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Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-81OR20722

HAZELWOOD INTERIM STORAGE SITE ANNUAL SITE ENVIRONMENTAL REPORT

Hazelwood, Missouri

Calendar Year 1988

April 1989

MASTER

Bechtel National, Inc.

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HAZELWOOD INTERIM STORAGE SITE
ANNUAL SITE ENVIRONMENTAL REPORT
CALENDAR YEAR 1988

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Prepared for

UNITED STATES DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.
P.O. Box 350
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MASTER

ABSTRACT

The environmental monitoring program, begun in 1984, was continued during 1988 at the Hazelwood Interim Storage Site (HISS), a U.S. Department of Energy (DOE) facility located in the City of Hazelwood, Missouri. Originally known as the Cotter Corporation site on Latty Avenue, HISS is currently used for storage of soils contaminated with residual radioactive material. HISS is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to decontaminate or otherwise control sites where residual radioactive material remains from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has mandated DOE to remedy. As part of the decontamination research and development project authorized by Congress under the 1984 Energy and Water Appropriations Act, remedial action is being conducted at the site and at vicinity properties by Bechtel National, Inc. (BNI), project management contractor for FUSRAP. The environmental monitoring program is also carried out by BNI.

The monitoring program at HISS measures radon concentrations in air; external gamma radiation levels; and uranium, radium, and thorium concentrations in surface water, groundwater, and sediment. To verify that the site is in compliance with the DOE radiation protection standard (100 mrem/yr) and assess its potential effect on public health, the radiation dose was calculated for a hypothetical maximally exposed individual. Based on the scenario described in this report, this hypothetical individual at HISS would receive an annual external exposure approximately equivalent to 1 percent of the DOE radiation protection standard. This exposure is less than the exposure a person receives during a flight from New York to Los Angeles (because of the greater amounts of cosmic radiation at higher altitudes). The cumulative dose to the population within an 80-km (50-mi) radius of HISS that results from radioactive materials

present at the site is indistinguishable from the dose that the same population receives from naturally occurring radioactive sources.

The results of 1988 monitoring show that HISS is in compliance with the DOE radiation protection standard.

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1.0 INTRODUCTION

Environmental monitoring has been conducted at the Hazelwood Interim Storage Site (HISS) since 1984. This report presents the findings of the environmental monitoring conducted at HISS during calendar year 1988. As part of the decontamination research and development project authorized by Congress under the 1984 Energy and Water Appropriations Act, Bechtel National, Inc. (BNI) is conducting remedial action on the site and at vicinity properties. The work is being performed as part of the U.S. Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP).

1.1 LOCATION AND DESCRIPTION

HISS is located in northern St. Louis County within the city limits of Hazelwood, Missouri, at 9200 Latty Avenue (Figure 1-1). (The site was originally known as the Cotter Corporation site on Latty Avenue.) The vicinity properties lie along Latty Avenue from Coldwater Creek to Highway 170 in Hazelwood, and HISS lies 3.2 km (2 mi) northeast of the control tower of Lambert-St. Louis International Airport. Figure 1-2 is an aerial photograph of HISS and its vicinity.

HISS is located on a broad, shallow bedrock depression known as the Florissant Basin. During glacial times, drainage from the area was blocked, and the Florissant Basin was filled with silts, clays, and sands. The surface and near-surface soils are fine-grained sandy silts and clayey silts. These materials are unconsolidated to poorly consolidated, erode easily, and have poor load-bearing capacity (Ref. 1).

Surface water runoff follows surface elevation contours and flows to the north and the south across the site. Water flowing to the north enters storm drainage ditches on both sides of Latty Avenue before discharging into Coldwater Creek, the main receiving body for site runoff. Water flowing to the south leaves the site via two ditches, one located near the western boundary and the other near the

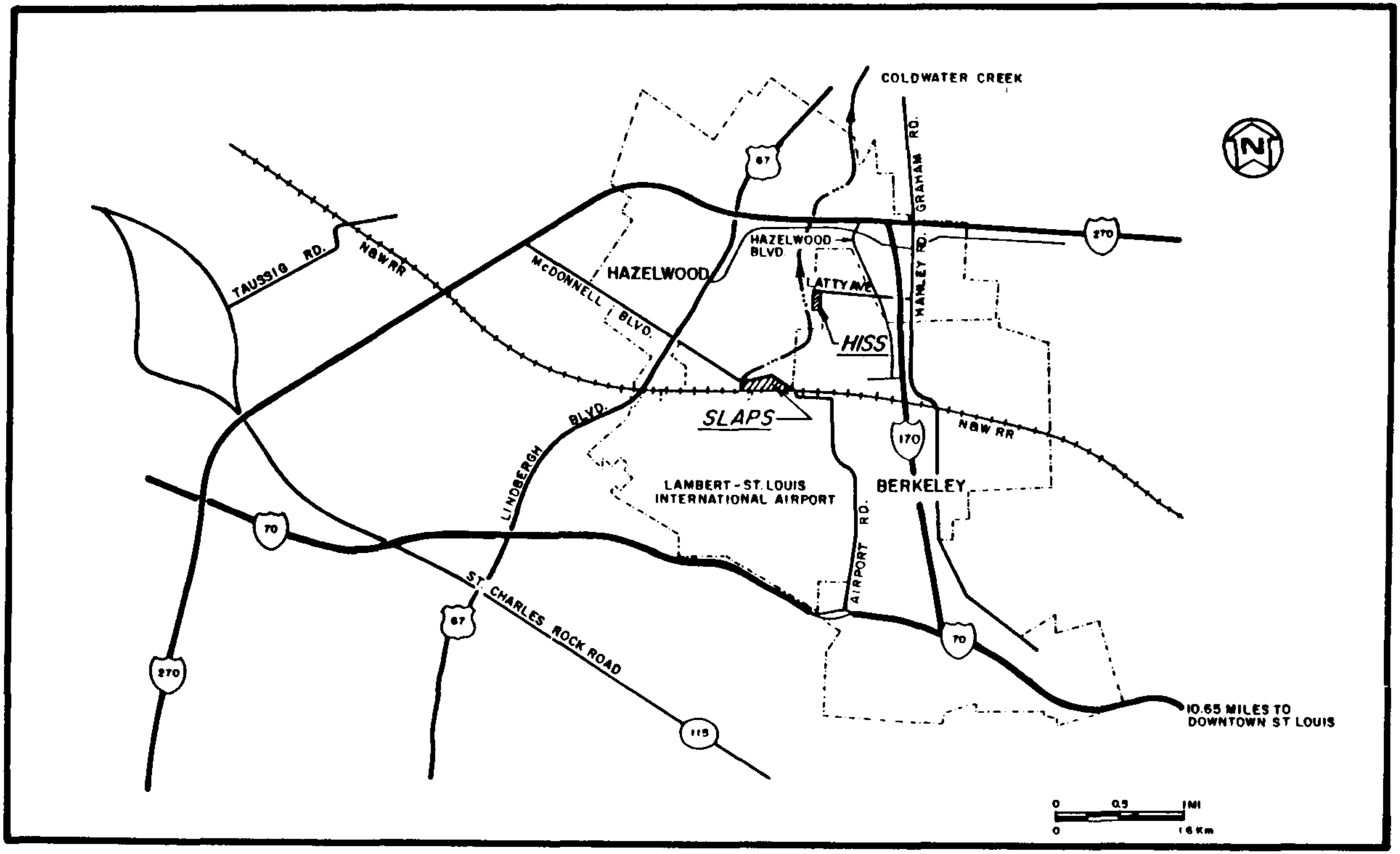


FIGURE 1-1 LOCATION OF HISS

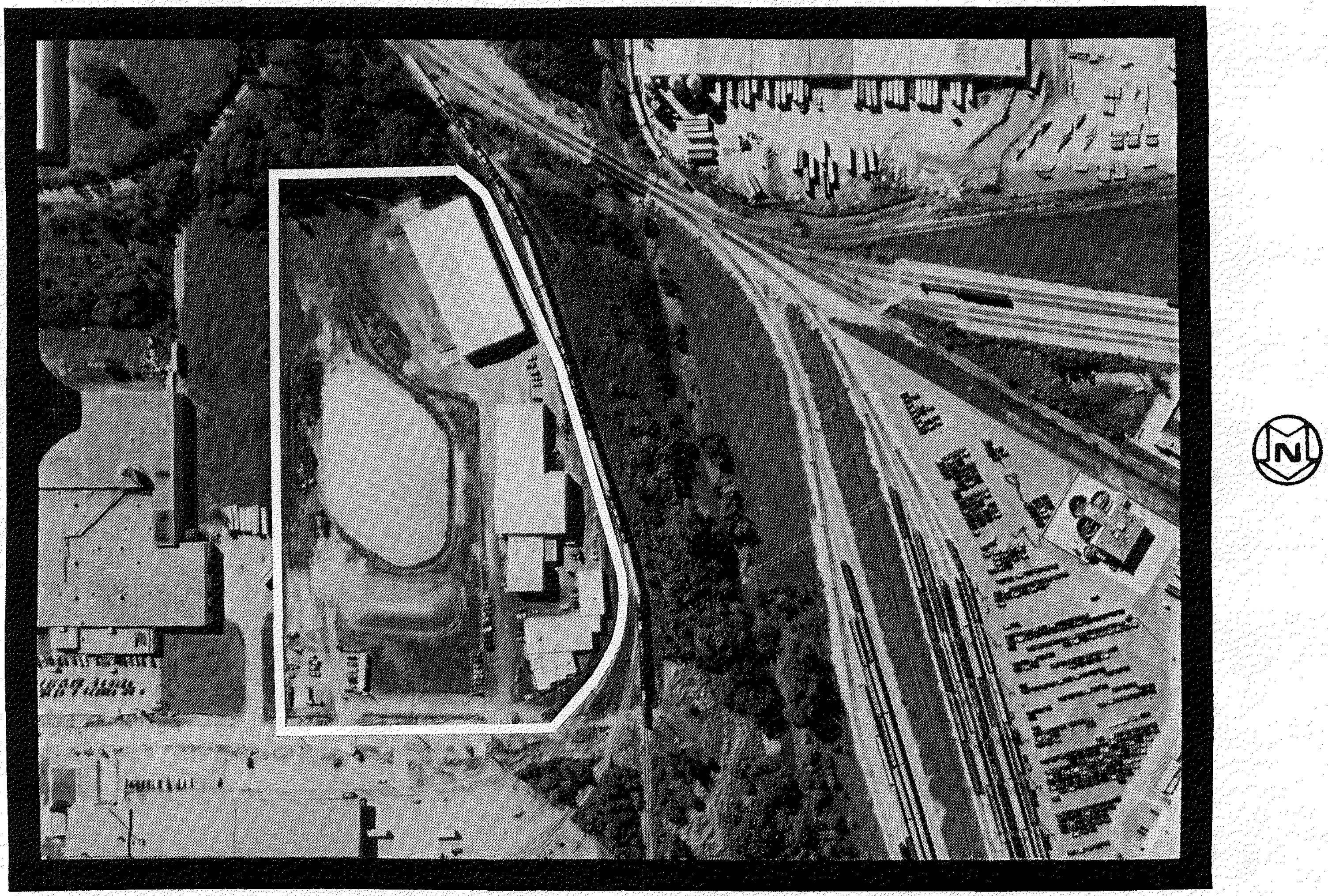


FIGURE 1-2 AERIAL VIEW OF HISS AND ITS VICINITY

southeastern boundary. These ditches discharge into an unnamed tributary before discharging into Coldwater Creek (see Figure 3-2). The 100-yr flood elevation for HISS is approximately 158.5 m (520 ft) above sea level (Ref. 2). Portions of the site are located in the 100-yr floodplain.

Groundwater in St. Louis County occurs in unconsolidated deposits and in bedrock aquifers. Shallow groundwater flow in the vicinity of the site generally follows surface topography; thus, the direction of flow is toward Coldwater Creek and its tributary channel (Ref. 1). In the area surrounding HISS, water content of the subsoils is very high, but percolation rates are low. Treated water from the Mississippi River is used for municipal drinking water in this area (Ref. 3).

The average annual daily maximum temperature for the HISS area is 18.6°C (65.5°F), and the average daily minimum is 7.4°C (45.4°F). The highest average monthly temperature is 31.7°C (89°F) (July) and the lowest is -6.7°C (19.9°F) (January). Average annual precipitation is 85 cm (34 in.), with an average annual snowfall of 65.8 cm (26.3 in.) (Ref. 4). As shown in Figure 1-3, prevailing winds in the vicinity of HISS are primarily from the south during the summer and fall. Wind speeds during these months average 13.9 km/h (8.7 mph). Winds during the winter months are from the west and west-northwest, averaging 17.6 km/h (11 mph) (Refs. 4 and 5).

The residential areas nearest the site are approximately 0.5 km (0.3 mi) east in the City of Hazelwood. Residences in the City of Berkeley lie southeast of the site. In 1980, the populations of Berkeley and Hazelwood were 16,146 and 8,819, respectively (Ref. 6). There are no churches, schools, hospitals, municipal buildings, or other community facilities adjacent to HISS or Latty Avenue.

As shown in Figure 1-4, land use in the vicinity is predominantly industrial. Other land uses (in descending order of prevalence)

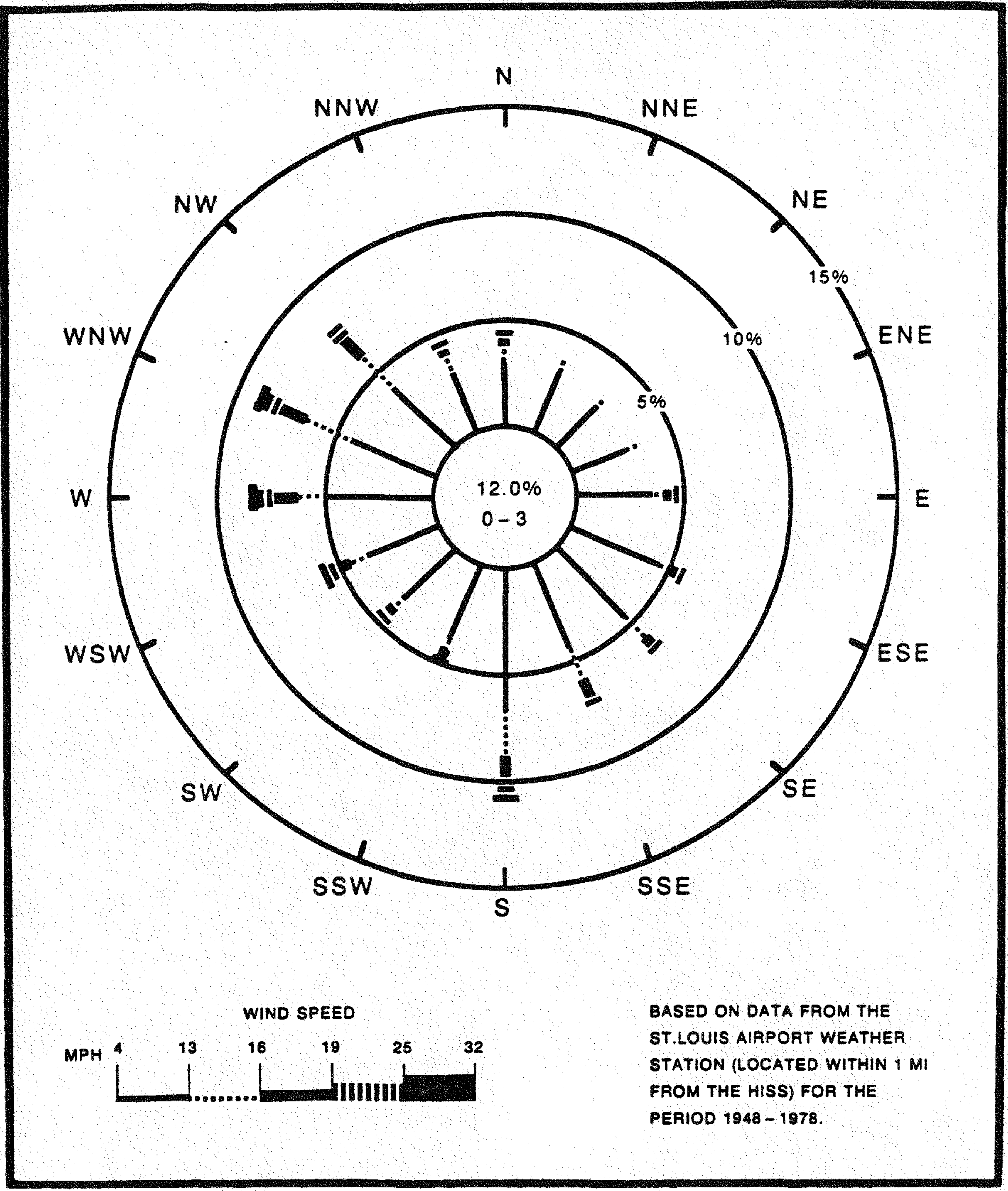
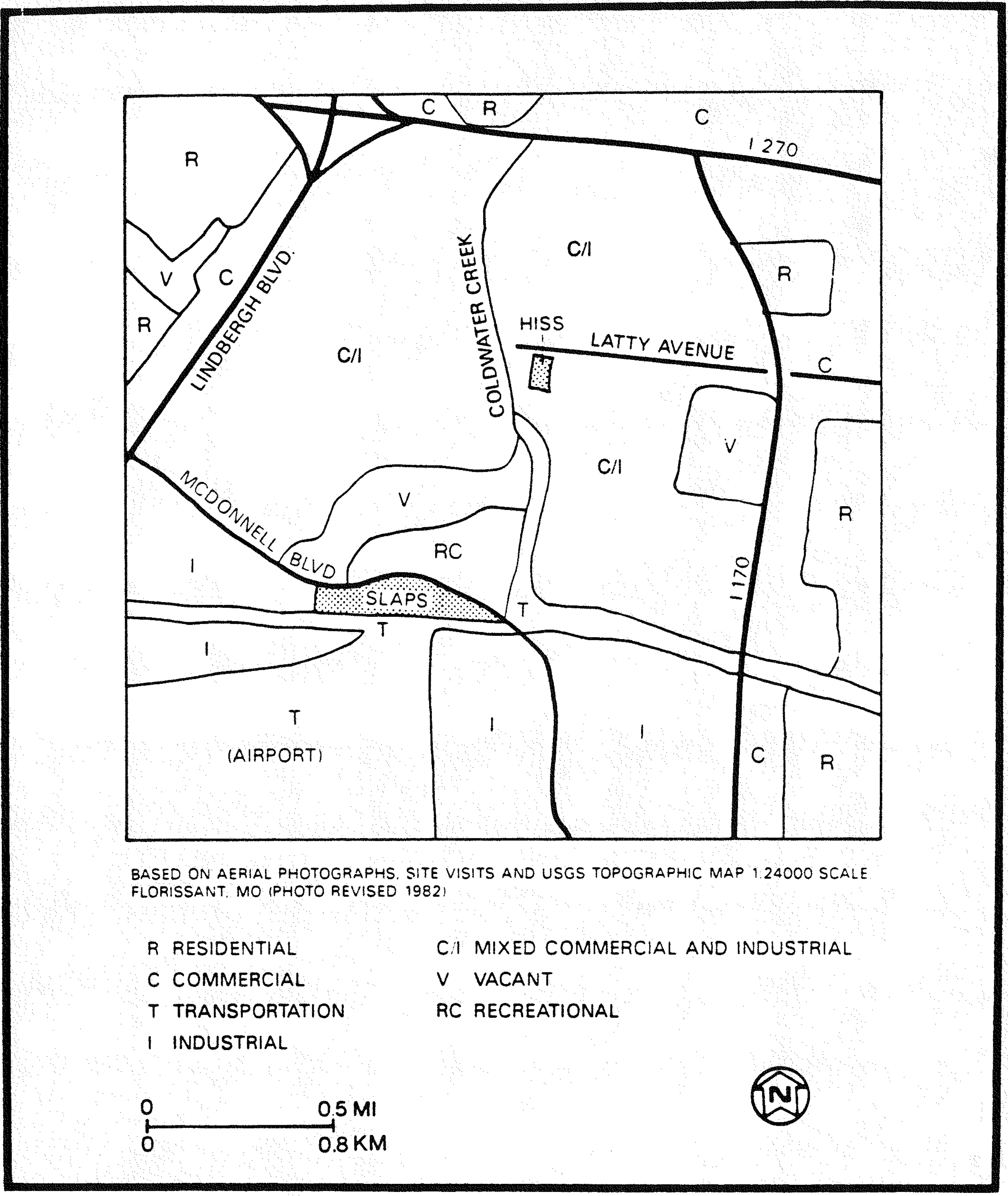


