HerSchy Environmental, Inc.

February 2, 2009

Mr. Eric Swenson
County of Merced
Department of Health
Division of Environmental Health
777 West 22nd Street
Merced, California 95340

RE: **Addendum to Final Remediation Plan**
Gas & Go
2104 G Street
Merced, California

Mr. Swenson:

HerSchy Environmental, Inc. is pleased to present this addendum to the Final Remediation Plan submitted November 12, 2008. The site is located at 2104 G Street in Merced, Merced County, California. This addendum to the remediation plan was prepared in response to the December 24, 2008 correspondence from the Merced County Department of Health, Environmental Health Division (**Appendix A**).

MONITORING WELL INSTALLATION

Additional groundwater monitoring wells are proposed for the site design. Four wells are currently installed onsite. Off site wells are needed to assess the groundwater plume for further remediation and to monitor any effects the on-site remediation may have on the groundwater plume. Locations of the proposed wells are included on **Figure 1**.

Drilling and Sampling Methods

Three borings will be drilled vertically to approximately 45 feet below surface grade (bsg) in preparation of groundwater well installations (MW-5 through MW-7). Drilling will be performed using hollow stem auger equipment with minimum eight-inch diameter augers. Augers will be steam cleaned prior to arriving on site.

Samples will be collected every five feet until water is detected. Soil samples will be collected using a California modified split spoon sampler equipped with brass or stainless steel liners. The split spoon sampler will be cleaned between sampling events.

Soil samples will be field screened using a portable organic vapor analyzer (OVA). A portion of the sample retrieved from each sampling interval will be placed in a plastic zip-lock bag, sealed in the bag for a minimum of ten minutes at 70 degrees Fahrenheit or more, and the OVA probe inserted into the bag to evaluate concentrations of volatile organic compounds (VOCs) in the soil. Soil samples with PID readings over 50 ppm will be submitted to the laboratory for analysis. A minimum of one sample per 15 feet will be submitted regardless.

Samples retained for analysis will be capped with Teflon tape and plastic end caps, and placed in a cooler chest with frozen gel packs ("blue ice") or ice, and maintained at or below four degrees Celsius until delivered to the laboratory. Soil samples and drill cuttings will be described in accordance with the Unified Soil Classification System, visual and manual methods, by qualified personnel. Cuttings will be stored in UN-approved 55 gallon drums and disposed of at a qualified disposal facility after profiling is complete.

Groundwater Monitoring Well Installation

The monitoring wells (MW-5 through MW-7) will be single completion wells each installed to a depth of 45 feet or fifteen feet below encountered water. The wells will be constructed with two-inch schedule 40 PVC well casing with screw joints. The screened intervals will be constructed with 0.020" slotted PVC and extend from five feet above water to 15 feet below water. Blank casing will extend from the top of each screened casing to the ground surface.

Annular materials will be installed through the hollow-stem augers. Annular materials will consist of #3 Monterey Sand or coarser materials extending from the bottom of each well to two feet above the screen. A minimum three foot bentonite seal will be placed above the sand. A sand-cement grout will be installed from the top of the seal to the ground surface. The wells will be completed flush with the surface grade with locking well caps in a traffic rated utility box. The newly installed wells will subsequently be surveyed to the nearest 0.01 feet by a licensed surveyor.

Laboratory Analysis

Soil samples will be analyzed by a California certified laboratory for gasoline-range total petroleum hydrocarbons (TPHg), benzene, toluene, ethylbenzene, and xylenes (BTEX), methyl tertiary butyl ethyl (MTBE), diesel-range total petroleum hydrocarbons (TPHd), di-isopropyl ether (DIPE), ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), tertiary butyl alcohol (TBA), 1,2-dichloroethane (1,2-DCA), and ethylene dibromide (EDB). TPHg will be analyzed using EPA Method 8015M, BTEX and MTBE by EPA method 8021, TPHd by the California LUFT method, and the additional oxygenates by EPA Method 8260b. Additionally, some samples will be analyzed for lead by EPA Method 6010 for disposal purposes.

Well Development and Sampling

The newly installed wells will be developed a minimum 48 hours after completion by pumping and surging using a 12-volt submersible pump until the discharge is relatively clear and free of sand. Development and purge water will be stored in UN-approved 55-gallon drums. In addition, the newly installed wells will subsequently be surveyed to the nearest 0.01 feet by a licensed surveyor.

REMEDIAL APPROACH

Based on the results of the vapor extraction test (VET), soil vapor extraction is an effective means of remediation at this site because of the large radius of influence and high mass removal rates. In addition to the vapor extraction system to treat soil, HerSchy recommends the injection of an oxidant and biological material along a transect on site to mitigate further down gradient transport and to remediate the down gradient groundwater. Air sparging is not recommended as an effective means of groundwater remediation at this site due to the scale of the plume and general inefficiency of that approach.

REMEDIATION WELL INSTALLATION

Based on the results of the VET, soil vapor extraction is an effective means of remediation at this site because of the large radius of influence and high mass removal rates.

Additional vapor extraction wells are proposed for the remediation system design. Originally four wells were proposed prior to the VET, however only two were installed.

Groundwater monitoring wells were used as additional extraction points. The screen sections are too large, however, for the wells to be used permanently as extraction points. Additionally, these wells are needed for continued groundwater monitoring.

Three borings will be drilled vertically to approximately 26 feet below surface grade (bsg) in preparation of a vapor extraction well installation (VEW-3A/B/C, VEW-4A/B/C, and VEW-5A/B/C). Drilling will be performed using hollow stem auger equipment with minimum ten-inch diameter augers. Augers will be steam cleaned prior to arriving on site.

Samples will be collected every five feet until water is detected. Soil samples will be collected using a California modified split spoon sampler equipped with brass or stainless steel liners. The split spoon sampler will be cleaned between sampling events.

Soil samples will be field screened using a portable organic vapor analyzer (OVA). A portion of the sample retrieved from each sampling interval will be placed in a plastic zip-lock bag, sealed in the bag for a minimum of ten minutes at 70 degrees Fahrenheit or more, and the OVA probe inserted into the bag to evaluate concentrations of volatile organic compounds (VOCs) in the soil. Soil samples with PID readings over 50 ppm will be submitted to the laboratory for analysis. A minimum of one sample per 15 feet will be submitted regardless.

Samples retained for analysis will be capped with Teflon tape and plastic end caps, and placed in a cooler chest with frozen gel packs ("blue ice") or ice, and maintained at or below four degrees Celsius until delivered to the laboratory. Soil samples and drill cuttings will be described in accordance with the Unified Soil Classification System, visual and manual methods, by qualified personnel. Cuttings will be stored in UN-approved 55 gallon drums and disposed of at a qualified disposal facility after profiling is complete.

Vapor Extraction Well Installation

The vapor extraction wells (VEW-3A/B/C, VEW-4A/B/C and VEW-5A/B/C) will be triple completion wells installed to depths of 9 (A), 21 (B), and 27 (C) feet. The wells will be constructed with two-inch schedule 40 PVC well casing with screw joints. Five or 10 foot screened intervals will be constructed with 0.020" slotted PVC and extend from four to nine feet, 11 to 21 feet, and 22 to 27 feet below grade surface. Blank casing will extend from the top of each screened casing to the ground surface.

