KAWAHARA NURSERY
INCORPORATED

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Alameda County
Environmental Health

March 7, 2008

Mr. Steven Plunkett
Alameda County Health Care Services Agency
Environmental Protection Division
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

Re: Perjury Statement
Kawahara Nursery, 16550 Ashland Avenue, San Lorenzo, California; RO-291

Dear Mr Plunkett,

"I declare under penalty of perjury, that the information and / or recommendations contained in the attached proposal or report is true and correct to the best of my knowledge."

John T. Kawahara

John Kawahara, President

GROWERS AND WHOLESALERS OF BEDDING PLANTS
698 Burnett Avenue, Morgan Hill, California 95037 • Telephone 408/779-2400 • Fax 408/779-6850

Corrective Action Plan
For Source Soil Excavation and Dewatering

Kawahara Nursery
16550 Ashland Avenue
San Lorenzo, California
ACDEH Fuel Leak Case No. RO0000291

February 1, 2008
BEI Job No. 94015

Prepared for:

Kawahara Nursery
16550 Ashland Avenue
San Lorenzo, California

Prepared by:

Blymyer Engineers, Inc.
1829 Clement Avenue
Alameda, CA 94501-1395
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Limitations

Services performed by Blymyer Engineers, Inc. have been provided in accordance with generally accepted professional practices for the nature and conditions of similar work completed in the same or similar localities, at the time the work was performed. The scope of work for the project was conducted within the limitations prescribed by the client. This report is not meant to represent a legal opinion. No other warranty, expressed or implied, is made. This report was prepared for the sole use of the client, the Kawahara Nursery.

Blymyer Engineers, Inc.

By: ______________________

Mark E. Detterman, CEG
Senior Geologist

PROFESSIONAL GEOLOGIST
MARK E. DETTERMAN
No. 1788
CERTIFIED
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STATE OF CALIFORNIA

And: ______________________

Michael S. Lewis, REA
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1.0 Background

The following Corrective Action Plan (CAP) provides additional details to implement corrective actions in order to remove hydrocarbon-impacted unsaturated and saturated soil, and to capture and treat impacted-groundwater as recommended in the *Remedial Action Plan* dated September 10, 2001. Added details were verbally requested by Mr. Steven Plunkett of the Alameda County Environmental Health Department (ACEHD) in a series of telephone conversations between February and April 2007.

Petroleum hydrocarbons have been detected in two areas at the site. A northern area with gasoline hydrocarbon related impacts and a southern area with diesel hydrocarbon related impacts. Both appear to have been associated with former underground storage tank (UST) locations in the vicinity of the discoveries. This CAP focuses only on the northern gasoline UST area at the site. The ACEHD has previously accepted use of a Soil Management Plan for the southern diesel hydrocarbon UST (*Modification of Remedial Action Plan*, dated March 8, 2004, as approved in an email communication from Ms. Eva Chu, dated March 24, 2004). Contaminants of concern at the northern gasoline UST location at the site include Total Petroleum Hydrocarbons (TPH) as gasoline, benzene, toluene, ethylbenzene, and total xylenes (BTEX), and methyl tert-butyl ether (MTBE) in soil and groundwater.

Remedial goals were previously defined by the generation of a Health Risk Assessment (*ASTM RBCA Health Risk Assessment*, dated October 11, 2002); however, with the promulgation of the San Francisco Bay Regional Water Quality Control Board's (RWQCB) Environmental Screening Levels (ESLs), lower nuisance concentrations for petroleum hydrocarbons were established, and at that time the ACEHD adopted a policy that required these nuisance concentrations be achieved in corrective actions. The Health Risk Assessment generated for the site is now dated. Consequently the corrective action goals for soil will be consistent with current ESLs. The most recent revision of the ESLs (November 2007) have been incorporated into Table VI.

The implementation of the CAP should significantly reduce hydrocarbon impacts at the site. The actions described in the CAP should provide both the fastest method and the most cost-effective approach to alleviate environmental conditions at the site (Figures 1 to 3). For further background details please see the most recent quarterly report, *Semiannual Groundwater Monitoring Report, Fall 2007*, dated December 12, 2007.

2.0 Project Planning and Design

This task will involve the development of necessary plans, obtaining necessary permits, and generating project design calculations to implement the CAP.

2.1.1 Plans and Permits

2.1.1 Plans

Necessary plans include:

1. An excavation or grading plan and Best Management Practices (BMPs) for storm water pollution prevention are required by the County of Alameda (County) to permit the excavation. These plans will be generated and submitted to the County by the selected corrective action contractor (CAC).

2. A Health and Safety Plan (HASP) that lists contaminants of concern and details appropriate site-specific safety measures for the project-related work, including personal protective equipment, and monitoring to be implemented to protect workers. The CAC will be responsible for generation of this plan for all of its site workers and subcontractors. Blymyer Engineers will operate under a separate HASP, as it will not be a subcontractor to the CAC. The Blymyer Engineers HASP will incorporate an Air Monitoring Plan.

3. A Dust Control Contingency Plan is not anticipated to be required due to the clayey nature of the soil; however, a water hose shall be present at the site for suppression of dust with sprays of water should significant dust be generated. Additional dust suppression measures may include:

   a. Haul trucks shall be covered, or shall maintain at least 2 feet of freeboard,

   b. Restrict non-essential traffic to offsite pavement,

   c. Limit vehicle speeds to 5 miles per hour on the unpaved site,

   d. Minimize drop heights while loading trucks, and

   e. Cover soil stockpiles.

2.1.2 Permits

Prior to the beginning of the project all necessary permits will be obtained. Required permits will include:

1. A POTW permit for the discharge of treated groundwater to the sanitary sewer system. This permit will be obtained by the CAC.
2. An Alameda County Public Works Agency (ACPWA) well destruction permit for well MW-3, which is located inside the planned excavation area, and a well construction permit for the 2-inch diameter vadose well to be installed in the center of the resulting excavation, will be obtained. Blymyer Engineers will obtain these permits.
3. A Bay Area Air Quality Management District (BAAQMD) permit will be obtained for the off-gassing of volatile organic compounds (VOCs) from soil stockpiles and the open excavation. This permit will be obtained by the CAC.

2.1.3 Utility Location

An onsite utility survey must be performed by the CAC to locate any possible known or unknown utility lines. An onsite water line was previously located and is reported to supply the residence. This line will need to be relocated by the CAC to insure continuous supply of water to the residence. Other utilities are known to service the residence as well. Underground Service Alert (USA), 1-800-227-2600, will be notified at least 48 hours prior to the start of construction activities.

2.1.4 Excavation Design

Four areas have been designated for excavation (Area A) or exploration (Areas B through D):

Area A: Elevated hydrocarbon concentrations in soil and a tank-like magnetic anomaly are located in this area. The remedial excavation will have dimensions of approximately 30 feet by 30 feet by 16 feet in depth (Figure 3). The CAC will be responsible for ensuring the safety of all adjacent structures, and for providing a safe working environment. Blymyer Engineers anticipates that portions of the excavation may require support by sheet piles and bracing. Should sheetpiles be selected, a starter trench should be installed that outlines the perimeter of the excavation, and reviewed by the site engineer prior to driving sheetpiling. The shoring and bracing details will be reviewed by a qualified professional engineer retained by the CAC to ensure the shoring will withstand earth pressures.

Areas B through D: These areas are located over suspect concrete pads or magnetic anomalies of undetermined origin. Exploration by excavation will occur in each of these areas. The maximum dimensions of Area B are anticipated to be approximately 30 feet by 10 feet by 5 feet in depth. The maximum dimensions of Area C are anticipated to be in the range of approximately 10 feet by 10 feet by 5 feet in depth. The maximum dimensions of Area D are anticipated to be in the range of approximately 10 feet by 5 feet by 5 feet in depth.

3.0 Excavation Dewatering

Dewatering of the excavation area and surrounding saturated soil will likely be required. Groundwater will be lowered to below the planned 16-foot bgs depth of excavation. The CAC will be required to obtain a POTW permit prior to pumping, treating and discharging groundwater from the excavation. At a minimum, two 20,000-gallon storage tanks will be maintained onsite during excavation activities, unless otherwise demonstrated to be unnecessary. Appropriate water treatment equipment will include, at a minimum, a settling tank, particulate filters and liquid-phase activated carbon.

4.0 Excavation and Stockpiling

4.1 Excavation

Excavation and removal of soil will be performed by the CAC, which will be a California-licensed contractor with a hazardous substance certification. The estimated volume of soil to be removed, based on excavation boundaries, is approximately 615 cubic yards, in-place. All workers on site, and visitors to the site, will observe OSHA safety standards and follow an approved HASP that addresses safety issues for workers conducting or overseeing the work, including equipment operation, and sampling. Air monitoring will be performed by Blymyer Engineers during soil excavation activities in accordance with the Air Monitoring Plan.

4.1.1 Excavation Confirmation Soil Samples

Sidewall and excavation bottom soil samples will be collected to document the extent of removal laterally and vertically, where possible. Two soil samples, each representing one half of the 900-square-foot Area A excavation, will be authoritatively collected from the base of the excavation, and analyzed for TPH as gasoline by Modified EPA Method 8015; BTEX, MTBE, other fuel oxygenates, and lead scavengers by EPA Method 8260B; and total lead by Method SW 7010. These two soil samples will be collected at the location of currently known impacted soil to document removal. Additionally one bottom soil sample from Areas B, C, and D will be collected from each excavation. Sidewall samples will be collected at approximately 20-foot intervals from all excavations, and authoritatively biased towards impacted soil. Use of sheetpile shoring would preclude sidewall sampling in those areas of use.

4.2 Stockpiling

Excavated soil should be stockpiled as close to the areas of excavation. Due to the need for the dewatering of deeper soils in Area A, these soils will be stockpiled adjacent to the excavation in order to control and funnel any runoff. Stockpile size is planned to average approximately 150 cubic yards. Each soil stockpile will be field screened to test gross VOC content in soils. Available TPH as gasoline and BTEX soil results indicate that the upper five to ten feet of soil is relatively clean, and this soil may be separated, profiled, and re-used for backfill or spread onsite, if approved by regulators. Waste characterization will observe standard industry protocols. Impacted soil will be stockpiled in a Visqueen plastic lined, bermed staging area prior to disposal. The soil stockpiles will be covered at the end of each working period to minimize dust and odor that might be liberated from the stockpile. Water-laden excavated soil will be stockpiled in an adjacent bermed area covered with a lining of Visqueen plastic. A temporary ditch may be excavated for the stockpile water to drain back into the excavation. Alternatively a low point will be constructed in the bermed area, and a sump pump will be used to remove the stockpile water and will discharge to either the remedial excavation, or preferably to the aboveground storage and treatment tanks, depending on practicality.

5.0 Waste Characterization

5.1 Extracted Groundwater

After soil excavation activities are completed, or the aboveground storage tanks reach capacity, a confirmation grab groundwater sample will be collected after the treatment unit to confirm concentrations are within POTW-defined discharge limits. Analysis shall conform to the POTW-required analytical program, but will at a minimum include TPH as gasoline by Modified

EPA Method 8015, and BTEX, and MTBE and the other fuel oxygenates and lead scavengers by EPA Method 8260B.

5.2 Excavated Soil

After the soil stockpiles are completed, discrete soil samples will be collected from each stockpile for analysis for the purpose of waste characterization.

1. Non-impacted near surface soil may be considered for reuse at the site. Characterization of soil stockpiles for reuse onsite will conform to the draft *Characterization and Reuse of Petroleum Hydrocarbon Impacted Soil as Inert Waste* issued by the RWQCB on October 20, 2006, as an Interim Final document.

    a. This document excludes reuse of Petroleum Hydrocarbon Impacted Soil (PHIS) within 5 feet of groundwater or 100 feet from a surface water body, requires protection against 100-year peak stream flows, requires a minimum 3-foot burial, requires an erosion-resistant cap (compacted soil, rock, asphalt, concrete), and requires property owner acknowledgement. Consequently, PHIS could be reused at the site between the depths of 3 to 7 feet bgs; however, should granular backfill be used between the depths of 16 to 6 feet bgs, reuse of PHIS would effectively be rendered inappropriate (Section 7.0). The hydrocarbon concentrations in reused soil will not be over the generic RWQCB ESLs.

    b. Soil suspected of being free of contamination will be sampled at an interval of one discrete soil sample for every 25 cubic yards of soil up to a maximum of 500 cubic yards, and then one sample for every 100 yards thereafter, and will be analyzed for TPH as gasoline by Modified EPA Method 8015, BTEX, MTBE, and other fuel oxygenates by EPA Method 8260B, and total lead by Method SW 7010.

    c. Soil documented to be free of contamination, as demonstrated in accordance with the draft PHIS document may be reused onsite.

2. Stockpiled PHIS will otherwise conform to landfill specifications for acceptance.

6.0 PHIS Removal and Disposal

Stockpiled soil will be profiled and profile data will be transmitted to the identified landfill for acceptance. Stockpiled soil will be loaded onto dump trucks and transported to the landfill for disposal. Dust control by wetting with water will be performed as necessary based on air monitoring measurements and physical conditions. Loaded trucks will move to a truck decontamination station, where soil will be removed from fenders and tires and the bed will be covered. Dump truck trays shall be lined with Visqueen plastic and either burrito-wrapped or tarped, for transport to the selected landfill. A signed waste manifest or bill of lading must accompany impacted soil from the site to landfill.

