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ORNL Radioactive Liquid Waste Disposal Pits and Trenches: History, Status, and Closure Characterization Needs

B. P. Spalding
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Abstract: 42 million gallons of radioactive liquid waste were dispsoed of in ORNL seepage pits and trenches between 1951 and 1966. 1.2 million acres of land-beta activity, most of which of short-lived isotopes such as 106Ru and Trivalent rare earth that have decayed. 200,000 Ci of 90Sr, 600,000 Ci of 137 Cs and smaller amounts of uranium and transuranic isotopes.
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B. P. Spalding and W. J. Boegly, Jr.

Environmental Sciences Division

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Summary

The seven ORNL seepage pits and trenches were used for the disposal of about 42 million gallons of radioactive liquid waste between 1951 and 1966. At the time of transfer to these pits and trenches, about 1.2 million curies of hard-beta activity were disposed although much of the short-lived isotopes, particularly the large amounts of ^{106}Ru and the trivalent rare earths, have decayed. However, there is a legacy of about 200,000 Ci of ^{90}Sr and 600,000 Ci of ^{137}Cs and a much smaller amount of U and transuranic isotopes which will remain a potential source of groundwater and surface water contamination for several hundred years. Past operational records, engineering designs, and characterization/performance investigations have been summarized. Appendices of reports, photographs, line drawings, and engineering drawings have been included. The planning and operational history have been presented in the context of the Laboratory's liquid waste disposal problems through the years. Concerns for both the long- and short-term radiological hazards posed by the operation of the pits and trenches led to their abandonment in 1966 when the hydrofracturing disposal technique became operational.

Although there is considerable existing characterization about these areas, many additional information needs were identified which will be required to plan their closure. Empirical leach rate data for the waste forms in each pit and trench will be required. Some improvement in the sites' groundwater and surface water monitoring system has been suggested including flow-proportional sampling and discharge monitoring in the one presently unmonitored drainage basin. In addition, the known active groundwater seeps in the area should be monitored for a two-year characterization period until their seasonal contributions to the areas' surface water discharges can be quantified. Other geologic, pedologic, and hydrologic characterizations of the area appear to be quite adequate for planning closure. However, the spatial distribution of radioactivity in and around each pit and trench needs to be determined with much more resolution than is available at present. The use of an in situ radiation detector, fitted on a retrievable and hydraulically insertable lance, is proposed as a tool to achieve this detailed mapping in the field.

Hydrologic and soil chemical speciation modeling needs are presented. Such models will be required to predict radionuclide migration into the future so that the radiological impacts of these sites can be determined. The techniques for the stabilization and closure of each pit and trench will depend strongly on the magnitude of these predicted radiological doses when these sites are no longer under the institutional control of ORNL.

Objectives

The objectives of this report are twofold. The first objective is to assemble in one document the ORNL organization's knowledge of the operation and performance of the seven pits and trenches used to dispose of liquid wastes between 1951 and 1966. To this end, a rather thorough search of official reports, line drawings, engineering drawings, and photographs has been completed. Both publicly-available and official-use-only documents were surveyed. The reporting of pits' and trenches' operations have been continuously documented in various Operations Division's report series. Excerpts from this variable-frequency chronological record have been assembled, with editorial comments required for the reader's clarification, in Appendix B. Other documents used for this report relate either directly to the performance evaluation of the various pits and trenches or indirectly through studies of soils, sediments, or groundwater whose information has an obvious extrapolation to or inclusion of the pits' and trenches' areas. Interviews with present or retired personnel were not used except to identify tangible records; personal files and log books of operators and researchers were also not used although this strategy may be needed at a later time to better understand the nuances and deviations from routine operations of particular pits or trenches.

The second objective of this report is to identify any additional information which is needed about these areas to plan their closure in an environmentally sound and regulatorily correct manner. This second objective has been more difficult to achieve than the first for two reasons. Firstly, the detailed needs of each of the seven disposal units, because of their quite different designs, inventories, and physical settings, are likely to be quite different. The scope of this report is limited to the general or generic needs of all of these sites. Secondly, site characterization information needs are never really generic and, to a large extent, depend on the stabilization and closure techniques to be considered. For example, if grouting were envisioned as a stabilization technique, the compatibility of the waste form (e.g. sludge) with the grout's set chemistry, would be a critical information need. This would not be a pertinent need if simple trench capping were considered as a stabilization technique. Similarly, the volatility of the waste's radionuclides would be a crucial need for stabilization via in situ vitrification but would be useless information for some in situ deep dynamic compaction technique. Thus, for the purposes of this report, the identified information needs have been limited to those required to answer the simple yet difficult question: What needs to be known to decide whether or not the pits and trenches can be left 'as is' to perform adequately to be deemed 'closed'? Obviously, our present

body of knowledge cannot provide an answer to this question. This situation does not reflect any inadequacies of ORNL's operations or research planning efforts through the years, but only the fact that the question has never been addressed before in anything but necessary expedients.

Introduction

The use of the seven seepage pits and trenches at ORNL between 1951 and 1966 for the disposal of liquid radioactive wastes was quite strongly linked to the changing missions and needs of the laboratory. Any judgment concerning the appropriateness of their use during that time, by imposing present-day environmental standards and regulations, would be both mooe and unfair. This legacy of about a million curies of mixed fission products contained in the near surface soil poses perhaps the largest risk of future environmental contamination for ORNL. The questions about these seepage pits and trenches, which need to be answered, are really quite simple to formulate. Which radionuclides and how much activity were disposed in them? Hcw is it presently distributed spatially within and around them? When and how much activity will find its way into White Oak Creek before decay? Answers to these questions will dictate what, if anything, needs to be done about these areas. As a first step in answering these questions, an understanding is required of ORNL's liquid waste disposal needs and resulting operations as they evolved historically. In several instances, the rationale for certain decisions in the planning and operation of the pits and trenches is not explicit and the logical process leading to those decisions had to be reconstructed. We sincerely hope that we have done this fairly and apologize in advance for the errors inherent in any interpretation of historical perspective.

Operational History of ORNL Liquid Waste Disposal

The detailed history of radioactive liquid waste disposal at ORNL is available in a number of sources (See Appendix A). Browder (1959) compiled the first detailed record covering the period from the initiation of liquid waste production up to the period of the most intensive use of the seepage pits in 1959. The primary mission of ORNL at that time was to test plutonium and uranium recovery techniques on a pilot scale as a model for the Hanford, Washington, plutonium production facilities. Since it was anticipated that the Laboratory would be a temporary facility, the volumes of liquid waste were envisioned to be comparatively small. These wastes, therefore, were to be stored in several sprayed-concrete (gunite) tanks. However, in 1943, the mission of ORNL was expanded into a state of indefinite continuation. The quantities of waste soon exceeded the limited gunite tank storage facilities and it was decided to precipitate radioactivity and uranium within the tanks by caustic addition. The resulting sludges were stored in the tanks and the supernatants decanted, with dilution by the large volume of process waste water, into White Oak Creek. To further aid in retention of radioactivity, a dam was built across White Oak Creek about 1.7 miles from its confluence with the Clinch River to

function as a further sediment trap for any radioactive solids in White Oak Creek. Apparently the levels of radioactivity in White Oak Creek were not acceptable so in June 1944 a 1.5 million gallon capacity settling basin (3513 pond) was completed to serve as a collection, sampling, and stilling pond for gunite tank supernatants to permit radioactive solids to settle from the waste before discharge to White Oak Creek.

After caustic treatment, wastes were typically held in one of the large gunite tanks as long as storage space was available to allow for sludge settling and decay of short-lived radioisotopes. Aged waste supernatant was decanted to the 3513 pond from other tanks on a rotating basis. ORNL was producing about 7,000 gallons per day of these high activity wastes which were given a precipitation-scavenging in the gunite tanks, about one month holdup for decay, and three solids-settling steps (in the gunite tank, the settling basin, and the sediment pond on White Oak Creek). It was calculated, based on the ultimate dilution by the Clinch River, that 5 curies per day of mixed fission products could be safely discharged to White Oak Creek. An average total discharge of 284 curies per year was maintained up to 1957 when the process waste treatment plant began operations; White Oak Creek discharges were greatly reduced due to this plant.

However, highly radioactive liquid waste volumes continued to increase until, in June 1949, an evaporator was added to reduce volumes stored in the gunite tanks. During the operation of this first ORNL waste water evaporator until its shutdown in 1954, 11,560,000 gallons of liquid waste were reduced to 423,000 gallons of concentrate yielding a 27:1 volume reduction. Nevertheless, storage space for this concentrate was limited to two of the gunite tanks so that alternate storage space was needed. The other gunite tanks had been dedicated to uranium waste storage for recovery operations. This lack of storage space for high-activity liquid waste concentrate led to the first use of the disposal pits in 1951. Further historical information on the complete ORNL liquid waste disposal system can be found in Feige et al. (1960), Struxness (1960), Manneschmidt and Witkowski (1962), Browder (1960), Manneschmidt and Witkowski (1967), Burch (1972), and Boyle et al. (1982).

Waste Pit No. 1

According to deLaguna et al. (1958), the first waste pit at ORNL was designed as a storage basin for liquid waste. Not surprisingly its capacity of 180,000 gallons was similar to that of a gunite tank. Pit 1 was located just west of Solid Waste Storage Area (SWSA) 4 in Melton Valley (see DWG-83-12602 and PHOTO-15895). Struxness (1960) described the rationale regarding the construction of Pit No. 1 (PHOTO-14844) as follows, "About 10 years ago the

Laboratory began to discharge medium-level liquid waste into pits dug into the weathered Conasauga shale. The first pit was thought of as a tank, dug into an impermeable formation, where value could be measured by its volumetric capacity and safety by the inability of the contents to leak out. The first pit did leak, although very slowly, and analysis of liquid in seeps which formed below the pit showed that the only radionuclide coming through was ruthenium and this only in greatly decreased concentration. The rest of the fission products were adsorbed by the soil and weathered rock".

This rationale was further documented in the Operations Division monthly report for July, 1951 (ORNL-1109), "This location provides a shale which will allow very little seepage over geologically long periods of time. This is expected to be a much safer and cheaper way of permanently disposing of liquid wastes. This project is considered to be an experiment at the present time". Such a rationale would seem quite unfounded given what is known about the hydrologic characteristics of the Conasauga formation today. However, at that time (1950-51), potential radioactive contamination problems associated with the use of the Chickamauga limestone areas at the main X-10 site seemed severe enough to recommend that soils in another formation be used for liquid and solid waste disposal (Stockdale 1951), "From the viewpoint of a geologist, a preferred site for the burial of radioactive solid wastes and contaminated materials in the Oak Ridge vicinity would be at a place underlain by a shale. Such rock is generally quite impermeable and is not subject to solution which might lead to the development of underground channels to permit free transfer of ground waters. In the Oak Ridge area, the most extensive geologic formation which is composed of shale is the Conasauga." Based on these recommendations of the USGS and UT (ORNL employed no geologists or hydrologists at the time), SWSA 4 was opened in 1951 in the Conasauga shale. Stockdale (1951) also recommended that no new waste ponds be constructed in the Chickamauga (underlying the main X-10 site). It would, therefore, seem logical to try this same geologic formation with such great potential for disposal of liquid wastes.

Waste pit No. 1 was constructed in July 1951 with a capacity of about 180,000 gallons and overall dimensions of 100 by 20 by 15 feet deep. About 123,000 gallons of concentrated liquid waste were hauled to the pit in 500 gallon tanks fitted on a Dempster Dumpster truck. With the discovery of leakage of radioactivity from the pit, discharges were terminated on October 5, 1951. The amount of activity added to Pit 1 was estimated at 389 curies of gross beta activity. Operations records indicate that Pit 1 also received 196 kg of uranium and 266 mg of plutonium. Struxness et al. (1955) described the waste added to Pit 1 as highly alkaline (pH approximately 12.5) containing mainly cesium and ruthenium (60% ^{137}Cs and 40% ^{106}Ru).

From 1962 through 1964 it received discharges from the

drains of the decontamination building 7819 until a separate septic drainage system was installed there in 1964. It is unclear if this drainage to Pit 1 was actually stopped in 1964 or whether it continued until 1981 when Pit 1 was filled. However, the nature of these discharges is unknown although the total activities were probably small because it was an unshielded decontamination operation. What, if any, effect decontamination agents, e.g. soaps and chelates, would have on the mobility of the limited inventory of radioactivity in Pit 1 is also unknown. In 1981, Pit 1 was filled with Conasauga shale and capped with asphaltic concrete.

Waste Pit No. 2

Although Pit 1 obviously leaked, a fact admittedly contrary to the stated site selection criteria noted above, the selectivity of the radionuclide seepage became apparent. The seeping radioactivity was found to be mainly ^{106}Ru, whose approximately 1 year half-life, made it a radionuclide of far less concern from a radiological protection perspective than the longer-lived ^{137}Cs or ^{90}Sr (30 and 28 year half-lives, respectively). Pit 1 probably contained little ^{90}Sr as this would be precipitated as a carbonate during caustic addition to the gunite tanks before transfer. The conclusion to this serendipitous situation was the concept of 'seepage disposal' where radioactivity could be removed by the soil formation, which was not so impermeable after all, and large volumes of decontaminated water allowed to seep to White Oak Creek.

Pit 2 was constructed in 1952 on a hillock southwest of Pit 1 (see PHOTO-15898). The pit had the shape of a frustrum of an inverted rectangular pyramid, 200 by 100 ft at the ground surface and 15 ft deep. The walls were sloped back at about a 30° angle to the horizontal (see engineering drawings 12249 and 12323). At a depth of 12 feet from its bottom, the pit had a volumetric capacity of 1,000,000 gallons. Initially, wastes were transferred to the pit in 500-gallon tanks on a Dempster Dumpster but a 4,000-gallon tank trailer was used beginning in February 1953 (see PHOTO-12115-12117). In 1954, a pipeline was constructed from the gunite tanks to Pit 2 and the waste evaporator was shut down. The evaporator shutdown was a logical consequence of the seepage concept because volume reduction made no sense unless hauling expenses were involved. The tank trailer continued to be used, however, to transfer inactive chemical wastes, mainly aluminum and ammonium nitrates, from special buildings.

Average daily waste generation during the period when Pit 2 was operating by itself was about 7,000 gal/day. Typically, 3,000 to 7,000 gal/day were pumped to Pit 2. In this period through December, 1954, when Pit 2 was operating alone, 1,294,000 gallons of liquid waste containing 16,600 curies of beta activity were disposed. As well as Pits 3

and 4, Pit 2 also received some sludge which was hauled by tank trailer from the Process Waste Water Treatment Plant after in began operations in 1957. This older Process Waste Treatment Plant should not be confused with the present one which began operations in April, 1976. This sludge, which was a mixture of illitic clay and calcium carbonate generated from its lime-soda water softening process, contained little radioactivity by comparison to the activities transferred to the pits in the intermediate-level liquid waste.

After January, 1955, when Pit 3 was opened, the inventory of wastes discharged to individual pits, both in volume and quantity of radioactivity, became harder to measure or estimate. Pit 3 was used for the initial discharge of the liquid waste and, when it became full, its overflow was piped downhill to Pit 2. Based on observed stage heights in the pits (DWG-28382), Pit 2 probably received no waste in 1955 because it required most of that year for Pit 3 to fill. In 1956, Pit 4 was added to receive overflow from Pit 2 which was approaching its capacity. Thus, although the total volumes and gross beta activities discharged during this latter interval were reported, their distribution among the three pits cannot be determined exactly.

During the period between 1959 and 1961, rather large discharges of ^{106}Ru were transferred to all the pits. Pit 2 was found to be seeping considerable ^{106}Ru on its west side (see PHOTO-15895 with labels). An interceptor trench was dug on its west side and its seepage pumped back into Pit 2. Sodium sulfide was added in an attempt to decrease the soluble ^{106}Ru complex; this technique had dubious results, and a mounting ^{106}Ru discharge problem (Cowser 1960) led to a curtailment of ^{106}Ru releases to the pits. During 1961, when isotope-specific discharges from the two pits' area drainages were routinely reported, ^{106}Ru discharges were several hundred curies per month in both streams.

Pit 2 was taken out of service and backfilling with soil begun in November, 1962, after Trench 7 became operational. Backfilling and grading were completed in late 1963 (see eng drawing 10830) because considerable time was required for it to drain. An asphalt cover was constructed in 1970 (see eng drawing 20932) and in this condition it has remained to the present.

Waste Pit No. 3

Soon after the operation of Pit 2 began, it became apparent that the volume of waste produced would soon exceed the seepage capacity of the pit. A new pit having the same dimensions was constructed northeast of Pit 2 in January 1955. Pit 3, because it was constructed by an outside contractor, was planned in much more detail (see eng drawings 14897-14900). Apparently because ORNL now employed a geologist, the stratigraphic exposure revealed by the

digging was curious enough to have resulted in the first photographs of the area's regolith (see PHOTO- 13395-13398). Pit 3 also had improvements in its liquid level monitoring devices and a sampling platform extending over it (see PHOTO-13852-13855). In addition, some of the mechanisms involved in the removal of radioisotopes by the soil were studied in an effort to estimate the capacity of these areas for radioactivity disposal (Brockett et al, 1954, three publications - see Appendix A).

Pit 3 was operated as the initial discharge point for the transfer pipeline and its overflow was routed to Pit 2 as discussed above. The quantity of waste actually placed in Pit 3 would be difficult to estimate. Lomenick et al. (1967) concluded that Pits 2 and 3 contain essentially all of the ^{90}Sr and about 85% of the ^{137}Cs discharged to the pits. His conclusion was based on a detailed analyses of several cores taken from Pits 2 and 3 which, apparently, are still stored in a temporary building between SWSA 4 and Pit 1. Obviously, radionuclides like ^{90}Sr, which would be associated with suspended solids in the transferred liquids, would tend to settle in the first discharge pond. An isotope like ^{137}Cs, which has a strong affinity for illitic clays in the Conasauga formation, would be expected to be rapidly sorbed from the liquid on contact with soil in the first pit. This scenario apparently operated and was supported by the findings of Lomenick et al. (1967). Cowser et al. (1961) made some estimates of the inter-pit transfers for the period through 1958. They also summarized the radioisotopic composition of the various wastes added to the pits in this period; ^{137}Cs, ^{106}Ru, and the trivalent rare earths isotopes were estimated as the principle contributors to the gross beta activity. Lesser amounts of ^{89}Sr, ^{90}Sr, ^{60}Co, and ^{125}Sb were also present. Generally, ^{137}Cs and ^{106}Ru accounted for 90% of the radioactivity. Neither ^{3}H nor ^{99}Tc, being soft beta emitters, were measured. About 930 tons of sodium and 1,360 tons of nitrate, the principle chemical constituents in the waste, were released to the pits through 1958.

Seepage rates from Pit 3 as well as the other pits were difficult to calculate. Although the inputs to the pits from the waste discharges and rainfall were measured, corrections for evaporative losses were difficult at best. An open pan filled with water was used to estimate evaporation (PHOTO-17488) and tenuous corrections were necessary to estimate actual evaporation from the pits (see Cowser et al. 1961). Given these caveats, the seepage rates estimated by Cowser et al (1961) of 700-1700 gallons per day for Pit 3 and 1900-3900 gallons per day for Pit 2 are about what one would expect from the hydraulic heads maintained within the pits and the hydraulic conductivity of the Conasauga formation soils, ca. 6×10^{-5} cm/s (Davis et al. 1984). Thus, the total seepage of Pits 2 and 3 was between 4,000 and 5,000 gallons per day. This rate of seepage was less than the rate of production of liquid

waste, i. e. ca. 7,000 galllons per day. Thus, the immediate need for another seepage pit became apparent after Pit 3 was in operation for less than one year (see Dwg-28382) as Pit 3 neared full stage.

Groundwater seeps were observed on the east side of Pit 3 (see PHOTO-15895 with labels) although these were not as severe as those of Pit 2 or later ones found originating from Pit 4. No corrective actions were taken. Pit 3 was taken out of service in September, 1961, and backfilling and grading were completed in 1963 (see Eng drawing 10166) along with an asphalt cap.

Waste Pit No. 4

In April of 1956, Pit 4 received its first overflow of liquid waste from Pit 2. This seepage pit was identical in design to Pits 2 and 3 (see Eng drawings 23690 to 23696) and was located just downhill from Pit 2. By this time, the Laboratory depended heavily on the pits for disposal of its liquid waste. A considerable research effort was initiated at this time and maintained well into the 1960's to support the technical basis of why the pits seemed to work so well. Before Pit 4 was used, geologic and hydrologic characterization were performed unlike the previous two pits. A pump test was performed which showed dramatically how drawdown was channeled by the stratigraphic structure (Drawing 28161). Extensive depth permeability testing was also performed (Drawing 11942) to establish that little movement of the liquid to depth was occurring. Extensive water table response data were collected (drawing 13396A) and grouted cased wells were used (drawing 11923) to monitor the movement of radioactivity beneath and lateral to the pit. Permanent weirs were installed (PHOTO 18474- 18475) in the drainages from the area. Sophisticated well logging equipment was fabricated (PHOTO-40690-40694) for use in the area. An extensive grid of monitoring wells was installed (drawing 11924A) in the pits area. Even trees were used for the first time as integrating groundwater samplers (drawing 25311).

For the first time, the control of geologic structure over the seepage pattern of the wastes became apparent as maps of geologic strikes and dips were prepared (drawing 28158). Excellent photographs of the eastern and western walls of Pit 4 (PHOTO-15647-15654) demonstrated this stratigraphic control of seepage. Given the amount of effort that went into trying to understand Pit 4, it seems ironic that it had the poorest performance of any of the three million-gallon-capacity pits.

Pit 4 leaked very rapidly (drawing 28382) and never held liquid to a degree anything like Pits 2 or 3. However, because it was at the end of the overflow train, it did not receive much waste volume and proportionally even less radioactivity. However, in 1959 when there occurred some large discharges of ^{106}Ru to the pits, some rather severe

seepage was noted on the east side of this pit (see PHOTO-15895 with labelled locations of these seeps). An interceptor trench was dug on the east side (PHOTO-49011-49013) which was 10 feet deep and 175 feet long; the intercepted seepage was collected at the downslope foot of the trench and pumped back to Pit 4. For awhile, approximately 50 curies of ^{106}Ru and 8,000 gallons per day were pumped back to Pit 4. Efforts were made to reduce the amounts of ^{106}Ru in the liquid waste system. Copper compounds were put into Pit 4 in an effort to reduce the solubility of ^{106}Ru and sorb it to the soil. However, none of these in situ chemical treatments seemed to work within the pits although there was good success in applying them while the wastes were in the gunite tanks. Although the ^{106}Ru discharge to the pits was curtailed about this time, discharges of ^{106}Ru through the pits' area drainages would remain high for several years to come. In 1961, in an effort to further reduce this ^{106}Ru discharge, another interceptor trench was dug on the west side of Pit 4 and its collectate pumped back to Pit 4. This was also the time when ten tons of sodium sulfide were placed into the pits system in an effort to enhance ^{106}Ru adsorption. Although trench 5 was now in operation, it would accept only about 4,000 gallons per day while waste was being generated at a rate of 7,000 to 8,000 gallons per day. Further, because it was desired to keep discharges to Pit 4 to a minimum because of its seepage problems, the three pits and trench 5 in late 1960 and early 1961 were operating at near capacity. Pit 4 remained open even when trenches 6 and 7 became operational as a standby pit and also to receive sludge from the Process Waste Treatment Plant. When the new Process Waste Treatment Plant became operational in 1976, Pit 4 was gradually backfilled and eventually paved with asphalt in 1980 (see Eng drawing 20938).

During their operational period up to November, 1962, the three pits received a total inventory of 522,565 curies of gross beta activity. Of this total, Lomenick estimated that it contained 42,000 Ci of ^{90}Sr, 184,000 Ci of ^{137}Cs, and 230,000 Ci of ^{106}Ru with about 70,000 Ci of trivalent rare earths. In total, these three pits received about 21 million gallons of liquid waste containing the above radionuclides.

Waste Trench No. 5

To meet the increasing demands for liquid waste disposal volumes at ORNL, Trench No. 5 was constructed in May, 1960. The design of this trench was quite different from the previous three seepage pits (see Eng drawings 38201-38205 and drawing 62129). The major design changes were effected to overcome several operational problems experienced with the three seepage pits. First, intense external radiation fields around the three open pits, particularly when they were at low stage height, limited

personnel activities near them (see drawing 14172); the earthen cover over trench 5 was designed to obviate this problem. Second, the open pits also required protective netting drawn over their surface to prevent wild fowl from landing on them and transporting radioactivity away; these protective barriers were also required to safeguard personnel from accidental falls when working in the vicinity. Thirdly, although there was some desirable evaporative loses of water from the pits during the summer, on an annual basis in this region of the country, there is a net gain of almost 2:1 of direct precipitation per unit of evaporative loss; thus, a covered trench design to prevent any trapping of precipitation more than compensated for the reduction in evaporative losses. In this same line, seepage rates from the open pits were quite hard to estimate because both additions due to precipitation and losses due to evaporation had to be figured in a tenuous manner. By operating a covered trench, seepage rates and particularly their changes with continued operation, could be measured directly. Fourthly, during the operation of the pits, it became apparent that the seepage occurred mainly along the bedding planes following the strike of the geologic formation; little seepage was observed perpendicular to strike or directly down to deeper strata. Thus, only the side walls of the pits, which were generally normal to strike, were contributing significantly to the seepage capacity of the pits. Therefore, the width of the trench would have little effect on its seepage rate. The narrower the width, the more soil formation remained for adsorption of the seeping radionuclides. Thus, for all these reasons, a narrow covered trench oriented perpendicular to strike seemed a tremendous improvement in design over the open pits.

Waste Trench 5 was photographed during its construction (PHOTO- 49219-49221) and was located based on geologic advice concerning both the dip and strike orientation and water table contours in the area. The 300 ft long by 15 ft deep trench was pretreated with 1800 pounds of copper sulfate and 1000 pounds of sodium sulfide in an attempt to overcome the ^{106}Ru mobility problem discussed above. It was also pretested by filling with water and its maximum seepage rate determined to be about 4,000 gallons per day. The trench was operated near this capacity during most of its life until liquid discharges to these seepage trenches were stopped in 1966 when the hydrofracture facility became operational. However, the liquid waste generation rate at the Laboratory was still about 7,000 to 8,000 gallons per day which situation required the continued use of the pits. It was the stated desire of the Laboratory to remove the open pits from service as soon as possible because of the ^{106}Ru discharge problem. Thus, within a year Trench 6 was constructed and its operation attempted.

Perhaps waste trench 5 performed the best of any of the pits and trenches judging by the amount of contamination of

its environs (see drawing 74624A). No point source groundwater seeps were ever observed during its operation. The operational records for this trench are quite clear; it received about 9.5 million gallons of waste with a total inventory of 311,824 gross beta curies. Also, from its initiation of operation, isotopic compositions of its radioactivity were also kept; it received 96,750 curies of $^{89-90}Sr$, 205,600 curies of ^{137}Cs, 6,385 curies of ^{106}Ru, and 3,045 Curies of ^{60}Co. Its mounded earthen surface was paved with asphalt in 1970 (see eng drawing 20941) about four years after it was last used for liquid discharges.

Waste Trench No. 6

Soon after Trench 5 became operational, it became apparent that it could only handle about 40 to 50% of the liquid waste volume needs of the laboratory. A new trench was needed so that the open pits could be taken out of service as soon as possible due to their seepage problems with ^{106}Ru. A 500 ft long trench was designed, about 50% larger than Trench 5, so that all of the Laboratory's waste could be handled with a 50% over-capacity factor to allow for contingencies. It was also apparent at this time that the variability in seepage rates of the pits and trenches required that a bigger trench be constructed to assure that a certain minimum seepage rate could be attained. Trench 6, however, was not located with geologic advice or preconstruction coring and water table monitoring (Kertesz 1961 and drawings 63051 and 70508). It was located on a ridgetop like trench 5 but the particular ridge apparently was selected because of its proximity to the end of the liquid waste transfer line (Kertesz 1961).

Trench 6 was constructed in June 1961. It was almost U-shaped (see eng drawings 43165-43171, 43136, and 43190) and only portions of it would have been perpendicular to strike as was a design criterion for Trench 5. It was pretreated with 20,000 pounds of copper sulfate in 140,000 gallons of water; this was an attempt to obviate the ^{106}Ru seepage problem so common at that time. On September 7, 1961, it received its first waste discharge. It was taken out of service on October 10, 1961 when significant seepage of 0.15 gallons per min containing ^{90}Sr and ^{137}Cs was found south of the trench (see drawing 63051). In the contaminated area the radiation field was 20mr/hr and the nature of the seeping radionuclides indicated a serious leakage problem through some open fissure. Various attempts to study or remedy the problem went on for a few months (Kertesz 1961) but the trench was finally given up and a new trench constructed within a year. Trench 6 received only about 130,000 gallons containing 145 Ci ^{90}Sr, 665 Ci ^{137}Cs, 501 Ci ^{106}Ru, and 24 Ci ^{60}Co. It was finally covered with asphalt in 1981 (see eng drawing 20944).

Waste Trench No. 7

The problems with leakage of trench 6 led to the immediate need for a new seepage trench. This trench was located and oriented based on geologic advice with preconstruction water table monitoring and coring. To overcome the potential for complete loss of service as was experienced with trench 6, the design of trench 7 delineated three 100 ft long segments to be operated independently (see eng drawings 52844-52848, 52858-52859, and 53000). In case a leak were found in one segment, the remaining segments could still be operational. With its planned capacity, successful operation of trench 7 would allow the two remaining pits, 2 and 4, to be removed from service. The third or northern-most segment of trench 7 was not constructed because preconstruction groundwater monitoring revealed a water table elevation in the area near the bottom of the planned segment. Construction was completed in August, 1962 (see PHOTO-58412-58421). The trench was pretreated with 50,000 gallons of 4% sodium hydroxide; presumably, this was done to enhance the adsorption of ^{90}Sr should any leakage occur like trench 6. The trench was not pretreated with copper sulfate or sodium sulfide as were trenches 5 and 6; there were probably two reasons for not doing this. First, the amounts of ^{106}Ru in the liquid waste had been greatly decreased as a result of the ^{106}Ru discharge problems in the seepage pits. Secondly, the inefficacy of these in situ chemical treatments probably became apparent about this time. Trench 7 was found to have a seepage capacity about four times that of trench 5. Thus, the combined seepage capacities of trenches 5 and 7 far superseded the generation rates of the Laboratory and the period of seepage trench construction ended.

Trench 7 was found to leak minor amounts of ^{106}Ru particularly on its eastern side (see DWG-74-9604). However, the levels were generally quite small. In general, Trench 7 performed well in handling the 9.5 million gallons of waste transferred to it. This waste contained about 48,000 Ci of ^{90}Sr, 231,000 Ci of ^{137}Cs, 3,400 Ci of ^{106}Ru, and 1,500 Ci of ^{60}Co. These inventories are also subdivided into the two trench segments, 7A and 7B, about equally. When hydrofracture disposal became operational in 1966, trenches 5 and 7 were used for the last time. Although the hydrofracture operation required that liquid waste be reduced in volume by a new evaporator and stored before injection, it was considered much safer than seepage pit disposal. The continuing problems of groundwater contamination, both major and minor, with all of the pits and trenches compromised the acceptability of this disposal technique (National Academy of Sciences 1957). Trench 7 was eventually paved with asphalt in 1970 (see eng drawing 20965) when pit 2 and trench 5 were also covered with asphalt.

Site Performance Monitoring

Site performance is best judged through the integration of groundwater and surface water monitoring information into a model of water dynamics of an area. Because there are no developed groundwater models, either crude water-budgeting or sophisticated finite element types, of the pits' and trenches' area, the present evaluation of its site performance must be based on a rather irregularly-collected set of data of ground and surface water radionuclide concentrations. A review of this existing data would seem most useful to identify future needs. The radionuclides of concern are listed in Table 1 along with their current maximum permissible concentrations (MPC's) for the unrestricted use of water (USNRC 1979); these MPC's are presented in three different units as a guide to the reader in interpreting the significance of concentrations reported by various investigators in differing units.

The initial network of groundwater monitoring wells (drawing 11924A) was set up in 1955 and the distribution of gross beta activity within it reported by Cowser and Parker (1958) and Cowser (1960). The observed results, at various times between 1957 and 1959, are depicted in drawings 21602, 28384R, 43912, 44013, and 44387 (Appendix C). The response of the water table to liquid seepage from the pits is depicted in drawings 13396A and 28159. These distributions of radioactivity and water tables in the pits' area, as well as those presented by deLaguna et al (1958), were not based on mathematical modeling outputs; they were hand-drawn interpolations of activity and water table measurements in the monitoring well network. Before 1959, groundwater concentrations of ^{106}Ru, i.e. gross beta counts, went as high as 0.01 μCi/mL which level was actually equivalent to the MPC in use at that time but about three orders of magnitude greater than the present day MPC (Table 1). It should be borne in mind that the explicit management objective at that time was to release as much radioactivity as the ultimate dilution by the Clinch river would allow to remain within safe limits as determined by MPC's. This philosophy is quite different from present day objectives of containment and keeping discharges as low as reasonably achievable.

Operational and monitoring records indicate that seeps around the pits often exhibited ^{106}Ru concentrations similar to those of the liquid within the pits indicating that there was little retardation of this radionuclide by the soil formation. This situation was the impetus for the construction of the three trenches which were placed along the sideslopes of the pits to intercept, collect, and pump back highly contaminated groundwater to the pits. During this same period, the concentration of ^{106}Ru in the streams draining either side of the pits area were about the same order of magnitude (drawing 39812). These discharge concentrations rose dramatically in the 1959 to 1961 period

Table 1
Maximum Permissible Concentrations, in various units, of Radionuclides Contained in the Pits and Trenches (USNRC 1979).

Isotope	Half-Life	μCi/mL	Bq/L	dpm/mL
^{3}H	12.3 yr	3×10^{-3}	111,000	6660
^{60}Co	5.3 yr	5×10^{-5}	1,850	111
^{90}Sr	28 yr	3×10^{-7}	11	0.7
^{99}Tc	210,000 yr	3×10^{-4}	11,100	666
^{106}Ru	1.0 yr	1×10^{-5}	370	22.2
^{125}Sb	2.7 yr	1×10^{-4}	3,700	222
^{137}Cs	30 yr	2×10^{-5}	740	44.4
^{233}U	162,000 yr	3×10^{-5}	1,110	66.7
^{235}U	7×10^{8} yr	3×10^{-5}	1,110	66.7
^{238}U	4×10^{9} yr	4×10^{-5}	1,480	88.8
^{238}Pu	89 yr	5×10^{-6}	185	11.1
^{239}Pu	24,000 yr	5×10^{-6}	185	11.1
^{240}Pu	6,580 yr	5×10^{-6}	185	11.1
^{241}Pu	14 yr	2×10^{-4}	7,400	444
^{241}Am	458 yr	4×10^{-6}	148	8.9
^{244}Cu	18 yr	7×10^{-6}	259	15.5

Note: These MPC's were back-calculated by USNRC using an allowable dose limit of 500 millirem/yr to a critical organ or whole body. Presently, this exposure limit is undergoing regulatory review and undoubtedly will be lowered by an order-of-magnitude or more. This will probably result in an order-of-magnitude reduction in these tabulated MPC's.

when the large ^{106}Ru transfers to the pits were made; during this period, ^{106}Ru discharges through the east and west weirs in the pits area reached monthly highs of 408 and 788 Ci, respectively, in September, 1961. These discharges contained only trace fractions of ^{90}Sr and ^{137}Cs during this same interval. The concentrations of ^{106}Ru continued to fall off until only a fraction of a curie per month was being observed when routine reporting of the monitoring of these drainages stopped in June, 1968. By this time, much of the ^{106}Ru had either leached away or had decayed. During 1967, ^{90}Sr and ^{137}Cs concentrations were usually reported as <0.01 Ci/month, the apparent detection limit at that time.

By 1980, it had become apparent that the major contributor to the calculated dose of White Oak Creek water, from all Laboratory sources, was ^{90}Sr. The routine reporting of the monitoring of the east and west pits' drainages was resumed because these are a potential source of ^{90}Sr. The monthly discharges of ^{90}Sr to the present have generally been less than or equal to 0.1 mCi for the eastern drainage and between 1 and 10 mCi for the western drainage depending on the season. The origin of the present day ^{90}Sr discharges through the eastern and western drainages is most likely associated with trench 6 and pit 1, respectively, based on other monitoring evidence to be presented later. By the present time (1985), all of the ^{106}Ru can be presumed to have decayed because about twenty half-lives of this isotope have expired since the last discharges to the pits or trenches.

The sampling of trees in the vicinity of pits 2-4 and trench 5 was used for a brief period in the late 1950's to determine the distribution of radionuclides in groundwater (Cowser et al. 1958). Aside from occasional trees proximate to a trench, these findings confirmed the groundwater observations that ^{106}Ru was the dominant mobile radionuclide. Tree sampling had the ostensible attribute that a tree would sample a rather large groundwater volume and integrate this into a convenient sample, the leaves or needles. However, these analyses generally found concentrations of radionuclides close to background levels associated with atmospheric fallout for isotopes other than ^{106}Ru. The analyses were also complicated by the known airborne drift of dust from the open pits.

Duguid (1975) looked at the concentrations of ^{90}Sr, ^{60}Co, ^{137}Cs, ^{125}Sb, and ^{106}Ru in the still active groundwater seeps within the pits' and trenches' area (Table 2). The location of these eight seeps are depicted in drawing 74-9604 (Appendix C). By comparison with each radionuclide's MPC, only seep 8, draining from trench 6, would seem to be a significant source of ^{90}Sr and only seep 7, draining east of trench 7, would be a significant source of ^{60}Co. By 1981-1982, Olsen et al. (1983) found this same trench 7 seep to have an average ^{60}Co concentration of 53 dpm/mL, a decrease which could be due to a combination of leaching and decay of the ^{60}Co.

Table 2
Concentrations of Radionuclides Observed in Groundwater Seeps in the Pits' and Trenches' Area (Duguid 1975).

Number	Location	^{90}Sr	^{60}Co	^{137}Cs	^{125}Sb	^{106}Ru
		(dpm/mL)				
1	NW-Pit 3	<0.3	<0.2	<0.1	<0.2	<0.7
2	West-Pit 2	<1.1	38.5	<0.3	<0.4	<5.0
3	West-Pit 4	<0.3	10.3	<0.2	<0.2	<2.0
4	SE-Pit 4	0.08	11.5	<0.3	0.7	<2.0
5	NE-Pit 4	<0.01	23.5	<0.5	8.7	4.5
6	South-Pit 3	0.07	13.4	<0.3	<0.3	<3.0
7	East-Trench 7	0.07	240.0	<3.0	<2.0	<10.0
8	South-Trench 6	2.0	<0.5	3.8	<0.5	<0.7
MPC	(USNRC 1979)	0.7	66.7	44.4	222	22.2

Cerling and Spalding (1981 and 1982) surveyed streambed gravels in the pits' and trenches' drainage areas for ^{90}Sr, ^{137}Cs, and ^{60}Co. They found pit 1 and trench 6 to be the only identifiable sources of ^{90}Sr in the area; ^{90}Sr streambed gravel concentrations were highest in the primary, seasonally-ephemeral streams draining these two sources (Figures 1, 2, and 3). These drainages showed no further downstream inputs as they drained past pits 2-4 or trenches 5 and 7. For ^{60}Co, dominant sources includes trench 7 and the eastern drainage of pits 2-4. Thus, the present day observations of ^{90}Sr discharges through the eastern pits' area drainage is most likely originating from pit 1 (Figure 2). Whether this is due to the actual waste transfer to the pit in 1951 or results from discharges into pit 1 from the decontamination facility, building 7819, cannot be determined at present. Only pit 6, with its known leakage problem, seemed to be a detectable source of ^{137}Cs.

The most recent groundwater monitoring in the pits' and trenches' area has been reported by Olsen et al (1983) which information focused on the trench 7 area. Olsen and Lowry have recently performed some detailed analyses of wells throughout the pits' and trenches' area (unpublished observations) and they have generously allowed some of these results to be presented (Table 3). These data include some of the first reports of ^{3}H and ^{99}Tc in the area groundwater although the levels of both radionuclides were always well below their MPC's. Only in the trench 7 area did ^{60}Co activity approach its MPC. Considering the half-life of ^{60}Co (5.25 years), this problem is probably best addressed by simply allowing further time for radioactive decay. Of more concern, are some of the ^{90}Sr concentrations proximate to trench 7 which were well above its MPC. Although the volume of groundwater with these ^{90}Sr concentrations is likely to be quite small and, hence, the total discharge of ^{90}Sr from this source trivial by comparison to other ORNL sources (Figure 2), the inventory of ^{90}Sr in trench 7 causes concern for how these concentrations and discharges might change in the future. Actually most of the high ^{90}Sr concentrations could well have resulted from the transfer line breakage and spill just north of trench 7 in 1966 (drawing 83-1514A). Several points, within the general pits' and trenches' area, have been contaminated as a result of leaks in the waste transfer lines. Two of these have recently been corrected (Walls et al 1983) and others are likely to be found during site characterization activities in the area.

Although all the radionuclides in, or presumed to be in, the pits and trenches are all of concern due to their potential for groundwater and surface water contamination, the shorter half-life isotopes, including ^{3}H, ^{125}Sb, ^{60}Co, ^{106}Ru, other trivalent rare earths (^{144}Ce, ^{154}Eu, and ^{155}Eu), ^{241}Pu, ^{242}Cu, and ^{244}Cu, will all decay to insignificant levels during a hypothetical period of ORNL institutional control of the area. The longer-lived

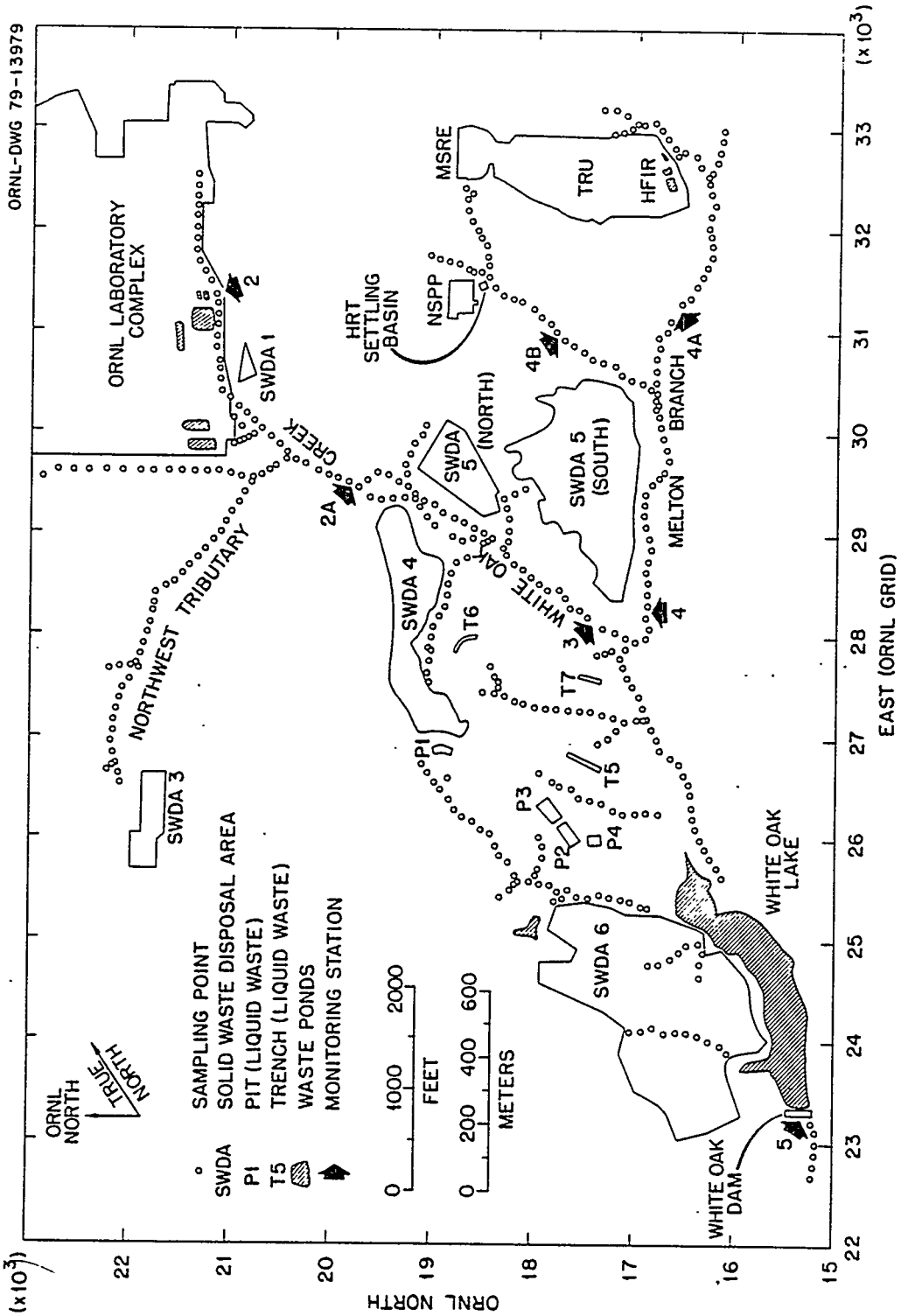

Figure 1. White Oak Creek watershed indicating solid waste storage areas, liquid waste pits and trenches, permanent monitoring stations, and streambed gravel sampling points (Cerling and Spalding 1981).

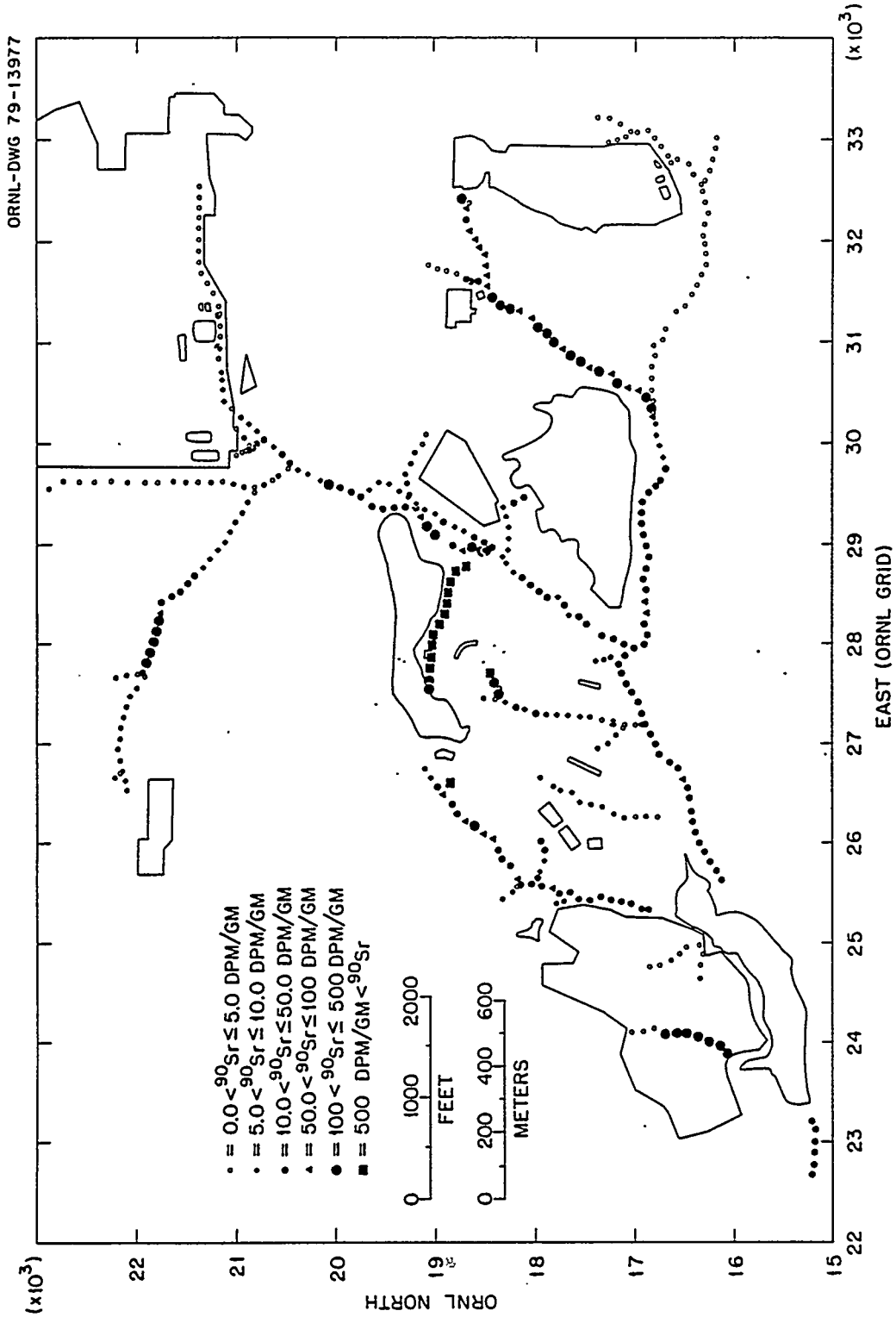

Figure 2. Areal distribution of ^{90}Sr activity in streambed gravels of White Oak Creek watershed from Cerling and Spalding (1981).

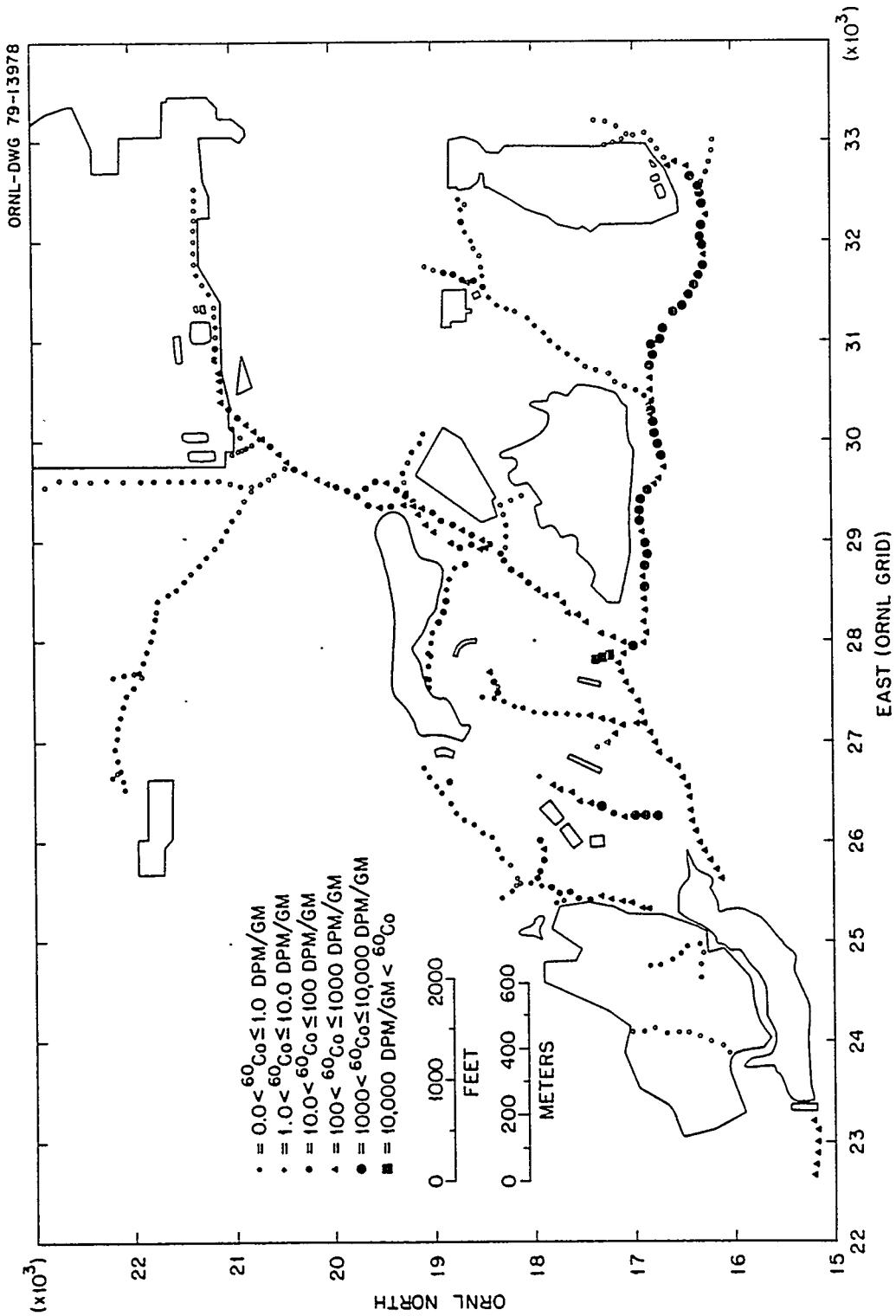

Figure 3. Areal distribution of ^{60}Co activity in streambed gravels of White Oak Creek watershed from Cerling and Spalding (1981).

Table 3
Concentrations of Radionuclides in Monitoring Wells of the Pits' and Trenches' Area in 1982 (Olsen and Lowry, unpublished).

Well No.	Location	^{90}Sr	^{137}Cs	^{60}Co	^{3}H	^{99}Tc
		(Bq/L)				
W113	NE-Pit 3	1.4	.066	0.6	<35	nd
W125	West-Pit 3	.54	<.07	8.1	380	nd
W117	West-Pit 2	.11	<.1	<.2	5100	1.9
W126	West-Pit 2	.47	<.08	1.9	150	nd
W106	SW-Pit 2	.48	<.07	2.0	110	250
W105	West-Pit 4	.06	<.8	190	3500	nd
W104	SW-Pit 4	.05	.045	0.8	67	47
W94	South-Pit 4	.04	.054	0.1	570	nd
W95	West-Pit 4	.51	<.6	200	6200	140
W85	SE-Pit 4	.88	<.3	34	2400	nd
W84	East-Pit 4	.30	.23	32	1500	61
W83	East-Pit 4	.32	<.3	15	510	nd
W96	SE-Pit 2	.29	<.08	6.6	360	180
WT-5-3	West-Tr 5	.32	<.08	7.3	110	270
WT-5-5	West-Tr 5	.06	<.08	11	4800	470
WT-5-6	South-Tr 5	.29	<.05	0.6	150	nd
W97	SE-Pit 3	.38	<.2	5.5	620	nd
W98	SE-Pit 3	.46	<.1	0.5	89	nd
T5-3	East-Tr 5	.36	<.2	37	150	nd
T7-10	East-Tr 7	1.7	<.2	41	2500	nd
T7-13	East-Tr 7	.26	<1	430	1000	1500
T7-3	East-Tr 7	.30	<2	1200	7500	1000
T7-5	SW-Tr 7	.56	<3	1500	300	nd
T7-6	West-Tr 7	1.1	<.2	32	56	nd
T7-7	North-Tr 7	2900	2.2	8.2	67	nd
WT-7-7	West-Tr 7	22	<.2	26	78	39
WT-7-5	West-Tr 7	90	.26	9.4	130	120
MPC	USNRC(1979)	11	740	1850	111000	11000

nd = not determined.

isotopes pose a much greater radiation protection concern since residuals of these will have to be left in a state which will not result in doses to future populations and individuals above certain regulatory limits. Although the inventories of ^{90}Sr and ^{137}Cs are probably fairly accurate, at least for trenches 5-7, the inventories of uranium and all the transuranic isotopes are, at best, poorly defined. Olsen et al (1983) made some of the best estimates of these by analyzing sludge samples from trench 7 and normalizing the observed concentrations to those of ^{90}Sr and ^{137}Cs whose disposal inventories were available. Similar information for the other pits and trenches is lacking. The observed concentrations of ^{233}U in several monitoring well samples in the trench 7 area were all orders of magnitude below its MPC (Olsen et al 1983). They also observed that ^{238}Pu, $^{239-240}Pu$, ^{244}Cu, and ^{241}Am, in two monitoring wells and the seep on the eastern side of trench 7, were orders of magnitude below their MPC's.

The present site performance monitoring of the pits and trenches appears adequate for the period of institutional control, i.e. a hypothetical 100-year-period. During this time, occasional monitoring of groundwater wells will need to be performed probably no more frequently than once a year and routine stream water sampling continued. Most of these activities are covered in the recommended groundwater quality survey for the SWSA and pits' and trenches' area (Switek 1981). What is lacking in the current plan is some provision to measure the water discharges as well as the radionuclide concentrations of the eight known seeps in the area (drawing 74-9604). Perhaps this might be achieved by insertion of culverts into the seeps and digging for spillways so that these culverts could be bucket-gaged or stage-height-recorded. These seeps obviously contribute most of the activity to these drainage areas and both their storm-event-related and longer-term-baseline discharges should be determined for some period of time, probably two years, until their discharge role is quantified. These point sources might well be easier to remedy than more diffuse groundwater seepage into the surface streams within the area. In addition, the nature of the discharges from pit 1 needs to be identified. Is it presently a groundwater seep, which is fed by recharge to the pit via the trench dug for the transfer drain from building 7819, or is it a result of surface runoff flowing over soil contaminated during its 1951 operation?

Streambed gravel surveys, similar to those of Cerling and Spalding (1981 and 1982), should prove useful at about five-year intervals. This type of monitoring should give ample warning of potential problems and provide the time required to plan and implement corrective actions. As an example, the proposed corrective actions at trench 7 (Stansfield 1984) are planned for 1985 to alleviate the seep discharge problem on its eastern drainage.

The longer-term monitoring system for the pits' and

trenches' area will depend very strongly on the stabilization measures ultimately taken. If covers and diversion ditches for surface runoff were to be required, the area which these are designed to protect will need to be monitored for water intrusion. If the closure plan were to reach the unlikely conclusion that the site can be left alone, then the present monitoring system would be adequate with the improvements and additions noted above.

Waste Forms of Radionuclides in the Pits and Trenches

Relatively little is known in much detail of the chemical waste forms per se transferred to the pits. This represents the most salient information need of the pits' and trenches' area. Quite a substantial amount of research has been done concerning the retention mechanisms and capacities of the Conasauga shale for the various major radionuclides in the liquid waste solutions (Brockett et al. 1954; Lacy 1957;Mohan et al. 1962). Many of these findings have been summarized in the Health Physics Annual Reports in the years between 1954 and 1960. Basically these studies concluded exactly what was found during the operation of the pits, i.e. ^{106}Ru was very poorly retained by the Conasauga shale while other radionuclides were retained more strongly. More recent work with ^{60}Co indicated that, if it complexes with EDTA, it is poorly adsorbed by soils whereas uncomplexed ^{60}Co is strongly adsorbed (Means et al, 1978). This complexation of ^{60}Co by EDTA probably contributed to the ^{60}Co leakage on the east side of trench 7 although there are confounding circumstances at that site.

Operational procedures and records are not precise enough to unambiguously conclude what the chemical form of each radionuclide is in each of the seven seepage pits and trenches. These forms can be inferred in general from the chemical processing of the liquid waste. As discussed previously, the transferred liquid waste was essentially a decantate from the alkalinity-adjusted and solids-sedimented contents of the gunite tanks. The sedimented solids would be expected to carry down the U and much of the Sr, Co, and trivalent rare earth isotopes. However, ^{90}Sr, ^{60}Co, and the trivalent rare earths would be only partially scavenged into the sedimented sludge. In addition, the separation of sludge and supernatant would be far from absolute employing only gravity-induced sedimentation within a gunite tank. Thus, considerable amounts of fine solids and suspended sludge, with its associated radionuclides, were also likely transferred to the pits and trenches. As Lomenick et al. (1967) pointed out, the suspended solids which were transferred tended to settle out in the first pit (No. 3) of the three pit drainage train. Thus, most of the ^{90}Sr will probably be contained within pits 2 and 3 and be in the form of a calcium carbonate-^{90}Sr coprecipitated sludge. From 1956 until the pits were finally covered, large quantities of the sludge from the Process Waste Water Treatment Plant were dumped into these pits; that sludge could also be scavenging ^{90}Sr from the liquid wastes. When ^{106}Ru discharges from the pits became serious in 1959-1960, sodium sulfide and copper sulfate were added to the chemical precipitation processing of the liquid wastes in the gunite tank to scavenge ^{106}Ru into the sludge. Prior to this change, ^{106}Ru, as well as ^{3}H, ^{99}Tc, and ^{137}Cs, would be expected to remain in the supernatant phase.

Lomenick et al. (1967) obtained samples of the sludges

from pits 2 and 3 and its surrounding weathered shale. They observed that strong nitric acid was required to remove ^{90}Sr from the sludge while either water or dilute calcium chloride were not effective. This behavior strongly indicates that the form of the ^{90}Sr was a coprecipitate with calcium carbonate (Spalding 1985). In contrast, the ^{90}Sr in the weathered shale was partially leachable by calcium chloride indicating that most of it was retained on the soil as exchangeable cations. Varga and Jacobs (1970) and Lomenick et al (1967) assessed the potential for this $Ca(^{90}Sr)CO_3$ sludge to dissolve in groundwater of the Conasauga and concluded that under natural conditions the process would be quite slow; the quantities of acid, required to dissolve the estimated quantities of calcium carbonate, would only become available over hundreds of years of geologic weathering. They also found that most of the ^{90}Sr in the pits' cores was contained in the sludge and had penetrated only a few inches into the unperturbed formation. However, since ^{90}Sr is the radionuclide most likely to compromise the performance of the pits and trenches, these qualitative conclusions need to be quantified by collecting actual leach data on the waste sludges and soil samples. The ^{137}Cs in both the sludge and the weathered shale samples of Lomenick et al. (1967) was not leachable by neutral salt solutions or water and required strong acid (6N) to remove most of it. This strong fixation of ^{137}Cs by illitic minerals within the Conasauga soils has been demonstrated by Tamura and Jacobs (1960). This empirical evidence, coupled with the operational experience that no significant ^{137}Cs, other than the leak at trench 6 through some large fissure, has been observed from the pits' area (Cerling and Spalding 1981 and 1982), is strong evidence that movement of this isotope is almost imperceptible in the Conasauga formation.

The form and leachability of other radionuclides, particularly the long-lived U and transuranic isotopes, and their subsequent retardation within the soil formation, are almost completely unknown. This information is one of the most crucial needs for the closure planning of the pits' and trenches' area. Empirical leach data for each isotope of concern (Table 1) for waste samples from each pit and trench would be required. These source terms can then be coupled to leach data for contiguous contaminated soil so that estimates of groundwater concentrations of each isotope can be determined. From this information, doses to hypothetical people, who might use this groundwater or its discharges to surface waters, can be calculated. The migration of isotopes like ^{90}Sr, once it is leached from the waste, can be described quantitatively using chemical models such as illustrated in the flow diagram (Figure 4) of a recently developed computer simulation of the chemical speciation of ^{90}Sr in soil (Spalding 1985 in preparation). If predicted groundwater concentrations remain below MPC, during the interval when the large inventory of ^{90}Sr decays, then no

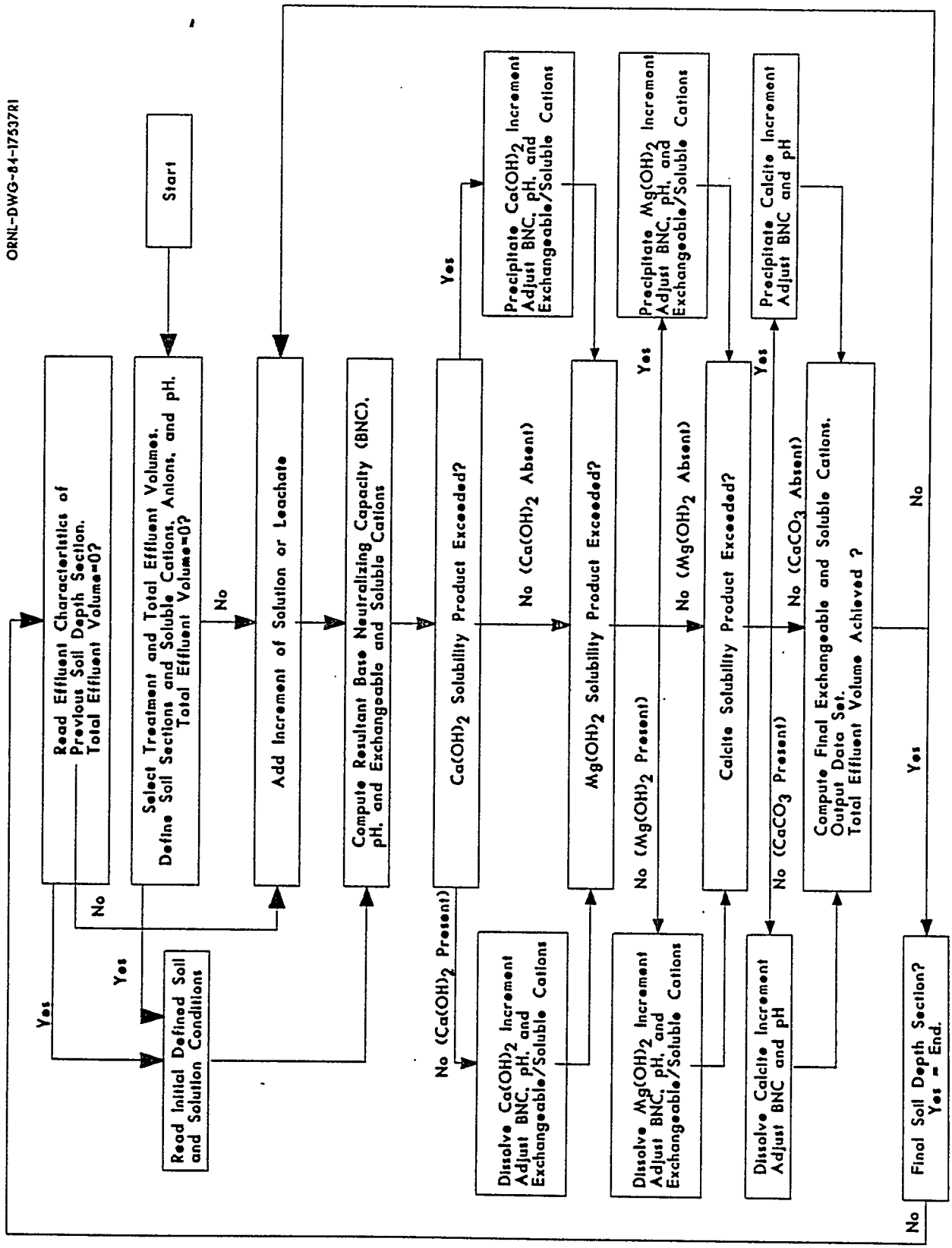

Figure 4. Logic flow diagram of a computer model of soil leaching and speciation of ^{90}Sr (Spalding 1985 in preparation).

closure action would be required; other isotopes may dictate other required actions. It must be reemphasized that the only method to reach such a decision about the needs for closure will be to couple empirical leach data, chemical speciation models of soil, and hydrologic models of the area. Because the nature of the wastes in each pit or trench will likely be somewhat different, these leach data will need to be obtained for each location whereas the soil chemical speciation model soil inputs can be more generic for the entire area.

Because much time and effort will be expended to obtain samples of the wastes from each pit and trench, these samples should also be screened for EPA priority pollutants (non-radioactive). Although there were non-radioactive waste transfers of aluminum and ammonium nitrates and sludges from the process waste water treatment plant, the pits and trenches are not likely to contain significant amounts of non-radioactive hazardous wastes. This condition would be most explicitly established by the analyses of the pits' and trenches' contents.

Site Characterization

The pits' and trenches' area is one of the most well studied sites on the Oak Ridge Reservation in terms of its geologic and hydrologic characteristics. In geology, the studies of deLaguna et al (1958) produced some of the most definitive relationships between geologic structure and seepage patterns (drawings 28158 and 28384R). deLaguna (1962) also did extensive coring and augering around pits 2 and 4 showing that particular bedding planes conducted most of the pits' seepage (drawings 62143-62148). This type of geologic input led to the improved design of trenches 5 and 7 which were oriented perpendicular to geologic strike. These geologic studies have probably told as much as can be learned in this complicated sedimentary formation, the Conasauga. More recent studies in adjoining areas (Davis et al 1984 in SWSA 6; and Rothschild et al. 1984 in the proposed SWSA 7 site) have added some details. The details of the geologic column of the Conasauga Group formation have been extended further (drawings 83-13887R2 and 82-13318) than what was available in 1958 (drawings 6631 and 28383). Two pictures summarize excellently how complicated is the secondary folding and faulting of the stratigraphic column in the area of the pits' and trenches: PHOTO-15654 of the southern portion of the east wall of pit 4 and drawing 81-21573B of the stratigraphic exposure along a roadcut on the eastern side of trench 7. This structure is so complicated on the scale of the pits and trenches that it has generally been concluded that the identification of precise flowpaths for seepage from the pits and trenches may be close to impossible or economically prohibitive using conventional coring and augering in these areas (deLaguna et al 1958; Olsen et al 1983). Clearly the work of Olsen et al (1983) has demonstrated that discrete fractures, conduits, or strata carried most of the seepage radioactivity (drawings 83-1555 and 83-1556). But without much more extensive coring or augering with borehole-logging, the assurance that all conducting structures have been identified cannot be guaranteed. If a complete picture of these conducting strata or features could be attained, then a monitoring system for the area could be recommended with confidence and accurate fracture-flow groundwater models of each trench could be produced to describe site performance. More pragmatically, such detailed knowledge of the spatial distribution of residual activity in and around the pits and trenches would put the planning of corrective actions on an accurate basis; areas needing the protection of engineered barriers could be accurately planned.

Such detailed knowledge of the spatial distribution of radioactivity in, around, and under each pit and trench might be obtained without the large expense and site disruption associated with coring, augering, and sample retrieval for expensive radiochemical analyses. The

gross-beta and gamma activity of soil profiles could well be obtained in situ by placing a GM tube detector in the ground. This technique has been used to log boreholes which were previously constructed by augering or coring (Olsen et al. 1983; Struxness and Morton 1956). A recent demonstration of grout-injection machinery at ORNL clearly showed that 1-inch diameter pipe, fitted with a well point to form a lance, could be inserted into the soil formation by a hydraulic driver using track guides. If the well point were fitted with an adapted GM-type detector, depth increments of the soil formation could be logged without previous augering or coring. Measurements could be taken in the field either during insertion or, more likely, on withdrawal of the lance. Insertions to depths of 20 feet could be performed in a few minutes so that borehole logging times would be determined by the radioactivity detection sensitivity desired; many depth logs could in theory be produced in one day. With such techniques, an entire pit or trench could be circumscribed; such perimeter surveys could be performed at several distances from the pit or trench to yield a detailed three-dimensional image of the distribution of gross-beta and gamma activity. Selected salient 'hot' spots could be cored subsequently so that radionuclide-specific analyses could be generated and correlations between known species and activities and the gross counts developed. Likewise, the distribution of activity within a pit or trench could be determined. Because the spatial resolution of the technique is potentially high, detailed mapping of the functional stratigraphic features, responsible for groundwater flow, may be possible for the first time due to the radioactive 'label' contained in this region of the Conasauga. This could be implemented by acquiring a modestly-priced piece of drilling equipment with a track-mounted drill-head (e.g. the Holegator of Acker Tool Co.) and development of GM detector 'well point'; the detailed characterization of the three dimensional distribution of radioactivity around each pit and trench then may be possible.

The pits' and trenches' area has been very extensively studied for hydrologic characteristics. The work of deLaguna et al. (1958) described the results of pump tests (drawing 28161) at the pit 4 site, seepage rate determinations for the formation (drawings 21681 and 28382), pressure testing of the formation to depths of 200 feet (drawing 11942), and water table elevation maps (drawings 13396A and 28159) based on an extensive monitoring well network (drawing 11924A). These distributions of radioactivity at points in time (drawing 21602) and as a function of time (drawing 21603R) could well be interpreted as a detailed groundwater tracer test. Radioactivity was logged with depth below pit 4 as a function of pit usage (drawing 15480A). Extensive tracer tests were run (drawing 11944A) at the nearby '4 acre site' (see PHOTO-15895 with labels) which was a candidate site for a new seepage pit but

was eventually used as a test site for hydrofracturing experiments. The movement of nitrate tracer from an experimental unlined seepage pit (drawings 4964A-4966A) as well as water table responses to seepage were also studied in 1954 on an adjoining hillock later to become part of SWSA 6; the location of this covered experimental pit can be seen in PHOTO-15903. The movement of tritiated water at the pit 4 site was later studied (drawing 64-7897) and groundwater velocities of 0.5 ft/day were observed (Lomenick et al. 1964).

The streams draining the pits' area were also extensively investigated under low-flow conditions (drawing 29285) and in response to storm events (drawing 29284). The radioactivity discharges of these streams were followed in detail in 1957-1958; routine monitoring, with flow-proportional sampling, continues to the present although records were not kept between 1968 and 1980. Discharges of seeps in the area were updated only once by Duguid (1975). Olsen et al. (1983) described the water table dynamics of the trench environs during a period of characterization in 1981-1982 for potential corrective actions to its ^{60}Co-contaminated groundwater seep.

In terms of surface water discharge characteristics, information is presently being obtained for the eastern and western drainages in the pits' area. Surface runoff channels immediately east and west of trench 7 will soon be continuously monitored as part of a project to evaluate the effectiveness of some corrective actions to be taken at trench 7 later this year; these actions include widening the asphalt cap on the trench and routing of surface runoff away from the trench and grouting the soil formation between the trench and its eastern seep (Stansfield 1984). The only unmonitored drainage remaining in the area will be the remainder of the 14 ha area between trenches 5, 6, and 7. If a weir were installed on this drainage, a complete surface water monitoring network would be available for the area. Provisions would have to be made for a central data collection and storage system and a hydrologic interpretation of this data would need to be made to summarize the output into a water budget. If this activity were to include water table elevation monitoring and seep discharge monitoring, as described previously, then the complete hydrologic characterization of the area could be completed in a two year observation period. This observation period would provide the information required to construct the needed hydrologic models of the area.

Detailed investigations of the soils in the pits' and trenches' area would be largely a superfluous effort. Detailed information is already available for two proximate sites: one in SWSA 6 (Davis et al. 1984) and another in proposed SWSA 7 (Rothschild et al. 1984). Both these sites have soils developed in the same portion of the Conasauga and have essentially identical geomorphology and vegetation. Similarly, meteorologic characterization of the area would

not be required because adequate data continues to be obtained in SWSA 6 and SWSA 5 and at several other sites on the Oak Ridge Reservation. Similarly, regional characteristics for such things as seismic activity, severe storms, flooding, ecology, and social, economic, and political characteristics can be used verbatim from other recent studies (e.g. Boyle et al. 1982).

Modeling Status and Needs

The simulation modeling of the hydrologic transport of radionuclides in the pits' and trenches' area is in an embryonic state. The application of finite element models to trench 7 was initially made by Duguid and Reeves (1976) and Duguid (1979). These efforts were later developed more generally by Yeh and Tamura (1982). Experimentally-determined parameters for these models (drawing 76-7075) were finally reported by Luxmoore (1982); the suction, hydraulic conductivity, and moisture content relationships were gathered during flooding of a specially-constructed undisturbed soil block near trench 7 (engineering drawing 20965). The distribution of a hypothetical species, with a distribution coefficient of 100 L/kg (probably ^{90}Sr) was simulated (drawing 76-7077) under transient and steady-state rainfall conditions (drawing 76-7076) through a cross-section of a hill dimensionally equivalent to trench 7 (drawing 76-7080); the distribution of the hydraulic head and the water table was also simulated (drawing 76-7078). These modeling efforts were an excellent beginning for hydrologic models of the area and were state-of-the-art for that time. However, they are based on the assumption that the aquifer is a homogeneous porous medium which is a considerable but necessary deviation from the reality of the site (Olsen et al. 1983).

Similar cross-sectional models (two dimensional) should be attempted for all the pits and trenches as well as cross-sections parallel to the length of each pit and trench up to real site boundaries, i.e. surface streams. Likewise, two-dimensional water table models would be extremely useful to define fluxes of water, moving through the soil profile and leaching the waste, as it varies both seasonally and transiently during storm events. The fluxes of water to surface streams, which are simulated by these models, need to be calibrated to the actual surface water discharges observed during site characterization.

Given good modeling estimates of the fluxes of water through the various waste pits and trenches, soil chemical models of radionuclide adsorption and dissolution will need to be developed so that the migration of radionuclides can be simulated. One modeling approach for the speciation of ^{90}Sr in soil has been discussed previously (Fig. 4). Input characteristics of the quality of the water leaching the waste will also be needed; such characteristics include pH, hardness, electrical conductivity, acidity, and alkalinity. These attributes are adequate to describe the dissolution and precipitation of $Ca(^{90}Sr)CO_3$ and its retention by soil cation exchange mechanisms. Other characteristics may be required to simulate the movement and adsorption of other radionuclides. A few laboratory-measured distribution coefficient determinations of these radionuclides between a typical groundwater and soils of the area will probably be all that is required for these simulations. The empirical

leach data of the waste itself will be needed to formulate source terms for the models. These inputs of radionuclides to the surrounding soil will be attenuated by the processes in the various soil chemical models for each radionuclide so that groundwater concentrations as a function of time can be simulated.

Regulatory and Environmental Assessment Needs

All of the afore-mentioned characterization needs and activities are required to satisfy two applicable federal regulations: 10CFR Part 61 and DOE Order 5820. Basically, these regulations require that the waste disposal sites do not adversely impact people. They require that radioactive doses to people, resulting from the site, do not result in more than a certain minimum dose. Because air-borne and solid-phase movement of radioactivity from these sites will be trivial pathways, both on- and off-site doses will be delivered by ground or surface water to potential or hypothetical users. Given the rather predictable amounts of water which people use in predictable ways, radiological doses can be converted into maximum concentrations of radionuclides in these waters. The entire characterization and modeling effort will be devoted to predicting what these concentrations will be both during the 100-year period of institutional control and in the post-institutional period.

During institutional control, if site performance problems arise and the off-site doses become unacceptable, corrective actions can be taken. Also during that period, no inadvertent intrusion by people needs to be considered, i.e in theory, the fence works. Fortunately, during this 100-year period, a significant reduction in the radionuclide inventory of the pits and trenches will occur and many short-lived isotopes will disappear (Table 1). However, very significant amounts of ^{90}Sr and ^{137}Cs will remain as well as a presently undetermined amount of U and transuranic isotopes.

After the institutional control period, intruders to the area need to be presumed and if these people use groundwater and surface water originating in the area, their doses can potentially be quite high. This situation is illustrated for the case of trench 7 in Table 4. The radionuclide inventory developed by Olsen et al. (1983), but not corrected for decay, was presumed to completely dissolve and disperse in the area's groundwater which was assumed to have a volume of 7.5×10^7 L(i.e. 150 x 100 x 10 m deep soil/rock aquifer with 50% porosity). This very conservative assumption of complete dissolution has been made for illustrative purposes only. It can be seen that ^{137}Cs and ^{90}Sr show the greatest divergence from their MPC's. The U and transuranic isotopes, except ^{241}Am, would be very close to their MPC's. It is very likely that empirical waste leach data and soil adsorption probably will reduce these concentrations well below regulatory concern. Thus, if the afore-mentioned characterization efforts demonstrate that the concentrations of ^{137}Cs and, particularly, ^{90}Sr in groundwater will remain below their MPC's, then the sites probably can be abandoned without further stabilization at the end of the institutional control period.

Table 4
Hypothetical Concentrations of Radionuclides in a Shallow Aquifer Beneath Seepage Trench 7 Assuming Complete Dissolution and Dispersion in a Groundwater Volume of 7.5×10^7 Liters.

Radionuclide	Inventory[1]	Concentration	MPC[2]
	(mCi)	(mCi/L)	(mCi/L)
^{90}Sr	29.7×10^6	4.0×10^{-2}	3×10^{-7}
^{137}Cs	13.8×10^7	1.8	2×10^{-5}
^{233}U	594	7.9×10^{-6}	3×10^{-5}
^{238}Pu	3,784	5.0×10^{-5}	5×10^{-6}
^{239}Pu	1,973	2.6×10^{-5}	5×10^{-6}
^{240}Pu	1,243	1.7×10^{-5}	5×10^{-6}
^{241}Am	432,432	5.8×10^{-3}	4×10^{-6}

[1] Inventory taken from the estimate of Olsen et al. (1983).

[2] Maximum Permissible Concentration from USNRC (1979).

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Appendix B

Excerpts of Operations Division's Reports

Excerpts from Operations Division Monthly Reports Pertaining to the Seepage Pits and Trenches

Month ending July 31, 1951 (ORNL-1109 p. 9)

In cooperation with the Health Physics Division, a site beyond the new burial ground [SWSA 4] has been chosen to locate a 200,000-gallon lagoon for the storage of metal-waste supernatant now stored in tank W-10. This location provides a shale which will allow very little seepage over geologically long periods of time. This is expected to be a much safer and cheaper way of permanently disposing of liquid wastes. This project is considered to be an experiment at the present time. Approximately 100,000 gallons containing about 100 curies of activity will be stored there until this method of disposal is proven to be safe and economically practical.

Month ending August 31, 1951 (ORNL-1122, p. 12)

The transfer of radiochemical metal waste supernate from W-10 to the chemical waste storage pit was begun on August 1, 1951, and discontinued on August 7, 1951, after a total of 26,400 gal, bearing 22.88 curies of beta activity, 134 kg of uranium, and 28.15 mg of plutonium was transferred. The transfer from this tank was discontinued because of the high uranium content. Further precipitation by the addition of 850 gal of 50%-caustic was made.

While the precipitate in tank W-10 was allowed to settle, a total of 15,000 gal of evaporator concentrate was transferred from W-8 to the storage pit. This transfer was started on August 7 and completed on August 10. The material carried 192.4 curies of beta activity, 15.5 kg of depleted uranium, and 8.48 mg of plutonium.

The entire transfer operation was successfully carried out. Two portable 500-gal tanks with the Dempster Dumpster truck were used. The operation presented no undue amount of radiation hazard.

Month ending September 30, 1951 (ORNL-1127, p. 7-8)

The transfer of radioactive metal waste supernate from W-10 to the chemical waste storage pit was resumed on September 24, 1951. The amount transferred from September 24 through September 30 was 43,200 gal, bearing 33.6 curies of beta activity, 17.7 kg of uranium, and 76 mg of plutonium.

The transfer of waste will continue until an adequate amount of free space is made available to transfer the contents of W-7 to W-10.

Month ending October 31, 1951 (ORNL-1156, p. 9)

The transfer of radioactive metal waste supernate from W-10 to the chemical waste storage pit was resumed October 1, 1951, and continued through October 3, 1951. In the 24,600 gal of material transferred,

there were 18,622 g of uranium, 65 mg of plutonium, and 8.2 curies of beta activity.

Transfer of chemical waste concentrate from W-8 to the pit was begun on October 3, 1951, and continued through October 5, 1951. This 13,000 gal of waste contained 132.3 curies of beta activity, 8.8 mg of plutonium and 10,238 g uranium.

The volume of waste in the chemical waste storage pit is decreasing at a rate of 500 to 600 gal per day and the plants near the pit have been found slightly radioactive. The Health Physics Division has the area under its surveillance.

Month ending November 30, 1951 (ORNL-1188)

No mention.

Month ending December 31, 1951 (ORNL-1212, p. 23)

At the suggestion of the Health Physics Division, additional storage space was provided last fall by transferring 123,000 gal of a mixture of evaporator concentrate and metal-waste supernatant to a 170,000 gal pit dug for this purpose southwest of the new burial ground [SWSA 4]. This method was to be considered an experiment which, if it proved to be practical, would pave the way for a simple and very economical method of permanent disposal of concentrated evaporator wastes. The pit and the surrounding area are still under Health Physics surveillance; no decision concerning the practicality of this method has yet been made.

Month ending January 31, 1952 (ORNL-1245)

No mention.

Month ending February 28, 1952 (ORNL-1259)

No mention.

Month ending March 31, 1952 (ORNL-1271, p. 12)

Construction of a new chemical-waste storage pit for hot chemical waste was about 50% complete at the end of the month [Pit 2].

Month ending April 30, 1952 (ORNL-1295, p.10)

Work on the new chemical-waste storage pit [Pit 2] has progressed until the project is about 97% complete.

Month ending May 31, 1952 (ORNL-1319, p. 10)

The chemical-waste storage pit [Pit 2] was completed this month.

Month ending June 30, 1952 (ORNL-1334, p. 11)

Approximately 12,000 gal of contaminated chemical waste that contained 187.0 beta curies were transferred from tank W-8 to lagoon

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No. 2 [Pit 2] this month. The radiation levels are high, so the transfer operation is confined to two shifts per week.

Month ending July 31, 1952 (ORNL-1363)

No mention.

Month ending August 31, 1952 (ORNL-1390)

No mention.

Month ending September 30, 1952 (ORNL-1404)

The movement of concentrated chemical waste from tank W-8 to chemical-waste pit No. 2 was resumed. There was 4200 gal of waste containing 103 curies of beta activity transferred, which brings the total amount transferred to date to 16,200 gal bearing 290 curies of beta activity.

Month ending October 31, 1952 (ORNL-1440, p. 9)

Approximately 900 gal of concentrated chemical waste from tank W-8, which contained 28.3 curies of beta activity, was moved to chemical-waste pit No. 2. The total transferred to this pit to date is 17,100 gal and bears 318 beta curies of activity.

Month ending November 30, 1952 (ORNL-1460, p. 9)

Approximately 16,200 gal of concentrated chemical waste from tank W-8, which contained 400 curies of beta activity, was moved to chemical-waste storage Pit No. 2. The total transferred to date is 33,300 gal bearing 718 curies of beta activity.

Month ending December 31, 1952 (ORNL-1485, p. 19)

Approximately 9600 gal of concentrated chemical waste from tank W-8, which contained 235 curies of activity, was moved to chemical waste pit No. 2. The total transferred to date is 42,600 gal bearing 953 curies of activity.

Month ending January 31, 1953 (ORNL-1502)

No mention.

Month ending February 28, 1953 (ORNL-1522, p. 10)

The tank trailer, with a capacity of about 4000 gal, for hauling concentrated chemical wastes from the tank farm to the waste storage pit was put into service this month. There was 45,600 gal, bearing 1131 curies of beta activity, transferred this month to give a total transferred to the pit to date of 55,200 gal containing 1366 curies of beta activity. The use of this equipment enables transfer of larger volumes of wastes with lower personnel radiation exposure than was encountered with the 500-gal tanks previously used.

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Month ending March 31, 1953 (ORNL-1539, p. 9)

A total of 21,600 gal of chemical-waste concentrate bearing 615.28 curies of beta activity was discharged to the chemical-waste storage pit No. 2 from tank W-8. The total transferred to date from the concentrate tank to the pit is 76,800 gal containing 1981 curies. Additional wastes, consisting of 600 gal bearing approximately 15 g of U-235 and 16 curies of beta activity from the Homogeneous Reactor Building and 6500 gal bearing approximately 6.13 curies of beta activity from the washings of the pit excavation at valve group No. 1 in the north tank farm, were also transferred to the same waste pit.

Month ending April 30, 1952 (ORNL-1553, p. 9)

There was 37,800 gal of chemical-waste concentrate containing 1897 curies of beta activity discharged to chemical-waste storage pit No. 2 from tank W-8. The total transferred to date from the concentrate tank to the pit is 114,600 gal bearing 3878 curies.

Month ending May 31, 1953 (ORNL-1564, p. 12)

There was 28,800 gal of chemical-waste concentrate containing 1377 curies of beta activity discharged to chemical-waste storage pit No. 2 from tank W-8. The total transferred to date from the concentrate tank to the pit is 143,400 gal bearing 5255 curies.

Month ending June 30, 1953 (ORNL-1586)

No mention.

Month ending July 31, 1953 (ORNL-1603)

No mention.

Month ending August 31, 1953 (ORNL-1619, p. 14)

A total of 29,400 gal of chemical-waste concentrate bearing 995 curies of beta activity was transferred from waste tank W-8 to waste storage pit No. 2. The total transferred to date is 172,800 gal containing 6250 curies of beta activity.

Month ending September 30, 1953 (ORNL-1635, p. 12)

A total of 32,400 gal of chemical-waste concentrate bearing 899 curies of beta activity was transferred from waste-tank W-8 to chemical-waste storage pit No. 2. The total transferred to date is 205,200 gal containing 7149 curies of beta activity.

Month ending October 31, 1953 (ORNL-1646, p. 12)

A total of 31,200 gal of chemical-waste concentrate bearing 802 curies of beta activity was transferred from waste-tank W-8 to

chemical-waste storage pit No. 2. The total transferred to date is 236,400 gal containing 7951 curies of beta activity.

Month ending November 30, 1953 (ORNL-1654)

No mention.

Month ending December 31, 1953 (ORNL-1668, p. 12)

Construction of the pump pit in the south tank farm has been started. This pit is for the waste line from the tank farm to the chemical-waste storage pit No. 2.

Year ending December 31, 1953 (ORNL-1680, p. 14-16)

Approximately 227,000 gal of concentrated radioactive waste containing 7716 curies of beta activity was transferred from the tank farm to the chemical-waste storage pit No. 2. The total transferred to the pit thus far is 270,000 gal containing 8669 curies (Fig. 3) [ORNL-PHOTO-12116].

A speed-up in the transfer of waste to the pit and an appreciable reduction in exposure of man power to radiation was accomplished by using an old, salvaged gasoline trailer which was excessed by the AEC and converted for waste-hauling purposes at the Laboratory. This equipment was far superior to the 500-gal Dempster Dumpster tanks originally used.

Construction of a pipe line connecting the tank farm to the waste-storage pit is expected to be completed early in 1954. This project will eliminate the hazardous hauling of waste by truck, will probably probably eliminate the need for concentrating wastes by the waste evaporator, and will greatly reduce the amount of effort and money expended in the disposal of liquid wastes.

[break] The construction of the pipe line to the waste-storage pit will eliminate the need for more chemical-waste storage tanks and will provide a safer and cheaper way of permanently disposing of the "hot" chemical wastes.

Month ending January 31, 1954 (ORNL-1683, p. 10)

Construction has been started on the transfer line from the south tank farm to chemical-waste storage pit No. 2. Construction continued on the pump pit for the waste transfer line in the south tank farm.

A total of 12,600 gal of chemical-waste concentrate bearing 262 curies of beta activity was transferred to chemical-waste Pit No. 2 this month. This brings the total transferred to date to 282,600 gal containing 8930 curies.

Month ending February 28, 1954 (ORNL-1699, p. 10-11)

A total of 49,200 gal of concentrated chemical waste bearing 1173 curies of beta activity was transferred to chemical-waste storage pit No. 2. This brings the total transferred to date to 331,800 gal containing 10,104 curies.

[Break]

Construction of the waste transfer line from the tank farm to the

chemical-waste storage pit has been completed by the contractor. The construction of the pumping station by the Laboratory forces continues and is scheduled to be completed in April, when delivery of the pump is expected.

Month ending March 31, 1954 (ORNL-1710, p. 12)

A total of 11,800 gal of nonradioactive concentrated chemical waste was transferred to chemical waste storage pit No. 2. Of this amount, 5000 gal was $Al(NO_3)_3$ waste from Unit Operations, Building 4505, and 6800 gal was NH_4NO_3 from metal recovery operations, Building 3505.

Month ending April 30, 1954 (ORNL-1730, p. 10)

The trailer used to haul radioactive wastes was temporarily removed from service for emergency repairs after it received serious corrosive attack from acidic wastes. One new surplus trailer has been procured to replace the damaged one since it could not be put back into its original good condition; another surplus trailer was also obtained as a spare.
[break]
A total of 29,160 gal of radioactive and inactive chemical wastes were transferred to chemical-waste storage pit No. 2. Of this amount, only 400 gal, received from the decontamination of the homogeneous reactor, was radioactive; it contained 0.696 beta curies. The remaining volumes were 10,550 gal of $Al(NO_3)_3$ waste from Unit Operations, Building 4505; and 18,210 gal of NH_4NO_3 from metal recovery operations, Building 3505.

Month ending May 31, 1954 (ORNL-1743, p. 8-9)

The trailer used to haul contaminated wastes was removed from service twice for emergency repairs because of leakage. The replacement trailers are at the shops awaiting alterations.
The black-iron drain line from the waste trailer unloading area to the waste storage pit was completely destroyed by low-pH wastes. The drain line was replaced with one made of terra cotta.
The pumping station in the line from the tank farm to chemical-waste storage pit No. 2 is essentially complete. Some minor work remains to be performed before the project is accepted for use. The equipment has been tested and meets the manufacturer's specifications.
[break]
A total of 26,613 gal of waste contaminated with natural uranium was transferred to chemical-waste storage pit No. 2. Of this amount, 4420 gal of $Al(NO_3)_3$ was received from Unit Operations, Building 4505, and 18,193 gal of NH_4NO_3 from metal recovery operations, Building 3505.

Month ending June 30, 1954 (ORNL-1752, p. 9-10)

The installation of the pumping station for the pipe line to the waste pit was completed and the waste transfer pipe line put into service on June 2. The performance of the pump was highly satisfactory; at 120-psi pump discharge pressure, the delivery rate was 1800 gph, 600 gph

more than the expected rate.

With the successful beginning of the waste transfer line operation, the waste evaporator was shut down and put in a standby condition. Hot wastes are now being pumped directly to the pit without a reduction in volume. The elimination of this operation is expected to reduce waste handling costs.

With the operation of the pipe line, it was also possible to eliminate usage of the waste trailer for hauling the concentrated NH_4OH wastes from the Metal Recovery Building. This waste is now being discharged to the tank farm storage tanks, where it is pumped to the waste pit along with the radioactive wastes.

A total of 99,460 gal of wastes, containing 1492 curies of beta activity, was transferred to the pit this month. Approximately 88,800 gal was transferred through the new pipeline and contained all the activity; 6700 gal was concentrated NH_4OH transported by tank truck from the Metal Recovery Building, and 3960 gal was $Al(NO_3)_3$ transferred by tank truck from the Unit Operations Building.

Month ending July 31, 1954 (ORNL-1764, p. 9-10)

Radioactive wastes containing 4666 curies (133,800 gal) were pumped from tank W-8 to chemical waste storage pit No. 2. In addition, 4127 gal of highly concentrated inactive $Al(NO_3)_3$ and NH_4NO_3 waste was transferred to the pit from Unit Operations. Building 4505, and the metal recovery operations, Building 3505. The total of all wastes discharged to waste storage pit No. 2 to date is 628,633 gal containing 16,263 curies. [break]

The trailer tank used to haul wastes to the chemical-waste pit was discarded because of leaks which could not be repaired. Surplus trailer tanks recently acquired are being repaired and their designs are being revised for plant use; one of these trailers should be available next month. Meanwhile, all wastes scheduled for pit disposal are being pumped to the chemical-waste pit.

Month ending August 31, 1954 (ORNL-1787, p. 9)

A 130,200-gal quantity of radioactive wastes containing 415 curies of radioactivity was pumped from tank W-8 to chemical waste storage pit No. 2. In addition, 4025 gal of highly concentrated inactive $Al(NO_3)_3$ waste was transferred to the pit from Unit Operations, Building 4505. The total of all wastes discharged to waste storage pit No. 2 to date is 762,858 gal, containing 16,678 curies.

The pump used to transfer wastes from tank W-8 to waste storage pit No. 2 failed and had to be removed for repair. Inspection revealed a plugging of the suction line and the pump casing with an unidentified white precipitate readily soluble in HNO_3. The pump was reinstalled and now operates satisfactorily.

Month ending September 30, 1954 (ORNL-1804, p. 10)

Radioactive wastes containing 744 curies in a volume of 165,600 gal were discharged into chemical-waste storage pit No. 2 from tank W-8. The total of all wastes discharged to waste storage pit No. 2 to date is 928,458 gal containing 17,422 curies. The chemical-waste system

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received 113,400 gal of waste during the month.

Alterations to the new hot-waste tank trailer have been completed.

Month ending October 31, 1954 (ORNL-1822, p. 9)

A total of 167,550 gal of wastes, containing 277.0 curies, was transferred to chemical storage pit No. 2 this month. Of the total, 3750 gal was not active and was trucked from Unit Operations Building 4505. The total of all wastes discharged to waste storage pit No. 2 to date is 1,095,708 gal containing 13,661 curies. (The curie figure has been erroneously reported 4038 curies too high since July, 1954, as the result of a calculating error.)

A total of 181,400 gal of waste was put through the chemical-waste system.

An additional line to the pump from the tank farm to chemical-waste storage pit No. 2 was installed from waste tank W-6, but it is not yet working satisfactorily.

Month ending November 30, 1954 (ORNL-1831, p. 10)

A total of 49,650 gal of wastes containing 2036 curies was transferred to chemical-waste storage pit No. 2 this month. Of the total, 450 gal was not active and was moved by truck from Unit Operations Building 3503. The remaining wastes were pumped from chemical waste tank W-6. This is the first time that waste has been pumped successfully from this tank. The total of all wastes discharged to the waste storage pit No. 2 to date is 1,145,358 gal containing 15,697 curies.

The chemical-waste system received 73,200 gal of waste during the month.

Another chemical-waste storage pit located adjacent to chemical-waste storage pit No. 2 is under construction. The capacity of this new pit will be 1,000,000 gal, the same as that of pit No. 2. Construction should be completed during December.

Month ending December 31, 1954 (ORNL-1841, p. 9)

A total of 116,400 gal of wastes containing 196 curies was transferred to chemical-waste storage pit No. 2 this month from chemical-waste tank W-6. The total of all wastes discharged to the waste storage pit No. 2 to date is 1,261,758 gal containing 15,893 curies. There was 88,000 gal of waste put into the chemical-waste system.

Chemical-waste storage pit No. 3 is still under construction. The pit now lacks only a gage board and protective fencing for completion. [break]

A piece of the transfer pipeline to the waste storage pit from the south tank farm was removed to allow revisions for servicing the new waste storage pit. Visual inspection of this piece of pipe indicated that no undue corrosion or wear has resulted from its use during the first seven months of operations.

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Excerpts form ORNL Radioactive Waste Disposal Annual Reports
Pertaining to the Seepage Pits and Trenches

Annual Report for 1954 (ORNL-CF-55-1-212, p. 1-2)

The most important change made in the hot-waste disposal operation during the last several years was the installation of a 1.5-mile pipeline and pumping station between the tank farm and the waste disposal pit area. Before the pipeline was put into operation in June of this year, all hot wastes were reduced in volume by evaporation and the concentrate was hauled by truck trailer to the waste disposal pits. The operation was expensive and hazardous because of radiation exposure of operating personnel and the possibility of contamination of roads. Now, the radioactive wastes are temporarily stored in the tank farm until some radioactive decay takes place; then they are pumped directly to the pits through the new pipeline. Operation of the evaporator was discontinued, and the equipment was put in standby condition.

Excavation of New Waste Pit

By shutting down the waste evaporator, the rate of transfer of waste to the 1,000,000-gal pit was increased by a factor of about 15. It became apparent within several weeks that the seepage rate into the soil surrounding this pit was too low to keep up with the Laboratory's waste production rate and the normal rainfall into the pit. To increase the pit disposal capacity, excavation was started on a second 1,000,000 gal pit in the vicinity of the first one. It is expected that the two pits will be adequate for the disposal of the Laboratory's hot wastes for the next several years. Completion of the work on the second pit is expected in January 1955 (see Fig. 3).

Nonradioactive Chemical Wastes

The waste pits were also used this year for the disposal of 87,000 gal of nonradioactive concentrated $Al(NO_3)_3$ and NH_4NO_3 wastes. These wastes were hauled by truck trailer directly from the operating buildings. In the transportation of these wastes, the tank of the converted gasoline tank trailer was corroded by the acidic wastes which had been insufficiently neutralized. The trailer was taken out of service and two AEC surplus gasoline tank trailers were obtained, one to be held as a spare.