Annular materials will be installed through the hollow-stem augers. Annular materials will consist of #3 Monterey Sand or coarser materials extending from the bottom of each well to the top of the screened casing. A one-foot bentonite seal will be placed in between each screened interval. A sand-cement grout will be installed from the top of the shallow seal to the ground surface.

The wells will be completed flush with the surface grade with locking well caps until connected to the system in a traffic rated utility box. The newly installed wells will subsequently be surveyed to the nearest 0.01 feet by a licensed surveyor.

Laboratory Analysis

Soil samples will be analyzed by a California certified laboratory for gasoline-range total petroleum hydrocarbons (TPHg), benzene, toluene, ethylbenzene, and xylenes (BTEX), methyl tertiary butyl ethyl (MTBE), diesel-range total petroleum hydrocarbons (TPHd), di-isopropyl ether (DIPE), ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), tertiary butyl alcohol (TBA), 1,2-dichloroethane (1,2-DCA), and ethylene dibromide (EDB). TPHg will be analyzed using EPA Method 8015M, BTEX and MTBE by EPA method 8021, TPHd by the California LUFT method, and the additional oxygenates by EPA Method 8260b. Additionally, some samples will be analyzed for lead by EPA Method 6010 for disposal purposes.

SYSTEM INSTALLATION

Soil vapor extraction will be performed by use of a skid mounted 250 CFM thermal oxidizer that has the availability to be modified to a catalytic oxidizer once the concentrations decrease. The skid would be mounted to a concrete pad. The stack height would be approximately 13 feet. The system will be contained in a secured fenced compound on the property and in an enclosure to mitigate sound with the approximate dimensions of 12 feet long by 7 feet wide. Three phase power will be installed with a separate electrical panel for the system. A natural gas line will be installed via trenching from the nearest gas utility to meet the gas service company standards. All trenching and utility installations will be approved by the City of Merced. Concrete and metal pillars will be installed around the compound for traffic safety and to meet fire codes.

The extraction wells will be trenched and connected to the system via 2-inch schedule 40 PVC. Extraction wells will be connected with a three-way connector to the system. Each well in the vault will have an individual ball valve connected at the well head with

one line of PVC leading to the system. This will allow for full manipulation of the system once it is operational.

A layout of the system with the trench locations is included as **Figure 2**. Pictures and drawings of the enclosure for the remediation system are included in **Appendix B**.

System Monitoring and Maintenance

Vapor samples will be retained for laboratory analysis at the startup of the system. Field monitoring will be conducted by use of a portable organic vapor analyzer (OVA) and combination of a hot wire air flow measuring device (TSI) and a pitot tube for air flow as required by permit. Any required maintenance will be conducted on the system as needed to retain at minimum a 75% operational rate for the system.

GROUNDWATER REMEDIATION PLAN

A minimum of two injection events of a biological aid, a chemical oxidant, or a combination will be conducted across the site in a transect to eliminate further down gradient migration of the onsite contamination and to help remediate down gradient contamination. The first injection would be performed on the site with a transect injection event in order to assess whether or not further injections would mobilize hazardous metals and to assess how much oxidant is required to treat the remaining concentration levels. It is not likely that they would, as shown from other LOP pilot studies in the city of Merced. During injection, temperature would be monitored. If the oxidant proves to mobilize hazardous metals, then the following injection(s) will be with a biological aid which would not mobilize any metals and would aid in the biological degradation of the residual petroleum hydrocarbons. The injections will be made with a direct push rig in the approximate locations shown on **Figure 2**. The injections will be at the suggested depth of the installer at the time of drilling as it is dependant on water levels. Information regarding the product is included in **Appendix C**.

SCHEDULE AND CLOSING

Permits will be required for the well installation and for the construction of the SVES. Well installations will take place after the permits are received. The system will take approximately two months to construct off-site. Utilities will need to be provided prior to the system being installed. The system should be permitted, installed with the new wells and operational within six months of written approval and pre approval of funding from the Underground Storage Tank Clean-up Fund.

Following the installation of all of the wells, a licensed surveyor will be contracted to survey the wells to GeoTracker standards. The groundwater monitoring wells will be added to the quarterly monitoring program after installation and development.

For questions or additional information, please contact the undersigned at the letterhead address or at (559) 641-7320.

With best regards,
HerSchy Environmental, Inc.

Katherine Lister
Project Geologist

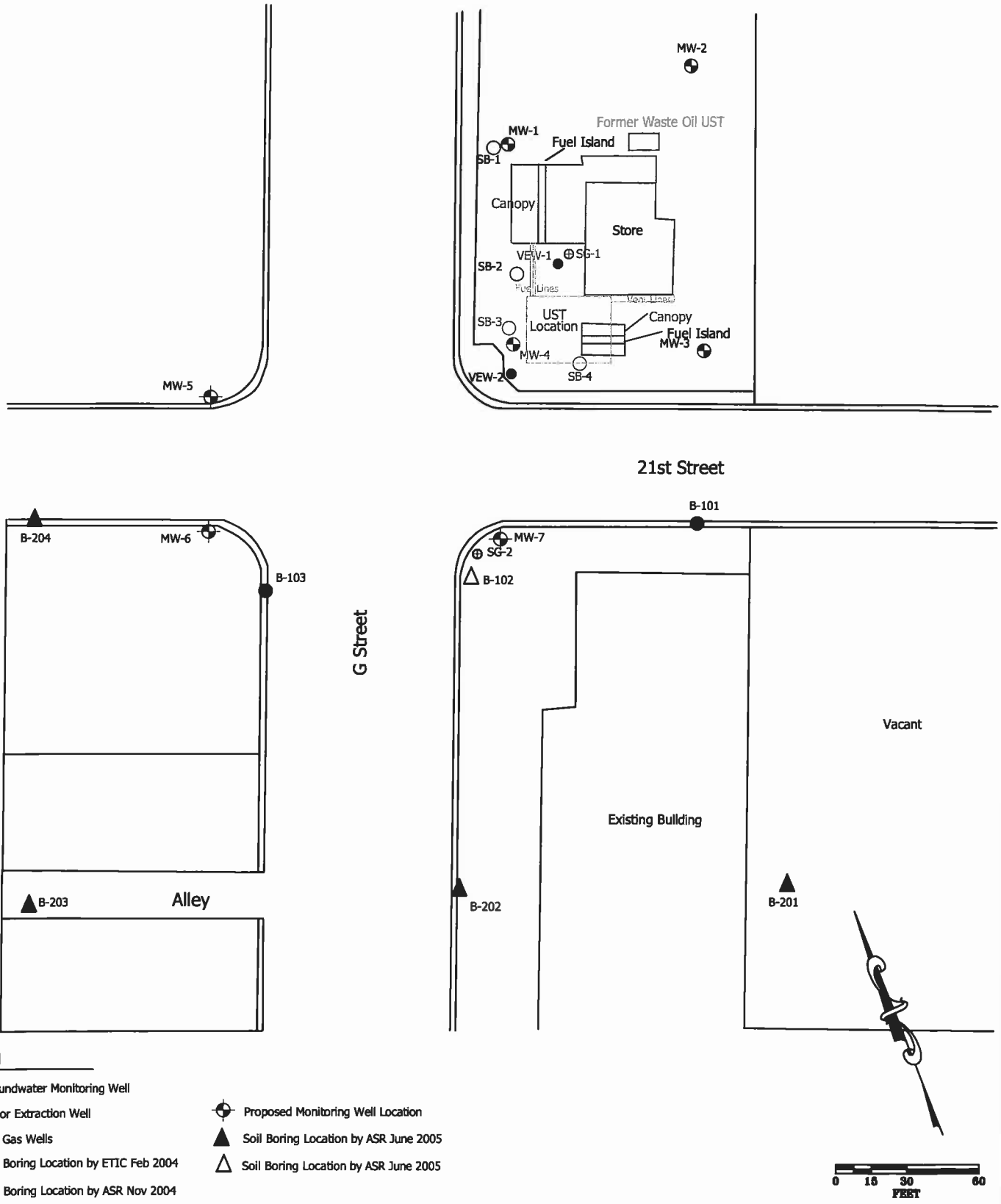
PROFESSIONAL GEOLOGIST
Scott A. Jackson
No. 7948
STATE OF CALIFORNIA

