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WORKPLAN FOR A PILOT TEST OF *IN SITU* BIOREMEDIATION OF PERCHLORATE IN GROUNDWATER AT THE FORMER ATOFINA CHEMICALS SITE, PORTLAND, OREGON

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1. INTRODUCTION

GeoSyntec Consultants Incorporated (GeoSyntec) was retained by Arkema Incorporated (Arkema) to conduct a laboratory biotreatability study to: i) evaluate the potential to biodegrade perchlorate in groundwater at the former ATOFINA Chemicals Inc. facility in Portland, Oregon (the Site; **Figure 1**); and ii) assess whether enhanced in situ bioremediation (EISB) may be an appropriate remediation technology for the Site groundwater. The results of the biotreatability study indicated that perchlorate could be biodegraded through the addition of appropriate nutrients (electron donors) and bioaugmentation with perchlorate-reducing bacteria. Legacy Site Services LLC (LSS), retained GeoSyntec to develop an approach for field pilot testing of EISB at the Site.

Based on the results of the biotreatability study, two potential EISB pilot test options (active recirculation and passive biobarrier) for the Site groundwater were identified. To determine the optimal EISB approach to pilot test, GeoSyntec identified several data needs that were addressed as pre-design data collection activities. The key results of the biotreatability study, the two potential EISB pilot test options and the proposed pre-design data collection activities were presented in a Workplan titled "Workplan for a Pilot Test of *In Situ* Bioremediation of Perchlorate in Groundwater at the Former Atofina Chemicals Site, Portland, Oregon" which was submitted to the Oregon Department of Environmental Quality (ODEQ) on March 10, 2006. ODEQ provided comments on this Workplan in a letter dated April 6, 2006 (see Appendix A).

The pre-design data collection activities have been completed. Based on the results of these activities, LSS has selected active recirculation as the most suitable pilot test approach for the Site. This Revised Workplan provides details regarding design and execution of the active recirculation EISB pilot test for the Site groundwater, and addresses the April 6, 2006 ODEQ comments on the Workplan. The results of the pre-design investigations will be to ODEQ provided under separate cover.

The remainder of this Workplan is divided into eight sections:

- Section 2 provides a description of current Site conditions, geology, hydrogeology, and groundwater chemistry;

- Section 3 provides background information on perchlorate biodegradation and presents the methodology, results and conclusions from the laboratory biotreatability study;
- Section 4 discusses the uncertainties and data needs that were addressed to select an appropriate remedial approach (active or passive system) for pilot scale implementation and summarizes the results of the pre-design activities;
- Section 5 presents the pilot test objectives, the approach and methodology for the pilot test system;
- Section 6 provides a project schedule; and
- Section 7 provides work plan references.

2. SITE DESCRIPTION

The following subsections briefly describe the Site geology and hydrogeology (Section 2.1) and the groundwater chemistry (Section 2.2).

2.1 Site Geology and Hydrogeology

The Site geology consists of fill, overlying a sequence of dark gray-brown and black sands interspersed with laterally discontinuous silts/fine sands. **Figure 2** presents a generalized hydrostratigraphic cross-section across the Site, oriented parallel to groundwater flow. The hydrogeology beneath the site consists of shallow, intermediate and deep aquifer zones, generally separated by semi-continuous layers of lesser permeability sandy silt. As described further below, perchlorate impacts at the Site are generally confined to the shallow and intermediate zones, and as such, these two zones are the focus of the design concepts presented herein.

Near the perchlorate source area, in the vicinity of the former Chlorate Cell Room (referred to henceforth as the "Source Area"), the shallow and intermediate zones are separated by a continuous sandy silt layer. The water table in the Source Area can be found within the dark gray-brown sand unit at an approximate depth of 22 ft bgs. The silt layer appears to pinch out beneath the salt pad located to the northeast of the Source Area, and the aquifer becomes a continuous sandy layer with interbedded sequences of thin discontinuous sandy silt layers. This area downgradient of the Source Area where the aquifer is continuous is referred to henceforth as the "Downgradient Area". In the Downgradient Area, the water table is found at an approximate depth of 25 ft bgs. Near the Willamette River, the fill extends from ground surface to the water table, and the aquifer beneath the fill consists of more laterally continuous sandy silt layers. The groundwater elevation fluctuates seasonally by as much as 5 to 10 feet across the Site.

The hydraulic conductivity (K) of the aquifer materials varies with location on the Site. Within the Source Area and near the Willamette River where the aquifer contains a higher predominance of sandy silt layers, the K values were estimated to be around 1.2 ft/day based on the constant discharge tests conducted as part of the pre-design investigation work (see Appendix B and GeoSyntec, 2006). In the Downgradient Area, the perchlorate distribution, water table elevation contours and the results of the pump test at PT-2 suggest the presence of higher conductivity (K = 187 ft/day) materials.

The hydraulic gradient (∇h) is high in the Source Area, and decreases downgradient near the Willamette River, approximately corresponding to the area where the silt layer separating the shallow and intermediates zones pinches out. From water elevation contours measured in 2003, it appears that estimates of ∇h of 0.037 ft/ft in the Source Area and 0.004 ft/ft in the Downgradient Area are reasonable estimates for both shallow and intermediate zones. Based on these values of K, ∇h, and assumed porosity values of 0.3 (professional judgment), the groundwater velocity is estimated to range between 6 ft/yr near the Willamette River, to 54 ft/yr in the Source Area to 910 ft/year in the Downgradient Area.

2.2 Groundwater Chemistry

Perchlorate and chromium are present in a co-mingled plume that appears to emanate from the former Chlorate Cell Room and migrates to the northeast in the direction of the Willamette River. Chloroform (CF) is found within the Downgradient Area and near the Willamette River at concentrations up to 597 µg/L (MWA-49i). DDT, bromodichloromethane, and chlorobenzene also have elevated concentrations in groundwater near the Willamette River. Based on July 2003, May 2005 and September 2005 groundwater data, a maximum perchlorate concentration of about 300 milligrams per liter (mg/L) was detected at shallow aquifer well MWA-25, which is a downgradient well near the former Chlorate Cell Room. The chromium concentration at this well in June 2003 was 9.79 mg/L. Data from February 14, 2006, after injection of reducing agents, confirmed the total chromium concentration has reduced to 0.133 mg/L. Perchlorate and chromium concentrations are generally lower in the intermediate flow zone in areas where the silt layer separates the flow zones. In downgradient reaches of the plume, where this silt layer appears to be absent, the shallow and intermediate flow zones appear to merge, and elevated perchlorate concentrations are detected in wells screened deeper in the sand sequence (e.g., MWA-32i; 200 mg/L in July 2003). These perchlorate concentrations, while relatively high, are well within the range of biodegradable concentrations. The distribution of perchlorate supports the site conceptual model described above.

Figure 3 shows the distributions of perchlorate in the shallow and intermediate zones, respectively. In the Source Area, perchlorate concentrations in both the shallow and intermediate zones are elevated, indicating the need for bioremediation of both groundwater zones. The perchlorate appears to be migrating to the east-northeast from the Source Area towards the river (see **Figure 3** for perchlorate distribution).

Chlorate concentrations in samples obtained from wells MWA-32i (intermediate depth, Downgradient Area) and MWA-25 (shallow depth, Source Area) for the biotreatability study ranged between 5,000 to 9,000 mg/L. Therefore, electron donor demand calculations for the design concepts must account for the concentration of chlorate in the groundwater.

Review of supporting groundwater chemistry data (**Table 1**) reveals two potential concerns with respect to inducing perchlorate biodegradation in situ, namely: elevated pH (~8.5 to 11.1) in both shallow and intermediate depth wells beneath and downgradient from the former Chlorate Cell Room, and also at intermediate depths near the Willamette River (e.g., 10.4 at MWA-34i); and elevated chloride (historically up to 164,000 mg/L, but more recently around 104,000 mg/L after decommissioning of the salt pads in the summer of 2001) in shallow and intermediate zone wells located near the former salt pads and adjacent to the Willamette River. These conditions do not appear to co-occur, and the biotreatability tests described in this report therefore evaluated the extent to which each of these unique Site conditions affects perchlorate biodegradation. In addition, the area selected for the pilot test is not located in an extremely high pH or chloride zone. This is further supported by pH and chloride values collected during the pump test at PT-2 (pH ranged from 6.69 to 7.15 and chloride from 6,000 to 7,300 mg/L [see Appendix B]). Electron acceptors are present that may influence electron donor demand and system performance, including nitrate, phosphate, chlorate and sulfate, and these were considered in design of the bioremediation treatability study. Perchlorate reduction can be accomplished without inducing sulfate reduction, provided that the amount of electron donor added is balanced against the amount of perchlorate that needs to be degraded.

3. OVERVIEW OF PERCHLORATE BIODEGRADATION STUDIES

The following subsections provide a brief overview of the perchlorate biodegradation mechanism (Section 3.1), the approach and methodology for the Site biotreatability study (Section 3.2), the results of the Site biotreatability study (Section 3.3), and the conclusions from the Site biotreatability study (Section 3.4).

3.1 Perchlorate Biodegradation Mechanism

Perchlorate biodegradation results from microbially-mediated redox reactions, whereby perchlorate serves as the electron acceptor, and is reduced via chlorate to chlorite. Chlorite then undergoes a biologically mediated dismutation/ disproportionation reaction, releasing chloride and oxygen (**Figure 4**). The oxygen is subsequently reduced to carbon dioxide (CO_2), provided electron donors are available. Both chlorate and chlorite are transient intermediates, and are typically not observed during in situ perchlorate reduction (reaction rates for these intermediates are typically too rapid for detection). At this Site, however, chlorate is present in the groundwater, and would be expected to degrade via the reduction reaction shown in **Figure 4**.

A variety of electron donors have been used to stimulate perchlorate reduction, including organic acids (e.g., acetate, lactate, oleate), alcohols (e.g., ethanol), sugars (e.g., molasses, corn syrup), edible oils (e.g., canola and soybean oil), and waste products (e.g., manure). While perchlorate-reducing bacteria are generally thought to be ubiquitous (dozens of perchlorate-reducing bacteria have been identified in the scientific literature), laboratory microcosm studies presented in this Workplan using site groundwater and aquifer materials showed that geochemical conditions in the subsurface at the Site, specifically those limited areas of high pH and high chloride, are fairly inhibitory to perchlorate reduction by the indigenous bacteria, and as such, addition of perchlorate–reducing bacteria will be required to achieve the desired level of biodegradation of these constituents (see Section 4).

3.2 Biotreatability Study Objectives, Approach and Methodology

A laboratory biotreatability study was conducted by SiREM Laboratories of Guelph, Ontario (SiREM; a wholly-owned division of GeoSyntec) to confirm the ability to bioremediate perchlorate in the Site groundwater, given the unique groundwater conditions (e.g., elevated pH and chloride). As a secondary goal, the study assessed the fate of chromium, which is understood to be present in the Site groundwater primarily in hexavalent form, under the varying biotreatment conditions. The study evaluated the potential to jointly treat perchlorate and hexavalent chromium via in situ bioremediation, or to sequence in situ bioremediation of perchlorate with chromium treatment using calcium polysulfide (CPS) reduction, which reduces soluble hexavalent chromium to insoluble trivalent chromium.

The objectives of the biotreatability study were to:

- determine whether elevated pH inhibits perchlorate reduction, and, if so, evaluate the potential to buffer the groundwater to a more favorable pH (less than 9) and achieve subsequent perchlorate biodegradation;
- determine whether elevated chloride inhibits perchlorate reduction, and, if so test several dilutions to assess the chloride concentration break point for perchlorate reduction;
- evaluate whether electron donor and CPS can be jointly added to microcosms containing Site soil and groundwater to promote simultaneous biological reduction of perchlorate and chemical reduction of chromium; and
- assess the potential of bioaugmentation of the site materials with specific perchlorate-degrading bacteria to increase the rate and extent of perchlorate biodegradation.

Treatability testing was conducted using materials from two test locations at the Site:

- MWA-25 (the inferred source area) - the area immediately downgradient from the Chlorate Cell Room, where perchlorate and chromium are present in groundwater with elevated pH; and

- MWA-32i - a downgradient location adjacent to the Willamette River, where perchlorate and chromium are present in groundwater with elevated chloride (but acceptable pH).

Site soil and groundwater were used to construct a variety of control and treatment microcosms for each test location:

i) Sterile control to assess losses of perchlorate due to abiotic transformation or experimental processes (both MWA-25 and MWA-32i).

ii) Electron donor treatments for MWA-25: a neutral pH electron donor (ethanol + acetate) and an acidic pH electron donor (citric acid) selected for potential to both buffer pH and promote perchlorate biodegradation. When no perchlorate degradation was observed in the ethanol + acetate microcosms after about 4 weeks of incubation, they were buffered to a lower pH to evaluate whether this would improve degradation.

iii) Combined CPS-electron donor treatments, to evaluate whether both reactants can be added simultaneously to promote biological reduction of perchlorate and chemical reduction of chromium.

iv) Electron donor treatment for MWA-32i: a neutral pH electron donor (ethanol + acetate). The fate of perchlorate was monitored over time in these microcosms. When no perchlorate degradation was observed after about 4 weeks of incubation (due to elevated chloride), a 10-fold dilution of these microcosms was tested to evaluate whether this would improve degradation.

v) A combined CPS-electron donor (ethanol + acetate) treatment, to evaluate whether both reactants can be added simultaneously to promote biological reduction of perchlorate and chemical reduction of chromium.

vi) A sequential CPS-electron donor (ethanol and acetate) treatment, to assess the ability to initially reduce chromium with CPS, followed by biological reduction of perchlorate.

Treatment and control microcosms were constructed by filling 250 milliliter (mL) (nominal volume) glass bottles with 60 g of soil and 210 mL of associated groundwater, leaving a small headspace for gas production (e.g., CO_2). Microcosms were sealed with Mininert™ valves to allow repetitive sampling of each microcosm, and the microcosms were incubated at room temperature in an anaerobic chamber. Resazurin was added to the microcosms to confirm development of appropriate anaerobic-reducing redox conditions in the microcosms (resazurin is clear under anaerobic conditions but turns pink if exposed to oxygen). The microcosms were incubated in an anaerobic chamber for a period of up to 36 weeks, and were sampled on an as needed basis for analysis of perchlorate, chloride, added electron donors (ethanol, acetate, citrate), and competing electron acceptors (e.g., nitrate, chlorate, sulfate). Sample intervals varied by treatment based on observed rates of substrate consumption and degradation activity. Selected microcosms were re-spiked with perchlorate and/or electron donors during the incubation period to confirm degradation activity and/or to maintain electron donor availability. Analyses were conducted by SiREM, with the exception of chromium, which was conducted by North Creek Analytical Laboratories, Bothell, WA. Perchlorate analyses were conducted by SiREM by ion chromatography (IC) following USEPA Method 314.0. To confirm the accuracy of these analyses, confirmatory samples were submitted to Severn-Trent Laboratories (STL, Arvada, CO) for analysis of perchlorate by IC-mass spectrometry (IC/MS) following Method SW846 method 8321A. Relative percent differences (RPDs) were 4% and 7% for the two samples in which SiREM detected perchlorate. STL detected perchlorate in the other two samples, but at levels below the SiREM quantitation limit for this study (20 micrograms per liter [ug/L]), so RPDs could not calculated for those two samples. These results indicate good agreement between the two methods, providing confidence in the accuracy of the SiREM analyses. Comparative results are provided in Appendix C.

3.3 Biotreatability Study Results

This section presents and discusses the results for the source area and downgradient area. Analytical data for the source and downgradient areas are provided in Appendix D.

3.3.1 Source Area (MWA-25)

Key results can be summarized as follows:

- Citric Acid Treatment: In these microcosms, the concentration of perchlorate declined rapidly from ~285 mg/L to <0.02 mg/L within 7 days following electron donor addition. To confirm this result, the citric acid microcosms were re-spiked with perchlorate (~290 mg/L) and concentrations again declined to <0.02 mg/L within 7 days (**Figure 5**). Despite the encouraging result, little consumption of citrate or reduction in chlorate was observed coincident with this perchlorate mass loss, and as such, it is not clear whether this activity was entirely due to biological causes.

- Citric Acid + CPS Treatment: Following the encouraging results of the citric acid treatment, a treatment was constructed to evaluate whether citric acid and CPS could be simultaneously added to treat both perchlorate and chromium. In this treatment, perchlorate did not biodegrade. Bioaugmentation with a perchlorate reducing microbial culture did not improve the rate of perchlorate biodegradation. The reasons for the difference in perchlorate biodegradation between the citric acid alone and the citric acid + CPS treatments are unclear, but may be the results of microbial heterogeneity in the soils used to construct the varying citric acid treatment microcosms. Of note, an increase in chromium concentration from about 10 mg/L to 26 mg/L was observed in this treatment, likely as a result of mobilization due to the low pH; however, the chromium was present as trivalent, not hexavalent, chromium.

- Ethanol & Acetate Treatment: The addition of electron donor (ethanol + acetate) did not result in biodegradation of perchlorate (**Figure 5**). Buffering of pH also failed to improve perchlorate degradation in this treatment.

- Ethanol & Acetate + CPS Treatment: The addition of CPS simultaneously with electron donor (ethanol and acetate) resulted in reduction of chromium concentrations from ~9.5 mg/L to approximately 0.1 mg/L within 4 hours (Appendix D). These data suggest that CPS and electron donor can be added together in a single injection event, without adversely affecting CPS performance. However, perchlorate did not biodegrade in this treatment (**Figure 5**), even with pH buffering.

- CPS Pre-Treatment - Ethanol & Acetate Treatment: The addition of CPS 4 hours prior to electron donor addition resulted in reduction of chromium concentrations from ~9.5 mg/L to approximately 0.1 mg/L within 4 hours (Appendix D). Through 150 days of incubation, perchlorate biodegradation was not observed (**Figure 5**). After 146 days, the microcosms were bioaugmented with a perchlorate-reducing microbial culture adapted to elevated concentrations of total dissolved solids. Following bioaugmentation, perchlorate concentrations declined from an average of 267 mg/L to 38 mg/L within 107 days (through the end of the study). Of note, perchlorate declined to <0.8 mg/L in one of the three replicates, indicating that treatment of perchlorate to low levels is possible. The reasons for the variability in perchlorate degradation rates between replicate microcosms are unclear.

3.3.2 Downgradient Area (MWA-32i)

Key results can be summarized as follows:

- Ethanol + Acetate Treatment: No perchlorate biodegradation was observed in the MWA-32i microcosms over the first 44 days of incubation, likely due to the high chloride concentrations. After 146 days, selected microcosms were diluted ten-fold to reduce the concentration of chloride in the groundwater in these microcosms from >26,000 mg/L to ~2,600 mg/L. Dilution alone failed to stimulate perchlorate biodegradation. On 7 June

2004, two of the three replicate microcosms were bioaugmented with a perchlorate-reducing microbial culture. Rapid biodegradation of perchlorate to <0.2 and <0.8 mg/L, respectively, was observed within three weeks of bioaugmentation (**Figure 6**). To confirm perchlorate biodegradation activity, the microcosms were re-spiked with perchlorate (target of 250 mg/L). Perchlorate concentrations declined to an average of 18 mg/L by the end of September 2004, with concentrations less than 0.8 mg/L in two of the three replicate microcosms.

- CPS Pre-Treatment - Ethanol + Acetate Treatment: No perchlorate biodegradation was observed in these microcosms over more than 150 days of incubation, likely due to the elevated chloride. After 146 days, the microcosms were bioaugmented with a perchlorate-reducing microbial culture. Little change in perchlorate concentrations was observed, and the microcosms were re-augmented with microbial culture on 21 days later. Perchlorate biodegradation was not observed following the second bioaugmentation. In response, the microcosms were diluted two-fold to reduce the concentration of chloride from >26,000 mg/L to ~13,000 mg/L. Perchlorate concentrations then declined to an average of 85 mg/L by the end of September 2004 (**Figure 6**).

3.4 Conclusions from the Biotreatability Study

Key conclusions of the biotreatability study can be summarized as follows:

- CPS treatment does not appear to adversely affect or interfere with biodegradation activity.

- The concentration of chloride significantly affects the rate and extent of perchlorate reduction. A chloride concentration below 14,000 mg/L appears to be required to initiate perchlorate reduction.

- Data for citric acid treatments were ambiguous, showing rapid biodegradation under initial test conditions but essentially no biodegradation in a treatment containing CPS. The presence of CPS is not suspected to be the cause of the limited perchlorate biodegradation. Rather, microbial heterogeneity in the soils used to construct the varying citric acid treatment microcosms is suspected to be the cause. Ethanol and acetate do not promote perchlorate reduction unless microcosms are bioaugmented.

- Bioaugmentation with a perchlorate-reducing microbial culture significantly improves the rate and extent of perchlorate reduction in both the source and downgradient area microcosms, and is likely to be required in those areas to achieve successful EISB at the Site.

4. PILOT TEST PRE-DESIGN CHARACTERIZATION ACTIVITIES AND RESULTS

During development of potential pilot test approaches for the Site, GeoSyntec identified several key uncertainties that needed to be resolved before completing pilot test design. The main uncertainties/data needs were: i) delineation of the potential perchlorate distribution in vadose zone soils that may serve as a long-term source to groundwater; and ii) hydraulic characterization of the aquifer in areas where electron donor injection and possibly groundwater extraction activities would occur. Pre-design data collection activities to address these data needs are described in Sections 4.1 and 4.2 respectively.

4.1 Assessment of Vadose Zone Perchlorate Distribution

Soil cores were collected from the perchlorate study area in two phases. Phase 1 consisted of an initial screening to evaluate whether more extended sampling was warranted. For Phase 1, soil cores were obtained from four locations shown on **Figure 7** to a total depth of 5 ft below the watertable (approximately 25 to 30 ft bgs), with soil samples collected from these cores at three foot intervals for further analysis. Additional soil samples were collected from wells PT-3 and MWA-70i (installed for hydraulic testing, see Section 4.2). Soil cores were logged for soil properties, and samples were then collected at the specified depth intervals for perchlorate and chlorate analysis. Results of the analyses from the Phase 1 sampling indicated that a second phase of sampling was required to refine the approximate extent of vadose zone soil impacts. The Phase 2 sampling consisted of 12 boreholes, shown in **Figure 7**. Five soil samples were obtained from each soil core at four foot depth intervals, except for location P2B-4 from which seven samples were collected at four foot depth intervals. The results of the Phase II sampling suggest that perchlorate in the vadose zone soils is primarily limited to the area beneath the former Chlorate Cell room. The results of the Phase 1 and 2 sampling suggest that perchlorate in the vadose zone soils is primarily limited to the area beneath the Former Chlorate Cell Room, and that the distribution of perchlorate at concentrations above the EPA industrial/commercial Preliminary Remedial Goal (PRG) 100 mg/kg is sporadic and limited. Overall, the assessment program has adequately delineated the lateral extent of the perchlorate distribution in the vadose zone and the shallow groundwater near the Former Chlorate Cell Room, such that additional investigation is not recommended. The available data will be used to assess the need for remediation activities for the vadose zone, pending the results of the enhanced in situ bioremediation pilot test for the perchlorate-impacted groundwater.

4.2 Hydraulic Testing Program

Hydraulic testing was conducted to assess the hydraulic properties of the aquifer for the purposes of completing pilot test design, and for collecting the required hydraulic data for assessment of potential full-scale EISB configurations (e.g., injection and/or extraction well spacing and rates).

Testing was conducted at three locations (see **Figure 7**), including: i) immediately upgradient from the former Chlorate Cell Room near existing shallow well MWA-33; ii) the MWA-25 area immediately downgradient of the former Chlorate Cell Room; and iii) a downgradient area near the river (i.e., MWA-19 area). These locations were selected to reflect areas with different geologic/hydraulic conditions, and also corresponding to potential locations for injection and/or extraction activities for potential pilot testing and/or full-scale EISB. Hydraulic testing was conducted solely for the shallow aquifer at each location, primarily to guide pilot test design. Activities consisted of a step-drawdown test in each area to evaluate the specific capacity of each well, and a constant-discharge test in each area to determine the transmissivity and storage coefficient of the shallow aquifer.

At each of the three locations, a 4-inch PVC well (PT-1, PT-2 and PT-3) was installed at a distance of 15 to 25 feet from an existing shallow monitoring well (MWA-33, MWA-25, MWA-19). The pumping wells were screened across the shallow aquifer at an equivalent interval to the corresponding monitoring well (generally ten foot screens between 20 to 35 ft bgs). During pump testing, drawdown in both the extraction well and the associated shallow aquifer monitoring well was monitored using pressure transducers and data loggers. In addition, drawdown in intermediate aquifer monitoring wells MWA-48i and MWA-34i, co-located with shallow aquifer wells MWA-25 and MWA-19, respectively, was monitored to quantify the degree of hydraulic interconnection between the shallow and intermediate aquifers during pumping of the shallow aquifer. For the MWA-33 location, a single 2-inch PVC monitoring well (MWA-70i) was installed in the intermediate aquifer (screen depth of 33 to 43 ft bgs) to allow for assessment of baseline perchlorate concentrations in this area, and to monitor hydraulic response during testing of the shallow aquifer pumping well.

A summary of the results of the hydraulic testing are included in Appendix B. The results of the hydraulic testing program indicated that groundwater injection/extraction within the shallow aquifer near the upgradient side of the Source Area and the Willamette River will be limited to a few gallons per minute. Much higher well yields (tens of gpm) are achievable in the Downgradient Area near MWA-25. The vertical connectivity between the shallow and intermediate aquifers appears to be limited within the Source Area and near the Willamette River, but good vertical connection was observed between these aquifers in the Downgradient Area (near MWA-25) where the hydraulic conductivities are higher.

5. FIELD PILOT TEST PROGRAM

A variety of EISB approaches have been successfully used to achieve bioremediation of perchlorate in groundwater, including: i) active recirculation systems, whereby soluble electron donors (e.g., citric acid, acetate, lactate, ethanol) are injected and circulated through the impacted aquifer; and ii) passive systems, whereby relatively insoluble, slow-release electron donors (e.g., emulsified vegetable oil [EVO], chitin, HRC™) are injected into the aquifer to create biobarriers that treat the groundwater as it flows through under natural gradient. Both EISB approaches have specific advantages, limitations, and uncertainties, but both approaches have potential to successfully remediate perchlorate in the Site groundwater.

The choice of EISB approach (particularly for full-scale remediation) depends largely on the remedial action objectives, the distribution of perchlorate that requires treatment, and the hydraulics of the area to be treated. Factors that influence the selection of EISB approach at this Site include: i) the potentially inhibitory concentrations of both chloride and pH in various locations across the Site; and ii) the varying site hydraulics. Based on these considerations, an active remedy in the vicinity of the ground water hot spot area of the more permeable aquifer materials (near MWA-25) was selected as the optimal pilot test approach for the Site. If necessary, the active recirculation approach will provide the ability to blend groundwater from several extraction wells to lower chloride concentrations and neutralize pH to levels more amenable for bioactivity. However, based on the data collected during the hydraulic testing in combination with the toxicity analysis (pH and chloride effects on the perchlorate-reducing microbial culture) during the bench scale treatability study, this may not be necessary for the pilot demonstration. Furthermore, an active pilot test system can likely be expanded to incorporate groundwater treatment in other areas (i.e., further upgradient beneath the former Chlorate cell Room, and/or near the Willamette River) with relative ease.

Pilot testing of the active recirculation approach will be performed according to the scope of work outlined below to confirm the results of the treatability study under field conditions, and to assess other factors that may impact the full-scale design (e.g., perchlorate degradation rates, pH neutralization demand, electron donor demand, etc.).

