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Monitoring Plan for Characterization of the Building 3019 Leak Site

ENVIRONMENTAL SCIENCES DIVISION · OAK RIDGE NATIONAL LABORATORY

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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MONITORING PLAN FOR CHARACTERIZATION OF THE BUILDING 3019 LEAK SITE

June 1986

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ABSTRACT

The Oak Ridge National Laboratory (ORNL) has established a Remedial Action Program to provide comprehensive management of areas where past research, development, and waste management activities have resulted in residual contamination of facilities or the environment.

In the winter of 1985, elevated levels of strontium-90 were detected in White Oak Creek and the ORNL sewage treatment plant. A leak was subsequently identified in a low-level waste transfer line north of Building 3019. The period of leakage and the exact chemical composition of the effluent are unknown. Two dye tests conducted at the leak site have identified several possible pathways for contaminant migration. The discovery of a solution cavity in the Chickamauga bedrock underlying the leak site and the rapid appearance of dye in the sump at Building 3042 indicate the extension of the cavity system along strike to the east.

This report outlines the available published and unpublished background information pertaining to the site and proposes a monitoring plan consisting of soil sample collection and monitor well installation to provide a preliminary assessment of the types and extent of contamination at the leak site. The plan is also designed to provide additional geologic and hydrologic data for evaluating possible contaminant migration pathways.

1.0 INTRODUCTION

Department of Energy (DOE) facilities are required to be in full compliance with all federal and state regulations. In response to these requirements, the Oak Ridge National Laboratory (ORNL) has established a Remedial Action Program to provide comprehensive management of areas where past research, development, and waste management activities have resulted in residual contamination of facilities or the environment.

On July 15, 1985, the U.S. Environmental Protection Agency (EPA) published final rules incorporating changes in the Resource Conservation and Recovery Act of 1976 (RCRA) resulting from the passage of the Hazardous and Solid Waste Amendments of 1984. As a part of the rule changes, a new section, 3004 (u), was added requiring that any facility permit issued after November 8, 1984, must include planned corrective actions for all releases of hazardous waste or constituents from any disposal unit at the facility regardless of when the release occurred. In publishing this new rule, EPA stated that any solid waste management unit located at a facility required to obtain a permit will be subject to corrective action for continuing releases. ORNL has applied for a hazardous waste storage permit, and as a result, it is necessary to characterize ORNL disposal units including pipeline leak sites to determine if and to what extent corrective measures will be required to control releases.

Five low-level waste (LLW) line leaks have been identified in the general area of Building 3019, two of which are immediately adjacent to the building. This report documents existing environmental information pertaining to the LLW line leak discovered in February of 1985 on the north side of Building 3019. The report also defines the additional information needed and outlines a monitoring plan to confirm the presence or absence of contaminants and the possible migration of those contaminants from the leak site.

Principal contributors to this report were C. Allen Motley and Donald A. Brice. The project was supervised by Edwin W. Morse and project review was provided by James J. Geraghty.

2.0 BACKGROUND

2.1 SITE LOCATION AND DESCRIPTION

Building 3019 (formerly Building 205) is located at the intersection of Third Street and Hillside Avenue in the main ORNL plant area (Figure 1). The building contains several different floor levels; it was constructed on a hillside and has had numerous additions. The lowest point in the building is the cell floor at an elevation of 830.3 ft msl. The main floor level is at an elevation of 850.25 ft msl and ground level on the downhill side is at an elevation of approximately 840 ft msl (Figure 2).

Building 3019A is the main portion of the RPP (Radiochemical Processing Plant), which is operated by the Pilot Plant Section of the Chemical Technology Division. The hot cells for the facility were constructed in 1943. The structural steel framing over the cells, the control room, and office area, and the rooms around the counting room were added in 1949. Building 3019B is the High Radiation Level Analytical Facility (HRLAF) and comprises the western end of Building 3019. The HRLAF, which was added onto Building 3019 in 1953, is now inactive and is the responsibility of the Analytical Chemistry Division.

