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FINAL DRAFT EVALUATION OF INTERIM REMEDY ACTION AT OPERABLE UNIT 4 (OU 4)
NTC ORLANDO FL
12/5/1996
ABB ENVIRONMENTAL

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December 5, 1996

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Commanding Officer
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2155 Eagle Drive
N. Charleston, S.C. 29419-9010

Attn: **Ms. Barbara Nwokike, Code 187300**

Subject: Information for: Evaluation of Interim Remedy for OU4 IRA
NTC, Orlando, Florida
Contract; N62467-89-D-0317/CTO 107

Dear Ms. Nwokike:

Enclosed please find a copy of the subject document for your review. This document provides background information that supports the technology option matrix. This is the final version of our November 22nd draft and will be used during our discussion of OU4 at the OPT meeting on December 11, 1996. It should be noted that this document is not an indepth review of any one option; but a collection of readily available information.

Should you have any questions concerning this document, please call Shannon Gleason at (703) 769-8181 or Harlan Faircloth at (407) 895-8845.

Very Truly Yours,
ABB ENVIRONMENTAL SERVICES, INC.

John P. Kaiser
Installation Manager

Enc.

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FINAL DRAFT

INFORMATION FOR EVALUATION OF INTERIM REMEDY
NTC, ORLANDO
OPERABLE UNIT 4 INTERIM REMEDIAL ACTION

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Additional Text

1.1 Contaminant Mass Balance Calculations A major aspect of the OU4 discussion during the November OPT meeting focused on the contribution of dissolved contaminants in groundwater to the surface water contamination observed in Lake Druid. Billy Hall noted that his preliminary calculations indicated an insignificant amount of contaminants were entering Lake Druid through groundwater, and that considerably more mass was present in the lake than would have been expected to accumulate from groundwater inflow.

ABB-ES has evaluated the mass of contaminants in the groundwater and the lake sediment in greater detail. Based on this evaluation, it appears that the total mass of VOCs in Lake Druid sediment (12 pounds) is about half the amount that is entering Lake Druid on a yearly basis (24 pounds).

This evaluation is discussed in greater detail below.

1.1.1 Groundwater Our preliminary calculations indicate that total VOCs entering Lake Druid via groundwater are approximately 24 pounds per year. This value is based on average contaminant concentrations in the plume, and the cross-sectional area of the plume as shown in Figure 4-4 of the IRA Focused Field Investigation Report for OU4.

The shallow portion of the plume with total VOCs greater than 1,000 µg/l was considered separately from the portion of the plume where VOC concentrations are between 1,000 µg/land 100 µg/l. The high concentration portion of the plume is shown in red on Figure 4-4. The cross-sectional area of this portion of the plume is approximately 840 square feet. VOC concentrations measured in groundwater during the direct push program were used to calculate the average concentration of each constituent. The average total VOC concentration is approximately 1250 µg/l, including 22 µg/l PCE, 590 µg/l TCE, and 635 µg/l cis-1,2-DCE. The Darcy velocity was used to represent groundwater flow rates for this calculation. The Darcy velocity (0.39 ft/day) is the product of the hydraulic conductivity (32.7 feet/day, from the pumping test) and the natural hydraulic gradient of 0.012. Note that the hydraulic gradient has been revised downward slightly from the value of 0.017 reported in the OU4 Focused Feasibility Study. The above values were used to calculate a total mass flow of approximately 9 lb/year total VOCs entering Lake Druid from the shallow high concentration zone.

Because the size of the portion of the plume where VOC concentrations are between 100 µg/l and 1,000 µg/l is much greater than the high concentration portion, total VOCs entering Lake Druid from this deeper, lower concentration zone are greater (approximately 14 lb/year) than the amount from the shallow "hot" zone. Again referring to Figure 4-4 of the IRA Focused Field Investigation Report, the cross-sectional area of this zone (shown in blue) is approximately 4,500 square feet. The average total VOC concentration is 355 µg/l, including 153 µg/l PCE, 102 µg/l TCE, and 100 µg/l cis-1,2-DCE.

The zone where VOC concentrations are between 10µg/l and 100 µg/l (Figure 4-4, shown in yellow) was also considered. However, the size and shape of this zone is somewhat speculative, due to the limited analytical data available in this area. Total VOCs entering Lake Druid from this zone are only 1 lb/year, based on an average total VOC concentration of 19 µg/l and an area of 7,435 square feet.

It should be noted that these calculations considered only advection, and did not consider dispersion, sorption, or degradation of the VOCs. However, the cross-section represented by Figure 4-4 is fairly close to the lakeshore, minimizing the effects of dispersion, sorption and degradation on the results of the calculation..

The total VOCs of 24 lb/year can be put into perspective by converting the TCE and DCE degradation byproducts back into PCE. The 24 lb/year of mixed contaminants is equivalent to 32 lb/year of pure PCE, or approximately 2.3 gallons of pure PCE. This value is entirely reasonable, considering PCE releases from the laundry were likely small in size.

1.1.2 Lake Druid Lake sediment data collected during the Focused Field Investigation was used to estimate the total mass of VOCs in Lake Druid sediment. Sediment VOC concentrations (expressed in µg/kg dry sediment) cannot be directly compared to VOC concentrations in groundwater (expressed in µg/l of water).

Figure 4-2 from the IRA Focused Field Investigation Report presents the range of VOC concentrations in the lake sediment. The highest concentrations were measured in sediment along a 300 foot long strip of shoreline, extending approximately 40 feet out into the lake, representing an area of 12,000 square feet. Typical concentrations ranged from 100 µg/kg to 1,000 µg/kg. However, total VOC concentrations of 4,500 µg/kg and 147,000 µg/kg were detected at two locations.

A total of 18 sediment analyses performed within the 12,000 square foot zone were averaged to arrive at an average total VOC concentration of 8,370 µg/kg. This average includes the two very high samples, and is therefore likely biased high with respect to the actual average concentration in this portion of the lake (Excluding the 147,000 µg/kg sample would reduce the average total VOC concentration to 640 µg/kg).

The total mass of VOCs in Lake Druid sediment was calculated using the average concentration of 8,370 µg/kg, an average dry sediment density of 125 lb/ft^3, and a sediment thickness of one foot across the 12,000 ft^2 area (total volume of 12,000 ft^3). This calculation yields a total mass of VOCs in Lake Druid sediment of approximately 12 pounds.

