Prepared for

Olin Corporation

and

Mallinckrodt US, LLC

COMPLIANCE MONITORING WORK PLAN

FREDERICKSON INDUSTRIAL PARK
FREDERICKSON, WASHINGTON

Prepared by

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Project Number GR4631

November 2013

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CAP	Cleanup Action Plan
CMWP	Compliance Monitoring Work Plan
CTC	Carbon Tetrachloride
Ecology	Washington Department of Ecology
MNA	Monitored Natural Attenuation
MTCA	Model Toxics Control Act
RI/FS	Remedial Investigation and Feasibility Study
USEPA	United States Environmental Protection Agency
WAC	Washington Administrative Code

1. INTRODUCTION

This *Compliance Monitoring Work Plan* (CMWP) has been prepared by Geosyntec Consultants on behalf of Olin Corporation and Mallinckrodt US LLC (the Companies), and is being submitted concurrently with the *Cleanup Action Plan* (CAP) to the Washington Department of Ecology (Ecology), for the Frederickson Industrial Park (the Property) in Frederickson, Washington (Figure 1-1). The CAP is based upon the Ecology-approved remedy of monitored natural attenuation (MNA) to address carbon tetrachloride (CTC) in groundwater. The rationale for the selection of MNA to remediate CTC was presented in the *Remedial Investigation/Feasibility Study (RI/FS) Report* (RI/FS Report) [Geosyntec, 2012] submitted to Ecology by the Companies on 28 March 2012. An Agreed Order 9514 (Order), once signed by the Companies and Ecology, will require implementation of the CAP remedy for the Site[1] .

1.1 <u>Purpose</u>

The purpose of the CMWP in the Model Toxics Control Act (MTCA) process is to fulfill requirements of Compliance Monitoring per Washington Administrative Code (WAC) 173-340-410. Compliance monitoring under WAC 173-340-410 consists of three elements, which are: 1) Protection Monitoring; 2) Performance Monitoring; and 3) Confirmational Monitoring.

Because the selected remedy is MNA and the monitoring well network already exists, there will be no need for Protection Monitoring, which is used to confirm that human health and the environment are protected during construction, operation and maintenance of the selected remedy. Thus, the CMP will include:

- Performance Monitoring to confirm that the cleanup action progresses towards and ultimately achieves cleanup standards site-wide; and

- Confirmational Monitoring to confirm the long-term effectiveness of the cleanup action once cleanup standards have been attained site-wide (i.e., upon completion of Performance Monitoring).

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[1] Per MTCA and Chapter 173-340-200 of the WAC, the Site is defined to be anywhere hazardous substances have come to be located, whereas the Property refers to the area contained within the property boundaries of the Frederickson Industrial Park.

As described in the RI/FS Report (Geosyntec, 2012), the proposed cleanup action will meet the requirements of WAC 173-340-360 to protect human health and the environment, comply with cleanup standards, comply with applicable state and federal laws, and provide for compliance monitoring.

1.2 Report Organization

The remainder of this CMWP is divided into the following sections:

- Section 2 – Compliance Monitoring Well Network;
- Section 3 – Performance & Confirmational Monitoring;
- Section 4 – Data Evaluation and Management; and
- Section 5 – References.

2. COMPLIANCE MONITORING WELL NETWORK

2.1 Existing Monitoring Well Network

Twenty-two (22) monitoring wells were sampled and analyzed for CTC during the most recent groundwater sampling event, which was conducted in February 2011. Of the wells sampled, nineteen (19) are screened in Aquifer A and three (3) are screened in Aquifer C. The locations of the monitoring wells are shown in Figure 2-1. Well construction details are provided in Table 2-1. Historical CTC data for the monitoring wells are provided in Table 2-2.

2.2 Compliance Monitoring Well Network

The CTC data from the existing monitoring well network were evaluated to identify wells to be included in the compliance monitoring network. Based on the evaluation, the compliance monitoring network consists of 11 monitoring wells discussed below, and shown on Figure 2-2. As discussed in more detail in Section 4, Confirmational Monitoring will use a subset of this monitoring well network. The monitoring wells considered for Performance Monitoring are listed here and the rationale for each well is provided below:

- 11-CL, HLA-1, BMW-18, MW-1, MW-13 and P2-S – these six wells were selected for compliance monitoring because each well had a CTC concentration in excess of the cleanup standard of 0.63 µg/L during the most recent sampling event in February 2011 (Table 2-2).

- 11-BL, MW-4, and P2-I – these three wells were selected for compliance monitoring because each well had a CTC concentration in excess of the cleanup standard of 0.63 µg/L during the June 2010 sampling event and the November 2002 sampling event (Table 2-2).

- BMW-3 and MW-7 – these two wells were selected for compliance monitoring because each well had a CTC concentration in excess of the cleanup standard of 0.63 µg/L during the November 2002 sampling event (Table 2-2), but not in subsequent events. During the first two rounds of Performance Monitoring, if BMW-3 and MW-7 are still below the cleanup standard, the Companies will request that Ecology allow removal of these two wells from the compliance monitoring network (i.e., dropped from the Performance Monitoring and Confirmational Monitoring programs).

Compliance monitoring of Aquifer C is not included as part of the CMWP given the recent absence of CTC detections in Aquifer C (i.e., Aquifer C does not exceed the 0.63 µg/L cleanup standard for CTC). Thus, with Ecology concurrence, compliance monitoring will focus on Aquifer A.

A subset of the above wells will be selected for Confirmational Monitoring, as detailed in Section 3.

3. PERFORMANCE & CONFIRMATIONAL MONITORING

Performance Monitoring will be implemented at the Site to: (i) evaluate whether MNA processes are effectively reducing CTC concentrations in groundwater, and (ii) determine when individual monitoring wells have achieved the cleanup standard for the Site and can be removed from the Performance Monitoring sampling program. Confirmational Monitoring will be implemented once the network of compliance monitoring wells has achieved the cleanup standard for the Site. The objective of Confirmational Monitoring is to demonstrate the long-term effectiveness of the cleanup action once cleanup standards have been attained site-wide. The Companies will submit a request for final site closure once Confirmational Monitoring is complete. Upon final closure of the Site, the monitoring well network will be appropriately decommissioned with Ecology approval.

3.1 Performance Monitoring Schedule

Performance Monitoring is anticipated to begin during 2014. The initial sampling frequency for the compliance monitoring well network will be semi-annual for the first two years of Compliance Monitoring and then will be changed to annual sampling[2]. The proposed semi-annual sampling frequency for the monitoring wells is considered to be appropriate for the following reasons:

- As indicated in Figure 2-8 of the RI/FS Report (Geosyntec, 2012), each of the wells included in the compliance monitoring network has exhibited a consistent, decreasing CTC concentration trend over the past 10 to 20 years. An increased sampling frequency would not improve the level of understanding of CTC fate at the Site;

- The remedial timeframes for the individual monitoring wells to achieve the cleanup standard were estimated in the RI/FS Report (Geosyntec, 2012) to range from 3 years (i.e., P2-S) to 28 years (i.e., BMW-18). The proposed sampling frequency is appropriate for the anticipated timescale of the MNA remedy; and

[2] As noted in Section 2.2, MW-7 and BMW-3 will be removed from the compliance monitoring well network if their CTC concentrations from the first two rounds of Performance Monitoring are below the cleanup level.

- Concentrations of CTC in groundwater, especially off-Property, are very low. An increased sampling frequency is not warranted given the low CTC concentrations.

The sampling frequency will be evaluated yearly. For certain wells, it may be appropriate to reduce the sampling frequency to bi-annually (every second year) in the future if concentration trends remain stable.

The criteria for removing individual compliance monitoring wells from the Performance Monitoring program will be based on WAC 173-340-720 (9). Specifically, in accordance with WAC 173-340-720 (9)(d)(i)(A), or as otherwise approved by Ecology, an individual compliance monitoring well will be removed from the Performance Monitoring program if the upper one-sided ninety-five percent confidence limit on the true mean groundwater concentration is below the MTCA cleanup level (which is currently 0.63 µg/L). The upper one-sided ninety-five percent confidence limit on the true mean groundwater concentration will be calculated using data from the preceding four sampling events.

