Clayton, Sr., P.E., Inc.
CIVIL & ENVIRONMENTAL ENGINEERING

LETTER OF TRANSMITTAL

TO: NCDENR, Division of Waste Management	DATE: December 2, 2008
Zinith Barbee NCDENR DWM SWS 1646 Mail Service Center Raleigh, NC 27699	PROJECT NO: 03 / TASK NO: 002B
	Re: Final ACM
	TRANSMITTAL NO: 1 / PAGE 1 OF 1

WE ARE SENDING: ☐ Originals ☐ Prints ☐ Shop Drawings ☐ Samples
☐ Specifications ☐ Calculations ☒ Other: See Below

Quantity	Drawing No.	Rev.	Description	Status
1			(1) Hard Copy of Final ACM for the DELF.	F. H

Issue Status Code: A. Preliminary B. Fabrication Only C. For Information D. Bid
E. Construction F. For Review & Comments G. For Approval H. See Remarks

REMARKS:

Zinith,

Please find attached an original copy of the Final ACM for the DELF facility and a copy of your approval letter dated October 25, 2007 is also attached there-in.

Regards,

Ryan Sadler

P. O. Box 578, COATS, NC 27521 PHONE:910 897-7070 FAX: 910 897-6767

Signed _____
Ryan Sadler

E:\LOT 08 1202 Barbee ACM Submittal.doc

ASSESSMENT OF CORRECTIVE MEASURES
HARNETT COUNTY DUNN-ERWIN LANDFILL
HARNETT COUNTY, N.C.

Harnett COUNTY NORTH CAROLINA
strong roots • new growth

PREPARED FOR
HARNETT COUNTY
CTC No. 03002

Revised August 2007

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering

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FINAL DOCUMENT
AS APPROVED BY LETTER FROM NCDENR-SOLID WASTE SECTION DATED OCTOBER 25, 2007 FROM MR. ZINITH BARBEE.

NCDENR
North Carolina Department of Environment and Natural Resources

Dexter R. Matthews, Director | **Division of Waste Management** | Michael F. Easley, Governor
William G. Ross Jr., Secretary

October 25, 2007

Jerry Blanchard
General Services Manager
Harnett County General Services
P. O. Box 940
Lillington, North Carolina 27546-0940

Re: Assessment of Corrective Measures
Harnett County Dunn-Erwin Landfill
Construction and Demolition Landfill Permit 43-02
Doc ID RCO 3290

Dear Mr. Blanchard:

The Solid Waste Section (SWS) has reviewed and approved the *Assessment of Corrective Measures* report for the Dunn-Erwin Landfill, revised draft dated August 2007, which described a variety of corrective measures addressing groundwater contamination described the report. The report had been prepared and submitted by C .T. Clayton, Sr., P.E., Inc. The SWS Rules require the county to hold a public meeting to discuss the assessed corrective measures with affected and interested parties. Requirements of the public meeting are specified in SWS Rule 15A NCAC 13B .1635 (d).

After the public meeting, the county shall select a remedy(ies) for the reported contamination. The remedy(ies) shall meet requirements listed in SWS Rules 15A NCAC 13B .1635 and .1636. The remedy(ies) shall also meet the Division of Water Quality Rules listed in 15A NCAC 2L, entitled "Classifications and Water Quality Standards Applicable to the Groundwaters of North Carolina." After the SWS approves the selected remedy(ies), the selected remedy(ies) and contingency plan(s) shall be submitted in a Corrective Action Plan (CAP). The CAP shall be reviewed by the SWS and, when approved by the SWS, implemented in accordance with 15A NCAC 13B .1637.

If you have any questions, I can be reached at 919-508-8525.

Sincerely,

Zinith Barbee

Zinith Barbee
Hydrogeologist
Solid Waste Section

cc: Ed Mussler — Solid Waste Section
Mark Poindexter — Field Operations Supervisor
Dennis Shackelford — Eastern Regional Supervisor
Drew Hammonds — Waste Management Specialist
C. Tyrus Clayton, Jr. — C. T. Clayton, Sr., P.E., Inc.
Central File

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1.0 INTRODUCTION

On behalf of Harnett County, C.T. Clayton, Sr., P.E., Inc. (CTC) has prepared this Assessment of Corrective Measures Report (ACM) for the Dunn-Erwin Landfill and Transfer Station Facility. The ACM was prepared in accordance with NC Solid Waste Management Rules (NCSWMR) I5A NCAC 13 B .1635. This ACM was developed as a result of the confirmed exceedance of permitted Ground water Protection Standards (GPS) in samples collected from the monitoring wells at the Dunn-Erwin Landfill as detailed in the "Assessment of Ground water Contamination Plume" report dated August 25, 2003.

This report addresses the requirements set forth in Section .1635 (a, b, & c). Upon completion of the NC Solid Waste Section's review of this assessment, a public meeting with interested and affected parties will be scheduled in accordance with .1635(d). Following the public meeting, a remedy that meets the standards set forth in .1636(b) will be selected and submitted to the Solid Waste Section (SWS) as a Corrective Action Plan (CAP) for evaluation and approval. Upon approval of the CAP, Harnett County will implement the approved corrective measure(s) in accordance with .1637.

1.1 Background Information

The existing Dunn-Erwin landfill has been in the same location since opening in 1978. It is located just north of NCSR 1725 in an area surrounded by farmland, forest, wetlands, and scattered houses and farms. The closest town to its boundary is the Town of Erwin, approximately two miles south of the landfill.

The facility currently accepts construction and demolition (C&D) materials under Permit 43-02 and is a transfer station for municipal solid waste generated in the county. The former MSW portion of the Dunn-Erwin Landfill was closed December, 1998, and capped to comply with regulations outlined under the guidance document 15A, NCAC 13B, Section .1627(c)(10). A mechanical gas venting system was installed in the area of the final cap overlying the emplaced solid waste. The closed portion of the landfill consists of approximately 21 acres. C&D waste is currently being placed on the capped area, as per SWS approval. (see Figure 1)

1.2 Previous Investigations

Ground water sampling at the Dunn-Erwin MSWLF has been preformed by Environment 1, Inc since October 1994. Semi-annual sampling at the Dunn-Erwin MSWLF was initiated in April 1997 and has continued through the present. Each semi-annual event is followed by a Statistical Analysis/Evaluation report interpreting and summarizing the results.

Prior to this ACM, an extensive study was completed in order to better understand the ground water contamination plume at the site, as described in the report dated August 25, 2003, including the field investigation performed in October 2002 in conjunction with the scheduled October 2002 semi-annual sampling event. Also, 12 new observation wells were installed in the general area of the ground water contamination plume during this field investigation. The field investigation was followed by additional laboratory testing, and an extensive analysis and computer modeling.

See Figures 2 and 3 for exhibits of the extent of the contamination plume.

1.2 Site Characteristics

A detailed description of the site topography, geological, and geotechnical properties and characteristics can be found in the August 25, 2003 report noted above. The site's hydrogeology including permeability, ground water levels and gradients, flow rates, and vertical flow analysis is also discussed at length in the August 25, 2003 report.

2.0 CONTAMINANT CHARACTERIZATION

The Dunn-Erwin Landfill (MSWLF) conducts semiannual ground water sampling and analyses in accordance with North Carolina Solid Waste Management Rules 15A N.C.A.C. 13 B, .1633 and .1634. Sampling events are coordinated and performed in the months of April and October of each year. Statistical analysis is then performed to evaluate whether the ground water and surface water monitoring results of the ground water and surface water monitoring results from the sampling events demonstrate compliance with North Carolina Groundwater Standards (NCGS) with respect to Appendix I and Appendix II constituents of the North Carolina Solid Waste Management Rules 15A N.C.A.C. 13 B, .1633(a) and .1634(a).

2.1 October 2006 Statistical Analysis Results

Statistical Analysis for the 2006 ground water sampling event was performed and documented in the *Statistical Analysis/Evaluation: October 2006* report dated February 14, 2007. The following information was taken from the Executive Summary of this report:

> *Data from the October 2006 semi-annual sampling were evaluated in sets. Set 1 consists of wells monitoring the recently closed (December 1998) solid waste landfill portion of the site where active construction and demolition debris (C&D) placement is ongoing, including monitoring wells (MWs) MW1, MW2, MW3R, MW4, MW5, MW6, MW7B, MW8, and MW31. Monitoring well MW3, which was previously damaged during site operations prior to April 2005 sampling event has been replaced by MW3R as of June 2005. Monitoring wells MW9 and MW10 were installed in March 2001 and have been added to Data Set 1 as of April 2001. These wells have been incorporated into the statistical analysis as their background sampling was completed in October 2002.*
>
> *….*
>
> *The statistical analysis results indicate that compliance wells MW6, MW7B, MW8, MW9, and MW10 in Set 1 have statistically significant levels of one or more organics over background levels when compared with the background wells. In addition, the following organics levels were above NCGS during this sampling event, showing generally lesser concentrations above NCGS when compared to the April 2006 results: methylene chloride, tetrachloroethylene, and trichloroethylene in MW6; methylene chloride, 1,1-dichloroethane, and trichloroethylene in MW7B; methylene chloride and tetrachloroethylene in MW8; and benzene, 1,1-dichloroethane, methylene chloride and trichloroethylene in MW9.*
>
> *As part of this event's statistical analysis, the prediction interval intra-well comparison was incorporated to verify certain Test of Proportions (TOP) results. In select cases the compliance-to-background well analyses are not accurate because natural, statistically significant variations existed prior to the facility operation commencement. If the TOP indicates a result of Statistically Significant Increase Over Background Level (SSIOBL) for such a constituent, the prediction interval intra-well comparison is used to verify the result. If the average post-operational concentrations of the constituent are within the prediction interval analysis calculated based on background concentrations, the result is not considered SSIOBL.*
>
> *Using this methodology, beryllium is not SSIOBL for MW2, MW3, and MW4*

and cobalt and lead are not SSIOBL for MW7B, which would have resulted as SSIOBL using just the TOP. Cobalt and mercury in MW6 and mercury in MW7B also show statistically significant levels through the TOP. However, cobalt was not detected during MW6's background sampling, and mercury was not included in either well's background sampling. Consequently, these constituents do not qualify for an intra-well comparison. Of the inorganics, only mercury in MW7B exceeded NCGS during this sampling event, representing an increase in the number of inorganics exceeding NCGS compared to the April 2006 results.

In Set 2, no organics or inorganics are statistically significant. No organics were detected in October 2006, consistent with the results from April 2006. No inorganics were detected, representing a decrease compared to April 2006.

Set 3 showed no SSIOBL for any of the tested constituents. No organics or inorganics were detected in October 2006, consistent with the April 2006 sampling event.

2.2 Contaminants of Concern (COC)

Based on the October 2006 statistical analysis report and the August 2003 detailed plume investigation report, the following conclusions regarding ground water contamination at the Dunn-Erwin MSWLF are presented:

- Based on updated ground water analytical data accumulated since October 1994 from the scheduled semi-annual sampling events, the top three organic contaminants most frequently detected in downgradient monitoring wells at concentrations that consistently have exceeded NCGS include methylene chloride, tetrachloroethylene, and trichloroethylene. Since October 2003, benzene has been detected in the downgradient plume only in MW9 during the last two events.

- Of these three organics only methylene chloride and trichloroethylene have been consistently considered as statistically significant in the semi-annual assessments. However, only methylene chloride has been consistently detected in average concentrations that are about one order of magnitude greater than NCGS. Therefore, methylene chloride has remained the key organic constituent in the ground water contamination plume, downgradient of the MSWLF.