Admittedly, there are numerous assumptions made to calculate the masses of VOCs in groundwater and sediment, each contributing to the uncertainty of the calculations. However, we attempted to perform the calculations conservatively.

Rather than focus on minor variations of each calculation, it is more important to consider what general conclusions can be drawn. We believe that these results show that the major contributor to the VOC contamination in Lake

Druid is groundwater, and that the mass of contaminants measured in the sediment could easily be explained by sorption from the contaminated groundwater discharging through the bottom of Lake Druid.

OU 4 MASS BALANCE CALCULATIONS

The calculations supporting the aforementioned writeup for the groundwater and sediment mass balance and transfer have not been included in this submittal. They still require final review and format checking. They will be distributed at the OPT meeting on December tenth.

2.0 TECHNOLOGY IDENTIFICATION MATRIX

The OPT has requested a qualitative evaluation of potential technologies that could be used for the *interim* remedy at OU 4. The following table represents this evaluation. Following this matrix are descriptions of each technology. These descriptions provide the justification (for the *interim* remedial action alternative) for the qualifers presented on the matrix table.

OU4 IRA Technology Screening Matrix

	Overall protection of human health and the environment	compliance with ARARs	** Long-term effectiveness and permanence	Short Term Effectiveness	reduction of toxicity, mobility, and volume of contaminants through treatment	* Overall Cost for one year of operation	O&M, Site Monitoring and Reporting Cost for one year of operation.	Consistent with Final Remedy	Regulatory/State Acceptance	Implementability	Status-(F)ull or (P)ilot Scale	Community Acceptability	Time To Implement
GROUNDWATER													
Groundwater Extraction and Treatment	O	O	O	O	O	285 177k to 212k	185 112k	O	★	★	F	O	2 to 5 mo
Air Sparging	O	O	O	O	O	125 173k to 320k	78 104k	O	Ø	O	P	O	4 to 6 mo
In-Situ/In Well Stripping	★	★	★	O	★	163 200k	99 62k	★	O	O	P - F	O	4 to 5 mo
SURFACE WATER/SEDIMENT													
Air Sparging	Ø	O	Ø	O	O	119 129k	69 70k	Ø	Ø	O	P - F	Ø	3 to 4 mo
Enhanced Bio-Treatment	O	O	★	O	★	126 later	66 later	★	O	O	P	★	4 to 5 mo
Phytoremediation	O	O	★	Ø	★	later	50k	★	O	O	P	O	4 to 5 mo
Natural Attenuation	Ø	O	★	Ø	O	monitoring only	50k	★	Ø	★	F	Ø	2 mo

Good	★
Average	O
Below Average	Ø

* Overall costs ranges based on permanent versus temporary installations and equipment previously purchased for the site, costs include planning, construction, permitting, O&M for one year, sampling and monitoring, and reporting.

** All surface water/sediment alternatives are considered to be combined with source control

3.0 TECHNOLOGY DESCRIPTIONS

The following pages provide a description of technologies listed on the Technology Evaluation Matrix. Specifically, justification for qualifers presented in this table are discussed. It should be noted that specific locations of wells or equipment that would be installed if any of these technologies were implemented at OU 4 would be decided during the design phase.

Description of the following technologies for groundwater and surface water/sediment are provided:

NTC, Orlando OU 4 IRA Technologies Considered for Interim Remedy	
Groundwater	**Surface water/sediment**
groundwater extraction and treatment air sparging in-well air stripping	natural attenuation enhanced bioremediation phytoremediation air diffusion/sparging

Groundwater
GROUNDWATER EXTRACTION AND TREATMENT

SYSTEM TYPE:

- previously piloted via pumping test
- full-scale treatment system

COMPONENTS:

- groundwater extraction via pumping well(s)
- treatment of extracted groundwater via air stripping
- discharge to Orlando Sewage Treatment Plant

OPERATIONAL CRITERIA:

- 1-year operation (or until final remedy for OU 4 is identified)
- groundwater, surface water, and sediment sampling and analysis
- system operation, maintenance, and monitoring

DESCRIPTION OF MAJOR COMPONENTS:

Hydraulic Control

- Hydraulic control of contaminated groundwater will be achieved through extraction using recovery well(s).
- The extraction system will likely consist of one or two recovery wells, and be positioned upgradient of Lake Druid, within the central portion of the plume, where the greatest mass removal of contaminants in the surficial aquifer can be achieved.
- It is recognized that some portion of contaminated surficial aquifer groundwater, beyond the point of stagnation of the extraction system, would continue to migrate to the lake. However, the location of the system would provide for the greatest mass removal of contaminants from the surficial aquifer. The location of the extraction system and its corresponding operational parameters will be evaluated during the design to minimize the amount of contaminated groundwater that would continue to migrate to the lake.
- Recovery wells will be connected via manifold and conveyance piping to the groundwater treatment system.
- ....

Air Stripping

- Air stripping would be accomplished using low profile forced aeration tray stripping.
- This technology would treat chemicals in groundwater to limits acceptable by the Orlando STP.
- It is estimated that a four-tray low profile forced aeration stripper with an air flow rate of 900 cubic feet per minute (cfm) and a minimum air to water ratio of 67.3 would be effective in reducing the concentrations of chemicals in extracted groundwater.
- Based on preliminary calculations to estimate the concentration of VOCs in the off-gas from the air stripper, it is not anticipated that off-gas treatment is necessary. However, samples of organic vapors from the air stripper would be collected and analyzed for VOCs on a regular basis, thereby providing a means to evaluate whether or not off-gas treatment were to become necessary.

- If treatment of the off-gas were to become necessary, vapor-phase GAC could be used to treat VOCs to acceptable levels. At least two GAC canisters, connected in series, would be installed at the exhaust from the air stripper. A stack would then be installed after the second GAC canister to adequately disperse the treated exhaust.

Treated Groundwater Discharge

- Treated groundwater from the low profile tray air stripper would be discharged to the Orlando STP.

- As defined in the Clean Water Act, the discharge would adhere to all general prohibitions (i.e., the introduction of contaminants to the POTW would not cause interference with the operation of the POTW, and would not pass through the system) and specific prohibitions (i.e., would not create a fire or explosion hazard in the sewer or POTW, would not cause corrosive damage to the POTW, and would not obstruct the flow of water to the POTW).

- Effluent from the air stripper would be sampled and analyzed for water quality parameters, such as BOD, pH, and total suspended solids. While it is not anticipated that treatment of extracted water for these parameters is necessary, effluent from the air stripper would be monitored for these parameters to ensure compliance.