3.2 Confirmational Monitoring Schedule

Confirmational Monitoring will be initiated after successful completion of Performance Monitoring (i.e., the upper one-sided ninety-five percent confidence limit on the true mean groundwater concentration for each individual compliance monitoring well is below the MTCA cleanup level, or as otherwise approved by Ecology). The Confirmational Monitoring well network will be identified at that time. Conceptually, it is anticipated that five monitoring wells will be selected for Confirmational Monitoring, likely to include one well within the upgradient portion of the current CTC plume (e.g., BMW-3), two wells within the current plume core (e.g., HLA-1 and BMW-18), and two off-Property wells (e.g., MW-13 and P2-S).

The timing of the Confirmational Monitoring sampling event will be determined in consultation with Ecology. Site-wide compliance with MTCA cleanup levels for CTC will be determined in accordance with WAC 173-340-720 (9). The true mean concentration of groundwater will be estimated from the data collected from the Confirmational Monitoring well network. Compliance shall be confirmed if the following are confirmed: (1) the upper one-sided ninety-five percent confidence limit on the true mean groundwater concentration is below the MTCA cleanup level [WAC 173-340-720 (9)(d)(i)(A)]; and, (2) no single monitoring well concentration is greater than two times the groundwater cleanup level [WAC 173-340-720 (9)(e)(i)]. If the criteria are not met, up to three additional Confirmational Monitoring events will be performed at one-year intervals. Following the successful completion of Confirmational Monitoring and all requirements of the agreed order have been met the Site will be proposed to Ecology for regulatory closure.

A contingency plan will be developed, and provided to Ecology for review and approval, if, during Confirmational Monitoring, the criteria are not achieved after four sampling events (i.e., the initial Confirmational Monitoring event plus the three subsequent Confirmational Monitoring events). Development of the contingency plan will use the monitoring data collected to evaluate MNA processes, and propose a path forward. Following successful implementation of the contingency plan, Confirmational Monitoring will be conducted.

3.3 Reporting

Performance Monitoring results will be reported to Ecology on an annual basis. The MNA Performance Monitoring Reports will provide monitoring results, analytical reports, and an evaluation of groundwater monitoring results and MNA trends. A discussion and proposal for approval by Ecology of any changes in the monitoring well network (reducing the monitoring frequency, transitioning a well from Performance Monitoring to Confirmational Monitoring, etc.) will be included. Environmental data collected during Performance and Confirmational Monitoring will be submitted to Ecology's Environmental Information Management System.

A Confirmational Monitoring Report will be submitted to Ecology for review and comment within 60 days of the Confirmational Monitoring sampling event. If the data conform to Site closure criteria, a request will be made to Ecology to discontinue monitoring at the Site.

3.4 Monitoring Procedures

3.4.1 Field Measurements

Water levels and field parameters will be measured during well purging. Field parameters will include:

- pH;

- Dissolved Oxygen (DO);
- Temperature;
- Conductivity;
- Oxidation/Reduction Potential (ORP); and
- Turbidity.

The initial monitoring periods will provide data to confirm that variation in MNA parameters is minimal. Given the low level CTC concentrations observed at the Site, sampling for CTC degradation products is not recommended. At the CTC concentrations observed, it is not likely that CTC degradation products will be present at quantifiable levels. Further, given the steady CTC concentration declines observed at the Site over the past 10 to 20 years, it appears conclusive that CTC in groundwater is attenuating at the Site primarily through physical mechanisms. Given the very low concentrations of CTC, coupled with the conclusive attenuation trends, in-depth monitoring of biological and/or chemical attenuation mechanisms does not appear to be warranted or beneficial.

3.4.2 Sampling Methods

Water level measurements will be collected prior to and during groundwater sampling (to maintain stable water levels during sampling). Sampling will be conducted using low-flow sampling procedures, as described in the Sampling and Analysis Plan (SAP) in Appendix A. The amount of purging at each well will be based on stabilization of pH, temperature, turbidity and specific conductivity field parameters. DO and ORP will also be measured, but will not be used as stabilization criteria since they tend to fluctuate. A Quality Assurance Project Plan (QAPP) is provided in Appendix B.

3.4.3 Sampling Parameters

Groundwater samples will be collected in VOA vials for laboratory analysis of CTC by EPA Method 8260C. Details on the analytical testing methodology are provided in Appendices A and B.

4. DATA EVALUATION AND MANAGEMENT

4.1 Data Validation

Monitoring reports provided to Ecology will contain a review of the data (Level 1 review) for consistency, quality control, and laboratory protocols, and laboratory data reports as attachments. Data packages from the laboratory will be sufficient to provide a Level 2 data validation, if necessary, based on USEPA Functional Guidelines (USEPA, 2008).

4.2 Data Evaluation

Performance and Confirmational laboratory data will be subjected to data review and evaluation, as described above, and the complete monitoring event data set compiled and evaluated with respect to existing monitoring data for field parameters, groundwater elevations, and laboratory analytical results.

Monitoring reports will evaluate collected data for indication that MNA is progressing, and if anomalies are encountered, these will be summarized and recommendations for contingencies provided.

5. REFERENCES

Geosyntec, 2012. *Remedial Investigation/Feasibility Study (RI/FS) Report, Frederickson Industrial Park, Frederickson, Washington*. March 2012

USEPA, 2008. *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA 540/R-08-01.

TABLES

Table 2-1
Compliance Monitoring Well Network with Water Level Data
Frederickson Industrial Park, Frederickson, Washington

Well	Ground Elevation (ft MSL)	Top of Casing Elevation (MSL)	Top of Screen (MSL)	Bottom of Screen (MSL)	Aquifer	Sample Date	Depth to Water (ft)	Water Level (MSL)
11-BL	395.5	396.08	331.5	321.5	Lower - Aquifer A	02/10/11	37.37	358.71
11-CL	403.69	404.55	329.7	319.7	Lower - Aquifer A	02/10/11	42.50	362.05
11-CU	403.69	404.67	363.7	353.7	Upper - Aquifer A	02/10/11	32.37	372.30
BMW-13R	416.48	416.48	381	351	Upper - Aquifer A	02/11/11	38.23	378.25
BMW-18	409.74	412.09	375.7	345.7	Upper - Aquifer A	02/11/11	40.94	371.15
BMW-19	413.12	415.66	373.6	343.6	Upper - Aquifer A	02/11/11	42.79	372.87
BMW-2	406.88	408.98	381.9	351.9	Upper - Aquifer A	02/11/11	33.81	375.17
BMW-22	409.53	412.13	376	346	Upper - Aquifer A	02/11/11	38.50	373.63
BMW-3	414.74	416.76	381.7	351.7	Upper - Aquifer A	02/11/11	40.53	376.23
HLA-1	403.86	405.81	320.9	310.9	Lower - Aquifer A	02/10/11	43.85	361.96
MW-1	413.27	415.79	324.8	314.8	Lower - Aquifer A	02/10/11	40.81	374.98
MW-2	402.77	405.18	255.8	245.8	Aquifer C	02/10/11	33.91	371.27
MW-3	389.2	391.41	299.2	289.2	Aquifer A	02/10/11	36.20	355.21
MW-4	465.5	467.72	317.9	307.9	Aquifer A	02/10/11	116.02	351.70
MW-7	350.7	350.12	310.2	300.2	Upper - Aquifer A	02/11/11	25.33	324.79
P1-D	334.6	336.87	235	225	Aquifer C	02/10/11	9.12	327.75
P1-I	335.67	337.44	272.7	267.7	Lower - Aquifer A	02/10/11	9.55	327.89
P1-S	335.01	337.84	320	310	Upper - Aquifer A	02/10/11	10.93	326.91
P2-D	340.23	342.78	231.2	221.2	Aquifer C	02/11/11	14.55	328.23
P2-I	340.65	343.23	270.7	265.7	Lower - Aquifer A	02/11/11	13.85	329.38
P2-S	340.55	343.6	320.6	310.6	Upper - Aquifer A	02/11/11	15.66	327.94
MW-13	394.5	394.1	284.5	274.05	Aquifer A	02/10/11	52.60	341.90

Table 2-2
Historical Carbon Tetrachloride Groundwater Data
Frederickson Industrial Park, Frederickson, Washington