2.3 Exposure Pathways

2.3.1 Methlylene Chloride

Introduction

Methylene chloride, also known as dichloromethane, is a colorless liquid that has a mild sweet odor, evaporates very quickly, and will not easily burn. It is widely used as an industrial solvent and as a paint stripper. It can also be found in certain aerosol and pesticide products and is used in the manufacture of photographic film. Methylene chloride does not appear to occur naturally in the environment. It is made from methane gas or wood alcohol. Most of the methylene chloride released to the environment results from its use as an end product by various industries and the use of aerosol products and paint removers in the home.

Fate & Transport

Methylene chloride is mainly released to the environment in air and to a lesser extent in water and soil, due to industrial and consumer uses. Because methylene chloride evaporates readily, most of it is released into the air. In air, it is broken down by sunlight and by reaction with other chemicals present in the air. About half of the methylene chloride disappears from air in 53-127 days. Although methylene chloride does not dissolve easily in water, small amounts may be found in some drinking water. Methylene chloride that is present in water is broken down slowly by reactions with other chemicals or by bacteria. Over 90 percent of the methylene chloride in the environment changes to carbon dioxide, which is non-toxic. It takes about 1 to 6 days for half the methylene chloride to break down in water. When methylene chloride is spilled on land, it attaches loosely to nearby surface soil particles. It moves from the soil into the air. Some may also move into ground water. We do not know how long it remains in soil. It is not expected that methylene chloride builds up in plants or animals.

Exposure Pathways

Exposure to methylene chloride may occur in air, water, food, or from consumer products. Because methylene chloride evaporates easily, the greatest potential for exposure is breathing in vapors of contaminated air.

2.3.2 Trichloroethylene

Introduction

Trichloroethylene (TCE) is also known as Triclene, Vitran and by other trade names in industry. It is a nonflammable, colorless liquid at room temperature with a somewhat sweet odor and a sweet, burning taste. This manmade chemical does not occur naturally in the environment. Trichloroethylene is now mainly used as a solvent to remove grease from metal parts. It is also used as a solvent in other ways and is used to make other chemicals. Trichloroethylene can also be found in some household products, including typewriter correction fluid, paint removers, adhesives, and spot removers.

Wastewater or municipal water supply treatment systems that rely on coagulation, sedimentation, precipitative softening, filtration, and chlorination are ineffective for reducing concentrations of TCE to nonhazardous levels. Other methods are required for remediation of water contaminated with TCE if the water is to be used for human consumption. TCE usually is remediated through pump and treat, using either air stripping or granular activated carbon, but there are many innovative cleanup methods—physical, chemical, thermal, and biological—that have been applied successfully to remove TCE from soil and ground water or to convert it into nonhazardous compounds.

Fate & Transport

By far, the biggest source of trichloroethene in the environment is evaporation from factories that use it to remove grease from metals. It can also enter the air and water when it is disposed of at chemical waste sites. It evaporates easily but can stay in the soil and in ground water. Once it is in the air, about half will be broken down within a week. When trichloroethene is broken down in the air, phosgene, a lung irritant, can be formed. Under certain conditions found in the workplace, trichloroethene can break down into chemicals such as dichloroacetylene and phosgene. In the body, trichloroethene may break down into dichloroacetic acid (DCA), trichloroacetic acid (TCA), chloral hydrate, and 2-chloroacetaldehyde. These chemical products have been shown to be toxic to animals and are probably toxic to humans. Once trichloroethene is in water, much will evaporate into the air; again, about half will break down within a week. It will take days to weeks to break down in surface water; in ground water the breakdown is much slower because of the much slower evaporation rate. Very

little trichloroethene breaks down in the soil, and it can pass through the soil into underground water. It is found in some foods; the trichloroethene found in foods is believed to come from contamination of the water used in food processing, or from the food processing equipment cleaned with trichloroethene. It does not build up in fish, but it has been found at low levels in them. It is not likely to build up in your body.

Exposure Pathways

Trichloroethene enters the body when breathing air or drinking water containing it. It can also enter the body if you get it on the skin. When breathing the chemical, about half the amount will get into the bloodstream and organs; the rest will be exhaled. If trichloroethene is swallowed, most of it will be absorbed into the blood. If trichloroethene comes in contact with the skin, some of it can enter the body, although not as easily as when it is breathed or swallowed.

2.3.3 Tetrachloroethlyene

Introduction

Tetrachloroethylene (PCE) is a man-made substance widely used for dry cleaning fabrics and textiles and for metal-degreasing operations. It is also used as a starting material (building block) for the production of other man-made chemicals. Other names that may be used for tetrachloroethylene include perchloroethylene, perc, PCE, perclene, and perchlor. Although tetrachloroethylene is a liquid at room temperature, some of the liquid can be expected to evaporate into the air producing an ether-like odor; evaporation increases as temperature increases.

Exposure Pathways

Because tetrachloroethylene evaporates quickly, the most common exposure to tetrachloroethylene comes from breathing air containing it. This is certainly true for individuals who work with the chemical, but it is probably also true for those who live in industrial and commercial areas where large amounts of the compound are used or disposed of. Tetrachloroethylene may also enter the body through drinking contaminated water or eating contaminated food. Because tetrachloroethylene does not pass through the skin to any significant

extent, entry into the body by this path is of minimal concern, although skin irritation may result from repeated or prolonged contact with the undiluted liquid.

2.4 Aquifer Use

In North Carolina, the "beneficial" or end use of the ground water is a source of drinking water according to the regulations under 15A NCAC Subchapter 2L, Section .0103. The ground water on-site is not currently used as a source of drinking water.

There are no public water supply wells within the two mile perimeter of the landfill. All public water is supplied by a county wide water system maintained by Harnett County. The main water line originates in the Town of Lillington, NC. There are no surface water intakes within a two mile perimeter of the landfill.

According to the Harnett County Health Department, there may be individual water wells within a two mile radius but well permits are not required and therefore the locations of such wells are unknown.

Monitoring well data and observed base flow conditions suggest that Stewart Creek to the south and an un-named tributary of Stewart Creek to the west are groundwater discharge zones. The aquifer is not used for drinking or recreational purposes between the waste boundary and the discharge zones. Harnett County controls the property between the waste boundary and the downgradient discharge zones.

No ground water withdrawal is occurring or will be allowed to occur within the vicinity of the dissolved contaminant plume, which still resides within the facility boundary. This area is unlikely to be developed in any way in the foreseeable future.

The future plan for the area downgradient of the contaminant plume is a new C&D disposal site.

2.5 Risk Assessment

After reviewing the exposure pathways of the three contaminants of concern, methylene chloride, trichloroethylene, and tetrachloroethylene, the risk to human receptors appears to be low. The low rate of transport and migration of impacted ground water does not pose an immediate threat of migration outside the facility boundaries. All water consumption near the Site is from a municipal (treated) water supply.

The main pathways for human contact with the contaminants of concern are inhalation and dermal contact. The facility employees and/or visitors (truck drivers and County residents) do not come into contact with the impacted ground water at the facility. Human contact by means of inhalation or skin contact is a cause of concern for personnel sampling ground water at the site. However, all sampling personnel are trained in procedures and the use of personal protective equipment to avoid contact with any potentially impacted water. The potential for inhalation or dermal contact during ground water sampling events is considered to be minimal. Under normal operation conditions at the facility, the possibility of human contact with ground water is very low.

The potential risk to the environment is to downgradient flora or fauna, and microorganisms in the impacted aquifer. Flora and fauna on or above the ground surface are at minimal risk, because there have been no confirmed detections of the contaminants of concern in the downstream surface water samples. Organisms suspected to be living in the subsurface at the site are at potential risk. However, soil microorganisms are known to use the organic acids and byproducts of the degradation process of the ground water plumes as a food source. Therefore, the potential risk to the environment from the impacted ground water is considered to be low.

3.0 AVAILABLE CORRECTIVE MEASURES – INITIAL SCREENING

3.1 Overview and Strategy

Rule .1635 states that any strategies identified during the assessment of corrective measures as being potentially effective remedies for the ground water contamination at the Dunn-Erwin MSWLF must meet the requirements and objectives described under Rule .1636. The remedies shall:

- Be protective to human health and the environment.
- Attain the approved ground water protection standards.
- Control the source(s) of release so as to eliminate, to the maximum extent practicable, further releases of Appendix II constituents into the environment.
- Comply with standards for management of wastes as specified in Rule .1637.

The assessment of corrective measures under Rule .1635 must address the following:

- Performance, reliability, ease of implementation, and potential impacts.
- Time required to begin and complete the remedy.
- Costs of the implementation.
- State and local permit requirements.
- Other environmental or public health requirements that may substantially affect implementation.

3.2 Existing Controls

The following protective measures are already in place at the facility:

- Institutional controls are in place that restricts access to the facility and to the contaminated ground water. Site access is controlled by fencing, restricted traffic lanes, and on-site personnel to monitor and direct traffic during daytime operations and locked security gates after hours. All ground water monitoring wells have padlocked steel protective outer casings at the surface.

- County ownership of property downgradient to contaminant plume.

- A final cap covering the disposal area of the closed MSW cell that meets the closure/post closure requirements set forth in Rule .1627.

- Mechanical gas extraction system including flare station with ongoing gas quality monitoring program.

- Semi-annual ground water and surface water quality monitoring that meets the requirements set forth in Rule .1633 and Rule .1634.

3.3 Practicable Technologies

In the following sections, corrective measures technologies that appear relevant as a potential corrective measure will be identified and subjected to preliminary screening for feasibility. Those corrective measures technologies, which obviously are not appropriate for this application (such as excavation and disposal, incineration, etc.) were not considered relevant, and therefore, were not subject to preliminary screening.

The remedial technologies evaluated can be classified into two categories based on their relative treatment schemes: in-situ treatment (i.e. in place), and ex-situ treatment (i.e., treatment out of place). All methods or combinations of methods will require continued ground water sampling to monitor progress of remediation.

3.4 Ground Water Extraction Technologies

The following three methods are practicable technologies that could be used at the Dunn-Erwin Landfill contaminant plume site to extract the impacted ground water.

3.4.1 Vertical Extraction Wells

This technology refers to the removal of impacted ground water using a series

of one or more vertically drilled extraction wells. Although the extraction of contaminated ground water can remove contaminant mass to some degree, ground water recovery/extraction is generally regarded as a containment method, not a physical treatment method. The extracted ground water would require some form of treatment prior to discharge.

Upfront capital costs can be high depending on the depth and number of wells required. Some operational and maintenance costs are required throughout the life of an extraction well (e.g., potential well rehabilitation and pump repair/replacement). This technology is retained for further consideration.

3.4.2 Horizontal Extraction Wells

Specialized drilling techniques are frequently used to position wells horizontally, or at an angle, to reach contaminants not readily accessible by direct vertical drilling. Horizontal extraction wells are typically more effective than vertical wells for hydraulic containment of ground water and plume mass removal.

The cost per linear foot for a horizontal extraction well is greater than a vertical well, and there is the potential for well collapse under significant overburden pressures. On the other hand, a single horizontal well can be installed to directly target a greater portion of a contaminant plume where multiple vertical wells would be required to achieve the same aerial extent. This recovery option has a high upfront capital cost to implement. This technology is retained for further consideration.

3.4.3 Interceptor Trenches

This technology refers to the construction of a shallow subsurface trench or drain to facilitate the collection of ground water and dissolved contaminants that enter the drain. These drains can be constructed by excavating a trench to the desired depth below the ground water table, placing a perforated drainage pipe in the base of the trench, and backfilling the trench with a high-permeability aggregate. Typical installation of interceptor trenches can be used to collect clean ground water from upgradient of a site to reduce the volume of ground water flow through the contaminated zone and/or to remove contaminated ground water at the downgradient edge of the plume for

subsequent treatment.

