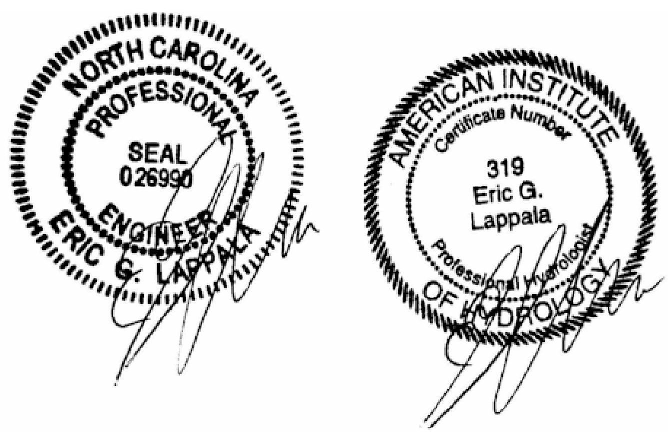
Hydrogeologic and Fate and Transport Analysis

Proposed Construction and Demolition Landfill
Hyde County, North Carolina

August 12, 2006



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Contents

List of Figures

List of Tables

1 Introduction

The proposed Alligator River, LLC (ARR), construction and demolition debris (C&D) landfill (the ARR C&D Landfill) will be located on approximately 570 acres in eastern Hyde County, approximately 15 miles west of the town of Swan Quarter and 10 miles east of Belhaven (the Site). The Site is located on the north side of the portion of the Atlantic Intracoastal Waterway (AIWW) that connects the Alligator and Pungo Rivers (Figure 1). The ARR C&D Landfill will be part of a larger facility (the Facility) that will include a barge terminal and waste processing area where a significant portion of the waste stream will be separated and recycled rather than landfilled.

During the review of the Environmental Assessment for the Facility, several parties requested additional information regarding the likely impact on groundwater and surface water of chemicals that have the potential to leach from C&D landfills. In particular, such information has been requested regarding the impact of metals that may have an impact on aquatic life in the Pungo River, its headwaters, the AIWW, and in major drainage canals regulated by North Carolina that discharge to the AIWW.

As part of the permitting process for the ARR C&D Landfill, ARR has collected a large amount geologic, hydrogeologic, and geotechnical data from field investigations at the Site, and has analyzed and presented this information in a framework (Garrett, 2005) that provides the basis for the conceptual and numerical models used for this report.

1.1 Purpose and Objectives

This report documents the results of the construction, calibration, and application of a three dimensional groundwater flow and transport model to assess the likely zones of groundwater and surface water that may be impacted by recharge that will emanate from the ARR C&D Landfill. Additionally, the model was used to assess the likely impact of leachate from the ARR C&D Landfill on concentrations of certain metals in groundwater and surface water.

The objectives of the analyses described in this report are to demonstrate that:

1) The occurrence and movement of groundwater under both pre-development and full development of the C&D landfill are reasonably well known and predictable. This includes the directions, flow rates, and areas of discharge of groundwater to surface waters under both average and seasonal conditions;

2) The mechanisms and quantities of recharge through the landfill to groundwater can be reasonably estimated based upon known climatic and soils data, conditions during the filling of landfill cells, conditions resulting from emplacement of the final cap and cover system;

3) Given reasonable and conservative estimates of the source concentrations of metals of concern that have the potential to leach from NC C&D landfills, the physical and chemical mechanisms that determine the fate and transport of the metals of concern in groundwater have been identified and used to assess the degree to which they affect

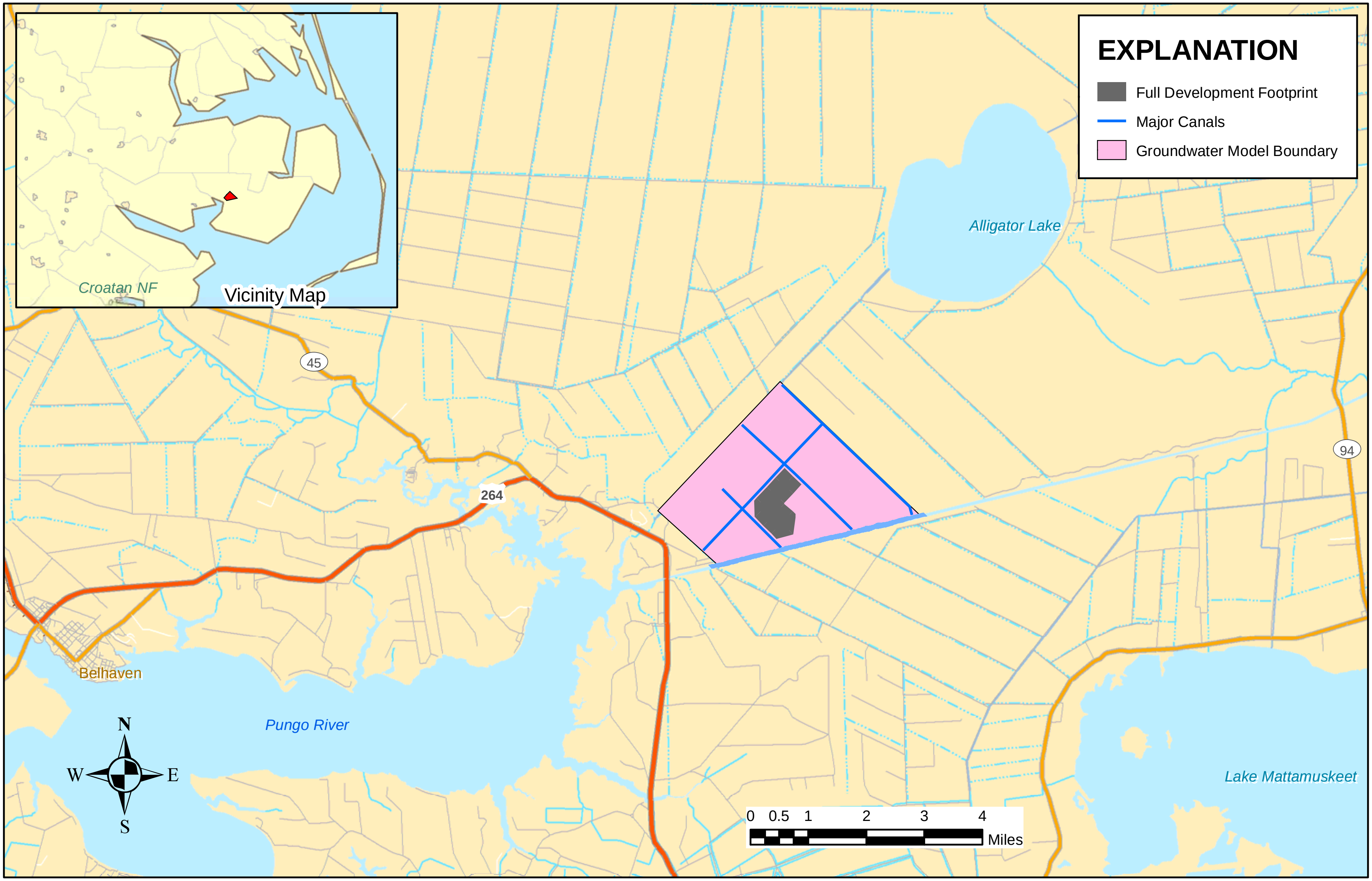
concentrations between the bottom of the landfill, groundwater compliance points, and regulated surface waters;

4) The likely concentrations of the metals of concern in both groundwater and surface water are expected to be below the applicable state standards; and

5) Groundwater monitoring wells can be located on the groundwater flow paths that are likely to contain the highest concentration of constituents that have the potential to be present in leachate emanating from the landfill. These wells can be located between the landfill and zones of discharge of groundwater to regulated surface water bodies.

1.2 Disclaimer

This work was performed by Eagle Resources, P.A. under contract to ARR. The analyses and conclusions presented in this report are based upon data and information provided by others. While Eagle Resources has assessed this information in light of its applicability to the purposes of this project, we make no representation as to its accuracy.



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ESRI: Streetmap USA

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Location Map Alligator River Proposed C&D Landfill Hyde County, NC		
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6/13/06	17011.1	E.G.Lappala

Figure 1

2 Groundwater Occurrence and Movement

The occurrence and movement of groundwater at the Site is demonstrated by first developing a conceptual model of subsurface conditions and the mechanisms of groundwater recharge and discharge. The conceptual model is then quantified by construction, calibration, and application of a three-dimensional numerical model.

2.1 Conceptual Model

The conceptual model has been developed using the large volume of data and analyses developed by ARR for the Site and reported by David Garrett (2005). This information has been supplemented by our experience and understanding of the Coastal Plain Aquifer System and local site conditions based upon site visits.

2.1.1 Topography and Drainage

The topographic control on local, intermediate, and regional groundwater flow and discharge as shown in Figure 2 is well known (Toth, 1965) The Site is located in an area of Hyde County that is characterized by extremely flat topography that is intersected by an extensive system of interconnected man-made drainage ditches and canals (Figure 2). This drainage system was constructed to lower groundwater levels so that the area can be used for agriculture. The drainage system receives groundwater discharge during all times of the year and discharges it to a combination of evaporation from water in the ditches and canals and eventual discharge to the AIWW.

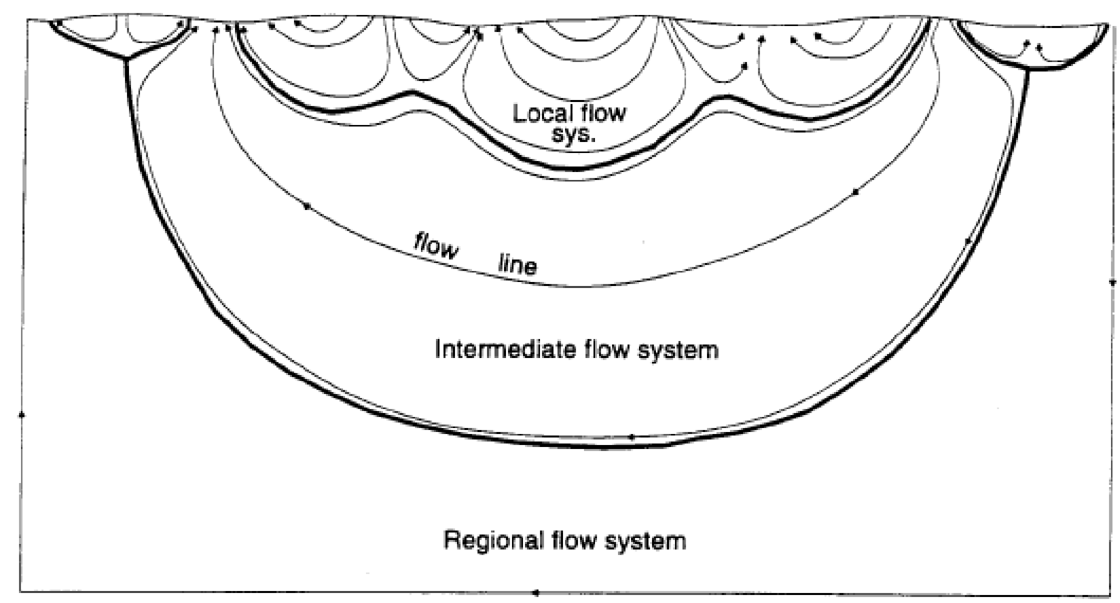


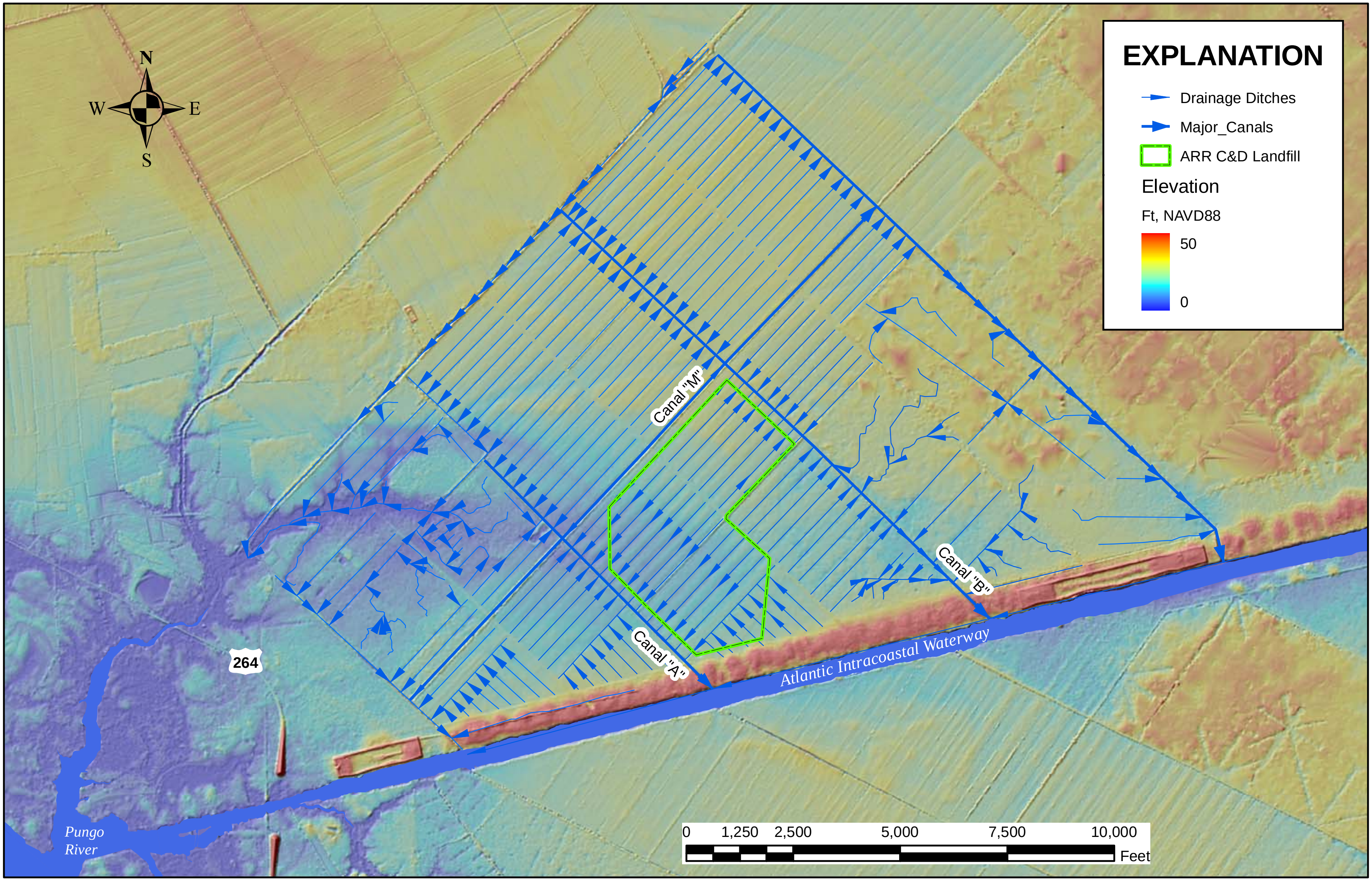
Figure 2.-- Topographic Control on Local, Intermediate, and Regional Groundwater Flow Systems (Modified from Toth, 1965).

