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Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-91OR21949

PERFORMANCE MONITORING REPORT FOR THE NIAGARA FALLS STORAGE SITE WASTE CONTAINMENT STRUCTURE

Lewiston, New York

Calendar Year 1991

July 1992

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PERFORMANCE MONITORING REPORT FOR THE NIAGARA FALLS STORAGE SITE WASTE CONTAINMENT STRUCTURE, LEWISTON, NEW YORK, FOR CALENDAR YEAR 1991

JULY 1992

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By

Bechtel National, Inc.

Oak Ridge, Tennessee

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ACRONYMS

DCG	derived concentration guide
DOE	Department of Energy
FUSRAP	Formerly Utilized Sites Remedial Action Program
MSL	mean sea level
NFSS	Niagara Falls Storage Site
PPT	pneumatic pressure transducer
TETLD	tissue-equivalent thermoluminescent dosimeter
VWPT	vibrating wire pressure transducer
WCS	waste containment structure

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UNITS OF MEASURE

Bq	becquerel
cm	centimeter
ft	foot
g	gram
gal	gallon
ha	hectare
in.	inch
km	kilometer
L	liter
m	meter
mi	mile
µCi	microcurie
ml	milliliter
mR	milliroentgen
mrem	millirem
pCi	picocurie
	second
yd	yard
yr	year

1.0 INTRODUCTION

A performance monitoring program was developed in 1986 for the waste containment structure (WCS) at the Niagara Falls Storage Site (NFSS). NFSS is a part of the Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP), a program initiated in 1974 to identify and decontaminate or otherwise control sites where residual radioactive contamination (exceeding current guidelines) remains from the early years of the nation's atomic energy program. The WCS contains soil contaminated with residual radioactive materials, rubble, and radioactive residues removed from various areas of NFSS and vicinity properties during remedial action conducted by DOE from 1981 through 1986. The design and construction of the WCS and the closure and post-closure activities have been previously documented (Bechtel 1986a, 1986b).

The purpose of the performance monitoring program is to verify that the main engineering elements of the WCS are functioning to minimize infiltration of rainfall, prevent pollution of groundwater, and prevent radon emanation. This report presents the findings of performance monitoring conducted at the WCS during calendar year 1991. The data collected during the initial performance monitoring period in 1986 established a baseline for the interpretations contained in this report (Bechtel 1987).

To evaluate the effectiveness of the containment facility accurately, it is necessary to assess the data from both the performance monitoring program and from the broader environmental monitoring program. The environmental monitoring program monitors radon concentrations in air; radium, uranium, and heavy metals concentrations in surface water, groundwater, and sediment; and external gamma radiation levels. It includes data from both the onsite and offsite monitoring wells, and from the 36 wells added to the monitoring program since 1986. Complete results of the environmental monitoring program are published annually in a separate report (Bechtel 1992). Summary information from that report is included in Subsection 3.3 of this document.

This report includes a summary of performance monitoring results for calendar year 1991, as well as a brief description of a

short-term project conducted during the summer to consolidate waste from three onsite sources into the WCS. The report contains data for surface, subsurface, and environmental monitoring; conclusions based on walkover surveys; comparisons with previous data; and actions required. The vibrating wire pressure transducer (VWPT) pore water pressure readings for this period have been expressed as hydraulic head and are plotted in Appendix A.

1.1 LOCATION AND DESCRIPTION

NFSS is a DOE facility located in northwestern New York in the Township of Lewiston (Niagara County). The site is located in a generally rural setting approximately 6.4 km (4 mi) south of Lake Ontario and 16 km (10 mi) north of the City of Niagara Falls. NFSS and its regional setting are shown in Figure 1-1. Figure 1-2 is a site plan of NFSS, a prominent feature of which is the WCS.

The WCS occupies 4 ha (10 acres) of the 77.4-ha (191-acre) NFSS. As shown in Figure 1-3, the WCS outer perimeter is formed by a dike and cutoff wall, each constructed of compacted clay and incorporated into the finished structure. The cutoff wall extends a minimum of 45 cm (18 in.) into an underlying gray clay unit. The gray clay unit and the cutoff wall/dike serve as adsorption barriers to vertical and horizontal migration of contaminants from the structure. Figure 1-4 presents an orthographic projection of the WCS [illegible] views.

An engineered, compacted clay cover is placed immediately over the waste and extends beyond the perimeter dike, completely enclosing the waste. This clay cover is the principal barrier against moisture intrusion and radon emanation. The clay cover is overlain by a surface layer of loosely compacted, 45-cm- (18-in.-) thick cover of soil and topsoil. This surface layer forms a protective blanket to reduce the effects of frost and prevent drying that could result in the formation of tension cracks within the clay layer. It also provides a base for shallow-rooted grass. The clay layer, soil cover, and topsoil compose the short-term, or interim, closure system for the WCS.

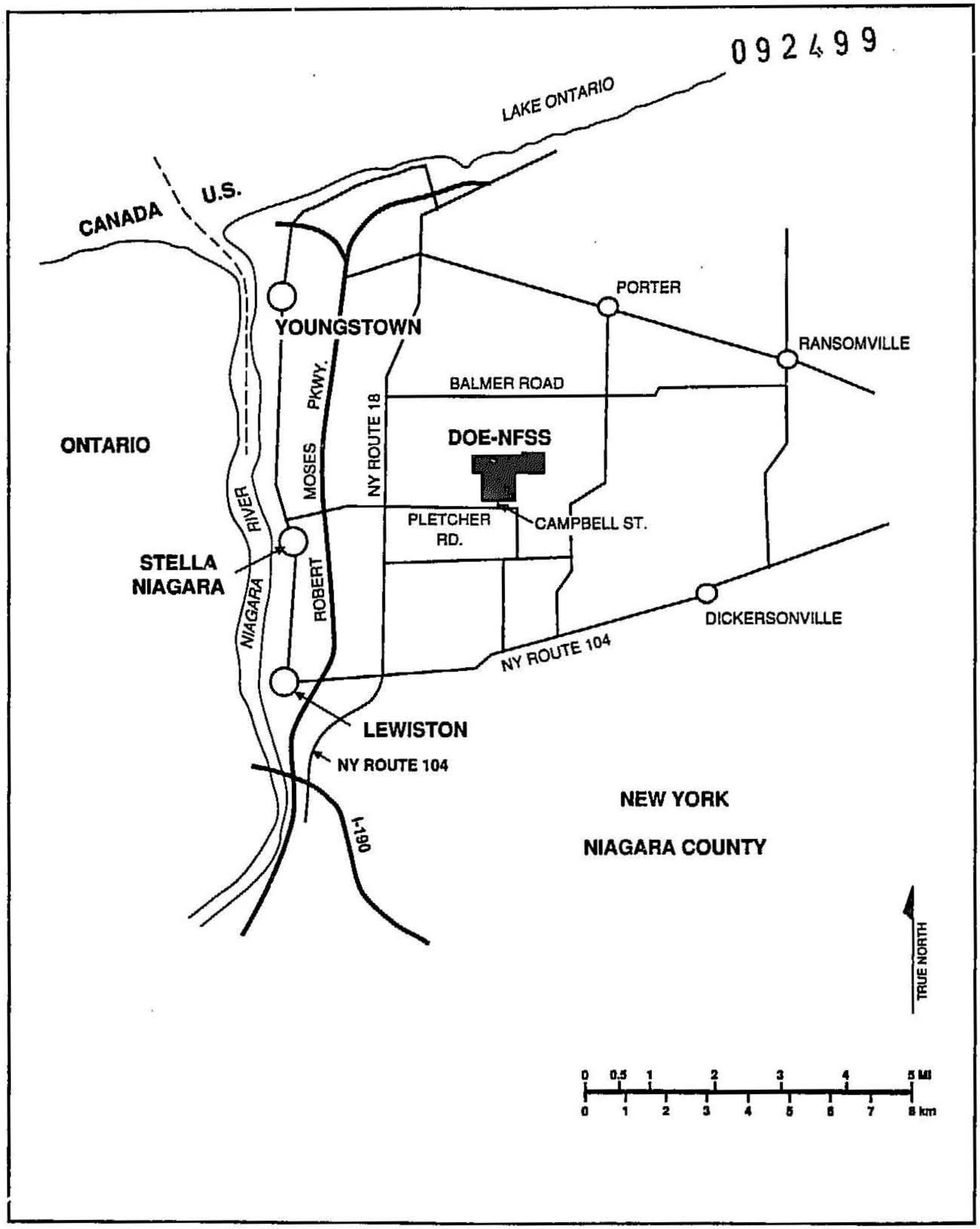

Figure 1-1
Regional Setting of NFSS

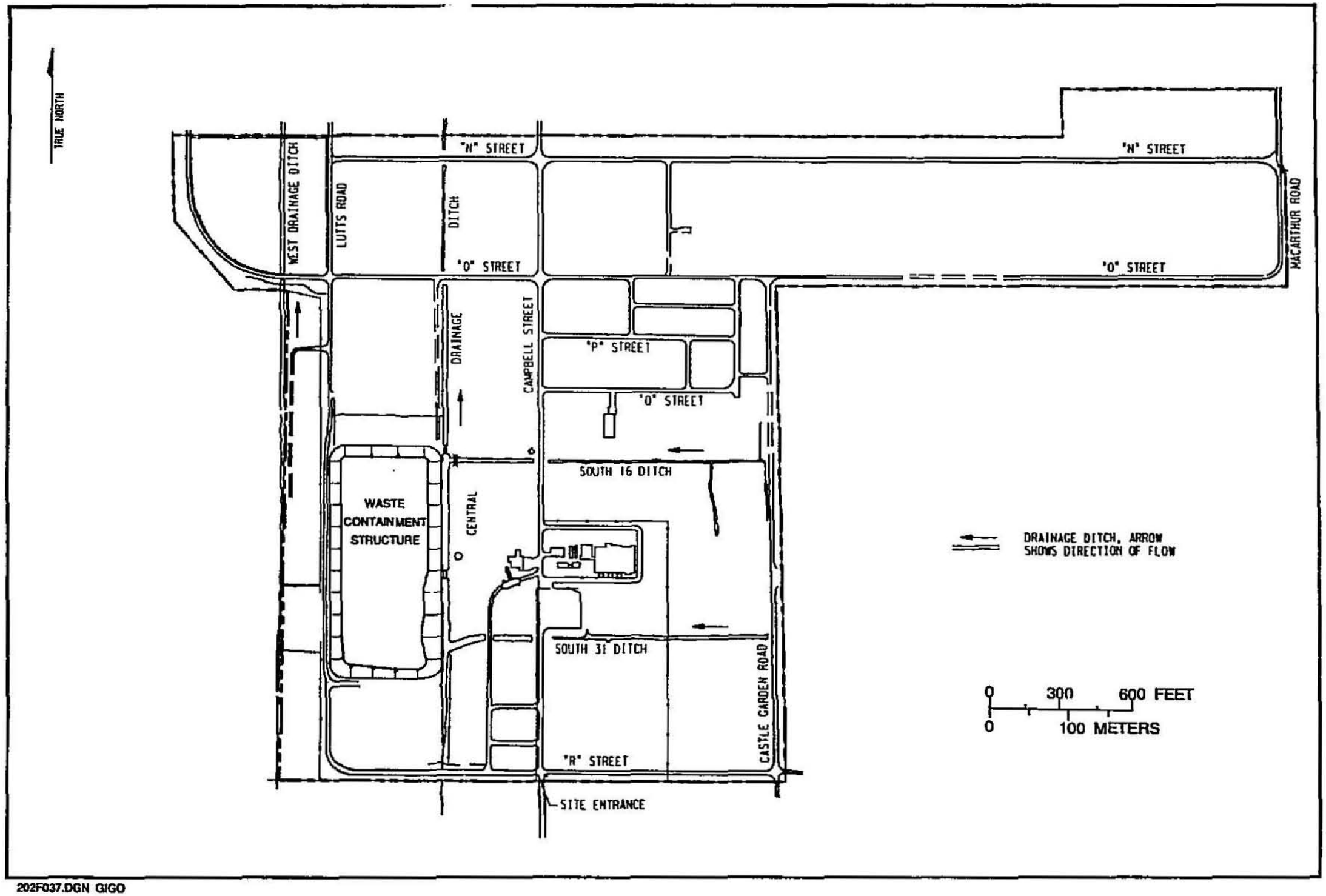

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Figure 1-2
Site Plan of NFSS

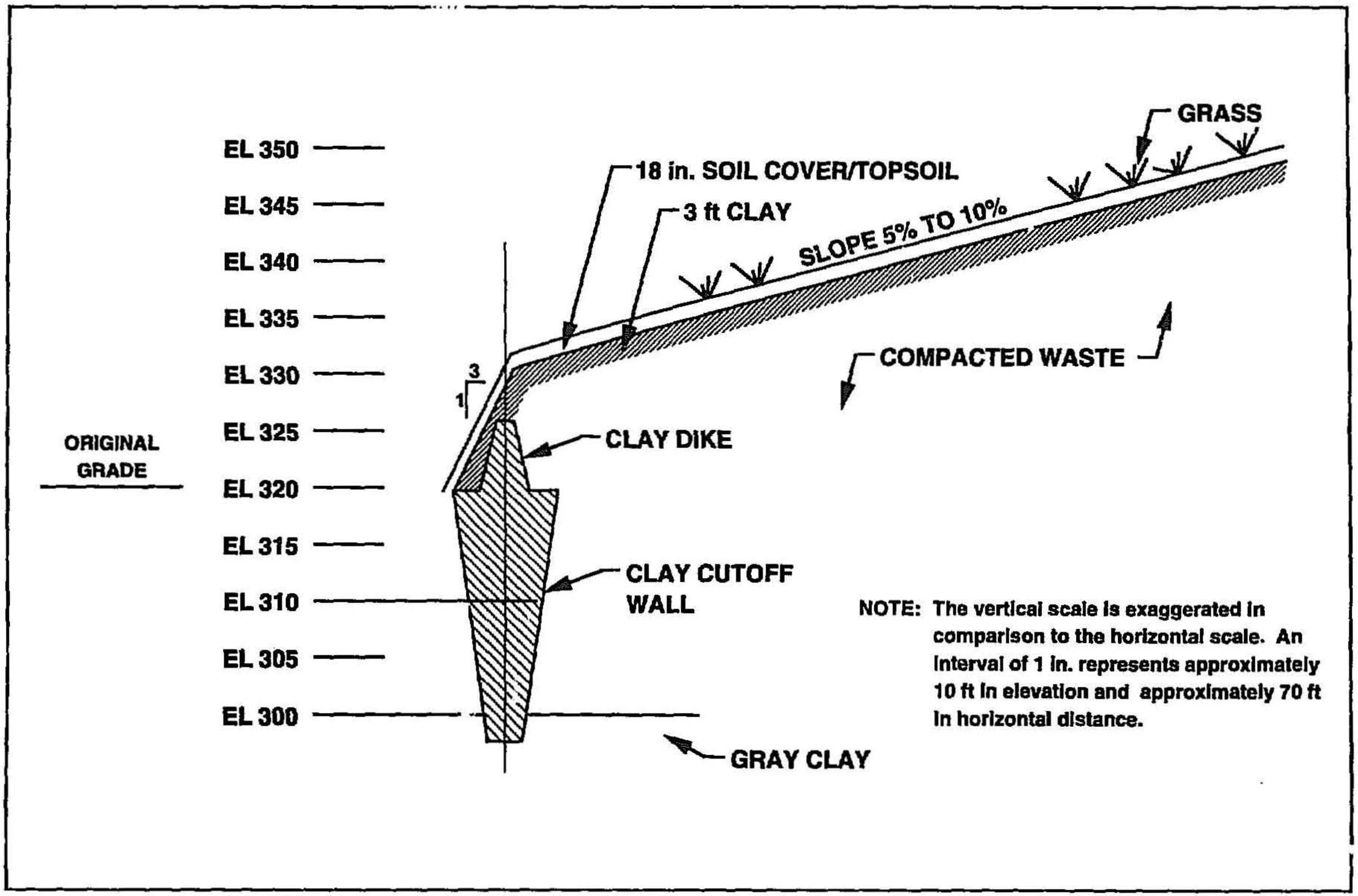

Figure 1-3
Cross Section of the WCS at NFSS

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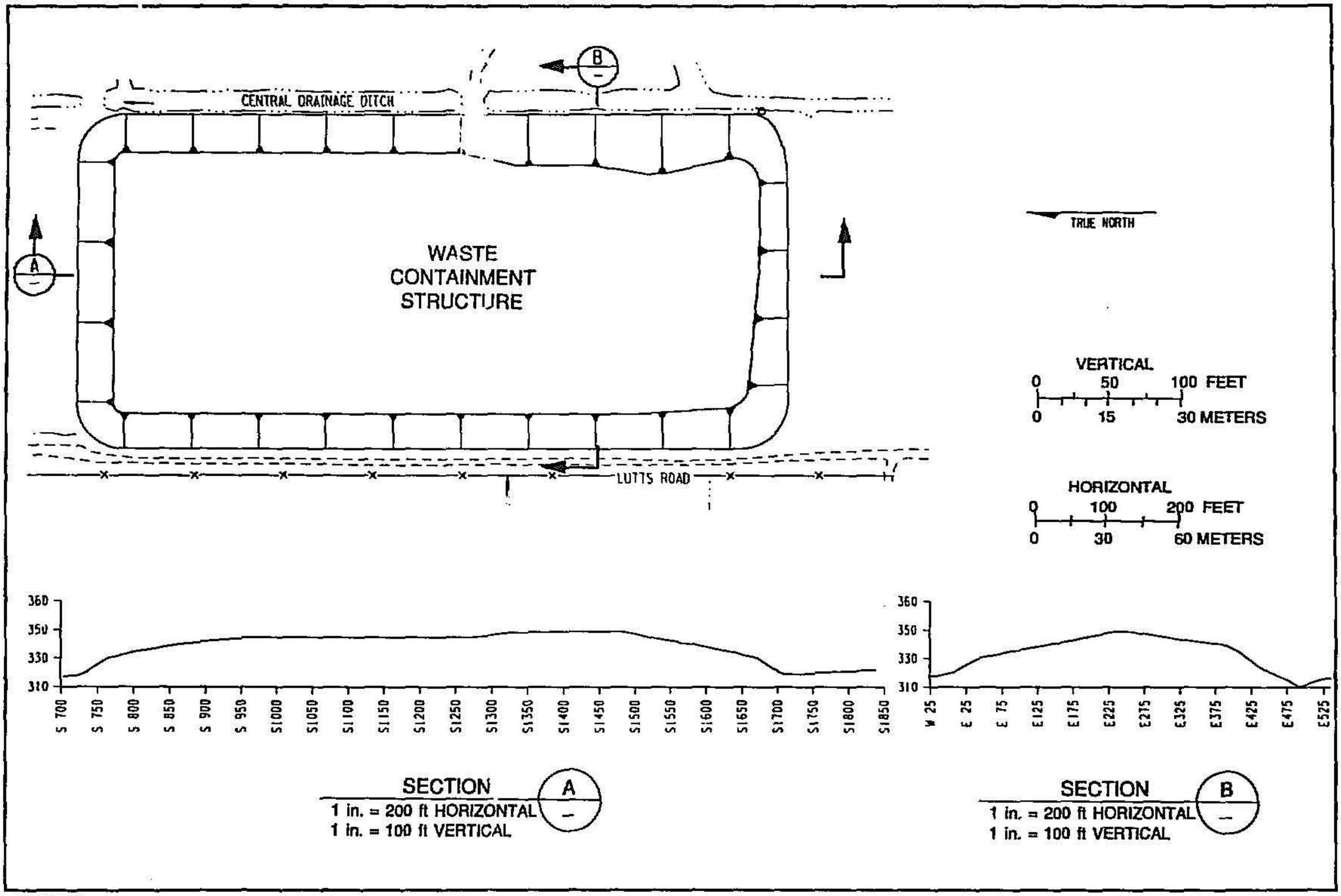

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Figure 1-4
Orthographic Projection of the WCS

1.2 PROGRAM OBJECTIVE

The primary objective of the performance monitoring program is the early detection of trends that could indicate weaknesses developing in the WCS. The monitoring system serves as the basis for a preventive maintenance program to ensure that corrective action is taken before the integrity of the structure is compromised. Consequently, surface and subsurface monitoring techniques are used. Possible indications of structural distress include:

- Differential settlement of the wastes
- Desiccation cracking of the WCS cover
- Deep surface erosion
- Animal burrows
- Deep-rooted vegetation
- Rapid rise of the potentiometric (saturated) surface inside the containment structure
- Residual reduction in soil density caused by frost heave

2.0 SUMMARY OF PERFORMANCE MONITORING PROGRAM

The performance monitoring program at NFSS was initiated in November 1986 to monitor the surface and subsurface conditions of the WCS. Surface monitoring techniques are used to check long-term waste settlement and surface drainage. Internal instrumentation monitors the performance of the clay cap, the gray clay unit, and the cutoff wall/dike.

