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Interim Remedial Action Plan  
Eagle Gas  
4301 San Leandro Street  
Oakland, CA  
January 14, 2004

Prepared For:  
Muhammad Jamil  
And  
Farah Naz  
40092 Davis Street  
Fremont, CA 94538

Prepared By:  
Clearwater Group  
229 Tewksbury Avenue  
Pt. Richmond, CA 94801

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- Figure 1: Site Location Map
- Figure 2: Site Plan
- Figure 3: iSOC Treatment Zones
- Figure 4: Proposed Well Diagram

- Table 1: Well Construction Data
- Table 2: Soil Sample Analytical Results
- Table 3: Groundwater Elevations and Sample Analytical Results

- Attachment A: KV Associates Case Study
- Attachment B: inVentures Technologies Incorporated Case Studies
- Attachment C: Illustrations of iSOC equipment and setup
- Attachment D: Clearwater Field Procedures

## 1.0 Purpose of Assessment

ACDEH requested via telephone on January 9, 2004 that an Interim Remedial Action Plan (IRAP) be prepared for the purpose of addressing the hydrocarbon contamination found in the groundwater beneath the project location.

## 2.0 Site Description

The site is located in the southern portion of Oakland, Alameda County, California at the south corner of San Leandro Street and High Street, approximately 1,000 feet east of Interstate Highway 880. The site is bounded by commercial property to the southeast, southwest and northwest and by the Bay Area Rapid Transit (BART) tracks to the northeast (**Figure 1.**) The site is predominantly underlain by clays with some clayey gravel and clayey sand at depths to approximately 10 feet below ground surface (bgs), and silty sand below 20 feet in some areas.

## 3.0 Background

On April 21 and 22, 1999, Clearwater, (formerly Artesian Environmental), oversaw the removal from the site of five underground storage tanks (UST) consisting of two 6,000-gallon gasoline USTs, two 4,000-gallon diesel USTs and one 300-gallon used oil UST (**Figure 2.**) Field observations included detection of strong petroleum odors from soils near the former UST locations. A total of five-confirmation soil samples and three groundwater samples were collected from the UST excavations. Laboratory analysis confirmed an unauthorized release of petroleum had occurred.

In a letter dated May 10, 1999, the ACDEH recommended that soil be remediated by over-excavation and that "as much groundwater as possible" be pumped from the excavation. Approximately 800 tons of petroleum-impacted soil was excavated and disposed of as Class II non-hazardous waste. Less than 1,000 gallons of petroleum-impacted groundwater was pumped and removed from the excavation. Groundwater did not recharge after the initial pumping. Existing on- and off-site structures limited the amount of soil that could be safely excavated. Soil samples collected from the

excavation walls and product piping trenches indicated some remaining petroleum and methyl tertiary butyl ether (MTBE) contamination.

On August 4 and 5, 1999, approximately 100 linear feet of product piping was removed. Vent piping from between the former USTs and the south corner of the on-site building was also removed. All piping was cut up and disposed of as scrap metal. On August 5, 1999, confirmation soil samples were collected along the piping trench. Six samples were collected from approximately three feet bgs. An additional four samples were collected, one for each of the four former fuel dispensers. Laboratory analytical results indicated the presence of hydrocarbon related contamination along the piping trenches.

On September 26, 2000 West Hazmat of Rancho Cordova, California, used a CME 75 drill rig to advance three borings to approximately 25 feet bgs (Figure 2), and collect soil samples. Each of the three borings was converted to a groundwater monitoring well using clean, flush-threaded, 2-inch diameter polyvinyl chloride (PVC) well materials (Table 1.) Soil sample analytical results are included as Table 2. On October 3 and 10, 2000, Clearwater surveyed the top of the casing elevations for each of the wells relative to an arbitrary datum, and developed the wells for monitoring. Initial groundwater samples collected from these wells contained 83,000 micrograms per liter ( $\mu\text{g/L}$ ) to 250,000  $\mu\text{g/L}$  total petroleum hydrocarbons as gasoline, (TPHg), and 33,000  $\mu\text{g/L}$  to 400,000  $\mu\text{g/L}$  MTBE (Table 3.)

