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17 November 1995

Northern Division
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Attn: Mr. Phil Otis

RE: Contract No. N62472-92-=D-1296, CTO No. 0032
Ground-Water and Surface Water Modeling Program
IR Program Site 09, Allen Harbor Landfill, NCBC Davisville
EA project No. 29600.32.3999

Dear Mr. Otis:

Enclosed is a copy of the description of the Ground-Water and Surface Water Modeling Program that was established during our related 30 October 1995 meeting at NCBC Davisville. EA is currently proceeding with this plan. Please contact me if you have any questions or comments.

Sincerely,

Nicholas A. Lanney, P.E.
CTO Manager

NAL/mcc
Enclosure

cc: C. Williams - EPA Region (1 copy)
R. Gottlieb - RIDEM (1 copy)
S. Gnewuch - ADL (1 copy)
Sharon File
Project File

Ground-Water and Surface Water Modeling for the Allen Harbor Landfill Phrase III RI

To address the comments and concerns of U.S. EPA and RIDEM and as agreed at the 30 October 1995 meeting, the following modeling will be performed for the Allen Harbor Landfill Phrase III RI study. The main purpose of this modeling work will be the development of a refined and recalibrated ground-water flow field that along with solute transport modeling and surface water modeling will further aid in the understanding of the general behavior and dynamics of the Site 09 related ground-water and surface water system. Additionally, the models will provide a basis from which to assess (simulate) the affects of various constituents, conditions, and sediment adsorptive capacity. A conceptual northeast-southwest hydrogeological cross-section of the Site 09 vicinity is provided as Figure A.

1. Ground-Water Flow Modeling

The numerical ground-water flow model, MODFOW, will be calibrated from mid-tide water levels measured on 19 April 1995 and 19 September 1995. Where appropriate, general head, no flow, and constant head conditions will be used to represent the boundaries in the three-layer model. Recharge from precipitation will be restricted to layer 1, the unconfined or water table layer; and recharge will be developed for monthly stress periods and areally distributed across the study area. Sensitivity analyses will be used to adjust the boundary conditions, recharge, and aquifer parameters; horizontal and vertical hydraulic conductivity, specific yield, and storage.

The purpose of developing the ground-water flow model is to provide a management tool that can simulate current conditions and potential future remediation scenarios. The scope of the modeling for this RI will be restricted to simulating both current and steady-state conditions and providing velocity components for the solute transport model. Potential remediation scenarios will not be run in this RI; however, they will be evaluated in the feasibility study (FS) of this site.

The modeling approach will include the following items.

1. A more detailed description of the development of hydraulic conductivity (K) and storage values for each layer utilizing where possible tidal and ground-water monitoring methods, slug test results, and the assignment of K and specific yield values to lithologic units within the geologic logs of the monitoring wells.

2. Recharge from precipitation to Layer 1 will be developed using the HELP model from known and assumed soils and materials at the site, land use at the site, and climatic data obtained from nearby weather station at the T.F.Green Airport. Recharge will vary areally across the site on a monthly basis.

3. Initially, boundary conditions will be established as no flow or constant head along the harbor and general heads along the west side in Layer 1 and general head along the bay sides and general head along the west side of Layers 2 and 3. Layers 2 and 3 will be extended east to the west shore of the Narragansett Bay.

4. Sensitivity analysis will be used to adjust the aquifer parameters and fluxes in the model. Areal recharge from precipitation will be adjusted by performing sensitivity analysis. The goal will be to simulate the water table mound in Layer 1 through areally variable recharge values. The vertical hydraulic conductivity between Layers 1 and 2 and Layers 2 and 3 will be adjusted by sensitivity analysis. The goal will be to simulate the existing water levels in Layers 2 and 3 by adjusting the vertical hydraulic conductivity between these layers. Sensitivity analysis will also be performed within each layer on the general head boundary nodes and on the other aquifer parameters, horizontal hydraulic conductivity, specific yield, and storage.