7.0 Excavation Backfill and Compaction

To provide suitable permeability for the Oxygen Releasing Compound (ORC) application, crushed rock, drain rock, or pea gravel is required for backfill to one-foot above the saturated zone of the excavation. Dimensions of drain rock will not exceed 3/4" by 1-1/2". The rock backfill will be augmented with 750 pounds of ORC slurry and bio-nutrients. The rock will be wetted and compacted due to a higher potential for settlement related to the heavy traffic load on the adjacent freeway. A geotextile fabric, Mirafi 500 or equivalent, will be placed on top of the rock. A minimum of six feet of soil will be placed in six-inch lifts to surface grade. The soil will be compacted to at least 90% relative density, and compaction testing results will be documented by an independent authority retained by the CAC. The disturbed areas will be resurfaced with like materials.

8.0 Application of ORC and Bio-Nutrients

8.1 Application of ORC

The contractor will purchase and apply the ORC material. REGENESIS software indicates that approximately 750 pounds of ORC should be introduced to the excavation. The ORC material will be mixed into the excavation backfill, below the level of groundwater, according to REGENESIS excavation mixing specifications (Appendix A). Specifically, the ORC will be mixed as slurry (at approximately 50% solids) into the selected backfill under the REGENESIS "Type 1" scenario. The resulting thick slurry allows the material to remain in place at depth once mixed into the backfill below groundwater in order to deliver oxygen to groundwater.

8.2 Application of Bio-Nutrient Package

If site conditions indicate that bio-nutrients are required by the subsurface microbes at the site, Blymyer Engineers will apply a nitrogen-phosphorous-potassium (NPK) bio-nutrient package. In order to determine if NPK are required, groundwater will be sampled and analyzed for background levels of NPK in groundwater at the site. If required, the NPK fertilizer will be mixed with the ORC slurry to provide bio-nutrient compounds to facilitate bacterial activity. The ratios of NPK will be determined by the method outlined in the April 2003 *Pollution Engineering* article entitled *Bionutrient Modeling for Design of In-Situ Bioremediation* (Appendix B). Full details will be provided prior to corrective actions.

9.0 Installation of 2-Inch-Diameter Monitoring Well

The contractor will install a groundwater monitoring well at the approximate location of the geophysical anomaly in order to monitor residual impact to groundwater, and to monitor contaminant concentration trends. Blymyer will obtain the required well construction permit from the ACPWA. The well will be installed at the time of backfilling and will be 2-inches in diameter, 16 feet in depth, and the screened casing will contain 0.010-inch perforations from 6 to 16 feet bgs. A minimum 8-inch diameter double casing will be used to encase the upper 5 feet of the well to provide a surface seal as required by the state. The lower approximately 2.5 feet of that seal will be hydrated bentonite clay, and the upper approximately 2.5 feet will be cement surrounding a surface-completed well box. These construction details have been approved by email from Mr. James Yoo at the ACPWA (February 7, 2007).

10.0 Reporting

After completion of field activities, and receipt of final documentation for disposal of the excavated soil and other wastes, a report will be prepared for submission to ACDEH. The report will include descriptions of field methods, observations, monitoring, and disposal documentation of excavated soil and other waste materials. Field and laboratory data will be tabulated as appropriate. Copies of appropriate documentation, including field and laboratory report data sheets, manifests or bills of lading, and permits, will be included.

11.0 Quarterly Groundwater Monitoring

Groundwater monitoring will convert to quarterly monitoring in order to monitor chemical trends at the site, and will continue uninterrupted through corrective action activities. To achieve final site closure, a period of groundwater monitoring, typically a minimum of four quarters after completion of remedial activities, is generally required. Should contaminant concentrations be reduced below regulatory acceptable levels or show a declining trend, then site closure may be achieved through the risk-based corrective action (RBCA) approach.

Tables

Table I, Summary of Groundwater Elevation Measurements BEI Job No. 94015, Kawahara Nursery, Inc. 16550 Ashland Avenue, San Lorenzo, California				
Well ID	Date	TOC Elevation (feet)	Depth to Water (feet)	Water Surface Elevation (feet)
MW-1	6/16/1993	100.00 *	10.7	89.3
	3/24/1994		11.11	88.89
	3/28/1994		11.26	88.74
	11/22/1994		12.04	87.96
	3/29/1995		7.26	92.74
	6/7/1995		8.67	91.33
	9/7/1995		10.56	89.44
	3/4/1999		Not Measured	Not Measured
	6/29/1999		8.81	91.19
	11/15/1999		Destroyed	Destroyed
	5/22/2000		Destroyed	Destroyed
	8/16/2000		Destroyed	Destroyed
	11/16/2000		Destroyed	Destroyed
	2/21/2001		Destroyed	Destroyed
	5/31/2001		Destroyed	Destroyed
	11/28/2001		Destroyed	Destroyed
	5/28/2002		Destroyed	Destroyed
	11/14/2002		Destroyed	Destroyed
	5/23/2003		Destroyed	Destroyed
	11/24/2003		Destroyed	Destroyed
	5/13/2004		Destroyed	Destroyed
	11/23/2004		Destroyed	Destroyed
	5/17/2005		Destroyed	Destroyed
	11/16/2005		Destroyed	Destroyed
	5/23/2006		Destroyed	Destroyed
	11/15/2006		Destroyed	Destroyed
	5/31/2007		Destroyed	Destroyed
	11/28/2007		Destroyed	Destroyed

Table I, Summary of Groundwater Elevation Measurements BEI Job No. 94015, Kawahara Nursery, Inc. 16550 Ashland Avenue, San Lorenzo, California				
Well ID	Date	TOC Elevation (feet)	Depth to Water (feet)	Water Surface Elevation (feet)
MW-2	6/16/1993	99.27 *	10.24	89.03
	3/24/1994		10.65	88.62
	3/28/1994		10.79	88.48
	11/22/1994		11.58	87.69
	3/29/1995		6.93	92.34
	6/7/1995		8.36	90.91
	9/7/1995		10.18	89.09
	3/4/1999		6.95	92.32
	6/29/1999		8.52	90.75
	11/15/1999		Destroyed	Destroyed
	5/22/2000		Destroyed	Destroyed
	8/16/2000		Destroyed	Destroyed
	11/16/2000		Destroyed	Destroyed
	2/21/2001		Destroyed	Destroyed
	5/31/2001		Destroyed	Destroyed
	11/28/2001		Destroyed	Destroyed
	5/28/2002		Destroyed	Destroyed
	11/14/2002		Destroyed	Destroyed
	5/23/2003		Destroyed	Destroyed
	11/24/2003		Destroyed	Destroyed
	5/13/2004		Destroyed	Destroyed
	11/23/2004		Destroyed	Destroyed
	5/17/2005		Destroyed	Destroyed
	11/16/2005		Destroyed	Destroyed
	5/23/2006		Destroyed	Destroyed
	11/15/2006		Destroyed	Destroyed
	5/31/2007		Destroyed	Destroyed
	11/28/2007		Destroyed	Destroyed

Table I, Summary of Groundwater Elevation Measurements BEI Job No. 94015, Kawahara Nursery, Inc. 16550 Ashland Avenue, San Lorenzo, California				
Well ID	Date	TOC Elevation (feet)	Depth to Water (feet)	Water Surface Elevation (feet)
MW-3	6/16/1993	99.52 *	10.46	89.06
	3/24/1994		10.81	88.71
	3/28/1994		10.96	88.56
	11/22/1994		11.68	87.84
	3/29/1995		6.95	92.57
	6/7/1995		8.48	91.04
	9/7/1995		10.3	89.22
	3/4/1999		7.98	91.54
	6/29/1999		8.49	91.03
	11/15/1999		10.35	89.17
	5/22/2000		7.65	91.87
	8/16/2000		9.44	90.08
	11/16/2000		9.86	89.66
	2/21/2001		8.65	90.87
	5/31/2001		9.56	89.96
	11/28/2001		11.04	88.48
	5/28/2002		9.17	90.35
	11/14/2002		10.23	89.29
	5/23/2003		8.73	90.79
	11/24/2003		11.05	88.47
	5/13/2004		9.11	90.41
	11/23/2004		10.28	89.24
	5/17/2005		8.19	91.33
	11/16/2005		10.20	89.32
	5/23/2006		7.08	92.44
	11/15/2006	42.86 **	9.40	33.46
	5/31/2007		9.52	33.34
	11/28/2007		10.85	32.01

Table I, Summary of Groundwater Elevation Measurements
BEI Job No. 94015, Kawahara Nursery, Inc.
16550 Ashland Avenue, San Lorenzo, California

Well ID	Date	TOC Elevation (feet)	Depth to Water (feet)	Water Surface Elevation (feet)
MW-4	11/22/1994	100.46 *	12.34	88.12
	3/29/1995		7.49	92.97
	6/7/1995		8.95	91.51
	9/7/1995		10.88	89.58
	3/4/1999		8.03	92.43
	6/29/1999		9.04	91.42
	11/15/1999		11.00	89.46
	5/22/2000		8.28	92.18
	8/16/2000		10.04	90.42
	11/16/2000		10.50	89.96
	2/21/2001		9.42	91.04
	5/31/2001		10.20	90.26
	11/28/2001		11.67	88.79
	5/28/2002		9.68	90.78
	11/14/2002		10.92	89.54
	5/23/2003		9.10	91.36
	11/24/2003		11.57	88.89
	5/13/2004		9.63	90.83
	11/23/2004		10.94	89.52
	5/17/2005		8.07	92.39
	11/16/2005		10.62	89.84
	5/23/2006		7.28	93.18
	11/15/2006	43.82 **	9.96	33.86
	5/31/2007		10.04	33.78
	11/28/2007		11.45	32.37

Table I, Summary of Groundwater Elevation Measurements BEI Job No. 94015, Kawahara Nursery, Inc. 16550 Ashland Avenue, San Lorenzo, California				
Well ID	Date	TOC Elevation (feet)	Depth to Water (feet)	Water Surface Elevation (feet)
MW-5	3/29/1995	98.14 *	5.76	92.38
	6/7/1995		7.33	90.81
	9/7/1995		9.11	89.03
	3/4/1999		6.63	91.51
	6/29/1999		7.41	90.73
	11/15/1999		9.18	88.96
	5/22/2000		6.68	91.46
	8/16/2000		8.27	89.87
	11/16/2000		8.68	89.46
	2/21/2001		7.51	90.63
	5/31/2001		8.40	89.74
	11/28/2001		9.79	88.35
	5/28/2002		8.05	90.09
	11/14/2002		9.03	89.11
	5/23/2003		7.90	90.24
	11/24/2003		9.94	88.20
	5/13/2004		8.05	90.09
	11/23/2004		8.90	89.24
	5/17/2005		6.80	91.34
	11/16/2005		9.00	89.14
	5/23/2006		6.27	91.87
	11/15/2006	41.49 **	8.26	33.23
	5/31/2007		8.41	33.08
	11/28/2007		9.70	31.79

Notes: TOC = Top of Casing
* = Surveyed to an onsite datum established at MW-1.
** = Resurveyed by CSS Environmental Services, Inc. on November 14, 2006.
Elevations in feet above mean sea level

Table II, Summary of Groundwater Sample Hydrocarbon Analytical Results
BEI Job No. 94015, Kawahara Nursery
16550 Ashland Avenue, San Lorenzo, California

Well ID	Sample Date	Modified EPA Method 8015 (µg/L)		EPA Method 8020 or 8021B (µg/L)					EPA Method 8260 (µg/L)
		TPH as Gasoline	TPH as Diesel	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	MTBE
MCL		N/A	N/A	1	150	700	1,750	13	13
TABLE A. Environmental Screening Levels (ESLs); Groundwater IS a Current or Potential Source of Drinking Water		100	100	1	40	30	20	5	5
MW-1	6/16/1993	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	3/28/1994	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	11/8/1994	NS	NS	NS	NS	NS	NS	NS	NS
	3/29/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	6/7/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	9/7/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	3/4/1999	NS	NS	NS	NS	NS	NS	NS	NS
	6/29/1999	NS	NS	NS	NS	NS	NS	NS	NS
	11/15/1999	NS	NS	NS	NS	NS	NS	NS	NS
	5/22/2000	NS	NS	NS	NS	NS	NS	NS	NS
	8/16/2000	NS	NS	NS	NS	NS	NS	NS	NS
	11/16/2000	NS	NS	NS	NS	NS	NS	NS	NS
	2/21/2001	NS	NS	NS	NS	NS	NS	NS	NS
	5/31/2001	NS	NS	NS	NS	NS	NS	NS	NS
	11/28/2001	NS	NS	NS	NS	NS	NS	NS	NS
	5/28/2002	NS	NS	NS	NS	NS	NS	NS	NS
	11/14/2002	NS	NS	NS	NS	NS	NS	NS	NS
	5/23/2003	NS	NS	NS	NS	NS	NS	NS	NS
	11/24/2003	NS	NS	NS	NS	NS	NS	NS	NS
	5/13/2004	NS	NS	NS	NS	NS	NS	NS	NS
	11/23/2004	NS	NS	NS	NS	NS	NS	NS	NS
	5/17/2005	NS	NS	NS	NS	NS	NS	NS	NS
	11/16/2005	NS	NS	NS	NS	NS	NS	NS	NS
	5/23/2006	NS	NS	NS	NS	NS	NS	NS	NS
	11/15/2006	NS	NS	NS	NS	NS	NS	NS	NS
	5/31/2007	NS	NS	NS	NS	NS	NS	NS	NS
	11/28/2007	NS	NS	NS	NS	NS	NS	NS	NS

