Board of County Commissioners

Leon County, Florida
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Agenda Item
Executive Summary

Tuesday, September 14, 2010

Title: Acceptance of a Status Report on the Remedial Action Plan Regarding Issues at the Apalachee Solid Waste Management Facility
Staff: Parwez Alam, County Administrator Alan Rosenzweig, Assistant County Administrator Tony Park, P.E., Public Works Director

Issue Briefing:
This item seeks Board acceptance of a status report on the Remedial Action Plan (RAP), designed to address th groundwater contamination issues associated with the Solid Waste Facility located on Apalachee Parkway (Attachmen #1, without appendices). The RAP is a requirement by the Florida Department of Environmental Protection (DEP) based on results from routine groundwater sampling conducted by the Solid Waste Management Division. The RAP i prepared by HDR Engineering, the County's environmental and solid waste management consultant. In addition, th item seeks approval of a Resolution and associated Budget Amendment Request, which provides funding fo implementation of the recommended RAP (Attachment #2).

Fiscal Impact:
The recommended approach is air sparging, first conducted on a pilot scale, then on a full scale. The RAP pilot projec is estimated to be $50,000. The full scale project is estimated to be $400,000. A Resolution and associated Budge Amendment Request provides $400,000 from the Solid Waste Fund's retained earnings.

Staff Recommendation:

Option #1: Accept the status report on the Remedial Action Plan regarding issues at the Apalachee Solid Wast Management Facility.

Option #2: Approve the Resolution and associated Budget Amendment Request, which provides $400,000 from th Solid Waste Fund's retained earnings.

Report and Discussion

Background:
The Solid Waste Management Facility located on Apalachee Parkway is required by the facility's Operating Permit t monitor the groundwater for any impacts that might result from solid waste disposal operations. The permit is issued b DEP. A series of monitoring wells are used to detect impacts to the groundwater around the different disposal cell located within the facility. There are 52 monitoring wells associated with this site, depicted on the site map provide (Attachment #3). Monitoring wells with numeric labels are screened within the surficial aquifer. Those with lette labels are screened within the Floridan aquifer.

Groundwater samples are collected from the wells, some quarterly, and some biannually. The samples are analyzed in laboratory for specific chemical constituents dictated in the DEP Operating Permit. Examples of chemical constituent include heavy metals such as arsenic, lead and iron and organic chemicals such as benzene, vinyl chlorides an ammonia. The results of each sample are reported to DEP. When chemical constituents are discovered above statutor limits, DEP requires some sort of action be taken to address the contamination.

If the concentrations of chemical constituents are considered by DEP to be stable and geographically isolated, DEP ma simply require the situation be monitored to see if the concentrations will naturally decline within a reasonable tim frame, by letting the natural system attenuate the problem. This approach is known as a Monitoring Only Plan (MOP). It may require installation of more monitoring wells to determine the extent of the chemical constituents. Such was th case following the detection of benzene above drinking water standards in 1998.

The standard for benzene is one microgram per liter (1 ug/l) equivalent to one part benzene to one billion parts water. A groundwater sample taken from monitoring well MW-8 in February 1998 showed a benzene level of 1.6 ug/l. In 200 DEP required the Facility to develop, submit and implement a Monitoring Only Plan (MOP) to address the benzene. The MOP required semiannual sampling, the same sampling interval as required for the Facility's operating permi Since the implementation of the MOP, the overall benzene concentrations have remained essentially constant. A table o historic benzene concentrations is provided as Attachment #4.

While benzene concentrations have remained rather constant, iron concentrations have continued to rise. Iron i regulated as a Secondary Drinking Water Standard (SDWS) with a value of 300 ug/l. Additionally, the University o Florida has published research indicating that iron has a health-based concentration of 4,200 ug/l (in other words concentrations below 4,200 ug/l do not represent a risk to human health). Since August 2004, DEP and staff have bee working collaboratively to better understand the complex hydrogeology and chemistry associated with the iro contamination. There has been an effort to assess the risk of the iron to the environment and human and health. Furthermore, the County has been evaluating the source of the iron concentrations, which are not likely completel attributable to the landfill. Iron is a naturally occurring metal in Florida soils and is commonly found above the SDW in the surficial aquifer throughout the entire State. The County's health department has been involved to ensure tha neither benzene nor iron pose a threat to drinking water in the surrounding neighborhoods.

Talquin Utilities has two community water supply wells south of the Apalachee Facility. Talquin has confirmed tha analytical samples from those wells have not detected the presence of benzene.

Elevated levels of iron in the 2008 groundwater monitoring samples heightened DEP and staff concern. The iron issu was shared with the Board in their 2008 annual retreat. A copy of the iron issue briefing is provided as Attachment #5. Presently, the area of concern is confined to the southeast corner of the 640 acre site. In August of 2008, DEP requeste installation of an additional monitoring well in the area to try to determine the extent of the contamination. The wells i question are circled for reference on the attached site map.

In July 2010, staff received a notice from DEP that the MOP was no longer an acceptable strategy to deal with thes issues and that submission of a Remedial Action Plan (RAP) is required by September 30, 2010. This requirement wa not a result of a new release or increase in chemical constituent concentrations; rather, it was a result of continuall consistent concentrations that have not shown a downward trend. HDR Engineering, the County's solid waste an environmental consultant, has been tasked with preparing the document.

Analysis:

Monitoring Only Plans must demonstrate that contaminant plumes are reducing in size and concentrations over time. With benzene remaining constant and iron on the rise, DEP is requiring the County submit a RAP. The plan explores number of potential options to remediate these contaminants. Options are evaluated in terms of cost effectiveness environmental soundness and technical viability. The RAP will be submitted to DEP for their review and approval.

The remedial action found most appropriate for this site is air sparging. Air sparging is a common in-situ technique fo the treatment and removal of benzene. Air is injected into the aquifer introducing oxygen into the groundwater. As th air bubbles travel upward, the benzene will be "stripped" from the groundwater. The presence of oxygen will als prompt the formation of iron hydroxide within the formation. The iron will precipitate and remain sequestered in th formation as insoluble iron.

A pilot scale study will be required to evaluate this technology prior to full-scale implementation. Providing successful pilot phase, a full-scale system can be operational within nine months. It is estimated that several years wil be required to achieve compliance with the iron groundwater standards.

The estimated cost of the pilot scale project is $50,000. The full-scale project is estimated to cost $400,000. Th operating and maintenance cost for the full-scale project is estimated to be $30,000 to $60,000 per year.

It is helpful to put the benzene concentrations in perspective. The University of Florida Center for Environmental & Human Toxicology has reported the risk to human health for benzene to be 490 ug/l. for residential watering of lawn and ornamentals and 26 ug/l for watering homegrown produce. A letter from the Center to DEP referencing these level is provided as Attachment #6.

Samples taken in August 2010 reveal a slight decrease in the overall concentrations. For instance, benzene i monitoring well 8 had dropped from a high of 3.3 ug/l in February 2010 to 1.5 ug/l in August. Benzene levels i monitoring well Q were 1.1 ug/l in '07; 1.3 ug/l in '08; 0.0 ug/l in '09 and 1.1 ug/l in August '10. The concentrations ar included in the historic Benzene Concentration table. These levels of 1.5 ug/l compare to the aforementioned acceptabl level of 26 ug/l for watering homegrown produce and 490 ug/l for residential watering of lawns and ornamentals.

One of the criteria for a petroleum-contaminated site is to use Natural Attenuation Monitoring as a cleanup option whe benzene levels are below 100 ug/l. According to DEP, Leon County has 284 petroleum storage facilities that hav reported at least one discharge. Several of these facilities have had contamination assessment activities. For example one site has revealed upwards of 6,400 ug/l benzene in one or more of the monitoring wells placed in the surficial zones.

Staff has been and will continue to work above and beyond DEP requirements to address this issue. To this point it ha been a collaborative effort between staff, HDR Engineering and DEP, with an emphasis on Leon County's interest i being good stewards of the environment surrounding the Apalachee Facility.

One exciting development is some recent research being conducted by Dr. Gang Chen at the FAMU/FSU School o Engineering. Laboratory experiments show some promising low cost and highly effective mechanisms for treating iro in the groundwater. Dr. Tim Townsend at the University of Florida's Department of Environmental Engineering is als working on this issue at the New River Landfill in Union County. In addition, DEP is planning to put together technical advisory group to help the state and local governments better understand the science associated with iro contamination of groundwater in Florida.

Options:

1. Accept the status report on the Remedial Action Plan regarding issues at the Apalachee Solid Waste Managemen Facility.
2. Approve the Resolution and associated Budget Amendment Request, which provides $400,000 from the Solid Wast Fund's retained earnings.
3. Do not accept the status report on the Remedial Action Plan (RAP) regarding issues at the Solid Waste Management Facility.
4. Board Direction.

Recommendation:
Options #1 and #2.

Attachments:

1. Remedial Action Plan, without Appendices *(Due to volume of pages, the Appendices can re reviewed at the Receptio Area, Fifth Floor, County Courthouse)*
2. Proposed Budget Amendment and Resolution
3. Site map with monitoring well locations
4. Historic benzene concentrations table
5. Iron Issue briefing
6. Letter from UF Center for Environmental & Human Toxicology

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LEON COUNTY US 27 SOUTH SOLID WASTE MANAGEMENT FACILITY TALLAHASSEE, FLORIDA

Remedial Action Plan
September 2010

Prepared by:
HDR Engineering, Inc.
4140 NW 37th Place, Suite A
Gainesville, Florida 32606

9/3/10

John D. Locklear
FL PG #2467

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Introduction

On behalf of the Leon County Solid Waste Management Division (County), HDR Engineering, Inc. (HDR), is submitting this Remedial Action Plan (RAP) for the Leon County U.S. 27 South Solid Waste Management Facility. This RAP has been prepared in response to a FDEP letter dated July 7, 2010. In the letter, the FDEP concluded that, "The results of the Iron Study and the Risk Assessment appear to indicate that the current impact from the Closed Class III landfill is beyond the ZOD (zone of discharge). The MOP (monitoring only plan) does not appear to be a viable option at this time."