FIGURE 1-3 ANNUAL WIND ROSE FOR HISS



BASED ON AERIAL PHOTOGRAPHS, SITE VISITS AND USGS TOPOGRAPHIC MAP 1:24000 SCALE FLORISSANT, MO (PHOTO REVISED 1982)

R	RESIDENTIAL
C	COMMERCIAL
T	TRANSPORTATION
I	INDUSTRIAL
C/I	MIXED COMMERCIAL AND INDUSTRIAL
V	VACANT
RC	RECREATIONAL

FIGURE 1-4 GENERALIZED LAND USE IN THE VICINITY OF HISS

are commercial, transportation-related, unused (vacant), and residential (Ref. 1).

There are no continuing commercial or industrial activities at HISS; therefore, no radioactive effluents exist at the site.

1.2 SITE HISTORY

In early 1966, ore residues and uranium- and radium-bearing process wastes that had been stored at the St. Louis Airport Site (SLAPS) were purchased by the Continental Mining and Milling Company, Chicago, Illinois. The residues and wastes were moved to a storage site at 9200 Latty Avenue, a part of which is the present-day HISS. These wastes had been generated by a St. Louis plant from 1942 through the late 1950s under contracts with the Atomic Energy Commission (AEC) and its predecessor, the Manhattan Engineer District (MED). Residues on the site at that time included 74,000 tons of Belgian Congo pitchblende raffinate containing approximately 113 tons of uranium; 32,500 tons of Colorado raffinate containing roughly 48 tons of uranium; and 8,700 tons of leached barium sulfate containing about 7 tons of uranium. In January 1967, the Commercial Discount Corporation of Chicago purchased the residues. Much of the material was then dried and shipped to the Cotter Corporation facilities in Canon City, Colorado. The material remaining at the Latty Avenue site was sold to Cotter Corporation in December 1969. From August through November 1970, Cotter Corporation dried some of the remaining residues at the site and shipped them to its mill in Canon City. In December 1970, an estimated 10,000 tons of Colorado raffinate and 8,700 tons of leached barium sulfate remained at the Latty Avenue site.

In April 1974, the newly established Nuclear Regulatory Commission (NRC) was informed by Cotter Corporation that the remaining Colorado raffinate had been shipped in mid-1973 to Canon City without drying and that the leached barium sulfate and 30 to 45 cm (12 to 18 in.) of topsoil had been removed and transported to a landfill area in St. Louis County.

Before the present owner occupied the site, a radiological characterization was performed by Oak Ridge National Laboratory (ORNL). Thorium and radium contamination in excess of DOE guidelines was found in and around the buildings, and in the soil to depths of up to 45 cm (18 in.). Consequently, in preparing the property for use, the owner demolished one building, excavated portions of the western half of the property, and paved certain areas in addition to erecting several new buildings. The material excavated during these activities was piled on the eastern portion of the property.

In 1981, Oak Ridge Associated Universities (ORAU) characterized the pile and surveyed the northern and eastern boundaries of the property for radioactivity. Levels of contamination (principally thorium-230) similar to those on-site were found in both boundary areas. As a followup to this survey, ORNL conducted a detailed radiological survey for DOE of the north and south shoulders of Latty Avenue in January and February 1984. Results indicated that contamination in excess of DOE guidelines was present along the road up to a location near its intersection with Hazelwood Boulevard. Properties adjacent to HISS were also found to be contaminated.

BNI is conducting remedial action at HISS and at a portion of the vicinity properties, which parallel Latty Avenue, in two phases. Phase I began in FY 1984 with the radiological characterization and initial cleanup of Latty Avenue and storage of the contaminated materials in the interim storage pile at HISS. In addition, an area of the site north of the pile was cleared, a decontamination facility was constructed, environmental monitoring stations were installed, and a perimeter fence was installed around the site. During 1985 and 1986 cleanup along Latty Avenue continued, and additional contaminated material removed along Latty Avenue during the installation of a storm sewer by the Cities of Berkeley and Hazelwood was stored in a supplementary pile at HISS (Figure 1-2). In 1987 additional contaminated material removed from along Latty Avenue was placed on the supplementary pile and covered.

Phase I also included radiological and chemical characterization of the property at 9200 Latty Avenue and radiological characterization of the vicinity properties along Latty Avenue. These activities began in 1986 and were completed in early 1988.

During Phase II, the contaminated soil at Latty Avenue properties (i.e., the Futura Coatings property), HISS, and the vicinity properties will be removed to a permanent disposal site pending completion of appropriate environmental compliance documentation.

1.3 HYDROGEOLOGICAL CHARACTERISTICS OF THE SITE

This section presents data on the hydrogeology of the site. The interpretations are based on groundwater levels measured in calendar year 1988. Groundwater monitoring wells (Figure 1-5) were installed at the HISS site in two phases. The first-phase wells (HISS-1 through HISS-8) were installed in 1982 as part of the radiological site assessment program conducted by ORAU (Ref. 7). Details of the construction for the first-phase wells are not available. The second-phase wells (HISS-9 through HISS-15) were installed by BNI in late 1984 (Ref. 7). A summary of well construction information is presented in Table 1-1. Further background information on site geology, hydrogeology, and well installation methods can be found in Ref. 7. An example of well construction details is include in this report as Appendix E.

Groundwater levels at HISS were measured with an electric downhole probe water level indicator. Water level measurements for 1988 were taken at weekly intervals.

1.3.1 Groundwater System

The potentiometric surface of the HISS groundwater system occurs in a zone approximately 1.5 to 4.9 m (5 to 16 ft) below the ground surface. (Potentiometric surface is defined as the level to which water will rise in tightly cased wells. Delineation of the

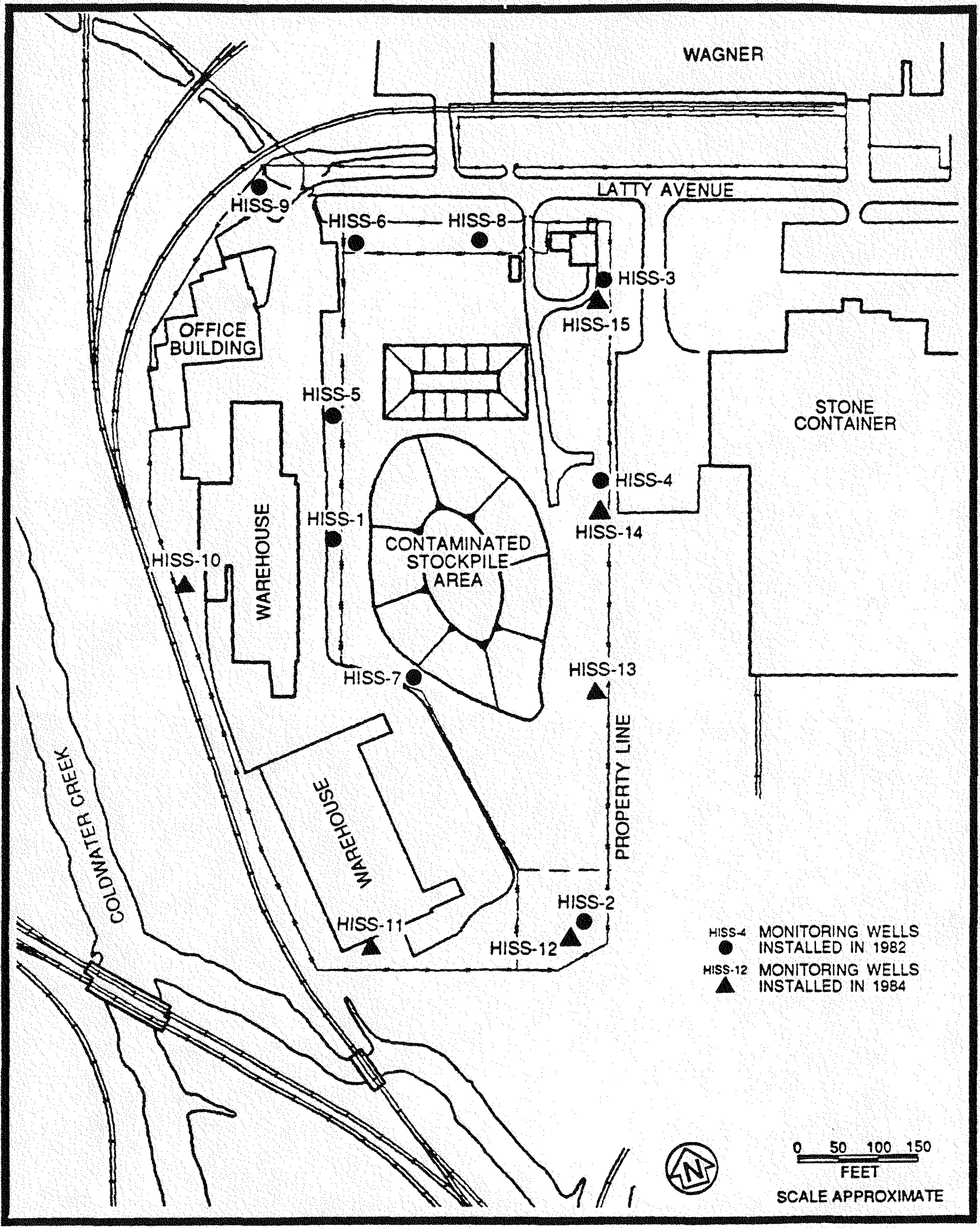


FIGURE 1-5 HISS MONITORING WELL LOCATIONS

TABLE 1-1

HISS MONITORING WELL CONSTRUCTION SUMMARY

Well Number	Completion Date	Total Depth [m (ft)]	Monitored or Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
HISS-1	Jan. 1982	6.2 (20.5)	No Documentation[a]	PVC[b]
HISS-2	Jan. 1982	9.8 (32.2)	No Documentation	PVC
HISS-3	Jan. 1982	6.6 (21.6)	No Documentation	PVC
HISS-4	Jan. 1982	6.8 (22.2)	No Documentation	PVC
HISS-5	Jan. 1982	6.4 (21.1)	No Documentation	PVC
HISS-6	Jan. 1982	4.6 (15.1)	No Documentation	PVC
HISS-7	Jan. 1982	5.2 (17.0)	No Documentation	PVC
HISS-8	Jan. 1982	6.4 (21.0)	No Documentation	PVC
HISS-9	Dec. 1984	8.7 (28.5)	5.9-8.7 (19.4-28.5)	PVC
HISS-10	Dec. 1984	7.6 (25.0)	4.3-7.2 (14.1-23.5)	PVC
HISS-11	Dec. 1984	7.3 (23.8)	3.9-6.2 (12.7-22.3)	PVC
HISS-12	Dec. 1984	6.1 (20.0)	3.0-5.6 (10.0-18.5)	PVC
HISS-13	Dec. 1984	7.6 (25.0)	3.0-7.2 (10.0-23.5)	PVC
HISS-14	Dec. 1984	9.1 (30.0)	2.8-8.7 (9.3-28.5)	PVC
HISS-15	Dec. 1984	6.2 (20.5)	3.1-5.8 (10.3-19.0)	PVC
B53W01S[c]	Nov. 1987	8.4 (27.5)	5.2-8.4 (17.0-27.5)	316 Stainless Steel
B53W01D[c]	Nov. 1987	28.5 (93.5)	24.3-28.5 (79.7-93.5)	316 Stainless Steel

[a] Being investigated.

[b] PVC - polyvinyl chloride.

[c] Background well. Located at Byassee Road, approximately 2.4 km (1.5 mi) southwest of HISS.

potentiometric surface of an aquifer indicates groundwater slope and flow direction.) Wells that show these water levels are screened in unconsolidated silty clays and clayey silts at depths of 3.7 to 7.9 m (12 to 26 ft). Groundwater surface elevations measured in 1988 for each well are shown as hydrographs (Figures 1-6 through 1-10).

Precipitation records for the St. Louis area were available from the U.S. Weather Service and are presented with the hydrographs in Figures 1-6 through 1-10.

The hydrographs for the HISS groundwater system show apparent seasonal fluctuations in groundwater elevation levels. During the late winter and early spring months, groundwater levels rose several feet, a slight amount, or not at all. This may have been due to spring thaw conditions that differed from well to well. Water level data that will be collected during the spring of 1989 may help to explain this behavior. A second period of rising and falling groundwater levels occurred in the late fall and early winter. These cycles of higher water levels may be related to seasonal precipitation or to on-site activities.

The slopes and flow directions of the HISS groundwater system were determined from potentiometric surface maps (Figures 1-11 through 1-14). The four dates plotted were chosen as representative of the 1988 seasonal fluctuations. Figure 1-11 represents the winter conditions, Figure 1-12 represents the spring, etc. The general flow pattern is radial, centered primarily in the area of HISS-1 toward the site perimeter. The slopes for all four configurations of the potentiometric surface were calculated using the southeast flow direction, as seen in Figures 1-11 through 1-14. The same flow direction was chosen for all maps to compare variations throughout the year. The calculated slopes range from 0.013 to 0.018.

