CIVIL/SANITARY/ENVIRONMENTAL ENGINEERERS

SOLID WASTE MANAGEMENT

Municipal Services Engineering Company, P.A.

SITE PLANNING/SUBDIVISIONS

SUBSURFACE UTILITY ENGINEERING (SUE)

February 25, 2009

Zinith Barbee, Hydrogeologist Permitting Branch
Solid Waste Section
Division of Waste Management
North Carolina Department of Environmental and Natural Resources
401 Oberlin Road, Suite 150
Raleigh, NC 27605

Re: Corrective Action Plan
Greene County Permit #40-02

Dear Mr. Barbie:

Enclosed you will find the Corrective Action Plan for the Greene County Landfill permit #40-02. As per request, one hard copy is included. An electronic copy with the Selection of Remedy is also included.

Feel free to contact us by phone at (919) 772-5393, should you have any questions or comments regarding this report.

Sincerely,
MUNICIPAL ENGINEERING SERVICES CO., P.A.

Sean K. Patrick, P.G.
Professional Geologist

Enclosures

Cc: David Jones – Greene County

PO Box 97, Garner, North Carolina 27529 (919) 772-5393
PO Box 828, Morehead City, NC 28557 (252) 726-9481
PO Box 349, Boone, NC 28607 (828) 262-1767

Corrective Action Plan

Prepared for

Greene County Landfill - Permit #40-02
Walstonburg, Greene County, North Carolina

MESCO Project Number: G07061.0

Completed on 6/30/2008
Revised on 2/25/2009

Municipal Engineering Services Company, P.A.
Garner, Boone and Morehead City, North Carolina

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 Site Background 1
1.2 Aquifer Characteristics 1
1.3 Contaminant Distribution 2
1.4 Site Conceptual Models 2
1.5 Regulatory Status 3

2 CONTAMINANT CHARACTERIZATION 4

2.1 Contaminants of Concern 4
2.2 Contaminant Source Confirmation 4
2.3 Source Control Measures 4
2.4 Risk Assessment 4
2.5 Contaminant Concentrations 4
2.5.1 Background Concentrations 4
2.5.2 Exceedances of Groundwater Quality Standards 5
2.5.3 Exceedances of Surfacewater Quality Standards 5
2.6 Media of Concern 5

3 SELECTED AND APPROVED REMEDY / TECHNICAL APPROACH 5

3.1 Technical Approach (Monitored Natural Attenuation w/ ZVI Injection) 6

4 GROUNDWATER AND SURFACEWATER MONITORING PLAN 7

4.1 Groundwater Sampling and Monitoring 7
4.2 Surfacewater Sampling and Monitoring 8

5 EVAULATION OF EFFECTIVENESS AND REPORT SUBMITTALS 8

5.1 Evaluation of Effectiveness 8
5.1.1 Qualitative and Quantitative Evaluation 8
5.1.2 Evaluation of Plume Area 10
5.2 Refining the Site Conceptual Model 10
5.3 Report Submittals 10

6 CONTINGENCY PLAN 11

6.1 Contingency Plan 11
6.2 Safeguard Measures and Site Security 11
6.3 Revisions 11

7 SCHEDULE AND MAINTENANCE 12

7.1 Operations & Maintenance 12
7.2 Timeline 12

8 FINANCIAL ASSURANCE REQUIREMENTS 12

9 COMPLETENESS OF CORRECTIVE ACTION 12

REFERENCES 14

TABLES

Table 1 Well Construction Details
Table 2 Historical Groundwater Elevation Data
Table 3 Summary of Slug Test Results
Table 4 Summary of Historical Organic Results
Table 5 Summary of Historical Background Results
Table 6 Summary of Current Groundwater Results
Table 7 Summary of Current Surfacewater Results
Tables 8A-8E Summaries of Corrective Measures Screening Results
Table 9 Timeline/Schedule of Corrective Action

PLATES

Plate 1 Topographic Map with Site Location
Plate 2 Site Map with Sampling Locations
Plate 3 Single-Day Potentiometric Surface Map
Plate 4 Cross-Sections
Plate 5 Remediation Area Map