There are high upfront costs for installation of trenches and recovery systems ($20 - $30/ft^2) and moderately high ongoing operation and maintenance (O&M) costs for the proper treatment/disposal of recovered ground water. This technology is retained for further consideration.

3.5 Ground Water Physical Treatment Technologies

Extracted ground water may be treated through various physical methods to reduce the toxicity, mobility, and/or volume of contaminants (mass reduction). Physical treatment technologies are proven technologies that have been utilized at landfills to remove contaminants from ground water. These technologies include carbon absorption, passive/reactive treatment walls, in-situ absorption, air sparging, air sparging, and intra-well vapor stripping.

3.5.1 Carbon Absorption

Carbon absorption technology is utilized to remove organic compounds from water (and air). Carbon absorption is a full-scale technology in which ground water is pumped through a series of vessels containing activated carbon to which dissolved contaminants absorb. When the concentration of contaminants in the effluent from the bed exceeds a certain level, the carbon can be regenerated in place; removed and regenerated at an off-site facility; or removed and properly disposed of. Absorption by activated carbon has a long history of use in treating municipal, industrial, and hazardous waste streams. The fixed bed configuration is the most widely used for absorption from liquids. Suspended solids in a liquid stream may accumulate in the column, causing an increase in pressure drop. When the pressure drop becomes too high, the accumulated solids must be removed, for example, by backwashing. The solids removal process necessitates system downtime and may result in carbon loss and disruption of the mass transfer zone. Pretreatment for removal of solids from influent streams to be treated is, therefore, an important design consideration.

Liquid phase carbon absorption is effective for removing contaminants (halogenated compounds) at low concentrations (less than 10mg/l) from water at nearly any flow rate. Carbon absorption is most commonly utilized for polishing ground water discharges from other remedial technologies to

attain regulatory compliance. Carbon absorption systems can be deployed rapidly and contaminant removal efficiencies are high (90% or greater). Logistic and economic disadvantages arise from the need to transport and decontaminate spent carbon. The concepts, theory, and engineering aspects of the technology are well developed. It is a proven technology with documented performance data. Carbon absorption is a relatively nonspecific absorbent and is effective for removing many organic, and some inorganic contaminants from liquid and gaseous streams. This technology is not retained for further consideration.

3.5.2 Passive/Reactive Treatment Walls

A permeable reaction wall is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. These barriers allow the passage of waster while prohibiting the movement of contaminants by employing such agents as zero-valent metals, chelators, (ligands selected for their affinity for a given metal), sorbents, microbes, and other agents. The cntaminants will either be degraded or retained in a concentrated form by the barrier material. The wall could provide permanent containment for relatively low-level contaminants or provide a decreased volume of the more toxic contaminants for subsequent treatment using another method. Modifications to the basic passive treatment walls may involve a funnel-and-gate system or an iron treatment wall. The funnel-and-gate system for in-situ treatment of contaminated plumes consists of low hydraulic conductivity (e.g. , 1x10-6 cm/sec) cutoff walls (the funnel) with a gate that contains in-situ reaction zones. Ground water primarily flows through the high conductivity gaps (the gates). The type of cutoff walls most likely to be used in the current practice are slurry walls or sheet piles. An iron treatment wall consists of iron granules or other iron bearing minerals for the treatment of chlorinated contaminants such as TCE, DCE, and VC. As the iron is oxidized, a chlorine atom is removed from the compound by one or more reductive dechlorination mechanisms, using electrons supplied by the oxidation of iron. The iron granules are dissolved in the process, but the metal disappears so slowly that the remediation barriers can be expected to remain effective for many years, possibly even decades. Passive treatment walls are generally intended for long-term operation to control migration of contaminants in ground water.

Iron filing reactors have been shown to be effective in degrading chlorinated compounds over a wide concentration range. Treatment wells are relatively expensive and are generally only cost effective where impacted ground water can be directed through a relatively small zone of treatment. This method counts on the presence of a low permeability aquitard at the base of the

plume within the limits of conventional trenching equipment. This technology is not retained for further consideration.

3.5.3 Ex-Situ Air Stripping/Sparging

Air stripping involves the mass transfer of VOCs from water to air. VOCs are partitioned from ground water by increasing the surface area of the contaminated water exposed to air. Aeration methods include packed towers, diffused tray, and spray aeration. The typical packed tower air stripper includes a spray nozzle at the top of the tower to distribute contaminated water over the packing in the column, a fan to force air countercurrent to the water flow, and a sump at the bottom of the tower to collect decontaminated water. Auxiliary equipment that can be added to the basic air stripper includes a feed water heater (normally not incorporated within an operational facility because of the high cost) and an air heater to improve removal efficiencies, automated control systems with sump level switches and safety features such as differential pressure monitors, high sump level switches and explosion proof components, and discharge air treatment systems such as activated carbon units, catalytic oxidizers or thermal oxidizers. Packed tower air strippers are installed either as permanent installations on concrete pads, or as temporary installations on skids and trailers.

Aeration tanks strip volatile compounds by bubbling air into a tank through which contaminated water flows. A forced air blower and a distribution manifold are designed to ensure air-water contact without the need for any packing materials. The baffles and multiple units ensure adequate residence time for stripping to occur. Aeration tanks are typically sold as continuously operated skid-mounted units, The advantages offered by aeration tank~ are considerably lower profiles (less than 6 feet high) than packed towers (15 to 40 feet high) where height may be a problem, and the ability to modify performance or adapt to changing feed composition by adding or removing trays or chambers. The discharged air from aeration tanks can be treated using the same technology as for packed tower air discharge treatment.

Air strippers can be operated continuously or in a batch mode where the air stripper is intermittently fed from a collection tank. The batch mode ensures consistent air stripper performance and greater energy efficiency than continuously operated units because mixing in the storage tanks eliminates any inconsistencies in feed water composition.

Air stripping is ineffective for inorganic contaminants. Some compounds that have been successfully separated from water using air stripping include BTEX, chloroethane, TCE, DCE, and PCE. The potential exists for inorganic *(e.g.,* iron greater than *5* mgll, hardness greater than 800 mg/l) or biological fouling of the equipment, requiring pretreatment or periodic column cleaning. Iron concentrations in excess of 5 mg/l are possible based on the geology of the former Landfill. Off-gases may require treatment depending upon mass emission rate.

Removal efficiencies around 99% are typical for removing compounds amenable to stripping. Removal efficiencies can be improved by adding a second air stripper in series with the first, heating the contaminated water, increasing the air/liquid ratio, or heating the air. Thermal units for treating air stripper emissions can be used as a source of heat. The performance of aeration tanks can be improved by adding chambers or trays, or by increasing the air supply, depending on the design of the tank. The major problem encountered with packed tower air strippers is fouling of the packing, which reduces the air-flow rate. Fouling is caused by oxidation of minerals in the feed water, such as iron and magnesium, by precipitation of calcium, and by biological growth on the packing material, which necessitates more frequent cleaning. Ground water at the former Landfill possess iron concentrations that may require frequent system cleaning. This option typically has moderate capital costs and moderate O&M costs. This technology is retained for further consideration.

3.5.4 In-Situ Air Sparging

Air sparging is an in-situ technology in which air is bubbled through a contaminated aquifer. 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 a vapor extraction system. Vapor extraction is commonly implemented in conjunction with air sparging to remove the generated vapor-phase contamination.

This technology is designed to operate at high flow rates to maintain increased contact between ground water and soil and strip more ground water by sparging. The target contaminant groups for air sparging are VOCs and fuels. Increased contaminant removal is accomplished due to both physical and biological mechanisms. This technology has been successfully

employed at similar sites, however, due to the limited permeability of the saturated and unsaturated zones, and the complexity of the fractured bedrock environment, air sparging may result in limited area of influence and the removal of the stripped contaminants from deep within the bedrock aquifer tends to complicate matters. Air sparging works best when there is a relatively large saturated thickness and the depth to ground water is greater than five feet. Air flow through the saturated zone may not be uniform, which implies that there can be uncontrolled movement of potentially dangerous vapors. Soil heterogeneity may cause some zones to be relatively unaffected. However, this technology is retained for further consideration.

3.5.5 Intra-Well Vapor Stripping (Circulating Wells)

Air is injected into a double screened (circulating) well, lifting the water in the well and forcing it out the upper screen. Simultaneously, additional water is drawn in the lower screen. Once in the well, some of the VOCs in the contaminated ground water are transferred from the dissolved phase to the vapor phase by air bubbles. The contaminated air rises in the well to the water surface where vapors are drawn off and treated by a soil vapor extraction system. This SVE system, in addition to collecting the vapors from within the well, collects vapors from the surrounding vadose zone once the water table is depressed by pumping. The partially-treated ground water is never brought to the surface; it is forced into the ui}saturated zone, and the . process is repeated as water follows a hydraulic circulation pattern or cell that allows continuous cycling of ground water. As ground water circulates through the treatment system in situ, contaminant concentrations are gradually reduced.

Modifications to the basic intra-well stripping process may involve additives injected into the stripping well to enhance biodegradation *(e.g.,* nutrients, electron acceptors, etc.). In addition, the area around the well affected by the circulation cell (radius of influence) can be modified through the addition of certain chemicals to allow in-situ stabilization of metals originally dissolved in ground water. This method is most effective at treating sites with volatile contaminants with relatively high aqueous solubility and strong biodegradation potential *(e.g.,* halogenated and non-halogenated VOC5) such are present at the former Landfill. Circulating wells operate more efficiently within aquifers with horizontal conductivities greater that io^3 cm/sec and a ratio of horizontal to vertical conductivities between 3 and 10. Lower permeability soils and discrete fractures within the bedrock portion of the aquifer may require a very tight spacing of stripper wells. This option tends to have a high capital cost and moderate to high O&M costs. This technology is not retained for further consideration.

3.6 Ground Water Chemical Treatment Technologies

After extraction, ground water can be treated with a variety of chemicals to reduce the toxicity, mobility, and/or mass of contaminants. The following chemical treatment technologies have been successfully implemented for the treatment of contaminants such as those at the former Landfill.

3.6.1 Ex-Situ Chemical Oxidation/Reduction (UV Light)

Chemical reduction/oxidation processes are used to transform contaminants through oxidation and reduction processes into innocuous by-products. Ultra violet (UV) oxidation is a destruction process that oxidizes organic constituents in water by the addition of strong oxidizers and irradiation with UV light. Oxidation of target contaminants is caused by direct reaction with the oxidizers, UV photolysis, and through the synergistic action of UV light, in combination with ozone (0_3) and/or hydrogen peroxide (H_2O_2). If complete mineralization is achieved, the final products of oxidation are carbon dioxide, water, and salt.

The main advantage of UV oxidation is that it is a destruction process, as opposed to air stripping or carbon adsorption, for which contaminants are extracted and concentrated in a separate phase (vapor or gas). UV oxidation processes can be configured in batch or continuous flow modes, depending on the throughput under consideration. In many cases, chlorinated hydrocarbons that are resistant to biodegradation may be effectively treated by UV/oxidation. Typically, easily oxidized organic compounds, such as those with double bonds *(e.g.,* TCE, PCE, and vinyl chloride), as well as simple aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in UV/oxidation processes. When UV/0_3 is used on volatile organics such as TCA, the contaminants may be volatilized *(i.e.,* “stripped”) rather than destroyed. They would then have to be removed from the off-gas by activated carbon adsorption or catalytic oxidation.