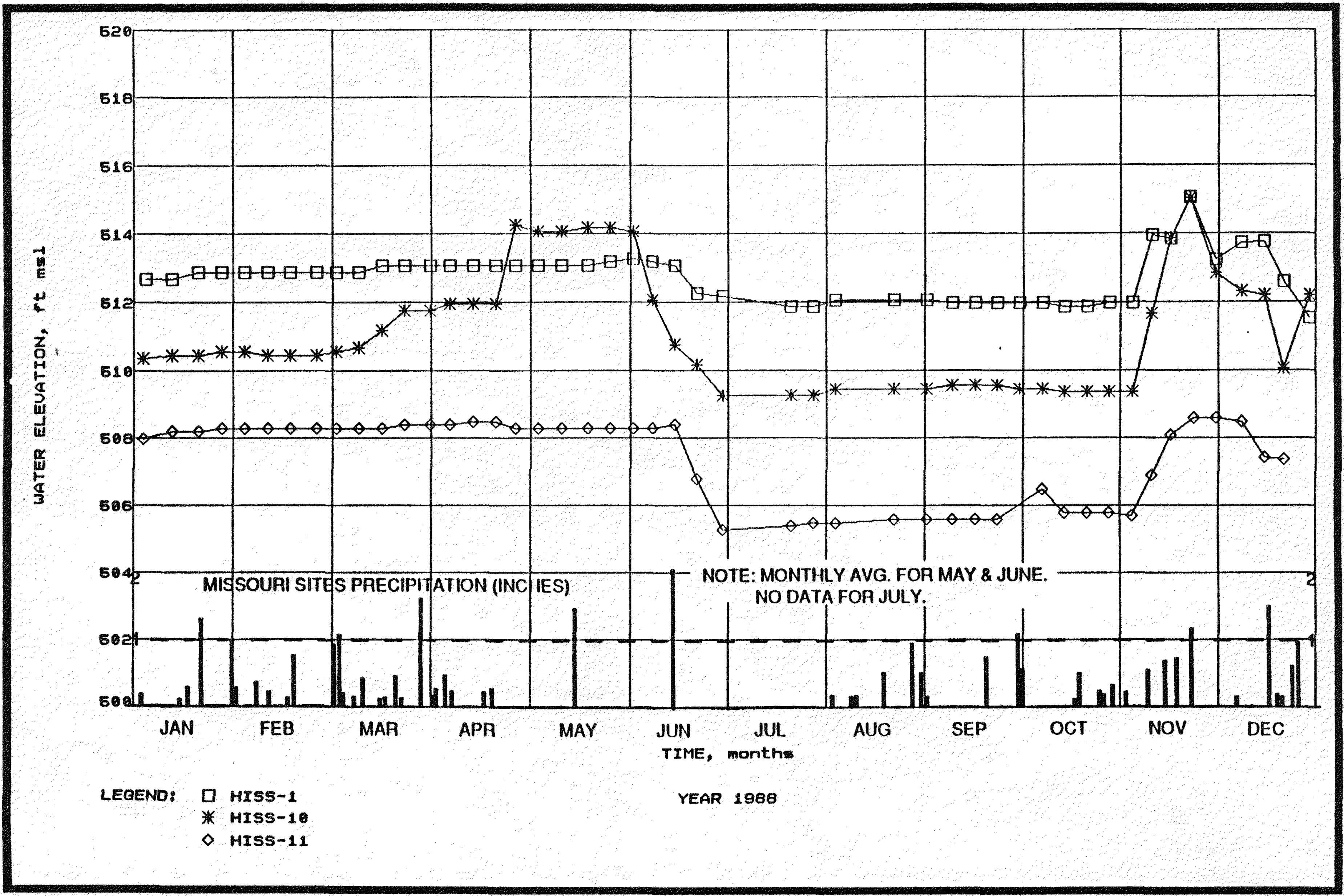


FIGURE 1-6 HYDROGRAPHS OF WELLS HISS-1, HISS-10, AND HISS-11

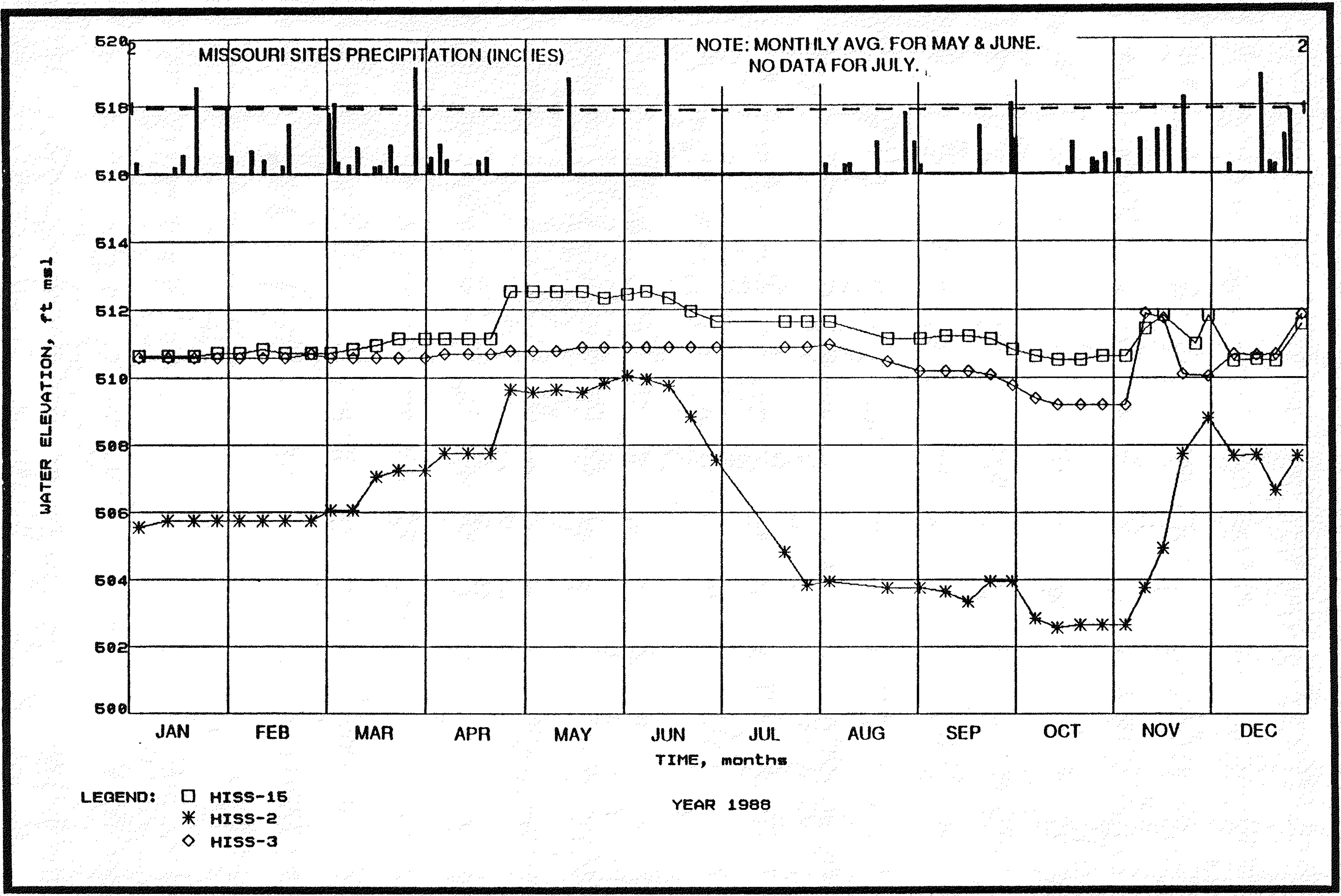


FIGURE 1-7 HYDROGRAPHS OF WELLS HISS-15, HISS-2, AND HISS-3

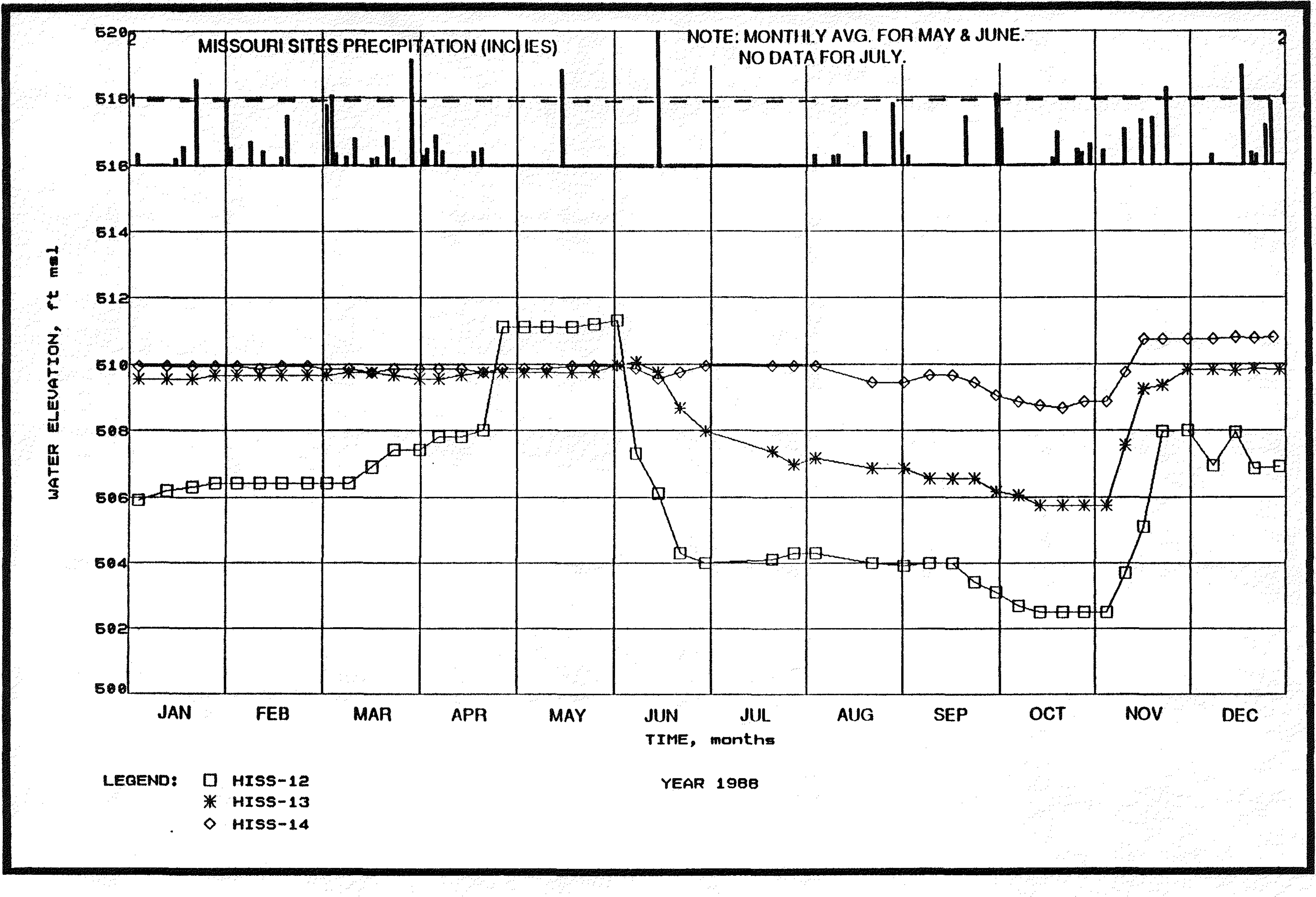


FIGURE 1-8 HYDROGRAPHS OF WELLS HISS-12, HISS-13, AND HISS-14

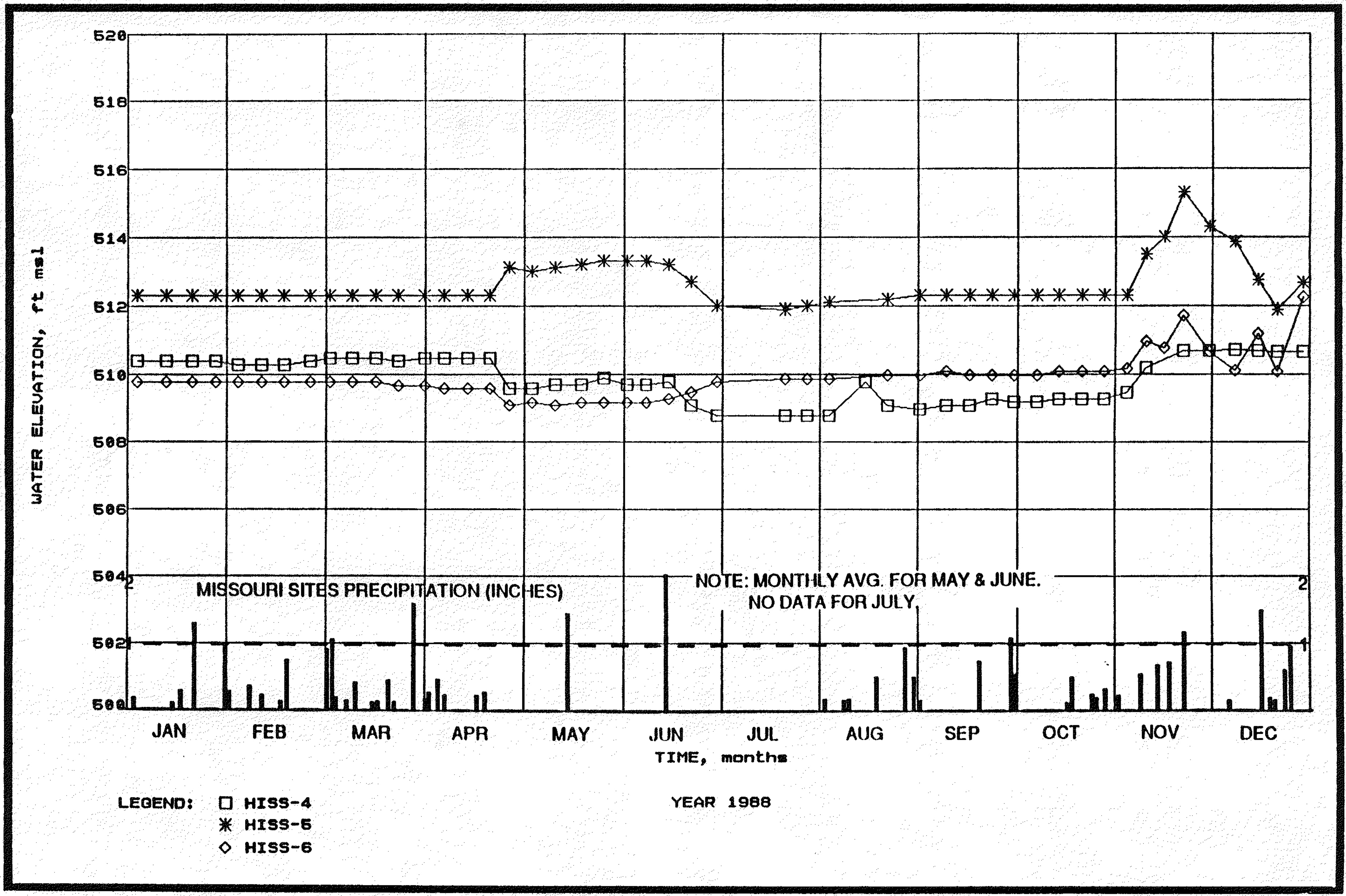


FIGURE 1-9 HYDROGRAPHS OF WELLS HISS-4, HISS-5, AND HISS-6

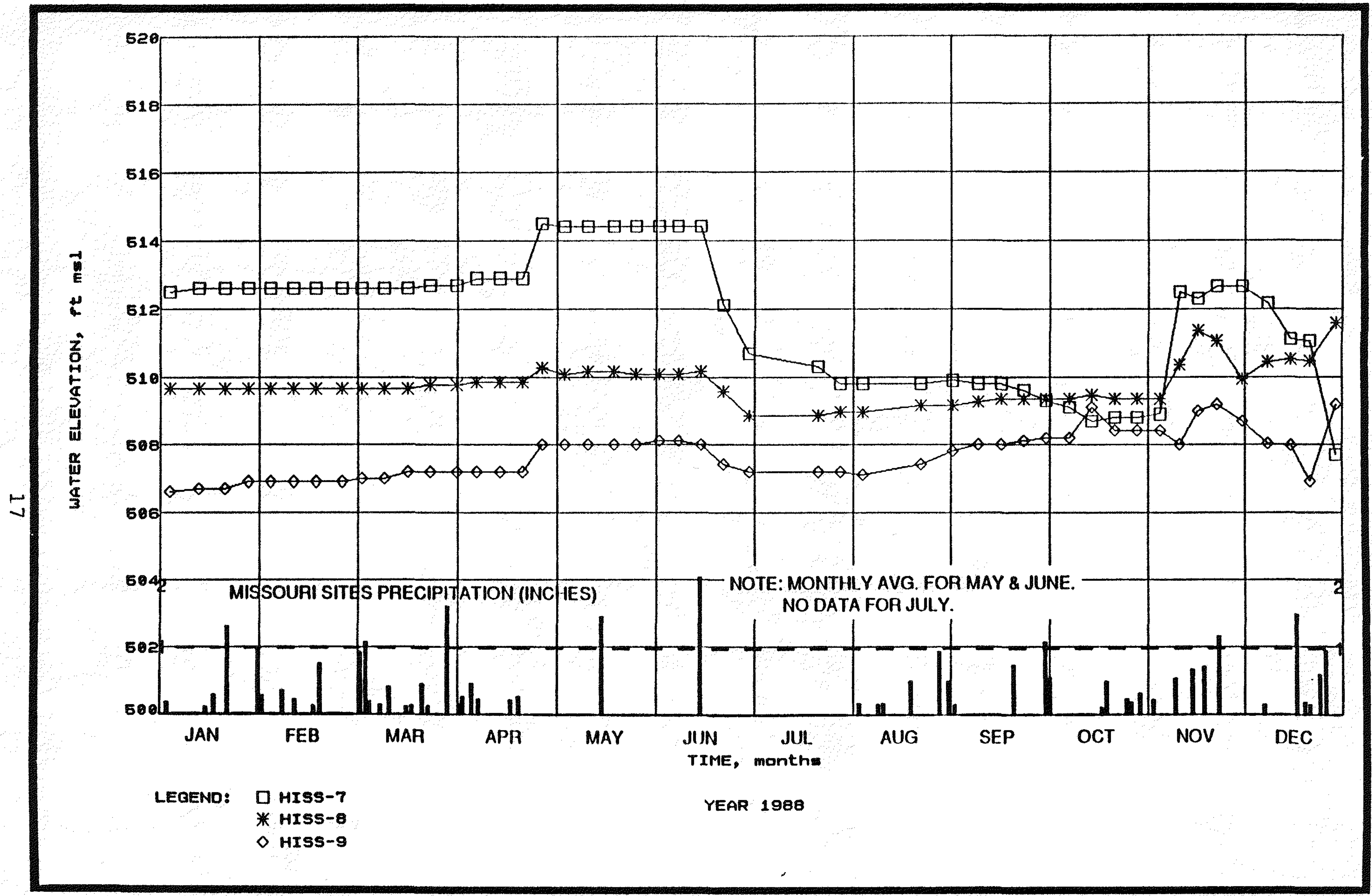


FIGURE 1-10 HYDROGRAPHS OF WELLS HISS-7, HISS-8, AND HISS-9

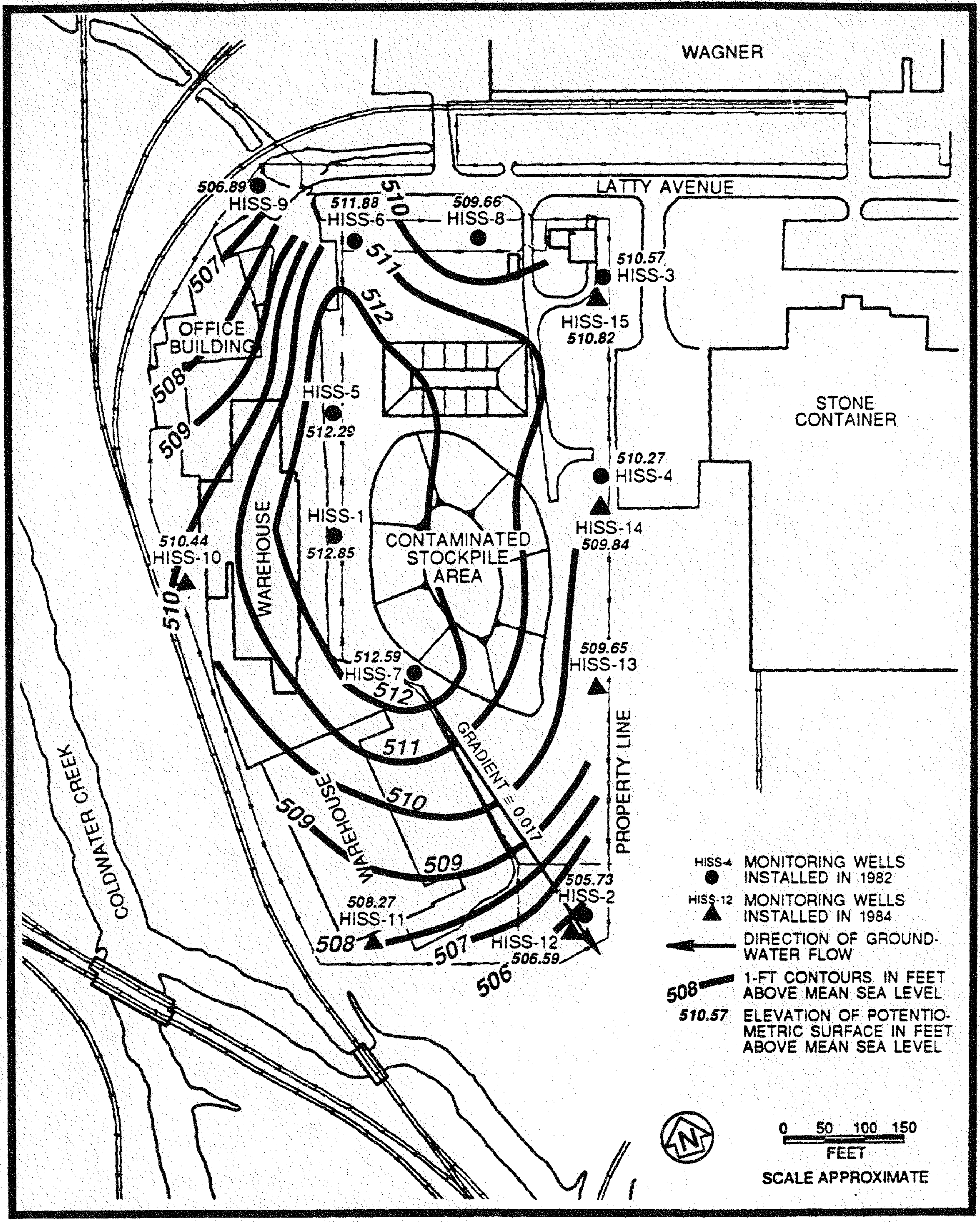


FIGURE 1-11 POTENTIOMETRIC SURFACE MAP OF HISS (2/11/88)