5. The ground-water flow model will be calibrated using the above two water levels. The calibration of the model will be assessed within each layer by examining both the root mean square error for all model nodes and scatter diagrams of simulated versus measured water levels at the monitoring wells. Calibration adjustments in aquifer parameters, boundary conditions, and recharge will be based upon the sensitivity analysis. After the model is calibrated, the flow model will be run with average annual fluxes under steady-state conditions. The output from this steady-state run will be used in the solute transport model..

6. A detailed discussion of the modeling approach will be presented. This will include figures delineating the model grid, boundary conditions, grid cross sections, and configurations of measured and simulated water levels for each layer. Model input data and results will be listed for the final calibration and steady-state runs. The results of the sensitivity analysis will be presented in tabular format. Model uncertainty and accuracy will be evaluated qualitatively.

2. Solute Transport Modeling

- The solute transport model will be re-executed using updated ground-water flows from the recalibrated MODFLOW. The present day mass flux from the landfill to Allen Harbor will be calculated for 19 VOC in a manner similar to the existing draft RI.

  Three additional modeling components will also be added:

- Modeling the long-term solute transport including environmental fate for constituent of concern including TCE, DCE, vinyl chloride, copper, zinc, arsenic, and naphthalene.

- A mass flux calculation from Layer 1 to Allen Harbor based directly on the modeled ground-water flow field and observed concentrations of the 19 VOC (as detected in the ground-water samples collected April 1995 from the monitoring wells), and copper, zinc, arsenic, and naphthalene (reported in the Phase II RI report by TRC).

- A surface water model of Allen Harbor which uses the estimated ground-water mass flux as a loading for TCE, DCE, vinyl chloride, zinc, copper, arsenic, and naphthalene.

These four components associated with solute transport at the Allen Harbor Landfill are discussed in greater detail in the following sections.

2.1 Solute Transport Modeling

The scope of the solute transport modeling in the RI is to provide "present day" mass flux estimates from the landfill to Allen Harbor and toward the wetland west of Stanford Road. The calculation of present day mass flux values from observed concentrations at the sampled wells can be performed without the inclusion of environmental fate in the model. This present day analysis differs from the prediction of a plume scenario 10-30 years in the future where environmental fate would be an important aspect.

The 19 VOC will be re-modeled using the ground-water flow field resulting from the recalibrated MODFLOW. The updated MODFLOW will include extension of Layers 2 and 3 east to the shore of Narragansett Bay. This will allow for additional evaluation of the potential for vertical migration from Layer 2 to Allen Harbor. The steady-state flow field from MODFLOW to be used in the solute transport modeling will be based on an annual average recharge condition.

The previous ground-water model extended Layers 2 and 3 only 2 cells under Allen Harbor. The concentration assigned to each cell was a smooth continuation under Allen Harbor based upon the gradient arising from the observed values at the Site 09 wells. With the extension of Layers 2 and 3, it will be more difficult to construct the present day constituent distribution in that area. For the present day analysis, the concentrations grided by Surfer will be allowed to extend further under the harbor with values continuing to decrease along the established gradient. In a later section with the inclusion of environmental fate for select constituents, the present day plume under Allen Harbor will be estimated by the solute transport model.

A more detailed presentation of the development of the initial particle distribution based on the observed concentrations will be provided in the draft final RI report, including tables of the concentrations and resulting mass flux along the edge of Allen Harbor for select constituents. Additional model parameters which will be reviewed include porosity, dispersivity, and retardation.

2.2 Plume Prediction with Environmental Fate

The solute transport model will be executed for a 25-40 year period representing the time since the landfill began and was closed. In addition to retardation which is used for the present day scenarios, environmental fate, including biodegradation will be utilized. To address parent-daughter interactions, the analysis will be preformed for the series TCE, DCE, and vinyl chloride. The model will also be executed for copper, zinc, arsenic, and naphthalene. The initial concentration distribution will be based upon present day observed values. For the TCE series, only TCE will be initialized in the model and the daughter products will arise as a result of decay processes. Assuming that the present day plume represents a quasi-steady state, a source term will be developed which maintains the existing concentrations within the landfill. In this manner, a constituent plume will be modeled representative of the historical age of the landfill and which is consistent with present day observed values (detected in ground-water samples from the Site 09 monitoring wells) while allowing the plume to extend freely beyond the landfill. The resulting estimate of the present day plume distribution beyond the landfill will be compared to the distribution resulting from Surfer developed as part of Section 2.1. Sensitivity analysis will include typical and worst case horizontal and vertical conductivity and fate coefficients. An additional scenario will be performed in which the dissolved equivalent of 55 gallons of TCE is released 30 years ago and tracked to the present day.

