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FACT SHEET
GROUNDWATER INVESTIGATION NEAR FORMER U LINE BEAM STOP

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SUMMARY

The U Line was used from 1973 through 1986 in Alternating Gradient Synchrotron (AGS) Fast Neutrino Beam experiments. BNL's enhanced groundwater monitoring program has detected tritium downgradient from the former U Line beam stop. Tritium levels are approximately two times the drinking water standard. The source of tritium is activated soil that was used as shielding. The contamination is located near the center of the BNL property, approximately two miles from the southern property boundary. BNL is taking corrective measures to prevent further releases of tritium and will be conducting additional characterization studies. BNL will closely monitor the effectiveness of those actions. No tritium has been detected in the closest potable water supply wells.

BACKGROUND

BNL's Environmental Management System includes a comprehensive groundwater protection program that relies heavily on pollution prevention—using operational and engineered controls to prevent contamination from entering the groundwater. Since a sole source aquifer is beneath the facility, it is a priority for BNL to protect that resource.

A key component of the groundwater protection program is the monitoring program, which is used to determine whether or not controls are effective and whether there are other problems that need to be addressed. There are over 700 monitoring wells onsite, most of which are associated with the Environmental Restoration program. As part of the Groundwater Monitoring Improvements Project, 84 additional permanent wells and approximately 25 temporary Geoprobe wells were installed between December 1998 and April 2000 around active research and support operations at the Laboratory.[1] The new wells plus 30 other existing wells are used to evaluate whether the controls for these facilities are effective in protecting groundwater quality.

BNL expected that these wells might detect problems in some of the operational areas, and is using the monitoring data to help determine what corrective actions may be needed, and whether those corrective actions are effective. These new wells did detect contamination near the g-2 experiment and at the E-20 beam catcher areas. Fact sheets on these groundwater investigations are available at http://www.esh.bnl.gov/esd/gw.htm.

The final set of wells installed under the Groundwater Monitoring Improvements Project have detected tritium near the former U Line beam stop, indicating that continued rainwater percolation through the activated soils near the inactive beam stop is leaching tritium to the groundwater.

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[1] The BNL Groundwater Monitoring Improvements Project Plan is available online at http://www.esh.bnl.gov/esd/gw.htm

FORMER U LINE BEAM STOP

As noted above, two areas are being monitored under the enhanced groundwater monitoring program: the former U Line target and the former U Line beam stop. The target and beam stop are located at the north end of the AGS Complex, approximately 2 miles from the BNL boundary. The former U Line target area is located approximately 200 feet north of the beam stop. The beam stop itself is about 100 feet long and 40 feet wide.

The monitoring wells were installed to evaluate possible impacts from neutrino experiments conducted from 1973 to 1986. During operation of the U Line, a proton beam first struck a target, and then the resulting secondary particles were selected by an assembly of two special magnets immediately downstream of the target. Secondary particles desired for research were focused by the magnets, while other particles entered the surrounding shielding. The U Line target and magnets were located in a ground-level tunnel covered by an earthen berm. Internal shielding was stacked around the special magnets. Although the U Line target and beam stop have not been in operation since 1986, the associated tunnel, shielding, and overlying soils remain in place.

Beam stops, and to some extent targets, are sinks used to absorb the energy and radiation from beams that have completed their utility. High energy particles are stopped through collisions with atoms at the beam stop or the shielding around a target. Pieces of the atoms are broken off in the collision process, and some of these pieces are radioactive (e.g., tritium and sodium-22). Beam stops are typically made of concrete and steel. The iron beam stop for the U Line experiments, for example, was approximately 100x40x40 feet, and was made from slabs of steel from a World War II war ship.[2]

The former U-line target and beam stop are areas where the interaction of secondary particles in the surrounding soil shielding that formed the tunnel resulted in the production of tritium and sodium-22.[3] Because the tunnel was not covered by an impermeable cap, the activated soils above and on the sides of the tunnel structure have been exposed to rainwater. When rainwater infiltrates through activated soils, it can leach the activation products into the groundwater.

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[2] Note: The downstream portion of this beam stop was removed in August 1999, and the iron shielding that formed the stop was used in other parts of the accelerator complex. The removal of a significant portion of the iron slabs at beam stop may have exposed soil beneath the stop to a new pattern of rainwater percolation through the activated soil.

