Appendix A

Groundwater Modeling in Support of Determining Locations and Screen Zones for Outpost Monitoring Wells Memorandum

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Date:
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ARCADIS Project No.:
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Subject:
Groundwater Modeling in Support of Determining Locations and Screen Zones for Outpost Monitoring Wells, Northrop Grumman Corporation.

Purpose of Outpost Monitoring Wells

The purpose of this memo is to outline the process followed to select potential outpost monitoring well locations for several public water supply wells located south (i.e., downgradient) of the Northrop Grumman Corporation/Naval Weapons Industrial Reserve Plant (NWIRP) sites in Bethpage, New York. The outpost monitoring wells will be used to monitor groundwater quality between the lower portion of the leading edge of the volatile organic compound (VOC) plume this is anticipated to impact the public supply wells and the supply wells potentially in the path of the plume. Outpost Well locations have been chosen to provide approximately 5 years notice to the water districts, specifically, the outpost monitoring well locations developed with this effort will enable detection of the groundwater plume at least 5 years before the supply wells have detections of VOCs.

The updated Northrop Grumman groundwater model (documented in the ARCADIS October 2002 letter report) was used in this evaluation to help identify the outpost monitoring well screen locations in the context of the aforementioned goals.

Determination of Municipal Wells that may have VOC Detections

Groundwater flow modeling with forward particle tracking was used to determine that the following supply wells downgradient of the leading edge of the lower portion of the plume have the potential to have VOC detections related to the plume: N5303 (Town of Hempstead [Levittown] Water District), N8480 and N9338 (New York Water Service), N6150, N4043, and N5148 (South Farmingdale Water District). Travel time from the plumes leading edge to these wells is summarized in Table A-1. Well locations are shown on Figure A-1.

The model predicted time to VOC detections in supply wells resulting from the evaluation summarized in this memo is based on the assumption that the steady state groundwater flow conditions simulated by the model remain constant through time. Therefore, if significant changes to pumping rates are made in the supply wells downgradient of the plume, the flow field would change and the potential for VOC detections would require re-evaluation. Recall that the particle tracking evaluation only indicates the potential for groundwater at the plumes leading edge to reach a downgradient receptor. It does not quantify the concentration of VOCs in the groundwater predicted to reach the well. However, solute transport modeling (conducted by ARCADIS) has predicted that the following supply wells would have influent concentrations above 0.5 µg/L within 30 years as a result of the VOC plume; time to VOC detection is shown in parenthesis: N4043 (11 years), N6150 (4 years), N8480 (18 years), and N9338 (24 years).

Although groundwater flow modeling with forward particle tracking indicated that municipal supply wells N5303 and N5148 were potential receptors of the groundwater plume, solute transport modeling indicates that when the plume reaches these wells, influent concentrations will remain below 0.5 µg/L for the 30 year evaluation period. Nevertheless, to be conservative, ARCADIS has developed an outpost monitoring well cluster location and screen zones for supply well N5303. An outpost monitoring well location was not developed for supply well N5148 because it is located in the same well field as supply well N4043 and model results predict a VOC detection in N4043 approximately 15 years before a detection in N5148 (see Table A-1). For well fields with multiple supply wells (South Farmingdale Well Field 1 and New York Water Service Wells 3S and 4S), locations for outpost monitoring wells were developed for the supply well in the field where the model predicted the first VOC detection to occur.

Selection of Outpost Monitoring Well Locations

Following the identification of supply wells with the potential to have VOC detections from the groundwater plume, and after determining the timing of the VOC detections with the model, the locations for placement of the outpost monitoring wells were defined both horizontally and vertically. In addition to being sufficiently distant from the supply well to provide a 5-year notification period, the wells were screened to detect that portion of the plume that, based on model predictions, had the potential to cause VOC detections in the supply well. In the case of supply well N5303, an outpost monitoring well location was selected in

spite of the uncertainty associated with the limit of the plumes western extent. The following sections describe the procedure used to select the location and screen zone for each of the outpost monitoring wells.

