This means Death Valley (Greenland Ranch, Calif.), which saw the mercury soar to a scorching 134 degrees on July 10, 1913, now holds the distinction of having achieved the Earth's hottest temperature.

Thirteen scientists from nine countries conducted a review of the Libyan record and uncovered five problems with the temperature measurement:

■ Use of antiquated instrumentation.

■ A likely inexperienced observer.

■ An observation site that was not representative of the desert surroundings.

■ Poor matching of the temperature to nearby locations.

■ Poor matching to temperatures recorded in that location after the record was established.

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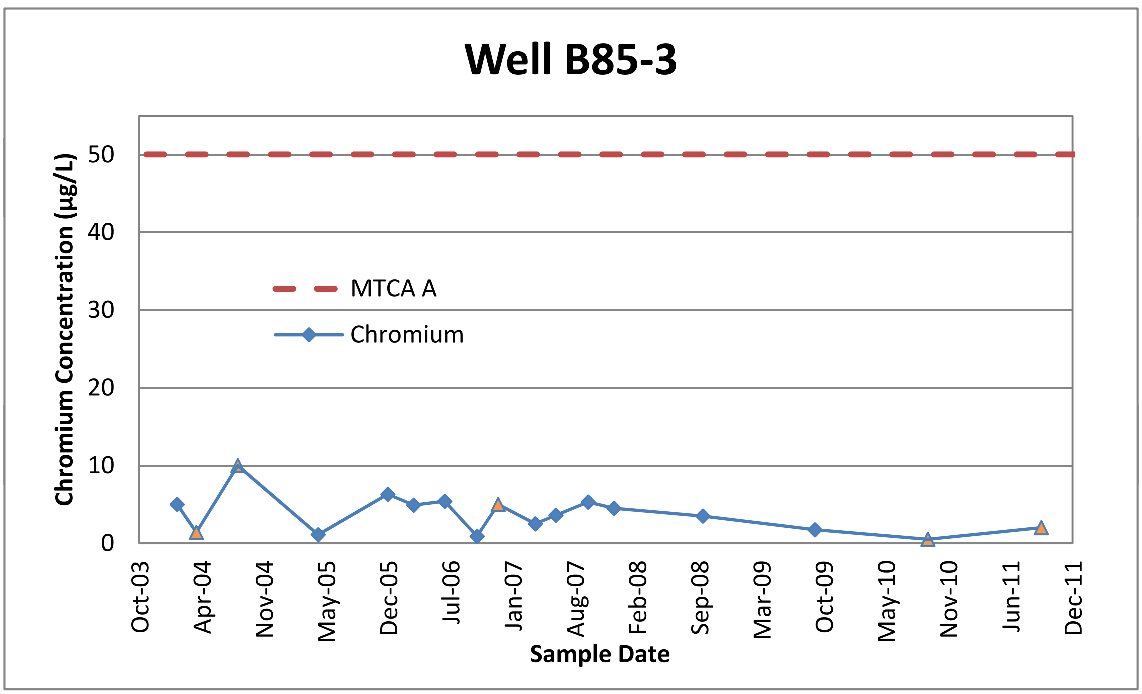
Copy of Public Notice

A public notice announcing this five-year review for the Site was published in The Columbian on Friday, September 14th, 2012. The notice provided a brief background of the Site, explained the reason for the five-year review, and invited the community to submit comments and questions regarding remedy performance via a toll-free phone number or by contacting the RPM directly. A copy of the public notice is provided in this Appendix.

Appendix F: Chromium Data 2003-2011

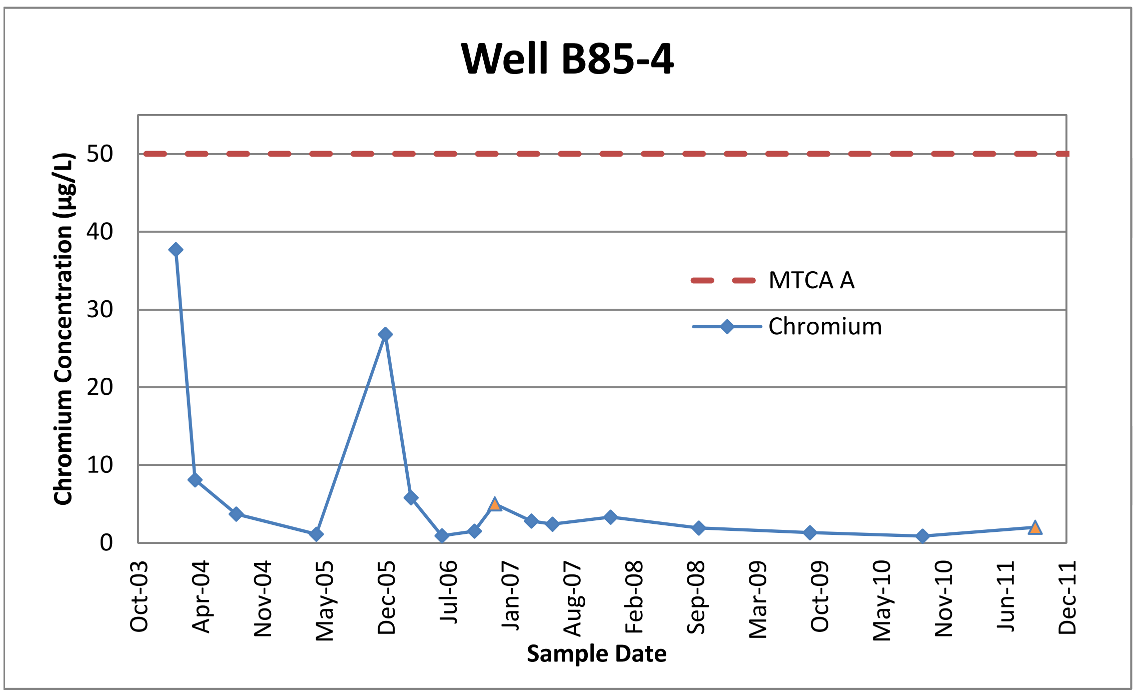
Well B85-3

SampleNumber	Matrix	Sample Date	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AH0	Water	5-Feb-04	Chromium	5	µg/L	J	Well B85-3	Total	1
MJ2BJ6	Water	7-Apr-04	Chromium	1.4	µg/L	U	Well B85-3	Total	3
MJ4732	Water	18-Aug-04	Chromium	10	µg/L	U	Well B85-3	Total	0
184232	Water	3-May-05	Chromium	1.1	µg/L		Well B85-3	Total	2.8
5504298	Water	13-Dec-05	Chromium	6.3	µg/L		Well B85-3	Total	8.1
104235	Water	6-Mar-06	Chromium	4.9	µg/L		Well B85-3	Total	7
244311	Water	14-Jun-06	Chromium	5.4	µg/L		Well B85-3	Total	6
394197	Water	26-Sep-06	Chromium	0.9	µg/L		Well B85-3	Total	1
494094	Water	3-Dec-06	Chromium	5	µg/L	U	Well B85-3	Total	7
134266	Water	1-Apr-07	Chromium	2.5	µg/L		Well B85-3	Total	5.1
234092	Water	6-Jun-07	Chromium	3.6	µg/L		Well B85-3	Total	4
384551	Water	18-Sep-07	Chromium	5.3	µg/L		Well B85-3	Total	9
504141	Water	10-Dec-07	Chromium	4.5	µg/L		Well B85-3	Total	7.7
8394092	Water	21-Sep-08	Chromium	3.5	µg/L		Well B85-3	Total	7.1
90906513	Water	16-Sep-09	Chromium	1.73	µg/L		Well B85-3	Total	2.34
1009065-10	Water	14-Sep-10	Chromium	0.5	µg/L	U	Well B85-3	Total	0.55
1009064-11	Water	14-Sep-11	Chromium	2	µg/L	U	Well B85-3	Total	1.51



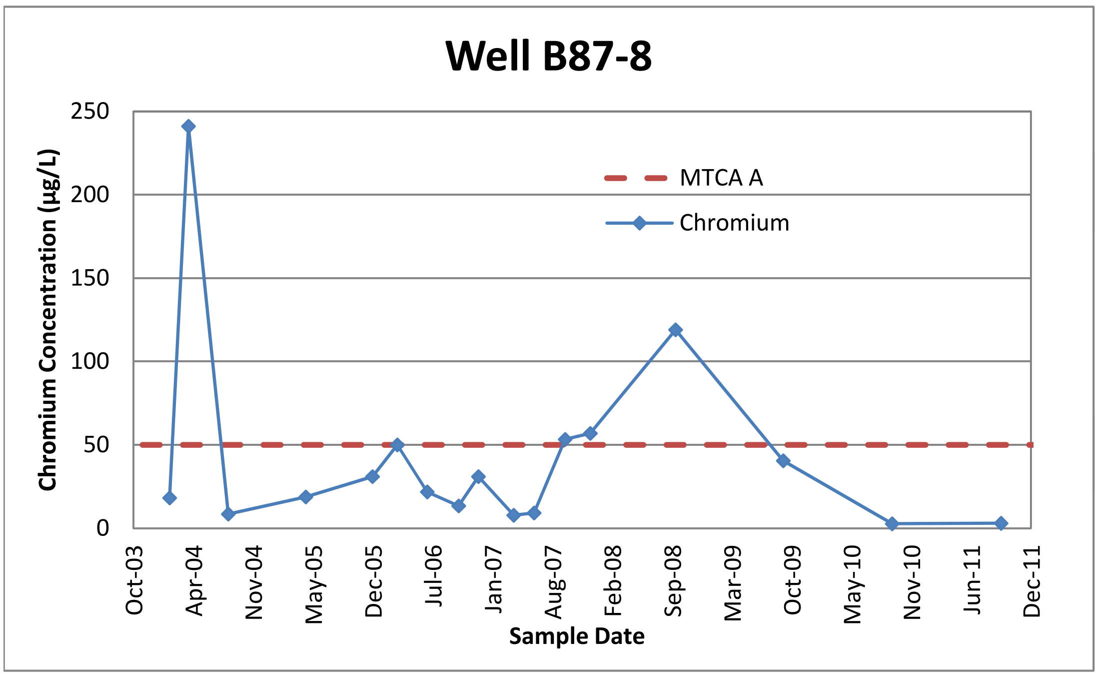
Well B85-4

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AH4	Water	5-Feb-04	Chromium	37.7	µg/L		Well B85-4	Total	1
MJ2BK1	Water	7-Apr-04	Chromium	8.1	µg/L	J	Well B85-4	Total	0
MJ4738	Water	18-Aug-04	Chromium	3.7	µg/L	J	Well B85-4	Total	4
184246	Water	4-May-05	Chromium	1.1	µg/L		Well B85-4	Total	2
5504296	Water	13-Dec-05	Chromium	26.8	µg/L		Well B85-4	Total	5.7
104237	Water	6-Mar-06	Chromium	5.8	µg/L		Well B85-4	Total	3.9
244310	Water	14-Jun-06	Chromium	0.9	µg/L		Well B85-4	Total	0.3
394207	Water	27-Sep-06	Chromium	1.5	µg/L		Well B85-4	Total	1
494084	Water	2-Dec-06	Chromium	5	µg/L	U	Well B85-4	Total	0
134252	Water	30-Mar-07	Chromium	2.8	µg/L		Well B85-4	Total	1.4
234091	Water	6-Jun-07	Chromium	2.4	µg/L		Well B85-4	Total	2.1
504143	Water	11-Dec-07	Chromium	3.3	µg/L		Well B85-4	Total	1.4
8394097	Water	21-Sep-08	Chromium	1.9	µg/L		Well B85-4	Total	3.3
90906517	Water	15-Sep-09	Chromium	1.31	µg/L		Well B85-4	Total	0.71
1009065-08	Water	14-Sep-10	Chromium	0.86	µg/L		Well B85-4	Total	0.25
1009064-08	Water	13-Sep-11	Chromium	2	µg/L	U	Well B85-4	Total	1.11



Well B87-8

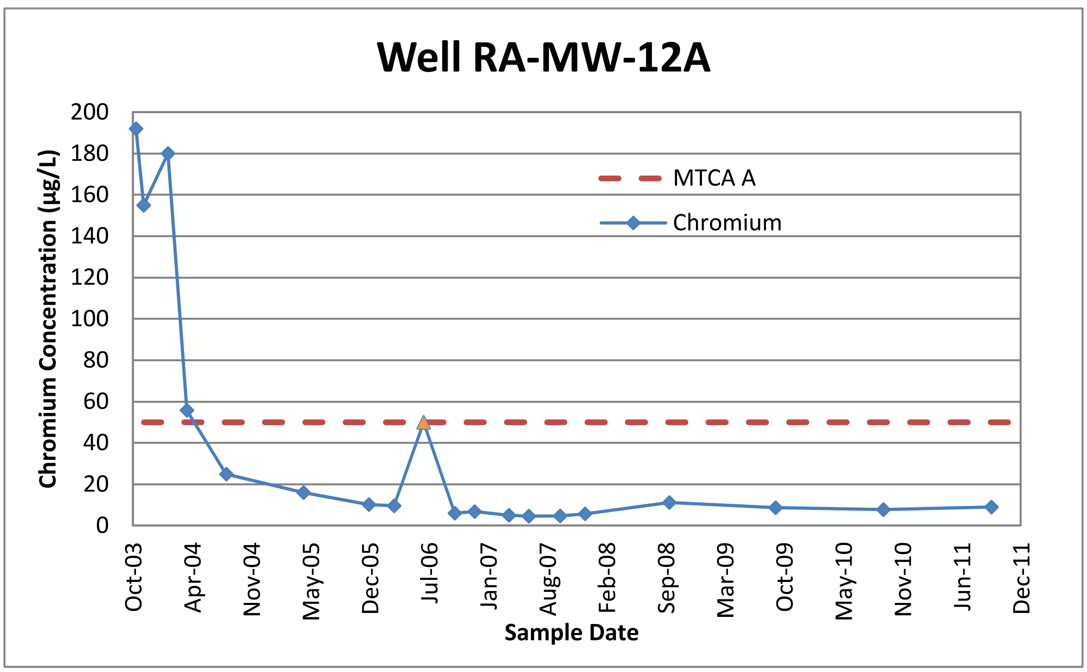
SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AG9	Water	4-Feb-04	Chromium	18.2	µg/L		Well B87-8	Total	2
MJ2BK0	Water	7-Apr-04	Chromium	241	µg/L		Well B87-8	Total	8
MJ4737	Water	18-Aug-04	Chromium	8.5	µg/L	J	Well B87-8	Dissolved	36
184247	Water	4-May-05	Chromium	18.8	µg/L		Well B87-8	Total	6.5
5504297	Water	13-Dec-05	Chromium	31	µg/L		Well B87-8	Total	5.1
104236	Water	6-Mar-06	Chromium	50	µg/L		Well B87-8	Total	8
244308	Water	14-Jun-06	Chromium	21.8	µg/L		Well B87-8	Total	3
394204	Water	27-Sep-06	Chromium	13.4	µg/L		Well B87-8	Dissolved	13
494082	Water	2-Dec-06	Chromium	31	µg/L		Well B87-8	Total	0.1
134251	Water	30-Mar-07	Chromium	7.8	µg/L		Well B87-8	Dissolved	11
234089	Water	6-Jun-07	Chromium	9.2	µg/L		Well B87-8	Dissolved	0.9
384552	Water	18-Sep-07	Chromium	53.3	µg/L		Well B87-8	Dissolved	2.1
504144	Water	11-Dec-07	Chromium	56.9	µg/L		Well B87-8	Dissolved	8.4
8394098	Water	21-Sep-08	Chromium	119	µg/L		Well B87-8	Dissolved	13
90906520	Water	16-Sep-09	Chromium	40.5	µg/L		Well B87-8	Dissolved	16.7
1009065-20	Water	15-Sep-10	Chromium	2.71	µg/L		Well B87-8	Dissolved	6.6
1009064-10	Water	14-Sep-11	Chromium	3	µg/L		Well B87-8	Dissolved	2.54



Note: Where a dissolved concentration is used, the NTU value listed is the pre-filtering value.

Well RA-MW-12A

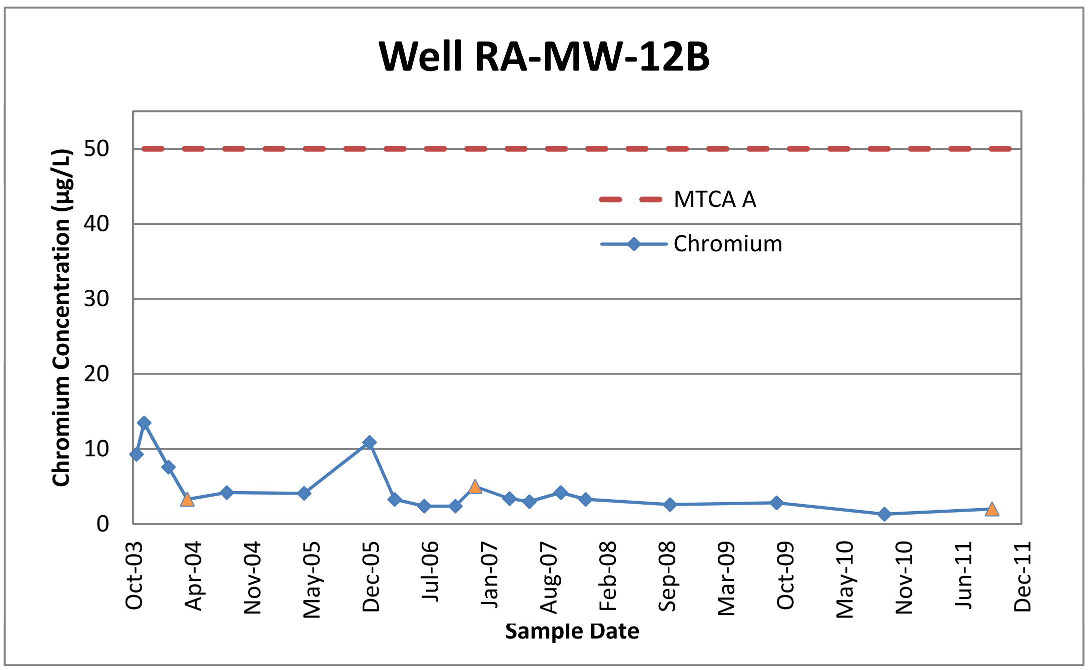
SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2524	Water	17-Oct-03	Chromium	192	µg/L		Well RA-MW-12A	Dissolved	>10
MJ27F5	Water	12-Nov-03	Chromium	155	µg/L		Well RA-MW-12A	Dissolved	>10
MJ2AF0	Water	2-Feb-04	Chromium	180	µg/L		Well RA-MW-12A	Total	7
MJ2BH9	Water	6-Apr-04	Chromium	55.8	µg/L		Well RA-MW-12A	Dissolved	17
MJ4725	Water	17-Aug-04	Chromium	24.9	µg/L		Well RA-MW-12A	Dissolved	12
184253	Water	5-May-05	Chromium	16	µg/L		Well RA-MW-12A	Dissolved	32
5504282	Water	12-Dec-05	Chromium	10.2	µg/L		Well RA-MW-12A	Dissolved	86
104243	Water	7-Mar-06	Chromium	9.6	µg/L		Well RA-MW-12A	Dissolved	60
244313	Water	15-Jun-06	Chromium	50	µg/L	U	Well RA-MW-12A	Dissolved	47
394218	Water	28-Sep-06	Chromium	6	µg/L		Well RA-MW-12A	Dissolved	80
494110	Water	4-Dec-06	Chromium	6.8	µg/L		Well RA-MW-12A	Dissolved	12
134255	Water	30-Mar-07	Chromium	5	µg/L		Well RA-MW-12A	Dissolved	85
234081	Water	5-Jun-07	Chromium	4.6	µg/L		Well RA-MW-12A	Dissolved	55
384560	Water	19-Sep-07	Chromium	4.7	µg/L		Well RA-MW-12A	Dissolved	11
504161	Water	12-Dec-07	Chromium	5.7	µg/L		Well RA-MW-12A	Dissolved	60
8394103	Water	22-Sep-08	Chromium	11.2	µg/L		Well RA-MW-12A	Dissolved	200
90906523	Water	16-Sep-09	Chromium	8.68	µg/L		Well RA-MW-12A	Dissolved	102
1009065-25	Water	15-Sep-10	Chromium	7.77	µg/L		Well RA-MW-12A	Dissolved	>10
1009064-24	Water	15-Sep-11	Chromium	9	µg/L		Well RA-MW-12A	Dissolved	40



Note: Where a dissolved concentration is used, the NTU value listed is the pre-filtering value.

