Supplement To:

REMEDIAL ACTION WORK PLAN FOR *IN SITU* TREATMENT USING ENHANCED BIOREMEDIATION

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SECTION 1
INTRODUCTION

This document is a supplement to the Remedial Action Work Plan (Work Plan) for *In Situ* Treatment using Enhanced Bioremediation (Parsons, February, 2010). It provides additional details and procedures related to the scope of work and construction elements provided in the Work Plan.

As discussed in the Remedial Action Work Plan, there are two major components of the *in situ* bioremediation: (1) an overburden bioreactor, and (2) vegetable oil-based substrate application to the bedrock groundwater. The overburden bioreactor will add organic carbon to the overburden groundwater to stimulate *in situ* degradation. The vegetable oil substrate will be injected into the bedrock groundwater, to add organic carbon and stimulate *in situ* degradation.

This document is organized into the following five sections.

1. Introduction,
2. Overburden,
3. Bioreactor Installation,
4. Substrate Injections Procedures,
5. Remediation Project Safety PSP Amendment, and References.

SECTION 2
OVERBURDEN BIOREACTOR INSTALLATION

2.1 BIOREACTOR SCOPE OF WORK

The bioreactor is comprised of two parallel trenches backfilled with a mixture of gravel and organic mulch. The bioreactor will consist of a mix of wood-chip mulch and gravel emplaced below the water table in the source area (see Figure 1). Additionally, horizontal piping will be installed in the excavation in the event that amendments need to be added to the bioreactor. Such future amendments would be added by injection of vegetable substrate into the piping. Vertical monitoring wells will be installed for testing groundwater within and adjacent to the bioreactor.

The bioreactor trenches will be excavated in the area shown on Figure 1. Each trench will be approximately 250 feet long and 3 feet wide. The 3-foot width of the trenches is intended to provide sufficient residence time of groundwater in the trench, limit the amount of soil excavated, and minimize the size of an open excavation at the surface. The trench will be excavated to the top of bedrock. Bedrock in the vicinity of the trenches ranges between 12 and 15 feet. The site soils consist of mostly red-brown clay and silt, with some sand near the top of rock. The red-brown clay varies from stiff to very stiff. The geotechnical properties of these soils indicate that the walls of the excavation will be stable.

There are two known utilities (sanitary and storm sewers) that cross the work area. Prior to excavation of the trenches both of the utilities will be hand exposed.

Following excavation, the trenches will be backfilled with a mixture of organic mulch, gravel and amendments that has been specified for use in the bioreactor. The mulch will consist of a natural untreated plant material (primarily tree mulch) shredded multiple times to increase the consistency of the chip size. The specific type of mulch is based on in-season material availability, and will be determined prior to starting the trench excavation. Gravel limestone will be washed of fines and uniform in grain size, comparable to the size of mulch the chips. Mulch/gravel material will extend from the bottom of the excavation to a depth of 5 feet below ground surface (bgs). Two horizontal substrate distribution pipes will be installed in each trench of the bioreactor at a depth of approximately 12 feet, and 6 feet bgs (see Figure 2). In addition to the substrate distribution piping, five monitoring wells will be constructed inside each trench. The mulch will then be covered with a non-woven geotextile to reduce fine soils from entering the top of the bioreactor. On top of the geotextile, a 3.5-foot layer of gravel will be backfilled and compacted to method specifications, and covered with a high strength woven geotextile. On top of this layer of high strength woven geotextile, one foot of gravel will be compacted to standard roadway specifications and covered with six inches of asphalt. The surface completion of the bioreactor will be concrete / asphalt. Figure 3 is a profile view of the trench.

A generalized sequence of events is provided below:

- Utility clearance and hand expose utilities.
- Remove concrete, and railroad tracks.

- Excavate upper 6 feet of soil (or to water table), stage for sampling and disposal.
- Excavate to bedrock.
- Backfill 2 feet of mulch gravel mixture.
- Install lower horizontal pipe, and gravel.
- Backfill to 6 feet bgs with mulch and gravel mixture.
- Install upper horizontal pipe, and gravel.
- Install the non-woven geotextile.
- Backfill gravel to 3.5 feet bgs.
- Install a high strength woven geotextile.
- Backfill one foot of gravel.
- Build flush-mount curb boxes for piping.
- Add 6-inch pavement.

2.2 BIOREACTOR BASIS FOR DESIGN

2.2.1 Sidewall Stability

Vertical sidewalls were selected for these trenches due to existing soil type, lack of persons entering the excavation, and the remedial objective. Trenches of narrow width also provide an increased arching action within the compacted backfill that eliminates the need for major structural support to support surface completion. The close proximity of the trenches to each other and the location of the trenches near the building (See Figure 1) also limit the ability to step the walls of the trench.

During excavation, the following engineering controls will be used to reduce the risk of consequences from side-wall collapse:

- No personnel will be entering the excavation when it is deeper than 4 feet.
- Soil conditions will be monitored for stability during the open excavation by an excavation competent person.
- A trench box will be available during the excavation as a contingency for stability or if personnel need to enter the excavation.

