DATA GAP SAMPLING WORK PLAN

for

EMF Site

Seattle, Washington

Prepared for:
The Boeing Company
Engineering Operations and Technology
EHS Remediation

Prepared by:
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Acronym List

APHA	American Public Health Association
ARARs	Applicable or Relevant and Appropriate Requirements
ARI	Analytical Resources, Incorporated
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
CCL	Contaminant Candidate List
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
cm/sec	centimeters per second
COC	chemicals of concern
CSM	Conceptual Site Model
DAF	dispersion-attenuation factor
DNAPL	dense non-aqueous phase liquid
DQO	Data Quality Objective
Ecology	Washington Department of Ecology
EMF	Electronics Manufacturing Facility
EPA	Environmental Protection Agency
ERD	enhanced reductive dechlorination
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FOD	Foreign Objects and Debris
foc	fraction organic carbon
FS	Feasibility Study
ft	feet
GEMS™	Geographic Environmental Management System
HASP	Health and Safety Plan
HI	Hazard Index
IDW	Investigation Derived Waste
KCIA	King County International Airport
Kd	soil-water partition coefficient
LDW	Lower Duwamish Waterway
L/kg	liter per kilogram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MHHW	mean higher high water
MLLW	mean lower low water
MTCA	Model Toxics Control Act
MW	monitoring well
NAPL	non-aqueous phase liquids
NAWQA	National Ambient Water Quality Assessment program

NCP	National Contingency Plan
NGVD29	National Geodetic Vertical Datum 1929
NPL	National Priorities List
PER	Principles of Environmental Restoration
PID	Photoionization detector
ppb	parts per billion
PPE	Personal Protective Equipment
PQL	practical quantitation limit
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
Rd	retardation coefficient
RFI	RCRA Facility Investigation
RI	Remedial Investigation
SAFER	Streamlined Approach for Environmental Restoration
SACM	Superfund Accelerated Cleanup Model
SGD	submarine groundwater discharge
SM	Standard Methods
SOP	Standard Operating Procedure
SWMUs	solid waste management units
TEA	terminal electron acceptor
TCE	trichloroethene
TBC	to be considered
trans-1,2-DCE	trans-1,2-dichloroethene
ug/L	micrograms per liter
USCS	Unified Soil Classification System
USGS	United States Geological Survey
VOC	volatile organic compound
WAC	Washington Administrative Code

DATA GAP SAMPLING WORK PLAN

EMF Site, Seattle, Washington

1.0 INTRODUCTION

This work plan describes planned investigation activities for the collection of data to address data gaps identified in the historical environmental data collected at and down gradient of the former Electronics Manufacturing Facility (EMF) site. The EMF site is located at Boeing Field/King County International Airport (KCIA) in Seattle, Washington. The data gaps have been defined based on a Data Quality Objectives (DQO) process (identifying anticipated project decisions, defining data necessary to support decisions, evaluation of existing data and definition of remaining data gaps).

Starting in 1982, investigations (and subsequent voluntary remedial actions) initially focused on the EMF property at the identified locations of hazardous material spills. In 1999, a larger volatile organic compound (VOC) plume in groundwater was identified (i.e., larger than the EMF property). Based on that data, subsequent voluntary investigations and remedial actions have been implemented in the down gradient areas impacted by the VOC plume from the EMF property.

This work plan has been prepared by CALIBRE Systems, Inc. (CALIBRE) for The Boeing Company (Boeing) in response to an Administrative Settlement Agreement and Order on Consent For Removal Action (Settlement Agreement) entered into by Boeing and the U.S. Environmental Protection Agency (EPA) on February 2, 2007.

For the purpose of this project, the term “EMF property” is used to define the physical location of the former EMF building and immediate surrounding area (parking areas for the facility). The terms EMF site, site, and VOC plume are used to describe any areas impacted by the VOC plume from the EMF property.

1.1 Site Description and Background

The EMF property is located on the east side of KCIA. The facility is situated between the active runways/taxiways and Perimeter Road located to the east, which forms the eastern boundary of the airport and ancillary support operations (see Figure 1-1). Past industrial activities at the EMF property resulted in the release of trichloroethene (TCE) to the ground and to groundwater beneath the property. The VOC plume has been transported by natural groundwater movement southwest from the EMF property, across KCIA, passing under Boeing Plant 2 towards the Lower Duwamish Waterway (LDW) located approximately 3,600 feet southwest of the former EMF property.

The site consists of the EMF property and the portions of KCIA and Boeing Plant 2 impacted by the EMF VOC plume that is located in a west to southwest direction from the EMF property. The down gradient boundary of the site is presumed to be the LDW. The contaminants of concern (COCs) that have been identified in the EMF VOC plume are

TCE, cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), and vinyl chloride. Additional background information is provided in the Historical Data Summary Report (CALIBRE 2008).

1.1.1 Access Constraints within the Airport

The proximity of the EMF VOC plume to an active airport (i.e., the airport overlies a portion of the VOC plume) poses some significant access constraints. The Federal Aviation Administration (FAA) has the statutory authority to issue airport operating certificates and establish safety standards for the operation of airports. The FAA uses this authority to issue requirements for the certification and operation of civil airports under Title 14, Code of Federal Regulations part 139 (14 CFR 139, Certification and Operation of Airports). These requirements, defined in the Federal Aviation Regulations (FAR), cover a broad range of airport operations including airspace control, markings and lighting, notification to air carriers of unsafe or changed conditions, and preparedness for accidents and other emergencies.

Part 77 of the FAR (Objects Affecting Navigable Airspace) has been adopted by KCIA as a means of monitoring and protecting the airspace required for safe operation of aircraft and the airport. FAR Section 77.25 (for civil airports) defines a controlled air space (starting at the runway surface and extending upward in a generally bowl-shaped pattern) used to determine if something is an obstruction affecting safe airport operations. In the area of the EMF plume, the controlled airspace starts at the runway edge and extends 250 ft horizontally from the runway (at ground surface), a transition zone is then defined rising with a slope of 7 to 1 from ground level (1 ft rise for each 7 ft horizontal distance). When the airport is open, if any temporary construction (such as a drill rig) is within the airport and exceeds the obstruction height defined by the FAR (based on proximity to the runway), the operator must be in radio communication with the control tower and be able to remove the obstruction when directed by the control tower on aircraft approach. Figure 1-2 presents the areas with FAA restricted access (height obstruction restrictions) within the vicinity of the EMF VOC plume.

The County operates KCIA 24 hours per day, 7 days per week with occasional planned maintenance shutdowns (typical 2 hours or less). All planned shutdowns must be coordinated in advance with all aircraft planning to land at KCIA (regional, national and international flights). The KCIA management team has also discussed concern related to two other issues affecting site access:

1) KCIA considers any larger equipment near or in an important line-of-sight from the active runways to be a significant safety hazard. The smaller runway (to the east) is used heavily by student pilots for training. KCIA considers equipment near the active runways to be a distraction safety hazard.
2) Experience at KCIA has shown that any modified tarmac/surface structure (e.g., surface monuments for wells) in active areas such as the runways and taxiways are subject to damage by routine operations (landing and movement of aircraft).

This is in specific reference to control of Foreign Objects and Debris (FOD) required for safe operations.

1.1.2 Coordination with Plant 2 Investigations

As noted previously, the VOC plume passes beneath KCIA and under Boeing Plant 2 before discharging to the LDW. A number of environmental investigations under the RCRA program for Plant 2 and other voluntary investigations for remedial design have been implemented throughout the area of the EMF VOC plume within Plant 2. The data derived from those investigations has been used to help characterize the EMF VOC plume and provide monitoring data which fulfill many of the prior data gaps identified for this project. All work, and characterization data developed, will be coordinated closely with the team completing the planned site characterization for Plant 2. Subsequent EMF VOC plume investigations will be implemented in specific areas (as necessary) where, or if, the Plant 2 characterization does not fulfill the identified data gap related to this project. This is particularly important in two areas planned for plume-wide transects of monitoring wells: at the LDW and at the east side of the 2-40 Building parking lot (the east edge of Plant 2).

1.2 Objectives

The objectives of this work plan are to identify and evaluate data gaps that exist in the historical site characterization data and present an investigation plan for addressing those data gaps, recognizing that some portion of the investigation (a significant portion within Plant 2) is likely to be completed by the Plant 2 team.

1.3 Work Plan Organization

Section 2.0 describes the conceptual site model and key data gaps as identified in the Historical Summary Report (CALIBRE 2008). The data gap analysis is presented in Section 3.0. Section 4.0 discusses the sampling design and rationale. Section 5.0 describes the field sampling procedures. Section 6.0 describes the data management plan. The bibliography is listed in Section 6.0. Attachment 1 presents the Standard Operating Procedures (SOPs); Attachment 2 presents the Quality Assurance Project Plan (QAPP); and Attachment 3 presents the Health and Safety Plan (HASP) for the site. The Sampling and Analysis Plan (SAP) information is presented in Sections 4, 5 and Attachment 1.

1.4 Applicable Procedures

The work to be completed under this work plan will be conducted in accordance with standardized field and lab procedures as defined by EPA, ASTM International, Puget Sound Estuary Program (PSEP), industry standards, and other recognized criteria. The results obtained using standardized procedures provide consistent and comparable data

as required by the Quality Assurance Project Plan (Attachment 2). High quality data are required to support anticipated project decisions as defined in the DQOs. Specific standards that will be used include:

- EPA Test Methods for Evaluating Solid Waste (SW-846)
  - Volatile Organic Compounds (EPA Method 8260B)
  - Priority Pollutant Metals (EPA Method 6010/6020)
  - Total Organic Carbon (EPA Method 415.1)
  - Non-halogenated Volatile organic compounds (EPA Method 8015)

- APHA Standard Methods (SM) for the Examination of Water and Wastewater (18th or more recent edition.)
  - pH (SM 4500-H)
  - Conductivity (SM 2510 A-B)
  - Dissolved Oxygen (SM 4500-O G)
  - Turbidity (SM 2130-B)
  - Temperature (SM 2550-B)

- ASTM Methods and Procedures
  - Description and Identification of Soils (ASTM Standard D-2488-90)
  - Design and Installation of Ground Water Monitoring Wells (ASTM Standard D-5092)
  - Classification of Soils for Engineering Purposes (Unified Soil Classification System, ASTM Standard D-2487)
  - Density (ASTM Standard D-698)
  - Moisture content (ASTM Standard D-2216)
  - Particle-Size Analysis of Soils (ASTM Standard D-422)
  - Oxidation-Reduction Potential (ASTM Standard D-1498-00)

1.5 Applicable Standards and Criteria

Under the prior voluntary MTCA RI/FS, an ARARs evaluation was completed to establish cleanup levels, this process is also consistent with the CERCLA requirements of the National Contingency Plan (NCP). The first consideration is to identify existing promulgated standards which have been established for protection of public health and ecological receptors (i.e., typical examples for water depend on the applicable exposure scenario and include Maximum Contaminant Levels [MCLs, established under the Safe Drinking Water Act] and Ambient Water Quality Criteria [AWQCs, established under the Clean Water Act]).

MTCA Method A cleanup standards are intended for some sites where the cleanup action may be “routine” or may involve relatively few hazardous substances. Under Method A, cleanup levels are set at concentrations at least as stringent as those specified in ARARs and in Tables 720-1, 740-1, and 745-1 included in WAC 173-340. Under Method A, if cleanup levels (for indicator hazardous substances) are not addressed under ARARs or Tables 720-1, 740-1, and 745-1, cleanup levels are to be established at concentrations which do not exceed the natural background concentration or the practical quantitation limit, whichever is higher.

Method B is the universal method for determining cleanup levels for all media at all sites. Under Method B, cleanup levels for individual hazardous substances are established using ARARs and the risk equations and other requirements specified in WAC 173-340-720 through 173-340-760. Under Method B, the first consideration is the availability of ARARs for the compound(s) and relevant exposure pathways (e.g., MCLs or AWQCs). If health-based criteria or standards have not been established under ARARs, the cleanup levels to protect human health are determined as:

1) Concentrations that are estimated to result in no acute or chronic toxic effects on human health as determined using a hazard quotient of 1.
2) For known or suspected carcinogens, concentrations for which the risk is less than or equal to 1×10^{-6} (the upper bound estimated excess cancer risk).
3) Concentrations that eliminate or minimize the potential for food chain contamination as necessary to protect human health.

Concentrations of individual hazardous substances established under Method B, including those based on ARARs, may need to be adjusted downward to take into account exposure to multiple hazardous substances and/or exposure resulting from more than one pathway of exposure. Pursuant to MTCA, these adjustments need to be made only if, without these adjustments, the hazard index would exceed 1 or the total excess cancer risk would exceed 1×10^{-5}.

Method C cleanup levels are intended for properties where reaching Method B cleanup levels may be infeasible or may cause greater environmental harm. Method C industrial soil cleanup levels may also be established at industrial properties that meet the criteria in WAC 173-340-745. Under Method C, cleanup levels for individual hazardous substances are established using applicable state and federal laws and the risk equations and other requirements specified in WAC 173-340-720 through 173-340-760. For individual carcinogens, Method C cleanup levels are based on risk of 1×10^{-5} (the upper bound of the estimated lifetime cancer risk). For individual noncarcinogenic substances, cleanup levels are set at concentrations which are anticipated to result in a hazard quotient of one or less (and no significant adverse effects on the protection and propagation of aquatic and terrestrial organisms). At sites involving multiple hazardous substances and/or multiple pathways of exposure, then Method C cleanup levels for individual substances are adjusted downward for additive health effects if the total excess

lifetime cancer risk for a site exceeds 1 x 10^{-5} or the hazard quotient for substances with similar noncarcinogenic toxic effects exceeds 1.

Under the MTCA as noted above, if the existing promulgated standard exceeds a 10^{-5} risk, then the Method B/C formulae and procedures are used to adjust the standard lower (a cleanup level lower than the existing promulgated standard) to meet a 10^{-5} risk threshold. The NCP is different from the MTCA in this regard, in that a 10^{-4} threshold is set before the criteria established in the promulgated standard is to be lowered.

Other modifying factors specified in MTCA include practical quantitation limits (PQLs), and background distributions of naturally occurring substances. If the cleanup level identified in the MTCA procedures (noted above) are below the PQL, then the MTCA cleanup level is adjusted upwards to the PQL. Recognizing the presence of various metals as naturally occurring substances, MTCA procedures establish the 90th percentile of the background distribution as the minimum threshold at which a cleanup level should be set (i.e., the cleanup level may be above the 90th percentile of the background distribution if there is no adverse human or ecological risk). Pursuant to MTCA, if the promulgated standard or calculated risk-based standard is below the 90th percentile of the naturally occurring distribution, the cleanup level is adjusted upwards to the 90th percentile of the background range. Consideration of naturally occurring background levels is explicit within MTCA. Regarding this subject Ecology (1994) states:

> "…awareness of environmental affairs and concern over industrial pollution … has led to more need to understand the natural concentrations of certain elements in the environment. This trend has taken hold in Washington State, as noted by the 1989 PTI Environmental Services study entitled B*ackground Concentrations of Selected Chemicals in Water, Soil, Sediments, and Air of Washington State.* This study (performed by PTI for the Department of Ecology), was designed to identify the concentrations of high-priority contaminants that are representative of background (or ambient) conditions in the water, soil, and air of Washington State. The information from this study was ultimately used in the development of cleanup standards for the Model Toxics Control Act (MTCA)."

Ecology (1994) presents a summary of background distributions for selected inorganics in soil (including means and 90th percentiles of distributions for statewide and regional values in Washington State). A description of the planned/suggested uses for the information presented in the 1994 Ecology study is summarized as (presented in Table 2 Anticipated Uses of the Background Soils Information, from the 1994 report):

> "Defining Background: Owner/operator of any site that does not want to complete a site-specific background study per MTCA requirements (using this data may be more cost-effective)."

The statewide data from Ecology (1994) are routinely applied at sites throughout Washington including specific criteria for arsenic, chromium, lithium, manganese and zinc (i.e., the default tabular values in MTCA).

Groundwater at and down gradient of the EMF property is not a current source of potable water; therefore, groundwater cleanup standards identified in the ARARs evaluation (pursuant to the MTCA RI/FS and NCP requirements) have been based on protection of non-potable surface water and were set equal to AWQCs for the specific COCs found at the site. The AWQCs are set for protection of the beneficial use of the surface water including both human exposure and ecological impacts. The EMF site has always been considered an industrial setting under the MTCA criterion. However, removal actions implemented in the 1997 MTCA RA excavated all soil above MTCA Method A standards (residential or unrestricted use). Both of these important factors (designation as non-potable water and future land use as an industrial setting) will be considered further in the EE/CA using the specific guidance from WAC 173-340 and OSWER Directives 9355.7-06P and 9355.7-04.