At the Site, the local flow system occurs at depths of less than approximately 100 feet and is controlled by the drainage ditches and canals. The intermediate and regional flow systems pertain to groundwater flow in the deeper units of the coastal plain sediments.

Without the presence of the drainage system, groundwater would naturally discharge from the Site to a tributary of the Pungo River as shown in Figure 3. Consequently, the configuration and elevation of the bottom of the ditches and canals control the discharge of groundwater from shallow, intermediate and deep components of the flow system.

The directions of flow of the constructed and natural drainage system were derived from analysis of the elevations in the lowest part of the ends of each drainage segment using data obtained using LIDAR as part of the North Carolina Floodplain mapping program (http://www.ncfloodmaps.com/default_swf.asp.) Both Bare Earth control points and a 20-ft by 20-ft grid of average elevations were downloaded from this site and used in this study. The Bare Earth points in this dataset are located approximately one foot apart and have a reported accuracy of 5 cm (.15 ft). The datum used for this survey is the North American Vertical Datum of 1988 (NAVD88).

Because the elevations of the bottoms of the canals that bound the Site (Canals A, B, and M) are so important in controlling the base level of groundwater discharge at the Site, additional elevation data was obtained by a survey conducted by the East Group in May 2006 under contract to ARR. This survey provided cross section profiles across Canals A, B, and M canals and water surface elevations at 10 locations.



Shaded relief topography from analysis of NC Floodplain Mapping LIDAR 20-ft digital elevation tiles.

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Topography and Drainage Before Development of Landfill.
Drainage Direction Arrows Shown Only in Area of Groundwater Model.

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6/13/06	17011.1	E.G.Lappala

Figure 3

2.1.2 Hydrostratigraphic Units

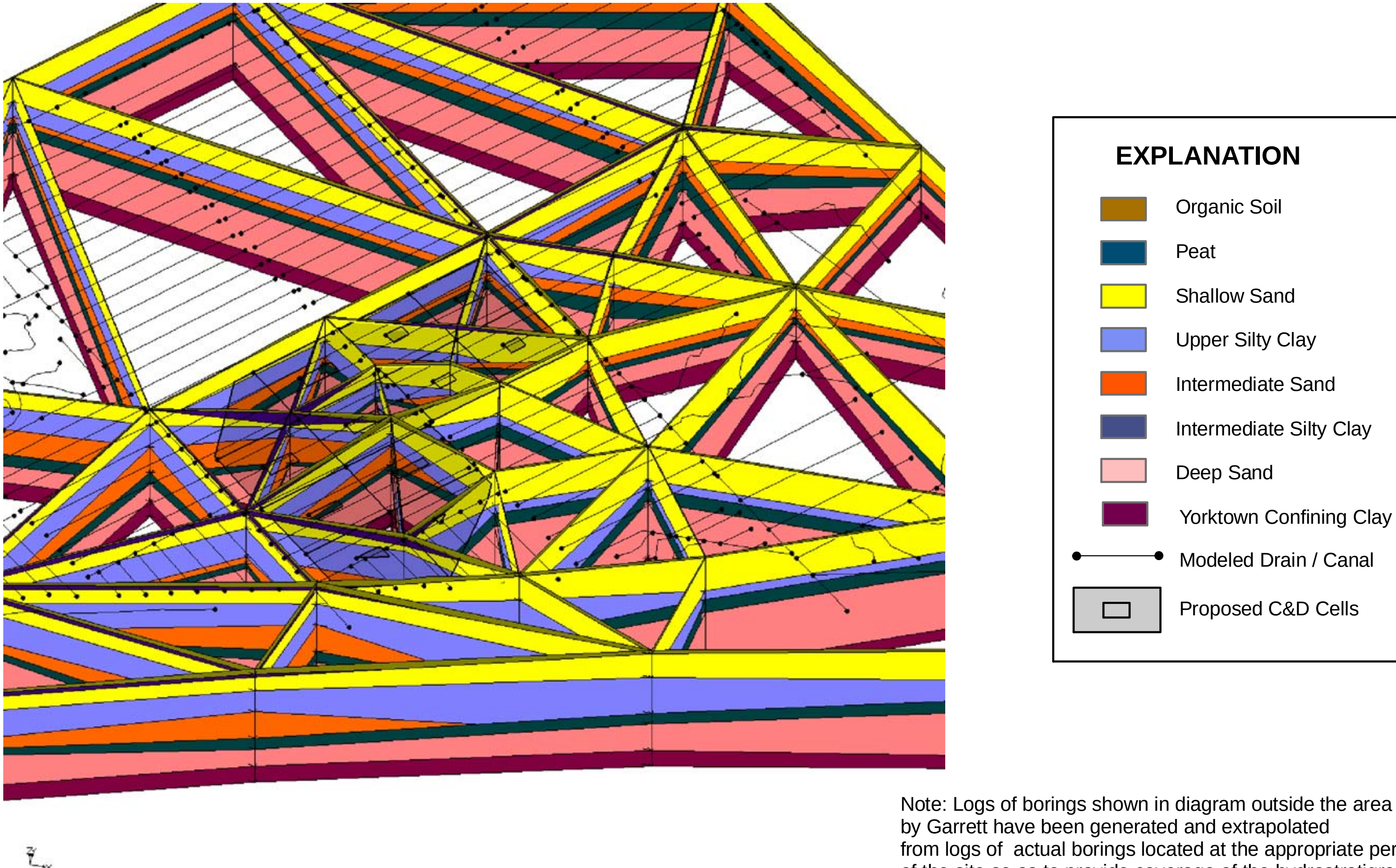
Six hydrostratigraphic units were used to construct the model based upon zones defined by field data and lithologic interpretations provided by ARR (Garrett, 2005, Table 1). The three dimensional distribution of these units is shown in Figure 4 as fence diagrams constructed using cross sections cut through solid models of each unit using tools in the Groundwater Modeling System (GMS™).

All hydrostratigraphic units are part of the Surficial Aquifer Unit as defined in the North Carolina Regional Aquifer Framework database (NCDENR, 2002) and the U.S. Geological Survey (Giese, *et al*, 1997). The Surficial Aquifer overlies low permeability sediments of the Yorktown Confining Unit, the top of which is considered to be the base of the hydrostratigraphic units explicitly considered in the present study. Based upon the log of the three wells closest to the Site in Aquifer Framework Database, the Yorktown confining unit is present at elevations ranging from -25 feet to -92 feet. At the East Lake Well, located approximately four miles northeast of the Site, the top of the Yorktown Confining Unit occurs at an elevation of -58 feet. Well logs of deep borings at the Site did not encounter the Yorktown Confining Unit at elevations greater than -70 feet.

For the conceptual and numerical models, the base of the Surficial Aquifer Unit is considered to be at a constant elevation of -85 feet, or a depth below the average land surface elevation of 90 feet. Because deepest borings at the Site extended to elevations of approximately -70 feet and ended in the deep sand unit, it was assumed that this unit extended to the top of the Yorktown Confining Unit.

2.2 Hydraulic Conductivity

The values of hydraulic conductivity used for each of the units are based upon field tests performed, interpreted and tabulated by David Garrett (Table 3). Table 1 summarizes the values assigned to each hydrostratigraphic unit for the conceptual and numerical models. No separate measurements of horizontal and vertical hydraulic conductivity are available for the Site. However based upon logs of test borings and lithologic descriptions provided by David Garrett, it is reasonable to consider that the hydraulic conductivity of the modeled units is anisotropic. It was assumed that the measured values reported by Garrett represented predominantly horizontal hydraulic conductivity and that the ratio of horizontal to vertical hydraulic conductivity is 10. The values of effective porosity in Table 1 were summarized from David Garrett's Table 2A.



Note: Logs of borings shown in diagram outside the area investigated by Garrett have been generated and extrapolated from logs of actual borings located at the appropriate permeter of the site so as to provide coverage of the hydrostratigraphic units over the modeled domain.

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Hydrostratigraphic Units Based Upon Data and Analyses Provided by D. Garrett (2005)		
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6/13/06	17011.1	E.G.Lappala

Figure 4

Hydrostratigraphic Unit	Hydraulic Conductivity, ft/day		Porosity	Specific Yield (Effective Porosity)
	Horizontal	Vertical		
Organic Soil (1)	0.5	0.5	0.5	0.25
Upper Silty Clay	0.57	0.57	0.46	0.15
Upper Fine Sand	7.3	0.73	0.27	0.2
Intermediate Silty Clay	0.53	0.053	0.55	0.15
Intermediate Sand	25	2.5	0.27	0.22
Deep Silty Clay	0.88	0.088	0.55	0.15
Deep Sand	25	2.5	0.22	0.2
Yorktown Clay (2)	0.01	0.01	0.55	0.1

Notes:

(1) Values for Organic Soil estimated from literature for a clayey silt with high organic matter content. These values also were assumed to represent the conductance of ditches and canals.

(2) Values for Yorktown Clay estimated from Giese, *et al*.

Table 1. Hydraulic Properties Assigned to Hydrostratigraphic Units.

2.3 Boundary Conditions

The Pungo River and the ICE represent boundaries that are controlled by the elevation of the water level in these water bodies. For this analysis a value of zero relative to NAVD88 was used for this water level. The drainage ditches and canals represent drain boundaries that control groundwater discharge by the specification of their invert elevations as described in section 2.2.1.

The lateral boundaries of the model represent no-flow boundaries because they are aligned with major canals or the southern edge of the AIWW and were assigned no-flow boundaries. The basal boundary of the model is the Yorktown Clay. Because of the very low hydraulic conductivity of this unit, a no-flow boundary was assumed for the base of the model.

2.4 Time Domain

All model analyses for this report were run as steady state or a succession of steady states, where multiple time periods were simulated during development of the landfill. This domain was used because the time periods used for the analysis of the landfill development were 5 years for filling of the landfill cells and 30 years following completion of the cap and cover system. The transient response to changed recharge during these periods is on the order of days to a few months based upon model sensitivity analyses. Therefore, the use of a succession of steady states is justified.

2.5 Groundwater Recharge and Discharge

The conceptual model for the Site includes both the addition of water by recharge to the groundwater system and removal by discharge to drains and evapotranspiration (ET).

2.5.1 Recharge

The source of recharge to the groundwater system at the Site is recharged by infiltration and deep percolation of precipitation. Initial estimates of recharge are available from NCDENR (Haven, 2004) based upon water balance modeling using county soil survey data and average climatic data. These values average approximately 4 inches per year for the Site. The USGS determined a value of average recharge of 12 inches per year at the Site as the result of calibrating regional groundwater flow models (Giese, *et al*, 1997, Figure 24).

As discussed subsequently the model was calibrated to both winter and summer water levels. Consequently, estimates of recharge during winter and summer conditions were necessary. The initial estimate of winter recharge when demands by ET are low was 30% of the annual precipitation rate of 52 inches per year measured at the Norfolk, VA climatic station, the closest long term record station to the Site. This initial estimated winter recharge was 16 inches per year (.0036 ft/day). As discussed subsequently this value was increased to 26 inches per year (0.006 ft/day) during model calibration.

2.5.2 Discharge

Groundwater discharge occurs from the modeled area by both flow to drains and canals that intercept the watertable as previously discussed and by ET that draws water through the capillary fringe above the water table to the root zone and the land surface. Because of the shallow groundwater conditions at the Site, ET from groundwater is a significant discharge mechanism during the growing season. The maximum potential ET from groundwater was taken as 42 inches per year during the growing season based calculations with the Priestley-Taylor equation. The maximum depth that ET from groundwater is considered effective was assumed to be eight feet.

Attempts to measure flow in the major canals were made on April 26, 2006 at the stations where canal cross-section profiles were surveyed (Figure 4). However the only location where the velocity in the canal was sufficient to measure was at one location on Canal M where the Site access road enters the Site. The velocity at that location was 0.13 feet per second and the water depth was 3 feet at the center of the 5-ft diameter steel culvert. Assuming that the mean velocity at this location is 0.6 of the measured value, the measured flow was approximately 0.78 ft^3/sec, or 350 gallons per minute. Because only one measurable value of flow in the drains was available model calibration only used this measurement as a qualitative, order of magnitude value against which to assess the reasonableness of modeled discharge to drains.

2.6 Numerical Model

The foregoing conceptual model was used to construct a three-dimensional numerical groundwater flow model. The plan view of the model boundary is shown on Figure 1. The model was solved using the U.S.Geological Survey standard MODFLOW2000 code running within GMS™ Modeling Shell. GMS™ was used as the preprocessor to translate boundary conditions, aquifer properties, recharge, observation well data, and aquifer layer geometry from GIS map coverages to the necessary MODFLOW2000 formats.

2.6.1 Computational Grid

Six layers were used to discretize the model in the vertical direction. Each layer was arbitrarily set to a thickness of 15 feet. To achieve adequate resolution in the horizontal dimension, a uniform grid of 100 feet by 100 feet was used. This resulted in a grid of 183 rows, 165 columns, and six layers, or a total of 18,175 computational cells. The grid was oriented parallel and perpendicular to the drainage ditches and canals on the Site to maximize the accuracy of representing these features.