Soil boring data and field tests including Standard Penetration Tests (SPT) from soil logs, thumb penetration tests, and plasticity tests were also used to form the basis for vertical walls. The SPT values and field tests from boring logs from wells in the vicinity of the proposed excavations indicate that the soils are dominantly stiff to very stiff CLAY, little silt (using Burmister Classification), which indicate undrained shear strength values of 1000 – 4000 pounds per square foot (psf) (Carter & Bentley, 1991). The bottom 2 to 4 feet of the clay has N-values of less than 10, indicating that these may be softer, possibly as low as 500 psf.

The critical height for a temporary vertical clay face in an "undrained" condition without tension cracks can be calculated using the equation:

$H_c = 4c_u/\gamma$ (Terzaghi, 1943)

For a factor of safety of 1.0 and a vertical face height of 15 feet for a typical soil unit weight of 125 pounds per cubic foot pcf, the critical undrained shear strength is about 500 psf. A factor of safety of 1.5 requires 750 psf and a factor of safety of 2.0 requires 1,000 psf. The un-drained condition is a temporary condition caused by the inability of the fine-grained soil to allow the internal pore-pressures to quickly approach equilibrium when the soil is stressed.

This leads to an apparent paradox of temporary slope or cut face stability. Stiff to hard soils have relatively high short-term strengths but the fissuring and fracturing typically present in these soils can allow failure surfaces to approach pore-pressure equilibrium in a much shorter time than in soft clays, in some cases about 5 times as fast. Since stiff clays undergo a reduction in pore pressure when excavated, maintaining the excavation in a dry condition with continued drying of the face can help delay the period when the soil mass approaches pore-pressure equilibrium while wet weather can accelerate it (Leroueil, 2001). Thus, this work should be conducted in dry weather unless shored. In these conditions, it is likely that a vertical face could be maintained for several days.

It is therefore typical to require factors of safety of 2 or more for excavations into stiff to hard clays while factors of safety of about 1.5 are often used for soft clays (Leroueil et al 1990). As a point of reference, the long-term stable slopes for most clays in this region are typically in the range of 2H:1V to 4H:1V although it may take several years of erosion and mass transport for the angles to become this flat, so transient conditions govern the behavior of the ground during excavation and construction.

Other evidence that supports the use of vertical sidewalls includes a previous excavation at the site. Stable vertical sidewalls were observed during the original tank removal. During this previous excavation, which was approximately 20ft by 20 ft to bedrock at 12 feet, the hole remained open with little wall stability issues. At another location on-site, a shallow excavation in similar materials suggests that the walls will likely remain stable.

2.2.2 Settlement of Trench

In order to reduce settlement of the trench, the following is specified. The gravel between the top of the non-woven geotextile and the bottom of the geogrid will be compacted using methods specifications that include:

- Washed gravel of uniform size will be backfilled in 1 – 2 foot lifts.
- In between lifts, the gravel will be compacted by three passes of an excavator-mounted hydraulic plate compactor.

The predominant settlement of the trench will be due to degradation of the mulch material. The bioreactor backfill (from 6 to 12 feet bgs) will be a mix of 60% gravel and 40% mulch.

Assuming that at least 50% of the mulch will occupy pore spaces between the gravel, the remaining 50% of mulch is available for settlement. Given the 6 feet of gravel mulch mixture, the settlement is expected to be a maximum of 1.2 feet in approximately 5 years. The 5 years is based on the typical longevity of a mulch biowall. Given the low groundwater flux through the clay and silt, longevity may be more than 5 years.

Arching action of the gravel backfill within the 3-foot wide trench may help to reduce the final settlement at the surface by allowing load transfer from the backfill to the adjacent trench sidewalls as the backfill moves downward. In addition, if the gravel backfill above the mulch is well compacted, the settlement process may be partially accommodated simply by loosening of the backfill, which would increase its volume.

At completion, settlement of the trench will be monitored as part of the Operations and Maintenance of the trench. Should settling of the trench greater than 2 inches occur, the surface completion of the trench in the settled area will be repaved/repaired.

2.2.3 Utility Support

During excavation, any utilities encountered will be handled in accordance with the pre-drilling/excavation protocols and procedures defined by the underground facilities protection organization. Utilities are to be exposed by hand. The trench will be backfilled and compacted as specified, providing the support for the utility at completion.

Depending on condition of the utilities, soils may be left in place beneath them for support. Leaving existing soil in place beneath the pipe and three feet either side of the pipe will minimize the risk of potential loss of support for the pipe. The left-in-place soils would be separated from the mulch gravel mixture by a sheet of metal to prevent their collapse during construction.

2.2.4 Minimum Requirements for the Geosynthetics

Non-woven geotextile over the mulch: Non-woven geotextile meeting AASHTO M-288 requirements for Separation function with a Class 2 survivability.

High Strength woven geotextile will have a minimum ultimate strength of 50kN/m in both machine and cross-machine directions measured using ASTM D6637. The edge of the geogrid shall extend at least 3 feet beyond the edge of the trench to provide anchoring. There shall be no longitudinal (along the length of the trench) seams or discontinuities within the trench or the 3 foot anchor zone on either side.

The non-woven geotextile specification is based on industry-accepted practices. The purpose is to put in a tensile element that could reduce the severity of issues related to local settlement of the backfill that could cause local collapse (pothole-like) of the pavement.