Table II, Summary of Groundwater Sample Hydrocarbon Analytical Results BEI Job No. 94015, Kawahara Nursery 16550 Ashland Avenue, San Lorenzo, California									
Well ID	Sample Date	Modified EPA Method 8015 (µg/L)		EPA Method 8020 or 8021B (µg/L)					EPA Method 8260 (µg/L)
		TPH as Gasoline	TPH as Diesel	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	MTBE
MCL		N/A	N/A	1	150	700	1,750	13	13
TABLE A. Environmental Screening Levels (ESLs); Groundwater IS a Current or Potential Source of Drinking Water		100	100	1	40	30	20	5	5
MW-2	6/16/1993	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	3/28/1994	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	11/8/1994	NS	NS	NS	NS	NS	NS	NS	NS
	3/29/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	5/7/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	9/7/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	3/4/1999	NS	NS	NS	NS	NS	NS	NS	NS
	6/29/1999	NS	NS	NS	NS	NS	NS	NS	NS
	11/15/1999	NS	NS	NS	NS	NS	NS	NS	NS
	5/22/2000	NS	NS	NS	NS	NS	NS	NS	NS
	8/16/2000	NS	NS	NS	NS	NS	NS	NS	NS
	11/16/2000	NS	NS	NS	NS	NS	NS	NS	NS
	2/21/2001	NS	NS	NS	NS	NS	NS	NS	NS
	5/31/2001	NS	NS	NS	NS	NS	NS	NS	NS
	11/28/2001	NS	NS	NS	NS	NS	NS	NS	NS
	5/28/2002	NS	NS	NS	NS	NS	NS	NS	NS
	11/14/2002	NS	NS	NS	NS	NS	NS	NS	NS
	5/23/2003	NS	NS	NS	NS	NS	NS	NS	NS
	11/24/2003	NS	NS	NS	NS	NS	NS	NS	NS
	5/13/2004	NS	NS	NS	NS	NS	NS	NS	NS
	11/23/2004	NS	NS	NS	NS	NS	NS	NS	NS
	5/17/2005	NS	NS	NS	NS	NS	NS	NS	NS
	11/16/2005	NS	NS	NS	NS	NS	NS	NS	NS
	5/23/2006	NS	NS	NS	NS	NS	NS	NS	NS
	11/15/2006	NS	NS	NS	NS	NS	NS	NS	NS
	5/31/2007	NS	NS	NS	NS	NS	NS	NS	NS
	11/28/2007	NS	NS	NS	NS	NS	NS	NS	NS

Table II, Summary of Groundwater Sample Hydrocarbon Analytical Results
BEI Job No. 94015, Kawahara Nursery
16550 Ashland Avenue, San Lorenzo, California

Well ID	Sample Date	Modified EPA Method 8015 (µg/L)		EPA Method 8020 or 8021B (µg/L)					EPA Method 8260 (µg/L)
		TPH as Gasoline	TPH as Diesel	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	MTBE
MCL		N/A	N/A	1	150	700	1,750	13	13
TABLE A. Environmental Screening Levels (ESLs); Groundwater IS a Current or Potential Source of Drinking Water		100	100	1	40	30	20	5	5
MW-3	6/16/1993	**120,000**	**170,000**	**4,600**	**8,400**	**2,100**	**27,000**	NS	NS
	3/28/1994	**23,000**	**94,000**	**4,800**	**6,500**	**3,000**	**15,000**	NS	NS
	11/8/1994	**35,000**	**27,000**	**3,600**	**4,100**	**2,700**	**18,000**	NS	NS
	3/29/1995	**18,000**	<50*	**1,600**	**1,400**	**780**	**6,200**	NS	NS
	6/7/1995	**20,000**	<50	**1,700**	**1,400**	**750**	**6,800**	NS	NS
	9/7/1995	**17,000**	<50	**1,100**	**800**	**570**	**4,800**	NS	NS
	3/4/1999	**1,300**	<50	**33**	<0.5	**1.2**	**17**	**5.3** [e]	NS
	6/29/1999	**8,000**	**<1,000**	**98**	**34**	**3.7**	**1,200**	**37** [e]	NS
	11/15/1999	**4,200**	**2,000** [a]	**63**	**25**	**65**	**590**	**33** [e]	NS
	5/22/2000	**5,800**	**1,480**	**53**	**29**	**58**	**490**	**4.9** [e]	NS
	8/16/2000	**2,400**	**530** [c], *	**18**	**5.8 b**	**18**	**182**	**12** [b, e]	ND [e]
	11/16/2000	**9,000**	**3,700** [c], *	**35**	**27**	**88**	**719**	<10 [e]	NS
	2/21/2001	**2,400**	**880** [c], *	**28**	**12**	**46**	**276**	<2.0	NS
	5/31/2001	**2,900**	**680** [c], *	**5.3**	**33 b**	**17**	**144**	<2.0	NS
	11/28/2001	**1,700**	**430** [c], *	**23**	**3**	**37**	**184**	**4.2** [e]	NS
	5/28/2002	**870**	**570** [c], *	**6.3**	**2.2**	**12**	**70**	**2.3** [e]	NS
	11/14/2002	**3,300** [f, g]	**910** [c, g]	**27**	**3.6**	**52**	**206**	<2.0 [e]	NS
	5/23/2003	**760** [f]	**360** [c, g]	**3**	**1**	**5.2**	**30**	<2.0 [e]	NS
	11/24/2003	<50	**170**	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	5/13/2004	**830** [f, g]	**330** [c, g]	**1.6**	**0.54**	**6.5**	**41.2**	**2.3** [e]	NS
	11/23/2004	**840**	**190** [c], *	**2.7**	**1**	**7.7**	**39.8**	<2.0 [e]	NS
	5/17/2005	**730** [f]	**340** [c, g]	**0.85**	<0.5	**4.1**	**28.5**	<2.0 [e]	NS
	11/16/2005	**240**	**200** [c, g]	<0.5	<0.5	**1.9**	**11.3**	<2.0 [e]	NS
	5/23/2006	**320** [i]	**260** [j]	**0.69**	**1.4**	**3.6**	**22**	<2.0 [e]	NS
	11/15/2006	**480** [k]	NS	<0.5	**2.2**	**5.8**	**30**	<5.0 [e]	NS
	5/31/2007	**510** [l]	NS	<0.5	**2.8**	**4.7**	**23**	<5.0 [e]	NS
	11/28/2007	**78** [l]	NS	<0.5	<0.5	**1.1**	**4.2**	<5.0 [e]	NS

Table II, Summary of Groundwater Sample Hydrocarbon Analytical Results BEI Job No. 94015, Kawahara Nursery 16550 Ashland Avenue, San Lorenzo, California									
Well ID	Sample Date	Modified EPA Method 8015 (µg/L)		EPA Method 8020 or 8021B (µg/L)					EPA Method 8260 (µg/L)
		TPH as Gasoline	TPH as Diesel	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	MTBE
MCL		N/A	N/A	1	150	700	1,750	13	13
TABLE A. Environmental Screening Levels (ESLs); Groundwater IS a Current or Potential Source of Drinking Water		100	100	1	40	30	20	5	5
MW-4	6/16/1993	NS	NS	NS	NS	NS	NS	NS	NS
	3/28/1994	NS	NS	NS	NS	NS	NS	NS	NS
	11/8/1994	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	3/29/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	6/7/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	9/7/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	3/4/1999	<50	<50	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	6/29/1999	**130**	<50	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	11/15/1999	<50	<50	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	5/22/2000	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	8/16/2000	<50	**56 *** [d]	<0.5	<0.5	<0.5	**0.51**	**2.3** [e]	NS
	11/16/2000	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	2/21/2001	<50	<50	<0.5	<0.5	<0.5	<0.5	**2.6** [e]	NS
	5/31/2001	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/28/2001	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	5/28/2002	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/14/2002	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	5/23/2003	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/24/2003	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	5/13/2004	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/23/2004	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	5/17/2005	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/16/2005	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	5/23/2006	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/15/2006	<50	NS	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	5/31/2007	<50	NS	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	11/28/2007	<50	NS	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS

Table II, Summary of Groundwater Sample Hydrocarbon Analytical Results BEI Job No. 94015, Kawahara Nursery 16550 Ashland Avenue, San Lorenzo, California									
Well ID	Sample Date	Modified EPA Method 8015 (µg/L)		EPA Method 8020 or 8021B (µg/L)					EPA Method 8260 (µg/L)
		TPH as Gasoline	TPH as Diesel	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	MTBE
MCL		N/A	N/A	1	150	700	1,750	13	13
TABLE A. Environmental Screening Levels (ESLs); Groundwater IS a Current or Potential Source of Drinking Water		100	100	1	40	30	20	5	5
MW-5	6/16/1993	NS	NS	NS	NS	NS	NS	NS	NS
	3/28/1994	NS	NS	NS	NS	NS	NS	NS	NS
	11/8/1994	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	3/29/1995	<50	**64**	<0.5	<0.5	<0.5	<0.5	NS	NS
	6/7/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	9/7/1995	<50	<50	<0.5	<0.5	<0.5	<0.5	NS	NS
	3/4/1999	<50	<50	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	6/29/1999	**160**	<50	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	11/15/1999	<50	<50	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	5/22/2000	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	8/16/2000	<50	<50	<0.5	<0.5	<0.5	<0.5	**3.5 [e]**	NS
	11/16/2000	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	2/21/2001	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	5/31/2001	<50	<50	<0.5	<0.5	<0.5	<0.5	**2.8 [e]**	NS
	11/28/2001	<50	<50	<0.5	<0.5	<0.5	<0.5	**4.2 [e]**	NS
	5/28/2002	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/14/2002	<50	<50	<0.5	<0.5	<0.5	<0.5	**3.1 [e]**	NS
	5/23/2003	<50	<50	<0.5	<0.5	<0.5	<0.5	**2.4 [e]**	NS
	11/24/2003	<50	<50	<0.5	<0.5	<0.5	<0.5	**2.2 [e]**	NS
	5/13/2004	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/23/2004	<50	<58 [h]	<0.5	<0.5	<0.5	<0.5	**3.9 [e]**	NS
	5/17/2005	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/16/2005	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	5/23/2006	<50	<50	<0.5	<0.5	<0.5	<0.5	<2.0 [e]	NS
	11/15/2006	<50	NS	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	5/31/2007	<50	NS	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS
	11/28/2007	<50	NS	<0.5	<0.5	<0.5	<0.5	<5.0 [e]	NS

Table II, Summary of Groundwater Sample Hydrocarbon Analytical Results BEI Job No. 94015, Kawahara Nursery 16550 Ashland Avenue, San Lorenzo, California									
Well ID	Sample Date	Modified EPA Method 8015 (µg/L)		EPA Method 8020 or 8021B (µg/L)					EPA Method 8260 (µg/L)
		TPH as Gasoline	TPH as Diesel	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	MTBE
MCL		N/A	N/A	1	150	700	1,750	13	13
TABLE A. Environmental Screening Levels (ESLs); Groundwater IS a Current or Potential Source of Drinking Water		100	100	1	40	30	20	5	5

Notes: ug/L = micrograms per liter
TPH = Total Petroleum Hydrocarbons
EPA = Environmental Protection Agency
MTBE = Methyl *tert* -Butyl Ether
RWQCB = California Regional Water Quality Control Board, San Francisco Bay Region
ESL = Environmental Screening Level
N/A = Not applicable
NS = Not sampled
ESL = Environmental Screening Level
<*x* = Analyte not detected at reporting limit *x*
* = Laboratory reported the presence of petroleum hydrocarbons with a chromatograph pattern uncharacteristic of diesel fuel.
[a] = Laboratory note indicates the result is within the quantitation range, but that the chromatographic pattern is not typical of fuel.
[b] = Laboratory note indicates that confirmation of the result differed by more than a factor of two.
[c] = Laboratory note indicates lighter hydrocarbons contributed to the quantification.
[d] = Laboratory note indicates the sample has an unknown single peak or peaks.
[e] = Detection of MTBE by EPA Method 8021B is regarded as erroneous; likely chemical detected is 3-methyl-pentane. See text and Table IV.
[f] = Laboratory notes that heavier hydrocarbons contributed to the quantitation.
[g] = Laboratory notes that the sample exhibits a fuel pattern that does not resemble the standard.
[h] = Initially reported at 7,900 µg/L by laboratory; re-extracted 3 days outside of 14-day hold period yielding this revised result.
[i] = Laboratory notes that unmodified or weakly modified gasoline is significant.
[j] = Laboratory notes that gasoline range compounds are significant.
[k] = Laboratory note indicates that heavier gasoline range compounds are significant and may indicate aged gasoline.
[l] = Laboratory notes heavier gasoline range compounds are significant (aged gasoline?).