Surface monitoring activities include topographic surveys, walkover surveys, and annual aerial photography. Initial aerial photographs were taken in early October 1986 to provide baseline photographic data. This aerial mapping provides a reference for detection of changes in the surface contours of the WCS to supplement the information provided by the topographic and walkover surveys.

The topographic and walkover surveys were initially performed in the fall of 1986, following closure of the WCS. These activities established the baseline for subsequent annual performance monitoring surveys. Data obtained at that time represent the initial condition of the WCS and provide the basis for determining whether any additional maintenance actions are required. As a result of the initial and subsequent walkovers, several actions have been taken to maintain the required performance. These actions include adding topsoil to low areas, seeding and fertilizing, installing erosion-control netting, and general surficial maintenance. The results of surface monitoring for 1991 are discussed in Subsection 3.1, and required actions are discussed in Section 5.0.

Internal monitoring instrumentation originally included 13 VWPTs to monitor pore-water pressure and a secondary system of 3 pneumatic pressure transducers (PPTs) to verify the operation of the VWPTs. The PPTs were installed adjacent to three of the VWPTs. The VWPTs and the PPTs were installed in a pattern over the waste containment area as shown in Figure 2-1. A pressure increase

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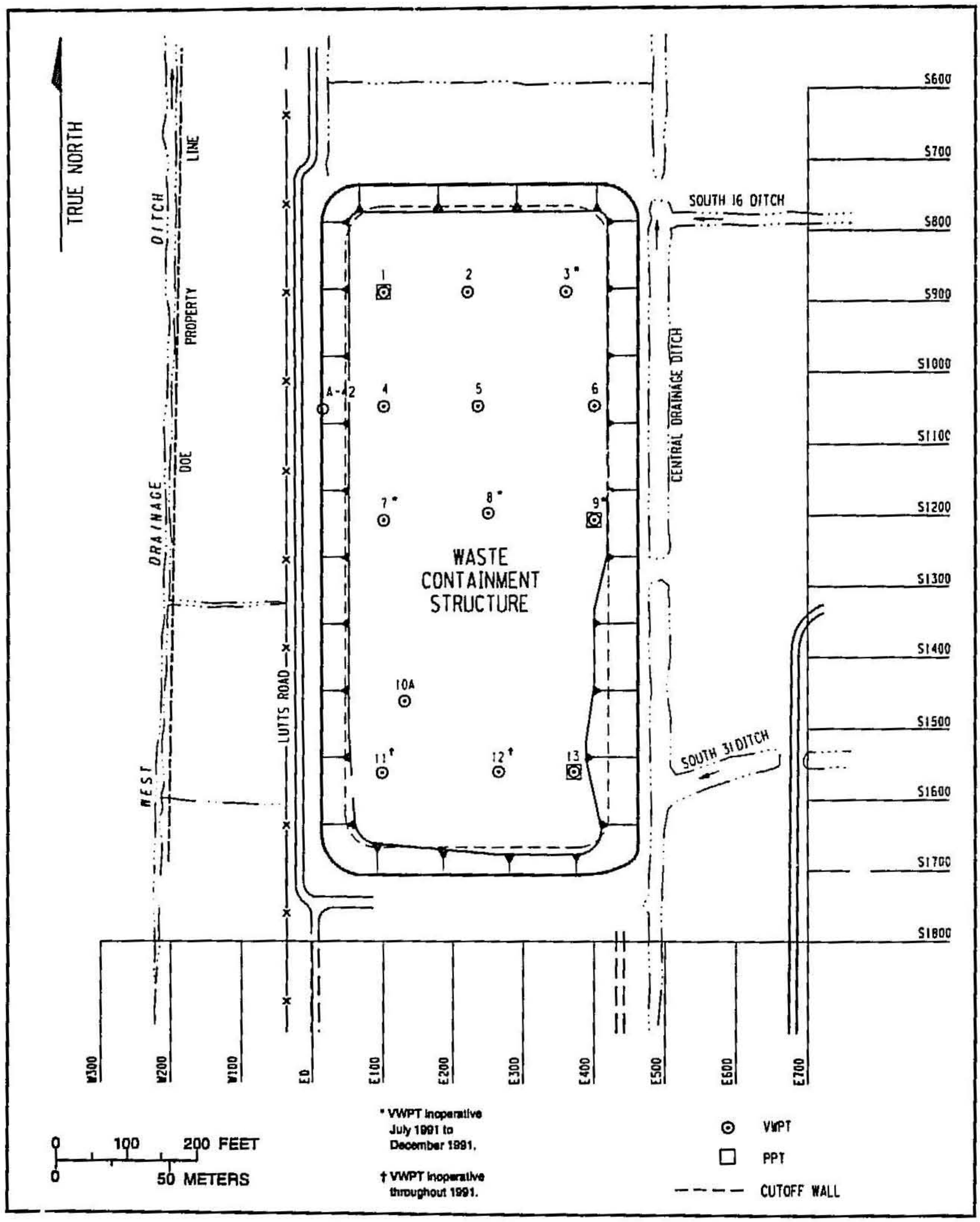

Figure 2-1
Locations of VWPTs and PPTs on the WCS

measured by these instruments can be translated into an increase in the depth of saturation above the instrument. The rate at which the pressure changes will indicate the method of entry of water causing the saturation. For example, rapid pressure increases will be indicative of an opening or a more permeable condition nearby. The VWPT instrument numbers, grid locations, recorder channels, ground surface elevations, and instrument elevations for 1987 are summarized in Table 2-1. In previous performance monitoring reports, the PPT results were presented and indicated that the VWPTs were performing correctly (Bechtel 1987; 1989; 1990). However, since the sole purpose of the PPTs was to verify data obtained from the VWPTs (which were providing automatic and more accurate readings), the manual readings from the PPTs were discontinued during 1990.

VWPTs are read monthly to allow for early detection of water breaching the WCS. Appendix A presents a summary of the VWPT data for 1991. The VWPT data indicate that moisture is accumulating in the bottom of the WCS. However, this accumulation is not considered to be the result of a breach in the cap or side walls, or from groundwater rise from below. The water observed at the bottom of the WCS corresponds to a redistribution of pore water from waste material placed in the WCS. Moisture accumulating in the bottom of the WCS will eventually migrate into the natural clay material below. This accumulating water condition is indicative of a perched table with a downward flow potential. During 1991, the maximum water level measured at monitoring well OW-4B was 97 m (318 ft), whereas the minimum water level inside the WCS at VWPT 2 was 98.85 m (324.3 ft), indicating that groundwater is not a factor in the rise within the WCS. This water will continue to be evaluated to determine its impact to the future pile configuration and monitoring.

The walkover surveys and data collected from monitoring wells and VWPTs confirm that the WCS is functioning as predicted and is effectively isolating the wastes.

Table 2-1

Summary of Subsurface Monitoring Instruments, 1987

Instrument (Borehole) Number	Site Grid Coordinates South	Site Grid Coordinates East	Recorder Channel	Elevation (ft MSL[a]) Ground (Cap) Surface	Elevation (ft MSL[a]) Instrument[b]
1	885	100	11	335.2	321.2
2	885	220	12	341.4	320.7
3[c]	885	360	13	335.6	320.1
4	1045	100	14	335.4	321.4
5	1045	235	15	344.9	320.6
6	1045	400	16	332.9	320.6
7[c]	1205	100	17	335.3	320.6
8[c]	1195	250	18	343.6	319.6
9[c]	1205	400	19	334.8	322.6
10A[d]	1460	130	10	338.9	327.6
11[e]	1561	98	1	339.0	323.8
12[e]	1560	265	2	341.4	329.4
13	1560	370	3	341.5	329.0

[a]Feet above mean sea level.

[b]Instrument elevations for 1987 are based on as-built conditions. Instrument [illegible] for 1986 are based on design conditions.

[c]Instrument was inoperative from July 1991 to December 1991.

[d]Instrument 10 was damaged during construction; instrument 10A was installed as a replacement.

[e]Instrument was inoperative throughout 1991.

3.0 PERFORMANCE MONITORING DATA

This section provides the results of performance monitoring and summarizes the results of environmental monitoring at NFSS for calendar year 1991. Hydraulic head monitoring results for this period are provided in Appendix A. Complete environmental monitoring information is provided in the 1991 annual site environmental report (Bechtel 1992).

3.1 SURFACE MONITORING

3.1.1 Aerial Photography

Figure 3-1 is an aerial photograph of the site immediately after completion of the WCS in 1986; Figure 3-2 shows the site in June 1991. The most recent aerial contour mapping of the WCS surface was performed in April 1991 (Figure 3-3) before initiation of the waste consolidation effort during the summer of 1991. The contour map documents the improved condition of the WCS resulting from maintenance performed under the performance monitoring program.

3.1.2 Grid Survey

Figures 3-4 through 3-6 are topographic plots resulting from monitoring surveys of the WCS. Figure 3-4, showing the as-built (1986) configuration of the WCS, is used as the baseline map. Figures 3-5 and 3-6 are the topographic representations of the WCS as surveyed during the spring and fall walkovers in 1991. Figure 3-7 shows the survey grid established in 1986 for the WCS. Table 3-1 compares data from the October 1986 baseline survey with the two 1991 grid surveys, and indicates subsidence at all survey locations. Table 3-1 also shows the changes in surface elevations of the WCS in the 6-month period between spring and fall 1991. Currently, the structure is expected to exhibit a maximum settlement of approximately 3 cm (1.2 in.) over a 6-month period. This settlement rate is not a constant and will decrease over the