SECTION 3
SUBSTRATE INJECTION INTO BEDROCK GROUNDWATER

The bedrock groundwater remediation is being conducted in a phased approach. This will allow the groundwater geochemistry to change slowly over time The first injection of substrate focuses around the source area. After a period of performance monitoring, the application of substrate can be expanded to other areas, as needed.

The following quantities are for the first phase of substrate injection. The substrate will be injected into INJ-06 while withdrawing groundwater from INJ-07, INJ-08, INJ-09, and INJ-10. Table 1 from the Remedial Action Work Plan provides additional information on quantities.

3.1 ANTICIPATED SUBSTRATE QUANTITIES

Total SRS-FR = 500 gal
Makeup water = 3500 gal
Makeup water push = 150 gal

Target NaBr = 500 mg/L
Given 1065 gal of mixture per injection = 7.5 Kilograms per well.

The above quantities may be subdivided to account for batch injections in order to reuse the groundwater extracted from the outer wells. If observations made during drilling, groundwater sampling, or other remediation tasks suggest the condition in the bedrock are different than anticipated, the volumes may be revised.

3.2 INJECTION PROCEDURES

1) Site preparation, layout, and health and safety

Discuss with site manager the logistics and basics of substrate injections (i.e. area, daily work hours, and site personnel, scope of activities). A simultaneous operations plan will be developed and reviewed with onsite personnel prior to the start of work.

2) Begin makeup water extraction for first injection.

3) Fill one tank with appropriate volume of groundwater.

4) Prepare for first injection at injection well:

- Set transducers in wells and reserve one for measuring tank.
- Install 100 PSI, nitrile packer in INJ-06. Isolate the open rock portion of the well from the protective casing portion (i.e. set packer at ~12-14 feet

bgs in 4" steel casing). Install pipe from the packer to the well head configuration; include pressure gauges as appropriate.

5) Measure conductivity and turbidity of groundwater in tank.

6) Add SRS-FR to Tank 1. Begin mixing in recirculation loop.

7) Measure conductivity and turbidity of substrate in tank and in the injection and monitoring wells.

8) Place reserved transducer in well.

9) Mix substrate in recirculation loop for 5 minutes.

10) Inject substrate into injection well at approximately 5 gpm, but not above 15 PSI. If back pressure is greater than 10 psi, stop the injection and call technical team before continuing.

11) Extract groundwater at INJ-07, INJ-08, INJ-09, and INJ-10 at approximately 1 - 2 gpm each, and collect into tank.

12) Monitor surrounding wells for breakthrough. Monitor: water levels (hand and transducer data), conductivity (logger data), turbidity, and visual identification of substrate.

13) After the substrate is injected from the first tank, pump groundwater into the injection tank and repeat above steps.

14) After the desired radius of influence (ROI) is achieved at the first well, inject the groundwater push.

3.3 CONTINGENCIES

If the injections are completed in the winter months or freezing temperatures which could effect the equipment, precautions must be taken to winterize the equipment. During the months where daytime high temperatures are consistently less than 40 degrees all piping, hoses and tubing be drained at the end of the work day. Tanks with substrate mixture or makeup water shall be drained (depending on volume) or insulated/ heated to prevent the liquids from freezing. Drums of SRS will be protected from cold weather by placing in temporary storage or using drum heaters.

Portable field equipment will be stored overnight indoors.

If the porosity is considerably less than 1%, the proposed injection volume at each well will be less. If this happens, the team will communicate with the technical advisors and decide whether or not the remainder of the substrate should be injected.

If the porosity is larger than 1%, additional substrate will be ordered. Volume will be recalculated using previous calculation sheets with revised porosity.

SECTION 4
REMEDIATION PROJECT SAFETY PLAN AMENDMENT

This section outlines the amendments to the Project Safety Plan (PSP) for implementing the Remedial Action Work Plan (Parsons, February, 2010). It complements the Work Plan and the PSP. All Parsons and subcontractor personnel must understand and implement the PSP and any addenda.

The Project Safety Plan (PSP) will be updated prior to the start of field work related to implementation of the remedial measures. The PSP will include Control of Work (CoW) forms including Task Safety Environmental Analysis (TSEA), Daily Toolbox Meeting Records, and appropriate work permits (ground disturbance, hot work, overhead utilities, working at heights, etc.) that may be required to complete the work. Any subcontractors used to complete the work will meet HSSE requirements. In addition, the HSSE plan will include an updated emergency response plan in the event of a situation or unplanned occurrence requiring assistance. The plan will provide the onsite user with critical information to be used in the event of an emergency.

Personnel performing activities that require training (i.e. confined space entry, excavation/trenching, scaffold use, HAZWOPER, etc.), will provide copies of training certifications, and proof of competency prior to starting the activity.

The PSP will be discussed with the current owner's representative and a copy of the plan available at the site.

4.1 BIOREACTOR SAFETY

Subcontractors must establish a safety program for their work and employees. Contract specifications require all subcontractors to review and accept Parsons PSP and prepare their own safety plan for presentation to the Parsons Project Manager at least 10 days before site mobilization.

A written plan will be developed to coordinate simultaneous work activities between field crews and site facility workers. The plan will be developed and reviewed with onsite personnel prior to the start of work. All field crew members and visitors will comply with health and safety policies. This includes participation in safety meetings, including TSEA (Task Safety Analyses, i.e. JSAs) and other policies.