Groundwater, Surface Water, Sediment, and System Monitoring

- Monitoring of groundwater, surface water, sediment, the influent and effluent to the treatment system, and off-gas of the air stripper would occur on a bi-weekly basis for the first month, then monthly for the next five months, and then bi-monthly until the end of the anticipated operational period for the system (i.e., one year).

- Samples collected during the monitoring program would be analyzed for TCL analytical parameters and biological parameters as well. Additional parameters may be added, as necessary. Data would be used to evaluate the migration of contaminated groundwater and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing.

- Data would be summarized and managed on a quarterly basis.

- In addition to these monitoring activities, the effectiveness of the treatment system and the operation of the low profile tray stripper will also be monitored on a continual basis. Proposed monitoring will include influent and effluent sampling and analysis, liquid and air flow measurements, and other process monitoring requirements.

EVALUATION:

Overall Protection of Human Health and the Environment

- Hydraulic control over the portion of the aquifer with total VOC concentrations greater than 100 µg/l should be obtained if this option were implemented. Groundwater containing VOCs and other contaminants would be extracted, thus reducing the mass of contaminants available for discharge to Lake Druid.

- VOCs in the extracted groundwater would be reduced through treatment via air stripping, with further treatment provided by the Orlando STP.

- Based on data collected to date at the OU, the implementation of this alterative will not have adverse short-term or cross-media (i.e., contaminate other media) effects.

- Contaminated groundwater downgradient of the capture zone would discharge to Lake Druid until that area is "flushed." For this period of time, the potential risk to humans exposed to surface water via swimming would remain.

Compliance with ARARs

- If this technology were implemented, compliance with ARARs would be achieved.

- A permit would most likely not be necessary for the air stripper, as the stripper would be considered a small source in operation for less than five years.

Long-Term Effectiveness and Permanence

- This alternative does offer a long-term and permanent remedy for groundwater remediation without relying on natural transformation processes (as long as the source of groundwater contamination is also addressed); however, this technology is not preferred as the final remedy.

- Extraction of groundwater removes contaminated groundwater within the capture zone of the extraction wells, thus reducing the available mass of VOCs and other contaminants in groundwater that would eventually discharge to Lake Druid.

- Pretreatment of extracted groundwater via air stripping and further treatment at the Orlando STP will reduce VOC and other contaminant concentrations in extracted groundwater.

- Groundwater, surface water, and sediment monitoring would provide a means of evaluating the concentrations of contaminants in these media over the IRA timeframe (i.e., one year or until final remedy for OU 4 is identified), and would provide a means of evaluating the effectiveness of the alternative.

- All controls proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative would permanently reduce the toxicity, mobility, and volume of VOCs and other contaminants in extracted groundwater.

- VOCs will be treated via air stripping, and the off-gas from the air stripper would be monitored to determine whether or not collection and treatment via Granular Activated Carbon (GAC) is necessary.

- The treated groundwater would be discharged to the Orlando STP for further treatment of VOCs and treatment of other contaminants.

Short-Term Effectiveness

- By implementing this alternative, the migration of groundwater contamination to Lake Druid would be affected as soon as the system is brought on-line. Contaminated groundwater within the capture zone would be extracted, thereby mitigating further migration from the "hot zone."

- Installing an extraction well, treating the groundwater, and discharging to the Orlando STP should not pose a significant risk to workers or the community.

- Workers who may install or operate the treatment system may be exposed to unacceptable risks that have not yet been quantified.

Implementability

- Construction of the extraction and treatment system is relatively easy to implement, as one extraction well already exists at the site.

- Construction of the treatment system would not pose a threat to workers or the community.

- Components of the proposed system are readily available (i.e., "off-the-shelf" products).

Cost

- Total direct costs are estimated to be approximately $65,000 to $100,000.

- Total O&M and monitoring costs (for one year) are estimated to be $112,000.

- The total cost for this alternative, including additional site monitoring and reporting requirements is estimated to be $177,000 to $212,000.

Consistency with Final Remedy

- Other remedies will be considered for long-term remediation at OU 4.

- Implementation of this alternative may be consistent with the final remedy if source control is initiated.

Regulatory/State Acceptance

- EPA and FDEP have indicated that groundwater extraction and treatment is an acceptable remedy for the OU 4 IRA.

Community Acceptance

- Community concerns for implementation of this technology at OU 4 are not anticipated.

Groundwater
AIR SPARGING

DEFINITION:
Air sparging is used to remove volatile organic compounds (VOCs) from groundwater without extracting the water. Air is injected into the saturated zone to create turbulence and volatilize organic compounds. As air moves up through the aquifer, contaminants partition into the gas phase and are then extracted as organic vapors from the vadose zone or allowed to escape through the vadose zone into the atmosphere.

SYSTEM TYPE:
- pilot-scale system to ensure effectiveness
- use observational approach to bring system to full-scale

COMPONENTS:
- install horizontal or vertical air injection wells
- construct blower system at well head(s)
- inject air into subsurface

OPERATIONAL CRITERIA:
- 1-year operation (or until final remedy for OU 4 is identified)
- groundwater, surface water, and sediment sampling and analysis
- system operation, maintenance, and monitoring

DESCRIPTION OF MAJOR COMPONENTS:

Pilot Test
- Prior to installing an air sparging system at OU 4, a pilot test should be conducted to obtain design criteria for the alternative and evaluate the technical feasibility of an air sparging system.
- Specifically, the pilot test would include:
  - estimating the efficiency of removal of VOCs from groundwater,
  - evaluating the potential for the water table to mound and the affects of this occurrence,
  - estimating VOC emission rates from the aquifer,
  - predicting and evaluating the path of air flow in the subsurface to assess the possibility of air migrating horizontally in the subsurface beneath the hard layer,
  - evaluating changes in aquifer characteristics (the effective porosity to water flow is reduced when air is introduced to the subsurface, or when there is a mixture of liquid and gas phases in the aquifer, and this may reduce the hydraulic conductivity), and
  - identifying the number of sparge wells and SVE wells that are necessary (i.e., determine the radius of influence of individual air sparging wells).

Install Air Sparging System
- It is anticipated that the air sparging system for OU 4 would be installed to a depth of 15 feet (or the depth of contamination).

- Either vertical or horizontal air injection wells could be installed. It is assumed that vertical wells would be installed during the IRA.