2.3 Mass Flux Calculation

A present day Layer 1 mass flux from the Landfill to Allen Harbor can be calculated directly from the ground-water flow field provided by MODFLOW and the observed concentrations detected in ground-water samples collected from the monitoring wells. This approach was previously considered but was not pursed in favor of developing the solute transport model which would be a useful projection tool for the FS. The direct calculation of mass flux will provide a verification of the values estimated by the solute transport modeling in Section 2.1.

The grided concentration matrix prepared for the solute transport model will be used in this analysis as the best available estimate of the concentration distribution along the western edge of Allen Harbor. At each model cell along the edge of Allen Harbor the corresponding concentration and horizontal ground-water flow will be multiplied to yield a mass flux.

The mass flux calculation will be performed for the 19 VOC analyzed in the solute transport model and also for copper, zinc, arsenic, and naphthalene using ground-water sample data presented in the Phase II RI report by TRC.

2.4 Sediment Adsorptive Capacity Assessment

Using the Mass flux developed in Section 2.3, EA will perform calculations to estimate the adsorptive capacity of the sediment at the Allen Harbor shoreline with Site 09. This information will be used to estimate whether this sediment is currently serving as a natural barrier (filter) to the horizontal (and vertical) migration of constituents dissolved in the ground water flowing into the harbor from Site 09; and if it is currently acting as such a filter, estimate how much longer it may continue before"breakthrough" may occur.