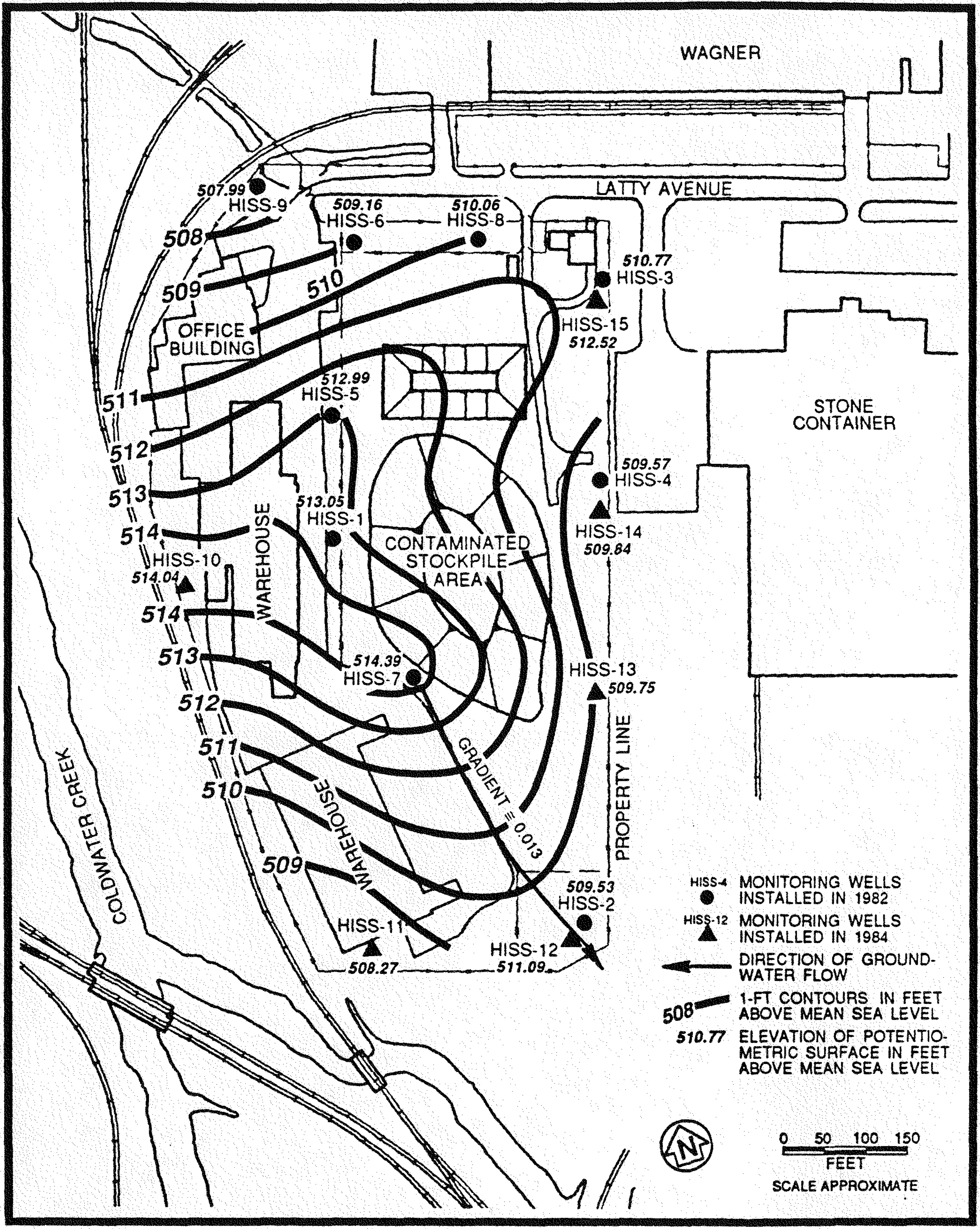


FIGURE 1-12 POTENTIOMETRIC SURFACE MAP OF HISS (5/4/88)

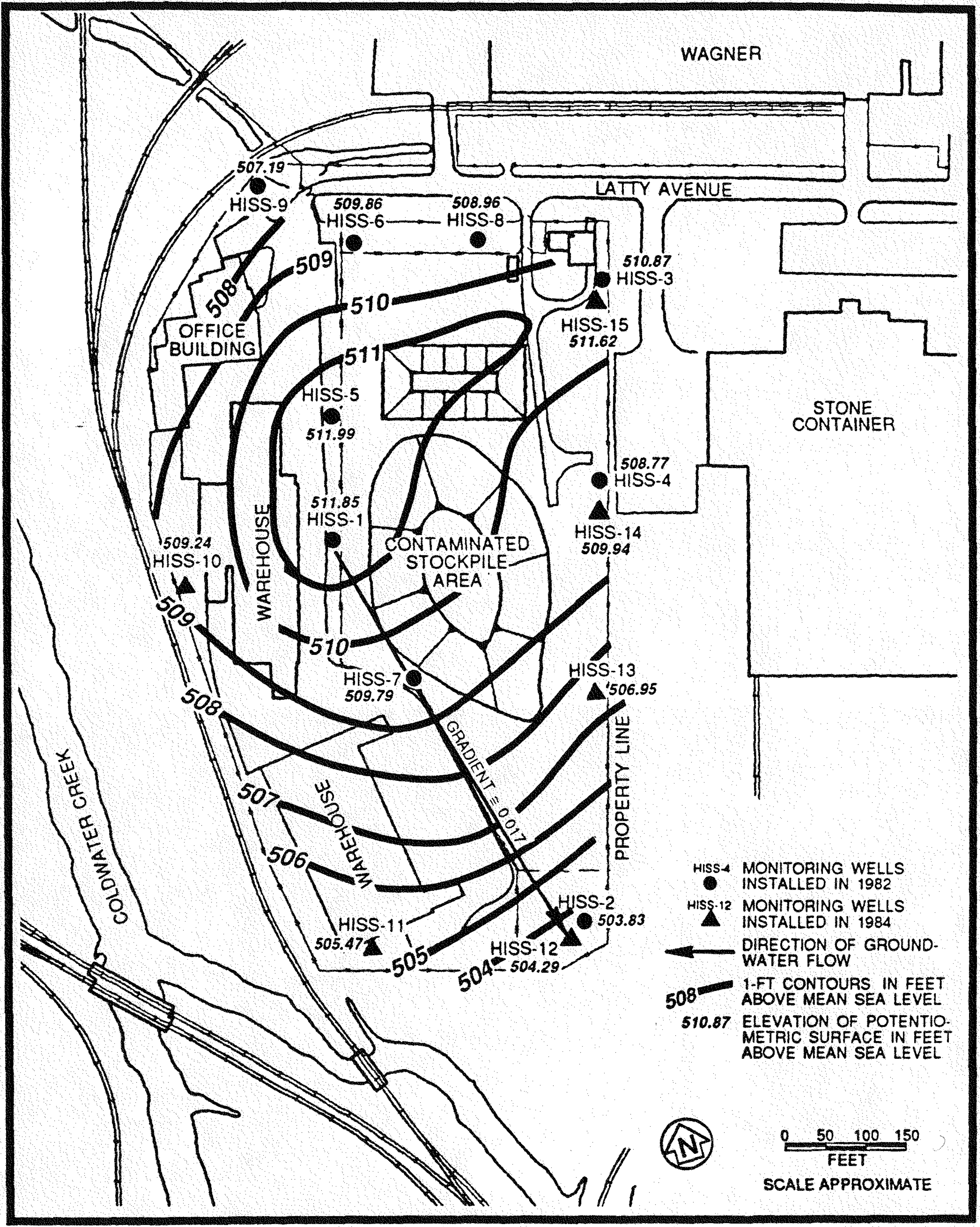


FIGURE 1-13 POTENTIOMETRIC SURFACE MAP OF HISS (7/28/88)

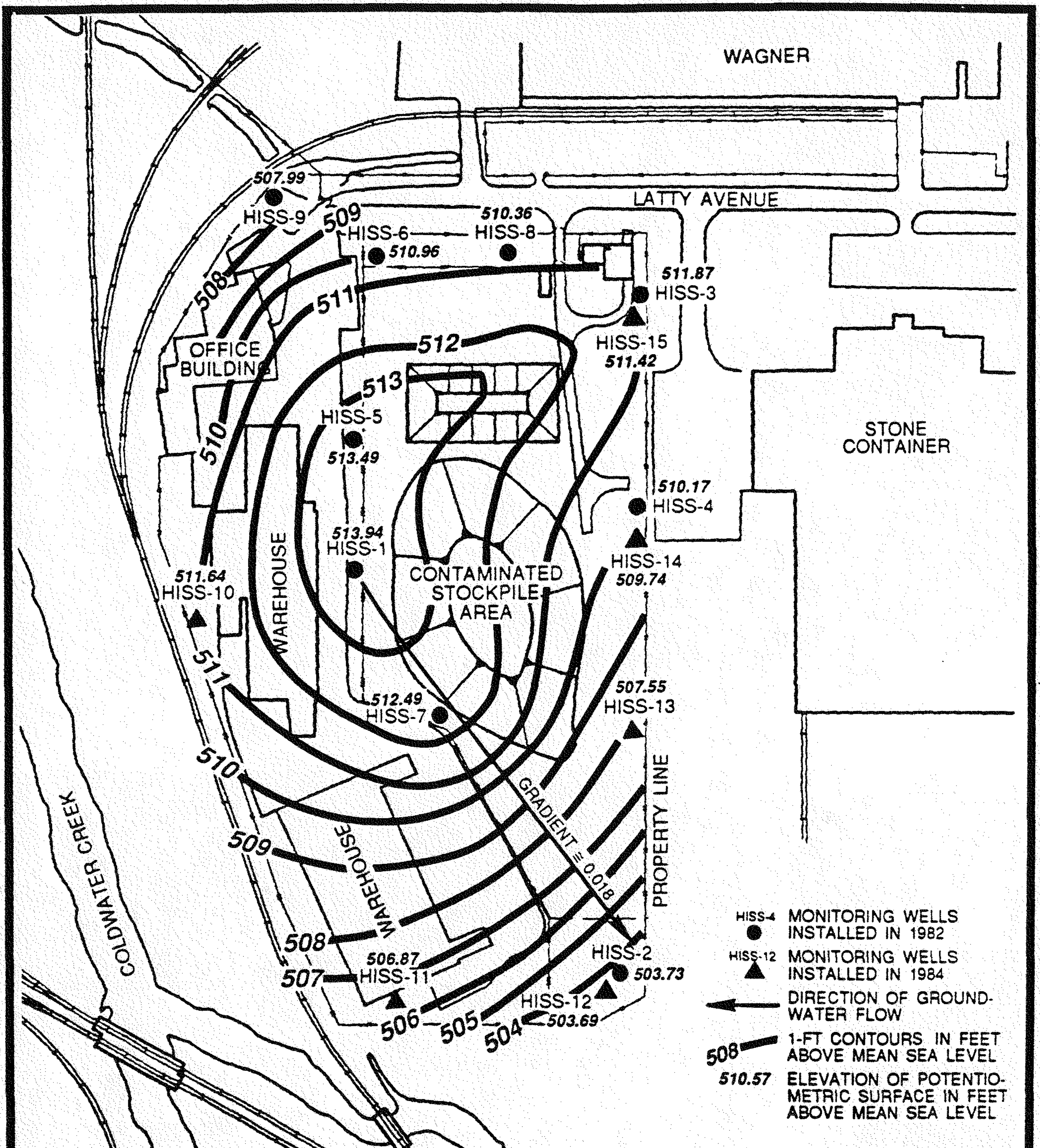


FIGURE 1-14 POTENTIOMETRIC SURFACE MAP OF HISS (11/10/88)

1.3.2 Discussion

The apparent seasonal variations shown by the hydrographs (Figures 1-6 through 1-10) do not affect the slopes and flow directions (Figures 1-11 through 1-14). On all four maps the potentiometric surface is at its highest under the central section of the site. Further monitoring will help to determine if this condition is due to precipitation, to on-site activities, or to the presence of the interim waste cell.

1.3.3 Conclusions

- The HISS groundwater surface is consistently 1.5 to 4.9 m (5 to 16 ft) below the ground surface, depending upon location on the site. Groundwater flows radially from the general area of HISS-1, with slopes ranging from 0.013 to 0.018.

- Frequency of water level measurements for the HISS monitoring well system will continue to be weekly throughout 1989.

2.0 SUMMARY OF MONITORING RESULTS

The environmental monitoring program at HISS, which began in 1984, continued in 1988; air, water, and sediment samples were taken, and radon levels and external gamma radiation levels were monitored to verify compliance with the DOE radiation protection standard of 100 mrem/yr (Ref. 8). The potential radiation dose that might be received by a hypothetical maximally exposed individual was calculated to determine the degree of compliance with the radiation protection standard.

Annual average radon concentrations in air ranged from 4×10^{-10} μCi/ml (0.4 pCi/l) to 1.3×10^{-9} μCi/ml (1.3 pCi/l), including background (Table 3-1). The average background radon concentration in the vicinity of HISS ranged from 4×10^{-10} μCi/ml (0.4 pCi/l) to 7×10^{-9} μCi/ml (0.7 pCi/l). Subsection 3.1 contains a discussion of radon concentrations at HISS in 1988. There have been no significant trends in radon concentrations measured at HISS since the initiation of environmental monitoring in 1984 (see Subsection 3.6.1) (Refs. 9-12).

Annual average external gamma radiation levels measured at HISS in 1988 ranged from 11 to 116 mR/yr above background, which was 73 mR/yr (Table 3-2). External radiation levels are discussed in Subsection 3.2. Since 1984, external gamma radiation levels have decreased sharply at almost all monitoring locations (see Subsection 3.6.2) (Refs. 9-12).

In surface water (Subsection 3.3.1), concentrations of total uranium, radium-226, and thorium-230 were at approximately background levels (Table 3-3). Concentrations of uranium in surface water have remained stable since 1985. Concentrations of radium-226 and thorium-230 have also remained basically stable (see Subsection 3.6.3) (Refs. 9-12).

In groundwater (Subsection 3.3.2), the highest annual average concentrations of total uranium, radium-226, and thorium-230 were 5×10^{-8} µCi/ml (50 pCi/l), 1.8×10^{-9} µCi/ml (1.8 pCi/l), and 2.4×10^{-8} µCi/ml (24 pCi/l), respectively (Table 3-4). There have not been enough data collected to draw any conclusions regarding trends for radionuclide concentrations in groundwater at the HISS. However, there has been little change in such concentrations since 1985 (see Subsection 3.6.4) (Refs. 9-12).

Concentrations of radionuclides in surface water and groundwater may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D.

In sediments (Subsection 3.4), the highest annual average concentrations of total uranium, radium-226, and thorium-230 were 2.2 pCi/g, 1.6 pCi/g, and 7.5 pCi/g, respectively (Table 3-5). The concentrations of radionuclides in sediments at HISS may be compared with the levels of radioactivity in phosphate fertilizers listed in Appendix D.

Calculations were made of radiological doses received by a hypothetical maximally exposed individual who, when all potential routes of exposure are considered, receives the greatest dose. Exposure to external gamma radiation was the exposure pathway quantified because it is the only one that is plausibly significant. The highest annual average external gamma radiation level at the HISS boundary was 116 mR/yr above background. When occupancy is considered, this radiation level results in an annual exposure to the hypothetical maximally exposed individual of 1 mR/yr above background (Subsection 3.5.1). Because 1 mR is approximately equivalent to 1 mrem, this exposure is equivalent to 1 percent of the DOE radiation protection standard of 100 mrem/yr. This exposure is less than the exposure a person receives during a flight from New York to Los Angeles from the greater amounts of cosmic radiation at higher altitudes. The cumulative dose to the population within an

80-km (50-mi) radius of HISS that results from radioactive materials present at the site is indistinguishable from the dose that the same population receives from naturally occurring sources.