APPENDIX

Appendix A MNA Screening
Appendix B Ground and Surfacewater Sampling and Analysis Plan
Appendix C ZVI Supplemental Information

1 INTRODUCTION

1.1 Site Background

The Greene County Construction and Demolition (C&D) landfill is located at 105 Landfill Road (SR 1239), Walstonburg, Greene County, North Carolina. Greene County C&D landfill operates under permit #40-02. Prior to operating as a C&D landfill, the site operated as a Municipal Solid Waste (MSW) unlined sanitary landfill. The MSW unit was closed with a cohesive cap of 18 inches of soil with a permeability of 1 x 10^{-5} cm/sec, and 18 inches of erosive layer. The MSW unit stopped receiving waste by January 1, 1998 as part of the *Transition Plan*.[15] The C&D landfill is constructed and operating on top of the MSW unit. The site is monitored under 15A NCAC 13B.1630. A topographic map showing the location of the site is included as **Plate 1**.

1.2 Aquifer Characteristics

The site lies within the Coastal Plain physiographic province, which is characterized by flat or gently undulating topography and dissected by drainage features with narrow to moderately sloped sides. Topographic relief across the facility is approximately 20 feet. Surface drainage across the site is generally northeast towards a tributary of Sandy Run. Sandy Run flows east towards Little Contentnea Creek, which drains into the Neuse River. A site map showing the layout of the permitted facility is included as **Plate 2**.

The site is underlain by unconsolidated surficial deposits that are made up of sand, clay and gravel, and dip generally to the southeast. The surficial sediments are underlain by the Yorktown formation, which consists of an overlying confining unit of clay, silty clay, or sandy clay that is approximately 25 feet thick; followed by an underlying unit of fine sand, silty sand, and clayey sand.[12] Groundwater at the site is relatively shallow, and typically occurs at depths of less than 20 feet below ground surface (bgs), with the shallowest depths occurring towards the eastern side of the property. Groundwater depths in the monitoring wells have been generally consistent over time, and occur in the following depth ranges:

- ≤ 10 ft. bgs: *MW-1R, MW-6*
- 10 to 20 ft. bgs: *MW-4, MW-5, MW-7, MW-8*

Historical groundwater elevations are provided in **Table 2**. Groundwater exhibits flow dynamics that are primarily controlled by local drainage features. Groundwater flow at the site is in a general west-southwesterly direction, with southwesterly and northwesterly flow away from the waste limits. A single-day potentiometric map depicting groundwater flow conditions on March 28, 2008 is provided as **Plate 3**.

Hydraulic conductivities, hydraulic gradients, and average linear groundwater velocities are summarized in **Table 3**. Hydraulic conductivity values, as determined from slug testing, ranged from 1.10 x 10^{-4} cm/sec (MW-4) to 1.14 x 10^{-3} cm/sec (MW-8), with a geometric mean of 2.70 x 10^{-4} cm/sec. Hydraulic gradient at the site is typically on the order of 0.015 to 0.025 ft/ft.[10] Average linear velocities (v_x) were calculated using the following equation:

$$v_x = \frac{K * i}{n_e}$$

where

v_x is the average linear velocity [length/time]

K is the hydraulic conductivity [length/time]

n_e is the effective porosity [unitless]

i is the horizontal hydraulic gradient in the direction of groundwater flow, taken as the difference in head elevation between two points divided by the distance between those points [unitless, or length/length]

The calculated average linear velocities were found to have a median value of 33.4 ft/yr.

1.3 Contaminant Distribution

Groundwater contamination at the site consists of dissolved-phase volatile organic compounds (VOCs) in concentrations exceeding established 15A NCAC 2L groundwater standards. Groundwater contaminants found to exceed 2L standards are: benzene, vinyl chloride, *p*-dichlorobenzene (1,4-dichlorobenzene) and lead. Benzene and *p*-dichlorobenzene are aromatic hydrocarbons. Vinyl chloride is a chlorinated aliphatic hydrocarbon. Lead is a toxic, heavy metal. Groundwater impact is limited to monitoring well MW-4 and, therefore, the unconfined surficial aquifer. Contamination has not been detected in compliance wells MW-7 and MW-8. Historical organic detected constituents are shown in **Table 4**.