Soil Vapor Collection

- Soil vapor extraction (SVE) is typically used to control off-gas generated by air sparging. Typically, vapor extraction wells or trenches are installed above the water table in a configuration to capture vapors generated from air sparging.

- At OU 4, the thickness of the unsaturated zone is less than 1.5 feet (in some places), and therefore the effectiveness of SVE in a limited vadose zone is questionable.

- SVE is therefore not a component of an air sparging system for OU 4.

Groundwater, Surface Water, Sediment, and System Monitoring

- Groundwater samples would be collected to evaluate the effectiveness (i.e., percent removal) of the air sparging system.

- The ambient atmosphere would be monitored in the vicinity of the system (i.e., over the top of the air sparging area) and at the property line to identify whether or not vapors released to the atmosphere are at a level of concern to human health or the environment.

- Surface water and sediment samples would be collected on a monthly basis from the shoreline of Lake Druid, and analyzed for total VOCs and other biological parameters. The analytical results would be reviewed to evaluate whether or not the concentrations of VOCs in the Lake were decreasing over time due to the implementation of air sparging.

EVALUATION:

Overall Protection of Human Health and the Environment

- The use of air sparging may potentially cause risks not associated with other interim remedial technologies (such as groundwater extraction). Air injection can enhance the undesirable off-site migration of vapors to the trailer park adjacent to the site. A preliminary assessment of these potential risks from volatile organic compounds in the air from the air sparging technology was performed. Preliminary calculations were made to determine an acceptable level of volatile organic compounds in the ambient air that would not cause an excess cancer risk greater than 10^{-6}. These calculations indicate that it is unlikely that the air sparging treatment technology would cause an unacceptable risk to residents of the trailer park adjacent to the site. (These calculations are presented in the pages following the evaluation section for air sparging)

Compliance with ARARs

- A permit would be required if air sparging were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.

Long-Term Effectiveness and Permanence

- Because the transfer of dissolved contaminants from groundwater to air occurs in subsurface conditions and laboratory simulation is difficult, conclusions regarding the path of subsurface air flow are based on limited laboratory-scale studies and field testing systems. Two theories have been proposed to describe the subsurface air flow: air flows in a stream of discrete air bubbles, or air flows in continuous air channels. As air enters the saturated zone, it creates hydraulic voids or "cavitation." These voids can occur in the form of bubbles or channels. The form of cavitation that occurs is primarily a function of grain size, shape, homogeneity, porosity, and other subsurface media characteristics. Laboratory observations indicate that air flow through porous media, such as coarse sand and gravel (greater than 4 mm in diameter) occurs through air bubbles that rise to the top of the water column. Conversely, air flow through fine media, such as fine sand, silt, and clay (less than 0.75 mm in diameter) occurs through streams or air channels. It is estimated that, given the fine sand present at OU 4, the potential exists for air channels to develop. This is important because the channeling reduces the air contact surface area to groundwater and aquifer material, which reduces the mass transfer of VOCs and oxygen and ultimately may reduce the effectiveness of this technology.

- The presence of the hard layer raises questions as to where the air bubbles or channels may escape, and the affect this may have on groundwater flow in the area. As far as migration of the air bubbles or channels, some air may migrate through the hard layer. Otherwise, it is possible that air may accumulate below the hard layer and migrate horizontally until it can escape into the vadose zone. This is a concern because contaminated air migrating along the hard layer to the fenceline could potentially introduce contamination to that area.

- When air is injected into the subsurface through a well(s), convection currents form that circulate the groundwater in the vicinity of the well. These currents form due to the density differences between the air/water mixture and the groundwater further away from the well. This action may create groundwater upwelling near the air sparging locations. At OU 4, the groundwater table is only approximately 1.5 feet bls, and it is possible that the upwelling effect may present itself as a pool of water on the ground surface. If this occurs, the potential exists for human and ecological receptors to be in direct contact with the contaminated groundwater, and the contamination of soil in that area.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- Technology would most likely reduce concentrations of VOCs in groundwater through volatilization.

- Technology may not reduce concentrations of VOCs to below Florida surface water standards.

Short-Term Effectiveness

- Technology would most likely be effective in the short term as volatilization and gas transfer is a relatively rapid treatment.

Implementability

- Installation of air sparging wells near the lakeshore may be difficult due to the physical environment in the area. Most likely, the injection wells cannot be installed via a hand auger; hand augering to this depth was attempted during the Focused Field Investigation, but the borehole would not remain open. Jet rotary installation of the wells should be considered, however, this method may create a zone around the well for preferential migration pathway for contaminated air.

- Construction of the treatment system in the wetland area may require a permit.

- Components of the proposed system are readily available (i.e., "off-the-shelf" products).

W = width of the site (longest side of site - estimated at 122 meters (400 feet)),
u = wind speed (6 m/s - mean annual wind speed through the mixing layer for Florida); and
H = mixing height (a standard default value - 2 meters roughly a man's height)

The calculated acceptable emission's rate for each chemical of concern is presented below:

Chemical	Target Ambient Air Concentration (ug/m^3)	Acceptable Emission Rate (ug/s)	Acceptable Emission Rate (g/d)	Acceptable Emission Rate (lbs/year)
Trichloroethylene (TCE)	0.6	878	76	61
Tetrachloroethene (PCE)	1.7	2489	215	173
Vinyl Chloride	0.01	15	1.3	1

Preliminary mass balance calculations (see part 1 of this evaluation packet) indicate that groundwater contributes volatile organic compounds to the surface water. If the same plume dimensions are considered in the evaluation of the air sparging technology then approximately the same amount of contamination will contact the air sparging wells in a year. Therefore, based on these calculations it is not likely that TCE or PCE would contribute to an excess cancer lifetime risk of greater than 10^{-6}. Additionally, since vinyl chloride was not detected in the groundwater (vinyl chloride was detected in surface water) and TCE degrades to vinyl chloride in anaerobic conditions it is unlikely that vinyl chloride would be a concern while using the air sparging technology.

