ARCADIS

Infrastructure, buildings, environment, communications

ARCADIS G&M, Inc.
88 Duryea Road
Melville
New York 11747
Tel 631 249 7600
Fax 631 249 7610
www.arcadis-us.com

Mr. Larry Leskovjan
Northrop Grumman Corporation
South Oyster Bay Road
Bethpage, New York 11714

ENVIRONMENTAL

Subject:
Updated Northrop Grumman Regional Groundwater Flow and Contaminant Transport Model Report, Northrop Grumman Corporation, Bethpage, New York.

Date:
30 October 2002

Contact:
Douglas Smolensky

Phone:
631 391 5290

Email:
dsmolensky@arcadis-us.com

Our ref:
NY001321.0006.00001

Dear Larry:

ARCADIS has prepared this report to document modifications and updates to the Regional Groundwater Flow and Contaminant Transport Model developed for the Northrop Grumman Corporation Site in Bethpage, New York. The updated model is based on the previously constructed flow model that was documented in the October 1997 report entitled, "Groundwater Flow Model, Northrop Grumman Corporation, Bethpage, New York" (hereinafter referred to as the 1997 flow model). The 1997 flow model (technically the flow model was completed prior to 1997 but is referred to as the 1997 model because that is the year the model was documented in a report) was the basis for contaminant transport simulations conducted to evaluate Feasibility Study alternatives, which are documented in the October 2000 Groundwater Feasibility StudyGrumman Aerospace-Bethpage, NY Site #130003A and Naval Weapons Industrial Reserve Plant Bethpage, NY Site #130003B as Appendix B, "Simulation of Groundwater Flow and Contaminant Transport" (hereinafter referred to as the 2000 transport model).

Introduction

This letter report describes the differences between the updated model and the 1997 flow model, the basis and intended purpose of the updated model, and the information used to develop the updated model.

Conceptual Groundwater Model

The conceptual model for the updated model is consistent with the conceptual model upon which the 1997 flow model is based. Please refer to the October 1997 report for a detailed description of the conceptual groundwater model.

Modeling Strategy

The technical objectives defined in the 1997 flow model report are consistent with the objectives of the model update effort on the regional scale. On the site-specific scale, the updated model represents a significant improvement with respect to model discretization, as described below under the heading "Model Construction".

Uses of the Model

The updated model will be used to conduct steady state groundwater flow and contaminant transport simulations for the following purposes:

- To assess the migration of the off-site portion of the TVOC plume associated with the Northrop Grumman and Navy NWIRP sites.
- To support the selection of outpost monitoring well locations and screen settings.
- To support off-site remedial system design via determination of the number, locations, screen settings, and extraction rates of remedial wells, locations of treated water discharge points, and approximate influent concentrations over time at the treatment facility, all in the context of achieving specific remedial goals.

Model Code Description

Simulations of groundwater flow will be conducted using the modular finite-difference groundwater flow code (MODFLOW) developed by the United States Geological Survey (1988).

Contaminant transport simulations will be conducted using MT3D, a modular three-dimensional transport model developed for the U.S. Environmental Protection Agency in 1990. MT3D was developed to use MODFLOW simulation output as the basis for advective transport.

Model Construction

Details such as model discretization and calibration of the updated model, and how it differs from the 1997 model are provided below.

Discretization

Consistent with the development of the 1997 model, project goals, available data, and other factors affecting the model design were considered in the model update. The updated model was expanded to cover a larger area and consists of 146 rows, 180 columns, and 11 layers. The 1997 and updated models have 56,576 and 289,080 model cells, respectively. The model has been designed to simulate groundwater flow in three dimensions over an area approximately 42,800 feet (north to south) by 29,000 feet (east to west). The original and updated model boundaries are shown on Figure 1. Dimensions of cells along row (east-west) and column (north-south) directions range from 100 to 1,200 feet. The finest grid resolution is generally used downgradient of the site with lateral grid cell dimensions of 100 by 100 feet to enhance computational accuracy and produce results at the desired level of detail. Fine-scale discretization downgradient of the site corresponds to critical areas with respect to model uses. A general rule-of-thumb was followed when systematically increasing grid spacing from areas of finer resolution to areas of coarser resolution, to minimize numerical dispersion. Generally, the variation in grid spacing progressed such that the maximum change in spacing did not exceed 1.5 times the adjacent cell.