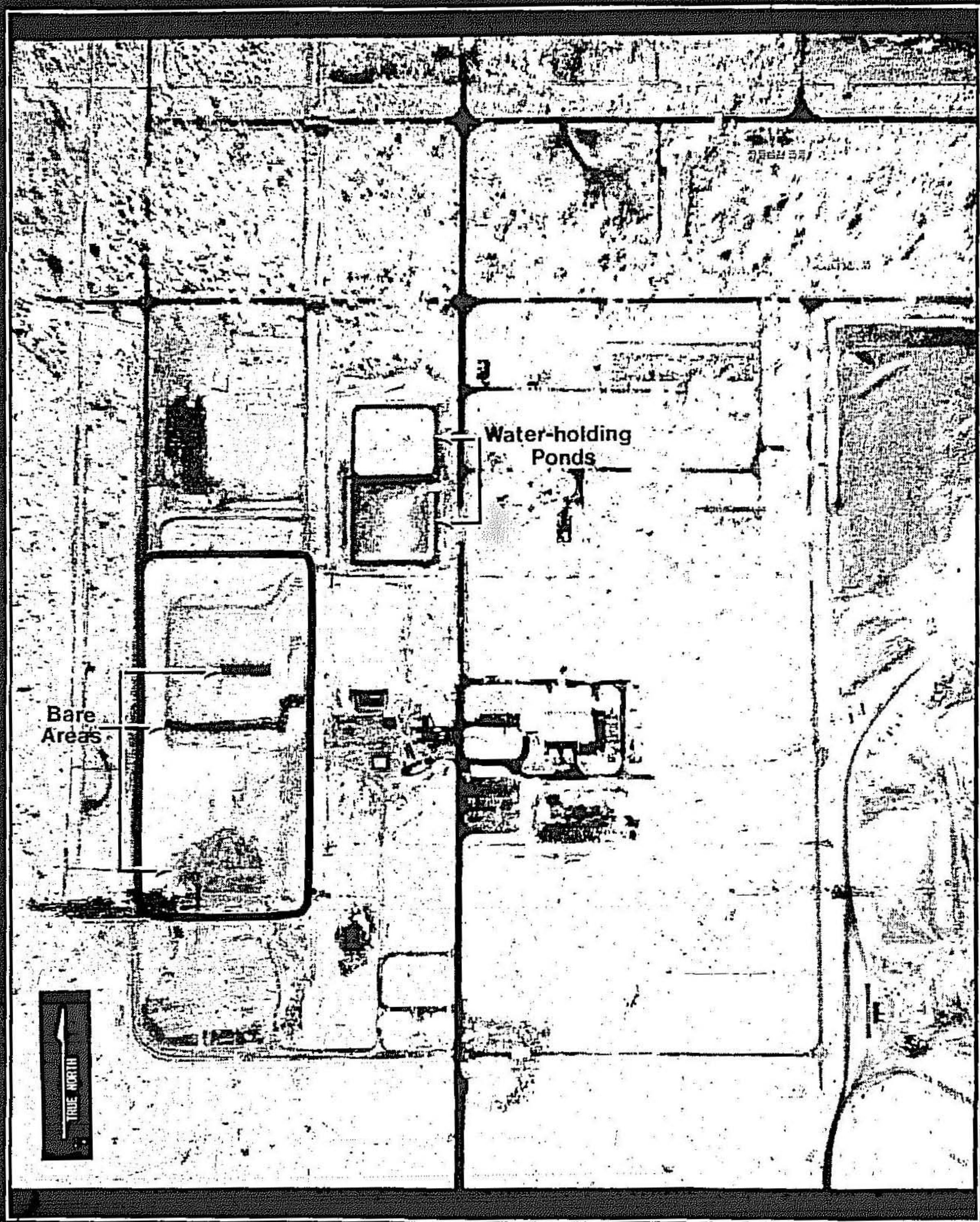

Figure 3-1
Aerial View of the WCS, October 1986

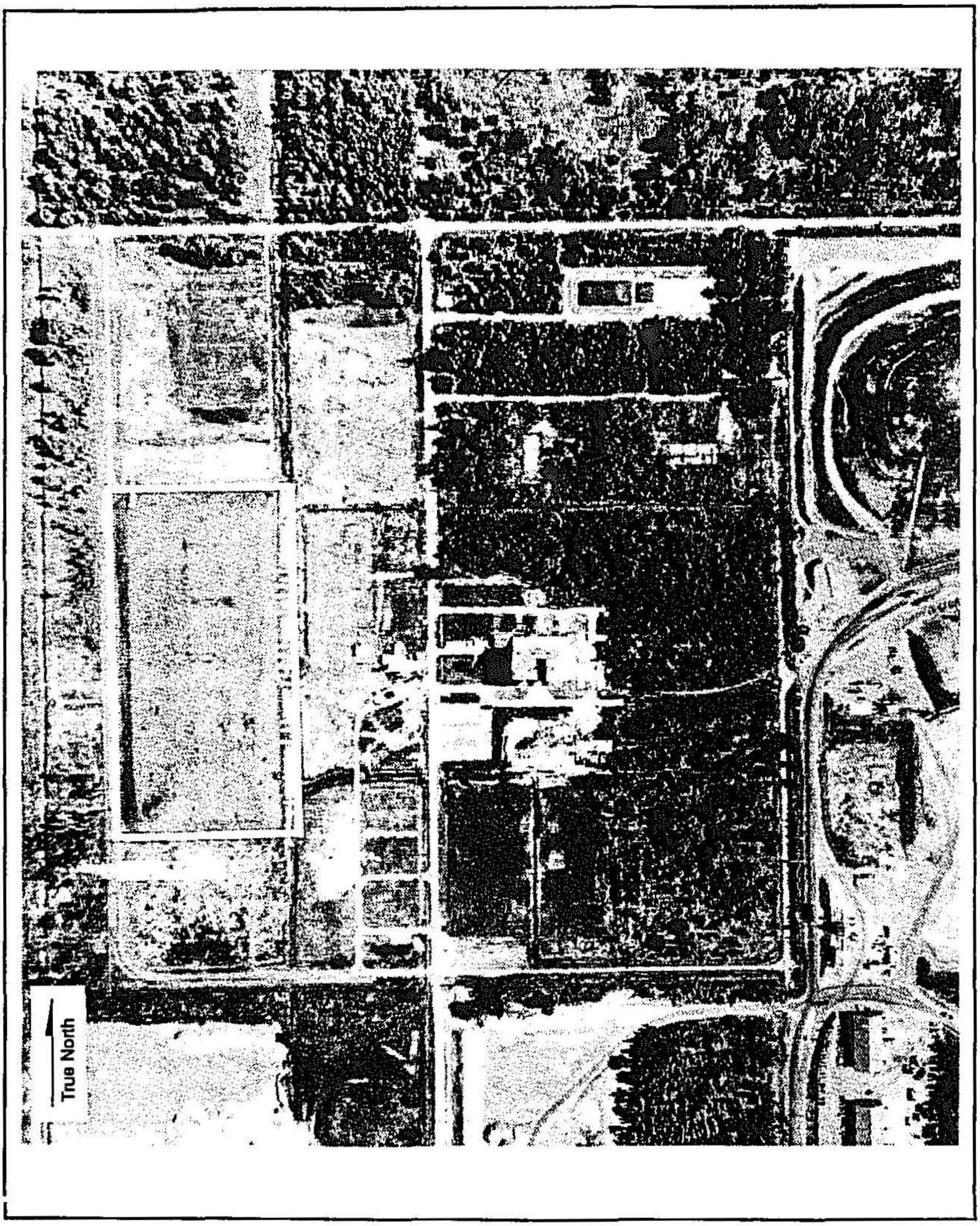

Figure 3-2
Aerial View of the WCS, June 1991

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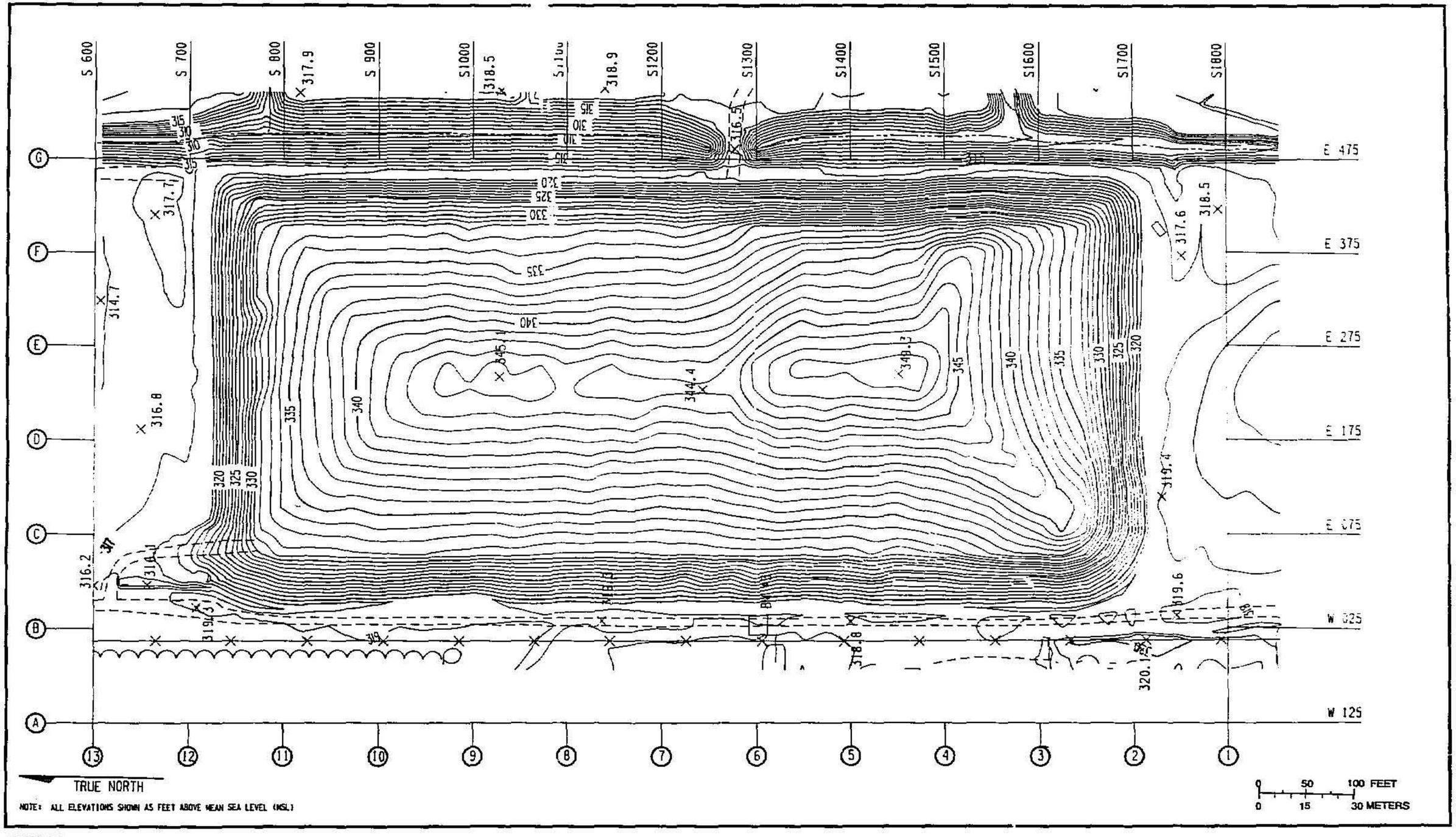

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Figure 3-3
Aerial Contour Map of the NFSS WCS, April 1991

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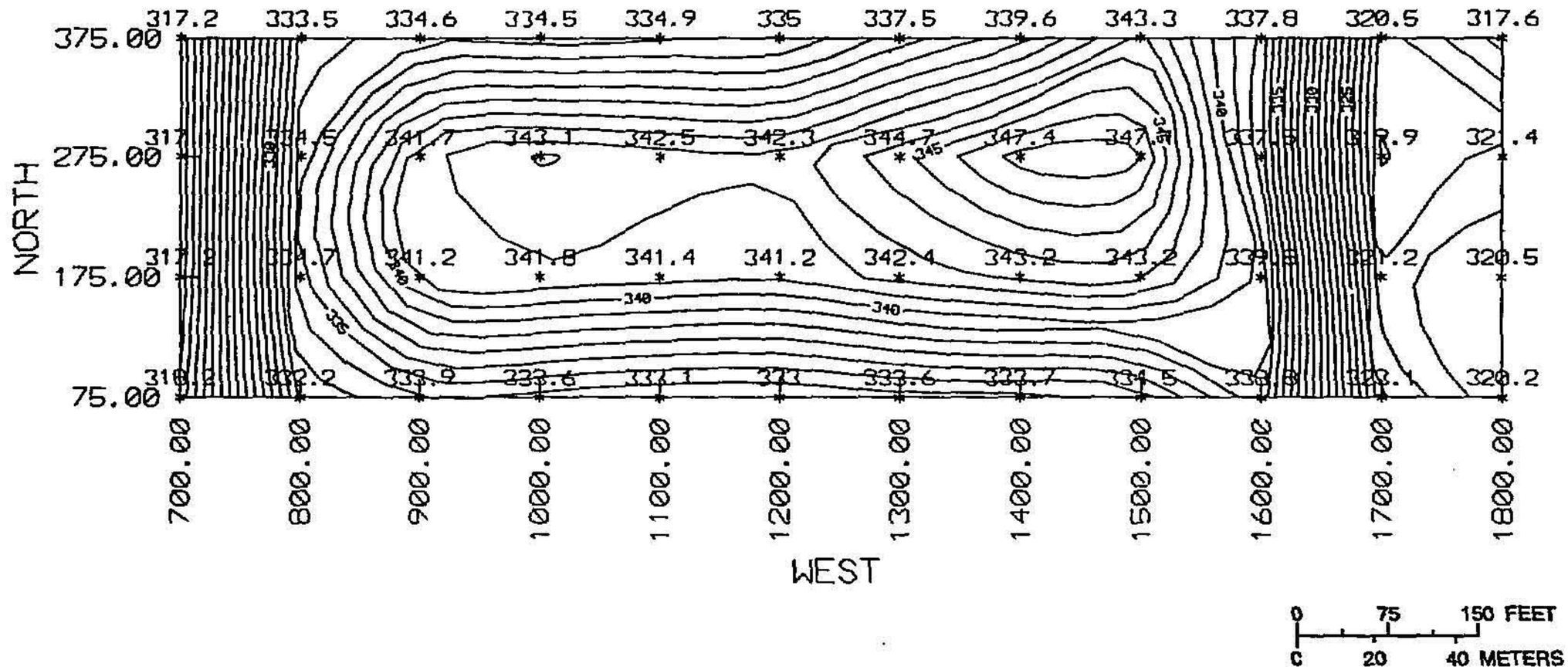

Figure 3-4
NFSS Monitoring Survey, October 1986

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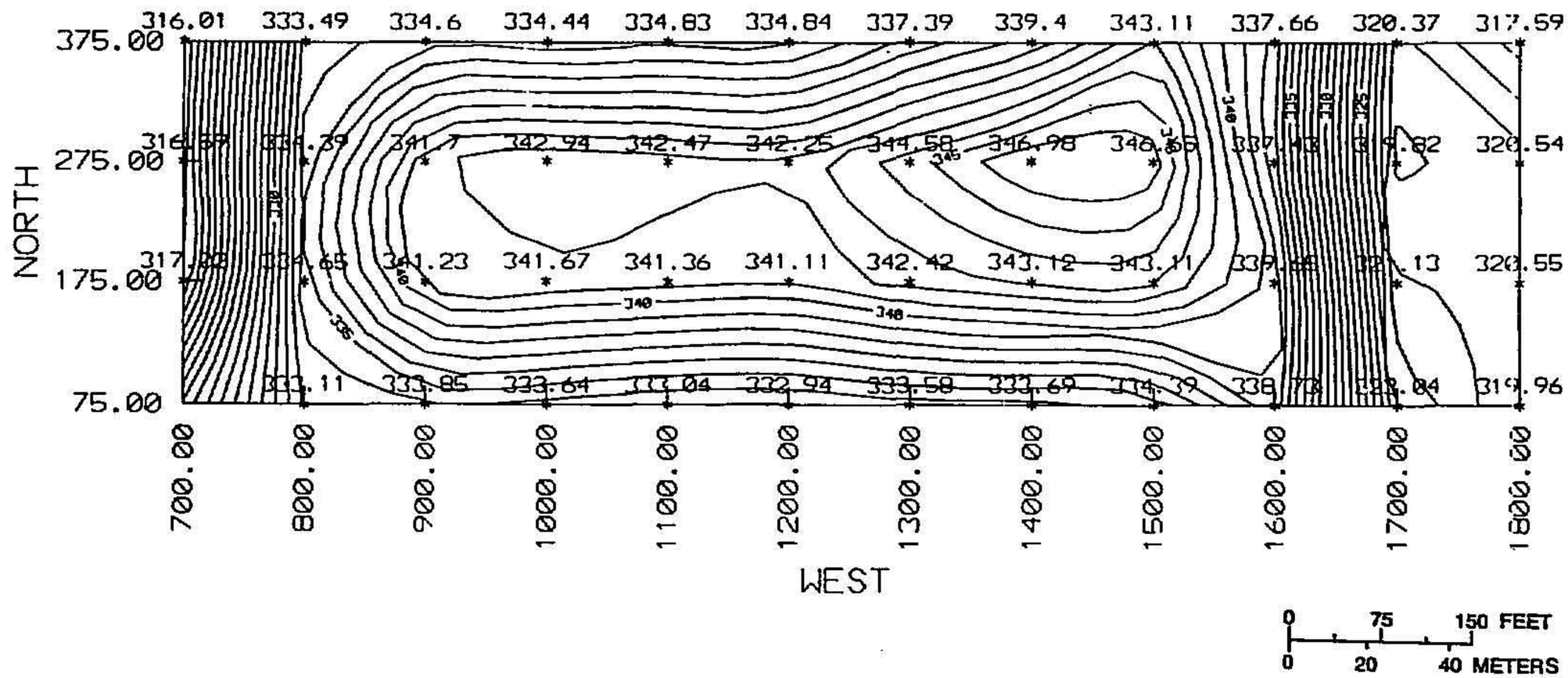

Figure 3-5
NFSS Monitoring Survey, April 1991

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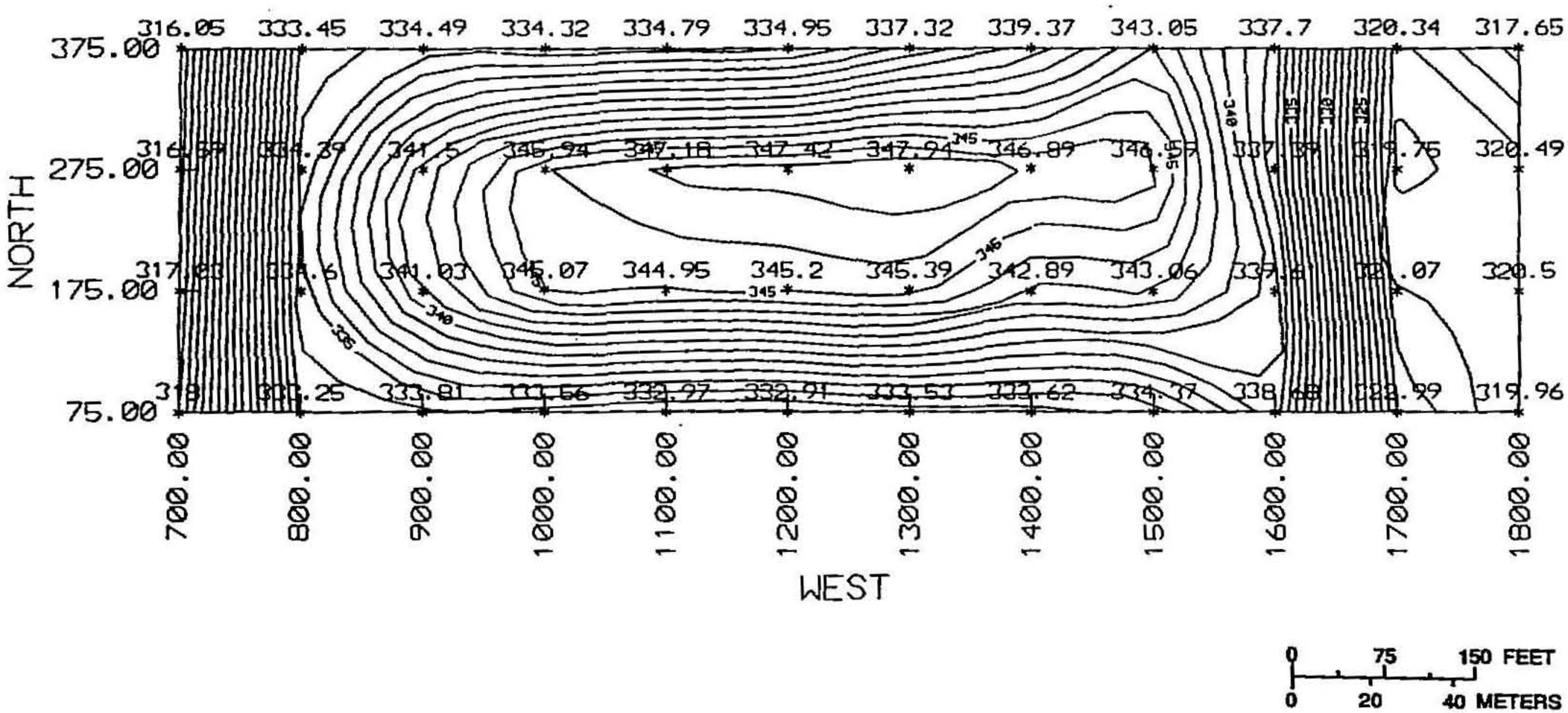

