STATE OF WASHINGTON
COWLITZ COUNTY SUPERIOR COURT

STATE OF WASHINGTON, DEPARTMENT OF ECOLOGY, Plaintiff, v. GOODRICH CORPORATION AND EMERALD KALAMA CHEMICAL LLC, Defendants.	NO. CONSENT DECREE

TABLE OF CONTENTS

I. INTRODUCTION

A. The mutual objective of the State of Washington, Department of Ecology (Ecology) and Goodrich Corporation (Goodrich) and Emerald Kalama Chemical LLC (Emerald Kalama Chemical) (collectively, Defendants) under this Decree is to provide for remedial action at a facility where there has been a release or threatened release of hazardous substances. This Decree requires the Performing Party to design, construct, implement and monitor the remedial actions set forth in the June 30, 2004, Cleanup Action Plan approved by Ecology.

Ecology has determined that these actions are necessary to protect human health and the environment.

B. The Complaint in this action is being filed simultaneously with this Decree. An Answer has not been filed, and there has not been a trial on any issue of fact or law in this case. However, the Parties wish to resolve the issues raised by Ecology’s Complaint. In addition, the Parties agree that settlement of these matters without litigation is reasonable and in the public interest, and that entry of this Decree is the most appropriate means of resolving these matters.

C. By signing this Decree, the Parties agree to its entry and agree to be bound by its terms.

D. By entering into this Decree, the Parties do not intend to discharge non-settling parties from any liability they may have with respect to matters alleged in the Complaint. The Parties retain the right to seek reimbursement, in whole or in part, from any liable persons for sums expended under this Decree.

E. The requirements of this Decree will concurrently satisfy Defendants’ obligations for corrective action (including financial assurance for such obligations) as set forth in WAC 173-303-64620.

F. This Decree shall not be construed as proof of liability or responsibility for any releases of hazardous substances or cost for remedial action nor an admission of any facts; provided, however, that Defendants shall not challenge the authority of the Attorney General and Ecology to enforce this Decree.

G. The Court is fully advised of the reasons for entry of this Decree, and good cause having been shown:

Now, therefore, it is HEREBY ORDERED, ADJUDGED, AND DECREED as follows:

II. JURISDICTION

A. This Court has jurisdiction over the subject matter and over the Parties pursuant to the Model Toxics Control Act (MTCA), Chapter 70.105D RCW.

B. Authority is conferred upon the Washington State Attorney General by RCW 70.105D.040(4)(a) to agree to a settlement with any potentially liable person (PLP) if, after public notice and any required hearing, Ecology finds the proposed settlement would lead to a more expeditious cleanup of hazardous substances. RCW 70.105D.040(4)(b) requires that such a settlement be entered as a consent decree issued by a court of competent jurisdiction.

C. Ecology has determined that a release or threatened release of hazardous substances has occurred at the Site that is the subject of this Decree.

D. Ecology has given notice to BF Goodrich Kalama, Inc. of Ecology’s determination that it is a PLP for the Site, as required by RCW 70.105D.020(16) and WAC 173-340-500. For the purposes of this Decree, Emerald Kalama Chemical LLC voluntarily accepts status as a PLP pursuant to WAC 173-340-500(5), with a waiver of its right to notice and comment.

E. The actions to be taken pursuant to this Decree are necessary to protect public health and the environment.

F. This Decree has been subject to public notice and comment.

G. Ecology finds that this Decree will lead to a more expeditious cleanup of hazardous substances at the Site in compliance with the cleanup standards established under RCW 70.105D.030(2)(e) and Chapter 173-340 WAC.

H. Defendants have agreed to undertake the actions specified in this Decree and consent to the entry of this Decree under MTCA.

III. PARTIES BOUND

This Decree shall apply to and be binding upon the Parties to this Decree, their successors and assigns. The undersigned representative of each party hereby certifies that he or she is fully authorized to enter into this Decree and to execute and legally bind such party to comply with this Decree. The Performing Party agrees to undertake all actions required by the terms and conditions of this Decree. No change in ownership or corporate status shall alter the Performing Party's responsibility under this Decree. The Performing Party shall provide a copy of this Decree to all agents, contractors, and subcontractors retained to perform work required by this Decree, and shall ensure that all work undertaken by such agents, contractors, and subcontractors complies with this Decree.

IV. DEFINITIONS

Unless otherwise specified herein, all definitions in RCW 70.105D.020 and WAC 173-340-200 shall control the meanings of the terms in this Decree.

A. Site: The Site is referred to as Emerald Kalama Chemical LLC and is generally located at 1296 Third Street NW, Kalama, Washington 98625. The Site is more particularly described in the Site Diagram and Legal Description (Exhibit A). The Site constitutes a Facility under RCW 70.105D.020(4).

B. Parties: Refers to the State of Washington, Department of Ecology; Goodrich Corporation; and Emerald Kalama Chemical LLC.

C. Performing Party: means that Defendant designated as the "Performing Party" under the provisions of (and subject to) Section VI (Work to be Performed) herein.

D. Defendants: Refers to Goodrich Corporation and Emerald Kalama Chemical LLC.

E. Consent Decree or Decree: Refers to this Consent Decree and each of the exhibits to this Decree. All exhibits are integral and enforceable parts of this Consent Decree. The terms "Consent Decree" or "Decree" shall include all exhibits to this Consent Decree.

F. Cleanup Action Plan or CAP: Refers to the Cleanup Action Plan (CAP) (Exhibit B) issued by Ecology relating to the Site, and all attachments developed for the Cleanup Action Plan pursuant to its terms.

V. FINDINGS OF FACT

Ecology makes the following findings of fact without any express or implied admissions of such facts by Defendants.

A. Kalama Chemical, Inc. purchased the property located at 1296 Third Street in Kalama, Washington from Dow Chemical in 1971 and wholly owned and operated it from 1971 to 1986. In 1986, BC Sugar Refinery Ltd. (BC Sugar) acquired less than 50 percent (50%) of Kalama Chemical, Inc.'s stock. By January 1990, BC Sugar acquired the remaining stock and Kalama Chemical, Inc. was a wholly owned subsidiary. In May 1994, BC Sugar sold all of its stock in Kalama Chemical, Inc. to Freedom Chemical. In March 1998, Kalama Chemical, Inc. was acquired by BF Goodrich and changed its name to BF Goodrich Kalama, Inc. Pursuant to an Asset Purchase Agreement dated November 2000, BF Goodrich sold its Performance Materials business, including BF Goodrich Kalama, Inc. and the Kalama facility subsequently changed its name to Noveon Kalama. In early 2004, Lubrizol acquired the Noveon Kalama facility. In May 2006, Emerald Performance Materials acquired Lubrizol's Noveon Kalama facility. The facility currently is referred to as Emerald Kalama Chemical LLC.

B. The property was operated as a dangerous waste management facility on or after November 19, 1980, the date that subjects facilities to RCRA permitting requirements, including interim status requirements pursuant to Section 3005 of RCRA and implementing regulations thereunder, and including authorized state regulations promulgated in Chapter 173-303 WAC.

C. Kalama Chemical, Inc. initially notified EPA of its dangerous waste management activities in August 1980. In the notification, Kalama Chemical, Inc. identified itself as managing a U118 waste at the facility. In a letter dated November 18, 1980, Kalama Chemical, Inc. notified EPA that the initial notification form contained a typographical error and that the actual listed dangerous waste managed at the facility was phenol (which has a U188 listing).

D. Pursuant to the August 1980 notification, Kalama Chemical, Inc. was issued identification number WAD 0006516 by EPA. EPA subsequently replaced this identification number with the current identification number WAD 092899574.

E. In January 1989, EPA performed a RCRA Facility Assessment (RFA) at the Facility. The purpose of an RFA is to identify those areas where releases of hazardous substances may have occurred or may be occurring.

F. In April 1991, Kalama Chemical, Inc. entered into an Agreed Order with EPA (EPA Agreed Order) pursuant to Section 3008(h) of RCRA. According to the terms of the EPA Agreed Order, a RCRA Facility Investigation (RFI) was conducted and was submitted to EPA in August 1994. EPA approved the RFI as final in January 1995.

G. Releases and/or potential releases of hazardous substances including, but not limited to, toluene, benzene, phenol, diphenyl oxide and metals are documented in the RFA Report, in the RFI dated August 1994, and in the draft Supplemental RFI report, as revised on December 19, 1997.

H. In December 1995, Kalama Chemical, Inc. constructed an interim corrective measure in the "North Impacted Area" of the Facility (the NIA ICM), which consisted of a 1,500 foot-long trench to capture shallow groundwater to prevent its discharge to a wetland adjacent to the Facility. In 1997, Kalama Chemical, Inc. constructed an interim corrective measure in the "West Impacted Area" of the Facility (the WIA ICM). The WIA ICM consists of a soil vapor extraction system (which operated from May 1997 through October 1999), seven recovery wells in the intermediate sand water-bearing zone, and two shallow interception trenches adjacent to the Columbia River. BF Goodrich Kalama, Inc. and its subsequent owners, as described below, have operated and maintained both the NIA ICM and the WIA ICM since their construction.

I. In November 1998, BF Goodrich Kalama, Inc., BC Sugar and its successor, Rogers Sugar, entered into Agreed Order No. DE98-S327 for corrective action (1998 Agreed Order). Pursuant to the 1998 Agreed Order and with Ecology oversight, BF Goodrich Kalama, Inc. developed a Remedial Investigation and Feasibility Study, a Compliance Monitoring Plan and a Cleanup Action Plan (CAP).

J. In July 2001, EPA and Ecology jointly issued a RCRA permit to Noveon Kalama. EPA administers the Boiler and Industrial Furnace (BIF) portion for incineration of hazardous waste; Ecology administers the corrective action portion of the permit. The corrective action portion of the permit incorporates by reference the 1998 Agreed Order.

K. Pursuant to the RCRA permit and the 1998 Agreed Order, Noveon Kalama developed a CAP. The draft CAP was approved by Ecology and finalized on June 30, 2004.

VI. WORK TO BE PERFORMED

This Decree contains a program designed to protect human health and the environment from the known release, or threatened release, of hazardous substances or contaminants at, on, or from the Site.

A. The Performing Party shall implement the CAP (Exhibit B) and all attachments developed for the CAP pursuant to its terms, as set forth and in accordance with the requirements in the Scope of Work and Schedule (Exhibit C).

B. The Performing Party agrees not to perform any remedial actions concerning the releases of hazardous substances addressed in the CAP (Exhibit B) if such remedial actions are outside the scope of this Decree or another order, permit, or written authorization issued by Ecology, unless the Parties agree to modify the CAP (Exhibit B) to cover these actions. All work conducted by the Performing Party under this Decree shall be done in accordance with Chapter 173-340 WAC unless otherwise provided herein.

C. Pursuant to its agreement to assume responsibility for certain remediation at the Site until February 28, 2011, including the corrective actions required by this Consent Decree, Goodrich is the "Performing Party" under this Decree until February 28, 2011. As the initial Performing Party under this Decree, except as otherwise specifically provided herein, Goodrich is solely responsible for completing all obligations under this Consent Decree until February 28, 2011, unless Ecology determines in accordance with this paragraph that Goodrich has failed to comply with its obligation(s) under this Consent Decree. In the event that Goodrich fails to fulfill any of its obligations as the Performing Party under this Consent Decree, Ecology shall, in its discretion, provide written notice to both Goodrich and Emerald Kalama Chemical of its determination that Goodrich has failed to comply with the obligation(s) and that Ecology designates both Goodrich and Emerald Kalama Chemical as Performing Parties under the Decree with respect to the applicable obligation(s).

D. On March 1, 2011, Emerald Kalama Chemical shall become the sole Performing Party under the Decree, unless Ecology determines in accordance with this paragraph that Emerald Kalama Chemical has failed to comply with its obligation(s) under this Consent Decree. In the event that Emerald Kalama Chemical fails to fulfill any of its obligations as the Performing Party under this Consent Decree, Ecology shall, in its discretion, provide written notice to both Goodrich and Emerald Kalama Chemical of its determination that Emerald Kalama Chemical has failed to comply with the obligation(s) and that Ecology designates both Goodrich and Emerald Kalama Chemical as Performing Parties under the Decree with respect to the applicable obligation(s).

E. A change in Performing Party designation under this Section VI shall not require an amendment of this Decree under Section XV (Amendment of Decree) and it shall not affect the facility's RCRA/HWMA permit.

VII. DESIGNATED PROJECT COORDINATORS AND COMMUNICATION AMONG THE PARTIES

The project coordinator for Ecology is:

Ha Tran
Department of Ecology
Industrial Section, Solid Waste & Financial Assistance Program
300 Desmond Drive
Lacey, WA 98504-7600
(360) 407-6064

The project coordinator for Goodrich is:

Michael J. Riley
S.S. Papadopulos & Associates, Inc.
101 North Capital Way, Suite 107
Olympia, WA 98501
(360) 709-9540

The project coordinator for Emerald Kalama Chemical LLC is:

Christopher Wrobel, Ph.D.
Emerald Kalama Chemical, LLC
1296 Third Street NW
Kalama, WA 98625
(360) 673-0289

Each project coordinator shall be responsible for overseeing the implementation of this Decree. Ecology's project coordinator will be Ecology's designated representative for the Site. To the maximum extent possible, communications among the Parties and all documents, including reports, approvals, and other correspondence concerning the activities performed pursuant to the terms and conditions of this Decree shall be directed through the project coordinators. The project coordinators may designate, in writing, working level staff contacts for all or portions of the implementation of the work to be performed required by this Decree.

Any party may change its respective project coordinator. Written notification shall be given to the other parties at least ten (10) calendar days prior to the change, or as soon as possible thereafter.

The Performing Party and/or Ecology, depending on who generates the material, shall copy all other Parties on all written communications, documents, reports, approvals and other correspondence concerning the activities performed pursuant to the terms and conditions of the Decree.

VIII. PERFORMANCE

All geologic, hydrogeologic or engineering work performed pursuant to this Decree shall be under the supervision and direction of a geologist licensed in the State of Washington or of an engineer registered in the State of Washington, as applicable, except as otherwise provided for by Chapters 18.220 and 18.43 RCW.

All construction work performed pursuant to this Decree shall be under the supervision of a professional engineer or a qualified technician under the supervision of a professional engineer. The professional engineer must be registered in the State of Washington, except as otherwise provided for by RCW 18.43.130.

Any documents submitted containing geologic, hydrologic or engineering work shall be under the seal of an appropriately licensed professional as required by Chapter 18.220 RCW or RCW 18.43.130.

The Performing Party shall notify Ecology in writing of the identity of any engineer(s) and geologist(s), contractor(s) and subcontractor(s), and others to be used in carrying out the terms of this Decree, in advance of their involvement at the Site.

IX. ACCESS

Emerald Kalama Chemical hereby grants Ecology or any Ecology authorized representative full authority to enter and freely move about all property at the Site at all reasonable times for the purposes of, *inter alia*: inspecting records, operation logs, and contracts related to the work being performed pursuant to this Decree; reviewing the Performing Party's progress in carrying out the terms of this Decree; conducting such tests or collecting such samples as Ecology may deem necessary; and verifying the data submitted to Ecology by the Performing Party. Ecology may use a camera, sound recording, or other documentary type equipment to record work done pursuant to this Decree, however, Ecology acknowledges that electronic equipment in certain areas of the Site can act as ignition sources and cause fire or explosion and, therefore, agrees to abide by Emerald Kalama Chemical's safety policies regarding the use of cameras and other electronic equipment. Emerald Kalama Chemical agrees not to raise safety concerns to limit Ecology's right to use cameras or other recording equipment unless Emerald Kalama Chemical confirms, by explosion meter analysis, that there is a potentially flammable or explosive atmosphere at the point and time of desired use. In addition, in making any such recordings, Ecology will respect Emerald Kalama Chemical's business confidentiality concerns and make all reasonable efforts to not record confidential information, equipment or processes to the extent such efforts do not foreclose Ecology from making recordings it deems necessary. The Performing Party shall make all reasonable efforts to secure access rights for those properties within the Site not owned or controlled by the Performing Party where remedial activities or investigations will be performed pursuant to this Decree. Ecology or any Ecology authorized representative shall give reasonable notice to both the Performing Party and Emerald Kalama Chemical or any successor owner before entering any Site property owned or controlled by Emerald Kalama Chemical or a successor owner unless an emergency prevents such notice. All Parties who access the Site pursuant to this Section shall comply with any applicable health and safety plan(s). Ecology employees and their representatives shall not be required to sign any liability release or waiver as a condition of Site property access.

X. SAMPLING, DATA SUBMITTAL, AND AVAILABILITY

With respect to the implementation of this Decree, the Performing Party shall make the results of all sampling, laboratory reports, and/or test results generated by it or on its behalf available to Ecology within thirty (30) days of receipt of validated laboratory data. The Performing Party shall provide unvalidated data to Ecology upon request. Pursuant to WAC 173-340-840(5), all sampling data shall be submitted to Ecology in both printed and electronic formats in accordance with Section XI (Progress Reports), Ecology's Toxics Cleanup Program Policy 840 (Data Submittal Requirements), and/or any subsequent procedures specified by Ecology for data submittal.

If requested by Ecology, the Performing Party shall allow Ecology and/or its authorized representative to take split or duplicate samples of any samples collected by the Performing Party pursuant to the implementation of this Decree. The Performing Party shall notify Ecology seven (7) days in advance of any sample collection or field activities governed by this Decree, unless Ecology has provided the Performing Party with a written exemption from notification at the Site. Ecology shall, upon request, allow the Performing Party and/or its authorized representative to take split or duplicate samples of any samples collected by Ecology pursuant to the implementation of this Decree, provided that doing so does not interfere with Ecology's sampling. Without limitation on Ecology's rights under Section IX (Access), Ecology shall notify the Performing Party prior to any sample collection activity unless an emergency prevents such notice.

In accordance with WAC 173-340-830(2)(a), all hazardous substance analyses shall be conducted by a laboratory accredited under Chapter 173-50 WAC for the specific analyses to be conducted, unless otherwise approved by Ecology.

XI. PROGRESS REPORTS

Except as otherwise provided in the Scope of Work and Schedule (Exhibit C), the Performing Party shall submit to Ecology written quarterly Progress Reports that describe the actions taken during the previous quarter to implement the requirements of this Decree. The Progress Reports shall include the following:

A. A list of on-site activities that have taken place during the reporting period;

B. Detailed description of any deviations from required tasks not otherwise documented in project plans or amendment requests;

C. Description of all deviations from the Scope of Work and Schedule (Exhibit C) during the current reporting period and any planned deviations in the upcoming reporting period;

D. For any deviations in schedule, a plan for recovering lost time and maintaining compliance with the schedule;

E. All validated data received by the Performing Party during the past reporting period and an identification of the source of the sample (The Performing Party need not include unvalidated data in its Progress Reports, but shall provide such unvalidated data upon specific request from Ecology); and

F. A list of deliverables for the upcoming reporting period if different from the schedule.

All Progress Reports shall be submitted by the fifteenth (15th) day of the month in which they are due after the effective date of this Decree. Unless otherwise specified, Progress Reports and any other documents submitted pursuant to this Decree shall be sent by certified mail, return receipt requested, or Federal Express to Ecology's project coordinator.

XII. RETENTION OF RECORDS

During the pendency of this Decree, and for ten (10) years from the date this Decree is no longer in effect as provided in Section XXVIII (Duration of Decree), the Performing Party shall preserve all records, reports, documents, and underlying data in its possession relevant to the implementation of this Decree and shall insert a similar record retention requirement into all contracts with project contractors. Upon request of Ecology, the Performing Party shall make all records available to Ecology and allow access for review within a reasonable time.

Upon completion of its Performing Party obligations, Goodrich shall ensure that all applicable records are promptly transferred to Emerald Kalama Chemical as the succeeding Performing Party. Upon an Ecology determination pursuant to Section VI.C or VI.D that both Goodrich and Emerald Kalama Chemical are Performing Parties, the preceding Performing Party shall ensure that copies of all applicable records are promptly supplied to the fellow Performing Party.

XIII. TRANSFER OF INTEREST IN PROPERTY

No voluntary conveyance or relinquishment of title, easement, leasehold, or other interest in any portion of the Site shall be consummated by Emerald Kalama Chemical without provision for continued operation and maintenance of any containment system, treatment system, and/or monitoring system installed or implemented pursuant to this Decree.

Prior to the transfer of any interest in all or any portion of the Site, and during the effective period of this Decree, Emerald Kalama Chemical or the Performing Party shall ensure that a copy of this Decree is provided to any prospective purchaser, lessee, transferee, assignee, or other successor in said interest; and, except as provided below, at least thirty (30) days prior to any transfer, Emerald Kalama Chemical or the Performing Party shall notify Ecology of said transfer. Notice that has been accepted by Ecology and EPA in satisfaction of Condition I.G of Permit No. WAD 092899574 shall satisfy the requirement of this section.

Upon transfer of any interest, Emerald Kalama Chemical shall restrict uses and activities to those consistent with this Consent Decree and notify all transferees of the restrictions on the use of the property.

XIV. RESOLUTION OF DISPUTES

A. In the event a dispute arises as to an approval, disapproval, proposed change, or other decision or action by Ecology's project coordinator, or an itemized billing statement under Section XXIV (Remedial Action Costs), the Parties shall utilize the dispute resolution procedure set forth below. The timelines below are established in recognition that multiple entities may be involved in a dispute under this Decree. The timelines provided below may be extended by Ecology upon request.

1. Upon receipt of Ecology's project coordinator's written decision, or the itemized billing statement, the Performing Party has twenty-one (21) days within which to notify Ecology's project coordinator in writing of its objection to the decision or itemized statement.

2. The Performing Party's and Ecology's project coordinators shall then confer in an effort to resolve the dispute. If the project coordinators cannot resolve the dispute within twenty-one (21) days, Ecology's project coordinator shall issue a written decision.

3. The Performing Party may then request regional management review of the decision. This request shall be submitted in writing to the Section Manager, Industrial Section, Solid Waste and Financial Assistance Program within fourteen (14) days of receipt of Ecology's project coordinator's written decision.

4. Ecology's Industrial Section Manager shall conduct a review of the dispute and shall issue a written decision regarding the dispute within thirty (30) days of the Performing Party's request for review.

5. If the Performing Party finds Ecology's Industrial Section Manager's decision unacceptable, the Performing Party may then request final management review of the

decision. This request shall be submitted in writing to the Solid Waste and Financial Assistance Program Manager within fourteen (14) days of receipt of the Industrial Section Manager's decision.

6. Ecology's Solid Waste and Financial Assistance Program Manager shall conduct a review of the dispute and shall issue a written decision regarding the dispute within thirty (30) days of the Performing Party's request for review of the Industrial Section Manager's decision. The Solid Waste and Financial Assistance Program Manager's decision shall be Ecology's final decision on the disputed matter.

B. If Ecology's final written decision is unacceptable to the Performing Party, the Performing Party has the right to submit the dispute to the Court for resolution. The Parties agree that one judge should retain jurisdiction over this case and shall, as necessary, resolve any dispute arising under this Decree. In the event the Performing Party presents an issue to the Court for review, the Court shall review the action or decision of Ecology on the basis of whether such action or decision was arbitrary and capricious and render a decision based on such standard of review.

C. The Parties agree to only utilize the dispute resolution process in good faith and agree to expedite, to the extent possible, the dispute resolution process whenever it is used. Where either the Performing Party or Ecology utilizes the dispute resolution process in bad faith or for purposes of delay, the other party may seek sanctions.

D. Implementation of these dispute resolution procedures shall not provide a basis for delay of any activities required in this Decree, unless Ecology agrees in writing to a schedule extension or the Court so orders.

XV. AMENDMENT OF DECREE

The project coordinators may agree to minor changes to the work to be performed without formally amending this Decree. Minor changes will be documented in writing by

Ecology. Changes to the Performing Party designation in accordance with Section VI (Work to be Performed) herein shall not require formal amendment of this Decree.

Substantial changes to the work to be performed shall require formal amendment of this Decree. This Decree may only be formally amended by a written stipulation among the Parties that is entered by the Court, or by order of the Court. Such amendment shall become effective upon entry by the Court. Agreement to amend the Decree shall not be unreasonably withheld by any party.

The Performing Party shall submit a written request for amendment to Ecology for approval. Ecology shall indicate its approval or disapproval in writing and in a timely manner after the written request for amendment is received. If the amendment to the Decree is a substantial change, Ecology will provide public notice and opportunity for comment. Reasons for the disapproval of a proposed amendment to the Decree shall be stated in writing. If Ecology does not agree to a proposed amendment, the disagreement may be addressed through the dispute resolution procedures described in Section XIV (Resolution of Disputes).

XVI. EXTENSION OF SCHEDULE

A. An extension of schedule shall be granted only when a request for an extension is submitted in a timely fashion, generally at least thirty (30) days prior to expiration of the deadline for which the extension is requested, and good cause exists for granting the extension. All extensions shall be requested in writing. The request shall specify:

1. The deadline that is sought to be extended;
2. The length of the extension sought;
3. The reason(s) for the extension; and
4. Any related deadline or schedule that would be affected if the extension were granted.

B. The burden shall be on the Performing Party to demonstrate to the satisfaction of Ecology that the request for such extension has been submitted in a timely fashion and that good cause exists for granting the extension. Good cause may include, but may not be limited to:

1. Circumstances beyond the reasonable control and despite the due diligence of the Performing Party including delays caused by unrelated third parties or Ecology, such as (but not limited to) delays by Ecology in reviewing, approving, or modifying documents submitted by the Performing Party;

2. Acts of God, including fire, flood, blizzard, extreme temperatures, storm, or other unavoidable casualty; or

3. Endangerment as described in Section XVII (Endangerment).

However, neither increased costs of performance of the terms of this Decree nor changed economic circumstances shall be considered circumstances beyond the reasonable control of the Performing Party.

C. Ecology shall act upon any written request for extension in a timely fashion. Ecology shall give the Performing Party written notification of any extensions granted pursuant to this Decree. A requested extension shall not be effective until approved by Ecology or, if required, by the Court. Unless the extension is a substantial change, it shall not be necessary to amend this Decree pursuant to Section XV (Amendment of Decree) when a schedule extension is granted.

D. An extension shall only be granted for such period of time as Ecology determines is reasonable under the circumstances.

XVII. ENDANGERMENT

In the event Ecology determines that any activity being performed at the Site is creating or has the potential to create a danger to human health or the environment, Ecology may direct the Performing Party to cease such activities for such period of time as it deems necessary to abate the danger. The Performing Party shall immediately comply with such direction. In such a case, no Defendant hereunder shall be subject to any enforcement action for stopping implementation of the subject activities pursuant to Ecology’s direction.

In the event the Performing Party determines that any activity being performed at the Site is creating or has the potential to create a danger to human health or the environment, the Performing Party may cease such activities. The Performing Party shall notify Ecology’s project coordinator as soon as possible, but no later than twenty-four (24) hours after making such determination or ceasing such activities. Upon Ecology’s direction, the Performing Party shall provide Ecology with documentation of the basis for the determination or cessation of such activities. If Ecology disagrees with the Performing Party’s cessation of activities, it may direct the Performing Party to resume such activities.

If Ecology concurs with or orders a work stoppage pursuant to this Section, the Performing Party’s obligations with respect to the ceased activities shall be suspended until Ecology determines the danger is abated, and the time for performance of such activities, as well as the time for any other work dependent upon such activities, shall be extended, in accordance with Section XVI (Extension of Schedule), for such period of time as Ecology determines is reasonable under the circumstances. In such a case, no Defendant hereunder shall be subject to any enforcement action for stopping implementation of the subject activities pursuant to Ecology’s direction.

Nothing in this Decree shall limit the authority of Ecology, its employees, agents, or contractors to take or require appropriate action in the event of an emergency.

XVIII. COVENANT NOT TO SUE

A. Covenant Not to Sue: In consideration of the Performing Party’s compliance with the terms and conditions of this Decree, Ecology covenants not to institute legal or administrative actions against any Defendant regarding the release or threatened release of hazardous substances covered by this Decree.

This Decree covers only the Site specifically identified in the Site Diagram (Exhibit A) and those hazardous substances that Ecology knows are located at the Site as of the date of entry of this Decree. This Decree does not cover any other hazardous substance or area. Ecology retains all of its authority relative to any substance or area not covered by this Decree.

This Covenant Not to Sue shall have no applicability whatsoever to:

1. Criminal liability;

2. Liability for damages to natural resources; and

3. Any Ecology action, including cost recovery, against PLPs not a party to this Decree.

If factors not known at the time of entry of the settlement agreement are discovered and present a previously unknown threat to human health or the environment, the Court shall amend this Covenant Not to Sue.

B. Reopeners: Ecology specifically reserves the right to institute legal or administrative action against the Performing Party to require it to perform additional remedial actions at the Site and to pursue appropriate cost recovery, pursuant to RCW 70.105D.050 under the following circumstances:

1. Upon the Performing Party’s failure to meet the requirements of this Decree, including, but not limited to, failure of the remedial action to meet the cleanup standards identified in the CAP (Exhibit B);

2. Upon Ecology’s determination that remedial action beyond the terms of this Decree is necessary to abate an imminent and substantial endangerment to human health or the environment;

3. Upon the availability of new information regarding factors previously unknown to Ecology, including the nature or quantity of hazardous substances at the Site, and Ecology’s determination, in light of this information, that further remedial action is necessary at the Site to protect human health or the environment; or

4. Upon Ecology's determination that additional remedial actions are necessary to achieve cleanup standards within the reasonable restoration time frame set forth in the CAP.

C. Except in the case of an emergency, prior to instituting legal or administrative action against the Performing Party pursuant to this Section, Ecology shall provide the Performing Party with fifteen (15) calendar days notice of such action.

D. All Defendants hereunder reserve all rights and defenses with respect to any additional remedial actions that Ecology may seek to require at the Site, including but not limited to reopening this Decree or seeking to amend the Covenant Not to Sue.

XIX. CONTRIBUTION PROTECTION

With regard to claims for contribution against Defendants, the Parties agree that Defendants are entitled to protection against claims for contribution for matters addressed in this Decree as provided by RCW 70.105D.040(4)(d).

XX. LAND USE RESTRICTIONS

The Performing Party and/or Emerald Kalama Chemical shall record or cause to be recorded a Restrictive Covenant (Exhibit D) with the office of the Cowlitz County Auditor within ten (10) days of the entry of this Decree. The Restrictive Covenant shall restrict future uses of the Site. The Performing Party shall provide Ecology with a copy of the recorded Restrictive Covenant within thirty (30) days of the recording date.

XXI. FINANCIAL ASSURANCES

A. Pursuant to WAC 173-340-440(11), the Performing Party shall establish and maintain financial assurance for corrective action in at least the amount necessary to implement the CAP, as provided in WAC 173-340 and required by WAC 173-303-646(20). Except as modified below and in the absence of detailed regulations, EPA's "Interim Guidance on Financial Responsibility for Facility Subject to RCRA Corrective Action" issued

September 30, 2003 shall be used as guidance for providing financial assurance for corrective action. At its discretion, Ecology may also use EPA's Proposed Rules issued October 24, 1986, (51 Fed. Reg. 37854) and May 1, 1996, (61 Fed. Reg. 19432) as additional sources of guidance, as well as any other source of guidance that may be available at the time. The Performing Party shall make satisfactory demonstration to Ecology that all financial assurance documents include appropriate provision for Ecology to gain access to the funds to implement corrective action in the event Ecology determines that corrective action is not being conducted in accordance with the provisions of this Decree. Upon evidence of the failure of the Performing Party to demonstrate continuous financial assurance for corrective action, Ecology may direct the payment or use of funds to assure that the approved corrective action plan is carried out. Acceptable mechanisms include letters of credit, surety bonds, liability insurance, trust funds, the financial test, the corporate guarantee, or equivalent mechanisms as approved by Ecology. The Performing Party shall provide Ecology's financial assurance officer with documentation of this financial assurance within sixty (60) days of the effective date of this Decree. Submission of unacceptable documentation, even if within the sixty (60) day requirement, does not fulfill the Performing Party's financial assurance obligation. During this sixty (60) day time period, at the request of the Performing Party, Ecology shall provide guidance and feedback regarding acceptability of the Performing Party's financial assurance documentation. The date that acceptable final original financial assurance documentation is received by Ecology's financial assurance officer is the "financial assurance anniversary date" of this Decree.

B. The Performing Party shall adjust the financial assurance coverage and provide Ecology's financial assurance officer with documentation of the updated financial assurance for:

1. Inflation, annually, within thirty (30) days of the financial assurance anniversary date; or if applicable, the modified anniversary date that has been set in 2, below.

2. Changes in cost estimates, within thirty (30) days of issuance of Ecology's approval of a modification or revision to the CAP.

Receipt of the updated financial assurance documents does not modify the financial assurance anniversary date.

If the Performing Party elects to use either the financial test or corporate guarantee to meet its financial assurance obligation, the Performing Party shall submit the required chief financial officer letter, auditor's reports, financial statements, and any applicable corporate guarantee. These documents shall be submitted within one hundred twenty (120) days after the Performing Party's fiscal year end, regardless of the financial assurance anniversary date. Changes to the financial assurance anniversary date do not affect this requirement. At its option, the Performing Party may elect to make the annual inflation adjustment simultaneously with this submittal, instead of within thirty (30) days of the financial assurance anniversary date.

C. The Performing Party shall notify Ecology's project coordinator and Ecology's financial assurance officer by certified mail of the commencement of a voluntary or involuntary bankruptcy proceeding under Title 11, United States Code, naming the Performing Party, within ten (10) days after commencement of the proceeding. A guarantor or a corporate guarantee must make such a notification if he is named as debtor as required under the terms of the corporate guarantee.

D. Once the Performing Party has established financial assurance for corrective action with an acceptable mechanism, the Performing Party will be deemed to be without the required financial assurance or liability coverage:

1. In the event of bankruptcy of the trustee or issuing institution; or

2. The authority of the trustee institution to act as trustee has been suspended or revoked; or

3. The authority of the institution issuing the surety bond, letter of credit or insurance policy has been suspended or revoked.

E. The Performing Party must establish other financial assurance within sixty (60) days of bankruptcy, or suspension/revocation of authority.

F. Emerald Kalama Chemical shall establish financial assurance within sixty (60) days of becoming the Performing Party under this Decree. A Performing Party's financial assurance obligations shall terminate on the sixty-first day after it ceases to be the Performing Party under this Decree, or upon the establishment of financial assurance by the succeeding Performing Party, whichever is earlier.

XXII. INDEMNIFICATION

The Performing Party agrees to indemnify and save and hold the State of Washington, its employees, and agents harmless from any and all claims or causes of action for death or injuries to persons or for loss or damage to property to the extent arising from or on account of acts or omissions of the Performing Party, its officers, employees, agents, or contractors in entering into and implementing this Decree. However, the Performing Party shall not indemnify the State of Washington nor save nor hold its employees and agents harmless from any claims or causes of action to the extent arising out of the negligent acts or omissions of the State of Washington, or the employees or agents of the State, in entering into or implementing this Decree.

XXIII. COMPLIANCE WITH APPLICABLE LAWS

A. All actions carried out by the Performing Party pursuant to this Decree shall be done in accordance with all applicable federal, state, and local requirements, including requirements to obtain necessary permits, except as provided in RCW 70.105D.090. The permits or other federal, state or local requirements that the agency has determined are applicable and that are known at the time of entry of this Decree have been identified in the CAP (Exhibit B).

B. Pursuant to RCW 70.105D.090(1), the Defendants are exempt from the procedural requirements of Chapters 70.94, 70.95, 70.105, 77.55, 90.48, and 90.58 RCW and of any laws requiring or authorizing local government permits or approvals. However, the Performing Party shall comply with the substantive requirements of such permits or approvals. The exempt permits or approvals and the applicable substantive requirements of those permits or approvals, as they are known at the time of entry of this Decree, have been identified in the CAP (Exhibit B).

The Performing Party has a continuing obligation to determine whether additional permits or approvals addressed in RCW 70.105D.090(1) would otherwise be required for the remedial action under this Decree. In the event either Ecology or the Performing Party determines that additional permits or approvals addressed in RCW 70.105D.090(1) would otherwise be required for the remedial action under this Decree, it shall promptly notify the other party of this determination. Ecology shall determine whether Ecology or the Performing Party shall be responsible to contact the appropriate state and/or local agencies. If Ecology so requires, the Performing Party shall promptly consult with the appropriate state and/or local agencies and provide Ecology with written documentation from those agencies of the substantive requirements those agencies believe are applicable to the remedial action. Ecology shall make the final determination on the additional substantive requirements that must be met by the Performing Party and on how the Performing Party must meet those requirements. Ecology shall inform the Performing Party in writing of these requirements. Once established by Ecology, the additional requirements shall be enforceable requirements of this Decree. The Performing Party shall not begin or continue the remedial action potentially subject to the additional requirements until Ecology makes its final determination.

C. Pursuant to RCW 70.105D.090(2), in the event Ecology determines that the exemption from complying with the procedural requirements of the laws referenced in RCW 70.105D.090(1) would result in the loss of approval from a federal agency that is necessary for the State to administer any federal law, the exemption shall not apply and the Performing Party shall comply with both the procedural and substantive requirements of the laws referenced in RCW 70.105D.090(1), including any requirements to obtain permits. Such a determination by Ecology shall not affect the applicability of the exemption to any of the other statutes referenced in RCW 70.105D.090(1).

XXIV. REMEDIAL ACTION COSTS

The Performing Party shall pay to Ecology costs incurred by Ecology pursuant to this Decree and consistent with WAC 173-340-550(2). These costs shall include work performed by Ecology or its contractors concerning this Decree for, or on, the Site under Chapter 70.105D RCW, including remedial actions and Decree preparation, negotiation, oversight and administration of this Decree. These costs shall include work performed both prior to and subsequent to the entry of this Decree. Ecology's costs shall include costs of direct activities and support costs of direct activities as defined in WAC 173-340-550(2). The Performing Party shall pay the required amount, except for those costs that the Performing Party disputes, within ninety (90) days of receiving from Ecology an itemized statement of costs that includes a summary of costs incurred, an identification of involved staff, a description of work performed, and the amount of time spent by involved staff members on the project. Itemized statements shall be prepared quarterly. Pursuant to WAC 173-340-550(4), failure to pay Ecology's costs, other than disputed costs, within ninety (90) days of receipt of the itemized statement of costs will result in interest charges as authorized by state law. The Performing Party shall pay any disputed costs that remain after completion of the dispute resolution process set forth in Section XIV above within thirty (30) days of such completion. Payments mailed via the U.S. Postal Service should be addressed to:

Department of Ecology
Cashiering Section
P.O. Box 5128
Lacey, Washington 98509-5128

Payments sent by a messenger/overnight delivery service should be addressed to:

Department of Ecology
Cashiering Section
300 Desmond Drive
Lacey, Washington 98503

So it is properly credited, the Performing Party should indicate the check is for cost recovery on the Emerald Kalama Chemical Facility, and enclose the bottom portion of Ecology's invoice.

Pursuant to RCW 70.105D.055, Ecology has authority to recover unreimbursed remedial action costs by filing a lien against real property subject to the remedial actions. Except under the circumstances provided under RCW 70.105D.055(3)(e), Ecology agrees to not file a lien against the Site unless it first seeks to obtain any unreimbursed remedial action costs from Emerald Kalama Chemical and unless Emerald Kalama Chemical fails to reimburse Ecology for those costs within six (6) months, or such other period to which Ecology and Emerald Kalama Chemical may agree. This agreement does not preclude Ecology from giving the notices required under RCW 70.105D.055(2)(e) or (3)(a).

XXV. IMPLEMENTATION OF REMEDIAL ACTION

If Ecology determines that the Performing Party has failed without good cause to implement the remedial action, in whole or in part, Ecology may perform any or all portions of the remedial action that remain incomplete after: (1) providing notice to all Defendants, unless an emergency situation precludes such notice; and (2) providing a reasonable opportunity, taking into account the nature of the activity and the circumstances at the Site, for such Defendants to implement the remedial action in accordance with Section VI (Work to be Performed). If Ecology performs all or portions of the remedial action because of Defendants' failure to comply with their obligations under this Decree, Defendants shall reimburse Ecology for the costs of doing such work in accordance with Section XXIV (Remedial Action Costs), provided that Defendants are not obligated under this Section to reimburse Ecology for costs incurred for work inconsistent with or beyond the scope of this Decree.

Except where necessary to abate an emergency situation, the Performing Party shall not perform any active remedial actions at the Site other than those remedial actions required by this Decree or another order, permit or written authorization issued by Ecology, unless Ecology concurs, in writing, with such additional remedial actions pursuant to Section XV (Amendment of Decree). For purposes of this Decree, the term “active remedial actions” shall mean on-the-ground investigation (including sampling), remedy construction, operation of remedial systems, or similar activities.

XXVI. PERIODIC REVIEW

As remedial action, including groundwater monitoring, continues at the Site, the Parties agree to review the progress of remedial action at the Site, and to review the data accumulated as a result of monitoring the Site as often as is necessary and appropriate under the circumstances. At least every five (5) years after the initiation of cleanup action at the Site the Parties shall meet to discuss the status of the Site and the need, if any, for further remedial action at the Site. At least ninety (90) days prior to each periodic review, the Performing Party shall submit a report to Ecology that documents whether human health and the environment are being protected based on the factors set forth in WAC 173-340-420(4). Ecology reserves the right to seek to require further remedial action at the Site under appropriate circumstances. Defendants reserve all rights and defenses with respect to any additional remedial action that Ecology may seek to require. This provision shall remain in effect for the duration of this Decree.

XXVII. PUBLIC PARTICIPATION

A Public Participation Plan (Exhibit E) is required for this Site. Ecology shall review any existing Public Participation Plan to determine its continued appropriateness and whether it requires amendment, or if no plan exists, Ecology shall develop a Public Participation Plan alone or in conjunction with the Performing Party.

Ecology shall maintain the responsibility for public participation at the Site. However, the Performing Party shall cooperate with Ecology, and shall:

A. If agreed to by Ecology, develop appropriate mailing list, prepare drafts of public notices and fact sheets at important stages of the remedial action, such as the submission of work plans, remedial investigation/feasibility study reports, cleanup action plans, and engineering design reports. As appropriate, Ecology will edit, finalize, and distribute such fact sheets and prepare and distribute public notices of Ecology's presentations and meetings.

B. Notify Ecology's project coordinator prior to the preparation of all press releases and fact sheets, and before major meetings with the interested public and local governments. Likewise, Ecology shall notify the Performing Party prior to the issuance of all press releases and fact sheets, and before major meetings with the interested public and local governments. For all press releases, fact sheets, meetings, and other outreach efforts by the Performing Party that do not receive prior Ecology approval, the Performing Party shall clearly indicate to its audience that the press release, fact sheet, meeting, or other outreach effort was not sponsored or endorsed by Ecology.

C. When requested by Ecology, participate in public presentations on the progress of the remedial action at the Site. Participation may be through attendance at public meetings to assist in answering questions, or as a presenter.

D. When requested by Ecology, arrange and/or continue information repositories at the following locations:

1. Kalama Library
312 North First
Kalama, WA 98625
(360) 673-4568

2. Department of Ecology
Southwest Regional Office
300 Desmond Drive
Lacey, WA 98504-7600

At a minimum, copies of all public notices, fact sheets, and press releases; all quality assured monitoring data; remedial actions plans and reports, supplemental remedial planning documents, and all other similar documents relating to performance of the remedial action required by this Decree shall be promptly placed in these repositories.

XXVIII. DURATION OF DECREE

The remedial program required pursuant to this Decree shall be maintained and continued until Defendants have received written notification from Ecology that the requirements of this Decree have been satisfactorily completed. This Decree shall remain in effect until dismissed by the Court. When dismissed, Section XVIII (Covenant Not to Sue) and Section XIX (Contribution Protection) shall survive.

XXIX. CLAIMS AGAINST THE STATE

Defendants hereby agree that they will not seek to recover any costs accrued in implementing the remedial action required by this Decree from the State of Washington or any of its agencies; and further, that Defendants will make no claim against the State Toxics Control Account or any local Toxics Control Account for any costs incurred in implementing this Decree. Except as provided above, however, Defendants expressly reserve their rights to seek to recover any costs incurred in implementing this Decree from any other PLP. This Section does not limit or address funding that may be provided under Chapter 173-322 WAC.

XXX. EFFECTIVE DATE

This Decree is effective upon the date it is entered by the Court.

XXXI. WITHDRAWAL OF CONSENT

If the Court withholds or withdraws its consent to this Decree, it shall be null and void at the option of any party and the accompanying Complaint shall be dismissed without costs and without prejudice. In such an event, no party shall be bound by the requirements of this Decree.

STATE OF WASHINGTON DEPARTMENT OF ECOLOGY	ROBERT M. McKENNA Attorney General
__________________________________ By:______________________________ Acting Program Manager Solid Waste & Financial Assistance Program (360) 407-6103	__________________________________ Andrew A. Fitz, WSBA # 22169 Assistant Attorney General (360) 586-6752
Date: __________________	Date: _________________
GOODRICH CORPORATION	EMERALD KALAMA CHEMICAL LLC
__________________________________ Bruce Amig Director of Global Remediation Services (704) 423-7071	__________________________________ Brian Denison Vice President, Health, Safety, Environmental, Technology & Logistics (330) 916-6705
Date: __________________	Date: _________________

ENTERED this _____ day of ________________, 20____.

____
JUDGE
Cowlitz County Superior Court

EXHIBIT A

Site Diagram and Legal Description

COWLITZ COUNTY
TITLE CO.

LIMITED LIABILITY CERTIFICATE

DATE: August 25, 1994 at 8:00 a.m.

Order No.	:102712
Charge	:$250.00
Tax	: 18.75
Total	:$268.75

This is a report as of August 8, 1994, covering the property hereinafter described. The information contained herein is made solely for the purpose of determining the status of the property described herein, is restricted to the use of the addressee, and is not to be used as a basis for closing any transaction affecting title to said property. Liability is limited to the charge made for this certificate.

LEGAL DESCRIPTION:

A PARCEL OF LAND IN SECTIONS 1 AND 12, TOWNSHIP 6 NORTH, RANGE 2 WEST OF THE W.M., AND SECTIONS 6 AND 7, TOWNSHIP 6 NORTH, RANGE 1 WEST OF THE W.M., COWLITZ COUNTY, WASHINGTON;

BEGINNING AT A POINT 916.0 FEET NORTH AND 610.9 FEET WEST OF THE SOUTHWEST CORNER OF SMITH M. HENSIL D.L.C. NO. 39, COWLITZ COUNTY, WASHINGTON;
THENCE RUNNING DUE WEST 479.63 FEET TO THE INTERSECTION OF THE GOVERNMENT MEANDER LINE ON THE EAST BANK OF THE COLUMBIA RIVER;
THENCE NORTHERLY ALONG SAID MEANDER LINE NORTH 52° 38' WEST 187.52 FEET, NORTH 38° 52' WEST 708.1 FEET, NORTH 49° 07' WEST 781.7 FEET, NORTH 4° 38' WEST 76.2 FEET, NORTH 22° 22' WEST 123.8 FEET, NORTH 71° 08' WEST 121.8 FEET, NORTH 45° 07' WEST 58.6 FEET, NORTH 31° 08' WEST 260.6 FEET, NORTH 22° 53' WEST 43.0 FEET;
THENCE RUNNING NORTH 57° 30' 00" EAST 2597.14 FEET TO A POINT ON THE WEST LINE OF SAID JAMES ROCKEY D.L.C. NO. 38;
THENCE SOUTH 34° 44' 50" EAST 1763.67 FEET TO THE INTERSECTION OF THE WEST LINE OF SAID JAMES ROCKEY D.L.C. WITH A LINE 60 FEET WEST AND PARALLEL TO THE WEST RIGHT OF WAY LINE OF THE GREAT NORTHERN, NORTHERN PACIFIC AND UNION PACIFIC RAILROADS;
THENCE SOUTH 17° 37' EAST 1738.32 FEET;
THENCE DUE WEST 1696.08 FEET TO THE POINT OF BEGINNING.

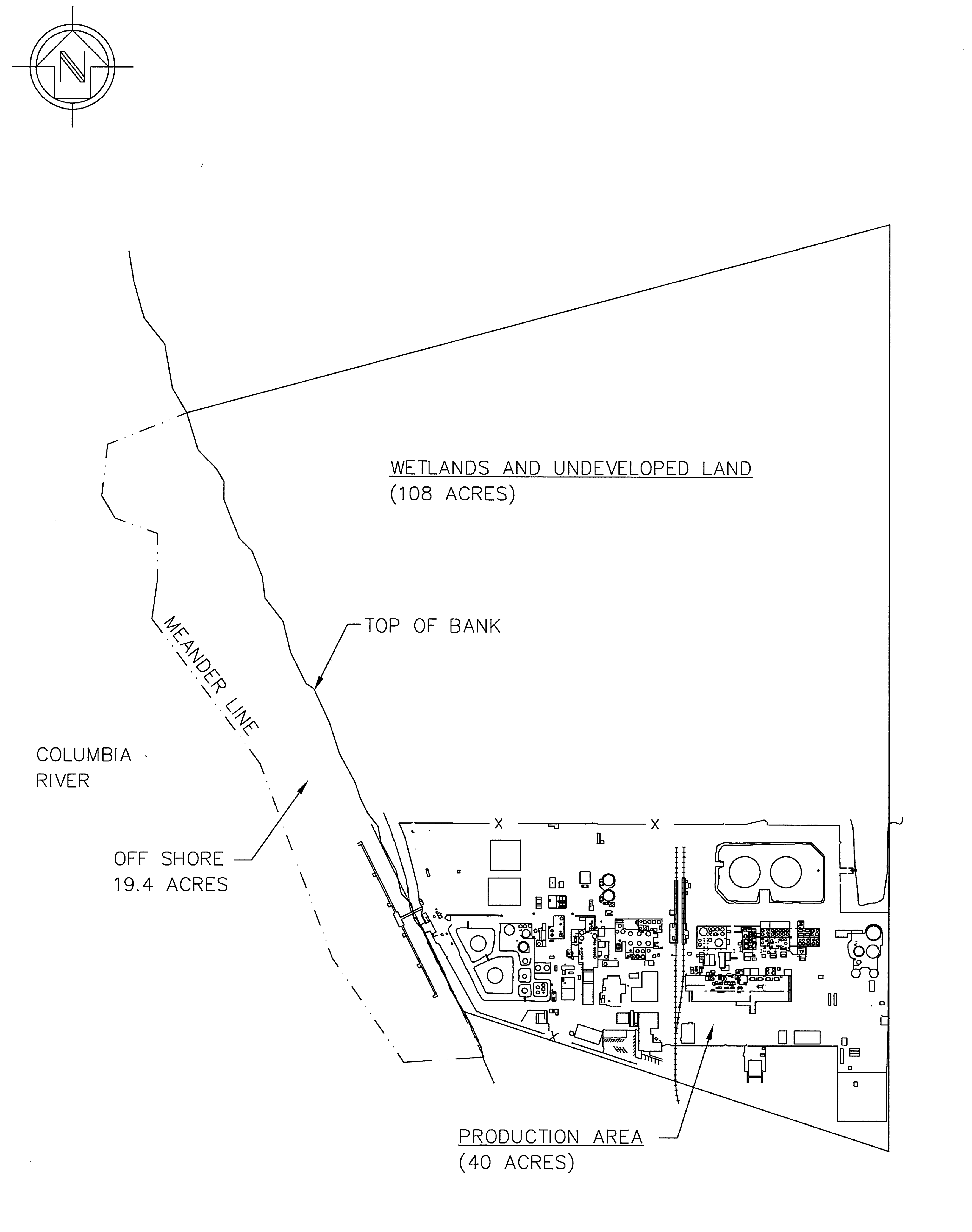
ALSO:

A PARCEL OF LAND LYING IN SECTION 6, TOWNSHIP 5 NORTH, RANGE 1 WEST OF THE W.M., BEING A PORTION OF THE JAMES ROCKEY D.L.C. NO. 38, DESCRIBED AS FOLLOWS:

BEGINNING AT A POINT IN THE INTERSECTION OF THE WEST LINE OF THE JAMES ROCKEY D.L.C. NO. 38 AND A LINE 60 FEET WEST OF AND PARALLEL WITH THE GREAT NORTHERN, NORTHERN PACIFIC AND UNION PACIFIC RAILROADS WEST RIGHT OF WAY LINE;
THENCE NORTH 34° 44' 30" WEST 1763.67 FEET ALONG THE WEST LINE OF SAID D.L.C.;
THENCE NORTH 57° 30' EAST 537.55 FEET TO A POINT 60 FEET WEST OF THE WEST RIGHT OF WAY OF THE GREAT NORTHERN, NORTHERN PACIFIC AND UNION PACIFIC RAILROADS;
THENCE SOUTH 17° 37' EAST 1823.49 FEET TO THE POINT OF BEGINNING.

SITUATE IN COWLITZ COUNTY, STATE OF WASHINGTON

1145 14th Avenue ■ Longview, Washington 98632
Phone: (206) 423-5330 Fax: (206) 423-5932 Night Owl Line: (206) 423-9916
"Service is the Difference"



REV MARK	DWG COORD	JOB No.	REVISION	BY	DATE	APP

DESIGNED
DRAWN LAG 7/27/00
CHECKED
APPROVED
NOTED
MFG REP

BFGoodrich Kalama, Inc.
Kalama, Washington

KALAMA PLANT
PROPERTY BOUNDRIES

JOB NUMBER
SCALE 1"=500'
1-001-000-PROP 0

Cleanup Action Plan

Noveon Kalama
Kalama, Washington

Prepared by:

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, WA 98134-1162

RETEC Project Number: BFGKI-15231-240

Prepared for:

Noveon Kalama
1296 Third Street N.W.
Kalama, Washington 98625 U.S.A.

and

Rogers Sugar, Ltd.
1508 W. Broadway, Suite #900
Vancouver, British Columbia V6J 1W8
Canada

June 30, 2004

Cleanup Action Plan

Noveon Kalama
Kalama, Washington

Prepared by:

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1508 W. Broadway, Suite #900
Vancouver, British Columbia V6J 1W8
Canada

Prepared by:

Allison J. Crowley
Allison J. Crowley, P.E., Project Manager

Reviewed by:

Halah M. Voges, P.E., Senior Program Manager

Allison J. Crowley FOR MJR
Michael J. Riley, Senior Project Engineer, S.S. Papadopulos & Associates

June 30, 2004

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Introduction

This report presents the Cleanup Action Plan (CAP) for the Noveon Kalama, Inc. (Noveon), facility in Kalama, Washington. The Noveon Kalama chemical manufacturing facility (facility) has been in operation since 1962. The facility was operated by Dow Chemical until 1971, when Kalama Chemical, Inc., purchased the facility. In 1990, Kalama Chemical, Inc., became a wholly owned subsidiary of BC Sugar Corporation, who then sold all of its stock in Kalama Chemical, Inc., to Freedom Chemical in 1994. In March 1998, Kalama Chemical, Inc., was acquired by BFGoodrich and changed its name to BFGoodrich Kalama, Inc. In 2001, BFGoodrich Kalama changed its name to Noveon Kalama, Inc.

1.1 Purpose

The purpose of this CAP is to:

- Summarize the cleanup action selected in the Feasibility Study (FS) (RETEC, 2003a)
- Describe the cleanup levels, points of compliance, and compliance monitoring program for the site
- Provide a document through which public comment may be solicited regarding the preferred cleanup action.

The CAP presents the site description and history, and summarizes the results of previous investigation efforts. These results are described in detail in the FS and are summarized in this document to provide background information pertinent to the remainder of the document.

The CAP also presents the preferred remedy for cleanup of the site and the rationale and evaluation criteria for the preferred action.

This CAP was prepared in accordance with WAC 173-340-380, which sets forth requirements for the CAP.

1.1.1 Applicability and Disclaimer

This CAP is applicable only to the Noveon Kalama Site in Kalama, Washington. The cleanup action has been developed as an overall remediation process conducted under Ecology oversight. Cleanup actions are not directly applicable to other sites.

1.1.2 The CAP and the Cleanup Process

The CAP is one in a series of documents required under the MTCA (WAC 173-340) cleanup process and Agreed Order No DE 98H-S327. The

Remedial Investigation (RI) (RETEC, 2000a) and the FS (RETEC, 2003a) presented the results of investigations of the nature and extent of contamination at the site. The FS (RETEC, 2003a) also evaluated the feasibility of remedial alternatives for the site.

Following Ecology's approval of the CAP, other documents that are anticipated to be developed and submitted for Ecology's approval pursuant to a consent decree to be subsequently negotiated between Noveon Kalama, Rogers Sugar Ltd., and Ecology or pursuant to another administrative mechanism are:

- Engineering Design Report and Construction Plans and Specifications, to provide the necessary technical drawings and specifications to allow a contractor to implement the cleanup.
- Completion Report and documentation of any changes or modifications that were necessary during the course of implementing the cleanup action.
- Compliance Monitoring Reports provided to Ecology at the reporting interval specified in the Compliance Monitoring Plan to confirm that the cleanup action attains the cleanup levels and performance standards identified in the approved CAP and to ensure long-term protection of human heath and the environment.
- Operation and Maintenance (O&M) Plan to outline protocols for the operation and maintenance of the Interim Corrective Measures (ICM) and the SVE and Waterloo Emitter™ systems.
- Documentation that institutional controls such as fencing, deed restrictions, security, safety, and educational procedures related to the CAP have been implemented.

1.2 Operational History

Toluene historically has been the principal raw material used at the facility, and is still used by Noveon to produce benzoic acid, phenol, and a variety of other products that are derived from toluene. Noveon's products are used as preservatives in foods and beverages and as additives in pharmaceuticals, fragrances, surfactants, plasticizers, and other consumer products.

Historic spills have resulted in groundwater contamination in some areas of the Noveon facility. Response measures included immediate recovery and containment activities, as well as longer-term recovery operations, procedural changes, and plant modifications. Noveon has adopted numerous procedures to ensure that valves, flanges, and fittings across the facility are routinely inspected and maintained. Noveon has also undertaken significant paving and containment projects to ensure that any potential leaks or spills are contained and appropriately managed.

Other known sources of historical groundwater contamination include the transfer sump, the process sewer system and the API separator. The process sewer system collects wastewater from process areas and equipment and conveys it to the API separator. The original process sewer system was constructed of vitrified clay pipe with polyvinyl chloride (PVC) joint rings; drain lines under paved areas were constructed of cast iron. Between 1987 and 1991, all underground piping for the process sewer was replaced with high-density polyethylene (HDPE) piping, slip-lined with thick-walled HDPE piping, or converted to overhead piping. Life of the HDPE piping is expected to be greater than 20 years. Isolated inspections of the installed piping revealed no signs of leakage.

The structural integrity of the API separator was inspected when the process sewer pipe was lined in the late 1980s. The east side of the API separator was exposed by a 10-foot-long trench. This side of the API separator was intact, and no signs of leakage or releases were apparent. The entire API separator has been inspected from the inside. No signs of leakage were apparent. A comprehensive discussion of known groundwater sources at the facility is included in the RI (ThermoRetec, 2000a).

1.3 Regulatory History

From time to time, the United States Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) have conducted inspections of the Noveon Kalama facility; EPA inspections have included a Comprehensive Groundwater Monitoring Evaluation and a multimedia inspection. Noveon and EPA entered into an Agreed Order, effective April 15, 1991, pursuant to Section 3008(h) of the Resource Conservation and Recovery Act (RCRA), 42 United States Code (U.S.C.) §6928 et seq. (1991 Order). The 1991 Order required the completion of a RCRA Facility Investigation (RFI), a Corrective Measures Study (CMS), and an Interim Corrective Measures Evaluation (ICME). The work described in the approved RFI Work Plan was initiated in 1992, and a draft RFI Report was submitted on August 29, 1994, which EPA approved as final on September 12, 1994. Subsequently, a draft Supplemental RFI (SRFI) was submitted to EPA on December 19, 1997. The SRFI was submitted to address specific data needs and to provide the basis for assessing final corrective measures at the facility.

On November 5, 1998, Ecology entered into an Agreed Order with Noveon and Rogers Sugar, Ltd. (successor by amalgamation to BC Sugar) under the Model Toxics Control Act (MTCA Order), and the 1991 RCRA Order with EPA was subsequently terminated on April 25, 1999. Under the MTCA Order, Noveon and Rogers Sugar, Ltd. have conducted a remedial investigation and feasibility study (RI/FS) and have prepared this draft cleanup action plan in accordance with WAC 173-340. Submittal of this CAP is required under the MTCA Order.

1.4 ICM History

In the RFI, the facility was divided into the North Impacted Area (NIA) and the West Impacted Area (WIA) based on distributions of COCs and the direction of groundwater flow. As part of the SRFI, two additional areas were identified: the Central Area and the East Area. Interim corrective measures (ICMs) were designed to address discharges of COCs from the NIA and WIA. These ICMs included an interception trench constructed in the NIA to control and reduce discharges from the upper sand to the wetland. In 1997, a soil vapor extraction (SVE) system, a shallow interception trench system, and an intermediate sand recovery well network were installed as ICMs in the WIA to control discharges to the Columbia River. The NIA ICM and WIA ICMs, with the exception of the SVE system, continue to operate and have removed over 37,100 pounds of organic contaminants from site soil and groundwater through October 2003. The SVE system was shut down with Ecology approval following a shutdown-startup test, which demonstrated that the system had been effective in removing the vapor-phase contaminants within the system area.

2 Cleanup Action Selection

The FS (RETEC, 2003a) presented a detailed screening of a number of technologies, from which the preferred remedial alternatives were selected. The preferred alternatives are discussed in detail in Section 3.1 of this document. This section briefly explains the selection process, describes the preferred cleanup action, and presents approved cleanup levels. Points of compliance, action levels and contingency plans are also discussed.

2.1 Remedial Goals and Objectives

An exposure assessment presented in the FS Work Plan (ThermoRetec, 2000b; Section 3) identified potential risks to human health and the environment from contamination at Noveon. The following remedial action objectives (RAOs) for the site address these exposure pathways:

- Protection of site workers from exposure to contaminated soil and groundwater that exceed protective levels

- Protection of recreational users of the Columbia River from exposure to contaminated surface water

- Protection of humans from exposure due to ingestion of drinking water and fish consumption

- Protection of wildlife from exposure to contaminated soil that exceeds protective levels

- Protection of aquatic organisms in surface water from contaminated groundwater that exceeds protective levels including compliance with the Endangered Species Act.

2.1.1 Cleanup Levels

The exposure risks were evaluated relative to whether COCs are or may be present at concentrations that exceed acceptable levels. Cleanup goals addressing these potential exposure pathways were developed in the FS Work Plan and the *Recommended Groundwater Cleanup Levels for Ecological Receptors* memorandum (RETEC, 2003b, Appendix G). Site data were compared to these goals to identify areas that must be targeted for remediation. Ecology-approved cleanup levels are presented in Table 2-1, and areas exceeding cleanup levels are shown on Figures 2-1 through 2-5.

Selected cleanup levels for groundwater are based on protection of surface water. Both ecological and human potential exposure risks are limited to surface water into which impacted groundwater may discharge. Cleanup levels for benzene and bis(2-ethylhexyl)phthalate are based on Human Health

Criteria for freshwater in the National Toxics Rule, 40 Code of Federal Regulations (CFR), Part 131, which protect humans from exposure from drinking water and fish consumption. Cleanup levels for benzoic acid, biphenyl, diphenyl oxide, phenol, and toluene are based on the site-specific literature evaluation documented in the RETEC memorandum *Recommended Groundwater Cleanup Levels for Ecological Receptors* (RETEC, 2003b, Appendix G). The levels chosen from the literature for these five constituents are lower than the human health criteria described above. Cleanup levels for these compounds were approved by Ecology on April 17, 2003. Cleanup levels for arsenic and copper are based on natural background concentrations in the area.

Soil cleanup levels define soil concentrations that protect humans from direct contact and cleanup levels that are protective of groundwater. Cleanup levels that are protective of groundwater were derived according to the criteria in WAC 173-340-747(4). Table 2-2 provides the input parameters used in the calculations. None of the COCs exceeded direct contact cleanup levels; however, benzene, toluene, benzoic acid, biphenyl, phenol, and arsenic exceed the soil cleanup levels that are protective of groundwater. Thus, cleanup alternatives for the site will address the potential leaching of these COCs to groundwater.

Figures 2-3 through 2-5 show areas where groundwater cleanup levels are exceeded based on results of site-wide groundwater sampling that was conducted during the RI in 1999. If a well was not sampled in 1999, earlier data were reviewed to determine if cleanup levels were exceeded at the well. The areas that exceed cleanup levels continue to be consistent with ongoing monitoring that is conducted to evaluate the performance of the ICMs.

2.1.2 Points of Compliance

WAC 173-340-740(6) provides the factors to be considered in establishing a point of compliance for soil. The point of compliance for soil can vary depending on the basis for the soil cleanup levels. For soil cleanup levels based on direct contact, the point of compliance is the upper 15 feet of soil throughout the site. For soil cleanup levels based on protection of groundwater, the point of compliance is also throughout the site. For cleanup levels based on terrestrial ecological risk, a conditional point of compliance has been established throughout the site to a depth of 6 feet below ground surface (bgs).

WAC 173-340-720(8) provides the factors to be considered in establishing a point of compliance for groundwater. Per WAC 173-340-720(8)(b), the standard point of compliance for groundwater "shall be established throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site."

2.2 Alternatives Evaluated in the Feasibility Study

Alternatives included in the FS were evaluated based on media. Five remedial alternatives were developed for soil cleanup and thirteen (six for the WIA and seven for the Central/NIA) were developed for the groundwater cleanup. A No Further Action Alternative was included for all media and is summarized here. Other alternatives are summarized below.

No Further Action Alternative

The No Further Action alternative served as a basis for comparing the effectiveness of other approaches to site cleanup. For soil, no specific removal, treatment, or containment would have occurred in this alternative beyond what was previously accomplished with the SVE ICM.

For groundwater, in the no further action scenario, all ICM operation would be discontinued. Site activities would occur without regard for existing groundwater contamination. There would be no monitoring of groundwater or implementation of institutional controls.

2.2.1 Soil Alternatives

Five remedial alternatives (including No Further Action) were developed for the cleanup of soil. All alternatives included institutional controls.

Paving/Physical Barrier Alternative

The Paving/Physical Barrier alternative would have installed an asphalt or gravel cover over soils above cleanup criteria and less than 6 feet below ground surface (bgs). The cover would prevent direct contact between wildlife and impacted soils. Because contamination above cleanup standards would still be present at the site, institutional controls such as access and deed restrictions would have been implemented to prevent future exposures. Cover maintenance and inspection would have been necessary compliance measures to ensure that the integrity of the cover was preserved.

Capping Alternative

The Capping alternative combined all aspects of the Paving/Physical Barrier alternative with additional design criteria for installation of an impermeable asphalt cap over all exposed impacted soils above cleanup criteria. The asphalt cap would have had a minimum thickness of 3 inches with a maximum hydraulic conductivity of 1×10^{-7} centimeters per second. Cap thickness may have increased in areas where heavy loads could have contributed to breakdown of the asphalt surface; however, the cap thickness would always have been a minimum of 3 inches. Cap maintenance and inspection would have been necessary compliance measures to ensure that the integrity of the cap was preserved.

Soil Vapor Extraction Alternative

As one of the preferred alternatives, SVE will be implemented in the Central Area and in the WIA in the area of the transfer sump to remove VOCs. Some volatilization and biodegradation of SVOCs is also expected as part of this alternative. Soil vapor will be extracted through either vertical or horizontal extraction wells. The type of extraction well will be determined during pilot testing and the remedial design stage. The need for off-gas treatment will be determined through the Southwest Clean Air Agency (SWCAA) permitting process. SWCAA is responsible for enforcing federal, state, and local outdoor air quality standards and regulations in southwest Washington State. SWCAA has adopted regulations for the control of air contaminant emissions, including toxic air contaminants, substances for which primary and secondary National Ambient Air Quality Standards (NAAQS) have been established, and volatile organic compounds.

The permit requirements for the proposed SVE system will likely be similar to those specified in the permit used to operate the SVE system in the west tank farm from 1997 to 1999. The permit issued in 1997 specified stringent emission limitations and implementation of Best Available Control Technology (BACT). The use of a thermal oxidizer to control exhaust gases (VOCs) from the soil vapor extraction unit was determined to meet BACT for exhaust gases. Since the proposed SVE system will be installed in an area of the site with elevated soil and groundwater concentrations, an off-gas treatment system will be required initially to meet the requirements of the SWCAA permit.

Soil Excavation and Disposal Alternative

The Soil Excavation and Disposal alternative would have excavated soil exceeding cleanup levels in areas of the site accessible to heavy equipment. Soil would have been excavated to the water table, approximately 10 to 15 feet bgs. Impacted soil below the water table would have been addressed by the groundwater remedy. Building foundations in the area might potentially be impacted by excavation activities. Some areas may have been inaccessible to excavating equipment. Impacted soil would likely have been excavated during dry weather conditions (when the water table is near its lowest level) to maximize removal of impacted soil.

Excavated soil would contain the listed dangerous waste U220, thereby requiring management in accordance with the dangerous waste regulations. Options for disposal of the soil would be dependent upon toluene concentrations in the soil and whether the soil receives a "contained-in" determination. In the past, small volumes of soil excavated from the site or generated during well installation have received a RCRA "contained-in" determination that the soil "does not contain" U220-listed dangerous waste. The basis for a RCRA "contained-in" determination for a large volume of excavated soil would likely be the MTCA Method A soil cleanup level (7 milligrams per kilogram [mg/kg] for toluene).

Available disposal options include:

- Reuse/recycle excavated soil on site with a "contained-in" determination
- Soil disposal in a Subtitle C facility or managed and treated on site, such as in a soil aeration pile
- Incineration. Incineration would occur off-site as the plant does not currently have a permit to incinerate contaminated soil on site.

Based on soil data presented in the RI and assuming that Ecology would make a "contained-in" determination for soil with toluene concentrations less than 7 mg/kg, excavated soil would have been managed as follows:

- 20 percent would be incinerated off-site
- 50 percent would be reused on site
- 30 percent would be:
    - Disposed of at a Subtitle C facility or
    - Treated on site in a soil aeration pile

2.2.2 Groundwater Alternatives

Six groundwater alternatives were identified for the WIA and seven alternatives were identified for the Central/NIA. Both areas included the No Further Action alternative identified above and the Natural Attenuation and Institutional Controls Alternative summarized here. All other alternatives are identified in this section below the appropriate subheading.

Natural Attenuation and Institutional Controls Alternative

Monitored natural attenuation refers to naturally occurring chemical, physical, and biological processes that contain or degrade environmental contaminants. In general, natural attenuation may be assumed to occur to some extent in all hydrocarbon-impacted groundwater. In this alternative, monitoring of contaminants and other indicator compounds (e.g., biodegradation products, dissolved oxygen, redox potential) would have been conducted to conclusively demonstrate the effectiveness of natural attenuation processes. Natural processes would have been relied upon to contain the dissolved-phase plume and potentially reduce COC concentrations to protective levels in the long term.

In addition to monitored natural attenuation, institutional controls would have been implemented to ensure that future development considers known contamination in the subsurface and the remedial measures that have been implemented. Possible control measures included imposition of deed restrictions at the site to preclude the use of groundwater as drinking water.

West Impacted Area

Continue ICM Operation Alternative

This alternative combines the monitoring and institutional controls in the natural attenuation alternative with continued operation of the existing ICMs (WIA shallow interception trench system and WIA intermediate sand recovery well system). The WIA ICMs were described in the FS (RETEC, 2003a) and would have continued to operate without modification.

ICM Upgrade Alternative

As one of the preferred alternatives, WIA ICM operations will be continued and upgraded as described below. Groundwater will be extracted from the WIA upper sand and intermediate sand aquifers to prevent impacts to surface water.

The intermediate sand recovery well (ISRW) system has kept water levels below the measured water level in the Columbia River with inward gradients within the ISRW system in most of the wells. This indicates successful capture of groundwater in the intermediate sand aquifer. In order to ensure containment of impacted groundwater at all times, the ISRW system will be upgraded with the installation of three additional extraction wells and a replacement well for ISRW-2. Wells will be located in the most highly impacted area of the intermediate sand aquifer and will be screened to the bottom of the intermediate sand aquifer to ensure containment and maximize mass removal.