Groundwater
UVB/IN SITU IN-WELL AIR STRIPPING

SYSTEM TYPE:

- pilot-scale system
- use operational approach to bring system to full-scale
- pumping test data (already available) may lead to full-scale operation

COMPONENTS:

- in situ containment/remediation of the groundwater VOC plume through UVB technology
- install UVB well and UVB system

OPERATIONAL CRITERIA:

- may be operated through closure
- surface water, sediment, and groundwater sampling and analysis
- system operation, maintenance, and monitoring
- 1-year operation (or until final remedy for OU 4 is identified)

DESCRIPTION OF MAJOR COMPONENTS:

- In situ containment of groundwater is established through a specialized well which creates a circulation sphere within the aquifer. The dimensions of the circulation sphere are dependent on site specific conditions (i.e. hydraulic conductivity, gradient, saturated thickness, recirculation rates, etc.). Part of the groundwater entering the specialized well represents new upstream waters that enter through the up-gradient capture zone, while an equal treated portion exits the sphere through the down-gradient release zone.

- The vertical circulation sphere in the saturated zone is established by creating a pressure differential, with a pump and/or vacuum blower, across two screens in the specialized well. In the ordinary mode of operation, groundwater enters the well through the upper screen and leaves through the lower screen.

- While traveling through the specialized well, the groundwater passes through an in-well treatment system which includes an air stripper/aerator. The volatilized VOCs are subsequently transported through the well and up to the off-gas treatment unit or to the atmosphere, by means of the vacuum blower.

- Co-substances, such as nutrients, may be added through the circulating process within the specialized well to further facilitate in situ biodegradation of contaminants in the aquifer.

- Vertical circulation flow (i.e., in situ remedial sphere) allows for both vertical and horizontal containment/treatment of the affected aquifer.

EVALUATION:

Overall Protection of Human Health and the Environment

- In situ containment and treatment of the portion of the aquifer with total VOC concentrations greater than 100 ug/l should be obtained with one well were this option to be implemented. Groundwater containing VOCs would be contained and treated in situ through the vertical circulation sphere via in-well stripping.

- VOC off-gasses can be can be captured and treated if necessary.

- By implementing this technology, no adverse short term or cross-media effects are anticipated.

Compliance with ARARs

- This alternative may comply with chemical-specific ARARs (Florida surface water standards) in the short term.
- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) is apparent, however, evaluation would be ongoing.
- A permit would be required if this technology were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.
- A permit would most likely not be necessary for the air stripper, as the stripper would be considered a small source in operation for less than five years.

Long-Term Effectiveness and Permanence

- Implementation of this alternative would have long term effectiveness due to its ability to contain and remediate the aquifer.
- Once the source area is defined, this technology could also be used in the source area.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative will reduce toxicity, mobility, and volume of VOCs migrating to the surface water.
- Groundwater VOCs will be treated via in-well stripping, any off-gas would be monitored to determine whether collection and treatment is necessary.

Short-Term Effectiveness

- By implementing this technology, the migration of groundwater with VOC concentrations to Lake Druid would be affected immediately. Contaminated groundwater would be contained and treated in situ, thereby mitigating further migration.
- In situ treatment of the groundwater should not pose a significant risk to workers or the community.
- Workers who may install or operate the treatment system may be exposed to unacceptable risks that have not yet been quantified.

Implementability

- Construction of the UVB system should be relatively easy to implement.
- Components of the proposed system are proprietary.

Cost

- Direct cost are estimated to be $138,000.
- Site O&M and monitoring costs are estimated to be $62,000 per year. May be a shared cost with any sediment treatment option.
- Reporting costs are estimated at approximately $200,000.

Consistency with Final Remedy

- Would be consistent with long term/final remedy chosen.

Regulatory/State Acceptance

- EPA and FDEP seems favorable implementation of this technology at OU 4 as the interim remedy.

Community Acceptance

- Community concerns regarding implementation of this technology is anticipated to be favorable.

Surface Water/Sediment
NATURAL ATTENUATION

SYSTEM TYPE

- None (monitoring only)

COMPONENTS

- control of contaminated groundwater entering the lake to eliminate contaminant source

OPERATIONAL CRITERIA

- 1-year operation (or until final remedy for OU 4 is identified)
- surface water and sediment sampling and analysis

DESCRIPTION OF MAJOR COMPONENTS

Hydraulic Control

- control of the contaminants entering the lake will be achieved during the IRA through use of a groundwater treatment technology. The evaluation of these technologies is included elsewhere in this report.

Surface Water and Sediment Sampling and Analysis

- Preliminary sediment sampling during the focused field investigation indicated anaerobic conditions were present in the lake sediments. Anaerobic bacteria appear to be degrading the chlorinated solvents, based on the generation of vinyl chloride in the lake.

- This technology assumes control of contaminants migrating into the lake, effectively eliminates the primary source of lake contamination. Therefore, continued degradation of VOCs in lake sediment should gradually remediate the lake until Florida surface water standards are no longer exceeded. This evaluation (for costing purposes) assumes one year of lake monitoring (or until the final remedy for OU 4 is decided). Actual duration will depend on the rate of contaminant degradation and volatilization, and cannot be predicted at this time.

Groundwater, Surface Water, Sediment, and System Monitoring

- Monitoring of groundwater, surface water, and sediment would occur on a bi-weekly basis for the first month, then monthly until the end of the anticipated operational period for the system (i.e., one year or until the final remedy for OU 4 is decided).

- All samples collected during the monitoring program would be analyzed for TCL analytical parameters. Sediment and surface water will also be monitored for nutrient concentrations, bacterial populations, and degradation byproducts. Additional parameters may be added, as necessary. Data would be used to evaluate biological conditions and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing.

- Data would be summarized and managed on a quarterly basis.

EVALUATION:

Evaluation of technologies to provide control of contaminants entering the lake through groundwater are provided elsewhere in this report. The following discussion will focus only on natural attenuation in the lake.

Overall Protection of Human Health and the Environment

- Successful implementation of this technology should degrade VOCs present in Lake Druid sediments, and gradually reduce VOC concentrations in surface water below Florida standards.

- However, until these concentrations are reduced, the potential for risk to human and ecological receptors based on exposure to surface water and sediment would exist. These risks have not yet been quantified.

Compliance with ARARs

- This alternative may not comply with chemical-specific ARARs (Florida surface water standards) in the short term, as natural attenuation is not likely to immediately reduce concentrations of VOCs in surface water and sediment.

- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) would be expected. No actions proposed for this alternative should trigger location-specific ARARs.

Long-Term Effectiveness and Permanence

- Successful implementation of this alternative, combined with control of the source of VOCs to Lake Druid, offers a long-term and permanent remedy for VOC contamination of Lake Druid sediment and surface water.

- Natural biodegradation of the VOCs in the lake sediment would remove the remaining source of VOC contamination in surface water.