The following subsections provide: a summary of the advantages, limitations and uncertainties of the active EISB approaches (Section 5.1); the objectives of EISB testing for the Site (Section 5.2); details regarding design, installation, operation and performance monitoring of the active recirculation pilot test approach (Section 5.3); and a description of the data interpretation and reporting activities that will be conducted following the completion of the active recirculation pilot test (Section 5.4).

5.1 Overview of Active Recirculation

Figure 8 provides a conceptualization of an active EISB design. Active recirculation will allow the amount of electron donor being added to be balanced with the amount of perchlorate (and other electron acceptors such as oxygen, phosphate, nitrate and chlorate) in the groundwater, which reduces consumption (wastage) of electron donor by undesirable microbial processes, and which minimizes impacts to secondary water quality (e.g., production of methane, sulfide, dissolved metals). For the Site, active recirculation of the groundwater will also produce a beneficial impact with regards to equilibrating the concentrations of constituents that may inhibit microbial activity and perchlorate reduction, such as elevated chloride and alkaline pH, should these conditions prove inhibitory. The main disadvantage of an active recirculation approach is that it requires ex situ infrastructure for water extraction/recirculation and electron donor delivery, and requires more active operations.

5.2 Pilot Test Objectives

The objectives of EISB pilot test are to:

1. Evaluate the rate and extent of perchlorate biodegradation that can be achieved under field conditions, through electron donor addition and bioaugmentation with perchlorate-reducing bacteria;

2. Demonstrate the concentration to which perchlorate can be biodegraded for the purposes of assessing technology performance and evaluating suitable remedial goals;

3. Evaluate the dosing rate for electron donor required to achieve perchlorate biodegradation;

4. Assess the impacts of the EISB process on chlorate and other geochemical parameters (e.g., hexavalent chromium, VOCs, arsenic, etc.) in the groundwater;

5. Evaluate the impacts of specific geochemical conditions (e.g., elevated chloride and pH) on performance and assess methods to reduce these inhibitions (e.g., pH neutralization);

6. Identify other design and operational factors that influence the successful performance of the active EISB approach (such as biofouling of electron donor delivery wells) and optimize system operation with respect to these factors; and

7. Generate performance, design and cost data that can be used for evaluation and possible selection of the in situ bioremediation technology for full-scale application at the Site.

The scope of work to address these objectives through pilot testing is described in the following sections.

5.3 Pilot Test Scope of Work

Pilot testing of the active EISB approach will employ an active recirculation system, whereby groundwater is extracted from the aquifer from two downgradient extraction wells, amended with soluble electron donor (e.g., ethanol and/or citric acid) and, if required, a pH neutralizing solution (e.g., hydrochloric acid or sulfuric acid), and recharged back to the aquifer via three to four recharge wells that have been bioaugmented with perchlorate-reducing bacteria to promote perchlorate biodegradation in situ. The following sections summarize the key details regarding anticipated pilot test layout, infrastructure, pilot test area (PTA) characterization, operations and maintenance, performance monitoring, and anticipated duration.

Layout: Based on review of the site data, it appears that the MWA-25 area is a suitable location for the active PTA for the following reasons:

- relatively open access;
- the aquifer hydraulics are such that several pore volumes can be recirculated within the pilot test duration;
- the residence time within the PTA (estimated at ~2 months) is sufficient to allow adequate estimation of the perchlorate degradation rate; and
- a substantial amount of perchlorate mass in the subsurface (the Hot Spot) will be treated during pilot testing activities.

Groundwater will be extracted from two new 4-inch PVC extraction wells (tentatively named EW-1 and EW-2) located downgradient of MWA-25 at approximately 15 gallons per minute from each extraction well. The groundwater extraction rate has been estimated to correspond to the aquifer discharge through the PTA to ensure adequate capture. Groundwater recharge will require installation of four new 4-inch PVC injection wells (tentatively named IW-1 to IW-4) located upgradient of the extraction wells, and ideally upgradient of well MWA-25, to allow use of MWA-25 and other existing wells for performance monitoring. Groundwater will be reinjected at approximately 10 gallons per minute at each of three injection wells (one of the four injection wells will remain inactive to allow for rotating well rehabilitation while maintaining a full injection rate of 30 gpm). **Figure 9** provides the tentative layout for the active EISB pilot testing infrastructure. Final well placements will be determined based on initial soil borings, with the intent of targeting placement of the PTA downgradient of the pinch-out of the sandy silt confining layer separating the shallow and intermediate aquifers, to allow for adequate re-injection rates. One additional nested monitoring well (PMW-1 and PMW-1i) will also be required to assess perchlorate biodegradation performance within the recirculation loop (tentative location shown in **Figure 9**).

Infrastructure: The active recirculation system will consist of a number of automated components which will serve to: 1) extract groundwater from the extraction wells; 2) record flow rate and volume totals; 3) measure pH using in-line electrodes; 4) introduce conservative tracer, pH neutralizing solution, and/or electron donor to the extracted groundwater; and 5) recharge the amended groundwater to the PTA via the recharge wells (IW-1 to IW-4). Groundwater extraction will be accomplished using dedicated downhole stainless steel pumps. An in-line flow sensor installed at each well head will be used to continuously measure the flow rate of extracted groundwater from each well and the rate being reinjected into each injection well. Output (4 to 20 mA signal) from the flow sensor will be used to: i) provide feedback control to the pump to maintain steady extraction/recirculation rates; and ii) control the delivery rate of tracer, pH neutralizing solution, if necessary, and/or electron donor solution to the feed groundwater to maintain a fixed concentration of these components in the amended groundwater. The amended groundwater will then pass through an in-line mixer, an in-line filter system to remove precipitates formed as a result of pH adjustment, followed by an in-line monitoring electrode to measure pH in the neutralized groundwater, and will then be recharged via a submerged delivery line into three of the four recharge wells. The fourth injection well will remain off-line for purposes of backup in case one of the other wells has to be shut down for maintenance or rehabilitation, to avoid total system shut-downs. It is anticipated that a rotating injection well rehabilitation program will be implemented for the four wells, such that each well is inactive for one quarter of the 12-month pilot test period. The system will be fitted with manual sampling ports at each extraction well head to allow collection of samples to measure analyte concentrations in the extracted groundwater, and immediately following the mixing column (just prior to recharge) to measure tracer, pH neutralizing solution, electron donor and blended effluent concentrations in the feed groundwater.

Electron donor delivery equipment will include an electron donor storage tank, a solenoid valve and a flow sensor. Ethanol will be the primary electron donor, based on the performance of ethanol in the biotreatability study, and may be supplemented with citric acid as needed to aid in neutralizing the groundwater pH. Ethanol is a cost-effective substrate that readily biodegrades to carbon dioxide and does not involve the introduction of associated salts such as sodium or potassium or trace contaminants (e.g., selenium) that are present in some other electron donors (e.g., molasses, corn syrup). The use of ethanol therefore has no lasting impact to groundwater quality, other than transient shifts in redox and alkalinity.

Equipment for delivery of the pH neutralizing solution, if necessary, will include a corrosion-proof storage tank (or drums) with secondary containment, and a metering pump rated for acidic solutions. The acid solution (hydrochloric acid or sulfuric acid) will be metered continuously into the groundwater feed line to provide continuous adjustment of the pH to a more neutral value (e.g., less than 8). Lab testing will be conducted prior to field implementation to determine the acid demand from the soil and groundwater and thus the required dosing rates. Injection of hydrochloric acid will result in the disassociation of the hydrogen and chloride in the groundwater, resulting in lower pH and slightly increased chloride concentrations. It is anticipated that the additional chloride will be minimal in comparison to the existing chloride in groundwater, and that the net effect on groundwater quality will be positive due to the lower groundwater pH.

Equipment for delivery of the tracer solution will consist of drums for mixing and storing of the tracer and a proportional feed pump, which will dose the tracer at a rate proportional to the rate of groundwater recirculation. Tracer will be metered continuously into the groundwater for a period of only two weeks. The mass of bromide to be added to the groundwater (approximately 250 kg) will result in slightly elevated concentrations of bromide in the groundwater (~25 mg/L), which is expected to further decrease as the bromide migrates downgradient and is impacted by dispersion and dilution.

The amendment delivery components (metering pumps, flow meters, etc) will be housed in a secure, temperature-controlled construction trailer or temporary building, located within a secure enclosure. Storage tanks and nitrogen tanks will be located outside of the building. LSS will be responsible for securing electrical service and potable water supply for the construction trailer.

To prevent biofouling of the electron donor delivery well, the pilot test system will be instrumented with a pilot-scale chlorine dioxide generator and injection system to allow periodic dosing of the injection wells. Chlorine dioxide is commonly used to disinfect drinking water, and to prevent biofilm formation in ex situ treatment systems, cooling towers and industrial applications. The byproducts of chlorine dioxide disinfection are chloride and oxygen, which are already present in the aquifer; hence no new compounds are being introduced to groundwater. Typically, the chlorine dioxide reacts with organic material to produce chlorite, which is dismutated by perchlorate-reducing bacteria as part of their normal metabolism to chloride as the final product. No trihalomethanes, haloacetic acids, or similar disinfectant byproducts are produced by the reaction of chlorine dioxide with groundwater constituents. This approach has been successfully used in field demonstrations in California, Nevada and Utah, with approval by the prevailing regulatory authorities.

System operation will be controlled using a programmable logic controller (PLC). The control system will record the groundwater extraction and reinjection rates, electron donor dosing volumes, pH electrode measurements, and water levels in the recharge wells at suitable intervals. The extraction well will be instrumented with a low-level water sensor/pump-shutoff to limit drawdown and protect the pump. Similarly, the recharge well will be instrumented with a high-level sensor/pump-shutoff to prevent overflow in the event of biofouling or well plugging, and will also be instrumented with a pressure transducer to facilitate real-time evaluation of well fouling.

A conceptual design of the infrastructure is shown in Figure 10.

Baseline Geochemical Characterization: Groundwater samples will be collected for baseline characterization of groundwater chemistry in the PTA, and will include the extraction wells and associated monitoring wells. Baseline analyses will include: field parameters (DO, ORP, pH, specific conductance and temperature), electron donor (ethanol, citrate, acetate), perchlorate, chlorate, anions (bromide, chloride, nitrate, nitrite, phosphate and sulfate), dissolved hydrocarbon gases (ethene, ethane and methane), volatile organic compounds (VOCs), metals (dissolved metals including iron, manganese, and arsenic, and hexavalent and total chromium), and metabolic products (e.g., sulfide). Samples will be collected following standard sampling protocols established for the Site. Analyses will be conducted by STL following published analytical protocols. **Table 2** summarizes the parameters that will be analyzed as part of the baseline characterization, and provides details of analytical methods, container size and type, preservation method, and sample holding times.

Tracer Testing: A conservative tracer test will be conducted in conjunction with electron donor addition to: 1) evaluate groundwater flow patterns in the PTA; 2) confirm groundwater flow velocities and system residence times; and 3) confirm approximate sample times for the performance monitoring wells (i.e., when tracer and/or electron donor-amended groundwater would be expected to reach the performance monitoring wells). A conservative tracer (i.e., bromide) will be continuously added at a concentration of about 50 mg/L to the re-injected groundwater for a period of 14 days. Groundwater samples will be collected on a semi-weekly basis for bromide analysis using IC methods from the performance monitoring wells for the two month post-injection monitoring period. Breakthrough curves for the tracer will be generated based on the collected data to confirm the groundwater flow velocity and residence times between the delivery wells and performance monitoring wells, as well as quantify the degree of dilution and dispersion at each well.

Operations & Maintenance: Electron donor (one or both of ethanol and/or citric acid) will be added using a pulsed-addition mode (less than one hour pulse per day) to minimize microbial fouling of the delivery well. The estimated TWA electron donor addition concentration to treat the perchlorate will be estimated based on the baseline groundwater chemistry data. Chlorine dioxide dosing will be accomplished through either daily doses (1 hour daily pulses) of low concentrations (1 to 2 mg/L) of chlorine dioxide, or semi-weekly doses of higher concentrations (10 to 20 mg/L). Both approaches have been used with similar success in controlling biofouling. Routine oversight will include inspection of the groundwater circulation system, filling of electron donor supply tanks, periodic dosing of the recharge well with chlorine dioxide for biofouling control, replacement of filters, periodic downloading of automated data collection systems, and groundwater sampling.

Performance Monitoring: Performance monitoring and assessment will be conducted for a period of 12 months. The in-line electrode will measure pH in the neutralized groundwater at appropriate intervals (e.g., daily), and these data will be logged to the data acquisition system. Groundwater samples will be collected from the various PTA wells on a weekly, bi-weekly or monthly basis (depending on parameter and point in the pilot test). **Table 3** summarizes the anticipated sampling for the pilot test. The frequency of sampling may be modified during the pilot test in response to tracer test results and field observations. Sampling will be conducted following standard sampling protocols approved for the site. Details regarding the analytical techniques and sample handling are summarized in **Table 2**.

Bioaugmentation: The pilot test will be initiated with electron donor addition and bioaugmented with the perchlorate-reducing culture that was used in the biotreatability studies to achieve effective perchlorate reduction. This culture has been used to successfully seed fluidized bed bioreactors at a site in Nevada. Bioaugmentation will be conducted by delivering the culture to the PTA via the recharge wells through a submerged delivery line. A nitrogen gas blanket in the delivery vessel will be used to prevent/limit oxygen contact with the culture during delivery. The survival and fate of the introduced bacteria will be tracked using molecular analytical techniques for groundwater samples.

Duration: It is anticipated that the active EISB pilot test would be conducted for a period of 12 months.

Regulatory Needs: The injection points will be registered with the ODEQ Water Quality Program Underground Injection Control (UIC) Program prior to injection of groundwater or amendments.

5.4 Data Interpretation and Reporting

The data obtained from the EISB pilot test will be tabulated, reviewed and interpreted to estimate the rate and extent of degradation of perchlorate. To the extent possible, factors affecting bioremediation performance will be identified and optimized throughout the pilot test. GeoSyntec will prepare a Pilot Test Report containing detailed study methods, all data generated during the study, our assessment of the data, conclusions, and recommendations. This information may then be used (pending pilot test outcome) by the project team for evaluation and design of a full-scale in situ bioremediation approach for the Site.

To maintain project schedules, GeoSyntec will provide LSS with monthly project status updates detailing project progress and status, and notifying LSS of known or anticipated changes in project scope, schedule or costs. It is anticipated that LSS will periodically update the agencies as to study progress.

6. SCHEDULE

Figure 11 provides the anticipated project schedule.

7. REFERENCES

ERM, 2005. Remedial Investigation Report, Arkema Facility, Portland, Oregon.

Exponent 1999. *Elf Atochem Acid Plant Area Remedial Investigation Interim Data Report.* Exponent, Lake Oswego, Oregon. June 1999.

TABLE 1
BASELINE GROUNDWATER GEOCHEMISTRY
Arkema Facility, Portland, Oregon

Analyte (mg/L)	Pilot Test Area (MWA-25)
Perchlorate	285
Chlorate	7,545
Chloride	2,571
Nitrite as nitrogen	< 2
Nitrate	< 2
Sulfate	206
Bromide	< 14
Phosphate	< 5
pH	9.68
Bromodichloromethane [a]	0.0014
Chloroform [a]	0.29
Total Chromium [b]	9.83
Hexavalent Chromium [b]	8.01
Dissolved Manganese [b]	0.0255

Notes:
mg/L - milligrams per liter
Data collected by ERM in July 2003 unless otherwise noted.
[a] Data collected April 2002.
[b] Data collected March 2003.

TABLE 2
ANALYTICAL DETAILS
Arkema Facility, Portland, Oregon

Parameter	Analytical Method	Method Number	Quantitation Limit	Sample Container	Preservative	Holding Time
Field Parameters (pH, DO, ORP, specific conductance, temperature)	Ion Specific Electrode	Field	Varies	NA	NA	NA
Perchlorate	Ion Chromatography	EPA 314	4 μg/L	120 mL plastic	cool to 4°C	28 days
Anions (chlorate, bromide, chloride, nitrate, nitrite, sulfate, phosphate)	Ion Chromatography	EPA 300	0.03 to 0.05 mg/L	120 mL plastic	cool to 4°C	2 to 28 days
Hexavalent Chromium	Colorimetric	EPA 7196A	varies	500 mL plastic	cool to 4°C	24 hours
Total Chromium	Inductively Coupled Plasma/Atomic Emission Spectrometry field filter for dissolved	EPA 6010B	varies	500 mL plastic	nitric acid to pH<2, cool to 4°C	28 days
Metals (dissolved)	Inductively Coupled Plasma/Atomic Emission Spectrometry field filter for dissolved	EPA 6010B	varies	500 mL plastic	nitric acid to pH<2, cool to 4°C	28 days
Volatile Organic Compounds	Gas Chromatography/ Mass Spectral Detector	EPA 8260B	varies	3 x 40 mL VOA vial	HCl to pH<2, cool to 4°C	14 days
Methane	Gas Chromatography/ Flame Ionizing Detector	RSK-175 or EPA 8015B	10 μg/L	2 x 40 mL VOA	cool to 4°C	14 days
Ethanol	Gas Chromatography/ Flame Ionizing Detector	EPA 8015B	1 ppm	2 x 40 mL VOA	HCl to pH<2, cool to 4°C	14 days
Volatile Fatty Acids (propionate, acetate, lactate, citrate, butyrate)	Ion Chromatography / UV	Laboratory Specific	1 ppm	250 mL amber glass	phosphoric acid	28 days
Sulfide	Titrimetry, Potentiometry	NB 3653:139	0.3 mg/L	500 mL plastic	zinc acetate, sodium hydroxide to pH>9, cool to 4°C	7 days
Perchlorate-reducing bacteria	PCR Assay	NA	NA	2 x 1 L plastic	cool to 4°C	30 days

Notes:
NA - Not Applicable

TABLE 3
ANTICIPATED SAMPLING FREQUENCY - ACTIVE EISB PILOT TEST
Arkema Facility, Portland, Oregon

Parameter	Sampling Frequency				
	Baseline	**Semi-Weekly**	**Monthly**	**Quarterly**	**Semi-Annual**
Baseline Characterization					
Water Levels	PTA Wells[1]	--	--	--	--
Field Parameters[2]	PTA Wells	--	--	--	--
Perchlorate, Chlorate	PTA Wells	--	--	--	--
Anions[3]	PTA Wells	--	--	--	--
Electron Donor (ethanol and/or VFAs)[4]	PMW Wells	--	--	--	--
Volatile Organic Compounds	PTA Wells	--	--	--	--
Methane	PTA Wells	--	--	--	--
Hexavalent Chromium	PTA Wells	--	--	--	--
Dissolved Metals	PMW Wells	--	--	--	--
Sulfide	PMW Wells	--	--	--	--
Perchlorate-reducers (PCR assay)	PMW Wells	--	--	--	--
Tracer Testing (8 Weeks)*					
Water Levels	--	PTA-1 Wells	--	--	--
Field Parameters[2]	--	PTA-1 Wells	--	--	--
Bromide	--	PTA-1 Wells	--	--	--
Performance Monitoring (12 Months)*					
Water Levels	--	--	PTA Wells	--	--
Field Parameters[2]	--	--	PTA Wells	--	--
Perchlorate, Chlorate	--	--	PTA Wells	--	--
Anions[3]	--	--	PTA Wells	--	--
Electron Donor (ethanol and/or VFAs)[4]	--	--	PTA Wells	--	--
Volatile Organic Compounds	--	--	PTA Wells	--	--
Methane	--	--	PTA Wells	--	--
Hexavalent Chromium	--	--	PTA Wells	--	--
Dissolved Metals	--	--	--	PTA Wells	--
Sulfide	--	--	--	PTA Wells	--
Perchlorate-reducers (PCR assay)	--	--	--	--	PMW Wells

Notes:

PTA - Pilot Test Area

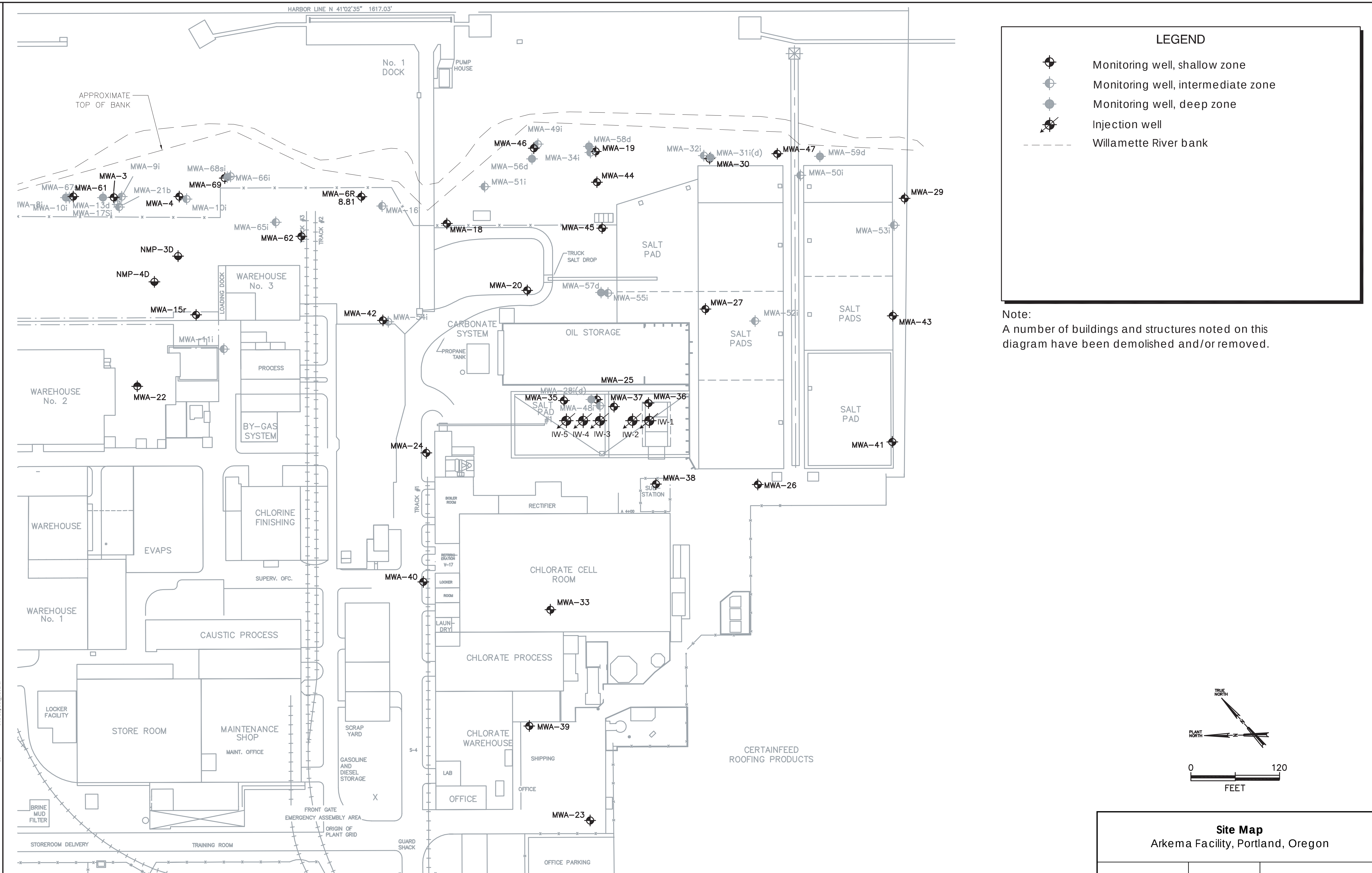
1 - PTA Wells = EW-1, EW-2, MWA-25, MWA-48i, PMW-1, PMW-2, influent
PMW Wells = PMW-1, PMW-1i, MWA-25, MWA-48i, MWA-55i, MWA-27 and MWA-52i

2 - Field Parameters = pH, dissolved oxygen, oxidation-reduction potential, specific conductance, temperature

3 - Anions = bromide, chloride, nitrate, nitrite, sulfate, phosphate

4 - VFAs = volatile fatty acids, including propionate, butyrate, lactate, citrate and acetate

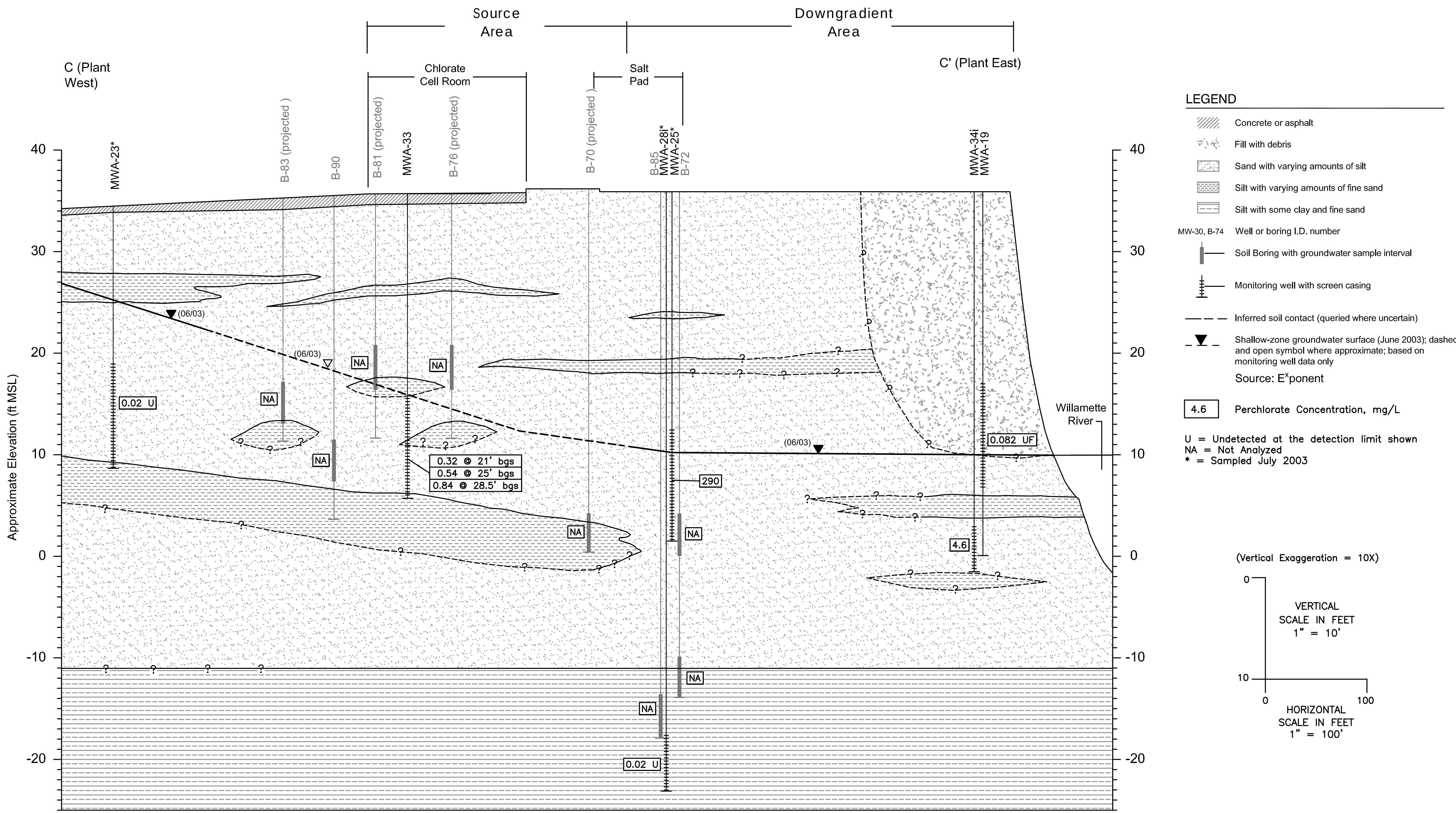
* Sampling frequency may increase/decrease during the pilot test depending upon concentration trends and baseline results