After the first tank trailer was taken out of service, an attempt was made to transfer the nonradioactive wastes through the pipeline. This operation ran into difficulty when the pump became gas-bound with ammonia caused by decomposition of NH_4NO_3.

[Table 1 Summary - 997,000 gal containing 7,224 beta curies were transferred to Pit 2. Waste Pit 1 was used in year 1951 only. The stated volume transferred includes 87,000 gal of nonradioactive chemical wastes hauled by truck directly from operation buildings to Pit 2.]

Annual Report for 1955 (ORNL-CF-55-12-170, p. 1-2)

Waste Disposal Operating Costs

The excavation of waste pits was an unusual expense item and accounts for more than the amount of increase [in operating cost over

last year]. Only $10,623, representing a portion of one pit excavation was charged to the operation in the year 1954, while $20,365 was charged in 1955 to complete the excavation begun in 1954 and to almost complete the work on a new one. It is interesting to note that the pit dug by the Laboratory forces and completed early in 1955 cost a total of $14,320, while the new one, which is, for the most part, under contract to a construction company, has already cost $16,668, and several thousand dollars more will have to be spent before the job will be completed.

Waste Volume and Activity

The disposal of wastes into open pits, without evaporation, was continued throughout 1955. A total of 1,674,000 gal of radioactive waste, containing 21,391 "beta curies" of activity, was pumped into the pits. This represents an increase of 84% in volume and 196% in activity over the previous year. Significant waste-disposal data for 1955 are compared with those of the five previous years in Table 1.

The waste evaporator was not operated during 1955. This was the first full year that the evaporator had been shut down since pit disposal was begun in 1951, which accounts for the increase in volume and a large portion of the increase in activity pumped into the pits. Without a reduction in volume, the waste could not be stored in the tank farm for a long period of time to permit decay of short-lived materials prior to transfer to the pits.

The total volume of radioactive waste received was 1,691,000 gal, which is lower by 20% than the average for the five previous years but higher by 7% than the volume in 1954, the lowest on record. The low volume in 1954 was due mainly to a long shutdown of operations at the Hot Pilot Plant.

Excavation of Waste Pits

The second 1,000,000-gal waste pit (No. 3) was completed and put in service in January 1955. The excavation of the third pit (No. 4) was completed by the contractor in October but will not be ready for use until the Laboratory forces install a sampling platform and a screen cover. It is estimated that at the current rate of production the capacity of the two pits used at present will be adequate for several more months. The pits currently used are shown in Fig. 2.

Annual Report for Calendar Year 1956 (ORNL-CF-57-1-172, p. 2)

Waste Volume and Activity

A total of 2,694,000 gal of waste containing 34,989 curies of "beta activity" was pumped to the waste pits in 1956. This was an increase of 61% in volume and 64% in activity over the previous year. The increases were due to the expansion of the operating activities at the Hot Pilot Plant and the Metal Recovery Plant. Other significant waste-disposal data for 1956 are compared with those of six previous years in Table 2.

The increase in volume is viewed with no concern, since the capacity of the waste-disposal system is far greater than the volumes currently produced and can be limited only by the seepage rates in the three waste pits now in use. Present rates appear to be adequate for several more years, and no further excavation of pits or expansion of the hot-waste facilities is anticipated unless the present waste-disposal methods are found to be unsafe for wastes produced for some future Laboratory

programs such as the Power Reactor Fuel Processing now in the proposal stage.

Annual Report for 1957 (ORNL-CF-57-12-143, p. 4-6)

Waste Volume and Activity

The disposal of all hot wastes to waste pits 2, 3, and 4 continued throughout the year. By the end of 1957 the total of all wastes discharged into the pits was 8,546,000 gal containing 114,191 curies (at the time of transfer). There was no indication of a significant loss of pit seepage capacity or breakthrough of activity into White Oak Creek. A total of 41,918 curies was discharged to the waste pits in 1957, an increase of 20% over that in 1956. The increase was due mainly to high radiation levels in processing at the Hot Pilot Plant.

The volume of waste in 1957 was 2,903,000 gal, an increase of 8% over that in 1956. There were two reasons for the increase: a higher discharge from the Hot Pilot Plant and the diversion of some wastes into the system that in previous years were handled by the process waste system. The diversion into the hot waste system, of wastes of lower activity level and of those that had to be analyzed to determine whether they could be handled by the process waste system, helped to reduce the activity discharged to the Creek and eliminated costly analyses. A comparison of volumes as well as activity handled by the system in the last five years is given in Table 2.

End of the Annual Report Series.

Appendix B
Excerpts of Operations Division's Reports

Excerpts from Operations Divisions Quarterly Reports Pertaining to the Seepage Pits and Trenches

January-March, 1958 (ORNL-CF-58-2-67, p. 23)

[Routine reporting of transfer of 239,000 gal containing 9,614 curies to Pits 2, 3, and 4 bringing total inventory to 123,805 curies.]

April-June, 1958 (ORNL-CF-6-122)

[Routine reporting of transfer of 735,000 gal containing 19,020 curies to Pits 2, 3, and 4 bringing total inventory to 144,886 curies.]

July-September, 1958 (ORNL-CF-9-88, p. 101)

[Routine reporting of transfer of 941,000 gal containing 11,560 curies to Pits 2, 3, and 4 bring total inventory to 156,446 curies. New waste transfer line to the pits was tested with air pressure and found to be performing well.]

October-December, 1958 (ORNL-CF-12-147, p. 74-75)

[Routine reporting of transfer of 845,000 gal containing 10,540 curies to Pits 2, 3, and 4 bringing total inventory to 166,986 curies.]

January-March, 1959 (ORNL-CF-59-3-1, p. 24)

[Routine reporting of transfer of 914,000 gal containing 12,053 curies to Pits 2, 3, and 4 bringing total inventory to 179,039 curies.]

April-June, 1959 (ORNL-CF-59-6-131, p. 50)

[Routine reporting of transfer of 807,000 gal containing 60,042 curies to Pits 2, 3, and 4 bringing total inventory to 239,081 curies.]

July-September, 1959 (ORNL-CF-59-9-111, p. 59)

[Routine reporting of transfer of 1,163,000 gal containing 166,000 curies to Pits 2, 3, and 4 bringing total inventory to 369,000 curies.]

October-December, 1959 (ORNL-CF-59-12-102, p. 33-34)

A potentially serious break-through of Ru^{106} activity in the bank on the east side of waste pit No. 4 to White Oak Creek occurred during this period. It is estimated that between 300 and 350 curies of activity were released in to the creek; this accounts for about one-fourth of the 11 percent of MPC shown in Table 4.1. Excavation of the area east of the pit revealed that the bulk of the release came through a narrow channel which flowed under the road into the swampy area east of the pit. The activity in the material released approached that contained in the pit itself; approximately 10^5c/m/ml.

Plans are now being made to discontinue the use of the existing pits for future high-level wastes by replacing them with a covered soil

column and another seepage pit in another location. For the interim period the condition has been corrected by intercepting the leakage and pumping it back into the pit.

The data for high-level waste pumped to the lagoons or pits are given in Table 4.3. [706,000 gal containing 78,000 curies bringing total inventory in pits to 447,000 curies].

January-March, 1960 (ORNL-CF-60-3-148, p. 53-55)

The Laboratory's long-range program for improving liquid waste disposal methods includes the addition of a third system for disposal of extremely active wastes such as those anticipated from the power reactor fuel reprocessing program. The waste to be handled in the new system is now referred to as "high-level waste." Beginning with this report, the waste previously called high-level waste will be termed "intermediate-level waste" to maintain a differentiation between the two types.

The main portion of the Ru^{106} leakage from waste pit No. 4 to White Oak Creek, mentioned in the previous report, has been eliminated since January 6. This was accomplished by digging a 10-ft deep, 175-ft long trench perpendicular to the direction of seepage on the east side of pit No. 4 to intercept the active solution and pumping the solution back into the pit. Approximately 50 curies in 8,000 gal of solution is being returned to the pit daily.

The use of pit No. 4 will be discontinued, and the pit will be sealed when the new trench No. 5 is put in operation. Construction of this trench is now 95% complete. In the meantime, plans are being made to further reduce the discharge of Ru^{106} from the existing pits by fixing the activity in the pits by the addition of copper compounds. The development of the process is essentially complete, and an effort is being made to procure the materials.
[859,400 gal containing 10,150 curies was transferred to pits 2, 3, and 4 bringing the total inventory to 457,150 curies.]

April-June, 1960 (ORNL-CF-60-6-127, p. 55-59)

Construction of seepage trench No. 5 was completed May 20, and metering of solution was immediately started for the purpose of calibration and pretreatment. To enhance the Ru retaining characteristics of the soil and limestone, 1800 lb of $CuSO_4$ and 1000 lb of Na_2S were metered into the 64,000 gal of water required to fill the trench to the 9-ft level, 6 in. below the overflow point. The trench was allowed to empty itself by seepage, in 19 days, and was ready for the first filling with waste at the end of the quarter. The average seepage rate when the trench was full was approximately 4,300 gal per day.

Level recording and control devices are on order and will be installed as soon as they are available. The equipment will give an indication of the liquid level in the trench and will prohibit filling above a preset level to prevent overflow into the creek.

There were two breaks in the waste transfer line to the pits during this quarter; one, approximately 50 ft from the pump in the south tank farm, resulted from corrosion and the other, located where the line crosses the creek near the bridge to the 7500 Area, was due to damage by heavy equipment. Although neither incident resulted in a serious

hazard, the second could have seriously contaminated the creek if it had occurred at a time when a waste transfer was being made. To prevent this possibility in the future and until the replacement line is put into operation, better controls have been established over digging work in the vicinity of the waste lines. The replacement line, now awaiting AEC approval, has been laid out so that it does not cross the creek at any point.

An inspection of the line at the creek, while repairs were being made, indicated that there may be other potential leaks in the line. An X-ray of a weld near the break but not touched by the digging equipment showed that the weld was faulty; the weld was repaired. To forestall any large release into the creek through weak points in the line that are not now apparent, a radiation monitor, similar to that used in the process waste system at the automatic diversion valve, is being installed in the creek downstream from the bridge. The information will be telemetered and recorded at the Process Waste Treatment Plant. During the period while the instrument is being installed, the creek is sampled and analyzed every two hours while waste is being pumped.

A summary of the waste pumped to the waste pits is given in Table 4.3. All waste during this quarter was pumped to pits 2, 3, and 4. Trench No. 5 is scheduled to be put into operation during the first week in June.

[638,400 gal were transferred containing 5,479 gross beta curies bringing total inventory to date to 462,629 beta curies.
First data presented on the isotopic composition of the waste: ^{89}Sr(15.8Cu), ^{90}Sr(291.9Cu), ^{106}Ru(3068.0Cu), ^{137}Cs(708.0 Cu), ^{134}Cs(99.3 Cu), TRE(2149.0 Cu) with average nitrate and phosphate concentration of 0.11 and 0.002 moles/gal, respectively.]

July-September, 1960 (ORNL-CF-60-9-121, p. 53-56)

Trench No. 5 was placed in operation at the beginning of the quarter. An average of 23,000 gallons of waste/week was pumped into the pit. This represents 40 percent of the waste transferred to the lagoon area. Pit No. 4, originally scheduled to be taken out of service, has been used sparingly. An estimated 50,000 gallons were diverted into this pit over the three-month period.

Contracts for the new 2-in. transfer line and the emergency pond are expected to be open for bids in October. Alterations involving the settling basin, a by-pass installation, and basin enlargement have been deferred to a future date.

Table 4.4. summarizes waste transfers to the lagoon area.

[468,000 gal containing 3,485 beta curies to pits 2, 3, and 4.
356,400 gal containing 2,062 beta curies to Trench 5.
Isotopic composition to each trench also presented.]

Seepage Trench No. 6

During the quarter, seepage trench No. 5 was operated continuously at a rate of approximately 3,000 gallons/day, with a maximum seepage rate of 4,000 gallons/day. Since the rate of intermediate-level waste generation approximates 7,000 to 8,000 gallons/day, it has been necessary to use Pits No. 2, 3, and 4 to take the excess. In order to eliminate this necessity and permanently remove these pits from service, it is planned to construct a second closed seepage trench. A location northeast of trench No. 5 was first chosen because of its accessibility

by road and its nearness to the waste pipe line. Some doubt was raised, however, as to the effective operation of a trench located on that particular ridge due to its narrow crest and steep sides. A second site is being investigated and cost estimates are being prepared for each location. The inclusion of a treatment trench was suggested, and plans for this are now being studied. Such a trench would be about 30,000 gal capacity, would have impermeable walls, and would be filled with a variety of materials that would adsorb and remove most of the radioactivity from the incoming waste. The discharge would then go to the seepage trenches where the balance of the activity would be removed by seepage through the soil. At the completion of the necessary Laboratory development work, now under way, the actual engineering of such a trench can proceed.

October-December, 1960 (ORNL-CF-60-12-122, p. 32-33)

There was practically no reduction in the volume of intermediate-level waste, even though substantial reductions were accomplished in some areas by eliminating unnecessary dilution. An abnormally large volume, accounting for about 40% of the Laboratory total, was received from Building 3019 where extensive cell decontamination work was done. The success of efforts made to reduce the volume of waste will not become obvious until the cell decontamination is completed. Other intermediate-level waste data are given in Table 4.6.
[Pits 2, 3, 4 received 424,800 gal containing 2,380 gross beta curies.
Trench 5 received 376,200 gal containing 1,474 gross beta curies.
Isotopic composition for each trench is also presented.]
Seepage Trench No. 6.

Engineering design of seepage trench No. 6 is nearing completion. A site with favorable topographic characteristics was chosen on a ridge northeast of the trench No. 5 area. The new trench will extend approximately 500 ft along this ridge. Trench No. 6, being 50% longer than trench No. 5, should have sufficient capacity to dispose of all the intermediate-level waste now going to Pits No. 2, 3, and 4. The estimated cost of the new trench, including access road, is $30,000; construction is expected to begin in early May, 1961.

January-March, 1961 (ORNL-CF-61-3-138, p. 32-34)

The waste pits and trench No. 5 were maintained at maximum levels during this quarter because of heavy rainfall and high volumes received (see Figure 4.2.), mainly from Building 3019. During this period, two seeps were detected on the west side of pit No. 2. It is evident that the operation of the pits at the high levels was responsible for the development of the new seeps.

In an effort to reduce the amount of ruthenium activity released from the new seeps, a trench, similar to the one on the east side of pit No. 4, was dug on the west side of pit No. 2. The trench intercepts the seeps, and the liquid is pumped back into the pit. To fix the activity in the soil, ten tons of sodium sulfide was introduced into the three open pits.

The monitoring wells at trench No. 5 were sampled, and the analytical results were turned over to the Health Physics Division for appraisal. Monthly samples taken from the creek on the west side of trench No. 5

gave no indication of activity released in that direction.

A contract for construction of trench No. 6 has been awarded. The scheduled completion date is August 8. This, along with trench No. 5, will provide enough capacity for the Intermediate-Level Waste, allowing the open pits to be sealed.

The activity transferred to the pits and trench is given in Table 4.4. [1,368 curies to trench 5 for a total to date of 4,904 curies. 1,498 curies to pits 2, 3, and 4 for a total to date of 469,993 Ci. From Fig. 4.2, 150,000, 280,000, and 275,000 gal of waste were transferred in January, February, and March respectively.]

April-June, 1961 (ORNL-CF-61-6-115, p. 40-42)

The waste pits and trench No. 5 operated at full capacity for the entire quarter. Heavy rainfall and continued high-volume releases from Building 3019 resulted in a maximum inventory of the system (see Figure 4.2 and Table 4.3).
[1,958 Ci to trench 5 raising total inventory to 6,862 Ci and 1,992 Ci to pits 2, 3, and 4 raising total inventory to 471,985 Ci. Isotopic compositions of these discharged activities is also presented. From Fig. 4.2, it is estimated that 300,000, 305,000 and 190,000 gal of waste were discharged in April, May, and June, respectively.]

Two leaks developed in the west bank of pit No. 4. An intercepting trench was excavated at the junction of these leaks and liquid accumulations are pumped back to the pit.

The excavation and filling of the new waste trench No. 6 has been completed; and the installation of an access road, power line, and connecting pipeline by August 1 will complete the project. The new 2-in. waste line is currently being held in standby pending the installation of valve stations for future facilities. In the meantime, the old waste line is being used.

End of this Series. The next two Operations Division Quarterly Reports (ORNL-CF-61-9-68 and ORNL-CF-61-12-78) contain no information on radioactive waste management operations.

Appendix B
Excerpts of Operations Division's Reports

Excerpts from Laboratory Facilities - Waste Disposal Monthly Reports

Pertaining to the Seepage Pits and Trenches.

The first five monthly reports do not bear ORNL-CF-numbers but copies were obtained from the files of L. C. Lasher (ORNL Operations Division). These reports were prepared by J. F. Manneschmidt until February, 1963, when L. C. Lasher assumed responsibility for their production.

July, 1961 (p. 2)

The waste pits and Trench No. 5 continue to operate at maximum inventory. Major contributors of intermediate level waste for the month of July were as follows: Building 3019 (37,000gal), Reactor Operations (29,000gal), Fission Products Development Laboratory, Bldg. 3517 (27,000gal), Radioisotopes Processing Area (24,000gal), and Segmenting Cells, Bldg. 3026 (13,000gal). Activity transfer data for the system are given in Table 3; volumes are shown in Figure 2.
[Fig. 2. indicates 140,000 gal to pits and trench 5; 477 Ci to trench 5 and 482 Ci to pits 2, 3, and 4; isotopic data by ^{89}Sr, ^{90}Sr, ^{106}Ru, ^{137}Cs, and TRE presented.]

Chemical treatment of Trench No. 6 was initiated this month. The trench was filled with 0.07 M copper sulfate solution and will be allowed to seep dry before the introduction of radioactive waste. A total of 20,000 lbs. of $CuSO_4.5H_2O$ in approximately 140,000 gals of water was used in this operation. Normal usage of the trench is anticipated by mid-September. At that time, filling and sealing of the open pits will proceed.

August, 1961

[Report not located.]

September, 1961 (p. 1-2)

Over 240,000 gallons of intermediate level waste containing 1300 curies of activity were disposed of during the month. This volume is slightly less than that processed during July or August and is about equal to the monthly average for 1961. Major contributors to the system during September were as follows:.....
Activity transfer data for the system are given in Table 3; volumes are shown in Figure 2.
[Fig. 2 indicates that in August, 1961 (the previous month for which a report was not located) 260,000 gal were disposed. Also, by subtracting the year-to-date total curies for this month from that reported in July, 1961, the activities discharged in August were obtained: 5,014 - 4,487 = 527 Ci to trench 5 and none to pits 2, 3, or 4. Table 3 indicates 666 curies were discharged to trench 6.]

Trench No. 6 assumed operational status on September 7 and during the balance of the month received 125,000 gallons of waste. Approximately 25% of Pit No. 3 was backfilled during September and it is estimated that filling and sealing will be completed by February 1962.

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October, 1961 (p. 1-2)

The break-through of activity was located on the slope south of Trench No. 6 early this month. The radiation field in the contaminated area was greater than 20 mr/hr at contact and abnormal amounts of Sr and Cs were detected in the seepage. The trench was taken out of service at this time, and waste was rerouted to Pits Nos. 2 and 4. The total volume of intermediate level waste transferred during the month was 309,000 gals. (Figure 2), with the major contributors, as follows:....
[Trench 5 received 6,034 Ci., trench 6 378 Ci., and Pits 2 and 4 received 5,777 Ci. Trench 6 was in operation from September 7 to October 10, 1961 only. Isotopic data for the discharges to each trench is also given and, since September, 1961, includes differentiation of ^{60}Co.]

November, 1961 (p. 1-2)

A total of 240,000 gals. of intermediate level waste was transferred to Pits 2 and 4 and to Trench No. 5 during the month of November. (Figure 2). Trench No. 6 remains out of service due to the activity break-through reported last month. This break-through is being studied by the E & M Division and, if corrective measures can be taken to insure safe operation, Trench No. 6 may again become operable. Major contributors to the intermediate level waste system were as follows: .....
More complete data on the activity transferred to the pits and trenches are given in Table 3.
[Table 3 indicates that 4,773 Ci went to trench 5 and 3,600 Ci went to Pits 2 and 4 this month. Isotopic data on these waste transfers is also presented.]

Report for December 1961 (ORNL-CF-62-2-55, p. 1-2)

A total of 409,000 gals. of intermediate level waste were transferred to the soil disposal areas during the month (Figure 2). This represents a volume increase of 70% over the total reported for November. Heavy rainfall and clean-up activities the building 3505 storage canal contributed to this surge. Major users of the system were as follows: .....
More complete data on the intermediate level waste activity transfers are given in Table 3.
[372 Ci went to trench 5 and 2,469 Ci went to pits 2 and 4 yielding total inventories to date of 19,717 and 500,360 Ci, respectively. Isotopic data for Sr, Ru, Cs, and TRE is also given.]

Report for January 1962 (ORNL-CF-62-3-38, p. 5)

[Routine reporting of 340,000 gals transferred; 569 Ci to trench 5 and 1,516 Ci to pits 2 and 4 with isotopic composition.]

Report for February 1962 (ORNL-CF-62-4-49, p. 6)

[Routine reporting of 240,000 gal transferred; 1,717 Ci to trench

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5 and 1,418 Ci to pits 2 and 4 with isotopic data including ^{60}Co.]

Report for March 1962 (ORNL-CF-62-5-64, p. 5)

Storage facilities for intermediate level waste remained filled to capacity and nearly 400,000 gallons were transferred to the disposal area. This represents an increase of 70% over the month of February. Major contributors to the ILW system were as follows:.....

A site was selected for a new covered storage trench [No. 7] and preliminary design of the facility was begun. ILW volumes are shown in Figure 2; transfer data are given in Table 3.
[2,448 Ci to trench 5 and 5,778 Ci to pits 2 and 4 with isotopic composition.]

Report for April 1962 (ORNL-CF-62-6-10, p. 7-9)

275,000 gallons of intermediate level waste was transferred to the disposal area during the month of April. (See Liquid Waste Volumes, Fig. 2). This is a 30% reduction below the volume pumped in March and is attributed to a decrease in rainfall during the month and completion of repair work on leaking waste lines in the Radioisotopes Processing Area. The volume of waste received into the system invariably goes up during wet weather because of leakage into lines, accumulation of water in pump pits, and for other reasons. Discharges from the Metal Recovery Building canal continue to be abnormally high and will probably remain so until the present temporary operations being carried out at that laboratory are completed. In spite of the reduction in intermediate level waste volume experienced during this month, the volume was still above the monthly average for 1960 and 1961. Transfer data on ILW disposal is given in Table 3.
[2,366 Ci to trench 5 and 2,748 Ci to pits 2 and 4 with isotopic composition including ^{60}Co.]

The back filling of waste pit No. 3 was resumed this month and only 300 sq ft of the surface area remains uncovered. The preliminary design work for trench No. 7 was begun.

Report for May 1962 (ORNL-CF-62-7-16, p. 4)

[Routine reporting of 415,000 gallons transferred; 1,302 Ci to trench 5 and 3,470 Ci to pits 2 and 4 with isotopic composition.]

Report for June 1962 (ORNL-CF-62-8-7, p. 5)

[Routine reporting of 380,000 gallons transferred; 968 Ci to trench 5 and 1,800 Ci to pits 2 and 4 with isotopic composition.]

Report for July 1962 (ORNL-CF-62-8-78, p. 5)

[Routine reporting of 420,000 gallons transferred; 1,656 Ci to trench 5 and 2,844 Ci to pits 2 and 4 with isotopic composition data.]
Open waste pit No. 3 was backfilled and sealed with asphalt during the period, and, late in the month, construction of covered trench No. 7 was started. Completion of this facility is expected by the end of August.

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Report for August 1962 (ORNL-CF-62-10-39, p. 5)

[Routine reporting of 265,000 gallons transferred; 221 Ci to trench 5 and 217 Ci to pits 2 and 4 with isotopic compositions.]

Report for September 1962 (ORNL-CF-62-11-24, p. 6)

[Routine reporting of 295,000 gallons transferred; 1,615 Ci to trench 5 and 953 Ci to pits 2 and 4 with isotopic compositions.]

Disposal Trench No. 7 was completed during the month and the Laboratory assumed beneficial occupancy of the facility. The trench was pretreated by filling with 50,000 gallons of 4% NaOH solution which was allowed to seep out. This operation was accomplished in less than a week which indicated a very rapid seepage rate for the trench. By comparison, seepage of pretreatment solution from Trench No. 5 took over a month.

The first pumping of waste into trench No. 7 is scheduled for the first week in October. Open pits Nos. 3 and 4 are now out of service and the use of pit No. 2 will be discontinued when Trench No. 7 becomes operable. ILW transfer data for September is given in Table 4.

Report for October 1962 (ORNL-CF-62-12-2, p. 6)

Transfers totalling approximately 350 thousand gallons were made from the ILW collection system to the soil disposal system during the month of October (See Figure 2). The two units of Trench No. 7 were put into operation on October 4 and during the remainder of the month 37% of the total volume of waste was pumped to that facility. Only about 13% of the intermediate waste was pumped to the open pit system (Pit No. 2) and in the near future that unit will be taken out of service.

The monitoring wells in the vicinity of the disposal trenches and the drainage system for the immediate area are surveyed on a weekly basis. To date, no significant quantities of radioactivity have been found.

[Routine reporting of the activity discharges is presented; 685 Ci to pit 2, 3,110 Ci to trench 5, 910 Ci to trench 7A, and 937 Ci to 7B with isotopic compositions.]

Report for November 1962 (ORNL-CF-63-1-23, p. 6)

November transfers of intermediate-level waste to the soil disposal area totalled 340 thousand gallons (See Figure 2).

Distribution was made to the pits and trenches , as follows: [pit No. 2 = 78,660, trench 5 = 160,200, trench 7A = 50,400, and Trench 7B = 51,600 gallons]

The operation of trench 7 has been continued at a rate far below its capacity. Small amounts of radioactivity have been detected in two monitoring wells located on the east side of the north (A) section of Trench No. 7. Although the level of activity, which is predominantly ruthenium, was almost insignificant, continuing surveillance of the wells will be maintained.

Pit No. 2 was taken out of service late in the month and back-fill operations started. Pit No. 4 will continue to be used for the disposal of sludge from the Waste Treatment Plant and as a stand-by facility.

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[pit 2 received 716 Ci, trench 5 923 Ci, Trench 7A 222 Ci, and Trench 7B 485 Ci with isotopic compositions.]
[This month was the last use of pits 2, 3, and 4 area. The total activity discharged to pit 2 during 1961 is given: 1,657 Ci of ^{90}Sr, 757 Ci of ^{106}Ru, 12,889 Ci of ^{137}Cs, 855 Ci of TRE, and a total of 16,148 Ci. The 1962 totals are also given: 1513 Ci of ^{90}Sr, 741 Ci of ^{106}Ru, 17,561 Ci of ^{137}Cs, 111 Ci of ^{60}Co, and 21,070 Ci total. The total activity discharged to the pits in the period of use is stated as 522,505 Ci but this cannot be subdivided among the pits because of their method of operation; this figure cannot be subdivided into isotopes either since previous to 1960 only gross beta counts were determined.]

Report for December 1962 (ORNL-CF-63-1-73, p. 6)

[160,500 gal to trench 5, 97,900 gal to trench 7A, and 63,900 gal to trench 7B]
Filling operations at Pit No. 2 are still in progress; completion by late January is anticipated.
Complete transfer data on this system is given in Table 4.
[1,203 Ci to trench 5, 869 Ci to trench 7A, 567 Ci to trench 7B with isotopic compositions. No discharge to pits.]

Report for January 1963 (ORNL-CF-63-3-39, p. 4-8)

[Routine reporting of 169,200 gal (2273 Ci) to trench 5, 87,000 gal (1,663 Ci) to trench 7A, and 84,900 gal (1,629 Ci) to trench 7B with isotopic compositions.]
Pit No. 2 has been completely back-filled and, with Pit No. 3, is now permanently out of service. Pit No. 4 remains open and is used as a disposal facility for sludge from the waste treatment plant.
Complete transfer data on the ILW system is given in Table 4.

Report for February 1963

[Report not found]

Report for March 1963 (ORNL-CF-63-5-14, p. 8)

[Routine reporting of 98,400 gal (1790 Ci) to trench 5, 108,000 gal (1726 Ci) to trench 7A, and 94,800 gal (1533 Ci) to trench 7B with isotopic compositions.]
Analyses of samples taken from the trench 7 drainage area indicate that the approximate rates of release of strontium, ruthenium, and cobalt are as listed below:

$Sr^{89\ 90}$	<1.6 microcuries/day
Ru^{106}	20 mc/day
Co^{60}	6 mc/day

Report for April 1963 (ORNL-CF-63-5-75, p. 8)

[Routine reporting of 164,400 gal (112 Ci) to trench 5, 39,000 gal (no total Ci given) to trench 7A, and 97,200 gal (no total Ci given) to trench 7B although there are isotopic compositions.]

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Report for May 1963 (ORNL-CF-63-6-44, p. 1-8)

[Routine reporting of 180,000 gal (5376 Ci) to trench 5, 100,800 gal (3221 Ci) to trench 7A, and 109,200 gal (3600 Ci) to trench 7B with isotopic compositions.]
Analyses of composite samples taken at the trench 7 drainage areas indicate that the approximate rates of release of strontium, ruthenium, cesium and cobalt are as listed below:

1. Strontium 3 microcuries per day
2. Cesium 66 microcuries per day
3. Ruthenium 61 millicuries per day
4. Cobalt 24 millicuries per day

Report for June 1963 (ORNL-CF-63-8-4, p. 7)

[Routine reporting of 178,800 gal (2550 Ci) to trench 5, 109,200 gal (2142 Ci) to trench 7A, and 120,000 gal (2255 Ci) to trench 7B with isotopic compositions.]

Report for July 1963 (ORNL-CF-63-8-64, p. 6-10)

[Routine reporting of 189,800 gal (4759 Ci) to trench 5, 230,400 gal (8484 Ci) to trench 7A, and 125,400 gal (4242 Ci) to trench 7B with isotopic compositions.
The abnormally high volumes resulted from accelerated processing activities and a faulty pipe connection to the system in Building 3019. Increased volumes were also received from the Radioisotopes Processing Area and the Reactor Area. A transfer of 49,000 gallons of supernatant from the metal waste system to the intermediate-level system also contributed to the excessive volume.]

Report for August 1963 (ORNL-CF-63-10-5, p. 9)

[Routine reporting of 180,200 gal (12,259 Ci) to trench 5, 77,600 gal (4105 Ci) to trench 7A, and 95,600 gal (5051 Ci) to trench 7B with isotopic compositions mostly ^{137}Cs to trench 5.]

Report for September 1963 (ORNL-CF-63-11-10, p. 8)

[Routine reporting of 173,200 gal (10,209 Ci) to trench 5, 63,800 gal (4403 Ci) to trench 7A, and 90,400 gal (6604 Ci) to trench 7B with isotopic compositions, mostly ^{137}Cs to trench 5.]

Report for October 1963 (ORNL-CF-63-12-11, p. 7)

[Routine reporting of 102,000 gal (7325 Ci) to trench 5, 46,800 gal (1233 Ci) to trench 7A, and 87,000 gal (2311 Ci) to trench 7B with isotopic compositions.]

Report for November 1963 (ORNL-CF-64-1-28, p. 7)

[Routine reporting of 117,600 gal (900 Ci) to trench 5, 95,000 gal (950 Ci) to trench 7A, and 66,000 gal (654 Ci) to trench 7B with

isotopic compositions.]

Report for December 1963 (ORNL-CF-64-2-30, p. 8)

[Routine reporting of 72,000 gal (1681 Ci) to trench 5, 99,600 gal (2458 Ci) to trench 7A, and 93,600 gal (2307 Ci) to trench 7B with isotopic compositions.]

Report for January 1964 (ORNL-CF-64-3-21, p. 6-9)

[Routine reporting of 122,400 gal (2520 Ci) to trench 5, 147,600 gal (3979 Ci) to trench 7A, and 108,000 gal (2652 Ci) to trench 7B with isotopic compositions.]

Report for February 1964 (ORNL-CF-64-3-57, p. 6-10)

[Routine reporting of 80,400 gal (807 Ci) to trench 5, 184,000 gal (4258 Ci) to trench 7A, and 88,200 gal (2840 Ci) to trench 7B with isotopic compositions.]
Analyses of grab samples, taken at intervals of approximately two months, indicate that there is no significant movement of radioactive strontium in the seep streams from the covered trenches to the creek and that the ruthenium being released from the same trenches is only a small fraction of the amount being released from the area of the waste pits that have been taken out of service. Two of the waste pits have been filled and will be covered with an asphalt pavement as soon as weather permits the asphalting operation. The third pit [No. 4] remains open and is being used for disposal of the Process Waste Treatment Plant Lime-soda ash-clay sludge.

Report for March 1964 (ORNL-CF-64-4-87, p. 9)

[Routine reporting of 98,200 gal (1105 Ci) to trench 5, 163,800 gal (857 Ci) to trench 7A, and 112,200 gal (572 Ci) to trench 7B with isotopic compositions.]

Report for April 1964 (ORNL-CF-64-5-68, p. 6-9)

[Routine reporting of 91,800 gal (889 Ci) to trench 5, 166,900 gal (4302 Ci) to trench 7A, and 85,400 gal (2868 Ci) to trench 7B with isotopic compositions.]
An additional 52,500 gallons of waste was pumped to the Shale Fracturing Area for experimental disposal.

Report for May 1964 (ORNL-CF-64-7-6, p. 2-3)

[Routine reporting of 150,200 gal (2580 Ci) to trench 5, 176,600 gal (4997 Ci) to trench 7A, and 97,600 gal (3331 Ci) to trench 7B with isotopic compositions.]
An additional 20,000 gallons of waste was pumped to the Shale Fracturing Area for experimental disposal.

Report for June 1964 (ORNL-CF-64-7-63, p. 2)

Appendix B
Excerpts of Operations Division's Reports

[Routine reporting of 141,600 gal (1387 Ci) to trench 5, 137,200 gal (1762 Ci) to trench 7A, and 70,400 gal (881 Ci) to trench 7B with isotopic compositions.]

Report for July 1964 (ORNL-CF-64-8-77, p. 2)

[Routine reporting of 150,200 gal (5796 Ci) to trench 5, 137,200 gal (4869 Ci) to trench 7A, and 82,400 gal (2435 Ci) to trench 7B with isotopic compositions.]

Report for August 1964 (ORNL-CF-64-9-63, p. 2)

[Routine reporting of 182,800 gal (9089 Ci) to trench 5, 169,700 gal (6923 Ci) to trench 7A, and 121,600 gal (5014 Ci) to trench 7B with isotopic compositions.]

Report for September 1964 (ORNL-CF-64-10-57, p. 2)

[Routine reporting of 172,432 gal (3500 Ci) to trench 5, 146,735 gal (7128 Ci) to trench 7A, and 92,877 gal (4112 Ci) to trench 7B with isotopic compositions.]

Report for October 1964 (ORNL-CF-64-12-15, p. 2-3)

[Routine reporting of 169,464 gal (34,003 Ci) to trench 5, 144,918 gal (23,911 Ci) to trench 7A, and 102,265 gal (16,937 Ci) to trench 7B with isotopic compositions - mainly ^{137}Cs.]
The total of 73,000 curies of ^{137}Cs shown as transferred during this month, as well as other ^{137}Cs transferred in previous months, cannot be reconciled with the analyses of wastes of the Fission Product Development Laboratory, the main source of ^{137}Cs. Arrangements have been made to isolate and to sample and analyze the FPDL wastes prior to their transfer to the trenches in the future.

Report for November 1964 (ORNL-CF-64-12-47, p. 2-3)

[Routine reporting of 136,703 gal (2543 Ci) to trench 5, 81,771 gal (1315 Ci) to trench 7A, and 81,451 gal (1315 Ci) to trench 7B with isotopic compositions.]
The waste from the Fission Products Development Laboratory is currently stored separately at the South Tank Farm.

Report for December 1964 (ORNL-CF-65-1-57, p. 2-3)

[Routine reporting of 182,850 gal (7027 Ci) to trench 5, 63,320 gal (3162 Ci) to trench 7A, and 69,720 gal (3794 Ci) to trench 7B with isotopic compositions.]
The waste from the Fission Product Development Laboratory is currently stored separately at the South Tank Farm for possible future reprocessing.
Seep streams draining the Trench 5 and Trench 7 areas were sampled during the month. Estimates of discharges of several nuclides are tabulated below:

Nuclides	Curies Discharged in 31 Days

Appendix B
Excerpts of Operations Division's Reports

1. Strontium 89-90	3.6×10^{-5}
2. Cesium 137	2×10^{-3}
3. Ruthenium 106	2
4. Cobalt 60	1

Report for January 1965 (ORNL-CF-65-3-11, p. 2)

[Routine reporting of 133,120 gal (953 Ci) to trench 5, 149,570 gal (1807 Ci) to trench 7A, and 105,370 gal (1321 Ci) to trench 7B with isotopic compositions.]

Report for February 1965 (ORNL-CF-65-3-55, p. 3)

[Routine reporting of 119,700 gal (145 Ci) to trench 5, 140,160 gal (321 Ci) to trench 7A, and 88,190 gal (201 Ci) to trench 7B with isotopic compositions.]

Report for March 1965 (ORNL-CF-65-5-15, p. 2-3)

[Routine reporting of 103,619 gal (791 Ci) to trench 5, 184,484 gal (4620 Ci) to trench 7A, and 84,913 gal (2087 Ci) to trench 7B with isotopic compositions.]

Report for April 1965 (ORNL-CF-65-5-52, p. 2-3)

[Routine reporting of 123,853 gal (3944 Ci) to trench 5, 211,464 gal (7713 Ci) to trench 7A, and 81,547 gal (3000 Ci) to trench 7B with isotopic compositions.]

A total of 416,864 gallons of waste was pumped to the ground disposal area this month. Included in this amount was part of the backlog of contaminated water accumulated during heavy rainfall and 10,000 gallons from the Melton Valley area.

Report for May 1965 (ORNL-CF-65-6-53, p. 2)

[Routine reporting of 149,426 gal (4299 Ci) to trench 5, 110,413 gal (2350 Ci) to trench 7A, and 89,348 gal (1852 Ci) to trench 7B with isotopic compositions.]

Curium-242 was detected this month in the east seep stream from trench 7 and in the White Oak Dam discharge to Clinch River. Although the amount released was not significant and will not become serious because of the small amount (62 curies) put into that trench, it has become apparent that the trench cannot be used for disposal of large quantities of curium. Arrangements have been made to hold curium-bearing wastes in storage tanks until the waste evaporator is put into operation and trench disposal of wastes is discontinued.

Report for June 1965 (ORNL-CF-65-8-11, p. 2)

[Routine reporting of 152,300 gal (1802 Ci) to trench 5, 87,800 gal (835 Ci) to trench 7A, and 112,300 gal (1057 Ci) to trench 7B with isotopic compositions.]

Report for July 1965 (ORNL-CF-65-9-10, p. 2)

Appendix B
Excerpts of Operations Division's Reports

[Routine reporting of 137,674 gal (4964 Ci) to trench 5, 89,374 gal (1701 Ci) to trench 7A, and 91,813 gal (1701 Ci) to trench 7B with isotopic compositions.]

Report for August 1965 (ORNL-CF-65-9-62, p. 2)

[Routine reporting of 164,869 gal (26,543 Ci) to trench 5, 53,213 gal (4234 Ci) to trench 7A, and 125,891 (10,349 Ci) to trench 7B with isotopic compositions - a lot of total ^{90}Sr without comments.]

Report for September 1965 (ORNL-CF-65-11-7, p. 2)

[Routine reporting of 168,640 gal (15,538 Ci) to trench 5, 49,310 gal (3994 Ci) to trench 7A, and 100,600 gal (7449 Ci) to trench 7B with isotopic compositions - mainly ^{137}Cs to trench 5.]

Report for October 1965 (ORNL-CF-65-12-18, p. 2)

[Routine reporting of 173,690 gal (72,259 Ci) to trench 5, 60,470 gal (3,967 Ci) to trench 7A, and 100,640 gal (6997 Ci) to trench 7B with isotopic compositions - mainly ^{90}Sr to trench 5.]

Report for November 1965 (ORNL-CF-66-1-20, p. 2)

[Routine reporting of 164,780 gal (5496 Ci) to trench 5, 44,900 gal (1621 Ci) to trench 7A, and 77,800 gal (3,243 Ci) to trench 7B with isotopic compositions - mainly ^{137}Cs.]

Report for December 1965 (ORNL-CF-66-2-21. p. 3)

[Routine reporting of 169,000 gal (3159 Ci) to trench 5, 39,000 gal (1050 Ci) to trench 7A, and 96,000 gal (2624 Ci) to trench 7B with isotopic compositions.]

Report for January 1966 (ORNL-CF-66-3-14, p. 2)

[Routine reporting of a total of 321,000 gallons, without trench breakdown, with 1845 Ci to trench 5, 758 Ci to trench 7A, and 758 Ci to trench 7B with each's isotopic composition.]

Report for February 1966 (ORNL-CF-66-4-19, p. 2)

[Routine reporting of 118,000 gal (2381 Ci) to trench 5, 144,000 gal (3922 Ci) to trench 7A, and 111,000 gal (3105 Ci) to trench 7B with isotopic compositions.]

Report for March 1966 (ORNL-CF-66-5-29, p. 2)

[Routine reporting of 133,000 gal (2481 Ci) to trench 5, 122,000 gal (2321 Ci) to trench 7A, and 111,000 gal (2099 Ci) to trench 7B with isotopic compositions.]

The construction of the 600 gph evaporator was completed this month and test runs, using actual waste, were begun on March 29. The limited

operations experienced thus far have been satisfactory.

Report for April 1966 (ORNL-CF-66-6-32, p. 2-3)

At the end of the month, the evaporator completed 33 days of operation. During this period, a number of operating difficulties were experienced which prevented the processing of all of the waste generated. None of them, however, could be considered serious for a startup of a new plant.

The worst of the difficulties was excessive foaming of some of the waste, which led to an accidental discharge of approximately 10 curies of activity to the process waste system. The operator, not having experienced the great variation in the amount of foam that could be produced by different wastes, applied too much heat at the start of a run of waste that had not been previously processed. The contents of the evaporator foamed up so suddenly that some of the waste carried over to the condensate catch-tank even though the steam to the evaporator coils was automatically cut off before the foam reached the top of the evaporator tank. The catch-tank drain valve, which is supposed to automatically close when excessive activity is measured, failed to operate. It was later found that the valve was made inoperable for testing other equipment prior to the startup of the plant, and it had not been returned to service.

The evaporator operation was begun with a large backlog of waste stored in the tank farm; all tanks were practically full. The total volume processed through the evaporator in April was 340,000 gallons, which is roughly equal to the average volume of waste received each month (see Figure 6). During the month of April, however, the volume was approximately 100,000 gallons above normal so that it became necessary to pump 95,000 gallons of waste to the seepage trenches.

Near the end of the waste transfer to the trenches, a section of plastic pipeline ruptured and approximately 3,000 gallons of waste were spilled in an area just north of trench 7. The total activity was estimated at 100 curies, consisting mainly of cesium and cerium and about 10 curies of strontium. The contamination was covered with approximately five feet of soil and the area was contoured to prevent leaching by surface water. None of the contamination was permitted to reach the creek.

[Routine reporting of the final discharges to trenches 5 and 7; 67,000 gal to trench 5 (3588 Ci) and 28,000 gal to trench 7, 3 and 4 Ci to 7A and 7B, respectively.
The final inventories for trenches 5, 7A, and 7B are given with isotopic compositions:

	Total to Date		
Nuclide	Trench 5	Trench 7A	Trench 7B
Total Sr	96755	24681	23633
^{106}Ru	6385	1873	1523
^{137}Cs	205639	123009	107718
^{60}Co	3045	788	766

Appendix B
Excerpts of Operations Division's Reports

TOTALS	311824	150351	133640

This ends the reporting of discharges to the pits and trenches although the monitoring data for the east and west weirs in the pits 2, 3, and 4 area is continued in the series.
The discharge monitoring of these drainages continues until July, 1968, (ORNL-CF-68-8-51):

"The routine sampling of seeps from the waste pits area at station 5 and 6 (see Figure 7) has been discontinued because the activity measured at these stations has decreased to an insignificant level since the use of the waste pits was discontinued several years ago. In the future, the seeps will be sampled at six-month intervals to check on possible movement of strontium."

However, no reporting was found until the period of February, 1980, (ORNL-CF-80-67) when the routine reporting of the monitoring of ^{90}Sr at the east and west weirs of the pits' drainage areas was resumed.

Appendix C
ORNL Laboratory Records Drawings Related to Seepage Pits and Trenches

ORNL-LR-DWG-4964A 1954
Experimental Pit - Dispersion of nitrate

ORNL-LR-DWG-4965A 1954
Experimental Pit, water table after recharge

ORNL-LR-DWG-4966A 1954
Experimental Pit, normal water table contours

ORNL-LR-DWG-11923 1955
Design of grouted wells near/in pit 4

ORNL-LR-DWG-11924A 1955
Well locations in pits area

ORNL-LR-DWG-11942 1955
Pressure test results of wells in pit 4 area

ORNL-LR-DWG-11944A 1955
Groundwater tracer results at 4 acre site

ORNL-LR-DWG-6631 1955
Generalized geologic section of waste areas

ORNL-LR-DWG-13396A 1956
Water table cross section of pit 4

ORNL-LR-DWG-14172 1956
External radiation levels in pit area May 1956

ORNL-LR-DWG-15480A 1956
Radioactivity logs of boreholes around pit 4

ORNL-LR-DWG-21602 1957
Dispersion of radioactivity near pits Feb 1957

ORNL-LR-DWG-21603R 1957
Radioactivity in wells of pit 4, 1956-57

ORNL-LR-DWG-21681 1957
Movement of radioactivity under pit 4 - 1956

ORNL-LR-DWG-21682 1957
Conceptual design of new pit (trench 5)

ORNL-LR-DWG-25311 1957
Tree sample locations around pits 2,3,and 4

ORNL-LR-DWG-28158 1958
Geologic structure of waste pit area

ORNL-LR-DWG-28159 1958
Water table contour map of pits area Jan, 1958

ORNL-LR-DWG-28161 1958
Pump test results in pit 4 area

Appendix C

ORNL Laboratory Records Drawings Related to Seepage Pits and Trenches

ORNL-LR-DWG-28382 1958
Liquid levels in pits 2,3, 4 - 1955-1957

ORNL-LR-DWG-28383 1958
General geologic cross section in waste areas

ORNL-LR-DWG-28384R 1958
Distribution of radioactivity near pits Feb 1958

ORNL-LR-DWG-29284 1958
Stream flow and radioactivity at pits Apr 4, 57

ORNL-LR-DWG-29285 1958
Stream flow and radioactivity at pits Mar 3, 57

ORNL-LR-DWG-32547R 1958
Tree sample locations around pits 2, 3, 4

ORNL-LR-DWG-39812 1959
Radioactivity discharge in pit area streams 1957

ORNL-LR-DWG-43912 1959
Dispersion of radioactivity near pits May 1958

ORNL-LR-DWG-44013 1959
Dispersion of radioactivity near pits Aug 1958

ORNL-LR-DWG-44387 1959
Dispersion of radioactivity near pits Feb 1957

ORNL-LR-DWG-54430 1961
Waste pit radionuclide inventory through 1960

ORNL-LR-DWG-62129 1962
Typical liquid waste disposal trench design

ORNL-LR-DWG-62143 1962
Index map of waste pit boreholes - deLaguna

ORNL-LR-DWG-62144 1962
Log of borehole 1 southwest of pit 2

ORNL-LR-DWG-62145 1962
Log of borehole 2 south end of pit 2

ORNL-LR-DWG-62146 1962
Log of borehole 3 south of pit 2

ORNL-LR-DWG-62147 1962
Log of borehole 4 east of pit 4

ORNL-LR-DWG-62148 1962
Log of borehole 5 southwest of pit 2

ORNL-LR-DWG-63051 1962
Map of proposed areas for trench 7 (deLaguna)

Appendix C
ORNL Laboratory Records Drawings Related to Seepage Pits and Trenches

ORNL-LR-DWG-70508 1962
Trench 6 groundwater levels June 26, 1962

ORNL-LR-DWG-74624A 1962
Contamination plume around trench 5 Sep 1962

ORNL-DWG-64-7897 1964
Groundwater tritium tracer movement near pit 3

ORNL-DWG-64-929 1964
Longitudinal cross section of pit 3 postclosure

ORNL-DWG-74-9604 1974
Seep locations around pits and trenches

ORNL-DWG-75-5575 1975
Trench to dispersion model of Kd=100 species

ORNL-DWG-75-5576 1975
Trench discretization and head to stream model

ORNL-DWG-76-1519 1976
Monitoring well locations near Trench No. 7

ORNL-DWG-76-7075 1976
Pressure, moisture, and conductivity relations

ORNL-DWG-76-7076 1976
Rainfall boundary model conditions May 1972

ORNL-DWG-76-7077 1976
Trench 7 simulated tritium migration

ORNL-DWG-76-7078 1976
Trench 7 water table and head simulations

ORNL-DWG-76-7080 1976
Cross sectional discretization of trench 7

ORNL-DWG-81-14036ESD 1981
Trench 7 Groundwater Flow Paths to Seep

ORNL-DWG-81-14037ESD 1981
Plan cross section of trench 7

ORNL-DWG-81-21573B 1981
Stratigraphic exposure on roadcut east of T7

ORNL-DWG-82-13318 1982
Generalized Stratigraphy around X-10 (ORNL)

ORNL-DWG-83-12417 1983
Yearly groundwater levels around trench 7

ORNL-DWG-83-12418 1983
Weekly groundwater levels around trench 7

Appendix C
ORNL Laboratory Records Drawings Related to Seepage Pits and Trenches

ORNL-DWG-83-12419 1983
233-U vs. Phosphorus/pH at well T7-21 at trench 7

ORNL-DWG-83-12602 1983
Topographic map of pits and trenches area

ORNL-DWG-83-13887R2 1983
Stratigraphic column of Conasauga formation

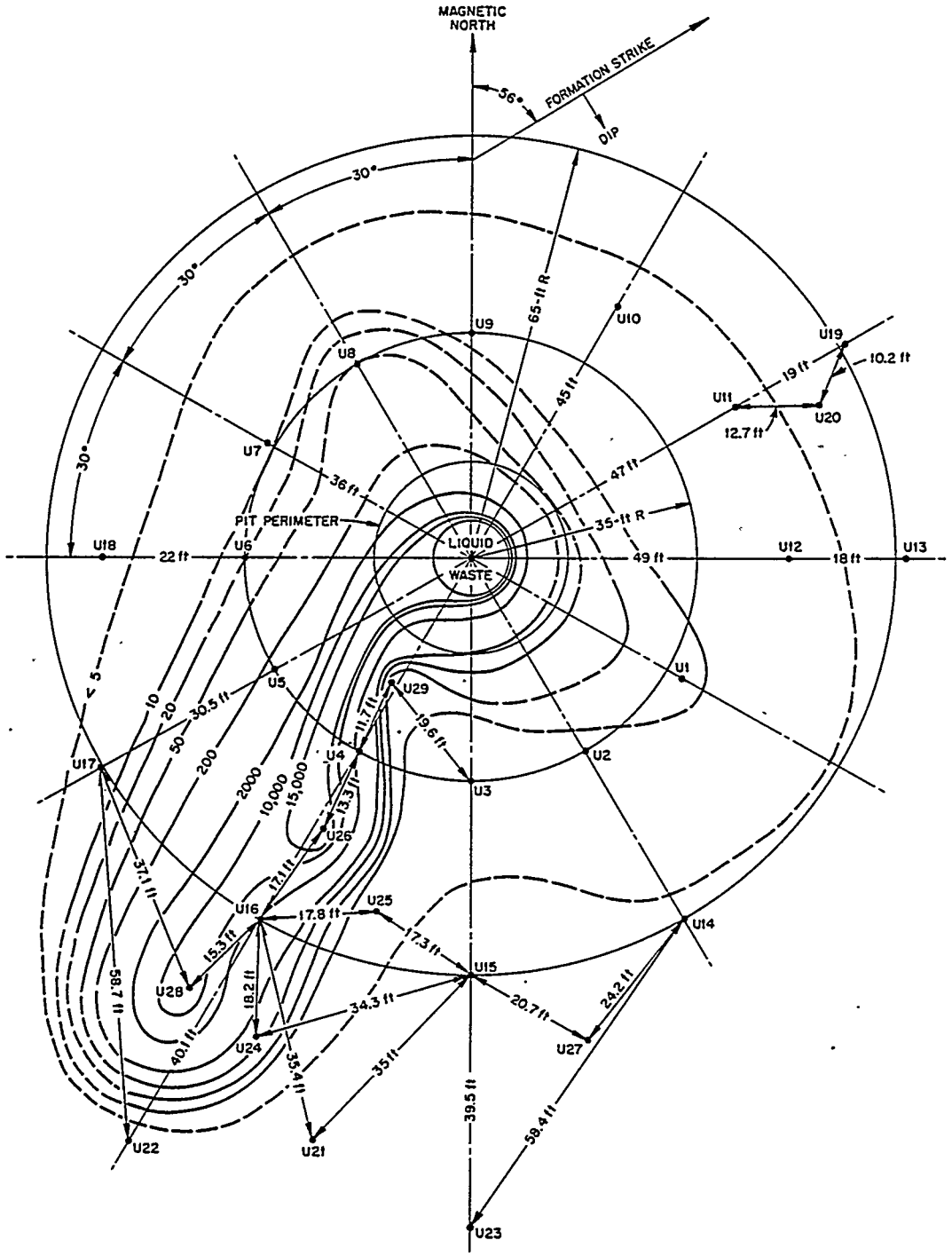
ORNL-DWG-83-1514A 1983
Map of monitoring well locations around trench 7

ORNL-DWG-83-1515 1983
Stratigraphic exposure east of trench 7

ORNL-DWG-83-1555 1983
Gamma activity profiles of wells near trench 7

ORNL-DWG-83-1556 1983
Gamma activity log of well T7-20 at trench 7

ORNL-DWG-83-1558 1983
Lithologic, 137-Cs, 60-Co profiles north trench 7

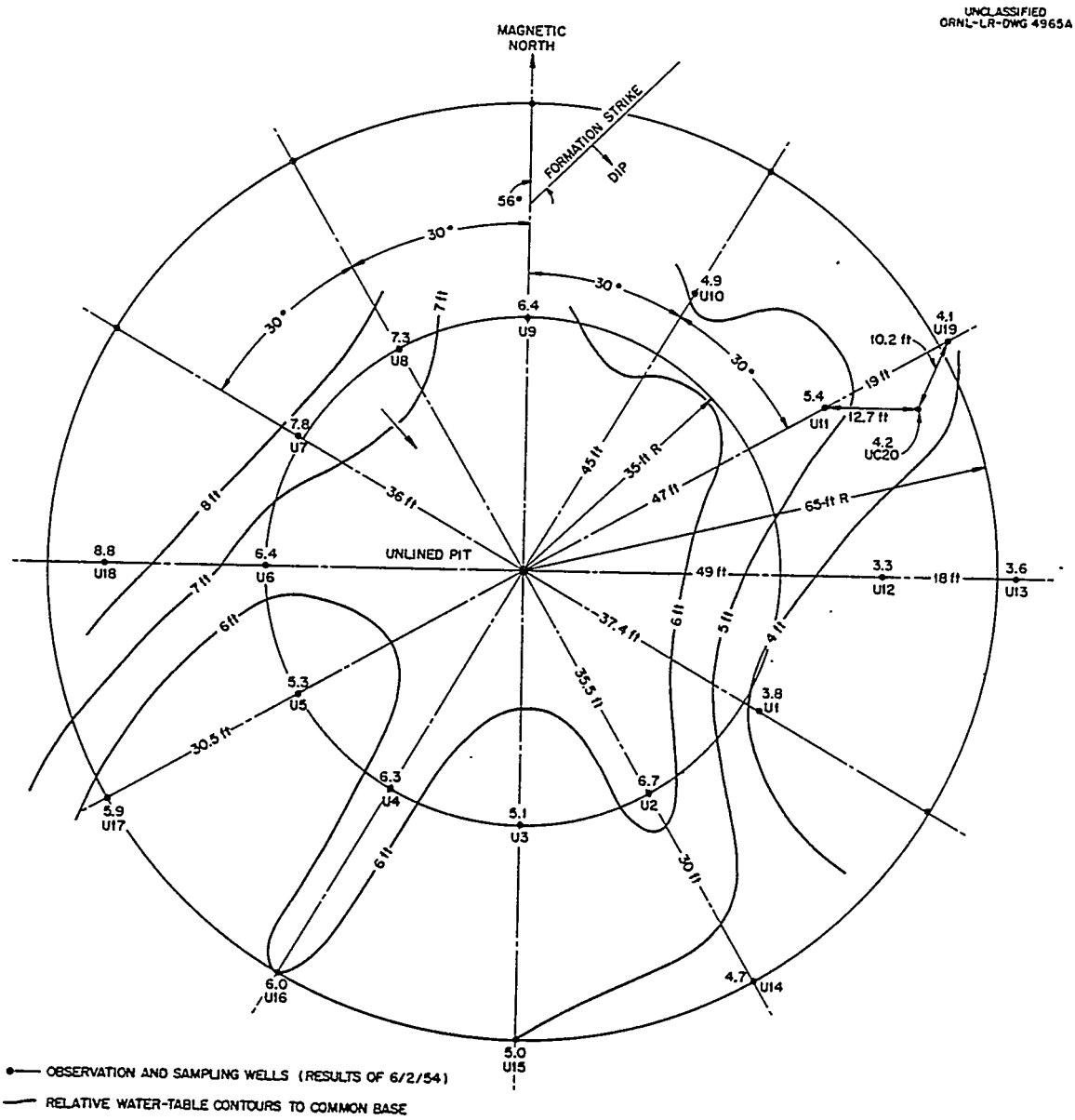


● —— OBSERVATION AND SAMPLING WELLS (RESULTS OF 9/13-14/54)

—— NITRATE CONTAMINATION CONTOURS IN PARTS PER MILLION BASED ON FIELD AND LABORATORY ANALYSIS—LOCATION APPROXIMATE

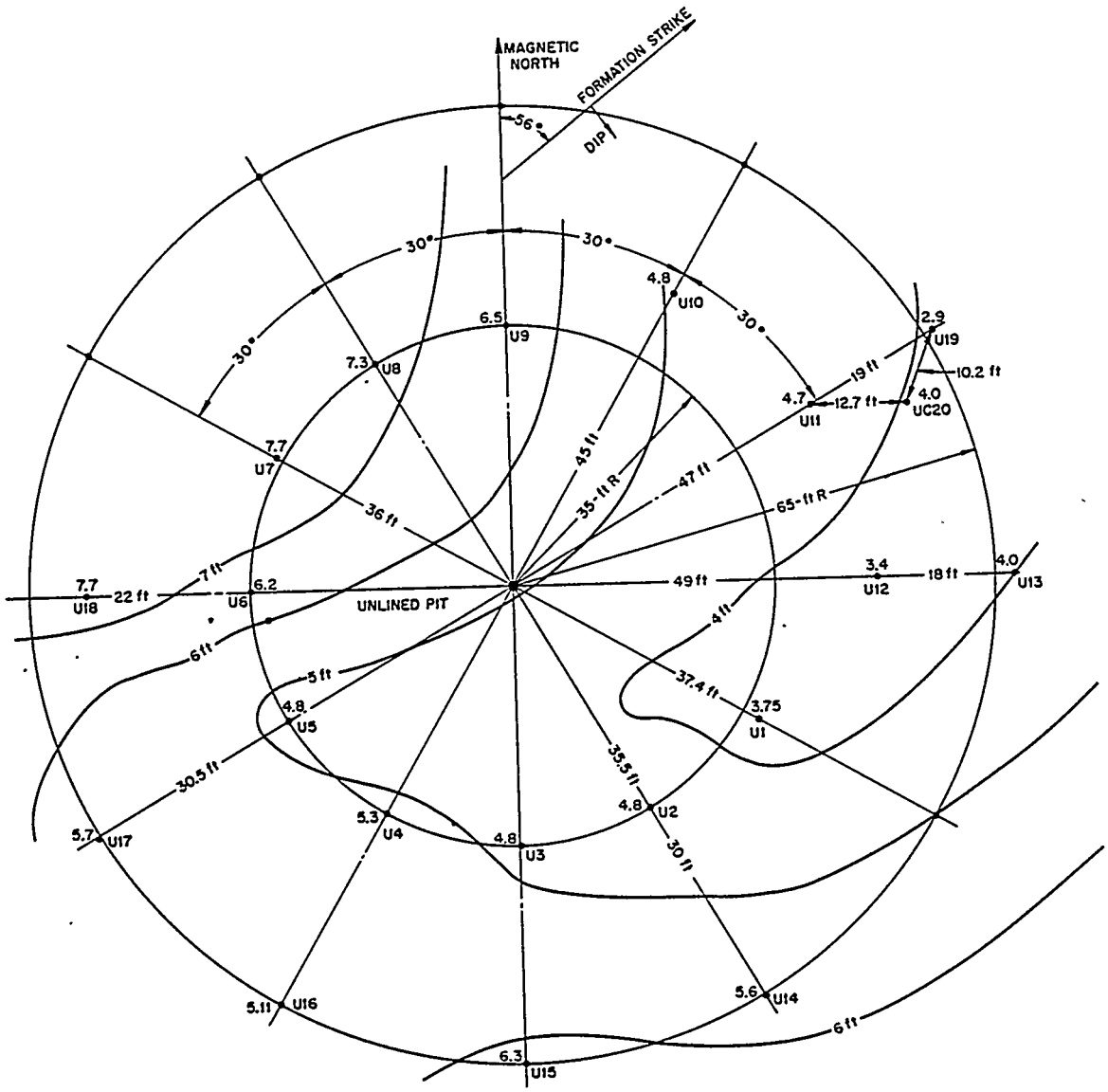
—— NITRATE CONTAMINATION CONTOURS—LOCATION INFERRED OR PROJECTED

ORNL-LR-DWG-4964A 1954
Experimental Pit - Dispersion of nitrate

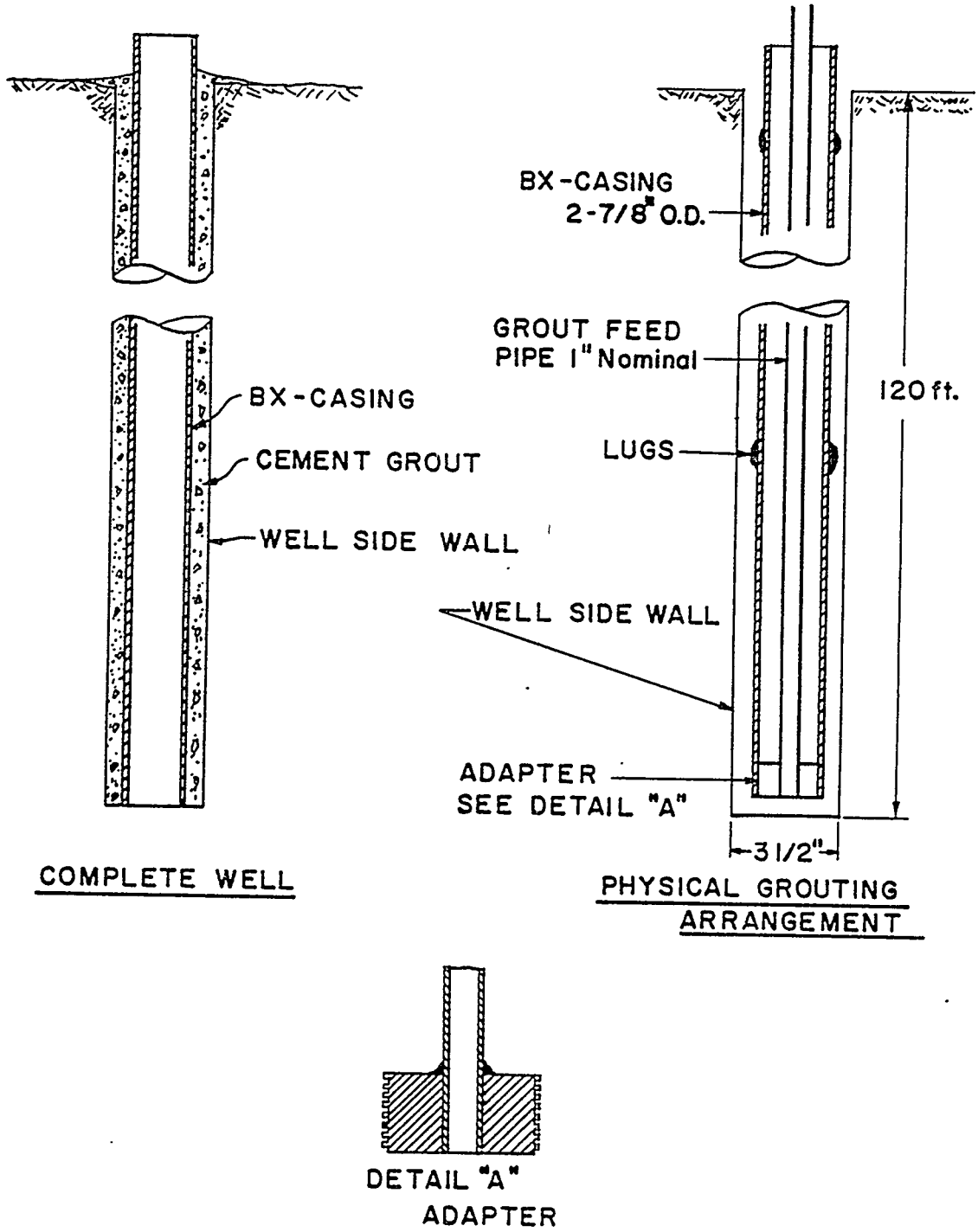


ORNL-LR-DWG-4965A 1954
Experimental Pit, water table after recharge

UNCLASSIFIED
ORNL-LR-DWG 4966A



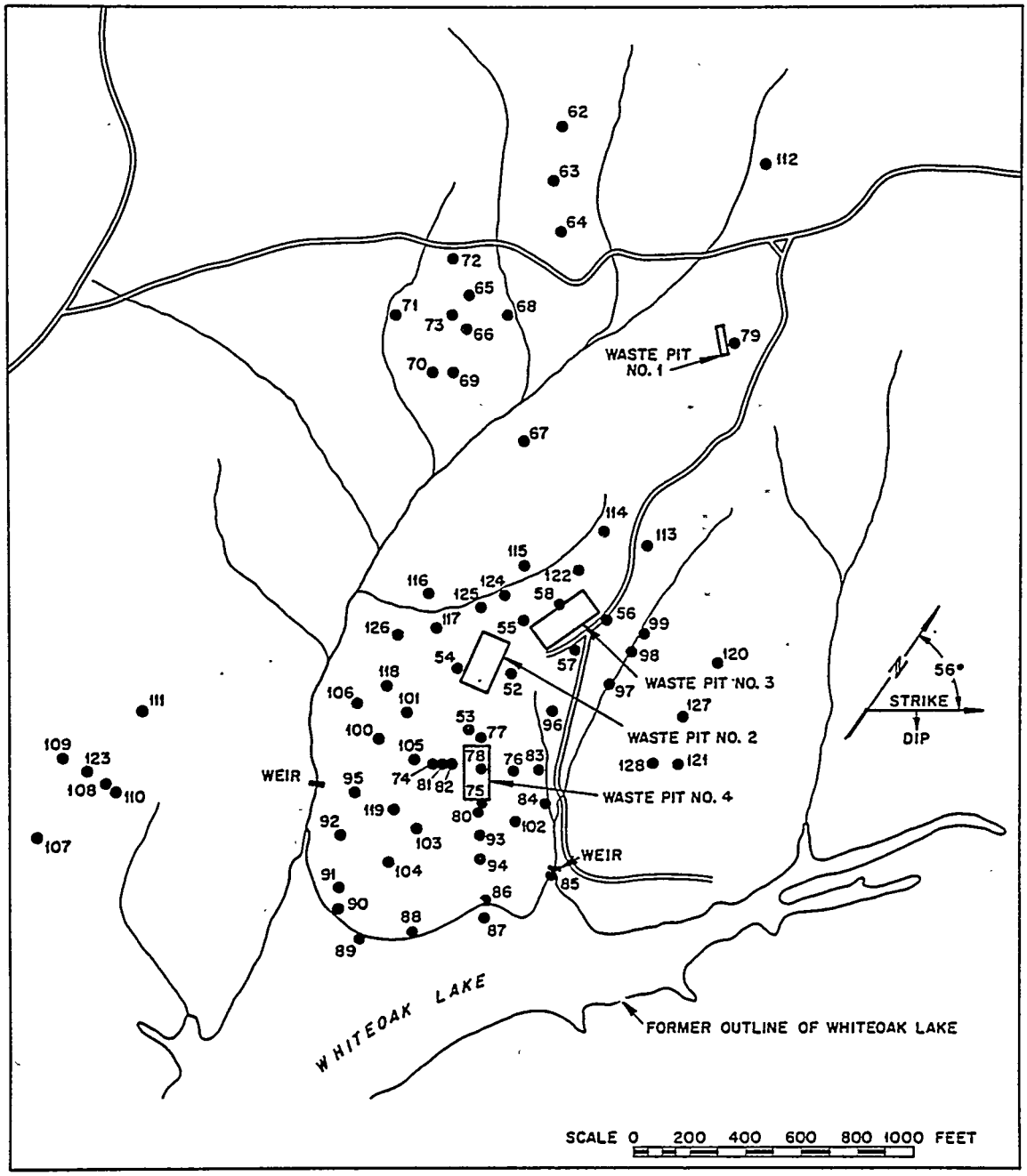
ORNL-LR-DWG-4966A 1954
Experimental Pit, normal water table contours



GROUTED WELL DETAILS

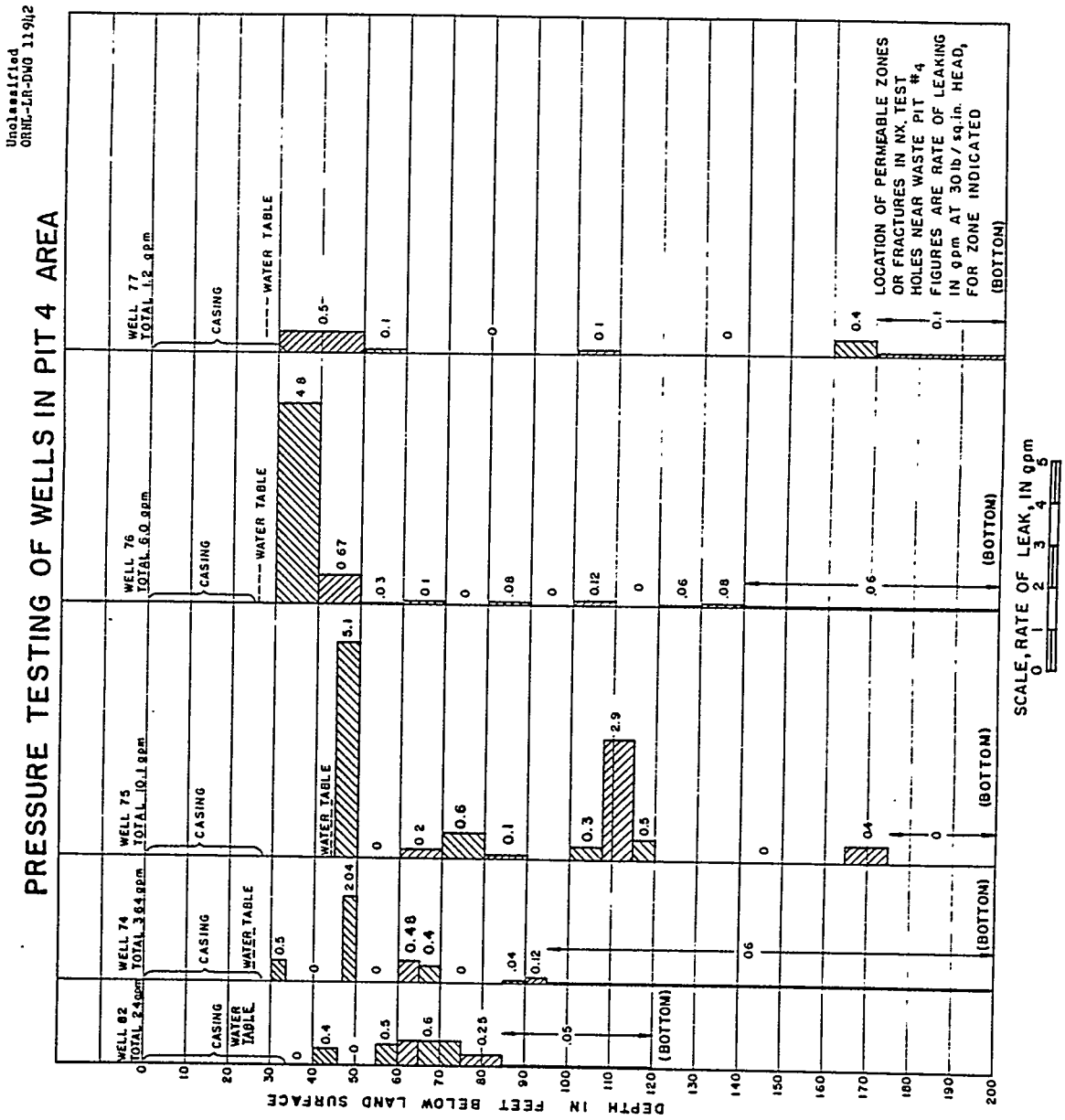
ORNL-LR-DWG-11923 1955
Design of grouted wells near/in pit 4

UNCLASSIFIED
ORNL-LR-DWG 11924A

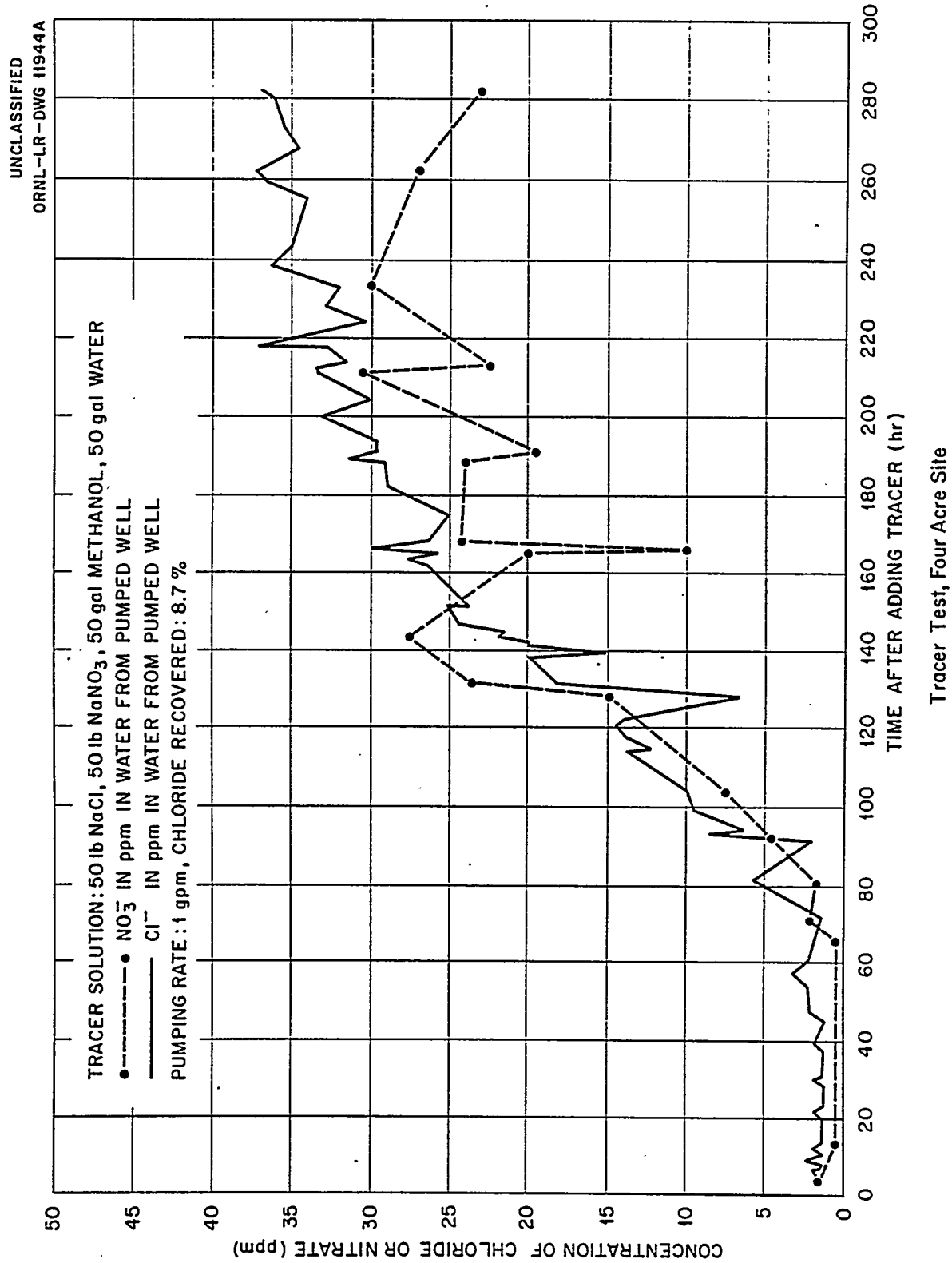


Waste Pit Disposal Area.

ORNL-LR-DWG-11924A 1955
Well locations in pits area



ORNL-LR-DWG-11942 1955
Pressure test results of wells in pit 4 area



ORNL-LR-DWG-11944A 1955
Groundwater tracer results at 4 acre site

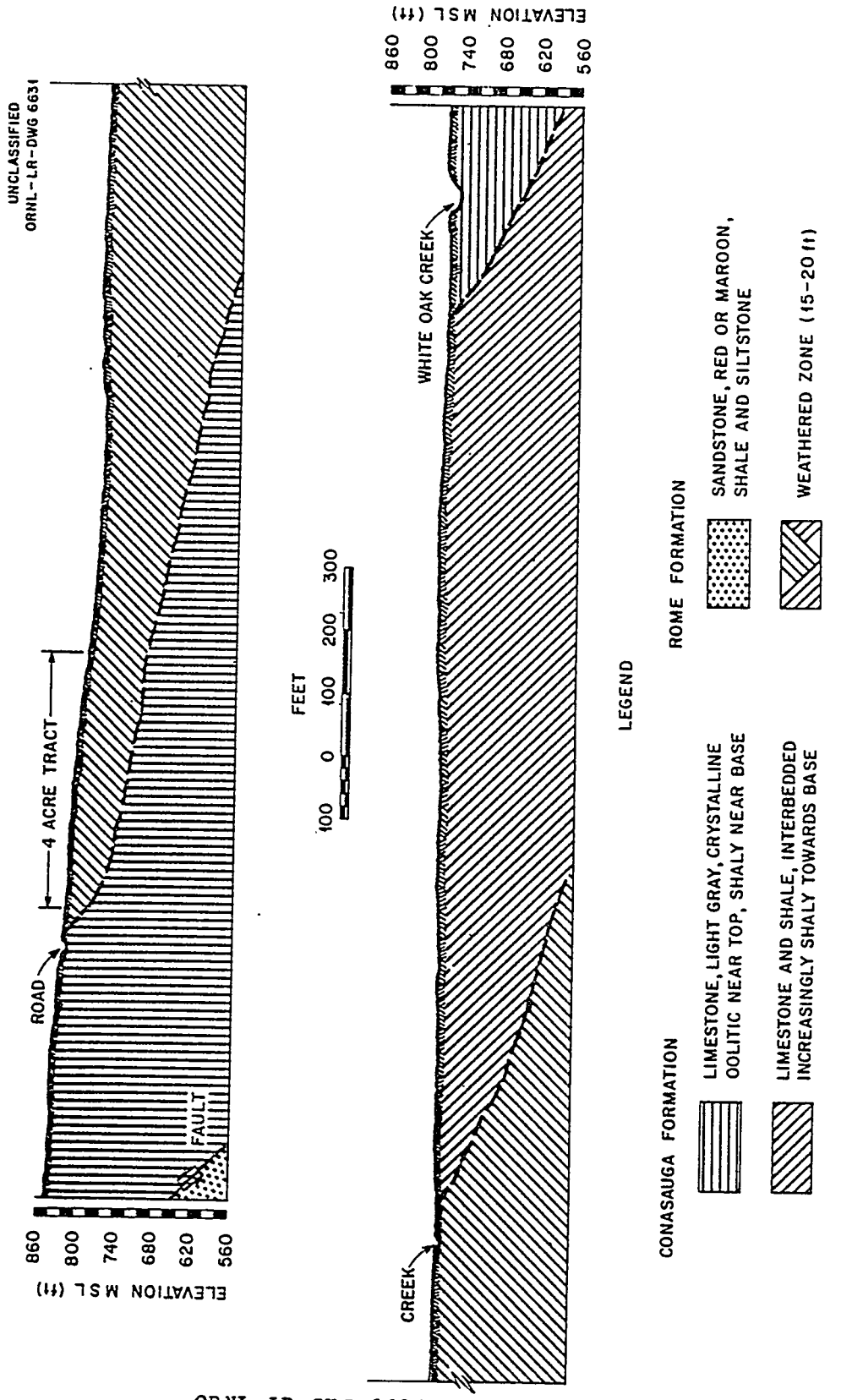
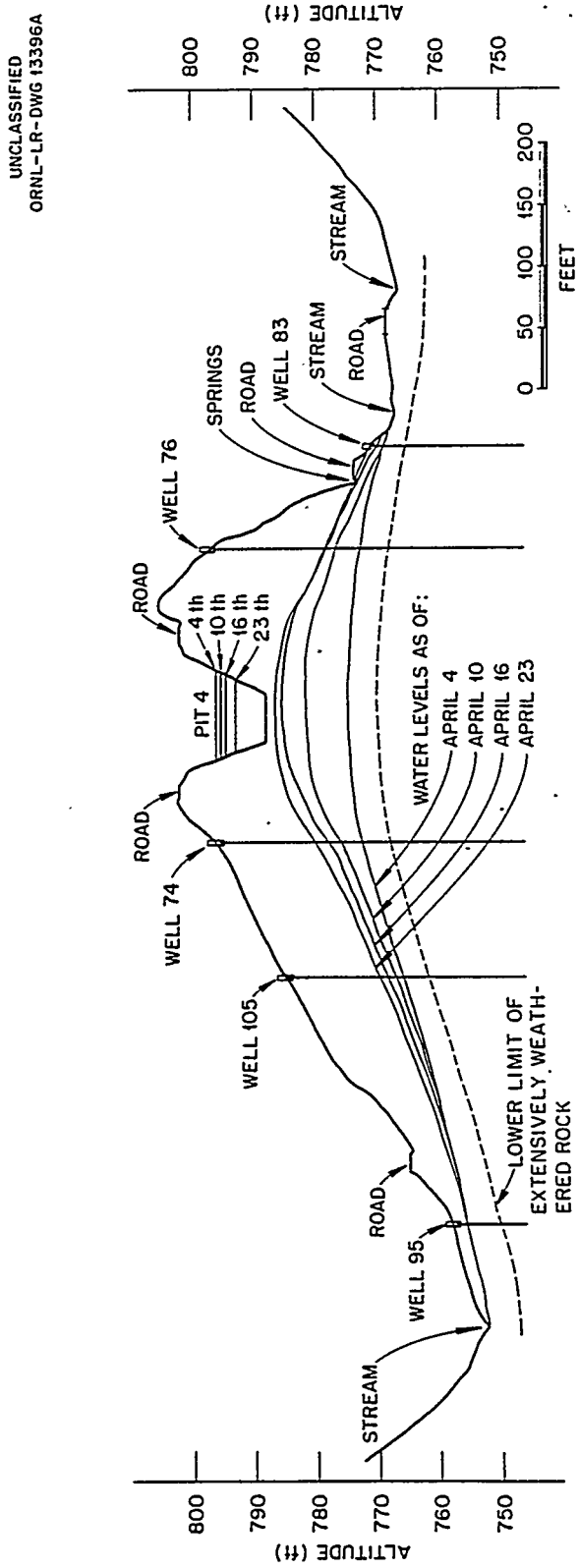
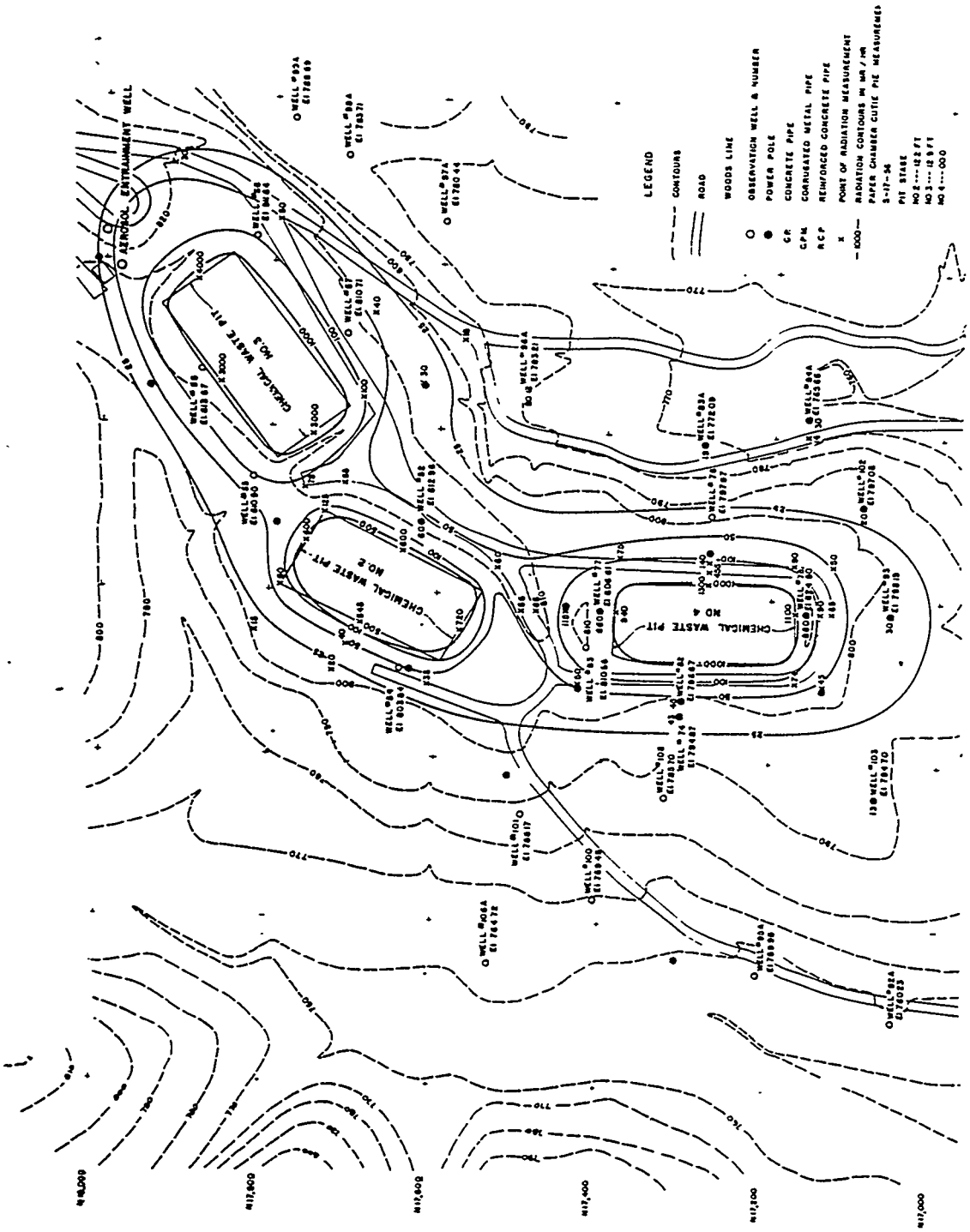


Fig. 2. Generalized Geologic Section—Waste Disposal Area, Oak Ridge National Laboratory.

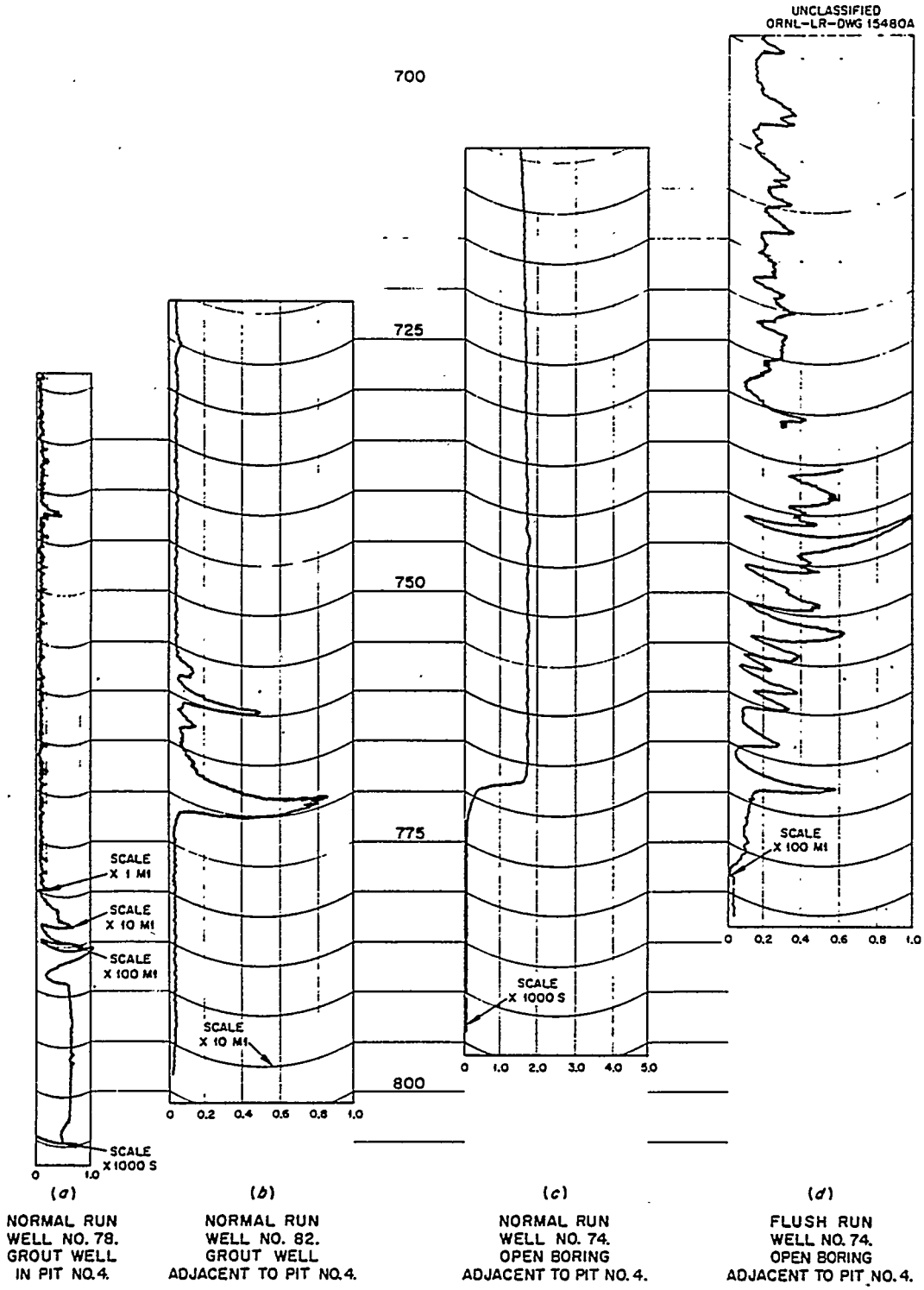
ORNL-LR-DWG-6631 1955
Generalized geologic section of waste areas



ORNL-LR-DWG-13396A 1956
Water table cross section of pit 4



ORNL-LR-DWG-14172 1956
External radiation levels in pit area May 1956



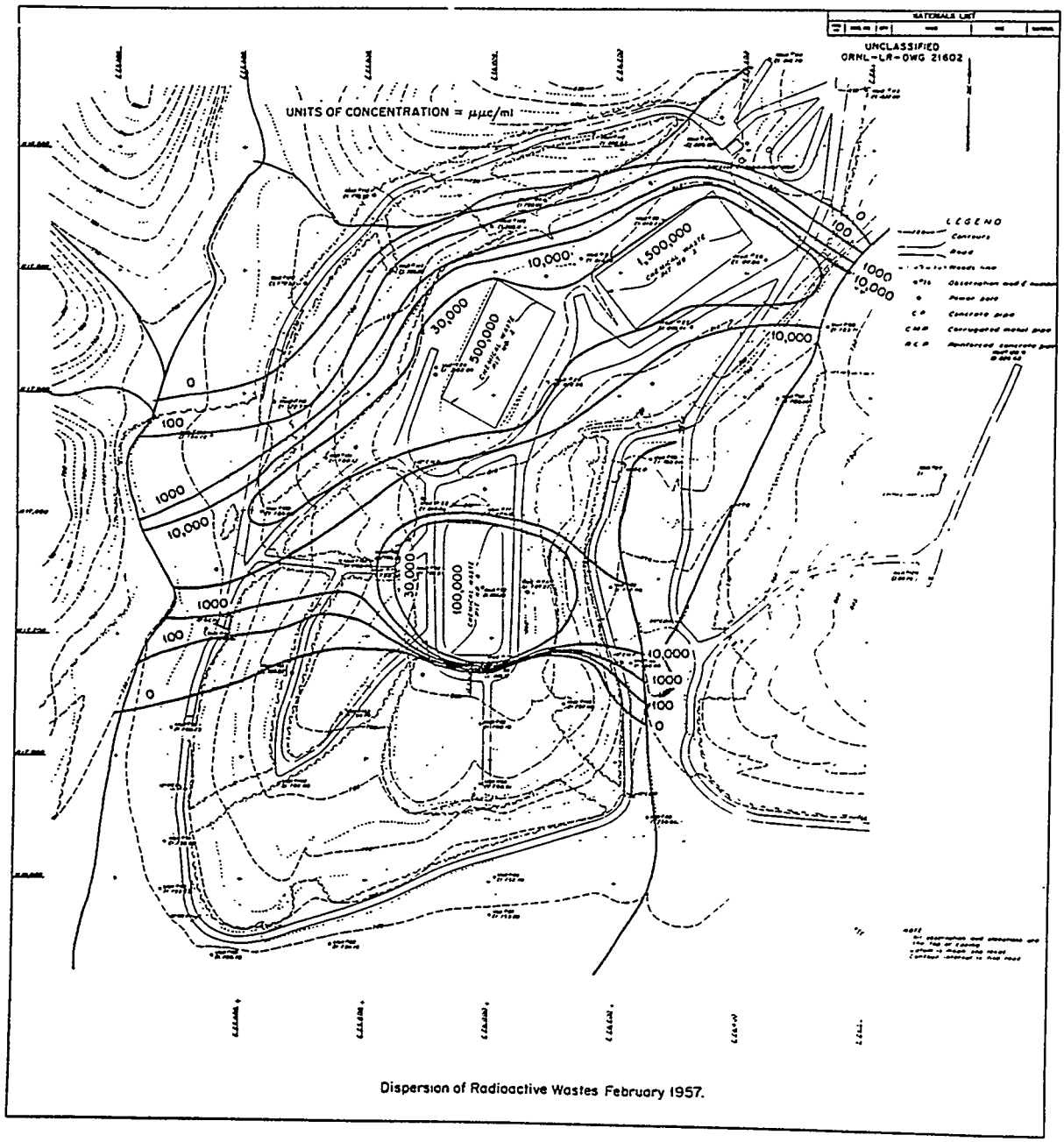
(a) NORMAL RUN WELL NO. 78. GROUT WELL IN PIT NO. 4.

(b) NORMAL RUN WELL NO. 82. GROUT WELL ADJACENT TO PIT NO. 4.

(c) NORMAL RUN WELL NO. 74. OPEN BORING ADJACENT TO PIT NO. 4.

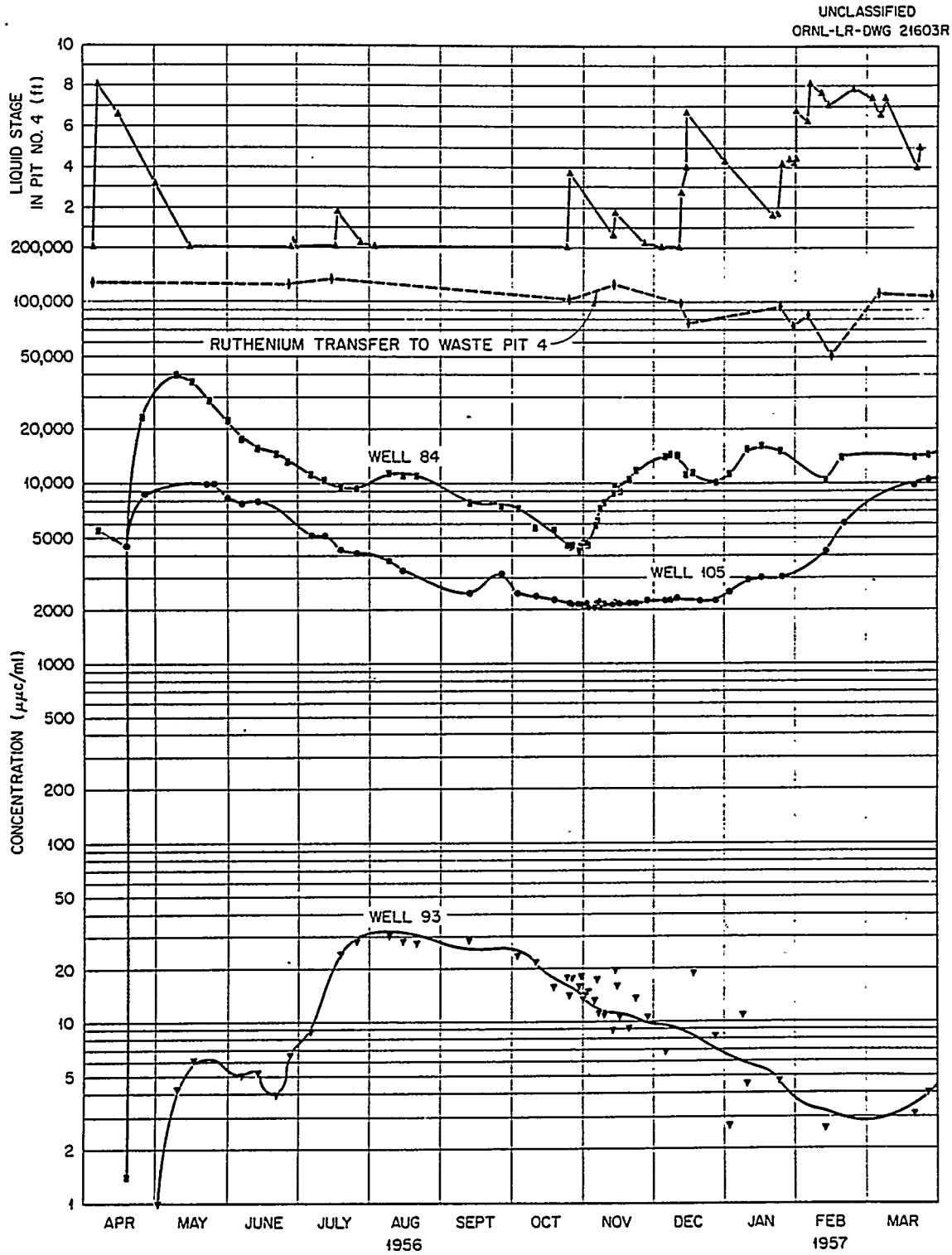
(d) FLUSH RUN WELL NO. 74. OPEN BORING ADJACENT TO PIT NO. 4.