Scott Jackson
Professional Geologist #7948

Figures 1 – Site Map with Proposed Well Locations
2 – System Layout

Appendices
A – December 24, 2008 MCDEH Letter
B – Remediation System Design Plans and Photos
C – Injection Information

cc: Mr. Joel Simmons



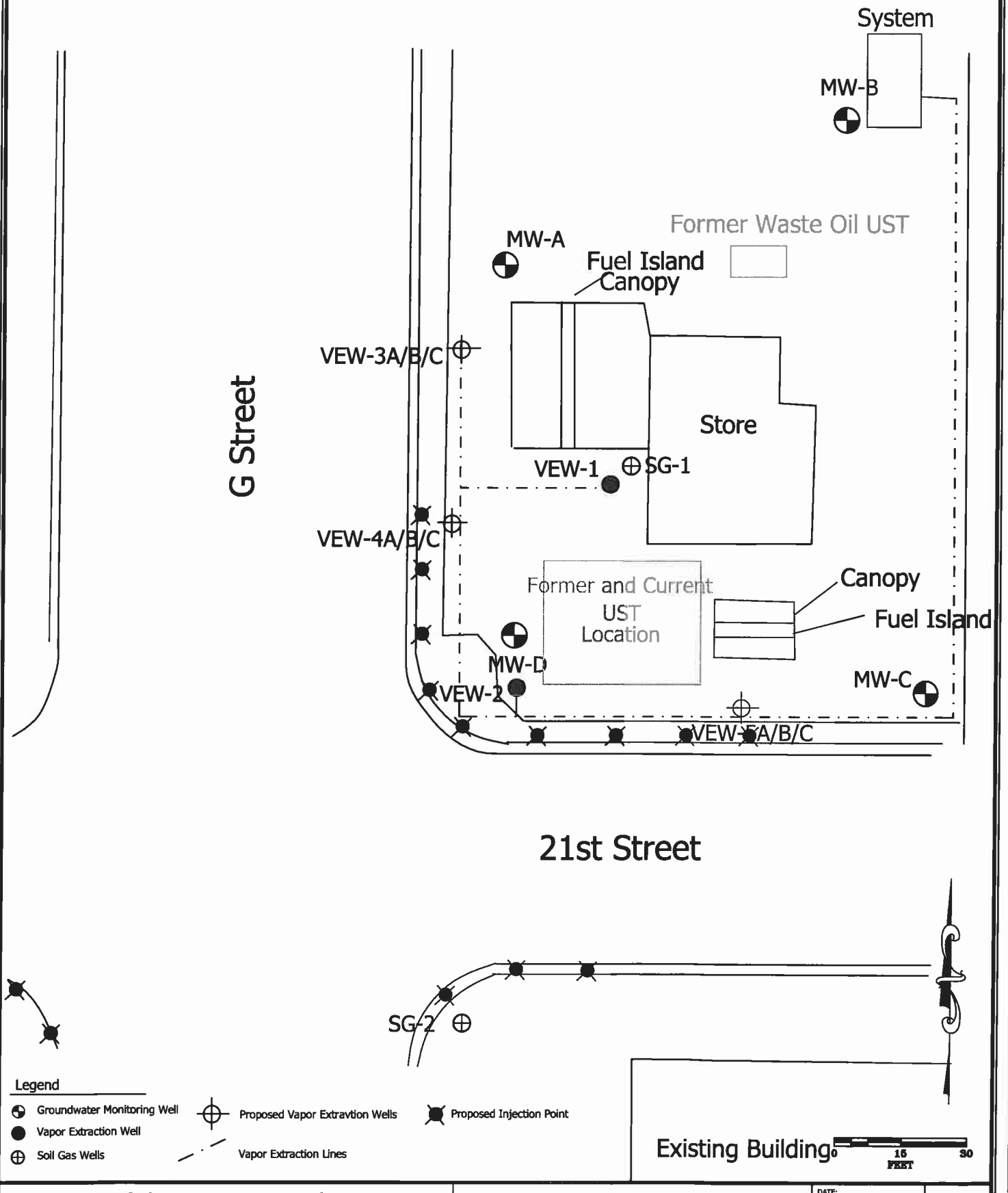
HerSchy Environmental, Inc.
Environmental Consulting and Remediation
P. O. Box 229
Bass Lake, California 93604-0229
Tel. (559) 641-7320, Fax (559) 641-7340

PROPOSED MONITORING WELLS

BARTLETT PETROLEUM GAS-N-GO
2104 G Street, Merced, CA

DATE: January 2009
FILE NO.: B29-01
DRAWN BY: KAL

FIGURE 1



HerSchy Environmental, Inc.
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REMEDIATION DESIGN PLAN

BARTLETT PETROLEUM GAS-N-GO
2104 G Street, Merced, CA

DATE:	January 2009
FILE NO.:	B29-01
DRAWN BY:	KAL

FIGURE 2

APPENDIX A

DECEMBER 24, 2008 MCEHD LETTER

MERCED COUNTY

DEPARTMENT OF PUBLIC HEALTH
Division of Environmental Health

John Volanti, M.P.H.
Director of Public Health

Health Administration
260 E. 15th Street
Merced, CA 95340
(209) 381-1200
(209) 381-1215 Fax

Jeff Palsgaard, M.S.
Director of Environmental Health

Environmental Health
777 W. 22nd Street
Merced, CA 95340
(209) 381-1100
(209) 384-1593 Fax
www.co.merced.ca.us

Equal Opportunity Employer

December 24, 2008

Leon H. Bartlett
P.O. Box 390
Merced, CA 95341

Site: **Former Gas-N-Go, 2104 G Street, Merced, CA 95340; APN# 034-071-014; Local Oversight Program 2404, EAR Site # R02-063**

Subject: ***Final Remediation Plan*** **(FRP) dated November 12, 2008 by HerSchy Environmental Inc.**

Dear Mr. Bartlett,

Thank you for providing the FRP referenced above. Unfortunately, requested information regarding proposed groundwater remediation was not included in the FRP and therefore the RFP is not complete. The following additional information is required:

- The proposed location for MW-5, MW-6, and MW-7 was not provided. Please provide the proposed location of these monitor wells.
- Merced County Division of Environmental Health's (MCDEH's) August 8, 2008 letter in part required:
  - Proposed remedial approach for both soil and groundwater.
  - A description of the remedial technology.
  - Detailed plans for installation of the remediation system.