Basemap provided by ERM

Site Map
Arkema Facility, Portland, Oregon

July 2006 | Figure: **1** | GeoSyntec Consultants

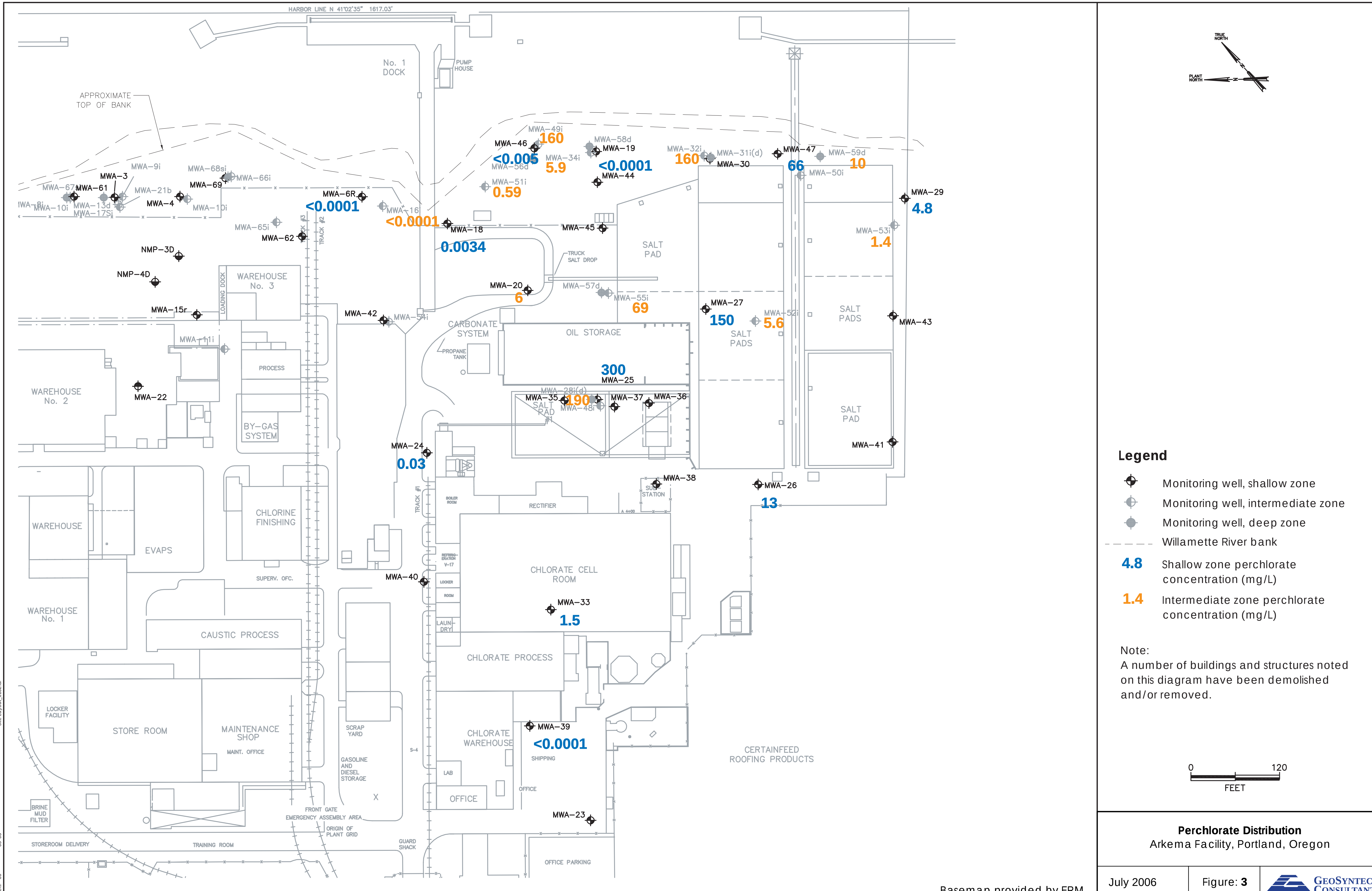


Drawing provided by ERM

Hydrostratigraphic Cross Section

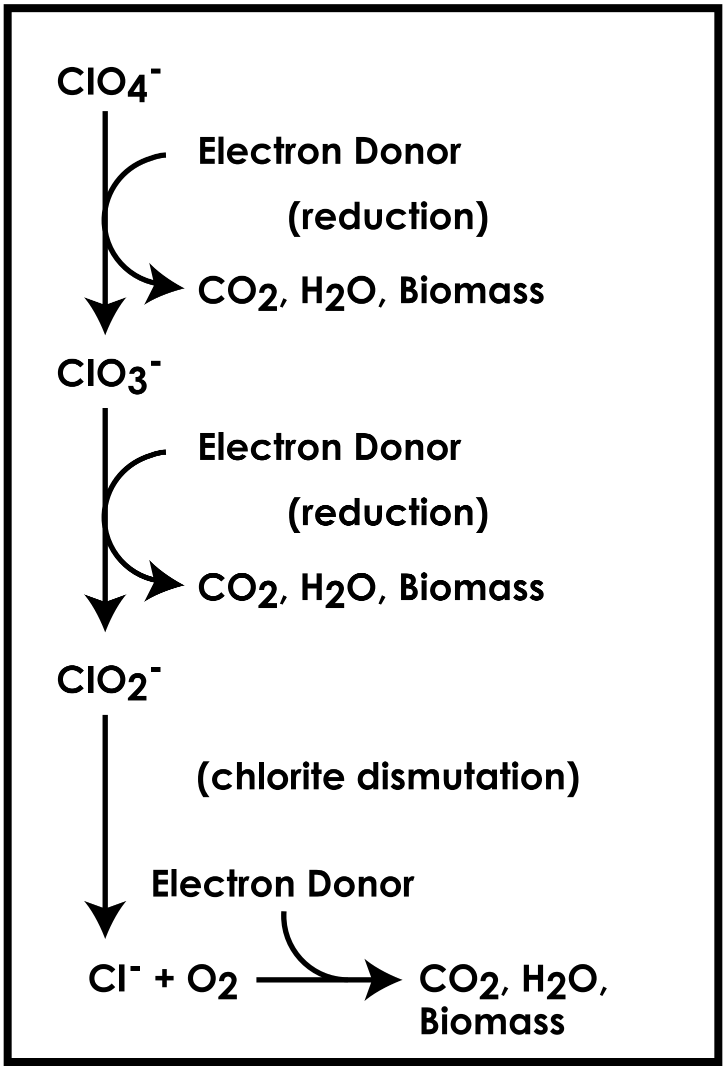
Arkema Facility, Portland, Oregon

July 2006	Figure: **2**	GeoSyntec Consultants



Perchlorate Distribution
Arkema Facility, Portland, Oregon

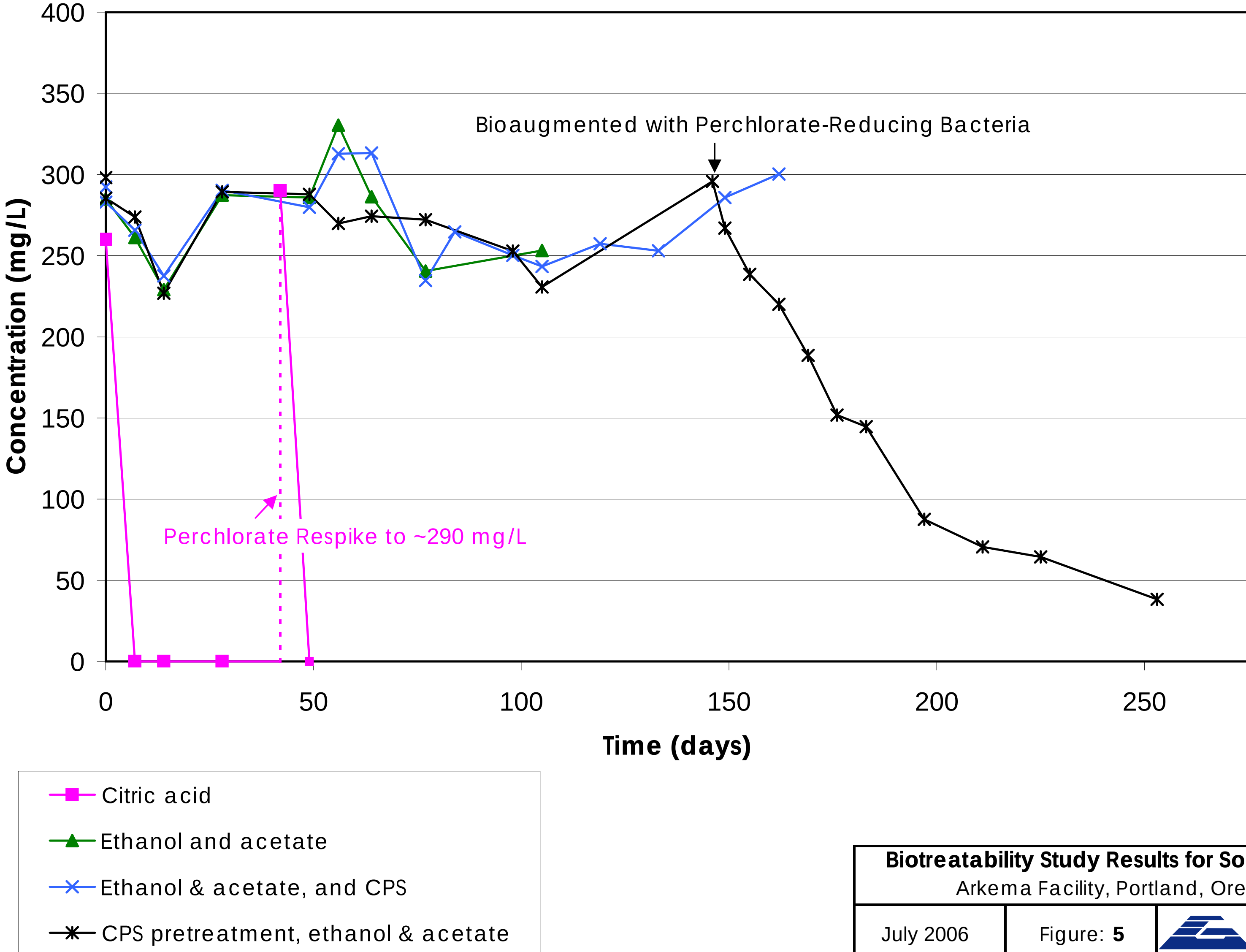
July 2006 | Figure: 3 | GeoSyntec Consultants



Pathway for the Biodegradation of Perchlorate

Arkema Facility, Portland, Oregon

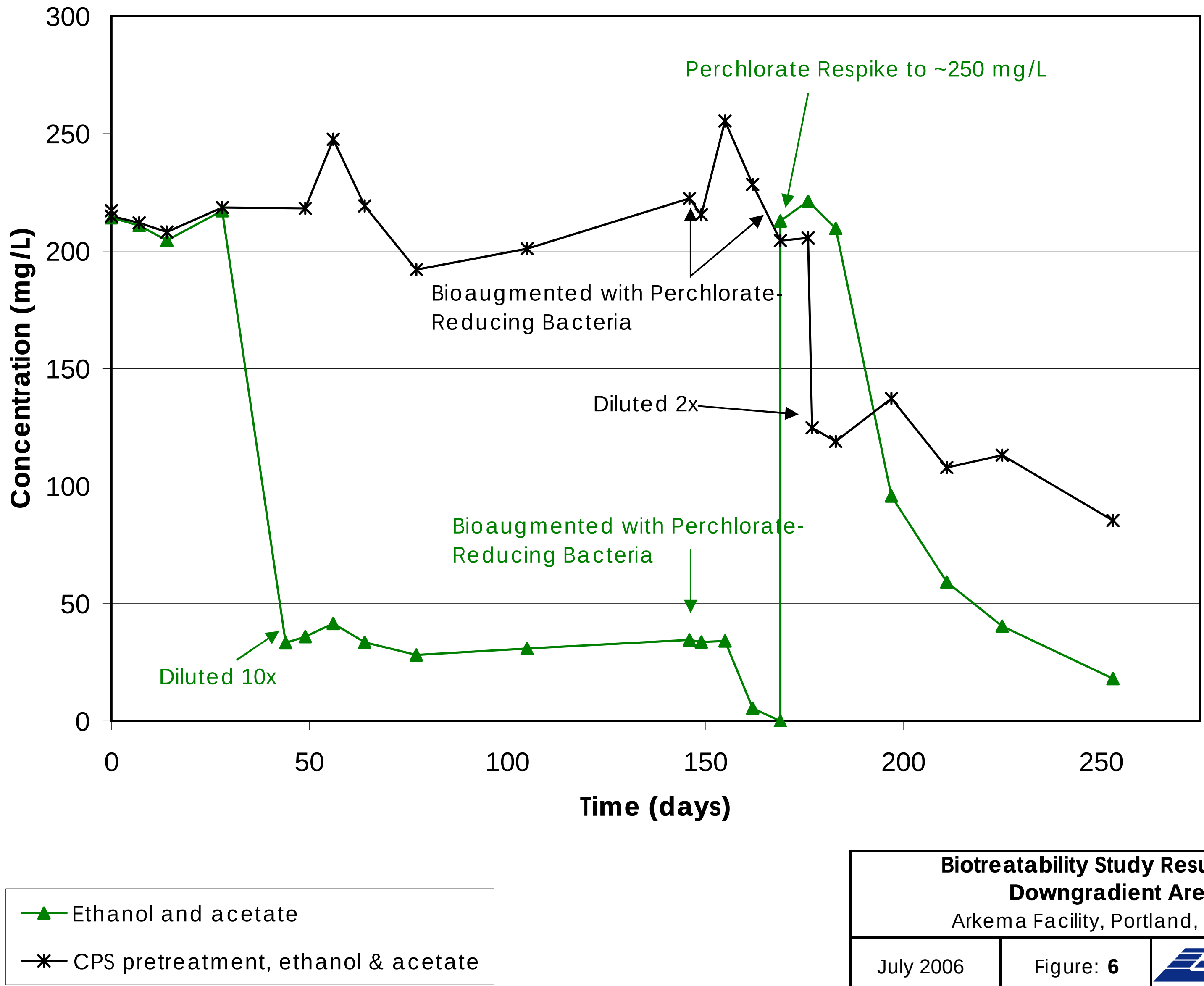
July 2006	Figure: **4**	GeoSyntec Consultants



Biotreatability Study Results for Source Area

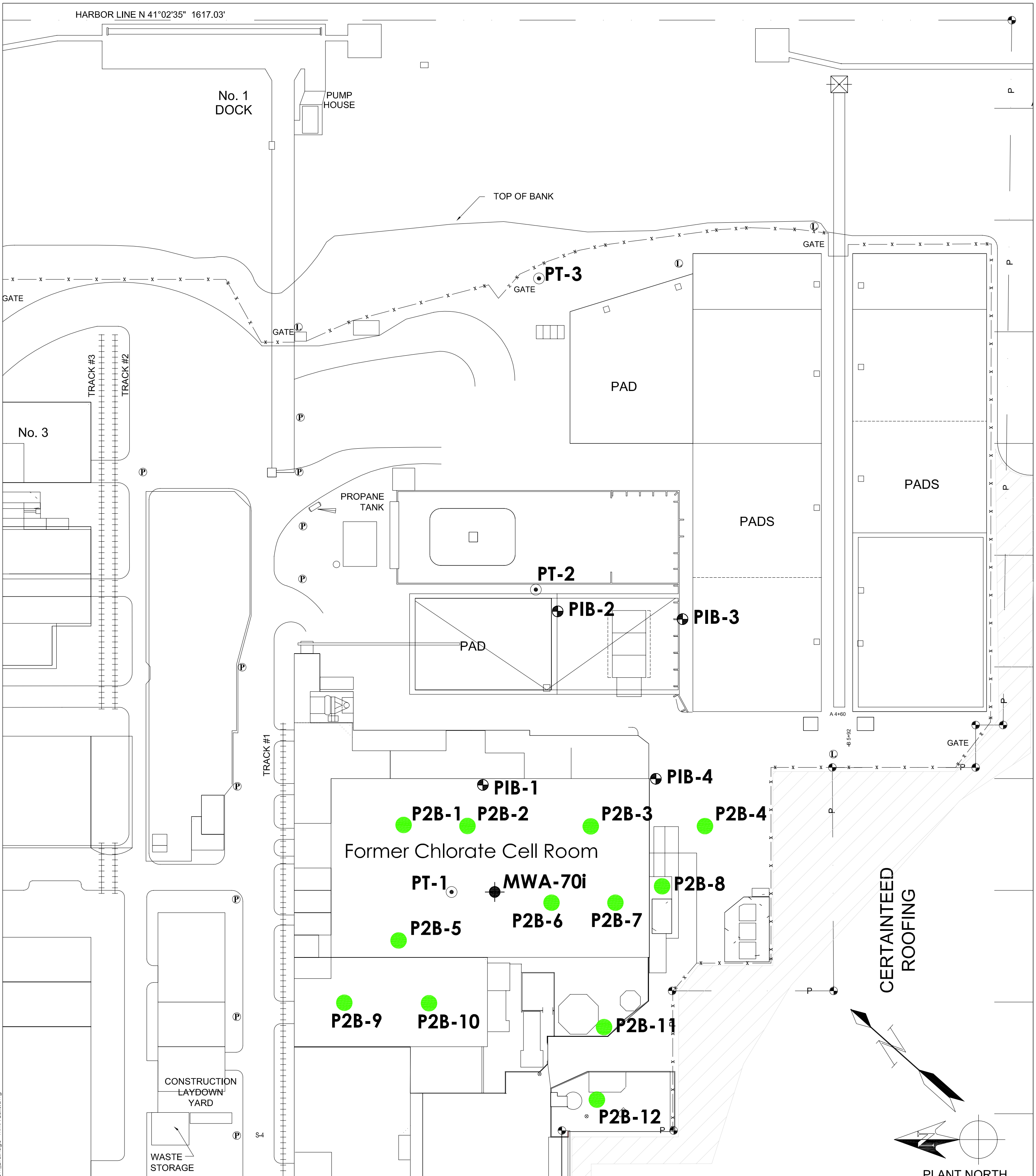
Arkema Facility, Portland, Oregon

July 2006	Figure: **5**	GeoSyntec Consultants



Biotreatability Study Results from Downgradient Area
Arkema Facility, Portland, Oregon

July 2006	Figure: **6**	GeoSyntec Consultants



LEGEND

SOURCE: ARKEMA INC. 2005

— · · — · · —	LEGAL BOUNDARY, EASEMENT
++++++++	RAILROAD
— x — x —	FENCE
(L) (P)	LIGHT POLE, POWER POLE
⊕	NEW INTERMEDIATE DEPTH MONITORING WELL
◐	LOCATION OF PHASE I SOIL BOREHOLES OR MONITORING WELLS
●	LOCATION OF PHASE II SOIL BOREHOLES
⊙	NEW SHALLOW PUMP TEST WELL

0 100 200
Scale (ft)

Vadose Zone Sampling and Hydraulic Testing Locations
Arkema Facility, Portland, Oregon

July 2006 | Figure: **7**

GEOSYNTEC CONSULTANTS

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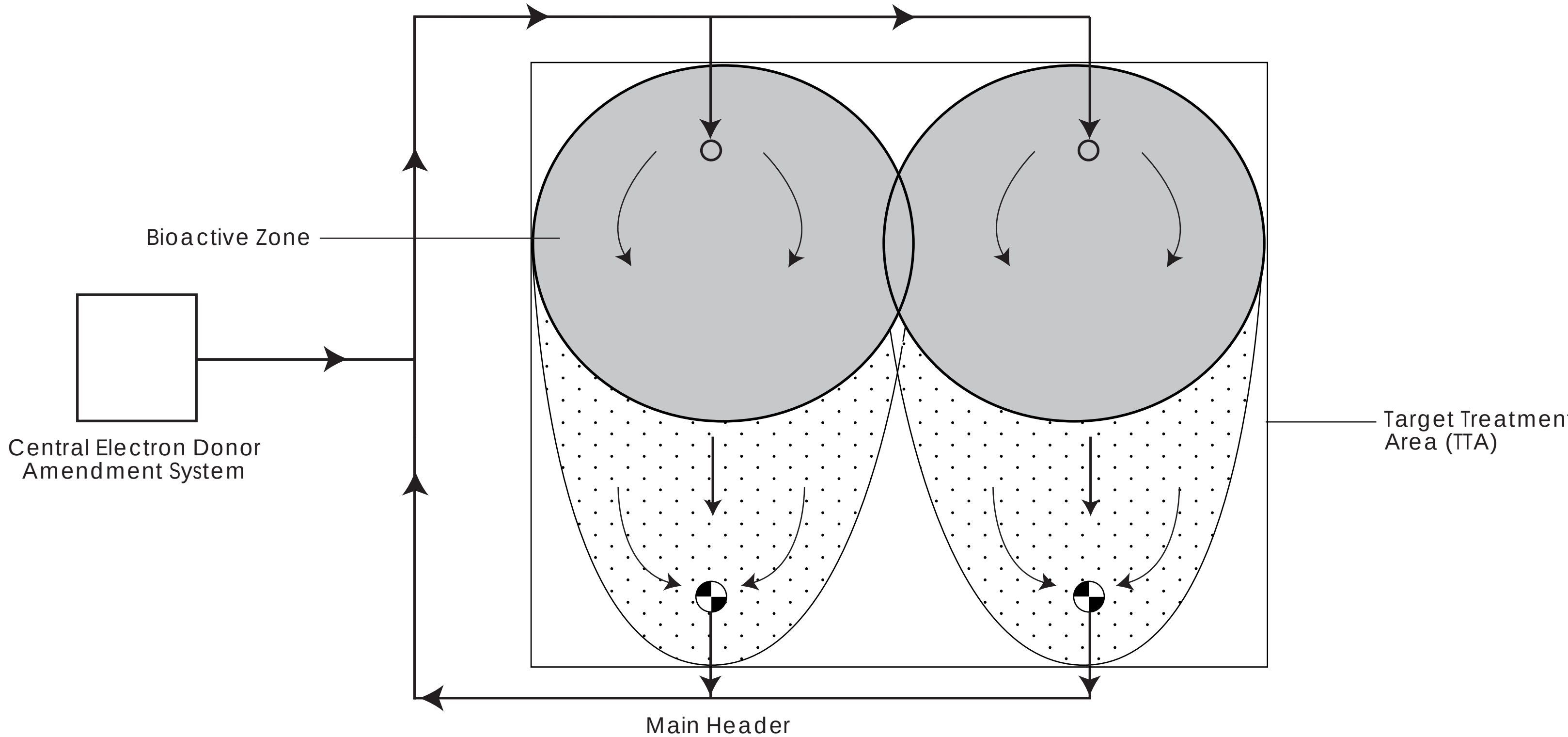


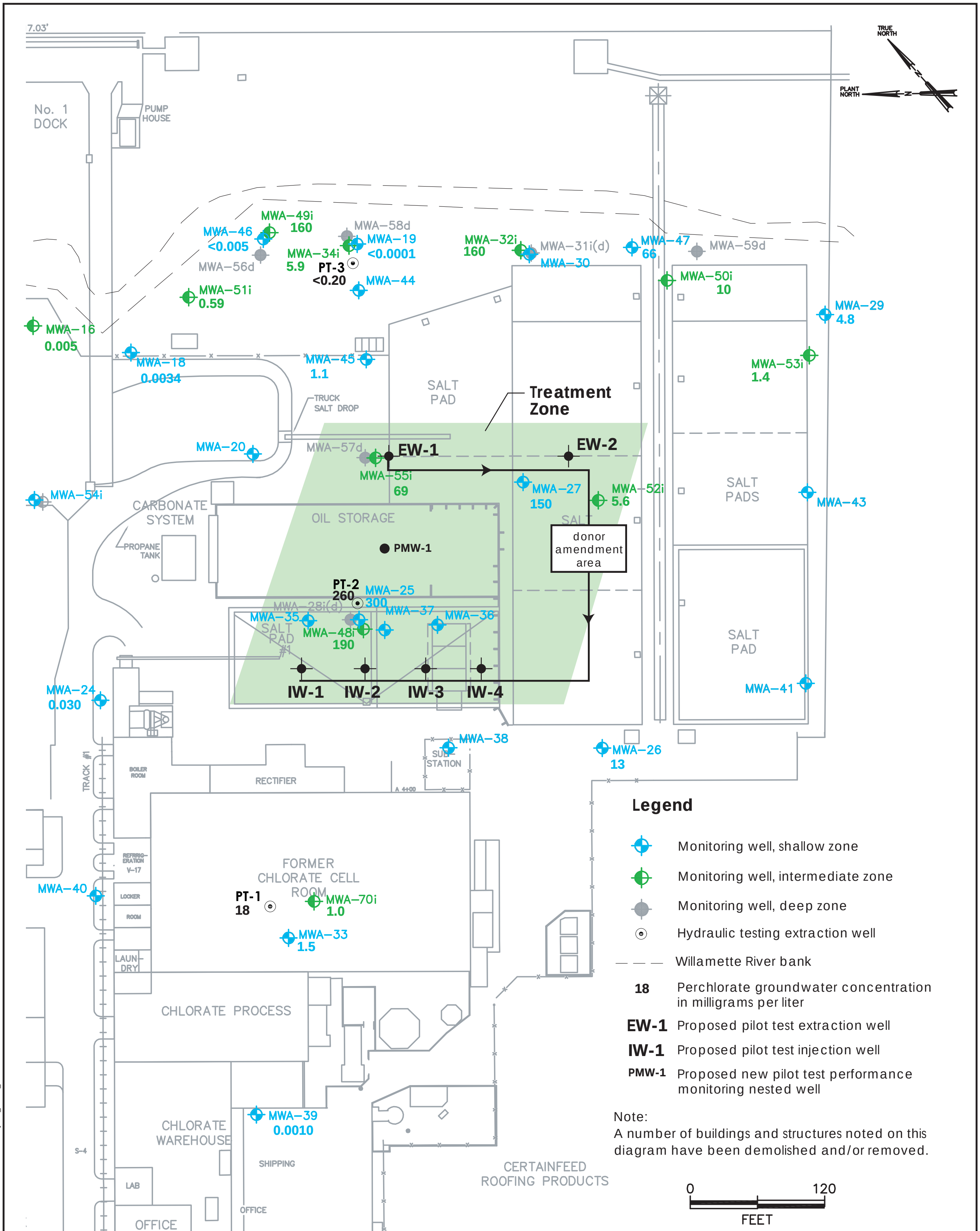
Extraction Well

Injection Well

Conceptualization of Active In Situ Bioremediation Approach for Perchlorate in Groundwater
Arkema Facility, Portland, Oregon