[3] In 1987, a study of soil activation at the U Line experimental area was performed, and it was estimated that 2.9 curies of sodium-22 and 1.2 curies of tritium were produced in the soil after 10 years of operations (from 1973 to 1983). (P. Gollon, *et al*., " A Study of Radioactivity In Local Soil At AGS Fast Neutrino Beam," BNL-43558, Informal Report, Brookhaven National Laboratory, Upton, New York 11973, 1987.) On an annual basis, this is about 100 times more than the annual production for other beam lines used in all other AGS programs at that time. The difference was due to:

1) more protons per year in the U Line versus all other beam lines,
2) soil on all sides of U Line target area and beam stop (as opposed to concrete walls and caps used on other beam lines), and
3) less concrete shielding between the U Line beam and the soil shield.

The U Line target-area was moved forward several feet and internal shielding added in 1984 to reduce soil activation. Another 0.36 curies of tritium is estimated to have been added to soil in three additional running periods between 1984 and 1986. There was no significant beam in the U Line after 1986.

GROUNDWATER MONITORING AND RESULTS

The predominant groundwater flow direction in the former U Line area is to the south-southeast. [4] The depth to groundwater is approximately 23 feet below land surface, and the area is underlain by predominantly fine- to coarse-grained sand and fine gravel.

Initial groundwater monitoring in the U Line target area was conducted in the 1980s. Although low-level tritium contamination (below the drinking water standard) had been detected earlier, the original monitoring program was not extensive enough to properly monitor the entire target and beam stop area. As noted above, in January and February 2000, four new permanent wells were installed to evaluate groundwater quality near the former U Line *target* area. These wells have been sampled, and results showed that tritium and sodium-22 concentrations were well below the applicable drinking water standards. The activated soil in this area is covered by a concrete pad, which prevents rainwater infiltration. The former U Line *beam stop* was identified as another potential source of groundwater contamination due to activated soils. In late March 2000, four Geoprobe wells were installed approximately 200 feet downgradient of this beam stop (see Figure 1).

Table 1 summarizes the available monitoring data for the former U Line beam stop area. No tritium or sodium-22 were detected in the two northernmost Geoprobe wells (054-131 and 054-132). On April 11, 2000, BNL received results from the third well (054-133), which is about 150 feet from the beam stop. Tritium concentrations in 054-133 were up to 48,100 pCi/L at a depth of 35-39 feet below land surface (approximately 12 to 16 feet below the water table). The drinking water standard for tritium is 20,000 pCi/L. Sodium-22 was not detected. The lack of sodium-22 is consistent with the age of the activated soil. The beam stop has not been in use since 1986, and sodium-22 has a half-life of only 2.6 years, which means that it is not present today due to radioactive decay. Tritium, on the other hand, has a half-life of 12.3 years. Data from the fourth Geoprobe well (Well 054-134), located approximately 20 feet further to the south of the Geoprobe location 054-133 indicate a maximum tritium concentration of only 4,800 pCi/L. Therefore, the plume (as defined by concentrations >20,000 pCi/L) appears to be very narrow - only 20 to 25 feet wide.

Groundwater onsite moves approximately 0.75 feet per day. Geoprobe well 054-133 was located approximately 200 feet from the presumed soil activation area at the former beam stop. The estimated travel time from the presumed soil activation area (at the former beam stop) to the Geoprobe location was, therefore, about nine months. However, since the presumed soil activation area had not been protected by a cap or other engineered structure, this plume may have been in existence since 1973. The nearest downgradient wells, which are approximately 600 feet southeast of the former U Line target, have shown trace levels of tritium and sodium-22.

The closest drinking water supply well (Well 10) is located approximately 1,600 feet to the east of the former U Line target. This well has been operational since 1980. It is currently sampled on a monthly basis for tritium. A preliminary review of tritium results from 1985 to the present indicates only two well water samples with tritium concentrations above the Minimum Detection Limit.[5] When Well 10 is fully operational (i.e., running for extended periods of time), water from

[4] Groundwater flow direction onsite is somewhat variable, as it is influenced by variations in on-site water supply pumping.

[5] The highest value was 750 pCi/L for a sample collected in January 1993. The Minimum Detection Limit is usually 350 to 400 pCi/L. Note: Well 10 was out of service from late 1989 through mid-1992 due to 1,1,1-trichloroethane concentrations that exceeded the drinking water standard. Carbon filters were effective in removing the 1,1,1-trichloroethane, and the well was returned to service.

the former U Line beam stop area would be drawn into the well after several years of migration through the aquifer. However, because of natural radioactive decay and the dilution that occurs in the aquifer as the plume migrate, this tritium would not be expected to be at detectable levels at Well 10 or other water supply wells. It is important to note that recent changes in water supply operations have resulted in almost no pumping from Well 10 in the past three months. It is anticipated that long-term water supply needs will require only limited pumping from Well 10.