Figure 3-6
NFSS Monitoring Survey, October 1991

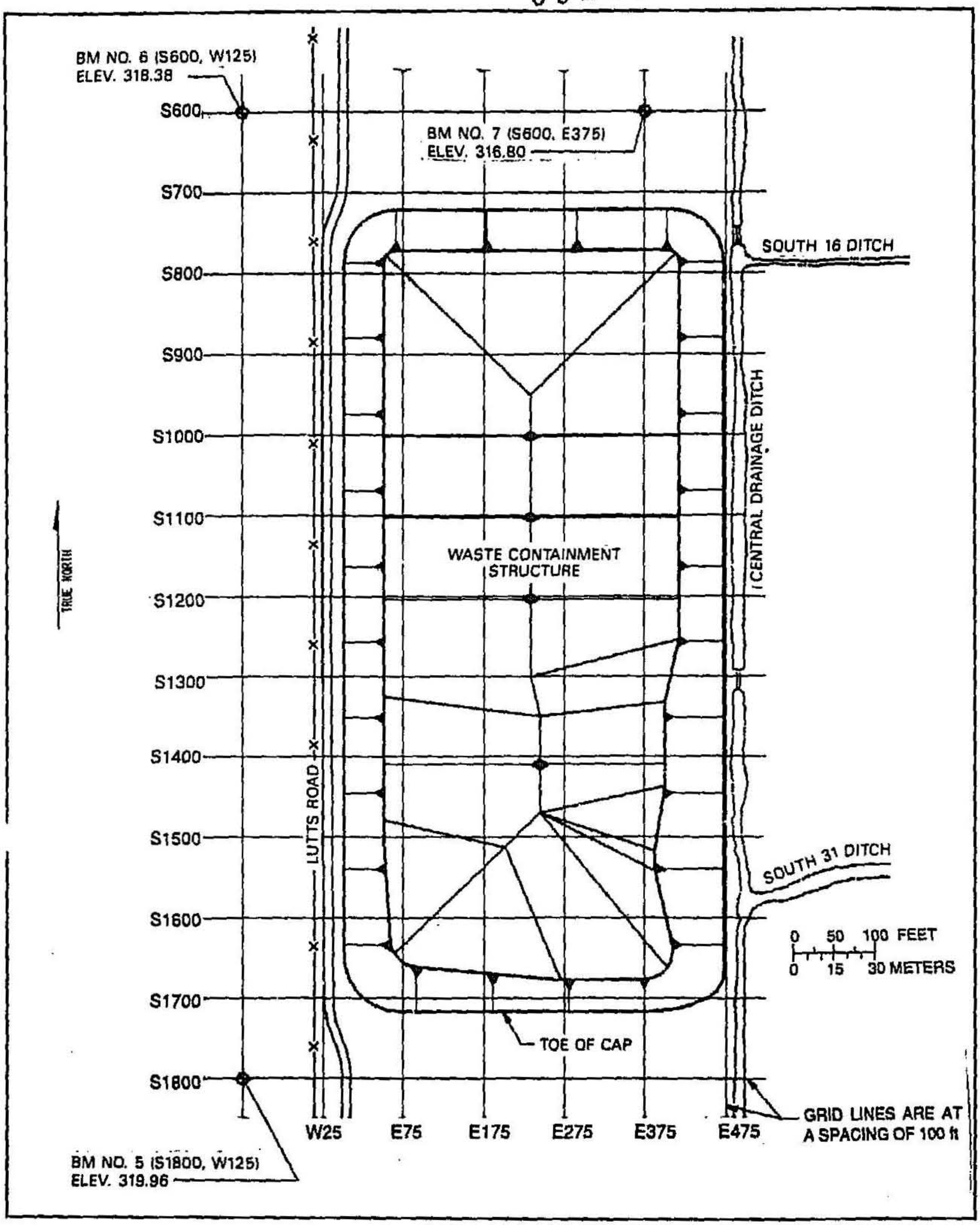

Figure 3-7
Survey Grid for the WCS

Table 3-1
Grid Survey for the Niagara Falls Storage Site

Coordinates South/East	Elevation (ft MSL)[a] 10/14/86	04/22/91		10/17/91		
700 / 75	318.2	N.D.[b]	[N.D.][c]	318.0	[-0.2][c]	[N.D.][d]
700 / 175	317.2	317.0	[-0.2]	317.0	[-0.2]	[0.0]
700 / 275	317.1	316.6	[-0.5]	316.6	[-0.5]	[0.0]
700 / 375	317.2	316.0	[-1.2]	316.1	[-1.1]	[0.1]
800 / 75	332.2	333.1	[0.9]	333.3	[1.1]	[0.2]
800 / 175	334.7	334.7	[0.0]	334.6	[-0.1]	[-0.1]
800 / 275	334.5	334.4	[-0.1]	334.4	[-0.1]	[0.0]
800 / 375	333.5	333.5	[0.0]	333.5	[0.0]	[0.0]
900 / 75	333.9	333.9	[0.0]	333.8	[-0.1]	[-0.1]
900 / 175	341.2	341.2	[0.0]	341.0	[-0.2]	[-0.2]
900 / 275	341.7	341.7	[0.0]	341.5	[-0.2]	[-0.2]
900 / 375	334.6	334.6	[0.0]	334.5	[-0.1]	[-0.1]
1000 / 75	333.6	333.6	[0.0]	333.6	[0.0]	[0.0]
1000 / 175	341.8	341.7	[-0.1]	345.1	[3.3][e]	[3.4][e]
1000 / 275	343.1	342.9	[-0.2]	345.9	[2.8][e]	[3.0][e]
1000 / 375	334.5	334.4	[-0.1]	334.3	[-0.2]	[-0.1]
1100 / 75	333.1	333.0	[-0.1]	333.0	[-0.1]	[0.0]
1100 / 175	341.4	341.4	[0.0]	345.0	[3.6][e]	[3.6][e]
1100 / 275	342.5	342.5	[0.0]	347.2	[4.7][e]	[4.7][e]
1100 / 375	334.9	334.8	[-0.1]	334.8	[-0.1]	[0.0]
1200 / 75	333.0	332.9	[-0.1]	332.9	[-0.1]	[0.0]
1200 / 175	341.2	341.1	[-0.1]	345.2	[4.0][e]	[4.1][e]
1200 / 275	342.3	342.3	[0.0]	347.4	[5.1][e]	[5.1][e]
1200 / 375	335.0	334.8	[-0.2]	335.0	[0.0]	[0.2]
1300 / 75	333.6	333.6	[0.0]	333.5	[-0.1]	[-0.1]
1300 / 175	342.4	342.4	[0.0]	345.4	[3.0][e]	[3.0][e]
1300 / 275	344.7	344.6	[-0.1]	347.9	[3.2][e]	[3.3][e]
1300 / 375	337.5	337.4	[-0.1]	337.3	[-0.2]	[-0.1]
1400 / 75	333.7	333.7	[0.0]	333.6	[-0.1]	[-0.1]
1400 / 175	343.2	343.1	[-0.1]	342.9	[-0.3]	[-0.2]
1400 / 275	347.4	347.0	[-0.4]	346.9	[-0.5]	[-0.1]
1400 / 375	339.6	339.4	[-0.2]	339.4	[-0.2]	[0.0]
1500 / 75	334.5	334.3	[-0.2]	334.4	[-0.1]	[0.1]
1500 / 175	343.2	343.1	[-0.1]	343.1	[-0.1]	[0.0]
1500 / 275	347.1	346.7	[-0.4]	346.6	[-0.5]	[-0.1]
1500 / 375	343.3	343.1	[-0.2]	343.1	[-0.2]	[0.0]
1600 / 75	338.8	338.7	[-0.1]	338.7	[-0.1]	[0.0]
1600 / 175	339.8	339.7	[-0.1]	339.6	[-0.2]	[-0.1]
1600 / 275	337.5	337.4	[-0.1]	337.4	[-0.1]	[0.0]
1600 / 375	337.8	337.7	[-0.1]	337.7	[-0.1]	[0.0]
1700 / 75	323.1	323.0	[-0.1]	323.0	[-0.1]	[0.0]
1700 / 175	321.2	321.1	[-0.1]	321.0	[-0.2]	[-0.1]
1700 / 275	319.9	319.8	[-0.1]	319.8	[-0.1]	[0.0]

Table 3-1

(continued)

Coordinates South/East	Elevation (ft MSL)[a] 10/14/86	04/22/91		10/17/91		
1700 / 275	320.5	320.4	[-0.1][c]	320.3	[-0.2][c]	[-0.1][d]
1800 / 75	320.2	320.0	[-0.2]	320.0	[-0.2]	[0.0]
1800 / 175	320.5	320.6	[0.1]	320.5	[0.0]	[-0.1]
1800 / 275	321.4	320.5	[-0.9]	320.5	[-0.9]	[0.0]
1800 / 375	317.6	317.6	[0.0]	317.7	[0.1]	[0.1]

[a]Feet above mean sea level.

[b]N.D. = not determined.

[c]Bracketed values in this column indicate changes in elevation from the October 1986 baseline survey.

[d]Bracketed values in this column indicate changes in elevation between the April 1991 and October 1991 surveys.

[e]Area within these grid coordinates were used for the waste consolidation work as discussed in Subsection 3.1.4 and depicted in Figure 3-8.

life of the structure. The data presented in Table 3-1 demonstrate that most of the survey locations showed a settlement of 3 cm (1.2 in.) or less. Survey locations showing settlement greater than 3 cm (1.2 in.) over the 6-month period will be evaluated to determine the cause. Some of the points showing settlement greater than 3 cm (1.2 in.) resulted from the stockpiling of construction materials on the structure during the waste consolidation work. Changes in elevations from the baseline survey are provided for historical purposes and are not meant to indicate a settlement trend in the WCS.

The waste consolidation effort in summer 1991 resulted in a noticeable increase in elevation in the affected area of the WCS. The elevation increase varied from 0.8 m (2.5 ft) to slightly more than 1.8 m (6 ft). The grid survey locations within the WCS area used for waste consolidation have been identified in Table 3-1.

Because the grade stakes used for performing the grid survey showed signs of uplift caused by frost heave, it was decided to record the elevations at the ground surface adjacent to the established survey grid points. A 100-ft by 100-ft grid system will be established on the top surface of the WCS for surveying purposes, except for the area where waste consolidation was performed during the summer of 1991. For this newly constructed area of the WCS, a 50-ft by 50-ft grid system will be established for closer monitoring. In addition, surface elevations will be measured at four locations outside of the WCS (S600 E075, S600 E275, S1800 E075, and S1800 E375) to monitor the general changes in the elevations of the area surrounding the structure.

3.1.3 Walkover Surveys

The first walkover survey of the WCS was performed on November 17 and 18, 1986, to determine whether any actions would be required beyond normal maintenance. The survey team evaluated settlement or movement, cracking, undesired plant growth, and minor conditions such as localized areas of sparse grass, tire tracks, poor water drainage, and isolated areas of erosion on the WCS cap. To conduct the walkover survey, team members walked a preplanned

route based on an established grid that ensured complete and systematic inspection of the cap.

Since the fall of 1986, walkover surveys of the WCS have been performed during the spring and fall of each year to evaluate the overall performance of the WCS. The walkover survey generally covers the WCS, major site drainage ditches, and other features determined by the team to be pertinent to the stability of the site. The walkover survey team consists of representatives from engineering, geotechnical, soils engineering, and site operations departments.

The walkovers detailed in this section were performed following the same walkover pattern used in previous performance appraisals. Close-spaced, north-south routes were followed, starting at the southwest corner of the WCS. The walkover team members were free to adjust their routes along each traverse to view the cap surface in whatever detail seemed appropriate. Team members kept notes of conditions that required maintenance and placed pin-flag markers at those locations to assist the maintenance team in relocating them. This section of the report presents the results of the 1991 spring and fall walkover surveys.

Calendar Year 1991

The walkover surveys for 1991 were performed in April and October. During the spring walkover, the survey team traversed the total surface area of the WCS; the fall walkover did not include an inspection of the area where the waste consolidation effort was completed during the previous summer.

The turf coverage continues to improve, but grass density is sparse at some locations. An unusually low amount of snowfall during the previous winter resulted in a noticeable winter-kill of grass, but the grass coverage had improved by the fall walkover. The lower grass density does not pose an immediate threat to the integrity of the cap, but it may reduce the vigor of the turf in the future. The spring fertilization and weed control program was postponed because of the waste consolidation effort planned for the summer season. This resulted in the growth of weeds on the WCS

surface, including broad-leaf varieties such as dock, clover, dandelions, and deep-rooted alfalfa.

Holes formed by burrowing animals (moles, mice, etc.) were discovered at several locations along the south and east transition slopes during both spring and fall walkovers. The burrows ranged from 2.5 to 15 cm (1 to 6 in.) in diameter and 15 to 20 cm (6 to 8 in.) deep (the larger holes were detected during the fall walkover). These and other holes were filled with soil and compacted; the resulting bare patches will be seeded in spring 1992. These holes were located outside the clay dike and did not penetrate the waste material.

Drainage of the WCS was found to be functioning properly except for a portion of the toe-of-slope at the southern end of the WCS, where water was draining around the toe of the slope toward the west side of the structure and ponding at the culvert under Lutts road. This area was repaired during the waste consolidation work. Other areas of suspected water ponding that were observed on top of the WCS during the spring walkover were repaired before the fall walkover. Undulations, which appear to be the result of long-term settlement, were observed along the north/south axis of the WCS, mainly along the north portion of the cap.

The VWPT cable junction manhole was repaired and appeared to be draining well. The backfill over the 3-in. drainpipe installed at the bottom of the precast manhole showed signs of minor sloughing during the spring walkover. During the fall walkover, it was noted that minor cracking and settlement of the backfill material had created a surface channel. The settled area was backfilled to avoid soil erosion and subsequent development of a surface runoff drain. The drainpipe appears to be securely in place, but this area will be regularly inspected by the site maintenance staff, particularly after heavy rains.

During the fall walkover, minor desiccation cracks [0.6 to 1.3 cm (0.25 to 0.50 in.) wide and 2.5 to 5 cm (1 to 2 in.) deep] were observed along the top break-in-slope on the west side of the WCS. The cracks occurred in an area of poor grass cover and were associated with severe drying of the topsoil during the summer because of minimal rainfall. The cracks will be observed by the

site maintenance staff until spring 1992 for possible expansion resulting from the freezing and thawing cycle during the winter.

Areas disturbed during waste consolidation on the top surface of the WCS were devoid of grass cover. These spots will be reseeded along with the fertilizer application during spring 1992.

Drainage channels observed during the spring walkover along the west slope of the central drainage ditch had not eroded further by fall and did not require remedial action. The portion of the cap reconstructed during the waste consolidation work will be monitored for the development of new drainage channels. A low area at the east edge of the newly constructed cap will also be monitored because it may become a potential drainage pathway for surface runoff from the cap.

3.1.4 Waste Consolidation

In summer 1991, a small waste containment cell was excavated in the existing WCS to incorporate waste materials identified at NFSS after the closure of the WCS in 1986. The waste included 2,450 m^3 (3,200 yd^3) of contaminated soil, four steel tanks from the dismantled Hittman water treatment system, miscellaneous debris, and the tarp and geotextile materials used to cover the waste, which had been stored in two temporary storage piles. Also, sixty-four 55-gal drums containing solidified tars and resins stored in Building 401, approximately 900 boxes of contaminated soil samples stored in Building 401A, and the contaminated material excavated from the isolated residual radioactivity area were placed in the waste containment cell.

To incorporate the additional contaminated materials in the WCS, a designated area of the structure [99 m by 58.5 m (325 ft by 192 ft)] was excavated to a depth of 1 m (3.25 ft), including 0.46 m (1.5 ft) of topsoil and 0.54 m (1.75 ft) of clay; a 0.38-m (1.25-ft) cover remained over the contaminated materials previously placed in the WCS. After the contaminated materials were placed in the prepared waste containment cell, a 0.9-m- (3-ft-) thick clay cap, followed by a 0.46-m (1.5-ft) layer of topsoil was constructed over the excavated opening in the WCS. Figures 3-8 through 3-10

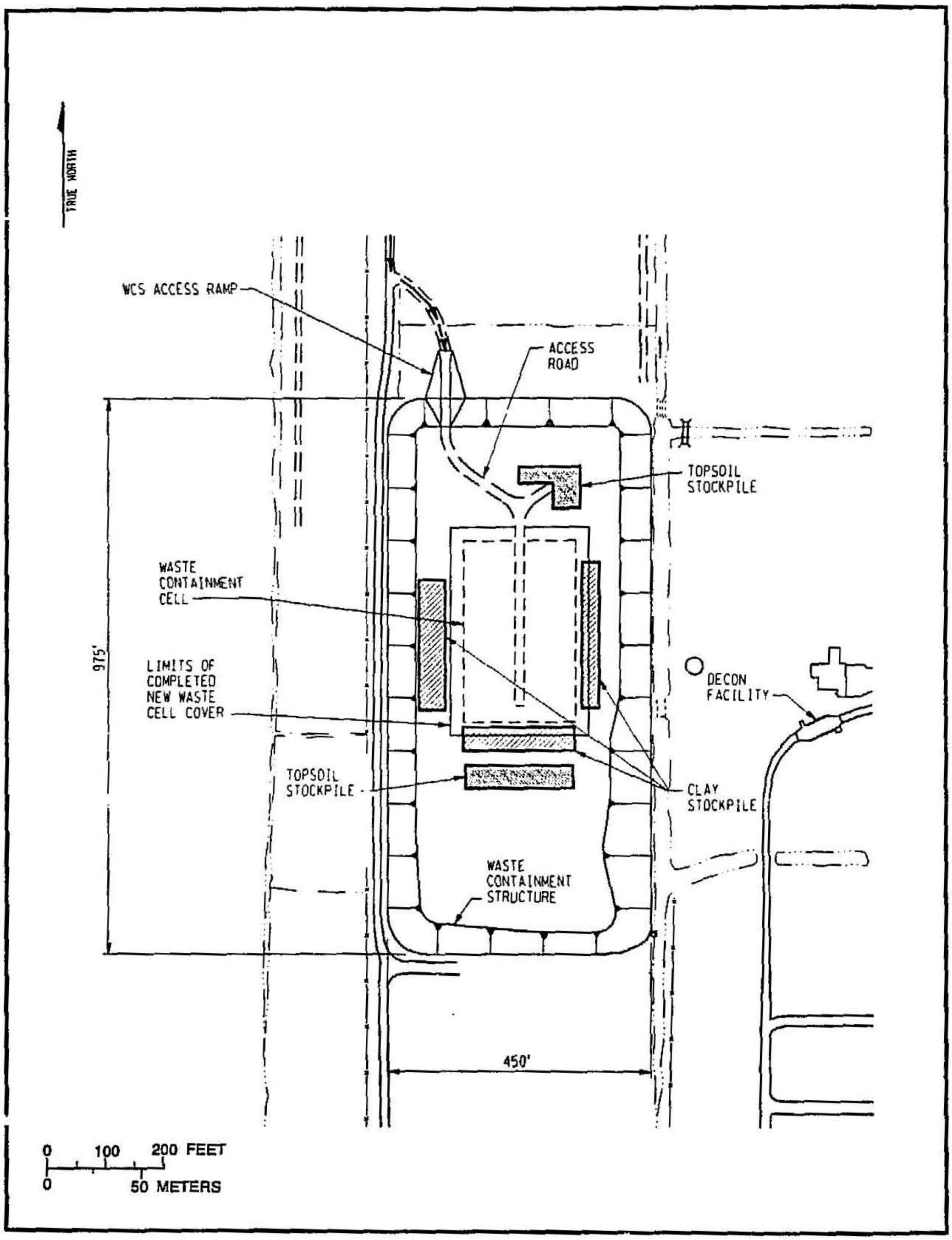

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Figure 3-8
Plan View of the WCS