On August 3, 2001 Clearwater submitted its *Groundwater Monitoring Report, Second Quarter 2001, Sensitive Receptor Survey and Workplan for Continuing Investigation*. It was determined at that time that there are no major ecological receptors, permanent surface waters or domestic-use wells within a 2,000-foot radius of the site. The proposed scope of the workplan included the installation of eight groundwater-monitoring wells around the site to delineate the water-borne MTBE plume. In response to Clearwater's workplan, the ACDEH, in correspondence dated October 18, 2001, recommended that off-site monitoring wells not be installed for the time being. Instead, the ACDEH requested that further characterization of subsurface soils and groundwater on-site be completed prior to the installation of any off-site wells.

## 4.0 Proposed Remediation Methods

### 4.1 Groundwater Extraction and Treatment

Groundwater extraction and treatment has been proven as an effective means of controlling contaminant migration and reducing contaminant levels. Although dissolved concentrations can be reduced through groundwater extraction, this method generally will not bring dissolved contaminant concentrations to below the stringent clean-up levels identified. However, once asymptotic concentrations are reached, further reduction in concentrations generally slow down considerably, and natural attenuation becomes the primary process of contaminant reduction. The chemical properties of gasoline range hydrocarbons suggest the groundwater extraction for contaminant mass removal alone is ineffectual. It is a more useful technology in situations with MTBE contamination, because it is more soluble than gasoline hydrocarbons. The greatest benefit of groundwater extraction comes from exerting hydraulic control over a migrating plume and lowering the water table to expose soil to the effects of vapor extraction.

The water generated can sometimes be discharged untreated to local sanitary sewer districts at relatively high cost, otherwise treatment is usually required prior to discharge to either a sanitary sewer or storm sewer. If treatment is required, a remediation system will need to be designed and constructed. Due to the extremely high levels of MTBE detected in the groundwater samples collected from MW-2 (710,000 µg/L), the system must include various components for the removal of MTBE in the groundwater prior to treatment using activated granular carbon.

Clearwater will perform a brief step-drawdown test on MW-2, which allow for rough determination of sustainable flow-rates and the specific capacity of the well. The test will be performed in steps by pumping water from the well at increasing flow rates using a submersible electric pump and monitoring depth to water in the pumping well using an electric water sensor.

### 4.2 Chemical Oxidation (In-situ)

This technique enhances the natural microbial activity in the groundwater through the addition of dissolved oxygen. Indigenous microbes use dissolved-oxygen to naturally

breakdown hydrocarbons in groundwater. Unless an additional source of oxygen is present, microbial activity in the presence of an energy source (hydrocarbons) usually occurs faster than dissolved oxygen can be replenished naturally through groundwater recharge. If an energy source is not present, microbial activity will be minimal and dissolved-oxygen will not be depleted. As a result, microbial activity tends to deplete the oxygen in the center of dissolved hydrocarbon plumes. Once oxygen is depleted, anaerobic degradation predominates. However, anaerobic degradation rates are much lower than aerobic degradation rates. Thus, the rate at which natural biodegradation of the hydrocarbons occurs is restricted by the rate at which dissolved-oxygen can be replenished. The use of dissolved oxygen in contaminated ground water to enhance natural attenuation of gasoline constituents (MTBE, benzene, toluene, ethyl benzene and xylenes (BTEX)) has been growing as a remediation technology since the mid 1990's. Presently there are a variety of technologies available which will introduce low to moderate concentrations (10-20 ppm) of stable dissolved oxygen into ground water.

Once this elevated dissolved oxygen mixes with gasoline-contaminated ground water, natural biodegradation occurs and aerobic microorganisms consume the gasoline constituents. Enhanced bioremediation by the use of injected dissolved oxygen has been proven to be an effective technology to reduce both BTEX and MTBE. However many ground water environments that are high in ferrous iron and BOD, for example, will consume large volumes of injected dissolved oxygen before aerobic bacteria can utilize the oxygen as part of the process of consuming BTEX and MTBE. Therefore delivery of super-saturated levels of dissolved oxygen into ground water is essential to insure that an abundance of oxygen will remain for the bioremediation of BTEX and MTBE. The addition of dissolved oxygen via air injection or chemical injection (i.e. hydrogen peroxide or magnesium peroxide) to oxygenate depleted areas allows degradation to proceed aerobically at much higher rates.

