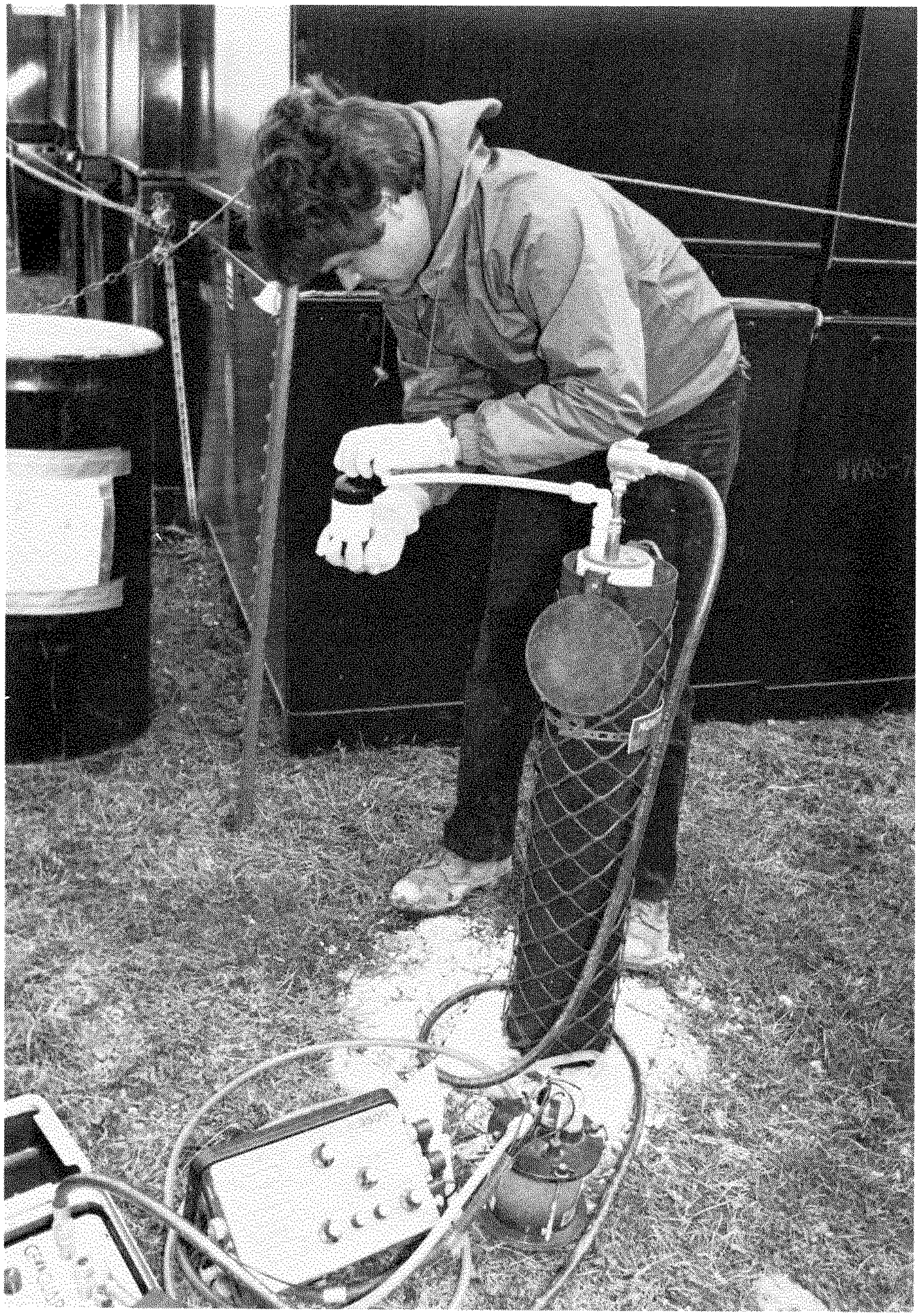

**Sampling with a Dedicated Bladder Pump
Installed in an On-site Groundwater Monitoring Well**

Groundwater Monitoring

Geologic History of the West Valley Site

The West Valley Demonstration Project is located on the dissected and glaciated Allegheny Plateau at the northern border of Cattaraugus County in southwestern New York. The area is drained by Cattaraugus Creek, which is part of the Great Lakes-St. Lawrence watershed (Tesmer 1975). Geologic conditions encountered at the site are the result of geologically recent events in the earth's history, including repeated glaciation during the Pleistocene epoch, 1.6 million to ten thousand years ago.

The WVDP site rests immediately on a thick sequence of glacial deposits that ranges up to 150 meters in thickness. These glacial deposits are underlain by a bedrock valley eroded into the upper Devonian shales and siltstones of the Canadaway and Conneaut Groups, which dip southward at about 5 m/km (Rickard 1975). Total relief in the area is approximately 400 meters (1,300 ft.), with summits reaching 732 meters (2,400 ft.) above sea level.

Oscillations of the Laurentide ice sheet during the ice ages include four major stages of ice advance and retreat. The last of these, and the one of greatest concern here, was the Wisconsinan glaciation (Broughton et al. 1966).

The most widespread glacial unit in the site area is the Kent till, deposited between 15,500 and 24,000 years ago toward the end of the Wisconsinan glaciation. At that time the ancestral Buttermilk Creek Valley was covered with ice. As the glacier receded, debris trapped in the ice was left behind in the vicinity of West Valley. Meltwater, confined to the valley by the debris dam at West Valley and the ice front, formed a glacial lake that persisted until the glacier receded far enough northward to uncover older drainageways. As the ice continued to melt, more material was released and deposited to form the lacustrine and kame delta deposits that presently overlie the Kent till. Continued recession of the glacier ultimately led to drainage of the proglacial lake and exposure of its sediments to erosion (LaFleur 1979).

About 15,000 years ago the ice began its last advance (Albanese et al. 1984). Material from this advance covered the kame delta and lacustrine deposits with as much as 40 meters (130 ft.) of glacial till. This unit, the Lavery till, is the uppermost unit throughout much of the site, with a thickness of about 24 meters (80 ft.) at the waste burial areas. The retreat of the Lavery ice left behind another proglacial lake that ultimately drained, allowing modern Buttermilk Creek to flow northward to Cattaraugus Creek. The modern Buttermilk Creek has cut the modern valley since the final retreat of the Wisconsinan glacier. Post-Lavery outwash and alluvial fans, including the fan that underlies the northern part of the WVDP, were deposited on the Lavery till between 15,000 and 14,200 years ago (LaFleur 1979).

Hydrogeology of the West Valley Site

The site can be divided into two regions: the north plateau, on which the plant and its associated facilities reside, and the south plateau, which contains the NRC-licensed disposal area (NDA) and the state-licensed disposal area (SDA) that were previously used to dispose of waste. (See Fig.3-1, a geological cross section of the north plateau, and Fig.3-2, a geological cross section of the south plateau.)

South Plateau

The uppermost geologic unit on the south plateau is the Lavery till, a very compact, gray silty clay with scattered pods of silt to fine sand. Below this is a sequence of more permeable lacustrine silt and sand, which in turn overlies the less permeable Kent till.