2.6.2 Hydraulic Conductivity of Model Layers

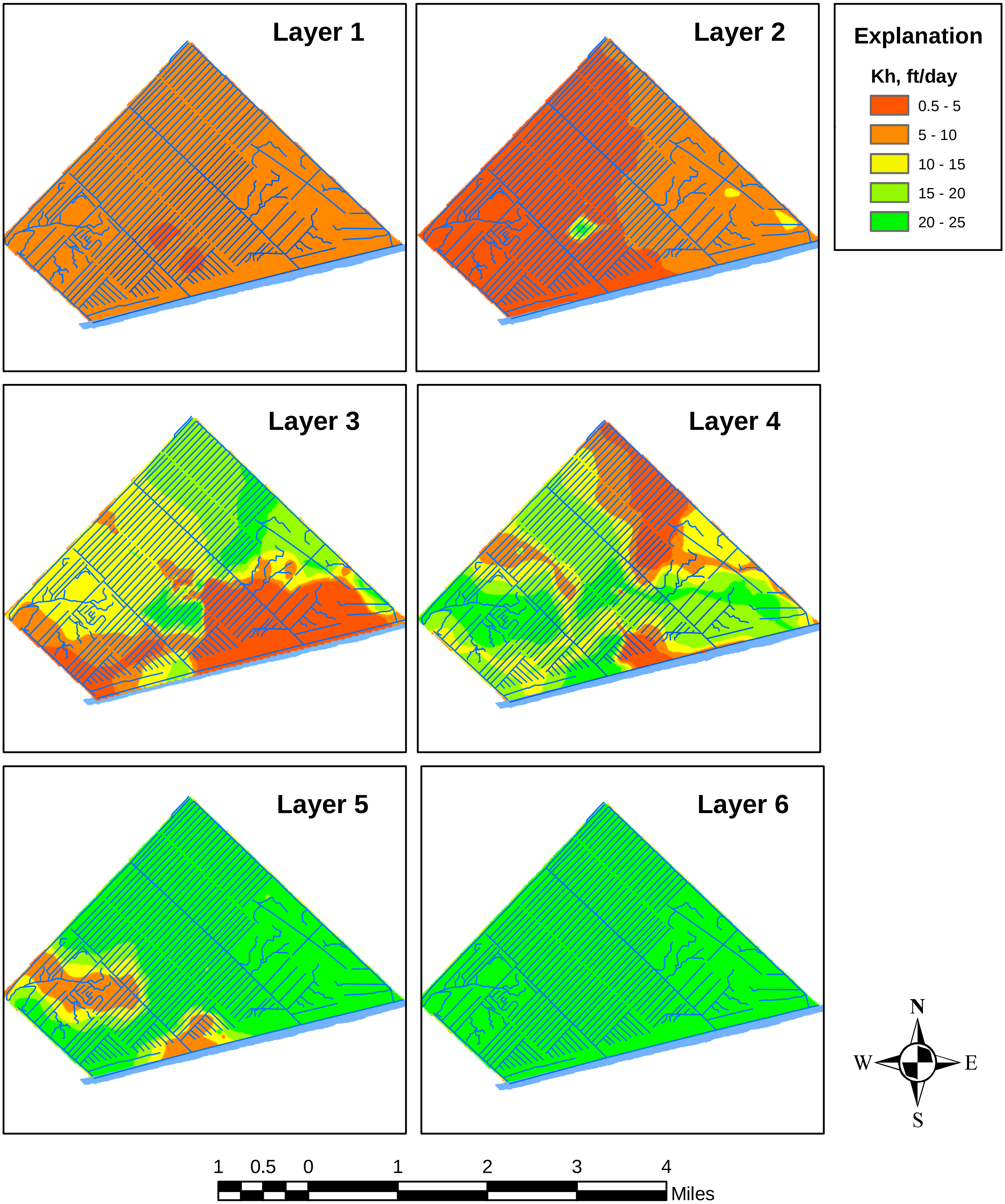
Because the occurrence of the hydrostratigraphic units is complex at the Site it was not possible to assign a discrete model layer to each unit. Consequently, a thickness-weighted conductivity was assigned to each node in each layer using the thickness of each of the units shown in Figure 5 and the hydraulic conductivity values in Table 1. The resultant hydraulic conductivity distribution for layers one through five each layer is shown in Figure 5. These values were not changed during model calibration.

2.6.3 Boundary Conditions

The boundary condition used to represent the Pungo River and the AIWW was a River Boundary that is present only in the top layer of the numerical model. The top of the river bed elevation for this boundary condition was set at an elevation of -5 feet and the thickness of the river bed was set at one foot. The conductance of the river bed was set at the large value of 1000 ft^2/day/ft to assure a high degree of hydraulic connection with the groundwater system.

A Drain Boundary was used to represent the drainage ditches and the major canals. As previously discussed, the elevations of these major canals were defined by a field survey. These surveyed elevations and elevation data from the LIDAR survey were used to set the elevation at each end of the canals. The elevations between these endpoints were automatically calculated by GMS™ using linear interpolation. The elevations of the drainage ditches were taken from interpretation of the LIDAR survey data.

The initial conductance of the drains and canals computed using the assumed hydraulic conductivity of the Organic Soil unit shown in Table 1 (0.5 ft/day), and a width of 3 feet for the ditches and 20 feet for the canals. Because this model parameter was not measured by field tests, it was considered a model calibration parameter.



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Horizontal Hydraulic Conductivity (Kh) for Each Model Layer. Thickness-weighted Values Developed Using Thickness from Figure 4 and Kh from Table 1.			Figure 5
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6/15/2006	17011.1	E.G.Lappala	

2.6.4 Model Calibration and Verification

Steady state analyses cannot uniquely identify recharge and hydraulic conductivity values by calibration unless both water levels and groundwater discharge measurements are available. Because groundwater discharge values were not possible to obtain for the Site, as previously discussed, model calibration only involved varying the winter recharge to achieve a reasonable match between observed and modeled water level elevations. Water level measurements made on January 21, 2005 and June 1,2005 provided by ARR (Garrett, 2005, Table 5) were used for model calibration.

2.6.4.1 Model Calibration

Model calibration comprised adjusting the winter recharge rate and the conductance of the drains and canals until a reasonable match between observed and modeled water levels in wells in the well clusters was achieved. Figure 6 shows the result of the best fit that was obtained by increasing the winter recharge rate to 26 inches per year (0.006 ft/day).

The drain conductance was reduced from the initial estimated values of 5 feet per day to 0.5 ft^2/day/ft to achieve an acceptable degree of calibration. This value is reasonable because it is essentially equivalent to the vertical conductivity used to simulate the top layer of the model that contains the drains. The winter simulation did not include ET from groundwater. Hydraulic conductivity values shown in Figure 5 were not adjusted during model calibration.

2.6.4.2 Model Verification

To assess the adequacy of model calibration to winter water levels, a comparison to measured summer water levels was made using the calibrated values for winter recharge and drain conductance, and adding ET from groundwater. The match shown in Figure 6 illustrates that this combination of model parameters reasonably well represents measured water levels during both wet and dry seasons.

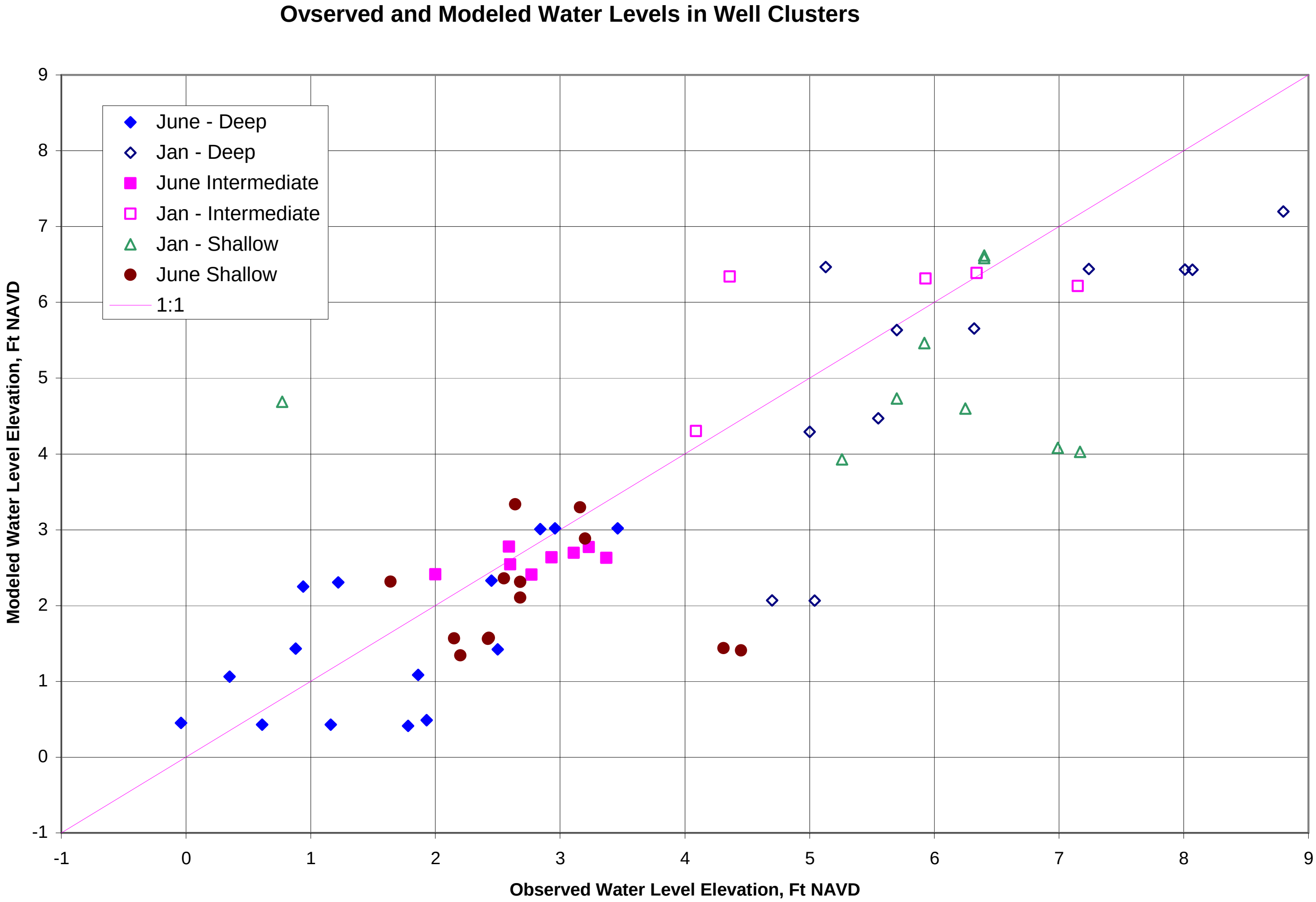
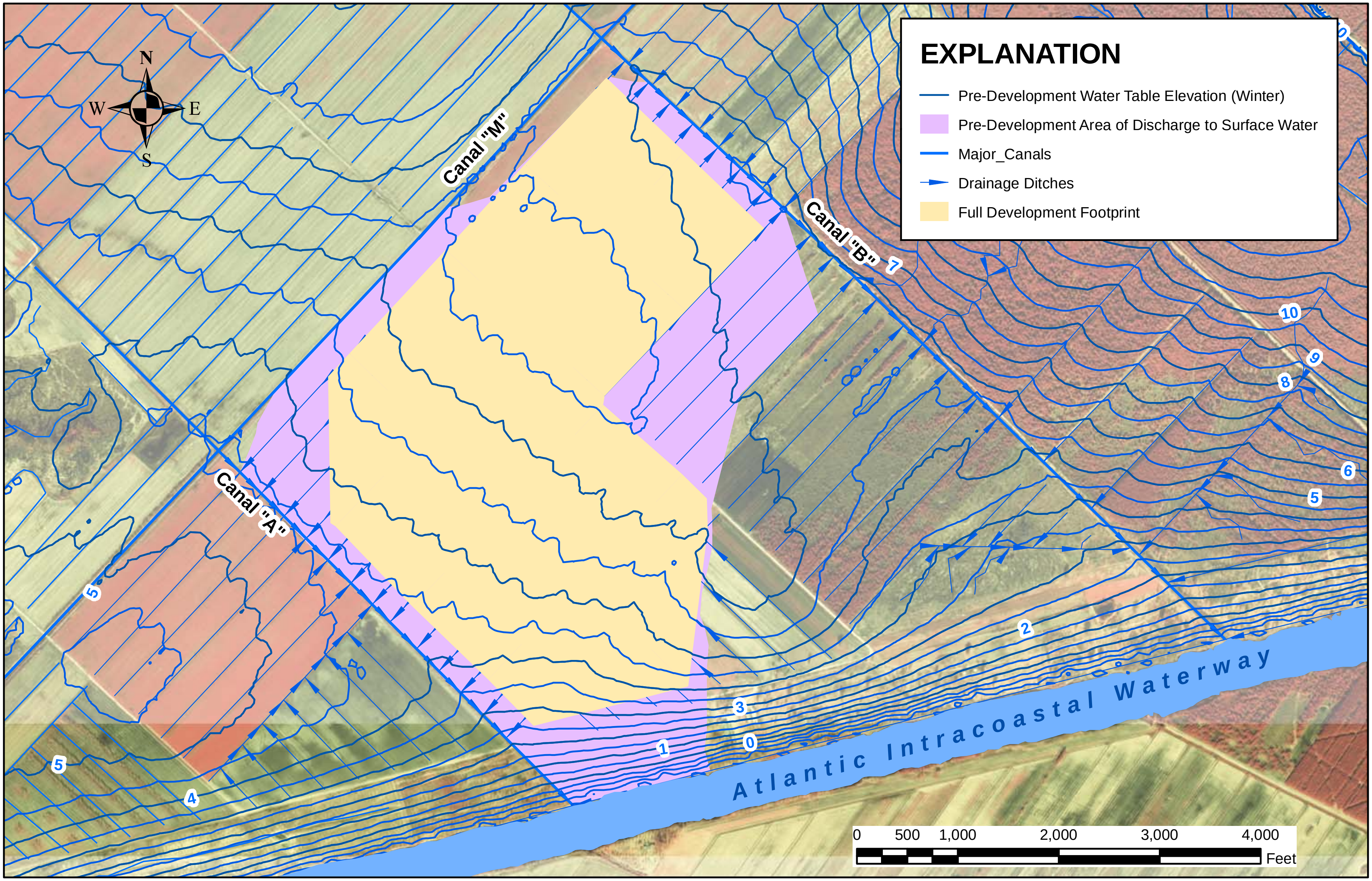


Figure 6.-- Observed and Modeled Water Level Elevations in Well Clusters for January 2005 and June 2005.

2.7 Pre-Landfill Groundwater Discharge to Surface Water

The portions of drainage ditches and canals to which groundwater will likely discharge from the area to be occupied by the ARR C&D Landfill prior to construction was analyzed using groundwater pathline analyses. For this analysis a hypothetical particle was placed at on the watertable at the center of each 100-foot square model grid cell that will be overlain by the completed landfill.

The pathline analysis used the steady state head distribution from the model and effective porosity values to compute the path followed by each hypothetical particle from its origin on the watertable to its eventual discharge point. The locus of these points comprises the maximum distance from the landfill that recharge from the landfill will affect surface water in drains, canals, and the AIWW. Figure 7 shows these areas and illustrates that all recharge emanating from the landfill will be discharged to drainage ditches that drain to Canals A, B, and M and to the AIWW and that no discharge of such recharge occurs to the headwaters of the tributary to the Pungo River lying to the west of the Site.