Distance from municipal supply wells

Groundwater flow modeling with reverse particle tracking was used to define the appropriate distance upgradient of each supply well for the installation of the outpost monitoring well. Reverse particle tracking was used to define the capture zone resulting from the operation of each supply well, and to determine the distance from the supply well beyond which a particle of groundwater would travel for at least 5 years before reaching the supply well. As stated above, this evaluation and its results are based on the assumption that the conditions modeled will remain constant through time. If the rate of groundwater production at the supply well in question, or the rate at nearby supply wells is significantly varied from the simulated production rate for extended periods, groundwater velocities near the supply wells will vary and the selected outpost monitoring well location may not provide a 5-year notification period.

Selection of Screen Zones

The results of the groundwater flow modeling with forward particle tracking discussed earlier were used to evaluate which portion of the plume moved fastest as it approached the municipal supply wells. The layer through which the fastest moving portion of the plume traveled as it approached the well was selected as the primary horizon to be monitored for advanced warning of the approaching plume. As a conservative approach, the layer through which the second fastest moving portion of the plume traveled as it approached the well was selected as the secondary horizon to be monitored. At South Farmingdale's Wellfield No. 1 there were two layers that contained the fastest moving portion of the plume, and so three outpost wells are proposed for this wellfield.

Modeling Results

The supply well capture zones were evaluated along with the results of forward particle tracking of the plumes leading edge, to define both the horizontal and vertical location to be monitored to detect the advancing TVOC plume at least five years before VOC detections occur in the supply well. Based on the evaluation of the groundwater modeling described above, ARCADIS recommends the installation of four clusters of outpost monitoring wells. The clusters will consist of two or three monitoring wells, each targeting a specific portion of the aquifer. ARCADIS recommends the installation of a three-well cluster to monitor groundwater upgradient of South Farmingdale's Well Field No. 1 (N4043, N5148, and N7377). Two-well clusters are recommended to monitor groundwater quality upgradient of South Farmingdale's Well Field No. 3 (N6150), the New York Water Service Well Field (N8480, and N9338), and the Town of Hempstead (Levittown) Well Field (N5303). Locations for the outpost monitoring well clusters are shown on Figures A-2 through A-5; screen zones for the proposed outpost monitoring wells are summarized in Table A-2. The distance from the outpost monitoring well clusters to the supply wells, the model predicted

trigger values, time to trigger value at the outpost wells, and time to VOC detection at the supply wells are given in Table A-3, along with the nearest street intersection to the recommended outpost well location. Any differences between Tables A-1 and A-3 (regarding time of travel) are a function of the transport mechanisms simulated. Table A-1 is based on particle tracking (advective transport modeling), while Table A-3 is based on solute transport modeling. When differences are significant, the recommendations are conservative as the shortest time was always used in the decision making process.

Table A-1. Groundwater travel time (in years) from the plumes leading edge in each model layer to municipal supply wells, Northrop Grumman Corporation - Bethpage, New York.

	Model Layer									
Well ID	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
South Farmingdale Well Field 1										
4043	21	22	12	12	12	--	--	--	--	--
5148	27	--	--	--	--	--	--	--	--	--
7377	--	--	--	--	--	--	--	--	--	--
South Farmingdale Well Field 3										
6150	--	--	--	12	8	>30	>30	>30	>30	--
New York Water Service Wells 3S and 4S										
8480	23	25	17	24	24	>30	>30	>30	>30	>30
9338	--	30	23	27	24	>30	>30	>30	>30	>30
Town of Hempstead (Levittown) Well 13										
5303	--	--	--	--	>30	--	>30	--	--	--

-- No model predicted detection of TVOCs.
>30 Model predicts detection of TVOCs after 30 years.

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Table A-2. Municipal Supply Well Data and Screen Zones of Proposed Outpost Monitoring Well Clusters, Northrop Grumman Corporation - Bethpage, New York.