  Adequate information regarding soil type, contaminant type, and approximate extent currently exists to select a remedial technology. A method of remediation of groundwater contamination in the source area is supported by recent groundwater monitoring data. Historical groundwater concentrations of contaminants of concern in the downgradient direction have decreased. Provide selected detailed information on remedial technology or technologies proposed for site. If pilot or bench scale testing is needed to implement these technologies, provide a detailed description of the proposed testing, schedule, and budgeted cost. Many injection technologies could benefit from limited groundwater pumping to aid in movement of remedial injectables (hydrogen peroxide, oxygen, etc.). If groundwater pumping is to be incorporated into remedial approach, provide detailed description of proposed system.

- The proposed location of the thermal oxidizer is adjacent to residential property. A City of Merced building permit will be required for construction of this remediation system. List design measures intended to comply with noise and fire restrictions for construction of this compound. Attached are fire regulations that will likely apply to the construction of this compound. Provide a detailed design drawing of the equipment compound including location of major equipment and clearance distances. Indicate construction measures planned for noise attenuation (concrete block walls, sound blankets, noise enclosures, etc.).
- Provide information on proposed stack height of thermal oxidizer.

Provide the requested information not later than February 2, 2009.

If you have any questions regarding this matter, please contact me at (209) 381-1075.

Sincerely,

Eric Swenson, P.E.
Civil and Mechanical Engineer
C68836, M23279

Atch
County Fire Vapor Recovery System Requirements, December 2008

cc: (1) Warren Gross, RWQCB, Central Valley Region, 1685 'E' St., Fresno, CA 93726
(2) Kirpal S. Gill, 3460 Station Avenue, Atwater, CA 95301
(3) Katie Lister, HerSchy Environmental Inc., P.O. Box 229, Bass Lake, CA 93604-0229
(4) Joseph Angulo, City of Merced, 678 West 18th St., Merced, CA 95340

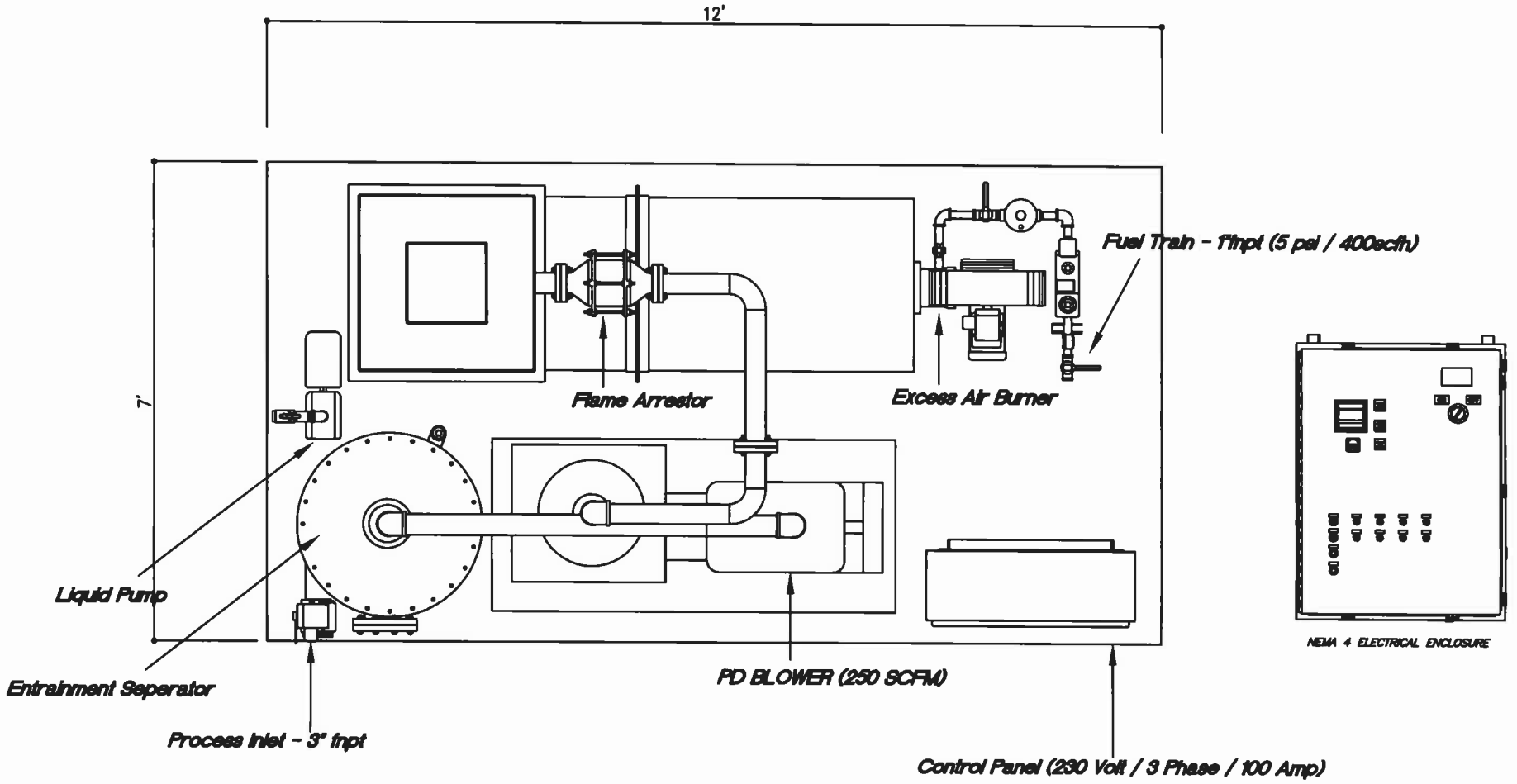
Merced County Fire Department Requirements for Vapor Recovery Systems, December 2008:

1. Not less than 10 feet from buildings or property lines that can be built on.
2. At least 20 feet from dispensing devices.
3. Vent pipes shall terminate at least 12 feet above grade.
4. Vapor-processing units shall be securely mounted on concrete, masonry or structural steel supports on concrete or other noncombustible foundations.
5. As far as site control, fences, bumper post or other control measures so as to prevent tampering or to prevent access, not less than 15 feet.
6. Vapor–processing equipment shall be located at or above grade. Sources of ignition shall be located not less than 50 feet from fuel-transfer areas and not less than 18 inches above tank fill openings and tops of dispenser islands.
7. EXCEPTION: where the required distances to buildings, property lines or fuel-transfer areas cannot be obtained, means shall be provided to protect equipment against fire exposure. Acceptable means include: 1. Approved protective enclosures, which extend at least 18 inches above the equipment, constructed of fire-resistant or non-combustible materials, or 2. Fire protection using an approved water-spray system.