Basemap:
March, 1998 Color Infrared Orthophotos
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Pre-Development Watertable Elevation and Area of Groundwater Discharge from Area of Landfill Winter Condition		
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6/13/06	17011.1	E.G.Lappala

Figure 7

3 Recharge During and Following Landfill Construction

Two time periods were used to assess the likely recharge during and following landfill emplacement: 1) during the filling of each landfill cell, and b) thirty years following the completion of the landfill cap and cover system. The time periods used for this assessment comprised sequential periods of five years to fill each of the proposed 12 landfill cells, followed by capping of each cell in turn, followed by 30 years following the capping of the final cell.

3.1 Recharge during Filling of Active Cells

Landfill operations should remove the seasonality of recharge. Consequently, the recharge used for the fill periods for all areas of the model not occupied by active of completed landfill cells was taken as the average between the winter rate of 26 inches per year and the rate computed with the model during the model verification analysis that included ET from groundwater during the growing season. This net average annual recharge rate was 10.5 inches per year, which is close to the 12 inches per year determined by the USGS for the area including the Site (Giese, *et al*, 1997).

Based upon information in the Conceptual Facility Plan (Garrett, 2005), it was assumed that construction and compaction of the pad and emplaced waste and daily cover and collection of storm runoff will reduce the opportunity for groundwater recharge. Consequently during fill periods, recharge was assumed to be 6 inches per year. The effect of this on maximum groundwater mounding beneath the landfill was assessed using sensitivity analyses as described in section 3.3.

Active landfill operations will remove the potential for groundwater to be discharge by ET because of the construction of the four–foot thick pad (Garrett, 2005) and the emplacement and compaction of landfill materials which will increase the depth to the water table. The porosity and bulk density of the landfill materials will also likely eliminate capillary rise from a water table even if it is present at the predevelopment grade elevation. Consequently ET from groundwater was not explicitly included in analyses of the impact of the landfill on groundwater flow patterns.

3.2 Recharge with Cap and Cover System in Place

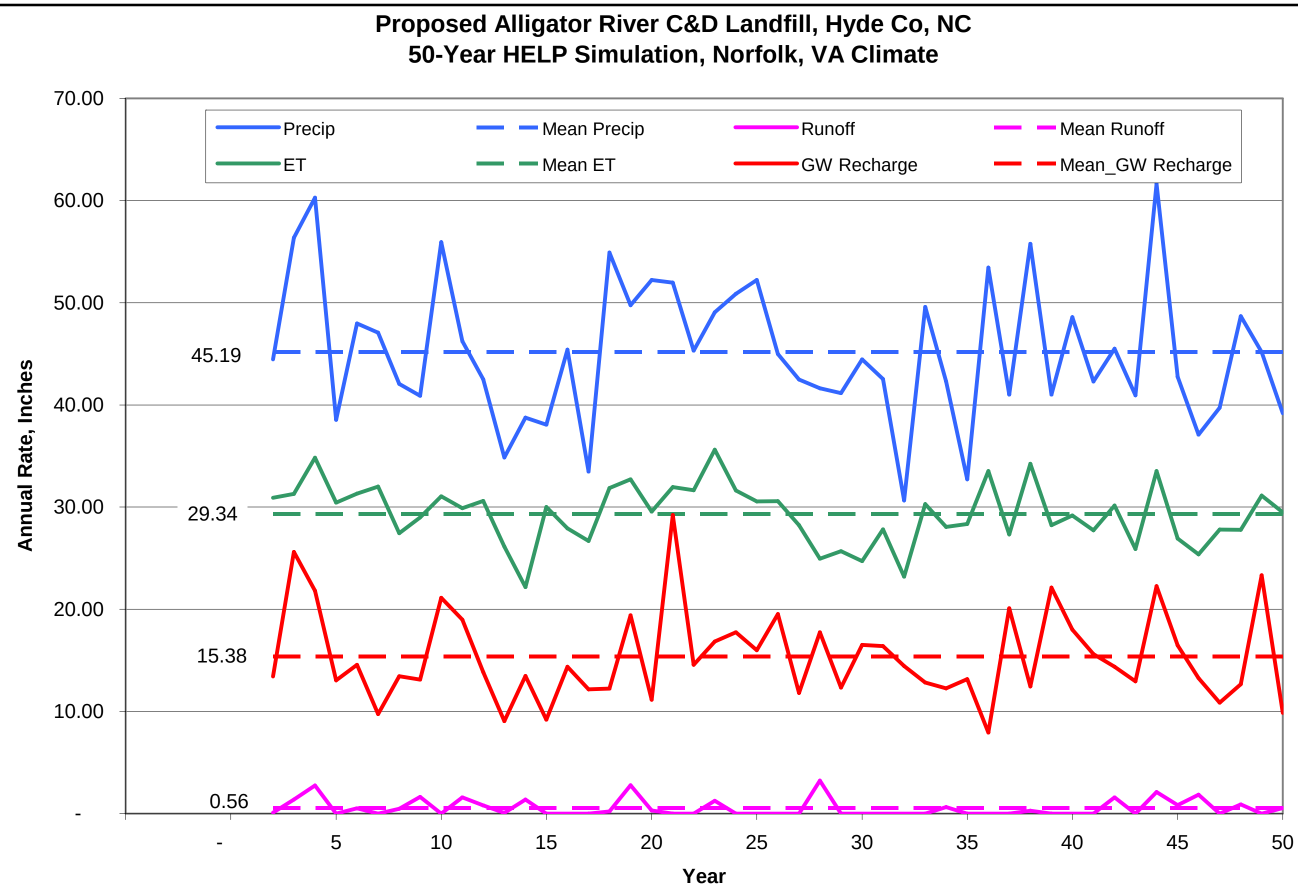
The AAR C&D Landfill will be required to emplace a cap and cover system on completed landfill cells to minimize infiltration of precipitation and leachate generation. The likely recharge to groundwater resulting from this system, the emplaced waste and the pad beneath the cells was assessed using the Hydrologic Evaluation of Landfill Performance model. This model is an industry standard to assess the components of the hydrologic balance for landfills.

The HELP analysis used 50 years of synthetic climatic data generated using parameters derived from the Norfolk, VA climatic station. This station is the closest station to the sit with long term records that are provided in the HELP standard input database tables.

The design of the landfill cover system was provided by David Garrett (Personal Communication, 2006) to be consistent with new cap and cover requirements of the North Carolina Division of Waste Management. The design parameters for the pad to be placed beneath each landfill cell are shown in Figure 8.

Figure 9 shows the annual values of the components of the hydrologic budget for the simulated ARR C&D Landfill for the 50-year period used for analysis. The average annual recharge to groundwater is 15.4 inches per year. This rate was applied to all landfill cells in the order they were assumed to be filled based on information provided by ARR (Dan Moore, Personal Communication, 2006).

Figure 9 shows the maximum mounding beneath the completed landfill cells. This maximum occurs approximately 10 years following the closure of the last cell.



Landfill Design

Layer	Layer Description	Texture / Slope	Thick-ness Ft	Ksat cm/sec	Water Content Vol Fraction Total	Field Capacity	Wilting Point
1	Vegetation	Silty Loam 5%	0.5	1.00 e-04	0.50	0.28	0.14
2	Drainage	Loamy Sand 5%	0.25	1.00 e-02	0.44	0.11	0.05
3	Protective Cap	Silty Clay 5%	1.5	1.00E-05	0.48	0.37	0.25
4	C&D Waste	Waste (20 lb.ft^3) 0%	145.0	1.00 e-03	0.67	0.29	0.08
5	Compacted Base	Silty Loam 0%	2.5	1.00 e-05	0.50	0.28	0.14
6	Subbase	Silty Loam 0%	5.0	1.00 e-04	0.50	0.28	0.14

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Alligator River HELP Simulation 50-Year Synthetic Climate based upon Norfolk, VA. Landfill layer design from David Garrett.

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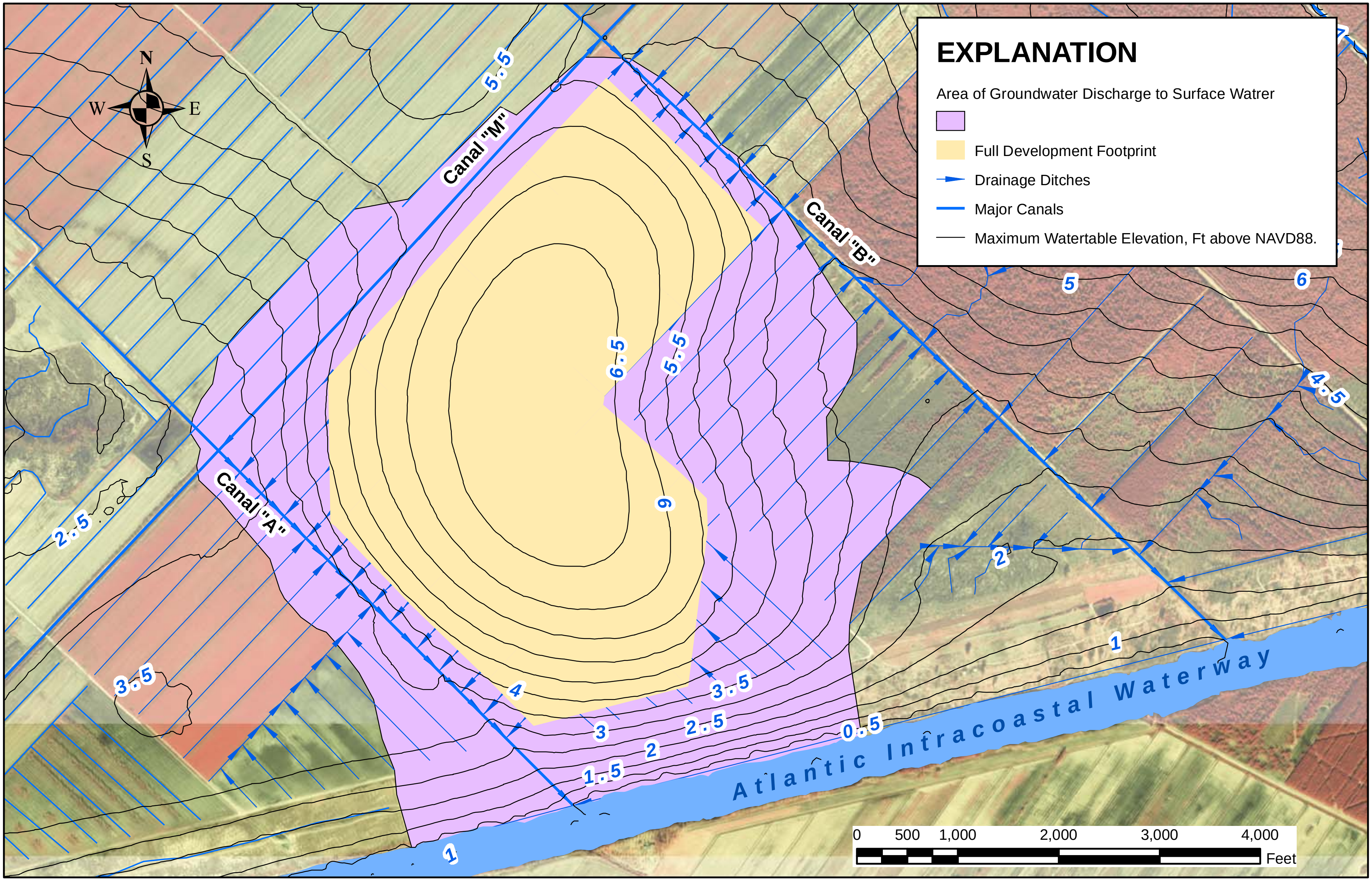
5/15/06	17011.1	E.G.Lappala

Figure 8



Basemap:
March, 1998 Color Infrared Orthophotos
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Full Development Watertable Elevation and Area of Groundwater Discharge from Area of Landfill		
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6/13/06	17011.1	E.G.Lappala

Figure 9

4 Fate and Transport Mechanisms

A review of the technical literature identifying constituents of concern in the C&D waste stream was conducted by ENSR International. ENSR concluded that the analytical results for leachate from a C&D landfill in North Carolina provided the most representative available data for expected concentrations in leachate from the ARR C&D Landfill. To provide conservative analysis (maximum simulated concentrations), the upper 95% confidence interval values concentration values reported by ENSR for all constituents (Arsenic[As], Lead [Pb], Chromium [Cr], and Cadmium [Cd]) were used as source terms for fate and transport modeling. Table 2 shows the values of these source concentrations.

Simulated Metal	Source Concen-tration (ENSR, 2006) mg/l	NC 2L Standard mg/l	NC 2B Standard mg/l	Distribution Coefficient (Kd) for Each Model Layer L/kg					
				1	2	3	4	5	6
Arsenic	0.011	0.05	0.05	none	none	none	none	none	none
Lead	0.0052	0.015	0.025	1,500	20	20	20	20	20
Chromium	0.0113	0.05	0.05	20	20	20	20	20	20
Cadmium	0.0015	0.00175	0.002	20	20	20	20	20	20

Table 2.-- Source Term Concentrations and KD Values Used to Assess the Fate and Transport of Constituents of Concern.

The source term for the metals in Table 2 was simulated by assigning the source concentration to recharge to the watertable below the footprint of the landfill cells.

As part of the assessment of potential impact of these metals on groundwater and surface water by leachate, soil samples were collected at one to three depths ranging from 12 to 40 inches at 12 locations in the footprint area of the proposed ARR C&D Landfill. Figure 11 shows the location of the soil samples. These metals were analyzed for background values of mercury (Hg), arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), lead (Pb), selenium (Se), and silver (Ag). Splits of the samples were also submitted to the North Carolina Department of Agriculture laboratory for analyses of the properties such as organic matter content, Cation Exchange Capacity (CEC), and bulk density to aid in assessing the potential of the sampled soils to attenuate the metals of concern. Table 3 shows the results of the laboratory analyses for these parameters.

Table 3.-- Results of Laboratory Analyses of Soil Samples Collected from Multiple Depths and Locations within the Area of the Proposed ARRR C&D Landfill.