The WIA shallow trench system has significantly reduced the amount of contaminated groundwater being discharged to the Columbia River. Following installation of the trench system, VOC concentrations in monitoring wells downgradient of the trench segments have decreased, indicating a decrease in contaminant migration to the Columbia River. In this alternative, the WIA shallow trench system will continue operation without modification.

ICM Upgrade with Air Sparging/SVE Alternative

In this alternative, the intermediate sand recovery well system would have been upgraded as described in the ICM Upgrade Alternative. The WIA shallow interception trench system would also have continued to operate. In recent years, one sample result north of the north trench segment exceeded the cleanup level for toluene. This area had been below cleanup levels for 2 years and results from the most recent sampling show the toluene concentration below the cleanup level, therefore continued monitoring results will be evaluated prior to implementation of further remedial actions in this area. If groundwater monitoring results indicate that further remediation is necessary in the area north of the north trench segment, air sparging in addition to SVE will be implemented in this area.

In-situ air sparging is often an effective approach for remediation of VOCs such as benzene and toluene that combines air stripping with *in-situ* aerobic biodegradation. Air is injected into the groundwater, using compressed air in a well bore that contains a screened section below the water table. Movement of air through the saturated soil formation both oxygenates the groundwater and strips VOCs. Oxygenation of the groundwater stimulates the biodegradation of dissolved hydrocarbons by native organisms present in the formation. Volatile compounds exposed to the sparged air are converted to the gas phase and are carried by the air into the unsaturated zone. Soil vapor extraction is used in conjunction with air sparging to remove vapors from the unsaturated zone. Soil vapors collected by the SVE system are treated as necessary to control emissions of air pollutants.

Specific criteria to determine if implementation is necessary are included in Subsection 3.1.2 of this document.

ICM Upgrade with Groundwater Extraction Alternative

In this alternative, the intermediate sand recovery well system would have been upgraded as described in the ICM Upgrade Alternative. The WIA shallow interception trench system would also have continued to operate. If continued groundwater monitoring results indicate that further remediation is necessary in the area north of the north trench segment, additional groundwater extraction would be implemented if this alternative was selected.

Additional groundwater extraction in the area of the north WIA trench could be conducted using either vertical or horizontal groundwater extraction wells or with a groundwater extraction trench. Installation of a groundwater extraction system in this area would be difficult because of numerous underground utilities (including a toluene distribution line and process water influent and effluent lines) crossing this part of the plant.

Central Area / NIA

Continue ICM Operation Alternative

This alternative combines the monitoring and institutional controls identified above with continued operation of the existing NIA interception trench ICM. The NIA interception trench would have continued to operate without any system modifications. Results presented in annual reports show that the NIA trench continues to effectively control and contain the discharge of volatile contaminants from the upper sand aquifer to the wetland. This conclusion is supported by consistent improvements in VOC concentrations in wetland surface water since installation of the ICM (ThermoRetec, 2000a; Table 4-5). The length of the trench is adequate to provide containment of the volatile contaminants in the NIA upper sand aquifer. This conclusion is based on the low concentrations of contaminants detected in wells MW-245 and MW-256 (located at the ends of the trench), and data from wetland surface water locations M2 and M4 (ThermoRetec, 2000a; Table 4-5). However, analytical results from sampling of monitoring wells KC-8, MW-245, and MW-256 indicate the continuing migration of low levels of some semivolatile constituents, in particular diphenyl oxide, east and west of the NIA trench towards the Kalama wetland. The NIA trench has also effectively removed contaminant mass from the upper sand aquifer.

The NIA ICM was described in the FS and would have continued to operate without modification. ICM performance has been documented in annual monitoring reports (ThermoRetec, 2000c, 2001; RETEC 2002, 2003c). The NIA ICM has continued to fulfill its purpose of controlling and containing discharge of volatile contaminants from the upper sand aquifer to the wetland.

Air Sparging Alternative

In-situ air sparging would have been implemented in the Central Area in a manner similar to that described in the WIA ICM Upgrade alternative. Soil vapor extraction would have been used in conjunction with air sparging to remove vapors from the unsaturated zone. Soil vapors collected by the SVE system would have been treated as necessary to control emissions of air pollutants.

Air injection and extraction wells would have been installed in one row southeast-to-northwest, through the Central Area. For the conceptual design of the system it was assumed that 26 wells would have been installed to provide coverage of the area where diphenyl oxide exceeds the cleanup level since the cleanup timeframe is largely determined by this compound. The actual number of wells would have been determined based on the results of pilot testing. The location of wells (RETEC, 2003a, Figure 4-2) is an effective alignment as it extends across the diphenyl oxide plume without unduly interfering with plant structures. However, well placement will likely be hindered by existing facility structures (buildings, tanks, underground piping) to some extent.

ORC Alternative

ORC® is a more passive technology used to enhance aerobic degradation of contaminants in groundwater that does not require continuous mechanical operation or maintenance. ORC® is a patented formulation of magnesium peroxide (MgO_2) that slowly releases oxygen when moist. The hydrated product is magnesium hydroxide ($Mg(OH)_2$). The oxygen release rate is dependent upon the level of the contaminant flux. Generally, the product will continue to release oxygen for about 3 to 6 months. ORC® would have been reintroduced into the subsurface every 3 months until remedial standards in groundwater were achieved.

ORC® would have been introduced into the groundwater either with application of ORC® filter socks into wells or with an ORC® slurry injected directly into the aquifer via a direct-push or hollow-stem augered hole. The alignment of injection wells is the same as discussed for the air sparging alternative. The actual number and spacing of the wells would have been determined based on the results of pilot testing. ORC® wells would have been screened across the saturated thickness of the upper sand aquifer (approximately 8 feet) to ensure that all impacted groundwater is treated.

In-Situ Oxidation Alternative

This alternative couples *in-situ* chemical oxidation in the Central Area with continued ICM operation in the NIA. Chemical oxidants (e.g., potassium permanganate, hydrogen peroxide) would have been injected into the subsurface to aid in the destruction of contaminants. For the purpose of cost estimating the alignment of injection points was assumed to be identical to the other *in-situ* alternatives described above. The actual number and spacing of injection wells would have been determined based on the results of pilot testing.

Chemical oxidation consists of the use of liquid potassium permanganate or hydrogen peroxide in a low percentage solution to destroy volatile organic contaminants. These chemical oxidants readily oxidize aromatic compounds such as benzene, toluene, and diphenyl oxide. The oxidative reaction cleaves the double bonds of benzene rings. Concerns regarding the use of chemical oxidants include the potential reduction of pH and the eradication of existing microorganisms that degrade VOCs. Microbe destruction may have resulted in a longer restoration timeframe for COCs that are not treated by chemical oxidation. Additionally, appropriate personal protective equipment must be worn during injection solution preparation to prevent exposure. While these concerns can be mitigated with careful system design and management, this technology is unproven, and effectiveness is difficult to predict.

Waterloo Emitter™ Alternative

As one of the preferred alternatives, this option couples *in-situ* treatment in the Central Area with continued ICM operation in the NIA. Oxygen will be introduced into impacted groundwater to stimulate the aerobic biodegradation of organic contaminants by naturally occurring subsurface microorganisms. Oxygen will be diffused into source areas using the Waterloo Emitter™ (Appendix A). Emitter points will be installed to reduce the cleanup timeframe, which is largely driven by diphenyl oxide concentrations in the Central Area. Consequently, the alignment of emitter points will be southeast-to-northwest across the diphenyl oxide plume (Figure 3-3). Operation of the Waterloo Emitter™ is described below.

The Waterloo Emitter™ utilizes diffusive tubing that provides for the controlled and uniform diffusive release of oxygen. The tubing on the emitter is pressurized with air or oxygen and the induced concentration gradient causes oxygen to diffuse out of the tubing and dissolve directly into the groundwater flowing past the emitter. By avoiding the introduction of a gas phase, this introduction of oxygen into the groundwater is more efficient, wastes very little gas, and does not require soil vapor extraction to control and treat soil vapor emissions. The emitters will be connected to a supply of oxygen (e.g., a compressor or tank) and will continue to release oxygen as long as the supply (compressor or tank) is active. At the Noveon Kalama site, a compressor will be used as the oxygen source. The compressor will utilize ambient air, which should provide adequate oxygen delivery. If additional oxygen transfer is needed, the compressor can be operated at higher pressure, longer emitters can be used in the wells and/or more wells can be installed. These design parameters will be evaluated further during pilot testing.

The Waterloo Emitters™ will be implemented in the Central Area in a manner similar to *in-situ* air sparging (described above). Air injection wells will be installed in one row, southeast-to-northwest, through the Central Area. For the conceptual design of the system it has been assumed that 26 wells will be installed to provide coverage of the area that exceeds cleanup levels (Figure 3-3). The actual number and spacing of injection wells will be determined based on the results of pilot testing.

3 Preferred Cleanup Action

3.1 Description of Preferred Cleanup Action

The preferred remedies for the Noveon Kalama site were selected in the FS and include the following activities:

- Soil vapor extraction in the most highly impacted soil areas (former flare stack line and transfer sump) to remove a long-term source of groundwater impacts. Soil vapor extraction will be augmented by paving or other physical barriers to enhance the effectiveness of this technology and to provide protection to terrestrial receptors. Physical barriers will be used in some areas of the site for protection of terrestrial receptors. The specific type and location of physical barriers will be evaluated and submitted for Ecology approval during the remedial design phase.

- *In-situ* treatment using Waterloo Emitter™ and continued operation of the NIA interception trench to provide a reduction in contaminant mass and prevent impacted groundwater from reaching the wetland.

- Continued operation of the WIA shallow interception trench system to provide a reduction in contaminant mass and prevent impacted groundwater from reaching the Columbia River.

- Upgrade of the WIA intermediate sand recovery well system to provide a reduction in contaminant mass and prevent impacted groundwater from reaching the Columbia River.

- Monitoring of groundwater and implementation of a compliance monitoring program to ensure that groundwater discharging to the Columbia River and the wetland is protective.

- Implementation of institutional controls to limit or prohibit activities that may interfere with the integrity of the remediation systems or that may result in exposure of workers or the public to hazardous substances at the site.

- If necessary air sparging will be added in the area north of the north trench segment (see subsection 3.1.2 for criteria to be used to determine whether the addition of air sparging will be necessary).

3.1.1 Cleanup Actions for Soils

The preferred remedial action for soil includes soil vapor extraction in the areas of highest soil contamination in the Central Area and in the north portion of the WIA.

Soil vapors may be extracted through either vertical or horizontal extraction wells. The type of extraction well (i.e., horizontal or vertical) will be further evaluated during the remedial design.

Pilot tests will be conducted to determine the radius of influence (ROI) in the Central Area and in the north portion of the WIA. Data collected during pilot tests may also be used to determine mass removal rates, flow and vacuum relationships, and the type of off-gas controls necessary for treatment of vapors. Work on the pilot tests is anticipated to be underway at the time of public comment. A separate work plan will be submitted for Ecology approval.

Proposed well locations are shown on Figure 3-1. The ROI for the SVE system in the west tank farm was approximately 50 feet for the area capped with an HDPE liner. Although portions of the area proposed for SVE are paved, the area is predominantly unpaved, which may result in a decreased ROI. In order to provide protection to terrestrial receptors as well as to increase the ROI, physical barriers may be used in this area (Figure 3-1). The type and location of any physical barriers will be determined based in part on the results of the pilot testing. Types of physical barriers anticipated to be used are described in Section 2.5.1 of the Feasibility Study and may include paving, buildings, and lined or gravel-covered surfaces. Assuming an ROI of 25 feet, pending the results of pilot testing, approximately 11 extraction wells will be installed in the Central Area with another 2 to 6 wells in the north end of the WIA.

The Southwest Clean Air Agency (SWCAA) permitting process will determine the need for off-gas treatment. SWCAA is responsible for enforcing federal, state, and local outdoor air quality standards and regulations in southwest Washington State. SWCAA has adopted regulations for the control of air contaminant emissions, including toxic air contaminants, substances for which primary and secondary National Ambient Air Quality Standards (NAAQS) have been established, and volatile organic compounds.

SWCAA requires that a Notice of Construction application be submitted for all new installations and for modifications of existing process and emission control equipment. SWCAA's Notice of Construction review program requires proposed new sources and modifications of existing sources to demonstrate that all applicable emission standards have been met prior to approval. The review program uses information submitted in a Notice of Construction application as the basis for determining whether applicable emission standards have been met. The Washington Clean Air Act requires all new sources and modifications, which increase emissions to employ Best Available Control Technology (BACT). SWCAA may approve use of the existing active Order of Approvals if the emission limits can be achieved.

The permit requirements for the proposed SVE system will likely be similar to those specified in the permit used to operate the SVE system in the west tank farm from 1997 to 1999. The permit issued in 1997 specified stringent emission limitations and implementation of BACT. The use of a thermal oxidizer to control exhaust gases (VOCs) from the soil vapor extraction unit was determined to meet BACT for exhaust gases. Since the proposed SVE system will be installed in an area of the site with elevated soil and groundwater concentrations, an off-gas treatment system will be required initially to meet the requirements of the SWCAA permit. Emission limitations in the 1997 permit were as follows:

- Volatile organic compounds – 1.0 ton per year
- Benzene – 20.0 pounds per year

The permit also specified that "When inlet concentrations to the thermal oxidizer are less than the benzene and VOC emission limits, the oxidizer is not required to be used" (Southwest Air Pollution Control Authority [SWAPCA] 97-1986 Order of Approval, amended by SWCAA 00-2328 Section 24(aa)).

3.1.2 Cleanup Actions for Groundwater

The preferred remedial action for groundwater includes continued ICM operations with upgrades in the West Impacted Area (WIA) and continued operation of the existing NIA interception trench ICM with *in-situ* treatment in the Central Area and North Impacted Area (NIA).

West Impacted Area

In the WIA, ICM operations will be continued and upgraded as described below. Groundwater will be extracted from the WIA upper sand and intermediate sand aquifers to prevent impacts to surface water.

WIA Intermediate Sand Aquifer

As of September 2003, the intermediate sand recovery well system of the WIA had effectively removed approximately 25,300 pounds of toluene from the intermediate sand aquifer since system startup in April 1997. Intermediate sand water levels are mostly below the measured water level in the Columbia River or show inward gradients within the ISRW system, indicating successful capture of groundwater in the intermediate sand aquifer. In order to ensure containment of impacted groundwater at all times, the ISRW system will be upgraded with the installation of three additional extraction wells (Figure 3-2) and a replacement well for ISRW-2. Wells are located in the most highly impacted area of the intermediate sand aquifer and will be screened to the bottom of the intermediate sand aquifer to ensure containment and maximize mass removal.

WIA Upper Sand Groundwater

The WIA shallow trench system has also effectively removed contaminants from groundwater. As of September 2003, approximately 3,905 pounds of organic compounds had been removed from the upper sand aquifer since system startup in November 1997. Following installation of the trench system, VOC concentrations in monitoring wells downgradient of the trench segments have decreased, indicating a decrease in contaminant migration to the Columbia River. The WIA shallow trench system will continue operation without modification as part of this CAP.

Air sparging will be added to the WIA SVE system in the area north of the north trench segment, if needed. The need for air sparging will be determined from groundwater sampling results at monitoring wells MW-244 and MW-255. If the concentration of benzene or toluene exceeds the respective cleanup level during two out of three consecutive sampling events, then implementation of air sparging will be evaluated in consultation with Ecology. The approximate location of air injection wells, if determined to be necessary, are shown on Figure 3-2. The specific locations of these injection wells would be determined based on results of pilot testing. If air sparging is determined to be necessary, a work plan for an air sparging pilot test will be submitted to Ecology for approval.

Central Area and North Impacted Area

The alternative to be implemented in the Central Area and NIA combines monitoring and institutional controls and continued operation of the existing NIA interception trench ICM with *in-situ* treatment in the Central Area.

In-situ treatment will consist of diffusing oxygen into impacted groundwater using the Waterloo Emitter™ technology to enhance the aerobic biodegradation of organic contaminants by naturally occurring subsurface microorganisms. Emitter wells will be installed as shown on Figure 3-3 to intercept the portion of the diphenyl oxide plume flowing towards the wetlands which exceeds the cleanup level (410 µg/L). The enhanced biodegradation of the portion of the diphenyl oxide plume passing through the emitter wells will also provide some reduction in the overall cleanup timeframe. The cleanup timeframe is largely driven by diphenyl oxide, which is more resistant to naturally occurring biodegradation than other constituents of concern (benzene, toluene).

The Waterloo Emitter™ utilizes diffusive tubing that provides for the controlled and uniform diffusive release of oxygen. The tubing on the emitter is pressurized with air or oxygen and the induced concentration gradient causes oxygen to diffuse out of the tubing and dissolve directly into the groundwater flowing past the emitter. By avoiding the introduction of a gas phase, this introduction of oxygen into the groundwater is more efficient, wastes very little gas, and does not require soil vapor extraction to control and treat soil vapor emissions. The emitters will be connected to a supply of oxygen (e.g., a compressor or tank) and will continue to release oxygen as long as the supply (compressor or tank) is active. At the Noveon Kalama site, a compressor will be used as the oxygen source. The compressor will utilize ambient air, which should provide adequate oxygen delivery. If additional oxygen transfer is needed, the compressor can be operated at higher pressure, longer emitters can be used in the wells and/or more wells can be installed. These design parameters will be evaluated further during pilot testing. The potential to use the emitter wells to inject nutrient amendments (in addition to oxygen) to provide an optimal environment for aerobic biodegradation will be evaluated based on the results of the treatability testing that will be conducted as part of the pilot test.

The Waterloo Emitters™ will be implemented in the Central Area in a manner similar to *in-situ* air sparging. Air injection wells will be installed in one row, southeast-to-northwest, through the Central Area. For the conceptual design of the system, it was assumed that 26 wells will be installed to provide coverage of the most highly impacted areas (the area that exceeds cleanup levels) as shown on Figure 3-3. The radius of influence for the injection wells is assumed to be 20 feet. The actual number, specific location, and spacing of the emitter wells will be determined based on the results of pilot testing. The alignment of the emitter wells was chosen with the intent of expediting the cleanup timeframe.

4 Justification for Preferred Cleanup Action

4.1 Regulatory Evaluation

The preferred remedies have been designed to satisfy the MTCA threshold requirements and other requirements (WAC 173-340-360(2)(a) and (b)). The threshold requirements state that the overall cleanup action must provide the following:

- Protection of human health and the environment
- Compliance with the cleanup standards set forth in WAC 173-340-700 through 173-340-760
- Compliance with applicable state and federal laws
- Provision for compliance monitoring.

MTCA also defines other requirements, which the cleanup action must satisfy. These are:

- Use of permanent solutions to the maximum extent practicable
- Provision for a reasonable restoration time frame
- Consideration of public concerns raised during the public comment period.

MTCA further identifies specific measures to be taken to ensure that these requirements are met. This section describes how the preferred remedial alternative will satisfy these requirements within the framework set forth in MTCA.

4.2 Protection of Human Health and the Environment

The preferred remedies provide adequate protection of human health and the environment. This protection will occur by:

- Eliminating the direct soil contact pathway to terrestrial organisms and industrial workers on the Noveon Kalama site
- Eliminating direct contact with impacted groundwater

- Reducing exposure and risk associated with aquatic organisms through groundwater discharge to surface water and the wetland
- Eliminating the soil direct contact pathway and site groundwater exposure pathway for members of the public
- Eliminating the surface water exposure pathway for recreational users.

Soil vapor extraction in the Central Area will be augmented by physical barriers to eliminate the direct contact pathway for both terrestrial organisms and industrial workers.

Operation of the upgraded ICMs in the WIA including the upgraded intermediate sand recovery well system will ensure that groundwater discharges remain below surface water quality criteria. Discharges at or below the surface water criteria will be protective of aquatic receptors and humans. With respect to humans, health will be protected for recreational users and for consumers of fish.

Operation of the Waterloo Emitters™ in the Central Area and the ICM trench in the NIA will significantly reduce exposure of aquatic organisms and plants in the wetland to contaminated groundwater discharge to the wetland.

4.3 Compliance with Cleanup Standards and Laws

The preferred cleanup actions will comply with MTCA cleanup standards and all applicable laws and regulations. Compliance monitoring will be performed to assess whether cleanup levels are achieved. The preferred alternative meets all state and federal laws and all activities used to implement the remedy will meet any laws requiring government permits or approvals.

4.4 Provision for Compliance Monitoring

The preferred alternative provides for compliance monitoring during implementation of the remedy to ensure that human health and the environment are protected during construction and throughout the life of the remedy. This monitoring will be performed in compliance with a health and safety plan and substantive requirements of any applicable local permits.

4.5 Use of Permanent Solutions

This criterion is based on the preference stated in WAC 173-340-360 to utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

In order to determine whether a remedial alternative is protective to the maximum extent practicable, the alternative is evaluated based on the following criteria:

- Overall protectiveness of human health and the environment
- Long term effectiveness
- Short term effectiveness
- Permanent reduction of toxicity, mobility, and volume of hazardous substance
- Ability to be implemented
- Cleanup costs.

Overall protectiveness of human health and the environment was previously discussed in Section 4.2 since these are also threshold criteria under MTCA. The other five criteria are discussed below.

4.5.1 Long Term Effectiveness

The long-term effectiveness criterion is primarily concerned with residual risk remaining at the site after completion of the remedial action. This analysis includes consideration of the degree of threat posed by the hazardous substances remaining at the site after completion of the remedial action and the adequacy of any controls used to manage these hazardous substances. Alternatives that afford the highest degree of long-term effectiveness and permanence are those that minimize waste remaining at the site such that long-term maintenance is unnecessary and reliance on institutional controls is minimized.

The preferred remedies for the Noveon Kalama site include SVE, groundwater extraction with treatment and *in situ* treatment of groundwater, which are destruction and detoxification technologies. Destruction or detoxification form one of the most preferable long-term cleanup categories identified in the MTCA rules (WAC 173-340-360(3)(f)(iv)).

4.5.2 Short Term Effectiveness

The short-term effectiveness criterion addresses the effects to human health and the environment of the alternative during the construction and implementation phase until remedial response objectives are met. Factors used in assessing short-term effectiveness are:

- Short-term risks posed to the community during implementation of the alternative
- Risks to site workers during implementation

- Environmental impacts that may be caused by implementation
- The length of time that the short-term risks may be required.

The greatest short-term risk during remedial activities at the site will be related to soil handling and final management of soil generated during drilling activities for the SVE and in-situ treatment systems. Site workers will be trained in accordance with OSHA and WISHA requirements for hazardous waste site workers. There will be no potential exposure to the community.

The proposed cleanup actions will be implemented so as to comply with applicable state and federal laws as described in Section 8. Additionally RCRA requirements for handling of U220 listed waste will be followed as needed. Substantive requirements of necessary permits will be followed and permitting agencies will provide guidance and approval on substantive requirements for necessary state and local permits.

4.5.3 Reduction of Toxicity, Mobility, or Volume Through Treatment

The reduction of toxicity, mobility, or volume through treatment criteria is a reflection of Ecology's expectation under WAC 173-340-360(3)(f)(ii) to implement remedial actions that employ treatment technologies that permanently reduce the toxicity, mobility, or volume of the hazardous substances. This criterion is used to assess

- The volume of impacted media treated or recycled
- The degree to which the treatment is irreversible
- The type and quantity of the treatment residues
- The degree to which treatment reduces principal site concerns.

The preferred remedies provide for contaminated soil and groundwater to be treated with irreversible processes (SVE, oxidation and enhanced biodegradation) resulting in only minor treatment residuals. Additional remedies in the NIA and WIA provide for capture of impacted groundwater with onsite treatment in Noveon Kalama's onsite wastewater treatment plant.

4.5.4 Implementability

The implementability criterion includes an evaluation of the technical and administrative feasibility of implementing the alternative and the availability of various services and materials required for implementation. Technical feasibility includes the ease with which alternatives may be constructed, operated, and monitored. Administrative feasibility considers coordination with other agencies, obtaining permits or meeting requirements for onsite and offsite activities, and identifying the availability of the prospective technologies.

All of the technologies that comprise the preferred remedial alternative are considered technically feasible. SVE has already been successfully implemented at the Noveon Kalama site as an ICM. Successful operation of the WIA recovery wells and trench and the NIA trench has been documented in annual reports (ThermoRetec, 2000c, 2001; RETEC 2002, 2003c). The Waterloo Emitter™ technology has also been used successfully at other remediation sites. Case studies of applications of the Waterloo Emitter™ technology to stimulate and enhance naturally occurring aerobic biodegradation are provided in Appendix A. Permits for the preferred remedy are all readily obtainable and should not impact the implementability of the preferred remedy.

4.5.5 Cost and Cost Effectiveness

A cost estimate was prepared for the preferred remedial alternative. This estimate includes capital costs plus the present worth of future operating and maintenance costs amortized over the expected life of the project. The cost estimate and a list of the assumed unit costs and other engineering assumptions are provided in Appendix B of the FS (RETEC, 2003a). A summary of the cost estimate is provided in Table 4-1.

Cost estimates for the FS (RETEC, 2003a) were based on interpretation of existing data to provide "probable" costs based on current understanding of site conditions. These costs are based on a variety of information available at the time of the estimate, including generic unit costs, vendor information, and prior experience. The actual cost of the alternative will depend on true labor and material costs, site conditions, competitive market conditions, final project scope, the implementation schedule, and other variable factors.

Capital costs were estimated for each alternative and include the design and construction of facilities. Examples of items included in the capital costs include: pilot testing, installation of injection wells, purchase of equipment (e.g. Waterloo Emitter™, compressor, manifolds, etc.), and engineering and construction management associated with the above tasks.

Operations and maintenance costs are all costs associated with the operation of a remediation system that must operate continuously for a period of years to accomplish its objectives. Examples of operations and maintenance costs are those costs associated with: inspection and repairs to SVE manifold & blower; inspection/repairs/replacement to Waterloo Emitter™; and periodic compliance groundwater sampling and reporting.

Cost effectiveness is a measure of practicability. A cleanup alternative is not considered "practicable" if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative (WAC 173-340-360(3)(e)(i).

4.5.6 Reasonable Restoration Time Frame

The remedial approach recommended in this CAP includes treatment of soils and removal and treatment of impacted groundwater. Soil vapor extraction also includes a physical cover over areas with soil impacts above cleanup levels and less than 6 feet bgs. Installation of remedial systems can be completed in a two to three month timeframe. Treatment of impacted soils with SVE is expected to be completed in approximately 3 years while groundwater treatment is expected to last approximately 11 to 15 years as calculated by Noveon's consultant (Appendix B). Installation of the system is currently anticipated to commence in late summer 2004 and should be complete by fall 2004.

4.5.7 Community Acceptance

Community acceptance refers to the type of input the public typically may present during the RI/FS process. The opinion of the community will be formally solicited during the public comment period. Assessment of community acceptance will occur following completion of the public comment period.

4.5.8 Additional Controls

Engineering Controls

An operations and maintenance (O&M) program will be developed to ensure that the engineered systems are maintained with minimal disruption of operations and that shutdowns are reported to Ecology in a timely manner.

The systems will be designed for unattended operation, however, weekly system checks of system components (e.g., SVE blower, ISRW well pump rates, Waterloo Emitter™ compressor) and adjustment of flow rates will be performed to ensure proper operation. In addition, inspections will be made following any condition causing the system to alarm. Periodic monitoring, consisting of measurement of water levels and groundwater quality will be conducted to evaluate system performance and make any necessary adjustments.

A detailed Operations and Maintenance (O&M) Plan will be submitted for Ecology approval during the remedial design phase. The O&M plan will address inspection and maintenance procedures, reporting of major system failures and/or shutdowns, and will include procedures for ensuring timely repair and/or replacement of system components as necessary.

Institutional Controls

Institutional controls are typical components of comprehensive site remedies and are required under certain circumstances by WAC 173-340-360(2)(e) and

WAC 173-340-440. Institutional controls required at this site are described in Section 7.

Compliance Monitoring Plan

The compliance monitoring plan, described in Section 6, is intended to provide ongoing protection of surface water from groundwater discharge and to confirm the effectiveness of the remedial actions. The compliance plan proposed in this CAP addresses the MTCA requirement that compliance monitoring be included in all cleanup actions (WAC 173-340-360(2)(a)(iv)).

5 Schedule for Implementation of Final Remedies

A schedule for implementing the remedies described in this CAP will be established in a consent decree (CD) or other administrative mechanism. Engineering design will commence immediately upon entry of the CD. Installation of the SVE system and the Waterloo Emitter™ system and completion of the WIA ISRW upgrade would begin within two months of the approval of the final design. It is expected that installation/upgrade activities will take approximately four months to complete.

The schedule for implementing compliance groundwater monitoring is outlined in Section 6 and in the Compliance Monitoring Plan.

6 Compliance Monitoring

6.1 Overview

Monitoring is one of the threshold requirements for cleanup actions under MTCA (WAC 173-340-360(2)(a)(iv)). Compliance monitoring as defined in WAC 173-340-410 requires three types of monitoring: protection monitoring, performance monitoring, and confirmational monitoring.

- Protection monitoring is performed to confirm that human health and the environment are adequately protected during the construction and operation and maintenance periods of the action. This type of monitoring will be addressed in the site specific Environmental Health and Safety Plan.
- Performance monitoring is completed to confirm that the "cleanup action has attained cleanup standards or if appropriate other performance standards such as monitoring necessary to demonstrate compliance with a permit, or where a permit exemption applies, the substantive requirements of other laws" (WAC 173-340-410).
- Confirmational monitoring is performed to confirm the long-term effectiveness of the cleanup action once cleanup standards, remediation levels, or other performance standards have been attained.

Protection monitoring will be addressed in a site specific Environmental Health and Safety Plan to be developed during the remedial design phase. Performance and confirmational monitoring are described in the Compliance Monitoring Plan.

7 Institutional Controls

The following institutional controls will be implemented at the site in accordance with WAC 173-340-440:

- Fencing and appropriate security will be maintained to limit pubic access to the site
- A restrictive covenant with appropriate use restrictions and notice provisions that comply with WAC 173-340-440(9) will be executed and recorded on the property after review and approval by Ecology
- Site remediation systems will be maintained in accordance with this CAP and all applicable documents developed under the CAP and Consent Decree
- Measures will be taken to educate employees regarding site contamination, site remediation systems, and ways to limit exposure to contamination.

8 Applicable State and Federal Laws

MTCA requires that all cleanup actions comply with applicable state and federal laws (RCW 70.105D.030(2)(e); WAC 173-340-710). For purposes of MTCA, the term "applicable state and federal laws" includes (1) those requirements that apply as a matter of law to the cleanup action; and (2) those requirements that the Ecology determines, based on consideration of the criteria in WAC 173-340-710(4), are relevant and appropriate requirements. The term "relevant and appropriate requirements" includes those standards, criteria and other limitations established under state and federal law that, while not legally applicable to the hazardous substances, cleanup action, location or other specific circumstances at the Kalama Site, nevertheless address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the site. Tables 8-1 and 8-2 summarize applicable state and federal laws for the Kalama Site and indicate whether they are "legally applicable" or "relevant and appropriate." Laws that are neither are not listed.

9 References

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RETEC, 2003a. *Feasibility Study*. Prepared for Noveon Kalama, Inc., and Rogers Sugar, Ltd., by The RETEC Group, Inc., Seattle, Washington. December 22.

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ThermoRetec, 2000a. *Remedial Investigation, Revision 2*. Prepared for BFGoodrich Kalama, Inc., and Rogers Sugar, Ltd., by ThermoRetec Consulting Corporation, Seattle, Washington. December 15.

ThermoRetec, 2000b. *Feasibility Study Work Plan, Revision 2*. Prepared for BFGoodrich Kalama, Inc., and Rogers Sugar, Ltd., by ThermoRetec Consulting Corporation, Seattle, Washington. December 21.

ThermoRetec, 2000c. *Interim Corrective Measure Annual Monitoring Report*. Prepared for BFGoodrich Kalama, Inc., and Rogers Sugar, Ltd., by ThermoRetec Consulting Corporation, Seattle, Washington. July 28.

ThermoRetec, 2001. *Interim Corrective Measure Annual Monitoring Report*. Prepared for Noveon Kalama, Inc., and Rogers Sugar, Ltd., by ThermoRetec Consulting Corporation, Seattle, Washington. July 27.

Table 2-1 Selected Cleanup Levels

Compound	Soil [1] (mg/kg)	Groundwater (µg/L)
Volatile Organic Compounds		
Benzene	0.00676	1.2 [2]
Toluene	14.5	2,000 [3]
Semivolatile Organic Compounds		
Benzoic Acid	99	24,590 [4]
Biphenyl	5.9	230 [5]
Bis(2-ethylhexyl)phthalate	4.01	1.8 [2]
Diphenyl Oxide	15.2	410 [6]
Phenol	11.7	2,560 [7]
Metals		
Arsenic	6 [4]	51 [8]
Copper	NA	115 [8]

Notes:

µg/L – micrograms per liter
mg/kg – milligrams per kilogram
NA – not applicable

[1] Soil cleanup levels are based on protection of groundwater.

[2] Cleanup level based on Human Health Criteria for freshwater in the National Toxics Rule, 40 CFR Part 131.

[3] Cleanup level based on the lowest reported chronic No Observed Effects Concentration (NOEC) for daphnids (RETEC, 2003b, Table 9a).

[4] Cleanup level based on the geometric mean calculated from the estimated chronic Lowest Observed Effects Concentration (LOEC) values (RETEC, 2003b, Table 5).

[5] Cleanup level based on the lowest reported chronic LOEC for daphnids (RETEC, 2003b, Table 6).

[6] Cleanup level based on the lowest reported acute NOEC for daphnids.

[7] Cleanup level based on the non-promulgated EPA Ambient Water Quality Criteria.

[8] Cleanup level based on equilibrium partitioning between soil and groundwater using natural background soil concentrations for Clark County. Calculations are provided in the Feasibility Study Work Plan (ThermoRetec, 2000b, Section 4.5.1).

Table 2-2 Supporting Calculations for Soil Cleanup Levels

COC	Groundwater Cleanup Level (µg/L)	K_{oc} (mg/g)	K_d (mg/g)	Henry's Law Constant (dimensionless)	Unsaturated Zone Soil Concentration (mg/kg)
Benzene	1.2	62	0.062	0.228	0.00676
Toluene	2,000	140	0.14	0.272	14.5
Benzoic Acid	24,590	0.6	0.0006	6.31E-05	99
Biphenyl	230	1,072	1.072	0.016	5.9
Bis(2-ethylhexyl) phthalate	1.8	111,123	111.123	4.18E-06	4.01
Diphenyl Oxide	410	1,655	1.655	0.0089	15.2
Phenol	2,560	28	0.028	1.63E-05	11.7
UCF	0.001		mg/µg		
DF (unsaturated)	20				
Theta w (unsaturated)	0.3				
Theta air (unsaturated)	0.13				
soil bulk density	1.5		kg/L		
fraction of organic carbon	0.001				

Notes:

µg/L – micrograms per liter

COC – chemical of concern

DF – dilution factor

kg/L – kilograms per liter

mg/µg – milligrams per microgram

mg/g – milligrams per gram

mg/kg – milligrams per kilogram

UCF – unit conversion factor (1 mg/1000 µg)

Soil concentrations were calculated using the equations and default parameters in WAC 173-340-747(4).

Input parameters from Tables 747-1, 747-2, and 747-4 in WAC 173-340 were used with the following exceptions:

- Diphenyl oxide is not listed in Table 747-2. A K_{oc} value was computed using log K_{ow} and the following equation: Log $K_{oc} = 0.72(\log K_{ow}) + 0.49$. K_{ow} of 3.79 (Montgomery, 1996) was used.
- The Henry's Law constant for diphenyl oxide was also taken from Montgomery, 1996.
- Henry's Law constants for benzoic acid, bis(2-ethylhexyl)phthalate, and phenol were obtained from *1996 EPA Soil Screening Guidance: Technical Background Document*.
- The K_{oc} value for phenol was obtained from *1996 EPA Soil Screening Guidance: Technical Background Document*.
- The Henry's Law constant and K_{oc} value for biphenyl were taken from Montgomery (1996).

Table 4-1 Remedial Action Cost Summary

Technology	Probable Cost
SVE[1]	
Capital Costs	$900,000
Performance Monitoring (annual costs)	$10,000
O&M Costs (annual costs)	$75,000
WIA ICM Upgrade	
Capital Costs[2]	$70,000
O&M Costs (annual costs)	$99,000
Waterloo Emitter	
Capital Costs	$210,000
Performance Monitoring[3]	$30,000
O&M Costs (annual costs)[4]	$8,000
Continued NIA Trench Operation	
Capital Costs	$0
O&M Costs (annual costs)	$20,000
Total Capital Costs	**$924,000**
Total Annual Costs	**227,000**

[1] SVE operation expected to last 3 years. Costs are total costs for expected life of operation

[2] ICM upgrade

[3] Startup performance monitoring. Computed as annual cost in FS, but may be limited to only few years after startup.

[4] Replacement cost for Waterloo Emitters™ presented as annualized cost, but may occur as one-time future expense.

Table 8-1 Legally Applicable and Relevant and Appropriate State Laws

Law	Determination	Comments
Model Toxics Control Act (MTCA) Ch. 70.105D RCW	Applicable	MTCA is directly applicable as the key State legislation governing the investigation and cleanup process at sites contaminated by hazardous substances. MTCA creates a liability scheme that applies to potentially liable persons (PLP) and delegates authority to Ecology to establish specific rules for adoption of cleanup standards, enforcement of cleanup actions, and settlement with PLPs. Development of the Kalama RI/FS, site cleanup standards and this CAP have all been designed to comply with MTCA and the MTCA Rules. MTCA is the State analogue to the federal Superfund law. MTCA is the legal mechanism for satisfying corrective action requirements under Kalama's Boiler and Industrial Furnace (BIF) permit issued under authority of EPA's RCRA regulations and the State's Dangerous Waste Regulations, WAC Ch. 173-303.
MCTA Rules WAC Ch. 173-340	Applicable	The MTCA Rules set forth administrative procedures and standards to identify, investigate and clean up facilities where hazardous substances have been released. This CAP has been adopted in accordance with the MTCA Rules, WAC 173-340-380, and will be implemented in accordance with WAC 173-340-400. All site remedial actions since transfer of jurisdiction from EPA to Ecology have been designed to comply with the MTCA Rules. Site cleanup standards have been adopted in accordance with Part VII of the MTCA Rules. Part V of the MTCA Rules (Administrative Procedures for Remedial Actions) governs the Agreed Order entered into with Ecology, and will govern creation of the consent decree or other administrative mechanism used to implement this cleanup action.
Hazardous Waste Management Act (HWMA) Ch. 70.105 RCW	Applicable	Washington's HWMA is the State's analogue to the federal Resource Conservation and Recovery Act (RCRA) and applies to the management of dangerous and extremely hazardous waste. Like MTCA, it authorizes Ecology to promulgate detailed rules and standards for implementation of the legislation. EPA has delegated to the State the authority to implement nearly all aspects of the RCRA subtitle C hazardous waste management program. Ecology's regulations create a management program that is stricter in some respects than the EPA's RCRA regulatory scheme. For example, the State regulates some wastes that are not regulated by EPA's RCRA regulations. The HWMA also contains provisions that are not found in the federal RCRA, such as a private right of action for recovery of damages on account of violation of a permit. MTCA exempts Kalama from compliance with the procedural requirements of the HWMA, but compliance with substantive provisions is still required. RCW 70.105D.090.

Table 8-1 Legally Applicable and Relevant and Appropriate State Laws

Law	Determination	Comments
Dangerous Waste Regulations WAC Ch. 173-303	Applicable	Ecology's Dangerous Waste Regulations contain detailed requirements for all aspects of dangerous waste management, including designation, treatment, storage and disposal requirements. Kalama has a BIF permit that is jointly administered by EPA and Ecology. EPA administers the BIF portion of the permit under the federal RCRA regulations, and Ecology administers the corrective action portion of the permit. As noted above, the MTCA cleanup action is designed to satisfy the BIF permit's corrective action requirements under the Dangerous Waste Regulations, WAC 173-303-646. Any dangerous or extremely hazardous wastes generated as a result of this cleanup action must be designated and managed in accordance with the requirements of the Dangerous Waste Regulations. Since the preferred remedy focuses on treatment through destruction of hazardous substances, it is not anticipated that significant quantities of hazardous wastes will be generated.
State Environmental Policy Act (SEPA) Ch. 43.21C RCW	Applicable	SEPA is an overlay statute that applies to all proposals or actions that may impact the environment in the State of Washington. SEPA is patterned after the federal National Environmental Policy Act (NEPA). MTCA cleanup actions, including those carried out under a consent decree or agreed order, are not exempt from SEPA's procedural requirements. Although SEPA is primarily a procedural statute, it requires governmental decision makers to consider environmental impacts when exercising discretion in issuing permits or taking other actions. The Kalama cleanup action will receive SEPA review through a threshold determination by the lead agency, Ecology in this case. If Ecology determines, based on an Environmental Checklist, that the cleanup action will likely not have a significant adverse impact on the environment, Ecology will issue a Determination of Non-Significance (DNS) or mitigated DNS with conditions. Most MTCA cleanup actions receive DNSs. The alternative is preparation of an Environmental Impact Statement (EIS) for actions likely to have significant adverse impacts. Since the CAP is designed to reduce impacts on the environment, including the Columbia River and associated wetlands, a DNS would be appropriate.
SEPA Rules WAC Ch. 197-11	Applicable	The SEPA Rules contain detailed provisions for compliance with SEPA, including provisions for lead agency designation (Ecology), identifying environmental impacts, categorical exemptions from SEPA, threshold determinations, the contents of SEPA documents (including EISs), and appeals. The sections most applicable to the Kalama cleanup will be WAC 197-11-310, 197-11-330, 197-11-335 and 197-11-340 governing the threshold determination process.

Table 8-1 Legally Applicable and Relevant and Appropriate State Laws

Law	Determination	Comments
Water Pollution Control Act (WPCA) Ch. 90.48 RCW	Applicable	The WPCA is Washington's analogue to the federal Clean Water Act. Pursuant to a delegation from EPA, Ecology implements the federal National Pollutant Discharge Elimination System (NPDES) permit program in Washington. Under authority of the WPCA, Ecology has adopted detailed regulations establishing surface and ground water quality standards, permit programs, water resource protection, and control of total maximum daily pollutant loading in designated watersheds. Washington's WPCA is broader than the federal Clean Water Act in that the WPCA authorizes regulation of non-point sources through a waste discharge permit system. The WPCA applies to the Kalama cleanup because of the proximity of the Columbia River and associated wetlands, and the existence of ground water beneath the Site. The Kalama Site is exempted from compliance with WPCA procedural requirements by MTCA, RCW 70.105D.090, but must still comply with substantive requirements.
NPDES Program Regulations WAC Ch. 173-220	Relevant and Appropriate	The NPDES permit program is a federally delegated program that is implemented in Washington by Ecology. An NPDES permit is required for any point source discharge of pollutants to waters of the State. The discharge from Noveon Kalama's wastewater treatment plant, which treats groundwater along with industrial wastewater and stormwater, is regulated under an NPDES permit issued by Ecology. The Kalama Site remedial actions are exempted from the procedural permit requirement by MTCA, RCW 70.105D.090. Moreover, the discharges of pollutants, which will be reduced by the remediation systems, may not fall within the category of "point source" discharges. Some of the NPDES program's treatment standards may be considered relevant and appropriate to the remedial actions.
Waste Discharge Permit Regulations WAC Ch. 173-216	Relevant and Appropriate	As noted above, Washington has also adopted a waste discharge permit program that applies to any discharge of pollutants, even non-point sources, to waters of the State. Waters of the State include surface and ground waters as well as the vadose zone. This permit program is covered by the same MTCA procedural exemption for Sites like Kalama that are undergoing remediation under a consent decree or Ecology order. Although not directly applicable, some of the treatment standards may be considered relevant and appropriate.
Surface Water Quality Standards WAC Ch. 173-201A	Applicable	Washington has adopted surface water quality standards that are considered protective of human health, aquatic organisms and the aquatic environment. These standards are used in conjunction with federal standards to condition discharge permits and derive cleanup standards for MTCA sites where groundwater discharges to surface water . Because of proximity to the Columbia River and associated wetlands, these surface water quality standards were considered during the process of deriving ground water cleanup standards for the Kalama Site.

Table 8-1 Legally Applicable and Relevant and Appropriate State Laws

Law	Determination	Comments
Minimum Standards for Construction and Maintenance of Water Wells WAC Ch. 173-160	Applicable	Ecology has established minimum standards for construction and maintenance of water wells that apply to ground water monitoring wells at the Kalama Site. The standards also apply to other wells associated with the remediation systems. Ecology's regulations also specify procedures for well abandonment or decommissioning that will take place once the cleanup action is completed.
Washington Clean Air Act Ch. 70.94 RCW	Applicable	The Kalama cleanup action is exempted from the procedural requirements of Washington's Clean Air Act but is subject to the substantive requirements such as emission control and air quality standards that have been primarily adopted by Ecology and local Clean Air Agencies as regulations and orders. The Act and implementing regulations are applicable to any new sources of regulated air emissions resulting from the Kalama cleanup action, such as the enhanced SVE system.
General Regulations for Air Pollution Sources WAC Ch. 173-400	Applicable	These regulations establish substantive standards for the control and prevention of air pollution that potentially apply to the Kalama cleanup. The regulations require that all sources of air contaminants meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions.
Controls for New Sources of Air Pollutants WAC Ch. 173-460	Applicable	These regulations contain requirements for testing emissions from new sources, quantifying emissions, assessing risk through modeling, evaluating ambient impacts and establishing acceptable source impact levels. The regulations are potentially applicable because of treated emissions from the enhanced SVE system.
Southwest Clean Air Agency (SWCAA) Regulations and Orders	Applicable	The SWCAA is the primary regulatory and permitting authority for air emissions from the Kalama Site. SWCAA's Notice of Construction review program will likely apply to emissions from the enhanced SVE system. An SWCAA permit was issued in 1997 that imposed emission limitations and technology requirements for the SVE system in the west tank farm area. Use of a thermal oxidizer to control VOC exhaust gases was determined to meet Best Available Control Technology (BACT) for the emissions. A more detailed discussion of air emission control requirements is contained in Section 3.1.4 of the FS.
Shoreline Management Act (SMA) Ch. 90.58 RCW	Relevant and Appropriate	The SMA regulates development within 200 feet of shorelines of the State, or any development that impacts water quality or shorelines of the State. The SMA creates a broad regulatory program that is implemented primarily by local jurisdictions under their Shoreline Master Programs adopted in accordance with Ecology regulations. The Kalama cleanup action will be exempted from the procedural requirements of the SMA and any associated local Master Program. Thus, it will not be necessary to obtain a shoreline substantial development or conditional use permit in order to perform construction within 200 ft. of the shoreline or wetlands. Some of the substantive requirements may be relevant and appropriate, depending on the location and nature of construction.

Table 8-2 Legally Applicable and Relevant and Appropriate Federal Laws

Law	Determination	Comments
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) 42 U.S.C. §§ 9601, *et seq.*	Relevant and Appropriate	CERCLA and the National Contingency Plan (NCP) potentially apply to the Kalama Site because CERCLA hazardous substances exist in soil and ground water at the Site. However, the cleanup action is being conducted under authority of the State's MTCA and MTCA Rules. In addition, the cleanup will satisfy dangerous waste corrective action requirements under the BIF permit jointly issued by Ecology and EPA to the facility under authority of the State's HWMA and the federal Resource Conservation and Recovery Act (RCRA). Thus, CERCLA and the NCP are only marginally relevant and appropriate requirements for this cleanup action.
National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 C.F.R. Pt. 300	Relevant and Appropriate	
Clean Water Act 42 U.S.C. §§ 1251, *et seq.*	Relevant and Appropriate	The Clean Water Act establishes a comprehensive set of programs for protection of waters of the United States through adoption of surface water quality standards, the NPDES permit program, grants to States, establishment of total daily maximum pollutant loads (TMDLs) and various other water resource protection programs. The Clean Water Act and the EPA regulations promulgated under the Act are relevant and appropriate for consideration during the Kalama cleanup due to the proximity of the Columbia River and associated wetlands. However, the laws are not directly applicable because of EPA's delegation to the State of the NPDES permit program, and because of the State's adoption of surface and ground water quality standards and a waste discharge permit program. For this reason, the EPA regulations governing the NPDES program and establishment of water quality standards are listed but not discussed here. The Clean Water Act is another example of a "flow-down" federal law where implementation of the federal program is placed in the hands of qualifying states.
EPA Water Quality Standards Regulations 40 C.F.R. Pt. 131	Relevant and Appropriate	

Table 8-2 Legally Applicable and Relevant and Appropriate Federal Laws

Law	Determination	Comments
EPA National Pollutant Elimination System (NPDES) Program 40 C.F.R. Pts. 122 to 125	Relevant and Appropriate	
Resource Conservation and Recovery Act (RCRA) 42 U.S.C. §§ 6901, *et seq.*	Relevant and Appropriate	RCRA Subtitle C establishes a comprehensive scheme for "cradle-to-grave" management of hazardous wastes, including regulation of treatment, disposal and storage of hazardous wastes and facilities that handle such wastes. The Kalama facility's RCRA permit is jointly administered by EPA and Ecology. EPA administers the BIF portion of the permit, and Ecology administers the corrective action provision. RCRA is another example of a "relevant and appropriate" federal flow-down law where regulatory authority has been delegated to qualifying states, such as the State of Washington. Washington's extensive dangerous waste management program has already been described in Table 8-1. For this reason, no discussion is included of EPA's RCRA regulations, set forth in Title 40 of the Code of Federal Regulations, is included here. Regulation of hazardous or dangerous wastes generated by the Kalama cleanup action will fall under Ecology's Dangerous Waste Program. It should be noted that the universe of State dangerous wastes exceeds that of federal hazardous wastes. Thus, the State's program is stricter than the parallel RCRA program.
Hazardous Materials Transportation Act (HMTA) 49 U.S.C. §§ 1801, *et seq.*	Applicable	The HMTA creates a comprehensive regulatory scheme applicable to the transportation of "hazardous materials" whose definition includes but is not limited to all "hazardous wastes" under RCRA, "hazardous substances" under CERCLA, and "pollutants" under the Clean Water Act. The U.S. Department of Transportation is the regulatory agency. The HMTA and its implementing regulations are applicable to the Kalama cleanup action, insofar as any hazardous materials must be transported over public highways. However, since the cleanup action does not include removal and off-site disposal, the impact is anticipated to be small.
Hazardous Materials Transportation Regulations 49 C.F.R. Pt. 171	Applicable	

Table 8-2 Legally Applicable and Relevant and Appropriate Federal Laws

Law	Determination	Comments
Clean Air Act	Relevant and Appropriate	The Clean Air Act creates a comprehensive regulatory scheme for reduction of air emissions, including hazardous air pollutants, and protection of air quality through State Implementation Programs. The Clean Air Act is implemented in Washington through Ecology's regulations and the regulations and orders of local Clean Air Agencies, including the Southwest Clean Air Agency that has jurisdiction over regulating emissions from the Kalama Site. Given the comprehensive State and local regulation of air emissions discussed in Table 8-1, the federal Act and EPA regulations are considered relevant and appropriate but not directly applicable.
Endangered Species Act (ESA) 16 U.S.C. §§ 1531, *et seq.*	Applicable	The ESA and Joint Implementing Regulations promulgated by the U.S. Fish & Wildlife Service and NOAA Fisheries (the "ESA Agencies") create a comprehensive scheme for protection of endangered and threatened animal and plant species through identification and listing of endangered or threatened species, consultation by federal agencies, prohibitions against "takes" of endangered species, permits for incidental takes, and scientific studies. The ESA and implementing regulations were applicable to Kalama's U-3 Boiler system because of the federal BIF permit, and were fully satisfied by the Section 7 consultation that occurred between the EPA and the ESA Agencies, resulting in issuance of "not likely to adversely affect" determinations by the ESA Agencies. The BIF permit requires that corrective action occur under the authority of MTCA.
Joint ESA Implementing Regulations (U.S. Fish and Wildlife Service and NOAA Fisheries) 50 C.F.R. Ch. IV	Applicable	

LEGEND

■ SOIL SAMPLE

● DOES NOT EXCEED CLEANUP LEVELS

● EXCEEDS VOC CLEANUP LEVELS

● EXCEEDS SVOC CLEANUP LEVELS

EXCEEDS ARSENIC CLEANUP LEVELS

AREA COVERED BY PAVEMENT/BUILDINGS

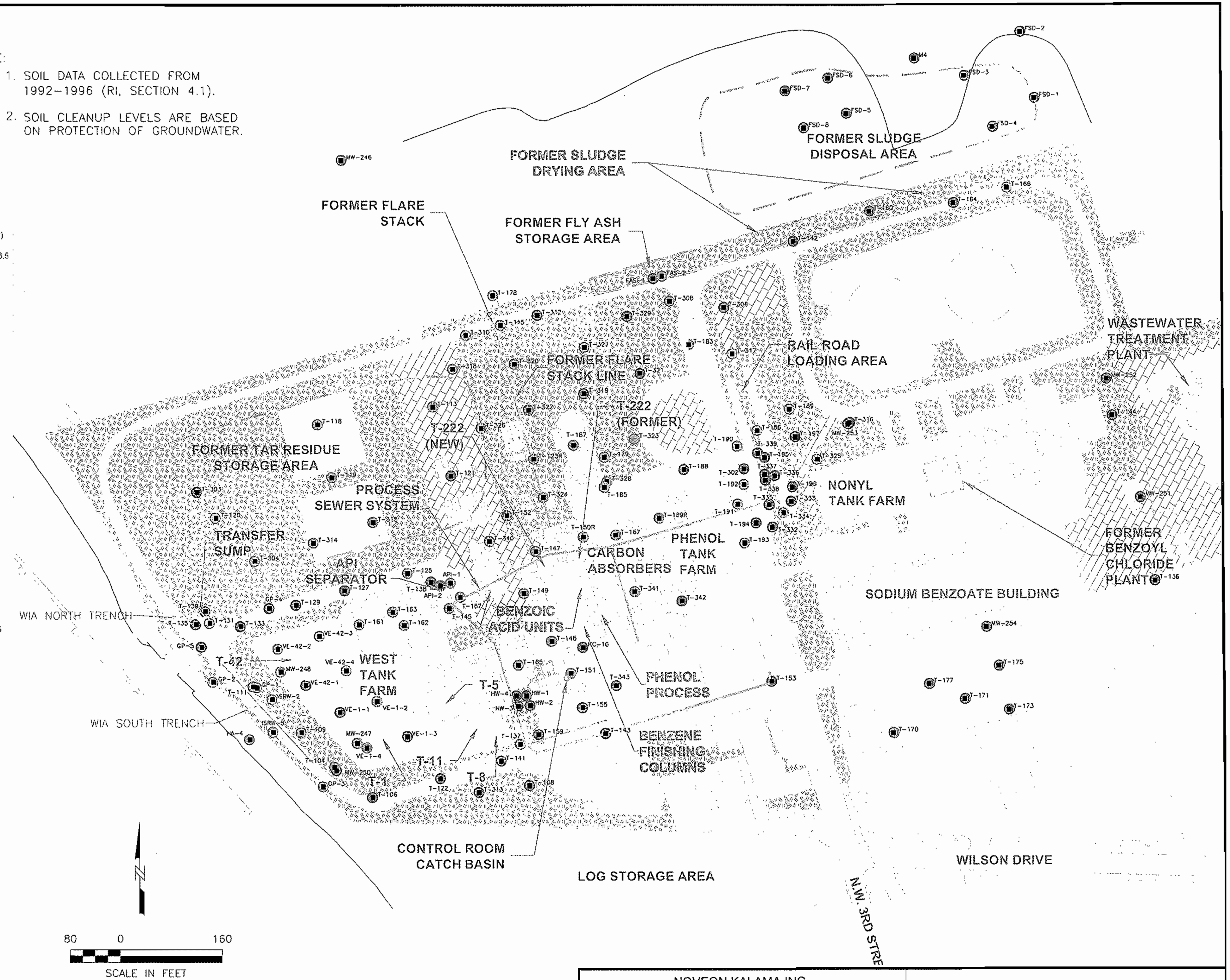
▨ AREA COVERED BY GRAVEL

▨ NO VEGETATION

NOTE:

1. SOIL DATA COLLECTED FROM 1992-1996 (RI, SECTION 4.1).
2. SOIL CLEANUP LEVELS ARE BASED ON PROTECTION OF GROUNDWATER.

Location	Compound(s) Exceeding Clean Up Levels	Depth of Exceedence (ft)
AP-1	Benzene	0
B-1	Toluene	15, 16.5, 18.5, 20.75, 26.5
B-2	Benzene, Toluene	15, 17.5, 20.5, 22, 25
B-3	Benzene, Toluene	17.75, 19, 20, 27.5
FAS-2	Benzene	0
HA-4	Benzene, Toluene	3.5, 8.5, 12, 15
ISRW-2	Toluene	14, 20, 24
ISRW-5	Benzene, Toluene	17
MW-247	Benzene	17.5, 21 25
MW-248	Toluene	16, 18.5, 19, 21
T-104	Benzene, Diphenyl Oxide, Toluene	7.5, 10, 11.5
T-109	Benzene	10.5
T-111	Benzene, Diphenyl Oxide, Toluene	2.5, 5, 7.5, 12.5
T-113	Benzene, Diphenyl Oxide, Toluene	0.5, 10
T-115	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 5, 7.5, 10
T-118	Benzene, Diphenyl Oxide	11.5, 13.6
T-119	Benzene	14.8
T-120	Benzene	9.7, 11.7
T-123	Benzene, Benzoic Acid, Biphenyl, Diphenyl Oxide, Phenol, Toluene	2.5, 5, 7.5, 10
T-125	Benzene, Biphenyl, Diphenyl Oxide, Toluene	2.5, 5, 7.5, 10
T-131	Benzene	0.5
T-137R	Benzene, Diphenyl Oxide	0.5, 10
T-138R	Diphenyl Oxide	0.5
T-139	Biphenyl, Toluene	10
T-145	Diphenyl Oxide	9.5
T-147	Benzene, Biphenyl, Diphenyl Oxide, Toluene	5, 7.5, 10
T-148	Diphenyl Oxide	0.5
T-149	Benzene, Diphenyl Oxide	0.5
T-150	Diphenyl Oxide	0.5, 2.5
T-150R	Benzene, Biphenyl, Diphenyl Oxide	0.5, 7, 7.5
T-151	Benzene	0.5
T-152	Benzene, Diphenyl Oxide, Toluene	0.5, 2.5, 7.5, 10
T-157	Benzene, Biphenyl, Diphenyl Oxide, Toluene	2.5, 5, 7.5
T-161	Benzene	2.5
T-162	Benzene	0.5, 7.5, 10
T-163	Benzene, Diphenyl Oxide	10
T-165	Benzene	7.5, 10
T-166	Benzene	0.5, 2.5, 5, 7.5, 10, 12.5
T-167	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5, 7.5, 10
T-169	Benzene	0.5, 2.5
T-169R	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5, 7.5, 10
T-170	Benzene, Diphenyl Oxide	0.5
T-178	Benzene, Biphenyl, Diphenyl Oxide, Toluene	7.5
T-179	Benzene, Diphenyl Oxide	0.5, 5
T-183	Arsenic, Toluene	0.5
T-185	Benzene, Diphenyl Oxide	7.5, 10
T-186	Benzene	0.5
T-187	Diphenyl Oxide	0.5
T-189	Benzene	5
T-190	Benzene	7.5
T-191	Benzene, Biphenyl, Diphenyl Oxide, Toluene	7.5, 10
T-192	Benzene, Biphenyl, Diphenyl Oxide, Toluene	7.5
T-193	Benzene	10
T-304	Benzene, Toluene	2.5
T-308	Diphenyl Oxide	0.5
T-310	Benzene, Diphenyl Oxide, Phenol, Toluene	0.5, 7.5
T-314	Diphenyl Oxide	2.5, 5
T-315	Diphenyl Oxide	0.5, 2.5, 5
T-317	Benzene	0.5
T-318	Diphenyl Oxide	0.5, 2.5
T-320	Diphenyl Oxide	0.5
T-322	Benzene, Benzoic Acid, Biphenyl, Diphenyl Oxide, Toluene	0, 0.5, 10
T-323	Diphenyl Oxide	0.5
T-324	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5, 7.5, 10
T-325	Benzene, Diphenyl Oxide, Phenol	0.5, 5, 10
T-326	Benzene, Diphenyl Oxide, Phenol, Toluene	0.5, 2.5, 5, 7.5, 10
T-327	Diphenyl Oxide	0.5
T-328	Benzene	0.5, 2.5, 5, 16
T-334	Benzene, Diphenyl Oxide	0.5, 5
T-340	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 10
T-341	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5, 7.5, 10



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DATE: 03/18/04

DRWN: A.S./SEA

SOIL CLEANUP LEVEL EXCEEDANCES ALL

FIGURE 2-1

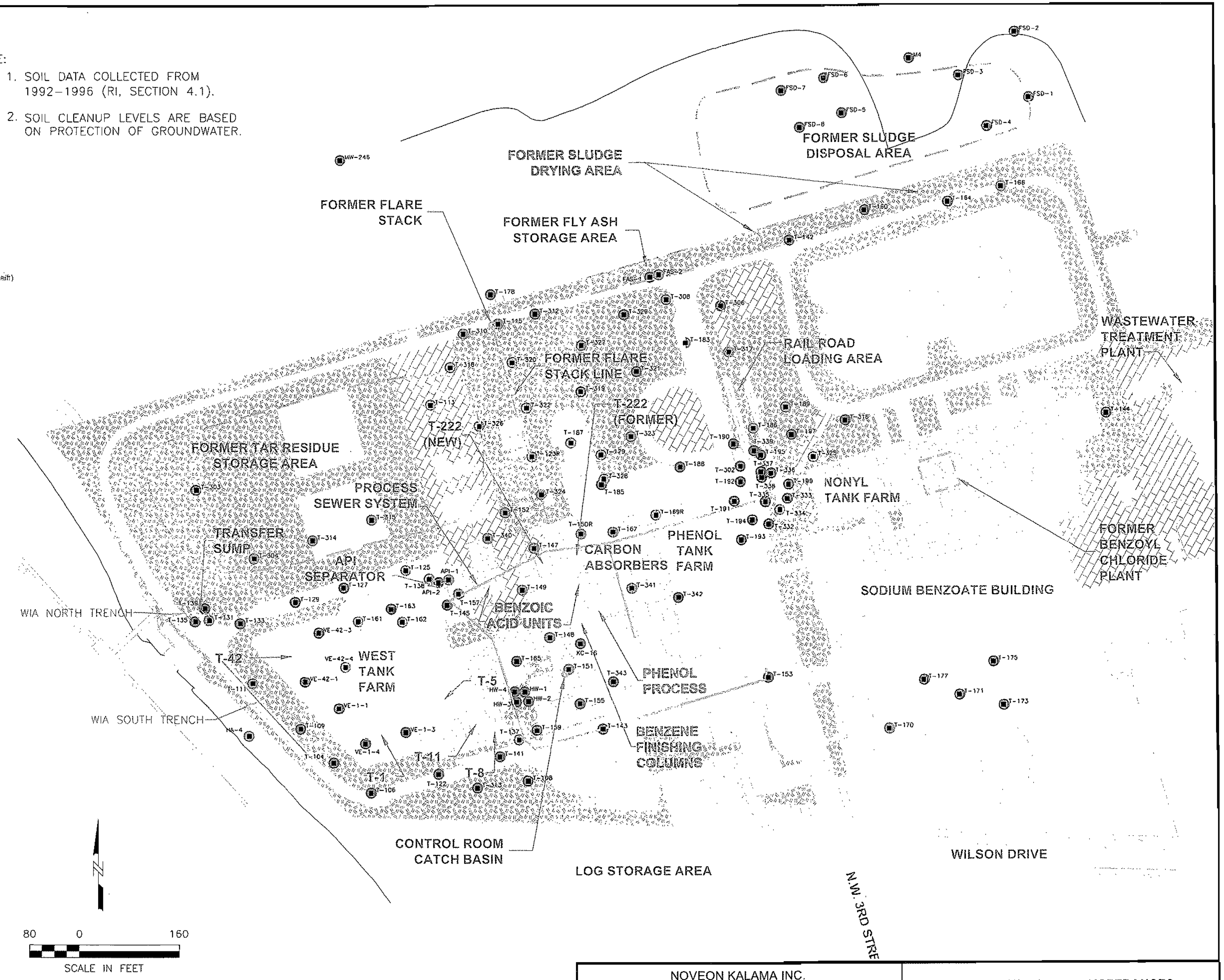
LEGEND

- ■ SOIL SAMPLE
- ● DOES NOT EXCEED CLEANUP LEVELS
- ● EXCEEDS VOC CLEANUP LEVELS
- ● EXCEEDS SVOC CLEANUP LEVELS
- EXCEEDS ARSENIC CLEANUP LEVELS
- AREA COVERED BY PAVEMENT/BUILDINGS
- ▨ AREA COVERED BY GRAVEL
- ▨ NO VEGETATION

NOTE:

1. SOIL DATA COLLECTED FROM 1992–1996 (RI, SECTION 4.1).
2. SOIL CLEANUP LEVELS ARE BASED ON PROTECTION OF GROUNDWATER.

Location	Compound(s) Exceeding Clean Up Levels	Depth of Exceedence(ft)
AP-1	Benzene	0
FAS-2	Benzene	0
HA-4	Toluene	3.5
T-111	Diphenyl Oxide, Toluene	2.5, 5
T-113	Diphenyl Oxide	0.5
T-115	Benzene, Diphenyl Oxide, Toluene	0.5, 5
T-123	Benzene, Benzoic Acid, Biphenyl, Diphenyl Oxide, Phenol, Toluene	2.5, 5
T-125	Benzene, Biphenyl, Diphenyl Oxide, Toluene	2.5, 5
T-131	Benzene	0.5
T-137R	Diphenyl Oxide	0.5
T-138R	Diphenyl Oxide	0.5
T-147	Benzene, Diphenyl Oxide, Toluene	5
T-148	Diphenyl Oxide	0.5
T-149	Benzene, Diphenyl Oxide	0.5
T-150	Diphenyl Oxide	0.5, 2.5
T-150R	Benzene	0.5
T-151	Benzene	0.5
T-152	Diphenyl Oxide	0.5, 2.5
T-157	Benzene, Diphenyl Oxide, Toluene	2.5, 5
T-161	Benzene	2.5
T-162	Benzene	0.5
T-166	Benzene	0.5, 2.5, 5
T-167	Benzene, Diphenyl Oxide	0.5, 2.5, 5
T-169	Benzene	0.5, 2.5
T-169R	Benzene, Diphenyl Oxide	0.5, 2.5, 5
T-170	Benzene, Diphenyl Oxide	0.5
T-179	Benzene, Diphenyl Oxide	0.5, 5
T-183	Arsenic, Toluene	0.5
T-186	Benzene	0.5
T-187	Diphenyl Oxide	0.5
T-189	Benzene	5
T-304	Benzene, Toluene	2.5
T-308	Diphenyl Oxide	0.5
T-310	Benzene, Diphenyl Oxide, Phenol, Toluene	0.5
T-314	Diphenyl Oxide	2.5, 5
T-315	Diphenyl Oxide	0.5, 2.5, 5
T-317	Benzene	0.5
T-318	Diphenyl Oxide	0.5, 2.5
T-320	Diphenyl Oxide	0.5
T-322	Benzene, Benzoic Acid, Biphenyl, Diphenyl Oxide, Toluene	0, 0.5
T-323	Diphenyl Oxide	0.5
T-324	Benzene, Biphenyl, Diphenyl Oxide	0.5, 2.5, 5
T-325	Benzene	0.5, 5
T-326	Benzene, Diphenyl Oxide, Phenol, Toluene	0.5, 2.5, 5
T-327	Diphenyl Oxide	0.5
T-328	Benzene	0.5, 2.5, 5
T-334	Benzene, Diphenyl Oxide	0.5, 5
T-340	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5
T-341	Benzene, Diphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5
VE-42-4	Benzene	5



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SOIL CLEANUP LEVEL EXCEEDANCES ABOVE 6 FEET

FIGURE 2-2

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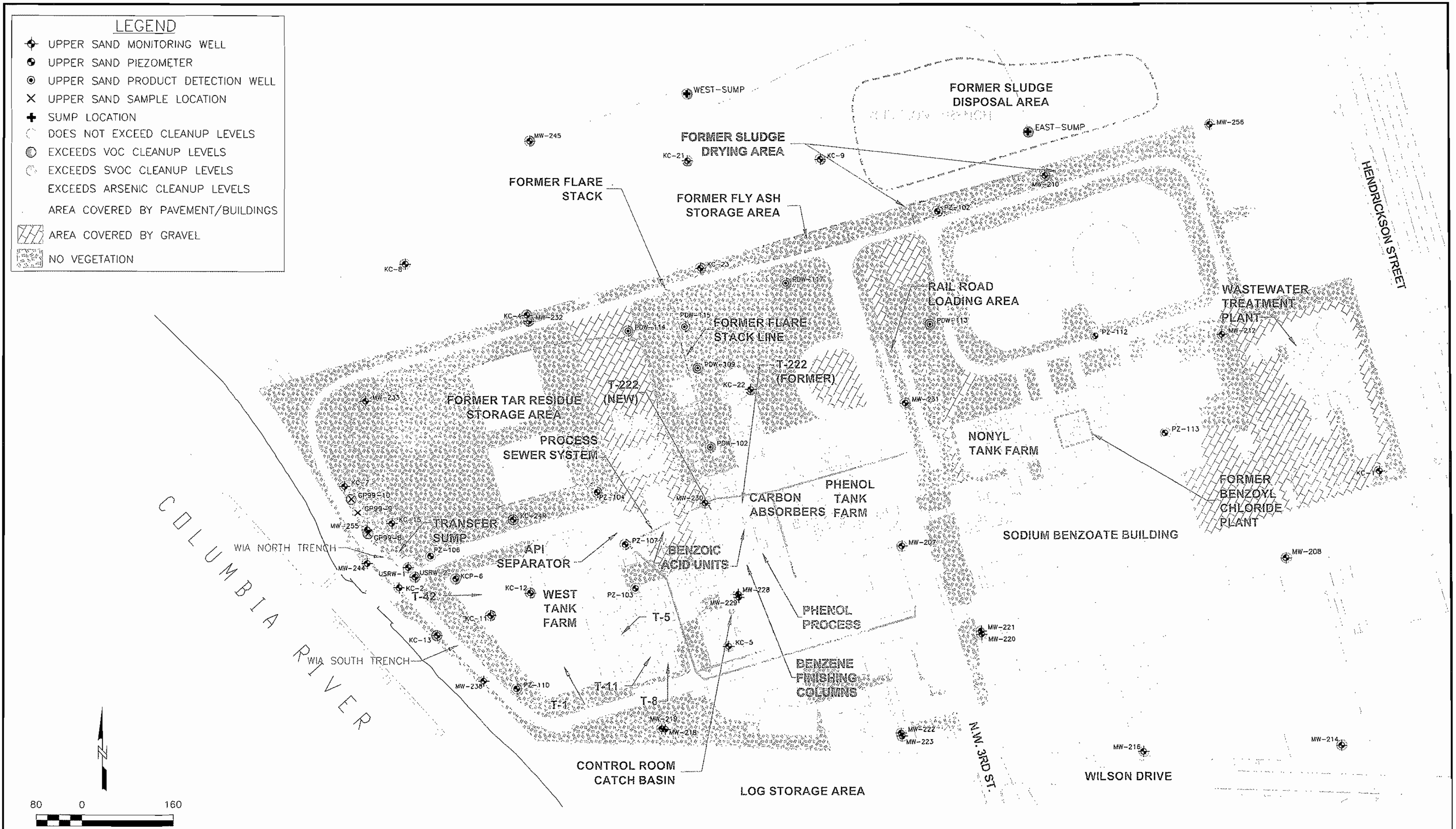

80 0 160

SCALE IN FEET

NOTE: RESULTS OF GROUNDWATER SAMPLES COLLECTED IN 2003 WERE USED TO CREATE THIS FIGURE (RI, SECTION 4.2). IF A WELL WAS NOT SAMPLED IN 2003, EARLIER DATA WERE REVIEWED TO DETERMINE IF CLEANUP LEVELS WERE EXCEEDED AT THE WELL.