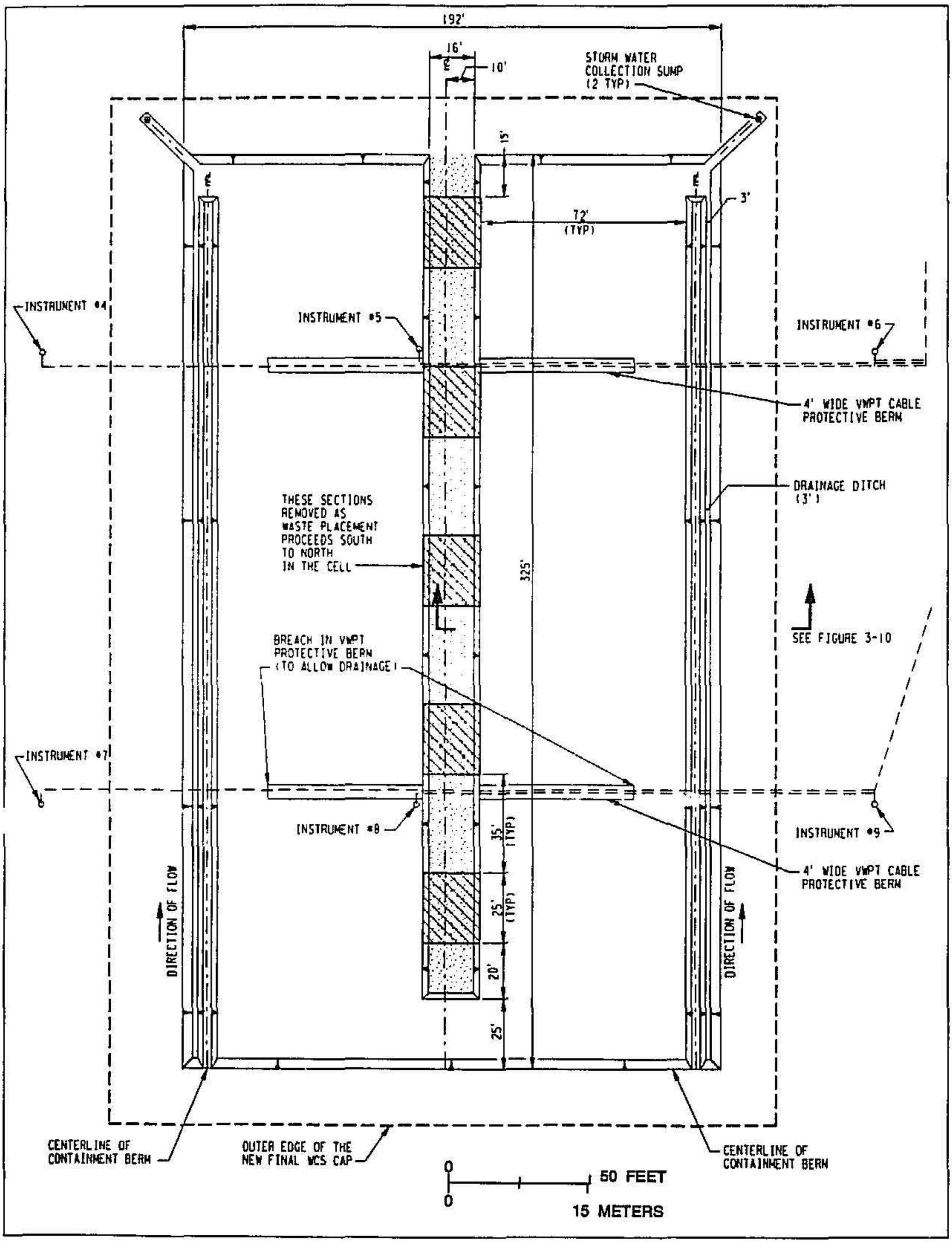

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Figure 3-9
Waste Containment Cell Excavation Plan

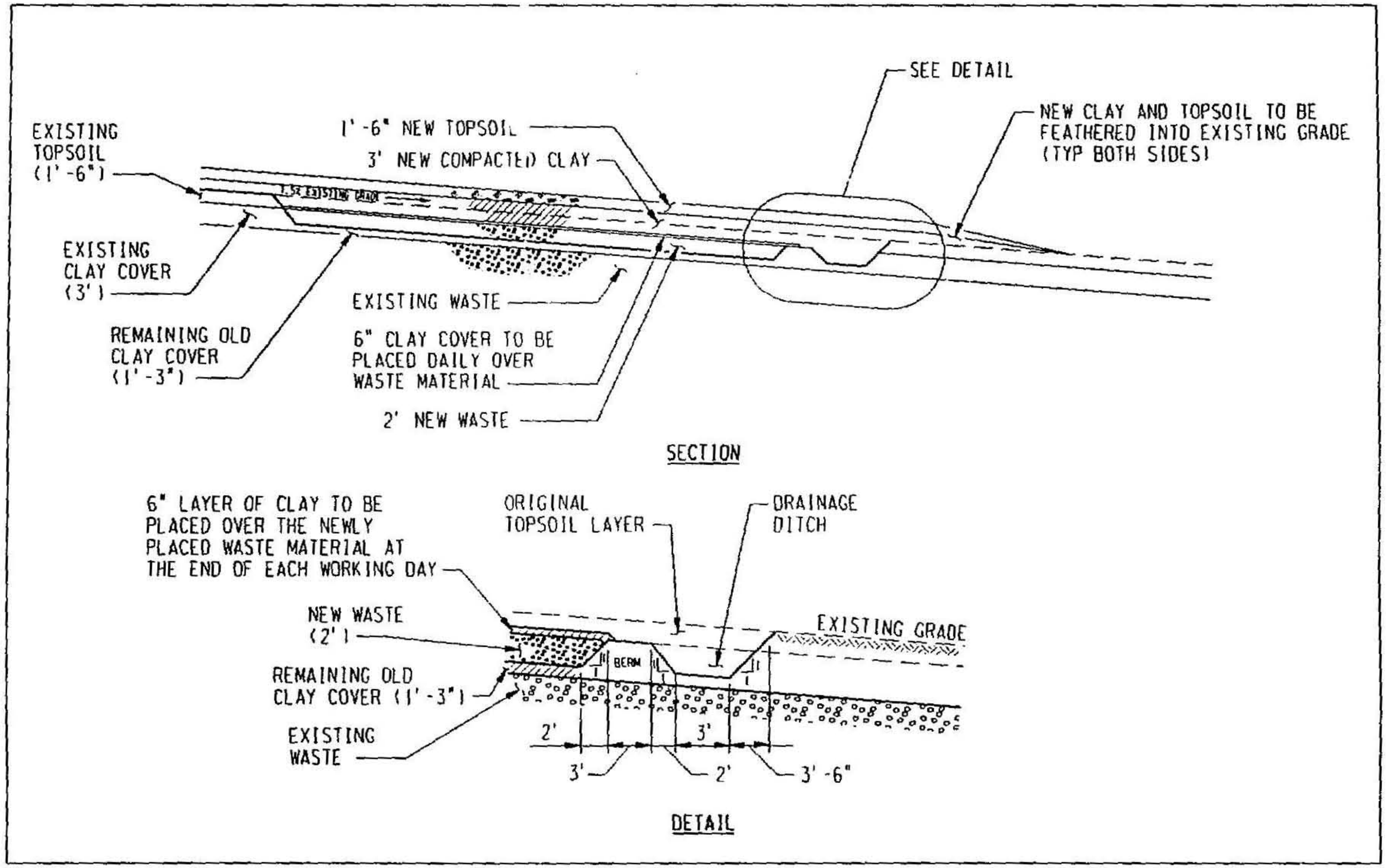

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Figure 3-10
Cross Section and Detail

show the details of the waste consolidation work. The topsoil layer was feathered into the existing surface of the WCS to maintain the homogeneity of the structure. The newly constructed cap of the waste containment cell was fertilized and seeded after completion of the waste consolidation activities and is expected to have a viable uniform grass cover by spring 1992.

3.2 SUBSURFACE MONITORING

From January 1991 through May 1991, daily VWPT readings were recorded by an automatic vibrating-wire data acquisition system. In June 1991, the automatic read-out system was damaged by lightning, and only monthly readings were available for the rest of the year. The monthly readings were recorded by a manually operated vibrating-wire frequency indicator. The data from the VWPTs have been converted to hydraulic head and are presented in Appendix A. Because the daily data were not available from June onward, the plots were created from values obtained at the beginning of each month from January through December 1991 (except for July, when the system was temporarily inoperative). In general, the plots exhibit a continuation of the seasonal trends observed during previous years, characterized by a maximum head elevation in early spring (March or April) and a minimum head elevation during fall (September or October).

VWPT instruments 11 and 12 failed to operate for the entire calendar year 1991. Instrument 3, which has exhibited a complex operating history of reading and nonreading cycles in previous years operated until June, but no readings were available from this instrument for the rest of the year. Instrument 4 did not provide readings for November and December 1991. Instruments 7, 8, and 9 were inoperative after July. The cause of these malfunctions has not been determined; however, a complete diagnostic test of the system to identify and correct the problem will be performed during spring 1992.

The peak low-water levels recorded in the upper and lower groundwater systems were significantly lower than those recorded

during the previous three years. This is probably a combined effect of lower-than-normal rainfall during summer and fall and higher-than-normal evapotranspiration. The hydrographs from monitoring wells in the upper and lower groundwater systems (Figures 3-11 and 3-12) illustrate the groundwater deficit. The upper groundwater system showed recovery to normal by the end of the year, but the lower groundwater system did not reach its peak low by the end of 1991. This is the lowest recorded water level at NFSS since the wells were installed.

The data collected to date do not indicate the development of weaknesses in the clay cap, the cutoff wall, the clay dike, or the gray clay unit.

3.3 ENVIRONMENTAL MONITORING

Radiological environmental monitoring in 1991 at NFSS included sampling for radon concentrations in air, external gamma radiation exposure, and radium-226 and total uranium concentrations in surface water, sediment, and groundwater. The monitoring systems include onsite, property-line, and offsite sampling locations to provide sufficient information on potential effects of the site on human health and the environment. NFSS environmental monitoring results summarized in this document are reported in the annual site environmental monitoring report for 1991 (Bechtel 1992).

3.3.1 Radon Levels

Radon monitoring is conducted to confirm that NFSS is not significantly adding to the natural background radon levels and to ensure compliance with environmental regulations. Radon monitoring locations are shown in Figures 3-13 and 3-14.

The maximum quarterly ambient air radon concentration detected was 1.9 pCi/L (0.07 Bq/L) at location 13. The annual average radon concentration onsite and at the property line was less than the average background concentration. No quarterly or annual average level was higher than the DOE interim storage site guideline of 3.0 pCi/L.

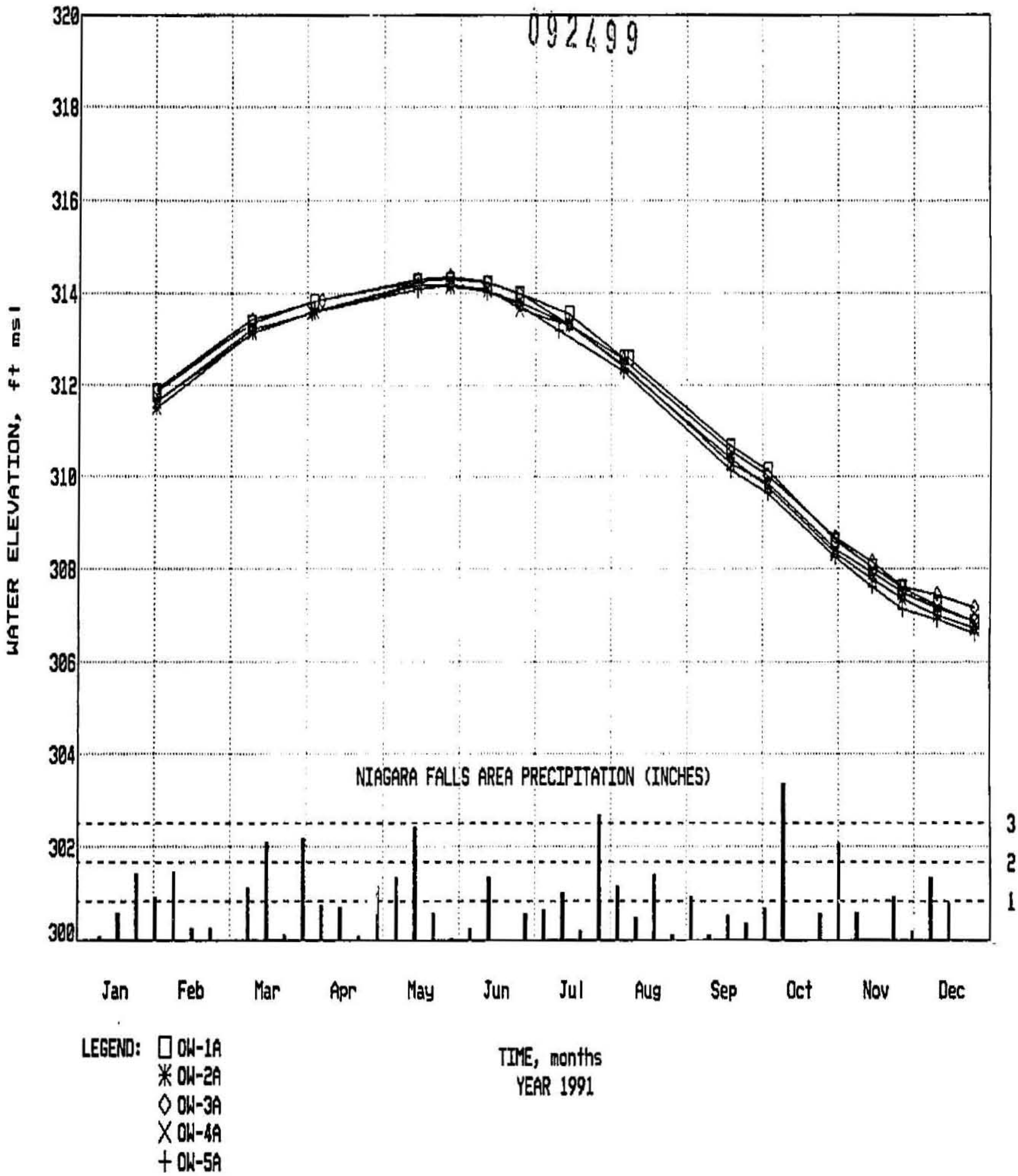

Figure 3-12
NFSS Hydrographs for 1991 (Lower Groundwater System)

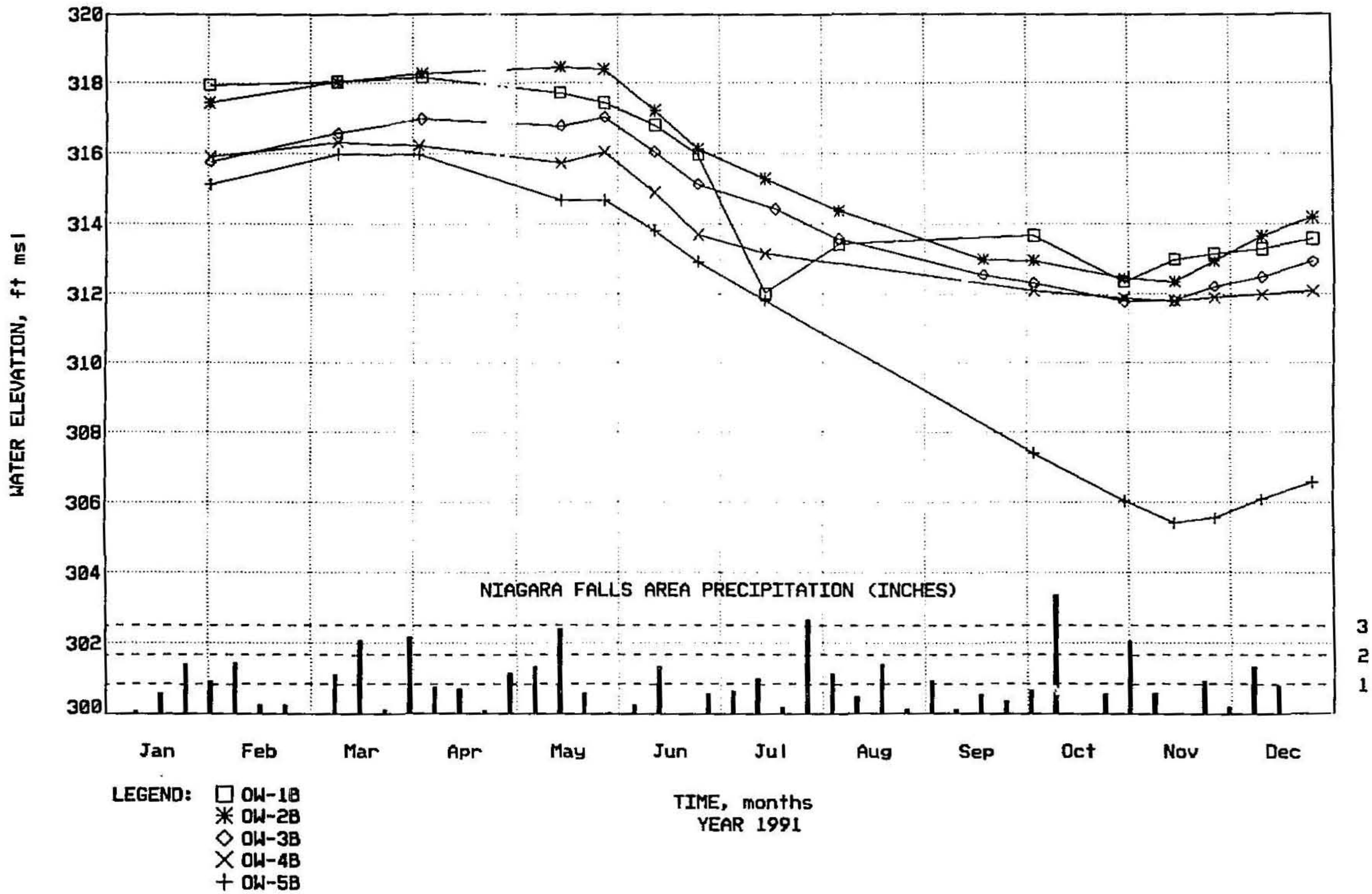

Figure 3-11
NFSS Hydrographs for 1991 (Upper Groundwater System)

