HYDROGEOLOGICAL REPORT
PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

17 November 2004

Prepared by:

US Army Corps
of Engineers
Louisville District

COMPLETION OF INDEPENDENT TECHNICAL REVIEW

The District has completed this Hydrogeological Report for the Plum Brook Reactor Facility at Sandusky, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy. The study was accomplished by personnel from Louisville District; and the independent technical review was accomplished by personnel from Louisville and Buffalo Districts.

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17 November 2004
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LIST OF ACRONYMS

AEI............Area of Environmental Interest
bgs.............below ground surface
CD.............Compact Disk
CmA..........Colwood loam
EnA...........Elnora loamy fine sand
GdA...........Gilford fine sandy loam
IT...............International Technology Corporation
NASA........National Space and Aeronautical Administration
NRC..........Nuclear Regulatory Commission
OaB...........Oakville loamy fine sand
ODNR.......Ohio Department of Natural resources
OEPA........Ohio Environmental Protection Agency
PBOW.......Plum Brook Ordnance Works
PBRF.........Plum Brook Reactor Facility
PBS...........Plum Brook Station
.pdf............Adobe Acrobat Portable Document File
RCRA........Resource Conservation and recovery Act
SVOC........Semi- Volatile Organic Compound
SWMU......Solid Waste Management Unit
TOC...........Top of Casing
UdB...........Udorthents, loamy
UNT..........Un-Named Tributary
USACE.....United States Army Corps of Engineers
UST...........Underground Storage Tank
VOC..........Volatile Organic Compound
WEMS......Water Effluent Metering Station
WWII........World War II

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EXECUTIVE SUMMARY

This report of the hydrogeology of the Plum Brook Reactor Facility (PBRF) has been prepared to support the efforts by the National Aeronautics and Space Administration (NASA) to decommission the reactor facility and terminate its Nuclear Regulatory Commission (NRC) license. The PBRF was constructed in the late 1950s, and prior to defueling in 1973, was used to conduct radiological experiments as part of the NASA mission. Prior to World War II (WWII), the site was used as agricultural land. Beginning in early 1941, the PBRF was part of the larger Plum Brook Ordnance Works (PBOW), which produced more than one billion pounds of explosives during WWII.

Since 1989, a number of environmental investigations have been directed at the impact of explosives, solvents, metals, and petroleum releases to soil and groundwater at the PBOW. The purpose of this report is to compile and synthesize the existing hydrogeological information into a single document that focuses on the 27-acre PBRF. This effort includes a discussion of the existing information and previous reports for the site and surrounding area.

The PBRF is located at the boundary between the eastern edge of the Bellevue-Castalia Karst Plain and the western most portion of the Erie Lake Plain, in the Central Lowlands Physiographic Province. The location of the PBRF on the boundary between these two areas results in the prominent features of both areas (karst to the west, and glacial lake basin to the northeast) being subdued and not well developed in the transitional zone between the areas. Surface water drainage at the site is generally to the north, ultimately into Lake Erie, through a series of northward flow streams, although the site itself is graded and drained so that runoff is directed through the Water Effluent Metering Station (WEMS). The direction of surface water drainage appears to be at least partially controlled by bedrock structure and fracture zones.

The nearly flat-lying bedrock dips gently to the southeast into the Appalachian Basin, due to the site's position on the east flank of the Findley Arch. The slope of the eroded bedrock surface is generally toward the northeast, toward Lake Erie. Unconsolidated deposits are predominantly Late Wisconsinan tills of the Erie Lobe. During final glacial retreat, a series of proglacial lakes covered much of the area, eroding till and bedrock at the surface and depositing the reworked till and lacustrine (glacial lake) deposits.

Groundwater which occurs in both the bedrock and unconsolidated deposits at the site generally exhibits a natural flow direction to the north, toward Lake Erie. Dewatering activities at a stone quarry located about 7000 ft north of the PBRF reinforces the natural horizontal groundwater flow direction. The quarry is in line with the natural northerly flow direction toward Lake Erie.

The cities of Sandusky and Huron utilize water from Lake Erie as a public water supply, and provide water from this source to several surrounding communities. The nearest public water supply utilizing groundwater is the City of Milan, located about seven miles southeast of the PBRF, and it is not anticipated that Milan's groundwater production will affect the groundwater flow conditions at the PBRF. Where public water is not supplied, groundwater for domestic and industrial use is largely produced from the bedrock aquifers. Because the depth to bedrock near the PBRF is typically less than 20 ft, and often less than 10 ft, the unconsolidated deposits in this area are not exploited for water production.

Two hydrostratigraphic units are present at the site. The upper unit is primarily composed of lake-wave reworked glacial sediments, primarily cohesive soils with thin, discontinuous granular units. Where the unconsolidated deposits overlie the weathered remains of an eroded shale unit, the two formations are hydraulically connected and act as a single hydrostratigraphic unit. The underlying bedrock aquifer is composed of fractured Paleozoic carbonate (limestone and dolomite) rocks.

Groundwater conditions in the unconsolidated deposits are in an unconfined to semi-confined condition, and groundwater conditions in the bedrock aquifer vary from slightly confined to slightly unconfined, depending on seasonal groundwater fluctuations. The hydraulic characteristics (hydraulic conductivity, porosity, etc.) of these two units appears to be within the typical ranges associated with glacially-derived materials and sedimentary bedrock.

Site specific groundwater flow mapping at the PBS has refined the understanding of local groundwater flow conditions. Flow in the unconsolidated deposits is somewhat influenced by surface topography, and flow in the bedrock aquifer is likely strongly influenced by preferential flow in bedrock fracture zones, coupled with the quarry dewatering operations to the north.

Dewatering from foundation drains and sumps at the PBRF is conducted to protect the subsurface structures. In addition, a groundwater pump and treat remediation system is operating, which includes a groundwater extraction well. These activities create a zone of influence in both the unconsolidated deposits and bedrock aquifer. The pumping activities will cease after closure of the PBRF and the RCRA groundwater remedial action are complete. At that time, groundwater flow conditions in the unconsolidated deposits are expected to resemble those currently present in the area to the south of the PBRF. Groundwater flow will continue to the north, and a natural groundwater gradient will return to the site as the groundwater levels recover from the current pumping. Bedrock groundwater flow will continue to be dominated by the quarry dewatering and preferential flow in bedrock fractures. In the event that quarry dewatering ceases in the future, flow in the bedrock aquifer will continue to be generally to the north, toward Lake Erie.

The vertical groundwater flow gradient at the PBRF is strongly downward, as a result of the anthropogenic groundwater pumping activities and preferential flow in the bedrock fracture zones. Current groundwater flow in areas away from the fracture flow zone suggests that when pumping is ceased, the vertical gradient may be seasonally variable (upward and downward), and that groundwater levels in both the unconsolidated deposits and bedrock aquifer will rise to within a few feet of the ground surface. These water levels will fluctuate on a seasonal cycle.

1. BACKGROUND

The Plum Brook Reactor Facility (PBRF), located at the Plum Brook Station (PBS) south of Sandusky, Ohio (Figure 1), is pursuing decommissioning and license termination through the Nuclear Regulatory Commission (NRC). This report has been prepared to support that effort, and presents a compilation of the existing geologic and hydrogeologic information available for the PBRF and the surrounding area.

The 27-acre PBRF is a part of the larger 6500-acre PBS, a facility utilized by the National Space and Aeronautical Administration (NASA). The PBRF was used to conduct radiological experiments as part of the NASA mission. The PBRF was defueled and shut down in 1973, and is currently undergoing decommissioning. Prior to World War II (WWII), the site was used as agricultural land, and beginning in early 1941, the PBS operated as the Plum Brook Ordnance Works (PBOW).[1] The PBRF occupies a portion of the former Pentolite Area. The PBOW produced more than one billion pounds explosives from 1941 through 1945, and was shut down at the end of WW II. Decontamination of the production facilities, intended to remove explosives hazards, was completed in the last quarter of 1945.

Since 1989, a number of environmental investigations have been directed at the impact of the former PBOW on the environment, and a number of Areas of Environmental Interest (AEIs) have been identified and investigated. These AEIs are generally related to explosives, solvents, metals, and petroleum releases to soil and groundwater. As a part of those investigations, monitoring wells and soil borings have been installed and the hydrogeology of the former PBOW has been studied.

The purpose of this report is to synthesize the existing hydrogeological information into a single document that focuses on the 27-acre PBRF. In addition to the reactor building, a number of supporting structures are present at the PBRF (Photo 1 and Figure 2)

2. GEOLOGIC SETTING

The PBRF is in an area where nearly flat-lying Paleozoic bedrock is mantled with a relatively thin layer of Pleistocene glacial deposits.

2.1 Physiography

The PBRF is located at the boundary between the eastern edge of the Bellevue-Castalia Karst Plain and the western most portion of the Erie Lake Plain (Figure 3). These physiographic units are part of the Huron – Erie Lake Plains Section of the Central Lowlands Physiographic Province. The Bellevue-Castalia Karst Plain is characterized by hummocky terrain of rock knobs

[1] The boundaries of the PBS (6500 acres) and the former PBOW (9009 acres) do not completely coincide because some parcels of the PBOW have been transferred to other owners. However, for the purpose of this report, the two boundaries are considered to be essentially similar.

and numerous sinkholes, large solution features, caves and springs (Figure 4). The area is mantled with thin glacial deposits. The Erie Lake Plain consists of a low-relief glacial lake basin separated from modern Lake Erie by shoreline cliffs. Major streams in this area occur in deep channels. The location of the PBRF on the boundary between these two areas results in the prominent features of both areas being subdued and not well developed in the transitional zone between the areas. The dramatic karst features near Castalia, a few miles west of the PBRF, diminish and are not reflected in the surficial topography of the PBRF.

2.2 Bedrock Geology

The rock at the bedrock surface in the Sandusky area is assigned to the Devonian System (Figure 5). Devonian rocks in north-central Ohio are primarily carbonate and shale units. Underlying the Devonian rocks are a thick section of lower Paleozoic sedimentary rocks (Figure 6) that rest on pre-Cambrian Grenville Province igneous and metamorphic rocks at a depth of about 3600 feet below ground surface (bgs) (Baranoski, 2002).

The PBRF is located on the east flank of the Findlay Arch, a positive structural feature that passes through Findlay, Ohio on a northeast-southwest trend and separates the Appalachian Basin to the south and east from the Michigan Basin to the northwest. Bedrock at the site dips gently to the southeast into the Appalachian Basin. The slope of the eroded bedrock surface is generally toward the northeast (Figure 7).

2.3 Unconsolidated Deposits

The unconsolidated deposits in Erie County are the result of extensive Pleistocene glaciation (Figure 8). These deposits in the area surrounding the PBRF are generally less than 25 feet in thickness, although some areas are slightly thicker (Figure 9). Surficial materials are predominantly Late Wisconsinan tills of the Erie Lobe. During final glacial retreat, a series of proglacial lakes covered much of the area, eroding till and bedrock at the surface and depositing the reworked till and lacustrine (glacial lake) deposits.

2.4 Surface Water Drainage

Surface water drainage at the PBS is generally to the north, ultimately into Lake Erie, through a series of northward flow streams: Plum Brook to the east, Pipe Creek to the west, two unnamed tributaries (UNTs) to Plum Brook, and an UNT to Lake Erie (Figure 1). The PBRF is situated on a slight southwest-northeast trending ridge between the eastern UNT to Pipe Creek and the UNT to Lake Erie.

Based on surface topography, it appears that prior to development of the PBRF, the surface water from the northern portion of the PBRF drained to the north-northwest to the UNT of Pipe Creek, and surface water from the southern portion of the PBRF drained to the southeast, into the UNT to Lake Erie. However, all of the 27-acre PBRF was graded during construction so that surface water drains to the Waste Effluent Metering Station (WEMS, Photo 2), to Pentolite Ditch, and then to Plum Brook.

The generally northward surface water drainage at the PBRF and the surrounding area does not follow bedrock dip, which is to the southeast. Surface water flow is generally parallel to the bedrock strike, and also to the predominant set of bedrock fractures, as discussed in Section 4.8. Those fractures may have played a role in the development of the pre-glacial drainage pattern that was later blanketed by glacial deposits.

2.5 Regional Hydrogeology

Groundwater occurs in both the bedrock and unconsolidated deposits in the PBS area. Groundwater flow is generally to the north, toward Lake Erie. Wagner Quarries, located about 7000 ft north of the PBRF, quarries rock from the Delaware Limestone, the Columbus Limestone, and the Detroit River Formation. Dewatering is performed to support this effort. The quarry reportedly produces an average of 25 to 30 millions gallons per month from a sump to maintain a water level at a depth of 165 ft bgs. The amount of water produced varies seasonally, with ranges from 13 to 40 million gallons per month reported for January and August 2004, respectively (Kinney, 2004). The effect of this dewatering, relative to the PBRF, is to reinforce the natural horizontal groundwater flow direction, as the quarry is in line with the natural northerly flow direction toward Lake Erie. It also imparts a strong downward vertical flow gradient within its zone of influence.

The cities of Sandusky and Huron utilize water from Lake Erie as a public water supply, and provide water from this source to several surrounding communities. The nearest public water supply utilizing groundwater is the City of Milan, located about seven miles southeast of the PBRF (Ohio Environmental Protection Agency [OEPA], 2004). Milan produces about 6,000,000 gallons per month from a sand and gravel aquifer associated with the Huron River and an associated bedrock low in central Erie County (Figure 7), where the unconsolidated deposits thicken (Figure 9). It is not anticipated that Milan's groundwater production will affect the groundwater flow conditions at the PBRF.

Hundreds of Ohio Department of Natural Resources (ODNR) Well Log and Drilling Report forms from Perkins, Oxford, Huron, and Milan Townships in Erie County were reviewed during the preparation of this report. Groundwater for domestic and industrial use in the area is largely produced from the bedrock aquifers. In the area near the Huron River (several miles east of the PBRF), groundwater is also produced from a sand and gravel glacial outwash aquifer. With the exception of a few localized areas, the unconsolidated deposits in this area are not thick or permeable enough to serve as aquifers. The depth to the bedrock surface in the area around the PBS is typically less than 20 ft, and often less than 10 ft.

Because of the relative thinness and low permeability of the unconsolidated deposits in the PBRF area, the predominant groundwater flow component is likely downward through the unconsolidated deposits, rather than horizontal. This vertical gradient is strengthened by the operation of the dewatering sumps and remediation system at the PBRF, and the dewatering at Warner Quarries.

3. PREVIOUS HYDROGEOLOGICAL AND SUBSURFACE INVESTIGATIONS

The following sections include a chronological discussion of the relevant reports that were reviewed to prepare this document. As noted below, selected sections of those reports are included in Appendix A as Adobe Acrobat portable document files (.pdf). Some of those reports include repeated copies of previous documents, such as boring logs, which were not included in Appendix A to keep it to a manageable size. However, all of the relevant documents are included at least once.

Many of these projects were directed at the former PBOW, and are of use in the present investigation because monitoring wells were installed that help define groundwater conditions at the PBRF, either directly or by inference. Therefore, the discussion in the following sections focuses on the aspects of interest from the PBRF perspective, and is not intended to be a complete review of the existing PBOW information or of the environmental impact to the PBS.

3.1 1956 Geotechnical Test Borings

Five test borings (T-1, T-2, T-3, T-4, and T-5) were installed in the reactor building footprint prior to design and construction of the reactor facility. Logs of the borings, along with the boring locations and other boring information, are presented on National Advisory Committee for Aeronautics Drawing Number PF00101, dated 27 August 1956 (Appendix B, Section 1). One of the test borings (T-4) was located in the geometrical center of the reactor building, and the other four borings were located radially away from the T-4 location. Test boring T-1 is located about 50 ft southwest of test boring T-4, test boring T-2 is located about 50 ft northwest of test boring T-4, test boring T-3 is located about 50 ft northeast of test boring T-4, and test boring T-5 is located about 35 south-southeast of test boring T-4.

The ground surface elevation at the five test boring locations prior to development of the reactor facility ranged from El 631.5 to El 632.0.[2] The subsurface conditions encountered in these test borings show that limestone bedrock was encountered at elevations ranging from El 606.0 to El 609.5, with the thickness of unconsolidated deposits ranging from 22.0 to 26.0 ft. Four of the test borings (T-1, T-2, T-3, and T-4) extended from 9.4 to 15 ft into limestone bedrock, and test boring T-5 was extended 39.1 ft into bedrock, with the lower 4.1 ft of the boring reportedly encountering sandstone at El 571.0 to El 566.9.

Samples of unconsolidated deposits were obtained from test borings T-1 and T-5, while test borings T-2, T-3, and T-4 were blank drilled to the bedrock surface. In general, the majority of the materials sampled from test borings T-1 and T-5 are reported to be "clay and sand", "sandy blue clay", "blue clay and sand", "soft blue clay", and "blue clay". A layer of gravel nearly two ft thick overlies bedrock at test boring T-5, and is overlain by a few inches of "hardpan", which is in turn overlain by about 7 ft of materials reported as "quick sand". The nature of the hardpan is

[2] The ground surface elevation at the time of the 1956 test borings almost certainly did not represent the original, natural ground surface at the facility. During the closure of the Pentolite Area following WWII, soil was removed from this area during the explosives decontamination activities.

not described in the boring logs. "Red clay", possibly indicating the presence of residual explosives, is reported from the upper seven ft of boring T-5. The unconsolidated deposits in the reactor building footprint were subsequently excavated during the construction of the facility. Some bedrock was also excavated.

3.2 1959 Final Hazards Summary

The *Final Hazards Summary, NASA Plum Brook Reactor Facility* (NASA, 1959) includes a discussion of the geology, surface water, groundwater, and seismology of the reactor site. Also included are drawings that illustrate the subsurface components of the PBRF. Selected sections of text and illustrations are included in Appendix A, Section 1.

3.3 1981 Deep Rock Core Description

A Masters thesis prepared by a geology student (Weekes, 1981) includes a description of a rock core drilled at the Plum Brook Station to a depth of 1267 ft. The core was drilled about 9000 ft southwest of the PBRF as part of a 1969 project to evaluate the potential for development of an underground air storage facility. The rock core penetrated the entire Silurian System (Cayugan, Niagaran, and Alexandrian Series), and the upper portion of the Ordovician System (Cincinnatian Series). The thesis consists of an interpretation of the depositional environments of the various rock strata represented in the core. Table 1 from the thesis, which presents the stratigraphic nomenclature assigned to the units in the core, is included in Appendix A, Section 2.

3.4 1990 Contamination Evaluation

A draft version[3] of a 1990 report entitled *Engineering Report for the Contamination Evaluation at the Former Plum Brook Ordnance Works, Sandusky, Ohio* (International Technology Corporation [IT], 1990) describes the installation of four monitoring wells screened in the unconsolidated deposits (IT-MW01, IT-MW02, IT-MW05, and IT-MW06), which were directed at characterizing the former waste disposal areas and burning grounds. A field hydraulic conductivity test was performed at monitoring well MW-02, which is screened in unconsolidated deposits reported to be sandy silt to silty clay. The hydraulic conductivity test yielded a value of $K = 8.8 \times 10^{-5}$ cm/sec. Because of the slow recharge to the well, no additional hydraulic conductivity testing was performed. Selected sections of the report are included in Appendix A, Section 3.

3.5 1990 Closure Assessment for Tanks 21, 22, and 23

Three steel underground storage tanks were installed adjacent to one another in the Reactor Area in 1961, south of Building 1131 (Reactor Service Equipment Building). Two of the tanks were 7900-gallon fuel oil tanks, and the third was a 500-gallon waste oil tank that may have also held chlorinated waste solvents. The report entitled *Closure Assessment for Tanks 21, 22, and 23 at Plum Brook Station* (Ebasco Environmental, 1990) discusses the tank closures and closure assessment including soil sampling and analysis that was performed at the time the tanks were removed. That sampling and analysis indicated that product releases to the environment had

[3] The final version of this report was not located for review.

occurred. Selected sections of the report are included in Appendix A, Section 4.

3.6 1991 Underground Storage Tank Study

Ebasco Environmental (1991) prepared a report entitled *Underground Storage Tank Corrective Actions Remedial Investigation/Feasibility Study* that provided a comprehensive review of the underground storage tanks at the PBS, including the three that were removed from the Reactor Area in December 1989. Monitoring wells were installed in October 1990 to evaluate the impact that the tank releases may have had on groundwater.

Six soil borings were completed in the Reactor Area at depths ranging from 10 to 22 ft, and were converted into monitoring wells. RA-01 and RA-06 were planned as background wells, and RA-02, RA-03, RA-04, and RA-05 were installed to characterize the contaminated area. These wells were all installed with the screens positioned in unconsolidated deposits. The wells were sampled and some were found to be contaminated with volatile and semi-volatile organic compounds (VOCs and SVOCs). The report contains two groundwater flow maps (Appendix C) depicting the depressed groundwater levels around the PBRF, based on groundwater elevation data from January 10 and May 9, 1991 (Appendix D). Selected sections of the report are included in Appendix A, Section 5.

3.7 1993 Preliminary Site Investigation (USTs)

Morrison Knudson Ferguson Group (1993) prepared a report entitled *Preliminary Site Investigation, 100% Submittal, Phase I, Remediation of Contaminated Underground Storage Tank Sites* that reviews to earlier Ebasco reports and includes the results of additional sampling and analysis. Four soil borings, one of which was converted to a monitoring well (B-1/MW-1) were installed in the Reactor Area to follow-up on the earlier tank investigation. Selected sections of the report are included in Appendix A, Section 6.

3.8 1995 Closure Work Plan for Reactor Area

The *Closure Work Plan, Reactor Area, NASA Plum Brook Station, Sandusky, Ohio* (URS Consultants, 1995) contains information regarding the site history, geology, sump operation, previous site investigations, and a summary of soil and groundwater contamination at the PBRF. The discussion of the sump operation is of particular interest in this report. Selected sections are in included in Appendix A, Section 7.

3.9 1997 Records Review Report

Section 6.0 of the *Records Review Report for the Plum Brook Ordnance Works* (Dames & Moore, 1997a) contains a discussion of the prior use of the PBRF as the Pentolite Area. Included is a description of the pentolite waste water settling basins, which were located in the area immediately south of the reactor building, and the removal of the basins during closure of the Pentolite Area. The basins extended from the ground surface (approximately El 626) to about El 619.7. Removal activities included the excavation of explosives-contaminated soil. Section 6.0 of the report, and the accompanying illustrations, are included in Appendix A, Section 8.

3.10 1997 Site-wide Groundwater Investigation (Dames & Moore)

The objectives of this investigation, reported in the *Sitewide Groundwater Investigation Final Report* (Dames & Moore, Inc., 1997b), included evaluation of groundwater occurrence and flow conditions in the overburden and bedrock aquifers, assessment of groundwater quality in the former Red Water Ponds and TNT manufacturing areas, investigation of site-wide groundwater quality in the bedrock aquifer, and evaluation of the need for further groundwater investigations. The report concludes that the PBS is impacted by explosives, metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs).

This investigation did not directly address groundwater conditions at the PBRF. However, it did include the installation of a number of monitoring wells (Appendix B) across the PBS that are useful in establishing the groundwater flow conditions at the PBRF. Sieve analysis of soil samples from those installations are reported. Of great interest is a bedrock fracture trace analysis (Appendix I) that was performed at the PBS. Selected sections of the report are included in Appendix A, Section 9.

3.11 1997 Site-wide Groundwater Investigation (IT)

The *Site-Wide Groundwater Investigation* (International Technology Corporation, 1997) did not directly address issues at the PBRF, but did include the installation of three overburden monitoring wells (IT-MW-08, IT-MW-09, and IT-MW-10) at other portions of the site. Selected sections of the report are included in Appendix A, Section 10.

The report includes the results of in-situ hydraulic conductivity testing (Appendix F) on monitoring well IT-MW-08. Grain size and Atterberg limits tests were performed on selected samples. The report also includes an overburden groundwater flow map and a bedrock groundwater flow map (Appendix C) prepared from data collected in October 1996.

3.12 1999 Summary Report, Site-Wide Groundwater Monitoring, 1997-1998

The report entitled *Summary Report, Site-Wide Groundwater Monitoring (1997-1998)* (IT, 1999) summarized the previous work conducted at the site, and evaluated the results of that work in regard to human health and environmental risk. Three overburden monitoring wells and one piezometer (AA1-GW-002, AA2-GW-002 [piezometer], and AA3-GW-002), and eight bedrock wells (AA1-BEDGW-001, AA2-BEDGW-001, AA3-BEDGW-001, ABG-BEDGW-001, BG8-BEDGW-001, MNTA-BEDGW-001, TNTB-BEDGW-002, and TNTB-BEDGW-002) were installed, and quarterly water level measurements were obtained. Site-wide groundwater monitoring was conducted at the PBS in November 1997 and May 1998, and the report discusses the results of the groundwater analysis.

The report includes overburden and bedrock groundwater flow maps (Appendix C) for August 1997, November 1997, February 1998, and May 1998 for the PBS. In addition, groundwater flow maps for the Reactor Area prepared from data collected in November 1997 and May 1998 are included in the report. Geologic cross sections (Appendix E) of the PBS are included, some of which illustrate conditions near the PBRF. Selected portions of the report are included in Appendix A, Section 11.

3.13 2000 Amended Closure Plan

Due to the presence of solvents in one of the USTs at the reactor facility (Tank No. 23), the PBRF is pursuing a Resource Conservation and Recovery Act (RCRA) closure of this tank, which is considered a RCRA solid waste management unit (SWMU). This document includes a description of the PBRF hydrogeology, and the logs of several test borings and monitoring wells that were installed in 1998 in the Reactor Area (soil borings RA-A1, RA-A2, RA-A3, RA-B1, RA-B2, RA-B3, RA-C1, RA-C2, RA-C3, RA-D1, RA-D2, RA-D3, RA-E1.5, and RA-E2.5; monitoring wells RA-MW-01, RA-MW-02, RA-MW-03, RA-MW-04, RA-MW-04, and RA-MW-05 (Appendix B, Section 1)). Also included are groundwater flow maps for the Reactor Area prepared from data collected on 10 November 1998, 17 February 1999, 19 May 1999, and 23 August 1999 (Appendix C). Selected portions of the report are included in Appendix A, Section 12.

3.14 2001 Environmental Baseline Survey

Tetra Tech, Inc (2001) prepared a *Final Environmental Baseline Survey Report for the Plum Brook Reactor Facility Decommissioning Project* which provides a comprehensive summary of the environmental conditions at and near the PBRF. A copy of this document is included in Appendix A, Section 13.

3.15 2002 Report: 2001 Groundwater Remedial Investigation

The report entitled *2001 Groundwater Remedial Investigation* (IT, 2002) (Appendix A) describes the continuing groundwater investigation and reports the installation of ten bedrock monitoring wells (PB-BED-GW22, PB-BED-GW23, PB-BED-GW24, PB-BED-GW25, PB-BED-GW26, PB-BED-GW27, TNTA-BEDGW-001, TNTB-BEDGW-003, TNTB-BEDGW-004, and TNTC-BEDGW-001). Monitoring well PB-BED-MW23 serves as an upgradient well for the Reactor Area. These wells and selected previous installed wells were sampled in late September and early October 2001. Slug testing was performed on the ten new wells (Appendix F).

The report includes updated versions of the geologic cross sections (Appendix E, Section 2) from the 1999 IT report, as well as PBS site-wide overburden and bedrock groundwater flow maps prepared from data collected in August and November 2001. Groundwater flow maps specifically for the reactor area for these dates are included (Appendix C), along with calculated vertical hydraulic gradients (Appendix G).

3.16 2003 Groundwater Well Installation

The installation of monitoring wells RA-07S, RA-07D, RA-08S, and RA-08D is reported in two letter reports prepared by CATI (2003a, 2003b). These wells are located in the northern portion of the Reactor Area. The reports are included in Appendix A, Section 15.

3.17 2003 Report: 2002 Groundwater Data Summary and Evaluation Report

This report, entitled *2002 Groundwater Data Summary and Evaluation Report, Former Plum Brook Ordnance Works, Sandusky, Ohio* (Shaw, 2003) describes the continuing effort at the explosives manufacturing and red water pond areas. Groundwater flow maps included in the report are for side-wide PBS Delaware Limestone bedrock and overburden/shale for November 2001 and May 2002 (Appendix C). These site-wide maps are the latest, most comprehensive groundwater flow maps for the PBS, are based on the largest number of well locations, provide the most site coverage, and are based on a re-interpretation of hydrostratigraphic units at the site.

The November 2001 and May 2002 groundwater flow maps contained in the 2003 report include a revised assessment of wells and stratigraphic units that comprise the shallow and bedrock aquifers. Data from wells screened in the shallow weathered portion of the Ohio Shale and the Olentangy Shale are now included with data from the wells screened in unconsolidated glacial materials. The bedrock aquifer flow maps are now prepared with data only from wells screened in the Delaware Limestone. This re-interpretation of groundwater hydrostratigraphic units is based on the data showing similarity of water level data in well pairs screened in shale and unconsolidated deposits, depth similarity of groundwater encountered in soil (overburden) and shale wells site-wide, and the merging of overburden and bedrock contours along the shale outcrops and the shale/limestone contact.

3.18 Groundwater Modeling

Shaw Environmental is currently preparing a digital groundwater flow model for the PBS. It is understood that model will include the PBRF area, and that the information contained in this Hydrogeological Report will be considered during the preparation of the groundwater model.

4. SITE GEOLOGY AND HYDROGEOLOGY

Information from the previous site investigations at the PBS and the PBRF was used to develop a conceptual site hydrogeological model for the PBRF. As noted above, selected sections of those reports are included in Appendix A.

Information of particular interest to the PBRF is extracted from the individual reports and included in the following Appendices:

Appendix B .... Boring logs and well construction diagrams
Section 1: PBRF Logs
Section 2: PBS Logs
Appendix C .... Groundwater flow maps
Appendix D .... Groundwater level measurements
Appendix E .... Geologic cross sections
Section 1: IT (1999)
Section 1: IT (2002)
Section 1: IT (2003)
Appendix F......... In-situ hydraulic conductivity tests
Appendix G .... Vertical hydraulic gradients
Appendix H .... Well survey data
Appendix I .... Fracture trace analysis

These appendices are voluminous (3000+ pages), as the intent of presenting this data was to create a single repository for reports that are related to the PBRF hydrogeology. Therefore, the reports are presented as Adobe Acrobat .pdf files rather than hard copy appendices.

4.1 Site Geology

Bedrock that subcrops at the PBRF consists of Devonian Delaware Limestone and the overlying Devonian Plum Brook Shale Member of the Olentangy Shale (Figure 10), as shown on geologic cross sections A-A' and B-B' (Figures 11 and 12, cross section line locations shown on Figure 1). The majority of the site is underlain by Olentangy Shale, with the subcrop of Delaware Limestone limited to the northern and southeastern portion of the PBRF. Underlying the Delaware Limestone is a thick section of predominantly carbonate bedrock consisting of the Columbus Limestone and the Detroit River Formation.

The bedrock surface at the PBS generally slopes toward the north, although the PBS is located in an area where an apparent bowl-shaped feature is present (Figure 13). In-filling of the bedrock depression has resulted in a similar thickening of unconsolidated deposits at the PBRF (Figure 14).

Test borings and monitoring wells at the PBRF (Figure 15) show that unconsolidated deposits consist mostly of glacial till (or ground moraine) that occurs as a thin veneer over the bedrock surface. The thickness of these materials at the PBRF is typically about 25 ft (Figures 16 and 17, cross section line locations shown on Figure 1). As discussed in Section 4.2 below, the native surficial deposits at the PBRF have been extensively disturbed. Boring logs for the PBRF test borings and monitoring wells show that the unconsolidated deposits consist predominantly of cohesive soil, interbedded with some relatively thin, discontinuous granular units. The pro-glacial lacustrine depositional environment in which these deposits formed tends to homogenize the deposits through wave reworking. While localized lenses of granular materials do exist, it does not appear that these lenses are continuous across the site, and these units should not be considered to be indicative of the typical site stratigraphy.

4.2 USDA Soil Survey

The United States Department of Agriculture, Natural Resources Conservation Service (2002) has recently revised the *Soil Survey of Erie County, Ohio.* The soil within the 27-acre PBRF is mapped as Udorthents, disturbed soil that has been affected by construction activities (Figure 18). Review of the soils surrounding the PBRF provides insight regarding what was likely present prior to disturbance. The soils in the immediate vicinity of the PBRF consist of Colwood Loam, 0-1 percent slopes (CmA); Elnora loamy fine sand, 0-4 percent slopes (EnA); Gilford fine sandy loam, 0-1 percent slopes (GdA); Oakville loamy fine sand, 0-6 percent slopes (Oab), and Udorthents, loamy, 0-6 percent slopes (UdB). These undisturbed soils are composed of loam, loamy fine sand, fine sandy loam, and loamy fine sand, respectively (Figure 19).

The typical engineering and physical properties of these soils are summarized in Table 1, and the following sections describe the undisturbed soil types that surround the PBRF.

- *Colwood loam, 0 to 1 percent slopes (CmA).* CmA is associated with lake plains. It is located in extensive flat areas, drainage ways, and depressions. CmA is classified as poorly drained to very poorly drained, which makes it prone to very brief ponding. CmA has a typical profile that extends more than 80 inches, classifying it as a very deep soil. CmA is loam from 0 to 11 inches, silty loam from 11 to 53 inches, stratified loamy sand to silt loam from 53 to 80 inches. This is a hydric soil. Permeability is moderately slow in the subsurface. This could be prime farm land if it is well drained. Cropland limitations or hazards include high potential for ground water pollution, frost heave, and ponding.

- *Elnora loamy fine sand, 0 to 4 percent slopes (EnA).* EnA is associated with lake plains. It is located on rises, summits, backslopes, and shoulders. EnA is classified as moderately well drained and is not prone to ponding. EnA has a typical profile that extends more than 80 inches, classifying it as a very deep soil. EnA is loamy fine sand from 0 to 10 inches, loamy fine sand to fine sand from 10 to 31 inches, and fine sand to loamy fine sand from 31 to 80 inches. Permeability is rapid throughout the profile. Cropland limitations or hazards include high potential for ground water pollution, seasonal high water table and wind erosion.

- *Gilford fine sandy loam 0 to 1 percent slopes (GdA).* GdA is associated with lake plains. It is located in flat areas, depressions, and drainage ways. GdA is classified as poorly drained and very poorly drained, which makes it prone to very brief ponding. GdA has a typical profile that extends more than 80 inches, classifying it as a very deep soil. GdA is fine sandy loam from 0 to 12 inches, sandy loam to fine sandy loam from 12 to 32 inches, loamy sand, to sand, to loamy fine sand from 32 to 44 inches, and sand, to fine sand, to loamy fine sand from 44 to 80 inches. GdA is a hydric soil. Permeability is rapid in the lower part of the subsoil and substratum. This can be prime farm land if it is well drained. Cropland limitations or hazards include high potential for ground water pollution, frost heave, excessive permeability, and ponding.

- *Oakville loamy fine sand, 0 to 6 percent slopes (OaB).* OaB is associated with dunes on lake plains, and beach ridges on lake plains. It is located on backslopes, shoulders, and summits. OaB is classified as very well drained and is not prone to ponding. OaB has a typical profile that extends more than 80 inches, classifying it as a very deep soil. OaB is brown very friable loamy fine sand from 0 to 9 inches, brownish yellow, very friable loamy fine sand from 9 to 26 inches, and loose loamy fine sand from 26 to 80 inches. Permeability is rapid throughout the profile. Cropland limitations of hazards include high potential for groundwater pollution, excessive permeability, wind erosion, and limited available water capacity.

- *Udorthents, loamy, 0 to 6 percent slopes (UdB).* UdB is associated with ground moraines, lake plains, stream terraces, and flood plains in flat areas and rises. This soil is in areas altered during construction activities. The properties vary depending on location and are similar to stockpiles of disturbed materials.

The surficial soil at the PBRF has been extensively disturbed and the values included in Table 1 are likely not representative of the surficial materials at the PBRF. During decontamination of the Pentolite Area after WWII, soil was reportedly removed from the site (Dames & Moore, 1997a). During construction of the PBRF, soil was excavated to bedrock in the Reactor Building area, and soil excavation was also performed to construct the tunnel, the Reactor Service Equipment Building, the Hot Retention Area, the Cold Retention Area, and the Emergency Retention Basin (Figure 2). In addition, the entire site was reportedly regraded to promote surface water to flow to the southeast corner of the PBRF.

These excavation and grading activities have resulted in the entire PBRF being mapped by NRCS as Udorthents. Photographs during construction show stockpiled soil, which was presumably used to backfill around the structures and to support the regrading activity. Therefore, it is likely that the surficial materials at the PBRF are a mixture of variable thickness composed of the entire section of unconsolidated deposits, which at depth predominantly consists of cohesive soils.

4.3 Hydrostratigraphic Units

For the purposes of site conceptualization, two hydrostratigraphic units are present at the PBRF. The upper unit consists of the unconsolidated deposits, and where present, the weathered portion of the remaining Olentangy Shale. The lower unit is the underlying carbonate sequence, consisting of the Delaware Limestone and the Columbus Limestone.

The unconsolidated deposits and weathered shale act as an unconfined to semi-confined aquifer. The underlying Delaware Limestone is sometime under slightly confined conditions, and occasionally under unconfined conditions, based on seasonal water level variations. When confined, the upper confining layer is either the unconsolidated deposits or the Olentangy Shale, where it is present.

4.4 Hydraulic Conductivity

No records of in-situ hydraulic conductivity testing at the PBRF have been located. In-situ hydraulic conductivity tests have been performed on the PBS wells as listed in Table 2. These values provide the best available estimates of the hydraulic conductivity of the PBRF materials, although it should be recognized that these tests were not performed on wells at the PBRF.

Most of the unconsolidated deposits monitoring wells are screened across more than one soil texture, and some are screened across both granular and cohesive soil. Therefore, these slug test results provide information about the average, or equivalent, hydraulic conductivity of these units. The lack of monitoring wells screened exclusively in cohesive soil precludes the direct measurement of the hydraulic conductivity of these materials. Monitoring well IT-ABG-GW-002 is screened exclusively in fine silty sand, and the slug test result in this well is an indication of the hydraulic conductivity of this granular soil, although slug tests are recognized to be less desirable than pumping tests for the determination of hydraulic conductivity of formations with K values larger than 10^{-2} cm/sec (Kraemer, Hankins, and Mohrbacher, 1990).

The hydraulic conductivities of the bedrock units are a function of the primary porosity and secondary porosity. Hydraulic conductivity associated with primary porosity of shale and limestone is generally low and can usually be neglected for all practical purposes unless the limestone is exceedingly porous. The hydraulic conductivity associated with secondary porosity (fractures, joints, bedding plane features, solution conduits, etc.) generally controls the overall porosity of bedrock units. Of these features, fractures and joints are likely the most significant influence on the bedrock hydraulic conductivity at the PBRF.

Weathered and fractured shales commonly exhibit higher secondary porosity than limestones, which are more crystalline and competent. The greater secondary porosity in shale is caused by brittle rock with thin bedding, which creates dense fracturing within beds that truncate at the bedding plane. Limestones commonly exhibit more massive bedding with less dense fracturing that can propagate "through" bedding planes. Consequently, shales have more secondary porosity but greater tortuosity in groundwater flow paths and little solution widening of their fracture network; these conditions manifest moderate K values. Limestones alternatively have less fracture density but greater fracture extent that can undergo solution widening and produce zones of high K values (transmissive "master fractures") adjacent to low K zones of more competent rock.

The degree to which the monitoring well screen and sand pack intercept bedrock fractures controls the accuracy of the estimation of hydraulic conductivity using slug tests. The interpretation of slug test data is based on the assumption that Darcian flow occurs, which is typically not the case when groundwater is flowing in fractures and conduits. In addition, bedrock fractures generally occur with greater density proximal to the bedrock surface, and decrease with depth. Therefore, slug tests performed in a limited vertical extent of a fractured bedrock formation do not represent the hydraulic conductivity of the entire formation.