Costs may be higher than competing technologies because of energy requirements. A bench-scale or pilot test is required to evaluate necessary design requirements and system sizing. Pretreatment of the aqueous stream may be required to minimize ongoing cleaning and maintenance of UV reactor and quartz sleeves. When using hydrogen peroxide as a catalysis the

process is only efficient at rather low wavelengths. High levels of turbidity in the treatment stream can inhibit contaminant destruction efficiency. Finally, the handling and storage of oxidizers require special safety precautions. This technology is not retained for further consideration.

3.6.2 In-Situ Chemical Oxidation (Oxidant Injection)

Chemical oxidation can be used to transform contaminants in-situ through injection of chemical reagents. This process involves the injection of oxidants (typically hydrogen peroxide, but can also include sodium permanganate, ozone, dithionite, gaseous hydrogen sulfide, colloidal iron [Fenton's Reagent], and various surfactants and co-solvents) into the ground water via injection wells installed across the zone of contamination. The oxidants chemically destroy chlorinated VOCs into innocuous by-products (mono- and di-carboxylic acids), carbon dioxide, and water.

Chemical injection wells can be used in the vicinity of the contamination and/or as a barrier to react with contaminants as they flow downgradient.

This remedial alternative can completely destroy primary contaminants, thereby lowering the long-term liability exposure and the application is completely in-situ without external hardware or equipment. However, the ground water must have a moderate calcium carbonate, hardness, and organic matter content (<400 mg/l), and a low pH between 3 and *5* standard units (su). Additionally, this process releases large quantities of oxygen (when hydrogen peroxide is used) that may severely disrupt natural on-going reductive dechlorination (natural bioatteuation) processes. In addition, the resulting release of large quantities of oxygen in close proximity of a landfill with an actiye gas extraction system may serve to raise oxygen levels within the landfill increasing the potential for a subsurface fire within the waste mass. The improper application of this method can be dangerous and even reduce the overall effectiveness of other remedial options that may be used in conjunction with this method. Particulates can be generated during the treatment process (precipitates) that causes a loss in permeability in the aquifer. The production of fugitive emissions is possible with peroxide and ozone use and potentially toxic byproducts can be produced.

For hydrogen peroxide enhanced treatment, costs are an order of magnitude more expensive than other methods of oxygen enhancement. O&M cost of hydrogen peroxide enhancement can be significant because a continuous source of hydrogen peroxide must be delivered to the contaminated ground

water. Concentrations of hydrogen peroxide greater than 100 to 200 mg/l in ground water are inhibiting to microorganisms. Microbial enzymes and high iron content of subsurface materials can rapidly reduce concentrations of hydrogen peroxide and reduce zones of influence. Therefore, this technology is not retained for further consideration.

3.6.3 Enhanced Bioremediation (HRC®)

Hydrogen Release Compound (HRC®) enhanced biodegradation process uses an environmentally compatible material (food quality and polylacetate ester) that produces a slow release of lactic acid upon hydration. Indigenous anaerobic microbes metabolize the lactic acid and produce hydrogen. Subsequently, this hydrogen is used by other indigenous microbes, which are reductive dehalogenators. No residual waste stream is generated. HRC® is an innovative technology, which has only recently been developed and implemented. HRC® is used to stimulate rapid degradation of chlorinated solvent contaminants often found in ground water and soil. It has been applied to treat compounds such as chlorinated VOCs (including PCE, TCE, *cis* 1,2-DCE, and vinyl chloride). HRC® has been shown to achieve rapid in-situ degradation of target contamination without the costs and disruption associated with complex engineered remediation systems. HRC® serves to assist and enhance the rate and abilities of the aquifers natural attenuation abilities. The process by which HRC® operates is a rather complex series of chemical and biologically mediated reactions. Initially, when in contact with subsurface moisture, the HRC® slowly releases lactic acid. Indigenous anaerobic microbes (such as acetogens) metabolize the lactic acid producing consistent low concentrations of dissolved hydrogen. The resulting hydrogen is then used by other subsurface microbes (reductive dehalogenators) to strip the solvent molecules of their chlorine atoms and allow for further biological degradation. When in the subsurface, HRC® continues to operate in this fashion for a period of a up to several years, cost effectively degrading a wide range of chlorinated VOCs.

HRC® is a proprietary, environmentally safe, food quality, polylactate ester specially formulated for slow release of lactic acid upon hydration. The HRC® is applied to the subsurface via direct injection, within dedicated wells or within trenches installed into the ground water. The HRC® is then left in-place where it passively works to stimulate rapid contaminant degradation.

This technology does not require extraction of impacted ground water or separate discharge of treated ground water. In addition, remediation with

HRC® can he less costly than many other remedial technologies. This technology requires monitoring during implementation. Prior to full-scale implementation, it may be necessary to conduct pilot tests to determine site-specific effectiveness of this technology. This technology is retained for further consideration.

3.7 Biological Treatment Technologies

Biological treatment relies on microbes (native, specialized, or genetically engineered) to transform contaminants into innocuous byproducts. The rate of bioremediation of organic contaminants by microbes can be enhanced by increasing the concentration of electron acceptors and nutrients in ground water, surface water, and leachate. Oxygen is the main electron acceptor for aerobic bioremediation. Nitrate serves as an alternative electron acceptor under anoxic (anaerobic) conditions. Bioremediation may be further enhanced through the addition of various nutrients. This technology can be implemented in either above ground or in-situ applications. Monitored natural attenuation (MNA) is considered separate from biological treatment and is discussed in the next subsection. Another form of biological treatment (phytoremediation) relies on plants to uptake contaminants in water and either bind them to the plant tissue or vent the contaminants to the atmosphere as a byproduct of cellular respiration. This technology is retained for further consideration.

3.8 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) is a form of biological treatment, which relies on the monitoring of native microbes, which transform contaminants (without stimulation from added electron acceptors, nutrients, or oxygen enhancements) to innocuous compounds along the ground water flow path. Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed to reduce chemical concentrations to acceptable levels. Natural attenuation is a natural process of contaminant degradation that will reduce contaminant concentrations in water. During natural attenuation, contaminants are ultimately transformed via biodegradation to innocuous byproducts such as carbon dioxide and water. Co-metabolism (microorganisms growing on one compound produce an enzyme that chemically transforms another compound on which they cannot grow) may be particularly useful in this MSW landfill application. In particular, microorganisms that degrade methane (methanotrophic bacteria) have been found to produce enzymes that can facilitate the oxidation of a variety of hydrocarbon compounds including vinyl chloride. MNA is

not the same as “no action”. As the name implies, MNA requires systematic monitoring of the ground water during remedy implementation.

There are several methods of biodegradation, direct aerobic, direct anaerobic, aerobic cometabolic, and reductive dechlorination (dehalorespiration). Under direct aerobic biodegradation, chlorinated solvents are degraded under oxygen-rich conditions by microbes, which gain energy and carbon from the biodegradation process. This method is limited to the less chlorinated compounds such as *cis-1,2-DCE* and VC. Direct aerobic biodegradation, chlorinated compounds are degraded under the lack of oxygen. This is also effective for *cis-1,2*-DCE and VC. Co-metabolic biodegradation occurs when chlorinated compounds are degraded by co-metabolic bacteria, which use other contaminants (such as toluene, ammonia, phenol) as substrates. This has been shown effective on TCE, 1,1 and 1,2-DCE, and VC The most common method is reductive dechlorination (or dehalorespiration). This process occurs under anaerobic and highly reducing conditions and is responsible for the primary reduction of PCE to TCE to DCE to VC to ethene.

This technology does not require extraction of impacted ground water or separate discharge of treated ground water. In addition, ground water remediation via natural attenuation can be less costly than other remedial technologies. This technology requires specialized monitoring during implementation and during operation. Additional performance monitoring and sentinel wells are more than likely to be required to effectively implement this technology. However, the potential risks in using MNA may be unacceptable due to the length of time required to achieve cleanup goals. This technology is retained for further consideration.

3.9 Phytoremediation

Phytoremediation is the use of certain plants to clean up soil, sediment, and water contaminated with metals and/or organic contaminants such as crude oil, solvents, and polyaromatic hydrocarbons (PAHs). It is a name for the expansion of an old process that occurs naturally in ecosystems as both inorganic and organic constituents cycle through plants. Plant physiology, agronomy, microbiology, hydrogeology, and engineering are combined to select the proper plant conditions for a specific site. Phytoremediation is an aesthetically pleasing mechanism that can reduce remedial costs, restore habitat, and clean up contamination in place rather than entombing it in place or transporting the problem to another site.

Photoremediation can be used to clean up contamination in several ways:

- **Phytovolatiliaztion**: Plants take up water and organic contaminants through the roots, transport them to the leaves, and release the contaminants as a reduced of detoxified vapor into the atmosphere.

- **Microorganism stimulation**: Plants excrete and provide enzymes and organic substances from their roots that stimulate growth of microorganisms such as fungi and bacteria. The microorganisms in the root zone then metabolize the organic contaminants.

- **Phytostabilization**: Plants prevent contaminants from migrating by reducing runoff, surface erosion, and ground-water flow rates. "Hydraulic pumping" can occur when tree roots reach ground water, take up large amounts of water, control the hydraulic gradient, and prevent lateral migration of contaminants within a ground water zone.

- **Phytoaccumulation/extraction**: Plant roots can remove metals from contaminated sites and transport them to leaves and stems for harvesting and disposal.

- **Phytodegradation by plants**: Organic contaminants are absorbed inside the plant and metabolized to non-toxic molecules by natural chemical processes within the plant.

There are several advantages and disadvantages with this technology which are listed below:

Advantages	Disadvantages
Works on a variety of organic and inorganic componds	May take several years to remediate
Can be either *In Situ/ Ex Situ*	May depend on climatic conditions
Easy to implement and maintain	Restricted to sites with shallow contamination within rooting zone
Low-cost compared to other treatment methods	Harvested biomass from phytoextraction may be classified as a RCRA hazardous waste
Environmentaly Friendly and aesthetically pleasing to the public	Consumption of contaminated plant tissue is also a concern
Reduces the amount of wastes to be landfilled	Possible effect on the food chain

Although this site does not necessarily have a shallow contamination, it is thought that the overburden soils could be removed above the contaminated ground water to a depth which would allow the selected plants to root within the aquifer. Therefore this technology is retained for further consideration.

4.0 ASSESSMENT OF CORRECTIVE MEASURES

The purpose of this report is to identify technologies or combination of technologies that are realistic, potential remedies for contaminant release at the DELF facility. Selection of realistic remedies is driven by site conditions and characteristics of the COCs reported at the facility. Based on the findings presented in the 2003 *Assessment of Groundwater Contamination Plume* and the subsequent semiannual monitoring results of the contaminant release at the landfill consist of VOCs. In addition, data presented in the *October 2006 Statistical Analyses/Evaluation* indicated that within the contaminant plume, three contaminants have been frequently detected at concentrations that consistently have exceeded NCGS standards and are considered statistically significant. These COCs were found in a dissolved phase, within the upper most aquifer underlying the facility, and are limited in distribution to within the facility boundary.

There are numerous technologies available, as presented in Section 3 that can remediate groundwater contaminated with dissolved phase VOCs. However, the selection of a successful remedy is based on the geologic and hydrogeologic conditions of the uppermost aquifer at the facility, and the potential risks associated with the contaminant plume. Additionally, the type and size of the source (one that can be removed versus one that cannot be removed) and the urgency of the remedial effort, or aggressiveness, are considered when selecting a remedy. The need for an aggressive or non-aggressive remedy is usually controlled by the risk(s) associated with the release (i.e., a high risk may dictate an aggressive remedy while a low risk may dictate a less aggressive, more cost effective remedy). Additionally, the use of more than one remedy may be required to meet regulatory standards.