This RAP includes (1) a brief background of the facility and environmental setting, (2) a description of recent groundwater data, (3) a review of potential remedial action alternatives, and (4) a discussion of the recommended remedial approach and associated assessment monitoring program. This RAP is being submitted in accordance with the regulations promulgated in Rule 62-780.700 of the Florida Administrative Code (FAC) and the RAP summary form (FDEP form 62-780.900(4)) is included as Appendix A.

1.0 Background and Environmental Setting

1.1 Site Location and Background

The facility is located approximately 8 miles southeast of Tallahassee, Florida in Sections 4 & 5 of Township 1 South, Range 2 East. The facility is an active solid waste disposal facility operating under Florida Department of Environmental Protection (FDEP) permits 9560-008-SO, 9560-009-SF, and 9560-010-SO. The facility is comprised of two closed Class I disposal areas (Phase I and Phase IIA), three active Class I disposal areas (Phase IIB, IIC and IID), one active Class III disposal area (Class III South) and three closed/inactive Class III disposal areas (Class III North, Class III West and Class III East). A site plan depicting the disposal areas and related site features is provided as Figure 1.

Contamination assessment monitoring was implemented in the late 1990s in response to concentrations of benzene above the Primary Drinking Water Standard (PDWS) in the vicinity of the Class III East landfill. A Contamination Assessment Report was submitted in 1999 which recommended a Monitoring Only Plan (MOP). The MOP was originally approved in September 2000. Quarterly MOP sampling continued from 2000 to 2003, when FDEP approved a semiannual monitoring frequency. Annual MOP reports summarizing groundwater quality data have been submitted since 2000, with the most recent report submitted in March 2010.

1.2 Regional Geology

The regional geology was described by Ardaman & Associates, Inc. (Ardaman 1996) as follows:

Brooks (1981) includes the surface soils on site and in the surrounding area in the upper Miocene age Miccosukee Formation and characterizes the formation as composed of granular sand and clayey sand with some clay lenses, with mottled yellowish, orange and red colors. Hendry and Sproul (1966) included the surface soils in the site vicinity in the Miocene age Hawthorn Formation and described them as fine to medium grained quartz sand, sand-sized phosphoritic, silt clay and sandy, phosphoritic limestone.

The Hawthorn Formation unconformably overlies the Tampa age (lower Miocene) St. Marks Formation. The St. Marks is described as fine to medium grained, partially recrystallize, silty to sandy limestones that have undergone degrees of secondary dolomitization. The color ranges from very pale orange to grayish orange depending on the degree of dolomitization.

The St. Marks Formation uncomformably overlies the Suwannee Limestone (Oligocene) and is evidenced by distinct lithologic differences. The Suwannee Limestone is very pale orange, fossiliferous, partially recrystallized limestone with a finely crystalline matrix. The Suwannee Limestone is the deepest formation of interest because it is part of the principal aquifer in the area and the contact with deeper Eocene age sediments is somewhat uncertain but believed to be an unconformity with the Crystal River Formation.

1.3 Regional Hydrogeology

The regional hydrogeology was described by Ardaman (1996) as follows:

To the north of the landfill property is Lake Lafayette. Surface topography is such that stormwater falling onto the site generally either sheet flows toward the north or northeast into Lake Lafayette and the low lying areas on the site or percolates down into the ground. The following is a description of the lake as reported by Hendry and Sproul (1966):

> *"Lake Lafayette is located in east-central Leon County, extending from the eastern edge of Tallahassee nearby to the Leon-Jefferson County line. The basin is elongated in a west-northwest to east-southeast direction. It is about six miles long and one-quarter to one-half mile wide. The elevation of the basin bottom is 30 to 40 feet and the elevation of the crests of the highest surrounding hills approach 170 feet. At the eastern end of the lake an arm extends from the main basin in a northwest direction for about two miles. The lowest part of the basin is the western end where several large sinks have developed. During periods of excessive rainfall, water moves from this basin into poorly defined streams that are tributary to the upper reaches of the St. Marks River.*
>
> *The eastern end of the basin is swampy and overgrown with cypress trees. The western portion of the basin is normally dry except where dams have artificially captured the flow from the small stream that intermittently flows down the basin. There is a large sinkhole along the northern edge of the basin near the western*

end that has captured much of the water in the lake in the past. It has recently been dammed off, and the water level in the sink stands at or just below the basin bottom and represents the piezometric level in the area."

The surficial aquifer occurs in the clayey sands of the upper Miocene age deposits and is recharged by local rainfall. Groundwater flow in this aquifer is generally north and east from the topographically high areas (115 to 125 feet NGVD) near the center of the property toward Lake Lafayette which has bottom elevations between 30 and 40 feet (NGVD). Hendry and Sproul (1966) state that the water table is perennially higher than the potentiometric surface of the Floridan aquifer.

The Floridan aquifer is the chief source of drinking water supply in the region. It consists of the limestone units of the St. Marks, Suwannee, and Ocala formations. This aquifer is confined beneath the clayey soils of the Hawthorn Formation. Although the Floridan aquifer is present within the St. Marks formation, most production wells are installed within the underlying Suwannee or Ocala formations. Stewart (1980) places the site at the edge of an "area of high recharge" which he characterizes as a well- drained upland area with poorly developed stream drainage and many closed depressions, some of which contain water perennially. He defines "high recharge" as a rate between 10 and 20 inches/year of seepage into the Floridan aquifer from the overlying sediments. A significant amount of this recharge probably reaches the aquifer through sinkholes which occur in the depressions of the area and in the bottom of Lake Lafayette. The upland areas adjacent to these "low" areas probably have a recharge rate of less than 10 inches per year.

1.4 Site Specific Geology

Site specific geology was described by Ardaman (1996). The geologic cross sections referenced by Ardaman and prepared by Dames & Moore are provided in Appendix B.

U.S. Soil Conservation Service Soil Survey (1981) provides a detailed description of the on-site surficial soils. The soils belong to the Orangeburg-Lucy-Norfolk association which is described as well-drained. The specific soil series found in the proposed expansion area are: Orangeburg fine sandy loam, 5 to 8 percent slopes; Orangeburg fine sandy loam, 2 to 5 percent slopes; Lucy fine sand, 0 to 5 percent slopes; and Lynchburg fine sandy loam. These soils are well drained except for the Lynchburg soil which is somewhat poorly drained. The Orangeburg soils are the predominant surface soils on the site.

It is apparent from the lithology encountered in various borings conducted on the site that the Miccosukee Formation overlies the Hawthorn. The St. Marks Formation may be as thick as 40 feet in the site vicinity and represents the top of the Floridan aquifer. The top of the Suwannee Limestone is expected approximately -20 feet (NGVD) in the vicinity of the site.

Based on subsurface conditions encountered in recent boreholes created during construction of monitor wells at the site, Dames & Moore (1993) presented two geologic cross-sections in the vicinity of the proposed Cell II-D and these are included in Appendix 1. In summary, the geology beneath the site as described by Hendry and Sproul (1966) and Brooks (1981) can be generalized in the following profile:

Depth (Feet)		
From	*To*	*Geologic Formation*
0	*15**	*Miccosukee Formation*
15	*60*	*Hawthorn Formation*
60	*100*	*St. Marks Formation*
100	*280(?)*	*Suwannee Limestone*

2.0 Groundwater Quality

2.1 Monitoring Network

The Class III East groundwater monitoring network is comprised of seven surficial aquifer monitoring wells and two Floridan aquifer monitoring wells. In addition, there are seven off-site surficial aquifer monitoring wells owned by Talquin Electric which are routinely sampled in conjunction with the site monitoring program. A summary of well construction information for each of the wells is provided in Table 1.

TABLE 1 – Monitoring Well Construction Details

WELL	TOP OF CASING ELEVATION IN FEET, NAVD	BOTTOM OF SCREEN ELEVATION IN FEET, NAVD	TOP OF SCREEN ELEVATION IN FEET, NAVD
MW-8	80.29	38	48
MW-21	88.13	52	62
MW-22	87.40	56	66
MW-23	69.60	39	49
MW-32	65.02	45	55
MW-33	59.21	41	51
MW-36	94.22	49	59
MW-H	94.45	-2	8
MW-Q	104.81	3	13
TALQUIN 1	74.44	44	NA
TALQUIN 2	65.75	40	NA
TALQUIN 3	NA	NA	NA
TALQUIN 4	63.45	41	NA
TALQUIN 5	67.05	43	NA
TALQUIN 6	NA	NA	NA
TALQUIN 7	NA	NA	NA

2.2 Groundwater Flow Characteristics

The site hydrogeology is comprised of two aquifer systems; (1) a laterally discontinuous surficial aquifer system; and (2) the Floridan aquifer system. A discussion of each aquifer system is provided below.

Surficial Aquifer System

Substantial subsurface data collection indicates that the water bearing units of the surficial aquifer are absent in many areas of the site. The units are present in the immediate vicinity of the Class III East landfill, however, past reports (Ardaman 1993) have indicated that these units pinch out to the west and northwest of the Class III East area. Additionally, efforts to install surficial aquifer monitoring wells south of MW-36 yielded no water producing wells.