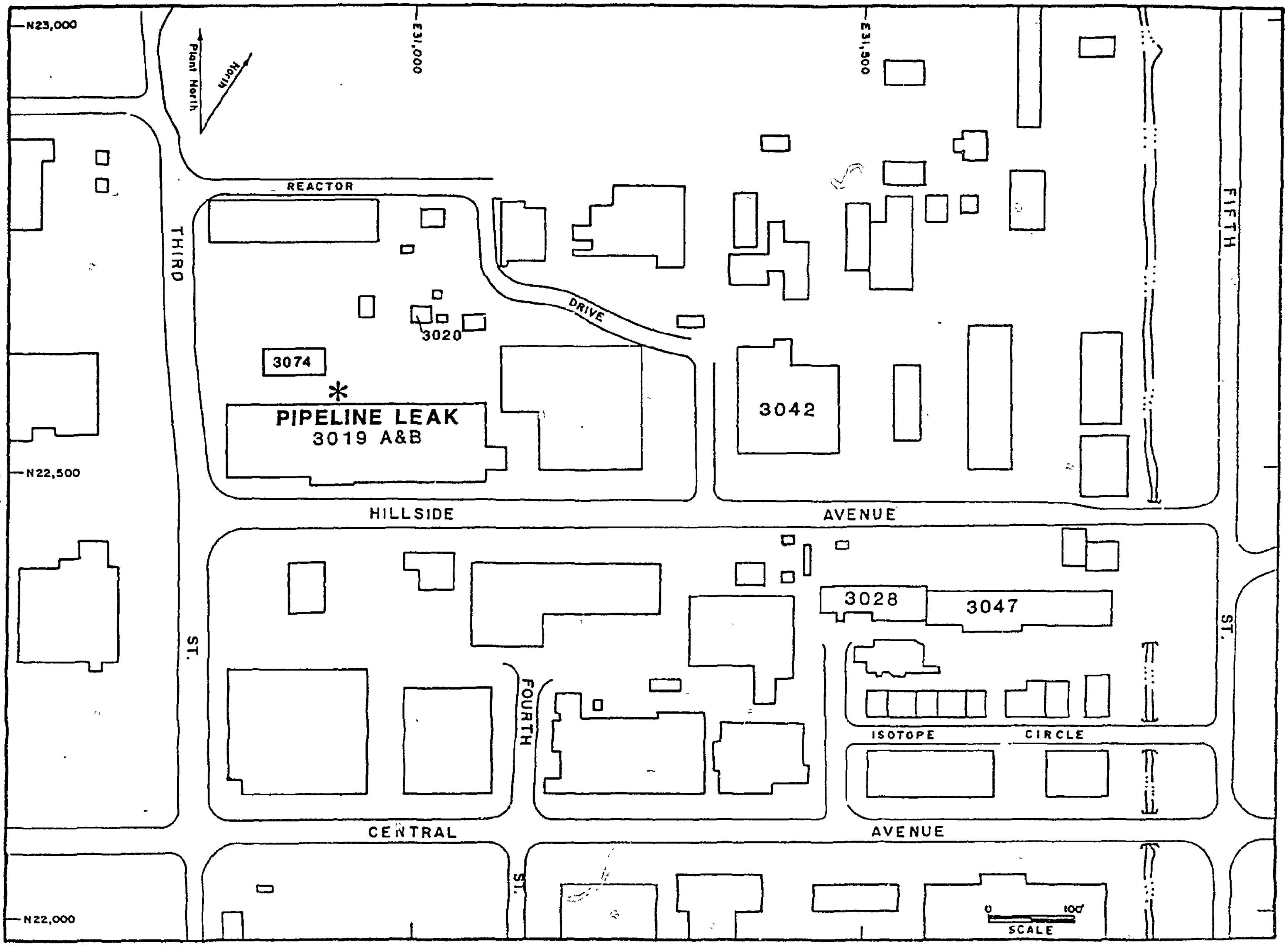

FIGURE 1. THE 3019 PIPELINE LEAK SITE

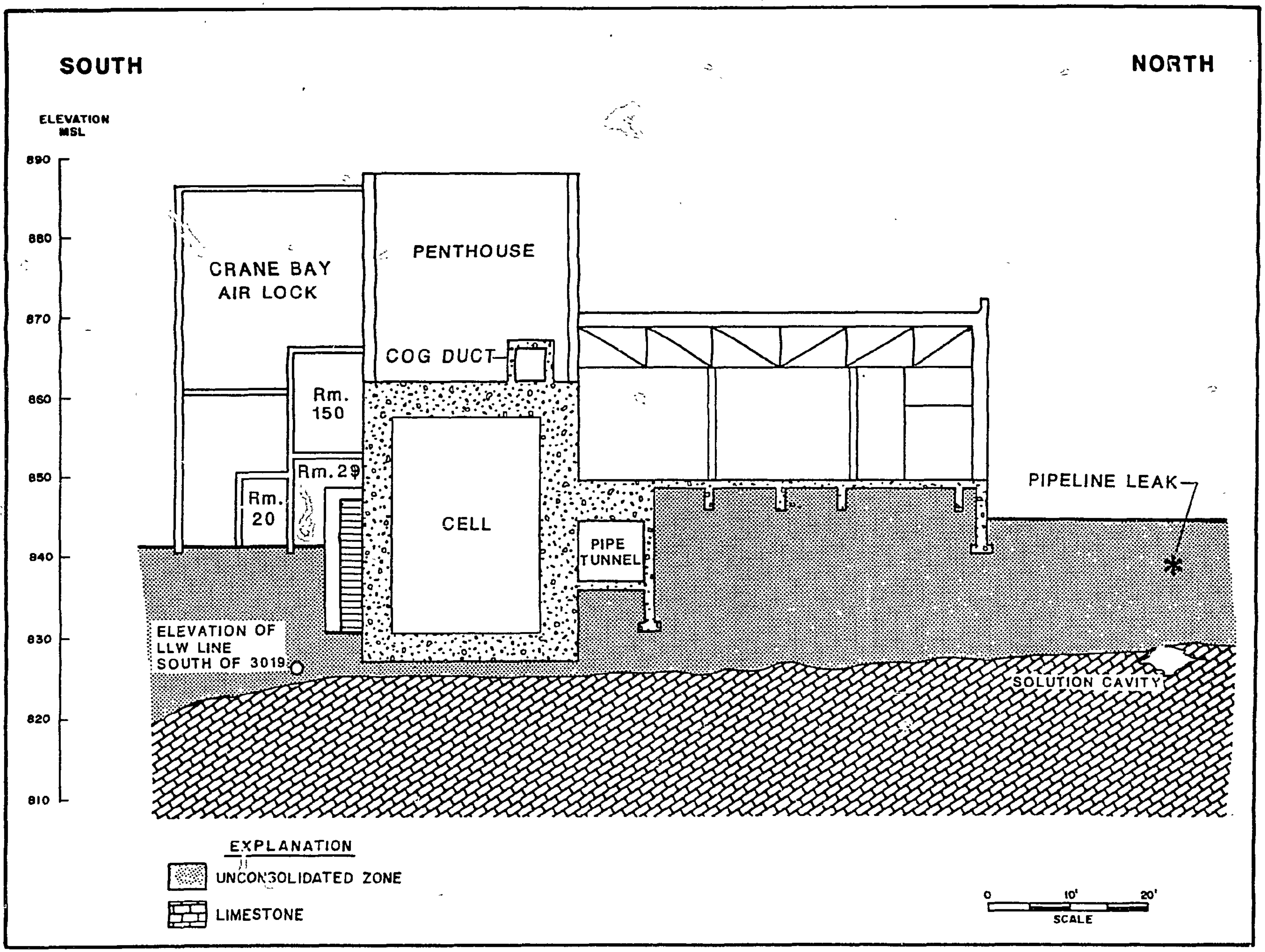

FIGURE 2. GENERALIZED NORTH-SOUTH CROSS-SECTION OF BUILDING 3019 & THE PIPELINE LEAK SITE

2.2 PURPOSE OR FUNCTION OF FACILITY

Some activities in the Building 3019 area have been in operation for over 40 years. Several well-known methods for nuclear fuel reprocessing (e.g., Purex, Thorex, Fluoride Volatility) were developed and operated at the RPP. The RPP has served as the national repository for uranium-233 since 1963. The RPP also contains the Plutonium-Uranium Oxide Microsphere Preparation (PUMP) Facility and the Consolidated Edison Uranium Solidification Program (CEUSP) Facility. The remainder of Building 3019 is occupied by the HRLAF.

The main function of the RPP is storage and processing of uranium-233 in conjunction with its current status as the national repository for that material. The uranium-232 content in the uranium-233 governs the containment and other special safety considerations associated with the materials. A decay daughter of uranium-232, thallium-208, emits gamma rays at 2.6 Mev and dictates the shielding requirements for the handling of the uranium-233. Retention of off-gas streams for a period greater than ten minutes is necessary to prevent transport of decay daughters of the gaseous radionuclide radon-220 through particulate filters.

The RPP also processes multikilogram amounts of other fissile radionuclides including uranium-235 and plutonium-239 and 241. Kilogram quantities of non-fissile radionuclides including thorium-232 and uranium-238 are also processed. The PUMP facility in Building 3019 prepares plutonium-uranium mixed oxide microspheres. The CEUSP facility is used to convert a special batch of uranium containing both uranium-233 and 235 from a nitrate to a solid oxide form.

The HRLAF is the responsibility of the Analytical Chemistry Division and is no longer in operation; however, the cells in the facility still contain a variety of materials and equipment.

3.0 EXISTING INFORMATION

Little published or unpublished environmental information is available for the Building 3019 site. The bulk of the available information was obtained through personal communications with ORNL personnel and review of intra-laboratory correspondence.

The recent installation of ground-water monitoring piezometers at ORNL provided water-level data and geologic information used in the preparation of the monitoring plan. Water-quality samples have been collected but analytical results are not available as of this writing (R. Ketelle, pers. comm., April 1986).

3.1 CONTAMINANT INVENTORY

3.1.1 Radiochemical Processing Plant

The RPP is involved in solvent-extraction processing of highly irradiated nuclear fuels and contains equipment necessary to store and process multikilogram amounts of fissile materials. Because the RPP serves as the national repository for uranium-233, storage and processing of that material is predominant.

Fissile materials including uranium-233 and 235 and plutonium-239 and 241 are stored and processed in the RPP. Containment of these materials and their decay daughters requires strict safety measures. Smaller amounts of non-fissile radionuclides such as thorium-232 and uranium-238 are also processed in the RPP.

3.1.2 High Radiation Level Analytical Facility

The HRLAF comprises rooms 12 through 15 of Building 3019. The facility contains seven working cells (AC-1 through AC-7) and one storage/loading cell (A-1). None of the cells is currently in use, although they still contain a variety of materials and equipment. The cells and their contents are highly contaminated with transuranic isotopes and long-lived fission products. In addition, zinc bromide solution has leaked from a broken shielding window into an in-cell drain to the LLW header line.