Due the above considerations, as well as the remedy selection criteria set forth in Rule .1636(b) and the remedy implementation criteria presented in Rule .1637(d), a screening matrix was used to objectively rate available and proven technologies capable of attaining approved groundwater protection standards.

4.1 Development of Corrective Measures Alternatives

A total of 16 remedial alternatives were evaluated against 17 performance criteria. The 17 performance criteria were grouped into three performance groups: Feasibility and Effectiveness, Implementability, and Cost. These performance groups were evaluated as follows:

4.1.1 Feasibility and Effectiveness

Achieve target contaminant levels; protective of human health and the environment; long-term effectiveness; address toxicity, mobility, or volume of contaminants; safety impacts; cross media impacts; and residuals produced.

4.1.2 Implementability

Ease to Implement; system reliability/maintainability; regulatory/permitting acceptability; and community acceptability.

4.1.3 Cost

Overall cost; capital or operation and maintenance intensive; time to implement; and time to complete cleanup.

The screening matrix is provided in Table 3. Based on results from the screening matrix and results of the 2003 *Assessment of Groundwater Contamination Plume,* the following five remedial alternatives were retained for further review:

1. Monitored Natural Attenuation (MNA)
2. Groundwater Extraction System
3. Air Sparging (Ex-Situ or above ground)
4. Enhanced Bioremediation
5. Phytoremediation

4.2 Detailed Evaluation of Selective Remedial Alternatives

4.2.1 Monitored Natural Attenuation

MNA was previously described in general scope and detail in Section 3.8. MNA is currently being used at numerous sites around the county, ranging from superfund to fuel spill sites. MNA is a cost effective semi non-invasive technique to remove contaminants. MNA generally involves a long timeline to completely remedy a site.

Ease of Implementation

The implementation of MNA is not likely to require any additional groundwater monitoring wells to be installed due the number currently installed in and down gradient of the contaminant plume. One year of quarterly monitoring is often sufficient to establish the relationship between readily degraded contaminants and electron acceptor/reduction product concentrations. (USEPA, May 1996)

Implementation Requirements

Implementation of MNA requires documentation that there are no imminent risks to human health or the environment posed by the site as it currently exists. Based on the information currently available, there are no identified off-site risks associated with the impacted groundwater at the DELF facility.

The implementation of MNA at the DELF facility would require a comprehensive initial round of sampling designed to collect the data necessary to estimate the degradation rates and the biological processes active at the site. If the evaluation of the initial round of data supports the conditions for natural attenuation, and the rate of degradation is determined to be sufficient to keep up with the release rate from the source, a MNA Monitoring Plan will be developed.

The MNA Monitoring Plan would identify the groundwater and surface water sampling locations, the sampling frequency, the analyte list, and any other data deemed necessary to document the biodegradation rates. Finally, the MNA Monitoring Plan would detail the procedures to be used in determining the biodegradation rates and would contain a series of trigger concentrations at which MNA would be deemed insufficient for meeting the remediation goals.

Remediation Impacts

There are no major remediation related impacts associated with MNA, since MNA results in the destruction of the contamination. Minor impacts would include the generation of contaminated purge water during groundwater sampling events.

Remediation Timeframe

The timeframe for achieving objectives should be reasonable compared to other alternatives. Because the contaminant plume is not migrating off site at

concentrations greater than NC 2L Drinking Water Standards, MNA will be used to constrain the plume to its current footprint. If the plume expands significantly beyond its current footprint as defined by a minimum of 3 years of analytical data, then a more aggressive remedy should be considered.

Remediation Costs

The costs associated with MNA would include preparing the MNA Monitoring Plan, installing additional monitoring wells as required, sampling and analysis, and data evaluation and reporting
(Due the extensive network of wells installed to complete the *Assessment of Groundwater Contamination Plume* within and downgradient of the plume, very few new monitoring wells are anticipated to be needed). Based on the existing site conditions, we estimate the implementation costs of MNA at the DELF Facility as follows:

Estimated MNA Implementation Costs		
Initial Start Up Costs	MNA Monitoring Plan, Monitoring, and Data Evaluation	$25,000
Design Costs	Design Costs Permitting Costs	$ 8,000 $ 5,000
Construction Costs	Additional Wells (as required)	$10,000
Contingencies		$ 8,000
Total Estimated Remedy Implementation Costs:		**$56,000**

The actual cost and design of the MNA program will be determined if MNA is selected as a remedial alternative. At that time a detailed work plan will be completed to aid in cost analysis. Depending on the final design of the MNA monitoring network and monitoring frequency, the annual monitoring and reporting costs associated with MNA are estimated at $10,000 to $22,000 per year until the landfill remediation goals are achieved.

Institutional Requirements

The SWS will likely require a modification to the operating permit for the DELF Facility.

4.2.2 Groundwater Extraction (Pump and Treat)

Groundwater Extraction (GE) was previously described in general scope and detail in Section 3.8. GE is currently being used at numerous sites around the county, ranging from superfund to fuel spill sites. Installation of a GE system would require a large upfront capital cost. Also, a GE system would have the potential for higher O&M costs due to the hauling and treatment of the removed water prior to discharge at a public waster water treatment facility. GE could potentially involve a long timeline to completely remedy a site. Due to the site constraints, a GE System would more than likely be an interceptor trench style system.

Ease of Implementation

The implementation of a GE system is likely to require extensive construction and fairly substantial equipment costs (pumps, generator, monitoring equipment). However, a GE system is not likely to require any additional groundwater monitoring wells to be installed due to the number currently installed in and down gradient of the contaminant plume. Six months of quantitative monitoring of the system should be adequate to calibrate and detect removal efficiencies.

Implementation Requirements

Implementation of a GE system requires documentation that there are no imminent risks to human health or the environment posed by the site as it currently exists. Based on the information currently available, there are no identified off-site risks associated with the impacted groundwater at the DELF facility.

However, storage facilities (holding tanks, lagoons, etc) for the pumped groundwater will need to be adequately protected to inhibit the general public from access.

The implementation of the GE system at the DELF facility would require a comprehensive initial round of sampling designed to collect the data necessary to estimate accurate flow and conductivity rates of the groundwater within the plume area in order to provide the necessary data for the design of the system. In addition, contact will need to be made with the local treatment facility that will be receiving the contaminated water to ascertain if additional pretreatment activities will be necessary for the treatment facilities to accept the contaminated water.

A GE System Monitoring Plan will need to be generated to ascertain the effect on groundwater flow and treatment efficiencies, as required, during the operation of the GE system. The GE System Monitoring Plan would identify the groundwater and surface water sampling locations, the sampling frequency, the analyte list, and any other data deemed necessary to document the operation of the system. Finally, the GE System Monitoring Plan would detail the procedures to be used in determining the degradation rates and would contain a series of trigger concentrations at which GE would be deemed insufficient for meeting the remediation goals.

Remediation Impacts

There are no major remediation related impacts associated with GE, since GE results in the physical removal of the contamination. Minor impacts would include the generation of contaminated purge water during groundwater sampling events and spill containment at the transport/pumping facility.

Remediation Timeframe

The timeframe for achieving objectives will more than likely take several years due to the low conductivity of the contaminated aquifer at the site. Because the contaminant plume is not migrating off site at concentrations greater than NC 2L Drinking Water Standards, GE will be used to constrain the plume to its current footprint. If the plume expands significantly beyond its current footprint as defined by a minimum of 1.5 years of analytical data, then a different remedy should be considered.

Remediation Costs

The costs associated with GE System would include preparing the GE System Monitoring Plan, installing GE removal System as required, sampling and analysis, and data evaluation and reporting (Due to the extensive network of wells installed to complete the *Assessment of Groundwater Contamination Plume* within and downgradient of the plume, very few, new monitoring wells are anticipated to be needed). Based on the existing site conditions, we estimate the implementation costs of GE System at the DELF Facility as follows:

Estimated GE Implementation Costs		
Initial Start Up Costs	GE System Monitoring Plan, Monitoring, and Data Evaluation	$ 25,000
Design Costs	Design Costs Permitting Costs	$ 45,000 $ 12,000
Construction Costs	GE System Additional Wells (as required)	$330,000 $ 10,000
Contingencies		$ 20,000
Total Estimated Remedy Implementation Costs:		**$ 442,000**

The actual cost and design of the GE program will be determined if GE is selected as a remedial alternative. At that time a detailed work plan will be completed to aid in cost analysis. Depending on the final design of the GE System, monitoring network and monitoring frequency, the annual monitoring and reporting costs associated with GE are estimated at $15,000 to $26,000 per year until the landfill remediation goals are achieved. O& M costs would be in the range of $140,000.

Institutional Requirements

The SWS will likely require a modification to the operating permit for the DELF Facility. In addition, GE technologies have the potential to produce concentrated liquids that could require an NCDENR-DWQ pump and haul permitting in order to transport the liquid to the local waste water treatment facility.

4.2.3 Air Stripping (Ex-Situ)

Air Stripping (AS) was previously described in general scope and detail in Section 3.5.3. AS is currently being used at numerous sites around the county, ranging from superfund to fuel spill sites to waste water treatment facilities. Installation of a AS system would require a large upfront capital cost due to this system requiring a GE system to remove the water prior to treatment. AS systems have a potential higher O&M costs for the hauling of the treated water prior to discharge at a public waste water treatment facility since re-injection of the water to the site is an almost impossible task to get approved and permitted. AS could potentially involve a long timeline to completely remedy a site.

Ease of Implementation

The implementation of a AS system is likely to require extensive construction and fairly substantial equipment costs (aerators, pumps, generator, monitoring equipment). However, a AS system is not likely to require any additional groundwater monitoring wells to be installed due the number currently installed in and down gradient of the contaminant plume. Six months of quantitative monitoring of the system should be adequate to calibrate and detect remediation efficiencies.

Implementation Requirements

Implementation of a AS system requires documentation that there are no imminent risks to human health or the environment posed by the site as it currently exists. Based on the information currently available, there are no identified off-site risks associated with the impacted groundwater at the DELF facility.

However, storage/aeration facilities (holding tanks, lagoons, etc) for the pumped groundwater will need to be adequately protected to inhibit the general public from access.

The implementation of the AS system at the DELF facility would require a comprehensive initial round of sampling designed to collect the data necessary to estimate accurate flow and conductivity rates of the groundwater within the plume area in order to provide the necessary data for the design of the system. In addition, contact will need to be made with the local treatment facility that will be receiving the pretreated water to ascertain what level of pretreatment activities will be necessary for the treatment facilities to accept the water.

A AS System Monitoring Plan will need to be generated to ascertain the effect on groundwater flow and treatment efficiencies, as required, during the operation of the AS system. The AS System Monitoring Plan would identify the groundwater and surface water sampling locations, the sampling frequency, the analyte list, and any other data deemed necessary to document the operation of the system. Finally, the AS System Monitoring Plan would detail the procedures to be used in determining the degradation rates and would contain a series of trigger concentrations at which AS would be deemed insufficient for meeting the remediation goals.

Remediation Impacts

There are no major remediation related impacts associated with AS, since AS results in the physical removal of the contamination. Minor impacts would include the generation of contaminated purge water during groundwater sampling events and spill containment at the transport/pumping facility.

Remediation Timeframe

The timeframe for achieving objectives will more than likely take several years due to the low conductivity of the contaminated aquifer at the site. Because the contaminant plume is not migrating off site at concentrations greater than NC 2L Drinking Water Standards, AS will be used to constrain the plume to its current footprint. If the plume expands significantly beyond its current footprint as defined by a minimum of 1.5 years of analytical data, then a different remedy should be considered.