ORNL-LR-DWG-15480A 1956
Radioactivity logs of boreholes around pit 4

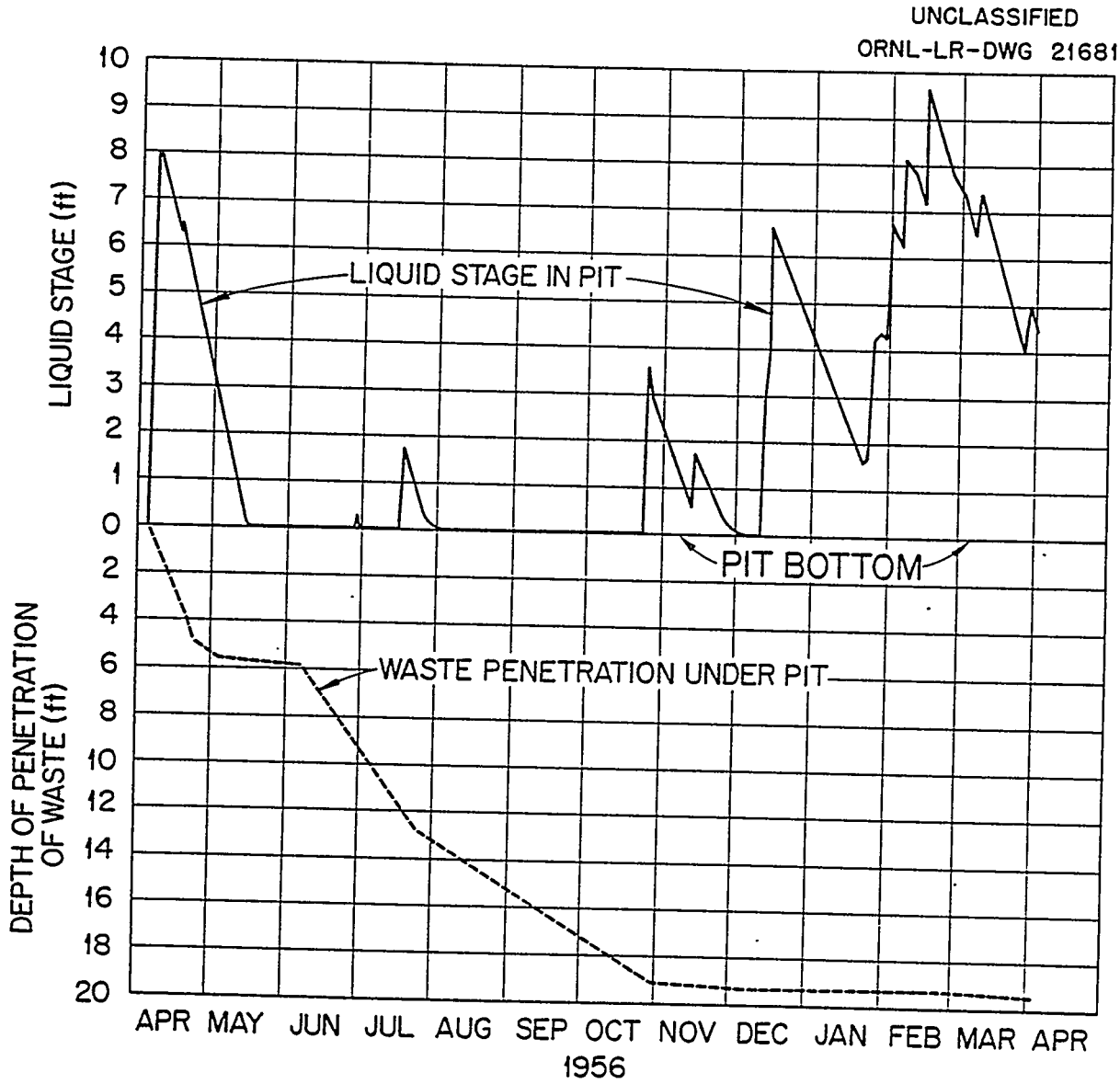


Dispersion of Radioactive Wastes February 1957.

ORNL-LR-DWG-21602 1957
Dispersion of radioactivity near pits Feb 1957

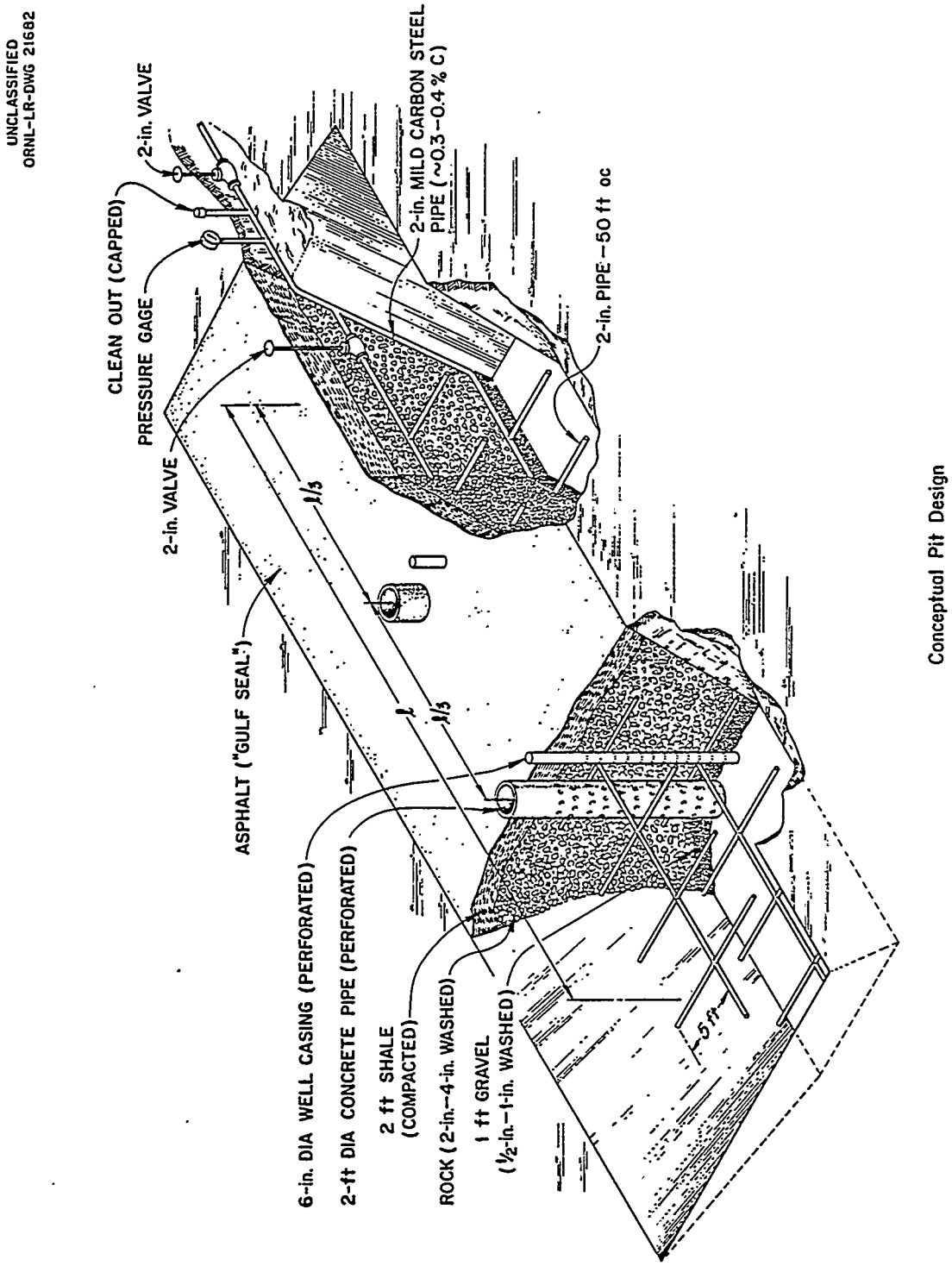


ORNL-LR-DWG-21603R 1957
Radioactivity in wells of pit 4, 1956-57

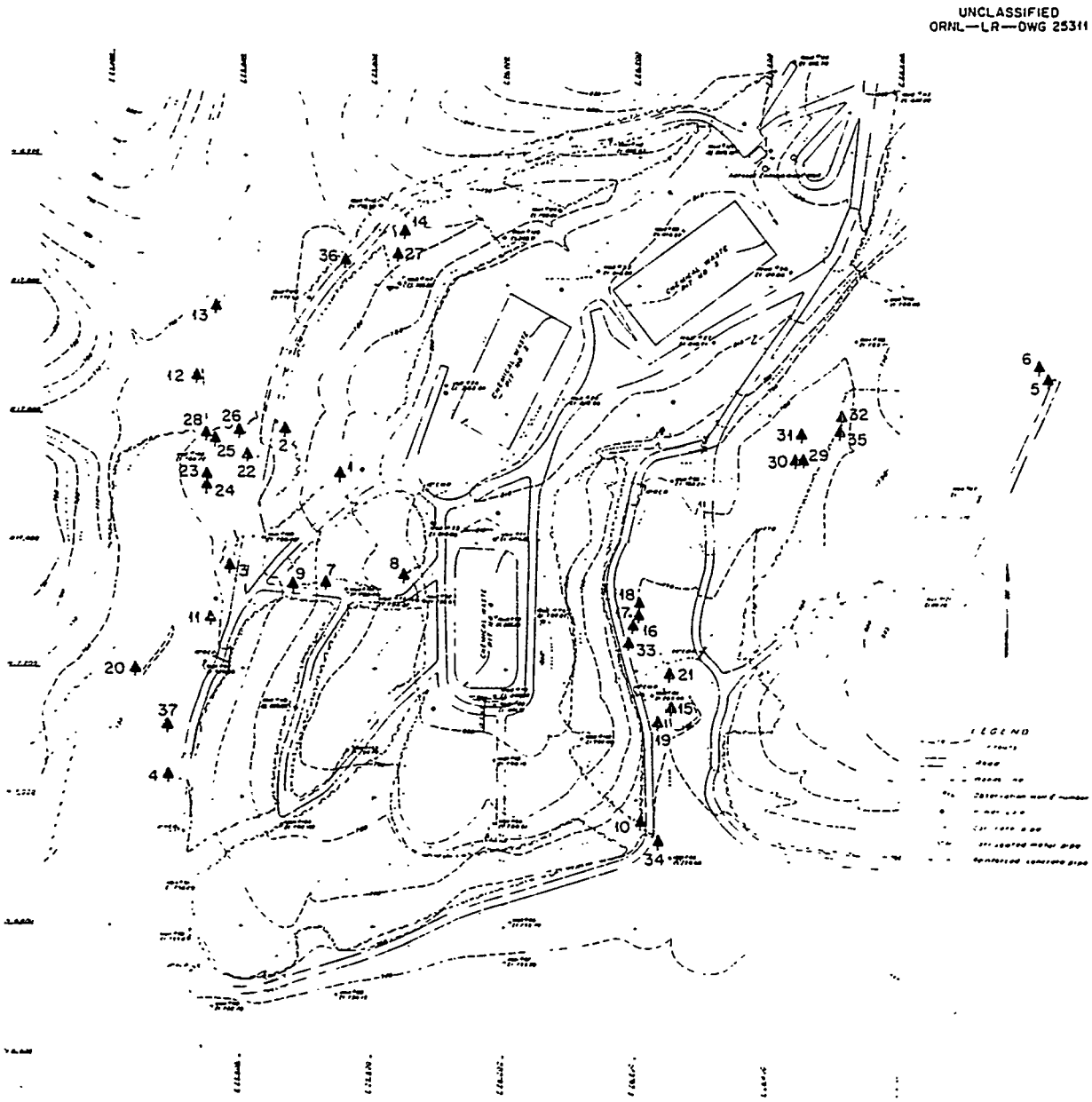


Waste Pit No. 4 – Movement of Waste Under Pit.

ORNL-LR-DWG-21681 1957
Movement of radioactivity under pit 4 - 1956



ORNL-LR-DWG-21682 1957
Conceptual design of new pit (trench 5)



ORNL-LR-DWG-25311 1957
Tree sample locations around pits 2,3,and 4

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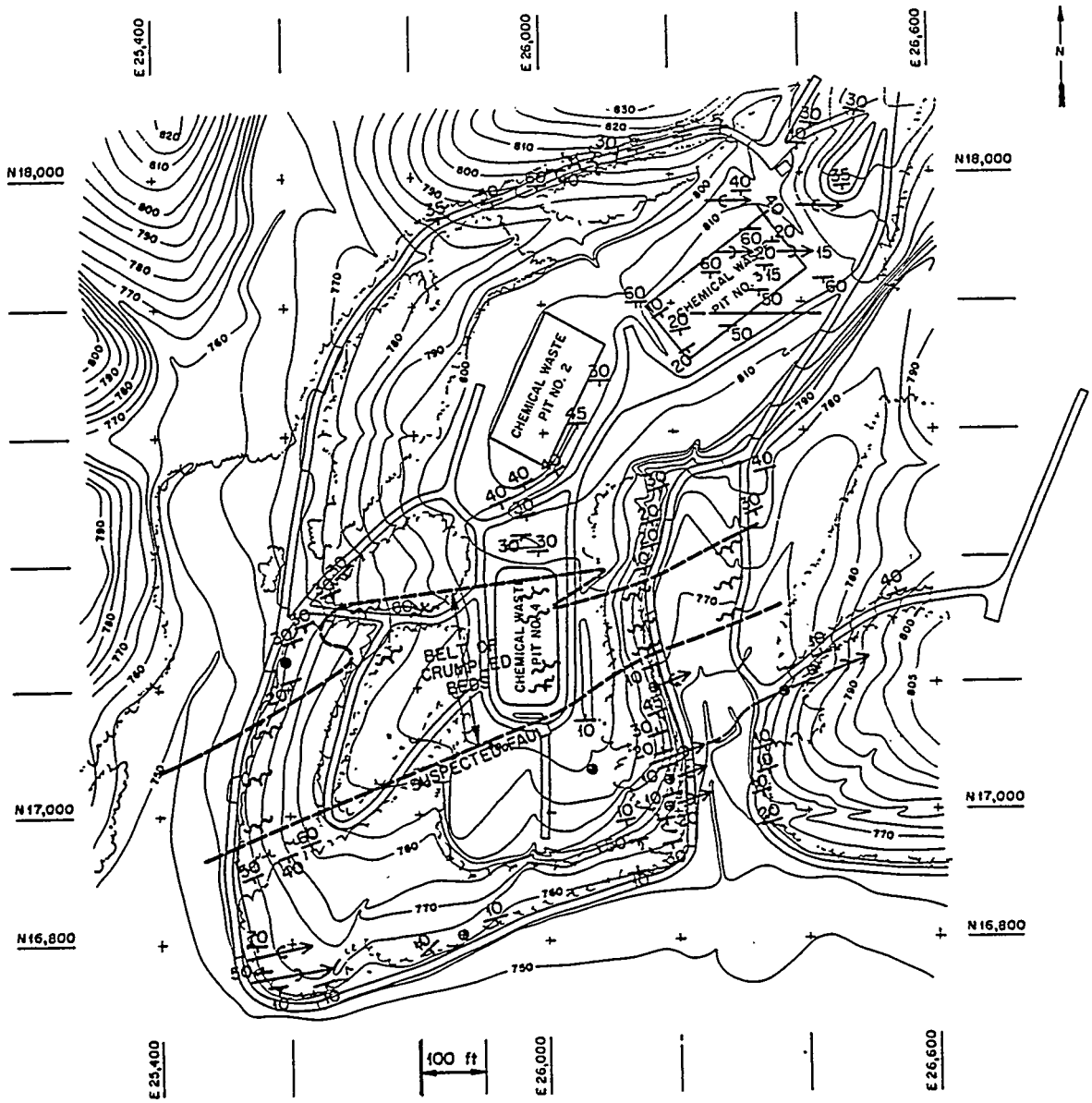
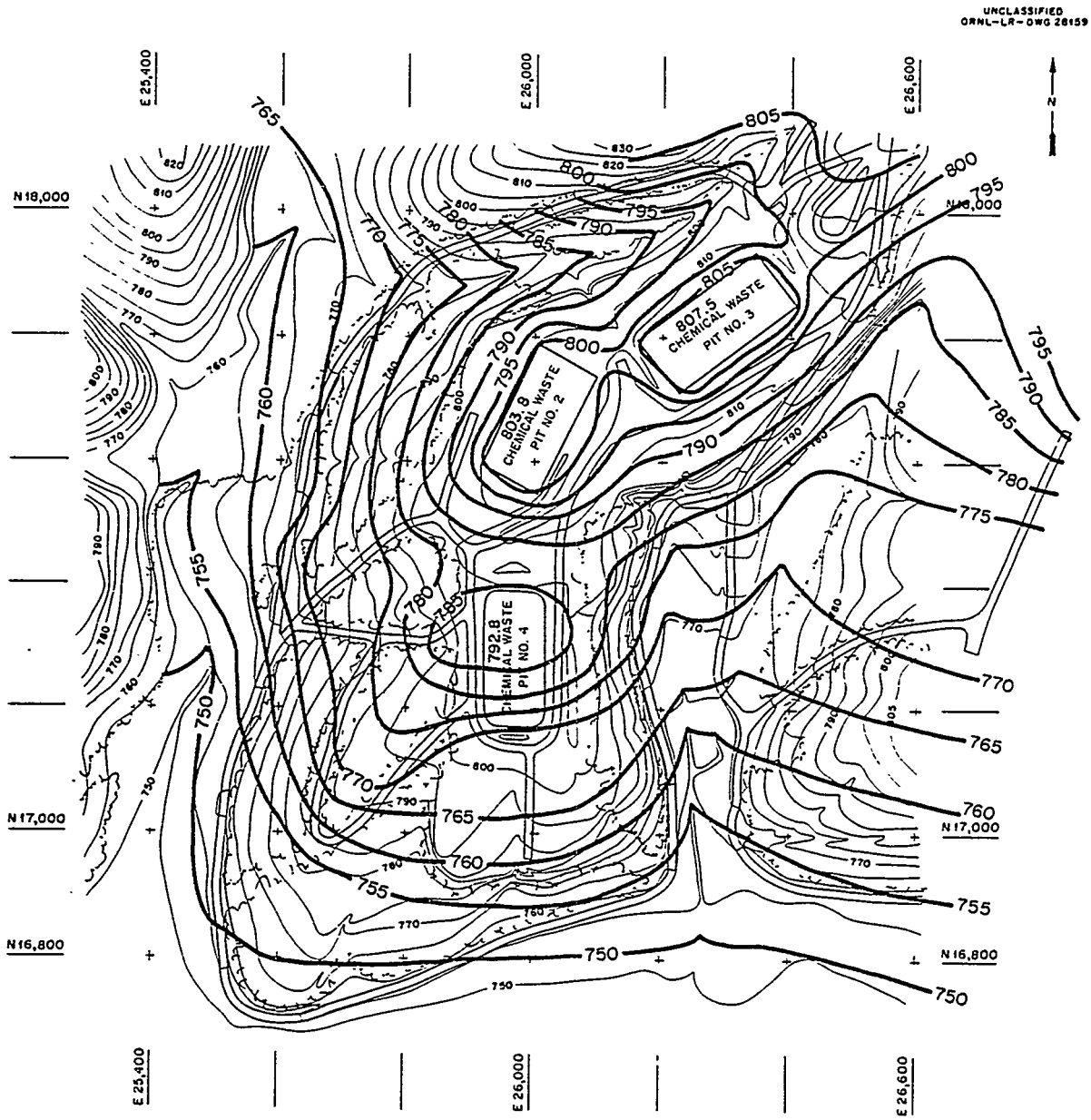
ORNL-LR-DWG 28158



10 STRIKE AND DIP OF BEDS
GENERALIZED STRIKE AND DIP OF CRUMPLED BEDS
HORIZONTAL BEDS
AXIS OF ANTICLINE
AXIS OF SYNCLINE

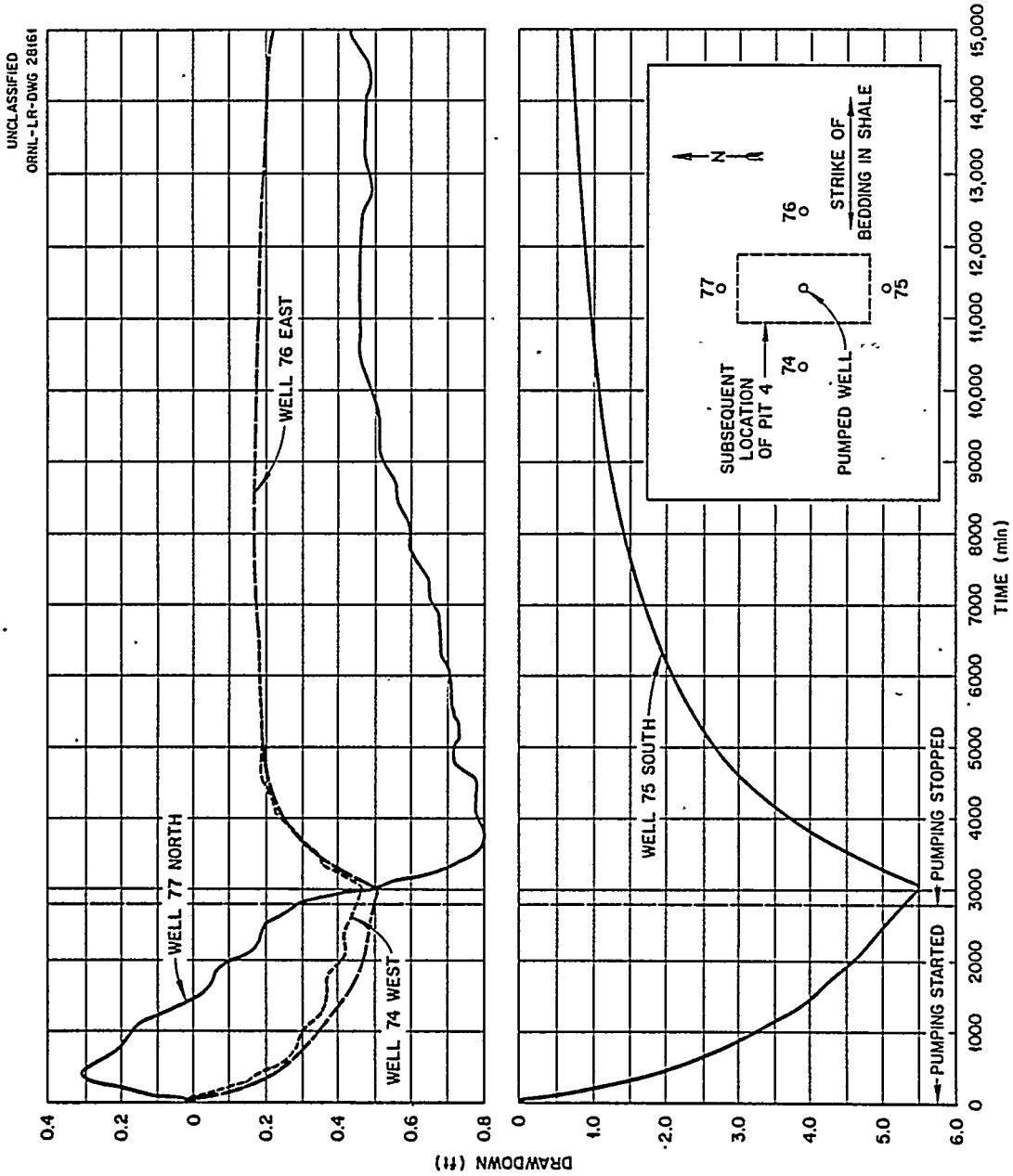
Geologic Structure. Waste Pit Area.

ORNL-LR-DWG-28158 1958
Geologic structure of waste pit area



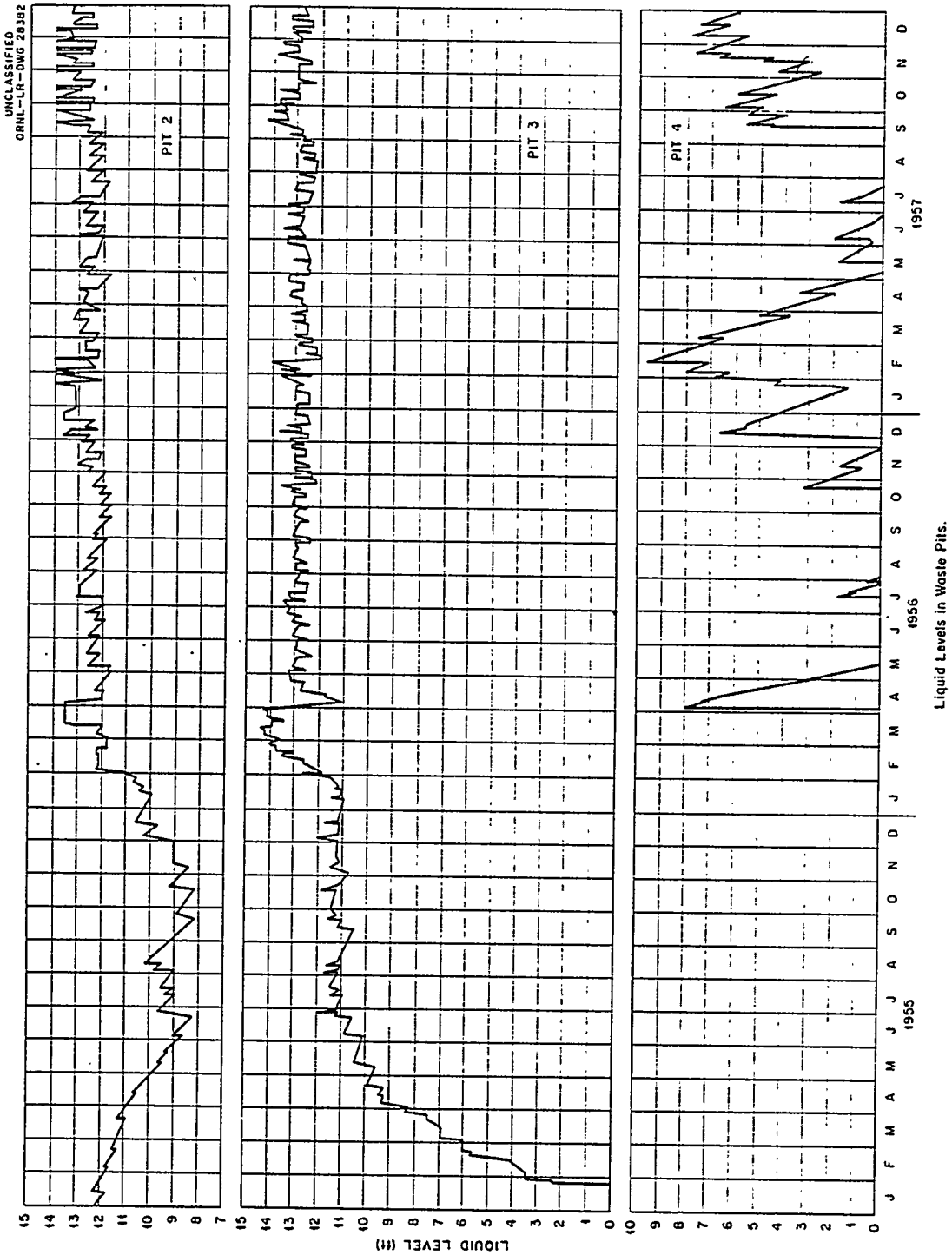
Water Table Contour Map — Janurary 10, 1958.

ORNL-LR-DWG-28159 1958
Water table contour map of pits area Jan, 1958

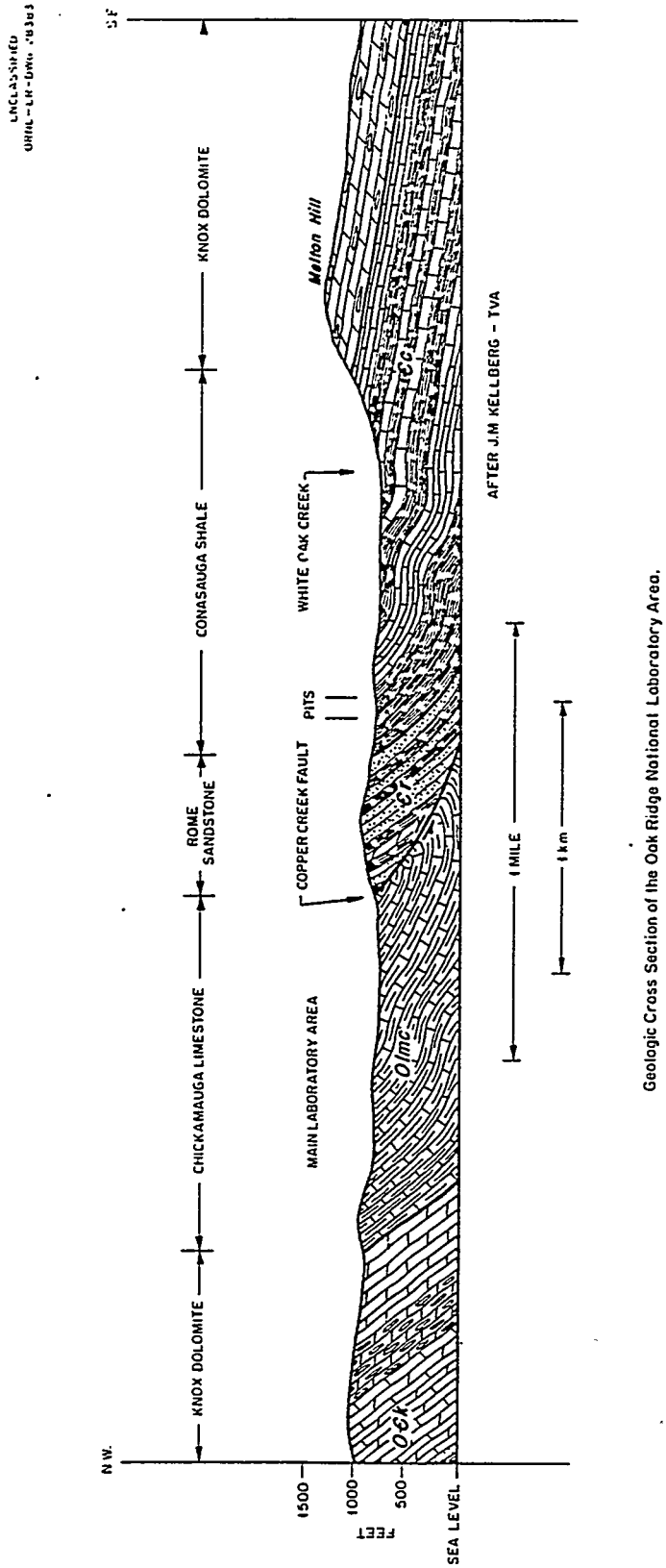


Pumping Test, Pit 4, Aug. 31 – Sept. 10, 1955.

ORNL-LR-DWG-28161 1958
Pump test results in pit 4 area



ORNL-LR-DWG-28382 1958
Liquid levels in pits 2,3, 4 - 1955-1957



Geologic Cross Section of the Oak Ridge National Laboratory Area.

ORNL-LR-DWG-28383 1958
General geologic cross section in waste areas

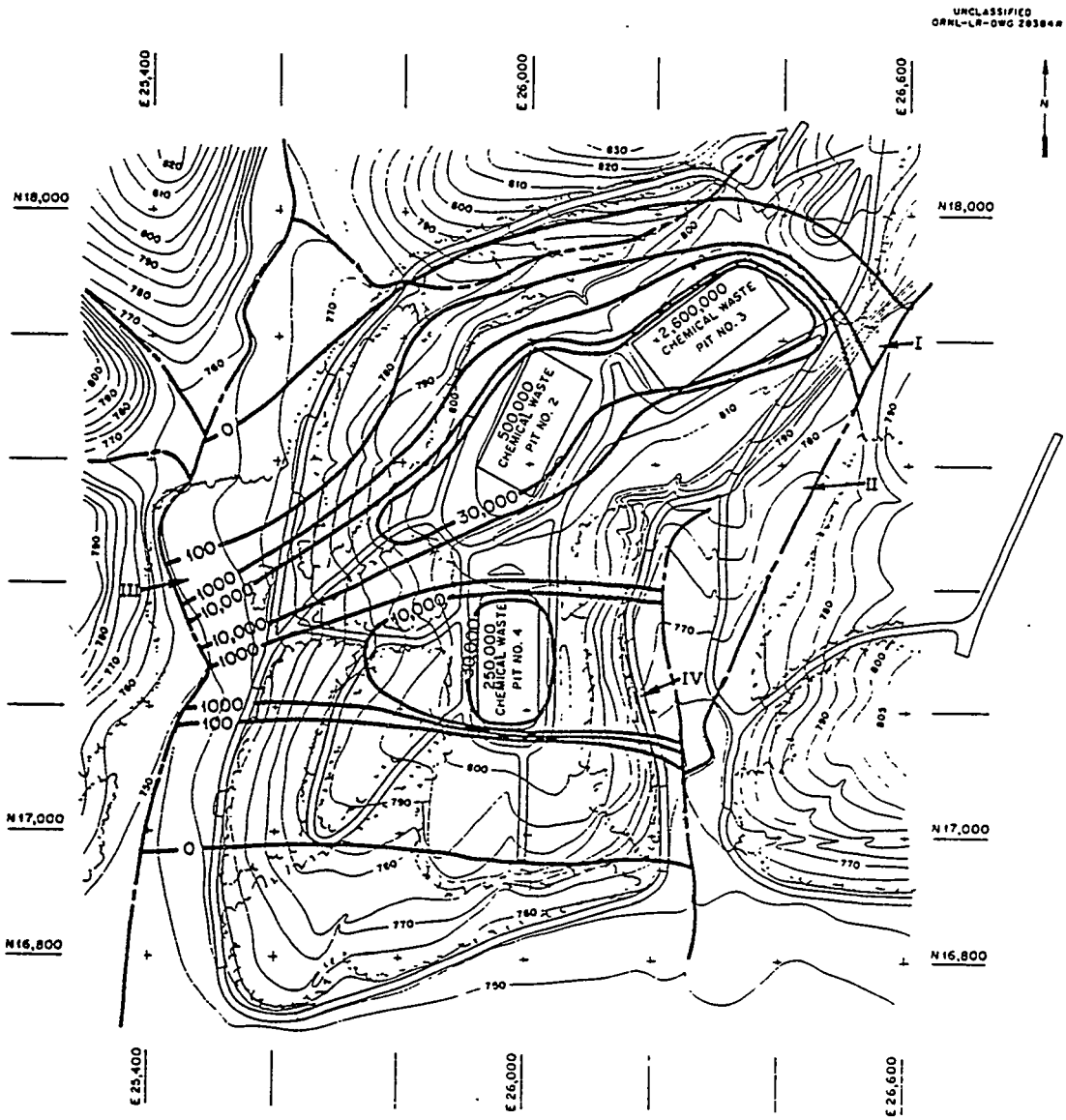
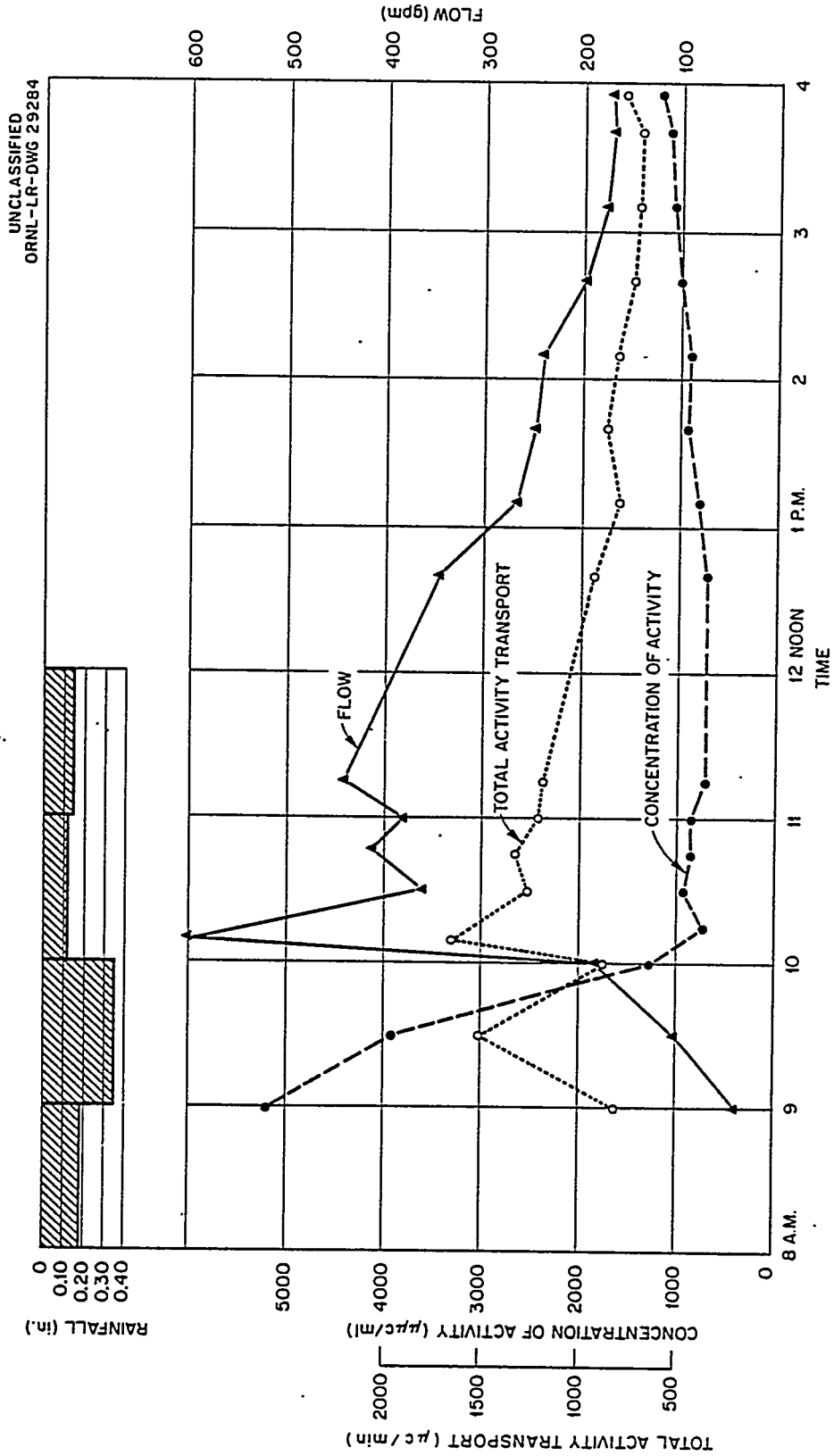


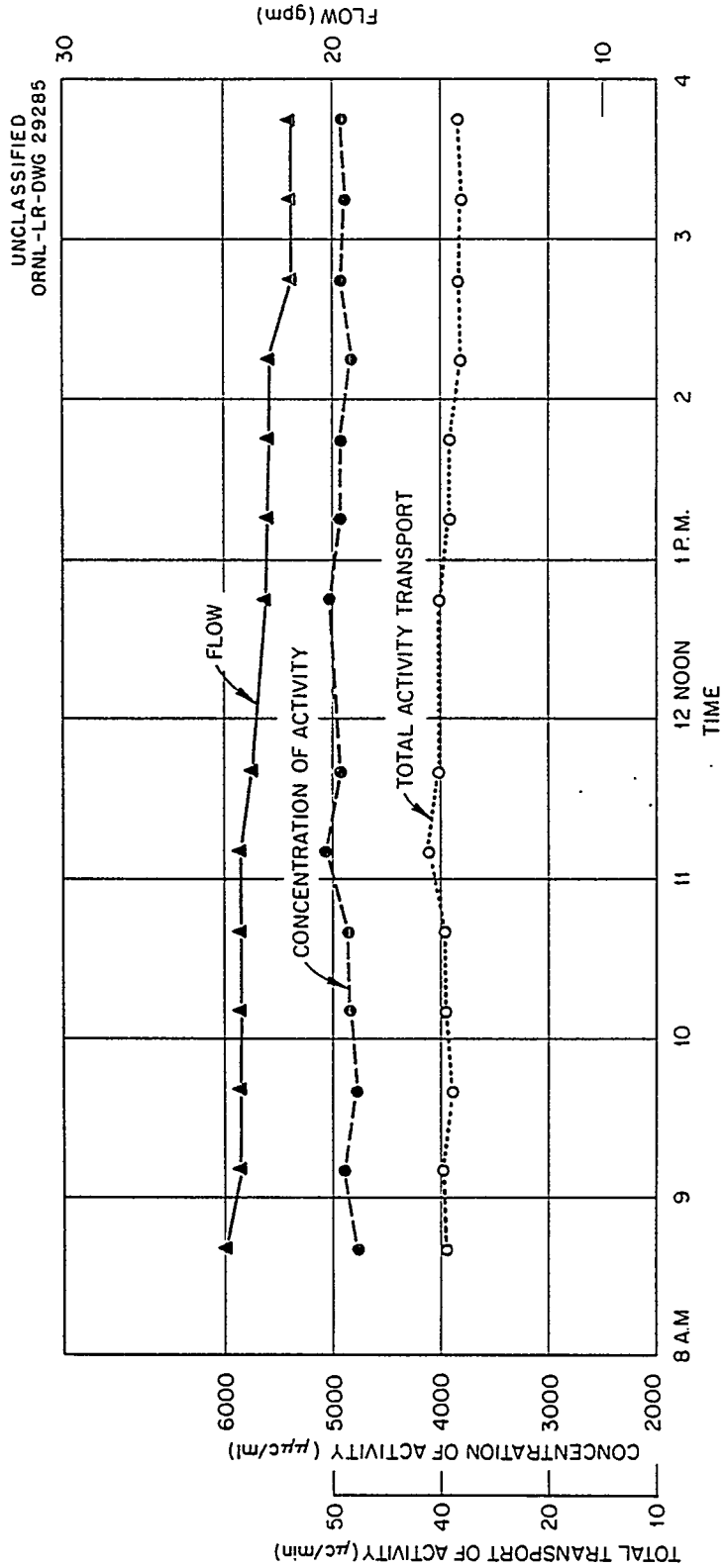
Fig. 11. Dispersion of Radioactive Wastes – February 1958. I, II, III, and IV represent radioactive seeps and springs; unit of concentration is $\mu\mu c/ml$.

ORNL-LR-DWG-28384R 1958
Distribution of radioactivity near pits Feb 1958



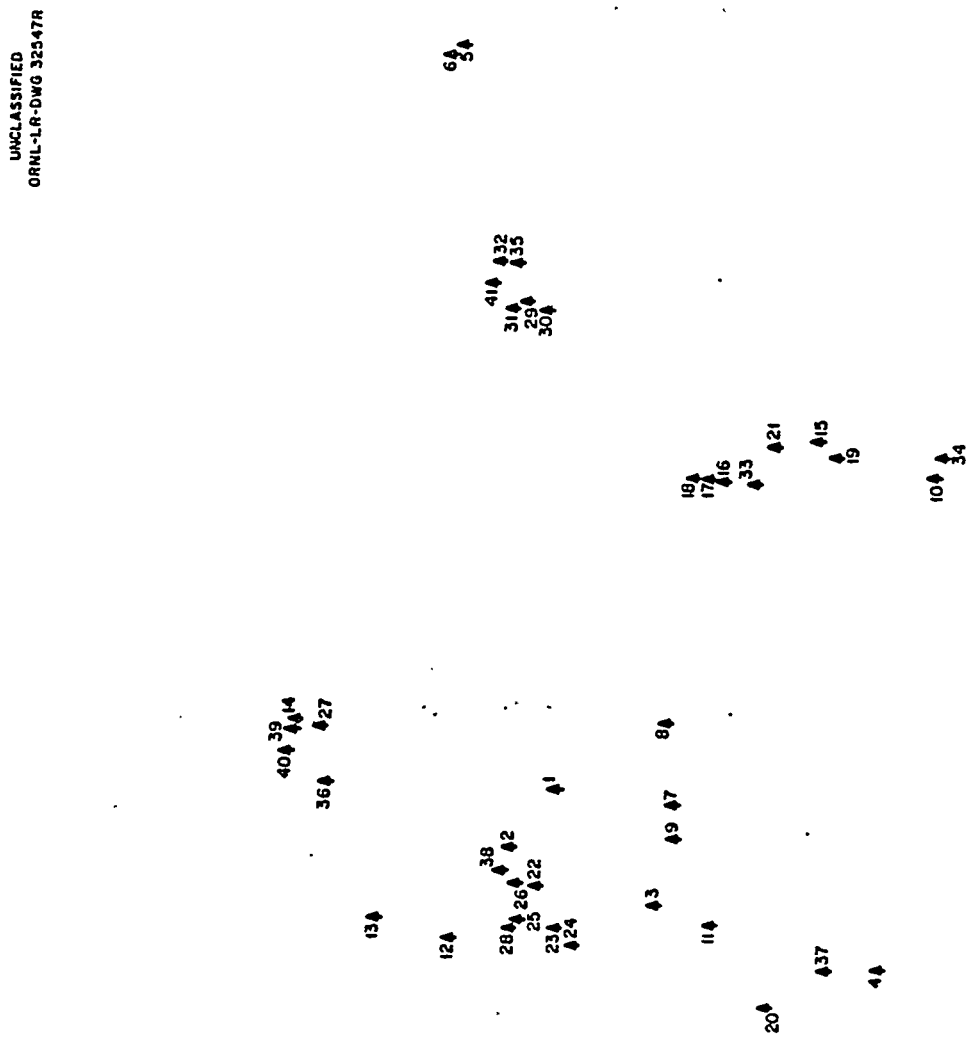
Flow and Radioactivity Transport Past Stream Monitoring Station During Rainfall – April 4, 1957 (Weir at Well 85).

ORNL-LR-DWG-29284 1958
Stream flow and radioactivity at pits Apr 4, 57

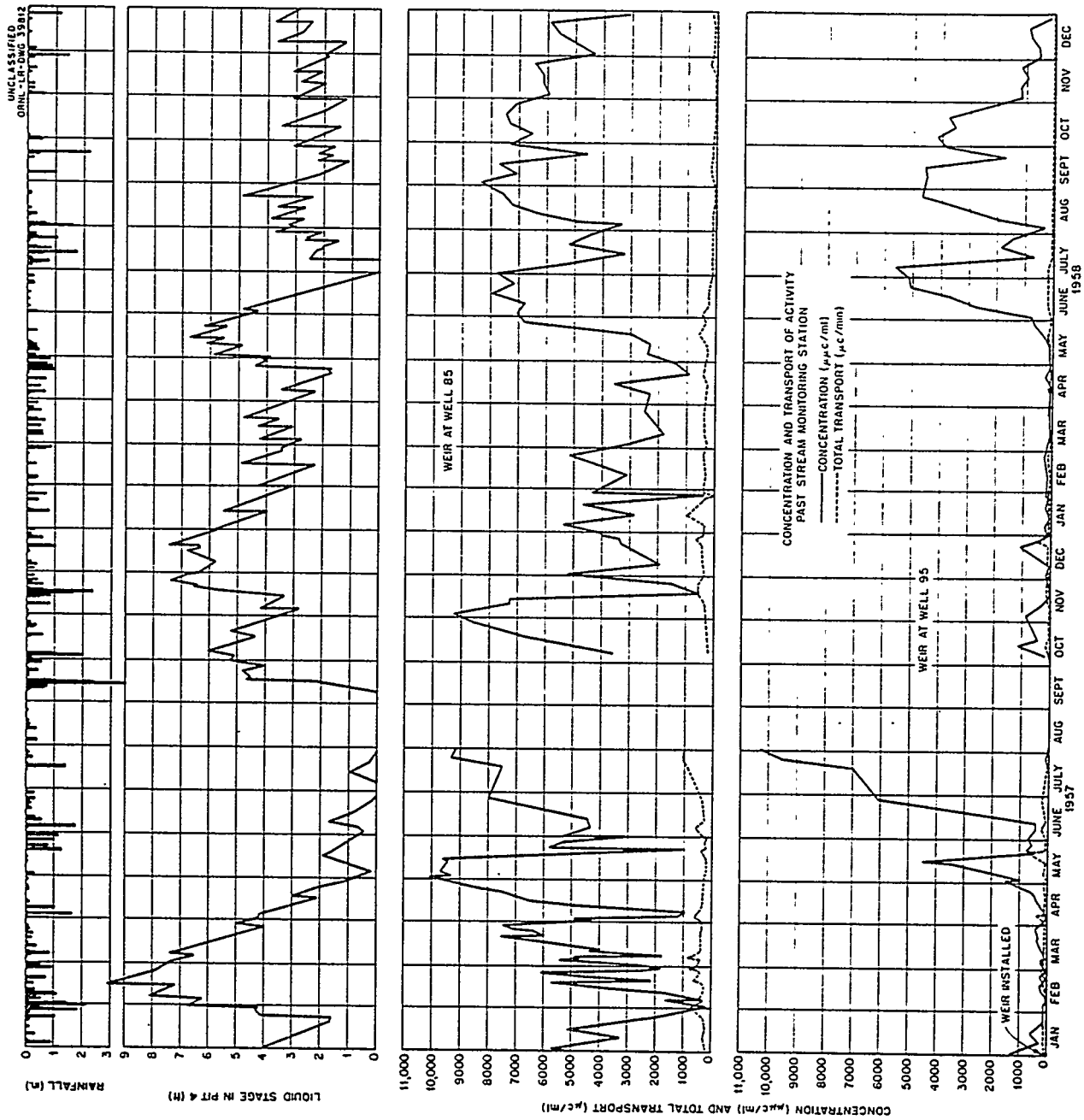


Flow and Radioactivity Transport Past Stream Monitoring Station During Dry Weather—March 3, 1957
(Weir at Well 85).

ORNL-LR-DWG-29285 1958
Stream flow and radioactivity at pits Mar 3, 57



ORNL-LR-DWG-32547R 1958
Tree sample locations around pits 2, 3, 4



ORNL-LR-DWG-39812 1959
Radioactivity dischage in pit area streams 1957

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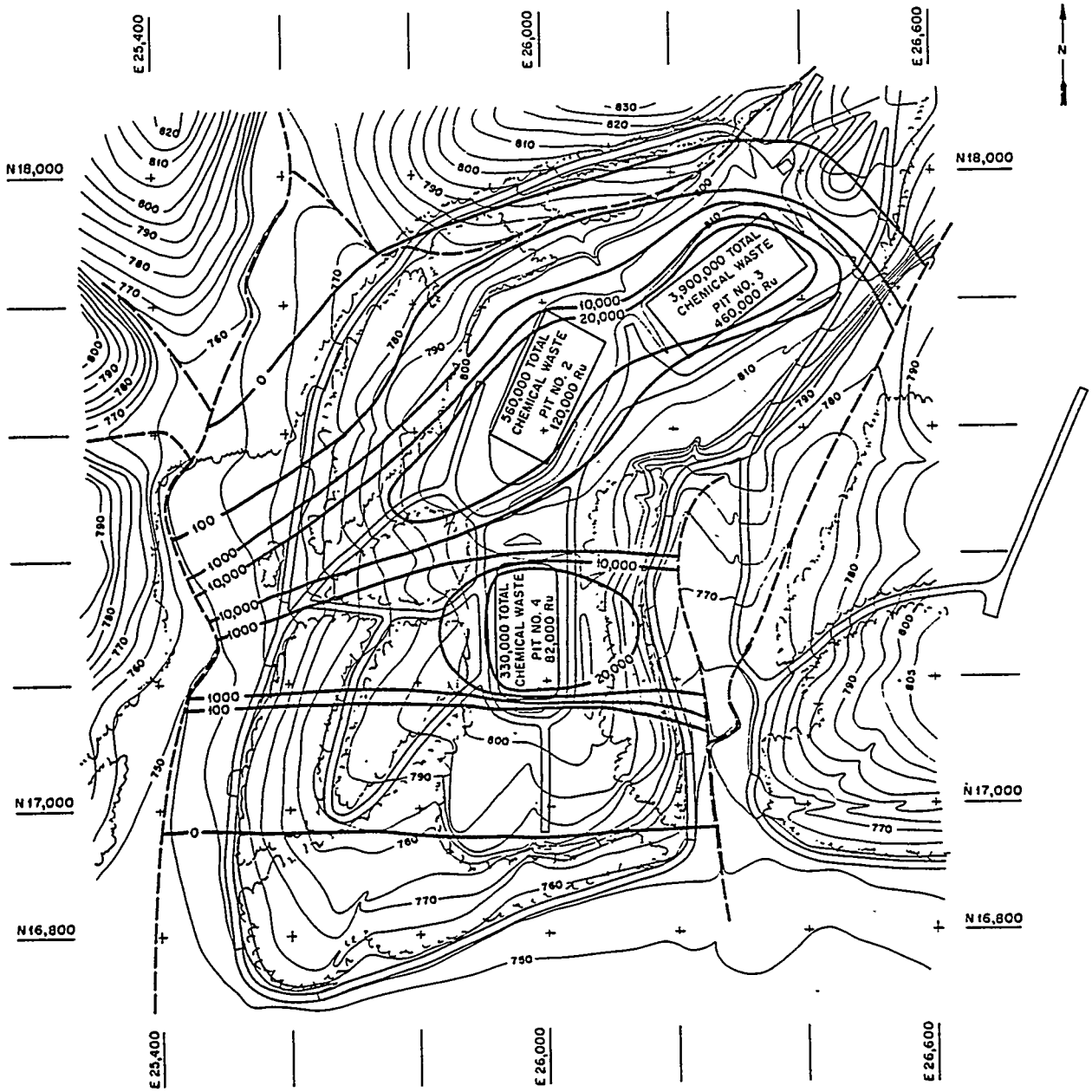
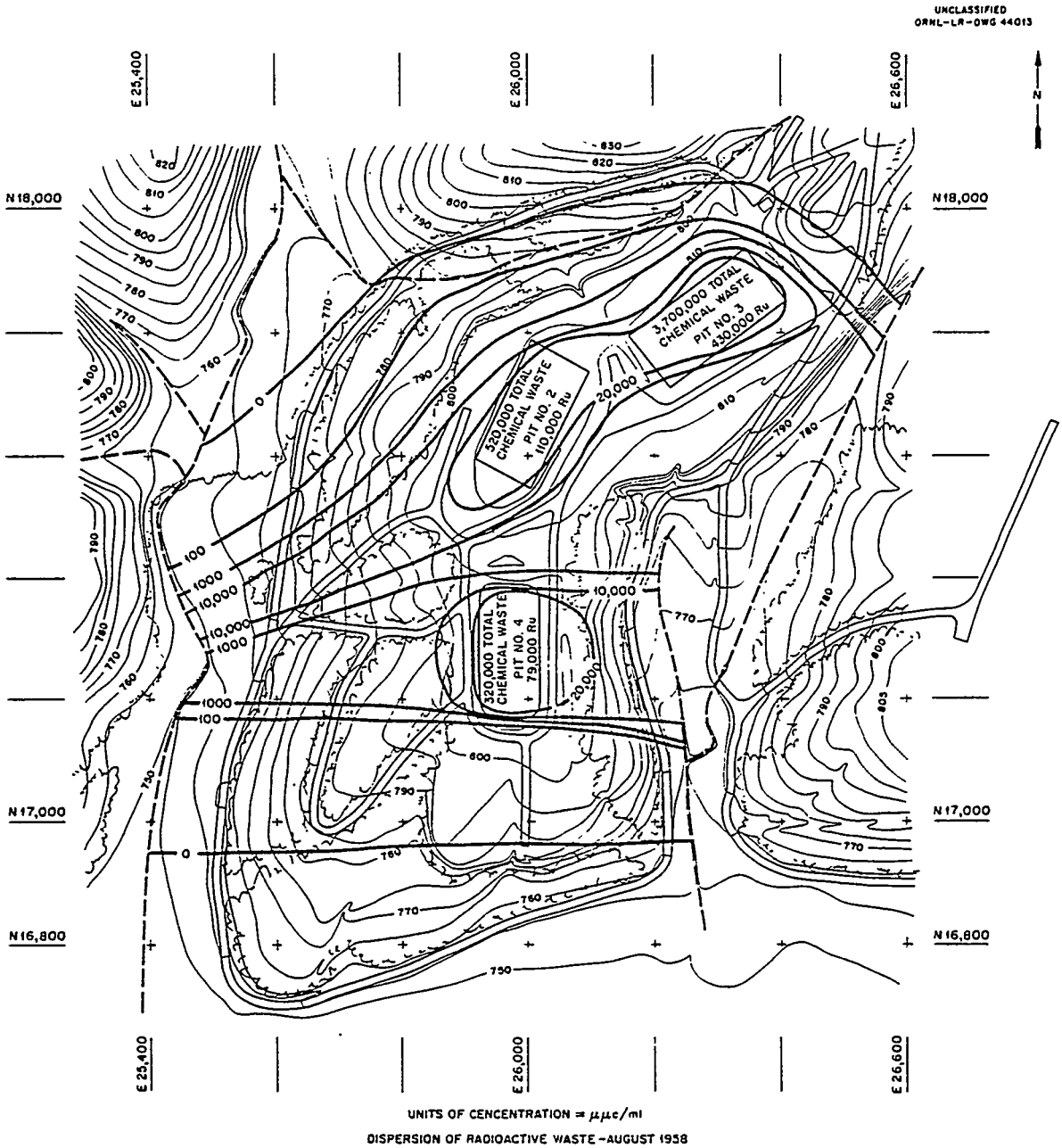
ORNL-LR-DWG 43912



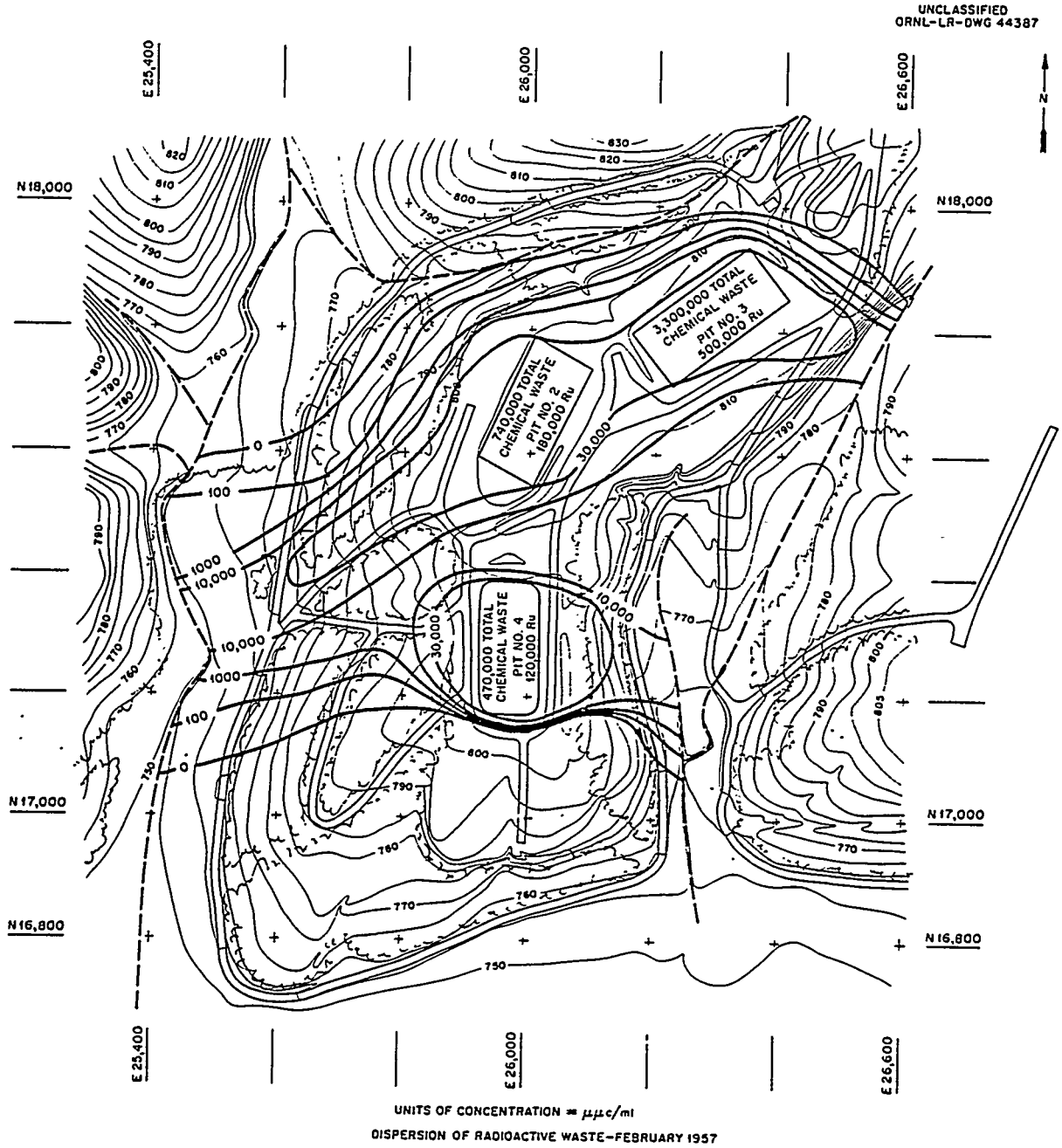
UNITS OF CONCENTRATION = $\mu\mu c/ml$

DISPERSION OF RADIOACTIVE WASTE-MAY 1958

ORNL-LR-DWG-43912 1959
Dispersion of radioactivity near pits May 1958



ORNL-LR-DWG-44013 1959
Dispersion of radioactivity near pits Aug 1958



ORNL-LR-DWG-44387 1959
Dispersion of radioactivity near pits Feb 1957

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ORNL-LR-DWG. 54430

TABLE I. WASTE PIT SYSTEM INVENTORY

	Gals ($\times 10^3$)	Curies										(3) GROSS BETA
		(1) Ru^{103}	Ru^{106}	(1) Cs^{134}	Cs^{137}	(1) Zr	(1) Nb	Sr^{89}	Sr^{90}	(2) TRE	YEAR TOTAL	
JUNE 1952-1955	432(4)	---	5,000	---	11,000	---	---	---	---	---	---	11,600
	2,433	---	4,400	---	28,000	---	---	---	---	---	---	25,700
1956 ----------	2,779	---	5,500	---	18,500	---	---	730	1,830	5,400	31,960	33,500
1957 ----------	2,902	---	4,500	---	10,500	---	---	110	420	4,000	19,530	41,800
1958 ----------	3,156	---	2,800	---	17,000	---	---	500	9,800	9,000	39,100	45,400
1959 ----------	3,590	19,500	197,400	14,800	65,500	9,200	12,600	3,300	24,700	52,900	399,900	273,900
1960 ----------	1,878	---	9,800	---	2,600	---	---	100	1,370	5,900	19,770	18,700
TOTAL --------	17,170	19,500	229,400	14,800	153,100	9,200	12,600	4,740	38,120	77,200		450,600

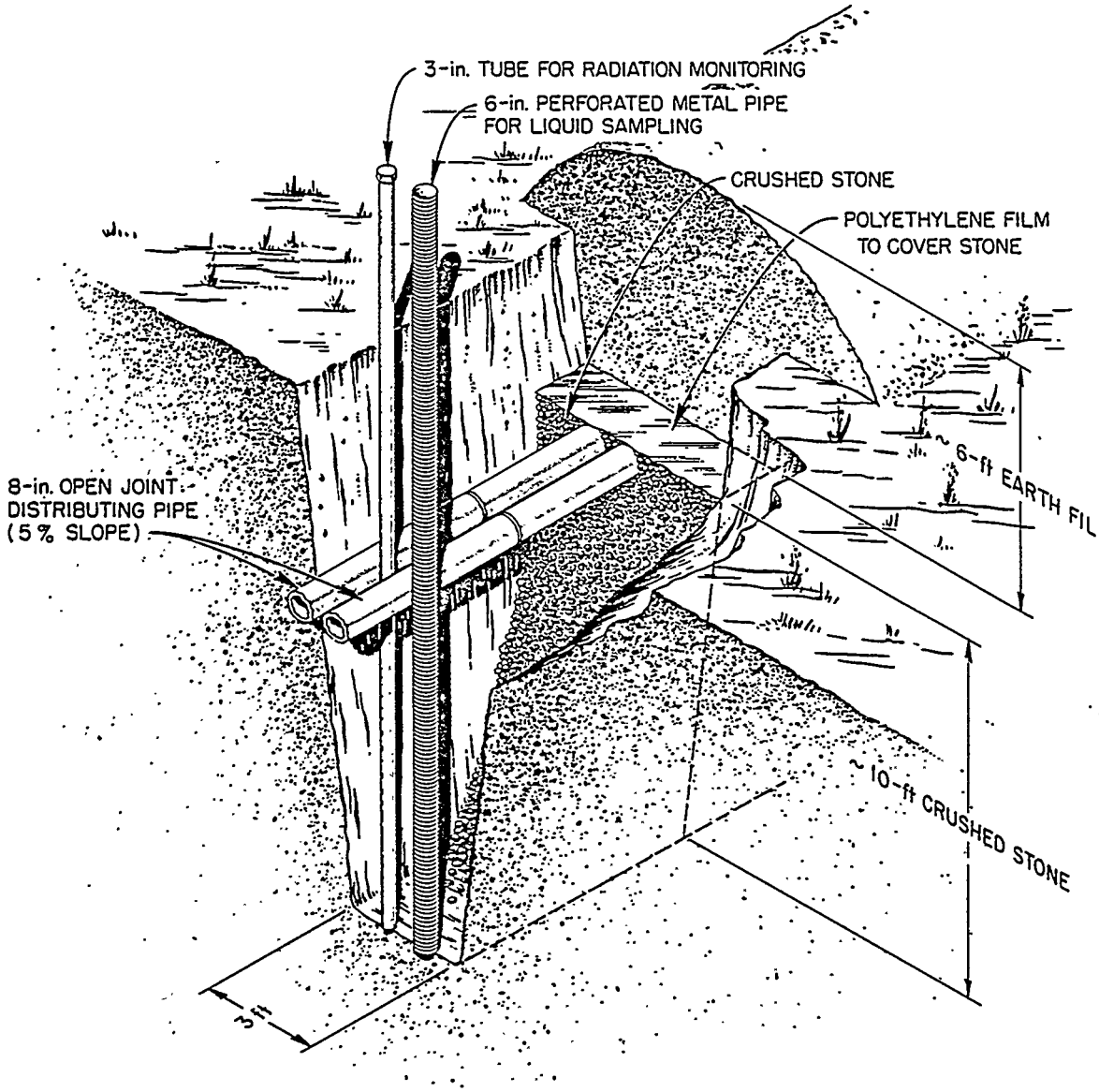
(1) ACCOUNTED FOR AFTER 8/20/59.

(2) EXCLUSIVE OF Y^{90}.

(3) BASED ON A COUNTING EFFICIENCY OF 12.6% EMPLOYED BY OPERATIONS DIVISION.

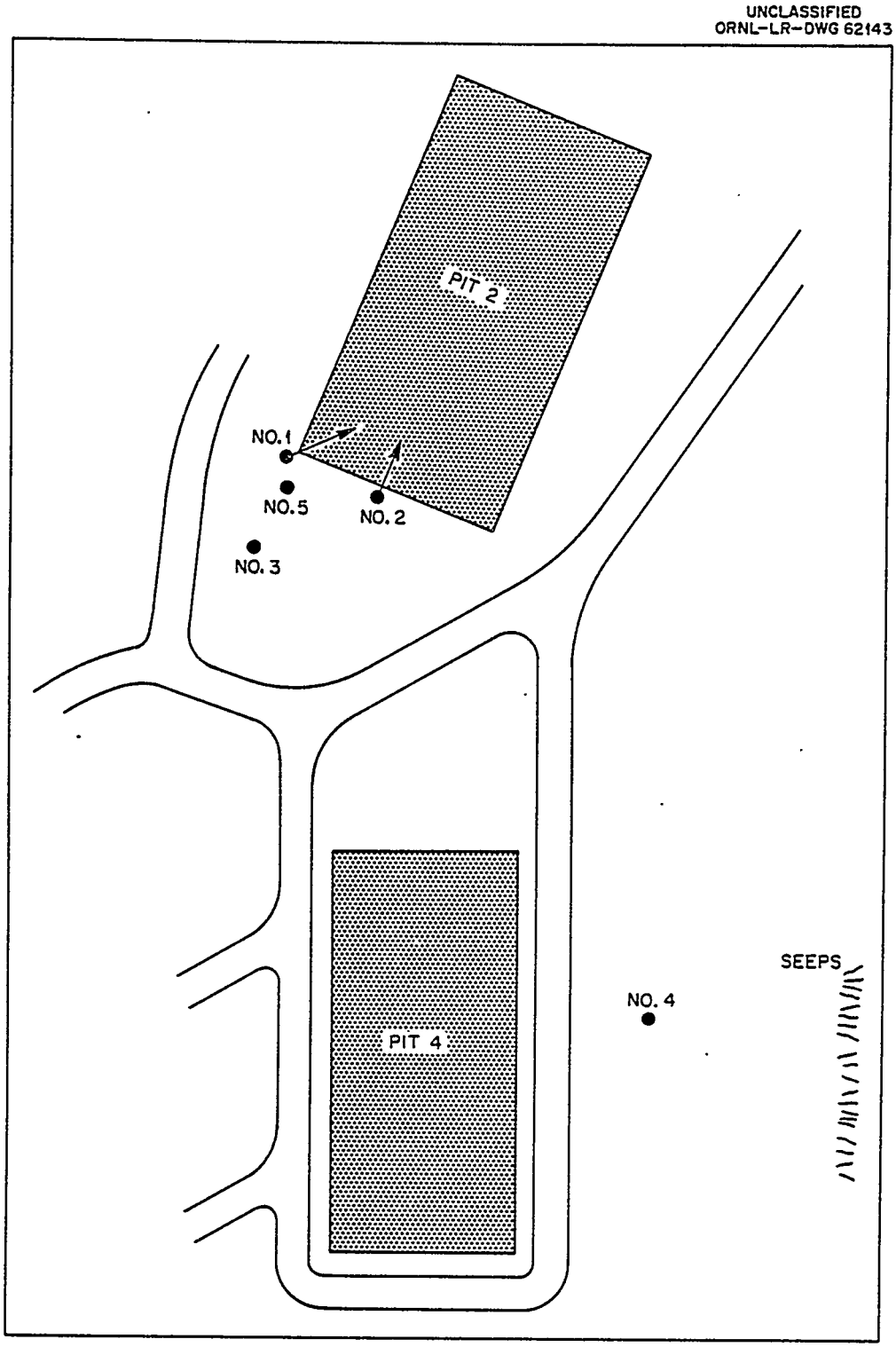
(4) EVAPORATOR CONCENTRATE RELEASED TO PIT 2.

ORNL-LR-DWG 62129



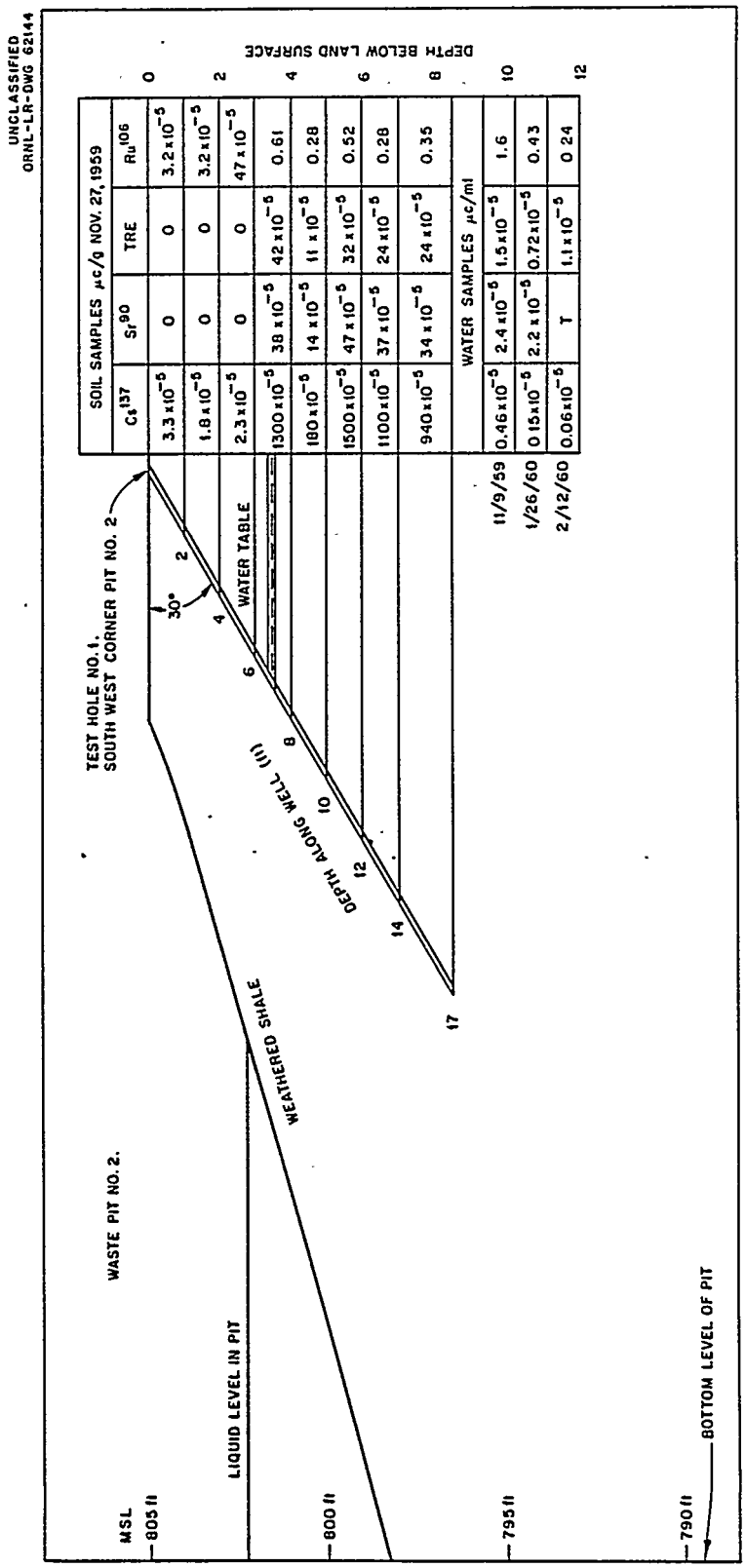
Typical Waste Disposal Trench.

ORNL-LR-DWG-62129 1962
Typical liquid waste disposal trench design

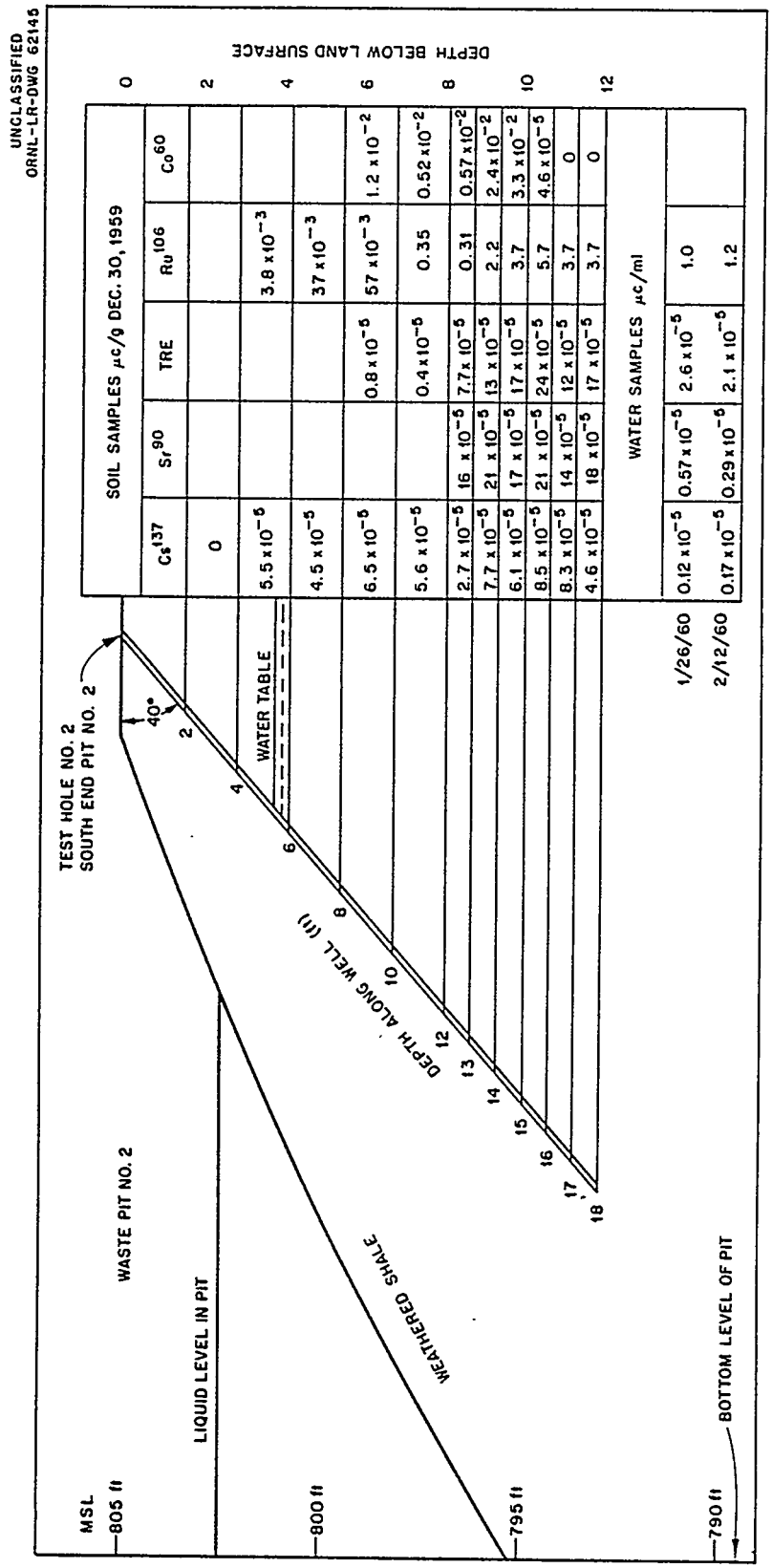


Index Map; Test Holes

ORNL-LR-DWG-62143 1962
Index map of waste pit boreholes - deLaguna



ORNL-LR-DWG-62144 1962
Log of borehole 1 southwest of pit 2



ORNL-LR-DWG-62145 1962
Log of borehole 2 south end of pit 2

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ORNL-LR-DWG 62146

WELL NO. 3. OCT. 6, 1959, 70 ft SOUTH OF PIT NO. 2.

MSL	FEET		SOIL SAMPLES $\mu c/g$			
			Cs^{137}	Sr^{90}	TRE	Ru^{106}
805 ft	0		0.2×10^{-5}	0	0	3×10^{-5}
	2		2×10^{-5}	0	0	2×10^{-5}
	4		0.2×10^{-5}	0	0	4×10^{-5}
800 ft	6		1.3×10^{-5}	0	0	2×10^{-5}
	8		2×10^{-5}	0	0	2×10^{-2}
795 ft	10		0.5×10^{-5}	0	0	1.3×10
	12	WATER TABLE	2.5×10^{-5}	0	0	7.8×10^{-5}
	14					
790 ft	16	BOTTOM LEVEL OF PIT	1.8×10^{-5}	9.5×10^{-5}	4.7×10^{-5}	13×10^{-5}
	18		2×10^{-5}	17×10^{-5}	11×10^{-5}	18×10^{-5}
785 ft	20		1.8×10^{-5}	13×10^{-5}	9×10^{-5}	18×10^{-5}

ORNL-LR-DWG-62146 1962
Log of borehole 3 south of pit 2

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ORNL-LR-DWG 62147

TEST HOLE NO. 4. 70 ft EAST OF PIT NO. 4. AUG. 1, 1961

MSL	FEET		GROSS counts/min/g	Ru^{106} μc/g	Co^{60} μc/g	Cs^{137} μc/g	Sr^{90} μc/g	TRE
800 ft	0	CLAY AND SILT DRY						
	5		65					
		CLAY AND SILT DAMP	50					
790 ft	10							
			10					
	15	WATER TABLE						
		CLAY AND SILT WET	1.48×10^4	–	–	1.2×10^{-5}	0.1×10^{-5}	0.4×10^{-5}
770 ft	20		2.0×10^4	0.126	135×10^{-5}	0.4×10^{-5}	T	0.4×10^{-5}
		CLAY AND SILT WET	3.0×10^4	0.167	232×10^{-5}	0.7×10^{-5}	0.1×10^{-5}	3.5×10^{-5}
	25	80% LIMESTONE, 20% WEATHERED SHALE	0.26×10^4					
		25% LIMESTONE, 75% WEATHERED SHALE						
		50% LIMESTONE, 50% WEATHERED SHALE	2.34×10^4					
		80% LIMESTONE, 20% WEATHERED SHALE	0.75×10^4					
760 ft	30	50% LIMESTONE, 50% WEATHERED SHALE	1.43×10^4					
		50% LIMESTONE, 50% WEATHERED SHALE	0.63×10^4					
		50% LIMESTONE, 50% FRESH SHALE	0.02×10^4					
	34.3	50% LIMESTONE, 50% FRESH SHALE	0.04×10^4					

ORNL-LR-DWG-62147 1962
Log of borehole 4 east of pit 4

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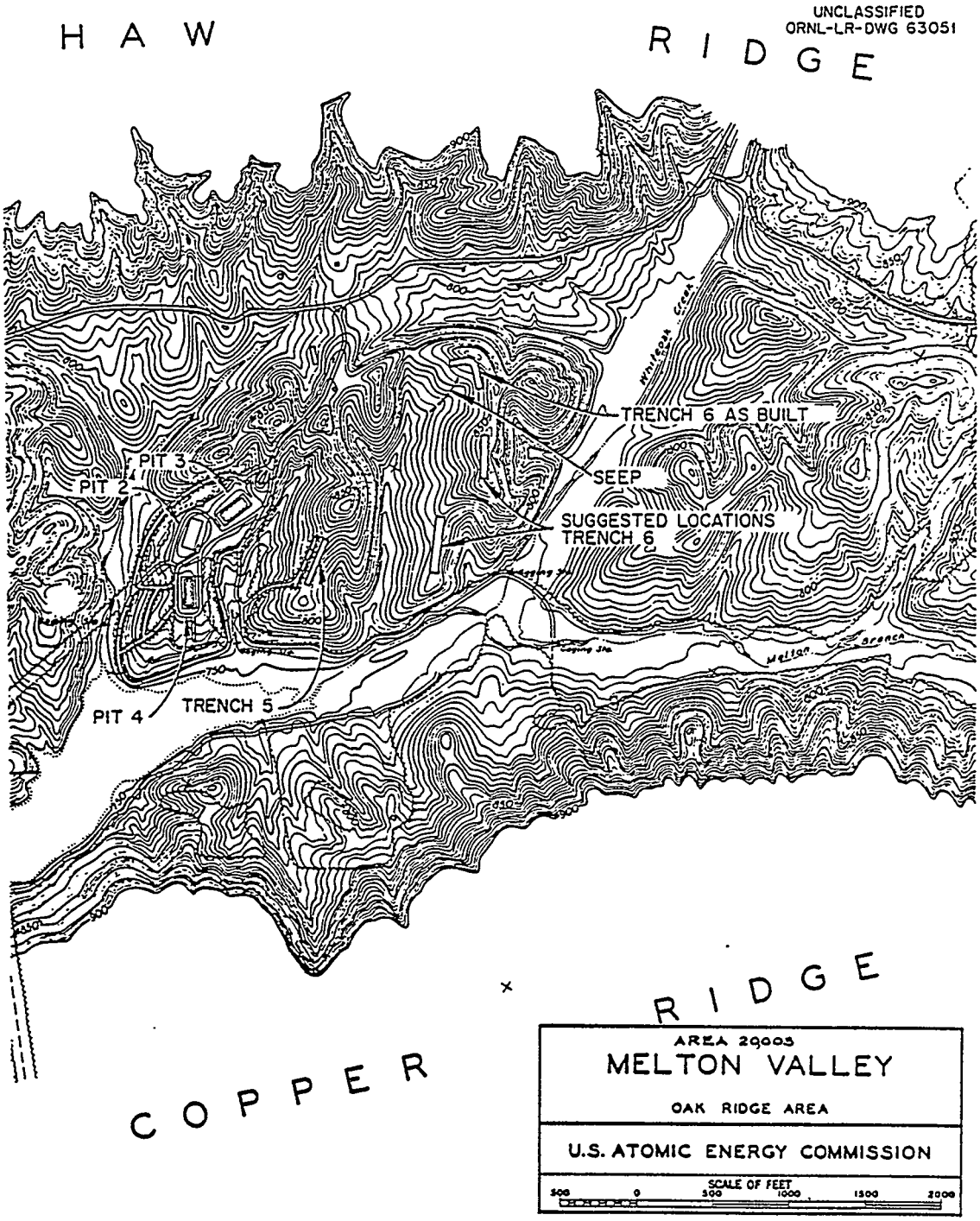
ORNL-LR-DWG 62148

TEST HOLE NO. 5. 20 ft SOUTH OF SOUTH-WEST CORNER PIT NO. 2, AUG. 1, 1961

MSL	FEET		GROSS γ counts/min/g	Ru^{106} $\mu c/g$	Co^{60} $\mu c/g$	Cs^{137} $\mu c/g$	Sr^{90} $\mu c/g$	TRE $\mu c/g$
805 ft	0	BROWN CLAY AND SILT DRY						
800 ft	5	BROWN CLAY AND SILT DAMP	4.0×10^4	0.227	197×10^{-5}	0.4×10^{-5}	1.3×10^{-5}	2.3×10^{-5}
			1.95×10^4					
795 ft	10	BROWN CLAY AND SILT WET WATER TABLE	1.43×10^4	0.088				
		BROWN CLAY AND SILT	1.42×10^4	0.119	491×10^{-5}			
		CLAY AND SILT SOFT						
790 ft	15	BROWN CLAY AND SILT	0.83×10^4	0.0617	191×10^{-5}			
785 ft	20	BROWN CLAY AND SILT VERY SOFT	0.65×10^4	0.0385				
		GRAY CLAY AND SILT AND WEATHERED SHALE	0.4×10^4	0.022	94×10^{-5}			
		GRAY WEATHERED SHALE	4.9×10^4	0.278	273×10^{-5}	0.1×10^{-5}	1.3×10^{-5}	0.2×10^{-5}
780 ft	25	LIMESTONE AND WEATHERED SHALE	5.1×10^4	0.308	262×10^{-5}	0.1×10^{-5}	3.5×10^{-5}	0.3×10^{-5}
			1.1×10^4					
		LIMESTONE AND PARTLY WEATHERED SHALE	0.6×10^4					
775 ft	30	FRESH SHALE	VERY LOW NOT MEASURED					
	31.9							

WATER SAMPLE FROM 19.6 ft 0.119×10^4 counts/min/ml GROSS GAMMA

ORNL-LR-DWG-62148 1962
Log of borehole 5 southwest of pit 2



ORNL-LR-DWG-63051 1962
Map of proposed areas for trench 7 (deLaguna)

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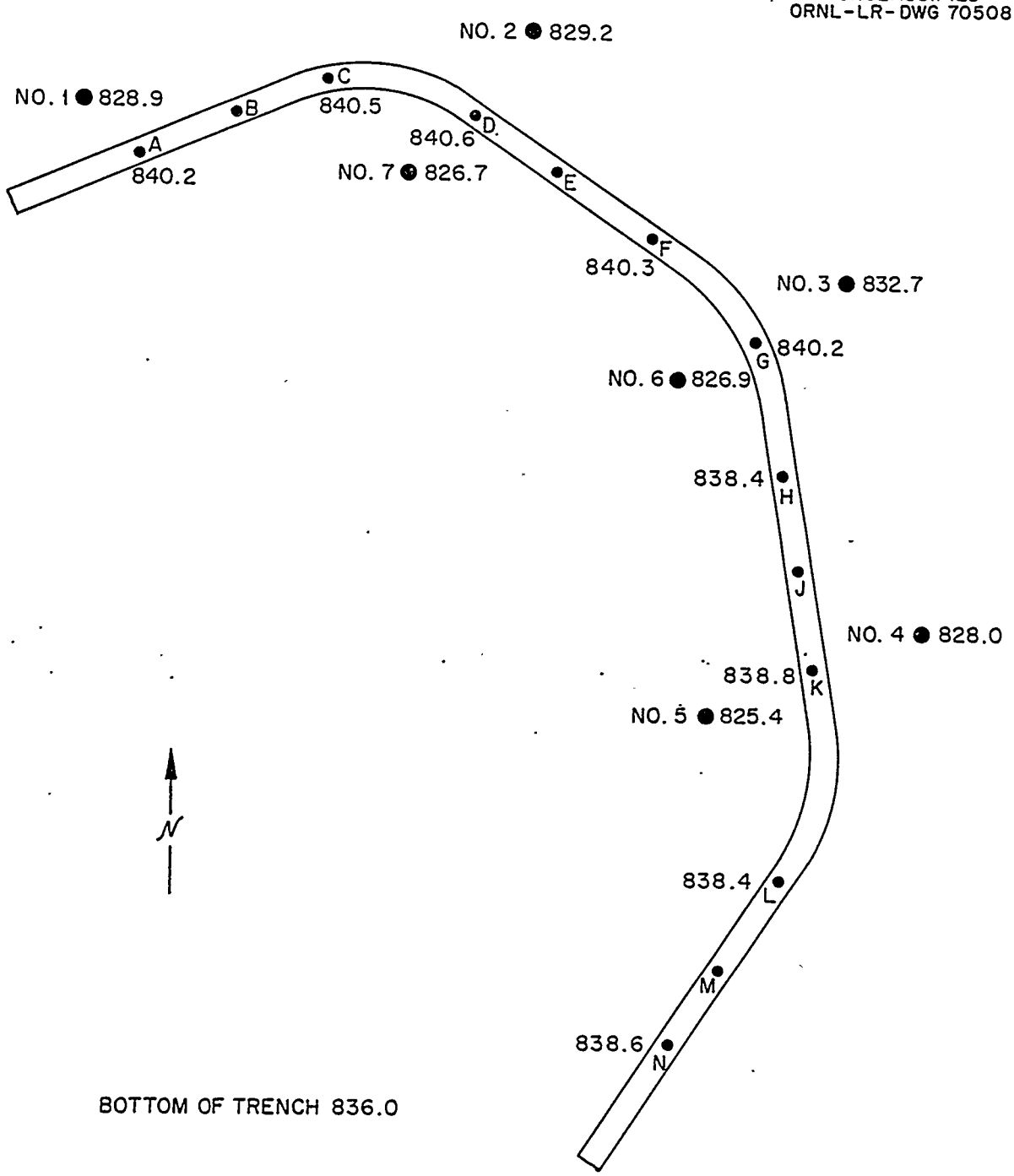
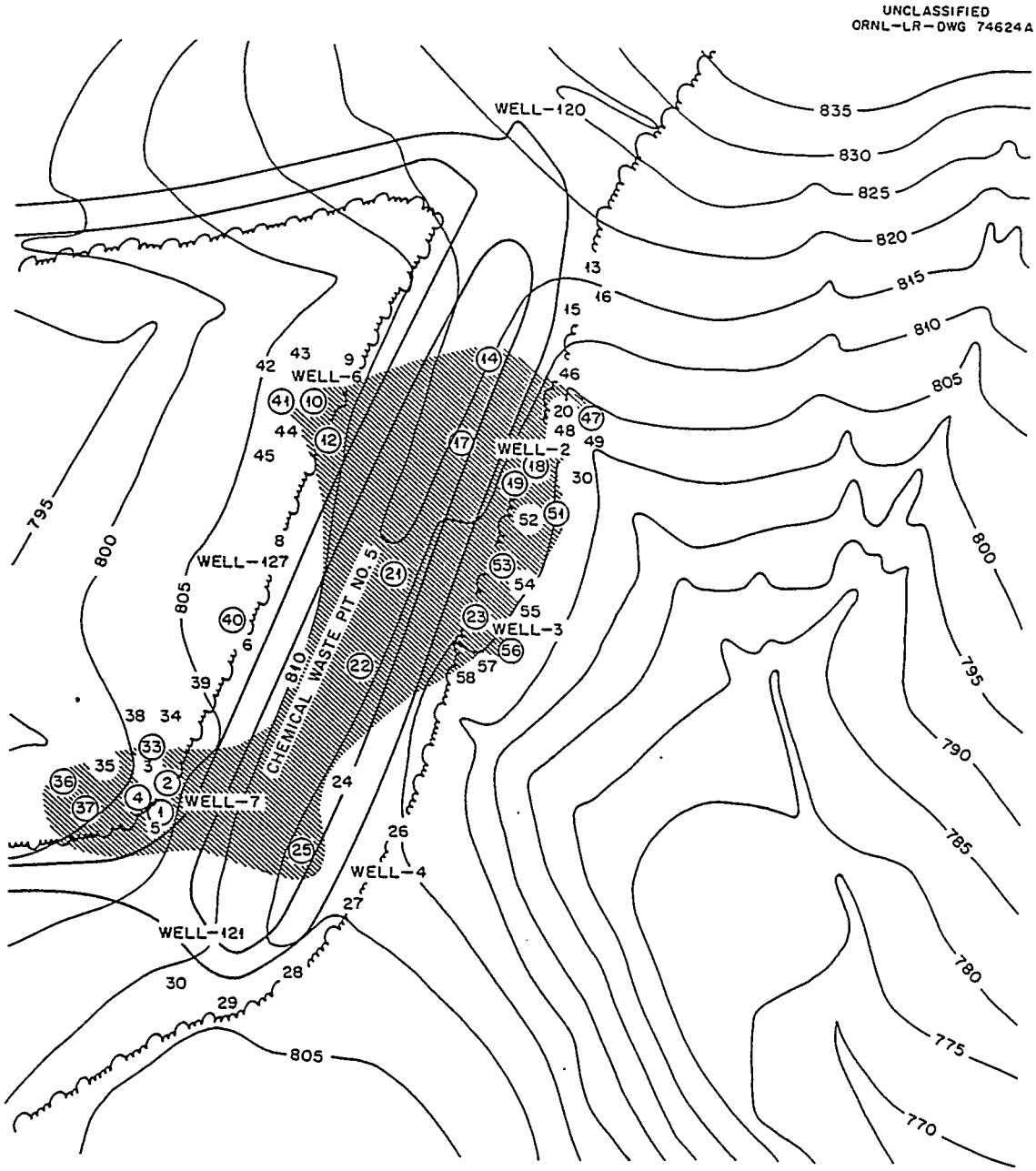
ORNL-LR-DWG 70508



Trench No. 6 Liquid Level, 6-26-62; MSL Elevations.

