Brookhaven National Laboratory
Source Water Assessment for Drinking Water Supply Wells

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Nassau and Suffolk Counties have a long history of groundwater management. The Long Island 208 Study (Koppelman, 1978) was the first comprehensive attempt at water quality management on Long Island. The 208 Plan delineated eight major hydrogeologic zones on Long Island based on groundwater flow patterns and determined the areas that contribute recharge to the Upper Glacial and Magothy aquifers (sources of public drinking water). The Long Island Comprehensive Special Groundwater Protection Area Plan (SCDHS, 1992) established nine special groundwater protection areas that are deemed critical for the maintenance of good water quality in the Upper Glacial and Magothy aquifers. These concepts were forerunners of the Safe Drinking Water Act's Wellhead Protection Program, which is a pollution prevention program designed to protect groundwater sources that are relied upon by public drinking water systems.

The 1996 amendments to the Safe Drinking Water Act require the preparation of Source Water Assessments for all sources of water that are used to supply public drinking water. The BNL Source Water Assessment was prepared to satisfy this requirement (Bennett *et al*., 2000). Together with BNL's Environmental Management System, this Source Water Assessment is designed as a management tool to further protect the sole source aquifer system underlying the BNL site. The content of the BNL source water assessment is consistent with the requirements outlined in the *NYS Source Water Assessment Program Plan* (NYSDOH, 1999), and with Nassau and Suffolk County's proposed plan for conducting source water assessments for public water supply wells on Long Island (*Long Island Source Water Assessment Program – Technical Work Plan*, 1999).

There are three distinct water-bearing units underlying the BNL site: the Upper Glacial aquifer, Magothy aquifer, and the Lloyd aquifer. Detailed descriptions on the hydrogeology of the BNL site can be found in deLaguna 1963; Warren *et al.* 1968; and Scorca *et al*. 1999. The water supply for Brookhaven National Laboratory is obtained exclusively from six onsite wells that draw water from the Upper Glacial aquifer. These wells pump approximately 2.2-million gallons of water per day to meet the site's need for drinking water, process cooling water and fire protection.

Source water areas for BNL's potable water wells were determined using the BNL Regional Groundwater Model. The calibrated groundwater flow model (which is based on the computer code MODFLOW and was developed for BNL by Arcadis Geraghty & Miller, Inc. [1996, 1999]) was used to simulate the groundwater flow regime under two water supply operating scenarios. A particle track analysis was then performed to trace the groundwater flow paths in the study area. The analysis code of the groundwater flow path used was a semi-analytical particle-tracking scheme known as MODPATH (Pollack 1994). The flow path was delineated using

reverse particle tracking, whereby particles were introduced into the modeled supply well and tracked backwards along flow path lines. Two-year and five-year travel time zones were delineated using this time-of-travel approach. This method is consistent with the USEPA guidance on Wellhead Protection (USEPA, 1987). Because of BNL's extensive environmental protection and monitoring programs, the two and five year travel time zones are considered adequate for source water protection planning at BNL.

Groundwater models are a simplified representation of the complex groundwater system. Particle-tracking codes simulate advective transport only (the dominant contaminant transport mechanism at BNL) and neglect contaminant attenuation processes (e.g., dispersion, sorption, chemical reactions, and dilution), which can slow the rate of migration. Because particle tracking does not simulate dispersion (which can cause low levels of contamination to migrate ahead of its center of mass), it needs to be applied cautiously to compute the first arrival of measurable contamination. Nevertheless, particle tracking is recognized as a suitable planning technique if applied carefully.