Well RA-MW-12B

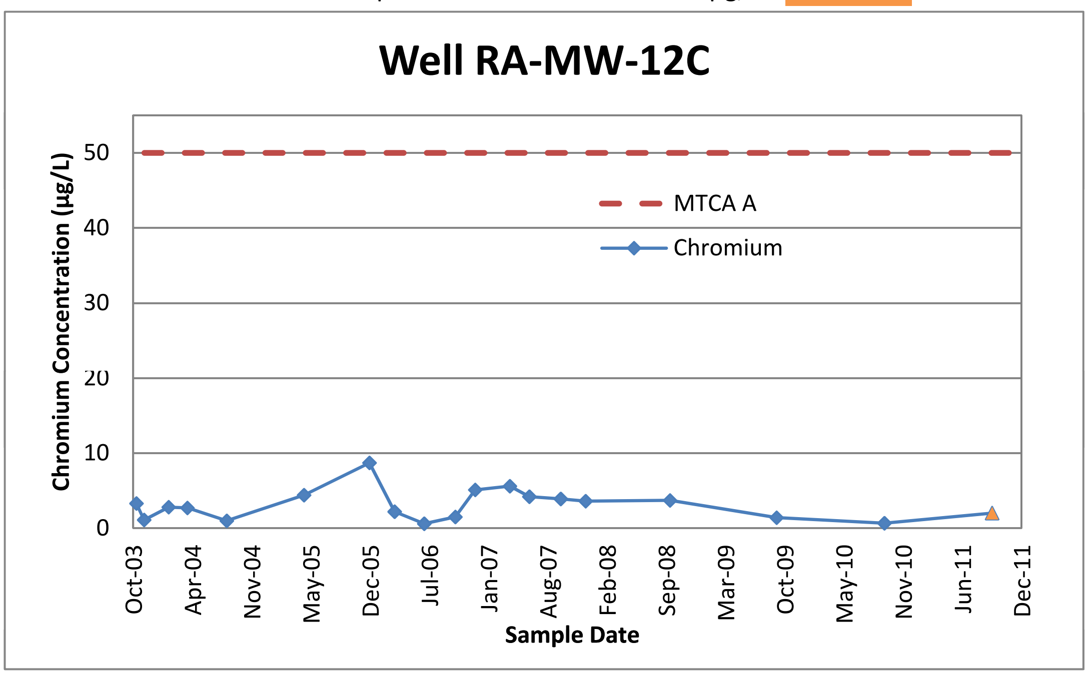
SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2526	Water	17-Oct-03	Chromium	9.3	µg/L	BJ	Well RA-MW-12B	Dissolved	>10
MJ27F7	Water	12-Nov-03	Chromium	13.5	µg/L		Well RA-MW-12B	Dissolved	>10
MJ2AF1	Water	2-Feb-04	Chromium	7.6	µg/L	J	Well RA-MW-12B	Total	6
MJ2BJ0	Water	6-Apr-04	Chromium	3.3	µg/L	U	Well RA-MW-12B	Total	0
MJ4726	Water	17-Aug-04	Chromium	4.2	µg/L	J	Well RA-MW-12B	Total	2
184254	Water	5-May-05	Chromium	4.1	µg/L		Well RA-MW-12B	Total	4.5
5504283	Water	12-Dec-05	Chromium	10.9	µg/L		Well RA-MW-12B	Total	8
104242	Water	7-Mar-06	Chromium	3.3	µg/L		Well RA-MW-12B	Total	1.7
244315	Water	15-Jun-06	Chromium	2.4	µg/L		Well RA-MW-12B	Total	14
394216	Water	28-Sep-06	Chromium	2.4	µg/L		Well RA-MW-12B	Total	1
494108	Water	4-Dec-06	Chromium	5	µg/L	U	Well RA-MW-12B	Total	2
134253	Water	30-Mar-07	Chromium	3.4	µg/L		Well RA-MW-12B	Total	2.2
234082	Water	5-Jun-07	Chromium	3	µg/L		Well RA-MW-12B	Total	1.1
384562	Water	19-Sep-07	Chromium	4.2	µg/L		Well RA-MW-12B	Total	0.8
504162	Water	12-Dec-07	Chromium	3.3	µg/L		Well RA-MW-12B	Total	0.6
8394105	Water	22-Sep-08	Chromium	2.6	µg/L		Well RA-MW-12B	Total	0.9
90906524	Water	17-Sep-09	Chromium	2.84	µg/L		Well RA-MW-12B	Total	0.97
1009065-24	Water	16-Sep-10	Chromium	1.32	µg/L		Well RA-MW-12B	Total	<10
1009064-22	Water	15-Sep-11	Chromium	2	µg/L	U	Well RA-MW-12B	Total	0.99



Note: Where a dissolved concentration is used, the NTU value listed is the pre-filtering value.

Well RA-MW-12C

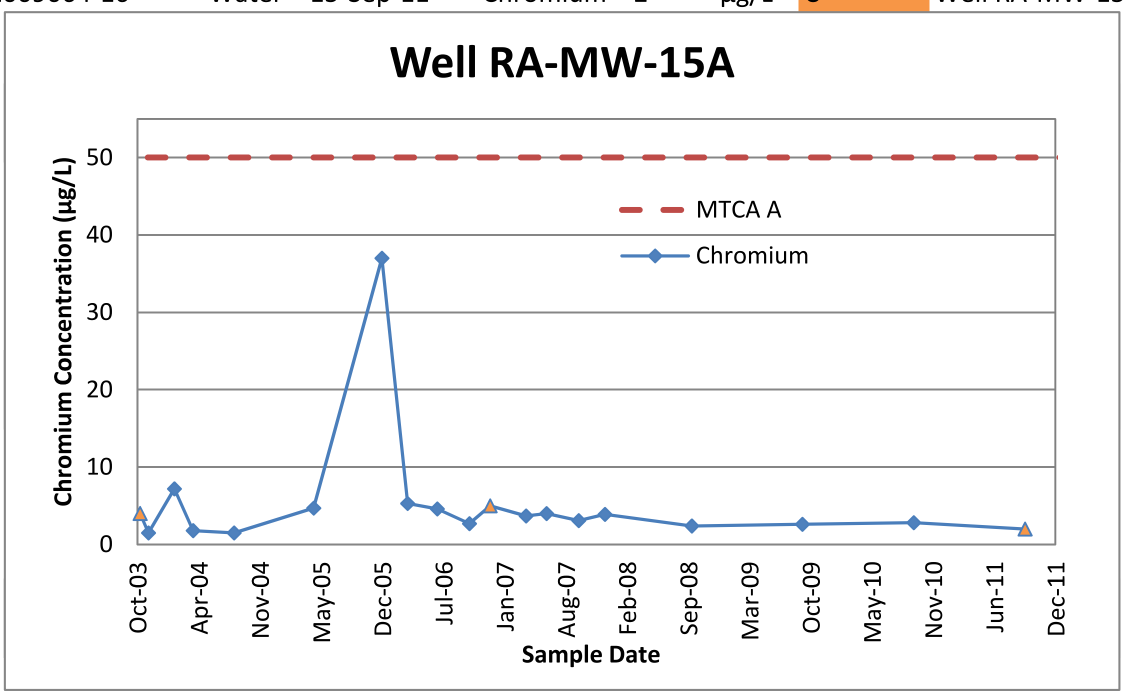
SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2528	Water	17-Oct-03	Chromium	3.3	µg/L	BJ	Well RA-MW-12C	Dissolved	>10
MJ27F9	Water	12-Nov-03	Chromium	1.1	µg/L	BJ	Well RA-MW-12C	Dissolved	>10
MJ2AF2	Water	3-Feb-04	Chromium	2.8	µg/L	J	Well RA-MW-12C	Total	1
MJ2BJ1	Water	6-Apr-04	Chromium	2.7	µg/L	J	Well RA-MW-12C	Total	0
MJ4727	Water	17-Aug-04	Chromium	0.98	µg/L	J	Well RA-MW-12C	Total	2
184255	Water	5-May-05	Chromium	4.4	µg/L		Well RA-MW-12C	Total	5.2
5504284	Water	12-Dec-05	Chromium	8.7	µg/L		Well RA-MW-12C	Total	3
104245	Water	7-Mar-06	Chromium	2.2	µg/L		Well RA-MW-12C	Total	1
244317	Water	15-Jun-06	Chromium	0.6	µg/L	J	Well RA-MW-12C	Total	0.3
394215	Water	28-Sep-06	Chromium	1.5	µg/L		Well RA-MW-12C	Total	0.4
494117	Water	4-Dec-06	Chromium	5.1	µg/L		Well RA-MW-12C	Total	3
134256	Water	31-Mar-07	Chromium	5.6	µg/L		Well RA-MW-12C	Total	3.4
234079	Water	5-Jun-07	Chromium	4.2	µg/L		Well RA-MW-12C	Total	1.9
384563	Water	19-Sep-07	Chromium	3.9	µg/L		Well RA-MW-12C	Total	2.9
504163	Water	12-Dec-07	Chromium	3.6	µg/L		Well RA-MW-12C	Total	3.3
8394106	Water	22-Sep-08	Chromium	3.7	µg/L		Well RA-MW-12C	Total	1.9
90906525	Water	17-Sep-09	Chromium	1.4	µg/L		Well RA-MW-12C	Total	1.55
1009065-23	Water	16-Sep-10	Chromium	0.66	µg/L		Well RA-MW-12C	Total	<10
1009064-23	Water	15-Sep-11	Chromium	2	µg/L	U	Well RA-MW-12C	Total	0.68



Note: Where a dissolved concentration is used, the NTU value listed is the pre-filtering value.

Well RA-MW-15A

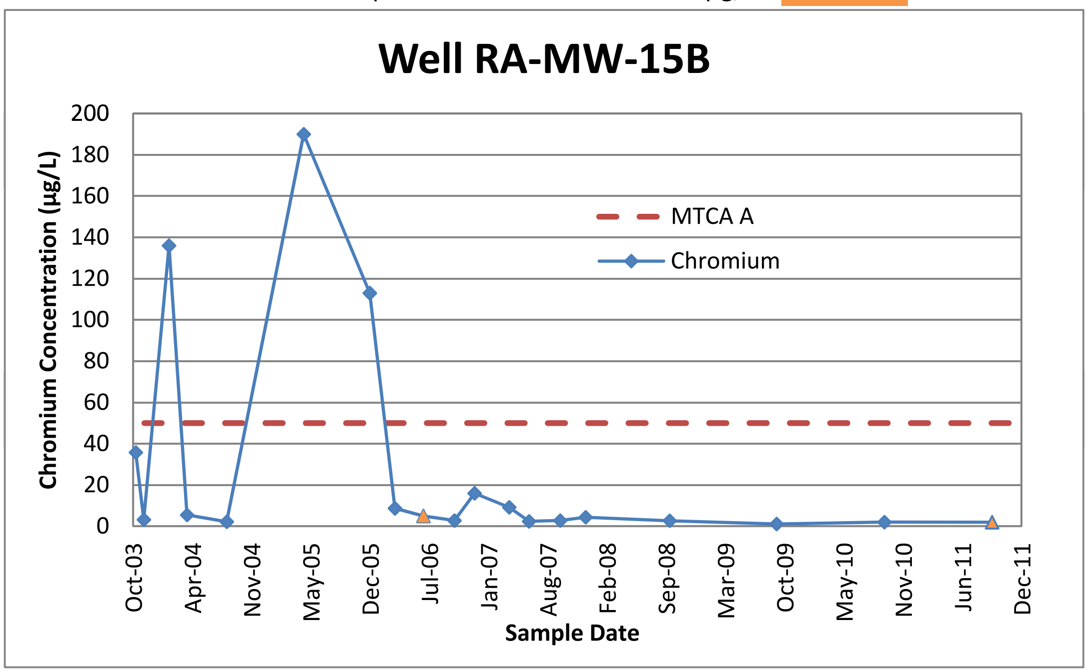
SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2506	Water	15-Oct-03	Chromium	4	µg/L	U	Well RA-MW-15A	Total	<10
MJ27E8	Water	11-Nov-03	Chromium	1.5	µg/L	BJ	Well RA-MW-15A	Total	<10
MJ2AG7	Water	4-Feb-04	Chromium	7.2	µg/L	J	Well RA-MW-15A	Total	1
MJ2BH1	Water	5-Apr-04	Chromium	1.8	µg/L	J	Well RA-MW-15A	Total	0
MJ4722	Water	17-Aug-04	Chromium	1.5	µg/L	J	Well RA-MW-15A	Total	0
184248	Water	4-May-05	Chromium	4.7	µg/L		Well RA-MW-15A	Total	2
5504290	Water	13-Dec-05	Chromium	37	µg/L		Well RA-MW-15A	Total	1.3
104251	Water	7-Mar-06	Chromium	5.3	µg/L		Well RA-MW-15A	Total	0
244290	Water	12-Jun-06	Chromium	4.6	µg/L		Well RA-MW-15A	Total	0.6
394192	Water	25-Sep-06	Chromium	2.7	µg/L		Well RA-MW-15A	Total	0.2
494090	Water	2-Dec-06	Chromium	5	µg/L	U	Well RA-MW-15A	Total	2
134241	Water	29-Mar-07	Chromium	3.7	µg/L		Well RA-MW-15A	Total	0.3
234068	Water	4-Jun-07	Chromium	4	µg/L		Well RA-MW-15A	Total	0.5
384541	Water	17-Sep-07	Chromium	3.1	µg/L		Well RA-MW-15A	Total	0.4
504153	Water	12-Dec-07	Chromium	3.9	µg/L		Well RA-MW-15A	Total	1.1
8394093	Water	21-Sep-08	Chromium	2.4	µg/L		Well RA-MW-15A	Total	0.3
90906514	Water	17-Sep-09	Chromium	2.62	µg/L		Well RA-MW-15A	Total	1.32
1009065-19	Water	16-Sep-10	Chromium	2.82	µg/L		Well RA-MW-15A	Total	<10
1009064-16	Water	15-Sep-11	Chromium	2	µg/L	U	Well RA-MW-15A	Total	2.46



Note: Where a dissolved concentration is used, the NTU value listed is the pre-filtering value.

Well RA-MW-15B

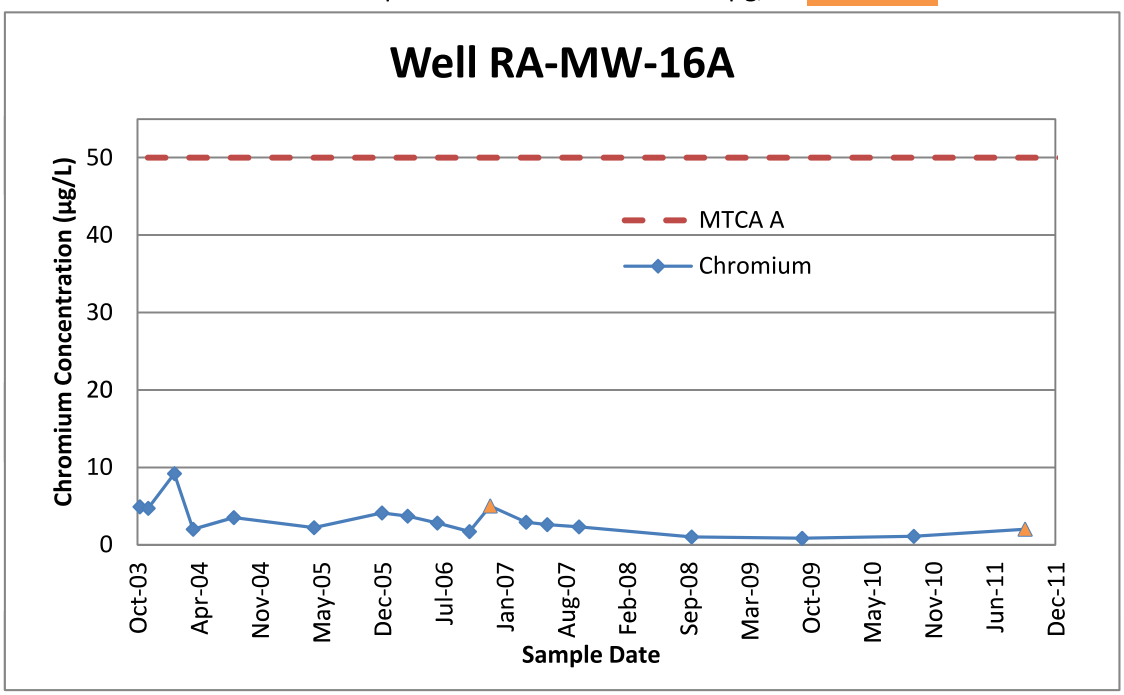
SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2507	Water	15-Oct-03	Chromium	35.8	µg/L		Well RA-MW-15B	Total	<10
MJ27E9	Water	11-Nov-03	Chromium	3.2	µg/L	BJ	Well RA-MW-15B	Total	<10
MJ2AG8	Water	4-Feb-04	Chromium	136	µg/L		Well RA-MW-15B	Total	2
MJ2BH2	Water	5-Apr-04	Chromium	5.5	µg/L	J	Well RA-MW-15B	Total	0
MJ4723	Water	17-Aug-04	Chromium	2.2	µg/L	J	Well RA-MW-15B	Total	1
184249	Water	4-May-05	Chromium	190	µg/L		Well RA-MW-15B	Total	9.7
5504288	Water	13-Dec-05	Chromium	113	µg/L		Well RA-MW-15B	Total	3.5
104252	Water	8-Mar-06	Chromium	8.7	µg/L		Well RA-MW-15B	Dissolved	5
244292	Water	12-Jun-06	Chromium	5	µg/L	U	Well RA-MW-15B	Dissolved	4
394190	Water	25-Sep-06	Chromium	2.8	µg/L		Well RA-MW-15B	Dissolved	4
494092	Water	2-Dec-06	Chromium	16	µg/L		Well RA-MW-15B	Dissolved	7
134243	Water	29-Mar-07	Chromium	9.2	µg/L		Well RA-MW-15B	Dissolved	2.4
234069	Water	4-Jun-07	Chromium	2.4	µg/L		Well RA-MW-15B	Dissolved	3.4
384543	Water	17-Sep-07	Chromium	2.8	µg/L		Well RA-MW-15B	Dissolved	2.6
504155	Water	12-Dec-07	Chromium	4.4	µg/L		Well RA-MW-15B	Dissolved	4.5
8394094	Water	21-Sep-08	Chromium	2.7	µg/L		Well RA-MW-15B	Dissolved	1.3
90906515	Water	17-Sep-09	Chromium	1.13	µg/L		Well RA-MW-15B	Dissolved	0.32
1009065-21	Water	16-Sep-10	Chromium	2.02	µg/L		Well RA-MW-15B	Dissolved	<10
1009064-17	Water	15-Sep-11	Chromium	2	µg/L	U	Well RA-MW-15B	Dissolved	0.95



Note: Where a dissolved concentration is used, the NTU value listed is the pre-filtering value.

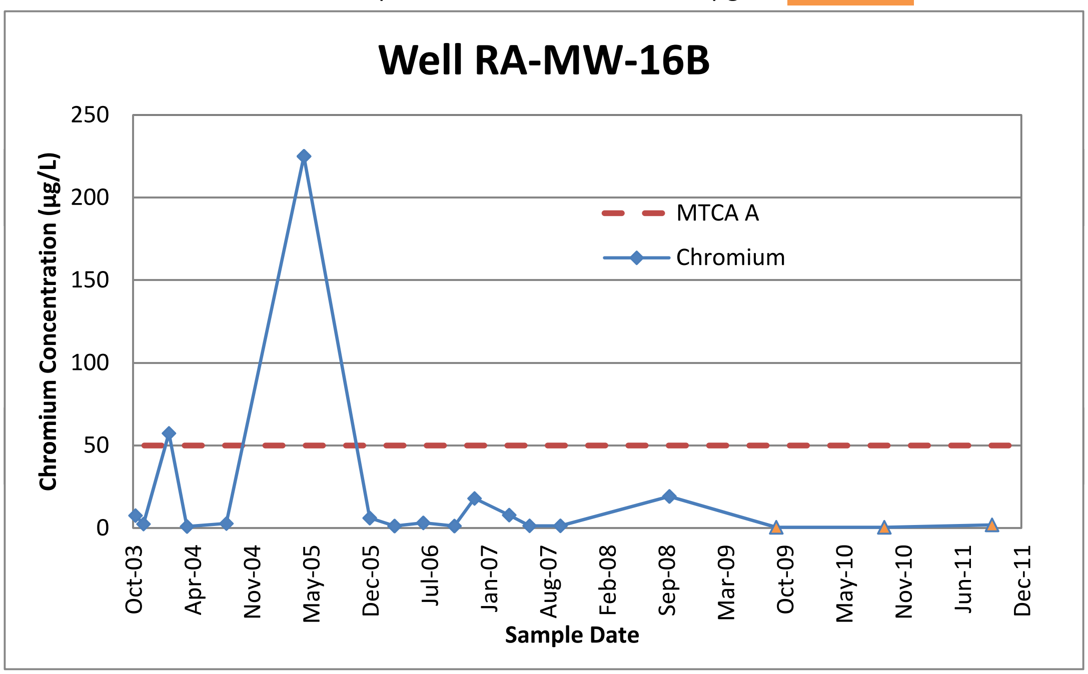
Well RA-MW-16A

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2502	Water	14-Oct-03	Chromium	4.9	µg/L	BJ	Well RA-MW-16A	Total	<10
MJ27E0	Water	10-Nov-03	Chromium	4.7	µg/L	BJ	Well RA-MW-16A	Total	<10
MJ2AG5	Water	4-Feb-04	Chromium	9.2	µg/L	J	Well RA-MW-16A	Total	1
MJ2BG8	Water	5-Apr-04	Chromium	2	µg/L	J	Well RA-MW-16A	Total	1
MJ4716	Water	16-Aug-04	Chromium	3.5	µg/L	J	Well RA-MW-16A	Total	2
184257	Water	5-May-05	Chromium	2.2	µg/L		Well RA-MW-16A	Total	8.5
5504293	Water	13-Dec-05	Chromium	4.1	µg/L		Well RA-MW-16A	Total	1.2
104238	Water	7-Mar-06	Chromium	3.7	µg/L		Well RA-MW-16A	Total	1.7
244304	Water	12-Jun-06	Chromium	2.8	µg/L		Well RA-MW-16A	Total	1
394189	Water	25-Sep-06	Chromium	1.7	µg/L		Well RA-MW-16A	Total	1
494087	Water	2-Dec-06	Chromium	5	µg/L	U	Well RA-MW-16A	Total	0.1
134236	Water	29-Mar-07	Chromium	2.9	µg/L		Well RA-MW-16A	Total	1.7
234085	Water	6-Jun-07	Chromium	2.6	µg/L		Well RA-MW-16A	Total	1
384538	Water	18-Sep-07	Chromium	2.3	µg/L		Well RA-MW-16A	Total	0.7
8394088	Water	20-Sep-08	Chromium	1	µg/L		Well RA-MW-16A	Total	1.3
90906509	Water	16-Sep-09	Chromium	0.83	µg/L		Well RA-MW-16A	Total	0.48
1009065-17	Water	16-Sep-10	Chromium	1.09	µg/L		Well RA-MW-16A	Total	<10
1009064-19	Water	15-Sep-11	Chromium	2	µg/L	U	Well RA-MW-16A	Total	1.05