ORNL-LR-DWG-70508 1962
Trench 6 groundwater levels June 26, 1962



ORNL-LR-DWG-74624A 1962
Contamination plume around trench 5 Sep 1962

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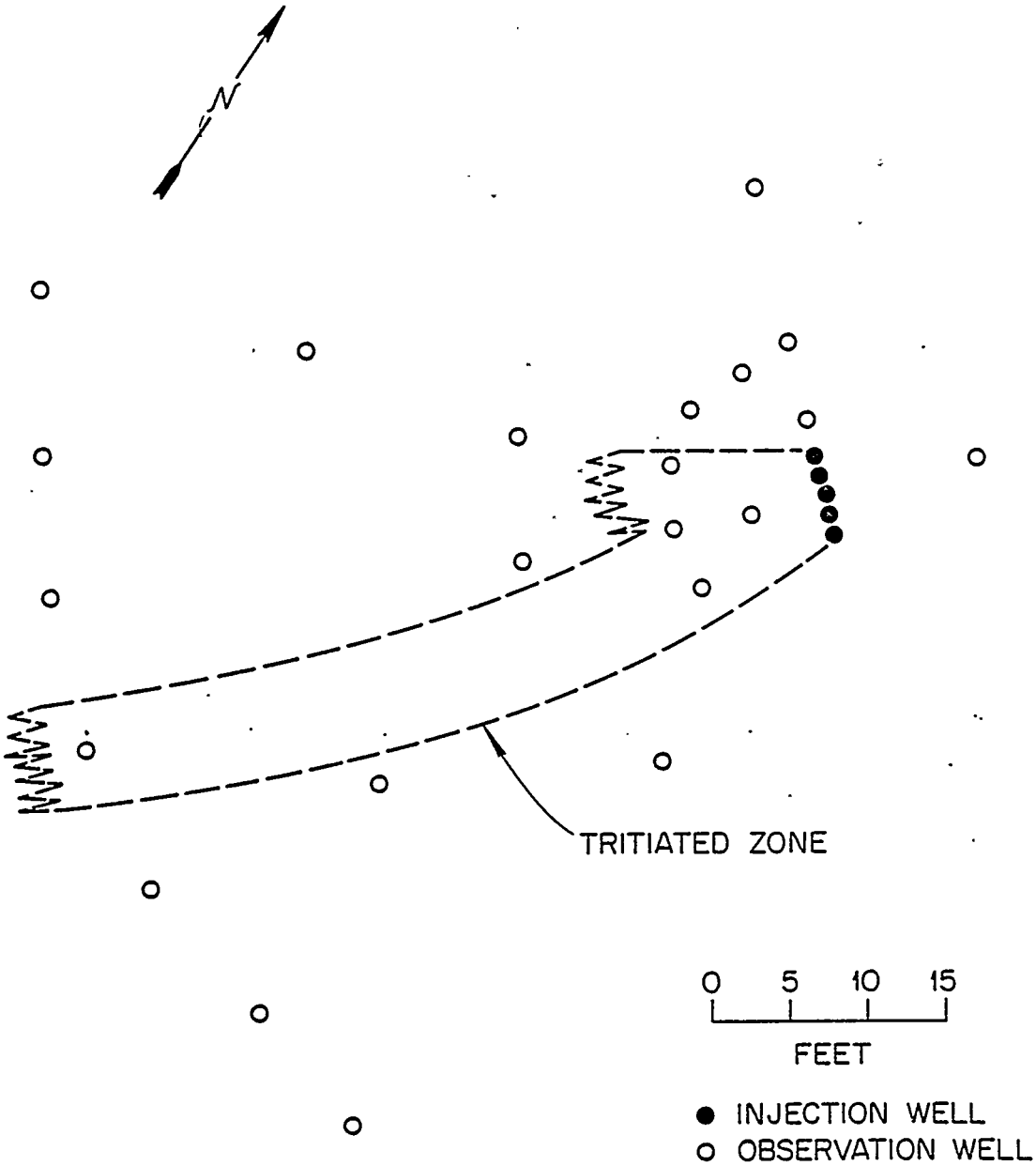
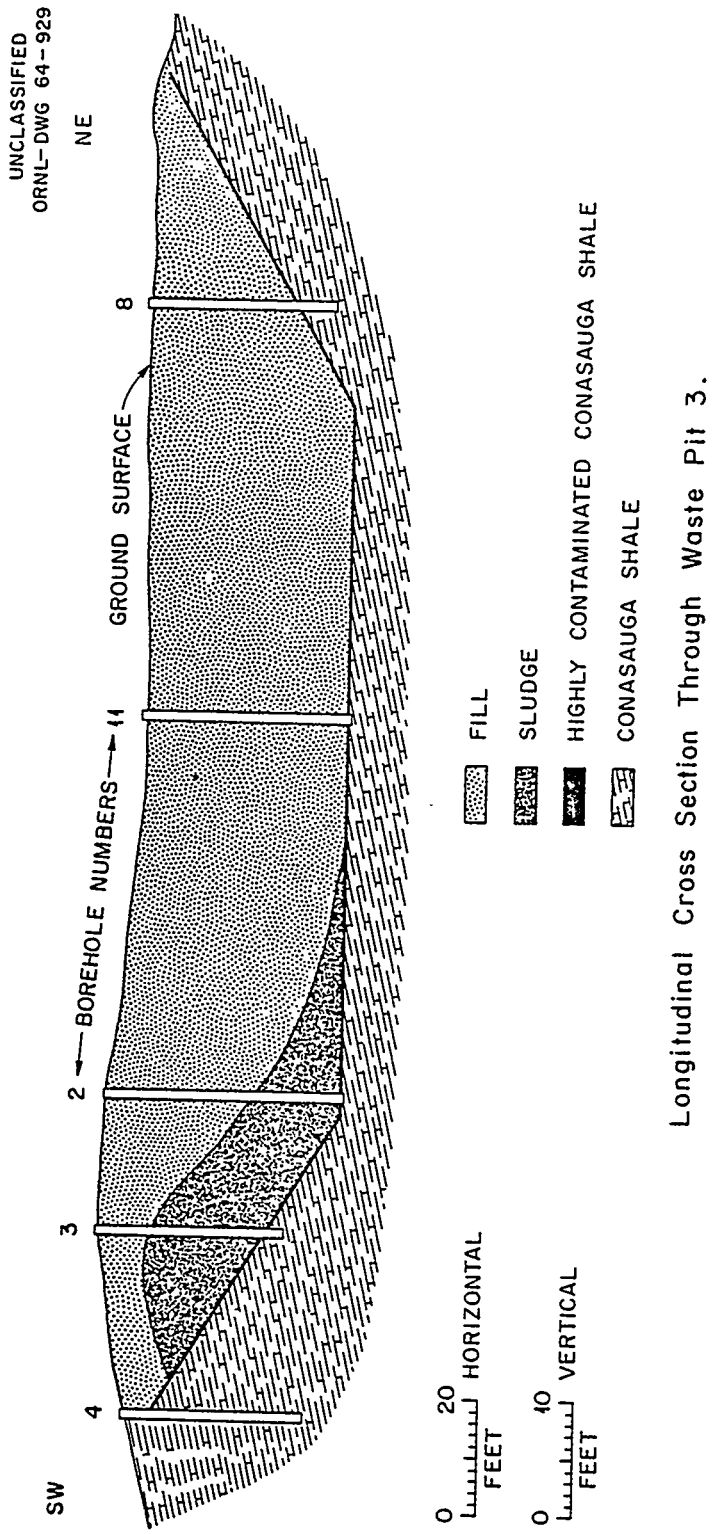
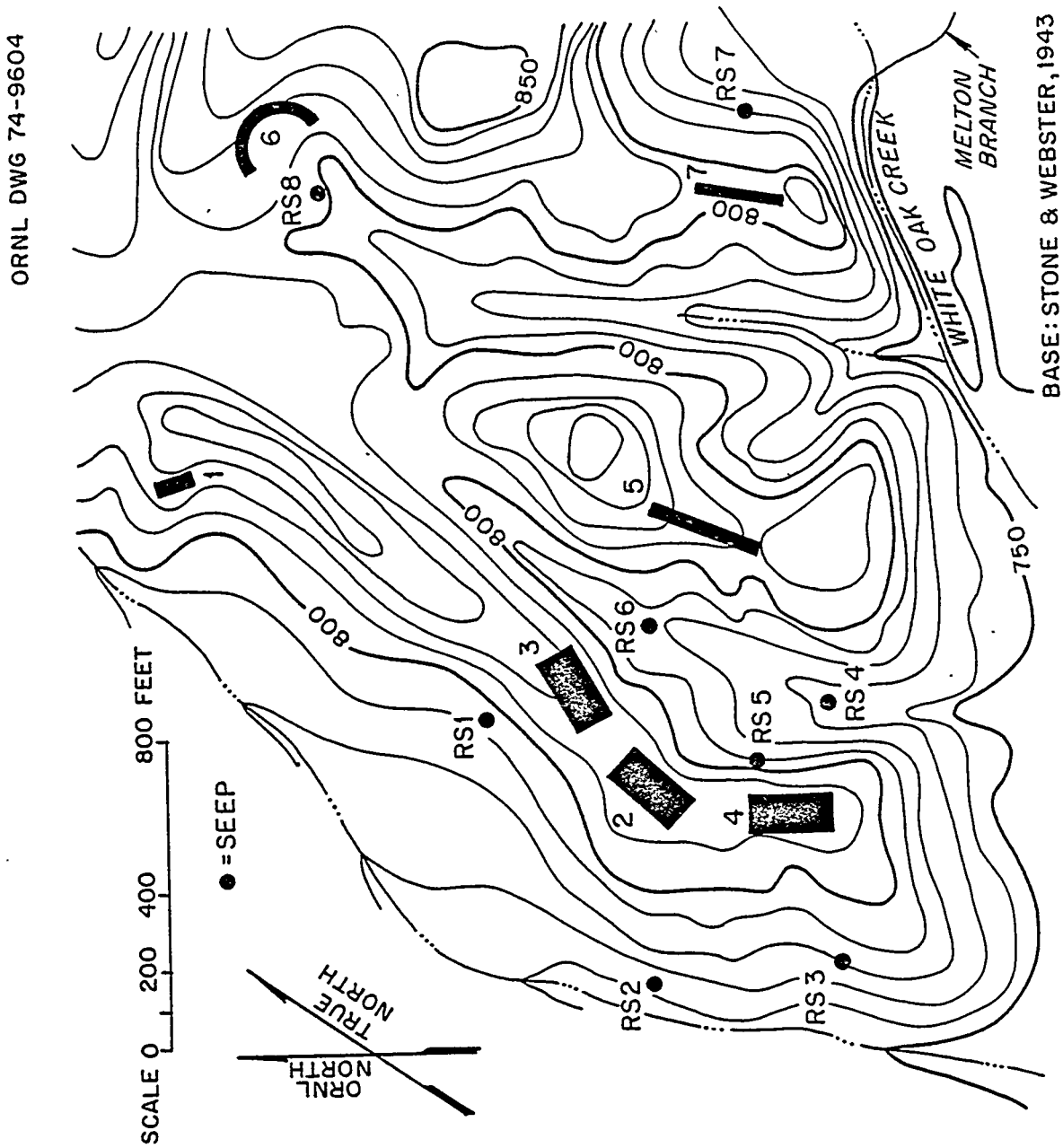
ORNL-DWG 64-7897



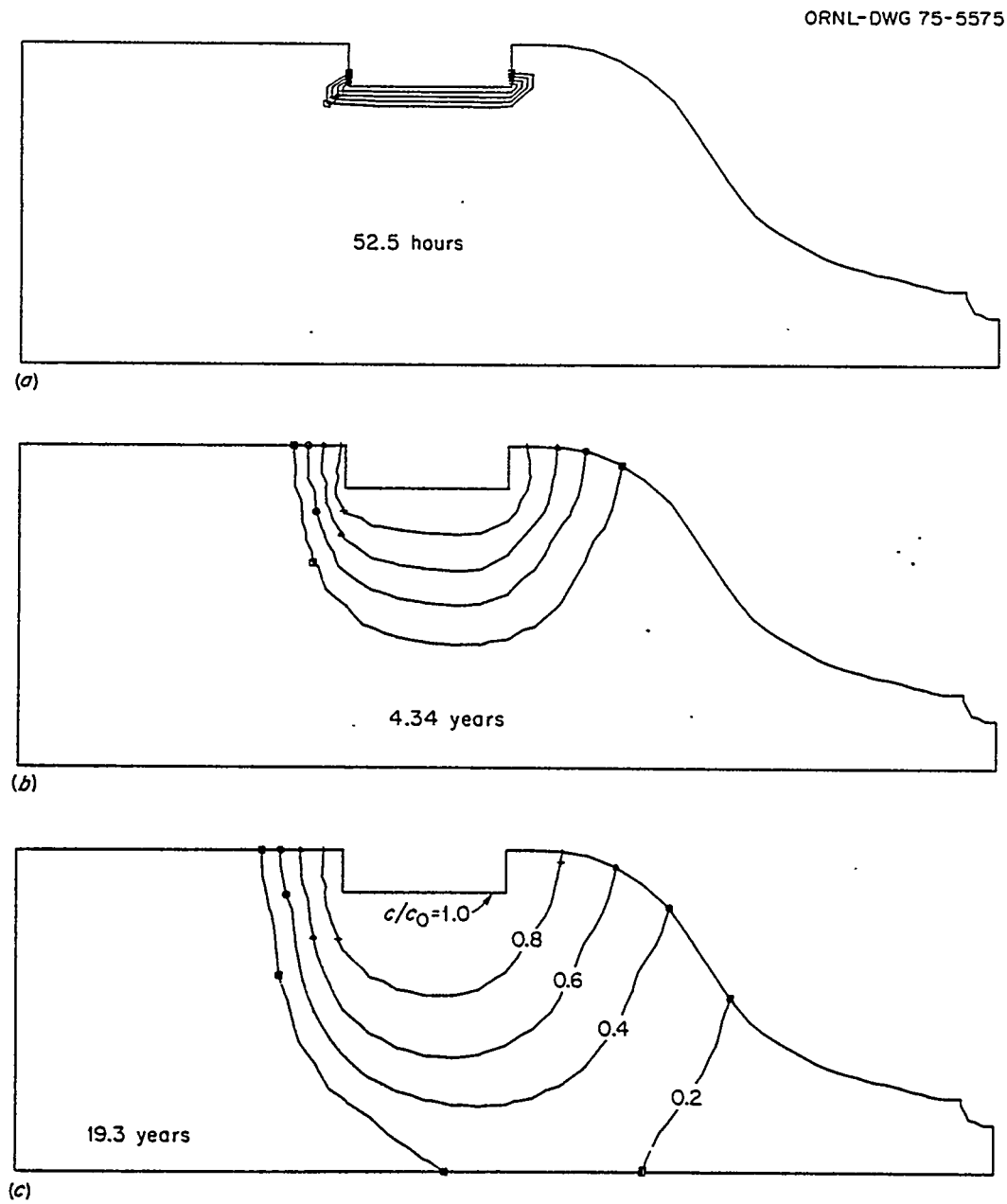
ORNL-DWG-64-7897 1964
Groundwater tritium tracer movement near pit 3



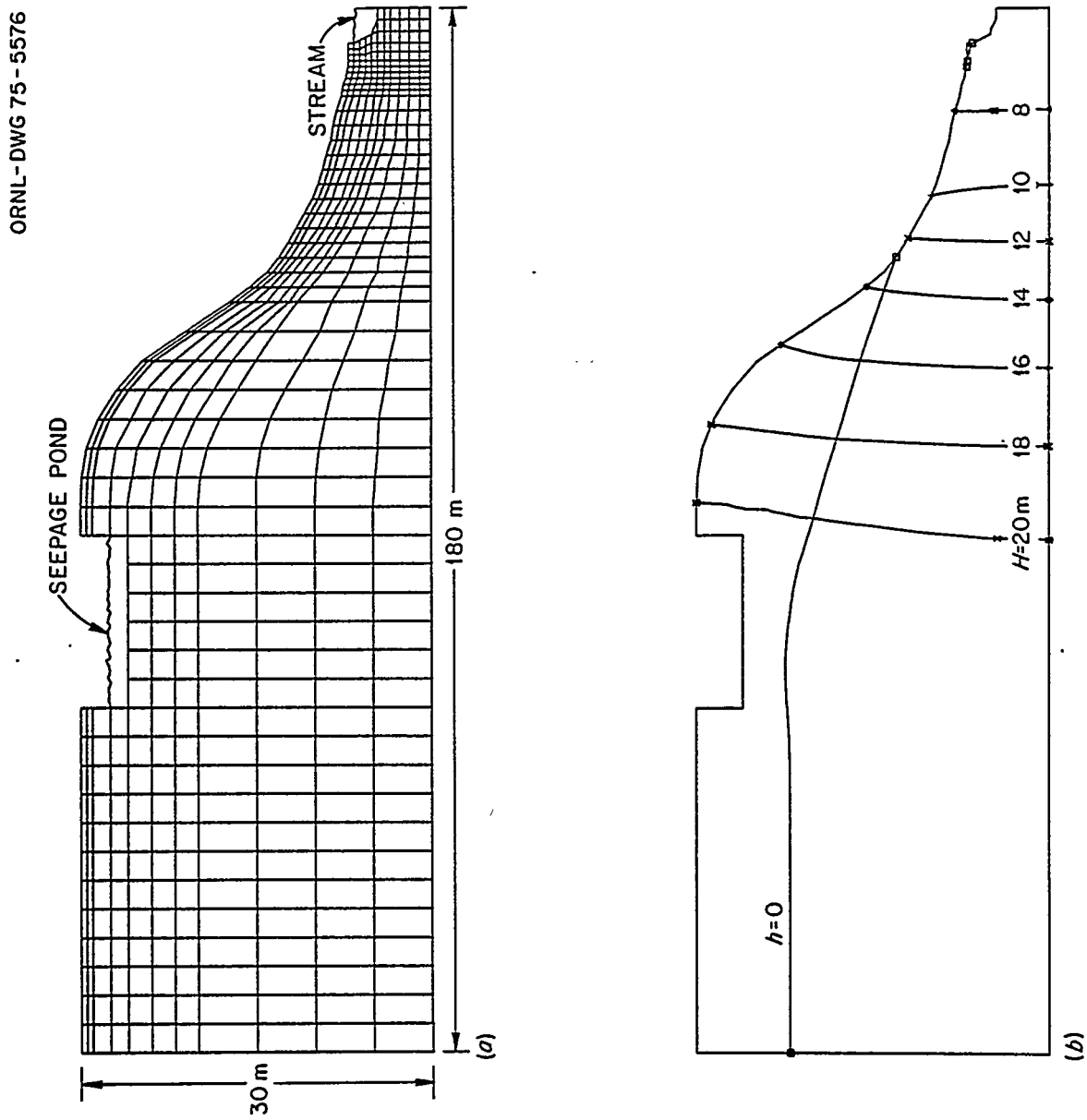
ORNL-DWG-64-929 1964
Longitudinal cross section of pit 3 postclosure



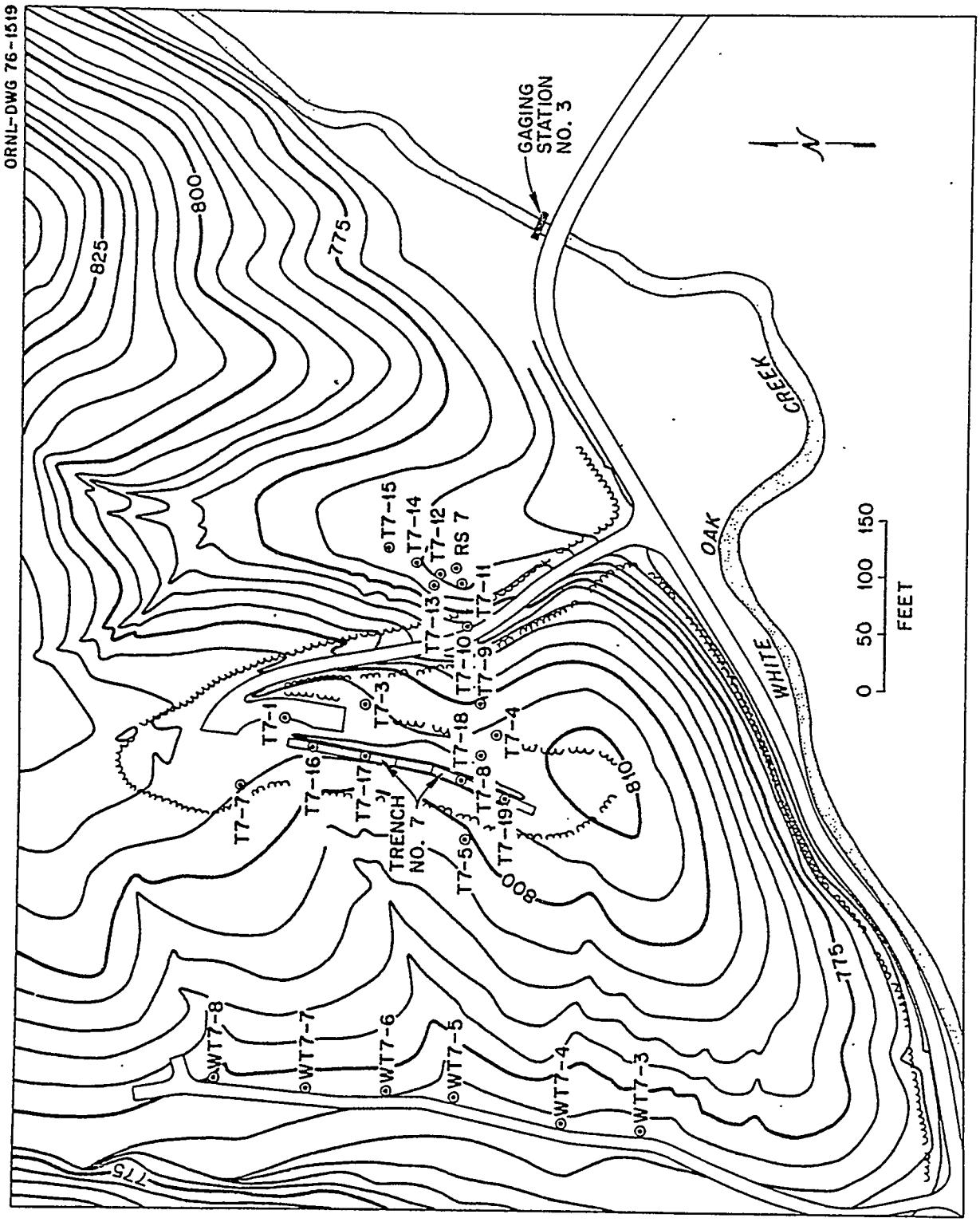
ORNL-DWG-74-9604 1974
Seep locations around pits and trenches



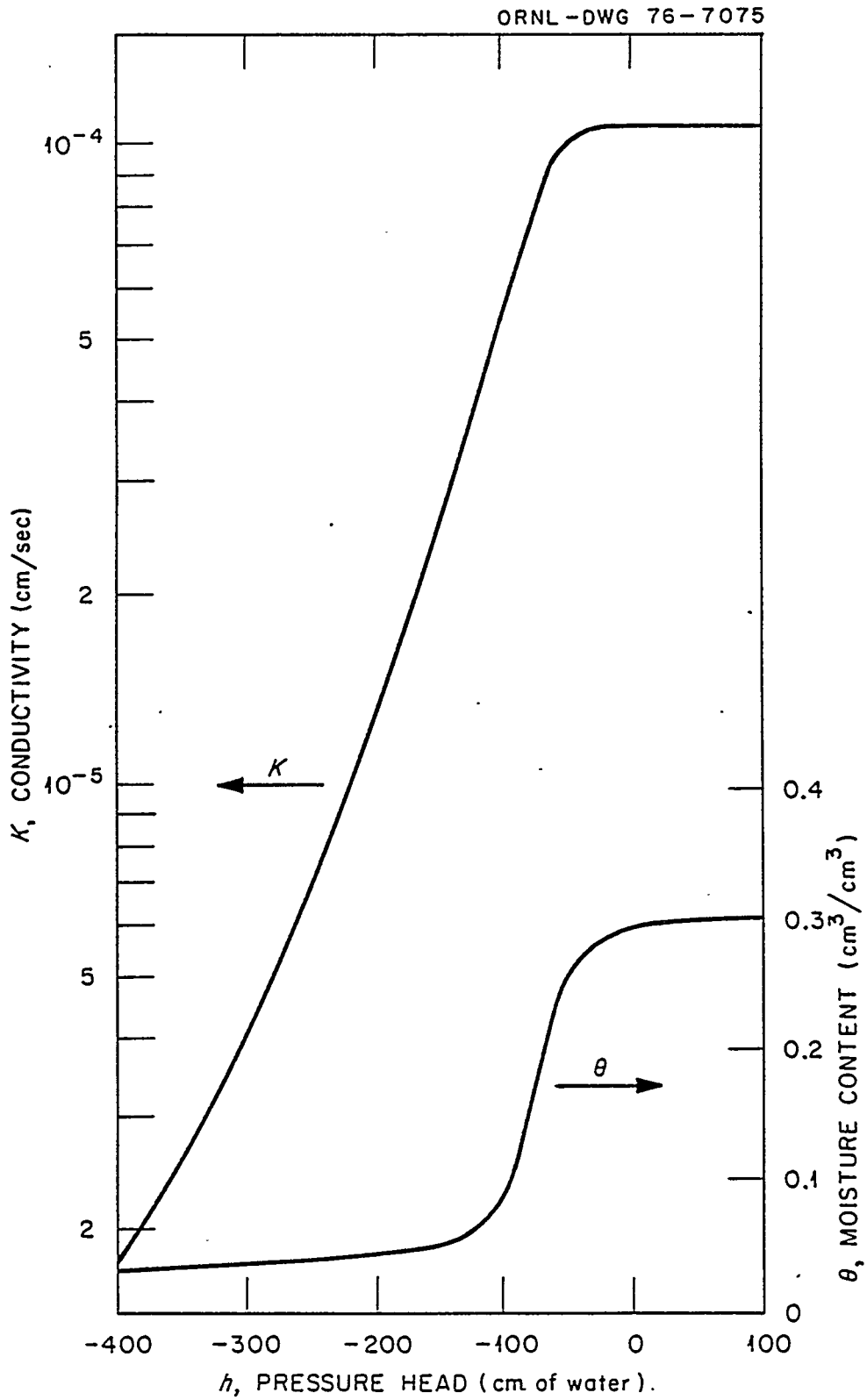
ORNL-DWG-75-5575 1975
Trench to dispersion model of Kd=100 species



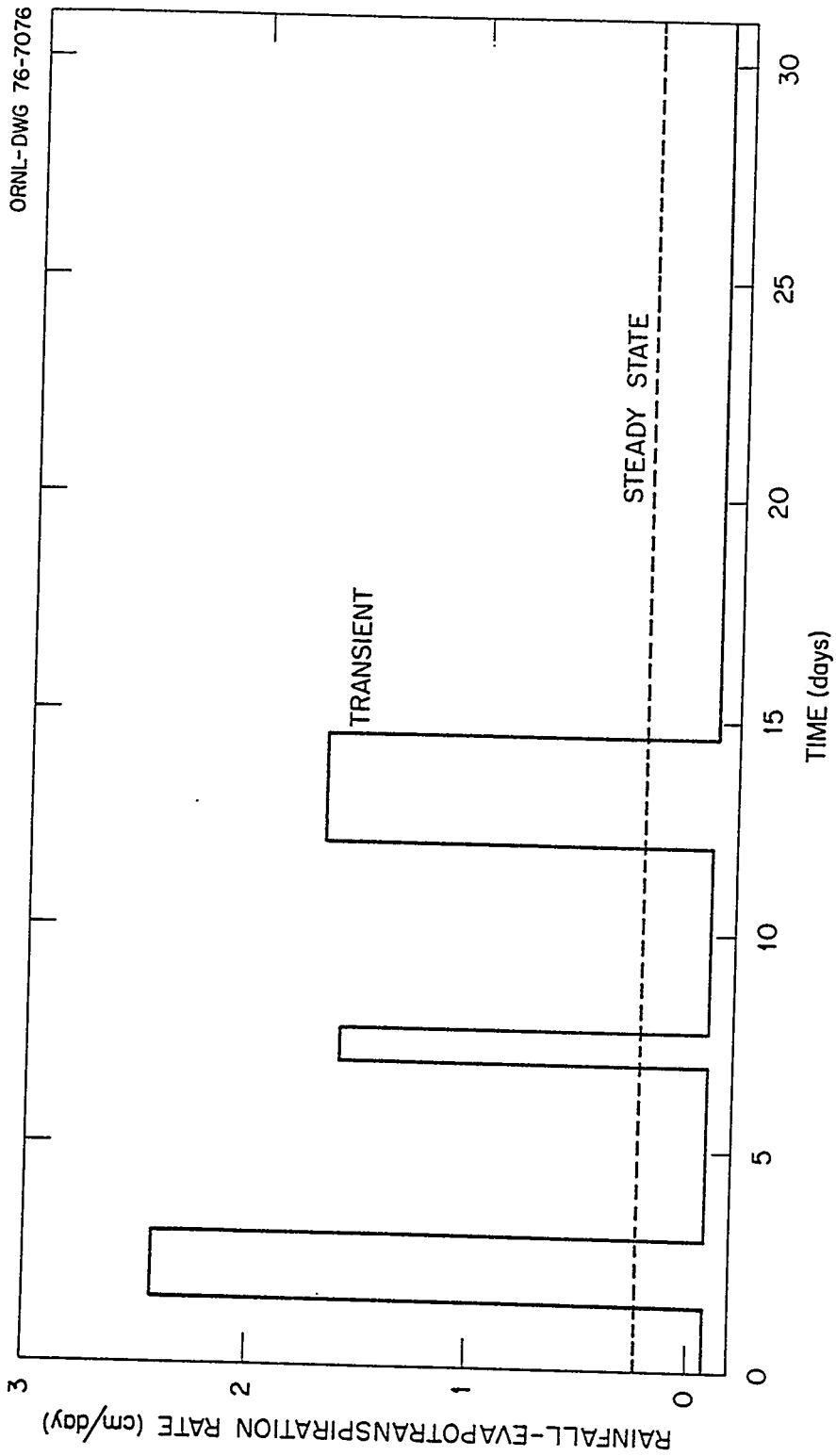
ORNL-DWG-75-5576 1975
Trench discretization and head to stream model



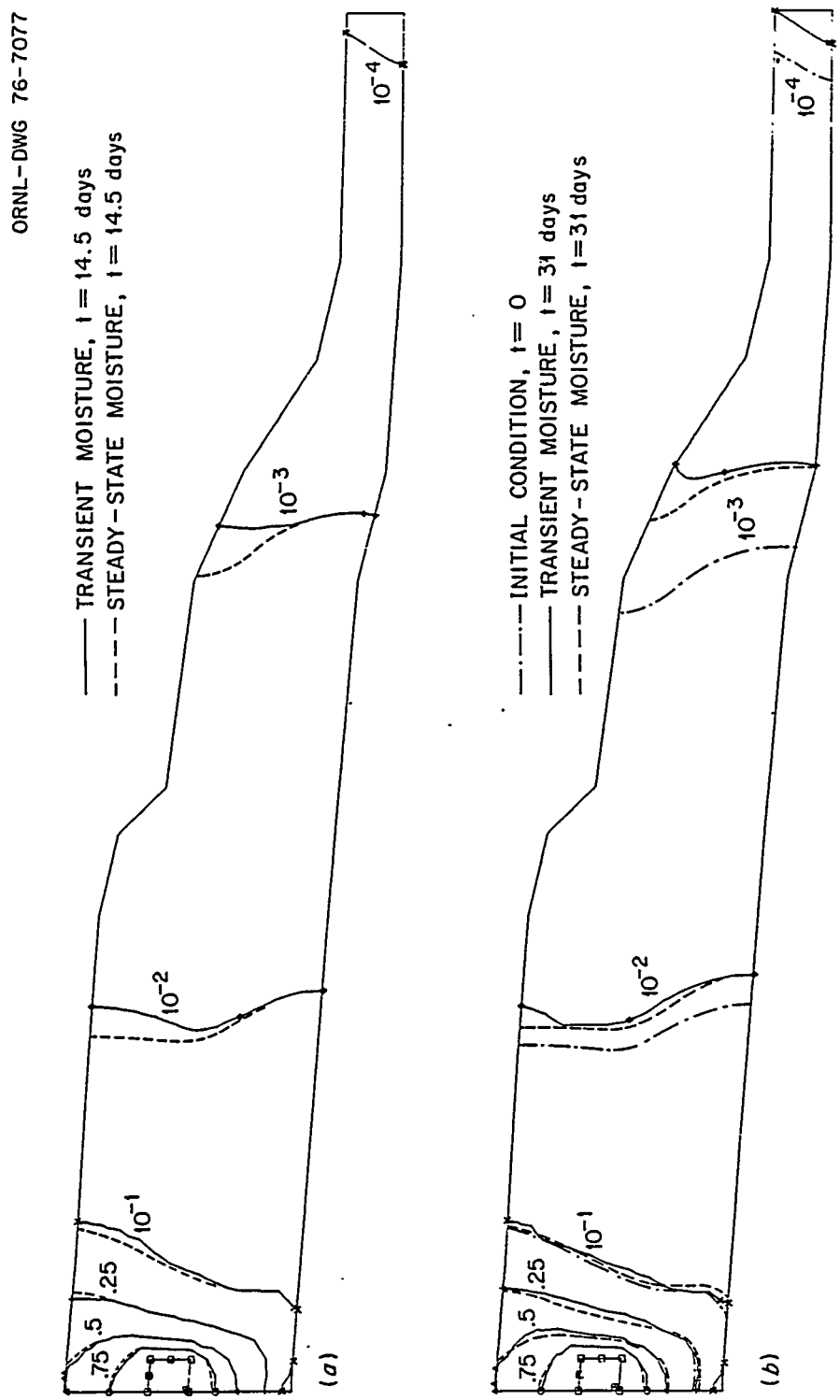
ORNL-DWG-76-1519 1976
Monitoring well locations near Trench No. 7



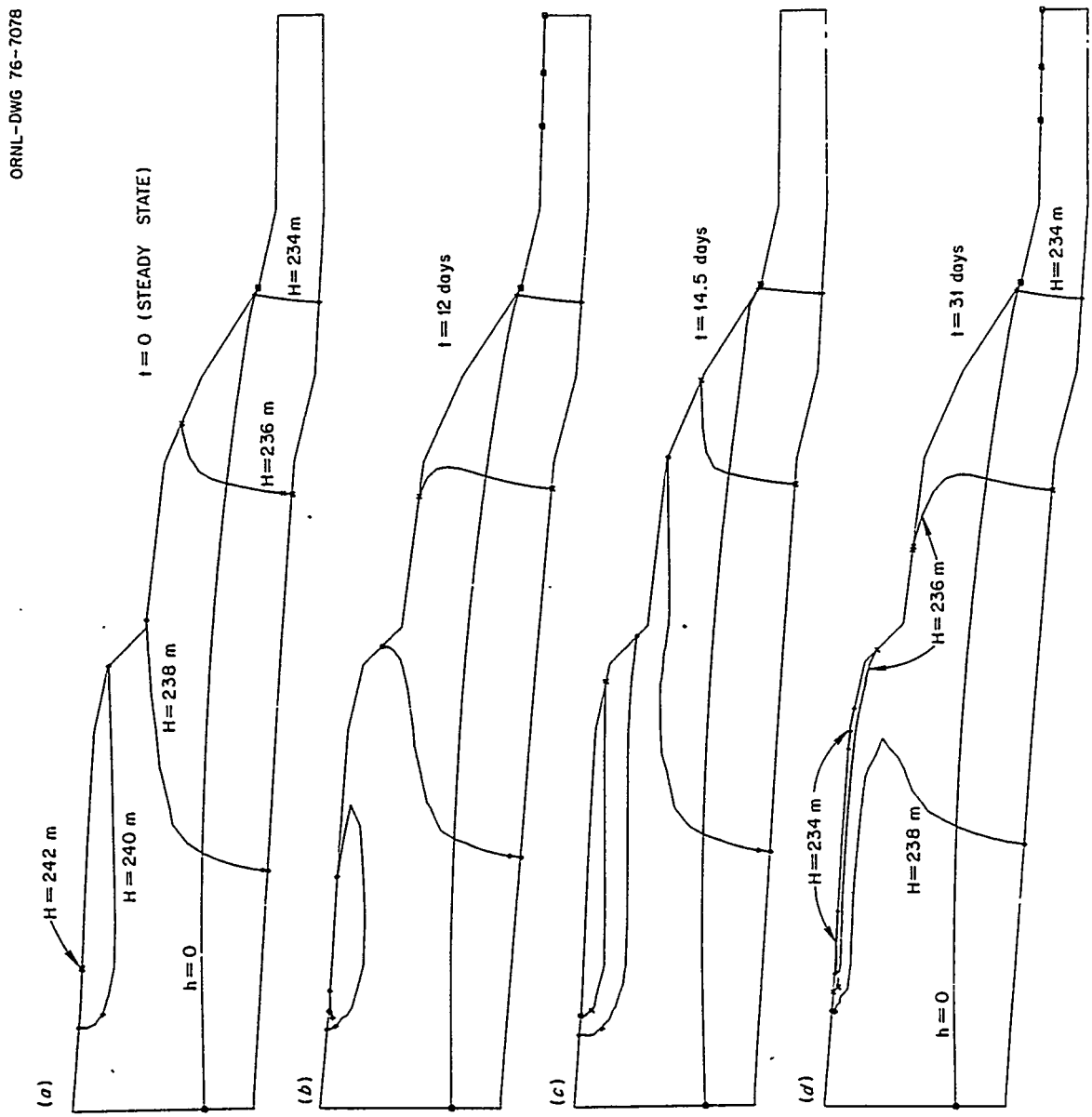
ORNL-DWG-76-7075 1976
Pressure, moisture, and conductivity relations



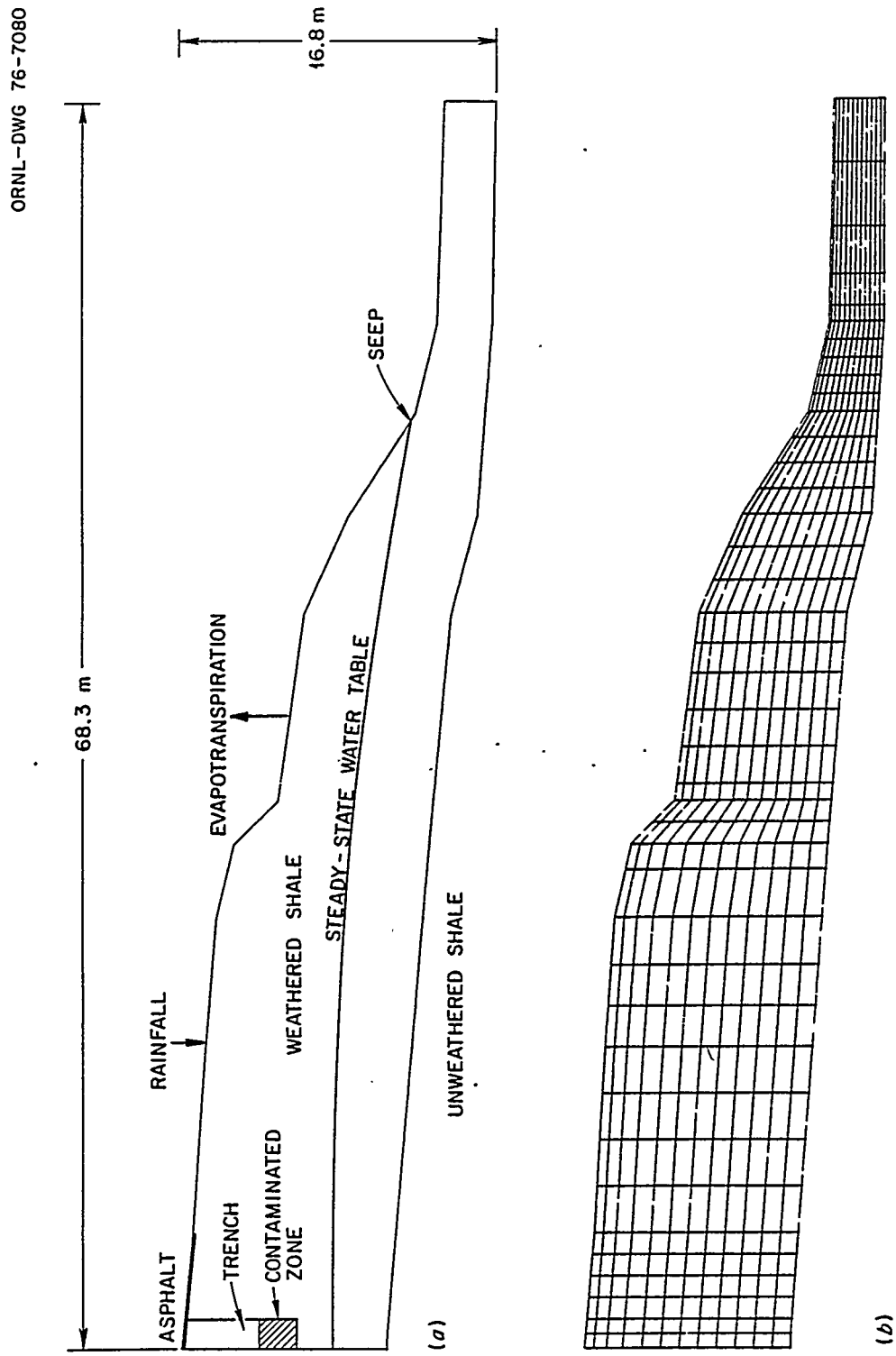
ORNL-DWG-76-7076 1976
Rainfall boundery model conditions May 1972



ORNL-DWG-76-7077 1976
Trench 7 simulated tritium migration

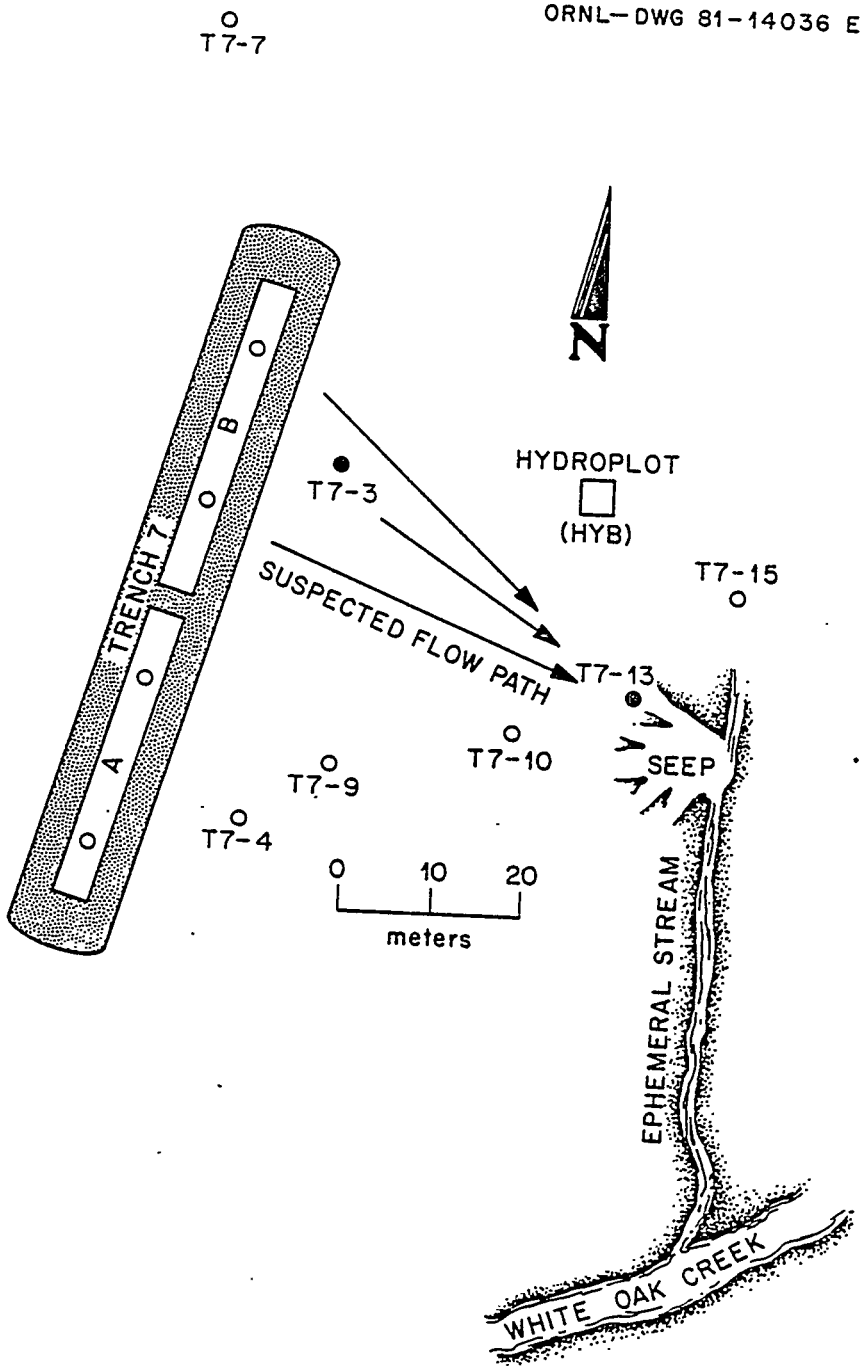


ORNL-DWG-76-7078 1976
Trench 7 water table and head simulations

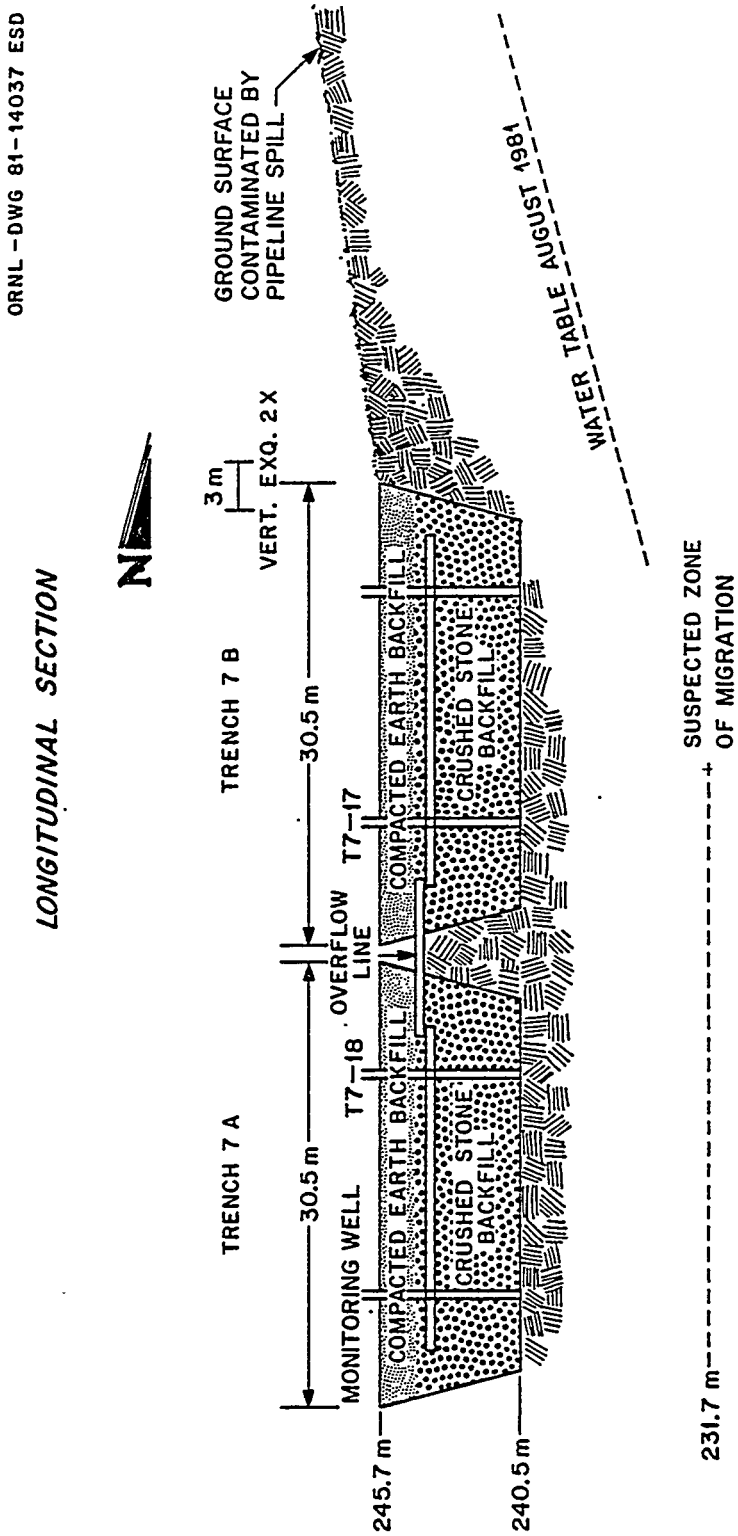


ORNL-DWG-76-7080 1976
Cross sectional discretization of trench 7

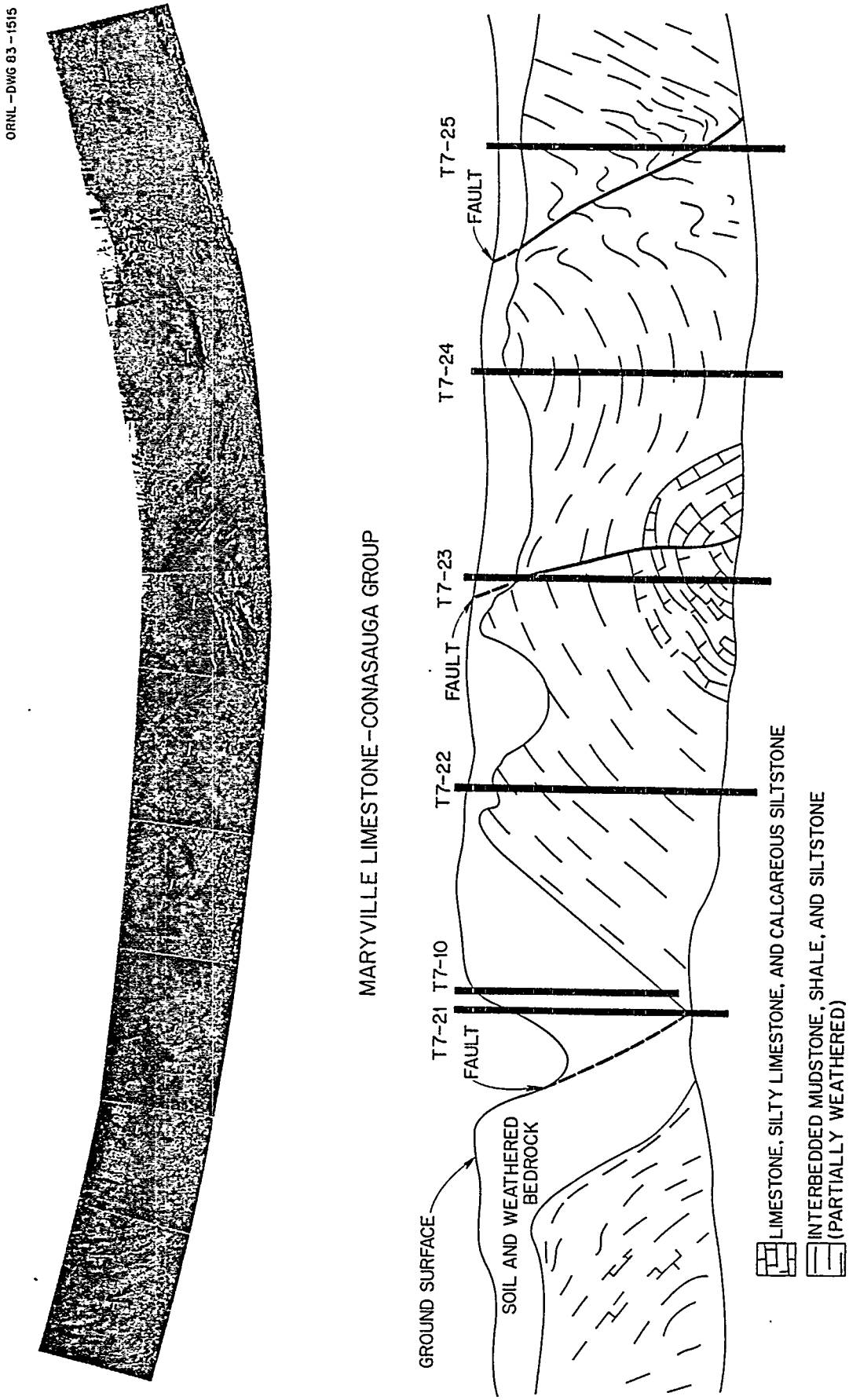
ORNL-DWG 81-14036 ESD



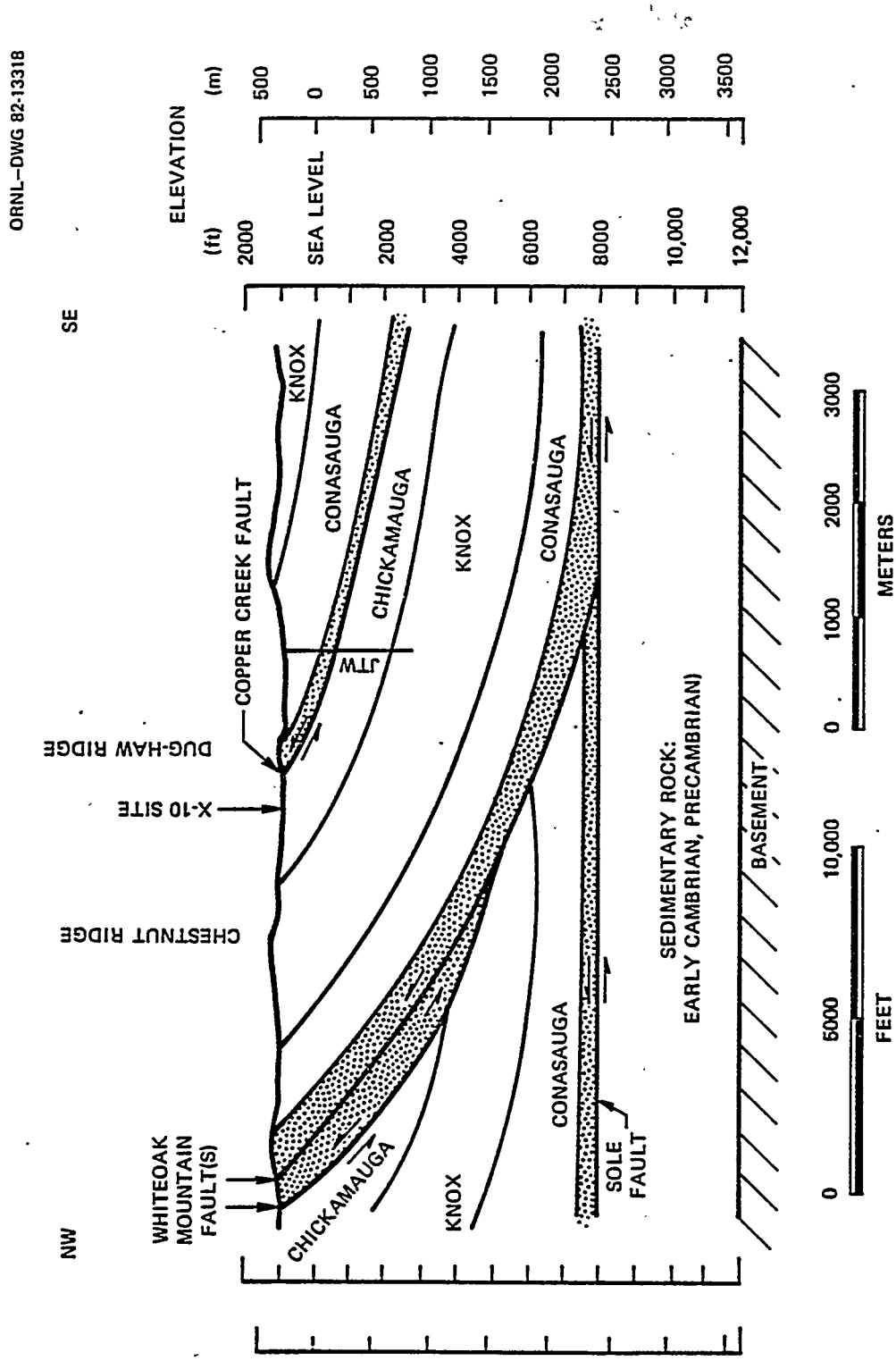
ORNL-DWG-81-14036ESD 1981
Trench 7 Groundwater Flow Paths to Seep



ORNL-DWG-81-14037ESD 1981
Plan cross section of trench 7

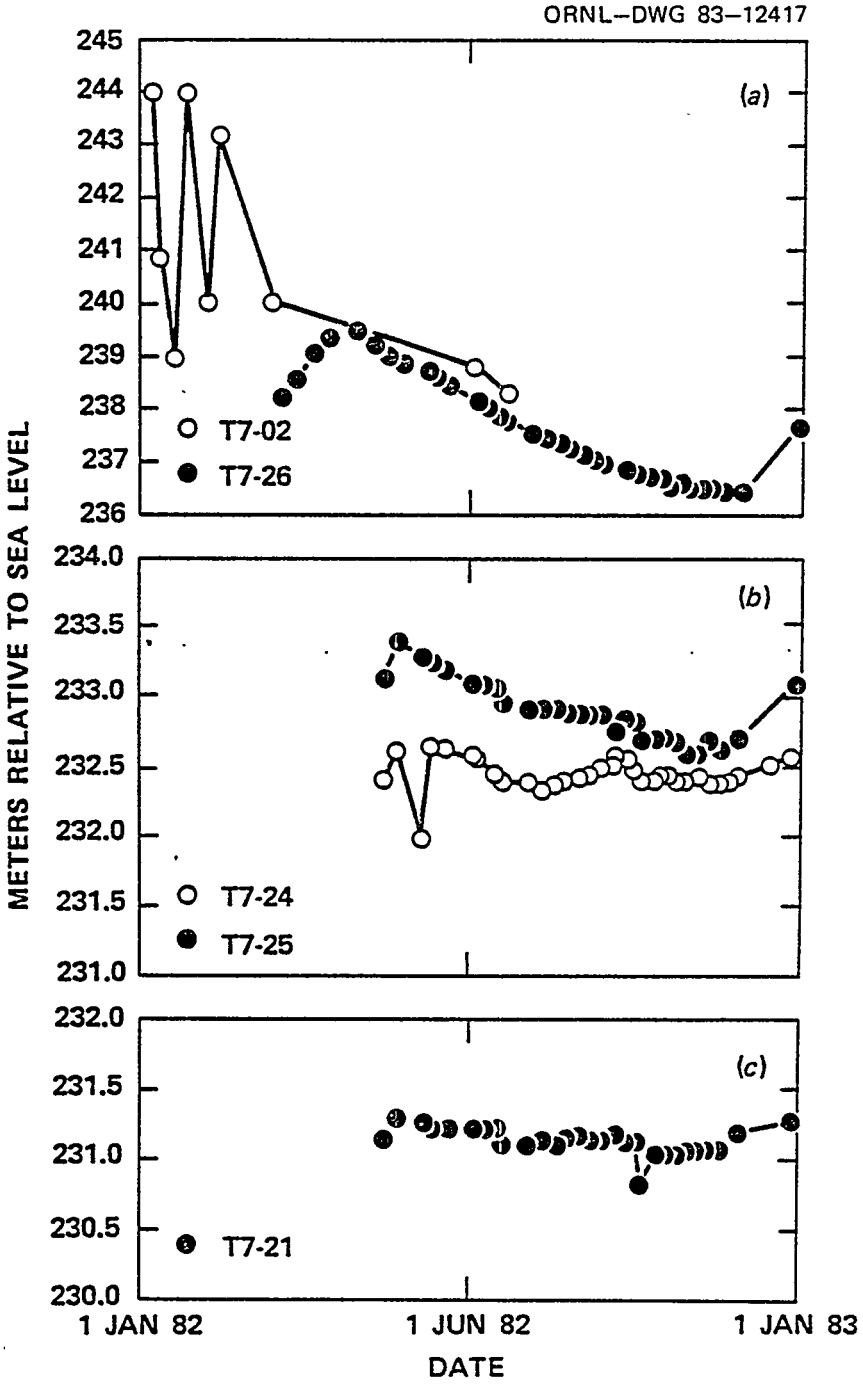


ORNL-DWG-83-1515 1983
Stratigraphic exposure east of trench 7



ORNL-DWG-82-13318 1982
Generalized Stratigraphy around X-10 (ORNL)

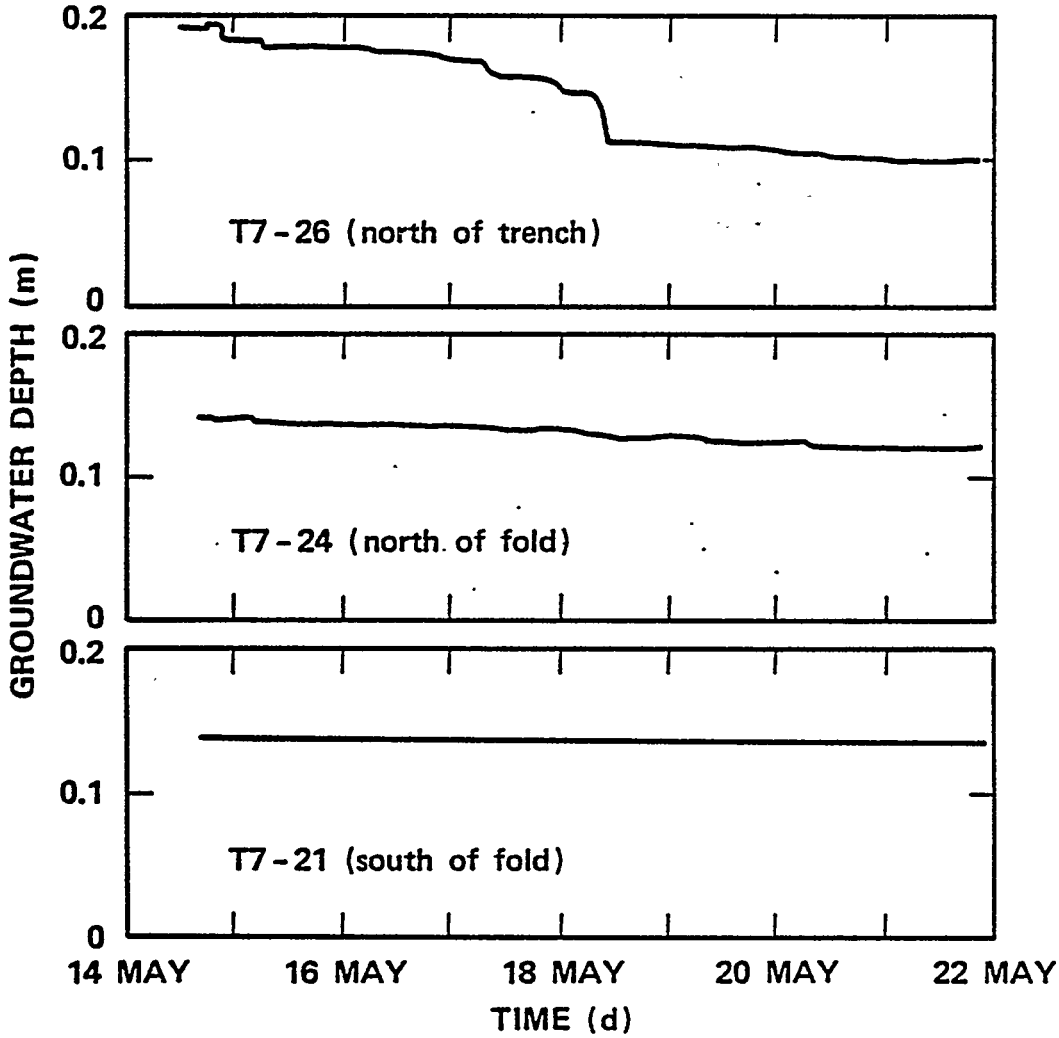
YEARLY FLUCTUATION IN GROUNDWATER LEVELS



ORNL-DWG-83-12417 1983
Yearly groundwater levels around trench 7

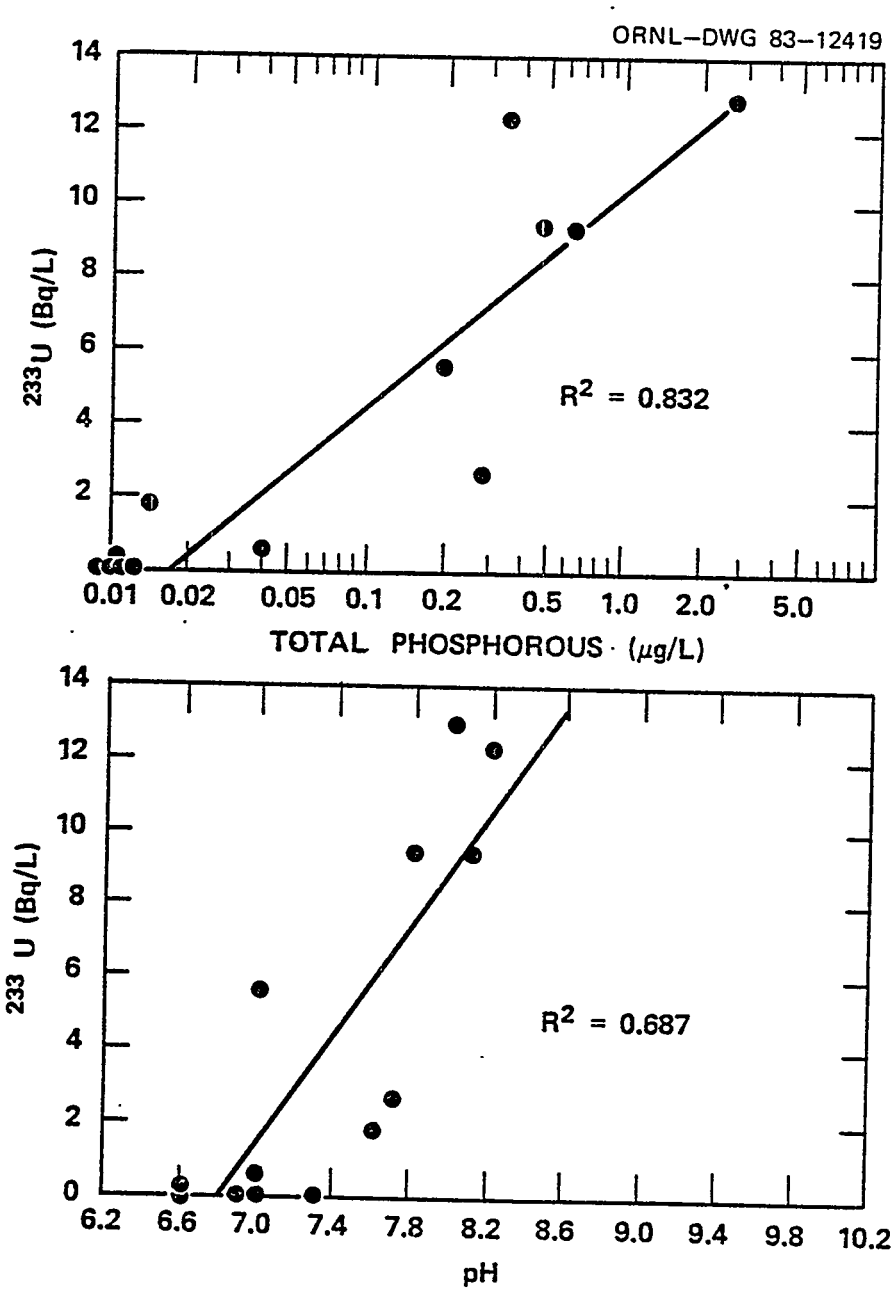
WEEKLY FLUCTUATION IN GROUNDWATER LEVELS

ORNL DWG 83-12418



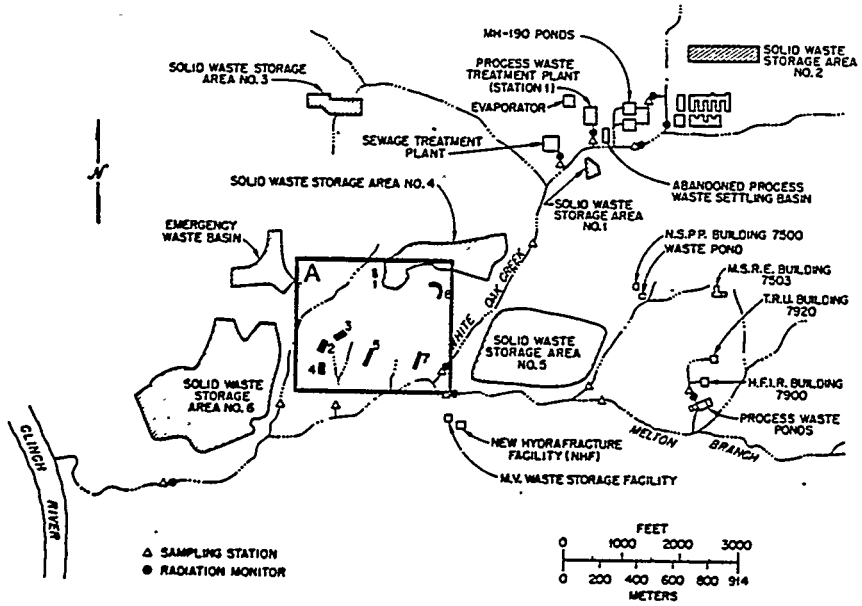
ORNL-DWG-83-12418 1983
Weekly groundwater levels around trench 7

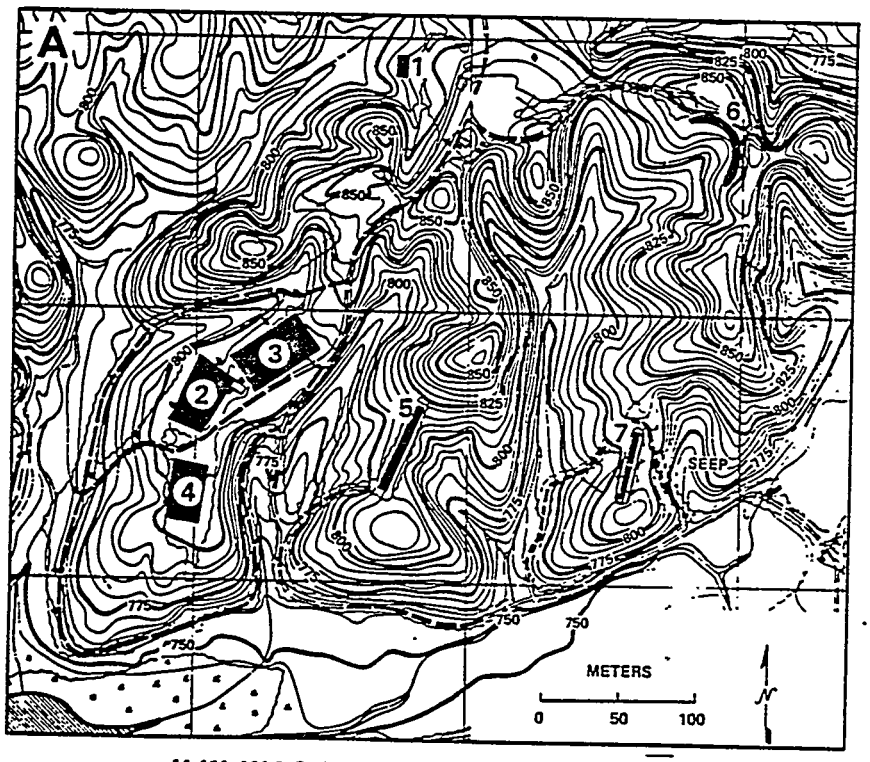
^{233}U CONCENTRATION AS A FUNCTION OF TOTAL PHOSPHOROUS AND pH



ORNL-DWG-83-12419 1983
233-U vs. Phosphorus/pH at well T7-21 at trench 7

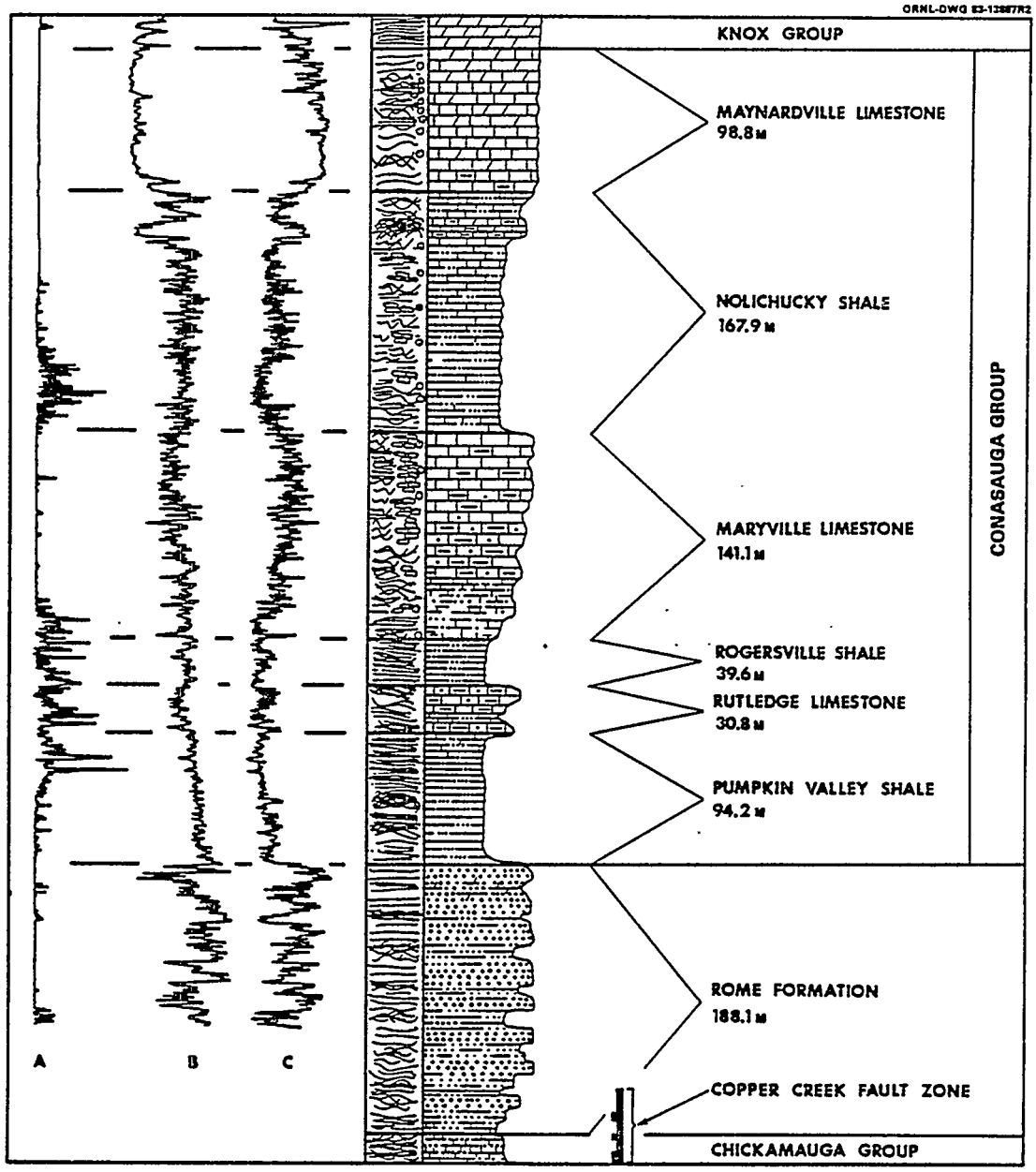
ORNL-DWG 83-12602





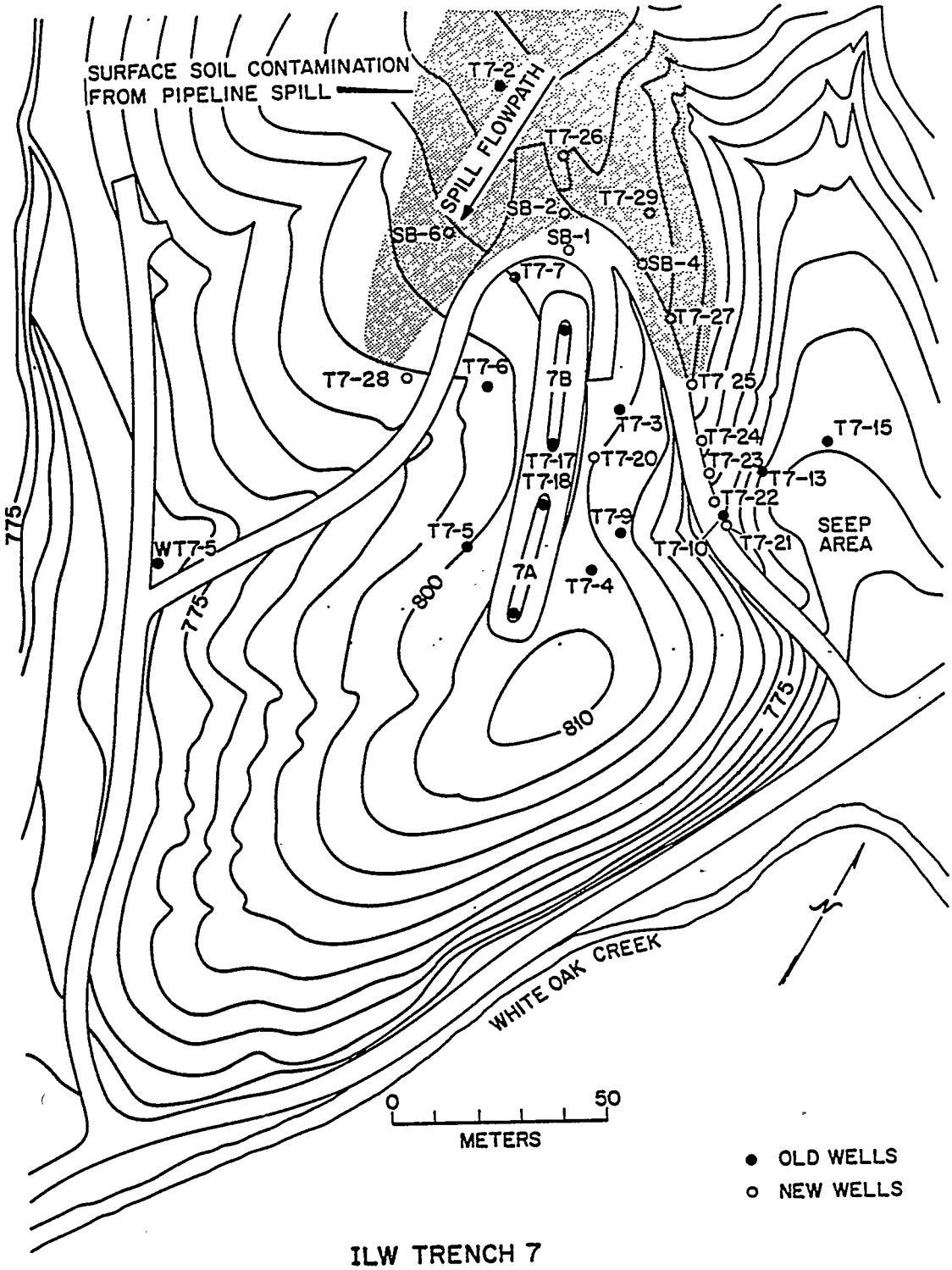
ILW WASTE PITS AND TRENCHES

ORNL-DWG-83-12602 1983
Topographic map of pits and trenches area



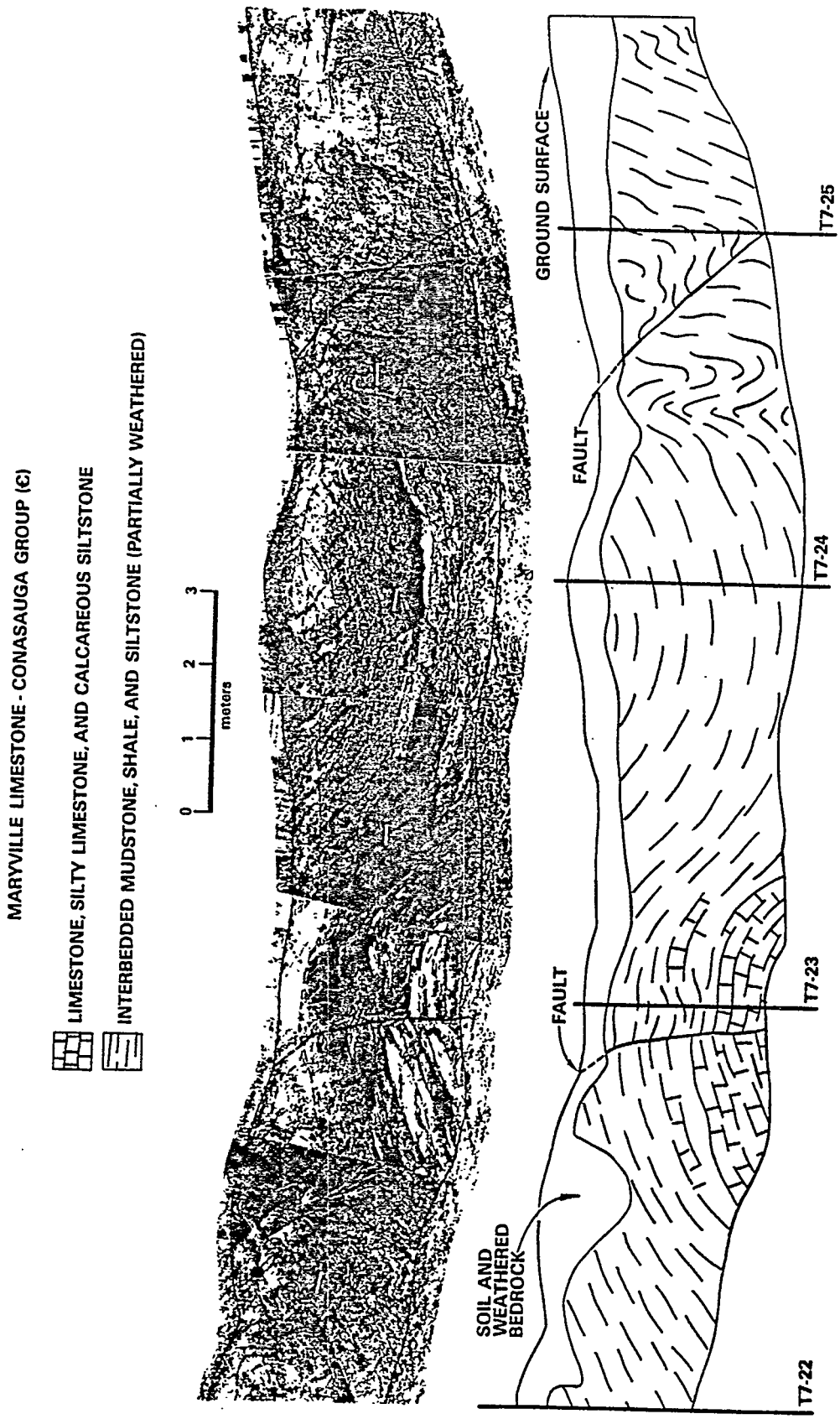
ORNL-DWG-83-13887R2 1983
Stratigraphic column of Conasauga formation

ORNL-DWG 83-1514A



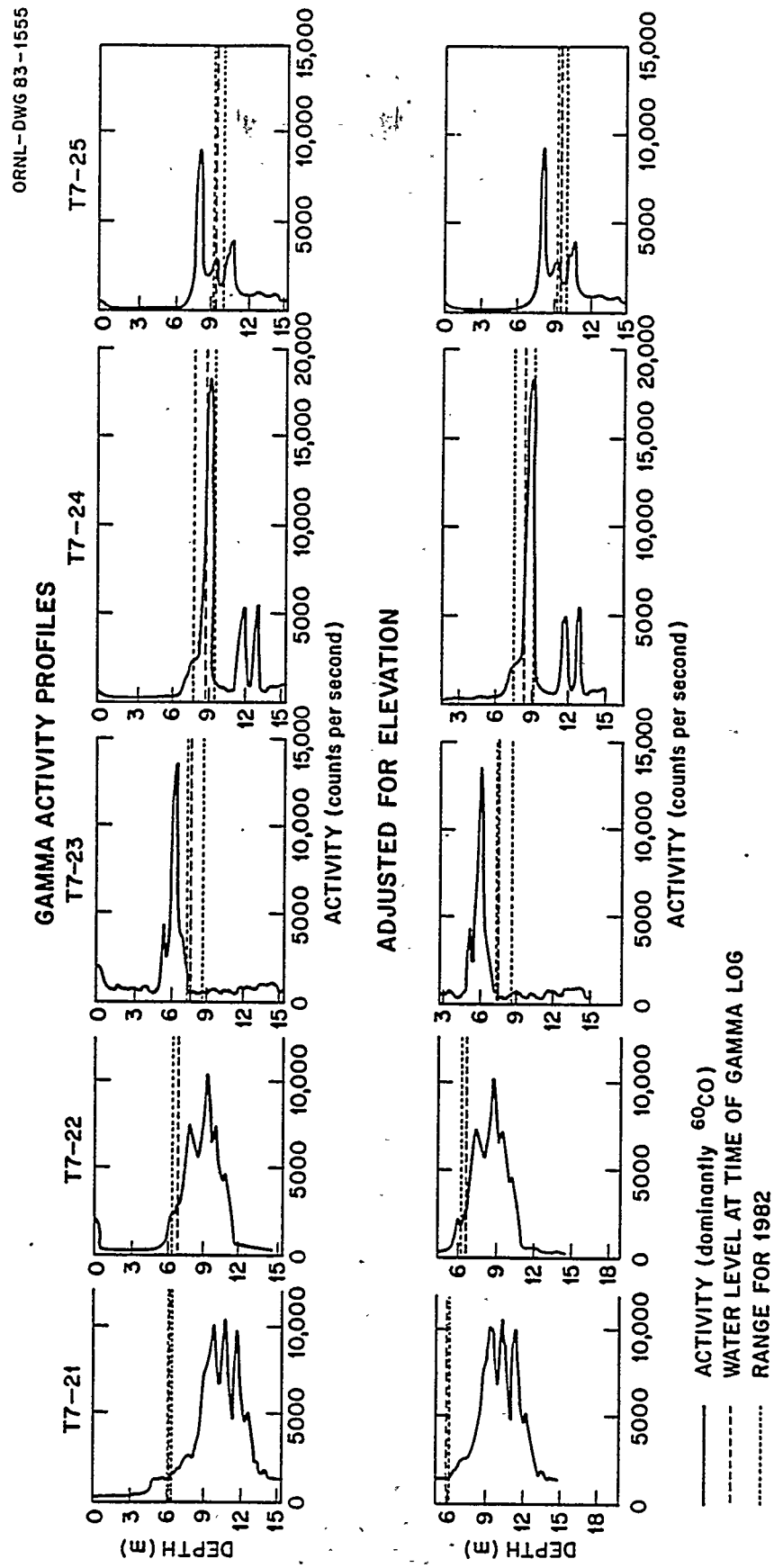
ILW TRENCH 7

ORNL-DWG-83-1514A 1983
Map of monitoring well locations around trench 7

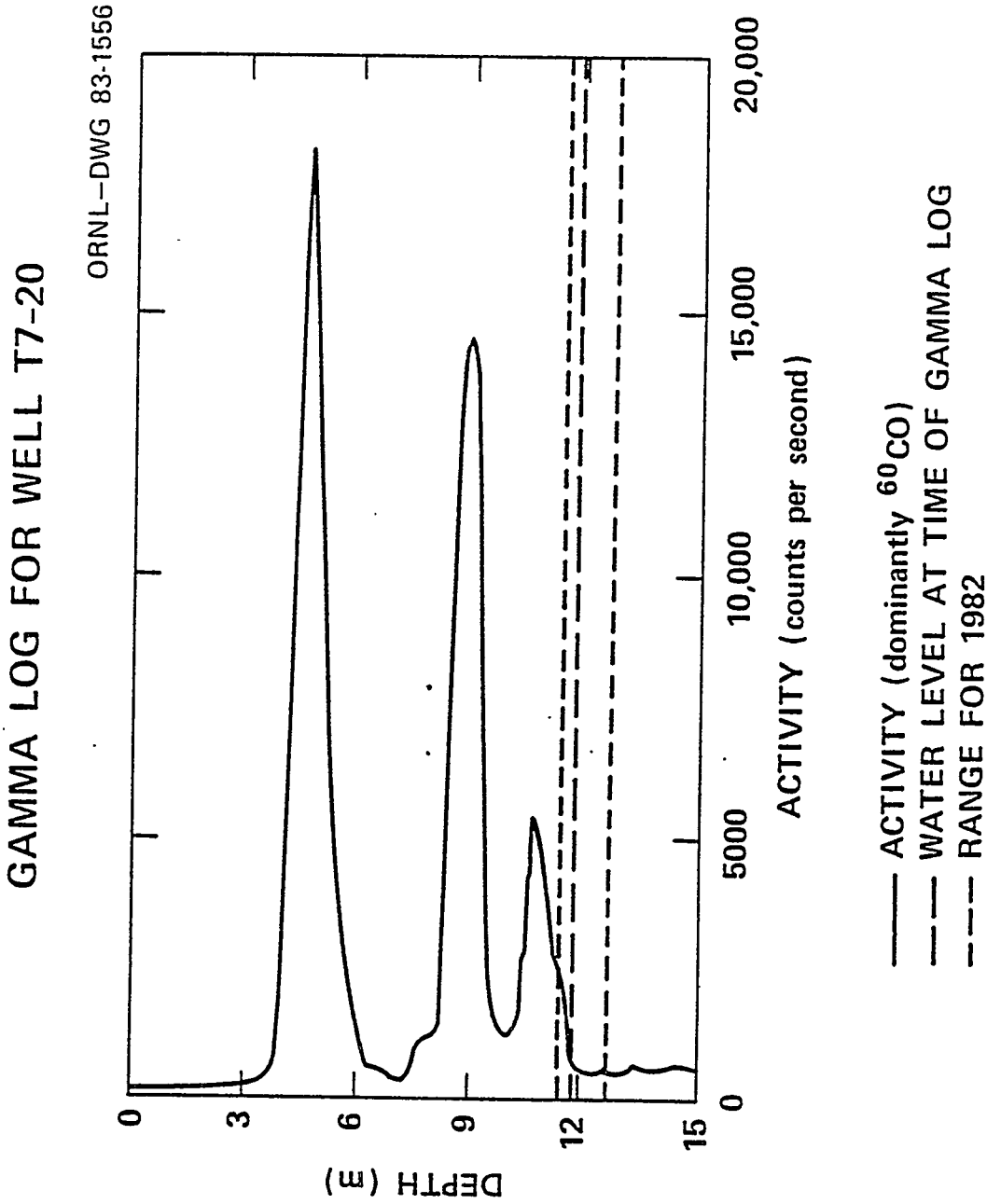


ORNL-DWG-81-21573B 1981

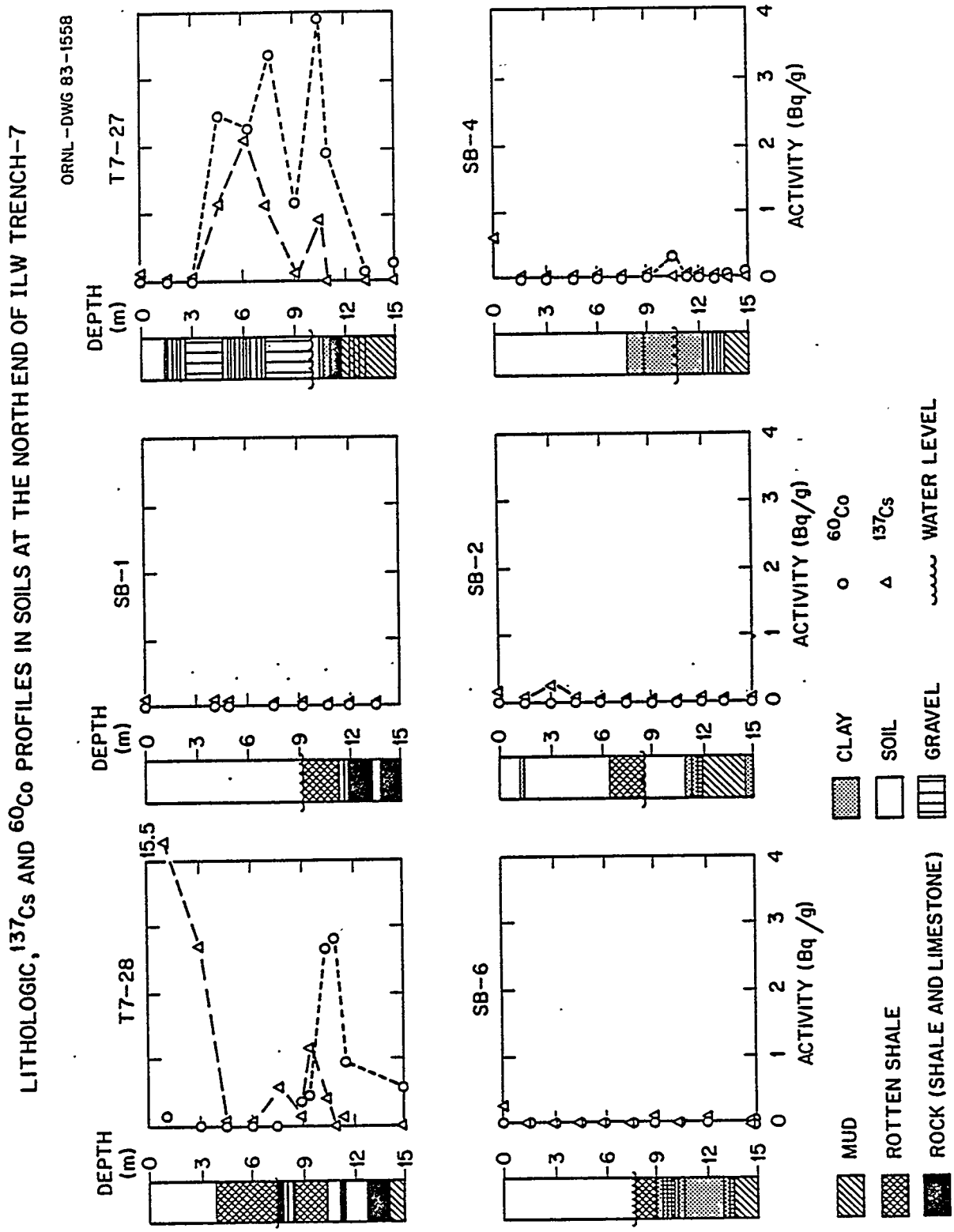
Stratigraphic exposure on roadcut east of T7



ORNL-DWG-83-1555 1983
Gamma actiity profiles of wells near trench 7



ORNL-DWG-83-1556 1983
Gamma activity log of well T7-20 at trench 7



ORNL-DWG-83-1558 1983
Lithologic, 137-Cs, 60-Co profiles north trench 7

Appendix D
ORNL Engineering Drawings Related to Seepage Pits and Trenches

12249 10APR52
Waste Lagoon No. 2, Topographic Plan

12323 29APR52
Waste Lagoon No. 2, Plan and Sections

14898 23AUG54
Waste Lagoon No. 3, Plot Plan

14897 27AUG54
Waste Lagoon No. 3, Grading Plan

14900 31AUG54
Waste Lagoon No. 3, Sampling Bridge, sections

14899 03SEP54
Waste Lagoon No. 3, Section,Profile, and Detail

15592 08SEP54
Waste Lagoon No. 3, Sections and Detail

23691 04AUG55
Chemical Waste Pit 4, Grading Plan

23692 04AUG55
Chemical Waste Pit 4, Plot Plan

23693 04AUG55
Chemical Waste Pit 4,Sections,Profiles, Details

23696 04AUG55
Chemical Waste Pit 4, Specifications

23690 10AUG55
Chemical Waste Pit 4, Locality Map

23732 31JAN56
Topographic Survey, Waste Pit 4 Area

23773 11MAY56
Chemical Waste Pit Area - Topography

23774 11MAY56
Chemical Waste Pit Area - Topography

23714 09SEP56
Proposed East Ridge Waste Pit(5) Plans

27135 28FEB57
Truck Station and Waste Transfer Line Pit 4

38201 11JAN60
Location Plan Pit 5

38202 22JAN60
Pit 5 Site Topography, Sheet 1

Appendix D
ORNL Engineering Drawings Related to Seepage Pits and Trenches

38203 22JAN60
Pit 5 Site Topography, Sheet 2

38204 22JAN60
Pit 5 Site Topography, Sheet 3

38205 22JAN60
Pit 5, Plans, Sections, Elevations, Details

43136 21NOV60
Chemical Waste Pit 6, Plans and Sections (Sketch)

43190 04JAN61
Chemical Waste Pit 6, Electrical Service

43165 23JAN61
Locality Map and Drawing Index, Pit No. 6

43166 23JAN61
Chemical Waste Pit 6, Grading Plan, Sheet 1

43167 23JAN61
Chemical Waste Pit 6, Grading Plan, Sheet 2

43168 23JAN61
Chemical Waste Pit 6, Grading Plan, Sheet 3

43169 23JAN61
Chemical Waste Pit 6, Plot Plan, Sheet 1

43170 23JAN61
Chemical Waste Pit 6, Plot Plan, Sheet 2

43171 23JAN61
Chemical Waste Pit 6, Plans, Sections, Details

43172 23JAN61
Chemical Waste Pit 6, Filter Pit, Grading Plot plan

53000 24MAY62
Chemical Waste Pit 7, Electrical Plot Plan

52856 06JUN62
Chemical Waste Pit Area Extended Topo. Map

52844 12JUN62
Chemical Waste Pit 7, Grading Plan

52847 12JUN62
Chemical Waste Pit 7, Longitudinal Sections

52845 14JUN62
Chemical Waste Pit 7, Plot Plan

52846 14JUN62
Chemical Waste Pit 7, Plan and Profile

Appendix D
ORNL Engineering Drawings Related to Seepage Pits and Trenches

52848 14JUN62
Chemical Waste Pit 7, Plans, Sections, Details

52858 18JUL62
Chemical Waste Pit 7, Regional Topography, Sheet 1

52859 18JUL62
Chemical Waste Pit 7, Regional Topography, Sheet 2

54729 19NOV62
Decontamination Bldg 7819, Locality and Index

54730 19NOV62
Decontamination Bldg 7819, Grading and Plot Plan

10063 27JUN63
Chemical Waste Pit Area-Site Topography and Wells

10166 15AUG63
Cover Waste Pit 3, Grading Plan-Sections and Details

10830 18OCT63
Cover Waste Pit 2, Grading Plan-Sections and Details

10953 11MAR64
Septic Tank and Drain Field 7819, Plan and Section

20941 20MAY70
Chemical Waste Pit 5, Paving Plan and Notes

20965 20MAY70
Chemical Waste Pit 7, Paving Plan and Notes

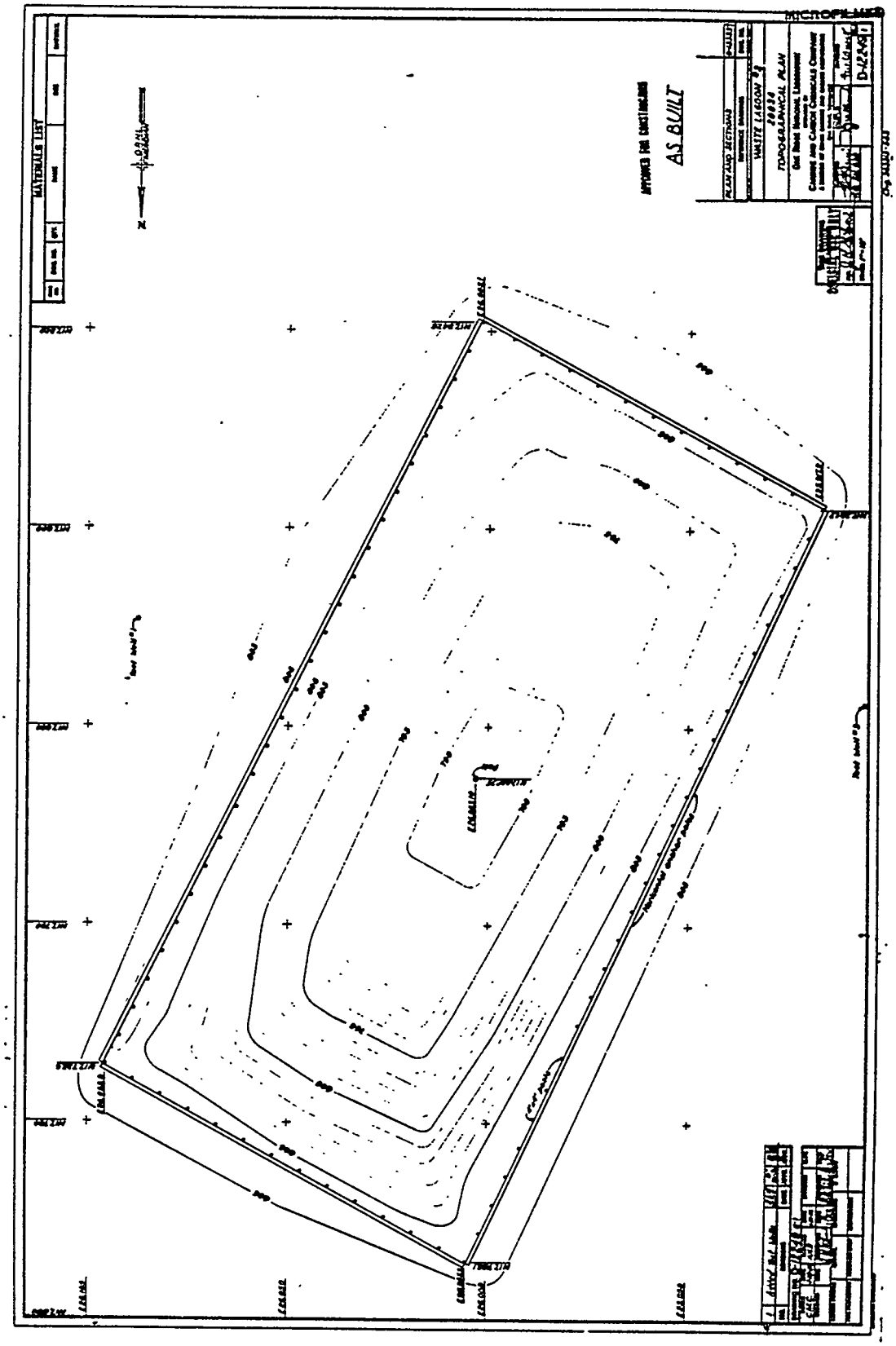
20932 21MAY70
Chemical Waste Pit 2, Asphalt cover, Grading Paving