RETEC

NOVEON KALAMA INC.		GROUNDWATER CLEANUP LEVEL EXCEEDANCES UPPER SAND AQUIFER
BFGKI-15231-230		
DATE: 03/18/04	DRWN: A.S./SEA	FIGURE 2-3

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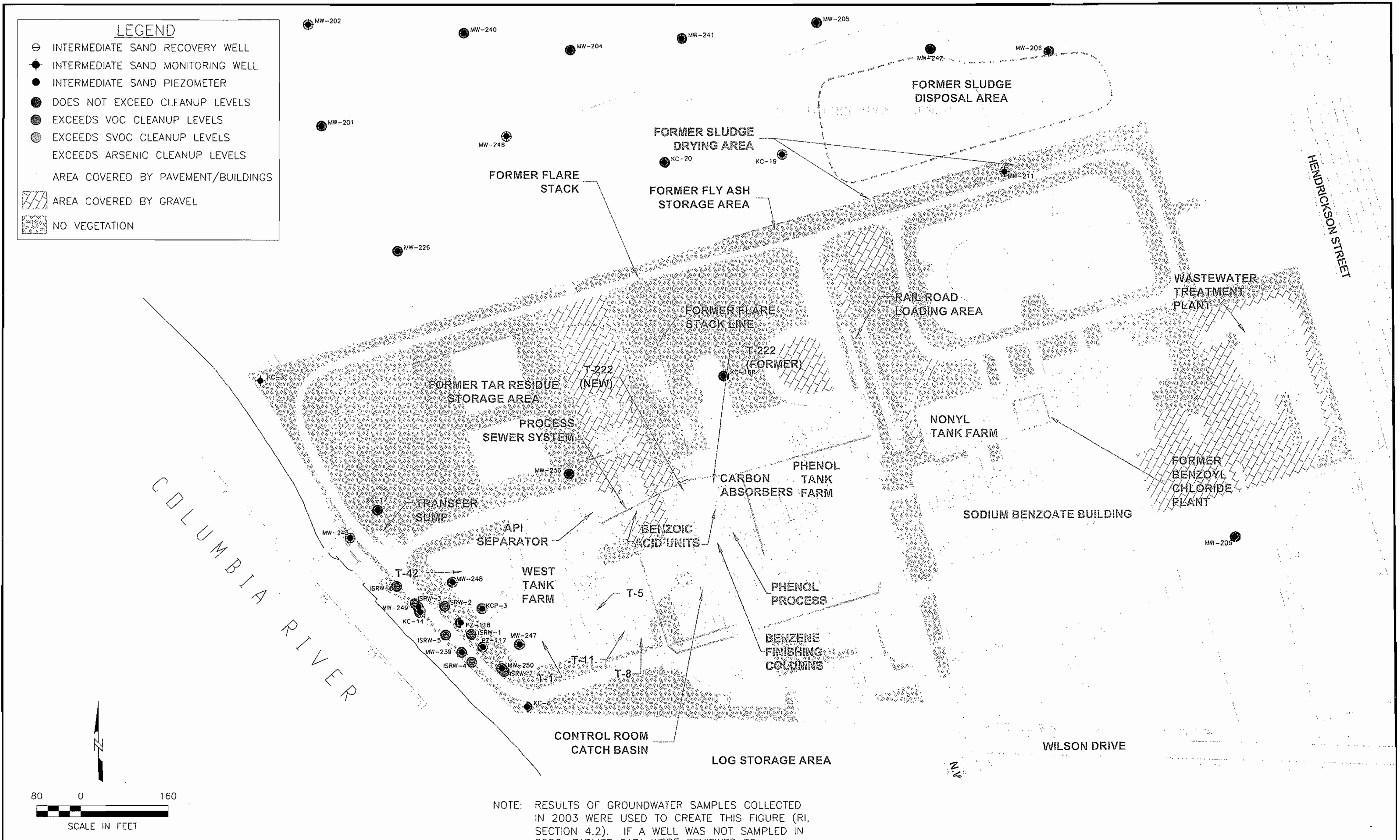

NOTE: RESULTS OF GROUNDWATER SAMPLES COLLECTED IN 2003 WERE USED TO CREATE THIS FIGURE (RI, SECTION 4.2). IF A WELL WAS NOT SAMPLED IN 2003, EARLIER DATA WERE REVIEWED TO DETERMINE IF CLEANUP LEVELS WERE EXCEEDED AT THE WELL.

RETEC

NOVEON KALAMA INC. BFGKI-15231-230	GROUNDWATER CLEANUP LEVEL EXCEEDANCES INTERMEDIATE SAND AQUIFER
DATE: 03/18/04 DRWN: A.S./SEA	FIGURE 2-4

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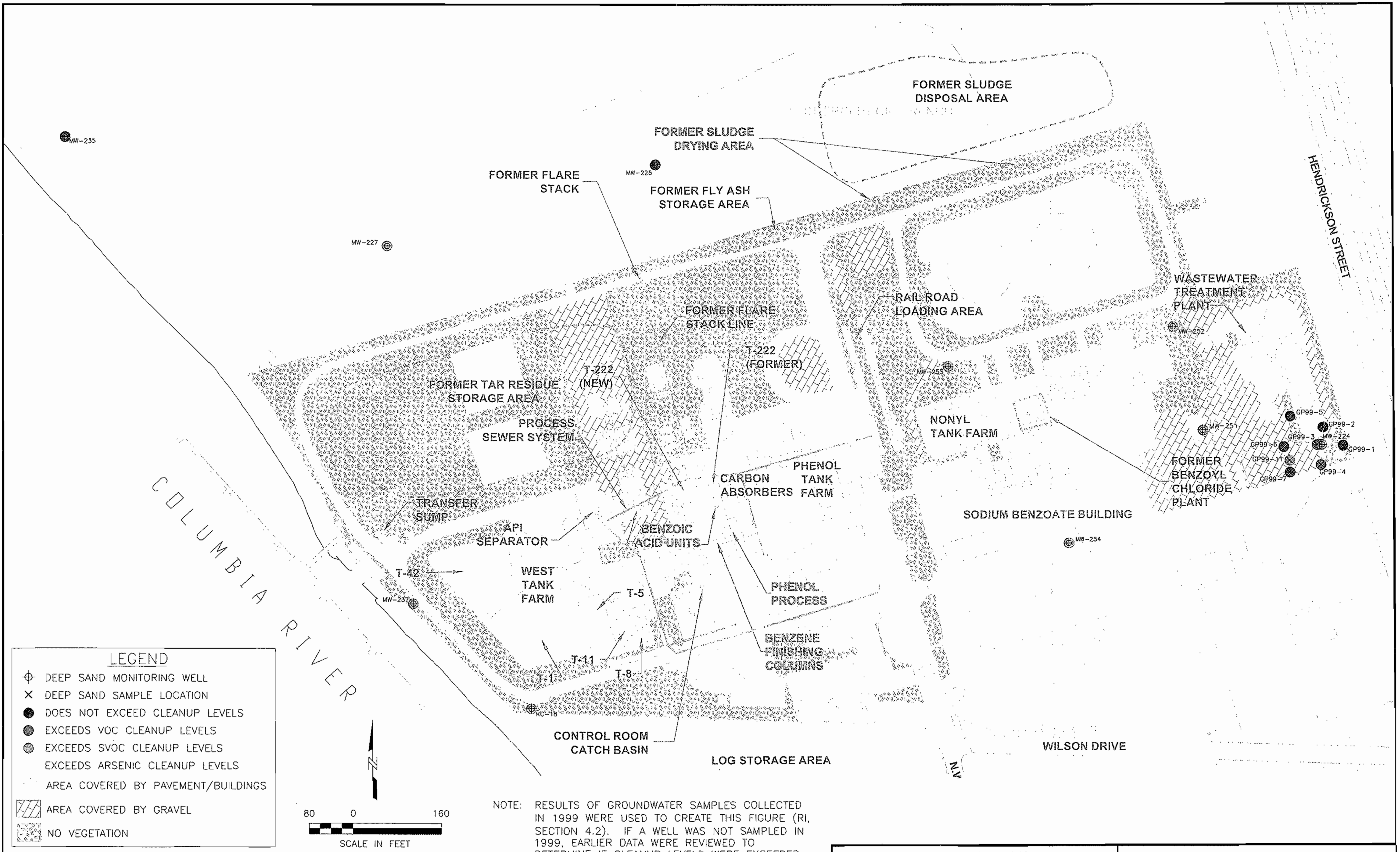

NOTE: RESULTS OF GROUNDWATER SAMPLES COLLECTED IN 1999 WERE USED TO CREATE THIS FIGURE (RI, SECTION 4.2). IF A WELL WAS NOT SAMPLED IN 1999, EARLIER DATA WERE REVIEWED TO DETERMINE IF CLEANUP LEVELS WERE EXCEEDED AT THE WELL.

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DATE: 03/18/04

DRWN: A.S /SEA

GROUNDWATER
CLEANUP LEVEL EXCEEDANCES
DEEP SAND AQUIFER

FIGURE 2-5

LEGEND

- ■ SOIL SAMPLE
- ● DOES NOT EXCEED CLEANUP LEVELS
- ● EXCEEDS VOC CLEANUP LEVELS
- ● EXCEEDS SVOC CLEANUP LEVELS
- EXCEEDS ARSENIC CLEANUP LEVELS
- ☼ SVE WELLS
- AREA TO BE PAVED OR COVERED TO ENHANCE RADIUS OF INFLUENCE
- AREA COVERED BY PAVEMENT/BUILDINGS
- ▨ AREA COVERED BY GRAVEL
- ▨ NO VEGETATION

Location	Compound(s) Exceeding Clean Up Levels	Depth of Exceedence (ft)
AP-1	Benzene	0
B-1	Toluene	15, 16.5, 18.5, 20.75, 26.5
B-2	Benzene, Toluene	15, 17.5, 20.5, 22, 25
B-3	Benzene, Toluene	17.75, 19, 20, 27.5
FAS-2	Benzene	0
HA-4	Benzene, Toluene	3.5, 8.5, 12, 15
ISRW-2	Toluene	14, 20, 24
ISRW-5	Benzene, Toluene	17
MW-247	Benzene	17.5, 21.25
MW-248	Toluene	16, 18.5, 19, 21
T-104	Benzene, Diphenyl Oxide, Toluene	7.5, 10, 11.5
T-109	Benzene	10.5
T-111	Benzene, Diphenyl Oxide, Toluene	2.5, 5, 7.5, 12.5
T-113	Benzene, Diphenyl Oxide, Toluene	0.5, 10
T-115	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 5, 7.5, 10
T-118	Benzene, Diphenyl Oxide	11.5, 13.6
T-119	Benzene	14.8
T-120	Benzene	9.7, 11.7
T-123	Benzene, Benzoic Acid, Biphenyl, Diphenyl Oxide, Phenol, Toluene	2.5, 5, 7.5, 10
T-125	Benzene, Biphenyl, Diphenyl Oxide, Toluene	2.5, 5, 7.5, 10
T-131	Benzene	0.5
T-137R	Benzene, Diphenyl Oxide	0.5, 10
T-138R	Diphenyl Oxide	0.5
T-139	Biphenyl, Toluene	10
T-145	Diphenyl Oxide	9.5
T-147	Benzene, Biphenyl, Diphenyl Oxide, Toluene	5, 7.5, 10
T-148	Diphenyl Oxide	0.5
T-149	Benzene, Diphenyl Oxide	0.5
T-150	Diphenyl Oxide	0.5, 2.5
T-150R	Benzene, Biphenyl, Diphenyl Oxide	0.5, 7, 7.5
T-151	Benzene	0.5
T-152	Benzene, Diphenyl Oxide, Toluene	0.5, 2.5, 7.5, 10
T-157	Benzene, Biphenyl, Diphenyl Oxide, Toluene	2.5, 5, 7.5
T-161	Benzene	2.5
T-162	Benzene	0.5, 7.5, 10
T-163	Benzene, Diphenyl Oxide	10
T-165	Benzene	7.5, 10
T-166	Benzene	0.5, 2.5, 5, 7.5, 10, 12.5
T-167	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5, 7.5, 10
T-169	Benzene	0.5, 2.5
T-169R	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5, 7.5, 10
T-170	Benzene, Diphenyl Oxide	0.5
T-178	Benzene, Biphenyl, Diphenyl Oxide, Toluene	7.5
T-179	Benzene, Diphenyl Oxide	0.5, 5
T-183	Arsenic, Toluene	0.5
T-185	Benzene, Diphenyl Oxide	7.5, 10
T-186	Benzene	0.5
T-187	Diphenyl Oxide	0.5
T-189	Benzene	5
T-190	Benzene	7.5
T-191	Benzene, Biphenyl, Diphenyl Oxide, Toluene	7.5, 10
T-192	Benzene, Biphenyl, Diphenyl Oxide, Toluene	7.5
T-193	Benzene	10
T-304	Benzene, Toluene	2.5
T-308	Diphenyl Oxide	0.5
T-310	Benzene, Diphenyl Oxide, Phenol, Toluene	0.5, 7.5
T-314	Diphenyl Oxide	2.5, 5
T-315	Diphenyl Oxide	0.5, 2.5, 5
T-317	Benzene	0.5
T-318	Diphenyl Oxide	0.5, 2.5
T-320	Diphenyl Oxide	0.5
T-322	Benzene, Benzoic Acid, Biphenyl, Diphenyl Oxide, Toluene	0, 0.5, 10
T-323	Diphenyl Oxide	0.5
T-324	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5, 7.5, 10
T-325	Benzene, Diphenyl Oxide, Phenol	0.5, 5, 10
T-326	Benzene, Diphenyl Oxide, Phenol, Toluene	0.5, 2.5, 5, 7.5, 10
T-327	Diphenyl Oxide	0.5
T-328	Benzene	0.5, 2.5, 5, 16
T-334	Benzene, Diphenyl Oxide	0.5, 5
T-340	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 10
T-341	Benzene, Biphenyl, Diphenyl Oxide, Toluene	0.5, 2.5, 5, 7.5, 10

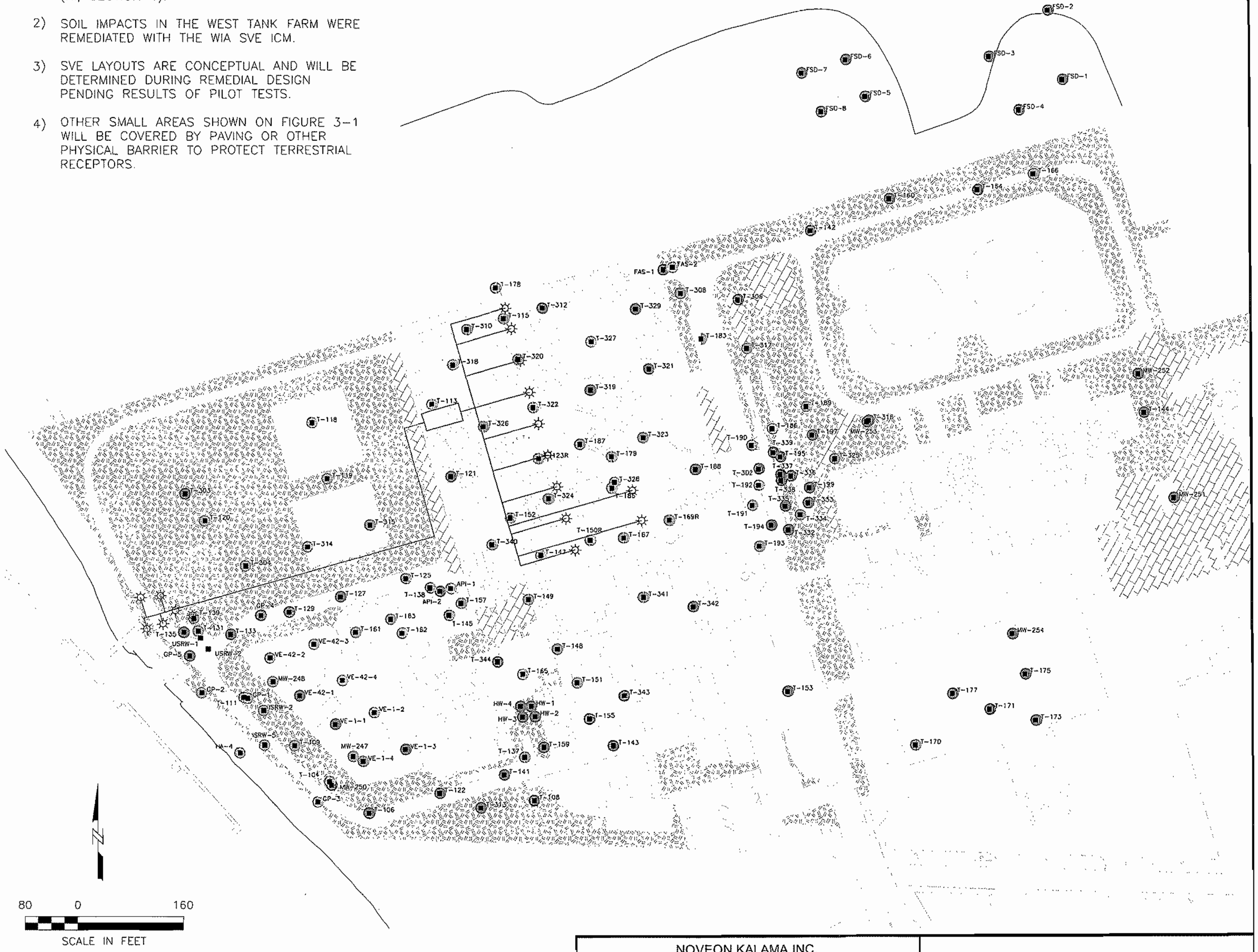
NOTES:

1) SOIL DATA COLLECTED FROM 1992–1996 (RI, SECTION 4).

2) SOIL IMPACTS IN THE WEST TANK FARM WERE REMEDIATED WITH THE WIA SVE ICM.

3) SVE LAYOUTS ARE CONCEPTUAL AND WILL BE DETERMINED DURING REMEDIAL DESIGN PENDING RESULTS OF PILOT TESTS.

4) OTHER SMALL AREAS SHOWN ON FIGURE 3-1 WILL BE COVERED BY PAVING OR OTHER PHYSICAL BARRIER TO PROTECT TERRESTRIAL RECEPTORS.



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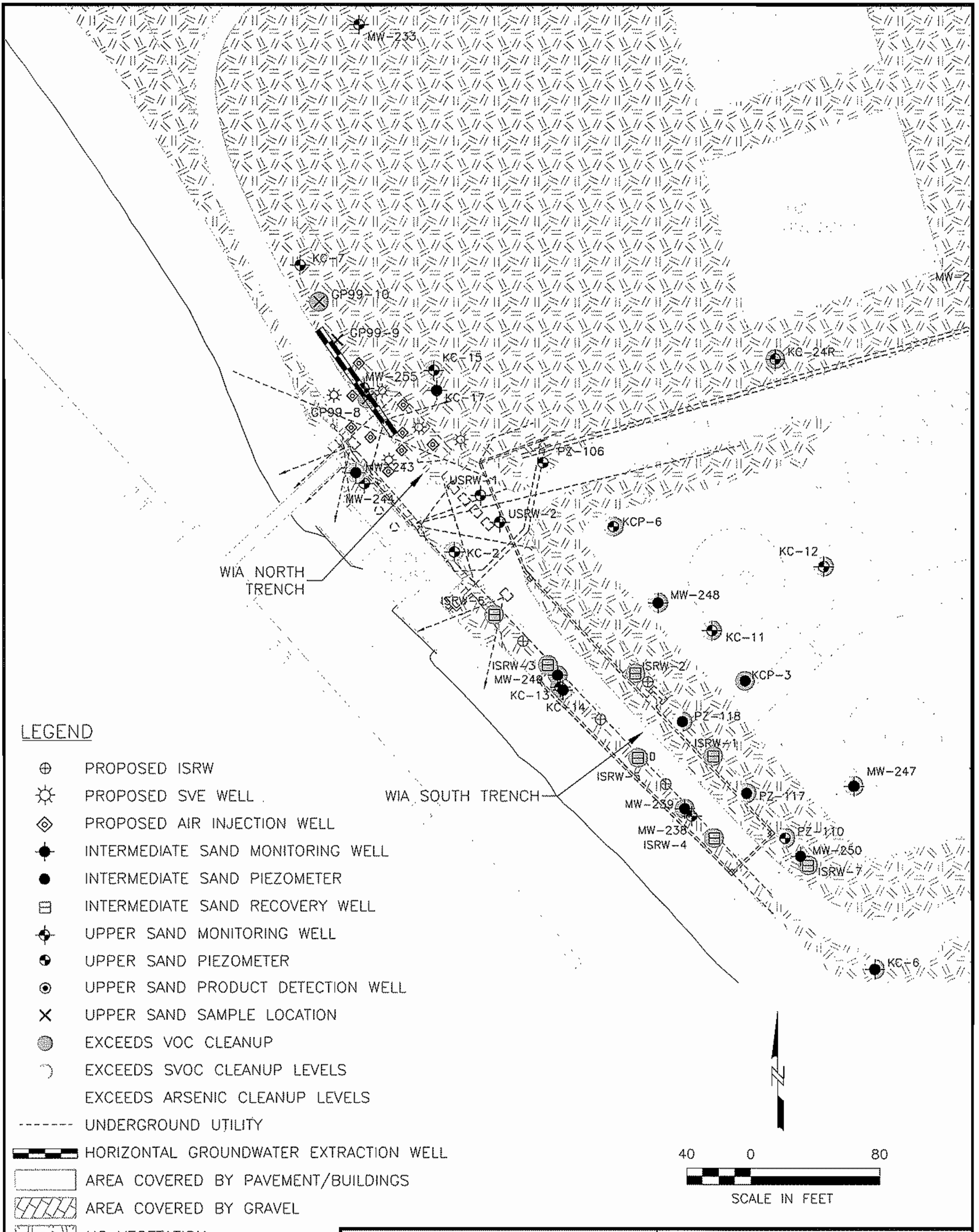
ALTERNATIVE S4 PROPOSED SOIL VAPOR EXTRACTION LAYOUT

FIGURE 3-1



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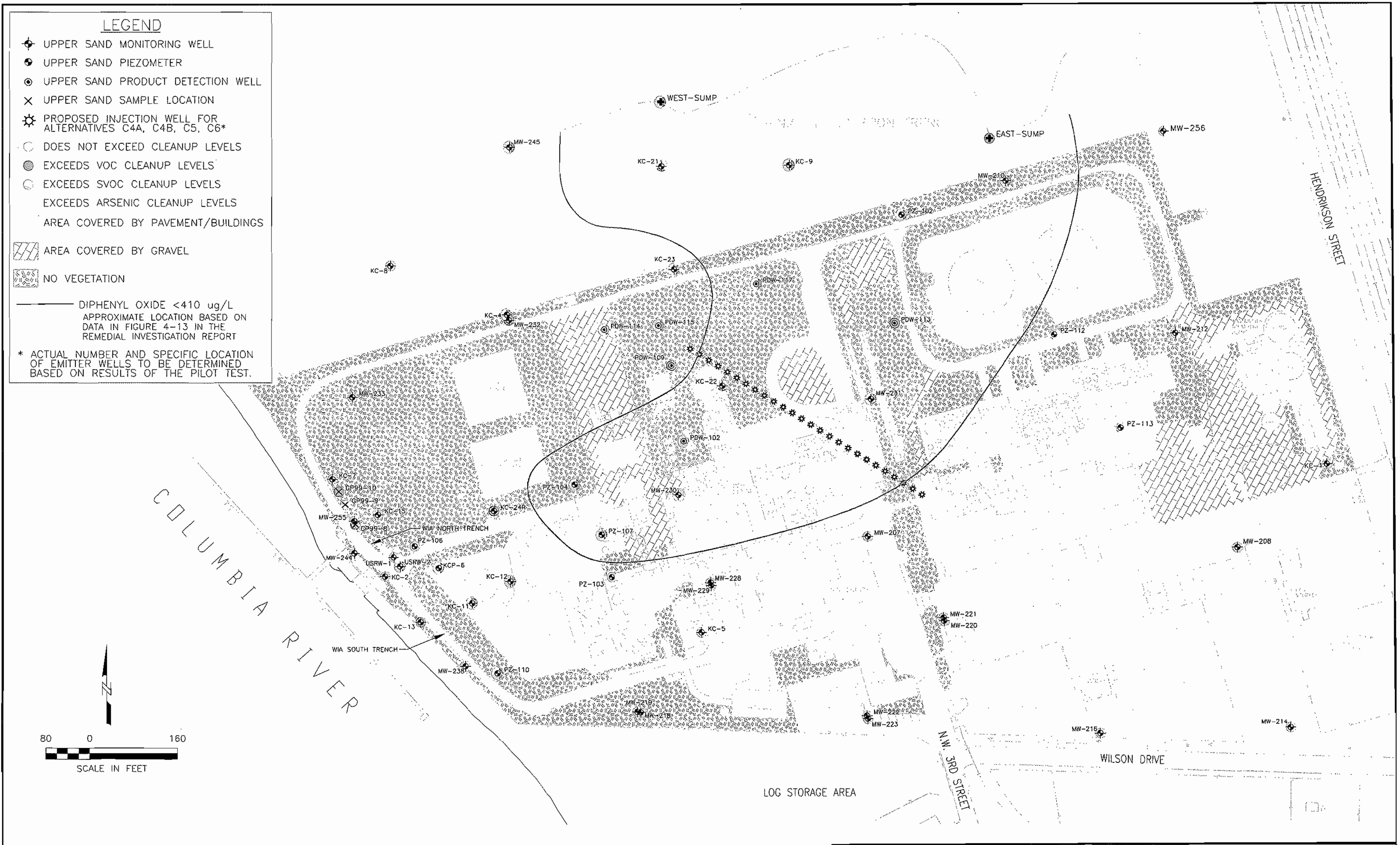
DATE: 03/18/04 | DRWN: A.S./SEA

WIA UPGRADE ALTERNATIVES

FIGURE 3-2



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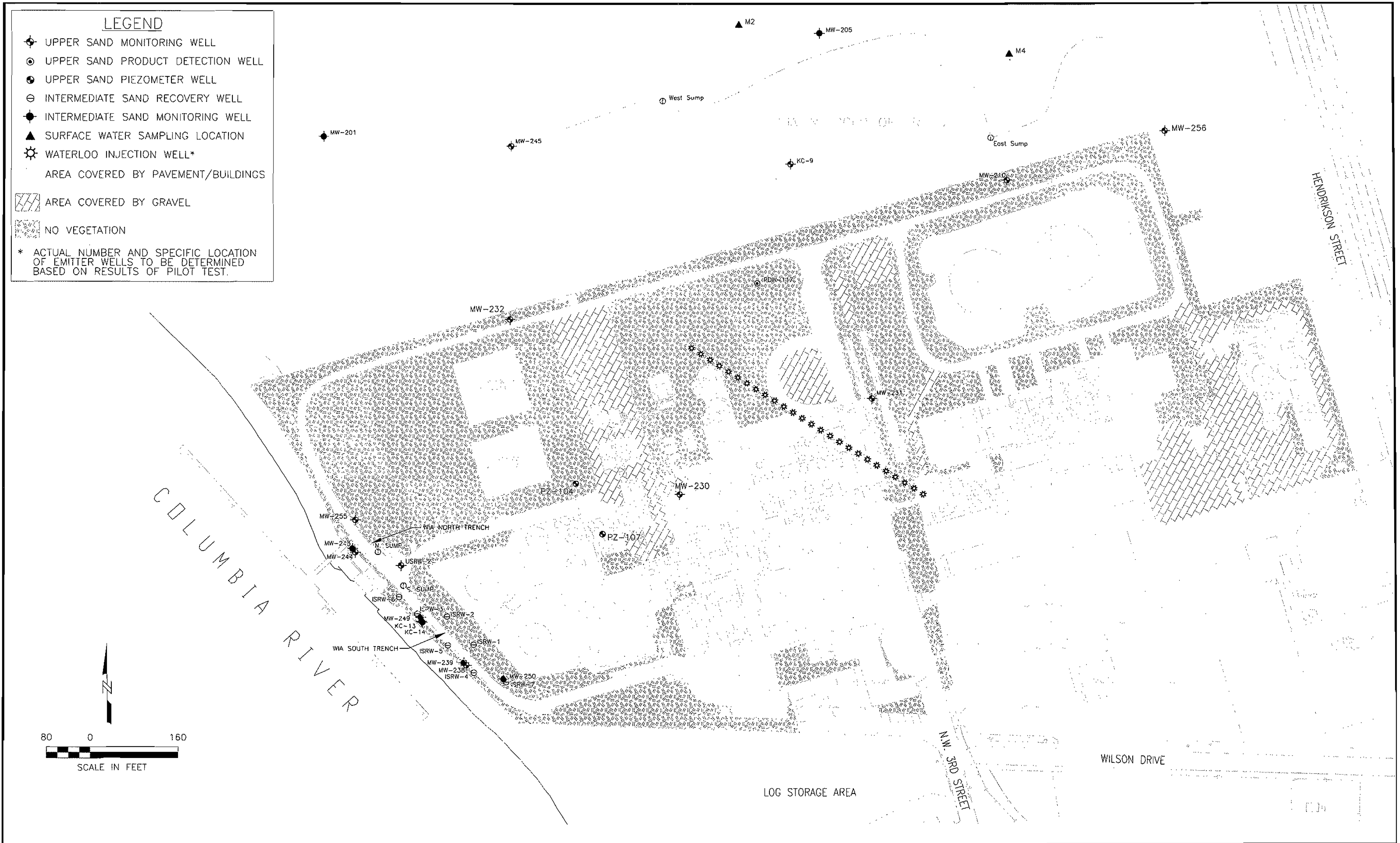
DATE: 05/18/04 DRWN: A.S./SEA

CENTRAL AREA INJECTION WELL LOCATIONS

FIGURE 3-3



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COMPLIANCE MONITORING NETWORK

FIGURE 6-1

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Appendix A

Waterloo Emitter™ Case Studies

Waterloo Emitter™ Brochure

WATERLOO EMITTER™

Diffusive Release of Groundwater Amendments "Elegance in its Simplicity"

unrivalled simplicity, versatility and cost effectiveness.

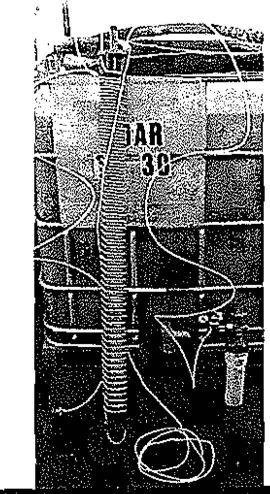
Developed by University of Waterloo researchers, the patented Waterloo Emitter™ offers remediation professionals a new cost effective and low maintenance option for a wide variety of groundwater applications.

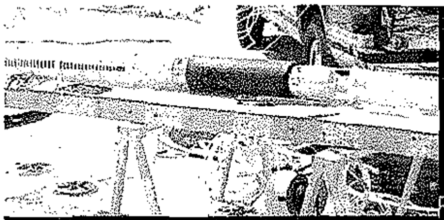
- Unrivalled versatility - diffusive release of treatment additives (gaseous and liquid sources) for a wide range of groundwater applications
- O2 or H2 release for enhanced bio-remediation of MTBE, BTEX, other contaminants
- co-substrate release (eg. propane, toluene) for co-metabolic treatment
- groundwater monitoring tracers (eg. SF6)
- pH adjustment (eg. CO2)
- Maximum installation flexibility (wells, excavated trenches, permeable barriers)
- Passive (under natural groundwater flow) or active (re-circulation pumping) modes of operation

Traditional bio-enhanced remediation techniques are designed to release one specific type of amendment and are often associated with significant ongoing maintenance cost expenditures. The Waterloo Emitter™ utilizes a patent protected engineered diffusive device that provides for the controlled and uniform diffusive release of bio-enhancing amendment materials (important to sustain a constant and active micro-organism population).

In addition to the installation and mode of operation flexibility, the convenient Waterloo Emitter™ design easily accommodates the insertion of down-well instrumentation to monitor groundwater conditions and remediation performance.

Numerous projects utilizing the Waterloo Emitter™ for the bio-enhanced remediation of groundwater contaminated from leaking underground gasoline storage tanks, particularly MTBE, have demonstrated the ability of the Waterloo Emitter™ to release elevated and sustainable concentrations of the desired amendment material (dissolved oxygen in the case of MTBE) to the bio-remediation treatment target zone.





University of
Waterloo

For more information, refer to www.WaterlooEmitter.com
contact Scott Inwood: sinwood@uwaterloo.ca | 519 888 4567, ext. 3728

GWMR – Diffusive Oxygen Emitters for Enhancement of Aerobic *In Situ* Treatment

[redacted]

Diffusive Oxygen Emitters for Enhancement of Aerobic In Situ Treatment

by Ryan D. Wilson and Douglas M. Mackay

Abstract

Aerobic biodegradation can be enhanced within contaminant plumes by elevating typically low dissolved oxygen (D.O.) levels using materials or devices that passively release oxygen. We have developed passive devices that provide a uniform, steady, long-term source of oxygen by diffusion from pressurized polymeric tubing and report test results under lab and field conditions. Lab flow-through reactor tests were conducted to determine the diffusion coefficient (D) of oxygen through four readily available tubing materials. Oxygen diffusion was greatest through Tygon® 3350 platinum-cured silicone ($D = 6.67 \times 10^{-7}$ cm^2/sec), followed by 2075 Ultra Chemical Resistant Tygon (1.59×10^{-7} cm^2/sec), 2275 High Purity Tygon (5.11×10^{-8} cm^2/sec), and low-density polyethylene (LDPE; 1.73×10^{-8} cm^2/sec). Variable-pressure release tests with LDPE resulted in very close estimates of D, which confirmed that mass transfer is controlled by diffusion and that the concentration gradient is a valid approximation of the chemical potential driving diffusion. LDPE emitter devices were designed and installed in seven 8-inch-diameter well screens across a portion of a gasoline plume at a former service station. With the devices pressurized to 620.5 kPag (kilopascals gauge) late in the test, steady-state D.O. concentrations reached as high as 25 mg/L, comparing favorably to the value predicted using the mass-transfer coefficient estimated from the lab test (26.3 mg/L). The method can also be used to release other gases for other reasons: gaseous tracers (i.e., sulphur hexafluoride, helium, and argon), hydrogen (for reductive dechlorination), or light alkanes (for cometabolic biodegradation of methyl tertiary butyl ether [MTBE] or chlorinated solvents).

Introduction

It has been shown that some ground water contaminants naturally biodegrade at rates sufficient to make natural attenuation a viable remedial option (Barker et al. 1987; National Research Council 1993; Wiedemeier et al. 1999). This has certainly been demonstrated in the case of gasoline hydrocarbons, which have been shown to biodegrade under aerobic (Jamison et al. 1975; Atlas 1981; Alvarez et al. 1991), nitrate-reducing (with the possible exception of benzene) (Hutchins et al. 1991; Barbaro et al. 1992), iron-reducing (Lovley et al. 1989), sulfate-reducing (Edwards et al. 1992), and methanogenic (Grbic-Galic and Vogel 1987) conditions. Based on the thermodynamics of BTEX (benzene, toluene, ethylbenzene, and xylene) oxidation, aerobic degradation provides the greatest energy for microbes. Further, it has been generally observed that aerobic biodegradation rates are much greater than that of any of the anaerobic processes (Borden and Bedient 1986; Thierrin et al. 1995). Also, contaminants such as fuel oxygenates (MTBE, ETBE, TAME) and some chlorinated solvents (vinyl chloride and *cis*-1,2 DCE) are often recalcitrant under anaerobic conditions but may readily degrade aerobically (Davis and Carpenter, 1990; Semprini et al. 1991; Salanitro et al. 1994; Cowan and Park 1996; Mo et al. 1997). Often, however, contaminant plumes are anaerobic because background dissolved oxygen (D.O.) is depleted as the ground water migrates through the contaminant source area and because typically

Pages 88–98

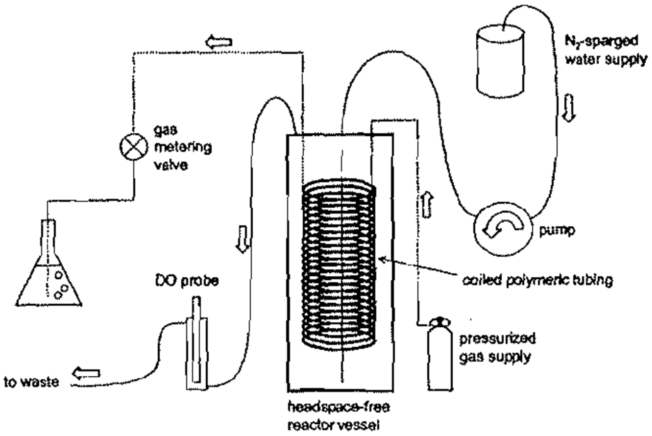


Figure 2. Schematic of lab test setup. Tubing details are compiled in Table 1. All tests were conducted at room temperature. Effluent water temperature varied by <0.5°C. Water flow varied by <3% in each test.

the saturated zone, and may provide more predictable long-term delivery and distribution. At steady state, the rate of oxygen flux from the tubing matches the oxygen flux carried from the well by flowing ground water (assuming no oxygen is used within the well). The steady-state concentration is therefore dependent on the rate of ground water flow and oxygen mass flux from the tubing, which is in turn dependent on the concentration driving force (tubing pressure) and the length/wall thickness of tubing. Sanford et al. (1996) used this method to prepare solutions of dissolved inert gas tracers for lab column studies and to passively release helium and neon in a field tracer test. Gibson et al. (1998) also used devices based on this concept in a pilot test of a semiactive (limited pumping) treatment of a gasoline plume, but did not present any specific oxygen release data. In this paper, we summarize our investigations of the factors that influence oxygen release from polymeric tubing, provide results useful for designing field applications of the emitter technology, and report on one field application within a contaminant plume.

Theory

The oxygen emitters we are investigating consist of a continuous coil of polymeric tubing wound around a support and connected to a supply of oxygen (Figure 2). The wall of the tubing is in essence a polymeric membrane. The transport of fixed gases (e.g., oxygen, helium, nitrogen, and sulphur hexafluoride) through a polymeric membrane is a four-stage process (Gruenwald 1993): (1) adsorption to the polymer surface, (2) solubilization into the polymer, (3) mass transport through the polymer, and (4) desorption from the polymer surface.

It is well established that the mass transport of gases through polymeric materials is a diffusion-controlled process (van Amerongen 1946; Michaels and Bixler 1961a; Crank and Park 1968; Comyn 1985). Gas diffusion through polymers is known to be temperature dependent (Barrer 1937; van Amerongen 1946); e.g., Michaels and Bixler (1961a) observed that a 1°C rise in polymer temperature resulted in a 7% increase in the diffusion coefficient of gases through low-density polyethylene (LDPE).

The diffusive mass flux of a gaseous species through a polymeric membrane is given by Fick's first law:

$$J = -D\delta c/\delta x \qquad (1)$$

Strictly speaking, the force driving diffusion is not a concentration gradient (i.e., $\delta C/\delta x$), but rather a chemical potential gradient (Park, 1986). However, in this work, we have assumed that oxygen behaves as an ideal gas and that the driving force for diffusion can be approximated by the concentration gradient imposed across the membrane (i.e., across the tubing wall). The following development provides the rationale for this assumption. The driving force moving a molecule across a membrane of thickness δx is

$$[q - (q + \delta q)]/\delta x = \delta q/\delta x \qquad (2)$$

where q is the mean energy per molecule. The mean energy per mole in a uniform system is the chemical potential, μ, and thus the mean energy per molecule is μ/N, where N is Avogadro's number. The driving force per molecule can therefore be defined as

$$F = -(1/N)\,\delta\mu/\delta x \qquad (3)$$

The chemical potential of gaseous species can be defined in terms of fugacity, or under low-pressure conditions in terms of partial pressures (Stumm and Morgan 1996):

$$\mu = \mu^o + RT\ln(p/P^o) \qquad (4)$$

where μ^o is the standard potential and P^o is a reference pressure (usually 1 atm). If it is assumed that the gas behaves ideally, partial pressure can be converted to mass-per-volume concentration using the ideal gas law and the molecular mass. The flux of molecules moving through a unit area of polymer in unit time is

$$J = v \times c \qquad (5)$$

where v is mean molecular velocity defined as the driving force for movement (F) divided by resistance to that movement imposed by the polymer (τ):

$$v = -(\delta\,\mu/\delta x)/(N\tau) \qquad (6)$$

Substituting Equations 4 and 6 into Equation 5 gives

$$J = -(RT/N\tau)\,\delta c/\delta x \qquad (7)$$

Thus the diffusion coefficient is given by a constant term ($RT/N\tau$) and the driving force is approximated by a concentration gradient. Note that this derivation does not take into account the solubility of gases in, and sorp-

Table 1
Tubing Statistics and Operating Conditions of Lab Diffusion Tests

Tubing Material	Inside Diameter (mm)	Outside Diameter (mm)	Wall Thickness (mm)	Tubing Length (cm)	Test Pressure (kPa gauge)	Maximum Rated Pressure (kPa gauge)	Average Water Flow Rate (L/day)	Average Contractor Residence Time (days)
Silicone	3.2	6.4	1.6	75	103.4	145	7.2	0.97
2275 Tygon	3.2	6.4	1.6	200	103.4	206	2.0	3.5
2075 Tygon	3.2	6.4	1.6	200	110.3	206	10.2	0.48
LDPE	4.8	6.4	0.8	300	*	758	10.3	0.48

LPDE: Low-density polyethylene. Tygon registered® Norton Performance Plastics Corp. Silicone: Tygon 3350 formulation, platinum cured.
*Pressure in the LDPE test was increased stepwise from 82.7, 124.1, 193.1, 330.9, to 465.4 kPag.

ent ports and the vessel was sealed, placed on a magnetic stirrer, and filled headspace-free with N_2-purged tap water. As shown in Figure 2, oxygen from a pressurized cylinder was conducted to and from the vessel through LDPE tubing connected to the vessel using standard compression fittings. N_2-purged water from a 20 L reservoir was metered via a peristaltic pump into the vessel and out through a small volume flow-through cell equipped with an Orion model 835 galvanic D.O. probe.

Water was allowed to flow for two to three days before starting oxygen release to stabilize flow and establish influent D.O. concentrations. At time zero, the tubing line was pressurized by opening the O_2 cylinder valve and setting the regulator to the desired operating pressure. Atmospheric gas was displaced from the tubing by venting O_2 through the line for three to four seconds. To maintain the set pressure and to ensure a uniform concentration gradient throughout each test, oxygen was slowly bled through the line using a metering valve at the end of the effluent gas line (Figure 2). Flow rates of the effluent water were gravimetrically determined daily during the tests. D.O. readings were collected frequently until the system approached a steady state, and less frequently thereafter until the test was terminated. The analytical range of the probe was 0 to 80 mg/L, with accuracy on the order of ±1%. Tubing parameters and experimental conditions are compiled in Table 1.

Results

According to the equations that describe the system shown in Figure 2 (Wilson and Mackay 1995), the concentration history observed in the contactor should describe a sinusoidal curve. At early time, the diffusant has not broken through the tubing wall and there is no increase in concentration in the contactor. After breakthrough, concentrations increase slowly as diffusive flux from the tubing starts to overcome the flux out of the contactor. As the diffusion gradient through the tubing approaches steady state, flux increases and concentrations in the contactor increase linearly. Once diffusion through the tubing has reached steady state, the flux from the tubing remains constant and concentration increase in the contactor slows. The whole system is at steady state when the diffusive flux from the tubing is equal to the flux out of the contactor.

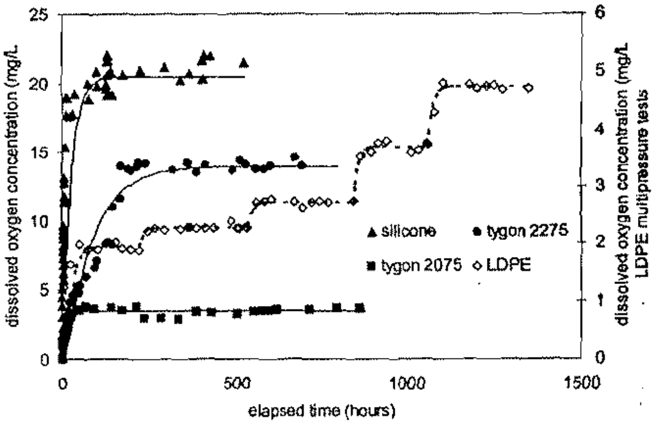


Figure 3. Oxygen concentration history and fit model curves in each of the four release tests. Symbols represent observed concentrations and the lines represent the model fits to those data. Diffusion coefficients fit at the five pressures in the LDPE test were, in order of increasing pressure ($\times 10^{-8}$ cm^2/sec): 1.776, 1.776, 1.775, 1.645, and 1.666.

Figure 3 shows the D.O. concentration histories of the four lab tests, each of which clearly exhibits the linear concentration increase and steady-state phases. The combination of thin tubing wall, small diffusant size, and large imposed concentration gradient resulted in rapid breakthrough and a very short early phase. After 200 hours, the pressure in the LDPE test was increased in several steps. Because oxygen was already at a diffusive steady state, onset of linear concentration increase was nearly immediate after each pressure increase. If our analytical resolution was much better and we sampled at much greater frequency shortly after increasing the pressure, we may have been able to discern this early phase. For various practical reasons, each material was tested under slightly different conditions (different tubing length, wall thickness, pressures, and/or pumping rates). In general, however, steady state in all the tests was achieved within six contactor residence times and concentrations varied thereafter by an average of 2.4%. The results were normalized by back-fitting oxygen diffusion coefficients (D) through each tubing (Table 2) using a simple computer

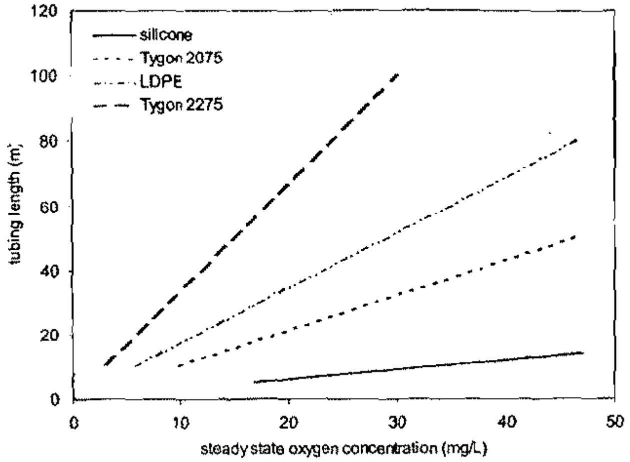


Figure 4. Relationship between steady-state oxygen concentration and tubing length. Operating pressure is assumed to be 80% of rated maximum, and temperature is constant.

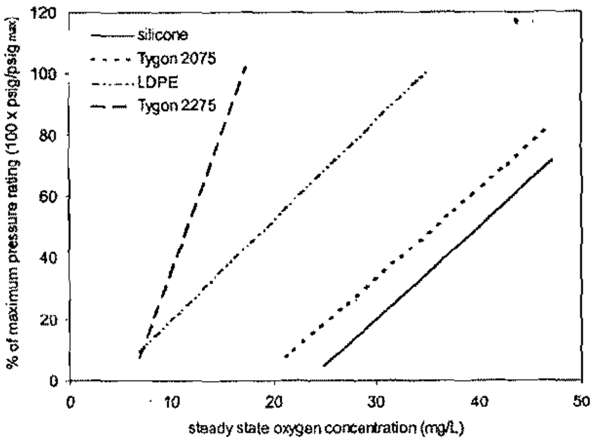


Figure 5. Relationship between steady-state oxygen concentration and operating pressure for fixed tubing lengths: 2075, 2275, and LDPE = 50 m, silicone = 15 m (the latter is based on observed diffusivity and availability). Temperature is assumed constant.

this, the total oxygen flux potential from the two materials is similar because the latter can be pressurized four times higher than the former (four times greater concentration gradient). Like 2275, the 2075 material is expensive and the manufacturer does not recommend prolonged exposure to either pure phase or high dissolved concentration of organic solvents. Nevertheless, 2075 may be a reasonable choice for field application where total organic contaminant loading is low. LDPE can be reliably plumbed using standard compression fittings that we have tested to 620.5 kPag in other work. Thus, in spite of the fact it has the lowest diffusion coefficient, it may still be useful in field applications given its low cost, chemical resistance, connection reliability, and wide working pressure range.

The relative differences between the four materials can be further demonstrated by considering a simple application scenario. Assume that an emitter is installed in a 20.3 cm diameter by 1.5 m long well screen emplaced within an aquifer with a ground water flow rate of 10 cm/d.

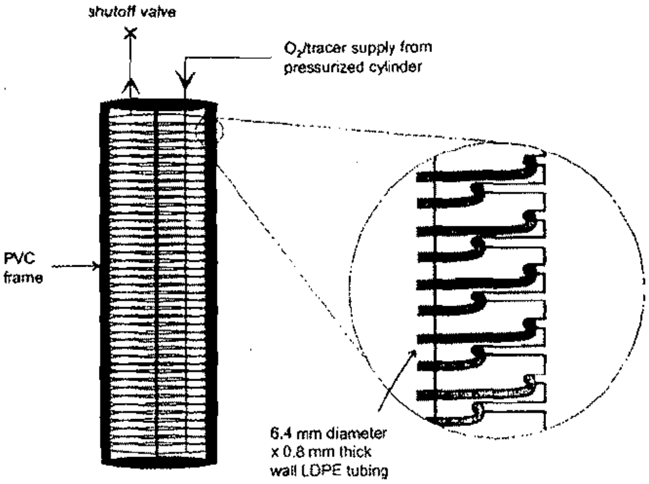


Figure 6. Schematic of passive oxygen emitter used in field trials. Device was 17.2 cm in diameter and 121.9 cm long. A 1.9 cm O.D. PVC pipe was threaded to the top of the frame to facilitate installation in the well, house gas supply and return lines, and allow access for sampling tubes.

The well screen is unpumped, serving solely as a permeable location for the ground water to contact the emitter. Theory suggests that the well screen will capture ground water flowing through an area roughly twice its own width (Drost et al. 1968; Halevy et al. 1967). Once a well (or other contactor) is installed, contactor volume is fixed and residence time is defined by the ground water flow rate. Tubing length and pressure are two design variables that are easiest to manipulate to achieve some delivery goal. The relationship between tubing length and steady-state D.O. concentration for emitters operated at a fix pressure (80% of maximum rating) is shown in Figure 4, whereas Figure 5 shows steady-state concentrations for fixed lengths of tubing operated at a range of pressures.

It is evident from Figure 4 that only very short lengths of silicone are needed to generate significant D.O. concentrations. However it is also evident that high D.O. concentrations can be achieved with polymers that have lower effective diffusion coefficients for oxygen provided they have a higher operational pressure range (e.g., LDPE). Table 2 lists the length of each tubing material required to generate 30 mg/L D.O., assuming the tubing was operated at 80% maximum pressure, along with the approximate cost for that length. Silicone and LDPE stand out as cost-effective alternatives. Alternatively, tubing length may be fixed by certain geometric constraints (chosen well diameter or emitter design). In Figure 5, we plot the steady-state D.O. concentrations for fixed lengths of tubing over a range of operating pressures (15 m for silicone, 50 m for the other materials). We have found in our own field experience that 50 m of tubing is a practical amount for an emitter designed for a 1.2 m long by 20.3 cm diameter well screen. The shorter length of silicone was used because of the high observed oxygen diffusivity, and as a practical matter silicone tubing is commonly available in 15 m lengths. Figure 5 also demonstrates the flexibility inherent in these diffusive emitters.

Results

The in situ contaminant treatment achieved by use of the oxygen emitters is the subject of an upcoming manuscript and will not be addressed here. Instead we focus on the oxygen release performance of the emitters under field conditions. Given the length, diameter, and wall thickness of tubing used to construct the emitters, the measured ground water flow rate and the intended operating pressures, the anticipated steady-state D.O. concentration was estimated using the effective diffusion coefficient determined in the lab. For the first 80 days, the system was operated at 344.7 kPag and then turned up to 620.5 kPag. The predicted D.O. concentrations for both periods (16.3 and 26.3 mg/L) compare favorably to the concentrations measured in the release wells (approximately 13 and 25 mg/L, Figure 8), in spite of the presence of degradable hydrocarbons. Note that emitter performance was not noticeably affected by exposure to NAPL (units 3, 6, and 7), although exposure time was at most two to three months. The weaker performance of the emitter in well 3 is likely the result of a pinch in the LDPE tubing that we subsequently discovered, which we surmise prevented adequate venting of that emitter. The concentration gradient was therefore not as high as it was for the other emitters. Pressure was maintained at the intended setting throughout the test, and no visible signs of polymer deterioration were observed when the emitters were removed.

All seven wells were slug-tested before and after the trial period to detect any changes in flow through the wells as a result of any chemical precipitation on or biofouling of the screens. Estimated hydraulic conductivities differed by less than 2% (data not shown), suggesting that the hydraulic performance of the wells did not change over the six-month trial period.

After reaching steady state, D.O. concentrations were relatively uniform during each three-month operational period. This demonstrates the steady and uniform nature of oxygen delivery possible with the diffusive emitters over long time frames. One other advantage of this method of oxygen release is that operation and maintenance demands are low. For the six-month test, only two tanks (approximately 22 kg) of industrial grade oxygen were needed. Furthermore, only a very minor amount of electrical power was required to operate the venting timer and solenoid valves; this could conceivably be supplied entirely by batteries in remote applications lacking line power. Uniform, steady oxygen release and low operation and maintenance demands can be contrasted to the results of the prior demonstration (Chapman et al. 1997) in which the oxygen concentrations released from the solid oxygen sources decayed exponentially from near saturation levels just after the start of the test to an average of roughly 2 mg/L on day 182. This nonsteady release suggests that at this and similar sites frequent replacement of the oxygen source would be necessary to ensure an adequate supply of oxygen to meet long-term plume demand.

Potential Field Applications

Diffusive oxygen emitters could be used in a number of scenarios. The field test described is an example of a passive discontinuous PRB. These PRBs rely on the modest hydraulic capture of unpumped wells to direct plume into a treatment zone and thus require small spacing between wells. Emitters could also be installed at key points within other hydraulic management systems (e.g., funnel and gate systems or collector trenches with treatment at nodes) to minimize the number of emitters needed. Various semiactive schemes could be envisioned that all have the goal of increasing spacing of emitter locations, e.g., in-well recirculation or recirculation between two neighboring wells. The horizontal flow treatment well (HFTW) concept (Figure 1c) is an extension of the latter approach. In that method, wells can be placed much farther apart than they would in a passive PRB application. However, the pumping rate needed to achieve acceptable capture and recirculation would result in a significant reduction in contactor residence time, which in turn imposes a significant demand on the oxygen emitter. Nevertheless, based on the diffusion coefficients obtained in this work, it should be possible to derive an HFTW/emitter design combination that will result in sufficient oxygen delivery to a relatively large treatment zone using a small number of wells and emitters. For example, pairs of 10.2 cm diameter wells spaced on the order of 3 to 5 m apart and pumped at 2 to 5 L/min provide sufficient residence time to deliver sufficient oxygen to meet demand in some situations. In high demand situations, the interwell spacing would have to be reduced if emitters were the preferred method of oxygen release.

Summary

Natural attenuation is an aquifer restoration option that has gained favor recently. However, there are some sites where intrinsic processes do not reduce the flux of contaminants sufficiently to control risk. At such sites, some intervention is required. In the case of aerobically degradable contaminants, the efficient delivery of dissolved oxygen at concentrations adequate to sustain or enhance in situ biodegradation is a key requirement. The method described herein provides steady and uniform long-term release of oxygen from pressurized polymeric tubing. Mass transfer is controlled by diffusion through the tubing in response to the concentration gradient imposed as a result of pressurization. Of the four types of tubing material tested, platinum-cured silicone was found to have the highest oxygen diffusion coefficient, followed by 2075 Tygon, 2275 Tygon, and LDPE. The choice of tubing material for a given application will be defined by site conditions. High VOC loading may require the use of LDPE, which is the most chemically resistant of the materials tested. In cases where the risk of damage by VOC loading is minimal but high oxygen demand is imposed from other sources (dissolved or solid), silicone may be an appropriate choice. Other practical concerns may factor into the selection of a material. For example, LDPE is the least expensive of the group, and its rigid nature gives it superior mechanical strength. We are continuing to look at the release characteristics of other polymers, the effects of organic solvents on release behavior, and methods to release ionic solutes.

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Biographical Sketches

Ryan D. Wilson *is a lecturer in the Department of Civil and Structural Engineering at the University of Sheffield, U.K., having recently completed his Ph.D. in the Department of Earth Sciences, University of Waterloo. His interests include transport and attenuation of ground water contaminants, enhanced in situ bioremediation and permeable reactive biobarrier application, and lab and field studies of spatially variable processes controlling mass transport. His most recent work involved controlled field experiments on enhanced MTBE biodegradation, and ongoing work focuses on factors controlling natural attenuation processes in plume fringes. (University of Sheffield, Sheffield, UK, S1 3JD; +44 (0)114 222 5719; fax +44 (0)114 222 5700; r.d.wilson@sheffield.ac.uk).*

Douglas M. Mackay *is an adjunct professor in the Department of Land, Air and Water Resources at the University of California at Davis, research associate professor in the Department of Earth Sciences, University of Waterloo, and consulting professor in the Department of Civil and Environmental Engineering, Stanford University. His work has included field tests of contaminant transport/transformation/remediation in ground water, as well as laboratory studies of processes controlling field behavior. Recently his research has focused on in situ remediation of MTBE and understanding the longevity of petroleum hydrocarbon contamination in heterogeneous geologic media. He has served on two National Research Council committees culminating in two reports: Alternatives to Groundwater Cleanup (NRC 1994) and Natural Attenuation for Groundwater Remediation (NRC 2000). (University of California, Davis, CA 95616; (650) 324-2809; fax (650) 324-2259; dmmackay@ucdavis.edu).*

EPA – *In Situ* Bioremediation of MTBE at Vandenberg Air Force Base

In Situ Bioremediation at Vandenberg Air Force Base

Site Name: Vandenberg Air Force Base

Site Location: Lompoc, California

Contaminant: MTBE

Media: Groundwater

Technology: *In situ* bioremediation

Technology Scale: Field Demonstration

Period of Operation: 1999 to ongoing (data available through December 1999)

Technology Researcher:
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Site History [1]:

Site 60 at Vandenberg Air Force Base (AFB) is the location of an abandoned service station. Leaks from gasoline tanks resulted in contamination of the groundwater with MTBE, BTEX, and other petroleum hydrocarbons. As shown in Figure 1, data from November 1997 showed the MTBE plume extended approximately 1,700 feet downgradient from the source area, and the smaller BTEX/TPH plume, located within the MTBE plume, extended approximately 100 feet downgradient of the source area. The BTEX/TPH plume appears to have degraded relatively rapidly, while the MTBE plume appears to have continued to migrate.

A research project to study in situ bioremediation of MTBE has been underway at Vandenberg AFB since 1998. As part of this project, Site 60 is being used to study possible methods for stimulating aerobic in situ biodegradation of MTBE using native and non-native microbes. To achieve aerobic conditions in an otherwise anaerobic plume, researchers studied the use of diffusive emitters to introduce oxygen into the subsurface. The field pilot studies are being conducted near the apparent centerline of the existing MTBE plume, approximately 200 feet downgradient of the source area. At this location, MTBE is the only VOC detected at significant concentrations on a regular basis.

This report addresses three pilot tests being performed at the site. Two of the tests involve evaluating different configurations of oxygen emitters - cylindrical and rectilinear in terms of their ability to create aerobic conditions in the subsurface and to enhance intrinsic degradation of MTBE. The third test involves evaluating the effects of adding an emplaced MTBE degrader (strain PM1) under aerobic conditions on the degradation of MTBE.

Technology Description [1, 2, 5]:

The three pilot tests being conducted at Site 60 are:

1. Release wells
2. Release panel (permeable panel)
3. Emplaced MTBE degraders (strain PM1) (permeable trench)

Figure 1 shows the location of the pilot test areas with respect to the MTBE and TPH/BTEX plumes. Figure 2 shows the general layout of the three pilot tests. The tests are being conducted in the same general area to increase the probability that each technology is treating groundwater with similar characteristics, allowing for comparison of results. Sulfur hexafluoride (SF_6) is being used as a tracer in each of the tests to verify that the injection and monitoring systems were working properly.

Release Wells

The objectives of this pilot test include evaluating release wells that house cylindrical oxygen emitters to create aerobic conditions in the aquifer and evaluating the growth and activity of native microbes for oxidizing MTBE.

Figure 3 is a plan view of the release well test. Two 8 inch diameter wells (RW1 and RW2), screened to a depth of 8 ft, were installed at the site using standard auger drilling techniques, and seven multi-level wells (T1 through T7) were installed up- and down-gradient of the release wells. As shown in Figure 4, the multi-level wells were multi-chambered (7 "levels"), screened at locations above, within, and below the screened interval of the release wells.

Each release well contained an oxygen emitter. The emitters consist of continuous coils of low density polyethylene (LDPE) tubing looped around a PVC frame; each emitter contained two tubes – one inner and one outer. The length of the inner and outer tubes on the RW1 emitter are 41.4 and 54 meters, respectively. On the RW2 emitter, the length of the inner and outer tubes are 39.5 and 55.9 meters, respectively. The tubing is connected to a gas cylinder (oxygen or oxygen/ SF_6) and is pressurized (50 psi) to force the oxygen to diffuse from inside the tubing into the water flowing through the well screen. During the first 60 days of operation, oxygen only was released into the groundwater. After 60 days of operation, SF_6 was added to the gas as a tracer .

Release Panel

The objectives of this test include evaluating a flat panel approach for housing rectilinear emitters to create aerobic conditions in the aquifer, and evaluating the growth and activity of native microbes for oxidizing MTBE.

Figure 4. Plan View of the Multi-Level Wells [1]

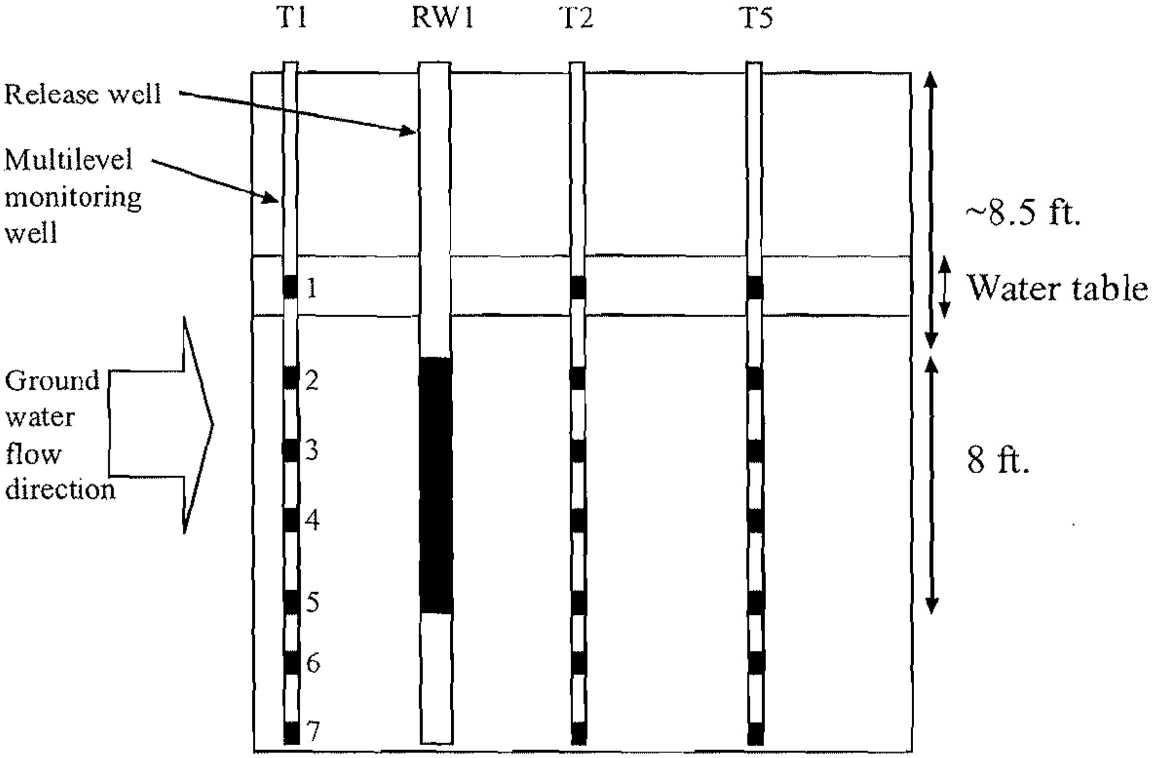
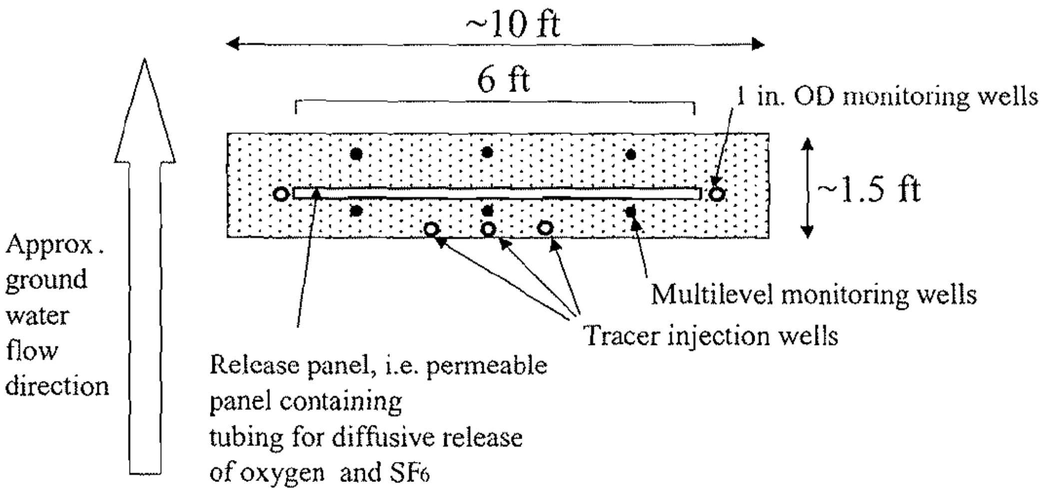


Figure 5 is a plan view of the release panel test. According to the researchers, the use of flat panels oriented orthogonal to the groundwater flow offer the potential for relatively uniform solute release over considerable cross-sectional areas. The panel consists of three layers of prefabricated stripdrain material, each 6 ft by 6 ft by approximately 1 inch. Continuous lengths of ¼ inch LDPE tubing are woven around the internal supports of the stripdrain and the panel is covered with a high permeability geotextile designed for subsurface drainage applications.

Figure 5. Plan View of the Release Panel Test [1]



Technology Performance [1, 2, 3, 5]:

Release Wells

Data on concentrations of dissolved oxygen (DO) and SF_6 in and around the release wells is available for the first 140 days of operation (no data on MTBE concentrations were available at the time of this report). After 140 days, a gradual buildup of SF_6 was observed in the release wells, and SF_6 was observed in all the T-series monitoring wells. According to the researchers, this indicates that the emitters are working as expected. In addition, the highest concentrations of SF_6 were found in level 4 of the T-series multilevel monitoring wells, suggesting that a particularly conductive stratum is sampled by level 4 of the multilevels.

Figure 7 shows the concentration of DO for a flowpath along the conductive stratum from T1 (up-gradient) through RW1 to T2 (down-gradient). Upgradient of the release well (well T-1), the concentration of DO was negligible throughout the 140 days of operation. In the release well itself, the initial DO concentration was approximately 1 mg/L before increasing to 20-25 mg/L after approximately 20 days. From day 20 to day 100, the DO concentration remained relatively constant, then decreased. According to the researchers, the reasons for the decrease are not known at this time.

Downgradient of the release well (well T-2), the DO concentration was initially negligible, then increased to approximately 2.5 mg/L after about 60 days of operation. The DO concentration remained at that level through day 140. The researchers indicated that the oxygen demand of the groundwater and/or aquifer material is significant, and may be slowing the rate of progress of DO into the aquifer.