3.1.3 LLW Line Leak North of Building 3019

In February 1985, elevated concentrations of strontium-90 were measured in White Oak Creek and the ORNL sewage treatment plant. A leak was subsequently identified in a LLW transfer line north of Building 3019. The leak occurred at a "T" in a concrete encased chemware line leading from Buildings 3074 and 3020. The period of the leakage as well as the exact chemical composition of the contaminants is unknown. Deterioration in the line may have been accelerated by the disposal of waste hydrofluoric acid (Huff, pers. comm., September 1985). A partial list of substances reportedly disposed of into the line north of Building 3019 is presented in Table 1. After discovery of the leak, the line was taken

TABLE 1. SUBSTANCES REPORTED IN LLW LINE NORTH OF BUILDING 3019

Nitric Acid
Hydrochloric Acid
Hydrofluoric Acid
Strontium-90
Cesium-137
Uranium-233

Source: Huff, pers. comm., September 1985; Benn, pers. comm., May 1986 out of service and a grout plug was placed in both the upstream and downstream connecting lines.

3.1.4 Additional Sources of Contaminants

An undetermined number of leaks occurred during the 1970s near the southwest corner of Building 3019 in the LLW line draining the HRLAF cells; the last leak occurred in 1978. The line was known to contain strontium-90, cobalt-60, mixed fission products, and alpha emitters.

The leak was repaired in 1978. Soil in the immediate vicinity of the leak was found to have activity levels of 100 mR/hr. No effort was made to remove all of the contamination, but the soil excavated to repair the line was disposed and replaced by clean fill. This site is a possible source of ground-water contamination.

3.2 GEOLOGY

3.2.1 Regional Geology

ORNL lies in the Valley and Ridge Physiographic Province of the Appalachian Mountains. The Valley and Ridge Province is characterized by linear, northeast-southwest trending, parallel ridges and intervening valleys. The rocks have been folded and faulted considerably by tectonic processes in the geologic past. Thrust faults, several of which are present on the Oak Ridge Reservation, are responsible for the repetition of many of the rock formations in the region.

Bedding dip ranges from approximately 30 to 45 degrees to the southeast over most of the area.

Bethel Valley is bordered by Haw Ridge on the south and by Chestnut Ridge on the north. The main ORNL complex in Bethel Valley is underlain by limestones, siltstones, shales, and bedded chert of the Chickamauga Group (middle to late Ordovician). Haw Ridge is underlain by resistant siltstones and sandstones with interbedded shale of the Rome Formation (Cambrian). A thrust fault separates the Rome Formation from the underlying Chickamauga Group rocks. Chestnut Ridge is underlain by siliceous dolostone and limestone of the Knox Group (upper Cambrian to lower Ordovician).

3.2.2 Site-Specific Geology

The bedrock underlying the main ORNL complex is composed mainly of limestones and shales of the Chickamauga Group. Stockdale (1951) separated the Chickamauga Group into eight separate and mappable informal members (A through H, oldest to youngest) based on lithology. The Building 3019 site is underlain by the D member (see Figure 3), which forms a chain of low hills along strike in Bethel Valley.

The D member is composed mainly of gray to olive-gray, thin to massive bedded limestone. A distinguishing feature of the D member is the large amount of bedded chert. Thin shale interbeds comprise the bulk of the remaining rocks.

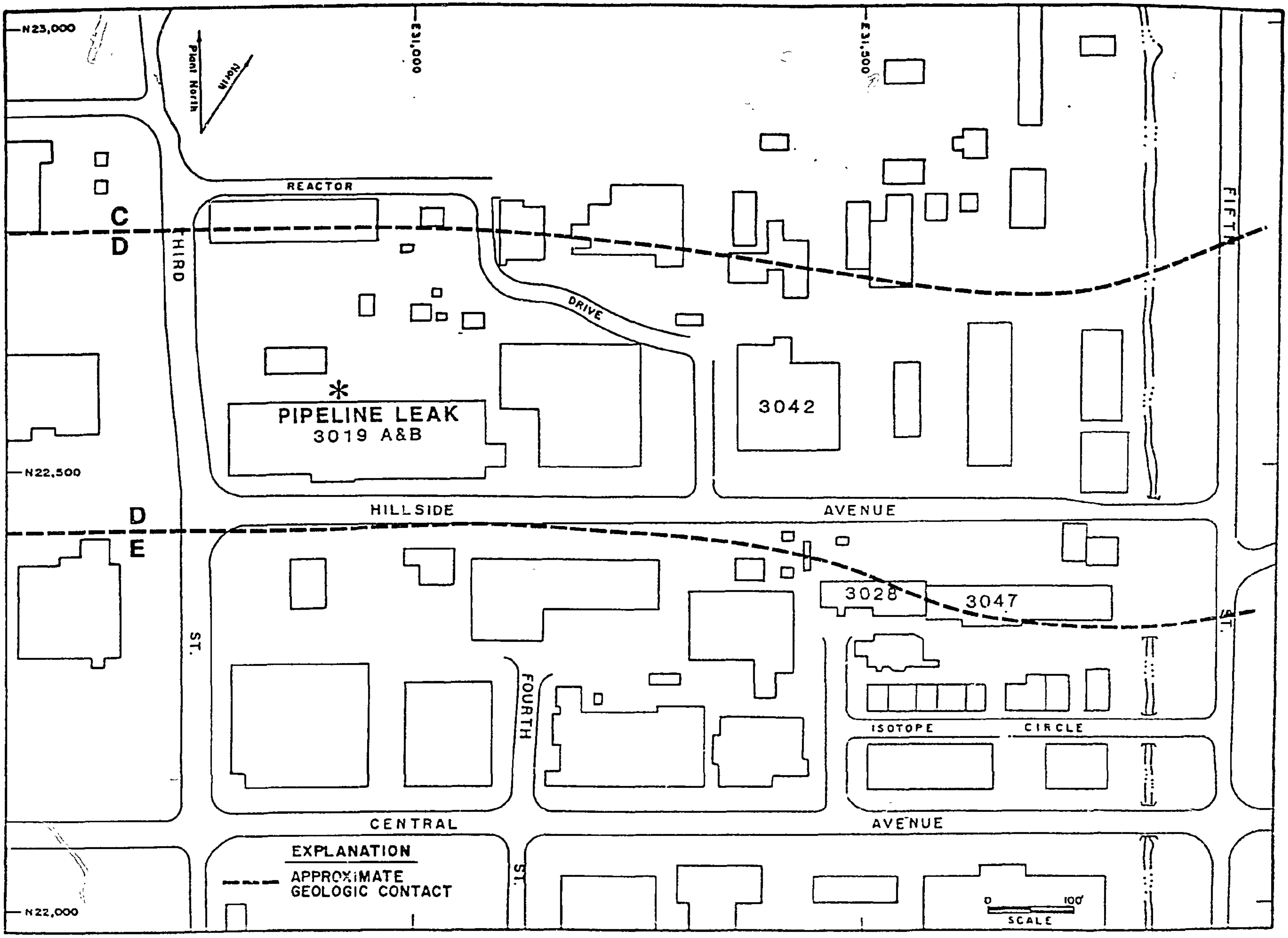

FIGURE 3. GENERALIZED GEOLOGIC MAP OF THE 3019 PIPELINE LEAK SITE

Solution cavities in the D member, which have been documented by Stockdale (1951), appear to occur along strike and are probably controlled by bedding. This situation is not uncommon in steeply dipping carbonates (Quinlan, et al, 1986). Solution activity in the D member probably has been accelerated by low pH waste products leaking from the LLW lines in the Building 3019 area.