Well RA-MW-16B

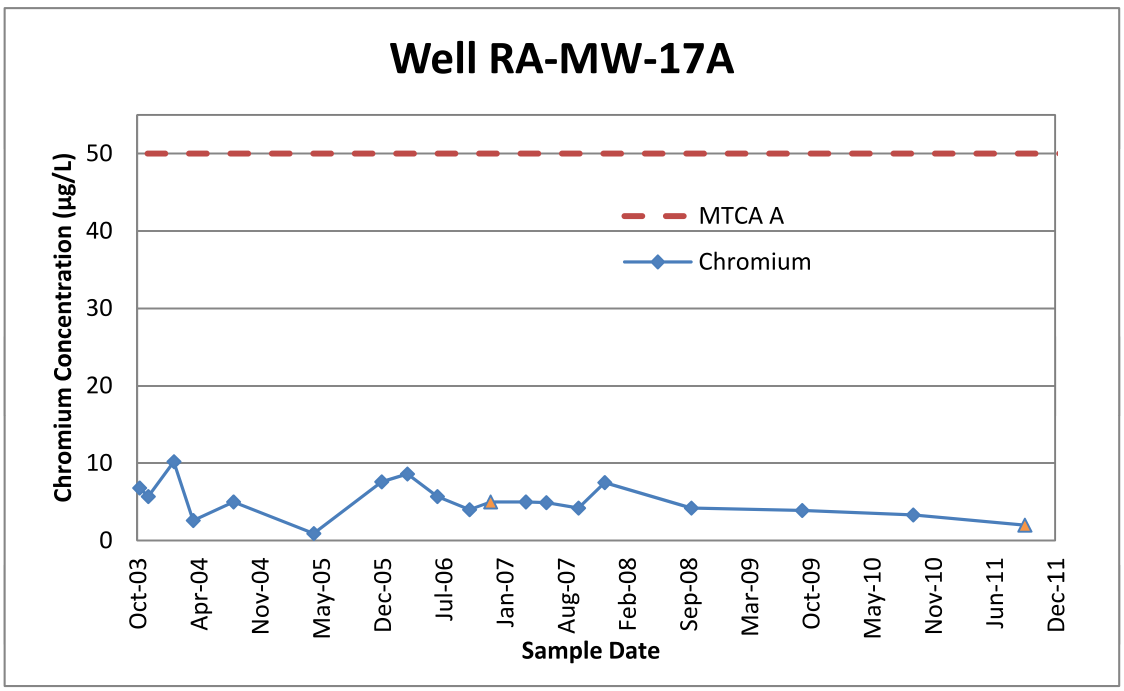
SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2503	Water	14-Oct-03	Chromium	7.6	µg/L	BJ	Well RA-MW-16B	Total	<10
MJ27E1	Water	10-Nov-03	Chromium	2.5	µg/L	BJ	Well RA-MW-16B	Total	<10
MJ2AG6	Water	4-Feb-04	Chromium	57.4	µg/L	BJ	Well RA-MW-16B	Total	1
MJ2BH0	Water	5-Apr-04	Chromium	1	µg/L	J	Well RA-MW-16B	Dissolved	0
MJ4717	Water	16-Aug-04	Chromium	2.8	µg/L	J	Well RA-MW-16B	Total	3.6
184256	Water	5-May-05	Chromium	225	µg/L		Well RA-MW-16B	Total	5.7
5504291	Water	13-Dec-05	Chromium	6.1	µg/L		Well RA-MW-16B	Dissolved	3.9
104239	Water	7-Mar-06	Chromium	1.3	µg/L		Well RA-MW-16B	Total	0
244305	Water	12-Jun-06	Chromium	3.2	µg/L		Well RA-MW-16B	Total	0.3
394187	Water	25-Sep-06	Chromium	1.3	µg/L		Well RA-MW-16B	Dissolved	0.7
494089	Water	2-Dec-06	Chromium	18	µg/L		Well RA-MW-16B	Dissolved	0.2
134238	Water	29-Mar-07	Chromium	7.9	µg/L		Well RA-MW-16B	Dissolved	3.7
234087	Water	6-Jun-07	Chromium	1.4	µg/L		Well RA-MW-16B	Dissolved	0.3
384540	Water	18-Sep-07	Chromium	1.4	µg/L		Well RA-MW-16B	Dissolved	3
8394089	Water	20-Sep-08	Chromium	19.2	µg/L		Well RA-MW-16B	Total	0.3
90906510	Water	16-Sep-09	Chromium	0.5	µg/L	U	Well RA-MW-16B	Total	0.85
1009065-18	Water	16-Sep-10	Chromium	0.5	µg/L	U	Well RA-MW-16B	Total	<10
1009064-20	Water	15-Sep-11	Chromium	2	µg/L	U	Well RA-MW-16B	Total	0.85



Note: Where a dissolved concentration is used, the NTU value listed is the pre-filtering value.

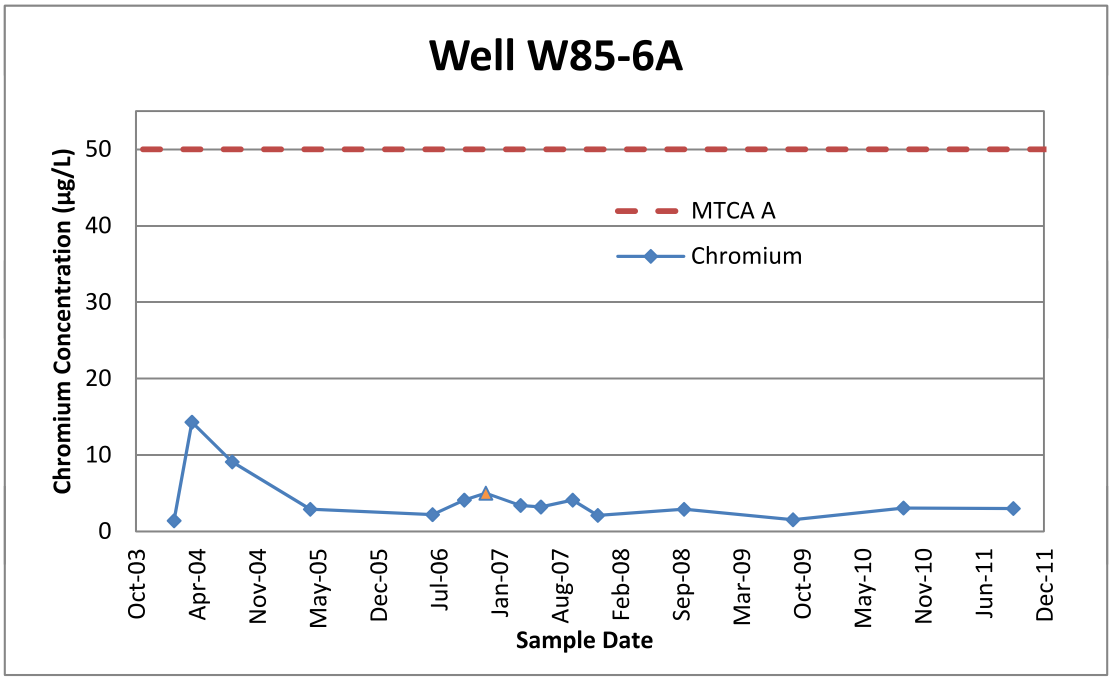
Well RA-MW-17A

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2501	Water	14-Oct-03	Chromium	6.8	UG/L	BJ	Well RA-MW-17A	Total	<10
MJ27E5	Water	11-Nov-03	Chromium	5.7	UG/L	BJ	Well RA-MW-17A	Total	<10
MJ2AG0	Water	3-Feb-04	Chromium	10.2	UG/L	J	Well RA-MW-17A	Total	1
MJ2BH7	Water	6-Apr-04	Chromium	2.6	UG/L	J	Well RA-MW-17A	Total	0
MJ4715	Water	16-Aug-04	Chromium	5	UG/L	J	Well RA-MW-17A	Total	1
184260	Water	5-May-05	Chromium	0.92	UG/L		Well RA-MW-17A	Total	10
5504299	Water	13-Dec-05	Chromium	7.6	UG/L		Well RA-MW-17A	Total	3.1
104240	Water	7-Mar-06	Chromium	8.6	UG/L		Well RA-MW-17A	Total	7
244293	Water	13-Jun-06	Chromium	5.7	UG/L		Well RA-MW-17A	Total	1
394193	Water	26-Sep-06	Chromium	4	UG/L		Well RA-MW-17A	Total	1
494105	Water	4-Dec-06	Chromium	5	UG/L	U	Well RA-MW-17A	Total	0.8
134232	Water	29-Mar-07	Chromium	5	UG/L		Well RA-MW-17A	Total	1.2
234064	Water	4-Jun-07	Chromium	4.9	UG/L		Well RA-MW-17A	Total	2.7
384532	Water	17-Sep-07	Chromium	4.2	UG/L		Well RA-MW-17A	Total	1.7
504157	Water	12-Dec-07	Chromium	7.5	UG/L		Well RA-MW-17A	Total	0.9
8394090	Water	20-Sep-08	Chromium	4.2	UG/L		Well RA-MW-17A	Total	1.6
90906511	Water	17-Sep-09	Chromium	3.9	UG/L		Well RA-MW-17A	Total	0.57
1009065-15	Water	15-Sep-10	Chromium	3.31	UG/L		Well RA-MW-17A	Total	1.1
1009064-21	Water	15-Sep-11	Chromium	2	µg/L	U	Well RA-MW-17A	Total	1.12



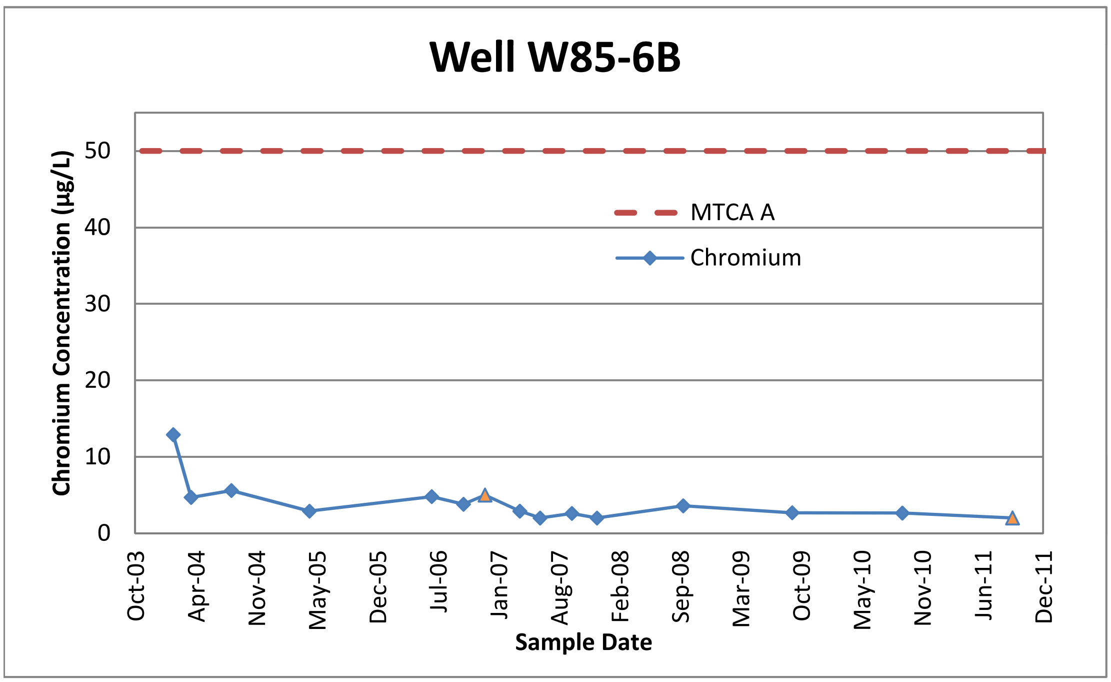
Well W85-6A

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AJ8	Water	9-Feb-04	Chromium	1.4	µg/L	J	Well W85-6A	Total	No Data
MJ2BL0	Water	8-Apr-04	Chromium	14.3	µg/L		Well W85-6A	Total	0
MJ4747	Water	19-Aug-04	Chromium	9.1	µg/L	J	Well W85-6A	Total	<10
184235	Water	4-May-05	Chromium	2.9	µg/L		Well W85-6A	Total	1
244284	Water	12-Jun-06	Chromium	2.2	µg/L		Well W85-6A	Total	0.7
394182	Water	25-Sep-06	Chromium	4.1	µg/L		Well W85-6A	Total	0.1
494113	Water	5-Dec-06	Chromium	5	µg/L	U	Well W85-6A	Total	2
134245	Water	30-Mar-07	Chromium	3.4	µg/L		Well W85-6A	Total	0.5
234072	Water	5-Jun-07	Chromium	3.2	µg/L		Well W85-6A	Total	0.2
384545	Water	18-Sep-07	Chromium	4.1	µg/L		Well W85-6A	Total	0.6
504132	Water	10-Dec-07	Chromium	2.1	µg/L		Well W85-6A	Total	0.5
8394083	Water	20-Sep-08	Chromium	2.9	µg/L		Well W85-6A	Total	0.2
90906501	Water	15-Sep-09	Chromium	1.53	µg/L		Well W85-6A	Total	0.64
1009065-03	Water	15-Sep-10	Chromium	3.06	µg/L		Well W85-6A	Total	0.15
1009064-03	Water	13-Sep-11	Chromium	3	µg/L		Well W85-6A	Total	0.61



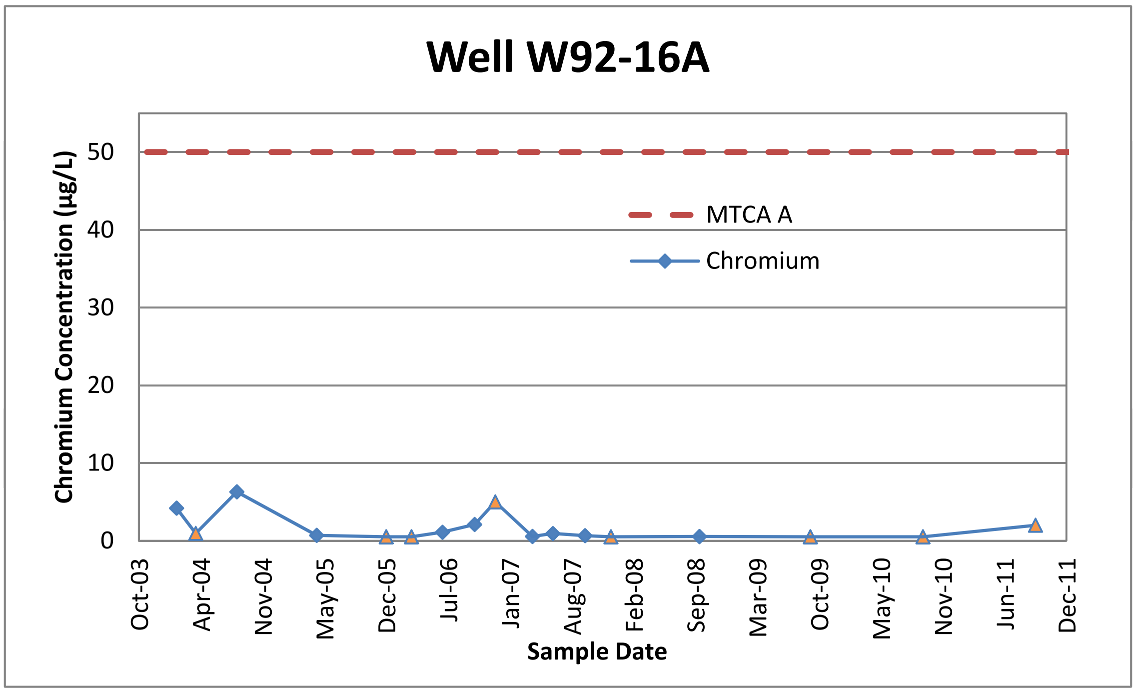
Well W85-6B

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AJ9	Water	9-Feb-04	Chromium	12.9	µg/L		Well W85-6B	Total	No Data
MJ2BL1	Water	8-Apr-04	Chromium	4.7	µg/L	J	Well W85-6B	Total	0
MJ4748	Water	19-Aug-04	Chromium	5.6	µg/L	J	Well W85-6B	Total	5
184236	Water	4-May-05	Chromium	2.9	µg/L		Well W85-6B	Total	1
244286	Water	12-Jun-06	Chromium	4.8	µg/L		Well W85-6B	Total	49
394183	Water	25-Sep-06	Chromium	3.8	µg/L		Well W85-6B	Total	14
494114	Water	5-Dec-06	Chromium	5	µg/L	U	Well W85-6B	Total	9
134246	Water	30-Mar-07	Chromium	2.9	µg/L		Well W85-6B	Total	4.6
234073	Water	5-Jun-07	Chromium	2	µg/L		Well W85-6B	Total	1.8
384546	Water	18-Sep-07	Chromium	2.6	µg/L		Well W85-6B	Total	1.3
504133	Water	10-Dec-07	Chromium	2	µg/L		Well W85-6B	Total	0.3
8394081	Water	20-Sep-08	Chromium	3.6	µg/L		Well W85-6B	Total	0.2
90906502	Water	15-Sep-09	Chromium	2.69	µg/L		Well W85-6B	Total	0.35
1009065-05	Water	14-Sep-10	Chromium	2.65	µg/L		Well W85-6B	Total	0.3
1009064-05	Water	13-Sep-11	Chromium	2	µg/L	U	Well W85-6B	Total	0.54



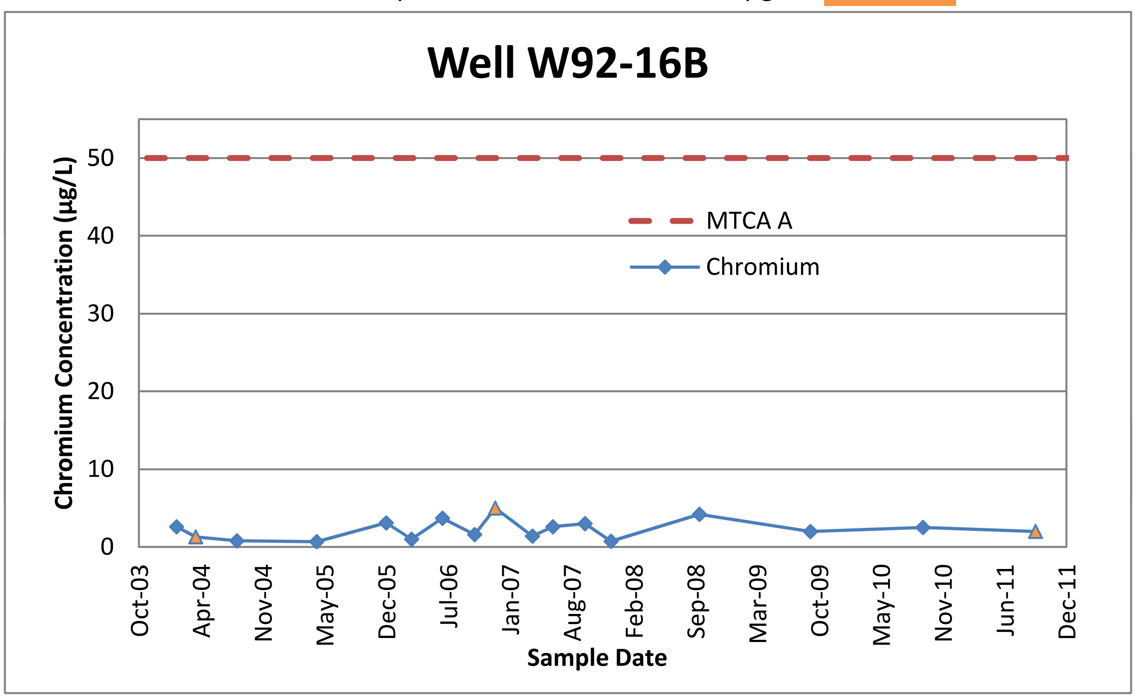
Well W92-16A

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AH1	Water	5-Feb-04	Chromium	4.2	µg/L	J	Well W92-16A	Total	2
MJ2BJ7	Water	7-Apr-04	Chromium	0.95	µg/L	U	Well W92-16A	Total	0
MJ4734	Water	18-Aug-04	Chromium	6.3	µg/L	J	Well W92-16A	Total	0
184234	Water	3-May-05	Chromium	0.7	µg/L		Well W92-16A	Total	0.7
5504311	Water	14-Dec-05	Chromium	0.5	µg/L	U	Well W92-16A	Total	0.7
104234	Water	6-Mar-06	Chromium	0.5	µg/L	U	Well W92-16A	Total	0.7
244304	Water	14-Jun-06	Chromium	1.1	µg/L		Well W92-16A	Total	2
394200	Water	26-Sep-06	Chromium	2.1	µg/L		Well W92-16A	Total	4
494085	Water	2-Dec-06	Chromium	5	µg/L	U	Well W92-16A	Total	0.1
134267	Water	1-Apr-07	Chromium	0.56	µg/L		Well W92-16A	Total	2.5
234093	Water	6-Jun-07	Chromium	0.94	µg/L		Well W92-16A	Total	1.8
384549	Water	18-Sep-07	Chromium	0.66	µg/L		Well W92-16A	Total	1.3
504152	Water	11-Dec-07	Chromium	0.5	µg/L	U	Well W92-16A	Total	0.4
8394091	Water	22-Sep-08	Chromium	0.55	µg/L		Well W92-16A	Total	1.5
90906521	Water	16-Sep-09	Chromium	0.5	µg/L	U	Well W92-16A	Total	0.48
1009065-12	Water	15-Sep-10	Chromium	0.5	µg/L	U	Well W92-16A	Total	0.5
1009064-12	Water	14-Sep-11	Chromium	2	µg/L	U	Well W92-16A	Total	0.47