#### 4.2.1 Chemical Injection

The direct addition of liquid chemicals such as hydrogen peroxide ( $H_2O_2$ ) to raise dissolved-oxygen (DO) levels can be expensive, difficult to obtain permits for, and can be difficult to control, often requiring extraction wells in addition to injection wells. However, Oxygen Release Compound<sup>®</sup> (ORC) is a patented magnesium peroxide compound, in a solid form that is placed in excavation backfill or in wells and borings,

and releases oxygen to naturally occurring microbes as it is hydrated. Thus, the need for controls and the expense related to weekly or daily maintenance is precluded. The additional oxygen provided by ORC stimulates aerobic microbial growth and activity. ORC is 10% oxygen by weight and approximately 4% by weight is liberated from the plugs.

Feasibility testing would have to be performed to determine if indigenous hydrocarbon degrading microbes and sufficient nutrients are present to support enhanced aerobic bioremediation.

#### 4.2.2 Ozone Infusion

In-situ air stripping with microencapsulated ozone chemically oxidizes MTBE from contaminated groundwater with the use of fine bubbles with a high surface to volume ratio. The ozone contained within the bubble reacts extremely rapidly to chemically decompose the MTBE into simple products (alcohols, acetate and formate). The residual oxygen from the reaction encourages bioremediation, which consumes the breakdown products and converts them to carbon dioxide and water. The reaction is produced with very low ozone concentrations-molar ratios-compared to volatile organic compounds (VOC) concentrations in the groundwater. Ozone lasts approximately 20 minutes in water depending on a variety of factors.

Air and ozone are injected directly into the groundwater through specially designed spargers to create "microbubbles". The Henry's Constant which regulates the partitioning of MTBE from aqueous to gaseous state is about one-tenth that of benzene derivatives. The surface-to-volume ratio increase of over 30-fold compensates to promote rapid in-situ stripping of MTBE. MTBE is rapidly degraded with time. The rate of removal is sensitive to ozone concentration, pressure and iron silicate content. A case study provided by KV Associates is included as **Attachment A**.

#### 4.2.3 Oxygen Infusion

A growing number of remediation contractors in the US, Canada and Brazil are utilizing a Canadian technology called in-situ Submerged Oxygen Curtain (iSOC™) that infuses oxygen, using a spargeless technique, into ground water via monitor wells. Case studies

provided by inVentures Technologies Incorporated are included as **Attachment B**. The proprietary structured polymer used in iSOC provides large surface area for gas transfer into a 15 inch by 1.75-inch probe, which is placed down a 2 or 4-inch monitor well. The probe is connected to a regulated canister supply of industrial compressed oxygen secured within a remediation compound. Oxygen infusion enriches the dissolved oxygen (DO) content of groundwater without causing aeration and volatilization of organic compounds. Super saturation levels of oxygen can be achieved in the range of 40 to 50 milligrams per liter (mg/L or ppm). This technology requires no external power, with a minimum monthly exchange of oxygen canisters. During this time, the large and continuous supply of oxygen infused into the ground water system is able to provide significant enhanced degradation of both BTEX and MTBE. The dissolved oxygen is infused from the iSOC into the monitoring well at a typical rate of 15 to 20 cubic centimeters per minute. The effective radius of influence of super-saturated ground water leaving the monitoring wells with the iSOC's is typically 10-15 feet. Illustrations of equipment and a typical setup are shown in **Attachment C**.

The iSOC technology has been reported to remediate BTEX levels in excess of 100,000 ppb at sites in Canada and Brazil. In those countries MTBE is currently not being used in gasoline. In the United States iSOC technology is being used to remediate BTEX and both MTBE and TBA.

Typically sites that are good candidates for the application of this technology are also good candidates for air sparging and soil vapor extraction (AS/SVE). The technology may be applied to sites that are not good candidates for AS/SVE, as the expected results would generally occur over a greater period of time than for the ideal project location. The success of oxygen infusion also depends on the lack of liquid phase hydrocarbons (LPH), with the presence of dissolved phase concentrations of total VOC and MTBE. The infusion system also requires the presence of a monitoring well network (2 inches in diameter or larger) that can be used for infusion and to monitor performance. The system may be installed onsite within the existing network of monitoring wells to treat the "source", or it may be used in a new network of wells installed perpendicular to the direction of groundwater movement beneath the site.