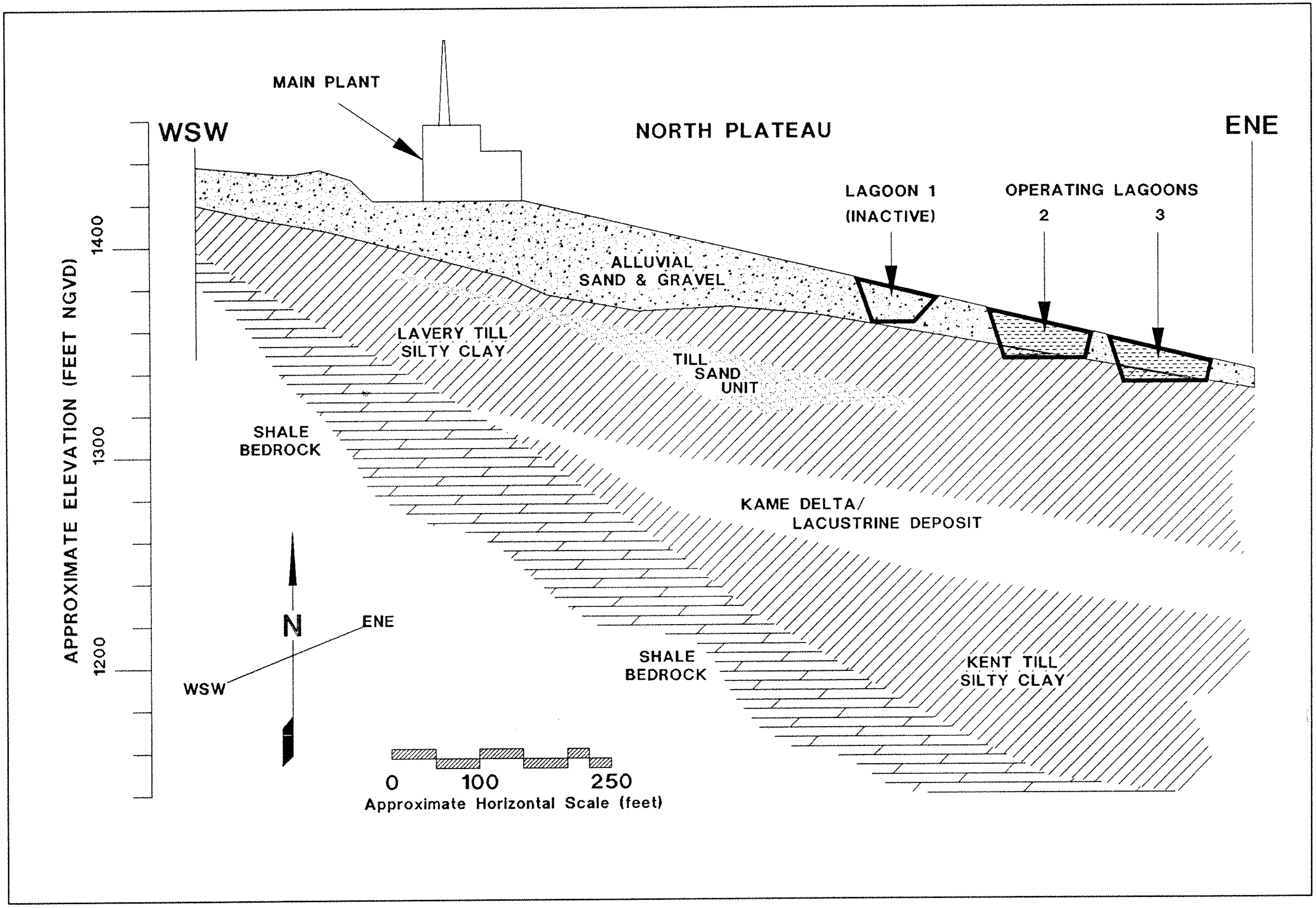

Figure 3-1. Geologic Cross Section Through the North Plateau

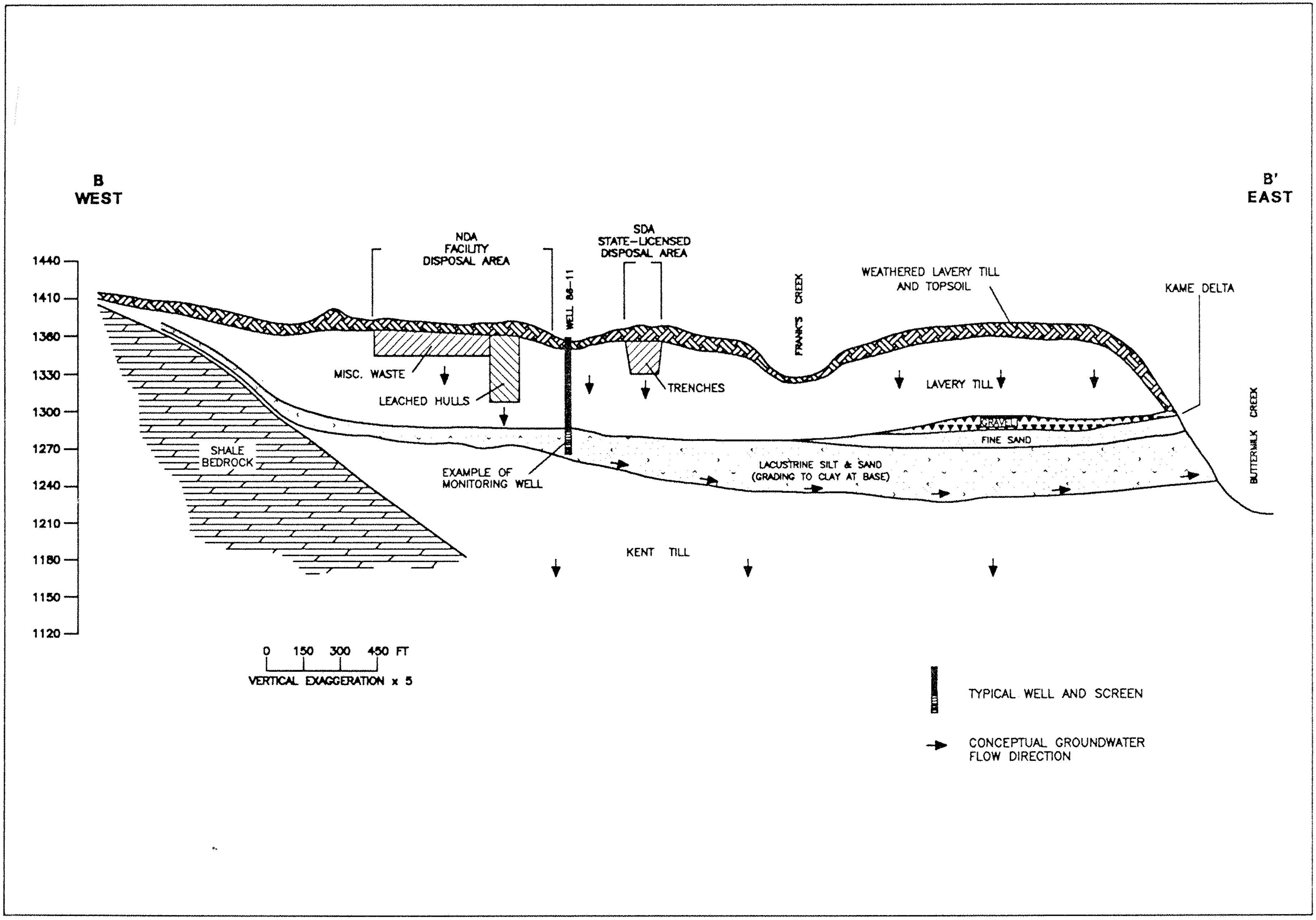

Figure 3-2. Geological Cross Section Through the South Plateau.

The water table beneath the south plateau occurs in the upper 4.5 meters (0 ft. to 15 ft.) of the Lavery till. Groundwater flow in this unit, for the most part, is vertical to the lacustrine unit. The upper, weathered portion of the Lavery till exhibits a horizontal flow, which enables groundwater to move laterally before moving downward or discharging to nearby land-surface depressions or stream channels. (Bergeron and Bugliosi 1988). Some laterally moving water eventually percolates downward into the underlying unweathered till. Values of vertical and horizontal hydraulic conductivity obtained from laboratory analysis of undisturbed cores and from field analyses of piezometer recovery tests suggest that the till is virtually isotropic. The hydraulic conductivity of the fresh, unweathered till averages 2.92 x 10^{-8} cm/sec. On a field scale, the hydraulic conductivity of the fractured unweathered till is five times greater than that of the fresh, unweathered till, and the hydraulic conductivity of the fractured weathered till is ten times greater than that of the fresh, unweathered till.

The lacustrine sequence at the WVDP acts as a semiconfined unit that is recharged primarily from the bedrock to the west. Water levels in piezometers completed in this unit indicate a northeastward lateral flow under a gradient of 0.023. Minor recharge also occurs from the overlying Lavery till, making this unit a possible conduit of Lavery discharge to Buttermilk Creek. The lacustrine unit is underlain by the relatively impermeable Kent till (LaFleur 1979).

North Plateau

The north plateau differs from the south plateau in that it is mantled by a sequence of alluvial sand and gravel up to 10 meters thick that is immediately underlain by the Lavery till.

The depth to the groundwater on the north plateau varies from 0 meters to 5 meters (0 ft. to 16 ft.), being deepest at the process building and intersecting the surface farther north towards the security fence. Most of the groundwater beneath the north plateau moves horizontally through the alluvial sand and gravel unit from an area southwest of the process building to the northeast, southeast, and east; a small percentage percolates downward into the underlying Lavery till (Yager 1987). Groundwater discharge from the north plateau occurs at seepage points along the banks of Frank's Creek, Erdman Brook, Quarry Creek, and at the wetlands near the northern perimeter of the security fence. The geometric mean of the hydraulic conductivity of the alluvial sand and gravel unit is 4.6 x 10^{-3} cm/sec (Bergeron et al. 1987). Recent on-site investigations (1989-1990) identified a sandy unit of limited areal extent and variable thickness within the Lavery till, primarily beneath the north plateau. This unit, called the till-sand, was not specifically identified in previous studies as a hydrologic unit.

Groundwater Monitoring Program Overview

An expanded groundwater monitoring program was phased in during 1991. Ninety-six new wells were added to thirteen pre-existing monitoring points to form the expanded network. These 109 groundwater monitoring points provide radiological and chemical surveillance of both active and inactive super solid waste management units (SSWMUs) and of general site-wide conditions. On-site groundwater monitoring point locations are shown on Fig. 3-3.

Monitoring includes the five different geologic units discussed above: the sand and gravel unit, the weathered Lavery till, the unweathered Lavery till, the till-sand unit, and the lacustrine unit. Table 3-1 lists the twelve super solid waste management units, the well position within the waste management unit, the geologic unit monitored, and the depth of each well. Figure 3-4 shows the outline of the twelve identified super solid waste management units at the West Valley Demonstration Project. (Twenty-one of the wells are in the state-licensed disposal area [SDA] and are the responsibility of NYSERDA. Although the state-licensed disposal area is a closed radioactive waste landfill contiguous to the Project premises, the WVDP is not responsible for the facilities or activities relating to it. Under a joint agreement with the New York State Energy Research and Development Authority (NYSERDA), however, the Project provides specifically requested technical support to NYSERDA in SDA-related matters.)