Analytical results for chemicals are summarized in Subsection 4.1. Currently, no environmental permits are required for HISS.

Results of the 1988 monitoring show that HISS is in compliance with the DOE radiation protection standard.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

This section provides the results of environmental monitoring conducted at HISS in 1988 (Ref. 13) and includes descriptions of the sampling, monitoring, and analytical procedures used. Calculations were made to determine the estimated possible maximum radiation dose based on environmental conditions, measurements recorded, and evaluation of potential exposure pathways.

Data are presented in summary tables by sample category. Summaries of data include minimum and maximum values recorded, number of data points collected, and average value. The average value for a given sampling location is the average of individual results for that location. Individual sources of error (e.g., analytical error or sampling error) were not estimated. The "less than" notation (<) is used to denote sample analysis results that are below the limit of sensitivity of the analytical method based on a statistical analysis of parameters. In computing the averages, where no more than one value is less than the limit of sensitivity of the analytical method, that value is considered to be equal to the limit of sensitivity and the average value is reported without the "less than" notation.

During 1988, the environmental monitoring program for HISS included radon monitoring, measurement of external gamma radiation levels, sampling of surface water and sediment, and sampling of groundwater from monitoring wells within the site boundary.

Trend tables are provided for radon, external gamma radiation levels, surface water, and groundwater. These tables list annual averages for each monitoring location for 1984-1988 to allow for comparisons of data and identification of trends in monitoring results (see Subsection 3.6).

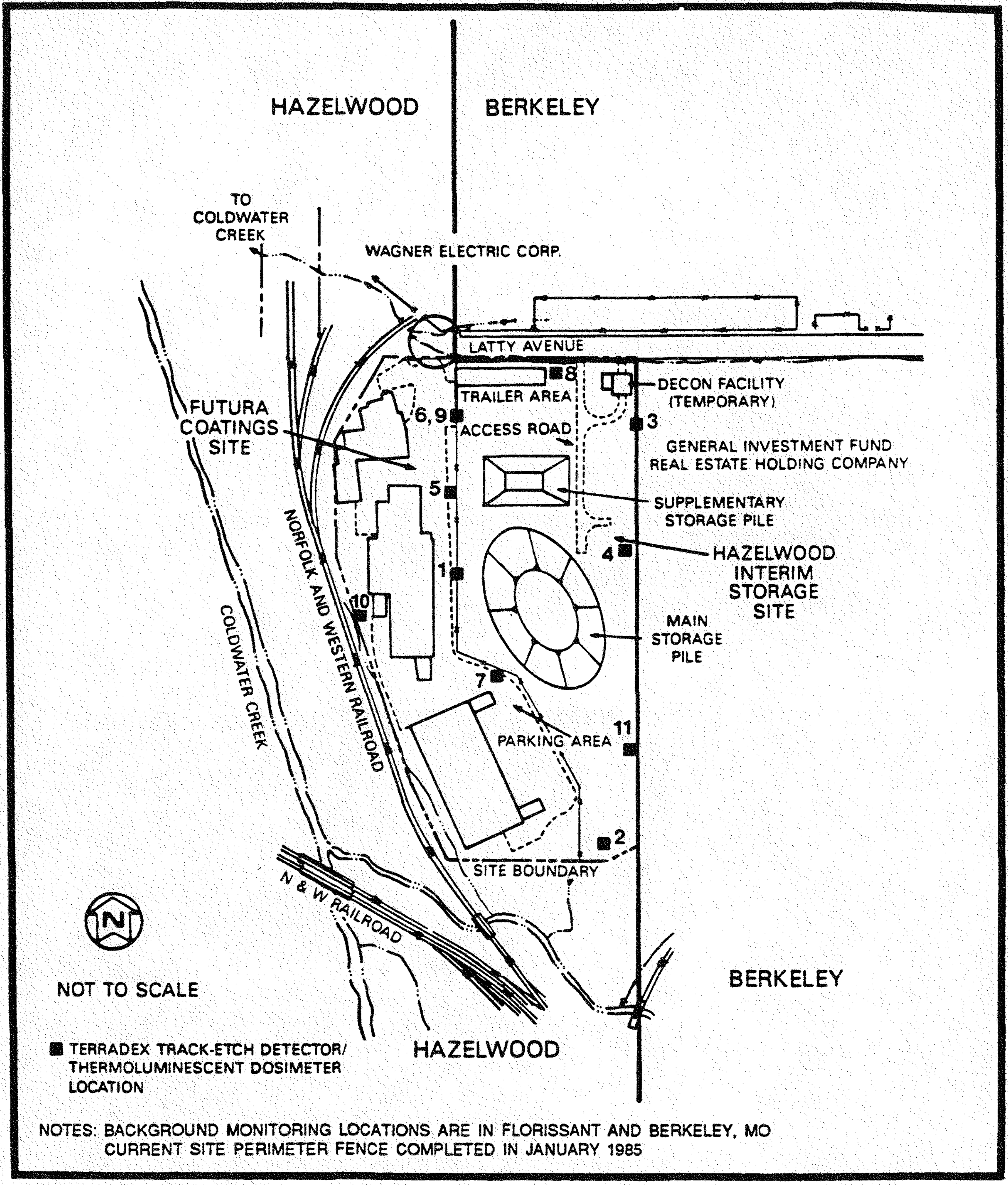
3.1 RADON SAMPLING

Radon detectors were maintained at 10 locations on the site and along the site boundary, as shown in Figure 3-1. Two of these locations were added in August 1986. Detectors are spaced along the site boundary to ensure adequate detection capability under most atmospheric conditions. To measure background radon levels, locations are maintained off-site approximately 24 km (15 mi) northeast and 8 km (5 mi) east of HISS.

Radon concentrations are determined using monitors purchased from the Terradex Corporation. These devices (Terradex Type F Track-Etch) consist of an alpha-sensitive film contained in a small plastic cup covered by a membrane through which radon can diffuse. Radon will diffuse through the membrane (in or out of the cup) when a concentration gradient exists; therefore, it will equilibrate with radon in the outside air. Alpha particles from the radioactive decay of radon and its daughters in the cup create tiny tracks when they collide with the film. When returned to Terradex for processing, the films are placed in a caustic etching solution to enlarge the tracks. Under strong magnification, the tracks can be counted. The number of tracks per unit area (i.e., tracks/mm^2) is related through calibration to the concentration of radon in air. Fresh Track-Etch monitors are obtained from Terradex each quarter. Site personnel place these units in each sampling location and return the exposed monitors to Terradex for analysis.

Table 3-1 reports the measured concentrations of radon in the air at HISS. Annual average concentrations ranged from 4×10^{-10} to 1.3×10^{-9} µCi/ml (0.4 to 1.3 pCi/l), including background, which ranged from 4×10^{-10} µCi/ml to 7×10^{-10} µCi/ml (0.4 to 0.7 pCi/l).

For a comparison of radon concentrations measured at the site from 1984 through 1988, see Subsection 3.6.1.



NOTES: BACKGROUND MONITORING LOCATIONS ARE IN FLORISSANT AND BERKELEY, MO
CURRENT SITE PERIMETER FENCE COMPLETED IN JANUARY 1985

FIGURE 3-1 RADON AND EXTERNAL GAMMA RADIATION MONITORING LOCATIONS AT HISS

TABLE 3-1

CONCENTRATIONS OF RADON-222 AT HISS, 1988

Sampling Location[a]	Number of Samples	Concentration (10^{-9} μCi/ml)[b,c]		
		Minimum[d]	Maximum	Average
1	4	0.6	1.1	0.9
2	4	0.3	1.4	0.7
3	4	0.3	1.0	0.6
4	4	0.5	2.4	1.3
5	4	0.6	1.7	0.9
6	4	0.3	1.5	0.7
7	4	0.3	0.9	0.6
8	4	0.3	1.2	0.6
9[d]	4	0.4	1.3	0.9
10	4	0.3	0.7	0.4
11	4	0.5	1.0	0.8
Background				
16[e]	4	0.3	0.6	0.4
19[f]	2	0.4	1.0	0.7

[a] Sampling locations are shown in Figure 3-1.

[b] 1 x 10^{-9} μCi/ml is equivalent to 1 pCi/l.

[c] Background has not been subtracted from the reported values. Note: Some locations have concentrations below background.

[d] Location 9 is a quality control for Location 6.

[e] Located in Florissant, MO, approximately 24 km (15 mi) northeast of HISS.

[f] Located at North Hanely Road, Berkeley, MO, approximately 8 km (5 mi) east of HISS. Established in April 1988.

3.2 EXTERNAL GAMMA RADIATION LEVELS

External gamma radiation levels were measured at 10 locations, all of which correspond to the radon (Terradex) detector locations shown in Figure 3-1. Detectors are located around the site boundary to ensure adequate measurement of external gamma radiation levels.

External gamma radiation levels are measured using lithium fluoride (LiF) thermoluminescent dosimeters (TLDs). The system of measurement used in 1988 utilizes tissue-equivalent dosimeters to provide values that are more realistic in terms of radiation dose to the tissues of the body at a depth of 1 cm. This dosimetry system offers advantages in accuracy and sensitivity that were not available with the system used in previous years.

Each dosimetry station contains a minimum of four dosimeters, which are exchanged after one year of accumulated exposure. For example, a dosimeter placed in the station in October 1987 would be removed in October 1988. Each dosimeter contains five individual LiF chips (each group of which was preselected on the basis of having a reproducibility of ±3 percent across a series of laboratory exposures), the responses of which are averaged. Analysis is performed by Thermo Analytical/Eberline (TMA/E). The average value is then corrected for the shielding effect of the shelter housing (approximately 8 percent) and for the effect of fade.

Fade is the loss of dose information brought about by environmental effects, primarily high summer temperatures. Fade is determined by collocating dosimeters that have been exposed to a known level of radiation (called a spike) before they are placed at a minimum of two site stations, generally located on the eastern and western boundary of a site. The fade factor can be determined by subtracting the station radiation value from the fade control dosimeter followed by dividing by the known spike level. The corrected value is then converted to milliroentgens per year by dividing by the number of days of exposure and subsequently multiplying by 365 days.

Some differences in external gamma radiation values may be noted in the 1988 data in comparison with the 1987 values. The current measurement system is more sensitive to low radiation levels and more accurate in its resolution than the system used previously. Therefore, some stations that previously demonstrated no measurable external gamma radiation value in excess of background now exhibit a small measurable value. Similarly, at some other stations values are higher or lower because of the improved method of measurement, not because of deterioration of site conditions or remedial action.

The results of external gamma monitoring are presented in Table 3-2. The average background external gamma radiation level for the HISS area (73 mR/yr) has been subtracted from the measured levels in Table 3-2 to provide an estimate of the effect of the site on levels measured at the site boundary. The highest annual average external gamma radiation level was 116 mR/yr at Location 2, where a 2-h/week occupancy factor is appropriate. On this basis, the external exposure to an individual working on this property would be 1 mR/yr. Because 1 mR is approximately equivalent to 1 mrem, this exposure is approximately equivalent to 1 percent of the DOE radiation protection standard of 100 mrem/yr.

The background external gamma radiation value for a given location is not a static constant. Because the background radiation value is a combination of both natural terrestrial sources and cosmic radiation sources, factors such as the location of the detector in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil can affect the value measured. Independent of the placement of the detector at the Earth's surface are the factors of site altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Ref. 14).

Because of these factors, the background radiation level is not constant from one location to another even over a short time. Thus it is not abnormal for some stations at the boundary of a site to have an external gamma radiation value less than the background level measured some distance from the site.

TABLE 3-2

EXTERNAL GAMMA RADIATION LEVELS AT HISS, 1988

Sampling Location[a]	Number of Measurements	Radiation Level (mR/yr)[b]		
		Minimum	Maximum	Average
1	4	19	59	40
2	4	70	160	116
3	4	0[c]	24	14
4	4	63	105	83
5	4	28	70	51
6	4	26	54	44
7	4	51	73	61
8	4	0[c]	17	11
9[d]	4	0[c]	82	49
10	3	10	18	13
11	4	41	69	56
Background[e]				
16[f]	4	63	86	73

[a] Sampling locations are shown in Figure 3-1.

[b] Measured background has been subtracted from the readings taken at the sampling locations shown in Figure 3-1.

[c] Measurement was less than or equal to the measured background value.

[d] Location 9 is a quality control for Location 6.

[e] An additional background location was established in April 1988 at North Hanely Rd., Berkeley, MO, approximately 8 km (5 mi) east of HISS. Data are not reported because the location has been monitored for less than a year. Data will be presented in the 1989 environmental monitoring report.

[f] Located in Florissant, MO, approximately 24 km (15 mi) northeast of HISS.

In April 1988, an additional background location was established at the Berkeley City Hall, approximately 8 km (5 mi) east of HISS. Because the six months of exposure time is not representative of the yearly fluctuations in background caused by seasonal weather variations, data from this location will be reported in 1989. For statistical analyses to be accurate, longer exposure times are needed.

For comparisons of external gamma radiation levels measured from 1984 to 1988, see Subsection 3.6.2.

3.3 WATER SAMPLING

During 1988, sampling was performed at six monitoring locations to determine the concentrations of total uranium, radium-226, and thorium-230 in surface water in the vicinity of HISS (Figure 3-2). The seven groundwater sampling locations are shown in Figure 1-5.

3.3.1 Surface Water

Surface water samples were collected quarterly at sampling locations established on the basis of potential contaminant migration and discharge routes from the site. Sampling points were both upstream, to establish background conditions; and downstream, to determine the effect of runoff from the site on surface waters in the vicinity. Sampling Locations 1 and 2 were removed from the monitoring program because installation of a subsurface sewer system made them inaccessible.

Nominal 1-liter (0.26-gal) grab samples were collected to fill a 4-liter (1-gal) container and were analyzed by TMA/E. The concentration of total uranium was determined by a fluorometric method. Radium-226 concentrations in water were determined by radon emanation. (This method consists of precipitating radium as sulfate and transferring the treated sulfate to a radon bubbler, where

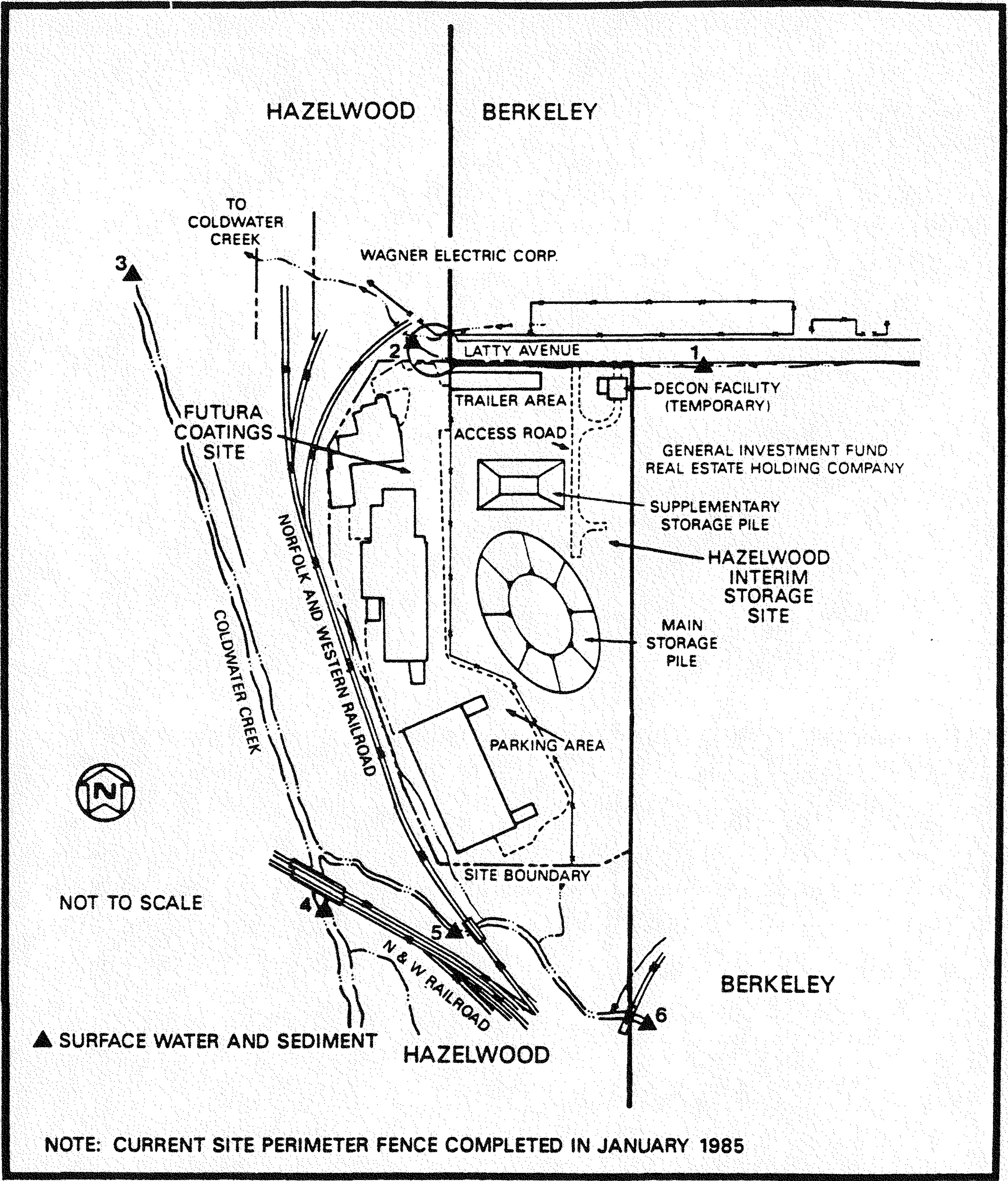


FIGURE 3-2 SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS AT HISS

radon-222 is allowed to come to equilibrium with its radium-226 parent. The radon-222 is then withdrawn into a scintillation cell and counted by the gross alpha technique. The quantity of radon-222 detected in this manner is directly proportional to the quantity of radium-226 originally present in the sample.) Thorium-230 was eluted in solution, electrodeposited on stainless steel discs, and counted by alpha spectrometry.