One of the requirements under the Settlement Agreement is an EE/CA. Establishing cleanup criteria defined by ARARs will be a step in the EE/CA. Consistent with the NCP requirements for the scoping and RI/FS phases (40 CFR 300.430 a, 2, b, 9, and 300.430 e, 2, i, a) this project has identified remedial action objectives specifying contaminants and media of concern, potential exposure pathways, and remediation goals, with the preliminary remediation goals based on readily available information, such as chemical-specific ARARs or other reliable information. Under the planned EE/CA, EPA has indicated they will be developing additional criteria “to be considered“ (TBCs) under the NCP pursuant to 40 CFR 300.400, g, 3. EPA has indicated that the TBC criteria that will be derived will consider protection of various exposure pathways including protection of aquatic organisms as well as the people who consume fish and shellfish harvested from the LDW.

1.6 Project Team and Responsibilities

The management of the site investigation and remedial action implementation work is the responsibility of the Boeing project coordinator and consultants/contractors. The following sections describe the roles and responsibilities of key individuals and organizations responsible for project implementation. The table below provides addresses and telephone numbers for all designated key personnel.

Table 1-1 Project Key Personnel Contact List

Organization/Name	Address	Telephone Number
Boeing/ Carl Bach	PO Box 3707, MC IW-12 Seattle, Washington 98124-2207	(206) 898-0438
CALIBRE/ Tom McKeon	16935 SE 39th St Bellevue, Washington 98008	(425) 643-4634
Analytical Resources Inc./ Kelly Bottem	4611 S. 134th Place Tukwila, Washington, 98168-3240	(206) 695-6211

1.6.1 The Boeing Company

Boeing will be responsible for the overall project management of the investigation and remedial action work on the EMF site. Key Boeing personnel are as follows:

Carl Bach is the Project Coordinator for Boeing. Mr. Bach is Boeing's designated Project Coordinator, responsible for overseeing the implementation of necessary actions to meet the requirements of the Settlement Agreement. To the extent possible, all documents, including reports, approvals and other correspondence concerning the activities performed pursuant to the Settlement Agreement will be directed through Mr. Bach.

1.6.2 CALIBRE Systems, Inc.

CALIBRE will provide environmental consulting/design and remedial implementation services to Boeing during the implementation of EMF investigations and remedial actions. Tom McKeon, P.E. will be responsible for coordination of CALIBRE's work activities and will serve as primary contact with Boeing. He will have the responsibility for meeting the CALIBRE project schedule and scope of work requirements on a day-to-day basis. Additional CALIBRE staff will contribute to the planned work, as appropriate, based on their expertise required to meet project goals.

1.6.3 Other Contractors

Other project contractors will be selected by Boeing on the basis of competitive bid.

Analytical Resources Incorporated (ARI) will provide analytical laboratory services for samples collected during investigative and remedial activities. Boeing may elect to use other analytical laboratories at various times within the project.

1.7 Project Management Strategy

Project management is required to define, monitor, and control the scope of work, schedule, quality, and budget to meet the defined project objectives. For this project, the general work scope is defined in the Settlement Agreement. All work will be completed using appropriate scientific and engineering principles and practices to ensure that the

work is conducted in a manner that meets all regulatory and design criteria. The defined project objective has been developed in the DQO problem statement:

> *The site characterization data, exposure pathways and ARARs were used to develop a conceptual site model (CSM). As reflected in the CSM, the historical site data indicated that the contamination in the EMF plume at the point of discharge had reached concentrations in excess of ARARs and remedial action was required to meet those ARARs. The site remedial action needs to address contamination in a way that ensures against any unacceptable risks and meet ARARs.*

1.7.1 Requirements

In order to develop an effective project implementation approach the following project management elements are planned.

1) Identify Project Requirements
2) Communicate those with decision makers/project team and revise as necessary
3) Develop implementation plan, scope and schedule
4) Implement scope with required quality assurance (QA)
5) Conduct appropriate review of all deliverables

The project requirements include legal requirements and procedural requirements. The legal requirements are anticipated to include CERCLA/NCP, MTCA, other applicable sections of the Washington Administrative Code (WAC), and the terms of the Settlement Agreement. The procedural requirements are anticipated to include various EPA Office of Solid Waste and Emergency Response (OSWER) guidance documents developed to clarify CERCLA/NCP expectations and steps; various methods and procedures specified in SW-846, ASTM and Standard Methods procedures for testing/analysis; the project QAPP, HASP and SOPs; work practices to meet the OSHA/WISHA requirements; Boeing defined procedures for work on their facilities (such as waste management handling, tracking and labeling); and other factors to be considered in project implementation.

Compared to a more typical CERCLA site (i.e., nomination to the NPL following a hazard ranking scoring), the EMF site is a relatively mature project with a significant amount of voluntary site characterization, MTCA FS, and remedial action work implemented (under the MTCA VCP) over the last decade. Consistent with the streamlining guidance[1] prepared by EPA and other Federal Agencies with CERCLA decision authority, Boeing desires to manage the project and implement a remedial action phase as early as possible. None of the streamlining initiatives are legal requirements but rather guidelines that have been developed to accelerate the implementation of remedies. The overarching goals of all these initiatives include:

[1] See for example, Streamlined Approach for Environmental Restoration (SAFER), Superfund Accelerated Cleanup Model (SACM), RCRA Stabilization Initiative, Principles of Environmental Restoration (PERs)

- Effective Communication
- Problem Identification and Definition
- Identification of Likely Response Actions
- Uncertainty Management
- Defining Project Closure Strategies and Requirements

To the extent practical and where applicable, these CERCLA streamlining initiatives and overarching goals will be included in each element of the project planning and management approach. The streamlining initiatives are structured around a data quality objectives (DQO) approach. The communication of the project objectives and requirements (with decision makers and the project team) is planned in multiple DQO sessions. The DQO process is intended to define and communicate the project objectives, decisions and data requirements with the team. With the project objectives, decisions and data requirements defined, the work scope will be broken into discrete tasks with identified scope and end-point and corresponding schedule. The work will be implemented following the requirements of the project QAPP and include sufficient review/audits to verify that project goals are met and the data developed are of sufficient quality to meet their intended use. All work products will include appropriate review to verify they meet the intended objectives, requirements, and quality for the intended use (support of project decisions).

1.8 Project Schedule

The planned project schedule (focused solely on this Data Gaps Sampling) is shown in Figure 1-3. Other project activities (voluntary) are planned which include bi-annual sampling of site wells and continued implementation of the voluntary ERD remedial action throughout the VOC plume.

Figure 1-3 Project Schedule

Task	Duration	Jan-10	Apr-10	Jul-10	Oct-10	Jan-11	Apr-11	Jul-11
	days							
Review of Data Gaps Work Plan	236							
Final Data Gaps Work Plan	30							
Start of field work	1							
Initial activities*	30							
Field Sampling	90							
Laboratory Analysis and Data Validation	120							
Draft Investigation Data Summary Report	90							

Days are in calendar days (7 days/week)

Schedule for other deliverables required under Settlement Agreement (final data summary report and EE/CA) will be established after sampling is completed

*Field location marking, utility clearance, pre-field work safety review, concrete coring, scheduling review with KCIA, contracting and mobilization. All schedules after this date will depend on access to KCIA and Plant 2 areas and subcontractor availability.

2.0 Conceptual Site Model and Identification of Data Gaps

2.1 Summary of CSM

A release of hazardous substances to the environment at the site was identified in 1982. Since that time, a significant amount of work has been completed with voluntary site characterization and remedial actions implemented at the source area and throughout the plume over the last several years. As a result, a large body of environmental, hydrogeologic, and geochemical data has been collected at the EMF site based on the project history and maturity of the environmental restoration efforts (including extensive performance data from voluntary remedial actions implemented). Prior voluntary MTCA remedial investigation and remediation work at the site is summarized in the Historical Data Summary Report (CALIBRE 2008).

2.1.1 Objective

The overall objective of the Conceptual Site Model (CSM) is to assemble and summarize existing data in a consistent framework and understanding for project stakeholders. The specific objective of the CSM is to assist in subsequent project planning and implementation in the following manner:

1) Use existing site data and CSM in the DQO process to define likely future site decisions and establish the data requirements necessary to support the decisions.
2) Identify and prioritize relevant site exposure pathways.
3) Identify data gaps (in existing site characterization data) that must be satisfied to support decisions.

2.1.2 Key Elements of CSM

Key elements of the CSM include:

1) Site setting and boundaries
2) Geologic and hydrogeologic conditions
3) Source(s) of chemical release
4) Chemicals of concern
5) Contaminant transport pathways from the site
6) Exposure pathways for human and ecological receptors
7) VOC plume boundaries
8) Voluntary remedial actions implemented to date
9) Performance metrics

The CSM forms the basis for organizing all site data, testing the efficacy of proposed data collection efforts going forward, and ultimately, testing performance of proposed and

implemented remedies. As such, the CSM must be developed to reflect the best interpretation of all relevant site data at any given time. As new data are collected, they are to be tested for consistency with the CSM and the CSM modified as appropriate. The CSM is intended to evolve with our understanding of the site through collection of additional data and performance monitoring of remedial measures.

A CSM has been developed for the site that discusses the key elements listed above based on data collected during voluntary site investigations and remedial actions. The elements of the CSM are discussed in detail in the Historical Summary Report (CALIBRE 2008) and summarized in Table 2-1. A graphical representation of the CSM is shown in Figure 2-1.

2.2 Data Gaps Identified Using Data Quality Objectives Process

A DQO process was used to define project objectives and corresponding data requirements. The DQO process was structured around the following steps:

1) Define the problem statement/objectives.
2) Define the boundaries of the study.
3) Identify anticipated project decisions that must be made in order to select the best response for the defined problem.
4) Identify the data necessary to make those decisions (including a review of existing data and summary of other data necessary for a decision).
5) Identify data gaps within the existing data that must be addressed to make the decisions from 3) above.
6) Identify the preliminary decision criteria/thresholds that can be used to formulate decision rules linking actions to the outcome of efforts to fill data gaps identified in 5) above.

A review of the existing project data was conducted and used to identify existing data that can be used to support decisions defined in 3) above. The DQO process applied to the EMF site is summarized in Table 2-2.

2.2.1 Problem Statement

The site characterization data, exposure pathways, and ARARs were used to develop a conceptual site model (CSM). As reflected in the CSM, the historical site data indicated that the contamination in the EMF plume at the point of discharge had reached concentrations in excess of ARARs and remedial action was required to meet those ARARs. The site remedy needs to address contamination in a way that ensures there are no unacceptable risks and ARARs are met.

2.2.2 Boundaries of the Study

The boundaries of the study (necessary to define the DQOs) are that portion of the Duwamish valley watershed that is impacted by releases from the EMF facility from the EMF property to the discharge point (or points, if more than one discharge location are found to exist) at the LDW.

2.2.3 Key Decisions

Evaluation of the likely considerations/outcomes of the problem statement indicates the following key decisions are needed to resolve the problem:

1. Does the VOC plume represent a potential exposure risk at the discharge point which exceeds ARARs or other TBCs?
2. Have all sources contributing to the plume been identified; specifically are there other locations/ properties with releases that have comingled with the EMF CVOC plume?
3. Are there areas of the EMF CVOC plume in excess of ARARs that have not been or are not being addressed with ongoing remedial actions?
4. Have the source control actions implemented at the EMF property (or other properties if other sources exist) been sufficient to mitigate the risks from the plume migration from the source?
5. Are other exposure pathways (indoor air and storm drains) complete pathways?
6. Can the existing treatment process selected in the MTCA RI/FS and implemented in the MTCA RA be translated to wider areas of the plume not yet addressed, or are other remedial actions more appropriate?
7. Does the voluntary MTCA remedial action as implemented, have unintended adverse impacts (e.g., mobilization of metals)? If adverse impacts are expected, can they be mitigated?

Table 2-1 Summary of Conceptual Site Model EMF VOC Plume		
CSM Elements	Conditions Considered Within CSM	Basis
Setting and Boundaries	• Former Electronics Manufacturing Facility (EMF) located on east side of KCIA. The down gradient boundary is presumed to be the Lower Duwamish Waterway (LDW). • Present land use as an airport (KCIA), air transport facility, aircraft delivery center, and industrial manufacturing; similar projected land use in foreseeable future.	Zoning, present and projected future land uses.
Geology and Hydrogeology	• Alluvium within river valley, interbedded silts and sands. Locally, silty sand/sand to ~45 to 50 feet bgs, underlain by unit with relatively fine-grained silt. Beneath the low permeability unit is a silty/sand- sandy/silt unit forming another (deeper) water-bearing zone. • Groundwater flows towards and discharges to LDW. Deeper brackish groundwater affects flow and vertical mixing. Hydraulic conductivity (K) is 400 ft/day based on aquifer pumping test. In shallow zone, the gradient (i) has been measured at 0.001 ft/ft, with a calculated groundwater pore velocity of 450 ft/year (based on K, i, and porosity). These velocities/fluxes apply solely to the interval of the EMF VOC plume. A limited tracer test was conducted as part of the ERD pilot (PPC 2004) which indicated a similar velocity: (0.8 ft/day < groundwater velocity <1.2 ft/day).	Regional studies, EMF site and plume characterization, hydrogeologic characterization studies within Boeing Plant 2.
	• The flow path of the plume has been mapped in multiple transects and appears to bend north due the regional recharge (the upper area on Beacon Hill directed into the aquifer approximately 1000 ft south of the EMF Site) and then discharges roughly perpendicular to the LDW.	Tracing the plume flow path (the center of mass) across the Duwamish Valley. Results are consistent with the 3-D Duwamish flow model (Fabritz et al 1998).

Table 2-1 Summary of Conceptual Site Model EMF VOC Plume		
CSM Elements	Conditions Considered Within CSM	Basis
Source(s) of Chemical Release	• Release of hazardous substances identified in 1982. TCE and hexavalent chromium released from supply and return lines for storage tanks and sumps in plating process within the building at the EMF property. • Other releases investigated (as reported in 1997 MTCA RI report): TPH (from USTs) and PCBs (from transformers) at relatively low levels. TPH and PCBs addressed during 1997 removal action to current MTCA Method A (residential) levels, chromium below MTCA standards (inclusive of both human and ecological exposure criteria). • Recent data (monitoring wells in the Fire Station transect) indicate a new toluene plume in groundwater is arriving in the area from an unknown up gradient source. Historical data demonstrate that a toluene source was not present at the EMF property (~ 1997 to 2001) and recent data indicates increasing toluene concentrations in the Fire Station area (from prior non-detect levels). The new plume appears to be toluene without any other aromatic compounds (i.e., other constituents commonly associated with fuel are not present). The source is unknown.	Known materials used in plating processes, spills known/reported, other suspect areas investigated in MTCA voluntary RI. Soil and water sampling from throughout the EMF property between 1996 to 2000, and monitoring data from 4 transects from EMF to the Fire Station.
Chemicals of Concern	• TCE and degradation daughter products, 1,2-DCE and vinyl chloride and toluene. Concentrations of vinyl chloride detected above AWQCs near LDW. All toluene levels detected in the new plume have been below the AWQC (for toluene). • Others COCs considered: TPH in soil removed to below MTCA Method A levels for residential land use; Sampling conducted in the 1997 MTCA RI indicated all locations with PCBs and metals in soil below MTCA standards for residential land use. Other considerations evaluated include leaching from soil to groundwater and discharge to LDW. Recent groundwater samples for metals analysis from the area of the VOC plume indicates all analytes below AWQCs (inclusive of both human and ecological exposure criteria). See Tables, 2-3 2-4, and 2-5 for summary of other analytes detected in soil and groundwater along with applicable ARARs used for comparison.	MTCA RI data and comparison with MTCA risk based standards. Groundwater monitoring in locations throughout the defined VOC plume footprint has included analysis for metals in groundwater.

Table 2-1 Summary of Conceptual Site Model EMF VOC Plume		
CSM Elements	Conditions Considered Within CSM	Basis
Transport Pathways	• Primary transport from source area is through groundwater. Key processes include: - Groundwater velocity (~450 ft/yr) - Adsorption/retardation (K_d =0.3 L/kg, R_d = 2.4 for TCE; K_d =0.07 L/kg, R_d = 1.4 for cis-1,2-DCE and K_d =0.04 L/kg, R_d = 1.2 for vinyl chloride) - Degradation via reductive dechlorination (degradation life, $T_{½}$= 19 months prior to ERD; 0.7 months after ERD implementation). - Tidally-enhanced dispersion (within groundwater) prior to point of discharge (dispersion-attenuation factor, DAF, of 50:1 in groundwater before surface water discharge based on modeling evaluation). • Other pathways considered include soil vapor, soil contact and migration through storm water conveyance system. These have not been considered significant due to the stratified nature of the VOC plume (i.e., clean water of approximate thickness of 20 feet is present above the plume).	Shallow groundwater with stratified VOC plume; measured fraction organic carbon in soil; baseline degradation and ERD pilot test results; Modeling of flux at tidal boundary and pore-water sampling in LDW. Stratified plume is bounded by clean water; from water table down to a depth of 20 ft below water table.
Exposure Pathways	• Discharge of groundwater to the Lower Duwamish Waterway is considered to be the primary exposure pathway at the site. Groundwater is not a source of potable water. The LDW is saline and not a potable source of water. Exposure pathway for human health risk is expected to be (primarily) ingestion of fish from the Duwamish Waterway. • Incomplete exposure pathways include soil, soil vapor, and surface water drainage and are not significant due to stratified VOC plume	Site setting and land use, hydrogeology, MTCA RI data, stratified VOC plume.