Bold results indicate detectable analyte concentrations.
Note: Shaded cell indicates that detected concentration exceeds ESL

Table III, Summary of Groundwater Sample Natural Attenuation Analytical Results BEI Job No. 94015, Kawahara Nursery 16550 Ashland Avenue, San Lorenzo, California								
Well ID	Date Sampled	Field Meter	EPA Method 310.1	EPA Method 353.3	Method AM20GAX	SM 3500	EPA Method 310.1	EPA Method 375.4
		Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	Nitrate/ Nitrogen (mg/L)	Methane (ug /L)	Ferrous Iron (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
MW-1	3/4/1999	NS	NS	NS	NS	NS	NS	NS
	6/29/1999	NS	NS	NS	NS	NS	NS	NS
	11/15/1999	NS	NS	NS	NS	NS	NS	NS
	5/22/2000	NS	NS	NS	NS	NS	NS	NS
	8/16/2000	NS	NS	NS	NS	NS	NS	NS
	11/16/2000	NS	NS	NS	NS	NS	NS	NS
	2/21/2001	NS	NS	NS	NS	NS	NS	NS
	5/31/2001	NS	NS	NS	NS	NS	NS	NS
	11/28/2001	NS	NS	NS	NS	NS	NS	NS
	5/28/2002	NS	NS	NS	NS	NS	NS	NS
	11/14/2002	NS	NS	NS	NS	NS	NS	NS
	5/23/2003	NS	NS	NS	NS	NS	NS	NS
	11/24/2003	NS	NS	NS	NS	NS	NS	NS
	5/13/2004	NS	NS	NS	NS	NS	NS	NS
	11/23/2004	NS	NS	NS	NS	NS	NS	NS
	5/17/2005	NS	NS	NS	NS	NS	NS	NS
	11/16/2005	NS	NS	NS	NS	NS	NS	NS
	5/23/2006	NS	NS	NS	NS	NS	NS	NS
	11/15/2006	NS	NS	NS	NS	NS	NS	NS
	5/31/2007	NS	NS	NS	NS	NS	NS	NS
	11/28/2007	NS	NS	NS	NS	NS	NS	NS

Table III, Summary of Groundwater Sample Natural Attenuation Analytical Results BEI Job No. 94015, Kawahara Nursery 16550 Ashland Avenue, San Lorenzo, California								
Well ID	Date Sampled	Field Meter	EPA Method 310.1	EPA Method 353.3	Method AM20GAX	SM 3500	EPA Method 310.1	EPA Method 375.4
		Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	Nitrate/ Nitrogen (mg/L)	Methane (ug /L)	Ferrous Iron (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
MW-2	3/4/1999	NS	NS	NS	NS	NS	NS	NS
	6/29/1999	NS	NS	NS	NS	NS	NS	NS
	11/15/1999	NS	NS	NS	NS	NS	NS	NS
	5/22/2000	NS	NS	NS	NS	NS	NS	NS
	8/16/2000	NS	NS	NS	NS	NS	NS	NS
	11/16/2000	NS	NS	NS	NS	NS	NS	NS
	2/21/2001	NS	NS	NS	NS	NS	NS	NS
	5/31/2001	NS	NS	NS	NS	NS	NS	NS
	11/28/2001	NS	NS	NS	NS	NS	NS	NS
	5/28/2002	NS	NS	NS	NS	NS	NS	NS
	11/14/2002	NS	NS	NS	NS	NS	NS	NS
	5/23/2003	NS	NS	NS	NS	NS	NS	NS
	11/24/2003	NS	NS	NS	NS	NS	NS	NS
	5/13/2004	NS	NS	NS	NS	NS	NS	NS
	11/23/2004	NS	NS	NS	NS	NS	NS	NS
	5/17/2005	NS	NS	NS	NS	NS	NS	NS
	11/16/2005	NS	NS	NS	NS	NS	NS	NS
	5/23/2006	NS	NS	NS	NS	NS	NS	NS
	11/15/2006	NS	NS	NS	NS	NS	NS	NS
	5/31/2007	NS	NS	NS	NS	NS	NS	NS
	11/28/2007	NS	NS	NS	NS	NS	NS	NS

Table III, Summary of Groundwater Sample Natural Attenuation Analytical Results BEI Job No. 94015, Kawahara Nursery 16550 Ashland Avenue, San Lorenzo, California								
Well ID	Date Sampled	Field Meter	EPA Method 310.1	EPA Method 353.3	Method AM20GAX	SM 3500	EPA Method 310.1	EPA Method 375.4
		Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	Nitrate/ Nitrogen (mg/L)	Methane (ug /L)	Ferrous Iron (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
MW-3	3/4/99 & 3/8/1999	**1.2**	**4.4**	**26.0**	NS	<0.01	**520**	**1,000**
	6/29/1999	**0.4**	**3.5**	**10.0**	NS	<0.10	**500**	**73**
	11/15/1999	**0.5**	**48.0**	**5.7**	NS	<0.01	**530**	**110**
	5/22/2000	**0.0**	**63.3**	**18.0**	NS	<0.10	**460**	**63**
	8/16/2000	**1.0**	**59.8**	**13.0**	NS	**0.5**	**450**	**62**
	11/16/2000	**1.2**	**63.5**	**8.9**	NS	**2.2**	**470**	**52**
	2/21/2001	**1.2**	**63.0**	**12.0**	NS	**0.4**	**430**	**50**
	5/31/2001	**1.8**	**50.0**	**14.0**	NS	**0.5**	**410**	**49**
	11/28/2001	**0.8**	**47.0**	**7.7**	2.9	**0.5**	**450**	**43**
	5/28/2002	**0.7**	**63.0**	**11.0**	NS	<0.10	**440**	**50**
	11/14/2002	**0.6**	**75.0**	**4.1**	NS	**1.2**	**540**	**41**
	5/23/2003	NS	NS	NS	NS	NS	NS	NS
	11/24/2003	NS	NS	NS	NS	NS	NS	NS
	5/13/2004	NS	NS	NS	NS	NS	NS	NS
	11/23/2004	NS	NS	NS	NS	NS	NS	NS
	5/17/2005	NS	NS	NS	NS	NS	NS	NS
	11/16/2005	NS	NS	NS	NS	NS	NS	NS
	5/23/2006	NS	NS	NS	NS	NS	NS	NS
	11/15/2006	NS	NS	NS	NS	NS	NS	NS
	5/31/2007	NS	NS	NS	NS	NS	NS	NS
	11/28/2007	NS	NS	NS	NS	NS	NS	NS

Table III, Summary of Groundwater Sample Natural Attenuation Analytical Results
BEI Job No. 94015, Kawahara Nursery
16550 Ashland Avenue, San Lorenzo, California

Well ID	Date Sampled	Field Meter	EPA Method 310.1	EPA Method 353.3	Method AM20GAX	SM 3500	EPA Method 310.1	EPA Method 375.4
		Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	Nitrate/ Nitrogen (mg/L)	Methane (ug /L)	Ferrous Iron (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
MW-4	3/4/99 & 3/8/1999	**2.1**	**2.3**	**13.0**	NS	<0.01	**320**	**390**
	6/29/1999	**1.2**	**21.0**	**12.0**	NS	<0.10	**360**	**46**
	11/15/1999	**1.4**	**22.0**	**8.9**	NS	<0.01	**370**	**140**
	5/22/2000	**1.6**	**35.6**	**19.0**	NS	<0.10	**340**	**49**
	8/16/2000	**2.9**	**42.2**	**14.0**	NS	0.1	**350**	**51**
	11/16/2000	**3.7**	**34.4**	**12.0**	NS	<0.10	**390**	**53**
	2/21/2001	**1.9**	**40**	**13.0**	NS	0.2	**310**	**55**
	5/31/2001	**1.4**	**32.0**	**14.0**	NS	<0.10	**350**	**56**
	11/28/2001	**4.2**	**36.0**	**13.0**	**2.0**	<0.10	**370**	**60**
	5/28/2002	**0.8**	**34.0**	**12.0**	NS	<0.10	**380**	**70**
	11/14/2002	**0.7**	**51.0**	**15.0**	NS	<0.10	**370**	**66**
	5/23/2003	NS	NS	NS	NS	NS	NS	NS
	11/24/2003	NS	NS	NS	NS	NS	NS	NS
	5/13/2004	NS	NS	NS	NS	NS	NS	NS
	11/23/2004	NS	NS	NS	NS	NS	NS	NS
	5/17/2005	NS	NS	NS	NS	NS	NS	NS
	11/16/2005	NS	NS	NS	NS	NS	NS	NS
	5/23/2006	NS	NS	NS	NS	NS	NS	NS
	11/15/2006	NS	NS	NS	NS	NS	NS	NS
	5/31/2007	NS	NS	NS	NS	NS	NS	NS
	11/28/2007	NS	NS	NS	NS	NS	NS	NS

Table III, Summary of Groundwater Sample Natural Attenuation Analytical Results BEI Job No. 94015, Kawahara Nursery 16550 Ashland Avenue, San Lorenzo, California								
Well ID	Date Sampled	Field Meter	EPA Method 310.1	EPA Method 353.3	Method AM20GAX	SM 3500	EPA Method 310.1	EPA Method 375.4
		Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	Nitrate/ Nitrogen (mg/L)	Methane (ug /L)	Ferrous Iron (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
MW-5	3/4/99 & 3/8/1999	**1.8**	**2.1**	**140**	NS	<0.01	**370**	**500**
	6/29/1999	**0.9**	**7**	**14**	NS	<0.10	**360**	**46**
	11/15/1999	**0.9**	**6**	**11**	NS	<0.01	**370**	**150**
	5/22/2000	**0.4**	**35.1***	**11**	NS	<0.10	**360**	**50**
	8/16/2000	**0.8**	**38.25***	**12**	NS	**0.13**	**360**	**47**
	11/16/2000	**2.4**	**34.3**	**12**	NS	<0.10	**380**	**48**
	2/21/2001	**2.7**	**38**	**11**	NS	**0.23**	**350**	**49**
	5/31/2001	**2.1**	**30**	**11**	NS	<0.10	**360**	**48**
	11/28/2001	**3.5**	**32**	**12**	2	<0.10	**360**	**47**
	5/28/2002	**0.8**	**30**	**12**	NS	<0.10	**370**	**47**
	11/14/2002	**0.7**	**42**	**14**	NS	<0.10	**340**	**45**
	5/23/2003	NS	NS	NS	NS	NS	NS	NS
	11/24/2003	NS	NS	NS	NS	NS	NS	NS
	5/13/2004	NS	NS	NS	NS	NS	NS	NS
	11/23/2004	NS	NS	NS	NS	NS	NS	NS
	5/17/2005	NS	NS	NS	NS	NS	NS	NS
	11/16/2005	NS	NS	NS	NS	NS	NS	NS
	5/23/2006	NS	NS	NS	NS	NS	NS	NS
	11/15/2006	NS	NS	NS	NS	NS	NS	NS
	5/31/2007	NS	NS	NS	NS	NS	NS	NS
	11/28/2007	NS	NS	NS	NS	NS	NS	NS

Notes: NS = Not sampled
Field = Field instruments used for measurement of parameter.
mg/L = Milligarms per liter
* = Average value

Table IV, Summary of Groundwater Sample Fuel Oxygenate Analytical Results
BEI Job No. 94015, Kawahara Nursery
16550 Ashland Avenue, San Lorenzo, California

Well ID	Sample Date	EPA Method 8260B (ug/L)				
		TAME	TBA	DIPE	ETBE	MTBE
RWQCB Groundwater ESLs Table F-1a: Groundwater Screening Levels (groundwater IS a current or potential drinking water source)		NV	12	NV	NV	5.0
MW-3	8/16/2000	<0.50	<20	<0.50	<0.50	<0.50

Notes:
TAME = Methyl tert-Amyl Ether
TBA = tert-Butyl Alcohol
DIPE = Di-isopropyl ether
ETBE = Ethyl tert-butyl ether
MTBE = Methly tert-butyl ether
(µg/L) = Micrograms per liter
NV = No value

Bold results indicate detectable analyte concentrations.
Note: Shaded cell indicates that detected concentration exceeds ESL

Table V, Summary of Soil Sample Physical Parameters
BEI Job No. 94015, Kawahara Nursery
16550 Ashland Avenue, San Lorenzo, California

Sample ID	Date	ASTM E3173			ASTM 2974c	EPA 150.1	EPA 351.3	EPA 9060
		Weight % Moisture (%)	Bulk Density (g/cc)	Porosity (vol %)	FOC (wet %)	pH	TKN (mg/kg)	TOC (mg/kg)
SB-2 5'	8/9/99	NA	NA	NA	NA	7.73	258	6,910
SB-2 12.5'	8/9/99	21	2.0	40	2.8	NA	NA	NA
SB-5 12'	8/9/99	20	1.9	41	3.8	NA	NA	NA
SB-4 15'	8/9/99	NA	NA	NA	NA	8.04	190	849