#### 4.3 Natural Attenuation

The predominant attenuation process is intrinsic biodegradation (aerobic and anaerobic) mediated by hydrocarbon degrading bacteria. Other factors in natural attenuation include physical and chemical processes such as volatilization, dispersion, sorption and hydrolysis. Unless otherwise referenced, the following information was derived from McAllister and Chiang (1994).

In aerobic respiration, microbes utilize dissolved oxygen (DO) as an electron acceptor during hydrocarbon oxidation (degradation), producing carbon dioxide, water, and microbial biomass. The electron acceptor is a substance that facilitates the reaction by taking up the electrons released by oxidation; the electron acceptor then becomes reduced during the process of biodegradation.

The aerobic process is the most important form of biodegradation wherever DO concentrations exceed 1 to 2 mg/L. Under hypoxic conditions (0.1 to 2 mg/L DO), aerobic degradation may occur along the edges of the plume while anaerobic degradation predominates in the center of the plume.

Microbes may also degrade hydrocarbons via anaerobic processes by utilizing alternate biochemical pathways when DO concentrations are insufficient for aerobic degradation. Anaerobic degradation is much slower than the aerobic process and not all BTEX compounds are consistently degraded. Some studies indicate benzene is recalcitrant to anaerobic degradation while others have demonstrated limited degradation (Rifai et al, 1995). Anaerobic degradation generally occurs in the center of the plume where DO has been depleted by aerobic degradation. Research into the efficacy of anaerobic processes is ongoing.

Anaerobic electron acceptors include [in order of sequential use and decreasing redox potential (Eh)]:

- nitrate ( $\text{NO}_3^-$ ),
- oxides of ferric iron ( $\text{Fe}^{3+}$ ),
- sulfate ( $\text{SO}_4^{2-}$ ),
- water.

The associated biochemical processes are: denitrification (or nitrate reduction), iron reduction, sulfate reduction, and methanogenesis. Manganese ( $Mn^{4+}$ ) may also function as an electron acceptor. Nitrate and sulfate reduction do not degrade alkanes such as methane, propane, and butane.

Dissolved plume mass can be reduced by volatilization of contaminants to the vapor phase in the unsaturated zone. Normally volatilization is a negligible component of natural attenuation, however, it may contribute 5% or more of total mass loss in shallow (<15 feet), warm and/or fluctuating water table conditions in permeable soils (Rifai et al, 1995).

Mechanical/molecular mixing reduces dissolved concentrations substantially by lateral spread. No dissolved contaminant mass is removed from the system by this process. Dispersion (D) is generally modeled based on the length of the plume (x). Conservative practice calls for dispersion in the downgradient direction (longitudinal dispersivity,  $D_x$ ) to be modeled at 0.1 times the plume length. Dispersion in the transverse direction (transverse dispersivity,  $D_y$ ) is modeled at 0.33 times  $D_x$ ; dispersion in the vertical direction (vertical dispersivity,  $D_z$ ) is modeled at 0.05 times  $D_x$  (Connor, et al., 1995).

Contaminants partition between the aqueous phase and the soil matrix. Adsorption onto the soil surface significantly retards migration but does not permanently remove BTEX which may desorb later. Carbon is the most effective sorption material in soils, and although clay minerals and amorphous minerals such as iron hydroxides also have some influence, only sorption to carbon in soil is included in most contaminant fate and transport computer models.

Sorption is controlled by the organic carbon content of soil ( $f_{OC}$ ), the chemical specific organic carbon partition coefficient ( $K_{OC}$ ), the soil bulk density ( $\rho_s$ ), and the water content of the soil as measured by the porosity ( $\phi_s$ ).  $K_{OC}$  is a measure of the affinity of a given chemical to sorb from water onto solid organic material (Table 1). Once the porosity, bulk density,  $K_{OC}$ , and  $f_{OC}$  have been established, the retardation factor (R) for the site can be calculated as follows:

$$R = (1 + k_s * \rho_s / \phi_s) \quad \text{where: } k_s = f_{OC} * K_{OC}$$

The retardation factor is used in transport models (discussed below) as a measure of the degree to which the rate of plume migration is reduced by sorption processes.