20935 21MAY70
Resurface Cover Chemical Pit 3, Paving Plan and Notes

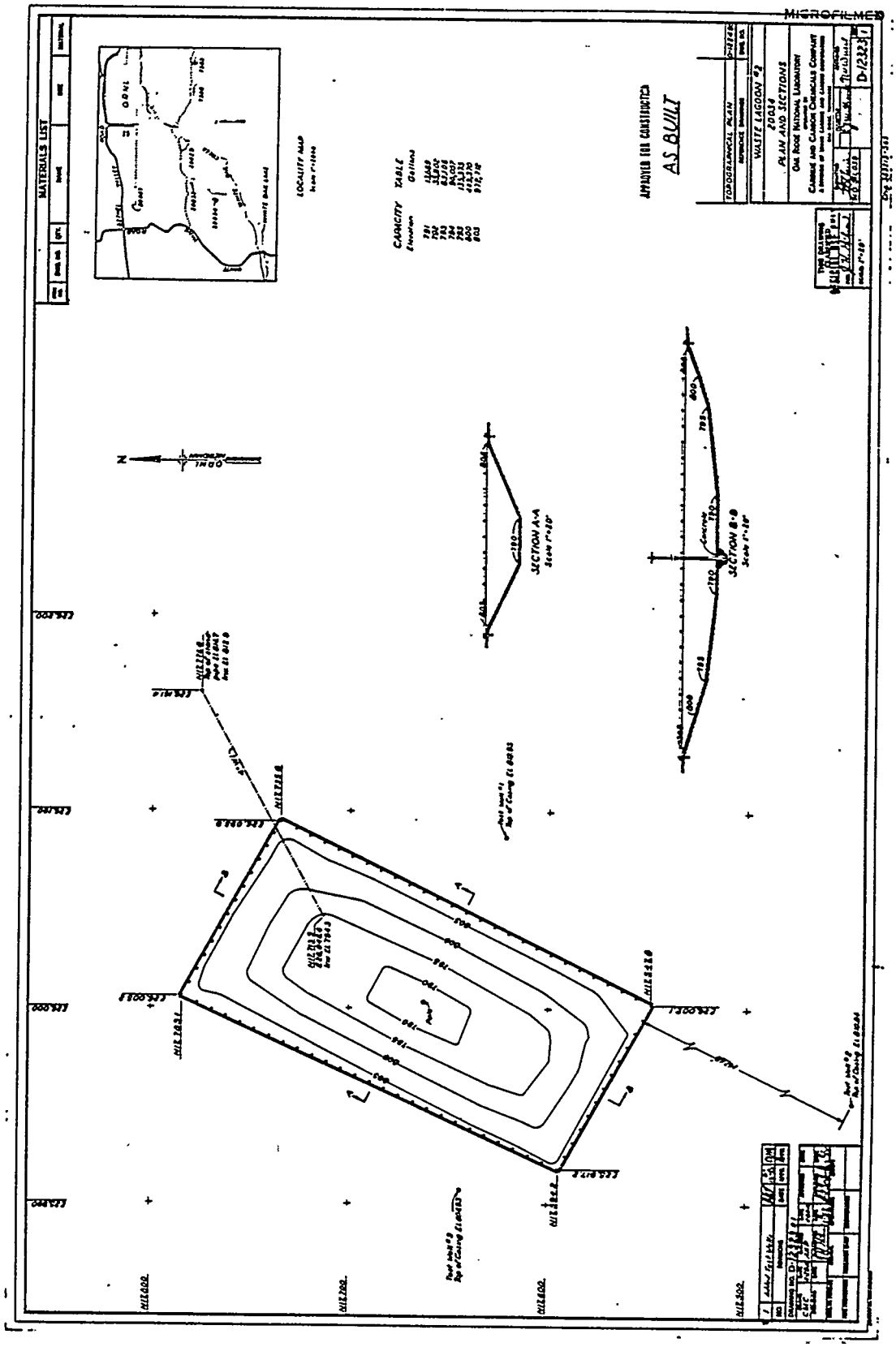
20938 15OCT80
Chemical Waste Pit 4, Paving Plan and Site Location

20929 13JAN81
Waste Pit No. 1 Paving Plan and Locality Map

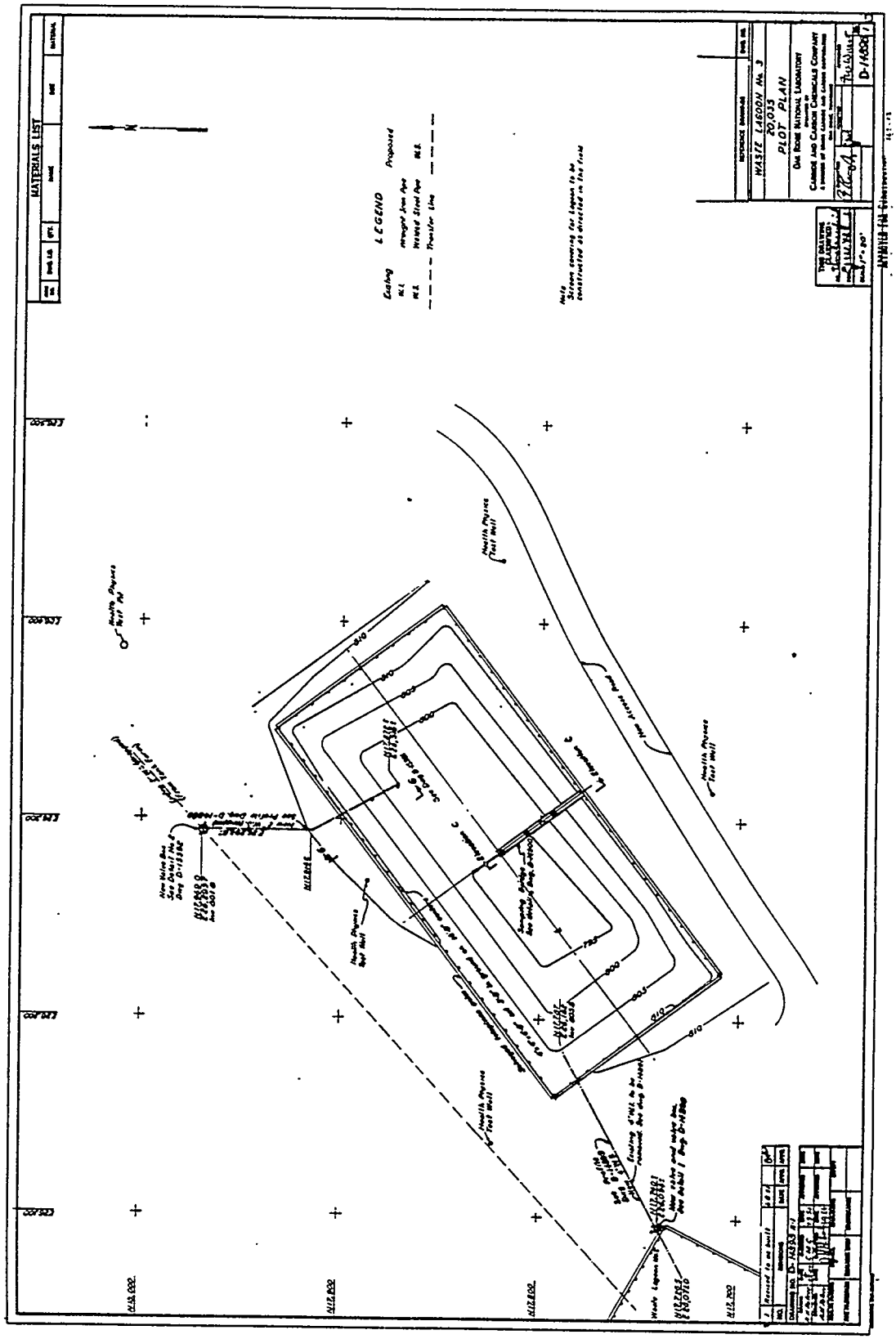
20944 13JAN81
Chemical Waste Pit 6, Paving Plan and Pit Section



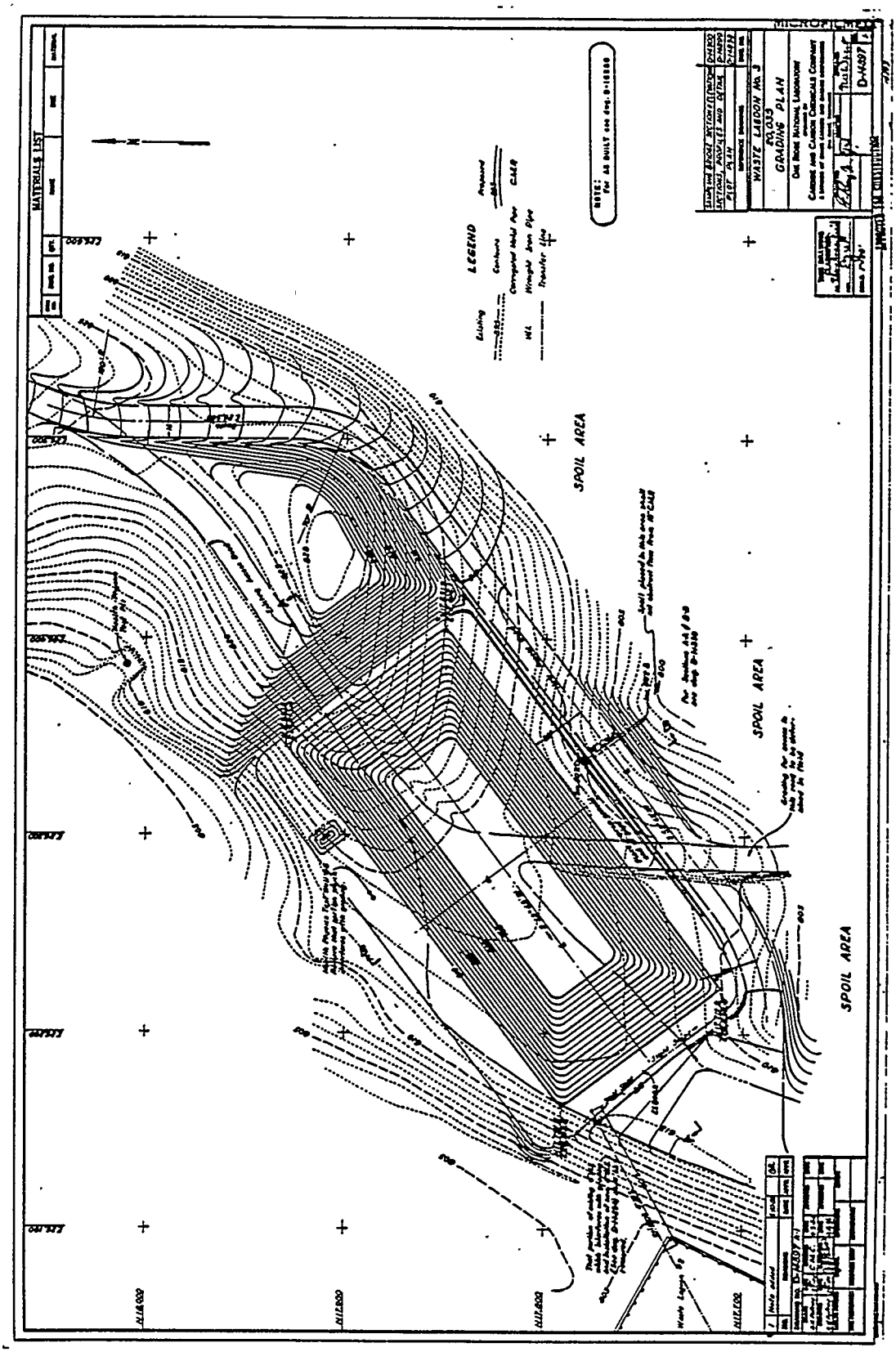
12249 10APR52
Waste Lagoon No. 2, Topographic Plan



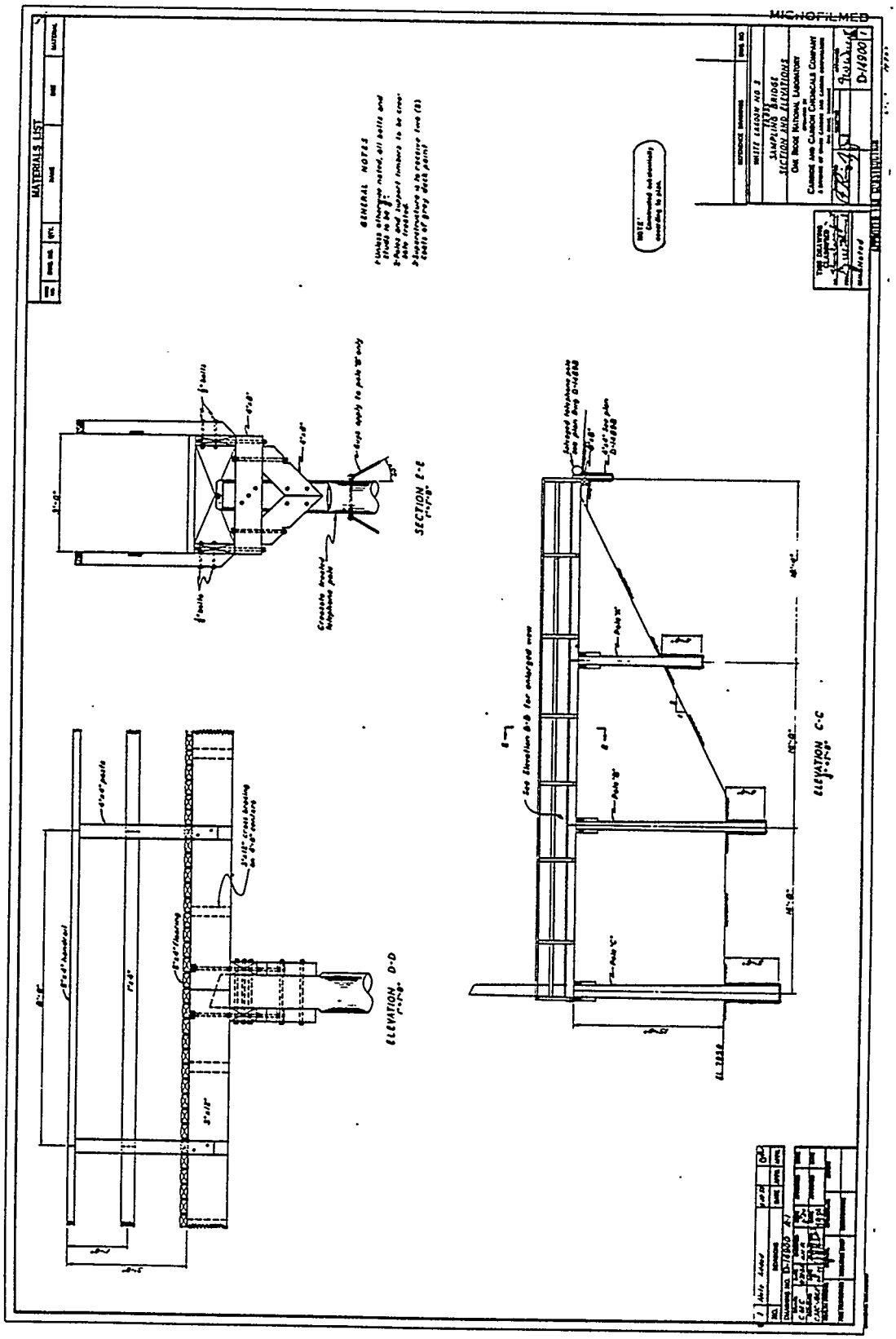
12323 29APR52
Waste Lagoon No. 2, Plan and Sections



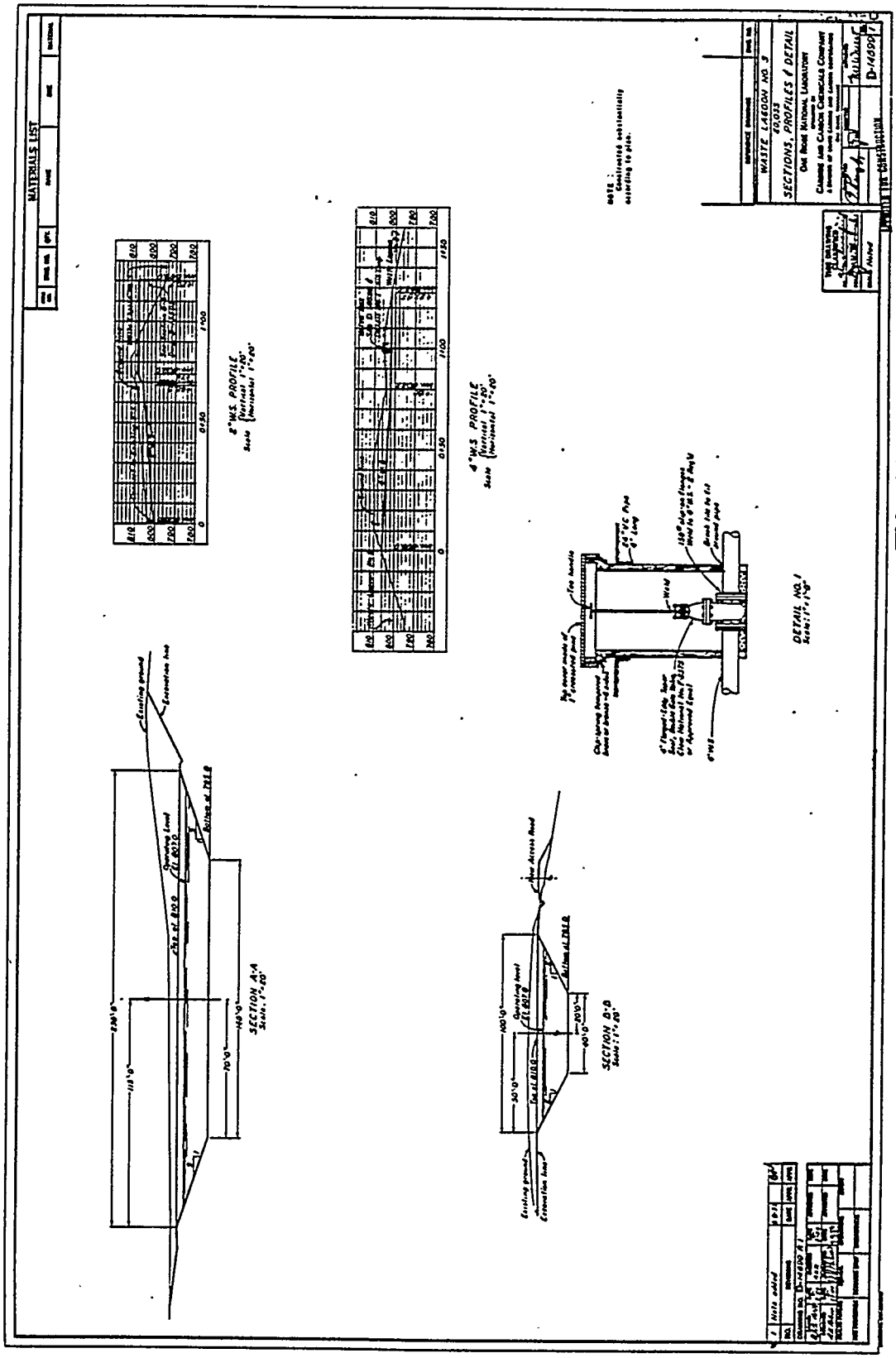
14898 23AUG54
Waste Lagoon No. 3, Plot Plan



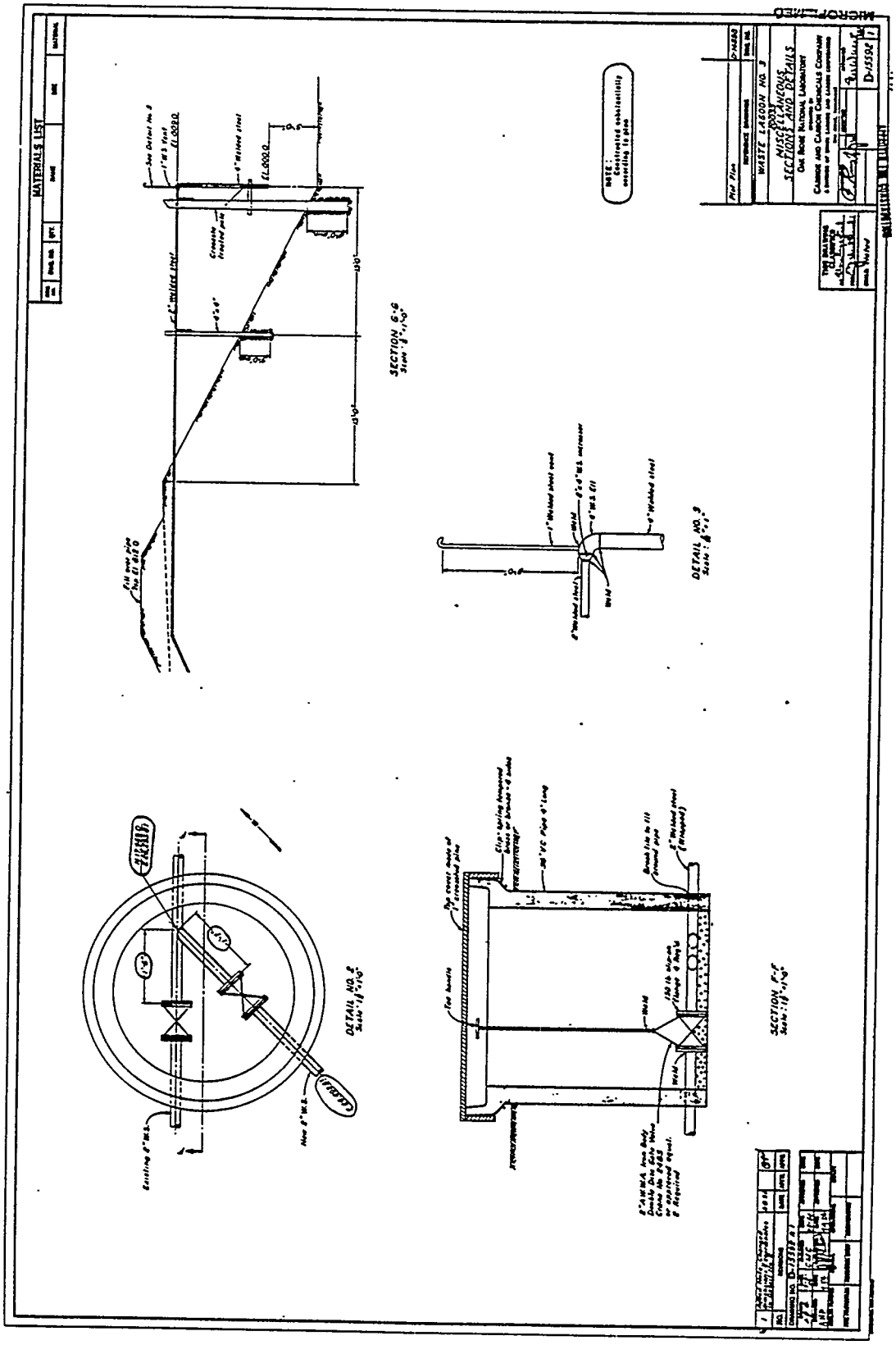
14897 27AUG54
Waste Lagoon No. 3, Grading Plan



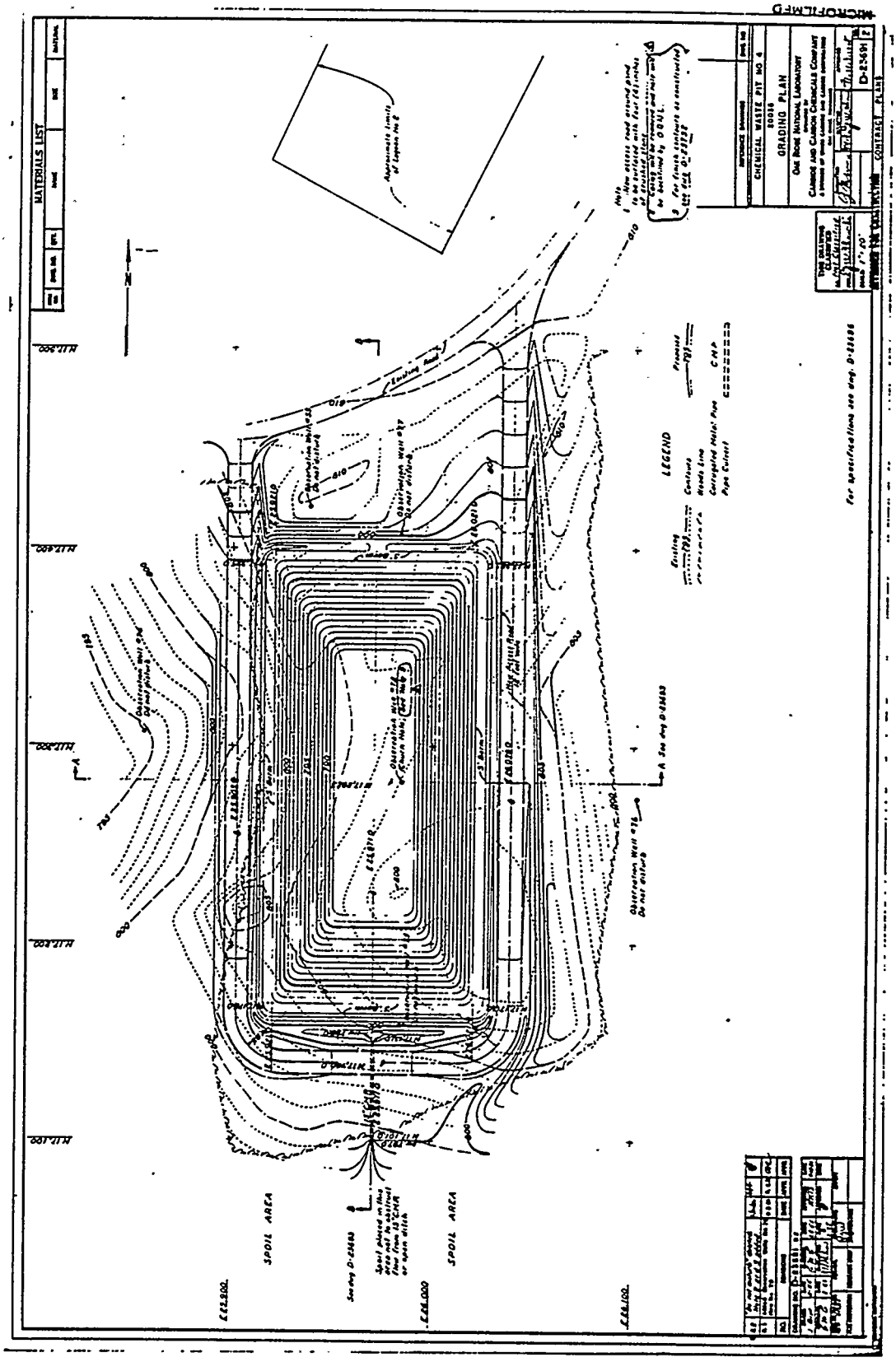
14900 31AUG54
Waste Lagoon No. 3, Sampling Bridge, sections



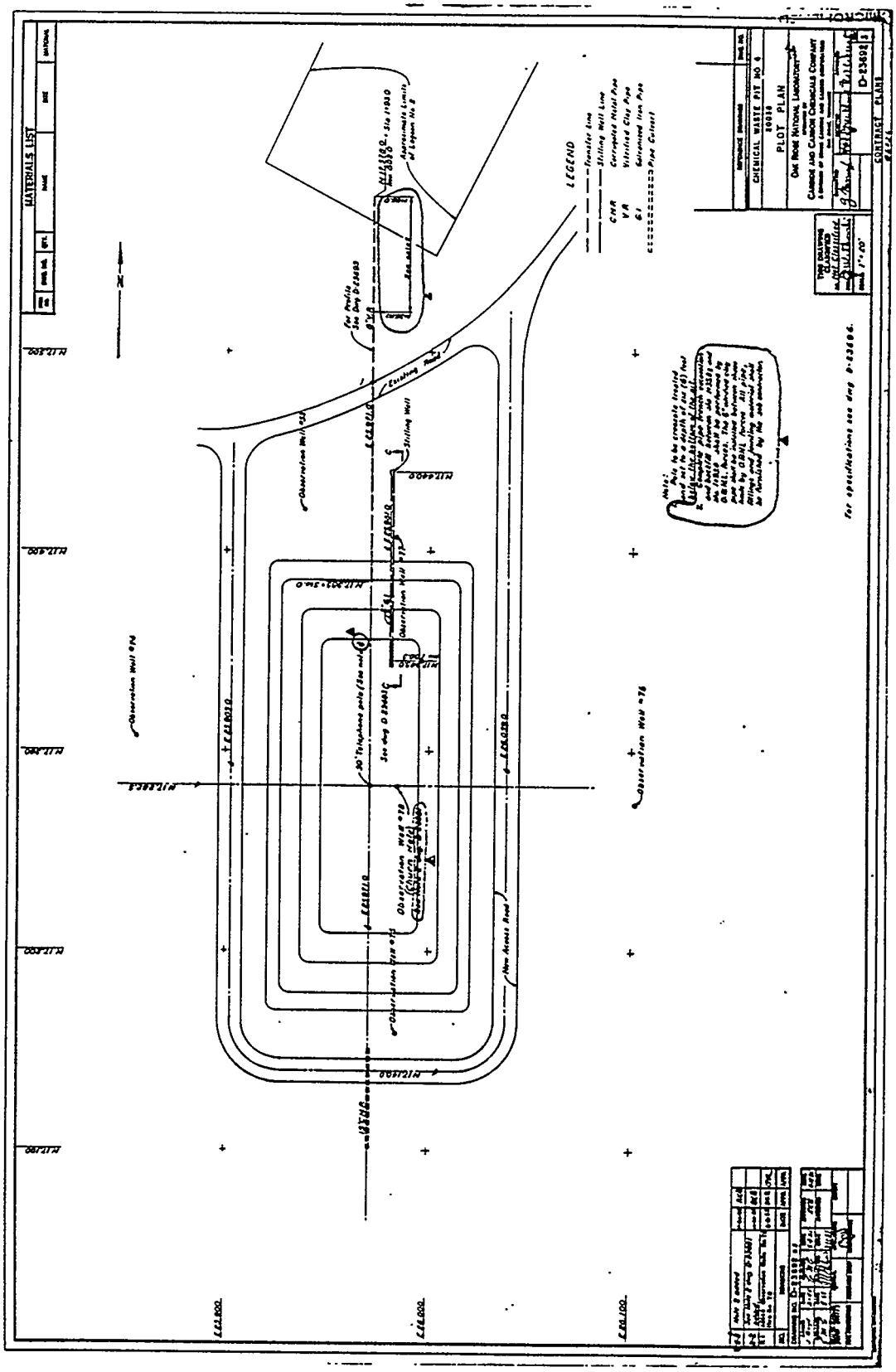
14899 03SEP54
Waste Lagoon No. 3, Section,Profile, and Detail

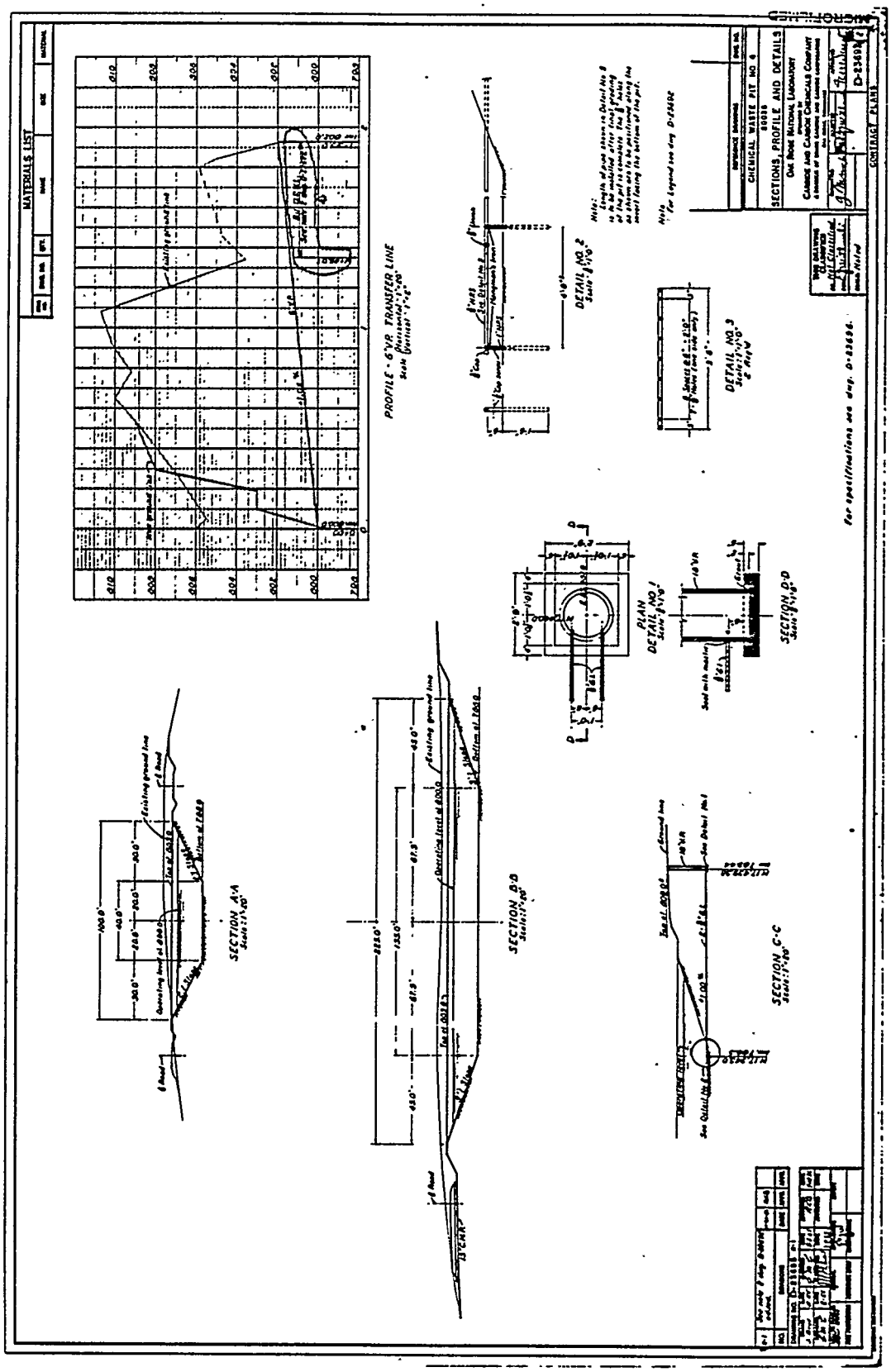


15592 08SEP54
Waste Lagoon No. 3, Sections and Detail



23691 04AUG55
Chemical Waste Pit 4, Grading Plan


MATERIALS LIST
LEGEND
Transfer Line
Stilling Well Line
CMR Corrugated Metal Pipe
VR Vitrified Clay Pipe
GI Galvanized Iron Pipe
Pipe Culvert
Existing Road
Stilling Well
Observation Well #18
Observation Well #19
Observation Well #20
Observation Well #21
Observation Well #78
Observation Well #79
Observation Well #80
Observation Well #81
Observation Well #82
Observation Well #83
Observation Well #84
Observation Well #85
Observation Well #86
Observation Well #87
Observation Well #88
Observation Well #89
Observation Well #90
Observation Well



23693 04AUG55
Chemical Waste Pit 4,Sections,Profiles, Details

23696 04AUG55
Chemical Waste Pit 4, Specifications

MATERIALS LIST

ITEM NO.	DWG. NO.	QTY.	NAME	SIZE	MATERIAL

SPECIFICATIONS

CLEARING METHODS: Clearing shall include the felling and cutting up of trees and other vegetation and the satisfactory disposal thereof, together with any hand clearing, grubbing, brush, rubble and debris, which may be within the specified limits of clearing. All trees and other vegetation, which are to be removed, and all stumps, roots and brush within the area to be cleared shall be cut off flush with, or slightly below the existing ground line.

LIMIT OF FULL AND COMPLETE CLEARING: Full and complete clearing shall be limited only to that area north of the waste pit contained by the south line and the construction limits of the access road along A36,900.0.

SPOIL AREA CLEARING: Spoil areas shall be cleared only to the extent necessary for the contractor to dispose of the excavated material from the waste pit and access road. Clearing shall be limited to trees, down timber, stumps, etc. that would interfere with the operation of the contractor's equipment.

WASTE PIT EXCAVATION: Excavation for the waste pit shall be carried to finished elevations indicated on the drawings and excavated material shall be disposed of at the spoil areas indicated on drawing D-23691.

EXCAVATION: As far as can be determined from available information, no solid rock should be encountered during excavation.

SPOIL AREAS: Spoil areas shall be graded to permit drainage of surface water and together as possible shall blend with the surrounding terrain

CONSTRUCTION OF ACCESS ROAD EMBANKMENT: Subgrade for access road shall be compacted to a depth of [illegible] inches below the crushed stone surfacing by means of a sheepsfoot roller. Earth fill required to bring road bed to grade shall be placed in horizontal layers not exceeding six (6) inches in thickness and each layer shall be rolled and thoroughly compacted.

CRUSHED STONE SURFACING: The material to be used where crushed stone surfacing is specified shall be crusher run stone, meeting II Penetrac, and placed in two (2) approximately equal layers, each thoroughly compacted to produce a surface four (4) inches thick.

PIPE TRENCH EXCAVATION: Pipe trenches shall be excavated to exact width and even grade as required for the proper bedding of pipe, including excavating as required for bell, fittings, etc. Bottom width below pipe rough grade shall be two (2) feet, unless otherwise indicated on the drawings. Pipe trenches shall be kept free from water.

BRACING, SHORING AND BRACING: The contractor shall provide all sheet piling, shoring and bracing required for the support of earth banks during the excavation and erection of the work. Bracing shall be withdrawn in stages until immediately before backfilling and then shall be removed by stages as the backfilling progresses.

PIPE TRENCH BACKFILLING: Pipe trenches shall be backfilled with selected earth deposited in six (6) inch layers and carefully rammed until pipe has a cover of not less than two (2) feet. Remainder of backfill shall be placed in trenches in horizontal layers not more than twelve (12) inches in depth, and thoroughly and compacted by power tampers to a density of equal to that of the surrounding earth.

BACKFILLING AROUND SITTING WELL: Backfill around sitting well shall be deposited in horizontal layers of the same size in approximately the same elevation. (2) Backfill shall be placed to the level of the original surrounding earth surface or to an grade level 12 inches higher than lower than existing grade) as required to provide for anticipated settlement.

PIPING: (a) Sitting well pipe and fittings shall conform to A. S. T. M. specification C-[illegible] for the trench line and sitting well.

(b) [illegible] pipe shall be standard strength galvanized corrugated steel pipe as manufactured by the American Rolling Mill Company, or an approved equal.

(c) Sitting well ring shall be galvanized straight steel schedule 40, F.S.S. Fittings shall be galvanized malleable iron, 3000 pounds.

JOINTS IN CLAY PIPE: Joints in clay pipe shall be well caulked with joint packing to reach a depth as will leave a space sufficient for the end of the bell of at least one (1) inch for pipes 12 inches and less in diameter and (2) inches for pipes 15-24 inches in diameter. The remainder of the joint shall be completely filled with asphalt 3-4 compound, "Bitu-Seal", as manufactured by Universal Sewer Pipe Corp., or an approved equal.

JOINT BACKING: Packing for vitrified clay trench line and sitting well shall be asbestos rope packing impregnated for chemical service and shall be Garlock Type 180, or an approved equal.

CONCRETE: Concrete for the sitting well base shall develop a minimum compressive strength of 3000 pounds per square inch at 28 days.

NO.	REVISIONS	DATE	APPR.	APPR.

DRAWING NO. D-23696

DESIGN	DATE	DRAWN	DATE	DRAWING	DATE
CHECKING	DATE	CHECKING	DATE	DRAWING	DATE
FIELD INSTALLATION		DESIGN	CHECKING	DRAWN	
FIELD TRANSMITTAL		FIELD INSTALLATION	TRANSMITTAL		

THIS DRAWING CLASSIFIED as Not Classified

REFERENCE DRAWINGS | DWG. NO.

CHEMICAL WASTE PIT NO 4

20036

SPECIFICATIONS

OAK RIDGE NATIONAL LABORATORY

OPERATED BY

CARBIDE AND CARBON CHEMICALS COMPANY

A DIVISION OF UNION CARBIDE AND CARBON CORPORATION

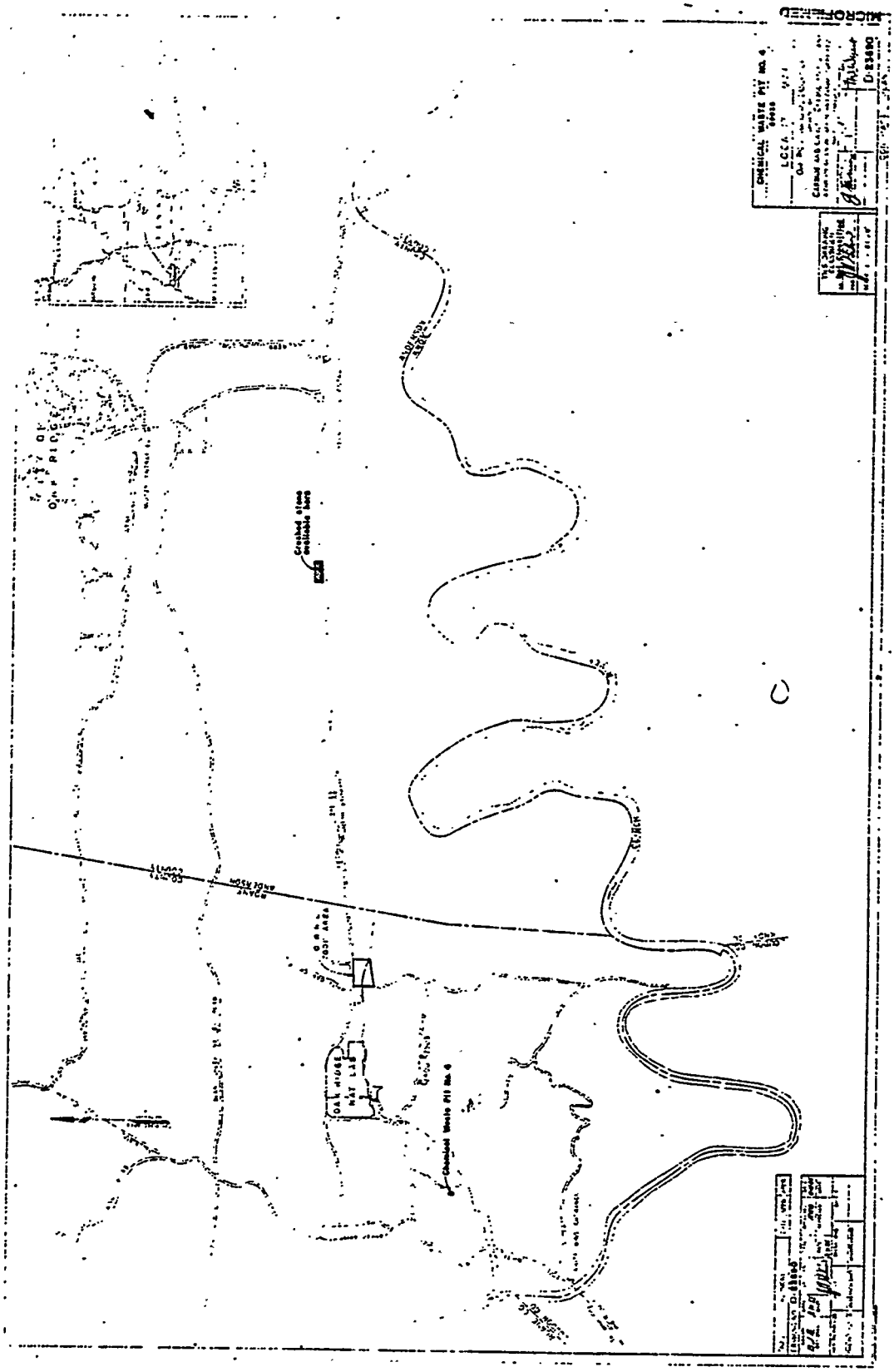
UNITED STATES ATOMIC ENERGY COMMISSION

DIRECTOR

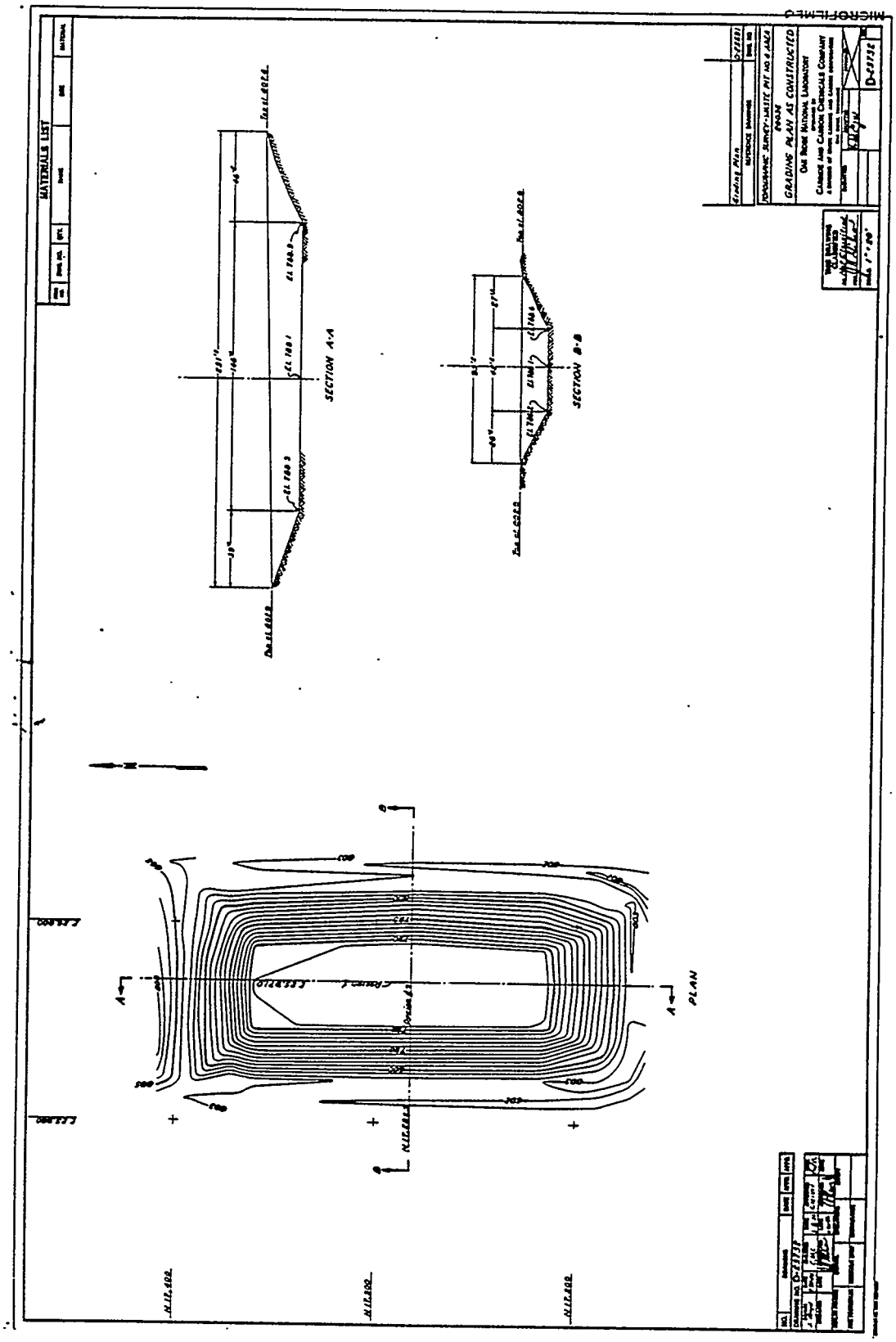
D-23696

CONTRACT PLANS

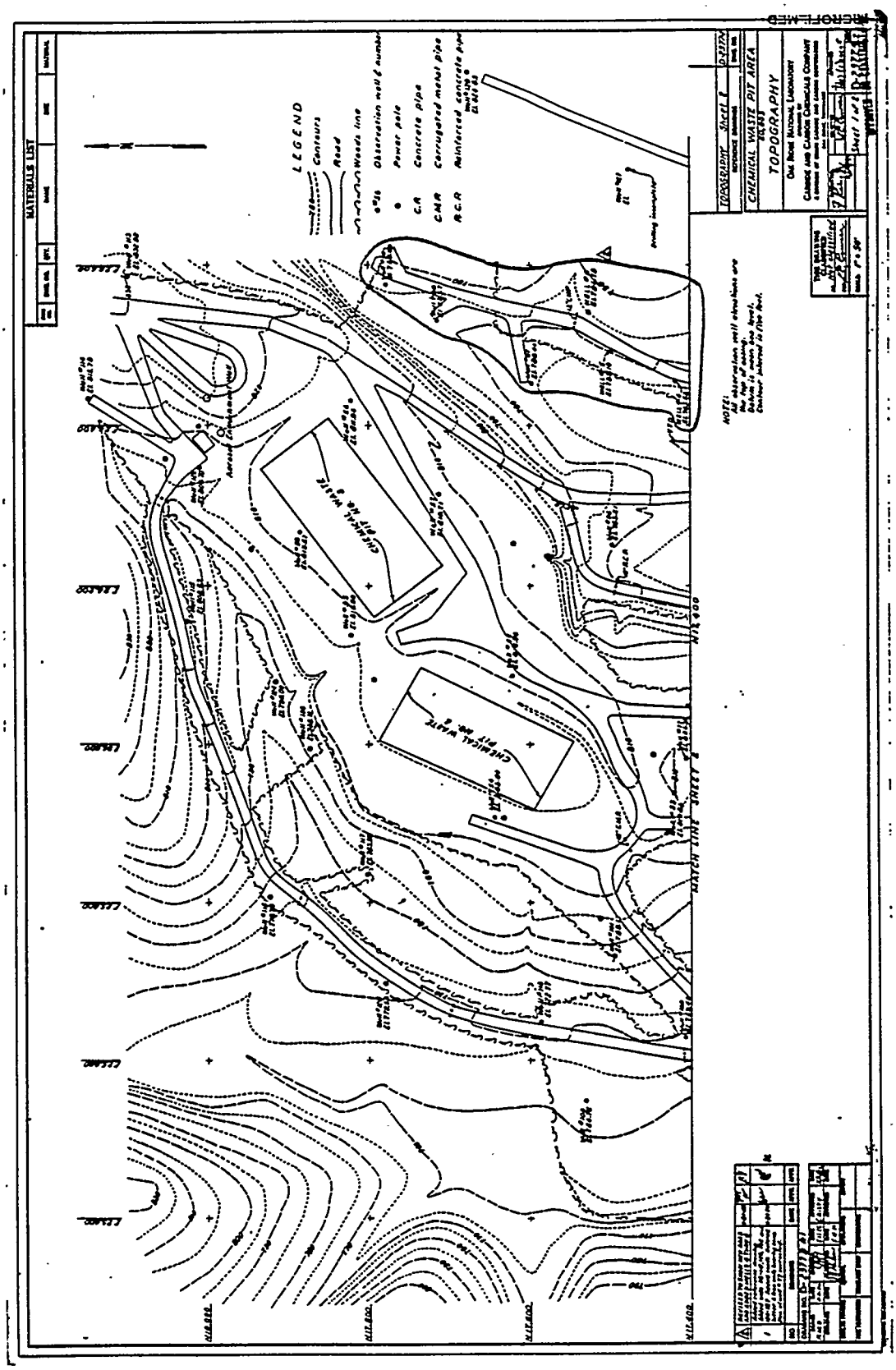
D-14



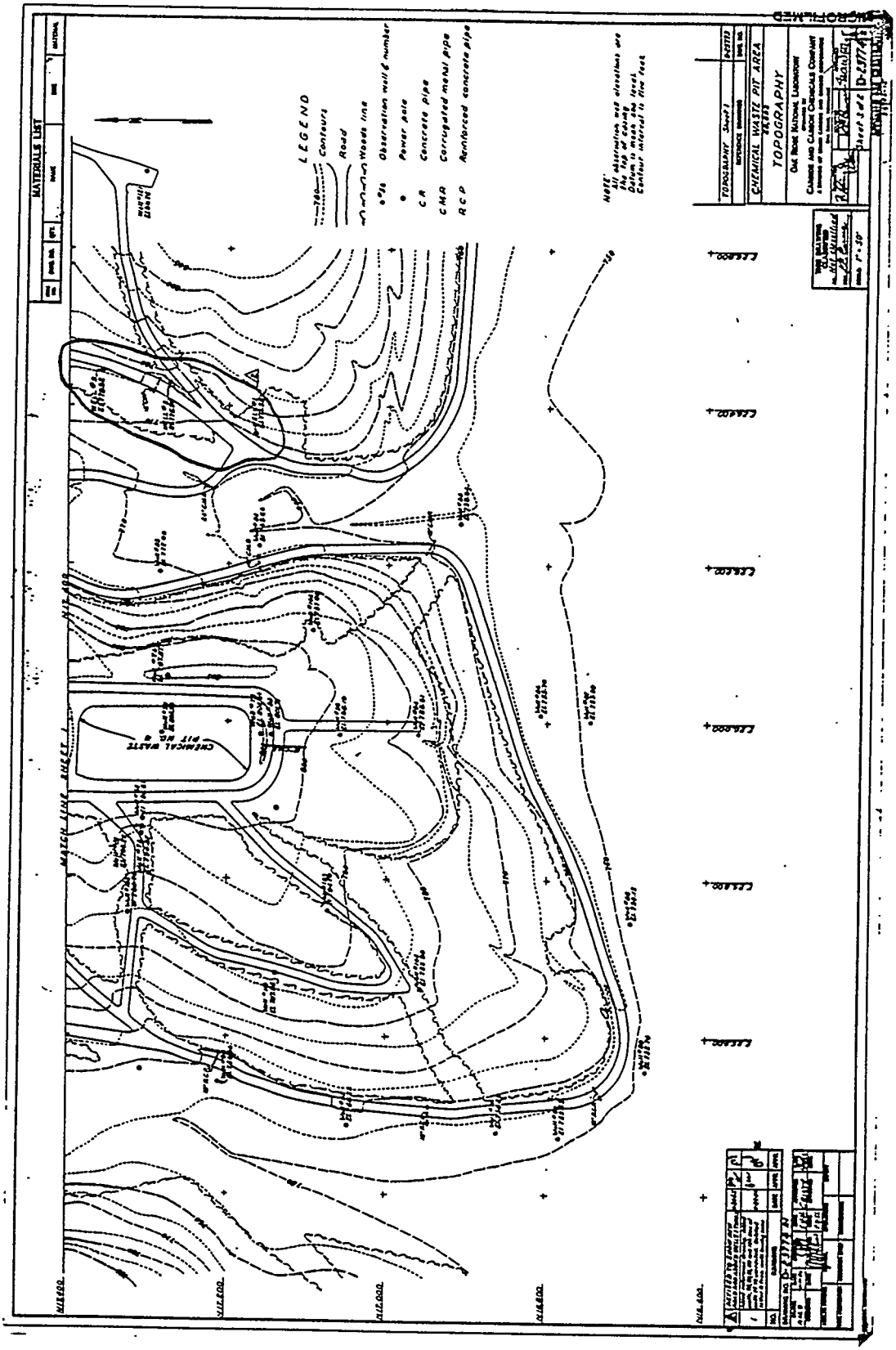
23690 10AUG55
Chemical Waste Pit 4, Locality Map



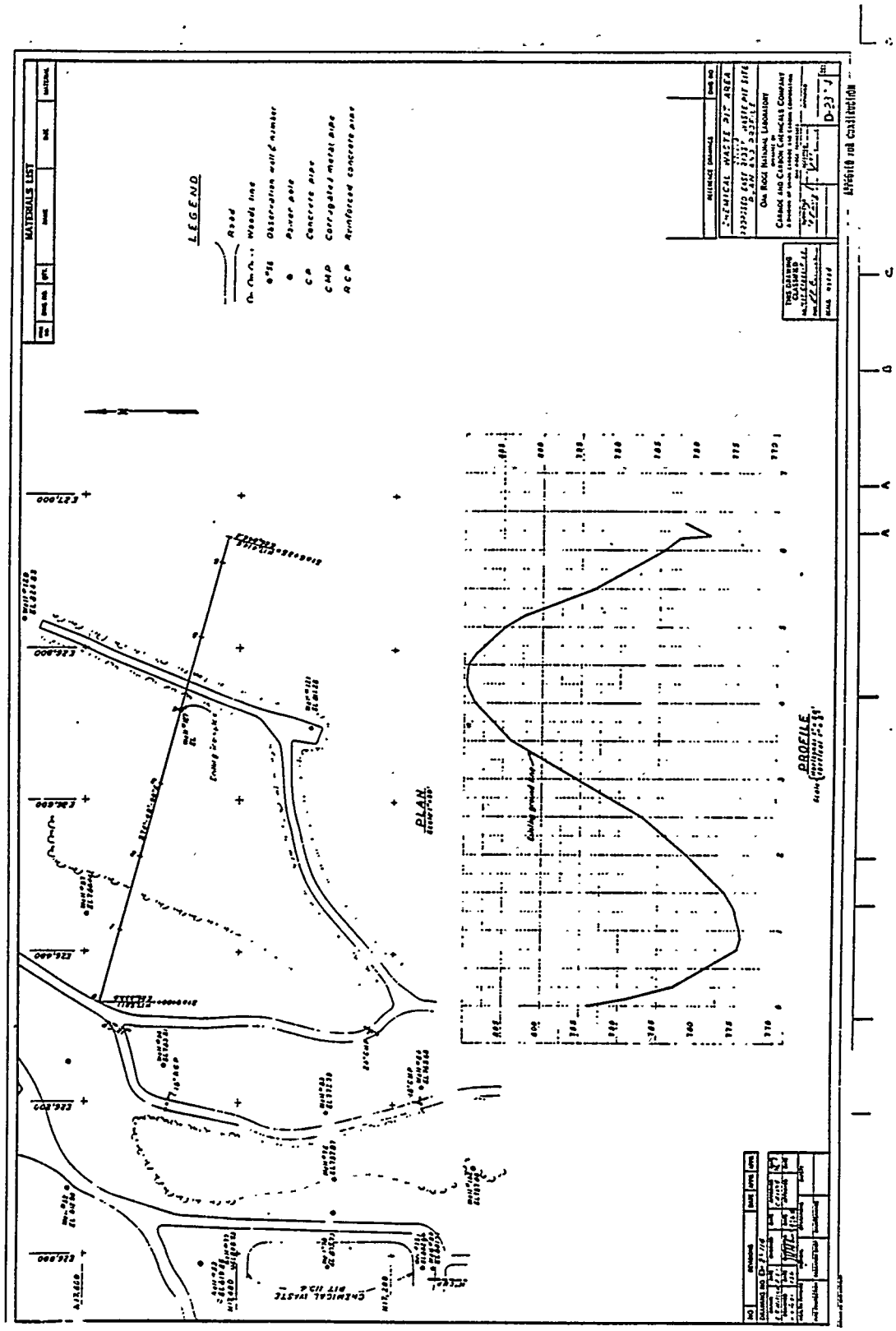
23732 31JAN56
Topographic Survey, Waste Pit 4 Area



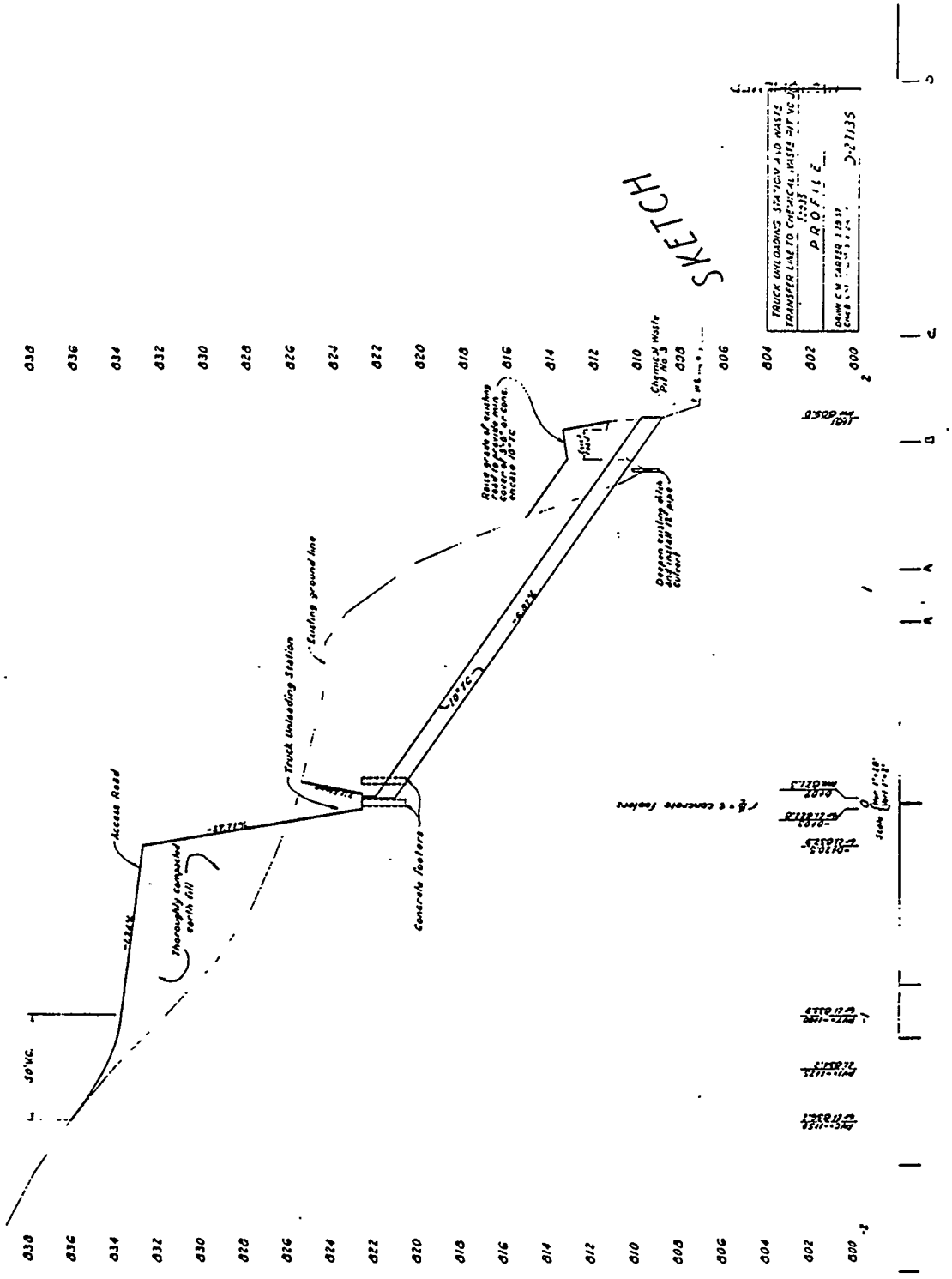
23773 11MAY56
Chemical Waste Pit Area - Topography



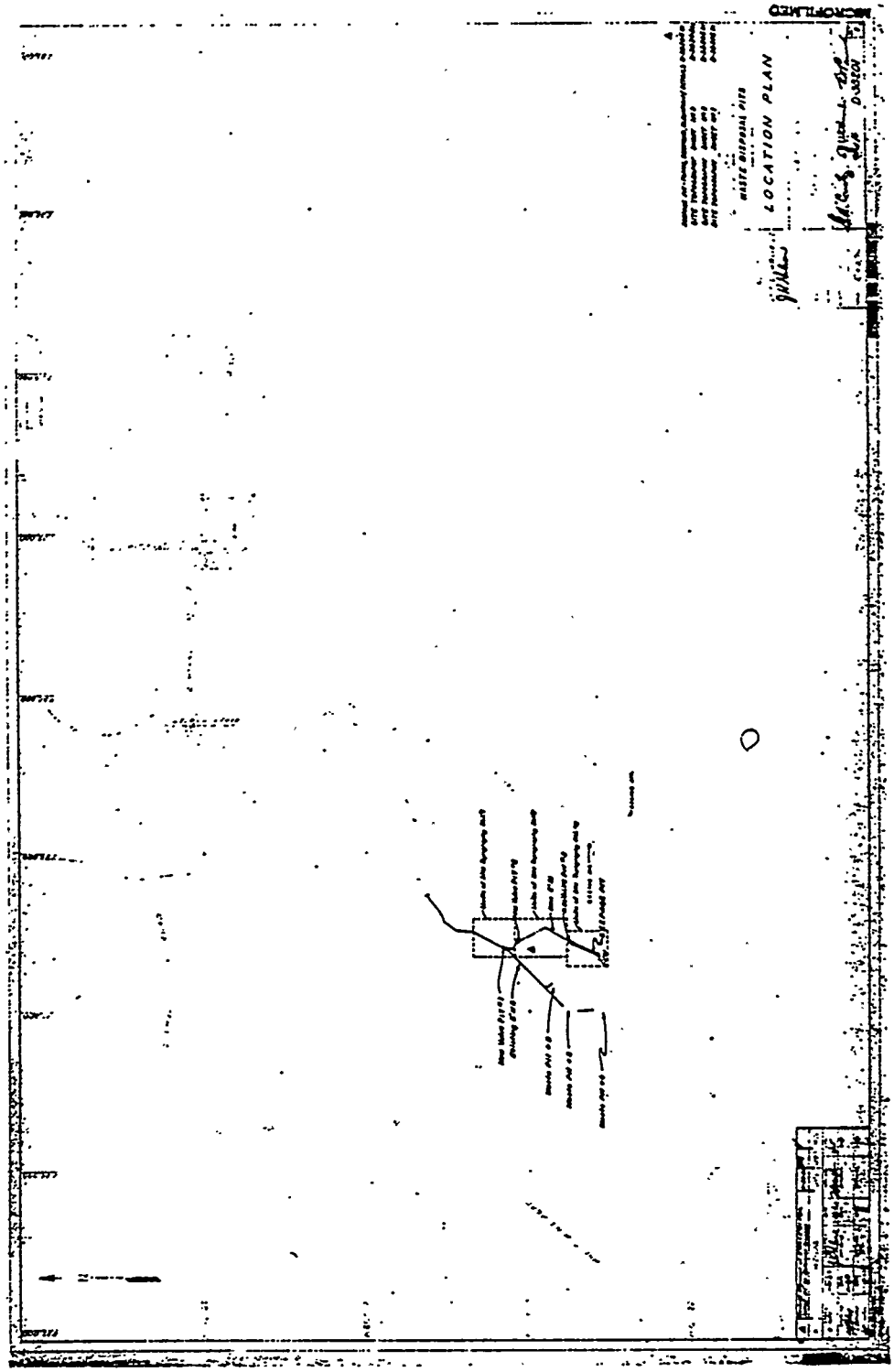
23774 11MAY56
Chemical Waste Pit Area - Topography



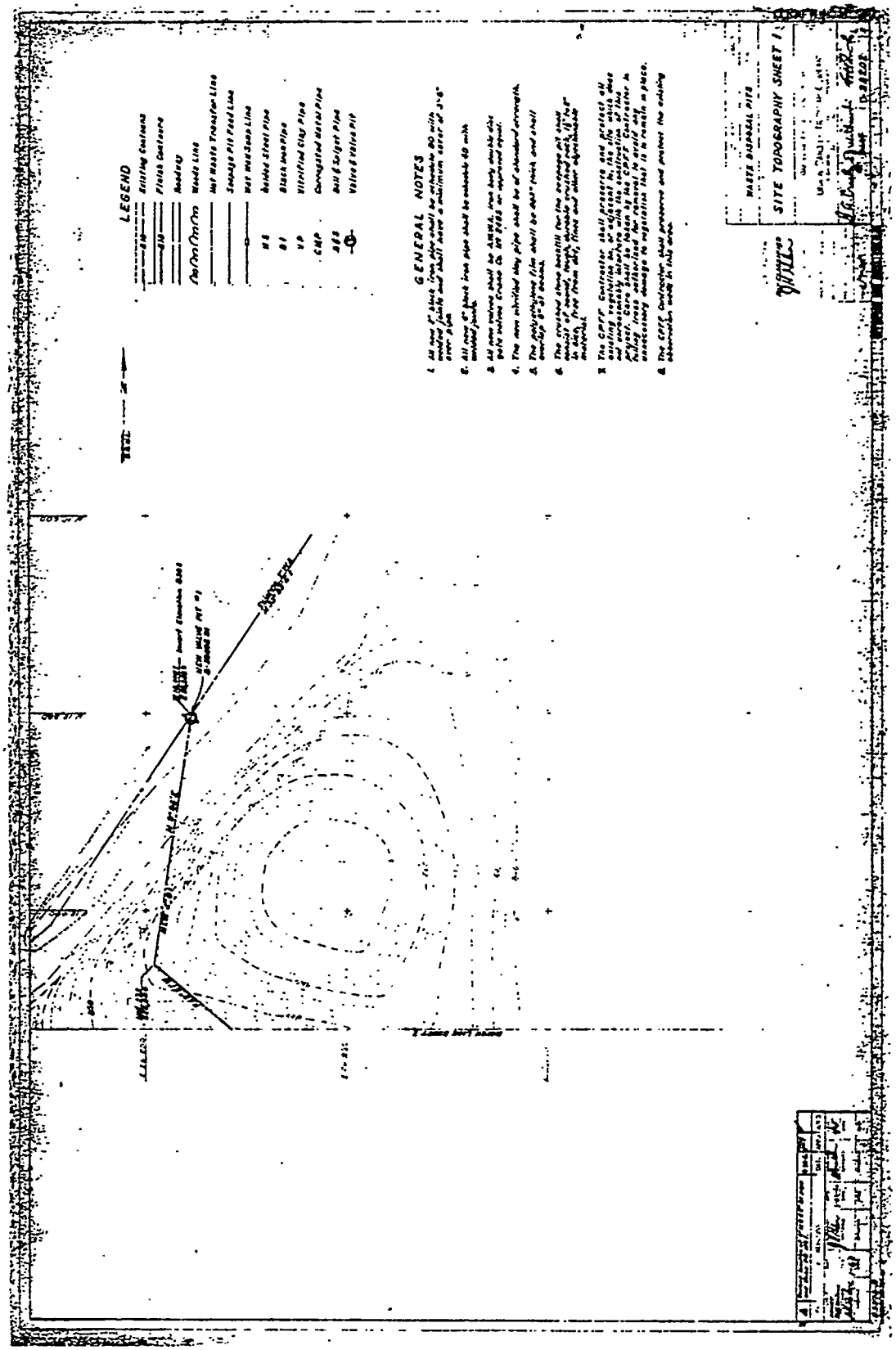
23714 09SEP56
Proposed East Ridge Waste Pit(5) Plans



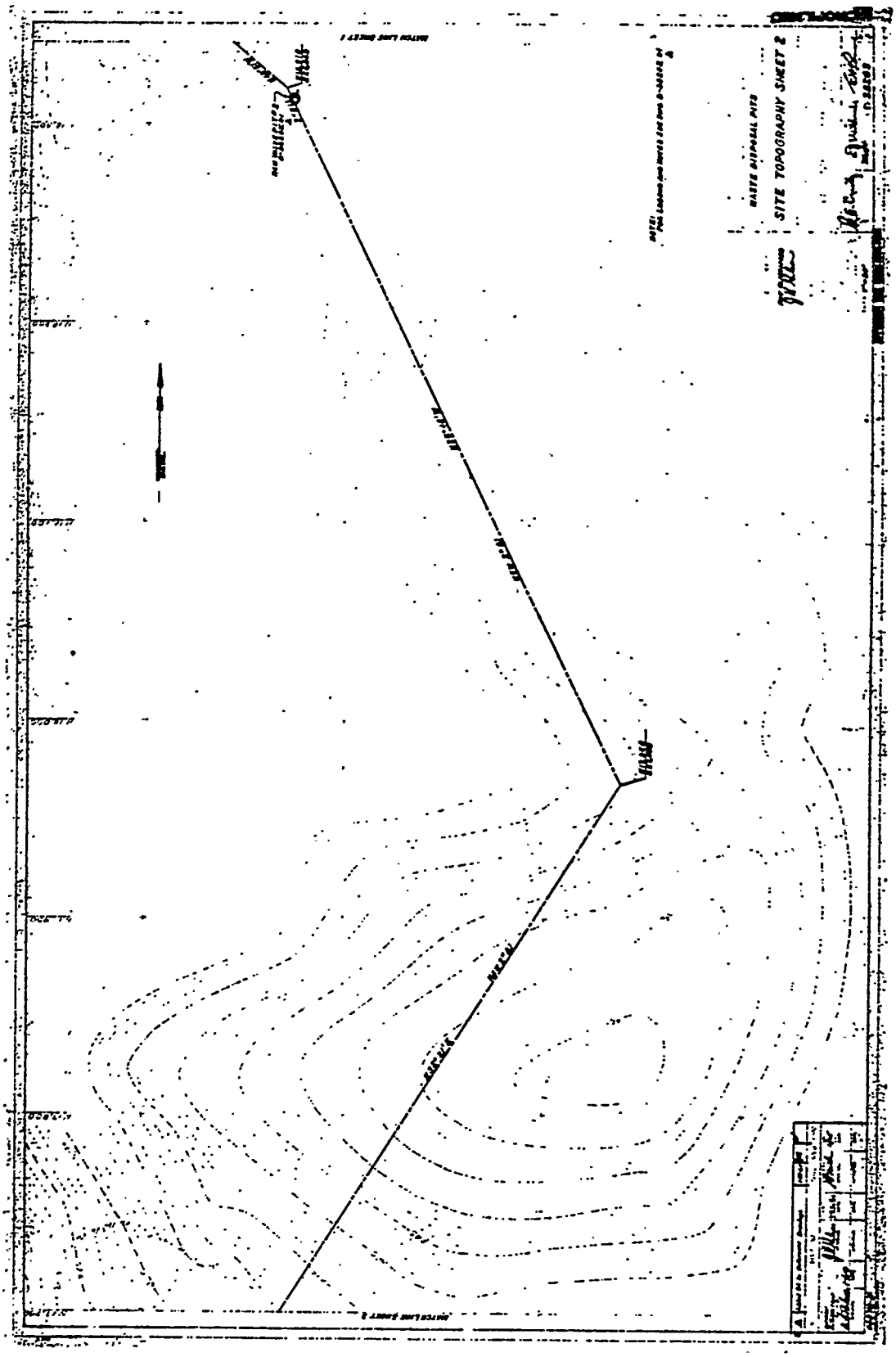
27 135 28FE857
Truck Station and Waste Transfer Line Pit 4



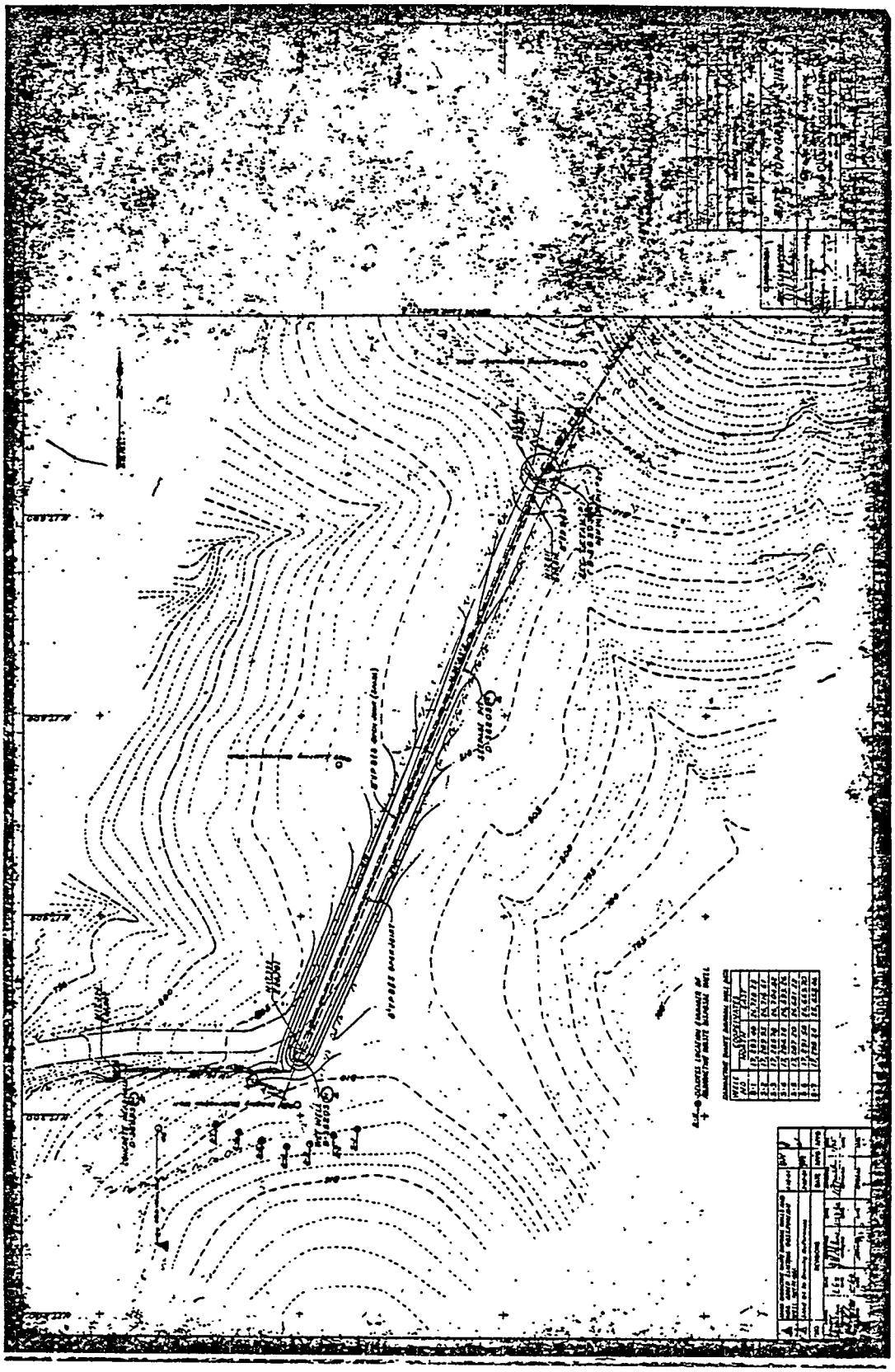
38201 11JAN60
Location Plan Pit 5



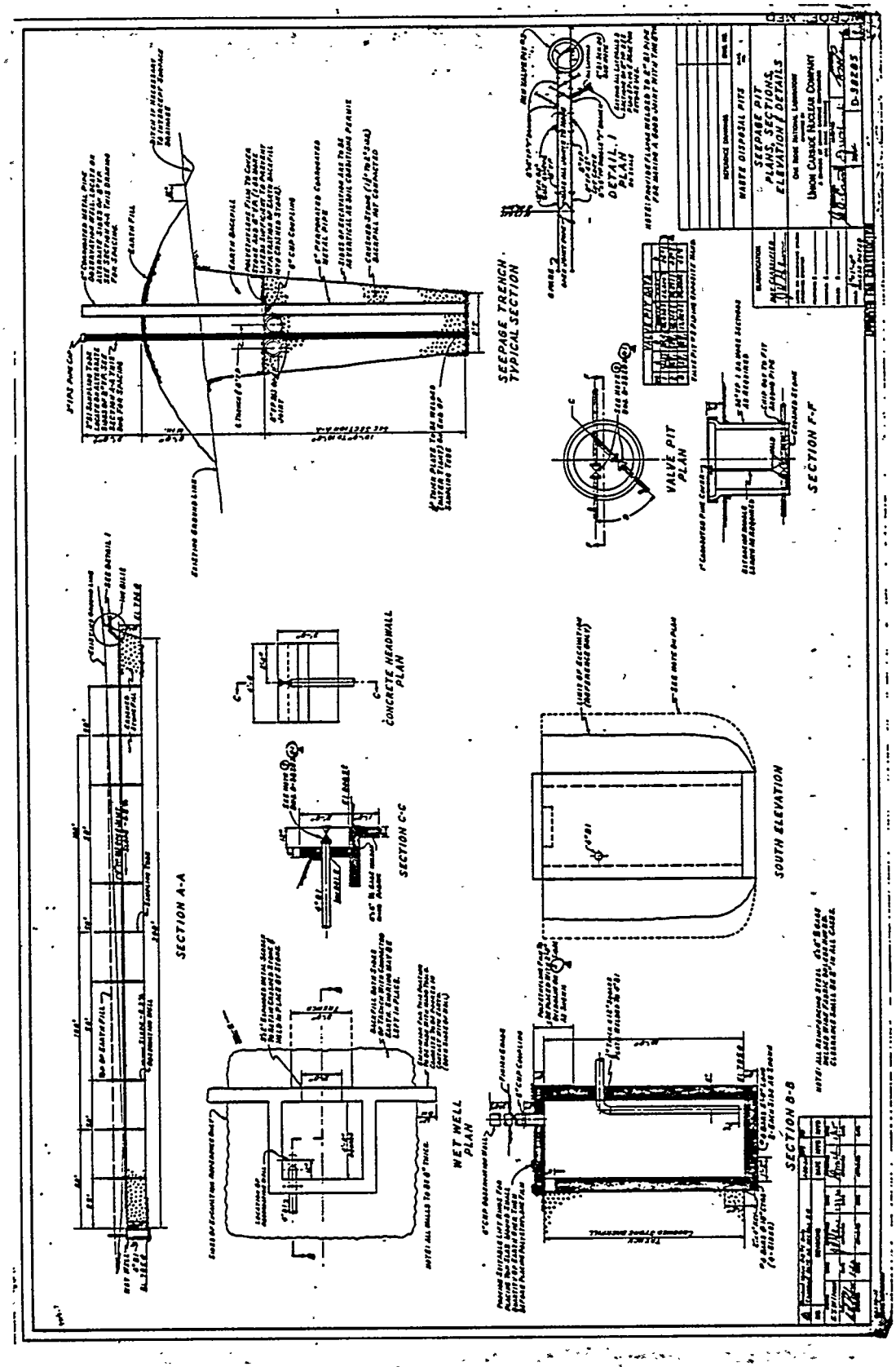
38202 22JAN60
Pit 5 Site Topography, Sheet 1



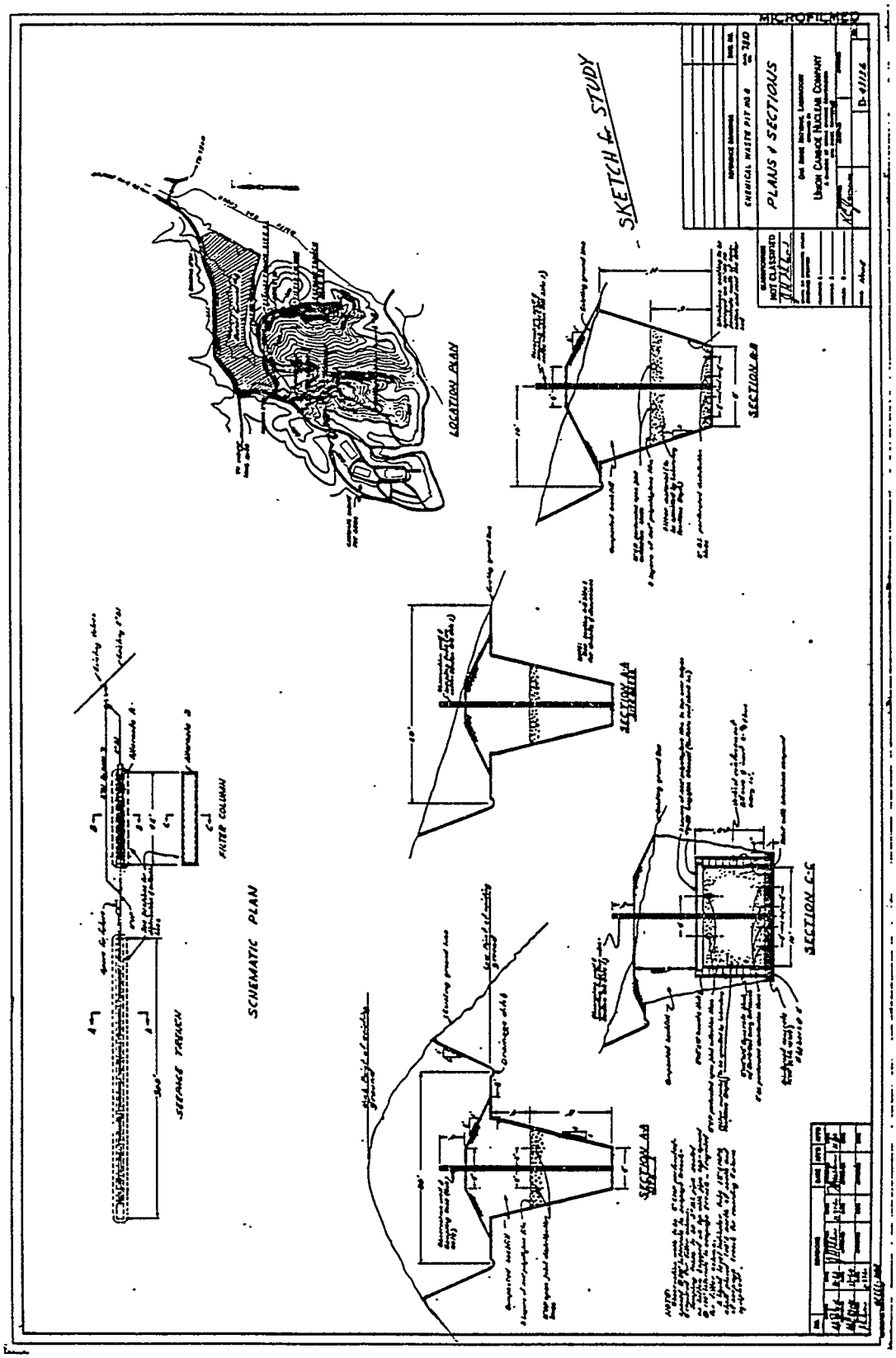
38203 22JAN60
Pit 5 Site Topography, Sheet 2



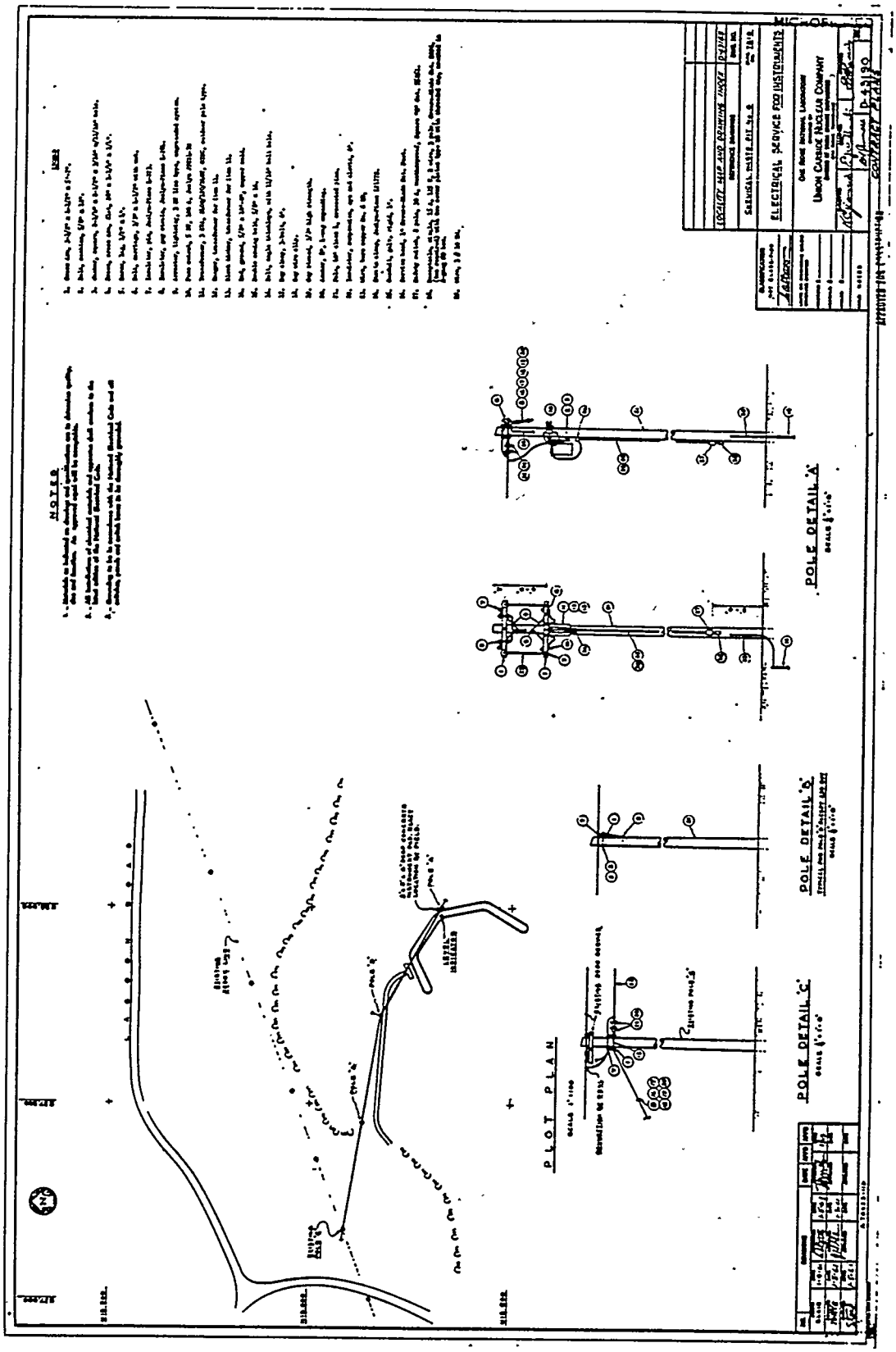
38204 22JAN60
Pit 5 Site Topography, Sheet 3



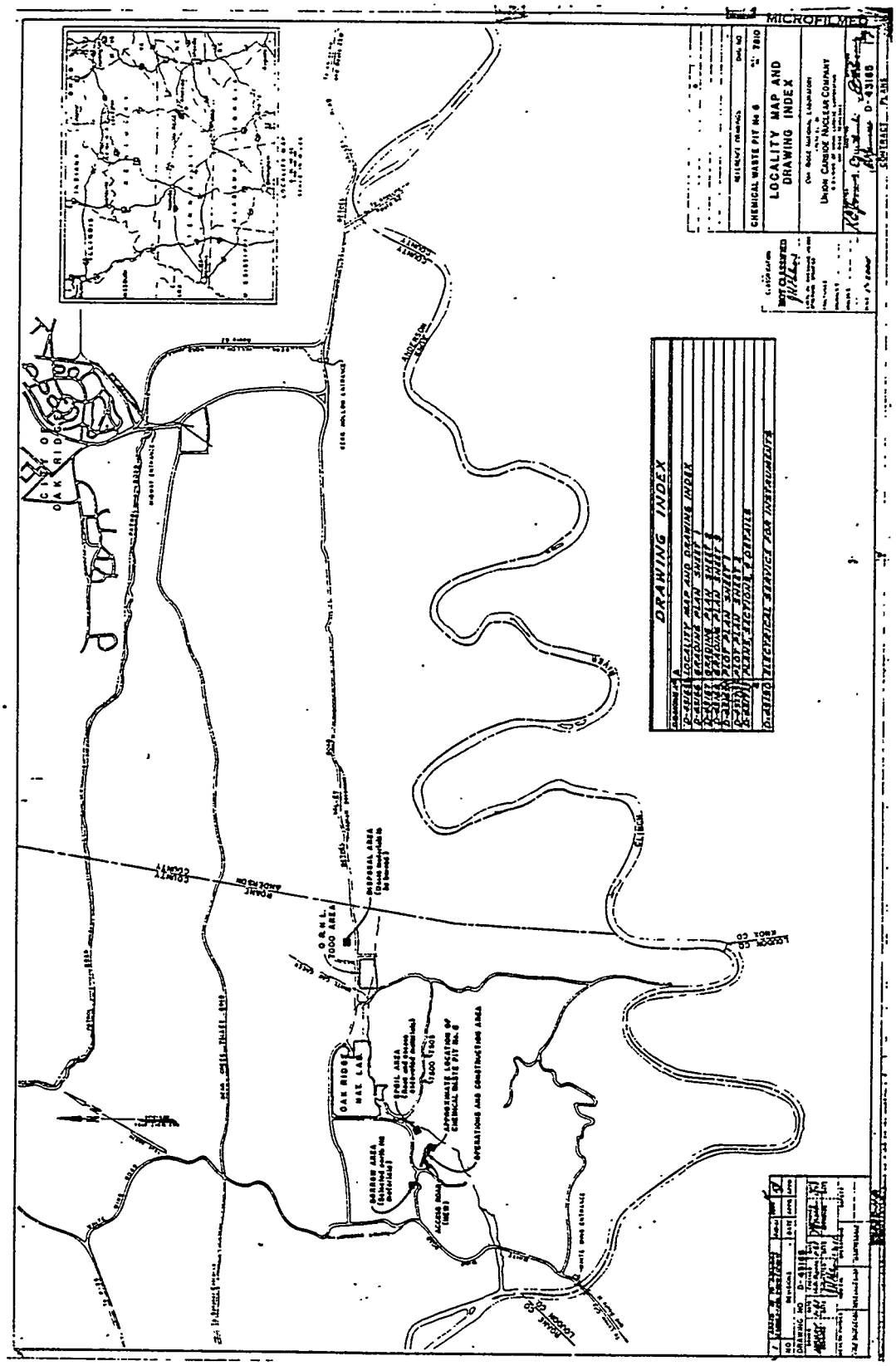
38205 22JAN60
Pit 5, Plans, Sections, Elevations, Details



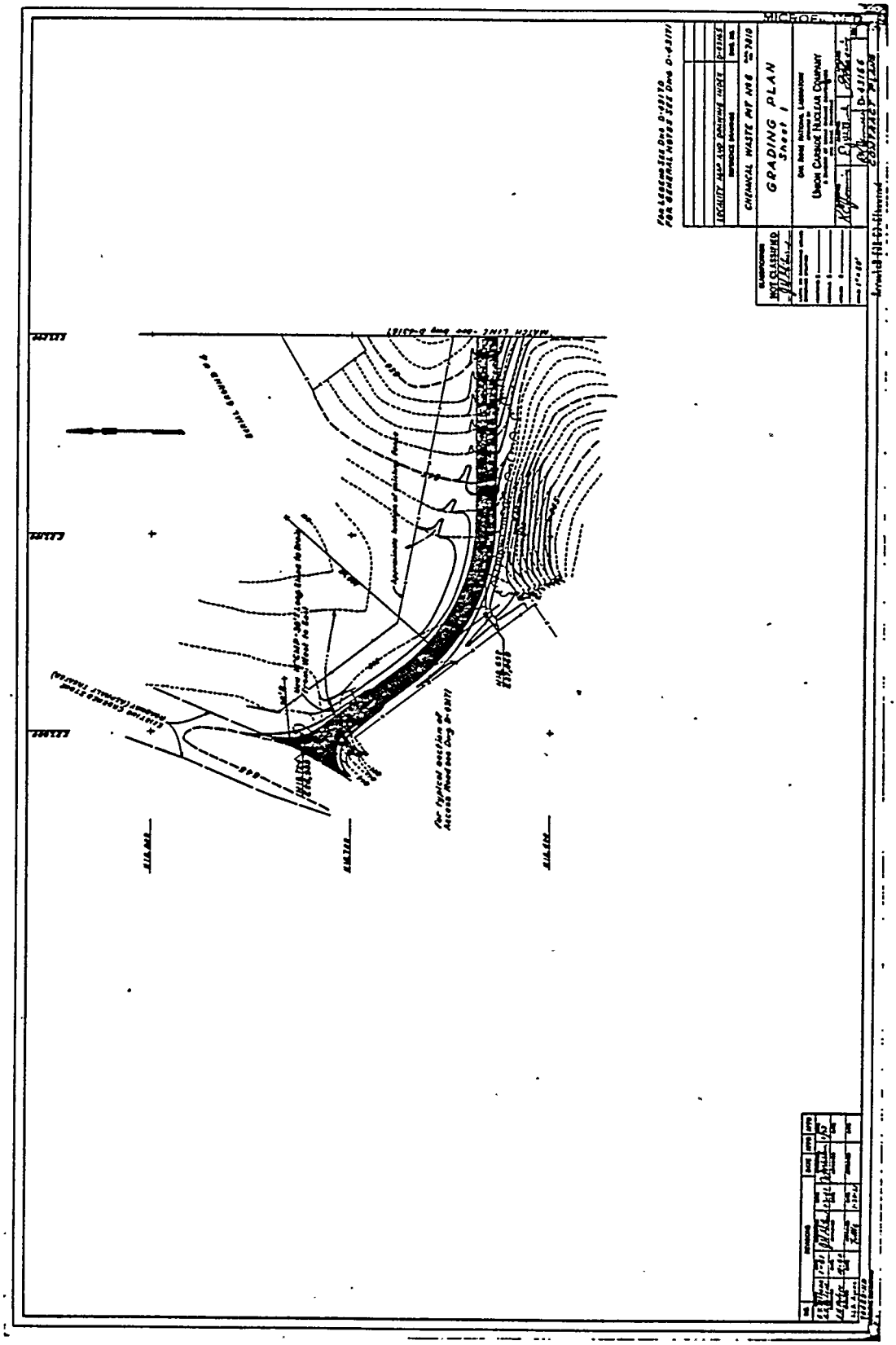
43 136 21NOV60
Chemical Waste Pit 6, Plans and Sections (Sketch)



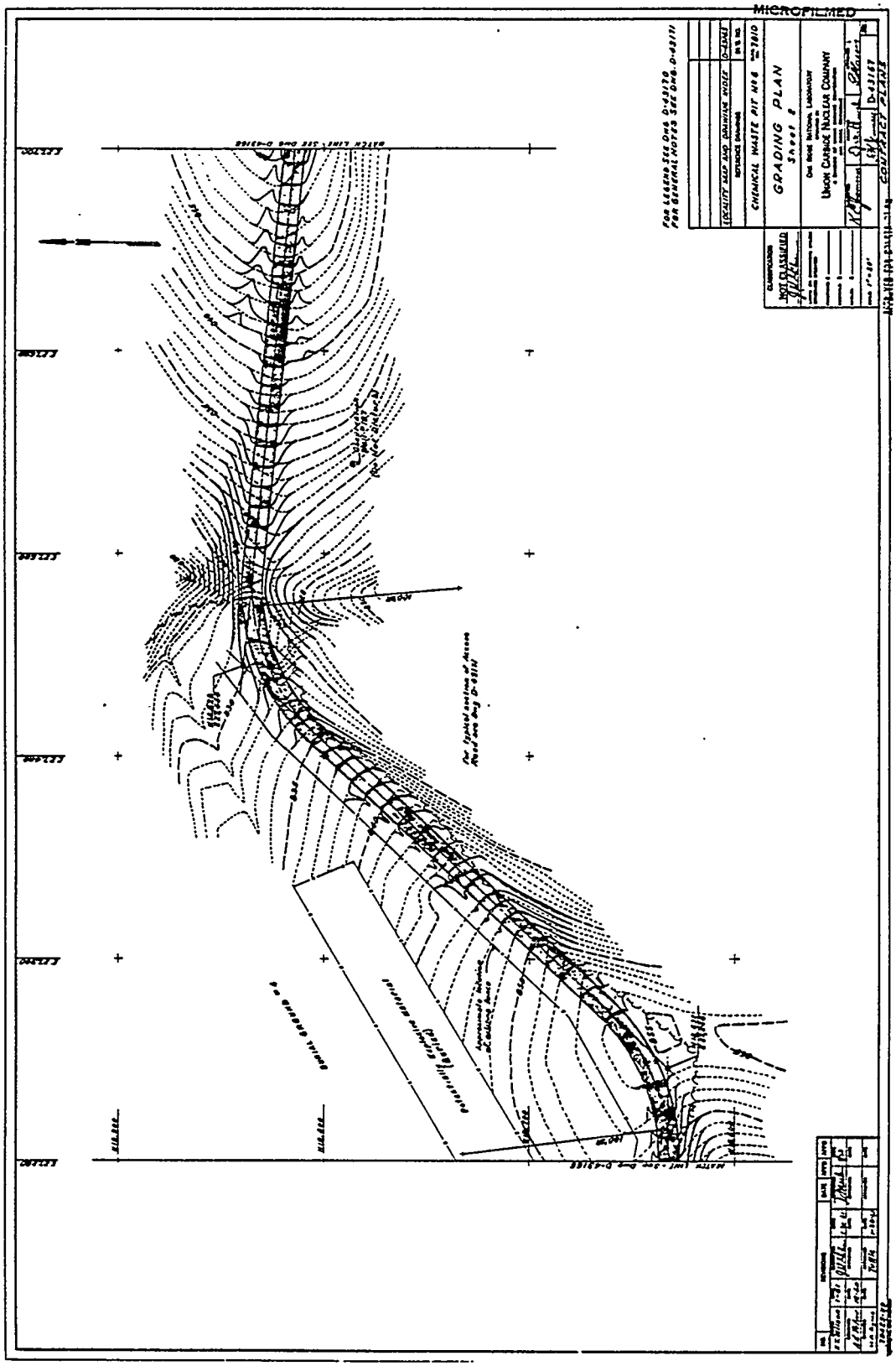
43190 04JAN61
Chemical Waste Pit 6, Electrical Service



