**EPS 31-R1**

# Appendix EPS 31-R1
# Groundwater Protection Management Program

## Introduction

The objective of the Jefferson Lab Groundwater Protection Management Program is to minimize the facility's impact on groundwater resources. This program ensures compliance with federal, state and local regulations and effective resource management practices. The program requires a comprehensive site wide groundwater monitoring plan that assesses and addresses the effect of past, current, and future Jefferson Lab activities on groundwater quantity and quality.

Groundwater contamination is hard to detect in a timely manner, requires special expertise to predict the spread and path of the contaminant, and is very difficult and costly to cleanup. Groundwater contamination is more difficult to correct than surface water pollution. It is best to prevent groundwater contamination in the first place.

This program will be reviewed and updated every three years, as required, or more often if significant changes occur.

Environmental Management System (EMS) significant aspects are:

- Ionizing radiation - soil activation
- Ionizing radiation - water activation

# The Groundwater Regime

Jefferson Lab is in the northern section of Newport News, Virginia, at an average elevation of about 35 feet above mean sea level (MSL), which is above the 100-year floodplain level of 13 feet. The vast majority of the site is located in the watershed of Brick Kiln Creek, that discharges to Big Bethel Reservoir. A small section to the west is in the Deep Creek watershed and drains to the James River. The only long-lasting stream on-site is the permanent channel handling the dewatering discharge from the end station areas. Localized ponds occur during periods of heavy precipitation and drain via surface runoff and groundwater recharge.

The geology and hydrogeology in the Jefferson Lab vicinity have been evaluated and described in a 1987 Environmental Assessment (EA) and in a series of studies. These documents can be found at ESH&Q Reporting, ARC, Suite 340.

- Preliminary Geotechnical Exploration (Law Engineering Oct. 85)
- Initial Hydrogeologic Study (Law Engineering Jan. 88)
- Background Water Quality Study (Law Engineering Dec. 88)
- Geotechnical Studies (Law Engineering Nov. 89)
- Analysis of Dewatering System (Virginia Geotechnical Services Feb. 90)
- Limited Site Investigation at Bomarc Missile Site (Malcolm-Pirnie July 91)
- Follow-up Study of Bomarc Missile Site (Law Engineering Mar. 92, Malcolm-Pirnie Dec. 94)
- Hydrogeologic Review (Malcolm-Pirnie Sept. 95)
- Hydrogeologic Review (Malcolm-Pirnie, Nov. 01)

The 1995 and 2001 Hydrogeologic Reviews that were conducted compiled past and current groundwater information to provide up-to-date pictures of the site hydrogeology. Key points and recommendations from the report have been incorporated into this program.

## Regional Hydrogeologic Framework

Jefferson Lab is located in the Atlantic Coastal Plain Physiographic Province of Virginia, which is underlain by unconsolidated sediments ranging from the early Cretaceous to Holocene age. The sediments, dipping and thickening eastward, consist primarily of sand, clay, silt, and gravel with variable amounts of shell material. The sediments lie directly upon Precambrian granitic and metamorphic rock or Mesozoic sedimentary rock.

The framework for the lower Peninsula is a series of aquifers and intervening confining units defined on the basis of the lithologic and the hydrologic properties of the unconsolidated Coastal Plain sediments.

Refer to **Figure 1: Geologic Map** at the end of this appendix

# Site Characteristics

The site is located toward the southeastern end of the lower James-York Peninsula. The surficial unit mapped at the Jefferson Lab site belongs to the Columbia Group of middle Pleistocene age.

## Geology

Sediments found within 50 feet of the surface belong to the Yorktown Formation (Chesapeake Group) and overlying Columbia Group. The Columbia Group, previously referred to as the Norfolk Formation, is now subdivided into four formations - the Tabb, Shirley, Chuckatuck, and Windsor.

The lowermost unit encountered in drilling is the Yorktown Formation. Sediments comprising the Yorktown at Jefferson Lab consist of greenish-gray clayey silt and clayey sand with abundant interbedded silty sand layers and indurated shells. The top of the Yorktown varies between +15 feet and +10 feet above MSL, or about 21 to 26 feet below the surface. These sediments serve as a confining unit separating the overlying water table aquifer from the Yorktown aquifer, the top of which occurs at a depth of approximately -50 to -80 feet MSL. The shell hash associated with the Yorktown Formation can locally influence groundwater quality. Calcium hardness and pH are generally higher where the shell hash contacts the water table aquifer.

Unconformably overlying the Yorktown Formation is the Shirley Formation. These sediments consist of a sequence of coarse sand and gravel near the base to the finer sandy clay near the surface. Where basal sand and gravel are present, a soft organic rich clay is commonly found. The organic matter in clays tend to have a localized influence on groundwater quality and can result in higher sulfate and organic carbon concentrations and lower pH values.

Refer to **Figure 2: Geologic Units** at the end of this appendix

## Hydrogeology

The uppermost hydrostratigraphic unit encountered at Jefferson Lab is the water table aquifer, which is composed of sediments of the Columbia Group. The thickness of the water table aquifer is between 15 and 30 feet, with a seasonal variability that can exceed 8 feet. During the seasonal groundwater low period from July through November, the water table aquifer may be absent.

Groundwater flows from a groundwater high area that is located around an open area east of the Test Lab. The dominant direction of flow from this high area is to the east and south towards the North Linac. Hydraulic conductivities for monitoring wells were measured in 1995 and 2001 and groundwater seepage velocities estimated based on measured gradients and an assumed effective porosity of 0.22. Hydraulic conductivities in 2001 ranged from $2.7 \times 10^{-5}$ cm/sec to $1.7 \times 10^{-2}$ cm/sec. These values had a geometric mean value of $2.0 \times 10^{-3}$ cm/sec, which is typical of aquifer materials that are predominantly composed of medium to fine sands with silt and clay.

Refer to **Figure 3: Top of Yorktown Formation** at the end of this appendix.

Groundwater contour maps continue to show a predominantly southeastern flow direction beneath much of the property with more eastern flow in the eastern portions. Expected seasonal fluctuations are seen with highest levels in the 1st quarters and lowest levels in the 3rd quarters. The mean value of the flow rate is 4328 cm per year (142 feet/year).