Groundwater monitoring fulfills multiple technical and regulatory requirements, which are summarized in the site's ENVIRONMENTAL MONITORING PROGRAM PLAN, WVDP-098 (WVNS 1991), the draft SAMPLING AND ANALYSIS PLAN FOR THE GROUNDWATER MONITORING NETWORK (WVNS 1990), the annual site GROUNDWATER PROTECTION MANAGEMENT PROGRAM PLAN, WVDP-091 (WVNS 1990), and the draft RCRA FACILITY INVESTIGATION WORKPLAN, WVDP-113 (WVNS 1991).

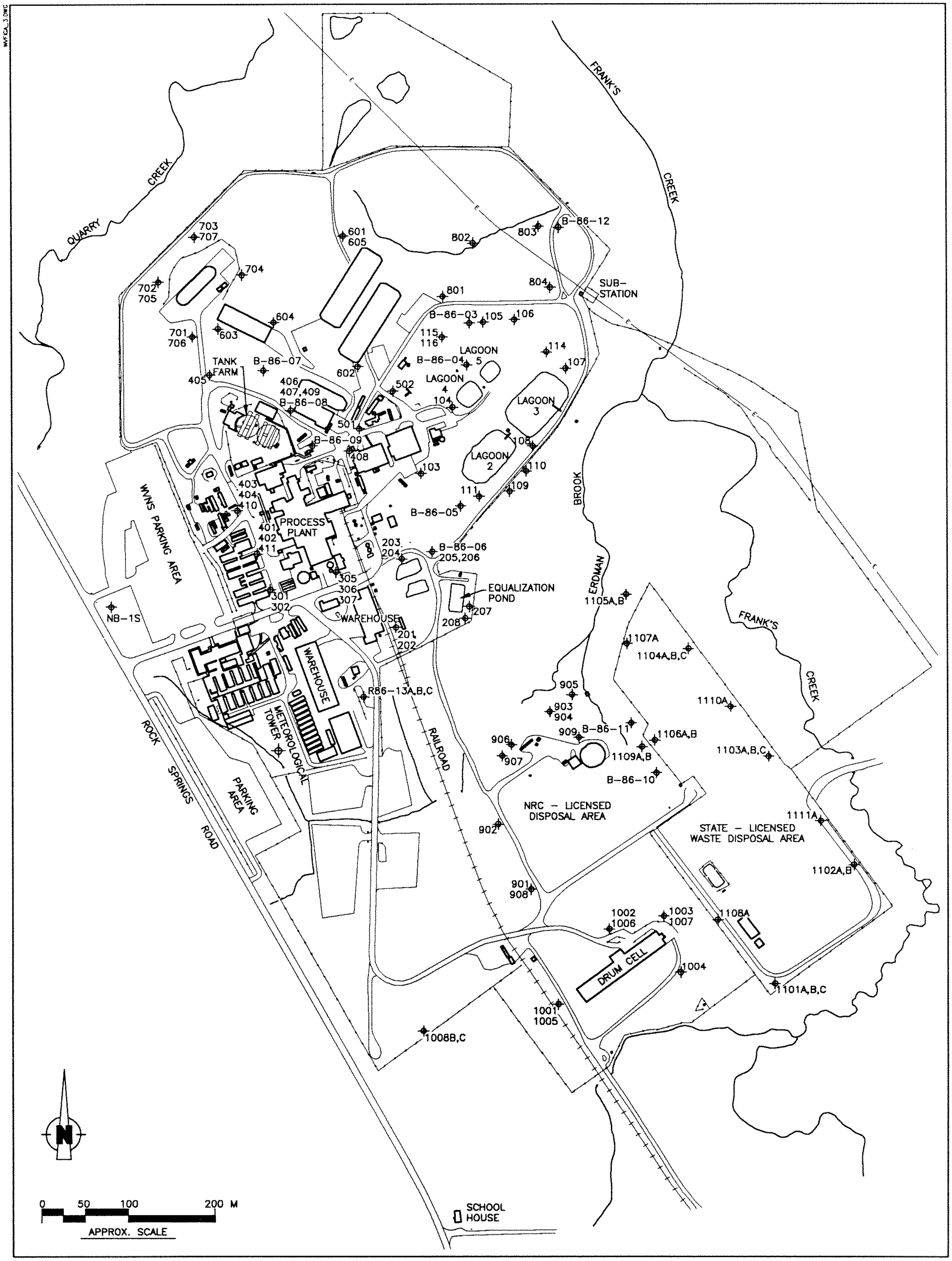

Figure 3-3. Location of On-Site Groundwater Network Wells.

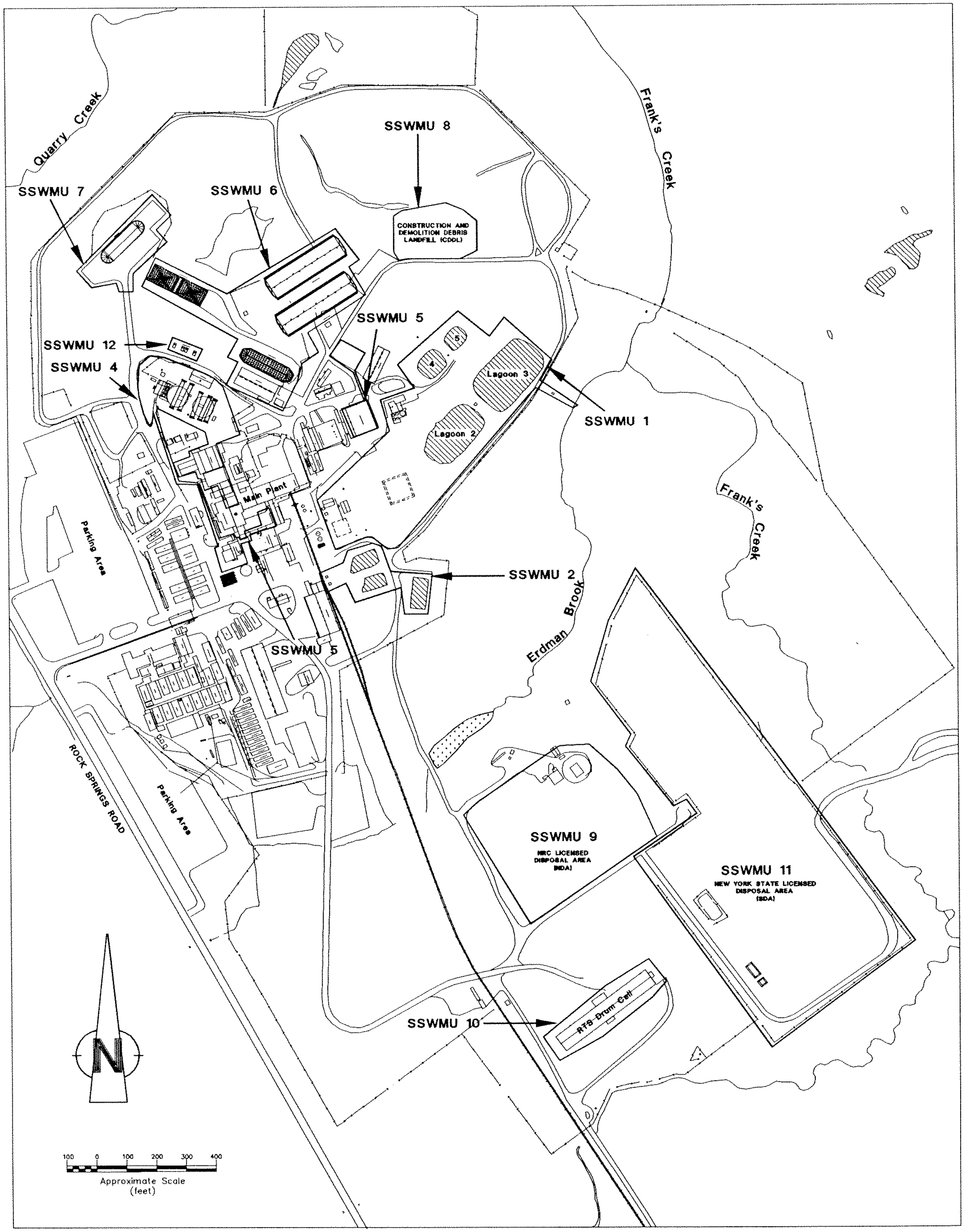

Figure 3-4. Location of Super Solid Waste Management Units (SSWMUs)

TABLE 3-1

GROUNDWATER MONITORING NETWORK: SUPER SOLID WASTE MANAGEMENT UNITS

SSWMUs and Constituent SWMUs	Well Identification Number	Geological Unit Monitored	Well Position	Depth(ft) Belowgrade
SSWMU No. 1 - Low-Level Waste Treatment Facilities:				
	WNW-0103	S	U	21.00
• Former Lagoon 1	WNW-0104	S	U	23.00
• LLWTF Lagoons	WNW-0105	S	D	28.00
• LLWTF Building	WNW-0106	S	D	14.50
• Interceptors	WNW-0107	U	D	28.00
• Neutralizer Pit	WNW-0108	U	D	33.00
	WNW-0109	U	D	33.00
	WNW-0110	U	D	33.00
	WNW-0111	S	D	11.00
	WNW-0114	U	D	29.00
	WNW-0115	U	D*	28.00
	WNW-0116	S	D*	11.00
	WNW-86-03	S	D*	25.42
	WNW-86-04	S	D*	23.00
	WNW-86-05	S	D	13.00
	WNSP008	Groundwater French Drain Monitoring Point		
SSWMU No. 2 - Miscellaneous Small Units:				
	WNW-0201	S	U	20.00
• Sludge Ponds	WNW-0202	TS	U	38.00
• Solvent Dike	WNW-0203	S	U	18.00
• Effluent Mixing Basin	WNW-0204	TS	U	43.00
• Paper Incinerator	WNW-0205	S	D	11.00
	WNW-0206	TS	D	37.80
	WNW-0207	S,U	D	11.00
	WNW-0208	TS	D	23.00
	WNW-86-06	S	D	13.00
SSWMU No. 3 - Liquid Waste Treatment System:				
	WNW-0301	S	U	16.00
• Liquid Waste	WNW-0302	TS	U	28.00
Treatment System	WNW-0305	S	D*	31.00
• Cement Solidification System	WNW-0306	L	D*	81.00
• Main Process Bldg. (Specific Areas)	WNW-0307	S	D*	16.00
• Background (North Plateau)	WNW-NB1S	S,W	B	13.00