Outpost	Model Layer				Proposed Outpost Wells Screen Zones						
Wells ID	Number	Top Elevation	Bottom Elevation	Middle Elevation	Top Elevation	Bottom Elevation	Length Feet	Screened Interval feet bls	Municipal Well Field Monitored	Municipal Supply Well Nos.	Screened Interval of Municipal Supply Well feet bls
OW1-1	4	-114	-170	-142	-122	-162	40	196-236	South Farmingdale Well Field 1	4043[1], 5148, 7377	312-372 (4043); 309-369 (5148); 607-758 (7377)
OW1-2	5	-170	-270	-220	-200	-240	40	274-314	South Farmingdale Well Field 1	4043[1], 5148, 7377	312-372 (4043); 309-369 (5148); 607-758 (7377)
OW1-3	6	-270	-360	-315	-295	-335	40	369-409	South Farmingdale Well Field 1	4043[1], 5148, 7377	312-372 (4043); 309-369 (5148); 607-758 (7377)
OW2-1	6	-265	-355	-310	-290	-330	40	350-390	South Farmingdale Well Field 3	6150	545-612
OW2-2	7	-355	-437	-396	-376	-416	40	436-476	South Farmingdale Well Field 3	6150	545-612
OW3-1	7	-354	-435	-394.5	-374.5	-414.5	40	436.5-476.5	New York Water Service 3S and 4S	8480[1], 9338	570-665 (8480); 585-646 (9338)
OW3-2	9	-524	-601	-562.5	-542.5	-582.5	40	604.5-644.5	New York Water Service 3S and 4S	8480[1], 9338	570-665 (8480); 585-646 (9338)
OW4-1	10	-583	-630	-606.5	-586.5	-626.5	40	652-692	TOH Water District (Levittown) 13	5303	602-736
OW4-2	11	-630	-740	-685	-665	-705	40	730-770	TOH Water District (Levittown) 13	5303	602-736
									Massapequa Water District, Northwest Wellfield	6442, 6443	524-612, 770-850
									Massapequa Water District, Northeast Wellfield	4602, 5703, 8214, 9173	381-445, 382-458, 606-686, 764-845

Outpost monitoring wells are not planned for the Massapequa Water District at this time as modeling does not predict impacts at these wells in the 30-year modeling time period.

Elevations are given in feet relative to mean sea level.

(1) First well in well field predicted by modeling to be potentially impacted with VOCs; monitoring well cluster designed to monitor potential impacts at this well.