Underlying the water table aquifer are sediments of the Yorktown Formation. These sediments form a confining layer separating the lower, coarser units of the Yorktown Formation from the water table aquifer. The thickness of the confining unit is greater than 50 feet and the vertical hydraulic conductivity is generally less than $1x10^{-6}$ cm/sec.

## Aquifer Characteristics

The sediments found within the upper 70 feet of the surface are divided into two hydrostratigraphic units. The confining layer for the Yorktown-Eastover aquifer is the lowermost unit and the water table aquifer, the Columbia, is the upper unit. Hydraulic characteristics for the two units were presented in the 1995 Hydrogeologic Review.

The base of the Columbia aquifer at Jefferson Lab corresponds with the lowermost sand unit of the Shirley Formation. The hydraulic conductivity ranges from a mean of $3.2 \times 10^{-4}$ to $1.4 \times 10^{-2}$ cm/sec. The sediments are comprised of interbedded sands, silty clays, and sandy clays and are grouped into three types of sub-units for discussion in the Hydrologic Review. The hydraulic gradient for this aquifer is relatively flat and ranges between 0.002 and 0.006 across the site. Average calculated flow velocity is approximately 11 m/year and ranges between 2 m/yr to 76 m/year and is dependent upon the hydraulic conductivity.

The confining layer separating the Columbia aquifer from the underlying Yorktown-Eastover aquifer is the Mogarts Beach Member of the Yorktown Formation. The Mogarts Beach Member is generally a greenish gray silty clay with very fine sand. Shells and shell fragments are common, with some scattered thin beds of silty sand and clay. Hydraulic conductivities for this layer ranged between $7.3 \times 10^{-6}$ to $1.7 \times 10^{-7}$ cm/sec in 1995. This estimated vertical hydraulic conductivity is about three orders of magnitude less permeable than the horizontal hydraulic conductivity of the overlying Columbia Group sediments.

The Yorktown-Eastover aquifer in the Jefferson Lab area is a confined artesian aquifer. There are no wells at Jefferson Lab installed in this aquifer. The top of this aquifer, based on surrounding wells, is about -60 feet MSL. Groundwater levels are measured at a USGS Observation well near Lee Hall Reservoir. The levels vary from +28 feet MSL to +32 feet MSL.

The vertical flow between the water table aquifer and the lower aquifer was not directly measured at Jefferson Lab. From available information, a general evaluation of potential vertical flow was made in the Hydrogeologic Review. The net potential flow gradient between the two aquifers is approximately zero, but there may be a slight potential flow gradient from the lower aquifer into the Columbia aquifer.

In 1995, the maximum potential flow rate from the Columbia aquifer down into the lower aquifer was calculated to be 4 x $10^{-8}$ cm/sec and from the upper to the lower was calculated to be 7 x $10^{-8}$ cm/sec. Note that both aquifer levels fluctuate seasonally, with the highest groundwater elevations in the winter and the lowest groundwater elevations in the summer.

## Groundwater Withdrawals


**Dewatering Collection Tank in the Counting House basement**

The generally southeasterly groundwater flow is physically disturbed due to the use of a dewatering system at the end stations. Groundwater flows to a collection basin in the Counting House basement through a gravity collection system situated below each end station. The water is pumped to the surface and discharged to a surface stormwater runoff channel.

Some of the potential impacts of the dewatering system on groundwater levels include localized changes in flow directions and long-term lowering of the groundwater table to about -1 foot MSL. Both of these impacts to groundwater conditions may affect the groundwater monitoring program. There is a localized depression of the groundwater table centered around the dewatering networks which extends less than several hundred feet from the halls. Periodic review of the groundwater elevations for all monitoring locations is performed by RadCon to monitor effects of changes in flow direction.

## Water Level Data Evaluation

### Groundwater Elevation Data

Local groundwater elevation data have been taken during various hydrogeologic studies, during regular sampling under the original site Virginia Department of Environmental Quality (DEQ) Virginia Pollutant Abatement (VPA) Permit and under the current DEQ Virginia Pollution Discharge Elimination System (VPDES) Permit No. VA0089320. These measurements include data from borings made in 1985 (28) and in 1988 (16), and regular measurements under the DEQ permits starting in 1989.

Since the 1996 VPDES permit update, RadCon has coordinated the quarterly measurement of groundwater elevations at all site wells, though the DEQ permit only requires monitoring at the wells sampled under the permit. Elevation data shall be taken to the nearest 0.01 foot with respect to MSL. This data shall be recorded and tracked. The data shall be reviewed at least every three years and used to evaluate flow rates as well as the ability for any well to supply representative samples.

Refer to **Figure 4: Groundwater Levels** at the end of this appendix.

### Groundwater Flow

Groundwater flow has been generally consistent over the monitoring period from 1988 through the end of 2001per results from the most recent (2002) flow study, with a groundwater high in the open area east of the Test Lab in the vicinity of wells GW-12, GW-13, and GW-14. The flow travels from this high to the east and south towards the North Linac. This groundwater high, which

is an area topographically higher than the surrounding area, most likely results from a higher recharge rate in the cleared areas than in the adjacent forested and impervious areas.

Data on long term groundwater levels continue to be collected. The water levels in the wells near the experimental halls appear to have been significantly influenced by the dewatering activity. In the other wells some cyclicity in groundwater levels is noted over time but does not appear to be a seasonal effect. The highs and lows for the northwest wells do not correspond to those for the southeast wells. This may be due to fluctuations related to construction activities.

## Groundwater Quality and Quantity

Groundwater resources of the York-James Peninsula are abundant; however, the generally poor water quality limits groundwater use. The water quality of the groundwater in the unconfined aquifer was investigated and the results are reported in the 1987 EA.

In 1987, sixteen wells were recorded in the Newport News area, but only one well was in use (as a cooling water supply). The wells were drilled to depths ranging from 60 to 330 m (200 to 1100 ft), with the depth to water ranging from 0.6 to 15m (2 to 50 ft).

A test well was drilled by the Army Corps of Engineers around 1987 near the Big Bethel Reservoir with the intent of developing a groundwater supply. The test well was drilled to 100 ft. and results of water quality testing indicated the water was too brackish for use as a water supply.