1.4 Site Conceptual Models

Site conceptual and analytical models were developed in the *ACM*. The models consisted of conceptual cross sections and analytical modeling using MODFLOW with MT3D[96]. The lithologic cross sections from the *ACM* are provided as **Plate 4**.

Physical Process

The primary mechanism of physical movement of the plume is through advection. Advection flow with applied sorption (retardation) coefficients (R) was calculated in the *ACM*. The following table expresses the time requirement for impact to reach the relevant point of compliance, excluding biological decay and dilution.

Contaminant Velocity (Obtained from ACM)		
Monitoring Well	**MW-4**	**Time to relevant point of compliance (approx. 125 ft from MW-4)**
Benzene	3.46 ft/year	36.1 years
Vinyl Chloride	12.6 ft/year	9.9 years
p-Dichlorobenzene	0.68 ft/year	183.8 year

The above table suggests that contamination has the potential to travel at or near the seepage velocities identified in the *ACM*. Summaries of the corrective action screening results as presented in the *ACM* are included as **Tables 8A-8E** (attached).

Chemical/Biochemical Process

Chemical degradation processes, primarily that of half life decay, is typically expressed based on surface water measurements. The identified contamination consisted of constituents dissolved in groundwater. There are no identified surface water receptors within 2,000 feet of the landfill. Benzene and vinyl chloride experience rapid volatilization from soil when released near the surface and rapid volatilization when released to surface waters. *p*-Dichlorobenzene has an environmental fate of rapid volatilization when released from surfacewater and low to moderate adsorption when released into soils. [4] Half-life reactions in groundwater vary greatly. A summary of published half life reactions in groundwater is included below.

Half-Life in Groundwater [7]		
Constituent	**Half-Life (high)**	**Half-Life (low)**
Benzene	24 months	10 days
Vinyl Chloride	70 months	14 weeks
p-Dichlorobenzene	12 months	8 weeks

Biotransformation of most chlorinated solvents, including halogenated aliphatics, occurs through reductive dechlorination.[5] The reductive dechlorination process utilizes the chlorinated solvents as the electron acceptor. Through reductive dechlorination, carbon is utilized as the electron donor for microbial growth. The potential carbon source may be the aromatic hydrocarbons.

1.5 Regulatory Status

The Greene County Landfill operates as a C&D landfill over a MSWLF landfill under permit #40-02. Assessment monitoring is currently performed on a semi-annual basis at the site.

2 CONTAMINANT CHARACTERIZATION

2.1 Contaminants of Concern

The following chemical compounds were identified in the *ACM* as being contaminants of concern (COCs):

- benzene, *p*-Dichlorobenzene – *aromatic hydrocarbons*
- vinyl chloride – *chlorinated aliphatic hydrocarbon*

2.2 Contaminant Source Confirmation

The source of the release has been identified as the MSW landfill. The mechanism for the presence of this contamination is precipitation that has percolated through the landfill waste, allowing VOCs to partition from solid/liquid phases into a dissolved phase, and that has subsequently migrated downwards to mix with groundwater. To limit water percolation, the MSW unit was closed with a cohesive cap of 18 inches of soil with a permeability of 1 x 10^{-5} cm/sec, and 18 inches of erosive layer. Ultimately groundwater will discharge into unnamed creeks east of the landfill. These creeks are tributaries of Sandy Run. There are no known groundwater users within 2,000 feet of the facility.

2.3 Source Control Measures

The landfill stopped receiving MSW by October 1998 and was closed with a cohesive cap of 18 inches of soil with a permeability of 1 x 10^{-5} cm/sec, and 18 inches of erosive layer. A passive horizontal gas venting system for methane extraction/collection was installed as part of the *Transition Plan*.

2.4 Risk Assessment

Risk assessment was performed as part of the *ACM*, and assumed direct contact with the identified contamination. Exposure pathways are limited to on-site contact with groundwater. Monitoring wells are cased and secured with locking well caps. Access to the site is limited during operational hours. Adult hazard index values for contaminants of concern were less than 1 from inhalation, dermal, and oral ingestion exposure. Additionally, child hazard index values for contaminants of concern were less than 1 from inhalation, dermal, and oral ingestion exposure.