APPENDIX B

REMEDIATION SYSTEM DESIGN PLANS AND PHOTOS

250 MAKOCAT



MAKO INDUSTRIES MFG	
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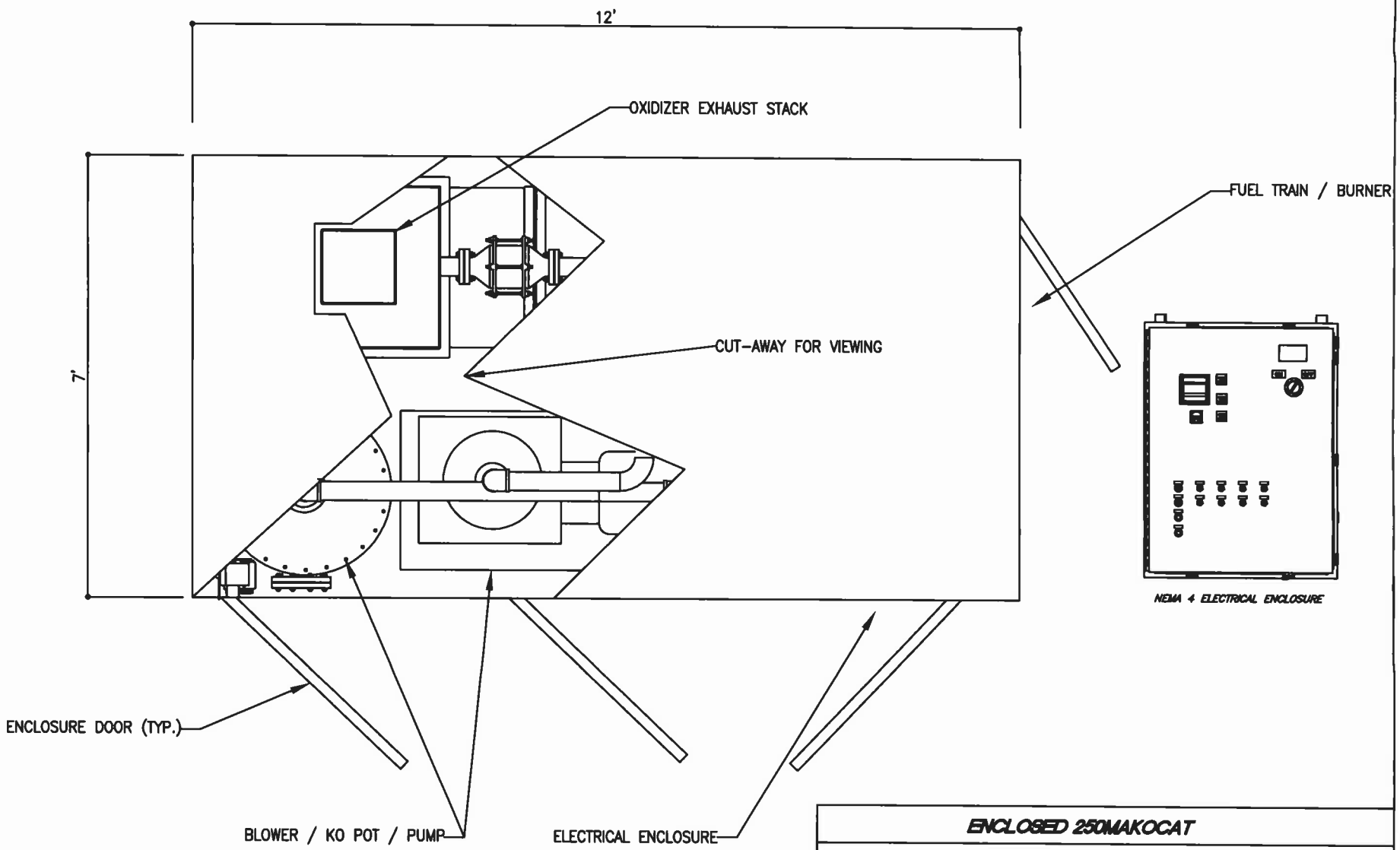
	250MAKOCAT

250 MAKOCATMV



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GENERAL ARRANGEMENT - WITH ENCLOSURE
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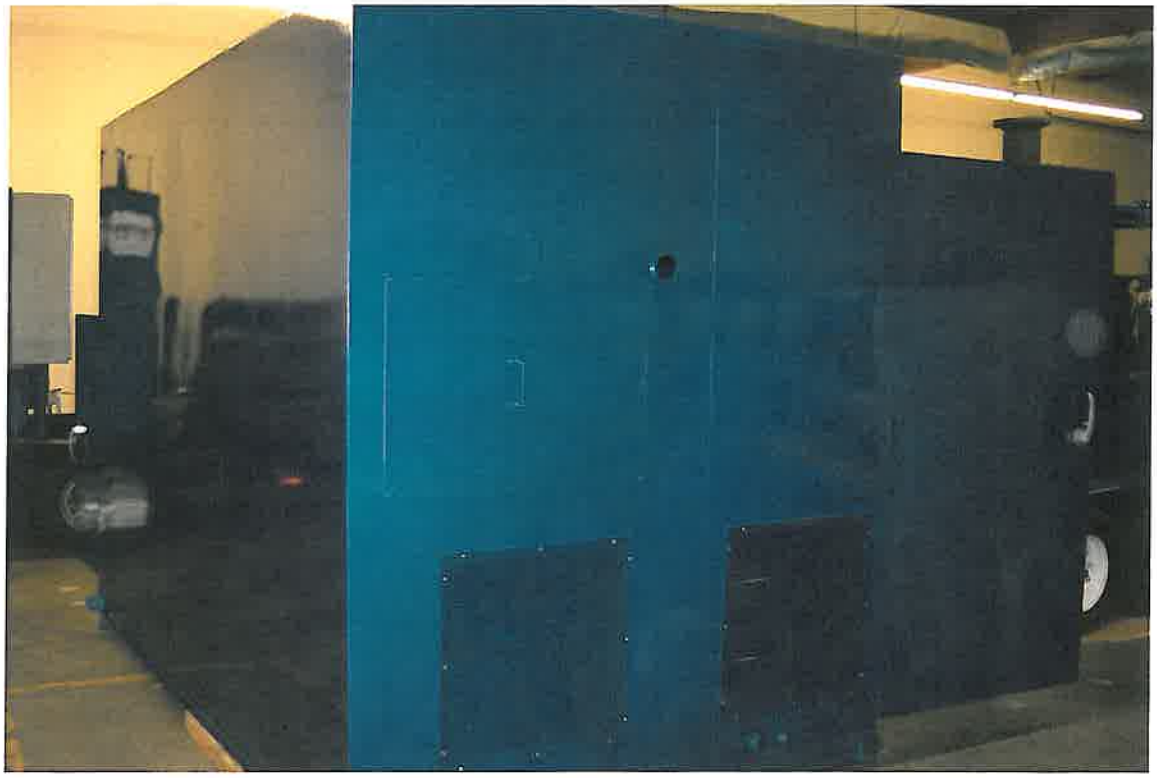
MAKOCAT



APPENDIX C

INJECTION INFORMATION

REGENESIS

February 26, 2007

RegenOx and ORC *Advanced* Simultaneous Application

RegenOx™ is a two part chemical oxidant capable of treating a broad range of soil and groundwater contaminants. RegenOx was designed as an easily handled and applied high-contaminant-concentration mass reduction technology. RegenOx is an aggressive fast acting oxidative technology that can be coupled with a less aggressive slow release technology like Oxygen Release Compound Advanced (ORC *Advanced*) without negative effects on either products contaminant destructive ability or the aquifer/soil geochemistry.