Baseline groundwater quality was collected from the initial site investigation in 1985 to 1995. Analyses have been performed for conventional water quality parameters and radionuclides. The preoperational monitoring performed under the VPA Permit provides the most complete baseline information on temporal and spatial distribution of certain groundwater constituents. Baseline data are summarized in the 1995 Hydrogeologic Review.

The groundwater constituents vary across the site, generally related to heterogeneities in the sediments. The naturally present radionuclide levels also varied significantly both temporally and spatially. The temporal variation appears to relate to construction activities and the increased sediment disturbance. No consistent trends within a well were noted for radionuclide levels.

Jefferson Lab withdraws groundwater from below the three experimental halls (Halls A, B, and C) to preserve their structural integrity. This dewatering is covered under a DEQ Permit to Withdraw Groundwater issued in 1994. The current Permit allows for a maximum of 6,000,000 gal of pumping per month and 23,036,790 gal in any year. This flow information is tracked by Facilities Management and provided monthly to ESH&Q Reporting, who reports to the DEQ on a quarterly basis.

The normal dewatering flow ranges between 400,000 and 600,000 gallons per month. The water flows into a stormwater runoff located south of the end stations. The channel extends south and east with water leaving the site across from the west end of the South Linac. The runoff system eventually connects with the Big Bethel Reservoir, which serves as a drinking water source.

This dewatering discharge is also monitored quarterly under the terms of the VPDES groundwater quality permit (No. VA0089320) mentioned above. The pumping operation draws groundwater from a very limited area. The 1995 Hydrogeologic Review noted that groundwater patterns in the end station area are significantly affected by this dewatering operation. These patterns were used to determine optimal placement of monitoring wells for sampling under this current VPDES Permit. Refer to the next section for permit information.

There are no projected needs for the use of groundwater on the Jefferson Lab site. The surrounding area, however, is expanding, and additional sources of water are under investigation. The 1995 hydrogeologic study verified that the groundwater underlying the Jefferson Lab site would not be affected by any new city well system in the near future. Future studies will again review area-wide use.

# Groundwater Monitoring Program

This section describes the philosophy and general approach of our groundwater monitoring program. Specific details are described in Chapter **6711** *Environmental Monitoring* and Chapter **6315** *Environmental Monitoring of Radiation*. The groundwater portion of the environmental monitoring program contains documentation of the sampling plans and frequencies, well locations, sampling procedures, preservation techniques, sample handling procedures, analytical parameters, data management and the rationale for selecting these elements. Quality control and audit requirements are also addressed.

## Groundwater Monitoring System

The existing groundwater monitoring well system was installed on-site to determine site groundwater flow and quality characteristics around the accelerator and experimental areas. Some of the wells were monitored regularly to meet the terms of the VPA Permit. A different selection of wells shall be monitored under the noted VPDES Permit, and are shown as Figure 5. Samples are collected and analyzed according to the permitted conditions. The well system is maintained in order to provide a means to obtain representative samples. Standards and procedures exist for well installation, maintenance, inspections, and sampling and analysis activities.

### Special Responsibilities: RadCon staff

RadCon addresses the following program actions.

- Ensure subcontracted analysis lab is kept informed of changes to permit conditions regarding monitoring and recordkeeping requirements.
- Perform measurement of groundwater elevations at identified site wells to 0.01 foot.
- Review groundwater elevation data at least every three years to evaluate flow rates and the ability for any well to supply representative samples.
- Manage annual well inspections and follow up annual well inspections to ensure that necessary services, repair, or replacement is completed in a timely manner.
- Ensure sufficient tests, such as slug tests at all new well installations, are performed to adequately characterize groundwater flow, especially when there is any facility or dewatering system addition or modification. Test adequacy shall be reviewed every three years or upon any significant system addition or modification.
- Periodically review and document need for offsite monitoring.
- Keep the vicinity of the well sites maintained and free of debris.

### Well logs and construction diagrams

Well construction shall comply with standard guidance documents such as the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA, 1986) and the Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells (Aller et al, 1989). Acceptable construction practices that shall be included in any well installation are:

- Well construction using a material appropriate for site conditions.
- Presence of a locked security casing.

- Presence of features, such as a concrete pad, that prevent surface water from entering the well.
- Well screen shall be joined to the well casing in an acceptable manner.
- An appropriate slotted well screen and a sand/gravel pack shall be placed around the well screen to a minimum of two feet above the last slot opening of the screen and the sand/gravel pack extended horizontally a minimum of 1-inch from the well casing to the borehole wall.
- A minimum of 1-foot thick bentonite seal shall be placed above the sand/gravel pack and a bentonite-cement grout shall be placed above the seal to the surface.
- A sloped cement pad 4-inches high by 2-feet wide shall be placed around the well with the slope decreasing away from the well.

The subcontractor shall provide well logs and construction diagrams to the SOTR for any well installed on-site. The SOTR shall provide this information to ESH&Q Reporting and RadCon upon completion.

### Inspection

Monitoring wells shall be inspected periodically to ensure their integrity. At least yearly, an inspection shall be performed and documented by RadCon. All identified issues shall be satisfactorily completed and noted as such on the records. Items to be addressed on the annual inspection are:

- Access
- Steel security casing (presence/absence, condition, locked cap)
- Well number identification (readability, exterior/interior)
- PVC cap (presence/absence, type, vented)
- Cement grout (presence/absence, exterior of security casing, between security casing and well casing)
- Standing water between security casing and well casing (presence/absence)
- Sedimentation
- Water elevation (feet above MSL)
- Measured depth of well
- Stick-up height

(these may not be necessary annually)

- Well casing (type, inner/outer diameter)
- Pumps/dedicated bailers (presence/absence, type)

## Preoperational Monitoring Program

Groundwater monitoring relies on samples taken from existing wells established for this purpose. Preoperational monitoring for groundwater quality was performed under the terms of the VPA Permit. On-site groundwater has been monitored accordingly since October 1989. Samples were taken and analyzed monthly for the first year, then after DEQ approval, quarterly monitoring was performed. This routine continued until the VPDES Permit became effective in July 1996. RadCon manages this program across the site.

Refer to **Table 1** for a list of currently monitored wells and **Figure 5: Long Term Monitoring Well Locations** at the end of this appendix.