### 5.0 Evaluation of Proposed Remediation Methods

Many factors must be considered when choosing the correct technology to remediate a hydrocarbon-impacted site. The amount of contamination and phase it is primarily found in, the geology and hydrogeology of the site, the location and size of the contaminant plume, the location and size of the project site, surrounding land use, sensitive receptors, clean-up goals and money.

The primary source of contamination was removed in 1999 when approximately 800 tons of petroleum-impacted soil was excavated and disposed of as Class II non-hazardous waste. Soil samples collected from the excavation walls and product piping trenches indicated some remaining petroleum and methyl tertiary butyl ether (MTBE) contamination. Since that time, groundwater samples collected from the three-groundwater monitoring wells located at the project location have indicated that the remaining sorbed-phase contamination has migrated into the groundwater.

Groundwater extraction, "pump and treat", is best used in locations of loose geologic formations such as sands and gravels. The project site is predominantly underlain by clay and clayey gravels to approximately 10 feet bgs. Clayey sands were documented to at least 20 feet bgs. During the over-excavation of contaminated soils less than 1,000 gallons of petroleum-impacted groundwater was pumped and removed from the excavation. Groundwater did not recharge after the initial pumping. The tight clay formation makes groundwater extraction undesirable as an approach to effectively remediate the project site.

The tight formation also makes Chemical Injection and Ozone Infusion impractical approaches to remediation. Fractures in clays and other low permeable sediments create preferred remedial pathways for the ORC™. The matrix of the fractured low permeable soil is unlikely to be uniformly treated. Ozone sparging works best in soil with a permeability of  $10^{-1}$  to  $10^{-5}$  centimeters per second (cm/sec). Clayey soils typically have a permeability of  $10^{-6}$  cm/sec, which is considered too tight for effective use of ozone. The

ozone may also corrode metals that it comes into contact with also making it a poor choice for remediation due to the close proximity of neighboring buildings.

Natural attenuation is an impractical approach to remediation due to the extremely high levels of contamination detected in the groundwater samples from all groundwater-monitoring wells.

Enhanced bio-remediation through the use of oxygen infusion appears to be the only practical approach to groundwater remediation at the project site. The infused oxygen molecule is smaller than the ozone molecule and the water molecule; it will be able to travel further through the tight pore space of the clay, which dominates the lithology of the site. The oxygen molecule and microbes are smaller than the clay pore openings. The infused oxygen molecule provides no health or structural risks as it travels down gradient towards the neighboring buildings.

## **6.0 Application of the Oxygen Infusion System**

### 6.1.1 Monitoring Well Network

Each iSOC™ unit has a treatment radius of up to 15 feet. Maximum efficiency of the iSOC™ system will require the installation of approximately nine groundwater monitoring/system wells at the project location (Figure 3). If maximum efficiency is not desired or deemed to costly then a minimum of six monitoring wells will be required to treat the hydrocarbon plume on the perimeter of the project site.

### 6.1.2 Drilling, Soil Sampling, and Analysis

Prior to conducting field activities, appropriate well installation permits will be obtained from the appropriate agencies. Underground Service Alert will be requested to identify utilities leading to the site. All field personnel on-site will review and sign the site Health and Safety plan, prepared in accordance with OSHA 1910.120, at the start of each field day. All fieldwork will be conducted in accordance with Clearwater's Field Procedures (Attachment D).

Under supervision of a Clearwater geologist, a C-57 licensed drilling contractor will advance the soil borings. The soil borings will be advanced sufficiently deep so that

water is encountered to approximately 25 feet bgs. Soil samples will be collected at five-foot depth intervals and retained for laboratory analysis. Portions of each soil sample will be retained for visual classification according to the Unified Soil Classification System. Soil samples will be screened for the presence of volatile hydrocarbons using a photo-ionization detector (PID). Additionally, a groundwater sample will be taken from the borehole, using a disposable or clean stainless steel bailer.

The water samples will be analyzed for concentrations of total petroleum hydrocarbons as diesel (TPHd) by EPA method 8015 modified, TPHg, BTEX, and five-fuel oxygenates; MTBE, diisopropyl ether (DIPE), tertiary butyl alcohol (TBA), tertiary amyl methyl ether (TAME) and ethyl tertiary butyl ether (ETBE) by EPA methods 8260 by a DHS-certified laboratory.