ORC *Advanced*™ is a state-of-the-art innovative product designed to stimulate aerobic bioremediation through controlled release of oxygen within the subsurface. It offers unparalleled, maximum oxygen release for periods up to 12 months on a single injection and is specifically designed to minimize oxygen waste while maximizing contaminant remediation.

Preliminary Aquifer Volume Testing

Prior to application of the RegenOx + ORC *Advanced* material, it is critical that a clear water injection be performed at the site. The injection a non-reactive (clear water) material at a volume that is approximately 25% greater than the anticipated application volume of RegenOx will provide good evidence of the aquifers capacity to accept the designed volume of RegenOx + ORC-*Advanced.*

RegenOx Solution Mixing Calculation

RegenOx s a two part product, the RegenOx Part A is an oxidant and the Part B is an activator. Depending on the relative aquifer capacity (effective pore volume) of the target zone soil matrix a RegenOx solution should be applied as a solution ranging from 3-5% by weight. The volume of water required to make a 3-5% RegenOx solution can be calculated using the formula provided below (a detailed discussion on RegenOx Mixing Instructions is attached).

Volume of water (gallons/vertical foot of injection):

$$\frac{\text{RegenOx Oxidizer lbs/foot}}{(8.34\ \text{lbs/gal water})(\%\ \textit{RegenOx\_Oxidizer}\ \text{solids})}\left[1-(\%\ \textit{RegenOx\_Oxidizer}\ \text{solids})\right]$$

Quick Reference Solution Estimates

- Approximate 3% oxidant solution: 10 lbs of Part A oxidant mixed with 39 gallons of water.
- Approximate 4% oxidant solution: 10 lbs of Part A oxidant mixed with 29 gallons of water.
- Approximate 5% oxidant solution: 10 lbs of Part A oxidant mixed with 23 gallons of water.

1011 CALLE SOMBRA ~ SAN CLEMENTE, CA 92673 ~ TELEPHONE: 949-366-8000 ~ FAX: 949-366-8090

tech@regenesis.com ~ www.regenesis.com

ORC *Advanced* Solutions Mixing Calculation

ORC *Advanced* can be mixed in to a slurry solution ranging from 15-35% by weight with water. This slurry is well documented in the literature. For a detailed discussion of these techniques please see the ORC/ORC *Advanced* mixing instructions available on the Regenesis website (www.regenesis.com).

NOTE: for this coupled technology application we strongly recommend that ORC-A be applied as an amendment to the site specific design volume of RegenOx material. This will ensure that the more reactive RegenOx material is applied in a stable and format that will facilitate optimal oxidative contaminant destruction.

RegenOx + ORC-A Solution Mixing & Application

A solution ranging from 3-5% RegenOx solution can be easily mixed directly together with the recommended quantity of ORC *Advanced* and injected simultaneously as described below:

1. Prepare the site specific designed RegenOx Part A solution (3-5% solution).

2. Open the 5-gallon bucket and remove the pre-measured bag of ORC *Advanced* (each bag contains 25 lbs of ORC *Advanced*).

2. Measure and pour the ORC Advanced powder into the previously prepared RegenOx solution.

3. Use an appropriate mixing device to thoroughly mix the ORC *Advanced* into the RegenOx solution. A hand-held drill with a "jiffy mixer" or a stucco mixer on it may be used in conjunction with a small paddle to scrape the bottom and sides of the container. Standard environmental slurry mixers may also be used, following the equipment instructions for operation.

4. Transfer the contents of the mixing tank to the pump hopper using a gravity drain or a sump pump.

5. For some types of pumps (e.g. piston pumps), it may be desirable to perform a volume check prior to injecting RegenOx/ORC *Advanced.* Determining the volume displaced per pump stroke can be accomplished in two easy steps.

    a) Determine the number of pump strokes needed to deliver 3 gallons of RegenOx/ORC *Advanced* (use a graduated bucket for this)

    b) Divide the resulting 3 gallons by the results from the first step to determine the number of gallons of RegenOx/ORC *Advanced* delivered by each pump stroke.

6. Connect the delivery hose to the pump outlet and the delivery sub-assembly. Circulate RegenOx/ORC *Advanced* through the hose and the delivery sub-assembly to displace air in the hose.

7. Connect the sub-assembly to the drive rod. After confirming that all of the connections are secure, pump the RegenOx/ORC *Advanced* through the delivery system to displace the water/fluid in the rods.

8. Slowly withdraw the drive rods. Commonly RegenOx/ORC *Advanced* injection progress at 1-foot intervals. However, continuous injection while slowly withdrawing single lengths of drive rod (3 or 4 feet) is an acceptable option. The pre-determined volume of RegenOx/ORC *Advanced* should be pumped into the aquifer across the desired treatment interval.

9. Remove one section of the drive rod. The drive rod may contain some residual RegenOx/ORC *Advanced* solution. Place the RegenOx/ORC *Advanced*-filled rod in a clean, empty bucket and allow the RegenOx/ORC *Advanced* to drain. Eventually, the RegenOx/ORC *Advanced* should be returned to the pump hopper for reuse.

10. Observe any indications of aquifer refusal. This is typically indicated by a high-pitched squeal in the pump's hydraulic system or (in the case of shallow applications) RegenOx/ORC *Advanced* "surfacing" around the injection rods or previously installed injection points. At times backpressure caused by gassing will impede pump movement. This can be corrected by bleeding the pressure off using a pressure relief/bypass valve (placed inline between the pump discharge and the delivery sub-assembly) and then resume pumping. If aquifer acceptance appears to be low, allow enough time for the aquifer to equilibrate prior to removing the drive rod.

11. Repeat steps 1 through 11 until treatment of the entire contaminated vertical zone has been achieved. It is recommended that the procedure extend to the top of the capillary fringe/smear zone, or to the top of the targeted treatment interval.

12. Install an appropriate seal, such as bentonite, above the RegenOx/ORC *Advanced* material through the entire vadose zone. Prior to emplacing the borehole seal, we recommend placing clean sand in the hole to the top of the RegenOx/ORC *Advanced* treatment zone (especially important in holes that stay open). Bentonite chips or granular bentonite should be placed immediately above the treatment zone, followed by a cement/bentonite grout to roughly 0.5 feet below ground surface. Quick-set concrete should then be used as a surface seal.

13. Remove and clean the drive rods as necessary.

14. Finish the borehole at the surface as appropriate (concrete or asphalt cap, if necessary). We recommend a quick set concrete to provide a good surface seal with minimal set up time.

15. A proper borehole and surface seal assures that the RegenOx/ORC *Advanced* remains properly placed and prevents contaminant migration from the surface. Each borehole should be sealed immediately following RegenOx/ORC *Advanced* application to minimize RegenOx/ORC *Advanced* surfacing during the injection process. If RegenOx/ORC *Advanced* continues to "surface" up the direct push borehole, an appropriately sized (oversized) disposable drive tip or wood plug/stake can be used to plug the hole until the aquifer equilibrates and the RegenOx/ORC *Advanced* stops surfacing. If wells are used for RegenOx/ORC *Advanced* injection the injection wells and all nearby groundwater monitoring wells should be tightly capped to reduce potential for surfacing through nearby wells.