Wells	11-BL	11-CU	11-CL	HLA-1	BMW-2	BMW-3	BMW-13R	BMW-18	BMW-19	BMW-22	MW1	MW2	MW3	MW4	MW6	MW7	P1S	P1I	P1D	P2S	P2I	P2D	MW-13
Ground Elevation (MSL)	395.5	403.69	403.69	403.86	406.88	414.74	416.48	409.74	413.12	409.53	413.27	402.77	389.2	465.5	353.58	350.7	335.01	335.67	334.6	340.55	340.65	340.23	394.5
Top of Screen (MSL)	331.5	329.7	363.7	320.9	381.9	381.7	381	375.7	373.6	376	324.8	255.8	299.2	317.9	245.6	310.2	320	272.7	235	320.6	270.7	231.2	284.5
Bottom of Screen (MSL)	321.5	319.7	353.7	310.9	351.9	351.7	351	345.7	343.6	346	314.8	245.8	289.2	307.9	235.6	300.2	310	267.7	225	310.6	265.7	221.2	274.1
Aquifer Zone	A - Lower	A - Upper	A - Lower	A - Lower	A - Upper	A - Upper	A - Upper	A - Upper	A - Upper	A - Upper	A - Lower	C - Upper	A - Middle	A - Middle	C - Upper	A - Upper	A - Upper	A - Lower	C - Upper	A - Upper	A - Lower	C - Upper	Aquifer A
Data																							
Jun-85	ND(1.0)	ND(1.0)	15.7																				
Jul-85	ND(1.0)	ND(1.0)	51.3																				
Aug-85			25.0																				
Dec-85	0.3		9.7																				
Jan-86	15.7		19.8																				
Feb-86	28.7		53.1																				
Apr-86	1.7		6.9																				
Jun-86	0.5		10.4																				
Jul-90	ND(1.0)	ND(1.0)	11.0																				
Aug-90																							
Nov-90	1.1	ND(1.0)	16.0																				
Sep-88								13.0	ND(1.0)	3.3													
Nov-92	1.0	ND(0.2)	12.0			2.8	ND(0.2)	14.0	ND(0.2)	0.4													
Feb-94						2.0																	
May-94					ND(0.2)			9.3															
Jun-94						0.9		12.0															
Jul-94				9.7																			
Aug-94					ND(0.2)																		
Apr-95																							
Jul-95	4.3			9.9	0.3	0.5		11.0															
Aug-95																							
Apr-99	1.5	ND(0.5)	10.0	12.0	0.25		ND(0.5)	9.6	ND(0.5)	0.7													
Nov-00	2.2	ND(0.2)	12.0	12.0	ND(0.2)	0.55	ND(0.2)	12.0	ND(0.2)	0.94	3.4	ND(0.2)	ND(0.2)	1.1	ND(0.2)		ND(0.2)	ND(0.2)	ND(0.2)	1.5	1.2	ND(0.2)	
Nov-02	1.2	ND(0.2)	8.1	8.1	ND(0.2)	0.65	ND(0.2)	7.5	ND(0.2)	0.48	1.7	ND(0.2)	ND(0.2)	0.88	ND(0.2)	1.3	ND(0.2)	ND(0.2)	ND(0.2)	1.3	1.1	ND(0.2)	
Jun-10	1.0	ND(0.1)	9.4	8.8/9.3	ND(0.1)	***0.35***	ND(0.1)	7.7/7.8	ND(0.1)	***0.16***	1.2	ND(0.1)	ND(0.1)	1.0		***0.11***	ND(0.1)	ND(0.1)	ND(0.1)	0.5	0.64	ND(0.1)	
Feb-11	***0.3***	ND(0.1)	3.1	4.1/4.2	ND(0.1)	***0.16***	ND(0.1)	4.5/4.4	ND(0.1)	ND(0.1)	0.86	ND(0.1)	ND(0.1)	***0.3***		***0.17***	ND(0.1)	ND(0.1)	ND(0.1)	0.71	0.59	ND(0.1)	2.0

NOTES

0.5 Estimated Value (i.e., concentration greater than method detection limit but less than method reporting limit)

ND(XX) Non-Detected(Method Detection Limit)

FIGURES

Legend

Property Boundary

Source:
Bing Aerial Photography, October 2006

Property Location

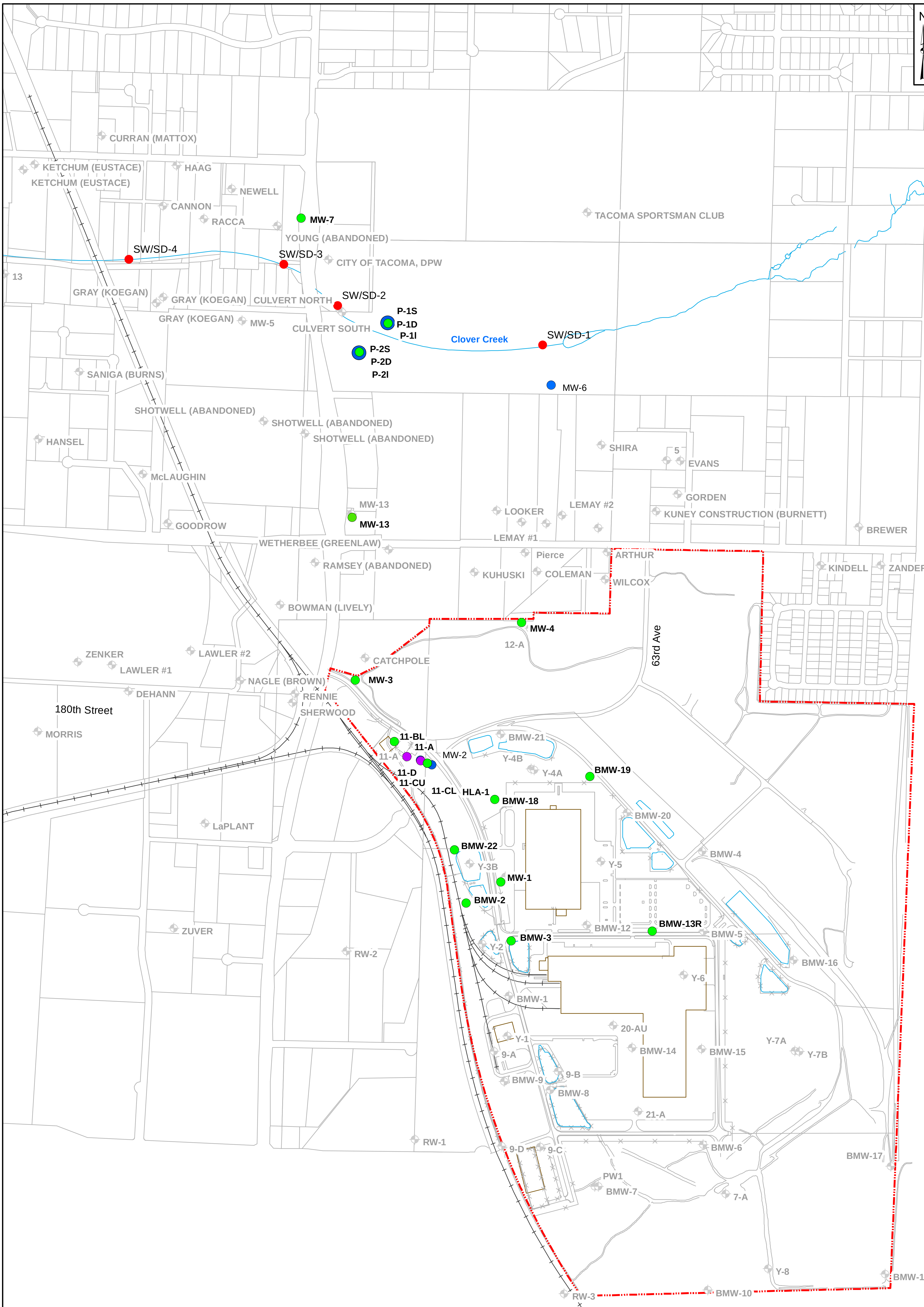
Fredrickson Industrial Park
Fredrickson, WA