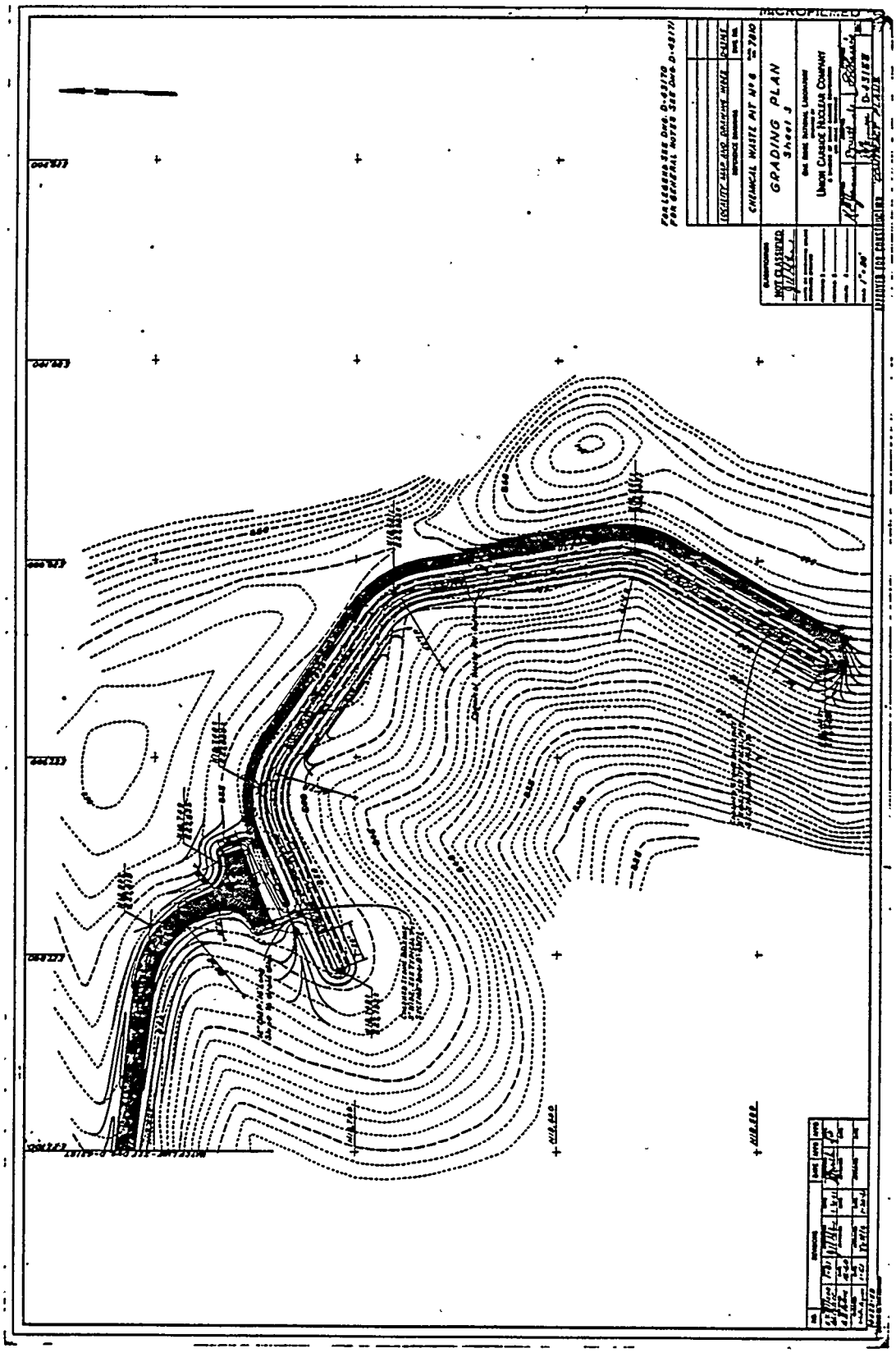
43165 23JAN61
Locality Map and Drawing Index, Pit No. 6



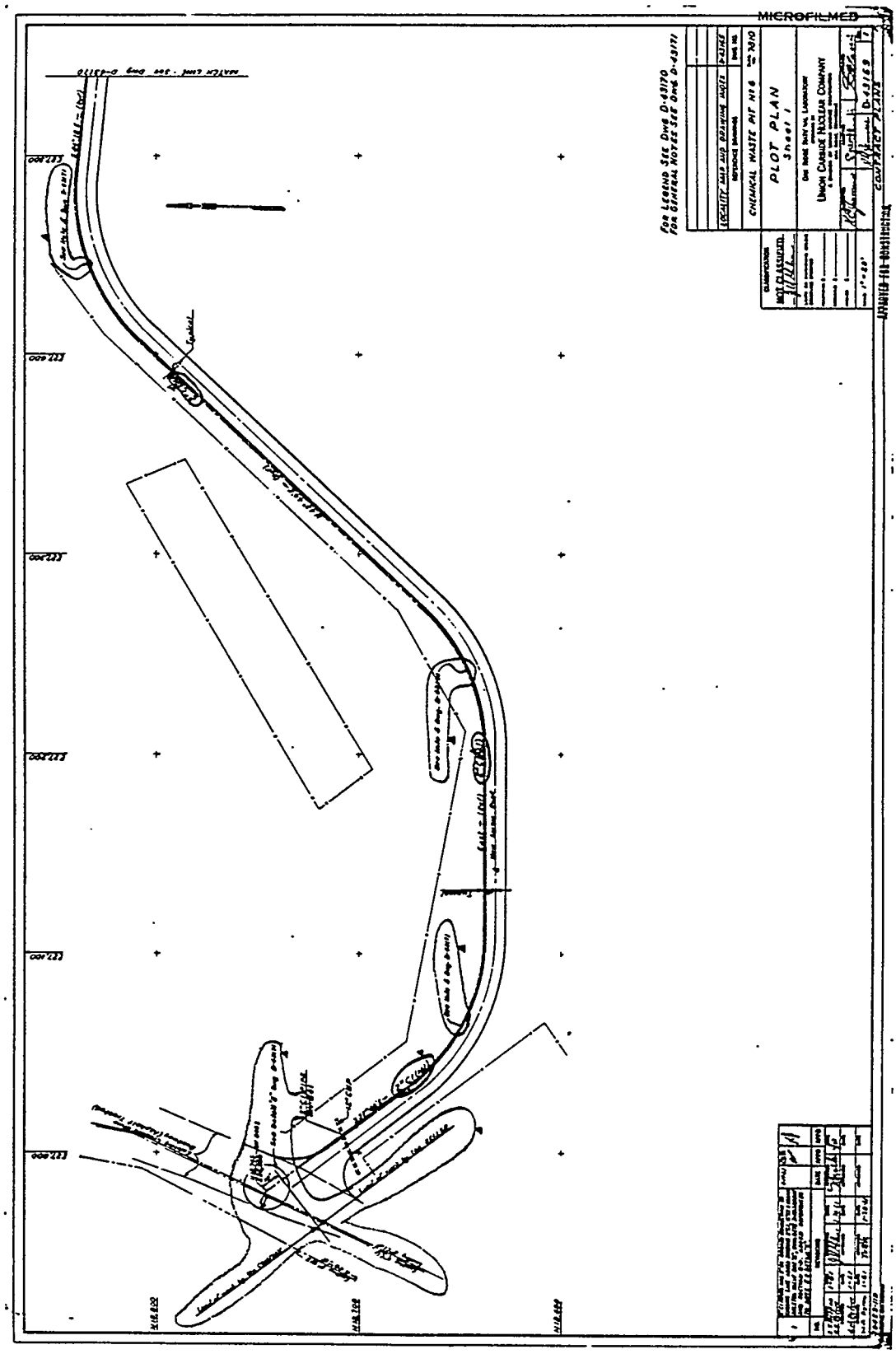
43166 23JAN61
Chemical Waste Pit 6, Grading Plan, Sheet 1



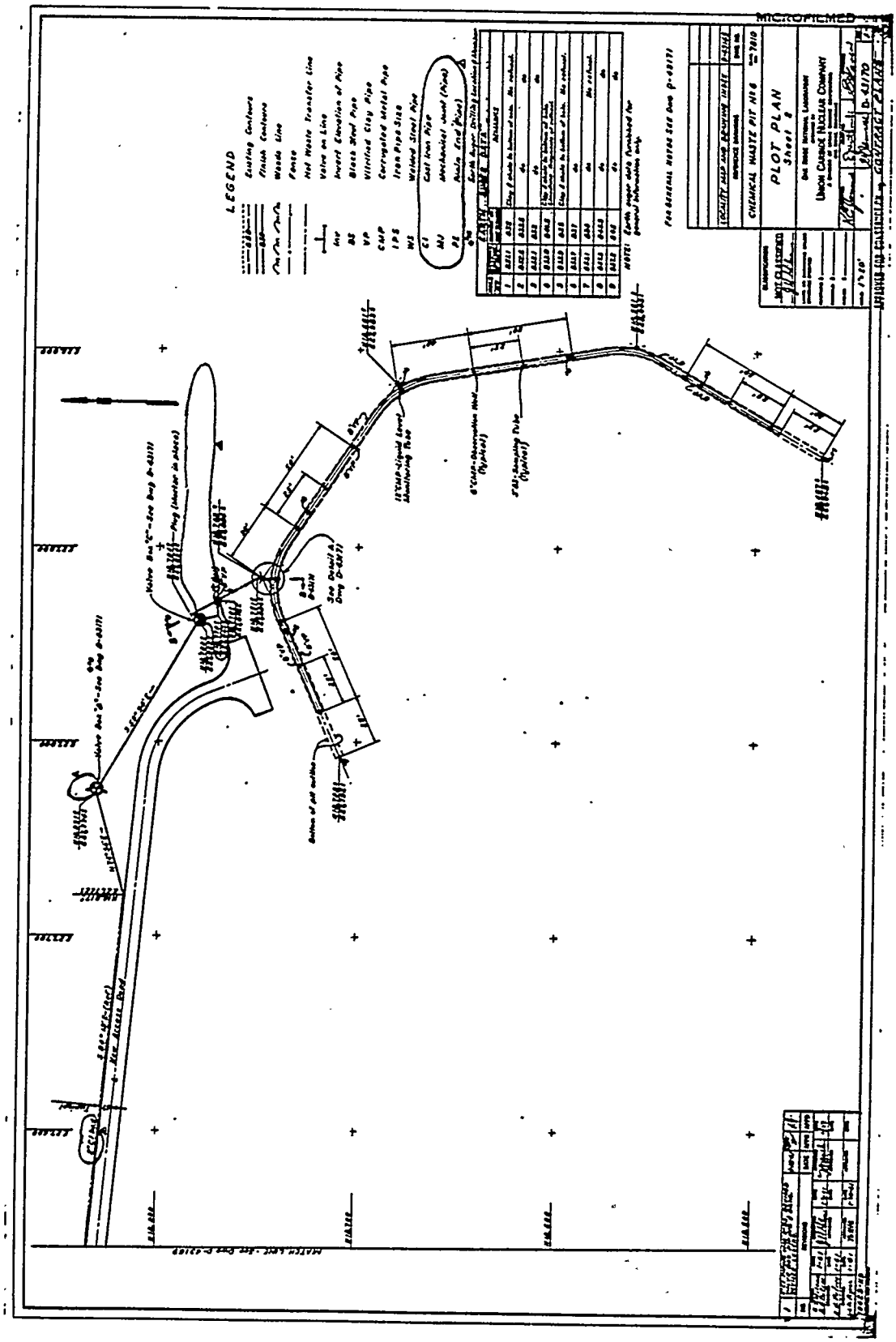
43167 23JAN61
Chemical Waste Pit 6, Grading Plan, Sheet 2



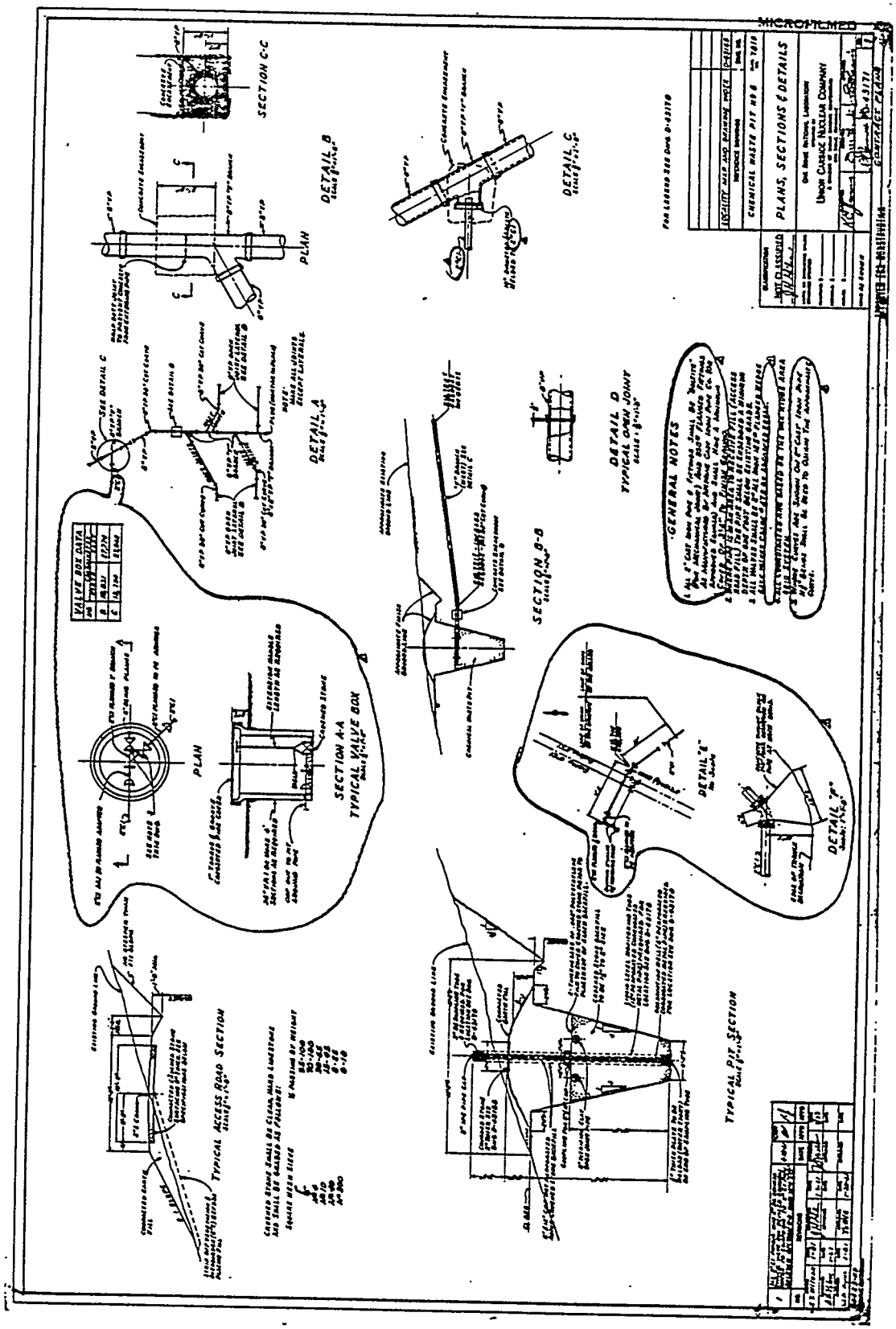
43168 23JAN61
Chemical Waste Pit 6, Grading Plan, Sheet 3



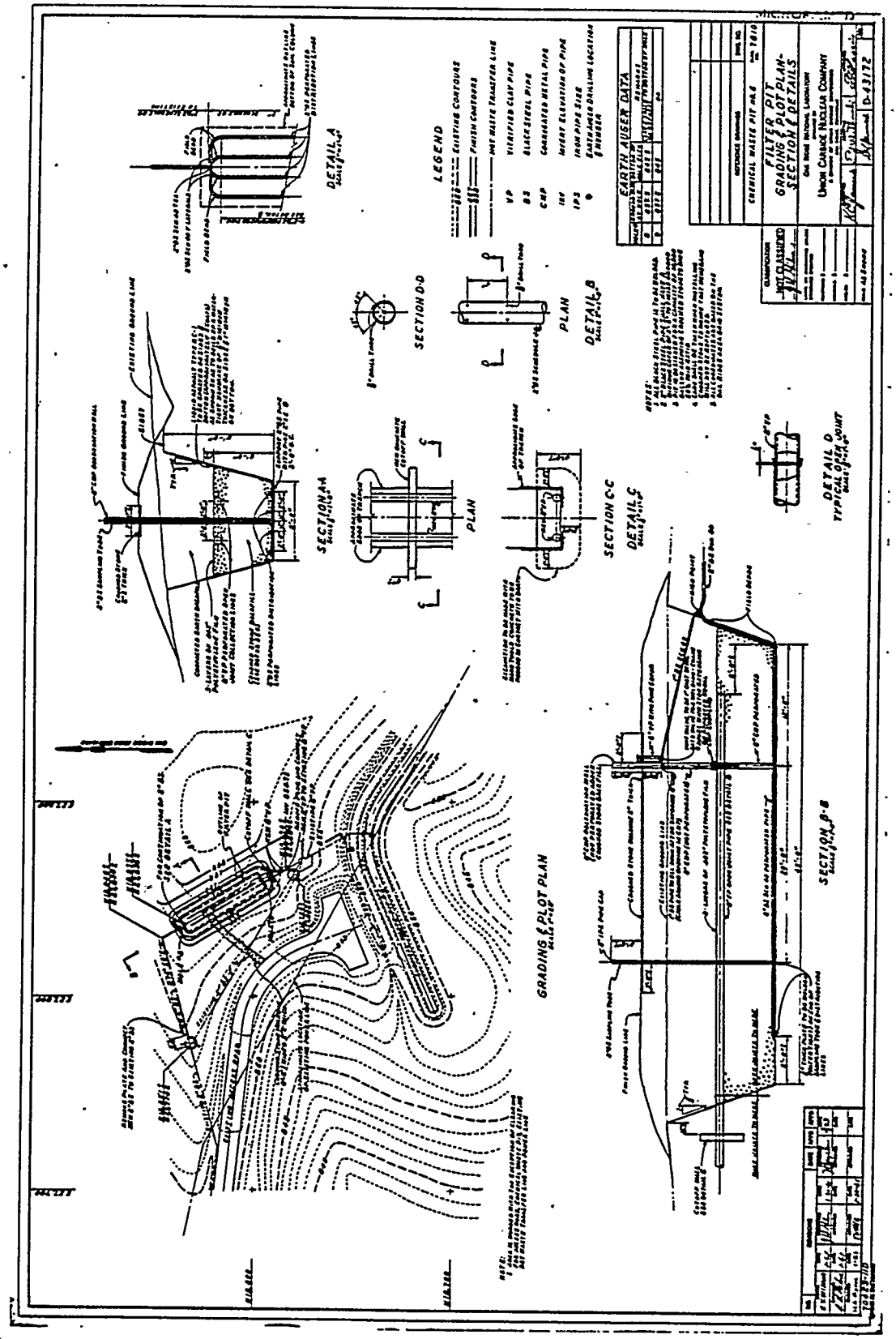
43169 23JAN61
Chemical Waste Pit 6, Plot Plan, Sheet 1



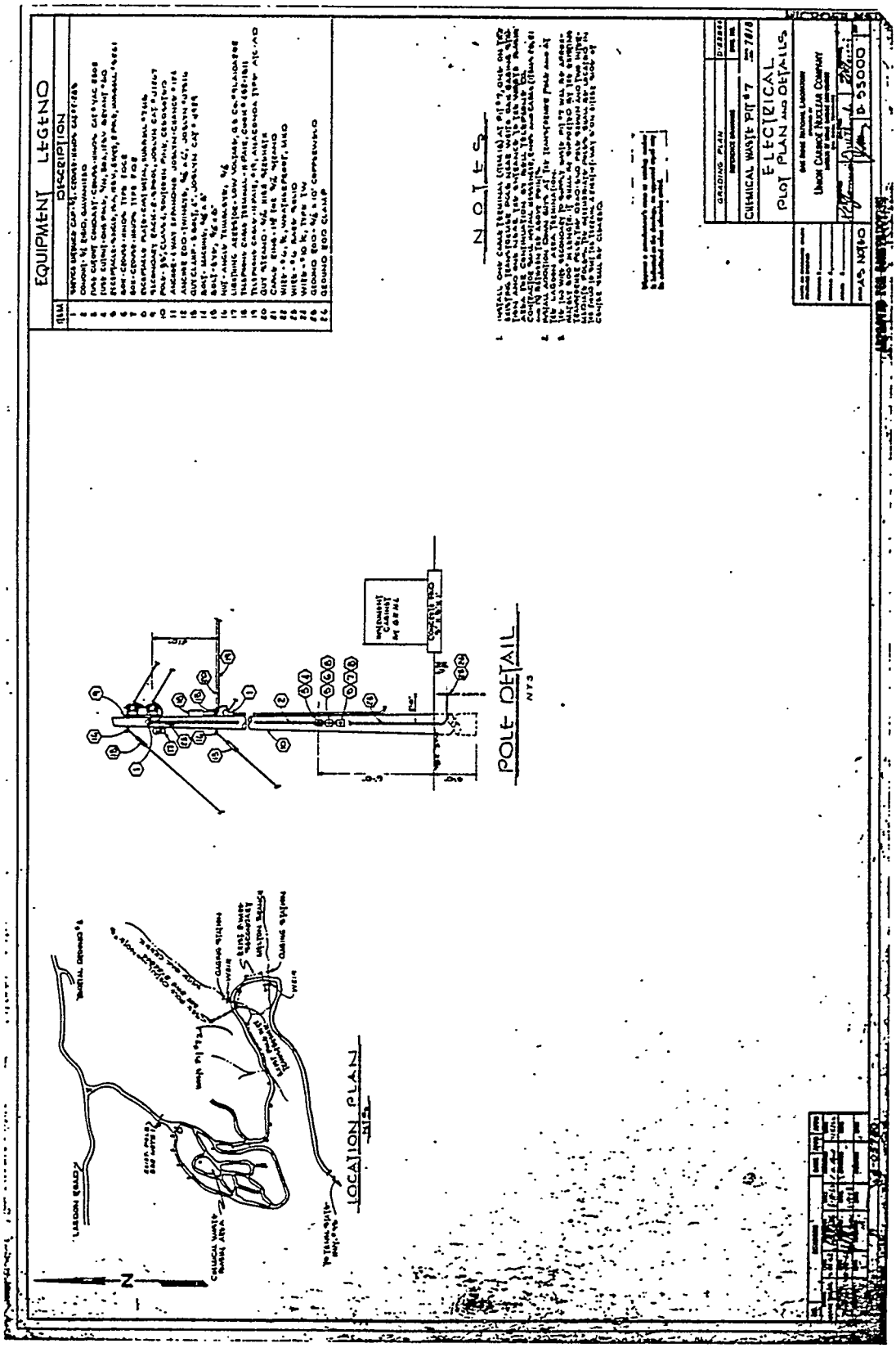
43170 23JAN61
Chemical Waste Pit 6, Plot Plan, Sheet 2



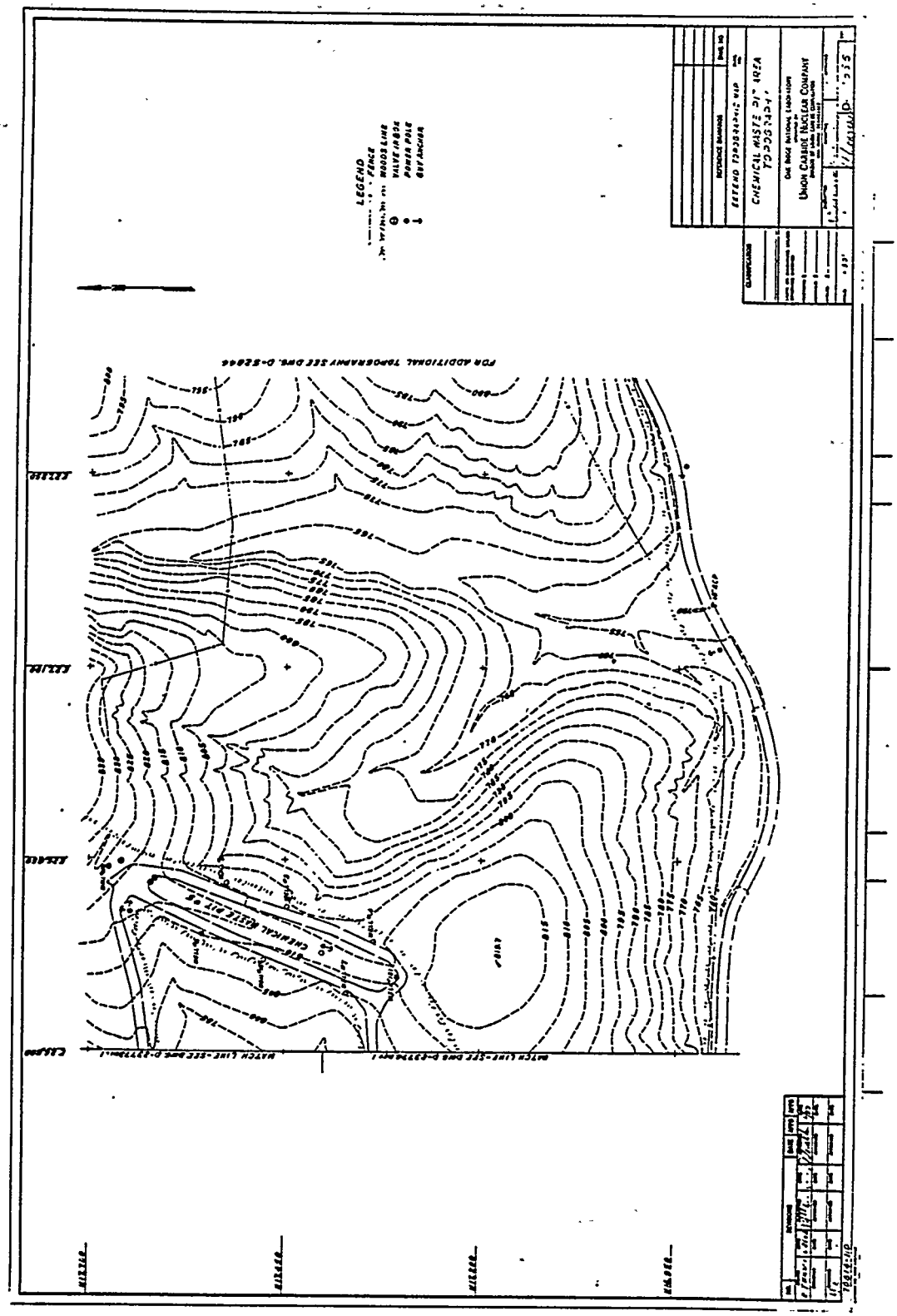
43171 23JAN61
Chemical Waste Pit 6, Plans, Sections, Details



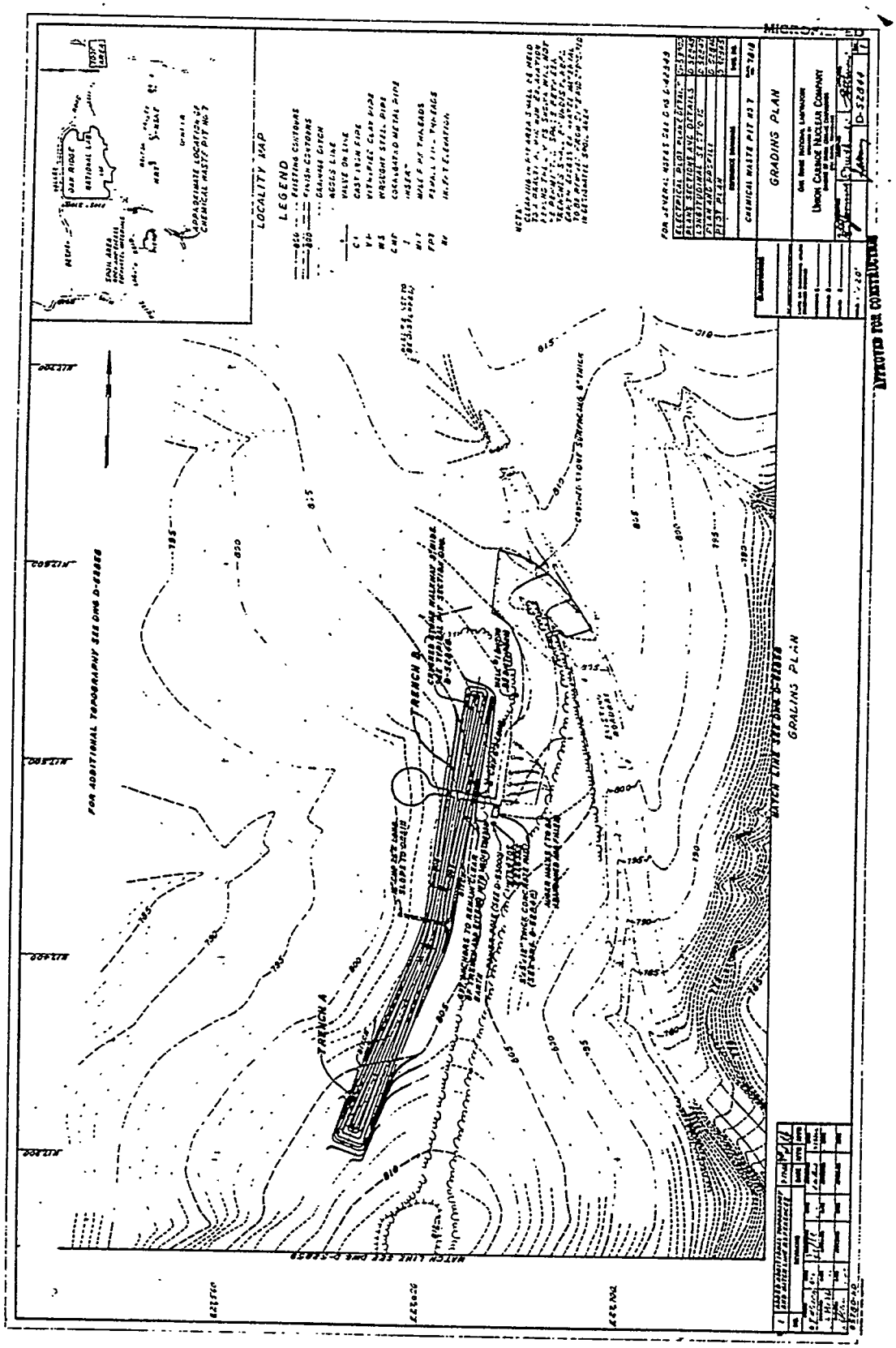
43 172 23JAN61
Chemical Waste Pit 6, Filter Pit, Grading Plot plan



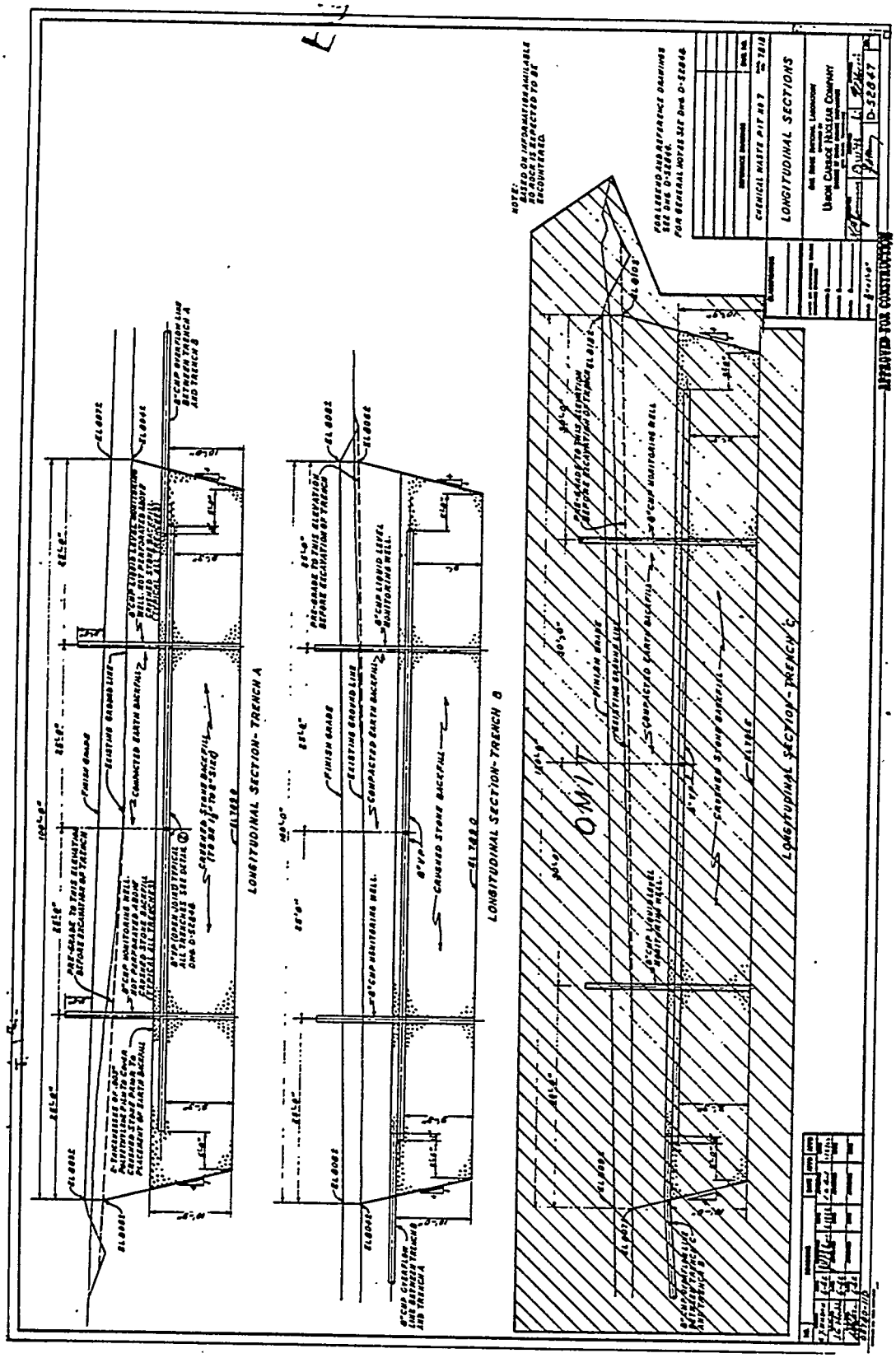
53000 24MAY62
Chemical Waste Pit 7, Electrical Plot Plan



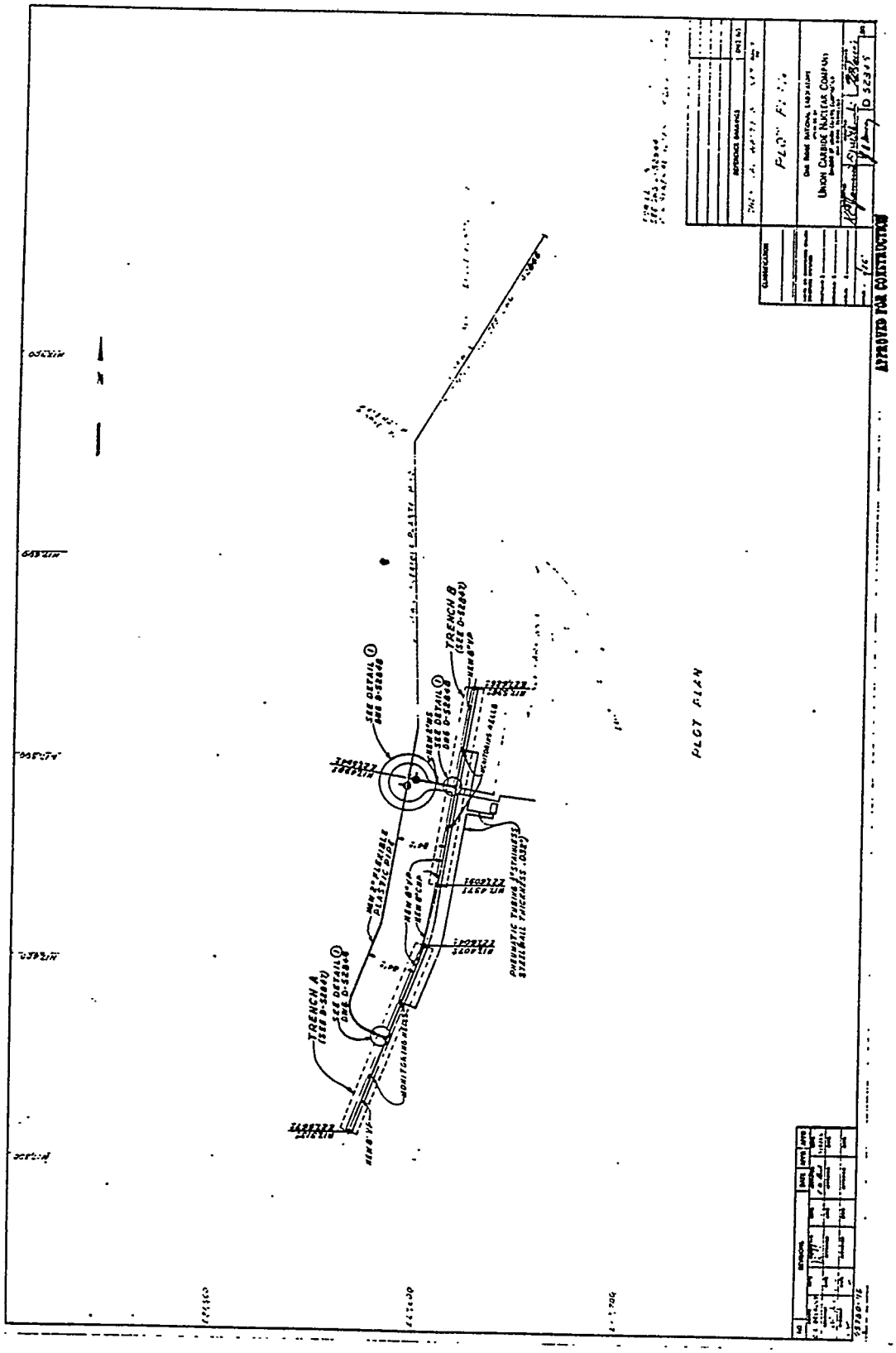
52856 06JUN62
Chemical Waste Pit Area Extended Topo. Map



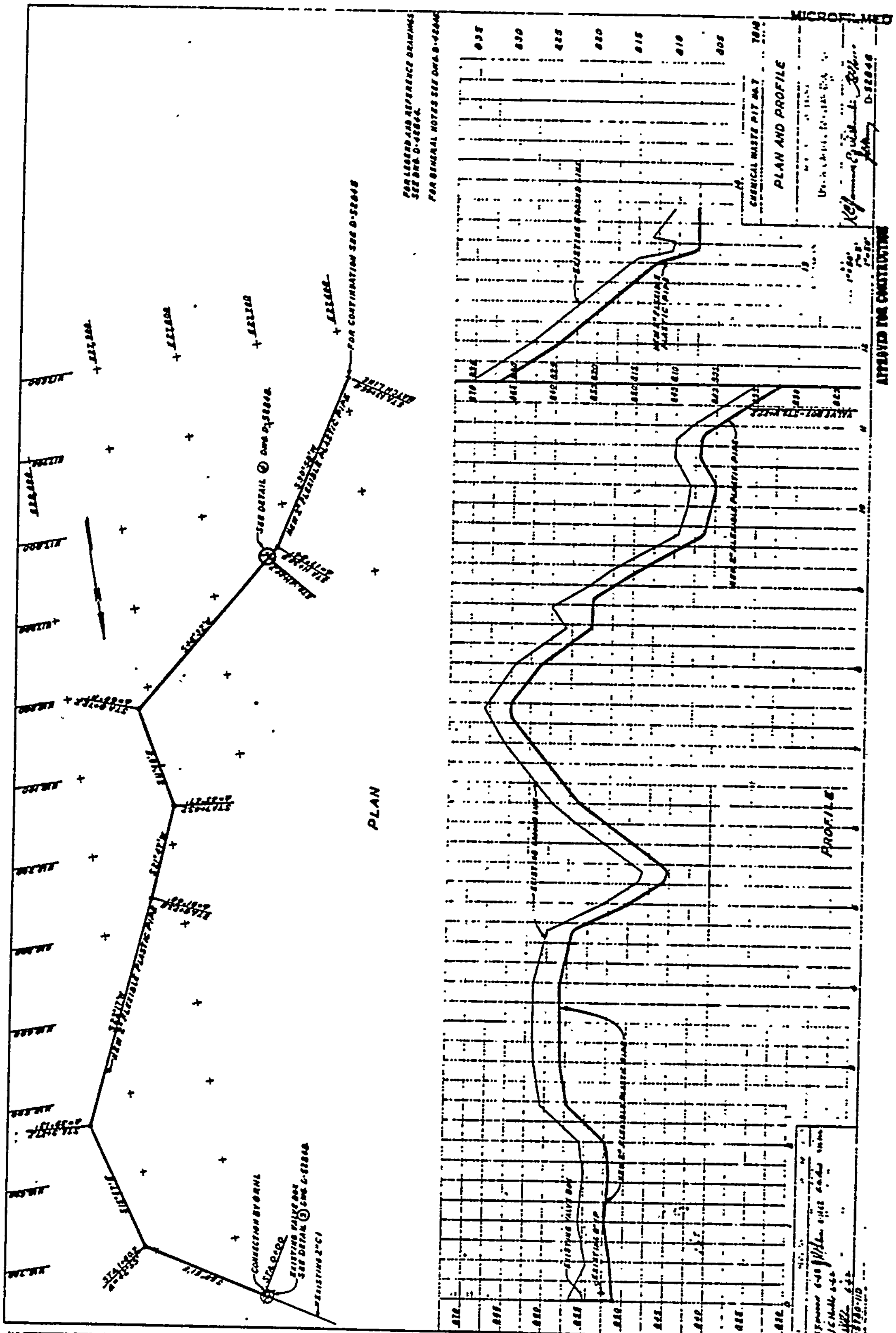
52844 12JUN62
Chemical Waste Pit 7, Grading Plan



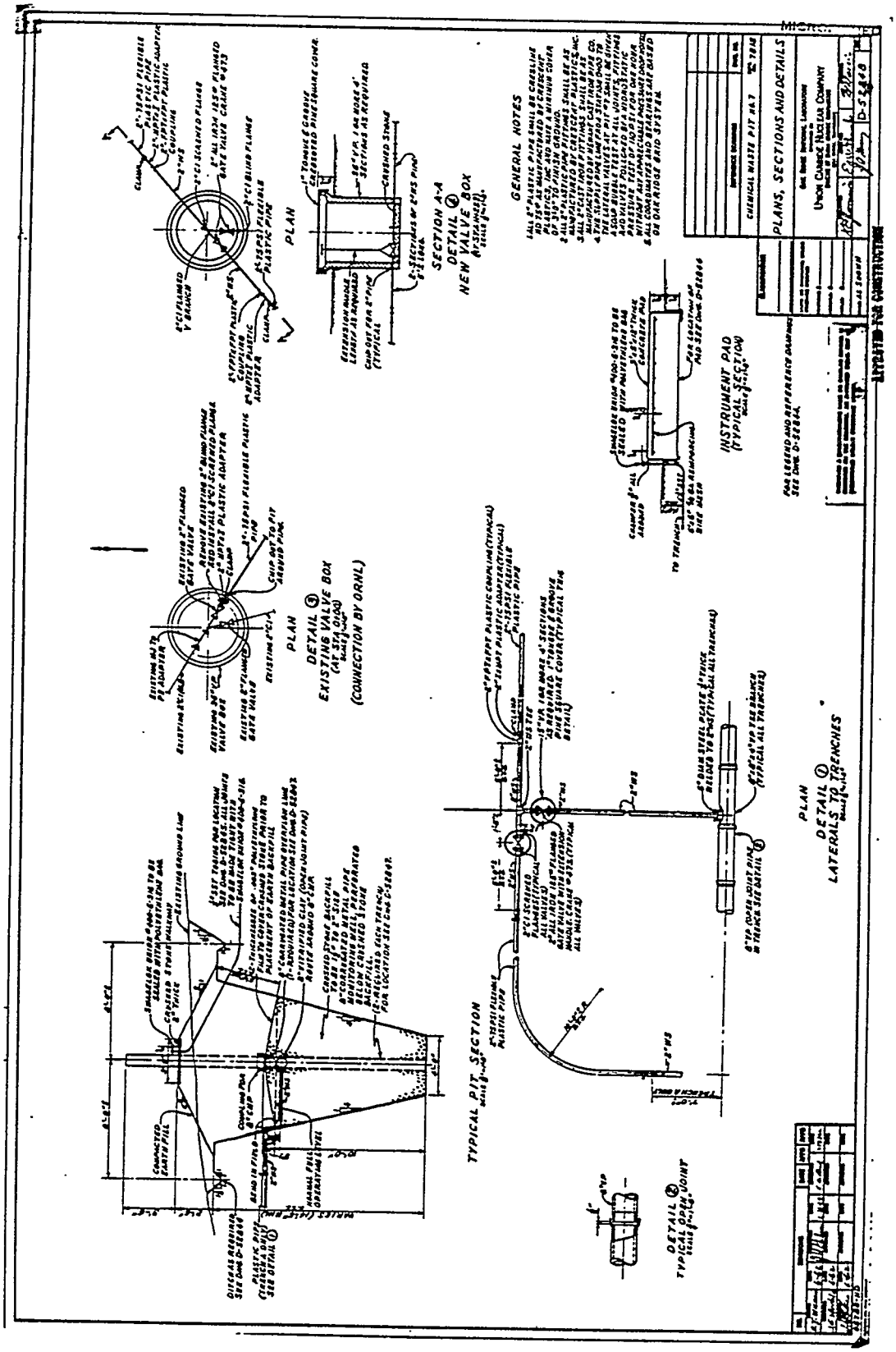
52847 12JUN62
Chemical Waste Pit 7, Longitudinal Sections



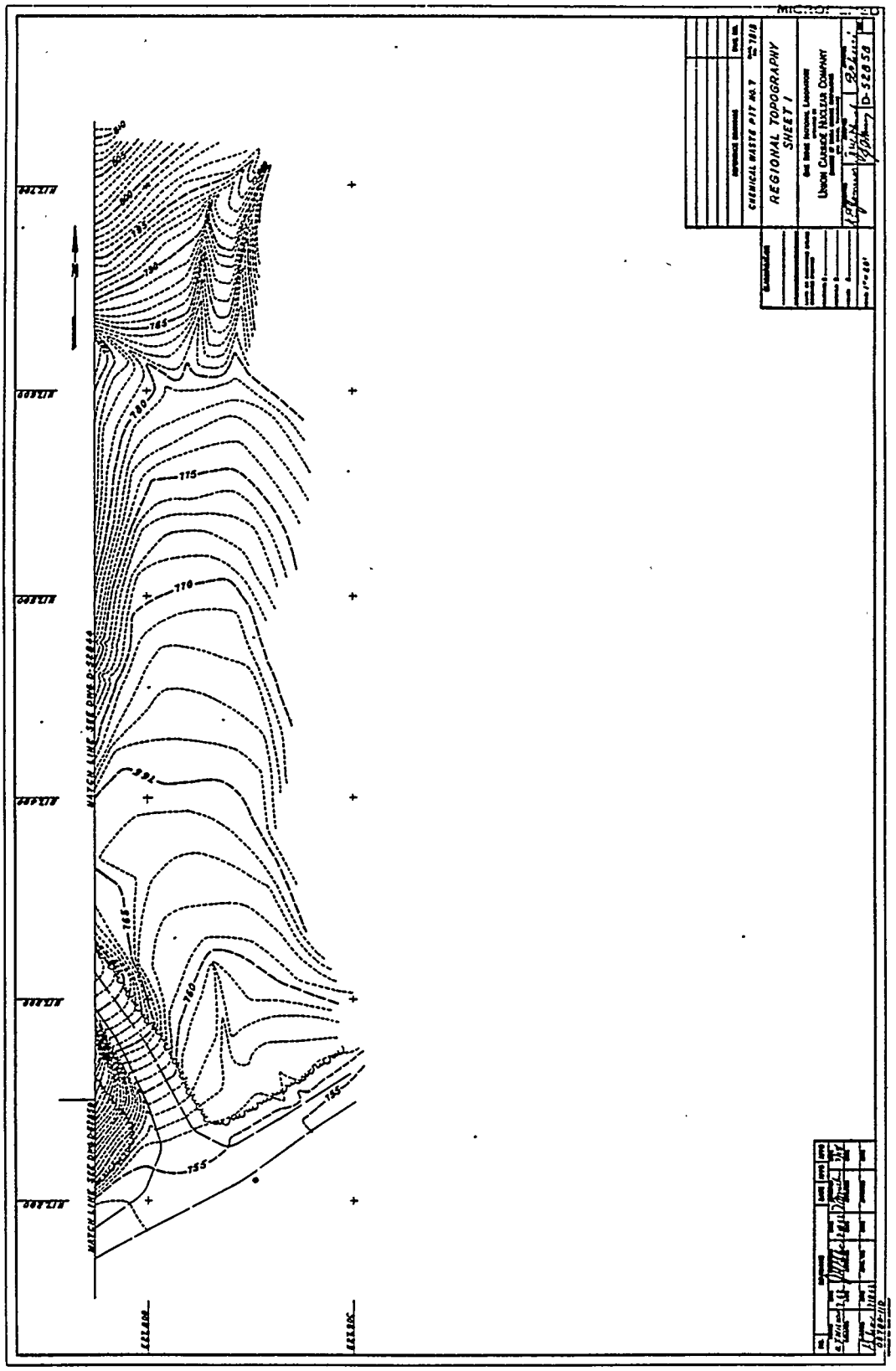
52845 14JUN62
Chemical Waste Pit 7, Plot Plan



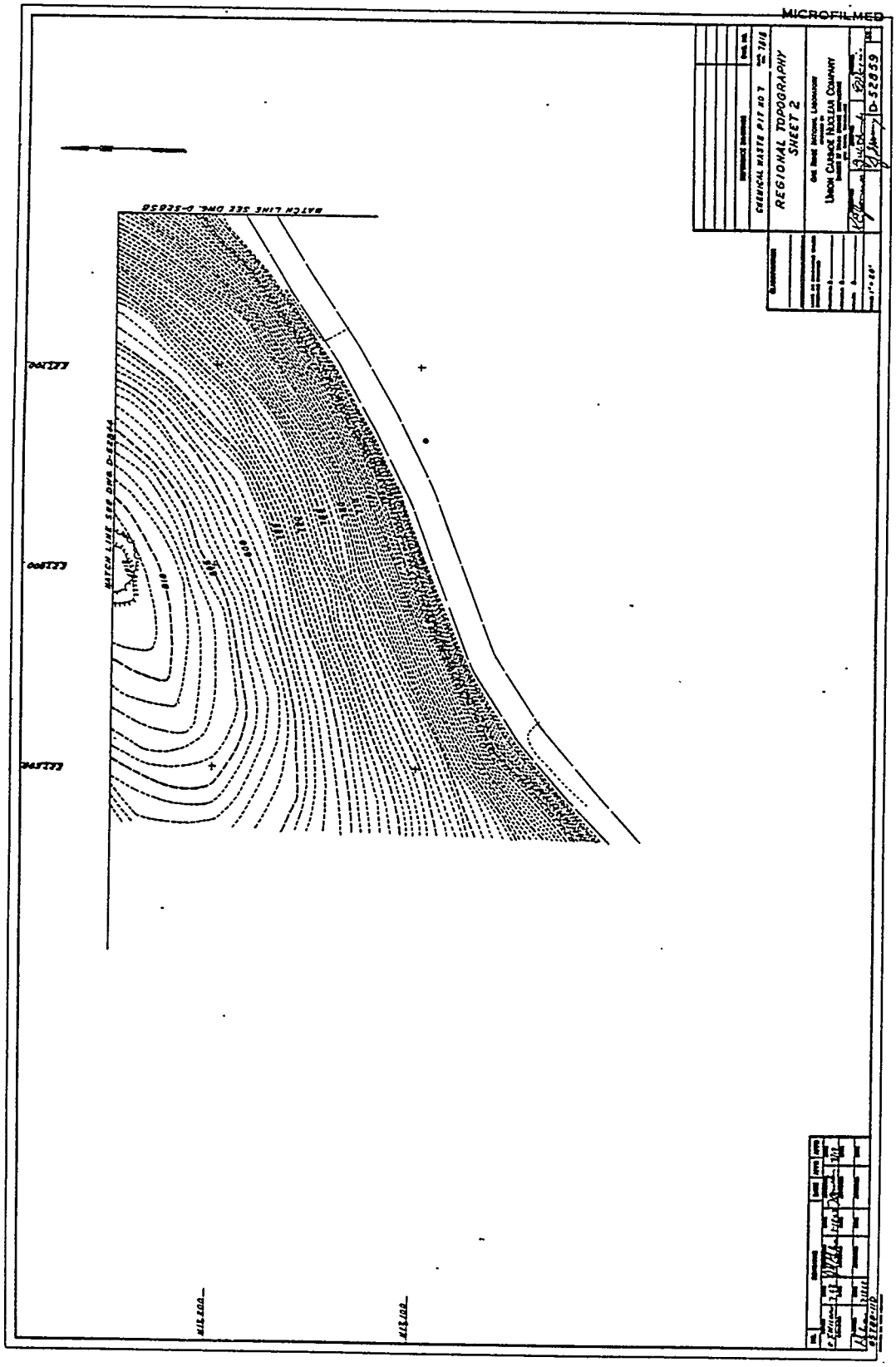
52846 14JUN62
Chemical Waste Pit 7, Plan and Profile



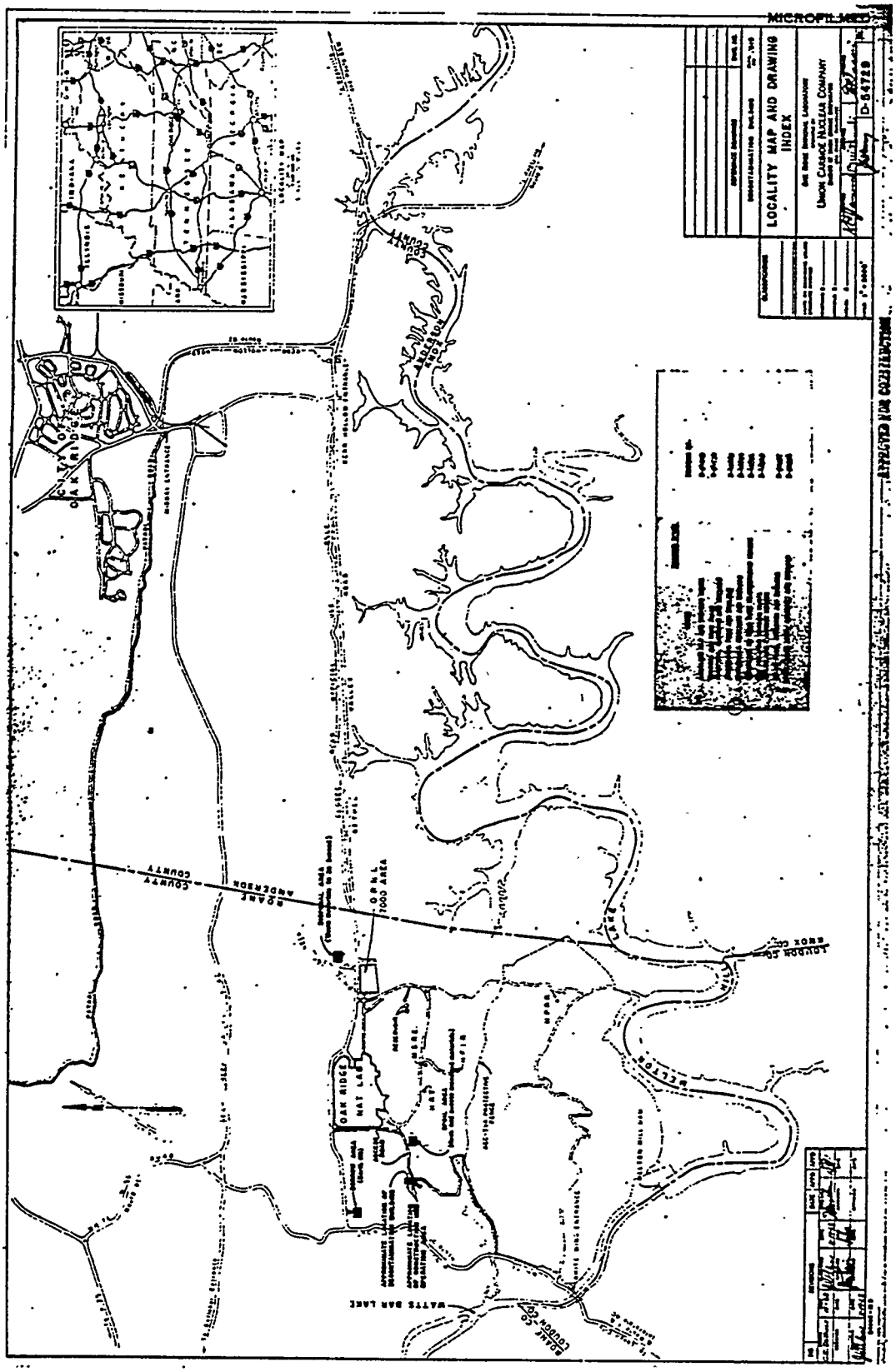
52848 14JUN62
Chemical Waste Pit 7, Plans, Sections,Details



52858 18JUL62
Chemical Waste Pit 7, Regional Topography, Sheet 1

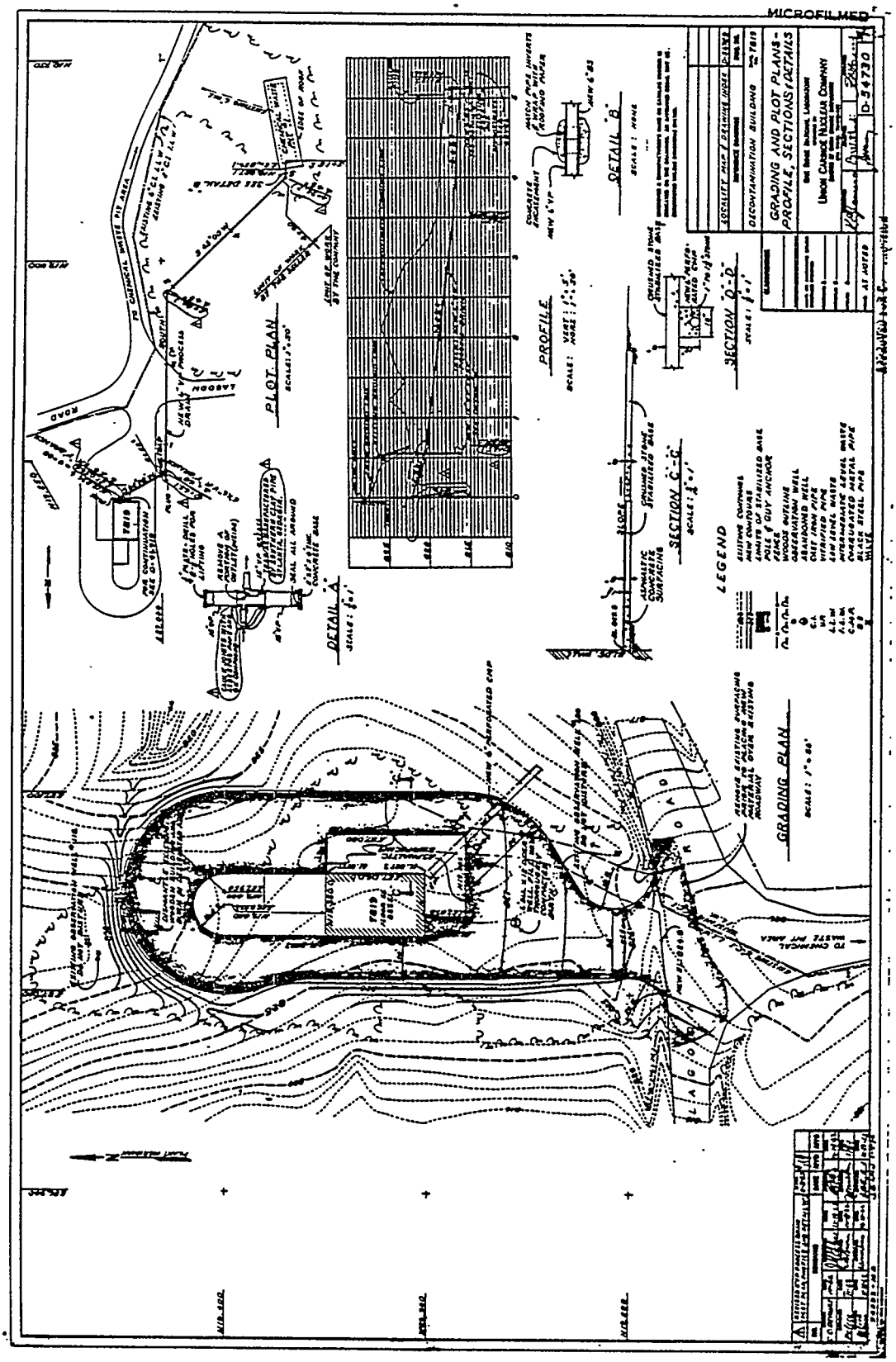


52859 18JUL62
Chemical Waste Pit 7, Regional Topography, Sheet 2

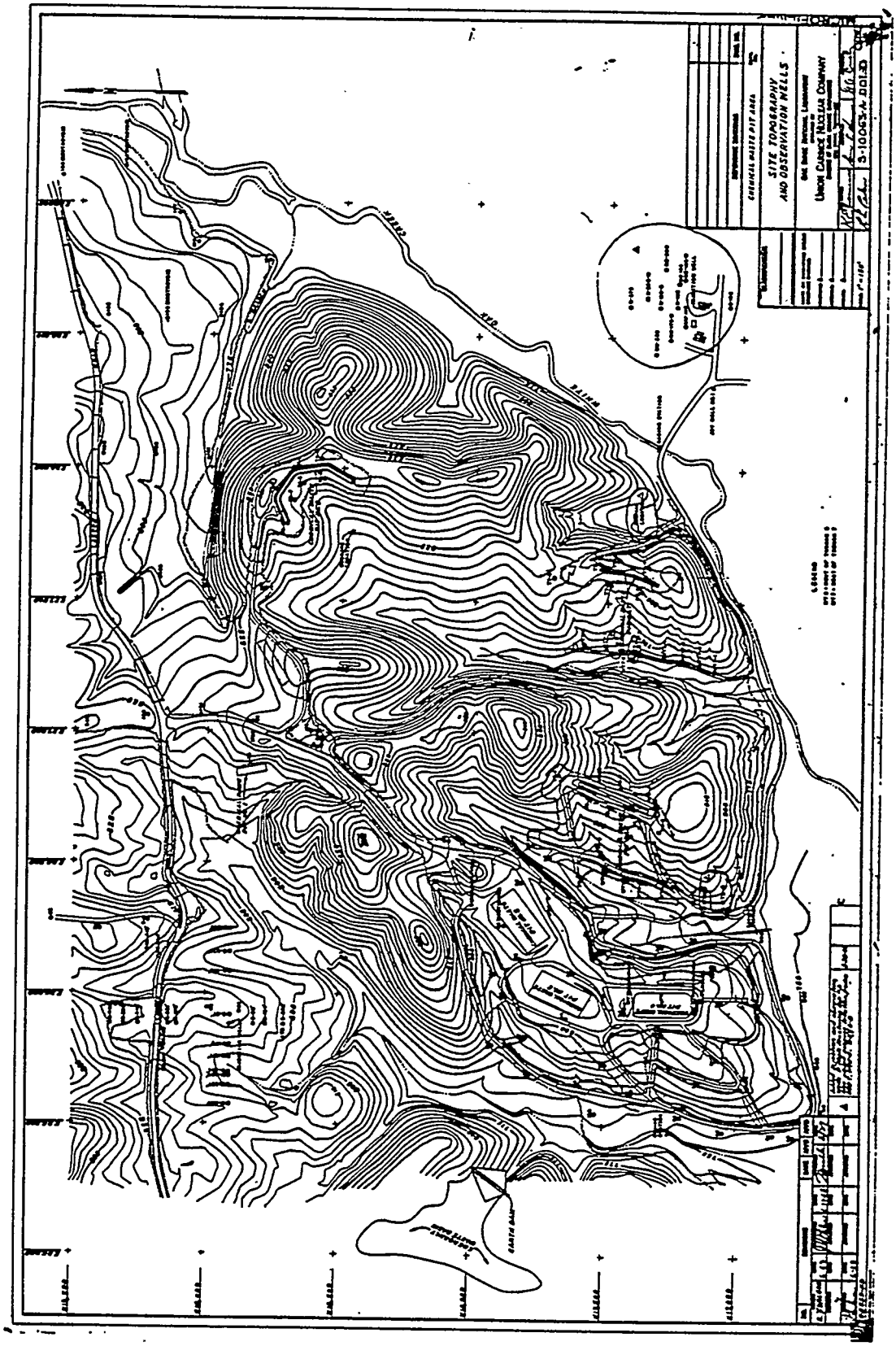


54729 19NOV62
Decontamination Bldg 7819, Locality and Index

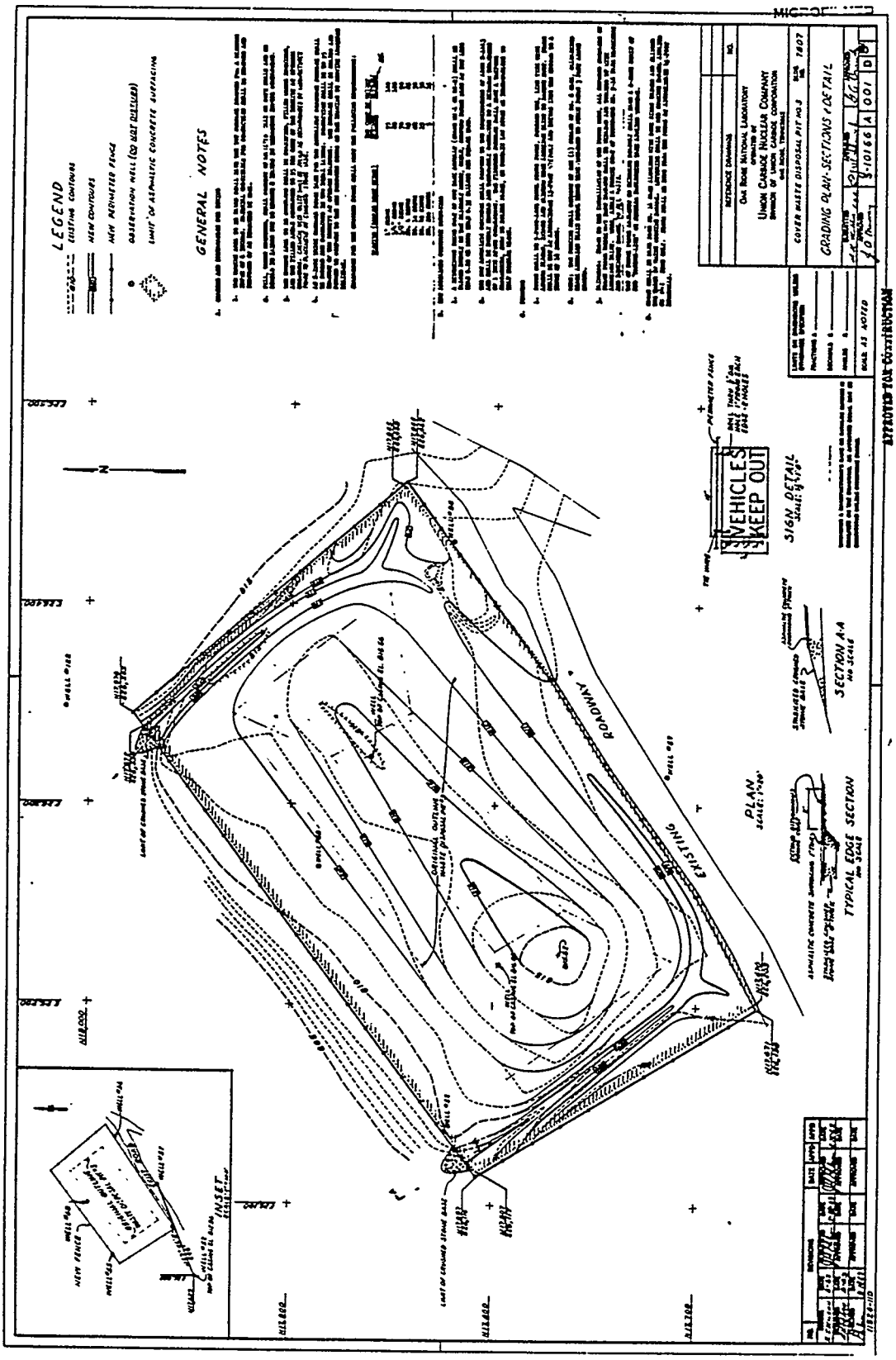
MICROFILMED



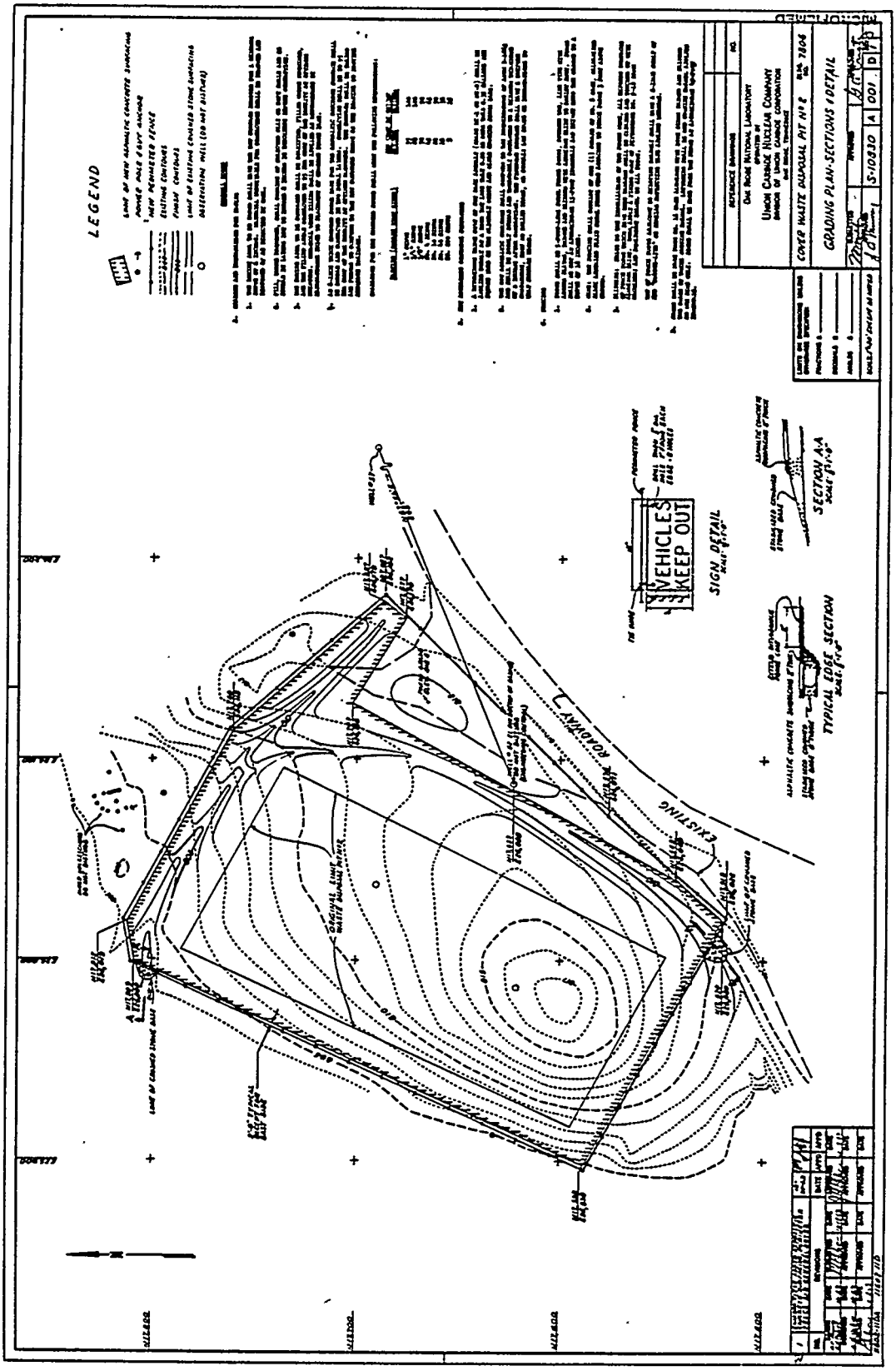
54730 19NOV62
Decontamination Bldg 7819, Grading and Plot Plan



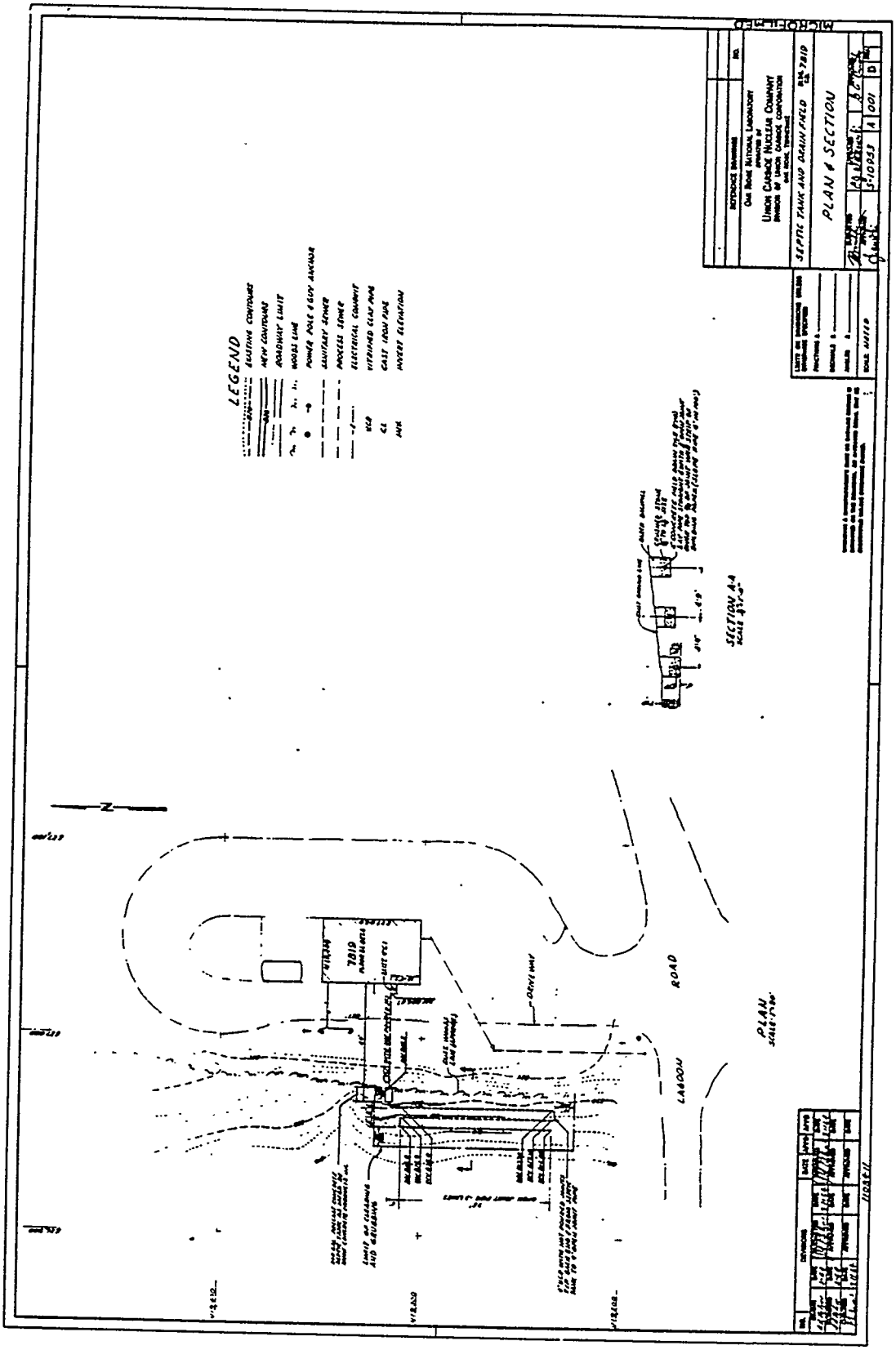
10063 27JUN63
Chemical Waste Pit Area-Site Topography and Wells



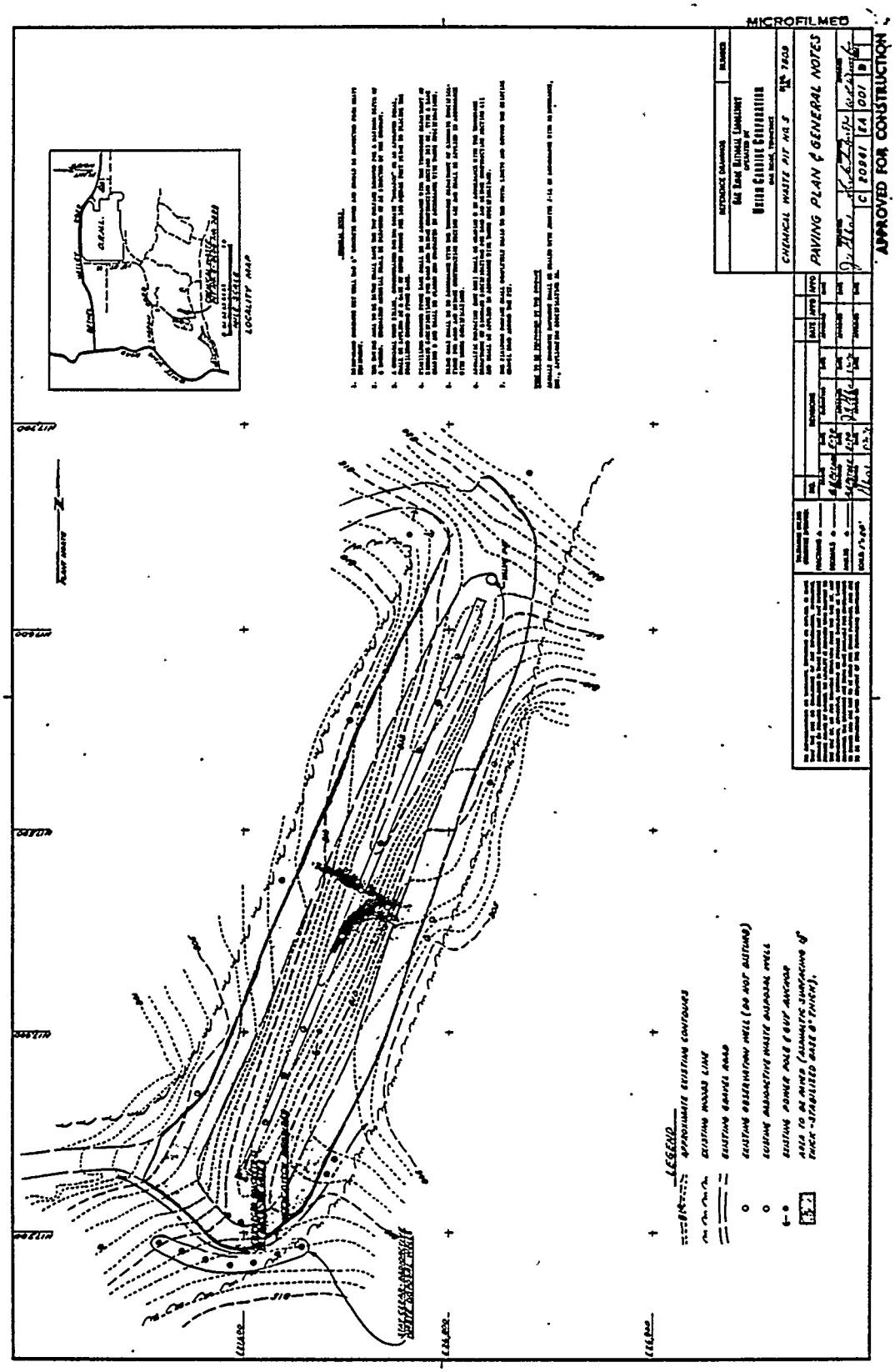
10 166 15AUG63
Cover Waste Pit 3, Grading Plan-Sections and Details



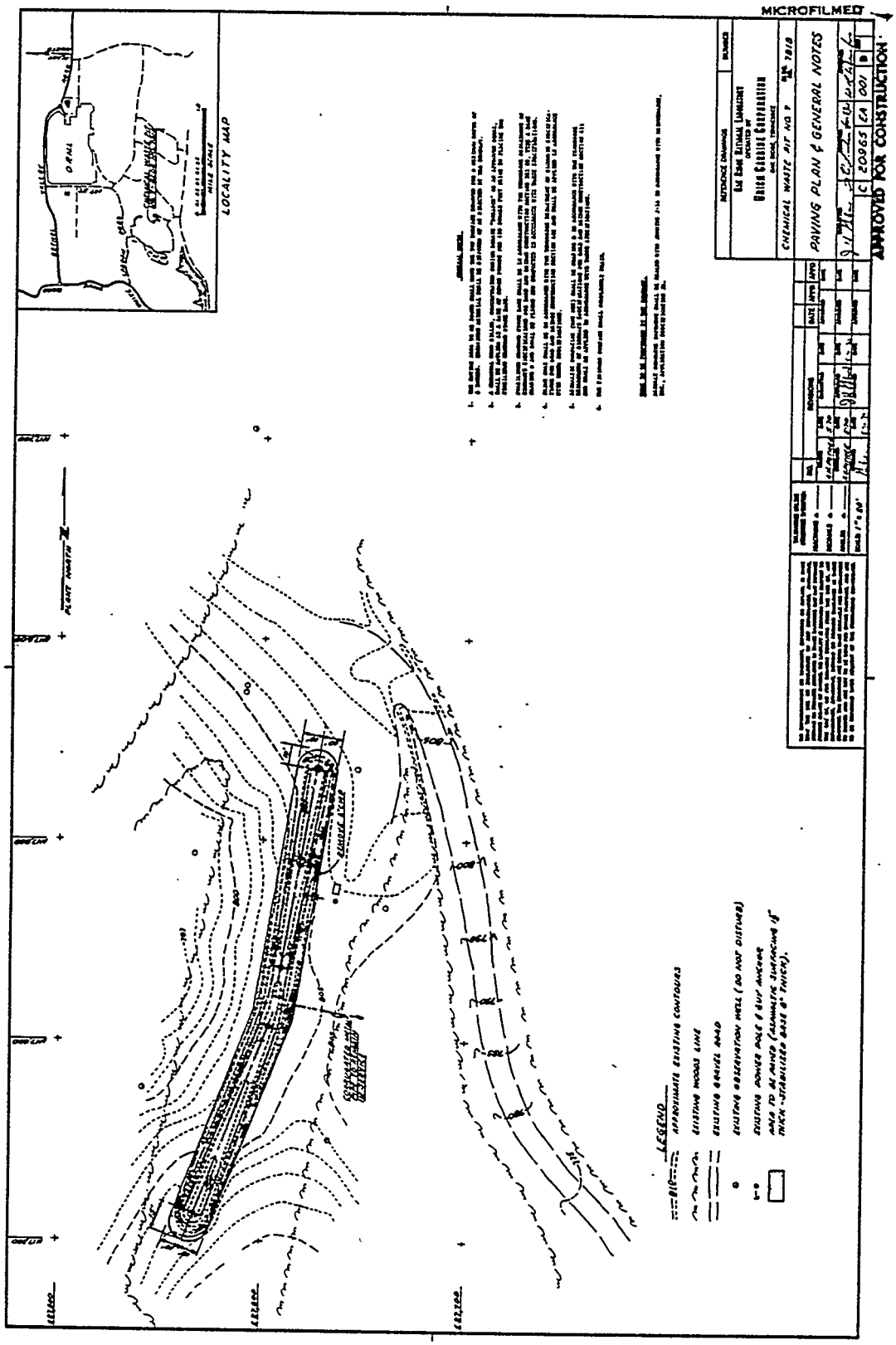
10830 18OCT63
Cover Waste Pit 2, Grading Plan-Sections and Details



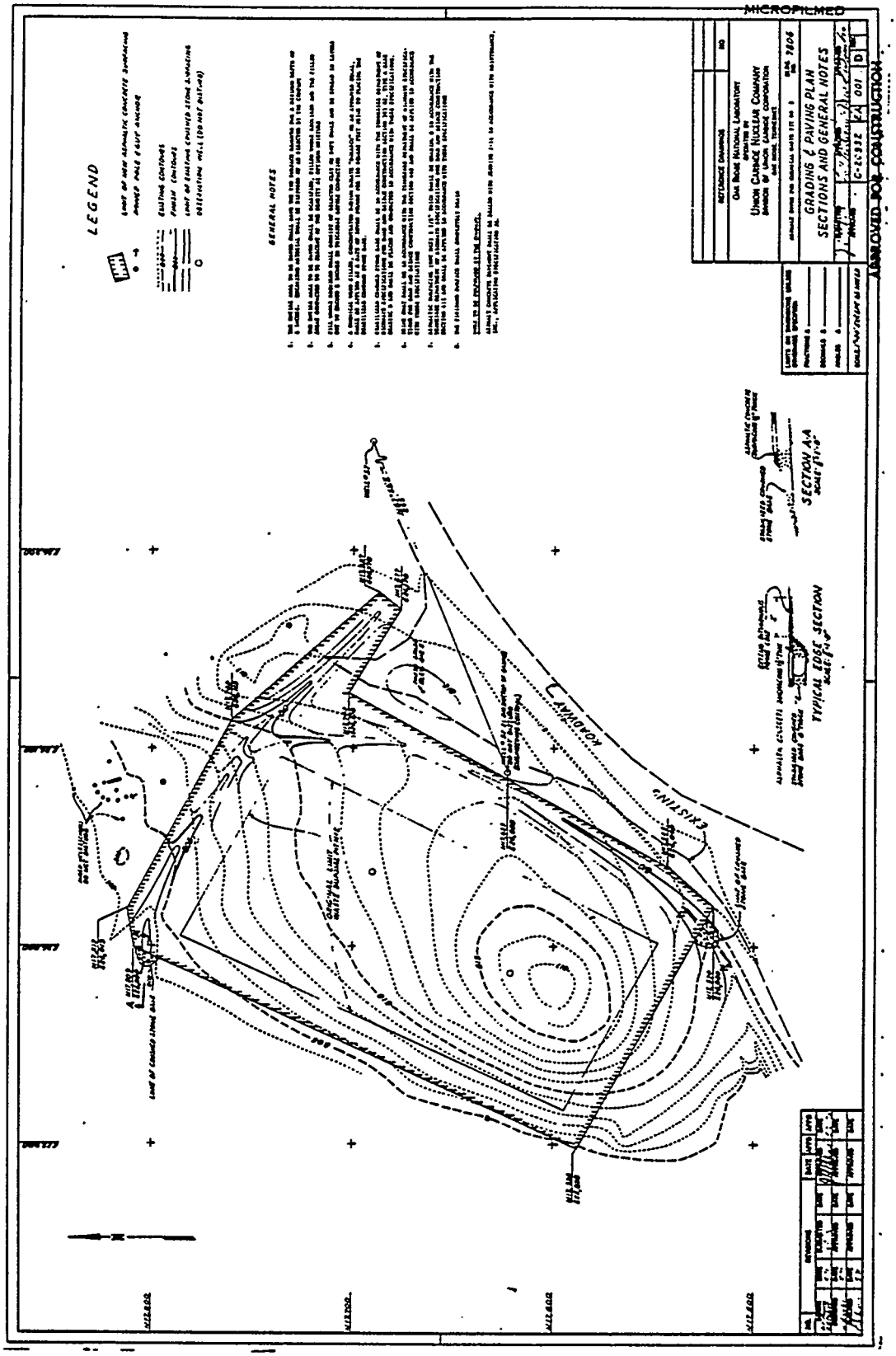
10953 11MAR64
Septic Tank and Drain Field 7819, Plan and Section



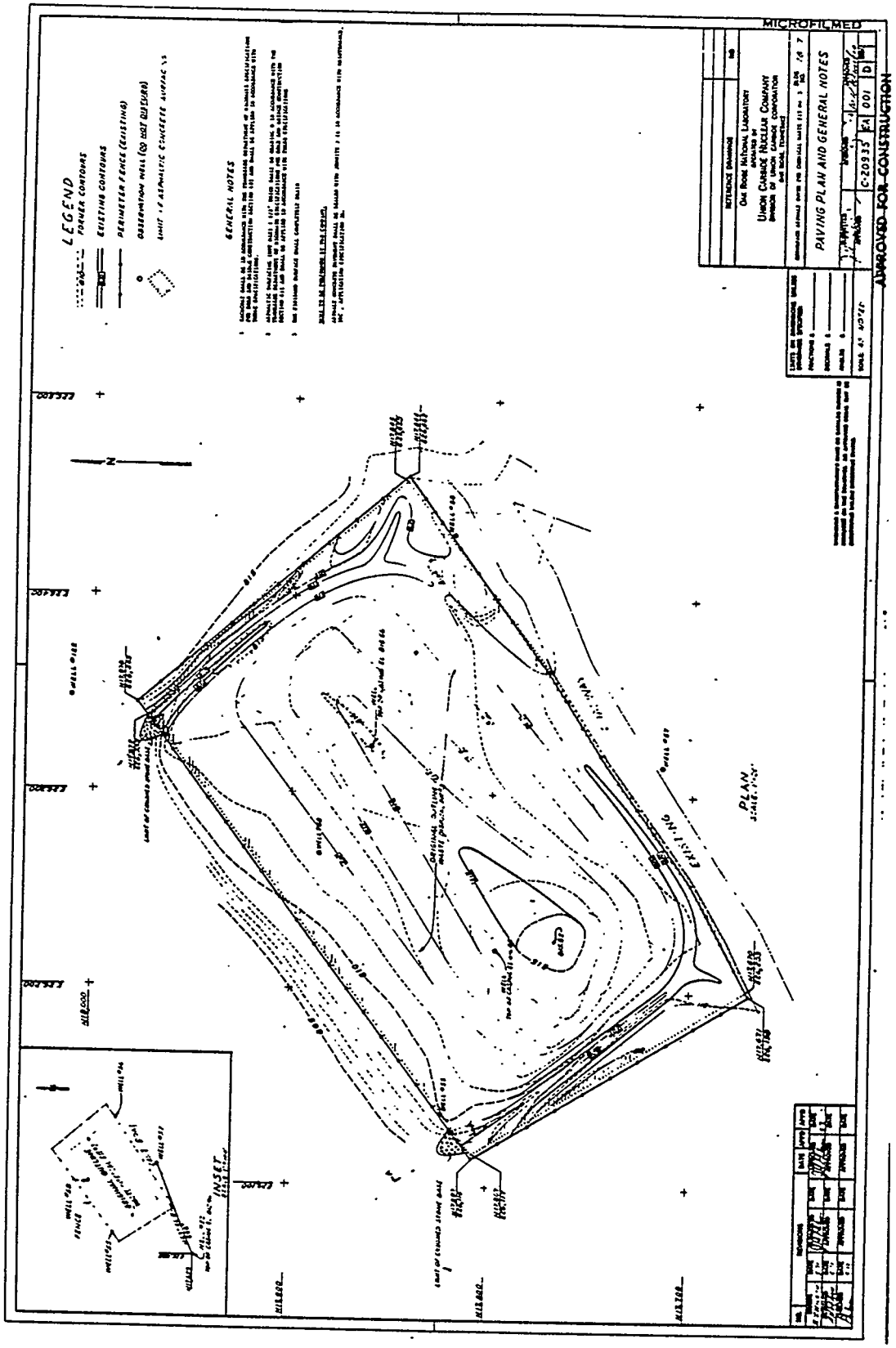
20941 20MAY70
Chemical Waste Pit 5, Paving Plan and Notes



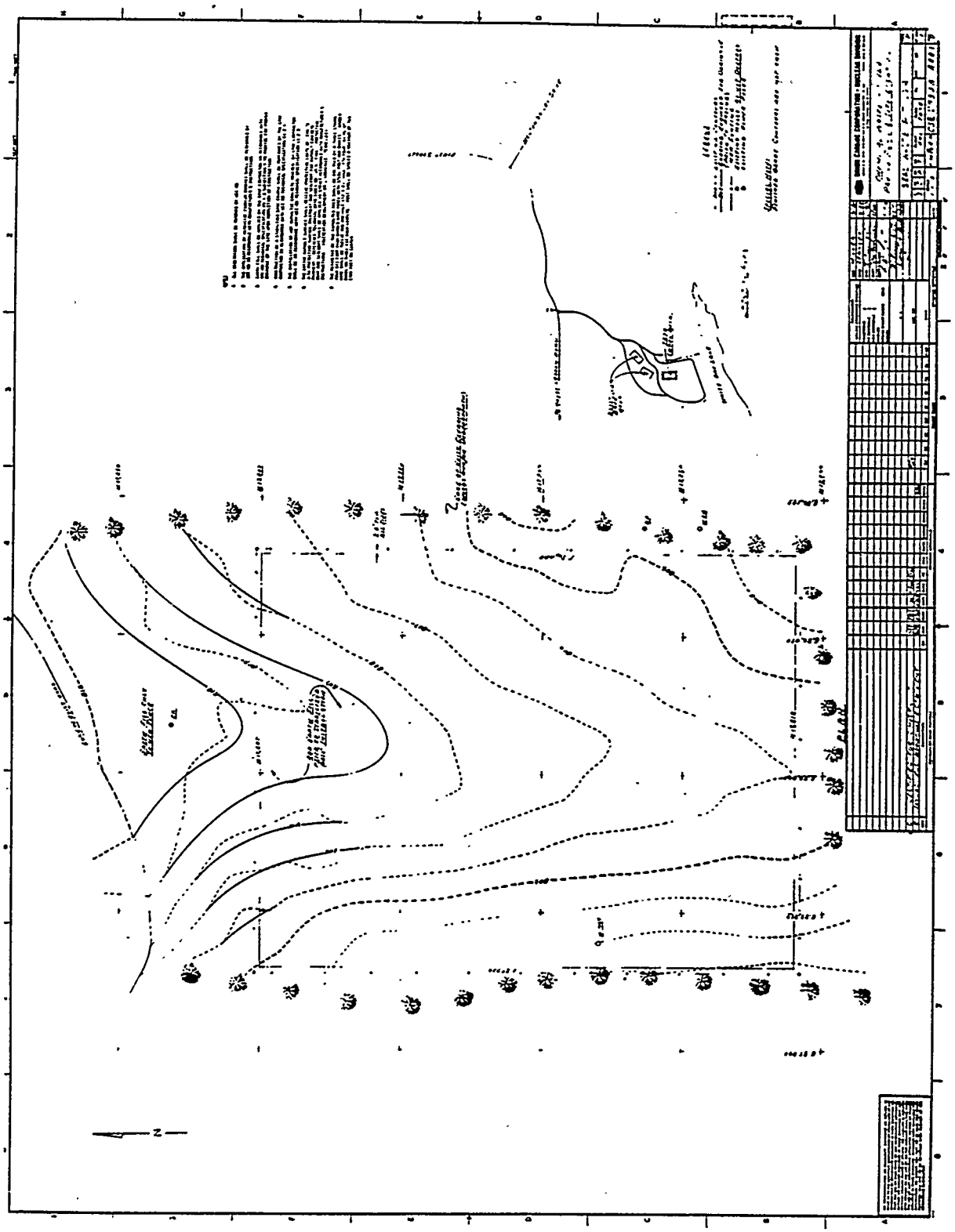
20965 20MAY70
Chemical Waste Pit 7, Paving Plan and Notes



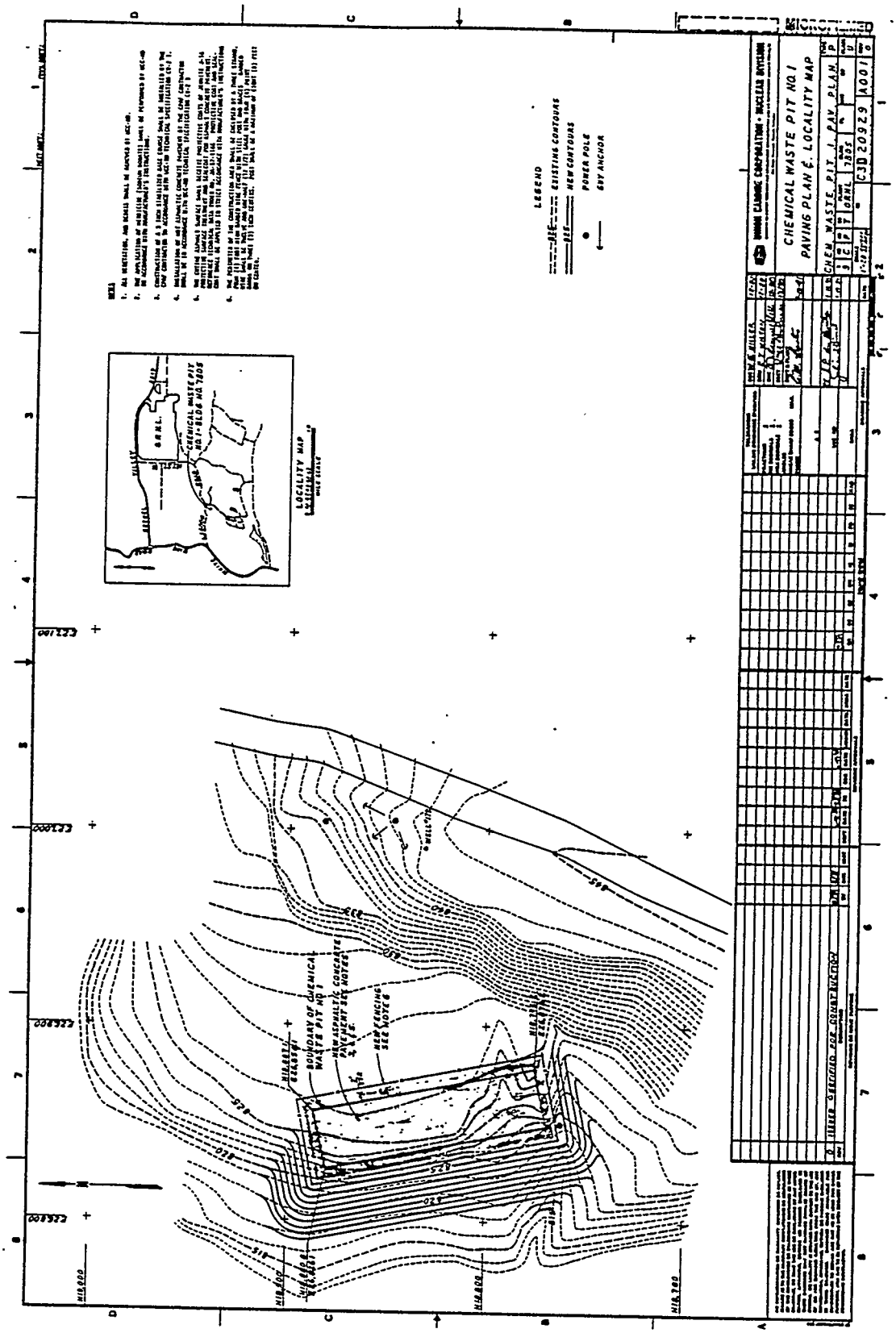
20932 21MAY70
Chemical Waste Pit 2, Asphalt cover, Grading Paving