The results of analyses of surface water samples are presented in Table 3-3. Average total uranium, radium-226, and thorium-230 concentrations did not vary significantly from background. These values may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D.

For comparisons of radionuclide concentrations measured in surface water from 1984 through 1988, see Subsection 3.6.3.

3.3.2 Groundwater

Groundwater samples were collected quarterly in 1988 from seven monitoring wells established along the perimeter of the property and from two background wells on the basis of available hydrogeological data. After the wells had been bailed dry or three casing volumes had been removed, the wells were allowed to recharge for 24 h before nominal 1-liter (0.26-gal) grab samples were collected to fill a 4-liter (1-gal) container. Samples were analyzed by TMA/E for total uranium, dissolved radium-226, and dissolved thorium-230 using the methods applied to surface water analyses (see Subsection 3.3.1).

Results of the analyses of groundwater samples are presented in Table 3-4. The highest annual average total uranium, radium-226, and thorium-230 concentrations were 5×10^{-8} µCi/ml (50 pCi/l), 1.8×10^{-9} µCi/ml (1.8 pCi/l), and 2.4×10^{-8} µCi/ml (24 pCi/l), respectively. These values may be compared with the levels of radioactivity in the commonly consumed liquids listed in

TABLE 3-3

CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SURFACE WATER IN THE VICINITY OF HISS, 1988

Sampling Location[a,b]	Number of Samples	Concentration (10^{-9} μCi/ml)[c,d]		
		Minimum	Maximum	Average
Total Uranium				
3	3[f]	<3	5	4
4[e]	3[f]	<3	4	4
5	3[f]	<3	4	4
6	3[f]	<3	3	3
Radium-226				
3	3[f]	0.2	0.3	0.3
4[e]	3[f]	0.2	0.3	0.3
5	3[f]	0.1	0.4	0.3
6	3[f]	0.1	0.3	0.3
Thorium-230				
3	3[f]	0.1	0.3	0.2
4[e]	3[f]	0.1	0.6	0.3
5	3[f]	0.0	0.2	0.1
6	3[f]	0.0	0.9	0.3

[a] Locations are shown in Figure 3-2.

[b] Sampling Locations 1 and 2 were destroyed by construction activities conducted during July 1987.

[c] 1×10^{-9} μCi/ml is equivalent to 1 pCi/l.

[d] Where no more than one value is less than the limit of sensitivity of the analytical method, values are considered equal to the limit of sensitivity, and the average value is reported without the notation "less than."

[e] Location is upstream of the site to represent background conditions.

[f] Surface water location was frozen during the first quarter.

TABLE 3-4

CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN GROUNDWATER AT HISS, 1988

Page 1 of 2

Sampling Location[a]	Number of Samples	Concentration (10^{-9} μCi/ml)[b,c]		
		Minimum	Maximum	Average
Total Uranium				
6	4	18	87	50
9	4	<3	3	<3
10	4	<3	5	4
11	4	<3	5	5
12	4	5	7	6
13	4	7	9	8
15	4	<3	13	6
Background				
B53W01S	2[d]	<3	4	3
B53W01D	2[d]	<3	5	4
Radium-226				
6	4	0.5	3.7	1.8
9	4	0.4	0.7	0.6
10	4	0.1	0.9	0.4
11	4	0.5	1.7	1.0
12	4	0.3	1.4	1.3
13	4	0.4	0.6	0.6
15	4	0.5	1.3	0.8
Background				
B53W01S	2[d]	0.3	0.8	0.6
B53W01D	2[d]	1.0	1.1	1.1
Thorium-230				
6	4	2.5	64.0	24.0
9	4	0.2	0.3	0.2
10	4	0.1	1.3	0.7
11	4	0.1	3.0	1.5
12	4	0.2	6.2	2.3
13	4	<0.3	1.2	0.6
15	4	3.2	10.0	5.7

TABLE 3-4
(continued)

Page 2 of 2

Sampling Location[a]	Number of Samples	Concentration (10^{-9} μCi/ml)[b,c] Minimum	Maximum	Average
Thorium-230 (continued)				
Background				
B53W01S	2[d]	0.1	0.2	0.2
B53W01D	2[d]	1.2	0.2	0.2

[a] Sampling locations are shown in Figure 1-5.

[b] 1 x 10^{-9} μCi/ml is equivalent to 1 pCi/l.

[c] Where no more than one value is less than the limit of sensitivity of the analytical method, values are considered equal to the limit of sensitivity, and the average value is reported without the notation "less than."

[d] New wells, first sampled in July 1988. Located at Byassee Road, approximately 2.4 km (1.5 mi) southwest of the site.

Appendix D. For a comparison of radionuclide concentrations measured in groundwater at HISS from 1985 through 1988, see Subsection 3.6.4.

3.4 SEDIMENT SAMPLING

Sediment samples consisting of composites weighing approximately 500 g (1.1 lb) were collected quarterly at surface water sampling locations where sediment is present. The bases for selection of the individual sampling locations are given in Subsection 3.3.1.

TMA/E analyzed the samples for total uranium, radium-226, and thorium-230. The total uranium concentration was calculated by summing the analytical results for isotopic uranium. Isotopic uranium and thorium-230 were determined by alpha spectrometry, where the uranium and thorium-230 are leached, extracted, and electroplated on metal substrates. Radium-226 concentrations were determined by radon emanation (described earlier).

Results of these analyses, based on dry weight, are presented in Table 3-5. Average total uranium concentrations ranged from 1.4 to 2.2 pCi/g, average radium-226 concentrations from 0.8 to 1.6 pCi/g, and average thorium-230 concentrations from 1.5 to 7.5 pCi/g. These values may be compared with the levels of radioactivity in phosphate fertilizers listed in Appendix D.

3.5 RADIATION DOSE

To assess the potential health effects of the radioactive materials stored at HISS, radiological exposure pathways were evaluated to calculate the dose to a hypothetical maximally exposed individual. This individual is one who is assumed to be adjacent to the site and who, when all potential routes of exposure are considered, receives the greatest dose. An evaluation of potential pathways (ingestion of water, exposure to

TABLE 3-5

CONCENTRATIONS OF RADIUM-226, THORIUM-230, AND URANIUM IN SEDIMENT IN THE VICINITY OF HISS, 1988

Page 1 of 2

Sampling Location[a,b]	Number of Samples	Concentration [pCi/g (dry)]		
		Minimum	Maximum	Average
Radium-226				
3	4	0.5	1.6	1.0
4	4	0.6	1.9	1.2
5	3[c]	1.4	1.8	1.6
6	4	0.4	1.3	0.8
Thorium-230				
3	4	0.8	10.0	5.8
4	4	0.1	11.0	4.3
5	3[c]	4.4	13.0	7.5
6	4	0.8	2.9	1.5
Uranium-234				
3	4	0.4	0.8	0.6
4	4	0.5	1.5	1.1
5	3[c]	0.9	1.1	1.0
6	4	0.4	0.9	0.6
Uranium-235				
3	4	<0.1	<0.1	<0.1
4	4	<0.1	<0.1	<0.1
5	3[c]	<0.1	<0.1	<0.1
6	4	<0.1	<0.1	<0.1
Uranium-238				
3	4	0.5	1.0	0.7
4	4	0.5	1.4	1.0
5	3[c]	1.0	1.0	1.0
6	4	0.5	1.0	0.7
Total Uranium				
3	4	1.0	1.9	1.4
4	4	1.1	3.0	2.2
5	3[c]	2.0	2.2	2.1
6	4	1.0	2.0	1.4

TABLE 3-5

(continued)

Page 2 of 2

Sampling Location[a,b]	Number of Samples	Concentration [pCi/g (dry)]		
		Minimum	Maximum	Average

[a] Sampling locations shown in Figure 3-2. Location 4 is upstream of the site and is a background location.

[b] Construction activities in July 1987 destroyed sampling Locations 1 and 2.

[c] No sediment at sampling location in the first quarter.

external gamma radiation, and inhalation of radon) indicated that exposure to external gamma radiation was the only plausibly significant pathway.

The dose from ingesting groundwater or surface water from sources on the site was not calculated because it was considered unrealistic to assume that ingestion of this water could occur. HISS is fenced and locked, security is well maintained, and a member of the public could only consume water on the site by trespassing on the property. To consume groundwater from a well at the site, the trespasser would have to be equipped with a means of removing the well cap (which is locked) and would also need a power source, a pump, and a hose.

Most of the annual average radon concentrations measured at the boundary of HISS were within the normal variation associated with background measurements for this area. Given the amount of time that the hypothetical maximally exposed individual would spend near the higher-than-background locations, the dose from radon would be indistinguishable from the dose received from background. Consequently, this pathway would not contribute additional dose to the maximally exposed individual.

3.5.1 Dose to the Maximally Exposed Individual

To identify the individual in the vicinity of HISS who would receive the highest dose from on-site radioactive materials, the dose from exposure to external gamma radiation was calculated at various monitoring locations that could be accessible to the public. This dose was then reviewed with regard to land use and occupancy factors for areas adjacent to the monitoring points. For the properties surrounding HISS, the highest overall dose would be received by an individual west of the site. Because this is a commercial area parking lot, the calculated dose was based on an estimated exposure period of 2 h/week. Exposure to workers in nearby commercial buildings is negligible because of the distance of the buildings from the site perimeter and the attenuation provided by the building walls.

The highest average exposure rate above background was 116 mR/yr, as measured at monitoring Location 2 (Figure 3-1). Exposure at this rate for 2 h/week would result in an annual exposure to the total body of approximately 1 mR. Because 1 mR is approximately equivalent to 1 mrem, this exposure is approximately equivalent to 1 percent of the DOE radiation protection standard of 100 mrem/yr. This scenario is highly conservative because it is unlikely that any individual would spend so much time at this location. A more realistic assessment of the use of the site would demonstrate that the incremental dose is less than 1 mrem/yr. This exposure is less than the exposure a person receives during a flight from New York to Los Angeles from the greater amounts of cosmic radiation at higher altitudes.

3.5.2 Dose to the Population in the Vicinity of HISS

The dose to the population represents the conceptual cumulative radiation dose to all residents within an 80-km (50-mi) radius of a given site. This calculated dose includes contributions from all potential pathways. For HISS these pathways are direct exposure to gamma radiation, inhalation of radon, and ingestion of water containing radioactivity.

The contribution to the population dose made by gamma radiation from the radioactive materials present on-site is too small to be measured, because gamma radiation levels decrease rapidly as distance from the source of contamination increases. For example, if the gamma exposure rate at a distance of 0.9 m (3 ft) from a small-area radioactive source were 100 mR/yr, the exposure rate at a distance of 6.4 m (21 ft) from the source would be indistinguishable from naturally occurring background radiation.

Similarly, radon is known to dissipate rapidly as distance from the radon source increases (Ref. 15). Therefore, exposure from the low radon concentrations at the HISS does not contribute significantly to population dose.

On the basis of radionuclide concentrations measured in water leaving HISS, it also appears that there is no plausible pathway by which ingestion of water could result in a significant dose to the population. As water migrates farther from the source, radionuclide concentrations are further reduced, thereby lowering potential doses to even less significant levels. Because the contributions to population dose via all three potential exposure pathways are inconsequential, calculation of dose to the population is not warranted. The cumulative dose to the population within an 80-km (50-mi) radius of HISS that would result from radioactive materials present at the site would be indistinguishable from the dose that the same population would receive from naturally occurring radioactive sources.

3.6 TRENDS

The environmental monitoring program at HISS was established to allow an annual assessment of the environmental conditions at the site, provide a historical record for comparisons from year to year, and permit detection of trends over time. In the following subsections, 1988 annual averages for each monitoring location for radon, external gamma radiation, surface water, and groundwater are compared with results for 1984 through 1987.

3.6.1 Radon

As shown in Table 3-6, there have been no significant trends in radon concentrations at HISS since 1984. Overall, radon concentrations have remained basically stable, with slight increases at some monitoring stations and slight decreases at others.

TABLE 3-6

ANNUAL AVERAGE CONCENTRATIONS OF RADON-222 AT HISS, 1984-1988[a]

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[c,d]				
	1984[e]	1985	1986	1987	1988
1	2.2	0.3	0.9	1.0	0.9
2	0.6	0.5	0.8	0.7	0.7
3	0.3	0.4	0.3	0.6	0.6
4	0.8	0.5	1.3	1.5	1.3
5	0.4	0.4	0.6	0.3	0.9
6	0.4	0.7	0.6	0.8	0.7
7	0.5	0.4	1.1	1.8	0.6
8	2.0	0.3	0.2	0.3	0.6
9	0.4	0.5	0.5	0.3	0.9
10[f]	-[f]	-[f]	0.2[f]	0.4	0.4
11[f]	-[f]	-[f]	1.8[f]	1.2	0.8
<u>Background</u>					
16[g]	-[g]	0.5	0.3	0.4	0.4
19[h]	-[h]	-[h]	-[h]	-[h]	0.7

---

[a] Data sources for 1984-1987 are the annual site environmental reports for those years (Refs. 9-12).

[b] Sampling locations are shown in Figure 3-1.

[c] 1×10^{-9} µCi/ml is equivalent to 1 pCi/l.

[d] Measured background has not been subtracted.

[e] Monitoring program began in September 1984, and 1984 data are for approximately one quarter only.

[f] Sampling location established in August 1986.

[g] Background location established in 1985, approximately 24 km (15 mi) northeast of HISS.

[h] Background location established in April 1988, approximately 8 km (5 mi) east of HISS.

3.6.2 External Gamma Radiation Levels

As shown in Table 3-7, external gamma radiation levels measured at HISS have declined sharply since 1984 at all monitoring locations except Location 2, where levels decreased from 1984 to 1986 but increased slightly in 1987 and 1988. The overall decline reflects the progress of remedial action at the site.

3.6.3 Surface Water

As shown in Table 3-8, concentrations of uranium in surface water in the vicinity of HISS have declined dramatically since 1984. This decline reflects the effects of remedial action at the site. Concentrations of radium-226 have remained almost unchanged. Overall, thorium-230 concentrations have been relatively stable over the 5-year monitoring period.

3.6.4 Groundwater

Because of the remedial action conducted at HISS, almost all wells monitored at the site during 1984 were removed, and new monitoring wells were put into service in 1985. Therefore, Table 3-9 reports data for 1985 through 1988 only, and a meaningful trend analysis is not possible.

A rise in thorium-230 concentrations occurred in wells 15 and 6 in 1988. The thorium-230 levels peaked in July. During the late spring through late summer, a nearby company was observed excavating a shallow trench along the eastern boundary of HISS. This trench was used to divert wastewater from the company's truck washing operation. Commercial detergents contain phosphates and EDTA, for which thorium-230 has an affinity. These chemicals in the detergent may have increased the solubility of the thorium-230 in well 15. In turn, the soluble thorium-230 may have migrated, via runoff during a summer rainstorm, to well 6 and caused the elevated level there.

TABLE 3-7

ANNUAL AVERAGE EXTERNAL GAMMA RADIATION LEVELS AT HISS, 1984-1988[a]

Sampling Location[b]	Radiation Level (mR/yr)[c] 1984[d]	1985	1986	1987	1988
1	501	58	34	44	40
2	328	87	68	113	116
3	219	25	23	20	14
4	1062	83	71	74	83
5	466	141	77	46	51
6	1106	287	179	29	44
7	613	89	46	50	61
8	307	7	17	27	11
9[e]	202	261	151	61	49
10[f]	-[f]	-[f]	21[f]	17	13
11[f]	-[f]	-[f]	15[f]	44	56
<u>Background</u>[g]					
16[h]	-[h]	99	97	77	73

[a] Data sources for 1984-1987 are the annual site environmental reports for those years (Refs. 9-12).

[b] Sampling locations are shown in Figure 3-1.

[c] Measured background has been subtracted from the readings taken at the sampling locations shown in Figure 3-1.

[d] Monitoring program began in September 1984, and 1984 data are for approximately one quarter only.

[e] Location 9 is a quality control for Location 6.

[f] Sampling location established in August 1986.

[g] An additional background location was established in April 1988 at the Berkeley City Hall, approximately 8 km (5 mi) east of HISS. No values are reported this year because the TLDs have not yet been operational for a year. Data will be presented in the 1989 environmental report.

[h] Background monitoring location established in 1985, approximately 24 km (15 mi) northeast of HISS.

TABLE 3-8

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SURFACE WATER IN THE VICINITY OF HISS, 1984-1988[a]

Sampling Location[b]	Concentration (10^{-9} μCi/ml)[c]				
	1984	1985	1986	1987	1988
Total Uranium					
1	67.0	<3.0	<3.0	-[d]	-[d]
2	69.0	<3.0	<3.0	-[d]	-[d]
3	97.0	4.3	4.0	4.0	4
4	116.0	4.3	4.0	5.0	4
5	67.0	<3.0	<3.0	<3.0	4
6	69.0	<3.0	<3.0	<3.0	<3
Radium-226					
1	0.3	0.1	0.3	-[d]	-[d]
2	0.3	0.1	0.1	-[d]	-[d]
3	0.1	0.1	0.3	0.2	0.3
4	0.1	0.2	0.3	0.2	0.3
5	0.2	0.1	0.2	0.3	0.3
6	0.2	0.2	0.2	0.2	0.3
Thorium-230					
1	0.2	0.1	0.2	-[d]	-[d]
2	15.4	0.4	<0.1	-[d]	-[d]
3	0.4	3.3	0.4	0.3	0.2
4	0.5	0.2	0.2	0.4	0.3
5	0.5	0.2	0.4	0.3	0.1
6	0.5	2.9	0.2	0.1	0.3

[a] Data sources for 1984-1987 are the annual site environmental reports for those years (Refs. 9-12).

[b] Sampling locations are shown in Figure 3-2.

[c] 1×10^{-9} μCi/ml is equivalent to 1 pCi/l.

[d] Construction activities in July 1987 destroyed the sampling location.