16. Periodically compare the pre- and post-injection volumes of RegenOx/ORC *Advanced* in the pump hopper using pre-marked volume levels. Volume level indicators are not on all pump hoppers. In

this case, volume level markings can be temporarily added using known amounts of water and a carpenter's grease pencil (Kiel crayon). We suggest marking the water levels in 3-gallon increments.

17. Move to the next probe point, repeating steps 1 through 17. We recommend that the next RegenOx/ORC *Advanced* injection point be as far a distance as possible within the treatment zone from the previous RegenOx/ORC *Advanced* injection point. This will further minimize RegenOx/ORC *Advanced* surfacing and short circuiting up an adjacent borehole. When possible, due to the high volumes of liquid being injected, working from the outside of the injection area towards the center will limit expansion of the plume.

Pump Information

Regenesis has evaluated a number of pumps that are capable of delivering RegenOx/ORC *Advanced* to the subsurface at a sufficient pressure and volumetric rate. Although a number of pumps may be capable of delivering the RegenOx/ORC *Advanced* to the subsurface at adequate pressures and volume, each pump has a set of practical issues that make it difficult to manage in a field setting. In general, Regenesis strongly recommends using a pump with a minimum pressure rating of 200 pounds per square inch (psi) in sandy formations or 800 psi in silt, clay or weathered bedrock formations, and a minimum delivery rate of 5 gallons per minute (gpm). A lower gpm rated pump can be used; however, they are not recommended due to the amount of time required to inject the volume of liquids typically associated with a RegenOx/ORC *Advanced* injection.

Pump Cleaning

For best results, use a hot water pressure washer (150 - 170 °F or 66 - 77 °C) to clean equipment and rods periodically throughout the day. Internal pump mechanisms and hoses can be easily cleaned by circulating hot water and a biodegradable cleaner such as Simple Green through the pump and delivery hose. Further cleaning and decontamination (if necessary due to subsurface conditions) should be performed according to the equipment supplier's standard procedures and local regulatory requirements.

Personal Protective Equipment

Personnel working with or in areas of potential contact with RegenOx/ORC *Advanced* should be required at a minimum to be fitted with modified Level D personal protective equipment:

- Eye protection – Wear well sealed goggles or a face shield (face shield recommended for full face protection)
- Head – Hard hat when required
- Respiratory – Use dust respirator approved by NIOSH/MSA
- Hands – Wear neoprene gloves
- Feet – Wear steel toe shoes with chemical resistant soles or neoprene boots
- Clothing – Wear long sleeve shirts and long pant legs. Consider using a Tyvek® body suit, Carhartt® coverall or splash gear

Typical Installation Equipment

- Direct push rig
- Drive Rods (typically 1 ½-inch O.D.) & Injection Tooling with fluid deliver sub-assembly
- Injection Pump rated for 5 gpm @ 200 psi for sandy formations and 800 psi for silt and clay formations (Geoprobe DP-800, Yamada, Moyno, Rupe Models 9-1500 and 9-1600, Wilden, etc.)
- Injection hosing and a pressure relief valve with a bypass
- Clear hosing between mixing tank/drum and pump
- Pressure gauges
- Power drill paint stirrer (3-inch diameter or smaller propeller tip)
- Plastic bucket lid puller tool/opener tool
- 5-amp sump pump (such as Little Giant) and hose
- Three to four 55-gallon drums or similarly sized mixing tanks for RegenOx and ORC *Advanced* mixing
- Sand, bentonite chips, granular bentonite, cement, hydraulic cement, and quick-set concrete for closing and sealing temporary injection holes
- Wood plugs or similar for temporarily sealing injection holes prior to grout sealing
- Access to water
- Access to electricity

REGENESIS

RegenOx™

CHEMICAL OXIDATION REDEFINED

RegenOx™ *In Situ* Chemical Oxidation Application Instructions

Using Direct-Push Injection (Step-by-Step Procedures)

RegenOx™ is the new generation of chemical oxidation. RegenOx™ is a proprietary (patent-applied-for) *in situ* chemical oxidation process using a solid oxidant complex (sodium percarbonate/catalytic formulation) and an activator complex (a composition of ferrous salt embedded in a micro-scale catalyst gel). RegenOx™ with its catalytic system has very high activity, capable of treating a very broad range of soil and groundwater contaminants including both petroleum hydrocarbons and chlorinated solvents.

Instructions

1) Prior to the installation of RegenOx™, any surface or overhead impediments should be identified as well as the location of all underground structures. Underground structures include but are not limited to utility lines; tanks; distribution piping; sewers; drains; and landscape irrigation systems. The planned installation locations should be adjusted to account for all impediments and obstacles. These considerations should be part of the SSHP or HASP.

2) Pre-mark the installation locations, noting any points that may have different vertical application requirements or total depth.

3) Set up the direct push unit over each point and follow the manufacturer standard operating procedures (SOP) for the direct push equipment. Care should be taken to assure that probe holes remain in the vertical.

4) For most applications, Regenesis suggests using 1.5-inch O.D./0.625-inch I.D drive rods. However, some applications may require the use of 2.125-inch O.D./1.5-inch I.D. or larger drive rods.

5) Advance drive rods through the surface pavement, as necessary, following SOP.

6) Push the drive rod assembly with an expendable tip to the desired maximum depth. Regenesis suggests pre-counting the number of drive rods needed to reach depth prior to starting injection activities.

7) After the drive rods have been pushed to the desired depth, the rod assembly should be withdrawn three to six inches. Then the expendable tip can be dropped from the drive rods, following SOP. If an injection tool was used instead of an expendable tip, the application of material can take place without any preliminary withdrawal of the rods.

8) In some cases, introduction of a large column of air prior to RegenOx™ application may be problematic because the air can block water flow to the treatment area. This is particularly the case in deep injections (>50 ft) with large diameter rods (>1.5-inch O.D.). To prevent the injection of air into the aquifer during RegenOx™ application, as well as to prevent problems associated with heaving sands, fill the drive rods with water, or the RegenOx™ mixture prior dropping the expendable tip or exposing the injection tool.

9) The RegenOx™ percent of the oxidizer in solution should range between 3% to 5%. Although solutions up to 8% may be used, this will likely increase the difficulty of injection due to reactivity. Solutions with greater than 8% oxidizer in solution will result in excess reaction and flocculation prior to injection and are not typically recommended

   Measure the appropriate quantity of RegenOx™ Oxidizer for one to four vertical foot of injection into a 55 gallon drum or mixing tank. The volume of water per injection location can be calculated from the following formula:

$$\frac{\text{RegenOx Oxidizer lbs/foot}}{(8.34\ \text{lbs/gal water})(\%\ RegenOx\_Oxidizer\ \text{solids})}\left[1-(\%\ RegenOx\_Oxidizer\ \text{solids})\right]$$

   Tighter formations (clays and silts), and even some fine sand formations will likely require higher oxidant percentages since less volume can be injected per location. The following are guides to various RegenOx™ mixing ratios based on the above equation.