The unconsolidated zone overlying the bedrock, which consists of weathering residuum and man-made fill, is approximately 20 ft thick. A contour map of the top of bedrock is shown in Figure 4. Weathering products of the D member include red to brown clay and chert fragments. This material is assumed to be of low to moderate permeability owing to its predominantly clayey nature.

Fill material is present in various amounts around the Building 3019 site. Building 3019 was built on a hillside and some cut and fill was necessary in construction. Fill is probably most prevalent around the building foundation and in road beds and pipeline trenches.

3.3 HYDROLOGY

3.3.1 Surface Water

Most of the Building 3019 area is occupied by a building or covered with pavement. The majority of rainfall at the site is diverted as runoff to the storm sewer system, from

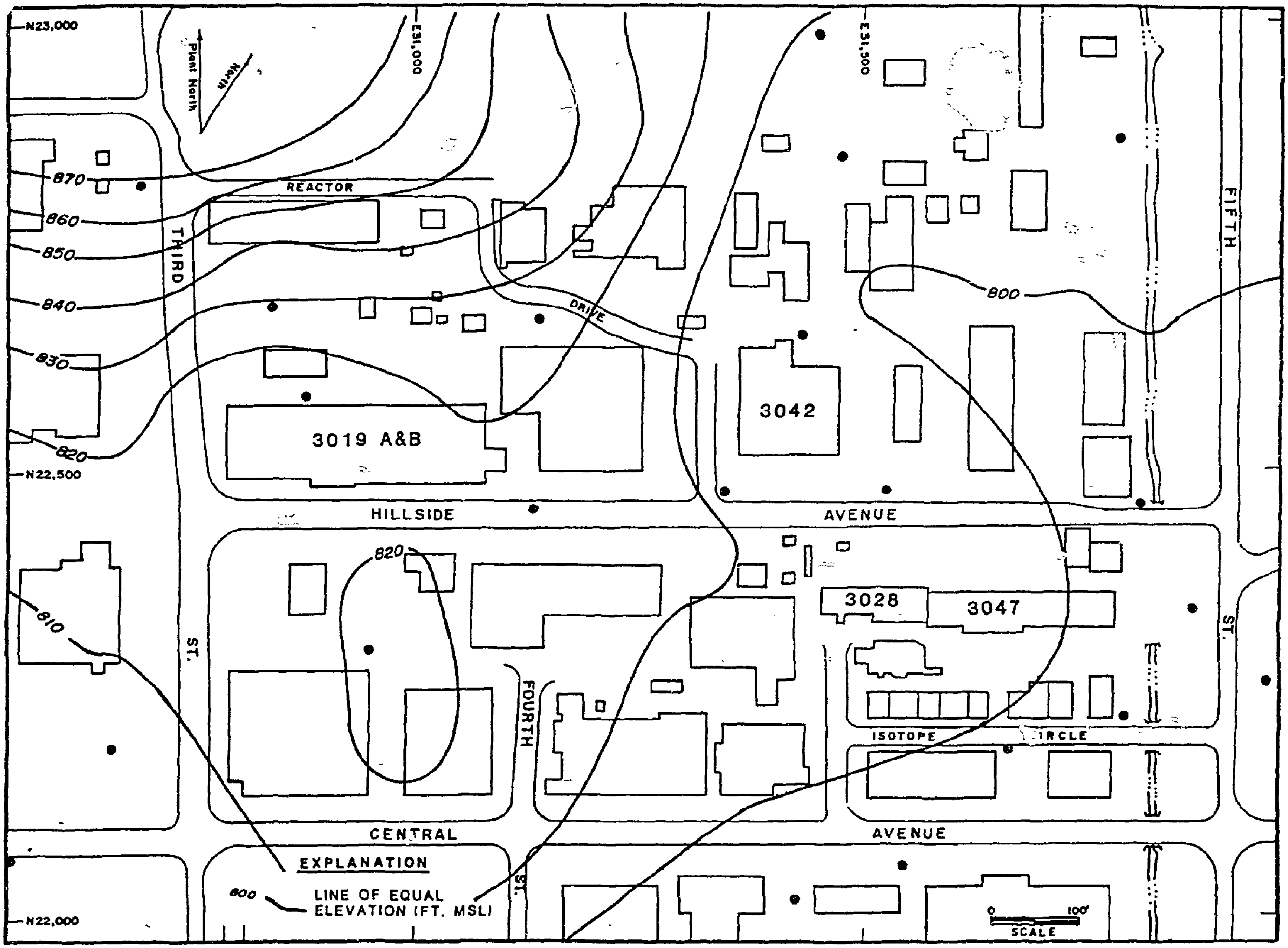

FIGURE 4. BEDROCK ELEVATION

which it eventually discharges into either White Oak Creek, approximately 1,300 ft to the south, or Fifth Creek, approximately 1,000 ft to the east.

3.3.2 Ground Water

Shallow ground water at ORNL generally occurs under unconfined conditions. The configuration of the water table is influenced by topography, local pumping of sumps, availability of recharge, and depth to bedrock. Preferred paths of ground-water movement may be created by the abundant man-made structures and pipelines.

A ground-water characterization program was initiated in the Fall of 1985 at ORNL. The water-table contour map (Figure 5) was constructed from water-level data obtained during the spring of 1986, a period of record low rainfall; therefore, it may reflect low water-table conditions.

3.3.2.1 Bedrock

The Chickamauga Group is generally considered a poor aquifer due to its high percentage of shale and siltstone. Large solution cavities are not common at depth although numerous small openings are known to occur within 100 ft of the surface. Ground water is generally restricted to fractures and bedding plane solution cavities (Debuchananne and Richardson, 1956). Meteoric waters have access to bedding where it is truncated by erosion.