Key:

* Position to be further evaluated

Well position in SSWMU: U = upgradient; D = downgradient; B = background; C = crossgradient

Geologic Unit: W = weathered till; U = unweathered till; S = sand and gravel; L = lacustrine; TS = till-sand

TABLE 3-1 (continued)

GROUNDWATER MONITORING NETWORK: SUPER SOLID WASTE MANAGEMENT UNITS

SSWMUs and Constituent SWMUs	Well Identification Number	Geological Unit Monitored	Well Position	Depth (ft) Belowgrade
SSWMU No. 4 - HLW Storage and Processing Area:				
	WNW-0401	S,U	U	16.00
• Vitrification Facility	WNW-0402	TS	U	29.00
• Vitrification Test Tanks	WNW-0403	S	U	13.00
• HLW Tanks	WNW-0404	TS	U	36.50
• Supernatant Treatment System	WNW-0405	U	D	12.50
	WNW-0406	S	D	16.80
	WNW-0407	U,L	D	75.50
	WNW-0408	S	D	38.00
	WNW-0409	U	D	55.00
	WNW-0410	L	U	78.00
	WNW-0411	U,L	U	65.50
	WNW-86-07	S	D	18.75
	WNW-86-08	S	D	19.00
	WNW-86-09	S	D	25.00
SSWMU No. 5 - Maintenance Shop Leach Field:				
	WNW-0501	S	U	33.00
• Maintenance Shop Leach Field	WNW-0502	S	D	18.00
SSWMU No. 6 - Low-Level Waste Storage Area:				
	WNW-0601	S	D	6.00
• Hardstands (Old & New)	WNW-0602	S	D	13.00
• Lag Storage	WNW-0603	S	U	13.00
• Lag Storage Additions	WNW-0604	S	D	11.00
	WNW-0605	S,U	D	11.00
	WNW-86-07	S	U	18.75
	WNW-86-08	S	U	19.00
SSWMU No. 7 - CPC Waste Storage Area:				
	WNW-0701	S,TS	U	28.00
• CPC Waste Storage Area	WNW-0702	TS	D	38.00
	WNW-0703	U	D	21.00
	WNW-0704	U	D	15.50
	WNW-0705	U	D	21.00
	WNW-0706	S	U	11.00
	WNW-0707	W,U	D	11.00

Key:

* Position to be further evaluated

Well position in SSWMU: U = upgradient; D = downgradient; B = background; C = crossgradient

Geologic Unit: W = weathered till; U = unweathered till; S = sand and gravel; L = lacustrine; TS = till-sand

TABLE 3-1 (continued)

GROUNDWATER MONITORING NETWORK: SUPER SOLID WASTE MANAGEMENT UNITS

SSWMUs and Constituent SWMUs	*Well Identification Number*	*Geological Unit Monitored*	*Well Position*	*Depth (ft) Belowgrade*
SSWMU No. 8 - Construction and Demolition Debris Landfill:				
	WNW-0801	*S*	*U*	*17.50*
• *Former Construction and Demolition Debris Landfill*	*WNW-0802*	*S,U*	*D*	*11.00*
	WNW-0803	*S*	*D*	*18.00*
	WNW-0804	*S*	*U*	*9.00*
	WNGSEEP	*Groundwater Seepage*		
	WNDMPNE	*Monitoring Points*		
	WNW86-12	*S*	*D*	*18.83*
SSWMU No. 9 - NRC-Licensed Disposal Area:				
	WNW-0901	*L,U*	*U*	*136.0*
• *NRC-Licensed Disposal Area*	*WNW-0902*	*L,U*	*U*	*128.0*
• *Container Storage Area*	*WNW-0903*	*L,U*	*D**	*133.0*
• *Trench Interceptor Project*	*WNW-0904*	*U*	*D*	*26.00*
	WNW-0905	*TS*	*D*	*23.00*
	WNW-0906	*W*	*D**	*10.00*
	WNW-0907	*W,U*	*D**	*16.00*
	WNW-0908	*W,U*	*U*	*21.00*
	WNW-0909	*W,U*	*D*	*23.0*
	WNW-86-10	*L*	*D*	*114.0*
	WNW-86-11	*L*	*D*	*120.0*
SSWMU No. 10 - IRTS Drum Cell:				
	WNW-1001	*L,U*	*U*	*116.0*
• *IRTS Drum Cell*	*WNW-1002*	*L,U*	*D*	*113.0*
	WNW-1003	*L*	*D*	*138.0*
	WNW-1004	*L,U*	*D*	*108.0*
	WNW-1005	*W,U*	*U*	*19.00*
	WNW-1006	*W,U*	*D*	*20.00*
	WNW-1007	*W,U*	*D*	*23.00*
• *Background (South Plateau)*	*WNW-1008b*	*L,U*	*B*	*51.00*
	WNW-1008c	*W,U*	*B*	*18.00*

Key:

* *Position to be further evaluated*

Well position in SSWMU: U = upgradient; D = downgradient; B = background; C = crossgradient

Geologic Unit: W = weathered till; U = unweathered till; S = sand and gravel; L = lacustrine; TS = till-sand

TABLE 3-1 (concluded)

GROUNDWATER MONITORING NETWORK: SUPER SOLID WASTE MANAGEMENT UNITS

SSWMUs and Constituent SWMUs	Well Identification Number	Geological Unit Monitored	Well Position	Depth (ft) Belowgrade
SSWMU No. 11 - State-Licensed Disposal Area:				
• State-Licensed Disposal Area (SDA)	WNW-1101a	W,U	U	16.00
	WNW-1101b	U	U	30.00
	WNW-1001c	L	U	110.0
	WNW-1102a	W,U	D	17.00
	WNW-1102b	U	D	31.00
	WNW-1103a	W,U	D	16.00
	WNW-1103b	U	D	26.00
	WNW-1103c	L	D	111.0
	WNW-1104a	W,U	D	19.00
	WNW-1104b	U	D	36.00
	WNW-1104c	L	D	114.0
	WNW-1105a	U	D	21.00
	WNW-1105b	U	D	36.00
	WNW-1106a	W,U	U	16.00
	WNW-1106b	U	U	31.00
	WNW-1107a	W,U	D	19.00
	WNW-1108a	W,U	U	16.00
	WNW-1109a	W,U	U	16.00
	WNW-1109b	U	U	31.00
	WNW-1110	W,U	D	20.00
	WNW-1111	U	D	21.00
SSWMU #12 - Hazardous Waste Storage lockers	(No wells installed for SSWMU #12)			
Motor Fuel Storage Area (Monitors Underground Storage Tanks; not a SSWMU)	R86-13A	S,U	C	8.00
	R86-13B	S	C	8.00
	R86-13C	S	D	6.50

Key:

* Position to be further evaluated

Well position in SSWMU: U = upgradient; D = downgradient; B = background; C = crossgradient

Geologic Unit: W = weathered till; U = unweathered till; S = sand and gravel; L = lacustrine; TS = till-sand

The data generated as part of the groundwater monitoring program will also be used to support preparation of an environmental impact statement (EIS) that will assess the effect of Project completion and site closure.

Four designations are often used to indicate a well's function within a groundwater monitoring program:

Upgradient well. A well installed hydraulically upgradient of the unit under study that is capable of yielding groundwater samples that are representative of local conditions and that are not affected by the unit in question.

Downgradient well. A well installed hydraulically downgradient of the unit that is capable of detecting the migration of contaminants from the unit under study.

Background well. A well installed hydraulically upgradient of all waste management units that is capable of yielding groundwater samples that are representative of natural conditions. In some cases upgradient wells may be downgradient of other units, which makes them unsuitable for use as true background wells. However, they are still useful in providing upgradient information about the unit under study.

Crossgradient well. A well installed to the side of the major downgradient flow path.

Table 3-1 identifies the position of a well relative to the waste management unit monitored. The wells monitoring a given geologic unit (e.g., sand and gravel, lacustrine) also may be arranged in a generalized upgradient to downgradient order based upon their location within the geologic unit. The hydraulic position of a well relative to a super solid waste management unit (i.e., upgradient or downgradient) does not necessarily match that same well's position within a geologic unit. For example, a well upgradient relative to a SSWMU may be located at any position within a geologic unit, depending on the geographic position of the SSWMU within the geologic unit. In general, the following text and graphics refer to the hydraulic position of monitoring wells within their respective geologic units, thus providing a site-wide geologic unit perspective.