The preoperational program included quarterly monitoring of wells GW-2, GW-3, GW-7, GW-8, GW-15, and Arc West (now known as GW-17), which draw water from the upper artesian aquifer located in the Yorktown Formation, and the discharge from the dewatering operation. In January 1995, five new wells were added to the

monitoring program: GW-6a, GW-22, GW-25, GW-26, GW-27, and one well, GW-15a, was installed to replace GW-15 which was formally abandoned when a road was realigned. Sampling information for these wells was also gathered and provided to the DEQ on a quarterly basis.

The preoperational monitoring program concentrated on analysis for potential accelerator produced radionuclides together with others produced naturally and from fallout: Be-7, Ca-45, Cs-134, Co-60, H-3, Mn-54, Na-22, Na-24, Sr-90, Th-230, Th-232, gross alpha, gross beta and total radium. Limited chemical analyses have also been completed on the samples from these wells. Variables monitored include pH, total organic carbon, conductivity, chemical oxygen demand, copper, iron, lead, manganese, nickel, zinc, sodium and hardness.

The original long-term VPA Permit requirements included monitoring a total of 31 wells. The wells were to be positioned in an ‘A’, ‘B’, and ‘C’ concentric configuration, labeled as to proximity to the accelerator interaction areas. Jefferson Lab collected data on all parameters to establish the environmental baseline until the noted VPDES Permit took effect. A preliminary statistical baseline was provided to the DEQ and was used to establish conditions and action levels for the VPDES Permit.

No increases in radionuclide concentrations were detected as a result of intermittent accelerator testing during this preoperational period. The lower limits of detection used for sample analyses have been at least an order of magnitude below the applicable Derived Concentration Guides (DCG) for accelerator-produced isotopes taken from applicable DOE DCGs and EPA regulations set forth in 40 CFR 141. The DOE DCGs used for this purpose are those which correspond to the delivery of a committed effective dose equivalence of 4 mrem/yr (millirem per year) to a person using the on-site water as their sole source of drinking water.

The discharge from the groundwater withdrawal system was monitored for the same parameters. The other monitoring requirement for this discharge stream is under the terms of the Permit to Withdraw Groundwater, where only the quantity of discharge is required to be metered and tracked. This requirement is addressed by the Facilities Management Department. Effects of this operation are described in the earlier subsection entitled, Site Characteristics.

# Long Term Monitoring Program

The 1995 hydrogeologic study assisted in clarifying environmental site characteristics from before facility construction, during construction, and since the major construction was completed and normal structural dewatering began. One goal of the study was to delineate a plan for selecting the optimal locations for the monitoring wells to be included in any long-term monitoring permit requirement.

VPDES Permit No. VA0089320, that superseded the VPA Permit, incorporates the relevant location and monitoring requirements as determined by Jefferson Lab, DOE, and the DEQ. A location plan of the fifteen wells to be monitored is shown in Figure 5 and described in Table 1 below. The VPDES Permit requires that the following wells be monitored at the frequencies noted.

**Table 1: Long-Term Groundwater Monitoring Wells**

| | Well Designation | Well Location |
|---|---|---|
| **Upgradient:** annually | GW-15a | |
| **A Ring:** quarterly | GW-20<br>GW-21<br>GW-22 | South Linac Recombiner<br>South Linac Spreader<br>Beam Switchyard |
| **B Ring:** semi-annually | GW-3<br>GW-6a<br>GW-23<br>GW-24<br>GW-25<br>GW-26<br>GW-27 | Experimental Hall C<br>South Linac Recombiner<br>South Linac Spreader<br>Beam Switchyard<br>Beam Dump Hall A<br>Beam Dump Hall B<br>Beam Dump Hall C |
| **C Ring:** annually | GW-2<br>GW-28<br>GW-29<br>GW-30 | Beam Switchyard<br>South Linac Recombiner<br>South Linac Spreader<br>Experimental Halls |

Well locations are shown on **Figure 5**.

Under the VPDES Permit, the facility shall analyze the well samples for pH, conductivity, total suspended solids (TSS), total dissolved solids (TDS), gross beta, tritium, sodium-22, beryllium-7, and manganese-54. The groundwater elevation at all wells across the site shall be taken and recorded quarterly to aid in planning activities.

Action or trigger levels for the parameters listed are provided in the permit and are based on the environmental baseline data provided to the DEQ. In addition, water contamination levels at the ‘A’ and ‘B’ wells are restricted to 1 mrem/yr, one-quarter of the regulated drinking water standards to 5,000 pCi/l (picocuries per liter) of tritium, and to 50pCi/l of gross beta.

At no time are the “C” wells to exceed the background levels established during preoperations.

Well locations will be regularly reviewed by RadCon and local temporary test wells will be used to sample in potential problem areas. Sampling point relocations would be considered based on results of any review.

## Dewatering Discharge

The groundwater withdrawal discharge will be monitored under the VPDES Permit. Table 2 shows the parameters to be monitored quarterly.

**Table 2: Limits at the Dewatering Discharge**

| Radionuclide | Maximum Limits |
|---|---|
| Tritium | 20,000 pCi/liter |
| Sodium-22<br>Beryllium-7<br>Manganese-54 | $\Sigma < 4$ mrem/year<br>(total for the year) |
| Gross beta | 50 pCi/l (for screening only) |

Note: Maximum daily flow rate and a pH range of 6.0 to 9.0 is also included in the permit.

Jefferson Lab will also monitor the conductivity, TSS and TDS to use as a basis for comparison with past values and the other monitoring locations.

For more information, the groundwater monitoring program is now incorporated into Chapter **6711** *Environmental Monitoring* and radiological issues are covered in Chapter **6315** *Environmental Monitoring of Ionizing Radiation*. Impacts on groundwater are not expected in non-accelerator areas of the site.

The VPDES Permit No. 0089320 conditions include:

- Monitoring records
  Records of analyses and any other information resulting from groundwater monitoring must be retained for at least three years by the subcontracting lab and longer if required by the DEQ. Records are currently retained indefinitely by ESH&Q Reporting and RadCon. The data reports submitted to the DEQ are retained for ten years by ESH&Q Reporting.