Figure 7. Concentration of DO for a Flowpath Along Conductive Stratum [1]

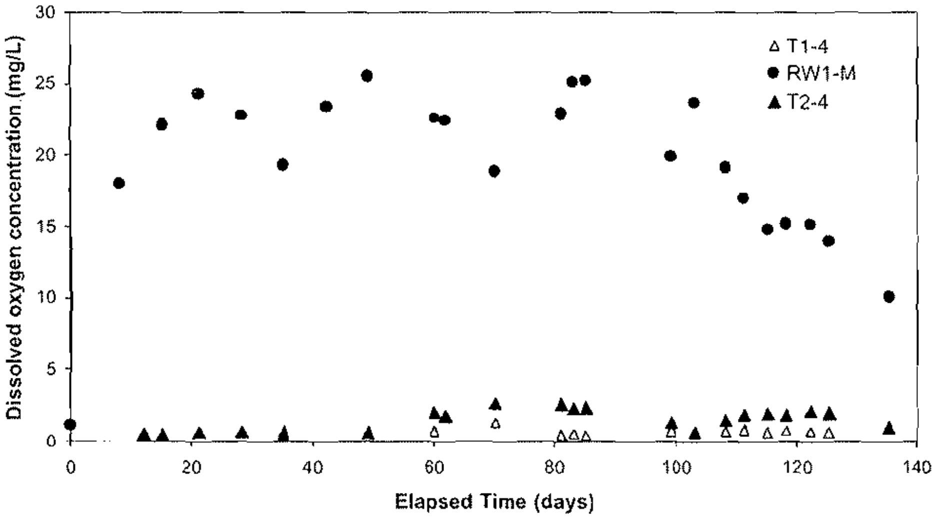


Figure 8. Analytical Results from Release Panel Tests – 10/21/99 [2, 3]

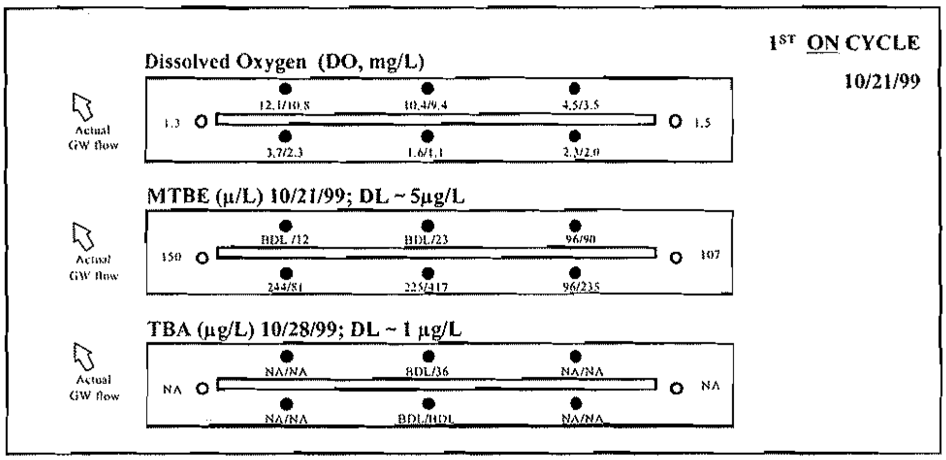


Figure 9. Analytical Results from Release Panel Tests – 12/14/99 [2, 3]

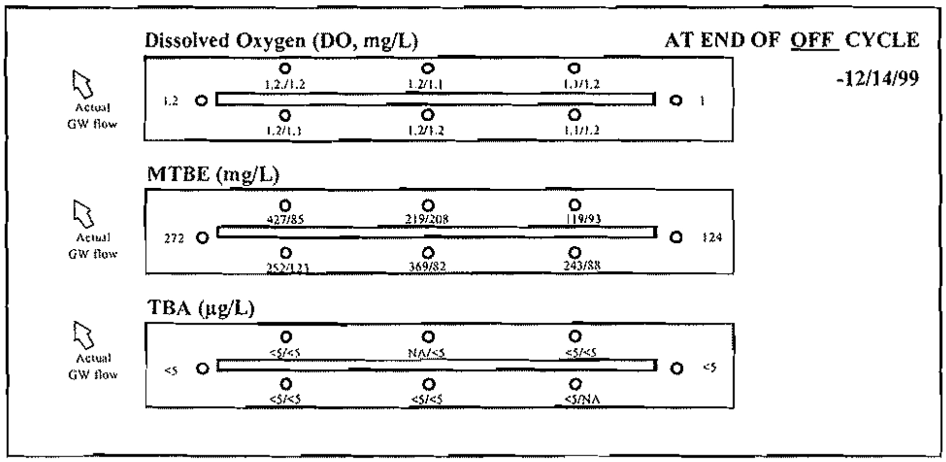
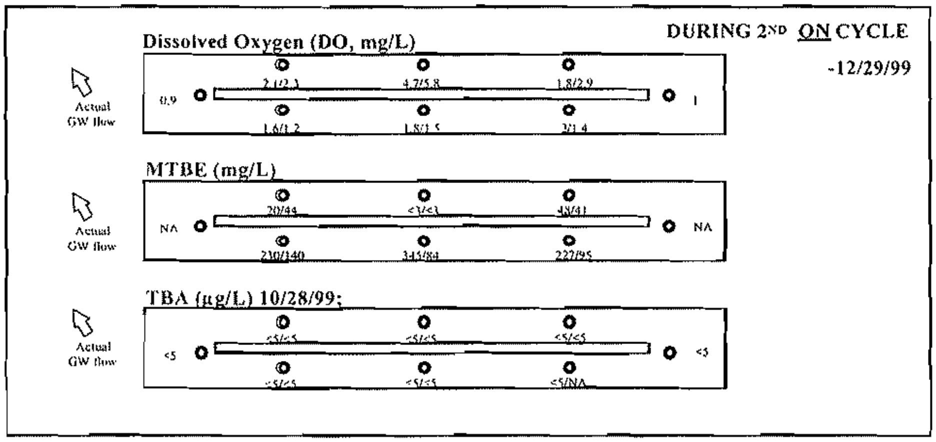


Figure 10. Analytical Results from Release Panel Tests – 12/29/99 [2, 3]



○ 1.3 =conc. in well

● 12.3/10.8 = conc. in middle/lower point of multilevel sampler

NA = not analyzed

BDL = below DL

ES&T – *In Situ* MTBE Biodegradation Supported by Diffusive Oxygen Release

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In Situ MTBE Biodegradation Supported by Diffusive Oxygen Release

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Microcosm studies with sediments from Vandenberg Air Force Base, CA, suggest that native aerobic methyl *tert*-butyl ether (MTBE)-degrading microorganisms can be stimulated to degrade MTBE. In a series of field experiments, dissolved oxygen has been released into the anaerobic MTBE plume by diffusion through the walls of oxygen-pressurized polymeric tubing placed in contact with the flowing groundwater. MTBE concentrations were decreased from several hundred to less than 10 μg/L during passage through the induced aerobic zone, due apparently to in situ biodegradation: abiotic MTBE loss mechanisms were insignificant. Lag time for initiation of degradation was less than 2 months, and the apparent pseudo-first-order degradation rate was 5.3 day^{-1}. Additional MTBE was added in steps to raise the influent concentration to a maximum of 2.1 mg/L. With each step, MTBE was degraded within the preestablished aerobic treatment zone at rates ranging from 4.4 to 8.6 day^{-1}. Excess dissolved oxygen suggested that even higher MTBE concentrations could have been treated. Continued flow through the treatment zone was repeatedly confirmed through tracer and other tests. These and others' results suggest that it is possible to create permeable in situ treatment zones solely by releasing oxygen to support native microbial degradation of MTBE.

Introduction

Methyl *tert*-butyl ether (MTBE), primarily because of its widespread use as a gasoline additive, has been inadvertently released to the subsurface environment at thousands of sites in the United States (*1*), in Europe, and perhaps elsewhere. In some cases, these releases have impacted or posed a potentially significant threat to water supply wells (*1, 2*). While field evidence suggests that considerable anaerobic transformation of MTBE may occur within or near source zones under some conditions (*3*), the flux of MTBE out of those zones is often high enough to generate plumes of concern. Other evidence suggests that the plumes are bioattenuated during transport through some subsurface environments, but biodegradation rates are apparently low (*4, 5*) except where sufficient dissolved oxygen (DO) is present such as at groundwater–surface water interfaces (*6*). When DO is limited or absent, as is often the case in groundwater impacted by petroleum hydrocarbon spills, natural attenuation of MTBE plumes may be insufficient for risk management. Thus, there is considerable interest in developing approaches for in situ treatment of MTBE, with biotreatment approaches receiving the most attention.

MTBE has been shown in microcosm studies to be biodegraded by a number of pure (*7–10*) and mixed (*6, 11–13*) microbial cultures under aerobic conditions and, in some cases, demonstrated to serve as the sole carbon and energy source for these organisms. *Tert*-butyl alcohol (TBA) is noted as an intermediate of aerobic degradation of MTBE, although it can be aerobically degraded by some microorganisms (*6, 9, 13, 14*). Because degradation rates under aerobic conditions are believed to be more rapid than those under anaerobic conditions (*9*) and given the variety of ways to increase the oxygen concentration of contaminated groundwater, there have been many attempts to increase the rate of in situ aerobic degradation of MTBE. Most attention has been directed to the permeable reactive barrier (PRB) approach, i.e., the creation of an in situ aerobic biotreatment zone through which the plume migrates under the natural gradient and within which MTBE is degraded. A PRB effective at enhancing in situ aerobic microbial treatment of MTBE must (i) create steady aerobic conditions, (ii) generate and/or sustain enough microbial biomass to accomplish the treatment at a practically useful rate, and (iii) ensure that the contaminated groundwater continues to flow through the aerobic treatment zone.

The field research on in situ MTBE treatment reported to date has generally succeeded in demonstrating the first two requirements but has provided little evidence that the third requirement is met. Salanitro et al. (*9, 15*) injected a non-native MTBE-degrading bacterial culture into an existing MTBE plume at Port Hueneme, CA, and, providing oxygen via a pulsed sparging system, showed evidence of treatment over a sustained period of time. Interestingly, in a non-bioaugmented comparison plot also amended with oxygen, microorganisms native to Port Hueneme groundwater were also observed to degrade MTBE in situ after a lag period of approximately 173–230 days. Salanitro et al. (*9*) noted that under the conditions of their study, the bioaugmented plot apparently had an initially higher rate of degradation than the non-bioaugmented plot. In addition, they reported that TBA appeared to emanate untreated or only partially treated from the zone of oxygen stimulation of the native microorganisms in the non-bioaugmented plot. These findings led them to suggest that in many cases bioaugmentation may be preferred even in the presence of native MTBE-degrading microorganisms. However, their work did not address a possible side effect of employing bioaugmentation and injecting oxygen gas, namely, a reduction in the permeability of the aquifer within the intended treatment zone. Such a permeability reduction might lead to reduced groundwater flow through the treatment zone and thus result in partial bypass of contaminated groundwater around it. Since the groundwater flow within the treatment zone was somewhat uncertain, the field data do not yield reliable estimates of the rate of in situ MTBE degradation. However, in microcosm studies using sediments and groundwater from the site (not bioaugmented but spiked with MTBE to approximately 11 mg/L), Salanitro et al. (*9*) reported a lag period of 14-21 days, after which time the MTBE was degraded by native microbial populations at an apparently zero-order rate (254 μg/L day^{-1}) to nondetect within 63 days. No results

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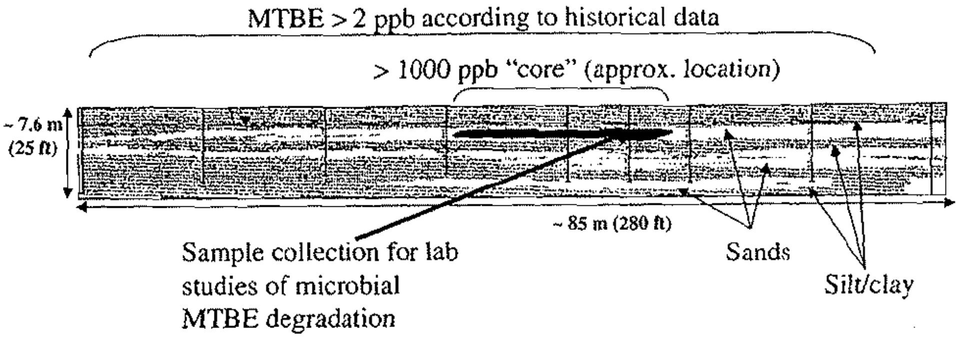

FIGURE 2. Cross section along transect B, illustrating the layered nature of the alluvium and the approximate location of the MTBE plume in March 1999. Permeable, sandy units are depicted in white. Less permeable, silty/clay units are depicted in gray.

of the media and the fact that the MTBE plume is almost entirely migrating within one thin aquifer, i.e., within a vertical interval of 2.7–3.6 m bgs.

Groundwater at the site, both upgradient of the source area and within the plume, is weakly anaerobic (DO <0.5 mg/L, E_h ~40 mV), of a neutral pH (6.7–6.9), and contains moderately high levels of total dissolved solids. Groundwater temperature ranges between 15 and 19 °C seasonally. Near the test facilities, monitoring showed that the predominant electron acceptor was SO_4^{2-} (~150 mg/L); concentrations of other redox indicator species were ND for NO_3^-, ~0.2 mg/L for S^{2-}, ~0.5 mg/L for Fe^{2+}, ~200 mg/L for CO_2, and ~400 mg/L alkalinity (as HCO_3^-). Temporal and spatial variability and relatively sparse geochemical monitoring data made it difficult to compare parameters in background and plume samples. In general, evidence points, as expected, to anaerobic processes occurring during migration of groundwater through and beyond the source zone. Methane concentrations were similar inside and outside the MTBE plume, suggesting that methanogenic reactions were relatively insignificant or that there was a sink for methane produced within the plume. Major ions near the in situ test facility were dominated by Ca^{2+} (130 mg/L), Na^+ (250 mg/L), Mg^{2+} (45 mg/L), and Cl^- (400 mg/L). Typical inorganic nutrient concentrations (PO_4^{2-}, K^+, and NH_4^+) were generally low (ND, 7 mg/L, and 0.3 mg/L respectively).

Experimental Methods

Laboratory Studies. Microcosm studies were conducted with sediments taken from the MTBE-contaminated aquifer at the location on transect B indicated in Figure 1. Along transect B, the MTBE concentrations vary significantly spatially and temporally (*18*), but no other VOCs are consistently detected. At or near the location of where the solids were sampled, indicated in Figure 1, MTBE concentrations range from 100 to 5000 μg/L.

Sediments were collected from approximately 3.1 m bgs at the location shown in Figure 2. The core samples were sealed and kept cool during transport to the laboratory. The sediments were then homogenized, and approximately 1 kg was separated and triple-autoclaved for use in killed controls. Aseptic procedures were followed during microcosm construction. Approximately 200-g aliquots of sediment were slurried into each of six autoclaved 1-L bottles using 400 mL of VOC-purged site water, submerging the sediments. Three bottles received autoclaved sediments, and three received sediments that were not autoclaved. To each bottle was added a 100-mL aliquot of a 10 mg/L MTBE stock solution prepared using the same VOC-purged site water. The nonautoclaved microcosms were sealed, serving as the "active" tests. The bottles containing the autoclaved sediments were further sterilized by addition of 7 mL of 10% w/w NaN_3, thus serving as killed or abiotic controls. The air-filled headspace of all the microcosms contained sufficient oxygen to support aerobic degradation of all the MTBE introduced. The systems were incubated in the dark at room temperature with occasional stirring by hand for over 280 days. The microcosms were sampled every 3–7 days, depending on the previous results. A total of 5 mL of water was collected for each sampling event, prepared using an HP 7694 automated headspace sampler, and analyzed using an HP5890 GC-FID. The detection limits for MTBE and TBA were approximately 3 and 100 μg/L, respectively. After the microcosm systems were sampled, ambient air was allowed to replace the volume of water removed, thus also replenishing oxygen. The microcosms were respiked several times with MTBE at various concentrations, as discussed later.

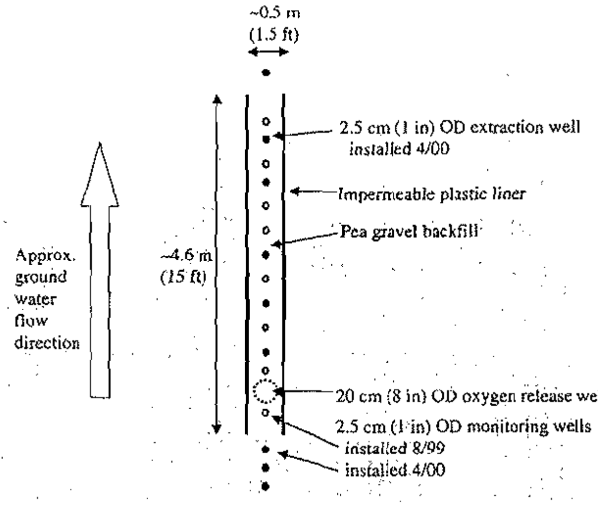

FIGURE 3. Plan view of the LTF. Note that the pea gravel backfill (clear) is in contact with the formation (stippled) at its upgradient and downgradient ends but is separated from it on the sides by an impermeable geotextile. The approximate locations of various wells are depicted.

Field Studies. Two pilot test facilities were created within the MTBE plume along transect B (Figure 1). The panel test is reported elsewhere (*16, 17*) and briefly summarized above. The Longitudinal Test Facility (LTF) is the focus of this paper.

Figures 3 and 4 present a plan view and vertical sections of the LTF, which was constructed as follows. A backhoe was used to create a 3.7-m-deep trench, aligned as closely as possible to our estimate of the natural groundwater flow direction. Because of the geotechnical properties of the native media, the trench remained open while we lined its lateral sides and bottom with a sheet of impermeable geotextile (MCF-1212; TC Mirafi, Pendergrass, GA), emplaced various wells (discussed below), and backfilled the interior with non-native, highly permeable pea gravel to the typical seasonal high water level. Impermeable geotextile was placed on top of the pea gravel, and the rest of the excavation was backfilled

TABLE 1. Schedule of Gas Release Conditions in the LTF, Starting 8/15/99

days since start	gas pressure (psig)	gas supply	focus
0–107	25	O_2/SF_6	in situ treatment of ambient MTBE
108–192	0	None	evaluation of abiotic MTBE loss
193–229	25	O_2	in situ treatment of ambient MTBE
230–389	25	O_2	bromide release to test system for MTBE release
390–416	0	None	reestablishment of ambient conditions in LTF
417–430	25	O_2	in situ treatment of ambient MTBE
431–452	25	O_2/SF_6	evaluation of treatment of higher MTBE concentrations and flow confirmation
453–466	25	O_2	evaluation of treatment of higher MTBE concentrations
467–492	25	O_2	system on but unmonitored over holidays
493–511	0	None	system off
512–571	35	N_2	confirmation of insignificant stripping of MTBE
571–continuing	25	O_2/SF_6	new series of tests of in situ treatment of ambient MTBE (not included in this paper)

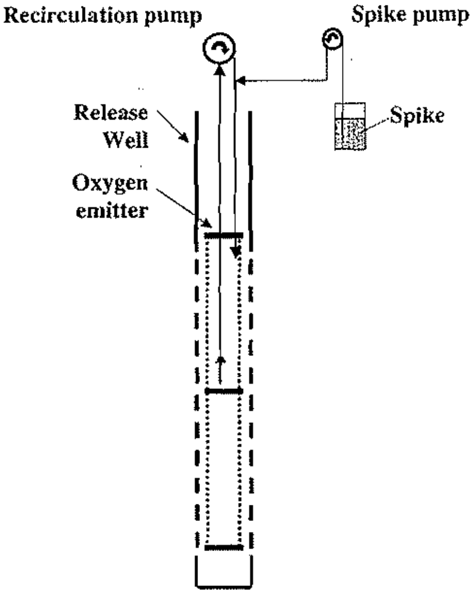

FIGURE 6. Schematic (vertical view, not to scale) illustrating the system used to spike the release well with bromide or MTBE.

into and through the release well, back out into the pea gravel, and ultimately back out into the aquifer. Contact with the oxygen emitter would increase the dissolved oxygen concentration of the otherwise anaerobic groundwater. We hypothesized that native aerobic MTBE-degrading microbes would migrate with the groundwater from the native sediments and populate the oxygenated zone of the pea gravel, creating a permeable in situ aerobic treatment zone downgradient of the RW. For 430 days, the LTF was operated in this mode, i.e., with the existing plume migrating through the LTF under the natural gradient.

Because the MTBE concentrations in the existing plume influent to the LTF were relatively low during the 430-day initial period of study (20–750 μg/L), a system was devised to artificially increase the MTBE concentrations entering the treatment zone in the LTF by releasing MTBE into the RW (Figure 6). Water was withdrawn from and reintroduced to the interior of the RW (the top half of the oxygen emitter) in order to set up a recirculation into which an MTBE spike solution was metered at a controlled rate by a digital peristaltic pump. The total MTBE concentration (ambient plus added) could be manipulated by varying the concentration of the spike solution and the rate at which the spike solution was metered into the recirculating flow. This system was used initially for a series of tests involving bromide release to the LTF (Table 1) in order to evaluate system performance and thus gain regulatory approval for the controlled release of MTBE.

Tracer tests were conducted at times throughout this work to confirm that groundwater continued to flow through the treatment zone and, in some cases, to estimate the groundwater flow velocity in the LTF. The first tracer test was conducted by releasing a mass of potassium bromide via a small volume aqueous injection into the RW. The migration of the bromide was monitored by periodically collecting samples in the wells along the LTF. In some cases, ambient MTBE was used as a tracer when no in situ treatment was occurring; thus the migration of MTBE back into the previously treated zone could be monitored. Finally, at some times we used an SF_6/O_2 mixture as the gas supplied to the oxygen emitters, thus leading to the simultaneous release of the two gases in dissolved form. The SF_6 functioned as a nondegradable tracer. Thus when first released, SF_6 could be monitored as it migrated through the LTF. Alternatively, when SF_6 release was stopped, its elution from the LTF could be monitored. Both approaches were used to confirm continued flow through the LTF.

During all phases of the LTF study, groundwater samples were drawn from monitoring positions through a flow-through cell using a peristaltic pump. The cell was instrumented with an Orion model 835 dissolved oxygen probe, a VWR model 34105–030 RedOx combination electrode probe, and an Orion model 9107BN pH/T/conductivity probe. Bromide was analyzed using both Orion model 9435BN and Cole-Parmer model BRO-1508 ion-specific probes. Detection limits of both probes were estimated to be on the order of 6 mg/L due to interfering solutes such as chloride. VOC samples were preserved with 10% w/w NaN_3 and either shipped to the University of Waterloo (UW) for MTBE analysis or analyzed on site. At UW, VOCs were prepared on an HP 7694 automated headspace sampler and quantified on an HP 5890 GC-FID (estimated detection limits for MTBE and TBA of 3 and 100 μg/L, respectively). Some samples were analyzed on site using an SRI 8610C GC fit with an automated purge-and-trap concentrator and FID (estimated detection limits for MTBE and TBA of approximately 3 and 100 μg/L, respectively). Accuracy of the field results was good, as confirmed by comparison to analyses of split samples at Waterloo. Selected VOC samples were sent to Turtle Bayou Laboratories (Liberty, TX) for TBA analyses via GC/MS (estimated detection limit 1 μg/L). Inorganic parameters were determined colorimetrically on site using either a HACH model DR2010 spectrophotometer or HACH digital titration. Major ions were analyzed at UW Solutions Laboratory by ICP. Sampling frequency depended on the phase of the test and its goals and the known or anticipated rate of change of analyte concentrations.

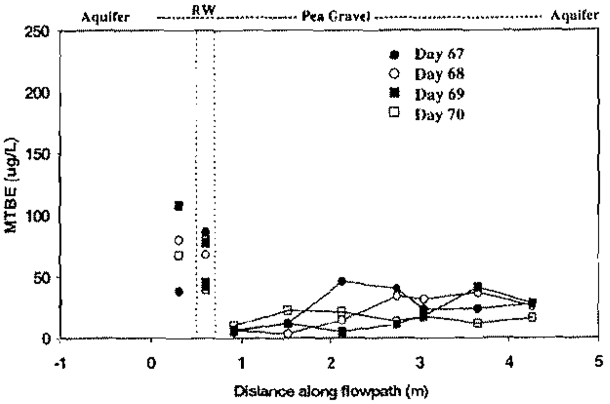

FIGURE 10. MTBE concentration vs distance along the flow path into and through the LTF at four times after approximately 2 months of oxygen release. Note that the concentrations downgradient of the release well are significantly lower than those upgradient, suggesting treatment by native MTBE-degrading bacteria.

this predicted value because of immediate but partial oxygen consumption within the release well due to abiotic and/or biotic oxygen demands (including those associated with MTBE metabolism discussed below). More slowly expressed oxygen demands apparently led to the development of a steady-state profile of DO downgradient of the release well, as indicated in Figure 9.

Figure 10 presents MTBE concentrations measured along the flow path into and through the LTF at the same sampling times depicted in Figure 9. MTBE concentrations varied somewhat in the groundwater entering the trench, as was expected based on other monitoring of transect B (*18*). MTBE concentrations downgradient of the release well were, in general, considerably lower than the influent values. These results strongly suggested that MTBE was biodegraded as it passed into and through the oxygenated zone, consistent with the results of the laboratory microcosms and the panel test (*17*). TBA was not detected in any of the samples from the LTF, either in regular analyses (DL ~100 μg/L) or occasional analyses of selected samples using a method with a lower detection limit (~1 μg/L). The apparent slight increase in MTBE concentrations with distance along the LTF is likely due to nonidealities in the construction of and flow within the LTF. In perfectly uniform media, convergent/divergent groundwater flow through the release well would result in highest DO along the plan view centerline and low or zero DO along the lateral sides of the LTF (*24*). Thus, the treatment zone is not expected to be uniform laterally but rather most efficient along the centerline. However, as mentioned previously it is very likely the backfill in the LTF is not uniform but possesses slight permeability variations that can lead to additional variations in oxygen distribution and treatment efficiency and uneven flushing of water and MTBE resident in the LTF prior to the initiation of oxygen release. Finally, it is unlikely the positioning of the monitoring wells is perfect, i.e., exactly vertical and on the centerline. Thus, because of the combination of these factors, the treatment will be most clearly detected by monitoring close to the release well. Monitoring further along the flow path will be confounded by mixing of more and less efficiently treated water. This problem decreases with time after initiation of treatment as the treatment zone and treated water invades progressively larger portions of the LTF but reoccurs when treatment is halted during cessation of oxygen release. Also, note that these early data were collected under natural gradient conditions. Later, during the MTBE step-amendment experiments (i.e., Figure 14), groundwater was continuously recirculated within the release well in the manner previously described. This recirculation may have resulted in broader distribution of dissolved oxygen and therefore more complete treatment of MTBE across the LTF.

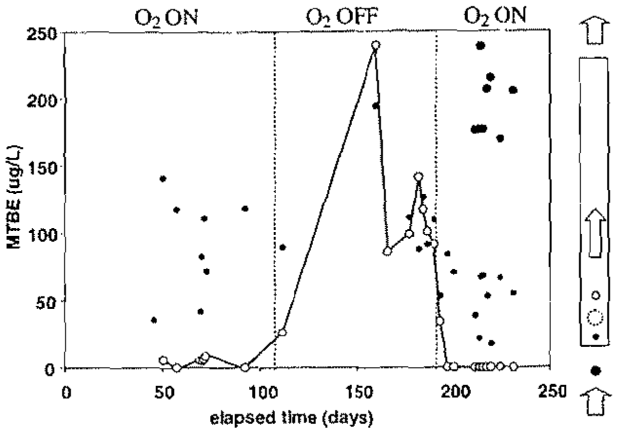

FIGURE 11. MTBE vs time at three points along the flow path into and through the LTF. The schematic to the right indicates the locations of the monitoring points. As noted above the graph, the oxygen supply was on during the first 107 days, off until day 192, and back on for the remainder of the time depicted.

Using the estimated groundwater velocity through the LTF (approximately 0.88 m/day), the data in Figure 10 can be used to make a very rough estimate of the apparent rate of in situ MTBE degradation. By assuming that the concentration influent to the treatment zone is represented by that measured at the monitoring point at approximately 0.3 m (just upgradient of the RW) and assuming that the in situ treatment starts in the center of the RW, we estimate that the low MTBE concentrations detected at the monitoring well at 0.9 m are consistent with a pseudo-first-order degradation rate of 5.3 ± 0.1 day^{-1}. Given that the treatment zone appears to be short in the direction of flow, the contribution of longitudinal dispersion to the attenuation of MTBE is expected to be insignificant. This rate estimate is considered very rough since the data are few and noisy but suggests that the rate of degradation within the LTF is considerably faster than that observed in the microcosms discussed earlier. We believe this is reasonable since, unlike the microcosms, there are essentially no oxygen mass transfer limitations within the LTF; the oxygen is provided quite uniformly to the flowing groundwater and thus to any MTBE-degrading microbes present in the LTF.

In Figures 9 and 10 and in data from subsequent monitoring over 15 months of operation, there is a disparity between the amount of MTBE degraded downgradient of the release well and the amount of oxygen consumed at the same time. The decrease in MTBE concentration was at most 140 μg/L. Assuming complete mineralization, 1 g of MTBE requires 2.73 g of oxygen. Thus, mineralization of 140 μg/L (0.14 mg/L) of MTBE would exert an oxygen demand of less than 0.5 mg/L. Therefore, the majority of the oxygen demand noted during in situ treatment of the plume was likely due to "nontarget" reduced substances either in the groundwater (dissolved, colloidal, or particulate) or on solids. Work is ongoing to understand the relative importance of the potential components of the "nontarget" oxygen demand, speculated to be reduced minerals, partial degradation products of constituents of spilled gasoline or oil, and/or indigenous organic matter.

Dependence of Degradation on Oxygen Release. To test the hypothesis that MTBE disappearance was directly related to oxygen release to the subsurface and thus in situ aerobic biodegradation, we measured the response of MTBE concentration to turning the oxygen supply off and on in the LTF (Table 1). Figure 11 is a plot of MTBE concentration versus time at monitoring points along the flow path into

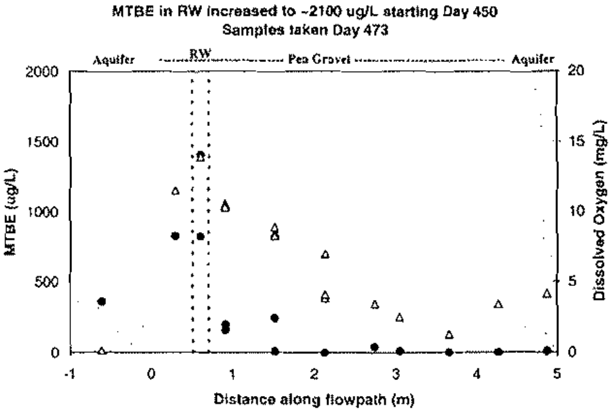

FIGURE 14. Plot of MTBE (solid dots) and DO (open triangles) vs distance along flow path through the LTF approximately 3 weeks after MTBE addition to 2100 μg/L total had begun.

to and held steady at approximately 2100 μg/L. Figure 14 presents the results of monitoring at the end of that period. Note that some sampling locations were measured at more than one depth within the well. Despite some evidence of minor vertical variability in MTBE transport and/or degradation, the LTF system continued to effectively treat MTBE. Excess oxygen was evident downgradient of the release well, suggesting that the system could handle an even higher influx of MTBE. Using the estimated groundwater velocity through the LTF and assuming that the in situ treatment starts in the center of the RW, the observed concentration profile yields a pseudo-first-order degradation rate of 5.2 day^{-1}, which is very close to that estimated from the day 67–70 data.

The MTBE degradation rates estimated from our field data are quite rapid as compared to the rates we estimate from the microcosm data reported herein. We believe that the rapid rates are due, in part, to the fact that oxygen and MTBE are uniformly mixed within the diffusive oxygen release well and that this mixture of electron acceptor and donor is delivered in a steady and efficient fashion to the microorganisms by the groundwater flow. In the laboratory microcosms discussed above, MTBE and oxygen reside predominantly in separate phases (MTBE in the water, oxygen in the headspace), and the microcosms are only infrequently mixed, leading to much more significant mass transfer limitations than occur in the field test. Furthermore, it is likely that there are significant variations in mass transfer limitations among the different microcosm methods applied to evaluating MTBE degradation. Thus the similarities or differences in apparent degradation rates among microcosm studies by different groups may in part be an artifact of the differences in the experimental methods, making a comparison of such rates inappropriate. Similarly, we believe that variations in mass transfer limitations may explain at least in part why our field degradation rates appear higher than those found in other field evaluations of in situ aerobic MTBE degradation. When oxygen is provided by sparging or introduction of oxygen-releasing particles to the subsurface (e.g., refs *6* and *9*), the hydraulic conductivity of the permeable medium should be reduced in the vicinity of the introduced oxygen gas or oxygen-releasing particles. This should theoretically reduce the water flow in the vicinity of the oxygen sources and, because of the weak dispersive processes in porous media, lead to limitations on mixing of the released oxygen with the MTBE-contaminated water. In our experiments, the oxygen source (the diffusive emitter) is housed in a very high permeability well screen, thus leading to convergence of water flow into the well screen and good contact of the MTBE-contaminated water with the oxygen source that is further enhanced by modest turbulence occurring within the well screen.

Thoughts on Practical Applications

The evidence presented above, coupled with those of others, suggests that it may often be possible to create permeable bioreactive zones to achieve rapid in situ MTBE biodegradation solely by the addition of oxygen. A key design challenge is to ensure that the method of oxygen addition manages to create conditions conducive to efficient in situ treatment. For a PRB, this means characterizing and satisfying total oxygen demand imposed by both groundwater and sediments (i.e., not just that imposed by MTBE). Target and nontarget oxygen demand may be both spatially and temporally variable and may require more detailed site characterization than that typically conducted at many sites (*18*).

We have previously described a passive PRB approach based on the use of arrays of umpumped well screens (*24*) that we have field tested with solid oxygen sources (*25*) and diffusive oxygen emitters such as employed in this work (*20*). Others have reported promising results of the use of horizontal flow treatment wells to amend groundwater with dissolved solutes including oxygen (*26, 27*), and still others have espoused the use of sparging to create oxygenated situations in situ (*9*). We believe a wide range of methods are available to create aerobic conditions; what is needed is an assessment of the efficacy of each method for a range of hydrogeologic and geochemical conditions and continued work to understand the prevalence and reliability of native MTBE-degrading microbes.

Acknowledgments

This project has been funded since December 1997 by the American Petroleum Institute (API, Contract 97-0000-2565) and also in part by grants from the California MTBE Research Partnership (NWRI Award MTBE 699-507-99), Chevron Research and Technology Company, GeoSyntec Consultants, the Oxygenated Fuels Association (OFA), Grant 5P42ES04699 from the National Institute of Environmental Health Sciences (NIH), and the UC Water Resources Center. We are indebted to numerous individuals at Vandenberg Air Force Base for considerable in-kind support; to the California Central Coast Regional Water Quality Control Board for their continued interest and support; to G. Durrant, C. Naas, and others at the University of Waterloo for help in the field and the lab; to J. Cullen, D. Mason, and L. Zanini (all formerly with Conor Pacific/EFW) for help at various stages of the field work; and to Isaac Wood and Mark Morando (Santa Barbara) for their service as invaluable field research assistants. We are also grateful to the anonymous reviewers for their careful reviews and constructive comments.

Supporting Information Available

Additional information to support various conclusions (includes text and 7 figures). This material is available free of charge via the Internet at http://pubs.acs.org.

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Appendix B

Estimated Groundwater Cleanup Time Calculations

Appendix B – Estimated Groundwater Cleanup Time Calculations

Groundwater cleanup time for the upper sand groundwater in the Central Area and NIA was estimated using a pore volume flushing method described by Zheng and Bennett (1995). The method is a simple, but effective means of computing cleanup timeframes for the purpose of comparing relative cleanup times among various remedial alternatives. The method is applicable to VOCs and SVOCs that are readily transported by groundwater.

The method is not applicable in the following situations:

- for compounds with high sorption rates as these compounds are largely found sorbed to soil and organic matter in the soil and likely degrade *in situ* faster than they are transported by groundwater.
- if there are sources of contamination present in unsaturated zone soils or on-going releases on a site.
- when contaminant distribution does not indicated a well defined plume at concentrations above a cleanup level.

Bis(2-ethylhexyl)phthalate is a compound that has a high sorption rate and is also found at only a few isolated locations at concentrations above the cleanup level. Phenol is also found at only a few isolated locations at concentrations above its cleanup level. Consequently, the following analysis was conducted for benzene, toluene, benzoic acid, biphenyl, and diphenyl oxide.

The pore volume analysis is conservative (predicts longer cleanup timeframe) for compounds that readily degrade with time as the analysis does not include degradation. Therefore, the predicted cleanup timeframe is conservatively overestimated for benzene and toluene.

Description of Pore Volume Analysis

Zheng and Bennett (1995) state that "the number of pore volumes of clean water which must be circulated through a contaminated zone to achieve cleanup depends on a number of factors, such as sorption, aquifer heterogeneity, and the cleanup standard." A simple approach for estimating the required number of pore volumes to achieve a cleanup standard is to use the mixed linear reservoir model. In this model, the solute distribution in the contaminated zone is considered thoroughly mixed and the contaminated zone is characterized by a single uniform value. To reduce the initial concentration to a cleanup standard, the number of pore volumes required, based on the mixed linear reservoir model, is given by:

$$N_{pv} = -R \ln \frac{C_s}{C_i}$$

where:

N_{pv} is the number of pore volumes
R is the retardation factor

sampling results show that the west sump extracts the most highly impacted groundwater from the Central Area/NIA. The pore volume computation is shown in Table B-1. Computation of the cleanup timeframe is shown in Table B-2. Based on this analysis, the cleanup timeframe is over 40 years due to the time for diphenyl oxide to reach its cleanup level.

Table B-1 Computation of Total Pore Volume in Area under Alternatives C4, C5, and C6

	Benzene	Toluene	Benzoic Acid	Biphenyl	Diphenyl Oxide
Area (ft^2)	736,555	416,696	105,757	326,595	546,090
Average Saturated Thickness (ft)	8	8	8	8	8
Saturated Volume (area x thickness) (ft^3)	5,892,442	3,333,570	846,055	2,612,763	4,368,722
Porosity	0.3	0.3	0.3	0.3	0.3
Pore Volume (saturated volume x porosity).(ft^3)	1,767,733	1,000,071	253,817	783,829	1,310,617
Flow Rate to West Sump (gal)					
May 2002 - April 2003	10,273,311				
May 2001 - April 2002	10,273,000				
May 2000 - April 2001	5,682,000				
Average annual flow (ft^3/yr)	1,168,820	1,168,820	1,168,820	1,168,820	1,168,820
Pore Volume per Year (#/yr)	0.66	1.17	4.60	1.49	0.89

Table B-2 Computation of Cleanup Time Based on Pore Volume
(Assumes Natural Attenuation with Continued Operation of NIA Trench)

COC	Koc (L/kg)	Kd (L/kg)	R	Cleanup Level (ug/L)	Maximum Concentration (ug/L)	Number of Pore Volumes	Time (years)
Benzene	62	0.062	1.31	1.2	29,000	13.2	20.0
Toluene	140	0.14	1.7	2,000	460,000	9.2	7.9
Benzoic Acid	0.6	0.0006	1.0	24,590	690,000	3.3	0.7
Biphenyl	1,072	1.072	6.4	230	7,100	21.8	14.6
Diphenyl Oxide	1,655	1.655	9	410	23,000	37	41.9

Bulk Density	1.5 kg/L
Porosity	0.3
foc	0.10%

Notes:

K_{oc} and bulk density from FS Table 2-3

foc taken as MTCA default value. Site-specific average for shallow sand is approximately 0.085% (SRFI, draft 1, Table 6-5).

Maximum Concentration from RI report Table 3-5.

Calculations in the table do not include any assumption of biodegradation and are based on flushing of contaminants only.

Analysis for *In situ* Treatment

Scenario 2 was calculated only for diphenyl oxide since this compound drives the cleanup timeframe. Since *in situ* treatment also affects the other COCs analyzed in Scenario 1, the cleanup timeframe for these compounds would also be reduced. The cleanup timeframe for benzene and toluene would be further reduced by application of SVE in the Central Area/NIA.

EXHIBIT C

Scope of Work

ENSR | AECOM

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Memorandum

Date: October 19, 2007

To: Ha Tran
Washington State Department of Ecology

Michael Riley – SS Papadapoulus

From: Allison Crowley – ENSR

Subject: Goodrich Corporation – Emerald Kalama Chemical, LLC
Draft Consent Decree
BFGKI-15231-120

Scope of Work

Distribution:

This Scope of Work, which is an enforceable part of the Consent Decree (Decree) among the Washington Department of Ecology (Ecology), Goodrich Corporation, and Emerald Kalama Chemical LLC, addresses the design, construction and monitoring of the corrective actions set forth in the June 30, 2004 Cleanup Action Plan approved by the Department of Ecology at the Emerald Kalama Chemical facility.

Task 1: Draft Engineering Design Report

Due Date: 30 Days from Effective Date of Decree

The engineering design report (EDR) shall be prepared by or under the direct supervision of a registered professional engineer and shall be submitted for Ecology review in accordance with WAC 173-340-400(4)(a). The report shall include the following:

1) Goals of the cleanup action including specific cleanup or performance requirements

2) General information on the facility including a summary of information in the remedial investigation/feasibility study updated as necessary to reflect the current conditions

3) Identification of who will own, operate, and maintain the cleanup action during and following construction

4) Facility maps showing existing site conditions and proposed location of the cleanup action.

5) Characteristics, quantity, and location of materials to be treated or otherwise managed, including ground water containing hazardous substances.

6) A schedule for final design and construction.

7) A description and conceptual plan of the remaining final cleanup action per the Cleanup Action Plan. The Conceptual Design shall document:

    a) Installation of soil vapor extraction treatment system in the areas of the former flare stack line and transfer sump (as described in the Final Cleanup Action Plan);

    b) Installation of paving or physical barriers (as described in the Final Cleanup Action Plan);

    c) Installation of in situ Waterloo Emitter™ wells (as described in the Final Cleanup Action Plan) and continued operation of the North Area interception trench;

    d) Continued operation of the West Area interception trench; and

    e) Upgrade of the West Area intermediate sand recovery well system (as described in the Final Cleanup Action Plan).

8) Engineering justification for design and operation parameters, including:

    a) Design criteria assumptions, and calculations for all components of the cleanup action;

    b) Expected treatment, destruction, immobilization, and containment efficiencies and documentation on how that degree of effectiveness is determined;

    c) Demonstration that the cleanup action will achieve compliance with cleanup requirements by citing pilot and treatability test data, results from similar operations, or scientific evidence from the literature.

9) Design features for control of hazardous materials spills and accidental discharges per WAC 173-340-400(4)(a)(ix).

10) Design features to assure long-term safety of workers (e.g., hazardous substances monitoring devices, pressure valves, bypass systems, safety cutoffs).

11) A discussion of methods for management or disposal of any treatment residual and other waste materials containing hazardous substances generated as a result of the cleanup action.

12) Facility-specific characteristics that may affect design, construction, or operation of the selected cleanup action, including:

    a) Relationship of the proposed cleanup action to existing facility operations;

- b) Probability of flooding, probability of seismic activity, temperature extremes, local planning and development issues; and
- c) Soil characteristics and ground water system characteristics.

13) A general description of construction testing that will be used to demonstrate adequate quality control:

- a) A general description of construction procedures proposed to assure that the safety and health requirements of WAC 173-340-810 are met;
- b) Any information not provided in the remedial investigation/feasibility study needed to fulfill the applicable requirements of the State Environmental Policy Act (chapter 43.21C RCW);
- c) Any additional information needed to address the applicable state, federal and local requirements including the substantive requirements for any exempted permits; and property access issues which need to be resolved to implement the cleanup action.

Task 2: Final Engineering Design Report and Construction Plans and Specifications

Due Date: 165 Days from Receipt of Ecology Comments on Draft Engineering Design Report

The engineering design and the construction plans and specifications shall detail the cleanup actions to be performed. The Final Engineering Design Report shall be submitted for Ecology approval. The plans and specifications shall be prepared in conformance with currently accepted engineering practices and techniques and shall include the following information as applicable:

1) A general description of the work to be performed and a summary of the engineering design criteria from the engineering design report;

2) General location map and existing facility conditions map;

3) A copy of any permits and approvals;

4) Detailed plans, procedures, and material specifications necessary for construction of the cleanup action;

5) Specific quality control tests to be performed to document the construction, including specifications for the testing or reference to specific testing methods, frequency of testing, acceptable results, and other documentation methods;

6) Startup procedures and criteria to demonstrate the cleanup action is prepared for routine operation;

7) Additional information to address applicable state, federal, and local requirements including the substantive requirements for any exempted permits;

8) Provisions to assure safety and health requirements of WAC 173-340-810 are met.

Ecology does not intend to formally approve the construction plans and specifications. However, Ecology reserves the right to request changes to the construction plans and specifications consistent with WAC 173-340-400(4)(b), WAC 173-340-400(6)(d), and WAC 173-340-400(8). Ecology's request for revisions shall be submitted in a timely manner in order to prevent delays in the design process.

Task 3: Operations and Maintenance Plan

Due Date: 165 Days from Receipt of Ecology Comments on Draft Engineering Design Report

A plan for operation and maintenance of the final remedial actions systems shall include operating instructions, control parameters, safety limits, etc. for the groundwater/product extraction and treatment systems as well as a listing of regular maintenance items and inspection and maintenance procedures and frequencies. The plan shall present technical guidance and regulatory requirements to assure effective operations under both normal and emergency conditions. The operation and maintenance plan shall be submitted for Ecology approval and shall include the following elements, as appropriate:

1) Name and phone number of the responsible individuals;

2) Process description and operating principles;

3) Design criteria and operating parameters and limits;

4) General operating procedures, including startup, normal operations, operations at less than design loading, shutdown, and emergency or contingency procedures per WAC 173-340-400(4)(c)(iv);

5) A discussion of the detailed operation of individual treatment units, including a description of various controls, recommended operating parameters, safety features, and any other relevant information;

6) Procedures and sample forms for collection and management of operating and maintenance records;

7) Spare part inventory, addresses of suppliers of spare parts, equipment warranties, and appropriate equipment catalogues;

8) Equipment maintenance schedules incorporating manufacturers recommendations;

9) Contingency procedures for spills, releases, and personnel accidents;

10) Description of procedures which assure that the safety and health requirements of WAC 173-340-810 are met, including specification of contaminant action levels and contingency plans, as appropriate; and

11) Procedures for the maintenance of the facility after completion of the cleanup action, including provisions for removal of unneeded appurtenances, and the maintenance of covers, caps, containment structures, and monitoring devices.

Operation and maintenance of all remedial action systems shall be in conformance with, and shall execute the applicable requirements of the following Ecology-approved deliverables: Final Engineering Design Report, Operation and Maintenance Plan, and Compliance Monitoring Plan. Startup, operation and maintenance of the final remedial action system shall begin upon completion of system construction and shall follow the Operation and Maintenance Plan as approved by Ecology. The remedial systems shall thenceforth be run continuously with minimum down time, until Ecology approves each remedial system shut down in writing.

Task 4: Construction

Due Date: Substantial Completion of Construction within One Year[1] from Ecology's Approval of the Final Engineering Design Report

Construction of the final cleanup action shall be conducted in accordance with the construction plans and specifications, and other plans prepared under this Scope of Work. All aspects of construction shall be performed under the supervision of a professional engineer registered in the State of Washington or a qualified technician, under the direct supervision of a professional engineer registered in the State of Washington. During construction, detailed records shall be kept of all aspects of the work performed, including construction techniques and materials used, items installed, and tests and measurements performed.

Task 5: Construction Completion Report and Project Record Drawings

Due Date: Three Months after Completion of Cleanup Action Construction

At the completion of construction, the engineer responsible for the supervision of construction shall prepare a report documenting all aspects of Site construction work, including those portions of the final remedial systems which had been constructed prior to the issuance of this decree. The report shall include detailed final as-built drawings and an operation and maintenance manual for operation of the cleanup systems prepared in conformance with currently accepted engineering practices and techniques. This shall include mapping of all new and existing Site wells, remedial action piping,

---

[1] One year timeframe is dependent upon weather conditions. The construction of treatment wells during the dry season will ensure the safety of the workers, improve facility coordination, provide for improved quality control during construction, and for more effective management of contaminated soils.

treatment system components, and design details of monitoring wells, recovery wells, soil vapor extraction wells and Waterloo Emitter™ wells.

The report shall also contain an opinion from the Performing Party's project manager and its engineer as to whether the remedial systems have been completed in substantial compliance with plans and specifications and related documents.

Financial assurance and institutional control documentation related to the remedy will be submitted in accordance with the Decree and WAC 173-340-400(4)(c).

Task 6: Compliance Monitoring and Reporting

Compliance monitoring shall be performed in accordance with the Ecology approved Compliance Monitoring Plan (attached hereto as Attachment A), which was developed pursuant to the CAP and WAC 173-340-410.

Compliance Monitoring Plan

Emerald Kalama Chemical
Kalama, Washington

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October 18, 2007

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Introduction

This document provides the plan for monitoring the effectiveness of the remedial actions detailed in the Feasibility Study (RETEC, 2003) and the Cleanup Action Plan to be issued by the Department of Ecology. The remedial actions will be constructed at the Emerald Kalama Chemical, Inc facility in Kalama, Washington. The remedial actions include:

- Soil Vapor Extraction (SVE) in the Central Area
- *In situ* treatment using Waterloo Emitter™ in the Central Area
- Continued operation of the North Impacted Area (NIA) interception trench
- Continued operation of the West Impacted Area (WIA) shallow interception trench system
- Upgrade of the WIA intermediate sand recovery well (ISRW) system
- SVE north of the shallow interception trench in the WIA.

1.1 Operational History

Toluene historically has been the principal raw material used at the facility, and is still used by Emerald Kalama Chemical to produce benzoic acid, phenol, and a variety of other products that are derived from toluene. Emerald Kalama Chemical's products are used as preservatives in foods and beverages and as additives in pharmaceuticals, fragrances, surfactants, plasticizers, and other consumer products.

Historic spills have resulted in groundwater contamination. Response measures included immediate recovery and containment activities, as well as longer-term recovery operations, procedural changes, and plant modifications. Emerald Kalama Chemical has adopted numerous procedures to ensure that the valves, flanges, and fittings across the facility are routinely inspected and maintained. Emerald Kalama Chemical has also undertaken significant paving and containment projects to ensure that any potential leaks or spills are contained and appropriately managed.

Other known sources of historical groundwater contamination include the process sewer system and the American Petroleum Institute (API) separator. The process sewer system collects wastewater from process areas and equipment and conveys it to the API separator. The original process sewer system was constructed of vitrified clay pipe with polyvinyl chloride (PVC) joint rings; drain lines under paved areas were constructed of cast iron.

Between 1987 and 1991, all underground piping for the process sewer was replaced with high-density polyethylene (HDPE) piping, slip-lined with thick-walled HDPE piping, or converted to overhead piping. Life of the HDPE piping is expected to be greater than 20 years. Isolated inspections of the installed piping revealed no signs of leakage.

1.2 Purpose and Objectives

The purpose of this monitoring plan is to define the data collection and evaluation procedures that will be used to document the performance and effectiveness of the remedial actions in meeting the remedial objectives and cleanup levels in the Cleanup Action Plan. An overview of the specific components of the remedial action and their objectives is provided in Section 2.

Protection monitoring is described in Section 3. During operation of the various remedial systems, all wells included in this compliance monitoring plan will be sampled as described in the performance monitoring section (Section 4) until cleanup criteria have been met. Once cleanup levels have been achieved in compliance wells, monitoring will be performed as described in Section 5 of this document – Confirmational Monitoring.

2 System Description and Objectives

This section provides a description and summarizes objectives for each element of the remedial action.

2.1 North Impacted Area/Central Area

2.1.1 NIA Interception Trench

In October and November 1995, a 1,500-foot-long interception trench was installed at the edge of the facility nearest the wetlands as an interim corrective measure. The principal features of the trench were described in *Revised Design Report, North Impacted Area Interception Trench* (EMCON, December 1994). The trench is of variable depth and is keyed into the top of the upper silt layer, which forms the base of the upper sand fill aquifer. The base and downgradient face (wetland side) of the trench is lined with an impermeable, geosynthetic liner. The liner serves as a barrier wall to contain the groundwater that is present in the trench and prevents the inflow of standing water that may be seasonally present in the wetland area. A berm was constructed on the downgradient edge of the trench to further minimize the potential for surface flow between the trench and the wetlands.

The trench includes two collection sumps, an east sump and a west sump, from which water is extracted and discharged to the Emerald Kalama Chemical facility's wastewater treatment plant. The trench consists of four segments; two segments drain to each sump. Each segment is drained by a perforated collector pipe, laid with a minimum 0.5 percent slope, which discharges intercepted groundwater to the sump. The collector pipes are bedded in coarse drain rock and the drain rock is wrapped in filter fabric. Figure 2-1 provides a schematic representation of the interception trench.

From the sumps, the collected water is pumped to the wastewater treatment plant through a force main. Each sump pump was sized to accommodate the estimated 72 gallons per minute maximum trench inflow rate. Five piezometers were installed along the length of the trench: two were placed on each end, one is near the center of the trench, and one is adjacent to (west of) each of the two sumps.

The objectives of the NIA interception trench are to:

- Capture groundwater
- Capture contaminants
- Improve water quality conditions within the downgradient wetland area.

Monitoring of the NIA trench has demonstrated that these objectives have been successfully met since system startup in December 1995.

Documentation and assessment of groundwater and dissolved contaminant capture will be the primary focus of the monitoring plan because it is the primary objective of the interception trench. Effective capture has already been demonstrated through operation of the trench as an interim corrective measure (ICM) and continued monitoring will ensure that the trench continues to operate efficiently.

2.1.2 Soil Vapor Extraction System

SVE was successfully applied at the site as an interim corrective measure and will now be installed in the Central Area (e.g., the former flare stack line). Preliminary SVE well locations pending the results of pilot tests are shown on Figure 2-2. In order to provide protection to terrestrial receptors as well as to increase the radius of influence (ROI), asphalt or other physical barriers may be used in this area. Wells will be screened from approximately 2 feet bgs to 2 feet below the low water table. Vapors will be extracted with a blower available on site and treated with a thermal oxidizer. Assuming a radius of influence of 25 feet, approximately 11 extraction wells will be installed in the Central Area.

The objective of the SVE system is to provide source removal from impacted soils in the Central Area.

2.1.3 Waterloo Emitter™

Oxygen will be diffused into impacted groundwater to stimulate the aerobic biodegradation of organic contaminants by naturally occurring subsurface microorganisms. Oxygen will be diffused into source areas using the Waterloo Emitter™ technology. Emitter points will be installed to reduce the cleanup timeframe, which is largely driven by diphenyl oxide concentrations in the Central Area. Consequently, the alignment of emitter points will be southeast-to-northwest across the diphenyl oxide plume, as shown on Figure 2-3.

The Waterloo Emitter™ utilizes a diffusive tubing that provides for the controlled and uniform diffusive release of oxygen. The tubing on the emitter is pressurized with air or oxygen and the induced concentration gradient causes oxygen to diffuse out of the tubing and dissolve directly into the groundwater flowing past the emitter. By avoiding the introduction of a gas phase, the transfer of oxygen into the groundwater is more efficient, wastes very little gas, and does not require soil vapor extraction to control and treat soil vapor emissions. The emitters will be connected to a supply of oxygen (e.g., a compressor) and will continue to release oxygen as long as the compressor is active. The compressor will utilize ambient air, which should provide adequate oxygen delivery. If additional oxygen transfer is needed, the compressor can be operated at higher pressure, longer emitters can be used in the wells, and/or more wells can be installed.

The objective of the Waterloo Emitter™ system is to stimulate the aerobic biodegradation of impacted groundwater.

2.2 West Impacted Area

2.2.1 Intermediate Sand Recovery Well Network

The recovery well network consists of a series of recovery wells to reduce the mass of COCs and to contain impacted groundwater in the intermediate sand aquifer (Figure 2-4). Seven recovery wells were installed in February 1997. Startup of four of the recovery wells occurred in April 1997. Three additional recovery wells were brought on line in November and December 1997. A new recovery well will be installed to replace the existing ISRW-2. However the existing well will remain in place, to be used as a monitoring well if necessary.

Each of the recovery wells is equipped with a submersible pump and all recovery wells are operated at low pumping rates. Use of low pumping rates maintains saturated conditions within the area of residual/trapped product occurrence and reduces inflow from less contaminated areas including the Columbia River. Without low pump rates, the recovery wells could fail to extract groundwater that contacts residual product and result in smearing instead of recovering trapped product. The extracted groundwater is treated in the plant's wastewater treatment facility.

The objective of the intermediate sand recovery well system is to reduce the potential discharge of contaminants to the Columbia River by:

- Removing source materials (i.e., mobilizing product that is currently trapped) to reduce the overall mass of contaminants present in the intermediate sand aquifer

- Capturing the contaminated groundwater that is present in the intermediate sand aquifer in the specified area in the WIA

- Providing an inward gradient from the river to wells such that groundwater from the intermediate sand aquifer does not discharge to the river in this area.

2.2.2 Shallow Interception Trench

A shallow interception trench system was installed in the WIA to collect contaminated groundwater from the upper sand aquifer before it discharges to the Columbia River. A single trench system was initially planned for the WIA, but utilities in the WIA made it technically infeasible to install a single trench. Consequently, two trench segments were constructed to intercept groundwater in the area of the west tank farm and the transfer sump. The new shallow trench system replaced the shallow trench that was constructed in

January 1986 in response to a toluene release from tank T-42. Startup of the new shallow trench system occurred in November 1997.

The objective of the shallow trench system is to reduce the potential discharge of contaminants to the Columbia River by capturing contaminated groundwater that is present in the upper sand aquifer in the specified area in the WIA.

2.2.3 Soil Vapor Extraction

In addition to the Central Area location, SVE will also be applied in the north portion of the WIA. Installation of the system will be as described in Section 2.1.2 above and will be located in the north portion of the WIA near the area of the former transfer sump. Vapors from both the WIA and the Central Area will be extracted with a blower onsite and treated with a thermal oxidizer. Approximately two to six wells are assumed for the WIA. Proposed well locations are shown on Figure 2-2.

The objective of the SVE system is to provide source removal from impacted soils in the specified area in the WIA.

3 Protection Monitoring

The objective of protection monitoring is to “confirm that human health and the environment are adequately protected during construction and the operation and maintenance period” (WAC 173-340-410).

During construction as well as active operation and maintenance of the various systems (SVE, Waterloo Emitter™, NIA Trench, WIA Trench and ISRWs), worker protection monitoring will be performed in accordance with the site specific Environmental Health and Safety Plan to be developed during the remedial design phase. This may include such measures as vapor or dust monitoring, as well as best management practices for system operation to provide worker protection.

4 Performance Monitoring

4.1 North Impacted Area/Central Area

4.1.1 NIA Interception Trench

The monitoring plan for the interception trench in the north impacted area consists of two primary components. These components are: 1) collection of water elevation data to define the impact of the barrier and extraction pumps on groundwater flow direction and gradient, 2) collection of water quality data to assess the effectiveness of the trench in capturing dissolved contaminants and to assess the improvements to downgradient water quality.

Water Level Measurements

Water level measurements will be the primary means of evaluating the impacts of the interception trench barrier wall and extraction pumps on groundwater flow and direction. A geosynthetic liner was incorporated into the trench as a barrier wall to prevent seepage of water from the trench to the wetland area and to prevent standing water in the wetland from entering the trench. Four seep locations (M1, M2, M3, M4) have historically been observed and sampled near the downgradient face of the trench. Visual inspections will be made at these locations under low water conditions (summer time) to detect any observable seepage. If the geosynthetic barrier wall is intact, no seepage should be observed. The exception to this is that some of the standing water seasonally present downgradient of the berm may infiltrate the berm and be released as seeps when the level of standing water recedes. This should, however, be a relatively short-term phenomenon. Continued seepage will be an indication that liner repairs and/or a higher pumping rate are required to ensure containment.

Water level measurements will be obtained from the five piezometers (NTP-1, NTP-2, NTP-3, West Sump Piezo, East Sump Piezo) installed along the length of the trench and from shallow (sand fill) wells and piezometers (KC-4, KC-8, KC-9, KC-21, KC-23, MW-210, PZ-102, MW-245, and MW-256) located immediately upgradient of the trench. Table 4-1 and Figure 4-1 identify the wells and piezometers to be used for water level measurements.

Water level data will be collected semiannually in accordance with procedures provided in the Quality Assurance Project Plan (QAPP). Semiannual gauging and sampling will be scheduled to occur in late summer/early fall (the dry season) and early spring (the wet season). The data collected will be used to construct potentiometric surface maps and hydrographs (plots of water elevation over time). Historic data will be included in the preparation of hydrographs to assist with the determination of interception trench influence.

Water Quality Analysis

The interception trench is a containment system and as such has a goal of reducing contaminant discharge to the wetland. One potential way of measuring this goal is to define the mass of contaminants removed by the trench operation. Samples for this purpose will be collected on a semiannual basis from the East and West Sumps. These data, in conjunction with the continuous flow meter data obtained from each sump and from the combined flow, will be used to quantify the total mass of contaminants removed.

Trench effectiveness will also be determined by the collection of semiannual samples from pools of standing water within the wetland. These data will be used to assess the benefit of the trench operations in terms of downgradient water quality improvements. Finally, select wells (MW-232, MW-245, MW-256, MW-201, and MW-205) in the shallow and intermediate sand aquifers will also be sampled semiannually.

Semiannual sampling will be scheduled to occur in late summer/early fall (the dry season) and early spring (the wet season). The proposed water quality sampling locations and frequency are identified in Table 4-1 and Figure 4-1. Water quality samples will be submitted for analysis of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), arsenic, and copper as specified in Table 4-1 and the Sampling and Analysis Plan (SAP, Appendix A). Samples will be collected and analyzed in accordance with the procedures described in the SAP.

4.1.2 Soil Vapor Extraction System

The monitoring plan for the SVE system in the Central Area consists of several components. These components are: 1) system monitoring; 2) maintenance; 3) measurement of radius of influence; and 4) measurement of contaminant mass removal. These data will be used to evaluate system performance and compliance with objectives.

The system will be designed for unattended operation. Safety features built into the control system will shut down operations under the following circumstances:

- The vacuum extraction blower ceases to operate
- The thermal/catalytic oxidizer ceases to operate
- The air feed to the oxidizer exceeds 40 percent of the lower explosive limit (LEL).

It is anticipated that routine operations will require weekly system checks of blower and oxidizer operations during the first month of operation, and monthly system checks thereafter.

System Monitoring

Routine Monitoring

Vacuum and flow within the vapor extraction system will be measured weekly during the first month, and monthly thereafter, to verify that the system is operating at the desired parameters. The flow and vacuum for each well will be checked at the manifold and the wellhead vacuum will also be recorded. Figure 4-2 provides monitoring forms that are to be used during routine operations.

Subsurface Monitoring

The subsurface monitoring network will be determined following the system pilot test.

Gas Phase Monitoring

The monitoring wells will be used for routine measurement of air pressure and the concentrations of hydrocarbon and oxygen. Data will be collected before start-up of the system and periodically during operations. Equipment required to perform these measurements will include a magnehelic gauge, vacuum pump, photoionization detector or hydrocarbon analyzer, oxygen meter, and Tedlar bags. Measurement procedures are briefly described below:

- The vacuum at monitoring points will be measured with a magnehelic gauge and vinyl tubing connected to the wellhead. Existing wellheads will be fitted with removable caps with a ball valve and barbed hose connector.

- Hydrocarbon, oxygen, and carbon dioxide will only be measured at the vapor monitoring point (VMP) locations because of the small well volume that requires purging. Three well volumes will be purged using an air pump. The analyzers will be connected directly to the well following purging or they may be connected to the discharge of the air pump, if necessary. Alternatively, samples may be collected in Tedlar bags and analyzed by gas chromatograph.

Maintenance

The vapor extraction system will be designed to minimize maintenance requirements. Regenerative blowers for vapor extraction are maintenance-free. A moisture separator (knock-out drum), located immediately upstream of the blower, will be manually drained when a significant volume of water accumulates. A high level float switch in the moisture separator will prevent the blower from extracting groundwater.

The extraction wellheads will be inspected monthly to ensure that the wells are not damaged and that the vacuum gauges are functioning. Very low manifold pressures or the sound of escaping air may indicate significant wellhead damage.

The oxidizer will be supplied with a separate operations and maintenance manual. Based on previous operation of an SVE system in the WIA, the only foreseeable routine maintenance will be periodic system checks and restarts following shutdown.

Contaminant Mass Removal

Soil vapor samples will be collected at the blower discharge using evacuated sampling vials. All samples will be analyzed for benzene, toluene, ethylbenzene, xylenes (BTEX), total volatile hydrocarbons (TVH), and methane. Samples will be collected and analyzed in accordance with the procedures described in the QAPP.

Soil vapor samples will be collected daily during the first week of operation, weekly during the first month, and monthly thereafter, through the first year of operation. The frequency of measurements will be evaluated after the first year and adjusted if necessary. The location of sampling points will be determined following the pilot test.

4.1.3 Waterloo Emitter™

The monitoring plan for the Waterloo Emitters™ in the Central Area consists of collection of water quality data to assess the effectiveness of the emitters. Effectiveness includes the ability to oxygenate groundwater and the biodegradation of dissolved contaminants downgradient from the emitters. The monitoring plan also includes the collection of water quality data to assess the natural biodegradation of constituents of concern, in particular diphenyl oxide, at locations beyond the area of influence of the emitter wells.

Water Quality Analysis

Monitoring to assess contaminant degradation from the Central Area will include assessment of groundwater quality with time. Groundwater samples will be collected semi-annually from seven wells (MW-210, MW-230, MW-231, KC-9, PDW-117, PZ-104, PZ-107) and analyzed for contaminants of concern (COC: VOCs, SVOCs, and arsenic) and oxygen. The locations of water quality monitoring wells are shown on Figure 4-3. In addition, oxygen concentration will be measured in four emitter wells. The emitter wells to be monitored will be determined during final design.

Samples will be collected and analyzed in accordance with the procedures described in the SAP.

4.2 West Impacted Area

4.2.1 ISRW System

The monitoring plan for the ISRW system in the west impacted area consists of several components. These components are: 1) routine inspections to track system production; 2) measurement of discharge water quality; 3) sampling of monitoring wells; and 4) measurement of monitoring well water levels. These data will be used to evaluate system performance and compliance with objectives.

Routine Inspections

Weekly inspections of system components and adjustment of flow rates will be conducted to ensure effective performance of the recovery system components. In addition to weekly inspections, inspections will be made on an as-needed basis such as following any condition causing the system to alarm. Routine inspections will include checking:

- Proper pump operation (e.g., check for rapid pump cycling)
- Water level elevations in recovery wells
- Flow totalizer readings for weekly production
- Discharge pressure readings
- Flow rate
- Leaks in discharge piping.

Water level measurements, totalizer readings, discharge pressures and flow rates will be recorded during inspections and the totalizer readings and measured flow rates will be maintained for each recovery well. Detailed inspection procedures will be documented in the operations and maintenance manual that will be submitted for Ecology approval during the remedial design phase.

Water Level Measurements

Water level measurements will be made at 21 locations to evaluate groundwater containment. The 21 locations consist of the 20 monitoring wells shown on Figure 4-4 and the Columbia River at the dock. Water level measurement procedures will be completed in accordance with procedures provided in the SAP. Water levels will be measured and containment will be evaluated on a quarterly basis. Information from a tidal study completed in 1999 has been used to determine the appropriate time to collect water level measurements from the intermediate sand wells relative to high and low tides. This practice will be continued during performance monitoring events.

Gradient Evaluation

Use of gradient to evaluate the capture zone of the system is the preferred method of performance evaluation. Several different methods will be used for evaluating capture as summarized below:

- Water levels in monitoring wells will be compared to the Columbia River. If water levels measured at low tide or the average of high and low tides are less than the river elevation, capture would be indicated.

- Water levels in wells in line with ISRW-1 and ISRW-2 (e.g., PZ-118) will be compared to water levels in wells in line with ISRW-3 and ISRW-4 (e.g., ISRW-5). If, for example, the water level in well PZ-118 is lower than the water level in ISRW-5, the gradient is away from the river and capture is indicated.

- Water level data will be used to generate potentiometric surface contour maps. Twelve wells, not including the wells installed in the lower portion of the aquifer, will be used to generate potentiometric surface maps. If maps show groundwater flow toward recovery wells and not the river, capture will be indicated.

In addition, the water levels in the wells constructed in the lower portion of the aquifer will be compared to adjacent wells screened in the upper portion of the aquifer to evaluate the relative effects of the pumping system on vertical flow within the aquifer.

Contaminant Removal Monitoring

Monitoring to assess contaminant removal from the intermediate sand recovery wells will include analysis of samples of extracted groundwater and assessment of groundwater quality with time. Samples will be collected and analyzed in accordance with the procedures described in the QAPP.

Groundwater discharge samples will be collected semiannually from each extraction well and analyzed for VOCs. These data will be used to estimate contaminant removal, ensure that impacted groundwater is being extracted from each well, and provide the data for wastewater treatment plant operations. The removal efficiency of each well will be determined by calculating the mass of contaminant removed per volume of extracted water. These efficiencies will be compared to individual well flow rates.

Water Quality Analysis

Five wells (KC-14, MW-239, MW-243, MW-249, MW-250) will be sampled to evaluate the influence of the intermediate sand pumping on groundwater quality. The location of water quality monitoring wells is shown on Figure 4-4.

Samples will be collected and analyzed in accordance with the procedures described in the QAPP. Semiannual sampling will be scheduled to occur in late summer/early fall (the dry season) and early spring (the wet season). The proposed water quality sampling frequency is identified in Table 4-1. All water quality samples will be submitted for analysis of COCs (VOCs and arsenic).

4.2.2 Shallow Interception Trench

The monitoring plan for the interception trench in the west impacted area consists of two primary components. These components are: 1) collection of water elevation data to define the impact of the barrier and extraction pumps on groundwater flow direction and gradient, 2) collection of water quality data to assess the effectiveness of the trench in capturing dissolved contaminants.

Water Level Measurements

Water level measurements will be the primary means of evaluating the impacts of the interception trench barrier wall and extraction pumps on groundwater flow and direction. Water level data will be collected semiannually. The data collected will be used to construct potentiometric surface maps and hydrographs.

Water level measurements will be made at 15 locations to evaluate groundwater containment. The 15 locations are shown on Figure 4-4 and in Table 4-1. Water level measurement procedures will be completed in accordance with procedures provided in the SAP.

Water Quality Analysis

The interception trench is a containment system and as such has a goal of reducing contaminant discharge to the river. One potential way of measuring this goal is to define the mass of contaminants removed by the trench operation. Samples for this purpose will be collected on a semiannual basis from select wells identified in Table 4-1 and the north and south sumps. These data, in conjunction with the continuous flow meter data obtained from each sump and from the combined flow, will be used to quantify the total mass of contaminants removed.

Semiannual sampling will be scheduled to occur in late summer/early fall (the dry season) and early spring (the wet season). The proposed water quality sampling locations and frequency are identified in Table 4-1 and Figure 4-4. All water quality samples will be submitted for analysis of COCs (VOCs, SVOCs, and arsenic).

4.2.3 Soil Vapor Extraction System

The monitoring plan for the SVE system in the WIA consists of the same components as the Central Area SVE system: 1) system monitoring; 2) maintenance; 3) measurement of radius of influence; and 4) measurement of contaminant mass removal. These data will be used to evaluate system performance and compliance with objectives. Section 3.1.3 provides further details on each component of the SVE monitoring plan.

5 Confirmational Monitoring

Confirmational monitoring demonstrates the long-term effectiveness of the cleanup action after cleanup levels have been met. Confirmational monitoring is essentially the same as performance monitoring but extends for a period of time after cleanup actions have been met to ensure that the site is cleaned up. Specific confirmational monitoring locations and procedures will be developed and submitted to Ecology for approval after the performance monitoring indicates the cleanup levels have been achieved.

6 Reporting

6.1 Schedule

Preparation for construction activities will begin following final approval of the engineering design. A three-month construction period is planned beginning with well construction.

Following long-term system startup, performance monitoring will be performed as described in Section 4.

6.2 Reporting

Water level data and validated analytical results will be provided in quarterly progress reports through the first three years of operation and annually thereafter unless Ecology disapproves at that time.

Reports will document the previous period's operation and will contain all gauging data and sampling results. An assessment of the effectiveness of the remedial action in meeting objectives will also be included. The annual report will propose for Ecology's approval, any needed modifications to the installed remedial systems or monitoring network. Modifications to the monitoring program described in the annual report may include monitoring locations, analyses performed and/or frequency of monitoring.

7 References

EMCON, 1994. *Revised Design Report, North Impacted Area Interception Trench*.

RETEC, 2003. *Final Feasibility Study*. Prepared for Noveon Kalama, Inc. and Rogers Sugar, Ltd., by The RETEC Group, Inc., Seattle, Washington. December 22.

ThermoRetec, 2000. *Remedial Investigation, Revision 2*. Prepared for BFGoodrich Kalama, Inc., and Rogers Sugar, Ltd., by ThermoRetec Consulting Corporation, Seattle, Washington. December 15.