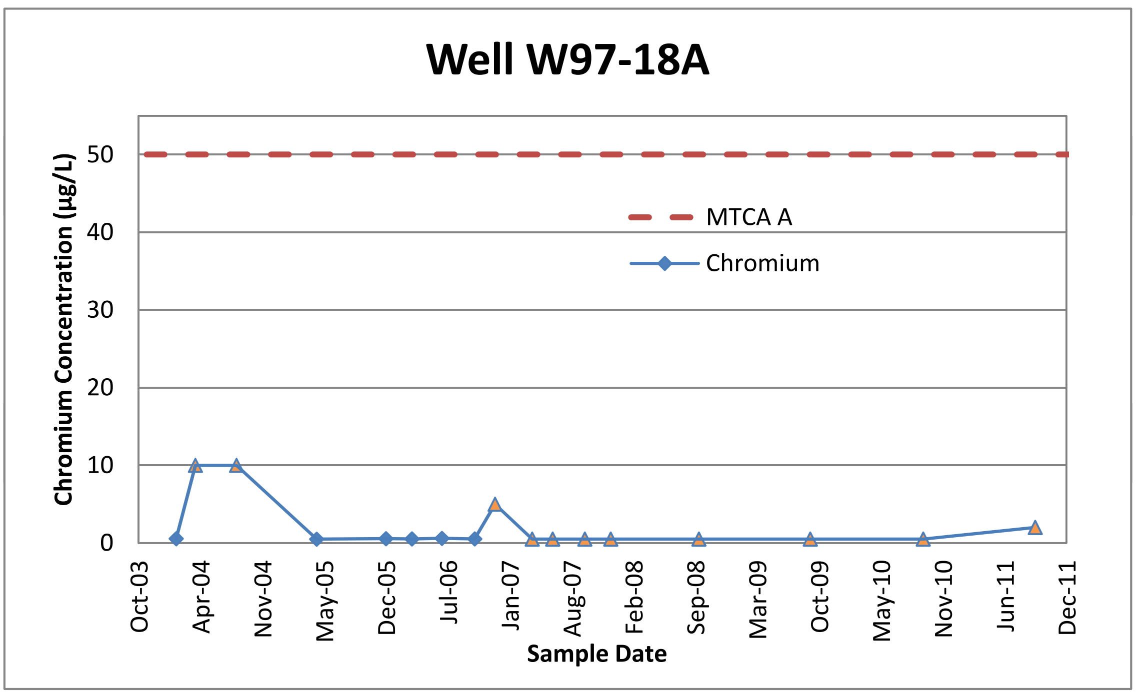
Well W92-16B

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AH3	Water	5-Feb-04	Chromium	2.6	µg/L	J	Well W92-16B	Total	7
MJ2BJ8	Water	7-Apr-04	Chromium	1.3	µg/L	U	Well W92-16B	Total	2
MJ4735	Water	18-Aug-04	Chromium	0.79	µg/L	J	Well W92-16B	Total	<10
184233	Water	3-May-05	Chromium	0.68	µg/L		Well W92-16B	Total	3.9
5504312	Water	14-Dec-05	Chromium	3.1	µg/L		Well W92-16B	Total	5.1
104233	Water	6-Mar-06	Chromium	1	µg/L		Well W92-16B	Total	8.7
244305	Water	14-Jun-06	Chromium	3.7	µg/L		Well W92-16B	Total	7
394201	Water	26-Sep-06	Chromium	1.6	µg/L		Well W92-16B	Total	0.7
494086	Water	2-Dec-06	Chromium	5	µg/L	U	Well W92-16B	Total	1
134268	Water	1-Apr-07	Chromium	1.4	µg/L		Well W92-16B	Total	6.8
234094	Water	6-Jun-07	Chromium	2.6	µg/L		Well W92-16B	Total	0.6
384550	Water	18-Sep-07	Chromium	3	µg/L		Well W92-16B	Total	2.2
504151	Water	11-Dec-07	Chromium	0.73	µg/L		Well W92-16B	Total	2.2
8394092	Water	22-Sep-08	Chromium	4.2	µg/L		Well W92-16B	Total	3.8
90906522	Water	16-Sep-09	Chromium	1.99	µg/L		Well W92-16B	Total	0.85
1009065-11	Water	15-Sep-10	Chromium	2.51	µg/L		Well W92-16B	Total	0.55
1009064-13	Water	14-Sep-11	Chromium	2	µg/L	U	Well W92-16B	Total	1.9



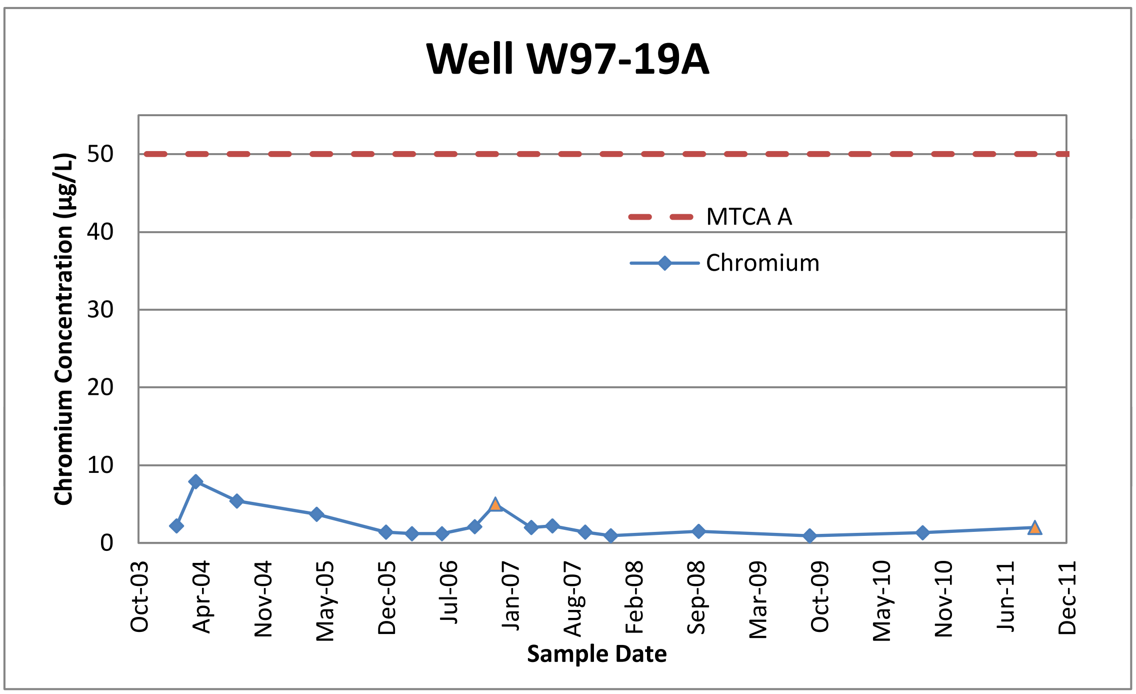
Well W97-18A

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AH5	Water	5-Feb-04	Chromium	0.56	µg/L	J	Well W97-18A	Total	14
MJ2BK2	Water	7-Apr-04	Chromium	10	µg/L	U	Well W97-18A	Total	0
MJ4739	Water	18-Aug-04	Chromium	10	µg/L	U	Well W97-18A	Total	5
184244	Water	4-May-05	Chromium	0.5	µg/L		Well W97-18A	Total	1
5504300	Water	14-Dec-05	Chromium	0.56	µg/L		Well W97-18A	Total	4
104256	Water	8-Mar-06	Chromium	0.53	µg/L		Well W97-18A	Total	0
244298	Water	13-Jun-06	Chromium	0.6	µg/L		Well W97-18A	Total	9
394209	Water	27-Sep-06	Chromium	0.53	µg/L		Well W97-18A	Total	6
494080	Water	2-Dec-06	Chromium	5	µg/L	U	Well W97-18A	Total	1
134269	Water	1-Apr-07	Chromium	0.5	µg/L	U	Well W97-18A	Total	8.5
234095	Water	6-Jun-07	Chromium	0.5	µg/L	U	Well W97-18A	Total	0.6
384555	Water	18-Sep-07	Chromium	0.5	µg/L	U	Well W97-18A	Total	7.7
504142	Water	11-Dec-07	Chromium	0.5	µg/L	U	Well W97-18A	Total	3.1
8394097	Water	21-Sep-08	Chromium	0.5	µg/L	U	Well W97-18A	Total	0.9
90906512	Water	16-Sep-09	Chromium	0.5	µg/L	U	Well W97-18A	Total	0.35
1009065-16	Water	16-Sep-10	Chromium	0.5	µg/L	U	Well W97-18A	Total	<10
1009064-09	Water	13-Sep-11	Chromium	2	µg/L	U	Well W97-18A	Total	0.88



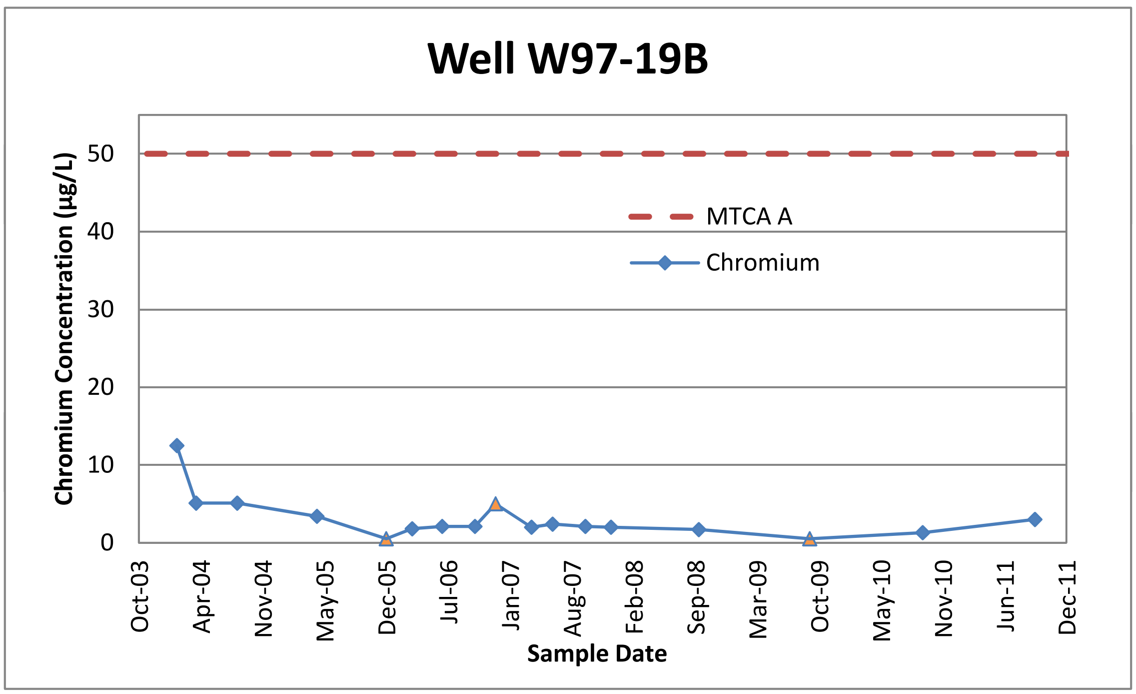
Well W97-19A

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AJ0	Water	6-Feb-04	Chromium	2.2	µg/L	J	Well W97-19A	Total	7
MJ2BK4	Water	8-Apr-04	Chromium	7.9	µg/L	J	Well W97-19A	Total	2
MJ4749	Water	19-Aug-04	Chromium	5.4	µg/L	J	Well W97-19A	Total	8
184242	Water	4-May-05	Chromium	3.7	µg/L		Well W97-19A	Total	1.8
5504303	Water	14-Dec-05	Chromium	1.4	µg/L		Well W97-19A	Total	0
104259	Water	8-Mar-06	Chromium	1.2	µg/L		Well W97-19A	Total	1
244296	Water	13-Jun-06	Chromium	1.2	µg/L		Well W97-19A	Total	1
394211	Water	27-Sep-06	Chromium	2.1	µg/L		Well W97-19A	Total	0.4
494095	Water	3-Dec-06	Chromium	5	µg/L	U	Well W97-19A	Total	1
134239	Water	29-Mar-07	Chromium	2	µg/L		Well W97-19A	Total	3.3
234077	Water	5-Jun-07	Chromium	2.2	µg/L		Well W97-19A	Total	1.8
384556	Water	19-Sep-07	Chromium	1.4	µg/L		Well W97-19A	Total	1.9
504149	Water	11-Dec-07	Chromium	0.94	µg/L		Well W97-19A	Total	1
8394084	Water	20-Sep-08	Chromium	1.5	µg/L		Well W97-19A	Total	1.9
90906505	Water	14-Sep-09	Chromium	0.92	µg/L		Well W97-19A	Total	3.23
1009065-01	Water	14-Sep-10	Chromium	1.33	µg/L		Well W97-19A	Total	3
1009064-01	Water	12-Sep-11	Chromium	2	µg/L	U	Well W97-19A	Total	0.7



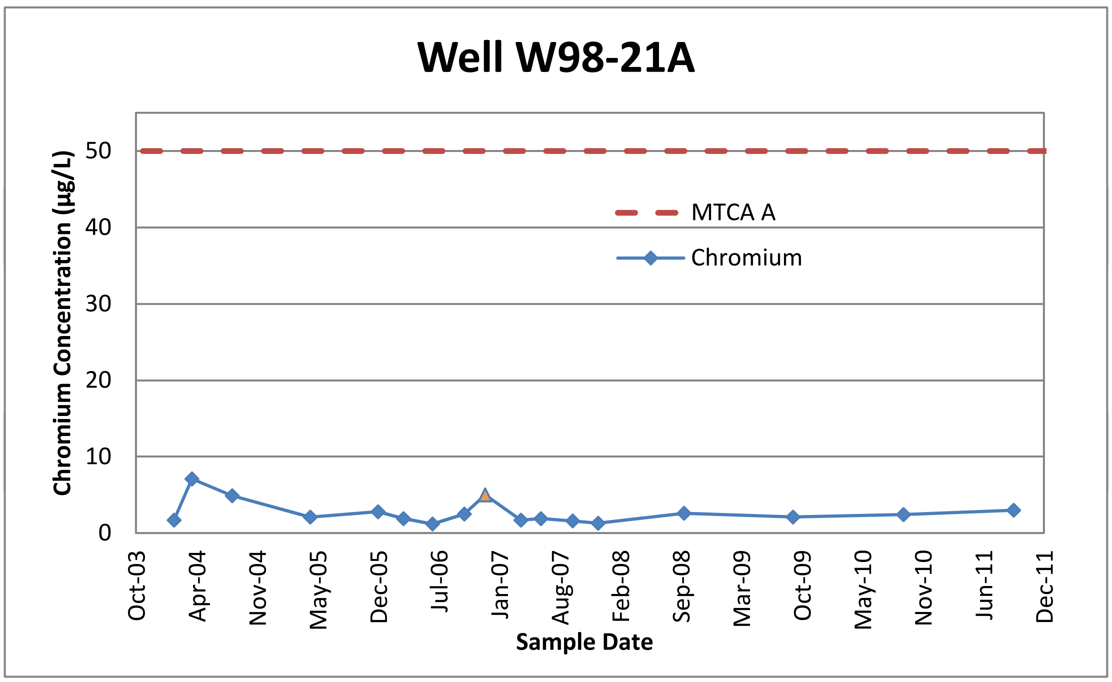
Well W97-19B

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AJ1	Water	6-Feb-04	Chromium	12.5	µg/L	J	Well W97-19B	Total	0
MJ2BK5	Water	8-Apr-04	Chromium	5.1	µg/L	J	Well W97-19B	Total	1
MJ4750	Water	19-Aug-04	Chromium	5.1	µg/L	J	Well W97-19B	Total	3
184243	Water	4-May-05	Chromium	3.4	µg/L		Well W97-19B	Total	1
5504304	Water	14-Dec-05	Chromium	0.5	µg/L	U	Well W97-19B	Total	0
104260	Water	8-Mar-06	Chromium	1.8	µg/L		Well W97-19B	Total	5
244297	Water	13-Jun-06	Chromium	2.1	µg/L		Well W97-19B	Total	0.5
394212	Water	27-Sep-06	Chromium	2.1	µg/L		Well W97-19B	Total	1
494096	Water	3-Dec-06	Chromium	5	µg/L	U	Well W97-19B	Total	1
134240	Water	29-Mar-07	Chromium	2	µg/L		Well W97-19B	Total	6.9
234078	Water	5-Jun-07	Chromium	2.4	µg/L		Well W97-19B	Total	1.9
384557	Water	19-Sep-07	Chromium	2.1	µg/L		Well W97-19B	Total	0.2
504150	Water	11-Dec-07	Chromium	2	µg/L		Well W97-19B	Total	4.7
8394085	Water	20-Sep-08	Chromium	1.7	µg/L		Well W97-19B	Total	0.2
90906506	Water	14-Sep-09	Chromium	0.5	µg/L	U	Well W97-19B	Total	0.5
1009065-02	Water	14-Sep-10	Chromium	1.3	µg/L		Well W97-19B	Total	0.2
1009064-02	Water	12-Sep-11	Chromium	3	µg/L		Well W97-19B	Total	0.54



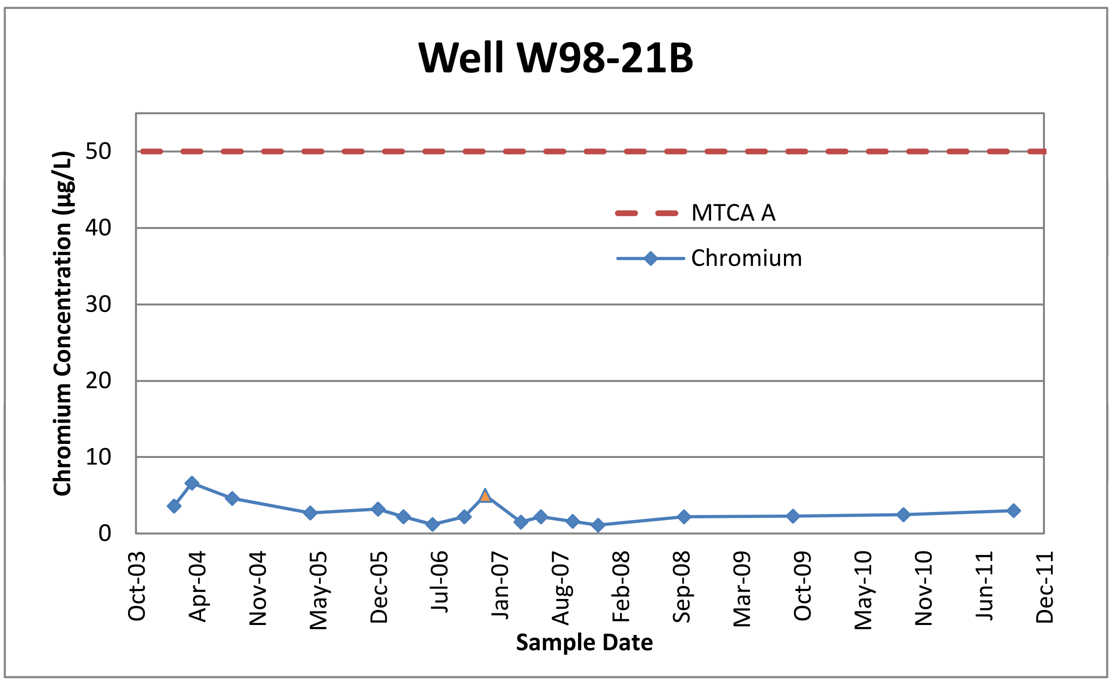
Well W98-21A

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AJ6	Water	9-Feb-04	Chromium	1.7	µg/L	J	Well W98-21A	Total	NoData
MJ2BK8	Water	8-Apr-04	Chromium	7.1	µg/L	J	Well W98-21A	Total	0
MJ4743	Water	19-Aug-04	Chromium	4.9	µg/L	J	Well W98-21A	Total	0
184237	Water	4-May-05	Chromium	2.1	µg/L		Well W98-21A	Total	1.3
5504309	Water	14-Dec-05	Chromium	2.8	µg/L		Well W98-21A	Total	0.1
104261	Water	8-Mar-06	Chromium	1.9	µg/L		Well W98-21A	Total	0
244282	Water	12-Jun-06	Chromium	1.2	µg/L		Well W98-21A	Total	0.3
394185	Water	25-Sep-06	Chromium	2.5	µg/L		Well W98-21A	Total	0.2
494098	Water	3-Dec-06	Chromium	5	µg/L	U	Well W98-21A	Total	0.1
134261	Water	31-Mar-07	Chromium	1.7	µg/L		Well W98-21A	Total	0.2
234074	Water	5-Jun-07	Chromium	1.9	µg/L		Well W98-21A	Total	0.9
384547	Water	18-Sep-07	Chromium	1.6	µg/L		Well W98-21A	Total	0.2
504146	Water	11-Dec-07	Chromium	1.3	µg/L		Well W98-21A	Total	2.6
8394082	Water	20-Sep-08	Chromium	2.6	µg/L		Well W98-21A	Total	0.1
90906503	Water	15-Sep-09	Chromium	2.11	µg/L		Well W98-21A	Total	0.72
1009065-13	Water	15-Sep-10	Chromium	2.43	µg/L		Well W98-21A	Total	0.15
1009064-14	Water	14-Sep-11	Chromium	3	µg/L		Well W98-21A	Total	0.59