- Surface water and sediment monitoring would provide a means of evaluating the concentrations of contaminants in these media over the IRA timeframe (i.e., one year), and would provide a means of evaluating the effectiveness of the alternative.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative would ultimately reduce toxicity, mobility, and volume of VOCs in Lake Druid surface water and sediment.

Short-Term Effectiveness

- Natural biodegradation can be a slow process. Some of the contaminants of concern are known to degrade very slowly under anaerobic conditions. Implementation of this alternative may not result in an immediate decrease in VOC concentrations.

Implementability

- This alternative does not require remedial construction for implementation. Monitoring activities are easily implemented.

Cost

- None. All associated monitoring costs are included in the evaluation of technologies to provide control of contaminants entering the lake through groundwater, provided elsewhere in this report.

Consistency with Final Remedy

- Would be consistent with long term/final remedy chosen.

Regulatory/State Acceptance

- EPA and FDEP seems favorable implementation of this technology at OU 4 as part of the interim remedy.

Community Acceptance

- Community concerns regarding implementation of this technology is anticipated to be favorable.

Surface Water/Sediment
ENHANCED BIOREMEDIATION

SYSTEM TYPE

- bench- or pilot-scale system to ensure effectiveness of technology
- use observational approach to bring system to full-scale

COMPONENTS

- enhancement of natural biological processes in sediment through injection of nutrients and/or non-indigenous bacteria
- control of contaminated groundwater entering the lake to eliminate contaminant source

OPERATIONAL CRITERIA

- 1-year operation (or until the final remedy for OU 4 has been decided)
- surface water and sediment sampling and analysis
- system operation, maintenance, and monitoring

DESCRIPTION OF MAJOR COMPONENTS

Hydraulic Control

- control of the contaminants entering the lake will be achieved during the IRA through use of a groundwater treatment technology. The evaluation of these technologies is included elsewhere in this report.

Nutrient/Bacterial Injection

- Preliminary sediment sampling during the focused field investigation indicated anaerobic conditions were present in the lake sediments. Anaerobic bacteria appear to be degrading the chlorinated solvents, based on the generation of vinyl chloride in the lake. This treatment option assumes that continued anaerobic degradation will be encouraged, rather than attempting to establish aerobic conditions in the lake sediment.

- This technology assumes existing conditions are limiting and biodegradation rates can be excelerated through the addition of nutrients, electron donors, and/or bacteria.

- The injection system could consist of a series of well points driven into the lake bottom in the area of highest sediment VOC concentrations. These well points would be manifolded back to an injection pump that would be used to introduce the appropriate amendments into the lake sediment. Amendments could be injected periodically or continuously.

- The location and number of the injection points, as well as the amendments necessary to enhance the natural biodegradation already occurring in the lake, would be determined after conducting additional lake sampling to better evaluate the current bacterial population and environment. Relatively simple bench-scale serum bottle testing may also be required to establish the appropriate mix of nutrients, electron donors, and/or non-indigenous bacteria to inject.

- Enhancement of the current anaerobic degradation process could lead to the increased generation of vinyl chloride, potentially increasing the vinyl chloride concentration in surface water. This could require additional human health and ecological risk evaluations.

- This evaluation of this technology assumes control of contaminants migrating into the lake, effectively eliminating the primary source of lake contamination. Therefore, treatment of the lake sediment is only required until VOC concentrations in the sediment have been reduced to the point where Florida surface water standards are no longer exceeded.

This evaluation assumes one year of operation (or until the final remedy for OU 4 is decided). Actual duration will depend on the rate of contaminant degradation and volatilization, and cannot be predicted at this time.

- Permits will likely be required to install the injection system and to introduce nutrients or bacteria to the lake environment. This requirement is currently under evaluation.

Groundwater, Surface Water, Sediment, and System Monitoring

- Monitoring of groundwater, surface water, sediment, and the injection solution would occur on a bi-weekly basis for the first month, then monthly until the end of the anticipated operational period for the system (i.e., one year or until the final remedy for OU 4 has been decided).

- All samples collected during the monitoring program would be analyzed for TCL analytical parameters. Sediment and the injected solution will also be monitored for nutrient concentrations, bacterial populations, and degradation byproducts. Ambient air monitoring for vinyl chloride may also be required. Additional parameters may be added, as necessary. Data would be used to evaluate biological conditions and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing.

- Data would be summarized and interpreted on a quarterly basis.

EVALUATION:

Evaluation of technologies to provide control of contaminants entering the lake through groundwater are provided elsewhere in this report. The following discussion will focus only on enhanced bioremediation in the lake.

Overall Protection of Human Health and the Environment

- Successful implementation of this technology should degrade VOCs present in Lake Druid sediments, and gradually reduce VOC concentrations in surface water below Florida standards.

- Adverse short-term effects associated with this alternative could include an increase in vinyl chloride concentrations and damage to the lake ecosystem by the installation of the injection system and the introduction of nutrients.

- Until contaminant concentrations are reduced, the potential for risk to human and ecological receptors based on exposure to surface water and sediment would exist. These risks have not yet been quantified.

Compliance with ARARs

- This alternative may not comply with chemical-specific ARARs (Florida surface water standards) in the short term, as enhanced biodegradation may not immediately reduce concentrations of VOCs in surface water and sediment.

- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) cannot be evaluated until permitting issues have been resolved.

- A permit would be required if this technology were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.

Long-Term Effectiveness and Permanence

- Successful implementation of this alternative, combined with control of the source of VOCs to Lake Druid, offers a long-term and permanent remedy for VOC contamination of Lake Druid sediment and surface water.

- Enhanced biodegradation of the VOCs in the lake sediment would remove the potential for VOC contamination in surface water.

- Surface water and sediment monitoring would provide a means of evaluating the concentrations of contaminants in these media over the IRA timeframe (i.e., one year), and would provide a means of evaluating the effectiveness of the alternative as the long term solution for the OU.

- Enhancing natural biodegradation in a lake ecosystem could be considered an unproven technology.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative would ultimately reduce toxicity, mobility, and volume of VOCs in Lake Druid surface water and sediment. However, initial increases in surface water vinyl chloride concentrations may occur.

- Higher vinyl chloride concentrations in surface water could lead to detectable vinyl chloride concentrations in ambient air.

Short-Term Effectiveness

- Biodegradation can be a slow process. Some of the contaminants of concern are known to degrade very slowly under anaerobic conditions. Implementation of this alternative may not result in an immediate decrease in VOC concentrations.