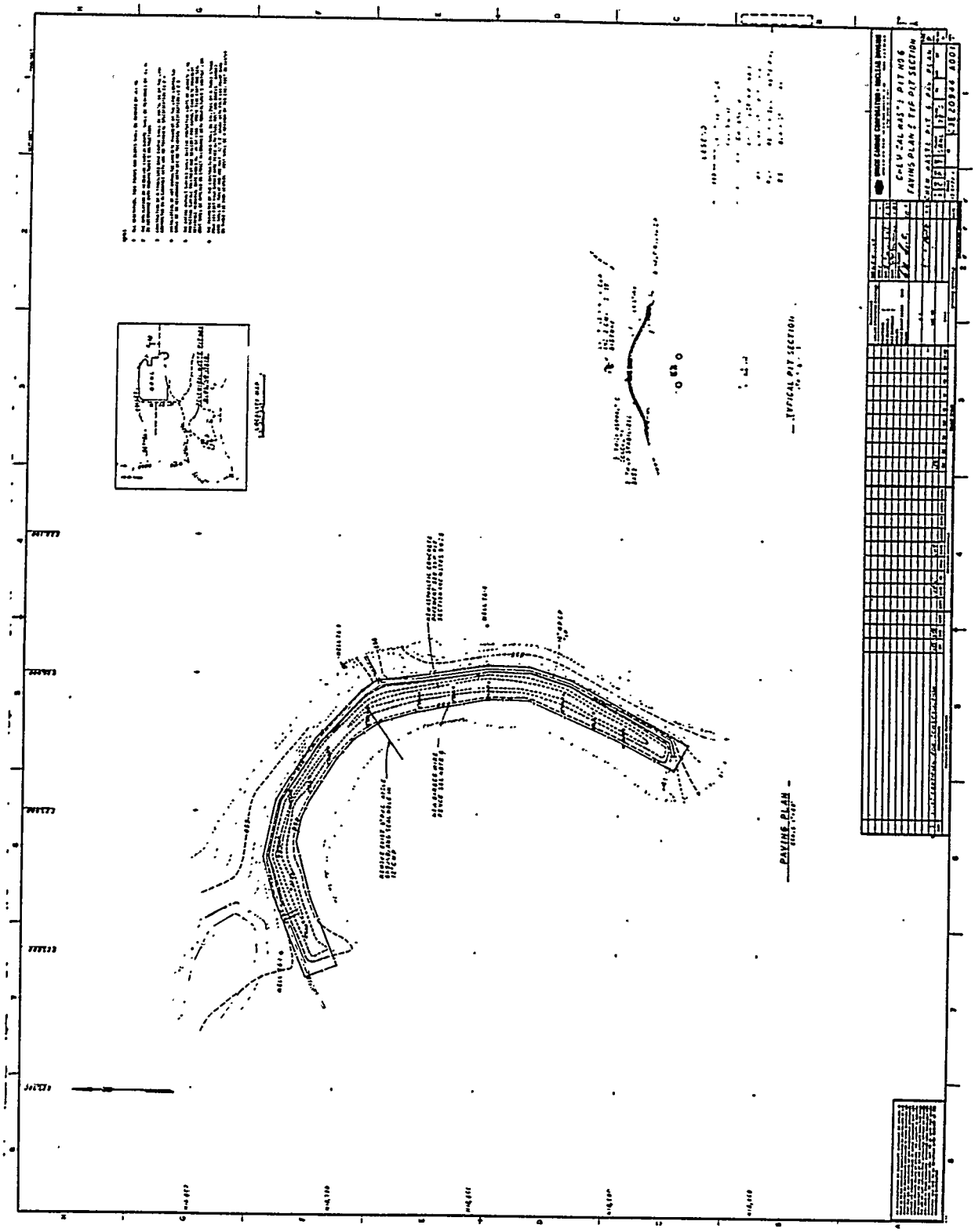
20935 21MAY70
Resurface Cover Chemical Pit 3,Paving Plan and Notes



20938 15OCT80
Chemical Waste Pit 4, Paving Plan and Site Location



20929 (3JAN81)
Waste Pit No. 1 Paving Plan and Locality Map



20944 13JAN81
Chemical Waste Pit 6, Paving Plan and Pit Section

Appendix E
ORNL Photographs Related to Seepage Pits and Trenches

12115 1954
Witkowski Pit 2 with truck 2-2-54

12116 1954
Witkowski Pit 2 with truck 2-2-54

12117 1954
Witkowski Intermediate-level waste transfer trailer 2-2-54

13395 1954
W. deLaguna Waste pit 3 Sideslope under construction 11-23-54

13396 1954
W. deLaguna Waste pit 3 floor under construction 11-23-54

13397 1954
W. deLaguna Waste pit 3 excavation 11-23-54

13398 1954
W. deLaguna Waste pit 3 excavation completed 11-23-54

13399 1954
W. deLaguna Waste pit 3 stratification exposure 11-23-54

13852 1955
Witkowski New pit 3 and old pit 2 looking southwest 3-4-55

13853 1955
Witkowski New pit 3 and old pit 2 looking southwest 3-4-55

13854 1955
Witkowski New pit 3 and old pit 2 looking northeast 3-4-55

13855 1955
Witkowski pits 2 and 3 looking southwest labeled 3-4-55

14841 1955
W. deLaguna Pit 3 7-15-55

14842 1955
W. deLaguna Pit3 7-15-55

14843 1955
W. deLaguna Observation well construction in pits area 7-15-55

14844 1955
W. deLaguna Pit 1 with its cover 7-15-55

15681 1955
W. deLaguna Solution cavity in core from Pit 4 area 11-7-55

16424 1956
W. deLaguna Evaporation pan in pits area 2-14-56

17481 1956
W. deLaguna drainage area east of pits at well 83 5-1-56

Appendix E
ORNL Photographs Related to Seepage Pits and Trenches

17482 1956
W. deLaguna groundwater seeps east of pit 3 5-1-56

17486 1956
K. Cowser Pit 3 looking northeast 5-2-56

17487 1956
K. Cowser Pit 3 5-2-56

17488 1956
K. Cowser Pits 2 and 3 evaporation apparatus 5-2-56

17489 1956
K. Cowser Pit 3 5-2-56

18474 1956
W. deLaguna Weir construction east of pits area 9-24-56

18475 1956
W. deLaguna Weir construction east of pits area 9-24-56

40690 1957
F. L. Parker well logging equipment for pits area 6-6-57

40691 1957
F. L. Parker roadcut in drainage of pits area 6-6-57

40692 1957
F. L. Parker roadcut in drainage of pits area 6-6-57

40693 1957
F. L. Parker Pit well logging equipment 6-6-57

40694 1957
F. L. Parker Pit well logging equipment 6-6-57

15647 1958
W. deLaguna Construction on south end of east side of Pit 4

15648 1958
W. deLaguna Construction outcrop Pit 4-northern east side

15649 1958
W. deLaguna Construction outcrop Pit 4-southern west side

15650 1958
W. deLaguna Construction outcrop Pit 4-northern east side

15651 1958
W. deLaguna Construction outcrop Pit 4-northwest corner

15652 1958
W. deLaguna Construction outcrop Pit 4-western side

15653 1958
W. deLaguna Construction outcrop Pit 4-southern west side

Appendix E
ORNL Photographs Related to Seepage Pits and Trenches

15654 1958
W. deLaguna Construction outcrop Pit 4-southern east side

15895 1958
W. deLaguna Helicopter photographs of pits looking north-labeled

15898 1958
W. deLaguna Helicopter photographs of pits looking east-labeled

15900 1958
W. deLaguna Helicopter photographs of pits looking southwest

15901 1958
W. deLaguna Helicopter photographs of pits looking northwest

15903 1958
W. deLaguna Helicopter shots of White Oak Lake and SWSA6 site

15904 1958
W. deLaguna White Oak Creek discharging to Clinch River

15911 1958
W. deLaguna White Oak Creek discharge to Clinch River

49011 1960
H. Wyrick Pit 4 eastern seep interceptor trench 1-28-60

49012 1960
H. Wyrick Pit 4 eastern seep interceptor trench 1-28-60

49013 1960
H. Wyrick Pit 4 site groundwater seep 1-28-60

49219 1960
W. deLaguna construction trench 5 3-10-60

49220 1960
W. deLaguna construction trench 5 3-10-60

49221 1960
W. deLaguna construction trench 5 3-10-60

57395 1962
W. deLaguna well northeast of pit 3 5-18-62

57396 1962
W. deLaguna Pit 3 area 5-18-62

57397 1962
W. deLaguna Pit 3 area 5-18-62

57398 1962
W. deLaguna Pit 3 area 5-18-62

57399 1962
W. deLaguna Pit 3 area 5-18-62

Appendix E
ORNL Photographs Related to Seepage Pits and Trenches

58370 1962
W. deLaguna Trench 7 construction 8-10-62

58371 1962
W. deLaguna Trench 7 construction 8-10-62

58372 1962
W. deLaguna Trench 7 construction 8-10-62

58373 1962
W. deLaguna Pit 3 backfilled looking southwest 8-10-62

58412 1962
W. deLaguna construction activity trench 7 8-15-62

58413 1962
W. deLaguna construction activity trench 7 8-15-62

58414 1962
W. deLaguna Construction activity Trench 7 8-15-62

58415 1962
W. deLaguna Construction activity Trench 7 8-15-62

58416 1962
W. deLaguna Construction activity Trench 7 8-15-62

58417 1962
W. deLaguna Construction activity Trench 7 8-15-62

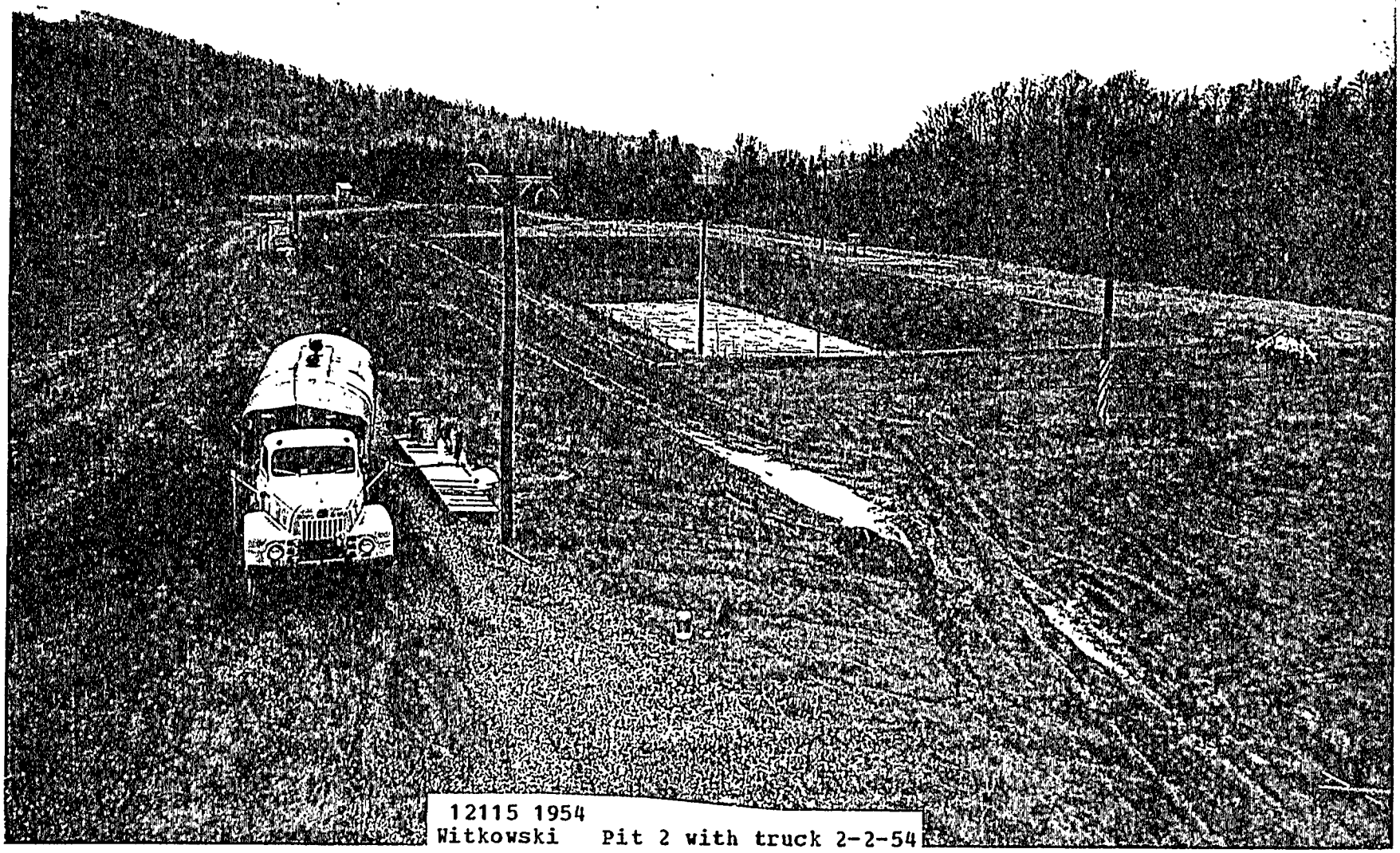
58418 1962
W. deLaguna construction activity trench 7 8-15-62

58419 1962
W. deLaguna construction activity trench 7 8-15-62

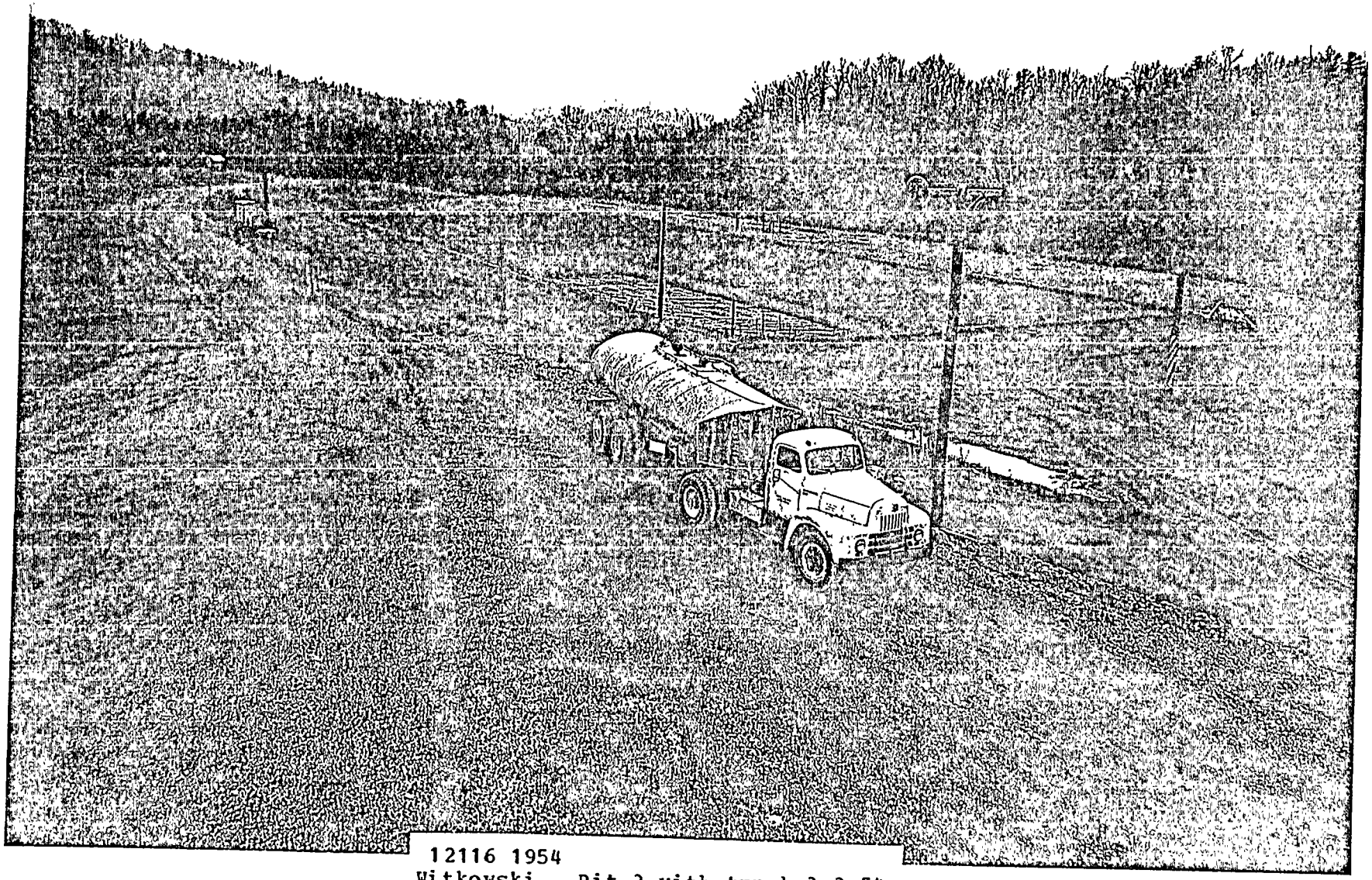
58420 1962
W. deLaguna construction activity trench 7 8-15-62

58421 1962
W. deLaguna construction activity trench 7 8-15-62

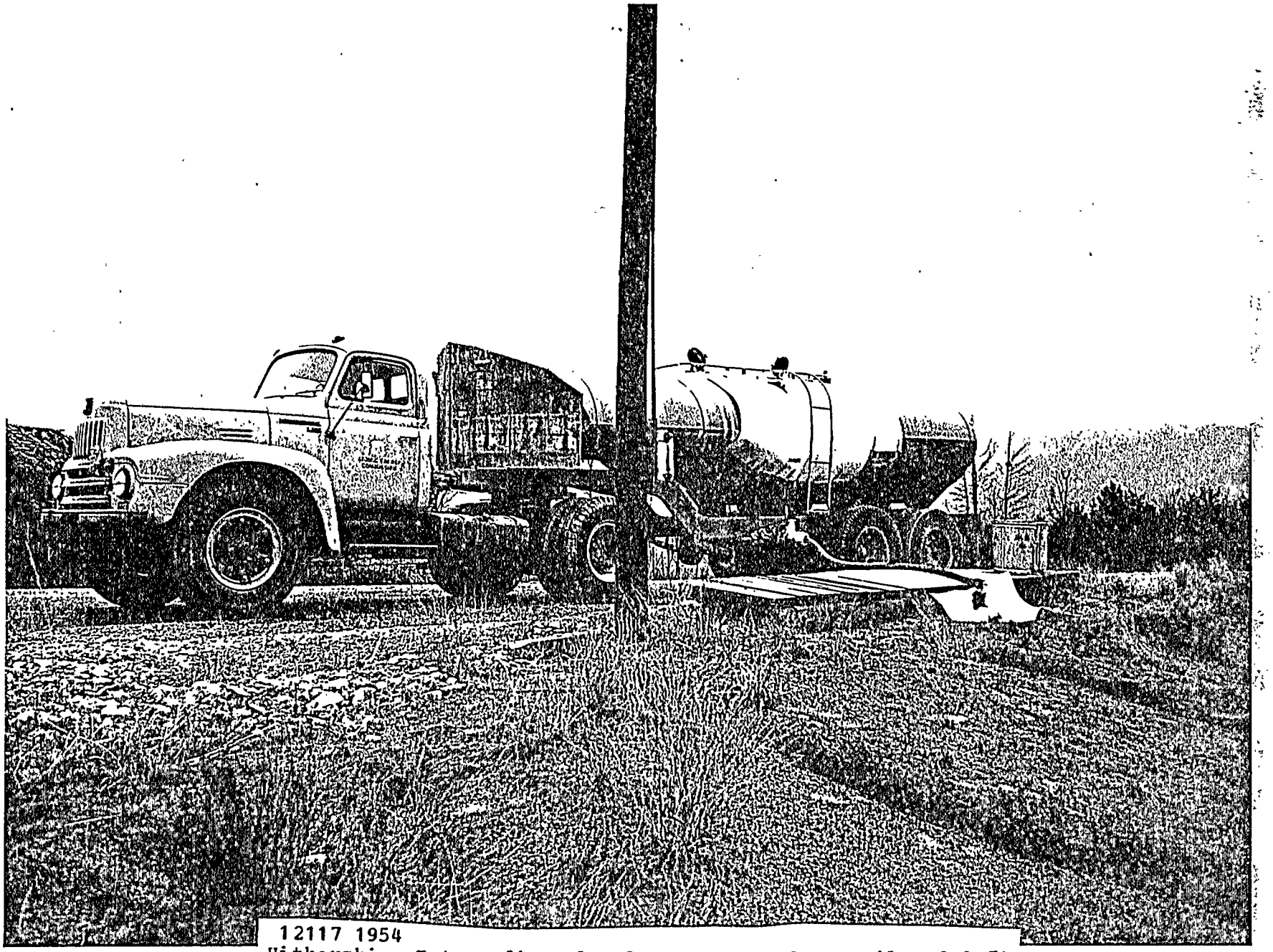
58886 1962
Auerbach Vegetation sampling at Trench 5



12115 1954
Witkowski Pit 2 with truck 2-2-54

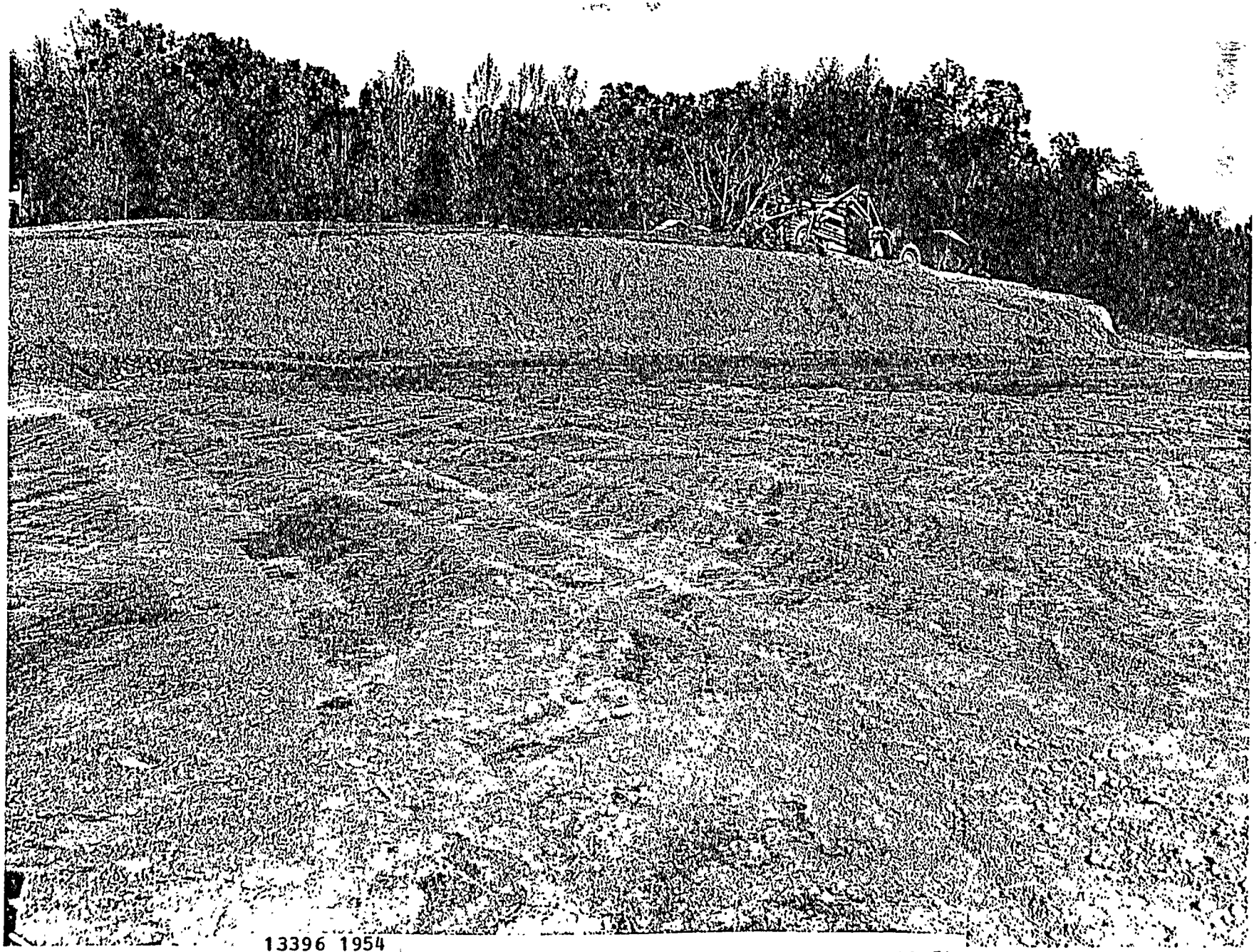


12116 1954
Witkowski Pit 2 with truck 2-2-54

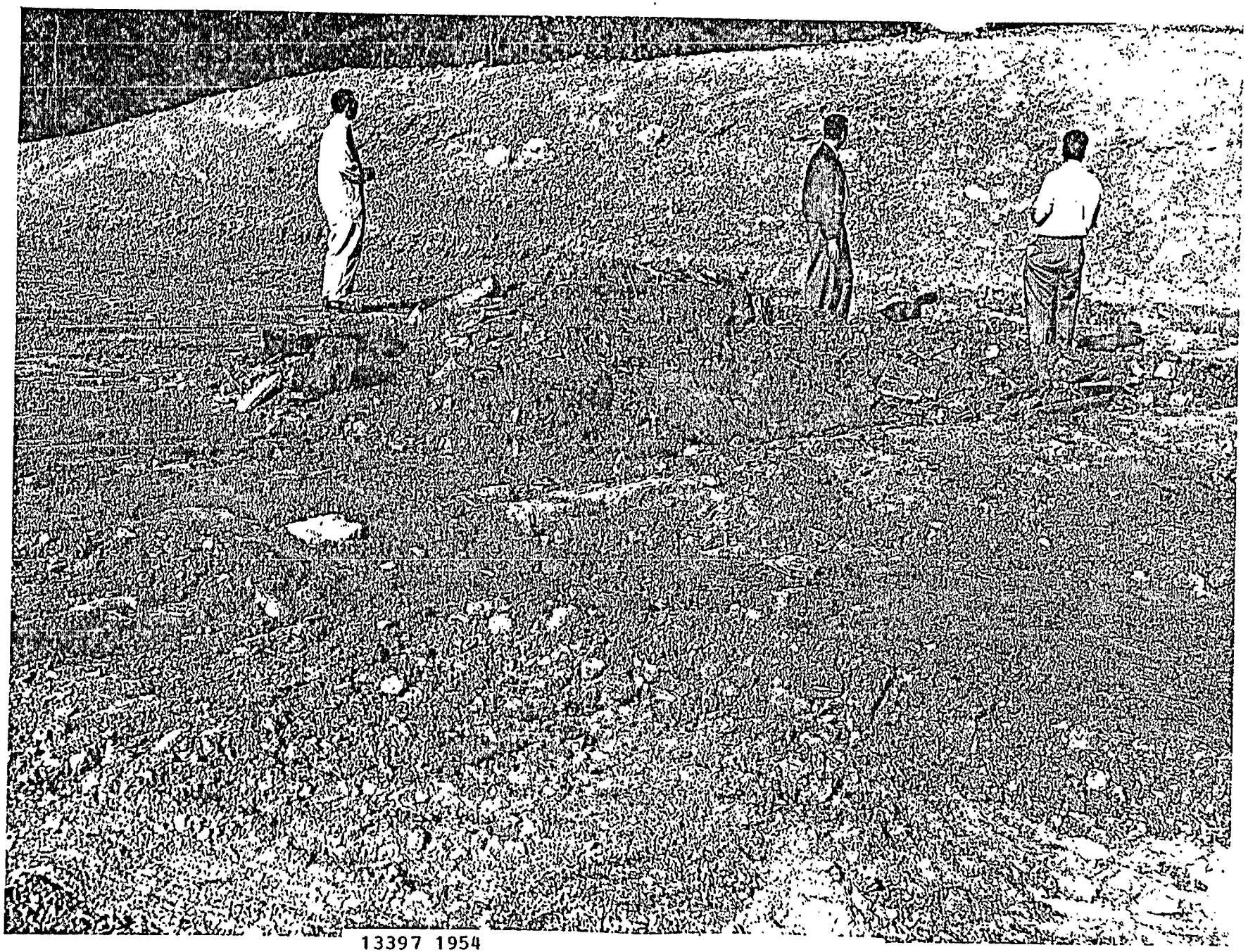


12117 1954
Witkowski Intermediate-level waste transfer trailer 2-2-54

13395 1954
W. deLaguna Waste pit 3 Sideslope under construction 11-23-54

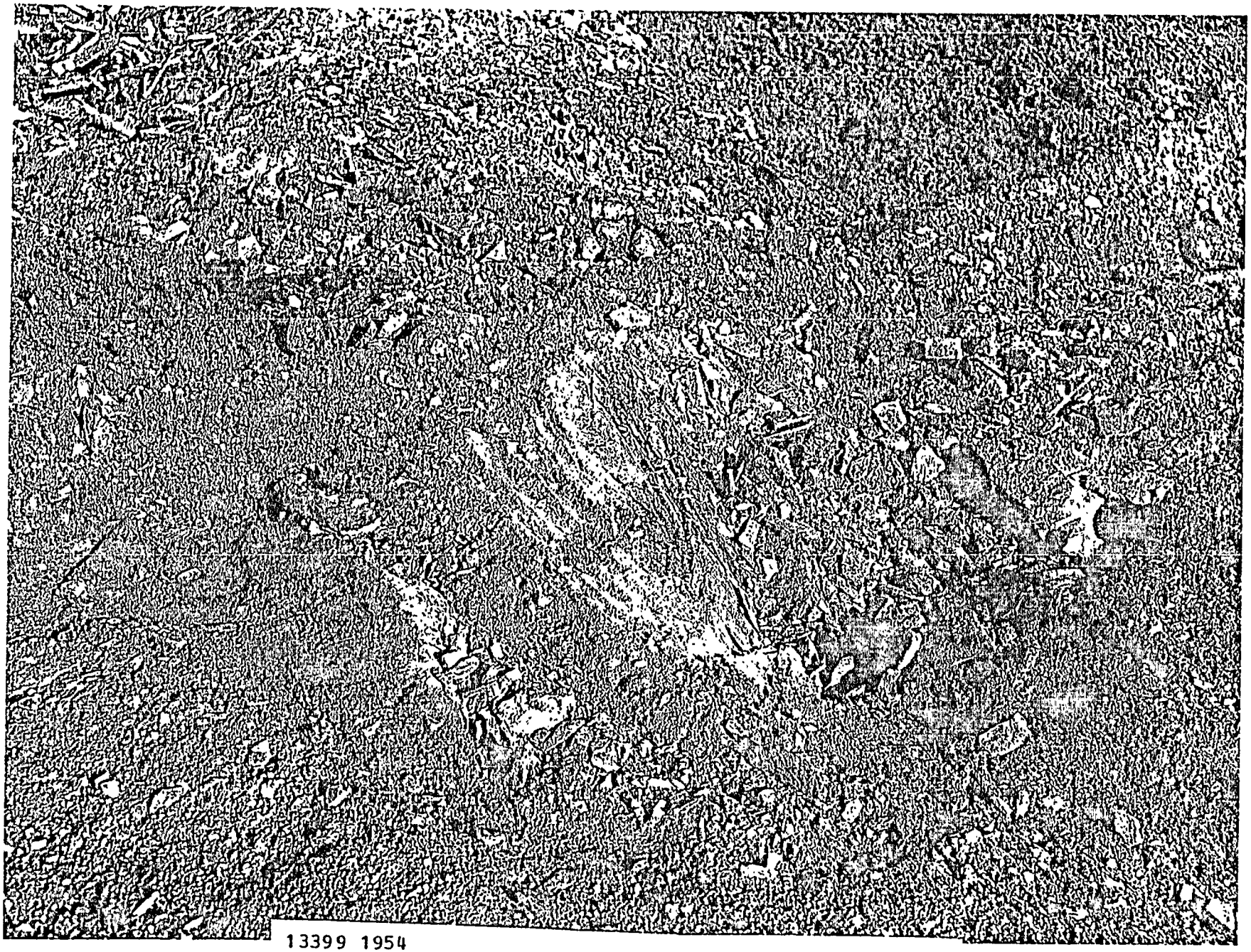


13396 1954
W. deLaguna Waste pit 3 floor under construction 11-23-54

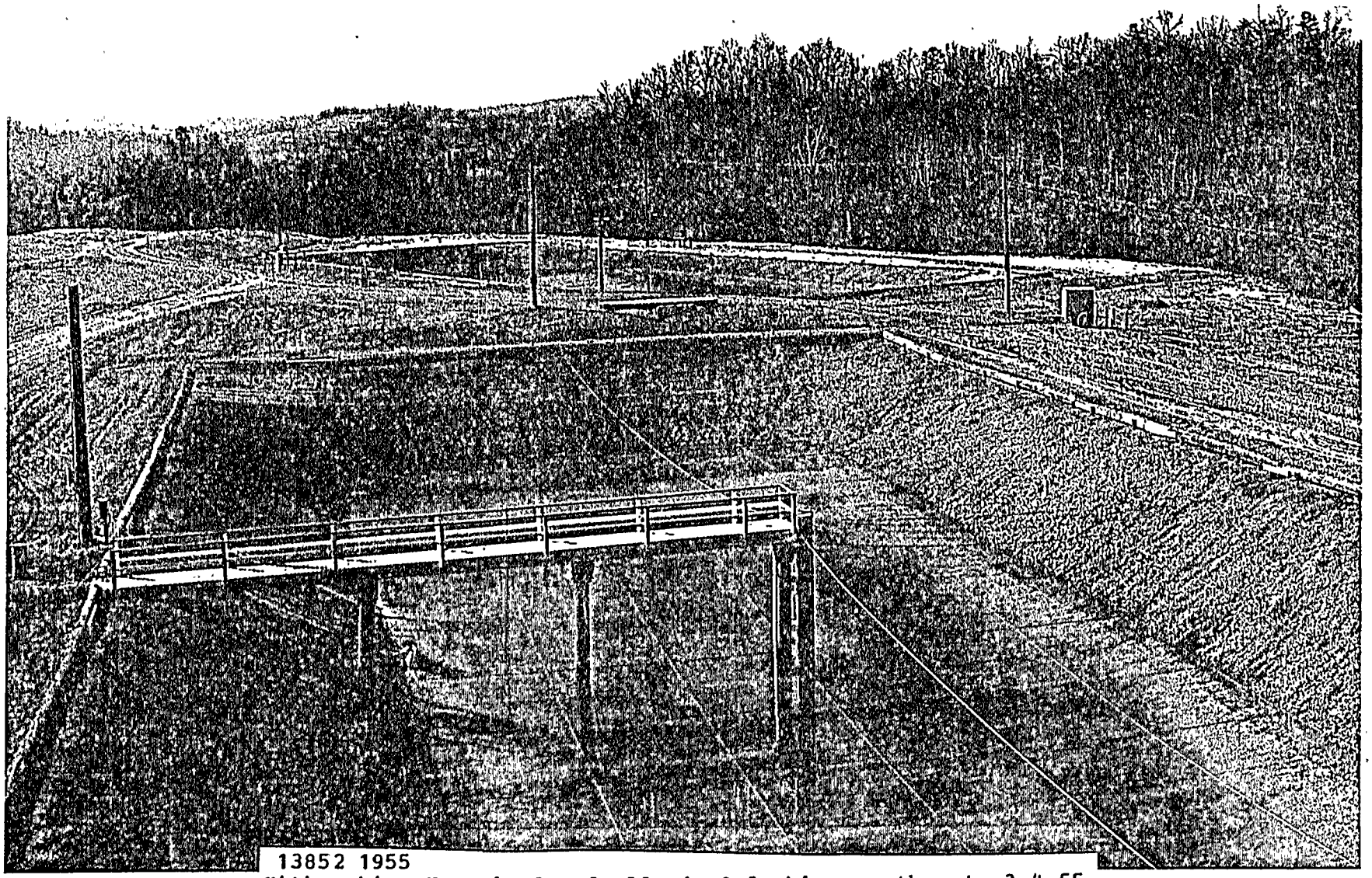


13397 1954
W. deLaguna Waste pit 3 excavation 11-23-54

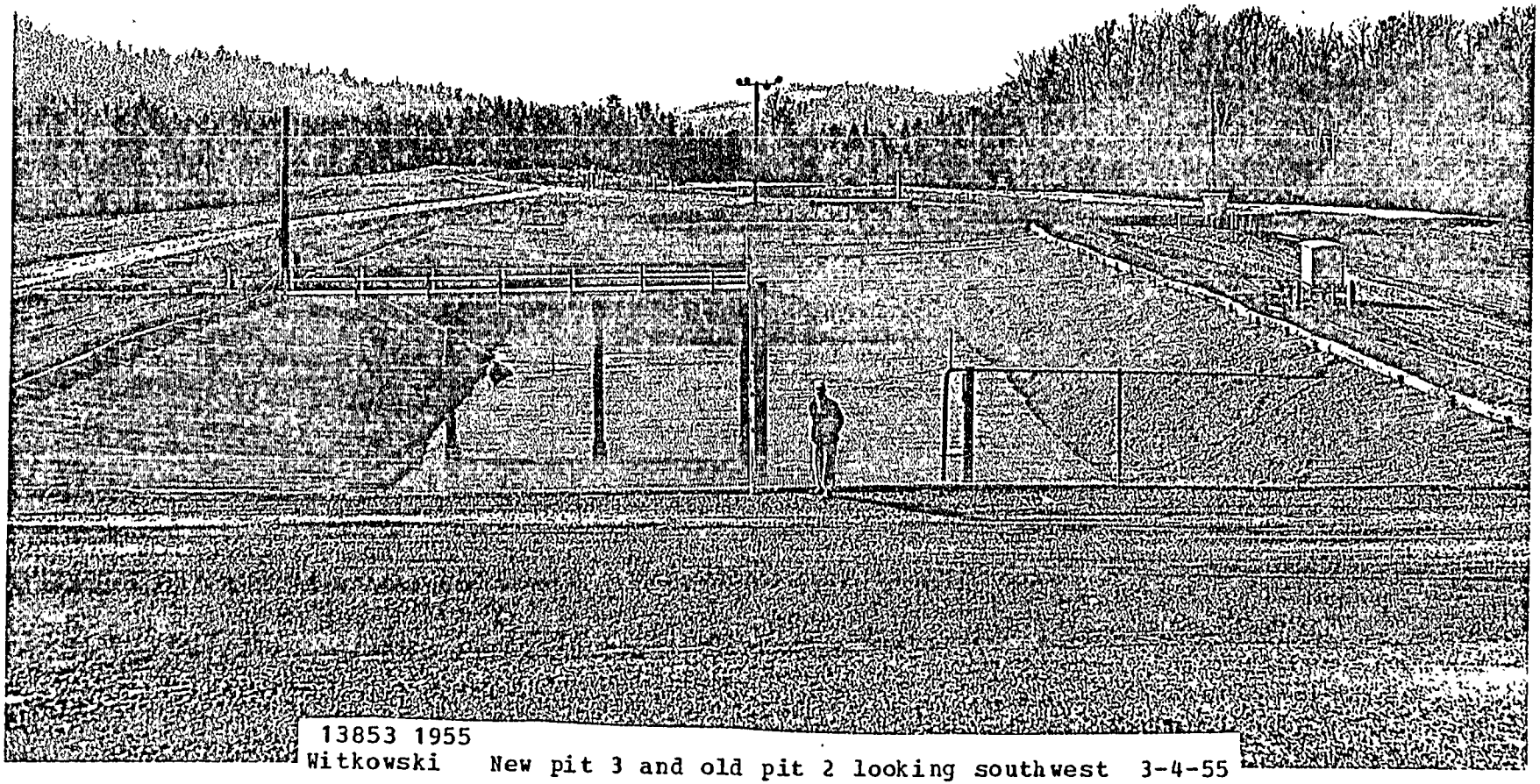
13398 1954
W. deLaguna Waste pit 3 excavation completed 11-23-54



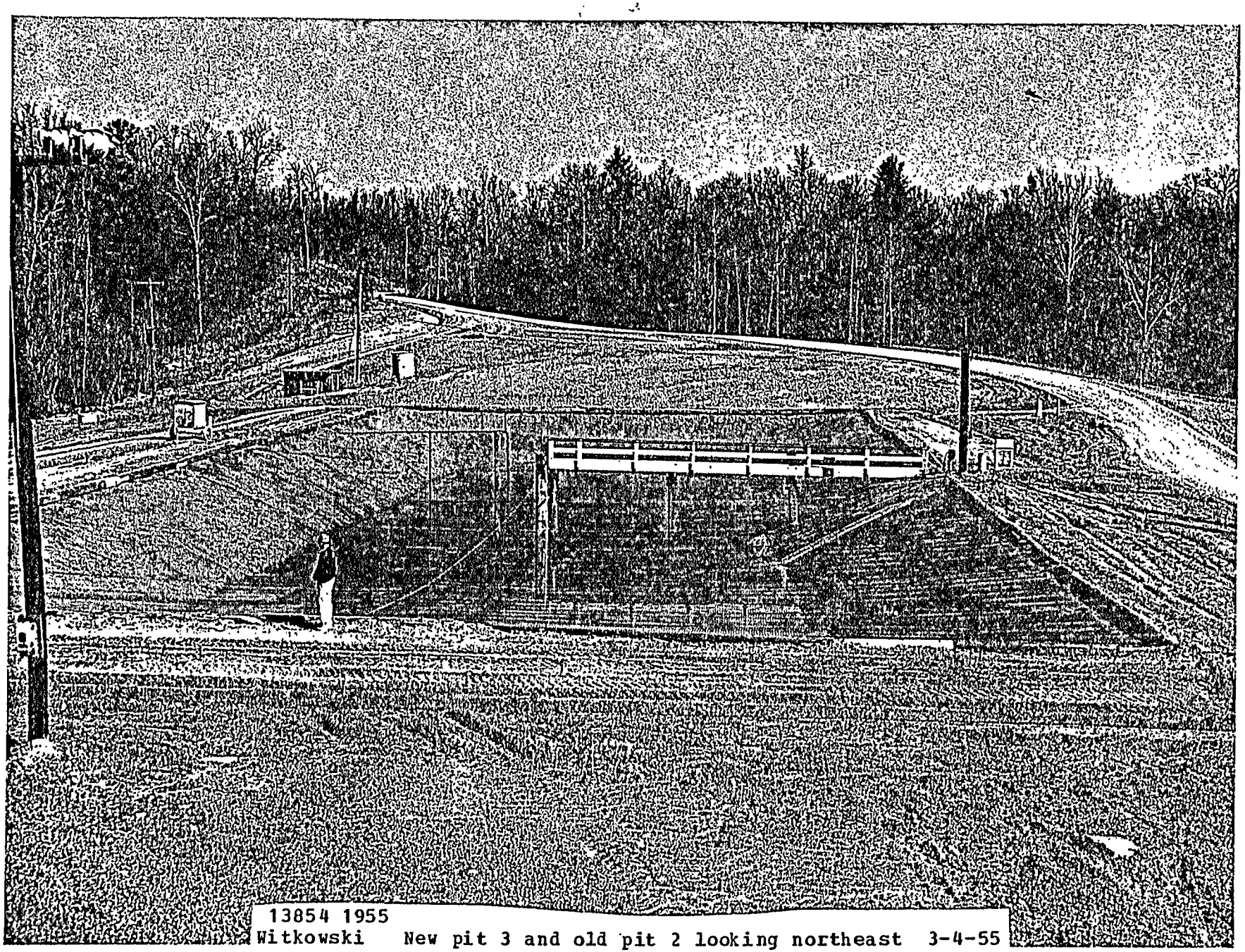
13399 1954
W. deLaguna Waste pit 3 stratification exposure 11-23-54



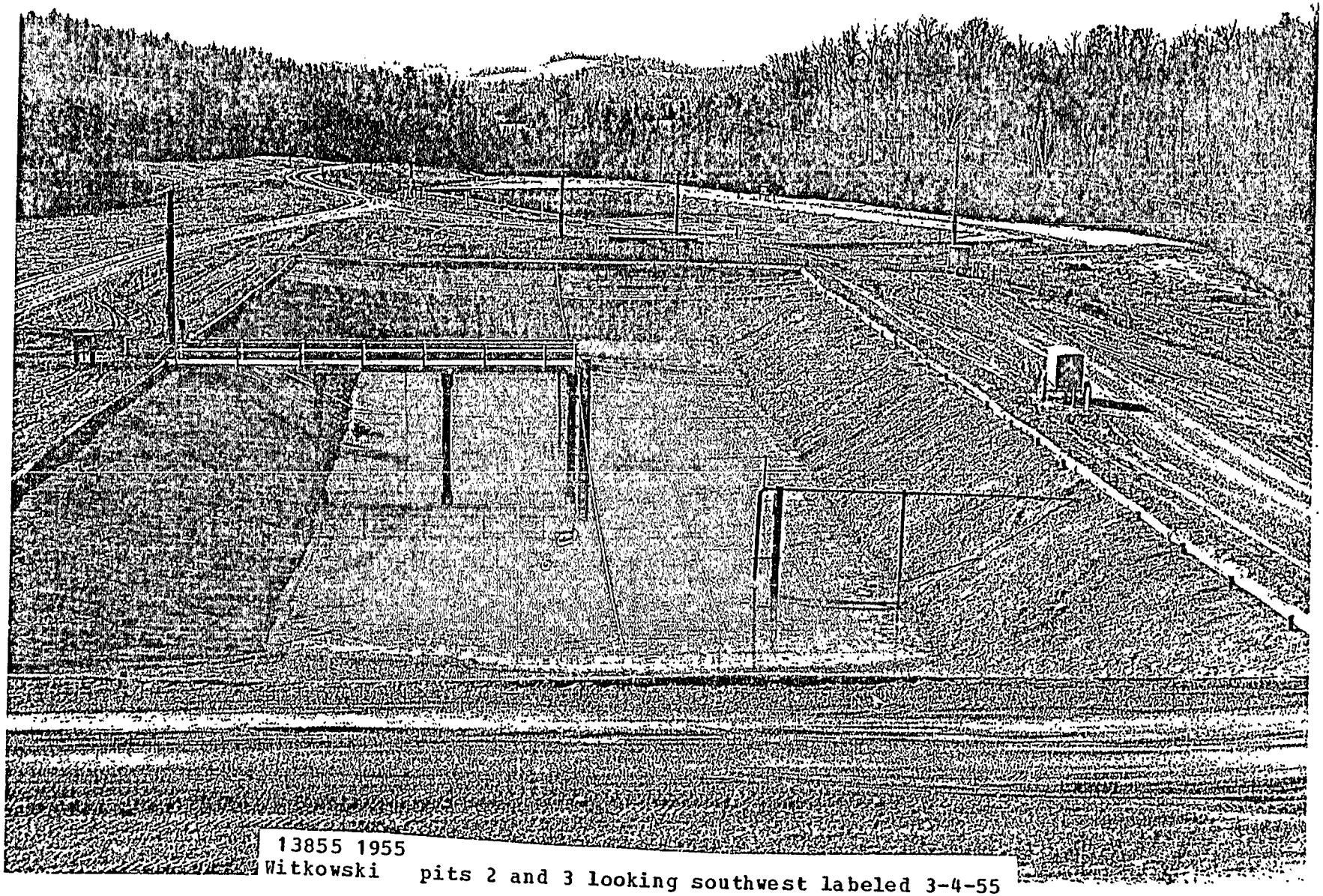
13852 1955
Witkowski New pit 3 and old pit 2 looking southwest 3-4-55



13853 1955
Witkowski New pit 3 and old pit 2 looking southwest 3-4-55



13854 1955
Witkowski New pit 3 and old pit 2 looking northeast 3-4-55



13855 1955
Witkowski pits 2 and 3 looking southwest labeled 3-4-55

PHOTO 13855

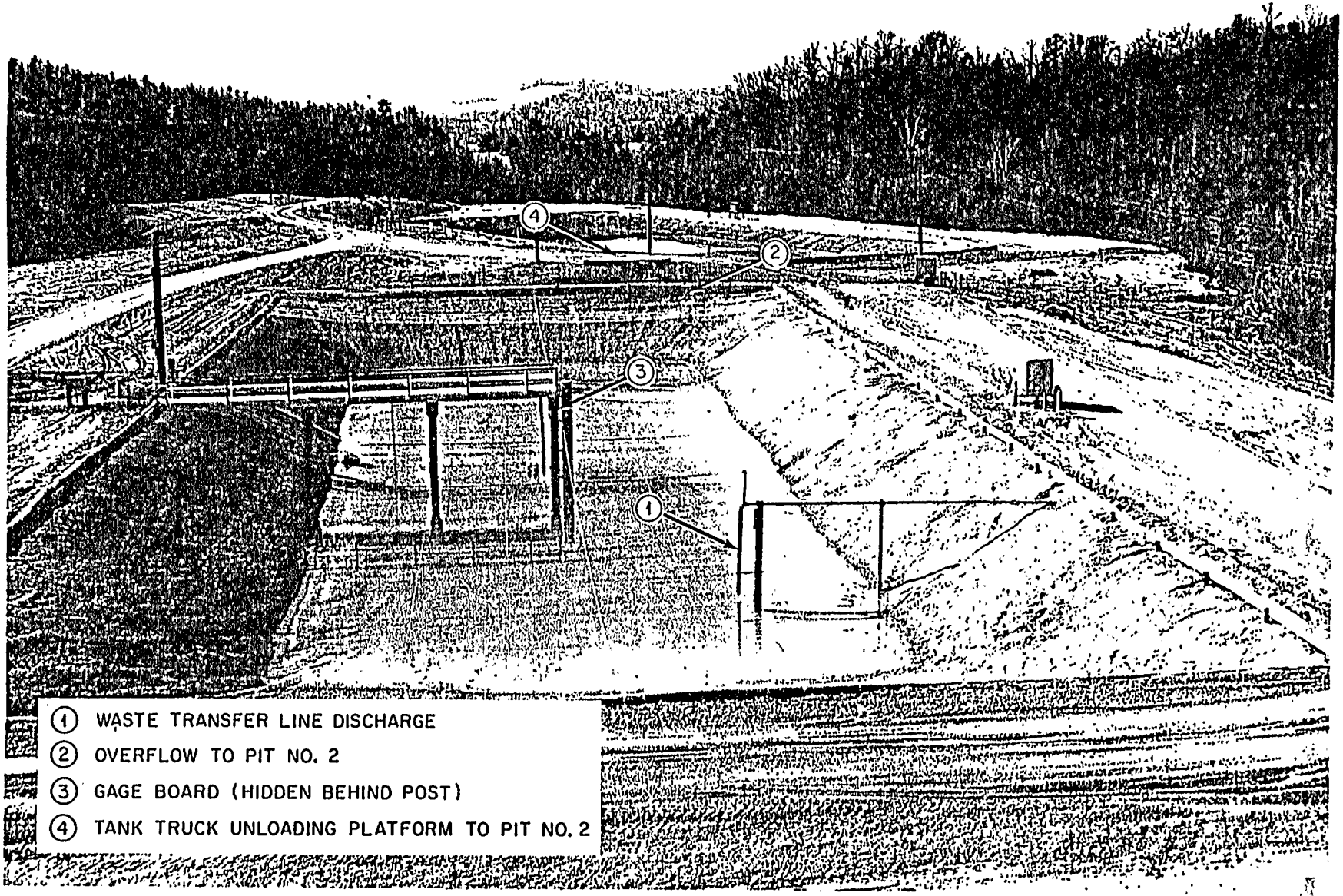
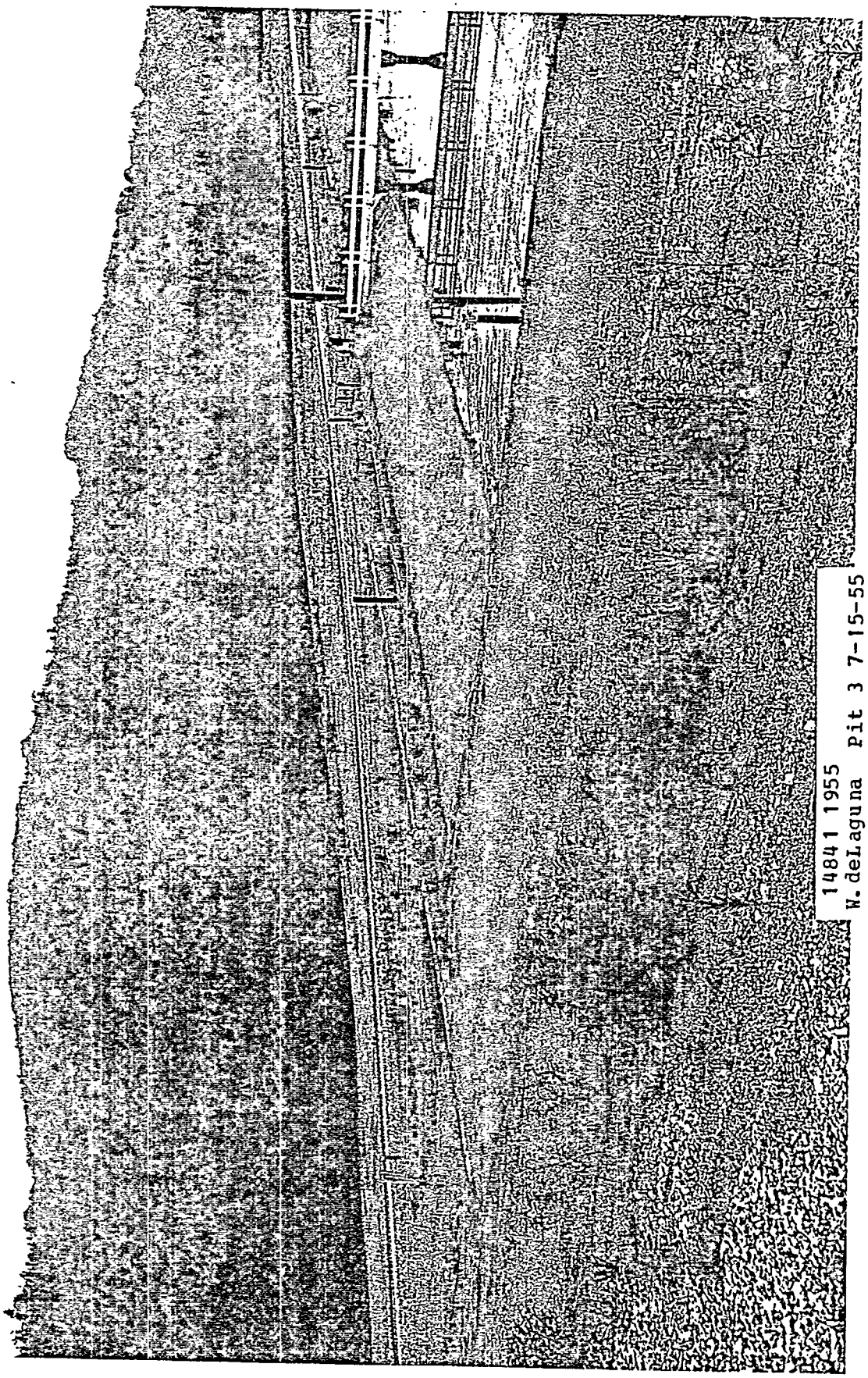
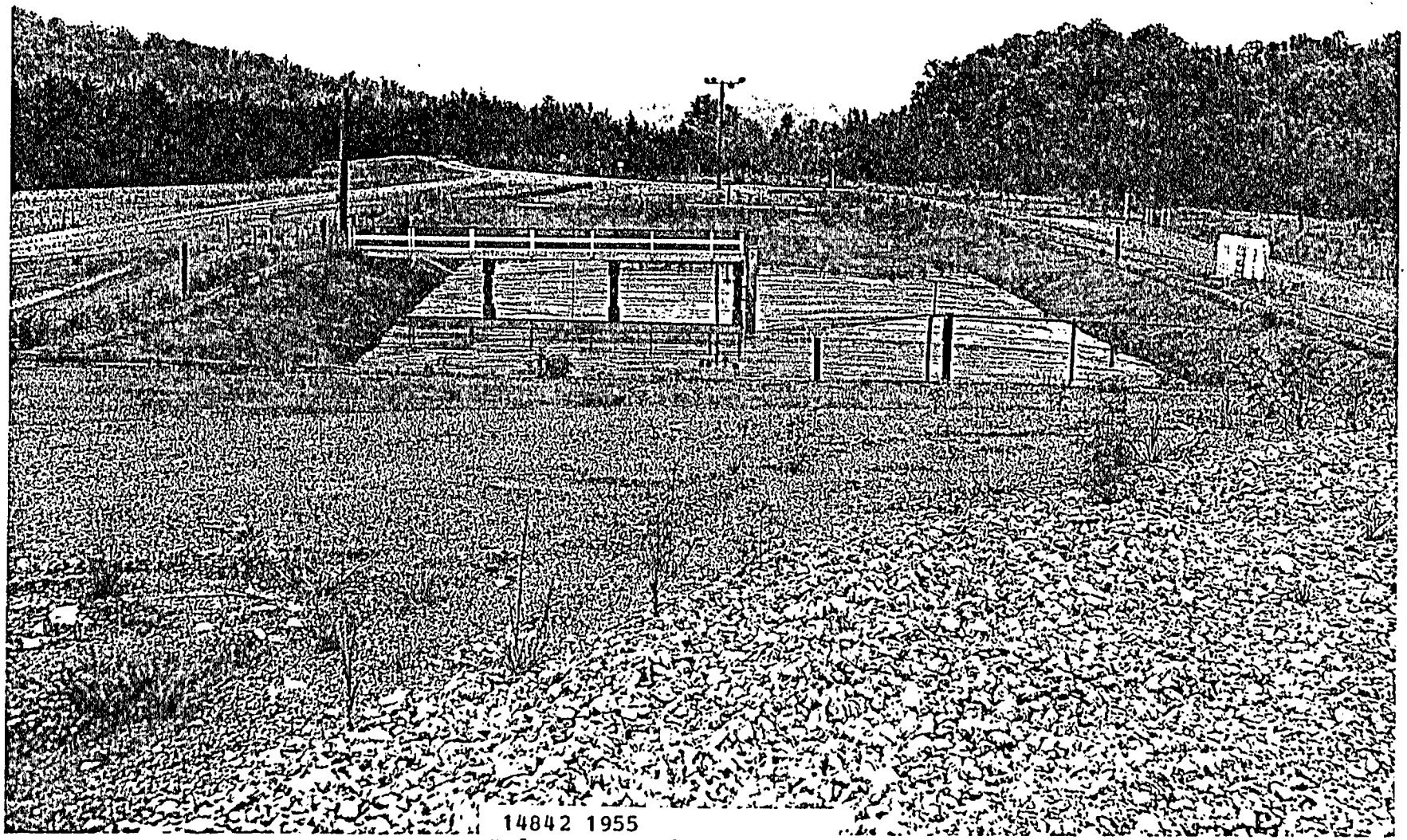


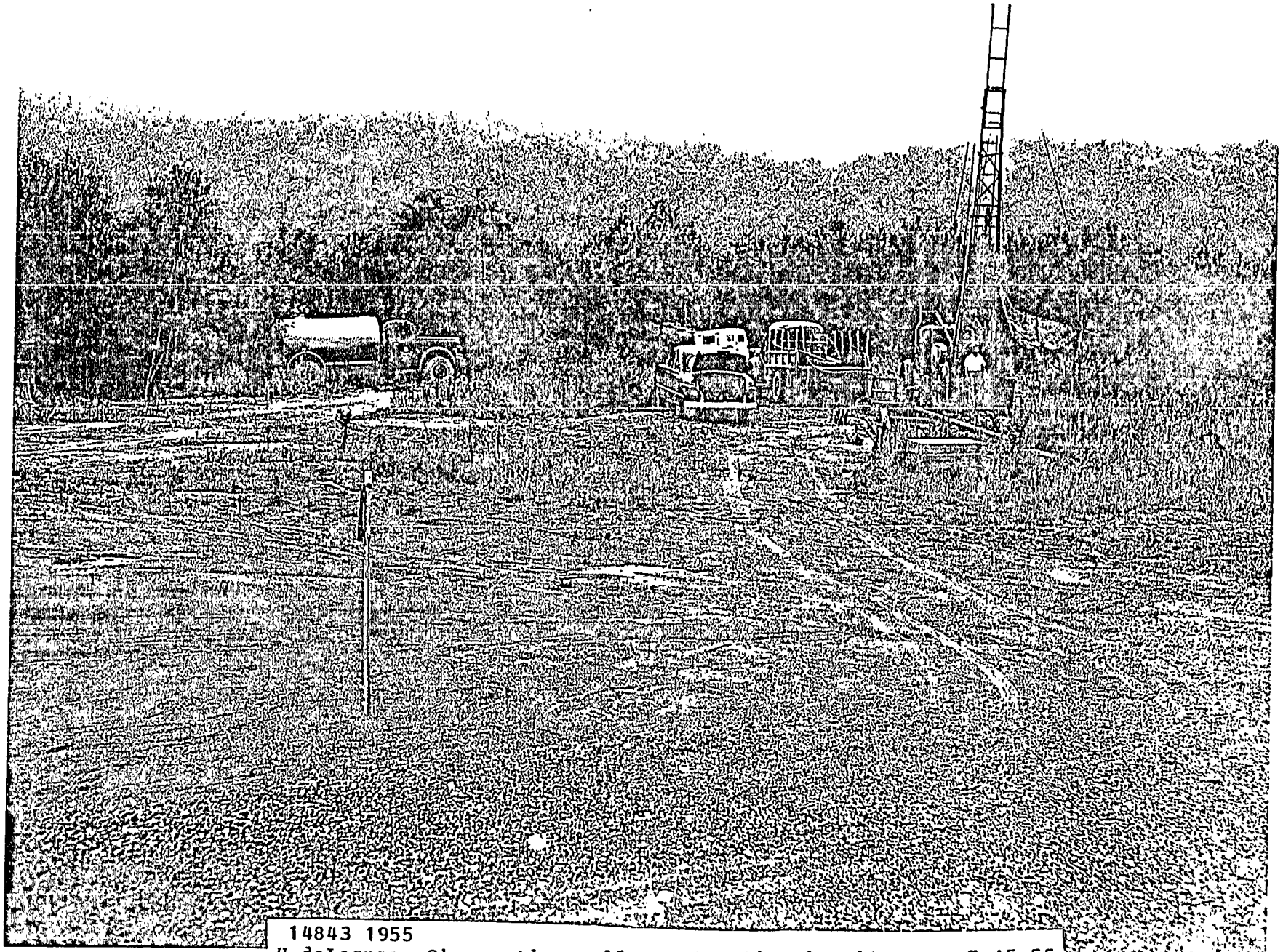
Fig. 2. Waste Disposal Pits Nos. 1 and 2, Facing West (No. 1 in Foreground, No. 2 in Background).

13855 1955
Witkowski pits 2 and 3 looking southwest labeled 3-4-55

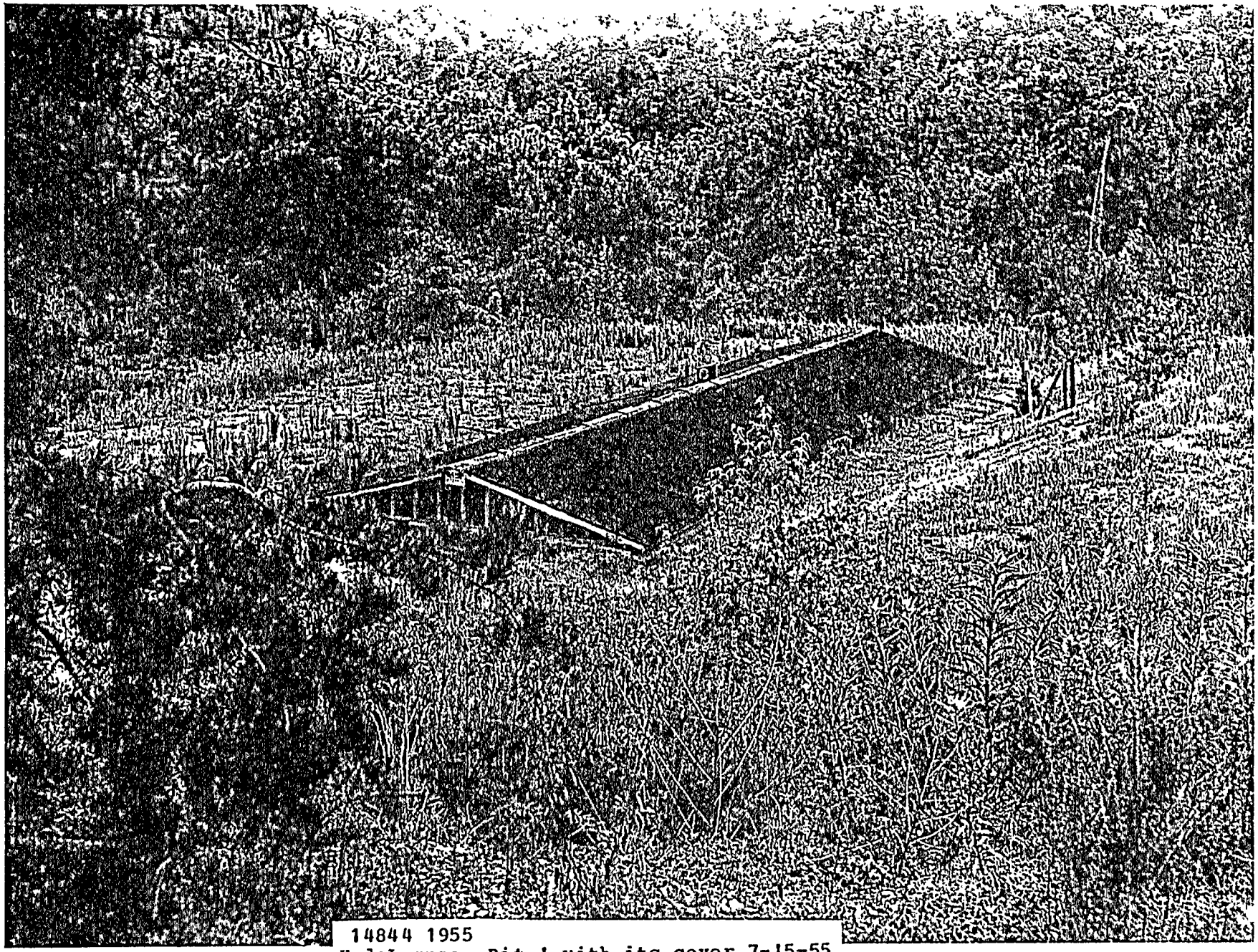

14841 1955
W. deLaguna Pit 3 7-15-55



14842 1955
W.deLaguna Pit3 7-15-55



14843 1955
W. deLaguna Observation well construction in pits area 7-15-55



14844 1955
W. deLaguna Pit 1 with its cover 7-15-55

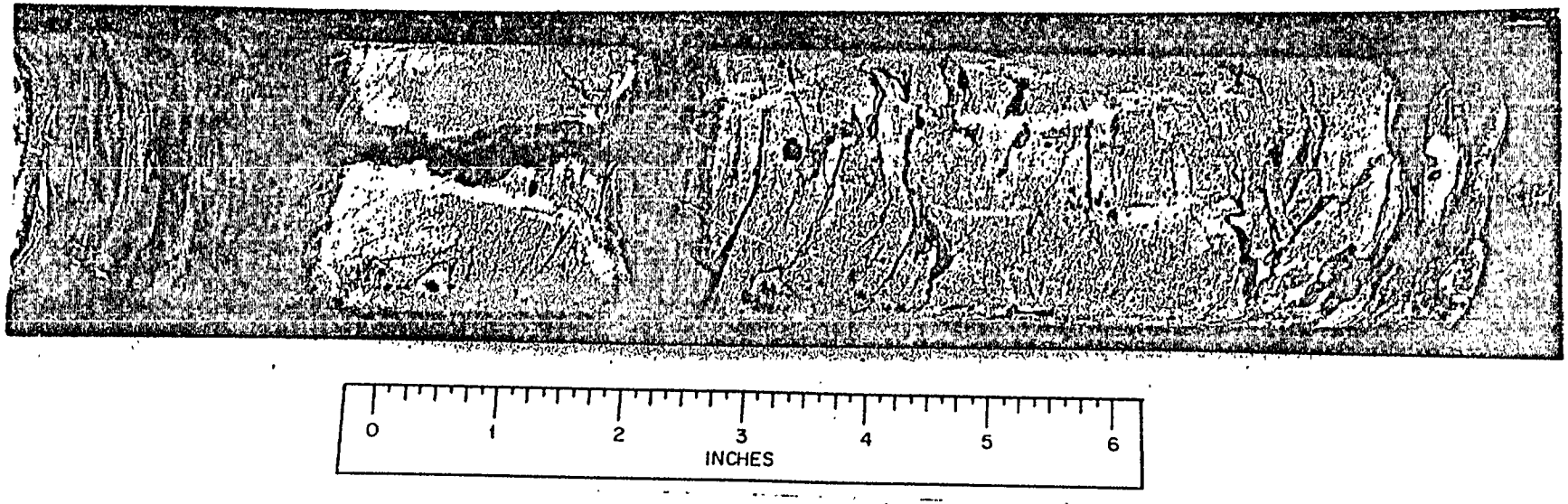
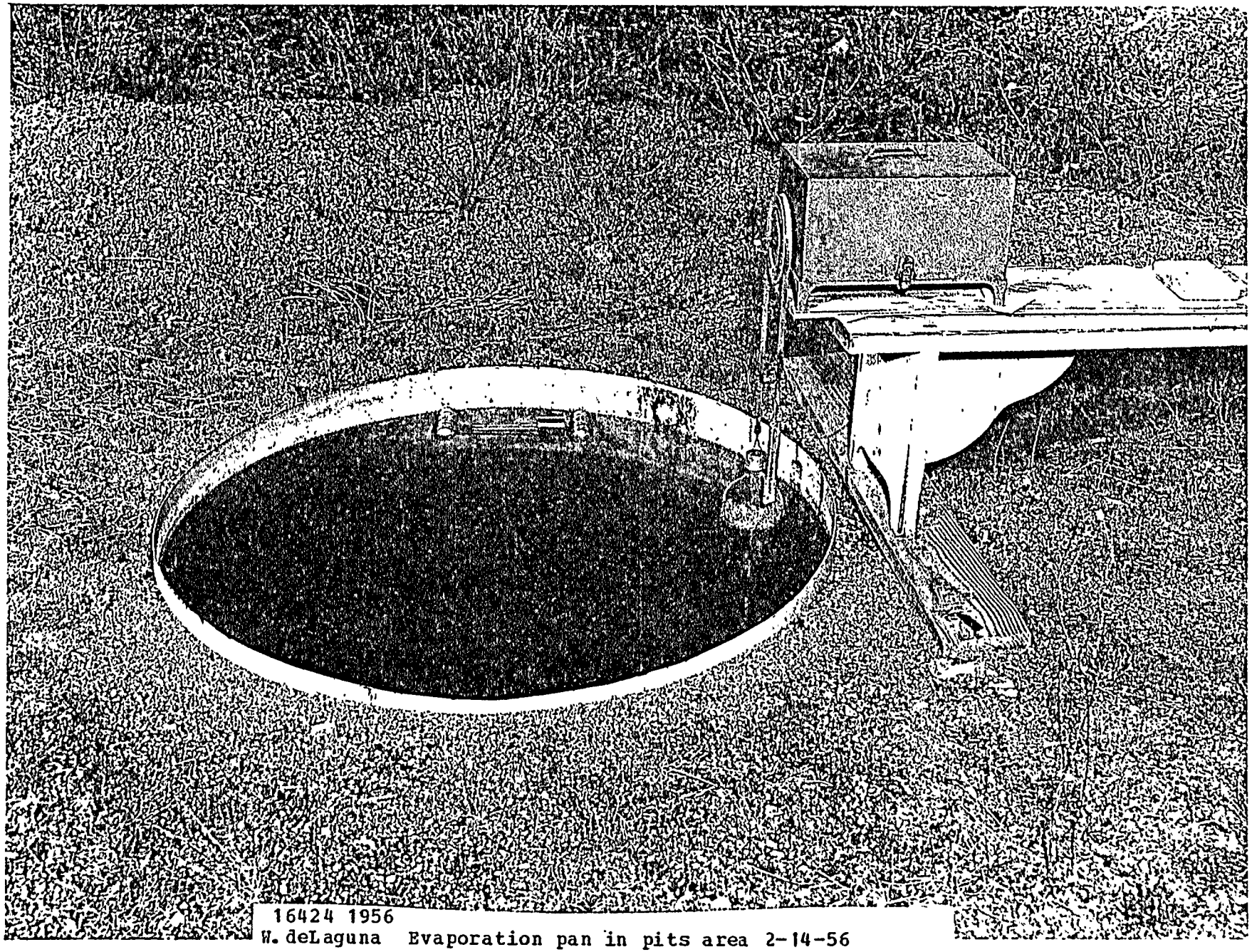
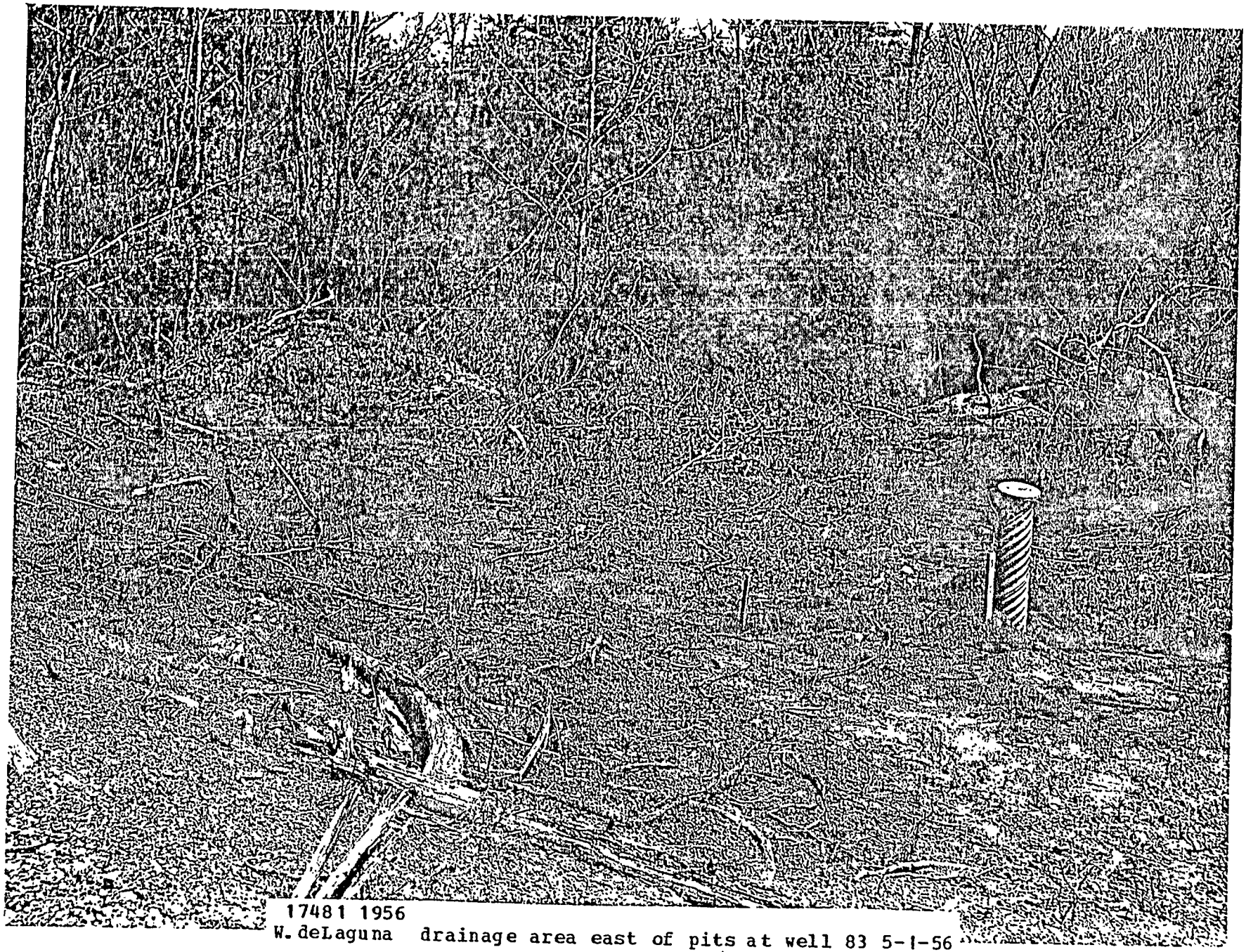


FIG. 2 SOLUTIONALLY ENLARGED FRACTURE IN LIMESTONE OF THE CONASAUGA GROUP

15681 1955
W. deLaguna Solution cavity in core from Pit 4 area 11-7-55

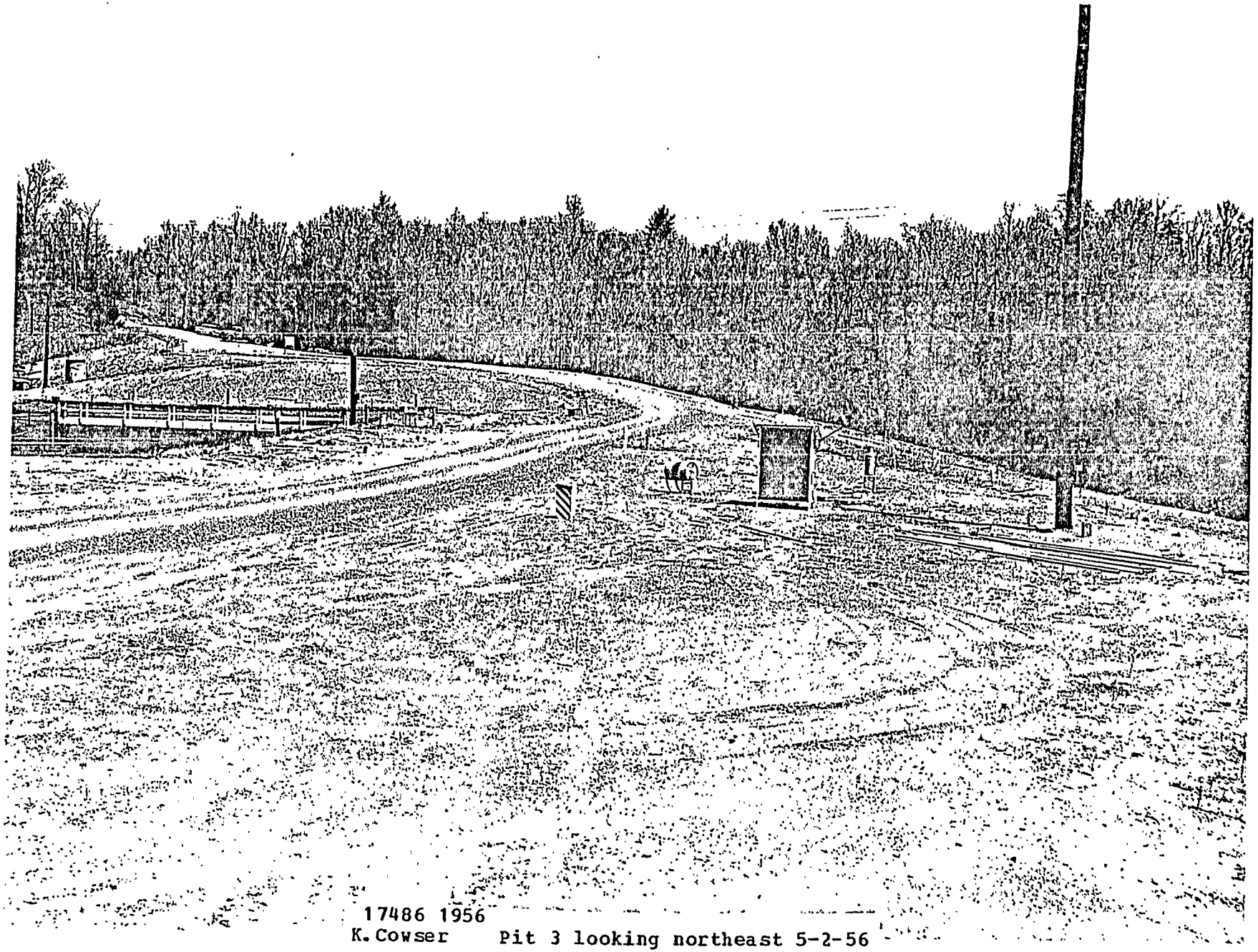


16424 1956
W. deLaguna Evaporation pan in pits area 2-14-56

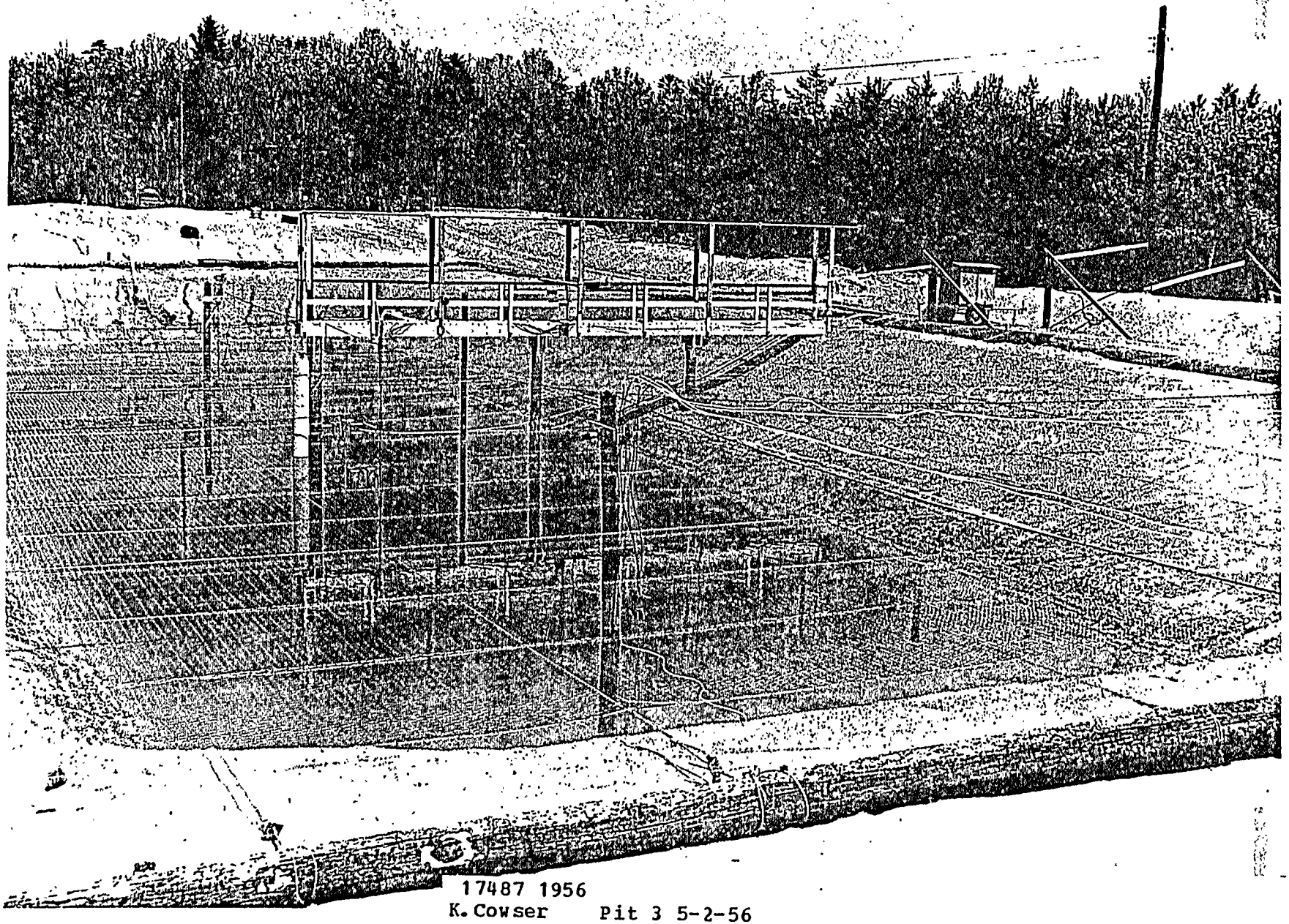


17481 1956
W. deLaguna drainage area east of pits at well 83 5-1-56

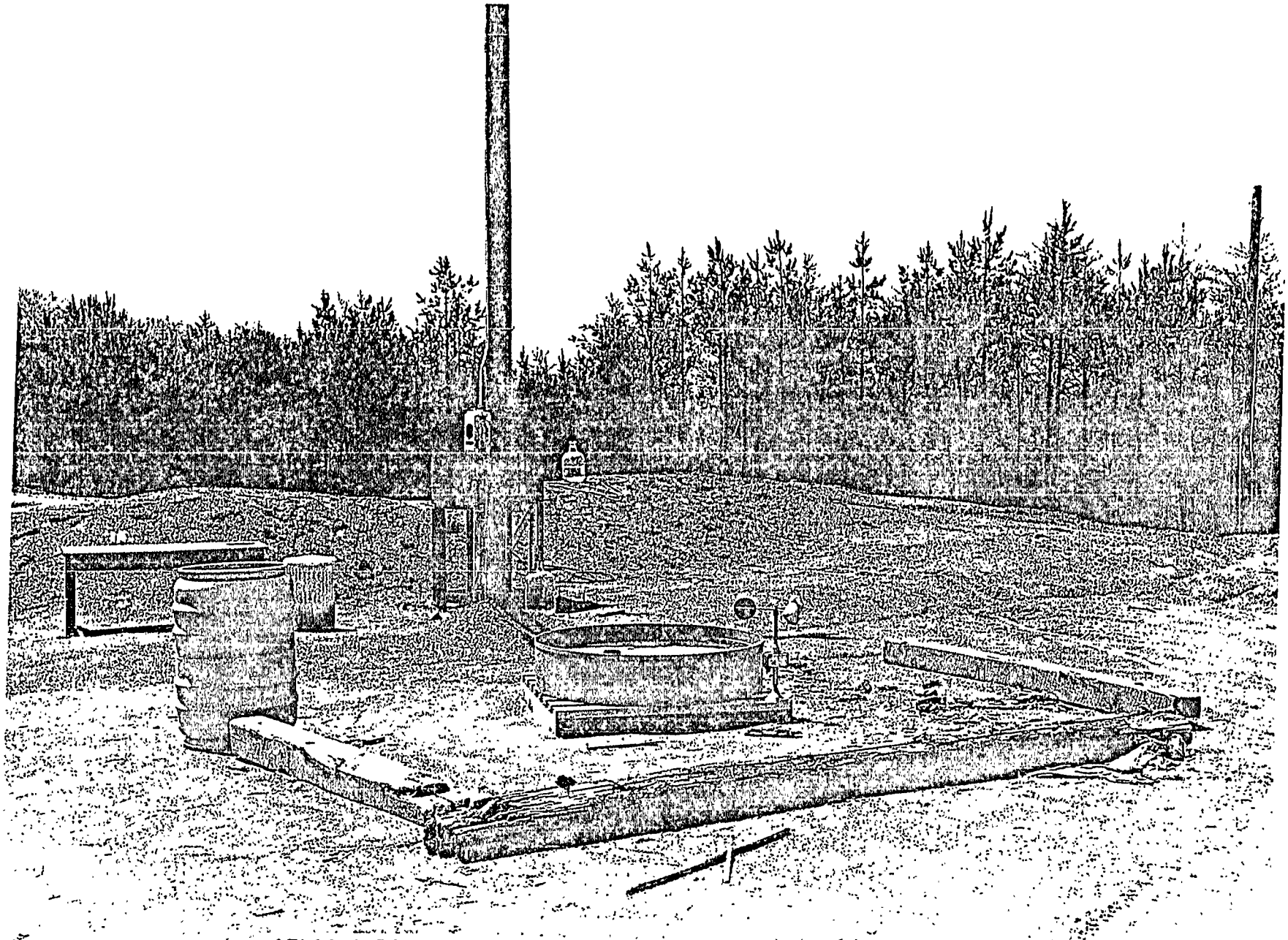
17482 1956
W. deLaguna groundwater seeps east of pit 3 5-1-56



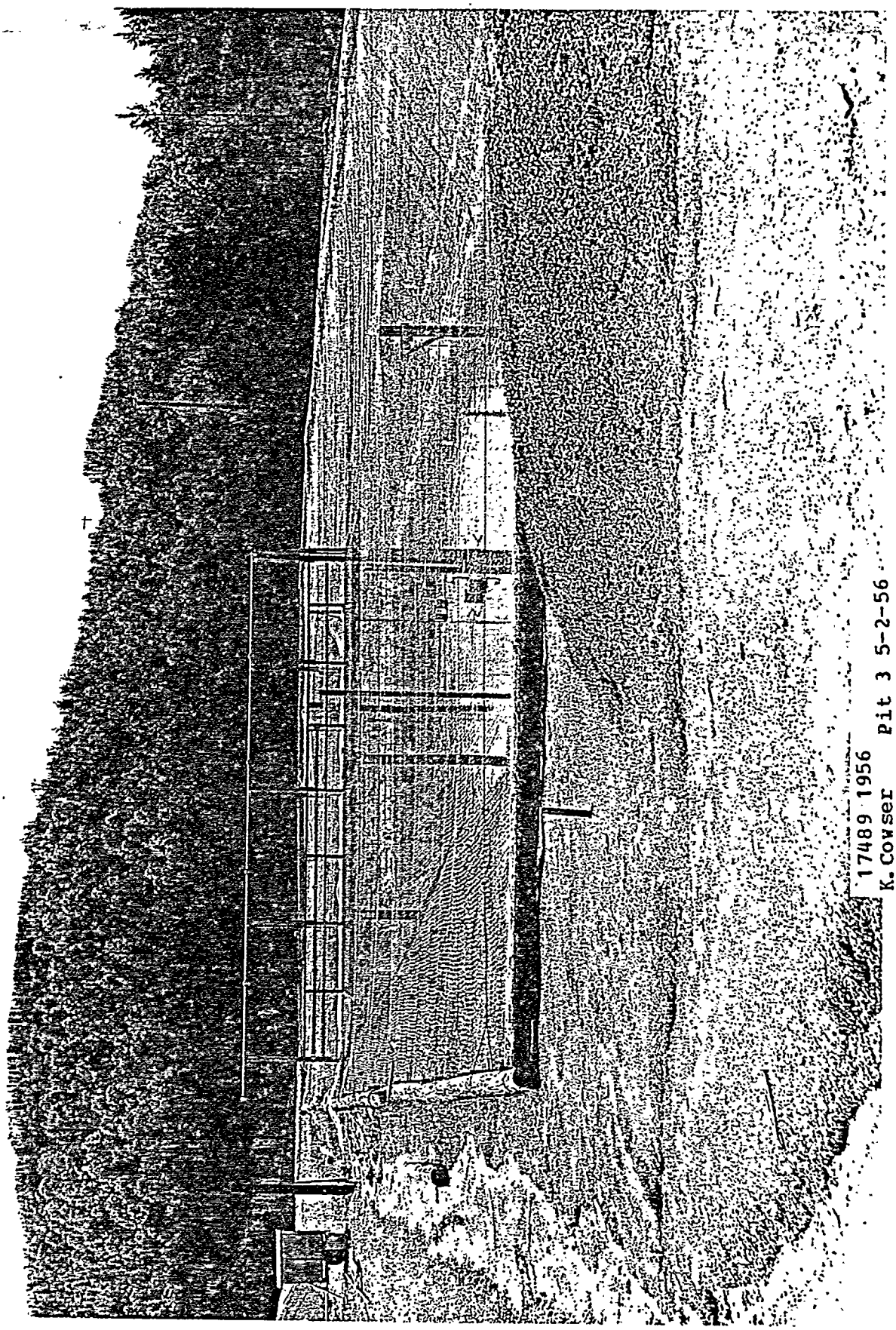
17486 1956
K. Cowser Pit 3 looking northeast 5-2-56



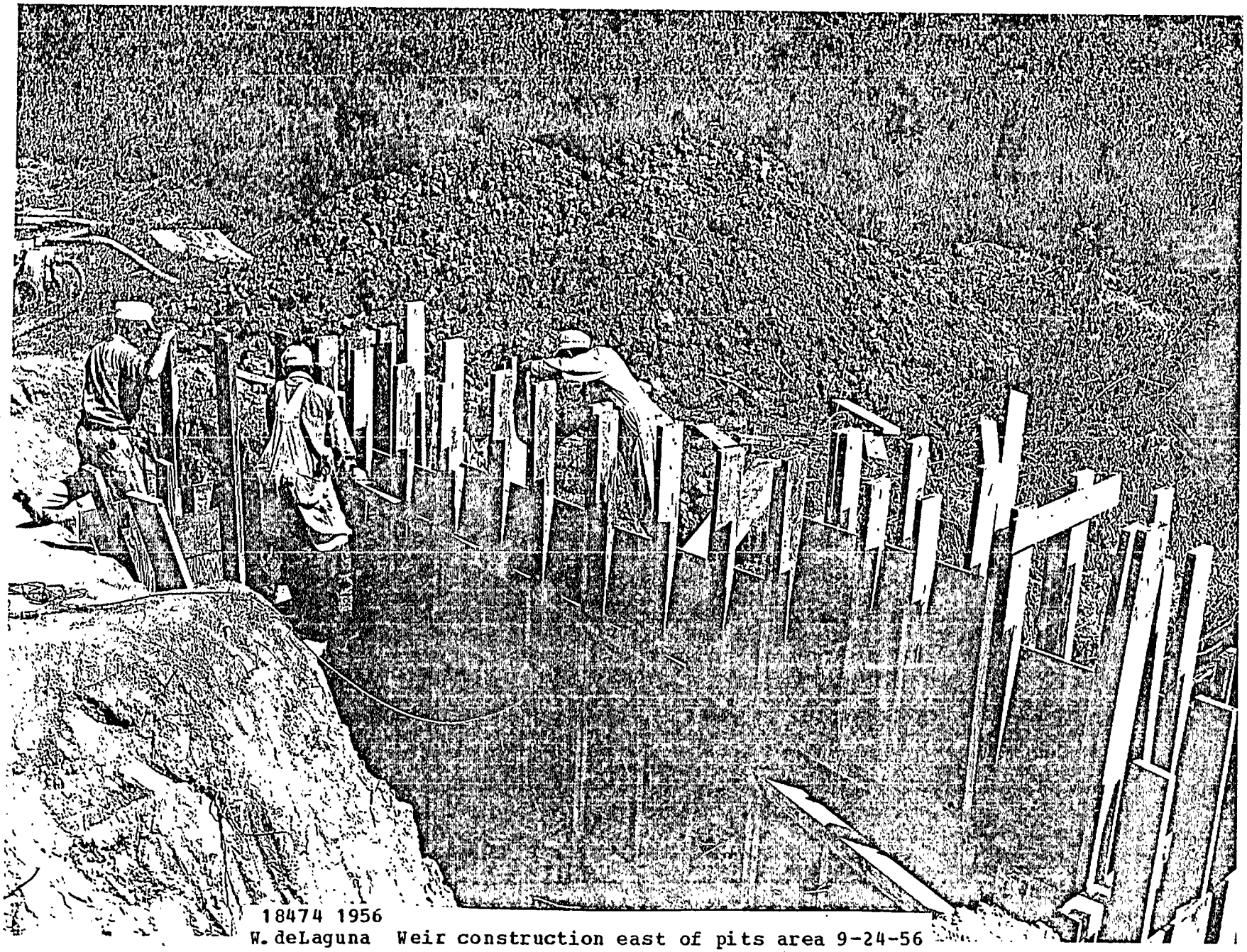
17487 1956
K. Cowser Pit 3 5-2-56



17488 1956
K. Cowser Pits 2 and 3 evaporation apparatus 5-2-56

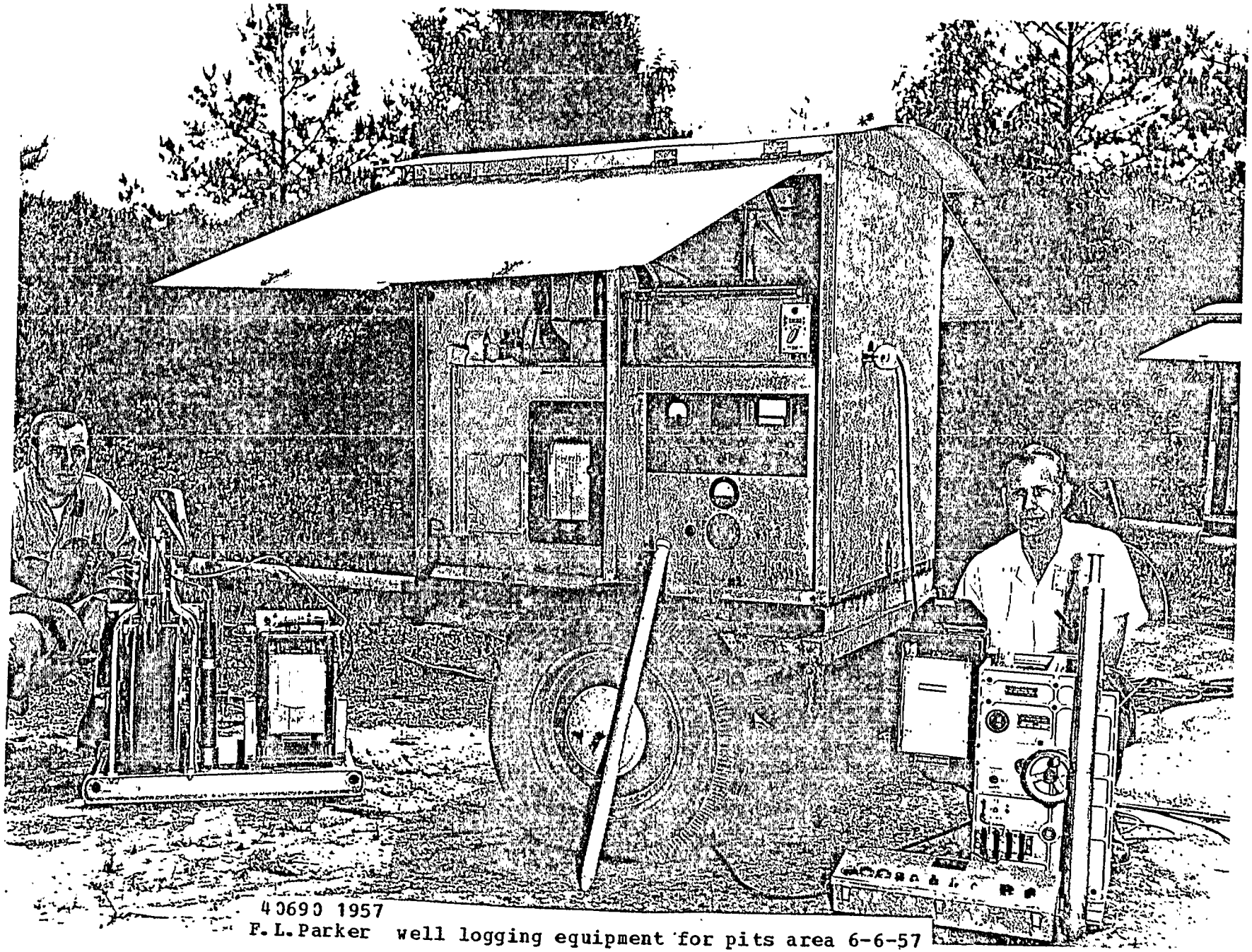


17489 1956 Pit 3 5-2-56
K. Cowser



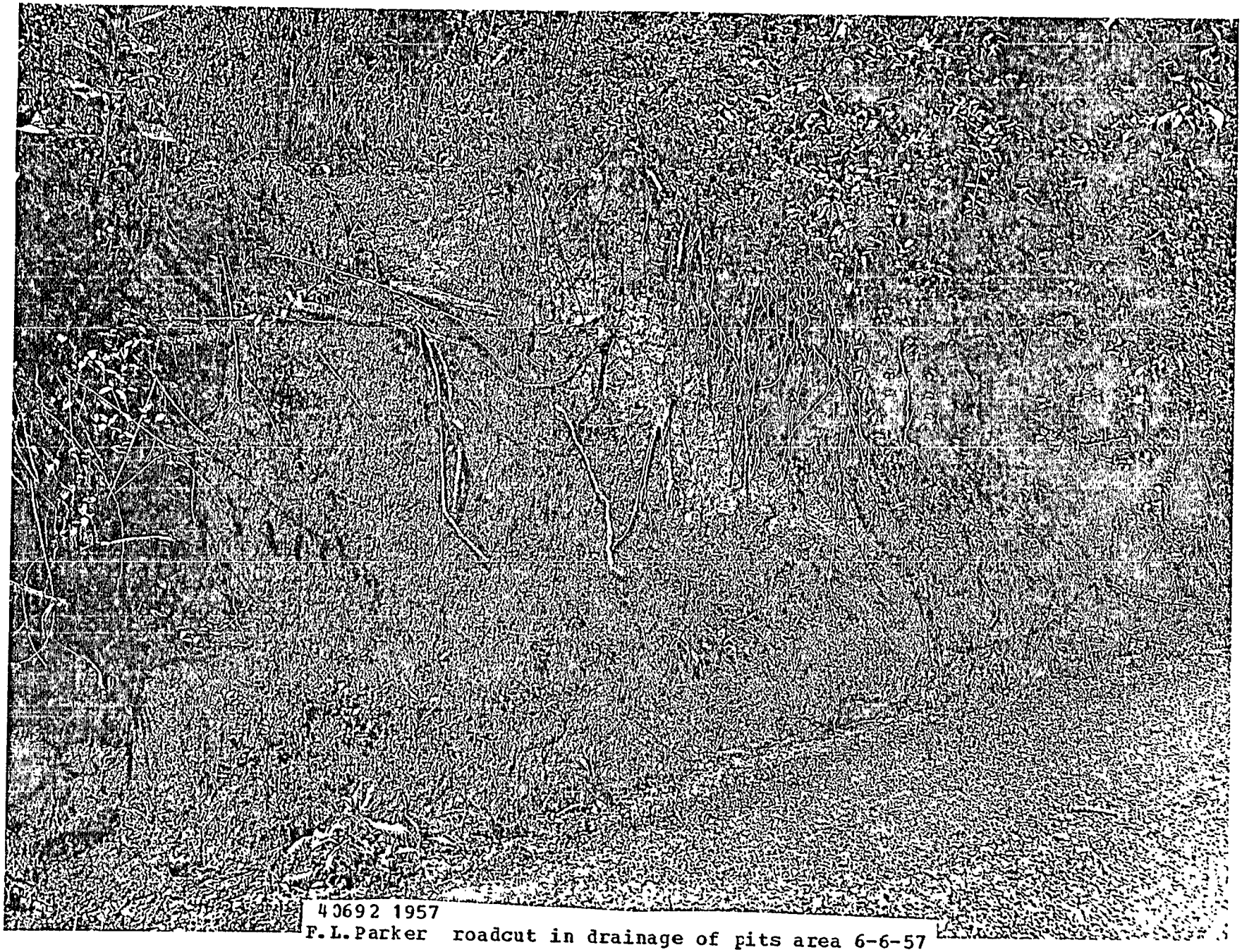
18474 1956
W. deLaguna Weir construction east of pits area 9-24-56