The increase in vertical discretization in the updated model (i.e., 8 layers in the 1997 model vs. 11 layers in the updated model) is based upon data collected from a series of vertical profile borings and monitoring wells installed downgradient of the site (since development of the 1997 model). Figure 2 provides a comparison between the layering scheme used in the 1997 model and that of the updated model. The hydrogeologic data collected from these wells/borings supports the definition of additional model layers, as wells as changes to hydraulic conductivity zonation as discussed below.

Boundary Conditions

In general, the top and bottom model boundaries (water table and Raritan Clay, respectively) are unchanged from the 1997 model; however, the elevation of the

Raritan clay has been lowered based upon data gathered from recently drilled vertical profile borings. The lateral model boundaries have been expanded primarily to the east and south of the site (in the direction of regional groundwater flow). The original model covered an area of approximately 25.2 sq miles, the updated model represents an area of approximately 44.5 square miles.

Parameter Zonation

Hydraulic conductivity zonation was updated to reflect the presence of several low permeability zones not represented in the 1997 model. Specifically, data collected from the vertical profile borings drilled near BWD Plants 4 and 5 was used to update hydraulic conductivities in the vicinity of GM38.

Areal Recharge

The areal recharge rate was updated after reviewing precipitation records from January 1984 through November 2001 for the precipitation station at MacArthur Airport located in the Town of Islip, Long Island. A long-term average annual rate was established based on these data. The areal recharge rate in the updated model is 0.00588 feet per day (25.75 inches per year), consisting of fifty percent of the average annual precipitation, and 10% of the modeled municipal pumpage (representing leakage from both municipal supply systems and sewers).

Groundwater Pumpage and On-Site Recharge

Regional groundwater pumping (from both on-site remedial wells and off-site supply wells) and recharge to on-site basins (Plant 5 and South Basins) were updated as follows. Quarterly monitoring of the on-site Northrop Grumman OU2 Groundwater Remediation system provides extraction well pumping rates. These data along with discussions with Northrop Grumman personnel regarding future development of the site were used as the basis for the on-site pumping and recharge rates used for the calibration and predictive simulation. Off-site pumping rates were developed based on monthly pumping rates (on a well by well basis) provided by the water districts represented in the model. Average production rates for each of the municipal supply wells based on reported pumpage from January 1998 through June 2001 were developed and used in the model to represent the long-term steady state pumping stress (see Table 1).

Model Calibration

Procedures used for the steady state calibration of the updated model are unchanged from those used in 1997. Eighty one calibration targets (water levels) were used in the updated model. The specific calibration criteria were as follows:

- Simulated flow patterns will adequately reproduce observed flow patterns.
- The average of residuals will be within 5 percent of the range in target heads.
- The residual standard deviation will be within 10 percent of the range in target heads.
- The distribution of residuals will not show any spatial bias.

All criteria for assessing if model calibration is acceptable were satisfied. Simulated flow patterns reproduced observed flow patterns; average residuals were less than 2.4 ft; the residual standard deviation was 3.05 ft; and the distribution of residuals did not show any spatial bias.

As described in the 1997 model report, model inflows must equal model outflows to ensure model accuracy and stability. The model calculated discrepancy between inflows and outflows (volumetric flow budget) for the updated model was 0.00 percent. Inflow to the model included areal recharge, on-site recharge through recharge basins, and an influx from constant heads along the model boundaries. Model outflows primarily were withdrawal by pumping wells, seepage to streams, and flow to constant head cells at the models southern boundary. These flows are consistent with the conceptualization of the groundwater flow system.