Table 2-1 Summary of Conceptual Site Model EMF VOC Plume		
CSM Elements	Conditions Considered Within CSM	Basis
VOC Plume Boundaries	• The lower boundary is the relatively fine-grained silt layer at a depth of ~45 to 50 feet bgs. The upper boundary is the upper sand layer at a depth of ~30 feet bgs. Deeper samples collected at the EMF property (Geoprobe samples) indicated non-detect for VOCs at ~ 55 feet bgs). • From the EMF property across KCIA (~ 1,950 ft of travel distance) the plume width had been defined by the location of wells with VOC concentrations near or below AWQCs. Deeper samples collected from a monitoring well on the west side of KCIA continue to indicate non-detect for VOCs (EMFWF-37 at 65 ft bgs). Recent sampling (August 2009) from the south end of the plume bounding well (at the Fire Station area) indicated increased vinyl chloride levels (up to 51 ug/l). • Within Plant 2, the plume boundaries have been defined with direct push (Geoprobe) samples (one-time sample, but multiple events implemented). The plume width is estimated to be ~200 to 400 feet wide west of KCIA and beneath Boeing Plant 2. • The plume is primarily present in a discrete stratum between depths of approximately 35 and 50 feet bgs (except see note below) with very little spreading or dispersion as it moves toward the Duwamish. Some Geoprobe samples indicate a potential for slightly deeper contamination, however, the Geoprobe sampling method is prone to carry-down problems associated with pushing a sampling probe through the plume to collect a sample beneath it (including multiple sequences of the rods pushed through and extracted from the hole). Within the center of the plume, some of the deeper Geoprobe samples and the deeper monitoring well (EMFWF-37 discussed above) are non detect for VOCs. • Seven deeper sampling points located at the LDW indicate that some portion of the VOC plume may have migrated to a deeper area (~ 65 ft bgs) in a small area near the LDW (one of the 7 points was above the AWQC for vinyl chloride). All up-gradient data (approximately 20+ samples) did not indicate a deeper plume.	Previous investigations, hydrogeology, multiple transects across EMF VOC plume.
Remedial Actions Implemented to Date	• 1982-1985: Removal action at source area (soil and groundwater) • 1997: Removal actions (TPH in soil) and start of in-well stripping at EMF property (including DNAPL recovery) • 2000-2002: Chemical oxidation at source area • 2003-2004: ERD pilot study within down gradient plume • 2005-2009: ERD full-scale implementation throughout VOC plume	1982 and 1985 RAs implemented as Interim Remedial Measures when release was found. Actions from 1997 to 2009 have been selected following a MTCA Voluntary FS.

Table 2-1 Summary of Conceptual Site Model EMF VOC Plume		
CSM Elements	Conditions Considered Within CSM	Basis
Performance metrics	• Soil removals focused on MTCA Method A levels (residential cleanup standards) – Confirmation monitoring with 1997 removal actions indicated cleanup standard were met. • AWQCs have been used as groundwater cleanup goals based on ARARs, site setting, and exposure pathways. • Initial sampling in groundwater (just prior to LDW discharge) indicated VOCs above AWQCs. • Significant decrease in VOC concentrations in source area and down gradient areas (concurrent increase in ethene/ethane concentrations demonstrates destruction through ERD process). • The last 7 rounds of sampling (July 2006 - August 2009) have indicated all VOCs below AWQCs at the last monitoring well located just up gradient of the LDW discharge point. • Estimated ERD degradation rate constant (after ERD treatment) of 0.031 ($days^{-1}$), corresponding to a half life of 0.7 months. • Consideration of other potential impacts (such as potential mobilization of metals through ERD).	Confirmational sampling ARARs Site characterization Performance monitoring Performance monitoring MTCA FS and design Performance monitoring

TABLE 2-2 Data Quality Objectives (DQO) Process and Data Summary

DQO process step	**Application to EMF VOC Plume**	**Existing Data**	**Additional Data Required to Support EE/CA and Select Remedial Action (or, if chosen, optimize Remedial Actions presently underway)**
The problem to be resolved at the site	Contamination is present above ARARs in EMF VOC plume. The site remedial action needs to address contamination in a way that ensures against any unacceptable risks and meet ARARs.	Conceptual model, degradation processes, exposure pathways, water quality data throughout plume, point of discharge, RA implemented and ARARs defined.	No other data required to determine if problem exists: ARARs are established and site characterization data (groundwater and pore-water data) exceeded standards. The approach to meet ARARs has been developed and implemented, it must be monitored to verify performance.
The boundaries of the study	EMF VOC Plume Horizontal and vertical boundaries Discharge point to Waterway Other potential exposure pathways (storm drains and vapor intrusion)	Water quality data throughout plume, the plume pathway is established (defined by the VOC plume footprint as a definitive tracer). The data indicate a very predictable plume pattern, Gaussian shape with symmetrical spread around highest concentration. Plume is highly stratified (no contamination, or very limited at elevations above 25 ft bgs, exposure via shallow groundwater pathways is unlikely).	Definition of discharge conditions at waterway (including evaluation of potential for a deeper plume). Shallow groundwater data at structures. As-built depths of storm drains.
The decisions needed to resolve the problem	1) Does the VOC plume represent a potential exposure risk at point of discharge?	Release occurred to the environment (soil, groundwater, surface water), existing water quality data throughout plume, pore-water sampling conducted by EPA, the existing data define the VOC plume path, groundwater concentrations above AWQCs exist.	Discharge to LDW; exactly where and at what concentration. Definition of discharge at waterway (position/location, width, depth, concentration).
	2) Have all sources contributing to the plume been identified; specifically are there other locations/properties with releases that have comingled with the EMF CVOC plume?	Soil and water sampling from throughout the EMF property between 1996 to 2000, monitoring data from 4 transects from EMF to the Fire Station, monitoring of transect wells (quarterly to bi-annual) from 1997 to 2009.	Review of known release sites in nearby areas, sampling to establish or refute flow path from source to EMF plume
	3) Are there other unknown areas of the EMF CVOC plume in excess of ARARs?	The plume has migrated southwest towards the Duwamish Waterway. The flow path of the plume has been established (the VOC data represent an approximate 40 year groundwater flow path and are definitive tracer data). The data for several years indicated a predictable plume pattern (Gaussian shape with symmetrical spread around the highest concentration). Recent sampling (2009) has indicated increasing CVOC concentrations outside of the prior plume boundaries and the arrival of a new toluene plume.	Plume boundaries (to applicable cleanup standards) where exposure may occur. Limited additional grab samples (one-time Geoprobe sampling) down gradient of and south of EMF property to verify plume boundaries and other potential sources

TABLE 2-2 (Continued)

DQO process step	Application to EMF VOC Plume	Existing Data	Additional Data Required to Support EE/CA and Select Remedial Action (or, if chosen, optimize Remedial Actions presently underway)
The decisions needed to resolve the problem	4) Have the source control actions implemented at the EMF property (or other properties, if applicable) been sufficient to mitigate the risks from the plume migration from the source?	Water quality monitoring from the wells throughout the EMF property for VOCs.	Continued performance monitoring. Identification of other sources, if they exist, and monitoring near those sources.
	5) Are other exposure pathways (indoor air and, storm drains) complete pathways?	Characterization data from MTCA RI (8 plume transects and subsequent wells) show stratified plume with no exposure potential to COCs in shallow groundwater.	As-built depths of storm drains
	6) Can the existing treatment processes selected in the MTCA RI/FS & implemented in the MTCA RA be translated to wider areas of plume (i.e., are there any fatal flaws that would suggest that the RAs implemented cannot meet the goals?	1) ISCO IRA at source has resulted in 98% to 99% reduction in VOCs in immediate down gradient well (the prior down gradient hot spot). 2) ERD (pilot and full scale) in multiple areas has reached non-detect levels in down gradient wells.	Characterize those areas (edges of plume near cleanup standards), monitor performance. Added sampling from selected locations/depths in source area to evaluate source control effectiveness.
	7) Does the RA, as implemented, have unintended adverse impacts (e.g., mobilization of metals)? If adverse impacts are expected can they be mitigated?	Monitoring of water quality from ERD pilot test and full scale implementation. Additional recent sampling for Priority Pollutant metals.	Evaluation of existing metals data from targeted areas throughout plume, if existing data demonstrate an unintended adverse impacts develop options to mitigate risk.
The inputs to the decision	Nature and extent of plume above AWQCs/final cleanup goals necessary to establish exposure pathways	Existing water quality data throughout plume defining horizontal and vertical extent (EMF site data, KCIA data, Plant 2 data).	Definition of discharge at waterway, attenuation processes from boundary wells to waterway (EPA pore water sampling and tidally-enhanced dispersion)
	Concentration of Contaminants of Concern (COCs) at the discharge.	Existing water quality data at discharge point	

TABLE 2-2 (Continued)

The decision rules	If ../ then… format with quantitative limits: 1) If VOC discharge is > AWQCs/final cleanup goals, then discharge to waterway is occurring and must be addressed; evaluate options for control (completed in prior MTCA RI/FS and to be reconsidered in the EE/CA) and implement actions. 2) If remedy selected (in prior FS and re-evaluated in the EE/CA) can meet the AWQCs/final cleanup goals, then expand remedy, implement and monitor performance. 3) The EE/CA will evaluate various response actions and if the remedy selected (in prior MTCA FS) cannot meet the final cleanup goals , alternate RAs will be considered further. 4) If other exposure pathways exist (or seem likely), then characterize potential, evaluate options and implement remedial actions. 5) If vinyl chloride at the discharge boundary to the LDW is above the AWQC/final cleanup goal then additional characterization may be required to define plume boundary. 6) If VOCs in existing boundary of mapped plume is > AWQCs/final cleanup goals and the shape does not follow an expected Gaussian plume pattern in the mapped plume, then flow path/condition may be different than anticipated and must be addressed through additional characterization to define plume boundary, sources, and appropriate RA.

TABLE 2-3 Summary of Other Potential COCs Detected in Soil in 1997 MTCA RI and Criteria Used for Comparison Evaluation

Analyte	Units	Maximum value detected in EMF MTCA RI	MTCA A	MTCA B considerations			Risk Based Comparison Criteria (RBCC)	ARAR	Statute (all from WAC)	Basis
				Residential contact	Eq. 747 leaching to GW**	90% of natural back-ground				
PCBs	mg/kg	0.57	1	0.5	2	NA	0.5	0.5(1)	173-340-705	residential contact
TPH-heavy oil	mg/kg	196 (2)	2,000	NA	NA	NA	2,000	2,000	173-340-747	MTCA cleanup level to protect groundwater
Copper	mg/kg	29	NA	3,000	1.38	36	36	36	173-340-705	90% of background range
Chromium (VI)	mg/kg	0.22 U to 0.28 U	19	240	4.2	NA	4.2	4.2	173-340-747	leaching impacts to groundwater and discharge to surface water
Chromium (total)	mg/kg	22.8	2,000	120,000	1,480(3)	48	1,480	1,480	173-340-747	leaching impacts to groundwater and discharge to surface water
Arsenic	mg/kg	13	20	0.67	0.08	7.3	7.3	7.3(4)	173-340-705	90% of natural background range, this does not consider the area- background range (5)
Zinc	mg/kg	82	NA	24,000	101	85	101	101	173-340-747	leaching impacts to groundwater and discharge to surface water
Nickel	mg/kg	30	NA	1,600	11	48	48	48	173-340-705	90% of background range
Lead	mg/kg	38	250	250	500	24	250	250	173-340-705	residential contact
Cadmium	mg/kg	0.5	2	80	0.034	1.2	1.2	1.2	173-340-705	90% of background range
Mercury	mg/kg	0.45	2	24	0.80	0.07	0.80	0.80	173-340-747	leaching impacts to groundwater and discharge to surface water
Trichloroethene	mg/kg	50.5	0.03	11	0.034	NA	0.034	0.034	173-340-747	leaching impacts to groundwater and discharge to surface water
cis-1,2-Dichloroethene	mg/kg	0.86		800	50	NA	23	50	173-340-747	leaching impacts to groundwater and discharge to surface water
trans-1,2-Dichloroethene	mg/kg	0.13		1,600	54	NA	34	54	173-340-747	leaching impacts to groundwater and discharge to surface water
Vinyl Chloride	mg/kg	0.028 U		0.67	0.015	NA	0.015	0.015	173-340-747	leaching impacts to groundwater and discharge to surface water

See all footnotes on following pages

[1] Only one soil sample at the EMF exceeded this RBCC. However, this surface soil sample (SB-EMF21-0005) was excavated at the time of a MTCA TPH removal in the source area. Although removal and confirmation was for TPH, the excavation in this portion of Excavation Area 1 was to three and a half feet below ground surface. A deeper (three feet bgs) PCB sample collected from this same boring (SB-EMF21-003) also met the comparison criteria (<0.5 mg/kg PCBs) and was excavated during the MTCA TPH removal action. All remaining EMF soil sample results are below this comparison criteria. The comparison criteria listed is from MTCA method B formulas, but following WAC 173-340-705 the cleanup criterion is to be based on existing promulgated standards if they are sufficiently protective, as presented in MTCA method A.

[2] TPH data represent confirmational sampling after removal action, initial values up to 3,000 mg/kg were detected hence removal action was implemented, MTCA soil criteria at that time was 200 mg/kg TPH.

[3] MTCA criteria listed/used for evaluation are for chromium III.

[4] Only one soil sample at the EMF exceeds this RBCC - SB-EMF03-004 with an arsenic result of 13 mg/Kg. This sample from four feet bgs is between a shallower and deeper sample from the same boring that are non-detect at 6 mg/Kg (SB-EMF03-002.5 and SB-EMF03-006). All remaining soil arsenic results are non-detect or below 7.3 mg/Kg and more than ten samples were collected. Presuming a natural background cleanup level of 7.3 mg/Kg, with no action, the site already meets the stricter criteria in WAC for determining a site is clean:
WAC 173-340-740 (7) (e) All data analysis methods used, including those specified in state and federal law, must meet the following requirements:

(i) No single sample concentration shall be greater than two times the soil cleanup level. Higher exceedances to control false positive error rates at five percent may be approved by the department when the cleanup level is based on background concentrations; and

(ii) Less than ten percent of the sample concentrations shall exceed the soil cleanup level. Higher exceedances to control false positive error rates at five percent may be approved by the department when the cleanup level is based on background concentrations.

[5] The property lies within the path of the Tacoma smelter plume. Recent sampling reported by Ecology (2002) indicated an average arsenic level of 32.9 mg/kg (surficial soil) in King County (within the footprint of the Tacoma smelter plume).