Notes:

ASTM	=	American Society for Testing and Materials
EPA	=	Environmental Protection Agency
FOC	=	Fractional organic content
TKN	=	Total Kjeldahl nitrogen
TOC	=	Total organic carbon
g/cc	=	Grams per cubic centimeter
wet %	=	Wet weight percent
NA	=	Not analyzed

Table VI, Summary of Soil Sample Analytical Results
BEI Job No. 94015, Kawahara Nursery, Inc.
16550 Ashland Avenue, San Lorenzo, California

Sample ID	Depth (Feet)	Collection Date	Modified EPA Method 8015 (mg/kg)		EPA Method 8020 (µg/kg)				
			TPH as Gasoline	TPH as Diesel	MTBE	Benzene	Toluene	Ethylbenzene	Total Xylenes
ELSs for Shallow or Deep Soils; Groundwater is a current of Potential Source of Drinking Water			83	83	0.023	0.12	29	33	31
MW-1	5	6/10/93	<1	<1	NA	<5	<5	<5	<5
MW-1	16	6/10/93	<1	<1	NA	<5	<5	<5	<5
MW-2	2.5	6/10/93	<1	**1.9**	NA	<5	<5	<5	<5
MW-2	11.5	6/10/93	<1	<1	NA	<5	<5	<5	<5
MW-3	6	6/10/93	<1	<1	NA	<5	<5	<5	<5
MW-3	15	6/10/93	<1	<1	NA	**200**	**980**	**680**	**4000**
MW-4	12	10/31/94	<1	<1	NA	<2.5	<2.5	<2.5	<2.5
MW-4	17	10/31/94	<1	<1	NA	<2.5	<2.5	<2.5	<2.5
MW-5	12.5	10/31/94	<1	<1	NA	<2.5	<2.5	<2.5	<2.5
MW-5	17	10/31/94	<1	<1	NA	<2.5	**11**	<2.5	**27**
SB-1	7.5	10/31/94	<1	<1	NA	<2.5	<2.5	<2.5	<2.5
SB-1	17	10/31/94	**130**	**4.1**	NA	<2.5	<2.5	<2.5	<2.5
SB-2	5	8/9/99	<1	<1	<50	<5	<5	<5	<5

Table VI, Summary of Soil Sample Analytical Results
BEI Job No. 94015, Kawahara Nursery, Inc.
16550 Ashland Avenue, San Lorenzo, California

Sample ID	Depth	Collection Date	Modified EPA Method 8015 (mg/kg)		EPA Method 8020 (μg/kg)				
	(Feet)		TPH as Gasoline	TPH as Diesel	MTBE	Benzene	Toluene	Ethylbenzene	Total Xylenes
ELSs for Shallow or Deep Soils; Groundwater is a current of Potential Source of Drinking Water			83	83	0.023	0.12	29	33	31
SB-2	10	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-2	12.5	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-3	10	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-3	15	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-4	5	8/9/99	<1	<1	<50	<5	<5	<5	**9**
SB-4	10	8/9/99	**1.4**	**1.6**	<50	<5	**33**	<5	<5
SB-4	15	8/9/99	**910**	**360**	<2,000	**870**	**10,000**	**14,000**	**92,000**
SB-5	10	8/9/99	**1.2**	<1	<50	<5	**26**	<5	<5
SB-5	12	8/9/99	**250**	**100**	<200	<10	**1,300**	**1,400**	**13,000**
SB-6	5	8/9/99	<1	**5.7**	<50	<5	<5	<5	**98**
SB-6	10	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-6	16	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-7	5	8/9/99	<1	**7.4**	<50	<5	<5	<5	**36**

Table VI, Summary of Soil Sample Analytical Results
BEI Job No. 94015, Kawahara Nursery, Inc.
16550 Ashland Avenue, San Lorenzo, California

Sample ID	Depth (Feet)	Collection Date	Modified EPA Method 8015 (mg/kg)		EPA Method 8020 (μg/kg)				
			TPH as Gasoline	TPH as Diesel	MTBE	Benzene	Toluene	Ethylbenzene	Total Xylenes
ELSs for Shallow or Deep Soils; Groundwater is a current of Potential Source of Drinking Water			83	83	0.023	0.12	29	33	31
SB-7	10	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-8	5	8/9/99	<1	**3.8**	<50	<5	<5	<5	<5
SB-8	10	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-8	15	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-9	5	8/9/99	<1	**1.8**	<50	<5	<5	<5	<5
SB-9	10	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-9	16	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-10	5	8/9/99	<1	<1	<50	<5	<5	<5	<5
SB-10	10	8/9/99	<1	<1	<50	<5	<5	<5	<5

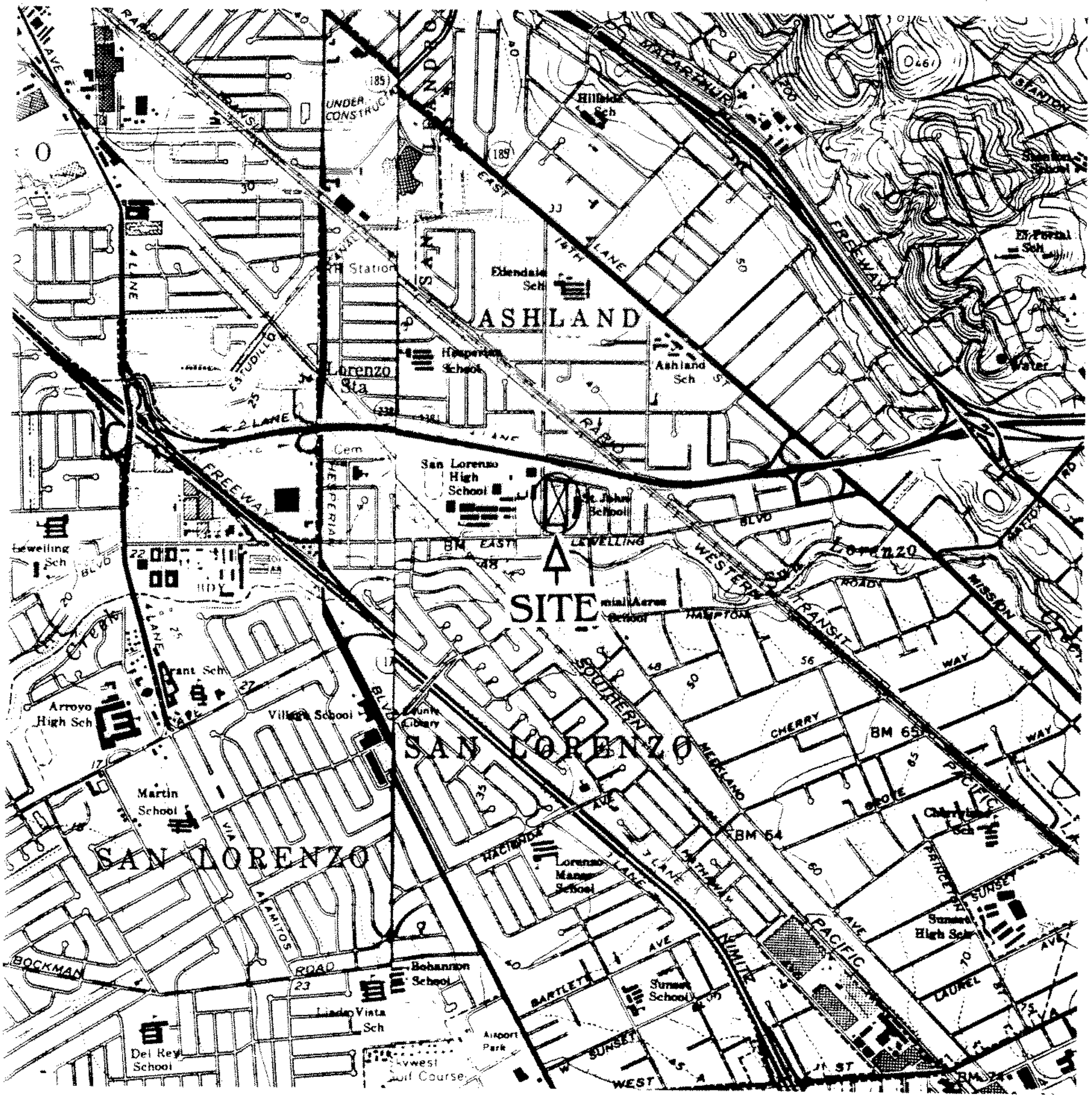
Notes: TPH = Total petroleum hydrocarbons
EPA = Environmental Protection Agency
<x = Not detected above the analytical method reporting limit of x
mg/kg = Milligrams per kilogram
μg/kg = Micrograms per kilogram
NA = Not analyzed

Table VII, Summary of Grab Groundwater Analytical Results
BEI Job No. 94015, Kawahara Nursery, Inc.
16550 Ashland Avenue, San Lorenzo, California

Sample ID	Collection Date	Modified EPA Method 8015 (μg/L)		EPA Method 8020 (μg/L)				
		TPH as Gasoline	TPH as Diesel	MTBE	Benzene	Toluene	Ethylbenzene	Total Xylenes
SB-2	8/9/99	<50	160	<5	<0.5	<0.5	<0.5	**1.6**
SB-3	8/9/99	<50	<50	<5	<0.5	<0.5	<0.5	**1.7**
SB-4	8/9/99	**140,000**	**990,000**	<200	**2,300**	**8,700**	**5,300**	**32,000**
SB-5	8/9/99	**730,000**	**610,000**	<800	**460**	**4,600**	**12,000**	**76,000**
SB-6	8/9/99	<50	<50	<5	<0.5	<0.5	<0.5	<0.5
SB-7	8/9/99	**220**	**73**	<5	<0.5	**0.69**	**1.4**	**5.7**
SB-8	8/9/99	<50	<50	<5	<0.5	<0.5	<0.5	**2.1**
SB-9	8/9/99	**58**	<50	<5	<0.5	**0.60**	**1.2**	**7.4**
SB-10	8/9/99	**810**	**500**	<5	<0.5	**6.1**	**18**	**120**
Trip Blank	8/9/99	<50	NA	<5	<0.5	<0.5	<0.5	<0.5

Notes:
- TPH = Total petroleum hydrocarbons
- EPA = Environmental Protection Agency
- <x = Not detected above the analytical method reporting limit of x
- μg/L = Micrograms per liter
- NA = Not analyzed

Figures



UNITED STATES GEOLOGICAL SURVEY 7.5' QUADS. "SAN LEANDRO, CA" AND "HAYWARD, CA" BOTH ED. 1959 . PHOTOREVISED 1980.

QUADRANGLE LOCATION

BLYMYER ENGINEERS, INC.		0 1000 2000 SCALE IN FEET (N)	SITE LOCATION MAP KAWAHARA NURSERY 16550 ASHLAND AVE. SAN LORENZO, CA	FIGURE 1
BEI JOB NO. 94015	DATE 4-9-99			