CORRECTIVE ACTIONS

In accordance with BNL's Groundwater Contingency Plan, regulators and the public were notified of our findings and planned corrective actions.

BNL plans to install more Geoprobe wells to better define the former U Line beam stop plume.

Several additional permanent wells will be needed for long term monitoring of this area.

Within three weeks, a temporary cap will be installed over the beam stop area. BNL will then design and install a permanent cap for long-term protection. Engineers are reviewing the design for the permanent cap to ensure that it will effectively prevent rainwater infiltration. Caps are proven technologies, used nationwide to prevent movement of pollutants out of the soil into the groundwater.

BNL will continue to closely monitor the water supply system. Coordination between the BNL water supply operations and the groundwater monitoring programs will continue.

Low intensity beam experiments are planned for this area later in 2000. Before additional experiments are conducted, a state-of-the-art impermeable, protective cap will be installed to prevent leachate from being generated.

BNL continues to evaluate other potential corrective actions and improvements to the groundwater protection program that may be required.

NOTE: OTHER AREAS WHERE ACTIVATED SOIL EXISTS

The Laboratory has identified all primary areas within the Collider-Accelerator Complex that catch or stop beams of particles.[6] There are four more beam-to-beam interaction points within the Relativistic Heavy Ion Collider (RHIC) ring, but soil activation is expected to be very low, and caps have been installed over the soil activation areas as an added level of protection. Secondary particles created in beam-stop and beam-target interactions have the potential to generate tritium and sodium-22 in adjacent soil used as shielding. Recent groundwater investigations have shown that elevated concentrations of both tritium and sodium-22 exist in groundwater in some of these areas (i.e., Brookhaven Linac Isotope Production (BLIP) facility, and the g-2 and E-20 experimental areas). Monitoring of other indoor beam-loss areas, such as targets and beam stops in the experimental halls, has shown no significant impacts to groundwater quality. New facilities such as RHIC and the Booster Applications Facility have been proactively designed to prevent impacts.

CONCLUSIONS

The enhanced groundwater monitoring network enabled BNL to identify and quickly characterize the area of legacy contamination.

[6] Drawing D10-M-494-4, dated August 1998.

Rainwater percolating through the residual activated soils near the former U Line beam stop has leached tritium to the groundwater. This has created a relatively narrow tritium plume (20-25 feet wide and <10 feet thick) with a maximum concentration of about two times the drinking water standard. Additional characterization of the plume is underway.

BNL is taking immediate and systematic corrective actions to address the source.

No tritium has been detected in the closest existing potable water supply well. BNL continues to monitor the potable water monthly as part of its routine monitoring program.

The contamination is located near the center of the site, and is not expected to move offsite at detectable levels.

The groundwater monitoring network, which is part of BNL's systematic approach to evaluating environmental impacts from its operations and facilities, is working as intended. The data indicated that our controls need to be enhanced, and BNL is taking the corrective actions listed above. However, groundwater monitoring is only a secondary means of protecting groundwater quality. BNL must continue to work hard to control or eliminate pollution at the source to protect Long Island's drinking water supply.

Table 1: Former U Line Beam Stop Groundwater Monitoring Data (as of April 13, 2000)

Geoprobe Well	Sample Depth (BLS)	Tritium (pCi/L)	Na-22 (pCi/L)
054-131	39’-43’	<315	ND
	35’-39’	<315	ND
	31’-35’	<315	ND
	27’-31’	<315	ND
	23’-27’	<315	ND
054-132	35’-39’	<361	ND
	31’-35’	<361	ND
	27’-31’	<361	ND
	23’-27’	<361	ND
054-133	35’-39’	48,100 +/- 1,110	ND
	31’-35’	35,700 +/- 975	ND
	27’-31’	2,170 +/- 308	ND
	27’-31’ (Duplicate)	2,380 +/- 314	ND
	23’-27’	428 +/- 221	ND
054-134	35’-39’	<361	ND
	31’-35’	1,700 +/- 285	ND
	27’-31’	4,800 +/- 394	ND
	23’-27’	2,300 +/- 308	ND
Drinking Water Standard		**20,000**	**400**

BLS = Below Land Surface
ND = Not Detected
NS = Not sampled
R = Reanalysis

Note: “<” symbols preceding a value (e.g., <304) indicates that the measured tritium value was less than the Minimum Detection Limit.

Figure 1: Former U Line Beam Stop and Locations of Geoprobe Wells and Permanent Monitoring Wells.