Geosyntec consultants

Kennesaw, GA | 06-Sep-2013

Figure 1-1

N:\Frederickson\GIS\CMWP\MXD\Figure 1-1 Property Location.mxd; NHirons; 9/6/2013



Legend

- Aquifer A Monitoring Wells
- Aquifer C Monitoring Wells
- Past Groundwater Extraction Wells
- SW/SD-1 = Surface Water/Sediment Sample Location
- Private/Domestic Wells
- Property Boundary

1,000 500 0 1,000 Feet

Site Plan

Fredericksson Industrial Park
Fredericksson, WA

Geosyntec consultants

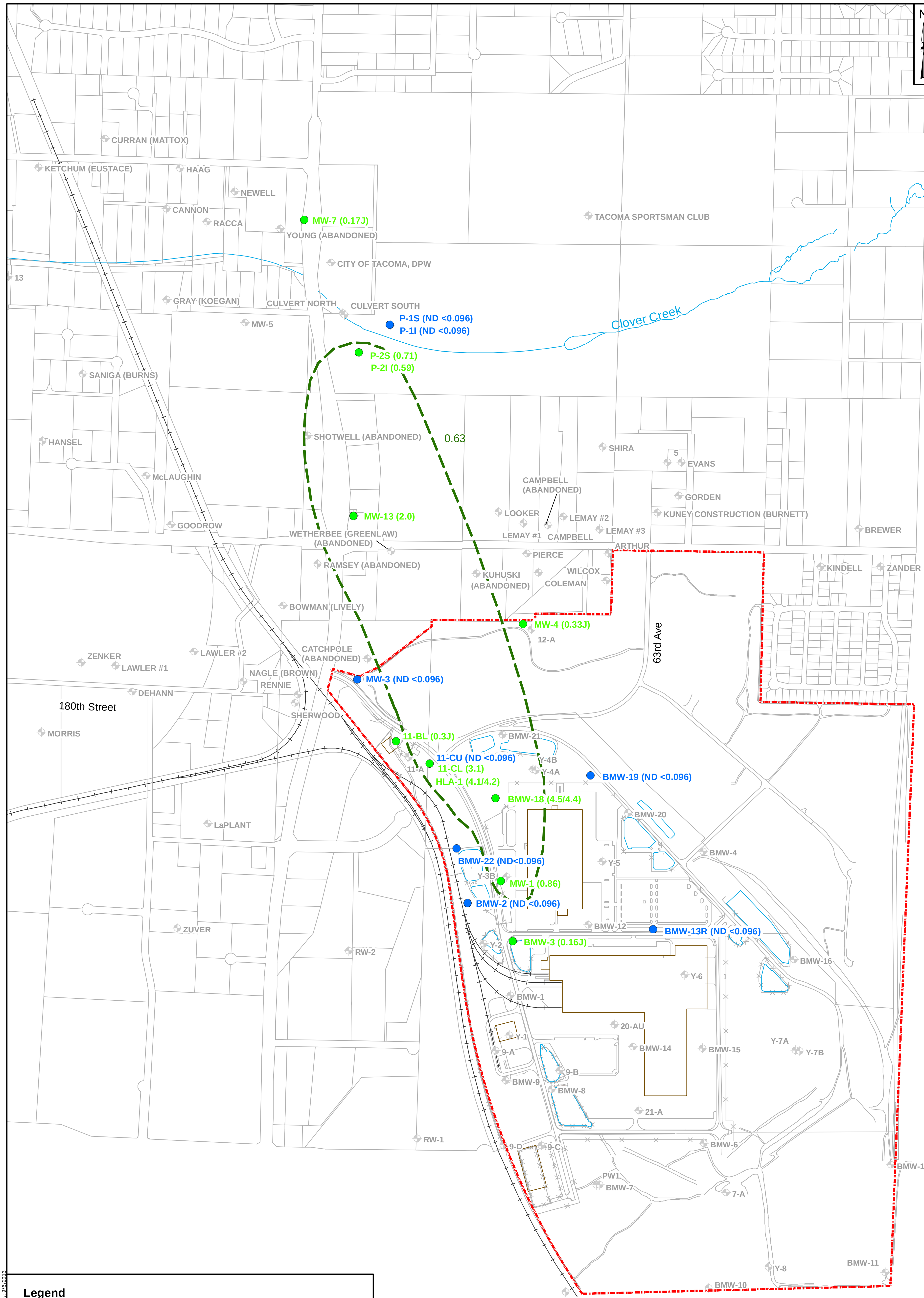
Figure

2-1

Kennesaw, GA

06-Sep-2013

N:\Fredericksson\GIS\CMWP\MXD\Figure 2-1.mxd; NHirons; 9/6/2013



N:\Frederickson\GIS\CMWP\MXD\Figure 2-2 CTC Compliance Monitoring.mxd; NHirons; 9/6/2013

Legend

- Aquifer A Compliance Monitoring Well (CTC Concentration µg/L))
- Aquifer A Monitoring Well Not Included in Compliance Monitoring Network (CTC Concentration (µg/L))
- Private/Domestic Wells
- CTC Contour of 0.63 µg/L (Based on Feb. 2011 Data)
- Property Boundary

MTCA Method B Cleanup Level for CTC = 0.63 ug/L

(0.17 J) The results were above the Method Detection Limit (MDL), but below the Method Reporting Limit (MRL) and thus the values are estimated (i.e., j - flagged)

1,000 500 0 1,000 Feet

Proposed Compliance Monitoring Well Network

Fredericksn Industrial Park
Frederickson, WA

Geosyntec consultants

Figure **2-2**

Kennesaw, GA | 06-Sep-2013

APPENDIX A

Sampling Analysis Plan

APPENDIX A SAMPLING AND ANALYSIS PLAN
for the
COMPLIANCE MONITORING WORK PLAN
FREDERICKSON INDUSTRIAL PARK
PIERCE COUNTY, WASHINGTON

1.0 Introduction

This Sampling and Analysis Plan (SAP) to the Fredrickson Industrial Park Compliance Monitoring Work Plan (CMWP) was prepared by Geosyntec Consultants (Geosyntec) at the request of Olin Corporation and Mallinckrodt US, LLC (the Companies). This SAP describes procedures and protocols to be adhered to during groundwater compliance monitoring. The groundwater compliance monitoring includes Performance Monitoring of up to ten existing monitoring wells. Upon successful completion of the Performance Monitoring, Confirmational Monitoring will occur in a subset of five of the ten monitoring wells. Carbon tetrachloride (CTC) is the analytical constituent of concern.

Procedures and protocols outlined in this SAP will be performed in conjunction with those presented in the Quality Assurance Project Plan (QAPP), in particular discussion of parameters to be analyzed, detection and quantitation limits, analytical techniques and procedures, and quality assurance and quality control procedures. Discussion of project schedule, organization and responsibilities are discussed in the CMWP and QAPP.

Groundwater monitoring includes the following activities:

- Hydraulic monitoring (water level measurements) in monitoring wells designated as part of the compliance monitoring network; and
- Groundwater sampling of wells in monitoring network.

Sampling procedures and protocols for the above referenced sampling activities are presented in the following sections. The purposes of the specific details of the groundwater monitoring are presented in the CMWP.

2.0 General Sampling Protocols

The following general sampling protocols will be employed during sampling throughout this program:

1) Sampling instruments and equipment will be cleaned in accordance with the protocol presented in Section 6.0 prior to sampling at each monitoring well location.

2) Where applicable and practical, the field activities will proceed from "clean" monitoring wells (i.e. low CTC concentration wells upgradient and downgradient) to relatively "impacted" monitoring wells.
3) A new pair of disposable gloves will be used at each monitoring well location. Additional glove changes will be undertaken as conditions warrant.
4) Sampling generated waste such as gloves, paper towels, etc., will be collected and contained for proper disposal.
5) Samples collected for off-Site chemical analysis will be iced to 4°C in laboratory supplied coolers after collection and labeling. The sample bottles will be surrounded by bags of ice to ensure proper temperature is achieved and maintained during transport. The temperature blank in each cooler will be treated the same way. Any remaining space in the coolers will be filled with packing to cushion the containers within the shipment coolers. The cooler will then be sealed with packing tape.
6) Samples will remain under control of the Companies' Site Representative until relinquished to the laboratory or commercial courier under a chain-of-custody (see QAPP, Attachment A).