**	PCBs	based on 0.1 ug/L PCBs in groundwater (the PQL) and Koc of 822,422
**	Copper	based on 3.1 ug/L Cu in water, and Kd of 22 L/kg
**	chromium (VI)	based on 11 ug/L Cr+6 in water, and Kd of 19 L/kg
**	Chromium	based on 74 ug/L Cr in water, and Kd of 1,000 L/kg
**	Arsenic	based on 0.14 ug/L As in water, and Kd of 29 L/kg
**	Zinc	based on 81 ug/L Zn in water, and Kd of 62 L/kg
**	Nickel	based on 8.2 ug/L Ni in water, and Kd of 65 L/kg
**	Lead	based on 2.5 ug/L Pb in water, and Kd of 10,000 L/kg
**	Cadmium	based on 0.25 ug/L Cd in water and Kd of 6.7 L/kg
**	Mercury	based on 0.77 ug/L Hg in water and Kd of 52 L/kg. Water quality standards for mercury in Washington State surface waters for the protection of aquatic organisms are 0.012 ug/L for fresh water and 0.025 ug/L for marine water (Table 240(3) of WAC 173-201A-240). Calculated soil concentrations

		protective of groundwater and ultimately protective of these surface water criteria are much lower than the maximum mercury detected in EMF soils.
**	Trichloroethene	based on 5.2 ug/L TCE in groundwater (modified MTCA B surface water value based on fish consumption calculated using a BCF of 14.1) and Koc of 94
**	cis-1,2-Dichloroethene	based on the 10,000 ug/L AWQC for trans isomer (trans-1,2-DCE) and a Koc of 36 to calculate a 50 mg/kg soil leaching to groundwater value. The lower RBCC value is based on 4,500 ug/L (modified MTCA B surface water value based on fish consumption calculated using a BCF of 5.79) and Koc of 36.
**	trans-1,2-Dichloroethene	The lower RBCC value is a leaching to groundwater value that is based on 6,300 ug/L (modified MTCA B surface water value based on fish consumption calculated using a BCF of 8.26) and Koc of 38.
**	Vinyl Chloride	based on 2.4 ug/L VC in groundwater (the AWQC) and Koc of 19

TABLE 2-4 Summary of Metals and VOCs detected in Site/Plume Groundwater and ARAR used for Evaluation

Date	EMF Well ID	Parameter	Plant 2 screening Level ug/L		Value ug/L	Data flags	Risk Based Screening Criteria ug/L	ARAR** ug/L	Basis (See footnotes)	Other Notes
9/15/06	EMF-WF-26	Antimony	5.13E+02	Total	<50	U	640	640	1	
9/15/06	EMF-WF-29			Dissolved	<50	U	640	640		
9/15/06	EMF-WF-26	Arsenic	1.94E-02	Total	3.5		8	8	2	
9/15/06	EMF-WF-26			Dissolved	1.1		8	8		
1/30/08	EMF-WF-32	Beryllium	1.35E+02	Total	<.2	U	273	273	3	All samples <DL
1/30/08	EMF-WF-32			Dissolved	<.2	U				
7/26/07	EMF-WF-32	Cadmium	8.80E+00	Total	<2	U	8.8	8.8	4	All samples <DL
7/26/07	EMF-WF-32			Dissolved	<2	U	8.8	8.8		
1/30/08	EMF-WF-32	Chromium		Total	<5	U	50	50	4	All samples <DL
1/30/08	EMF-WF-32			Dissolved	<5	U	50	50		
9/15/06	EMF-WF-29	Copper	3.10E+00	Total	4		8	8	2	
9/15/06	EMF-WF-29			Dissolved	2		8	8		
1/30/08	EMF-WF-32	Copper	3.10E+00	Total	1.6		8	8		
1/30/08	EMF-WF-32			Dissolved	<0.5	U	8	8		
1/30/08	EMF-WF-32	Lead	8.10E+00	Total	<1	U	2.5	2.5	4	All samples <DL
1/30/08	EMF-WF-32			Dissolved	<1	U	2.5	2.5		
1/29/08	EMF-WF-29	Manganese	1.00E+02	Total	764			-	5	
1/29/08	EMF-WF-29			Dissolved	725			-		
7/25/07	EMF-WF-33	Manganese	1.00E+02	Total	2,410			-		
7/25/07	EMF-WF-33			Dissolved	2,380			-		
1/30/08	EMF-WF-32	Manganese	1.00E+02	Total	1,050			-		
1/30/08	EMF-WF-32			Dissolved	977			-		
1/30/08	EMF-WF-32	Mercury	2.50E-02	Total	<0.1	U	0.77	0.77	4	All samples <DL
1/30/08	EMF-WF-32			Dissolved	<0.1	U	0.77	0.77		
7/26/07	EMF-WF-32	Nickel	8.20E+00	Total	1.2		8.2	8.2	4	
7/26/07	EMF-WF-32			Dissolved	0.8		8.2	8.2		
1/30/08	EMF-WF-32	Nickel	8.20E+00	Total	1		8.2	8.2		
1/30/08	EMF-WF-32			Dissolved	0.6		8.2	8.2		
7/25/07	EMF-WF-33	Nickel	8.20E+00	Total	4.4		8.2	8.2		
7/25/07	EMF-WF-33			Dissolved	0.6		8.2	8.2		
1/30/08	EMF-WF-32	Selenium	7.10E+01	Total	<50	U	5	5.0	4	
1/30/08	EMF-WF-32			Dissolved	<50	U	5	5.0		
1/30/08	EMF-WF-32	Silver	1.90E+00	Total	<0.2	U	1.9	1.9	4	All samples <DL
1/30/08	EMF-WF-32			Dissolved	<0.2	U	1.9	1.9		
1/30/08	EMF-WF-32	Thallium	4.70E-01	Total	<0.2	U	.47	0.47	1	All samples <DL
1/30/08	EMF-WF-32			Dissolved	<0.2	U	.47	0.47		
7/26/07	EMF-WF-32	Zinc	8.10E+01	Total	30		81	81	4	
7/26/07	EMF-WF-32			Dissolved	10	U	81	81		
		Trichloroethene	3.02E-01				5.2 (7)	30	1	
		cis-1,2-Dichloroethene	1.55E+03				4,500 (7)	10,000	8	
		trans-1,2-Dichloroethene	1.00E+04				6,300 (7)	10,000	1	
		Vinyl Chloride	7.31E-01				2.4	2.4	1	
		Toluene	1.50E+04				8,700 (7)	15,000	1	

See all footnotes on following page

** The ARARs listed are based on the Duwamish Waterway and the Duwamish Valley aquifer being considered as nonpotable, final cleanup levels may be different if the affected water bodies or groundwater are determined to represent a potable supply. The evaluation of groundwater potability will follow the MTCA criteria in WAC 173-340-720.

1 National recommended Water Quality criteria, based on consumption of fish/organisms
2 Naturally occurring background
3 MTCA Method B (surface water based on consumption of fish/organisms)
4 National recommended Water Quality criteria, based on protection of organisms
5 See discussion in text regarding manganese and expected range of background values
6 Plant 2 screening levels for groundwater based on 2003 CMS report and 2006 Background Study
7 Modified MTCA Method B (surface water based on consumption of fish/organisms) modified to use the BCF from The Hazardous Waste Companion Database to the Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities, Final. (EPA520-R-05-006).
8 The AWQC for trans-1,2-DCE (a different isomer of 1, 2 DCE) is used as a surrogate for cis-1,2-DCE.

TABLE 2-5 Summary of Other Potential COCs Detected in Soil, Screening Levels and Cleanup Criteria Used as ARAR for Evaluation

Analyte	CAS #	Plant 2 2004 Screening Levels[1] (mg/kg)	EPA Screening Levels[2] (mg/kg)		MTCA[3]				Risk-based Screening Criteria (mg/kg)	Applicable ARARs [4] (mg/kg)
			Residential Soil	Industrial Soil	Soil Method A, Industrial Land Use, Table Value (mg/kg)	Soil, Method A, Unrestricted Land Use, Table Value (mg/kg)	Soil, Method B, Standard Formula Value, Direct Contact (ingestion only), unrestricted land use (mg/kg)	Soil, Method C, Standard Formula Value, Direct Contact (ingestion only), industrial land use (mg/kg)		
Arsenic	7440-38-2	7.3	0.39	1.6	20	20	0.67	88	7.3	7.3
cadmium in soil	7440-43-9a	1.2	70	800	2	2	80	3,500	1.2	1.2
chromium (total)	7440-47-3	na	na	na	na	na	na	na	1,480	1,480
chromium (III)	16065-83-1	na	120,000	na	2,000	2,000	120,000	na	1,480	1,480
chromium(VI)	18540-29-9	19	0.29	5.6	19	19	240	11,000	4.2	4.2
Copper	7440-50-8	36	3,100	41,000	na	na	3,000	130,000	36	36
Zinc	7440-66-6	100	23,000	310,000	na	na	24,000	na	101	101
Lead	7439-92-1	1,000	400	800	1000	250	na	na	250	250
mercury (elemental)	7439-97-6	na	5.6	34	2	2	24	1,100	0.8	0.8
mercury (mercuric chloride)	7487-94-7	0.07	23	310	na	na	24	1,100	24	24
nickel soluble salts	7440-02-0	48	1,500	20,000	na	na	1,600	70,000	48	48
Polychlorinated Biphenyls										
PCB Mixtures	1336-36-3	0.033	na	na	10	1	.5	66	0.5	0.5
Polychlorinated Biphenyls (high risk)	1336-36-3	na	0.22	0.74	na	na	na	na	na	na
Polychlorinated Biphenyls (low risk)	1336-36-3	na	na	na	na	na	na	na	na	na
	53469-21-9	0.033	0.22	0.74	na	na	na	na	0.5 (7)	na
aroclor 1242	11097-69-1	0.033	0.22	0.74	na	na	1.6	70	0.5 (7)	1.6
aroclor 1254	11096-82-5	0.033	0.22	0.74	na	na	na	na	0.5 (7)	na
aroclor 1260										
TPH, heavy oils	na	2,000	na	na	2,000	2,000	na	na		2,000 [5]
Trichloroethene[6]	79-01-6	0.002	2.8	14	na	0.03	11	1,100 [8]	0.034	0.034
cis-1,2-Dichloroethene	156-59-2	79	780	10,000	na	na	800	35,000	23	50
trans-1,2-Dichloroethene	156-60-5	0.9	150	690	na	na	1,600	70,000	34	54
Vinyl Chloride	75-01-4	0.0046	0.06	1.7	na	na	0.67	88	0.015	0.015

See all footnotes on following page

1. Plant 2- 2004 Screening Levels
2. Soil Screening Levels (SSLs), developed by EPA; copied from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/xls/master_sl_table_run_MAY2010.xls downloaded as of Sept 2010): carcinogenic compounds based on 10^{-6} risk, non carcinogenic compounds based on HQ = 1.0; other HQ's may be used (e.g., 0.1) for other screening purposes.
3. MTCA Cleanup Levels and Risk Calculations (CLARC) tool, Washington Department of Ecology; https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx (run date 16 July 2008)
4. Applicable ARARs are based on the minimum applicable ARAR from this Table and values from Table 2-3.
5. Applicable ARAR based on MTCA Method A level for industrial land use because Method C level not available.
6. Different groups/databases noted above use different cancer potency factors for TCE: EPA Regional Screening Levels use oral cancer potency factor of 0.0059 kg-dy/mg (from CalEPA 2009 public health goals for TCE in drinking water), Ecology CLARC database uses a provisional oral cancer potency factor of 0.09 kg-dy/mg.
7. Based on MTCA Method B criteria for total PCBs
8. This MTCA Method C value (TCE, industrial land use direct contact (ingestion only) is based on noncarcinogenic effects which results in lower criterion than carcinogenic effects)

na. Not Available or exceeds 1 E+6 ppm

The data presented in Table 2-3 are the soil sampling data from the EMF property representing the highest concentration detected for each of the analytes (from the 1996 MTCA RI and subsequent voluntary MTCA cleanup actions implemented). The data are compared with cleanup criteria identified as the applicable ARARs (pursuant to procedures defined in the MTCA and the NCP). The footnotes listed at the bottom of Table 2-3 define the water quality criteria (based on exposure routes and beneficial use of groundwater discharging to the LDW) and specific leaching parameters used in the MTCA procedures established to predict the impacts of chemicals in soil leaching to groundwater (Equation 747-1, defined in WAC 173-340-747). For all of metals analysis, PCB and TPH analysis, the maximum detected values are less than the applicable ARARs. Based on the prior MTCA RI work (voluntary), the ARARS and this analysis, these compounds have not been considered further as COCs.

Boeing has sampled selected wells throughout the EMF VOC for Priority Pollutant metals starting in 2006 (initially based on data needs suggested by EPA before the Settlement Agreement). The selected wells, all within the VOC plume, extend from the EMF property to North Boeing Field on the west side of KCIA and through Plant 2 to the discharge point at the LDW. The data presented in Table 2-4 represent the highest concentration detected for each analyte (four sampling events from 2006 to 2008) from the wells sampled (along with other selected data as appropriate).

The measured concentrations are compared with cleanup criteria believed to be the applicable ARARs (pursuant to procedures defined in the MTCA and the NCP). The footnotes listed at the bottom of Table 2-4 define the specific ARARs used to set water quality criteria as the cleanup levels. Based on this sampling throughout the EMF plume, the ARARs and this analysis, these compounds (i.e., metals) have not been considered further as COCs.

For one compound listed, manganese, an applicable ARAR and corresponding water quality criteria was not identified. Manganese is a naturally occurring element in soil (representing approximately 0.1% of the earth's crust), and exists in multiple valence states (Mn^{+2}, Mn^{+3}, Mn^{+4}). The area of the EMF plume, as well as most of the Duwamish Valley, is known to have low dissolved oxygen and reducing groundwater conditions. The shallow aquifer contains abundant natural organic material within silty layers that are interbedded within the sandy aquifer. These materials, native from the former tideflat condition, deplete oxygen through natural biological oxygen demand. The reducing groundwater conditions tend to mobilize naturally occurring manganese (from soil) into a dissolved phase.

Manganese was not included in the 1989 Ecology study to define the range of naturally occurring background conditions in groundwater (PTI, 1989). Manganese in soil was included in the 1994 Ecology study regarding natural background of metals in soil (Ecology 1994). The 1994 Ecology data reported the following for statistics for naturally occurring manganese in soil in the Puget Sound Region:

The manganese data are log-normally distributed (soil data) with the following characteristics:

Mean	590 mg/kg
Median	470 mg/kg
90% of range	1,200 mg/kg

The USGS, in cooperation with Ecology, sampled 266 wells throughout the Puget Sound region in 1981 (USGS 1986) and report widespread levels of “excessive” manganese concentrations with concentrations ranging from non-detect up to 4,300 ug/L. Most wells sampled were larger water-supply wells (typically deep, with many in the 150 to 500+ ft range) and completed in areas/intervals suitable for water supply. The USGS report notes a correlation between iron and manganese (high iron levels were also found in virtually every well with high manganese levels). The authors suggest that the reducing condition in sedimentary deposits (from natural organic activity) causes the iron and manganese to be desorbed from background levels in soil.

Other recent regional data includes the Snohomish Health District summary of 347 water samples from residential wells collected between 1987 and 2003 (typically wells in 50 to 100 ft depth range). Key findings of the Snohomish County background geochemistry study was that manganese was detected in over 80% of the samples (with a maximum of 5,000 ug/L and many exceeding the secondary MCL of 50 ug/L) and the elevated levels of manganese are naturally occurring (Snohomish County 2006). Based on the existing data from the EMF sampling, MTCA procedures, and other regional data, manganese has not been considered further as a COC.

3.0 DATA GAP ANALYSIS

The data gap analysis for each decision identified in the prior Section includes the following elements:

- Description of the importance/relevance of the decision.
- Identification of the data necessary to make the decision.
- Identification and evaluation of existing data available from prior investigations/reports.
- Definition of remaining data gaps that must be filled in order to make a determination regarding the specific decision.

3.1 Key Decision #1 – Does the impact of the VOC plume result in concentrations that cause a potential exposure risk exceeding NCP risk standards or Ambient Water Quality Criteria (AWQC) for the COCs at the discharge point?

The intent of this decision is to determine if the VOC plume represents a potential exposure risk at the discharge point to the LDW. Specifically, if the VOC plume results in COC concentrations that exceed NCP risk standards or AWQCs at the discharge point, then remedial actions are necessary to mitigate that risk. This pathway (groundwater discharge to the LDW) is thought to be the primary pathway for potential exposure and this determination is likely the most important element of this project. The data required to make this determination are: Concentrations at the defined exposure points, or characterization data demonstrating an incomplete pathway.

3.1.1 Existing Site Data to Support this Determination

1) Historical site characterization data which define the VOC plume path from the source to the LDW.
2) Groundwater monitoring data from the monitoring well placed at the center of the EMF plume just up gradient from the LDW (well EMFWF-32), performance monitoring (for VOCs and dissolved gases known to be degradation by-products of TCE) indicating decreasing trends since the start of up-gradient remedial actions (voluntary), and groundwater monitoring from other wells in the immediate and nearby area of the EMF VOC plume at the LDW (including wells PL2-443A/B/C, PL2-442A/B/C, and PL2-420A/B/C).
3) Samples (for VOCs) from seeps in the vicinity of the EMF plume discharge area as reported in the RCRA Facility Investigation (RFI) (Weston 1997).
4) One pore water sample (for VOCs) from the expected zone of submarine groundwater discharge to the LDW (Lentz 2006).
5) Geoprobe sampling completed in May/June 2008 from 12 locations in the area in and around where the EMF VOC plume discharges to the LDW. Probe sample

locations and intervals included the following (oriented generally from northwest to southeast as a transect across the plume):

2-40-DP69, sampled at 10 ft bgs;
2-40-DP70, sampled at 10 ft bgs;
2-40-DP32, sampled at 10, 41 and 61 ft bgs;
2-40-DP45, sampled at 10, 19, 25, 41 and 61 ft bgs;
2-40-DP37, sampled at 10, 19, 41 and 61 ft bgs;
2-40-DP38, sampled at 19, 25, 41 and 61 ft bgs;
2-40-DP39, sampled at 10, 25, 31, 41 and 61 ft bgs;
2-40-DP40, sampled at 14, 19, 25, 41 and 61 ft bgs;
2-40-DP19, sampled at 10, 25, and 31 ft bgs;
2-40-DP41, sampled at 10, 19, 25, 31, 41 and 61 ft bgs;
2-40-DP42, sampled at 10, 19, 25, 31, 41 and 61 ft bgs; and
2-40-DP43, sampled at 10, 19, 25, 31, 41 and 61 ft bgs.

All of the locations/samples noted above were collected with a four foot screen interval on the Geoprobe and the depth noted is the top of screen (25 represents a sample from 25-29 ft bgs and 31 represents a sample from 31-35 ft bgs).

3.1.2 Evaluation of Existing Site Data

The plume mapping data to locate and define the position of the VOC plume are considered definitive and sufficient (multiple plume mapping transects were installed, wells were installed at the center of the plume based on the transect data, samples from various depths were collected, and all data clearly fit within the CSM).