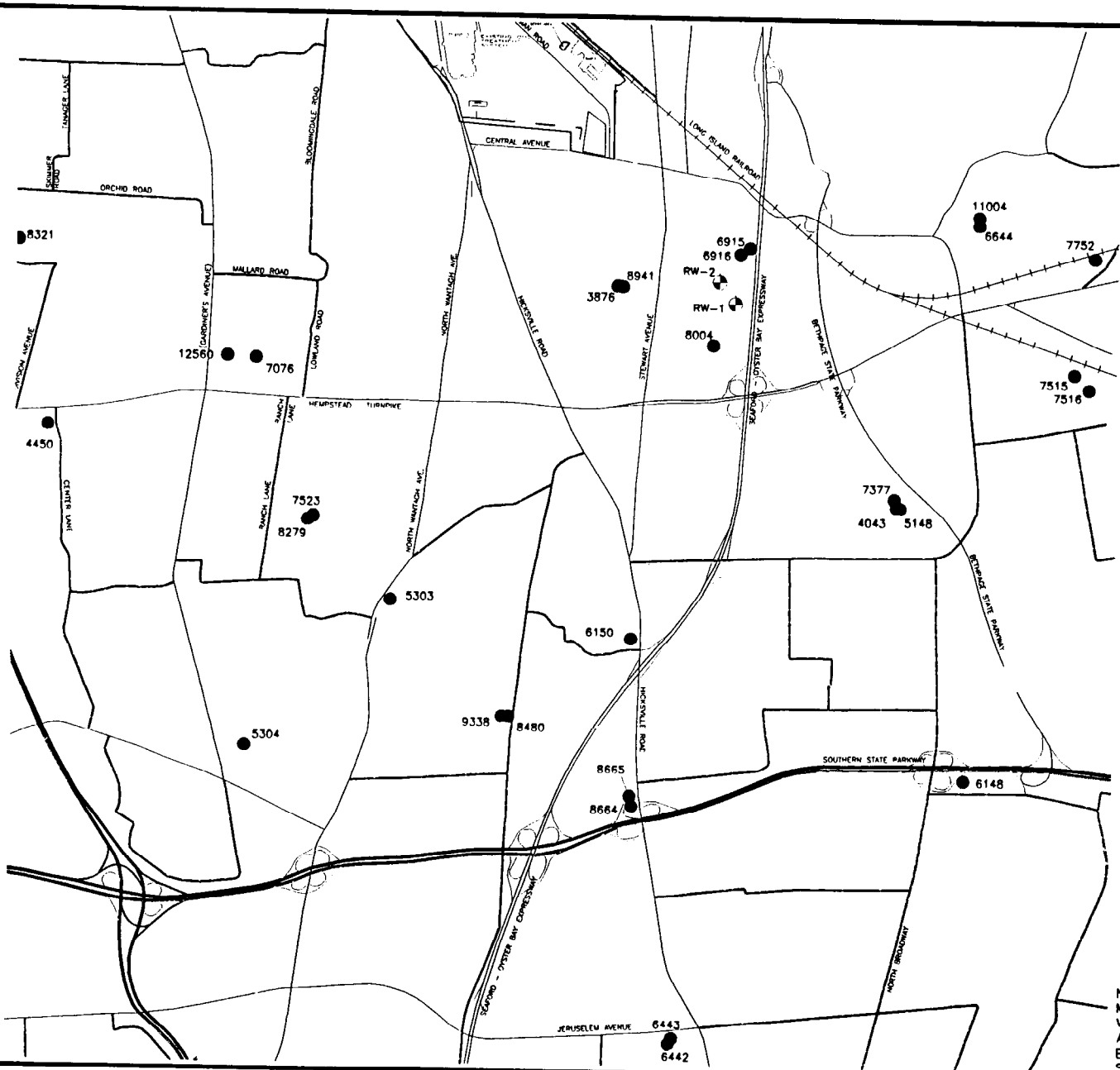
BLS Below landsurface
TOH Town of Hempstead
VOCs Volatile Organic Compounds

Table A-3. Outpost Monitoring Well Trigger Values, Northrop Grumman Corporation - Bethpage, New York.

Outpost Well ID	Nearest Street Intersection of Outpost Well Location	Distance from Outpost Well to Municipal Supply Well (feet)	Municipal Supply Well ID	Outpost Well Trigger Value (ppb)	Time to Reach Trigger Value in Outpost Well (years)	Time to Detection in Municipal Supply Well (years)
OW1-1, OW1-2, OW1-3	Lawrence Street & Bruce Drive	625	4043	0.6	6	11
OW-2-1, OW-2-2	Harriet Road & Gloria Road	320	6150	--	--	4
OW3-1, OW3-2	Red Maple Drive East & Red Maple Drive North	975	8480	1.5	13	18
OW4-1, OW4-2	Elm Drive West & Elm Drive North	850	5303	1.5	--	--

Time to detection is number of years before detection of 0.5 ppb total volatile organic compounds (TVOC) in municipal supply well.
Trigger Value is TVOC concentration at outpost well 5 years before model predicted detection of 0.5 ppb at municipal supply well.
For Well 6150, travel time is too brief to determine trigger value, detection will occur in less than 5 years.
For Well 5303 trigger value and time to detection cannot be determined because the model does not predict a detection to occur at Well 5303 based on current plume delineation, however, as a conservative measure a trigger value of 1.5 ppb has been selected (same as for Outpost Wells OW2-1, OW3-2). The highest of the calculated trigger values was selected because a trigger value for a well where there is no prediction of impact should not be lower than for a well where there is a prediction of impact.