Tables

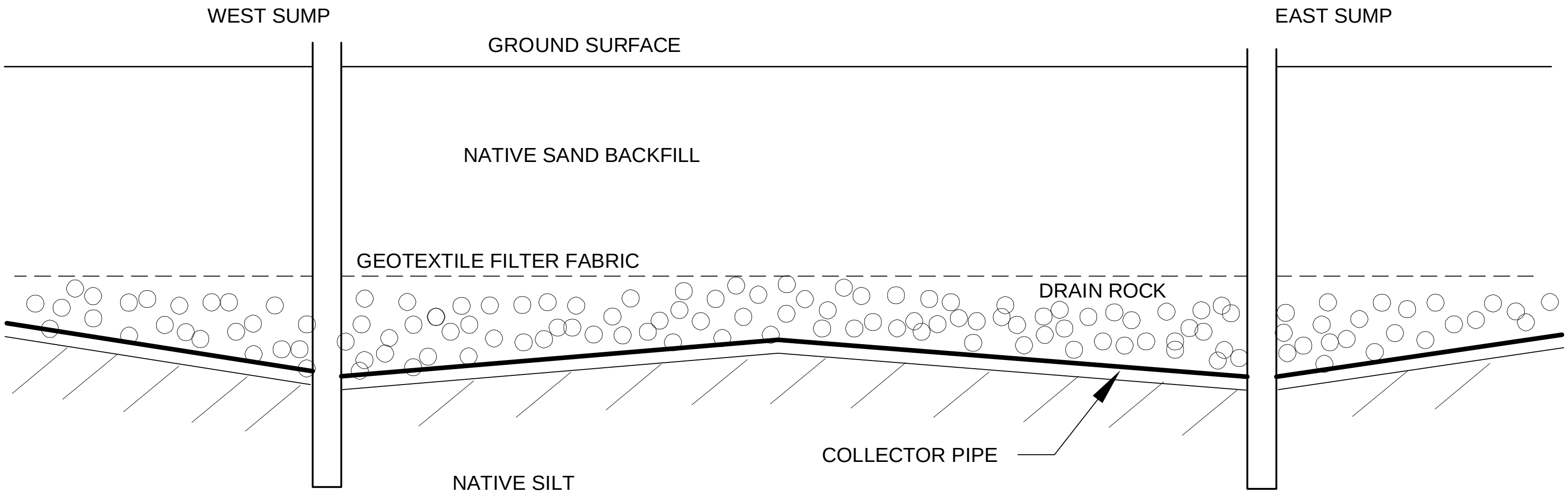
Table 4-1 Performance Monitoring Schedule

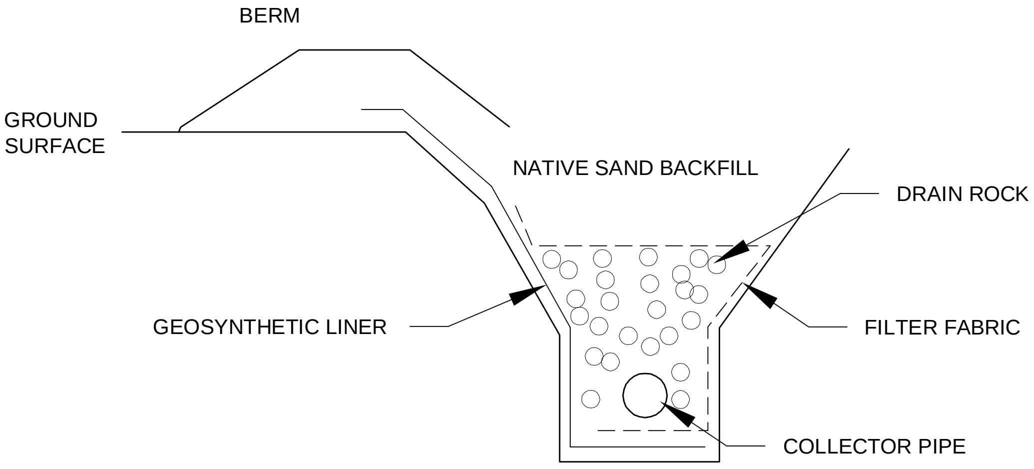
Well Location	Sampling Frequency	Analytical Parameters	Gauging Frequency
North Impacted Area			
NTP-1, NTP-2, NTP-3, West Sump Piezo, East Sump Piezo, KC-4, KC-8, KC-9, KC-21, KC-23, MW-210, PZ-102	—	—	Semiannually
East Sump, West Sump, PZ-107	Semiannually	VOCs, SVOCs	
MW-245, MW-256, MW-232	Semiannually	VOCs, SVOCs, Arsenic	
MW-201	Semiannually	Arsenic, Copper	
MW-205	Semiannually	Arsenic	
SVE System			
Manifold	Weekly for first month Monthly for first year Quarterly until Shutdown	Vacuum and Flowrate	—
MWs TBD in EDR			
VMP Wells	At system startup	Hydrocarbon, Oxygen, Carbon Monoxide	—
Blower Discharge	Daily for first Week Weekly for first Month Monthly for first Year Quarterly until Shutdown	Benzene, Toluene, Ethylbenzene, Xylenes, Total Volatile Hydrocarbons, Methane	
Central Area			
MW-210, MW-231, KC-9, PDW-117, MW-230, PZ-104,PZ-107	Semiannually	VOCs, SVOCs, Arsenic, Oxygen	—
WIA Upper Sand Aquifer			
KC-11, KC-12, KC-15, KC-24R, PZ-106, PZ-110, KCP-6, STP-1, KC-13, MW-238, MW-244, MW-255, USRW-2	—	—	Semiannually
N. Sump, S. Sump, KC-13, MW-238, MW-244, MW-255, KC-11, USRW-2	Semiannually	VOCs, SVOCs, Arsenic	
WIA Intermediate Sand Aquifer			
MW-236, MW-247, MW-248, KC-6, KC-17, KCP-3, PZ-117, PZ-118, Columbia River	—	—	Quarterly
ISRW-1, ISRW-2, ISRW-3, ISRW-4, ISRW-5, ISRW-6, ISRW-7	Semiannually	VOCs	
KC-14, MW-239, MW-243, MW-249, MW-250		VOCs, Arsenic	

Note:
VOCs include Benzene and Toluene
SVOCs include Benzoic Acid, Biphenyl, Bis(2-ethyl)phthalate, Diphenyl Oxide, Phenol
If conditions are not adequate to obtain representative samples at the locations listed, wells will need to be redeveloped or new wells will need to be installed.

Figures

File: H:\15231\15231G001.dwg Layout: FIG 2-1 User: emarshall Plotted: May 17, 2007 - 11:10am Xref's:





ENSR | AECOM

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RETEC

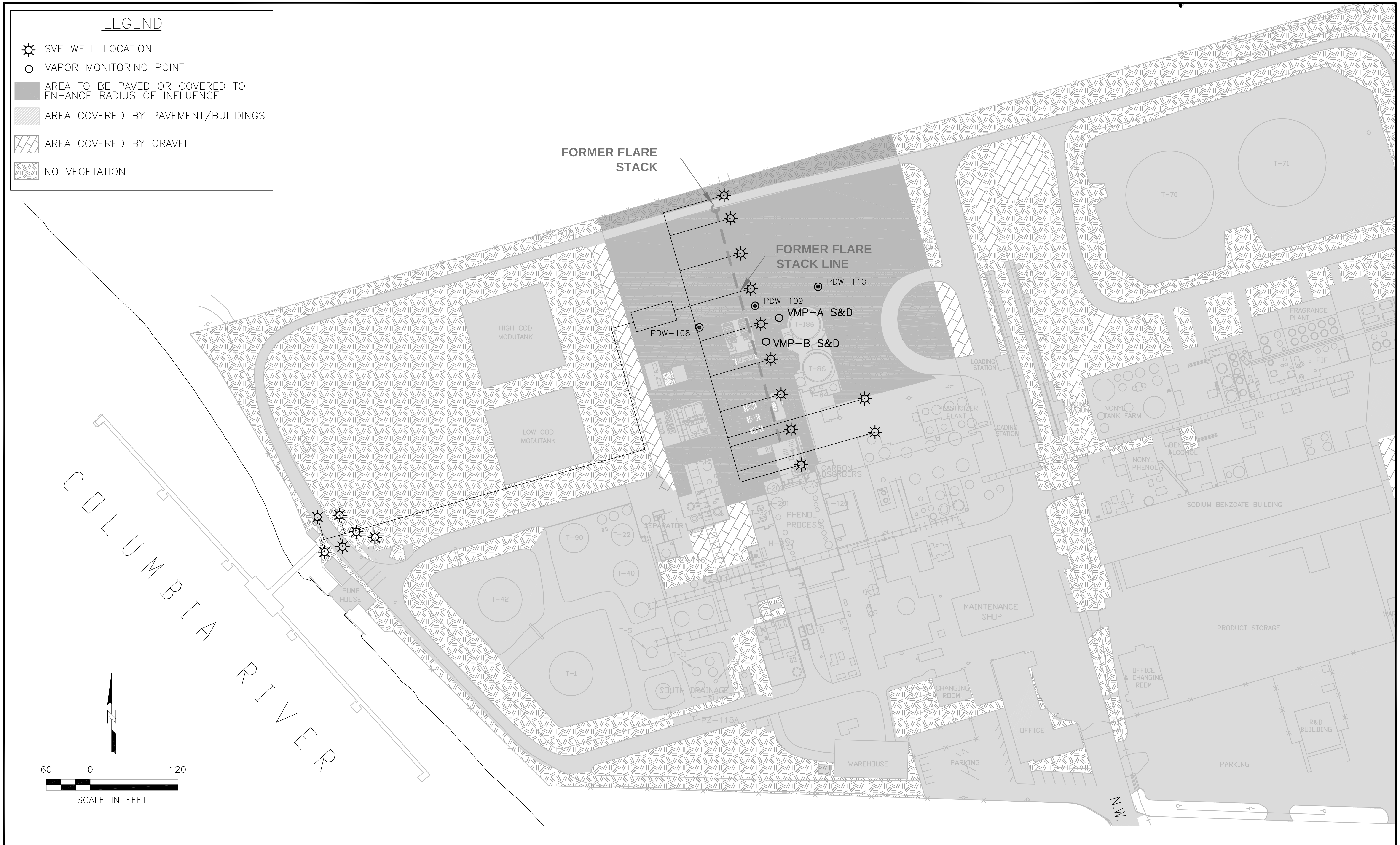
NOVEON KALAMA INC.

BFGKI-15231-240

NIA INTERCEPTION TRENCH SCHEMATIC

DATE: 05/17/07
DRWN: E.M./SEA

FIGURE 2-1



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ENSR | AECOM

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RETEC

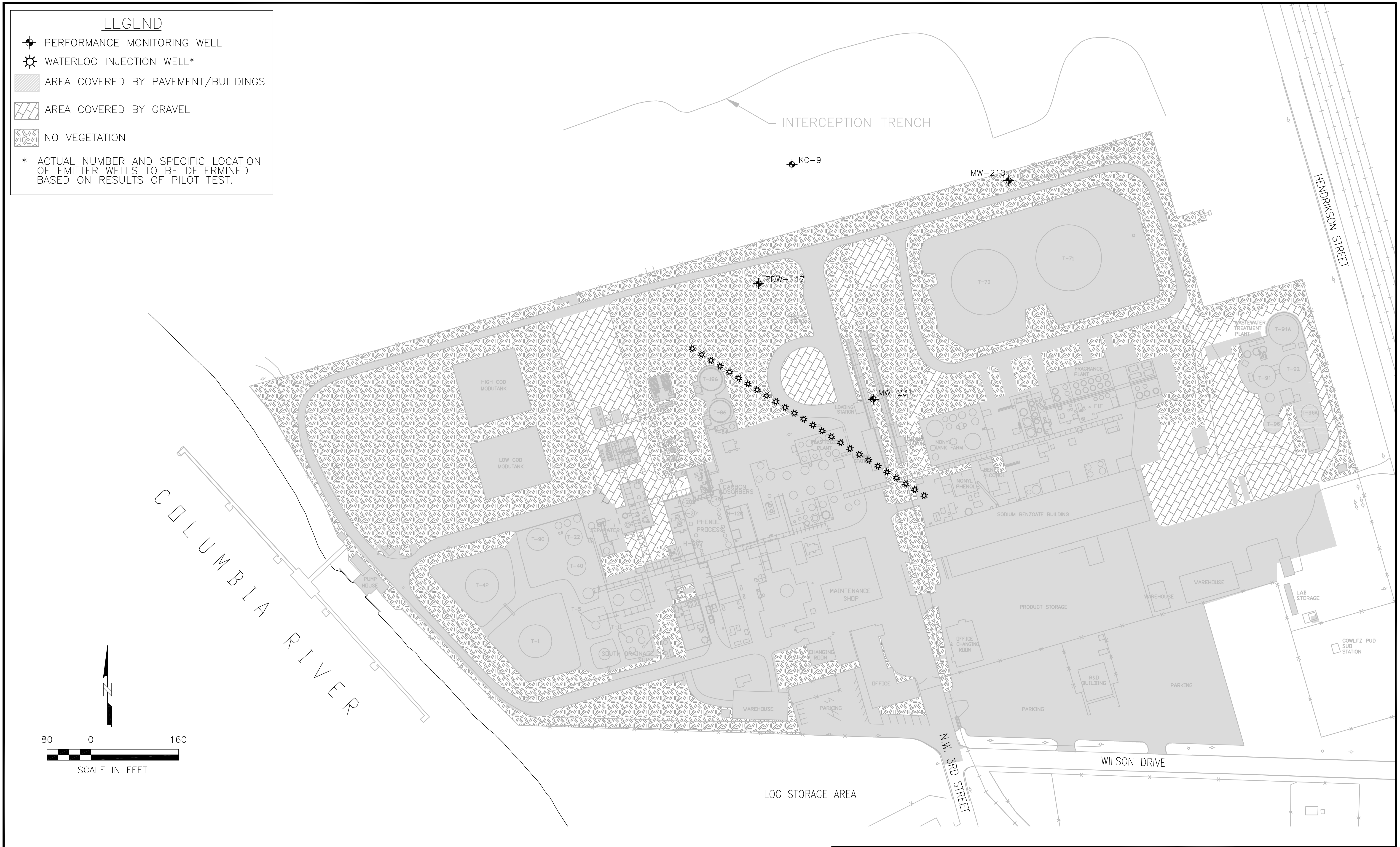
NOVEON KALAMA INC.

BFGKI-15231-240

DATE: 05/17/07 DRWN: E.M./SEA

SOIL VAPOR EXTRACTION LAYOUT

FIGURE 2-2



ENSR | AECOM

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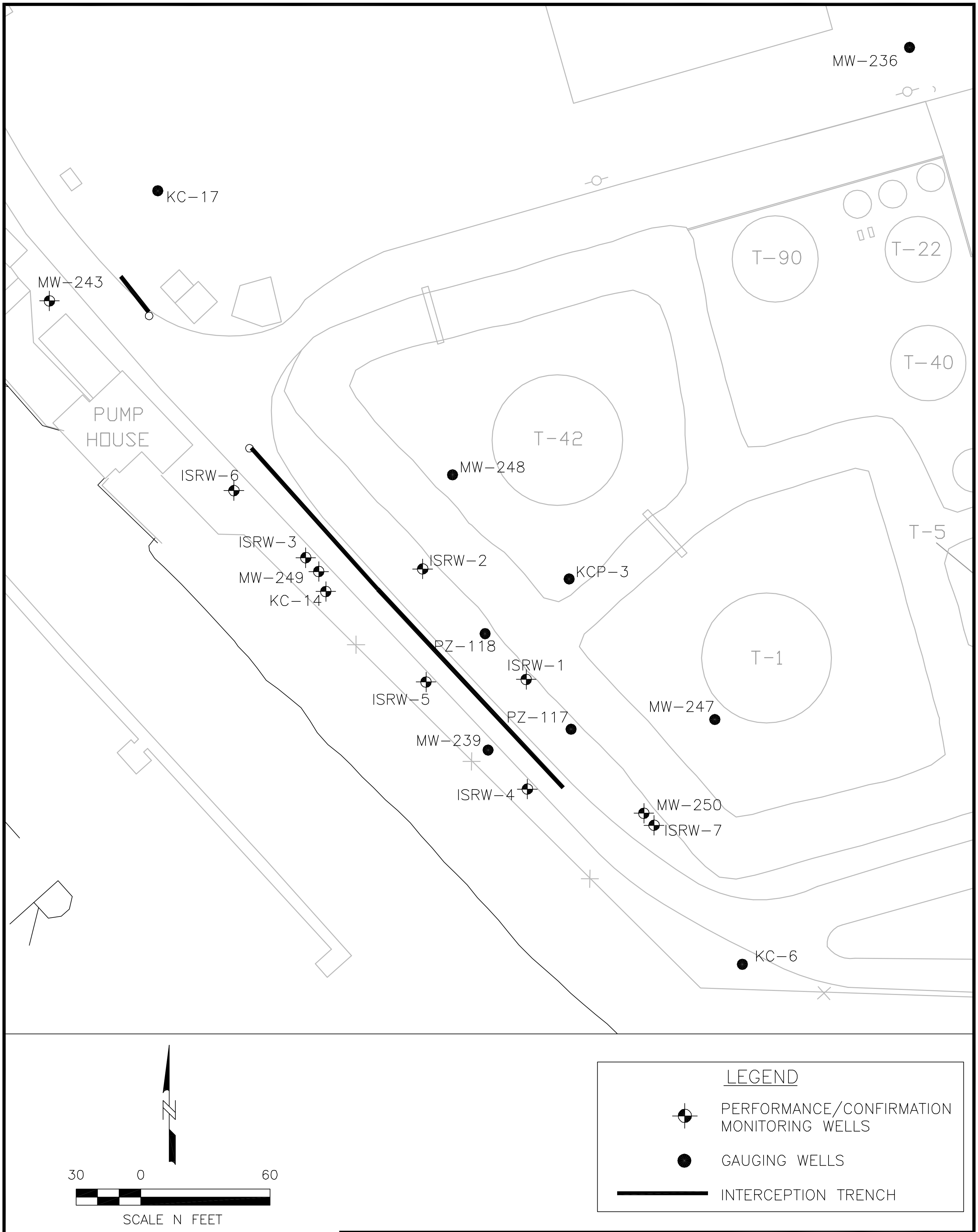
RETEC

NOVEON KALAMA INC. BFGKI-15231-230			WATERLOO EMITTER™ SYSTEM LAYOUT
DATE: 05/17/07	DRWN: E.M./SEA		FIGURE 2-3

File: H:\15231\15231S072.dwg Layout: FIG 2-3 User: emarshall Plotted: May 17, 2007 - 11:12am Xref's:



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RETEC

NOVEON KALAMA, INC.

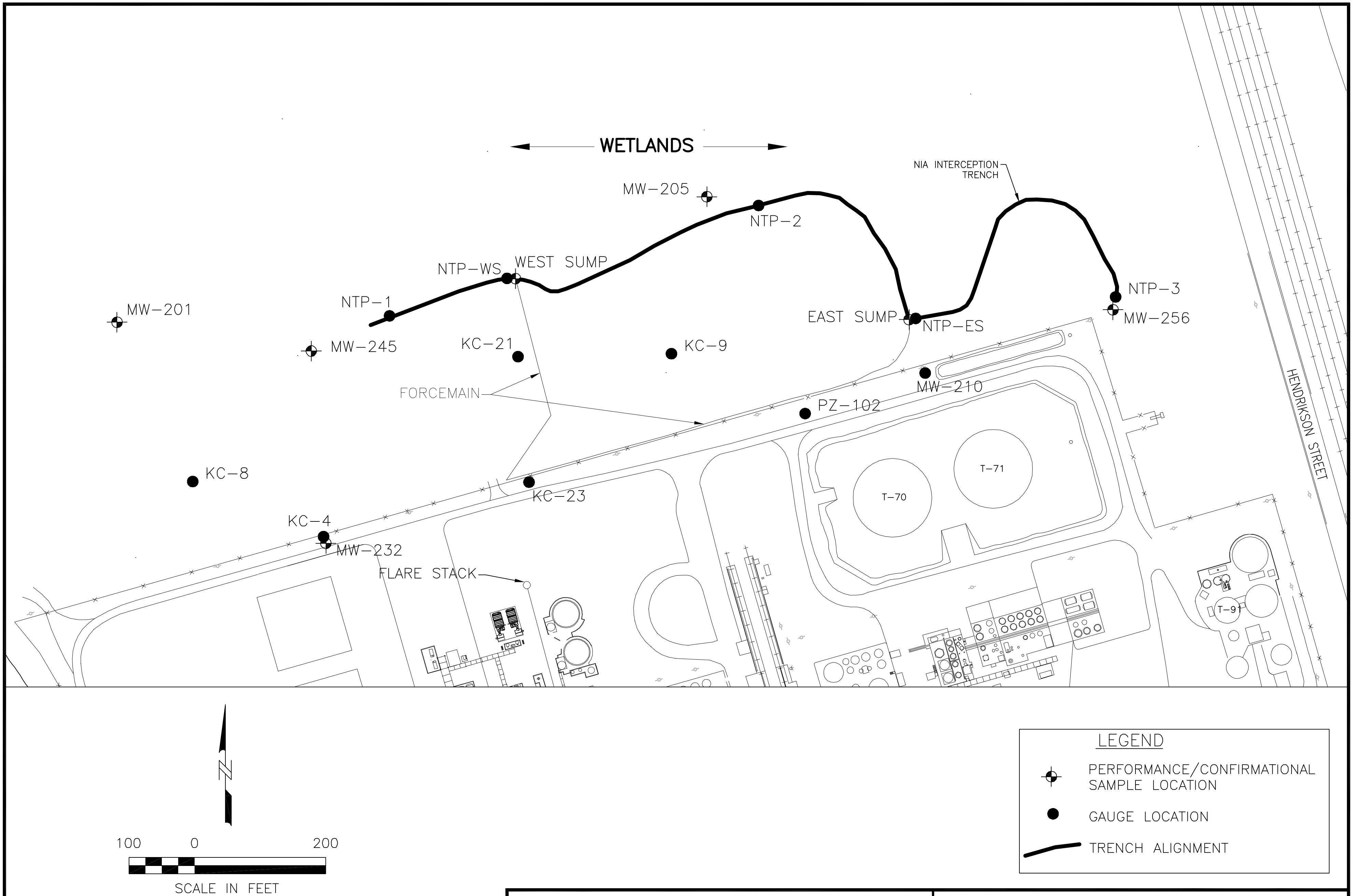
BFGKI-15231-330

DATE: 05/17/07 DRWN: E.M./SEA

WIA SYSTEM LAYOUT

FIGURE 2-4

File: H:\15231\15231S075.dwg Layout: FIG 4-1 User: emarshall Plotted: May 17, 2007 - 11:15am Xref's:



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RETEC

NOVEON KALAMA, INC.

BFGKI-15231-240

NIA GAUGING AND SAMPLING LOCATIONS

DATE: 05/17/07

DRWN: E.M./SEA

FIGURE 4-1

Figure 4-2 Kalama SVE Monitoring Form

Date:___________________ Time:_______ Name: _______________________

	Vacuum in H_2O	Flowrate scfm	O_2 %	Hydrocarbon	Carbon Monoxide	BTEX, TVH, CH_4	Comments
MW TBD			▨	▨	▨	▨	
MW TBD			▨	▨	▨	▨	
MW TBD			▨	▨	▨	▨	
MW TBD			▨	▨	▨	▨	
MW TBD			▨	▨	▨	▨	
MW TBD			▨	▨	▨	▨	
Manifold			▨	▨	▨	▨	
VMP Well	▨	▨					
VMP Well	▨	▨					
VMP Well	▨	▨					
VMP Well	▨	▨					
Blower Discharge							

Moisture separator vacuum (in Hg):

Other comments/observations:

Appendix A

Sampling and Analysis Plan

Sampling and Analysis Plan

Includes:
Field Sampling Plan and
Quality Assurance Project Plan

Emerald Kalama Chemical
Kalama, Washington

Prepared by:

The RETEC Group, Inc.
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Seattle, Washington 98134

RETEC Project Number: BFGKI-15231-240

Prepared for:

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and

Goodrich Corporation
Four Coliseum Centre
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September 24, 2007

Field Sampling Plan
Revision 2

Emerald Kalama Chemical
Kalama, Washington

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September 24, 2007

Field Sampling Plan

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Chapin L. Brackett, Project Engineer

Reviewed by:

Allison J. Crowley P.E., Project Manager

September 24, 2007

Table of Contents

Table of Contents

List of Tables

List of Attachments

List of Acronyms

CAS	Columbia Analytical Services
CMS	Corrective Measures Study
COC	Chemical of Concern
DTW	Depth to Water
EPA	Environmental Protection Agency
ESN	Environmental Services Northwest
FS	Feasibility Study
FSP	Field Sampling Plan
HASP	Health and Safety Plan
HSO	Health and Safety Officer
ICME	Interim Corrective Measures Evaluation
LNAPL	Light Non-Aqueous Phase Liquid
MTCA	Model Toxics Control Act
NAPL	Non-Aqueous Phase Liquid
PID	Photo-Ionization Detector
PM	Project Manager
PPE	Personal Protective Equipment
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QCM	Quality Control Manager
RETEC	The RETEC Group, Inc.
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SRFI	Supplemental RCRA Facility Investigation
SSO	Site Safety Officer
SVOC	Semi-Volatile Organic Compound
VOC	Volatile Organic Compound
WAC	Washington Administrative Code

1 Introduction

This document describes procedures for conducting sampling and analysis by field and laboratory personnel working at the Emerald Kalama Chemical facility (facility) in Kalama, Washington. Field activities, conducted by The RETEC Group, Inc. (RETEC), on behalf of Emerald Kalama Chemical and Goodrich Corporation and their predecessors have been ongoing since the early 1990s.

This Field Sampling Plan (FSP) presents the methodologies and procedures for all field sampling at the facility. The media for which samples will be collected include groundwater, surface water, soil vapor, and soil.

Field and laboratory activities will be conducted in accordance with this FSP, the Quality Assurance Project Plan (QAPP), and the Site-Specific Health and Safety Plan (HASP). Field methods and procedures specified in this plan and the QAPP supersede those described in the RETEC Standard Operating Procedures (SOPs), where discrepancies may exist. Companion documents to this FSP include the Feasibility Study (FS), Interim Corrective Measure Annual Monitoring Report, QAPP, Cleanup Action Plan and HASP.

1.1 Purpose and Objectives

Interim corrective measures have been implemented at the Emerald Kalama facility and final corrective measures will be implemented in the near future. The purpose of sample collection and analysis is to gather data necessary to monitor the performance of these corrective measures.

1.2 Organization of Field Sampling Plan

The organization of this FSP is as follows:

- **Section 2, Project Organization and Responsibilities:** Identifies the organization of the project and the responsibilities of key individuals.

- **Section 3, Documentation:** Defines proper field documentation procedures.

- **Section 4, QA Sampling Procedures:** Identifies the methods for collection of groundwater, surface water, and soil vapor. The analyte categories, analysis methods, holding times, and container requirements are also described.

- **Section 5, Sample Packing Procedures:** Defines proper packing procedures for environmental samples.

- **Section 6, Decontamination Procedures:** Defines proper decontamination procedures for sampling equipment.

- **Section 7, Management of Investigation-Derived Waste:** Describes the procedures for managing any wastes derived from the sampling activities.

- **Section 8, Quality Assurance/Quality Control Requirements:** Identifies the number and types of QA/QC samples to be collected by media.

- **Section 9, Field Data Management:** Presents proper procedures for management and evaluation of field data.

- **Section 10, References:** Provides citations for references used in this FSP.

2 Project Organization and Responsibilities

The organizational structure for the project will consist of a Program Manager, Project Manager, Regional Health and Safety Officer, Project Engineer, and Site Safety Officer. Subcontractors and analytical laboratories will also be involved in sampling activities. The specific roles, activities, and responsibilities of project participants are summarized below.

2.1 Internal Team

2.1.1 Program Manager

The Program Manager will have overall responsibility for the project. The Program Manager's duties will include:

- Review all major project deliverables for technical accuracy and completeness.

2.1.2 Project Manager

The Project Manager (PM) will be the primary point of contact and will have responsibility for technical, financial, and scheduling matters. The PM's responsibilities will include:

- Assign duties to the project staff and orient the staff to the needs and requirements of the project

- Supervise the performance of project team members

- Monitor all aspects of the project to verify that work is being completed in accordance with this sampling and analysis plan (SAP)

- Control the budget and schedule

- Coordinate all major project deliverables for technical accuracy and completion

- Act as the primary contact for regulatory and client concerns.

2.1.3 Regional Health and Safety Officer

The Regional Health and Safety Officer (HSO) has the following responsibilities:

- Interface with the Project Manager as required in matters of health and safety
- Approve the site-specific Health and Safety Plan (HASP) for the project
- Amend the approved HASP as site conditions warrant
- Monitor compliance with the approved HASP
- Assist the Project Manager in ensuring that proper health and safety equipment is available for the project
- Approve personnel to work on the site with regard to medical examinations and health and safety training.

2.1.4 Project Engineer

The Project Engineer has the following responsibilities:

- Implement field-related work plans and schedules
- Coordinate and manage field staff
- Coordinate and oversee technical efforts of subcontractors assisting the field team
- Identify problems at the field-team level and resolve issues in consultation with the PM
- Coordinate laboratory and data validation activities by the analytical services staff
- Maintain a complete set of laboratory data and import data into the project database following validation
- Participate in preparation of project deliverables.

2.1.5 Site Safety Officer

The Site Safety Officer (SSO) will be responsible for verifying that project personnel adhere to the site safety requirements outlined in the HASP. These responsibilities will include:

- Conduct the health and safety training for project personnel as appropriate
- Modify health and safety equipment or procedure requirements based on data gathered during the site work
- Determine the posting locations and routes to medical facilities, including poison-control centers, and arranging for emergency transportation to medical facilities
- Post the telephone numbers of local public emergency services and facilities
- Perform site audits to verify adherence to the requirements of the HASP.

The SSO has authority to stop any operation that threatens the health or safety of the work team or surrounding populace. The daily health and safety activities may be conducted by the SSO or a designated replacement.

2.2 Subcontractors

Subcontractors: Local subcontractors will be used as appropriate and when available, without compromising quality, schedule, and cost. Cascade Drilling, Inc. of Portland, Oregon may be utilized for drilling activities.

6400 S.E. 101st Avenue, Unit 2-D
Portland, Oregon 97266

Analytical Laboratories: Columbia Analytical Services (CAS) of Kelso, Washington will conduct chemical analyses of all water samples.

Greg Salata
1317 S. 13th Avenue, P.O. Box 479
Kelso, Washington 98626

Environmental Services Network Northwest (ESN) of Lacey, Washington will conduct chemical analyses of all vapor samples.

677 Woodland Sq Lp S.E., Ste D
Lacey, Washington 98503

3 Documentation

Original data recorded in field books and gauging/sampling logs will be written with waterproof ink. If an error is made on a project document, corrections should be made by drawing a single line through the error, initialing and dating the lined-out item, and entering the correct information.

None of these documents will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. Rather, all documents will be stored in the project file as a permanent record of field activities.

3.1 Field Notebooks

A bound, water-resistant field notebook, with numbered pages, will be maintained throughout collection activities by the Project Engineer to provide a daily record of events, observations, and measurements during field investigations. All entries will be signed and dated.

The notebooks and field forms are intended to provide sufficient data and observations to permit reconstruction of events that occurred during the project. The following information will be documented in the field notebooks:

- Name and title of author, date, and time of entry
- Names and responsibilities of other team members on site
- Names and titles of any site visitors
- Project name, project/contract number, and location
- Purpose of sampling activity
- Material to be sampled
- Site safety meeting
- Levels of PPE (if applicable): level of protection originally used, changes in protection if required, reason for changes
- Documentation on samples taken: date, time, location (and depth), type of sample, sample identifications, sample matrix, analyses required, sample characteristics and description (i.e., cloudy water), and readings taken (if any)
- Equipment utilized

- Project samples and QA samples: where they are to be sent, date they are sent, and shipping number (air bill number; if not hand delivered)
- On-site measurements
- Calibration records
- Field observations and remarks
- Weather conditions
- Unusual circumstances or difficulties and resolutions
- Photograph description, date, and location
- Chain-of-custody record numbers
- Investigation-derived wastes, such as contents and approximate volume of waste, type and predicted level of contamination, and disposal method
- Signature and date (entered by personnel responsible for observations) at the bottom of each page of the project field book or field form.

3.2 Gauging and Sampling Logs

Gauging and sample logs will be maintained throughout collection activities by the Project Engineer to provide a record of well measurements, water parameters, and sampling details. All field log sheets are included as Attachment A.

4 QA Sampling Procedures

This section outlines the activities, procedures, and objectives for sampling at the Emerald Kalama facility. Field activities will be conducted in accordance with this FSP, the QAPP, and the HASP for the project.

Prior to all field activities, the Project Engineer will ensure that the field equipment has been properly calibrated. Section 4 of the QAPP details the calibration procedures and frequency for field equipment.

4.1 Water Level Measurements

When taking a series of fluid-level measurements at a number of monitoring wells, it is generally good practice to go in order from the least to the most contaminated well. Additionally, the gauging of all site wells should be done consecutively and before any sampling activities begin. This will ensure the data are representative of aquifer conditions. All pertinent data should be entered in the Groundwater Gauging Logs (Attachment A) or the project field book.

4.1.1 Well Evaluation

Upon arrival at a monitoring well, the field technician should examine the surface seal and well protective casing for any evidence of frost heaving, cracking, or vandalism. All observations should be recorded on the Groundwater Gauging Log or in the project field book.

The area around the well should be cleared of weeds and other materials prior to measuring the static-water level. A drop cloth or other material (e.g., plastic garbage bag) should be placed on the ground around the well, especially if the ground is disturbed or potentially contaminated. This will save time and work for cleaning equipment or tubing if it falls on the ground during preparation or operation. The well protective casing should then be unlocked and the cap removed.

4.1.2 Measuring Point Location

The measuring point location for the well should be clearly marked on the outermost casing or identified in previous sample collection records. This point is usually established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If not marked from previous investigations, the water-level measuring point should be marked on the north side of the well casing and noted on the Groundwater Gauging Log or in the project field book. Monitoring well measurements for total depth and water level should be consistently measured from one reference point so that these data can be used for assessing trends in the groundwater.

4.1.3 Water-Level Measurement

Water-level measurements at the facility shall be made using an electronic well sounding water-level indicator or interface probe.

To obtain a water-level measurement, slowly lower the decontaminated probe into the monitoring well until the indicator (light, sound, and/or meter) shows water contact. At this time, the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement.

In wells having a layer of NAPL floating on the water, the electric tape will not respond to the oil surface and, thus, the fluid level determined will be different than would be determined by a steel tape. The difference depends on how much NAPL is floating on the water. Dual media tapes are recommended in that instance to measure both NAPL and water levels using the same measuring device. This procedure is discussed in Section 4.1.4

Water-level measurements should be entered on the Groundwater Gauging Log or in the project field book. The water-level measurement device shall be decontaminated immediately after use.

4.1.4 Procedures for Immiscible Fluids

In wells where LNAPL exists, the sampler should use a dual-purpose probe and indicator system. The probe can detect the presence of any fluid (through the wetting effect) and can also detect fluids that conduct electricity. Thus, if a well is contaminated with low density, non-conducting LNAPL such as gasoline, the probe will first detect the surface of the gasoline, but it will not register electrical conduction. However, when the probe is lowered deeper to contact water, electrical conduction will be detected.

4.1.5 Measurement of Total Depth

During water-level measurement, the total depth of the well may also be measured. This measurement gives an indication of possible sediment buildup within the well that may significantly reduce the screened depth. The most convenient time to measure the total well depth is immediately following measurement of the water level and prior to removing the measurement device completely from the well. The measurement device is lowered down the well until the measurement tape becomes slack indicating the weighted end of the tape or probe has reached the bottom of the well. While the probe remains touching the bottom and the tape pulled taut, the total well depth shall be recorded into the field book.

4.1.6 Quality Assurance/Quality Control

To ensure that accurate data are collected, repeated measurements of the fluid depths should be made. The readings should be within 0.01 to 0.02 feet of each other. A secondary check, if data are available, is to compare previous readings collected under similar conditions (e.g., summer months, wells pumping, etc.).

4.1.7 Documentation

Data will be recorded on the Groundwater Gauging Log form or in the project field book. Additional comments, observations, or details will also be noted. These documents will provide a summary of the water-level measurement procedures and conditions and will be kept in the project files.

4.2 Groundwater Sampling

The groundwater sample parameters, analytical methods, container requirements and preservation requirements are listed in Table 4-1. Groundwater samples will be collected using the low-flow sampling technique or from sample ports on the groundwater pumping equipment.

4.2.1Low Flow Groundwater Sampling

Well purging is the activity of removing a volume of water from a monitoring well in order to induce “fresh” groundwater to flow into the well prior to sampling. Purging must be performed for all groundwater monitoring wells prior to sample collection. Monitoring wells will be purged until groundwater paramters have stabilized or until three well volumes have been purged. The volume of water present in each well will be computed using two measurable lengths, length of water in the water column and monitoring well inside diameter. A low flow, electric driven pump (e.g., peristaltic pump) will be used to purge and sample well water.

The inlet of the peristaltic pump tubing will be lowered into the well slowly and carefully to a depth corresponding with the approximate midpoint of the screened interval of the aquifer, or 1-2 feet below the water level in the well, whichever is greater. A depth-to-water measurement device will be lowered into the well to monitor drawdown. The pump will be turned on at a flow rate of about 0.1 liters per minute (L/min). The flow rate will be adjusted up or down to maximize flow, yet ensure minimum drawdown. In no instance should a drawdown of more than 0.5 foot be allowed. The water level in the well should be carefully monitored to ensure that draw down does not increase during purging.

Groundwater will be pumped from the well into a sealed, flow-through chamber containing probes to measure the water temperature, pH, turbidity, conductivity, ORP, and DO using a Water Quality Meter. Field measurements of turbidity will also be obtained using a turbidity meter for comparison purposes. Calibration procedures and results will be documented in the project field notebook.

Field parameters values will be recorded on the Groundwater Gauging Logs or in the project field notebook along with the corresponding purge volume. After passing through the flow-through chamber, the water will be discharged into a container of known volume where the pumping rate will be measured with a watch. When the container is full, the water will be properly disposed following Site protocols.

Groundwater samples will be collected for laboratory analysis when the groundwater has stabilized; the change between successive readings of temperature, pH and conductivity are less than 10 percent, and turbidity is reduced to 10 NTUs or less. This may occur prior to removal of three well volumes. Stabilization of groundwater measurements is considered indicative of sampling fresh formation water and is a more reliable indicator of purging than removal of a standard volume of water.

The SOP for Low Flow Groundwater Sampling is included as Attachment B.

4.2.2 Sampling using Groundwater Pump Sample Ports

To sample the intermediate sand recovery wells and the constructed sumps, the sample ports on the groundwater pumping equipment will be used. Since the groundwater pumps cycle on and off on a frequent basis, the well is "purged" multiple times a day. As such, no manual purging of the wells is required before taking samples.

When sampling groundwater from recovery wells and sumps, the subsequent procedures can be followed:

1) Wait until the groundwater pump turns on or manually turn the pump on.

2) Locate the sample port.

3) Open the sample port value and fill the sample container directly.

4.3 Surface Water Sampling Methods

This section outlines the activities, procedures, and objectives for surface water sampling at the facility. Field activities will be conducted in accordance with this FSP, the QAPP, and the HASP for the project.

Surface water samples will be collected using a depth-discrete sampling device or equivalent. Sample collection will be staged such that volatile samples are collected first followed by SVOCs and conventionals. Water samples will be filled directly into sample containers during collection.

Analyte categories, analysis methods, container requirements, and holding times are listed in Table 4-1. In addition to sample collection, the field parameters of pH, conductivity, and temperature, will be measured and recorded on Surface Water Sampling Logs (Attachment A).

The station coordinates and any specific observations of water quality at the sampling location will be recorded on the Surface Water Sampling Log. The QA/QC sample requirements for surface water are discussed in Section 11.

4.4 Soil Vapor Sampling Methods

This section outlines the activities, procedures, and objectives for soil vapor sampling at the facility. Field activities will be conducted in accordance with the FSP, the QAPP, and the HASP for the project.

Soil vapor sample analyte categories, analysis methods, container requirements, and holding times are listed in Table 4-1. Subject to the emissions permit from the Southwest Clean Air Agency, the list of analyte categories may expand.

Vapor samples will be collected using extraction syringes and will be stored in 20-ml glass VOA vials. Each vial will be equipped with an air-tight septa cap. The samples will be collected using the following procedures:

1) Evacuate the VOA vials using a hand-pump device provided by ESN. Pump until a vacuum is created.

2) Use the extraction syringe to pull an air sample from the sampling port on the extraction well. Evacuate the syringe.

3) Repeat the extraction and evacuation process one to two more times.

4) Pull the final sample from the extraction well and inject it into the VOA vial. The sample will be automatically extracted from the syringe due to the vacuum in the vial. If the vacuum is not sufficient to pull the air sample into the vial, discard the vial and repeat the entire the sampling process.

During sample collection activities, field parameters (i.e.: extraction vacuum pressure and flow rate) will be measured and recorded on SVE Monitoring Logs (Attachment A).

4.5 Soil Sampling Methods

Soil cuttings will be generated during the installation of soil vapor extraction wells. Cuttings from each individual well will be visually examined and tested with a photo-ionization detector (PID). Based on the results of this examination, the soil will be classified as “clean” or “dirty.” Similarly classified 55-gallon drums will be used to store the soil.

Soil samples will be collected from the drums for waste characterization purposes. One sample will be collected for every five drums. To collect a sample, soil will be taken from the bottom, middle, and top of the five drums. The soil sample will be homogenized and placed in the sample container.

During sampling procedures, drums containing “dirty” soil will remain separated from drums containing “clean” soil. This will ensure that contaminated soils are not diluted.

Soil sample analyte categories, analysis methods, container requirements, and holding times are listed in Table 4-1.

5 Sample Packaging and Custody Procedures

All samples must be packaged so they do not leak, break, vaporize, or cause cross-contamination of other samples. Waste samples and environmental samples (e.g., groundwater, soil, etc.) should not be placed in the same shipping container. Each individual sample must be properly labeled and identified. A chain-of-custody record must accompany each shipping container. When refrigeration is required for sample preservation, samples must be kept cool during the time between collection and final packaging.

5.1 Sample Labels

All samples must be clearly identified immediately upon collection. Each sample bottle label will include the following information:

- Client or project name, or unique identifier, if confidential
- A unique sample ID
- Sample collection date and time
- Sampler’s name or initials
- Sample matrix.

5.2 Packing for Shipment

To prepare a cooler for shipment, the sample bottles should be inventoried and logged on the chain-of-custody form. At least one layer of sorbent protective material should be placed in the bottom of the container. A heavy-duty plastic bag, if available, should be placed in the shipping container to act as an inner container. Each sample bottle should be wrapped with protective material (e.g., bubble wrap, matting, or similar material) to prevent breakage. The protective material should be secured with tape. The sample should then be placed in a Ziploc® type bag. Each sample bottle should be placed upright in the heavy-duty plastic bag inside the shipping container. Each sample bottle cap should be checked during wrapping and tightened, if needed. Avoid over tightening, which may cause the bottle cap to crack and allow leakage. Additional packaging material, such as bubble wrap, should be spread throughout the voids between the sample bottles.

All water and soil samples require refrigeration as a minimum preservative. To ensure that samples are received by the laboratory within required temperature limits, place Ziploc® type bags filled with cubed ice directly over packed samples, making sure that ice is present on all sides of each sample. Coolers containing air samples should not be cooled with bags of ice. Rather, air samples should be kept at ambient air temperatures.

Place the original completed chain-of-custody record in a Ziploc® type plastic bag and place the bag on the top of the contents within the cooler or shipping container. Alternatively, the bag may be taped to the underside of the container lid. Retain a copy of the chain-of-custody record with the field records.

Close the top or lid of the cooler or shipping container and rotate/shake the container to verify that the contents are packed so that they do not move. Add additional packaging if needed and re-close. Then place the signed and dated chain-of-custody seal on the cooler or container lid and overlap with transparent packaging tape. The chain-of-custody seal should be placed on the container in such a way that opening the container will destroy the tape. Packaging tape should encircle each end of the cooler at the hinges. Use proper lifting techniques when picking up the cooler.

In most instances, the Project Engineer or appointed personnel will hand deliver samples to CAS and/or ESN during the return trip to Seattle (see Section 2.2 for laboratory addresses). If the sampling event is completed after the laboratories have closed, the samples will be hand delivered to the RETEC office. The next morning the samples will be sent via an overnight express service that can guarantee 24-hour delivery. Copies of all shipment records should be placed in the project file.

5.3 Chain-of-Custody

The Chain-of-Custody Form (Attachment A) will be initiated at the time a sample is collected, and will accompany the sample until its final disposal. These records are placed in the project files. The form will contain the following information:

- Sample IDs
- Collection date for each sample in the shipment
- Time the shipment was packed
- Number of containers of each sample
- Sample description (environmental matrix)
- Analyses required for each sample
- Shipment number
- Shipping address of the laboratory
- Date, time, and method of shipment
- Custody transfer signatures.

There will be a separate Chain-of-Custody Form for each cooler, listing only samples in that cooler.

Samples will either be hand-delivered or sent overnight to the analytical laboratory. Upon delivery, the analytical laboratory sample custodian will review and transfer the custody forms; a copy of the signed form will be provided to RETEC and filed in the project file.

6 Decontamination Procedures

Decontamination is performed as a quality assurance measure and a safety precaution. It prevents cross contamination between samples and helps to maintain a clean working environment. The purpose of decontamination is to remove contaminated materials clinging to gloves, boots, equipment, and sample containers prior to their removal from the work area. Decontamination also includes the removal and disposal of contaminated clothing and gloves.

Decontamination is achieved mainly by rinsing with soap or detergent solutions, tap water, deionized water, methanol, dilute acids, or acetone. Equipment will be allowed to air dry after being cleaned. Decontamination will be accomplished between each sample collection station.

The following is a list of supplies needed to provide decontamination of equipment:

- Clean gloves
- Cleaning liquids and dispensers: soap and/or a powdered detergent solution such as Alconox™, tap water, deionized water, and Simple Green™
- Waste storage containers: drums, boxes, and plastic bags
- Chemical-free paper towels.

6.1 Sampling Equipment

At a minimum, sampling equipment will be decontaminated prior to initial use and between sampling stations. Sampling equipment (i.e., spoons, bowls) decontaminated prior to field use will be wrapped in aluminum foil and stored in a sealed plastic bag to prevent contamination. Monitoring equipment (i.e., well probe, pH probe, tape measures) will be rinsed with distilled water and wiped dry with paper towels. Decontamination procedures include washing and scrubbing with an Alconox™ soap solution, rinsing with tap water, rinsing with distilled water, and air-drying. If heavy, oily substances are found on sampling equipment, Simple Green™ will be used to clean the equipment. Cross contamination will be minimized by sequencing sampling events from areas of suspected lower concentrations to areas suspected of relatively high concentrations.

7 Management of Investigation-Derived Wastes

The amount of personal protective equipment (PPE), water, and soil waste generated will be minimized to the volume necessary for sampling and analysis. The management procedures for each waste stream are detailed below.

Investigation-derived PPE will be placed in plastic garbage bags and disposed of on-site for transport to the municipal landfill.

Liquids generated from purging of groundwater wells, decontamination activities, and drilling activities will be temporarily stored in five-gallon buckets. As needed, the buckets will be emptied into the low COD lagoon for treatment in Emerald Kalama's on-site wastewater treatment plant.

Soil cuttings generated at each drilling location will be placed in 55-gallon drums. Each drum will be labeled using a grease pencil or paint pen to indicate the date sealed, location, contents, and point of contact name and number. Composite samples will be collected from cuttings generated at each borehole location and analyzed for disposal purposes (Section 4.5).

8 Quality Assurance/Quality Control Requirements

A summary of the QA/QC sampling frequency for all media is provided in Table 8-1.

The quality assurance/quality control samples will consist of equipment rinsate blanks, blind duplicates, MS/MSDs, and trip blanks. Each of the above QA/QC sample types will be collected for each sampling event. The purpose, frequency, and methods for collection of each are provided below.

Equipment rinsate blanks are intended to detect cross contamination potentially induced by sample contact with the sampling equipment and will be collected at a frequency of 1 per 20 samples (5 percent). A minimum of one rinsate blank will be collected per sampling event. The rinsate blanks will be prepared by passing reagent-grade water across sampling equipment and into the sample jar. The sample location, rinsate water source, and collection procedure will be recorded on the sampling logs and in the field notebook. Rinsate blanks will be analyzed for the same constituents as the groundwater samples.

Blind field duplicates will be collected to measure laboratory precision and will be collected at a frequency of 1 per 10 samples (10 percent) per sampling event. The procedure involves collecting two distinct samples in the field at the same location and submitting those samples separately under different labels for the same analyses. The duplicate samples will be analyzed for the same constituents as the environmental samples. Nomenclature for the blind duplicate will include a 100 added to the station identification. Notation of the duplicate will be recorded on the sampling logs and field notebook.

Matrix spike/matrix spike duplicates will be collected to determine if matrix interference exists in the sample media and will be collected at a frequency of 1 in 20 samples or one per event, whichever is more. Samples expected to contain high concentrations of contaminants will not be selected for MS/MSD analysis due to the potential for matrix interference and poor spike recoveries.

9 Field Data Management

9.1 Documentation

Field measurements and observations recorded in field notebooks, on field data forms, or on similar permanent records by field technicians are to become part of the project file. Field data is to be recorded directly and legibly in the notebooks or forms with all entries signed and dated.

9.2 Field Data Evaluation

Initial responsibility for verification of accurate entries will lie with the field data logger. At the end of the sampling day, the data logger must sign and date the notebook. The Project Engineer will review all collected data to ensure that all pertinent information has been entered, and that correct codes and units have been used. The Project Engineer will direct the field data logger to make any necessary corrections to the record and initial them.

After data are reduced into tables, the task managers will review data sets for anomalous values. Any inconsistencies will be resolved by seeking clarification from the field personnel responsible for data collection.

The Project Engineer will verify technical data for reasonableness and completeness. Whenever possible, peer review will also be incorporated into the data evaluation process in order to maximize consistency among field personnel. A dated signature will mark all data that has been evaluated.

9.3 Corrective Actions

The purpose of the evaluation process is to qualify or eliminate field information or samples that were not collected or documented in accordance with specified protocols outlined in the FSP. The Project Engineer will review the procedures being implemented in the field for consistency with the established protocols. Sample collection, preservation and labeling will be checked for completeness. Corrective actions will be defined by the Project Engineer and documented and implemented as appropriate.

Where procedures are not in compliance with the specified protocols, the deviations will be field documented and reported to the Project Manager.

10 References

RETEC, 1996. *Site-Specific Health and Safety Plan.* Prepared for BFGoodrich Kalama, Inc. by The RETEC Group, Inc., Seattle, Washington. March 28.

RETEC, 2001a. *RETEC Standard Operation Procedure (SOP) 210: Soil Sample Collection.* Prepared by The RETEC Group, Inc., Ft. Collins, Colorado. June 1.

RETEC, 2001b. *RETEC Standard Operation Procedure (SOP) 230: Groundwater Sampling.* Prepared by The RETEC Group, Inc., Ft. Collins, Colorado. December 26.

RETEC, 2002a. *Interim Corrective Measure Annual Monitoring Report.* Prepared for Noveon Kalama, Inc. and Rogers Sugar, Ltd., by The RETEC Group, Inc., Seattle, Washington. July 31.

RETEC, 2002b. *RETEC Standard Operation Procedure (SOP) 110: Packing and Shipping Samples.* Prepared by The RETEC Group, Inc., Ft. Collins, Colorado. May 2.

RETEC, 2002c. *RETEC Standard Operation Procedure (SOP) 120: Decontamination.* Prepared by The RETEC Group, Inc., Ft. Collins, Colorado. April 30.

RETEC, 2002d. *RETEC Standard Operation Procedure (SOP) 231: Water-Level Measurements.* Prepared by The RETEC Group, Inc., Ft. Collins, Colorado. April 30.

RETEC, 2003. *Final Feasibility Study.* Prepared for Noveon Kalama, Inc. and Rogers Sugar, Ltd., by The RETEC Group, Inc., Seattle, Washington. December 22.

RETEC, 2004. *Cleanup Action Plan.* Prepared for Noveon Kalama, Inc. and Rogers Sugar, Ltd., by The RETEC Group, Inc., Seattle, Washington. March 19.

Tables

Table 4-1 Sample Handling & Preservation Requirements

Matrix: Water

Analyte Category	Method	Holding Time 4°C	Container Requirements	Preservation
Volatile Organics *(Benzene & Toluene)*	8021B	14 days to analysis	3 40-ml VOA vials (no head space)	Hydrochloric acid 4°C
Semivolatile Organics *(Benzoic Acid, Biphenyl, bis(2-Ethylhexyl)phthalate, Diphenyl Oxide, Phenol)*	8270C SIM	7 days to extraction, 40 days from extraction to analysis	1-liter amber	4°C
Total Metals *(Arsenic & Copper)*	7060A/6010B	6 months	500-ml poly	Nitric acid 4°C
Field Parameters				
pH	Field Probe	NA	NA	NA
Temperature	Field Probe	NA	NA	NA
Conductivity	Field Probe	NA	NA	NA

Matrix: Soil Vapor

Analyte Category	Method	Holding Time	Container Requirements	Preservation
Volatile Organics *(Benzene & Toluene)*	8021B	3 days	2 20-ml VOA vials	No direct light Ambient air temperature

Matrix: Soil

Analyte Category	Method	Holding Time 4°C	Container Requirements	Preservation
Volatile Organics *(Benzene & Toluene)*	8260	14 days to analysis	2-oz jar (no headspace)	4°C
Leached Organics *(Benzene)*	TCLP Benzene	14 days to analysis	2-oz jar (no headspace)	4°C
Semivolatile Organics *(Benzoic Acid, Biphenyl, bis(2-Ethylhexyl)phthalate, Diphenyl Oxide, Phenol)*	8270 SIM	7 days to extraction, 40 days from extraction to analysis	8-oz jar	4°C
Total Metals *(Arsenic & Copper)*	7060A/6010B	6 months	8-oz jar	4°C

Table 8-1 Summary of Quality Assurance Samples

QA/QC Sample Type	Sampling and Analysis Frequency
Field-Collected QA/QC Samples	
Blind Field Duplicates	One per 10
Field/Equipment Blanks	One per 20
Trip Blanks	Will accompany all shipments of samples for VOC analysis
Matrix Spike	One per 20
Matrix Spike Duplicate	One per 20
Laboratory QA/QC (to be reported and validated)	
Method Blanks	One per 20
Laboratory Control Samples	One per 20
Laboratory Control Duplicates	One per 20
Matrix Spike - Field Collected	One per 20
Matrix Spike Duplicate - Field Collected	One per 20
Holding Times	Table 4-1
Surrogate Compounds	Every field & QA/QC sample
Laboratory QA/QC (internal lab requirements)	
Initial Calibration	Following Lab SOP
Continuing Calibration	Following Lab SOP
Internal Standards	Following Lab SOP

Attachment A

Field Logs

GROUNDWATER GAUGING LOG - WIA INTERMEDIATE SAND WELLS

Quarterly

PROJECT: Emerald Kalama

PROJECT #: BFGKI-15231

GAUGED BY: ____________________

DATE: ____________________

- Gauge twice per day: once at low tide, once at high tide.

WELL ID	**LAG TIME**	**LOW TIDE**		**HIGH TIDE**		**COMMENTS**
		TIME	**DTW (TOC)**	**TIME**	**DTW (TOC)**	
RIVER	0					
KC-14	0:22					
ISRW-6*	0:23					
MW-239	0:28					
ISRW-5*	0:29					
MW-249	0:38					
MW-250	0:39					
ISRW-7*	0:41					
MW-243	0:44					
PZ-118	0:47					
KC-6	0:54					
MW-248	1:03					
MW-247	1:03					
PZ-117	1:13					
KC-17	1:54					
ISRW-3*						
ISRW-4*						
ISRW-1*						
KCP-3						
ISRW-2*						
MW-236						

Low tide time: ____________

High tide time: ____________

Note:

* = measure product and depth to water in well using interface probe; record thickness and amount bailed, if present

Lag times based on 4/97 tidal study

GROUNDWATER GAUGING LOG

WIA UPPER SAND WELLS

Quarterly

PROJECT: Emerald Kalama

PROJECT #: BFGKI-15231

GAUGED BY: ____________________

DATE: ____________________

WELL ID	TIME	DEPTH TO WATER (TOC)	COMMENTS
PZ-110			
MW-238			
KC-13			
MW-244			
KC-15			
PZ-106			
N. Trench Sump*			
S. Trench Sump*			
USRW-2			
KCP-6			
KC-11			
KC-12			
KC-24R			
STP-1			
MW-255			

NOTES:

* Measure each sump through hole in vault cover

GROUNDWATER GAUGING LOG **NIA WELLS**

Quarterly

PROJECT: Emerald Kalama
PROJECT #: BFGKI-15231
GAUGED BY:
DATE:

WELL ID	TIME	DTW (TOC)			COMMENTS
KC-8					
MW-245					
NTP-1					
W. SUMP PIEZO					
W. SUMP					pump on? (Y/N):
NTP-2					
E. SUMP PIEZO					
E.SUMP					pump on? (Y/N):
NTP-3					
KC-9					
KC-21					
KC-4					
KC-23					
PZ-102					
MW-210					
MW-256					

WELL ID	LOW TIDE		HIGH TIDE		COMMENTS
	TIME	DTW (TOC)	TIME	DTW (TOC)	
MW-201					
MW-205					
KC-20					

Staff Gauge Height: (feet)
E. Sump Flow Rate: (gpm)
W. Sump Flow Rate: (gpm)
Combined Discharge: (gpm)

GROUNDWATER SAMPLING LOG
WIA Intermediate Sand Wells

PROJECT NAME Emerald Kalama
PROJECT NO. BFGKI-15231-310
DATE

WELL NO.
SAMPLED BY

WELL INFORMATION	
DEPTH TO WATER	(TOC-ft)
	(wl.prot.-ft)
DEPTH OF WELL	(ft)
WELL DIAMETER	(inches)
FEET OF WATER	
CASING VOLUME*	(gal)
PURGE VOLUME	(gal)
PRODUCT THICK	(ft)
WELL CONDITION	
WEATHER	

NOTES:

PURGE DATA

START PURGE TIME:

VOL. PURGED (gal)					
TIME					
pH (units)					
CONDUCTIVITY (umhos/cm)					
TEMP. (C)					
WATER COLOR					

PURGE AND SAMPLE EQUIPT: Polyethylene bailer (Benzene, Toluene), Peristaltic Pump (As)

SAMPLE NUMBER	SAMPLE TIME	ANALYSIS	CONTAINER	# BOTTLES	PRESERVATIVE
		Benzene, Toluene	40 mL VOA		HCl
		Total As	500-ml poly		HNO3

ADDITIONAL INFORMATION:
TOC=Top of well casing
wl.prot.=top of well protector
*casing volume: 2" = 0.163 gal/ft 4" = 0.653 gal/ft

GROUNDWATER SAMPLING LOG
WIA Intermediate Sand Recovery Wells

PROJECT NAME Emerald Kalama

PROJECT NO. BFGKI-15231-310

DATE

WELL NO. ISRW-

SAMPLED BY

FLOW INFORMATION	
FLOW RATE	(gpm)
SAMPLE PORT CONDITION	
WEATHER	

NOTES:

SAMPLE NUMBER	SAMPLE TIME	ANALYSIS	CONTAINER	# BOTTLES	PRESERVATIVE
		Benzene, Toluene	40-ml VOA		HCl

GROUNDWATER SAMPLING LOG
WIA Upper Sand Wells

PROJECT NAME Emerald Kalama

PROJECT NO. BFGKI-15231-310

DATE

WELL NO.

SAMPLED BY

WELL INFORMATION	
DEPTH TO WATER	(TOC-ft)
	(wl.prot.-ft)
DEPTH OF WELL	(ft)
WELL DIAMETER	(inches)
FEET OF WATER	
CASING VOLUME*	(gal)
PURGE VOLUME	(gal)
PRODUCT THICK	(ft)
WELL CONDITION	
WEATHER	

NOTES:

PURGE DATA					
START PURGE TIME:					
VOL. PURGED (gal)					
TIME					
pH (units)					
CONDUCTIVITY (umhos/cm)					
TEMP. (C)					
WATER COLOR					
PURGE AND SAMPLE EQUIPT: Polyethylene bailer (Benzene, Toluene & SVOCs), Peristaltic Pump (As)					

SAMPLE NUMBER	SAMPLE TIME	ANALYSIS	CONTAINER	# BOTTLES	PRESERVATIVE
		Benzene, Toluene	40-ml VOA		HCl
		SVOCs	1-liter amber		none
		Total As	500-ml poly		HNO_3

ADDITIONAL INFORMATION:

TOC=Top of well casing

wl.prot.=top of well protector

*casing volume: 2" = 0.163 gal/ft 4" = 0.653 gal/ft

GROUNDWATER SAMPLING LOG
WIA Upper Sand Sumps

PROJECT NAME Emerald Kalama

PROJECT NO. BFGKI-15231-310

DATE

LOCATION NO.

SAMPLED BY

WELL INFORMATION	
DEPTH TO WATER (TOC-ft)	
SUMP CONDITION	
WEATHER	

NOTES:

SAMPLE NUMBER	SAMPLE TIME	ANALYSIS	CONTAINER	# BOTTLES	PRESERVATIVE
		Benzene, Toluene	40-ml VOA		HCl
		SVOCs	1-liter amber		none

GROUNDWATER SAMPLING LOG
NIA Wells

PROJECT NAME Emerald Kalama
PROJECT NO. BFGKI-15231-310
DATE

WELL NO.
SAMPLED BY

WELL INFORMATION	
DEPTH TO WATER	(TOC-ft)
	(wl.prot.-ft)
DEPTH OF WELL	(ft)
WELL DIAMETER	(inches)
FEET OF WATER	
CASING VOLUME*	(gal)
PURGE VOLUME	(gal)
PRODUCT THICK	(ft)
WELL CONDITION	
WEATHER	

NOTES:

PURGE DATA					
START PURGE TIME:					
VOL. PURGED (gal)					
TIME					
pH (units)					
CONDUCTIVITY (umhos/cm)					
TEMP. (C)					
WATER COLOR					
PURGE AND SAMPLE EQUIPT:					

SAMPLE NUMBER	SAMPLE TIME	ANALYSIS	CONTAINER	# BOTTLES	PRESERVATIVE
		Benzene, Toulune	40-ml VOA		HCl
		SVOCs	1-liter amber		none
		Total As	500-ml poly		HNO_3
		Total As, Cu	500-ml poly		HNO_3

ADDITIONAL INFORMATION:
TOC=Top of well casing
wl.prot.=top of well protector
*casing volume: 2" = 0.163 gal/ft 4" = 0.653 gal/ft

GROUNDWATER SAMPLING LOG
NIA Sumps

PROJECT NAME Emerald Kalama

PROJECT NO. BFGKI-15231-310

DATE

LOCATION NO.

SAMPLED BY

WELL INFORMATION	
DEPTH TO WATER (TOC-ft)	
SUMP CONDITION	
WEATHER	
SAMPLING EQUIPMENT:	Polyethylene bailer

NOTES:

SAMPLE NUMBER	SAMPLE TIME	ANALYSIS	CONTAINER	# BOTTLES	PRESERVATIVE
		Benzene, Toluene	40-ml VOA		HCl
		SVOCs	1-liter amber		none

SURFACE WATER SAMPLING LOG
NIA Surface Water Locations

PROJECT NAME Emerald Kalama
PROJECT NO. BFGKI-15231-310
DATE

LOCATION NO.
SAMPLED BY

LOCATION INFORMATION
DEPTH OF WATER
WEATHER

NOTES:

SAMPLE NUMBER	**SAMPLE TIME**	**ANALYSIS**	**CONTAINER**	**# BOTTLES**	**PRESERVATIVE**
		Benzene, Toluene	40-ml VOA		HCl
		SVOCs	1-liter Amber		none
		Total As, Cu	500-ml poly		HNO_3

SVE Monitoring Log

PROJECT: Emerald Kalama
PROJECT #: BFGKI-15231-
GAUGED BY: ______________________
DATE: ______________________

Vapor Monitoring Point OR Extraction Well	Time	Vacuum in H_2O	Flowrate scfm	O_2 %	Hydrocarbon	Carbon Monoxide	BTEX, TVH, CH_4	Comments
Blower Discharge								

Moisture separator vacuum (in Hg): ______________________

Other comments/observations: ______________________

RETEC

Boring/Well Log

Boring #:
Sheet___of___

Project:	Monument:	Stick Up:
Project #:	Northing: Easting:	Ground Elevation:
Location:	Drill Rig Type:	MP Elevation:
Client:	Method:	Total Depth:
Start Date & Time:	Casing ID:	Sand Pack Type/Interval:
Finish Date & Time:	Boring ID:	Seal Type/Interval:
Contractor:	Bit Type:	Grout Type/Interval:
Operator:	Logged By:	Screen Type/Interval:

Sample					Depth (ft.)	Soil and Rock Description Classification Scheme: _______	Depth (ft.)	Comments
Type & #	Depth Range (ft.)	Blows Per 6 Inch	% Rec	PID (ppm)				

Remarks and Datum Used:

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, WA 98134-1162
Phone: (206) 624-9349
Fax: (206) 624-2839

Sample Type
N = Split Spoon
GP = Geoprobe
GS = Grab Sample
C = Core

Groundwater		
Date	Time	Depth (ft.)

Chain of Custody Record

№ 100518

The RETEC Group, Inc.
1011 S.W. Klickitat Way, Suite 207 • Seattle, WA 98134-1162
(206) 624-9349 Phone • (206) 624-2639 Fax
www.retec.com

RETEC

Project Name:	Project Number:
Send Report To:	Sampler (Print Name):
Address:	Sampler (Print Name):
	Shipment Method:
	Airbill Number:
Phone:	Laboratory Receiving:
Fax:	

Page_____ of_____

Purchase Order #:____________________

Field Sample ID	Sample Date	Sample Time	Sample Matrix	Number of Containers	Analysis Requested											Comments, Special Instructions, etc.	Lab Sample ID (to be completed by lab)

Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:

Sample Custodian Remarks (Completed By Laboratory):

QA/QC Level	Turnaround	Sample Receipt	
Level I ☐	Routine ☐	Total # Containers Received?	
Level II ☐	24 Hour ☐	COC Seals Present?	
Level III ☐	1 Week ☐	COC Seals Intact?	
Other ☐	Other _____	Received Containers Intact?	
		Temperature?	

White: Lab Copy Yellow: PM Copy Pink: Field Copy Gold: PM/QA/QC Copy

Attachment B

SOP # 235 – Low Flow Groundwater Sampling

RETEC Standard Operating Procedure (SOP) 235
Low Flow Groundwater Sampling

1.0 Purpose and Applicability

The RETEC Group, Inc. (RETEC) SOP 235 describes methods used to obtain the collection of valid and representative groundwater samples from monitoring wells utilizing a low flow sampling technique. This technique is designed to reduce the influx of particulate matter into the well and groundwater sample to ensure a more representative analysis of groundwater quality, and to reduce aeration that can affect geochemical parameters.

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Job Hazard Analysis (JHA), Safety Task Analysis Review (STAR), or Site-Specific Health & Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The field sampling coordinator will have responsibility to oversee and ensure that all groundwater sampling is performed in accordance with the project specific sampling program and this SOP. It shall be the responsibility of the field sampling coordinator to observe all activities pertaining to sampling to ensure that all the standard procedures are followed properly, and to record all pertinent data on a field log or field book. The collection, handling, and storage of all samples will be the responsibility of the field sampling coordinator. In addition, the field sampling coordinator must ensure that all field workers are fully apprised of this SOP.

3.0 Health and Safety

This section presents the generic hazards associated with low flow groundwater sampling and is intended to provide general guidance in preparing site-specific health and safety documents. The site-specific HASP, JHA, and STAR will address additional requirements and will take precedence over this document. Note that low flow groundwater sampling usually requires Level D personal protection unless there is a potential for exposure to airborne site contaminants.

Health and safety hazards include but are not limited to the following:

- Slip, trips, and falls in tall grasses over obstacles and berms near well locations. Review terrain hazards prior to conducting these operations. Ensure there is a safe means of access/egress to the wellhead.

- Dermal exposure to potentially contaminated groundwater. Ensure that proper personal protective equipment (PPE) is used to mitigate the impact of splashes of groundwater to skin and/or eyes.

- Exposure to site contaminants. If there is product in the well (especially gasoline) take all precautions necessary to prevent fire/explosion and/or exposure to airborne vapors.

- Ergonomics. Use appropriate ergonomic techniques when inserting or retrieving equipment for the wells to preclude injury to the arms, shoulders or back.

4.0 Supporting Materials

The following list of equipment will be used to determine the depth to water, purged volume, and analytical parameters.

Sampling/Purging Equipment

- Low flow submersible bladder pump or peristaltic sampling pump
- Teflon and polyethylene tubing
- Water level measurement equipment

Field Analytical Parameter Measurement

- In-line water quality meter (e.g., flow-through cell)

- Water quality meter with individual temperature, pH, specific conductance, dissolved oxygen (DO), turbidity, salinity, and oxidation reduction potential (ORP) probes

- Turbidity meter

Supporting Documents

- Project specific Work Plan

- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants

- A copy of the Site-Specific HASP

- Field data sheets and log book

Decontamination Equipment

- Distilled water
- Isopropanol (laboratory grade)
- Spray bottles for decontamination solutions
- Chemical free paper towels

Sample Collection

- Preservation solutions (if necessary)
- Sample containers
- Coolers

Peristaltic Pump Sample Collection

- Generator and extension cord
- Battery packs

Bladder Pump Sample Collection

- Dedicated bladders
- Pump controller box
- Nitrogen (air supply)
- Detergent/Alconox
- Nitric or hydrochloric acid (laboratory grade)
- Cleaning brushes

Miscellaneous

- Disposable gloves
- Tubing cutters
- Plastic sheeting
- PPE
- Buckets and intermediate containers

5.0 Methods and Procedures

The following sections describe the methods and procedures required to collect representative groundwater samples.

5.1 Water Level Measurement

After unlocking and/or opening a monitoring well, the first task will be to obtain a water-level measurement. A static-water level will be measured in the well prior to the purging and collection of any samples. The water level is needed for estimating the purge volume and may also be used for mapping the potentiometric surface of the groundwater. Water-level measurements will be made using an electronic or mechanical device following the methods described in SOP 231.

Measurement of point location for the well should be clearly marked on the outermost casing or identified in previous sample collection records. This point is usually established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If not marked from previous investigations, the water level measuring point should be marked on the north side of the well casing and noted in the groundwater sampling form (Figure 1). Whatever measuring point is used, the location should be described on the groundwater sampling form.

To obtain a water level measurement lower a decontaminated mechanical or an electronic sounding unit into the monitoring well until the audible sound of the unit is detected or indicates water contact. At this time the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement. The water-level measurement should be entered on the groundwater sampling form. The water-level measurement device shall be decontaminated immediately after use following the procedures outlined in RETEC SOP 120 (Decontamination).

5.2 Purging and Sample Collection

5.2.1 Pumping

Purging must be performed for all groundwater monitoring wells prior to sample collection. The volume of water present in each well must be computed using two measurable lengths, length of water the water column and monitoring well inside diameter. A low flow, electric driven pump (e.g., bladder pump or peristaltic pump) will be used to purge and sample well water.

The inlet of the bladder pump or peristaltic pump tubing will be lowered into the well slowly and carefully to a depth corresponding with the approximate midpoint of the screened interval of the aquifer, or 1-2 feet below the water level in the well, whichever is greater. A depth-to-water measurement device will be lowered into the well to monitor drawdown. The pump will be turned on at a flow rate of about 0.1 liters per minute (L/min). The flow rate will be adjusted up or down to maximize flow, yet ensure minimum drawdown. In no instance should a drawdown of more than 0.5 foot be allowed. The water level in the well should be carefully monitored to ensure that draw down does not increase during purging.

If the well being sampled is newly installed and developed or has been redeveloped, sampling can be initiated as soon as the groundwater has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24-hours after development to sample a new monitoring well. Wells developed with stressful measures (e.g., backwashing, jetting, compressed air, etc.) may require as long as a 7-day interval before sampling.

5.2.2 Field Parameters

Groundwater will be pumped from the well into a sealed, flow-through chamber containing probes to measure the water temperature, pH, turbidity, conductivity, ORP, and DO using a Water Quality Meter. Field measurements of turbidity will also be obtained using a turbidity meter for comparison purposes. It is essential to properly calibrate the Water Quality Meter for the specific parameters being monitored, according to the procedures identified in the instrument manual. Calibration procedures and results must be documented in the site field notebook.

Field parameters values will be recorded on the Groundwater Sample Collection Record (Figure 1) or in the site field notebook along with the corresponding purge volume. After passing through the flow-through chamber, the water will be discharged into a container of known volume where the pumping rate will be measured with a watch. When the container is full, the water will be properly disposed following Site protocols.

Groundwater samples will be collected for laboratory analysis when the groundwater has stabilized; the change between successive readings of temperature, pH and conductivity are less than 10%, and turbidity is reduced to 10 NTUs or less. This may occur prior to removal of three well volumes. Stabilization of groundwater measurements is considered indicative of sampling fresh formation water and is a more reliable indicator of purging than removal of a standard volume of water.

5.2.3 Decontamination

Decontamination of non-dedicated equipment will follow the procedures outlined in RETEC SOP 120 (Decontamination), or following the procedures listed below for full field decontamination, conducted in the order presented:

- Remove gross contamination from the equipment by brushing or steam cleaning
- Wash with non-phosphate soap/detergent solution
- Rinse with laboratory-grade nitric acid (for potential inorganic contamination)
- Rinse with tap water
- Rinse with laboratory grade isopropanol
- Rinse with tap water
- Rinse with distilled water
- Allow to air dry
- Repeat as necessary

Teflon tubing will be dedicated to each well and will, therefore, not require decontamination.