July 2006	Figure: **8**	GeoSyntec Consultants

active in situ bio approach.ai

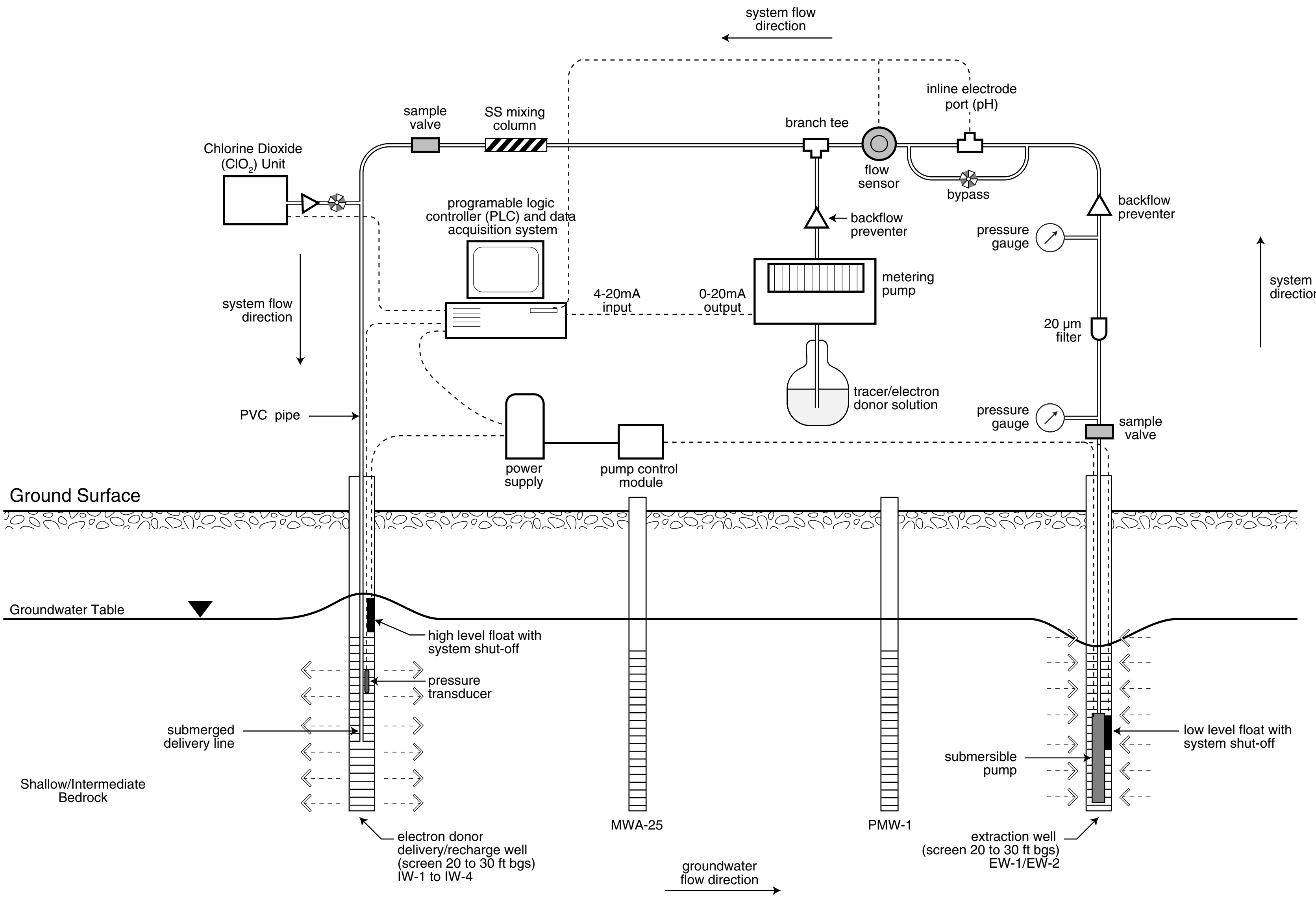


Basemap provided by ERM

Layout for Active Recirculation
Arkema Facility, Portland, Oregon

July 2006	Figure: **9**	GeoSyntec Consultants

Layers: 00 01 02 04 05 06 A
Site Layout_zoom_0162.ai



Not To Scale

Conceptual Design for Active Recirculation Pilot Test

Arkema Facility, Portland, Oregon

July 2006	Figure: **10**	GeoSyntec Consultants

nutrient delivery_Atofina.ai

SCHEDULE

ID	Task Name	Duration	Start
1	**PERCHLORATE PILOT STUDY/IRM**	**964 days**	**7/3/06**
2	Pilot Study Work Plan	5 days	7/3/06
3	DEQ Review and Approval	30 days	7/8/06
4	Pilot Study Design, Permitting, Procurement, Subcontracting	60 days	8/7/06
5	Field Pilot Study	365 days	10/6/06
6	a) System Installation	30 days	10/6/06
7	b) System Start-up Testing/Shakedown	30 days	11/5/06
8	c) Performance Monitoring	305 days	12/5/06
9	Midpoint Perchlorate Evaluation Tech Memo	30 days	4/4/07
10	Pilot Study Report and IRM Work Plan and Design	60 days	10/7/07
11	DEQ Review and Approval of IRM Design	30 days	12/6/07
12	Perchlorate IRM	368 days	1/5/08
13	Reporting	45 days	1/7/09

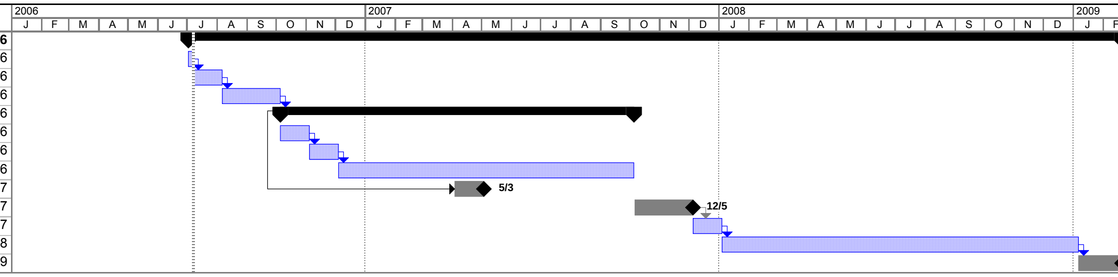


Figure 11: Pilot Test Schedule
Arkema Facility, Portland, Oregon

Task | Split | Milestone | Summary | Deadline

Note: Dates and duration of tasks shaded in gray are dependent on timing of agency review.

Pilot Test Schedule_07.07.2006.mpp

APPENDIX A

ODEQ COMMENTS & RESPONSES

Oregon
Theodore Kulongoski, Governor

Department of Environmental Quality
Northwest Region Portland Office
2020 SW 4th Avenue, Suite 400
Portland, OR 97201-4987
(503) 229-5263
FAX (503) 229-6945
TTY (503) 229-5471

April 6, 2006

Todd Slater
Legacy Site Services LLC
486 Thomas Jones Way
Exton Pennsylvania 19341

Re: Former Arkema Portland Plant
Perchlorate Pilot Test Workplan
ECSI No. 398

Dear Mr. Slater:

The Oregon Department of Environmental Quality (DEQ) reviewed the March 2006 document *Workplan for a Pilot Test of In Situ Bioremediation of Perchlorate in Groundwater at the Former Atofina Chemicals Site, Portland, Oregon.* This workplan was prepared for Arkema, Inc. by GeoSyntec Consultants and was provided to DEQ on March 10, 2006.

The following are DEQ review comments related to the proposed characterization of the vadose zone and hydraulic testing program (pre-pilot workplan).

Section 4.1 Assessment of Vadose Zone Perchlorate Distribution, Page 16 – Based on the presence of perchlorate in stormwater and the apparent longevity of the perchlorate groundwater plume, it is reasonable to expect widespread distribution of perchlorate in surface and vadose zone soils. In the event that perchlorate is not detected in the proposed Phase I soil testing, DEQ will likely require considerable additional soil testing to confirm the absence of perchlorate in surface and vadose zone soils for the purposes of addressing the perchlorate RI/FS nature and extent data gap.

Section 4.2 Hydraulic Testing Program – Specifics for managing the groundwater generated during the hydraulic testing program were not providing in the workplan.

There is potential for the proposed hydraulic testing program to exacerbate existing groundwater conditions in the former Chlorate Plant area by changing the contaminant distribution or boundaries of contaminant plumes. Before DEQ can approve the proposed hydraulic testing program, Arkema will need to provide an evaluation of the potential for the proposed hydraulic testing to exacerbate the existing groundwater conditions. It is requested that this evaluation include a figure that identifies the anticipated zone of influence for each of the test wells relative to groundwater contaminant plumes (i.e., pH, chloride, arsenic, hexavalent chromium, perchlorate and chlorobenzene) present in the vicinity of the proposed pumping wells. Plumes should be identified with isoconcentration contours.

Section 4.2 Hydraulic Testing Program, Page 18 – The groundwater data collected during the constant-rate test should include analysis for hexavalent chromium, arsenic and volatile organic compounds (EPA Method 8260).

DEQ requests that Arkema provide a workplan addendum that specifies the proposed management of the groundwater generated during the hydraulic testing program, includes an evaluation of the potential for the hydraulic testing program to exacerbate existing groundwater conditions and an acknowledgment of the requirement for the additional chemical testing.

The following are comments on the pending field pilot test program that was introduced in Section 5 of the draft workplan. DEQ requests that Arkema consider these comments in the preparation of the workplan for this effort. DEQ also requests that we schedule a meeting or conference call to review Arkema's field pilot strategy before the work plan is submitted.

General Comments

1. The field pilot test workplan will need to include a detailed evaluation of the potential for deleterious effects (both short and long term) of any substance proposed for injection (e.g., electron donor, biofouling agent and tracer) on groundwater quality and the Willamette River. This evaluation needs to include any degradation products.

2. The injection points for the proposed field pilots will need to be registered with the DEQ Water Quality Program. Information about the DEQ UIC Program and forms can be obtained at http://www.deq.state.or.us/wq/groundwa/uichome.htm. Arkema should indicate in the registration application that the UICs are related to the remedial work being conducted at the facility and identify myself as the DEQ Cleanup Program point of contact.

Specific Comments

Section 5 Field Pilot Test Program, Page 19 – Implementation of the field pilot test approach is subject to DEQ review and approval of the letter report and a field pilot workplan.

Based on the somewhat ambiguous biotreatability results, it is not clear what electron donor will be used in the pilot test or how that decision will be made. The workplan will need to support the selection of the electron donor proposed to be used.

Section 5.3 Active EISB Pilot Test – It is not clear why citrate is proposed as a potential donor given questions about its efficacy in the biotreatability study, and why benzoate was added and ethanol removed as potential treatment chemicals. The workplan should lay out the logic for the electron donor recommended for the field pilot.

Section 5.3 and 5.4 Active EISB Pilot Test and Passive EISB Pilot Test – For both active and passive schemes, distribution of the perchlorate-reducing culture through the impacted aquifer is an important factor for successful remediation. The document states that such cultures were used to successfully seed a bioreactor (above ground) at another site, but similar success for in-situ distribution of the microbial culture will be more challenging. While monitoring of the microbial population is proposed to be included in the workplan, the workplan should provide further discussion on the viability of in-situ culture distribution.

Section 5.4 Passive EISB Pilot Test – It does not appear that any slow-release electron donors were included in the biotreatability study. Consequently, what will be the basis for selection of an appropriate slow-release donor? Is there a track record for successful use of emulsified oil (for example) to address perchlorate contamination to groundwater?

Tracer Test, Page 28 – Note that monitoring for total organic carbon may be as effective for estimating the rate and degree to which an electron donor has infiltrated the saturated zone.

Section 6, Schedule – The schedule identified is not at all consistent with the earlier approved schedule for the perchlorate pilot study/interim remedial measure (IRM). Please provide an updated schedule by April 21st that reflects Arkema's current strategy for perchlorate treatment. The updated schedule should also identify how the perchlorate schedule matches up with the current EPA EE/CA schedule.

Should the field pilot demonstrate positive results early, DEQ would expect Arkema to accelerate the shift to a full-scale IRM.

Please contact me at (503) 229-5538 if you have any questions.

Sincerely,

Matt McClincy
Project Manager
Portland Harbor Section

cc: Tom Gainer, DEQ NWR
Dan Hafley, DEQ NWR
Larry Patterson, Arkema
Claudia Powers, Ater Wynne

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5 July 2006 GeoSyntec Ref: TR0162

Matt McClincy
Project Manager – Portland Harbor Section
Oregon Department of Environmental Quality
Northwest Region, Portland Office
2020 SW 4th Avenue, Suite 400
Portland, OR 97201-4987

Reference: Response to Comments on the Perchlorate Pilot Test Workplan, ECSI No. 398

Dear Mr. McClincy:

On behalf of Legacy Site Services, LLC (LSS), GeoSyntec Consultants, Incorporated (GeoSyntec) is providing this response to comments by the Oregon Department of Environmental Quality (DEQ) in a letter dated 6 April 2006 regarding the pre-design characterization program (PDDC) and the enhanced in situ bioremediation (EISB) pilot test proposed for the Former Atofina Chemicals Site, Portland, Oregon (the Site). GeoSyntec, in a letter dated 6 April 2006, previously provided responses to comments related to the PDDC program, and this program was successfully implemented. This letter provides responses to DEQ's comments related to the EISB pilot test. DEQ comments are provided in italics, followed by our response.

General Comments

DEQ Comment: *The field pilot test workplan will need to include a detailed evaluation of the potential for deleterious effects (both short and long term) of any substance proposed for injection (e.g., electron donor, biofouling agent and tracer) on groundwater quality and the Willamette River. This evaluation needs to include any degradation products.*

Response: As detailed in the Workplan (Section 5.3), the pilot test amendments will be limited to ethanol and citric acid as electron donors, chlorine dioxide for biofouling control, and sodium bromide as a conservative tracer. Ethanol and citric acid readily biodegrade to carbon dioxide, and do not involve the introduction of associated salts or trace contaminants (e.g., selenium) that can be present in some commonly used electron donors (e.g., molasses, corn syrup). The rate of donor addition will be balanced to the amount required to biodegrade the perchlorate and chlorate, and as such, the use of ethanol and citric acid is not expected to have any lasting impacts to groundwater and/or surface water quality, other than transient shifts in redox and alkalinity. Chlorine dioxide is commonly used to disinfect drinking water, and to prevent biofilm formation in ex situ treatment systems, cooling towers and industrial applications. The byproducts of chlorine dioxide disinfection are chloride and oxygen, which are already present in the aquifer; hence no new compounds are being introduced to groundwater. The concentrations of chloride produced by chlorine dioxide use are expected to be in the range of several mg/L, which is very low compared to the existing groundwater chloride concentrations, which are generally thousands of mg/L. Similarly, the concentration of bromide (either as sodium or potassium bromide) to be used for the short-term (14-day) tracer test is low (50 mg/L), and would not be expected to adversely affect groundwater or surface water quality.

DEQ Comment: *The injection points for the proposed field pilots will need to be registered with the DEQ Water Quality Program. Arkema should indicate in the registration application that the UICs are related to the remedial work being conducted at the facility and identify myself as the DEQ Cleanup Program point of contact.*

Response: Understood. GeoSyntec will apply for the necessary permits, citing the project and project manager as references.

Specific Comments

DEQ Comment: *Section 5 Field Pilot Test Program, Page 19 – Implementation of the field pilot test approach is subject to DEQ review and approval of the letter report and a field pilot workplan.*

Response: Understood.

DEQ Comment: *Based on the somewhat ambiguous biotreatability results, it is not clear what electron donor will be used in the pilot test or how that decision will be made. The workplan will need to support the selection of the electron donor proposed to be used.*

Response: As detailed in the Workplan, Arkema has decided to pilot test the active recirculation EISB approach, and as such, the soluble electron donors ethanol and citric acid will be used, with ethanol being the primary donor choice. These electron donors have been selected because: i) they do not cause lasting impacts to groundwater and/or surface water quality; ii) they provide a high number of electron equivalents per unit mass, which means that the volume of donor that must be handled is much lower than for other electron donors (e.g., acetate); and iii) they are readily available at reasonable cost. GeoSyntec has successfully used both electron donors for perchlorate biodegradation at sites in California, Nevada and Utah.

DEQ Comment: *Section 5.3 Active EISB Pilot Test – It is not clear why citrate is proposed as a potential donor given questions about its efficacy in the biotreatability study, and why benzoate was added and ethanol removed as potential treatment chemicals. The workplan should lay out the logic for the electron donor recommended for the field pilot.*

Response: Benzoate was initially suggested for pilot testing based on its current use at a full-scale EISB system at a site in Nevada. For sites requiring significant electron donor addition, the economics of benzoate are generally more favorable than for other electron donors. However, upon further review, it was determined that the use of sodium benzoate would require the addition of significant quantities of sodium to the aquifer, and as such, a decision to revert to ethanol was made. Ethanol is a very effective electron donor for perchlorate bioremediation at most sites, but can be less desirable for use due to its handling safety concerns. Citric acid has been retained as a potential electron donor for the pilot test because it may be beneficial for both buffering pH while supplementing ethanol addition. In our experience, once a microbial community is induced to biodegrade perchlorate, the electron donors can generally be interchanged with little impact to perchlorate degrading activity. It is our expectation that once the microbial populations at the Site become active, that they will be able to readily use both electron donors.

DEQ Comment: *Section 5.3 and 5.4 Active EISB Pilot Test and Passive EISB Pilot Test – For both active and passive schemes, distribution of the perchlorate-reducing culture through the impacted aquifer is an important factor for successful remediation. The document states that such cultures were used to successfully seed a bioreactor (above ground) at another site, but similar success for in-situ distribution of the microbial culture will be more challenging. While monitoring of the microbial population is proposed to be included in the workplan, the workplan should provide further discussion on the viability of in-situ culture distribution.*

Response: While GeoSyntec/SiREM has experience in successfully bioaugmenting more than 55 sites with KB-1^{TM} dechlorinator, a dehalorespiring microbial consortia used for PCE and TCE dechlorination, the culture proposed for this perchlorate EISB application has yet to be used in situ, and as such, its behavior in the pilot test remains to be observed. Of note, the pilot test will consist of a recirculation system, whereby groundwater is extracted from 2 wells and re-injected via 3-4 upgradient injection wells. Each of these injection wells will be bioaugmented with the perchlorate-reducing culture to create a biologically-active zone (BAZ) around each injection well. Treatment of perchlorate in the extracted and re-injected groundwater will occur in these BAZs, and as such, the EISB process does not require widespread distribution of the organisms throughout the site, as would be required by a passive EISB approach. The proposed molecular monitoring program will allow assessment of the successful introduction, growth and distribution of the bioaugmented culture in situ.

DEQ Comment: *Section 5.4 Passive EISB Pilot Test – It does not appear that any slow-release electron donors were included in the biotreatability study. Consequently, what will be the basis for selection of an appropriate slow-release donor? Is there a track record for successful use of emulsified oil (for example) to address perchlorate contamination to groundwater?*

Response: Arkema has decided to pilot test the active recirculation EISB approach, and as such, slow-release electron donors will not be used for the pilot test. Of note, emulsified oil substrate (EOS^{TM}) has been successfully used to bioremediate perchlorate in situ at an active rocket manufacturing facility in Maryland. This work has been presented and published by Bob Borden of IES Solutions/University of North Carolina.

DEQ Comment: *Tracer Test, Page 28 – Note that monitoring for total organic carbon may be as effective for estimating the rate and degree to which an electron donor has infiltrated the saturated zone.*

Response: Depending on the rate of substrate consumption, this may be the case. However, at some sites, consumption of the electron donor is fast relative to the travel time to monitoring points, and all total organic carbon (TOC) is consumed (converted to CO_2) before reaching the monitoring points, hence the need for a conservative tracer to estimate travel times.

DEQ Comment: *Section 6, Schedule – The schedule identified is not at all consistent with the earlier approved schedule for the perchlorate pilot study/interim remedial measure (IRM). Please provide an updated schedule by April 21st that reflects Arkema's current strategy for perchlorate treatment. The updated schedule should also identify how the perchlorate schedule matches up with the current EPA EE/CA schedule.*

Response: The Revised Workplan contains an updated schedule that is consistent with the EPA EE/CA schedule provided to DEQ in May 2006.

Please feel free to contact Todd Slater of LSS at 610-594-9430 if you have any questions with the responses provided above.

Sincerely,
GeoSyntec Consultants Incorporated

Evan E. Cox, M.Sc.
Principal

APPENDIX B

HYDRAULIC TESTING SUMMARY

APPENDIX B - HYDRAULIC TESTING

Hydraulic testing was conducted to assess the hydraulic properties of the aquifer for the purposes of completing pilot test design, and for collecting the required hydraulic data for assessment of potential full-scale enhanced in-situ bioremediation (EISB) configurations (e.g., injection and/or extraction well spacing and rates).

Testing was conducted at three locations (see **Figure B-1**), including:

i) PT-1 - a location immediately upgradient from the former Chlorate Cell Room near existing shallow well MWA-33;
ii) PT-2 - the MWA-25 area immediately downgradient of the former Chlorate Cell Room; and
iii) PT-3 - a downgradient area near the river (i.e., MWA-19 area).

These locations were selected to reflect areas with different geologic/hydraulic conditions, and also corresponding to likely locations for injection and/or extraction activities for potential pilot testing and/or full-scale EISB. Hydraulic testing was conducted solely for the shallow aquifer at each location, primarily to guide pilot test design. Activities consisted of a step-drawdown test in each area to evaluate the specific capacity of each well, and a constant-discharge test in each area to determine the transmissivity and storage coefficient of the shallow aquifer.

At each of the three locations, a 4-inch PVC well (PT-1, PT-2 and PT-3) was installed for hydraulic testing purposes at a distance of 15 to 25 feet from the existing shallow monitoring well (MWA-33, MWA-25, MWA-19, respectively). The pumping wells were screened across the shallow aquifer at an equivalent interval to the corresponding monitoring well (generally ten foot screens with an interval from 20 to 35 ft bgs). For the MWA-33 location, a single 2-inch PVC monitoring well (MWA-70i) was installed in the intermediate aquifer (screen depth of 32.7 to 42.5 ft bgs) to allow for assessment of baseline perchlorate concentrations in this area, and to monitor hydraulic response during testing of the shallow aquifer pumping well. There is currently no intermediate aquifer well in this area of the Site. Well installation was conducted in accordance with standard well installation procedures, and following local and/or state well permitting and installation guidelines. Well construction details are presented in **Table B-1**.

During pump testing, drawdown in both the extraction well and the associated shallow aquifer monitoring well was monitored using pressure transducers and data loggers. In addition, drawdown in intermediate aquifer monitoring wells MWA-48i and MWA-34i, co-located with shallow aquifer wells MWA-25 and MWA-19, respectively, was monitored to quantify the degree of hydraulic interconnection between the shallow and intermediate aquifers during pumping of the shallow aquifer.

Step-drawdown testing at each new pumping well consisted of extracting groundwater from the well at a series of increasing flow rates for a period of about one hour per step, and monitoring the dynamic water level changes either by regular sounding with a manual water level tape or using a pressure transducer and data logger. The test consisted of three to five flow rates, distributed across the range of sustainable pumping rates. Pumping began at low flow rates and proceeded to higher flow rates. The rates were adjusted based on field observations for each well. From these tests, the sustainable well yield of each pumping well was estimated for the follow-on constant-rate discharge tests.

Constant-rate discharge testing was conducted at a pumping rate that is near the sustainable well yield for up to four hours per pumping well. Prior to initiating the constant-rate discharge tests, the water level at the pumping well was allowed to return to a static condition following the step-drawdown test. Automatic (using a data-logger and pressure transducers) and manual water level readings were recorded at regular intervals in the pumping wells and nearby monitoring wells for several hours prior to, during, and for several hours after the constant-discharge test. The drawdown data was evaluated with appropriate graphical methods (Neuman and Moench analyses)to determine aquifer parameters, including storage coefficient, transmissivity, and hydraulic conductivity, and to assess the sustainable extraction/recharge rates and capture zone of the extraction wells. This information, combined with lithologic data collected during installation of the wells, was and will be used to optimize system extraction and injection rates for pilot and potential full-scale applications, number of extraction/reinjection wells, and to assess the need for nested wells. Results for of the graphical analyses for PT-1, PT-2 and PT-3 are provided in **Figures B-2** through **B-4**, and tabulated in **Table B-2**.

During the constant-rate discharge tests, groundwater samples were collected from the pumping wells at the start and end of the testing (under pumping conditions) for analysis of field parameters (DO, ORP, pH, specific conductance, TDS) and key geochemical parameters (perchlorate, chlorate, chloride, nitrate, nitrite, sulfate) to assess changes in groundwater chemistry under pumping conditions. Samples were submitted to STL for analysis following published analytical protocols. Results are presented in **Tables B-3** (field parameters) and **B-4** (groundwater chemistry).

The results of the hydraulic testing program indicated that groundwater injection/extraction within the shallow aquifer near the Source Area and the Willamette River will be limited to a few gallons per minute. Much higher well yields (tens of gpm) are achievable in the Downgradient Area near MWA-25. The vertical connectivity between the shallow and intermediate aquifers appears to be limited within the Source Area and near the Willamette River, but good vertical connection was observed between these aquifers in the Downgradient Area (near MWA-25) where the hydraulic conductivities are higher.