Initial sampling in 2002 from monitoring well EMFWF-32 indicated vinyl chloride above the AWQC. The most recent sampling (subsequent to the initiation of up-gradient voluntary remedial actions) has indicated a decreasing trend in vinyl chloride concentrations. The last five samples from this well were below the AWQC (June 2006, January and July 2007, January and July 2008). The sampling has also demonstrated large increases in ethene and ethane concentrations, which are the expected daughter products (benign) from the enhanced reductive dechlorination (ERD) remedial action that has been implemented (voluntarily). These data would suggest that there is no longer a discharge above the AWQC near well EMFWF-32 (placed at the center of the VOC plume based on the transect data), but the performance data are limited in this area because only one well existed within the plume at this location.

The seep samples from the 1996 RFI report did detect low levels of VOCs in one location; the levels detected were below the AWQCs (i.e., the current AWQCs revised as of 2003, as well as the AWQCs at that time). However, the vertical position of these samples (presumably collected at low tide from seeps in the bank) is expected to be

above the elevation/vertical position where the EMF VOC was subsequently mapped (in the EMF plume mapping transect completed in 2002).

The pore water sample collected by EPA in November 2005 (Lentz 2006) from the zone of the submarine groundwater discharge (SGD) of the EMF VOC plume was targeted at the center of the VOC plume based on the 2002 plume mapping transect and groundwater monitoring. The concentration of vinyl chloride (5.8 ug/L) was above the AWQC for vinyl chloride (2.4 ug/L). As noted above, voluntary remedial actions have been implemented in up-gradient areas and subsequent sampling of the immediate up-gradient monitoring well (EMFWF-32) has shown significant reductions in vinyl chloride concentrations (<1 ug/L). These data indicate a historical discharge above the AWQC, but recent data indicate that concentrations have been reduced and may no longer be a discharge above the AWQC (i.e., all data from this well for the last 7 events over 3 years have been below the AWQC). This single initial EMF monitoring well near the LDW (EMFWF-32 placed at the center of the plume) has been augmented with more monitoring wells for performance assessment and monitoring.

The probe sampling completed in May/June 2008 (from 12 locations covering the area in, and around, the position where the EMF VOC plume discharges to the LDW) provides sufficient data to establish the spatial locations for new wells. The 2008 probe samples include over 40 samples in the immediate area of the EMF VOC plume near the discharge to the LDW (see Figures 4-4a and 4-4b). Four of the probe samples in the area identified VOCs above AWQCs, two of which are not likely to be associated with the EMF plume (based on the presence of TCE and location immediately adjacent to a different Plant 2 source). The wells sampled in the area (PL2-443A/B/C, PL2-444A, EMFWF-32, PL2-442 A/B/C, and PL2-420A/B/C) detected low levels of VOCs (less than 1 ug/L and all less than AWQCs) in nine of eleven wells (and the two other wells as non detect). The existing C-zone wells in the area (PL2-443C, PL2-442C and PL2-420C) provide a reasonable monitoring network to identify the base of the EMF VOC plume, but additional data are necessary to define any zones between approximately 60 ft bgs and 80 ft bgs that may have higher VOC concentrations.

3.1.3 Remaining Data Gaps Necessary to Support Determination

The 2008 probe data define the north and south boundaries of the present discharge to the LDW. The VOC plume concentration at the discharge point into the LDW has changed since 2005 because of up-gradient remedial actions (and other pre-existing degradation processes). The monitoring well network at the point up gradient of the LDW discharge has already been expanded (beyond the initial well in the center of the plume) to characterize and confirm concentrations in the plume near the discharge point.

The monitoring wells installed (based on existing data and the CSM) include clustered pairs of monitoring wells (screened at three different intervals). The monitoring well

transect at the LDW will have four locations (each with a well pair, or a group of three wells) spaced across the transect in the following areas; two locations within the central area of the plume, one located outside the northern boundary of the plume, and one located outside the southern boundary of the plume. The work already completed has included Geoprobe samples to establish appropriate well positions. In any areas/vertical zones where the initial Geoprobe samples do not sufficiently bound the VOC plume, additional Geoprobes (secondary sampling) to extend the transect width or depth will be added. Geoprobe sampling has been and will be completed prior to selecting locations for new monitoring wells. The final locations and screened intervals of all new monitoring wells will be submitted to EPA for approval EPA prior to installation. Consistent with the other monitoring wells installed in the EMF plume, the sampling frequency for new wells (installed near the LDW) and existing wells in the transect will initially start out as quarterly (8 samples over 2 years) and then subsequently be adjusted based on the results of the analytical data.

The data from the existing and newly installed deeper C zone wells will be utilized in the EE/CA to demonstrate whether the plume extends deeper and/or is not caused to extend deeper by the voluntary remedial actions.

3.2 Key Decision #2 – Have all sources contributing to the plume been identified; specifically are there other sources/properties with releases that have comingled with the EMF CVOC plume?

The intent of this decision is to determine if all relevant sources contributing to the plume have been identified so that appropriate source control actions are implemented.

3.2.1 Existing Site Data to Support this Determination

Extensive analytical data from monitoring wells and probe sample locations have been collected throughout the EMF property. Initial groundwater monitoring started at the EMF property in 1985 with more extensive sampling started in 1996. Monitoring wells were placed at the northern and southern boundaries of the plume at the EMF property. Multiple phases of probe sampling were implemented to establish the source area, flow path, and plume. Plume mapping and down gradient monitoring have been implemented in areas identified as impacted from the EMF source area.

3.2.2 Evaluation of Existing Site Data

These monitoring wells, along with the probe sampling within the plume boundaries, provide sufficient data to establish the source areas for CVOCs within the EMF property. These same sampling data did not identify a toluene source at the EMF property. However, further down gradient at the Fire Station area (approximately 1,900 feet down gradient) recent sampling data has indicated the arrival of a toluene plume starting in 2008. These results indicate comingling of the CVOC plume with a toluene

source from another location/property (i.e., outside of the monitoring network for the CVOC source at the EMF property). The toluene migration rate appears to be approximately 1.5 to 2.5 feet per day and concentrations at the Fire Station area are increasing (up to 10,000 ug/L toluene as of August 2009).

The August 2009 sampling from EMF-WF-38 (the southern bounding well for the EMF CVOC plume at the Fire Station area) also indicated an increase in vinyl chloride up to 51 ug/L. This result is inconsistent with the last 3 years of sampling in this area, as well as sampling down gradient from this location within Plant 2. These results may represent a contribution from a different source or potentially a seasonal change/shift in the EMF VOC plume.

3.2.3 Remaining Data Gaps Necessary to Support Determination

To satisfy this data gap, the source of the newly identified toluene plume (arriving at the Fire Station, but not found in the investigations at the EMF property) needs to be established. At the same time, if other CVOC sources are identified (i.e., off of the EMF property), the general location of those sources and down gradient plumes should be established.

3.3 Key Decision #3 – Are there areas of the EMF CVOC plume in excess of ARARs that are not being addressed by ongoing voluntary remedial actions?

The intent of this decision is to determine if areas of the EMF CVOC plume in excess of AWQCs are present that are not effectively treated by the current voluntary remedial action (ERD through injection wells in multiple transects throughout the plume). If groundwater data indicate that the AWQCs are exceeded, then future remedial actions may be necessary to treat those portions of the EMF plume. The data required to make this determination are analytical data to define the position of the EMF CVOC plume (at the threshold of the AWQCs, or reasonably estimated based on a predictable plume pattern and data approaching the AWQCs) at the compliance point of discharge. Additionally, further characterization is necessary for up-gradient areas where a remedial action would be implemented (ERD or other as selected in the EE/CA).

3.3.1 Existing Site Data to Support this Determination

The source of the previously mapped CVOC plume is a TCE release at the EMF property. The plume has migrated southwest towards the Duwamish Waterway. The flow path of the plume has been established (the VOC plume serves as a definitive tracer and the flow path has been mapped). The historical data indicate a highly stratified and somewhat predictable VOC plume pattern with a symmetrical spread around the highest concentration (before the start of voluntary remedial actions at EMF, NBF and in the Plant 2 area).

The recent Geoprobe sampling data from the Plant 2 area (May/June 2008, VOC data from grab samples) collected in the vicinity of the EMF plume are shown in Figure 3-1 at a 61 ft depth interval and in Figure 3-2 at the typical EMF plume interval from 30 to 45 ft bgs (typical for the predominant plume interval). The August 2009 sampling data indicate a toluene plume arriving at the Fire Station area and increased vinyl chloride concentrations at the well serving as the southern boundary of the CVOC plume.

3.3.2 Evaluation of Existing Site Data

The approximate boundaries of the VOC plume were mapped using groundwater analytical data collected from monitoring wells and direct-push borings (as a one-time direct push samples, and again more recently throughout Plant 2; initially in 2002 and again in 2008). The plume width is bounded by permanent wells at the EMF property and near East Marginal Way (west side in the 2-40's building parking lot). At the discharge to the LDW, direct-push sampling data (from plume mapping transect near LDW) fully bounded the horizontal plume limits (based on 2002 and 2008 data).

3.3.3 Remaining Data Gaps Necessary to Support Determination

Additional monitoring wells are needed to identify the plume area(s) discharging to the LDW above ARARs as defined section 3.1.3 related to Key Decision # 1. It is anticipated the remedial action selected in the EE/CA (whatever that technology choice) may require a wider, and potentially deeper, treatment zone than presently provided in the ERD Transects (Area-1, Area-2, and Area-3). Monitoring wells to define the plume boundaries within Plant 2 have been installed and sampled (as part of the Plant 2 RCRA investigation work and EMF plume monitoring).

The expanded monitoring well network in the parking lot of the 2-40 Building includes a transect of monitoring wells that span the projected width of the plume. The monitoring wells presently existing (based on existing data and the CSM) include clustered pairs of monitoring wells (screened at two different intervals). The EMF VOC plume has been characterized and mapped in significant three-dimensional detail at a position approximately 190 feet up gradient from the monitoring well transect in the 2-40 parking lot. The water level elevation and groundwater gradient has also been mapped in this area. The recent June 2008 probe data from the 2-40s parking lot area is also consistent with the prior plume boundaries and CSM. This pre-existing data has been used to establish of the position of wells within this transect. The monitoring well transect at the 2-40 Building Parking lot has four locations (each with a well pair) spaced across the transect in the following areas; two locations within the central area of the plume, one located outside the northern boundary of the plume, and one located outside the southern boundary of the plume. The monitoring well network installed by the Plant 2 RCRA team also includes deeper C zone wells in this area (~ 80 feet bgs). The data from the existing and newly installed deeper C zone wells will be utilized in the

EE/CA to demonstrate whether the plume extends deeper and/or is not caused to extend deeper by the voluntary remedial actions.

In addition to the two monitoring well transects (at the LDW and in the 2-40 parking lot), Geoprobe samples (one time sampling event) may potentially be necessary for remedial design (i.e., for remedial design of the remedy that is ultimately to be selected in the EE/CA).

3.4 Key Decision #4 – Have source control actions at the EMF property (or other properties, if applicable) been sufficient to mitigate the risks from plume migration from the source(s)?

The intent of this decision has two components; 1) Evaluate if voluntary remedial actions at the former EMF facility have effectively remediated the source area; and 2) Determine if other sources are contributing to the plume and if prior remedial actions have controlled those sources. For the EMF facility, if analytical data show evidence of DNAPL (or elevated dissolved concentrations of VOCs indicative of DNAPL presence at the source area), then additional characterization data and possible remedial actions may be required. The data required to make this determination are the analytical results at/near the prior DNAPL/source areas on the EMF property. For other properties (if other sources are determined to exist), the data required to make this determination are the analytical results showing that the source/plume is contained.

3.4.1 Existing Site Data to Support this Determination

There is extensive analytical data from monitoring wells throughout the EMF property. Groundwater monitoring has been performed at the property since 1985. Performance monitoring in and around the source area has been conducted since the start of remedial actions.

If other sources of groundwater contamination exist (related to Key Decision # 2), any data from near the source area(s) needs to be identified and evaluated along with any performance monitoring of the remedial actions taken.

3.4.2 Evaluation of Existing Site Data

Analytical data from the EMF property have been collected throughout and after 10 years of active voluntary remedial actions. In 1997, a voluntary MTCA remedial action in the source area was implemented with the installation of two air-stripping wells. In 2000 – 2001, chemical oxidation was implemented in the source area to reduce VOC concentrations. The source area voluntary remedial actions appear to have been effective in treating high concentrations of VOCs. Additional ERD voluntary remedial actions have been implemented throughout the source area on the EMF property

starting in 2005. Separate phase DNAPL was encountered (and recovered) from treatment well EMF-NV-01. The concentration of TCE in EMF-NV-01 has declined from 1,007,000 ug/L to 570 ug/l between 1997 and 2009. Down gradient from EMF-NV-01 is well EMF-NV-02; recent TCE data from EMF-NV-02 (July 2007, January 2008, July 2008, February 2009 and August 2009) are 19000, 1700, 6400, 960 and 4200 ug/L, respectively.

Three up-gradient properties and numerous properties located to the south of the EMF property have (or had) industrial operations that would have typically used solvents (metal fabrication, non-destructive testing, fueling operations, air craft maintenance and other industries). Multiple properties have identified halogenated and non-halogenated compounds in soil and groundwater, not all of the nearby properties have had environmental sampling.

3.4.3 Remaining Data Gaps Necessary to Support Determination

To satisfy this data gap, analytical results for wells at and immediately down gradient of the former EMF facility will be evaluated for evidence of DNAPL. High dissolved VOC concentrations approaching 10% of the solubility limit for TCE would indicate that a DNAPL source was still continuing to affect the VOC plume. The July 2007 data from EMF-NV-02 indicate TCE at 1.9% of the solubility, January 2008 at 0.17%, July 2008 at 0.64% and February 2009 at 0.096% (all based on a TCE solubility of 1,000 mg/L). These data (along with other monitoring wells) will be compared with the specific conditions and considerations relevant to the range of TCE solubility suggested as indicative of DNAPL presence. Additional sampling at specific targeted intervals between the aquifer and underlying aquitard are necessary to identify or refute the presence of a TCE DNAPL.

For other possible sources, the general position and nature of the sources should be identified and data from sampling locations down gradient of the sources should be identified.

3.5 Key Decision #5 – Are other specific exposure pathways (indoor air, storm drains, stream channels) complete?

The intent of this decision is to determine if other specific exposure pathways represent an unacceptable risk from the VOC plume (other than the primary pathway, discharge to the LDW, noted above). No structures are present on the EMF property and, as presently planned, any future development on the EMF property would include the use of an appropriate vapor barrier to mitigate any impacts of vapor intrusion to a future structure. If a potential exposure pathway is complete and potential risk above NCP thresholds is identified then additional characterization data and possible remedial actions will be required. Primary considerations are groundwater discharge to storm drains, vapor intrusion to indoor air, potential VOC exposure in subsurface enclosed

spaces (e.g., vaults), and possible diversion of impacted groundwater flow via buried stream channels. Each of these potential exposure pathways are examined below.

1. Are the storm drains a complete pathway? If the depths of the storm sewers are found to intercept the top of the VOC plume then additional characterization may be required because of the potential for the VOC plume to enter a storm drain and discharge to the LDW via another mechanism and route.
2. Is vapor intrusion to indoor air a complete pathway? If shallow groundwater containing dissolved VOCs is found to be directly beneath an occupied building then additional characterization may be required because of the possible impact to human health through vapor intrusion.
3. Is exposure to VOC vapors in subsurface enclosed spaces (e.g., vaults) a complete pathway? If shallow groundwater containing dissolved VOCs is found to be close to or discharging to a subsurface vault, then additional characterization may be required because of the potential for worker exposure in the subsurface enclosed space.
4. Do buried stream channels divert the VOC plume? If buried stream channels are found to intercept the VOC plume, then additional characterization may be required to evaluate other potential discharge locations to the LDW if the VOC plume is somehow diverted.

The data required to make these determinations are: actual depths of storm drains and concentrations at transport pathways that connect to exposure points; or characterization data demonstrating an incomplete pathway, and bounding data for the VOC plume.

3.5.1 Existing Site Data to Support this Determination

1) Shallow (water table) groundwater is not impacted by VOCs in the down gradient plume because groundwater preferentially flows through a zone located at a depth of approximately 30 to 50 feet below ground surface (bgs).
2) Near the source area, where shallow groundwater has been impacted by VOCs, groundwater monitoring data from monitoring wells EMFMW-3S, EMFMW-4, and EMFMW-5 have low ug/L or non-detect concentrations of VOCs. These wells (EMFMW-3S, EMFMW-4, and EMFMW-5) have been sampled a number of times (20+) since the project inception: multiple events from 1986 to 1994 (~ 14 times for VOCs by the Method 8240 VOCs list); 8 events from 1996 to 1998 (quarterly for 2 years) for the Method 8260B VOCs list. Since 1998, the wells have been sampled periodically and include a short list of targeted VOCs based on evaluation of the prior monitoring data. All risk screening calculations for potential vapor intrusion using VOC data from these wells (located around the closest building) indicate either an incomplete pathway for vapor intrusion, or risk levels below applicable thresholds. These wells may, or may not, be located in

ideal locations for monitoring the shallow groundwater in locations immediately down gradient of the source area. Since no building presently exists, further characterization/evaluation of a potential indoor air exposure pathway will be deferred until such time as actual construction of occupied buildings is planned. With this deferred characterization approach (i.e., when a building exists and/or a building location is planned) this option will require an institutional control in the form of a deed restriction as part of the final remedy selection (to be summarized as a requirement in the EE/CA).