- Reportable events
  Unusual or extraordinary events that could adversely affect groundwater quality must be promptly reported to ext. 7400 and to the Facility Manager at 876-1750. The Facility Manager will make necessary external notifications. Events that affect water quality that could be reportable include spills, wastewater handling equipment breakdown, failure of pollution management activities, and floods.

Debris buildup, such as twigs and branches, can be reported directly to Facilities Management at ext. 7400.

- Facility changes
  Any facility modification that may add a new discharge or additional pollutants requires notification to ESH&Q Reporting who will evaluate the need for a permit modification or a new permit. (Note: permit applications normally require submittal six months in advance of a new operation.)

# Upgrading The Groundwater Monitoring Program

The existing groundwater monitoring well network will be evaluated for improvement to provide appropriately placed wells for effective monitoring of accelerator and physics program-produced effects. Jefferson Lab has determined that the original VPA well network was suitable to provide an adequate environmental baseline representative of the site groundwater. All well samples were taken from the upper artesian layer. The 1995 hydrogeology study confirmed that this was a suitable approach. This suitability will be reviewed in future evaluations. The positions and depths of new monitoring wells to provide information during accelerator and physics program activities shall be evaluated and constructed appropriately.

# Management Programs For Remediation Including SDWA, RCRA, and CERCLA

The laws that would address groundwater remediation concerns at Jefferson Lab are the:

- Safe Drinking Water Act (SDWA),
- Resource Conservation and Recovery Act (RCRA), and
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Refer to *Appendix 6710-R1* for descriptions of these laws.

As of early 1996, there were no known areas on the Jefferson Lab property that required addressing under any of these laws.

If remedial actions from previous or current site uses are determined necessary, ESH&Q Reporting, with support from the appropriate line organizations, will coordinate the management program for specific remedial actions under these acts.

# Identifying Potential Sources of Groundwater Contamination

## General Potential Contamination Sources

### Dewatering

The Groundwater Management Act of 1992 was instituted because unrestricted use of groundwater resources was contributing to pollution and a shortage of groundwater in some areas of Virginia. This Act provides for the management and control of groundwater resources. One of the Jefferson Lab activities that can affect groundwater is the dewatering operation at the end stations. Jefferson Lab does not withdraw more water than is necessary to maintain the structural integrity of the end stations. All withdrawals are managed within the Act and our Permit to Withdraw Groundwater limits. The dewatering operation is not likely to be a potential source of groundwater contamination. Surface water impacts are discussed in **EPS-31** *Groundwater Protection*.

### Industrial and construction activities

These activities are now managed under the DEQ's VPDES program. In 1994, the DEQ determined that a permit was not needed for industrial operations nor for the remaining construction activities. A new permit that addresses site wide storm water pollution prevention program became effective in June 2003. A new general permit that addresses storm water discharges during construction activities became effective in December 2003. Best management practices to prevent polluting surface waters are identified. The VPDES program will be reviewed periodically for further applicability if construction or industrial activity is planned. The VPDES applicability for accelerator operation and physics program effects is discussed in the next section. Proper use of permits will minimize chances for groundwater contamination.

### Monitoring wells

Any well can be contaminated by biological or chemical substances entering from the surface or from a well intake. Protection of water quality depends on well design and the methods and materials used to construct and maintain the well. Deficiencies in a groundwater protection program could result from insufficient well casings, inadequate seals between the well casing and the borehole, poor welding at casing joints, or lack of protection at the wellhead. Proper inspection and maintenance practices will minimize the chance of groundwater contamination from these sources.

### Environmentally harmful materials (EHMs)

Migration of chemicals in the underground or above ground environment may affect groundwater quality.

- Hazardous Wastes: Jefferson Lab is classified under RCRA as a small quantity generator of hazardous waste. Wastes accumulated include spent solvents, degreasers, and etchants.
- Storage Tanks and Equipment:
  - Three underground fuel-oil storage tanks were identified and have been removed from the site.

- Oil and fuel-containing tanks and equipment exist at known locations.
- The Jefferson Lab Spill Prevention, Control, and Countermeasure Plan describes site contacts for oil and petroleum products.

- Traces of PCBs: very small quantities of dried PCB oil exist on equipment located inside secure buildings have been identified in the past.
- Items with low-level activity: items with any measurable level of radioactivity are stored in secure areas that minimize exposure to environmental, as well as public health, pathways.

The above materials exist on the site, but have been characterized as having minimal potential to contaminate the groundwater.

There are no known waste tanks, surface impoundments, or land treatment facilities located on or near the Jefferson Lab site. Potential sources of contamination from beyond site boundaries may include septic tank system effluent, pesticide runoff, leaking underground gasoline tanks, and improperly disposed of chemical or oil residues, though none have been noted to date. Low levels of groundwater contamination, apparently fuel products, have been noted on the adjacent SURA property. No known significant contamination exists within or beyond the Jefferson Lab boundaries.

# Potential Contamination from Accelerator Operations

Soil radioactivation from operating accelerators and their experimental equipment can be another potential source of groundwater contamination. A groundwater monitoring program was established to determine a preoperational environmental quality baseline of various parameters to provide a basis for comparison when the facility began a long term physics program.

With the start of regular accelerator operations and physics program activities, the following nonradionuclide and radionuclide parameters (based on the VPDES Permit) will be monitored in groundwater: pH, conductivity, TSS, TDS; gross beta, tritium, Na-22, Be-7 and Mn-54. Although accelerator operations do not affect TSS and TDS, they are useful indicators of well “health”. Machine design controls and existing shielding measures should allow a minimal amount of radioactive material or on-site groundwater activation. No increase over established baseline levels is expected offsite.

Since the EPA drinking water standard of 4 mrem/yr was established, a very conservative approach to beamline design for all structures has been employed to further minimize groundwater risks. Design of the beamline and end station shielding ensures that the committed effective dose equivalent to any member of the public does not exceed 4 mrem/yr from all sources, or 1 mrem/yr from groundwater. This is done by surrounding the targets and beamlines with sufficient quantities of concrete and/or iron so the radiation (principally neutrons) which could activate the soil is sufficiently reduced by attenuation. The model is conservative and assumes radionuclide saturation equilibrium based on 1 mrem/yr at the “A” wells.