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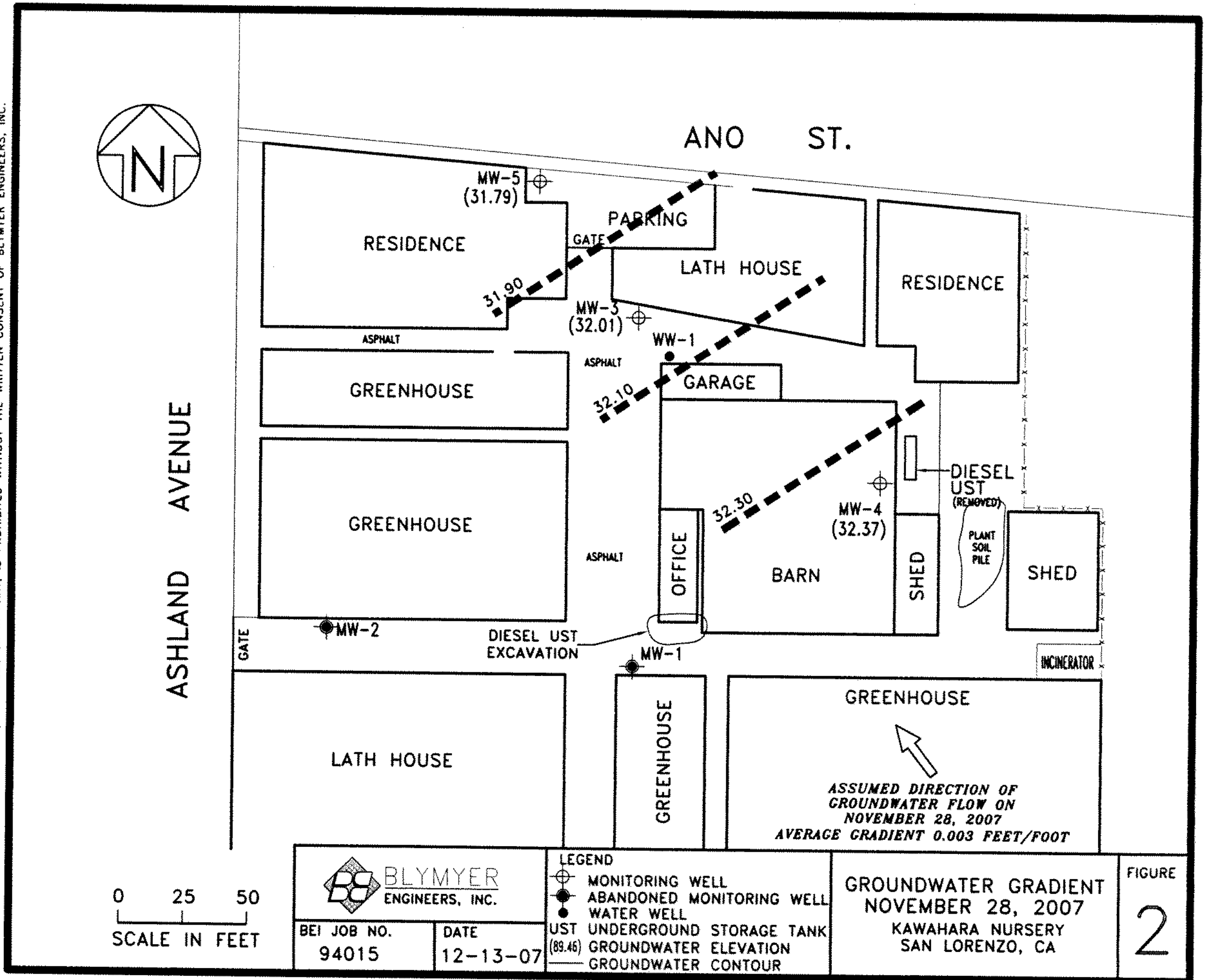

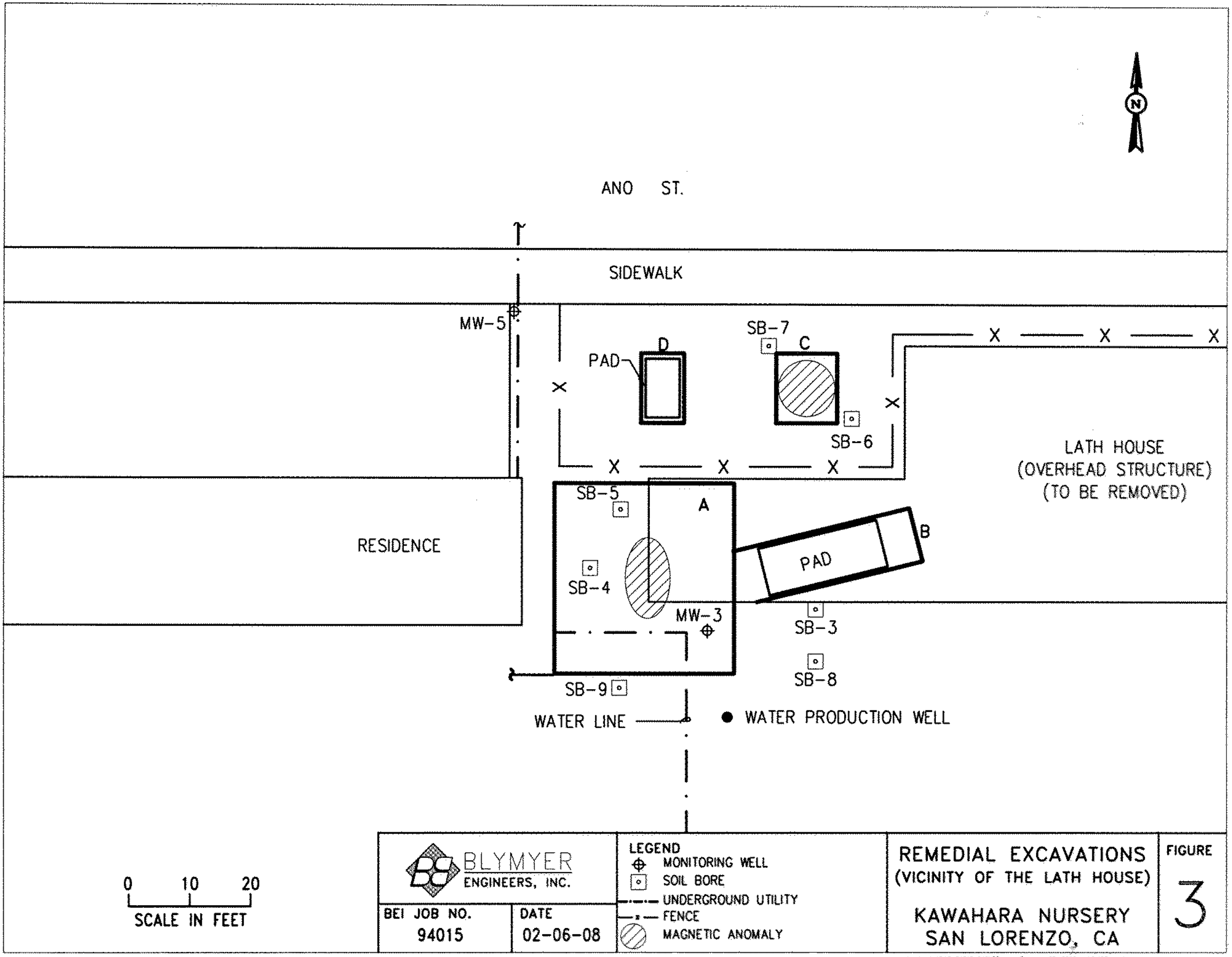

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Appendix A

REGENESIS ORC Excavation Mixing Specifications

REGENESIS

DIRECTIONS FOR ORC *Advanced*™ SLURRY MIXING

1. 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 water into the 5-gallon bucket according to the desired slurry consistency (a slurry calculation table is available on the Regenesis software in the Appendix tab):

% Solids	**Quantity of ORC *Advanced* (lbs)**	**Quantity of Water (gal)**
65	25	1.6
60	25	2.0
55	25	2.5
50	25	3.0
45	25	3.7
40	25	4.5
35	25	5.6
30	25	7.0
25	25	9.0
20	25	12.0

3. Add the corresponding quantity of water to the pre-measured quantity of ORC *Advanced*.

4. Use an appropriate mixing device to thoroughly mix the ORC *Advanced* and water together. 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. For small quantities, the slurry can be mixed by hand if care is taken to blend all lumps into the mixture thoroughly.

CAUTION: **ORC *Advanced* may settle out of slurry if left standing.** ORC *Advanced* eventually hardens into a cement-like compound and cannot be re-mixed after that has occurred. Therefore, mix immediately before using to ensure that the mixture has not settled out. **Do not let stand more than 30 minutes.** If a mechanical slurry mixer attached to a pump is being used, the material may be cycled back through the mixer to maintain slurry suspension and consistency.

REGENESIS
Oxygen Release Compound (ORC®) Installation Instructions
(Excavation Applications)

SAFETY:

Pure ORC is shipped to you as a fine powder, which is rated at -325 mesh (passes through a 44 micron screen). It is considered to be a mild oxidizer and as such should be handled with care while in the field. Field personnel should take precautions while applying the pure ORC. Typically, the operator should work up wind of the product as well as use appropriate safety equipment. These would include eye, respiratory protection and gloves as deemed appropriate by exposure duration and field conditions.

Although two options are discussed, application of ORC should never be applied by personnel within the tank excavation, unless proper shoring or sidewall cutback is in place.

GENERAL GUIDELINES:

ORC can be applied in a dry powder form or as a slurry. Field conditions dictate which form of ORC can be used most effectively.

Installation of ORC should be within the tank excavation floor and/or in an adequate backfill section thickness to account for the anticipated groundwater "smear zone".

Maximum treatment effect is obtained when ORC is mixed as thoroughly as possible within the backfill material. The more dispersed the ORC slurry/powder within the excavation backfill, the more effective the treatment.

The quantity of ORC to be used is generally calculated prior to moving into the field for installation. Generally it is applied at a rate of between 0.1% and 1.0% by weight of the soil matrix. The following illustrates a dilute application rate calculation:

> Use a weight/weight percent of ORC/backfill material to ensure distribution of the ORC into the desired aquifer section. For example: a 0.15% weight of ORC to weight of backfill for the standard ORC weight (30 pounds) per container calculates as follows: 30 lb. ORC/0.15% = 20,000 lbs. of soil matrix. Thus, to achieve a 0.15% mixture of ORC in the backfill material, 30 lb. of pure ORC should be mixed into 10 tons (20,000 lbs. ÷2,000 lbs./ton) of backfill, or approximately 7 - 10 cubic yards of soil depending on field conditions. Professional judgment should be used to select the appropriate soil mass per cubic yard for designing each site treatment.

CHOOSING THE FORM OF INSTALLATION:

Pure ORC is shipped to you in a powder form. Weather conditions (especially wind) may have a direct effect on the application of ORC as a tank backfill amendment.

Application of the dry powder may be difficult in windy conditions. To counter the effects of wind (and the subsequent potential loss of ORC), Regenesis recommends that a water source or a spray tank be on-site to wet down the ORC and the backfill material as ORC is applied.

Application of ORC in a slurry format is a very effective method and eliminates the wind issue.

Four somewhat different installation conditions can be encountered in the field:

- ORC in a pea gravel back-fill. ("Type 1")
- ORC in a soil back-fill. ("Type 2")
- ORC mixed in native soil in the bottom of a tank pit. ("Type 3")
- ORC installed in soil under standing water in the bottom of a tank pit. ("Type 4")

A single tank pit excavation can include more than one of these conditions, depending on the site and extent of treatment. Instructions for each condition are discussed separately in the following sections. After the installation instructions are detailed instructions for mixing the slurry, if that is the option chosen.

INSTALLATION INSTRUCTIONS:

"Type 1," ORC in a Pea Gravel Back-fill

The easiest method for installing ORC in pea gravel back-fill is to mix the ORC in the material in a backhoe or skiploader bucket before placing it in the excavation.

- **Dry Powder method**

Into each scoop of back-fill material add the appropriate portion of ORC being installed. Generally, it is advisable to moisten the material in the bucket to reduce wind blown ORC loss. Excessive winds make this method not feasible.

After mixing the dry powder in the bucket, it is dumped into the bottom of the excavation. The backhoe bucket can be used for further mixing in the excavation.

- **Slurry method**

Mix a 63% solids slurry of ORC and water (see "Steps to make ORC slurry). This relatively thick slurry is used to help keep the ORC dispersed through the pea gravel, even when it contacts water in the bottom of the excavation during installation. It is generally desirable to avoid having the ORC run down through the pea gravel and collect in the bottom of the excavation. The thick slurry addresses this issue.

In each scoop of back-fill material, add the appropriate amount of ORC slurry. Pre-mix the materials in the backhoe bucket After mixing, dump the slurry and back-fill into the bottom of the excavation. The backhoe bucket can be used for further mixing in the excavation.

If the slurry method is being used, observe the physical behavior of the ORC in the fill material. If the ORC collects at the bottom of the back-fill material, increase the percent solids content by reducing the amount of water being used to make the slurry.

"Type 2," ORC in a Soil Back-fill

Follow the instructions for the pea gravel back-fill method, except:

If the slurry method is being used, the solids content should be reduced. Typically a 50% solids is appropriate, although soil conditions sometimes dictate lower solids contents (see "Steps to make ORC slurry").

" Type 3," ORC Mixed in Native Soil in the Bottom of the Tank Pit

When ORC is added to the bottom of a tank pit it may be done by backhoe or injection. CAUTION: Personnel should never work within the tank excavation, unless proper shoring or sidewall cutback is in place.

- **Backhoe method**

A skilled backhoe operator can distribute the ORC around the bottom of the tank excavation and, using the bucket, mix it thoroughly. If there are no winds, it may be possible to:

1. Put the dry ORC powder in the backhoe bucket,
2. Lower it to the bottom of the pit,
3. Gently deposit the ORC evenly on the remaining soil,
4. Use the bucket to mix the powder into the soil,
5. To mitigate dusting, if necessary, spray water into the excavation during the process.

An alternative backhoe method is to use a 50% (or less) solids ORC slurry (see "Steps to make ORC slurry) in place of the dry powder. This eliminates the dusting problem, and in some cases enhances the even distribution of ORC into the soil. Observe the slurry mixing behavior in the bottom of the excavation, and adjust the water content of the slurry to optimize mixing, if necessary.

- **Injection method**

If available, a pump and root feeder may be used to inject an ORC slurry into the excavation floor. This may require a more dilute slurry mix, and care should be taken to assure that the solids do not settle out of the slurry prior to injection.

" Type 4." ORC installed in standing water in the bottom of a tank pit

Application of ORC into tank excavations with standing water requires the operator apply ORC in a slurry form. ORC powder application in this scenario is not advised because a portion of the ORC particle fraction is not likely to pass through the surface tension of the standing water. Caution: Personnel should never work within the tank excavation, unless proper shoring or sidewall cutback is in place.