Groundwater in the surficial aquifer generally flows to the east-northeast towards Lake Lafayette. Historic groundwater contour maps are provided in Appendix C. The elevation of the water table in the Class III East area generally ranges from 45 to 60 feet, NAVD. A hydrograph is provided in Appendix D.

Horizontal hydraulic conductivity testing was performed by Dames & Moore, Inc. in monitoring well MW-8. Copies of the testing data and calculations are provided in Appendix E. The hydraulic conductivity value reported for MW-8 was 0.00015 cm/sec.

Floridan Aquifer System

Groundwater in the Floridan aquifer generally flows to the west-northwest. Historic groundwater contour maps are provided in Appendix C. The elevation of the potentiometric surface in the Class III East area generally ranges from 25 to 35 feet, NAVD. A hydrograph is provided in Appendix D.

2.3 Groundwater Analytical Data

The constituents of concern identified by FDEP include benzene, ammonia and iron. A discussion of each parameter is provided below. All discussions reference data from 2008 through February 2010. A summary table of all data reported above the laboratory detection limit from 2008 through 2010 is provided in Appendix F. Trend graphs of selected parameters are provided in Appendix G.

Ammonia

Ammonia Nitrogen has a Groundwater Cleanup Target Level (GCTL) of 2.8 mg/L. Background concentrations of Ammonia within the surficial aquifer were all less than 0.01 mg/L. Concentrations above the GCTL were reported in surficial aquifer monitoring wells MW-28, MW-29, Talquin-6 and Talquin-7. Concentrations in MW-28 and MW-29 ranged from 7.5 to 20 mg/L and 7.8 to 66 mg/L, respectively. Monitoring wells MW-28 and MW-29 are associated with the Class III North cell as shown in Figure 1. It should be noted that MW-28 and MW-29 were abandoned in 2010 as it was discovered that they were installed into the solid waste. Replacement monitoring wells MW-28R and MW-29R were installed downgradient of the old wells outside of the waste. Samples collected from replacement monitoring wells MW-28R and MW-29R reported Ammonia concentrations of 0.02 and 1.9 mg/L, respectively. Remedial actions in the vicinity of these wells are not warranted and as such the remainder of this report focuses solely on the Class III East area.

Ammonia concentrations in Talquin-6 and Talquin-7 ranged from below the detection limit to 3.1 mg/L and 0.83 to 3.5 mg/L, respectively. It should be noted that these wells are located on the eastern side of the Talquin property immediately downgradient of infiltration ponds used in the wastewater treatment process by Talquin Electric. No other wells in the Class III East area reported Ammonia above the GCTL. The most likely source of the Ammonia is from the Talquin ponds. Therefore, Ammonia was excluded from further analysis in the RAP process.

Benzene

Benzene has a Primary Drinking Water Standard (PDWS) of 1 µg/L. Background concentrations in both the surficial and Floridan aquifers were below the laboratory detection limit (BDL). Concentrations in monitoring wells associated with Class III East are summarized below:

Well	Aquifer Monitored	Range of Benzene Concentrations in µg/L
MW-8	Surficial	2.8 to 3.3
MW-21	Surficial	2.4 to 3.5
MW-36	Surficial	1.3 to 2.3
MW-Q	Floridan	0.96I to 1.3
Talquin-1	Surficial	0.87I to 1.5

The benzene concentrations show no discernable trends over time. The source of the benzene does not appear to be landfill leachate based on an absence of elevated leachate indicator parameters in groundwater samples collected from impacted wells. Key leachate indicator parameters include Chlorides, Sodium, pH and Ammonia Nitrogen. Concentration graphs of benzene and key leachate indicator parameters are provided in Appendix G. The graphs demonstrate that Benzene in present in the impacted wells with no associated increase in any of the key leachate indicator parameters. The most likely source of the Benzene is landfill gas to groundwater contaminant migration.

Iron

Iron has a Secondary Drinking Water Standard (SDWS) of 300 mg/L. Background concentrations in both the surficial and Floridan aquifers were BDL. Concentrations in monitoring wells associated with Class III East are summarized below:

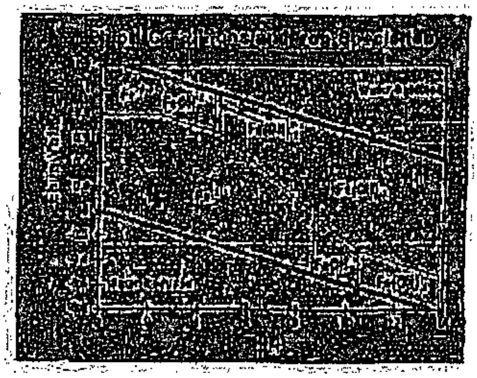
Well	Aquifer Monitored	Range of Iron Concentrations in mg/L
MW-8	Surficial	20,000 to 65,000
MW-21	Surficial	2,100 to 41,000
MW-22	Surficial	290 to 13,000
MW-23	Surficial	78 to 3,100
MW-32	Surficial	110 to 800
MW-33	Surficial	32,000 to 160,000
MW-36	Surficial	120,000 to 150,000
MW-H	Floridan	BDL
MW-Q	Floridan	120 to 430
Talquin-1	Surficial	260 to 3,900
Talquin-2	Surficial	29 to 1,300
Talquin-4	Surficial	130 to 3,600
Talquin-5	Surficial	4,000 to 22,000
Talquin-6	Surficial	330 to 29,000
Talquin-7	Surficial	3,800 to 40,000

2.4 Iron Geochemistry

Iron is the second most abundant metal and fourth most abundant element in the earths crust. The most common iron-containing ores are: Hematite (red iron ore Fe2O3), limonite (brown iron ore FeO(OH)nH2O) and magnetite (magnetic iron ore Fe3O4). The iron content of soils ranges up to several percent, and is dependent upon the source rocks from which the soil was derived, transport mechanisms, and overall geochemical history.

Soils in the panhandle of Florida are generally regarded to contain high concentrations of iron. Published data indicates that iron content in soils in the panhandle area vary widely, typically ranging from several 100 parts per million up to several percent. Site boring logs confirm the presence of colored iron oxides in the upper sediments. Testing conducted near the site has confirmed iron in soils at levels at least several thousand parts per million.

The SDWS for iron is 0.3 milligrams per liter (mg/L or ppm). Water with less iron should not have an unpleasant taste, odor, appearance or side effect caused by a secondary contaminant. Groundwater at the site contains up to several parts per million (mg/L) of iron and routinely exceeds the SDWS. Regional concentrations of iron in the shallow groundwater have been reported in Florida Geologic Survey (FGS) publications as being relatively high. FGS Special Publication 34 reports that "...49 percent of the Floridan aquifer violated the standard. There is no reason to believe that iron violations are anthropogenic. Iron is a natural constituent and chemical conditions are conducive to the transport of iron. Iron sources are widespread in the aquifer systems."



In addition to being commonly found in the environment, iron is reactive and changes readily to different forms with varying solubility. In groundwater, iron occurs in one of two oxidation states; reduced soluble divalent ferrous iron (Fe^{+2}) or oxidized insoluble trivalent ferric iron (Fe^{+3}). A stability diagram that depicts the speciation of iron with changes in pH and redox potential (Eh) is provided in below. Within the pH range of 4 to 8 standard units, iron is predominantly uncomplexed ferrous iron or ferric iron complexed with hydroxyl ions. Consequently, pH exhibits minor controls on iron solubility within the pH ranges normally encountered in the environment. Redox potential, conversely, more directly dictates iron solubility. As shown on the stability diagram the more mobile ferrous iron form is prevalent in slightly positive to negative Eh ranges. Under a highly reduced condition (where sulfide is formed from sulfate), ferrous iron can react with sulfide under highly reduced conditions to form insoluble iron sulfide (e.g., pyrite).

Ferrous iron is soluble as a cation; ferric iron however is not soluble. Ferric iron can form soluble complexes with many inorganic and organic ligands such as humic acid, fulvic acid and tannic acid (all examples of non-contaminant organic complexes). Ferrous iron normally can be oxidized to ferric iron in minutes. Complexed ferrous iron may take months to complete the same reaction.

Most of the iron in the shallow subsurface is typically in the oxidized ferric state due to the abundance (our atmosphere is 21% oxygen) of oxygen. Ferrous iron, when oxidized is converted (precipitates) to ferric hydroxide (Fe (OH)3). With time ferric hydroxide is mineralized to several forms of ferric iron including amorphous hydrous ferric oxide, maghemitie, lepidocrocite, hematitie, goethite (in order of decreasing solubility and increasing crystallinity). Amorphous hydrous ferric oxide at a neutral pH and oxidizing Eh conditions has a low solubility (0.6 ug/L), which is three orders of magnitude greater than that of goethite.

The time required for uncomplexed ferrous iron to undergo oxidation to the ferric state is dependent on many factors, the dominant being pH, temperature, dissolved oxygen level, and the presence of other soluble ions. The lower the pH and temperature the longer the time required for completion of the oxidation reaction. Increasing dissolved oxygen decreases the time required for oxidation (Zinati and Shuai, 2005). For example:

- at a pH of 7.0, 90 percent Fe^{+2} oxidation requires 1 hour at 21 degrees C (70 degrees F);
- at pH 7.0, 90 percent Fe^{+2} oxidation requires 10 hours at 5 degrees C (41 degrees F);
- at 21 degrees C and pH 8.0, 90 percent Fe^{+2} oxidation occurs in 30 seconds; and
- at 21 degrees C and pH 6.0, 90 percent Fe^{+2} oxidation requires 100 hours.