Conclusions and Recommendations

Updates and modifications to the 1997 groundwater model have been successfully completed. The changes enable the model to be used for advective and solute transport analysis in key off-site (downgradient) areas. Specifically, the model is appropriately designed to address both remedial issues in the "GM-38 area", and outpost monitoring well issues related to public water supply wells located downgradient of the site.

Please call if you have any questions.

Sincerely,

ARCADIS G&M, Inc.

Douglas A. Smolensky
Senior Modeler

Carlo San Giovanni
Project Manager

Michael F. Wolfert
Project Director

copies:
David Brayack – Tetratech NS, Inc.
Rob Burns – Dvirka & Bartilucci
John Cofman – Northrop Grumman Corporation
James Colter – U.S. Navy Northern Division
Frank Flood – Massapequa Water Service
William Gilday – NYSDOH
Ron Krumholz – Bethpage Water District
Larry Leskovjan – Northrop Grumman Corporation
Edoardo Licci – South Farmingdale Water District
Gary Loesch – H2M Group
Tom Maher - Dvirka & Bartilucci
John Molloy – H2M Group
Arnold Palleschi – Town of Hempstead Water District
Anthony J. Sabino – Office of the Town Attorney
Steven M. Scharf – NYSDEC
Bruce Smith - NCDOHS
Matt Snyder – New York Water Service

ARCADIS

Table 1. Public Supply Well Average Pumping Rate, Northrop Grumman Corporation, Bethpage, New York

Owner/ User	NYSDEC Well ID#	Local Well ID#	Elevation, Top of Screen (ft msl)	Elevation, Bottom of Screen (ft msl)	Average (1) Pumping Rate (mgd)
Bethpage Water District	3876	6-1	-238	-291	533,300
Bethpage Water District	6078	9			
Bethpage Water District	6915	4-1 (10)	-450	-513	492,500
Bethpage Water District	6916	4-2 (11)	-466	-516	659,933
Bethpage Water District	8004	5-1	-594	-655	177,800
Bethpage Water District	8767	7A	-459	-520	1,333,800
Bethpage Water District	8768	8A	-485	-558	285,233
Bethpage Water District	8941	6-2	-620	-680	109,900
Bethpage Water District	9591	BDG-1	-496	-562	114,467
Hicksville Water District	5336	2-2			
Hicksville Water District	6190	7-1	-375	-425	39,871
Hicksville Water District	6192	8-1	-444	-494	545,485
Hicksville Water District	7561	5-2			
Hicksville Water District	7562	1-4	-330	-380	-
Hicksville Water District	7562	1-4	-289	-310	120,602
Hicksville Water District	8193	8-2			
Hicksville Water District	8249	1-5			
Hicksville Water District	8525	3-2			
Hicksville Water District	8778	9-1	-389	-450	499,647
Hicksville Water District	8779	9-2	-385	-445	533,876
Hicksville Water District	9180	8-3	-470	-502	-
Hicksville Water District	9180	8-3	-417	-448	1,000,189
Hicksville Water District	9212	5-3			
Hicksville Water District	9463	10-1	-416	-452	176,400
Hicksville Water District	9463	10-1	-460	-496	
Hicksville Water District	9488	1-6	-355	-408	1,240,590
Hicksville Water District	10208	9-3	-432	-509	711,389
Hicksville Water District	10320	6-1R	-405	-415	743,767
Hicksville Water District	10320	6-1R	-435	-465	
Hicksville Water District	10555	11-1	-458	-543	337,146

Table 1. Public Supply Well Average Pumping Rate, Northrop Grumman Corporation, Bethpage, New York