Based on the slug test results, the above discussion, and experience with similar sites, the estimated hydraulic conductivities of the PBRF hydrostratigraphic units are listed in the following table, although local variations from these values are certainly expected.

Estimated Hydraulic Conductivity of PBRF Hydrostratigraphic Units

Hydrostratigraphic Unit	Estimated Average Equivalent Horizontal Hydraulic Conductivity, K, cm/sec (m/yr)
Mixed unconsolidated deposits)	5×10^{-4} (150)
Granular unconsolidated deposits (silty sand)	2×10^{-1} (60,000)
Ohio Shale (shallow)	3×10^{-5} (8)
Olentangy Shale (shallow)	2×10^{-3} (750)
Delaware Limestone (shallow)	1×10^{-4} (40)

It is generally recognized that slug testing produces hydraulic conductivity estimates that are accurate to within about one order of magnitude (Kraemer, Hankins, and Mohrbacher, 1990). It is also recognized that hydraulic conductivity test results are scale dependent. For a given geologic material, laboratory tests generally produce lower K values than slug tests, which in turn produce lower K values than pumping tests (Bradbury and Muldoon, 1990). Experience indicates that slug tests commonly produce K values that range from one-half to one order of magnitude lower than pumping test results for proximal wells in the same hydrostratigraphic zone.

4.5 Horizontal Groundwater Flow

The general horizontal groundwater flow direction at the PBS is toward the north (Appendix C). As discussed in Section 3.17, the *2002 Groundwater Data Summary and Evaluation Report* (Shaw, 2003) contains the most rational and complete groundwater flow maps that have been produced for the PBS and the PBRF (Figures 20, 21, 22, 23, 24, and 25). Pumping of groundwater from the sumps at the PBRF, along with a groundwater pump and treat system associated with the former USTs, creates a zone of influence proximal to the PBRF. Therefore, groundwater flow in this area radially converges to the footer drains that supply water to the sumps, and toward the remediation recovery well. The zone of influence is most prominent in the unconsolidated deposits, although it is present in the bedrock aquifer as well.

A larger influence on horizontal flow in the bedrock aquifer appears to be the presence of fracture zones, which allow preferential flow to occur that manifest as two potentiometric troughs (Figure 23), apparently due to the influence of the stone quarry dewatering efforts to the north of the PBRF. The bedrock fracture zone and its influence on groundwater flow are discussed more thoroughly in Sections 4.8 and 4.10.

Groundwater conditions to the south of the PBRF, and outside of the potentiometric troughs, appear to be unaffected by the PBRF pumping, and either unaffected or effected to a much smaller degree, by the quarry dewatering. This area should be indicative of the natural groundwater flow conditions at the PBRF after the cessation of pumping activities. Based on groundwater measurements obtained in November 2001 and May 2002, the horizontal groundwater flow gradient in the unconsolidated deposits is about 0.005 to 0.006 ft/ft, and in the Delaware Limestone aquifer is about 0.002 to 0.003 ft/ft.

A summary of the groundwater elevations obtained at the PBRF over the last ten years is presented in Table 3. It appears that some of the early data from monitoring well Rx-2 may be of questionable accuracy, as it is significantly different than the later data. The suspect groundwater elevations include the 27 August 1997, 12 November 1997, 15 August 2001, and 15 November 2001 data. The 5 August 2001, and 15 November 2001 groundwater elevations are above the top of casing (TOC) elevation. Discussion with others working at the site indicates that the monitoring well survey data may not be related to a single, consistent datum. However, discrepancies are thought to be less than about one ft and the existing groundwater elevation data can be considered to be roughly correct for flow mapping purposes. It is understood that the facility intends to perform a new survey of the PBRF monitoring wells to correct this situation.

4.6 Vertical Groundwater Flow

A strong downward groundwater flow gradient through the unconsolidated deposits is present proximal to the PBRF due to the groundwater pumping activities. The vertical gradient at the well nest RA-07 is typically about 0.5 ft/ft, and the vertical gradient at well nest RA-08 is about 1.2 ft/ft (Table 3). Based on the significantly lower groundwater elevations reported from monitoring well RA-08D, and the stronger vertical gradient, it appears that groundwater elevations in the Delaware Limestone at these locations are impacted by pumping, perhaps from the RCRA groundwater remediation system.

Groundwater gradients in other portions of the PBS that are unaffected by pumping appear to fluctuate, perhaps seasonally in response to varying levels of precipitation/infiltration. It is expected that these gradients will be typical of conditions at the PBRF once the groundwater pumping is terminated.

4.7 Groundwater Flow Velocity

Based on the characteristics discussed above, the horizontal groundwater flow velocity that is expected to be present when groundwater pumping at the PBRF is discontinued can be calculated using the following equation:

$$V = KI/n_e$$

where:

K = hydraulic conductivity (units)
I = hydraulic gradient (units)
n_e = effective porosity
V = average linear velocity

Hydraulic conductivity for the mixed unconsolidated deposits ranges from 49 to 270 meters/year (m/yr), gradient ranges from 0.005 to 0.006 ft/ft, and the porosity is expected to range from about 0.35 to 0.70 (Freeze and Cherry, 1979). The hydraulic conductivity of the Delaware Limestone ranges from 3 to 188 m/yr, and the gradient ranges from 0.002 to 0.003 ft/ft. The site specific effective porosity of the Delaware Limestone has not been established. Therefore, a published value for limestone must be used to calculate groundwater flow velocity: 0.01 to 0.3 (Fetter, 1988).

Calculated Horizontal Hydraulic Velocities (ft/yr)

Zone	Minimum	Maximum
Mixed unconsolidated deposits	1	15
Delaware Limestone	2	185

4.8 Fracture Zone Control on Groundwater Flow

Dames & Moore (1997b) conducted a fracture trace analysis (Appendix I). This effort was conducted to attempt to locate areas suitable for bedrock well installation, and to locate areas of preferential flow at the PBS. The analysis was performed by analyzing three sets of aerial stereographic photographs and identifying linear features that are present. Numerous fracture traces were identified and are illustrated on a site topographic map in Appendix I. Selected fractures were ground-truthed to verify the accuracy of the techniques used in the analysis. This resulted in some of the linear features being identified as man-made, and these were removed from the analysis.

Based on the mapping presented in the report, it appears that the bedrock fractures in the PBS and PBRF area consist of three sets with different orientations. These orientations, listed from most prevalent to least prevalent, are generally:

- Northeast to southwest
- North to south
- Northwest to southeast, with a subset that is nearly west to east

As discussed in Section 4.4, the field-scale hydraulic conductivity of the bedrock units is largely controlled by the nature of secondary porosity in the bedrock, including fractures, bedding planes, and solution features. Groundwater tends to flow preferentially through these fracture zones because they form areas that have significantly higher hydraulic conductivity than the surrounding unfractured rock (Lattiman and Parizek, 1964). Fetter (1988) suggests that the hydraulic conductivity of major fracture zones may locally be several orders of magnitude greater than that of the unfractured rock.

The bedrock groundwater flow map for May 2002 (Figure 23) shows two well-developed potentiometric troughs, one oriented northeast to southwest, and one oriented northwest to southeast. The confluence of these troughs occurs just east of the PBRF. From that point, a single potentiometric trough appears to extend slightly east of north, directly toward the Warner Quarry. It is possible, perhaps likely, that this potentiometric trough system represents zones of highly transmissive fractures that serve as preferential pathways for groundwater flow and drawdown driven by the quarry dewatering. The drawdown from the PBRF pumping, both from the sumps and the pump and treat system, is superimposed on this larger-scale drawdown (Fredrick, 2004).

The relationship of bedrock fractures and the potentiometric troughs is illustrated in Figure 26, which shows a portion of the May 2002 bedrock potentiometric surface from Figure 23 overlaid on a portion of the fracture trace analysis mapping from Appendix I.

4.9 Reactor Facility Design, Construction, and Operation Influences on Hydrogeology

The design of the PBRF included the excavation of bedrock in order to allow the construction of the subsurface elements of the reactor and supporting structures. The base of the reactor tank assembly (Figure 27, and Photo 3), i.e., the base of the sub-pile room, was placed at a depth of 56.2 ft bgs (Figures 28 and 29). Other PBRF structures that required rock excavation are the Cold Retention Area (Photo 4) and the Hot Retention Area (Photo 5). Photographic documentation of the Reactor Building excavation provides insight on the extent of bedrock excavation that was required to construct the facility (Photo 6).

The deepest excavation for the Reactor Building extended about 56 ft below the final grade (Photo 7). After construction, the annular space around the sub-pile room was filled with concrete (Photo 8), which extended up to a depth of about 25 ft below final grade (roughly coincident with the pre-construction bedrock elevation). Above this level, much of the interior space consisted of supporting rooms around the reactor assembly (Figures 28 and 29).

A system of foundation drains connected to interior sumps provided dewatering for the subsurface portion of the PBRF structures. Two levels of sumps are present, one with a top level at 15 ft bgs, and one at 25 ft bgs. The sumps extend several feet below these levels. The ultimate discharge of the sump water is through the WEMS, into Pentolite Ditch, and then into Plum Brook.

Discharge observations made by others (Lattimer, 2004) of the Reactor Building sump operation have indicated that during one period of observation, the combined discharge from the -25 ft sumps consisted of about 87 gallons per 4 minutes cycle, and the combined discharge from the -15 ft sumps was about 67 gallons per 40 minute cycle. Thus, the combined discharge from the sumps during these observations was about 23 gallons/minute (gpm).

Earlier studies of the sump operation (URS, 1995) from the entire PBRF sump system, including the Reactor Building, the Reactor Service Equipment Building, the Cold Pipe Tunnel, and the Hot Retention Area indicate that total discharge was about 200 to 250 gallons per hour, or 3 to 4 gpm. Of this total flow, about 180 gallons per hour was estimated to be from the Reactor Building sumps.

Surveyed elevations of the -25 ft sumps were not located during this investigation. The approximate -25 ft level is estimated to be about El 607, based on a typical ground surface elevation at the PBRF of about El 632. Design drawings reviewed for this study (Drawings PF00113 and PF00152) indicated that the sumps extend varying depths below the -25 ft floor level, with sumps #2 and #3 apparently the deepest, both with a sump depth of 8 ft. This corresponds to a sump bottom at about El 599. It is likely that the inlet for the pump would have been at least one ft above the bottom of the sump. Therefore, it is reasonable to assume that the deepest PBRF sumps could have affected groundwater levels to a maximum depth of about El 600.

Water levels measured in the PBRF monitoring wells are listed in Table 3, and are presented graphically in Figure 30. It appears that the water levels in a few wells, particularly RA-MW-08D, are lower than what would be expected based on operation of the PBRF dewatering sumps. Therefore, it is suspected that these wells are either influenced by the RCRA pump and treat system, or from quarry dewatering operations, through preferential flow in the bedrock fracture zone.

It is likely that the discharge of the PBRF sumps varies seasonally, in direct correlation with the groundwater levels in the unconsolidated deposits and the Delaware Limestone. The documented range of discharge from the system is relatively low, certainly less than several hundred gallons per hour. This information provides intuitive indication that the sediments surrounding the PBRF exhibit a relatively low hydraulic conductivity.

4.10 Predicted Post-Pumping Groundwater Levels

There are at least three anthropogenic influences on water levels at the PBRF: pumping from the PBRF sumps, operation of the RCRA pump and treat groundwater remediation system, and dewatering of the stone quarry. As these activities cease, the water levels at the PBRF will rise. It is likely that the shutdown order will be:

1. PBRF sumps
2. RCRA pump and treat system
3. Quarry dewatering system

Shut down of the PBRF sumps will likely result in a slight increase in groundwater levels proximal to the PBRF. Shutdown of the RCRA pump and treat system will likely intensify this effect. However, it appears that the potentiometric troughs are largely created by the quarry dewatering, and will remain as long as that activity continues. Once the quarry dewatering is terminated, it is likely that the potentiometric troughs will not be evident in the groundwater mapping. The troughs are the result of the stress induced in the bedrock aquifer by the extraction of groundwater. When that stress is removed, groundwater in the preferential pathways along fracture zones will no longer be drawn down. Under those conditions, the fracture zones will likely be represented by just slight undulations in the potentiometric surface. There is no projection on when the quarry will cease operations.

It is believed that past and current conditions at some areas of the PBS, distal to the PBRF and the fracture zone/quarry dewatering influence, may represent groundwater conditions that will be present at the PBRF after the cessation of anthropogenic influences on groundwater. Figure 31 shows groundwater levels measured in three well nests at the PBS. Two of these nests, the TNTA and TNTC nests, are located within the limits of the potentiometric troughs believed to be formed by preferential flow in bedrock fractures. The other nest (AA2) is located outside of the apparent zone of influence of the fracture flow drawdown.

Groundwater measurements at the TNTA and TNTC nests, within the potentiometric troughs, show a strong downward gradient, although the water level in the unconsolidated portion of the nest is within just a few feet of the ground surface. Groundwater measurements at the AA2 nest, away from the troughs, show that the vertical gradient fluctuates, sometimes representing upward flow, sometimes representing downward flow, and sometimes representing largely horizontal flow without a significant vertical component. This suggests that vertical gradient after pumping ceases may be seasonally variable, and at a lesser magnitude than is current observed. It is also likely that the bedrock aquifer will likely be under confined conditions at all times.

Groundwater levels in both the unconsolidated deposits and the bedrock aquifer will likely rise to within a few feet of the ground surface when pumping and dewatering activities are ceased. These groundwater levels will fluctuate seasonally, with higher groundwater levels in wet seasons, and lower water levels in dry seasons.

5. CONCEPTUAL HYDROGEOLOGICAL MODEL

The PBRF is located on the southeast flank of the Findley Arch, in an area where Paleozoic bedrock is mantled with a relatively thin layer of Pleistocene glacial deposits. Bedrock dips gently to the southeast into the Appalachian Basin. The topography to the west is dominated by a hummocky karst plain, while to the east, the landscape reflects the influence of lakebed deposits related to former higher water levels in Lake Erie.

Two hydrostratigraphic units are present at the site. The upper unit is primarily composed of lake-wave reworked glacial sediments, primarily cohesive soils with thin, discontinuous granular units. Where the unconsolidated deposits overlie the weathered remains of the eroded Olentangy Shale, the two formations are hydraulically connected and act as a single hydrostratigraphic unit. The underlying bedrock aquifer is composed of the Delaware Limestone and the Columbus Limestone, although only the Delaware Limestone subcrops at the PBRF.

Groundwater conditions in the unconsolidated deposits are in an unconfined to semi-confined condition, and groundwater conditions in the Delaware Limestone vary from slightly confined to slightly unconfined, depending on seasonal groundwater fluctuations. The hydraulic characteristics of these two units, as determined from information developed at the adjacent environmental sites at the PBS and published literature, are summarized in the following table.

Hydraulic Characteristics of PBRF Hydrostratigraphic Units

Characteristic	Mixed Unconsolidated Deposits	Delaware Limestone
Equivalent horizontal hydraulic conductivity, cm/sec (m/yr)	$9 \times 10^{-5} - 8 \times 10^{-4}$ (28 – 270) average: 5×10^{-4} (150)	$1 \times 10^{-5} - 6 \times 10^{-4}$ (3 – 188) Average: 1×10^{-4} (40)
Porosity, percent	35 -70	1 – 30
*Horizontal hydraulic gradient, ft/ft	0.005 – 0.006	0.002 – 0.003
*Groundwater flow velocity, m/yr	1 – 15	2 – 185

*Expected conditions when groundwater extraction at PBRF is terminated.

Regional horizontal groundwater flow at the PBS is to the north, toward Lake Erie, which is the regional base level. Dewatering at a stone quarry to the north of the PBRF creates a localized control on groundwater flow that reinforces the regional flow direction at the PBRF. Site specific groundwater flow mapping at the PBS has refined the understanding of local groundwater flow conditions. Flow in the unconsolidated deposits is somewhat influenced by surface topography, and flow in the bedrock aquifer is likely strongly influenced by bedrock fracture zones. A relation between potentiometric troughs and northeast-southwest and northwest-southeast trending fracture traces indicate that bedrock groundwater flow at the PBRF is likely occurring mostly in preferential pathways that are within the zone of influence of quarry dewatering operations to the north.

Dewatering from foundation drains and sumps at the PBRF is conducted to protect the subsurface structures, and a groundwater pump and treat remediation system is operating, which includes a groundwater extraction well. These activities create a zone of influence in both the unconsolidated deposits and bedrock aquifer. The on-site pumping activities will cease after decommissioning of the PBRF, and the RCRA groundwater remedial action is complete. At that time, groundwater flow conditions are expected to resemble those currently present, but with somewhat less drawdown in the PBRF area. Groundwater flow will continue to the north, and a natural groundwater gradient will return to the site as the groundwater levels recover from the current pumping. Bedrock groundwater flow will continue to be dominated by the quarry dewatering and fracture flow. In the event that quarry dewatering ceases in the future, flow in the bedrock aquifer will continue to be generally to the north, toward Lake Erie.

The vertical groundwater flow gradient at the PBRF is strongly downward, as a result of the anthropogenic groundwater pumping activities. Groundwater flow in areas away from the fracture flow zone suggests that when pumping is ceased, the vertical gradient may be seasonally variable (upward and downward), and that groundwater levels in both the unconsolidated deposits and bedrock aquifer will rise to within a few feet of the ground surface. The groundwater levels will exhibit seasonal fluctuation.

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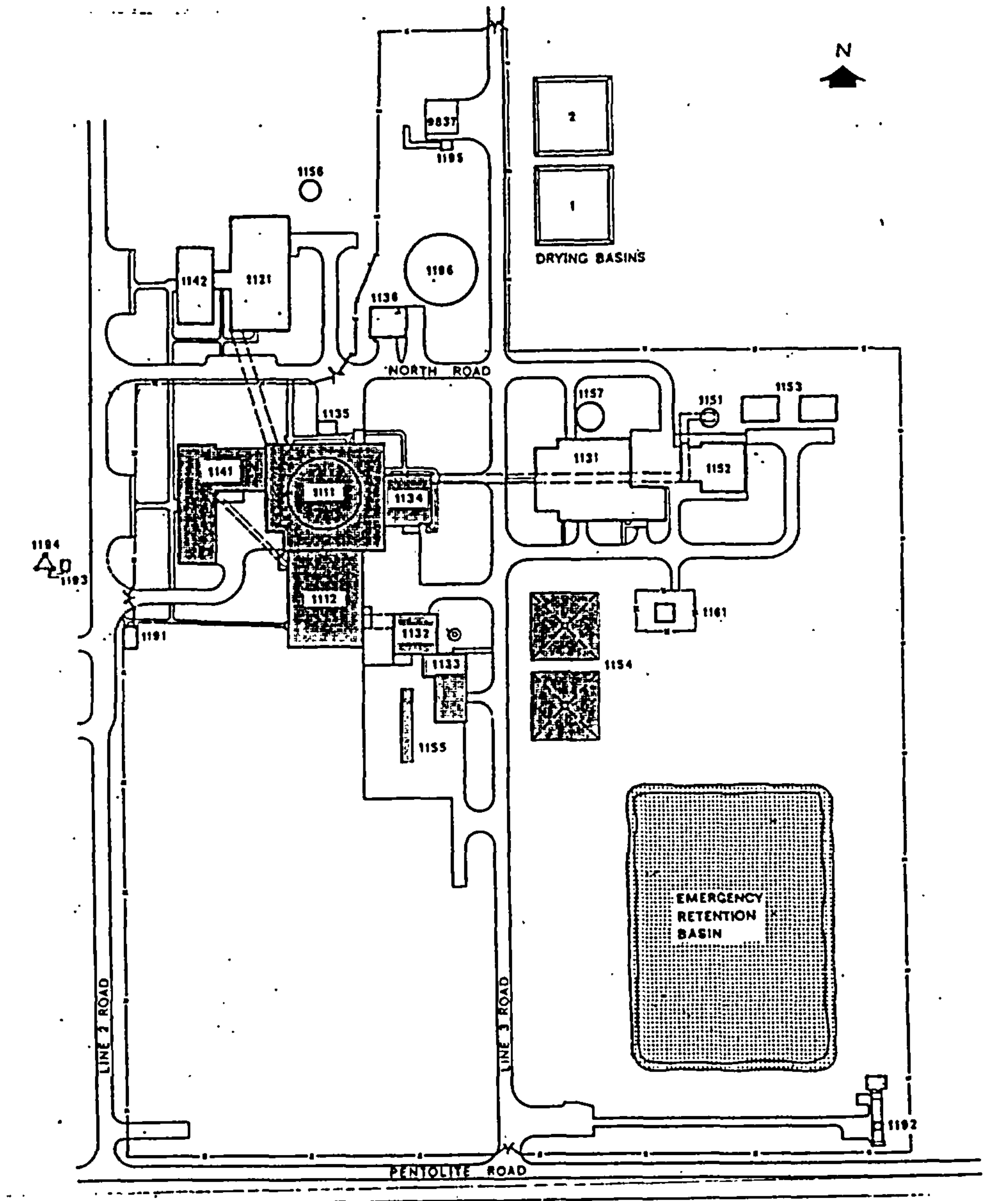
FIGURES

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: "FIGURE 1. LOCATION MAP SHOWING GEOLOGIC CROSS SECTION LINE LOCATIONS"

WITHIN THIS PACKAGE

D-01



1111	REACTOR BUILDING
1112	REACTOR HOT LABORATORY
1121	REACTOR ASSEMBLY TEST AND STORAGE BUILDING
1131	REACTOR SERVICE EQUIPMENT BUILDING
1132	REACTOR FAN HOUSE
1133	REACTOR WASTE HANDLING BUILDING
1134	REACTOR PRIMARY PUMP HOUSE
1135	REACTOR GAS SERVICES BUILDING
1136	REACTOR COMPRESSOR BUILDING
1141	REACTOR OFFICE AND LABORATORY
1142	REACTOR OFFICE BUILDING
1151	REACTOR WATER TOWER (F)
1152	REACTOR COOLING TOWER
1153	REACTOR SLUDGE BASINS
1154	REACTOR COLD RETENTION BASINS
1155	REACTOR HOT RETENTION BASINS
1156	REACTOR ATS WATER STORAGE TANK (200K GAL)
1157	REACTOR PRECIPITATOR
1161	REACTOR SUBSTATION (E)
1191	REACTOR SECURITY BUILDING
1192	REACTOR EFFLUENT METERING STATION
1193	REACTOR RADAR AND WEATHER TOWER HOUSE
1194	REACTOR RADAR AND WEATHER TOWER
1195	REACTOR CRYOGENIC AND GAS SUPPLY SYSTEM
1196	REACTOR GAS STORAGE STRUCTURE
9837	GHE FARM AT REACTOR

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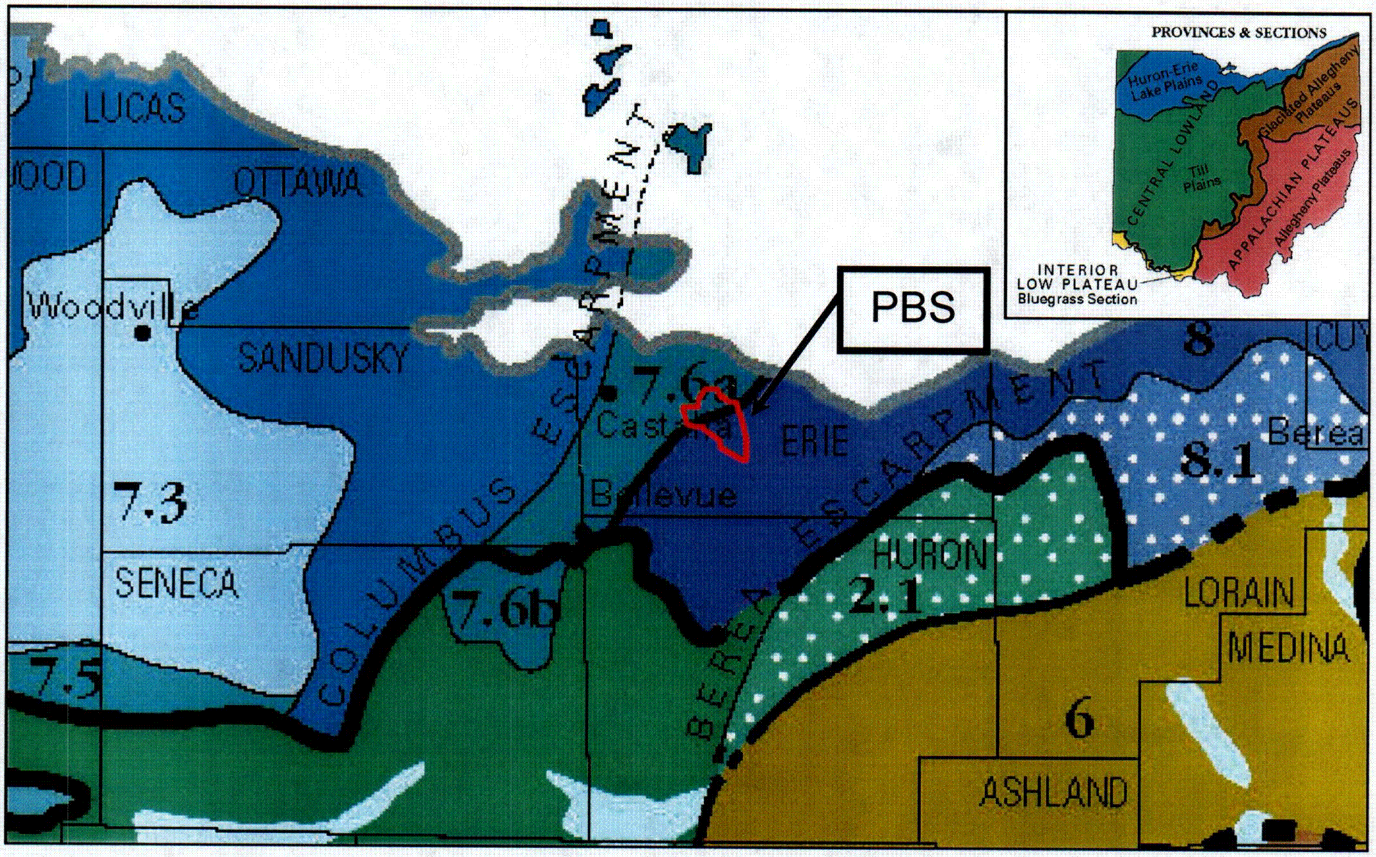
FIGURE 2. PBRF STRUCTURE IDENTIFICATION

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO



Till Plains

1. Steuben Till Plain
2. Central Ohio Clayey Till Plain
   - 2.1. Berea Headlands of the Till Plain
3. Southern Ohio Loamy Till Plain
   - 3.1. Union City-Bloomer Transitional Terrain
   - 3.2. Whitewater Interlobate Plain
   - 3.3. Bellefontaine Upland
   - 3.4. Mad River Interlobate Plain
   - 3.5. Darby Plain
   - 3.6. Columbus Lowland
4. Illinoian Till Plain
5. Dissected Illinoian Till Plain
6. Galion Glaciated Low Plateau

Transitional boundary

Lake basin/deposits outside Huron-Erie Lake Plains

Huron-Erie Lake Plains

7. Maumee Lake Plains
   - 7.1. Paulding Clay Basin
   - 7.2. Maumee Sand Plains
   - 7.3. Woodville Lake-Plain Reefs
   - 7.4. Findlay Embayment
   - 7.5. Fostoria Lake-Plain Shoals
   - 7.6a and 7.6b. Bellevue-Castalia Karst Plain
8. Erie Lake Plain
   - 8.1. Berea Headlands of the Erie Lake Plain

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FIGURE 3. PHYSIOGRAPHIC REGIONS OF NORTH-CENTRAL OHIO

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C01

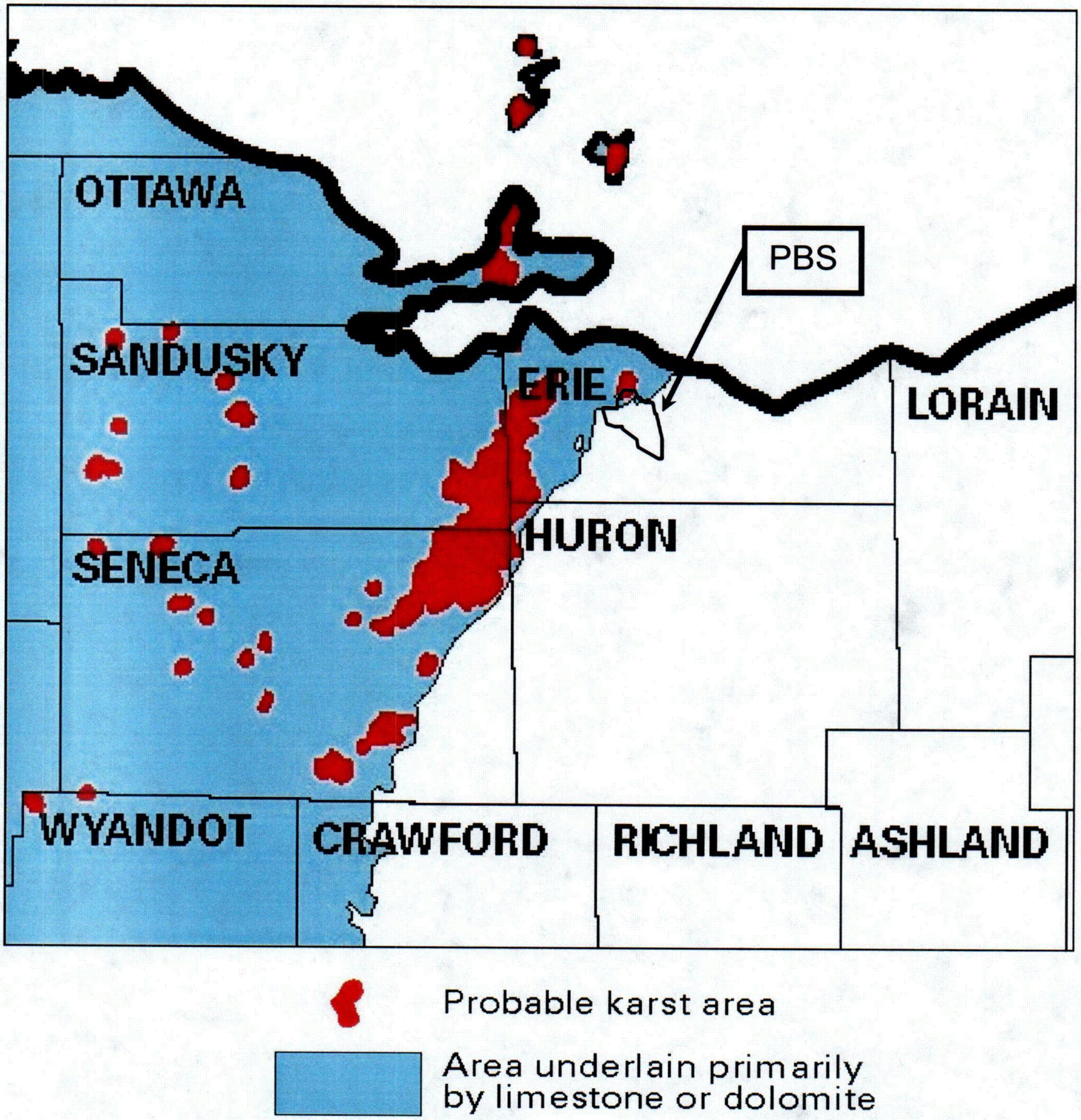

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FIGURE 4. KARST AREAS OF NORTH-CENTRAL OHIO

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C02

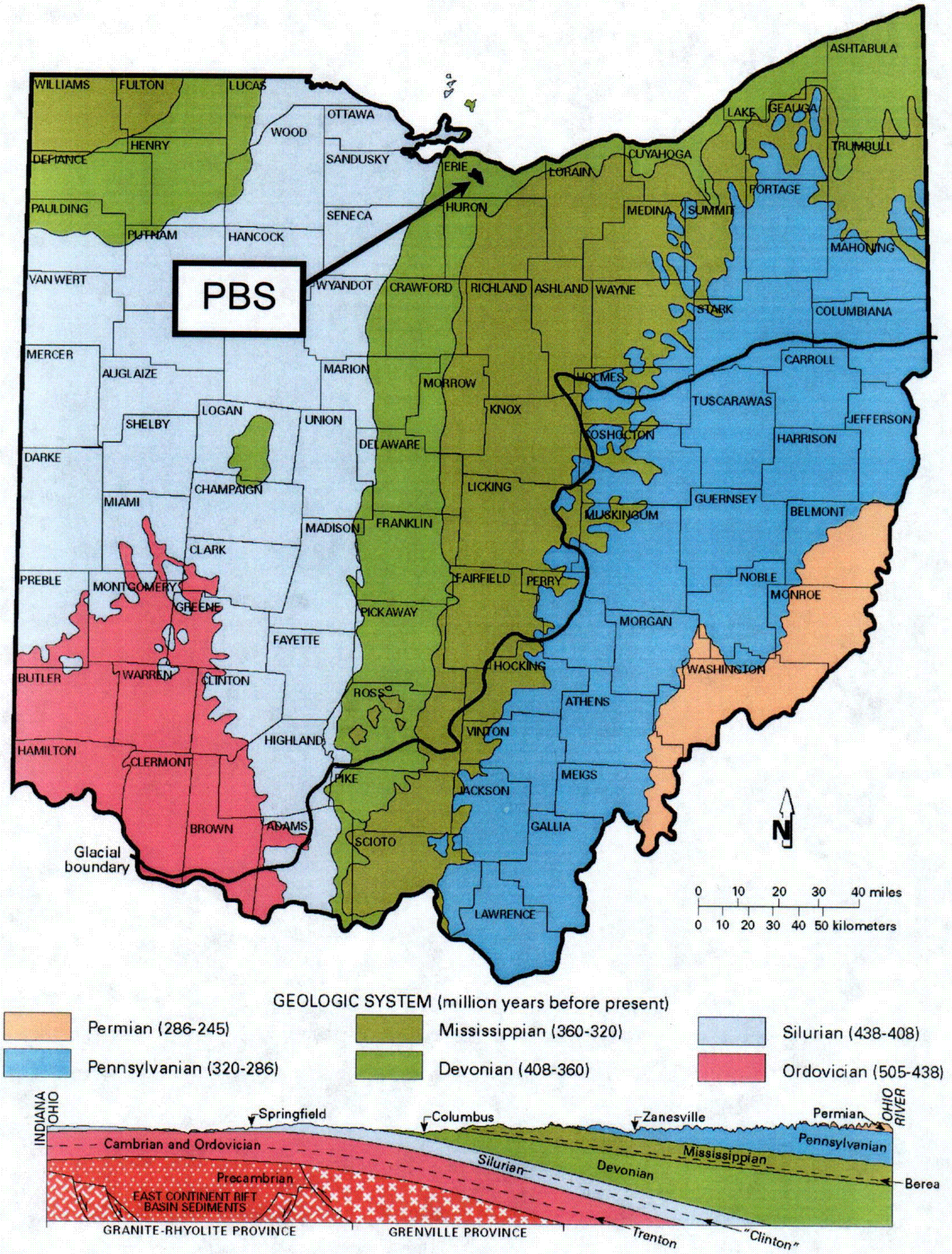

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FIGURE 5. BEDROCK GEOLOGY OF OHIO

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

CO3

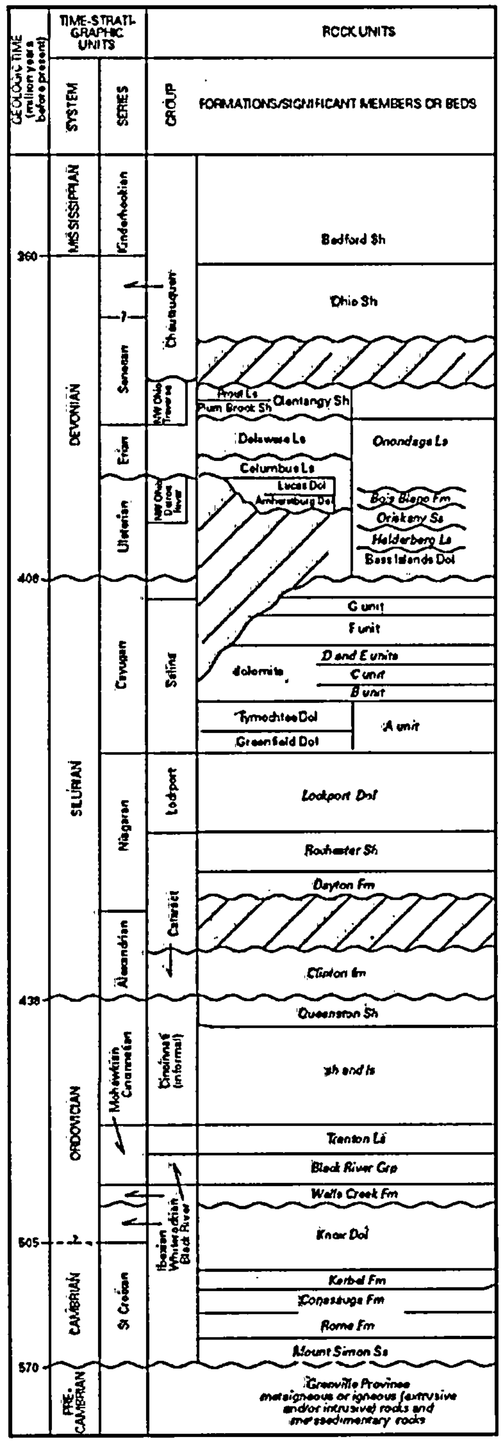

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FIGURE 6. BEDROCK STRATIGRAPHY