The target dissolved oxygen concentration is typically 2 mg/L. Below 2 mg/L ferrous *iron oxidation occurs slowly.*

To sequester insitu the ferrous iron mobilized due to reducing conditions requires an understanding of the source of the reducing conditions. Reducing conditions at landfills can be established through several mechanisms.

- Release of organic rich leachate with high Total Organic Carbon content which promotes indigenous microorganisms to utilize these organic compounds for metabolic functions, which consume oxygen. As stated above, geochemical indicators do not show landfill liquids are impacting groundwater.
- Shadow effect due to the reduction of precipitation over a large area. Oxygen rich precipitation is limited from infiltrating into groundwater slowly creating reducing conditions. Combined with the shadow effect may be landfill gas which displaces the oxygen immediately above the water table. Given the lack of leachate indicators in the groundwater samples this is likely the predominate mechanism at the site.
- Variations in iron concentrations in groundwater may occur due to seasonal fluctuation in rainfall. During periods of higher precipitation shallow groundwater may experience an influx of oxygenated water which can result in lower iron concentrations.

When dissolved oxygen, a free electron acceptor, is depleted due to abiotic and biotic reactions, the groundwater environment is characterized as reducing. Once available oxygen and nitrate are depleted, iron is then the most thermodynamically favorable electron acceptor. As free electrons are passed to the ferric ions compounds, ferric iron is transformed into ferrous ion, which is much more water soluble. Soil color is typically changed from the characteristic reddish brown into gray due to iron reduction and dissolution. These reactions will result in the mobilization of naturally occurring iron *that has become reduced iron in groundwater. As soon as iron-rich groundwater comes* in contact with dissolved oxygen, either through aeration or mixing with oxygenated recharge water, the dissolved ferrous iron (Fe(II)) will oxidize to ferric iron (Fe(III)) and subsequently precipitate in the form of ferric coatings on soil sediments (Appelo and Postma, 1993). Other metals (e.g. manganese) will be slower to react than ferrous iron when exposed to dissolved oxygen (Hem, 1985). However, in time other redox sensitive metals will also oxidize to form coatings on soil sediments.

Iron coatings act as strong adsorbents for other metals. During the reduction and dissolution of these iron coatings, the previously adsorbed metals are also mobilized into groundwater (Baedecker and Back, 1979). When the iron is later oxidized farther downgradient in the aquifer, they have the potential to co-precipitate or adsorb other metals as well.

3.0 Evaluation of Potential Remediation Alternatives

In this section corrective measure technologies that appear relevant will be identified and subjected to preliminary screening (Section 3.1) for feasibility to reduce benzene to levels below the PDWS and iron concentrations in groundwater to levels below the SDWS or alternate cleanup level established. Those corrective measure technologies that appear to be feasible for achieving the objectives will then be further compared in a detailed remediation technology evaluation (Section 3.2). The purpose of this process is to screen and evaluate technologies and alternatives to identify the most environmentally sound and effective remedial action.

3.1 Preliminary Groundwater Treatment Alternatives Screening

The goals of the screening process are to identify technologies that may be relevant to achieving corrective measures objectives, and to eliminate from further consideration those measures which are unsuitable based on site characteristics, waste characteristics, technology or regulatory limitations. Those corrective measures technologies which obviously are not appropriate for this application (such as excavation and disposal, incineration, etc.) were not considered relevant and not subjected to preliminary screening. Potential corrective measures that are eliminated will not be considered further.

A variety of groundwater treatment alternatives were evaluated to address the detection of iron in groundwater. Several mechanical technologies exist to remediate iron in groundwater as well as active in-situ technologies (*MNA*). *They include* physical removal (groundwater extraction), and a variety of oxidation, and physical containment strategies. The following paragraphs screen potentially applicable remedial strategies.

Institutional Controls

Institutional controls are those actions that will control land use access to the site and access to potentially impacted groundwater. Institutional controls will not affect site remediation, but will control deleterious effects by reducing the potential for public exposure. Institutional controls include monitoring groundwater and surface water quality, deed restrictions and site access control. These institutional controls have already been implemented at the site and are required by permit; therefore they are all retained but will not be discussed beyond this section.

Monitoring groundwater quality is the primary means of estimating the risks associated with groundwater impacts. Although monitoring will not accomplish any remediation of site impacts, it will provide a means of evaluating the effectiveness of other remedial actions. It will also keep the owners, regulators, planners and general public informed of the location and concentrations of site-related chemicals. Leon County is conducting groundwater sampling and analysis in accordance with an approved groundwater monitoring plan. Groundwater monitoring will continue.

Deed restrictions would restrict the possible future uses of this property. This would be important for protection of human health for reasons such as preventing the installation of a drinking water well on the property. Also, deed restrictions could restrict post-closure development on site. Georgia solid waste regulations require that upon closure, a notice will be placed in the deed for the property indicating that the property has been used for landfilling. Because deed restrictions provide a binding legal means of controlling future site uses, it will be retained for further consideration.

Access control restricts access to the site by humans. This is an important means of preventing human contact with impacted media. Access control is currently accomplished with fencing and locked gates at road entrances. Access control will continue.

Containment Technologies

Groundwater containment technologies involve containing groundwater and are generally not treatment technologies. Two primary approaches exist: 1) using low permeability subsurface barriers; 2) groundwater extraction systems. The low permeable barriers may be coupled with pump and treat systems to additionally control groundwater flow and limit hydraulic effects of the barriers. Barriers which completely encircle the contaminant area are more effective than those that only partially encircle the area of concern. These technologies are particularly useful when current technologies can't remediate source areas. Several types of containment technologies are occasionally utilized at landfills (EPA, 1990); these containment technologies include: slurry walls, grout curtains and sheet piling. Slurry walls are installed by trenching and filling the trench with a mixture of bentonite and water to form a low permeability barrier. Grout curtains are installed by pressure grouting to form a low permeability barrier. Sheet piling is driven into the ground and joined together to form a low permeability barrier. All of these options will encounter difficulty due to the depth (20 to 22 feet bgs) and thickness (5-10 feet) of the confining layer. These options will not remediate iron but could serve to contain groundwater on site. This option will not alter the redox conditions and therefore may not address iron levels offsite. This option is not retained for further consideration.

Pump and Treat (P&T) is a strategy that utilizes groundwater pumping/extraction to contain or hydraulically control the migration of groundwater. This technology typically involves pumping the iron rich groundwater and treating the groundwater on-site by a groundwater treatment system, typically some form of air stripping or series of oxidation and percolation ponds.

The success of this process greatly depends on the aquifer characteristics of the site. P&T generally requires returning the treated groundwater back into the formation by means of an infiltration gallery or re-injection wells after passing through a series of settling ponds. The lack of available property and the presence of off-site wetlands would limit configuration of settling ponds.

Although this approach is generally successful in VOC mass removal, other remedial approaches are more appropriate for the low level benzene concentrations at the site. Additionally, in this particular application, P&T does not address the geochemical cause of the iron laden groundwater. Natural site soils with their iron content represent a vast source of iron. With continued presence of reducing conditions iron will continue to be mobilized, therefore this approach is not retained for further evaluation.

Natural Attenuation (NA)

Natural attenuation is defined by EPA as naturally occurring processes in the environment that act without human intervention to reduce the mass, toxicity, mobility, volume or concentration of contaminants in those media. These in situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and or chemical and biochemical stabilization. Often natural attenuation provides substantial reductions in contaminant levels and risk to human health and environment. Natural attenuation of metals often means sequestering or transformation. As previously discussed under specific geochemical conditions, iron in groundwater will become sequestered in situ. This option requires environmental monitoring to determine if concentrations observed during the investigation phase decrease during the remediation phase and appropriate conditions are maintained.

The natural attenuation default criteria identified in Table V of 62-777 for iron is 10 times the SDWS. Therefore 3,000 ug/L is the value used for a technical evaluation of the appropriateness of natural attenuation. Site-specific conditions to be considered when selecting this alternative include distance to and type of use at the nearest receptor, and the time required to achieve background levels. Since iron concentration levels in the groundwater exceed Natural Attenuation Default Concentrations (NADCs) and it is unlikely that these levels will naturally attenuate to Groundwater Cleanup Target Levels (GCTLs) in 5 years or less without additional treatment, consequently, natural attenuation is not considered viable for this site at this time by itself. However, when paired with an additional technology, natural attenuation is more likely to attain remedial goals. Therefore, this option is retained for further consideration.

Air Sparging/Bio Sparging

Air sparging is a commonly selected proven remedial approach demonstrated to be effective in volatilizing VOC's from groundwater that are generally recovered with a vacuum extraction system. Both air sparging and biosparging (introduction of air at lower flow rates than air sparging) add oxygen to groundwater to enhance bioremediation. In addition to allowing volatilization of benzene, the sparge application will add oxygen to groundwater to convert the mobile ferrous iron to ferric iron. Air sparging is an in situ technology in which air is bubbled through a contaminated aquifer. Air bubbles traverse horizontally and vertically through the groundwater column, creating an oxidizing condition. Groundwater passing through this zone picks up the additional oxygen and carries it downgradient via advection. This process creates oxidizing conditions conducive to the precipitation of ferrous iron into ferric iron. Site-specific conditions to be considered when using this technology include hydrogeologic conditions, potential clogging of pore spaces and other metals which may coprecipitate. Implementation of this technology typically is in the form of sparge walls, sparge fields, or in-well air sparge systems. Sparge walls typically consist of a line of sparge points that produce a treatment wall, treating groundwater flowing through this wall. Sparge fields provide an areal treatment. In-well air sparge systems involve the recirculation of groundwater and air within a single vertical well. Vapor extraction is sometimes implemented in conjunction with air sparging to assist in removing the generated vapor phase contamination; however this is not likely necessary at this site based on the low concentrations of benzene. This technology can be designed to operate at a variety of flow rates to maintain contact between the air and groundwater. Increased contaminant sequestering can be accomplished due to both chemical and biological mechanisms. This technology has been successfully employed at sites in the Northwest District (although not specifically for iron). This technology is well established and is often more efficient in establishing oxidizing conditions than other technologies. One concern regarding implementation for this approach and all insitu approaches in general is the potential for precipitated iron (and other metals) to occlude the open pore space. Prior to detailed full scale remedial system design and implementation pilot tests are typically implemented to determine specific radius of influence and determine geochemical and operational parameters. This technology is retained for further consideration.