Additional protocols specific to the sampling methods are presented in the following sections.

3.0 Hydraulic Monitoring

Hydraulic monitoring in the monitoring wells will be conducted with an electronic battery-operated water level indicator. The equipment used during the hydraulic monitoring activities will be cleaned between monitoring well locations in accordance with protocols outlined in Section 6.0. The hydraulic monitoring activities will be performed in accordance with the CMWP and QAPP, and will be conducted according to the following protocol:

- The water level in monitoring wells will be measured with respect to the reference point (top of north side of inner riser pipe) to the nearest 0.01 ft using an electronic battery-operated water level indicator.
- Water level monitoring will occur during low-flow purging for analytical sampling and measured at 3-5 minute intervals, as with other field parameters.
- Final water level measurement will occur after the analytical sample has been collected and labeled.
- Sounding of the bottom of the monitoring well will occur as the last item in order to avoid stirring up of sediment in the well prior to collecting the analytical sample.

Hydraulic monitoring data will be recorded on a standard field sheet and field notebook.

4.0 Monitoring Well Sampling

4.1 General

Each monitoring well will be sampled using the following low flow protocol (LFP). Equipment used during the groundwater sampling/purging activities will be cleaned between monitoring well locations in accordance with the protocols outlined in Section 6.0. The groundwater purging/sampling activities will be conducted in accordance with the Health and Safety Plan dated October 1, 2010.

4.2 Well Purging

1. The groundwater level in the monitoring well will be measured to the nearest 0.01 foot using a pre-cleaned electric water level tape.

2. Purging will be conducted using the existing submersible pumps. At locations where a pump has not already been dedicated to the well, a pre-cleaned submersible pump will be rented.

3. The pumps will be positioned and secured such that the pump intake corresponds to the mid-point of the well screen, or a minimum of 2 feet above the well bottom or sediment level if present. The required nylon rope will be pre-measured before lowering the pump into the monitoring well to ensure accurate positioning of the pump intake.

4. Static groundwater level conditions in the monitoring well will be allowed to re-establish after lowering the pump into position. The groundwater level in the monitoring well will be measured (to nearest 0.01 foot) with the pump in place prior to beginning purging.

5. Purging of the monitoring well will be conducted using a pumping rate between 100 to 500 milliliters per minute (mL/min). Initial purging will begin using a pumping rate within the lower end of this range. The groundwater level will be measured while purging to ensure that less than 0.3 feet of drawdown occurs. The pumping rate may be gradually increased depending upon the amount of drawdown and the behavior of the stabilization parameters (see Item 6 below). Any pumping rate adjustments will generally be made within 15 minutes from the start of purging. While purging, the pumping rate and groundwater level will be measured and recorded every 10 minutes (or as appropriate). If it is apparent that stabilization of the purged groundwater (see item 6 below) will not be achieved rapidly, these measurements may be made at longer time intervals to allow field staff to perform other sampling activities.

6. The field parameters (temperature, pH, conductivity, dissolved oxygen (DO), and turbidity) will be monitored while purging to evaluate the stabilization of the

purged groundwater. As stabilization approaches, the field parameters will be measured and recorded every 5 minutes (or as appropriate). Stabilization will be considered to be achieved when 3 consecutive readings for each parameter, taken at 5 minute intervals, are within the following limits:

- pH ± 0.1 pH units;
- Dissolved Oxygen ± 10 percent of reading or 0.2 mg/L (optional);
- Temperature ± 5 percent of range;
- Conductivity ± 5 percent of range;
- Oxidation/Reduction Potential (ORP) ± 10 mV (optional);
- Turbidity ± the greater of 10 percent of range or 1 NTU; and
- Water level drawdown ± <0.1 meter (~0.33 feet).

The field parameters will be measured using a flow-through-cell apparatus. At the start of purging, the purge water will be visually inspected for water clarity prior to connecting the flow-through-cell. If the purge water appears turbid, purging will be continued until the purge water becomes visually less turbid before connecting the flow-through-cell.

In the event that the groundwater recharge to the monitoring well is insufficient to conduct LFP protocol, purging will be discontinued before the water level in the monitoring well drops below the top of the pump. Samples will be collected as soon as the volume of groundwater in the well has recovered sufficiently to allow sample collection. Wells in which recovery is insufficient to conduct the LFP protocol will not be subject to the above purging stabilization criteria.

7. Wells will be sampled within the same day as purging.

8. Water extraction equipment will be cleaned in accordance with the protocols presented in Section 6.0.

9. Purge water will be containerized, and placed in a designated storage area for proper disposal following the return of sample results from the laboratory. Of note, the purge water from monitoring wells did not exceed their applicable federal or state Maximum Contaminant Levels (MCLs) for CTC during the most recent groundwater sampling event (February 2011).

4.4 Well Sampling

Following well purging, monitoring well sampling will be carried out according to the following protocol.

1. The monitoring wells will be sampled in the order of lowest concentrations to highest concentrations.

2. Monitoring wells will be sampled, using the existing equipment in each well. These pumps will be operated in a continuous manner to that they do not produce pulsating samples that are aerated in the return tube or upon discharge. The sampling flow rate will not exceed the flow rate used during the purging activities. Prior to use in the initial and subsequent monitoring wells, where pumps have not been dedicated to the well, well sampling equipment will be cleaned as specified in Section 6.0.

3. The flow-through-cell will be disconnected prior to sample collection. The sample bottle will be filled by positioning the discharge line at the base of the sample bottle and the sample bottle will be filled with a meniscus of water above the rim of the bottle before sealing. After sealing the bottles will be turned upside down and inspected for bubbles.

4. Sufficient groundwater will be collected for chemical analysis. Groundwater samples will be collected in containers as specified in the QAPP. Sample containers will be shipped to the Site in sealed coolers.

5. Field measurements of pH, conductivity, temperature, dissolved oxygen, and turbidity will be taken during well development and purging. Calibration of field instruments will be undertaken as described in the QAPP.

6. Field duplicate, field rinsate, trip blanks and MS/MSD samples will be collected concurrently with field samples at the frequency specified in the QAPP.

7. Field rinsate blanks will be collected by pouring demonstrated analyte-free water over the pump saving the water into the appropriate sample bottle.

5.0 Sample Containers Preservation Packaging and Shipping

Required sample containers, sample preservation methods and maximum sample holding times are summarized in Table 5-1 of the QAPP.

6.0 Equipment Cleaning Protocols

6.1 Groundwater Sampling Equipment

Sampling apparatus will be properly decontaminated prior to its use in the field to prevent cross-contamination. Also to avoid cross-contamination, disposable gloves will be worn by the sampling team and changed between sampling points.

6.2 Decontamination Procedures

The required decontamination procedure for groundwater equipment is:

- Wash and scrub with low phosphate detergent;

- Deionized water rinse;
- Rinse with methanol; and
- Rinse thoroughly with deionized demonstrated analyte-free water (use at least five times the volume of solvent used in previous step).

Tubing, piping, and bailer cord or pump cord, evacuation equipment such as submersible pumps, and other equipment which are put into the borehole will be rinsed with soapy water and deionized water before use. Tubing will be Teflon. Tubing will be dedicated to individual wells (i.e., tubing will not be reused). Probes, such as for pH and conductivity measurements will be rinsed with deionized water before use.

Cleaned equipment will be placed on clean plastic sheeting or aluminum foil in order to avoid contacting contaminated surfaces before use.

The groundwater purging/sampling activities will be conducted in accordance with the Updated Health & Safety Plan.

APPENDIX B

Quality Assurance Project Plan

APPENDIX B QUALITY ASSURANCE PROJECT PLAN
for the
COMPLIANCE MONITORING WORK PLAN
FREDERICKSON INDUSTRIAL PARK
PIERCE COUNTY, WASHINGTON

1.0 Introduction

This Quality Assurance Project Plan (QAPP) was prepared by Geosyntec Consultants (Geosyntec) at the request of Olin Corporation and Mallinckrodt US, LLC. (the Companies). This QAPP covers groundwater monitoring as described in the Compliance Monitoring Work Plan (CMWP).