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

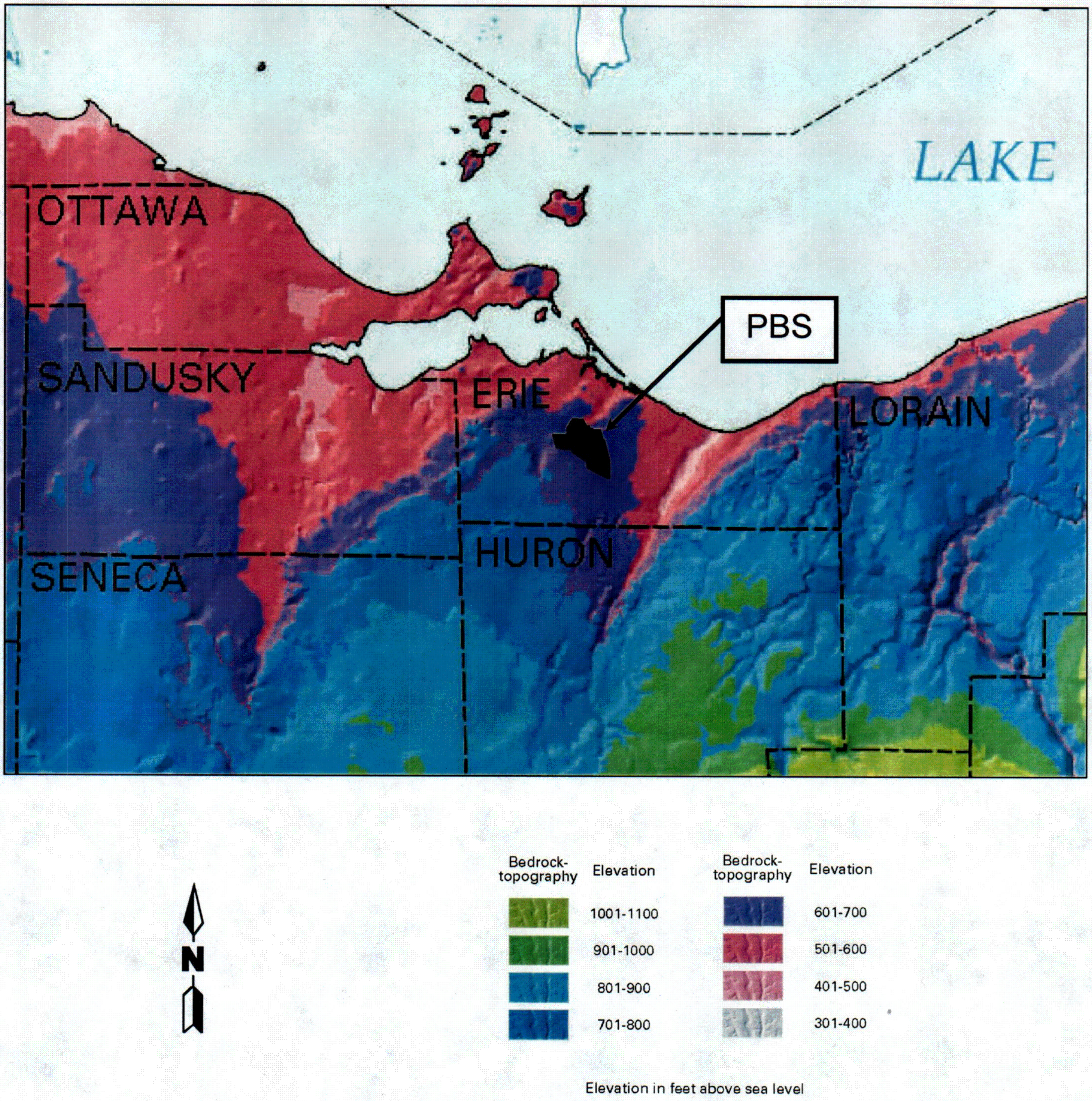

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FIGURE 7. BEDROCK TOPOGRAPHY OF NORTH-CENTRAL OHIO

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C04

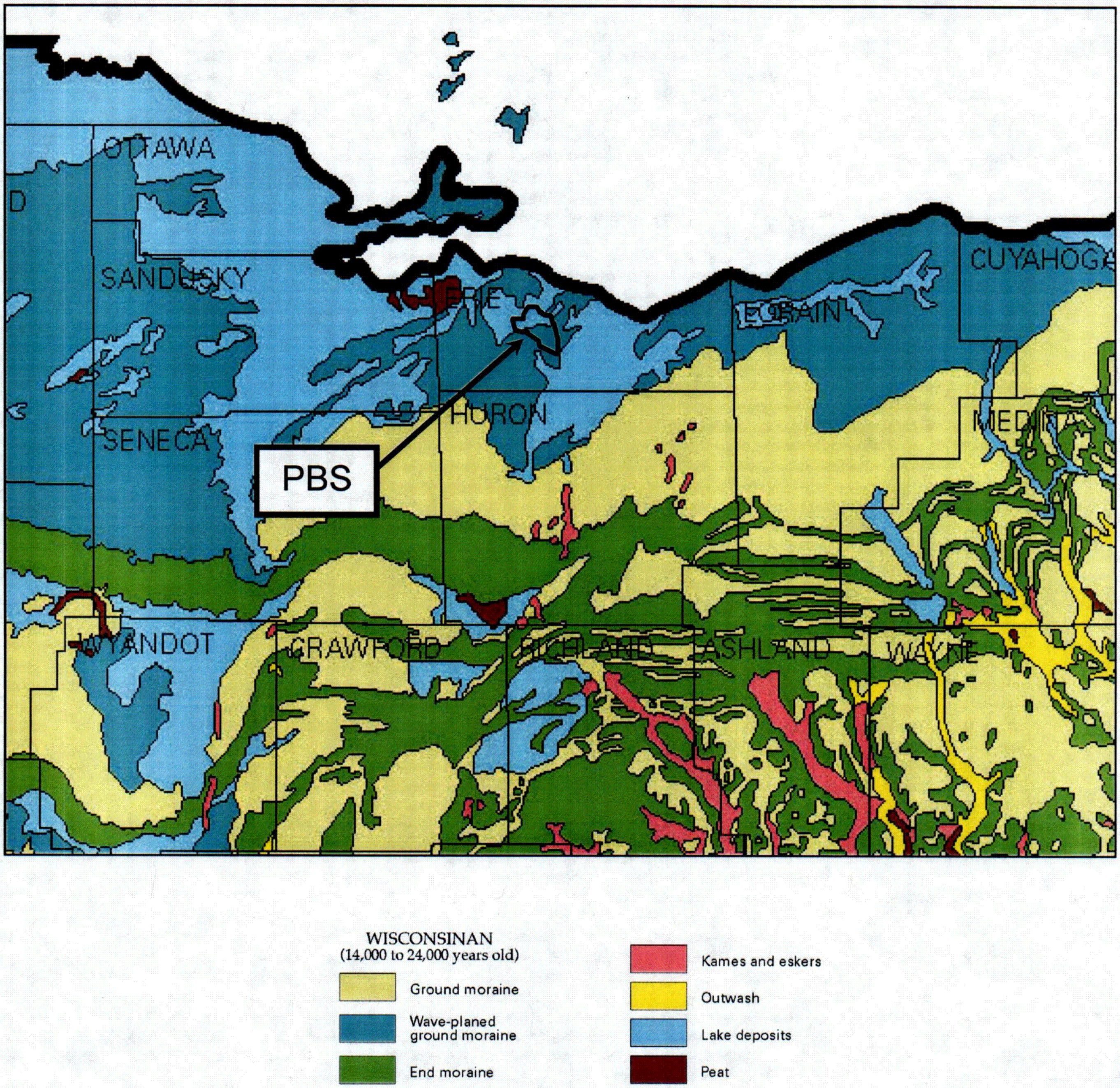

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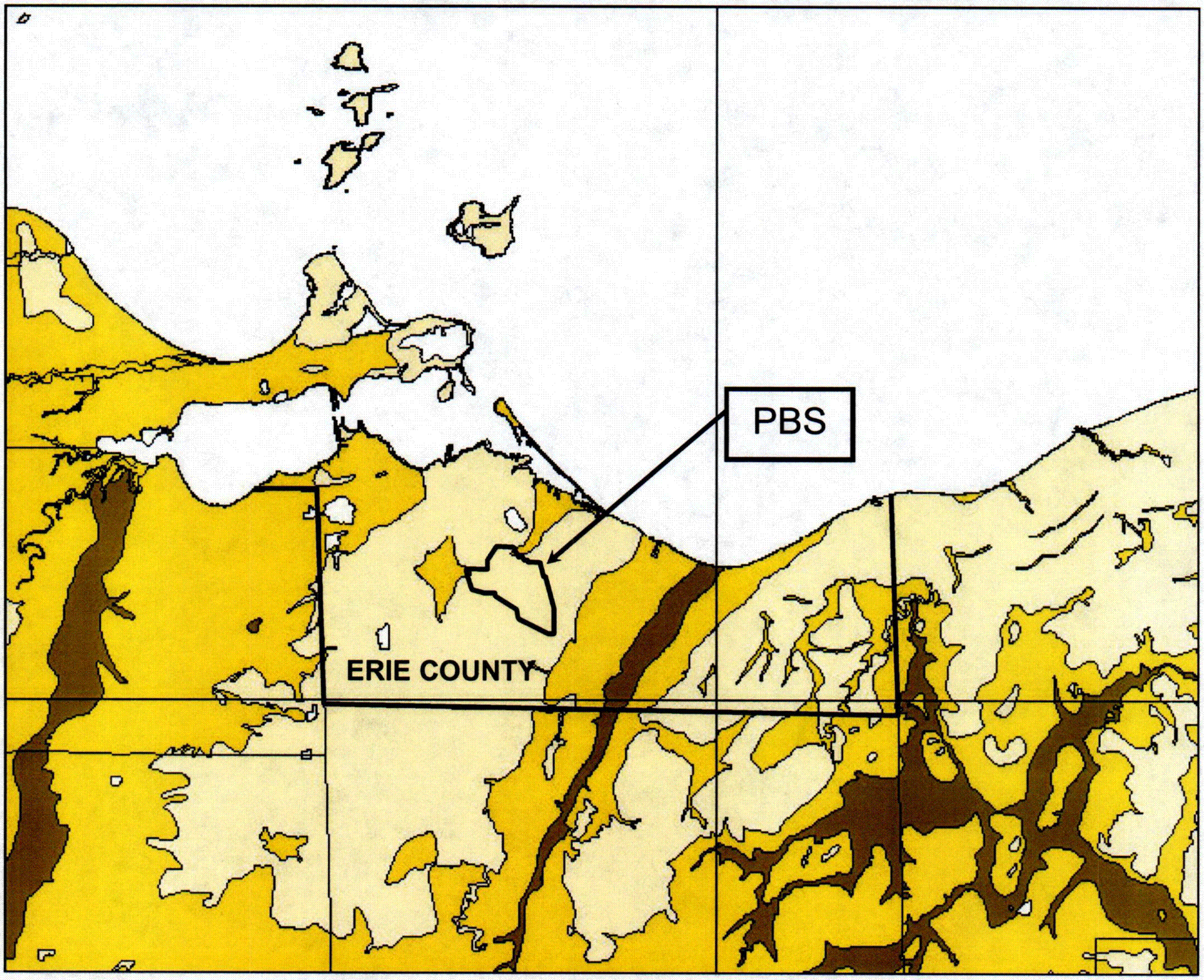
FIGURE 8. GLACIAL GEOLOGY OF NORTH-CENTRAL OHIO

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C05



Drift Thickness

- Less Than 25 Feet
- 25 to 100 Feet
- Greater Than 100 Feet
- No Drift Present (Unglaciated , Pits, Quarries)

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FIGURE 9. THICKNESS OF UNCONSOLIDATED DEPOSITS OF NORTH-CENTRAL OHIO

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C06

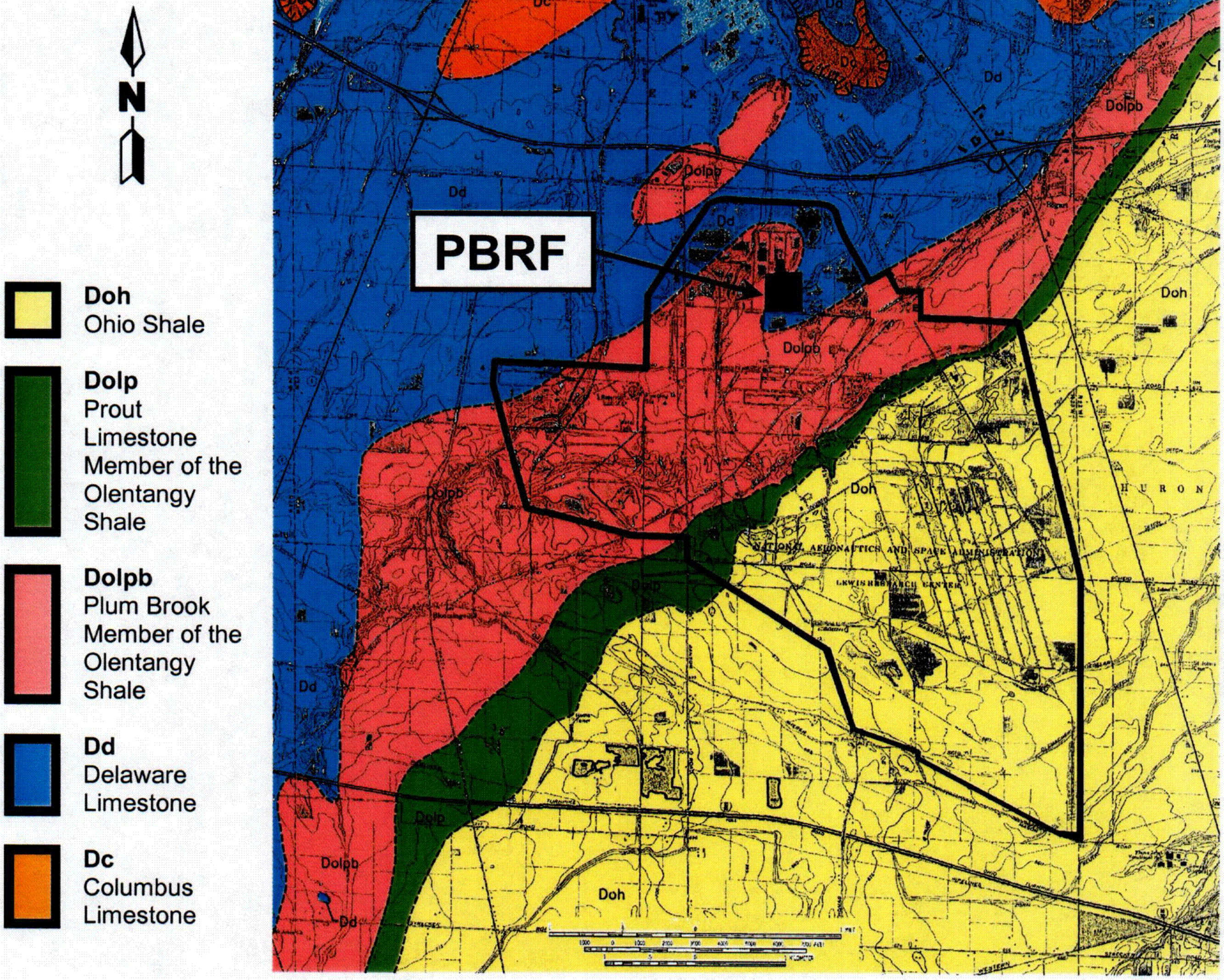

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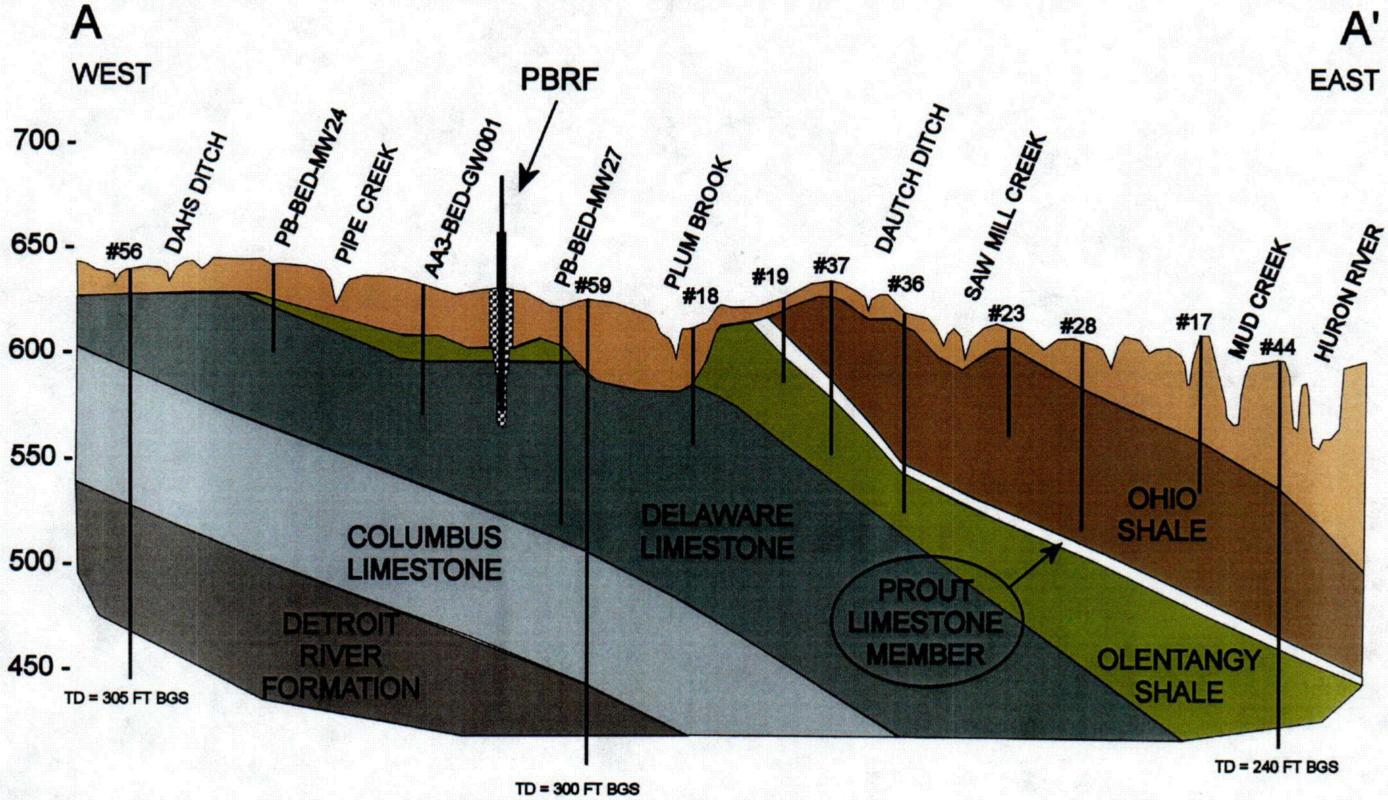
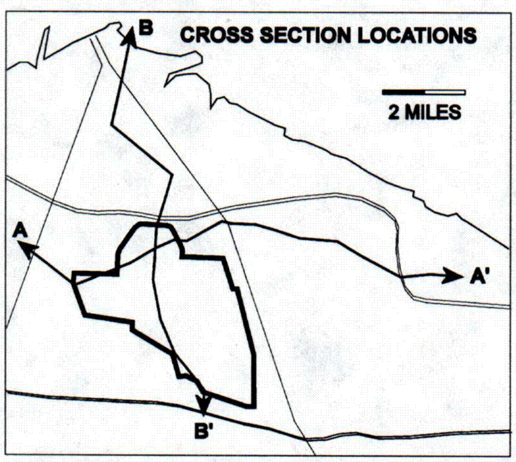
FIGURE 10. BEDROCK GEOLOGY AT PBRF

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C07

CROSS SECTION A-A'





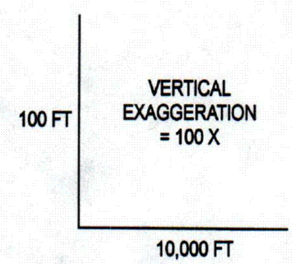


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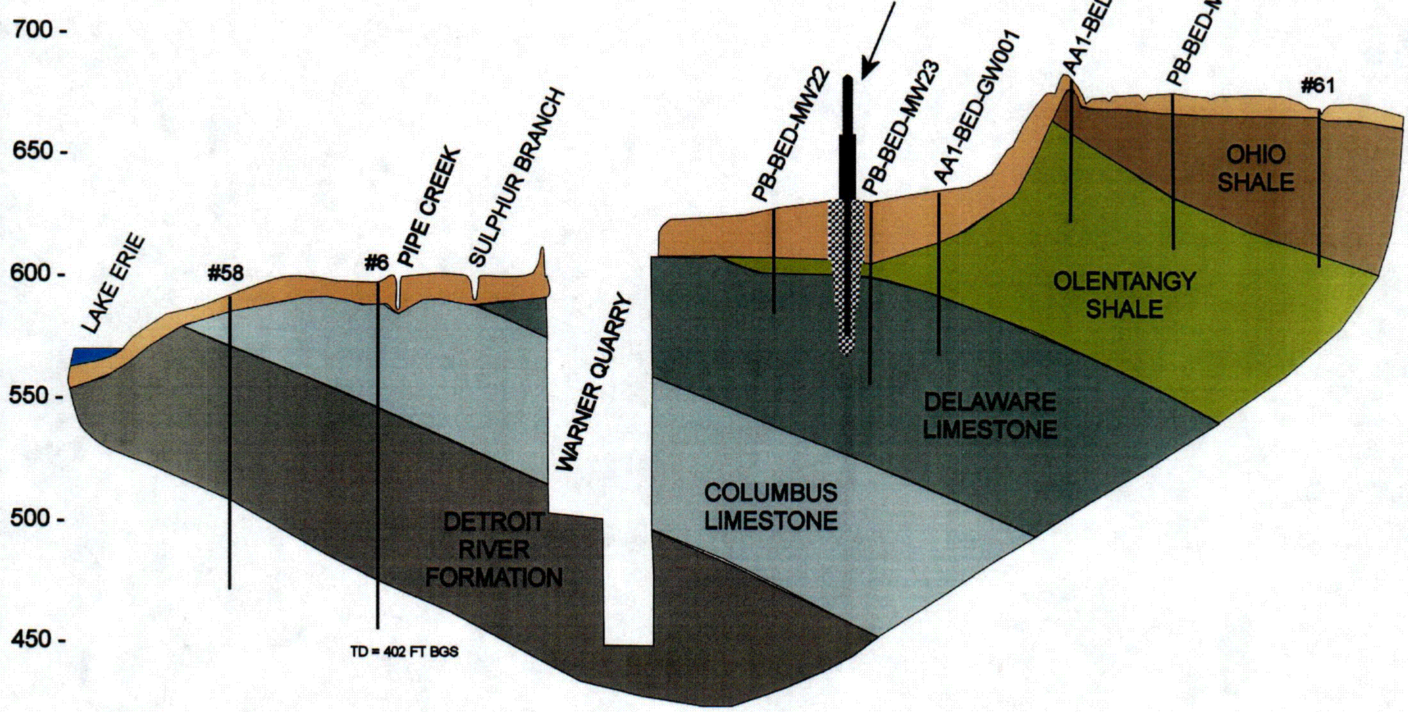
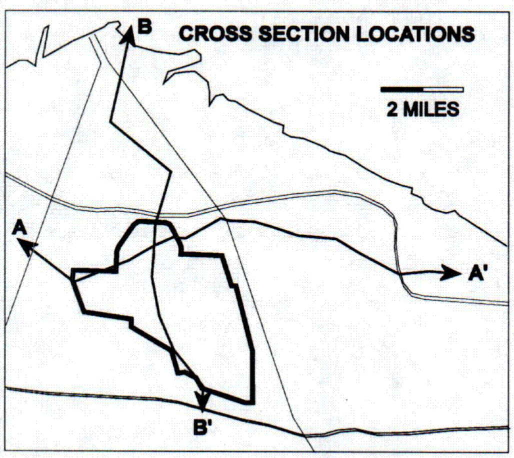
FIGURE 11. REGIONAL GEOLOGIC CROSS SECTION A-A'

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C08

CROSS SECTION B - B'





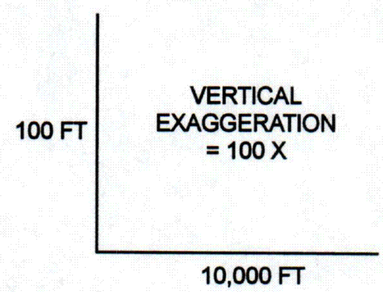


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FIGURE 12. REGIONAL GEOLOGIC CROSS SECTION B-B'

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C09

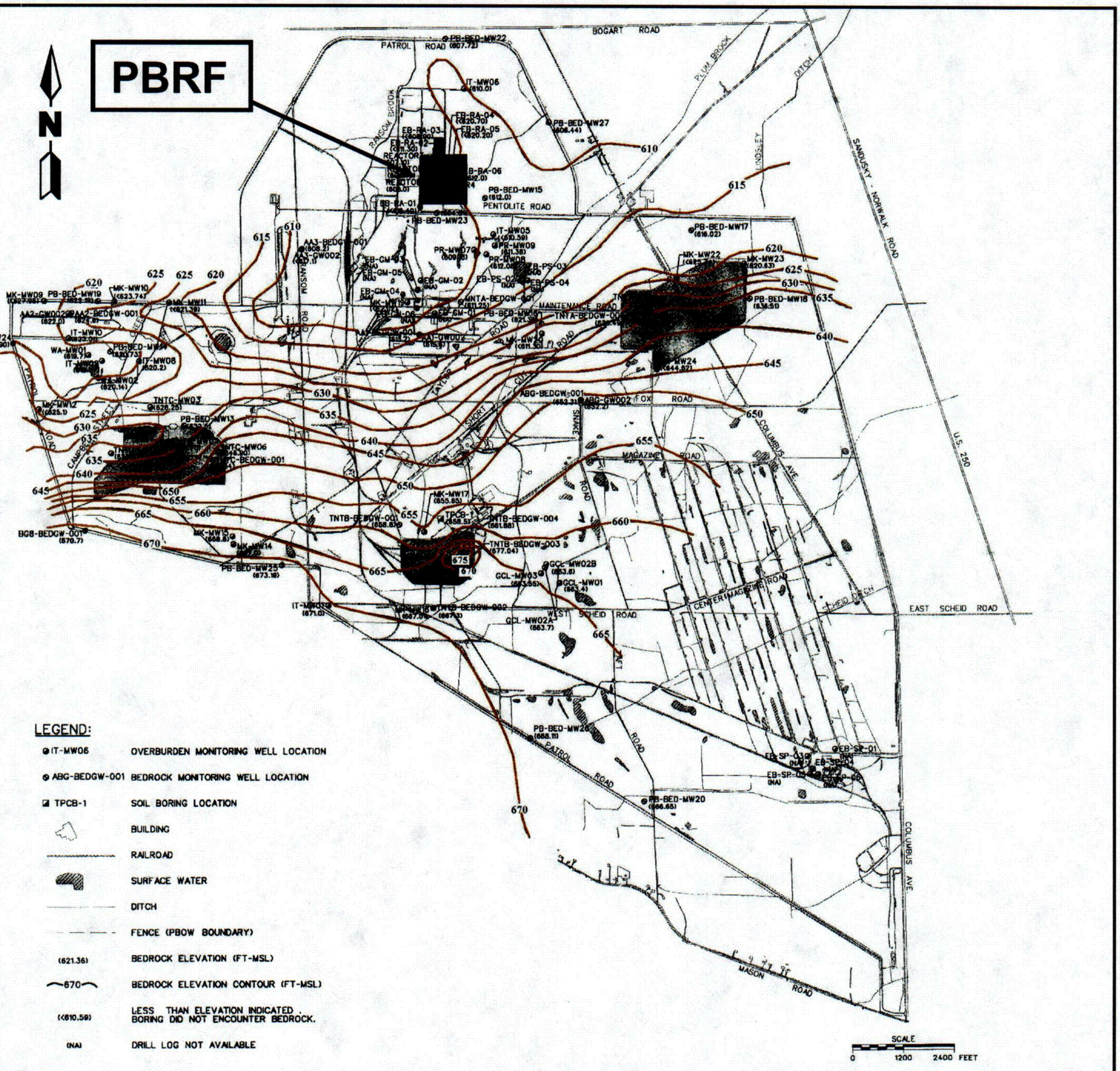

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FIGURE 13. BEDROCK ELEVATION AT PBRF

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C10

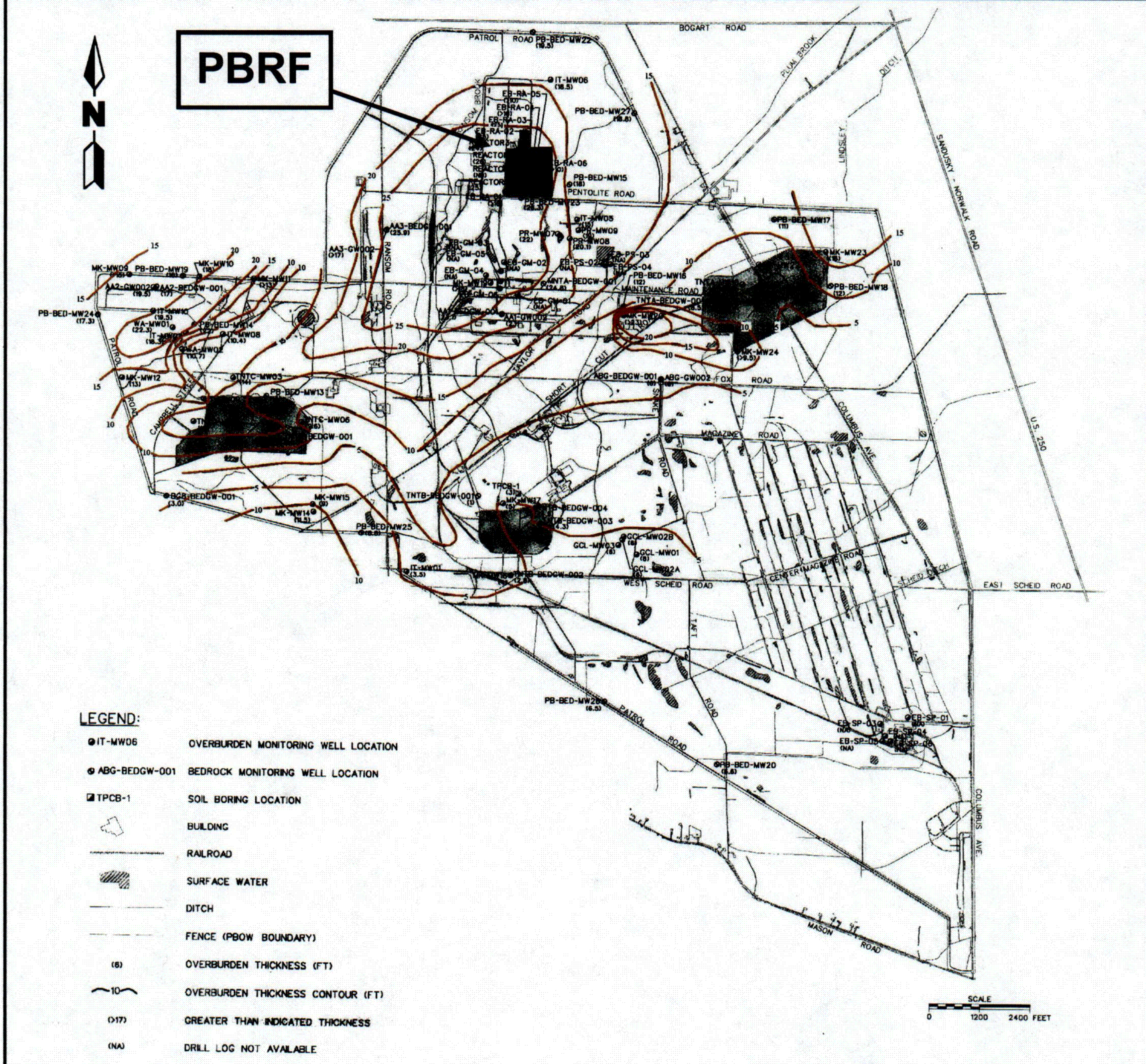

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FIGURE 14. THICKNESS OF UNCONSOLIDATED DEPOSITS AT PBRF

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

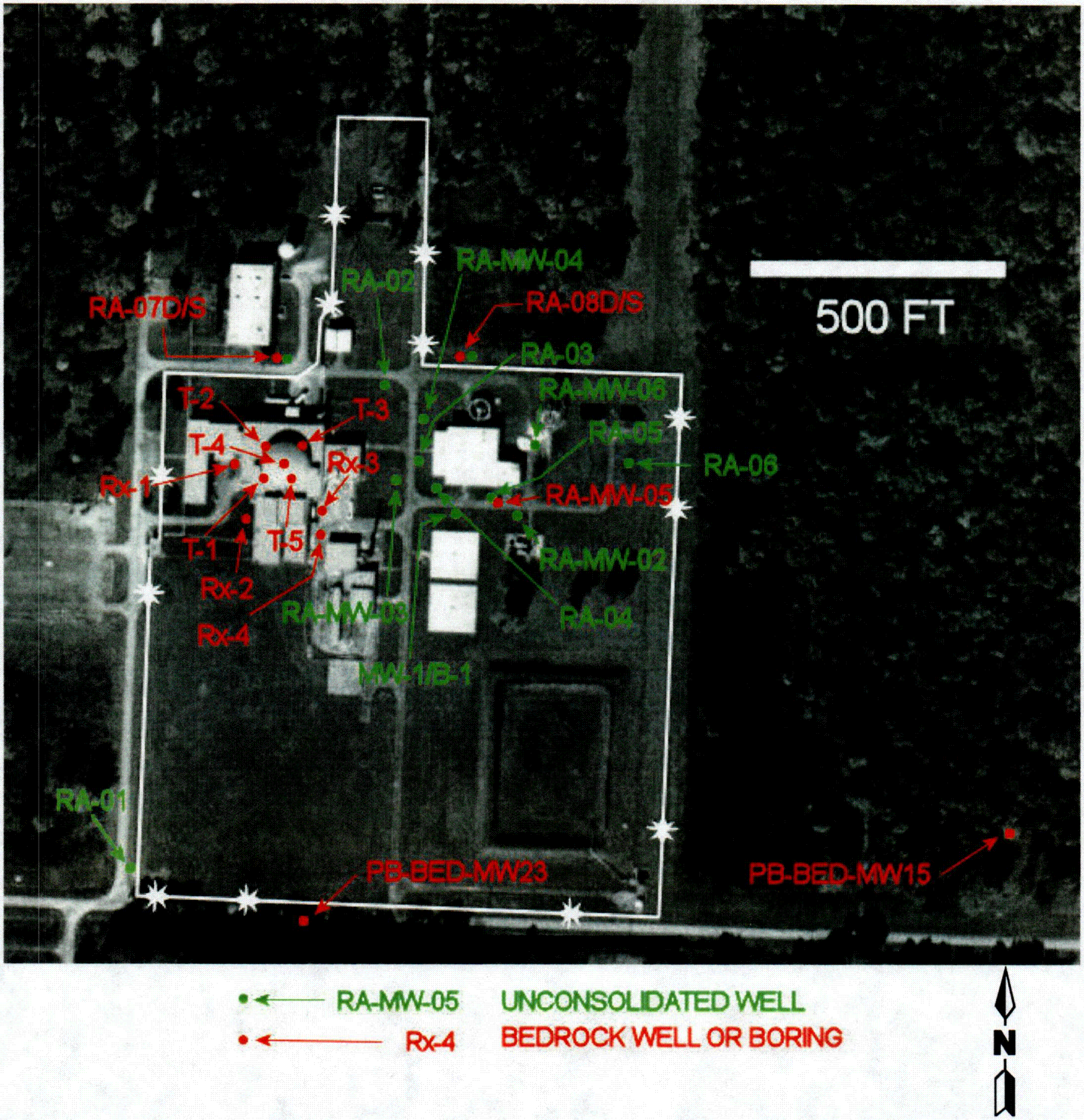

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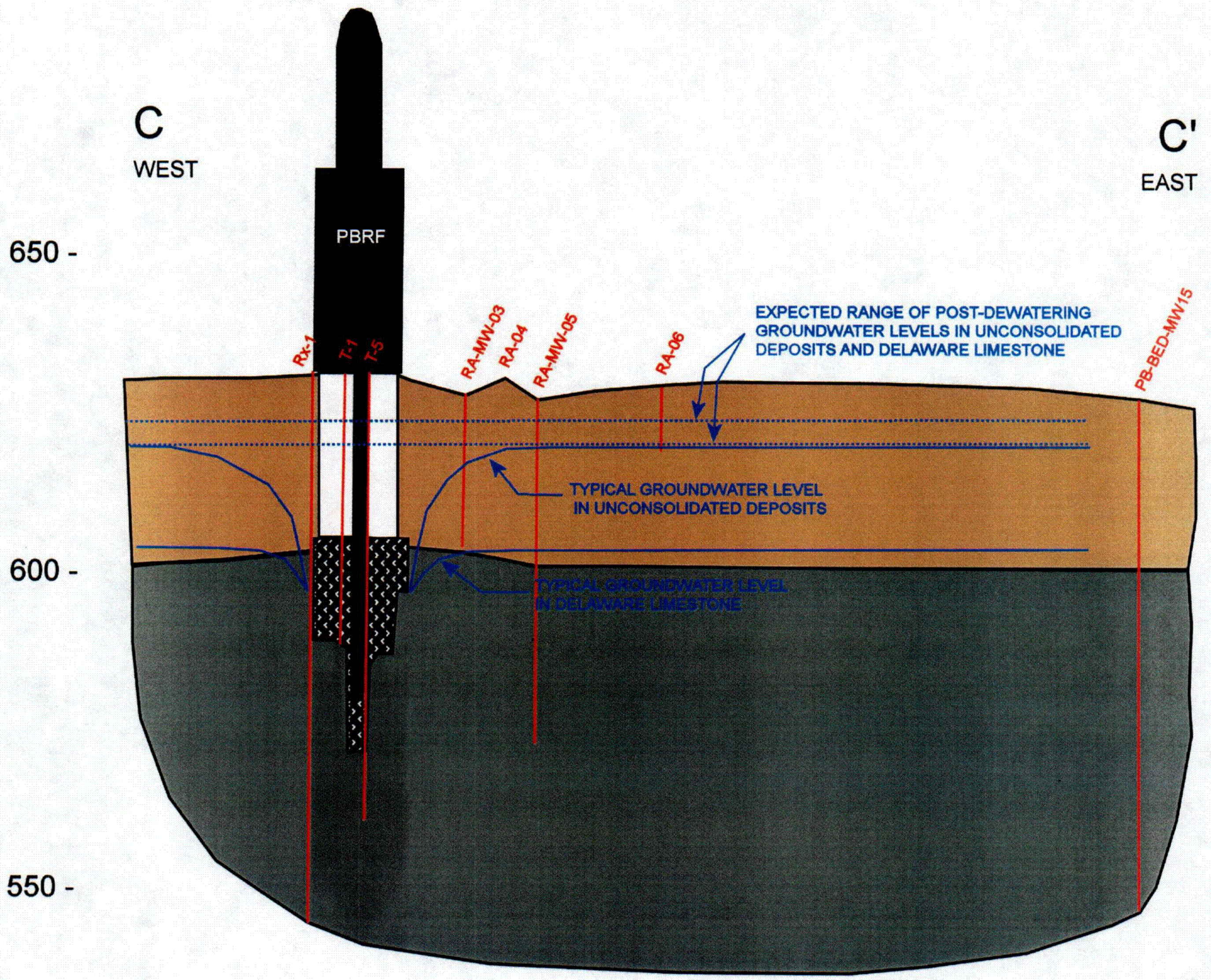
FIGURE 15. MASTER BORING PLAN

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C12

CROSS SECTION C-C'



VERTICAL EXAGGERATION = 15X

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FIGURE 16. GEOLOGIC CROSS SECTION C-C'

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C13

CROSS SECTION D-D'