Initial sampling of selected wells in the expanded network for a subset of the parameters listed in Table 3-2 began in 1990. Wells in the expanded monitoring network were gradually incorporated into the sampling schedule (Table 3-3).

Sampling at additional key wells began in January 1991, including wells monitoring SSWMUs #1,7, and 8, and wells from the former monitoring program. Samples were collected and analyzed for alpha, beta, tritium, pH, and conductivity. In addition, wells around the SDA were sampled and analyzed for alpha, beta, gamma isotopic, tritium, pH, and conductivity.

By May 1991 the expanded monitoring network locations had been sampled for indicator parameters. All points with adequate volume were sampled in May and June for the indicator and groundwater parameters listed in Table 3-2. The SDA wells were sampled for indicator, groundwater, and drinking water parameters. By October 1991 the full schedule had been initiated for all site groundwater monitoring points.

Groundwater Sampling Parameters

The three categories of groundwater sampling parameters, collected as noted in Table 3-2, are contamination indicator parameters, groundwater quality parameters, and EPA interim primary drinking water quality parameters. Table 3-3 indicates the way in which sampling for these parameters was incorporated into the program during 1991.

Contamination indicator parameters: Samples are collected eight times a year (four samples each semiannual period). Monitoring the contamination indicator parameters helps to identify more quickly any potential effect of past or present site operations.

Groundwater quality parameters: Samples are collected two times a year (one sample each semiannual period). The groundwater quality parameters selected provide information essential to migration modeling and to evaluating the indicator parameter results and the potential effect of a release.

EPA interim primary drinking water parameters: Samples are collected four times a year for one year only. These samples establish a baseline for water quality and are compared to the drinking water standards.

Sampling Methodology

Samples are collected from the monitoring wells using either Teflon well bailers or bladder pumps. Both of these methods meet all regulatory requirements for groundwater sample collection.

TABLE 3-2

SCHEDULE OF GROUNDWATER SAMPLING AND ANALYSIS

Contamination Indicator Parameters	
(Scheduled eight times per year)	*pH**
	Total Organic Carbon
	Gross Alpha
	Gamma Scan
	*Conductivity**
	Total Organic Halogens
	Gross Beta
	Tritium
	Volatile Organic Analysis
Groundwater Quality Parameters	
(Scheduled two times per year)	*Chloride*
	Iron
	Sodium
	Manganese
	Phenols
	Sulfate
	Magnesium
	Nitrate + Nitrite-N
	Calcium
	Potassium
	Ammonia
	Bicarbonate/Carbonate
EPA Interim Primary Drinking Water Standards	
(Scheduled four times per year, one year only)	*Arsenic*
	Barium
	Cadmium
	Chromium
	Lead
	Mercury
	Selenium
	Silver
	Fluoride
	Endrin
	Methoxychlor
	2,4 D
	Radium
	Nitrate + Nitrite-N
	Lindane
	Toxaphene
	2,4,5-TP Silvex
	*Turbidity **

** Field measurement*

TABLE 3-3

1991 PHASING-IN SCHEDULE FOR EXPANDED GROUNDWATER MONITORING NETWORK

Date	*Sample Rep*	*Contamination Indicator Parameters Scheduled and Collected*	*Groundwater Quality Parameters Scheduled and Collected*	*Drinking Water Quality Parameters Scheduled and Collected*
1/1/91 - 2/1/91	1	P	———	———
2/2/91 - 3/31/91	2	P	———	———
4/1/91 - 5/15/91	3	F	———	———
5/16/91 - 6/30/91	4	F	F	SDA
7/1/91 - 8/15/91	5	F	———	———
8/16/91 - 9/30/91	6	F	———	SDA
10/1/91 - 11/15/91	7	F	———	———
11/16/91 - 12/31/91	8	F	F	F
Total samplings per well in 1991:		6-8	2	1-3

Key:

P = Phase-in: Selected wells sampled for selected parameters.

F = All wells sampled for full parameters.

SDA = SDA wells only sampled for full parameters

The method of collection used depends on well construction, water depth, and the water-yielding characteristics of the well. Teflon bailers are used in wells with low standing volume; bladder pumps are used in wells with good water-yielding characteristics.

The Teflon bailer, a tube with a check valve at the bottom and the top, is lowered into the well until it reaches the desired point in the water column. The bailer is lowered slowly to ensure that the water column is not agitated and is then withdrawn from the well with a sample and emptied into a sample container. The bailer, bailer line, and bottom-emptying device used to drain the bailer are dedicated to the well, i.e., are used exclusively for that well at all times.

Bladder pumps use compressed air to gently squeeze a Teflon bladder, encased in a stainless steel tube, that is located near the bottom of the well. The air forces water out of a sample line extending from the pump to the top of the well. When the pressure is released, new groundwater flows into the bladder. A series of check valves ensures that the water flows only in one direction. The drive air is always kept separate from the sample and is expelled to the surface by a separate line.

Bladder pumps reduce mixing and agitation of the water in the well. Each bladder pump system is dedicated to its individual well to reduce the likelihood of sample contamination from external materials or cross contamination. The compressor and air control box are used from well to well but do not contact the sample.

To ensure that only representative groundwater is sampled, three well volumes are removed (purged) from the well before the actual samples are collected. If three well-casing volumes cannot be removed because of limited recharge, purging the well to dryness achieves the same results. Conductivity and pH are measured before and after sampling to help determine whether the quality of the groundwater changed while samples were being collected.

Immediately after the samples are collected they are put into a cooler and returned to the Project's Environmental Laboratory. The samples are then either packaged for overnight delivery to an off-site contract laboratory or put into controlled storage to await on-site testing.

Ten off-site wells, sampled for radiological parameters, pH, and conductivity, were also part of the groundwater monitoring program during 1991. These wells are used by site neighbors as sources of drinking water (Fig. 3-5).

Groundwater Monitoring Results

Results of the 1991 groundwater monitoring program are summarized below. Complete data are found in *Appendix E.*

Unlike last year's report, which presented the groundwater monitoring data based on identified SSWMUs, this year's results are grouped and summarized based upon the five geologic units. The purpose of grouping results based on geologic units is two-fold: it presents the results of the groundwater monitoring program on a site-wide basis and it provides an initial overview of the results of the groundwater monitoring program that may form the basis for additional reports to follow. More detailed assessment of potential effects of SSWMUs on the environment will be prepared as part of the site's RFI WORKPLAN required by the RCRA 3008(h) Order on Consent.

There are many aspects to the successful implementation of the WVDP's groundwater monitoring program, all of which are integral to generating high quality results representative of the groundwater environment. Some of these aspects include the proper placement of groundwater monitoring wells, the use of appropriate methods to collect samples and to identify and track samples and analytical results, thorough review of analytical data and quality control information, and appropriate methods of presenting, summarizing, and evaluating the resulting data.

Presentation of Results in Tables

Appendix E contains tables showing individual results of sampling for the contamination indicator parameters (*Appendix E*, Tables E-1 through E-5) and the groundwater quality parameters (*Appendix E*, Tables E-6 through E-10) as listed in Table 3-1. Contamination indicator parameters and groundwater quality parameters are listed in Table 3-2.

The tables in *Appendix E* present the results of the groundwater monitoring program grouped according to the five different geologic units monitored: the sand and gravel unit, the till-sand unit, the unweathered lavery till unit, the lacustrine unit, and the weathered lavery till unit. Results of sampling for volatile organics are part of the contamination indicator parameter grouping and are reported only where confirmed positive values were obtained (*Appendix E*, Table E-11).