3) At down-gradient locations where the VOC plume moves under an occupied building, such as the Boeing Fire Station or Plant 2, numerous groundwater samples from the shallow water table zone (~ 60+ samples) have not revealed VOCs above risk levels set for protection from vapor intrusion derived from the shallow groundwater (e.g., Plant 2 screening levels derived using the Johnson and Ettinger model, EPI 2006). The Plant 2 wells used to make this determination include: PL2-440A, PL2-445A, PL2-435A, PL2-442A, PL2-444A and PL2-420A. The Plant 2 shallow probe samples include GP-04003, GP-04004, GP-04005, GP-04007, GP-04008, GP-04010, SW-12, SW-18, SW-13, SW-19, SW-14, SW-15, SW-20, SW-21, DP-4104, DP-4106, DP-4107, DP-4142, SW-16, SW-50, SW-22, GP-4101, GP-4141 and GP-4142. The EMF plume Geoprobe sample locations include WF-16, WF-17, WF-18, WF-19, WF-20, WF-21, WF-22, WF-23, WF-24, WF-25, WF-26, WF-27, WF-27B, WF-30, WF-31, WF-32, WF-33, WF-34, WF-35, WF-37, WF-38, ERDGP-1, ERDGP-2, ERDGP-3, ERDGP-4, ERDGP-5, WFGP-39, WFGP-40, WFGP-41, WFGP-42, and WFGP-43.
4) Site data indicate the groundwater flow direction is consistently towards the LDW and none of the monitoring wells used for groundwater monitoring appear to be affected by buried stream channels diverting groundwater flow. The flow path of the plume has been established (defined by VOC data as the flow path with ~ 1,000+ samples for VOC analysis). The data indicate a predictable plume; a Gaussian shape with symmetrical spread along each plume mapping transect. The known information on the former stream channels (survey information from 1897 map) in the vicinity of the plume indicates a prior stream channel depth of approximately 10 feet below the current ground surface. Bounding wells are present on the up-gradient edge of the active airport runways/taxiways (EMFMW-4, EMF MW12dR, shallow and deep pair to the north; EMFMW-2 and EMFMW-14d to the south); all four are at non-detect for VOCs.

3.5.2 Evaluation of Existing Site Data

Characterization of the VOC plume from the eight transects and subsequent wells show a stratified plume with no exposure potential to COCs in shallow groundwater. Clean water above the plume (the stratified nature of the plume) precludes the potential for exposure from the shallow groundwater (<20 feet) or the vadose zone. Although the exact depths of storm drains on site are not known, it is unlikely that the backfill for

storm drains are located at depths approaching 20 feet. Near the source area, where shallow groundwater has been impacted by VOCs, the present analytical data (from shallow groundwater) do not indicate concentrations of VOCs that could impact any exposure pathways if groundwater were to infiltrate storm drains in the area.

Another element of this determination is to assess if vapor intrusion to indoor air could be an exposure pathway for the VOC plume to impact human health. Clean water above the plume (the stratified nature of the plume) precludes the potential for exposure through this pathway. Therefore, indoor air vapor intrusion is not a complete exposure pathway and additional data collection or evaluation is not necessary. No buildings exist above the source area of the EMF plume so there is no means to sample and evaluate exposure potential (it is an incomplete pathway). Future re-use of the property may include a building used for some type of airport support activity. If such a building is included in future re-development (and data indicate that vapor intrusion is likely), it will include engineering controls to prevent vapor intrusion (requirements for engineering controls to prevent vapor intrusion within buildings that could be constructed at the EMF site are specified in the lease termination agreement dated January 27th 2009 between Boeing and King County, Boeing 2009).

Another element of this determination is to assess if prior stream channels are likely to divert the groundwater flow and migration pathway of the VOC plume to an alternate discharge location at the LDW. Based on the water level data and the clearly defined plume flow path from the eight plume mapping transects, the groundwater flow direction appears to be consistently towards the LDW with no indication of discernable diversion of the plume. The shallow depth of the known stream channel (circa 1897) is too shallow to intercept the deeper VOC plume which is present at a depth of approximately 30 feet bgs. Historical stream channels at a deeper depth (presumed to be present based on the geologic setting) may (or may not) have an impact to divert the plume.

3.5.3 Remaining Data Gaps Necessary to Support Determination

Additional data are necessary to confirm the location and depths of storm drains in the source area. Actual depths of storm drains will be reviewed to assess the potential for a complete exposure pathway.

If vaults are present in an area with shallow groundwater contamination then exposure concentrations need to be determined.

Additional grab samples for VOCs (one-time samples with a Geoprobe) located north and south of the estimated VOC plume boundary will be evaluated to determine the potential for the VOC plume to be diverted by buried stream channels.

3.6 Key Decision #6 – If ERD is selected in the subsequent EE/CA, can the existing treatment process selected in the MTCA FS and implemented in the MTCA RA be translated to wider areas of the plume that have not yet been addressed?

This decision, and required data to support the decision, is not intended to pre-suppose the RA selection in the EE/CA but rather to provide sufficient data that can support the RA selection in the EE/CA.

The intent of this decision is to evaluate if the existing treatment process can be used to meet the remedial goals, if it is selected in the EE/CA. If the ERD remedial action (voluntary) can reduce VOCs to below ARARs, then it would rank high in a performance/technical feasibility evaluation in the EE/CA. The data required to make this determination are the analytical results of the current remedial performance monitoring.

3.6.1 Existing Site Data to Support this Determination

Prior to full-scale implementation of ERD, a pilot test was completed to demonstrate the efficacy of ERD at the site. Full-scale ERD has been performed at the site since 2004. Four years of analytical data has been collected from site monitoring wells to assess the performance of this specific voluntary remedial action (ERD). A large body of performance monitoring data exists.

3.6.2 Evaluation of Existing Site Data

The voluntary remedial action at the source area has resulted in 98 – 99% reduction in VOCs in the immediate down gradient well. The ERD voluntary remedial action in multiple areas has resulted in non-detect levels of VOCs in some down gradient wells. These performance data suggest that the remedial actions can meet the goals; continued operation and performance monitoring is required to verify performance.

3.6.3 Remaining Data Gaps Necessary to Support Determination

Additional data are needed to characterize the edges of the VOC plume where the revised AWQC for vinyl chloride have redefined the extent of contamination exceeding ARARs. New data will be compared with historical data to evaluate the effectiveness of ERD and bound the plume boundary above ARARs.

3.7 Key Decision #7 – Is the current voluntary remedial action mobilizing metals above AWQCs?

The intent of this decision is to evaluate if there is potential for adverse effects from the existing treatment process (ERD). Specifically, do ERD actions result in the mobilization of metals in site groundwater? If ERD actions mobilize metals above

AWQCs, then mitigation measures or alternative remedial actions will be evaluated. The data required to make this determination are representative monitoring data to detect changes in metals concentrations as a result of ERD actions taken.

3.7.1 Existing Site Data to Support this Determination

Water quality monitoring from the ERD pilot test (RCRA 8 metals) indicated no mobilization of metals. Recent additional sampling confirms no mobilization of metals for the more extensive list of Priority Pollutant Metals.

3.7.2 Evaluation of Existing Site Data

The analytical data for Priority Pollutant Metals was reviewed. No metals exceed their respective AWQC levels. The reporting limits provided by the laboratory in the recent sampling have all been below the AWQCs (indicating the non detect values are also less than the AWQCs). All samples have been non-detect below the mercury reporting limit of 0.1 ug/L, which is less than the mercury AWQC of 0.94 ug/L.

3.7.3 Remaining Data Gaps Necessary to Support Determination

In order to verify that remedial actions are not causing the mobilization of metals, the data from all the metals analysis in targeted areas should be periodically evaluated to determine if the ERD treatment has caused mobilization of metals and make a determination of whether or not any further monitoring of metals is necessary.

3.8 Summary of Data Gap Analysis

1. Additional monitoring structures needed to define present discharge concentrations at the LDW. One or more additional monitoring wells will be installed along the LDW.
2. The source of the toluene plume needs to be evaluated and if other CVOC sources are contributing to /comingling with the EMF CVOC plume they need to be evaluated. If appropriate, additional investigations to evaluate the source of toluene or other CVOCs sources may be required.
3. Additional sampling for plume definition to identify boundaries, or commingling from other plumes (to the south on the west side of KCIA, south of the Fire Station area). Probe samples (one-time grab samples) will be collected to characterize plume(s) in these areas, Additional probe sampling will be conducted on the east side of KCIA to collect data regarding the potential for the CVOC plume to be diverted by buried stream channels or commingling from other sources. After the probe data are collected and evaluated, a recommendation will be made in a work plan addendum regarding addition wells in these areas, if applicable (what spatial position, depth intervals, analytes and responsible parties).

4. Analytical results for wells at and immediately down gradient of the former EMF facility will be evaluated for evidence of DNAPL. Probe samples will also be collected from selected locations near EMF-NV-02. The probe samples will be collected at the interface of the aquifer and underlying aquitard. Probe samples will also be collected from selected locations near EMF-NV-01 for future remedial design. After the probe data are collected and evaluated, a recommendation will be made in a work plan addendum regarding addition wells in these areas if necessary (what spatial position and depth interval).
5. As-built depths of storm drains will be reviewed to assess the potential for a complete exposure pathway.
6. Performance monitoring data will be compared with historical data to evaluate the effectiveness of ERD.
7. The existing data for Priority Pollutant Metals collected from targeted areas near ERD treatment transects will be evaluated to verify that voluntary remedial actions have not caused the mobilization of metals.

4.0 INVESTIGATION DESIGN AND RATIONALE

This Section describes the general investigation plans for additional data collection activities to address the data gaps identified in the previous Section. The 2-40's area sampling completed for the Plant 2 RCRA team includes numerous sampling locations that are above, below, within and bounding (north and south) of the EMF VOC plume (based on existing data and the CSM). The general layout of wells and probe points near the EMF VOC plume that have been completed as part of the 2-40's area RCRA investigation is shown in Figure 4-1. The data derived from the Plant 2 RCRA characterization work in the 2-40's area investigation satisfies many of the defined data gaps listed in this document (i.e., those within the Plant 2 area). The Plant 2 RCRA investigation has been completed before field work for the EMF VOC plume sampling has started and all data derived (from the 2-40's area investigation) has been reviewed as part of planning for further EMF plume characterization.

For any characterization work to be completed solely for the EMF VOC plume, the detailed methods and procedures for direct-push sampling, well installation, and sampling and analysis are presented in the SOPs (Attachment 1). Project quality assurance/quality control (QA/QC) including field and laboratory QA/QC are specified in the QAPP (Attachment 2). Health and safety practices to be implemented during all field activities are presented in the Health and Safety Plan (HASP, Attachment 3). Appropriate SOPs and QAPP for the Plant 2 RCRA team have been submitted and approved previously.

The overall sampling approach has been structured to collect/provide data required to support the anticipated project decisions including the following:

1) The concentration of COCs at the discharge point.
2) The nature and extent of the plume above AWQCs necessary to establish the exposure pathways and to support selection of (with follow-on design of) remedial actions.
3) Performance monitoring associated with prior and ongoing voluntary remedial actions.

The existing monitoring well network and characterization data define the VOC plume boundaries at the EMF property and along the west side of KCIA (at the Boeing Fire Station) and have identified the center of the VOC plume across Plant 2 to the LDW discharge point. The first phase of sampling (already completed by the Plant 2 RCRA team) is near the discharge point to the LDW (in the 2-41 Building near the western side). The layout of existing wells and prior Geoprobe sampling points is shown in Figure 4-2 (not including the additional samples planned or completed by the Plant 2 RCRA team shown previously in Figure 4-1). The expanded investigation at the discharge point to the LDW (the point of compliance adjacent to the exposure point) has attempted to define the VOC plume boundaries to a non-detect level (based on uncertain future cleanup levels that have yet to be established). There are a number of other industrial uses and solvent plumes within Plant 2 (and throughout the Duwamish

Valley). As a result, defining the EMF VOC plume boundary at non-detect level may not be feasible if it is commingled with other solvent plumes (i.e., a defined non-detect boundary, to the EMF plume, may not exist).

With the plume boundaries defined at the LDW, those data have been combined with the existing data from the Fire Station area (see Figure 4-3) to interpolate the estimated boundaries (for any subsequent investigations and future remedial action efforts, to be selected in the EE/CA) at locations in between (from East Marginal Way through the 2-41 Building to the LDW).

4.1 First Phase – Groundwater Sampling in 2-41 Building near LDW

4.1.1 Data Gap #1 Discharge Concentrations at LDW

Additional groundwater analytical data are needed to define present discharge concentrations at the LDW. Additional monitoring wells will be installed along the LDW.

4.1.2 Sampling Considerations and Rationale for Locations

The initial approach to address Data Gap #1 (already completed as part of the Plant 2 RCRA efforts) consisted of Geoprobe borings and grab groundwater sampling to optimize the placement of new monitoring wells. As shown on Figure 4-4a, eleven Geoprobe borings were completed to depths ranging from 14 to approximately 65 feet with multiple samples over depth (see Section 3.1.1). The Geoprobe sampling sufficiently bounds the spatial position of the VOC plume (based on review of the un-validated of lab data), the transect depth will be expanded with a secondary Geoprobe sampling in the central area where the base on the VOC plume was not identified.

The data collected during the 2008 Geoprobe sampling were evaluated and used to determine the appropriate spatial locations and screened intervals for the new monitoring wells. The final locations and screened intervals of all new EMF plume monitoring wells will be (or have been) approved by EPA prior to installation. In order to avoid delays in field work, the notification to EPA will be via e-mail. The monitoring locations presently installed (based on existing data and the CSM) includes clustered pairs of monitoring wells (screened at two different intervals). The monitoring well transect at the LDW currently has three of the four locations (each with a well pair) spaced across the transect in the following areas; two locations within the central area of the plume, one located outside the northern boundary of the plume, and one located outside the southern boundary of the plume. As noted above, the work already completed includes Geoprobe samples to establish appropriate well positions but does not sufficiently bound the base of the VOC plume at the LDW. Any necessary secondary Geoprobe sampling will be completed prior to selecting locations for new EMF plume monitoring wells.

The two bounding locations (shallow and deep well pairs) have been installed at roughly 150 and 90 foot distances (north and south) from Well EMFWF-32. The shallow wells are screened between depths of 10 to 20 feet and the deeper wells between 35 and 45 feet. The two shallow wells (already existing) include PL2-443A (to the north) and PL2-420A (to the south). The deep wells are PL2-443B and PL2-420B. The Plant 2 RCRA team also installed deeper (C- zone wells at a depth of approximately 80 ft bgs) at each location. In addition, one deeper well will be installed to a depth anticipated to be approximately 70 feet deep. The spatial position, depth of the wells, and the screened intervals are based on the data from the Geoprobe samples and all locations and depth intervals will be approved by EPA prior to installation.

This monitoring well transect will also include two well locations within the plume boundary (each as a shallow and deep pair). One well pair will be PL2-444A (existing) and a new deep well (~ 45 ft bgs, designated EMFWF-39). The other well pair will be a new well (~25 ft bgs, designated EMFWF-40) and EMFWF-32 (already existing).
One additional deeper well (EMFWF-41) is planned to a depth ~ 70 ft bgs that will be located between prior Geoprobe sampling locations 2-40 DP37 and 2-40 DP38 (sampled in May/June 2008). The two probe samples (2-40 DP37 and 2-40 DP38) are located 25 feet apart. Geoprobe sampling will be completed (using a temporary conductor casing) at the well location prior to the sampling. Grab samples for VOC analysis from the probe point will be collected at depths of 61, 70 and 80 ft bgs. Each probe will be evaluated for the presence of DNAPL.

After the new wells are developed, the wells will be sampled and incorporated into the groundwater monitoring program. At the point of compliance wells at the waterway, low flow sampling will be completed with dedicated pumps installed in the wells (consistent with and/or part of the sampling done under the Plant 2 RCRA program).

After the deeper probe sampling near 2-40 DP37/2-40DP38 and drilling/sampling of EMFWF-41 is completed, the data will be evaluated (by comparison with AWQCs and final cleanup goals) to determine if further investigations (up gradient and/or cross gradient) are necessary to establish a point where a deeper plume may originate. If such work is necessary (based on data yet to be collected), additional sampling/ characterization will be implemented (contingent sampling). The scope for any added sampling/ characterization will be determined after review of the data to be collected in this work plan and will be summarized in a brief work plan addendum submitted to EPA (for review and approval) before the work is implemented.

4.1.3 Sample Types and Analyses

Grab groundwater samples will be analyzed for VOCs and salinity. Samples from the new monitoring wells will be analyzed for VOCs, dissolved gasses, and salinity. If pore-water sampling is conducted (based on VOC levels detected in wells), the samples will be analyzed for VOCs, dissolved gasses, and salinity, sodium and potassium. The new

deep well near the LDW (EMFWF-41) will also include a baseline analysis of metals to establish the concentration of metals in the deeper zone.