- **Backhoe method**

A skilled backhoe operator can distribute the ORC slurry within the excavation, and mix it into the soil underlying the standing water with the bucket. Steps for installation:

1. Mix a high solids content ORC slurry (63% solids). See ("Steps to make ORC slurry").
2. Pour slurry into the backhoe bucket.
3. Lower the bucket to the standing water level in the excavation, and deposit the slurry as evenly as possible across the excavation floor. The dense slurry (63%solids is 1.6 grams per ml) will tend to make the majority of the slurry sink quickly to the bottom of the water layer.
4. Use the bucket to mix the slurry into the soil.
5. Water in the vicinity of the ORC slurry will often turn white and milky, since some of the ORC is dispersed within the standing water. This provides additional dispersion within the standing water and back-fill material as it is added to the excavation.

- **Injection method**

If available, a pump and root feeder may be used to inject an ORC slurry into the soil in an excavation. This may require a more dilute slurry mix, and care should be taken to assure that the solids do not settle out of the slurry prior to injection.

MIXING ORC SLURRY:

ORC powder is shipped to you in pre-measured batches. Each batch is contained in a plastic bag which is shipped in a 5-gallon bucket.

Remove the pre-measured ORC bag from the 5-gallon bucket and open
Measure and pour the appropriate amount of water from the following table into the 5 gallon bucket

Slurry Solids Content (%)	Pounds of ORC	Gallons of Water
63%	30 lbs.	2.1 gal. (2 gal. + 2 cups)
50%	30 lbs.	3.6 gal. (3 gal + 2 1/2 qts.)

Add the entire ORC pre-measured bag to the water (30 pounds). If the slurry solids contents of less than 50% are desired, the quantity of ORC per batch mixed in the bucket must be reduced. For example, a bucket containing four gallons of water would require 22.4 pounds of ORC to make a 40% solids slurry, and 16.6 pounds of ORC to make a 33% slurry.

Use an appropriate mixing device to thoroughly mix ORC and water. Regenesis recommends use of a 0.5 Horsepower (minimum) hand held drill with a "jiffy mixer" or stucco mixer. A common paint paddle can be used to scrape the bottom and sides of the container to ensure thorough mixing. Standard environmental slurry mixers may also be used.

After mixing, small amounts of water can be added to adjust the consistency of the slurry.

When slurries are used, the early batches should be observed in the process of mixing with the soil. Each site can vary, due to soil type and moisture content. Based on professional judgment, additional water can be added to subsequent slurry batches.

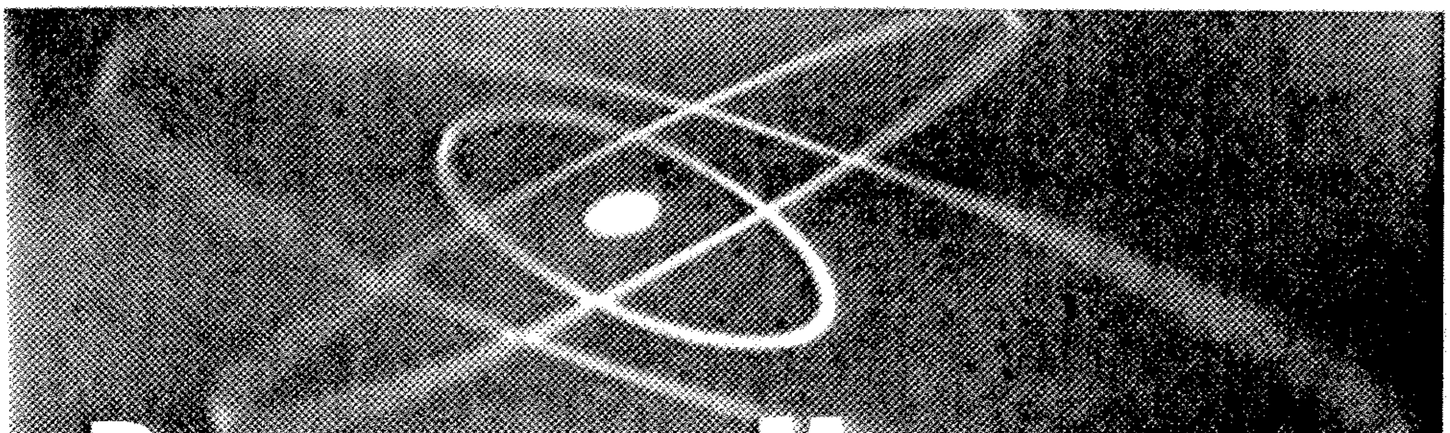
ORC slurry should be used ASAP; if the ORC slurry has been standing more than 15 minutes, it should be remixed immediately before using. Do not let stand more than 30 minutes without stirring. Otherwise, the slurry will begin to harden into a weak cement.

For direct assistance or answers to any questions you may have regarding these instructions, contact Regenesis Technical Services at 949-366-8000.

REGENESIS, 2002
www.regenesis.com

Appendix B

Bionutrient Modeling for Design of In-Situ Bioremediation,
Pollution Engineering, April 2003



Bionutrient Modeling for Design of In situ Bioremediation

by Warren B. Chamberlain, R.G., C.H.G., P.E.

Enhanced bioremediation is a remediation technology that involves the stimulation of natural microbial activity to address specific environmental contamination. In the "natural" state, microbial activity that is capable of degrading organic compounds can stall for lack of one or more of the elements necessary to promote bacterial activity — most often oxygen or hydrogen depending on the need for oxic or anoxic subsurface conditions. It is also commonly found that macronutrient compounds of nitrogen and/or phosphorous are also depleted. In biological terms, the missing or depleted nutrients are known as the Limiting Factor to microbial growth.

This article presents an anabolic design approach to quantifying macronutrient additions for in situ bioremediation projects.

Background

With the exception of methane, most organic solutes encountered in natural waters are not in thermodynamic equilibrium with their environment (Strumm and Morgan, 1981). Nonphotosynthetic organisms such as heterotrophic bacteria tend to restore thermodynamic equilibrium by decomposing "unstable" organic compounds through energy yielding oxidation-reduction reactions; in so doing, the bacteria obtain a source of energy for their metabolic needs. As such, bacteria play an active role in the breakdown process of complex organic compounds to more environmentally inert chemical compounds such as carbon dioxide, ethanol, or methane.

However, the traditional design approach for the degradation of say, benzene, is viewed as a simple redox reaction, with the following stoichiometric relationship for the breakdown of benzene (C6H6):

$$C_6H_6 + 7.5O_2 + bacteria \rightarrow 6CO_2 + 3H_2O$$

In this design approach, only the addition of oxygen (as a terminal electron acceptor) is deemed necessary, and the bacteria are viewed as mere catalysts.

Essentially, the traditional bioremediation design considers only those paths of the bacteria's metabolic process that are catabolic (reaction processes that liberate free energy due to the breakdown of complex molecules to simpler molecules). While this design approach is valid, it presents only a partial picture of the bacteria's role and the processes involved in contaminant degradation. While designers of the catabolic (or terminal electron acceptor) approach often state the need to consider macro and micronutrients, a method or procedure to quantify the macro and micronutrient requirements has not been established. Collectively termed bionutrients, macronutrients are usually nitrogen, sulfur, phosphorous, and potassium compounds, and micronutrients are usually trace metal compounds.

The addition of macronutrient compounds to groundwater is of particular concern to regulators, as the fate of added bionutrients is not usually well described in the bioremediation design. Because of this, regulators will typically permit the addition of (non-toxic) oxygen and hydrogen releasing compounds to groundwater but will not allow bionutrient compounds (for example, NPK fertilizers). This restriction can lead to less than optimum conditions for promoting bacterial metabolic activity and colony growth. However, when regulators are presented with more explicit quantification of the fate of macronutrients that will be added, they can be less restrictive.

In the bionutrient design approach, an additional element is considered in the design: the anabolic process, that is, the nutritional requirements for growing bacterial cells. The bacteria's nutritional/reproductive needs are estimated based on the stoichiometric make-up of a microbial cell. The bionutrient approach considers the quantity of the contaminant as a carbon source, and what macronutrients (and trace elements) are essential to grow new cells and increase the bacterial colony. As such, the bionutrient approach represents an extension of traditional catabolic bioremediation design; it presents a method to quantify the amount of macronutrients needed to facilitate bioremediation.

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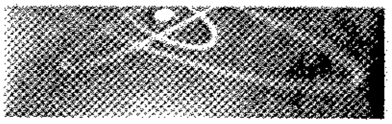
Microbial organisms are the product of inorganic matter and have a relatively constant stoichiometric composition of



$C_{106}H_{263}O_{110}N_{16}P_1$ plus species-specific trace elements. For contaminants to increase and promote bacterial growth, organisms also require a supply of inorganic chemicals to support the growth of new cellular structures and produce life-functioning proteins and enzymes (nitrogen based amino acids, and phosphorus based phospholipids and nucleic acids) for the expanding colony.

From a purely stoichiometric view, Stumm and Morgan (1981) provide the following reaction equation for the make-up of algal protoplasm (noting that the composition of simple organisms such as bacteria, yeast and algae are very similar) as an example of microbial elemental composition:

[illegible]

[illegible]

$C_{106}H_{263}O_{110}N_{16}P_1$ + 138 O_2

algal protoplasm

where:

C = Carbon, O = Oxygen, H = Hydrogen, N = Nitrogen and P = Phosphorus.

rP = rate of production of cellular organic matter (for bioremediation process this means an increase in the microbial population while consuming contaminants);

rR = rate of destruction of cellular organic matter.

For comparison with the above example, Metcalf and Eddy (1991), in the design of anaerobic digesters, use the stoichiometric relationship of $C_{60}H_{87}O_{23}N_{12}P_1$, to represent the cellular composition of anaerobic bacteria.

Furthermore, the composition of the algal protoplasm may be conveniently expressed in terms of a basic carbon unit and inorganic compounds, ammonia (NH_3) and orthophosphate (H_3PO_4) as:

$(CH_2O)_{106}$ [illegible] (H_3PO_4)

where:

(CH_2O) represents the carbohydrate unit (as basic sugar);

(NH_3) represents the basic nitrogen unit (as ammonia);

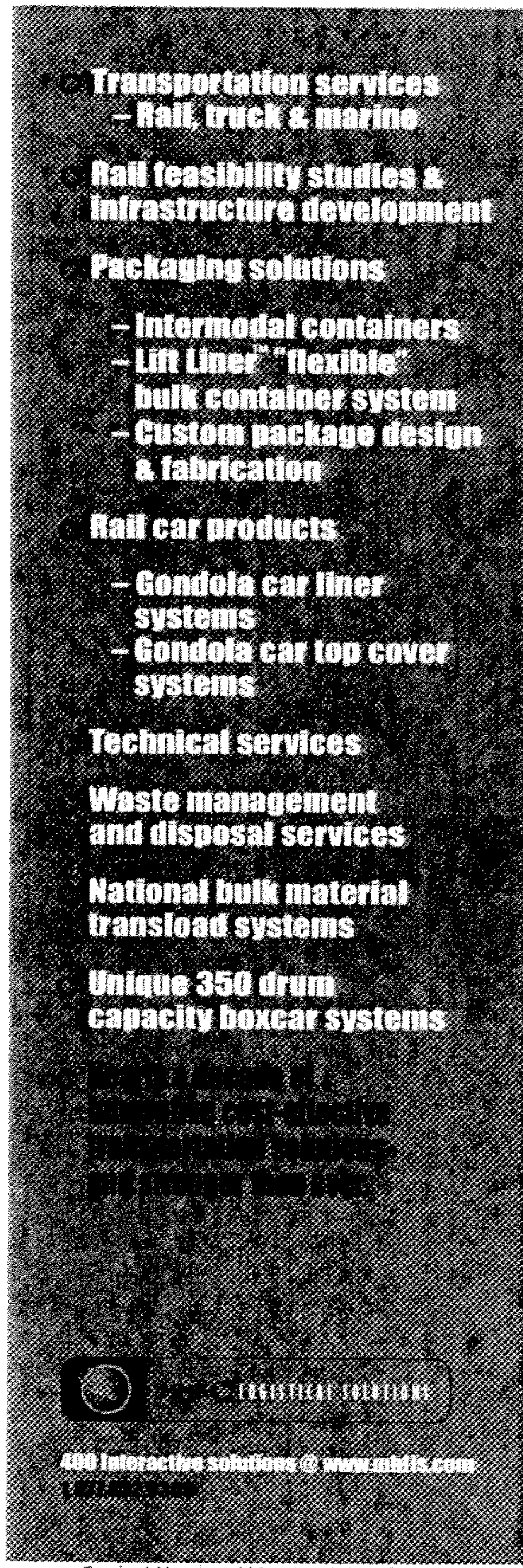
(H_3PO_4) represents the basic phosphorus unit (as orthophosphate).

These macronutrient molecules are readily soluble and electrochemically active, and therefore readily dispersed in the natural environment for uptake by microorganisms.