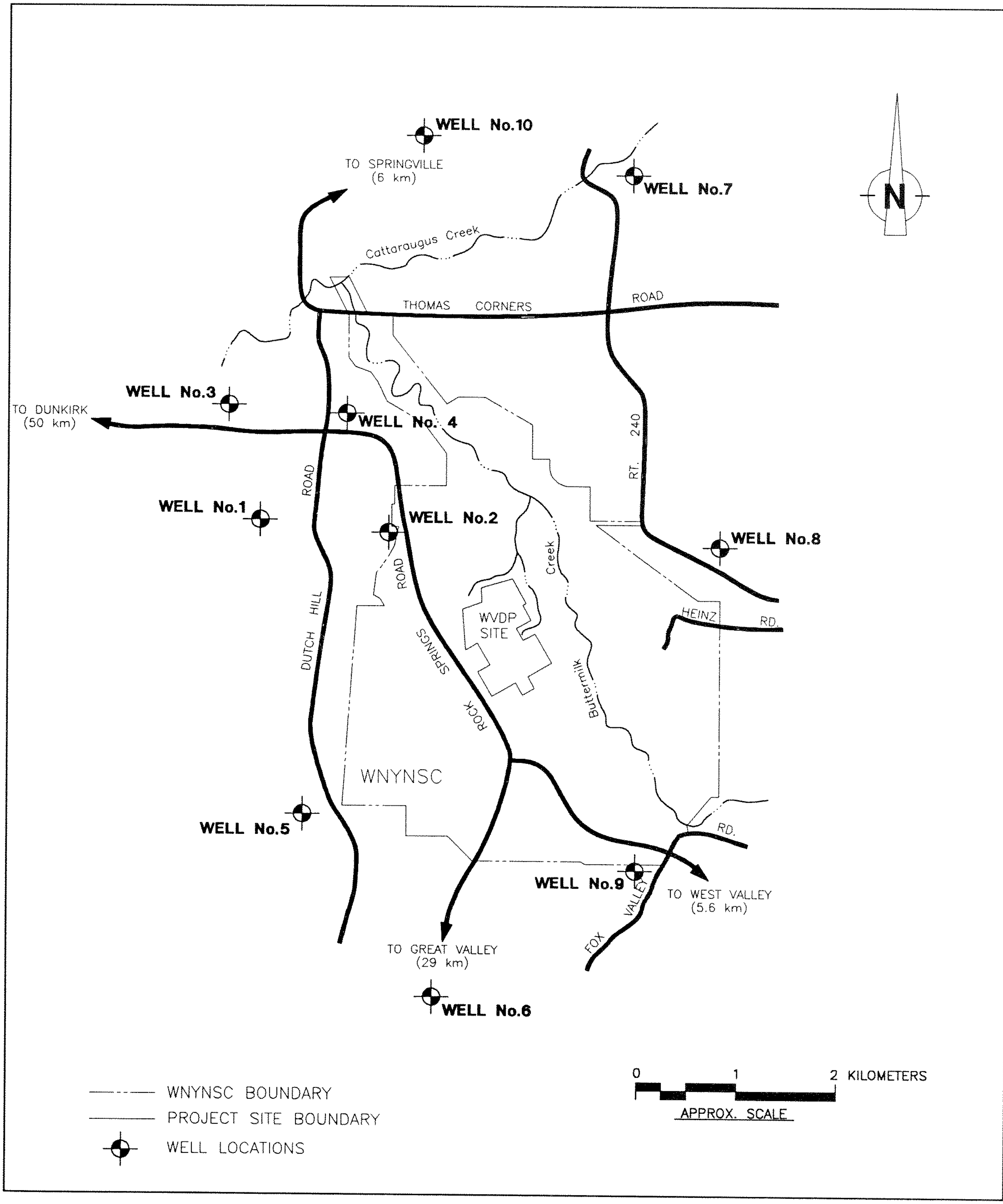

Figure 3-5. Off–Site Groundwater Monitoring Points.

Groundwater monitoring data to compare with EPA interim primary drinking water standards will be reviewed after the annual cycle of quarterly sampling and analysis now in progress is completed. These results will be reported in the 1992 SITE ENVIRONMENTAL REPORT.

The tables summarizing the contamination indicator parameters also include general information about each well's hydraulic position relative to other wells within the same geologic unit. These positions are identified by the terms "UP," which refers to either background or upgradient wells, and "DOWN - B," "DOWN - C," and "DOWN - D." Upgradient locations are designated "UP" because they are upgradient of all the other locations. Downgradient locations are designated B, C, or D to indicate their positions relative to each other. For example, wells denoted as "DOWN - C" in the sand and gravel unit are downgradient of "UP" and "DOWN - B" wells and upgradient to "DOWN - D" wells. These groupings have been used in order to provide a logical basis for presenting the groundwater monitoring data in the tables and graphics within this report.

The tables of contamination indicator data also give information about the sample collection period. The groundwater collection year is divided into two semiannual periods. Within each semiannual period four replicate samples, or "reps," may be collected from each well over evenly spaced six-week periods. Four of the reps may be collected during the period of January through June, and the remaining four reps may be collected during the period from July through December. Because the groundwater sampling program was phased in gradually during 1991 not all wells were sampled the same number of times during the year. (This is the primary reason for blank rows in some of the *Appendix E* contamination indicator parameter tables.) Table 3-3 summarizes the incorporation of all wells into the groundwater sampling program during 1991.

Presentation of Results in Graphs

A second way in which groundwater monitoring results are presented is through graphs to show trends in the data or to summarize large amounts of data into an interpretable format. Three different graphic aids are used in this report:

Multiple Box-and-Whisker Plots: The multiple-box-and-whisker plot is used to present contamination indicator data well-by-well for all wells grouped within the same geologic unit. All individual analytical results obtained for a selected parameter (pH, conductivity, total organic carbon, total organic halogens, gross alpha, gross beta, and tritium) were used to form the dimensions of the box-and-whisker diagram for each well within a given geologic unit. Box-and-whisker plots allow results of similar sample analyses for all wells within a geologic unit to be visually compared to each other.

Figure 3-6 is an example of a multiple box-and-whisker plot.

- The horizontal line within the box shows the median of the data set for a given well.
- The box outline itself shows the range of the middle 50% of the data for a given well (the upper and lower quartiles).
- The whisker extension shows the range of the data for a given well. (Values beyond 1.5 times the length of the box are plotted as individual points.)

The sample counting results for gross alpha, gross beta, and tritium, even if below the minimum detectable concentration, were used to generate the box-and-whisker plots. Thus, negative values sometimes were included.

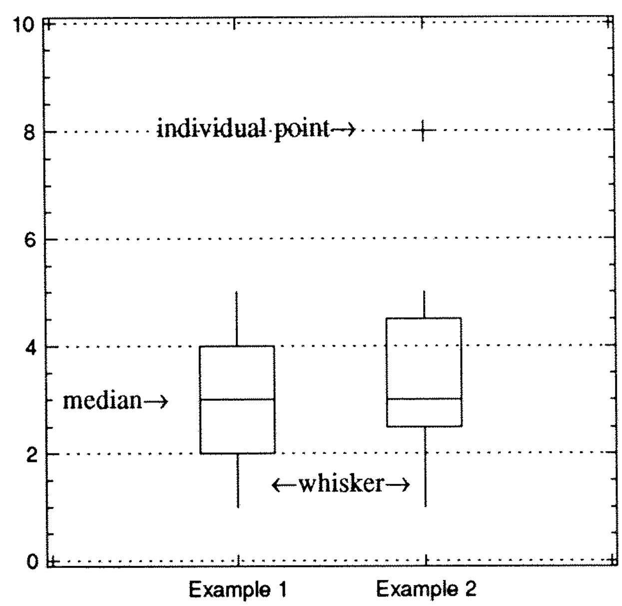

FIGURE 3 - 6. SAMPLE BOX-AND-WHISKER PLOT

This is most common for the gross alpha analyses, where sample radiological counting results are sometimes lower than the associated instrument background. In these cases, the sample results would be reported as "less than" values in the data tables in Appendix E.

All box-and-whisker plots shown in this section present the upgradient wells on the left side of the figure with the upgradient location code prefixed with the letter "A." Downgradient locations are plotted to the right and use the letters "B" through "D," as discussed above, to distinguish relative position within the downgradient flow regime.

Trend Plot: Trend plots or line plots can show how concentrations of a particular parameter change over time at selected monitoring locations. Results for the volatile organic compounds 1,1-dichloroethane (1,1-DCA) and 1,1,1-trichloroethane (1,1,1-TCA) are plotted using this format (see Fig. 3-42). Long-term trends of gross beta and tritium for selected groundwater monitoring locations are also shown in Fig. 3-43 and Fig. 3-44.

Pie Charts: Pie charts showing the major ion composition of groundwater for each well are found in *Appendix E*. These charts were constructed using averaged results of two samples collected for the major cations (calcium, magnesium, sodium, potassium) and anions (chloride, sulfate, bicarbonate and carbonate and, in some cases, hydroxide). The pie charts also indicate how the levels of cations and anions in the sample balance. Figure 3-6a is an example explanatory figure.

Results of Contamination Indicator Monitoring of the Sand and Gravel Unit

Figures 3-7 through 3-13a show box-and-whisker plots for selected contamination indicator parameters for forty-five wells monitoring the sand and gravel unit of the north plateau of the WVDP. Background site conditions are monitored by well WNWNB1S (coded ANB1S on the box-and-whisker plots), and upgradient monitoring is provided by wells WNW0301, WNW0401 and WNW0403 (coded A0301, A0401 and A0403, respectively, in the figures).

Downgradient conditions are monitored at forty-one locations within the sand and gravel unit. These locations are subdivided into three categories according to the well's general position within the groundwater flow regime. For example, downgradient wells prefixed with "B" in the figures are nearest to the background or upgradient wells (prefixed "A"), while wells prefixed with a "D" are farthest downgradient.