2.5 Contaminant Concentrations

2.5.1 Background Concentrations

Background water quality data is collected from upgradient monitoring well MW-1R. Water quality samples have been collected since 1994. Historical background results are shown in **Table 5**. Current groundwater results are shown in **Table 6**.

2.5.2 Exceedances of Groundwater Quality Standards

Groundwater contaminants that have exceeded 2L standards are benzene, *p*-dichlorobenzene, and vinyl chloride. Lead concentrations in some samples were also found to exceed 2L standards. However, this compound was identified in the *ACM* as occurring naturally, and is not of concern in this study.

2.5.3 Exceedances of Surfacewater Quality Standards

Laboratory analysis of surfacewater samples have not detected contaminant concentrations in excess of established NCAC 2B water quality standards. Surface water samples are collected off-site at the tributary of Sandy Run. One (1) upstream sample and one (1) downstream sample are collected. Current surfacewater results are shown in **Table** 7. The upstream sample was dry during the March 2008 sampling event.

2.6 Media of Concern

Groundwater is the primary media of concern at the site since it acts as the primary mechanism of transport for environmental contaminants emanating from the landfill. Dissolved-phase contaminants can potentially be transported via groundwater and discharged to surfacewater.

Landfill gas is a secondary media of concern since it can transport VOCs that have partitioned into the vapor phase, allowing them to re-partition into the dissolved phase into groundwater. A passive horizontal gas venting system for methane extraction/collection was installed as part of the *Transition Plan*.

3 SELECTED AND APPROVED REMEDY / TECHNICAL APPROACH

A number of factors influenced selection of remediation alternatives.

- Contamination is within the relevant point of compliance.
- There are no potable wells located within 2,000 feet of the facility.
- Contamination is below risk exposure levels.
- Contamination is limited to the unconfined, surficial aquifer.
- Natural attenuation mechanisms are actively controlling groundwater contaminant movement in this area.
- Modeling indicates that contamination (vinyl chloride) will reach the relevant point of compliance in 10 years. This does not include dilution, volatilization, dispersion, or degradation of contamination.

Remediation of relatively low level contamination in the 10 µg/L range can be difficult, expensive and may not be achievable. The most cost effective and efficient system for remediation is Monitored Natural Attenuation (MNA) supplemented by zero-valent iron (ZVI) injection.

3.1 Technical Approach (Monitored Natural Attenuation w/ ZVI Injection)

Bioscreen and Biochlor were initially run for MW-4 to assess the potential effectiveness of MNA. Bioscreen was focused on Benzene due to the high half life of 2 years. Bioscreen results showed a 47% decrease in contamination in 5 years through 1st order decay and a 100% decrease in contamination through instantaneous reaction model. Results of Bioscreen are provided in **Appendix A**.

Biochlor utilized site specific data for cis-1,2-dichloroethene and vinyl chloride. Dual modeling was utilized based on high half lives and low half lives. High half life results show an 8.1% decrease for cis-1,2-dichloroethene and a 5.5% decrease for vinyl chloride in 5 years through biotransformation modeling. Low half life results show a 51.4% decrease for cis-1,2-dichloroethene and a 48.5% decrease for vinyl chloride in 5 years through biotransformation modeling. Biochlor results are provided in **Appendix A**.

The MNA process will be enhanced by the introduction of zero-valent iron (ZVI) into the subsurface in the form of a permeable reactive barrier between the source area and the VOC plume. ZVI is a strong reducing agent that has been shown to abiotically degrade chlorinated hydrocarbons including the COCs identified in **Section 2** (e.g. vinyl chloride). One brand of commercially-available ZVI is H200 Plus™ iron powder which is manufactured by Hepure Technologies, Inc. (Wilmington, DE; Mill Valley, CA). According to Hepure Technologies, H200 Plus™ "is a proprietary high reactivity zero-valent iron material... It is designed to provide superior, cost-effective performance for most in-situ applications. The specific distribution of iron particles in H200 Plus ensures high initial reactivity combined with a longer reactive life to optimize and maintain reducing conditions in the treatment zone. It has effectively been used to remediate halogenated organic compounds, heavy metals and toxic metalloid contaminants. Typical iron content is 95.5%. H200 Plus™ can be provided with customized grain-size distribution to meet site-specific conditions." Prior to injection H200 is mixed with water and injected as slurry. A material safety data sheet (MSDS) and additional information on ZVI is included in **Appendix C**.