Labora-tory	Parameter	Site ID -->	SS-1	SS-2			SS-3			SS-4		SS-5		SS-6		SS-7		SS-8		SS-9		SS-10		SS-11		SS-12	
		Depth, In -->	24	12	21	24	12	30	36	12	24	12	24	12	24	12	24	12	40	12	40	12	24	12	24	12	24
	Total Solids	%	82.3			85.9	57.3		82.6		80.8		81.1	80.2	85.2	82.4	85		81.2		70.7	53.9	81.1	48.5	80.9	39.4	75.2
Environmental Science Corp.	Hg (mg/kg)	Value	0.031			BDL	BDL		BDL		0.041		BDL	BDL	BDL	0.046	BDL		BDL		BDL	BDL	BDL	BDL	BDL	0.08	0.03
		MDL	0.024			0.023	0.035		0.024		0.025		0.025	0.025	0.023	0.024	0.024		0.025		0.028	0.037	0.025	0.041	0.025	0.051	0.026
	As (mg/kg)	Value	BDL			BDL	BDL		BDL		BDL		BDL	BDL	BDL	BDL	BDL		BDL		BDL	BDL	BDL	BDL	BDL	BDL	BDL
		MDL	1.2			1.2	1.7		1.2		1.2		1.2	1.2	1.2	1.2	1.2		1.2		1.4	1.8	1.2	2.1	1.2	2.5	1.3
	Ba (mg/kg)	Value	12			8.5	31		8.3		18		7.7	5.6	11	33	31		6.3		9.2	36	5.7	37	20	68	21
		MDL	0.3			0.29	0.44		0.3		0.31		0.31	0.31	0.29	0.3	0.29		0.31		0.35	0.46	0.31	0.52	0.31	0.63	0.33
	Cd (mg/kg)	Value	BDL			BDL	BDL		BDL		BDL		BDL	BDL	BDL	BDL	BDL		BDL		BDL	BDL	BDL	BDL	BDL	BDL	BDL
		MDL	0.3			0.29	0.44		0.3		0.31		0.31	0.31	0.29	0.3	0.29		0.31		0.35	0.46	0.31	0.52	0.31	0.63	0.33
	Cr (mg/kg)	Value	5.4			1.5	2.9		2		4.5		2.4	1.5	1.9	20	18		2.8		4	4.3	3.2	3.2	2.9	3.4	3.6
		MDL	0.61			0.58	0.87		0.6		0.62		0.62	0.62	0.59	0.61	0.59		0.62		0.71	0.93	0.62	1	0.62	1.3	0.66
	Pb (mg/kg)	Value	3.5			1.6	2.7		2		3.3		1.4	1.1	1.7	7.9	5.7		1.4		1.9	3.1	2	1.9	2.3	5.6	2.1
		MDL	0.3			0.29	0.44		0.3		0.31		0.31	0.31	0.29	0.3	0.29		0.31		0.35	0.46	0.31	0.52	0.31	0.63	0.33
	Se (mg/kg)	Value	BDL			BDL	BDL		BDL		BDL		BDL	BDL	BDL	BDL	BDL		BDL		BDL	BDL	BDL	BDL	BDL	BDL	BDL
		MDL	1.2			1.2	1.7		1.2		1.2		1.2	1.2	1.2	1.2	1.2		1.2		1.4	1.8	1.2	2.1	1.2	2.5	1.3
	Ag (mg/kg)	Value	BDL			BDL	BDL		BDL		BDL		BDL	BDL	BDL	BDL	BDL		BDL		BDL	BDL	BDL	BDL	BDL	BDL	BDL
		MDL	0.61			0.58	0.87		0.6		0.62		0.62	0.62	0.29	0.61	0.59		0.62		0.71	0.93	0.62	1	0.62	1.3	0.66
NCDA&CS Agronomic Division Lab	Humic Matter	%		10+	10+	0.6	10+	0.66		6.99		6.02	0.97	7.96	0.81		0.13	9.21		9.21	0.86		0.71		1.14	1.94	6.99
	Density	g/cm^3		0.67	0.67	1.38	0.75	1.25		0.74		0.87	1.24	0.74	1.25		1.22	0.62		0.65	1.33		1.27		1.14	1	0.88
	CEC	meq/100cm^3		19.2	19.3	2.9	12.4	4.1		10.5		11.2	3.8	15.4	3.9		4	14		26.4	3.8		3.9		5.4	5.4	10.5
	Base Saturation	%		71	65	38	36	24		31		46	42	55	33		45	57		86	50		33		28	31	35
	Ca % of CEC	%		50	44	24	24	16		21		34	30	39	23		24	24		74	36		24		18	19	21
	Ca	meq/100cm^3		9.60	8.49	0.70	2.98	0.66		2.21		3.81	1.14	6.01	0.90		0.96	3.36	-	19.54	1.37		0.94		0.97	1.03	2.21
	Mg % of CEC	%		20	20	11	11	8		10		12	11	15	9		19	4		12	12		9		9	11	14
	Mg	meq/100cm^3		3.84	3.86	0.319	1.364	0.328		1.05		1.344	0.418	2.31	0.351		0.76	0.56	0	3.168	0.456		0.351		0.486	0.594	1.47
	Exchangable Acidity	meq/100cm^3		5.6	6.7	1.8	7.9	301		7.2		6	2.2	6.9	2.6		2.2	6		3.6	1.9		2.6		3.9	3.7	6.8
	pH			5.2	4.8	4.6	4	4.5		4.4		4.5	5	4.7	4.9		4.8	5.8		5.9	5.3		4.7		4.4	4.6	4.2
	P-Index			19	22	9	29	13		38		25	25	25	21		0	9		9	4		14		28	58	50
	K-Index			44	34	6	19	7		19		17	10	34	12		23	825		30	20		10		11	16	19
	Mn-Index			26	29	2	17	2		7		10	4	32	5		3	28		5	3		10		2	5	12
	Mn-Availability Index			38	43	11	35	11		29		31	12	44	16		12	30		15	12		16		11	13	32
	Zn-Index			214	187	8	46	0		61		27	11	72	9		7	29		43	12		11		11	15	30
	Zn-Availability Index			355	310	8	76	0		101		45	11	120	9		7	48		71	12		11		11	15	50
	Cu-Index			46	37	12	18	0		17		16	12	35	12		46	11		19	16		15		17	11	25
	Sulfer-Index			21	29	24	7	58		33		32	50	30	40		33	21		29	84		33		50	36	33

The fate and transport of these metals was assessed using the model MT3DMS (Zheng, *et al* 1999). That was developed for the U.S. Army Corps of Engineers. MT3DMS was used within the same GMS™ modeling shell used for MODFLOW-2000 for the groundwater flow model. The fate and transport mechanisms simulated by MT3DMS for this project are: advective transport with moving groundwater, hydrodynamic dispersion, and for all metals except arsenic, sorption on subsurface materials.

4.1 Advective Transport

The bulk movement of groundwater provides the basic transport mechanism to move chemicals from areas of recharge to areas of discharge. The direction and velocity of groundwater flow is determined in MT3DMS by using the three-dimensional distributions of: a) hydraulic head computed with the groundwater flow model, b) the hydraulic conductivity used to compute the hydraulic head, and c) the effective porosity of the materials comprising the hydrostratigraphic units.

4.2 Hydrodynamic Dispersion

Hydrodynamic dispersion is the mechanism responsible for the spread of the concentration distribution in directions transverse to the mean direction of groundwater flow. It is quantified in the transport equation solved by MT3DMS by the product of the groundwater velocity and measures of the formations tendency to cause paths taken by water and dissolved solutes to deviate from mean flow direction and magnitude. The longitudinal dispersivity is the measure of the tendency to deviate from the mean velocity in the direction of mean groundwater flow. Transverse and vertical dispersivity are the measures of the tendency to deviate in the lateral horizontal and lateral vertical directions.

The value of longitudinal dispersivity for the hydrostratigraphic units was estimated from literature values for similar materials and was assigned a value of 10 feet for all sediments. The effect of using this reasonably low value for the scale of the groundwater flow system is to decrease dilution and increase the sharpness of the front of solute.

4.3 Sorption

All of the metals simulated except arsenic have at least some potential to adhere (sorb) on aquifer materials. Arsenic is generally present as anionic species in groundwater and is generally not attenuated by sorption. This is particularly true if reducing conditions are present in the subsurface. Arsenic was therefore simulated as a conservative constituent.

The potential for sorption is a function of both the solute (metal) and the aquifer material. The sorption is measured by the relationship of the dissolved concentration of the solute in water to the concentration sorbed on the aquifer materials. This relationship can be simple or complex, and for the metals analyzed can be estimated by using geochemical equilibrium models. However this approach requires thermodynamic data for the metals of concern that was not available.

Consequently, sorption of metals other than arsenic for this study assumed that the distribution between the dissolved and sorbed phases was linear. The slope of this linear relationship is the so-called Distribution Coefficient (K_D). The source of values for K_D was the extensive compilation of values for metals and other constituents on four soil types by Sheppard and Thibault (1990). The values of K_D used for all metals on each of the subsurface materials are shown in Table 2. To be conservative, the values of K_D were reduced by a factor of 10 from those listed in Sheppard and Thibault. Values of K_D for all metals except lead were not varied by material type because the values tabulated by Sheppard and Thibault do not vary significantly between clays, sand, sandy loam and organic soils. However the value for lead is significantly higher for organic soils than for the other materials. Because layer one of the model contains a higher proportion of these soils, a higher value of K_D for lead was used for this layer.

5 Likely Impacts from Leachate to Groundwater and Surface Water

For the purposes of this report, only the filling and closure of cell 3-A was simulated. This cell was chosen because it is likely to be the first cell filled and closed (Dan Moore, personal communication, 2006) and because it's northern edge is only 200 feet from Canals B and M which are a regulated water bodies. Modeled impacts from other cells that are within 200 feet from these canals as well as Canal A would be similar, if not identical because of the groundwater flow pattern shown in Figure 9. Impacts to surface water from cells more distant from the canals would be lower than those simulated for Cell 3-A.

The analyses simulated recharge of water below the footprint of Cell 3-A for each of the metals in Table 3 for a period of 35 years: 5 years to fill the cell and 30 years of monitoring following the emplacement of the cap and cover system. The variation in recharge through the landfill during these time frames was as previously described in section 3 of this report.

5.1 Time Dependence of Source Concentrations

To simulate the conditions caused by the fact that the entire area of a cell will not be uniformly filled before the final cap and cover is emplaced, a time-varying source term was applied over the entire cell area. It was assumed that this variation was linear from zero at the time of the start of filling to the maximum values shown in Table 3 at the end of 5 years. This simulates the buildup of material that has the potential to leach and the development of leaching conditions and leachate during the 5-year period.

5.2 Simulated Extent of Metals in Groundwater

The transport model was used to compute the three-dimensional distribution of the simulated metals for 35 years following the initiation of waste emplacement in Cell 3-A. Review of model output showed that the maximum concentrations at the end of the 35-year period were represented by the distribution in Layer 1 of the model. Figures 10 through 13 show the simulated extent of each metal at the end of 35 years.

5.3 Simulated Impacts to Groundwater at Review Boundary

The compliance boundary for the assessment of likely impacts to groundwater and surface water was taken as the Site boundary, which is coincident with Canals A, B, and M. The edge of the landfill will be located 200 feet from these boundaries. The review boundary is established one half the distance from the waste boundary to the compliance boundary. To assess the likely concentration of metals at the review boundary potential monitoring locations were located at 200 foot intervals along a line 100 feet from the canals. Potential monitoring wells were simulated as being completed in the upper, intermediate, and deep sand (layers 1,3, and 5 of the model)

The model was used to compute the time history of the simulated metals at each of these locations to determine the location that the maximum concentration would likely occur at during the 35-year simulation period. That location was determined to be within the shallow system at a location assigned the number MW-24S. The simulated time series of concentrations in this well for each of the metals is shown in Figures 10 through 13. These charts show the results as the fraction of the North Carolina 2L standards. The maximum simulated concentration after 35 years is much less than the 2L standard.

5.4 Simulated Impacts to Regulated Surface Waters

To assess the likely impact of metals dissolved in groundwater that discharges to surface water. This impact was computed as the concentration in groundwater discharging to each drain or canal cell that received water that emanated from the landfill. The flow of water at each of these locations was determined by summing all groundwater discharge to connected drains upstream of these cells using GMS™ . The concentration in Canal B at each of ten stations corresponding to the confluence of drainage ditches from the north and Canal B was then computed using the following equation

$$C_{STA} = \frac{C_1 Q_1 = C_2 Q_2}{Q_1 + Q_2};$$

Where C_{STA} = Concentration below the confluence of Canal B and lateral ditches;
C_1 *and* C_2 = Concentration in Canal B and lateral ditches above the confluence; and
Q_1 *and* Q_2 = Flow in Canal B and lateral ditches above the confluence.

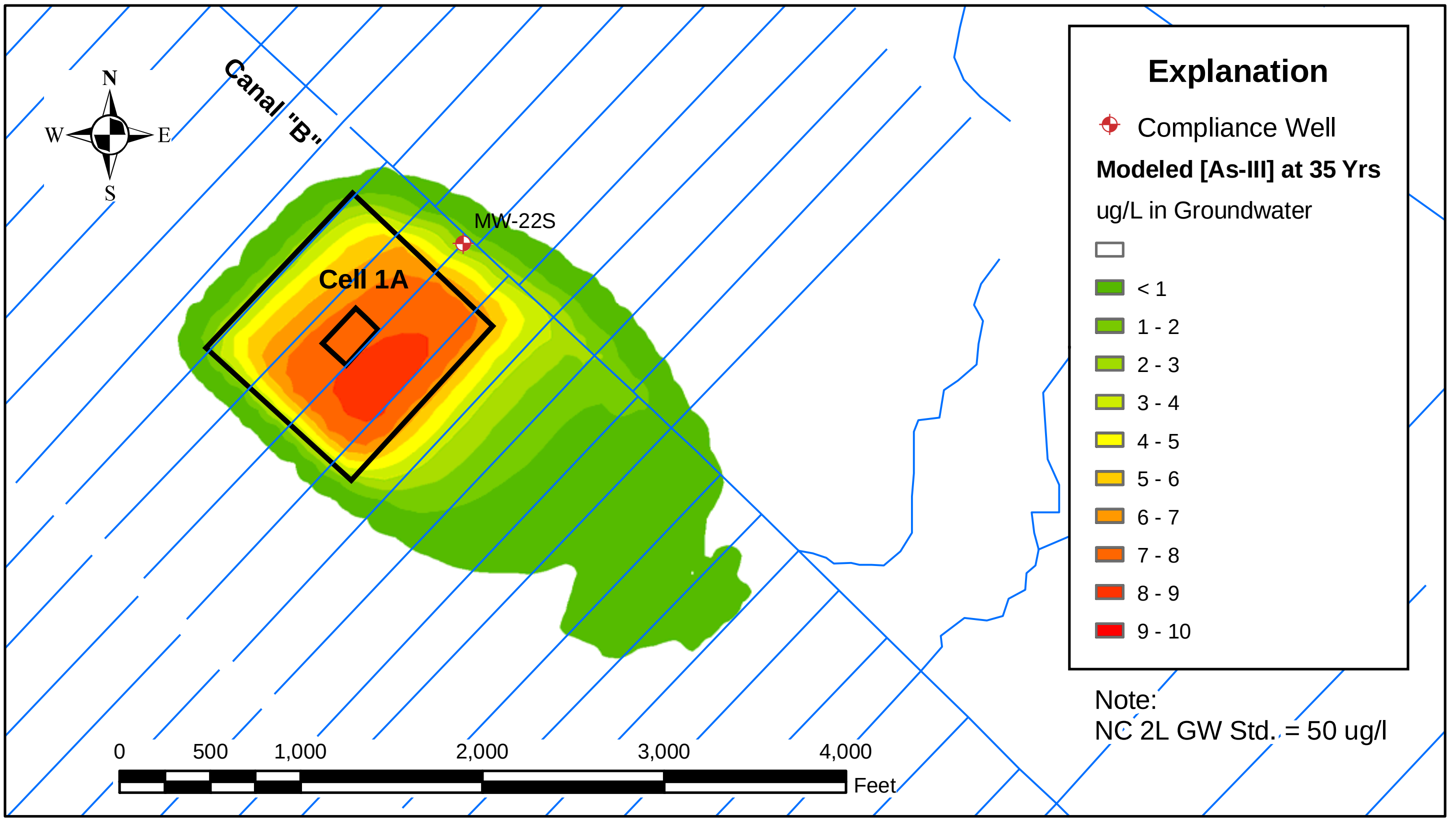
This equation accounts for dilution of concentrations discharged to the ditches and canals groundwater discharge to upstream canal segments that are not impacted by groundwater emanating from the landfill. This analysis is conservative because it does not account for additional dilution from surface runoff to laterals and canal segments.