Soil Vapor Extraction (SVE)/Vadose Zone Aeration (VZA)

Extraction of low oxygen vadose zone soil gas and replacing it with a more oxygenated atmosphere will partition oxygen into the groundwater and result in the formation of more oxidizing conditions in groundwater. SVE systems are commonly implemented at landfills to extract subsurface gases. In this approach, extraction of subsurface gas is intended to replace low oxygen concentration atmosphere immediately above the water table with an atmosphere more oxygen rich. This oxygen can partition into the groundwater and create more oxygenated conditions to promote insitu precipitation of iron.

As with active landfill gas extraction systems, a blower can be used to create a vacuum on the extraction wells. At times this technology may also utilize passive SVE vents. These passive vents can also serve as air injection points promoting the reaeration of the vadose zone. The overall intent of these technologies is the recovery of the landfill subsurface to pre-existing conditions. VZA pilot tests have been implemented but this technology has not yet established itself as an effective mechanism to reestablish oxidizing conditions at depth. This is an unproven technology that may have some benefit to supplement a primary technology at this site. This technology is not retained for further consideration.

Chemical Oxidation

Chemical Oxidation is a remediation technique that involves injecting a chemical oxidizing compound (such as potassium permanganate, hydrogen peroxide, ozone, etc.,) into the groundwater. Remediation takes place as the dissolved (mobile) ferrous iron is oxidized into the sequestered bound ferric iron. Chemical injection wells can be used in the vicinity of the area of elevated iron concentrations either as a barrier or areal application. This process releases large quantities of oxygen that may severely disrupt natural on-going natural processes. Additionally, the release of large quantities of oxygen in close proximity to a landfill may potentially serve to raise oxygen levels within the landfill potentially increasing the likelihood of a subsurface fire within the waste mass. These injectates along with less aggressive oxygen sources (such as readily commercially available compounds such as ORC) will require frequent replacement to maintain oxidizing conditions. Therefore this technology is not retained for further consideration.

Aerated Stormwater Circulation or Infiltration

Aerated stormwater circulation or infiltration is a technology that injects (or circulates) or otherwise allows oxygen rich water to infiltrate into the aquifer. The oxygen rich water creates oxidizing conditions in the aquifer which will result in the precipitation and sequestration of iron. Implementation of this method could involve creation of an infiltration trench to allow oxygen rich stormwater to infiltrate into the aquifer or involve the injection of oxygen rich stormwater into shallow injection wells. This technology can be implemented either as a "barrier wall" or in an areal approach. We understand a pilot test of aerated water circulation is being implemented in the western portion of Bay County. The recirculation of aerated stormwater can be established using a deep infiltration trench, or multiple circulation/injection wells. Additionally this technology could also utilize injection of aerated groundwater. This technology is unproven but theoretically can create oxidizing conditions at depth within the aquifer resulting in the sequestration of iron. Implementation of this technology should involve additional testing prior to implementation. We understand this technology has been proposed at other sites in the District. This technology is retained for further consideration.

Phytoremediation

Phytoremediation is the process of utilizing plants to remove contaminants from soil and groundwater. Several plants are identified as being capable of removing iron from the groundwater. Additionally plants can impart oxygen to the groundwater and surface water in low concentrations. However, due to the lengthy nature of this process and the total depth of the saturated interval, this method of remediation was excluded from further consideration.

Groundwater Flow-Through Ponds

This technology involves the construction of a deep pond to encounter groundwater to provide oxygenated water to the aquifer. This pond could be constructed as a groundwater flow-through pond while preventing any stormwater in-flow. The oxygenated water in these ponds could deliver aerated water to the aquifer thereby sequestering iron. Stormwater would generally be excluded from the pond. To provide supplemental oxygenation, aerators could be provided to keep the ponds aerated. Additionally a concentration of select vegetation can further promote oxidization or uptake of iron. Construction would involve excavation of a deep pond installed to a depth near the top of the clay confining layer. Establishment of oxidizing conditions in the groundwater will sequester mobile iron. Additionally groundwater flowing into the pond would also become oxidized. Installation of this technology would need to address the potential presence of wetlands on the western portion of site. Implementation of this remedy is retained for further consideration.

Permeable Reactive Barrier (PRB)

A permeable reactive barrier (PRB) is defined as an *in-situ* method for remediating contaminated groundwater that combines a passive chemical or biological treatment zone with subsurface fluid flow management. Traditional PRB treatment media may include zero-valent iron, chelators, sorbents, or microbes to address a wide variety of groundwater contaminants such as chlorinated solvents, other organics, metals, inorganics, and radionuclides. The contaminants are concentrated and either degraded or retained in the barrier material. PRBs can be installed as permanent or semi-permanent units. The most commonly used PRB configuration is that of a continuous trench in which the treatment material is backfilled. The trench is perpendicular to and intersects the ground-water plume. In this particular application the PRB would contain a reactive substance (limestone, or other oxidizing compound) which would oxygenate the groundwater flowing through the barrier. PRBs are more feasible in areas with shallow groundwater elevations because its construction involves excavating and backfilling trenches. Due to the depth required this technology is not retained for further consideration.

3.2 Detailed Remediation Technology Evaluation

In the previous section technologies were screened and appropriate alternatives were identified for more detailed evaluation. In this section four of the more appropriate technologies that were retained are evaluated in more detail include air sparging, aerated stormwater circulation/infiltration, groundwater flow-through ponds, and landfill gas venting. During the detailed analysis, each alternative is evaluated against:

- Long-term and short-term human health and environmental effects;
- Implementability, which may include ease of construction, site access , and necessity for permits;

- Operation and maintenance requirements;
- Reliability;
- Feasibility;
- Estimated time required to achieve cleanup; and
- Cost effectiveness of installation, operation and maintenance when compared with other site remediation alternatives

The results of this evaluation are then used to make comparisons among alternatives, and the key tradeoffs among alternatives can be identified. This approach to analyzing alternatives is designed to compare the alternatives and select an appropriate remedy for a site. We note that the costs provided are rough estimates based on our experience and do not constitute current market prices, but instead provides relative costs, to facilitate comparison between remedial technologies. Please note that the proposed alternatives include items that are already required by the site's solid waste permit. These include items such as site security, deed restrictions, groundwater and surface water monitoring. In developing order of magnitude cost estimates, the cost of such required items were not included in the cost estimate. Technologies that were retained for further consideration in the previous section are presented below:

Air Sparge/MNA

Long Term and Short Term Environmental Effects
Air Sparge and MNA are both proven and widely accepted remedial options. Under this combined approach the air sparge system remove volatiles from the groundwater and would over time alter subsurface geochemical conditions to address iron concentrations. Once geochemical conditions shifted MNA monitoring will be implemented to monitor iron concentrations at the point of compliance. If geochemical conditions shift back to the pre-sparging conditions the air sparge system could be run again. The goal of this approach is to use air sparge on an as needed basis as a "polishing" process so that iron concentrations reach the cleanup level.

Air sparging is a common in-situ technology for the treatment and removal of VOCs in groundwater. Air is injected into the aquifer and VOCs are stripped from the groundwater with a stream of injected air. Air bubbles traverse horizontally and vertically through the soil column, creating an underground stripper that removes contaminants by volatilization. These air bubbles carry the contaminants to the surface; however during this process these air bubbles also transfer oxygen to the groundwater. At lower flow rates, this technology is commonly implemented to increase the amount of dissolved oxygen in the groundwater and is regarded as an efficient means to transfer oxygen to the groundwater.

Coupled with monitored natural attenuation, air sparge would serve as a polishing step by converting subsurface conditions from anaerobic to aerobic. Under aerobic conditions groundwater will prompt the formation of iron hydroxide within the formation. The precipitated iron would remain sequestered in the formation as an insoluble iron hydroxide unless groundwater geochemical conditions (redox) became more reducing, at which point the iron could potentially become mobile again.

Construction of an air sparge system requires minimal site grading and land disturbance. A performance concern is whether the precipitated form will be mobile (colloidal) and whether a significant reduction in permeability will result from the iron precipitant. In at least two instances, it has previously been demonstrated (Wylie, et.al. 1997 and Hallberg and Martinell, 1976) that in-situ precipitation of iron has a negligible affect on formation permeability. This assumption however, should be verified with pilot scale testing. Therefore a pilot scale study will be required to evaluate this technology prior to full-scale implementation. The performance of air sparging is considered to be good under favorable conditions.

This is a relatively standard remedial technology which has demonstrated long-term effectiveness for VOC control. However, the response of the iron in site groundwater is site specific and has not been determined. To evaluate the short and long term effects of iron, pilot tests will be necessary.