For a biological system as indicated above, biomass will continue to form as long as there exists a continuous supply of carbon (organic or inorganic) and bionutrient compounds. Only when one or more nutrients become a limiting factor will the production of biomass cease. However, the reverse destruction of biomass is typically very slow compared to the rate of production, as the biomass produced is predominantly composed of large macromolecules (that is, proteins, etc.).

Application of the stoichiometric design approach

Using the preceding formulation to represent bacterial cells, it can be seen that there exists a molar ratio of carbon to nitrogen to phosphorus (C: N: P) of (106: 16: 1). On this premise, the bionutrient design approach seeks to create a subsurface condi-



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tion where macronutrient chemical elements are present and available for microbial uptake at ratios similar to the compositional make-up of the bacterial cell, with the contaminant of concern being the design limiting factor nutrient.

The mass ratio of the macronutrients (nitrogen and phosphorus) with respect to carbon can be found by multiplying the molecular weight of each element by its respective molar ratio to get equivalent mass. To express nutrient mass requirements in terms of per gram of carbon, divide the mass of each element by the total mass of carbon. These calculation steps are summarized in **Table 1**.

Thus, for every gram of carbon used to grow new cells, 0.176 grams of nitrogen, and 0.024 grams of phosphorus are required, that is (C: N: P) = (1: 0.176: 0.024). The above design procedure can be readily expanded to consider other essential macronutrients and trace metals as needed based on the knowledge of a specific bacteria's nutrient requirements.

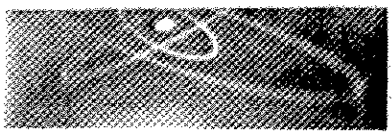
Example application

The following is an (applied) example of how the stoichiometric-bionutrient design approach is evaluated to determine macronutrient requirements for the aerobic degradation of a hydrocarbon plume:

Consider a (dissolved) gasoline plume with an average mass concentration of six milligrams per liter (mg/L). Assume that the gasoline consists primarily of hydrocarbon molecules, with the carbon to hydrogen ratio consistent with a mid-range gasoline compound such as toluene (C_7H_8). For aerobic degradation to occur, a source of dissolved oxygen (DO) will typically be required, and DO concentrations should be maintained at two mg/L to preserve aerobic conditions within the plume. Typically, the total DO requirements are taken as three to four times the average hydrocarbon concentration (see Suthersan, 1997) based on performing a mass balance of the hydrocarbon constituent

Table 1 - Equivalent Mass Calculation of Microorganism Stoichiometry

Element	Carbon	Nitrogen	Phosphorus
Molar ratio (moles)	106	16	1
Molecular Weight (grams per mole)	12	14	31
Mass ratio (grams)	1272	224	31
Per gram of carbon	1	.176	.024



redox reactions similar to the one presented for benzene.

Now to determine the quantity of macronutrients required:

- Step 1: Determine the carbon mass concentration within the plume; in this example carbon (represented as toluene) accounts for 90 percent of the contaminant mass or 5.4 mg/L.
- Step 2: Determine the mass ratio of the macronutrients (nitrogen and phosphorus) with respect to carbon. That is, 5.4 times (1: 0.176: 0.024).
- Step 3: Suppose groundwater analyses determined that dissolved nitrogen and phosphorus were present in the aquifer at concentrations of 0.2 and 0.03 mg/L, respectively.
- Step 4: Perform a mass balance of the gasoline plume zone to determine the quantity of macronutrients required to utilize all the contaminant mass to grow new cells. These steps are summarized in **Table 2**.

Based on the above calculations, nitrogen and phosphorus should be added to the system until the plume volume contains a concentration of nitrogen and phosphorus of at least 0.95 mg/L and 0.13 mg/L, respectively. That is, a sufficient volume of nitrogen and phosphorous compounds should be added to the aquifer to amend the lacking nitrogen (0.75 mg/L) and phosphorus (0.10 mg/L) within the area of contamination. If indicated by site characterization testing, consideration should also be given to non-contaminant sources of carbon in determining nutrient requirements.

The molecular ratios presented in **Table 1** may be used to determine nutrient requirements for the bacteria. The author has found that the use of the molecular formula for algal protoplasm to determine macronutrient requirements in conjunction with the addition of oxygen release compounds has worked well for the design of in situ biodegradation of petroleum hydrocarbon plumes. In cases where anaerobic conditions prevail and halorespirators, nitrogen, sulfate, or methane reducing bacteria are the active remediating organisms, these bacteria will have cellular composition similar to that stated above.

The ability of these bacteria to degrade contaminants is a function of their active (degrading) enzymes, and the bacteria are best able to

Table 2 - Sample Mass Balance Calculation to Determine Nutritional Needs

Calculation Step	Carbon	Nitrogen	Phosphorus
(1) Mass of carbon present	5.4		
(2) Mass of carbon present to bionutrients required (mg/L)	5.4	.95	.13
(3) Nutrients present (mg/L)	5.4	.2	.03
(4) Bionutrient deficiency (mg/L), Step (2)-(3)	0	.75	.1

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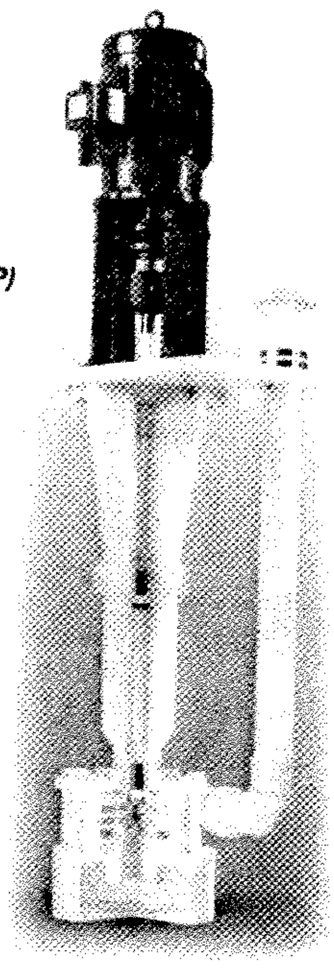

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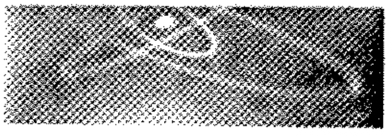


(reproduce the required degrading enzymes in an environment that has sufficient macro and micronutrients.

[illegible]

For sites where contaminated groundwater has the potential for use as a drinking water source, regulatory standards require the specific conductance of the groundwater to be less than 900 micromhos per centimeter. The addition of macronutrients (nitrate, sulfate, or orthophosphate) will increase the specific conductance of the groundwater due to their ionic nature (that is, macronutrient compounds are generally composed of soluble cations and anions). As such, a drinking water aquifer could be affected by the addition of excessive quantities of macronutrient compounds.

The federal government has determined Maximum Contaminant Levels (MCLs) for specific compounds in drinking water; if any one of the listed compounds exceeds its MCL in potable groundwater, consumption of the groundwater is considered to be potentially toxic. Nitrogen compounds have listed MCLs. However, the MCLs for the macronutrient compounds are usually 1,000 times higher than those established for organic or metal contaminants, as indicated in **Table 3**.

Table 3 - Comparison of typical MCL values for Pollutant Types

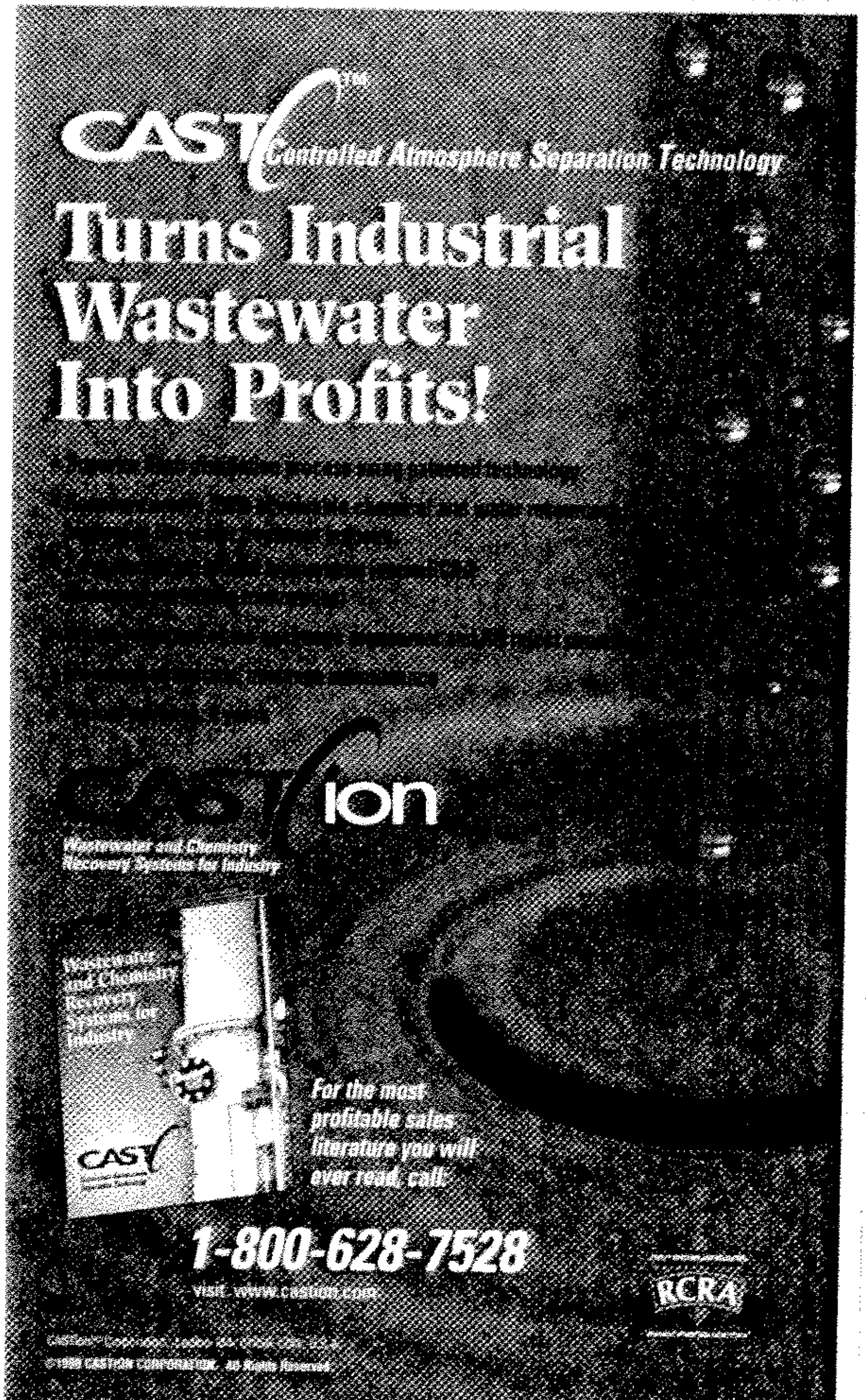
Contaminant	Pollutant	MCL
Benzene	Hydrocarbon	[illegible]
PCE	Chlorinated Solvents	[illegible]
Mercury	Metal	[illegible]
DDT	Insecticide	[illegible]
Nitrate	Inorganic	[illegible]

As shown in the example application presented above, the amount of macronutrient additions required to foster optimal contaminant biodegradation is significantly less than the mass of the contaminant of concern, and significantly less than the nitrate MCL. Therefore, if found to be lacking, macronutrients should be added only in amounts that do not exceed respective MCLs.

Furthermore, if the bioremediation is observed to be progressing, it may be reasonably assumed that the macronutrients are being assimilated by the bacteria and transformed into biomass (that is, used to synthesize complex biomolecules). The breakdown of biomass (organic proteins, etc.) to more fundamental compounds will take a significant amount of time.

Concluding remarks

The bionutrient (or anabolic) design approach focuses on how to expand a bacterial colony while considering the contaminant of concern as a limiting factor nutrient. The design approach provides a means



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to quantify macronutrient (nitrogen and phosphorous compounds) additions to groundwater, making the addition of bionutrients justifiable to regulators. When used in combination with the traditional terminal electron acceptor (or catabolic) bioremediation design approach, the bionutrient design approach completes the microorganism metabolic cycle. Considering both metabolic pathways in bioremediation design leads to procedures that optimize subsurface conditions, fosters bacterial activity, and achieves remedial goals at the site. PE

For more information regarding this article, contact Warren Chamberlain, R.G., CHG, P.E., at 925-462-2665 or by e-mail at wchamberlain@claytongrp.com.

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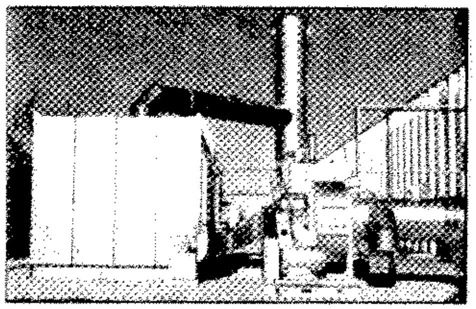

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