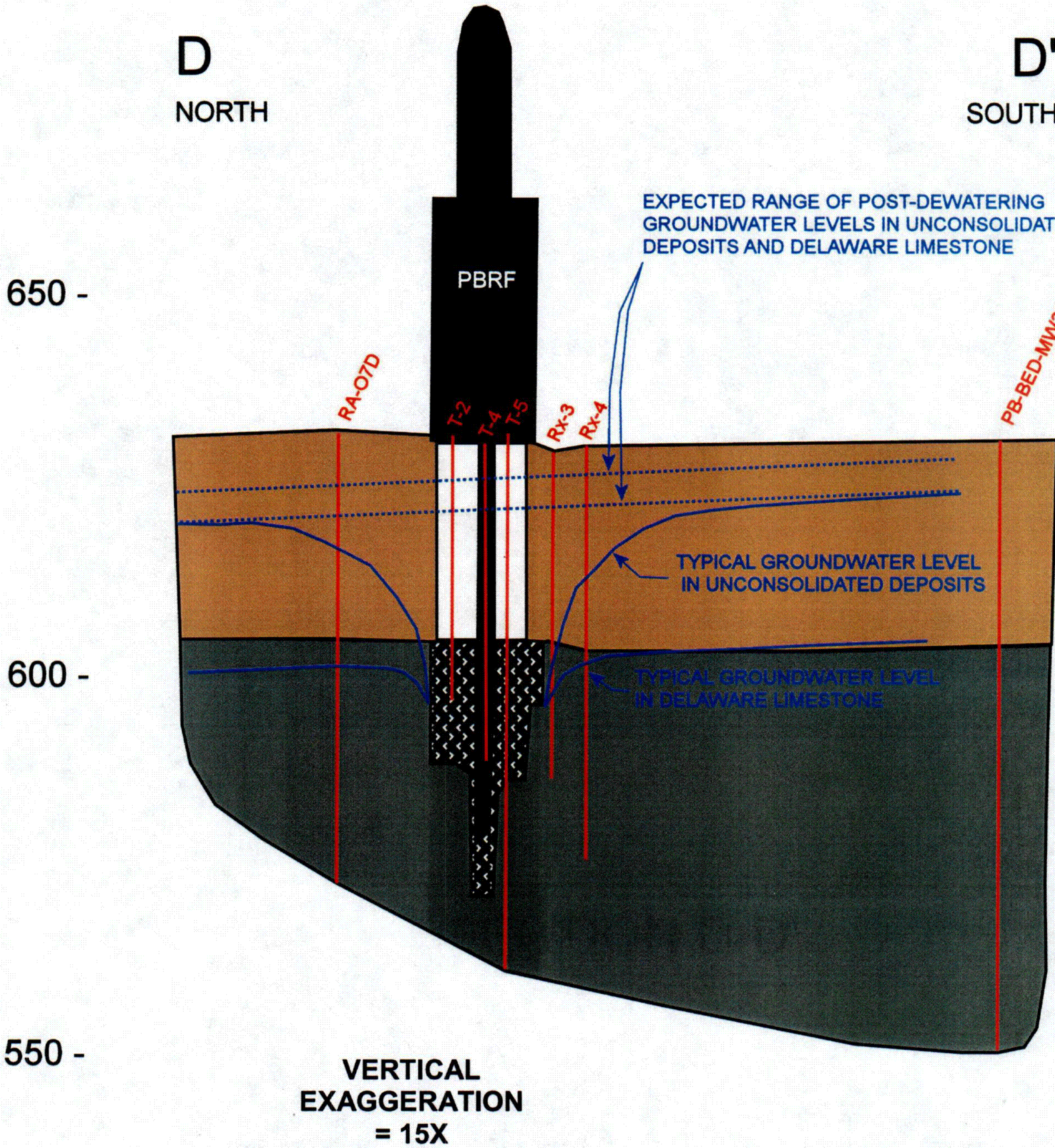

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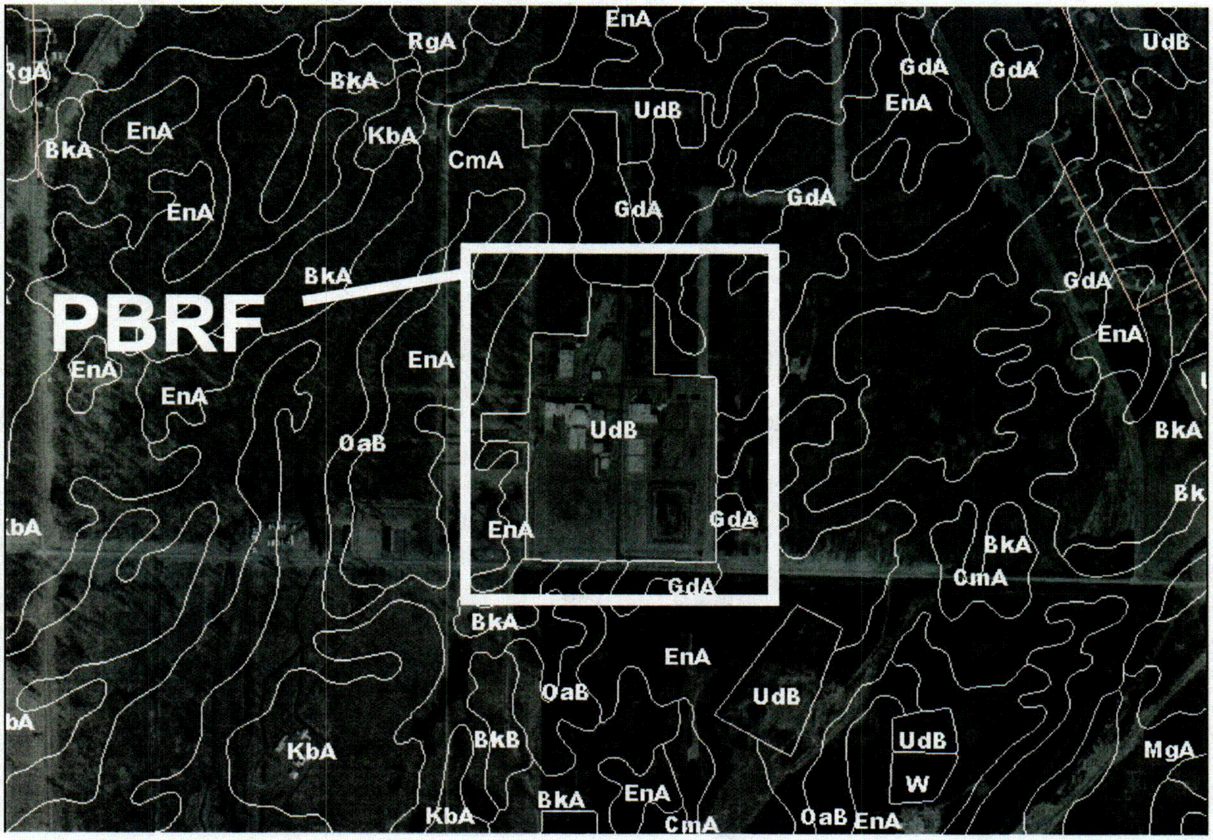
FIGURE 17. GEOLOGIC CROSS SECTION D-D'

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C14



CmA – Colwood loam
GdA – Gilford fine sandy loam
EnA – Elnora loamy fine sand
OaB – Oakville loamy fine sand
UdB – Udorthents, loamy

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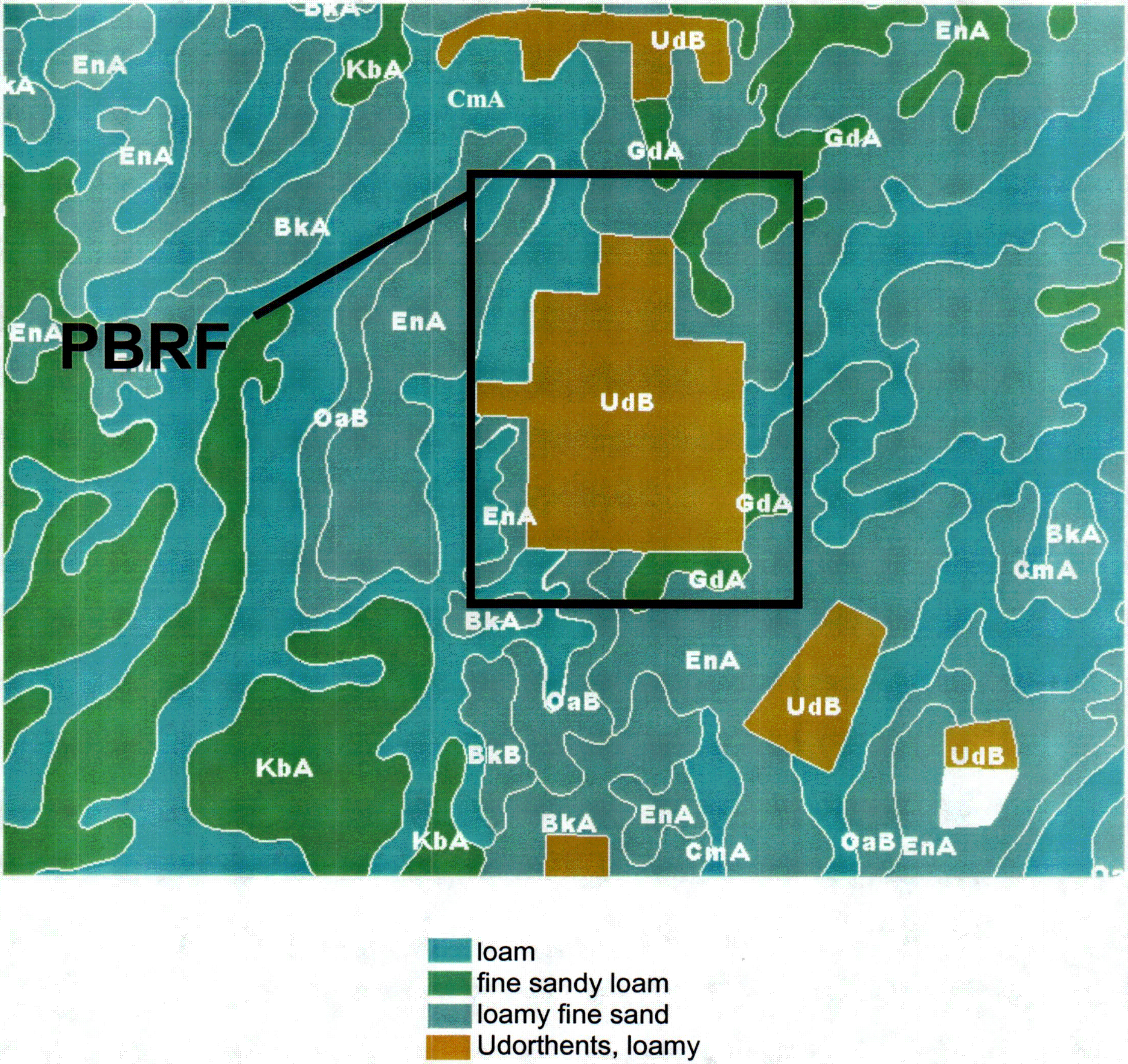

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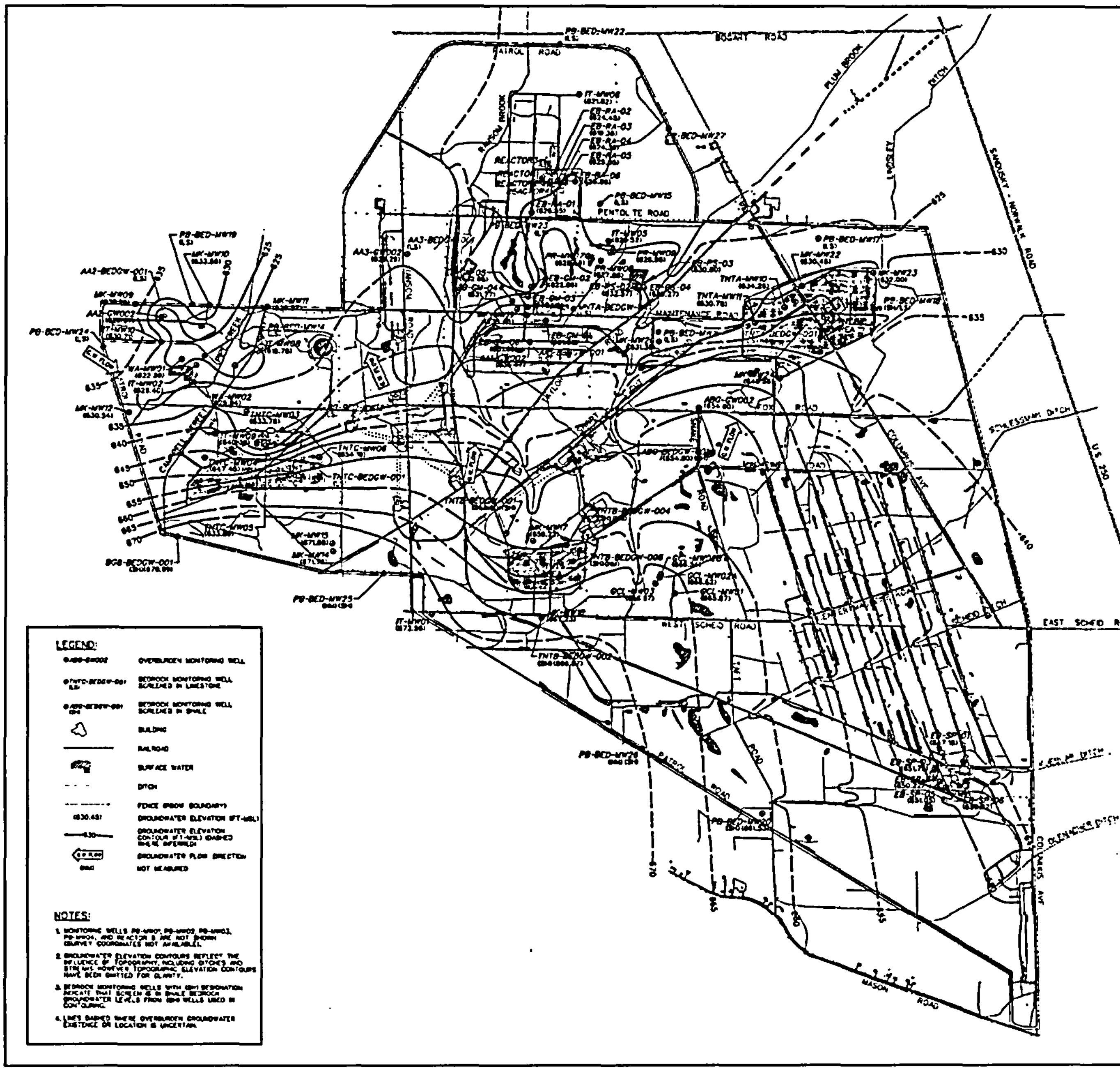
FIGURE 19. SOIL SURVEY MAP – SOIL TEXTURE

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C16



MAP TAKEN FROM SHAW (2003). SEE APPENDIX C FOR AN ENLARGEABLE ADOBE ACROBAT FILE OF THIS MAP.

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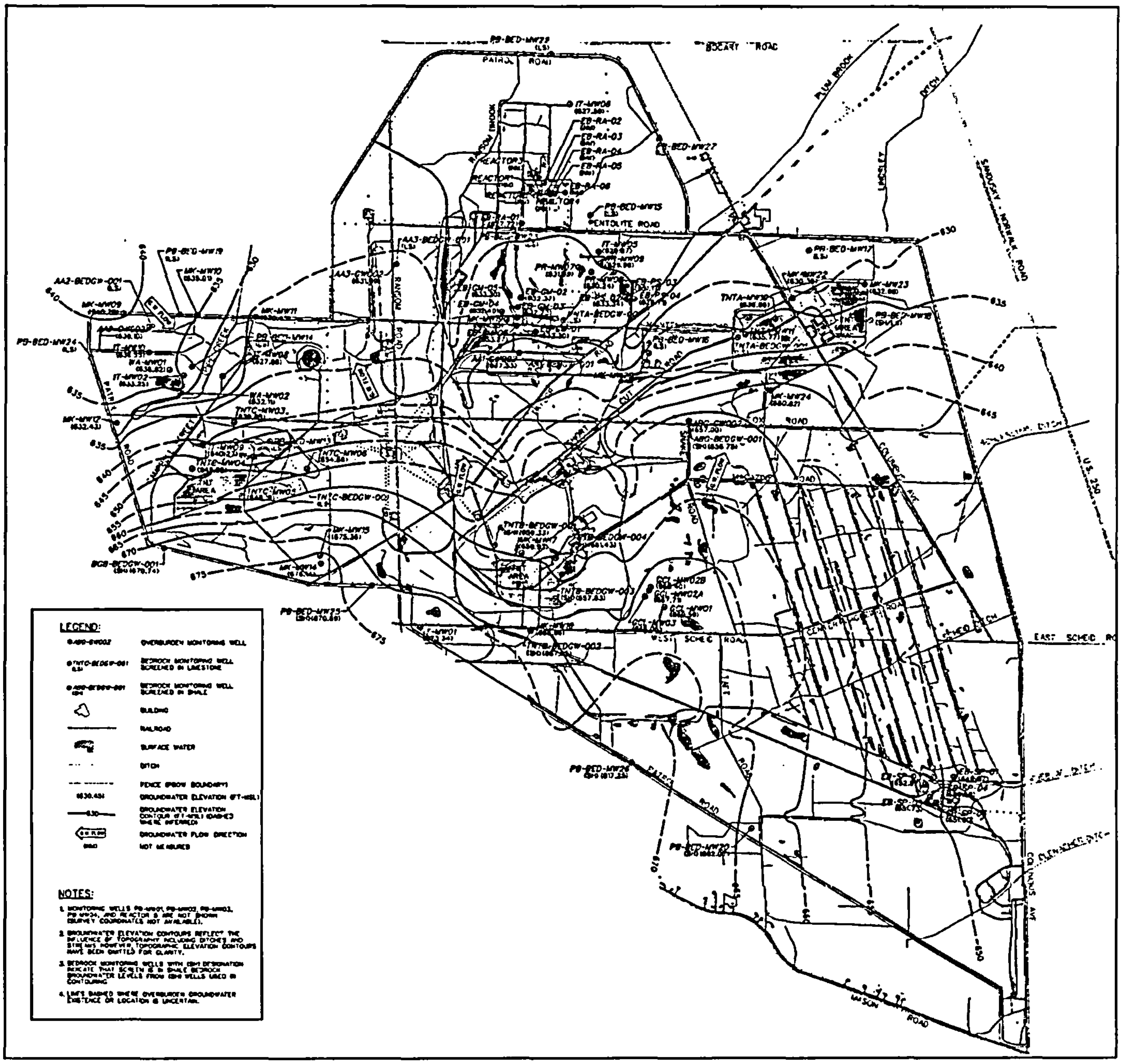
FIGURE 20. OVERBURDEN/SHALE GROUNDWATER ELEVATION CONTOUR MAP (NOVEMBER 2001)

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO



MAP TAKEN FROM SHAW (2003). SEE APPENDIX C FOR AN ENLARGEABLE ADOBE ACROBAT FILE OF THIS MAP.

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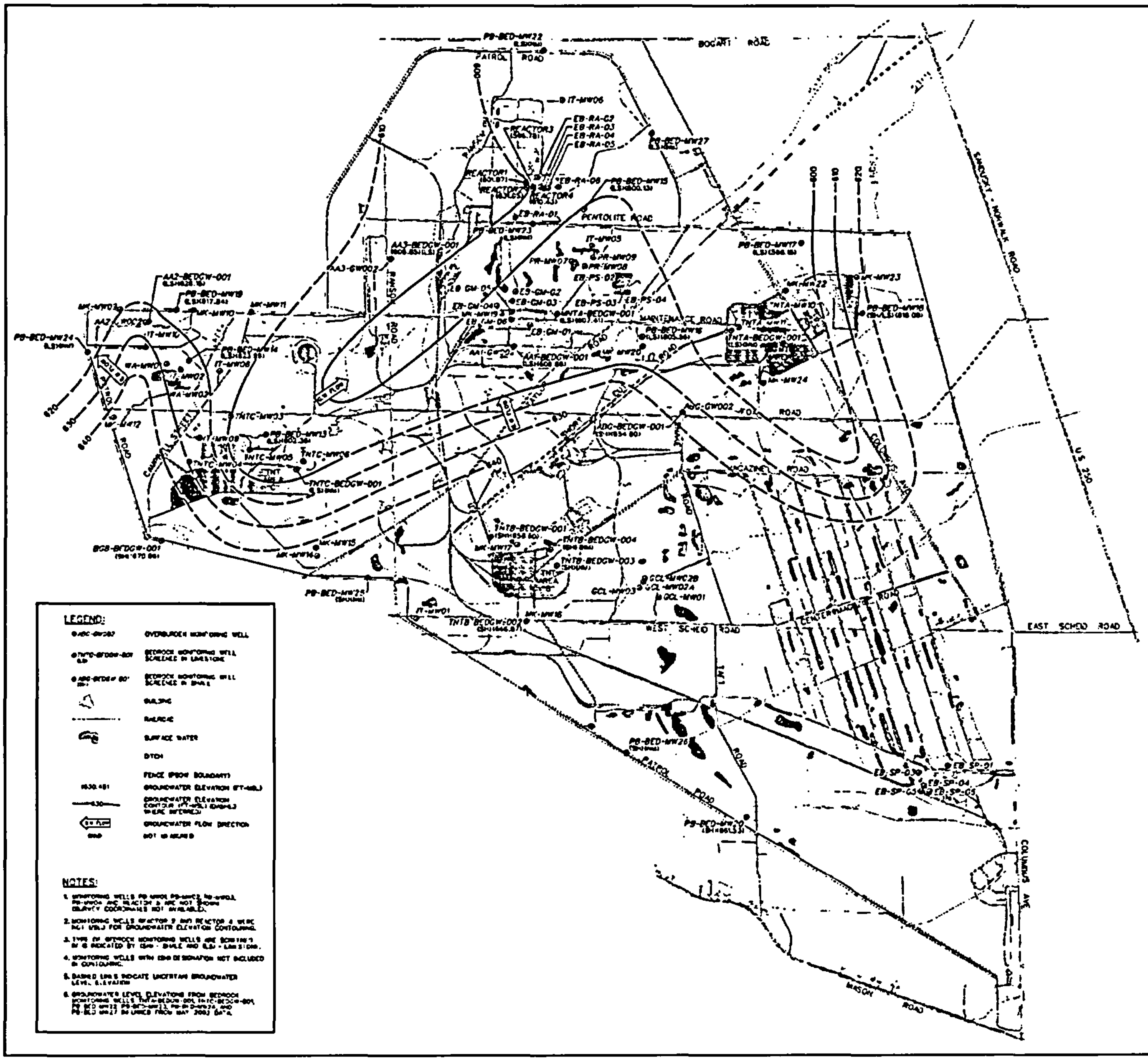
FIGURE 21. OVERBURDEN/SHALE GROUNDWATER ELEVATION CONTOUR MAP (MAY 2002)

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO



MAP TAKEN FROM SHAW (2003). SEE APPENDIX C FOR AN ENLARGEABLE ADOBE ACROBAT FILE OF THIS MAP.

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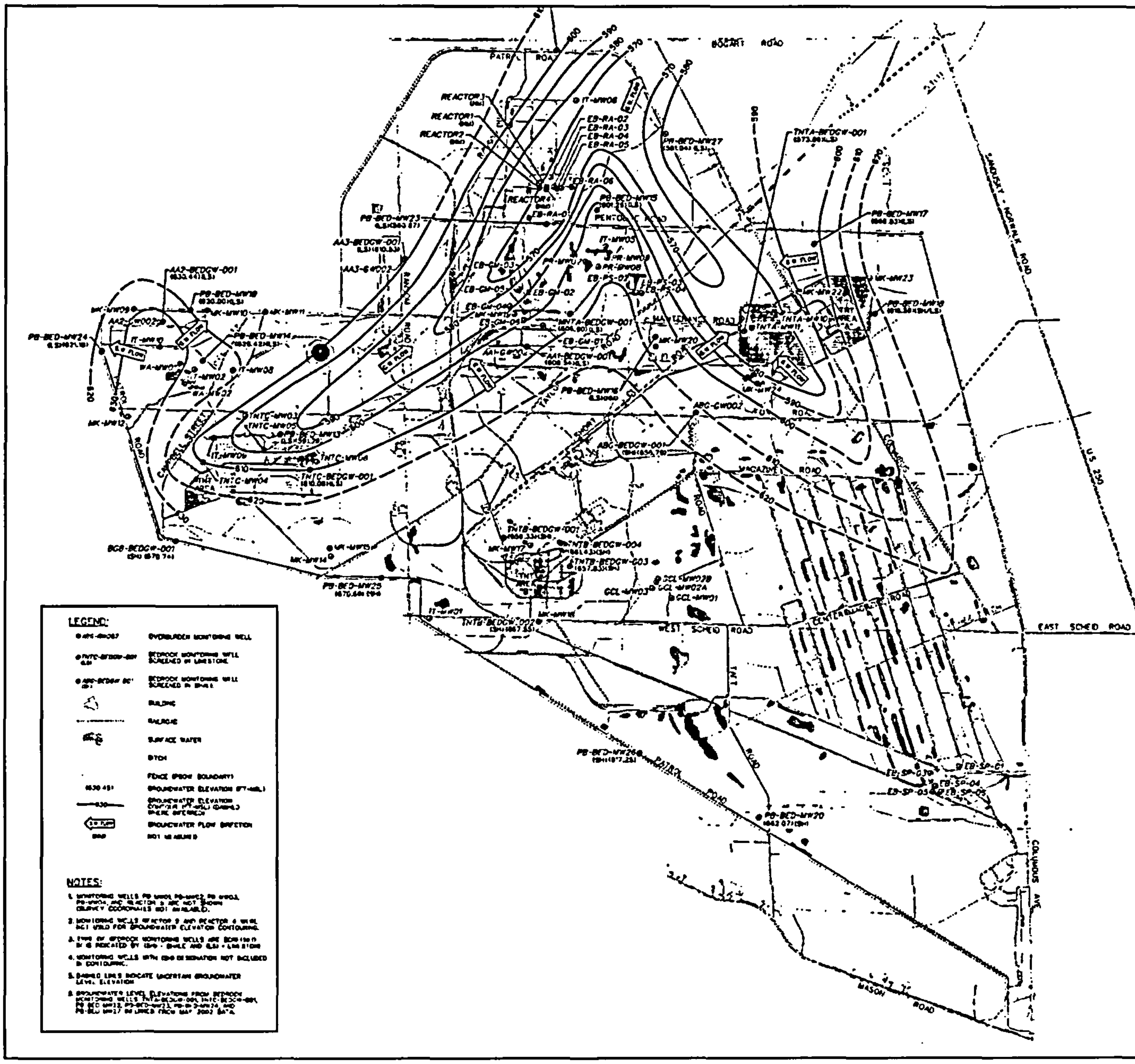
FIGURE 22. DELAWARE LIMESTONE GROUNDWATER ELEVATION CONTOUR MAP (NOVEMBER 2001)

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO



MAP TAKEN FROM SHAW (2003). SEE APPENDIX C FOR AN ENLARGEABLE ADOBE ACROBAT FILE OF THIS MAP.

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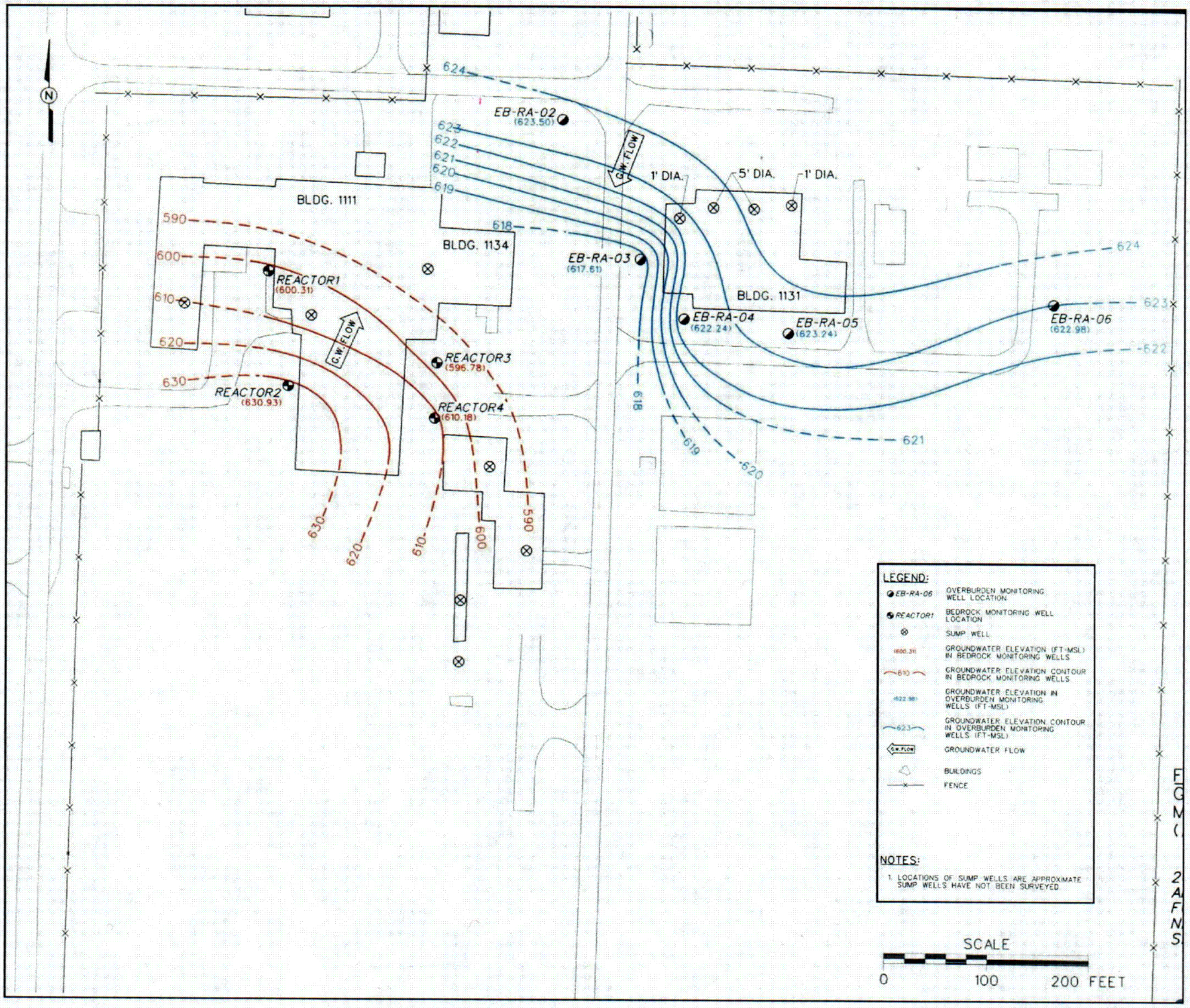
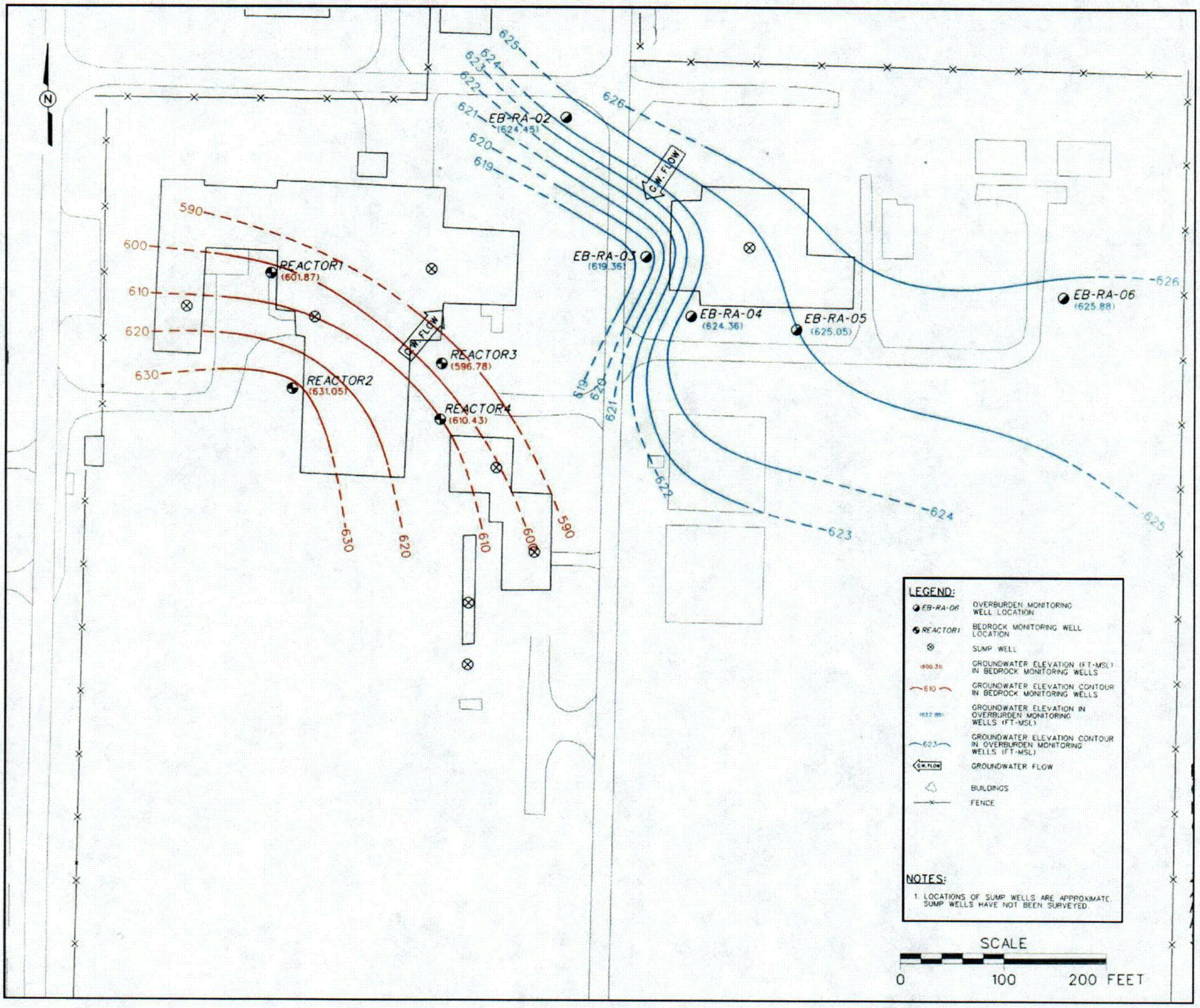
FIGURE 23. DELAWARE LIMESTONE GROUNDWATER ELEVATION CONTOUR MAP (MAY 2002)

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO



MAP TAKEN FROM SHAW (2003). SEE APPENDIX C FOR AN ENLARGEABLE ADOBE ACROBAT FILE OF THIS MAP.

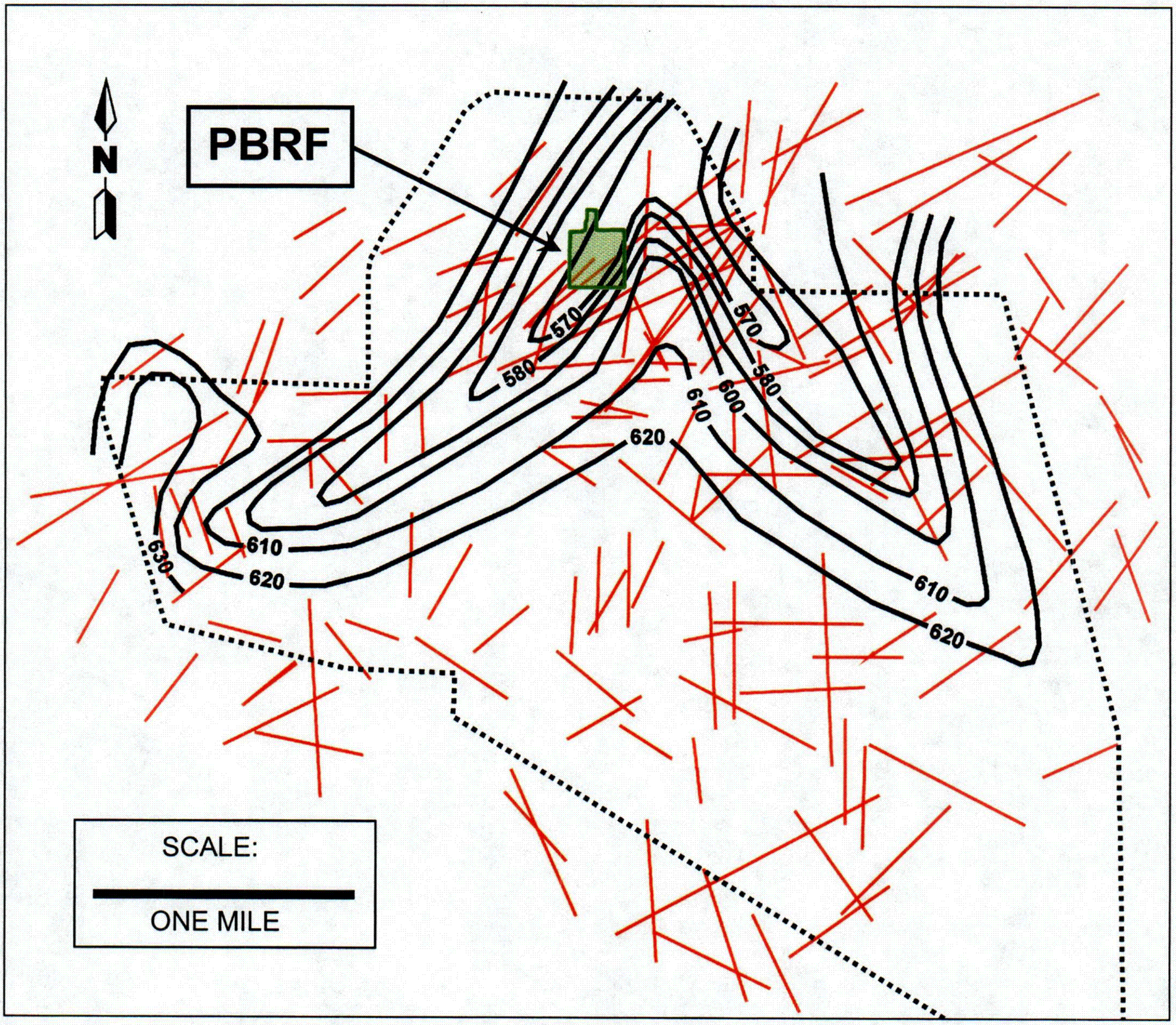
PREPARED BY US Army Corps of Engineers® Louisville District NOVEMBER 2004	**FIGURE 24. GROUNDWATER ELEVATION CONTOUR MAP, REACTOR FACILITY AREA (AUGUST 2001)** **PLUM BROOK REACTOR FACILITY** **SANDUSKY, OHIO**



MAP TAKEN FROM SHAW (2003). SEE APPENDIX C FOR AN ENLARGEABLE ADOBE ACROBAT FILE OF THIS MAP.

PREPARED BY US Army Corps of Engineers ® Louisville District **NOVEMBER 2004**	**FIGURE 25. GROUNDWATER ELEVATION CONTOUR MAP, REACTOR FACILITY AREA (NOVEMBER 2001)** **PLUM BROOK REACTOR FACILITY** **SANDUSKY, OHIO**

C18



POTENTIOMETRY FROM SHAW (2003), AS SHOWN IN FIGURE 23 IN THIS REPORT (WATER LEVELS FROM MAY 2002).

FRACTURE TRACES FROM DAMES AND MOORE (1997) AS SHOWN IN APPENDIX I OF THIS REPORT.