TABLE B-1
WELL CONSTRUCTION DETAILS AND WATER ELEVATIONS
Arkema Facility, Portland, Oregon

Well	Date Installed	Reference Elevation (ft amsl)	Total Depth (ft bgs)	Well Diameter (in)	Well Casing Material	Screen Type	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Water Elevation[1] (ft btoc)
PT-1	12-Apr-06	37.58595	31	4	Sch 40 PVC	20 Slot	19.9	29.1	14.9
PT-2	11-Apr-06	37.78498	34.5	4	Sch 40 PVC	20 Slot	24.4	33.5	22.8
PT-3	12-Apr-06	37.02265	29.5	4	Sch 40 PVC	20 Slot	19.5	28.7	22.4
MWA-70i	13-Apr-06	37.61740	46.5	2	Sch 40 PVC	10 Slot	32.7	42.5	19.5

Notes:

[1] Water elevations measured before continuous pump tests on 19 and 24 April 2006

in - inch

ft bgs - feet below ground surface

ft btoc - feet below top of casing

PVC - polyvinyl chloride

TABLE B-2
ANALYSIS OF CONSTANT RATE PUMPING TESTS
Arkema Facility, Portland, Oregon

Pumping Well			Observation Well									
Well	Screened Interval (ft bgs)	Pumping Rate (gpm)	Well	Screened Interval (ft bgs)	Distance (ft)	Transmissivity (ft^2/d)	Aquifer Thickness (ft)	Hydraulic Conductivity (ft/d)	Storativity (unitless)	Specific Yield (unitless)	Comments
PT-1	19.9 - 29.1	0.9	MWA-33	20 - 30	10.35	11.6	10	1.2	0.002	0.05	Neuman unconfined
		0.9	MWA-33	20 - 30	10.35	12.4	10	1.2	0.002	0.05	Recovery data only, Neuman unconfined
PT-2	24.4 - 33.5	27.6	MWA-25	24.4 - 33.5	12.91	3,928	21	187	0.009	0.03	Moench partial penetration unconfined
PT-3	19.5 - 28.7	0.75; 0.5	PT-3	19.5 - 28.7	0.12	18.1	4	4.5	0.003	0.05	Moench unconfined
		0.75; 0.5	PT-3	19.5 - 28.7	0.12	4.6	4	1.2	na	na	Theis recovery

Notes:
gpm - gallons per minute
ft bgs - feet below ground surface
ft - feet
ft^2/d - square feet per day
ft/d - feet per day
na - not applicable

TABLE B-3
GROUNDWATER FIELD PARAMETERS COLLECTED DURING CONSTANT DISCHARGE PUMPING TEST
Arkema Facility, Portland, Oregon

Date	Time	Pumping Rate (gpm)	Cumulative Volume (gallons)	Temperature (°C)	pH	Conductance (mS/cm)	DO (mg/L)	ORP (mV)	Test Type	Notes
PT-1										
18-Apr-06	9:55	3.5	35	12.0	10.57	3.203	2.38	-182	Well Development	Brown/turbid water
18-Apr-06	10:12	3.5	45	14.6	10.47	3.243	5.40	-152	Well Development	
18-Apr-06	10:31	3.5	60	9.2	10.59	3.308	7.43	-103	Well Development	
18-Apr-06	10:43	3.5	80	14.4	10.62	3.361	6.57	-140	Well Development	Clearing
18-Apr-06	10:48	3.5	90	14.5	10.64	3.385	7.05	-128	Well Development	
18-Apr-06	11:07	2.5	110	14.3	10.66	3.374	6.49	-140	Well Development	Clean
18-Apr-06	11:26	2.5	130	14.0	10.66	3.374	6.49	-142	Well Development	Clean
24-Apr-06	12:08	1	--	17.5	10.32	3.755	5.33	-57	Constant Discharge	
24-Apr-06	13:08	1	--	16.6	10.46	3.810	3.69	-254	Constant Discharge	
24-Apr-06	14:08	1	--	17.1	10.43	3.814	2.98	-262	Constant Discharge	
PT-2										
13-Apr-06	14:35	3	45	18.9	7.15	22.755	2.33	233	Well Development	
13-Apr-06	14:50	3	70	18.6	7.06	21.630	2.89	228	Well Development	
13-Apr-06	14:58	3	100	18.6	7.03	27.579	2.46	204	Well Development	
13-Apr-06	15:03	3	110	18.1	7.10	21.131	4.03	193	Well Development	
13-Apr-06	15:06	3	120	18.6	7.13	17.405	5.99	187	Well Development	
13-Apr-06	15:10	3	132	18.6	7.11	17.149	5.04	184	Well Development	
13-Apr-06	15:13	3	141	18.8	7.07	20.327	6.06	184	Well Development	
19-Apr-06	15:50	30.2	--	23.7	7.00	25.100	7.59	177	Constant Discharge	Taken from tank outlet
19-Apr-06	15:50	30.2	--	20.7	6.74	24.290	5.77	179	Constant Discharge	Taken from tank inlet
19-Apr-06	17:03	30.2	--	22.5	6.69	24.860	4.40	178	Constant Discharge	Taken from tank inlet
19-Apr-06	18:25	30.2	--	19.6	6.76	23.542	6.79	91	Constant Discharge	Taken from tank inlet
PT-3										
13-Apr-06	15:30	2	35	17.7	6.42	5.450	4.19	200	Well Development	
13-Apr-06	15:56	2	45	17.7	6.33	5.629	4.58	220	Well Development	
13-Apr-06	16:05	2	50	17.2	6.41	5.649	4.59	218	Well Development	
24-Apr-06	12:15	0.5	--	18.5	6.50	6.822	6.14	157	Constant Discharge	
24-Apr-06	13:05	0.5	--	19.0	6.40	6.957	5.74	-11	Constant Discharge	
24-Apr-06	14:38	0.5	--	20.5	6.32	7.317	7.21	48	Constant Discharge	
MWA-70i										
17-Apr-06	8:37	1.5	15	13.4	7.06	1.035	1.05	-48	Well Development	
17-Apr-06	8:40	1.5	18	--	--	--	--	--	Well Development	Pumped dry
19-Apr-06	18:05	0.3	5	16.1	5.81	0.004	5.47	87	Constant Discharge	
19-Apr-06	18:15	0.3	8	18.5	6.01	5.072	4.31	25	Constant Discharge	

Notes:

-- data not collected
gpm - gallons per minute
°C - degrees Celsius
mS/cm -milliSiemens per centimeter
mg/L - milligrams per liter
mV - millivolts

TABLE B-4
ANALYTICAL RESULTS FROM PUMP TEST WELLS AND MONITORING WELL MWA-70i
Arkema Facility, Portland, Oregon

Sample Location	Date Collected	Sample ID	Perchlorate (mg/L)[3]	Chlorate (mg/L)[3]	Chloride (mg/L)[3]	Nitrite-N (mg/L)[3]	Nitrate-N (mg/L)[3]	Sulphate (mg/L)[3]	Bromide (mg/L)[3]	Phosphate (mg/L)[3]
PT-1	19-Apr-06	PT-1-1	16	1,276	370	<0.12	<0.10	87	2.3	<0.57
	24-Apr-06	PT-1-2	18	1,410	337	<0.12	0.14	84	3.0	<0.57
	24-Apr-06	PT-1-2-Dup	17	1,405	336	<0.12	<0.10	78	2.1	<0.57
PT-2	18-Apr-06	PT-2-1	260	5,100	6,047	<0.12	<0.10	1,480	5.5	<0.57
	19-Apr-06	PT-2-2	207	4,192	7,274	<0.12	0.11	1,280	8.9	<0.57
PT-3	18-Apr-06	PT-3-1	<0.20	42	1,950	<0.12	0.20	743	<0.39	<0.57
	24-Apr-06	PT-3-2	<0.20	7.8	1,774	<0.12	0.30	876	3.2	<0.57
MWA-70i	19-Apr-06	MWA-70i-1	1.0	29	852	<0.12	0.41	134	<0.39	<0.57
Equip Blank	19-Apr-06	MWA-70i-B	<0.20	29	68	<0.12	<0.10	12	<0.39	<0.57

Notes:

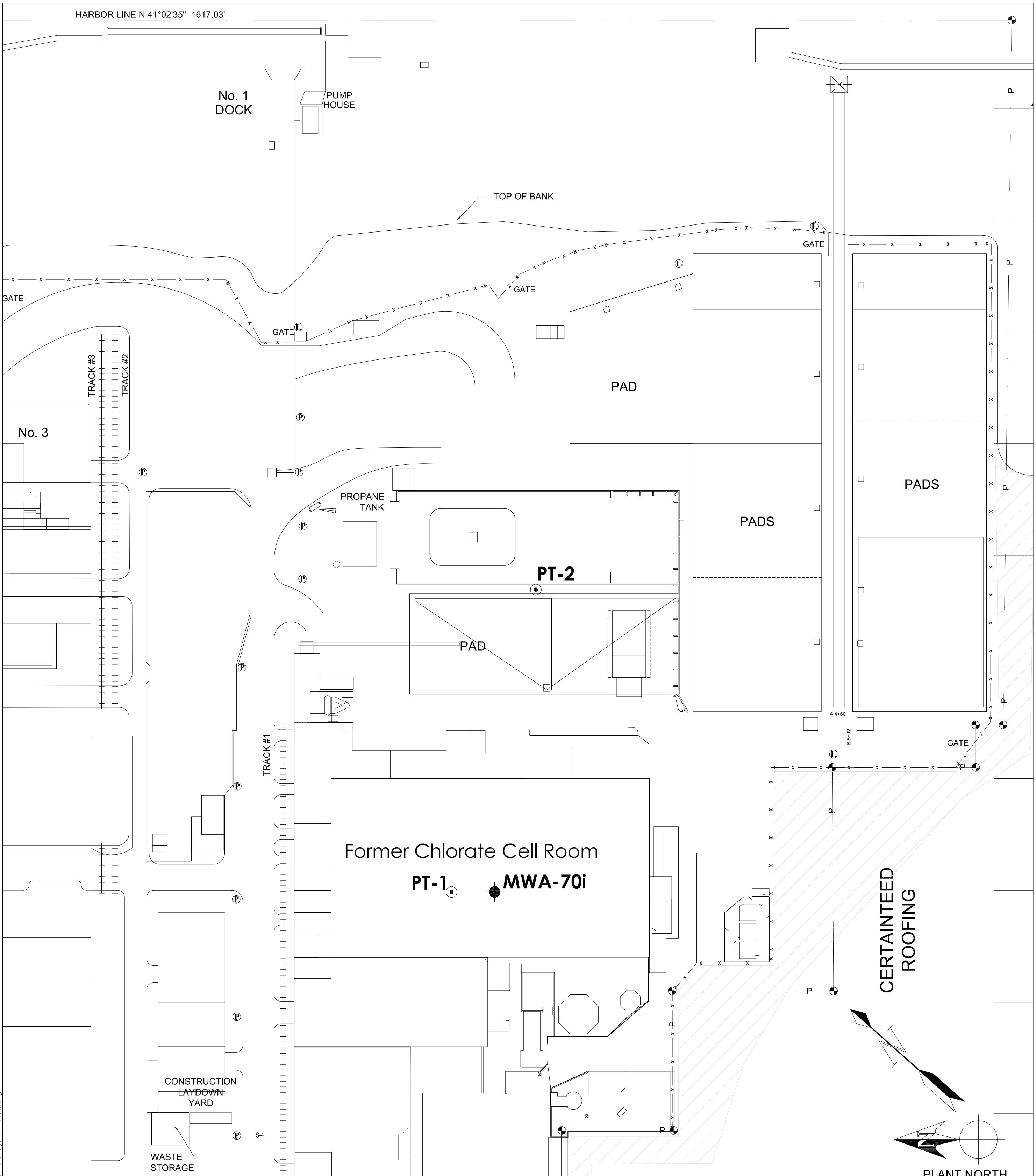
[1] Analyses by North Creek Analytical Labs, Bothell WA (EPA Method 7196A)

[2] Analyses by Severn-Trent Laboratories, Arvada, CO, (EPA Method 6020)

[3] Analyses by SiREM Laboratory, Guelph, ON, Canada (ion chromatography)

[4] 24-hour hold time exceeded

-1 - sample collected at the start of the step pump test
-2 - sample collected at the end of the constant-discharge pump test
B - estimated value, compound detected at concentration below reporting limit
U - non-detect, associated value is the reporting limit
< - non-detect, associated value is the quantitation limit
mg/L - milligrams per liter
µg/L - micrograms per liter



SOURCE: ARKEMA INC. 2005

LEGEND

- LEGAL BOUNDARY, EASEMENT
- RAILROAD
- FENCE
- LIGHT POLE, POWER POLE
- NEW INTERMEDIATE DEPTH MONITORING WELL
- NEW SHALLOW PUMP TEST WELL

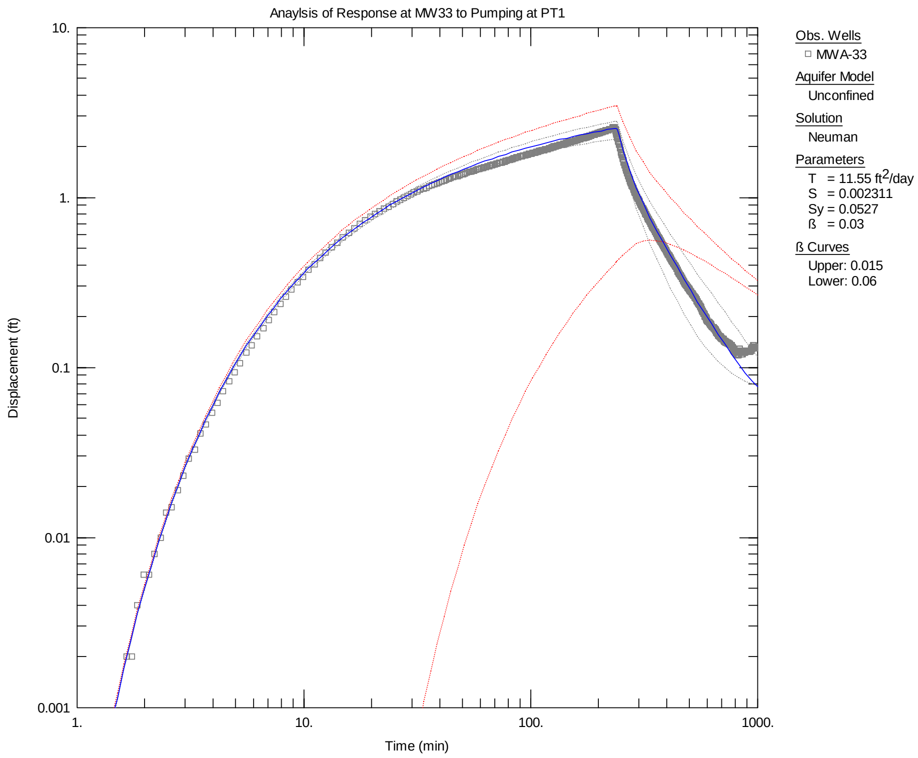
0 100 200
Scale (ft)

Hydraulic Testing Locations
Arkema Facility, Portland, Oregon

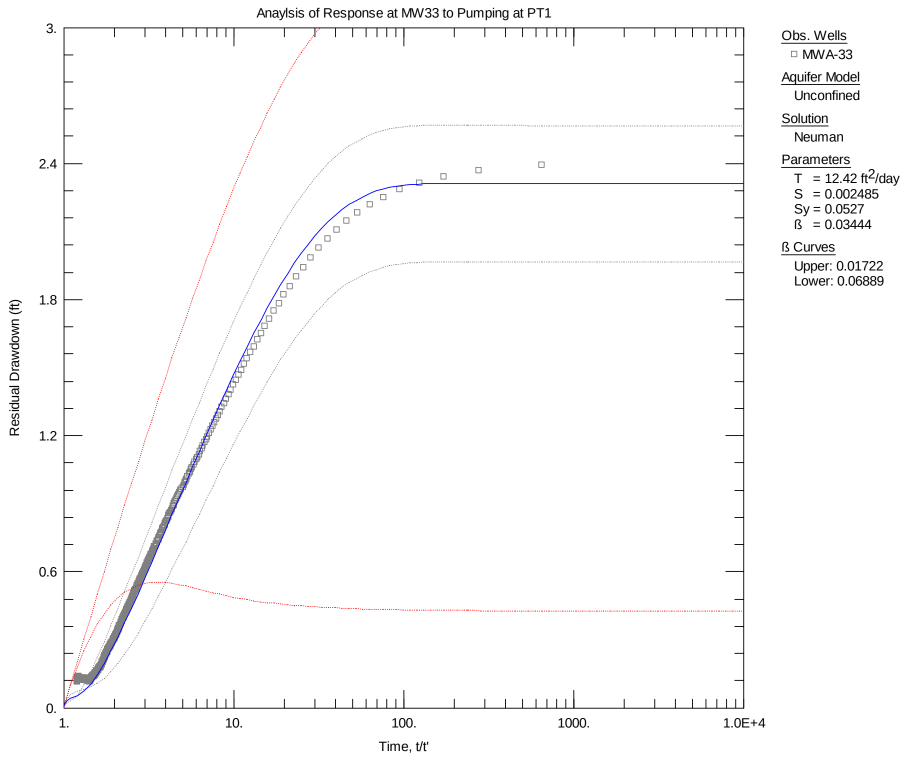
July 2006 | Figure: **B-1** | GeoSyntec Consultants

P:\Graphics\GeoSyntec PROJECTS\TR0162_ATOFINA\AutoCAD\Arkema_SW_Drainage - MWA Edits.dwg

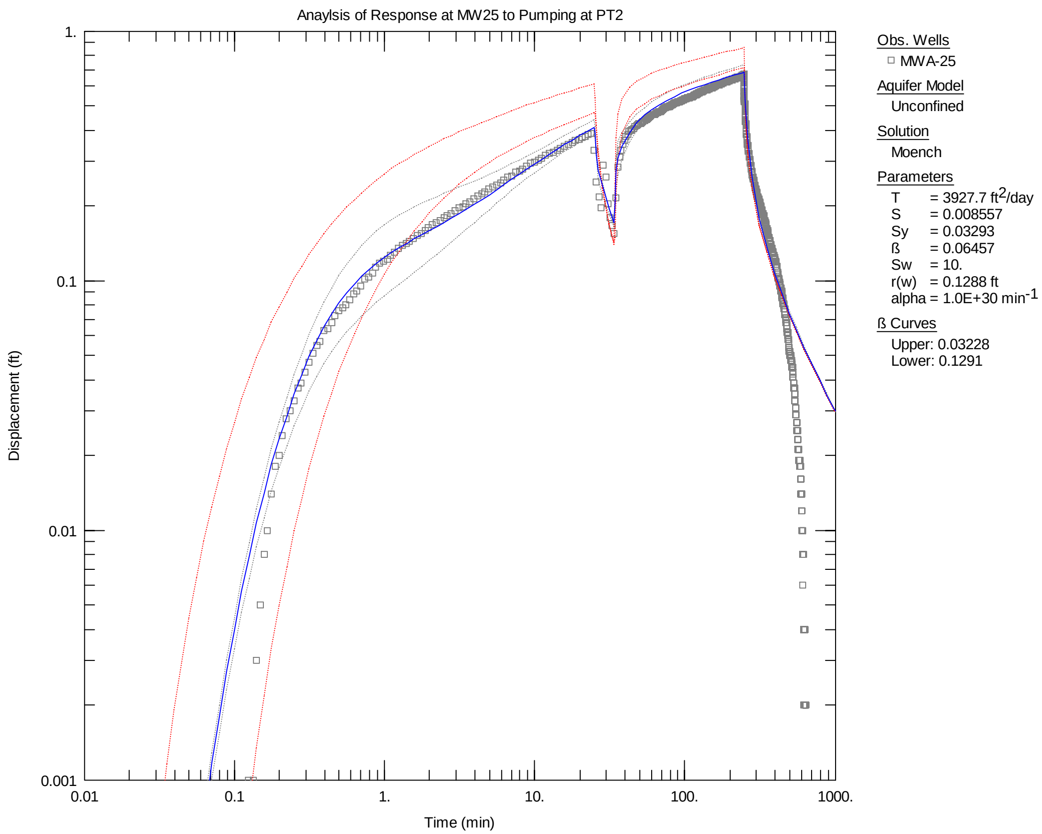
Analysis of PT-1 Constant Discharge Test



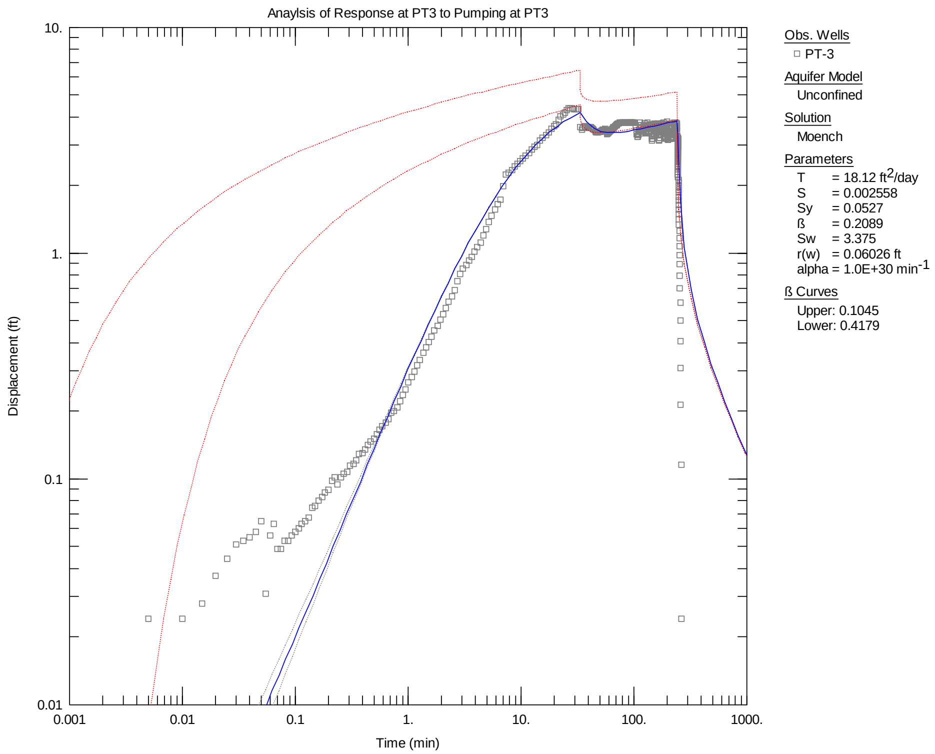
Analysis of Recovery at MW-33



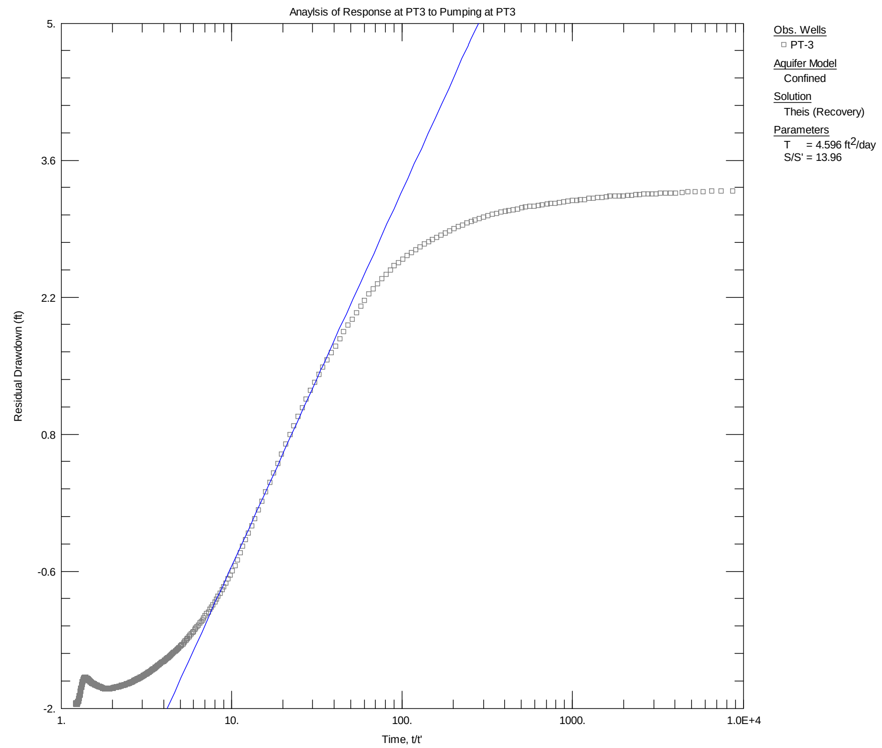
Analysis of PT-2 Constant Discharge Test
(includes compensation for partial penetration)



Analysis of PT-3 Constant Discharge Test



Analysis of Recovery at PT3



APPENDIX C

COMPARATIVE PERCHLORATE ANALYSIS FROM SELECTED BIOTREATABILITY STUDY SAMPLES

APPENDIX C
COMPARATIVE PERCHLORATE ANALYSIS FROM SELECTED BIOTREATABILITY STUDY SAMPLES
Arkema Facility, Portland, Oregon

Sample Number	Perchlorate by IC[1] (mg/L)	Perchlorate by SW 846 8321A[2] (mg/L)	RPD (%)
TR0162-7	298	320	7%
TR0162-15	0.06 U	0.0019	--
TR0162-19	0.06 U	0.013	--
TR0162-25	80	83	4%

Notes:
[1] - analyses by SiREM Laboratory (Guelph, ON, Canada)
[2] - analyses by Severn-Trent Laboratories (Arvada, CO)
U - not detected; associated value is quantitation limit
RPD - relative percent difference
IC - ion chromatography
mg/L - milligrams per liter
-- - RPD not calculated; one result is non-detect

APPENDIX D

ANALYTICAL DATA FROM BIOTREATABILITY STUDY

APPENDIX D-1
ANALYTICAL RESULTS FOR SOURCE AREA (MWA-25)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04	Sterile control	1	5.4	2585	<0.02	<0.02	202	<0.14	<0.05	7257	291	--	--	7
13-Jan-04	Sterile control	2	2.3	2468	<0.02	0.60	197	<0.14	<0.05	7254	288	--	--	--
13-Jan-04	Sterile control	3	3.1	2600	<0.02	<0.02	185	<0.14	<0.05	7261	285	--	--	--
13-Jan-04	average		3.6	2551	<0.02	0.20	195	<0.14	<0.05	7257	288			
20-Jan-04	Sterile control	1	2.1	2526	<0.02	0.81	211	<0.14	<0.05	7277	275	--	--	--
20-Jan-04	Sterile control	2	1.7	2288	<0.02	<0.02	210	<0.14	<0.05	6837	281	--	--	7
20-Jan-04	Sterile control	3	3.0	2180	<0.02	<0.02	173	<0.14	<0.05	6073	280	--	--	--
20-Jan-04	average		2.3	2331	<0.02	0.27	198	<0.14	<0.05	6729	279			
27-Jan-04	Sterile control	1	14	2362	<0.02	0.81	182	<0.14	<0.05	6611	246	--	--	7
27-Jan-04	Sterile control	2	3.0	2260	<0.02	<0.02	195	<0.14	<0.05	6783	260	--	--	--
27-Jan-04	Sterile control	3	3.6	2171	<0.02	<0.02	185	<0.14	<0.05	6203	225	--	--	--
27-Jan-04	average		6.8	2264	<0.02	0.27	187	<0.14	<0.05	6532	244			
10-Feb-04	Sterile control	1	8.0	2432	<0.02	0.81	214	<0.14	<0.05	6921	282	--	--	7
10-Feb-04	Sterile control	2	5.0	2003	<0.02	<0.02	155	<0.14	<0.05	5763	286	--	--	--
10-Feb-04	Sterile control	3	5.7	2473	<0.02	<0.02	197	<0.14	<0.05	6858	286	--	--	--
10-Feb-04	average		6.2	2303	<0.02	0.27	189	<0.14	<0.05	6514	285			
26-Feb-04	Sterile control	1	Added 8,955 mg/L of citric acid											
26-Feb-04	Sterile control	1	3.4	2613	<0.28	<0.02	257	<0.14	<0.05	7410	320	2721	--	2.77
26-Feb-04	average		3.4	2613	<0.28	0.00	257	<0.14	<0.05	7410	320			
2-Mar-04	Sterile control	1	0.3	2297	<0.28	<0.02	214	<0.14	<0.05	7553	239	3324	--	3
2-Mar-04	Sterile control	2	1.7	2586	<0.28	<0.02	230	<0.14	<0.05	7793	298	--	--	--
2-Mar-04	Sterile control	3	0.8	2706	<0.28	<0.02	244	<0.14	<0.05	7625	267	--	--	--
2-Mar-04	average		0.9	2530	<0.28	<0.02	229	<0.14	<0.05	7657	268			
9-Mar-04	Sterile control	1	3.8	2018	<0.28	<0.02	165	<0.14	<0.05	6251	259	2718	--	3
9-Mar-04	Sterile control	2	4.8	2365	<0.28	<0.02	208	<0.14	<0.05	6798	344	--	--	--
9-Mar-04	Sterile control	3	5.1	2596	<0.28	<0.02	226	<0.14	<0.05	7266	345	--	--	--
9-Mar-04	average		4.6	2326	<0.28	<0.02	200	<0.14	<0.05	6772	316			
17-Mar-04	Sterile control	1	0.83	2275	<0.28	<0.02	191	<0.14	<0.05	7113	318	3343	--	--
17-Mar-04	Sterile control	2	1.1	1800	<0.28	<0.02	149	<0.14	<0.05	5965	298	--	--	--
17-Mar-04	Sterile control	3	1.3	2662	<0.28	<0.02	225	<0.14	<0.05	8620	296	--	--	--
17-Mar-04	average		1.1	2246	<0.28	<0.02	189	<0.14	<0.05	7233	304			
30-Mar-04	Sterile control	1	4.4	2013	<0.28	<0.02	264	<0.14	<0.05	5900	199	2951	--	--
30-Mar-04	Sterile control	2	1.4	2023	<0.28	<0.02	205	<0.14	<0.05	5772	232	--	--	--
30-Mar-04	Sterile control	3	1.3	2468	<0.28	<0.02	239	<0.14	<0.05	6793	224	--	--	--
30-Mar-04	average		2.4	2168	<0.28	<0.02	236	<0.14	<0.05	6155	218			
27-Apr-04	Sterile control	1	4.3	2827	<0.28	<0.02	305	<0.14	<0.05	7490	247	--	--	--
27-Apr-04	Sterile control	2	2.7	2098	<0.28	<0.02	193	<0.14	<0.05	6273	269	--	--	--
27-Apr-04	Sterile control	3	4.9	2355	<0.28	<0.02	272	<0.14	<0.05	6392	266	--	--	--
27-Apr-04	average		4.0	2426	<0.28	<0.02	257	<0.14	<0.05	6718	261			