5.3 Sample Preparation

Proper packaging and shipment of samples will minimize the potential for sample breakage, leakage, or cross contamination and will provide a clear record of sample custody from collection to analysis. Information on sample custody and shipping is also detailed in RETEC SOP 110 (Packaging and Shipment of Samples). Samples will be packaged on ice and shipped in a container able to maintain a temperature at or below 4^{o}C.

6.0 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) requirements include, but are not limited to, blind field duplicates, blind rinsate blanks, and blind field blanks. These samples will be collected on a frequency of one QA/QC sample per 20 field samples or a minimum of one QA/QC sample per day unless otherwise specified in the project specific sampling plan.

7.0 Documentation

The groundwater sampling program will be documented to provide a summary of the sample collection procedures and conditions, shipment method, the analyses requested and the custody history. Such documentation shall include:

- Field notebook
- Groundwater sample collection record
- Sample labels
- Chain-of-custody forms
- Shipping receipts
- Health & Safety forms (JHA, STAR, and/or Site-Specific HASP amendments)

All documentation shall be placed in the project files and retained following completion of the project.

The RETEC Group, Inc.
Groundwater Sampling Form

PROJECT ________________ WELL NO.________________
PROJECT NO. ________________ SAMPLERS________________

1. WELL CONDITION CHECKLIST:
a. Bump posts________ Prot. casing/lock________ Surface pad________
b. Well visibility (paint)________
c. Well label________

2. WATER LEVEL MEASUREMENT:
DATE________________ TIME________________
WEATHER CONDITIONS________________
a. Location of measuring point________________
b. Depth of water table from measuring point________________
c. Height of measuring point above ground surface________________
d. Total depth of well below measuring point________________
e. Length of water column (line 2d-2b)________________

3. WELL PURGING:
DATE________________ TIME________________
WEATHER CONDITIONS________________
a. Purge method________________
b. Required purge volume at 3 well volumes________________

Pumping Duration	Volume Rmvd.	pH	Redox	Cond.	T(C)	Color	Turbidity

4. SAMPLE COLLECTION:
DATE________________ TIME________________
WEATHER CONDITIONS________________
a. Collection method________________
b. Meter calibration Date Model
pH meter________________
D.O. meter________________
c. Sample information pH________ Cond.________ T(C)________ Turbidity________

Analysis	Containers	Sample Prep./Preservation

d. Chain of custody form________________ COC tape________________
e. Shipping container________________

5. COMMENTS:________________
____
____

Quality Assurance Project Plan – Revision 4

Emerald Kalama Chemical
Kalama, Washington

Prepared by:

The RETEC Group, Inc.
1011 S.W. Klickitat Way, Suite #207
Seattle, Washington 98134

RETEC Project Number: BFGKI-15231-240

Prepared for:

Emerald Kalama Chemical
1296 Third Street N.W.
Kalama, Washington 98625

and

Goodrich Corporation
Four Coliseum Centre
2730 West Tyvola Road
Charlotte, North Carolina 28217-4578

September 24, 2007

Quality Assurance Project Plan – Revision 4

Emerald Kalama Chemical
Kalama, Washington

Prepared by:

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Prepared by:

Chapin L. Brackett, Project Engineer

Reviewed by:

Allison J. Crowley P.E., Project Manager

September 24, 2007

Table of Contents

List of Tables

List of Attachments

List of Acronyms

CAS	Columbia Analytical Services
COC	Chain of Custody
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
DO	Dissolved Oxygen
DQI	Data Quality Indicator
FSP	Field Sampling Plan
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LD	Laboratory Director
LPM	Laboratory Project Manager
LQAM	Laboratory Quality Assurance Manager
LSC	Laboratory Sample Custodian
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PARCC	Precision, Accuracy, Representativeness, Comparability, & Completeness
PQL	Practical Quantitation Limit
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QAM	Quality Assurance Manger
QC	Quality Control
QCM	Quality Control Manager
RETEC	The RETEC Group, Inc.
RPD	Relative Percent Difference
SMC	System Monitoring Compound
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compound
TIM	Testing, Inspection, & Maintenance
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

1 Project Management

This quality assurance project plan (QAPP) presents the Quality Assurance (QA) and Quality Control (QC) procedures for the collection of environmental samples at the Emerald Kalama Chemical facility (facility) in Kalama, Washington. All QA/QC procedures detailed in this QAPP are in accordance with applicable professional technical standards and project specific goals. This QAPP describes the minimum procedures that will be implemented to ensure that the precision, accuracy, representativeness, and completeness of the project data are sufficient to satisfy the project objectives.

1.1 Organization of the Quality Assurance Project Plan

The organization of this QAPP is as follows:

- **Section 1, Project Management:** Presents a summary of project organization and a description of the roles and responsibilities of project participants.
- **Section 2, Quality Assurance Objectives:** Introduces and defines the quality assurance objectives.
- **Section 3, Quality Control Procedures:** Describes the basic quality control procedures followed in the field and laboratory.
- **Section 4, Calibration Procedures and Frequency:** Discusses the calibration procedures for both field and laboratory equipment.
- **Section 5, Analytical Procedures:** Identifies the quality assurance aspects of the analytical procedures.
- **Section 6, Data Management:** Discusses the laboratory data review process and the project's data storage tools.
- **Section 7, Data Validation:** Describes the level of independent validation applied to project data.
- **Section 8, References:** Provides citations for references used in this QAPP.

1.2 Project Organization and Responsibilities

In regards to QA/QC, the organizational structure for the project will consist of a Project Engineer, Quality Control Manager, and Quality Assurance Manager. Analytical laboratories will also be involved in the QA/QC of project data. The specific roles, activities and responsibilities of project participants are summarized below.

1.2.1 Project Engineer

The Project Engineer has the following responsibilities:

- Identify problems at the field-team level and resolve issues appropriately
- Coordinate laboratory and data validation activities with the analytical services staff
- Maintain a complete set of laboratory data and import data into the project database following validation
- Participate in preparation of project deliverables.

1.2.2 Quality Control Manager

The Quality Control Manager (QCM) will be responsible for monitoring adherence to the project QA objectives. The QCM has the following responsibilities:

- Assist with laboratory coordination for scheduled analyses
- Assure that the specified field, analytical, and data management procedures are followed and documented
- Schedule and oversee data validation
- Provide the analytical data and sampling field notes to the data validator.

1.2.3 Quality Assurance Manager (Data Validator)

The Quality Assurance Manager (QAM), or Data Validator, has the following responsibilities:

- Assess the precision, accuracy, and completeness of the data derived from the investigations.

1.2.4 Analytical Laboratories

Columbia Analytical Services (CAS) of Kelso, Washington will conduct chemical analyses of all water samples.

Greg Salata
1317 S. 13th Avenue, P.O. Box 479
Kelso, Washington 98626

Environmental Services Network Northwest (ESN) of Lacey, Washington will conduct chemical analyses of all vapor samples.

677 Woodland Sq Lp S.E., Ste D
Lacey, Washington 98503

Laboratory Director

The Laboratory Director (LD) will be responsible for assuring compliance with the quality procedures and managing resources of the laboratory to meet the project needs.

Laboratory Project Manager

The Laboratory Project Manager (LPM) will communicate directly with the QCM and will report to the LD. The LPM will:

- Coordinate laboratory analyses
- Supervise in-house chain of custody (COC)
- Schedule sample analyses within required holding times
- Oversee data review and preparation of analytical reports and electronic data deliverables (EDDs)
- Approve final analytical reports and EDDs prior to submission to the QCM.

Laboratory Quality Assurance Manager

The Laboratory Quality Assurance Manager (LQAM) has overall responsibility for laboratory data. The LQAM or a designee will communicate data issues through the LPM and will:

- Review and approve laboratory QA/QC procedures
- Review QA documentation
- Conduct detailed data review
- Ensure accuracy of hardcopy and EDD analytical results
- Develop and implement laboratory corrective actions
- Define appropriate laboratory QA/QC procedures
- Evaluate the effectiveness of the project-specific quality program

- Review and approve laboratory Standard Operating Procedures (SOPs).

Laboratory Sample Custodian

The Laboratory Sample Custodian (LSC) will report to the LD and will:

- Receive, inspect, and record information concerning the condition of incoming sample containers
- Verify and sign sample COC forms
- Notify the LPM of sample receipt and inspection
- Assign samples a unique identification number and customer number, and enter each sample into the sample receiving log
- Initiate transfer of the samples to appropriate lab division
- Control and monitor access/storage of samples.

2 Quality Assurance Objectives

QA objectives include the quantitative determinations of the data quality indicators (DQIs) or precision, accuracy (bias), representativeness, comparability, and completeness (PARCC) parameters. The five assessment parameters, as well as detection limits, are described below.

2.1 Detection Limits

The detection limit for a given parameter is determined by procedures specified in the method. Table 2-1 summarizes the media to be sampled, the appropriate methods of analysis, the method detection limits, and the Ecology-approved cleanup levels. These detection limits will be observed for all laboratory analyses performed during this project, except where matrix interferences and high concentrations of target and non-target compounds increase the reporting detection limits.

2.2 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Precision is measured by the relative percent difference (RPD), which is a quantitative measure of the variability of a group of measurements compared to their average value. The overall precision of measurement data is a mixture of sampling and analytical factors. Precision is evaluated through field and laboratory duplicate samples.

Sampling precision will be evaluated by analysis of field duplicate samples from a given location. Field duplicate samples will be analyzed for the complete list of analyte constituents in order to provide precision information on the analysis of constituents, and also to indicate the presence of other possible contaminants. When determining field precision, the acceptable level of variability in these results will be no greater than 30 percent RPD for water and air samples and no greater than 50 percent RPD for soil samples. Field duplicate samples will be collected for analysis at a rate of 1 sample in 10 (10 percent).

Laboratory precision will be evaluated through analysis of laboratory duplicates, laboratory control sample duplicates (LCSDs), and matrix spike duplicates (MSDs). Control limits will vary with analysis and sample type (i.e., duplicate, LCSD, MSD). Laboratory precision will be determined by matrix for 1 sample in 20 (5 percent).

2.3 Accuracy

Accuracy measures the closeness of an individual measurement or the average of a number of measurements to the true value. Accuracy includes a combination of random and systematic error components that result from sampling and analytical operations. Sources of error include the sampling process, field contamination, sample preservation, sample handling, sample matrix, laboratory preparation, and analysis techniques.

Sampling accuracy will be assessed through the evaluation of field-generated blank and trip blank results. Field-generated blanks will be collected at a frequency ratio of 1 sample in 20 (5 percent). If analyzing for volatile organic compounds, one trip blank per cooler containing samples for volatile organic analysis will be submitted for analysis.

If a target analyte is found in a blank, but not found in the sample, no action is taken. Any target analyte detected in the sample (other than the common laboratory or field contaminants) that was also detected in the associated blank, is qualified as a false positive if the sample concentration is less than five times the blank concentration. For common laboratory or field contaminants (e.g., methylene chloride, acetone, phthalates) the sample concentration is qualified as a false positive for results less than ten times the blank concentration.

Laboratory accuracy for analytical methods will be assessed by spiking samples with known standards and measuring the percent recovery of the spiked analyte. Known standards include matrix spikes (MSs), surrogate spikes, and laboratory control samples (LCSs). Surrogate spikes are required for all environmental and QC samples analyzed for organics. Matrix spikes and/or laboratory control spikes will be submitted for no fewer than 1 sample in 20 (5 percent).

Recovery of surrogate, matrix, and laboratory control spikes will be evaluated after each analytical run by the laboratory analyst to verify that the values are within laboratory limits. If recovery values are outside control limits, the system will be evaluated to confirm that all instrumentation is operating properly. Documentation and bench sheets will be reviewed to verify that the concentrations of spike solutions are accurate. If no system, documentation, solution preparation or spiking errors are identified, the data will be reviewed to determine if the unacceptable spike results are due to matrix interference. If matrix interferences are affecting surrogate and/or matrix spike recovery and re-extraction is not deemed useful, the data will be annotated to document the situation. However, if a surrogate recovery is less than 10 percent, the sample will be re-extracted and reanalyzed once, unless there is objective evidence of matrix interference.

2.4 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter used to ensure proper design of the sampling program.

Making certain that sampling locations are selected properly and a sufficient number of samples are collected best satisfies representativeness criteria.

2.5 Completeness and Comparability

Completeness is defined as the percentage of measurements made that are judged to be valid measurements. Completeness is defined by the equation below:

$$\%C = \frac{S}{R}(100)$$

Where:

C = Completeness
S = Number of valid analyses
R = Number of requested analyses.

The completeness goal established for this project is 90 percent.

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through the use of standard techniques to collect and analyze representative samples and the consistent reporting of analytical results in appropriate units. Comparability is limited by the other PARCC parameters because the data sets can only be compared with confidence when precision and accuracy are known. For comparability, reporting limits for water and vapor analyses must achieve the practical quantitation limit (PQL) for those samples not subject to dilution or affected by sample matrix.

3 Quality Control Procedures

3.1 Sample Handling and Custody Requirements

Sample custody will be maintained and documented in the field from the time of collection through the time of delivery to the laboratory. Sample custody is documented through the use of a field notebook and laboratory-provided COC forms documenting the name of the sampler, the time of sample collection, and the relinquishment of samples (under custody seal) to the analytical laboratory.

The sampler is responsible for the care and custody of samples from the time they are collected until they are properly transferred to the laboratory.

Within the laboratory, COC procedures will be followed to document the integrity and security of the samples, as well as the sample paths and locations within the laboratory. Upon receipt of the samples, the LSC will follow these procedures:

- Check for custody seals and ensure that one was placed on the outside of the shipping container.

- Date and sign COC forms and any other documents using full signature.

- Open each cooler, place a thermometer inside the temperature blank until the temperature stabilizes, and record the cooler's temperature on the sample analysis form.

- Remove all sample containers from coolers and check for breakage.

- Compare sample identifications and number of bottles to the COC form. All discrepancies in COC, analysis requested, number of bottles, etc., will be recorded. If required, the QCM will be notified to resolve problematic sample receipt issues.

- Log samples into the laboratory database. Record date and time of sample collection, date received, turnaround time, name of person logging the job, client code, client project number and name, laboratory job number, number of jars, sample matrix, requested analyses, method of sample delivery, cooler temperature, integrity of samples, and the air bill number (if applicable).

- Fax or mail a copy of the sample checklist, completed COC, and a printout of scheduled analyses to the QCM for review and data tracking purposes.

- Log samples into the appropriate laboratory refrigerator. Custody has been relinquished as soon as samples are logged into appropriate laboratory refrigerator for storage.

For the laboratory to satisfy custody provisions, the following minimum procedures will be followed. When not in use, samples will be stored within the secured laboratory facility or in a locked storage facility where access is limited to the LSC and other key laboratory personnel. Transfer of the samples in and out of storage areas will be documented with an internal custody log-in/log-out form or laboratory tracking sheets. Analysts will maintain possession of samples and return samples to secured storage before the end of each working day, recording custody on the appropriate forms.

Internal COC records will be retained by the laboratory and are the responsibility of the LPM. A copy of the original field-to-laboratory COC record will be included in the final data report deliverable to RETEC.

3.2 Field QC Requirements

Laboratory analysis of field duplicates and field blanks will assess the precision and accuracy of field sampling techniques. The ratio of duplicate samples to field samples is 1 duplicate sample to every 10 field samples collected of each matrix (i.e., 10 percent), or a minimum of one per sample matrix. Field/equipment blanks will be collected at a minimum frequency of 1 per 20 samples of each matrix (5 percent). Trip blanks will accompany all shipments containing samples for analysis of volatile organic compounds (VOCs). QC samples will be collected in accordance with the applicable sampling procedures presented in the FSP.

The QC procedures for measuring pH, conductance, and temperature in groundwater or surface water samples will include calibrating the instruments, measuring duplicate samples, and checking the reproducibility of the measurements by taking multiple readings on a single sample or reference standard.

3.3 Laboratory QC Requirements

The following sections describe the general QC procedures inherent to the laboratory QA program (Attachment A).

All analytical procedures will be documented in writing as laboratory SOPs, with each SOP including a QA section that addresses the minimum QC requirements for the procedure. Certain QC requirements are matrix or method specific, but in general, the QA program must include the following:

- Instrument calibration
- Preparation and analysis of reagent/preparation blanks
- Analysis of instrument and/or method blanks
- Preparation and analysis of matrix spikes and matrix spike duplicates
- Preparation and analysis of surrogate spikes
- Preparation and analysis of laboratory control samples and standards.

An analytical batch is defined as 20 samples or less of the same type of matrix, prepared and analyzed as a group. The following analytical QC samples will be associated with each batch if the control procedure is applicable to the analysis.

Method Blank: A reagent or media blank will be analyzed as a check on laboratory contamination (glassware, reagents, analytical hardware) that might affect analytical results. A sample consisting of laboratory reagent-grade water (distilled and deionized water) or a solid matrix will be analyzed to monitor the analytical instrument for contamination. The method blank is processed through the entire analytical procedure, including sample preparation. The results are used in conjunction with other control data to validate overall system performance and identify bias that may impact data quality.

Laboratory Control Samples (LCS): Independently prepared check samples will be processed through the entire analytical procedure. The purpose of these samples is to monitor and assure the accuracy of the procedure in the absence of matrix interference. Results of the LCS are charted and must meet acceptance criteria.

LCS Duplicates (LCSD): Independently prepared check sample duplicates will be processed through the entire analytical procedure. The purpose of the LCSD is to assure the precision of the procedure in the absence of matrix interference.

System Monitoring Compounds (Surrogates): All sample aliquots and laboratory QC samples scheduled for organic analysis will be spiked with system monitoring compounds (SMCs). SMCs will be added to the sample immediately before extraction (for SVOC analysis) and purging (for VOC analysis). The purpose of the SMCs is to monitor and assure the accuracy of the analytical performance on individual samples and to indicate the presence of system bias, extraction inefficiencies, and/or matrix interferences.

Internal Standards: All sample aliquots and laboratory QC samples scheduled for GC/MS analysis will be spiked with interval standards prior to extraction or analysis as applicable. The purpose of the internal standards is to ensure GC/MS instrument sensitivity and stability, and to provide for accurate target analyte quantitation. The internal standard area counts and retention times are charted and must meet acceptance criteria.

Matrix Spikes: An aliquot of a sample will be spiked with a known amount of selected analyte(s). Percent recoveries of the selected spiked analytes are tabulated by subtracting the non-spiked concentration from the spiked sample results. Recovery of matrix spikes will be evaluated after each analytical run by the laboratory analyst to verify that the values are within laboratory control-charted limits

Percent recovery is calculated as follows:

$$\%R = \frac{(C_1 - C_0)}{C_2} \times 100$$

Where:

$\%R$ = Percent recovery;
C_1 = Measured concentration in spiked sample aliquot;
C_0 = Measured concentration in unspiked sample aliquot; and
C_2 = Actual concentration of spike added.

Duplicate Samples or Matrix Spike Duplicates: Will be analyzed to monitor the method precision. Results in RPD are tabulated and charted. The RPD calculation (for two samples, C_1 and C_2) is shown below. For analytical methods in which spiking is not applicable, sample duplicates are used to assess precision. The acceptable level of variability in these results will be no greater than 20 percent.

$$RPD = \frac{C_1 - C_2}{\left(\frac{C_1 + C_2}{2}\right)} \times 100$$

Where:

RPD = Relative percent difference;
C_1 = Larger of the two observed values; and
C_2 = Smaller of the two observed values.

Completed data reports from the laboratory will include a narrative outlining any problems, corrections, anomalies, and conclusions, as well as COC documentation and analytical results for all analyses and laboratory QC. Additionally, one copy of the associated EDD will be provided to RETEC by the laboratory.

4 Calibration Procedures and Frequency

This section establishes the procedures for maintaining the accuracy of instruments and measuring equipment used to conduct field and laboratory measurements.

4.1 Responsibilities

The Project Engineer or designated personnel is responsible for the calibration of field equipment. The responsibility for the calibration of laboratory equipment lies with the LQAM. For a discussion of laboratory equipment calibration, see the laboratory QA manual (Attachment A).

4.2 General Calibration Procedures

Field testing equipment used for analytical determinations fall into two categories: those calibrated prior to each use and those calibrated on a scheduled periodic basis. Frequency of calibration will be based on the type of equipment, manufacturer's recommendations, values given in national standards, and experience. Table 4-1 presents the calibration frequency of the field sampling equipment.

Equipment will be calibrated using reference standards (i.e, National Bureau of Standards (NBS) or accepted values of natural physical constants). If national standards do not exist, the basis for calibration will be documented in the daily field activity log. Field equipment calibration will be performed as described by the equipment manufacturer.

Scheduled periodic calibration of testing equipment will not relieve field personnel of the responsibility to verify that equipment is functioning properly. If an individual suspects an equipment malfunction, s/he will remove the device from service, tag it so that it is not inadvertently used, and see that recalibration is performed or substitute equipment is obtained. Instruments past due for calibration will be immediately removed from service.

4.3 Calibration Failures

Equipment that fails calibration or becomes inoperable during use will be removed from service, tagged to indicate that it is out of calibration, and segregated to prevent inadvertent use. Such equipment will be repaired and recalibrated or replaced as appropriate.

The Project Engineer will evaluate results of activities performed using equipment that has failed recalibration. If the activity results are adversely affected, the results of the evaluation will be documented. If water level measurements are found to be in error due to recalibration failure of the water level probe, the appropriate modifications will be made to the measurement according to the recalibration data and recorded in the field forms or field notebook. If pH, conductivity, or temperature meters fail recalibration, the data will be reviewed to determine whether alternative parameter data are sufficient to accept the groundwater sampling results. For instance, if the conductivity meter fails recalibration, pH and temperature readings will be used to verify that the purge water has stabilized. Since these parameters are calibrated prior to each use, it is unlikely that the data will be unacceptable.

4.4 Calibration Records

Calibration records will be maintained in daily activity logs or on appropriate field forms.

4.5 Maintenance

Each piece of equipment used in activities affecting data quality will be maintained according to specifications provided by the manufacturer. The Project Engineer will be responsible for performing routine maintenance and will have available tools and spare parts to conduct routine maintenance. If the equipment or instrument cannot be maintained to manufacturer’s specifications or cannot be properly calibrated, it will be returned to the manufacturer or other repair facility for proper maintenance and repair. Once received back from the manufacturer, the instrument will be checked for compliance to project specifications before being returned to routine field use.

5 Analytical Procedures

The laboratories utilized for analysis of samples collected under the QAPP shall perform all analyses according to EPA accepted methods. The specific analytical methods to be used are provided in Table 4-1 of the Field Sampling Plan.

5.1 Analytical Laboratories

Columbia Analytical Services (CAS) of Kelso, Washington will perform analysis on all water samples as described in Section 4.0 of the SAP. Environmental Services Network Northwest (ESN) of Lacey, Washington will analyze all soil vapor samples. The following documents have been supplied by the laboratories and are supplied in Attachment A:

- CAS Quality Assurance Manual
- ESNN Statement of Qualifications and Capabilities (includes the Quality Assurance Manual)

5.2 General Requirements

In general, the laboratories will adhere to those recommendations as promulgated in 21 CFR Part 58, "Good Laboratory Practices", criteria described in *Methods for Chemical Analysis of Water and Wastes*, and those criteria presented in 40 CFR 136, "Guidelines Establishing Test Procedures for Analysis of Pollutants Under the Clean Water Act."

5.3 Analytical Method Requirements

Documentation of appropriate method performance for the project target compounds will be available from the selected laboratory and will include the criteria for acceptance, rejection, or qualification of data. The laboratory is also required to periodically update method performance data such as control limits and method detection limits.

Corrective action in the analytical laboratory may be required due to equipment malfunction, failure of internal QA/QC checks, method blank contamination, noncompliance with QA requirements, or failure of performance or system audits. When measurement equipment or analytical methods fail QA/QC checks, the problem will be immediately brought to the attention of the appropriate persons in the laboratory, in accordance with the laboratory's SOPs. If failure is due to equipment malfunction, the equipment will be repaired, precision and accuracy will be reassessed, and the analysis will be rerun. Attempts will be made to reanalyze all affected parts of the analysis so that, in the end, results are not affected by failure of QA requirements.

6 Laboratory Data Review

6.1 Laboratory Data Review

Data reports and EDDs generated by the laboratory will undergo internal data approval by the LQAM or designee before being released to the QCM.

The laboratory will utilize automated data calculation. Analyses will be programmed to allow for raw data entry and editing at the keyboard, with integrated software performing calculations and permanent database generation. Data-entry errors will be checked by comparing the raw data printouts against the chemist's original work, minimizing the common sources of error in data reduction.

The LQAM will ensure that the EDD matches the laboratory hardcopy data report. This data review will be completed by the LQAM or designee and approved by the LPM before data is submitted to the QCM. Raw and final data will be stored electronically, with regularly scheduled backups performed and maintained at the laboratory.

Raw data from the chemists' notebooks or bench sheets will include all analytical variables compiled for samples, replicates, blanks, standards, and matrix spikes. The LQAM or designee will review all final results and EDDs. The LPM will approve submittal of the final data report and EDD after internal review and data verification.

6.2 Laboratory Data Verification

Technical verification requires comparison of QC and instrument performance standard results to required control limits. Technical verification is conducted throughout the analytical process, first by analysts, and finally by the LQAM or designee and LPM. No data will be released to the QCM prior to the completion of these data verification procedures. The following QC elements will be reviewed (as appropriate) for a full verification effort:

- Analytical holding times
- Blank contamination
- Initial instrument calibration
- Continuing instrument calibration
- Internal standards
- Interference checks

- Analytical accuracy (MS/MSD recoveries, LCS/LCSD recoveries, surrogate recoveries)
- Analytical precision (comparison of duplicate, LCSD, and MSD results, expressed as relative percent difference)
- Compound identification
- Compound quantitation and reported detection limits
- Target analyte list
- Transcription and calculation checks.

Final data reports from the laboratory must be complete and of sufficient quality to undergo the appropriate level of data validation by the RETEC QAM or designated validator. Incomplete data reports will not be accepted and will be returned to the laboratory for correction. The QAM compares EDDs to the data submitted and corrects any minor errors directly in the EDD files after verifying with the laboratory that the report entry is correct. If major errors are found, the QAM will reject the EDDs, and the laboratory will be obligated to correct and resubmit them. If errors are found in the hardcopy report data, the laboratory will provide a corrected data report and EDD, if it contains the same errors. Corrections to the data report or EDD, which are requested by the QAM, shall be provided by the laboratory within 3 business days of the request.

7 Data Validation

The independent data validation process assures technical data quality and method compliance, provides precision, accuracy, and completeness assessments, verifies that adequate analytical documentation was performed and reported, and determines whether the analytical data are usable.

7.1 Data Assessment Levels

Four RETEC data assessment levels have been developed. The levels identify the varying degree of methodology, documentation, and data assessment effort required to meet the data quality objectives of the project.

- **RETEC Level 1:** This level of data evaluation is for field tests only.

- **RETEC Level II:** This level of data assessment is for preliminary site investigations or on-going long-term monitoring events. With Level II data evaluation, the laboratory is entrusted to follow all internal quality control procedures (i.e., calibrations, performance checks) as directed in the analytical methods. A RETEC Level II data validation provides a definitive assessment of analytical precision, accuracy, and completeness but does not examine other internal quality control checks (i.e., calibrations, performance checks). Documentation provided by the laboratory for a Level II data package should include: case narratives, detection limits, percent moisture calculations, dilution factors, method blanks, surrogates, matrix spikes, laboratory control samples, laboratory duplicates, extraction and analysis dates, and COC forms.

- **RETEC Level III:** This level of data assessment is followed for site investigations of a more conclusive nature, sites undergoing risk assessment, and/or for sample data that must pass litigation scrutiny. All aspects provided in a Level II data package are contained in a Level III package, so precision, accuracy, and completeness can be assessed. Additionally, method compliance, analytical system performance, and overall qualitative and quantitative measurements are evaluated. In addition to the Level II documentation stated above, a Level III data package can include: system performance (tuning) reports, instrument calibrations, internal standards, interference checks, serial dilutions, preparation/extraction benchsheets, analysis run logs, and chromatograms and quantitation reports for all samples and standards.

- **RETEC Level IV:** Level IV assessment follows Level III procedures, and additionally contains back-calculation of 10% of the reported sample and QC results.

7.2 Data Validation for Precision, Accuracy, and Completeness

The QCM or his/her designee will conduct the data validation in accordance with RETEC Level II standards.

Data validation will include 100 percent review of the following QC measurements as they apply to the analytical methods followed:

- Detection limits and dilution factors
- Holding times
- Surrogates
- Instrument, preparation, and method blanks
- Matrix spike samples
- Duplicates
- Laboratory control samples.

Other validation and assessment techniques include:

- COC review
- 100 percent review of EDD to final data reports
- Check of significant figures reported.

Data validation qualifiers will be assigned and entered into the project database by the QCM or Project Engineer.

Evaluation of field data will be assigned by the QCM and will include reviewing project field notebook and tables or databases for transcription errors and reviewing table and database reduction.

7.3 Data Validation for Representativeness and Comparability

The QCM will assign a person to perform independent data validation for representativeness and comparability, which will have several components.

Basic Checklist: A standard check for simple errors in data handling will inspect data for:

- Typographical (data entry) errors

- Misplaced decimal points

- Detection limits parallel to dilution ratios

- Confusion of zero values, no detectable contaminant, and “no sample taken” notations

- Transposed “total,” “dissolved,” or “extractable” concentrations
- Verification that all data are traceable to a location, date, and analytical technique.

Supportive Information: Must be complete to properly interpret the data and includes:

- Documentation of sampling techniques.

Professional Judgment: A review for data that appear inconsistent with existing regional data and checking that data for possible errors. While this may appear to be a qualitative approach, it is in reality based upon the application of recognized data characteristics. Examples of the application of this approach will include:

- Comparison of data from samples to data from blanks
- Comparison with previous data from same unit/area
- Review relative to sample media and location
- Evaluation of the QC performance criteria against the site-specific ranges the laboratory has demonstrated an ability to achieve.

Data Handling Concepts: Checking the data for the implementation of “standard procedures” that are frequently omitted or misused, regarding:

- Handling outliers (do they represent real values or errors?)
- Interpretation of blanks (do “hits” on specific parameters in field, trip, or lab blanks represent problems with the raw data or other influences on data interpretation?)
- Level of detection (for samples having “less than detectable” values, has the detection level, half the detection level, or zero been used in statistical analyses or has the sample been dropped from the analysis?)

Flags will be used to highlight data that, as a result of the data quality review, appear to be useful for only limited purposes or should be qualified in some way. Flags for specific conditions will be created, incorporated, and defined in the computerized database.

8 References

EPA, 1979. 21 CFR, Part 58 – Good Laboratory Practices. In *Methods for chemical Analysis of Water and Wastes*. U.S. Environmental Protection Agency. EPA-600/4-79-020.

RETEC, 2004. *Field Sampling Plan.* Prepared for Noveon Kalama, Inc. and Rogers Sugar, Ltd., by The RETEC Group, Inc., Seattle, Washington. March 15.

RETEC, 2003. *RETEC Standard Operation Procedure (SOP) 410: Data Assessment.* Prepared by The RETEC Group, Inc., Ft. Collins, Colorado. January 17.

RETEC, 2004. *Cleanup Action Plan.* Prepared for Noveon Kalama, Inc. and Rogers Sugar, Ltd., by The RETEC Group, Inc., Seattle, Washington. March 19.

USEPA, 1991. *Model Quality Assurance Project Plan.* United States Environmental Protection Agency, Office of Superfund, Region V.

USEPA, 1994a. *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*. EPA 540/R-94/013. United States Environmental Protection Agency, Washington, D.C.

Guidelines establishing test procedures for analysis of pollutants under the Clean Water Act. *40 CFR, Part 136.*

Tables

Table 2-1 Detection Limits for Specified Methods

Matrix: Water

Analyte Category	Analysis Method	Detection Limits	Cleanup Levels
Volatile Organics	*8021B*	*(ug/L)*	*(ug/L)*
Benzene		0.06	1.2
Toluene		0.07	2,000
Semivolatile Organics	*8270C SIM*	*(ug/L)*	*(ug/L)*
Benzoic Acid		0.4	24,590
Biphenyl		1	230
bis(2-Ethylhexyl)phthalate		0.5	1.8
Diphenyl Oxide		1	410
Phenol		0.02	2,560
Total Metals		*(mg/L)*	*(mg/L)*
Arsenic	7060A	0.001	0.051
Copper	6010B	0.008	0.115

Matrix: Soil Vapor

Analyte Category	Analysis Method	Detection Limits
Volatile Organics	*8021B*	*(ppmv)*
Benzene		0.02
Toluene		0.05

Matrix: Soil

Analyte Category	Analysis Method	Detection Limits	Cleanup Levels
Volatile Organics	*8260*	*(mg/kg)*	*(mg/kg)*
Benzene		0.005	0.00676
Toluene		0.005	15
Leached Organics	*TCLP*	*(mg/kg)*	*(mg/kg)*
Benzene		0.2	0.5*
Semivolatile Organics	*8270 SIM*	*(mg/kg)*	*(mg/kg)*
Benzoic Acid		0.1	99
Biphenyl		0.001	5.9
bis(2-Ethylhexyl)phthalate		0.001	4.01
Diphenyl Oxide		0.001	15.2
Phenol		0.005	12
Total Metals		*(mg/kg)*	*(mg/kg)*
Arsenic	7060A	0.2	6
Copper	6010B	2	N/A

Table 4-1 Field Sampling Equipment Calibration Frequency

Instrument	Calibration Procedure	Calibration Frequency
Electric water-level proble	*Probe* : test in tap water *Tape* : test against known length	*Probe* : as needed if malfunctions *Tape* : annually
Electric oil/water interface proble	*Probe* : test in liquid to be measured *Tape* : test against known length	*Probe* : at start of site measurements *Tape* : annually
Photo-ionization detector	Test ambient air and then perform a one-point calibration with a known gas.	Daily
pH meter	Two-point calibration with pH buffers 7 and 4 or 10 as appropriate	Daily
Thermometer	Check with standard thermometer	Annually
Conductivity meter	One-point calibration	Daily

Attachment A

Laboratory Documents

QUALITY ASSURANCE MANUAL

for

Columbia Analytical Services, Inc.
1317 South 13th Avenue
Kelso, Washington 98626

February 5, 1999

Approved by:

Laboratory Director: ______________________
Jeff Christian

Quality Assurance Manager: Lee Wolf
Lee Wolf

DOCUMENT CONTROL

NUMBER: ____________

Initials: _____ Date: __________

2.0 TABLE OF CONTENTS

Figures Page

Appendices Page

3.0 INTRODUCTION AND COMPANY QUALITY ASSURANCE POLICY

Columbia Analytical Services, Inc. (CAS) is a professional analytical services laboratory which performs chemical and microbiological analyses on a wide variety of sample matrices, including drinking water, groundwater, surface water, wastewater, soil, sediment, sludge, tissue, industrial and hazardous waste, and other material.

It is a policy at CAS that there will be sufficient Quality Assurance (QA) activities conducted in the laboratory to ensure that all analytical data generated and processed will be scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. This goal is achieved by ensuring that adequate Quality Control (QC) procedures are used throughout the monitoring process, and by establishing a means to assess performance of these Quality Control and other QA activities.

CAS maintains control of analytical results by adhering to written standard operating procedures (SOPs) and by observing sample custody requirements. All analytical results are calculated and reported in units consistent with project specifications to allow comparability of data.

We recognize that quality assurance requires a commitment to quality by everyone in the organization - individually, within each operating unit, and throughout the entire laboratory.

The information in this document has been organized according to the format described in *Interim Guidance for the Preparation of Quality Assurance Project Plans*, QAM-005, USEPA, 1980; and *Guidance on Preparation of Laboratory Quality Assurance Plans*, USEPA, February 14, 1991.

4.0 PROGRAM DESCRIPTION

The purpose of the QA program at CAS is to ensure that our clients are provided with analytical data that is scientifically sound, legally defensible, and of known and documented quality. The concept of Quality Assurance can be extended, and is expressed in the mission statement of CAS:

> "The mission of Columbia Analytical Services, Inc., is to provide high quality, cost-effective, and timely professional testing services to our customers. We recognize that our success as a company is based on our ability to maintain customer satisfaction. To do this requires constant attention to customer needs, maintenance of state-of-the-art testing capabilities and successful management of our most important asset - our people - in a way that encourages professional growth, personal development and company commitment."

In support of this mission, our QA program addresses all aspects of laboratory operations, including laboratory organization and personnel, standard operating procedures, sample management, sample and quality control data, calibration practices, standards traceability data, equipment maintenance records, method proficiency data (such as method detection limit studies and control charts), document control/storage and staff training records.

4.1 Facilities and Equipment

CAS features over 25,000 square feet of laboratory and administrative workspace. The laboratory has been designed and constructed to provide safeguards against cross-contamination of samples and is arranged according to work function, which enhances the efficiency of analytical operations. The ventilation system has been specially designed to meet the needs of the analyses performed in each work space. In addition, the segregated laboratory areas are designed for safe and efficient handling of a variety of sample types.

These specialized areas include:

- Shipping and Receiving/Purchasing
- Sample Management Office (including a separate, controlled-access sample storage facility)
- Inorganic/Metals Sample Preparation Laboratories (2)
- Inorganic/Metals "clean room" sample preparation laboratory
- ICP-AES Laboratory
- ICP-MS Laboratory
- AA Laboratory
- Water Chemistry & General Chemistry Laboratories
- Gas Chromatography Laboratory (including a separate sample preparation laboratory)

- Gas Chromatography/Mass Spectrometry Laboratory (including a separate sample preparation laboratory)
- Petroleum Hydrocarbon Laboratory (including a separate sample preparation laboratory)
- Volatile Organics Laboratory (including a separate sample preparation laboratory)
- Microbiology Laboratory
- Laboratory Deionized Water System
- Laboratory Management, Client Service, Report Generation and Administration
- Data Archival, Data Review and support functions areas
- Information Technology (IT) and LIMS

In addition, the designated areas for sample receiving, refrigerated sample storage, dedicated sample container preparation and shipping provide for the efficient and safe handling of a variety of sample types. Figure 4-1 shows the facility floor plan. The laboratory is equipped with state-of-the-art analytical and administrative support equipment. The equipment and instrumentation is appropriate for the procedures in use. Appendix B lists the major equipment, illustrating the laboratory's overall capabilities and depth.

4.2 Technical Elements of the Quality Assurance Program

The Quality Assurance Program provides a platform on which technical operations are based. The program provides laboratory organization, procedures, and policies by which the laboratory operates. The necessary certifications and approvals administered by external agencies are maintained. This includes method approvals and audit administration. In addition, internal audits are performed to assess compliance with policies and procedures. Standard Operating Procedures (SOPs) are maintained for technical and administrative functions. A document control system is used for SOPs, as well as laboratory notebooks, QAPPs, and this QA Manual. Documentation of analyst training is performed to ensure proficiency and competency of laboratory analysts and technicians.

Acceptable calibration procedures are defined in the SOP for each test procedure. Calibration procedures for other laboratory equipment (balances, thermometers, etc.) are also defined. Quality Control (QC) procedures are used to monitor the testing performed. Each analytical procedure has associated QC requirements to be achieved in order to demonstrate data quality. The use of method detection limit studies, control charting, and preventative maintenance procedures further ensure the quality of data produced. Performance Evaluation (PE) samples are used as an external means of monitoring the quality and proficiency of the laboratory. PE samples are obtained from qualified vendors and are performed on a regular basis. Sample handling and custody procedures are defined in SOPs. Procedures are also in place to monitor the sample storage areas.

The technical elements of the QA program are discussed in further detail in later sections of this QA manual.

4.3 Operational Assessments

There are a number of methods used to assess the laboratory and its daily operations. In addition to the routine quality control (QC) measurements to measure quality, the senior laboratory management staff at CAS examine a number of other performance indicators to assess the overall ability of the laboratory to successfully perform analyses for its clients. On-time performance, Analytical Report defect rate and Customer Invoice defect rate are a few of the measurements performed at CAS that are used to assess performance from an external perspective (i.e., client satisfaction). The use of these and other indicators is outlined in the *SOP for Nonfinancial Performance Measures* (SOP No. ADM-NFPM). A frequent, routine assessment must also be made of the laboratory's facilities and resources in anticipation of accepting an additional or increased workload. CAS utilizes a number of different methods to insure that adequate resources are available in anticipation of the demand for service. Regularly scheduled senior staff meetings, tracking of outstanding proposals and an accurate, current synopsis of incoming work all assist the senior staff in properly allocating resources to achieve the required results.

4.4 Document Control

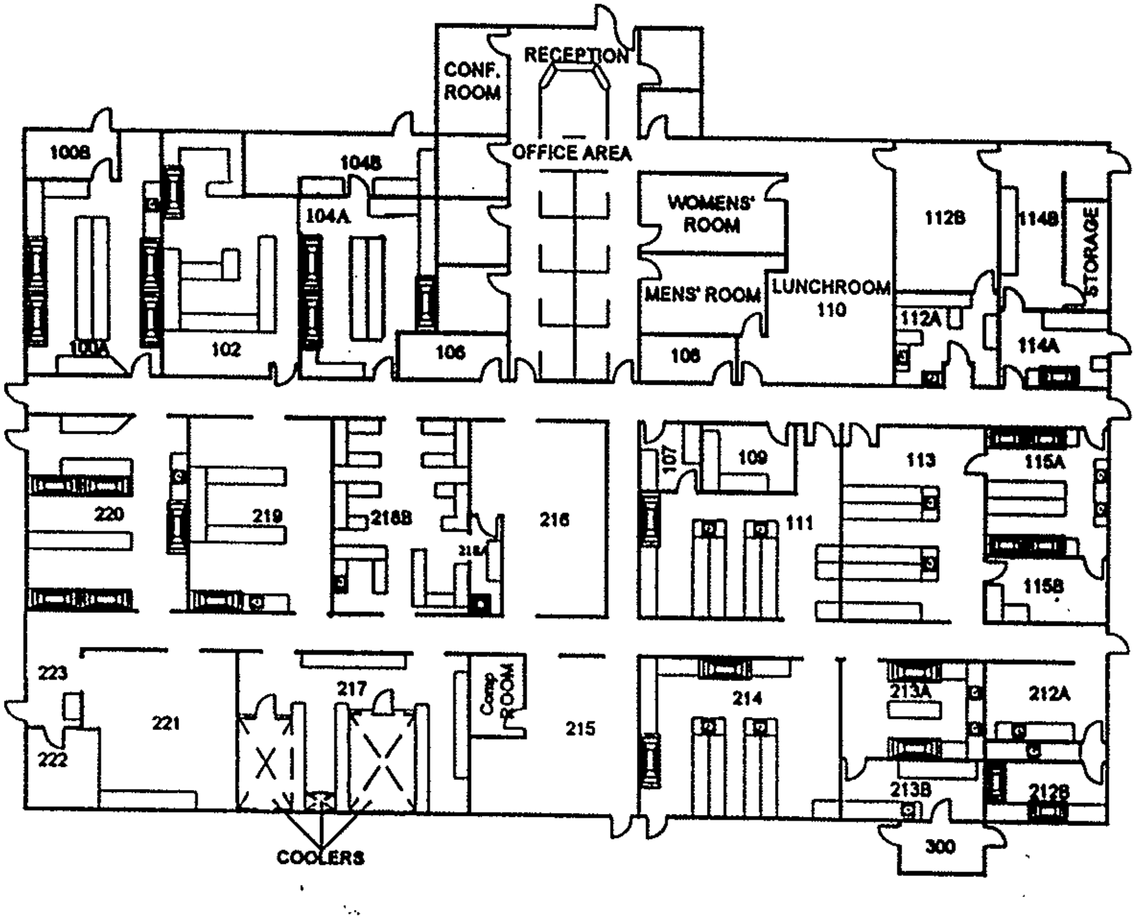
Procedures for control and maintenance of documents are described in the *SOP for Document Control (ADM-DOC_CTRL).* The procedures described in the SOP include distribution, tracking, filing, and copyrighting of CAS controlled documents. The requirements of the SOP apply to all standards preparation logbooks, instrument maintenance logbooks, run logbooks, certificates of analysis, standard operating procedures (SOPs), quality assurance manuals (QAMs), quality assurance project plans (QAPPs), safety manuals (SFM), and other controlled CAS documents.

Each controlled copy of a controlled document will be released only after a document control number is assigned and the recipient is recorded on a document distribution list. Filing and distribution in performed by the Quality Assurance Manager, or designee, and ensure that only the most current version of the document is distributed or is in use. A document control number is assigned to logbooks. Completed logbooks that are no longer in use are archived in a master logbook file.

4.5 Subcontracting

Analytical services are subcontracted when CAS/Kelso needs to balance workload and/or when the requested analyses are not performed by CAS/Kelso. However, subcontracting is only done with the knowledge and approval of the client. Subcontracting to another CAS laboratory is preferred over external-laboratory subcontracting. Further, subcontracting is done to capable and qualified laboratories. Established procedures are used to qualify external subcontract laboratories. These procedures are described in the *SOP for Qualification of Subcontract Laboratories Outside of CAS Network (ADM-SUBLAB).*

Figure 4-1
CAS/Kelso Laboratory Floor Plan



Room Designations

100A Organic Extractions Lab
100B Electrical Room
102 Chromatography Lab
104A Organic Extractions Lab
104B Chromatography Lab
106 Glasswashing Room
107 Oven Room
108 Zero Headspace Extractions Lab
109 Sample Preparation
110 Lunchroom
111 General Chemistry Lab
112A Microbiology Lab
112B Copy Center
113 Atomic Absorption Lab
114A SMO / Receiving
114B SMO / Receiving
115A Metals Digestion Lab
115B ICP Lab
212A ICP / MS Lab
212B Clean Digestion Lab
213A Digestion Lab
213B Sample Preparation
214 General Chemistry Lab
215 IT Department
216 QA /Records
217 Stock Room / Sample Storage
218A VOA Prepration
218B VOA Lab
219 GC/MS Lab
220 Organic Extraction Lab
221 Bottle Preparation Room
222 Purchasing Room
223 General Receiving
300 Janitorial Room

TITLE CAS Kelso Floor Plans	
FILENAME KFLRPLAN.VSD	PAGE 1 OF 2
DATE 9/13/96	DESCRIPTION Laboratory

Legend

▭ Fume Hood
☐ Sink
● Emergency Shower
☐ Sink

5.0 STATEMENT OF PROFESSIONAL CONDUCT AND LABORATORY PRACTICE

One of the most important aspects of the success of CAS as a company is the emphasis placed on the integrity of the data that are provided and the services that are performed. To promote product quality, CAS requires certain standards of conduct and ethical performance among our employees. The following examples of documented CAS policy are representative of these standards, and are not intended to be limiting or all-inclusive:

Under no circumstances is the willful act of fraudulent manipulation of analytical data condoned. Such acts are to be reported immediately to senior management for appropriate corrective action.

Unless specifically required in writing by a client, alteration, deviation or omission of written contractual requirements is not permitted. Such changes must be in writing and approved by senior management.

Falsification of data in any form will not be tolerated. While much analytical data is subject to professional judgment and interpretation, outright falsification, whenever observed or discovered, will be documented, and appropriate remedies and punitive measures will be taken toward those individuals responsible.

It is the responsibility of all CAS employees to safeguard sensitive company and client information. The nature of our business and the economic well-being of our company and of our clients is dependent upon protecting and maintaining proprietary company/client information. All information, data, and reports (except that in the public domain) collected or assembled on behalf of a client is treated as confidential. No information may be given to third parties without the consent of the client. Unauthorized release of confidential information about the company or its clients is taken very seriously and is subject to formal disciplinary action. As a condition of employment, all employees are required to sign and adhere to confidentiality requirements set forth in CAS' "Employee Agreement" at date of hire and upon termination.

At the time of hire, each employee is also required to sign a Commitment to Excellence in Data Quality. Employees are periodically reminded of their data quality and ethical conduct responsibilities.

6.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The CAS/Kelso staff, consisting of approximately 100 employees, includes chemists, technicians and support personnel. They represent diverse educational backgrounds and experience, and provide the comprehensive skills that a modern, state-of-the-art analytical laboratory requires. During seasonal workload increases, additional temporary employees may be hired to perform specific tasks.

CAS is committed to providing an environment that encourages excellence. Everyone within CAS shares responsibility for maintaining and improving the quality of our analytical services. The responsibilities of key personnel within the laboratory are described below. Table 6-1 lists the CAS/Kelso personnel assigned to these key positions. An organizational chart of the laboratory, as well as the resumes of these key personnel, can be found in Appendix A.

- The role of the **Laboratory Director** is to provide technical, operational, and administrative leadership through planning, allocation and management of personnel and equipment resources. The Laboratory Director provides leadership and support for the QA program and is responsible for overall laboratory efficiency and the financial performance of the Kelso facility. The Laboratory Director also provides resources for implementation of the QA program, reviews and approves this QA Manual, reviews and approves standard operating procedures (SOPs), and provides support for business development by identifying and developing new markets through continuing support of the management of existing client activities.

- The responsibility of the **Quality Assurance Manager** (QAM) is to oversee implementation the quality program and to coordinate overall QA activities within the laboratory. The QAM works with individual laboratory production units to establish effective quality control and assessment plans. The QAM is also responsible for maintaining this QA Manual and performing an annual review of it, updating it if necessary; reviewing, approving, and controlling SOPs and coordinating the annual review of each SOP (Section 4.2.1); maintaining QA records such as metrological records, archived logbooks, PE sample results, etc.; coordinating PE sample analyses and approving nonconformity and corrective action reports for any unacceptable PE sample results (Section 15.0); reviewing data (Section 12.0); maintaining the laboratory's certifications and approvals (Section 13.0); performing internal QA audits (Section 13.0); preparing QA activity reports (Section 16.0); etc. The QAM reports directly to the Laboratory Director. The QAM also interacts with the CAS Quality Assurance Director, who is responsible for the CAS laboratory-wide QA program.

  The <u>Quality Assurance Director</u> is responsible for the overall QA program at all the CAS laboratories. The QA Director is responsible for performing an annual on-site audit at each CAS laboratory and preparing a written report; maintaining a data base of information about state certifications and accreditation programs; writing laboratory-wide SOPs; maintaining a data base of CAS-approved subcontract laboratories; providing assistance to the laboratory QA staff and laboratory managers; preparing an annual QA activity report; etc.

- The **Environmental Health and Safety Officer** (EH&S) is responsible for the administration of the laboratory health and safety policies. This includes the formulation and implementation of safety policies, the supervision of new-employee safety training, the review of accidents, incidents and prevention plans, the monitoring of hazardous waste disposal and the conducting of departmental safety inspections. The EH&S officer is also designated as the Chemical Hygiene Officer. The EH&S Officer has a dotted-line reporting responsibility to CAS' EH&S Director.

- The **Client Services and Sample Management Office Manager** is responsible for the Client Services Department (customer services/project chemists, and marketing functions) and the sample management office/bottle preparation sections. The Client Services Department provides a complete interface with clients from initial project specification to final deliverables. The sample management office handles all the activities associated with receiving, storage, and disposal of samples.

- The **Sample Management Office** plays a key role in the laboratory QA program by maintaining documentation for all samples received by the laboratory, and by assisting in the archival of all laboratory results. The sample management office staff is also responsible for the proper disposal of samples after analysis.

- The **Project Chemist** is a senior-level scientist assigned to each client to act as a technical liaison between the client and the laboratory. The project chemist is responsible for ensuring that the analyses performed by the laboratory meet all project, contract, and regulatory-specific requirements. This entails coordinating with the CAS laboratory and administrative staff to ensure that client-specific needs are understood, and that the services CAS provides are properly executed and satisfy the requirements of the client.

- The Analytical Laboratory is divided into operational units based upon specific disciplines. Each department is responsible for establishing, maintaining and documenting a quality control program based upon the unique requirements within that department's responsibilities. Each **Department Manager and Supervisor** has the responsibility to ensure that quality control functions are carried out as planned, and to guarantee the production of high quality data. Department managers and bench-level supervisors have the responsibility to monitor the day-to-day operations to ensure that productivity and data quality objectives are met. Each analyst in the laboratory has the responsibility to carry out testing according to prescribed methods, standard operating procedures and quality control guidelines particular to the laboratory in which he/she is working.

- **Information Technology** (IT) staff are responsible for the administration of the Laboratory Information Management System (LIMS) and other necessary support services. Other functions of the IT staff include laboratory network maintenance, education of analytical staff in the use of scientific software, software development and implementation, Electronic Data Deliverable (EDD) generation, and data back-up, archival and integrity operations.

Table 6-1
Summary of Technical Experience and Qualifications

Personnel	Years of Experience	Project Role
Jeff Christian, B.S.	20	Laboratory Director
Lee Wolf, B.S.	13	Quality Assurance Manager
Eileen Arnold, B.A.	18	Environmental, Health and Safety Officer
Lynda Huckestein, B.S.	13	Senior Project Chemist Client Services Manager Sample Management Office Manager
Joe Wiegel, B.S.	9	Organics Manager Semivolatile GC/LC Dept. Manager
Jeff Coronado, B.S.	9	Metals Department Manager
Greg Jasper, A.A.	10	Metals Digestion Supervisor
Todd Poyfair, B.S.	7	General and Water Chemistry Department Manager
Jeff Grindstaff, B.S.	10	Volatiles and Semivolatiles GC/MS Department Manager
David Edelman, Ph.D.	19	CAS Technical Director, CAS Information Technology Director
Lawrence Jacoby, Ph.D.	26	CAS Quality Assurance Director CAS Environmental, Health and Safety Director
Steve Vincent, B.S.	23	CAS President

7.0 SAMPLING, SAMPLE PRESERVATION, AND HANDLING PROCEDURES

The quality of analytical results is highly dependent upon the quality of the procedures used to collect, preserve and store samples. CAS recommends that clients follow sampling guidelines described in 40 CFR 136, USEPA SW-846, and state-specific sampling guidelines, if applicable. Sample handling factors that must be taken into account to insure accurate, defensible analytical results include:

- Amount of sample taken
- Type of container used
- Type of sample preservation
- Sample storage time
- Proper custodial documentation

CAS uses the sample preservation, container, and holding-time recommendations published in a number of documents. The primary documents of reference are: USEPA SW-846, Third Edition and Updates I, II, IIA, IIB, III for hazardous waste samples, and USEPA 600/4-79-020, 600/4-91-010 and Supplement I, 600/4-82-057, 600/R-93/100, 600/4-88-039 and Supplements I and II, and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples. The complete citation for each of these references can be found in Section 18.0 of this document. The container, preservation and holding time information is summarized in Table 7-1.

CAS routinely provides sample containers with appropriate preservatives for our clients. The containers are purchased as "precleaned" to a level 1 status, and conform to the requirements for analytical sample established by the USEPA. Certificates of analysis for the sampling containers are available to clients if requested. Our sample kits typically consist of foam-lined, precleaned shipping coolers, (decontaminated inside and out with appropriate cleaner, rinsed thoroughly and air-dried), specially prepared and labeled sample containers individually wrapped in protective material, (VOC vials are placed in a specially made, foam holder), chain-of-custody (COC) forms, and custody seals. An example of a sample container label and a custody seal is shown in Figure 7-1. Figure 7-2 is a copy of the chain-of-custody form routinely used at CAS. For large sample container shipments, the containers may be shipped in their original boxes. Such shipments will consist of several boxes of labeled sample containers and sufficient materials (bubble wrap, COC forms, custody seals, shipping coolers, etc.) to allow the sampling personnel to process the sample containers and return them to CAS. The proper preservative will be always be added to the sample containers prior to shipment, unless otherwise instructed by the client. If any returning shipping cooler exhibits an odor or other abnormality after receipt and subsequent decontamination by laboratory personnel, a second, more vigorous decontamination process is employed. Containers exhibiting an odor or abnormality after the second decontamination process are promptly and properly discarded. CAS keeps client-specific shipping requirements on file and utilizes major transportation carriers to guarantee that sample shipping requirements (same-day, overnight, etc.) are met. CAS also provides its own courier service that makes regularly scheduled trips to the Greater Portland, Oregon Metropolitan area.

When environmental samples are shipped by CAS to other laboratories for analysis each sample bottle is wrapped in protective material and placed in a plastic bag (preferably Ziploc®) to avoid any possible cross-contamination of samples during shipping. The sample management office (SMO) follows formalized procedures for maintaining the chain of custody of the sample(s) (*Standard Operating Procedure for Chain of Custody for Sample Transfer between Laboratories* [SOP No. ADM - COC]), proper packaging and shipment, specification of proper methodology, etc. Blue or gel ice is the only temperature preservative used by CAS, unless otherwise specified by the client or receiving laboratory.

Table 7-1
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests				
Coliform, Fecal and Total	W	P,G	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Fecal Streptococci	W	P,G	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Inorganic Tests				
Acidity	W	P,G	Cool, 4°C	14 days
Alkalinity	W	P,G	Cool, 4°C	14 days
Ammonia	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical Oxygen Demand (BOD)	W	P,G	Cool, 4°C	48 hours
Bromide	W	P,G	None Required	28 days
Chemical Oxygen Demand (COD)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	W	P,G	None Required	28 days
Chlorine, Total Residual	W	P,G	None Required	24 hours
Color	W	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	W	P,G	Cool, 4°C, NaOH to pH>12, plus 0.6 g Ascorbic Acid	14 days
Cyanide, Weak Acid Dissociable	W	P,G	Cool, 4°C, NaOH to pH >12	14 days
Fluoride	W	P,G	None Required	28 days
Hardness	W	P,G	HNO_3 to pH<2	6 months
Hydrogen Ion (pH)	W	P,G	None Required	24 hours
Kjeldahl and Organic Nitrogen	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrate	W	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite	W	P,G	Cool, 4°C	48 hours
Orthophosphate	W	P,G	Filter Immediately, Cool, 4°C	48 hours
Oxygen, Dissolved (Probe)	W	G, Bottle and Top	None Required	Analyze immediately
Oxygen, Dissolved (Winkler)	W	G, Bottle and Top	Fix on Site and Store in Dark	8 hours
Phenolics, Total	W	G Only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus, Elemental	W	G Only	Cool, 4°C	48 hours
Phosphorus, Total	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, Total	W	P,G	Cool, 4°C	7 days
Residue, Filterable (TDS)	W	P,G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	W	P,G	Cool, 4°C	7 days
Residue, Settleable	W	P,G	Cool, 4°C	48 hours
Residue, Volatile	W	P,G	Cool, 4°C	7 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Silica	W	P Only	Cool, 4°C	28 days
Specific Conductance	W	P,G	Cool, 4°C	28 days
Sulfate	W	P,G	Cool, 4°C	28 days
Sulfide	W	P,G	Cool, 4°C, Add Zinc Acetate plus Sodium Hydroxide to pH>9	7 days
Sulfite	W	P,G	None Required	24 hours
Surfactants (MBAS)	W	P,G	Cool, 4°C	48 hours
Tannin and Lignin	W	P,G	Cool, 4°C	28 days
Temperature	W	P,G	None Required	Analyze immediately
Turbidity	W	P,G	Cool, 4°C	48 hours
Metals				
Chromium VI	W	P,G	Cool, 4°C	24 hours
Mercury	W	P,G	HNO_3 to pH<2	28 days
	S	P,G	Cool, 4°C	28 days
Metals, except Chromium VI and Mercury	W	P,G	HNO_3 to pH<2	6 months
	S	G, Teflon-Lined Cap	Cool, 4°C	6 months
Organic Tests				
Oil and Grease	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Carbon, Total (TOC)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Halogens, Total (TOX)	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2, No headspace	28 days
Organic Halogens, Adsorbable (AOX)	W	G, Teflon-Lined Cap	Cool, 4°C, HNO_3 to pH<2	6 months
Petroleum Hydrocarbons, Total Recoverable	W	G, Teflon-Lined Cap	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
Petroleum Hydrocarbons, Total	W	G, Teflon-Lined Cap	Cool, 4°C, HCl or H_2SO_4 to pH<2	7 days until extraction; 40 days after extraction
	S	G, Teflon-Lined Cap	Cool, 4°C	14 days until extraction; 40 days after extraction
Petroleum Hydrocarbons, Volatile (Gasoline-Range Organics)	W	G, Teflon-Lined Septum Cap	Cool, 4°C, HCl to pH<2 No Headspace	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C Minimize Headspace	14 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Volatile Organics				
Purgeable Halocarbons	W	G, Teflon-Lined Septum Cap	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace **Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool, 4°C, No Headspace	14 days
	S	G, Teflon-Lined Cap, or 5035[j]	Cool, 4°C, Minimize Headspace	14 days
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE)	W	G, Teflon-Lined Septum Cap	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace **Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool, 4°C, No Headspace	14 days
	S	G, Teflon-Lined Cap, or 5035[j]	Cool, 4°C, Minimize Headspace	14 days
Acrolein, Acrylonitrile, Acetonitrile	W	G, Teflon-Lined Septum Cap	Adjust pH to 4-5, Cool, 4°C, No Headspace	14 days
Semivolatile Organics				
Petroleum Hydrocarbons, Extractable (Diesel-Range Organics)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction
EDB and DBCP	W,S	G, Teflon-Lined Cap	Cool, 4°C, 3 mg $Na_2S_2O_3$, No Headspace	28 days
Alcohols and Glycols	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Phenols	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Phthalate Esters	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Nitrosamines	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Organochlorine Pesticides and PCBs	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction
Nitroaromatics and Cyclic Ketones	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

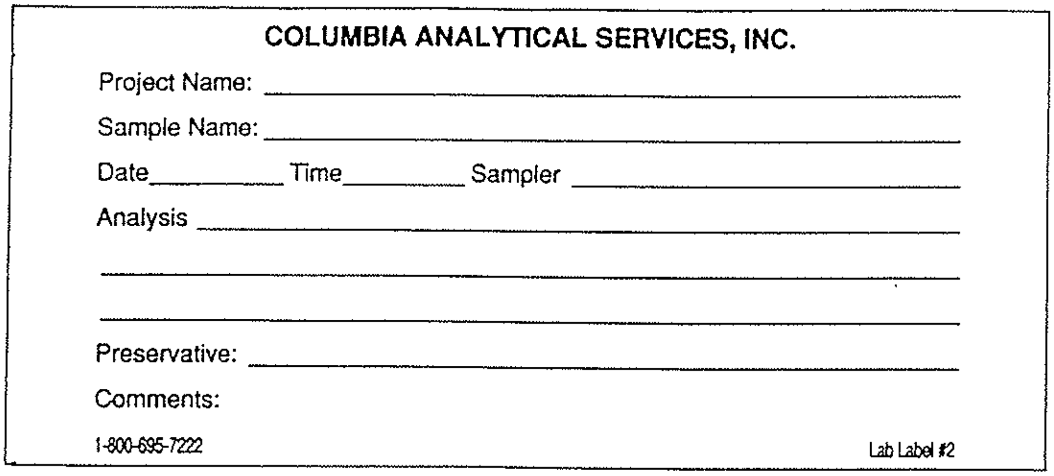
DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Polynuclear Aromatic Hydrocarbons	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Haloethers	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Hydrocarbons	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Organophosphorus Pesticides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Nitrogen- and Phosphorus-Containing Pesticides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Herbicides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Phenolics	W	G, Teflon-Lined Cap	H_2SO_4 to pH<2, Cool, 4°C[g]	30 days until extraction; 30 days after extraction
Resin and Fatty Acids	W	G, Teflon-Lined Cap	NaOH to pH ≥10, Cool, 4°C[g]	30 days until extraction; 30 days after extraction
Toxicity Characteristic Leaching Procedure (TCLP)				
Mercury	HW	P,G	Sample: Cool, 4°C TCLP extract: HNO_3 to pH<2	28 days until extraction; 28 days after extraction
Metals, except Mercury	HW	P,G	Sample: Cool, 4°C TCLP extract: HNO_3 to pH<2	180 days until extraction; 180 days after extraction
Volatile Organics	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C Minimize Headspace TCLP extract: Cool, 4°C, HCl to pH<2, No Headspace	14 days until extraction; 14 days after extraction
Semivolatile Organics	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C, Store in Dark[g] TCLP extract: Cool, 4°C, Store in Dark[g]	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Organochlorine Pesticides	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C TCLP extract: Cool, 4°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction
Chlorinated Herbicides	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C TCLP extract: Cool, 4°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction
Contract Laboratory Program (CLP)				
Cyanide, Total and Amenable to Chlorination	W	P,G	Cool, 4°C, NaOH to pH 12, plus 0.6 g Ascorbic Acid	12 days[h]
	S	P,G	Cool, 4°C	12 days[h]
Mercury	W	P,G	HNO_3 to pH<2	26 days[h]
	S	P,G	Cool, 4°C	26 days[h]
Metals, except Mercury	W	P,G	HNO3 to pH<2	6 months[h]
	S	P,G	Cool, 4°C	6 months[h]
Volatile Organics	W	G, Teflon-Lined Cap	HCl to pH <2, Cool, 4°C, Minimize Headspace	10 days[h]
	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	10 days[h]
Semivolatile Organics	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	5 days until extraction;[h,i] 40 days after extraction
Organochlorine Pesticides and PCBs	W,S	G, Teflon-Lined Cap	Cool, 4°C	5 days until extraction;[h,i] 40 days after extraction

a See Section 18.0 for sources of holding time information.
b W = Water; S = Soil or Sediment; HW = Hazardous Waste
c P = Polyethylene; G = Glass
d For chlorinated water samples
e The recommended maximum holding time is variable, and is dependent upon the geographical proximity of sample source to the laboratory.
f Fourteen days until extraction for soil, sediment, and sludge samples.
g If the water sample contains residual chlorine, 10% sodium thiosulfate is used to dechlorinate.
h Number of days following sample receipt at the laboratory.
i Ten days until extraction for soil, sediment, and sludge samples.
j For EPA Method 5035, refer to the method for details on sampling and preservation.

Figure 7-1
Sample Container Label and Custody Seal



COLUMBIA ANALYTICAL SERVICES, INC.

Project Name: ______________________________

Sample Name: ______________________________

Date__________ Time_________ Sampler ________________

Analysis ______________________________

____

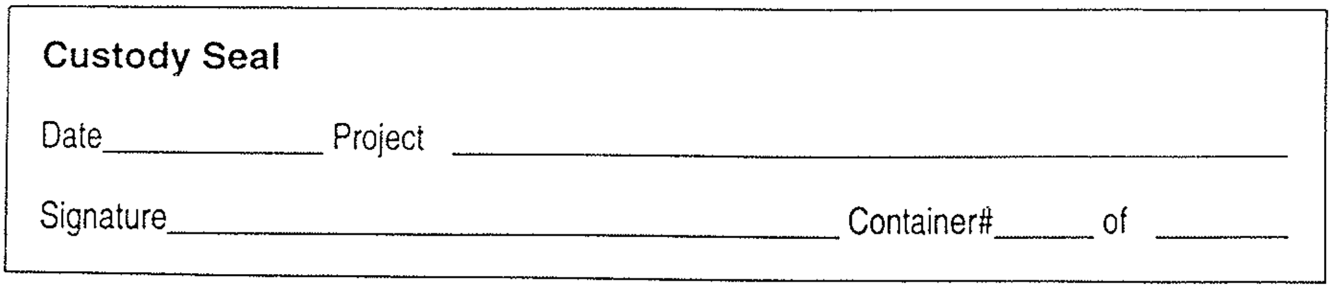
____

Preservative: ______________________________

Comments:

1-800-695-7222

Lab Label #2

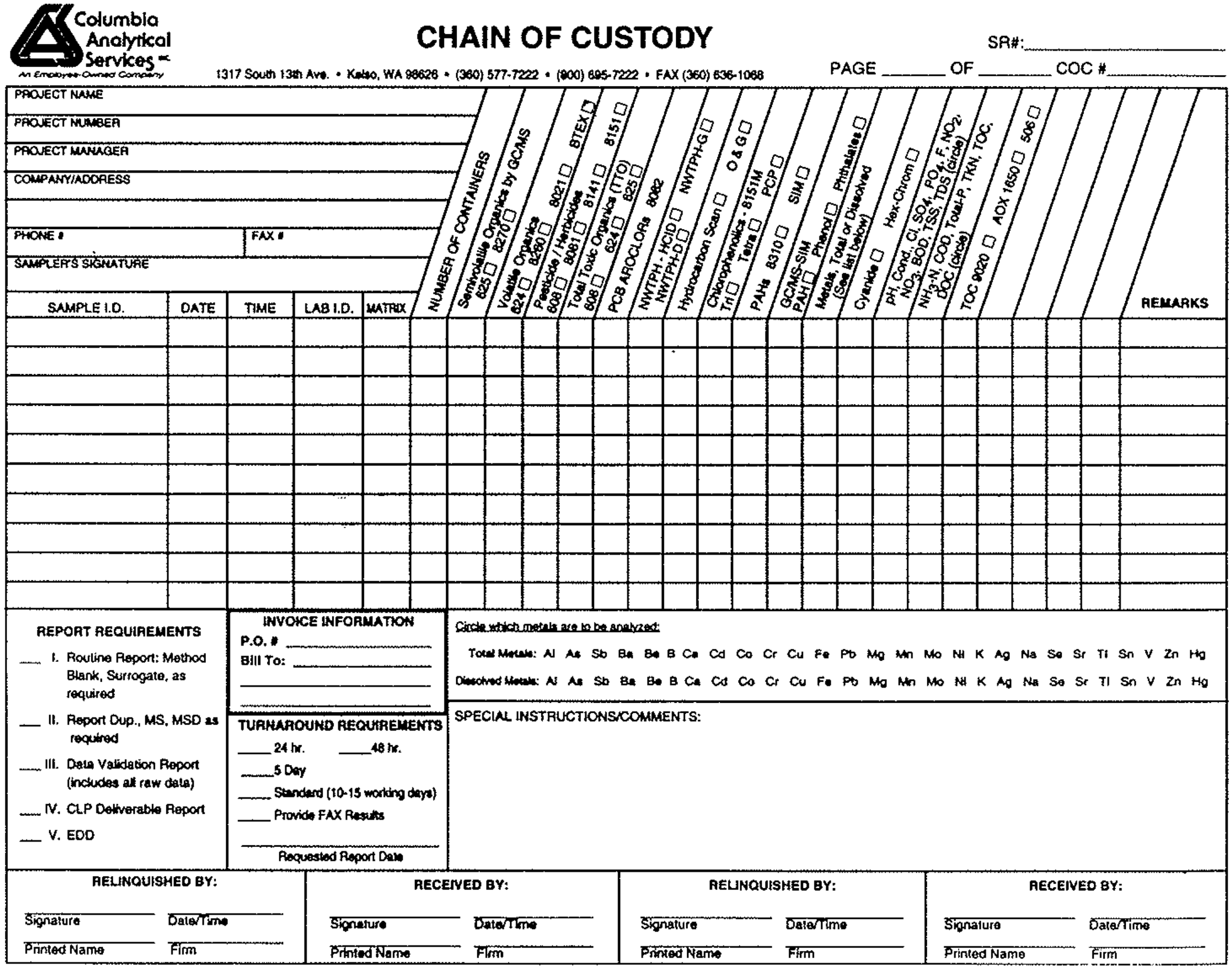


Custody Seal

Date_____________ Project ______________________________

Signature______________________________ Container#______ of ________

Figure 7-2
Chain of Custody Form



Columbia Analytical Services inc.
An Employee-Owned Company

CHAIN OF COUSTODY

1317 South 13th Ave. • Kelso, WA 98626 • (360) 577-7222 • (800) 695-7222 • FAX (360) 636-1068

SR#: ____________

PAGE ______ OF ______ COC #____________

PROJECT NAME
PROJECT NUMBER
PROJECT MANAGER
COMPANY/ADDRESS

PHONE # | FAX #
SAMPLER'S SIGNATURE

SAMPLE I.D.	DATE	TIME	LAB I.D.	MATRIX	NUMBER OF CONTAINERS	Semivolatile Organics by GCMS 625 ☐ 8270 ☐	Volatile Organics 624 ☐ 8260 ☐ 8021 ☐	Pesticide / Herbicides 608 ☐ 8081 ☐ 8141 ☐ BTEX ☐	Total Toxic Organics (TTO) 608 ☐ 624 ☐ 625 ☐ 8151 ☐	PCB AROCLORs 8082	NWTPH - HCID ☐ NWTPH-D ☐ NWTPH-G ☐	Hydrocarbon Scan ☐ O & G ☐	Chlorophenolics - 8151M Tri ☐ Tetra ☐ PCP ☐	PAHs 8310 ☐ SIM ☐	GCMS-SIM PAH ☐ Phenol ☐ Phthalates ☐	Metals, Total or Dissolved (See list below)	Cyanide ☐ Hex-Chrom ☐	pH, Cond., Cl, SO4, PO4, F, NO_2, NO_3, BOD, TSS, TDS (circle)	NH_3-N, COD, Total-P, TKN, TOC, DOC (circle)	TOC 9020 ☐ AOX 1650 ☐ 506 ☐					REMARKS

REPORT REQUIREMENTS

___ I. Routine Report: Method Blank, Surrogate, as required
___ II. Report Dup., MS, MSD as required
___ III. Data Validation Report (includes all raw data)
___ IV. CLP Deliverable Report
___ V. EDD

INVOICE INFORMATION

P.O. # ____________
Bill To: ____________

TURNAROUND REQUIREMENTS

____ 24 hr. ____ 48 hr.
____ 5 Day
____ Standard (10-15 working days)
____ Provide FAX Results

____
Requested Report Date

Circle which metals are to be analyzed:

Total Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature Date/Time	Signature Date/Time	Signature Date/Time	Signature Date/Time
Printed Name Firm	Printed Name Firm	Printed Name Firm	Printed Name Firm

8.0 SAMPLE CUSTODY

Standard Operating Procedures have been established for the receiving of samples into the laboratory. These procedures ensure that samples are received and properly logged into the laboratory, and that all associated documentation, including chain of custody forms, is complete and consistent with the samples received. Complete documentation of all sample storage is maintained in order to preserve the integrity of the samples.