4.2 Second Phase – Groundwater Sampling in Areas on/near KCIA

4.2.1 Data Gaps #2 and #3 Sources Contributing to the Plume/Areas above ARARs

The most recent sampling data indicate a new toluene plume has arrived within the monitoring well network for the EMF plume. In addition, increased vinyl chloride levels have been detected at the southern boundary well near the Fire Station area. The source of these changed conditions needs to be identified.

The EMF plume has been bounded by wells at the EMF property. At the west side of KCIA bounding wells to the north and south have been installed, but recent data indicate increased vinyl chloride concentrations (up to 51 ug/L for the August 2009 sampling) in the southern bounding well (EMF-WF-38). These results are inconsistent with the historical record and may represent a contribution from a different source or potentially a seasonal change/shift in the EMF VOC plume.

Additional data have been collected in Plant 2 (May/June 2008) to define the VOC plume limits in excess of AWQCs and final cleanup goals. The plume boundaries on the east side of Plant 2 (the 2-40 parking lot) have been identified by the existing well network. In addition, the recent (June 2008) probe sampling data within the 2-40s parking lot area supports those boundaries. Within Plant 2, a MTCA voluntary remedial action (ERD through injection wells in multiple transects throughout the plume) has been implemented in selected areas to the expected width of the VOC plume. If groundwater data indicate that the final cleanup goals are exceeded, then future remedial actions (to be selected in the EE/CA) may be necessary to treat those portions of the plume. The data required to make this determination are analytical data to define the position of the VOC plume (at the threshold of the AWQCs, or reasonably estimated based on a predictable plume pattern and data approaching the AWQCs).

4.2.2 Sampling Considerations and Rationale for Locations

The recent arrival of the toluene plume and the source/ causes of increased vinyl chloride levels at the south end of the Fire Station area need to be identified. The following sampling locations (probe samples as one-time grab samples and selected wells added to performance monitoring) are intended to help locate or refute plausible sources.

On the west side of KCIA, sampling is planned in an area located to the south of the mapped EMF plume (as presently mapped). The sampling will be conducted in an area located east of East Marginal Way S (as close to the airport as possible).

Five probe sample locations are planned for the above area (west side of KCIA) with water samples collected at depths of 20, 30, 40 and 50 ft bgs. The general position of sample locations is shown in Figure 4-5, actual sample locations may change based on access constraints and utility clearance.

On the east side of KCIA sampling is planned in two areas located north and south of the mapped EMF plume (as presently mapped). The sampling will be conducted in locations on the east side of KCIA where the airport managers allow access with short-term runway restrictions.

Probe sample locations are planned for each of the above areas (east side of KCIA) with water samples collected at depths of 15, 25, 35 and 45 ft bgs. The general position of sample locations is shown in Figure 4-6, actual sample locations may change based on site access and utility clearance.

Sampling has continued (and is expected to continue) associated with existing remedial action monitoring of the EMF plume. Additional wells that will be added as a one-time sampling with the performance monitoring include:

EMF Property	EMF-MW-6, EMF-MW-10, EMF-IW-27, EMF-IW-29, EMF-MW-2, EMF-MW-14D
On NBF Near Fire Station	EMF-WF-25, EMF -IW-32, EMF- WF-26, EMF-WF-27, EMF-IW-33, EMF-IW-36, EMF-WF-38
EMF Plume In Plant 2 Area	EMF-IW-7, EMF- IW-29, EMF-IW-4, EMF-IW-38

After the probe and well sampling data are evaluated, and the location of the plume(s)/source(s) identified in relation to the EMF property, a work plan addendum will be prepared for the installation of wells, if appropriate, based on the plume position, source(s) and responsible parties.

The existing monitoring well network in the parking lot of the 2-40 Building includes a transect of monitoring wells that span the width of the plume. The relevant monitoring wells presently existing (based on existing data and the CSM) include clustered pairs of monitoring wells (screened at two different intervals). The monitoring well transect at the 2-40 Building Parking lot (see Figure 4-7a) will have four locations (each with a well pair) spaced across the transect in the following areas; two locations within the central area of the plume, one located outside the northern boundary of the plume, and one

located outside the southern boundary of the plume. The EMF VOC plume has been characterized and mapped at a position approximately 190 feet up gradient from the monitoring well transect planned in the 2-40 parking lot (see Figure 4-3). This pre-existing data has been used to establish of the position of wells within this transect. Other historical data and recent data are shown in Figures 4-7a and 4-7b. Other characterization work at Plant 2 (under RCRA) has also included installation of several C-zone wells (to a depth of ~ 85 ft bgs) in the immediate area (wells PL2-440C, PL2-441C, and PL2-608C).

Existing shallow monitoring wells within the footprint of the EMF VOC plume include PL2-BF03a and PL2-440a. These two wells (existing) have been used to define the upper boundary of the EMF VOC plume. Existing well EMFWF-36 is installed in the EMF VOC plume and a Plant 2 well, PL2-440b, has been be added within the plume. A northern bounding location (2 wells, PL2-441a and PL2-441b) and a southern bounding location (2 wells, PL2-608a and PL2-608b) have been completed and sampled. As noted previously, the monitoring well network installed by the Plant 2 RCRA team also includes deeper C zone wells in this area (~ 80 feet bgs). The monitoring results from the C-zone wells in this area (data from ~ 80 ft bgs, see Figure 4-7b) indicate the COCs from the EMF plume at non-detect levels (< 0.2 ug/L), which is also consistent with the all of the Geoprobe data collected at depth of approximately 60 ft bgs which are also all non-detect (at < 0.2 ug/L).

Additional Geoprobe sample locations in selected areas within Plant 2 may also be required to bound areas above the AWQCs and final cleanup goals where future remedial actions and/or expanded voluntary remedial actions may be necessary. The planned investigations based on the remaining data gaps in general areas of the plume are summarized in Table 4-1.

Additional considerations for each sampling location will also include physical access and subsurface utility clearance. Each planned sampling point may be moved to an appropriate nearby location based on these considerations.

4.3 Third Phase – Sampling to Evaluate Source Control Actions

4.3.1 Data Gap #4 – Review and Evaluation of Source Control Actions

4.3.2 Sampling Considerations and Rationale for Locations

Prior voluntary remedial actions and corresponding performance data from the EMF remedial actions will be reviewed to evaluate if voluntary remedial actions at the former EMF facility have effectively remediated the source area. If analytical data show evidence of DNAPL (or elevated dissolved concentrations of VOCs indicative of DNAPL presence at the source area), then additional characterization data and possible remedial actions will be considered. The data required to make this determination are

the performance monitoring data for wells at and immediately down gradient of the EMF property. Separate phase DNAPL was encountered (and recovered) from treatment well EMF-NV-01. The concentration of TCE in EMF-NV-01 has declined from 1,007,000 ug/L to 570 ug/l between 1997 and 2009. Down gradient from EMF-NV-01 is well EMF-NV-02; recent TCE data from EMF-NV-02 (July 2007, January 2008, July 2008, February 2009 and August 2009) are 19000, 1700, 6400, 960 and 4200 ug/L, respectively. Down gradient from EMF-NV-01 is well EMF-MW-17; the concentration of TCE in EMF-MW-17 has declined from 4,760 ug/L to <1 ug/l between 2000 and 2009. Similar results for TCE and/or degradation daughter products (cis12 DCE and vinyl chloride) have been observed in wells EMF-MW-16, EMF-MW- 24 and EMF-MW-34, all located down gradient of the EMF source area.

To satisfy this data gap, analytical results for wells at and immediately down gradient of the former EMF facility will be evaluated for evidence of DNAPL. High dissolved VOC concentrations approaching 10% of the solubility limit for TCE would indicate that a DNAPL source was still continuing to affect the VOC plume.

In addition to sampling existing wells, sampling at specific targeted intervals between the aquifer and underlying aquitard are necessary to evaluate the presence of a TCE DNAPL. For the EMF source, probe samples will be collected near EMF-NV-02; two (2) locations will collect water samples at depths of approximately 42-46 ft bgs. In addition, four (4) other locations up gradient and closer to EMF-NV-01 will be sampled to collect remedial design data regarding the source/plume boundaries in those areas. The planned probe sampling locations on the EMF property are shown in Figure 4-8. The probe data and recent well sampling data will be evaluated and the need for other sampling will be determined.

For other possible sources (if any), the general position and nature of the source(s) must be established and data from sampling locations down gradient of the sources (if they exist) must be identified.

As part of the project planning/DQOs, concerns related to ERD treatment in the EMF source area have been noted and the following additions to site performance monitoring events have been added to address those concerns.

1. One time, new baseline sampling of multiple wells in the EMF property ERD area (Area 6), this sampling was completed in August 2009. Some wells are injection wells but no substrate has been injected for ~ 2 years and the data provide representative groundwater concentrations. The wells sampled included: EMF-NV-01, EMF-NV-02, EMF-MW-17, EMFMW-24, EMF-MW-34, EMF-MW-11D, EMF-MW-13D, EMF-MW-10, EMF-MW-16, EMFIW-18, and EMF-MW-11S. Well EMF-IW-27 has been transitioned from an injection well to a monitoring well and will be used as such for future sampling/remedial actions (August 2009

concentrations from EMF-IW-27 indicate; TCE<0.2, cis1,2DCE at 14, trans 1,2DCE at 7 and vinyl chloride at 8.1, all in ug/L).

2. For a period of 3 quarters, collect groundwater samples from EMF-NV-01, EMF-NV-02, EMF-MW-10, EMF-MW-17, EMF-MW-16, EMF-IW-20, EMF-MW-13D and EMF-MW-11D for VOC analysis.
3. Evaluate the data to determine how ERD is affecting wells in the immediate area; determine any adverse impacts, and/or any optimization measures that can be implemented to improve performance.

Table 4-1. Summary of Characterization Sampling Associated with Data Gaps 1, 2, 3 and 4

Plume Investigation Transect	Number of Planned Geoprobe Borings	Number of Grab Groundwater Samples[2]	Approximate Sample Depths (ft bgs)	Number of Monitoring Wells [1]
Lower Duwamish Waterway	1	3	61-65, 70-74 80-84	11 (EMFWF-32, PL2-444A, PL2-443A/B/C, PL2-442A/B/C, PL2-420A/B/C), plus 3 additional planned (including one deeper ~ 65 ft bgs)
Near ERD Area-1 (in 2-41 Building)	(completed with multiple locations sampled at depths from 10 to 65 ft bgs)	0		
Near ERD Area-2 (in 2-40 Building)	(completed with multiple locations sampled at depths from 10 to 65 ft bgs)	0		4 (EMFWF-33, EMFWF-34, EMFWF-35, EMFWF-31)
Near ERD Area-3 (in 2-40 Parking Lot)	(completed with multiple locations sampled at depths from 10 to 65 ft bgs)	0		9 (EMFWF-30, EMFWF-36, PL2-BF03a, PL2-440A/B, PL2-441A/B, PL2-608A/B); Plus 3 additional deep wells initially[3] PL2-440C, PL2-441C, PL2-608C
Area-4 (Fire Station/East Marginal Way)	(completed with multiple locations sampled at depths from 10 to 65 ft bgs)	0		6 (EMFWF-25, EMFWF-26, EMFWF-27, EMFWF-29, EMFWF-37 [deep], EMFWF-38)
South of Area 4 (West KCIA)	5	20	20, 30, 40, 50	None currently /to be determined after probe samples
West of EMF property (East KCIA)	4	16	20, 30, 40, 50	None currently /to be determined after probe samples
Other wells sampled to identify boundaries/ sources	0			13 (EMF-MW-6, EMF-MW-10, EMF-IW-27, EMF-IW-29, EMF-MW-2, EMF-MW-14D, EMF -IW-32, EMF-IW-33, EMF-IW-36, EMF-IW-7, EMF- IW-29, EMF-IW-4, EMF-IW-38)

Table 4-1. Summary of Characterization Sampling Associated with Data Gaps 1, 2, 3 and 4

Plume Investigation Transect	Number of Planned Geoprobe Borings	Number of Grab Groundwater Samples(2)	Approximate Sample Depths (ft bgs)	Number of Monitoring Wells (1)
Near EMF source	6	18	~ 42- 46 ft near EMF NV-2 ~25- 45 ft closer to EMF NV-01 (estimated depths, actual depths will be based on geologic contact)	Multiple wells exist and are part of performance monitoring /other wells may be added at specific depth after probe samples are collected and evaluated
EMF source (to evaluate impacts of ERD injections)	0	0		8 wells for 3 quarters after injection (EMF-NV-01, EMF-NV-02, EMF-MW-10, EMF-MW-17, EMF-MW-16, EMF-IW-20, EMF-MW-13D, EMF-MW-11D)

Notes:
1. Monitoring wells are periodically sampled as part of the groundwater monitoring program.
2. Sample count above will be increased with QA/duplicate samples per QAPP frequencies, samples for VOCs by 8260B analysis
3. Existing data indicates these wells are below the EMF VOC plume. Samples from these 3 additional deep zone wells will be collected a total of 4 times (two sampling rounds have been completed with all results for EMF COCs at non detect levels) and then dropped from the EMF monitoring program if subsequent results are below the cleanup levels.

4.3.3 Sample Types and Analyses

Grab groundwater and monitoring well samples will be analyzed for VOCs.

4.4 Fourth Phase – Other Data Evaluation

4.4.1 Data Gap #5 – Additional Exposure Pathways

Primary considerations are groundwater discharge to storm drains, vapor intrusion to indoor air, and possible diversion of impacted groundwater flow via buried stream channels.

Additional data are necessary to confirm the location and depths of storm drains in the source area. As-built depths of storm drains will be reviewed to assess the potential for a complete exposure pathway.

Sampling on the east side of KCIA at selected positions north and south of the VOC plume flow path (i.e., the existing plume map) , discussed previously, will also be used to evaluate the potential for the VOC plume to be diverted by buried stream channels (see Figure 4-6).

4.4.2 Data Gap #6 – Evaluation of Existing MTCA Voluntary Treatment Process

The existing MTCA voluntary treatment process will be reviewed to evaluate if it can be used to meet the remedial goals. If the MTCA voluntary remedial action, ERD, can reduce VOCs to below ARARs, then it is anticipated that this technology could rank high in the technical feasibility/performance evaluations of the EE/CA. The data required to make this determination are the analytical results of the current remedial performance monitoring.

The new Plant 2 probe data (2008) has been used to characterize the edges of the VOC plume where the revised AWQC for vinyl chloride have redefined the extent of contamination exceeding ARARs (Section 4.3.2). New data will be compared with historical data to evaluate the effectiveness of ERD and bound the plume boundary above ARARs. This effort can be used in the remedial design for the remedial action to be selected in the EE/CA.

4.4.3 Data Gap #7 – Evaluation of Metals above Groundwater AWQCs

Analytical data will be reviewed to evaluate if ERD voluntary remedial actions result in the mobilization of metals in site groundwater. If ERD actions mobilize metals above AWQCs, then mitigation measures or alternative remedial actions will be evaluated. The data required to make this determination are representative monitoring data to detect changes in metals concentrations as a result of ERD actions taken.

In order to verify that voluntary remedial actions are not causing the mobilization of metals, the existing data for metals analysis in targeted areas (spanning several years) have been evaluated. This evaluation will be documented in the data summary report (along with the existing data).

Wells have been sampled for Priority Pollutant metals in areas down gradient of ERD injection areas (EMFWF-29, EMFWF-36, EMFWF-31 and EMFWF-32). A new deeper zone well is planned near the LDW (EMFWF-41) and an initial baseline sampling of metals from this well will be collected.

5.0 FIELD SAMPLING PLAN

5.1 Drilling Operations and Sampling Methods

This section summarizes the activities required for well drilling/construction and sampling including utility clearance, concrete coring, Geoprobe groundwater sampling procedures, laboratory analysis for VOCs, sample data analysis, and well construction (including development and surveying).

All activities performed in the vicinity of KCIA and the Boeing Fire Station will be completed in accordance with the CALIBRE SOP for Foreign Object Debris/Damage (FOD) Awareness/Prevention Program (Attachment 1).

5.1.1 Utilities Clearance and Site Preparation

Underground utility (gas, water, sewer, power, communication, other) clearance is an initial step prior to any intrusive/drilling work. CALIBRE will conduct a field inspection of the site and review available subsurface utility drawings. The Utility Notification Center (UNC) will be notified at least 48 hours prior to initiation of subsurface investigation so that subscribers can mark their nearby utilities.

In addition, CALIBRE will retain an independent utility locator to assess the potential presence of subsurface utilities and structures that are not covered by UNC in the vicinity of the proposed borings. Subsurface anomalies detected during the utility survey will be marked with paint and/or flagging. The area around each location will be cleared to a minimum of 5 feet from the marked location to allow for alternate locations in case of refusal during drilling at the primary location.

After utilities have been cleared at the proposed boring locations, a subcontractor will core the concrete at each location. If the area indicates many nearby utilities, a vacuum truck equipped with an air knife will be used to clear each boring location to an approximate depth of 6- to 8-feet prior to drilling. If a subsurface utility or other obstruction is encountered, the boring locations will be adjusted as necessary.