Remediation Costs

The costs associated with AS System would include preparing the AS System Monitoring Plan, installing GE removal System and AS Treatement System, sampling and analysis, and data evaluation and reporting (Due the extensive network of wells installed to complete the *Assessment of Groundwater Contamination Plume* within and downgradient of the plume, very few, new monitoring wells are anticipated to be needed). Based on the existing site conditions, we estimate the implementation costs of AS System at the DELF Facility as follows:

Estimated GE Implementation Costs		
Initial Start Up Costs	GE System Monitoring Plan, Monitoring, and Data Evaluation	$ 30,000
Design Costs	Design Costs Permitting Costs	$ 55,000 $ 12,000
Construction Costs	GE System Additional Wells (as required)	$360,000 $ 10,000
Contingencies		$ 20,000
Total Estimated Remedy Implementation Costs:		**$ 487,000**

The actual cost and design of the AS program will be determined if AS is selected as a remedial alternative. At that time a detailed work plan will be completed to aid in cost analysis. Depending on the final design of the GE System, monitoring network and monitoring frequency, the annual monitoring

and reporting costs associated with AS are estimated at $15,000 to $26,000 per year until the landfill remediation goals are achieved.

Institutional Requirements

The SWS will likely require a modification to the operating permit for the DELF Facility. In addition, AS technologies have the potential to produce liquids that could require an NCDENR-DWQ pump and haul permitting in order to transport the liquid to the local waste water treatment facility.

4.2.4 Enhanced Bioremediation

Enhanced Bioremediation (EB) is an *in* situ active treatment method that was previously described in general scope and detail in Section 3.6.2 and 3.6.3. EB is a proven remedial alternative that has been used at a variety of contaminated sites to treat organic contamination in soil and groundwater. If properly designed, monitored, and maintained, EB is a reliable remedial alternative that can rapidly destroy contaminants in the subsurface. However, as with all *in situ* remediation methods, the limitation to an effective EB plan is the contact area of the treatment with impacted medium. In order for EB to be effective, the treatment must come in contact with contaminated groundwater. At the DELF Facility, EB would likely involve the injection of Hydrogen Release Compound (HRC®) to treat chlorinated organic compounds.

Implementation Requirements

Implementation requirements for EB include preliminary laboratory testing, which would be used to create a treatability study. The treatablility study would need to be performed prior to field implementation. Upon a successful treatability study, a field-scale pilot study would be undertaken to identify if site conditions are conducive to EB and then to develop an application plan for the HRC® or other treatment agent. Field work would be required to install injection wells and perform the injection of the compound, followed by routine monitoring of the progress of the EB effort. Periodic re-injections could be required to achieve the acceptable regulatory concentrations of COCs in groundwater.

Remediation Impacts

There are no major remediation related impacts associated with EB. Minor impacts would include the generation of contaminated purge water during groundwater sampling events.

Remediation Timeframe

The timeframe for an observable decrease in concentration is dependant upon the application of EB at the site. This remediation strategy would most likely be utilized as a bioremediation barrier along the western and south western boundaries of the contaminant plume and not used site-wide. By utilizing EB in this manner an observable decrease in the concentration of COCs is estimated to be 12 to 18 months. Since the source of the groundwater contamination may potentially be renewed, follow up injections would be required based on monitoring results. The ultimate success is dependant upon soil properties and the biodegrability of the COCs.

Remediation Costs

Cost associated with EB include design costs, permitting costs, capital costs to purchase the HRC® or other compounds, construction and installation costs, and evaluation costs. The estimated full-scale implementation costs for EB are as follows:

Estimated EB Implementation Costs		
Initial Start Up Costs	Initial Round of Monitoring and Data Evaluation	$ 20,000
Design Costs	Design Costs Permitting Costs	$ 25,000 $ 6,000
Equipment Costs	HRC® or other compound	$150,000
Construction Costs	Permanent Injection Points Additional Observation Wells (as required) HRC® Application, Oversight, and Documentation	$100,000 $ 25,000 $ 20,000
Contingencies		$ 30,000
Total Estimated Remedy Implementation Costs:		**$ 376,000**

The actual cost and design of the EB program will be determined if EB is selected as a remedial alternative. At that time a detailed work plan will be completed to aid in cost analysis. Depending on the final design of the EB System, monitoring network and monitoring frequency, the annual monitoring

and reporting costs associated with EB are estimated at $18,000 to $26,000 per year until the landfill remediation goals are achieved. Estimated follow-up injection costs including supplies, subcontractors, and oversight are $40,000 to $60,000 per event.

Institutional Requirements

The SWS will likely require a modification to the operating permit for the DELF Facility.

4.2.5 Phytoremediation

Phytoremediation is an *in* situ active treatment method that was previously described in general scope and detail in Section 3.9. Phytoremediation is a proven remedial alternative that has been used at a variety of contaminated sites to treat organic contamination in soil and groundwater. If properly designed, monitored, and maintained, phytoremediation is a reliable remedial alternative which can take contaminants from the subsurface and transform them into non-harmful byproducts. However, as with all *in situ* remediation methods, the limitation to an effective plan is the contact area of the treatment with impacted medium. In order for phytoremediation to be effective, the root-zone must come in contact with contaminated groundwater. At the DELF Facility, overburden soils would need to be removed to a depth that selected plants could come in contact with the groundwater.

Implementation Requirements

Implementation requirements for phytoremediation would include the hiring of a qualified consultant such as Edenspace™. The consultant would be expected to provide field services for phytoremediation, site applicability analyses, bioavailability and chemical migration analyses, training, and technical consulting. A treatablility study would need to be performed prior to field implementation. Upon a successful treatability study, a field-scale pilot study would be undertaken to identify if site conditions are conducive to phytoremediaition and then to develop an application plan. Field work would be required to remove the overburden soils and for plant installation, followed by routine monitoring of the progress of the phytoremediation effort.

Remediation Impacts

There are no major remediation related impacts associated with Phytoremediaiton.

Remediation Timeframe

The timeframe for an observable decrease in concentration is dependant upon the types of plants used and the length of growing season. We would expect an observable decrease in the concentration of COCs in 5 to 10 years. The ultimate success is dependant upon root contact with the contaminated groundwater and the ease of metabolization of the COCs.

Remediation Costs

Cost associated with Phytoremediation include design costs, permitting costs, capital costs to purchase the plants, construction and installation costs, and evaluation costs. The estimated full-scale implementation costs for Phytoremediation are as follows:

Estimated Phytoremediation Implementation Costs		
Initial Start Up Costs	Initial Round of Monitoring and Data Evaluation	$ 30,000
Design Costs	Design Costs Pilot Study Permitting Costs	$ 40,000 $ 15,000 $ 6,000
Material Costs	Plants & Soil Amendments	$ 25,000
Construction Costs	Overburden excavation, soil preparation, tree installation Irrigation System Application, Oversight, and Documentation	$ 50,000 $ 7,000 $ 25,000
Contingencies		$ 20,000
Total Estimated Remedy Implementation Costs:		**$ 218,000**

Depending on the final design of the Phytoremediation System, monitoring network and monitoring frequency, the annual monitoring and reporting costs associated with Phytoremediation are estimated at $10,000 to $20,000 per year until the landfill remediation goals are achieved. Expected O&M costs associated with irrigation and semi-annual tree pruning is $2,000/year.

Institutional Requirements

The SWS will likely require a modification to the operating permit for the DELF Facility.

5.0 SUMMARY AND CONCLUSIONS

5.1 Public Meeting

In accordance with Rule .1635(d), Harnett County will hold a public meeting discussing the corrective measures assessed, prior to selecting a remedy for the site and after approval of the ACM by the SWS. Public notice will be made at least 30 days prior to the meeting. The notice will include time, place, date, and purpose of the meeting. A copy of the notice will be sent to the Section at least 5 days prior to publication of the notice. The notice will, at minimum, be placed in the newspaper(s) serving Harnett County. If found necessary, notice will also be announced on the local radio station.

5.2 Conclusion

The purpose of the ACM is to evaluate the effectiveness of potential corrective measures. Harnett County has identified the most applicable remedies for the Dunn Erwin Landfill Facility, which are discussed in Section 4 and will be presented to the public upon approval by the Solid Waste Section. Upon receiving final approval from the Solid Waste Section, Harnett County will initiate the next phase of corrective action by holding a public meeting as discussed above, and selecting a remedy as set forth in Rule 01636 and fulfill the remaining requirements of Rule .1637

6.0 REFERENCES

The references cited herein may or may not be cited in the text of this report. They are listed here since they were used as references in the identification of applicable remedial alternatives for the initial screening of remedial alternatives.

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Table 1
Harnett County Dunn-Erwin Landfill
Groundwater Velocity Data
Based on Groundwater Gradients Estimated for the October 1995 Sampling Event

Shallow Wells									Estimated Velocities* (cm/s)			
	K (cm/sec)*			n values*				i*, Oct. 95	=(1)*i/(3)	=(1)*i/(4)	=(2)*i/(5)	=(2)*i/(6)
MW	Note Ref.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(a)	(b)	(c)	(d)
MW1		7.9E-07	1.0E-03	0.1	0.2	0.3	0.4	3.3E-02	2.6E-07	1.3E-07	1.1E-04	8.3E-05
MW2		3.5E-05	1.0E-03	0.1	0.2	0.3	0.4	4.0E-02	1.4E-05	7.0E-06	1.3E-04	1.0E-04
MW3		1.2E-05	1.0E-03	0.1	0.2	0.3	0.4	8.0E-02	9.2E-06	4.6E-06	2.7E-04	2.0E-04
MW4		1.2E-05	1.0E-03	0.1	0.2	0.3	0.4	8.0E-02	9.9E-06	5.0E-06	2.7E-04	2.0E-04
MW5		4.0E-05	1.0E-03	0.1	0.2	0.3	0.4	1.0E-01	4.0E-05	2.0E-05	3.3E-04	2.5E-04
MW6		3.5E-05	1.0E-03	0.1	0.2	0.3	0.4	8.0E-02	2.8E-05	1.4E-05	2.7E-04	2.0E-04
MW7B		NA	1.0E-03	0.1	0.2	0.3	0.4	1.0E-02	NA	NA	3.3E-05	2.5E-05
MW8		2.0E-06	1.0E-03	0.1	0.2	0.3	0.4	1.3E-02	2.5E-07	1.3E-07	4.2E-05	3.1E-05
MW9		8.6E-04		0.25				1.5E-02	5.2E-05			
MW10		3.0E-06		0.25				1.7E-02	2.0E-07			
MW11		2.5E-05		NA				NA	NA			
MW12		2.3E-05		NA				NA	NA			
MW13		5.5E-06		NA				NA	NA			
MW14		7.4E-07		NA				NA	NA			
MW15		2.2E-05		NA				NA	NA			
MW16		7.3E-08	1.0E-03	0.1	0.2	0.3	0.4	NA	NA	NA	NA	NA
MW23B		2.8E-04	1.0E-03	0.1	0.2	0.3	0.4	2.0E-02	5.6E-05	2.8E-05	6.7E-05	5.0E-05
MW31		3.2E-06	1.0E-03	0.1	0.2	0.3	0.4	2.5E-02	8.0E-07	4.0E-07	8.3E-05	6.3E-05
MW32		2.9E-06	1.0E-03	0.1	0.2	0.3	0.4	NA	NA	NA	NA	NA
MW33		4.1E-06	1.0E-03	0.1	0.2	0.3	0.4	NA	NA	NA	NA	NA
MW34		NA	NA	0.1	0.2	0.3	0.4	NA	NA	NA	NA	NA
MW35		NA	NA	0.1	0.2	0.3	0.4	NA	NA	NA	NA	NA

*** Equation** **V=Ki/n (cm/sec)**

Where V = Mean groundwater velocity as calculated by the above equation
i= Hydraulic gradient (unitless), see note (7)
n = Effective porosity (unitless), see notes (3) through (6)
k = hydraulic conductivity, see notes (1) and (2)

Notes:

NA refers to wells where data is unavailable
(1) In situ hydraulic conductivity as estimated by Withers and Ravenel, "Evaluation of Groundwater Flow and Direction", November 1994
(2) In situ site hydraulic conductivity as estimated for "Field Investigation of Contaminant Plume", October 1996, except
MW9 and MW10 installed in March 2001, for which values are obtained from the Titan report.
MW11 - MW15 calculated by ENSOL, Inc., August 2006 (based on slug tests).
(3) Estimated as the lower limit for effective porosity, n, by Withers and Ravenel, Evaluation of Groundwater Flow and Direction, November 1994
(4) Estimated as the upper limit for effective porosity, n, by Withers and Ravenel, Evaluation of Groundwater Flow and Direction, November 1994
(5) Lower limit of effective porosity estimation in "Field Investigation of Contaminant Plume", October 1996.
(6) Upper limit of effective porosity estimation in "Field Investigation of Contaminant Plume", October 1996.
(7) Hydraulic gradient as estimated from groundwater contours based on groundwater data sampled in October 1995.