Implementability

This alternative involves the installation of numerous air sparge points, which could be installed with conventional drilling technologies. Each sparge point would be connected to an air supply line supplied by one or more air compressors or blowers. This technology could be easily implemented to mitigate benzene and iron concentrations in groundwater. If selected, a pilot test system is necessary to evaluate site specific performance to provide the necessary information to design a full-scale system. Full-scale implementation is anticipated to consist of a series of 50 to 100 sparge wells. Sentinel wells will be needed downgradient of the treatment area to monitor the effectiveness of the alternative.

The installation of injection wells does not require excavating, moving and/or management of significant amounts of contaminated media, except small amounts of drill cuttings, therefore implementation of the air sparge wells is not an exposure concern.

Operation and Maintenance Requirements

Operation and maintenance of this system include system adjustment, system monitoring, and long-term maintenance. Routine inspections of operations will be necessary to ensure optimal performance.

Reliability

Air sparge systems have a proven track record and are considered reliable remedial approaches. MNA also has a proven track record and is considered reliable. This technology has been widely implemented at petroleum sites, including those with elevated iron concentrations. The reliability of the air sparge system is limited by the ability to circulate air within the groundwater. Uncertainty of the degree of anisotropy in an aquifer is another limitation affecting the reliability. Another reliability concern is the potential for the accumulation of iron within the formation and biofouling of the well sparge screen. Provided proper circulation can be established, the reliability is rated very good.

Feasibility
It is feasible to implement this technology at this site.

Estimated time to achieve cleanup
Once pilot testing is complete and the system is designed and permitted, the full-scale system can be operational within 9 months. The time required to complete the remedy is dependent on the site-specific conditions. It is estimated that several years will be required to achieve compliance with the iron groundwater standard at the point of compliance, though benzene concentrations would likely be ameliorated much more quickly. After finalizing the system, routine maintenance will be required to maintain proper injection rates, ongoing monitoring and preventative maintenance. In order to maintain compliance, it will likely be necessary to continue to operate the remediation system for many years, until reducing conditions diminish.

Cost Effectiveness of Installation, Operation, and Maintenance
The installation costs of an air sparging system are based primarily on the number of air sparging wells required to adequately cover the target treatment areas. The required number of wells is controlled by the extent to be treated and subsurface air distribution characteristics. The costs for well installation and construction increase as the depth to the impacted zone increases. Capital equipments costs are impacted by the air injection flow rates, which relate to compressor and blower sizing, and by any potential air treatment requirements. To accurately estimate these values requires the collection of additional data. However, assuming a very simple system and making many assumptions (assuming 50 sparge wells injecting ambient air, no off gas vapor treatment) a planning level cost estimate can be derived. The cost of implementing the air sparging system is approximately $300,000 to $400,000, which covers costs of installation through start-up of the system. Additional capital costs will include pilot scale system and monitoring which are estimated to range from $50,000 to $75,000.

The O&M costs are influenced primarily by those factors that tend to increase the time to reach remedial goals. Site subsurface characteristics are important because the achievable air injection rate and or extraction rate affects the rate of iron sequestration and therefore project duration. The soil characteristics also impact the required operating pressure for the injection which can increase energy use at the site.

Operation and maintenance of this system include system adjustment, system monitoring, long-term maintenance and MNA monitoring. These costs are expected to run approximately $30,000 to $60,000 per year and include maintenance of equipment.

Aerated Stormwater Circulation/Infiltration

Aerated stormwater circulation or infiltration is a technology that injects (or circulates) or allows oxygen rich stormwater to infiltrate into the aquifer which creates oxidizing conditions which will sequester the iron insitu.

Long Term and Short Term Environmental Effects
This technology has been proposed at other sites in the District, although we are not aware of any full scale implementation. This technology circulates oxygenated stormwater throughout the aquifer and creates geochemical conditions which sequester the iron in-situ. There are two general configurations for storm water circulation systems:

- Active system consisting of multiple recirculation/injection wells which inject and circulate stormwater into the aquifer.
- Passive system consisting of an infiltration trench or gallery. In this configuration a deep infiltration trench or basin which promotes infiltration of oxygen rich stormwater into the aquifer.

In both approaches the oxygenated stormwater will sequester the iron in-situ. For the purposes of this RAP, this evaluation will focus on the active system consisting of multiple circulation wells.

The stormwater circulation system described in this evaluation will include multiple circulation wells screened for the entire depth of the saturated surficial aquifer, approximately 20 feet. Oxygenated stormwater can be pumped/pulsed from a stormwater pond into the injection/circulation well. The oxygenated water will create conditions conducive for the in-situ sequestration of iron.

Construction of a stormwater circulation system will require minimal site grading and land disturbance. Like air sparging, a performance concern of aerated stormwater circulation is whether the precipitated form will be mobile (colloidal) and whether a significant reduction in permeability will result from the iron precipitant. Therefore a pilot scale study is suggested to evaluate this technology prior to full-scale implementation. The performance is considered to be good under favorable conditions. Iron precipitated in the formation, may mobilize if reducing conditions become re-established.

The response of the iron in site groundwater is site specific and has not been determined. To evaluate the short and long term effects of iron, pilot tests are necessary. Implementation will require monitoring.

Implementability
This alternative involves the installation of numerous stormwater circulation wells, which could be installed with conventional drilling technologies. Each stormwater circulation well would be connected via piping to a pump at the stormwater pond. The oxygen rich

stormwater would be pulsed into the injection wells. Supplemental aeration at the stormwater pond may be necessary. Additionally supplemental water may be necessary which could require additional stormwater pond construction. Aerated groundwater recirculation is a common remedial technology that is generally readily accepted by local communities. This technology is very similar. If selected, a work plan followed by installation of a pilot test system will be required to evaluate site specific performance to provide the necessary information to design a full-scale system. Depending upon location, sentinel wells may be needed down-gradient of the impacts to monitor the effectiveness of the alternative. Time to achieve full scale implementation is anticipated to be on the order of one year. The site is currently subject to local, state, and federal rules, which govern the facility's permits. An UIC permit may be required. A revision and modification to the stormwater permit may also be necessary.

Operation and Maintenance Requirements

Operation and maintenance of this system includes routine system adjustment, system monitoring, and long-term maintenance. However if an infiltration trench system were adopted O&M requirements would be minimal.

Reliability

The reliability of the system is limited by the ability to circulate oxygenated water within the groundwater. Uncertainty of the degree of anisotropy in an aquifer is another limitation affecting the reliability. Another reliability concern is the potential for the accumulation of iron within the formation and biofouling of the well screens. Provided proper circulation can be established, the reliability is rated very good.

Feasibility

It is feasible to implement this technology.

Estimated time to achieve cleanup

Once pilot testing is complete and the system is designed and permitted, the full-scale system can be operational within approximately 1 year. The time required to complete the remedy is dependent on the site-specific conditions. It is estimated that several years will be required to achieve compliance with groundwater standards at the point of compliance, based on preliminary estimates of aquifer characteristics at the site. After implementation, monthly maintenance will be required to maintain proper injection rates, ongoing monitoring and for preventative maintenance. In order to maintain compliance it will likely be necessary to continue to operate the remediation system for many years, until the level of groundwater reduction diminishes.

Cost Effectiveness of Installation, Operation, and Maintenance

The installation costs of an aerated stormwater circulation system are based primarily on the number of circulation wells required to adequately cover the target treatment areas. The required number of wells is controlled by the extent to be treated and subsurface distribution characteristics. The costs for well installation and construction increase with depth. Capital equipments costs are impacted by the air injection and extraction flow rates, which relate to compressor and blower sizing, and by air treatment requirements.

To accurately estimate these values requires the collection of additional data. However, assuming a very simple system and making many assumptions, assuming 30 circulation wells, a planning level cost estimate can be derived. The cost of implementing this system is approximately $300,000 – $400,000, which covers costs of installation through start-up of the system. Additional capital costs will include pilot scale system and monitoring.

The O&M costs are influenced primarily by those factors that tend to increase the time to reach remedial goals. Site subsurface characteristics are important because the achievable radius of influence will affect the rate of sequestration and therefore project duration. Operation and maintenance of this system include system adjustment, system monitoring, and long-term maintenance. These costs are expected to run approximately $40,000 to $80,000 per year and include maintenance of equipment.

Groundwater Flow-Through Ponds

This technology has been proposed at other sites in the District, although we are not aware of any full scale implementation. This technology involves the construction of a deep pond(s) to provide contact with oxygenated water, and allows groundwater to "flow through". This pond could be constructed as a groundwater flow-through pond while preventing stormwater in-flow. Iron rich groundwater upon encountering the oxygen rich water will oxidize the iron. Additionally aerobic plants and microbes can assist in iron sequestration and removal.

Long Term and Short Term Environmental Effects

During construction a fair amount of land moving and landscaping may be necessary. Exposure of soils to surface water may result in ion exchange with the soils, and a potential short term increase in calcium or sulfate. A performance concern is ferric iron occlusion of the pond interface. Therefore a pilot scale study will be required to evaluate this technology prior to full-scale implementation. The performance is considered to be good under favorable conditions. Iron precipitated in the pond or formation, may resolubilize if reducing conditions become re-established. Iron precipitated in the pond has the limited potential to clog the pond. Short term environmental effects are limited in nature and are associated with construction activities. Excavated materials could potentially be placed on the capped landfill to provide enhancement to the cap. Depending upon the specific layout some wetlands may be impacted which will require permitting. Groundwater monitoring will allow monitoring of potential environmental effects.

Implementability

This alternative involves the installation of a long deep stormwater pond which may be difficult due to space constraints between the Class III disposal area and the property boundary. Any potential wetland impacts will require permitting. If selected, this pond could be constructed in stages or in one continuous effort. The site is currently subject to local, state, and federal rules, which govern the facility's permits. A revision and modification to the stormwater permit may be necessary.