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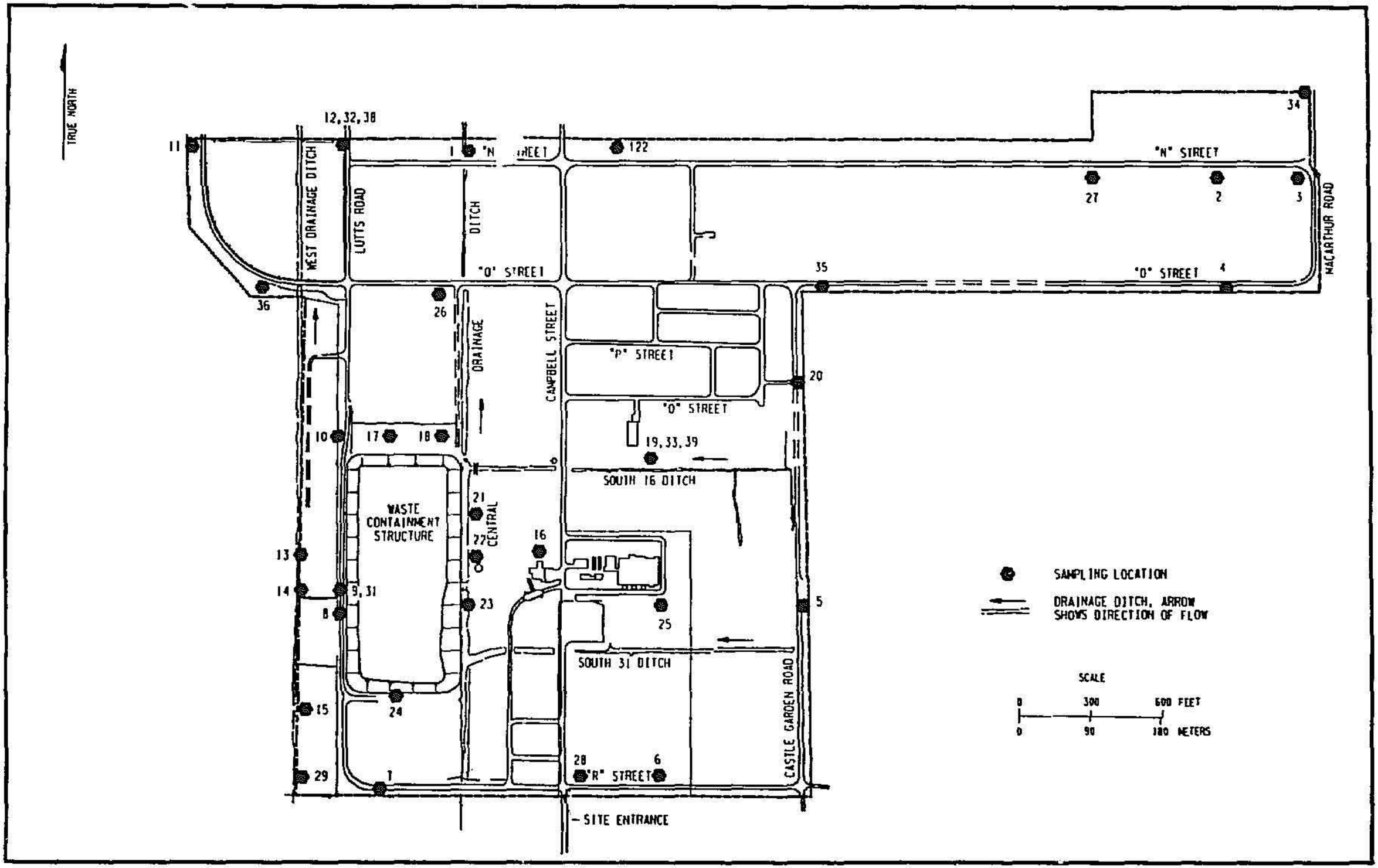

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Figure 3-13
Onsite and Fenceline Radon and External Radiation Monitoring Locations

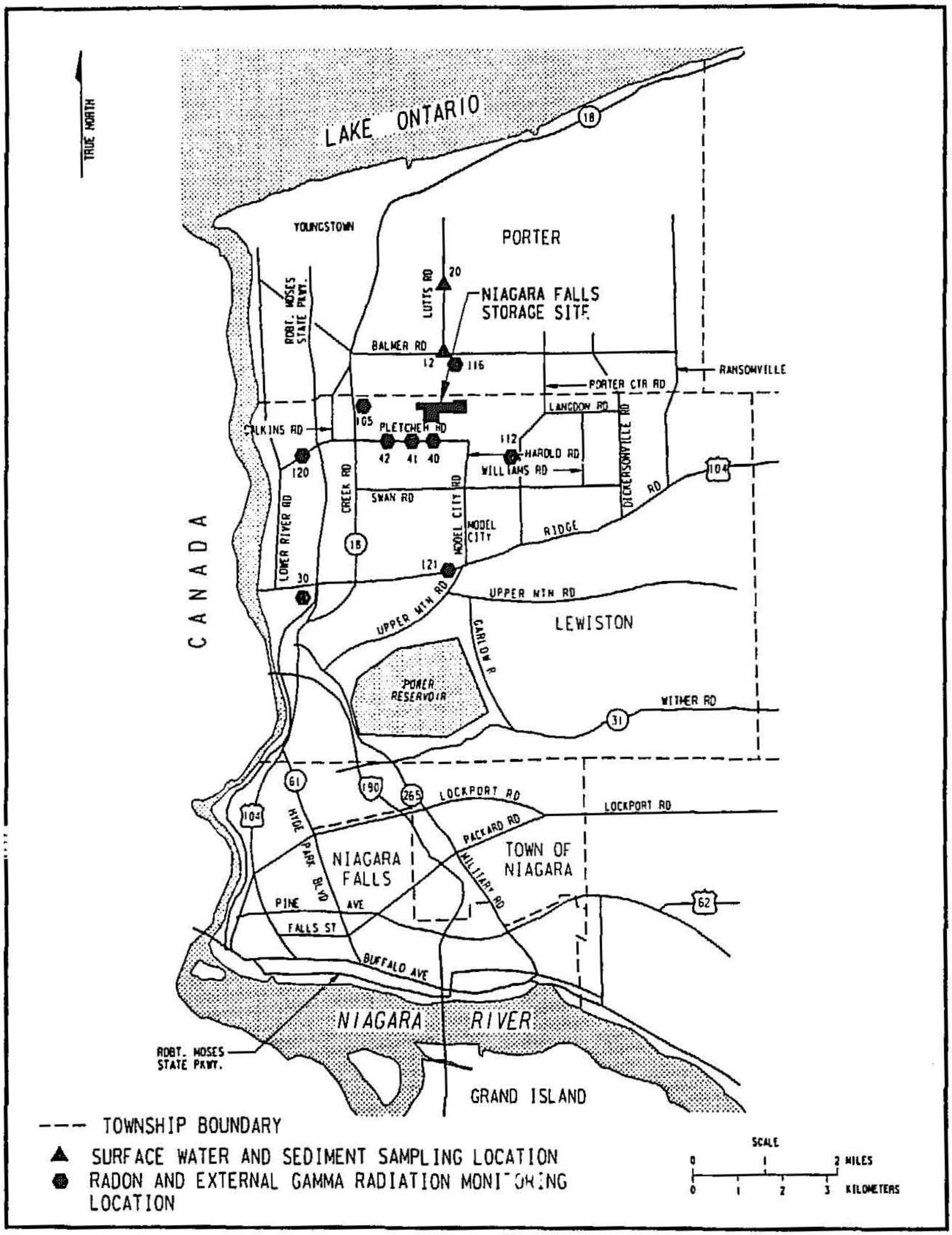

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Figure 3-14
Offsite Radon, External Gamma Radiation, Surface Water, and Sediment Monitoring Locations

The radon results for the WCS show an average flux rate of 0.05 pCi/m^2/s (0.02 Bq/m^2/s) with minimum and maximum levels of 0.04 and 3.3 pCi/m^2/s (1.5 x 10^3 and 0.12 Bq/m^2/s), respectively. These results demonstrate that the WCS is in compliance with the limit of 20 pCi/m^2/s (an averaged value) set forth in 40 CFR Part 61, Subpart Q.

3.3.2 External Gamma Radiation Levels

Since 1988, the external gamma radiation monitoring system has used tissue-equivalent thermoluminescent dosimeters (TETLDs) to provide realistic values of radiation dose to the tissues of the body. Although TETLDs are state of the art, the dosimeter accuracy is approximately ±10 percent at radiation levels between 100 and 1,000 mR/yr and ±25 percent at levels between 0 and 70 mR/yr. Therefore, for the low levels that are being monitored at NFSS (below 70 mR/yr), there can be seemingly large differences resulting from inaccuracies of detection and the processing system.

The average gamma radiation exposure level was 7 mR/yr onsite and 6 mR/yr at the property line, excluding an average background level of 75 mR/yr. The highest annual average external gamma radiation level at the property line, excluding background, was 13 mR/yr (locations 5 and 20). These levels are within the DOE guideline of 100 mrem/yr above background (1 mrem is approximately equivalent to 1 mR).

3.3.3 Surface Water and Sediment Sampling

Surface water monitoring is conducted to determine whether onsite surface water is contaminated, to determine whether runoff from NFSS contributes to the surface water contamination in the area, and to ensure compliance with environmental regulations. Onsite sampling locations for surface water (9, 10, and 11) are shown in Figure 3-15; offsite locations (12 and 20) are shown in Figure 3-14.

Location 9 is an upstream, background location established at the South 31 Ditch in October 1988. Locations 12 and 20 and 1.6

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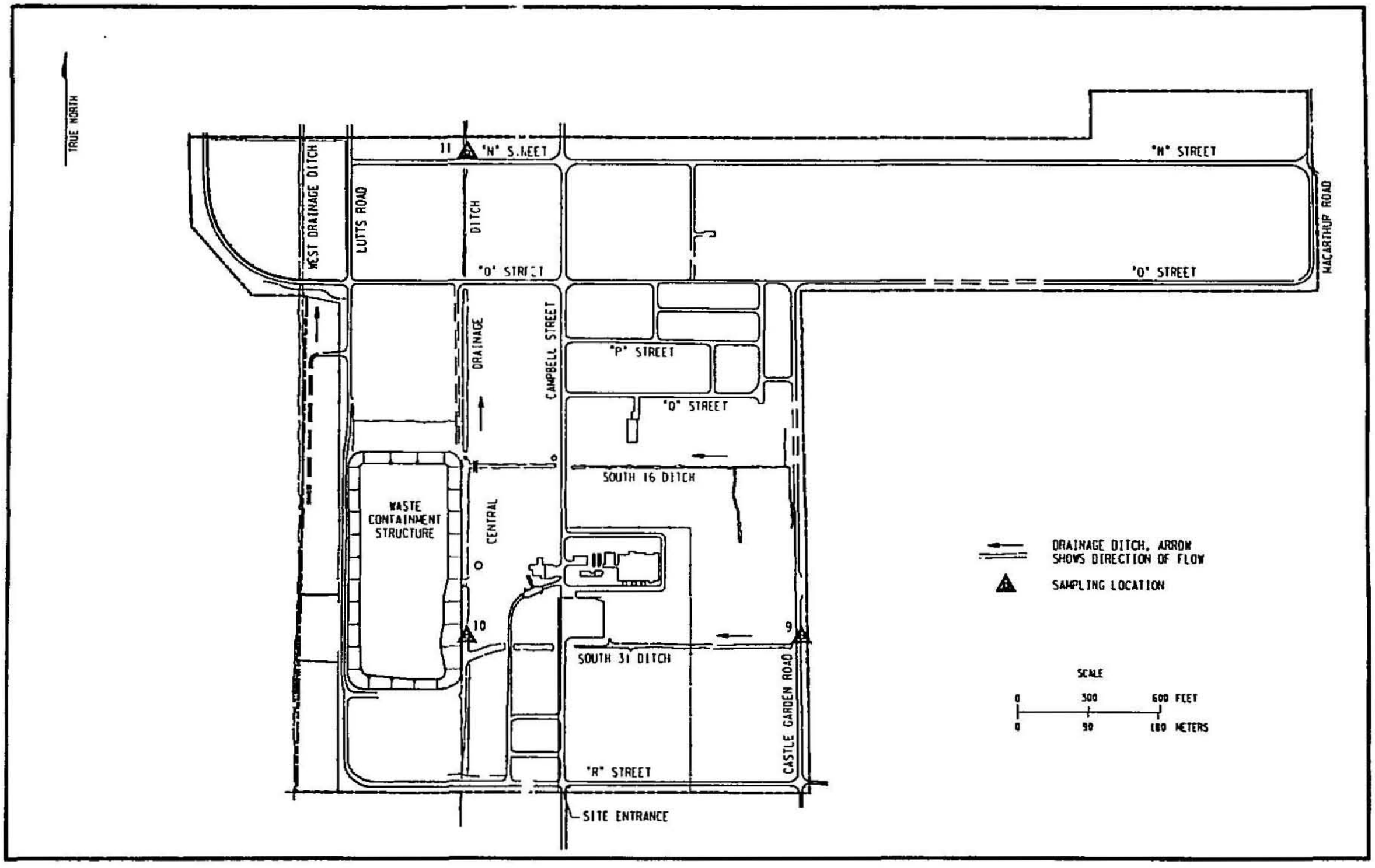

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Figure 3-15
Onsite Surface Water and Sediment Sampling Locations

and 3.2 km (1 and 2 mi) downstream, respectively, from the northern boundary of NFSS. Because surface water runoff from the site discharges via the Central Drainage Ditch, all sampling locations except location 9 were placed along that ditch.

Table 3-2 presents 1991 concentrations of total uranium and radium-226 in surface water, which were well below the derived concentration guides (DCGs) of 600 x 10^{-9} and 100 x 10^{-9} μCi/ml, respectively.

Sediment samples were collected quarterly at surface water sampling locations where sediment is present. Onsite sampling locations (9, 10, and 11) are shown in Figure 3-15; downstream, offsite locations (12 and 20) are shown in Figure 3-14.

Table 3-3 presents 1991 concentrations of total uranium and radium-226 in sediment at NFSS. The higher concentration of total uranium at location 9 (the upstream location) is probably due to residual radioactivity (below guidelines) remaining from previous remedial action activities. Total uranium concentrations were close to background throughout the year and below the FUSRAP soil guideline of 90 pCi/g established for NFSS. Radium-226 levels remained close to background throughout the year and below the established FUSRAP soil guidelines.

3.[illegible] [illegible]dwater Sampling

The monitoring well system is designed to provide sufficient coverage of both upgradient and downgradient conditions. Sampling locations (Figure 3-16) were selected based on the areas of known radioactive contamination and available hydrogeological data. Well BH-48 monitors background conditions in the lower groundwater system, including bedrock, and well 20S monitors background conditions in the upper groundwater system. Wells with the prefix "A" and suffix "S" are in the upper groundwater system; those with the prefix "BH" and suffix "D" are in the lower system. Most of the monitoring wells are located near the WCS. In 1987, 36 wells ("OW" wells in Figure 3-16) were added to the environmental monitoring program to closely monitor groundwater near the WCS to detect contaminant movement from the pile. The "OW" wells with the

Table 3-2

Concentrations[a,b] of Total Uranium and Radium-226 in Surface Water at NFSS, 1991

Sampling Location[c]	Quarter 1[d]	2	3	4	Avg
(Concentrations are in 1 x 10^{-9} µCi/ml)					
Total Uranium[d]					
9[e]	7	4	--[f]	4	5
10	11	7	--[f]	7	8
11	13	9	--[f]	16	13
12[g]	3	4	<4	3	4
13[h]	4	4	<4	3	4
20[g]	4	4	<4	4	4
Radium-226					
9[e]	2.3	0.1	--[f]	0.9	1
10	0.3	0.3	--[f]	1.5	0.7
11	3.3	0.5	--[f]	0.7	2
12[g]	0.2	0.1	0.9	1.0	0.6
13[h]	0.2	0.2	0.1	0.5	0.3
20[g]	0.3	0.4	0.4	0.5	0.4

[a]Note: 1 x 10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The derived concentration guides for total uranium and radium-226 are 600 x 10^{-9} and 100 x 10^{-9} µCi/ml, respectively.

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figures 3-14 and 3-15.

[d]Total uranium concentrations were determined by using the fluorometric method during the first three quarters and by kinetic phosphorescence analysis during the fourth quarter.

[e]Background, upstream sampling location.

[f]Because of drought conditions, the ditch was dry and could not be sampled.

[g]Offsite, downstream sampling location.

[h]Quality control for location 12.

Table 3-3

Concentrations[a,b] of Total Uranium and Radium-226 in Sediment at NFSS, 1991

Sampling Location[c]	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
	(Concentrations are in pCi/g)				
	Total Uranium				
9[d]	10.7	<9.1	--[e]	2.1	7.3
10	4.7	<4.4	--[e]	3.7	4.3
11	3.9	<4.4	--[e]	3.3	3.9
12[f]	1.6	<3.6	1.7	6.8	3.4
20[f]	1.8	<4.1	1.8	2.1	2.5
	Radium-226				
9[d]	2.1	1.0	--[e]	<1.4	2
10	0.6	1.1	--[e]	<0.7	0.8
11	1.9	0.9	--[e]	<1.4	1.4
12[f]	0.8	0.6	0.2	<1.1	0.7
20[f]	1.1	0.7	0.7	<1.7	1

[a]Note: 1 pCi/g is equivalent to 0.037 Bq/g. The FUSRAP soil guideline for total uranium is 90 pCi/g, and for radium-226 is 5 pCi/g.

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figures 3-14 and 3-15.

[d]Background, upstream sampling location.

[e]Because of drought conditions, the ditch was dry and could not be sampled.

[f]Offsite, downstream sampling location.