- Workers who may implement this technology may be exposed to unacceptable risks that have not yet been quantified.

Implementability

- Construction of the nutrient injection system is relatively easy to implement.

- Components of the injection system are readily available.

- Permitting requirements may affect schedule and limit the allowable nutrients or bacteria acceptable for injection into the lake.

Cost

- Total direct costs will be developed with input from Bechtel.

- Total O&M costs are estimated to be ....

- Total site monitoring costs are estimated to be ....

Consistency with Final Remedy

- Would be consistent with long term/final remedy chosen.

Regulatory/State Acceptance

- EPA and FDEP seems favorable implementation of this technology at OU 4 as part of the interim remedy.

- However, effects to ecological community and wetlands in the vicinity if nutrients were added should be evaluated.

Community Acceptance

- Community concerns regarding implementation of this technology is anticipated to be favorable.

PHYTOREMEDIATION

DEFINITION:
Phytoremediation is the use of plant and tree root systems for the in situ environmental remediation of contaminated soil, sediment, and water.

SYSTEM TYPE:

- bench/pilot scale system
- use operational approach to bring system to full-scale

COMPONENTS:

- enhance indigenous plant life to treat sediments with high chlorinated VOC concentrations
- addition of plant life to treat sediments with high chlorinated VOC concentrations
- control of contaminated groundwater entering the lake to eliminate contaminant source

OPERATIONAL CRITERIA:

- operation through overall RI/FS until no further action necessary
- groundwater, surface water, and sediment sampling and analysis
- ecological monitoring
- 1-year operation (or until the final remedy for OU 4 has been decided)

DESCRIPTION OF MAJOR COMPONENTS:

Hydraulic Control

- control of the contaminants entering the lake will be achieved during the IRA through use of a groundwater treatment technology. The evaluation of these technologies is included elsewhere in this report.

Phytoremediation

- Phytoremediation will be driven through research by the USEPA in conjunction with the University of Georgia (UGA).

- Laboratory and on-site research by the UGA will determine the method for initiating phytoremediation. Initiation will be through either the enhancement of the native plant life or the addition of plants that have been proven to successfully remediate the contaminants of concern. (Samples were provided to UGA on Nov. 11, 1996.)

- Phytoremediation is an innovative treatment technology, meaning that the technology has been tested and used for treatment of hazardous wastes however, it is lacking well-documented cost and performance data under a variety of conditions. To date the majority of the full-scale treatment system data is from the treatment of metals and munition wastes. Information regarding full scale remediation of chlorinated solvents using phytoremediation is still limited. On going analysis by UGA will be the major component in determining the phyto-remedial strategy for OU4.

Groundwater, Surface Water, Sediment and Eco-System Monitoring

- Monitoring of groundwater, surface water, and sediment will occur on a bi-weekly basis for the first month, then monthly until the end of the anticipated operational period.

- Monitoring schedules specific to phytoremediation will be decided by UGA.

- All samples collected during the monitoring program would be analyzed for TCL analytical parameters. Sediment and surface water will also be monitored for nutrient concentrations, bacterial populations, and degradation byproducts. Additional parameters may be added, as necessary. Data would be used to evaluate biological conditions and to assess whether or not contaminant concentrations in surface water and sediment samples from the lake were decreasing.

EVALUATION:
Evaluation of technologies to provide control of contaminants entering the lake through groundwater are provided elsewhere in this report. The following discussion will focus only on phytoremediation along the lake shore and in the lake.

Overall Protection of Human Health and the Environment

- Implementation of this technology will most likely reduce mass of contaminants in the sediment over time. Remediation time frame will be determined through research.
- Any ecological effects due to the addition of new plant life or the enhancement of indigenous life needs to be identified and evaluated, and is deferred to UGA research.
- Until contaminant concentrations are reduced, the potential for risk to human and ecological receptors based on exposure to surface water and sediment would exist. These risks have not yet been quantified.

Compliance with ARARs

- This alternative may not comply with chemical-specific ARARs (Florida surface water standards) in the short term, as phytoremediation is not likely to immediately reduce concentrations of VOCs in the surface water and sediment.
- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) may not be possible, however this is currently being evaluated).
- A permit would be required if this technology were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.

Long-Term Effectiveness and Permanence

- Successful implementation of this alternative, combined with control of the source of VOCs to Lake Druid, offers a long-term and permanent remedy for sediment remediation.
- Long-term effectiveness data at other similar sites is not available at this time. Long-term effectiveness and permanence will be evaluated during research by UGA.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative should permanently reduce toxicity, mobility, and volume of VOCs in sediment, and may possibly have an effect on the surface water VOCs.
- VOC contaminants will be phytodegradated, bio-treated through enhanced mineralization in the rhizosphere, and/or directly taken up by plants acting as organic pumps.

Short-Term Effectiveness

- Achieving optimum performance of phytoremediation may take time, therefore effectiveness in the short term is questionable.
- Workers who may implement this technology may be exposed to unacceptable risks that have not yet been quantified.

- Natural biodegradation can be a slow process. Some of the contaminants of concern are known to degrade very slowly under anaerobic conditions. Implementation of this alternative may not result in an immediate decrease in VOC concentrations.

Implementability

- Based on the variety and growth rate of existing plant life at the site, implementation may be relatively easy; however, implementability will also be evaluated by UGA.

Cost

- Direct cost will be identified through UGA.
- Site monitoring costs may depend largely on UGA but are estimated to be approximately $50,000 per year. Much of this cost may be shared with any groundwater treatment option.
- Reporting costs will depend largely on UGA.

Consistency with Final Remedy

- Should be consistent with any final solution.

Regulatory/State Acceptance

- EPA and FDEP seems favorable implementation of this technology at OU 4 as part of the interim remedy.
- However, effects to ecological community and wetlands in the vicinity should be evaluated.

Community Acceptance

- Negative community concerns regarding implementation of this technology at OU4 are not anticipated.