Operation and Maintenance Requirements
Operation and maintenance of this system includes routine vegetative management. Depending upon conditions, a supplemental mechanical aeration system may be added. An occasional infrequent re-dredging of the flow thorough pond may be necessary. Otherwise O&M requirements would be minimal for implementation of this technology.

Reliability
The reliability of the system is limited by the ability to maintain oxygenated water within the pond and adjacent groundwater and have groundwater flow through the oxygenated pond. Uncertainty of the degree of anisotropy in an aquifer is another limitation affecting the reliability. Another reliability concern is the potential for the accumulation of iron within the formation and biofouling of the pond walls.

Feasibility
It is feasible to implement this technology, however site specific constraints (depth to groundwater, on and off-site roads, space limitations, adjacent property activities) will complicate the construction of the pond(s) and potential impact their effectiveness.

Estimated time to achieve cleanup
Once the flow thorough pond design is complete the system can be operational within 1 year. Upon construction, metals should begin immediately oxidizing and become sequestered.

Cost Effectiveness of Installation, Operation, and Maintenance
The installation cost of a flow through aerated pond is dependant upon the size and depth of the pond. It is anticipated the pond would stretch along the eastern and southern boundaries of the site. The cost for pond construction and re-vegetation is estimated to be on the order of $200,000 to $250,000, though this cost may increase substantially if landfill disposal is required for any of the excavated material. Supplemental aeration is optional.

The O&M costs are limited to primarily vegetative management. If supplemental aeration is selected then O&M on the aerator will also be necessary. These costs are expected to range up to 40,000 per year for electricity and maintenance of equipment.

4.0 Recommended Remedial Approach

Several remedial technologies were screened and evaluated. The goal is to specify an effective remedial technology or combination of technologies to achieve cleanup criteria in a timely and cost effective manner. All the remedial options evaluated in Section 3.2 were appropriate for the site. The remedial action found most appropriate for this site is air sparging with additional groundwater monitoring. A pilot study is necessary to determine the site specific conditions and design criteria for the air sparge system. A pilot test workplan is provided in Section 4.1. Proposed groundwater monitoring activities are discussed in Section 4.2.

4.1 Air Sparge Pilot Test Workplan

Historic and recent sampling results confirm the presence of benzene at concentrations above the PDWS and iron at concentrations above SDWS at the Class III East landfill. The first step in implementation of the RAP is to conduct a pilot test to confirm design parameters and efficacy of this technology.

The following section details the proposed activities to be undertaken during the Air Sparge Pilot Test. The objective of the Air Sparge Pilot Test is to evaluate site specific design parameters to optimize the design and operation of a future remediation system onsite that will supplement MNA. The plan is intended to establish specific requirements, procedures, and goals to implement the Air Sparge pilot test.

The Pilot Test will be divided into Phases. Phase I, which is described in this work plan, will include the installation of two air sparge wells and two performance monitoring wells. The primary design parameters to be determined from the Phase I pilot test are, radius-of-influence (ROI), operating pressure and flow rates. Additionally, conducting a pilot test will provide initial information on the efficacy of restoring oxidizing conditions to sequester iron and the capacity of the groundwater system to remain oxidizing.

At the conclusion of Phase I, the results of the pilot test and the feasibility of implementing an air sparge system will be analyzed. If the results of Phase I of the pilot study suggest air sparge continues to be a feasible technology, a second phase of the pilot test will be designed and implemented. Phase II will include the installation of additional sparge wells as needed. The duration of Phase II of the pilot test will be much longer than Phase I, approximately 3-6 months and will include several groundwater monitoring events that will further gauge the effectiveness of the technology of benzene removal, altering geochemical conditions, sequestration of iron, and reducing the concentration of iron in groundwater monitoring wells. The second phase may also evaluate the effect of pulse sparging at low flow rates as well as the length of time subsurface conditions will remain aerobic without sparging. This information will aid in developing a full scale implementation of and operation of the sparging system

Air Sparge Pilot Test –Phase I

Phase I of the air sparge pilot test will consist of several components including: well installation, baseline sampling, implementation of air sparge test, and post pilot test monitoring. The pilot test is proposed to be conducted in the vicinity of existing wells MW-8 and MW-36 located near the southeastern corner of the landfill (Figure 2). Two air sparge wells will be installed as part of the pilot test. The air sparge wells will be installed to the same depths as MW-8 and MW-36.

Two air sparge pilot test wells (AS-1 and AS-2) will be installed for this pilot test at the approximate locations indicated in Figure 3. As indicated in Table 2 below these wells will be installed to a depth of approximately 45 feet below grade. The sparge well will be constructed with 1-inch diameter PVC casing and a 2-foot length of Schumasoil porous pipe (40 micrometer). We anticipate the screened intervals to be approximately 38-42 feet below grade for AS-1 and 41-45 feet for AS-2.

Table 2 – Phase I Pilot Test Well Construction Summary

Well	Diameter	Installation Method	Screen Interval and Material	Filter Pack
AS-1	1-Inch PVC	Direct push or Hollow Stem Auger	38-42 ft bls Schurmasoil porous pipe (40 Micrometer)	20/30 silica sand to 0.5 ft above the screen interval
AS-2	1-Inch PVC	Direct push or Hollow Stem Auger	41-45 ft bls Schurmasoil porous pipe (40 Micrometer)	20/30 silica sand to 0.5 ft above the screen interval
MW-8 (existing)	2-Inch PVC	Hollow Stem Auger	0.01 slot PVC screened 32-42 ft bls	N/A
MW-36 (existing)	2-Inch PVC	Hollow Stem Auger	0.01 slot PVC screened 35-45 ft bls	N/A

Pilot Test Procedures

Prior to initiation of the pilot test, baseline groundwater sampling will be conducted at MW-8 and MW-36. All field activities, sample collection and documentation activities will be performed in accordance with FDEP SOP's. Baseline monitoring will include field measurement of: water levels, dissolved oxygen, oxidation reduction potential, benzene, ferrous iron; total iron, hydrogen sulfide, turbidity, pH, and specific conductance.

After baseline sampling has been conducted Phase I of the pilot test will be implemented. The air sparge pilot test will be performed at several different flow rates. An air compressor will be attached via an air hose to AS-1 and AS-2. The compressor will be capable of producing up to approximately 16 CFM and will be powered by a portable generator. The compressor will include an air filter system which includes particulate and oil removal filters. The compressor will also include a pressure regulator with pressure gauge, an air flow rotometer with flow control valve. Well caps will include pressure reading ports.

The temperature, pressure, and rate of the flow of air will be measured before being delivered into AS-1 and AS-2. Upon start up, pressure will be applied to both sparge wells to induce air sparge breakthrough. Following breakthrough, the pressure will be adjusted to operate the sparge wells at two different flow rates. An initial flow rate of 1-2 SCFM will be implemented. Performance measurements will be recorded as indicated in the table below. Upon system stabilization a second higher flow rate will be implemented. It is anticipated this flow rate will be approximately 6-8 SCFM; however, observed conditions during sparging will dictate actual flow rates. The total duration of this initial testing phase will be 8 hours. The data will be analyzed to determine the appropriate flow rates and if other system adjustments will be necessary prior to longer term testing. Following initial system adjustments, the test will be performed at the appropriate flow rate for six months. Specific capacity will be measured prior to initiation of the test, at 3 months and at 6 months to evaluate potential iron fouling.

Table 3 below presents the operational data to be recorded during the initial pilot test activities to evaluate the effectiveness of the technology and ROI observed. Groundwater elevation, dissolved oxygen and redox will be monitored on a regular basis as described below. Some of these data may be collected using pressure transducers and data loggers. Following the initial 8 hour portion of data collection, the monitoring frequencies will be increased to weekly.

Table 3– Phase I Pilot Test 8-Hour Performance Monitoring

Well	Parameter Monitored	Frequency	Parameter	Frequency
AS-1	Pressure, water elevation, visual observation,	Before, every 15-30 minutes and after		
AS-2	Pressure, water elevation, visual observation,	Before, every 15-30 minutes and after		
MW-8	Water elevation, visual observation, DO, redox, pH	Before, every 15-30 minutes and after	Iron, dissolved iron, turbidity	Before, every 30-60 minutes, and after
MW-36	Water elevation, visual observation, DO, redox, pH	Before, every 15-30 minutes and after	Iron, dissolved iron, turbidity	Before, every 30-60 minutes, and after

Additionally, prior to starting the test and immediately afterwards, well headspace samples will be field measured for oxygen, carbon dioxide, and methane gas utilizing a GEM 2000 or equivalent. Before and at the conclusion of pilot testing, groundwater samples will be collected and field analyzed for ferrous iron and hydrogen sulfide.

Additionally approximately one week and again at approximately one month after completion of the pilot test, groundwater samples will be collected and analyzed for benzene, iron, dissolved iron, and field measured parameters to assist in evaluating the persistence of oxidizing conditions.

Reporting
The results of the pilot study will be summarized in a RAP addendum report. The report will summarize data collected during the Phase I pilot test and make design recommendations. The recommendations from the Phase I pilot test report will include a work plan for Phase II of the pilot study or recommend an alternate remedial technology.

Schedule
Field activities can commence within one month of receipt of FDEP approval of the work plan. It is anticipated a total duration of 5 months will be necessary to install the wells, survey the wells, conduct the pilot test, receive analytical data, and prepare a report summarizing the Phase I pilot test results.