Samples delivered to the CAS sample management office (SMO) and are received by a Sample Custodian. A Cooler Receipt and Preservation Check Form (CRF - See Figure 8-1 for an example) is used to assess the shipping cooler and its contents as received by the laboratory personnel. Verification of sample integrity by the Sample Custodian includes the following activities:

- Assessment of custody seal presence/absence, location and signature;
- Temperature of sample containers upon receipt;
- Chain of custody documents properly used (entries in ink, signature present, etc.);
- Sample containers checked for integrity (broken, leaking, etc.);
- Sample is clearly marked and dated (bottle labels complete with required information);
- Appropriate containers (size, type) are received for the requested analyses;
- Sample container labels and/or tags agree with chain of custody entries (identification, required analyses, etc.);
- Assessment of proper sample preservation (if inadequate, corrective action is employed); and
- VOC containers are inspected for the presence/absence of bubbles. (No assessment of proper preservation is performed for VOC containers by SMO personnel).

Any anomalies or discrepancies observed during the initial assessment are recorded on the CRF and chain of custody documents. All potential problems with a sample shipment are addressed by contacting the client and discussing the pertinent issues. When a satisfactory resolution has been reached by the Project Chemist and client, the log-in process may commence and analysis may begin. During the log-in process, each sample is given a unique laboratory code and a service request form is generated. The service request contains client information, sample descriptions, sample matrix information, required analyses, sample collection dates, analysis due dates and other pertinent information. This service request is reviewed by the appropriate Project Chemist for accuracy, completeness, consistency of requested analyses and for client project objectives.

Facility security and access is important in maintaining the integrity of samples received at CAS/Kelso. Access to the laboratory facility is limited by use of locked exterior doors with a coded entry, except for the reception area and sample receiving doors, which are manned during business hours and locked at all other times. In addition, the sample storage area within the laboratory is a controlled access area with locked doors with a coded entry. The CAS facility is equipped with an alarm system and CAS employs a private security firm to provide night-time and weekend security.

Samples are kept refrigerated until they undergo analysis, unless otherwise specified. CAS stores samples in one of nine various refrigerators or freezers, depending on the type of analysis and the matrix of the sample. CAS has two walk-in refrigerators which house the majority of sample containers received at the laboratory. In addition to the two walk-in refrigerators, there are three additional refrigerators, including dedicated refrigerated storage of VOC samples. These refrigerators are segregated by matrix type (soil or water) and method of analysis. CAS also has three sub-zero freezers capable of storing samples at -20° C; these are primarily used for tissue and sediment samples requiring specialized storage conditions. One additional freezer provides additional frozen storage capacity for miscellaneous samples. The temperature of each sample storage unit used at CAS is monitored daily and the data recorded in a bound logbook. Continuous-graph temperature recorders have also been placed in the two walk-in refrigerators to provide a permanent record of the storage conditions to which samples are exposed.

Upon completion of all analyses, aqueous samples and sample extracts are retained at ambient temperature on holding shelves for 30 days (unless other arrangements have been made in advance), and soil samples are retained at ambient temperature on holding shelves for 60 days. Upon expiration of these time limits, the samples are either returned to the client or disposed of according to approved disposal practices. All samples are characterized according to hazardous/non-hazardous waste criteria and are segregated accordingly. All hazardous waste samples are disposed of according to formal procedures outlined in the *CAS Health and Safety Manual.* It should be noted that all waste produced at the laboratory, including the laboratory's own various hazardous waste streams, is treated in accordance with all applicable local and Federal laws. Documentation is maintained for each sample from initial receipt through final disposal. This ensures that an accurate history of the sample from "cradle to grave" is generated.

Figure 8-1
Cooler Receipt and Preservation Check Form

Columbia Analytical Services Inc.
Cooler Receipt And Preservation Form

Project/Client________________________ Work Order K99______________

Cooler received on________ and opened on ________ by ________________________

1. Were custody seals on outside of cooler? YES NO
   If yes, how many and where?______________
2. Were seals intact and signature & date correct? YES NO
3. COC #

COC #					
Temperature of cooler(s) upon receipt:					
Temperature Blank:					

4. Were custody papers properly filled out (ink, signed, etc.)? YES NO
5. Type of packing material present ______________________________
6. Did all bottles arrive in good condition (unbroken)? YES NO
7. Were all bottle labels complete (*i.e.* analysis, preservation, etc.)? YES NO
8. Did all bottle labels and tags agree with custody papers? YES NO
9. *Were the correct types of bottles used for the tests indicated? YES NO*
10. Were all of the preserved bottles received at the lab with the appropriate pH? YES NO
11. Were VOA vials checked for absence of air bubbles, and if present, noted below? YES NO
12. Did the bottles originate from CAS/K or a branch laboratory? ______________ YES NO

Explain any discrepancies____

<u>Samples that required preservation or received outside of temperature range at the lab(circle)</u>

Sample ID	Reagent	Volume	Lot Number	Initials

9.0 QUALITY CONTROL OBJECTIVES (PRECISION, ACCURACY, AND MDLS)

A primary focus of Columbia Analytical Services Quality Assurance (QA) Program is to ensure the accuracy, precision and comparability of all analytical results. CAS has established Quality Control (QC) objectives for precision and accuracy that are used to determine the acceptability of the data that is generated in its laboratories. These QC limits are either specified in the methodology or are statistically derived based on the laboratory's actual historical data obtained from control-charting the various QC measurements for each analytical method. The Quality Control objectives are defined below and the numeric values are shown in the table in Appendix C.

9.1 Accuracy

Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of standard reference materials, standard solutions and laboratory-fortified blanks. In addition, laboratory-fortified (i.e. matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (% REC.) of the measured value, relative to the true or expected value.

If a measurement process produces results whose mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination). CAS utilizes several quality control measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement

9.2 Precision

Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis. The American Society of Testing and Materials (ASTM) recognizes two levels of precision: repeatability - the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory, with the same apparatus, under constant operating conditions, and reproducibility - the random error associated with measurements made by different test operators, in different laboratories, using the same method but different equipment to analyze identical samples of test material.

At CAS, our "within-batch" precision is measured through the use of replicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the replicate measurements. The "batch-to-batch" precision is calculated from the variance observed in results from analysis of standard solutions or laboratory control samples from multiple analytical batches.

9.3 Control Limits

The acceptance limits for accuracy and precision (shown in the table in Appendix C) originate from two different sources: For analyses having enough QC data, control limits are calculated at the 99% confidence limits. New control limits are generated using the data generated in the previous year. After review of the data by the Quality Assurance Manager, the new acceptance criteria replace the previous criteria and method conformity is assessed using the new values. For analyses not having enough QC data, or where the method is prescriptive, control limits are taken from the method on which the procedure is based. If the method does not have control limits stated in it, then control limits are assigned reasonable values. These control limits are updated when new statistical limits are generated for the appropriate surrogate, laboratory control sample, and matrix spike compounds (typically once a year) or when method prescribed limits change.

The acceptance limits for accuracy and precision shown in the table in Appendix C are given for the following QC samples: For accuracy limits, the values listed are for laboratory control samples. For inorganics, the precision limit values listed are for laboratory duplicates. For organics, the precision limit values listed are for duplicate laboratory control samples or duplicate matrix spike analyses.

9.4 Representativeness

Representativeness is the degree to which the field sample represents the overall sample site or material. This can be extended to the sample itself, in that representativeness is the degree to which the subsample that is analyzed gives results identical to analysis of the entire field sample. CAS has sample handling procedures and protocols to ensure that the sample used for analysis is representative of the entire sample. These include the *SOP for Sample Preparation, Compositing, and Subsampling*, the *SOP for Solid Sample Preparation*, and the *SOP for Tissue Sample Preparation*. Further, analytical SOPs specify appropriate sample handling and sample sizes to further ensure the sample aliquot that is analyzed is representative in entire sample.

9.5 Completeness

Completeness is a measure of the amount of valid data that is obtained, compared to the amount that is expected. For the purposes of this plan, completeness is calculated by dividing the number of samples having valid data by the total number of samples in the project, expressed as a percentage. The CAS objective for completeness is 100%.

9.6 Comparability

Comparability expresses the confidence with which one data set can be compared to another. To ensure comparability, standard operating procedures are used for the preservation, handling, and analysis of all samples. Data is reported in units specified by the customer.

9.7 Method Detection Limits

Method Detection Limits (MDL) for analytical methods routinely performed at CAS/Kelso are determined annually. The MDLs are determined by following the *Standard Operating Procedure for the Determination of Method Detection Limits* (SOP No. ADM - MDL) which is based on the procedure outlined in 40 CFR Part 136, Appendix B. The Method Reporting Limits (MRLs) used at CAS are the routinely reported lower limits of quantitation which take into account day-to-day fluctuations in instrument sensitivity as well as other factors. These MRLs are the levels to which CAS routinely reports results in order to minimize false positive or false negative results. The MRL is normally two to ten times the method detection limit.

10.0 QUALITY CONTROL PROCEDURES

The specific types, frequencies, and processes for quality control sample analysis are described in detail in method-specific standard operating procedures. These sample types and frequencies have been adopted for each method and a definition of each type of QC sample is provided below. In addition, a number of other quality control processes which may impact analytical results are also described below.

10.1 Standard Operating Procedures (SOPs) and Laboratory Notebooks.

CAS maintains a database of SOPs for use in both technical and administrative functions. SOPs are written following the format and content requirements described in the *SOP for Preparation of Standard Operating Procedures* (SOP No. ADM-SOP). Each SOP has been reviewed and approved by a minimum of two managers (the Laboratory Director and/or Department Manager and the Quality Assurance Manager). All SOPs undergo a documented annual review to make sure current practices are described. A comprehensive list of current SOPs is maintained by the QA Manager. The document control process ensures that only the most currently prepared version of an SOP is being used for guidance and instruction. The QA Manual, QAPPs, SOPs, standards preparation logbooks, run logbooks, et al., are controlled documents. The procedures for document control are described in the *SOP for Document Control* (SOP No. ADM-DOC_CTRL). In addition to SOPs, each laboratory department maintains a current file, accessible to all laboratory staff, of the promulgated methodology used to perform analyses. Laboratory notebook entries have been standardized following the guidelines in the *Making Entries into Logbooks and onto Benchsheets* SOP (SOP No. ADM-DATANTRY). The entries made into laboratory notebooks are reviewed and approved by the appropriate supervisor at a regular interval (e.g., weekly, monthly, etc.).

10.2 Deviation from Standard Operating Procedures

When a customer requests a modification to an SOP (such as a change in reporting limit, addition or deletion of target analyte(s), etc.), the project chemist handling that project must discuss the proposed deviation with the department manager in charge of the analysis and obtain their approval to accept the project. The project chemist is responsible for documenting the approved or allowed deviation from the standard operating procedure by placing a detailed description of the deviation attached to the quotation or in the project file and also providing an appropriate comment on the service request when the samples are received.

For circumstances when a deviation or departure from company policies or procedures involving any non-technical function is found necessary, approval must be obtained from the appropriate supervisor, manager, the laboratory director, or other level of authority.

Frequent departure from policy is not encouraged. However, if frequent departure from any policy is noted, the possible need for a change in policy will be addressed by the laboratory director.

10.3 Modified Procedures

CAS strives to perform published methods as described in the referenced documents. If there is a material deviation from the published method, the method is cited as a "Modified" method in the analytical report. Modifications to the published methods are listed in the standard operating procedure. Standard operating procedures are available to analysts and are also available to our clients for review, especially those for "Modified" methods. Client approval is obtained for the use of "Modified" methods prior to the performance of the analysis.

10.4 Analytical Batch

The basic unit for analytical quality control is the analytical batch. The definition that CAS has adopted for the analytical batch is listed below. The overriding principle for describing an analytical batch is that all the samples in a batch, both field samples and quality control samples, are to be handled exactly the same way, and all of the data from each analysis is to be manipulated in exactly the same manner.

The minimum requirements of an analytical batch are:

1. The number of (field) samples in a batch is not to exceed 20.
2. All (field) samples in a batch are of the same matrix.
3. The QC samples to be processed with the (field) samples include:
    a. Method Blank (a.k.a. Laboratory Reagent Blank)
    Function: Determination of laboratory contamination.
    b. Laboratory Control Sample (a.k.a. Laboratory Fortified Blank)
    Function: Assessment of method performance
    c. Matrix Spiked (field) Sample (a.k.a. Laboratory Fortified Sample Matrix)
    Function: Assessment of matrix problems
    NOTE: A sample identified as a field blank, an equipment blank, or a trip blank is not to be matrix spiked.

d. Duplicate Matrix Spiked (field) Sample or Duplicate (field) Sample (a.k.a. Laboratory Duplicate)

Function: Assessment of batch precision

NOTE: A sample identified as a field blank, an equipment blank, or a trip blank is not to be duplicated.

4. A single lot of reagents is used to process the batch of samples.

5. Each operation within the analysis is performed by a single analyst/technician/chemist, or by a team of analysts/technicians/chemists.

6. The time frame is not to exceed a 24 hour period. "Open batches" extending over more than one 24 hour period are not allowed.

7. (Field) samples are assigned to batches commencing at the time that sample processing begins. For example: for analysis of metals, sample processing begins when the samples are digested. For analysis of organic constituents, it begins when the samples are extracted.

8. The QC samples are to be analyzed in conjunction with the associated field samples prepared with them. However, for tests which have a separate sample preparation step that defines a batch (digestion, extraction, etc.), the QC samples in the batch do not require analysis each time a field sample within the preparation batch is analyzed (multiple instrument sequences to analyze all field samples in the batch need not include re-analyses of the QC samples).

9. Batch QC refers to the QC samples that are analyzed in a batch of (field) samples.

10. Specific project, program, or method SOP requirements may be exceptions. If project, program, or method SOP requirements are more stringent than these laboratory minimum requirements, then the project, program, or method SOP requirements will take precedence. However, if the project, program, or method SOP requirements are less stringent than these laboratory minimum requirements, these laboratory minimum requirements will take precedence.

10.5 Method Blank (a.k.a. Laboratory Reagent Blank)

The method blank is either analyte-free water or analyte-free soil (when available), subjected to the entire analytical process. When analyte-free soil is not available, anhydrous sodium sulfate, organic-free sand, or an acceptable substitute may be used instead. The method blank is analyzed to demonstrate that the analytical system itself is not contaminated with the analyte(s) being measured. The method blank results should be below the Method Reporting Limit

(MRL) or, if required, the Method Detection Limit (MDL) for the analyte(s) being tested, otherwise, corrective action must be taken. A method blank is included with the analysis of every analytical batch, every 20 samples, or as stated in the method, whichever is more frequent.

10.6 Calibration Blanks

For some methods, calibration blanks are prepared along with calibration standards in order to create a calibration curve. Calibration blanks are free of the analyte of interest and, where applicable, provide the zero point of the calibration curve.

10.7 Continuing Calibration Blanks

Continuing calibration blanks (CCBs) are solutions of either analyte-free water, reagent, or solvent that are analyzed in order to verify the system is contamination-free when CCV standards are analyzed. The frequency of CCB analysis is either once every ten samples or as indicated in the method, whichever is greater.

10.8 Calibration Standards

Calibration standards are solutions of known concentration prepared from primary standard solutions which are, in turn, prepared from stock standard materials. Calibration standards are used to calibrate the instrument response with respect to analyte concentration. Standards are analyzed in accordance with the requirements stated in the particular method being used.

10.9 Initial (or Independent) Calibration Verification Standards

Initial (or independent) calibration verification standards (ICVs) are standards that are analyzed *after* calibration with newly prepared standard(s) but *prior to* sample analysis, in order to verify the validity of the standards used in the calibration. Once it is determined that there is no systematic error in preparation of the calibration standard(s), they are considered valid standards and may be used for subsequent calibrations (as expiration dates and methods allow). The ICV standards are prepared from materials obtained from a source independent of that used for preparing the calibration standards. ICVs are also analyzed in accordance with method-specific requirements.

10.10 Continuing Calibration Verification Standards

Continuing calibration verification standards (CCVs) are midrange standards that are analyzed in order to verify that the calibration of the analytical system is still acceptable. The frequency of CCV analysis is either once every ten samples, or as indicated in the method.

10.11 Internal Standards

Internal standards consist of known amounts of specific compounds that are added to each sample following sample preparation or extraction. Internal standards are generally used for GC/MS and ICP-MS procedures to correct sample results that have been affected by changes in instrument conditions or changes caused by certain matrix effects. The integrated area of the internal standard compared to the continuing calibration check standard should vary by no more than the limits specified in each method.

10.12 Surrogates

Surrogates are organic compounds which are similar in chemical composition and chromatographic behavior to the analytes of interest, but which are not normally found in environmental samples. Depending on the analytical method, one or more of these compounds is added to method blanks, calibration and check standards, and samples (including duplicates, matrix spike samples, duplicate matrix spike samples and laboratory control samples) prior to extraction and analysis in order to monitor the method performance on each sample. The percent recovery is calculated for each surrogate, and the recovery is a measurement of the overall method performance. The acceptance criteria for these various analytes are listed in Appendix C, along with other data quality capabilities.

10.13 Matrix Spikes (a.k.a. Laboratory Fortified Sample Matrix)

Matrix spiked samples are aliquots of samples to which a known amount of the target analyte (or analytes) has been added. The samples are then prepared and analyzed in the same analytical batch, and in exactly the same manner as are routine samples. The stock solutions used for spiking the sample(s) are purchased and prepared independently of calibration standards. The spike recovery measures the effects of interferences caused by the sample matrix and reflects the accuracy of the method for the particular matrix in question. Spike recoveries are calculated as follows:

$$Recovery\ (\%) = (S - A) \times 100 \div T$$

Where: S = The observed concentration of analyte in the spiked sample,
A = The analyte concentration in the original sample, and
T = The theoretical concentration of analyte added to the spiked sample.

For the appropriate methods, matrix spiked samples are prepared and analyzed at a minimum frequency of one spiked sample (and one duplicate spiked sample, if appropriate) per twenty samples.

10.14 Laboratory Duplicates and Duplicate Matrix Spikes

Duplicates are additional replicates of samples that are subjected to the same preparation and analytical scheme as the original sample. Depending on the method of analysis, either a duplicate analysis (and/or a matrix spiked sample) or a matrix spiked sample and duplicate matrix spiked sample (MS/DMS) are analyzed. The relative percent difference between duplicate analyses or between an MS and DMS is a measure of the precision for a given method and analytical batch. The relative percent difference (RPD) for these analyses is calculated as follows:

$$\text{Relative Percent Difference (RPD)} = (S1 - S2) \times 100 \div S_{ave}$$

Where S1 and S2 = The observed concentrations of analyte in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike, and

S_{ave} = The average of observed analyte concentrations in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike.

Depending on the method of analysis, either duplicates (and/or matrix spikes) or MS/DMS analyses are performed at a minimum frequency of one set per 20 samples.

10.15 Laboratory Control Samples (a.k.a. Laboratory Fortified Blanks or Quality Control Samples)

The laboratory control sample (LCS) is an aliquot of analyte-free water or analyte-free soil (or anhydrous sodium sulfate or equivalent) to which known amounts of the method analyte(s) is(are) added. A standard reference material (SRM) of known matrix type, containing certified amounts of target analytes, may also be used as an LCS. The LCS sample is prepared and analyzed in the same analytical batch, and in exactly the same manner, as the other routine samples. Stock solutions used for LCSs are purchased or prepared independently of calibration standards. The percent recovery (% REC.) of the target analytes in the LCS assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy. Acceptance criteria for LCS analyses are obtained through the use of control charts. An LCS is prepared and analyzed at a minimum frequency of one LCS per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent.

If an insufficient quantity of sample is available to perform a laboratory duplicate or duplicate matrix spikes, duplicate LCSs will be prepared and analyzed.

10.16 Interference Check Samples

An interference check sample (ICS) is a solution containing both interfering and analyte elements of known concentration that can be analyzed to verify background and interelement correction factors in metals analyses. The ICS is prepared to contain known concentrations of interfering elements that will provide an adequate test of the correction factors. The ICS is spiked with the elements of interest at concentrations of approximately ten times the instrument detection limits. The ICS is analyzed at the beginning and end of an analytical run or every eight hours, whichever is more frequent, and the results must be within ± 20% of the true values.

10.17 Post Digestion Spikes

Post digestion spikes are samples prepared for metals analyses that have an analyte spike added to determine if matrix effects may be a factor in the results. The spike addition should produce a method-specified minimum concentration above the instrument detection limit. A post digestion spike is analyzed with each batch of samples and recovery criteria are specified for each method.

10.18 Source and Preparation of Standard Reference Materials

All analytical measurements generated at CAS are performed using materials and/or processes that are traceable to a Standard Reference Material (SRM). Metrology equipment (analytical balances, thermometers, etc.) is calibrated using SRMs traceable to the National Institute of Standards and Technology (NIST). These primary SRMs are themselves recertified on an annual basis. All sampling containers provided to the client by the laboratory are purchased as precleaned (Level 1) containers, with certificates of analysis available for each bottle type (see Section 7.0). This information is provided to the client when requested.

Consumable SRMs routinely purchased by the laboratories (e.g., analytical standards) are purchased from nationally-recognized, reputable vendors. All vendors have fulfilled the requirements for ISO 9001 certification and/or are accredited by A_2LA. CAS relies on a primary vendor for the majority of its analytical supplies; the selection of this vendor is made following the guidelines in the *Primary Vendor Process* SOP, (SOP No. ADM-PVP). In addition, consumable primary stock standards are obtained from certified commercial sources or from sources referenced in a specific method. Supelco, Ultra Scientific, AccuStandard, Chem Services, Inc., Aldrich Chemical Co., Baker, Spex, E. M. Science, etc. are examples of the vendors used by CAS. All reference materials that are received at CAS are recorded by the technical staff in the appropriate notebook(s) and are stored under conditions that provide maximum protection against deterioration and contamination. The notebook entry includes such information as an assigned logbook identification code, the source of the material (i.e. vendor identification), solvent (if applicable) and concentration of analyte(s), reference to the certificate of analysis and an assigned expiration date. In addition, the date that the standard is received in the laboratory is marked on the container. When the SRM container is used for the first time, the date of usage and the initials of the applicable technician are also recorded on the container. Stock solutions and/or calibration standard solutions are prepared fresh as often as necessary according to their stability. After preparation, all standard solutions are properly labeled as to analyte concentration, solvent, date, preparer, and expiration date; these entries are also recorded in the appropriate notebook(s) following the *SOP for Making Entries into Logbooks and onto Benchsheets* (SOP No. ADM-DATANTRY). Prior to introduction into the analytical system/process, **all** reference materials are verified with a second, independent source of the material (see section 10.9 above). Once the reference material has been verified to be accurate, it may then be used for instrument calibration and subsequent quantitative purposes. In addition, the independent source of reference material is also used to check the calibration standards for signs of deterioration.

10.19 Control Charting

The generation of control charts is routinely performed at CAS. Surrogate, Matrix Spike and LCS recoveries are all monitored and charted. In addition, the laboratory also monitors the Relative Percent Difference (RPD) measurement of precision. Control charts are available to each individual laboratory unit to monitor the data generated in its facility using control charts which have been programmed to identify various trends in the analytical results. If trends in the data are perceived, various means of corrective action may then be employed in order to prevent future problems with the analytical system(s). Finally, data quality reports using control charts are generated for specific clients and projects pursuant to contract requirements.

10.20 Glassware Washing

Glassware washing and maintenance play an crucial role in the daily operation of a laboratory. The glassware used at CAS undergoes a rigorous cleansing procedure prior to every usage. A number of SOPs have been generated that outline the various procedures used at CAS; each is specific to the end-use of the equipment as well as to the overall analytical requirements of the project. In addition, other equipment that may be routinely used at the laboratory is also cleaned following instructions in the appropriate SOP.

11.0 CALIBRATION PROCEDURES AND FREQUENCY

All equipment and instruments used at CAS are operated, maintained and calibrated according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Operation and calibration are performed by personnel who have been properly trained in these procedures. Documentation of calibration information is maintained in appropriate reference files. Brief descriptions of the calibration procedures for our major laboratory equipment and instruments are described below.

11.1 Temperature Control Devices

Temperatures are monitored and recorded for all of our temperature-regulating devices including ovens, incubators and refrigerators. Bound record books are kept which contain daily recorded temperatures, identification and location of equipment, acceptance criteria and the initials of the technician who performed the checks. The procedure for performing these measurements is provided in the appropriate SOP (SOP No. SMO-DALYCK). All thermometers have been identified according to serial number, and the calibration of these thermometers is checked annually against a National Institute of Standards and Technology (NIST) certified thermometer. The NIST thermometer is recertified by a professional metrology organization on an annual basis.

11.2 Analytical Balances

Analytical balances are serviced on an semi-annual basis by a professional metrology organization. New certificates of calibration for each balance are issued to the laboratory on an annual basis. The calibration of each analytical balance is checked daily with three class S or S-1 weights, which assess the accuracy of the balance at low, mid-level and high ranges. As needed, the balances are recalibrated using the manufacturers recommended operating procedures. Bound record books are kept which contain the recorded measurements, identification and location of equipment, acceptance criteria and the initials of the technician who performed the checks. The procedure for performing these measurements is provided in the appropriate SOP (SOP No. SMO-DALYCK).

11.3 Water Purification System

The water purification system used at CAS is designed to produce deionized water of 18 megohms resistivity or better, meeting specifications for ASTM Type I water. The system is monitored continuously with an on-line meter, which is recorded daily in a bound record book. Deionizers are rotated and replaced when the first unit in the series produces water of 0.5 megohms, which is monitored by a light on the unit. The status of the deionizers is also checked (resistivity reading and light status) and recorded daily in a bound record book. Activated carbon filters are also in series with the demineralizers to produce "organic-free" water. Finally, the water is checked at a point downstream of the original source - typically a spigot in one of the laboratory operating units. This information is also recorded on a weekly basis.

11.4 Inductively Coupled Plasma-Atomic Emission Spectrograph (ICP-AES)

Each emission line on the ICP is calibrated daily against a blank and against standards. Analyses of calibration standards, initial and continuing calibration verification standards, and inter-element interference check samples are carried out as specified in the EPA CLP Statement of Work for Inorganic Analysis, SOW No ILM04.0.

11.5 Inductively Coupled Plasma-Mass Spectrometer (ICP-MS)

Each element of interest is calibrated for using a blank and a single standard. Prior to calibration, a short-term stability check is performed on the system. Following calibration, an independent check standard is analyzed, and a continuing calibration verification standard (CCV) is analyzed with every ten samples.

11.6 Atomic Absorption Spectrophotometers (AAS)

These instruments are calibrated daily using a minimum of four standards and a blank. Calibration is validated using reference standards, and is verified at a minimum frequency of once every ten samples.

11.7 GC/MS Systems

All GC/MS instruments are calibrated at a minimum five different concentration levels for the analytes of interest (unless specified otherwise) using procedures outlined in Standard Operating Procedures and/or appropriate USEPA method citations. All SRMs used for this function are "EPA-Certified" and/or "A_2LA-Certified" standards. Compounds selected as system performance check compounds (SPCCs) must show a method-specified response factor in order for the calibration to be considered valid. Calibration check compounds (CCCs) must also meet method specifications for percent difference from the multipoint calibration. Method-specific instrument tuning is regularly checked using bromofluorobenzene (BFB) for volatile organic chemical (VOC) analysis, or decafluorotriphenylphosphine (DFTPP) for semi-volatile analysis. Mass spectral peaks for the tuning compounds must conform both in mass numbers and in relative intensity criteria before analyses can proceed.

11.8 Gas Chromatographs and High Performance Liquid Chromatographs

Calibration and standardization follow SOP guidelines and/or appropriate USEPA method citations. Initial calibration standards are prepared at three to five concentration levels for each analyte of interest. The lowest standard is near the method reporting limit; additional standards define the working range of the GC or LC detector. Results are used to establish response factors and retention-time windows for each analyte. Calibration is verified at a minimum frequency of once every ten samples.

11.9 Infrared Analyzer/FTIR

The instrument is calibrated using a blank and four standards. The calibration is validated at the beginning of each analysis, and continuing calibration is verified at a minimum frequency of once every ten samples.

11.10 UV-Visible Spectrophotometer (manual colorimetric analyses)

Routine calibrations for colorimetric and turbidimetric analyses involve generating a 5-point calibration curve including a blank. Correlation coefficients must meet method or SOP specifications before analysis can proceed. Independent calibration verification standards (ICVs) are analyzed with each batch of samples. Continuing calibration is verified at a minimum frequency of once every ten samples. Typical UV-Visible spectrophotometric methods at CAS include total phenolics, phosphates, surfactants and tannin-lignin.

11.11 Flow Injection Analyzer (automated colorimetric analysis)

A minimum of three standards and a blank are used to calibrate the instrument for cyanide analysis. A blank and five (or six) standards are used to calibrate the instrument for all other automated chemistries. Standard CAS acceptance limits are used to evaluate the calibration curve prior to sample analysis.

11.12 Ion Chromatographs

Calibration of the ion chromatograph (IC) involves generating a 5-point calibration curve. A correlation coefficient of 0.995 or better for the curve is required before analysis can proceed. Quality Control (QC) samples that are routinely analyzed include blanks and laboratory control samples. The target analytes typically determined by the IC include nitrate, nitrite, chloride, fluoride, sulfate and bromide.

11.13 Turbidimeter

Calibration of the turbidimeter requires analysis of three Nephelometric Turbidity Unit (NTU) formazin standards. Quality Control samples that are routinely analyzed include blanks, Analytical Products Group® QC samples (or equivalent) and duplicates.

11.14 Ion-selective electrode

Two standards are used to calibrate the electrodes before analysis. The slope of the curve must be within acceptance limits before analysis can proceed. Quality Control samples that are routinely analyzed include blanks, LCSs and duplicates.

11.15 Pipets

The calibration of pipets and autopipettors used to make critical-volume measurements is verified following the *SOP for Checking Pipet Calibration*. Both accuracy and precision verifications are performed, at intervals applicable to the pipet and use. Autopipet calibration is verified each day of use. The results of all calibration verifications are recorded in bound logbooks.

11.16 Other Instruments

Calibration for the total organic carbon (TOC), total organic halogen (TOX), and other instruments is performed following manufacturer's recommendations and applicable SOPs.

12.0 DATA REDUCTION, VALIDATION, AND REPORTING

CAS reports the analytical data produced in its laboratories to the client via the certified analytical report (CAR). This report includes a transmittal letter, a case narrative, client project information, specific test results, quality control data, chain of custody information, and any other project-specific support documentation. The following procedures describe our data reduction, validation and reporting procedures.

12.1 Data Reduction

Results are generated by the analyst who performs the analysis and works up the data. All data is initially reviewed and processed by analysts using appropriate methods (e.g., chromatographic software, instrument printouts, hand calculation, etc.). The resulting data set is either manually entered (e.g., titrimetric or microbiological data) into an electronic report form or is electronically transferred into the report from the software used to process the original data set (e.g., chromatographic software). Once the complete data set has been transferred into the proper electronic report form(s), it is then printed. The resulting hardcopy version of the electronic report is then reviewed by the analyst for accuracy. Once the primary analyst has checked the data for accuracy and acceptability, the hardcopy version of the data is forwarded to the supervisor or the department manager, who reviews the data for errors and manually rechecks a minimum of 10% of the calculations. When the entire data set has been found to be acceptable, a final copy of the report is printed and signed by the laboratory supervisor, departmental manager or senior laboratory staff. The entire data package is then placed into the appropriate service request file, and an electronic copy of the final data package is forwarded to the appropriate personnel for archival.

12.2 Confirmation Analysis

12.2.1 Gas Chromatographic and Liquid Chromatographic Analyses

For gas chromatographic (GC) and liquid chromatographic (LC) analyses, all positive results are confirmed by a second column, a second detector, a second wavelength (HPLC/UV), or by GC/MS analysis, unless exempted by one of the following situations:

- The analyte of interest produces a chromatogram containing multiple peaks exhibiting a characteristic pattern, which matches appropriate standards. This includes polychlorinated biphenyls and hydrocarbon fuels (e.g., gasoline and diesel).

- The sample is analyzed for benzene, toluene, ethylbenzene, xylenes, and naphthalene (BTEXN), and the sample is found, by a separate analysis, to contain gasoline. In a sample containing no gasoline, the presence of BTEXN compounds will be confirmed.

- The sample meets all of the following requirements:

  1. All samples (liquid or solid) come from the same source (e.g., groundwater samples from the same well) for continuous monitoring. Samples of the same matrix from the same site, but from different sources (e.g., different sampling locations) are not exempt.

  2. All analytes have been previously analyzed in sample(s) from the same source (within the last year), identified and confirmed by a second column or by GC/MS. The chromatogram is largely unchanged from the one for which confirmation was carried out, and the documents indicating previous confirmation must be available for review.

12.2.2 Confirmation Data

Confirmation data will be provided as specified in the method. Identification criteria for GC, LC or GC/MS methods are summarized below:

- GC and LC Methods

  1. The analyte must fall within plus or minus three times the standard deviation (established for the analyte/column) of the retention time of the daily midpoint standard in order to be qualitatively identified. The retention-time windows will be established and documented, as specified in the appropriate Standard Operating Procedure (SOP).

  2. When sample results are confirmed by two dissimilar columns or detectors, the agreement between quantitative results must be evaluated. The relative percent difference between the two results is calculated and evaluated against SOP and/or method criteria.

- GC/MS Methods - Two criteria are used to verify identification:

  1. Elution of the analyte in the sample will occur at the same relative retention time (RRT) as that of the analyte in the standard.

  2. The mass spectrum of the analyte in the sample must, in the opinion of a qualified analyst or the department manager, correspond to the spectrum of the analyte in the standard or the current GC/MS reference library.

12.3 Data Validation

The integrity of the data generated in the laboratory is assessed through the evaluation of the results of the analysis of method blanks, laboratory control samples, sample duplicates, matrix spiked samples, QC samples, trip blanks, et al. The numerical criteria for evaluation of these QC samples are listed within each method-specific Standard Operating Procedure. These various QC sample analyses are evaluated using the flow diagrams found in Figures 12-1 through 12-9. Other validation measures of the data include a check of the linearity of the calibration curve, an accuracy check of the QC standards and a check of the system sensitivity. Data transcriptions and calculations are also reviewed.

12.4 Data Reporting

When an analyst determines that a data package has met the data quality objectives (and/or any client-specific data quality objectives) of the method and has qualified any anomalies in a clear, acceptable fashion, the data package is reviewed by a trained chemist. Prior to release of the report to the client, the project chemist reviews and approves the entire report for completeness and to ensure that any and all client-specified objectives were successfully achieved. A case narrative may be written by the project chemist to explain any unusual problems with a specific analysis or sample, etc. The original raw data, along with a copy of the final report, is filed in project files by service request number for archiving. CAS maintains control of analytical results by adhering to standard operating procedures and by observing sample custody requirements. All data are calculated and reported in units consistent with project specifications, to enable easy comparison of data from report to report.

12.5 Documentation

12.5.1 Documentation and Archiving of Routine Analysis Data

The archiving system includes all of the following items for each set of analyses performed:

- Benchsheets describing sample preparation (if appropriate);
- Instrument parameters;
- Sample analysis sequence;
- Analysis benchsheets and instrument printouts;
- Chromatograms and peak integration reports for all samples, standards, blanks, spikes and reruns;
- Log book ID number for the appropriate standards;
- Copies of report sheets submitted to the work request file; and
- Copies of Nonconformity and Corrective Action Report (NCAR) forms, if necessary.

Individual sets of analyses are indexed by analysis date and service request number. Since many analyses are performed with computer-based data systems, the final sample concentrations can be automatically calculated. If additional calculations are needed, they are written on the integration report or securely stapled to the chromatogram, if done on a separate sheet.

12.5.2 Documentation of QC Data

To summarize the recovery data for surrogates and matrix spikes, a separate documentation system has been established. The results are segregated according to the sample matrix. Additional information is included, indicating those results affected by matrix interferences, etc. Surrogate and matrix spike acceptance limits are listed in Appendix C. This system also includes results for the most recent calibration curves, as well as method validation results.

12.5.3 Deliverables

In order to meet individual project needs, CAS provides several levels of analytical reports. Basic specifications for each level of deliverable are described in Table 12-1. Variations may be provided based on client or project specifications.

Figure 12-1
Evaluation of Method Calibration

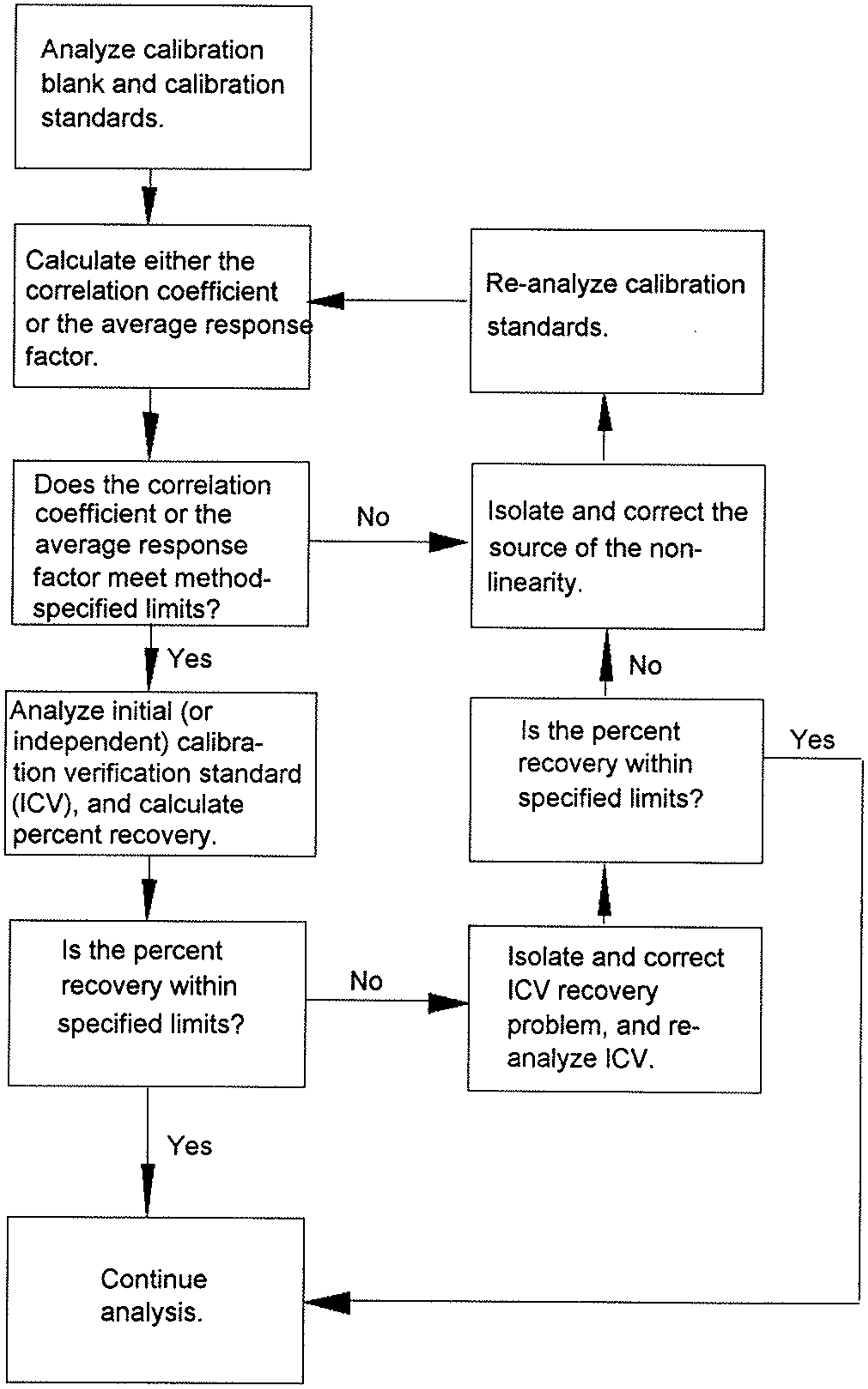


Figure 12-2
Evaluation of Continuing Calibration

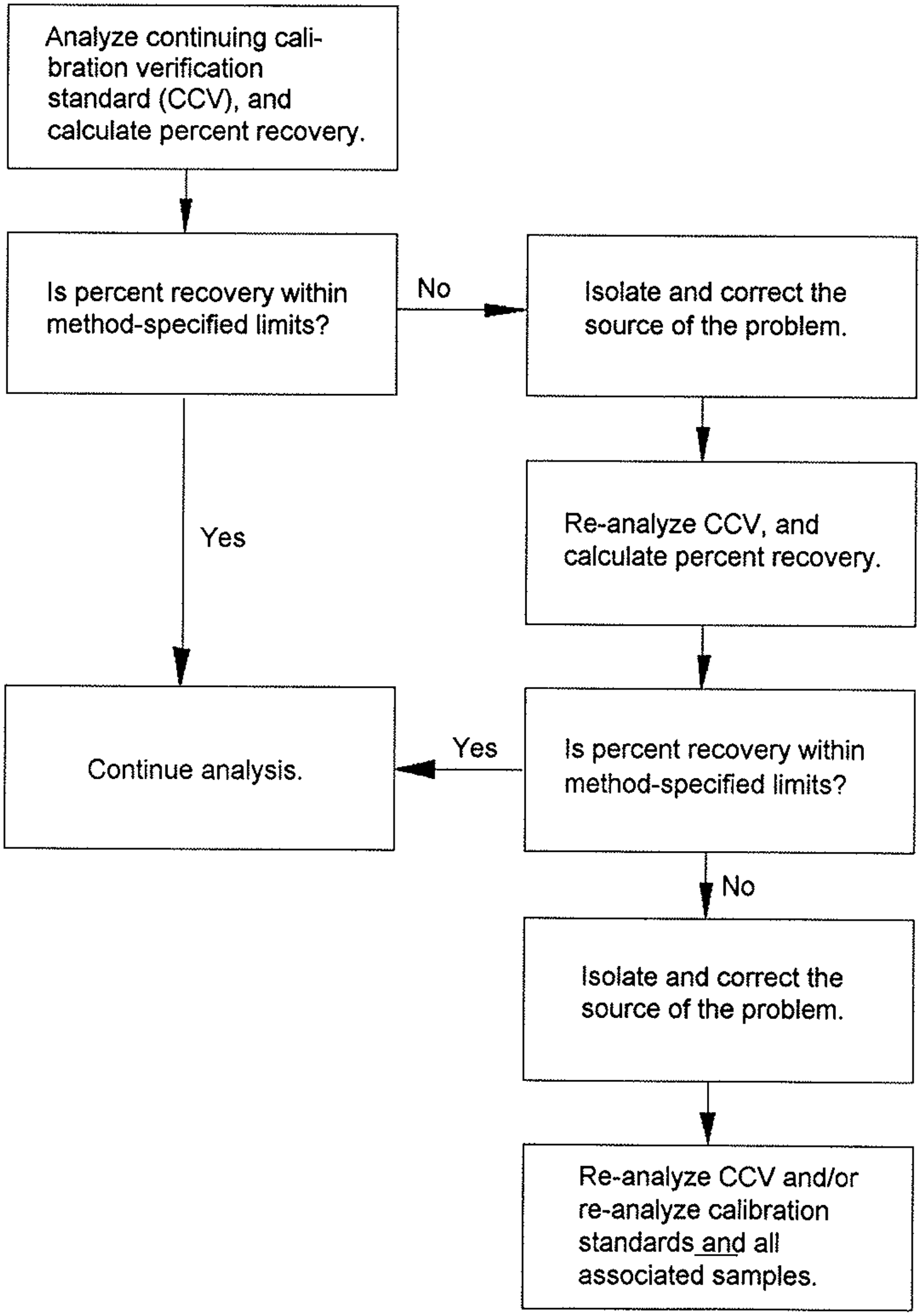


Figure 12-3
Evaluation of Method Blank and Instrument Blank Results

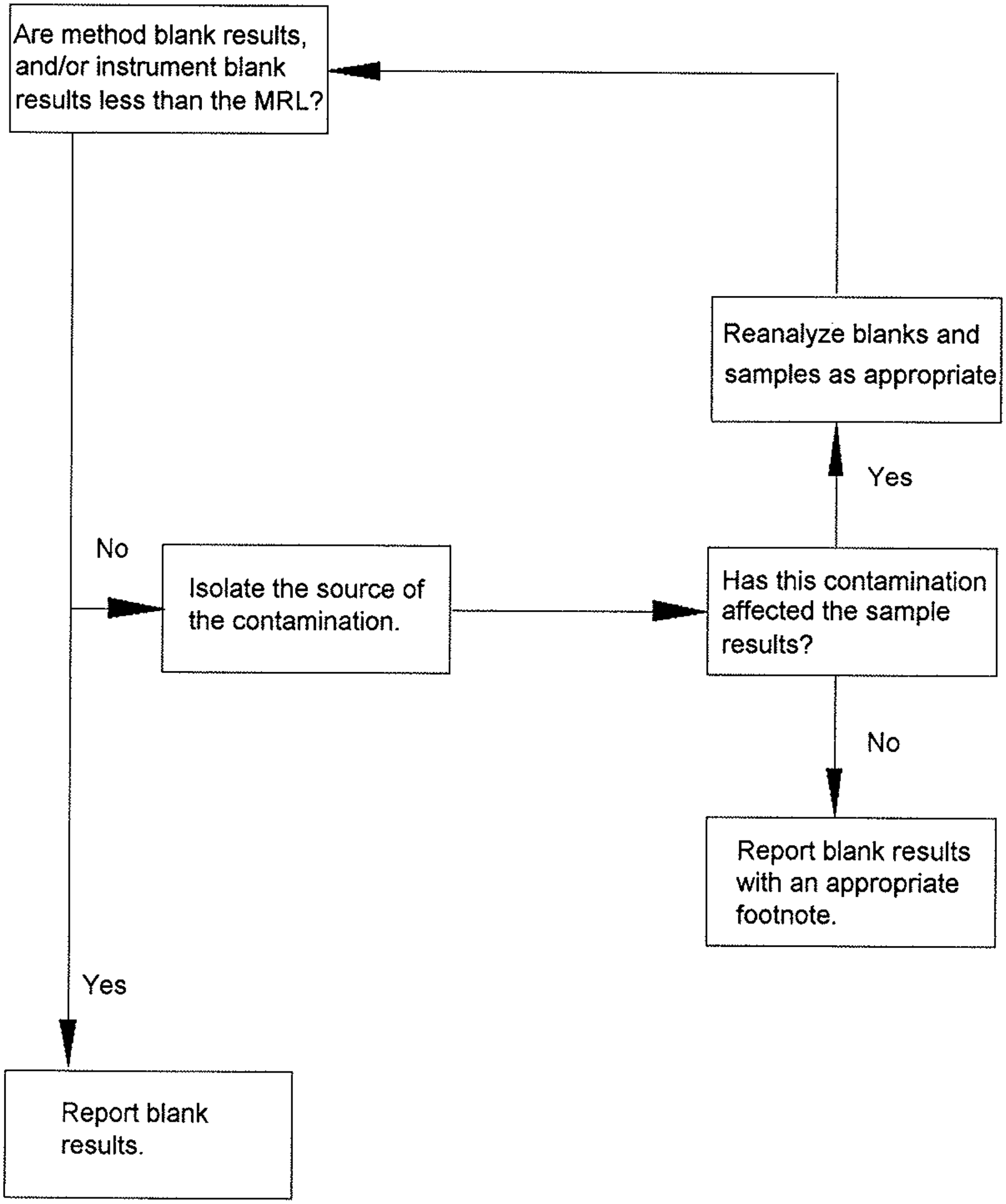


Figure 12-4
Evaluation of Sample Results for Inorganic Analyses

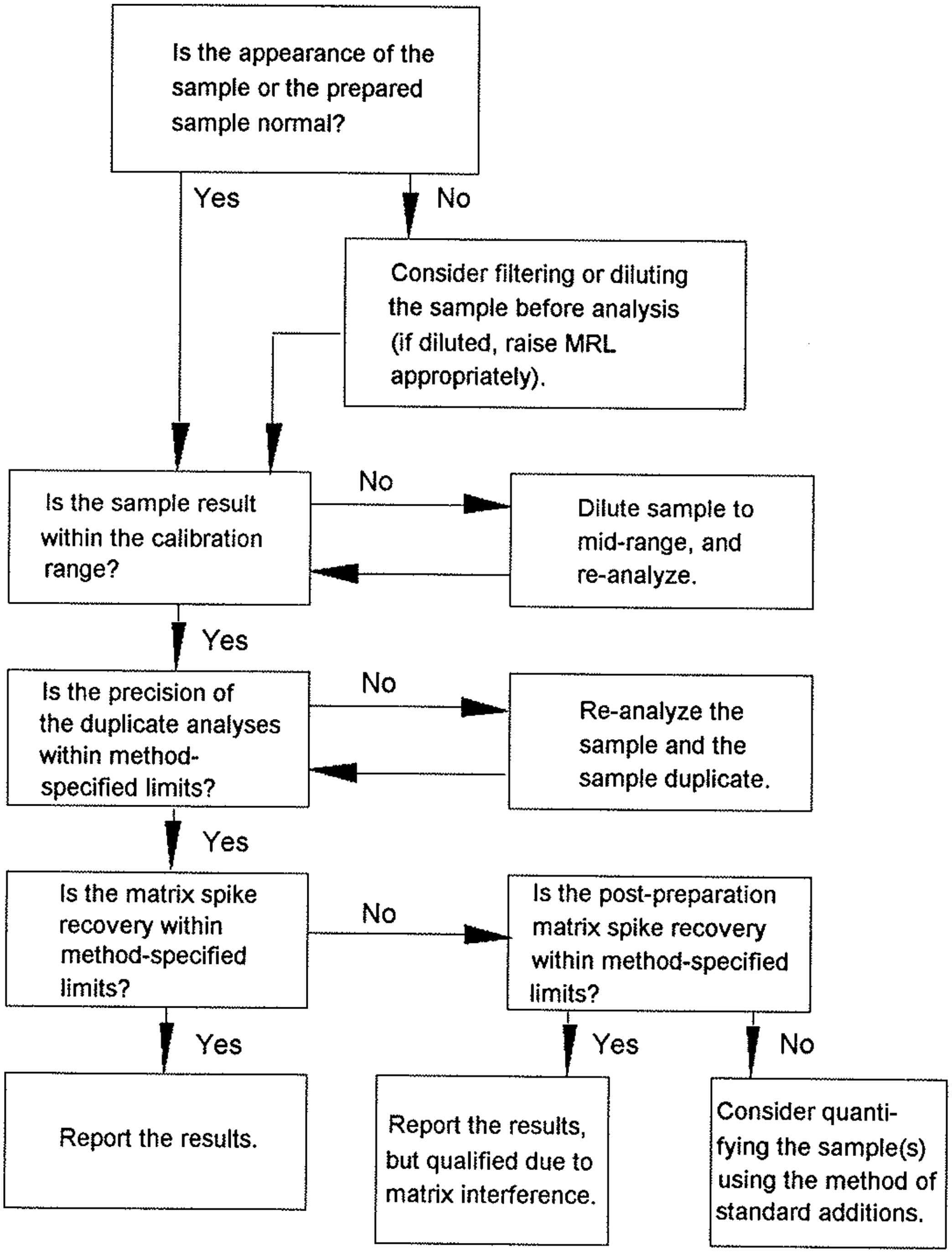


Figure 12-5
Evaluation of Sample Results for Organic Analyses

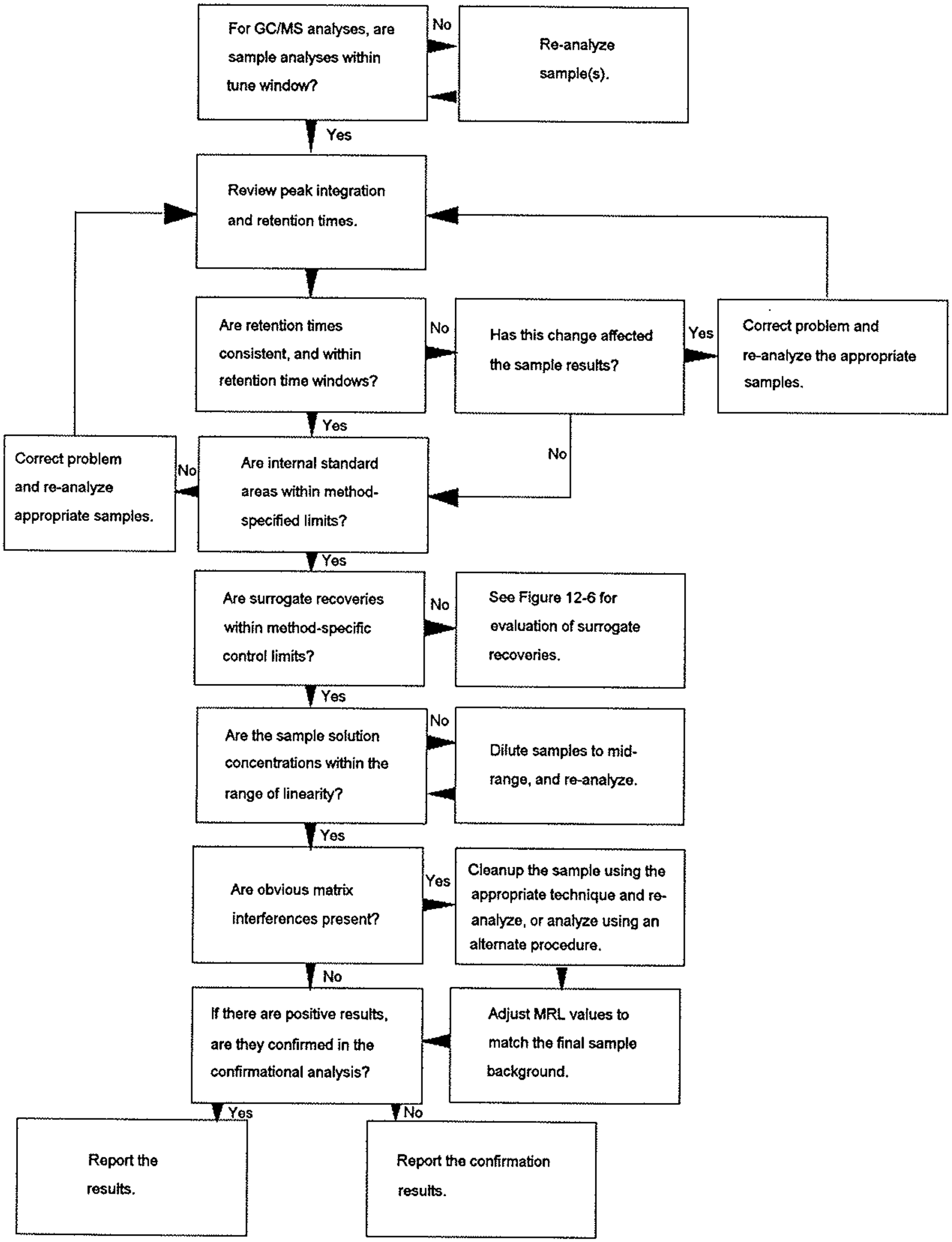


Figure 12-6
Evaluation of Surrogate Compound Recoveries

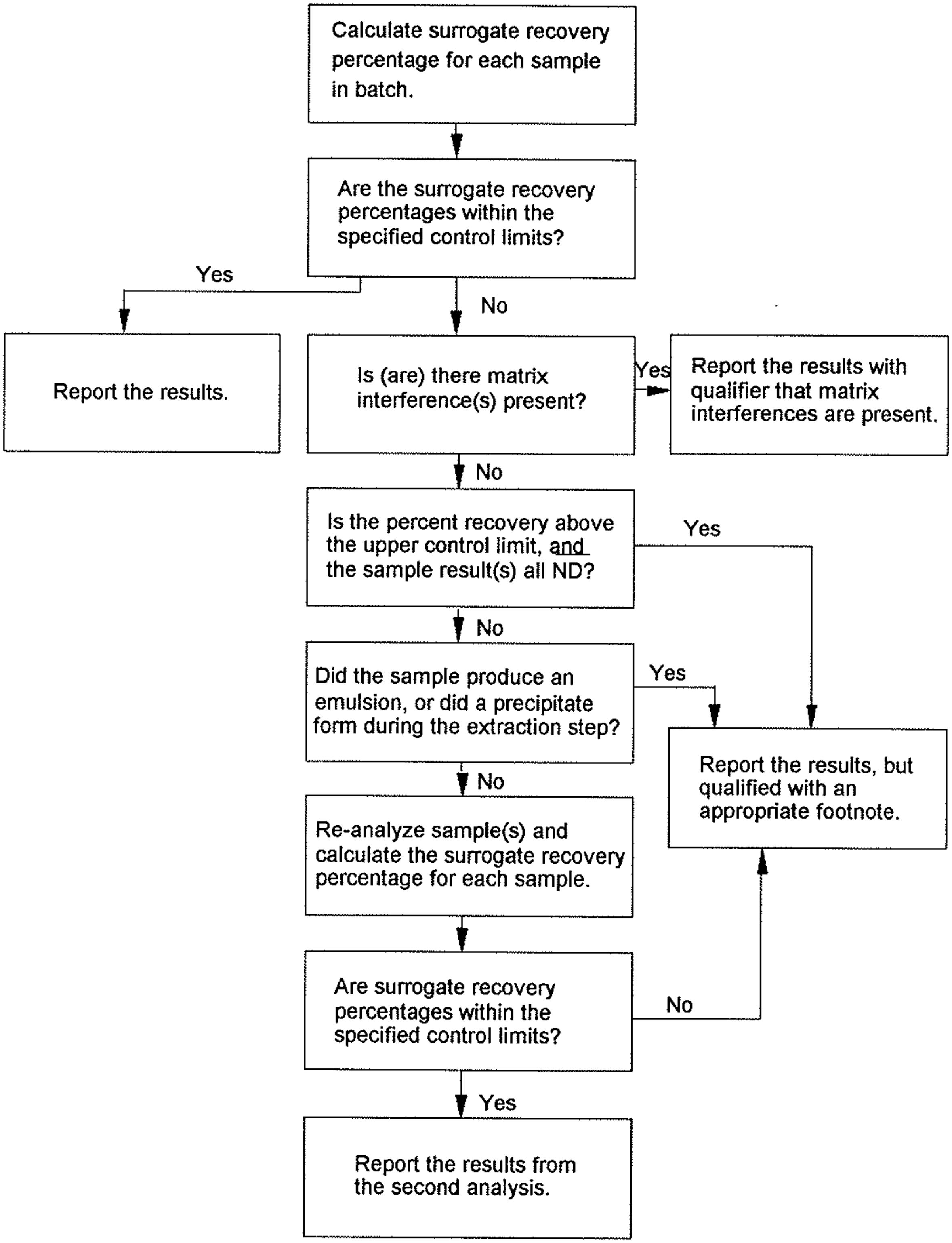


Figure 12-7
Evaluation of Duplicate Sample and/or Duplicate Matrix Spike Results

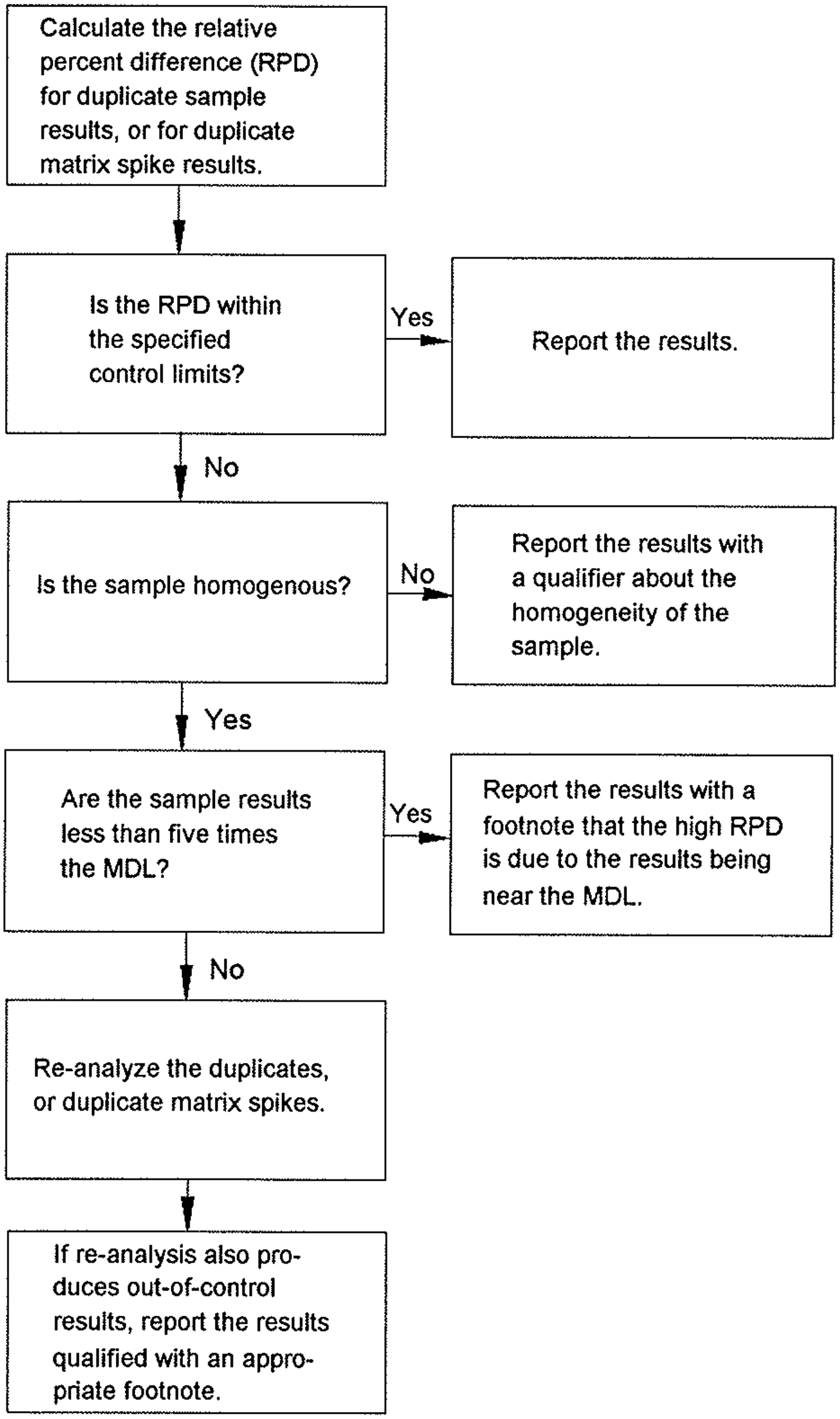


Figure 12-8
Evaluation of Matrix Spike Recoveries

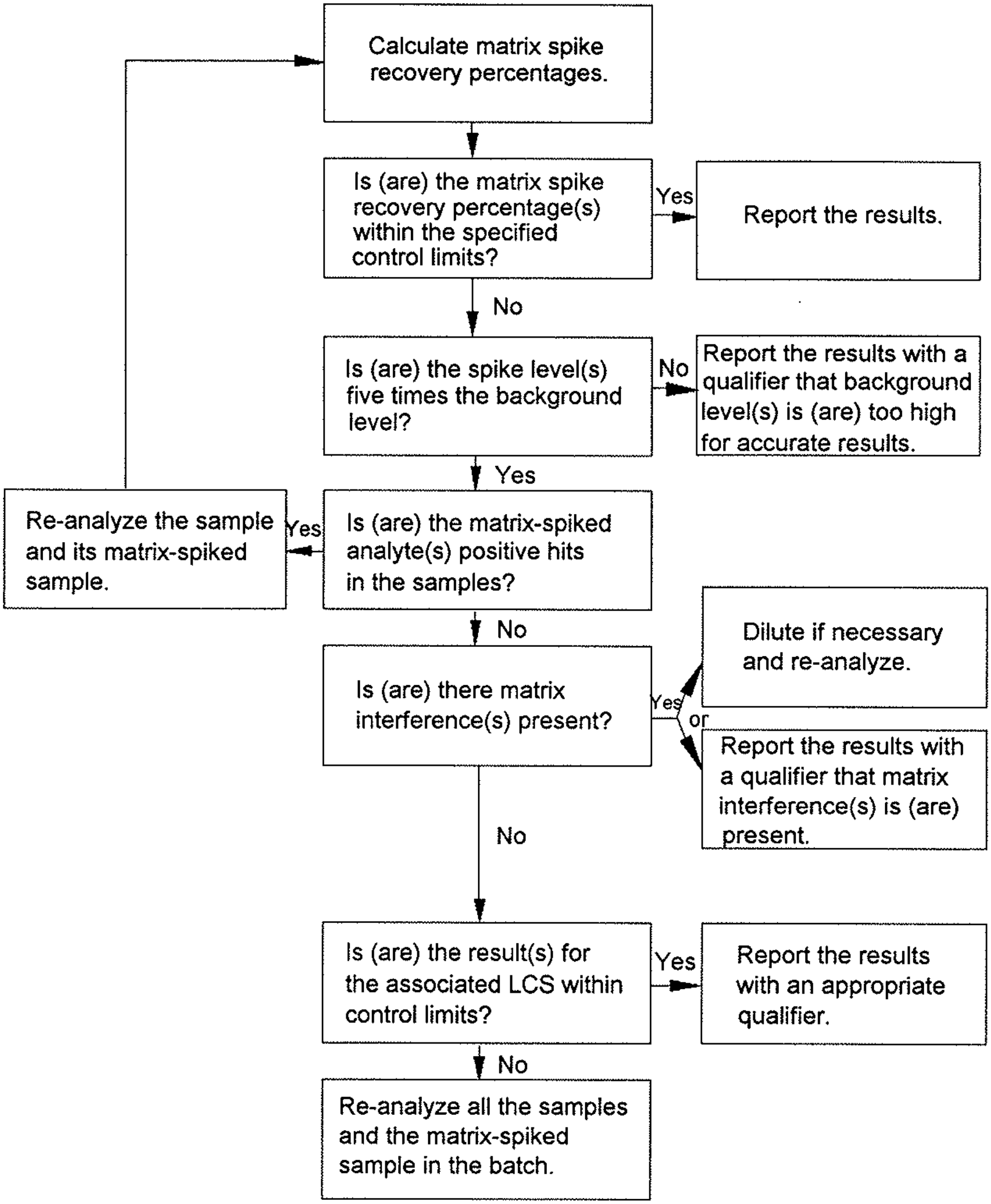


Figure 12-9
Evaluation of Laboratory Control Sample (LCS) Results

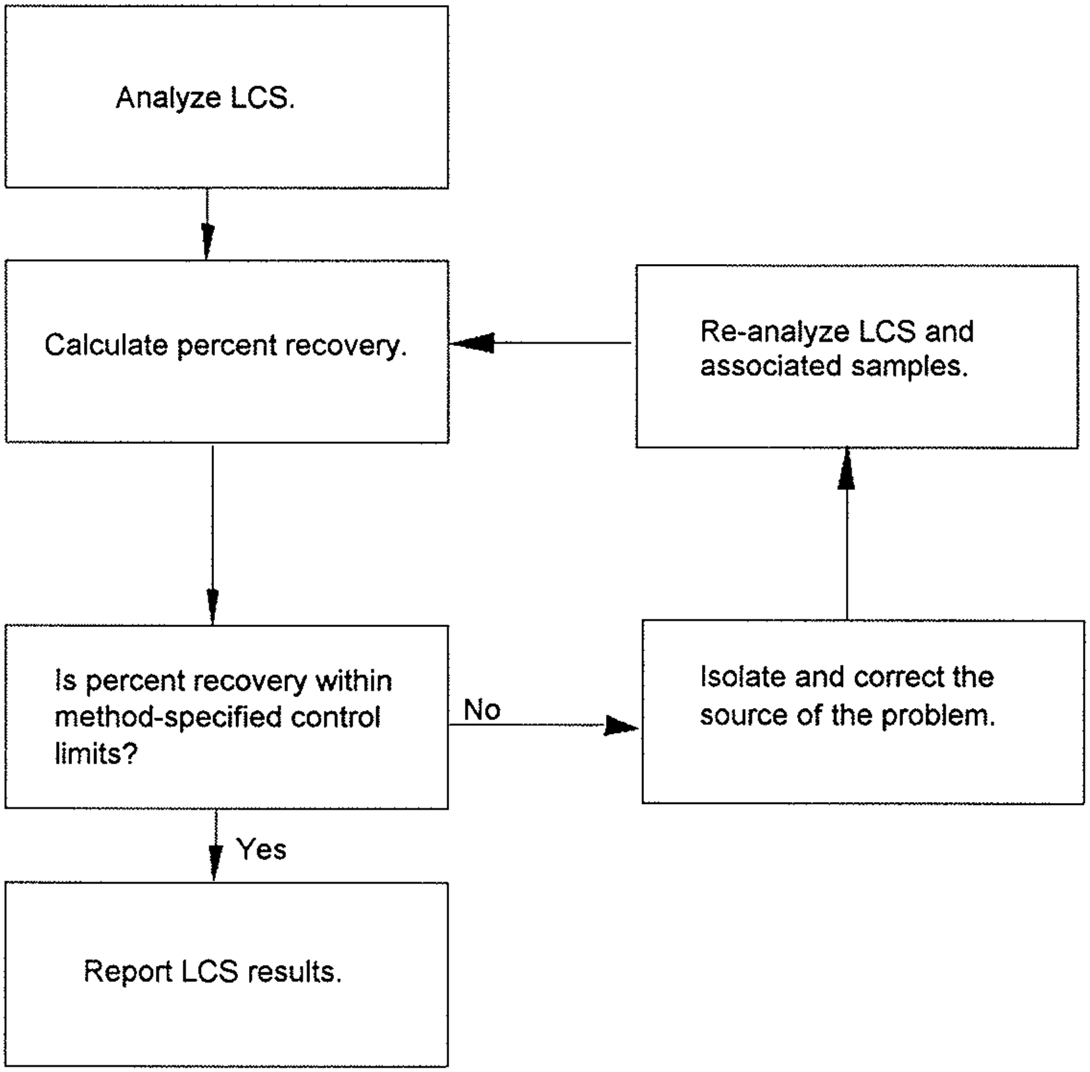


Table 12-1
Descriptions of CAS Data Deliverables

Tier I. Routine Certified Analytical Report (CAR) includes the following:

1. Transmittal letter
2. Sample analytical results
3. Method blank results
4. Surrogate recovery results for appropriate organic methods, including associated EPA or CAS acceptance criteria
5. Chain of custody documents
6. Dates of extraction and analysis for all tests

Tier II. In addition to the Tier I Deliverables, this CAR includes the following:

1. Matrix spike result(s) with calculated recovery, including associated EPA or CAS acceptance criteria
2. Duplicate or duplicate matrix spike result(s) (as appropriate to method), with calculated relative percent difference

Tier ADEC. In addition to the Tier I Deliverables, this CAR includes the following:

1. Laboratory control sample/duplicate laboratory control sample results, with calculated recovery and/or associated acceptance limit criteria
2. Results of initial and continuing calibration verification standards analyses, with calculated recoveries
3. Copies of the raw data for method blank(s) and sample(s)

Tier III. Data Validation Package. In addition to the Tier II Deliverables, this CAR includes the following:

1. Case narrative
2. Calibration records and results of initial and continuing calibration verification standards, with calculated recoveries
3. Results of laboratory control sample (LCS) or EPA QC check sample, with calculated recovery and/or associated acceptance limit criteria
4. Results of calibration blanks or solvent blanks (as appropriate to method)
5. Copies of all raw data, including extraction/preparation bench sheets, chromatograms, and instrument printouts. For GC/MS, this includes tuning criteria and mass spectra of all positive hits. Mass spectra and summary of TIC compounds will be included upon request.