TABLE 3-9

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN GROUNDWATER AT HISS, 1985-1988[a]

Page 1 of 2

Sampling Location[b]	Concentration (10^{-9} μCi/ml)[c]			
	1985	1986	1987	1988
Total Uranium				
6	71.6	33.0	40.0	50.0
9	25.6	<3.0	<3.0	<3.0
10	3.1	6.0	4.0	4.0
11	<3.0	5.0	4.0	5.0
12	<3.0	4.0	5.0	6.0
13	<3.0	8.0	8.0	8.0
15	<3.0	5.0	3.0	6.0
Background				
B53W01S	-[d]	-[d]	-[d]	3.0
B53W01D	-[d]	-[d]	-[d]	4.0
Radium-226				
6	0.8	0.7	1.2	1.8
9	0.4	0.2	0.2	0.6
10	0.2	0.1	0.2	0.4
11	0.3	0.4	0.2	1.0
12	0.4	0.4	0.5	1.3
13	0.1	0.3	0.3	0.6
15	0.3	0.4	0.4	0.8
Background				
B53W01S	-[d]	-[d]	-[d]	0.6
B53W01D	-[d]	-[d]	-[d]	1.1
Thorium-230				
6	5.5	2.6	2.9	24.0
9	0.2	0.6	0.2	0.2
10	0.2	0.7	0.3	0.7
11	0.9	1.3	0.8	1.5
12	0.4	2.0	0.8	2.3
13	0.3	1.0	0.3	0.6
15	0.5	1.3	0.8	5.7

TABLE 3-9
(continued)

Page 2 of 2

Sampling Location[b]	Concentration (10^{-9} μCi/ml)[c] 1985	1986	1987	1988
Background				
B53W01S	-[d]	-[d]	-[d]	0.2
B53W01D	-[d]	-[d]	-[d]	0.2

[a] Data sources for 1985-1987 are the annual site environmental reports for those years (Refs. 9-12).

[b] Sampling locations are shown in Figure 1-5.

[c] 1 x 10^{-9} μCi/ml is equivalent to 1 pCi/l.

[d] New well; first sampled in July 1988.

In October, the concentration of thorium-230 decreased to approximately the levels seen in January. Concentrations ranged from <0.1 to 2.5 pCi/l during January, April, and October.

4.0 RELATED ACTIVITIES AND SPECIAL STUDIES

4.1 RELATED ACTIVITIES

In April 1987, monitoring of the groundwater for chemical indicator parameters began at HISS. These indicator parameters are pH, specific conductance, total organic carbon (TOC), and total organic halides (TOX). These parameters indicate changes in the inorganic and organic composition of the groundwater.

Specific conductance and pH measure changes in the inorganic composition of the groundwater. Acidity or basicity of water is expressed as pH. A change in pH effects the solubility and mobility of chemical contaminants in groundwater. Specific conductance measures the capacity of water to conduct an electrical current. Generally, conductivity increases with an elevated concentration of dissolved solids. Waters with high salinities or high total dissolved solids exhibit high conductivities.

Groundwater is analyzed for TOC and TOX to determine organic content. TOC measures the total organic carbon content of water but is not specific to a given contaminant. TOX measures organic compounds containing halogens because many pollutants contain halogenated hydrocarbons, which are organic compounds containing fluorine, chlorine, bromine, and iodine.

As shown in Table 4-1, pH, TOC, and TOX are within approximately ±20 percent of the levels in wells B53W01S and B53W01D, which represent background concentrations. Well 15 has a maximum TOX value of 110 µg/l, which is approximately three times higher than the background concentration.

This elevated TOX value occurred in the third-quarter analyses; it may be attributable to nearby truck washing operations during the summer (see Subsection 3.6.4) or it may indicate the presence of organic halogens in groundwater in the area. Further analyses will be conducted in 1989 to determine the types of compounds present.

TABLE 4-1

ANALYSIS RESULTS FOR INDICATOR PARAMETERS IN GROUNDWATER AT HISS, 1988

	Parameter			
Sampling Location (Well No.)[b]	pH (Standard Units)	Total Organic Carbon (mg/l)	Total Organic Halide[a] (µg/l)	Specific Conductance (µmhos/cm)
6	6.9 - 7.3	3.4 - 20.3	23 - 52	467 - 8060
9	7.8 - 8.7	1.6 - 4.1	11 - 35	625 - 775
10	7.2 - 7.4	1.3 - 4.8	20 - 49	686 - 953
11	6.9 - 7.1	1.7 - 4.3	ND - 48	1330 - 1560
12	6.7 - 6.9	1.9 - 6.9	ND - 58	2660 - 4100
13	6.7 - 6.9	2.0 - 7.2	ND - 38	6280 - 8000
15	6.8 - 6.9	4.2 - 6.9	19 - 110	909 - 1210
Background[c]				
B53W01S[d]	7.1	2.7	23	1010
B53W01D	6.8 - 7.0	7.1 - 34.2	ND - 35	932 - 1010

[a] ND - no detectable concentration.

[b] Sampling locations are shown in Figure 1-7.

[c] Background wells B53W01S and B53W01D were added to the monitoring program in July 1988; located at Byassee Rd., approximately 2.4 km (1.5 mi) southwest of the site.

[d] Label error for samples in October 1988; no analyses performed.

Specific conductance across the site varies from a low of 467 to a high of 8,060 µmhos. The groundwater at the site contains corresponding levels of dissolved solids and is therefore of low quality.

Analytical results indicate that the groundwater at HISS is of poor quality, which is typical of groundwater in industrial urban areas.

4.2 SPECIAL STUDIES

No special studies were carried out at HISS in 1988.

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APPENDIX A

QUALITY ASSURANCE

APPENDIX A
QUALITY ASSURANCE

A comprehensive quality assurance (QA) program was maintained to ensure that the data collected were representative of actual concentrations in the environment. First, extensive environmental data were obtained to prevent reliance on only a few results that might not be representative of the existing range of concentrations. Second, current monitoring data were compared with historical data for each environmental medium to ensure that deviations from previous conditions were identified and evaluated. Third, samples at all locations were collected using published procedures to ensure consistency in sample collection. Fourth, each analytical laboratory verified the quality of the data by conducting a continuing program of analytical quality control (QC), participating in interlaboratory cross-checks, performing replicate analyses, and splitting samples with other recognized laboratories. Fifth, chain-of-custody procedures were implemented to maintain traceability of samples and corresponding analytical results. This program ensures that the monitoring data can be used to evaluate accurately the environmental effects of site operations.

The majority of the routine radioanalyses for the FUSRAP Environmental Monitoring Program were performed under subcontract by TMA/E, Albuquerque, New Mexico. This laboratory maintained an internal quality assurance program that involved routine calibration of counting instruments, source and background counts, routine yield determinations of radiochemical procedures, and replicate analyses to check precision. The accuracy of radionuclide determination was ensured through the use of standards traceable to the National Bureau of Standards, when available. The laboratory also participated in the Environmental Protection Agency's (EPA) Laboratory Intercomparison Studies Program. In this program, samples of different environmental media (water, milk, air filters, soil, foodstuffs, and tissue ash) containing one or more radionuclides in known amounts were prepared and distributed to the participating laboratories. After the samples were analyzed, the results were forwarded to EPA for comparison with known values and with the results from other laboratories. This program enabled the laboratory to regularly evaluate the accuracy of its analyses and take corrective action if needed.

Interlaboratory comparison of the TLD results was provided by participation in the International Environmental Dosimeter Project sponsored jointly by the DOE, the Nuclear Regulatory Commission, and the EPA. Table A-1 summarizes results of the EPA comparison studies for water samples.

To ensure the accuracy of dose calculations, all computed doses were double-checked by the originator and by an independent third party who also checked all input data and assumptions used in the calculations.

Chemical analyses were performed under subcontract by Weston Analytical Laboratory, Lionsville, Pennsylvania. Weston's standard practices manual was reviewed and accepted by BNI. The laboratory maintains an internal QA program that involves the following.

For inorganic analyses, the program includes:

- Initial calibration and calibration verification
- Continuing calibration verification
- Reagent blank analyses
- Matrix spike analyses
- Duplicate sample analyses
- Laboratory control sample analyses

TABLE A-1

SUMMARY COMPARISON OF WATER SAMPLE RESULTS

(EPA and TMA/E)

Analysis and Sample Date	Value (pCi/l) EPA	Value (pCi/l) TMA/E	Ratio (TMA/E:EPA)
Alpha			
1/88	28.0 ± 7.0	40.0 ± 2.0	1.43
2/88	4.00 ± 5.00	3.33 ± 0.60	0.83
5/88	6.0 ± 5.0	5.3 ± 0.6	0.88
7/88	46.0 ± 11.0	53.3 ± 2.9	1.16
8/88	15.0 ± 5.0	12.7 ± 0.6	0.85
11/88	8.00 ± 5.00	7.00 ± 1.00	0.88
Beta			
1/88	72.0 ± 5.0	90.0 ± 4.0	1.25
2/88	8.00 ± 5.00	9.30 ± 0.6	1.16
5/88	13.0 ± 5.0	16.3 ± 0.6	1.25
7/88	57.0 ± 5.0	69.7 ± 2.9	1.22
8/88	4.0 ± 5.0	5.0 ± 1.0	1.25
11/88	10.00 ± 5.00	10.00 ± 1.00	1.00
Ra-226			
1/88	4.80 ± 0.72	4.70 ± 0.26	0.98
1/88	4.80 ± 0.72	4.53 ± 0.15	0.94
5/88	7.60 ± 1.14	7.27 ± 0.25	0.96
7/88	6.40 ± 0.96	6.37 ± 0.59	1.00
8/88	10.0 ± 1.51	9.90 ± 0.53	0.99
11/88	8.40 ± 1.30	8.53 ± 0.15	1.02
Ra-228			
1/88	5.30 ± 0.80	4.35 ± 1.4	0.82
1/88	3.60 ± 0.54	4.60 ± 0.95	1.28
5/88	7.70 ± 1.16	8.73 ± 0.5	1.13
7/88	5.60 ± 0.84	6.50 ± 0.10	1.16
8/88	12.40 ± 1.86	14.80 ± 0.72	1.19
11/88	5.40 ± 0.80	5.33 ± 0.35	0.99
U (Natural)			
1/88	3.0 ± 6.0	3.33 ± 0.58	1.11
4/88	3.0 ± 6.0	3.7 ± 0.6	1.23
7/88	6.00 ± 6.00	6.33 ± 0.58	1.06
10/88	6.0 ± 6.0	7.0 ± 0.0	1.17

The laboratory for organic analyses conforms to QC procedures for the following:

- GC/MS instrumentation for both volatile and semivolatile compound analysis
- Initial multilevel calibration for each hazardous substance list (HSL) compound
- Continuing calibration for each HSL compound
- Addition of surrogate compounds to each sample and blanks for determining percent recovery information
- Matrix spike analyses
- Reagent blank analyses

Weston is currently an EPA-designated Contract Laboratory Program (CLP) laboratory for both organic and inorganic analyses. This requires passing EPA's blind performance evaluation testing each quarter. The technical specifications in BNI's subcontract with Weston specify QA/QC at, and in some cases beyond, the CLP level.

They participate in water studies to demonstrate technical competence for state drinking water certification programs. They also participate in water pollution studies to demonstrate technical competence for state wastewater certification programs. Currently, they participate in drinking water, wastewater, and/or hazardous waste certification programs. They are certified (or pending) in 35 such state programs. Continued certification hinges upon Weston's ability to pass the performance evaluation testing, and many of these tests are conducted semiannually.

Weston's QA program also includes an independent overview by their project QA coordinator and a corporate vice president who audits their program activities quarterly.

The FUSRAP sampling program was designed to provide for spikes, blanks, and QC duplicate sampling. Samples are tracked by chain-of-custody procedures to maintain traceability.

APPENDIX B

ENVIRONMENTAL STANDARDS

APPENDIX B
ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr above background level includes exposure from all pathways except medical treatments (Ref. 8). Evaluation of exposure pathways and resulting dose calculations are based on assumptions such as the use of occupancy factors in determining dose due to external gamma radiation; subtraction of background concentrations of radionuclides in air, water, and soil before calculating dose; closer review of water use, using the data that most closely represents actual exposure conditions rather than maximum values as applicable; and using average consumption rates of food and water per individual rather than maximums. Use of such assumptions will result in calculated doses that more accurately reflect the exposure potential from site activities.

TABLE B-1

CONVERSION FACTORS

---

1 yr = 8,760 h

1 liter = 1,000 ml

1 mR = 1 mrem

1 mrem = 1,000 uR

100 mrem/yr = 11.4 uR/h (assuming 8,760 hours of exposure per year)

1 µCi = 1,000,000 pCi

1 pCi = 0.000001 µCi

1 pCi/l = 10^{-9} µCi/ml

1 pCi/l = 0.000000001 µCi/ml

1 µCi/ml = 1,000,000,000 pCi/l

10^{-6} = 0.000001

10^{-7} = 0.0000001

10^{-8} = 0.00000001

10^{-9} = 0.000000001

10^{-10} = 0.0000000001

7×10^{-10} = 0.0000000007

APPENDIX C

ABBREVIATIONS

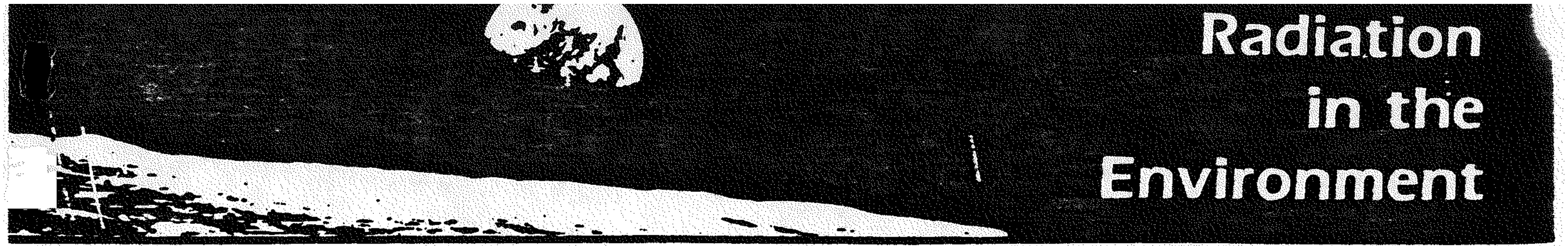
APPENDIX C

ABBREVIATIONS

cm	centimeter
cm/sec	centimeters per second
ft	foot
ft msl	feet above mean sea level
g	gram
gal	gallon
h	hour
ha	hectare
in.	inch
km	kilometer
km/h	kilometers per hour
lb	pound
m	meter
m^3	cubic meter
mg	milligram
mg/l	milligrams per liter
mi	mile
ml	milliliter
mph	miles per hour
mR	milliroentgen
mrem	millirem
mR/yr	milliroentgens per year
mrem/yr	millirem per year
µCi/ml	microcuries per milliliter
µg/l	micrograms per liter
µR/h	microroentgens per hour
pCi	picocurie
pCi/g	picocuries per gram
pCi/l	picocuries per liter
yd^3	cubic yard
yr	year

APPENDIX D

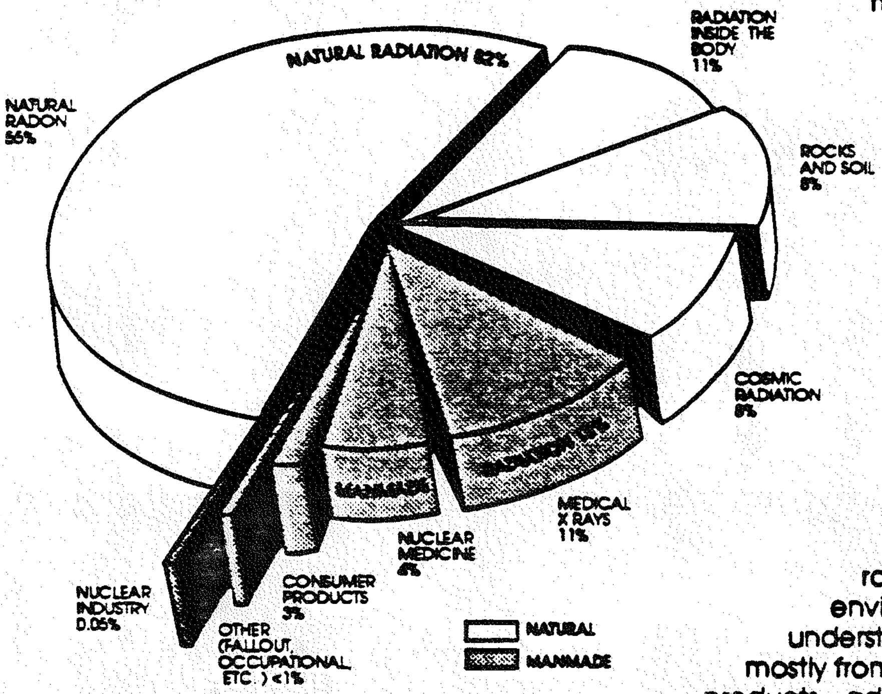
RADIATION IN THE ENVIRONMENT



Radiation in the Environment

Radiation is a natural part of our environment. When our planet was formed, radiation was present—and radiation surrounds it still. Natural radiation showers down from the distant reaches of the cosmos and continuously radiates from the rocks, soil, and water on the Earth itself.

During the last century, mankind has discovered radiation, how to use it, and how to control it. As a result, some manmade radiation has been added to the natural amounts present in our environment.



Sources of Radiation

Many materials—both natural and manmade—that we come into contact with in our everyday lives are radioactive. These materials are composed of atoms that release energetic particles or waves as they change into more stable forms. These particles and waves are referred to as *radiation,* and their emission as *radioactivity.*

As the chart on the left shows, most environmental radiation (82%) is from natural sources. By far the largest source is radon, an odorless, colorless gas given off by natural radium in the Earth's crust. While radon has always been present in the environment, its significance is better understood today. Manmade radiation—mostly from medical uses and consumer products—adds about eighteen percent to our total exposure.

TYPES OF IONIZING RADIATION

Radiation that has enough energy to disturb the electrical balance in the atoms of substances it passes through is called *ionizing radiation.* There are three basic forms of ionizing radiation.