Calculations for the amount of leachable radionuclides produced under radionuclide saturation conditions in soil regions outside beamline enclosures using established radiation shielding codes was completed. The model assumes that water migrating downward or

sideways would continue. Tritium and Na-22 are the principal radionuclides of concern because they are the only ones produced in significant abundance in existing accelerators and are sufficiently leachable from the soil.

Jefferson Lab will periodically, as part of its program for compliance with state and federal regulations, conduct an inventory of potential sources, routes and activities within established minimum setback zones. This inventory is used to decide if there are any existing potential sources or routes that pose threats to groundwater, especially potential drinking water supplies, and if additional protection is needed. RadCon will ensure the radiological component of this inventory is performed, periodically reviewed, and updated as necessary.

RadCon will maintain the current wells and use due care to keep the well vicinities clear of potential contaminants. Care will also be provided in the selection of new well sites and ensure proper well protection measures are taken.

# Strategies for Controlling Sources of Contaminants

It is anticipated that Jefferson Lab will not have any potential sources of contamination to drinking water supplies, unless the city decides to use area groundwater for a secondary drinking water supply. If sources or contamination routes are identified, a groundwater protection needs assessment will be completed in accordance with DEQ and EPA regulations. It will evaluate the hazards associated with any potential primary and secondary sources and potential routes contained within the groundwater recharge area. This assessment will take into account the characteristics of potential contamination sources and routes, the effectiveness of current containment measures, the attenuative qualities of local soils in relation to the substances involved, the rate and direction of groundwater flow, and the proximity of the uppermost geologic formation containing groundwater used by any local wells. It will also include an evaluation of the effectiveness of existing local controls in providing groundwater protection.

The environmental baseline for groundwater has been established during Jefferson Lab's construction, commissioning, and preoperational activities. The groundwater monitoring program, initially established with the VPA Permit, provided the baseline information. This baseline indicates that all of the potential contaminants identified in the Permit are present at some background level in all samples. These baseline values, which take naturally occurring variations into account, will serve as our maximum contaminant level and are incorporated into the noted VPDES Permit that shall be effective throughout the lifetime of the facility.

Compliance with the noted VPDES water quality permit is required to ensure that Jefferson Lab's activities and operations do not adversely affect off site groundwater. If any samples indicate a value exceeding the action levels, upon confirmation Jefferson Lab will immediately implement one of the following mitigation measures:

- Restrict use of the accelerator facility.
- Implement design modifications to reduce electron losses (which produce neutrons).
- Install local high-density shielding directly around the "trouble" spots.
- Add devices to control or contain groundwater flows.

If these measures fail to correct the contamination, accelerator operations and physics program activities will be suspended until permanent corrective actions can be taken or until the contamination is reduced through natural decay.

Once contamination of a local groundwater supply has occurred, action must be taken to (1) find and eliminate the source, (2) contain the contaminants in the area affected, and (3) restore the water quality of the aquifer. A remedial action program will be developed as part of the site RCRA program. Under RCRA, facility-specific "media cleanup standards" for groundwater are established for corrective action using applicable human health and environmental standards and/or acceptable health/environmental risk levels. This is done in accordance with requirements, protocols, and policies in state and federal regulations.

The potential contamination of groundwater from the surface through inadequately sealed wells has been addressed. Previous and new well drilling subcontractors are required to incorporate all measures essential to protect groundwater resources. This includes construction of RCRA class 2 monitoring wells. Careful site selection, proper well design, good drilling practices, and the inclusion of proper wellhead security eliminate the potential to contaminate groundwater.

A program for proper closure of wells and boreholes that complies with appropriate regulations shall be implemented. Implementation of these regulations will require Jefferson Lab to compile records and to inventory the status of a number of unused wells and boreholes on-site to determine if they have been sealed according to regulations.

## Decontamination, Decommissioning, and Other Remedial Programs

No remedial actions are required for the DOE-owned site at this time.

RadCon and ESH&Q Reporting maintain decontamination and decommissioning program files. These files could include information concerning spills, assessments and monitoring results. At the time of decommissioning, this information will be used to minimize risks to groundwater supplies and to mitigate potential sources. Other remedial action programs, as determined, will also be conducted in accordance with all applicable laws and regulations.

# References

**Applicable permits and reports**

| Jefferson Lab Documents | Master Record | Location |
|---|---|---|
| Environmental Assessment for the Continuous Electron Beam Accelerator Facility | ESH&Q Reporting | VARC, Room 78 |
| Hydrogeologic Review-1995 | | |
| Hydrogeologic Review-2001 | RadCon Group | ARC, Room 3-100 |
| Chapter **6315** *Environmental Monitoring of Radiation* | Policies & Manuals Group | Division offices and at http://www.jlab.org/ehs/manual/EHSbook.html |
| Chapter **6711** *Environmental Monitoring* | | |
| Radiation Control Group Tech Notes 92-009 and 93-016 | RadCon Group | ARC, Room 3-100 |
| Permit to Withdraw Groundwater | ESH&Q Reporting | VARC, Room 78 |
| VPDES Permit VA0089320 | | |
| VPDES Permit VAG250018 | | |
| VPDES VAR 040079 | | |
| VPA Permit 01001 (superseded) | | |

Refer to Table 1 in Chapter **2420** *Permits and Authorizations from External Agencies* for more information.

**Applicable regulations and other documents**

| Federal and State Documents | Master Record | Location |
|---|---|---|
| CERCLA, CWA, RCRA, SDWA | ESH&Q Reporting | VARC, Room 78 |
| Groundwater Management Act of 1992 | | |
| Applicable Commonwealth of Virginia regulations and CFR sections listed in the WSS Set under hazard issues 048, 050, 060 and 133/138. (Refer to *Appendix 2410-T2 TJNAF Work Smart Standards Set*) | | |

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CWA Clean Water Act
RCRA Resource Conservation and Recovery Act
SDWA Safe Drinking Water Act
VPA Virginia Pollutant Abatement
VPDES Virginia Pollution Discharge Elimination System