The objective of this QAPP is to describe the procedures which will be used during compliance monitoring to ensure that the Carbon Tetrachloride (CTC) data generated will be of a known and acceptable level of precision and accuracy. This QAPP is consistent with the requirements of the Model Toxics Control Act (MTCA) and the Agreed Order between Ecology and the Companies.

This QAPP provides information regarding the project personnel responsibilities, and sets forth specific procedures to be used during the sampling and analysis of groundwater.

The following quality assurance (QA) topics are addressed in this plan:

- Data quality objectives (DQOs) for measurement of data, including precision, accuracy, completeness, representativeness, and comparability;
- Project organization and responsibility;
- Sampling procedures;
- Sample custody;
- Analytical procedures;
- Calibration procedures, references and frequency;
- Internal quality control (QC) checks and frequency;
- QA performance audits, system audits, and frequency;
- QA reports to management;
- Preventative maintenance procedures and scheduling;
- Specific procedures routinely used to assess data precision, representativeness, comparability, accuracy, and completeness;
- Data validation;
- Corrective action.

2.0 Project Description

This QAPP provides QA/QC criteria for the work efforts associated with groundwater samples collected and analyzed as part of the CMWP which is being submitted concurrently with the Cleanup Action Plan (CAP). Compliance monitoring is being performed to monitor the progress of the monitored natural attenuation (MNA) cleanup action and to confirm groundwater has met the cleanup levels for CTC established in the CAP.

3.0 Project Organization and Responsibility

3.1 Project Organization

The Companies have selected Geosyntec to implement the CAP and associated CMWP. ALS Environmental Laboratory of Kelso, Washington will perform the analyses for samples collected during compliance monitoring. However, the companies and personnel currently selected to implement the CMWP and analyze the samples may change in the future. If this occurs, the Companies will notify Ecology and append the Companies' representative list below. Currently, key project personnel under the direction of the Companies include the following:

- <u>Project Manager</u> – Evan Cox (Geosyntec)
- <u>Project Coordinator</u> – James Deitsch (Geosyntec)
- <u>Quality Assurance/Quality Control Manager</u> – Dave Parkinson (Geosyntec)
- <u>Field Quality Assurance Manager</u> – Christa Tyrell (Geosyntec)
- <u>Laboratory Project Manager</u> – Greg Salata (ALS)
- <u>Laboratory Operations Manager</u> – Jeff Christian (ALS)
- <u>Laboratory QA Officer</u> – Julie Gish (ALS)
- <u>Sample Custodian</u> – Lynda Huckerstein (ALS)

The responsibilities for the project titles are:

Project Manager
- General overview of project to ensure that the objectives are met; and
- Participation in key negotiations.

Project Coordinator
- Overview of field activities;
- Overview of laboratory activities;
- Data assessment;
- Preparation and review of reports; and
- Technical representation of project activities;

Quality Assurance/Quality Control Manager

- Laboratory systems audit;
- Overview and review of field QA/QC;
- Coordinate supply of performance evaluation samples;
- Review laboratory QA/QC;
- Data validation and assessment;
- Advise on data corrective action procedures;
- Preparation and review of QA reports; and
- QA/QC representation of project activities;

Field Quality Assurance Manager

- Management of field activities and field QA/QC;
- Data assessment;
- Technical representation of field activities;
- Preparation of SOPs for field activities; and
- Preparation of reports.

Laboratory Project Manager

- Coordinate laboratory analyses;
- Supervise in-house chain-of-custody;
- Schedule sample analyses;
- Oversee data review;
- Oversee preparation of analytical reports; and
- Approve final analytical reports prior to submission to the Companies.

Laboratory Operations Manager

- Ensures the necessary resources of the laboratory are available on an as-required basis; and
- Overview of final analytical reports.

Laboratory Quality Assurance Officer

- Overview of laboratory quality assurance;
- Overview QA/QC documentation;
- Conduct detailed data review;
- Decide laboratory corrective actions, if required;
- Technical representation of laboratory QA procedures; and
- Oversee preparation of laboratory SOPs.

Sample Custodian

- Receive and inspect the incoming sample containers;
- Record the condition of the incoming sample containers;
- Sign appropriate documents
- Verify chain-of-custody documents and their correctness;
- Notify laboratory manager and laboratory supervisor of sample receipt and inspection;

- Assign unique identification number and customer number and enter each into the sample receiving log;
- With the help of the operations manager, initiate transfer of the samples to appropriate lab sections; and
- Control monitor access/storage of sample and extracts.

4.0 Quality Assurance Objectives for Measurement Data

The overall QA objective is to develop and implement procedures for field sampling, sample preparation and handling, sample chain-of-custody, and laboratory analyses and reporting which will provide accurate and precise data.

The purpose of this section is to define the precision, accuracy, representativeness, comparability, and completeness goals for the project. In addition, QA objectives for field measurements are defined.

4.1 Level of QA Effort

4.1.1 Field QC Sampling

To assess the quality of data resulting from the field sampling program, field duplicate samples, rinse blank samples, trip blanks and samples for matrix spike analyses will be collected (where appropriate) and submitted to the analytical laboratory. A summary of the field QC sampling and analysis requirements for CTC is provided in Table 4-1.

Rinse and trip blanks will be analyzed to check for procedural contamination emanating from sampling device cleaning procedures, ambient conditions at the Site, and contamination from sample shipment or storage. Field duplicate samples will be analyzed to assess the aggregate sampling and analytical reproducibility. MS/MSD and samples will be analyzed to evaluate analytical accuracy and precision relative to the sample matrix. Trip blank samples will be shipped by the laboratory to the Site and back to the laboratory without being opened in the field. Trip blank analyses will provide a measure of potential cross-contamination of samples during shipment, storage, handling, and ambient conditions at the Site.

4.1.2 Laboratory QC Sampling

4.1.2.1 Accuracy, Precision and Sensitivity of Analysis

The fundamental QA objective with respect to the accuracy, precision, and sensitivity of analytical data is to achieve the QC acceptance criteria of the analytical method. The purpose of the analytical work performed during the investigation is to generate data for use in monitoring Site wide groundwater contamination by CTC, and the evaluation of when cleanup standards have been met.

The targeted quantitation limit for this investigation of CTC is 0.5 µg/L.

The method accuracy will be determined by spiking selected samples (matrix spikes) with selected compounds of interest. Accuracy will be reported as the percent recovery of the spiking compound(s) and will be compared to the laboratory's control limits.

The method precision (reproducibility between duplicate analyses) will be determined from the duplicate analysis of matrix spike samples for groundwater samples and by the use of laboratory duplicates. A minimum of one MS/MSD sample and one laboratory duplicate sample set per sampling event for less than twenty samples, and per twenty samples for greater than twenty samples will be analyzed. Precision will be evaluated based on laboratory control limits for relative percent differences (RPDs) calculated from the MS and MSD and/or duplicate sample results.

Overall sampling and analytical precision will be evaluated using the data from field duplicate samples.

4.1.2.2 Completeness, Representativeness and Comparability

It is expected that the analyses conducted in accordance with the analytical methods for CTC will provide data meeting QC acceptance criteria for 85 percent of the samples tested. Any reasons for variances will be investigated by the laboratory and documented.

The analytical method used for the groundwater analyses is an updated version of the method used for previous studies to assure comparability of the data. Standard reference materials used by the laboratory will be traceable to National Institute of Standards and Technology (NIST) sources, if available.

4.2 Field Measurements

Measurement data will be generated in field activities. These include, but are not limited to, the following:

- Documenting time and weather conditions;
- Determining pH, dissolved oxygen, specific conductivity, oxidation/reduction potential, turbidity, and temperature of water samples;
- Determining sampling flow rate from groundwater wells;
- Observation of sample appearance and other conditions; and
- Measuring groundwater elevations in wells.

The general QA objective for measurement data is to obtain reproducible and comparable measurements to a degree of accuracy consistent with the use of standardized procedures.