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FIGURE 26. RELATION OF BEDROCK POTENTIOMETRY TROUGHS AND FRACTURE TRACE ANALYSIS

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C19

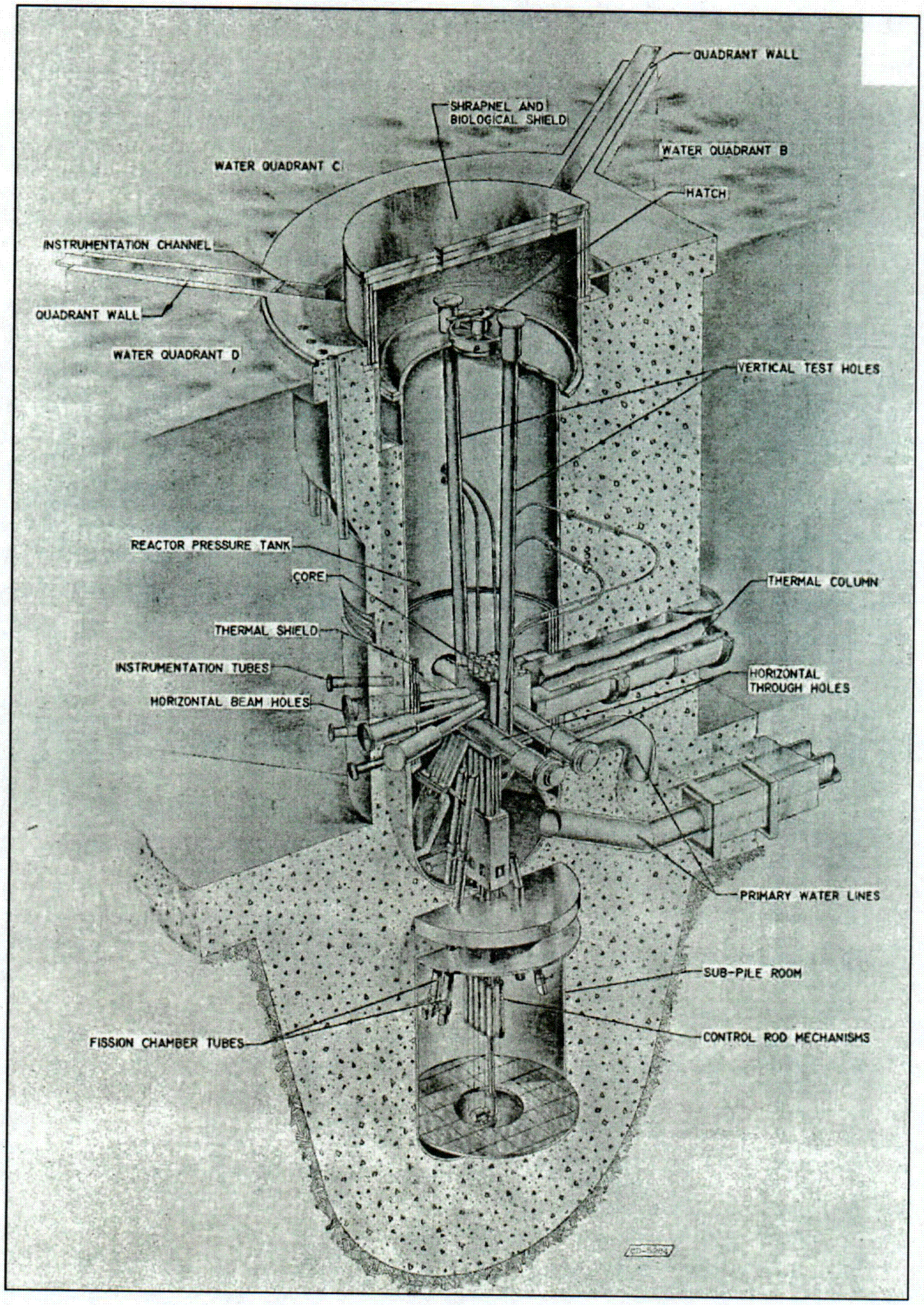

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FIGURE 27. CUT-AWAY PERSPECTIVE OF REACTOR TANK ASSEMBLY

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C20

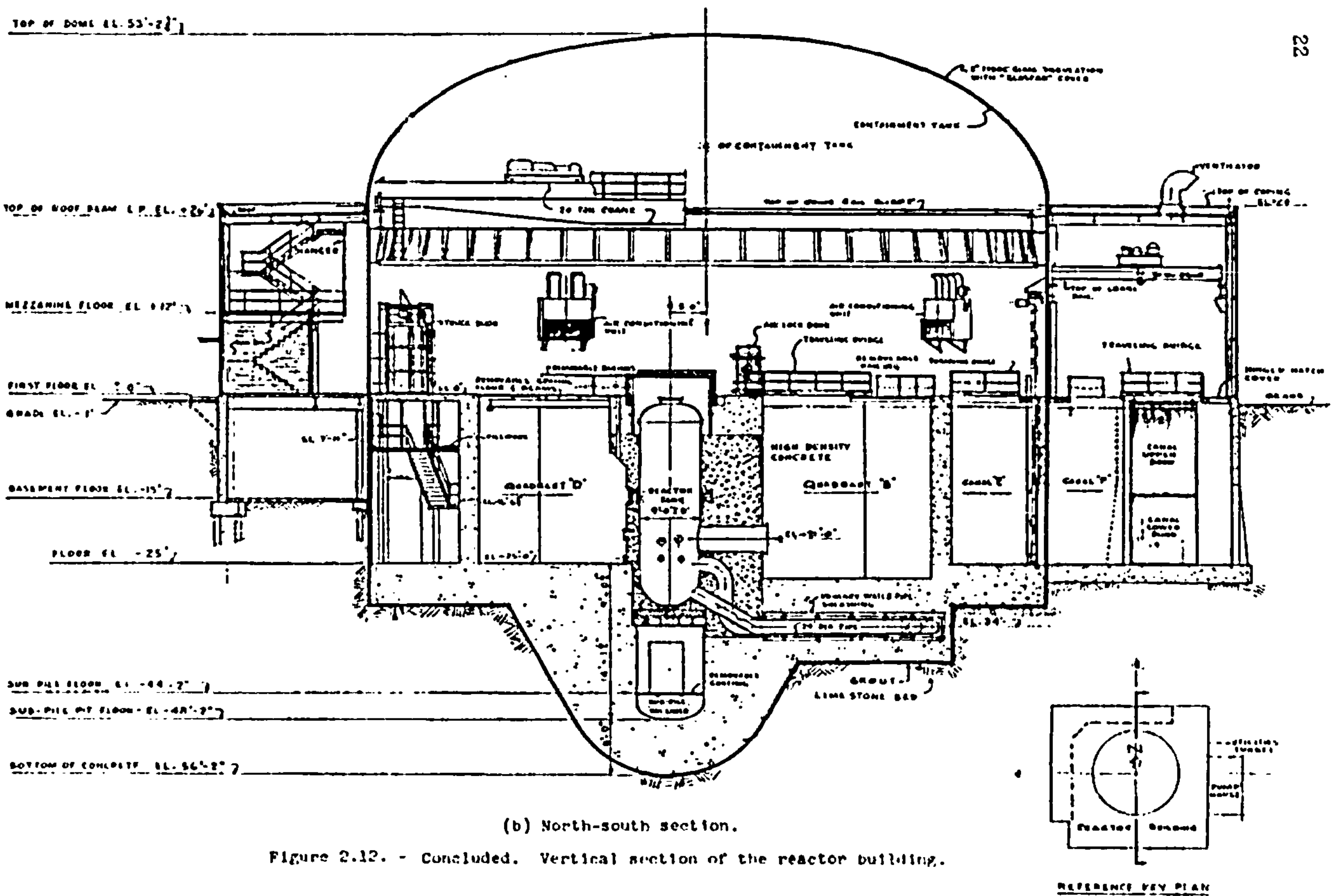

Figure 2.12. - Concluded. Vertical section of the reactor building.

22

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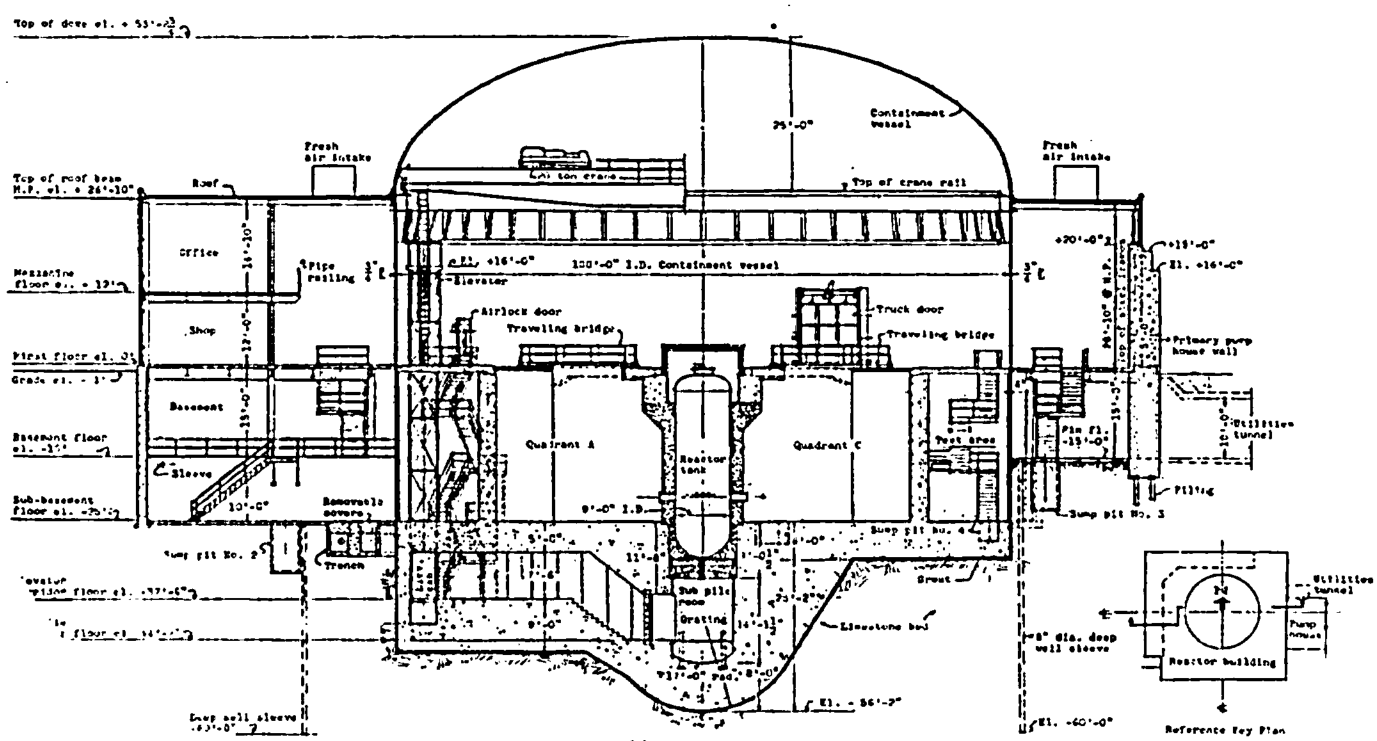
FIGURE 28. NORTH-SOUTH CROSS SECTION THROUGH REACTOR FACILITY

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO



(a) East-west section.

Figure 2.17. - Vertical section of the reactor building.

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FIGURE 29. EAST-WEST CROSS SECTION THROUGH REACTOR FACILITY

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

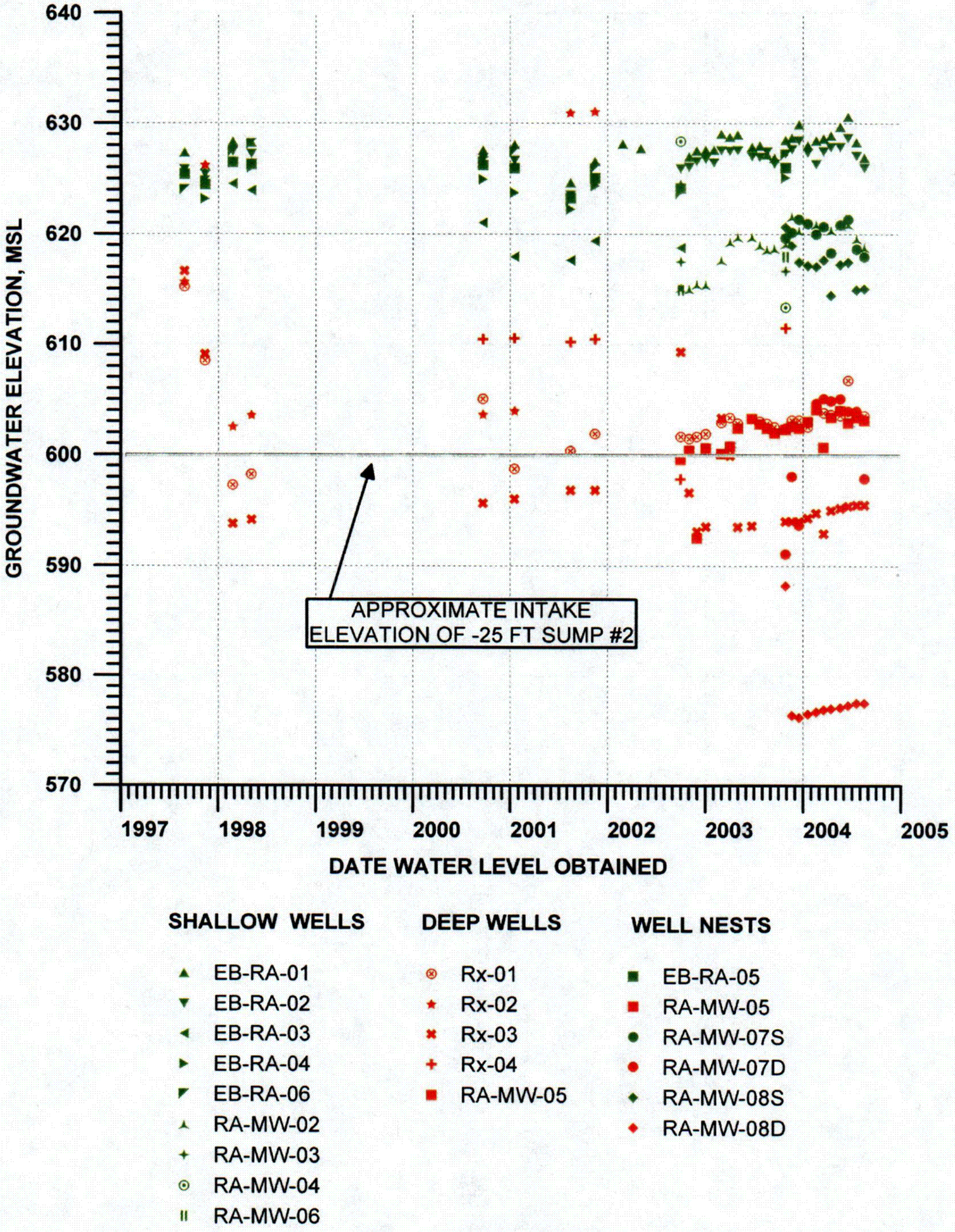

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FIGURE 30. 1997 – 2004 WATER LEVELS IN PBRF MONITORING WELLS

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C21

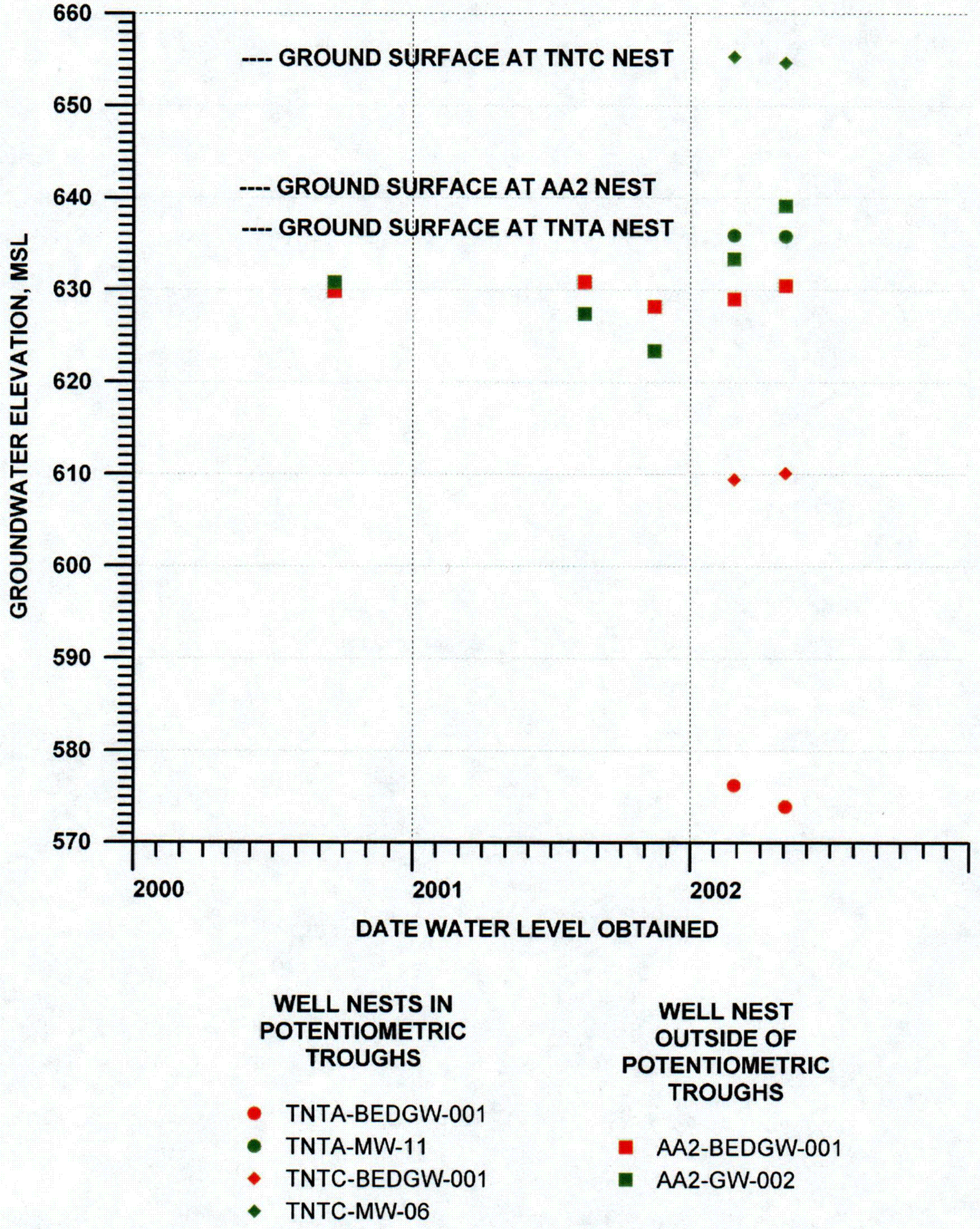

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FIGURE 31. 2000 – 2002 WATER LEVELS IN SELECTED WELL NESTS

PLUM BROOK REACTOR FACILITY
SANDUSKY, OHIO

C22

TABLES

Table 1
Engineering and Physical Properties of Soil Types that Occur Adjacent to PBRF

Map Symbol and Soil Name	Depth, inches	USDA Texture	USCS	Liquid Limit (%)	Plasticity Index	Sand (%)	Silt (%)	Clay (%)	Moist Bulk Density (g/cc)	Permeability, minimum and maximum						Available Water Capacity
										in/hr, min.	in/hr, max.	cm/sec, min.	cm/sec, max.	m/yr, min.	m/yr, max.	
CmA: Colwood	0-11	Loam	CL CL-ML ML	15 - 35	2 - 12			7 - 26	1.3 - 1.6	0.60	2.00	4.E-04	1.E-03	134	445	0.2 - 0.24
	11-53	Silt Loam Loam Silty Clay Loam	CL	25 - 45	8 - 20	15 - 40	30 - 55	18 - 35	1.3 - 1.6	0.20	0.60	1.E-04	4.E-04	45	134	0.17 - 0.22
	53-80	Stratified Loamy Sand To Silt Loam	CL ML SC SM	15 - 25	NP - 10			0 - 12	1.45 - 1.65	0.60	2.00	4.E-04	1.E-03	134	445	0.08 - 0.22
EnA: Elnora	0-10	Loamy fine sand	ML SM	0-14	NP-4			2 - 10	1.20 - 1.50	2.00	6.00	1.E-03	4.E-03	445	1335	0.08 - 0.16
	10-31	Loamy fine sand Fine sand	SM	0-14	NP-4	75-90	5-20	2 - 5	1.20 - 1.50	6.00	20.00	4.E-03	1.E-02	1335	4450	0.06 - 0.10
	31-80	Loamy fine sand Fine sand	SM	0-14	NP-4	85-97	1-10	2 - 5	1.45 - 1.65	6.00	20.00	4.E-03	1.E-02	1335	4450	0.03 - 0.06
GdA: Gilford	0-12	Fine sandy loam	SC SC-SM SM	15-30	4-10			10 - 20	1.50 - 1.70	2.00	6.00	1.E-03	4.E-03	445	1335	0.16 - 0.18
	12-32	Fine sandy loam Sandy Loam	SC SC-SM SM	10-25	NP-8			8 - 17	1.60 - 1.70	2.00	6.00	1.E-03	4.E-03	445	1335	0.12 - 0.14
	32-44	Loamy Sand Loamy fine sand Sand	SM SP SP-SM	0-14	NP-4	80-90	5-15	3 - 12	1.60 - 1.80	6.00	20.00	4.E-03	1.E-02	1335	4450	0.04 - 0.11
	44-80	Loamy fine sand Fine sand Sand	SM SP SP-SM	0-14	NP-4	85-95	1-15	2 - 10	1.65 - 1.80	6.00	20.00	4.E-03	1.E-02	1335	4450	0.03 - 0.11
OaB: Oakville	0-9	Loamy Fine Sand	SM	0-14	NP-4			2 - 14	1.30 - 1.55	6.00	20.00	4.E-03	1.E-02	1335	4450	0.09 - 0.12
	9-26	Loamy Fine Sand Fine Sand	SM SP-SM	0-14	NP-4	90-95		0 - 10	1.30 - 1.65	6.00	20.00	4.E-03	1.E-02	1335	4450	0.06 - 0.10
	26-80	Fine Sand Sand Loamy Fine Sand	SM SP-SM	0-14	NP-4	78-95	5-20	0 - 10	1.40 - 1.65	6.00	20.00	4.E-03	1.E-02	1335	4450	0.05 - 0.07

Table 2
In-situ Hydraulic Conductivity Tests at PBS

Well ID	Data Source	Formation Screened	Notes*	Hydraulic Conductivity, k, ft/min*	Hydraulic Conductivity, k, cm/sec	Average k for well, cm/sec	Hydraulic Conductivity, k, m/yr	Averge k per formation, m/yr
IT-AA1-GW-002	IT, 1999	mixed unconsolidated deposits	Aquifer Test	5.E-04	3.E-04	2.E-04	49	152
IT-AA1-GW-002	IT, 1999		AQTESOLVE	1.E-04	5.E-05			
IT-AA3-GW-002	IT, 1999		Aquifer Test	3.E-03	1.E-03	9.E-04	270	
IT-AA3-GW-002	IT, 1999		AQTESOLVE	5.E-04	2.E-04			
IT-MW-06	IT, 1990		test 1		9.E-05	9.E-05	28	
IT-MW-08	IT, 1997		test 1	9.E-04	5.E-04	8.E-04	262	
IT-MW-08	IT, 1997		test 2	2.E-03	1.E-03			
IT-MW-08	IT, 1997		test 3	2.E-03	1.E-03			
IT-ABG-GW-002	IT, 1999	fine silty sand	Aquifer Test	2.E-01	8.E-02	2.E-01	60,877	60,877
IT-ABG-GW-002	IT, 1999		AQTESOLVE	6.E-01	3.E-01			
IT-TNTB-BEDGW-002	IT, 1999	Ohio Shale	Aquifer Test	4.E-05	2.E-05	3.E-05	8	8
IT-TNTB-BEDGW-002	IT, 1999		AQTESOLVE	6.E-05	3.E-05			
IT-ABG-BEDGW-001	IT, 1999	Olentangy Shale	Aquifer Test	2.E-02	8.E-03	7.E-03	2,323	758
IT-ABG-BEDGW-001	IT, 1999		AQTESOLVE	1.E-02	7.E-03			
IT-BG8-BEDGW-001	IT, 1999		Aquifer Test	2.E-04	1.E-04	2.E-04	54	
IT-BG8-BEDGW-001	IT, 1999		AQTESOLVE	4.E-04	2.E-04			
IT-TNTB-BEDGW-001	IT, 1999		Aquifer Test	1.E-02	6.E-03	4.E-03	1,218	
IT-TNTB-BEDGW-001	IT, 1999		AQTESOLVE	3.E-03	2.E-03			
TNTB-BEDGW-003	IT, 2001		falling	2.E-06	9.E-07	9.E-07	0.27	
TNTB-BEDGW-004	IT, 2001		falling	2.E-03	8.E-04	1.E-03	380	
TNTB-BEDGW-004	IT, 2001		rising	3.E-03	2.E-03			
IT-PB-BED-MW25	IT, 2001		falling	4.E-03	2.E-03	2.E-03	572	
IT-PB-BED-MW25	IT, 2001		rising	3.E-03	2.E-03			
IT-AA1-BEDGW-001	IT, 1999	Delaware Limestone	Aquifer Test	5.E-05	3.E-05	4.E-05	12	39
IT-AA1-BEDGW-001	IT, 1999		AQTESOLVE	1.E-04	5.E-05			
IT-AA2-BEDGW-001	IT, 1999		Aquifer Test	2.E-05	1.E-05	1.E-05	3	
IT-AA2-BEDGW-001	IT, 1999		AQTESOLVE	2.E-05	9.E-06			
IT-AA3-BEDGW-001	IT, 1999		Aquifer Test	3.E-04	1.E-04	1.E-04	39	
IT-AA3-BEDGW-001	IT, 1999		AQTESOLVE	2.E-04	1.E-04			
IT-MNTA-BEDGW-	IT, 1999		Aquifer Test	2.E-05	1.E-05	1.E-05	3	
IT-MNTA-BEDGW-	IT, 1999		AQTESOLVE	2.E-05	9.E-06			
IT-PB-BED-MW22	IT, 2001		rising	2.E-04	9.E-05	9.E-05	29	
IT-PB-BED-MW23	IT, 2001		rising	5.E-05	2.E-05	2.E-05	7	
IT-PB-BED-MW24	IT, 2001		falling	1.E-03	5.E-04	6.E-04	188	
IT-PB-BED-MW24	IT, 2001		rising	1.E-03	7.E-04			
TNTC-BEDGW-001	IT, 2001		falling	2.E-04	1.E-04	9.E-05	27	
TNTC-BEDGW-001	IT, 2001		rising	1.E-04	7.E-05			

*Some of the test results were reported more than once in a given report, For example, some wells were tested with both falling head and rising head tests. Other wells were tested once, but two analysis were performed using different software. All results are reported here, and multiple results are averaged to represent that well.

Table 3
Groundwater Elevations at PBRF
Measured on Date Noted

Well Number	12/1/94	3/19/95	8/27/97	11/12/97	2/24/98	5/5/98	9/20/00	1/17/01	8/15/01
Unconsolidated Wells									
EB-RA-01			627.36	626.09	628.34	628.22	627.57	628.07	624.62
EB-RA-02			625.85	625.43	627.43	627.23	626.85	626.65	623.5
EB-RA-03					624.54	623.93	621.03	617.93	617.61
EB-RA-04			625.47	623.18	626.42	626.01	624.94	623.74	622.24
EB-RA-05			625.39	624.47	626.47	626.27	626.24	625.94	623.24
EB-RA-06			623.99	624.78	627.44	628.15	626.54	627.44	622.98
RA-MW-02									
RA-MW-03									
RA-MW-04									
RA-MW-06									
RA-07S									
RA-08S									
Bedrock Wells									
Reactor 1 - Rx01			615.19	608.45	597.26	598.21	605.01	598.71	600.31
Reactor 2 - Rx02	614.71	601.89	615.65	626.24	602.52	603.55	603.65	603.95	630.93
Reactor 3 - Rx03			616.61	609.04	593.76	594.13	595.61	596.01	596.78
Reactor 4 - Rx04							610.43	610.53	610.18
RA-MW-05									
RA-07D									
RA-08D									
vertical gradient calculation									
RA-07									
RA-08									

Table 3
Groundwater Elevations at PBRF
Measured on Date Noted

Well Number	11/15/01	2/27/02	5/5/02	10/2/02	11/2/02	12/1/02	1/3/03	2/3/03	3/3/03	4/3/03
Unconsolidated Wells										
EB-RA-01	626.55	628.12	627.72	624.48	626.98	627.52	627.59	627.58	629.03	628.77
EB-RA-02	624.45			625.91	626.04	626.55	626.76	626.45	627.54	627.50
EB-RA-03	619.36			618.76						
EB-RA-04	624.36			623.86						
EB-RA-05	625.05			624.15						
EB-RA-06	625.88			623.67						
RA-MW-02				615.12	614.97	615.41	615.37		617.61	619.28
RA-MW-03				617.47						
RA-MW-04				628.36						
RA-MW-06				614.92						
RA-07S										
RA-08S										
Bedrock Wells										
Reactor 1 - Rx01	601.87			601.62	601.42	601.62	601.86		602.90	603.36
Reactor 2 - Rx02	631.05									
Reactor 3 - Rx03	596.78			609.28	596.58	593.08	593.51		603.31	599.90
Reactor 4 - Rx04	610.43			597.80						
RA-MW-05				599.56	600.37	592.47	600.59		600.09	600.77
RA-07D										
RA-08D										
vertical gradient calculation										
RA-07										
RA-08										

Table 3
Groundwater Elevations at PBRF
Measured on Date Noted

Well Number	5/3/03	6/24/03	7/23/03	8/19/03	9/16/03	10/27/03	11/20/03	12/16/03	1/18/04	2/19/04
Unconsolidated Wells										
EB-RA-01	628.98	627.88	627.98	627.18	626.88	628.48	628.68	629.88	627.98	628.43
EB-RA-02	627.56	627.01	626.96	627.46	626.36	627.26	627.66	628.46	627.36	626.31
EB-RA-03						619.56				
EB-RA-04						625.10				
EB-RA-05						626.00				
EB-RA-06						627.17				
RA-MW-02	619.71	619.72	618.97	618.57	618.67	619.07	621.57	620.27		620.87
RA-MW-03						616.62				
RA-MW-04						613.36				
RA-MW-06						617.94				
RA-07S						619.63	620.13	621.33	620.93	619.98
RA-08S						620.62	618.92	617.42	617.12	617.02
Bedrock Wells										
Reactor 1 - Rx01	602.84	603.26	603.02	602.82	602.52	602.42	603.12	603.12	602.52	604.12
Reactor 2 - Rx02										
Reactor 3 - Rx03	593.48	593.58				593.98	593.98	593.98	594.28	594.73
Reactor 4 - Rx04						611.45				
RA-MW-05	602.38	603.27	602.77	602.37	601.97	602.27	602.57	602.37	602.97	604.07
RA-07D						591.04	598.04	593.64	602.94	604.64
RA-08D						588.16	576.36	576.16	576.46	576.66
vertical gradient calculation										
RA-07						0.908	0.701	0.879	0.571	0.487
RA-08						0.984	1.290	1.250	1.232	1.223

Table 3
Groundwater Elevations at PBRF
Measured on Date Noted

Well Number	3/17/04	4/14/04	5/19/04	6/17/04	7/19/04	8/17/04
Unconsolidated Wells						
EB-RA-01	628.62	628.88	629.68	630.58	628.28	626.88
EB-RA-02	627.46	627.86	627.86	628.66	627.06	625.96
EB-RA-03						
EB-RA-04						
EB-RA-05						
EB-RA-06						
RA-MW-02	620.77	620.32	620.77	620.87	619.57	618.77
RA-MW-03						
RA-MW-04						
RA-MW-06						
RA-07S	620.67	618.28	620.83	621.33	618.63	617.93
RA-08S	617.62	614.42	617.22	617.42	614.92	615.02
Bedrock Wells						
Reactor 1 - Rx01	603.77	603.62	603.52	606.72	603.42	603.52
Reactor 2 - Rx02						
Reactor 3 - Rx03	592.88	594.98	595.18	595.38	595.48	595.48
Reactor 4 - Rx04						
RA-MW-05	600.67	603.37	603.97	602.87	603.37	603.07
RA-07D	605.06	604.84	605.04	603.94	603.94	597.84
RA-08D	576.86	576.96	577.06	577.26	577.46	577.46
vertical gradient calculation						
RA-07	0.496	0.427	0.501	0.552	0.466	0.638
RA-08	1.235	1.135	1.217	1.217	1.135	1.138

PHOTOGRAPHS

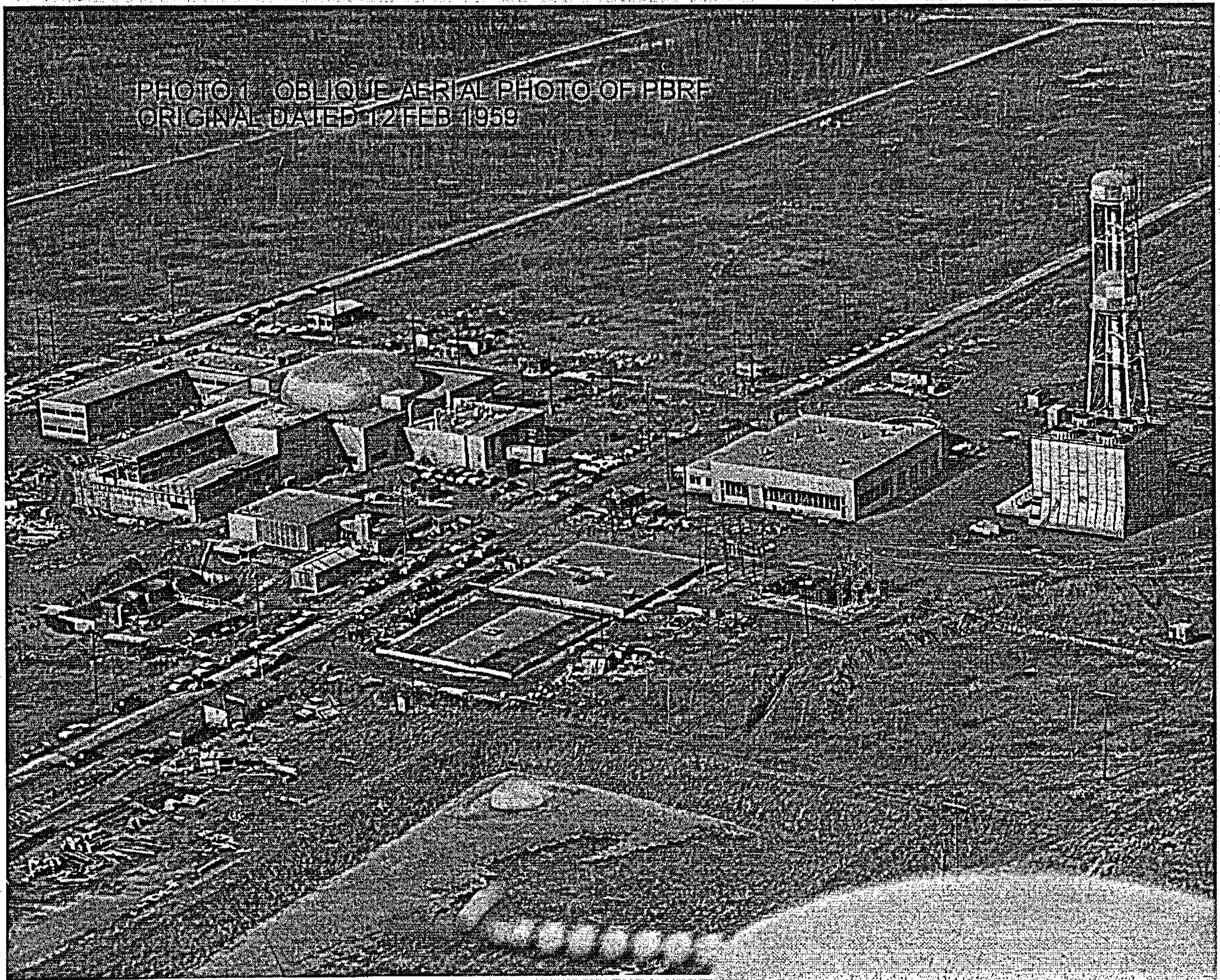
PHOTO 1. OBLIQUE AERIAL PHOTO OF PBRF
ORIGINAL DATED 12 FEB 1959