While all six of BNL's potable supply wells are in use each year, they are cycled on and off during any given period. Operationally, either the Western or Eastern Well Field is the primary source of water at any one time. Based on forecasts for the next five years (2000-2005), it is anticipated that Wells 4, 6, and 7 (the Western Well Field) will be operated in the "lead" position, and supply approximately 85% of the annual demand. Wells 10, 11, & 12 (the Eastern Well Field) will supply about 15% of annual demand. The modeled pumping rates are based on average annual demand for a particular well field and assume that the pumpage is divided equally among wells in that well field. For the purposes of the source water assessment, two pumping scenarios were evaluated. Under Scenario 1, the Western Well Field pumpage is 85% of demand (1.8 MGD), whereas the Eastern Well Field pumpage provides 15% of demand (0.32 MGD). Conversely, under Scenario 2 the Western Well Field pumpage provides 15% of demand (0.32 MGD), whereas the Eastern Well Field provides 85% of demand (1.8 MGD). These results indicate that during periods of "lead position" withdrawals (i.e., when a well field is supplying 85% or more of the average demand) the two-year source water areas extend approximately 1,000 feet away from each supply well, whereas the five-year source water areas typically extend up to 1,700 feet from each well.

The extent of these source areas was compared to the inventory of known and potential sources of contamination identified as part of BNL's Environmental Restoration and Environmental Protection programs. The existing engineered and operational controls on those potential threats were then evaluated to determine whether the water supply is adequately protected. This process was used to identify any activities that may need additional operational and/or engineered controls to increase the level of protection.

Figure 6 shows the projected source area of the western water supply well field with a geographical inventory of existing contaminant plumes, wastewater discharge outfalls permitted under SPDES, and Class V injection wells (e.g. dry wells and cesspools). Figure 8 shows the source water area for the western water supply well field with a geographical inventory of existing activated soil shielding areas and activated cooling water systems. Figure 10 shows the geographical inventory of bulk chemical/waste storage areas, underground storage tanks and above ground storage tanks. Table 1 lists the potential threat to water quality and what groundwater protection controls are in place to address the potential threat.

This evaluation concluded that the source water for BNL's Western Well Field (comprised of Supply Wells 4, 6, and 7) has relatively few threats of contamination and that identified potential

sources are already being carefully managed. The source water for BNL's Eastern Well Field (comprised of Supply Wells 10, 11, and 12) has moderate threats to water quality, primarily from several existing volatile organic compound and tritium plumes. The Laboratory has been carefully monitoring plume migration, and has made adjustments to water supply operations. Although a number of BNL's water supply wells were impacted by VOC contamination in the late 1980s, recent routine analysis of water samples from BNL's supply wells indicate that no drinking water standards have been reached or exceeded. The high quality of the water supply indicates that the operational and engineered controls implemented over the past ten years have effectively protected the quality of the water supply. These programs need to be maintained to provide adequate water supply protection.

The BNL water supply system meets all water quality standards and has sufficient pumping and storage capacity to meet current and anticipated future operational demands. Because BNL's water supply is drawn from the shallow Upper Glacial aquifer, BNL's source water is susceptible to contamination. The quality of the water supply is being protected through (1) a comprehensive program of engineered and operational controls of existing aquifer contamination and potential sources of new contamination, (2) groundwater monitoring, and (3) potable water treatment.

A copy of the complete report can be found on the BNL website at http://www.bnl.gov/esd/gw.htm.