It is proposed that ZVI be injected into the shallow, unconfined aquifer using truck or rig-mounted direct-push technology. Injection points will be spaced at approximate 10-ft intervals in a line transverse to groundwater flow, and located upgradient of monitoring well MW-4, between that well and the waste limit (see **Plate 5**), for a total distance of 200 lineal feet (20 injection points total). The injection depth at this location will be approximately 20 ft. bgs. This application of ZVI is intended to create a reactive barrier that will break down

COCs near the source area before they can migrate further downgradient. The existing plume will then be subject to natural biodegradation processes as it will be cut off from the contaminant source. Multiple injection events may be needed at roughly 12-month intervals in order to effectively implement this form of corrective action, since it is possible for ZVI to become deactivated over time.

In order to more completely delineate the extent of dissolved-phase VOCs in groundwater, it is recommended that groundwater sampling be conducted in the vicinity of monitoring well MW-4. To reduce costs, groundwater sampling may be conducted using direct-push methods (e.g. GeoProbe). Baseline sampling of monitoring wells MW-1R and MW-4 will be performed semi-annually for a two-year period, and will incorporate the MNA performance parameters listed in **Section 4** and **Appendix B**. Monitoring of stream quality will consist of sampling existing upstream and downstream surfacewater sampling points, located along the unnamed tributary of Sandy Run (see **Plate 2**).

4 GROUNDWATER AND SURFACEWATER MONITORING PLAN

4.1 Groundwater Sampling and Monitoring

Data with which to monitor and evaluate the performance of remediation shall be obtained through a groundwater sampling and monitoring program. All groundwater samples collected from the monitoring wells will be analyzed for Appendix I VOC concentrations by EPA method 8260, and for Appendix I metals concentrations by EPA method 6010. Additionally, groundwater samples collected from monitoring wells MW-1 and MW-4 will be analyzed for the following MNA performance parameters:

MNA Performance Parameters

Parameter	Analysis Type	Analytical Method
Dissolved Oxygen (DO)	Field Reading	Multi-parameter Field Instrument w/ flow-through cell
pH	Field Reading	
Oxidation-Reduction Potential (ORP)	Field Reading	
Turbidity	Field Reading	
Conductivity	Field Reading	
Temperature	Field Reading	
Dissolved CO_2	Field Reading	Field Instrument / Hach Kit
Alkalinity (Total as $CaCO_3$)*	Laboratory/Field*	EPA 310.2
Chloride*	Laboratory/Field*	SM 4500-CLB
Iron	Laboratory	SM3111B
Nitrate*	Laboratory/Field*	EPA 353.2 / SM 2320B
Sulfate*	Laboratory/Field*	EPA 375.4 / SM 4500-SO4E

MNA Performance Parameters		
Parameter	**Analysis Type**	**Analytical Method**
Sulfide*	Laboratory/Field*	EPA 376.1 or SM 4500SE
TOC/BOD/COD	Laboratory	EPA 415.1 / EPA 405.1 / EPA 410.1
Methane	Laboratory	RSK 175
Ethane, Ethene	Laboratory	RSK 175
Hydrogen	Laboratory	AM19GA
Volatile Fatty Acids	Laboratory	AM23G
*For budgetary considerations these analyses may be performed in the field using Hach® brand color wheel test kits.		

4.2 Surfacewater Sampling and Monitoring

Surfacewater sampling will be conducted to monitor COC concentrations in the adjacent stream areas. To date (January 2009) COC concentrations have been below respective NCAC 2B and 2L standards. Two (2) surfacewater sampling points, designated "Upstream" and "Downstream", have been established along an unnamed tributary of Sandy Run. The locations of both surfacewater sampling points are depicted in **Appendix B, Plate A** (attached). All surfacewater samples will be analyzed for Appendix I VOC and metals concentrations by EPA methods 8260 and 6010, respectively. The complete *Groundwater and Surfacewater Sampling and Analysis Plan* is presented as **Appendix B**.