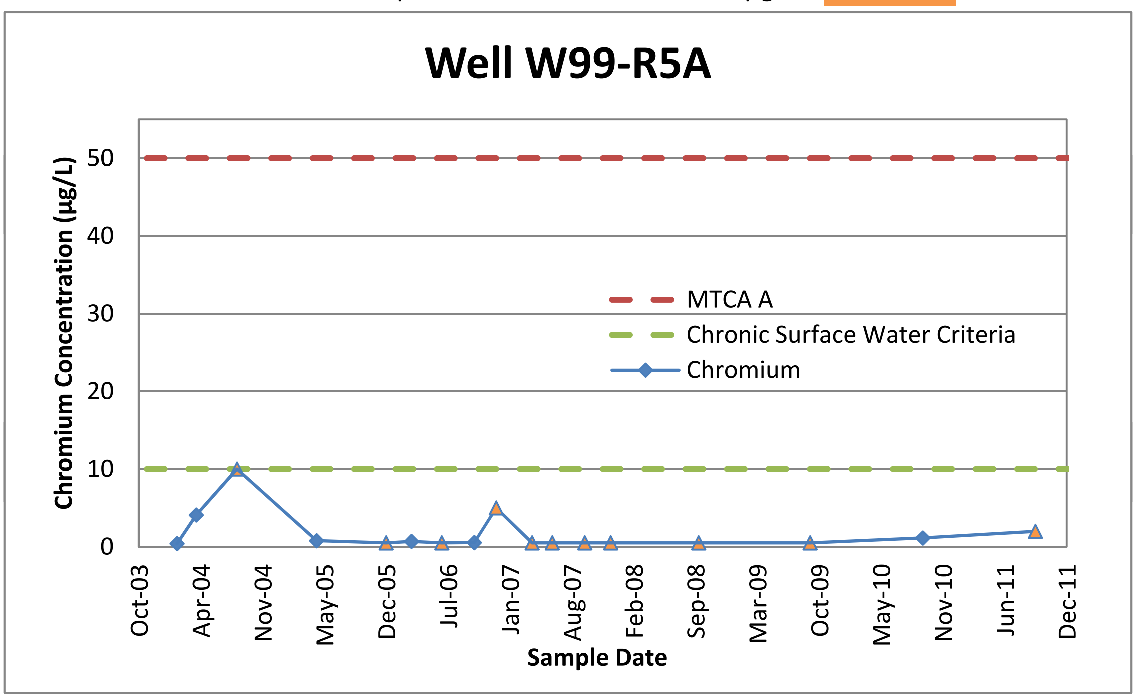
Well W98-21B

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AJ7	Water	9-Feb-04	Chromium	3.6	µg/L	J	Well W98-21B	Total	NoData
MJ2BK9	Water	8-Apr-04	Chromium	6.6	µg/L	J	Well W98-21B	Total	0
MJ4744	Water	19-Aug-04	Chromium	4.6	µg/L	J	Well W98-21B	Total	5
184238	Water	4-May-05	Chromium	2.7	µg/L		Well W98-21B	Total	0.5
5504310	Water	14-Dec-05	Chromium	3.2	µg/L		Well W98-21B	Total	0
104262	Water	8-Mar-06	Chromium	2.2	µg/L		Well W98-21B	Total	0
244283	Water	12-Jun-06	Chromium	1.2	µg/L		Well W98-21B	Total	0.3
394186	Water	25-Sep-06	Chromium	2.2	µg/L		Well W98-21B	Total	0.1
494099	Water	3-Dec-06	Chromium	5	µg/L	U	Well W98-21B	Total	0.2
134262	Water	31-Mar-07	Chromium	1.5	µg/L		Well W98-21B	Total	0.1
234075	Water	5-Jun-07	Chromium	2.2	µg/L		Well W98-21B	Total	0.2
384548	Water	18-Sep-07	Chromium	1.6	µg/L		Well W98-21B	Total	0.2
504147	Water	11-Dec-07	Chromium	1.1	µg/L		Well W98-21B	Total	1.7
8394083	Water	20-Sep-08	Chromium	2.2	µg/L		Well W98-21B	Total	0.4
90906504	Water	15-Sep-09	Chromium	2.28	µg/L		Well W98-21B	Total	0.76
1009065-14	Water	15-Sep-10	Chromium	2.47	µg/L		Well W98-21B	Total	0.45
1009064-15	Water	14-Sep-11	Chromium	3	µg/L		Well W98-21B	Total	0.61



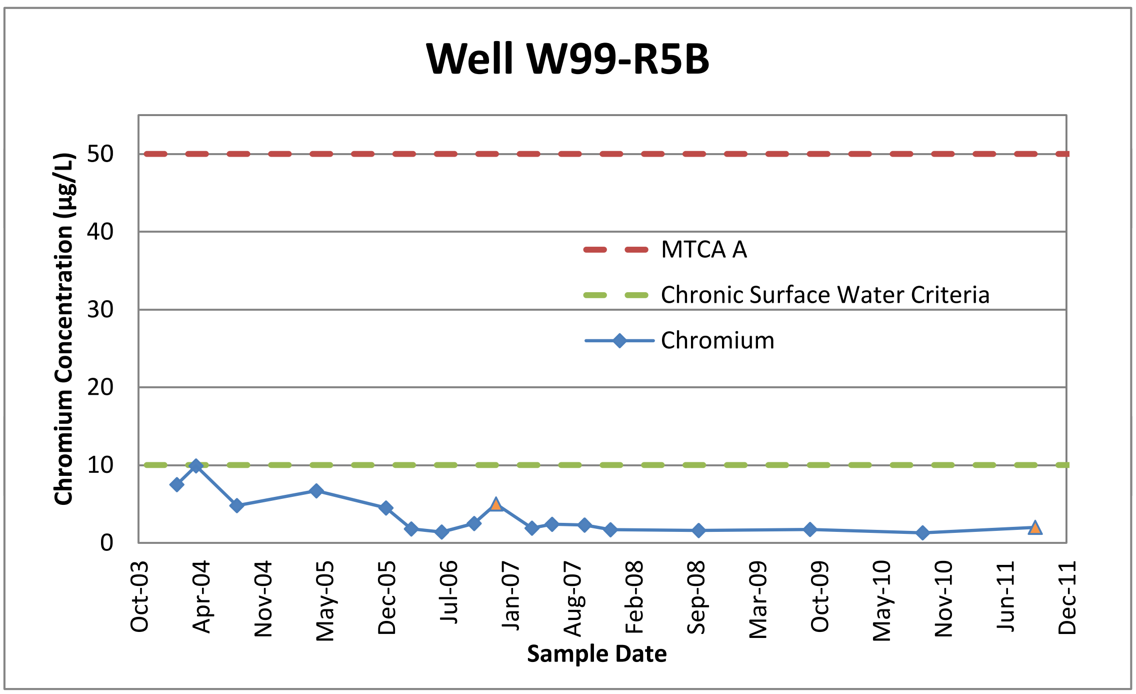
Well W99-R5A

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AJ3	Water	7-Feb-04	Chromium	0.41	µg/L	J	Well W99-R5A	Total	0
MJ2BL3	Water	9-Apr-04	Chromium	4.1	µg/L	J	Well W99-R5A	Total	0
MJ4745	Water	19-Aug-04	Chromium	10	µg/L	U	Well W99-R5A	Total	10
184230	Water	3-May-05	Chromium	0.79	µg/L		Well W99-R5A	Total	1
5504305	Water	14-Dec-05	Chromium	0.5	µg/L	U	Well W99-R5A	Total	0
104230	Water	6-Mar-06	Chromium	0.7	µg/L		Well W99-R5A	Total	0
244280	Water	12-Jun-06	Chromium	0.5	µg/L	U	Well W99-R5A	Total	1
394180	Water	25-Sep-06	Chromium	0.55	µg/L		Well W99-R5A	Total	1
494115	Water	5-Dec-06	Chromium	5	µg/L	U	Well W99-R5A	Total	1
134264	Water	31-Mar-07	Chromium	0.5	µg/L	U	Well W99-R5A	Total	0.3
234060	Water	4-Jun-07	Chromium	0.5	µg/L	U	Well W99-R5A	Total	0.4
384530	Water	17-Sep-07	Chromium	0.5	µg/L	U	Well W99-R5A	Total	1
504130	Water	10-Dec-07	Chromium	0.5	µg/L	U	Well W99-R5A	Total	0.5
8394086	Water	20-Sep-08	Chromium	0.5	µg/L	U	Well W99-R5A	Total	0.4
90906507	Water	15-Sep-09	Chromium	0.5	µg/L	U	Well W99-R5A	Total	0.22
1009065-07	Water	14-Sep-10	Chromium	1.14	µg/L		Well W99-R5A	Total	0.1
1009064-07	Water	13-Sep-11	Chromium	2	µg/L	U	Well W99-R5A	Total	0.54



Well W99-R5B

SampleNumber	Matrix	SampleDate	Analyte	Conc.	Units	Qualifier	StationLocation	Notes	NTU
MJ2AJ5	Water	7-Feb-04	Chromium	7.5	µg/L	J	Well W99-R5B	Total	0
MJ2BL4	Water	9-Apr-04	Chromium	9.9	µg/L	J	Well W99-R5B	Total	0
MJ4746	Water	19-Aug-04	Chromium	4.8	µg/L	J	Well W99-R5B	Total	8
184231	Water	3-May-05	Chromium	6.7	µg/L		Well W99-R5B	Total	2.3
5504306	Water	14-Dec-05	Chromium	4.5	µg/L		Well W99-R5B	Total	2.1
104231	Water	6-Mar-06	Chromium	1.8	µg/L		Well W99-R5B	Total	0
244281	Water	12-Jun-06	Chromium	1.4	µg/L		Well W99-R5B	Total	3
394181	Water	25-Sep-06	Chromium	2.5	µg/L		Well W99-R5B	Total	1
494116	Water	5-Dec-06	Chromium	5	µg/L	U	Well W99-R5B	Total	1
134265	Water	31-Mar-07	Chromium	1.9	µg/L		Well W99-R5B	Total	10
234061	Water	4-Jun-07	Chromium	2.4	µg/L		Well W99-R5B	Total	0.7
384531	Water	17-Sep-07	Chromium	2.3	µg/L		Well W99-R5B	Total	1.6
504130	Water	10-Dec-07	Chromium	1.7	µg/L		Well W99-R5B	Total	2
8394087	Water	20-Sep-08	Chromium	1.6	µg/L		Well W99-R5B	Total	0.8
90906508	Water	15-Sep-09	Chromium	1.73	µg/L		Well W99-R5B	Total	0.24
1009065-06	Water	14-Sep-10	Chromium	1.3	µg/L		Well W99-R5B	Total	0.2
1009064-06	Water	13-Sep-11	Chromium	2	µg/L	U	Well W99-R5B	Total	0.9



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Chromium Data 2003-2011

Total chromium data from 2003-2011 for the FHC site are presented in this Appendix. These data are compiled in each monitoring report. The Event 17 monitoring report was the most recent available at the time of this FYR, so this Appendix and any data analysis reflects data presented in the Event 17 monitoring report.

This Appendix is organized by well; each page contains a heading with the well name, then a table of all total chromium results since the beginning of long term monitoring, and a figure showing how these results compare to cleanup levels.

Wells were sampled with a peristaltic pump equipped with polyethylene tubing deployed to mid-screen depth at each well. The wells were purged prior to sampling until monitored field parameters (turbidity, conductivity, pH, DO, ORP, and temperature) stabilized.

In cases where groundwater turbidity was greater than 10 nephelometric turbidity units (NTUs), samples were passed through a 0.45-micron filter in the field and submitted for dissolved chromium analysis. The presented NTU values are pre-filtering values. There are instances where groundwater was filtered due to the presence of black particulates, even though the turbidity was not greater than 10 NTU.

In Event 17, all wells were sampled for total chromium. In all previous sampling events, all wells were sampled for total analyte list metals (Events 1-16). EPA and WDOE determined after Event 16 that it was no longer necessary to analyze the FHC groundwater for the complete list of Priority Pollutant metals. Metals were initially analyzed using method EPA CLP SOW ILM05.2. EPA methods 200.7 for digestion and 200.8 for analysis were used starting with Event 3 (August 2004). The method detection limit using these methods appear to be 0.5 μg/L. EPA method 200.7 was used in Event 17 (September 2011). Data qualifiers are defined as follows:

U- The compound was analyzed for, but not detected. These are noted on the tables with orange and in the figures as orange triangles.
J- The analyte was positively identified, but the associated numerical value is an estimate quantity because quality control criteria were not met or because concentrations reported are less than the quantitation limit or lower calibration standard.

Non-detect data qualifiers (U) above 0.5 μg/L appear to have been given for one of two reasons. First, samples were diluted prior to analysis due to matrix interference and the reporting limits were raised accordingly. This occurred several times, most notably in the Event 7 (Jun 2006) chromium sample from Well RA-MW-12A, which was diluted 100 times resulting in a reporting limit of 50 μg/L. Reporting limits of 5 μg/L and 10 μg/L are more common, and resulted from a 10 times and 20 times dilutions, respectively. Second, if chromium was detected in one or more preparation blanks, the associated analyte results were qualified as non-detected. This occurred in samples from many wells Event 2 (April 2004), for example.

Appendix G: Comparison of Conventional Parameters

Table 3: Comparison of Conventional Parameters

Well Number	Temperature (ºC)																
	Feb-04	**Apr-04**	**Aug-04**	**May-05**	**Dec-05**	**Mar-06**	**Jun-06**	**Sep-06**	**Dec-06**	**Mar-07**	**Jun-07**	**Sep-07**	**Dec-07**	**Sep-08**	**Sep-09**	**Sep-10**	**Sep-11**
B85-3	14.6	14.8	15.2	15.8	14.4	14.1	13.6	14.6	12.4	12.5	13.6	13.7	13.1	8.0	14.0	13.2	14.0
B85-4	14.1	14.4	15.1	14.4	13.9	13.5	14.3	14.5	13.8	14.6	14.4	—	13.5	8.7	14.7	17.0	14.9
B87-8	14.5	14.7	15.8	15.2	14.7	14.4	14.5	14.4	13.8	14.4	14.3	14.5	13.6	8.8	14.3	13.7	14.6
RA-MW-12A	14.9	15.9	17.9	15.2	14.9	14.6	14.3	14.9	13.9	14.0	13.9	14.4	13.8	8.7	15.5	13.5	14.5
RA-MW-12B	14.4	16.6	16.7	15.6	14.3	14.9	14.4	14.5	13.4	14.3	14.1	14.4	13.3	8.5	14.2	13.7	14.0
RA-MW-12C	14.4	16.5	16.6	15.1	14.2	14.3	14.2	14.2	13.1	13.3	14.1	14.1	13.2	8.5	14.4	13.2	14.5
RA-MW-15A	14.3	14.5	15.0	15.0	14.7	14.8	14.7	15.1	14.7	15.3	15.1	14.7	13.6	9.0	14.6	14.1	14.3
RA-MW-15B	13.9	14.4	15.4	14.7	14.1	14.0	14.5	17.2	14.1	14.8	14.9	14.3	13.4	8.8	14.6	14.0	14.3
RA-MW-16A	14.3	14.9	16.0	14.9	15.1	13.3	13.4	14.8	13.8	14.0	13.9	14.1	—	8.6	14.2	13.8	14.2
RA-MW-16B	14.3	14.6	16.0	14.7	13.9	13.7	13.8	15.2	13.4	14.3	13.8	14.1	—	8.8	14.4	14.0	14.1
RA-MW-17A	14.3	15.3	16.7	15.1	14.5	13.7	—	13.9	13.4	13.1	14.1	13.8	13.4	8.5	13.7	13.8	13.8
W85-6A	14.1	14.1	15.5	14.0	—	—	13.7	15.3	13.9	13.2	13.6	14.1	13.2	8.7	15.7	14.4	15.2
W85-6B	13.6	13.8	16.3	13.7	—	—	13.8	15.1	13.1	13.1	13.8	15.0	12.9	8.6	16.6	14.5	15.0
W92-16A	14.2	15.6	16.1	15.3	14.0	13.8	14.1	15.5	13.6	13.3	14.5	14.5	13.3	8.6	14.8	14.3	15.1
W92-16B	14.1	14.7	16.2	15.2	13.7	13.7	13.8	15.4	13.1	13.3	14.4	14.6	13.0	8.7	14.6	14.0	15.0
W97-18A	11.3	11.0	15.0	12.7	13.9	12.0	—	13.8	13.0	11.6	12.5	13.2	13.0	7.8	13.7	13.6	14.5
W97-19A	12.5	13.3	16.0	14.3	13.8	12.9	—	15.3	13.9	13.8	14.1	14.3	13.3	8.7	14.9	14.3	14.9
W97-19B	12.7	13.3	15.9	15.3	13.3	12.4	—	15.2	13.0	14.2	14.4	14.5	12.9	8.8	14.1	14.2	15.0
W98-21A	13.1	14.3	14.2	13.8	13.9	13.8	13.7	15.0	13.7	13.7	14.0	14.5	12.3	8.4	17.1	14.1	14.5
W98-21B	13.1	13.6	14.0	13.8	13.7	13.0	13.7	14.7	13.4	13.5	14.2	14.5	13.2	8.5	16.7	13.8	14.7
W99-R5A	14.2	14.9	15.7	14.8	14.8	14.7	15.1	—	13.9	13.9	15.5	15.4	14.1	10.0	14.7	14.3	14.8
W99-R5B	13.9	14.4	15.6	14.4	14.5	13.9	14.7	—	13.5	13.5	15.0	15.2	13.6	9.5	15.1	14.2	14.4
RA-MW-11A	15.7	16.5	17.4	15.7	15.0	15.1	15.1	14.9	13.7	13.8	14.0	14.0	13.5	—	—	—	—
RA-MW-11B	14.9	16.3	17.0	15.6	14.9	14.7	14.7	14.7	13.4	13.6	14.1	14.3	13.2	—	—	—	—
RA-MW-13A	15.0	14.6	15.7	14.9	14.5	14.3	13.7	14.1	12.8	13.8	14.3	14.3	13.2	—	—	—	—
RA-MW-13B	14.8	14.7	15.4	14.9	14.2	14.3	14.1	14.2	13.0	13.9	14.2	13.8	13.2	—	—	—	—
RA-MW-13C	14.2	15.0	14.9	14.5	14.3	13.8	13.8	14.1	12.4	13.9	14.0	14.0	12.9	—	—	—	—
RA-MW-14A	13.9	14.3	15.3	14.6	14.7	10.8	—	13.6	12.7	10.8	13.0	13.2	12.9	—	—	—	—
RA-MW-14B	14.0	14.9	15.5	14.5	14.1	12.3	—	14.0	12.8	11.3	13.8	13.5	12.9	—	—	—	—
W85-7A	11.4	12.6	14.9	13.9	14.5	12.3	13.7	15.9	13.4	12.7	13.4	—	14.5	—	—	—	—
W85-7B	12.1	13.0	14.5	13.6	14.1	12.8	13.4	14.4	13.0	13.0	13.4	—	13.4	—	—	—	—
W97-18B	11.4	12.4	14.4	13.5	13.0	10.7	—	13.8	12.6	12.0	13.6	—	—	—	—	—	—
W98-20A	13.8	12.5	15.4	14.3	14.3	13.1	—	15.3	14.0	13.1	13.6	—	13.2	—	—	—	—

(Table 3 continued)