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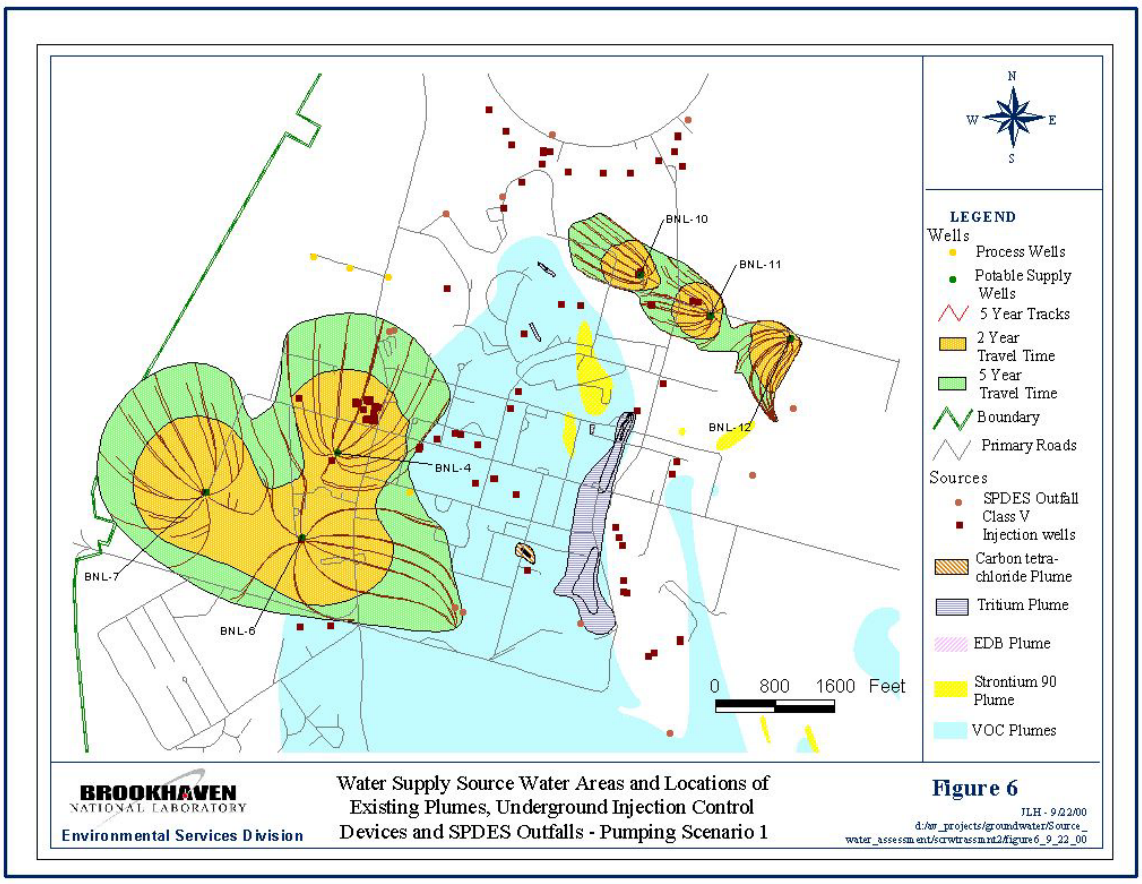