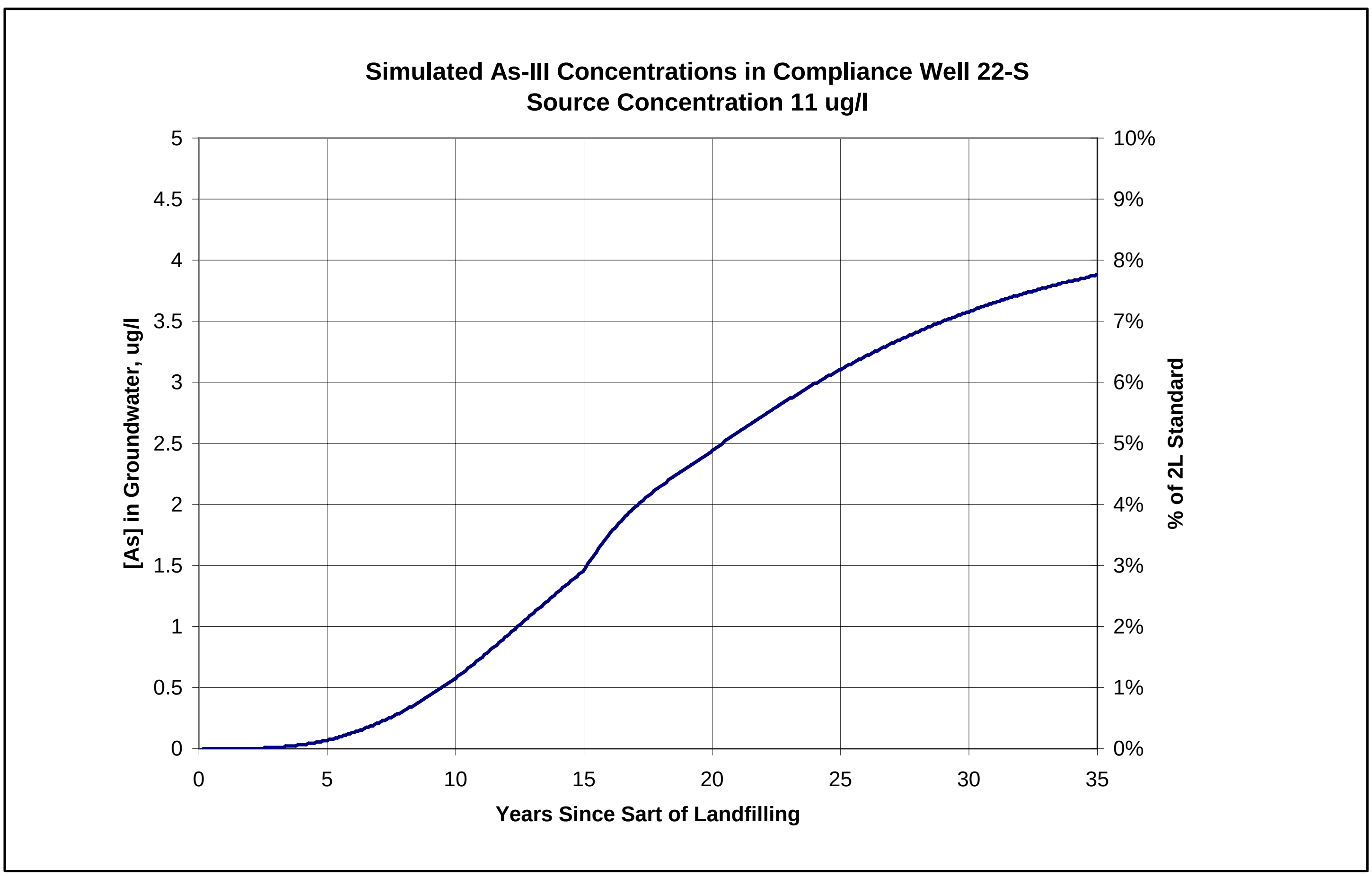
The results of this analysis are presented in Figure 14 and show that the maximum simulated concentrations of all metals are significantly less than the North Carolina 2B standards for surface water that have been established to be protective of aquatic life.

5.5 Estimated Maximum Leachate Concentrations for 2B Compliance

The results of the analyses of the likely impact to regulated surface water in Canal B was used to estimate the maximum concentrations of the simulated metals in leachate that would result in maximum concentrations in Canal B that remain below the North Carolina 2B Standards. The results of this analysis are shown in last line of the table included on Figure

14. These results show that that 2B compliance in Canal B is likely even if concentrations in leachate were to be much larger than those measured from the Foxhole Landfill as reported by ENSR(2006) and summarized in Table 2 Because the likely impacts to Canals A and M will be similar, if not identical to those to Canal B as previously discussed, these results pertain to the likely impacts from development of all cells of the proposed ARR C&D Landfill.





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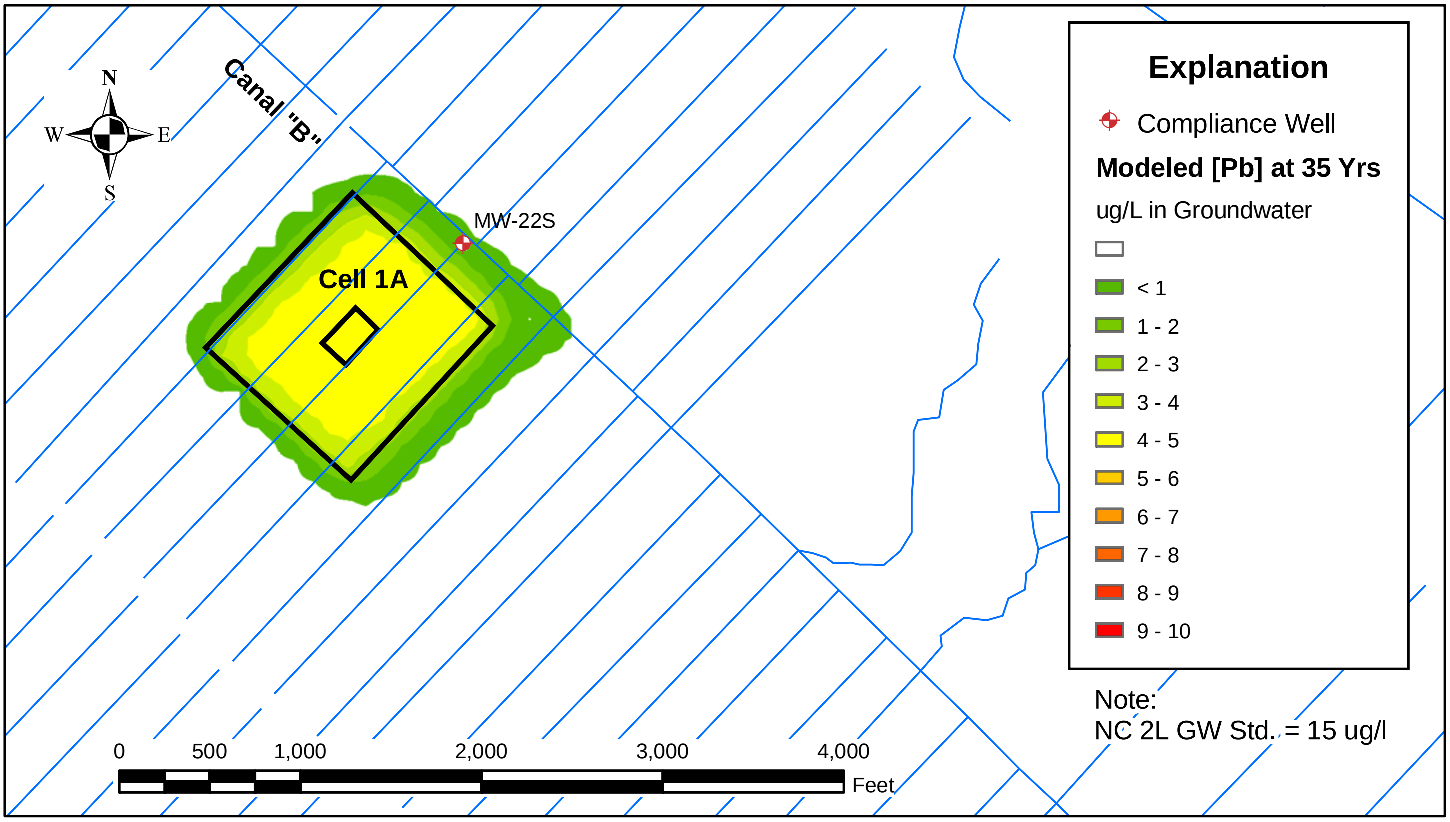
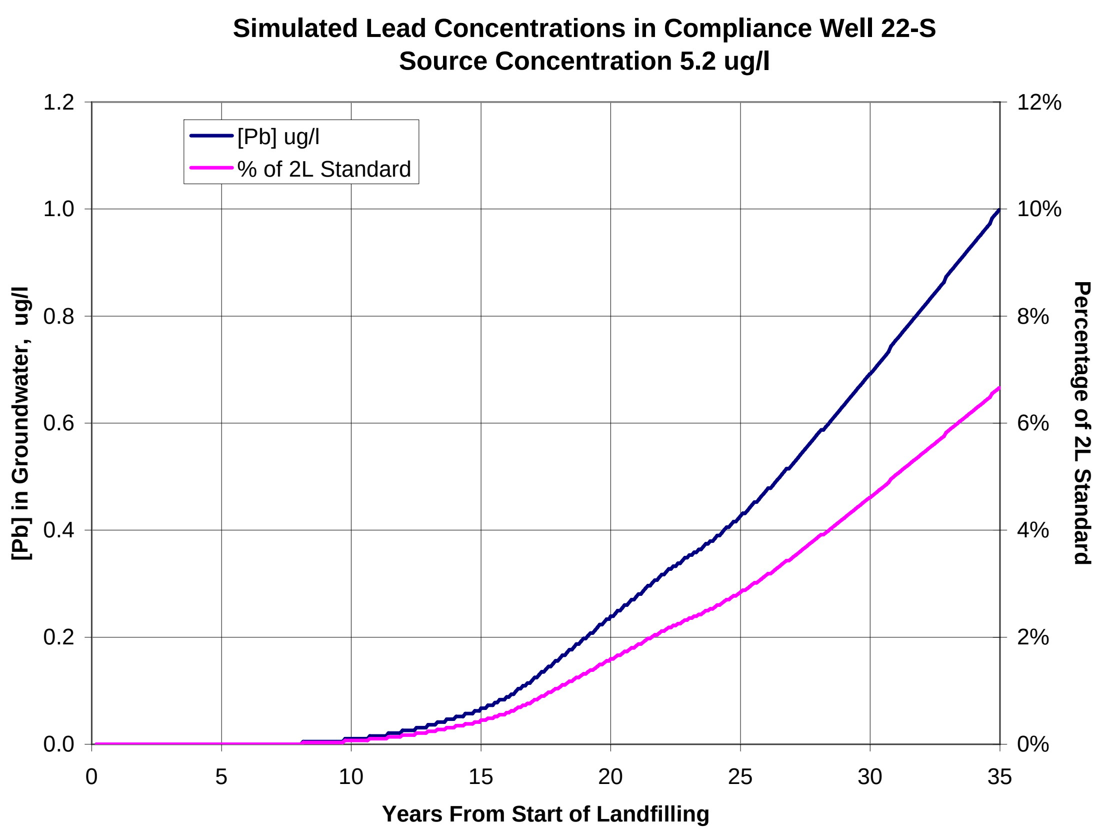
Simulated As-III Concentration in Shallow Groundwater after 35 Years. Source Concentration = 11 ug/L. No attenuation simulated. 2L Groundwater standard = 50 ug/L.		
Date	Project Number	Approved:
6/13/06	17011.1	E.G.Lappala

Figure 10





Simulated Lead Concentration in Shallow Groundwater after 35 Years. Source Concentration = 11 ug/L. Kd for Organic Soil = 1,500 L/Kg; Kd for Sand and Clay Layers = 20 L/Kg.		
Date	Project Number	Approved:
6/13/06	17011.1	E.G.Lappala