4.2 SUBSTRATE INJECTION SAFETY

Above-ground upright poly tanks will be used to perform batch injections. Substrate and site groundwater water will be mixed in one tank and then injected. While the site groundwater and substrate mixture from one tank is being injected, the other tank will be filled with make-up water from onsite wells. Both tanks will be located in a secondary containment system.

The substrate and groundwater mixture will be injected using a centrifuge or submersible pump. Injection tubing will be run through a packer that has been placed in the well, near the bottom of the casing. The packer will be inflated with nitrogen. Injection rates will be in the rage of 5 to 10 gallons per minute (gpm). The pressure on the injection line will be maintained below 15 pounds per square inch (psi). Plastic hose will be used for pumping from the tank into the injection well, in addition to the recirculation loop. Cam lock fittings will connect hosing to the tank, the pump, and the packer.

4.3 TEMPORARY CONSTRUCTION FENCE

A temporary chain link fence will be set up around the working area. The fence will serve to protect workers and equipment from vehicular traffic as well as keep visitors safely outside the working area. Site workers will be notified to park away from the work area, except when using the vehicle for a task.

When positioning the temporary fence, predominant traffic patterns as well as the proposed layout of hoses, data cables, and equipment will be taken into consideration.

4.4 SPILL PREVENTION

A secondary containment will be built around the tanks, pump, substrate staging area, hosing and well head area. A spill kit will be available near work area when fluids (groundwater, substrate, etc.) are being stored and/or used.

Prior to pumping groundwater substrate the system will be checked by pumping potable water. Cam locks and hosing will be thoroughly inspected. After the pump is turned on all connections will be check for leaks, or potential for leaks.

While pumping groundwater or substrate mixed with groundwater, a routine check every 5 to 10 minutes will be conducted on hosing and tubing to confirm that there are not any leaks or outward appearances of wear that could lead to a leak.

A pressure relief value will be included in the pump assembly, such that pressure above 15 psi will be diverted through the valve back to the storage tank.

The following is a list of equipment and compatibility requirements:

- High Density Polyethylene (HDPE) tanks: compatible with dissolved concentrations of site compounds, vegetable oil, dissolved sodium bromide (salt groundwater tracer), and sodium bicarbonate (baking soda).
- Injection pump: centrifuge pump compatible with groundwater and dissolved emulsified vegetable oil.
- Injection and relay hosing: 1” high pressure (70 psi) PVC hosing with cam lock fitting. Cam lock fittings will be secured with cotter pins or by other means.
- Generator: minimum 200 watt, diesel.
- Fuel transfer pump: hand crank pump compatible with petroleum based liquids.

4.5 WINTERIZATION

If the injections are completed in the winter months or freezing temperatures which could effect the equipment, precautions must be taken to winterize the equipment. During the months where daytime high temperatures are consistently less than 40 degrees all piping, hoses and tubing must be properly drained at the end of the work day. Tanks with substrate mixture or makeup water must be drained (depending on volume) or insulated/

heated to prevent the liquids from freezing. Drums of vegetable oil based substrate will be protected from cold weather by placing in temporary storage or using drum heaters. Portable field equipment will be stored overnight indoors.

4.6 SITE VISITORS

All site visitors will be required to check in with the Parsons Supervisor to complete site specific Health and Safety training and sign off on the PSP. Visitors will be responsible for complying with all Health and Safety documents for the site.

4.7 AIR QUALITY MONITORING

Air monitoring will be used to identify and quantify airborne levels of volatile organics. Periodic monitoring is required during excavation, groundwater pumping and substrate injection. Areas to monitor periodically include the trench, tank openings, area of the injection well, breathing zone, and any other wells that are opened for monitoring.

Air monitoring will be completed with a 11.7 mV photoionization detector (PID) to monitor the breathing zone. The action level is driven by the vinyl chloride, and is 1 ppm (sustained in the breathing zone and above background). If this level is reached, the field team must cease activities until concentrations drop to background levels or use engineering controls to reduce levels. If vapors continue to exceed background in the breathing zone, the Project Manager will be notified. Alternatively, the concentrations of vinyl chloride could be quantified using a drager tube and potentially the action level could be adjusted.

4.8 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The personal protection level prescribed for the project is OSHA Level D. Steel toe boots, hard hats, long sleeve shirt, high visibility vests, and safety glasses will be worn at the site. Workers must have work gloves with them and use them when appropriate for the task. Nitrile gloves will always be worn when handling potentially contaminated material. A face shield will be worn when operating the centrifuge pump and working in the area of the injection equipment. Additional personal protective equipment may be required when handling contaminated samples or equipment.

4.9 INJECTION RATES AND PRESSURES

Injection rates are estimated at 5 to 10 gpm. Based on aquifer coefficient testing previously conducted at the site for the injection zone, pressures at this rate are expected to be less than 15 psi. Pressure will be monitored during the injection using a pressure gauge and will not be allowed to exceed 15 psi. The system is engineered to handle much higher pressures. However, due the lack of need for a pressure injection, the maximum pressure is designated at 15 gpm. A pressure release valve of 15 PSI has been integrated into the injection line to prevent high pressure. Flow rates from the groundwater make-up wells will be at rates between 5 and 10 gpm, depending on the recovery rate of the two wells used.