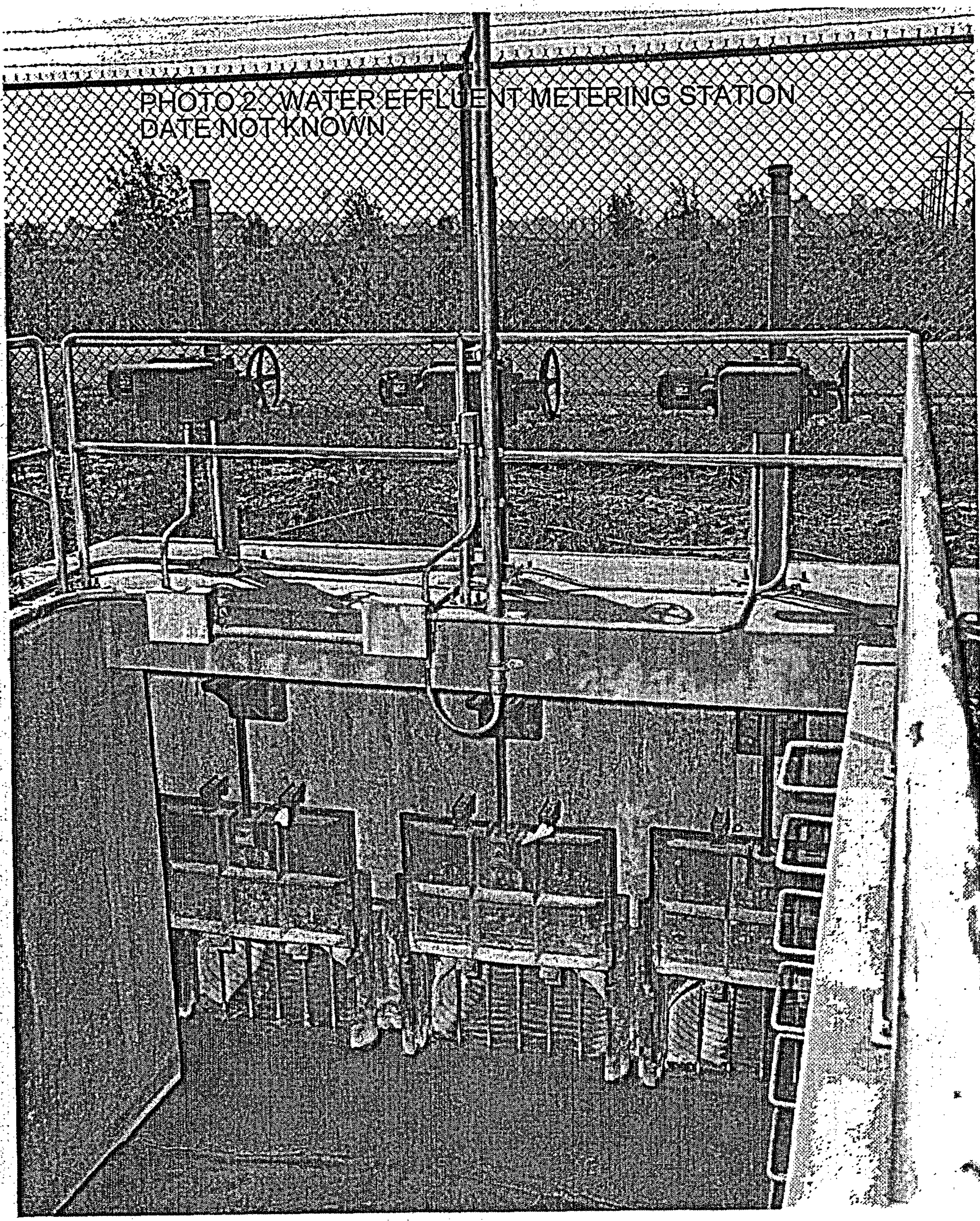

PHOTO 2. WATER EFFLUENT METERING STATION
DATE NOT KNOWN


PHOTO 3. ROCK EXCAVATION WITH BASE OF SUB-PILE ROOM IN PLACE
ORIGINAL DATED 24 APR 1957

PHOTO 4 OBLIQUE AERIAL PHOTO SHOWING CONSTRUCTION OF CRAs
ORIGINAL DATED 30 SEP 1958

PHOTO 5. EXCAVATION WITH HRA TANKS IN PLACE
ORIGINAL DATED 12 JAN 1959


PHOTO 6. EXCAVATION OF REACTOR BUILDING AREA
ORIGINAL DATED 28 FEB 1957

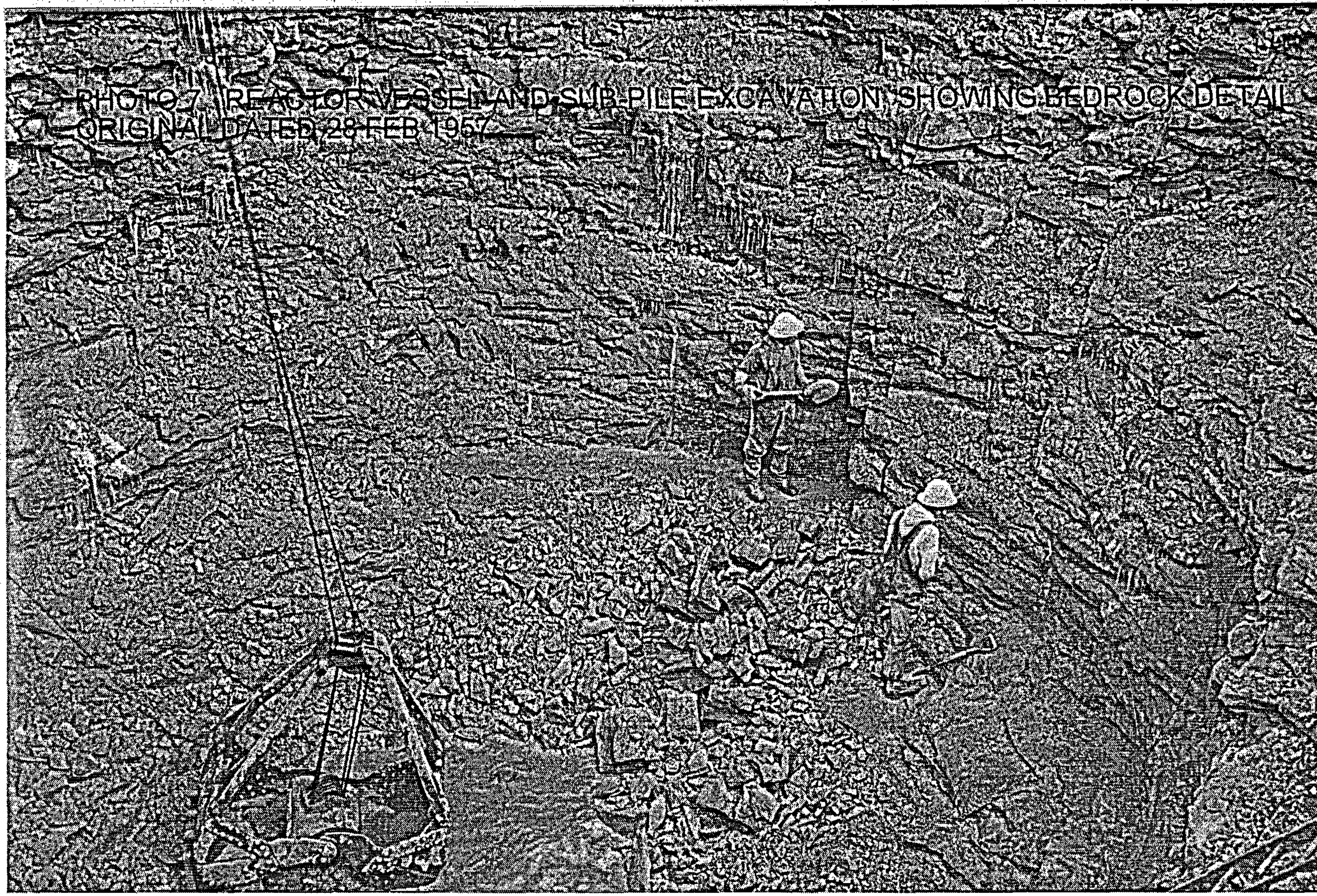

PHOTO 7. REACTOR VESSEL AND SUB-PILE EXCAVATION, SHOWING BEDROCK DETAIL
ORIGINAL DATED 28 FEB 1957

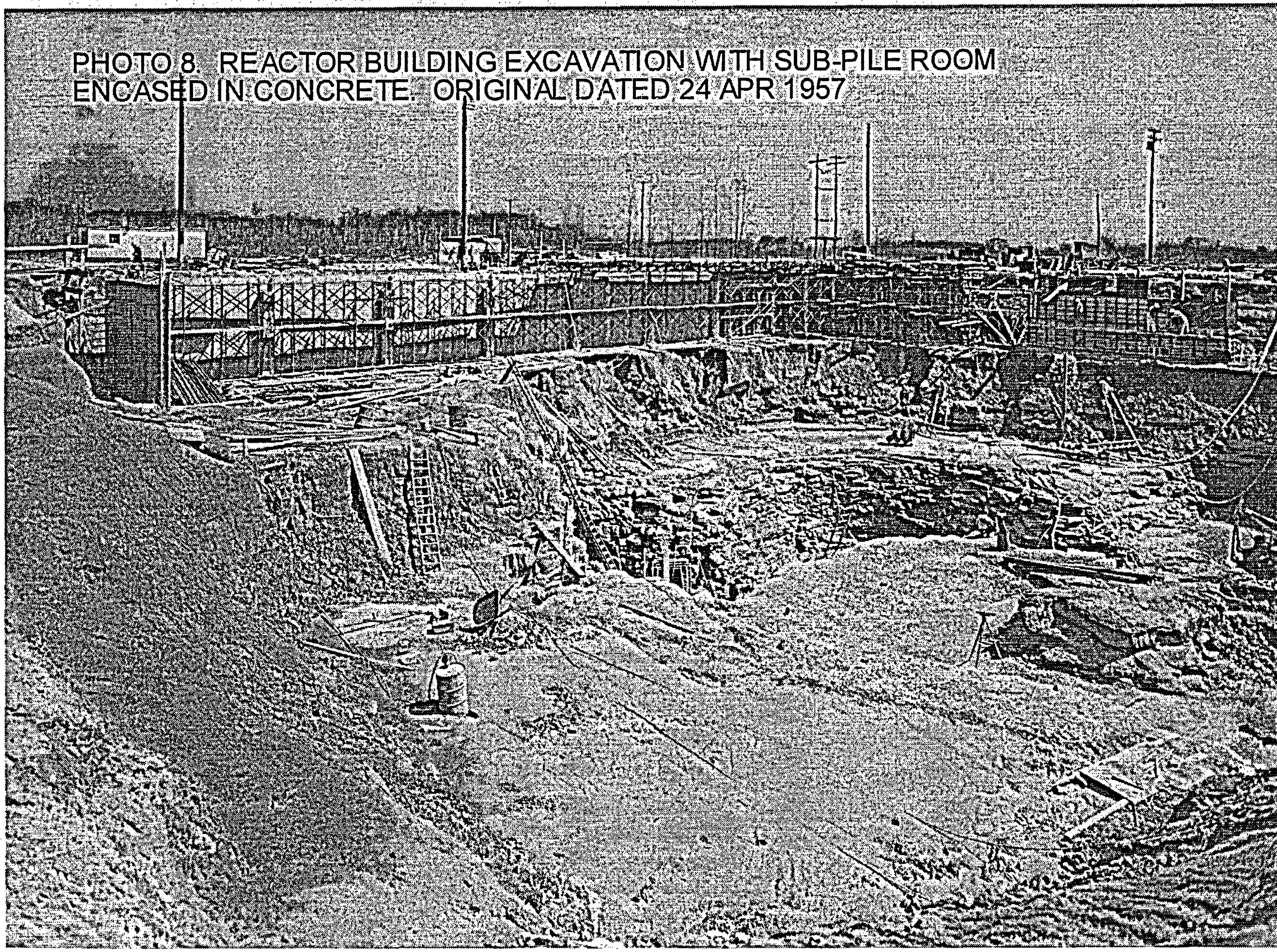
PHOTO 8. REACTOR BUILDING EXCAVATION WITH SUB-PILE ROOM
ENCASED IN CONCRETE. ORIGINAL DATED 24 APR 1957

APPENDICES

NASA PBRF Decommissioning Project Environmental Media Sampling and Analysis

Semi-Annual Report

November 2002 – April 2003

Peter C. Kolb, NASA
Sheryl A. Leeper, USACE

National Aeronautics and Space Administration

Glenn Research Center, Plum Brook Station
Plum Brook Reactor Facility

August 2003

Information Cutoff Date: 30 April 2003

Available from:

NASA Plum Brook Station
PBRF Decommissioning Project
6100 Columbus Avenue
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NASA PBRF Decommissioning Project Environmental Media Sampling and Analysis

Semi-Annual Report
November 2002 – April 2003

This semi-annual report shows the results for the sampling/reporting period November 2002 through April 2003 only, and is intended as a supplement to the *"NASA PBRF Decommissioning Project Environmental Media Sampling and Analysis Cumulative Report November 2000 – October 2002,"* published in March 2003. This semi-annual report does not go into detail about sampling methodology, derivation of project specific action limits, analytical requirements, quality control sampling, etc. Please reference the aforementioned cumulative report for that type information.

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EXECUTIVE SUMMARY

Analysis for the environmental media sampled during the reporting period shows no impacts attributable to current decommissioning operations at the Plum Brook Reactor Facility (PBRF). **It is important to note however, that no decommissioning activities have occurred during the reporting period that could contribute to any result above our Project Specific Action Limits (PSAL).** *The following is a synopsis of the sampling from* November 2002 *through* April 2003:

- Surface water and fenceline air filters results were below PSALs for the reporting period.
- Sediments results show above-PSAL gross alpha for all locations and three locations above-PSAL for gross beta. However, alpha and gamma spectroscopy revealed no PBRF-associated radionuclides (alpha: Plutonium, Americium, Curium; gamma: Strontium, Cesium). It is therefore ascertained that the above-PSAL results for sediments are attributed to either naturally occurring radioactive material (NORM) or other-than-PBRF sources.
- Groundwater well and sump results show below PSALs except for gross alpha at both RA-01 (upgradient) and MW-02 shallow wells. Alpha spectroscopy revealed no PBRF-associated radionuclides; results are attributable to other-than-PBRF sources. The above-PSAL gross alpha in October 2002 for RA-06 shallow well, did fall below the gross alpha PSAL for this reporting period.

Surface water and sediments are collected on a monthly basis. For groundwater: three shallow wells, one sump and three deep wells are sampled monthly; one sump quarterly; all others annually. Air samples are collected weekly.

When reviewing the tables and graphs, it is evident that individual results fluctuate month to month. Fluctuations are an expected occurrence particularly given seasonal variations within the environment, physical sampling differences, analytical precision and accuracy, matrix interferences, background levels, and the like.

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TABLE OF CONTENTS

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1.0 SURFACE WATER AND SEDIMENT

1.1 SURFACE WATER SAMPLING RESULTS NOVEMBER 2002 - APRIL 2003

Tables 1 and 2 below, show the surface water gross alpha and gross beta sampling results for the reporting period.

Table 1. Surface Water Results for the Reporting Period: Gross Alpha

Date	STA 1 (pCi/L)	STA 2 (pCi/L)	STA 3 (pCi/L)	STA 4 (pCi/L)	STA 5 (pCi/L)	STA 9 (pCi/L)	Project Specific Action Limit (pCi/L)
NOV 2002	*DRY*	1.10	5.00	3.10	2.30	2.80	20.00
DEC 2002	*DRY*	1.60	5.00	6.40	3.30	4.30	20.00
JAN 2003	*ICE*	2.40	3.30	*ICE*	*ICE*	*ICE*	20.00
FEB 2003	*ICE*	*ICE*	1.50	*ICE*	*ICE*	*ICE*	20.00
MAR 2003	*DRY*	1.30	1.30	2.20	2.00	1.80	20.00
APR 2003	3.60	1.10	2.30	1.70	3.10	5.60	20.00
DRY : Insufficient or No Water for Sampling, Did Not Sample *ICE : Water Frozen, Did Not Sample*							

Table 2. Surface Water Results for the Reporting Period: Gross Beta

Date	STA 1 (pCi/L)	STA 2 (pCi/L)	STA 3 (pCi/L)	STA 4 (pCi/L)	STA 5 (pCi/L)	STA 9 (pCi/L)	Project Specific Action Limit (pCi/L)
NOV 2002	*DRY*	3.60	5.60	7.90	6.70	7.20	500.00
DEC 2002	*DRY*	5.20	9.20	9.50	8.50	7.50	500.00
JAN 2003	*ICE*	5.90	7.50	*ICE*	*ICE*	*ICE*	500.00
FEB 2003	*ICE*	*ICE*	8.50	*ICE*	*ICE*	*ICE*	500.00
MAR 2003	*DRY*	2.90	3.40	4.10	4.40	3.30	500.00
APR 2003	2.10	2.40	5.00	2.00	3.70	6.00	500.00
DRY : Insufficient or No Water for Sampling, Did Not Sample *ICE : Water Frozen, Did Not Sample*							

1.1.1 SURFACE WATER ANALYSIS

All surface water samples for the reporting period were below the Project Specific Action Limit (PSAL) for gross alpha and gross beta. Figure 1 and Figure 2 show the results as a graph. Please note that gaps in the graph (data gaps) are a result of dry periods when surface water is not present at a particular sampling station or the presence of ice when samples cannot be collected.

Looking at the gross alpha and gross beta graphs a general trend, with similar slopes, is evident in both over the same time period. With the exception of Station 3, all start low in November 2002 and then trend upwards in December 2002. This repeats itself in March 2003 and April 2003 (starting low and ending upwards). The general trend at Station 3 is downward over the sampling period for both gross alpha and gross beta.

No such trend was evident for gross alpha and gross beta in November and December 2001 and March and April 2002.

Figure 1. Surface Water Results for the Reporting Period: Gross Alpha

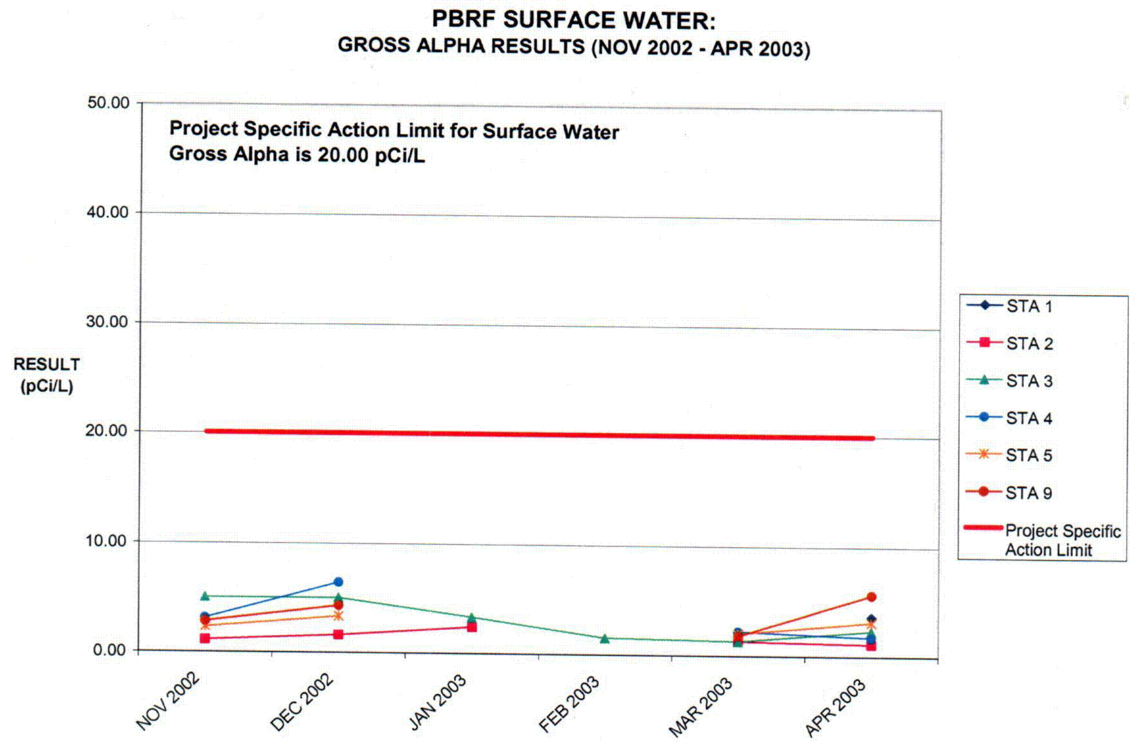
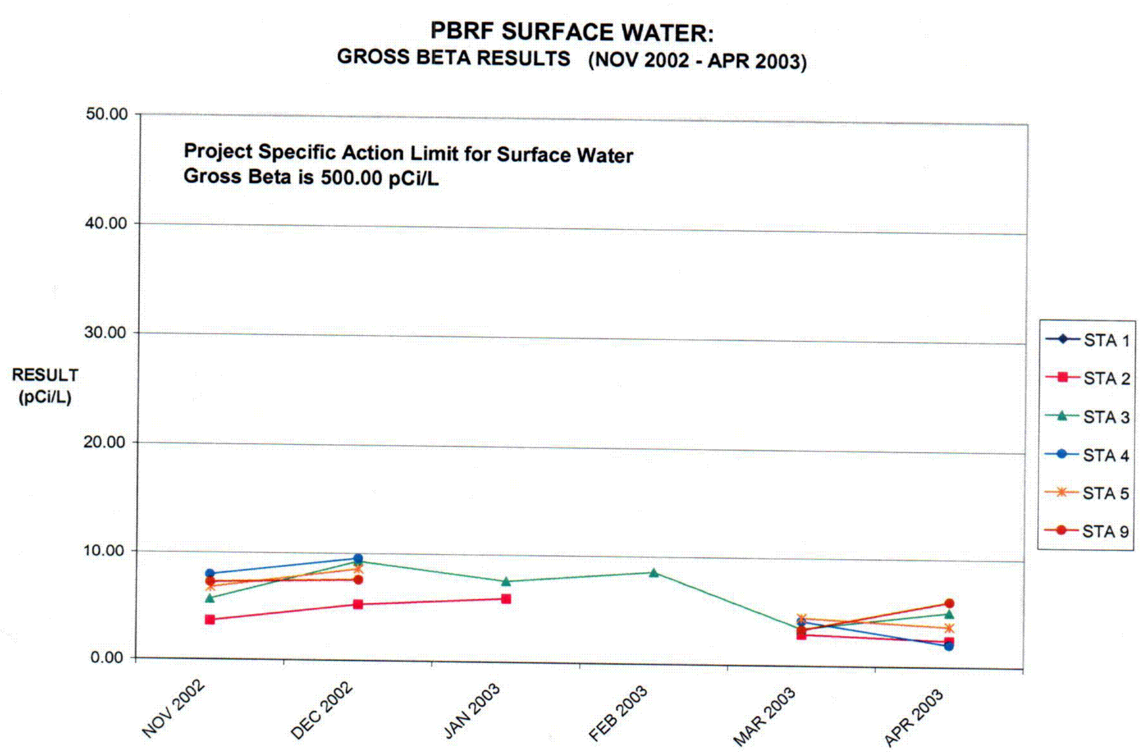


Figure 2. Surface Water Results for the Reporting Period: Gross Beta



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1.2 SEDIMENT SAMPLING RESULTS NOVEMBER 2002 - APRIL 2003

Tables 3 and 4 below, show the sediment gross alpha and gross beta sampling results for the reporting period.

Table 3. Sediment Results for the Reporting Period: Gross Alpha

Date	STA 1 (pCi/g)	STA 2 (pCi/g)	STA 3 (pCi/g)	STA 4 (pCi/g	STA 5 (pCi/g)	STA 9 (pCi/g)	Project Specific Action Limit (pCi/g)
NOV 2002	34.50	23.30	33.30	26.60	17.30	49.00	25.00
DEC 2002	30.70	16.20	41.80	29.60	34.20	14.50	25.00
JAN 2003	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	25.00
FEB 2003	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	25.00
MAR 2003	31.00	27.90	30.10	24.10	36.20	32.70	25.00
APR 2003	26.10	24.90	20.20	21.00	43.00	25.70	25.00
ICE : Water / Ground Frozen, Did Not Sample							

Table 4. Sediment Results for the Reporting Period: Gross Beta

Date	STA 1 (pCi/g)	STA 2 (pCi/g)	STA 3 (pCi/g)	STA 4 (pCi/g)	STA 5 (pCi/g)	STA 9 (pCi/g)	Project Specific Action Limit (pCi/g)
NOV 2002	32.20	90.00	41.10	42.50	21.40	48.30	45.00
DEC 2002	28.30	47.50	43.40	36.60	36.20	23.90	45.00
JAN 2003	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	45.00
FEB 2003	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	45.00
MAR 2003	33.60	56.80	41.90	35.40	38.20	30.00	45.00
APR 2003	37.00	138.00	51.00	43.00	47.00	32.30	45.00
ICE : Water / Ground Frozen, Did Not Sample							

1.2.1 SEDIMENT ANALYSIS

70% of the sediment samples for the reporting period were at or above the PSAL for gross alpha, while only 25% were above the PSAL for gross beta.

Stations 3, 5, and 9 trend up in both gross alpha and gross beta during November 2002 and December 2002, while Station 2 trended down in both gross alpha and gross beta during the same time period. (Station 9 is not in the same watershed and could not be impacted by PBRF operations). Station 5 is the only location trending up for gross alpha in March 2003 and April 2003; all others trend down for gross alpha. All stations trend upward for gross beta during the same time period. *(No such trends were evident for gross alpha and gross beta in November and December 2001 and March and April 2002 (same time periods the previous year), however all stations were trending upward (some going past the PSAL) in September and October 2001.)*

Since no decommissioning activities have occurred during the reporting period that could contribute to any results above Project Specific Action Limits, the unusual trends appear to be the result of seasonal variations when metals accumulate in the sediments, during dry weather conditions, and are more readily detected. Alpha and gamma spectroscopy revealed no PBRF-associated radionuclides (alpha: Plutonium, Americium, Curium; gamma: Strontium, Cesium), therefore the above-PSAL results for sediments should be attributed to other-than-PBRF sources.

Figure 3 and Figure 4 show the above results as a graph. Please note that gaps in the graph (data gaps) are due to the presence of ice when samples could not be collected.

Figure 3. Sediment Results for the Reporting Period: Gross Alpha

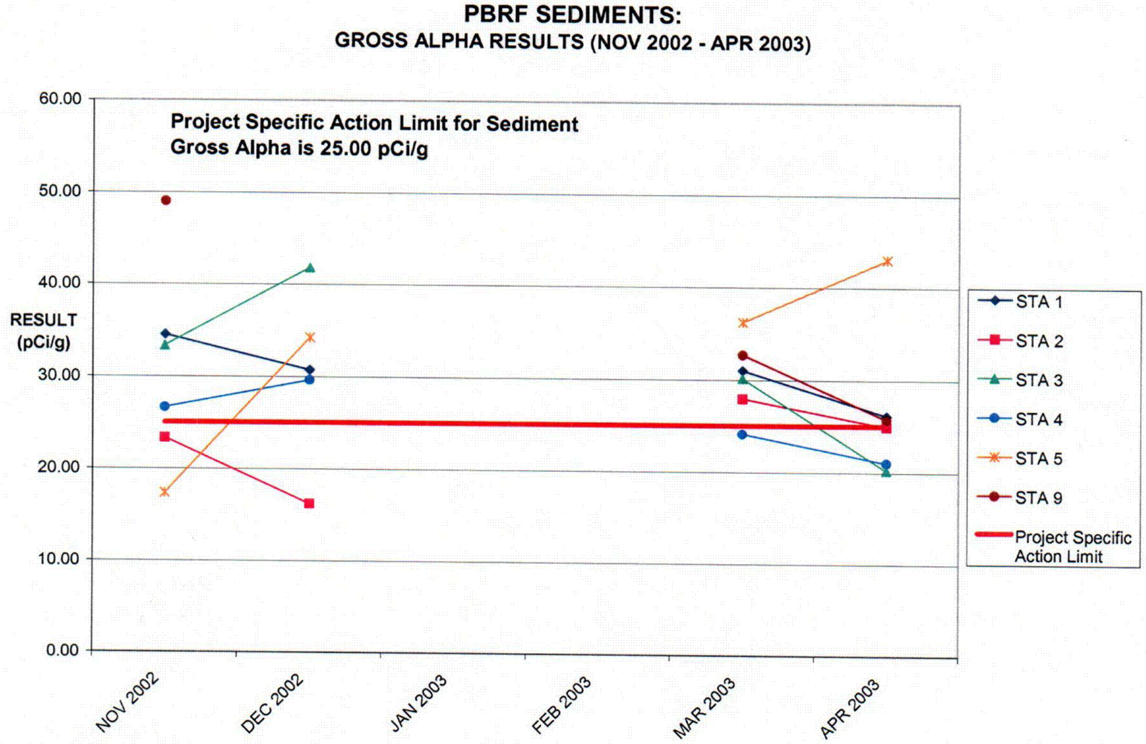
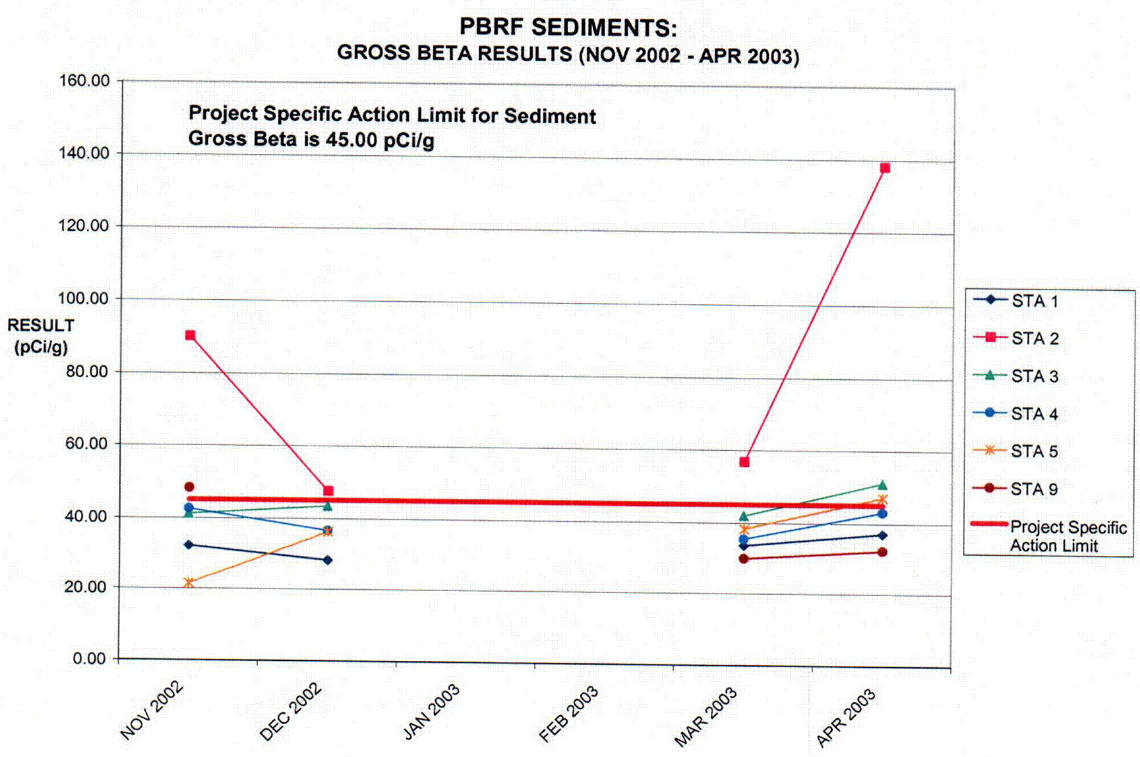


Figure 4. Sediment Results for the Reporting Period: Gross Beta



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2.0 GOUNDWATER WELLS AND SUMPS

2.1 GROUNDWATER SAMPLING RESULTS NOVEMBER 2002 - APRIL 2003

Tables 5 and 6 below, show the groundwater gross alpha and gross beta sampling results for the reporting period.

Please note that data gaps in the table are the result of ice at the well and no samples could be taken.

Table 5. Groundwater Results for the Reporting Period: Gross Alpha

Well/Sump ID	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	PSAL (pCi/L)
SHALLOW (UNCONSOLIDATED) WELLS (pCi/L)							
RA-01	4.20	14.50	12.50	4.50 U	15.00 U	18.00	15.00
RA-02	10.70	8.80	3.70	4.20	1.60 U	6.00	15.00
MW-02	16.20	21.50	2.42	*ICE*	4.50 U	7.20 U	15.00
RA-03							15.00
RA-04							15.00
RA-05							15.00
RA-06	*SAMPLED ANNUALLY*					13.40 **	15.00
MW-03							15.00
MW-04							15.00
MW-06							15.00
BUILDING SUMPS (pCi/L)							
Rx25	5.20 U	2.10 U	1.10	1.70	4.80 U	4.90 U	15.00
HRA25			1.80				15.00
SEB15	*SAMPLED ANNUALLY*						15.00
Rx15							15.00
DEEP (BEDROCK) WELLS (pCi/L)							
Rx01	4.60 U	3.50	*ICE*	*ICE*	3.10	3.10 U	15.00
Rx03	0.80 U	*ICE*	*ICE*	*ICE*	2.20 U	1.30 U	15.00
MW-05	5.20 U	*ICE*	*ICE*	*ICE*	8.80	7.00 U	15.00
Rx02							15.00
Rx04	*SAMPLED ANNUALLY*						15.00

ICE : Water / Ground Frozen at Well, No Sample Taken
*** : Sampled due to OCT 2002 Reading Above Project Specific Action Level for Gross Alpha*
U: Not Detected at or Above Minimum Detection Limit of Instrument

Table 6. Groundwater Results for the Reporting Period: Gross Beta

Well/Sump ID	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	PSAL (pCi/L)
SHALLOW (UNCONSOLIDATED) WELLS (pCi/L)							
RA-01	41.00	13.60	12.40	3.50 U	16.00 U	6.40 U	500.00
RA-02	84.00	39.00	4.10	209.00	41.00	92.00	500.00
MW-02	227.00	127.00	50.00	*ICE*	3.60 U	7.80	500.00
RA-03							500.00
RA-04							500.00
RA-05							500.00
RA-06	*SAMPLED ANNUALLY*					17.70 **	500.00
MW-03							500.00
MW-04							500.00
MW-06							500.00
BUILDING SUMPS (pCi/L)							
Rx25	1.90 U	3.50 J	6.10	3.50	5.00 U	18.60	500.00
HRA25			16.60				500.00
SEB15	*SAMPLED ANNUALLY*						500.00
Rx15							500.00
DEEP (BEDROCK) WELLS (pCi/L)							
Rx01	6.20	6.10	*ICE*	*ICE*	2.60 J	6.40	500.00
Rx03	14.90	*ICE*	*ICE*	*ICE*	4.70	6.50	500.00
MW-05	1.90 U	*ICE*	*ICE*	*ICE*	6.00	63.00	500.00
Rx02							500.00
Rx04	*SAMPLED ANNUALLY*						500.00

ICE* : *Water / Ground Frozen at Well, No Sample Taken
***** : Sampled due to OCT 2002 Reading Above Project Specific Action Level for Gross Alpha***
U : Not Detected at or Above Minimum Detection Limit of Instrument
J: Less Than Minimum Detection Limit of Instrument

2.1.1 GROUNDWATER ANALYSIS

Shallow well MW-02 is above the PSAL for gross alpha in November 2002 and December 2002 while upgradient, shallow well RA-01 is at the PSAL in March 2003 and above in April 2003.

Alpha spectroscopy of samples for MW-02 revealed no PBRF-associated radionuclides (Plutonium, Americium, Curium;), therefore the above-PSAL results for sediments should be attributed to either naturally occurring radioactive material (NORM), or other-than-PBRF sources.

(RA-01 was chosen because of its upgradient location and therefore is used to monitor NORM attributable to this area's "background" groundwater. Basically, results from the PBRF groundwater monitoring wells inside the fenceline can be reduced by the amount of "background" NORM results from those samples taken at RA-01 and other such upgradient locations).

All other wells and sumps were below the PSAL for both gross alpha and gross beta.
The shallow well RA-06 is sampled annually, in October. It was sampled again in April 2003 because the sample result during October 2002 was above our PSAL for gross alpha. As evidenced in Table 5, results are below the PSAL.

3.0 FENCE LINE AIR FILTER

3.1 AIR SAMPLING RESULTS NOVEMBER 2002 - APRIL 2003

Tables 7 and 8 below, show the air gross alpha and gross beta sampling results for the reporting period.

Tables 9 through 14 show the composite metals results for the reporting period.

Table 7. Air Filter Results for the Reporting Period: Gross Alpha

Month	STA 1 (µCi/mL)	STA 2 (µCi/mL)	STA 3 (µCi/mL)	STA 4 (µCi/mL)	STA 5 (µCi/mL)	STA 6 (µCi/mL)	PSAL (µCi/mL)
NOV 2002	6.20E-15	6.20E-15	6.20E-15	6.60E-15	7.20E-15	7.00E-15	5E-14
	9.90E-15	8.50E-15	9.10E-15	9.30E-15	8.70E-15	9.60E-15	5E-14
	3.36E-15	3.60E-15	4.00E-15	3.84E-15	3.45E-15	3.22E-15	5E-14
	3.19E-15	4.00E-15	4.70E-15	3.62E-15	3.90E-15	4.40E-15	5E-14
DEC 2002	7.40E-15	6.40E-15	6.70E-15	7.60E-15	7.40E-15	6.30E-15	5E-14
	9.70E-15	9.80E-15	1.11E-14	1.03E-14	8.90E-15	1.02E-14	5E-14
	1.10E-14	1.10E-14	9.80E-15	1.14E-14	9.50E-15	1.02E-14	5E-14
	9.20E-15	9.50E-15	8.10E-15	8.90E-15	8.80E-15	7.40E-15	5E-14
JAN 2003	9.80E-15	1.06E-14	9.90E-15	1.01E-14	1.00E-15	8.30E-16	5E-14
	3.72E-15	4.00E-15	3.78E-15	5.50E-16	5.20E-16	5.10E-16	5E-14
	6.60E-15	6.60E-15	5.50E-15	6.30E-16	4.70E-16	5.90E-16	5E-14
	6.80E-15	7.10E-15	5.70E-15	5.80E-16	5.80E-16	6.10E-16	5E-14
	4.20E-15	5.20E-15	5.70E-15	5.90E-16	5.50E-16	5.80E-16	5E-14
FEB 2003	6.00E-16	5.60E-16	6.30E-16	7.60E-16	7.40E-16	6.30E-16	5E-14
	4.40E-16	6.00E-16	5.00E-16	5.00E-16	4.00E-16	4.80E-16	5E-14
	3.55E-16	2.72E-16	3.63E-16	3.59E-16	3.67E-16	3.90E-16	5E-14
	4.60E-16	3.80E-16	4.30E-16	4.20E-16	3.41E-16	4.00E-16	5E-14
MAR 2003	1.03E-14	N.S.	9.10E-15	1.02E-14	1.06E-14	1.02E-14	5E-14
	1.00E-14	8.50E-15	9.00E-15	9.30E-15	7.80E-15	9.10E-15	5E-14
	7.50E-15	6.80E-15	6.50E-15	6.30E-15	7.10E-15	6.20E-15	5E-14
	6.00E-15	6.60E-15	6.70E-15	5.10E-15	5.50E-15	6.20E-15	5E-14
APR 2003	5.30E-15	5.10E-15	5.60E-15	5.40E-15	5.00E-15	4.30E-15	5E-14
	4.50E-15	4.60E-15	4.30E-15	4.00E-15	4.20E-15	4.80E-15	5E-14
	4.40E-15	4.20E-15	5.20E-15	5.70E-15	4.80E-15	4.40E-15	5E-14
	3.72E-15	3.80E-15	4.00E-15	3.70E-15	3.31E-15	4.60E-15	5E-14
	3.70E-15	4.00E-15	3.41E-15	2.97E-15	3.70E-15	4.90E-15	5E-14

N.S. No Sample Taken, Pump Found In Off Position

Table 8. Air Filter Results for the Reporting Period: Gross Beta

Month	STA 1 (µCi/mL)	STA 2 (µCi/mL)	STA 3 (µCi/mL)	STA 4 (µCi/mL)	STA 5 (µCi/mL)	STA 6 (µCi/mL)	PSAL (µCi/mL)
NOV 2002	2.62E-14	2.79E-14	2.64E-14	2.71E-14	2.78E-14	2.71E-14	2E-12
	4.95E-14	4.73E-14	5.31E-14	5.16E-14	5.24E-14	5.25E-14	2E-12
	1.77E-14	1.72E-14	1.86E-14	1.85E-14	1.76E-14	1.91E-14	2E-12
	2.42E-14	2.37E-14	2.47E-14	2.17E-14	2.19E-14	2.32E-14	2E-12
DEC 2002	1.82E-14	1.84E-14	1.89E-14	1.89E-14	1.80E-14	1.85E-14	2E-12
	3.09E-14	3.33E-14	3.23E-14	3.09E-14	2.96E-14	2.88E-14	2E-12
	3.33E-14	3.73E-14	3.66E-14	3.49E-14	3.24E-14	3.43E-14	2E-12
	2.80E-14	2.93E-14	2.89E-14	2.55E-14	2.79E-14	2.49E-14	2E-12
JAN 2003	3.79E-14	3.91E-14	3.74E-14	4.05E-14	3.71E-15	3.39E-15	2E-12
	1.47E-14	1.40E-14	1.39E-14	1.42E-15	1.54E-15	1.48E-15	2E-12
	2.37E-14	2.64E-14	2.47E-14	2.34E-15	2.77E-15	2.57E-15	2E-12
	2.44E-14	2.42E-14	2.55E-14	2.70E-15	2.58E-15	2.45E-15	2E-12
	2.10E-14	2.14E-14	2.26E-14	2.39E-15	2.20E-15	2.58E-15	2E-12
FEB 2003	3.49E-15	3.33E-15	3.45E-15	3.39E-15	3.43E-15	3.66E-15	2E-12
	2.61E-15	2.75E-15	2.67E-15	2.70E-15	2.35E-15	2.44E-15	2E-12
	1.97E-15	1.17E-15	1.92E-15	2.01E-15	1.96E-15	2.10E-15	2E-12
	2.67E-15	2.56E-15	2.76E-15	2.80E-15	2.40E-15	2.52E-15	2E-12
MAR 2003	2.98E-14	N.S.	3.30E-14	3.06E-14	3.08E-14	3.01E-14	2E-12
	2.83E-14	2.73E-14	2.76E-14	3.00E-14	2.65E-14	2.67E-14	2E-12
	2.71E-14	2.72E-14	2.39E-14	2.75E-14	2.58E-14	2.90E-14	2E-12
	2.00E-14	2.23E-14	1.87E-14	2.02E-14	1.88E-14	1.97E-14	2E-12
APR 2003	1.57E-14	1.57E-14	1.70E-14	1.67E-14	1.55E-14	1.65E-14	2E-12
	1.55E-14	1.72E-14	1.56E-14	1.56E-14	1.54E-14	1.49E-14	2E-12
	2.04E-14	2.14E-14	1.93E-14	1.92E-14	2.03E-14	2.13E-14	2E-12
	1.89E-14	1.99E-14	1.79E-14	1.89E-14	1.92E-14	1.94E-14	2E-12
	1.92E-14	1.87E-14	1.75E-14	1.72E-14	1.86E-14	2.00E-14	2E-12

N.S. : No Sample Taken, Pump Found in Off Position

3.1.1 AIR ANALYSIS

All air samples for the reporting period were below the Project Specific Action Limit (PSAL) for gross alpha and gross beta. Figure 5 and Figure 6 show the results as a graph. Note that there is one data gap, Station 2, first week in March 2003, due to the pump power switch found in the off position.