(a) Velocity as estimated using Withers and Ravenel estimated hydraulic conductivity (1), the lower limit for effective porosity (3), and the corresponding hydraulic gradient estimated from Figure 2.

(b) Velocity as estimated using Withers and Ravenel estimated hydraulic conductivity (1), the upper limit for effective porosity (4), and the corresponding hydraulic gradient estimated from Figure 2.

(c) Velocity as estimated using estimated hydraulic conductivity (2), the effective porosity (5), and the corresponding hydraulic gradient estimated from Figure 2.

(d) Velocity as estimated using estimated hydraulic conductivity (2), the effective porosity (6), and the corresponding hydraulic gradient estimated from Figure 2.

(e) For MW9 and MW10 installed in March 2001, velocity was computed for values obtained from the Titan report.

Table 2
Evaluation of Estimated Vertical Gradient and Flow Rate
Downgradient of the Dunn/Erwin Landfill

Nested Pair Piezometers (PZ-)	46-S	46-D	47-S	47-D	44-S	44-D	42-S	42-D
Average GW Level (ft)	194.19	193.35	182.59	162.41	180.16	172.7	162.02	152.77
Approximate Groundwater Head (ft)	0.84		20.18		7.46		9.25	
Top of Confining Layer (ft)	187		168		167		142	
Bottom of Confining Layer (ft)	179		146		136		120	
Estimated Confining Layer Thick. (ft)	8		22		31		22	
Approximate Vertical Gradient	0.11		0.92		0.24		0.42	
Average Vertical Gradient	0.42							
Average Vertical Flow Rate	**13 cm/year = 0.43 ft/year = 5 inch/year**							
Average Confining Layer Thickness (ft)	**20.75**							
Estimated Time to Pass Confining Layer	**Approximately 50 years**							

Notes:

1. Groundwater head is estimated based on the difference between average groundwater levels in the shallow and deep piezometers
2. Top and bottom of confining layer are estimated based on boring logs and piezometer screen depth found in the 2003 Plume Assessment Report.
3. Average vertical flow rate is estimated based on permeability of 1x10-7 cm/s selected for the IMP type soil of the confining layer
4. Flow rate was roughly estimated based Darcy's law, $q = k\, i / n_{eff}$
5. Effective porosity in IMP clayey soils on site, n_{eff}, is assumed as 0.1

TABLE 3
Dunn Erwin Landfill Facility
Harnett County, NC

REMEDIAL TECHNOLOGY	Feasibility and Effectiveness										Implementatbility					Cost					
	Achieve Target Contaminant Levels	Protective of Human Health & Environment	Long Term Effectiveness	Adresses (T)oxicity, (M)obility, or (V)olume		Safety Impacts	Residuals Produced (S)olid, (L)iquid, (V)apor		Rating for VOCs	Exposure to Residual Contamination	Ease to Implement	Enviromental Conditions	System Reliability and Maintainability	Regulatory/Permitting Acceptability	Community Acceptability	Capital Costs	O&M Costs	Time to Implement	Time to Complete Cleanup	Score	Comment
Rating System	Yes=3; Unkwn=2; No=1	Yes=3; Unkwn=2; No=1	Yes=3; Unkwn=2; No=1	1 pt. each		Best=3; Avg=2; Worse=1	-1 pt. each		Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1	Best=3; Avg=2; Worse=1		
Non-Intrusive Controls																					
Monitored Natural Attenuation	2	2	2	1	T	3	0	--	2	3	3	1	1	1	1	3	3	3	1	**31**	Analytical results indicate cleanup may take extreme amount of time (>50 yrs)
Groundwater Containment																					
Vetical Barrier Walls	1	1	2	1	M	3	-1	S	1	1	1	1	3	2	2	2	3	2	1	**25**	Site condition would require a laterally extensive barrier system = $
Groundwater Extraction System	2	3	3	3	T,M,V	2	-1	L	1	1	1	1	2	3	2	2	1	2	2	**28**	High visible system - Perfomance is realatively low but can be used in conjunction with other technologies.
Hydraulic Gradient Controls (Injection)	1	1	2	2	T,M	3	0	--	1	3	1	1	1	1	2	2	1	2	1	**24**	Easy to implement, but may cause undesirable redirection
In-Situ (Groundwater Biological Treamtent)																					
Enhanced Bioremediation (HRC®)	3	3	3	2	T,V	2	0	--	3	3	2	2	2	2	2	2	1	2	2	**34**	May be highly effective. If Landfill continues to leak, O&M may expand with additional HRC injections.
Enhanced Bioremediation (Oxidation)	3	3	3	2	T,V	2	0	--	3	3	2	1	2	2	2	2	1	2	2	**33**	May be highly effective. If Landfill continues to leak, O&M may expand with additional oxidant required'.
Enhanced Bioremediation (Nitrate)	3	3	3	2	T,V	2	0	--	1	3	2	2	2	2	2	2	2	2	2	**33**	Permit required to inject N. NO_2 in groundwater regulated.
Phytoremediation	2	2	3	2	T,M	3	-1	S	2	2	1	3	3	1	3	3	3	2	1	**34**	Overburden soils would need to be removed to gain plant access to ground water. Consultant would need to be hired.
In-Situ - Groundwater Abiotic Treatment																					
Air Sparging	3	3	3	3	T,V,M	3	-1	L	3	1	2	3	2	2	2	2	2	2	3	**35**	Treatment will be limited to area of sparging
Hot Water or Steam Flushing/Stripping	3	3	3	1	T	2	-2	L,V	2	1	1	2	1	2	2	2	2	2	3	**27**	No full scale success has been achieved. Subsurface injection if prohibited
Dual Phase Extraction	3	3	3	2	T,M	2	-2	L,V	3	1	2	3	2	2	2	2	2	2	2	**32**	Dual phase requires both groundwater and vapor treatment. Vapor is not of major concern at this facility.
Vacuum Vapor Extraction	3	3	3	2	T,M	2	-2	L,V	3	1	2	2	3	3	2	2	2	2	2	**33**	No full scale success has been achieved. Fouling is of concern due to oxidation.
Ex-Situ Groundwater Treatment																					
Air Stripping w/ NPDES Disposal	3	3	3	2	M,V	2	-1	L	3	2	2	2	2	2	2	2	2	2	2	**33**	Off-gases may require treatment
Carbon Adsorption (liquid phase)	3	3	3	3	T,M,V	2	-1	S	2	2	2	2	2	2	2	2	1	2	2	**32**	Water soluble and small molecules are not adsorbed well.
Public Owned Treatment (WWTP)	3	3	3	3	T,M,V	3	-2	S,L	2	2	2	2	3	1	2	1	1	2	3	**31**	Pretreatment is required. Hauling cost are extreme.
UV Oxidation	3	3	3	3	T,M,V	2	-1	L	3	2	2	3	2	2	2	1	1	2	2	**33**	Handling/storage require safety. Significant O&M $

NOTES:

Achieve Target Contaminant Levels	the remedial alternative will effectively reduce the concentration of contaminants identified to levels equal to or less than the levels established for each constituent that are protective of human health and the environment.
Protective of Human Health and the Environment	Implementation and/or operation of remdial alternative will not increase risk to human health or environment.
Long-Term Effectiveness	the effects of the remedial alternative are long term as opposed to temporary.
Adress Toxicity, Mobility, or Volume	the remedial alternative reduces the toxicity of the contaminant, the mobility of the contaminent, or the volume of the contaminated media.
Safety Impacts	the alternative has short term impacts on the physical safety of humans.
Residuals Produced (Solid, Liquid, or Vapor)	by-products produced by implementing or operating the remedial alternative
Exposure to Residual Contamination	whether or not humans could come in contact with any residuals produced by the remedial alternative.
Ease to Implement	the degree to which implementing the remedial alternative can be accomplished
Environmental Conditions	the effects of environmental conditions (e.g., structure of subsurface soils, microbial population, groundwater depth, etc.) on the effectiveness of the remedial alternative.
System Reliablility/Maintainability	the acceptance by the regulatory agency of the remedial alternative as a viable means by which to migrate any or this site, and the ease in which a permit can be obtained.
Community Acceptability	the degree to which use of the technology is acceptable to the public.
Capital Cost	cost for design, construction, and initial implementaton of the remedial system
O&M Cost	cost for operation and maintenance of the remedial system, following implementation and throughout the entire corrective action process.
Time to Implement	the relative amount of time required to implement the alternative, including the time spent obtaining all required permits
Time to Cleanup	the relative amount of time before remedial endpoints will be met.