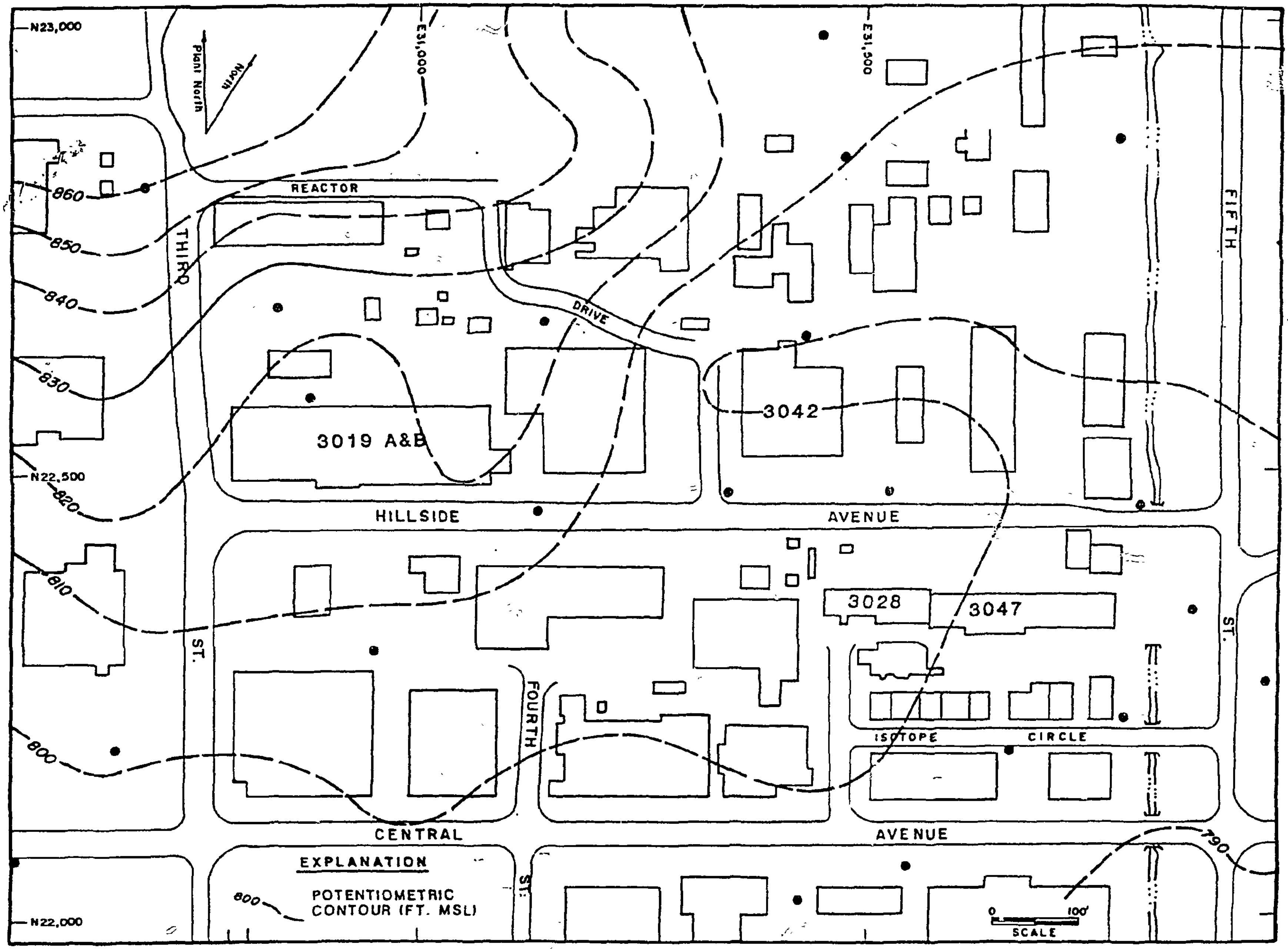

FIGURE 5. WATER TABLE ELEVATION, APRIL 9, 1986

Some characteristics of the D member of the Chickamauga Group, including thin to massive bedding, high angle of dip, and layers of bedded chert, make it susceptible to development of solution cavities. Solution occurs along strike and cavity growth may be partially controlled by the less soluble chert beds. The number and extent of cavities in the D member is unknown.

The overall hydraulic gradient of ground water in the Building 3019 area is down the topographic slope to the grid south-southeast direction. However, a large component of ground-water flow in the bedrock in the vicinity of Building 3019 is along strike to the grid east direction. Results of two separate dye tests suggest that a solution cavity, discovered upon excavation of the leaking pipeline, extends along strike to the east (Figure 6) and is at least partially controlled by bedding. Dye injected at the leak site was detected in a sump under Building 3042 approximately 500 ft to the east within 48 hours after the tests were initiated. Geraghty & Miller, Inc., (1985, Unpublished) and Huff (1985, Unpublished) provide discussions of the procedures used for the first (June 1985) dye test and summarizess the results. Melroy and Huff (1986, Unpublished) provides a summary of the June 1985 test and presents the methods and results of the March 1986 test. Pumping from the Building 3042 sump depresses the water table and enhances the eastward flow of water from Building 3019.

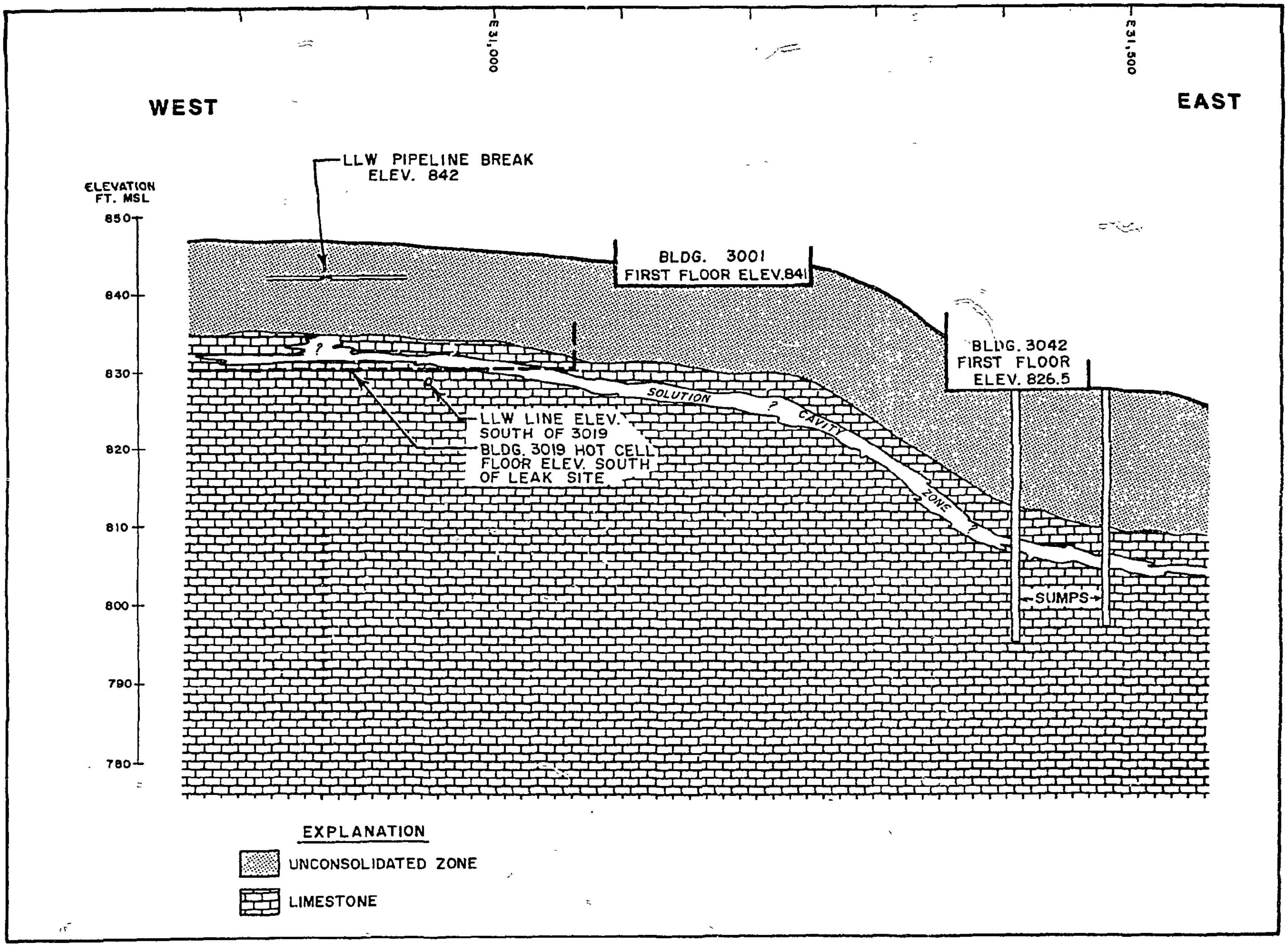

FIGURE 6. GENERALIZED EAST-WEST CROSS-SECTION OF THE 3019 PIPELINE LEAK SITE

3.3.2.2 Unconsolidated Zone

The unconsolidated zone at Building 3019 consists of artificial fill and residual weathering products derived from the D member of the Chickamauga Group. This zone is largely unsaturated during low water-table conditions, when flow is vertically downward to the saturated zone. The position of the water table during periods of high precipitation and recharge is not known.