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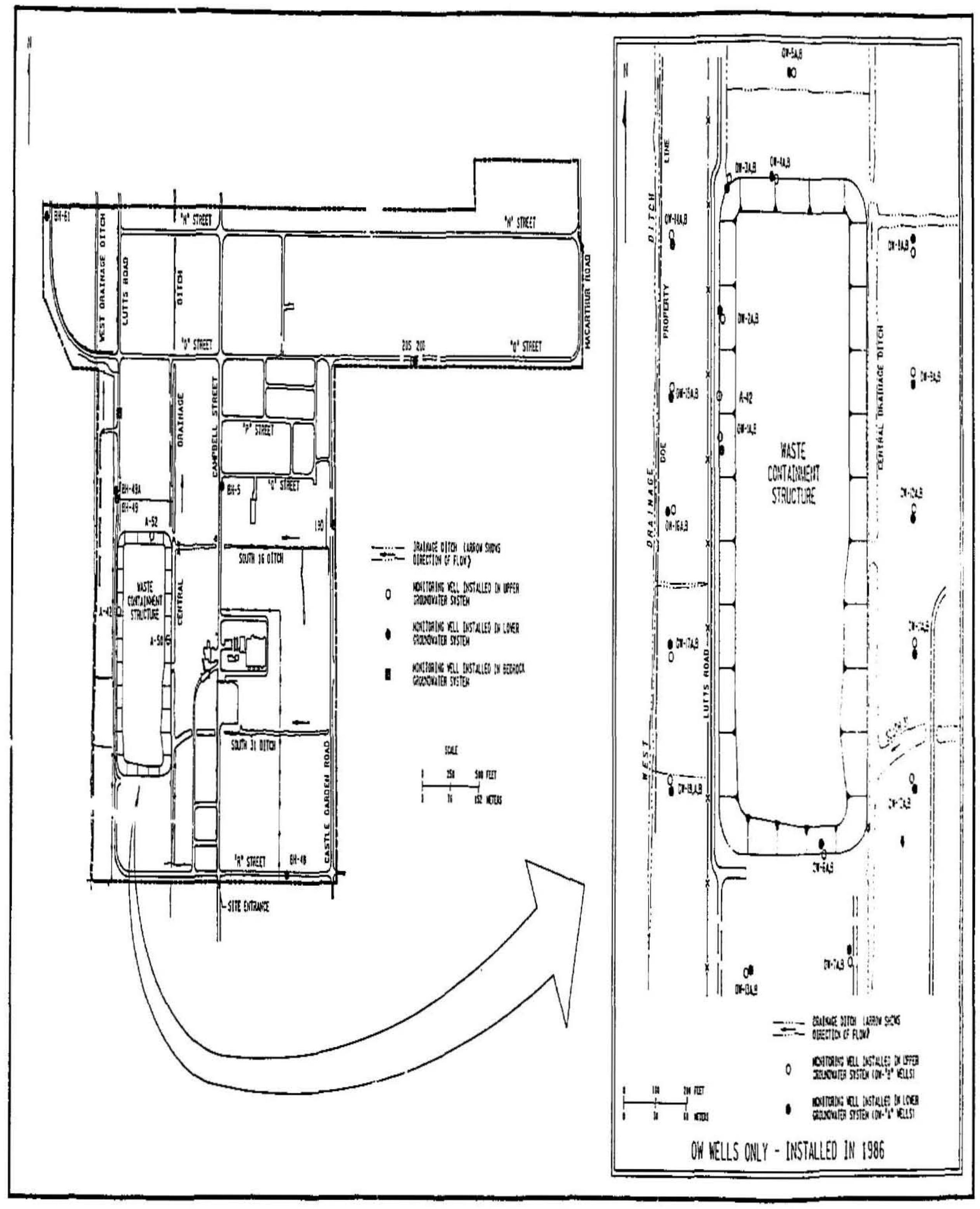

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Figure 3-16
Groundwater Sampling Locations at NFSS

suffix "A" are in the lower groundwater system; those with the suffix "B" are in the upper system.

Because of elevated uranium values in well A-42, chemical, radiological, and hydrogeological conditions in the well were investigated in December 1988; results indicate that the sand lens through which the well was driven is not in hydraulic connection with the zones of completion of adjacent wells (Bechtel 1991). Additionally, results of subsequent sampling conducted in 1989 indicate that radioactive contamination in well A-42 is probably associated with contaminated soils in or near the well and not with leakage from the WCS.

Three wells (19D, 20S, and 20D) were added to the environmental monitoring program in June 1990 to monitor groundwater near the NFSS/Modern Disposal landfill boundary.

Quarterly groundwater samples were analyzed for radium-226 and total uranium. Radium-226 concentrations in groundwater samples are presented in Table 3-4. Drought conditions in 1991 affected the elevation of water levels in the upper groundwater system; Wells OW-1B, OW-3B, OW-5B, OW-7B, OW-8B, OW-9B, OW-11B, OW-12B, OW-15B, OW-17B, OW-18B, A-50, and 20-S (Figure 3-16) did not refill with water after purging. Therefore, samples were not collected from some of these wells during the fourth quarter because the amount of water was insufficient. Samples were not collected from [illegible] the third quarter because of inaccessibility. Samples were also not collected from OW-4A during the third quarter because the bailer was stuck in the well and could not be removed. Data available for the first, second, and third quarters for most of the wells in the upper groundwater system are presented in Tables 3-4 and 3-5; the average levels for these quarters are compared with average background levels in well 20S.

There were no major differences in upgradient and downgradient radionuclide concentrations in the upper or lower groundwater systems for the wells in the WCS area. All radium-226 concentrations were below the DCG of 100 x 10^{-9} μCi/ml.

Total uranium concentrations in groundwater samples are presented in Table 3-5. There were no significant differences in radionuclide concentrations between the background and downgradient

Table 3-4

Concentrations[a] of Radium-226 in Groundwater

at NFSS, 1991

Sampling Location[b]	Quarter 1	2	3	4	Avg
(Concentrations are in 10^{-9} µCi/ml)					
Upper Groundwater System					
OW-1B	--[c]	0.4	0.4	--[d]	0.4
OW-2B	0.1	0.1	0.1	0.7	0.3
OW-3B	0.2	0.4	0.2	0.2	0.3
OW-4B	0.2	0.2	0.6	3.1	1.0
OW-5B	--[c]	0.3	--[e]	--[d]	0.3
OW-6B	0.1	0.3	0.2	0.1	0.2
OW-7B	0.3	0.4	0.3	--[d]	0.3
OW-8B	0.1	0.1	0.3	--[d]	0.2
OW-9B	0.3	0.3	0.1	--[d]	0.2
OW-10B	0.1	0.3	1.7	0.6	0.7
OW-11B	0.2	0.1	0.3	--[d]	0.2
OW-12B	0.4	0.1	--[d]	--[d]	0.3
OW-13B	0.8	0.1	0.4	0.7	0.5
OW-14B	0.2	0.1	0.7	2.2	0.8
OW-15B	0.2	0.1	0.5	--[d]	0.3
OW-16B	0.5	0.2	0.8	2.4	1.0
OW-17B	0.4	0.4	0.1	0.2	0.3
OW-18B	0.4	0.8	0.5	--[d]	0.6
[illegible]	0.8	0.3	0.2	0.5	0.[illegible]
A-44[f]	0.2	0.3	0.2	1.9	0.7
A-50	0.2	0.4	0.5	--[d]	0.4
A-52	0.7	0.5	0.5	2.7	1.1
BH-49A	0.7	0.5	3.1	2.7	1.2
20-S[g]	0.3	0.5	0.4	--[d]	0.4
Lower Groundwater System					
OW-1A	0.5	0.2	0.4	0.8	0.5
OW-2A	0.7	0.4	0.4	0.3	0.5
OW-3A	0.3	0.4	0.3	0.7	0.4
OW-4A	0.2	0.7	--[h]	0.2	0.4
OW-5A	0.3	0.2	0.5	0.9	0.5
OW-6A	0.2	0.6	0.5	1.7	0.8
OW-7A	0.3	0.2	0.1	2.1	0.7

Table 3-4

(continued)

Sampling Location[b]	Quarter 1	2	3	4	Avg
	(Concentrations in 10^{-9} µCi/ml)				
	Lower Groundwater System (cont'd)				
OW-8A	0.8	0.6	0.9	1.4	0.9
OW-9A	0.5	0.4	0.3	2.3	0.9
OW-10A	0.2	0.2	0.3	1.5	0.6
OW-11A	0.2	0.1	0.6	4.1	1.3
OW-12A	0.3	0.1	0.4	0.4	0.3
OW-13A	0.4	0.1	0.5	0.4	0.4
OW-14A	0.5	0.1	0.3	0.5	0.4
OW-15A	1.3	0.1	0.5	1	0.7
OW-16A	0.9	0.1	0.5	0.4	0.5
OW-17A	0.2	0.5	0.3	3.6	1.2
OW-18A	0.6	0.4	0.2	0.4	0.4
BH-5	0.2	0.4	0.4	1.9	0.7
BH-49	0.6	0.5	0.4	0.9	0.6
BH-53[i]	1.6	0.9	2.2	3.4	2
BH-61[j]	0.2	0.5	0.7	0.2	0.4
19-D	0.3	0.4	0.1	0.7	0.4
20-D	0.5	0.6	0.7	1.1	0.7
BH-48[g]	2.5	1.1	1	2.8	1.9

[a]Note: 1 x 10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The derived concentration guide is 100 x 10^{-9} µCi/ml.

[b]Sampling locations are shown in Figure 3-16.

[c]Not enough water for sample.

[d]Well did not recover after purging.

[e]Wasp nest in well; could not sample.

[f]Quality control for well A-42.

[g]Background well.

[h]Bailer stuck in well; could not sample.

[i]Quality control for well BH-48.

[j]Downgradient well.

Table 3-5

Concentrations[a] of Total Uranium in Groundwater at NFSS, 1991

Sampling Location[b]	Quarter 1	2	3	4	Avg
(Concentrations are in 10^{-9} µCi/ml)					
Upper Groundwater System					
OW-1B	--[c]	3	3	--[d]	3
OW-2B	8	7	11	6.6	8
OW-3B	14	15	13	10.8	13
OW-4B	4	5	8	5.5	6
OW-5B	--[c]	10	--[e]	--[d]	10
OW-6B	30	6	19	16.2	18
OW-7B	10	12	13	--[d]	12
OW-8B	9	5	26	--[d]	13
OW-9B	18	22	20	--[d]	20
OW-10B	7	14	28	5.8	14
OW-11B	15	28	27	--[d]	23
OW-12B	12	14	--[d]	--[d]	13
OW-13B	19	18	17	18	18
OW-14B	5	4	13	5.1	7
OW-15B	7.4	31.8	12.2	--[d]	17
OW-16B	5	14	3	4.9	7
OW-17B	5	9	3	6	6
OW-18B	14	17	12	--[d]	14
A-42	63	56	47	60.9	57
A-44[f]	47	55	52	60	53
A-50	6	10	4	--[d]	7
A-52	15	19	13	16.6	16
BH-49A	6	11	14	9.9	10
20-S[g]	5	8	4	--[d]	6
Lower Groundwater System					
OW-1A	3	3	3	0.8	3
OW-2A	11	3	3	0.3	4
OW-3A	6	4	4	6.4	5
OW-4A	3	3	--[h]	2.3	3
OW-5A	3	7	3	1	4
OW-6A	3	9	5	1.7	5

Table 3-5

(continued)

Sampling Location[b]	Quarter 1	2	3	4	Avg
Lower Groundwater System (cont'd)					
OW-7A	3	6	5	2.8	4
OW-8A	3	12	4	2.6	5
OW-9A	3	13	5	3	6
OW-10A	3	3	10	2.3	5
OW-11A	3	5	7	1.8	4
OW-12A	3	3	7	0.2	3
OW-13A	3	5	14	2.5	6
OW-14A	3	3	3	0.2	2
OW-15A	3	3	4	0.9	3
OW-16A	3	3	4	0.7	3
OW-17A	3	5	22	1.4	8
OW-18A	3	6	5	0.9	4
BH-5	3	3	3	0.1	3
BH-49	3	3	18	0.1	6.3
BH-53[i]	3	4	3	1.6	3
BH-61[j]	3	3	3	0.5	2
19D	4	4	4	0.1	3
20D	3	3	3	0.4	3
BH-48[g]	3	3	3	1.7	3

[a]Note: 1 x 10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The [illegible] concentration guide is 600 x 10^{-9} µCi/ml.

[b]Sampling locations are shown in Figure 3-16.

[c]Well did not recover after purging.

[d]Not enough water for sample.

[e]Wasp nest in well; could not sample.

[f]Quality control for well A-42.

[g]Background well.

[h]Bailer stuck in well; could not sample.

[i]Quality control for well BH-48.

[j]Downgradient well.

wells in the lower groundwater system. The average concentration in downgradient wells in the upper groundwater system was two times greater than the average background concentrations. Total uranium concentrations were well below the DCG of 600 x 10^{-9} μCi/ml.

4.0 COMPARISON WITH PREVIOUS DATA

Surface conditions at the WCS have improved greatly since performance monitoring began in November 1986. Turf conditions are generally good over the WCS, with the exception of bare areas resulting from the waste consolidation effort that was carried out during the summer of 1991.

Survey results of the WCS indicate subsidence at all survey locations (see Table 3-1), except for the area affected by the waste consolidation effort, which shows significantly higher elevations. Based on the topographic data currently available for the WCS, there appears to be no significant trend other than a general consolidation of waste over the entire WCS.

A trend toward water-level equalization within the WCS has continued as predicted. The grass covering the WCS is maturing and appears to be controlling erosion. At some locations on the new cap, minor erosion was observed during late fall 1991, but the situation is expected to improve with establishment of the grass cover by spring 1992. Desiccation cracking in the topsoil has also shown significant improvement as compared with previous years.

5.0 ACTIONS REQUIRED

Items requiring action were noted during the semiannual walkovers in April and October 1991 and have been discussed in this document. Follow-up reviews will be conducted to ensure appropriate consideration of the following actions:

- Continue the turf management as required; correct the general lack of vigor of the turf to minimize desiccation cracking and erosion

- Implement an appropriate weed-control program, as required, and follow up on designated treatment areas

- Establish the proposed grid system for performing the semiannual monitoring survey of the WCS cap

- Perform diagnostic testing of the geotechnical internal monitoring instruments (VWPTs) to determine the cause of malfunction and correct the problem

- Grade the southwest toe-of-slope of the WCS to drain the area

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Bechtel National, Inc., 1987. Performance Monitoring Report for the Niagara Falls Storage Site Waste Containment Structure for Calendar Year 1986, DOE/OR/20722-159, Oak Ridge, Tenn. (July).

Bechtel National, Inc., 1989. Performance Monitoring Report for the Niagara Falls Storage Site Waste Containment Structure for Calendar Year 1987 and January-July 1988, DOE/OR/20722-208, Oak Ridge, Tenn. (January).

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Bechtel [illegible], Inc., 1991. Well A-42 Investigation Report for the Niagara Falls Interim Storage Site, Lewiston, New York, DOE/OR/20722 (SFMP), Oak Ridge, Tenn. (April).

Bechtel National, Inc., 1992. Niagara Falls Storage Site Annual Environmental Report, for Calendar Year 1991, DOE/OR/21949-343, Oak Ridge, Tenn. (April).