Owner/ User	NYSDEC Well ID#	Local Well ID#	Elevation, Top of Screen (ft msl)	Elevation, Bottom of Screen (ft msl)	Average [(1)] Pumping Rate (mgd)
Massapequa Water District	4602	1	-344	-408	686,200
Massapequa Water District	5703	3	-345.5	-376	1,167,933
Massapequa Water District	5703	3	-390	-420.6	
Massapequa Water District	6442	4	-542.9	-569	-
Massapequa Water District	6442	4	-481	-522.8	879,833
Massapequa Water District	6443	5	-727	-807	208,233
Massapequa Water District	6866	6			
Massapequa Water District	6867	7			
Massapequa Water District	6867	7			
Massapequa Water District	6867	7			
Massapequa Water District	8214	8	-569	-649	414,267
Massapequa Water District	9173	2R	-727	-808	293,500
New York Water Service	3463	-			
New York Water Service	3780	1			
New York Water Service	3893	2S			
New York Water Service	8480	3S	-509	-594	1,602,533
New York Water Service	9338	4S	-527	-588	1,241,867
New York Water Service	9514	4J	-534.5	-625.5	1,533,433
New York Water Service	9878	4N	-521	-623	
New York Water Service	10195	5J	-477.5	-545.5	1,143,267
Plainview Water District	4095	1-1	-270	-320	306,666
Plainview Water District	4096	1-2	-274	-324	526,333
Plainview Water District	4097	3-1			
Plainview Water District	6077	4-2	-240	-300	242,097
Plainview Water District	6580	3-2	-376	-436	219,582
Plainview Water District	7526	2-1	-370	-380	-
Plainview Water District	7526	2-1	-390	-410	-
Plainview Water District	7526	2-1	-430	-455	-
Plainview Water District	7526	2-1	-340	-355	245,187
Plainview Water District	12535	4-3	-398	-458	641,709

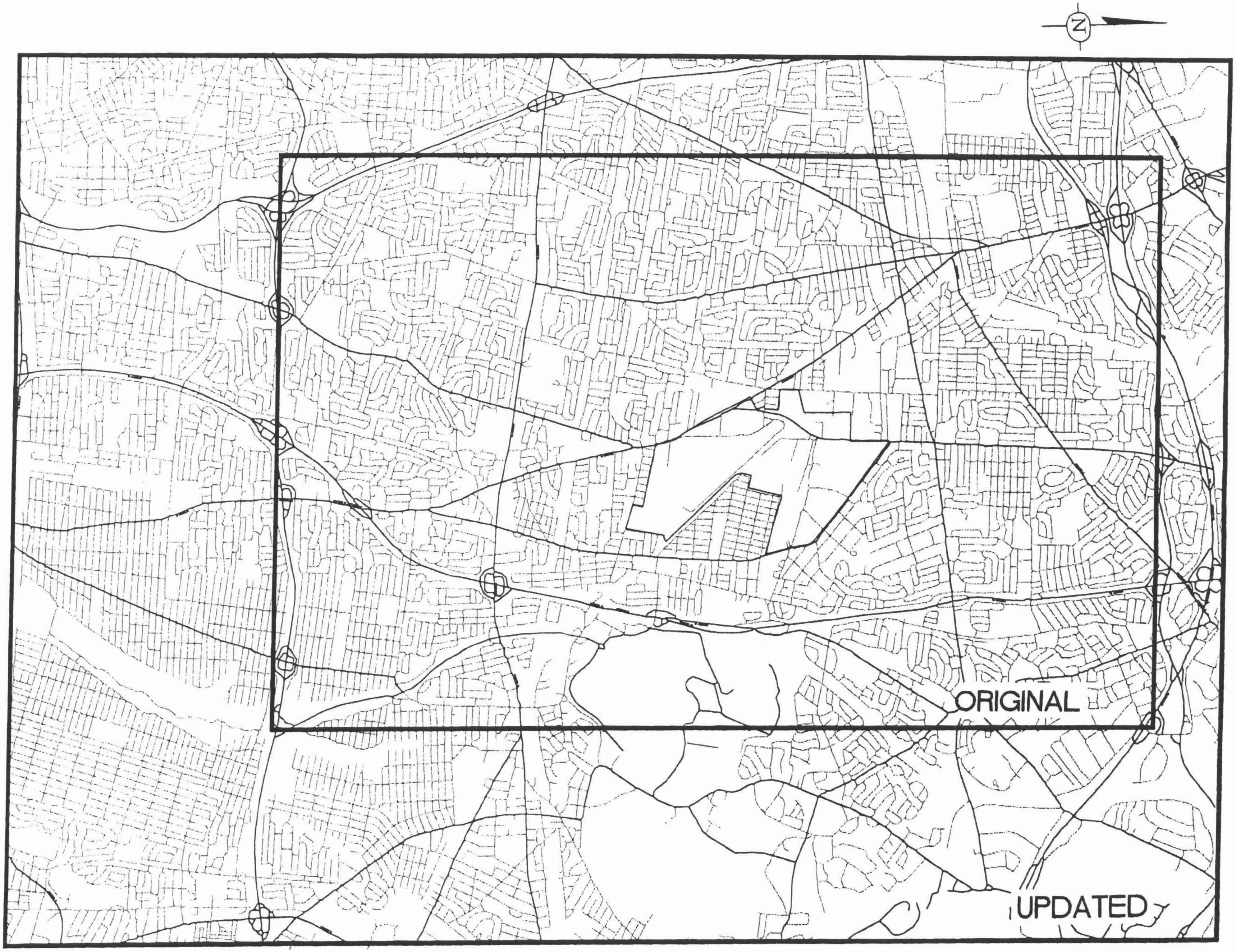
Table 1. Public Supply Well Average Pumping Rate, Northrop Grumman Corporation, Bethpage, New York