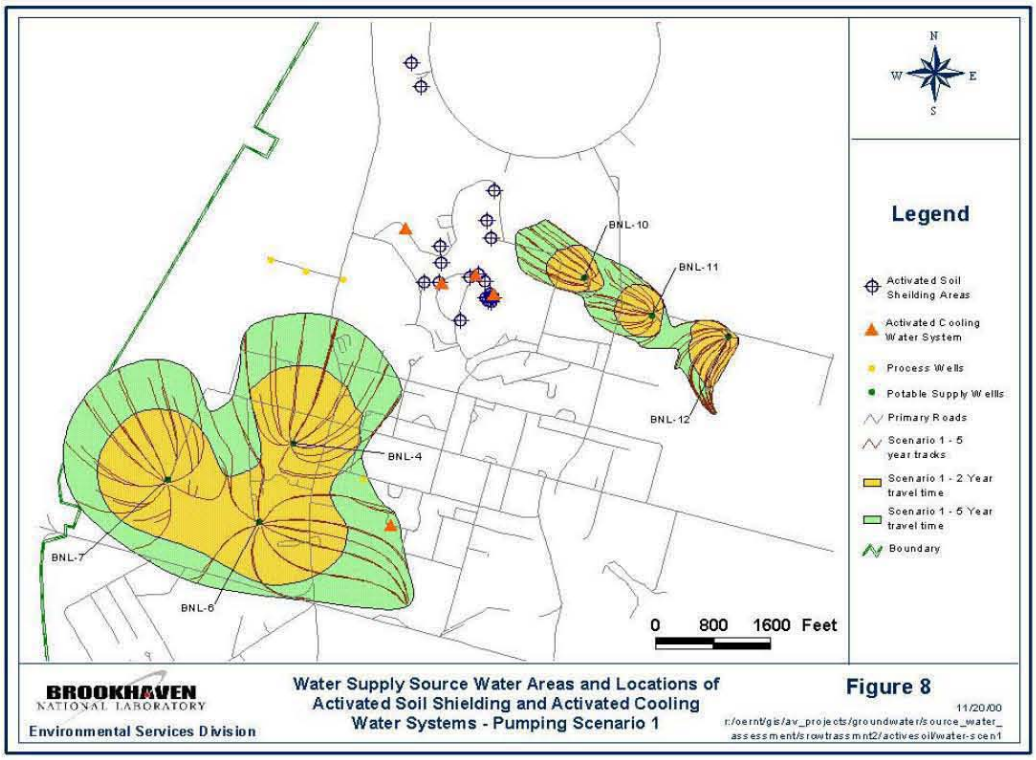
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Process Wells
Potable Supply Wells
Primary Roads
Scenario 1 - 5 year tracks
Scenario 1 - 2 Year travel time
Scenario 1 - 5 Year travel time
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Water Supply Source Water Areas and Locations of Activated Soil Shielding and Activated Cooling Water Systems - Pumping Scenario 1
Figure 8
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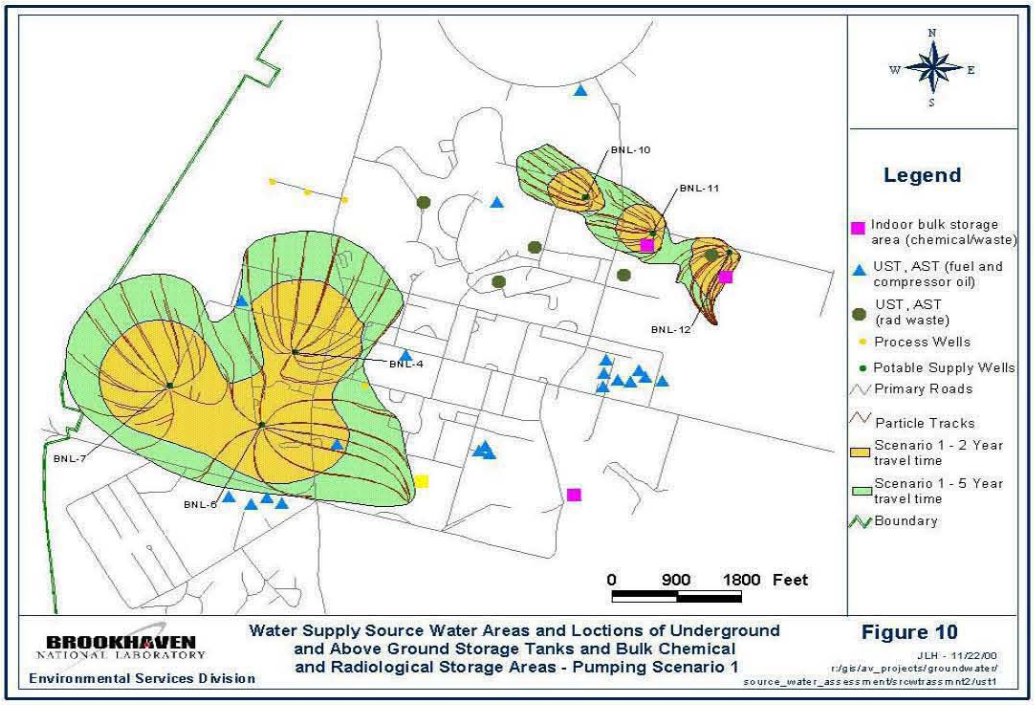
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Indoor bulk storage area (chemical/waste)
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Potable Supply Wells
Primary Roads
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Scenario 1 - 2 Year travel time
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Water Supply Source Water Areas and Loctions of Underground and Above Ground Storage Tanks and Bulk Chemical and Radiological Storage Areas - Pumping Scenario 1
Figure 10
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Table 1
BNL Source Water Assessment for Drinking Water Supply Wells
Contaminant Source Inventory for Western Well Field