ppb parts per billion



LEGEND

- PROPOSED REMEDIAL WELL
- SUPPLY WELL

NOTES:
MASSAPEQUA WATER DISTRICT PUBLIC SUPPLY WELLS 4602, 5703, 8214, AND 9173 LOCATED APPROXIMETLY 7,000 FT EAST OF NORTH BROADWAY AND 1,600 FT SOUTH OF SOUTHERN STATE PARKWAY.

0 3000
SCALE IN FEET

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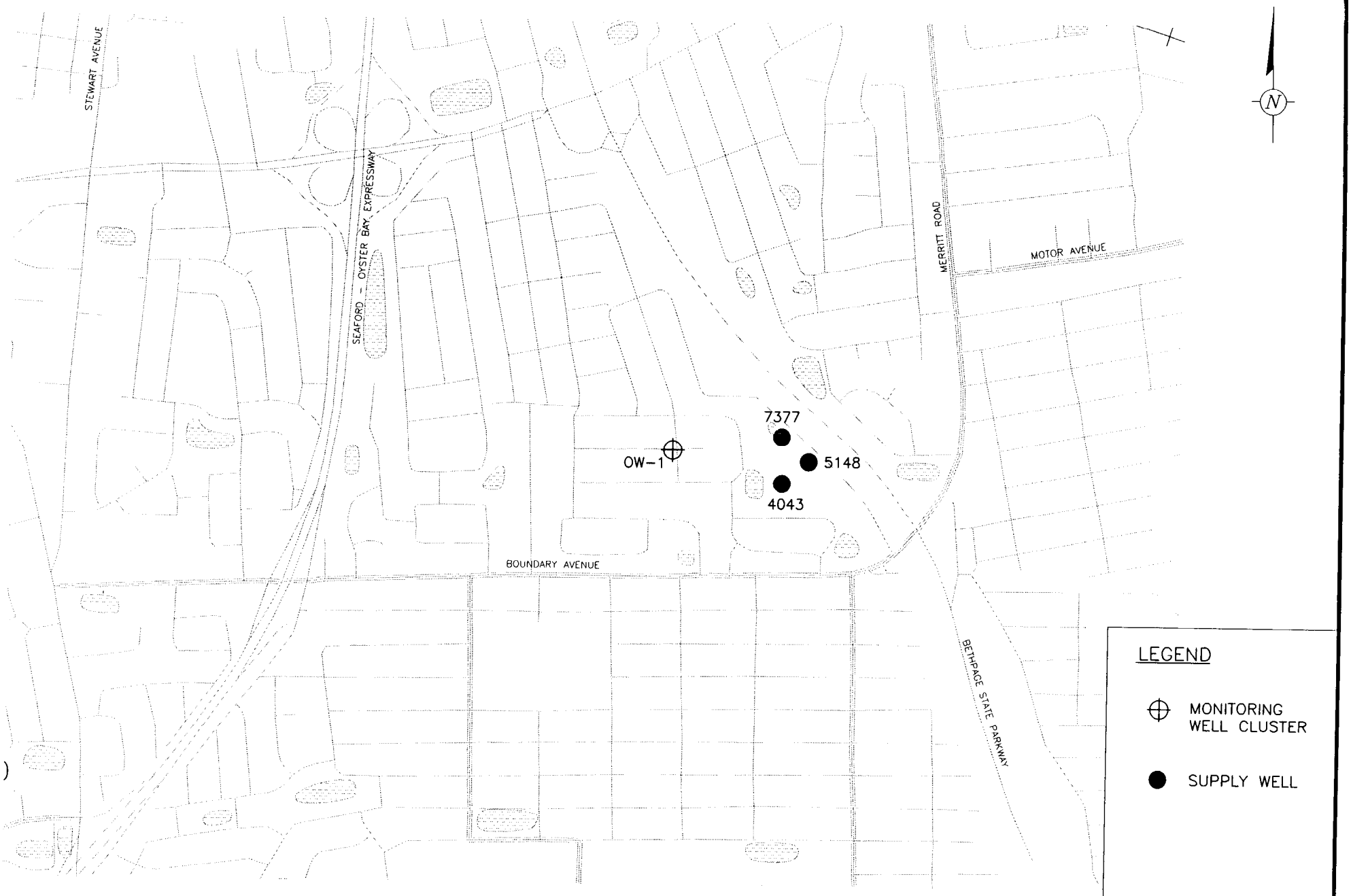
DRAWN: LMC	DATE: 11/26/02	PROJECT MANAGER: R. PORSCHE	DEPARTMENT MANAGER: N. VALKENBURG
LOCATIONS OF SELECT MUNICIPAL SUPPLY WELLS AND PROPOSED REMEDIAL WELLS NORTHROP GRUMMAN CORPORATION		LEAD DESIGN PROF.	CHECKED: R. PORSCHE
		PROJECT NUMBER: NY001321.0006.00003	DRAWING NUMBER: A-1