Purge water will be discharged through a flow cell for field parameter measurements. Discharge will be into a 5-gallon bucket, and flow rate measured using a graduated container of sufficient size. Field measurements will be collected at 3-5 minute intervals until parameters have stabilized for three consecutive measurements. Stabilization criteria are:

- pH ± 0.1 pH units;
- Dissolved Oxygen ± 10 percent of reading or 0.2 mg/L (optional);
- Temperature ± 5 percent of range;
- Conductivity ± 5 percent of range;
- Oxidation/Reduction Potential (ORP) ± 10 mV (optional);
- Turbidity ± the greater of 10 percent of range or 1 NTU; and
- Water level drawdown ± <0.1 meter (~0.33 feet).

Purging and measurement of the above parameters will continue until stabilization is obtained.

5.0 Sampling Procedures

The sample container, preservative, shipping and packaging requirements for CTC are identified in Table 5-1.

6.0 Sample Custody and Document Control

The following documentation procedures will be used during sampling and analysis to document the chain-of-custody during transfer of samples from collection through laboratory receipt and log-in. Recordkeeping documentation will include use of the following:

- Field log book (bound with numbered pages);
- Labels to identify individual samples; and
- Chain-of-custody record to document analyses to be performed; and
- Laboratory sample custody log book.

6.1 Field Log Book

In the field, the sampler will record the following information in the field log book for each sample collected:

- Project number;
- Sample matrix;
- Name of sampler;
- Sample source;

- Time and date;
- Pertinent data (i.e. depth to water, pumping method);
- Analysis to be conducted;
- Sampling method (i.e. pump type);
- Appearance of each sample;
- Preservatives added;
- Number of sample bottles collected;
- Analyses performed in the field (temperature, pH, specific conductivity, etc.); and
- Pertinent weather data.

Each field log book page will be signed by the sampler. A unique sample numbering system will be used to identify each collected sample. This system will provide a tracking number to allow retrieval and cross-referencing of sample information. The sample numbering system to be used is as follows:

Example GW-110512-AA-123
where: GW = Designates sample type (GW – Groundwater)
110512 = Date of collection (mmddyy)
AA = Sampler initials
123 = Unique sample number

Field duplicates and field blank samples will also be numbered with a unique sample number and submitted to the laboratory blind (i.e. without designation as duplicate or blank). Samples designated for MS/MSD analysis will be identified on the chain-of-custody.

6.2 Chain-Of-Custody Records

Chain-of-custody forms will be completed for each sample collected to document the transfer of sample containers. Custody seals will be placed over the lids of each cooler. Samples will be shipped with bagged ice and delivered to the analytical laboratory by a commercial courier or will be hand delivered. Samples requiring refrigeration will be maintained at 4°C (±2°C) by the laboratory.

The chain-of-custody record, completed at the time of sampling, will contain, but not be limited to, the sample number, date, and time of sampling, and the name of the sampler. The chain-of-custody document will be signed by the sampler noting the date and time when the samples are transferred.

Each sample container being shipped to the laboratory will contain a chain-of-custody form. The chain-of-custody form consists of four copies that are distributed to the sampler, to the shipper, to the laboratory, and to the office file. The sampler and shipper will maintain their copies while the other two copies are enclosed in a waterproof enclosure within the shipping container. The laboratory, upon receiving the samples, will complete the remaining copies. The laboratory will maintain one copy for its records. The executed original will be returned with the data deliverables package.

6.3 Sample Documentation in the Laboratory

Each sample or group of samples shipped to the laboratory for analysis will be given a unique identification number. The laboratory Sample Custodian will record the client name, number of samples and date of sample receipt in the sample receiving log. Samples removed from storage for analysis will be recorded by the laboratory using internal chain-of-custody.

The laboratory will be responsible for maintaining analytical log books and laboratory data for submittal to the Companies on an "as required" basis. Raw laboratory data produced from the analysis of samples submitted for this program will be inventoried and maintained by the laboratory for a period of five years at which time the Companies will advise the laboratory regarding the need for additional storage.

6.4 Storage of Samples

After the Sample Custodian has completed the chain-of-custody forms and the incoming sample receiving log, samples will be stored in the appropriate locations. Samples will be stored within an access-controlled custody room or refrigerator. Samples will be maintained at 4°C (±2°C) until analytical work is complete.

6.5 Final Evidence Files

Evidentiary files for the entire project will be maintained and will consist of the following:

- Project related plans;
- Project log books;
- Field data records;
- Sample identification documents;
- Chain-of-custody documents;
- Report notes, calculations, etc.;
- References, copies of pertinent literature;
- Miscellaneous – photos, maps, drawings, etc.; and
- Copies of final reports pertaining to the project.

The evidentiary file materials shall be the responsibility of the project manager with respect to maintenance and document removal.

6.6 Document Control System

A document control system ensures that documents are accounted for when the project is complete. The project number assigned to this project is GR4631. This number will appear on sample labels, log books, data sheets, project memos, analytical reports, document control logs, corrective action forms and logs, QA plans, and other project-related records.

7.0 Calibration Procedures and Frequency

7.1 Instrument Calibration and Tuning

Calibration of instrumentation is required to ensure that the analytical system is operation correctly and functioning at the proper sensitivity to meet established reporting limits. Each instrument is calibrated with certified standard solutions and the linear range established for the analytical method. The frequency of calibration and the concentration of calibration standards are determined by the analytical method in Section 8.0.

7.1.1 Instrument Tuning Verification

It is necessary to establish that a given gas chromatograph/mass spectrometer (GC/MS) meets the standard mass spectral abundance criteria prior to initiating calibration or sample analysis. This is accomplished through the analyses of tuning compounds as specified in the analytical methods.

7.1.2 GC/MS Calibration

The initial calibration should be verified according to method protocol once every 12 hours prior to sample analysis as detailed in the method. . Calibration will be performed using procedures specified in the method.

8.0 Analytical Procedures

Samples collected for laboratory analysis will be analyzed for CTC using EPA Method 8260C (Table 4-1).

9.0 Data Reduction, Validation, Assessment, and Reporting

9.1 General

The laboratory will perform analytical data reduction and validation in-house under the direction of the laboratory QA Officer. The laboratory's QA Officer and/or area supervisor will be responsible for assessing data quality and advising of any data which were rated preliminary or unacceptable or other qualifications based on the QC criteria outlined in the relevant methods, which would caution the data user of possible unreliability. Data reduction, validation, and reporting by the laboratory typically will be conducted as detailed below:

- Raw data produced and checked by the responsible analysts will be turned over for independent review by another analyst;
- The area supervisor will review the data for attainment of the QC criteria presented in the referenced analytical methods and determine whether any sample reanalysis is required;
- Upon completion of required reviews and acceptance of the raw data, a report will be generated and sent to the laboratory QA Officer or Laboratory Project Manager;
- The Laboratory QA Officer or Laboratory Project Manager will complete a thorough inspection of the required reports; and
- Upon acceptance of the preliminary reports, final reports will be generated and signed by the Laboratory Project Manager.

The QA/QC Manager will conduct an evaluation of data reduction and reporting by the laboratory. These evaluations will consider the sample data, rinsate blank data, procedural and method blanks, field duplicate data, and the data from surrogate and matrix spikes. The final data will be checked for legibility, completeness, correctness, and the presence of requisite dates, initials, and signatures. The results of these checks will be assessed and reported to the Project Manager noting any discrepancies and their effect upon the usability of the data.

Validation of the analytical data will be performed by the QA/QC Manager. The data validation will be performed in accordance with the analytical method and the relevant review criteria in the guidance document "USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review" 2008, EPA 540/R-08-01.

Data assessment will include checks on data consistency through comparability of duplicate analyses, comparability to previous data from the same sampling location, adherence to accuracy and precision control criteria detailed in this QAPP, and anomalously high or low parameter values. The results of these data validations will be reported to the Project Manager, noting any discrepancies and their effect upon usability of the data.

9.2 Laboratory Data Deliverables and Final Report

Reporting and deliverables will include the following:

- A case narrative that includes a summary of analytical methods used and a description of any unusual action or conditions;
- Dates of sample receipt, preparation, and analysis;

- Laboratory and field sample identification numbers;
- Sample results in tabular format;
- Method blank sample data summaries;
- Surrogate compound percent recovery data and control limits;
- MS/MSD and percent recovery and RPD data and control limits; and
- Executed chain-of-custody forms.

Raw data and the corresponding QA/QC data will be maintained by the laboratory and will be accessible to the Companies in hard copy or electronic format as necessary.