**Figure 1: Jefferson Lab Area Geologic Map**

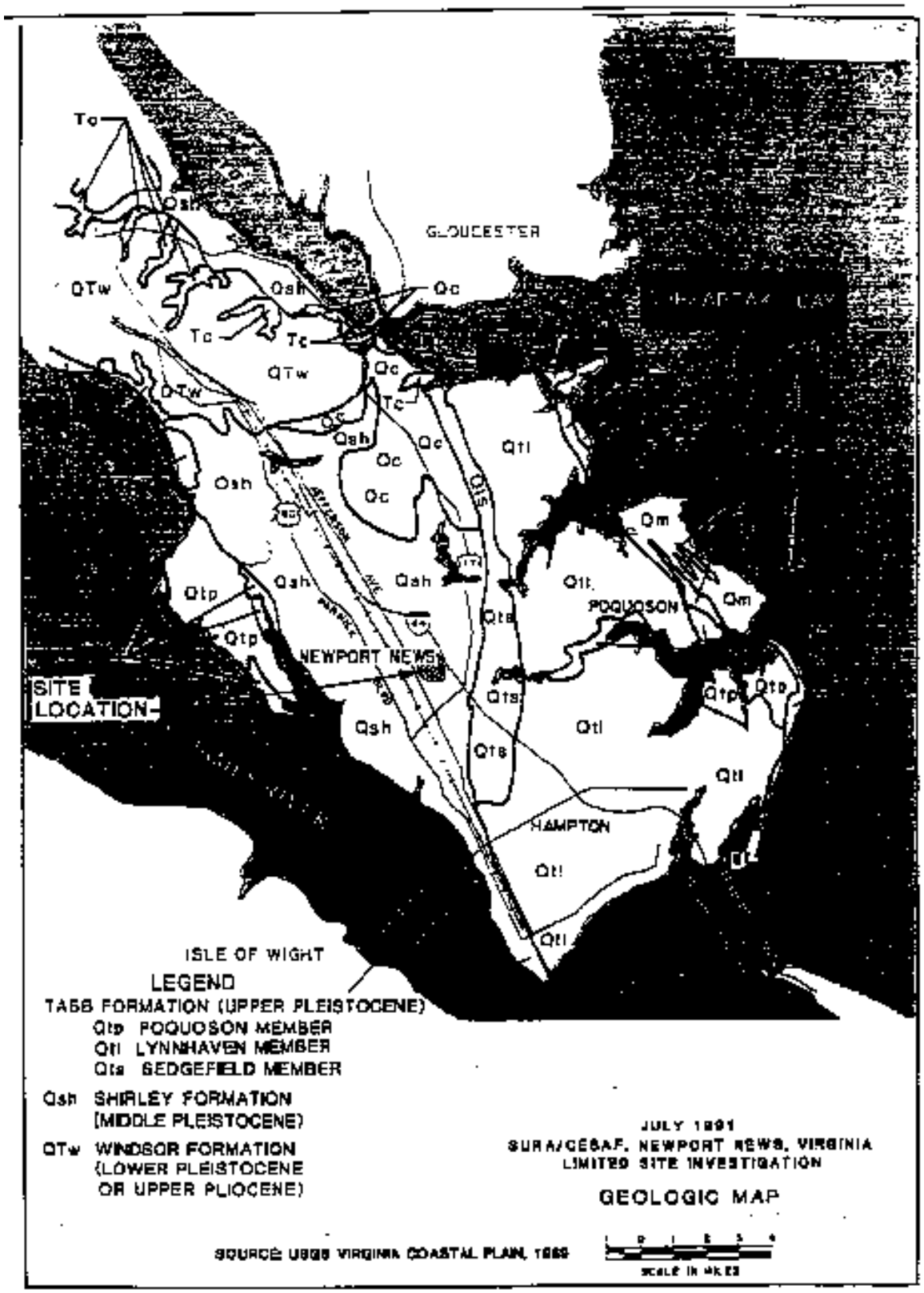

**Figure 2: Geologic Units in the Jefferson Lab Area**

| System | Series | Geologic Unit | | |
|---|---|---|---|---|
| Quaternary | Holocene | Alluvial and Marsh deposits | | |
| | Pleistocene | Tabb Formation | | |
| | | Shirley Formation | | |
| | | Chuckatuck Formation | | |
| Tertiary | Pliocene | Windsor Formation | | |
| | | Bacons Castle Formation | | |
| | | Chesapeake Group | Yorktown Formation | Moore House Member |
| | | | | Morgarts Beach Member |
| | | | | Rushmere Member |
| | | | | Sunken Meadow Member |
| | Miocene | | Eastover Formation | Cobharn Bay Member |
| | | | | Claremont Manor Member |
| | | St. Mary's Formation | | |
| | | Calvert Formation | | |

**Figure 3: Top of Yorktown Formation**

(See **Figure 5** for locations of wells currently being monitored.)