Well Number	Specific Conductivity (mS/cm)																
	Feb-04	**Apr-04**	**Aug-04**	**May-05**	**Dec-05**	**Mar-06**	**Jun-06**	**Sep-06**	**Dec-06**	**Mar-07**	**Jun-07**	**Sep-07**	**Dec-07**	**Sep-08**	**Sep-09**	**Sep-10**	**Sep-11**
B85-3	0.99	0.90	0.98	0.81	0.54	0.74	0.64	0.72	0.97	0.84	0.68	0.77	0.90	0.81	0.77	0.72	0.65
B85-4	0.41	1.17	0.51	0.71	0.28	0.74	0.33	0.56	0.92	739.00	0.60	—	0.43	0.63	0.58	0.55	0.34
B87-8	0.26	0.55	0.36	0.29	0.24	0.38	0.27	0.36	0.44	0.39	0.19	0.33	0.36	0.27	0.32	0.45	0.31
RA-MW-12A	6.01	5.40	4.00	3.32	2.52	2.47	2.37	2.26	2.95	0.85	1.11	1.98	2.34	2.55	2.92	2.59	2.55
RA-MW-12B	2.25	1.19	1.52	2.56	2.47	1.34	1.39	1.19	2.12	1.12	0.89	1.55	1.49	1.55	1.74	1.11	0.78
RA-MW-12C	2.18	1.34	1.13	0.68	1.09	0.69	0.88	0.53	1.05	0.65	0.49	0.58	0.81	0.80	0.97	0.72	0.54
RA-MW-15A	1.88	1.04	1.08	1.30	1.42	1.53	1.44	1.27	1.74	1.10	1.06	1.06	1.28	1.03	1.04	0.99	0.89
RA-MW-15B	0.47	0.86	0.68	0.64	0.91	0.92	0.80	0.46	1.60	1.16	0.49	0.81	1.22	0.93	0.85	0.49	0.33
RA-MW-16A	2.95	1.46	2.00	1.70	1.07	1.04	1.01	0.80	1.13	1.02	0.83	0.91	—	0.93	1.04	0.89	0.83
RA-MW-16B	2.42	1.19	1.40	1.81	0.92	0.67	0.51	0.43	1.34	1.05	0.32	0.48	—	0.74	0.66	0.49	0.50
RA-MW-17A	1.80	1.80	1.80	1.39	1.18	1.30	—	1.18	1.30	1.04	1.03	1.16	1.47	1.46	1.43	1.23	0.96
W85-6A	0.11	0.33	0.34	299.00	—	—	0.23	0.24	0.24	0.36	0.27	0.32	0.30	0.27	0.24	0.26	0.22
W85-6B	0.31	0.41	0.33	0.26	—	—	0.10	0.11	0.17	0.24	0.19	0.20	0.26	0.32	0.22	0.19	0.18
W92-16A	0.33	0.25	0.27	0.23	0.24	0.28	0.28	0.37	0.47	0.57	0.47	0.53	0.64	0.61	0.48	0.36	0.36
W92-16B	1.17	1.37	0.95	0.66	0.09	0.34	0.42	0.32	0.61	0.57	0.25	0.44	0.60	0.50	0.15	0.21	0.27
W97-18A	0.11	0.09	0.11	0.08	0.10	0.19	—	0.15	0.16	0.16	0.10	0.14	0.18	0.23	0.21	0.19	0.16
W97-19A	0.25	0.26	0.28	0.23	0.23	0.19	—	0.21	0.26	0.24	0.19	0.22	0.26	0.30	0.30	0.26	0.24
W97-19B	0.26	0.26	0.29	0.22	0.06	0.19	—	0.20	0.28	0.23	0.19	0.21	0.25	0.30	0.09	0.26	0.24
W98-21A	0.16	0.23	0.29	0.45	0.19	0.19	0.22	0.25	0.29	0.29	0.27	0.27	0.09	0.29	0.30	0.28	0.22
W98-21B	0.24	0.27	0.27	0.25	0.18	0.22	0.21	0.24	0.32	0.31	0.21	0.26	0.27	0.29	0.26	0.30	0.20
W99-R5A	0.24	0.25	0.24	0.22	0.21	0.20	0.20	—	0.27	0.22	0.21	0.21	0.20	0.27	0.28	0.26	0.22
W99-R5B	0.26	0.26	0.27	0.23	0.22	0.22	0.22	—	0.28	0.24	0.21	0.22	0.26	0.29	0.27	0.25	0.23
RA-MW-11A	1.67	1.89	2.02	1.48	1.82	2.01	1.46	1.70	2.21	1.75	1.22	1.62	1.99	—	—	—	—
RA-MW-11B	1.49	2.08	2.02	1.72	2.25	1.17	0.94	1.10	1.50	1.21	0.77	1.05	1.59	—	—	—	—
RA-MW-13A	5.21	2.42	3.29	2.83	2.49	2.17	1.66	1.13	2.33	1.34	1.23	1.47	1.69	—	—	—	—
RA-MW-13B	3.73	1.38	2.15	2.41	2.16	0.81	0.82	0.50	2.22	1.23	0.50	0.98	1.34	—	—	—	—
RA-MW-13C	3.07	1.82	1.41	1.28	0.71	0.79	0.82	0.57	1.36	0.93	0.51	0.60	0.93	—	—	—	—
RA-MW-14A	1.43	1.71	1.96	1.08	0.88	0.87	—	0.92	0.77	0.87	0.74	0.89	0.95	—	—	—	—
RA-MW-14B	1.56	1.21	0.98	1.08	1.00	0.78	—	0.69	0.89	0.87	0.68	0.85	1.02	—	—	—	—
W85-7A	0.13	0.14	0.21	0.12	0.11	0.10	0.16	0.16	0.13	219.00	0.11	—	0.27	—	—	—	—
W85-7B	0.28	0.31	0.32	0.01	0.01	0.01	0.02	0.01	0.03	0.01	0.02	—	0.02	—	—	—	—
W97-18B	0.26	0.24	0.27	0.22	0.19	0.19	—	0.19	0.28	0.23	0.17	—	-	—	—	—	—
W98-20A	0.16	0.15	0.23	0.12	0.12	0.13	—	0.18	0.25	0.18	0.16	—	0.26	—	—	—	—

(Table 3 continued)

Well Number	Dissolved Oxygen (mg/L)																
	Feb-04	**Apr-04**	**Aug-04**	**May-05**	**Dec-05**	**Mar-06**	**Jun-06**	**Sep-06**	**Dec-06**	**Mar-07**	**Jun-07**	**Sep-07**	**Dec-07**	**Sep-08**	**Sep-09**	**Sep-10**	**Sep-11**
B85-3	1.11	0.16	1.57	4.50	0.12	2.97	0.22	1.04	0.80	0.02	0.24	0.15	0.21	0.18	0.39	0.27	0.62
B85-4	0.65	1.37	1.50	0.33	0.20	0.22	0.52	1.61	0.30	0.03	0.27	—	0.24	0.26	0.40	0.34	0.55
B87-8	0.13	1.03	1.06	0.35	0.28	0.53	0.37	0.52	0.25	0.01	7.00	0.19	0.11	0.24	0.40	0.17	0.62
RA-MW-12A	0.24	0.09	0.20	0.13	0.04	0.00	52.70	17.00	56.41	0.00	0.00	-0.47	0.00	0.00	0.51	1.96	1.28
RA-MW-12B	0.27	0.07	0.27	0.07	0.05	1.26	45.10	12.16	73.22	0.00	9.82	-0.39	0.00	0.00	0.40	0.23	0.27
RA-MW-12C	0.20	0.14	0.42	0.25	0.07	1.10	5.16	4.93	3.33	0.01	0.40	0.23	0.00	0.28	0.53	0.20	0.18
RA-MW-15A	0.33	0.21	1.53	0.47	0.15	8.34	0.47	2.89	0.29	0.04	0.19	0.48	0.10	0.32	0.48	0.32	0.56
RA-MW-15B	0.22	0.10	0.74	0.44	0.18	0.79	0.30	1.25	0.30	0.06	0.15	0.18	0.12	0.30	0.60	0.26	0.54
RA-MW-16A	0.73	0.27	1.39	1.60	0.11	5.40	0.54	0.49	0.31	0.05	0.36	0.31	—	0.15	0.43	0.31	0.65
RA-MW-16B	0.75	0.15	0.86	0.75	0.33	1.85	0.27	0.27	0.21	0.05	0.24	0.16	—	0.19	0.33	0.25	0.36
RA-MW-17A	0.60	0.19	1.99	0.60	0.20	3.69	—	0.74	0.35	0.11	0.14	0.22	0.10	0.19	0.51	0.32	0.45
W85-6A	4.92	0.43	0.85	4.90	—	—	1.86	2.06	2.63	0.09	0.51	0.93	2.52	2.08	4.01	2.97	3.51
W85-6B	3.46	6.13	6.54	5.50	—	—	7.87	3.83	5.15	0.05	4.96	5.95	6.10	4.87	13.98	10.48	9.20
W92-16A	0.98	0.13	2.49	3.10	0.28	0.15	0.45	0.32	0.33	0.13	0.32	0.22	0.11	0.15	0.54	0.28	0.48
W92-16B	0.14	0.53	1.97	3.40	5.40	1.02	0.54	2.12	0.23	0.80	4.16	1.60	0.11	1.31	14.02	10.90	8.21
W97-18A	1.27	0.74	1.09	0.50	1.10	4.00	—	1.45	0.90	0.90	0.67	0.69	0.69	0.64	0.33	0.19	0.66
W97-19A	4.72	1.79	22.73	4.60	0.97	3.51	—	3.50	9.37	1.00	3.74	3.57	4.69	3.92	6.56	2.42	3.67
W97-19B	1.81	1.31	2.60	2.60	1.10	2.99	—	3.43	4.13	0.52	2.83	3.55	3.44	3.01	9.81	1.67	4.06
W98-21A	1.29	1.49	3.03	13.30	1.20	1.05	3.26	2.59	4.97	0.07	0.80	2.44	2.53	2.58	3.18	2.81	3.52
W98-21B	1.24	3.29	2.82	17.70	3.90	1.08	3.37	2.42	4.90	0.02	3.52	1.98	2.73	2.58	8.21	2.60	7.13
W99-R5A	4.72	4.26	5.60	5.30	3.30	1.83	5.10	—	6.26	4.90	4.53	4.55	5.38	5.40	6.33	5.10	5.13
W99-R5B	3.97	2.71	4.70	5.10	1.90	2.03	4.20	—	4.90	3.40	3.49	3.86	4.66	4.34	5.76	5.03	4.55
RA-MW-11A	0.32	0.10	0.66	6.69	0.16	0.00	24.20	22.50	1.80	0.00	0.13	-0.12	0.00	—	—	—	—
RA-MW-11B	0.19	0.15	0.50	0.14	0.10	0.19	26.60	4.44	2.50	0.00	0.81	0.15	0.00	—	—	—	—
RA-MW-13A	1.63	0.17	1.13	0.53	0.11	0.38	0.27	1.00	0.00	0.04	0.24	0.20	0.11	—	—	—	—
RA-MW-13B	0.73	0.16	0.73	0.51	0.21	0.45	0.35	0.49	0.00	0.09	0.14	0.51	0.09	—	—	—	—
RA-MW-13C	0.22	0.15	0.43	1.40	2.98	0.96	0.41	0.80	0.00	0.06	0.46	0.26	0.07	—	—	—	—
RA-MW-14A	0.89	0.22	5.96	0.51	0.22	6.74	—	0.88	1.75	0.60	0.21	0.17	0.11	—	—	—	—
RA-MW-14B	1.08	0.10	2.77	0.42	0.12	2.58	—	0.52	1.73	0.90	0.13	0.20	0.10	—	—	—	—
W85-7A	4.05	3.17	2.18	4.30	2.20	6.70	5.89	3.09	2.39	0.18	3.29	—	2.60	—	—	—	—
W85-7B	2.78	5.11	6.10	8.70	4.00	10.30	10.96	3.77	0.06	0.10	8.79	—	7.85	—	—	—	—
W97-18B	2.01	5.56	4.52	4.90	2.00	1.17	—	4.25	4.59	1.09	4.72	—	—	—	—	—	—
W98-20A	4.92	3.76	5.50	5.00	3.20	5.10	—	3.63	9.14	5.70	3.03	—	4.87	—	—	—	—

(Table 3 continued)

Well Number	pH																
	Feb-04	**Apr-04**	**Aug-04**	**May-05**	**Dec-05**	**Mar-06**	**Jun-06**	**Sep-06**	**Dec-06**	**Mar-07**	**Jun-07**	**Sep-07**	**Dec-07**	**Sep-08**	**Sep-09**	**Sep-10**	**Sep-11**
B85-3	6.49	6.68	6.91	6.39	6.70	6.64	6.42	6.33	6.73	6.68	6.66	6.88	7.02	6.88	6.74	6.85	5.82
B85-4	6.14	6.26	6.53	6.22	6.51	6.49	6.21	6.28	6.47	6.53	6.53	—	7.21	6.62	6.28	6.41	5.20
B87-8	6.55	6.31	6.73	6.54	6.68	6.57	6.35	6.61	6.71	6.71	6.89	6.99	7.44	6.90	6.90	6.63	6.14
RA-MW-12A	8.86	8.73	8.86	8.98	8.41	8.19	8.46	8.54	7.59	7.86	7.97	7.97	8.53	7.16	7.64	7.79	6.58
RA-MW-12B	7.77	7.83	7.92	8.30	8.68	8.16	7.76	7.83	8.06	7.94	7.55	7.79	8.28	7.75	7.25	7.31	6.43
RA-MW-12C	8.13	7.92	8.09	7.95	8.14	7.89	7.92	7.90	7.74	7.80	7.79	8.14	8.57	7.99	7.81	7.70	6.68
RA-MW-15A	6.35	6.37	6.74	6.20	6.30	6.47	6.28	6.09	6.53	6.61	6.50	6.68	7.19	6.63	6.53	6.51	5.80
RA-MW-15B	6.35	6.83	7.18	6.39	6.39	6.51	6.26	6.61	6.39	6.48	6.84	6.73	7.18	6.66	6.52	7.01	6.33
RA-MW-16A	6.61	6.61	6.75	6.42	6.44	6.62	6.44	5.96	6.68	6.71	6.64	6.82	—	6.74	6.62	6.56	4.35
RA-MW-16B	6.42	7.12	7.09	6.31	7.12	7.06	6.85	6.09	6.62	6.78	7.27	7.41	—	7.11	7.18	7.28	5.43
RA-MW-17A	6.55	6.43	6.61	6.20	6.39	6.50	—	6.42	6.66	6.59	6.47	6.69	7.26	6.65	6.68	6.55	5.57
W85-6A	6.23	6.22	6.40	6.36	—	—	6.25	5.47	6.63	6.47	6.50	6.77	6.85	6.71	6.24	6.52	6.07
W85-6B	6.40	6.42	6.68	6.62	—	—	8.93	7.16	8.05	6.83	6.76	7.15	7.09	6.87	8.50	9.12	7.80
W92-16A	6.42	6.42	6.72	6.60	6.56	6.60	6.67	5.87	6.59	6.52	6.44	6.75	7.41	6.61	6.40	6.56	5.47
W92-16B	7.51	7.58	7.63	7.59	6.88	7.54	7.38	6.35	7.46	7.62	7.51	7.70	8.23	7.21	7.22	7.17	5.93
W97-18A	5.83	5.96	6.19	6.17	6.78	6.57	—	5.08	6.29	6.32	6.23	6.54	7.07	6.33	6.33	6.30	5.20
W97-19A	6.35	6.24	6.28	6.35	6.59	6.41	—	5.53	6.55	6.58	6.57	6.91	7.33	6.51	6.35	6.53	3.30
W97-19B	6.68	6.49	6.30	6.47	6.68	6.68	—	5.89	6.83	6.76	6.72	6.95	7.50	6.65	7.14	6.78	4.94
W98-21A	5.92	6.07	6.68	6.18	6.30	6.25	6.11	4.80	6.16	6.43	6.34	6.53	6.81	6.48	6.07	6.25	5.62
W98-21B	6.04	6.07	6.90	6.24	6.64	6.36	6.07	5.55	6.38	6.39	6.46	6.48	7.08	6.44	6.19	6.38	5.34
W99-R5A	6.03	5.98	6.28	6.21	6.22	6.28	6.23	—	6.40	6.30	6.18	6.58	6.73	6.31	6.52	6.35	5.60
W99-R5B	6.20	6.23	6.55	6.33	6.63	6.55	6.26	—	6.62	6.63	6.54	6.90	6.92	6.54	6.66	6.67	5.95
RA-MW-11A	7.51	7.53	7.00	6.52	6.64	6.64	6.46	6.48	6.43	6.69	6.68	6.86	7.26	—	—	—	—
RA-MW-11B	7.66	7.90	7.20	6.70	6.73	7.00	6.69	6.85	6.86	7.01	6.94	7.17	7.61	—	—	—	—
RA-MW-13A	7.15	7.15	7.03	6.70	6.86	6.82	6.82	6.96	7.02	7.08	6.95	7.11	7.21	—	—	—	—
RA-MW-13B	7.23	7.56	7.30	6.86	6.99	7.15	6.95	7.52	7.04	7.06	7.43	7.35	7.27	—	—	—	—
RA-MW-13C	7.36	7.35	7.44	7.33	7.48	7.25	7.25	7.45	7.45	7.44	7.53	7.81	7.62	—	—	—	—
RA-MW-14A	6.64	6.81	6.99	6.50	6.60	6.60	—	5.98	6.76	6.65	6.62	6.89	6.85	—	—	—	—
RA-MW-14B	6.90	7.14	7.33	6.75	6.78	6.87	—	6.40	6.98	6.82	6.89	7.06	7.04	—	—	—	—
W85-7A	6.24	6.04	6.26	6.20	6.30	6.35	6.24	5.69	6.45	6.33	6.40	—	6.61	—	—	—	—
W85-7B	6.63	6.51	6.71	5.91	6.18	6.14	6.37	5.39	6.57	6.23	6.30	—	6.71	—	—	—	—
W97-18B	6.57	6.35	6.67	6.41	6.60	6.16	—	6.25	6.55	6.61	6.68	—	—	—	—	—	—
W98-20A	6.01	5.91	6.32	5.97	6.29	6.18	—	4.90	6.26	6.41	6.19	—	7.02	—	—	—	—

(Table 3 continued)

Well Number	ORP (mV)																
	Feb-04	**Apr-04**	**Aug-04**	**May-05**	**Dec-05**	**Mar-06**	**Jun-06**	**Sep-06**	**Dec-06**	**Mar-07**	**Jun-07**	**Sep-07**	**Dec-07**	**Sep-08**	**Sep-09**	**Sep-10**	**Sep-11**
B85-3	-7	-107	-37	-47	-93	-62	-43	-53	-59	-43	-66	-30	-52	-39	27	-61	-50
B85-4	10	41	59	218	-26	75	86	179	161	182	90	—	123	108	162	220	479
B87-8	-8	31	17	199	2	73	86	160	167	170	87	95	106	96	107	12	42
RA-MW-12A	-468	-466	-430	-417	-403	-393	-363	-311	-373	-324	-374	-369	-396	-310	-154	-304	-333
RA-MW-12B	-363	-321	-315	-415	-414	-345	-327	-355	-374	-313	-363	-361	-379	-318	-215	-283	-308
RA-MW-12C	-282	-179	-154	-239	-314	-234	-191	-164	-217	-137	-129	-235	-289	-219	-167	-233	-275
RA-MW-15A	-47	4	39	10	-12	-137	-28	-52	-24	13	-58	41	7	47	93	50	68
RA-MW-15B	-5	28	15	17	-11	16	34	76	32	48	-15	64	29	82	122	75	407
RA-MW-16A	-94	-45	-58	-156	-103	-160	-93	-125	-125	-112	-109	-21	—	-30	120	96	315
RA-MW-16B	-57	-70	-60	-85	-130	-131	-66	-155	-113	-88	-112	-43	—	-46	29	21	490
RA-MW-17A	-91	-40	-7	-5	-27	-89	—	-106	-34	-128	-79	74	-25	-11	-6	-39	54
W85-6A	17	57	86	163	—	—	107	356	123	172	168	240	176	218	200	144	328
W85-6B	19	76	72	159	—	—	79	340	70	164	161	236	177	229	165	117	357
W92-16A	1	-14	30	110	110	-32	61	129	127	76	100	98	112	113	154	118	413
W92-16B	-116	-61	-60	73	119	-103	30	253	113	71	60	116	114	121	152	151	459
W97-18A	32	57	67	103	58	137	—	317	192	119	135	133	130	147	60	140	505
W97-19A	71	94	72	218	69	149	—	311	96	71	156	233	128	205	127	155	609
W97-19B	56	86	56	52	76	142	—	295	88	74	153	240	121	193	138	163	562
W98-21A	28	69	79	182	113	160	114	484	157	-55	165	243	135	228	183	196	453
W98-21B	33	72	47	202	121	161	117	471	148	111	161	249	140	226	188	194	486
W99-R5A	58	96	97	153	123	197	116	—	131	100	81	237	186	226	134	174	403
W99-R5B	58	78	74	201	92	204	111	—	122	92	90	239	180	213	167	162	414
RA-MW-11A	-384	-391	-316	-110	-241	-246	-216	-294	-671	-260	-263	-258	-259	—	—	—	—
RA-MW-11B	-394	-393	-332	-296	-289	-301	-278	-317	-303	-261	-287	-276	-313	—	—	—	—
RA-MW-13A	-155	-102	-97	-94	-204	-176	-93	-153	-121	-125	-144	-69	-101	—	—	—	—
RA-MW-13B	-129	-123	-104	-105	-125	-197	-85	-152	-125	-144	-166	-79	-99	—	—	—	—
RA-MW-13C	-136	-126	-116	-142	-33	-175	-112	-135	-137	-133	-143	-100	-140	—	—	—	—
RA-MW-14A	-77	-41	-54	-75	-82	-136	—	-80	-64	-104	-154	-25	-14	—	—	—	—
RA-MW-14B	-112	-95	-102	-112	-134	-133	—	-98	-144	-141	-129	-57	-64	—	—	—	—
W85-7A	68	83	57	197	116	113	127	246	131	186	160	—	175	—	—	—	—
W85-7B	59	73	66	215	132	146	167	259	141	187	161	—	189	—	—	—	—
W97-18B	57	63	60	188	83	152	—	233	187	123	118	—	—	—	—	—	—
W98-20A	52	116	84	219	116	171	—	366	143	91	166	—	153	—	—	—	—