4.10 SECURITY

The site is fenced with two car gates operated by key card. The site is active and employees have access. The work area will have a temporary chain-link fence. The chain-link temporary fence will deter vehicular traffic and pedestrians. All wells will be secured when not working at the site. Drums of substrate will be secured overnight in the fenced area. Other tools and materials will be removed from the site during non-working hours or otherwise secured in the site trailer.

4.11 TASK SAFETY AND ENVIRONMENTAL ANALYSIS

A Task Safety Environmental Analysis (TSEA) will be completed for each activity preformed. TSEAs will be completed and reviewed on a daily basis in the morning safety meeting. The Work Risk Analysis Tool contains the list of TSEAs.

SECTION 5
REFERENCES

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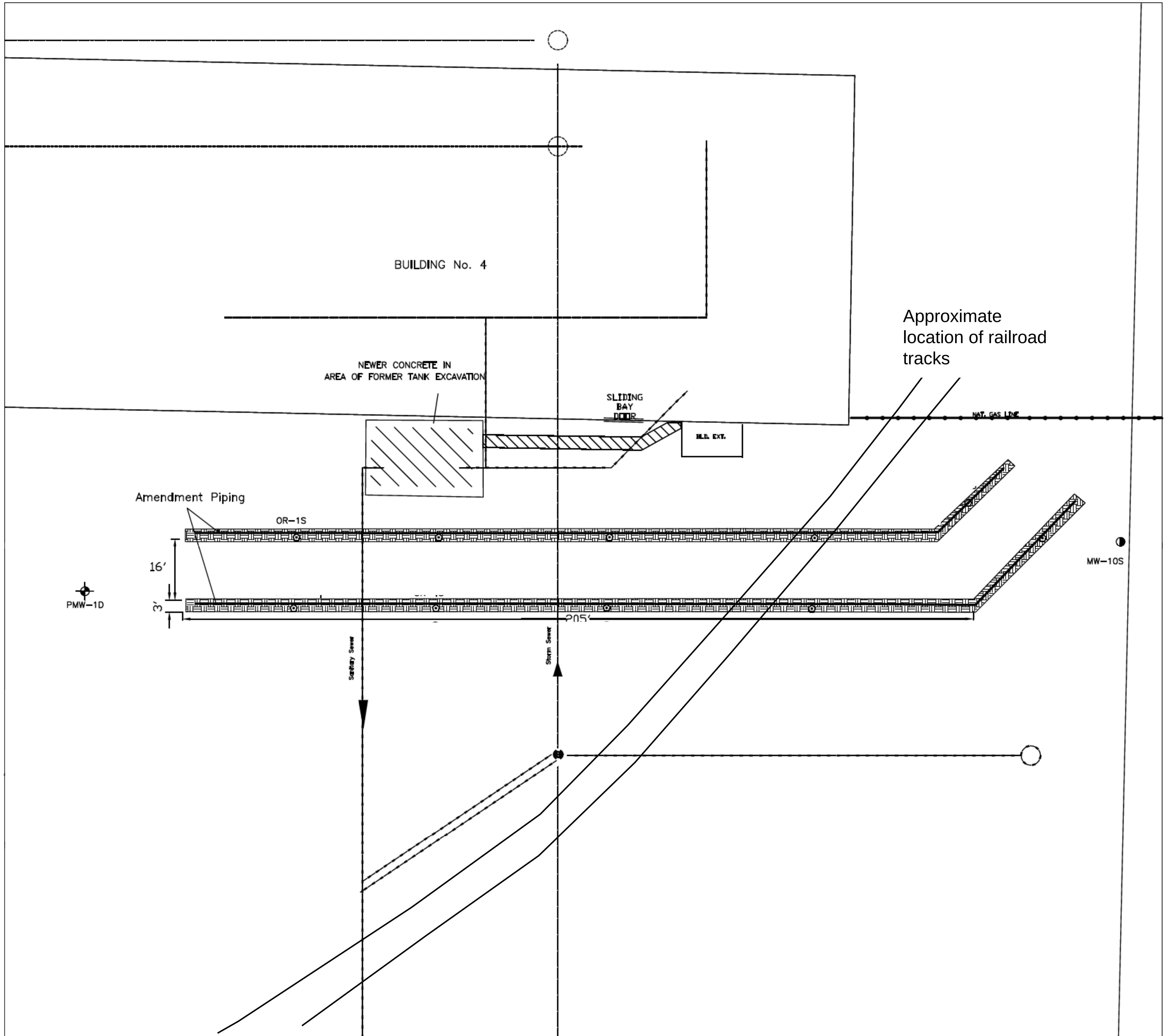

LEGEND:

- EXISTING SHALLOW INVESTIGATION WELL
- EXISTING REPLACEMENT BEDROCK INVESTIGATION WELL
- OVERBURDEN PERFORMANCE MONITORING WELL
- BIOREACTOR MONITORING WELL
- MULCH AND GRAVEL BIOREACTOR

30 15 0 30

SCALE BAR (FEET)

NOTES: UTILTY LOCATIONS ARE APPROXIMATE
OTHER UTILITIES MAY EXIST
FINAL LOCATIONS WILL BE DEPENDENT UPON
SITE CONDITIONS AND PLANT OPERATIONS