The laboratory will submit a hard copy and electronic version of the final analytical report within 21 calendar days of their receipt of the samples from each sampling event, unless a more rapid turnaround time is requested.

10.0 Internal Quality Control Checks and Frequency

10.1 Field QC

Quality control procedures for field measurements will be limited to checking the reproducibility of the measurement in the field by obtaining multiple readings and by calibrating the instruments (where appropriate).

Quality control of the field sampling procedures will include collecting field duplicates, trip blanks, and rinsate blanks (where appropriate) in accordance with the applicable procedures and at the frequencies identified in Section 4.0.

10.2 Laboratory QC

Specific procedures related to internal laboratory QC samples are described in the following subsections.

10.2.1 Method Blanks

A method blank will be analyzed by the laboratory at a frequency of one blank per analytical batch of 20 or fewer samples. The method blank, an aliquot of analyte-free water will be carried through the entire analytical procedure.

10.2.2 MS/MSD Analyses

An MS/MSD sample will be analyzed at a minimum frequency of one per twenty groundwater samples, or a minimum of one per sampling event. A representative subset of the analytes of interest will be used as spiking compounds for VOC MS/MSD analyses. Percent spike recoveries will be used to evaluate analytical accuracy while RPD values will be used to assess analytical precision. Control limits will be established by the laboratory.

10.2.3 Surrogate Analyses

Surrogates are organic compounds which are similar to the analytes of interest, but which are not normally found in environmental samples. Surrogates are added to samples for VOC analysis to monitor the effect of the matrix on the accuracy of the analysis. Every blank, standard, and environmental sample will be spiked with surrogate compounds prior to sample analysis. The compounds that will be used as surrogates and the concentration levels recommended for spiking are identified in the analytical method. Percent recoveries of the surrogates will be reported for each Site sample and QC sample analyzed.

10.2.4 Laboratory Control Samples (LCS/LCSD)

QC checks samples (also known as laboratory control samples or laboratory performance solution) will be analyzed with every batch of 20 or fewer groundwater samples. QC check samples are prepared from standard reference materials that are from a different source than the standards used for calibration. As such, QC check sample data provide a check on the accuracy of the analyses, and with the duplicates, provide a measure of the precision.

11.0 Performance and System Audits

The laboratory routinely performs internal systems and performance audits under the guidance of the Laboratory QA Officer. The results of these audits are maintained by the Laboratory QA Officer. External systems and performance audits may be performed at the discretion of the State of Washington Department of Ecology for the groundwater and soil sample analyses.

The QA/QC manager may carry out performance and/or systems audits to ensure that the data of known and defensible quality are consistently produced during this program.

Systems audits are qualitative evaluations of the field and laboratory quality control measurement systems. They determine whether the measurement systems are being used appropriately. The audits may be carried out before systems are operational, during the program, or after completion of the program. Such audits typically involve a comparison of the activities specified in this QAPP with activities actually scheduled or performed.

Performance audits are quantitative evaluations of the measurement systems used for a monitoring program. It requires testing the measurement systems with samples of known composition or behavior to quantitatively evaluate precision and accuracy. A performance audit may be carried out by or under the auspices of the QA/QC manager without the knowledge of the laboratory during each sampling event for this program.

The Project Manager may schedule systems audits of the field activities to ensure that the QAPP and Sampling and Analysis Plan are being adhered to and/or that variances are justified and documented. These audits will be scheduled to allow oversight of as many different field activities as possible, and will be performed by the Project Manager or their designee.

12.0 Preventive Maintenance

12.1 Laboratory Preventive Maintenance

This section applies to both field and laboratory equipment. Specific preventive maintenance procedures for field equipment will be consistent with the manufacturers' guidelines. Specific preventive maintenance protocols for laboratory equipment will be consistent with the laboratory's standard operating procedures.

Analytical instruments used in this project will be serviced by laboratory personnel at regularly scheduled intervals in accordance with the manufacturers' recommendations. Instrument failure may result in unscheduled service or repairs. Requisite servicing beyond the abilities of laboratory personnel will be performed by the equipment manufacturer or a qualified service technician.

13.0 Data Precision, Accuracy, and Completeness

13.1 QA Measurement Quality Indicators

13.1.1 Precision

Precision will be assessed by comparing the analytical results between duplicate matrix spike analyses or duplicate sample analyses. Precision as relative percent difference will be calculated as follows:

$$\text{RPD} = \frac{|(D_1 - D_2|)}{(D_1 + D_2/2} \times 100$$

Where:

D_1 = value from first determination

D_2 = value from second determination

13.1.2 Accuracy

Accuracy will be assessed by comparing a set of analytical results to the accepted or "true" values that would be expected. In general, MS/MSD and check sample recoveries will be used to assess accuracy. Accuracy as percent recovery will be calculated as follows:

Percent Recovery = $\frac{A-B}{C} \times 100$

Where:

A = The analyte amount determined experimentally from the spike sample

B = The background amount determined by a separate analysis of the unspiked sample

C = The amount of spike added.

13.1.3 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under normal conditions.

To be considered complete, the data set must contain QC check analyses verifying precision and accuracy for the analytical protocol. In addition, data are reviewed in terms of stated goals in order to determine if the data set is sufficient.

When possible, the percent completeness for each set of samples will be calculated as follows:

Percent Completeness = $\frac{(valid\ data\ obtained)}{(total\ data\ planned)} \times 100$

13.1.4 Outliers

Procedures discussed previously will be followed for documenting deviations. In the event that a result deviates significantly from method established control limits, this deviation will be noted and its effect on the quality of the remaining data assessed and documented.

14.0 Corrective Action

The need for corrective action may be identified by system or performance audits or by the QC procedures within the analytical methods. The essential steps in the corrective action system will be:

- Checking the predetermined limits for data acceptability beyond which corrective action is required;
- Identifying and defining problems;
- Assigning responsibility for investigating the problem;
- Investigating and determining the cause of the problem;

- Determining a corrective action to eliminate the problem (this may include reanalysis or resampling and analysis);
- Assigning and accepting responsibility for implementing the corrective action;
- Implementing the corrective action and evaluating the effectiveness;
- Verifying that the corrective action has eliminated the problem; and
- Documenting the corrective action taken.

For each measurement system, the need for corrective action may be identified by the analyst during sample analysis or by others during data review. The Laboratory Operations Manager, in consultation with the analyst and/or group leader, will initiate and implement the corrective action. The Laboratory QA Officer will document that the corrective action has been effective and the measurement system is functioning properly.

15.0 Quality Assurance Reports

Final reports will contain a discussion on QA/QC summarizing the quality of the data collected and/or used as appropriate for each phase of the project. The Project Coordinator, who has responsibility for these summaries, will rely on written reports/memoranda documenting the data assessment activities, performance and systems audits, and footnotes identifying qualifications of the data if any.

Each summary of sampling activities will include a tabulation of the data including:

- Investigative sample and field duplicate sample results;
- Maps showing well locations; and
- An explanation of any sampling conditions or QA problems and their effect on data quality.

QA reports will be prepared by the QA/QC manager following receipt of the analytical data. These reports will include discussions of QC sample data and their effects on the quality of investigative sample data reported. In addition, the QA reports will summarize any QA problems, and give a general assessment of QC results.

Table 4-1
Sample Container Preservation, Holding Time, Volume and Shipping Requirements
Compliance Monitoring Plan Quality Assurance Project Plan
Frederickson Industrial Park, Pierce County, Washington

Sample Matrix	Analytical Parameters	Analytical Method	Investigative Samples	Field Duplicates	Rinse Blanks	MS/MSD	Trip Blanks
Groundwater	Carbon Tetrachloride	EPA Method 8260C	10	1/10	1/10	1/10	1/Cooler

Table 5-1
Sample Container Preservation, Holding Time, Volume and Shipping Requirements
Compliance Monitoring Plan Quality Assurance Project Plan
Frederickson Industrial Park, Pierce County, Washington

Groundwater Analyses	Sample Containers	Preservation	Investigative Samples	Sample Volume	Shipping
Carbon Tetrachloride	3 40-mL teflon lined septum vials	HCl to pH <2 Cool to 4±2ºC	14 days	Fill completely, no headspace	Overnight Courier or Hand Delivery