Looking at the gross alpha and gross beta graphs, a general trend with very similar slopes, is evident in both over the same time period. No such trends were evident for gross alpha and gross beta in November and December 2001 and March and April 2002 (same time periods the previous year)

Air filter metal results from the four stations on the PBRF fence line (Stations 1-4) against both the up wind and down wind stations (Stations 5 and 6) are similar to those of the same time period of the previous year. Arsenic levels at all stations were higher in November 2002 and December 2002 than during the same time the previous year, but have dropped significantly January 2003 through April 2003 in relation to the same period the previous year. It appears that these fluctuations are the result of other-than-PBRF operations as no decommissioning activities occurred during the reporting period that could have affected ambient area air conditions.

Figure 5. Air Filter Results for the Reporting Period: Gross Beta

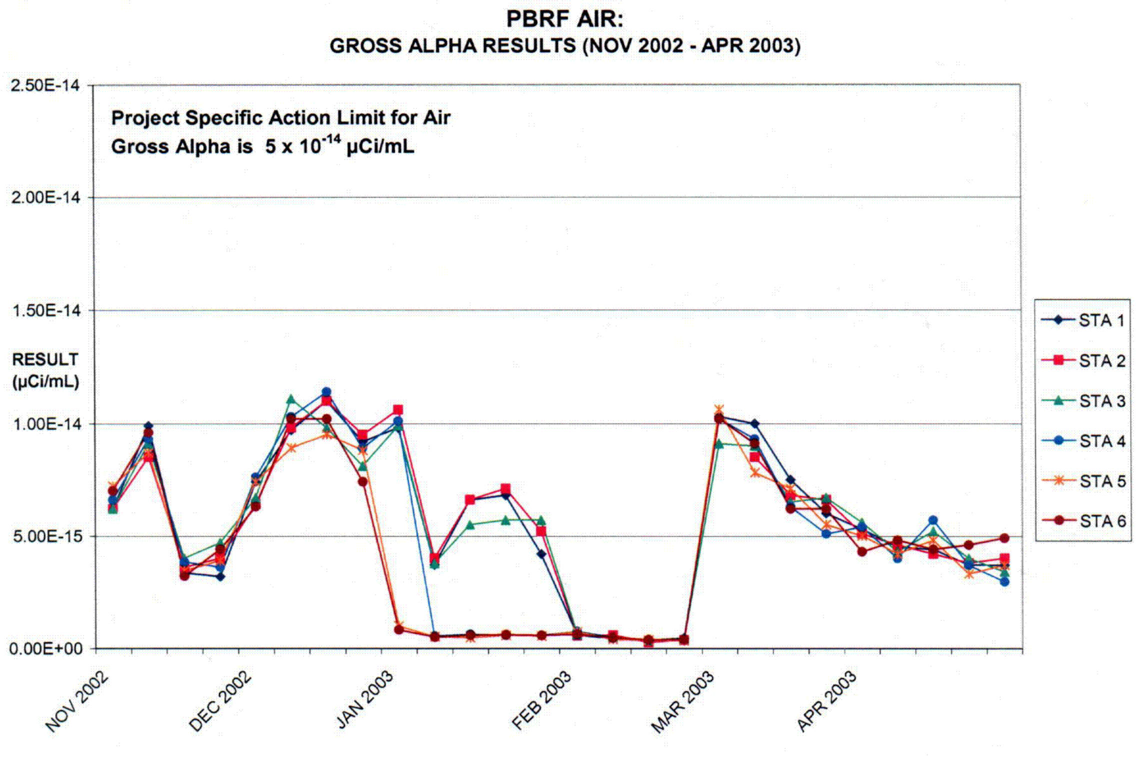

Figure 6. Air Filter Results for the Reporting Period: Gross Beta

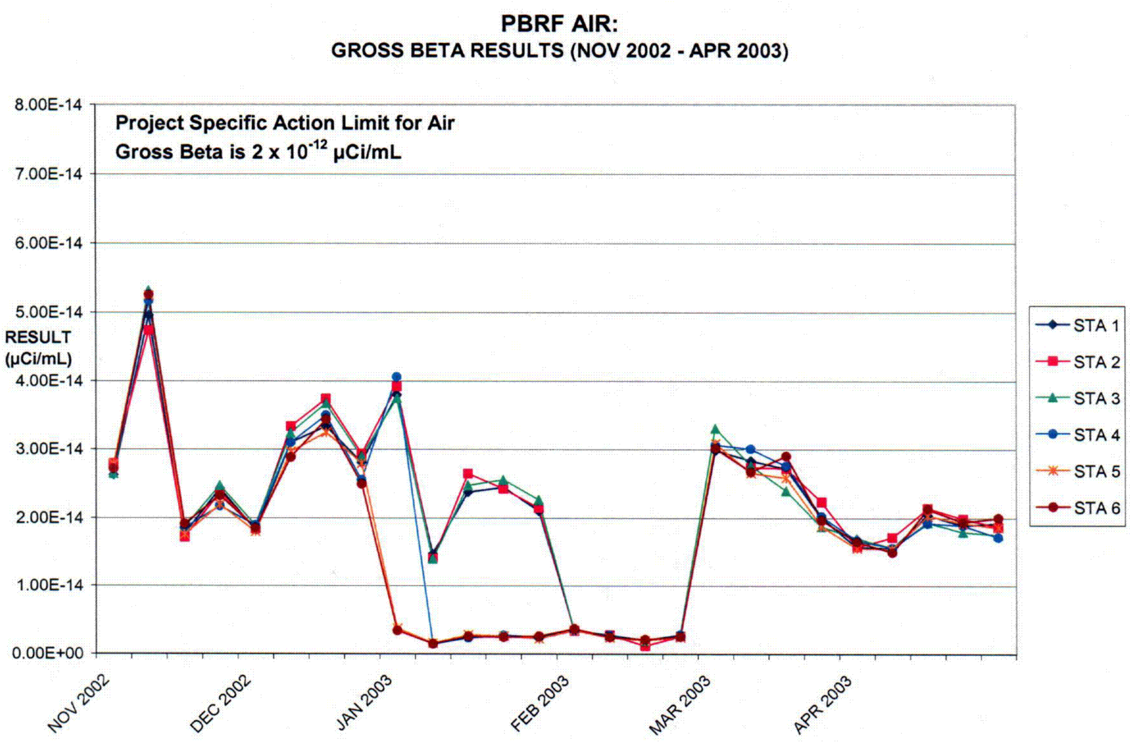

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Table 9. Fence Line Air Filter Metal Results
Monthly Composites – November 2002

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	37.200	0.500 U	0.500 U	0.880 B	3.100	8.000	0.022 B	1.800 B
STA 2	61.400	0.500 U	0.290 B	1.100	3.100	8.600	0.024 B	2.700
STA 3	42.900	0.160 B	0.480 B	1.300	3.300	9.000	0.023 B	2.400
STA 4	51.300	0.046 B	0.370 B	1.100	3.300	8.600	0.230 B	3.100
STA 5	61.600	0.500 U	0.330 B	1.100	3.300	8.700	0.022 B	3.200
STA 6	65.600	0.500 U	0.290 B	1.100	3.000	8.900	0.230 B	2.200

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 10. Fence Line Air Filter Metal Results
Monthly Composites – December 2002

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	7.600	0.500 U	0.500 U	0.820 B	2.600	6.700	0.040 U	1.500 B
STA 2	10.000	0.500 U	0.500 U	0.990 B	4.500	8.900	0.040 U	1.700 B
STA 3	7.800	0.140 B	0.400 B	1.000	3.000	7.500	0.040 U	2.000 B
STA 4	10.200	0.500 U	0.290 B	0.950 B	2.900	7.600	0.040 U	1.900 B
STA 5	9.600	0.500 U	0.500 U	0.860 B	2.700	7.600	0.040 U	1.700 B
STA 6	11.800	0.500 U	0.500 U	1.200	3.300	8.200	0.040 U	1.900 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 11. Fence Line Air Filter Metal Results
Monthly Composites – January 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	8.300	0.500 U	0.500 U	0.740 B	2.600	5.500	0.040 U	1.200 B
STA 2	9.600	0.500 U	0.500 U	0.920 B	2.900	6.400	0.040 U	1.400 B
STA 3	11.200	0.500 U	0.500 U	0.910 B	2.900	6.100	0.040 U	1.600 B
STA 4	10.600	0.500 U	0.500 U	0.850 B	3.300	6.100	0.040 U	1.600 B
STA 5	14.500	0.500 U	0.280 B	1.100	3.600	8.100	0.040 U	1.900 B
STA 6	14.700	0.500 U	0.280 U	1.300	3.000	7.300	0.040 U	1.600 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 12. Fence Line Air Filter Metal Results
Monthly Composites – February 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	11.700	0.028 B	0.460 B	1.500	3.600	9.900	0.040 U	1.900 B
STA 2	13.500	0.500 U	0.490 B	2.500	4.200	8.100	0.040 U	6.000
STA 3	11.800	0.500 U	0.400 B	2.300	3.900	9.400	0.040 U	2.700
STA 4	7.800	0.500 U	0.440 B	1.400	4.000	10.000	0.040 U	2.400
STA 5	11.500	0.500 U	0.410 B	1.400	3.600	9.300	0.040 U	2.200
STA 6	12.300	0.500 U	0.400 B	1.400	3.600	9.500	0.040 U	1.900 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 13. Fence Line Air Filter Metal Results
Monthly Composites – March 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	8.900	0.500 U	0.310 B	1.600	3.600	10.700	0.040U	2.100
STA 2	7.400	0.500 U	0.320 B	1.200	6.900	8.200	0.040 U	2.000
STA 3	8.000	0.500 U	0.370 B	1.800	3.400	10.400	0.021 B	2.400
STA 4	11.800	0.500 U	0.390 B	2.100	4.500	13.000	0.026 B	3.500
STA 5	10.500	0.500 U	0.310 B	1.800	3.700	10.700	0.040U	3.000
STA 6	12.500	0.500 U	0.420 B	2.000	4.400	13.000	0.023 B	3.100

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 14. Fence Line Air Filter Metal Results
Monthly Composites – April 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	8.200	0.500 U	0.270 B	1.100	4.000	8.500	0.024 B	3.000
STA 2	7.400	0.500 U	0.250 B	0.950 B	3.400	7.400	0.021 B	2.500
STA 3	8.500	0.500 U	0.300 B	1.200	4.300	9.100	0.023 B	4.400
STA 4	7.600	0.500 U	0.270 B	1.200	4.000	8.600	0.021 B	3.000
STA 5	9.900	0.500 U	0.330 B	1.300	4.800	12.000	0.027 B	4.300
STA 6	8.100	0.500 U	0.270 B	1.100	4.200	7.800	0.021 B	4.600

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

4.0 CONCLUSION

In viewing the graphs, several trends are evident depending upon the media sampled but cannot be duplicated between the same time period for the previous year. Upward trends occur at sampling locations that cannot be affected by PBRF operations (past or present). Sediment sampling results for the reporting period appear to validate that upward trends are the result of seasonal variation when during dry weather conditions (as is the case during the late summer through late winter months) metals accumulate in the sediments and are more readily detected. Regardless of the sampling result or trend, it is important to note that no decommissioning activities have occurred during the reporting period that could contribute to any result above Project Specific Action Limits (PSAL).

5.0 REFERENCES

U.S. Army Corps of Engineers. Louisville District. NASA PBRF Decommissioning Project Environmental Media Sampling and Analysis Cumulative Report November 2000 – October 2002. Sandusky, Ohio. March 2003.

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NASA PBRF Decommissioning Project Environmental Media Sampling and Analysis

2003 Annual Report

November 2002 – October 2003

Peter C. Kolb, NASA
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National Aeronautics and Space Administration

Glenn Research Center, Plum Brook Station
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April 2004

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Environmental Media Sampling and Analysis

2003 Annual Report
November 2002 – October 2003

This report shows the results for the sampling/reporting period November 2002 through October 2003 only, and is intended as a follow-on to the *"NASA PBRF Decommissioning Project Environmental Media Sampling and Analysis Cumulative Report November 2000 – October 2002,"* published in March 2003. This report does not go into detail about sampling methodology, derivation of project specific action limits, analytical requirements, quality control sampling, etc. Please reference the aforementioned cumulative report for that type information.

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EXECUTIVE SUMMARY

Analysis for the environmental media sampled during the reporting period shows no impacts attributable to current decommissioning operations at the Plum Brook Reactor Facility (PBRF). A major decommissioning milestone this reporting period was the start of reactor segmentation in August 2003. The following is a synopsis of the sampling from November 2002 through October 2003:

- Surface water and air filter results were below Project Specific Action Limits (PSALs) for the reporting period.

- Sediment PSALs were re-calculated as more sampling data for locations upgradient has become available. Results show one, above-PSAL gross alpha sample at one location and four, above-PSAL sample for gross beta at two locations. However, laboratory analysis revealed no PBRF-associated radionuclides (alpha: Plutonium, Americium, Curium; beta-gamma: Strontium, Cesium). It is therefore ascertained that the above-PSAL results for sediments are attributed to either naturally occurring radioactive material (NORM) or other-than-PBRF sources.

- Groundwater results show wild fluctuation above and below PSALs for gross alpha. However, just as in the sediment results above, laboratory analysis revealed no PBRF-associated radionuclides and that the results can be attributable to other-than-PBRF sources. It appears that the fluctuations of groundwater data shows that: (1) no real trend is taking shape for the two years of data accumulated; and, (2) the greater amount of sediment in the groundwater, the greater the range of gross alpha and gross beta readings, although there are no parallels between gross alpha and gross beta.

Samples for surface water and sediment are collected on a monthly basis. Samples for groundwater: three shallow wells, one sump and three deep wells are sampled monthly; one sump quarterly; all others annually. Air samples are collected weekly.

In October 2003 there were four, new wells installed at the end of this reporting period. Two pair of nested wells, RA-07D/S and RA-08D/S (Deep and Shallow), are located north of the reactor building and service equipment building respectively, are outside the PBRF fenceline, and are sampled monthly. The two pair of nested wells fills a potential data gap by allowing sampling of groundwater that could migrate north toward Lake Erie.

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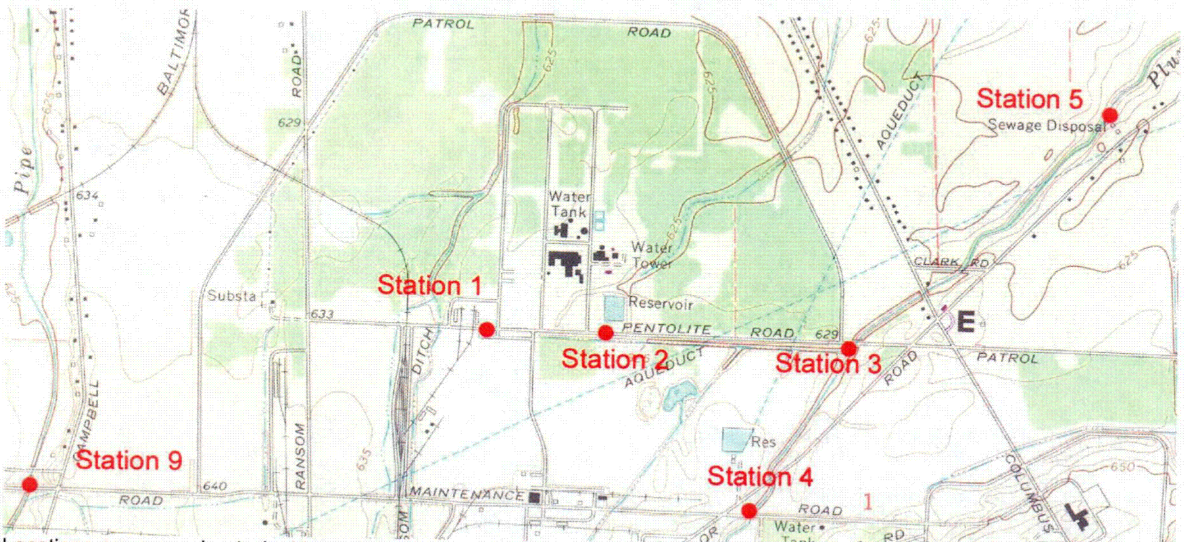
1.0 SURFACE WATER AND SEDIMENT

Surface water and sediment samples are collected monthly from six locations as shown below. Stations 1, 4 and 9 (STA 1, STA 4, STA 9) are upstream of the PBRF and cannot be influenced by waters exiting the PBRF (floods or other such exceptional natural events not withstanding). Station 2 (STA 2) is located at the PBRF outfall and the other stations (STA 3 and STA 5) are located downstream of the PBRF. It is important to note that STA 1 is frequently dry during the year and that all sampling locations can be completely frozen during the winter months.

Figure 1. Surface Water and Sediment Sampling Locations (North is at top).



Locations are approximate (not to scale)

1.1 SURFACE WATER SAMPLING RESULTS NOVEMBER 2002 - OCTOBER 2003

Tables 1 and 2 below, show the surface water gross alpha and gross beta sampling results for the reporting period.

Table 1. Surface Water Results for the Reporting Period: Gross Alpha

Date	STA 1 (pCi/L)	STA 2 (pCi/L)	STA 3 (pCi/L)	STA 4 (pCi/L)	STA 5 (pCi/L)	STA 9 (pCi/L)	Project Specific Action Limit (pCi/L)
NOV 2002	*DRY*	1.1	5	3.1	2.3	2.8	20
DEC 2002	*DRY*	1.6	5	6.4	3.3	4.3	20
JAN 2003	*ICE*	2.4	3.3	*ICE*	*ICE*	*ICE*	20
FEB 2003	*ICE*	*ICE*	1.5	*ICE*	*ICE*	*ICE*	20
MAR 2003	*DRY*	1.3	1.3	2.2	2	1.8	20
APR 2003	3.60	1.1	2.3	1.7	3.1	5.6	20
MAY 2003	2.70	2.2	3.3	3.9	4.9	2.9	20
JUN 2003	*DRY*	9.3	2.5	2	2.6	2.2	20
JUL 2003	*DRY*	7.8	2.7	10.7	3.3	4.8	20
AUG 2003	*DRY*	3.8	4	6.1	4.1	6.1	20
SEP 2003	*DRY*	0.07	2.1	3.7	0.09	1.9	20
OCT 2003	*DRY*	2.4	5.5	2.1	0.03	4.3	20

***DRY :* Insufficient or No Water for Sampling, Did Not Sample**
***ICE :* Water Frozen, Did Not Sample**

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Table 2. Surface Water Results for the Reporting Period: Gross Beta

Date	STA 1 (pCi/L)	STA 2 (pCi/L)	STA 3 (pCi/L)	STA 4 (pCi/L)	STA 5 (pCi/L)	STA 9 (pCi/L)	Project Specific Action Limit (pCi/L)
NOV 2002	*DRY*	3.6	5.6	7.9	6.7	7.2	500
DEC 2002	*DRY*	5.2	9.2	9.5	8.5	7.5	500
JAN 2003	*ICE*	5.9	7.5	*ICE*	*ICE*	*ICE*	500
FEB 2003	*ICE*	*ICE*	8.5	*ICE*	*ICE*	*ICE*	500
MAR 2003	*DRY*	2.9	3.4	4.1	4.4	3.3	500
APR 2003	2.1	2.4	5	2	3.7	6	500
MAY 2003	2.6	4.4	7.8	5.7	6.6	7.7	500
JUN 2003	*DRY*	94	4.5	5.3	4.7	4.8	500
JUL 2003	*DRY*	10.7	5.8	9.8	6.5	8.7	500
AUG 2003	*DRY*	4.9	6.7	8.1	5.7	9.1	500
SEP 2003	*DRY*	4.9	4.1	9.9	3.8	5.6	500
OCT 2003	*DRY*	4.9	7.4	5.3	4.5	9.3	500
DRY : Insufficient or No Water for Sampling, Did Not Sample *ICE : Water Frozen, Did Not Sample*							

1.1.1 SURFACE WATER ANALYSIS

All surface water samples for the reporting period were below the Project Specific Action Limit (PSAL) for gross alpha and gross beta. Figure 2 and Figure 3 show the results as a graph. Please note that gaps in the graph (data gaps) are a result of dry periods when surface water is not present at a particular sampling station or the presence of ice when samples cannot be collected.

Looking at the gross alpha and gross beta graphs for the reporting period, a general trend with similar slopes is evident in both over the same time period. Most start low in November 2002 and then trend upwards in December 2002. This repeats itself in March 2003 and April 2003 (starting low, trending upwards) in June 2003 and July 2003, then again in September 2003 and October 2003.

Figure 2. Surface Water Results for the Reporting Period: Gross Alpha

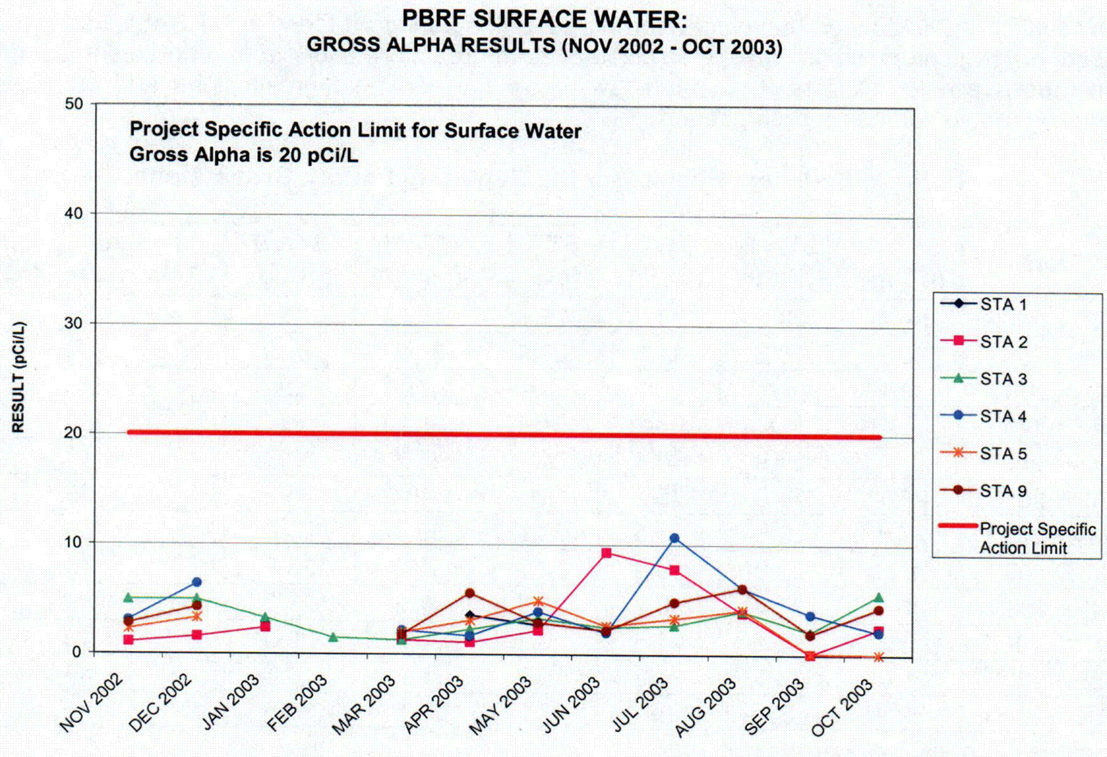
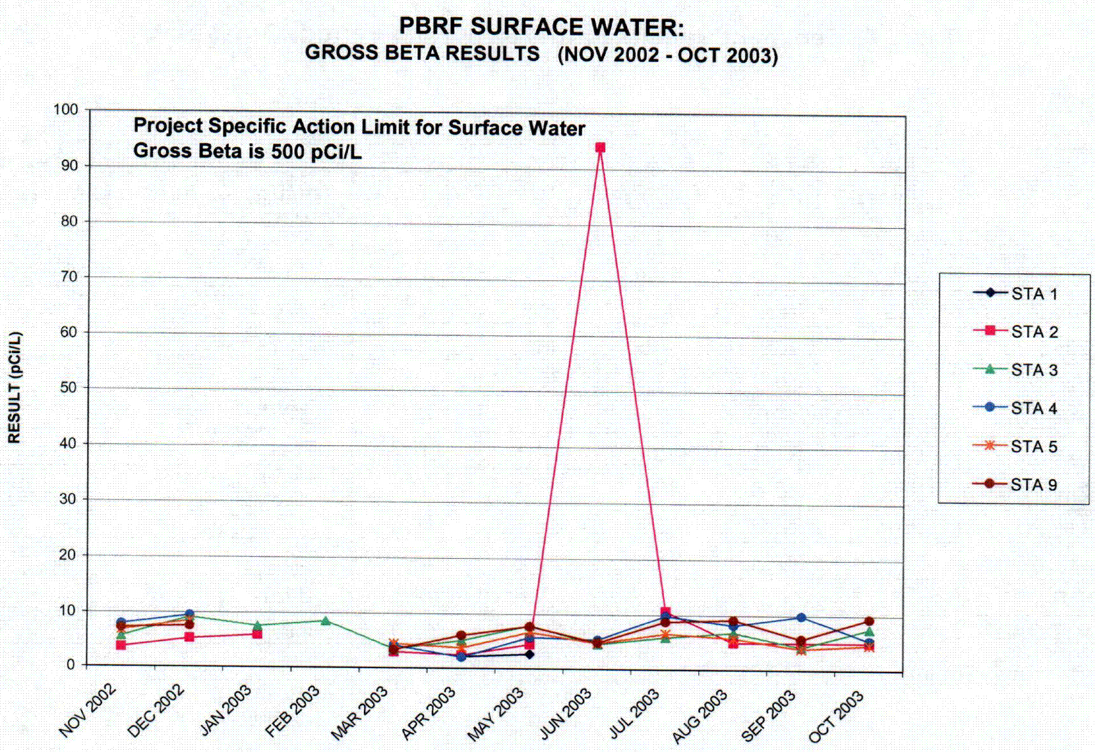


Figure 3. Surface Water Results for the Reporting Period: Gross Beta



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1.2 SEDIMENT SAMPLING RESULTS NOVEMBER 2002 - OCTOBER 2003

New sediment PSALs were developed for this reporting period and forward. PSALs, that are not based on regulatory limits, are re-calculated as more information from upgradient samples becomes available. Tables 3 and 4 below, show the sediment gross alpha and gross beta sampling results for the reporting period.

Table 3. Sediment Results for the Reporting Period: Gross Alpha

Date	STA 1 (pCi/g)	STA 2 (pCi/g)	STA 3 (pCi/g)	STA 4 (pCi/g	STA 5 (pCi/g)	STA 9 (pCi/g)	Project Specific Action Limit (pCi/g)
NOV 2002	34.5	23.3	33.3	26.6	17.3	49	46
DEC 2002	30.7	16.2	41.8	29.6	34.2	14.5	46
JAN 2003	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	46
FEB 2003	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	46
MAR 2003	31	27.9	30.1	24.1	36.2	32.7	46
APR 2003	26.1	24.9	20.2	21	43	25.7	46
MAY 2003	27.6	23.8	19.5	28.7	39.3	23.8	46
JUN 2003	27.6	23.8	19.5	28.7	39.3	23.8	46
JUL 2003	25.4	23.4	33.9	32.4	42.8	23.2	46
AUG 2003	24	18.1	21.5	26.6	30.9	29.9	46
SEP 2003	29.2	28.3	28.8	16.7	29.6	28.7	46
OCT 2003	32.9	33	29	33.5	31.8	30.9	46
ICE : Water / Ground Frozen, Did Not Sample							

Table 4. Sediment Results for the Reporting Period: Gross Beta

Date	STA 1 (pCi/g)	STA 2 (pCi/g)	STA 3 (pCi/g)	STA 4 (pCi/g)	STA 5 (pCi/g)	STA 9 (pCi/g)	Project Specific Action Limit (pCi/g)
NOV 2002	32.2	90	41.1	42.5	21.4	48.3	51
DEC 2002	28.3	47.5	43.4	36.6	36.2	23.9	51
JAN 2003	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	51
FEB 2003	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	*ICE*	51
MAR 2003	33.6	56.8	41.9	35.4	38.2	30	51
APR 2003	37	138	51	43	47	32.3	51
MAY 2003	29.5	31.4	39.9	34.1	36.2	29.4	51
JUN 2003	25.9	28.8	40.5	37.1	40.8	30.2	51
JUL 2003	29.4	28.2	35	33.8	37.6	25.3	51
AUG 2003	29.1	27.3	35.6	27.6	33.5	28.9	51
SEP 2003	42.2	42.8	51.2	42.6	42.5	31.1	51
OCT 2003	41.1	39.5	36.3	37.1	33.6	29.7	51
ICE : Water / Ground Frozen, Did Not Sample							

1.2.1 SEDIMENT ANALYSIS

Only one of the sediment samples for the reporting period was at or above the PSAL for gross alpha, while only four were above the PSAL for gross beta.

Stations 3, 5, and 9 trend up in both gross alpha and gross beta during November 2002 and December 2002, while Station 2 trended down in both gross alpha and gross beta during the same time period. (Station 9 is not in the same watershed and could not be impacted by PBRF operations). All stations except 2 and 9 follow similar trends for the period March through October 2003 for gross alpha. With the exception of Stations 3 and 5 during November and December 2002, all stations follow parallel trends for gross beta during the sampling period.

Reactor segmentation started late in the reporting period (August 2003). This activity had no containment breaches where contamination could have escaped the confines of the reactor building. Therefore, no decommissioning activities have occurred during the reporting period that could contribute to any results above Project Specific Action Limits and the unusual trends can be attributed to seasonal variations when metals accumulate in the sediments, during dry weather conditions, and are more readily detected. Alpha and gamma spectroscopy revealed no PBRF-associated radionuclides (alpha: Plutonium, Americium, Curium; gamma: Strontium, Cesium), therefore the above-PSAL results for sediments should be attributed to other-than-PBRF sources.

Figure 4 and Figure 5 show the table results as a graph. Please note that gaps in the graph (data gaps) are due to the presence of ice when samples could not be collected.

Figure 4. Sediment Results for the Reporting Period: Gross Alpha

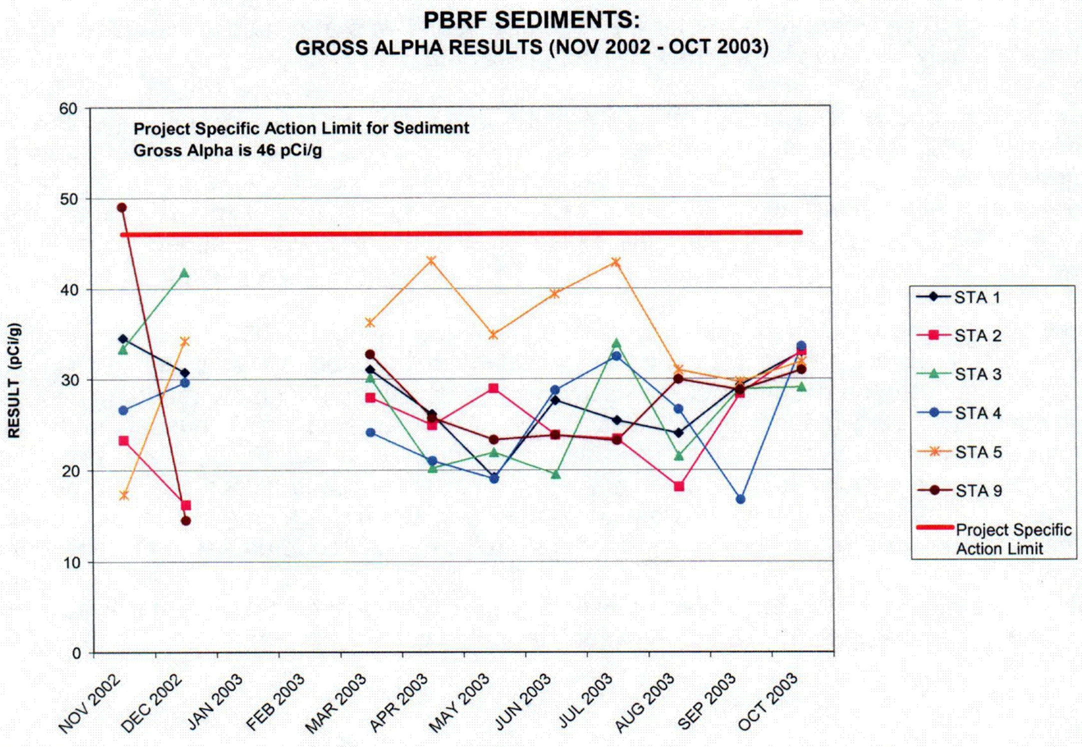
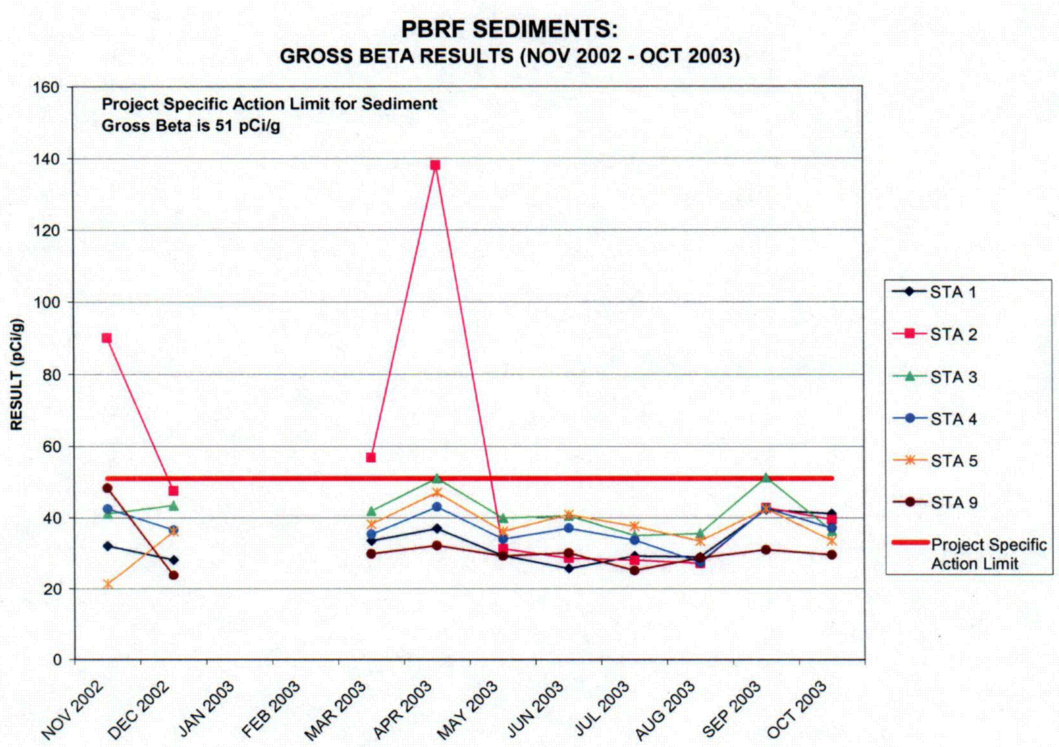


Figure 5. Sediment Results for the Reporting Period: Gross Beta



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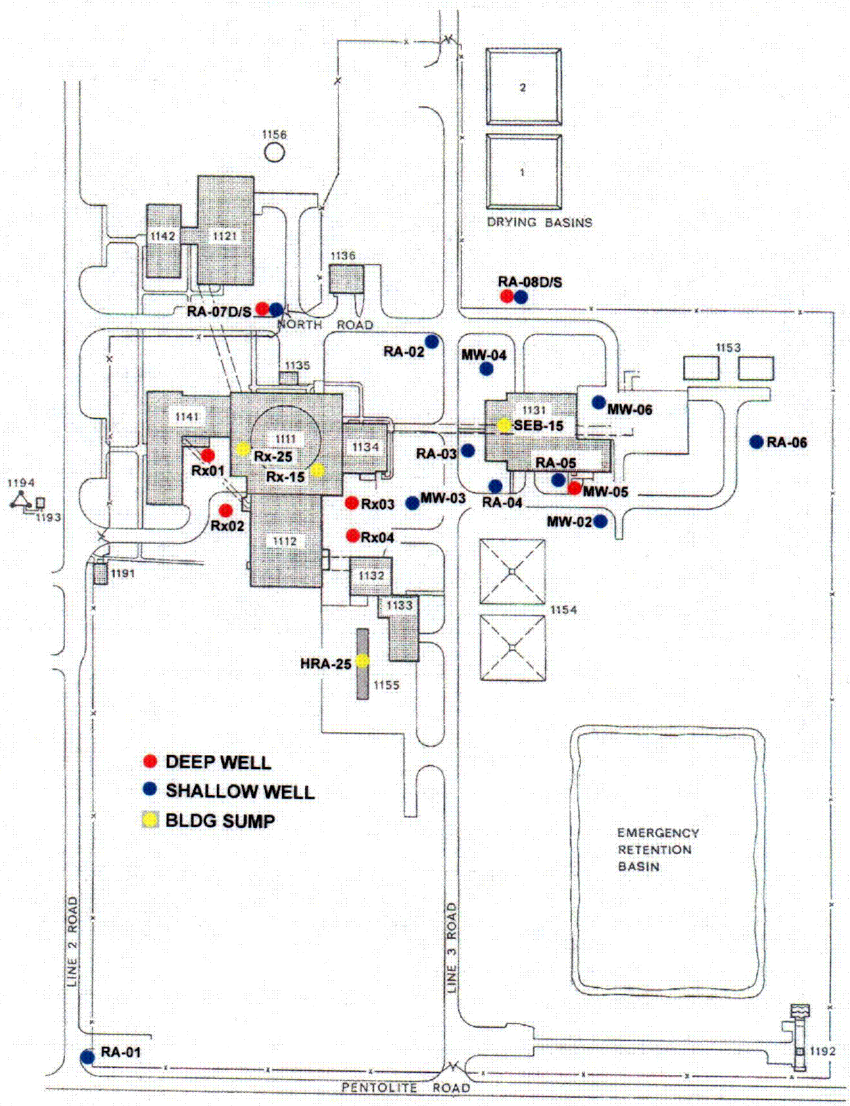
2.0 GOUNDWATER WELLS AND SUMPS

Groundwater sampling is done monthly from either shallow or deep wells, and in building sumps. Shallow wells range in depth from 10 to 30 feet below grade, deep wells range from 40 to 90 feet below grade and building sumps are typically 15 or 25 foot below grade. Sampling frequency dictated by the type and location of each well/sump and is done monthly, quarterly or annually. In any case, all wells and sumps are sampled annually. Sampling locations are shown below.

There were four, new wells installed during this reporting period, in October 2003. Two pair of nested wells, RA-07D/S and RA-08D/S (Deep and Shallow), are located north of the reactor building and service equipment building respectively, are outside the PBRF fenceline and are sampled monthly. The two pair of nested wells fill a potential data gap by allowing sampling of groundwater that could migrate north toward Lake Erie.

Figure 6. Location of Groundwater Sampling Wells and Building Sumps (North is at top)



Locations are approximate (not to scale)

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2.1 GROUNDWATER SAMPLING RESULTS NOVEMBER 2002 - OCTOBER 2003

Tables 5 and 6 below, show the groundwater gross alpha and gross beta sampling results for the reporting period.

Please note that data gaps in the table are either insufficient water for sampling or the result of ice at the well and no samples could be taken.