APPENDIX D-1
ANALYTICAL RESULTS FOR SOURCE AREA (MWA-25)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04	Citric acid	4	2.4	2565	<0.02	<0.02	231	<0.14	<0.05	7495	262	3652	--	4
13-Jan-04	Citric acid	5	2.2	2209	<0.02	<0.02	204	<0.14	<0.05	6865	255	3117	--	--
13-Jan-04	Citric acid	6	1.6	1582	<0.02	<0.02	151	<0.14	<0.05	4847	264	2468	--	--
13-Jan-04	average		2.1	2119	<0.02	<0.02	195	<0.14	<0.05	6402	260	3079		
20-Jan-04	Citric acid	4	4.8	2222	<0.02	<0.02	245	<0.14	<0.05	6739	<0.02	3497	--	--
20-Jan-04	Citric acid	5	3.2	2055	<0.02	<0.02	199	<0.14	<0.05	6334	<0.02	3300	--	--
20-Jan-04	Citric acid	6	5.1	2395	<0.02	<0.02	247	<0.14	<0.05	7249	<0.02	3233	--	4
20-Jan-04	average		4.4	2224	<0.02	<0.02	231	0.00	<0.05	6774	<0.02	3343		
								<0.14						
27-Jan-04	Citric acid	4	1.2	1924	<0.02	<0.02	216	<0.14	<0.05	6689	<0.02	3601	--	--
27-Jan-04	Citric acid	5	1.7	1958	<0.02	<0.02	216	<0.14	<0.05	6840	<0.02	3741	--	--
27-Jan-04	Citric acid	6	2.3	1950	<0.02	<0.02	218	<0.14	<0.05	6721	<0.02	3713	--	4
27-Jan-04	average		1.7	1944	<0.02	<0.02	217	<0.14	<0.05	6750	<0.02	3685		
10-Feb-04	Citric acid	4	6.5	1839	<0.02	<0.02	166	<0.14	<0.05	5228	<0.02	2791	--	--
10-Feb-04	Citric acid	5	6.9	1598	<0.02	<0.02	145	<0.14	<0.05	4653	<0.02	2572	--	4
10-Feb-04	Citric acid	6	1.7	2408	<0.02	<0.02	255	<0.14	<0.05	7108	<0.02	3675	--	--
10-Feb-04	average		5.0	1948	<0.02	<0.02	188	<0.14	<0.05	5663	<0.02	3013		
24-Feb-04	Citric acid	4	Perchlorate respiked to 290 mg/L											
24-Feb-04	Citric acid	5	Perchlorate respiked to 290 mg/L											
24-Feb-04	Citric acid	6	Perchlorate respiked to 290 mg/L											
24-Feb-04														
2-Mar-04	Citric acid	4	6.3	2330	<0.28	<0.02	236	<0.14	<0.05	6609	<0.02	3259	--	4
2-Mar-04	Citric acid	5	5.9	2174	<0.28	<0.02	224	<0.14	<0.05	6412	<0.02	3313	--	--
2-Mar-04	Citric acid	6	1.2	2201	<0.28	<0.02	211	<0.14	<0.05	6257	<0.02	3272	--	--
2-Mar-04	average		4.4	2235	<0.28	<0.02	224	<0.14	<0.05	6426	<0.02	3282		
30-Mar-04	Citric acid + CPS	47	7.7	2069	<0.28	<0.02	255	<0.14	<0.05	6662	175	4332	--	--
30-Mar-04	Citric acid + CPS	48	4.4	1702	<0.28	<0.02	213	<0.14	<0.05	5818	168	3767	--	--
30-Mar-04	Citric acid + CPS	49	15	2025	<0.28	<0.02	260	<0.14	<0.05	6893	183	6117	--	--
30-Mar-04			9.1	1932	<0.28	<0.02	242	<0.14	<0.05	6458	175	4739		
6-Apr-04	Citric acid + CPS	47	1.2	2271	<0.28	<0.02	310	<0.14	<0.05	6748	250	3833	--	--
6-Apr-04	Citric acid + CPS	48	14	2012	<0.28	<0.02	267	<0.14	<0.05	6390	263	3676	--	--
6-Apr-04	Citric acid + CPS	49	8.8	2032	<0.28	<0.02	321	<0.14	<0.05	6107	263	5217	--	--
6-Apr-04			7.9	2105	<0.28	<0.02	299	<0.14	<0.05	6415	259	4242		
27-Apr-04	Citric acid + CPS	47	17	2340	<0.28	<0.02	312	<0.14	<0.05	5621	253	--	--	3.93
27-Apr-04	Citric acid + CPS	48	19	3209	<0.28	<0.02	320	<0.14	<0.05	6271	236	--	--	3.89
27-Apr-04	Citric acid + CPS	49	24	3093	<0.28	<0.02	346	<0.14	<0.05	5060	225	--	--	3.73
27-Apr-04			20	2881	<0.28	<0.02	326	<0.14	<0.05	5651	238			
7-Jun-04	Citric acid + CPS	47	180	3735	<0.28	<0.02	580	<0.14	<0.05	NA	301	868	--	--
7-Jun-04	Citric acid + CPS	48	124	3101	<0.28	<0.02	482	<0.14	<0.05	NA	273	752	--	--
7-Jun-04	Citric acid + CPS	49	176	3524	<0.28	<0.02	696	<0.14	<0.05	NA	271	1289	--	--
7-Jun-04			160	3453	<0.28	<0.02	586	<0.14	<0.05		282	970		
7-Jun-04	Citric acid + CPS		Bioaugmented all three reps with perchlorate degrading culture											

APPENDIX D-1
ANALYTICAL RESULTS FOR SOURCE AREA (MWA-25)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
10-Jun-04	Citric acid + CPS	47	101	2681	<0.28	<0.02	374	<0.14	<0.05	6907	282	576	--	4.4
10-Jun-04	Citric acid + CPS	48	93	2416	<0.28	<0.02	349	<0.14	<0.05	6639	267	574	--	4.4
10-Jun-04	Citric acid + CPS	49	133	2552	<0.28	<0.02	463	<0.14	<0.05	6382	266	861	--	4.2
10-Jun-04			109	2549	<0.28	<0.02	395	<0.14	<0.05	6643	272	671		
16-Jun-04	Citric acid + CPS	47	118	2344	<0.28	<0.02	312	<0.14	<0.05	5978	266	466	--	--
16-Jun-04	Citric acid + CPS	48	128	2352	<0.28	<0.02	338	<0.14	<0.05	6411	259	531	--	--
16-Jun-04	Citric acid + CPS	49	156	2338	<0.28	<0.02	411	<0.14	<0.05	5888	NA	729	--	--
16-Jun-04			134	2345	<0.28	<0.02	354	<0.14	<0.05	6092	263	575		
23-Jun-04	Citric acid + CPS	47	258	3060	<0.28	<0.02	435	<0.14	<0.05	7873	272	599	--	--
23-Jun-04	Citric acid + CPS	48	242	3261	<0.28	<0.02	480	<0.14	<0.05	8627	256	684	--	--
23-Jun-04	Citric acid + CPS	49	259	2837	<0.28	<0.02	520	<0.14	<0.05	7215	248	851	--	--
23-Jun-04			253	3053	<0.28	<0.02	479	<0.14	<0.05	7905	259	711		
28-Jun-04	Citric acid + CPS		Re-Bioaugmented all three reps with perchlorate degrading culture											
30-Jun-04	Citric acid + CPS	47	32	2830	<0.28	<0.02	484	<0.14	<0.05	7018	269	518	--	--
30-Jun-04	Citric acid + CPS	48	34	2844	<0.28	<0.02	411	<0.14	<0.05	7433	256	594	--	--
30-Jun-04	Citric acid + CPS	49	44	2774	<0.28	<0.02	477	<0.14	<0.05	6533	251	829	--	--
30-Jun-04			37	2816	<0.28	<0.02	457	<0.14	<0.05	6995	259	647		
7-Jul-04	Citric acid + CPS	47	250	2857	<0.02	<0.02	420	<0.14	<0.05	7205	262	559	--	--
7-Jul-04	Citric acid + CPS	48	278	2788	<0.28	<0.02	421	<0.14	<0.05	9441	247	508	--	--
7-Jul-04	Citric acid + CPS	49	371	3407	<0.28	<0.02	759	<0.14	<0.05	10489	250	786	--	--
7-Jul-04			300	3017	<0.28	<0.02	534	<0.14	<0.05	9045	253	618		
14-Jul-04	Citric acid + CPS	47	207	2410	<0.02	<0.02	331	<0.14	<0.05	5873	240	557	--	--
14-Jul-04	Citric acid + CPS	48	185	1954	<0.28	<0.02	291	<0.14	<0.05	5080	243	531	--	--
14-Jul-04	Citric acid + CPS	49	258	2028	<0.28	<0.02	375	<0.14	<0.05	4947	219	701	--	--
14-Jul-04			217	2131	<0.28	<0.02	332	<0.14	<0.05	5300	234			

APPENDIX D-1
ANALYTICAL RESULTS FOR SOURCE AREA (MWA-25)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04	Ethanol and acetate	7	2434	2406	<0.02	<0.02	208	<0.14	<0.05	7224	286	--	1898	7
13-Jan-04	Ethanol and acetate	8	2363	2083	<0.02	<0.02	171	<0.14	<0.05	6562	275	--	1812	--
13-Jan-04	Ethanol and acetate	9	2402	2364	<0.02	<0.02	190	<0.14	<0.05	6999	294	--	1864	--
	average		2399	2284	<0.02	<0.02	190	<0.14	<0.05	6928	285		1858	
20-Jan-04	Ethanol and acetate	7	3011	2346	<0.02	<0.02	193	<0.14	<0.05	6261	256	--	1489	--
20-Jan-04	Ethanol and acetate	8	2900	2132	<0.02	<0.02	179	<0.14	<0.05	5809	258	--	1544	--
20-Jan-04	Ethanol and acetate	9	3152	2443	<0.02	<0.02	215	<0.14	<0.05	6351	270	--	1820	7
	average		3021	2307	<0.02	<0.02	196	<0.14	<0.05	6140	261		1618	
27-Jan-04	Ethanol and acetate	7	2925	2662	<0.02	<0.02	211	<0.14	<0.05	6626	226	--	1759	--
27-Jan-04	Ethanol and acetate	8	3194	2409	<0.02	<0.02	196	<0.14	<0.05	6198	229	--	1837	7
27-Jan-04	Ethanol and acetate	9	3370	2515	<0.02	<0.02	199	<0.14	<0.05	6402	232	--	1722	--
	average		3163	2529	<0.02	<0.02	202	<0.14	<0.05	6408	229		1773	
10-Feb-04	Ethanol and acetate	7	2416	2107	<0.02	<0.02	164	<0.14	<0.05	5233	289	--	1681	7
10-Feb-04	Ethanol and acetate	8	2799	2678	<0.02	<0.02	203	<0.14	<0.05	6313	280	--	1870	--
10-Feb-04	Ethanol and acetate	9	2911	2867	<0.02	<0.02	209	<0.14	<0.05	6681	293	--	1747	--
	average		2709	2551	<0.02	<0.02	192	<0.14	<0.05	6075	287		1766	
27-feb-04 - 03-mar-0	Ethanol and acetate	7	Added HCl to bottle #7 to attempt to bring pH down to pH=5.5											
2-Mar-04	Ethanol and acetate	7	2282	2767	<0.28	<0.02	159	<0.14	<0.05	4876	297	--	1663	6
2-Mar-04	Ethanol and acetate	8	2637	2045	<0.28	<0.02	155	<0.14	<0.05	4855	273	--	1793	--
2-Mar-04	Ethanol and acetate	9	2773	2149	<0.28	<0.02	166	<0.14	<0.05	5037	287	--	1551	--
	average		2564	2320	<0.28	<0.02	160	<0.14	<0.05	4923	286		1669	
3-Mar-04	Ethanol and acetate	7	pH samples taken											5.07
4-Mar-04	Ethanol and acetate	7	pH samples taken											5.15
9-Mar-04	Ethanol and acetate	7	2667	3829	<0.28	<0.02	203	<0.14	<0.05	5971	328	--	--	5.17
9-Mar-04	Ethanol and acetate	8	2830	2453	<0.28	<0.02	202	<0.14	<0.05	5881	328	--	--	7.27
9-Mar-04	Ethanol and acetate	9	2719	2646	<0.28	<0.02	197	<0.14	<0.05	5944	335	--	--	7.25
9-Mar-04	average		2739	2976	<0.28	<0.02	201	<0.14	<0.05	5932	330			
17-Mar-04	Ethanol and acetate	7	3112	4616	<0.28	<0.02	266	<0.14	<0.05	7393	282	--	1469	--
17-Mar-04	Ethanol and acetate	8	2921	3036	<0.28	<0.02	223	<0.14	<0.05	6682	283	--	1845	--
17-Mar-04	Ethanol and acetate	9	3009	2662	<0.28	<0.02	239	<0.14	<0.05	6929	294	--	1713	--
17-Mar-04	average		3014	3438	<0.28	<0.02	243	<0.14	<0.05	7001	286		1676	
30-Mar-04	Ethanol and acetate	7	2444	3574	<0.28	<0.02	246	<0.14	<0.05	5354	244	--	1565	5.30
30-Mar-04	Ethanol and acetate	8	2607	2640	<0.28	<0.02	274	<0.14	<0.05	5713	227	--	1468	--
30-Mar-04	Ethanol and acetate	9	2699	2775	<0.28	<0.02	311	<0.14	<0.05	6101	251	--	1490	--
30-Mar-04	average		2583	2996	<0.28	<0.02	277	<0.14	<0.05	5723	240		1508	
27-Apr-04	Ethanol and acetate	7	2455	3296	<0.28	<0.02	181	<0.14	<0.05	5468	249	--	--	5.19
27-Apr-04	Ethanol and acetate	8	2038	2507	<0.28	<0.02	208	<0.14	<0.05	4014	250	--	--	6.83
27-Apr-04	Ethanol and acetate	9	2493	2544	<0.28	<0.02	248	<0.14	<0.05	5319	261	--	--	7.14
27-Apr-04	average		2329	2782	<0.28	<0.02	212	<0.14	<0.05	4934	253			

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Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04(T=0)	Ethanol and acetate + CPS	10	2224	2257	<0.02	<0.02	205	<0.14	<0.05	6955	289	--	1662	--
13-Jan-04(T=0)	Ethanol and acetate + CPS	11	2325	2395	<0.02	<0.02	216	<0.14	<0.05	7011	295	--	3399	--
13-Jan-04(T=0)	Ethanol and acetate + CPS	12	2459	2485	<0.02	<0.02	217	<0.14	<0.05	7694	292	--	0	--
13-Jan-04	average		2336	2379	<0.02	<0.02	213	<0.14	<0.05	7220	292		1687	
13-Jan-04(T=4)	Ethanol and acetate + CPS	10	2591	2426	<0.02	<0.02	213	<0.14	<0.05	7488	282	--	1636	8
13-Jan-04(T=4)	Ethanol and acetate + CPS	11	2701	2637	<0.02	0.64	228	<0.14	<0.05	7757	284	--	3914	--
13-Jan-04(T=4)	Ethanol and acetate + CPS	12	2730	2596	<0.02	<0.02	233	<0.14	<0.05	8054	283	--	0	--
13-Jan-04	average		2674	2553	<0.02	0.21	225	<0.14	<0.05	7766	283		1850	
20-Jan-04	Ethanol and acetate + CPS	10	2934	2429	<0.02	<0.02	214	<0.14	<0.05	6899	262	--	1492	7
20-Jan-04	Ethanol and acetate + CPS	11	3044	2387	<0.02	<0.02	208	<0.14	<0.05	6921	269	--	3680	--
20-Jan-04	Ethanol and acetate + CPS	12	3078	2272	<0.02	<0.02	191	<0.14	<0.05	6548	266	--	2030	--
	average		3019	2363	<0.02	<0.02	205	<0.14	<0.05	6790	266		2401	
27-Jan-04	Ethanol and acetate + CPS	10	2854	2488	<0.02	<0.02	208	<0.14	<0.05	6575	239	--	1547	7
27-Jan-04	Ethanol and acetate + CPS	11	3400	2514	<0.02	<0.02	247	<0.14	<0.05	6913	230	--	4058	--
27-Jan-04	Ethanol and acetate + CPS	12	2924	2320	<0.02	<0.02	193	<0.14	<0.05	6278	244	--	2494	--
	average		3059	2441	<0.02	<0.02	216	<0.14	<0.05	6589	237		2700	
10-Feb-04	Ethanol and acetate + CPS	10	2462	2879	<0.02	<0.02	241	<0.14	<0.05	5880	286	--	1450	7
10-Feb-04	Ethanol and acetate + CPS	11	2897	2715	<0.02	<0.02	211	<0.14	<0.05	6758	295	--	3827	--
10-Feb-04	Ethanol and acetate + CPS	12	2864	2797	<0.02	<0.02	223	<0.14	<0.05	6605	289	--	2090	--
	average		2741	2797	<0.02	<0.02	225	<0.14	<0.05	6415	290		2456	
27-feb-04 - 03-mar-0	Ethanol and acetate + CPS	10	Added HCl to bottle #10 (tested OUTSIDE glovebox) to attempt to bring pH down to pH=5.5											
2-Mar-04	Ethanol and acetate + CPS	10	36	5031	<0.28	<0.02	222	<0.14	<0.05	322	274	--	529	6.89
2-Mar-04	Ethanol and acetate + CPS	11	2686	2045	<0.28	<0.02	151	<0.14	<0.05	4858	282	--	3548	--
2-Mar-04	Ethanol and acetate + CPS	12	2254	2244	<0.28	<0.02	179	<0.14	<0.05	4658	284	--	1970	--
	average		1659	3107	<0.28	<0.02	184	<0.14	<0.05	3279	280		2016	
2-Mar-04	Ethanol and acetate + CPS	10	Added HCl to bottle #10 to attempt to bring pH down to pH=5.5											
3-Mar-04	Ethanol and acetate + CPS	10	pH samples taken											6.37
4-Mar-04	Ethanol and acetate + CPS	10	pH samples taken											6.31
4-Mar-04	Ethanol and acetate + CPS	10	Added HCl to bottle #10 to attempt to bring pH down to pH=5.5											
9-Mar-04	Ethanol and acetate + CPS	10	200	8134	<0.28	<0.02	293	<0.14	<0.05	0.86	274	--	--	--
9-Mar-04	Ethanol and acetate + CPS	11	2864	3193	<0.28	<0.02	234	<0.14	<0.05	6300	308	--	--	--
9-Mar-04	Ethanol and acetate + CPS	12	2842	3136	<0.28	<0.02	247	<0.14	<0.05	5767	356	--	--	--
9-Mar-04	average		1968	4821	<0.28	<0.02	258	<0.14	<0.05	4023	313			
9-Mar-04	Ethanol and acetate + CPS	11	Added HCl to bottle #11 (tested INSIDE glovebox) to attempt to bring pH down to pH=5.5											7.10
10-Mar-04	Ethanol and acetate + CPS	11	pH samples taken											5.88
11-Mar-04	Ethanol and acetate + CPS	11	pH samples taken											5.69
17-Mar-04	Ethanol and acetate + CPS	10	467	9505	<0.28	<0.02	326	<0.14	<0.05	<0.2	280	--	<10	--
17-Mar-04	Ethanol and acetate + CPS	11	3326	5212	<0.28	<0.02	243	<0.14	<0.05	7913	382	--	3556	--
17-Mar-04	Ethanol and acetate + CPS	12	2495	4739	<0.28	<0.02	289	<0.14	<0.05	3995	278	--	1414	--
17-Mar-04	average		2096	6485	<0.28	<0.02	286	<0.14	<0.05	3970	313		1657	
17-Mar-04	Ethanol and acetate + CPS	11	--	--	--	--	--	--	--	--	--	--	--	5.75

APPENDIX D-1
ANALYTICAL RESULTS FOR SOURCE AREA (MWA-25)
Arkema Facility, Portland, Oregon

Date	Treatment	Bottle	Analyte											
			Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
30-Mar-04	Ethanol and acetate + CPS	10	511	7051	<0.28	<0.02	126	<0.14	<0.05	<0.2	219	--	351	7.1
30-Mar-04	Ethanol and acetate + CPS	11	2683	4272	<0.28	<0.02	220	<0.14	<0.05	5764	236	--	3351	6.03
30-Mar-04	Ethanol and acetate + CPS	12	1630	5801	<0.28	<0.02	393	<0.14	<0.05	39	249	--	277	--
30-Mar-04	average		1608	5708	<0.28	<0.02	247	<0.14	<0.05	1934	235		1326	
6-Apr-04	Ethanol and acetate + CPS	10	731	7934	<0.28	<0.02	26	<0.14	<0.05	<0.2	248	--	--	--
6-Apr-04	Ethanol and acetate + CPS	11	2803	4517	<0.28	<0.02	243	<0.14	<0.05	6191	240	--	--	--
6-Apr-04	Ethanol and acetate + CPS	12	1411	5651	<0.28	<0.02	340	<0.14	<0.05	3.4	306	--	--	--
6-Apr-04	average		1648	6034	<0.28	<0.02	203	<0.14	<0.05	2065	265			
20-Apr-04	Ethanol and acetate + CPS	10	450	7938	<0.28	<0.02	2.5	<0.14	<0.05	<0.2	246	--	40	--
20-Apr-04	Ethanol and acetate + CPS	11	2647	4473	<0.28	<0.02	253	<0.14	<0.05	5942	246	--	3793	--
20-Apr-04	Ethanol and acetate + CPS	12	1724	5970	<0.28	<0.02	404	<0.14	<0.05	3.8	258	--	35	--
20-Apr-04	average		1607	6127	<0.28	<0.02	220	<0.14	<0.05	1982	250		1289	
23-Apr-04	Ethanol and acetate + CPS		fed bottles 10 and 12 70uL of EtOH											
27-Apr-04	Ethanol and acetate + CPS	10	687	6631	<0.28	<0.02	6.4	<0.14	<0.05	<0.2	241	--	--	6.52
27-Apr-04	Ethanol and acetate + CPS	11	2705	4436	<0.28	<0.02	263	<0.14	<0.05	5883	234	--	--	6.06
27-Apr-04	Ethanol and acetate + CPS	12	1405	4456	<0.28	<0.02	254	<0.14	<0.05	<0.2	255	--	--	7.11
27-Apr-04	average		1599	5174	<0.28	<0.02	175	<0.14	<0.05	1961	243			
11-May-04	Ethanol and acetate + CPS	10	1110	9082	<0.28	<0.02	5.1	<0.14	<0.05	<0.2	255	--	546	--
11-May-04	Ethanol and acetate + CPS	11	2626	5257	<0.28	<0.02	335	<0.14	<0.05	7346	261	--	3754	5.72
11-May-04	Ethanol and acetate + CPS	12	1537	6127	<0.28	<0.02	366	<0.14	<0.05	<0.2	257	--	<1	--
11-May-04	average		1757	6822	<0.28	<0.02	235	<0.14	<0.05	2449	257		1434	
17-May-04	Ethanol and acetate + CPS		fed bottles 10 and 12 70uL of EtOH											
25-May-04	Ethanol and acetate + CPS	10	1405	8109	<0.28	<0.02	8.8	<0.14	<0.05	<0.2	261	--	--	6.41
25-May-04	Ethanol and acetate + CPS	11	2563	4070	<0.28	<0.02	223	<0.14	<0.05	6227	226	--	--	5.76
25-May-04	Ethanol and acetate + CPS	12	1839	5774	<0.28	<0.02	258	<0.14	<0.05	<0.2	273	--	--	7.34
25-May-04	average		1935	5984	<0.28	<0.02	163	<0.14	<0.05	2076	253			
10-Jun-04	Ethanol and acetate + CPS	10	2080	10723	<0.28	<0.02	1.7	<0.14	<0.05	<0.2	278	--	--	6.5
10-Jun-04	Ethanol and acetate + CPS	11	3414	6061	<0.28	<0.02	357	<0.14	<0.05	9478	287	--	--	5.9
10-Jun-04	Ethanol and acetate + CPS	12	2075	6159	<0.28	<0.02	34	<0.14	<0.05	<0.2	293	--	--	7.5
10-Jun-04	average		2523	7648	<0.28	<0.02	131	<0.14	<0.05	3159	286			
23-Jun-04	Ethanol and acetate + CPS	10	2123	10339	<0.28	<0.02	9.2	<0.14	<0.05	2.6	320	--	17	--
23-Jun-04	Ethanol and acetate + CPS	11	3389	6157	<0.28	<0.02	386	<0.14	<0.05	9322	287	--	1953	--
23-Jun-04	Ethanol and acetate + CPS	12	2414	7238	<0.28	<0.02	15	<0.14	<0.05	196.8	294	--	<1	--
23-Jun-04	average		2642	7911	<0.28	<0.02	137	<0.14	<0.05	3174	300		657	
24-Jun-04	Ethanol and acetate + CPS		fed bottles# 10 and 12 140uL of EtOH											

APPENDIX D-1
ANALYTICAL RESULTS FOR SOURCE AREA (MWA-25)
Arkema Facility, Portland, Oregon