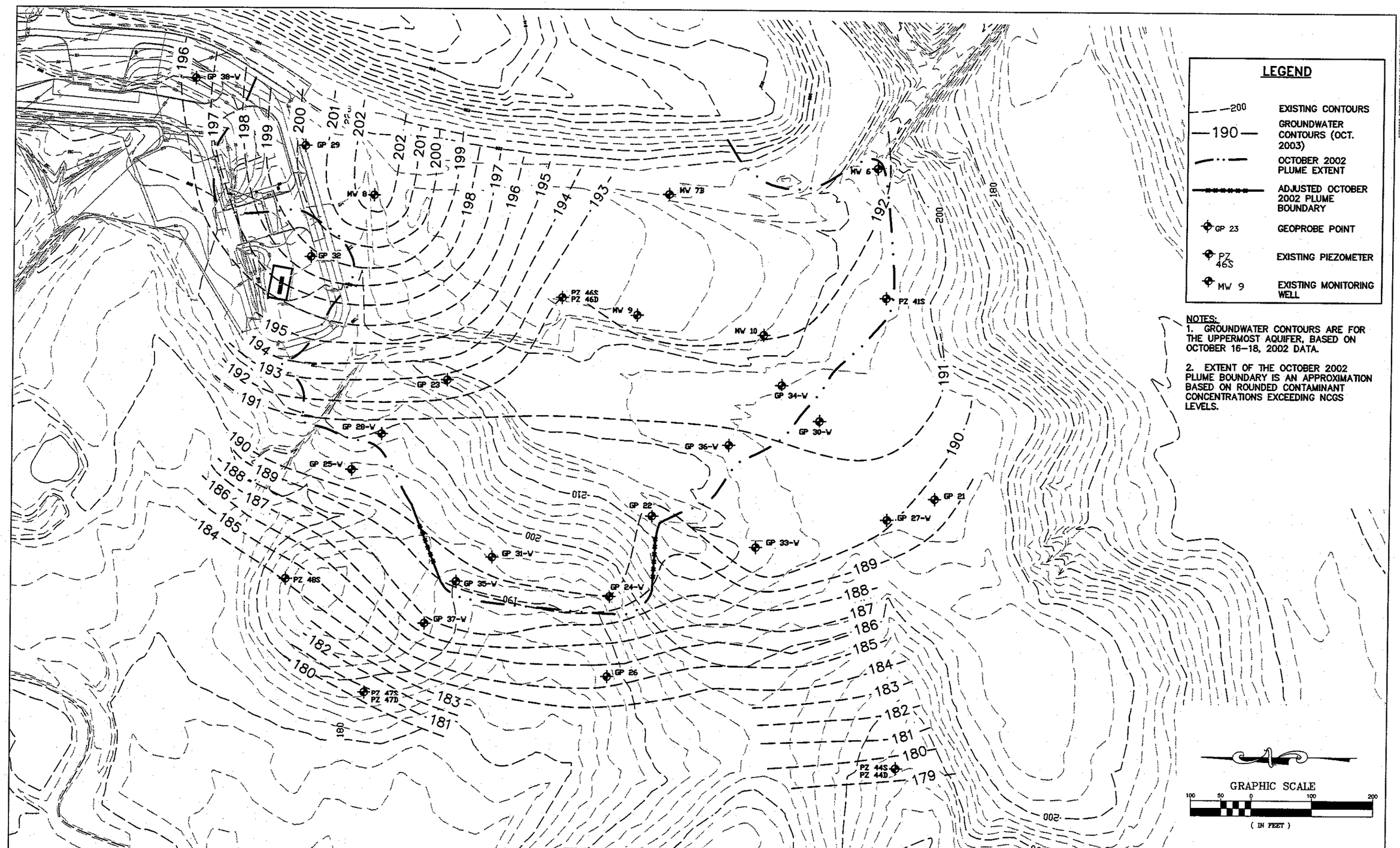
Figure 1
SITE MAP
of
DUNN-ERWIN LANDFILL
HARNETT COUNTY NORTH CAROLINA

PROJECT # : 000000
FIELD: MGR.: GTG
DRAWN BY : GTG Jr.
FIELD FILE: C.F.
CAD FILE : GMSP Figure 000X.dwg
SCALE : 1" = 200'
DATE : APRIL 4, 2000
SHEET # : 1 OF 1

DATE:

Clayton, Sr., P.E., Inc.
Civil & Environmental Engineering
PO BOX 670
COATS, NC 27521
Phone: 910-897-7070
Fax: 910-897-6707
Email: tyrone@clayton.com

\\Server\Projects\00 Harnett County\000002 Dunn Erwin\CAD\000X\dwg\000XMAP.dwg, Mar 12, 2007, 4:07pm



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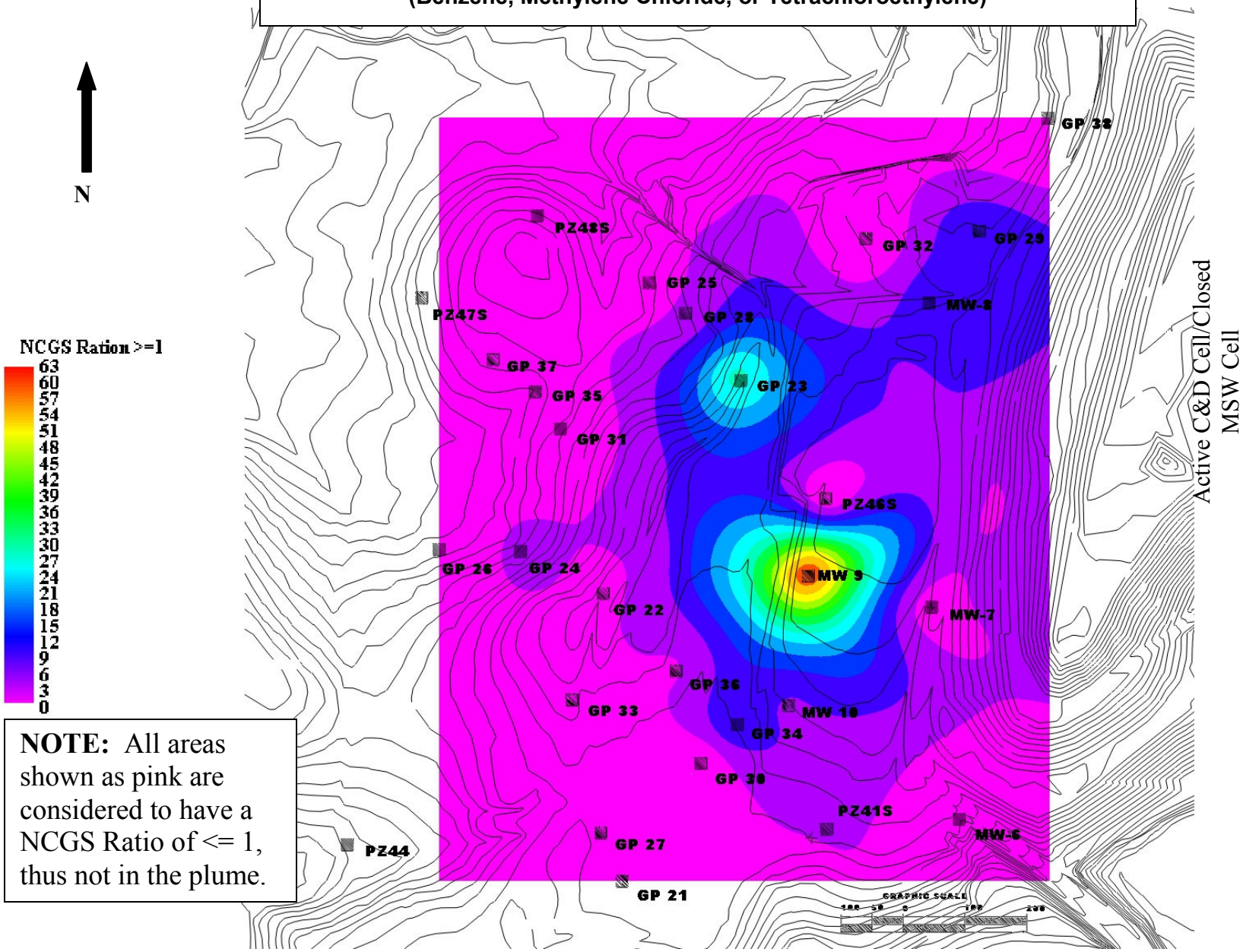
PO BOX 12794
NEW BERN, NC 28561
Phone: 252 672-0304 Mobile: 252 671-6979
Home Fax: 910 897-0860 Fax: 252 672-8577

DATE:

Figure 2
CONTAMINANT PLUME ASSESSMENT
at
DUNN/ERWIN LANDFILL
HARNETT COUNTY NORTH CAROLINA

PROJECT # : 0053002
PROJ. ENG. : CTC
DRAWN BY : CTC Jr.
CHECKED BY : CJP
CAD FILE : DELF Plume 2003.dwg
SCALE : SEE GRAPHICAL SCALE
DATE : AUGUST 20, 2003
SHEET # : 1 OF 1
Email: ctc@cox.net

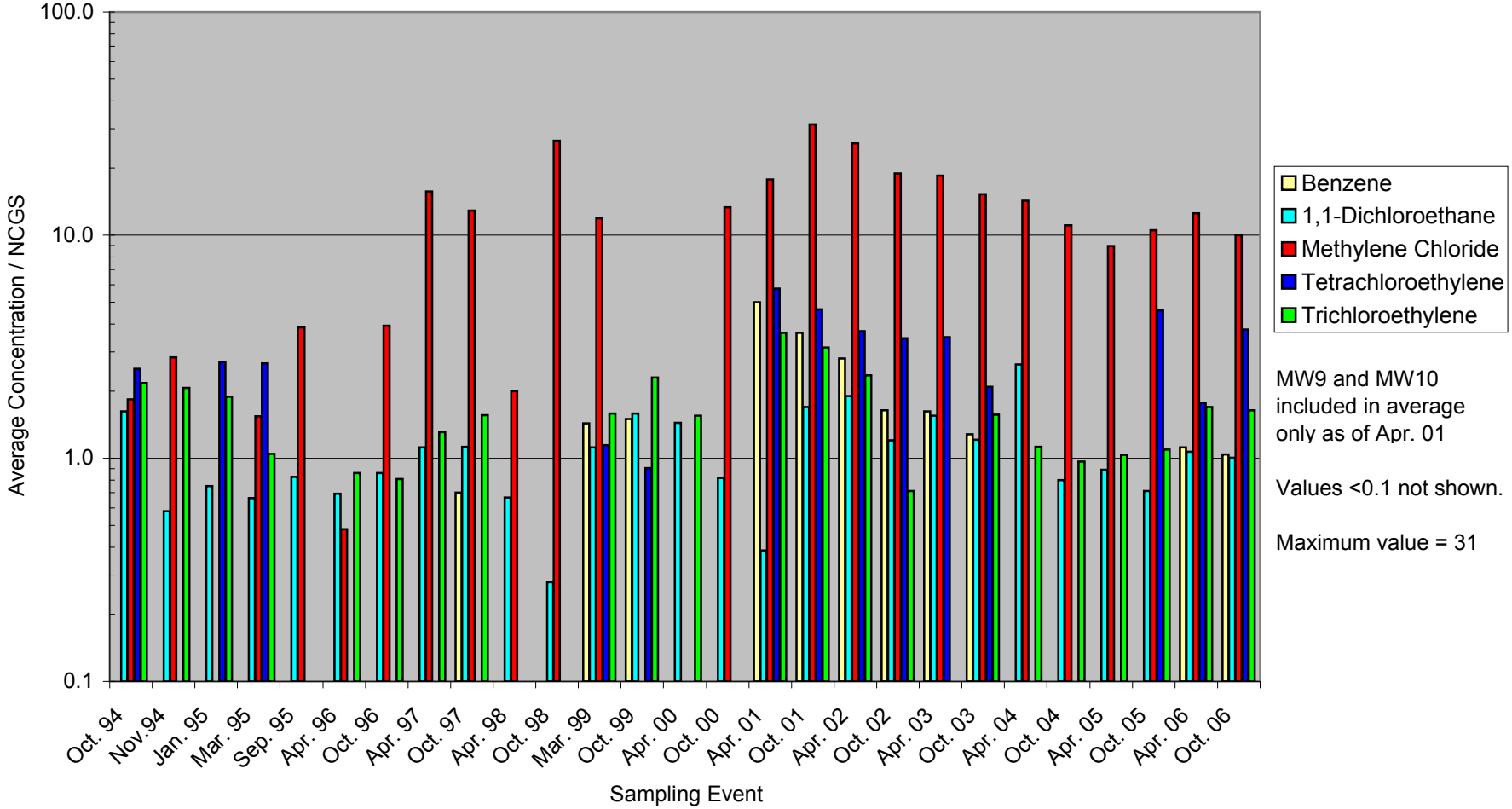
Figure 3
Estimated Extent of Contamination Plume in October 2002
Shown for any of the Three Marker Contaminants with NCGS Ratio > 1
(Benzene, Methylene Chloride, or Tetrachloroethylene)



NOTE: All areas shown as pink are considered to have a NCGS Ratio of <= 1, thus not in the plume.

Figure 4

Top Five, NCGS-Normalized Average Organics Concentrations per Sampling Event
Averages for Select Downgradient Wells (Contaminant Plume Area)
MW6, MW7B, MW8, MW9, MW10
Dunn-Erwin Landfill, Harnett County



03025-Figure-4.xls