FIGURE 1

EKONOL POLYESTER
RESINS FACILITY
WHEATFIELD, NEW YORK

BIOREACTOR TRENCHES

PARSONS
40 La Riviere Dr. Suite 350 Buffalo, NY 14202

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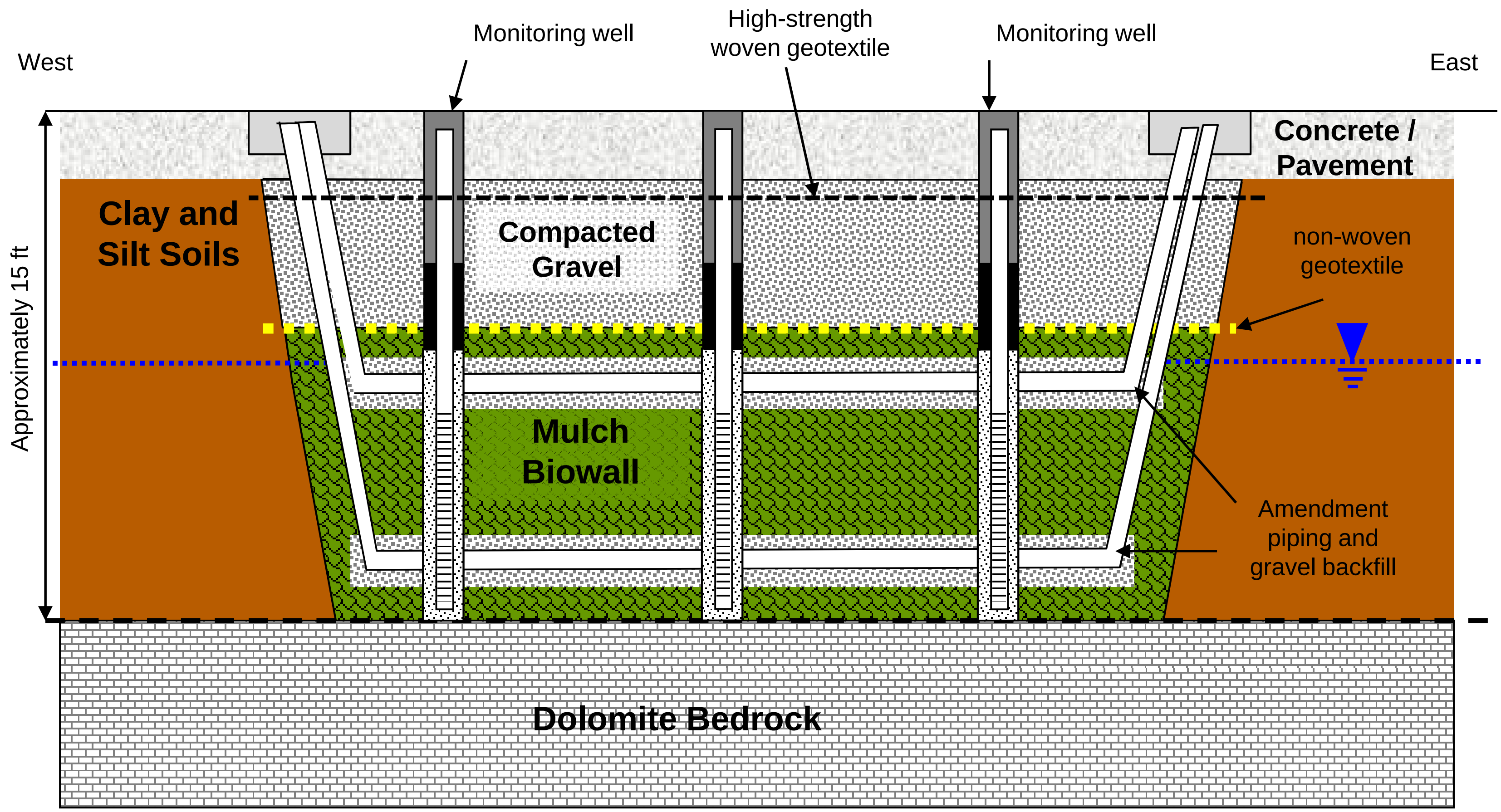
No XREFs



Not to scale

FIGURE 2
EKONOL POLYESTER RESINS FACILITY WHEATFIELD, NEW YORK
CROSS-SECTION OF BIOREACTOR TRENCH
PARSONS 40 La Riviere Drive, Suite 350, Buffalo, New York 14202