5 EVAULATION OF EFFECTIVENESS AND REPORT SUBMITTALS

5.1 Evaluation of Effectiveness

As remediation progresses at the site certain changes in the physical and chemical characteristics of the contaminant plumes should occur. In all areas contaminant concentrations are expected to decrease over the period of remediation, thus resulting in a decrease in the physical extent of the plume. The various methods for evaluating the effectiveness of remediation are discussed in the sections below.

5.1.1 Qualitative and Quantitative Evaluation

Qualitative Evaluation

Qualitative methods include graphical analysis of groundwater analytical data over time in order to visualize changing trends in groundwater chemistry that are expected to occur over time as a result of the various remedial mechanisms/processes that are occurring at the site (e.g. biodegradation, reductive dechlorination, etc.). Examples of graphical analyses that will be used include, but are not be limited to, time-series graphs of contaminant concentrations and groundwater levels, distance-concentration graphs of analytical data, and mapping of the contaminant plumes over time.

Quantitative Evaluation

Quantitative evaluation will be conducted through annual revision of Bioplume and Bioscreen models, and through analysis of groundwater analytical data using statistical tests for significance. Statistical significance tests can be grouped into two types, *inter-well* and *intra-well*. *Inter-well* methods determine statistical significance by examining trends in contaminant concentrations from performance wells with respect to those from background wells, which are used as a control group. As remediation progresses, the performance well data is expected to exhibit decreases in contaminant concentrations, while contaminant concentrations in the background wells are expected to remain relatively stable. Background wells are selected on the basis of location (typically upgradient) and analytical history (non-impacted wells are best). *Intra-well* methods determine statistical significance within individual performance wells by examining historical analytical results (time series) for a given well, thus indicating if changing contaminant concentrations at a given well location result from either remedial activity or natural fluctuation. Comparisons of background well data with sentinel and compliance well data will also be performed to monitor groundwater contaminant movement over time.

Various types of significance tests have been developed to analyze differing types of data populations based upon characteristics such as distribution type (normal vs. non-normal), trend type (changing vs. non-changing), percentage of "non-detect" results for a given population, and the sample population size. This allows for the selection of particular methods that are appropriate for a given situation. For the remedial activity at the subject facility the following statistical tests are proposed for use, although others may be used as the course of remediation progresses:

- Wilcoxon Rank-Sum (Inter-well) - *normal or non-normal data, invariant trends, < 90% non-detects, >3 samples/per well.*
- Parametric Prediction Limit (Inter-well) – *normal data, varying trends,< 15% non-detects.*
- Parametric Prediction Limit (Intra-well) – *normal data, varying trends,≥ 4 samples/well, < 15% non-detects.*
- Non-Parametric Prediction Limit (Inter-Well & Intra-Well) – *normal or non-normal data, can tolerate high percentage of non-detects, compares recent to historical data.*

As indicated by the list above, it is important to note that prior to conducting any test of statistical significance a baseline of analytical data must first be established. For the MNA parameters listed in **Section 4.0** this baseline will consist of the four (4) semi-annual sampling events mentioned previously.

5.1.2 Evaluation of Plume Area

Monitoring well MW-1R will be used as the background well for inter-well statistical analysis of MNA data. Monitoring well MW-4 will be used as a performance well, while downgradient wells MW-7 and MW-8 will be compliance wells. The remaining wells will be used as assessment monitoring wells.

Within 1-3 months of ZVI injection decreases in groundwater contaminant concentrations on the order of a few ppb are to be expected to occur. Oxidation-reduction potential (ORP) levels in groundwater should decrease to near -400 mV or less in the areas immediately downgradient of the ZVI barrier. Since ZVI reactions produce few intermediate compounds, COC levels are expected to decrease in groundwater immediately downgradient of the ZVI injection zone, while end products such as methane, ethane, ethene, and chloride are also expected to increase. COC levels throughout the contaminant plume should decrease as a result of natural attenuation during the two-year period following injection. Direct-push groundwater sampling may be necessary to collect additional groundwater samples with which to evaluate ZVI performance.