Date	Treatment	Bottle	Analyte											
			Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04(T=0)	CPS pretreatment, ethanol + acetate	13	18	2356	<0.02	<0.02	200	<0.14	<0.05	7046	295	--	NA	--
13-Jan-04(T=0)	CPS pretreatment, ethanol + acetate	14	9.2	2524	<0.02	<0.02	213	<0.14	<0.05	7437	300	--	NA	--
13-Jan-04(T=0)	CPS pretreatment, ethanol + acetate	15	6.3	2324	<0.02	<0.02	200	<0.14	<0.05	7160	299	--	NA	--
13-Jan-04	average		11	2402	<0.02	<0.02	204	<0.14	<0.05	7214	298			
13-Jan-04(T=4)	CPS pretreatment, ethanol + acetate	13	2827	2526	<0.02	<0.02	218	<0.14	<0.05	7569	287	--	2105	8
13-Jan-04(T=4)	CPS pretreatment, ethanol + acetate	14	2894	2735	<0.02	<0.02	225	<0.14	<0.05	8102	285	--	2217	--
13-Jan-04(T=4)	CPS pretreatment, ethanol + acetate	15	2915	2576	<0.02	<0.02	236	<0.14	<0.05	8016	285	--	2243	--
13-Jan-04	average		2878	2612	<0.02	<0.02	226	<0.14	<0.05	7896	285		2188	
20-Jan-04	CPS pretreatment, ethanol + acetate	13	3504	2447	<0.02	<0.02	217	<0.14	<0.05	6494	275	--	1956	--
20-Jan-04	CPS pretreatment, ethanol + acetate	14	3560	2515	<0.02	<0.02	208	<0.14	<0.05	6953	274	--	2111	7
20-Jan-04	CPS pretreatment, ethanol + acetate	15	3532	2251	<0.02	0.80	195	<0.14	<0.05	6580	273	--	2133	--
	average		3532	2405	<0.02	0.27	207	<0.14	<0.05	6676	274		2067	
27-Jan-04	CPS pretreatment, ethanol + acetate	13	3261	2431	<0.02	<0.02	202	<0.14	<0.05	6278	219	--	2125	--
27-Jan-04	CPS pretreatment, ethanol + acetate	14	3649	2623	<0.02	<0.02	231	<0.14	<0.05	6450	228	--	1994	--
27-Jan-04	CPS pretreatment, ethanol + acetate	15	3724	2434	<0.02	0.80	198	<0.14	<0.05	6463	233	--	2308	7
	average		3545	2496	<0.02	0.27	211	<0.14	<0.05	6397	227		2142	
10-Feb-04	CPS pretreatment, ethanol + acetate	13	3671	2654	<0.02	<0.02	234	<0.14	<0.05	6406	289	--	2142	7
10-Feb-04	CPS pretreatment, ethanol + acetate	14	3458	2451	<0.02	<0.02	253	<0.14	<0.05	5561	289	--	2191	--
10-Feb-04	CPS pretreatment, ethanol + acetate	15	3777	2461	<0.02	0.80	231	<0.14	<0.05	6301	290	--	2275	--
	average		3635	2522	<0.02	0.27	239	<0.14	<0.05	6089	289		2203	
27-feb-04 - 03-mar-0	CPS pretreatment, ethanol + acetate	13	Added HCl to bottle #13 to attempt to bring pH down to pH=5.5											
2-Mar-04	CPS pretreatment, ethanol + acetate	13	2443	2694	<0.28	<0.02	150	<0.14	<0.05	4430	288	--	1773	6.51
2-Mar-04	CPS pretreatment, ethanol + acetate	14	2897	2099	<0.28	<0.02	156	<0.14	<0.05	4503	287	--	2093	--
2-Mar-04	CPS pretreatment, ethanol + acetate	15	3062	1976	<0.28	<0.02	156	<0.14	<0.05	4896	289	--	1977	--
	average		2801	2256	<0.28	<0.02	154	<0.14	<0.05	4610	288		1948	
3-Mar-04	CPS pretreatment, ethanol + acetate	13	pH samples taken											5.74
4-Mar-04	CPS pretreatment, ethanol + acetate	13	pH samples taken											6.05
4-Mar-04	CPS pretreatment, ethanol + acetate	13	Added HCl to bottle #13 to attempt to bring pH down to pH=5.5											
9-Mar-04	CPS pretreatment, ethanol + acetate	13	3253	4436	<0.28	<0.02	229	<0.14	<0.05	6134	351	--	--	--
9-Mar-04	CPS pretreatment, ethanol + acetate	14	3236	3024	<0.28	<0.02	225	<0.14	<0.05	6191	224	--	--	--
9-Mar-04	CPS pretreatment, ethanol + acetate	15	3809	2680	<0.28	<0.02	225	<0.14	<0.05	6590	235	--	--	--
9-Mar-04	average		3433	3380	<0.28	<0.02	226	<0.14	<0.05	6305	270			
9-Mar-04	CPS pretreatment, ethanol + acetate	14	Added HCl to bottle #14 to attempt to bring pH down to pH=5.5											7.23
10-Mar-04	CPS pretreatment, ethanol + acetate	14	pH samples taken											6.23
11-Mar-04	CPS pretreatment, ethanol + acetate	14	pH samples taken											6.07
17-Mar-04	CPS pretreatment, ethanol + acetate	13	3367	5156	<0.28	<0.02	260	<0.14	<0.05	6647	252	--	1974	--
17-Mar-04	CPS pretreatment, ethanol + acetate	14	3326	4560	<0.28	<0.02	252	<0.14	<0.05	6535	275	--	1469	--
17-Mar-04	CPS pretreatment, ethanol + acetate	15	4454	3246	<0.28	<0.02	339	<0.14	<0.05	7900	295	--	2475	--
17-Mar-04	average		3716	4321	<0.28	<0.02	283	<0.14	<0.05	7027	274		1973	
17-Mar-04	CPS pretreatment, ethanol + acetate	14	--	--	--	--	--	--	--	--	--	--	--	5.95

APPENDIX D-1
ANALYTICAL RESULTS FOR SOURCE AREA (MWA-25)
Arkema Facility, Portland, Oregon

			Analyte											
			Acetate	Chloride	Nitrite-N	Nitrate	Sulphate	Bromide	Phosphate	Chlorate	Perchlorate	Citrate	Ethanol	pH
Date	Treatment	Bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
30-Mar-04	CPS pretreatment, ethanol + acetate	13	2826	4233	<0.28	<0.02	323	<0.14	<0.05	5393	257	--	1682	6.38
30-Mar-04	CPS pretreatment, ethanol + acetate	14	3076	4548	<0.28	<0.02	319	<0.14	<0.05	5788	307	--	1757	6.50
30-Mar-04	CPS pretreatment, ethanol + acetate	15	3818	2865	<0.28	<0.02	332	<0.14	<0.05	6603	252	--	1769	--
30-Mar-04	average		3240	3882	<0.28	<0.02	325	<0.14	<0.05	5928	272		1736	
20-Apr-04	CPS pretreatment, ethanol + acetate	13	3103	5231	<0.28	<0.02	344	<0.14	<0.05	6341	245		1977	--
20-Apr-04	CPS pretreatment, ethanol + acetate	14	3435	5855	<0.28	<0.02	416	<0.14	<0.05	7092	261		1944	--
20-Apr-04	CPS pretreatment, ethanol + acetate	15	3432	3214	<0.28	<0.02	351	<0.14	<0.05	6829	252		1927	--
20-Apr-04	average		3323	4767	<0.28	<0.02	370	<0.14	<0.05	6754	253		1949	
27-Apr-04	CPS pretreatment, ethanol + acetate	13	2770	4296	<0.28	<0.02	275	<0.14	<0.05	5221	229	--	--	6.37
27-Apr-04	CPS pretreatment, ethanol + acetate	14	2736	4004	<0.28	<0.02	237	<0.14	<0.05	4827	225	--	--	6.48
27-Apr-04	CPS pretreatment, ethanol + acetate	15	3279	2557	<0.28	<0.02	253	<0.14	<0.05	5200	239	--	--	7.17
27-Apr-04	average		2928	3619	<0.28	<0.02	255	<0.14	<0.05	5083	231			
7-Jun-04	CPS pretreatment, ethanol + acetate	13	3205	5509	<0.28	<0.02	324	<0.14	<0.05	7422	297	--	--	--
7-Jun-04	CPS pretreatment, ethanol + acetate	14	3226	5288	<0.28	<0.02	331	<0.14	<0.05	7038	294	--	--	--
7-Jun-04	CPS pretreatment, ethanol + acetate	15	2254	6608	<0.28	<0.02	291	<0.14	<0.05	1.7	297	--	--	--
7-Jun-04	average		2895	5802	<0.28	<0.02	315	<0.14	<0.05	4821	296			
7-Jun-04	CPS pretreatment, ethanol + acetate		Bioaugmented all three reps with perchlorate degrading culture											
10-Jun-04	CPS pretreatment, ethanol + acetate	13	3366	5608	<0.28	<0.02	370	<0.14	<0.05	7332	281	--	--	6.5
10-Jun-04	CPS pretreatment, ethanol + acetate	14	3297	5194	<0.28	<0.02	359	<0.14	<0.05	6655	280	--	--	6.6
10-Jun-04	CPS pretreatment, ethanol + acetate	15	2242	5729	<0.28	<0.02	209	<0.14	<0.05	1.7	239	--	--	7.3
10-Jun-04	average		2968	5510	<0.28	<0.02	313	<0.14	<0.05	4663	267			
16-Jun-04	CPS pretreatment, ethanol + acetate	13	2519	4815	<0.28	<0.02	262	<0.14	<0.05	4909	272	--	796	--
16-Jun-04	CPS pretreatment, ethanol + acetate	14	2725	5194	<0.28	<0.02	295	<0.14	<0.05	5157	255	--	860	--
16-Jun-04	CPS pretreatment, ethanol + acetate	15	2168	4975	<0.28	<0.02	121	<0.14	<0.05	29	190	--	<0.1	--
16-Jun-04	average		2470	4995	<0.28	<0.02	226	<0.14	<0.05	3365	239		552	
16-Jun-04	CPS pretreatment, ethanol + acetate		fed bottles #13 and 14 195 uL of EtOH and #15 70uL of EtOH											
23-Jun-04	CPS pretreatment, ethanol + acetate	13	856	9136	<0.28	<0.02	412	<0.14	<0.05	92	271	--	1828	--
23-Jun-04	CPS pretreatment, ethanol + acetate	14	966	8479	<0.28	<0.02	356	<0.14	<0.05	<0.2	272	--	1818	--
23-Jun-04	CPS pretreatment, ethanol + acetate	15	3285	7156	<0.28	<0.02	130	<0.14	<0.05	<0.2	117	--	<1	--
23-Jun-04	average		1702	8257	<0.28	<0.02	299	<0.14	<0.05	31	220		1215	
24-Jun-04	CPS pretreatment, ethanol + acetate		fed bottle#15 140 uL of EtOH											
30-Jun-04	CPS pretreatment, ethanol + acetate	13	573	7215	<0.28	<0.02	254	<0.14	<0.05	<0.2	240	--	1366	--
30-Jun-04	CPS pretreatment, ethanol + acetate	14	802	7531	<0.28	<0.02	280	<0.14	<0.05	<0.2	238	--	1495	--
30-Jun-04	CPS pretreatment, ethanol + acetate	15	3353	6154	<0.28	<0.02	63	<0.14	<0.05	<0.2	88	--	53	--
30-Jun-04	average		1576	6967	<0.28	<0.02	199	<0.14	<0.05	<0.2	189		971	
7-Jul-04	CPS pretreatment, ethanol + acetate	13	894	6378	<0.02	<0.02	207	<0.14	<0.05	<0.2	193	--	1260	--
7-Jul-04	CPS pretreatment, ethanol + acetate	14	1363	8788	<0.28	<0.02	340	<0.14	<0.05	<0.2	195	--	1379	--
7-Jul-04	CPS pretreatment, ethanol + acetate	15	2935	5186	<0.28	<0.02	21	<0.14	<0.05	<0.2	67	--	<1	--
7-Jul-04	average		1731	6784	<0.28	<0.02	189	<0.14	<0.05	<0.2	152		880	
8-Jul-04	CPS pretreatment, ethanol + acetate		fed bottle#13 and 14 25uL of EtOH and #15 140 uL of EtOH											
14-Jul-04	CPS pretreatment, ethanol + acetate	13	1331	7035	<0.02	<0.02	216	<0.14	<0.05	<0.2	175	--	1097	--
14-Jul-04	CPS pretreatment, ethanol + acetate	14	1843	6840	<0.28	<0.02	30	<0.14	<0.05	<0.2	187	--	687	--
14-Jul-04	CPS pretreatment, ethanol + acetate	15	3196	5386	<0.28	<0.02	5.4	<0.14	<0.05	<0.2	72	--	190	--
14-Jul-04	average		2123	6420	<0.28	<0.02	84	<0.14	<0.05	<0.2	145		658	

APPENDIX D-1
ANALYTICAL RESULTS FOR SOURCE AREA (MWA-25)
Arkema Facility, Portland, Oregon

Date	Treatment	Bottle	Analyte											
			Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
22-Jul-04	CPS pretreatment, ethanol + acetate		fed all three reps 50uL of EtOH											
28-Jul-04	CPS pretreatment, ethanol + acetate	13	2367	6841	<0.28	<0.02	63	<0.14	<0.05	<0.2	116	--	201	--
28-Jul-04	CPS pretreatment, ethanol + acetate	14	2656	6751	<0.28	<0.02	80	<0.14	<0.05	<0.2	114	--	104	--
28-Jul-04	CPS pretreatment, ethanol + acetate	15	3328	5324	<0.28	<0.02	3.9	<0.14	<0.05	<0.2	33	--	185	--
28-Jul-04	average		2784	6305	<0.28	<0.02	49	<0.14	<0.05	<0.2	88		163	
3-Aug-04	CPS pretreatment, ethanol + acetate		fed all three reps 50uL of EtOH											
11-Aug-04	CPS pretreatment, ethanol + acetate	13	2376	6252	<0.28	<0.02	45	<0.14	<0.05	<0.2	98	--	<1	--
11-Aug-04	CPS pretreatment, ethanol + acetate	14	2546	6387	<0.28	<0.02	65	<0.14	<0.05	<0.2	105	--	<1	--
11-Aug-04	CPS pretreatment, ethanol + acetate	15	3251	5353	<0.28	<0.02	2.7	<0.14	<0.05	<0.2	8.5	--	90	--
11-Aug-04	average		2724	5997	<0.28	<0.02	37	<0.14	<0.05	<0.2	71		30	
12-Aug-04	CPS pretreatment, ethanol + acetate		fed reps #1 and #2 100uL of EtOH and rep #3 50 uL of EtOH											
13-Aug-04	CPS pretreatment, ethanol + acetate	13	--	--	--	--	--	--	--	--	--	--	--	~5-6
13-Aug-04	CPS pretreatment, ethanol + acetate	14	--	--	--	--	--	--	--	--	--	--	--	~5-6
13-Aug-04	CPS pretreatment, ethanol + acetate	15	--	--	--	--	--	--	--	--	--	--	--	~6-7
13-Aug-04	average													
16-Aug-04	CPS pretreatment, ethanol + acetate		adjusted the pH of reps#1 and #2 back up to ~7											
13-Aug-04	CPS pretreatment, ethanol + acetate	13	--	--	--	--	--	--	--	--	--	--	--	7.08
13-Aug-04	CPS pretreatment, ethanol + acetate	14	--	--	--	--	--	--	--	--	--	--	--	6.82
25-Aug-04	CPS pretreatment, ethanol + acetate	13	2942	7683	<0.28	<0.02	32	<0.14	<0.05	<0.2	88	--	233	--
25-Aug-04	CPS pretreatment, ethanol + acetate	14	3066	7989	<0.28	<0.02	55	<0.14	<0.05	<0.2	103	--	311	--
25-Aug-04	CPS pretreatment, ethanol + acetate	15	4525	6659	<0.28	<0.02	<0.03	<0.14	<0.05	<0.2	1.9	--	8.2	--
25-Aug-04	average		3511	7444	<0.28	<0.02	29	<0.14	<0.05	<0.2	64		184	
8-Sep-04	CPS pretreatment, ethanol + acetate		fed all three reps 50uL of EtOH											
16-Sep-04	CPS pretreatment, ethanol + acetate		fed all three reps 50uL of EtOH											
22-Sep-04	CPS pretreatment, ethanol + acetate	13	3196	7200	<0.28	<0.02	1.4	<0.14	<0.05	<0.2	55	--	1.5	--
22-Sep-04	CPS pretreatment, ethanol + acetate	14	3395	7429	<0.28	<0.02	21	<0.14	<0.05	<0.2	60	--	4.6	--
22-Sep-04	CPS pretreatment, ethanol + acetate	15	3948	5212	<0.28	<0.02	4.8	<0.14	<0.05	<0.2	<0.8	--	1.6	--
22-Sep-04	average		3513	6613	<0.28	<0.02	8.9	<0.14	<0.05	<0.2	38		2.6	

Notes:
mg/L - milligrams per liter
uL - microliters
CPS - calcium polysulfide
EtOH - ethanol

APPENDIX D-2
ANALYTICAL RESULTS FOR DOWNGRADIENT AREA (MWA-32i)
Arkema Facility, Portland, Oregon

Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04	Sterile control	16	8.5	26391	<0.02	<0.02	421	<0.14	<0.05	4375	214	--	--	6
13-Jan-04	Sterile control	17	4.1	25935	<0.02	<0.02	417	<0.14	<0.05	4292	219	--	--	--
13-Jan-04	Sterile control	18	14	26136	<0.02	<0.02	372	<0.14	<0.05	4323	216	--	--	--
13-Jan-04	average		9.0	26154	<0.02	<0.02	403	<0.14	<0.05	4330	216			
20-Jan-04	Sterile control	16	15	27014	<0.02	<0.02	416	<0.14	<0.05	4307	197	--	--	6
20-Jan-04	Sterile control	17	12	26847	<0.02	<0.02	412	<0.14	<0.05	4283	200	--	--	--
20-Jan-04	Sterile control	18	12	26894	<0.02	0.49	423	<0.14	<0.05	4298	209	--	--	--
20-Jan-04	average		13	26918	<0.02	0.16	417	<0.14	<0.05	4296	202			
27-Jan-04	Sterile control	16	2.3	24958	<0.02	<0.02	381	<0.14	<0.05	3981	182	--	--	--
27-Jan-04	Sterile control	17	5.3	25052	<0.02	<0.02	382	<0.14	<0.05	4012	186	--	--	6
27-Jan-04	Sterile control	18	2.4	24579	<0.02	0.49	336	<0.14	<0.05	3940	189	--	--	--
27-Jan-04	average		3.3	24863	<0.02	0.16	366	<0.14	<0.05	3978	186			
10-Feb-04	Sterile control	16	3.4	24585	<0.02	<0.02	391	<0.14	<0.05	3910	208	--	--	--
10-Feb-04	Sterile control	17	3.6	25881	<0.02	<0.02	408	<0.14	<0.05	4091	208	--	--	6
10-Feb-04	Sterile control	18	3.2	25564	<0.02	0.49	383	<0.14	<0.05	4053	209	--	--	--
10-Feb-04	average		3.4	25343	<0.02	0.16	394	<0.14	<0.05	4018	209			
2-Mar-04	Sterile control	16	3.6	25645	<0.28	<0.02	422	<0.14	<0.05	4030	213	--	--	--
2-Mar-04	Sterile control	17	53	24942	<0.28	<0.02	431	<0.14	<0.05	4034	209	--	--	6
2-Mar-04	Sterile control	18	3.3	25545	<0.28	<0.02	406	<0.14	<0.05	4158	206	--	--	--
2-Mar-04	average		20	25377	<0.28	<0.02	420	<0.14	<0.05	4074	209			
9-Mar-04	Sterile control	16	4.7	28237	<0.28	<0.02	349	<0.14	<0.05	4454	244	--	--	--
9-Mar-04	Sterile control	17	3.6	27793	<0.28	<0.02	349	<0.14	<0.05	4377	237	--	--	--
9-Mar-04	Sterile control	18	4.2	27452	<0.28	<0.02	343	<0.14	<0.05	4333	248	--	--	--
9-Mar-04	average		4	27827	<0.28	<0.02	347	<0.14	<0.05	4388	243			
17-Mar-04	Sterile control	16	2.2	27393	<0.28	<0.02	342	<0.14	<0.05	4332	210	--	--	--
17-Mar-04	Sterile control	17	2.4	28050	<0.28	<0.02	352	<0.14	<0.05	4445	214	--	--	--
17-Mar-04	Sterile control	18	1.4	26876	<0.28	<0.02	374	<0.14	<0.05	4320	217	--	--	--
17-Mar-04	average		2.0	27440	<0.28	<0.02	356	<0.14	<0.05	4366	214			
30-Mar-04	Sterile control	16	0.67	24656	<0.28	<0.02	408	<0.14	<0.05	4056	183	--	--	--
30-Mar-04	Sterile control	17	0.68	24939	<0.28	<0.02	401	<0.14	<0.05	4085	189	--	--	--
30-Mar-04	Sterile control	18	0.64	25073	<0.28	<0.02	347	<0.14	<0.05	4066	182	--	--	--
30-Mar-04	average		0.66	24889	<0.28	<0.02	385	<0.14	<0.05	4069	185			
27-Apr-04	Sterile control	16	7.2	23480	<0.28	<0.02	358	<0.14	<0.05	3755	200	--	--	--
27-Apr-04	Sterile control	17	7.6	25232	<0.28	<0.02	381	<0.14	<0.05	4030	203	--	--	--
27-Apr-04	Sterile control	18	6.1	23409	<0.28	<0.02	356	<0.14	<0.05	3728	188	--	--	--
27-Apr-04	average		7.0	24040	<0.28	<0.02	365	<0.14	<0.05	3838	197			

APPENDIX D-2
ANALYTICAL RESULTS FOR DOWNGRADIENT AREA (MWA-32i)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04	Ethanol and acetate	19	1473	25906	<0.02	0.3303	385	<0.14	<0.05	4296	206	--	1028	6
13-Jan-04	Ethanol and acetate	20	1476	26209	<0.02	<0.02	399	<0.14	<0.05	4390	221	--	1081	--
13-Jan-04	Ethanol and acetate	21	1479	25837	<0.02	<0.02	392	<0.14	<0.05	4308	216	--	983	--
13-Jan-04	average		1476	25984	<0.02	0.11	392	<0.14	<0.05	4331	214		1031	
20-Jan-04	Ethanol and acetate	19	1656	26797	<0.02	<0.02	413	<0.14	<0.05	4053	210	--	950	--
20-Jan-04	Ethanol and acetate	20	1802	25969	<0.02	<0.02	399	<0.14	<0.05	3932	211	--	904	6
20-Jan-04	Ethanol and acetate	21	1760	26692	<0.02	<0.02	404	<0.14	<0.05	4042	211	--	851	--
20-Jan-04	average		1739	26486	<0.02	<0.02	405	<0.14	<0.05	4009	211		902	
27-Jan-04	Ethanol and acetate	19	1740	25139	<0.02	<0.02	394	<0.14	<0.05	3799	216	--	1090	6
27-Jan-04	Ethanol and acetate	20	1803	25121	<0.02	<0.02	383	<0.14	<0.05	3759	219	--	1038	--
27-Jan-04	Ethanol and acetate	21	1732	25047	<0.02	<0.02	384	<0.14	<0.05	3783	179	--	1018	--
27-Jan-04	average		1758	25102	<0.02	<0.02	387	<0.14	<0.05	3780	205		1049	
10-Feb-04	Ethanol and acetate	19	1776	26372	<0.02	<0.02	385	<0.14	<0.05	3881	218	--	1021	--
10-Feb-04	Ethanol and acetate	20	1855	26885	<0.02	<0.02	414	<0.14	<0.05	3933	217	--	1050	6
10-Feb-04	Ethanol and acetate	21	1752	26218	<0.02	<0.02	382	<0.14	<0.05	3838	216	--	1014	--
10-Feb-04	average		1795	26492	<0.02	<0.02	393	<0.14	<0.05	3884	217		1028	
26-Feb-04	Ethanol and acetate	19	diluted 10X with Millipore water											
26-Feb-04	Ethanol and acetate	20	diluted 10X with Millipore water											
26-Feb-04	Ethanol and acetate	21	diluted 10X with Millipore water											
26-Feb-04	average													
26-Feb-04	Ethanol and acetate	19	217	2546	<0.28	<0.02	56	<0.14	<0.05	597	36	--	--	6.19
26-Feb-04	Ethanol and acetate	20	198	3062	<0.28	<0.02	46	<0.14	<0.05	451	35	--	--	6.08
26-Feb-04	Ethanol and acetate	21	193	3103	<0.28	<0.02	46	<0.14	<0.05	459	29	--	--	6.25
26-Feb-04	average		202	2904	<0.28	<0.02	49	<0.14	<0.05	502	33			
2-Mar-04	Ethanol and acetate	19	245	1390	<0.28	<0.02	81	<0.14	<0.05	672	39	--	128	6
2-Mar-04	Ethanol and acetate	20	252	1167	<0.28	<0.02	81	<0.14	<0.05	666	37	--	174	--
2-Mar-04	Ethanol and acetate	21	222	2311	<0.28	<0.02	69	<0.14	<0.05	567	32	--	90	--
2-Mar-04	average		240	1623	<0.28	<0.02	77	<0.14	<0.05	635	36		131	
9-Mar-04	Ethanol and acetate	19	233	1150	<0.28	<0.02	70	<0.14	<0.05	735	45	--	--	--
9-Mar-04	Ethanol and acetate	20	232	1196	<0.28	<0.02	65	<0.14	<0.05	707	43	--	--	--
9-Mar-04	Ethanol and acetate	21	203	2083	<0.28	<0.02	58	<0.14	<0.05	598	37	--	--	--
9-Mar-04	average		222	1477	<0.28	<0.02	65	<0.14	<0.05	680	42			
17-Mar-04	Ethanol and acetate	19	228	1677	<0.28	<0.02	63	<0.14	<0.05	621	36	--	98	--
17-Mar-04	Ethanol and acetate	20	265	1273	<0.28	<0.02	78	<0.14	<0.05	755	35	--	139	--
17-Mar-04	Ethanol and acetate	21	218	2052	<0.28	<0.02	59	<0.14	<0.05	554	29	--	93	--
17-Mar-04	average		237	1667	<0.28	<0.02	67	<0.14	<0.05	644	33		110	
30-Mar-04	Ethanol and acetate	19	251	1197	<0.28	<0.02	82	<0.14	<0.05	660	30	--	--	--
30-Mar-04	Ethanol and acetate	20	228	1992	<0.28	<0.02	69	<0.14	<0.05	559	29	--	--	--
30-Mar-04	Ethanol and acetate	21	221	2632	<0.28	<0.02	70	<0.14	<0.05	542	25	--	--	--
30-Mar-04	average		233	1940	<0.28	<0.02	73	<0.14	<0.05	587	28			
27-Apr-04	Ethanol and acetate	19	520	3527	<0.28	<0.02	62	<0.14	<0.05	485	34	--	--	6.62
27-Apr-04	Ethanol and acetate	20	435	2732	<0.28	<0.02	42	<0.14	<0.05	363	31	--	--	6.42
27-Apr-04	Ethanol and acetate	21	443	2871	<0.28	<0.02	50	<0.14	<0.05	390	27	--	--	6.49
27-Apr-04	average		466	3043	<0.28	<0.02	51	<0.14	<0.05	413	31			

APPENDIX D-2
ANALYTICAL RESULTS FOR DOWNGRADIENT AREA (MWA-32i)
Arkema Facility, Portland, Oregon

Date	Treatment	Bottle	Analyte											
			Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
7-Jun-04	Ethanol and acetate	19	231	1736	<0.28	<0.02	74	<0.14	<0.05	761	37	--	--	--
7-Jun-04	Ethanol and acetate	20	250	1078	<0.28	<0.02	83	<0.14	<0.05	838	36	--	--	--
7-Jun-04	Ethanol and acetate	21	217	2413	<0.28	<0.02	71	<0.14	<0.05	687	30	--	--	--
7-Jun-04	average		233	1742	<0.28	<0.02	76	<0.14	<0.05	762	35			
7-Jun-04	Ethanol and acetate		Bioaugmented all three reps with perchlorate degrading culture											
10-Jun-04	Ethanol and acetate	19	176	1250	<0.28	<0.02	76	<0.14	<0.05	564	36	--	--	6.7
10-Jun-04	Ethanol and acetate	20	194	1861	<0.28	<0.02	73	<0.14	<0.05	592	35	--	--	6.6
10-Jun-04	Ethanol and acetate	21	204	3760	<0.28	<0.02	64	<0.14	<0.05	584	30	--	--	6.7
10-Jun-04	average		192	2291	<0.28	<0.02	71	<0.14	<0.05	580	34			
16-Jun-04	Ethanol and acetate	19	58	1879	<0.28	<0.02	67	<0.14	<0.05	78	37	--	26	--
16-Jun-04	Ethanol and acetate	20	86	2620	<0.28	<0.02	63	<0.14	<0.05	193	35	--	32	--
16-Jun-04	Ethanol and acetate	21	131	3615	<0.28	<0.02	58	<0.14	<0.05	241	30	--	26	--
16-Jun-04	average		91	2705	<0.28	<0.02	63	<0.14	<0.05	171	34		28	
16-Jun-04	Ethanol and acetate		Fed all three reps 24uL of EtOH											
23-Jun-04	Ethanol and acetate	19	99	1286	<0.28	<0.02	74	<0.14	<0.05	0.30	<0.8	--	164	--
23-Jun-04	Ethanol and acetate	20	103	1359	<0.28	<0.02	78	<0.14	<0.05	<0.2	8.4	--	134	--
23-Jun-04	Ethanol and acetate	21	88	2019	<0.28	<0.02	70	<0.14	<0.05	5.2	8.1	--	111	--
23-Jun-04	average		97	1555	<0.28	<0.02	74	<0.14	<0.05	1.8	5.5		136	
30-Jun-04	Ethanol and acetate	19	70	2076	<0.28	<0.02	66	<0.14	<0.05	<0.2	<0.8	--	157	--
30-Jun-04	Ethanol and acetate	20	88	2865	<0.28	<0.02	60	<0.14	<0.05	<0.2	<0.8	--	113	--
30-Jun-04	Ethanol and acetate	21	91	1906	<0.28	<0.02	71	<0.14	<0.05	<0.2	<0.8	--	92	--
30-Jun-04			83	2282	<0.28	<0.02	66	<0.14	<0.05	<0.2	<0.8		121	
30-Jun-04	Ethanol and acetate		Re-spiked all three reps to ~250mg/L ClO4 Fed all three reps 50uL of EtOH and 741mg/L acetate											
30-Jun-04	Ethanol and acetate	19	--	--	--	--	--	--	--	--	231	--	--	--
30-Jun-04	Ethanol and acetate	20	--	--	--	--	--	--	--	--	202	--	--	--
30-Jun-04	Ethanol and acetate	21	--	--	--	--	--	--	--	--	206	--	--	--
30-Jun-04											213			
7-Jul-04	Ethanol and acetate	19	347	1020	<0.02	<0.02	78	<0.14	<0.05	0.25	251	--	194	--
7-Jul-04	Ethanol and acetate	20	323	1806	<0.28	<0.02	66	<0.14	<0.05	1.5	212	--	145	--
7-Jul-04	Ethanol and acetate	21	337	1157	<0.28	<0.02	74	<0.14	<0.05	0.30	200	--	123	--
7-Jul-04			336	1328	<0.28	<0.02	73	<0.14	<0.05	0.7	221		154	
8-Jul-04	Ethanol and acetate		Fed all three reps 25uL of EtOH											