Wells monitoring downgradient conditions in the sand and gravel unit are part of the monitoring network for eight of the identified on-site SSWMUs and for the motor fuel storage area. The SSWMUs monitored by wells in the sand and gravel unit are: SSWMU #1 - the low-level waste treatment facility; SSWMU #2 - miscellaneous small units; SSWMU #3 - the liquid waste treatment system; SSWMU #4 - the high-level waste

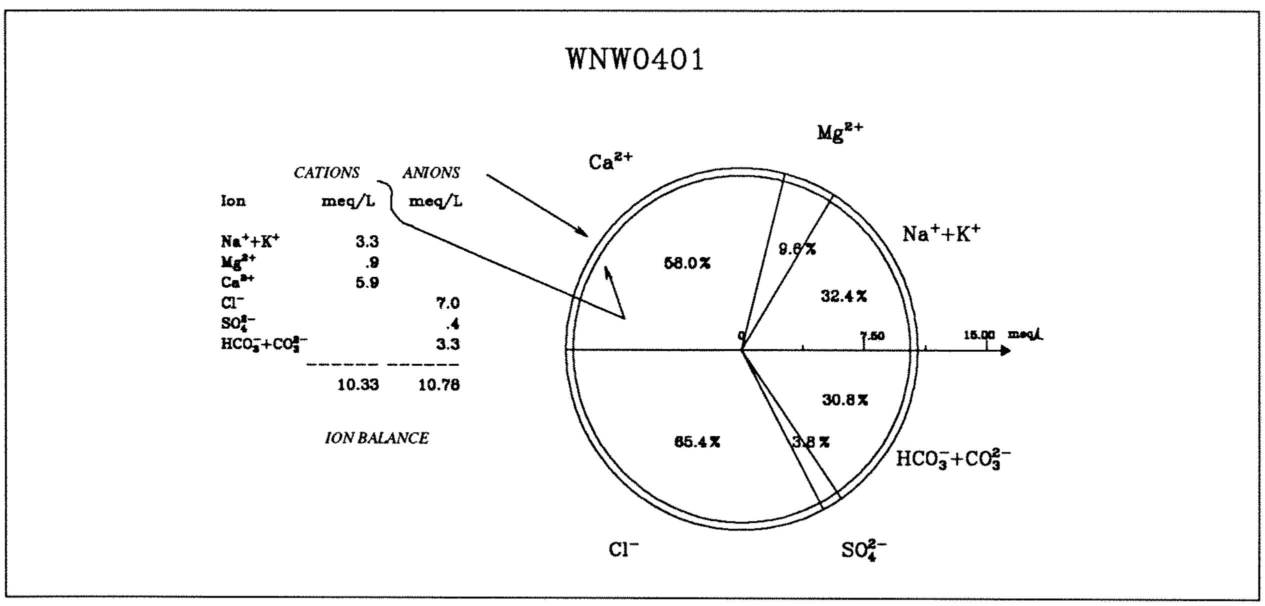

FIGURE 3 - 6A. SAMPLE PIE CHART

storage and processing area; SSWMU #5 - the maintenance shop leach fields; SSWMU #6 - the low-level waste storage area; SSWMU #7 - the chemical process cell waste storage area; and SSWMU #8 - the construction and demolition debris landfill. (See Table 3-1, which identifies the SSWMUs and associated individual SWMUs, the geological unit monitored, and the depth of each well.)

The box-and-whisker plots for the sand and gravel geologic unit show elevated levels of pH and conductivity and high levels of total organic carbon in well WNW0103 (coded C0103 in the figures). Note that only the lower whisker is visible in the plots for conductivity and total organic carbon. The central box is off-scale: this scaling was selected in order to adequately size the other data in the figures. Well WNW0103 is part of the monitoring network for the low-level waste treatment facility (SSWMU #1) and is located in the vicinity of a spill of caustic sodium hydroxide that occurred in 1984. Results of groundwater quality analyses of WNW0103 waters indicate high levels of sodium and hydroxide. (See *Appendix E*, Table E-6).

The pie plot for this well (*Appendix E*, Figure E-1, Groundwater Quality Plots for Sand and Gravel Wells) shows that sodium and hydroxide form the majority of the ionic make-up of WNW0103 waters. The pH levels for all other sand and gravel wells appear to rest within a normal environmental range. Several other wells show marginally elevated levels of conductivity, but none are elevated to the degree of WNW0103 and none show a corresponding shift in groundwater pH.

Results of radiological analyses of samples collected from wells monitoring the sand and gravel unit indicate various levels of gross beta and tritium activity across the sand and gravel unit. Results of gross alpha analyses, reflecting mostly below minimum detectable levels, do not indicate any migration of alpha activity. Gross beta results range from an average background level for well WNWNB1S of 3.1E-09 µCi/mL to a high of more than 1.5E-04 µCi/mL at well WNW0408, an approximate 50,000-fold change in concentration between background and downgradient groundwater monitoring locations.

Similarly, the concentrations of tritium (H-3) range from 1.0 E-07 µCi/mL at background locations to a high of approximately 2.5E-05 µCi/mL at location WNW0408. This represents a 250-fold change in concentration between background and downgradient locations. Thus, the highest levels of gross beta and tritium activity appear at well location WNW0408 and appear to decline as one moves north-northeast to locations WNW0501, WNW0502, WNW0602, and WNW0116. These latter locations are more distant from the main process plant.

Other monitoring locations with elevated levels of gross beta and tritium activity within the sand and gravel unit include points monitoring the low-level waste treatment facility: wells WNW0111, WNW8604, WNW8605, and the french drain, WNSP008. Additional wells show elevated levels of activity, although lower than the wells just noted, as indicated in Figures 3-12a and 3-13a, which show the same results as Figures 3-12 and 3-13 except that the scales have been expanded in order to adequately display lower concentration data.

The New York State groundwater quality standard for gross beta activity (1.0E-06 µCi/mL) was exceeded at well locations WNW0111, WNW0408, WNW0501, WNW0502, WNW8604, and WNW8605. The New York State groundwater quality standard for tritium (2.0E-05 µCi/mL) was exceeded for one measurement of a sample collected from well WNW0408.

Results of Contamination Indicator Monitoring of the Till-Sand Unit

Eight wells monitor groundwater in the till-sand unit. As noted in the discussion of hydrogeology, the till-sand unit was recently identified as a hydrologic unit of limited areal extent and variable thickness within the Lavery till. General upgradient conditions are monitored by wells WNW0302, WNW0402, and WNW0404 (denoted with the letter "A" in the box-and-whisker plots). Wells WNW0202, WNW0204, WNW0206, WNW0208, and WNW0905 monitor general downgradient conditions.

Figures 3-14 through 3-20 show the box-and-whisker plots for selected contamination indicator parameters for the till-sand unit. Well WNW0202, which is 38 feet belowgrade, shows elevated levels of pH and conductivity. The pH of water from well WNW0202 (11.5 - 12.5) indicates the presence of substantial hydroxide concentrations. However, this groundwater is much lower in overall ionic concentration than well WNW0103 and shows much lower levels of conductivity and sodium. The origin of the high pH levels at this well is unknown at this time.

Pie charts of major groundwater quality constituents for the till-sand unit are shown in *Appendix E*, Figure E-2.

The pie chart for well WNW0202 shows the influence of hydroxide ion on the overall anion balance of groundwater at this location. Groundwater monitoring of the surficial sand and gravel unit at the same location (WNW0201 at a depth of 20 feet) indicates normal pH and conductivity levels. (See Figs. 3-7 and 3-8.) Concentrations of total organic carbon, shown in Figure 3-16, are low for all wells in this geologic unit with the exception of WNW0905. Well WNW0905 is positioned downgradient of SSWMU #9, the NRC-licensed disposal area (NDA).

Concentrations of radiological constituents are low in all wells monitoring the till-sand unit and resemble near background concentrations. Marginally elevated levels of gross beta activity are indicated in well WNW0202, and marginally detectable tritium (greater than the minimum detectable level of 1E-07 µCi/mL) in well WNW0905. These values are well below the New York State groundwater quality standards for these constituents (1.0E-06 µCi/mL and 2.0E-05 µCi/mL, respectively).

Results of Contamination Indicator Monitoring of the Unweathered Lavery Till Unit

Twenty-four wells monitor the unweathered Lavery till unit, which extends across both the north and south plateaus of the WVDP. Site background conditions are monitored by well WNW1008C. Three additional wells, WNW0405, WNW0704, and WNW0707, are grouped together as being representative of general upgradient, although not necessarily true, background conditions.

Wells monitoring the unweathered Lavery till are part of the monitoring network for several SSWMUs: SSWMU #1 - the low-level waste treatment facility, SSWMU #4 - the high-level waste storage and processing area; SSWMU #7 - the chemical process cell waste storage area; SSWMU #9 - the NRC-licensed disposal area; SSWMU #10 - the IRTS drum cell; and SSWMU #11 - the state-licensed disposal area. Results of groundwater contamination indicator monitoring for this geologic unit are shown in box-and-whisker Figures 3-21 through 3-27.

There are no observable anomalies for pH and conductivity data for wells in this unit. Data for pH and conductivity are grouped fairly tightly for a given well, as indicated by the relatively narrow range associated with the individual box-and-whisker figures representing data for individual wells.

Concentrations of both total organic carbon (Fig.3-23) and total organic halogens (Fig.3-24) appear slightly elevated for well WNW0704, which extends 15.5 feet belowgrade and is part of the monitoring network associated with the chemical process cell waste storage area. Levels of gross beta are also slightly elevated at this location. However, the levels of gross beta activity are well below the New York State groundwater quality standard of 1.0E-06 µCi/mL. Six of the twenty-four wells associated with the unweathered Lavery till unit show median tritium concentrations above the minimum detectable level of 1.0E-07 µCi/mL. Five of these wells are associated with SSWMU #1, and one is associated with SSWMU #11. All levels of tritium are well below the New York State groundwater quality standard of 2.0E-05 µCi/mL.

Results of Contamination Indicator Monitoring of the Lacustrine Unit

Twelve wells monitor groundwater conditions within the lacustrine unit. These wells are all situated on the site's south plateau and represent the deepest groundwater monitoring points on-site.

Background conditions are monitored by well WNW1008B, which is 51 feet belowgrade. Three additional wells, WNW0901, WNW0902, and WNW1001, provide upgradient monitoring of the lacustrine unit. These wells range in depth from 116 to 136 feet belowgrade.

General downgradient monitoring is provided by eight wells ranging in depth from 108 to 138 feet.

The lacustrine unit is monitored as part of the groundwater monitoring program associated with SSWMU #9 - the NRC-licensed disposal area; SSWMU #10 - the IRTS drum cell; and SSWMU #11 - the state-licensed disposal area.