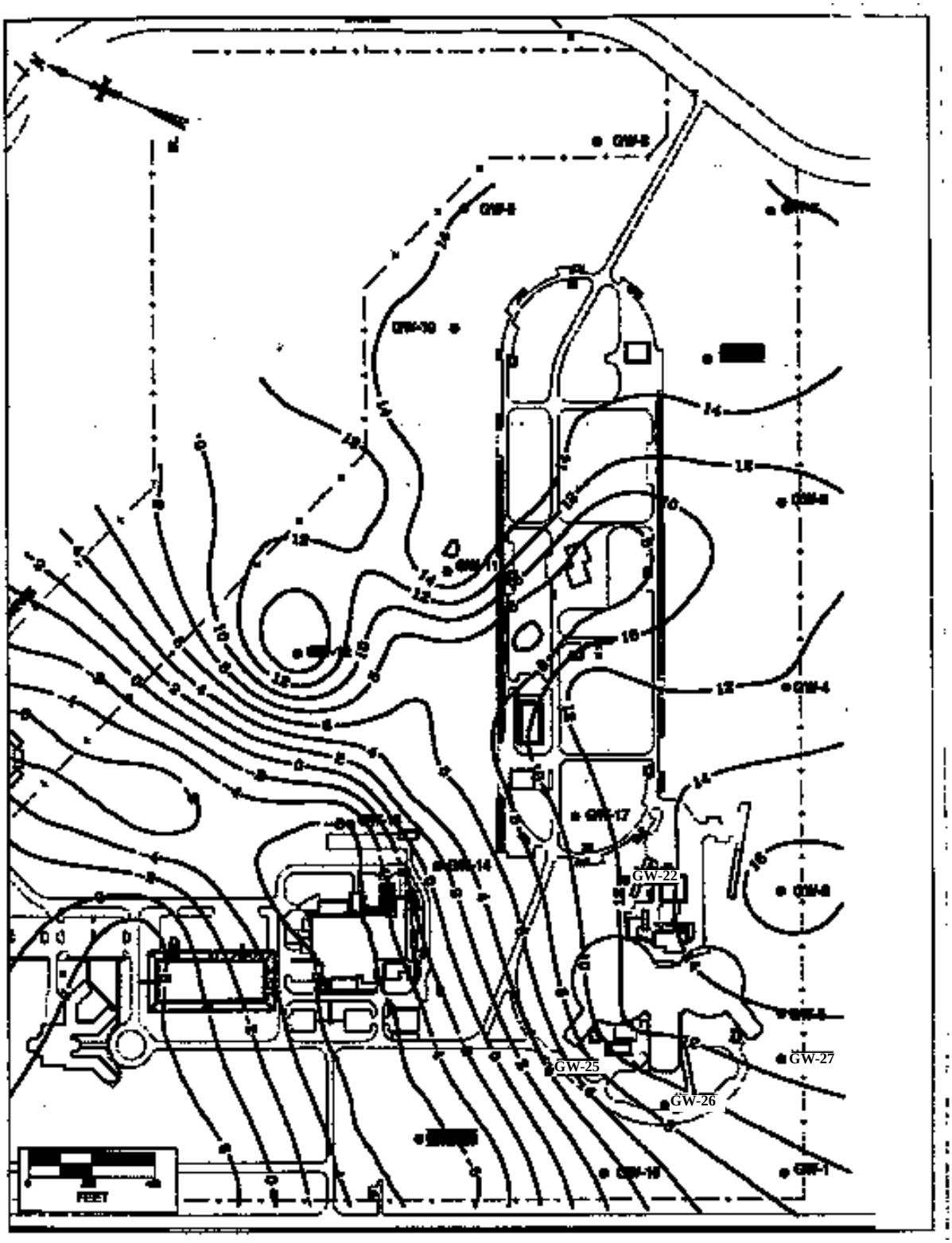

**Figure 4: Groundwater Levels**
Fourth Quarter 2001
(feet above mean sea level)

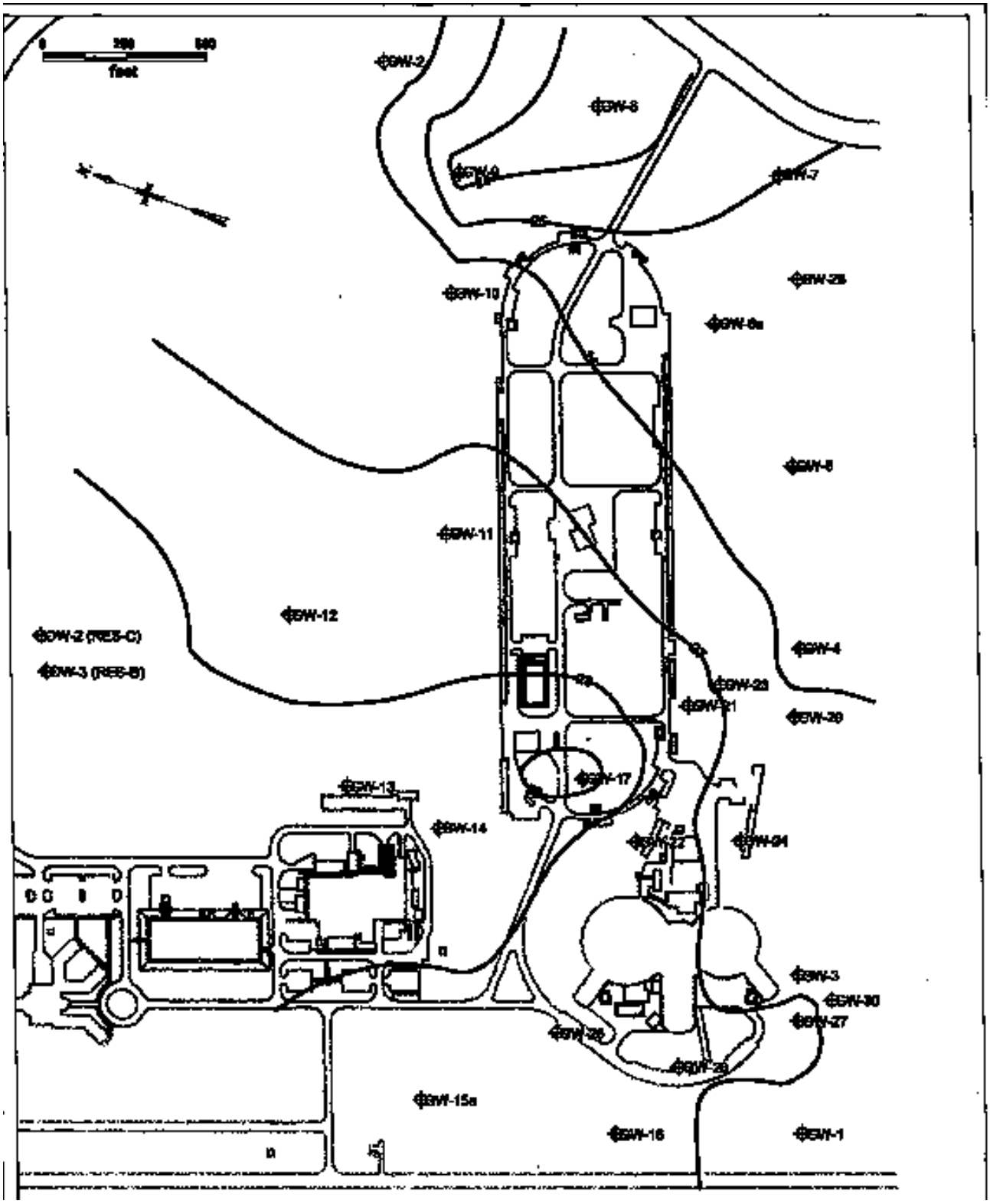

**Figure 5: Jefferson Lab Long Term Monitoring Wells**