Alpha

Alpha particles are the largest and slowest moving type of radiation. They are easily stopped by a sheet of paper or the skin. Alpha particles can move through the air only a few inches before being stopped by air molecules. However, alpha radiation is dangerous to sensitive tissue inside the body.

Beta

Beta particles are much smaller and faster moving than alpha particles. Beta particles pass through paper and can travel in the air for about 10 feet. However, they can be stopped by thin shielding such as a sheet of aluminum foil.

Gamma

Gamma radiation is a type of electromagnetic wave that travels at the speed of light. It takes a thick shield of steel, lead, or concrete to stop gamma rays. X rays and cosmic rays are similar to gamma radiation. X rays are produced by manmade devices; cosmic rays reach Earth from outer space.

Units of Measure

Radiation can be measured in a variety of ways. Typically, units of measure show either 1) the total amount of radioactivity present in a substance, or 2) the level of radiation being given off.

The radioactivity of a substance is measured in terms of the number of transformations (changes into more stable forms) per unit of time. The *curie* is the standard unit for this measurement and is based on the amount of radioactivity contained in 1 gram of radium. Numerically, 1 curie is equal to 37 billion transformations per second. The amounts of radioactivity that people normally work with are in the millicurie (one-thousandth of a curie) or microcurie (one-millionth of a curie) range. Levels of radioactivity in the environment are in the picocurie, or pCi (one-trillionth of a curie) range.

Levels of radiation are measured in various units. The level of gamma radiation in the air is measured by the *roentgen*. This is a relatively large unit, so measurements are often calculated in milliroentgens. Radiation absorbed by humans is measured in either *rad* or *rem*. The rem is the most descriptive because it measures the ability of the specific type of radiation to do damage to biological tissue. Again, typical measurements will often be in the millirem (mrem), or one-thousandth of a rem, range. In the international scientific community, absorbed dose and biological exposure are expressed in *grays* and *seiverts*. 1 gray (Gy) equals 100 rad. 1 seivert (Sv) equals 100 rem. On the average, Americans receive about 360 mrem of radiation a year. Most of this (97%) is from natural radiation and medical exposure. Specific examples of common sources of radiation are shown in the chart below.

Cosmic Radiation

Cosmic radiation is high-energy gamma radiation that originates in outer space and filters through our atmosphere.

Sea Level	26 mrem/year
(increases about 1/2 mrem for each additional 100 feet in elevation)	
Atlanta, Georgia (1,050 feet)	31 mrem/year
Denver, Colorado (5,300 feet)	50 mrem/year
Minneapolis, Minnesota (815 feet)	30 mrem/year
Salt Lake City, Utah (4,400 feet)	46 mrem/year

Terrestrial Radiation

Terrestrial sources are naturally radioactive elements in the soil and water such as uranium, radium, and thorium. Average levels of these elements are 1 pCi/gram of soil.

United States (average)	26 mrem/year
Denver, Colorado	63 mrem/year
Nile Delta, Egypt	350 mrem/year
Paris, France	350 mrem/year
Coast of Kerala, India	400 mrem/year
McAlpe, Brazil	2,558 mrem/year
Pocos De Caldas, Brazil	7,000 mrem/year

Buildings

Many building materials, especially granite, contain naturally radioactive elements.

U.S. Capitol Building	85 mrem/year
Base of Statue of Liberty	325 mrem/year
Grand Central Station	525 mrem/year
The Vatican	800 mrem/year

Radon

Radon levels in buildings vary, depending on geographic location, from 0.1 to 200 pCi/liter.

Average Indoor Radon Level	1.5 pCi/liter
Occupational Working Limit	200.0 pCi/liter

RADIATION IN THE ENVIRONMENT

Because the radioactivity of individual samples varies, the numbers given here are approximate or represent an average. They are shown to provide a perspective for concentrations and levels of radioactivity rather than dose.

mrem = millirem
pCi = picocurie

Food

Food contributes an average of 20 mrem/year, mostly from potassium-40, carbon-14, hydrogen-3, radium-226, and thorium-232.

Beer	390 pCi/liter
Tap Water	20 pCi/liter
Milk	1,400 pCi/liter
Salad Oil	4,900 pCi/liter
Whiskey	1,200 pCi/liter
Brazil Nuts	14 pCi/g
Bananas	3 pCi/g
Flour	0.14 pCi/g
Peanuts & Peanut Butter	0.12 pCi/g
Tea	0.40 pCi/g

Medical Treatment

The exposures from medical diagnosis vary widely according to the required procedure, the equipment and film used for x rays, and the skill of the operator.

Chest X Ray	10 mrem
Dental X Ray,Each	100 mrem

Consumer Goods

Cigarettes-two packs/day (polonium-210)	8,000 mrem/year
Color Television	<1 mrem/year
Gas Lantern Mantle (thorium-232)	2 mrem/year
Highway Construction	4 mrem/year
Airplane Travel at 39,000 feet (cosmic)	0.5 mrem/hour
Natural Gas Heating and Cooking (radon-222)	2 mrem/year
Phosphate Fertilizers	4 mrem/year

Natural Radioactivity in Florida Phosphate Fertilizers (in pCi/gram)

	Normal Superphosphate	Concentrated Superphosphate	Gypsum
Ra-226	21.3	21.0	33.0
U-238	20.1	58.0	6.0
Th-230	18.9	48.0	13.0
Th-232	0.6	1.3	0.3

Porcelain Dentures (uranium)	1,500 mrem/year
Radioluminescent Clock (promethium-147)	<1 mrem/year
Smoke Detector (americium-241)	0.01 mrem/year

International Nuclear Weapons Test Fallout from pre-1980 atmospheric tests

(average for a U.S. citizen)	1 mrem/year

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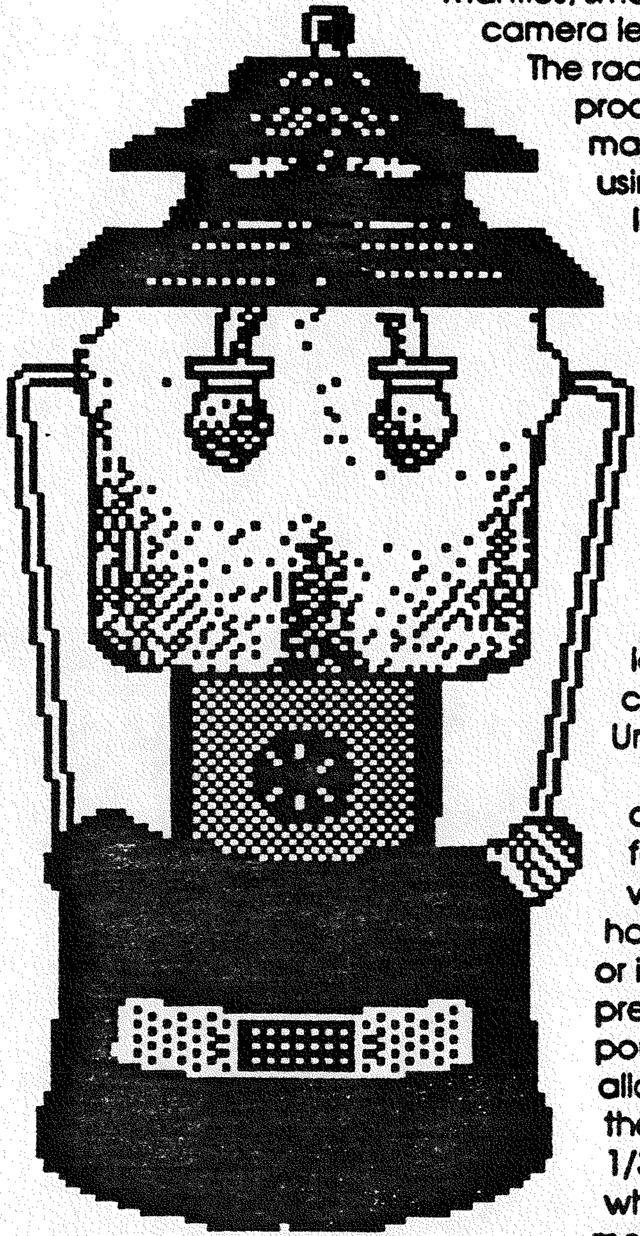
PERSPECTIVE: Radioactivity in Gas Lantern Mantles

Around the House

Many household products contain a small amount of radioactivity. Examples include gas lantern mantles, smoke detectors, dentures, camera lenses, and anti-static brushes. The radioactivity is added to the products either specifically to make them work, or as a result of using compounds of elements like thorium and uranium in producing them. The amount of radiation the products gives off is not considered significant. But with today's sensitive equipment, it can be detected.



Lanterns: In a New Light

About 20 million gas lantern mantles are used by campers each year in the United States.

Under today's standards, the amount of natural radioactivity found in a lantern mantle would require precautions in handling it at many Government or industry sites. The radioactivity present would contamimate 15 pounds of dirt to above allowable levels. This is because the average mantle contains 1/3 of a gram of thorium oxide, which has a specific activity (a measure of radioactivity) of approximately 100,000 picocuries per gram. The approximately 35,000 picocuries of radioactivity in the mantle would, if thrown onto the ground, be considered low-level radioactive contamination.

From information provided by W.L. Beck, Bechtel National, Inc.

PERSPECTIVE: How Big is a Picocurie?

The *curie* is a standard measure for the intensity of radioactivity contained in a sample of radioactive material. It was named after French scientists Marie and Pierre Curie for their landmark research into the nature of radioactivity.

The basis for the curie is the radioactivity of one gram of radium. Radium decays at a rate of about 2.2 trillion disintegrations ($2.2X10^{12}$) per minute. A *picocurie* is one trillionth of a curie. Thus, a picocurie represents 2.2 disintegrations per minute.

To put the relative size of one *trillionth* into perspective, consider that if the Earth were reduced to one trillionth of its diameter, the "pico earth" would be smaller in diameter than a speck of dust. In fact, it would be six times smaller than the thickness of a human hair.

The difference between the curie and the picocurie is so vast that other metric units are used between them. These are as follows:

Millicurie = $\frac{1}{1,000}$ **(one thousandth) of a curie**

Microcurie = $\frac{1}{1,000,000}$ **(one millionth) of a curie**

Nanocurie = $\frac{1}{1,000,000,000}$ **(one billionth) of a curie**

Picocurie = $\frac{1}{1,000,000,000,000}$ **(one trillionth) of a curie**

The following chart shows the relative differences between the units and gives analogies in dollars. It also gives examples of where these various amounts of radioactivity could typically be found. The number of disintegrations per minute has been rounded off for the chart.

UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	$2x10^{12}$ or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	$2x10^{9}$ or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco	Amount Used for a Brain or Liver Scan
1 Microcurie	µCi	$2x10^{6}$ or 2 Million	All-Star Baseball Player's Salary	Amount Used in Thyroid Tests
1 Nanocurie	nCi	$2x10^{3}$ or 2 Thousand	Annual Home Energy Costs	Consumer Products
1 Picocurie	pCi	2	Cost of a Hamburger and Coke	Background Environmental Levels

Chart provided by W.L. Beck, Bechtel National, Inc.

APPENDIX E

SAMPLE WELL CONSTRUCTION DETAILS

OBSERVATION WELL

PROJECT	FUSRAP	WELL NO. HISS-15

JOB NO. 14501	SITE HAZELWOOD I.S.S.	LOCATION STA. 8+64.5 OFFSET 101.9 FT. RIGHT	
BEGUN 12/14/84	COMPLETED 12/14/84	PREPARED BY L. MATTHEWS	REFERENCE POINT FOR MEASUREMENTS TOP OF RISER CASING

GENERALIZED GEOLOGIC LOG

0.0 - 3.0 FT. FILL: ROCK, CONCRETE, AND ASPHALT FRAGMENTS, ETC.

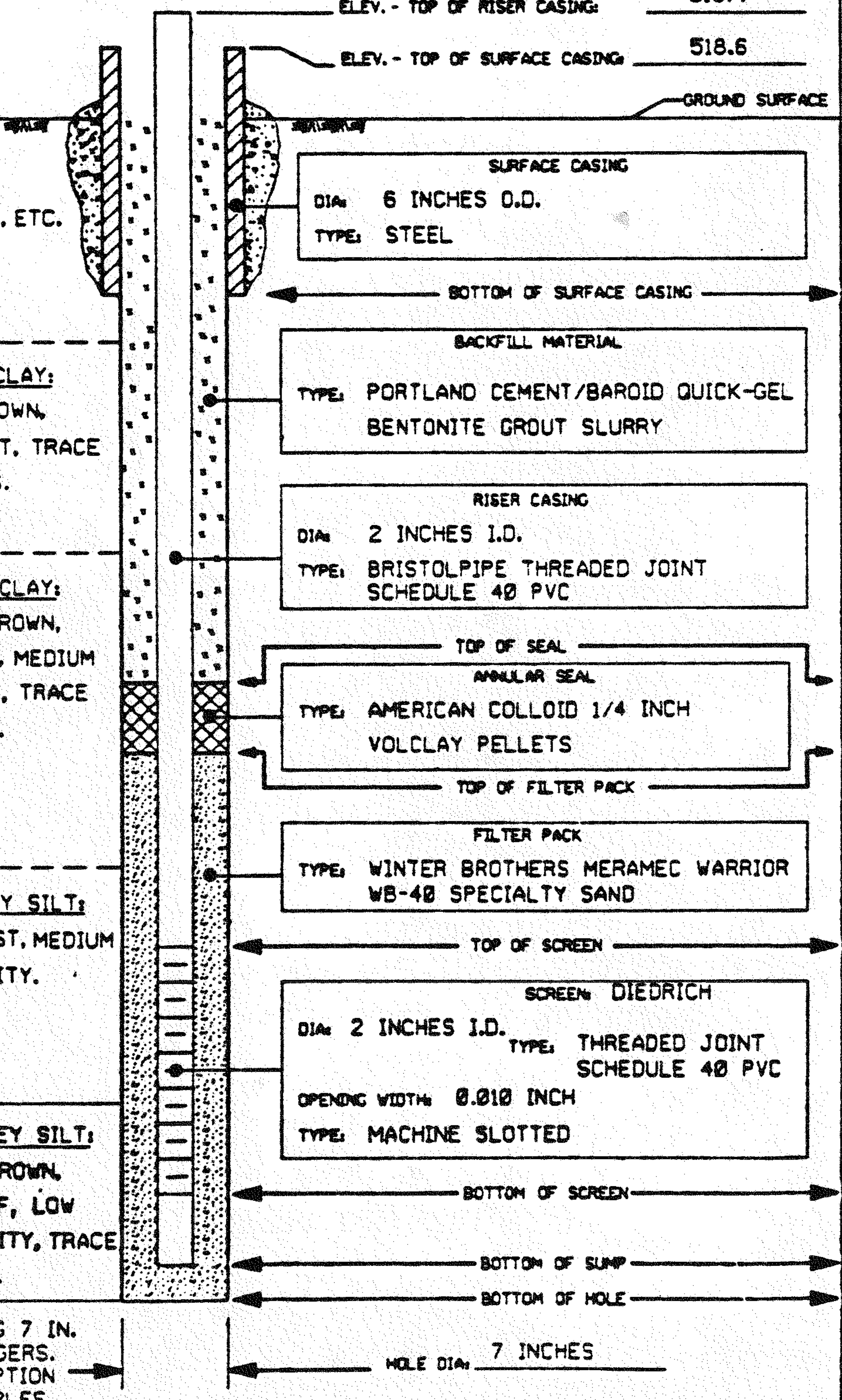
3.0 - 6.0 FT. SILTY CLAY: DARK YELLOWISH BROWN, DAMP TO MOIST, SOFT, TRACE OF ROCK FRAGMENTS.

6.0 - 11.0 FT. SILTY CLAY: DUSKY YELLOWISH BROWN, DAMP, MEDIUM STIFF, MEDIUM TO HIGH PLASTICITY, TRACE OF VERY FINE SAND.

11.0 - 15.0 FT. CLAYEY SILT: GREENISH GRAY, MOIST, MEDIUM STIFF, LOW PLASTICITY.

15.0 - 20.5 FT. CLAYEY SILT: DUSKY YELLOWISH BROWN, MOIST, MEDIUM STIFF, LOW TO MEDIUM PLASTICITY, TRACE OF VERY FINE SAND.

HOLE ADVANCED USING 7 IN. O.D. HOLLOW-STEM AUGERS. LOG IS FROM DESCRIPTION OF SPLIT-SPOON SAMPLES.



	DEPTH (FT)	ELEV. (FT)
ELEV. - TOP OF RISER CASING:		518.9
ELEV. - TOP OF SURFACE CASING:		518.6
GROUND SURFACE	0.0	515.9
BOTTOM OF SURFACE CASING	2.3	513.6
TOP OF SEAL	8.2	507.7
TOP OF FILTER PACK	10.3	505.6
TOP OF SCREEN	12.2	503.7
BOTTOM OF SCREEN	16.9	499.0
BOTTOM OF SUMP	19.0	496.9
BOTTOM OF HOLE	20.5	495.4

SURFACE CASING
DIA: 6 INCHES O.D.
TYPE: STEEL

BACKFILL MATERIAL
TYPE: PORTLAND CEMENT/BAROID QUICK-GEL BENTONITE GROUT SLURRY

RISER CASING
DIA: 2 INCHES I.D.
TYPE: BRISTOLPIPE THREADED JOINT SCHEDULE 40 PVC

ANNULAR SEAL
TYPE: AMERICAN COLLOID 1/4 INCH VOLCLAY PELLETS

FILTER PACK
TYPE: WINTER BROTHERS MERAMEC WARRIOR WB-40 SPECIALTY SAND

SCREEN: DIEDRICH
DIA: 2 INCHES I.D.
TYPE: THREADED JOINT SCHEDULE 40 PVC
OPENING WIDTH: 0.010 INCH
TYPE: MACHINE SLOTTED

HOLE DIA: 7 INCHES

APPENDIX F

DISTRIBUTION LIST FOR HAZELWOOD INTERIM STORAGE SITE ANNUAL SITE ENVIRONMENTAL REPORT

APPENDIX F

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