Figure 11

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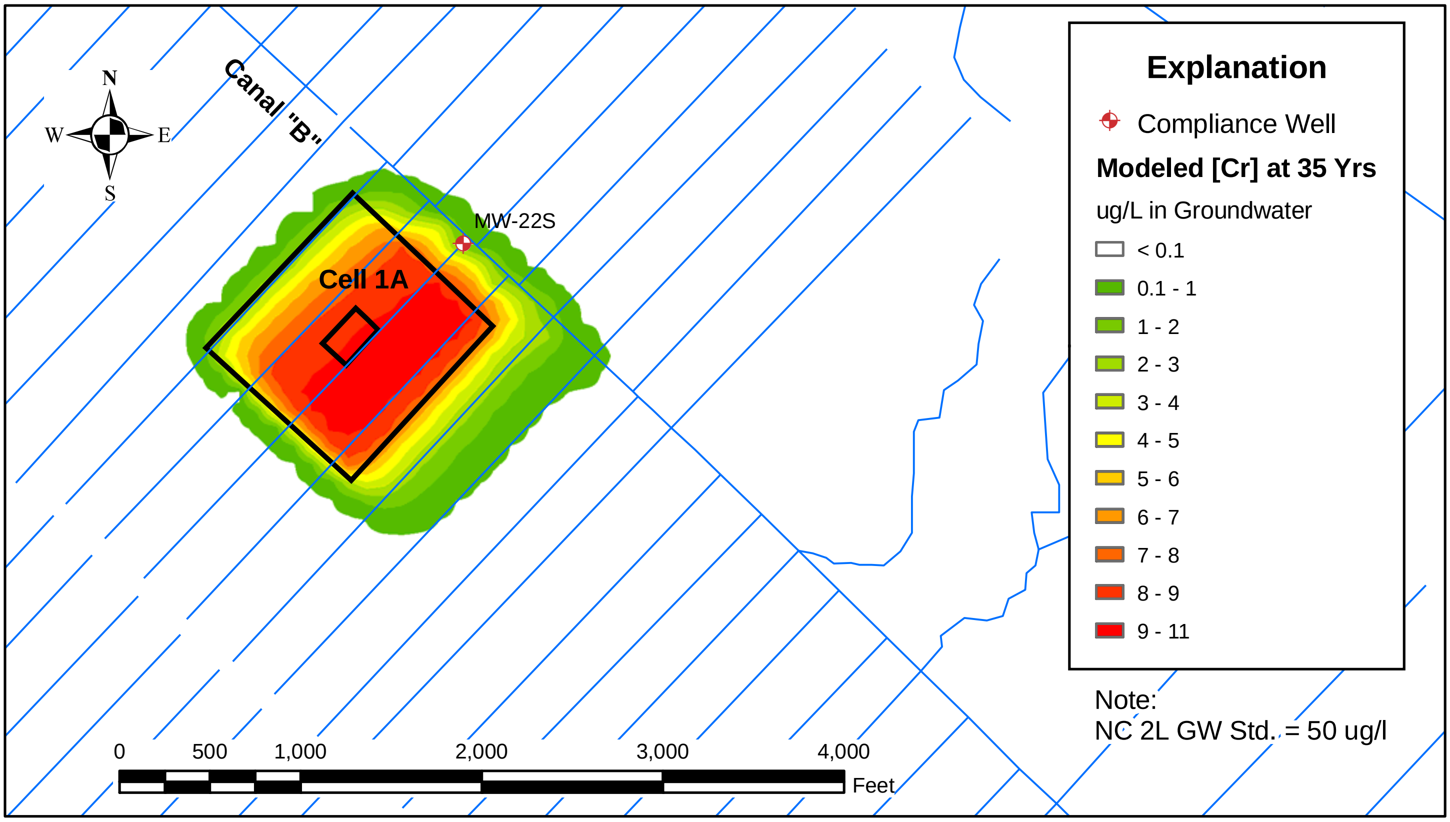

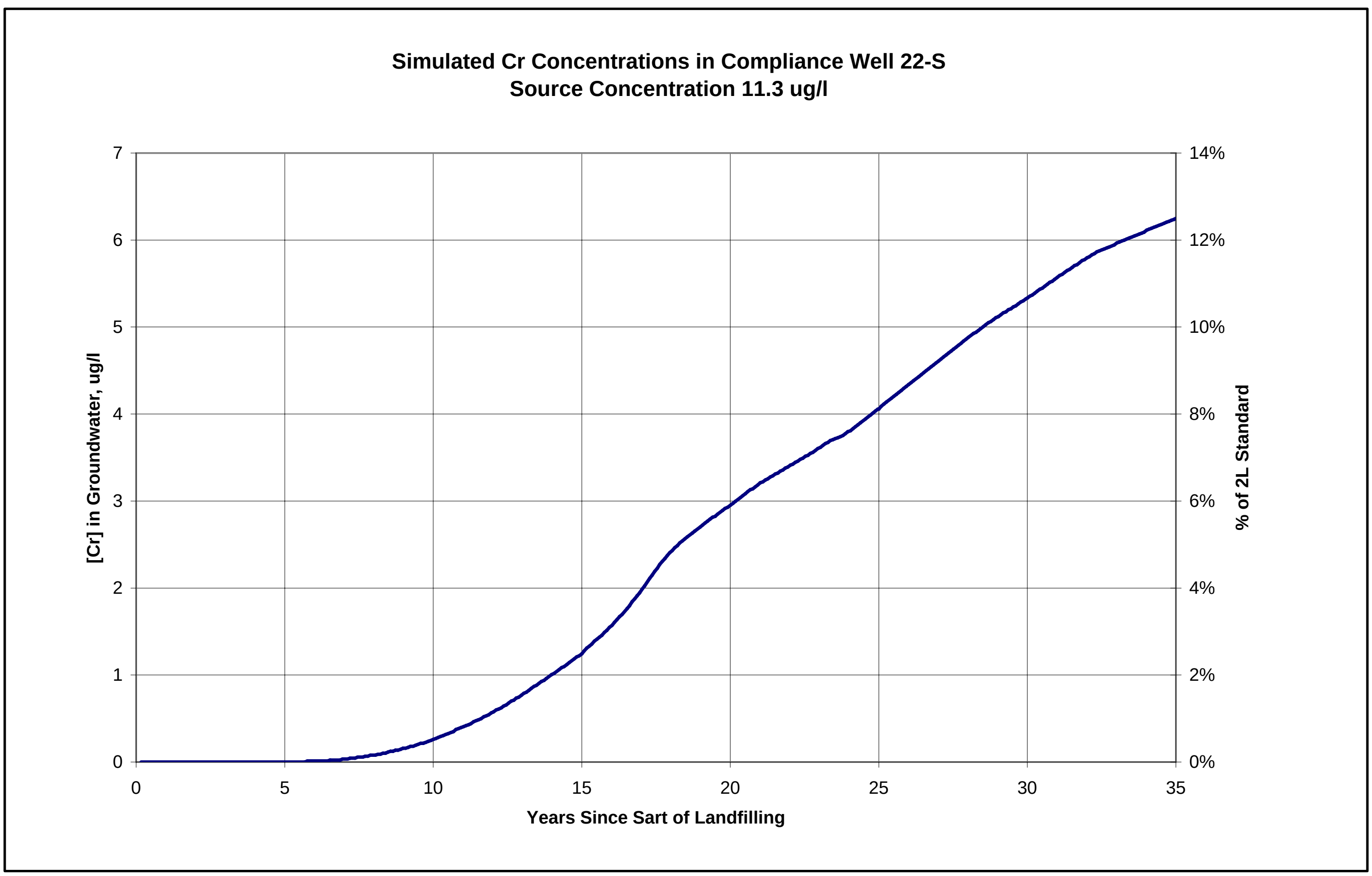

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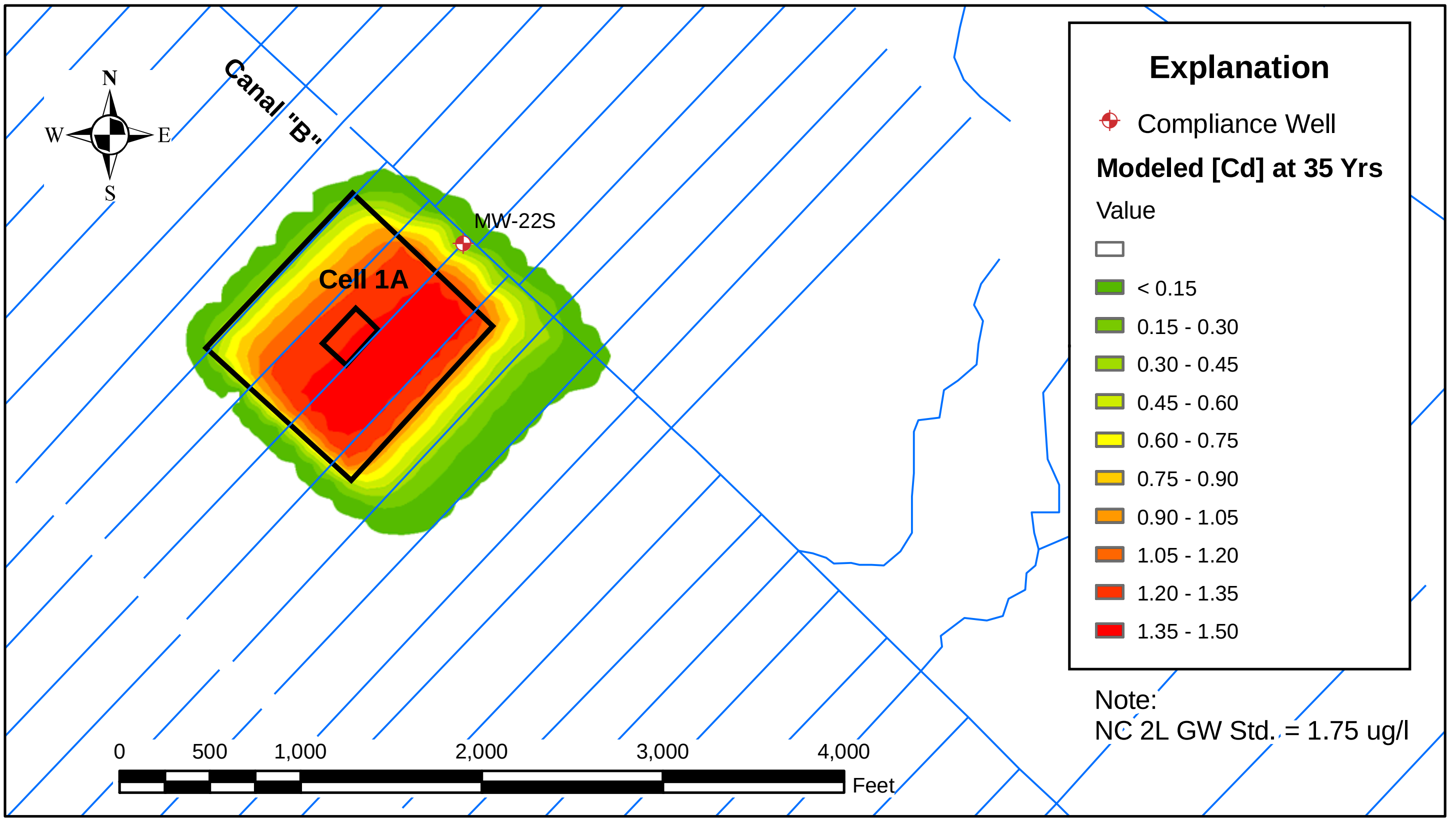
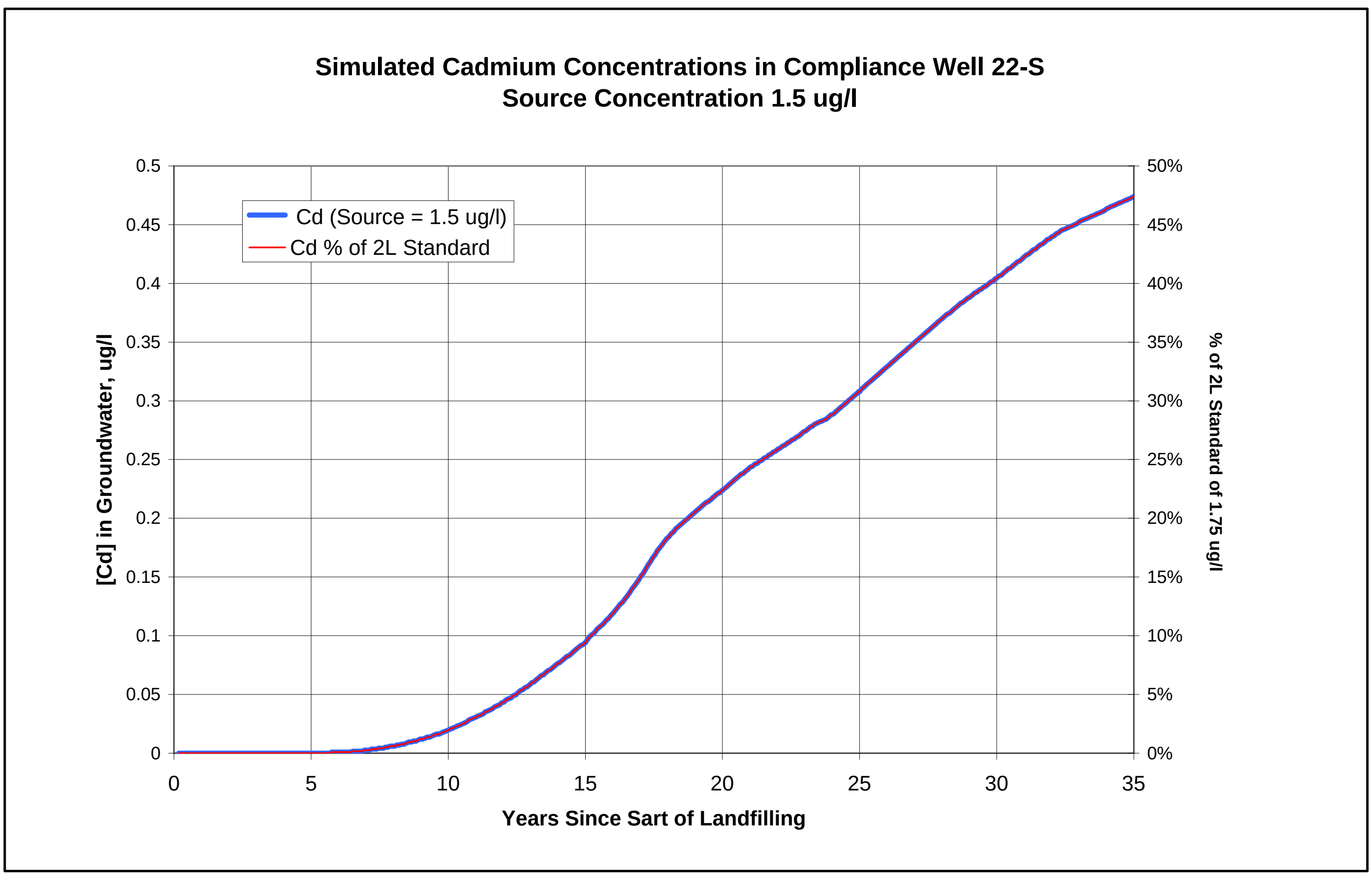
Simulated Chromium Concentration in Shallow Groundwater after 35 Years. Source Concentration = 11.3 ug/L Kd for all Materials = 20 L/Kg.		
Date	Project Number	Approved:
6/13/06	17011.1	E.G.Lappala

Figure 12





Simulated Cadmium Concentration in Shallow Groundwater after 35 Years. Source Concentration = 1.5 ug/L Kd for all Materials = 20 L/Kg.		
Date	Project Number	Approved:
6/13/06	17011.1	E.G.Lappala