5.2 Refining the Site Conceptual Model

Over the course of corrective action the site conceptual model will be refined in order to determine the appropriate course of remediation. Additional information on groundwater chemistry, site lithology, plume characteristics, etc. will be used to further improve understanding of contaminant fate and transport at the site, and to determine any changes to the approved remedial measures if necessary.

5.3 Report Submittals

Corrective action sampling and monitoring reports will be submitted on a semi-annual basis, within 30 days of receiving all complete laboratory analytical reports. All reports submitted regarding evaluation of effectiveness will establish trends of the indicator parameters and contain tables, maps and figures relating to field and laboratory data. Laboratory reports, groundwater maps, contamination concentration maps and cross sections will be included. Specific parameters for individual plume areas will also be ascertained.

Injection reports for the ZVI injection will be submitted in accordance with the injection permits to be issued for the site by the NCDENR Underground Injection Control Section. These reports typically consist of an *Injection Event Record* report detailing the actual event, and subsequent monitoring reports submitted at semi-annual intervals.

6 CONTINGENCY PLAN

6.1 Contingency Plan

Should the selected remedial approach not perform as expected and/or the constituent concentrations do not decrease within five years after implementation of remedial measures, contingency plans will be needed.

Alternate Substrates

Should the introduction of ZVI fail to significantly reduce contaminant concentrations within two years of implementation, substrates other than ZVI may need to be employed. Another substrate that has been shown to effectively reduce contaminant concentrations is oxygen-release compound (ORC) and zero-valent iron (ZVI). ORC as manufactured by Regenesis, Ltd. consists of a dry mixture of calcium hydroxides with potassium phosphates that is injected with water as a slurry. Issues to consider prior to its use are its high pH (11-13), and its insolubility which may lead to settlement during mixing and handling. Hydrogen release compound (HRC) has been shown to effectively enhance reductive dechlorination of halogenated hydrocarbons, but to be less effective with remediating aromatic hydrocarbons. The design and implementation of alternate injection substrates is beyond the scope of this CAP report.

6.2 Safeguard Measures and Site Security

Exposure pathways are limited to on-site contact with groundwater. Monitoring wells are cased and secured with locking well caps. Access to the site is limited during operational hours. Public water is available to the surrounding area. A passive horizontal gas venting system for methane extraction/collection was installed as part of the *Transition Plan.* [9]

6.3 Revisions

Requests for modification of the approved corrective action and implementation schedule will be submitted in writing to the Solid Waste Section. No actions regarding modification will be implemented until written approval is received from the Division of Waste Management. Approval of changes to ZVI injection will be required by the NCDENR Underground Injection Control Section prior to implementation.

7 SCHEDULE AND MAINTENANCE

7.1 Operations & Maintenance

Greene County will oversee day-to-day operation and upkeep of the remediation technology. Any equipment required for remediation will be the responsibility of Greene County. If problems with the remediation system arise, the Solid Waste Section will be notified and a written report will be issued. The Greene Department of Solid Waste can be contacted at (252) 747-5720 regarding daily activities.

7.2 Timeline

Implementation of corrective action will begin within 30 days of CAP approval. Initial activities will consist primarily of administrative tasks including scheduling of drilling and remediation subcontractors, permit preparation/submittal, and materials purchasing. ZVI injection will be performed after the July 2009 semi-annual sampling and monitoring, during which the MNA performance parameter baseline will be established. A timeline estimate for sampling events and performance evaluation is presented in **Table 9**.

8 FINANCIAL ASSURANCE REQUIREMENTS

In general accordance with 15A NCAC 13B .0546, demonstration of financial assurance was achieved through the local government financial test. Semi-annual sampling costs are/were estimated in the post closure financial assurance. Corrective action MNA sampling is incorporated with the semi-annual sampling. The additional expense for MNA is seen in laboratory costs.

ZVI Injection Subcontractor Services + Materials = $30,000
GeoProbe Groundwater Sampling Subcontractor Services = $2,500
<u>MNA Samples (4 @ $750/sample) = $3,000</u>
Estimated Total Cost - $35,500

9 COMPLETENESS OF CORRECTIVE ACTION

Results indicate that reduction of the low level contamination can be achieved through monitored natural attenuation supplemented with ZVI injection. There is no indication that the contamination will reach the relevant point of compliance in a reasonable time period. Institutional controls limit access to the site. Public water is available to the surrounding area. The source area has been capped to limit the infiltration. Monitored Natural Attenuation will be implemented to correspond with semi-annual sampling.