5.1.2 Permitting

The wells will be constructed to meet the minimum standards for construction and maintenance of wells as outlined in Chapter 173-160 WAC and described in Section 5.1.4 of this Work Plan. All drilling and well installation will be performed by Cascade Drilling, Inc., a licensed State of Washington Water Well Operator.

A notification fee and documentation in the form of a Start Notification (Start Card) will be provided to the Washington Department of Ecology (Ecology) before construction begins and a well log will be filed upon completion.

5.1.3 Drilling and Borehole Logging

During the initial phase of field work, borings will be advanced using the direct-push (Geoprobe) method. The actual boring depth will be determined in the field based on the presence of VOC-impacted groundwater and the lithology encountered.
After analytical results have been received and reviewed, the second phase of field work (well installation) will be performed. The borings for the monitoring wells will be drilled using the hollow-stem auger method or other appropriate drilling method (as determined by the driller and project manager). Other drilling methods that would be considered, based upon the site conditions and specific objectives for the well installation, include air-rotary and sonic drilling. Based on prior work at the site (and throughout the Duwamish valley) it is anticipated that most wells will be drilled using the hollow-stem auger method. Well design and installation is described in Section 5.1.4 and will include EPA approval of the final locations and screened intervals.

Prior to arriving at the site, the drill rig, tools, and accessories will be decontaminated with a pressure washer/steam cleaner. Down-hole drilling tools and sampling equipment, such as bits, augers, rods, and split spoons will be manually washed/rinsed, pressure washed, and/or steam cleaned between boreholes/wells at a designated decontamination area. All decontamination wash/rinse water will be collected on site and containerized for disposal/treatment in accordance with applicable regulations and existing Boeing procedures (Section 5.1.6).

The CALIBRE field geologist/engineer who supervises the drilling and well installation will prepare lithologic logs of the borings using the Unified Soil Classification System (USCS) following the general guidelines of ASTM Standard D-2488 (Description and Identification of Soils). The field geologist/engineer will keep a detailed log for each sample location including the date sampling occurred and the location, depth, standard penetration test/blow counts (if applicable), lithologic description (including grain size, relative proportion of grains, angularity, moisture, and color) in accordance with the USCS, screening results, and estimate of percent sample recovery. Visual indications of staining or field screening are also recorded on the borehole sample/core log.

Following sample collection, each Geoprobe boring will be backfilled with bentonite chips placed from the total depth of each boring to ground surface. The tops of the borings will be patched with concrete or asphalt as appropriate to match the surrounding surface.

5.1.4 Monitoring Well Design and Installation

Well casing diameter and screen length is dependent on the purpose of the well, the amount and size of downhole equipment that must be accommodated, and the lithology intercepted by the screened interval. The general design and construction of the wells will follow ASTM Standard D-5092 (Standard Practice for Design and Installation of

Ground Water Monitoring Wells in Aquifers). Details of the well design (i.e., the specific position and targeted screen interval) will be based upon a review of prior characterization data in the area including the existing (and revised) plume maps/profiles, data from existing wells, and Geoprobe sampling points. The final locations and screened intervals of all new monitoring wells will be approved by EPA prior to installation. In order to avoid delays in field work, the notification to EPA may be via e-mail.

The wells will be constructed with either 2- inch or 4-inch diameter, Schedule 40 PVC well casing. Two monitoring wells will be completed in the relatively deeper water-bearing zone. These wells will be constructed in an appropriate manner to isolate contamination (present in the upper water bearing zone) from migration into the deeper water-bearing zone.

The screen lengths of the new monitoring wells are anticipated to be 10-feet long. Based on nearby wells, the expected screened interval is estimated to be between 30 to 50 feet bgs (except for deeper wells, which are estimated to be approximately 60 to 70 feet bgs). Actual screened intervals will be based on field observations and results from the grab groundwater sampling. The screen slot size for the monitoring wells is anticipated to use 10-slot openings with 20-40 filter pack and may be as large as 30-slot openings (with 10-20 filter pack) depending on the lithology of the targeted screen interval. The screen slot size and filter pack for the wells may be changed/adjusted based on field observations of the grain-size within the planned screened interval.

The wells will be located in areas exposed to vehicular or pedestrian traffic and will be completed below grade using a steel well monument/cover set in the annular cement seal. The well monument will be set in concrete about 1/2-inch above grade and sloped to promote surface water drainage away from the wells. The identification number of each well will be permanently marked on the well casing, the well cover/ monument and in the concrete.

The locations of the new monitoring wells will be surveyed by a surveyor licensed in the State of Washington. Each well will be surveyed to determine its map coordinates with reference to the State Plane Coordinate System. All horizontal points will have an accuracy of ± 1 foot. The measuring point elevation on the top of the PVC well casing will be surveyed for the new monitoring wells. The elevations will be surveyed to within 0.01 foot and referenced to the National Geodetic Vertical Datum, 1929 Adjustment (NGVD29).

A well construction diagram for each well will be completed in the field on a CALIBRE well log form by the field geologist/engineer (Attachment 1). Well installation and construction data will be summarized in the daily field log and subsequently transcribed to a well completion diagram.

5.1.5 Well Development

The well development will follow general guidelines in ASTM Standard D-5092 (Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers). Each well will be developed by performing surge and pump cycles until the water is substantially clear. Surging over the length of the screened interval will be performed for a set period of time or a minimum of ten surges. The well will then be pumped until the water clears significantly. These surge and pump cycles will be repeated until the water is substantially clear shortly after the start of pumping. Other wells in the immediate area have typically been developed using 4 to 6 surge and pump cycles with approximately 160 gallons removed. Development water will be contained on site in drums for appropriate characterization/ disposal/ treatment.

5.1.6 Investigation-Derived Waste

The drilling and sampling methods described in this Work Plan will generate the following investigation-derived waste (IDW):

- Soil and drilling cuttings (spoils)
- Groundwater (development water and purge water)
- Decontamination water
- Personal protective equipment (PPE)

Based on the site history and results of previous investigations, potential contaminants in the IDW may include VOCs and could potentially contain other known Boeing Plant 2 contaminants that may be encountered while drilling and sampling within the Plant 2 area. All IDW generated by field investigations will be properly characterized, handled and disposed of according to local, state, and federal laws and applicable Boeing procedures. The waste management procedures will follow the attached SOPs (Attachment 1) and will be coordinated with designated on-site Boeing personnel.

IDW generated during field activities will be stored in DOT-approved 55-gallon drums and temporarily stored onsite. Drum labels will be placed on the side of each drum and will include information on the type of IDW stored in the drum, the well number, the date of waste generation, and a contact phone number. All drums will be placed on pallets and secured for transport in accordance with Boeing procedures defined in Attachment 1. Disposable PPE will be placed in a plastic bag and disposed of in an industrial dumpster.

5.2 Sampling Procedures and Analytical Methods

5.2.1 Groundwater Sampling and Analysis

5.2.2 Grab Samples

Grab groundwater samples will be collected from each of the Geoprobe boring locations. Samples will be collected using a peristaltic pump or tubing with a foot valve. Laboratory analytical results from the grab groundwater samples will be reviewed along with previously-collected data to identify the location of the VOC plume in the targeted treatment area. The analytical results will be used to optimize the location of the monitoring wells.

Groundwater from the target intervals will be prescreened with a photo ionization detector (PID). A 40-ml VOA bottle will be filled halfway, agitated for several seconds, and analyzed with the PID. This field screening method has been successfully used in prior investigations to delineate the EMF VOC plume. The borings will be advanced to the targeted depth (different depths for different probe points).

5.2.3 Monitoring Well Samples

Collection of water samples from monitoring wells will be conducted in accordance with the current performance monitoring requirements and the CALIBRE Sampling SOP (Attachment 1). Most groundwater samples (from wells) for characterization of the EMF VOC plume over the last several years have been collected using passive diffusion bags (PDBs). The point of compliance wells located near the LDW will use low-flow sampling with dedicated pumps. The remainder of the wells will use PDBs generally (unless other parameters such as metals are included in that sampling event).

5.2.4 Soil Sampling

No soil samples are planned for laboratory analysis (for VOCs) associated with site characterization. Soil sampling for lithologic logging will be conducted and selected samples will be collected for grain size analysis. Grain size samples will be collected in 1 gallon baggies and appropriately labeled to identify the location and depth. Some soil samples for waste characterization associated with Investigation Derived Waste (IDW) will be collected. These samples will be collected in accordance with the SOPs in Attachment 1.

5.2.5 Pore-Water Sampling

The present sample data requirements do not include pore-water sampling. If future project objectives, decisions and data requirements subsequently determine that pore-water sampling is necessary (or appropriate), it will be implemented in a manner similar

to that described below Pore-water sediment samples would be collected at three locations in the LDW adjacent to the point of discharge as defined by the wells at the LDW. At each location, pore-water samples would be collected at two depth intervals (~2 and ~10 feet below MLLW). This is the expected interval of the EMF plume discharge; however, these elevations may be changed if the Geoprobe data indicate a different interval. The sampling would be conducted at a low tide. The pore-water samples would be analyzed for VOCs and dissolved gasses (methane, ethane, ethene).

Samples would be collected from a probe (or mini-piezometer) set into the sandy/gravelly zone of the river bottom sediment. The piezometer is a ¼-inch diameter stainless steel tube with a small screened area near the tip, which is pushed into the subsurface to access the groundwater within the groundwater/surface water transition. A long, small diameter plastic tube is then placed on the top end of the piezometer and routed to a peristaltic pump on the boat. A SOP for this sampling procedure is included in Attachment 1.

5.2.6 Sample Handling and Transport

Sample containers, preservation requirements, maximum holding time, and target method reporting limits are listed in the QAPP (Attachment 2). Collection of grab groundwater samples will be conducted in accordance with CALIBRE's Sampling Standard Operating Procedures (SOP). SOPs are included in Attachment 1.

Sample handling will be conducted in accordance with applicable CALIBRE Sample Packaging and Shipment SOPs. Collected samples will be checked to ensure all required data has been recorded on the label and chain-of-custody form and will then be transported to Analytical Resources, Inc. (ARI) for laboratory analyses.

5.2.7 Analytical Methods

Groundwater samples will be analyzed for VOCs using EPA Method 8260B and for metals using the following methods:
EPA Method 6010B (for cadmium, chromium, iron, manganese, selenium, vanadium, and zinc),
EPA Method 7470A (for mercury),
EPA Method 7041(for antimony),
EPA Method 200.8 (for arsenic, beryllium, copper, lead, nickel, silver, thallium).

Field QA/QC samples, including field duplicate samples and trip blank samples, will be collected and analyzed in accordance with the project QAPP. Approximately 30 VOC samples for Method 8260B analysis are anticipated and will include trip blanks and field duplicates in accordance with the QAPP (Attachment 2).

In addition, laboratory quality control samples for analysis will include surrogate spikes, method blanks, and matrix spikes/duplicate matrix spikes. Laboratory QA/QC, such as number and type of QC samples, control limits, and corrective actions, will be in accordance with ARI's Quality Assurance Manual and those in the QAPP.

For field matrix QC measures (i.e., as matrix spikes, duplicates, field/trip blanks, project specific control limits will be established in the QAPP and/or Sampling and Analysis Plan (SAP) and will be evaluated during data review/validation procedure.

6.0 DATA MANAGEMENT AND REPORTING

Effective data management is a requirement to providing consistent, accurate, and defensible environmental data and subsequent project decisions/determinations based on the data. Environmental data will be collected, measured and interpreted during field, laboratory, and data evaluation efforts on this project. The project plans for data management and reporting are discussed in the following sections.

6.1 Field Data

Daily field records (a combination of field logbooks and task specific data sheets) will comprise the main documentation for field activities. As soon after collection as possible, field notes, data sheets, core logs, and chain-of-custody forms will be scanned to create an electronic record for use in creating field summary reports. Appropriate field data will be hand-entered into the database. All of the transferred data will be verified based on hard copy records (one-hundred percent). QA checks to identify anomalous values will also be conducted following entry.

6.2 Sample Numbering

All samples will be assigned a unique identification code based on a sample designation scheme developed to suit the needs of the data users, data management system/ structure, and field personnel. Sample identifiers will consist of three components separated by dashes.

- The first component is the site [**EMF**].
- The second field is a location identifier (e.g., well "**MW03**" or other suitable location identifier such as "**GP44**".
- The third field will be either the date (for water samples from fixed monitoring wells, **070124)**, or a depth interval from single time sample locations (such as Geoprobe points, **32-36).**

For example a sample from well MW03 on Jan 24 2007 would be labeled:

EMF-MW03-070124

A Geoprobe sample from location GP34 at a depth of 32-36 feet would be labeled:

EMF-GP34-32-36

6.3 Laboratory Data

The contract laboratory will submit data in both electronic and hard-copy format as described in Section B10.2 of the QAPP (Attachment 2). The Laboratory Project Manager (Kelly Bottem at ARI) will contact the Project QA Coordinator (John Frerich) prior to data delivery to discuss specific format requirements. Written documentation will also be used to clarify how field and laboratory duplicates and QA/QC samples were

recorded in the data tables and to provide explanations of other issues that may arise. The data management task will include keeping accurate records of field and laboratory QA/QC samples so that project managers and technical staff who use the data will have appropriate documentation. Data management files will be stored on a secure computer or on a removable hard drive that can be secured.

In addition to placing all data and identifiers in an electronic database, hard copies of all original analytical data or study records will be placed in a filing system. Each analytical data set (or including any extra lab documentation) will be given a unique documentation code based on the original source of the data or information, and filed based on that code. A master list of all filed documents, sorted in order by filing code, will be maintained for easy retrieval from the library.

6.4 Data Management

CALIBRE will use the Geographic Environmental Management System (GEMS™) data management system in conjunction with mapping tools (AutoCAD or another geographic information system, GIS tools) to manage, summarize, and report the generated data. In addition, data are available for export/transfer in a Microsoft Access format.

GEMS™, a commercial data management developed by de maximis Data Management Solutions (ddms), is a Microsoft Access based data management system. GEMS™ allows the user to acquire, store, organize, query, trend, and visualize environmental data sets. GEMS™ is intended to allow the user to analyze the physical and chemical characteristics of a site efficiently and also allow the user to easily generate report-ready tables, graphs, and figures.

To ensure proper documentation and consistency in chemical nomenclature, methodologies, and the standardization of analytical reporting of results, the system contains reference tables that store typical terminology for investigative/sampling projects. These reference tables are used to verify that chemical data being added into the system are reasonable and comparable. They are also used to ensure that queries of specific data facts out of the system are done using consistent approaches.

6.5 Data Validation

In order to ensure that data is of a known and acceptable quality, a data quality review will be performed by CALIBRE (or qualified subcontractor) and will include a review of laboratory performance criteria and sample-specific criteria. The reviewer will determine whether the project objectives have been met and will calculate data completeness for the project. The QAPP and/or Sampling and Analysis Plan (SAP) for the project will establish various field matrix QC measures such as matrix spikes, duplicates, field/trip blanks, project specific control limits. The data review/validation

procedure include a review of these project QC measures. The primary data quality review will consist of the following elements:

- Verification that sample numbers and analyses match the chain-of-custody request.
- Verification that sample preservation and holding times are met.
- Verification that field and laboratory blanks were performed at the proper frequency and that no analytes were present in the blanks.
- Verification that field and laboratory duplicates, matrix spikes, and laboratory control samples were run at the proper frequency and that control limits were met.
- Verification that surrogate compound analyses have been performed and that results met the criteria.
- Verification that established reporting limits have been achieved.

The data quality review will also include a review of the precision, bias, and completeness of analytical data. Precision will be assessed based on the RPD of MS/MSD and/or duplicate pairs. Calculated RPDs will be compared to the control limits and if the RPD is within these limits, the precision of the analysis will be assumed to meet the DQOs of the project. Bias will be reviewed by comparing the percent recoveries of surrogates, MS, and LCS to the appropriate control limits. The control limits will be compared to the most current control limits provided by the laboratory. Data will be reviewed in accordance with the analytical methods, laboratory's standard operating procedures, the project SOPs and QAPP and the following EPA documents: USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Organic Data Review (October 1999) and USEPA CLP National Functional Guidelines for Inorganic Data Review (October 2004).

6.6 Data Review and Reporting Schedule

The deliverable schedule will be as generally described in the project work plan; however, the work plan does not presently specify more than 1 phase of sample analyses. If the analytical data collected indicate that added phases of sampling are necessary, then the schedule will be modified and added sampling will be completed and reported. As the project progresses, the reporting and schedule requirements may be altered, if necessary.

Data validation reports will be prepared by an independent validator following receipt of the complete laboratory data package for each analytical round. A draft field summary data report will be prepared by CALIBRE and submitted within 60 working days after receipt of the final validation report for the first tier analyses.

The field report will include a description of the field sampling effort (e.g., procedures, sample and locations and depths, field sample observations), descriptions and rationale

for any deviations from the SAP and QAPP; a detailed discussion of any data quality issues; and tabulated field and laboratory data. Electronic data will be provided to EPA once all analyses and data validation have been completed. EPA will review the field sampling report to evaluate data suitability.

7.0 REFERENCES

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FIGURES