Owner/ User	NYSDEC Well ID#	Local Well ID#	Elevation, Top of Screen (ft msl)	Elevation, Bottom of Screen (ft msl)	Average [1] Pumping Rate (mgd)
S. Farmingdale Water District	4042	1-1			
S. Farmingdale Water District	4043	1-2	-247	-304	374,457
S. Farmingdale Water District	5147	2-1	-122	-177	15,365
S. Farmingdale Water District	5148	1-3	-284	-299	-
S. Farmingdale Water District	5148	1-3	-228	-262	590,824
S. Farmingdale Water District	6148	4-1	-483	-511	-
S. Farmingdale Water District	6148	4-1	-412	-439	503,358
S. Farmingdale Water District	6149	2-2	-548	-598	519,049
S. Farmingdale Water District	6150	3-1	-487	-547	558,241
S. Farmingdale Water District	7377	1-4	-568	-583	-
S. Farmingdale Water District	7377	1-4	-594	-604	-
S. Farmingdale Water District	7377	1-4	-657	-683	-
S. Farmingdale Water District	7377	1-4	-533	-553	222,150
S. Farmingdale Water District	7515	5-1	-220	-277	420,158
S. Farmingdale Water District	7516	5-2	-460	-513	-
S. Farmingdale Water District	7516	5-2	-423	-443	677,202
S. Farmingdale Water District	8664	6-1	-525	-550	-
S. Farmingdale Water District	8664	6-1	-475	-515	851,607
S. Farmingdale Water District	8665	6-2	-451	-521	354,764
TOH Water District(East Meadow)	5321	9			
TOH Water District(East Meadow)	5322	10	-400	-440	754,704
TOH Water District(Levittown)	2580	3			
TOH Water District(Levittown)	3193	5			
TOH Water District(Levittown)	3194	6			
TOH Water District(Levittown)	3618	6A			
TOH Water District(Levittown)	4450	9	-332	-389	1,060,433
TOH Water District(Levittown)	4451	10			
TOH Water District(Levittown)	5301	11			
TOH Water District(Levittown)	5302	12	-365	-418	874,710
TOH Water District(Levittown)	5303	13	-559	-675	881,391
TOH Water District(Levittown)	5304	14	-360	-417	142,753