Respectfully submitted

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

NORTH CAROLINA LICENSED GEOLOGIST SEAL 1776 SEAN K. PATRICK

Sean K. Patrick, P.G.

Professional Geologist

REFERENCES

[1] Arnot, J, Gouin, T, Mackay, D 2005, Developed and Application of Models of Chemical Fate in Canada, Practical Methods for Estimating Environmental Biodegradation Rates, Canadian Environmental Modelling Network.

[2] Brown, P.M., 1959, Geology and Ground-water resources in the Greenville Area, North Carolina: North Carolina Department of Conservation and Development, Division of Mineral Resources Bullettin 73, 87p

[3] Environmental Protection Agency, Integrated Risk Information System (IRIS), http://www.epa.gov/iris/index.html.

[4] EPA Technical Factsheets, http://www.epa.gov/OGWDW/contaminants/index.html

[5] Environmental Protection Agency (EPA), 1998, Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in the Ground Water, EPA/600/R-98/128, September.

[6] Environmental Protection Agency (EPA), 1989, Risk Assessment Guidance for Superfund, Volume 1, Human Heath Evaluation Manual (Part A), Interim Final, EPA/540/1-89/002, December.

[7] Environmental Protection Agency (EPA), 2000, BIOCHLOR Natural Attenuation Decision Support System User's Manual Version 1.0 EPA/600/R-00/008, January.

[8] Environmental Protection Agency (EPA), 1996, BIOSCREEN Natural Attenuation Decision Support System User's Manual Version 1.3 EPA/600/R-96/087, August.

[9] Fetter, C.W., 1994, Applied hydrogeology 3rd ed.: Prentice-Hall Inc., New Jersey, p. 93.

[10] Freeze, R.A. and Cherry, J.A., 1979, Groundwater: Prentice Hall, Inc., Englewood Cliffs, New Jersey, 604 p.

[11] GAI Consultants, 1994, Water Quality Monitoring System Modifications and Water Sampling and Testing, Greene County Landfill, Wootens Crossroads, North Carolina, Permit No. 40-02.

[12] Giese, G. L., Eimers, J. L., Coble, R. W., 1997, Simulation of Ground-Water flow in the Coastal Plain Aquifer System of North Carolina. U.S Geological Survey Professional Paper 1404-M, 142p.

[13] Howard, P.H., Boethling, R.S., Jarvis, W.F., Myelan, W.M., and Michalenko, E.M., 1991, Handbook of Environmental Degradation Rates, Lewis Publishers, Inc, Chelsea, MI.

[14] Johnson, A.I. 1967, Specified yield-compilation of specific yields for various materials: U.S. Geological Survey Water-Supply Paper 1662-D.

[15] Municipal Engineering Services Company, P.A, April 1994. Greene County Transition Plan.

[16] Municipal Engineering Services Company, P.A, August 2007. Assessment of Corrective Measures, Greene County Landfill – Permit #40-02.

[17] Olaniran, A. O., Pillay, D., and Pillay, B., Chloroethenes contaminants in the environment: Still a cause for Concern, In African Journal of Biotechnology Vol. 3: 675-682.

[18] Pettenger, Robert, 1997, Evaluation and Statistical Analysis of Ground Water Monitoring Data for Waste Disposal Facilities, Ph.D. Thesis, Purdue University; in ChemStat RCRA Subtitle C & D Statistical Analysis for Windows 95/NT.

[19] Rittmann, B. E., McCarty, P. L., 2001, Environmental Biotechnology: Principles and Applications: McGraw-Hill Companies, New York, NY, 754 p.

[20] State Climate Office of North Carolina. (SCONC), http://www.nc-climate.ncsu.edu/.

[21] U.S. Geological Survey, 2004, National Uranium Resource Evaluation (NURE) Hydrogeochemical and Stream Sediment Reconnaissance data: U.S. Geological Survey, Denver, CO.