4.2 Additional Groundwater Monitoring

In addition to implementation of the pilot study, collection of additional groundwater data is warranted. The following activities are proposed to be conducted concurrently with the pilot study:

- Install a surficial aquifer monitoring well in cluster with existing Floridan aquifer monitoring well MW-Q to determine potential impacts to water quality within the surficial aquifer in this area.
- Install a Floridan aquifer monitoring well at the edge of the ZOD south of existing monitoring well MW-Q to determine the horizontal extent of benzene concentrations above the PDWS within the Floridan aquifer.

RESOLUTION NO.

WHEREAS, the Board of County Commissioners of Leon County, Florida, approved a budget for fiscal year 2009/2010; and,

WHEREAS, the Board of County Commissioners, pursuant to Chapter 129, Florida Statutes, desires to amend the budget.

NOW, THEREFORE, BE IT RESOLVED, that the Board of County Commissioners of Leon County, Florida, hereby amends the budget as reflected on the Departmental Budget Amendment Request Form attached hereto and incorporated herein by reference.

Adopted this 14th day of September, 2010.

LEON COUNTY, FLORIDA

BY: ______________________
Bob Rackleff, Chairman
Board of County Commissioners

ATTEST:
Bob Inzer, Clerk of the Court
Leon County, Florida

BY: ______________________

Approved as to Form:
Leon County Attorney's Office

BY: ______________________
Herbert W. A. Thiele, Esq.
County Attorney

FISCAL YEAR 2009/2010
BUDGET AMENDMENT REQUEST

No: BAB10064
Date: 9/2/2010

Agenda Item No:
Agenda Item Date: 9/14/2010

County Administrator

Parwez Alam

Assistant County Administrator

Alan Rosenzweig

Request Detail:

Revenues

Account Information							
Fund	Org	Acct	Prog	Title	Current Budget	Change	Adjusted Budget
401	000	399900	000	Appropriated Fund Balance	1,114,347	400,000	1,514,347
				Subtotal:		400,000	

Expenditures

Account Information							
Fund	Org	Acct	Prog	Title	Current Budget	Change	Adjusted Budget
401	036032	53400	534	Remedial Action Plan	-	400,000	400,000
				Subtotal:		400,000	

Purpose of Request:

This amendment realizes $400,000 from Solid Waste retain earnings and establishes a budget for the Remedial Action Plan which is designed to address the groundwater contaminations issues associated with the Solid Waste Facility located on Apalachee Parkway. The Remedial Action Plan is a requirement by the Florida Department of Environmental Protection based on the results from routine groundwater sampling conducted by the Solid Waste Management Division.

Group/Program Director

OMB Director

Scott Ross

Approved By: Resolution [X] Motion [ ] Administrator [ ]

Leon County Solid Waste Facillity

Historical Benzene Concentrations

2003 - 2010

Well #	1998	2003		2004		2005		2006		2007		2008		2009		2010	
	Feb	Feb	Aug	Feb	Aug	Feb	Aug	Feb	Aug	Feb	Aug	Feb	Aug	Feb	Aug	Feb	Aug
MW-8	First Detect 1.6	2.8			3.1	3.4	2.9	3.4	3.2	3.8	3.5	2.9	3.2	3.2	2.8	3.3	1.5
MW-21							3.5	3.8	3.6	3.3	3.1	2.4	3.5	3.3		2.8	2.2
Tal-1						First	4.8	3.0	2.0	1.6	2.1	1.4	1.5	<1		<1	<1
MW-32		Not Sampled for benzene															BDL
MW-33		Not Sampled for benzene															BDL
MW-36											Well installed in 2008	First	2.3	2.1		1.4	1.5
MW-Q		4.6			BDL	1.2	1.2	1.1	1.1	1.1	1.1	1.2	1.3	BDL	BDL	1.1	1.1
MW-H					BDL	→	→	→	→	→	→	→	→	→	→	→	
MW-G					BDL	→	→	→	→	→	→	→	→	→	→	→	
MW-D		BDL	→	→	→	→	→	→	→	→	→						
MW-E		BDL	→	→	→	→	→	→	→	→	→						

1.0 ug/l = MCL for G-II Aquifers
BDL = Below Detection Limits

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Iron Issue at the Apalachee Solid Waste Management Facility

Introduction
Iron is a naturally occurring element in groundwater in this part of Florida. In certain circumstances excessive amounts of iron can pose a threat to the environment. The Florida Department of Environmental Protection (DEP) has established standards for concentrations of iron and other chemicals. The groundwater in and surrounding the Apalachee Solid Waste Management Facility (SWMF) is monitored semi-annually for dozens of different potential contaminants, including iron.

Iron Issue
Iron has shown up, in very high concentrations, near the southeast corner and northeast portion of the SWMF. It is a reasonable assumption that unlined cells at the SWMF are a contributing factor to these high levels of iron. It is interesting to note, however, similar problems exist in association with lined landfills elsewhere. This issue is certainly not unique to Leon County. Many other jurisdictions, especially those in the panhandle, are grappling with this problem.

To date, DEP has agreed to simply allow Leon County to monitor the situation. Recent data indicates the iron problem continues. It is expected that DEP may require some kind of action to lower iron concentrations in the near future.

Current Activities
In close cooperation with DEP, there is an ongoing effort to determine the extent of the groundwater contamination. New groundwater monitoring wells are being added, both upstream and downstream. Contrary to what was expected, iron concentrations have actually been higher at some sampling locations farther from the edge of the landfill than those close to the edge.

The County has hired Chris Teaf,Ph.D., an environmental toxicologist, to perform a health risk assessment based upon the data collected so far. His original assessment indicates an acceptable risk. While DEP has asked for additional information, the conclusions of the assessment will not change. Dr. Teaf is working on a response to DEP at this writing.

Future Activities
The County's solid waste consultant, HDR Engineering, is working with staff to address this issue. It seems to be a hydro-geologic issue rather than a solid waste one, with the landfill having an indirect effect. The science surrounding this issue is inconclusive, leaving the approach to take somewhat ambiguous. Thankfully, DEP has taken a cooperative stance. Staff will continue to work closely with DEP and HDR to deal with this potentially significant problem. Once a clear plan of action is established, a full report will be made to the Board.

UF UNIVERSITY of FLORIDA

Center for Environmental & Human Toxicology

PO Box 110885
Gainesville, FL 32611-0885
352-392-2243, ext. 5500
352-392-4707 Fax

March 16, 2009

Ligia Mora-Applegate
Bureau of Waste Cleanup
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Re: Irrigation water risk-based criteria for acenaphthene, acenaphthylene, anthracene, and benzene

Dear Ms. Mora-Applegate:

At your request we calculated groundwater cleanup target levels for acenaphthene (CAS# 83-32-9), acenaphthylene (CAS# 208-96-8), anthracene (CAS# 120-12-7), and benzene (CAS# 71-43-2) that are protective of human health under an irrigation scenario (IGCTLs). In the irrigation scenario, receptors are exposed to contaminated groundwater outdoors while irrigating lawns, ornamental beds, and vegetable crops. From this scenario, separate criteria were developed based upon: 1) exposure for residents using contaminated water for lawn and ornamental bed irrigation, including exposure from recreational use of the lawn sprinklers by children; 2) exposure for landscape maintenance workers using contaminated water for the irrigation of lawns and ornamental beds at commercial facilities; and 3) exposure for residents who use contaminated water to grow fruit and vegetables for personal consumption.

IGCTLs for these chemicals are listed in Table 1 and the chemical-specific variables used for their derivation are listed in Table 2. A description of the methodology used for the calculation of these IGCTLs was provided in a letter dated January 14, 2009. For watering of lawns and ornamentals in a residential setting, the IGCTLs are: 11,000 µg/L for acenaphthene, 7,400 µg/L for acenaphthylene, 27,000 µg/L for anthracene, and 490 µg/L for benzene. In an industrial setting, where the exposed individual might be a landscape maintenance worker, the IGCTLs are somewhat higher: 800,000 µg/L for acenaphthylene and 1,300 µg/L for benzene. This scenario is not of concern for acenaphthene and anthracene (the calculated criterion for each of these chemicals exceeds 1,000,000 µg/L). Using the Briggs model, the homegrown produce IGCTLs are: 4,500 µg/L for acenaphthene, 1,700 µg/L for acenaphthylene, 11,000 µg/L for anthracene, and 28 µg/L for benzene.

Please let us know if you have any questions regarding these calculations.

Sincerely,

Stephen M. Roberts, Ph.D.

Leah D. Stuchal, Ph.D.

Table 1 – Irrigation water risk-based criteria for acenaphthene, acenaphthylene, anthracene, and benzene

Chemical	Residential IGCTL (µg/L)	Industrial IGCTL (µg/L)	Produce IGCTL (µg/L)
Acenaphthene	11,000	NC	4,500
Acenaphthylene	7,400	800,000	1,700
Anthracene	27,000	NC	11,000
Benzene	490	1,300	26

NC - not of concern for this scenario

Table 2 – Chemical-specific variables for acenaphthene, acenaphthylene, anthracene, and benzene

Chemical	log Kow	Koc (L/kg)	HLC (atm-m³/mol)	K_p (cm/h)	K_p Source*
Acenaphthene	3.9	2,580	1.55E-04	1.3E-01	DERMWIN
Acenaphthylene	4.1	3,100	1.13E-04	1.8E-01	DERMWIN
Anthracene	4.5	29,500	6.50E-05	2.4E-01	DERMWIN
Benzene	2.1	59	5.55E-03	1.5E-02	RAGS E

* - The preferred source for Kp values is RAGS E. When Kp values are not available from RAGS E, they are estimated using DERMWIN