Table 1. Public Supply Well Average Pumping Rate, Northrop Grumman Corporation, Bethpage, New York

Owner/ User	NYSDEC Well ID#	Local Well ID#	Elevation, Top of Screen (ft msl)	Elevation, Bottom of Screen (ft msl)	Average (1) Pumping Rate (mgd)
TOH Water District(Levittown)	7076	5A	-527	-543	951,305
TOH Water District(Levittown)	7523	8A	-555	-607	-
TOH Water District(Levittown)	7523	8A	-512	-537	699,117
TOH Water District(Levittown)	8279	7A	-394	-470	785,586
TOH Water District(Levittown)	8321	2A	-528	-576	-
TOH Water District(Levittown)	8321	2A	-476	-514	697,845
TOH Water District(Levittown)	12560	6B	-519	-544	-
TOH Water District(Levittown)	12560	6B	-444	-464	1,040
Village of Farmingdale	1937	2-1			
Village of Farmingdale	6644	2-2	-75	-127	1,400,000
Village of Farmingdale	7752	1-3	-333	-391	1,600,000
Village of Farmingdale	11004	2-3	-160	-247	1,900,000

NYSDEC: New York State Departement of Environmental Conservation.
(1) Average pumping rate based on pumpage from January 1998 through June 2001.
ft msl: feet relative to mean sea level.
mgd: Millons of gallons per day.
TOH: Town of Hempstead.
S. Farmingdale: South Farmingdale.



NO.	DATE	REVISION DESCRIPTION	BY / CKD

ARCADIS G&M

DRAWN LMC	DATE 6/5/02	PROJECT MANAGER R. PORSCHE	DEPARTMENT MANAGER D. SMOLLENSKY
COMPARISON OF ORIGINAL MODEL AND UPDATED MODEL AREAL EXTENT REGIONAL GROUNDWATER FLOW AND TRANSPORT MODEL NORTHROP GRUMMAN CORPORATION BETHPAGE, NEW YORK		LEAD DESIGN PROF.	CHECKED R. PORSCHE
		PROJECT NUMBER NY001321.0006	DRAWING NUMBER 1

FILE: G:\PROJECT\NORTHROP GRUMMAN\SUPERFUND\NY001321.0006\0005\FLOW_COMPARISON_SITE.DWG, DATE: 06/04/2002 10:10:03AM

MODEL LAYER HORIZONS
IN THE VICINITY OF GM-38D/D2

ORIGINAL MODEL	ELEVATION (1)	UPDATED MODEL
▽	55 (WT)	▽
1		1
	30	
2		
	15	
3		
		2
	-50	
4		
		3
	-140	
		4
5		
	-235	
		5
6		
		6
	-365	
		7
7		
		8
		9
	-580	
		10
8		
(Raritan Clay)	-680	
		11
		(Raritan Clay)

LEGEND

▽ AND WT WATER TABLE

/////// RARITAN CLAY

(1) – FEET MEAN SEA LEVEL

NO.	DATE	REVISION DESCRIPTION	BY	CKD

ARCADIS G&M

DRAWN LMC | DATE 6/5/02 | PROJECT MANAGER R. PORSCHE | DEPARTMENT MANAGER D. SMOLLENSKY

LEAD DESIGN PROF. | CHECKED R. PORSCHE

CONPARISON OF MODEL LAYERING

REGIONAL GROUNDWATER FLOW AND TRANSPORT MODEL
NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK

PROJECT NUMBER NY001321.0006 | DRAWING NUMBER 2

FILE: G:\APROJECT\NORTHROP GRUMMAN\SUPERFUND\NY001321.0006\MODEL\MODEL LAYERING.DWG, DATE: 10/29/2002 10:15:41AM