APPENDIX D-2
ANALYTICAL RESULTS FOR DOWNGRADIENT AREA (MWA-32i)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
14-Jul-04	Ethanol and acetate	19	416	4342	<0.02	<0.02	68	<0.14	<0.05	<0.2	249	--	479	--
14-Jul-04	Ethanol and acetate	20	411	4178	<0.28	<0.02	66	<0.14	<0.05	11	185	--	337	--
14-Jul-04	Ethanol and acetate	21	390	3601	<0.28	<0.02	58	<0.14	<0.05	13	195	--	306	--
14-Jul-04			406	4040	<0.28	<0.02	64	<0.14	<0.05	8.0	210		374	
22-Jul-04	Ethanol and acetate		Fed all three reps 50uL of EtOH											
28-Jul-04	Ethanol and acetate	19	342	4407	<0.28	<0.02	67	<0.14	<0.05	<0.4	0.42	--	552	--
28-Jul-04	Ethanol and acetate	20	416	4252	<0.28	<0.02	68	<0.14	<0.05	12	147	--	432	--
28-Jul-04	Ethanol and acetate	21	392	3569	<0.28	<0.02	58	<0.14	<0.05	2.9	140	--	360	--
28-Jul-04			383	4076	<0.28	<0.02	65	<0.14	<0.05	5.0	96		448	
3-Aug-04	Ethanol and acetate		Fed all three reps 25uL of EtOH											
11-Aug-04	Ethanol and acetate	19	428	3887	<0.28	<0.02	0.10	<0.14	<0.05	<0.2	0.19	--	607	--
11-Aug-04	Ethanol and acetate	20	358	3650	<0.28	<0.02	54	<0.14	<0.05	<0.2	129	--	460	--
11-Aug-04	Ethanol and acetate	21	367	3572	<0.28	<0.02	57	<0.14	<0.05	<0.2	48	--	429	--
11-Aug-04			384	3703	<0.28	<0.02	37	<0.14	<0.05	<0.2	59		499	
12-Aug-04	Ethanol and acetate		Fed all three reps 25uL of EtOH											
13-Aug-04	Ethanol and acetate	19	--	--	--	--	--	--	--	--	--	--	--	~6-7
13-Aug-04	Ethanol and acetate	20	--	--	--	--	--	--	--	--	--	--	--	~6-7
13-Aug-04	Ethanol and acetate	21	--	--	--	--	--	--	--	--	--	--	--	~6-7
13-Aug-04														
25-Aug-04	Ethanol and acetate	19	527	3592	<0.28	<0.02	<0.03	<0.14	<0.05	<0.2	0.29	--	296	--
25-Aug-04	Ethanol and acetate	20	388	3977	<0.28	<0.02	60	<0.14	<0.05	0.46	118	--	489	--
25-Aug-04	Ethanol and acetate	21	322	2985	<0.28	<0.02	46	<0.14	<0.05	<0.2	2.9	--	489	--
25-Aug-04			412	3518	<0.28	<0.02	35	<0.14	<0.05	0.15	40		424	
8-Sep-04	Ethanol and acetate		Fed all three reps 50uL of EtOH											
16-Sep-04	Ethanol and acetate		Fed all three reps 50uL of EtOH											
22-Sep-04	Ethanol and acetate	19	729	4419	<0.28	<0.02	0.22	<0.14	<0.05	<0.4	<0.8	--	<1	--
22-Sep-04	Ethanol and acetate	20	412	4323	<0.28	<0.02	66	<0.14	<0.05	<0.4	54	--	305	--
22-Sep-04	Ethanol and acetate	21	445	3704	<0.28	<0.02	0.20	<0.14	<0.05	<0.4	<0.8	--	196	--
22-Sep-04			529	4149	<0.28	<0.02	22	<0.14	<0.05	<0.4	18		167	

APPENDIX D-2
ANALYTICAL RESULTS FOR DOWNGRADIENT AREA (MWA-32i)
Arkema Facility, Portland, Oregon

Date	Treatment	Bottle	Analyte											
			Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04(T=0)	Ethanol and acetate + CPS	22	1480	26334	<0.02	<0.02	378	<0.14	<0.05	4397	220	--	903	6
13-Jan-04(T=0)	Ethanol and acetate + CPS	23	1424	25889	<0.02	0.29	387	<0.14	<0.05	4324	220	--	1001	--
13-Jan-04(T=0)	Ethanol and acetate + CPS	24	1588	26281	<0.02	<0.02	366	<0.14	<0.05	4349	235	--	1038	--
13-Jan-04	average		1497	26168	<0.02	0.10	377	<0.14	<0.05	4357	225		981	
13-Jan-04(T=4)	Ethanol and acetate + CPS	22	1610	27826	<0.02	<0.02	415	<0.14	<0.05	4699	213	--	1015	--
13-Jan-04(T=4)	Ethanol and acetate + CPS	23	1490	26435	<0.02	0.33	409	<0.14	<0.05	4415	213	--	1073	--
13-Jan-04(T=4)	Ethanol and acetate + CPS	24	1645	26782	<0.02	<0.02	365	<0.14	<0.05	4431	212	--	1040	--
13-Jan-04	average		1581	27014	<0.02	0.11	396	<0.14	<0.05	4515	213		1043	
20-Jan-04	Ethanol and acetate + CPS	22	1835	26437	<0.02	<0.02	403	<0.14	<0.05	4121	211	--	950	6
20-Jan-04	Ethanol and acetate + CPS	23	1700	26606	<0.02	<0.02	412	<0.14	<0.05	4012	210	--	904	--
20-Jan-04	Ethanol and acetate + CPS	24	1718	23955	<0.02	<0.02	326	<0.14	<0.05	3742	214	--	851	--
20-Jan-04	average		1751	25666	<0.02	<0.02	380	<0.14	<0.05	3958	212		902	
27-Jan-04	Ethanol and acetate + CPS	22	1826	25362	<0.02	<0.02	369	<0.14	<0.05	3840	200	--	896	--
27-Jan-04	Ethanol and acetate + CPS	23	1738	25132	<0.02	<0.02	398	<0.14	<0.05	3762	185	--	1080	6
27-Jan-04	Ethanol and acetate + CPS	24	1965	25497	<0.02	<0.02	372	<0.14	<0.05	3835	190	--	913	--
27-Jan-04	average		1843	25330	<0.02	<0.02	380	<0.14	<0.05	3813	192		963	
10-Feb-04	Ethanol and acetate + CPS	22	1834	26836	<0.02	<0.02	387	<0.14	<0.05	3973	216	--	971	--
10-Feb-04	Ethanol and acetate + CPS	23	1757	26522	<0.02	<0.02	443	<0.14	<0.05	3849	217	--	960	6
10-Feb-04	Ethanol and acetate + CPS	24	1989	26515	<0.02	<0.02	389	<0.14	<0.05	3925	218	--	883	--
10-Feb-04	average		1860	26624	<0.02	<0.02	406	<0.14	<0.05	3916	217		938	
26-Feb-04	Ethanol and acetate + CPS	22	Added 606mg/L citric acid											
26-Feb-04	Ethanol and acetate + CPS	23	Added 606mg/L citric acid											
26-Feb-04	Ethanol and acetate + CPS	24	Added 606mg/L citric acid											
26-Feb-04														
26-Feb-04	Ethanol and acetate + CPS	22	1957	26306	<0.28	<0.02	454	<0.14	<0.05	4024	228	278	--	5.52
26-Feb-04	Ethanol and acetate + CPS	23	1858	26327	<0.28	<0.02	438	<0.14	<0.05	4006	275	189	--	5.68
26-Feb-04	Ethanol and acetate + CPS	24	1943	23215	<0.28	<0.02	398	<0.14	<0.05	3606	226	237	--	5.50
26-Feb-04	average		1919	25283	<0.28	<0.02	430	<0.14	<0.05	3879	243	235		
2-Mar-04	Ethanol and acetate + CPS	22	1332	23897	<0.28	<0.02	419	<0.14	<0.05	3564	204	118	780	--
2-Mar-04	Ethanol and acetate + CPS	23	1256	22862	<0.28	<0.02	411	<0.14	<0.05	3326	304	110	783	--
2-Mar-04	Ethanol and acetate + CPS	24	1455	23842	<0.28	<0.02	426	<0.14	<0.05	3549	195	124	717	5
2-Mar-04	average		1348	23533	<0.28	<0.02	419	<0.14	<0.05	3480	234	118	760	
9-Mar-04	Ethanol and acetate + CPS	22	1311	24250	<0.28	<0.02	304	<0.14	<0.05	4112	254	228	--	--
9-Mar-04	Ethanol and acetate + CPS	23	1283	24406	<0.28	<0.02	307	<0.14	<0.05	4053	246	206	--	--
9-Mar-04	Ethanol and acetate + CPS	24	1437	24077	<0.28	<0.02	308	<0.14	<0.05	4073	243	206	--	--
9-Mar-04	average		1344	24244	<0.28	<0.02	306	<0.14	<0.05	4079	248	213		
17-Mar-04	Ethanol and acetate + CPS	22	1367	24014	<0.28	<0.02	315	<0.14	<0.05	4086	240	187	653	--
17-Mar-04	Ethanol and acetate + CPS	23	1349	24049	<0.28	<0.02	318	<0.14	<0.05	3728	218	183	612	--
17-Mar-04	Ethanol and acetate + CPS	24	1464	22136	<0.28	<0.02	303	<0.14	<0.05	4031	217	171	582	--
17-Mar-04	average		1393	23400	<0.28	<0.02	312	<0.14	<0.05	3948	225	180	616	
30-Mar-04	Ethanol and acetate + CPS	22	1314	20464	<0.28	<0.02	327	<0.14	<0.05	3567	175	287	--	--
30-Mar-04	Ethanol and acetate + CPS	23	1254	20577	<0.28	<0.02	317	<0.14	<0.05	3458	176	242	--	--
30-Mar-04	Ethanol and acetate + CPS	24	1449	20880	<0.28	<0.02	334	<0.14	<0.05	3620	175	244	--	--
30-Mar-04	average		1339	20640	<0.28	<0.02	326	<0.14	<0.05	3548	175	258		
27-Apr-04	Ethanol and acetate + CPS	22	2191	24915	<0.28	<0.02	409	<0.14	<0.05	3606	193		--	6.26
27-Apr-04	Ethanol and acetate + CPS	23	2118	29264	<0.28	<0.02	433	<0.14	<0.05	4162	203		--	6.49
27-Apr-04	Ethanol and acetate + CPS	24	2027	22526	<0.28	<0.02	326	<0.14	<0.05	3283	194		--	6.19
27-Apr-04	average		2112	25568	<0.28	<0.02	389	<0.14	<0.05	3683	197			

APPENDIX D-2
ANALYTICAL RESULTS FOR DOWNGRADIENT AREA (MWA-32i)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
13-Jan-04(T=0)	CPS pretreatment, ethanol + acetate	25	9.1	27002	<0.02	<0.02	405	<0.14	<0.05	4476	210	--	NA	--
13-Jan-04(T=0)	CPS pretreatment, ethanol + acetate	26	1.7	29990	<0.02	<0.02	468	<0.14	<0.05	5061	219	--	NA	--
13-Jan-04(T=0)	CPS pretreatment, ethanol + acetate	27	2.9	26484	<0.02	0.5615	414	<0.14	<0.05	4437	223	--	NA	--
13-Jan-04	average		4.5	27825	<0.02	0.19	429	<0.14	<0.05	4658	217			
13-Jan-04(T=4)	CPS pretreatment, ethanol + acetate	25	1353	27993	<0.02	<0.02	439	<0.14	<0.05	4675	214	--	1290	6
13-Jan-04(T=4)	CPS pretreatment, ethanol + acetate	26	1531	27827	<0.02	<0.02	389	<0.14	<0.05	4656	216	--	1212	--
13-Jan-04(T=4)	CPS pretreatment, ethanol + acetate	27	1676	26920	<0.02	0.2928	385	<0.14	<0.05	4486	215	--	1322	--
13-Jan-04	average		1520	27580	<0.02	0.10	404	<0.14	<0.05	4606	215		1275	
20-Jan-04	CPS pretreatment, ethanol + acetate	25	1796	25877	<0.02	<0.02	404	<0.14	<0.05	3868	211	--	1240	--
20-Jan-04	CPS pretreatment, ethanol + acetate	26	1776	26059	<0.02	<0.02	394	<0.14	<0.05	3955	212	--	1040	--
20-Jan-04	CPS pretreatment, ethanol + acetate	27	1805	20910	<0.02	<0.02	322	<0.14	<0.05	3120	213	--	1082	6
20-Jan-04	average		1792	24282	<0.02	<0.02	373	<0.14	<0.05	3648	212		1121	
27-Jan-04	CPS pretreatment, ethanol + acetate	25	1792	25281	<0.02	<0.02	370	<0.14	<0.05	3784	218	--	1181	--
27-Jan-04	CPS pretreatment, ethanol + acetate	26	1918	25092	<0.02	<0.02	355	<0.14	<0.05	3799	220	--	1215	6
27-Jan-04	CPS pretreatment, ethanol + acetate	27	2114	25347	<0.02	<0.02	365	<0.14	<0.05	3817	187	--	1067	--
27-Jan-04	average		1942	25240	<0.02	<0.02	363	<0.14	<0.05	3800	208		1154	
10-Feb-04	CPS pretreatment, ethanol + acetate	25	1837	26134	<0.02	<0.02	440	<0.14	<0.05	3804	219	--	1200	--
10-Feb-04	CPS pretreatment, ethanol + acetate	26	1958	25826	<0.02	<0.02	401	<0.14	<0.05	3814	219	--	1103	6
10-Feb-04	CPS pretreatment, ethanol + acetate	27	2115	26334	<0.02	<0.02	384	<0.14	<0.05	3891	218	--	1132	--
10-Feb-04	average		1970	26098	<0.28	<0.02	408	<0.14	<0.05	3836	219		1145	
2-Mar-04	CPS pretreatment, ethanol + acetate	25	1551	21864	<0.28	<0.02	359	<0.14	<0.05	3108	217	--	1181	--
2-Mar-04	CPS pretreatment, ethanol + acetate	26	1705	22277	<0.28	<0.02	347	<0.14	<0.05	3194	219	--	1238	6
2-Mar-04	CPS pretreatment, ethanol + acetate	27	1956	23432	<0.28	<0.02	409	<0.14	<0.05	3364	219	--	1089	--
2-Mar-04	average		1737	22524	<0.28	<0.02	372	<0.14	<0.05	3222	218		1169	
9-Mar-04	CPS pretreatment, ethanol + acetate	25	1756	29196	<0.28	<0.02	381	<0.14	<0.05	4214	244	--	--	--
9-Mar-04	CPS pretreatment, ethanol + acetate	26	1981	29321	<0.28	<0.02	383	<0.14	<0.05	4233	250	--	--	--
9-Mar-04	CPS pretreatment, ethanol + acetate	27	1972	27457	<0.28	<0.02	349	<0.14	<0.05	3979	249	--	--	--
9-Mar-04	average		1903	28658	<0.28	<0.02	371	<0.14	<0.05	4142	248			
17-Mar-04	CPS pretreatment, ethanol + acetate	25	1794	26968	<0.28	<0.02	373	<0.14	<0.05	4045	216	--	1152	--
17-Mar-04	CPS pretreatment, ethanol + acetate	26	2032	30289	<0.28	<0.02	418	<0.14	<0.05	4494	221	--	1076	--
17-Mar-04	CPS pretreatment, ethanol + acetate	27	2098	27442	<0.28	<0.02	359	<0.14	<0.05	4052	221	--	1042	--
17-Mar-04	average		1975	28233	<0.28	<0.02	383	<0.14	<0.05	4197	219		1090	
30-Mar-04	CPS pretreatment, ethanol + acetate	25	1682	23826	<0.28	<0.02	398	<0.14	<0.05	3498	194	--	--	--
30-Mar-04	CPS pretreatment, ethanol + acetate	26	1815	23460	<0.28	<0.02	398	<0.14	<0.05	3470	185	--	--	--
30-Mar-04	CPS pretreatment, ethanol + acetate	27	2080	25179	<0.28	<0.02	432	<0.14	<0.05	3731	197	--	--	--
30-Mar-04	average		1859	24155	<0.28	<0.02	409	<0.14	<0.05	3566	192			
27-Apr-04	CPS pretreatment, ethanol + acetate	25	2039	26090	<0.28	<0.02	387	<0.14	<0.05	3728	204	--	--	6.75
27-Apr-04	CPS pretreatment, ethanol + acetate	26	2151	23807	<0.28	<0.02	334	<0.14	<0.05	3390	203	--	--	6.72
27-Apr-04	CPS pretreatment, ethanol + acetate	27	2450	24779	<0.28	<0.02	347	<0.14	<0.05	3531	197	--	--	6.69
27-Apr-04	average		2213	24892	<0.28	<0.02	356	<0.14	<0.05	3550	201			
7-Jun-04	CPS pretreatment, ethanol + acetate	25	1739	28514	<0.28	<0.02	424	<0.14	<0.05	4679	221	--	--	--
7-Jun-04	CPS pretreatment, ethanol + acetate	26	1813	27006	<0.28	<0.02	447	<0.14	<0.05	4468	223	--	--	--
7-Jun-04	CPS pretreatment, ethanol + acetate	27	1975	27853	<0.28	<0.02	390	<0.14	<0.05	4562	223	--	--	--
7-Jun-04	average		1842	27791	<0.28	<0.02	420	<0.14	<0.05	4570	222			

APPENDIX D-2
ANALYTICAL RESULTS FOR DOWNGRADIENT AREA (MWA-32i)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
7-Jun-04	CPS pretreatment, ethanol + acetate		Bioaugmented all three reps with perchlorate degrading culture											
10-Jun-04	CPS pretreatment, ethanol + acetate	25	1968	30819	<0.28	<0.02	517	<0.14	<0.05	5190	214	--	--	6.8
10-Jun-04	CPS pretreatment, ethanol + acetate	26	1977	28526	<0.28	<0.02	472	<0.14	<0.05	4796	214	--	--	6.8
10-Jun-04	CPS pretreatment, ethanol + acetate	27	2054	27305	<0.28	<0.02	437	<0.14	<0.05	4532	218	--	--	6.8
10-Jun-04	average		1999	28883	<0.28	<0.02	475	<0.14	<0.05	4840	215			
16-Jun-04	CPS pretreatment, ethanol + acetate	25	1637	25805	<0.28	<0.02	401	<0.14	<0.05	3898	229	--	516	--
16-Jun-04	CPS pretreatment, ethanol + acetate	26	1737	25175	<0.28	<0.02	405	<0.14	<0.05	3851	226	--	501	--
16-Jun-04	CPS pretreatment, ethanol + acetate	27	1949	25813	<0.28	<0.02	421	<0.14	<0.05	4005	311	--	490	--
16-Jun-04	average		1774	25598	<0.28	<0.02	409	<0.14	<0.05	3918	255		503	
16-Jun-04	CPS pretreatment, ethanol + acetate		Fed all three reps 120uL of EtOH											
23-Jun-04	CPS pretreatment, ethanol + acetate	25	1688	28042	<0.28	<0.02	401	<0.14	<0.05	3974	264	--	901	--
23-Jun-04	CPS pretreatment, ethanol + acetate	26	1849	29788	<0.28	<0.02	437	<0.14	<0.05	4265	216	--	849	--
23-Jun-04	CPS pretreatment, ethanol + acetate	27	1992	28630	<0.28	<0.02	421	<0.14	<0.05	4176	205	--	911	--
23-Jun-04	average		1843	28820	<0.28	<0.02	420	<0.14	<0.05	4138	228		887	
28-Jun-04	CPS pretreatment, ethanol + acetate		Re-Bioaugmented all three reps with perchlorate degrading culture											
30-Jun-04	CPS pretreatment, ethanol + acetate	25	1469	24504	<0.28	<0.02	331	<0.14	<0.05	3121	204	--	705	--
30-Jun-04	CPS pretreatment, ethanol + acetate	26	1560	26275	<0.28	<0.02	374	<0.14	<0.05	3368	205	--	701	--
30-Jun-04	CPS pretreatment, ethanol + acetate	27	1884	27597	<0.28	<0.02	399	<0.14	<0.05	3658	204	--	762	--
30-Jun-04	average		1638	26125	<0.28	<0.02	368	<0.14	<0.05	3382	205		723	
7-Jul-04	CPS pretreatment, ethanol + acetate	25	1487	26243	<0.02	<0.02	434	<0.14	<0.05	2981	207	--	695	--
7-Jul-04	CPS pretreatment, ethanol + acetate	26	1018	22129	<0.28	<0.02	327	<0.14	<0.05	1516	202	--	646	--
7-Jul-04	CPS pretreatment, ethanol + acetate	27	1579	24981	<0.28	<0.02	410	<0.14	<0.05	2816	208	--	794	--
7-Jul-04	average		1361	24451	<0.28	<0.02	390	<0.14	<0.05	2437	206		712	
8-Jul-04	CPS pretreatment, ethanol + acetate		Diluted all reps 2X with D.I. water											
8-Jul-04	CPS pretreatment, ethanol + acetate	25	--	--	--	--	--	--	--	--	124	--	--	--
8-Jul-04	CPS pretreatment, ethanol + acetate	26	--	--	--	--	--	--	--	--	114	--	--	--
8-Jul-04	CPS pretreatment, ethanol + acetate	27	--	--	--	--	--	--	--	--	136	--	--	--
8-Jul-04	average										125			
14-Jul-04	CPS pretreatment, ethanol + acetate	25	845	12641	<0.02	<0.02	208	<0.14	<0.05	1133	115	--	152	--
14-Jul-04	CPS pretreatment, ethanol + acetate	26	423	13399	<0.28	<0.02	195	<0.14	<0.05	31	110	--	114	--
14-Jul-04	CPS pretreatment, ethanol + acetate	27	988	14002	<0.28	<0.02	208	<0.14	<0.05	1242	132	--	178	--
14-Jul-04	average		752	13347	<0.28	<0.02	204	<0.14	<0.05	802	119		148	
22-Jul-04	CPS pretreatment, ethanol + acetate		fed all three reps 50uL of EtOH											
28-Jul-04	CPS pretreatment, ethanol + acetate	25	394	13827	<0.28	<0.02	205	<0.14	<0.05	<0.2	144	--	<1	--
28-Jul-04	CPS pretreatment, ethanol + acetate	26	477	13649	<0.28	<0.02	194	<0.14	<0.05	<0.2	117	--	117	--
28-Jul-04	CPS pretreatment, ethanol + acetate	27	579	14772	<0.28	<0.02	214	<0.14	<0.05	<0.2	151	--	170	--
28-Jul-04	average		483	14083	<0.28	<0.02	204	<0.14	<0.05	<0.2	137		96	
3-Aug-04	CPS pretreatment, ethanol + acetate		fed all three reps 50uL of EtOH											

APPENDIX D-2
ANALYTICAL RESULTS FOR DOWNGRADIENT AREA (MWA-32i)
Arkema Facility, Portland, Oregon

			Analyte											
Date	Treatment	Bottle	Acetate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate mg/L	Sulphate mg/L	Bromide mg/L	Phosphate mg/L	Chlorate mg/L	Perchlorate mg/L	Citrate mg/L	Ethanol mg/L	pH
11-Aug-04	CPS pretreatment, ethanol + acetate	25	639	14358	<0.28	<0.02	25	<0.14	<0.05	<0.2	114	--	<1	--
11-Aug-04	CPS pretreatment, ethanol + acetate	26	771	13205	<0.28	<0.02	1.3	<0.14	<0.05	<0.2	96	--	<1	--
11-Aug-04	CPS pretreatment, ethanol + acetate	27	764	14823	<0.28	<0.02	58	<0.14	<0.05	<0.2	114	--	<1	--
11-Aug-04	average		725	14128	<0.28	<0.02	28	<0.14	<0.05	<0.2	108		<1	
12-Aug-04	CPS pretreatment, ethanol + acetate		fed all three reps 100uL of EtOH											
13-Aug-04	CPS pretreatment, ethanol + acetate	25	--	--	--	--	--	--	--	--	--	--	--	~6-7
13-Aug-04	CPS pretreatment, ethanol + acetate	26	--	--	--	--	--	--	--	--	--	--	--	~6-7
13-Aug-04	CPS pretreatment, ethanol + acetate	27	--	--	--	--	--	--	--	--	--	--	--	~6-7
13-Aug-04	average													
25-Aug-04	CPS pretreatment, ethanol + acetate	25	1109	21880	<0.28	<0.02	3	<0.14	<0.05	<0.2	117	--	159	--
25-Aug-04	CPS pretreatment, ethanol + acetate	26	870	13398	<0.28	<0.02	<0.03	<0.14	<0.05	<0.2	96	--	112	--
25-Aug-04	CPS pretreatment, ethanol + acetate	27	1106	19398	<0.28	<0.02	24	<0.14	<0.05	<0.2	126	--	172	--
25-Aug-04	average		1029	18225	<0.28	<0.02	9	<0.14	<0.05	<0.2	113		148	
8-Sep-04	CPS pretreatment, ethanol + acetate		fed all three reps 50uL of EtOH											
16-Sep-04	CPS pretreatment, ethanol + acetate		fed all three reps 50uL of EtOH											
22-Sep-04	CPS pretreatment, ethanol + acetate	25	927	14576	<0.28	<0.02	1.1	<0.14	<0.05	<0.4	87	--	<1	--
22-Sep-04	CPS pretreatment, ethanol + acetate	26	941	13799	<0.28	<0.02	0.62	<0.14	<0.05	<0.4	71	--	<1	--
22-Sep-04	CPS pretreatment, ethanol + acetate	27	1050	15780	<0.28	<0.02	0.49	<0.14	<0.05	<0.4	98	--	<1	--
22-Sep-04	average		973	14718	<0.28	<0.02	0.73	<0.14	<0.05	<0.4	85		<1	

Notes:
mg/L - milligrams per liter
uL - microliters
CPS - calcium polysulfide
EtOH - ethanol