Source Type	*Facility/Plume*	*Threat*	*Current Groundwater Quality*	*Controls*
Operating Facility	Water Treatment Plant Recharge Basin	Backwash from iron filters.	No identifiable impacts from WTP operations.	• Outfall monitoring (SPDES Program) • Groundwater monitoring (Environmental Surveillance Program).
	Basin HP/ OU III Groundwater Treatment system recharge basin	• Liquid polyphospate (anti-foulant) in BMRR non-contact cooling water, • OU III Groundwater treatment system is designed to meet DWS before discharge, but could be a threat if fail safes do not operate as designed.	No identifiable impacts from Basin HP/OU III Treatment Plant operations.	• Groundwater monitoring (Environmental Restoration Program). • Fail-safe engineered controls to shut OU III system down, if operational parameters are off-normal (Environmental Restoration Program)
	Class V Injection wells (multiple locations)	Accidental discharges or spills to these recharge features.	No identifiable impacts from Class V injection wells located in this source water area.	• Some UIC targeted for closure (EPA Phase II Agreement). • Connection of facilities to BNL Sanitary System. • Proper control, storage, and transportation of chemical and radioactive materials (RCRA regulations, DOT regulations, and BNL standard operating procedures) • BNL Spill Response Program
	Accidental Spills	Petroleum products (e.g., gasoline, hydraulic fluids)	Shallow soils have been impacted by historical and recent spills. No identifiable impacts to groundwater quality.	• BNL Spill Response Program – most heavily contaminated soils were removed.
	BMRR	Primary cooling water contains high levels of tritium	Groundwater has been impacted by low level tritium contamination (concentrations < NYSDWS)	• Groundwater monitoring (Environmental Surveillance Program). • All piping systems conform with SC Article 12 requirements. All floor drains are properly sealed. • Operating procedures are in place for the proper handling and storage of primary water.
	Motor Pool Area	Petroleum storage and dispensing	Groundwater has been impacted by historical use of solvents. 1,1,1-trichloroethane is detected at concentrations above NYSDWS. Low level MTBE detected, but below NYSDWS.	• Groundwater monitoring (Environmental Surveillance Program) . • Product inventory (BNL standard operating procedures) • Double-walled storage tanks with leak detection (conform with SC Article 12 requirements). • Paved work areas.

Table 1 (Continued)
BNL Source Water Assessment for Drinking Water Supply Wells
Contaminant Source Inventory for Western Well Field

Source Type	*Facility/Plume*	*Threat*	*Current Groundwater Quality*	*Controls*
Operating Facility	Biology Greenhouse Area	Use of pesticides and heavy metals.	No identifiable impacts from greenhouse operations.	• Groundwater monitoring (Environmental Surveillance Program). • Procedures are in place for the proper use and storage of pesticides and herbicides. • Applicators are NYS Licensed.
	Paint Shop	Use of solvents	Historical spillage of solvents impacted soils near shop. Are suspected to have contributed to historical low level VOC contamination detected in Well 4.	• Contaminated soils were removed. • Groundwater monitoring (Environmental Restoration program). • Procedures are in place for the proper use, storage and disposal of paints and paint thinners.
	Sanitary Lines	Sanitary Line Leakage – possible release of bacteria and low level VOCs and radionuclides.	There are no indications that releases from sanitary lines located within the Source Water Areas are impacting groundwater quality.	• Laboratory-wide procedures prohibit the unauthorized disposal of chemical or radioactive waste to the sanitary system. • Supply Well water is routinely tested for chemical, radioactive and bacteriologic contaminants. • Drinking water is treated by chlorination.
Existing Groundwater Plumes	Western edge off the OU III VOC plume.	Historical discharge of solvents to land surface and cesspools in the AGS operations areas.	TVOC (primarily 1,1,1-trichloroethane) detected in monitoring wells at concentrations less than 50 µg/L. Low level 1,1,1-trichloroethane (< NYSDWS) is occasionally detected in Supply Well 4	• Groundwater monitoring (Environmental Surveillance and Restoration Programs). • Active remediation systems to improve groundwater quality. • Proper control, storage, and transportation of chemical and radioactive materials (RCRA regulations, DOT regulations, and BNL standard operating procedures).