Results of contamination indicator monitoring of the lacustrine unit are seen in Figures 3-28 through 3-34. The pH and conductivity box-and-whisker plots (Figs. 3-28 and 3-29) show variations across well locations. These variations may reflect differences in groundwater geochemistry. Some of the wells in the lacustrine unit exhibit very low groundwater recharge rates, which limit the ability to collect enough sample for all analyses and can also impair the ability to thoroughly flush or purge the well before sampling. For example, SDA well WNW1103C exhibits very limited recharge, allowing only a limited set of analyses to be made.

Results of sampling for the remaining contamination indicator parameters suggest the lack of any direct site-induced effects on the waters of the lacustrine unit. For example, detection of tritium in groundwater would probably be the first indicator of contamination from tritium becoming incorporated into and moving with the groundwater. Figure 3-34 shows that all median values for all wells monitoring this unit are below the minimum detectable level of 1.0E-07µCi/mL.

Elevated levels of gross beta activity in SDA well WNW1103C are indicated. However, this well does not show a corroborating level of tritium activity. Further analysis of this beta component would be necessary to help identify its origin.

All levels of radioactivity measured within the lacustrine unit are below New York State groundwater quality standards.

Results of Contamination Indicator Monitoring of the Weathered Lavery Till Unit

Sixteen wells are used to monitor groundwater in the weathered Lavery till unit, which is the surficial geologic unit on the south plateau of the site. Three SSWMUs are monitored as part of groundwater monitoring in the weathered Lavery till: SSWMU #9 - the NRC-licensed disposal area; SSWMU #10 - the IRTS drum cell; and SSWMU #11 - the state-licensed disposal area.

Well WNW1008C monitors background conditions in the weathered Lavery till. Well WNW0908 and WNW1005 within the weathered Lavery till unit monitor general upgradient conditions. Wells monitoring this unit range in depth from 10 to 23 feet belowgrade.

The results of downgradient monitoring of pH (Fig.3-35) fall within a range of 6.5 to 7.5, with one SDA well, WNW1107A, falling between about 6.3 to 6.6. The range of conductivity values is relatively wide across this unit, with the variability within a given well generally small. Downgradient values for conductivity are within the range of the upgradient and background results as shown in Figure 3-36.

Median values for total organic carbon (Fig.3-37) and total organic halogens (Fig.3-38) indicate elevated levels of these constituents at the SDA well WNW1107A. Additional sampling and analysis followed up these apparently elevated levels of total organic carbon and total organic halogens. Additional samples for an expanded set of organic analyses were collected from both WNW1107A and WNW1101A in September 1991 and analyzed for semi-volatile organic compounds using method 8270 from *Test Methods for Evaluating Solid Waste, SW-846* (EPA 1986). Well WNW1101A acted as a control or background location since it showed low levels of both total organic carbon and total organic halogens. The results for all compounds were below the method quantitation limits for both locations sampled.

Gross alpha (Fig.3-39) and gross beta (Fig.3-40) show levels grouped within a range that may be considered near background levels. Several of the wells within the unit, e.g., WNW0906, WNW0907, WNW0908, and WNW1108A, are sometimes dry or have a reduced volume of water and very limited recharge. The variation in gross alpha levels indicated in Figure 3-39 for WNW0908 represents a range of below minimum detectable levels caused primarily by elevated levels of solids in the analytical process. These values thus indicate variations in the detection limit as opposed to true positive results. The apparently elevated levels of gross beta activity in upgradient well WNW0908 (1.18E-08 µCi/mL to 1.87E-08 µCi/mL), although representing positive values, may be related to the elevated solids discussed above for gross alpha activity and are well below the groundwater quality standard for gross beta activity of 1.0E-06 µCi/mL.

Several wells monitoring the SDA show detectable levels of tritium activity (Figs. 3-41 and 3-41a). Levels of tritium in well WNW1107A are slightly above the New York State groundwater quality standard of 2.0E-05 µCi/mL. Several other SDA wells (WNW1103A, WNW1106A, WNW1109A) consistently show much lower levels of tritium (see Fig. 3-41a) that are well below the groundwater quality standard.

Results of Monitoring of Site Groundwater for Volatile Organic Compounds

All groundwater wells that are part of the on-site groundwater monitoring program are monitored regularly for volatile organic compounds as part of the contamination indicator parameters. (See Table

3-3, which summarizes the 1991 sampling schedule. Samples collected for volatile organic compounds are analyzed by off-site contract laboratories according to method 8240 from *Test Methods for Evaluating Solid Waste, SW-846* (EPA 1986). Results of the analysis of these samples generate data on fifty-eight volatile organic compounds. Table E-11 lists the individual compounds and the typical practical quantitation limit (PQL) for each compound. The practical quantitation limit is the lowest concentration of the compound that can be reliably determined within the method-specified level of precision and accuracy under routine laboratory conditions. (Practical quantitation limits are roughly equivalent to method detection limits [MDLs]).This listing of volatile organic compounds originates from 40 CFR Part 264, referred to as the Appendix IX Groundwater Monitoring List. The volatile organic compounds are a sub-list of the entire Appendix IX listing.

The results of groundwater monitoring for volatile organic compounds continue to reveal very low levels of two different compounds. At wells WNW8609 and WNW8612, 1,1-dichloroethane continues to be detected and 1,1,1-trichloroethane continues to be detected at location WNGSEEP. Analytical results for these compounds for the above locations are shown in Table E-12. A two-year trend figure (Fig.3-42) shows how concentrations of these volatile organic compounds have varied over the two years. The results shown in Fig. 3-42 represent routine groundwater monitoring data from relatively evenly spaced sampling intervals (one through eight) for each year shown. The detection of 1,1,1-trichloroethane at WNGSEEP is the subject of a draft report being prepared to fulfill the RCRA 3008(h) Order on Consent (WVNS 1992).

Analysis of volatile organic compounds by method 8240 uses an instrument called a gas chromatograph/mass spectrometer (GC/MS). This instrument has the ability to qualitatively identify the presence of compounds below the method practical quantitation limits (PQLs) shown in Table E-11. Such detections, taken on an individual basis, must be viewed with caution because they may indicate false detections. However, when the same compound is detected repeatedly at levels below the PQL at the same groundwater location, it may indicate the actual presence of that compound, but at levels below that which the GC/MS can accurately measure.

The repeated detection of compounds below the associated PQL (5 µg/L for the compounds in question) has occurred at three groundwater monitoring locations:

- WNW8612. Repeated detections of 1,1,1-trichloroethane below the PQL of 5 µg/L have been observed. The possible presence of this compound at this location may or may not be related to 1,1,1-trichloroethane at location WNGSEEP. As noted above, WNW8612 shows positive levels of 1,1-dichloroethane.

- WNW0103 and WNW0202. Both wells have shown repeated detections below the PQL of 5 µg/L for toluene and xylene. These wells have both shown elevted levels of pH and hydroxide alkalinity. It is not known at this time if the volatile compounds are related to the high pH at these locations. A source for these volatile organic compounds also has not been identified.

Volatile organic compounds at wells WNW8613A, WNW8613B, and WNW8613C are monitored as a check on the integrity of the site's underground storage tanks used for petroleum fuels. Results of analysis for benzene, toluene, and xylene were all below method detection limits for samples collected in the vicinity of these tanks during 1991.

Long-term Trends of Gross Beta and Tritium at Selected Groundwater Monitoring Locations

Trend graphs showing results of groundwater monitoring from 1986 through 1991 for gross beta (Fig. 3-43) and tritium (Fig. 3-44) were prepared for selected locations. These graphs show annual averaged results for these parameters over a six-year period. Results are presented on a logarithmic scale to adequately represent locations of differing concentrations. These specific locations were selected for trending because they have shown elevated levels of these constituents (WNW8605) or have shown rising or falling trends over time.

The results for gross beta activity (Fig. 3-43) indicate a steadily rising trend for location WNW8604. Other locations show a general leveling off after what appears as several years of continual rise in some cases (e.g., locations WNSP008 and WNW8603).

The trend graph for tritium for the same locations as above shows a general leveling or falling trend for all locations since 1987. All locations presented are associated with monitoring of the sand and gravel geologic unit around SSWMU #1, the low-level waste treatment facility.

Groundwater Quality Parameters

Results of the two rounds of sampling for groundwater quality parameters are in *Appendix E*, Tables E-6 through E-10. The results for the major cations (calcium, magnesium, sodium, and potassium), and anions (chloride, sulfate, bicarbonate, carbonate, and, in some cases, hydroxide) are also summarized in pie charts as indicated above in Figures E-1 through E-5 in *Appendix E*. Compiling groundwater quality results in pie charts provides a convenient way to present data in a format that allows rapid comparison of results between different wells. These pie charts are very useful for identifying the major constituents of the groundwater, the relative percentages of these various constituents, the degree to which the cation and anions balance, and the overall ionic content of the groundwater. The pie charts (see *Appendix E*) are grouped by geologic unit, and the wells are presented in the same order as in the tables for contamination indicator parameters.

Off-site Groundwater Monitoring Program

During 1991 all of the off-site groundwater residential wells were sampled for radiological constituents, pH, and conductivity. Sampling and analysis indicated no evidence of contamination by the WVDP of these off-site water supplies. Analytical results are found in Table C-1.8 in *Appendix C-1*.