Figure 13

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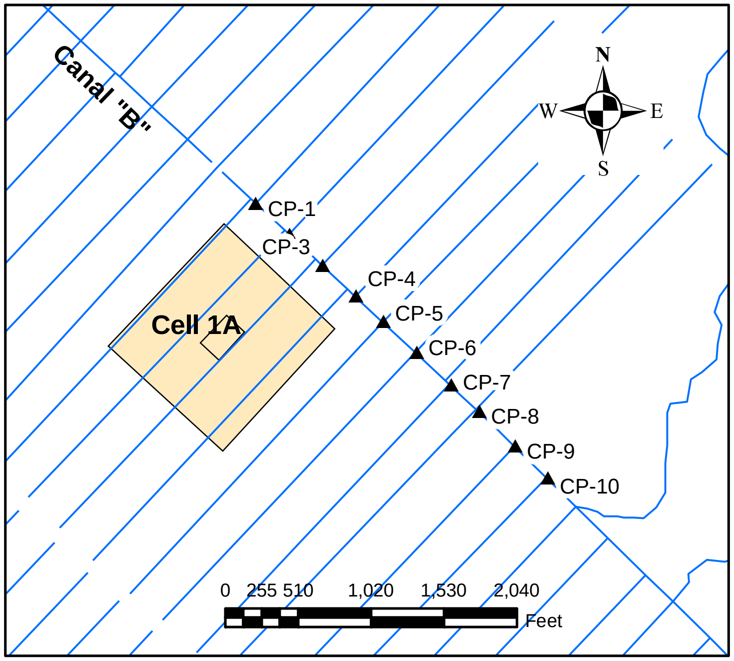

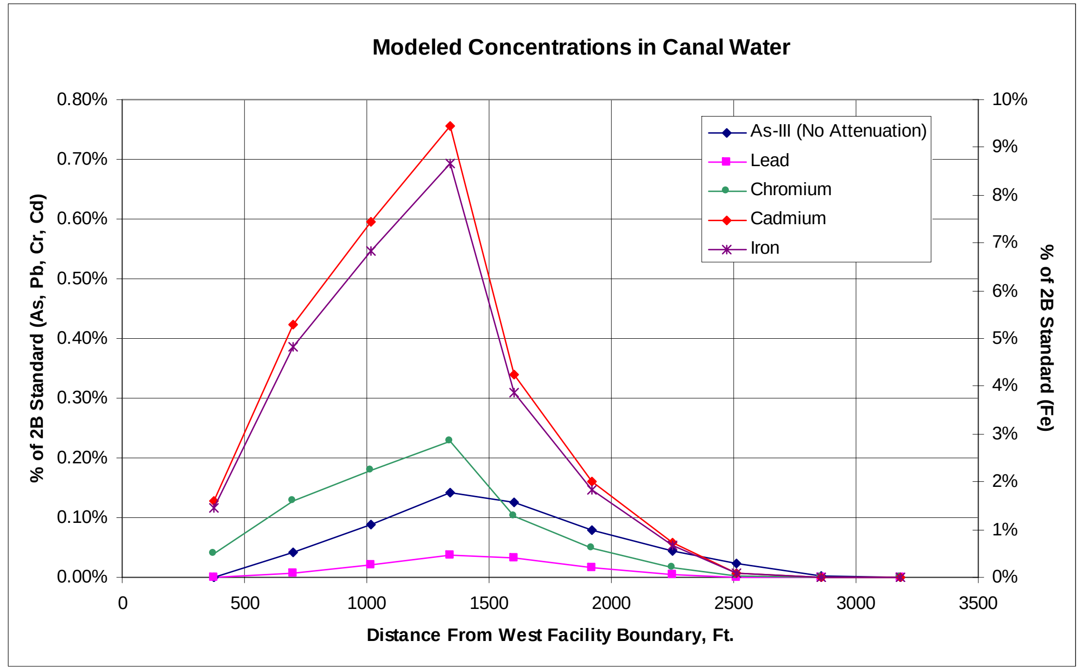

Canal Station	Distance Ft from W. Boundary	Flow At Station gpm	AS-III Conc. in Canal ug/l	AS-III % of 2B Std	Lead Conc. in Canal ug/l	Lead % of 2B Std	Chromium Conc. in Canal ug/l	Chromium % of 2B Std	Cadmium Conc. in Canal ug/l	Cadmium % of 2B Std	Iron Conc. in Canal ug/l	Iron % of 2B Std
CP-1	375	50	-	0.00%	-	0.00%	0.019	0.04%	0.003	0.13%	14.6	1.46%
CP-2	700	104	0.021	0.04%	0.002	0.01%	0.064	0.13%	0.008	0.42%	48.3	4.83%
CP-3	1015	148	0.044	0.09%	0.005	0.02%	0.090	0.18%	0.012	0.60%	68.2	6.82%
CP-4	1340	187	0.071	0.14%	0.009	0.04%	0.114	0.23%	0.015	0.76%	86.6	8.66%
CP-5	1600	223	0.062	0.12%	0.008	0.03%	0.051	0.10%	0.007	0.34%	38.7	3.87%
CP-6	1920	254	0.039	0.08%	0.004	0.02%	0.024	0.05%	0.003	0.16%	18.4	1.84%
CP-7	2250	282	0.022	0.04%	0.001	0.01%	0.009	0.02%	0.001	0.06%	6.6	0.66%
CP-8	2510	315	0.012	0.02%	-	0.00%	0.001	0.00%	0.000	0.01%	0.8	0.08%
CP-9	2860	333	0.001	0.00%	-	0.00%	-	0.00%		0.00%	-	0.00%
CP-10	3180	353	-	0.00%	-	0.00%	-	0.00%		0.00%	-	0.00%
Maximum in Reach			0.071		0.009		0.114		0.015		86.6	
2B Standard			50		25		50		2		1000	
Maximum / 2B Standard			0.142%		0.038%		0.228%		0.757%		8.66%	
Max Conc in Leachate to Stay < 2B			7,734		13,712		658		200		99,106	

Modeled Metals Concentrations in Canal Water after 35 Years.
Dilution only from Groundwater Inflow to Ditches and Canals.
Additional Dilution by Surface Runoff Not Accounted For.

Date	Project Number	Approved:
6/13/06	17011.1	E.G.Lappala

Figure 14

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6 Sensitivity Analyses

Sensitivity analyses were performed to assess the effect of higher and lower values of horizontal hydraulic conductivity, drain conductance, and recharge rates that were used for groundwater flow model that supported the fate and transport analyses. The sensitivity analyses were also used to demonstrate that the results of simulated concentrations of metals in both groundwater and surface water are conservative.

The measures used to assess the effects of the sensitivity analyses were the goodness of fit statistics used in model calibration, the maximum water table mound height beneath the landfill at completion, and the maximum concentration in compliance monitoring well 22-S 30 years following the filling and capping of landfill Cell 1. Table 2 shows the results of the sensitivity analyses. Sensitivity analyses for the ratio of horizontal to vertical conductivity for all model layers were conducted but are not included in Table 2 because the results fell between the values obtained by varying the horizontal hydraulic conductivity.

The simulation results for both the flow and transport model are fairly sensitive to the conductance of the drains values that are both higher and lower than the values that were used to achieve the initial best fit to winter and summer water levels. This supports using the value for drain conductance that is essentially equal to the vertical hydraulic conductivity used for model layer 1 that contains the drains.

The simulation results for both the flow and transport model are relatively insensitive to values of hydraulic conductivity different from those used for prediction. However, as shown in the last line of Table 2, an improved fit to both summer and winter groundwater levels as measured by the goodness of fit statistics was achieved when the multiplier for horizontal hydraulic conductivity was 0.5 for layer one and 0.2 for layers 2 through six. These lower values hydraulic conductivity also result in slower groundwater velocities, and a lower simulated concentration of arsenic at sentinel monitoring well 22-S. Similar or greater reductions will be present at 22-S for the other metal species which were simulated using attenuation by sorption on aquifer materials.

As shown in the last line in Table 2, the lower values horizontal hydraulic conductivity that produced the best fit to summer and winter water levels result in a significantly higher simulated maximum watertable elevation beneath the closed landfill at full development. However, even with this higher watertable mound, the simulated concentration of arsenic in sentinel well 22-S are lower than those simulated with the higher hydraulic conductivities used to produce the values in Figures 10 through 13.

As shown in Figures 10 through 13, simulated concentrations at well 22-S are representative of the highest concentrations in the groundwater system that discharge to Canal B. Therefore, the than us than those used to simulate concentration values shown in these figures would produce a proportionally lower maximum concentration in surface water. Consequently, the simulated values of metals in both groundwater at sentinel well 22-S and surface water in Canal B should be considered conservative.

Sensitivity Analysis	Goodness of Fit Statistic, January, 2005 Water Levels			Goodness of Fit Statistic, June, 2005 Water Levels			Full Development		As-III Concentration in Well 22-S 30 yrs after Cell 1A closure (ug/l)	Kh Multiplier for Layer						Drain Conductance multiplier	Recharge multiplier
	Mean Residual ft	Mean Abs Residual ft	RMSE	Mean Residual ft	Mean Abs Residual ft	RMSE	Maximum Mound Elevation ft	Discharge to Canals and Ditches gal/min		K1	K2	K3	K4	K5	K6		
Manual calibration, pre-sensitivity	0.56	1.37	2.34	0.48	0.81	1.52	6.80	814	5.15	1	1	1	1	1	1	1	1
Layer 1 Kh	0.82	1.50	2.54	0.28	0.64	1.22	6.08	790	3.54	5	1	1	1	1	1	1	1
	0.43	1.32	2.26	0.43	0.77	1.46	7.29	820	4.74	0.2	1	1	1	1	1	1	1
Layer 2 Kh	0.71	1.46	2.47	0.55	0.87	1.63	6.49	803	3.70	1	5	1	1	1	1	1	1
	0.40	1.30	2.24	0.41	0.76	1.44	7.27	820	4.98	1	0.2	1	1	1	1	1	1
Layer 3 Kh	0.67	1.41	2.43	0.54	0.86	1.59	6.08	811	1.80	1	1	5	1	1	1	1	1
	0.44	1.30	2.20	0.42	0.76	1.40	7.34	820	4.26	1	1	0.2	1	1	1	1	1
Layer 4 Kh	0.80	1.46	2.48	0.60	0.90	1.62	5.65	776	7.59	1	1	1	5	1	1	1	1
	0.45	1.31	2.25	0.42	0.76	1.44	7.54	826	4.01	1	1	1	0.2	1	1	1	1
Layer 5 Kh	0.77	1.46	2.48	0.59	0.91	1.66	5.46	776	8.53	1	1	1	1	5	1	1	1
	0.49	1.33	2.29	0.44	0.77	1.45	7.70	823	2.97	1	1	1	1	0.2	1	1	1
Layer 6 Kh	0.93	1.54	2.57	0.67	0.97	1.72	5.30	758	7.96	1	1	1	1	1	5	1	1
	0.41	1.27	2.24	0.39	0.74	1.41	7.82	833	4.94	1	1	1	1	1	0.2	1	1
Drain Conductance	(3.96)	3.96	4.32	(0.38)	0.60	0.80	8.42	642	2.27	1	1	1	1	1	1	0.5	1
	3.21	3.26	3.44	0.75	0.87	1.07	4.11	1,192	2.24	1	1	1	1	1	1	10	1
Recharge	(1.52)	1.73	2.12	(0.00)	0.66	0.80	9.36	1,190	7.50	1	1	1	1	1	1	1	1.5
Calibration using best fit from sensitivity analyses	(0.47)	1.23	1.52	0.03	0.47	0.60	16.10	877	1.49	0.5	0.2	0.2	0.2	0.2	0.2	1	1
		= Sensitivity Parameter															

Table 4.--Sensitivity Analysis Summary.

7 Conclusions

A six-layer, three-dimensional groundwater flow model was constructed using the large amount of site-specific geologic and hydrogeologic data collected for the Site by David Garrett. This model was successfully calibrated to winter (January 2005) groundwater levels in 25 monitoring wells by only changing the original estimate of winter recharge to groundwater and drain conductances. The values of hydraulic conductivity based upon field tests by David Garrett were not altered during model calibration. The calibrated model was verified by simulating summer (June 2005) water levels by including the simulation of the discharge of groundwater by ET during the growing season.

A review of the technical literature identifying constituents of concern in the C&D waste stream was conducted by ENSR International. ENSR concluded that the analytical results for leachate from a C&D landfill in North Carolina provided the most representative available data for expected concentrations in leachate from the ARR C&D Landfill. To provide conservative analysis (maximum simulated concentrations), the upper 95% confidence interval values concentration values reported by ENSR for all constituents (Arsenic[As], Lead [Pb], Chromium [Cr], and Cadmium [Cd]) were used as source terms for fate and transport modeling.

The source concentrations used for the simulated constituents are higher than those expected from the ARR C&D Landfill because the samples from which they were derived were collected from a leachate collection system that includes a relatively impermeable liner. Based upon the physics of variably saturated flow in lined landfills, these conditions result in the waste in the bottom of the cell generally remaining saturated, which allows for additional leaching of landfill materials. Concentrations of leachate constituents depend on the contact time between the waste and infiltrating water. The design of the proposed ARR C&D Landfill does not include a liner which will minimize the opportunity for saturated leaching conditions.

Fate and transport of these constituents was simulated using a three-dimensional transport model that includes advection, hydrodynamic dispersion, and sorption on aquifer materials. The calibrated groundwater model was used to provide the three-dimensional groundwater flow directions and velocities to compute advective flux of the simulated metals. Conservative values of the model parameters that account for spreading of a plume were used so that the time of arrival of the maximum concentration at observation points was minimized. Sorption for arsenic was not simulated because it generally occurs as an anion. Values of the distribution coefficients used to simulate the effects of sorption for all other metals were taken from an extensive literature compilation of such values on four soil types: sand, clay, sandy loam, and organic soil. To provide a conservative analysis of the fate and transport of metals except arsenic, the literature values for the distribution coefficients were reduced by a factor of ten.

Fate and transport analyses were performed by simulating the filling and closure of cell 3-A. of the proposed landfill. This cell was chosen because it is likely to be the first cell filled and closed and because its northern edge is only 200 feet from Canals B and M which are a regulated water bodies. Modeled impacts from other cells that are within 200 feet from these canals as well as Canal A would be similar, if not identical because of the simulated groundwater flow pattern. Impacts to surface water from cells more distant from the canals would be lower than those simulated for Cell 3-A.

The maximum simulated concentrations for all of the simulated constituents of concern at groundwater compliance boundaries and in regulated surface water bodies were significantly less than the applicable North Carolina groundwater and surface water standards.

Sensitivity analyses were performed to assess the effect on the goodness of fit to measured water levels, the degree of water table rise beneath the completed landfill, and the likely maximum constituent concentrations in sentinel monitoring wells located between the landfill and Canal B of higher and lower values of horizontal hydraulic conductivity, drain conductance, and recharge rates that were used for groundwater flow model that supported the fate and transport analyses. The sensitivity analyses were also used to demonstrate that the results of simulated concentrations of metals in both groundwater and surface water are conservative.

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