Soil cuttings and sampler rinseate will be stored on-site in labeled 55-gallons drums pending future removal and disposal.

#### 6.1.3 Monitoring Well Installation and Survey

Clearwater will supervise the construction of the monitoring wells (proposed MW-4 through MW-12). It is assumed the wells will not be installed past a depth of approximately 25 feet bgs, however, final well construction will depend on hydrogeologic observations made at the time of drilling. Tentative well construction details are shown on **Figure 4**.

The wells will be constructed of clean, flush-threaded, 2-inch diameter PVC well materials. Well screen, with 0.02-inch perforations, will extend from the bottom of each boring to approximately 10 feet bgs, and blank casing will be extended to ground surface. A filter pack of Lonestar #3 sand will extend from the bottom of each boring to one foot above the screened interval. The filter pack will be sealed by a two-foot layer of hydrated bentonite. The remaining annular space will be filled with cement and a tamper-resistant box will be concreted in place over the wellhead. Clearwater will survey the top of casing elevations relative to a permanent benchmark, accurate to within  $\pm 0.01$ -feet.

#### 6.1.4 Well Gauging, Development, Sampling, and Analysis

The new and existing wells will be monitored and sampled following installation. An electronic water level indicator, accurate to within  $\pm 0.01$ -foot, will be used to gauge depth to water. All wells will be checked for the presence of separate-phase hydrocarbons (SPH) prior to development and sampling.

The new wells will be developed by surging and bailing. Development will involve the removal of water from each well until such time that it is relatively free of sediment, and pH, temperature, and conductivity parameters have stabilized. Removal of well water for development will serve as purging prior to sampling. It is anticipated that the water volume removed will not exceed ten saturated casing volumes. The existing wells will also be purged until physical parameters stabilize prior to sampling. Groundwater monitoring and well purging information will be recorded on Gauge Data/Purge Calculations and Purge Data sheets.

Following recovery of water columns to at least 80% of their static levels, or after passage of two hours (if designated recovery levels have not occurred), groundwater samples will be collected from the monitoring well using dedicated polyethylene bailers. Samples will be decanted into laboratory-supplied containers, labeled, documented on a chain-of-custody form, and placed on ice in a cooler for transport to the project laboratory. Groundwater samples will be analyzed by Kiff Analytical LLC, a California DHS-certified laboratory, located in Davis, California, for concentrations TPHd by EPA Method 8015 modified, TPHg, BTEX, and five-fuel oxygenates by EPA Method 8260.

Purging devices will be decontaminated between wells in an Alconox® wash followed by double rinse in clean tap water to prevent cross-contamination. Rinseate will be stored on-site in labeled 55-gallons drums pending future removal and disposal.

Prior to system implementation, a baseline-sampling event will be conducted on the onsite monitoring wells. The samples will be analyzed for TPHd, TPHg, BTEX, five-fuel oxygenates, nitrate, sulfate, ortho-phosphate, ammonia nitrogen, biological oxygen demand (BODS), and chemical oxygen demand (COD), DO, and pH. In addition, DO, redox potential conductivity (ORP), temperature, and pH measurements will be

gathered in the field. This data will be used to assess whether sufficient nutrients still exist at the site to provide the necessary conditions for biodegradation. If it is concluded that the levels do not exist, then nutrients will be added. The network of wells will continue to be monitored on a quarterly basis to evaluate remedial progress and to estimate the time needed to reach remedial target levels. The monitoring well samples will be analyzed according to USEPA Method 8260B for concentrations of TPHd, TPHg, BTEX and five-fuel oxygenates.

Trenching options will be discussed after the quantity of system wells is determined. The system tubing may be laid directly into a 2 by 12 inch saw-cut path and sealed with concrete or a larger 6 by 12 inch trench may be dug from the wells to a remediation compound that will house the system equipment. One-quarter inch flexible polyurethane tubing will be installed in the trenches and used to connect the infusion probes to the cylinders in the compound.

### **7.0 Equipment Requirements**

Application of the infusion technology requires the use of certain equipment to monitor the airflow rate being supplied to the groundwater and regulate the pressure at which oxygen is delivered. Based on manufacturer recommendations, the system should operate at an oxygen flow rate of 15 cubic centimeters per minute (cc/min) and a pressure of 5 pounds per square inch (psi) above the maximum static water pressure.