(Table 3 continued)

Well Number	Sulfur (mg/L)																
	Feb-04	**Apr-04**	**Aug-04**	**May-05**	**Dec-05**	**Mar-06**	**Jun-06**	**Sep-06**	**Dec-06**	**Mar-07**	**Jun-07**	**Sep-07**	**Dec-07**	**Sep-08**	**Sep-09**	**Sep-10**	**Sep-11**
B85-4	23	150	31	87	20	103	21	59	67	59	75	—	23	39	32	33	12.6
B87-8	9	52	22	17	23	48	21	42	31	34	43	28	24	14	17	35	11.7
W85-6A	—	15	14	18	—	—	12	15	7	26	19	19	10	9	6	7	7.27
W98-21A	—	—	—	—	8	10	—	—	—	—	—	—	—	—	—	—	—
W99-R5A	5	6	4	5	6	7	6	5	5	5	5	5	6	6	6	5	5.15
RA-MW-11A	286	296	304	285	460	448	322	402	342	311	304	311	345	—	—	—	—
RA-MW-13A	743	246	324	372	363	310	213	111	207	107	130	148	122	—	—	—	—
RA-MW-14A	189	228	214	136	122	158	124	140	72	107	117	113	103	—	—	—	—
W85-7A	3	4	5	4	4	3	5	6	3	10	4	—	7	—	—	—	—
	Sulfate (mg/L)																
B85-4	58	410	104	222	50	253	75	169	212	201	195	—	60	107	95	97	38
B87-8	21	137	73	170	63	125	74	117	98	113	120	87	61	39	54	102	35
W85-6A	5	36	44	44	—	—	35	41	21	85	51	59	27	20	19	20	22
W98-21A	—	—	—	—	19	25	—	—	—	—	—	—	—	—	—	—	—
W99-R5A	12	12	13	15	13	15	18	14	14	16	14	15	16	17	19	15	16
RA-MW-11A	620	751	1040	736	1200	3040	993	1170	1120	954	795	995	989	—	—	—	—
RA-MW-13A	1960	712	1056	985	971	1980	682	323	657	362	331	451	342	—	—	—	—
RA-MW-14A	477	635	697	357	351	429	396	400	225	358	283	347	284	—	—	—	—
W85-7A	6	9	15	13	8	8	18	16	7	30	10	—	18	—	—	—	—

— = Not Analyzed
mg/L = milligrams per liter
mV = millivolts
mS/cm = milliSiemens per centimeter

Appendix H: 2003-2011 MAROS Output

MAROS Mann-Kendall Statistics Summary

Project: Frontier Hard Chrome 2nd FYR

User Name: Aaron King

Location: Vancouver

State: Washington

Time Period: 10/14/2003 **to** 9/15/2011

Consolidation Period: No Time Consolidation

Consolidation Type: Geometric Mean

Duplicate Consolidation: Average

ND Values: Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
CHROMIUM, TOTAL								
B85-3	T	17	12	0.65	-42	95.4%	No	D
B85-4	S	16	14	1.58	-54	99.2%	No	D
B87-8	S	17	17	1.37	-7	59.6%	No	NT
RA-MW-12A	S	19	18	1.55	-95	100.0%	No	D
RA-MW-12B	T	19	16	0.70	-92	100.0%	No	D
RA-MW-12C	T	19	18	0.66	-11	63.5%	No	S
RA-MW-15A	S	19	16	1.49	-34	87.4%	No	NT
RA-MW-15B	S	19	17	1.90	-86	99.9%	No	D
RA-MW-16A	T	18	16	0.64	-77	99.9%	No	D
RA-MW-16B	S	18	15	2.65	-32	87.8%	No	NT
RA-MW-17A	T	19	17	0.45	-66	98.9%	No	D
W85-6A	T	15	14	0.81	-25	88.0%	No	S
W85-6B	T	15	13	0.68	-59	99.9%	No	D
W92-16A	T	17	9	1.11	-42	95.4%	No	D
W92-16B	S	17	14	0.56	21	79.2%	No	NT
W97-18A	T	17	6	1.62	-56	98.9%	No	D
W97-19A	T	17	15	0.77	-53	98.5%	No	D
W97-19B	T	17	14	0.91	-58	99.1%	No	D
W98-21A	T	17	16	0.58	-10	64.2%	No	S
W98-21B	T	17	16	0.52	-34	91.2%	No	PD
W99-R5A	T	17	6	1.50	-10	64.2%	No	NT
W99-R5B	T	17	15	0.73	-78	100.0%	No	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Linear Regression Statistics Summary

Project: Frontier Hard Chrome 2nd FYR

User Name: Aaron King

Location: Vancouver

State: Washington

Time Period: 10/14/2003 **to** 9/15/2011

Consolidation Period: No Time Consolidation

Consolidation Type: Geometric Mean

Duplicate Consolidation: Average

ND Values: Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Average Conc (mg/L)	Median Conc (mg/L)	Standard Deviation	All Samples "ND" ?	Ln Slope	Coefficient of Variation	Confidence in Trend	Concentration Trend
CHROMIUM, TOTAL									
B85-3	T	3.7E-03	3.6E-03	2.4E-03	No	-4.0E-04	0.65	93.7%	PD
B85-4	S	6.6E-03	2.6E-03	1.0E-02	No	-7.7E-04	1.58	98.8%	D
B87-8	S	4.3E-02	2.2E-02	5.9E-02	No	-6.0E-04	1.37	94.0%	PD
RA-MW-12A	S	4.0E-02	9.6E-03	6.2E-02	No	-1.1E-03	1.55	100.0%	D
RA-MW-12B	T	4.7E-03	3.3E-03	3.3E-03	No	-5.2E-04	0.70	100.0%	D
RA-MW-12C	T	3.1E-03	2.8E-03	2.0E-03	No	-1.1E-04	0.66	69.5%	S
RA-MW-15A	S	5.3E-03	3.7E-03	7.8E-03	No	-1.2E-04	1.49	71.7%	NT
RA-MW-15B	S	2.9E-02	4.4E-03	5.5E-02	No	-1.0E-03	1.90	99.2%	D
RA-MW-16A	T	3.1E-03	2.7E-03	2.0E-03	No	-5.1E-04	0.64	99.9%	D
RA-MW-16B	S	2.0E-02	2.7E-03	5.3E-02	No	-7.3E-04	2.65	94.0%	PD
RA-MW-17A	T	5.1E-03	5.0E-03	2.3E-03	No	-2.0E-04	0.45	88.8%	S
W85-6A	T	4.2E-03	3.1E-03	3.4E-03	No	-2.7E-04	0.81	91.0%	PD
W85-6B	T	4.0E-03	2.9E-03	2.7E-03	No	-4.2E-04	0.68	99.8%	D
W92-16A	T	1.6E-03	7.0E-04	1.8E-03	No	-3.8E-04	1.11	91.0%	PD
W92-16B	S	2.2E-03	2.0E-03	1.3E-03	No	2.1E-04	0.56	85.4%	NT
W97-18A	T	2.0E-03	5.3E-04	3.2E-03	No	-4.2E-04	1.62	87.8%	NT
W97-19A	T	2.5E-03	2.0E-03	1.9E-03	No	-4.3E-04	0.77	98.6%	D
W97-19B	T	3.1E-03	2.1E-03	2.8E-03	No	-5.0E-04	0.91	97.8%	D
W98-21A	T	2.7E-03	2.1E-03	1.6E-03	No	-1.2E-04	0.58	77.5%	S
W98-21B	T	2.8E-03	2.3E-03	1.5E-03	No	-2.2E-04	0.52	92.1%	PD
W99-R5A	T	1.7E-03	5.0E-04	2.5E-03	No	-2.1E-04	1.50	73.7%	NT
W99-R5B	T	3.5E-03	2.3E-03	2.5E-03	No	-6.0E-04	0.73	100.0%	D

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Non-detect (ND); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); COV = Coefficient of Variation

Individual Well Cleanup Status - Optional Analysis Results

Project: Frontier Hard Chrome 2nd FYR **User Name:** Aaron King

Location: Vancouver **State:** Washington

From Period: 10/14/2003 **to** 9/15/2011

				Normal Distribution Assumption			Lognormal Distribution Assumption		
Well	**Sample Size**	**Sample Mean**	**Sample Stdev.**	**Significantly < Cleanup Goal?**	**Power**	**Expected Sample Size**	**Significantly < Cleanup Goal?**	**Power**	**Expected Sample Size**
CHROMIUM, TOTAL			Cleanup Goal (mg/L) = 0.05		Alpha Level = 0.05		Expected Power = 0.8		
B85-3	17	3.74E-03	2.45E-03	YES	1.000	<=3	YES	1.000	<=3
B85-4	16	6.57E-03	1.04E-02	YES	1.000	<=3	YES	1.000	<=3
B87-8	17	4.27E-02	5.86E-02	NO	0.126	>100	NO	0.090	>100
RA-MW-12A	19	4.02E-02	6.23E-02	NO	0.166	>100	NO	0.276	>100
RA-MW-12B	19	4.67E-03	3.28E-03	YES	1.000	<=3	YES	1.000	<=3
RA-MW-12C	19	3.08E-03	2.03E-03	YES	1.000	<=3	YES	1.000	<=3
RA-MW-15A	19	5.25E-03	7.83E-03	YES	1.000	<=3	YES	1.000	<=3
RA-MW-15B	19	2.87E-02	5.46E-02	NO	0.510	42	YES	0.629	30
RA-MW-16A	18	3.14E-03	2.00E-03	YES	1.000	<=3	YES	1.000	<=3
RA-MW-16B	18	2.00E-02	5.29E-02	YES	0.762	20	YES	0.921	13
RA-MW-17A	19	5.11E-03	2.29E-03	YES	1.000	<=3	YES	1.000	<=3
W85-6A	15	4.15E-03	3.36E-03	YES	1.000	<=3	YES	1.000	<=3
W85-6B	15	4.01E-03	2.73E-03	YES	1.000	<=3	YES	1.000	<=3
W92-16A	17	1.62E-03	1.80E-03	YES	1.000	<=3	YES	1.000	<=3
W92-16B	17	2.25E-03	1.27E-03	YES	1.000	<=3	YES	1.000	<=3
W97-18A	17	1.99E-03	3.22E-03	YES	1.000	<=3	YES	1.000	<=3
W97-19A	17	2.49E-03	1.92E-03	YES	1.000	<=3	YES	1.000	<=3
W97-19B	17	3.09E-03	2.81E-03	YES	1.000	<=3	YES	1.000	<=3
W98-21A	17	2.70E-03	1.56E-03	YES	1.000	<=3	YES	1.000	<=3
W98-21B	17	2.80E-03	1.45E-03	YES	1.000	<=3	YES	1.000	<=3
W99-R5A	17	1.69E-03	2.53E-03	YES	1.000	<=3	YES	1.000	<=3
W99-R5B	17	3.47E-03	2.53E-03	YES	1.000	<=3	YES	1.000	<=3

Note: N/C refers to "not conducted" because of insufficient data (N<4); S/E indicates the sample mean significantly exceeds the cleanup level and thus no analysis is conducted; Sample Size is the number of concentration data in a sampling location that are used in the power analysis; Expected Sample Size is the number of concentration data needed to reach the Expected Power under current sample variability; The Target Level is the expected mean concentration in wells after cleanup attainment, it is only used in individual well celanup status evaluation. The Student's t-test on mean difference is used in this analysis. Refer to Appendix A.6 of MAROS Manual for details.

MAROS Power Analysis for Individual Well Cleanup Status

Project: Frontier Hard Chrome 2nd FYR

User Name: Aaron King

Location: Vancouver

State: Washington

From Period: 10/14/2003 **to** 9/15/2011

Well	Sample Size	Sample Mean	Sample Stdev.	Normal Distribution Assumption Cleanup Status	Lognormal Distribution Assumption Cleanup Status	Alpha Level	Expected Power
CHROMIUM, TOTAL				Cleanup Goal (mg/L) = 0.05	Target Level (mg/L) = 0.04		
B85-3	17	3.74E-03	2.45E-03	Attained	Attained	0.05	0.8
B85-4	16	6.57E-03	1.04E-02	Attained	Cont Sampling	0.05	0.8
B87-8	17	4.27E-02	5.86E-02	Cont Sampling	Cont Sampling	0.05	0.8
RA-MW-12A	19	4.02E-02	6.23E-02	Cont Sampling	Cont Sampling	0.05	0.8
RA-MW-12B	19	4.67E-03	3.28E-03	Attained	Attained	0.05	0.8
RA-MW-12C	19	3.08E-03	2.03E-03	Attained	Attained	0.05	0.8
RA-MW-15A	19	5.25E-03	7.83E-03	Attained	Attained	0.05	0.8
RA-MW-15B	19	2.87E-02	5.46E-02	Cont Sampling	Cont Sampling	0.05	0.8
RA-MW-16A	18	3.14E-03	2.00E-03	Attained	Attained	0.05	0.8
RA-MW-16B	18	2.00E-02	5.29E-02	Cont Sampling	Cont Sampling	0.05	0.8
RA-MW-17A	19	5.11E-03	2.29E-03	Attained	Attained	0.05	0.8
W85-6A	15	4.15E-03	3.36E-03	Attained	Attained	0.05	0.8
W85-6B	15	4.01E-03	2.73E-03	Attained	Attained	0.05	0.8
W92-16A	17	1.62E-03	1.80E-03	Attained	Attained	0.05	0.8
W92-16B	17	2.25E-03	1.27E-03	Attained	Attained	0.05	0.8
W97-18A	17	1.99E-03	3.22E-03	Attained	Cont Sampling	0.05	0.8
W97-19A	17	2.49E-03	1.92E-03	Attained	Attained	0.05	0.8
W97-19B	17	3.09E-03	2.81E-03	Attained	Attained	0.05	0.8
W98-21A	17	2.70E-03	1.56E-03	Attained	Attained	0.05	0.8
W98-21B	17	2.80E-03	1.45E-03	Attained	Cont Sampling	0.05	0.8
W99-R5A	17	1.69E-03	2.53E-03	Attained	Cont Sampling	0.05	0.8
W99-R5B	17	3.47E-03	2.53E-03	Attained	Attained	0.05	0.8

Note: N/C refers to "not conducted" because of insufficient data (N<4); S/E indicates the sample mean significantly exceeds the cleanup level and thus no analysis is conducted; Sample Size is the number of concentration data in a sampling location that are used in the analysis; The Target Level is the expected mean concentration in wells after cleanup attainment, it is only used in individual well celanup status evaluation. The test for evaluating attainment status is from EPA (1992). Refer to Appendix A.6 of MAROS Manual for details.

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2003-2011 MAROS Output

Statistical trend analyses were performed for total chromium for the 22 monitoring wells using data from 2003-2011 using the same methodology as in the LTMO report. The Monitoring and Remediation Optimization System (MAROS) was used to perform Mann-Kendall (M-K) and linear regression (LR) trend analyses. The MAROS tool was also used to identify monitoring wells that have statistically achieved site cleanup goals with greater than 80% statistical power, and also those wells that have attained cleanup goals using the Sequential T-test method (EPA, 1992), which is a more rigorous statistical test than the 80% statistical power evaluation. MAROS assumes either a normal or lognormal distribution in the calculations; the reliability of t-tests may be questionable if the data do not have normal distributions. Additional information about these calculations and their use can be found in the most recent MAROS User's Guide version 2.2 (Air Force Center for Environmental Excellence, 2006) or the LTMO Report. Non-detect values were left at the reporting limit, making this a conservative analysis. MAROS output for chromium from 2003-2011 for the FHC site is provided in this Appendix.

Appendix I: Site Inspection Report

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Site Inspection Report

Site Inspection Trip Report

Frontier Hard Chrome Superfund Site

EPA ID: WAD053614988

Attendees:

USACE:

Sharon Gelinas, Hydrogeologist

Aaron King, Environmental Engineer

EPA:

Claire Hong

Bernie Zavala, Hydrogeologist

WDOE:

Guy Barrett, Site Manager

Mohsen Kourehdar

Purpose

A site visit was conducted to provide information about the site's status and to visually inspect and document the conditions of the remedy, the site, and the surrounding area for inclusion into the second five-year review report.

Report

On 18 October 2012 at approximately 10:00 am, USACE, EPA, and WDOE met at the Frontier Hard Chrome site located at 113 Y Street in Vancouver, WA. The weather was mild and sunny.

The meeting started with a brief overview of the site history and current status. Soils and groundwater beneath the site were contaminated with hexavalent chromium by discharges to an on-site dry well. The selected remedy addressed the contamination through in-situ reduction of hexavalent chromium to trivalent chromium, which is generally immobile and non- toxic. Chromium reduction occurred through the injection, or mixing, of reducing agents into contaminated soils and groundwater at the site. A groundwater monitoring program was included as part of this remedy.

Mr. Zavala led the site visit, which included a tour of the monitoring wells and the location where ISRM wall was installed. The locations of the demolished structures and the approximate area of source zone treatment were also identified. Most wells were located. The general vicinities of wells W85-3A, W85-3B, W92-16A, W92-16B, W85-2B, B85-6, W85-6A, W99-R5A, and W99-R5B were identified; of these, W92-16A, W92-16B, W85-6A, W99-R5A, and W99-R5B are still a part of the monitoring program and were sampled in Event 17 (the most recent available monitoring report), indicating that the sampling contractor has been able to find the wells. Wells were properly secured and locked. Wells that are sampled annually are identified in the Event 17 Long-term Monitoring Report. The wells are generally in good condition, but it was noted that they are getting older. Water has been observed inside the vaults of wells in the area of RA-MW-15A, -15B, -16A, and -16B, though the wells were determined to be adequately sealed to prevent this water from entering the well.

Mr. Barrett indicated that, in the future, J.H. Kelly intends to further develop the former Frontier Hard Chrome property.

While at the Vancouver Community Library, the local public repository for Frontier Hard Chrome documents was found. The repository contained two documents: the Focused Feasibility Study and the 2008 Five-Year Review.

Recommendations

USACE makes the following recommendations based on the observations during this site visit:

- Continue to be in close contact with the developer regarding redevelopment activities and the protection of the monitoring network.
- Continue to monitor the adequacy of the well seals for wells in the former Frontier Hard Chrome property to ensure that no rainwater/runoff enters the wells and affects water quality.

Photo Log

Photo 1. Overview of site. Taken from near location of monitoirng well W85-3A, looking southeast.

Photo 2. Location of reactive barrier. Monitoring wells RA-IW-4A/B in foreground.

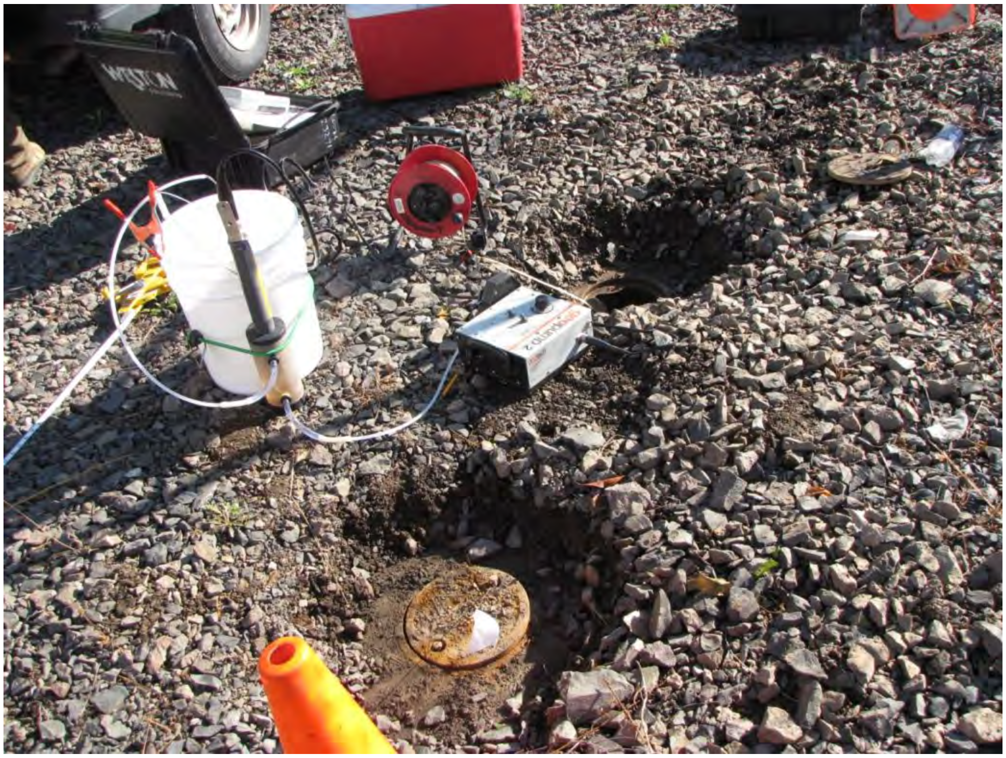

Photo 3. Groundwater sampling at monitoring well RA-MW-16A.