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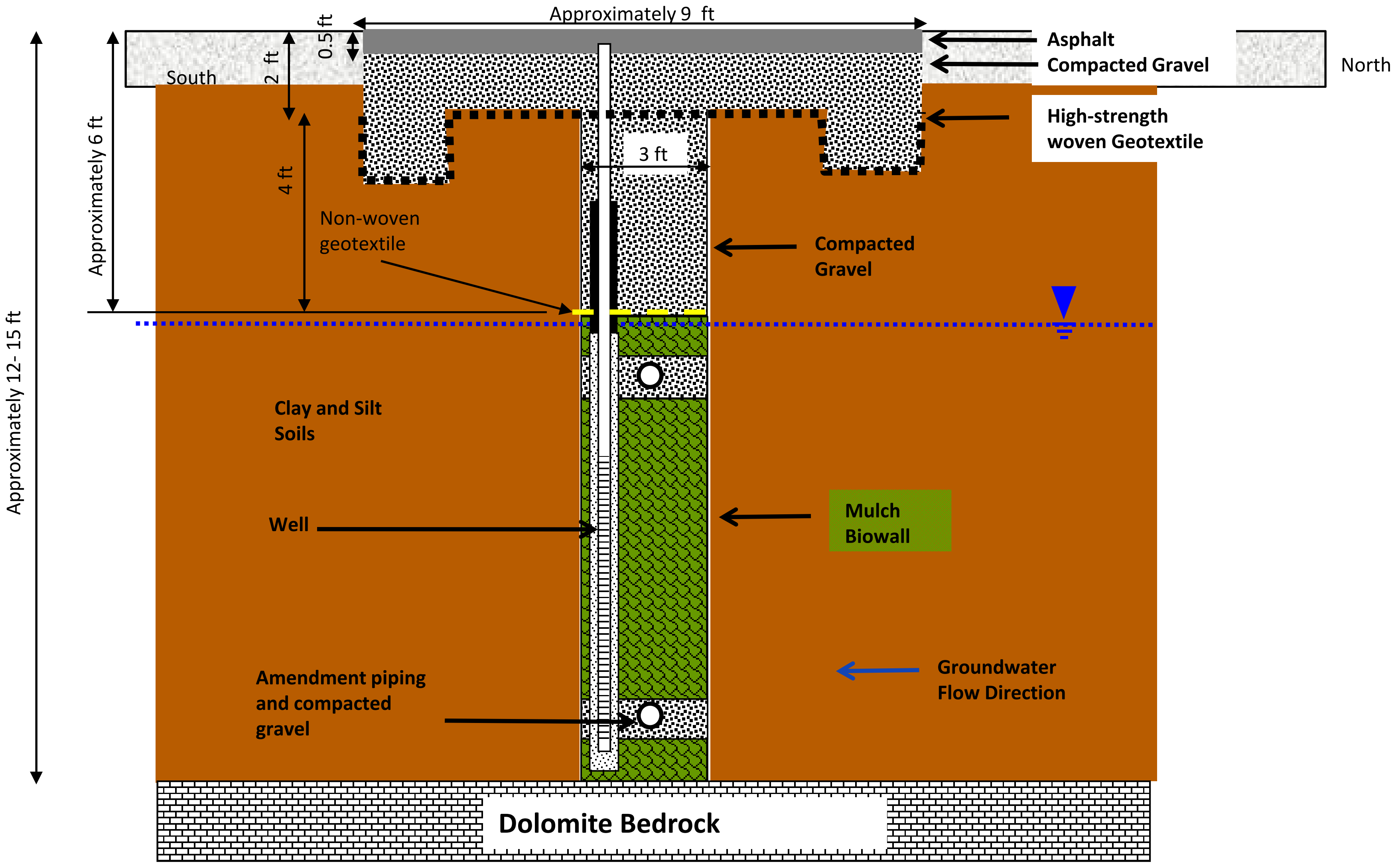

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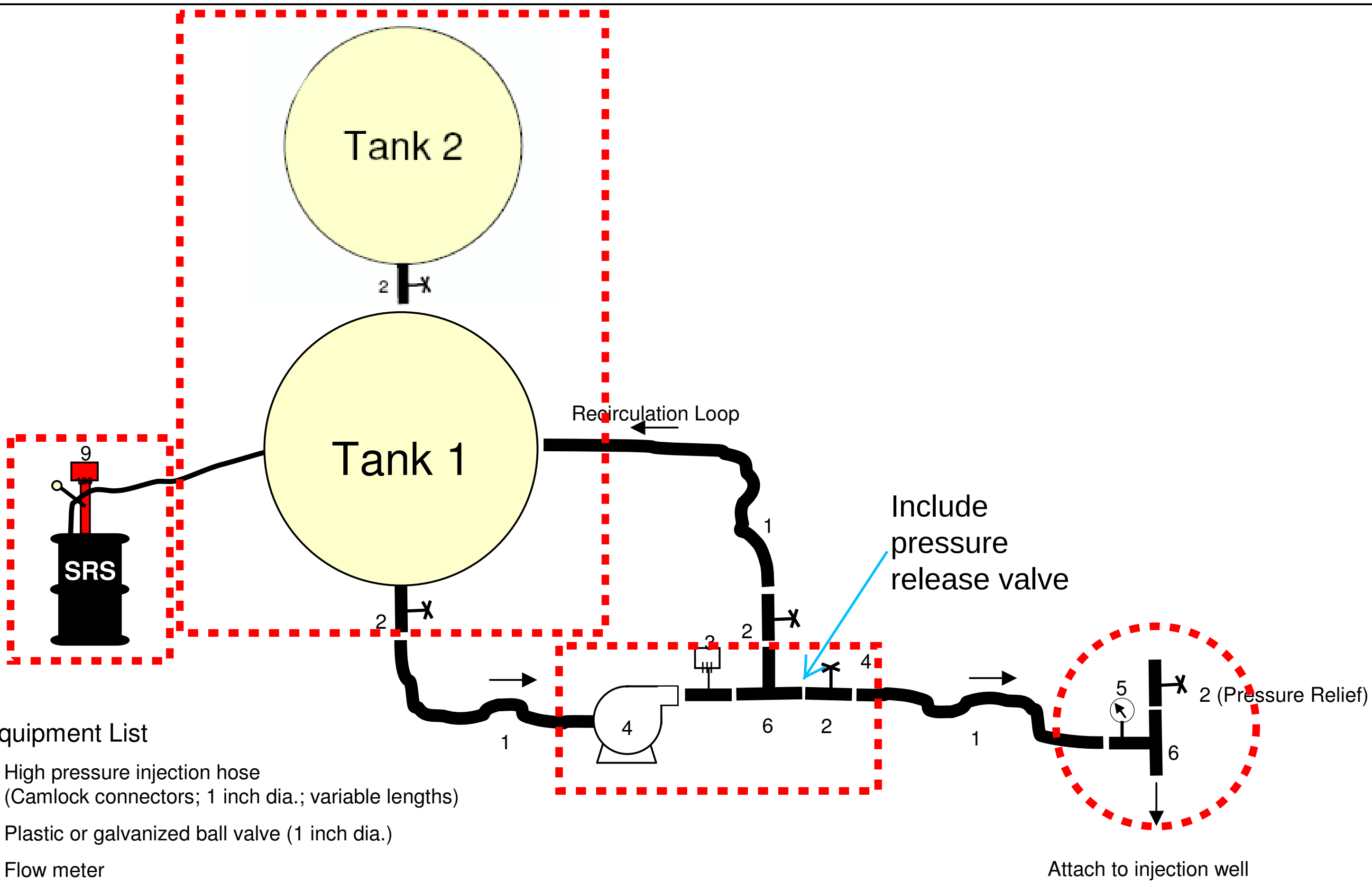
FIGURE 3