Crushed limestone used as subbase material, trench fill, and building backfill may create preferred paths of flow in the unconsolidated zone. These paths would be most active during recharge events and high water-table conditions. Figure 7 shows the location of several abandoned pipelines under the west end of Building 3019. Most of these lines were removed for construction of the HRLAF.

Water leakage into the basement along the west side of Building 3019 is at least partly controlled by recharge events, inasmuch as an increase in leakage has been noted during and after precipitation events. However, the leak is also occasionally active between precipitation events suggesting that a leaking pipeline may be a contributing factor. Complete chemical analysis of the water has not been performed, but initial scanning detected no radioactivity.

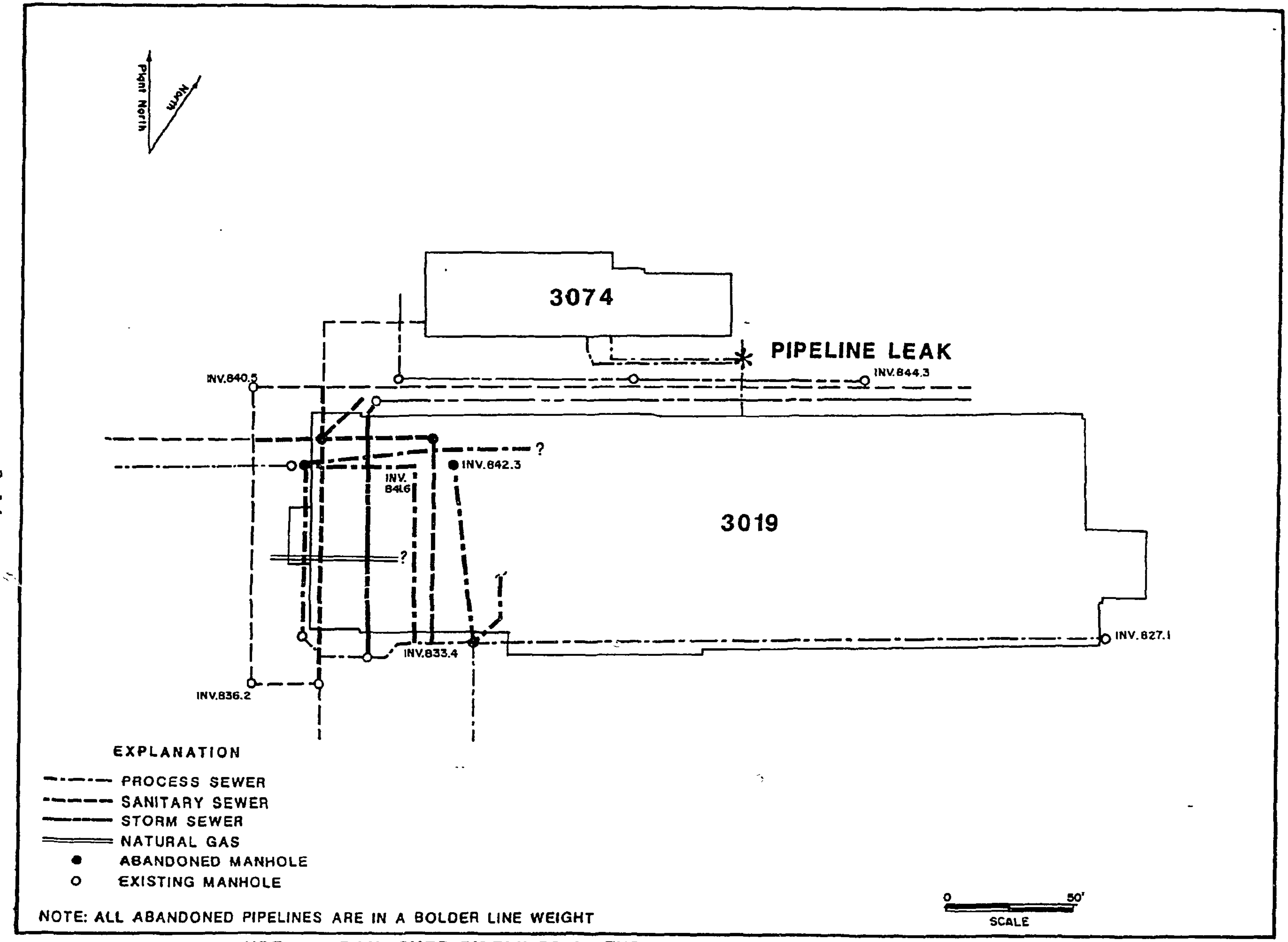

FIGURE 7. ABANDONED PIPELINES AT THE WEST END OF BUILDING 3019

3.4 ECOLOGY

No specific studies have been published on the ecology of the Building 3019 area. Little, if any, of the area remains in its natural state; most of the area is paved and the unpaved areas are neatly landscaped. Pre-existing wildlife habitats have probably been obliterated by the extensive above and below ground construction.

4.0 ADDITIONAL INFORMATION NEEDED

The discovery of the solution cavity below the pipeline leak prompted the performance of two dye tracer tests. The dye tests led to the delineation of some possible pathways for contaminant migration from the leak site. The results of these tests and data from the recently installed piezometers at the plant have provided most of the hydrologic and geologic information used in the preparation of this report. Very little additional information is available for the site.

4.1 CONTAMINANT INVENTORY

An account of the specific types and volumes of substances disposed of into the LLW drains upstream from the leak site is not available, nor is any information available on the length of time the leak was active. However, collection and chemical analysis of soil samples from the leak site should provide information on the type of contaminants present in the soils.

4.2 GEOLOGY AND SOILS

4.2.1 Geology

The discovery of a solution cavity in the bedrock underlying the pipeline leak and the confirmation, as a result of the dye test, of a highly permeable pathway from the leak site to the sump in Bulding 3042 have led to the hypothesis that these two locations are interconnected by a solution cavity system. However, the ultimate discharge point for the cavity system is not known. Piezometer 588 (See Figure 8) was installed along strike between the leak site and Building 3042. This piezometer encountered an anomalously thick zone of unconsolidated material (60 ft) and was not extended down to bedrock. It is not known if this thick unconsolidated zone is indicative of the presence of the solution cavity system at that location.

4.2.2 Soils

The collection and chemical analysis of continuous soil samples from the surface down to bedrock will identify contaminants present at the leak site and should provide an estimate of the horizontal and vertical distribution of these contaminants. The soil samples also can be used to evaluate mobility of the contaminants and the rates of attenuation in the soil. An ORNL Intra-Laboratory Correspondence of April 2, 1985, from N. H. Cutshall, outlines a procedure for soil leaching studies to be applied to soils of the Building 3019 area. These are important factors to be evaluated because the leak occurred above the saturated zone; therefore, the possibility exists for increased contaminant transport during recharge events or high water-table conditions.

4.3 HYDROLOGY

The effects of man-made subsurface structures on the ground-water hydrology of the site have not been adequately determined. The backfilled trenches for underground pipelines and footings and the pumpage from nearby sumps may alter the ground-water flow pathways. Also, hydraulic conductivity values for the cavity system need to be determined and an effort must be made to locate the discharge point for the system.

Water is reported to infiltrate intermittently into the basement of Building 3019 (Krichinsky, pers. comm., April 1986). The infiltration does not appear to coincide with precipitation events; therefore, the source of this water should be investigated.

The hydraulic conductivity of the unconsolidated zone and backfilled trenches needs to be determined. A slug-test performed in wells installed in these materials will provide the necessary data for computing these values.