Photo 4. Monitoring well RW97-18A.

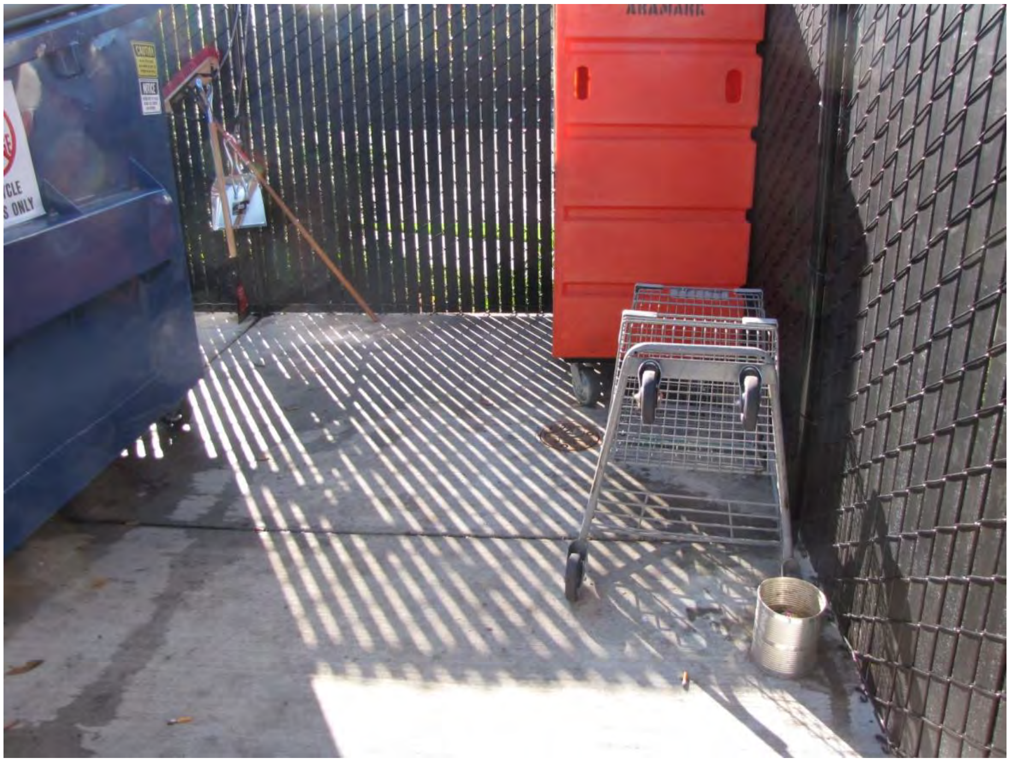

Photo 5. Monitoring well W98-20A.

Photo 6. Monitoring wells W97-19A/B.

Appendix J: Interview Record

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Interview Record

Site: Frontier Hard Chrome Superfund Site	**EPA ID No:** WAD053614988

Interview Type: E-mail
Location of Visit: n/a
Date: 8/21/2012 **Time:** 12:35 PM

Interviewer:	**Title:**	**Organization:**
Aaron King	Environmental Engineer	U.S. Army Corps of Engineers

Individual Contacted

Name:	**Title:**	**Organization:**
Guy Barrett	Site Manager	Washington State Department of Ecology
Telephone:	**Address:**	
(360) 407-7115	300 Desmond Drive SE Lacey, WA 98503	

Summary of Conversation

1) What is your overall impression of the project (general sentiment)?

The remedy continues to be protective of human health and the environment. Our contractor is able to obtain groundwater monitoring well samples annually with no problems. The groundwater plume has been shrinking and I look forward to project closeout in the future.

2) What is your current role and your agency's role with respect to the site?

I am Ecology's Site Manager at this Site. We have 100% O&M responsibilities which includes groundwater monitoring.

3) Have there been routine communications or activities (for example, site visits, inspections, etc.) conducted by your office regarding the site? If so, please give purpose and results.

I rely on our contractor to communicate after conducting monitoring at the Site, which they do. I have spoken to the developer about the status of their plans as well.

4) Have there been any complaints, violations, or other incidents related to the site requiring a response by your office? If so, please give details of the evens and results of the responses.

No.

5) What effects have site operations (cleanup) had on the surrounding community?

I am not aware of any. A large development was constructed a few years ago just south of the FHC property.

6) Are you aware of any community concerns regarding the site or its operation? If so, please summarize your concerns.

I am not aware of any.

7) Do you feel well informed about the site's activities and progress?

Yes.

8) Are you aware of any changes in State/County/Local laws and regulations that may impact the protectiveness of the site?

No.

9) Do you have any comments, suggestions, or recommendations regarding the site's management, operation, or any other aspects of the site?

No.

10) What are the annual operating costs for your organization's involvement for the site?

The cost in 2011 was $13,850.

Appendix K: ARARs Discussion

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ARARs Discussion

Action-specific ARARs

WAC 173-340-360 (Model Toxics Control Act, Selection of Cleanup Actions) describes the minimum requirements and procedures for selecting cleanup actions. WAC 173-340-440 (Institutional Controls) applies where cleanup measures will not attain MTCA cleanup levels or until groundwater cleanup standards are achieved. Neither of these regulations has been updated since 2003.

The Underground Injection Control Program (WAC 173-218) sets forth procedures and practices applicable to the injection of fluids through wells. This regulation is applicable to the injection of reducing agents into site soils and groundwater. WAC 173-218 was updated in July 2008, though the purpose of the amendment was to protect groundwater and public health and safety from contamination due to geologic sequestration of CO_2. It is assumed that the applicable requirements were attained during remedy implementation.

Several regulations mentioned in the ROD Amendment pertain to the off-site disposal of treated groundwater: 33 United States Code (USC) §1317 (Clean Water Act: Toxic and pretreatment effluent standards), 40 CFR §403.5 (National pretreatment standards: Prohibited discharges), Revised Code of Washington (RCW) 90.48 (Water pollution control), RCW 90.54 (Water Resources Act of 1971), and WAC 173-208 (Grant of Authority Sewerage Systems). However, the remedy did not call for the extraction and disposal of treated groundwater. Therefore, none of these regulations are applicable and are only listed for completeness.

RCW 18.104 (Water Well Construction Act) and WAC 173-160 (Minimum Standards for Construction and Maintenance of Wells) specify requirements for well construction and abandonment intended to protect groundwater from contamination. These regulations are applicable to the construction of injection, extraction, and monitoring wells; and the abandonment of existing and future wells as needed. WAC 173-160 was amended in December 2008 to make technical and typographical corrections, but none of the corrections affect the remedy. It is assumed that these ARARs were complied with in the construction of wells during remedy implementation and monitoring well installation.

WAC 173-400 (General Regulations for Air Pollution Sources) establishes technically feasible and reasonably attainable standards that are generally applicable to the control and/or prevention of the emission of air contaminants. Additionally, WAC 173-470 (Ambient Air Quality Standards for Particulate Matter) and Southwest Washington Clean Air Agency (SWCAA) Regulation 400 (General regulations for air pollution sources) identify suspended particulate standards applicable to excavation activities associated with building demolition and other remedial activities at the FHC site. Emission of air contaminants is unlikely based on the selected remedy and no demolition took place during this FYR period; it is assumed that these ARARs were complied with during remedy construction.

The ROD Amendment identified several regulations that establish requirements for the proper designation, storage, treatment, and disposal of hazardous waste: 42 USC §6921-22 (Resource Conservation and Recovery Act: Identification and listing of hazardous waste), 40 CFR §261

(Identification and listing of hazardous waste), 40 CFR §262 (Standards applicable to generators of hazardous waste) subparts A (General), B (The Manifest), C (Pre-transport Requirements), and D (Recordkeeping and Reporting), 40 CFR §264 (Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities) subparts I (Use and Management of Containers) and J (Tank Systems), WAC 173-303-070 (Designation of dangerous waste), 173-303-170 through -200, and 173-303-630 (Use and management of containers). There are several potential hazardous waste streams (RCRA characteristic) that may be managed at the site. These waste streams include:

• Demolished concrete from building foundations contaminated by soils with high concentrations of hexavalent chromium.
• Excess contaminated surface soil, debris and water from limited removal, as required, and/or equipment/personnel decontamination.
• Personal Protective Equipment contaminated with hexavalent chromium.

40 CFR §261 and 262 and the corresponding State Dangerous Waste Regulations are applicable to any hazardous waste generated during the treatment of contaminated groundwater. These regulations require proper designation and characterization of hazardous waste. In addition, 40 CFR §264, subparts I and J are relevant and appropriate for the ground- water treatment portion of the remedy. These regulations, as well as the corresponding State Dangerous Waste Regulations, require proper use and management of containers and require appropriate controls on tank systems. However, contaminated groundwater was treated *in situ* through injection or augering/injection, according to the remedy; extraction of groundwater to control migration downgradient of the treatment area was not necessary and, thus, not performed. 40 CFR §261 and 262 and WAC 173-303-070 also apply to chromium contaminated soil that may be disposed of off-site, if the soil is classified as dangerous, hazardous, or extremely hazardous waste. WDOE removed chromium-contaminated soil from the eastern side of the Site and properly disposed of it according to the Dangerous Waste Regulations, though.

RCW 70.95 (Solid Waste Management-Reduction and Recycling Act) and WAC 173-304 (Minimum Functional Standards for Solid Waste Handling) establish requirements for the disposal of non-hazardous waste. However, because any non-hazardous waste would be disposed of off-site, these regulations are not ARARs and are included for completeness. RCW 90.52.040 (Pollution Disclosure Act of 1971) requires that wastes are to be provided with all known, available, and reasonable methods of treatment prior to their discharge or entry into waters of the state. However, treated groundwater or other wastes were not extracted downgradient of the treatment area or discharged to the City of Vancouver sanitary sewer. 49 CFR §171-180 (Hazardous Materials Regulations) and WAC 446-50 (Transportation of Hazardous Materials) establish requirements for transportation of hazardous materials. These regulations are applicable to the transportation of soil, concrete, and other debris to off-site disposal facilities, though none of these activities took place during this FYR period. It is assumed that these ARARs were complied with during the demolition phase.

Chemical-specific ARARs

WAC 173-340-705 (Use of Method B Cleanup Standards), -720 (Ground Water Cleanup Standards), -740 (Unrestricted Land Use Soil Cleanup Standards), -747 (Deriving Soil Concentrations for Groundwater Protection), and 173-201A (Water Quality Standards for Surface Waters of the State of Washington) establish cleanup standards for groundwater and soil contaminants. Of these, only WAC 173-201A has been updated since the first FYR, though the update does not concern chromium. However, the value listed for chronic state standard for the protection of freshwater aquatic organisms (10.0 µg/L; WAC 173-201A-240) is slightly different than the value listed in the previous FYR and ROD Amendment (10.5 µg/L). Chromium concentrations in monitoring wells W99-R5A and W99-R5B, the wells nearest to the Columbia River (approximately 1,500 feet from the river), have been below the10.0 µg/L standard since February 2004 when long-term monitoring began (Appendix F). Therefore, this change does not affect the protectiveness of the remedy.

40 CFR §141 (Safe Drinking Water Act National Primary Drinking Water Regulations) and WAC 246-290 (Public Water Supplies) specify primary standards for drinking water (MCLs). They are applicable at the tap for municipal water supplies and, therefore, relevant and appropriate for groundwater at the site since the aquifer is used as a drinking water source. The groundwater cleanup goals for this site include restoring the groundwater to MTCA Method A standards for groundwater cleanup, which are more stringent than the MCL for chromium in groundwater. In any case, neither regulation has changed with respect to chromium since the first FYR.

ARARs Summary

The table below summarizes the ARARs listed in the 2001 ROD Amendment. The chemical-specific ARARs are the only ones currently applicable to the FHC site, though action-specific ARARs may be applicable to future activities at the site.

ARAR Summary Table

Requirement	Citation	Document	Description	Effect on Protectiveness	Comments	Amendment Date
Model Toxics Control Act: Selection of Cleanup Actions	WAC 173-340-360	2001 ROD Amendment	Describes minimum requirements and procedures for selecting cleanup actions.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	Cleanup actions were selected previously.	
Institutional Controls	WAC 173-340-440	2001 ROD Amendment	Applies where cleanup measures will not attain MTCA cleanup levels or until groundwater cleanup standards are achieved.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.		
Underground Injection Control Program	WAC 173-218	2001 ROD Amendment	Sets forth procedures and practices applicable to the injection of fluids through wells.	Amended to protect groundwater and public health and safety from contamination due to geologic sequestration of CO_2. Protectiveness is not affected.	CO_2 is not a contaminant of concern.	July 20, 2008
Clean Water Act: Toxic and pretreatment effluent standards	33 USC §1317	2001 ROD Amendment	Establishes limitations on effluents for toxic pollutants.	This requirement is not applicable, so protectiveness is not affected.	The remedy did not call for the extraction and disposal of treated groundwater, so this regulation is not applicable.	

National pretreatment standards: Prohibited Discharges	40 CFR §403.5	2001 ROD Amendment	Establishes responsibilities of Federal, State, and local government, industry and the public to implement National Pretreatment Standards to control pollutants which pass through or interfere with treatment processes in Publicly Owned Treatment Works (POTWs) or which may contaminate sewage sludge.	This requirement is not applicable, so protectiveness is not affected.	The remedy did not call for the extraction and disposal of treated groundwater, so this regulation is not applicable.	
Water pollution control	RCW 90.48	2001 ROD Amendment	Maintain the highest possible standards to insure the purity of all waters of the state consistent with public health and public enjoyment thereof, the propagation and protection of wild life, birds, game, fish and other aquatic life, and the industrial development of the state, and to that end require the use of all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the state of Washington	This requirement is not applicable, so protectiveness is not affected.	The remedy did not call for the extraction and disposal of treated groundwater, so this regulation is not applicable.	
Water Resources Act of 1971	RCW 90.54	2001 ROD Amendment	Set forth fundamentals of water resource policy for the state to insure that waters of the state are protected and fully utilized for the greatest benefit to the people of the state of Washington and, in relation thereto, to provide direction to the department of ecology, other state agencies and officials, and local government in carrying out water and related resources programs	This requirement is not applicable, so protectiveness is not affected.	The remedy did not call for the extraction and disposal of treated groundwater, so this regulation is not applicable.	
Grant of authority sewerage systems	WAC 173-208	2001 ROD Amendment	Pertains to waste discharges into publicly operated sewerage systems to the governing bodies of cities, towns, and municipal corporations operating such sewerage systems and receiving into them industrial and commercial wastes	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	The remedy did not call for the extraction and disposal of treated groundwater, so this regulation is not applicable.	

Water Well Construction Act	RCW 18.104	2001 ROD Amendment	Regulation and licensing of well contractors and operators and for the regulation of well design and construction	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	The remedy did not call for the extraction and disposal of treated groundwater, so this regulation is not applicable.	
Minimum standards for Construction and Maintenance of Wells	WAC 173-160	2001 ROD Amendment	Establishes minimum standards for the construction and decommissioning of all wells in the state of Washington.	Amended to correct technical and typographical errors, but corrections do not affect the protectiveness of the remedy.	173-160-171 mandates that all wells shall not be located within certain minimum distances of known or potential sources of contamination.	December 19, 2008
General regulations for air pollution sources	WAC 173-400	2001 ROD Amendment	Establishes technically feasible and reasonably attainable standards that are generally applicable to the control and/or prevention of the emission of air contaminants	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	Continuing site activities are not expected to result in the emission of air contaminants.	
Ambient Air Quality Standards for Particulate Matter	WAC 173-470	2001 ROD Amendment	Establishes maximum acceptable levels for particulate matter in the ambient air.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	Continuing site activities are not expected to result in the emission of particulate matter.	
General regulations for air pollution sources	SWCAA Regulation 400	2001 ROD Amendment	Regulations for the control of air contaminant emissions, prevent air pollution.	Updates to the requirement do not affect the protectiveness of the remedy.	Continuing site activities are not expected to result in the emission of air contaminants.	November 15, 2009

Resource Conservation and Recovery Act: Identification and listing of hazardous waste	42 USC §6921-22	2001 ROD Amendment	Establishes criteria for the identification and listing of hazardous waste.	This requirement is not applicable, so protectiveness is not affected.	No hazardous waste has been generated and disposed off-site during this FYR period.	
Identification and listing of hazardous waste	40 CFR §261	2001 ROD Amendment	Identifies solid wastes subject to regulation as hazardous wastes.	This requirement is not applicable, so protectiveness is not affected.	No hazardous waste has been generated and disposed off-site during this FYR period.	
Standards applicable to generators of hazardous waste	40 CFR §262	2001 ROD Amendment	Establishes standards for generators of hazardous waste.	This requirement is not applicable, so protectiveness is not affected.	No hazardous waste has been generated and disposed off-site during this FYR period.	
Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities	40 CFR §264	2001 ROD Amendment	Establishes minimum national standards which define the acceptable management of hazardous waste.	This requirement is not applicable, so protectiveness is not affected.	No hazardous waste has been generated and disposed off-site during this FYR period.	
Dangerous waste regulations	WAC 173-303	2001 ROD Amendment	Establishes a comprehensive framework for the planning, regulation, control, and management of hazardous waste.	Updates to the requirement do not affect the protectiveness of the remedy.	No hazardous waste has been generated and disposed off-site during this FYR period.	June 30, 2009
Solid Waste Management Reduction and Recycling Act	RCW 70.95	2001 ROD Amendment	Establishes a comprehensive statewide program for solid waste handling, and solid waste recovery and/or recycling which will prevent land, air, and water pollution and conserve the natural, economic, and energy resources of this state.	This requirement is not applicable, so protectiveness is not affected.	Because any non-hazardous waste would be disposed of off-site, these regulations are not ARARs.	

Minimum functional standards for solid waste handling	WAC 173-304	2001 ROD Amendment	Protect public health, to prevent land, air, and water pollution, and conserve the state's natural, economic, and energy resources .	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	Because any non-hazardous waste would be disposed of off-site, these regulations are not ARARs.	
Pollution Disclosure Act of 1971	RCW 90.52.040	2001 ROD Amendment	Requires that wastes are to be provided with all known, available, and reasonable methods of treatment prior to their discharge or entry into waters of the state.	This requirement is not applicable, so protectiveness is not affected.	Treated groundwater or other wastes were not extracted downgradient of the treatment area or discharged to the City of Vancouver sanitary sewer.	
Hazardous Materials Regulations	49 CFR §171-180	2001 ROD Amendment	Establishes regulations for the transportation of hazardous materials.	This requirement is not applicable, so protectiveness is not affected.	These regulations are applicable to the transportation of soil, concrete, and other debris to off-site disposal facilities, though none of these activities took place during this FYR period	
Transportation of Hazardous Materials	WAC 446-50	2001 ROD Amendment	Protect persons and property from unreasonable risk of harm or damage due to incidents or accidents resulting from the transportation of hazardous materials and hazardous waste and to insure that the vehicle equipment of all carriers of radioactive waste materials are inspected by the Washington state patrol.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	These regulations are applicable to the transportation of soil, concrete, and other debris to off-site disposal facilities, though none of these activities took place during this FYR period.	

Use of Method B Cleanup Standards	WAC 173-340-705	2001 ROD Amendment	Develop cleanup levels unless one or more of the conditions for using Method A or Method C are demonstrated to exist and the person conducting the cleanup action elects to use that method.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.		
Ground Water Cleanup Standards	WAC 173-340-720	2001 ROD Amendment	Establish groundwater cleanup standards.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.		
Unrestricted Land Use Soil Cleanup Standards	WAC 173-340-740	2001 ROD Amendment	Establish solid cleanup standards for unrestricted land use.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.		
Deriving Soil Concentrations for Groundwater Protection	WAC 173-340-747	2001 ROD Amendment	Establish soil concentrations that will not cause contamination of groundwater at levels that exceed the groundwater cleanup levels established under WAC 173-340-720.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.		
Water Quality Standards for Surface Waters of the State of Washington	WAC 173-201A	2001 ROD Amendment	Establishes water quality standards for surface waters of the state of Washington consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife, pursuant to the provisions of chapter 90.48 RCW.	Amended to correct typographical errors and clarify sections that have caused confusion for stakeholders, but changes do not affect the protectiveness of the remedy.		April 20, 2011

Safe Drinking Water Act National Primary Drinking Water Regulations	40 CFR §141	2001 ROD Amendment	Establishes primary drinking water regulations pursuant to section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act and related regulations applicable to public water systems.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	Groundwater cleanup standards calculated through MTCA A method in WAC 173-340-720 are more stringent.	
Public Water Supplies	WAC 246-290	2001 ROD Amendment	Define basic regulatory requirements and to protect the health of consumers using public drinking water supplies.	There have been no changes to this requirement since the first FYR. Protectiveness is not affected.	Groundwater cleanup standards calculated through MTCA A method in WAC 173-340-720 are more stringent.	