EKONOL POLYESTER RESINS FACILITY
WHEATFIELD, NEW YORK

ALONG AXIS PROFILE OF BIOREACTOR TRENCH

PARSONS
40 La Riviere Drive, Suite 350, Buffalo, New York 14202



Equipment List

1. High pressure injection hose
   (Camlock connectors; 1 inch dia.; variable lengths)
2. Plastic or galvanized ball valve (1 inch dia.)
3. Flow meter
4. 1/2 hp centrifugal pump
5. Pressure gauge (0 to 100 psi) with fittings
6. Plastic or galvanized T (1 inch dia.)
7. Submersible pump
8. Tubing for groundwater extraction
9. Oil transfer pump or submersible pump (meter optional)

Other Equipment:

1 - 625 gallon tank, 1 - 325 gallon tank

Threaded camlock [Cam & Groove] fittings (Not shown; 1 inch; male and female)

Threaded plastic or galvanized nipples (1 inch dia.; variable lengths to 1')

Plastic or galvanized reducers and bushings (various sizes, as needed)

Secondary containment

NOT TO SCALE

Note: Arrows indicate direction of water flow

Figure 4

Injection System Layout

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TABLE 1

ESTIMATED SUBSTRATE INJECTION AND LOADING RATE SCENARIO FOR INITIAL BEDROCK INJECTION

	Injection Points		Substrate Injection Mixture					Post-Emulsion Push			Total Volume		Estimated		
	Injection	Injection	Emulsion Product		Soybean Oil		Makeup	WillClear		Makeup		Water/	Injection	Effective	Radius of
Well	Interval	Spacing	Volume	Weight	Component		Water	Volume	Lactic Acid	Water	Substrate	Substrate	Interval	Porosity	Influence
ID	(feet)	(feet)	(gallons)	(pounds)	(gallons)	(pounds)	(gallons)	(gallons	(pounds)	(gallons)	(pounds)	(gallons)	(feet)	(percent)	(feet)
Injection Wells															
INJ-06	15-26	22.5 x 30	500	3,978	306	2386.5	3500	0.0	0.0	150	2,514	4,150	10	1%	42
SUBTOTAL:			**500**	**3,977**	**306**	**2,387**	**3,500**	**0**	**0**	**150**	**2,514**	**4,150**			
Weight Emulsion Product (lbs):				**3,977**											

SUBSTRATE COST ESTIMATE

Substrate Lactic Acid Concentration: 3,701 milligrams per liter

Substrate Oil Concentration: 69,061 milligrams per liter

Residual Percent Oil in Substrate Mixture: 7.4%

EFFECTIVE TREATMENT ZONE CONCENTRATIONS

Effective Lactic Acid Concentration: 54 milligrams per liter

Effective Vegetable Oil Concentration: 1,014 milligrams per liter

Total Effective Porosity of Treatment Zone + Groundwater Flux: 282,559 gallons

Total Design Factor	**0.9**	**54**	**mg/L**	**Final Vegetable Oil Concentration (mg/L):**	**1,014**
Design Period (years):	**1.500**	**0.02**		**Vegetable Oil Design Factor**	**0.93**
Design Period (months):	**18.0**	**4,208.6**	**gallons**		
Hydrogen Demand (lbs):	**296.2**	**282,559**	**gallons**		

NOTES:

1. Assumes emulsion product is 60 percent soybean oil by weight.
2. Soybean oil/emulsifier mix is approximately 7.8 pounds per gallon.
3. Volumes are approxiamte and may be adjusted based on field conditions.
4. Sodium Bicarbonate may be added as a pH buffer.