Tier IV. CLP Data Packages

A complete Contract Laboratory Program (CLP) data package, utilizing CLP methods, CLP forms, and fulfilling all deliverable requirements, as specified in the EPA CLP Statement of Work. The data package may include diskette deliverables, upon request.

13.0 PERFORMANCE AND SYSTEM AUDITS

Quality audits are an essential part of CAS/Kelso's quality assurance program. There are two types of audits used at the facility: System Audits are conducted to qualitatively evaluate the operational details of the QA program, while Performance Audits are conducted by analyzing performance evaluation samples in order to quantitatively evaluate the outputs of the various measurement systems.

13.1 System Audits

The system audit examines the presence and appropriateness of laboratory systems. External system audits of CAS/Kelso are conducted regularly by various regulatory agencies and clients. Table 13-1 summarizes some of the major programs in which CAS/Kelso participates. Additionally, internal system audits of CAS/Kelso are conducted regularly by the Quality Assurance Manager and by the CAS Quality Assurance Director. The internal system audits are scheduled as five auditing events as follows:

- Comprehensive lab-wide system audit - annually during 1st calendar quarter
- Comprehensive "vertical" project audits examining compliance with all QA program requirements as applied to selected projects - 2 per year
- Focused audits examining the lab-wide implementation of a selected QA program requirement - 2 per year.

The results of each audit are reported to the Laboratory Director for review and comment. Any deficiencies noted by the auditor are summarized in an audit report and corrective action is taken within a specified length of time to correct each deficiency. Should problems impacting data quality be found during an internal audit, any client whose data is adversely impacted will be given written notification if not already provided.

13.2 Performance Audits

CAS/Kelso also participates in the analysis of performance evaluation (PE) samples. Participation in PE studies is performed on a regular basis and are designed to evaluate all analytical areas of the laboratory. In addition to those PE studies required by programs listed in Table 13-1, CAS participates in additional studies as follows:

- Water Pollution (WP) and Water Supply (WS) PE studies, equivalent to past USEPA studies.
- Environmental Resource Associates (ERA) Soil PE studies, 2 per year.
- ERA Water PE studies, "non-WS,WP" parameters, 2 per year.
- ERA Underground Storage Tank PE studies, 2 per year.
- USEPA Microbiology (WSM) PE studies, 2 per year.

PE samples are processed by entering them into the LIMS system as samples (assigned Service Request, due date, testing requirements, etc.) and are processed the same as field samples. The laboratory sections handle samples the same as field samples, performing the analyses following method requirements and performing data review. The laboratory sections prepare an analytical report, which is forwarded to the QA Manager for subsequent reporting to the appropriate agencies or study coordinator. Results of the performance evaluation samples and audits are reviewed by the Quality Assurance Manager, Laboratory Director, the laboratory staff, and the CAS Quality Assurance Director. For any results outside acceptance criteria, the analysis data is reviewed to identify a possible cause for the deficiency, and corrective action is taken and documented.

Table 13-1
Current CAS Performance and System Audit Programs

Federal and National Programs

- American Association for Laboratory Accreditation (A_2LA)
  - Environmental Laboratory Accreditation No. 0490-01
- Naval Facilities Engineering Service Center (formerly NEESA)
  - Approved Laboratory for Drinking Water, Wastewater and Hazardous Waste
- U.S. Air Force, Air Force Center for Environmental Excellence (AFCEE)
  - Approved Laboratory for Drinking Water, Wastewater and Hazardous Waste
- U.S. Army Corps of Engineers - MRD, HTRW Mandatory Center of Expertise
  - Validated for Drinking Water, Wastewater and Hazardous Waste
- USEPA, Contract Laboratory Program (CLP)
  - Contract 68-D5-0135

State and Local Programs

- State of Alaska, Department of Environmental Conservation
  - UST Laboratory
  - Drinking Water Laboratory
- State of Arizona, Department of Health Services
  - License No. AZ0339
- State of California, Department of Health Services, Environmental Laboratory Accreditation Program
  - Certification No. 2286
- State of Delaware, Delaware Health and Social Services
  - Certified Drinking Water Laboratory
- State of Florida, Department of Health
  - Environmental Water Testing Certification No. E87412
- State of Idaho, Department of Health and Welfare
  - Certified Drinking Water Laboratory
- State of Massachusetts, Department of Environmental Protection
  - Certified Laboratory No. M-WA035
- State of Minnesota, Department of Health
  - Certified Environmental Laboratory - effective April 1999.
- State of Montana, Department of Health and Environmental Sciences
  - Certified Drinking Water Laboratory
- State of Oklahoma, Department of Environmental Quality
  - General Water Quality/Sludge Testing, Lab I.D. 9801
- State of Tennessee, Department of Environment and Conservation, Div. of Underground Storage Tanks
  - UST Approved Laboratory
- State of Oregon, Department of Human Resources, Health Division
  - Certified Drinking Water Laboratory No. WA035
- State of Utah, Department of Health, Division of Laboratory Services
  - Certified Environmental Laboratory
- State of Washington, Department of Health
  - Certified Drinking Water Laboratory No. 017
- State of Washington, Department of Ecology, Environmental Laboratory Accreditation Program
  - Certification No. C001

14.0 PREVENTIVE MAINTENANCE

Preventive maintenance is a crucial element of Columbia Analytical Services Quality Assurance program. Instruments at CAS (e.g., GC/MS systems, atomic absorption spectrometers, analytical balances, gas and liquid chromatographs, etc.) are maintained under commercial service contracts or by qualified, in-house personnel. All instruments are operated and maintained according to the instrument operating manuals. All routine and special maintenance activities pertaining to the instruments are recorded in instrument maintenance logbooks. The maintenance logbooks used at CAS contain extensive information about the instruments used at the laboratory.

An initial demonstration of analytical control is required on **every** instrument used at CAS before it maybe used for sample analysis. If an instrument is modified or repaired, a return to analytical control is **required** before subsequent sample analyses can occur. When an instrument is acquired at the laboratory, the following information is noted in a bound maintenance notebook specifically associated with the new equipment:

- The equipment's serial number;
- Date the equipment was received.;
- Date the equipment was placed into service.;
- Condition of equipment when received (new, used, reconditioned, etc.); and
- Prior history of damage, malfunction, modification or repair (if known).

Preventive maintenance procedures, frequencies, etc. are available for each instrument used at CAS. They may be found in the various SOPs for routine methods performed on an instrument and may also be found in the operating or maintenance manuals provided with the equipment at the time of purchase. Responsibility for ensuring that routine maintenance is performed lies with the section supervisor. The supervisor may perform the maintenance or assign the maintenance task to a qualified bench level analyst. In the case of non-routine repair of capital equipment, the section supervisor is responsible for providing the repair, either by performing the repair themselves with manufacturer guidance or by acquiring on-site manufacturer repair. Each laboratory section maintains a critical parts inventory. The parts inventories include the items needed to perform the preventive maintenance procedures listed in Appendix D. This inventory or "parts list" also includes the items needed to perform any other routine maintenance and certain in-house non-routine repairs such as gas chromatography/mass spectrometry jet separators and electron multipliers and ICP/MS nebulizer.

When performing maintenance on an instrument (whether preventive or corrective), additional information about the problem, attempted repairs, etc. is also recorded in the notebook. Typical logbook entries include the following information:

- Details and symptoms of the problem;
- Repairs and/or maintenance performed;
- Description and/or part number of replaced parts;
- Source(s) of the replaced parts;
- Analyst's signature and date; and
- Demonstration of return to analytical control.

See the table in Appendix D for a list of preventive maintenance activities and frequency for each instrument.

15.0 CORRECTIVE ACTION

Failure to meet established analytical controls, such as the quality control objectives outlined in Section 9.0, prompts corrective action. In general, corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible analyst, the supervisor, team leader, the department manager, and/or the Quality Assurance Manager may examine and pursue alternative solutions. In addition, the appropriate project chemist may be notified in order to ascertain if contact with the client is necessary.

Problems with analysis, as well as the corresponding corrective actions taken, are documented on Nonconformity and Corrective Action Reports (See Figure 15-1) following the requirements in the *SOP for Nonconformity and Corrective Action Documentation* (SOP No. ADM - NCAR). This form is utilized to document corrective actions in response to out-of-control situations. The Quality Assurance Manager reviews each problem, ensuring that effective corrective action has been taken by the appropriate personnel. The Nonconformity and Corrective Action Report (NCAR) is filed in the associated service request file and a copy is kept by the Quality Assurance Manager. The Quality Assurance Manager periodically reviews all NCARs looking for chronic, systematic problems that need more in-depth investigation and alternative corrective action consideration. In addition, the appropriate project chemist is promptly notified of any problems in order to inform the client and proceed with any action the client may want to initiate.

Corrective action due to a performance audit or a check sample problem is initiated by the Quality Assurance Manager; the affected laboratory personnel are promptly informed, as are the laboratory supervisors and managers.

Figure 15-1

COLUMBIA ANALYTICAL SERVICES, INC.

Nonconformity and Corrective Action Report

SAMPLES/SYSTEM/JOB/CLIENT AFFECTED

NONCONFORMITY

Analysis/Event: ______________________________

Instrument/System: ______________________ Date: ____________

Detailed Description:

Originator: ______________________ Date: ____________

Supervisor Verification: ______________________ Date: ____________

CORRECTIVE ACTION AND OUTCOME

Detailed Description: (Re-establishment of conformity must be demonstrated and documented. Describe the steps that were taken, or are planned to be taken, to correct the problem. Describe the outcome.)

Person Responsible: ______________________ Date: ____________

Supervisor Verification: ______________________ Date: ____________

NOTIFICATION - CUSTOMER/CLIENT - INTERNAL/EXTERNAL

Project Chemist Notified? No Yes: Date: ____________

Customer Notification Necessary? (Attach telephone record) No Yes: Date: ____________

Notifier: ______________________ Date: ____________

ACCEPTANCE OF CORRECTIVE ACTION

QA Coordinator: ______________________ Date: ____________

Original: Client File Photocopies: Supervisor and QA Coordinator CORACTRP.DOC 10/29/96

16.0 QUALITY ASSURANCE REPORTS

Quality assurance requires an active, ongoing commitment by CAS personnel at all levels of the organization. Information flow and feedback mechanisms are designed so that analysts, supervisors and managers are aware of quality assurance issues in the laboratory.

Analysts performing routine tests in the laboratory are aware of the various method acceptance criteria and in-house control limits that must be met in order to generate acceptable results. The analysts are also responsible for generating a Data Quality Report (DQR) form with every analytical batch they process; this report contains explicit documentation of the various controls that must be met during the analysis. The DQR form also allows the analyst to provide appropriate notes and/or a case narrative if problems were encountered with the analyses. A Non-Conformity and Corrective Action Report (NCAR) (see Section 15.0) may also be attached to the data prior to review. This may or may not supersede the laboratory's own DQR depending on the nature of the problem. Supervisors review all of the completed analytical batches to ensure that all QC criteria have been examined and any deficiencies noted and corrected if possible.

It is the responsibility of each laboratory unit to provide the project chemist with a final report of the data, accompanied by signature approval. Footnotes and/or narrative notes must also accompany any data package if problems were encountered that require further explanation to the client. Each data package is submitted to the appropriate project chemist, who in turn reviews the entire collection of analytical data for completeness. The project chemist must also review the entire body of data to ensure that any and all client-specified objectives were successfully achieved. A case narrative may be written by the project chemist to explain any unusual problems with a specific analysis or sample, etc.

The Quality Assurance Manager (QAM) provides overview support to the project chemists if required to do so (e.g., contractually specified, etc.). The QAM is also responsible for the oversight of all internal and external audits, for all performance evaluation sample and analysis programs, and for all laboratory certification/accreditation responsibilities.

The QAM also prepares quarterly reports for the Laboratory Director which summarize the various QA/QC activities that have occurred during the previous quarter. The typical report will address such topics as the following:

- Status, schedule, and results of internal and external audits (e.g., deficiency resolution status);
- Status, schedule, and results of internal and external performance evaluation studies;
- Status of certifications, accreditations, and approvals;
- Status of SOPs review;
- Status of MDLs studies;

- Discussion of QC problems in the laboratory;
- Discussion of corrective action program issues;
- Status of staff training and qualification; and
- Other topics as appropriate.

Any problems noted by the Laboratory Director are then discussed during the regularly-scheduled senior staff operations meetings with all appropriate department managers. The Laboratory Director performs an annual documented review of the quality system.

17.0 PERSONNEL TRAINING

Technical position descriptions are available for all employees, regardless of position or level of seniority. These documents are maintained by the Human Resources personnel and are available for review. In order to assess the technical capabilities and qualifications of a potential employee, all candidates for employment at CAS are evaluated, in part, against the appropriate technical description.

Information of previously acquired skills and abilities for a new employee is entered into a centralized database (namely, First Resource) maintained by the Human Resources personnel. The database is also used to record the various technical skills and abilities acquired and maintained by an employee while employed by CAS. Information in the database includes the employee's name, a description of the skill including the appropriate method reference, the name of the supervisor who certified completion of the training, and the date the training was completed. Technical training is documented following the *SOP for Documentation of Technical Personnel Training* (SOP No. ADM-TRANDOC).

Training begins the first day of employment at CAS when the company policies are presented and discussed. Training in analytical procedures typically begins with the reading of the Standard Operating Procedure (SOP) for the method. Hands-on training begins with the observation of an experienced analyst performing the method, followed by the trainee performing the method under close supervision, and culminating with independent performance of the method on quality control samples. Successful completion of the analysis of quality control samples qualifies the analyst to perform the method independently. An periodic demonstration of proficiency is required to maintain continuing qualification, as described in the *SOP for Documentation of Technical Personnel Training* (SOP No. ADM-TRANDOC).

Safety training begins with the reading of the *Safety Manual*. All employees must pass a safety test within the first month of employment. All employees are also required to attend monthly safety meetings during which the safety program is discussed and safety training is presented by the Environmental, Health and Safety Officer.

CAS encourages its personnel to continue to learn and develop new skills that will enhance their performance and value to the Company. Ongoing training occurs for all employees through a variety of mechanisms. The "CAS University" education system, external and internal technical seminars and training courses, laboratory-specific training exercises and performance of external (independent) PE sample analyses are all used to provide employees with professional growth opportunities.

Safety and QA/QC requirements are integral parts of all technical SOPs and, consequently, are integral parts of all processes at CAS.

18.0 REFERENCES FOR ANALYTICAL PROCEDURES

The analytical methods used at CAS generally depend upon the end-use of the data. Since most of our work involves the analysis of environmental samples for regulatory purposes, specified federal and/or state testing methodologies are used and followed closely. Several factors are involved with the selection of analytical methods to be used in the laboratory. These include the method detection limit, the concentration of the analyte being measured, method selectivity, accuracy and precision of the method, the type of sample being analyzed, and the regulatory compliance objectives. Typical methods used at CAS are taken from the following references:

- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, (September 1986) and Updates I (July 1992), II (September 1994), IIA (August 1993), IIB (January 1995), III (December 1996), and Proposed Update IVA (January 1998). See Chapters 1, 2, 3, and 4.

- *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, (Revised March 1983).

- *Methods for the Determination of Inorganic Substances in Environmental Samples*, EPA/600/R-93/100 (August 1993).

- *Methods for the Determination of Metals in Environmental Samples*, EPA/600/4-91/010 (June 1991) and Supplement I, EPA/600/R-94/111 (May 1994).

- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA 600/4-82-057 (July 1982) and 40 CFR Part 136, Appendix A.

- *Methods for the Determination of Organic Compounds in Drinking Water*, EPA/600/4-88/039 (December 1988) and Supplement I, EPA/600/4-90/020 (July 1990) and Supplement II, EPA/600/R-92/129 (August 1992) and Supplement III, EPA/600/R-95/131 (August 1995).

- *Standard Methods for the Examination of Water and Wastewater*, 16th Edition (1985); 17th Edition (1989); 18th Edition (1992); 19th Edition (1995). See Introduction in Part 1000.

- 40 CFR Part 136, Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act.

- 40 CFR Part 141, National Primary Drinking Water Regulations.

- State-specific total petroleum hydrocarbon methods for the analysis of samples for gasoline, diesel, and other petroleum hydrocarbon products (Alaska, Arizona, California, Massachusetts, Oregon, Washington, Wisconsin, etc.).

- Annual Book of ASTM Standards, Part 31, Water.

- EPA Contract Laboratory Program, Statement of Work for Organic Analysis, SOW Nos. OLM01.8, OLM02.0, OLM03.1, and OLM03.2.

- EPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, SOW No. ILM04.0.

- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA-540/R-94/012 (February 1993).

- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA-540/R-94/013 (February 1994).

- National Institute for Occupational Safety and Health (NIOSH) *Manual of Analytical Methods*, Third Edition (August 1987); Fourth Edition (August 1994).

- *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound*, for USEPA and USACE (March 1986), with revisions through April 1997.

- WDOE 83-13, *Chemical Testing Methods for Complying with the State of Washington Dangerous Waste Regulations* (March 1982) and as Revised (July 1983 and April 1991).

- *Identification and Listing of Hazardous Waste,* California Code of Regulations, Title 22, Division 4.5, Chapter 11.

- *Analytical Methods for the Determination of Pollutants in Pulp and Paper Industry Wastewater*, EPA 821-R-93-017 (October 1993).

- *Analytical Methods for the Determination of Pollutants in Pharmaceutical Manufacturing Industry Wastewaters*, EPA 821-B-98-016 (July 1998).

- National Council of the Pulp and Paper Industry for Air and Stream Improvement (NCASI).

- *Good Automated Laboratory Practices, Principles and Guidance to Regulations For Ensuring Data Integrity In Automated Laboratory Operations*, EPA 2185 (August 1995).

- *Manual for the Certification of Laboratories Analyzing Drinking Water*, 4th Edition, EPA 815-B-97-001 (March 1997).

ESN NORTHWEST

STATEMENT OF QUALIFICATIONS AND CAPABILITIES

June 15, 2003

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TABLE OF CONTENTS

SECTION **PAGE**

1.0 Introduction to ESN Northwest

ESN Northwest operates certified fixed base and mobile laboratories that are equipped to measure volatile and semi-volatile organic compounds (petroleum hydrocarbons, aromatics, halogenated hydrocarbons, and fixed gases) and metals in soil, water, and gases. ESN Northwest also conducts soil gas surveys, both active and passive. All laboratories follow approved EPA protocols. ESN Northwest's client list includes large and small environmental consultants and engineers, major oil and other private companies, and all branches of the U.S. military, both in the continental U.S. and abroad, with extensive experience in Hawaii and the Pacific Rim.

ESN Northwest uses the latest technology in hydraulic drive point or direct push sampling systems to collect reliable soil, water and soil gas samples. Designed specifically to support site assessments, ESN Northwest's Direct Push Probes are a multi-media sampling system capable of reaching depths of 80 feet or more below ground surface. Soil samples may be obtained through continuous coring as well as discrete sampling in stainless steel, brass, or acetate liners. Waters can be sampled via hydropunch style discrete sampling or via installation of 1" PVC wells. Our Probe uses a 2" driveable well casing to insure proper installation and packing of 1" miniwells. Our MegaProbe also installs 2" wells meeting specifications for the Washington State Department of Ecology using 3" driveable well casing.

ESN Northwest also performs soil vapor extraction pilot testing, point permeability testing, and passive soil gas surveys using a variety of techniques and adsorbents.

ESN Northwest is accredited by the Washington State Health Department to analyze for methamphetamine.

Northwest Area Experience

ESN Northwest, a leading environmental sampling and testing firm, established its Olympia analytical laboratory in 1989 and has been operating its Bellevue analytical laboratory since 1997. Since its inception, the Olympia laboratory has performed analytical testing for projects throughout the nation. Through the use of its mobile laboratories, ESN Northwest has performed a number of off-site projects in remote parts of Alaska, throughout the Pacific Northwest, New Mexico, Texas, Maine, Georgia, Oklahoma, Utah, Montana, Idaho, Wyoming, and California. ESN Northwest is independently owned.

ESN Northwest has extensive experience in on-site geochemistry throughout the Pacific Basin. ESN Northwest has worked for the Navy under CLEAN and for the Army Corps of Engineers on several projects in the Northwest. ESN Northwest has also worked extensively in the Northwest for the Army, Navy, Air Force, and Coast Guard as well as many of other private sector projects. (Please refer to attached Project List section 7.0).

Competence

Technical Expertise and Diversity of Services

ESN Northwest has an abundance of trained professionals within the system, including five geologists, seven licensed well drillers, a certified geophysicist, and numerous degreed chemists and engineers.

Concerning diversity of services, ESN Northwest offers the following services:

Environmental Mobile Laboratory Services: ESN Northwest's state certified mobile lab performs the following test procedures on soil, water, underground vapors, and gas samples:

Aromatic hydrocarbons (BTEX) by EPA 8021B.
Fuel hydrocarbons (gas, diesel, and motor oil) by NWTPH-Gx, Dx & Dx-Extended.
Polynuclear aromatic hydrocarbons (semi-volatiles) by EPA 8100.
Halogenated volatile hydrocarbons (chlorinated solvents) by EPA 8021B.
Polychlorinated biphenyls (PCBs) and chlorinated pesticides by EPA 8081 & 8082.
Total recoverable petroleum hydrocarbons by EPA 418.1 mod.
Biogenic gases (CO_2, O_2, methane) by GC/TCD (vapor samples only).
Metals by Flame AA, EPA 7000.

When serving remote areas, ESN Northwest often will ship instrumentation and set up locally in either a room or trailer close to the worksite or in a locally rented van for the duration of the project. This is a more cost-effective alternative for conducting on-site remote chemistry than shipping an entire mobile laboratory.

Soil Gas Surveys: ESN Northwest has extensive worldwide experience in soil gas surveys, both active and passive. Passive soil gas techniques include adsorbent as well as equilibrium methods for a wide variety of analytes.

Sampling: ESN Northwest uses the latest technology in hydraulic drive point or direct push sampling systems to collect reliable soil, water, and soil gas samples. Designed specifically to support site assessments, ESN Northwest's Direct Push Probes are multi-medium sampling systems capable of reaching depths of 80 feet or more below ground surface. Soil samples may be obtained through continuous coring as well as discrete samples in stainless, brass, or acetate liners. Waters can be sampled by hydropunch style discrete sampling or by installation of 1" PVC wells. Our Direct Push Probes use a 2" driveable well casing to insure proper installation and packing of 1" miniwells. Our MegaProbe also installs 2" wells meeting specifications for the Washington State Department of Ecology using 3" driveable well casing.

Injection of ORC, HRC, etc: ESN Northwest uses Direct Push Probes to inject products into the formation to facilitate bioremediation.

Sparge Point Installation: ESN Northwest can use Direct Push Probes to install groundwater-sparging points to boost the effectiveness of vapor extraction systems and/or bioremediation.

Quality of Work

ESN Northwest is committed to quality in all areas of our work. **Performing the majority of our analytical work in the field allows us to get the most reliable data for volatiles**. Recent research indicates that substantial losses in volatiles can occur in less than 48 hours after sampling. Performing analyses on-site also allows us to focus on each set of samples without distractions of conflicting deadlines on multiple projects. Each chemist is committed entirely to his or her project and performs all analyses in person as opposed to using autosamplers. This eliminates the process of having to sort through large quantities of data at the conclusion of an autosampler queue**.** QA/QC is specific to each project and is scrutinized by the analyst on-site as well as by a senior chemist for final review. **ESN Northwest's on-site analysis of samples eliminates many of the errors that are often associated with processing data in a fixed base environment**.

ESN Northwest's commitment to quality is not limited to the lab. Our Direct Push Probes are the largest, most powerful direct push rigs in the market today and offer the largest variety of sampling tools available. Making the tools ourselves allows us unparalleled flexibility in rig and sampler design. This helps us to conform to the constantly changing needs of the sampling market quickly and efficiently. Our operators are professionals, possessing at least a 4-year degree in the physical or earth sciences.

Complex Tasks

Remote/Isolated Area Experience

A quick review of our attached references will demonstrate our ability to mobilize quickly to remote areas and get the job done. ESN Northwest uses SRI gas chromatographs for remote jobs. They are much smaller than conventional gas chromatographs and yield high quality data comparable with any larger GC. With a SRI GC, a hydrogen generator, a laptop computer, and a van, we can go to practically any location and generate high quality, cost-effective, on-site analyses.

Our Direct Push system can easily be shipped on any commercial transport that can take a full size pickup truck. The Direct Push rigs are 4-wheel drive with considerable ground clearance. Overhead clearance required to unfold the mast is 12’. As an alternative, ESN Northwest collects samples in remote locations through the use of slide-hammer probes and electric rotary hammer driven sampling equipment. Whatever the need, ESN Northwest has the equipment for the job.

Knowledge

Innovative Technology

ESN Northwest’s uses of innovative technologies are covered in detail in the above sections. Some of the more pertinent services using innovative technology are as follows:

> **Custom Direct Push Probes** for sampling soils, waters, and vapors. These Probes produces no cuttings, making them ideal for use in remote locations. Our larger probes are capable of installing 1”mini-wells and 2” wells.
>
> **Soil gas surveys, both active and passive,** can be used to gather large amounts of data to accelerate the site characterization process.
>
> **UXO clearance** can be performed using a system developed by ESN Northwest and UXB. This system can be used in conjunction with our Direct Push Probes, offering traditional UXO without producing the cuttings normally associated with this process.
>
> **Rapid screening** for volatiles using GC and GCMS.

Ecological Environments

ESN Northwest has worked in sensitive marine coastal environments, fragile ecosystems, and wetlands throughout the Pacific Northwest. Due to our direct push technology and many sampling options, we are uniquely qualified to have the least adverse impact on these sensitive environments.

2.0 Analytical Capabilities

Trace Metals

Parameter	*Method*
Mercury, Cold vapor AA	EPA 7471
Copper	EPA 7210
Zinc	EPA 7950
Lead	EPA 7420
Cadmium	EPA 7130
Chromium	EPA 7190
Silver	EPA 7760
Nickel	EPA 7520
Arsenic	EPA 7061
Selenium	EPA 7741
Barium	EPA 7080

Organics by GC

Parameter	*Method*
Halogenated Volatile Organics	EPA 8021B
Aromatic Volatile Organics	EPA 8021B
Volatile Organic Compounds	EPA 8021B
BTEX	EPA 8021B
EDB & DBCP	EPA 8021B
Pentachlorophenol	EPA 8041
Chlorinated Pesticides	EPA 8081
Chlorinated Pesticides & PCB’s	EPA 8081
PCB’s in Water	EPA 8082
PCB’s in Soil	EPA 8082
PCB’s in Wipes	SAS EPA 8082 Modified
PCB’s in Oil	EPA 8082
Glycol’s in Water	Mod. EPA 8015
Methamphetamine	Mod. EPA 8015

Washington State DOE & Oregon DEQ Program

Parameter	*Method*
Qualitative Hydrocarbon ID	NWTPH-HCID
Gasoline Range Organics	NWTPH-Gx
Diesel Range Organics	NWTPH-Dx
Heavy Petroleum Oils	NWTPH-Dx/Dx-Extended
BTEX	by GC/PID EPA 8021B
NWTPH-Gx with BTEX Combination	NWTPH-Gx/EPA 8021B
TCLP Lead	EPA 7141 & 1311 & 7420

Toxicity Characteristics Leaching Procedure (TCLP)

Parameter	***Method***
Extraction (non-volatile)	EPA 1311
Metals	EPA 6000/7000 Series

Immunoassay Screening Methods (EPA SW-846)

Parameter	***Method***
Screening for PCB’s by Immunoassay	Method-4020
Soil Screening for Petroleum Hydrocarbons By Immunoassay	Method-4030
Soil Screening for PAH’s by Immunoassay	Method-4035

Other

Asbestos	Polarized Light Microscopy

QA/QC FOR ANALYTICAL METHODS

GENERAL

The ESN Northwest Laboratory quality assurance and quality control (QA/QC) procedures are conducted following the guidelines and objectives that meet or exceed certification/accreditation requirements of California DOHS, Washington DOE, and Oregon DEQ. The Quality Control Program is a consistent set of procedures which assures data quality through the use of appropriate blanks, replicate analyses, surrogate spikes, and matrix spikes, and with the use of reference standards that meet or exceed EPA standards.

When analyses are taking place on-site with the mobile lab, the need for Field Blanks or Travel/Trip Blanks is eliminated. If there is going to be a delay before sample preparation for analysis, the sample is stored at 4^{o} C.

ANALYTICAL METHODS

ESN Northwest Labs use analytical methodologies that are in substantial conformity with U.S. Environmental Protection Agency (EPA), Washington DOE, and Oregon DEQ methodologies. When necessary and appropriate due to the nature or composition of the sample, ESN may use variations of the methods that are consistent with recognized standards or variations used by industry and government laboratories.

Purgeable Volatile Halocarbons
(Chlorinated Hydrocarbons, EPA 8021-B, 8260)

A check standard is run at the beginning of the day. The standard must be within 15% of the calibration curve value. The standard is rerun at the end of the day or every 20 samples. All samples are prepared with a surrogate spike, and the recovery must be between 65% and 135%. At least 1 method blank is run per day or per batch of 20 samples. A sample duplicate is run every 10 samples. A Laboratory Control Standard (LCS), Matrix Spike (MS) and Matrix Spike Duplicate (MSD) are run for each batch of 20. Recovery must be between 65% and 135% per set.

Purgeable Volatile Aromatics
(BTEX, EPA 8021-B)

A check standard is run at the beginning and the end of the day or per batch of 20. Both open and close standards must be within 15% of the calibration curve value. All samples are prepared with a surrogate spike, and the recovery must be between 65% and 135% unless high sample concentrations interfere with the determination of the recovery percentage. At least 1 method blank is run per day. A duplicate sample is run at a rate of 1 per 10 samples. A Laboratory Control Standard (LCS) is run every 20 samples. At least 1 method blank is run per 20 samples analyzed.

TPH-Gasoline, TPH-Diesel
(Gasoline and/or Diesel, Modified EPA 8015)

A check standard is run at the beginning and the end of the day or per 20 samples. Both open and close standards must be within 15% of the calibration curve value. All samples are prepared with a surrogate spike, and the recovery must be between 65% and 135% unless high sample concentrations interfere with the determination of the recovery percentage. A duplicate sample is run at a rate of 1 per 10 samples. At least 1 method blank is run per 20 samples analyzed.

PCBs, Polychlorinated Biphenyls
(EPA 8082)

A method blank and a check standard are run at the beginning of the day. The standard must be within 15% of the continuing calibration curve value. The check standard is run at the end of the day. All samples are prepared with a surrogate spike, and the recovery must be between 65% and 135%. Samples which measure outside of the linear range of the calibration curve must be carefully diluted to fall into the upper range of the linear calibration. At least 1 method blank is run per 20 samples analyzed. A sample duplicate is run every 10 samples. A Matrix Spike (MS) and Matrix Spike Duplicate (MSD) are run for each batch of 20. Recovery must be between 65% and 135% per set.

More stringent surrogate recovery parameters are possible per your specifications

4.0 Direct Push Probes Equipment List

ESN Northwest currently operates 5 truck-mounted Direct Push Probe vehicles and a Limited Access Rig (LAR). Each sampling platform has the ability to perform a wide range of sampling operations including ground water, soil, and soil gas sampling. The following list is representative of the type of equipment carried on the sampling platforms:

Heavy Duty Sampling Tools

1.5” OD x .75” ID heavy duty drive rod and accessories
2.0” OD x 1.5” ID x 18-24” long split barrel piston sampler for discreet soil sampling
1.5” OD x 1.0” ID x 18” long split barrel piston sampler for discreet soil sampling
2.0” OD x 1.5” ID x 36” long continuous soil sampler
Stainless steel, brass, and clear plastic liners to fit all soil samplers
Heavy duty drive rod with expendable point holder, 1.75” OD expendable point, and PRT adapter for soil gas sampling
2.0” OD x 1.5” ID x 36” long ground water sampler with shielded drop-out stainless steel screen insert, similar to Hydropunch II
1.5” OD x .75” ID heavy duty rod to accept .50” slotted PVC screen for ground water sampling
2.0” OD x 1.5” ID heavy duty casing to accept up to 1.0” OD PVC well screen for ground water sampling

Standard Duty Sampling Tools

1.3” OD x 1.1” ID large bore piston discrete soil samplers
2.0” OD x 48” long continuous soil sampler
1.0” OD x .5” ID drive rod
1.25” OD x .5” ID drive rod
1.0” OD and 1.50” OD expendable points, point holders, and PRT fittings for 1.0” and 1.25” drive rod, respectively, for soil gas sampling
Syringes, 3-way valves, and tubing necessary to collect soil gas samples
1.0” OD ground water sampler, similar to Hydropunch II
Stainless steel and PVC bailers; all tubing necessary to collect ground water samples

Miscellaneous Items

Grout pump
4.0 kW Generator
Rotary hammer and bits
Concrete and asphalt patching materials
Backfill and hole abandonment materials: sand, bentonite, etc.
Decontamination equipment: triple bucket rinse
Complete set of various hand tools
Peristaltic pump for sampling large volumes of groundwater
Water level meter
All necessary PPE
High pressure steam cleaner

5.0 Professional Staff Qualifications

Personnel: ESN Northwest has an abundance of trained professionals within the system, including five registered geologists, certified well drillers, certified geophysicists, chemists, and engineers.

The following is a summary of key personnel who are likely to be actively involved in work resulting from any particular RFP.

NAME	POSITION
Michael A. Korosec	President – ESN Northwest Geochemist

EDUCATION AND AFFILIATIONS

Phillips Exeter Academy, 1972. Bachelor of Science, Biology; Minors: Geology, English; Case Western Reserve University, 1975. Master of Science, Geological Sciences; Specialties: Oceanography, Geochemistry; University of Southern California, 1978. Master of Business Administration; Specialties: Finance, Management; City University, Seattle, Washington, and Pacific Lutheran University, Washington, 1987.
OSHA 40 hour training 1994. OSHA 8 hour refresher 1997.
OSHA 8 hour supervisor training 1995.

EXPERIENCE

Mr. Korosec's academic research included studies of the chemical and physical controls on the transport of dissolved nutrients across a sediment-water interface, using UV spectrophotometry and gas chromatography. Mr. Korosec has written technical newsletters and user manuals for Chi Corporation, Cleveland, OH. He taught oceanography at the University of Southern California and at Pierce College for three years. Mr. Korosec spent 8 years as a geologist for the Washington Department of Natural Resources, Division of Geology and Earth Resources, and managed the state-wide Department of Energy-funded geothermal exploration program. This work included the development of a water analysis laboratory for the determination of dissolved cations, anions, and trace metals in thermal and mineral springs and well waters. Instrumentation included AA spectrophotometer, UV spectrophotometer, mercury analyzer, and specific ion meters. Additional work included drilling programs for temperature gradient and heat-flow studies, whole rock geochemistry, age dating, and geologic mapping. As program manager, Mr. Korosec was responsible for all contracting, subcontracting and reporting to the U.S. Department of Energy. Mr. Korosec has over 23 years of experience in low temperature geochemistry, including ten years as President and Director of ESN Northwest.

With ESN Northwest, Mr. Korosec owns a fleet of Direct Push Probes and mobile environmental laboratories, and two fixed-base laboratories. Mr. Korosec also owns ESN Pacific located in Hawaii on the Island of Oahu. ESN NW is part of the ESN, a national network of direct push, mobile and fixed base environmental laboratories. At ESN Northwest, Mr. Korosec is responsible for method development for on-site analysis and determination of contaminants in different matrices, including the analysis of PCB's, pesticides, PAH's, phenols, and metals.

1991 – present: President for ESN Northwest

1984 – 1989: Geologist 3: Washington State Department of Natural Resources (DNR)

1980 – 1988: Geologist 3: Geothermal Program Manager; Washington State DNR

1978 – 1980: Geologist 2: Division of Geology and Earth Sciences; Washington DNR

1977 – 1978: Instructor: Oceanography, Pierce College.

NAME	**POSITION**
Patricia Korosec	Owner - ESN Northwest Office Manager

EDUCATION AND AFFILIATIONS
Paralegal Certificate, Pierce College, 1984.

EXPERIENCE
Ms. Korosec has dedicated twenty years of service to the state of Washington in various capacities. These include: Clerk/Steno 11 for the Washington State Department of Highway and Transportation-Architectural Division; Secretary for the Washington State Department of Natural Resources – Geologist Division; and Paralegal for both the Washington State Department of Ecology and Washington State Attorney General's Office. Ms. Korosec supervised staff, administrated attorney services, and prepared and compiled legal documents for presentation to court and the Environmental Hearing Board.

As owner of ESN Northwest, Ms. Korosec tracks and manages all invoicing and accounts receivable. She supervises personnel and human relations, focusing on maintaining a qualified staff and enhancing a productive and supportive working environment. Ms. Korosec oversees office administration and client relations, providing support and expertise to ESN Northwest's staff and clients.

NAME	**POSITION**
Eric Nassau	Chemist Environmental Geologist Direct Push Probe Operator

EDUCATION AND AFFILIATIONS

Bachelor of Science, Environmental Chemistry, Evergreen State College, Olympia, Washington, 1990.
OSHA 40 hour training 1994.
OSHA 8 hour refresher 1999.
OSHA 8 hour supervisor training 1995.
CPR and First Aid Certification, American Red Cross, 2000.
Washington State Driller
Oregon State Driller

EXPERIENCE
Mr. Nassau earned a BS from the Evergreen State College in 1990 with a major in environmental studies and chemistry. In the spring of 1991 he spent a short training period at Analytical Resources learning EPA-approved extraction methods. He then pursued gas chromatography work in the Rush Fuels department at Analytical Technologies in Renton for the next three years. He spent a year of that time managing the volatile fuels group and also worked in departments analyzing volatile organics, pesticides and PCBs.

In 1994 he began working for ESN Northwest, primarily as a Mobile Laboratory chemist. In 1996 he started doing occasional direct push sampling work and then began dividing his duties between chemistry and drilling for the next six years. During that time he also helped bring our Hawaii office on line, smoothing the transition period for both the lab and the drilling departments at that location.

In April 2003 Mr. Nassau took on the task of managing the ESN lab in Bellevue. He is well suited to the challenge. His years spent as a GC chemist, his hands-on experience delineating environmental contamination in the field, and the depth of his communication skills allows him to offer excellent service to those seeking quality environmental analysis.

NAME	**POSITION**
Karis Vandehey	Senior Environmental Geologist Direct Push Probe Operator

EDUCATION AND AFFILIATIONS
Bachelor of Science, Geology, University of Puget Sound, Tacoma, Washington, 1993.
CPR and First Aid Certification, American Red Cross, 2000.
OSHA 40 hour training 1994.
OSHA 8 hour refresher 1999.
OSHA 8 hour supervisor training 1995.
Washington State Driller
Oregon State Driller

EXPERIENCE
As a research assistant, Ms. Vandehey collected heavy mineral beach sands throughout the Columbia River Basin, and analyzed them by x-ray diffraction. She selected major tributaries and performed a quantitative and qualitative survey of their contribution to the main river system.

Ms. Vandehey is Manager of Field Services and is responsible for the scheduling and oversight of Direct Push Probe projects as well as Direct Push Probe operation. Ms. Vandehey also assists as a laboratory technician, helping with sample preparation, extraction, and mobile-lab operation. Ms. Vandehey has been with ESN Northwest since 1994

NAME	**POSITION**
Kevin Vandehey	Senior Environmental Geologist Direct Push Probe Operator

EDUCATION AND AFFILIATIONS
Bachelor of Science, Geology, University of Puget Sound, 1993.
CPR and First Aid Certification, American Red Cross, 1999.
OSHA 40 hour training 1994.
OSHA 8 hour refresher 1999.
OSHA 8 hour supervisor training 1995.
Washington State Driller
Oregon State Driller

EXPERIENCE
Mr. Vandehey was a geology lab assistant for four years, and he has managed a small business. Mr. Vandehey carried out x-ray diffractometric analyses of heavy mineral sands from the Columbia River drainage basin. He underwent intensive geologic field methodology training in Salida, Colorado.

Mr. Vandehey is our senior Direct Push Probe operator and manager of field services. He is responsible for product and service development and project oversight. Mr. Vandehey has been with ESN Northwest since 1994.

NAME	**POSITION**
Anisa Newman	Environmental Geologist Direct Push Probe Operator

EDUCATION AND AFFILIATIONS

Bachelor of Science, Geology; Minor: Chemistry; Texas Tech University, Lubbock, Texas, 1993.
OSHA 40 hour training 1998.
OSHA 8 hour refresher 1999.
CPR and First Aid Certification, American Red Cross, 1999.
Washington State Driller Trainee
Oregon State Driller

EXPERIENCE

Ms. Newman performed microscopic geoscience analyses, and researched journal articles as a student assistant. As a geophysical data processor, she maintained a processing office and acted as liaison with clients. Ms. Newman meticulously compiled airborne magnetic radiometric data as a geophysical technician.

At ESN Northwest, Ms. Newman runs Direct Push Probes, and is responsible for the operation and maintenance of drilling and sampling equipment. Ms. Newman has been with ESN Northwest since 1998.

NAME	**POSITION**
Todd Klein	Environmental Geologist Direct Push Probe Operator

EDUCATION AND AFFILIATIONS

Bachelor of Science, Environmental Science, Stockton State College, Pomona, New Jersey, 1987. Wastewater Treatment Operations Licensing Course, Rutgers University, New Brunswick, New Jersey, 1990. AutoCAD training course, Blasland, Bouck, and Lee (BB & L), Tampa, Florida, 1992.
CPR and First Aid Certification, BB & L, Tampa, 1993; Seattle, 1999, lacey, 2000.
OSHA 8 hour refresher 2000.
Washington State Driller
Oregon State Driller

EXPERIENCE

Mr. Klein has prepared Environmental Impact Statements for proposed coastal zone construction and development, has performed ocean-core and sediment sampling, and participated in pollutant transport and dispersion studies. Mr. Klein has performed Phase I and II site assessments, has removed UST’s, implemented remedial action plans for contaminated sites, negotiated contracts, drafted final reports, and provided technical assistance to litigation teams in legal proceedings. At ESN Northwest, Mr. Klein is responsible for maintenance and operation of drilling and sampling equipment. Mr. Klein has been with ESN Northwest since 1996.

NAME	**POSITION**
Kevin Boone	GC/MS Chemist

EDUCATION AND AFFILIATIONS

Bachelor of Science in Biological Science from Florida State University, Tallahassee, Florida 2001.
Awards: Summa Cum Laude, Phi Betta kappa, Phi Kappa Phi, Golden key, Phi Eta Sigma, National Society of Collegiate Scholars.

EXPERIENCE

In his last year of college, Mr. Boone worked as a Teaching Assistant in the Department of Biological Science. Since then he has worked at our ESN Georgia office as a GC/MS chemist, where for the last seven months he has also been the lab manager. He was responsible for managing chemists in the wet chemistry lab and doing organic analysis by GC and GC/MS, metals by ICAP and waters by IC. He was also responsible for routine maintenance of equipment and validation of GC, GC/MS, IC, and ICAP results by performing appropriate QA/QC analyses. Mr. Boone is proficient in EPA methods for Stormwater analysis, including the determination of pH, Chemical Oxygen Demand, Turbidity, Mercury, Total Suspended Solids, Cyanide, Dissolved Oxygen, and Oil and Grease.

NAME	**POSITION**
Marilyn Farmer	Environmental Chemist Mobile Laboratory Specialist

EDUCATION AND AFFILIATIONS

Medical Laboratory Technology, A.S.C.P. 1988
Medical Technology License A.S.C.P.
EMT, Emergency Medical Technician, Tacoma Community College
Associate of Science, Western Washington University 1980
General Science Studies, Pacific Lutheran University, 1977,1978
Asbestos Analysis Certification: Forensic Analytical 2001
OSHA 40 hour training 1995
OSHA 8 hour refresher 1999
HAZMAT certification 2002

EXPERIENCE

Ms. Farmer worked for ten years at the Capital Medical Center in the laboratory and pathology departments. Her duties included analysis in bio-chemistry, toxicology, and immunology, as well as hematology, coagulation and bloodbank studies. She used fluorescent and polarized light microscopy for testing in the microbiology and pathology departments. During her time at CMC, Ms. Farmer was often called to fill in as an assistant in the emergency room. She also engaged in appropriate quality control, CAP studies and inter-laboratory verification for in house and industrial medicine.

From 1997 to 1998 Ms. Farmer worked to help set up an internal medicine laboratory for Walck Family Practice medical clinic. Ms. Farmer has been with ESN as an environmental chemist since that time, using the multi-tasking, analytical and triage skills honed in the challenging field of emergency room and laboratory medicine to insure fast, accurate and reliable results in the realm of organic chemistry, especially in our mobile labs. Since coming to ESN she has improved her microscopy skills further by taking the PLM asbestos identification course at Forensic Analytical in California and earning the appropriate degree certification.

NAME	**POSITION**
Tim McCall	Laboratory Manager Environmental Chemist Mobile Laboratory Operator

EDUCATION AND AFFILIATIONS

Bachelor of Science, Chemistry, Washington State University, 1996
OSHA 40 hour training 1998.
OSHA 8 hour refresher 1999.
CPR and First Aid Certification, American Red Cross, 2000

EXPERIENCE
1984 - 1997
San Jose University: Radio-chemist and lab asst/ instructor
Syntex, Inc.: HP and safety specialist
Radiation Detection Company: Radio-chemist
Washington Public Power Supply System Reactor #2: HP Support Staff
Smith Kline, Inc.: Hematology specialist

1997 - present
ESN Northwest and ESN Pacific
Mr. McCall has worked for ESN for the last seven years in various capacities, from bench chemist to mobile lab chemist to laboratory manager. He has developed extensive experience in the various analyses of petrochemical contamination and metals and is well versed in EPA approved methodologies. Mr. McCall is also the QA/QC specialist for ESN, employing his analytical mind and critical eye for detail to positive effect.

NAME	**POSITION**
Julie Mielke	Administrative Officer

EDUCATION AND AFFILIATIONS
Classes in Lotus, DOS, WordPerfect, dBase, and English Composition, Grays Harbor Community College, 1994. Classes in Keyboarding and Speech, South Puget Sound Community College, Olympia, Washington, 1997. Certificate of Office Automation, Business Computer Training Institute, 1998.
CPR and First Aid Certification, American Red Cross, 1999.

EXPERIENCE
Ms. Mielke has six years experience in customer service in fast-paced environments, and is a team player. She has extensive experience in office computer use, business correspondence, and basic bookkeeping. Ms. Mielke is the secretary and receptionist for ESN Northwest. She types invoices and cover letters for client reports. Ms. Mielke is responsible for office administration, communications with clients, and scheduling appointments. Ms. Mielke has been with ESN Northwest since 1998.

6.0 Major Instrumentation

Description	Manufacturer	Year(s)	Model
Gas Chromatograph, field PID	Photovac	1989	10550
Gas Chromatograph (ECD/ECD)	Hewlett Packard	1989	5890
Gas Chromatograph (FID, ELCD/PID)	Hewlett Packard	1989	5890
Gas Chromatograph (FID)	Hewlett Packard	1990	5890
Gas Chromatograph (FID, ECD)	Hewlett Packard	1992	5890 ser. ll
Gas Chromatograph (FID, ELCD/PID)	Hewlett Packard	1990	5890
Detector (ELCD/PID, on above GC's, 2)	IO	1989/90	4420/4430
Purge & Trap (on above GC's, 2)	IO	1989/90	4460A
Auto Sampler/P&T (On above P&T, 3)	IO	1990	MPM16
Flame atomic Absorption (FAA)	PE	1989	2380
FAA Data System (On above FAA)	Labtronics	1992	DP500
Infrared Spectrophotometer	Buck	1990	HC-404
Exhaust Fan, s/s/ Duct, Hood for FAA	Fox	1989	
Gas Chromatograph (PID/FID)	Shimadzu	1991	14A
Gas Chromatograph (2 FID)	Shimadzu	1992	14A
Gas Chromatograph (2 FID/2 ECD)	Shimadzu	1992	14A
Gas Chromatograph (2 FID/PID)	Shimadzu	1992	14A
Gas Chromatograph (2 FID/2 ECD)	Shimadzu	1992	14A
Gas Chromatograph (2 FID/1 PID)	SRI	1993	8610
Gas Chromatograph (2 FID/1 PID)	Shimadzu	1994	14A
Gas Chromatograph (2 FID/1 PID)	Shimadzu	1995	14A
Gas Chromatograph (2 FID/ 2 ECD)	Shimadzu	1996	14A
Gas Chromatograph (2 FID)	Shimadzu	1997	14A
Gas Chromatograph (2 FID)	Shimadzu	1999	14A
Gas Chromatograph (2 FID)	Shimadzu	1999	14A
Flame Atomic Absorption	Buck	1994	200A
ENSYS field kit and case (1)			
Water filtration system (1)			
Ford 150 XLT		1983	
Ford 250 XLT		1993	
Ford 250 XLT		1994	
Jeep Grand Cherokee Ltd.		1997	
Ford 250 4x4		1991	
DirectProbe 5: Ford 350 4x4		1994	
DirectProbe 11: Ford 350 4x4		1994	
MegaProbe20: Ford 450		1996	
MegaProbe 25: Ford 350 4x4		1997	
MegaProbe 30: Ford 350 4x4		1999	
AMS PowerProbe 9600-P		2000	
Kubota Diesel Tractor 2400		2000	
MobileLab 1: RV – 1 Winnebago Warrior		1990	
MobileLab 2: RV – 2 Winnebago Warrior		1990	
MobileLab 3: RV – 3 Trailer Wilderness 30'		1991	
MobileLab 4: RV – 4 Custom Winnebago		1994	
MobileLab 5: 16' Wells Cargo Trailer		1991	
MobileLab 6: 26' Wells Cargo Trailer		1991	
ST-1: Support Trailer		1997	
ST-2: Support Trailer		1999	

7.0 Representative Client List

Agra Earth & Environmental
Alisto Engineering Group
Alton Geoscience
Applied Geosciences
Applied Geotechnology
ARCO
ASI
ATC Environmental
Boeing Corporation
Bonneville Power Administration
Bovay Northwest
CDM Federal
CH2M Hill
Chevron
Columbia Environmental
Dames & Moore
Dowl Engineers
E A Engineering Science & Technology
ECOVA
EGE
EMCON
EMR
Enecotech
ENSR Consulting & Engineering
Environmental Associates
Environmental Science & Engineering
ERM Northwest
Fluor Daniel GTI
Foster Wheeler Environmental
GeoEngineers
Geotech Consultants
Geraghty & Miller
Golder & Associates
Hart Crowser
ICF Kaiser
IT Corporation
Kennedy/Jenks Consultants
Kleinfelder & Associates
Landau Associates
Maxim Technologies
Ninyo & Moore
Nowicki & Associates
OHM Remediation Services Corporation
Optech
Pacific Environmental Services Group
Project Performance Corp
PBS Environmental
Radian
Riedel Environmental Services
SAIC
SCS Engineers
SECOR International
Shannon & Wilson
SME Corporation
Tacoma Public Utilities
Tetra Tech
Texaco Environmental Services
ThermoRetec Consulting Corporation
Thomas Hill Associates
Time Oil Company
Unocal
URS Greiner Woodward Clyde
U.S. Coast Guard
U.S. Navy
W. W. Irwin
Washington State Department of Ecology
Westinghouse Remediation Services
Roy F. Weston
Weyerhaeuser

8.0 List of Representative Projects

Past Performance

ESN Northwest has an excellent record with the military. All of our projects have been completed in the time originally allotted or sooner. Having backup personnel and equipment that we draw upon in a jam helps to insure that ESN Northwest can accommodate the ever-changing schedules inherent in fieldwork. The best source, however, for information regarding our performance, is our clients. We have included contact information in our attached references. We encourage you to call them.

Environmental Project Summary

A summary of recent projects completed by ESN Northwest:

Facility: Boeing Facilities, Boeing Field
Date conducted: July through November 1994
Scope of Work: Multi-level water profiling to 55 and 90 feet
Number of Sampling Points: 300+
Required Time to Complete Program: 12 weeks
Consultant: Roy F. Weston (Keith Pine, 206-521-7600)

Facility: Long Beach Naval Shipyard, CA
Date conducted: July through August 1994
Compounds: Aromatic & halogenated hydrocarbons, metals
Number of Sampling Points: 30 borings, soil, soil vapor, and water samples
Required Time to Complete Program: 15 days
Consultant: Bethel for Navy Clean II (Lynn Edland, 303-807-2302)

Facility: Pacific Airmotive, Burbank, CA
Date conducted: July 1994
Compounds: Aromatic & halogenated hydrocarbons
Number of Sampling Points: 150 soil vapor samples
Required Time to Complete Program: 10 days
Consultant: Kennedy/Jenks (Russ Purcell, 714-261-1577)

Facility: Georgia Underground Storage Tanks
Date conducted: July 1994 - 1997
Compounds: Total Petroleum Hydrocarbons, full range of aromatics
Number of Sampling Points: 2,500+ soil samples
Required Time to Complete Program: 3 years
Consultant: GA Dept. of Natural Resources (M. Gottschalk, Ph.D. 404-362-2687)

Facility: Fairchild & Four Lakes Airforce Base, Spokane
Date conducted: August 1998, January 1999, and July 1999
Scope of Work: Direct Push Probe sampling to depth in tough substrate, soil vapor survey with mobile laboratory, and monitoring well installation
Consultants: ERM (Mike Arnold, 425-462-8591), EA Science, Engineering & Technology (Tom Colligan, 425-451-7400)
Facility: Fort Lewis Base, Army Corps of Engineers
Date conducted: October 1998, March 1999
Mobile Lab Work: Analysis of VOC's in soil vapor, soil, and groundwater
Direct Push Probing: Collection of soil vapor, and multilevel groundwater samples as deep as 40 feet through fine grain till
Consultant: URS Greiner Woodward Clyde (Bill Deutsch & Nancy Walker, 206-674-1800)

RTA Project
ESN Northwest demonstrated its abilities and dependability on many RTA project sites in late 1998 through early 1999. Our Direct Push Probe was used to investigate station sites in Puyallup, Kent, Sumner, Seattle, and Auburn.
Consultant: Shannon & Wilson (Gretchen Miller Reid, 206-633-6731)

Seattle Water Department
ESN Northwest was part of a team that replaced a creosote-laden pipeline with an underground pipeline for the Seattle Water Department. Our quick laboratory turnaround time ensured that the project was completed on schedule.
Consultant: Seattle Water Department (Don Kaizen, 206-386-4045)

Friday Harbor UW
ESN Northwest recently provided Mobile Laboratory services for the University of Washington on Friday Harbor Island. Our onsite services allowed the site to be investigated and remediated in one effort.
Consultant: University of Washington (Jim Broadlick)

Weekend Jobs
ESN Northwest was part of a team assembled to investigate and remediate a trucking facility. ESN Northwest provided Mobile Laboratory services many weekends to support the cleanup of the site.
Consultant: Kleinfelder (Rory Galloway, 425-562-4200)

Puget Sound Energy
ESN Northwest is working for Puget Sound Energy on a continuing basis in an effort to evaluate their facilities.
Consultant: GeoEngineers (Kurt Fraise, 425-861-6000)

Fred Hutchinson
ESN Northwest provided Fred Hutchinson with analytical and sampling services as part of a team helping to expand the facility.
Consultant: Dames & Moore (David Raubvogel, 206-728-0744)

Stadium Project
ESN Northwest has provided Direct Push Probe and analytical services for the Mariner Stadium project, enabling rapid environmental assessment of various sites.
Consultants: Hart Crowser (Rick Moore, 206-324-9530), Shannon & Wilson (Gretchen Miller Reid, 206-633-6731)

Air National Guard
ESN Northwest was part of two teams that conducted Phase II investigations at the Air National Guard facilities in Springfield, IL, Seattle, WA, Coos Head, OR, Lakewood, WA, and Salt Lake City, UT, during 1994-1999.
Consultants: ERM (John Borkovich, 916-444-9378), Optech (Mike Giles, 423-483-8020)

Navy
ESN Northwest provided onsite laboratory services at a remote location (Barrow, AK) for site investigations of petroleum hydrocarbons and tetrachloroethene in soil, air, and water samples associated with an excavation and remediation system in 1994.
Consultants: Shannon & Wilson (Scott Gulke, 206-632-8020), Foster Wheeler (Bernie Wong, 425-688-3700 ext3925)

Vancouver, Washington, Superfund Site
ESN Northwest provided mobile laboratory and Direct Push Probe services to collect and analyze soil vapor for chlorinated compounds.
Consultant: EA Engineering, Science & Technology (Tom Colligan, 425-451-7400)

9.0 Certifications and Affiliations

Federal and State Accreditation and Testing Programs

EPA Lab Testing Program	Lab Number WA140
Washington State Department of Ecology	Lacey Accreditation No. C076 Bellevue Accreditation No. C134
California DOHS Certification	Certification No. 1887

Other Formal Audits and Testing Programs

Certification for PLM asbestos analysis; AIHA (American Industrial Hygiene Assoc.) Lab # 159533

ARCO Contract Lab

Bonneville Power Administration Approved Lab

Chevron Approved Lab

Foster Wheeler Lab Audit

Geraghty & Miller Lab Audit

Los Angeles Regional Water Board Approval

Texaco Environmental Services Approved Lab

Texas Water Commission Approval

U.S. Navy CLEEN (NEESA) Audit

URS Consultants Lab Audit

Woodward Clyde Lab Audit

EXHIBIT D

Restrictive Covenant

After Recording Return to:
Ha Tran
Department of Ecology
Industrial Section
Solid Waste & Financial Assistance Program
300 Desmond Drive
Lacey, WA 98504-7600

EXHIBIT D

RESTRICTIVE (ENVIRONMENTAL) COVENANT
EMERALD KALAMA CHEMICAL LLC

Grantor:	Emerald Kalama Chemical LLC
Grantee:	State of Washington, Department of Ecology
Legal:	See Exhibit A to Consent Decree for full legal description
Tax Parcel Nos.:	61335, 62816002

Grantor, Emerald Kalama Chemical LLC (hereafter "Emerald Kalama Chemical"), hereby binds Grantor, its successors and assigns to the land use restrictions identified herein and grants such other rights under this environmental covenant (hereafter "Covenant" or "Restrictive Covenant") made this ______ day of ____________, 200__, in favor of the State of Washington, Department of Ecology (hereafter "Ecology"). Ecology shall have full right of enforcement of the rights conveyed under this Covenant pursuant to the Model Toxics Control Act, RCW 70.105D.030(g), and the Uniform Environmental Covenants Act, Chapter 64.70 RCW.

This Declaration of Restrictive Covenant is made pursuant to RCW 70.105D.030(1)(f) and (g) and WAC 173-340-440 by Emerald Kalama Chemical LLC (hereafter "Emerald Kalama Chemical"), its successors and assigns, and Ecology, its successors and assigns.

A remedial action (hereafter "Remedial Action") is occurring at the property that is the subject of this Restrictive Covenant. The Remedial Action conducted at the property is described in the following documents, among others:

1) Consent Decree, dated _____________________.

2) Cleanup Action Plan (CAP), dated June 2004.

These documents are on file at Ecology's Industrial Section Central Files.

This Restrictive Covenant is required because the Remedial Action will result in residual concentrations of contaminants of concern (COCs) identified in the CAP (including toluene, benzene, and diphenyl oxide) that exceed the Model Toxics Control Act (MTCA) cleanup levels for groundwater specified in the CAP.

This Restrictive Covenant is required as long as hazardous substances remain at the site in concentrations that exceed MTCA cleanup levels specified in the CAP. Upon demonstration that residual concentrations of the COCs do not persist on the Property after completion of the Remedial Action specified in the Consent Decree and CAP, the owner of the Property may proceed under Section 7 of this covenant, pending Ecology's written concurrence.

The undersigned, Emerald Kalama Chemical, is the fee owner of real property in the County of Cowlitz, State of Washington, a portion of which is subject to this Restrictive Covenant (hereafter "Property"). The legal description of the Property subject to this Restrictive Covenant is contained in Exhibit A to the Consent Decree.

Emerald Kalama Chemical (hereafter "Owner") makes the following declaration as to limitations, restrictions, and uses to which the Property may be put and specifies that such declarations shall constitute covenants to run with the land, as provided by law and shall be binding on all parties and all persons claiming under them, including all current and future owners of any portion of or interest in the Property.

Section 1. Any activity on the Property that may interfere with the integrity of the Remedial Action and continued protection of human health and the environment is prohibited.

Section 2. Unless authorized by the CAP or this Restrictive Covenant, any activity on the Property that may result in the release or exposure to the environment of a hazardous substance that remains on the Property as part of the Remedial Action, or create a new exposure pathway for a hazardous substance that remains on the Property as part of the Remedial Action, is prohibited without prior written approval from Ecology in accordance with Section 5 of this Restrictive Covenant, which approval shall not be unreasonably withheld. Such activities include, but are not limited to, the withdrawal of groundwater for domestic uses. Activities performed in accordance with Section 8 herein shall be deemed to be authorized by this Restrictive Covenant and, therefore, shall not require notification to or approval from Ecology and shall not be subject to public notice and comment under Section 5 herein.

Section 3. Except as otherwise specified herein, the Owner of the Property must give thirty (30) day advance written notice to Ecology of the Owner's intent to convey any interest in the Property. Where is it not possible for the Owner to notify Ecology of such transfer at least thirty (30) days in advance due to the timing of the transfer, the Owner must provide written notice to Ecology as soon as it becomes aware of the impending transfer. No conveyance of title, easement, lease, or other interest in the Property shall be consummated by the Owner without adequate and complete provision for continued monitoring, operation, and maintenance of the Remedial Action. This Section 3 shall not be construed as granting any exemption from, or any waiver of, any other requirements that may require notice of such conveyance of interest under applicable laws, rules and regulations.

Section 4. The Owner must restrict leases to uses and activities consistent with the Restrictive Covenant and notify all lessees of the restrictions on the use of the Property.

Section 5. The Owner must notify and obtain written approval from Ecology prior to conducting any activity on the Property that is not authorized by the CAP or by this Restrictive Covenant that may result in the release or exposure to the environment of a hazardous substance that remains on the Property as part of the Remedial Action, or create a new exposure pathway for a hazardous substance that remains on the Property as part of the Remedial Action. Ecology may approve any such use only after public notice and comment. Approval by Ecology pursuant to Section 5 shall not be unreasonably withheld. Activities performed in accordance with Section 8 herein shall be deemed to be authorized by this Restrictive Covenant and, therefore, shall not require notification to or approval from Ecology and shall not require public notice and comment under this Section.

Section 6. The Owner shall allow authorized representatives of Ecology the right to enter the Property at reasonable times and in compliance with applicable health and safety plans for the purpose of evaluating the Remedial Action; to take samples, to inspect Remedial Actions conducted at the Property, and to inspect records that are related to the Remedial Action.

Section 7. The Owner of the Property reserves the right under WAC 173-340-440 to record an instrument that provides that this Restrictive Covenant shall no longer limit use of the Property or be of any further force or effect. However, such an instrument may be recorded only if Ecology, after public notice and opportunity for comment, concurs, which concurrence shall not be unreasonably withheld.

Section 8. Notwithstanding any other provision in this Restrictive Covenant, construction and maintenance and related excavation activities shall be deemed consistent with and authorized by the terms of this Restrictive Covenant, and may occur on the Property without notice to or approval from Ecology, and without public notice and comment, provided that such construction and maintenance and related excavation activities shall not involve any excavation of soil at depths greater than six feet below the existing ground surface, and provided further that following such activities, physical barriers required by the CAP or by this Restrictive Covenant shall be restored or created to prevent the release or exposure to the environment of a hazardous substance that remains on the Property as part of the Remedial Action, or to prevent a new exposure pathway for a hazardous substance that remains on the Property as part of the Remedial Action. Notification will be made to Ecology for approval, without the public notice and comment, if the disturbed barriers are not restored or created within 30 days after the completion of such activities. Any construction and maintenance and related excavation activities at depths greater than six feet below the existing ground surface shall not occur on the Property without prior written approval from Ecology in accordance with Section 5, which approval shall not be unreasonably withheld. This Section 8 shall not be construed as granting any exemption from, or any waiver of, any permitting or other requirements that may apply to such uses and activities under applicable laws, rules and regulations, including requirements related to worker safety and waste management involving contaminated media.

EMERALD KALAMA CHEMICAL LLC	STATE OF WASHINGTON DEPARTMENT OF ECOLOGY
______________________________	______________________________
Brian Denison Vice President, Health, Safety Environmental, Technology & Logistics	Ha Tran Industrial Section, Solid Waste & Financial Assistance Program
Dated: ____________________	Dated: ____________________

STATE OF WASHINGTON)
) ss.
COUNTY OF COWLITZ)

I certify that I know or have satisfactory evidence that ____________________ is the person who appeared before me, and said person acknowledged that he/she was authorized to execute the instrument and acknowledged it to be the free and voluntary act and deed of such party for the uses and purposes mentioned in this instrument.

DATED this _____ day of ________________.

____
By: ______________________________
Notary public in and for the State of Washington,
residing at ____________________ County
My appointment expires ______________

EXHIBIT E

Public Participation Plan

Public Participation Plan

Emerald Kalama Chemical Facility

Introduction and Overview

This Public Participation Plan (Plan) outlines the public involvement activities for the draft Consent Decree and at the Emerald Kalama Chemical facility, formerly owned and operated by BF Goodrich, Inc. (Goodrich) and Noveon, Inc., among others, located in Kalama, Washington. The legal agreement, called a Consent Decree, among Ecology, Goodrich and Emerald Kalama Chemical (Emerald), will ensure that the cleanup meets the requirements of the Model Toxics Control Act (WAC Chapter 173-340) (MTCA). The Cleanup Action Plan, which is being implemented under the Consent Decree, describes the Ecology-approved cleanup actions and the work to be performed at the site. For more information about the site's history and previous and ongoing cleanup actions, please review the attached Consent Decree.

The activities set forth in this Plan are designed to involve the affected community in the cleanup process in a meaningful way and at facilitating open communication among the community, Ecology, Goodrich and Emerald.

While certain aspects of a public participation plan are prescribed by regulation, this Plan has been tailored to meet the needs of the public based on the stage and nature of the cleanup, the level of public concern and the risks posed by the site.

Public Involvement

Ecology uses a variety of tools that are aimed at facilitating public participation in the planning and cleanup of a MTCA site. The following is a list of these tools, their purpose and when and how they will be used during this site cleanup.

Formal Public Comment Period

Comment periods are the primary way Ecology obtains feedback from the public on proposed cleanup decisions. Comment periods usually last 30 days and are required at key points of the cleanup process before final decisions are made. During a comment period, the public can comment in writing. Oral comments are taken if a public hearing is held.

For this site, since the comment period will coincide with a Class 3 RCRA/HWMA permit modification for the Emerald Kalama Chemical facility, a 60-day public comment period will be held from December 24, 2007 to February 22, 2008. During this time, the community will have the opportunity to comment on the draft Consent Decree and this Public Participation Plan. The Cleanup Action Plan already has undergone Ecology review and public comment and was approved by Ecology on October 11, 2004.

Public Meetings and Hearings

Under MTCA, if ten or more people request a public hearing during the public comment period, Ecology will hold a public hearing for the purpose of taking oral comments on the draft documents. In this case, since the comment period will coincide with a Class 3 RCRA/HWMA permit modification for the Emerald Kalama Chemical facility, a public hearing will be held during the comment period. The precise date will be established and publicized.

Responsiveness Summaries

After every public comment period, Ecology reviews and responds to all comments received, both oral and written, in a responsiveness summary. Ecology considers changes or revisions based on the input from the public. If significant changes are recommended, then a second comment period is held. If no significant changes are recommended, then the Consent Decree is considered final and is recorded in the Washington State Superior Court in Cowlitz County. All of those who submit comments will be advised when the responsiveness summary is available. The responsiveness summary also will be made available at the Information Repositories listed below.

Information Repositories

Information repositories are convenient places where you may review site information. The information repositories are often at libraries or community sites where the public has access. During the comment period, the site documents will be available for review at each repository. Documents remain at the repository for the duration of the cleanup. Ecology's Central Files can make copies of documents for a fee.

For this site, drafts of the Consent Decree and this Public Participation Plan will be available at the following repositories for public review. The final Cleanup Action Plan and site Agreed Order are also available at the repositories. In addition, copies of all public notices, fact sheets, and press releases; all quality-assured monitoring data; remedial action plans and reports, supplemental remedial planning documents, and all other similar documents relating to performance of the remedial action required by the Consent Decree will be promptly placed in these repositories:

Kalama Library
312 North First
Kalama, WA 98625
360-673-4568

Ecology's Industrial Section Office
300 Desmond Drive
Lacey, WA 98504-7600

Site Register

One of the communication tools of Ecology's Toxics Cleanup Program is the Site Register. All public meetings and comment periods as well as many other activities are published in this bimonthly report. The public comment period for this site will be announced in an upcoming edition of the Site Register. To receive the Site Register, contact Carol Dorn at

(360) 407-7224 or register at www.ecy.wa.gov/programs/tcp/pub_inv/pub_inv2.html.

Mailing List

Ecology has compiled a mailing list for the site. The list includes all residences and businesses adjacent to the site, individuals, groups, public agencies, elected officials, and private businesses and industries that request site-related mailings, as well as other known interested parties. The list will be maintained at Ecology's Industrial Section Office and will be updated as needed.

Fact Sheets

Fact sheets are site-specific newsletter like publications that are mailed to interested persons, business and government agencies in and around affected communities. The fact sheet is used to inform them of comment periods and important site activities. Fact sheets are also used to informally update the community on the progress of the site cleanup.

For this site, Ecology has prepared a fact sheet and will mail copies of the fact sheet to interested parties on the Mailing List to announce the formal comment period and availability of site documents to be reviewed.

Display Ads

Display advertisements are placed in the newspaper of largest circulation and local community newspapers to announce the public comment period and, if applicable, the public hearing. Display ads are preferred to legal notices as they are easier to find and easier to understand than legal notices.

The display ad to announce the public comment period for this site will be placed in the Longview Daily News on December 24, 2007.

Amendments to Plan

This Plan may be updated as the project proceeds. If an update is necessary, the revised plan will be submitted to the public for comment.

Public Points of Contact

Department of Ecology

Ha Tran
Industrial Section, Solid Waste & Financial Assistance Program
300 Desmond Drive
Lacey, WA 98504-7600
(360) 407-6064

Goodrich:

Michael J. Riley
S.S. Papadopulos & Associates, Inc.
101 North Capital Way, Suite 107
Olympia, WA 98501
(360) 709-9540

Emerald:

Christopher Wrobel, Ph.D.
Emerald Kalama Chemical, LLC
1296 Third Street NW
Kalama, WA 98625
(360) 673-0289