   - to make a roughly 3% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx™), use 38 gallons of water.
   - to make a roughly 4% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx™), use 28 gallons of water.
   - to make a roughly 5% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx™), use 22 gallons of water.

10) Pour the pre-measured quantity of RegenOx™ Oxidizer into the pre-measured volume of water to make the desired target % oxidant in solution. NOTE: always pour the Oxidizer into water, do not pour water into the Oxidizer. Mix the water and oxidant with a power drill and paint stirrer or other mechanical mixing device to ensure that the Oxidizer has dissolved in the water.

11) Pour the applicable quantity of the pre-mixed RegenOx™ Activator into the oxidant:water solution. Mix the Oxidant and Activator using a power drill paint stirrer or other mechanical mixing device for at least 5 minutes until a homogenous mixture is formed. After mixing the RegenOx™ mixture should be injected into the subsurface as soon as possible.

12) Do not mix more RegenOx™ material than will be used over roughly 1 to 4 feet of injection so as to minimize potential above ground reaction/flocculation prior to injection.

    Transfer the contents of the mixing tank to the pump using gravity feed or appropriate transfer pump. (See Section 9.2: Pump Selection) For some types of pumps, it may be desirable to perform a volume check prior to injecting RegenOx™

13) Connect the delivery hose to the pump outlet and the delivery sub-assembly. Circulate RegenOx™ though the hose and the delivery sub-assembly to displace air in the hose. NOTE: an appropriately sized pressure gauge should be placed between the pump outlet and the delivery sub-assembly in order to monitor application pump pressure and detect changes in aquifer backpressures during application.

14) Connect the sub-assembly to the drive rod. After confirming that all of the connections are secure, pump the RegenOx™ through the delivery system to displace the water/fluid in the rods.

15) Slowly withdraw the drive rods. Commonly RegenOx™ injection progress at 1-foot intervals. However, continuous injection while slowly withdrawing single lengths of drive rod (3 or 4 feet) is an acceptable option. The pre-determined volume of RegenOx™ should be pumped into the aquifer across the desired treatment interval.

16) Remove one section of the drive rod. The drive rod may contain some residual RegenOx™. Place the RegenOx™-filled rod in a clean, empty bucket and allow the RegenOx to drain. Eventually, the RegenOx™ should be returned to the RegenOx™ pump hopper for reuse.

17) Monitor for any indications of aquifer refusal. This is typically indicated by a spike in pressure as indicated or (in the case of shallow applications) RegenOx™ "surfacing" around the injection rods or previously installed injection points. At times backpressure caused by reaction off-gassing will impede the pumps delivery volume. This can be corrected by bleeding the pressure off using a pressure relief/bypass valve (placed inline between the pump discharge and the delivery sub-assembly) and then resume pumping. If aquifer acceptance appears to be low, as indicated by high back pressure, allow sufficient time for the aquifer to equilibrate prior to removing the drive rod.

18) Repeat steps 13 through 23 until treatment of the entire contaminated vertical zone has been achieved. It is recommended that the procedure extend to the top of the capillary fringe/smear zone, or to the top of the targeted treatment interval.

19) Install an appropriate seal, such as bentonite, above the RegenOx™ material through the entire vadose zone. Prior to emplacing the borehole seal, we recommend placing clean sand in the hole to the top of the RegenOx™ treatment zone (especially important in holes that stay open). Bentonite chips or granular bentonite should be placed immediately above the treatment zone, followed by a cement/bentonite grout to roughly 0.5 feet below ground surface. Quick-set concrete should then be used as a surface seal.

20) Remove and clean the drive rods as necessary.

21) Finish the borehole at the surface as appropriate (concrete or asphalt cap, as needed). We recommend a quick set concrete to provide a good surface seal with minimal set up time.

22) A proper borehole and surface seal assures that the RegenOx™ remains properly placed and prevents contaminant migration from the subsurface. Each borehole should be sealed immediately following RegenOx™ application to minimize RegenOx™ surfacing during the injection process. If RegenOx™ continues to "surface" up the direct push borehole, an appropriately sized (oversized) disposable drive tip or wood plug/stake can be used to plug the hole until the aquifer pressures equilibrates and the RegenOx™ stops surfacing. If wells are used for RegenOx™ injection the RegenOx™ injection wells and all nearby groundwater monitoring wells should be tightly capped to reduce potential for surfacing through nearby wells.

23) Periodically compare the pre- and post-injection volumes of RegenOx™ in the holding tank or pump hopper using the pre-marked volume levels. Volume level may not be present on all tanks or pump hoppers. In this case, volume level markings can be temporarily added using known amounts of water and a carpenter's grease pencil (Kiel crayon).

24) Move to the next probe point, repeating steps 8 through 29. We recommend that the next RegenOx™ injection point be as far a distance as possible within the treatment zone from the previous RegenOx™ injection point. This will further minimize RegenOx™ surfacing and short circuiting up an adjacent borehole. When possible, due to the high volumes of liquid being injected, working from the outside of the injection area towards the center will limit expansion of the plume.

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Pump Selection

Regenesis has evaluated a number of pumps and many are capable of delivering RegenOx™ to the subsurface at a sufficient pressure and volumetric rate. However, even though a number of the evaluated pumps may be capable of delivering the RegenOx™ to the subsurface based on adequate pressures and delivery rates, each pump has its own set of practical issues that may make it more or less difficult to manage in a field setting.

In general, Regenesis strongly recommends using a pump with a pressure rating of 200 pounds per square inch (psi) in sandy soil settings, and 800 psi in silt, clay or weathered bedrock settings. Any pump under consideration should have a minimum delivery rate of 5 gallons per minute (gpm). A lower gpm rated pump may be used; however, they are not recommended due to the amount of time required to inject the volume of liquids typically associated with a RegenOx™ injection (i.e. 1,000 lbs of RegenOx™ [500 lbs Oxidant/500 lbs Activator] require roughly 1,100 gallons of water to make a 5% Oxidant solution).

Quite often diaphragm pumps are used for the delivery of chemical oxidants. Generally, these pumps operate pressures from 50-150 psi. Some of these pumps do not have the pressure head necessary to overcome the back pressure encountered in silt and clay lenses. In these cases the chemical oxidant thus ends up being delivered to the surrounding sands (the path of least resistance) and is not delivered to soil with residual adsorbed contamination. The use of a positive displacement pump such as a piston pump or a progressing cavity pump is may be superior because these pumps have the pressure necessary to overcome the resistance of low permeability soils. NOTE: be aware that application at pressures that are too high may over-consolidate the soil and minimize the direct contact of the oxidant. The key is to inject at a rate and pressure that maximizes the radius of influence without causing preferential flow. This can be achieved by injecting at the minimum pressure necessary to overcome the particular pressures associated with your site soil conditions.

Whether direct injection or wells are used, it is best to start by injecting RegenOx™ outside the contaminated area and spiral laterally inwards toward the source. Similarly, RegenOx™ should be applied starting vertically at the bottom elevation of contamination, through the layer of contamination, and a couple of feet above the layer of contamination. The reagents can be pushed out from the well bore with some water.

Pump Cleaning

For best results, flush all moving parts and hoses with clean water at the end of the day; flush the injection system with a mixture of water and biodegradable cleaner such as Simple Green.

For more information or technical assistance please call Regenesis at 949-366-8000