At the infusion wells, a high range DO/ORP meter should be used; an example of this type of DO meter is an OxyQuard Handy Alpha provided by Point Four Systems, Inc. At surrounding monitoring wells, a typical DO meter will be adequate. In addition, a dual stage low flow (0-4psi) pressure regulator and a low air flow meter should be used. The type of regulator predominantly used is a Victor 270 or equivalent available from Thermadyne. The appropriate air flow meter is a Cole Parmer Model P-03217 available from Cole Parmer Instrument Company. Miscellaneous fittings and supplies are available from Environmental Bio-Systems. Compressed air cylinders can be obtained from local welding shops, such as Airgas.

## 8.0 Scope of Work

Upon approval of the IRAP by the ACDEH, Clearwater will initiate the previously mentioned well installation. After the new wells are installed the extent of required trenching will be apparent. The goal is to install a remediation compound in a convenient location large enough to house the compressed air cylinder (oxygen source), air flow meter and miscellaneous supplies. The remediation design layout will depend solely upon the number and location of newly installed monitoring wells. Diagrams of the remediation design will be available for review once the layout of monitoring wells has been established.

The remediation system will be connected from the probe at each infusion well location to ¼-inch OD flexible polyurethane tubing laid securely within the piping trench leading to the compound. The piping trench and associated tubing will terminate within the compound through the use of an above grade well manifold. Each individual infusion well will be attached to a pressure gauge on the manifold and include a valve to regulate the airflow. The manifold will be connected to an oxygen cylinder or a series of cylinders depending on the number of infusion wells within the system. The cylinders will also be equipped with pressure gauges to monitor the available oxygen supply.

Following startup of oxygen infusion, groundwater DO concentrations in the infusion wells will be monitored once a week until a relatively constant DO is reached in the infusion wells, DO monitoring will then be performed quarterly along with the groundwater sampling events. Each of the quarterly sampling events will consist of collecting groundwater samples from the network of monitoring wells for analysis of TPHd, TPHg, BTEX and five -fuel oxygenates using EPA Method 8260B.

After concentrations decline to levels amenable to remediation by natural -attenuation, without the aide of enhanced oxygen infusion, the gas cylinders will be disconnected. The probes will be removed from the infusion wells and quarterly monitoring will continue at the site until site closure can be considered. As a precaution the tubing for the system should remain in place until site closure is granted. This will allow for the

return use of oxygen infusion if for some reason the concentrations of petroleum related hydrocarbons spike during a quarterly monitoring event.

### **9.0 Proposed Schedule of Remedial Action**

The proposed schedule for remedial action is provided to identify the sequence of key tasks to remediate the groundwater at the site:

- Install new network of groundwater monitoring wells
- Conduct base-line sampling event
- Bid out system installation
- Apply and secure all appropriate permits from the various Alameda County entities
- Install remediation system
- Start up system, and monitor DO levels until parameters have stabilized
- Prepare start up report
- Monitor and sample remaining network of wells, adjust infusion rates as required, until natural attenuation of the hydrocarbon plume can continue without the aide of enhanced oxygen infusion
- Continue quarterly monitoring of groundwater wells until concentrations of petroleum related hydrocarbons fall below risk based screening levels (RBSL) for threatened drinking water;\
- Once concentrations fall below RBSL, the site should continued to be monitored quarterly for one year
- If dissolved hydrocarbon concentrations remain acceptable after one year, a petition for regulatory closure will be made
- Decommission all wells and system components upon receipt of regulatory closure.

## 10.0 CERTIFICATION

This report was prepared under the supervision of a professional Registered Geologist in the state of California. All statements, conclusions and recommendations are based solely upon published results from previous consultants, field observations by Clearwater and laboratory analysis performed by a California State-certified laboratory related to the work performed by Clearwater.

Information and interpretation presented herein are for the sole use of the client and regulating agency. The information and interpretation contained in this document should not be relied upon by a third party.

The service performed by Clearwater Group has been conducted in a manner consistent with the level of care and skill ordinarily exercised by members of our profession currently practicing under similar conditions in the area of the site. No other warranty, expressed or implied, is made.

Prepared by:

Reviewed by:

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Jessica Chiaro  
Project Scientist

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Jim Jacobs, R.G., No. 4815  
C.H.G. No. 88

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