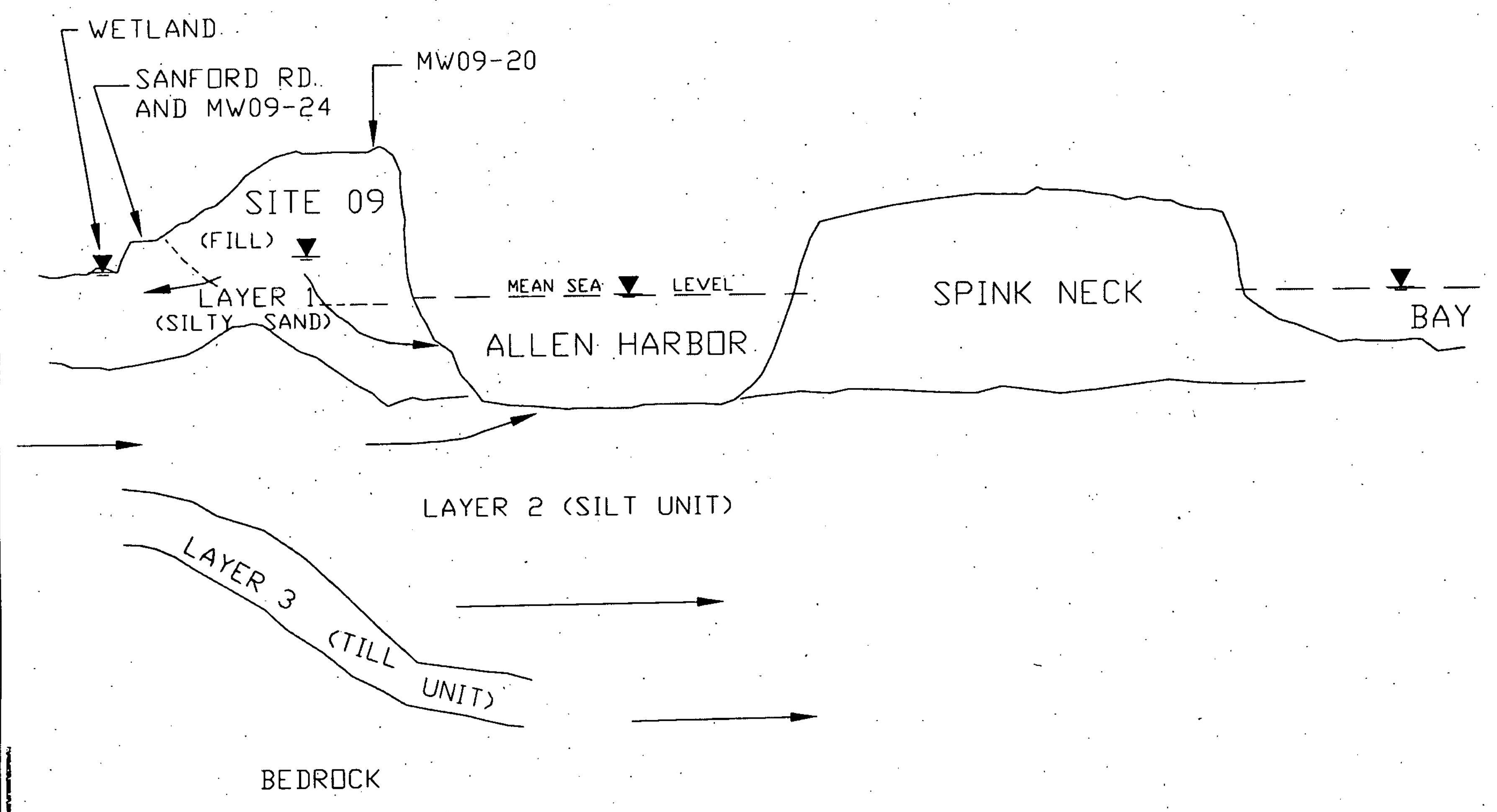
3. Surface Water Modeling

The effect of the Allen Harbor Landfill on surface water will be further addressed by employing a surface water model. The surface water model will be executed for the parameters for which environmental fate was provided in the solute transport model: TCE, DCE, vinyl chloride, copper, zinc, arsenic, and naphthalene. The model will include both the Layer 1 ground-water mass flux along the edge of Allen Harbor as well as vertical migration from Layer 2 through the floor of the harbor. Potential solute transport originating from Layer 3 that may reach the Harbor would have to flow into Layer 2 first and, therefore, is included in the Layer 2 component. The model used for this task, RMA-2, is a 2-dimensional finite-element hydrodynamic model supported by the US Army Corps at the Waterways Experiment Station in Vicksburg, Miss.

A finite element grid has been constructed for Allen Harbor and the inlet channel from Narragansett Bay. The finite-element technique allows a variable cell size which results in a more accurate representation of the geometry. The depth data was taken from the most recent NOAA chart of the local area (chart 13223). The tidal flushing in the model is driven by a sinusoidal tide at the Narragansett Bay boundary.

The model will provide surface water concentrations both spatially over a tidal cycle and as a tidal average. The sensitivity of surface water concentration to the assumed configuration of the mass loading will be examined. The Layer 1 ground-water mass flux will be input both along the shoreline cell and also with 50 % along the shoreline and 50 % through a mid-point in the harbor bottom.

As part of the surface water modeling task the ground-water mass flux through the harbor bottom will be partitioned between sediment and pore water. This will provide model verification relative to existing sediment data.



WATER LEVEL

CONCEPTUAL GROUND-WATER FLOW PATH

CONCEPTUAL NORTHEST - SOUTHWEST
HYDROGEOLOGICAL CROSS SECTION
IR PROGRAM SITE 09 VICINITY
NCBC DAVISVILLE, RI

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DRAWN BY	JFW
CHECKED BY	JAS
PROJECT MANAGER	RBG
PROJECT NUMBER	29600.32.3999
SCALE	NONE
FILE NAME	CONCEPT
DRAWING NUMBER	-
FIGURE	A