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SCALE IN FEET

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DRAWN: LMC	DATE: 11/26/02	PROJECT MANAGER: R. PORSCHE	DEPARTMENT MANAGER: N. VALKENBURG
OUTPOST MONITORING WELL CLUSTER LOCATION FOR SOUTH FARMINGDALE'S WELL FIELD NO. 1 NORTHROP GRUMMAN CORPORATION		LEAD DESIGN PROF.	CHECKED: R. PORSCHE
		PROJECT NUMBER: NY001321.0006.00003	DRAWING NUMBER: A-2

0 1000
SCALE IN FEET

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ARCADIS

OUTPOST MONITORING WELL CLUSTER LOCATION FOR SOUTH FARMINGDALE WELL FIELD NO. 3
NORTHROP GRUMMAN CORPORATION

DRAWN	DATE	PROJECT MANAGER	DEPARTMENT MANAGER
LMC	11/26/02	R. PORSCHE	N. VALKENBURG
		LEAD DESIGN PROF.	CHECKED R. PORSCHE
		PROJECT NUMBER NY001321.0006.00003	DRAWING NUMBER A-3

LEGEND

⊕ MONITORING WELL CLUSTER

● SUPPLY WELL

0 1000

SCALE IN FEET

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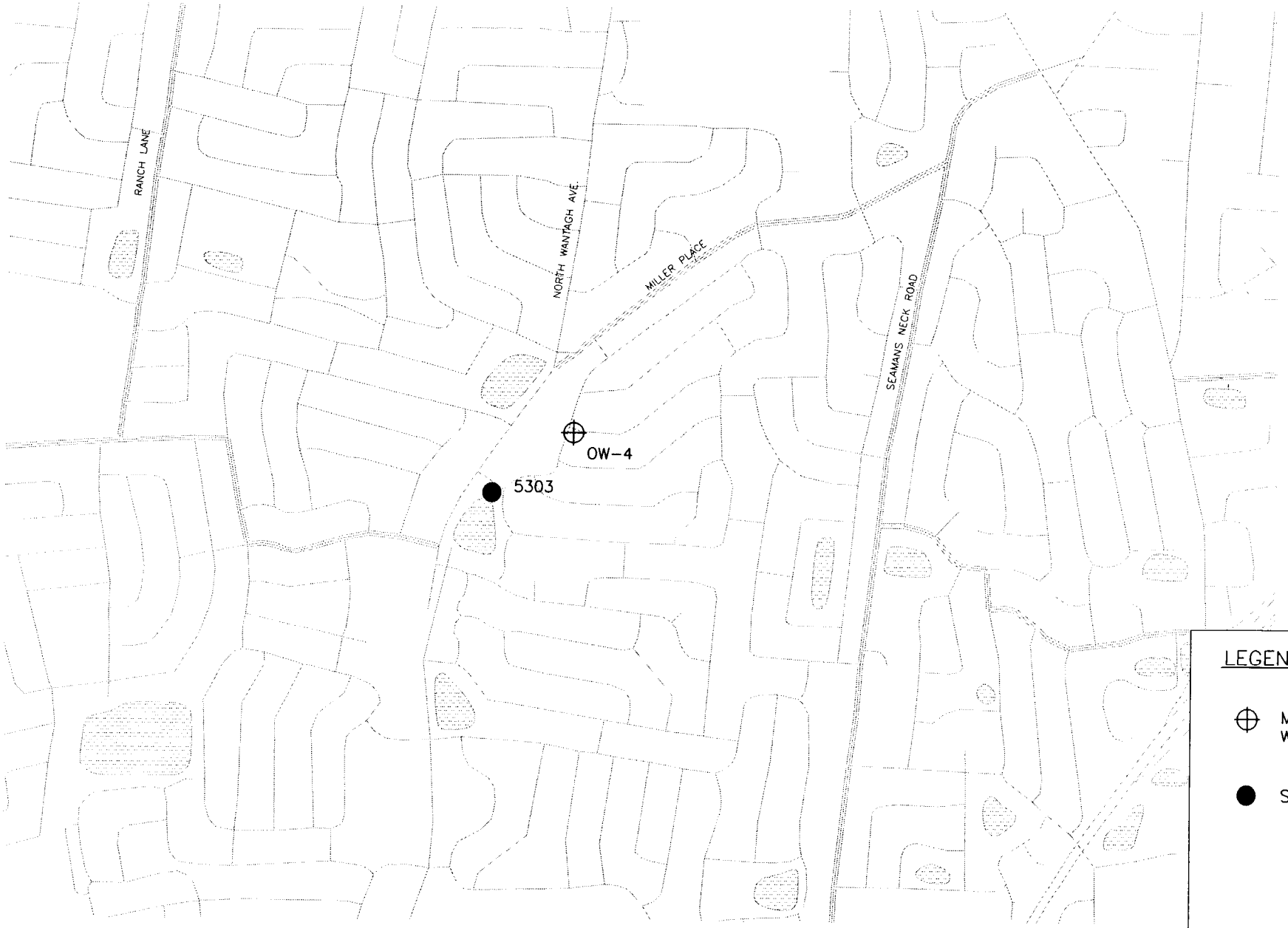
ARCADIS

DRAWN: LMC	DATE: 11/26/02	PROJECT MANAGER: R. PORSCHE	DEPARTMENT MANAGER: N. VALKENBURG
OUTPOST MONITORING WELL CLUSTER LOCATION FOR THE NEW NEW YORK WATER SERVICE WELL FIELD (WELLS 8480 AND 9338) NORTHROP GRUMMAN CORPORATION		LEAD DESIGN PROF.	CHECKED: R. PORSCHE
		PROJECT NUMBER: NY001321.0006.00003	DRAWING NUMBER: A-4



LEGEND

⊕ MONITORING WELL CLUSTER

● SUPPLY WELL

0 1000

SCALE IN FEET

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DRAWN LMC	DATE 7/22/03	PROJECT MANAGER R. PORSCHE	DEPARTMENT MANAGER N. VALKENBURG
OUTPOST MONITORING WELL CLUSTER LOCATION FOR THE TOWN OF HEMPSTEAD WATER DISTRICT (LEVITTOWN) WELL FIELD NO. 13 NORTHROP GRUMMAN CORPORATION		LEAD DESIGN PROF.	CHECKED R. PORSCHE
		PROJECT NUMBER NY001321.0006.00003	DRAWING NUMBER A-5