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APPENDIX A

SUMMARY OF VWPT DATA FOR CALENDAR YEAR 1991

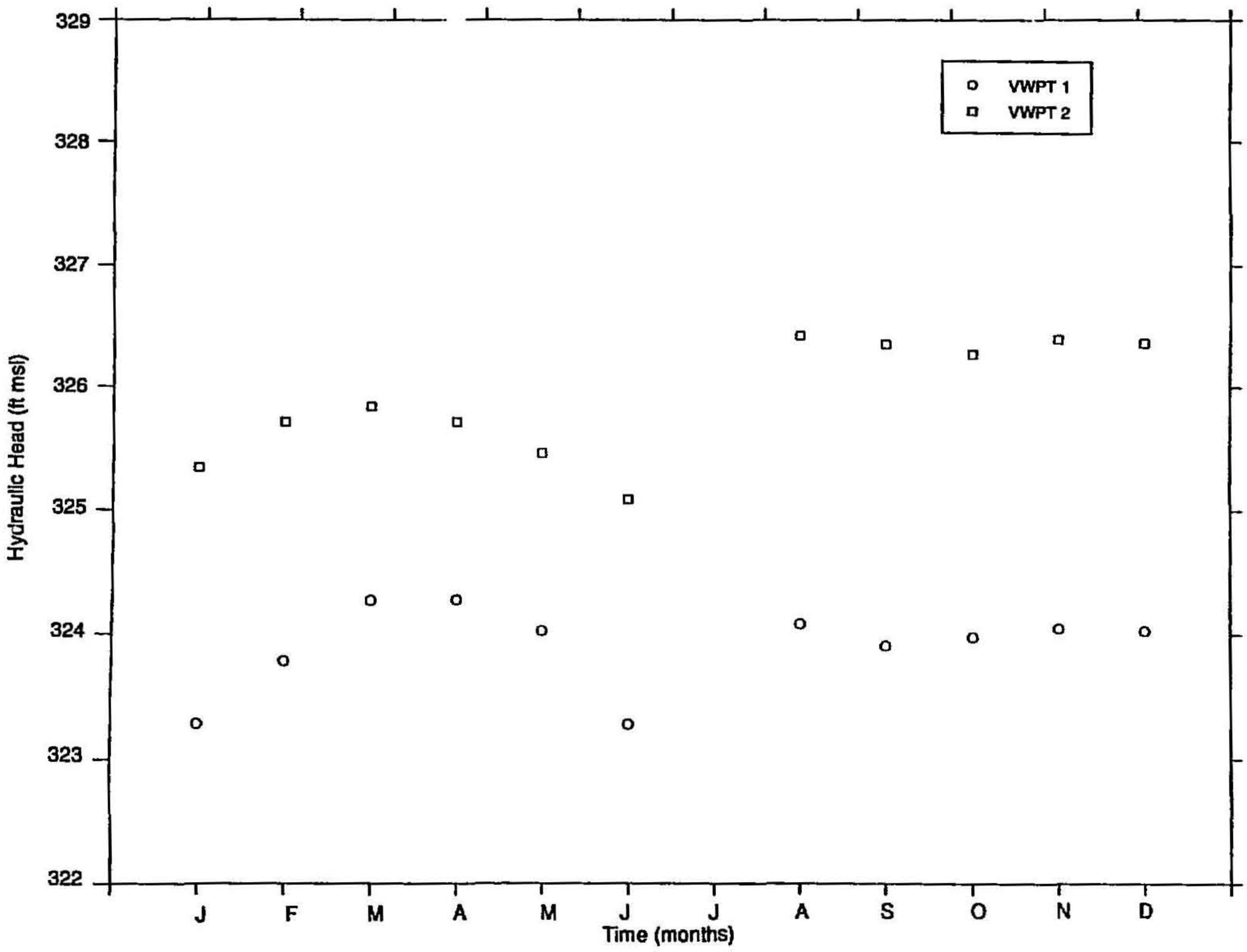

Figure A-1
VWPT Data for NFSS, 1991

092199

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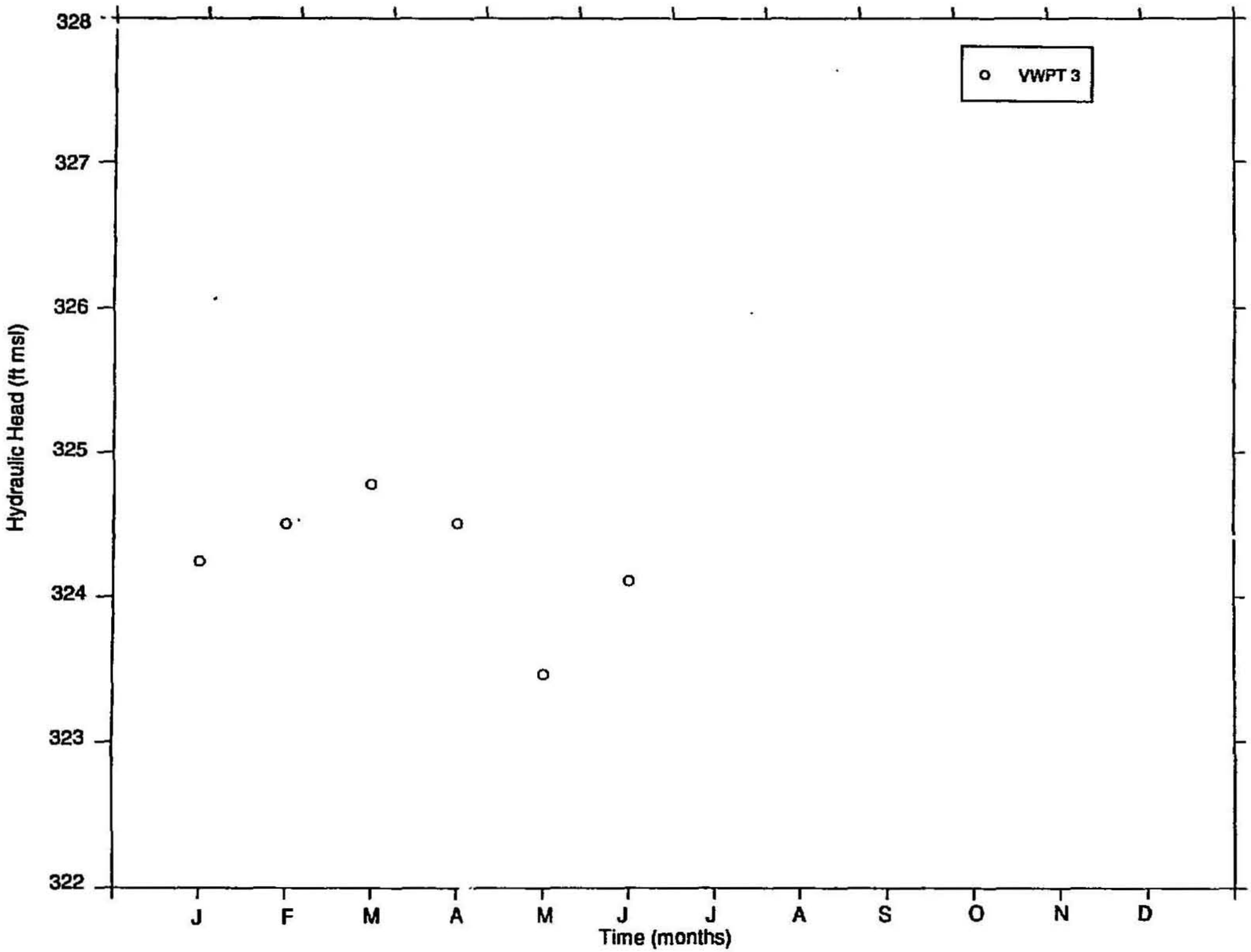

Figure A-2
VWPT Data for NFSS, 1991

092499

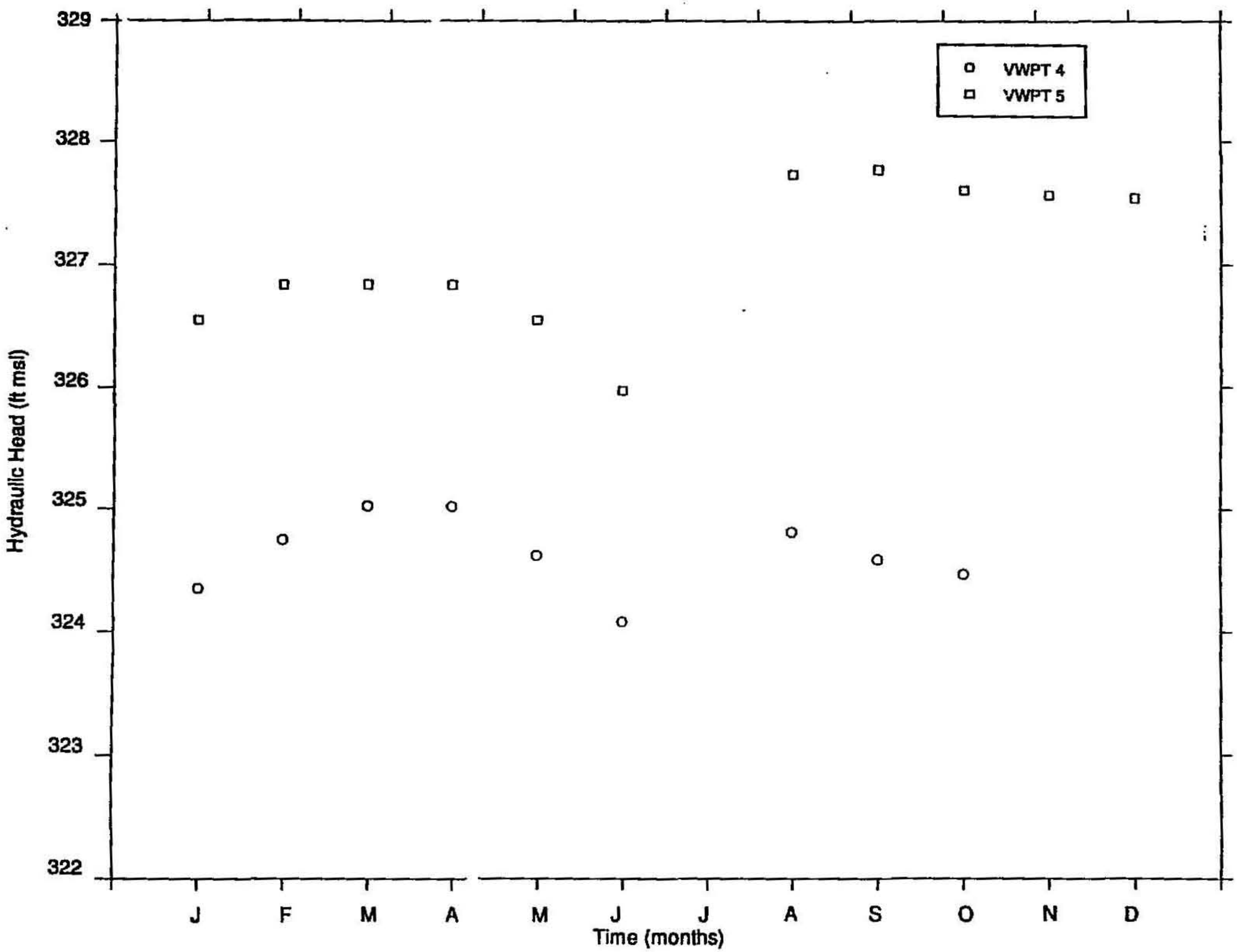

Figure A-3
VWPT Data for NFSS, 1991

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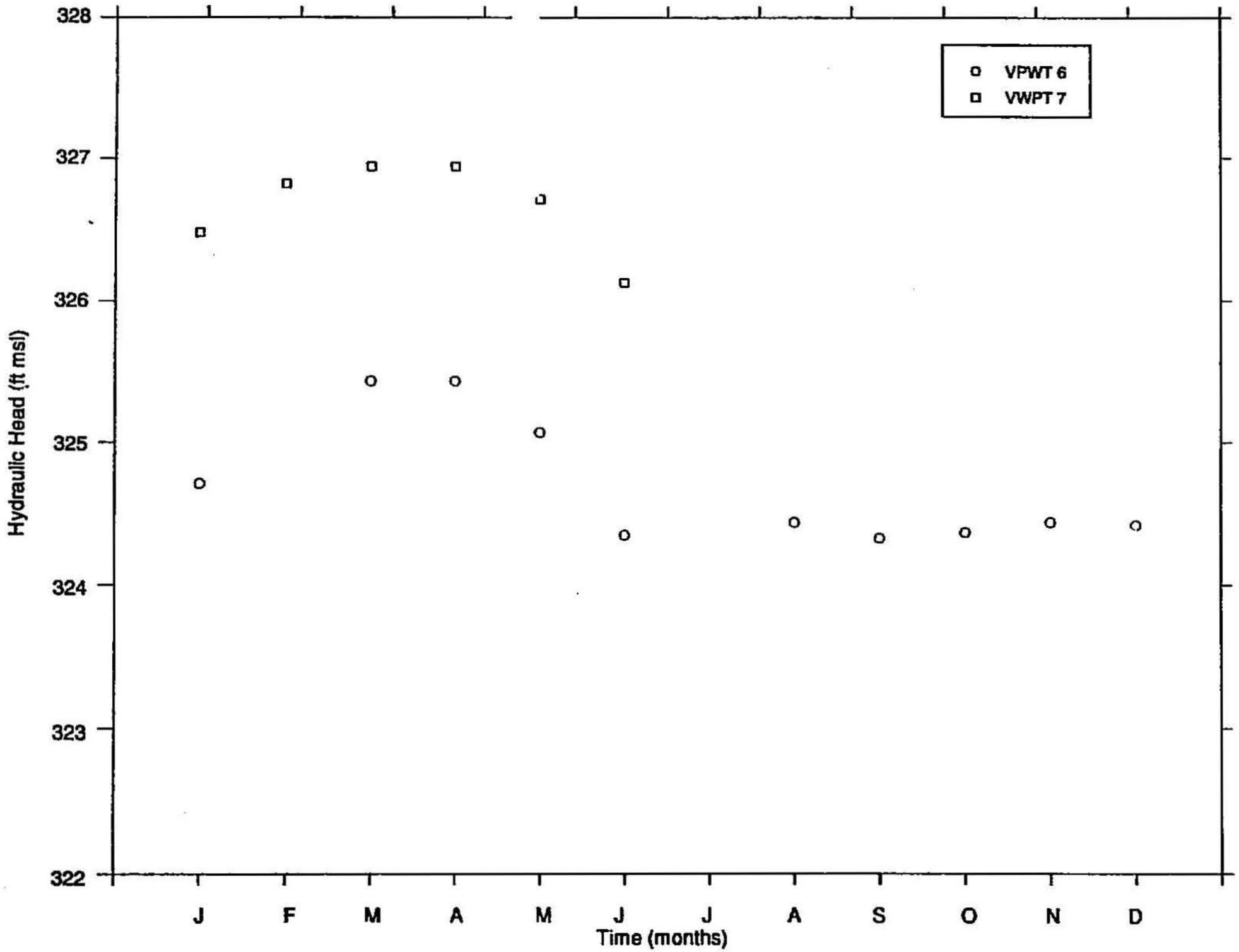

Figure A-4
VWPT Data for NFSS, 1991

092499

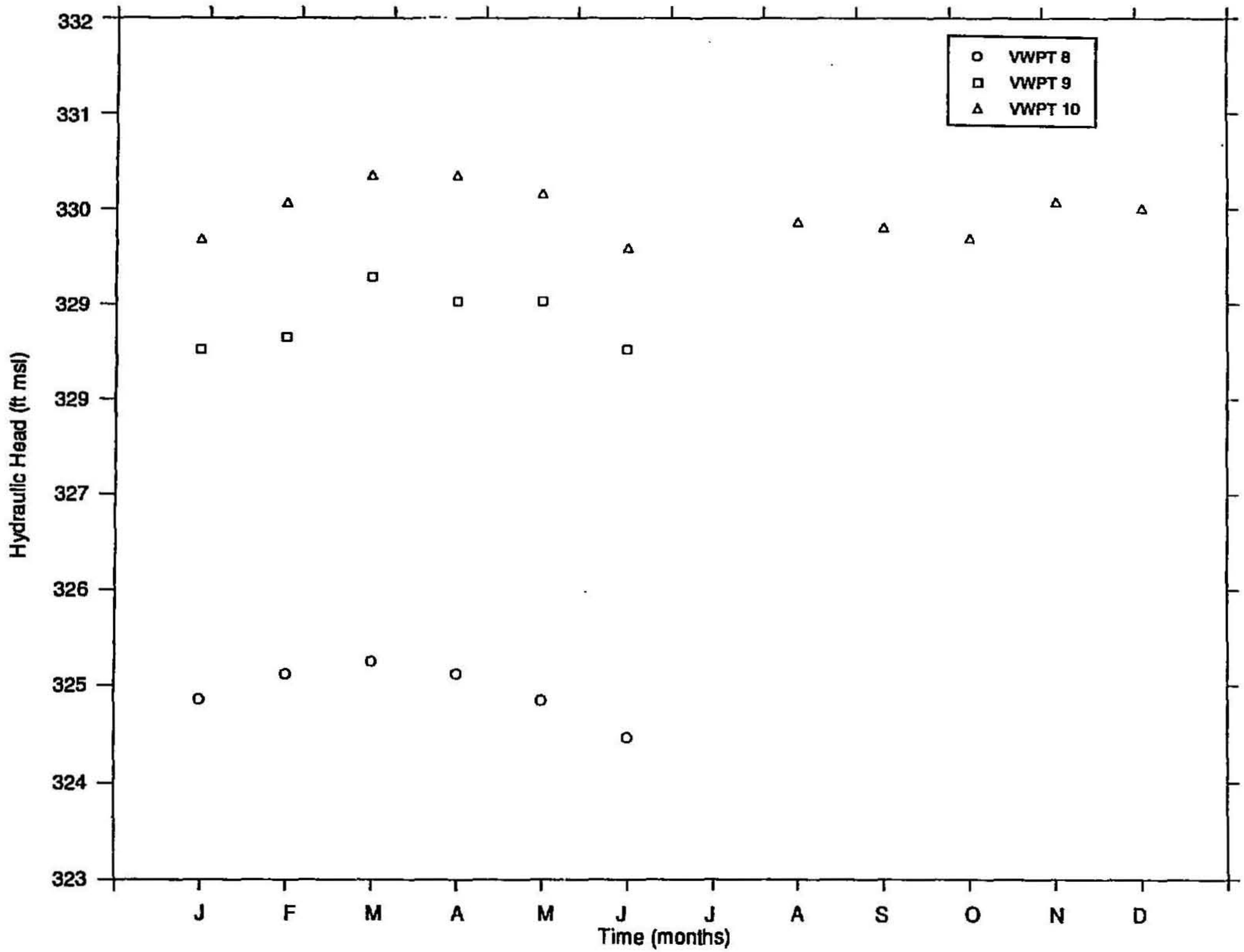

Figure A-5
VWPT Data for NFSS, 1991

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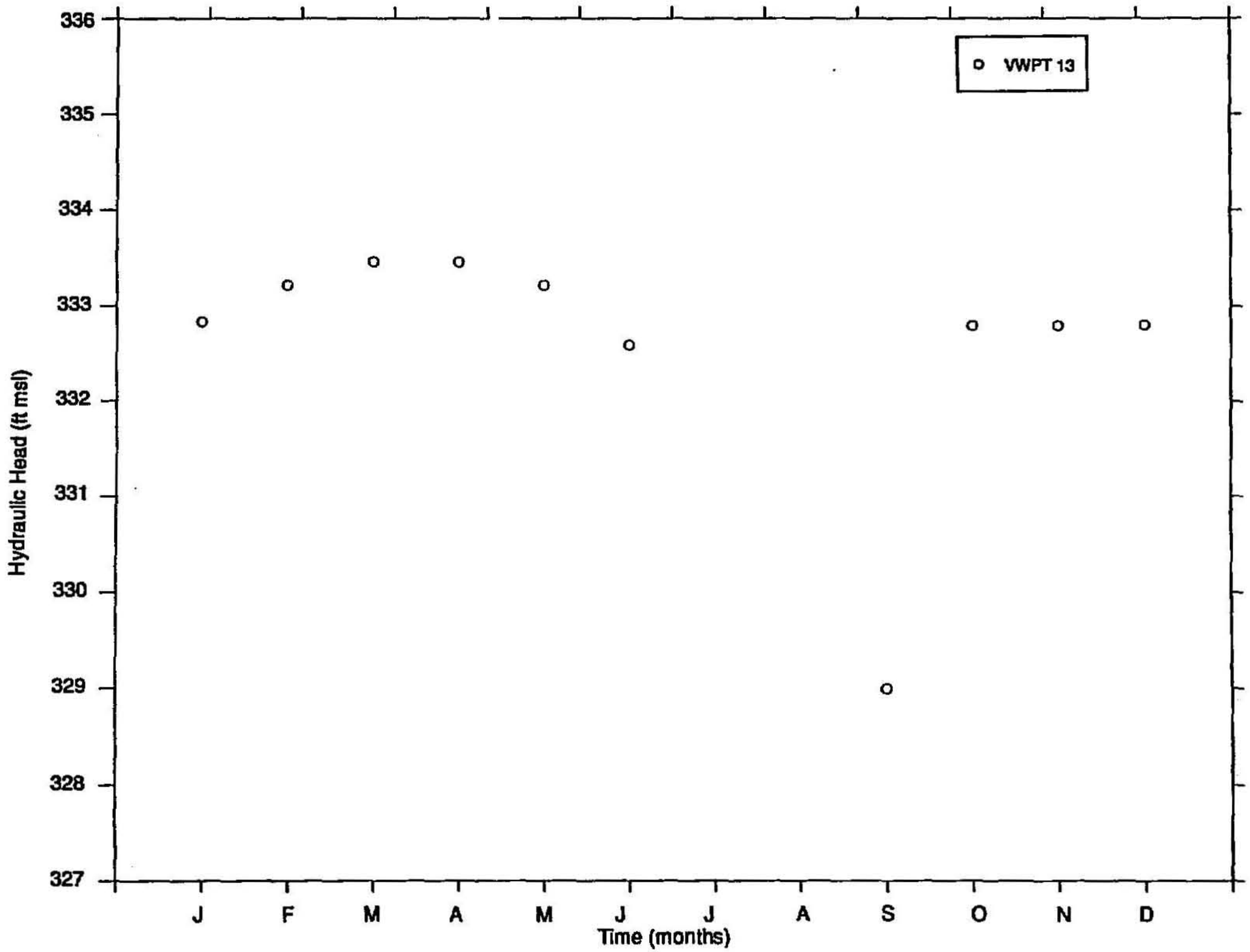

Figure A-6
VWPT Data for NFSS, 1991