4.4 ECOLOGY

No ecological study specific to the Building 3019 area has been undertaken. The area is dominated by man-made structures and little of it remains in its natural state. A characterization and study of the biota at the Building 3019 site would be necessary to evaluate the ecological impact of the leak; however, this impact is expected to be minimal owing to the subsurface location of the leak and the alteration of the natural ecological state by construction activities in the area. Analysis of the data collected after implementation of the monitoring plan will aid in evaluating the potential for ecological impact on the White Oak Creek watershed.

5.0 MONITORING PLAN

The monitoring plan is designed to provide a preliminary assessment of the extent of contamination at the Building 3019 leak site. One soil boring (A) would be drilled directly east of the leak site as shown in Figure 8. This boring would be augered to bedrock, during which split spoon soil samples would be collected and analyzed for strontium-90, cesium-137, and gross alpha. The borehole would be extended into bedrock at least 5 ft below the water table and a monitor well would be installed. This well, which would be constructed of 2-inch-diameter PVC casing with a 5-ft screen, is expected to intercept the cavity system. Figure 9 illustrates the recommended well construction.

Fluorescein dye, presumably from the dye tracer test, was found in the sanitary sewer line in manhole 17 southwest of the leak site. Backfilled trenches west or southwest of Building 3019 or the building foundation are suspected of being pathways for contaminant migration. Monitor well B would be installed into the backfilled trench containing the sanitary sewer west of the leak site and east of the junction between the existing sanitary line and the abandoned sanitary line (See Figures 7 and 8). If perched saturation exists, this well would provide a water-quality monitoring point and should allow interception of flow in the trench before it reaches the abandoned trenches aligned north-south in the area now occupied by the HRLAF addition to Building 3019.