Surface Water/Sediment
AIR DIFFUSION/SPARGING

SYSTEM TYPE:

- pilot-scale/full-scale system
- use operational approach to bring system to full-scale

COMPONENTS:

- install piping system with compressor(s)
- diffuser system installed on top of sediment organic mat present at site
- surface water air sparging through air diffuser system
- control of contaminated groundwater entering the lake to eliminate contaminant source

OPERATIONAL CRITERIA:

- 1-year operation (or until the final remedy for OU 4 has been decided)
- operation through closure, or until a secondary treatment option such as phytoremediation can be established
- surface water, sediment, ambient air, and groundwater sampling and analysis
- ecological monitoring
- system operation, maintenance, and monitoring

DESCRIPTION OF MAJOR COMPONENTS:

Hydraulic Control

- control of the contaminants entering the lake will be achieved during the IRA through use of a groundwater treatment technology. The evaluation of these technologies is included elsewhere in this report.

Air Diffusion/Sparging

- An air diffuser system will be used to removed VOCs from surface water. The most effective application would be to install in concert with a groundwater technology.

- The system will be installed by resting perforated diffuser pipes above the sediment mat, air would be injected through the pipe to strip VOCs from the surface water above the mat.

- Because of the limited depth of surface water above the organic sediment mat and possible short circuiting of air to water contact due thick aquatic growth, the diffuser pipes will require close spacing to get effective removal efficiencies of VOCs in the surface water.

- An on-site pilot test should be conducted to evaluate the effectiveness of the diffuser system prior to full scale implementation.

Groundwater, Surface Water, Sediment and Eco-System Monitoring

- Monitoring for the groundwater system will occur on a bi-weekly basis for the first month, then monthly until the end of the anticipated operational period.

- Monitoring schedules for the air diffusion/sparging system would run concurrent with the groundwater treatment monitoring.

EVALUATION:

Evaluation of technologies to provide control of contaminants entering the lake through groundwater are provided elsewhere in this report. The following discussion will focus only on air diffusion/sparging of the surface water above the organic sediment mat in the lake.

Overall Protection of Human Health and the Environment

- Implementation of this technology may reduce the mass of contaminants in the surface water above the sediment mat.

- The use of this technology may potentially cause risks not associated with other interim remedial technologies. A preliminary assessment of these potential risks from volatile organic compounds in the air from the air sparging technology was performed. Preliminary calculations were made to determine an acceptable level of volatile organic compounds in the ambient air that would not cause an excess cancer risk greater than 10^{-6}. These calculations indicate that it is unlikely that the air sparging treatment technology would cause an unacceptable risk to residents of the trailer park adjacent to the site. (These calculations were presented in the pages following the evaluation section for air sparging.)

- Addition of oxygen and turbulence created by the aeration could possibly pose negative ecological effects.

Compliance with ARARs

- This alternative may comply with chemical-specific ARARs (Florida surface water standards) in the short term.

- Compliance with location-specific ARARs (such as those governing the wetlands or the lake ecosystem) may not be possible, however it is currently being evaluated.

- A permit would be required if this technology were installed in the wetland area. The permit, a minimum activity permit, would be required, and is relatively easy to obtain.

- A permit would most likely not be necessary for the air stripper, as the stripper would be considered a small source in operation for less than five years.

Long-Term Effectiveness and Permanence

- Implementation of this alternative would not be effective in the long term unless combined with treatment of VOCs in groundwater and sediment.

- Implementation of source controls may eliminate need for technology.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

- This alternative may reduce toxicity, mobility, and volume of VOCs in surface water above the sediment mat.

- Unclear how surface water depth limitations will effect the efficiency of the technology. With limited efficiency the technology implementation may cause increases of vinyl chloride concentrations.

- Effects on the ambient air quality as a risk will be evaluated.

Short-Term Effectiveness

- If air to water contact is sufficient, implementation of this technology should result in an immediate decrease of VOC concentrations in surface water above the sediment.

- Workers who may implement this technology may be exposed to unacceptable risks that have not yet been quantified.

Implementability

- Construction of diffuser pipes on top of the sediment mat along with connection to a header and an air compressor should be relatively easy to implement.
- All system components are readily available.
- Wetland concerns may inhibit implementability.

Cost

- Direct cost estimated to be $59,000.
- Site O&M and monitoring costs are estimated to be $70,000 per year. Much of this cost may be shared with any groundwater treatment option.
- Reporting costs are estimated at approximately $129,000.

Consistency with Final Remedy

- Consistency with final remedy is dependent on source control alternative chosen.

Regulatory/State Acceptance

- EPA and FDEP seem to have concerns with implementation of this technology at the OU.

Community Acceptance

- Community concerns regarding implementation of this technology is anticipated not to be favorable.

4.0 ALTERNATIVE IDENTIFICATION MATRIX

The OPT has requested that various alternatives be identified that include implementation of aforementioned technologies at different areas of the site.

Alternatives for implementing various groundwater technologies are identified on the first table.

Alternatives for implementing various surface water or sediment technologies are identified on the second table.

As it is unclear at this time whether or not a groundwater and a surface water/sediment technology would be implemented simultaneously, these alternatives options are not identified. However, the OPT should evaluate the following two tables side by side and realize that any number of combinations of a groundwater technology with a surface water/sediment technology is possible.

Table 1
Alternative Identification Matrix -- Groundwater Technologies

Alternative	groundwater		
	extraction/ treatment	air sparging	in-well air stripping
1	X (hot spot)		
2		X (lakeshore)	
3			X (lakeshore)
4	X (hot spot)	X (source)	
5	X (hot spot)		X (source)
6	X (hot spot)	X (lakeshore)	
7	X (hot spot)		X (lakeshore)
8	X (hot spot)	X (source)	X (lakeshore)
9	X (hot spot)	X (lakeshore)	X (source)
10	X (hot spot)	X (source) X (lakeshore)	
11	X (hot spot)		X (source) X (lakeshore)
12		X (source)	X (hot spot)
13		X (source)	X (lakeshore)
14		X (source)	X (lakeshore) X (hot spot)
15		X (lakeshore)	X (hot spot)
16		X (lakeshore)	X (source)
17		X (lakeshore)	X (source) X (hot spot)

1) *hot spot* = the area where the highest level of contamination was detected, or the area where the existing extraction well is located.
2) *source area* = the assumed source, or the vicinity of the surge tank
3) *lakeshore* = the area where shallow groundwater discharges to surface water
1) It is assumed that groundwater extraction and treatment would only be implemented in the hot spot.

Table 2
Alternative Identification Matrix – Surface Water/Sediment Technologies

Alternative	surface water/sediment			
	natural attenuation	enhanced bioremediation	phyto-remediation	air diffusion/ sparging
1	X			
2		X		
3		X	X	
4		X		X
5			X	
6			X	X
7				X