Table 5. Groundwater Results for the Reporting Period: Gross Alpha

Well / Sump ID	NOV 2002	DEC 2002	JAN 2003	FEB 2003	MAR 2003	APR 2003	MAY 2003	JUN 2003	JUL 2003	AUG 2003	SEP 2003	OCT 2003	PSAL (pCi/L)
SHALLOW (UNCONSOLIDATED) WELLS (pCi/L)													
RA-01	4.2	14.5	12.5	4.5 U	15 U	18	2.1	20.4	34.0	29	10	6.8	15
RA-02	10.7	8.8	3.7	4.2	1.6 U	6	1.6	5.3	6.4	1.7 U	148	8.4	15
MW-02	16.2	21.5	2.4	*ICE*	4.5 U	7.2 U	4.7	3.9 U	21.5	4.7 U	270	13.1	15
RA-07S	NEWLY INSTALLED OCTOBER 2003											7.2	15
RA-08S												8.3	15
RA-03												37.9	15
RA-04												7.9 U	15
RA-05												17.3	15
RA-06	***SAMPLED ANNUALLY***					13.4	***SAMPLED ANNUALLY***					19	15
MW-03												11.6	15
MW-04												12.4	15
MW-06												7.3 U	15
BUILDING SUMPS (pCi/L)													
Rx25	5.2 U	2.1 U	1.1	1.7	4.8 U	4.9 U	3.3 U	4.5 U	5.3	3.3 U	2.6	7 U	15
HRA25			1.8					0.5 U				*N.S.*	15
SEB15	***SAMPLED ANNUALLY***											0.06 U	15
Rx15												1.3 U	15
DEEP (BEDROCK) WELLS (pCi/L)													
Rx01	4.6 U	3.5	*ICE*	*ICE*	3.1	3.1 U	0.1	1.9 U	6.2 U	3.3 U	3.3	4.9 U	15
Rx03	0.8 U	*ICE*	*ICE*	*ICE*	2.2 U	1.3 U	*DRY*	*DRY*	*DRY*	*DRY*	*DRY*	*DRY*	15
MW-05	5.2 U	*ICE*	*ICE*	*ICE*	8.8	7 U	17 U	7 U	7 U	12.5	31	14 U	15
RA-07D	NEWLY INSTALLED OCTOBER 2003											8.4	15
RA-08D												*DRY*	15
Rx02	***SAMPLED ANNUALLY***											*DRY*	15
Rx04												0.4 U	15

ICE : Water / Ground Frozen at Well, No Sample Taken
DRY: Insufficient or No Water in Well, No Sample Taken ***N.S.: Did Not Sample - Could Not Access***
U: Not Detected at or Above Minimum Detection Limit of Instrument

Table 6. Groundwater Results for the Reporting Period: Gross Beta

Well / Sump ID	NOV 2002	DEC 2002	JAN 2003	FEB 2003	MAR 2003	APR 2003	MAY 2003	JUN 2003	JUL 2003	AUG 2003	SEP 2003	OCT 2003	PSAL (pCi/L)
SHALLOW (UNCONSOLIDATED) WELLS (pCi/L)													
RA-01	41	13.6	12.4	3.5 U	16 U	6.4 U	440	69	121	139	147	9.1	500
RA-02	84	39	4.1	209	41	92	92	139	66	57	272	186	500
MW-02	227	127	50	*ICE*	3.60 U	7.8	45	94	259	200	471	191	500
RA-07S	NEWLY INSTALLED OCTOBER 2003											11.5	500
RA-08S												9.5	500
RA-03												128	500
RA-04												24.5	500
RA-05												16.9	500
RA-06	*SAMPLED ANNUALLY*					17.7		*SAMPLED ANNUALLY*				30.9	500
MW-03												17.6	500
MW-04												206	500
MW-06												93	500
BUILDING SUMPS (pCi/L)													
Rx25	1.9 U	3.5 J	6.1	3.5	5 U	18.6	5.7	6.1	4.7 U	3.9	5.9	5.2 U	500
HRA25			16.6					19.3				*N.S.*	500
SEB15						*SAMPLED ANNUALLY*						5.8	500
Rx15												4.2 U	500
DEEP (BEDROCK) WELLS (pCi/L)													
Rx01	6.2	6.1	*ICE*	*ICE*	2.6 J	6.4	8	5.6 U	11.3	10.7	7.6	8.2	500
Rx03	14.9	*ICE*	*ICE*	*ICE*	4.7	6.5	*DRY*	*DRY*	*DRY*	*DRY*	*DRY*	*DRY*	500
MW-05	1.9 U	*ICE*	*ICE*	*ICE*	6	63	38	42	24	76	73	57	500
RA-07D	NEWLY INSTALLED OCTOBER 2003											7.4	500
RA-08D												*DRY*	500
Rx02												*DRY*	500
Rx04						*SAMPLED ANNUALLY*						6	500

ICE : Water / Ground Frozen at Well, No Sample Taken

DRY: Insufficient or No Water In Well, No Sample Taken *N.S.: Did Not Sample - Could Not Access*

J: Less Than Detection Limit of Instrument U: Not Detected at or Above Minimum Detection Limit of Instrument

2.1.1 GROUNDWATER ANALYSIS

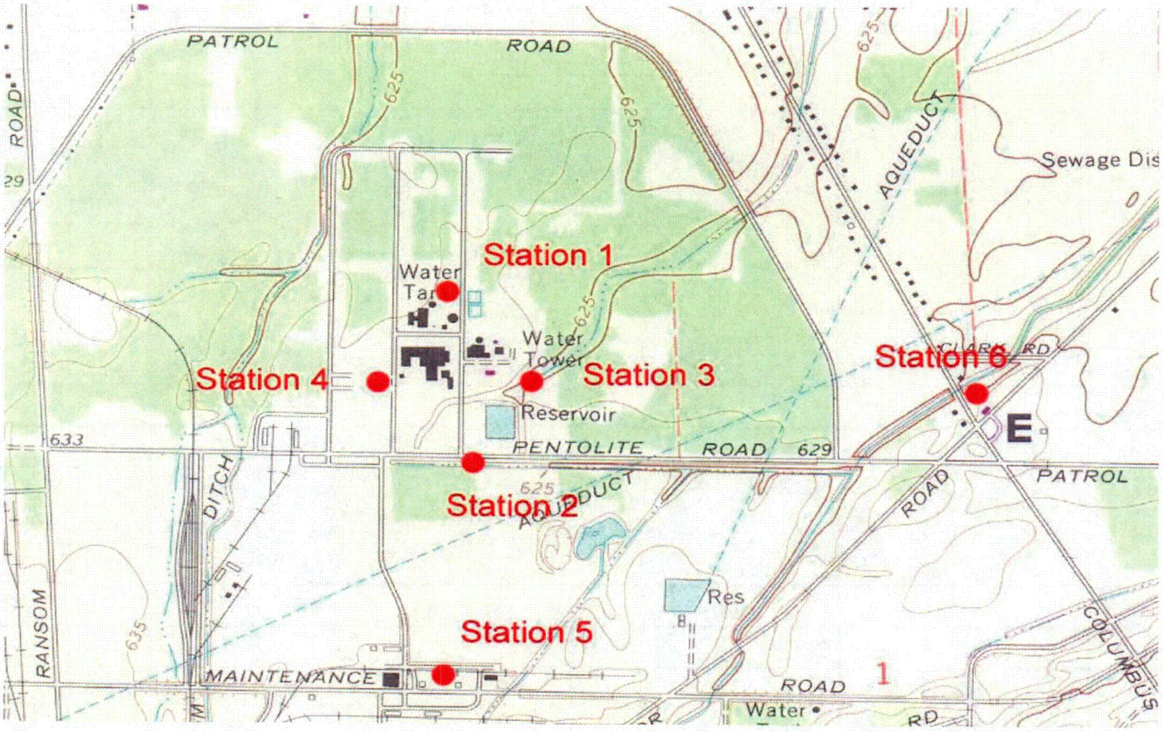
As shown in Table 5, some shallow wells were above the PSAL for gross alpha, especially in May 2003, July 2003 and September 2003; a few with wild fluctuations, typically a result of high sediment content in the groundwater. Alpha spectroscopy of samples for those wells revealed no PBRF-associated radionuclides (Plutonium, Americium, Curium;), therefore the above-PSAL results for groundwater should be attributed to either naturally occurring radioactive material (NORM), or other-than-PBRF sources.

All sumps were below PSAL for gross alpha and all wells and sumps were below the PSAL for gross beta.

3.0 FENCE LINE AIR FILTER

Air samples are collected weekly from six locations as shown below. For most of the year, the prevailing winds are such that Stations 2, 4 and 5 (STA 2, STA 4, STA 5) are upwind of the PBRF and thus are typically not influenced by activities at the PBRF. Stations 1, 3 and 6 (STA 1, STA 3 and STA 6) are located downwind of the PBRF during most of the year.

Figure 7. Air Monitoring Station Locations (North is at top)



Approximate locations (not to scale)

3.1 AIR SAMPLING RESULTS NOVEMBER 2002 - OCTOBER 2003

Table 7 and Table 8 show the air gross alpha and gross beta sampling results for the reporting period.

Tables 9 through 14 show the composite metals results for the reporting period.

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Table 7. Air Filter Results for the Reporting Period: Gross Alpha

Month	STA 1 (µCi/mL)	STA 2 (µCi/mL)	STA 3 (µCi/mL)	STA 4 (µCi/mL)	STA 5 (µCi/mL)	STA 6 (µCi/mL)	PSAL (µCi/mL)
NOV 2002	6.20E-15	6.20E-15	6.20E-15	6.60E-15	7.20E-15	7.00E-15	5E-14
	9.90E-15	8.50E-15	9.10E-15	9.30E-15	8.70E-15	9.60E-15	5E-14
	3.36E-15	3.60E-15	4.00E-15	3.84E-15	3.45E-15	3.22E-15	5E-14
	3.19E-15	4.00E-15	4.70E-15	3.62E-15	3.90E-15	4.40E-15	5E-14
DEC 2002	7.40E-15	6.40E-15	6.70E-15	7.60E-15	7.40E-15	6.30E-15	5E-14
	9.70E-15	9.80E-15	1.11E-14	1.03E-14	8.90E-15	1.02E-14	5E-14
	1.10E-14	1.10E-14	9.80E-15	1.14E-14	9.50E-15	1.02E-14	5E-14
	9.20E-15	9.50E-15	8.10E-15	8.90E-15	8.80E-15	7.40E-15	5E-14
JAN 2003	9.80E-15	1.06E-14	9.90E-15	1.01E-14	1.00E-15	8.30E-16	5E-14
	3.72E-15	4.00E-15	3.78E-15	5.50E-16	5.20E-16	5.10E-16	5E-14
	6.60E-15	6.60E-15	5.50E-15	6.30E-16	4.70E-16	5.90E-16	5E-14
	6.80E-15	7.10E-15	5.70E-15	5.80E-16	5.80E-16	6.10E-16	5E-14
	4.20E-15	5.20E-15	5.70E-15	5.90E-16	5.50E-16	5.80E-16	5E-14
FEB 2003	6.00E-16	5.60E-16	6.30E-16	7.60E-16	7.40E-16	6.30E-16	5E-14
	4.40E-16	6.00E-16	5.00E-16	5.00E-16	4.00E-16	4.80E-16	5E-14
	3.55E-16	2.72E-16	3.63E-16	3.59E-16	3.67E-16	3.90E-16	5E-14
	4.60E-16	3.80E-16	4.30E-16	4.20E-16	3.41E-16	4.00E-16	5E-14
MAR 2003	1.03E-14	N.S.	9.10E-15	1.02E-14	1.06E-14	1.02E-14	5E-14
	1.00E-14	8.50E-15	9.00E-15	9.30E-15	7.80E-15	9.10E-15	5E-14
	7.50E-15	6.80E-15	6.50E-15	6.30E-15	7.10E-15	6.20E-15	5E-14
	6.00E-15	6.60E-15	6.70E-15	5.10E-15	5.50E-15	6.20E-15	5E-14
APR 2003	5.30E-15	5.10E-15	5.60E-15	5.40E-15	5.00E-15	4.30E-15	5E-14
	4.50E-15	4.60E-15	4.30E-15	4.00E-15	4.20E-15	4.80E-15	5E-14
	4.40E-15	4.20E-15	5.20E-15	5.70E-15	4.80E-15	4.40E-15	5E-14
	3.72E-15	3.80E-15	4.00E-15	3.70E-15	3.31E-15	4.60E-15	5E-14
	3.70E-15	4.00E-15	3.41E-15	2.97E-15	3.70E-15	4.90E-15	5E-14
MAY 2003	5.40E-15	5.40E-15	4.90E-15	5.90E-15	6.10E-15	4.90E-15	5E-14
	3.90E-15	4.70E-15	5.30E-15	5.10E-15	5.00E-15	4.70E-15	5E-14
	4.40E-15	3.77E-15	4.00E-15	3.63E-15	3.59E-15	4.60E-15	5E-14
	4.10E-15	4.00E-15	4.20E-15	4.20E-15	4.30E-15	4.70E-15	5E-14
JUN 2003	3.70E-15	9.50E-15	4.90E-15	4.40E-15	3.90E-15	3.65E-15	5E-14
	4.60E-15	5.40E-15	4.20E-15	4.30E-15	4.40E-15	4.70E-15	5E-14
	2.85E-15	3.80E-15	4.20E-15	3.21E-15	3.42E-15	3.34E-15	5E-14
	4.20E-15	2.95E-15	3.47E-15	3.39E-15	3.08E-15	4.30E-15	5E-14
JUL 2003	6.36E-15	1.03E-14	9.15E-15	8.73E-15	8.33E-15	9.25E-15	5E-14
	8.68E-15	5.66E-15	1.05E-14	8.89E-15	1.03E-14	9.45E-15	5E-14
	9.82E-15	8.54E-15	6.26E-15	7.10E-15	5.92E-15	6.63E-15	5E-14
	9.54E-15	8.01E-15	8.52E-15	7.33E-15	6.05E-15	9.45E-15	5E-14
	5.91E-15	1.09E-14	7.47E-15	8.34E-15	7.20E-15	6.64E-15	5E-14
AUG 2003	6.59E-15	7.83E-15	7.54E-15	7.92E-15	7.27E-15	6.64E-15	5E-14
	5.61E-15	6.29E-15	6.98E-15	6.80E-15	7.13E-15	7.19E-15	5E-14
	6.73E-15	8.31E-15	6.20E-15	7.61E-15	7.73E-15	5.47E-15	5E-14
	6.87E-15	8.90E-15	6.31E-15	1.75E-15	7.55E-15	7.71E-15	5E-14
SEP 2003	7.10E-15	8.30E-15	5.90E-15	6.60E-15	6.80E-15	7.10E-15	5E-14
	8.20E-15	8.60E-15	7.00E-15	8.80E-15	6.90E-15	7.70E-15	5E-14
	6.80E-15	8.00E-15	8.40E-15	8.80E-15	7.80E-15	8.80E-15	5E-14
	6.30E-15	7.80E-15	7.80E-15	6.70E-15	8.60E-15	8.20E-15	5E-14
	5.20E-15	5.00E-15	5.20E-15	5.60E-15	4.80E-15	5.50E-15	5E-14
OCT 2003	6.00E-15	6.80E-15	6.70E-15	6.60E-15	7.20E-15	5.90E-15	5E-14
	1.62E-14	1.50E-14	1.22E-14	1.56E-14	1.68E-14	1.48E-14	5E-14
	1.18E-14	1.56E-14	1.31E-14	1.05E-14	8.20E-15	1.00E-14	5E-14
	6.15E-15	7.30E-15	6.70E-15	6.40E-15	6.80E-15	7.80E-15	5E-14

N.S. No Sample Taken, Pump Found In Off Position

Table 8. Air Filter Results for the Reporting Period: Gross Beta

Month	STA 1 (µCi/mL)	STA 2 (µCi/mL)	STA 3 (µCi/mL)	STA 4 (µCi/mL)	STA 5 (µCi/mL)	STA 6 (µCi/mL)	PSAL (µCi/mL)
NOV 2002	2.62E-14	2.79E-14	2.64E-14	2.71E-14	2.78E-14	2.71E-14	2E-12
	4.95E-14	4.73E-14	5.31E-14	5.16E-14	5.24E-14	5.25E-14	2E-12
	1.77E-14	1.72E-14	1.86E-14	1.85E-14	1.76E-14	1.91E-14	2E-12
	2.42E-14	2.37E-14	2.47E-14	2.17E-14	2.19E-14	2.32E-14	2E-12
DEC 2002	1.82E-14	1.84E-14	1.89E-14	1.89E-14	1.80E-14	1.85E-14	2E-12
	3.09E-14	3.33E-14	3.23E-14	3.09E-14	2.96E-14	2.88E-14	2E-12
	3.33E-14	3.73E-14	3.66E-14	3.49E-14	3.24E-14	3.43E-14	2E-12
	2.80E-14	2.93E-14	2.89E-14	2.55E-14	2.79E-14	2.49E-14	2E-12
JAN 2003	3.79E-14	3.91E-14	3.74E-14	4.05E-14	3.71E-15	3.39E-15	2E-12
	1.47E-14	1.40E-14	1.39E-14	1.42E-15	1.54E-15	1.48E-15	2E-12
	2.37E-14	2.64E-14	2.47E-14	2.34E-15	2.77E-15	2.57E-15	2E-12
	2.44E-14	2.42E-14	2.55E-14	2.70E-15	2.58E-15	2.45E-15	2E-12
	2.10E-14	2.14E-14	2.26E-14	2.39E-15	2.20E-15	2.58E-15	2E-12
FEB 2003	3.49E-15	3.33E-15	3.45E-15	3.39E-15	3.43E-15	3.66E-15	2E-12
	2.61E-15	2.75E-15	2.67E-15	2.70E-15	2.35E-15	2.44E-15	2E-12
	1.97E-15	1.17E-15	1.92E-15	2.01E-15	1.96E-15	2.10E-15	2E-12
	2.67E-15	2.56E-15	2.76E-15	2.80E-15	2.40E-15	2.52E-15	2E-12
MAR 2003	2.98E-14	N.S.	3.30E-14	3.06E-14	3.08E-14	3.01E-14	2E-12
	2.83E-14	2.73E-14	2.76E-14	3.00E-14	2.65E-14	2.67E-14	2E-12
	2.71E-14	2.72E-14	2.39E-14	2.75E-14	2.58E-14	2.90E-14	2E-12
	2.00E-14	2.23E-14	1.87E-14	2.02E-14	1.88E-14	1.97E-14	2E-12
APR 2003	1.57E-14	1.57E-14	1.70E-14	1.67E-14	1.55E-14	1.65E-14	2E-12
	1.55E-14	1.72E-14	1.56E-14	1.56E-14	1.54E-14	1.49E-14	2E-12
	2.04E-14	2.14E-14	1.93E-14	1.92E-14	2.03E-14	2.13E-14	2E-12
	1.89E-14	1.99E-14	1.79E-14	1.89E-14	1.92E-14	1.94E-14	2E-12
	1.92E-14	1.87E-14	1.75E-14	1.72E-14	1.86E-14	2.00E-14	2E-12
MAY 2003	1.34E-14	1.37E-14	1.41E-14	1.39E-14	1.47E-14	1.48E-14	2E-12
	1.29E-14	1.38E-14	1.45E-14	1.26E-14	1.45E-14	1.46E-14	2E-12
	1.42E-14	1.45E-14	1.21E-14	1.22E-14	1.37E-14	1.34E-14	2E-12
	1.37E-14	1.44E-14	1.50E-14	1.32E-14	1.54E-14	1.51E-14	2E-12
JUN 2003	1.31E-14	3.37E-14	1.36E-14	1.37E-14	1.53E-14	1.39E-14	2E-12
	1.85E-14	2.12E-14	2.08E-14	1.69E-14	2.11E-14	2.04E-14	2E-12
	1.62E-14	1.74E-14	1.76E-14	1.58E-14	1.71E-14	1.69E-14	2E-12
	1.69E-14	1.99E-14	2.03E-14	1.73E-14	1.72E-14	1.71E-14	2E-12
JUL 2003	1.47E-14	2.79E-14	2.47E-14	2.30E-14	2.61E-14	2.44E-14	2E-12
	2.00E-14	1.58E-14	2.59E-14	2.77E-14	2.58E-14	2.94E-14	2E-12
	2.26E-14	2.24E-14	1.44E-14	1.65E-14	1.45E-14	1.54E-14	2E-12
	2.44E-14	2.05E-14	2.12E-14	2.12E-14	1.91E-14	2.17E-14	2E-12
	1.91E-14	2.49E-14	2.09E-14	2.17E-14	2.12E-14	2.03E-14	2E-12
AUG 2003	2.26E-14	2.56E-14	2.63E-14	2.82E-14	2.45E-14	2.45E-14	2E-12
	1.89E-14	2.33E-14	2.84E-14	2.26E-14	2.16E-14	2.70E-14	2E-12
	2.61E-14	3.07E-14	1.95E-14	2.23E-14	2.82E-14	2.19E-14	2E-12
	2.63E-14	2.73E-14	2.21E-14	1.75E-15	2.70E-14	2.42E-14	2E-12
SEP 2003	2.25E-14	2.27E-14	2.19E-14	2.12E-14	1.93E-14	2.19E-14	2E-12
	2.38E-14	2.61E-14	2.57E-14	2.40E-14	2.51E-14	2.13E-14	2E-12
	2.86E-14	3.09E-14	3.12E-14	3.02E-14	3.19E-14	3.13E-14	2E-12
	2.69E-14	2.56E-14	2.78E-14	2.52E-14	2.55E-14	2.82E-14	2E-12
	1.88E-14	1.86E-14	1.83E-14	1.66E-14	1.69E-14	2.00E-14	2E-12
OCT 2003	1.51E-14	1.72E-14	1.58E-14	1.71E-14	1.60E-14	1.57E-14	2E-12
	4.16E-14	4.96E-14	3.98E-14	4.24E-14	4.06E-14	4.09E-14	2E-12
	2.97E-14	4.70E-14	3.58E-14	2.90E-14	2.87E-14	3.16E-14	2E-12
	2.03E-14	2.30E-14	1.93E-14	1.99E-14	1.98E-14	2.15E-14	2E-12

N.S. No Sample Taken, Pump Found in Off Position

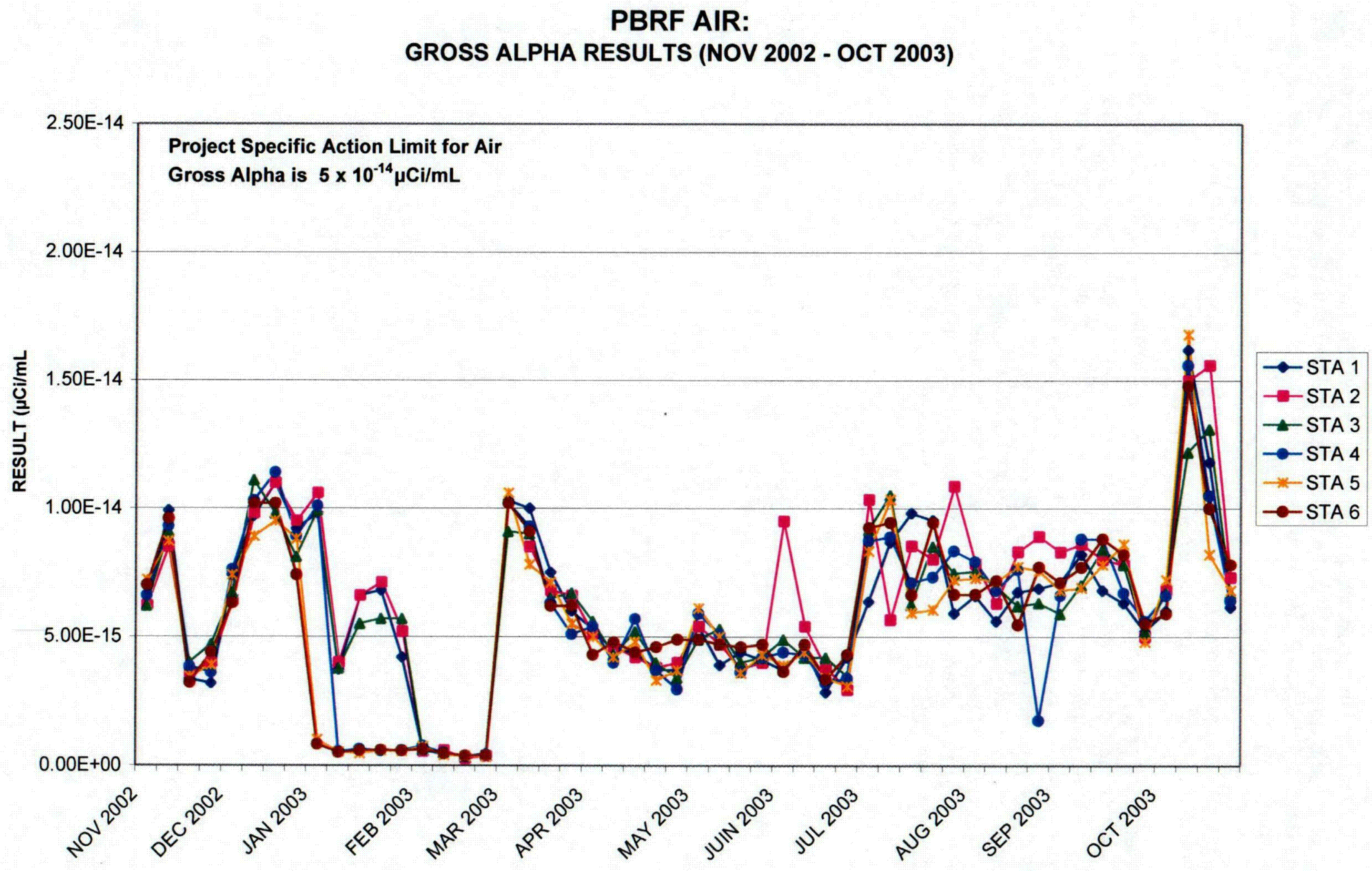
3.1.1 AIR ANALYSIS

All air samples for the reporting period were below the Project Specific Action Limit (PSAL) for gross alpha and gross beta. Figure 8 and Figure 9 show the results as a graph. Note that there is one data gap, Station 2, first week in March 2003, due to the pump power switch found in the off position.

Looking at the gross alpha and gross beta graphs, a general trend with very similar slopes, is evident in both over the same time period.

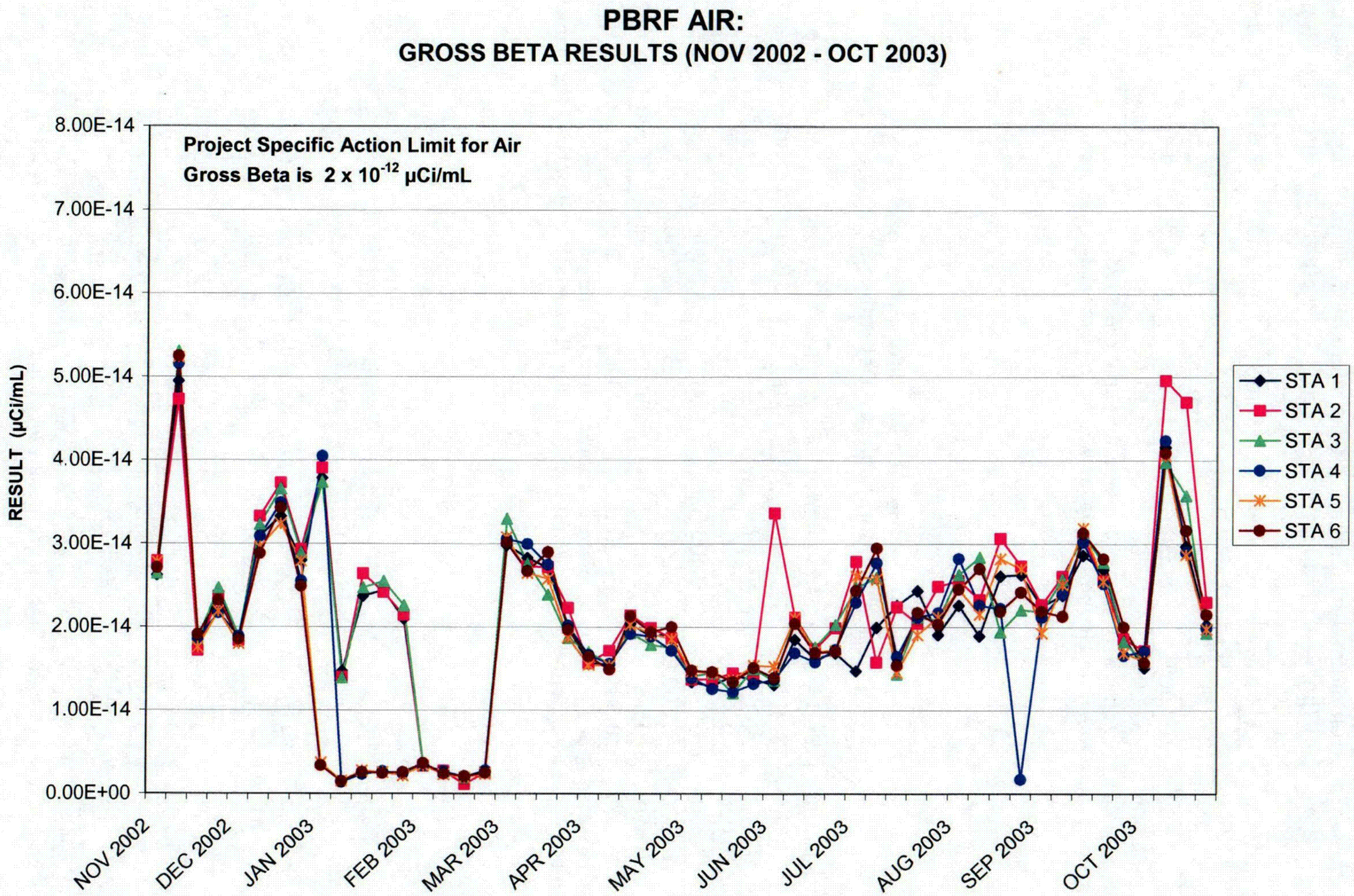
Air filter metal results from the four stations on the PBRF fence line (Stations 1-4) against both the up wind and down wind stations (Stations 5 and 6) are similar to those of the same time period of the previous year with the exception of Arsenic. Arsenic levels at all stations were high in November 2002 and December 2002 and from July 2003 through October 2003, but dropped significantly for the time spanning January 2003 through June 2003. However, during the previous year, January 2002 through August 2002 had high arsenic levels (a reverse trend from this reporting period). It appears that these fluctuations are the result of other-than-PBRF operations as no decommissioning activities occurred during the reporting period that could have affected ambient area air conditions.

Figure 8. Air Filter Results for the Reporting Period: Gross Alpha



C31

Figure 9. Air Filter Results for the Reporting Period: Gross Beta



C32

Table 9. Fence Line Air Filter Metal Results
Monthly Composites – November 2002

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	37.200	0.500 U	0.500 U	0.880 B	3.100	8.000	0.022 B	1.800 B
STA 2	61.400	0.500 U	0.290 B	1.100	3.100	8.600	0.024 B	2.700
STA 3	42.900	0.160 B	0.480 B	1.300	3.300	9.000	0.023 B	2.400
STA 4	51.300	0.046 B	0.370 B	1.100	3.300	8.600	0.230 B	3.100
STA 5	61.600	0.500 U	0.330 B	1.100	3.300	8.700	0.022 B	3.200
STA 6	65.600	0.500 U	0.290 B	1.100	3.000	8.900	0.230 B	2.200

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 10. Fence Line Air Filter Metal Results
Monthly Composites – December 2002

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	7.600	0.500 U	0.500 U	0.820 B	2.600	6.700	0.040 U	1.500 B
STA 2	10.000	0.500 U	0.500 U	0.990 B	4.500	8.900	0.040 U	1.700 B
STA 3	7.800	0.140 B	0.400 B	1.000	3.000	7.500	0.040 U	2.000 B
STA 4	10.200	0.500 U	0.290 B	0.950 B	2.900	7.600	0.040 U	1.900 B
STA 5	9.600	0.500 U	0.500 U	0.860 B	2.700	7.600	0.040 U	1.700 B
STA 6	11.800	0.500 U	0.500 U	1.200	3.300	8.200	0.040 U	1.900 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 11. Fence Line Air Filter Metal Results
Monthly Composites – January 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	8.300	0.500 U	0.500 U	0.740 B	2.600	5.500	0.040 U	1.200 B
STA 2	9.600	0.500 U	0.500 U	0.920 B	2.900	6.400	0.040 U	1.400 B
STA 3	11.200	0.500 U	0.500 U	0.910 B	2.900	6.100	0.040 U	1.600 B
STA 4	10.600	0.500 U	0.500 U	0.850 B	3.300	6.100	0.040 U	1.600 B
STA 5	14.500	0.500 U	0.280 B	1.100	3.600	8.100	0.040 U	1.900 B
STA 6	14.700	0.500 U	0.280 U	1.300	3.000	7.300	0.040 U	1.600 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 12. Fence Line Air Filter Metal Results
Monthly Composites – February 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	11.700	0.028 B	0.460 B	1.500	3.600	9.900	0.040 U	1.900 B
STA 2	13.500	0.500 U	0.490 B	2.500	4.200	8.100	0.040 U	6.000
STA 3	11.800	0.500 U	0.400 B	2.300	3.900	9.400	0.040 U	2.700
STA 4	7.800	0.500 U	0.440 B	1.400	4.000	10.000	0.040 U	2.400
STA 5	11.500	0.500 U	0.410 B	1.400	3.600	9.300	0.040 U	2.200
STA 6	12.300	0.500 U	0.400 B	1.400	3.600	9.500	0.040 U	1.900 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 13. Fence Line Air Filter Metal Results
Monthly Composites – March 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	8.900	0.500 U	0.310 B	1.600	3.600	10.700	0.040U	2.100
STA 2	7.400	0.500 U	0.320 B	1.200	6.900	8.200	0.040 U	2.000
STA 3	8.000	0.500 U	0.370 B	1.800	3.400	10.400	0.021 B	2.400
STA 4	11.800	0.500 U	0.390 B	2.100	4.500	13.000	0.026 B	3.500
STA 5	10.500	0.500 U	0.310 B	1.800	3.700	10.700	0.040U	3.000
STA 6	12.500	0.500 U	0.420 B	2.000	4.400	13.000	0.023 B	3.100

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 14. Fence Line Air Filter Metal Results
Monthly Composites – April 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	8.200	0.500 U	0.270 B	1.100	4.000	8.500	0.024 B	3.000
STA 2	7.400	0.500 U	0.250 B	0.950 B	3.400	7.400	0.021 B	2.500
STA 3	8.500	0.500 U	0.300 B	1.200	4.300	9.100	0.023 B	4.400
STA 4	7.600	0.500 U	0.270 B	1.200	4.000	8.600	0.021 B	3.000
STA 5	9.900	0.500 U	0.330 B	1.300	4.800	12.000	0.027 B	4.300
STA 6	8.100	0.500 U	0.270 B	1.100	4.200	7.800	0.021 B	4.600

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 15. Fence Line Air Filter Metal Results
Monthly Composites – May 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	12.200	0.500 U	0.260 B	1.100	3.300	7.800	0.026 B	2.000 B
STA 2	9.200	0.500 U	0.260 B	1.500	3.600	8.100	0.040 U	2.300 B
STA 3	10.300	0.500 U	0.250 B	1.300	3.200	8.100	0.040 U	2.200 B
STA 4	9.300	0.500 U	0.240 B	1.100	3.500	7.800	0.040 U	2.100 B
STA 5	10.200	0.500 U	0.230 B	1.000	3.400	8.700	0.021 B	2.900 B
STA 6	8.500	0.500 U	0.240 B	1.400	3.700	8.200	0.029 B	2.700 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 16. Fence Line Air Filter Metal Results
Monthly Composites – June 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	12.300	0.500 U	0.260 B	0.940 B	3.300	8.300	0.040 U	2.000 B
STA 2	8.100	0.500 U	0.260 B	2.900	5.900	8.700	0.040 U	4.600
STA 3	9.200	0.500 U	0.200 B	1.300	3.200	7.500	0.023 B	1.900 B
STA 4	8.100	0.500 U	0.200 B	1.000	3.100	7.200	0.020 B	3.200 B
STA 5	9.700	0.500 U	0.220 B	1.200	3.400	8.000	0.035 B	2.800 B
STA 6	10.700	0.500 U	0.270 B	1.700	3.400	8.100	0.027 B	2.100 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 17. Fence Line Air Filter Metal Results
Monthly Composites – July 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	31.600	0.500 U	0.280 B	1.200	6.500	9.800	0.034 B	2.100 B
STA 2	53.500	0.500 U	0.290 B	1.500	7.100	11.000	0.031 B	3.100 B
STA 3	44.700	0.098 B	0.360 B	1.800	5.600	10.800	0.036 B	2.800 B
STA 4	48.800	0.500 U	0.280 B	1.500	5.500	10.400	0.024 B	3.600 B
STA 5	29.800	0.500 U	0.270 B	1.500	5.600	10.100	0.031 B	5.400
STA 6	28.100	0.500 U	0.260 B	1.700	7.600	9.800	0.031 B	3.000 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 18. Fence Line Air Filter Metal Results
Monthly Composites – August 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	57.600	0.500 U	0.200 B	1.300	3.100	7.900	0.029 B	3.100 B
STA 2	45.500	0.500 U	0.220 B	1.200	4.000	8.400	0.033 B	2.600 B
STA 3	63.700	0.500 U	0.230 B	1.400	3.500	9.100	0.040 U	3.000 B
STA 4	39.200	0.500 U	0.130 B	0.990 B	2.400 B	5.100	0.040 U	3.400 B
STA 5	52.500	0.500 U	0.290 B	1.300	4.200	8.900	0.026 B	2.700 B
STA 6	24.800	0.500 U	0.160 B	0.990 B	3.300	6.100	0.040 U	1.400 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 19. Fence Line Air Filter Metal Results
Monthly Composites – September 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	9.100	0.500 U	0.410 B	1.300	4.200	12.400	0.040 U	2.300
STA 2	11.600	0.500 U	0.360 B	1.400	4.600	13.200	0.032 B	2.700
STA 3	14.100	0.500 U	0.360 B	1.400	4.200	11.200	0.024 B	2.900
STA 4	14.900	0.500 U	0.360 B	1.300	4.300	10.900	0.021 B	2.900
STA 5	13.800	0.500 U	0.350 B	1.300	4.100	10.800	0.027 B	3.400
STA 6	12.700	0.500 U	0.360 B	1.500	4.400	10.900	0.028 B	2.700

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

Table 20. Fence Line Air Filter Metal Results
Monthly Composites – October 2003

Location	Arsenic (µg)	Beryllium (µg)	Cadmium (µg)	Chromium (µg)	Copper (µg)	Lead (µg)	Mercury (µg)	Nickel (µg)
STA 1	37.000	0.500 U	0.400 B	1.300	5.400	16.200	0.030 B	1.700 B
STA 2	38.400	0.500 U	0.420 B	1.400	5.600	13.100	0.036 B	1.800 B
STA 3	58.800	0.500 U	0.400 B	1.500	4.900	12.800	0.028 B	1.700 B
STA 4	44.500	0.057 B	0.470 B	1.600	5.300	14.600	0.034 B	2.000 B
STA 5	64.400	0.500 U	0.430 B	1.500	4.900	12.100	0.032 B	1.600 B
STA 6	65.300	0.500 U	0.420 B	1.600	5.500	12.700	0.037 B	1.700 B

U = not detected at or above the laboratory reporting limit provided.
B = the compound was found in the sample, as well as the associated Laboratory QC blank

4.0 CONCLUSION

In viewing the graphs, several trends are evident depending upon the media sampled but cannot be duplicated between the same time period for the previous year. Upward trends occur at sampling locations that cannot be affected by PBRF operations (past or present). Sediment sampling results for the reporting period appear to validate that upward trends are the result of seasonal variation when during dry weather conditions (as is the case during the late summer through late winter months) metals accumulate in the sediments and are more readily detected. Regardless of the sampling result or trend, it is important to note that no decommissioning activities have occurred during the reporting period that could contribute to any result above Project Specific Action Limits (PSAL).

5.0 REFERENCES

U.S. Army Corps of Engineers. Louisville District. NASA PBRF Decommissioning Project Environmental Media Sampling and Analysis Cumulative Report November 2000 – October 2002. Sandusky, Ohio. March 2003.

U.S. Army Corps of Engineers. Louisville District. NASA PBRF Decommissioning Project "Environmental Media Sampling and Analysis Plan. Sandusky, Ohio. September 2002.

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