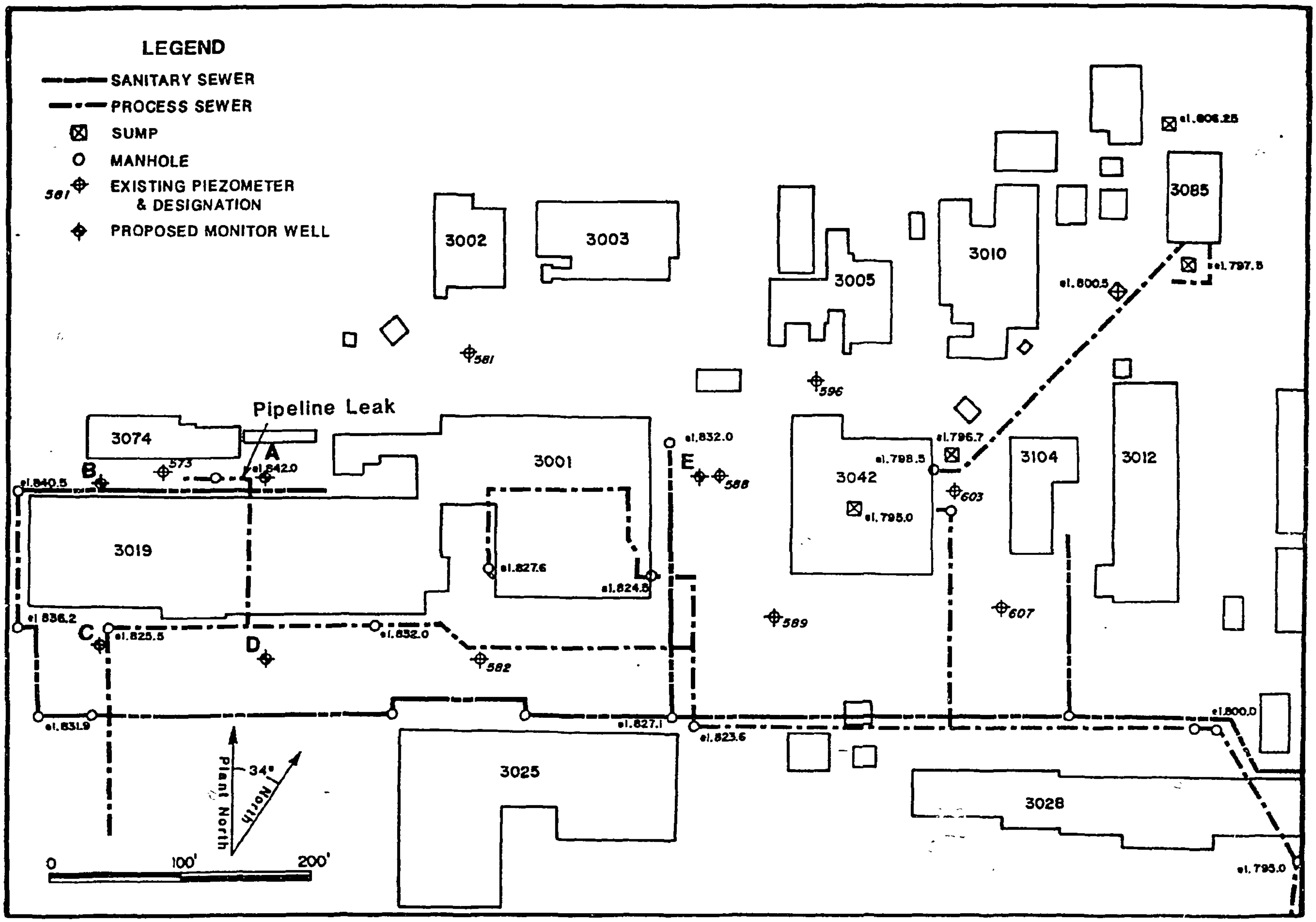

FIGURE 8. PROPOSED MONITOR WELLS FOR THE 3019 PIPELINE LEAK SITE

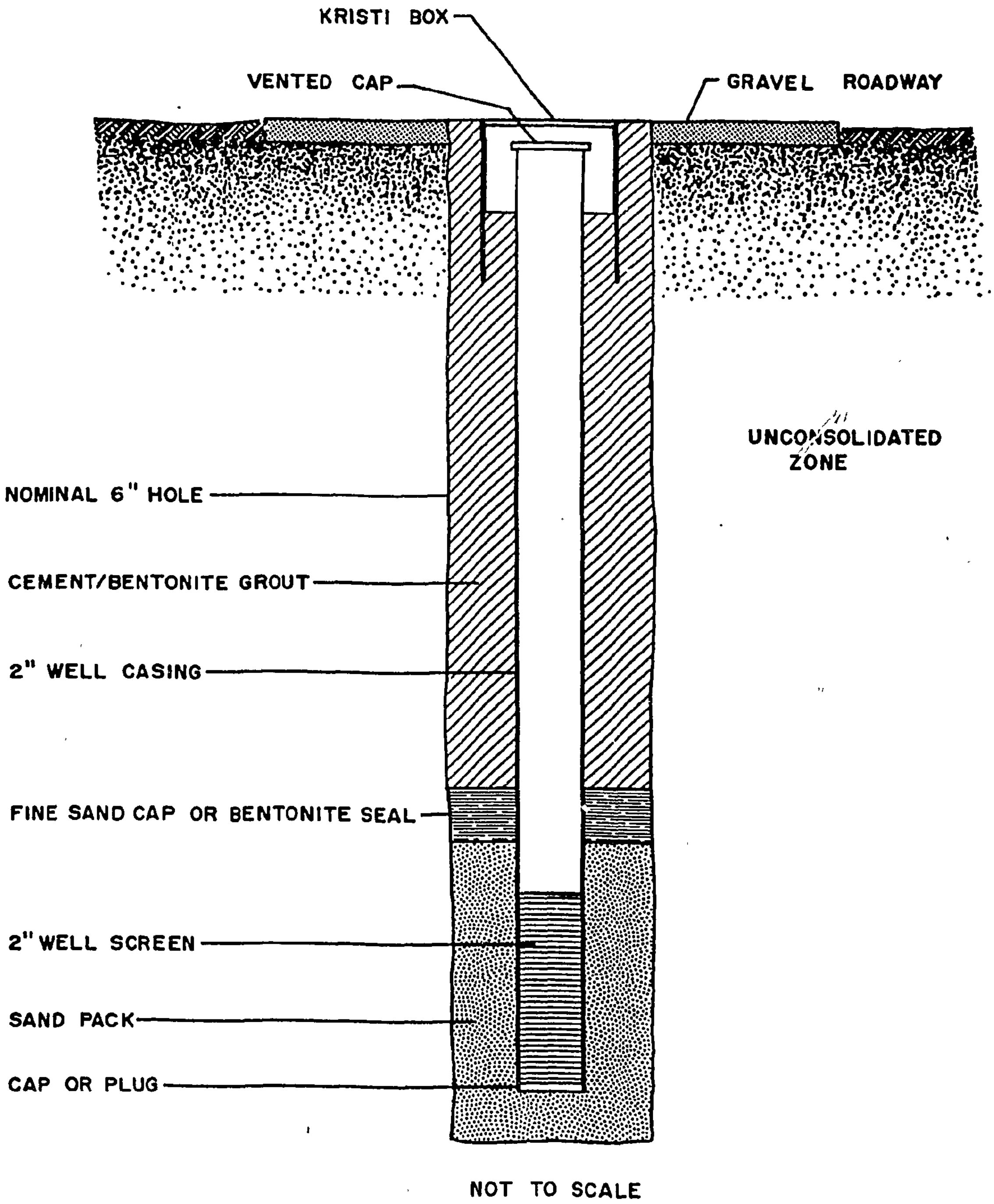

FIGURE 9. DESIGN OF MONITOR WELL SCREENED IN THE UNCONSOLIDATED ZONE

Monitor well C would be installed into the backfilled trench containing the process sewer and LLW lines south of Building 3019. This trench is the most deeply excavated trench in the area around Building 3019 in addition to being downgradient from the leak site. Figure 9 illustrates the recommended well construction for wells B and C.

Monitor well D would be installed downgradient from the leak site, on the south side of Building 3019. This well would extend approximately 10 ft below the water table and would be constructed as shown in Figure 10.

Monitor well E would be located adjacent to piezometer 588 and will be extended at least 10 ft into bedrock. Drilling of this well would provide the bedrock elevation at this location; the well would be logged to note the occurrence of solution cavities. Construction details for well E are illustrated in Figure 10.

Piezometers 573, 582, and 588 can be used for collecting water-quality and water-level data. Water samples taken from the monitor wells and the piezometers should be analyzed for gross alpha, strontium-90, and cesium-137.

In-situ hydraulic testing by the slug-test method would be performed on all the wells. The results of the tests would be used to calculate hydraulic conductivity values for

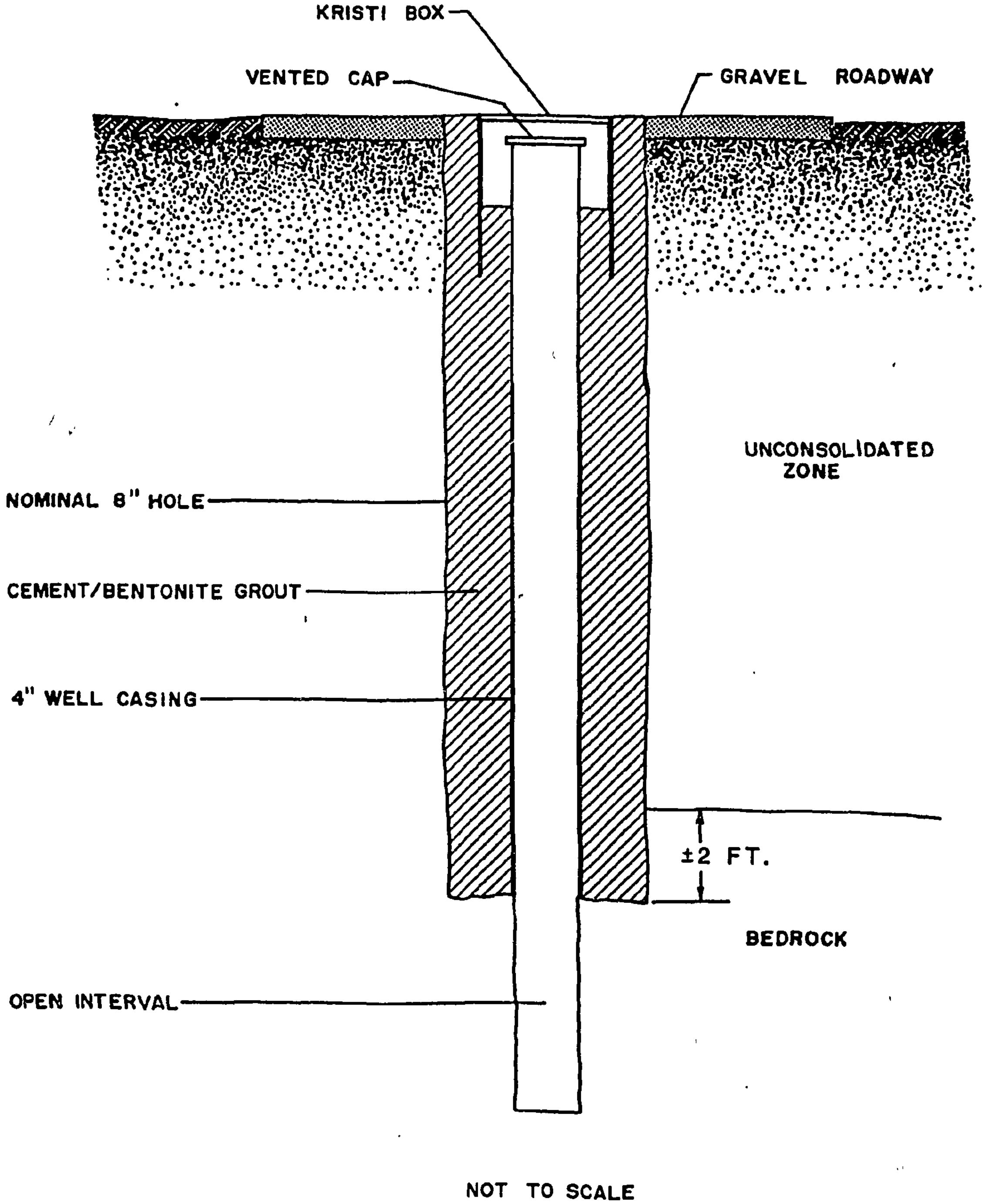

FIGURE 10. DESIGN OF MONITOR WELL WITH OPEN HOLE IN BEDROCK

the unconsolidated zone, bedrock and/or the solution cavity zone, and trench backfill.

Sampling and analysis of the water infiltrating the basement of Building 3019 would aid in the determination of the source of the water. Provisions must be made for notification of the occurrence of infiltration and for the collection of a sample, which would be complicated by the health and safety procedures that must be followed for access to this area of Building 3019. The samples should be analyzed for chloride, iron, manganese, sodium, sulfate, nitrate, pH, specific conductance, total organic carbon, total organic halogen, gross alpha, and gross beta.

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