18475 1956
W. deLaguna Weir construction east of pits area 9-24-56

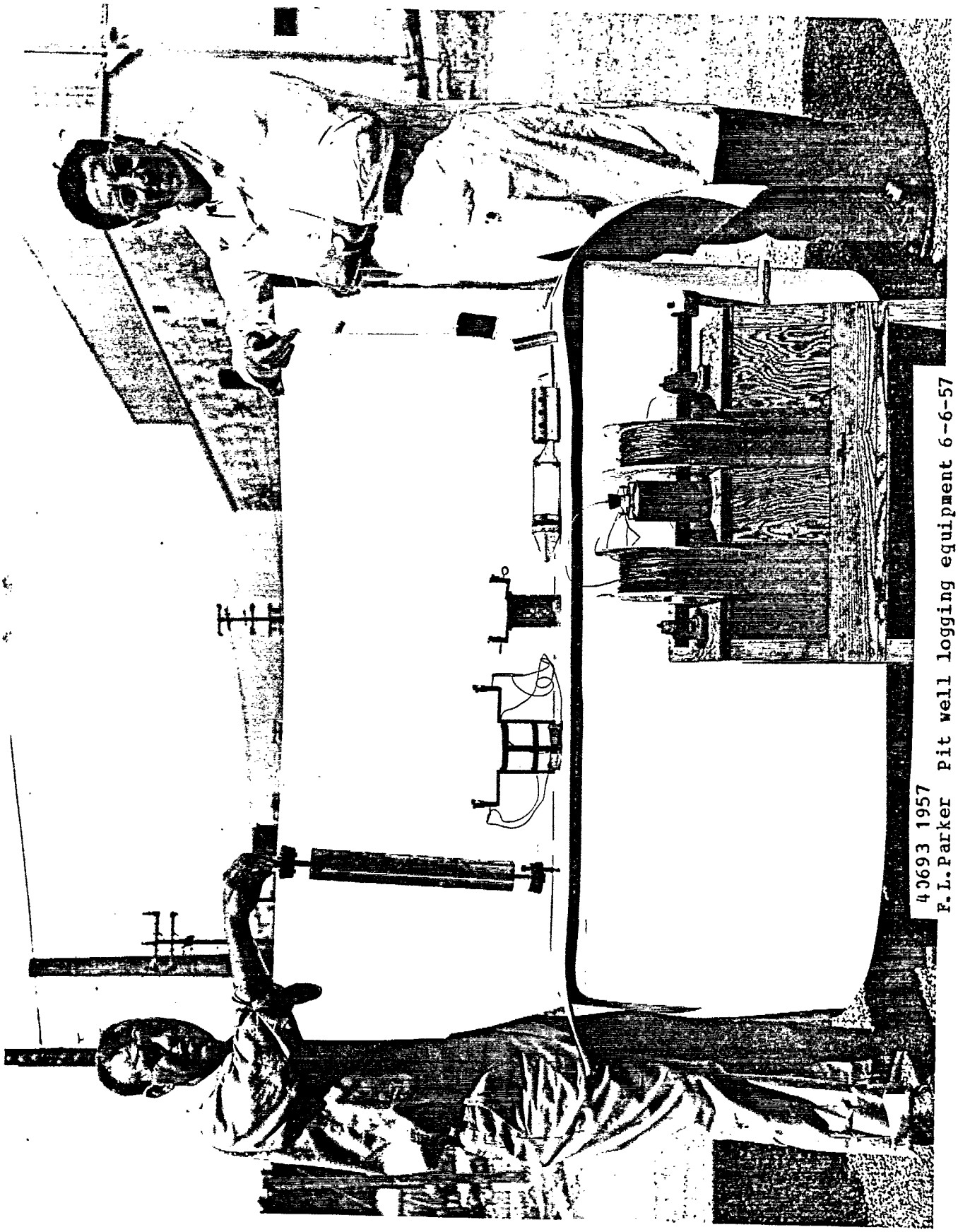


40690 1957
F. L. Parker well logging equipment for pits area 6-6-57

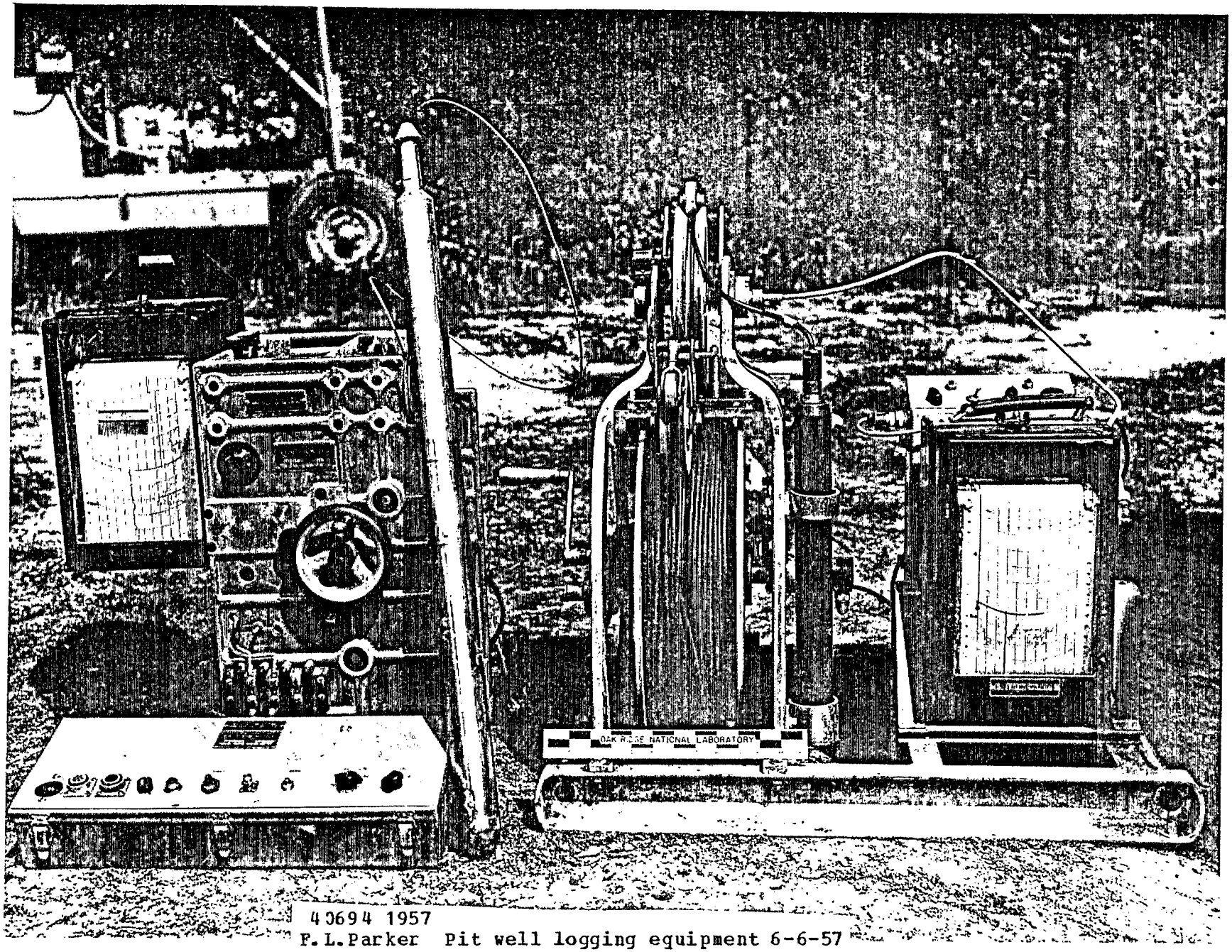
40691 1957
F.L.Parker roadcut in drainage of pits area 6-6-57



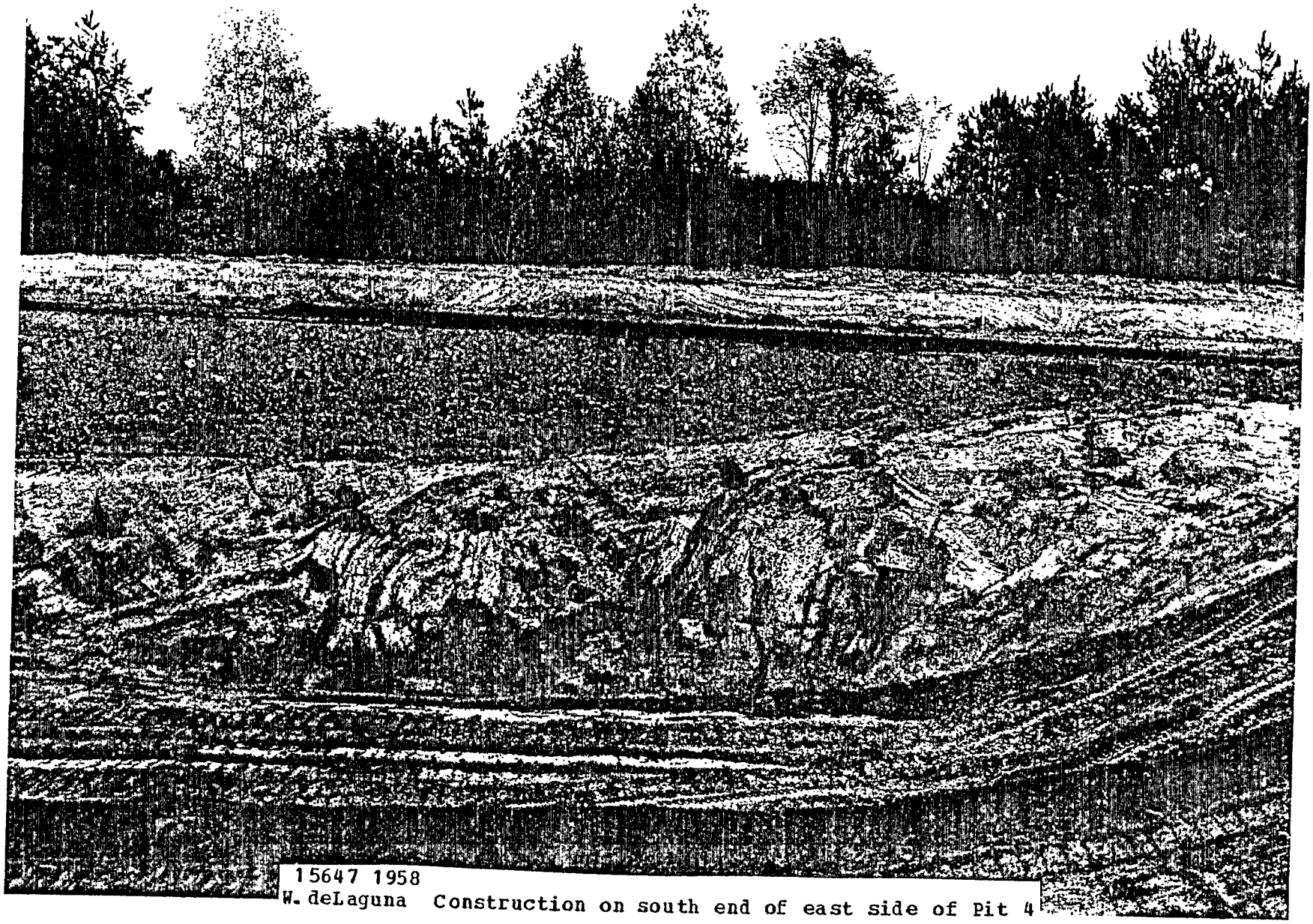
40692 1957
F.L.Parker roadcut in drainage of pits area 6-6-57



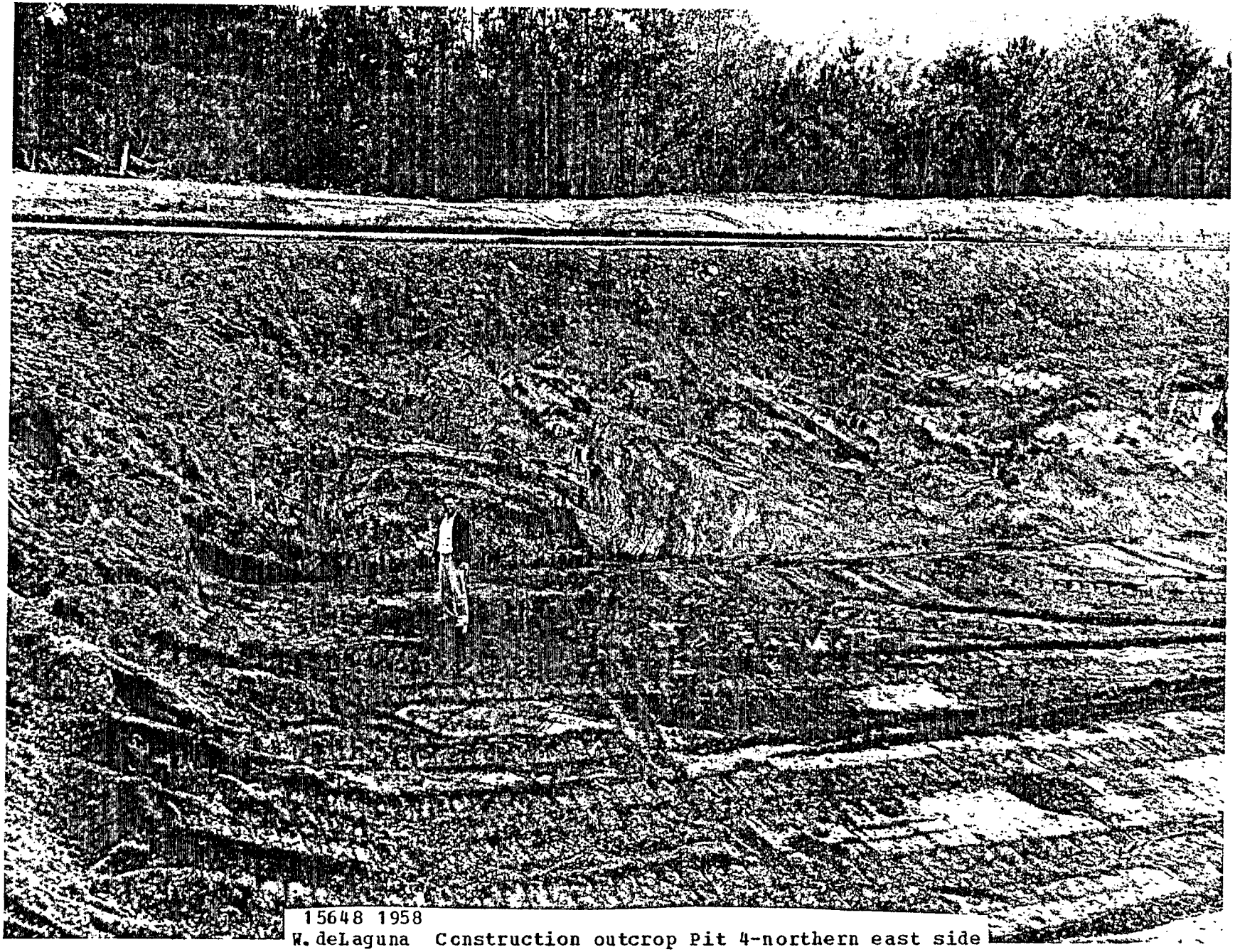
40693 1957
F.L.Parker Pit well logging equipment 6-6-57



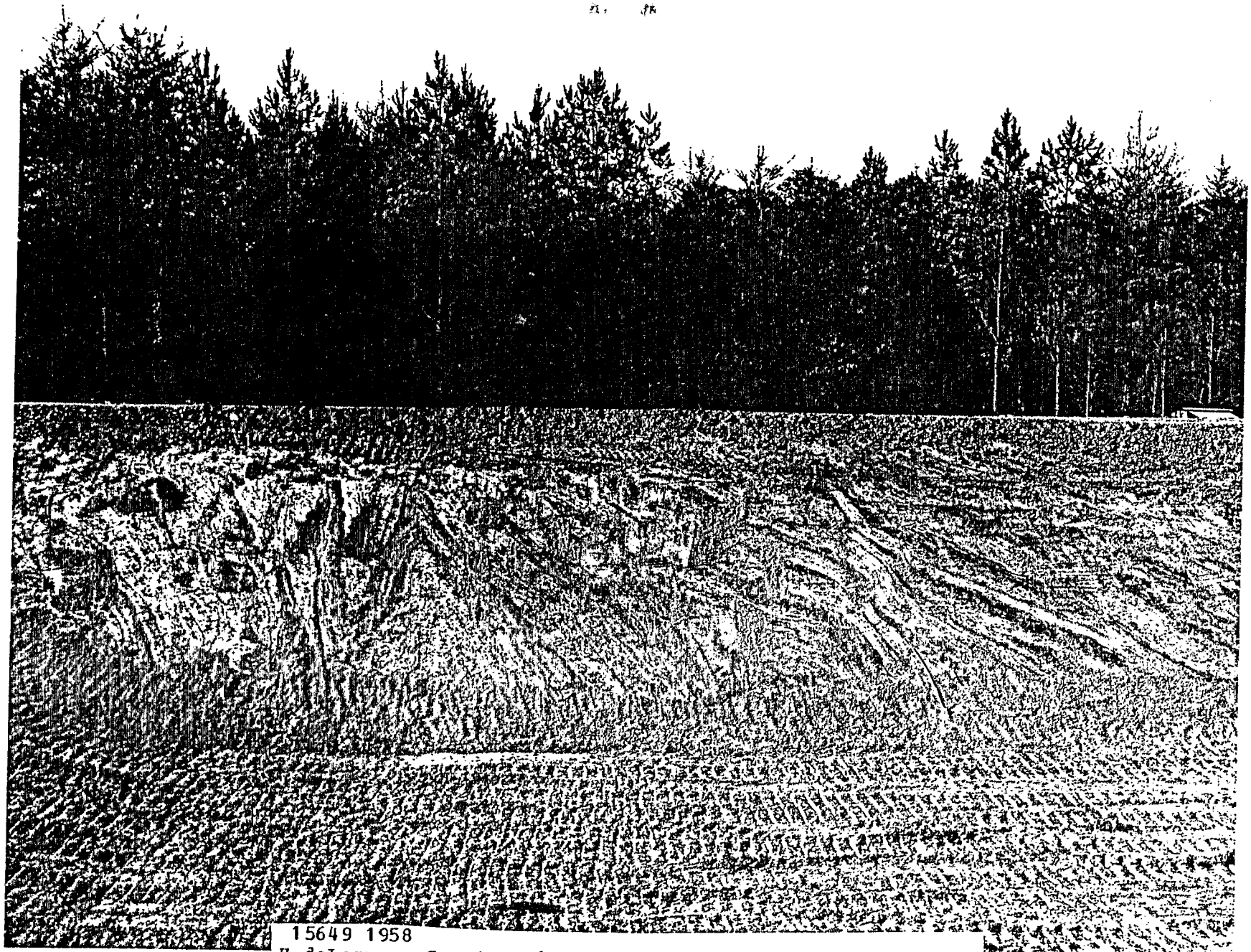
40694 1957
F.L.Parker Pit well logging equipment 6-6-57



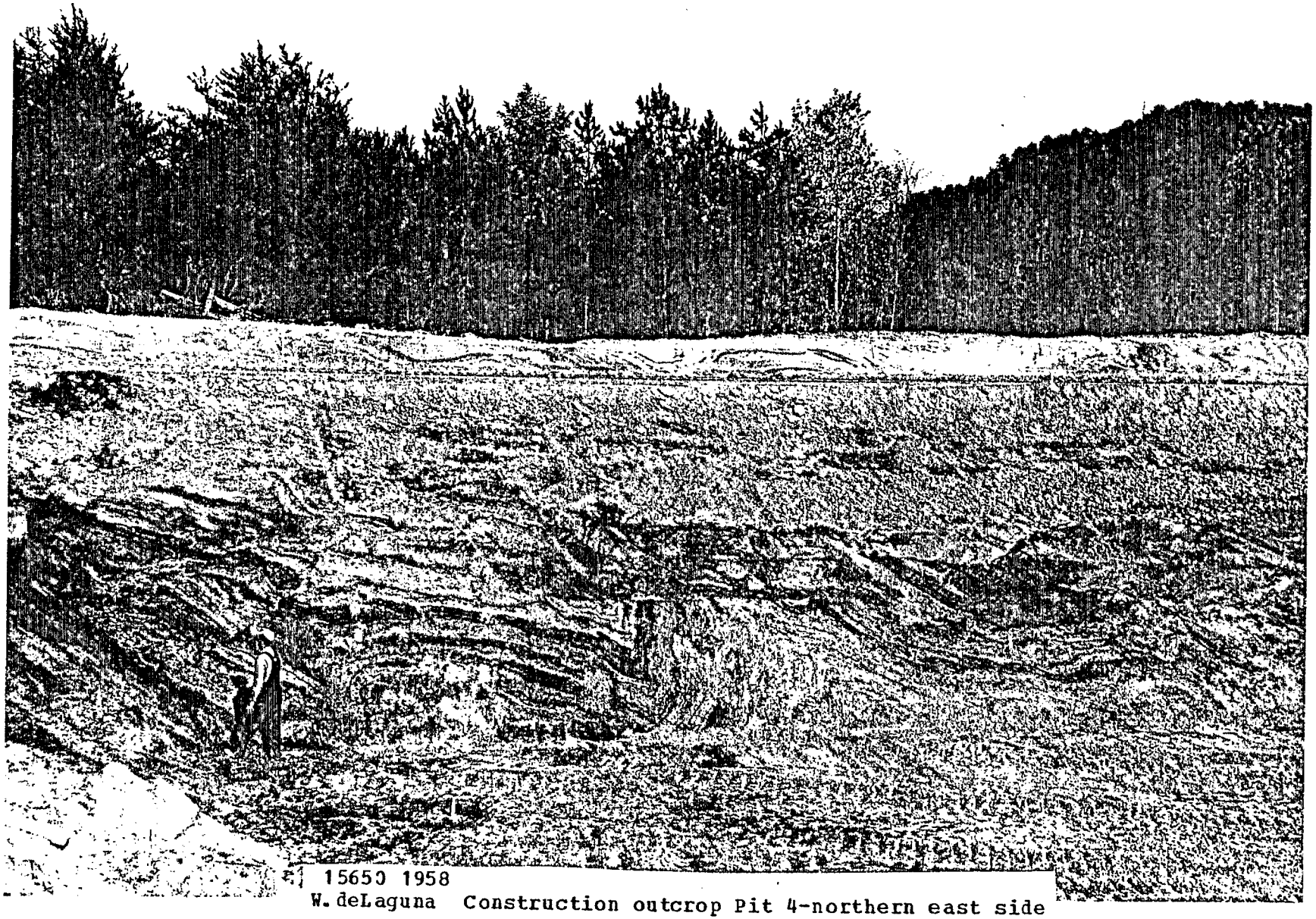
15647 1958
W. deLaguna Construction on south end of east side of Pit 4



15648 1958
W. deLaguna Construction outcrop Pit 4-northern east side



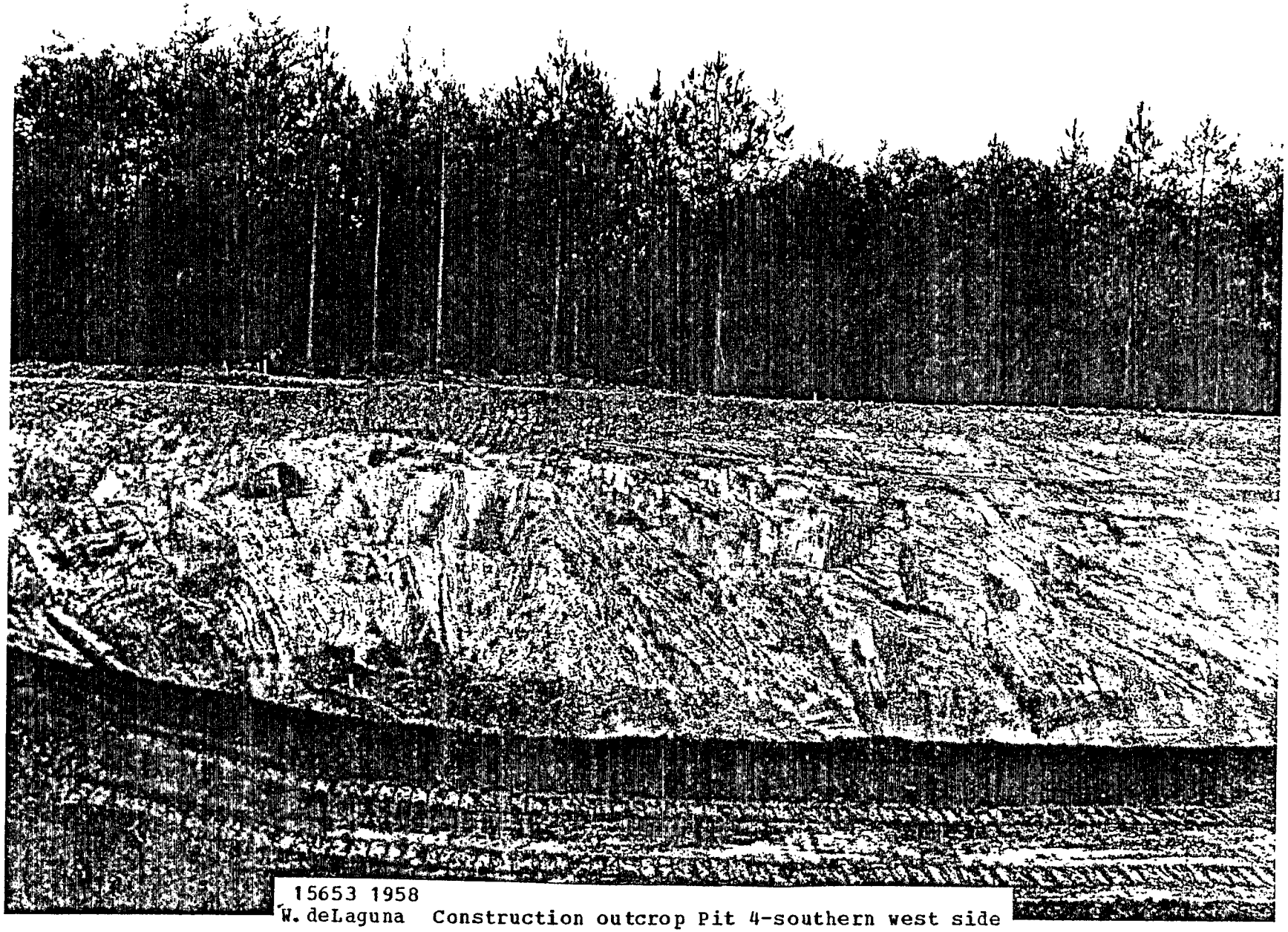
15649 1958
W. deLaguna Construction outcrop Pit 4-southern west side



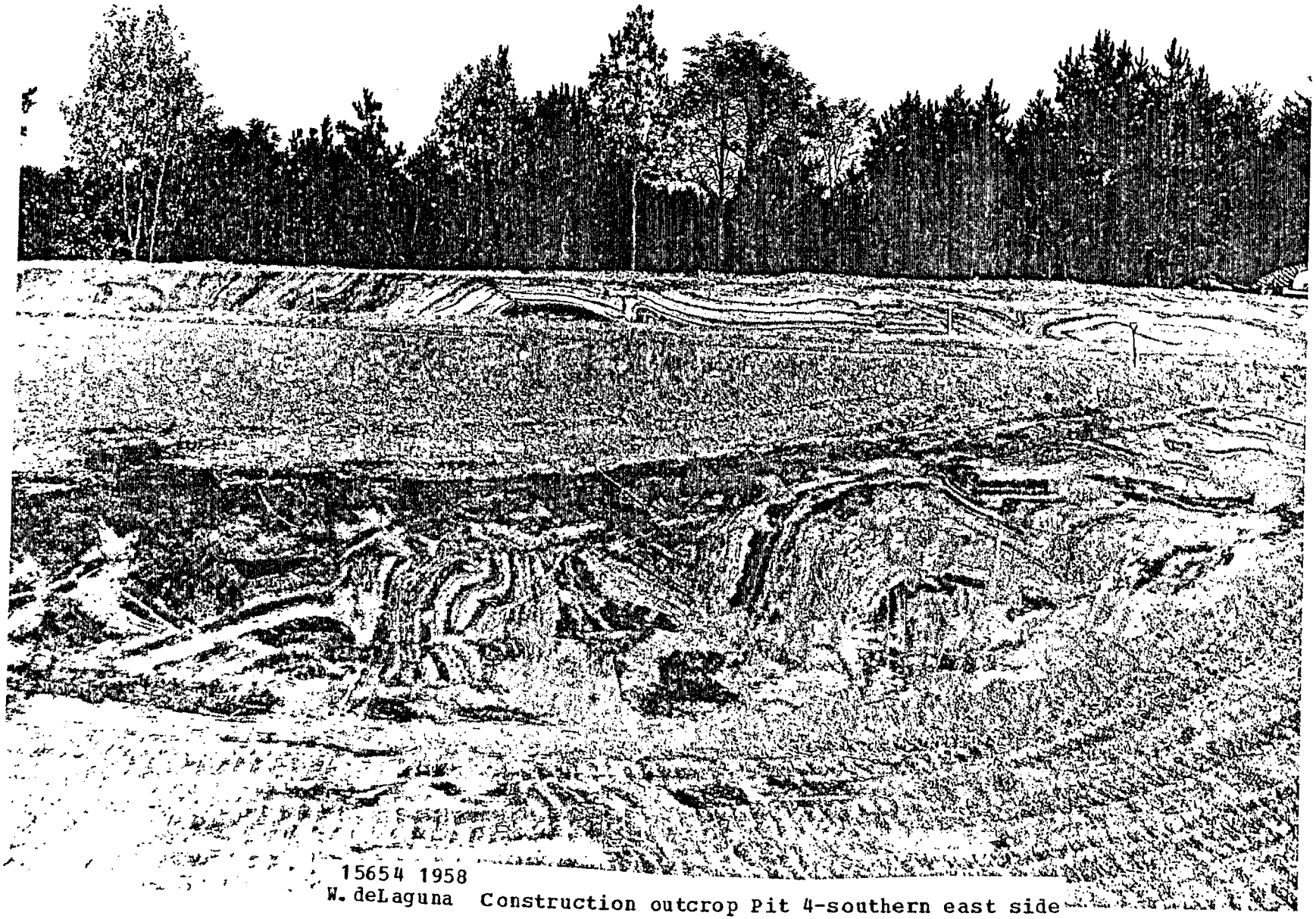
15650 1958
W. deLaguna Construction outcrop Pit 4-northern east side

15651 1958
W. deLaguna Construction outcrop Pit 4-northwest corner

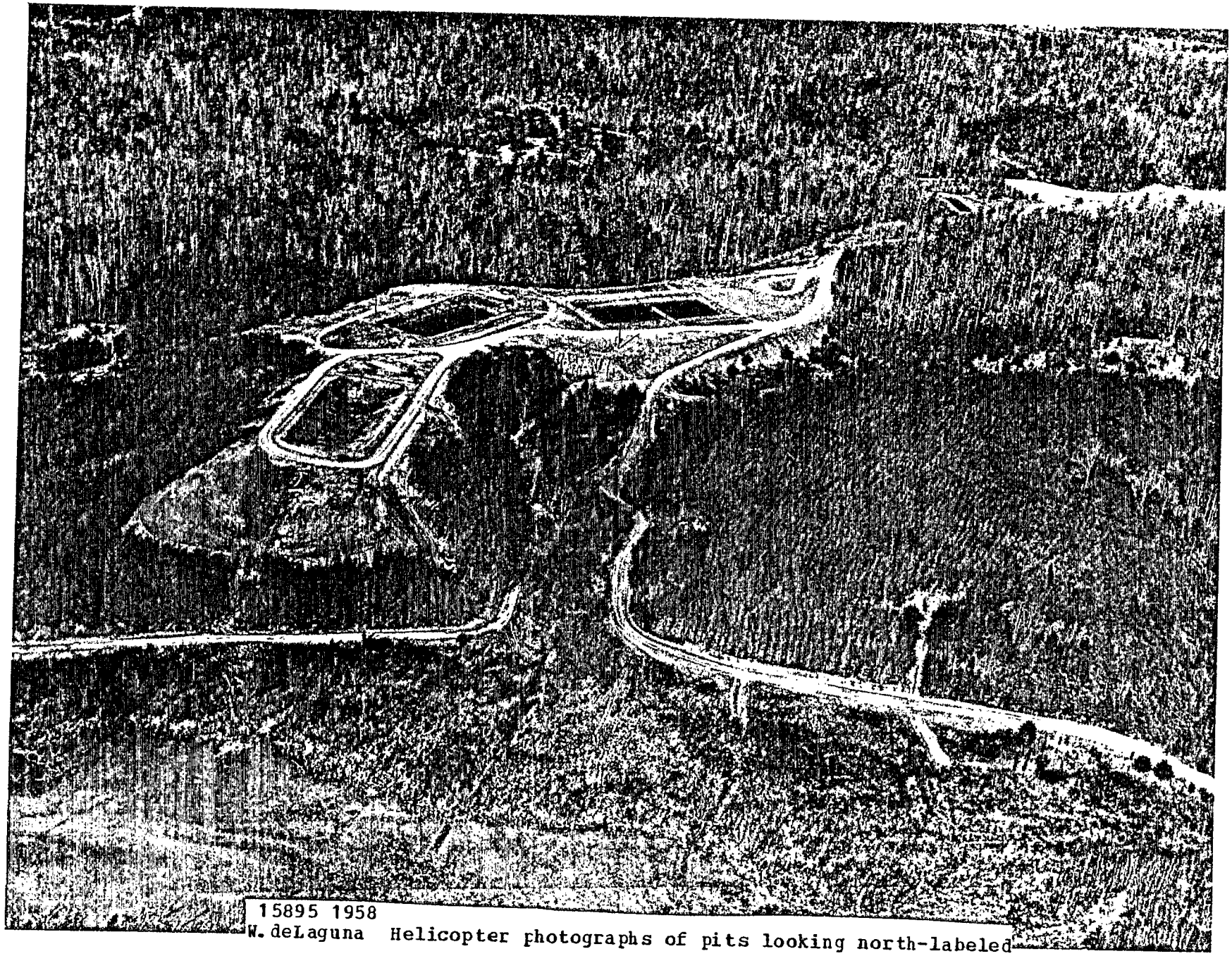
15652 1958
W. deLaguna Construction outcrop Pit 4-western side



15653 1958
W. deLaguna Construction outcrop Pit 4-southern west side



15654 1958
W. deLaguna Construction outcrop Pit 4-southern east side



15895 1958
W. deLaguna Helicopter photographs of pits looking north-labeled

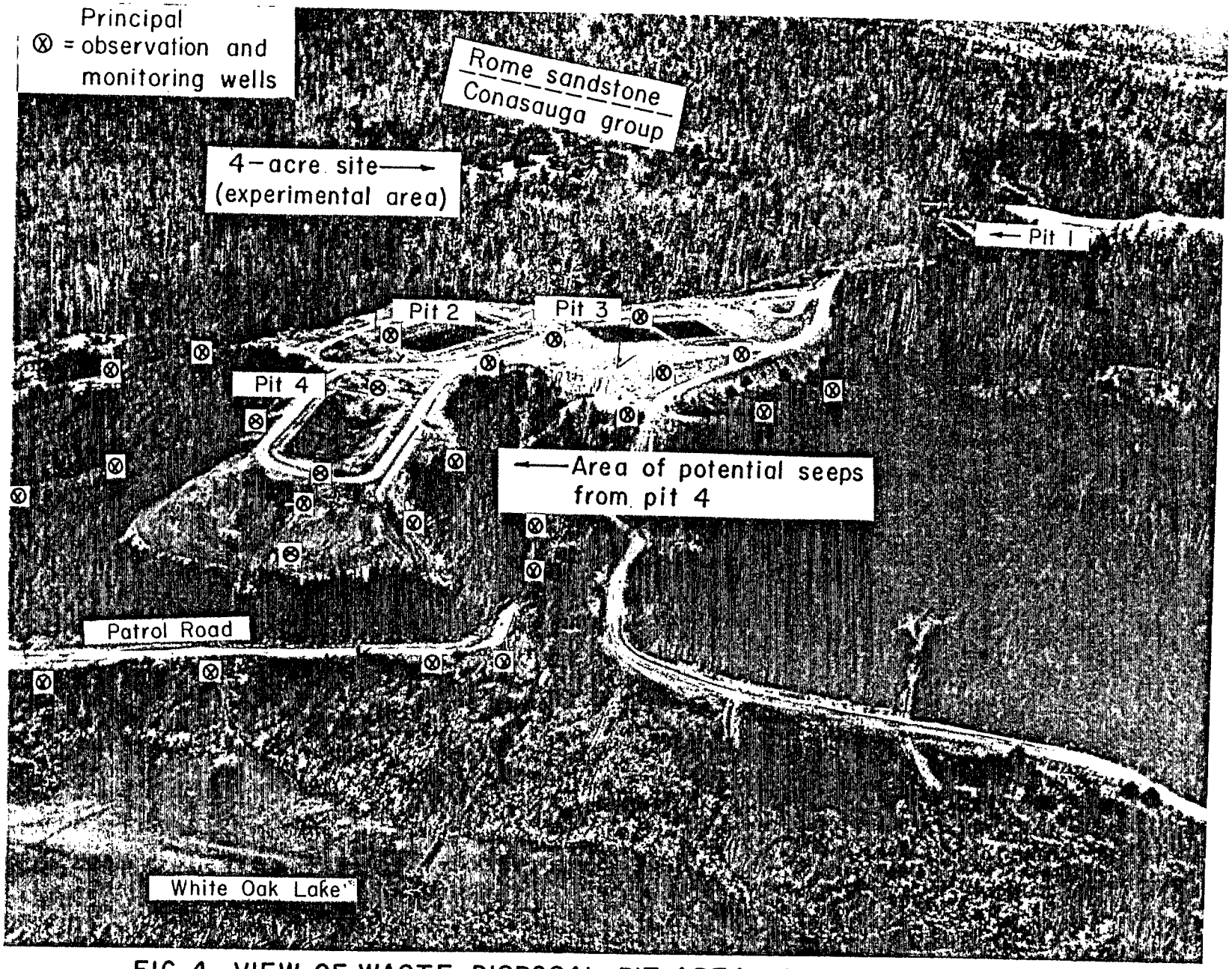
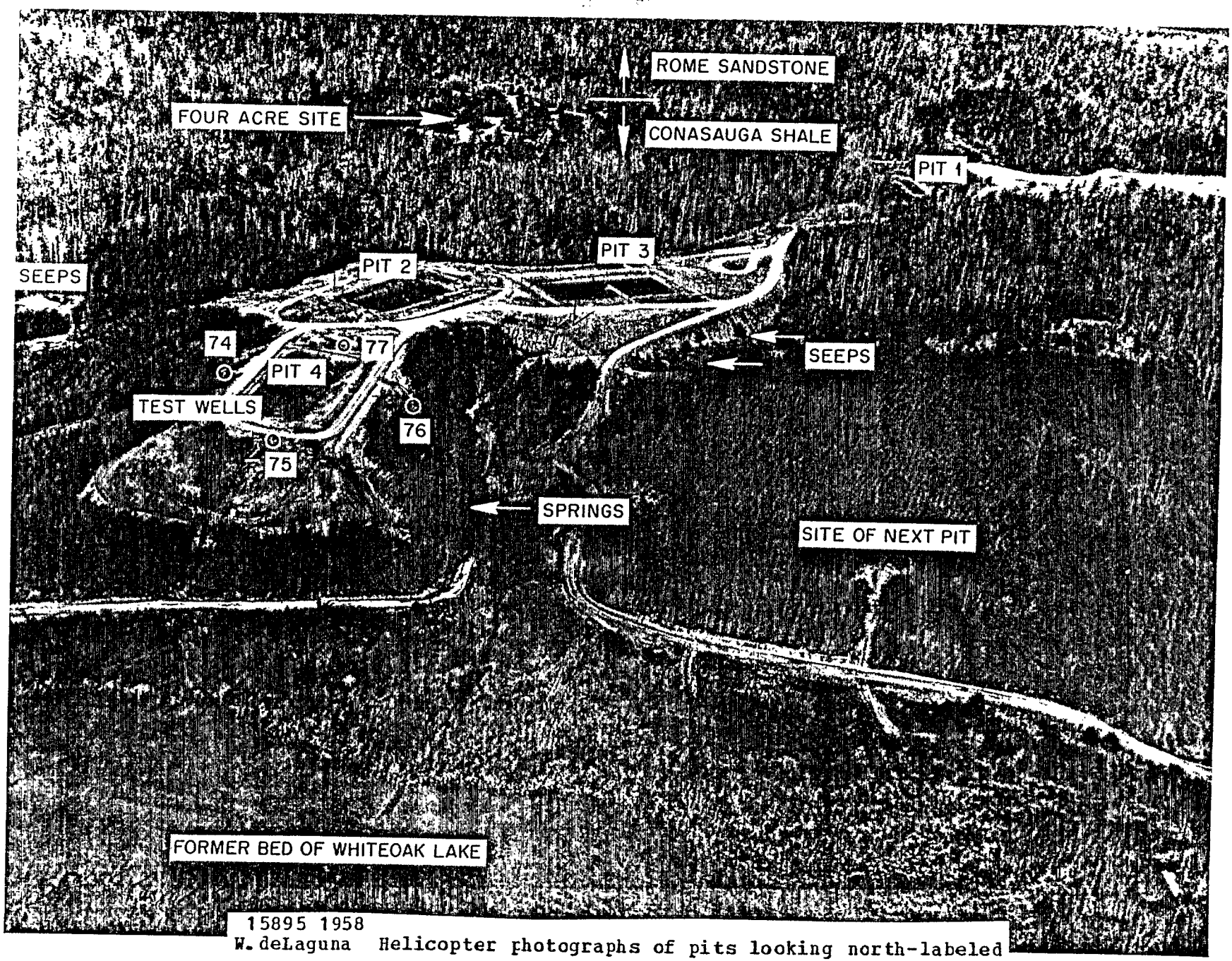


FIG. 4 VIEW OF WASTE-DISPOSAL-PIT AREA, LOOKING NORTH

15895 1958
W. deLaguna Helicopter photographs of pits looking north-labeled



15895 1958
W. deLaguna Helicopter photographs of pits looking north-labeled

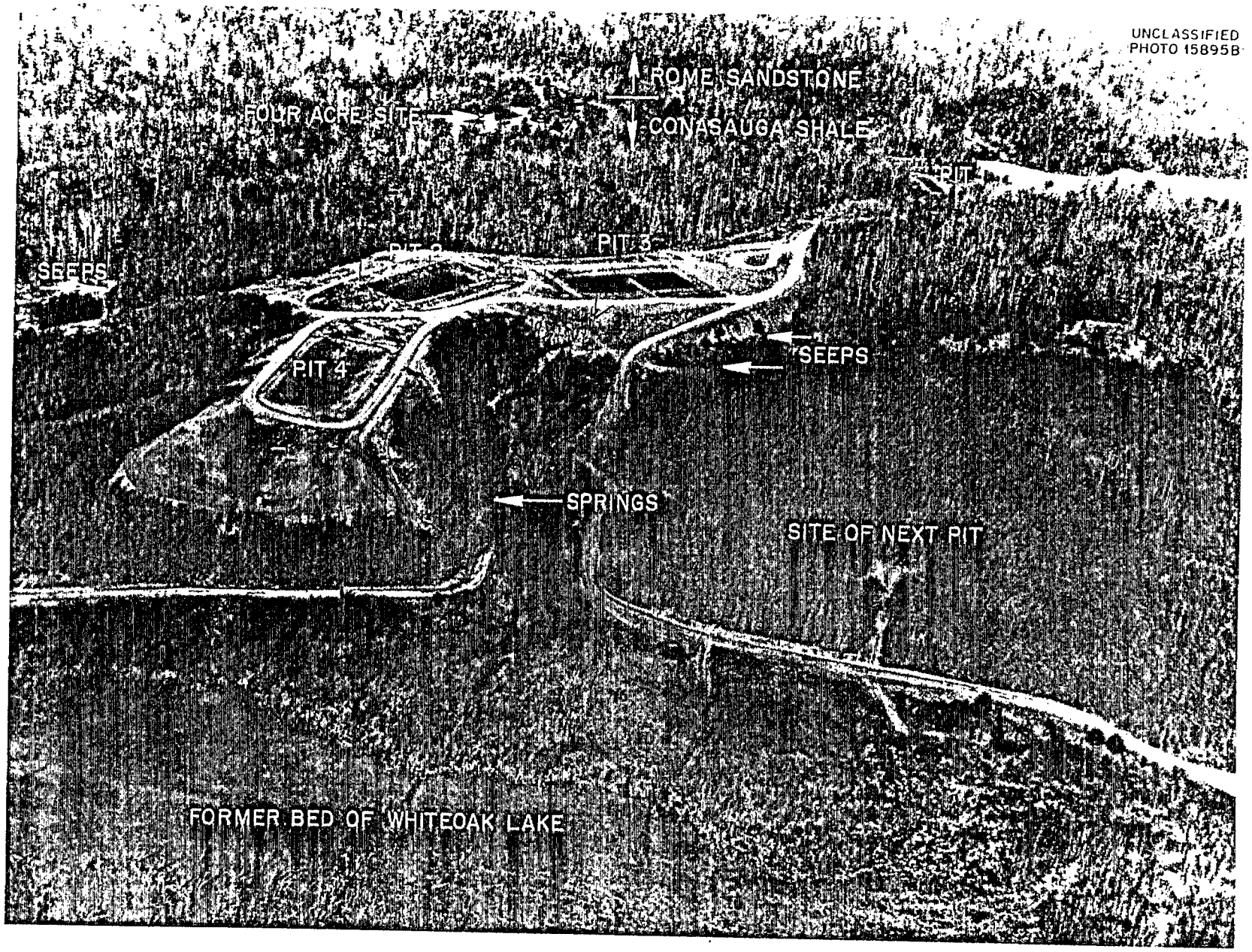
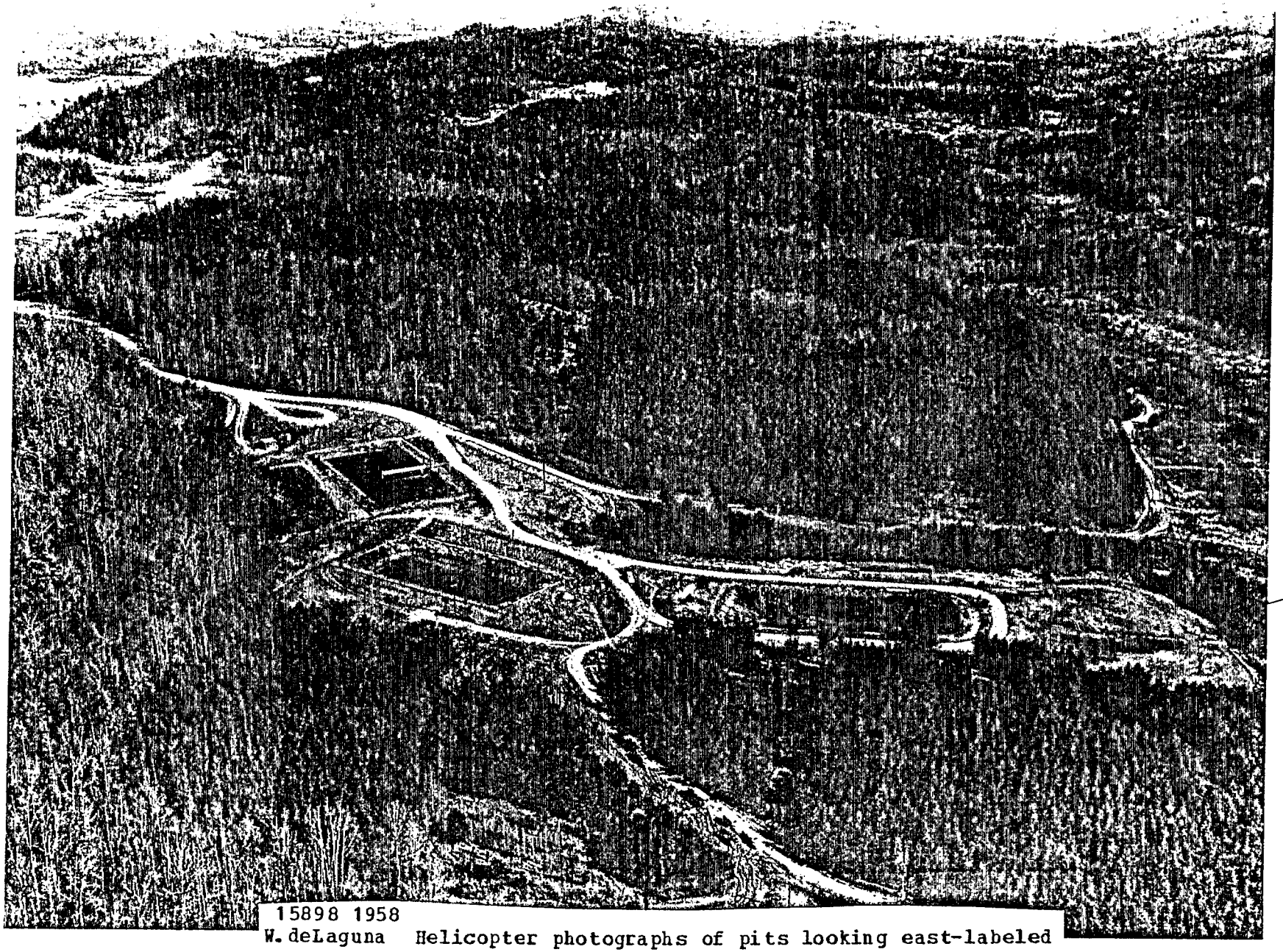


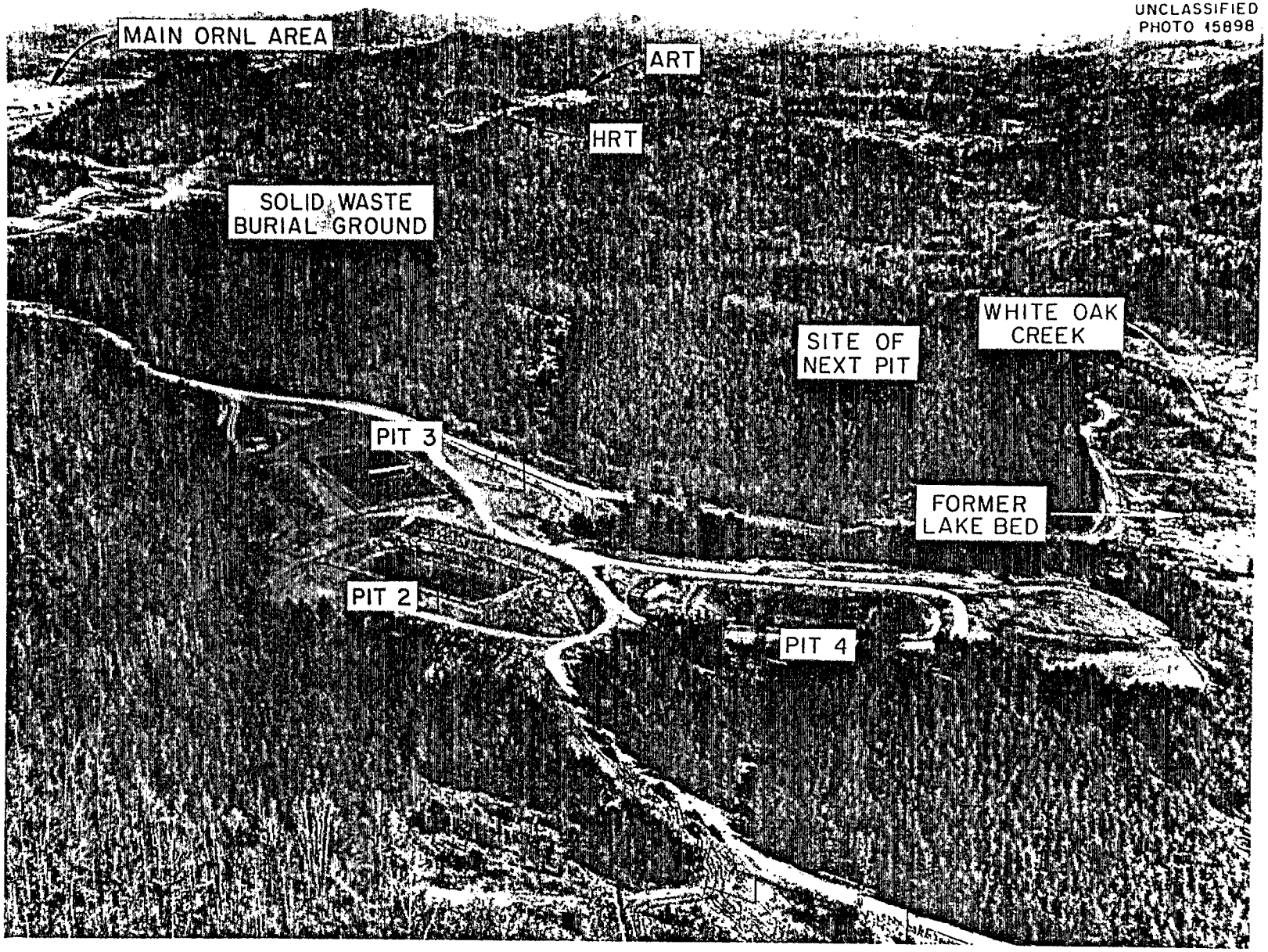
Fig. 1. Aerial View of Waste Pits.

15895 1958
W. deLaguna Helicopter photographs of pits looking north-labeled



15898 1958
W. deLaguna Helicopter photographs of pits looking east-labeled

UNCLASSIFIED
PHOTO 15898



ORNL WASTE DISPOSAL AREA

15898 1958
W. deLaguna Helicopter photographs of pits looking east-labeled

UNCLASSIFIED
PHOTO 15898A

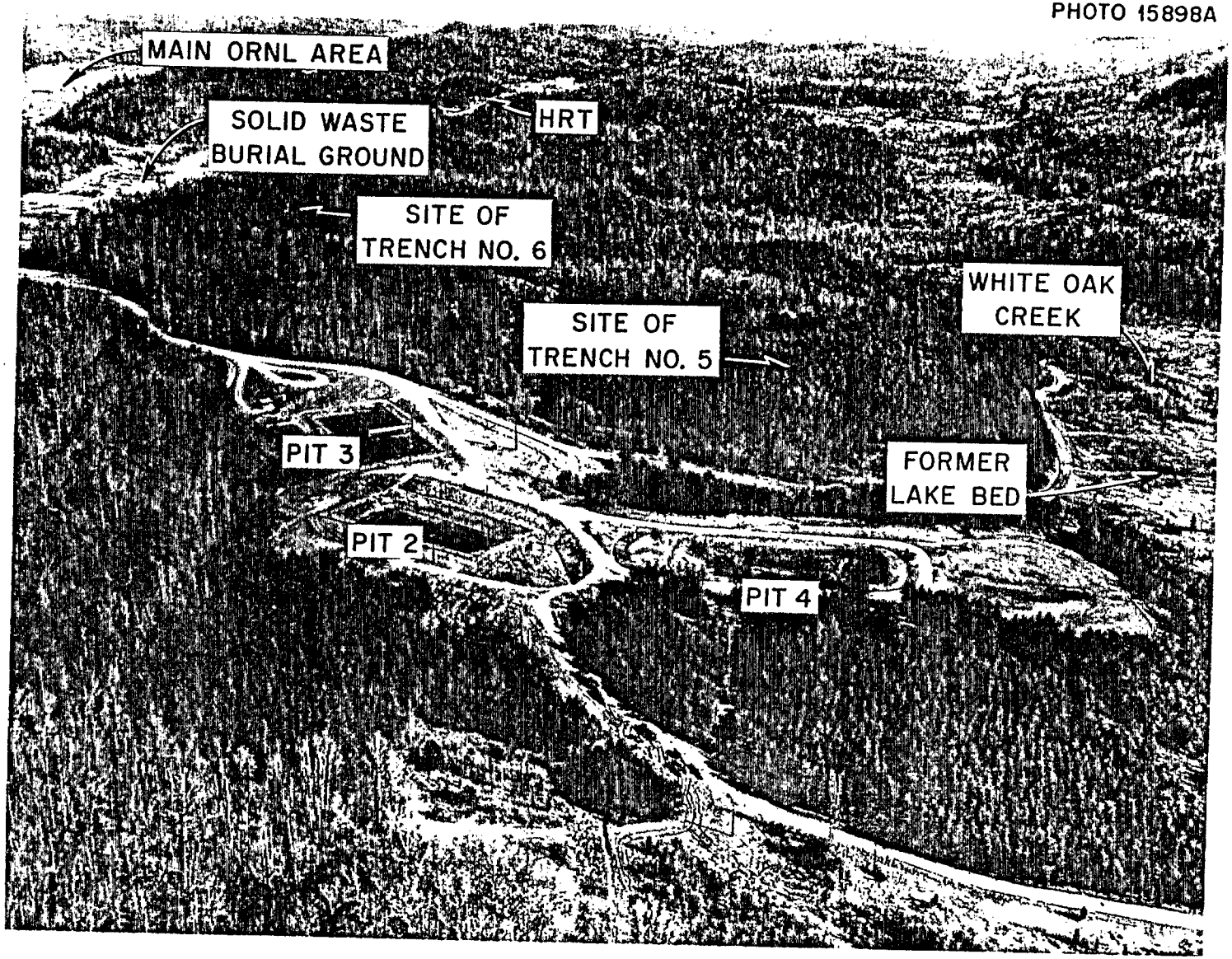
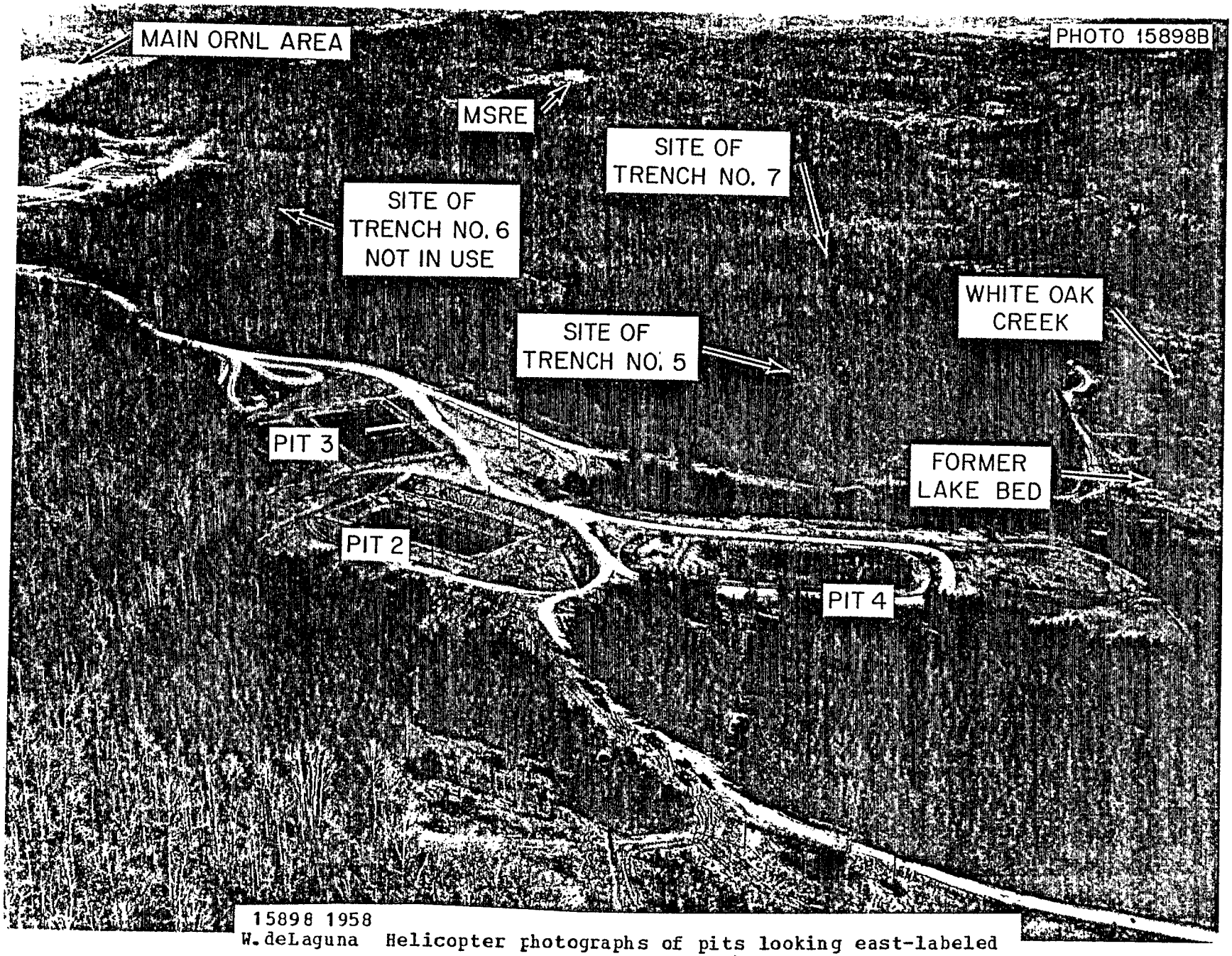


Fig. 3. ORNL Waste Disposal Area.

15898 1958
W. deLaguna Helicopter photographs of pits looking east-labeled



15898 1958
W. deLaguna Helicopter photographs of pits looking east-labeled

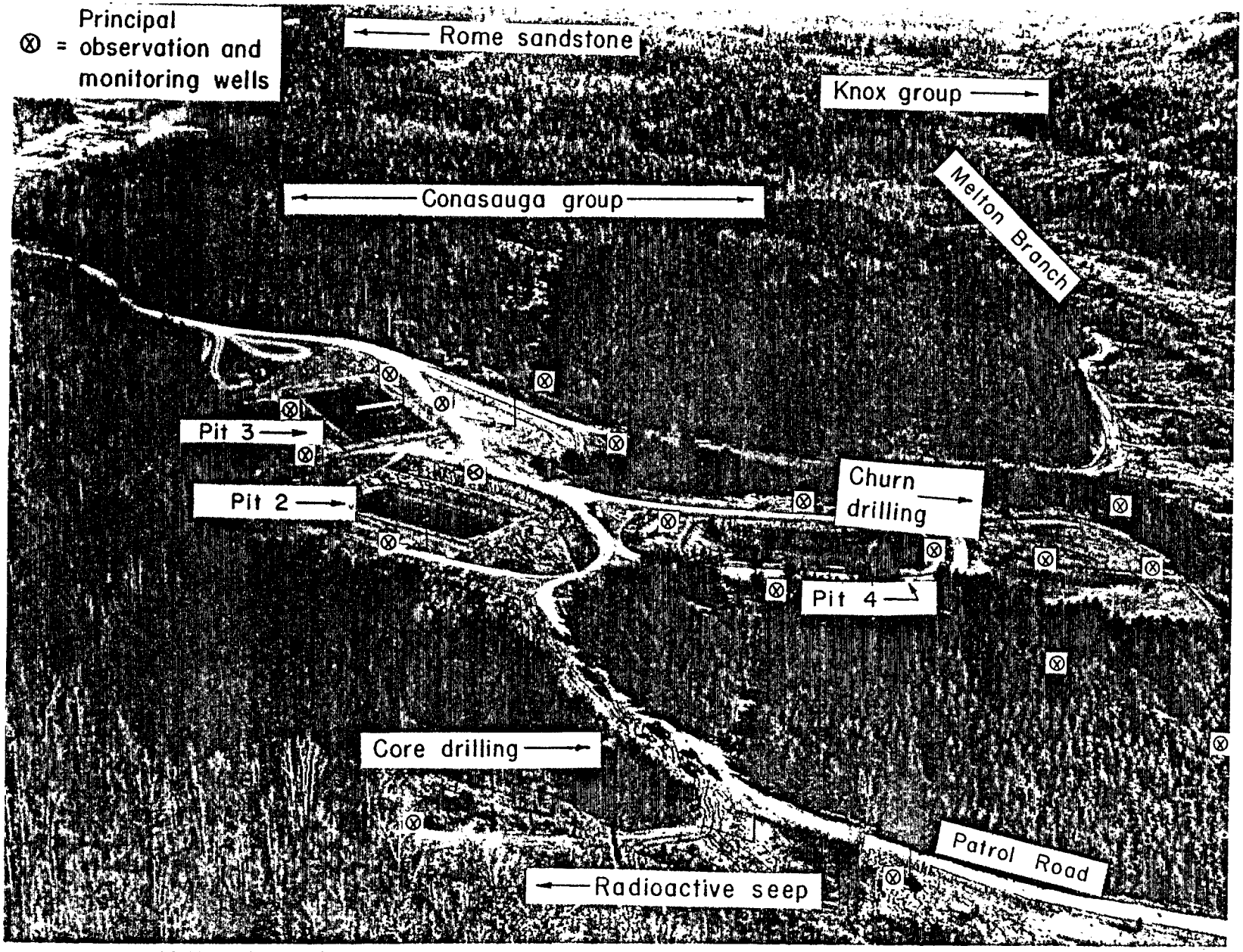
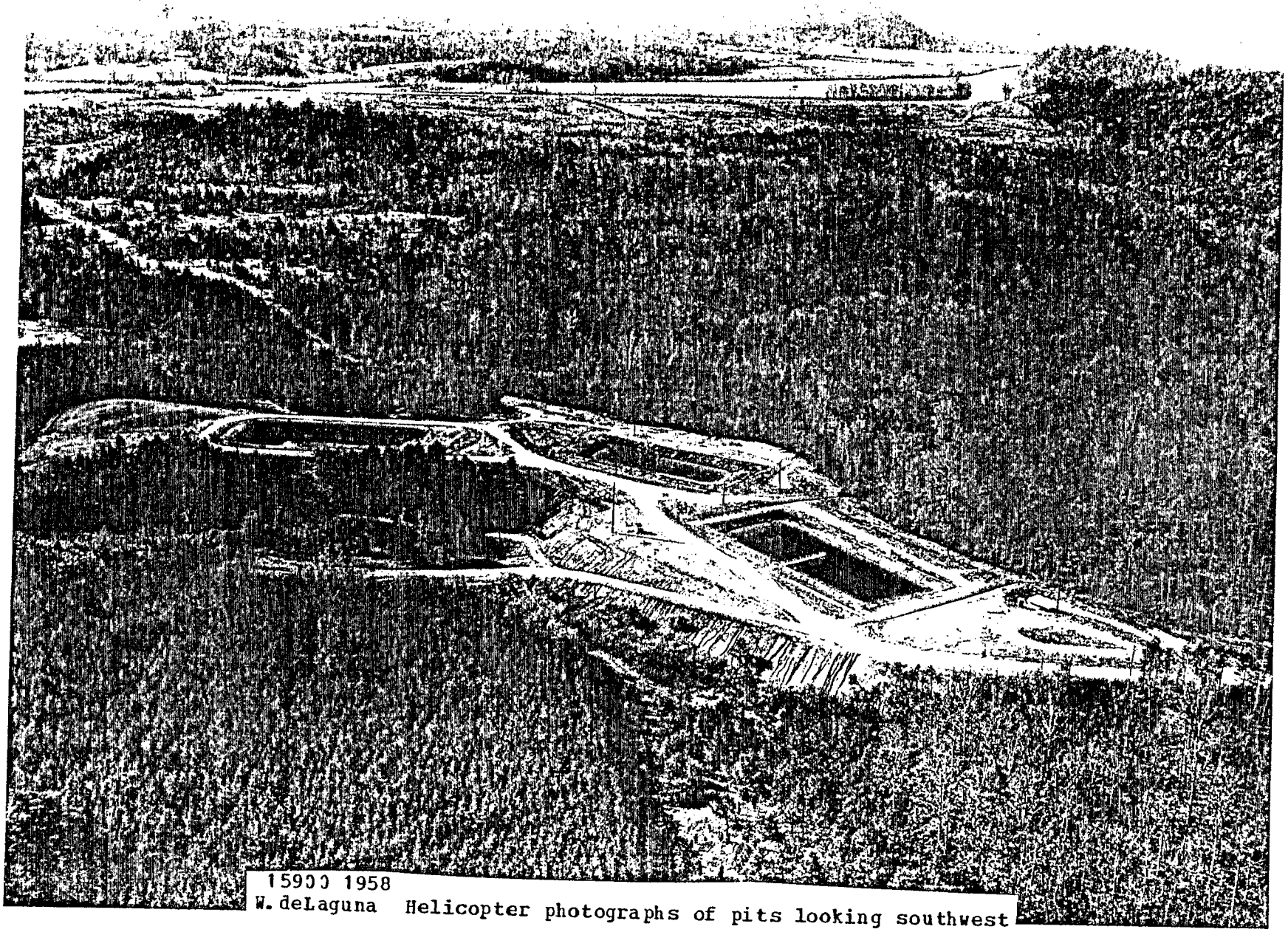
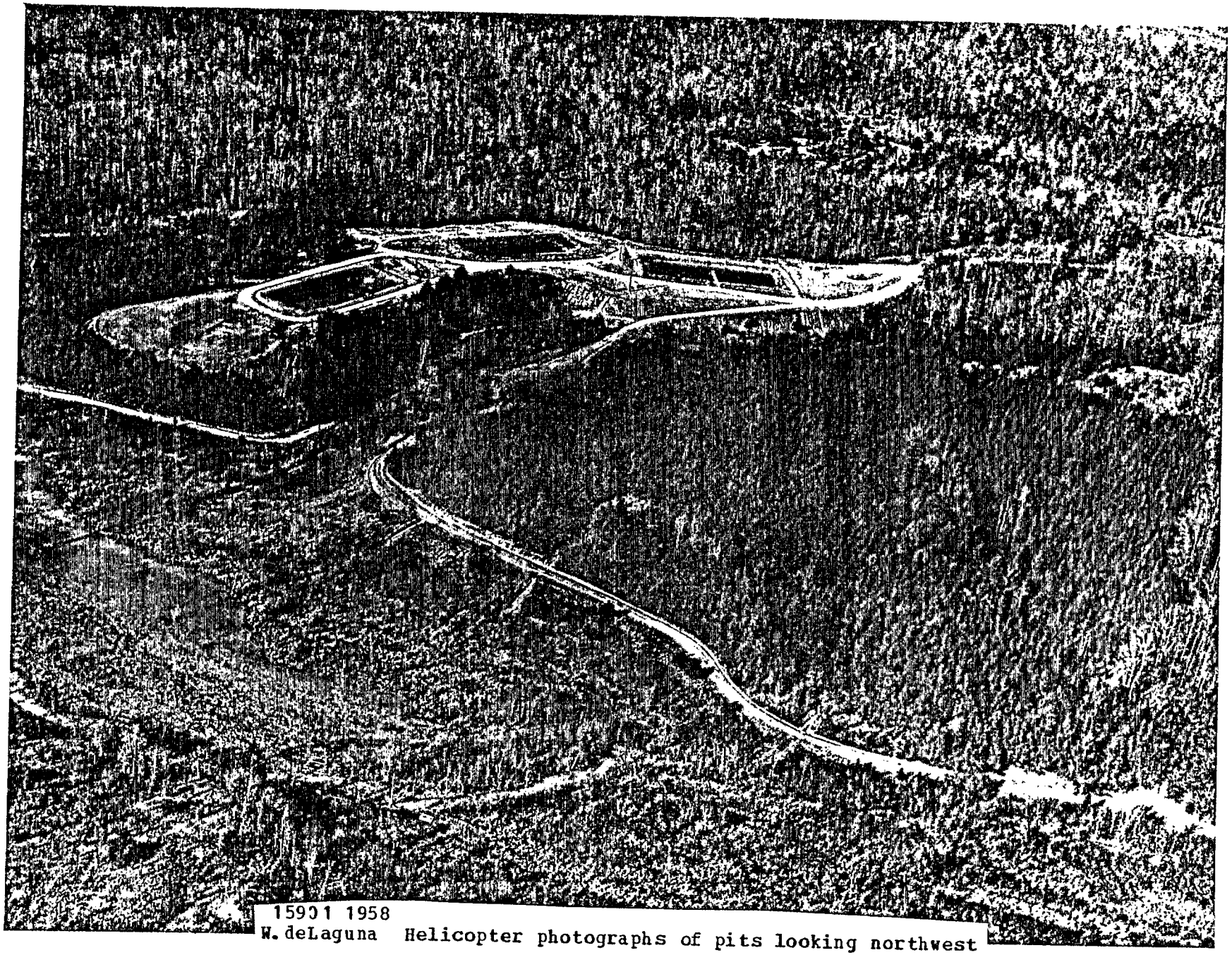


FIG. 3 VIEW OF WASTE-DISPOSAL-PIT AREA, LOOKING NORTHEAST

15898 1958
W. deLaguna Helicopter photographs of pits looking east-labeled

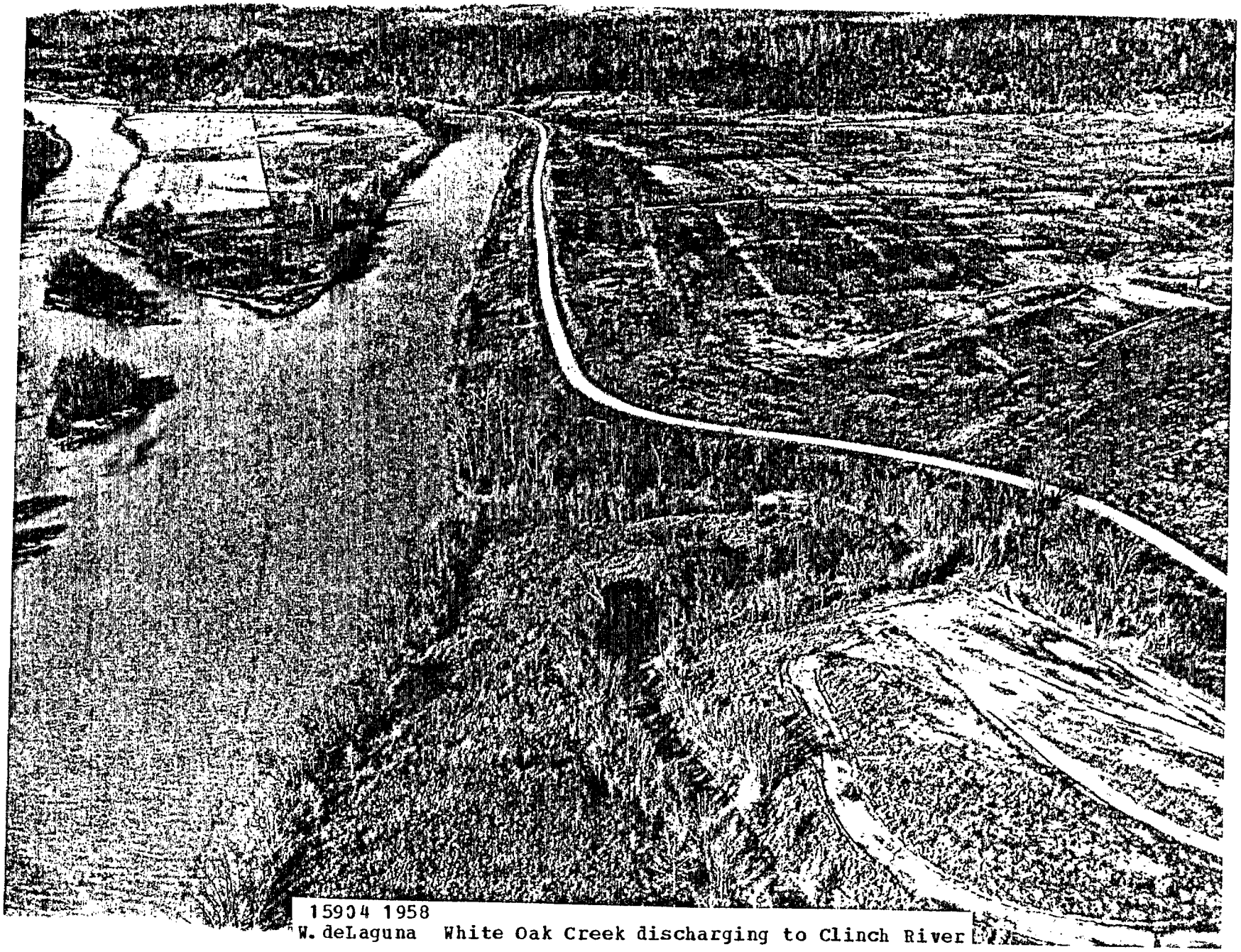


15900 1958
W. deLaguna Helicopter photographs of pits looking southwest

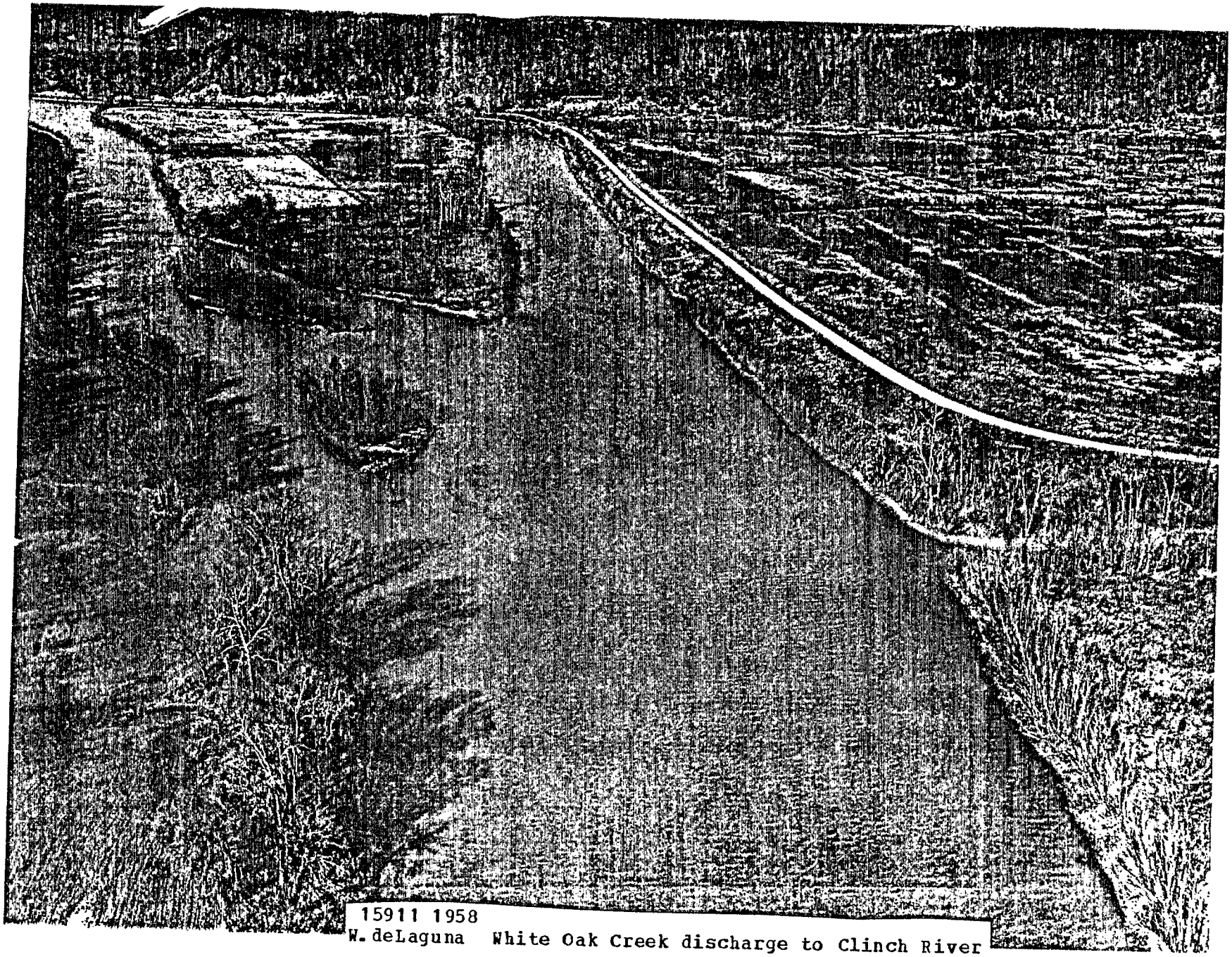


15901 1958
W. deLaguna Helicopter photographs of pits looking northwest

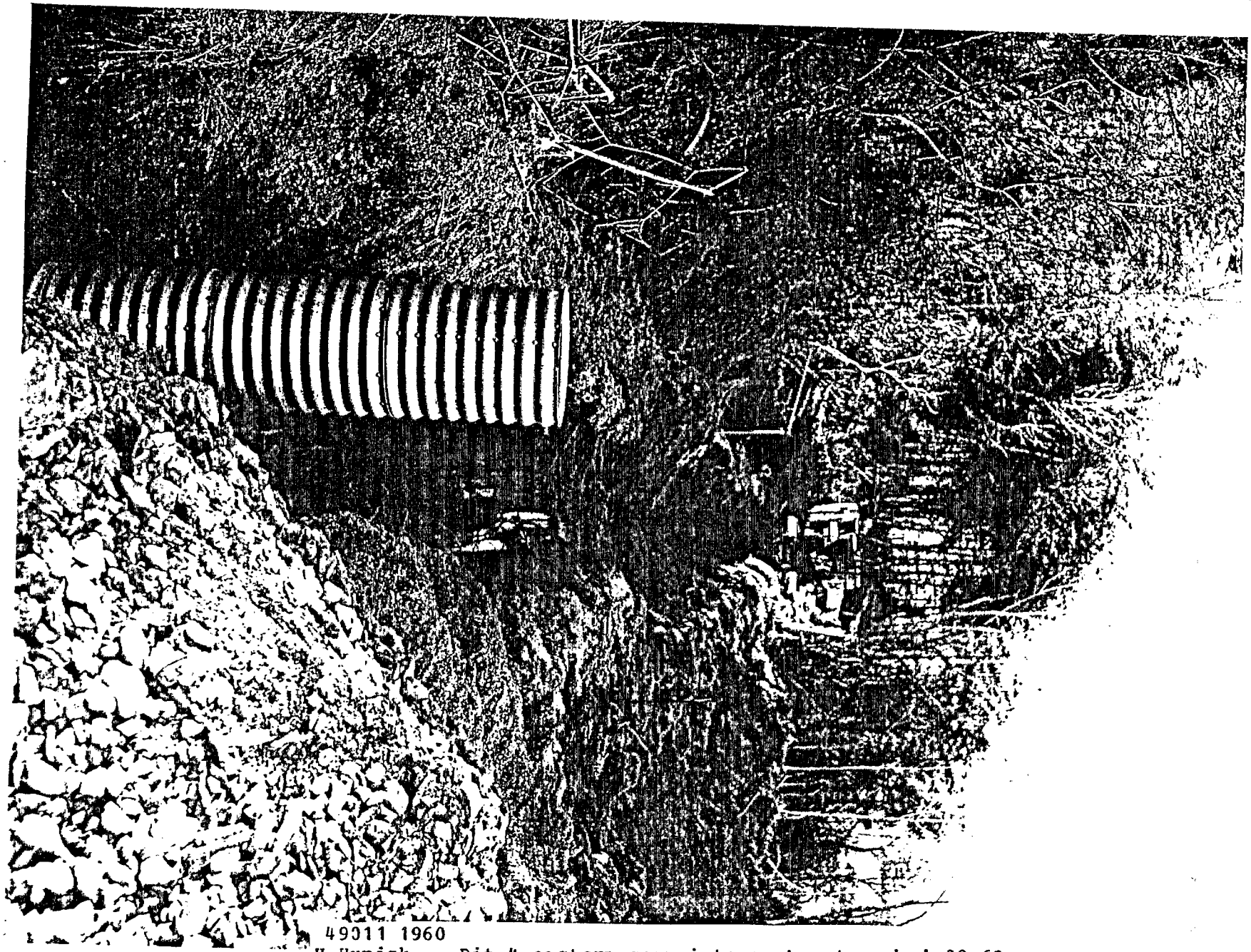
15903 1958
W. deLaguna Helicopter shots of White Oak Lake and SWSA6 site



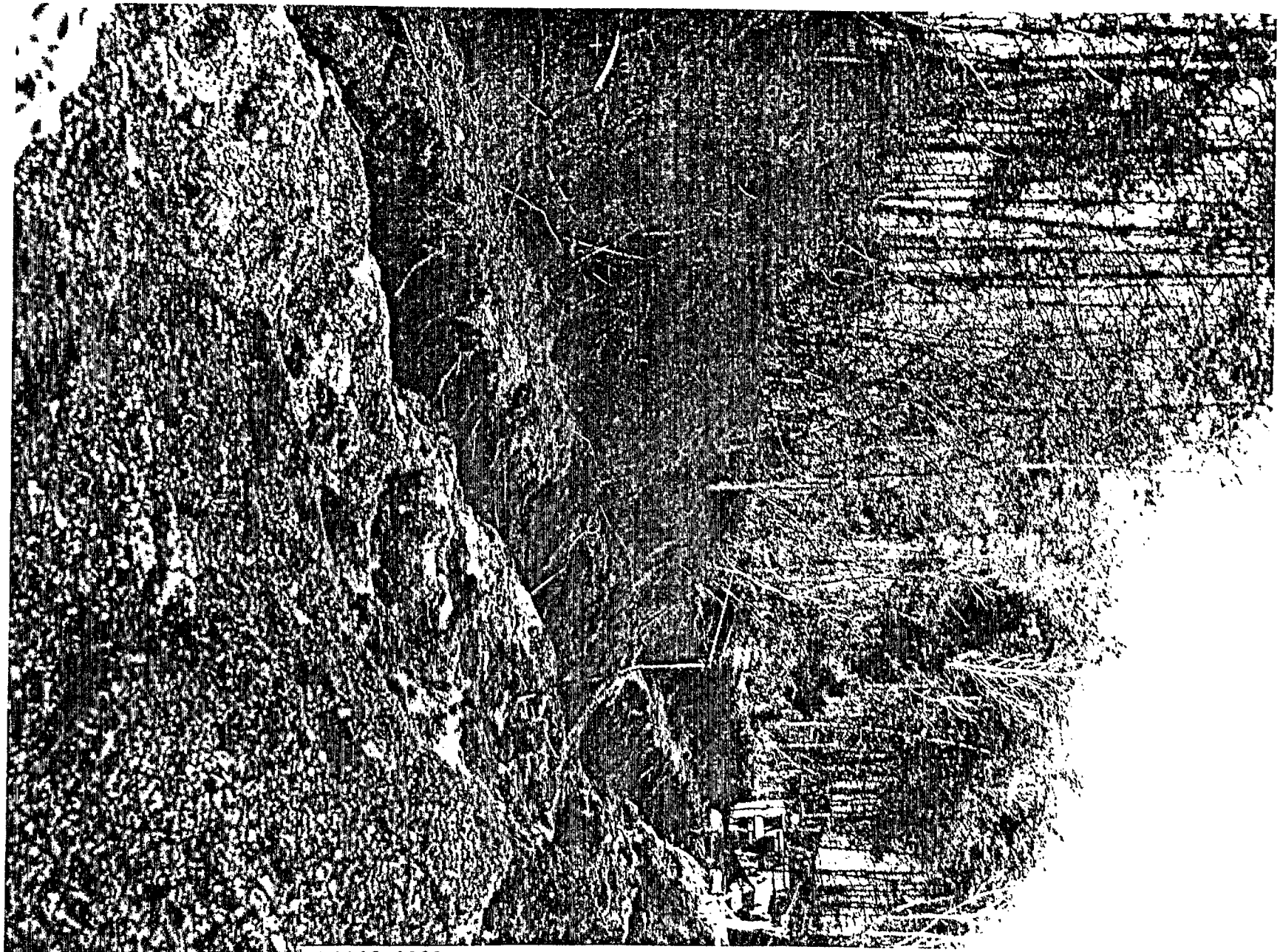
15904 1958
W. deLaguna White Oak Creek discharging to Clinch River



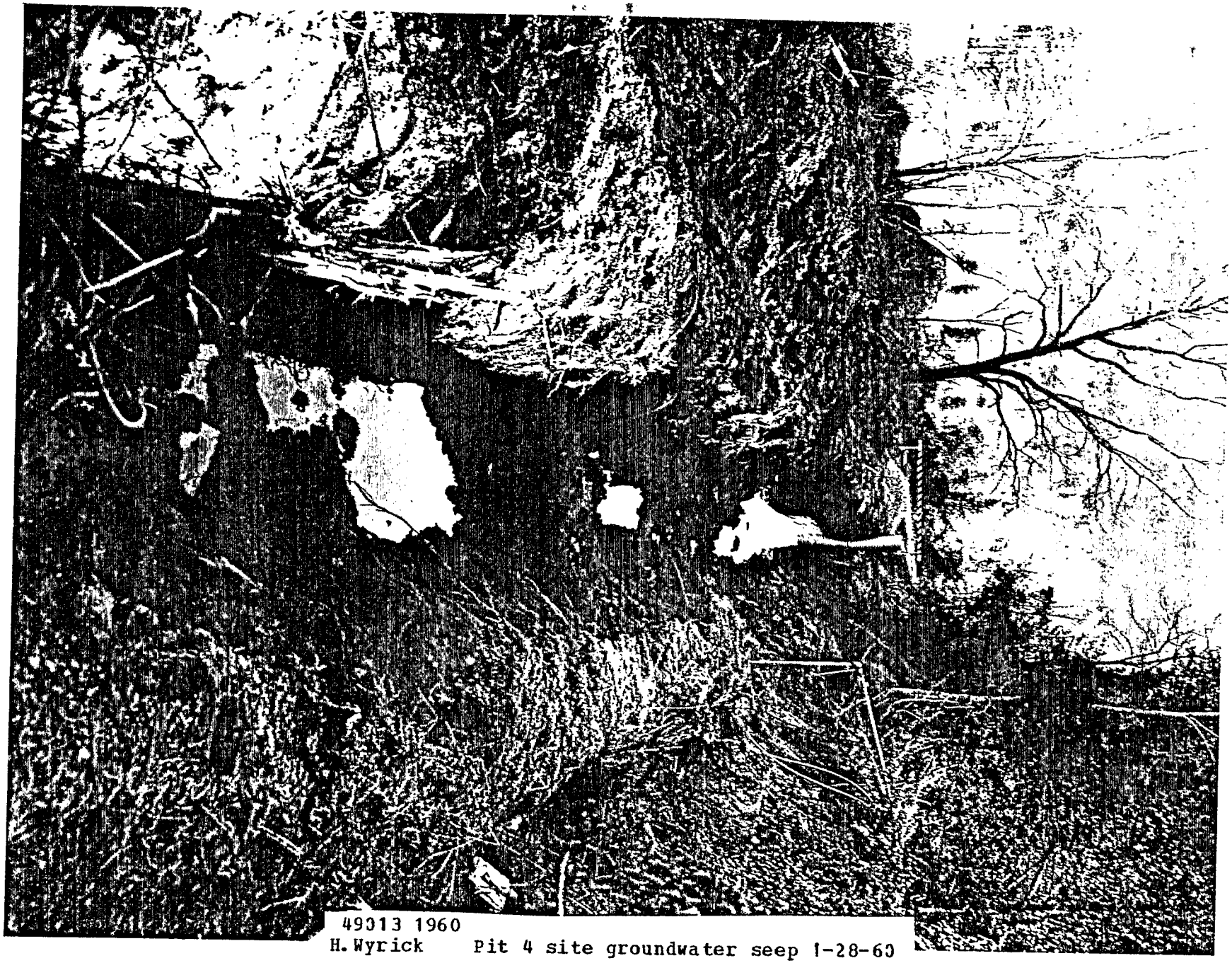
15911 1958
W. deLaguna White Oak Creek discharge to Clinch River



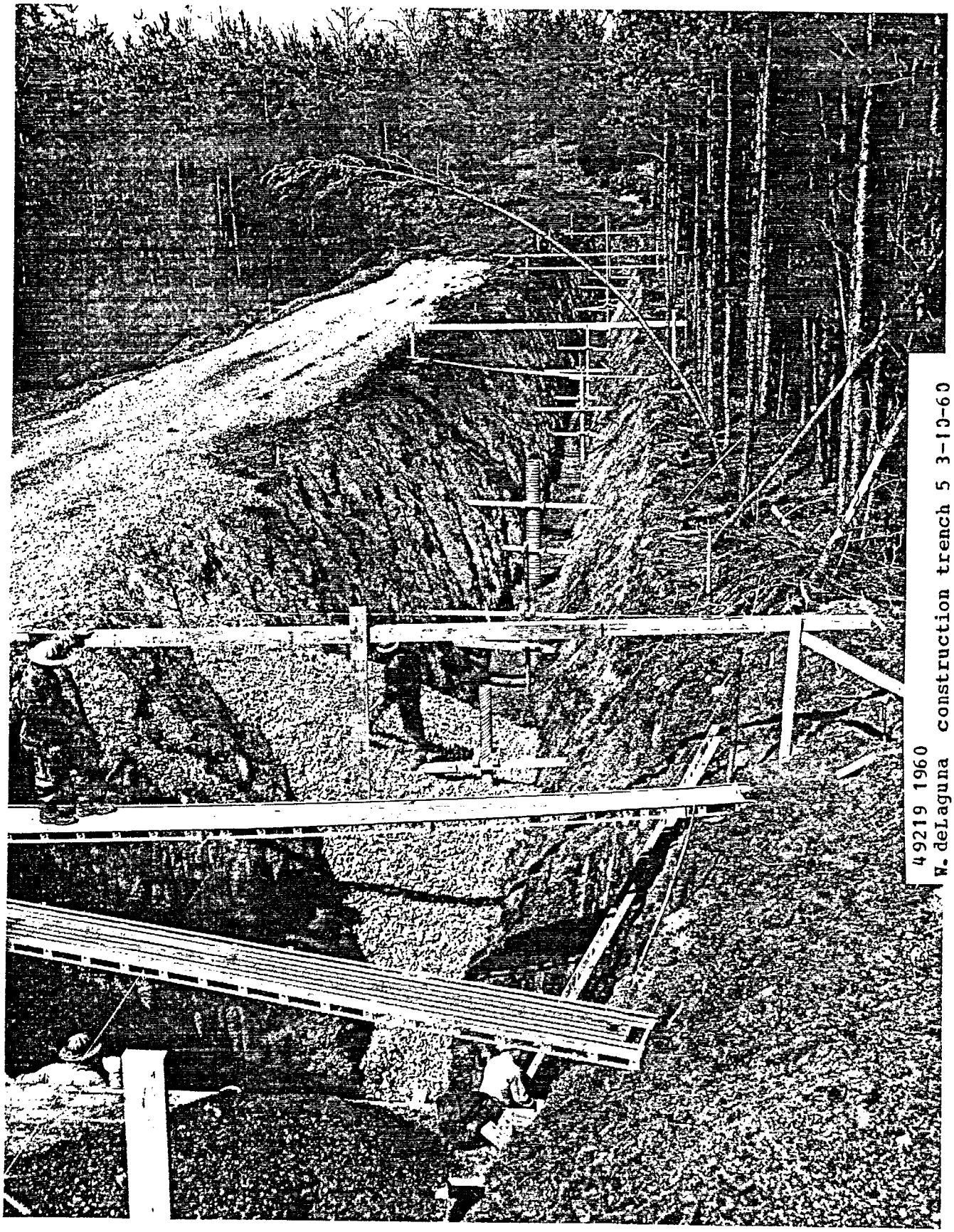
49011 1960
H. Wyrick Pit 4 eastern seep interceptor trench 1-28-60



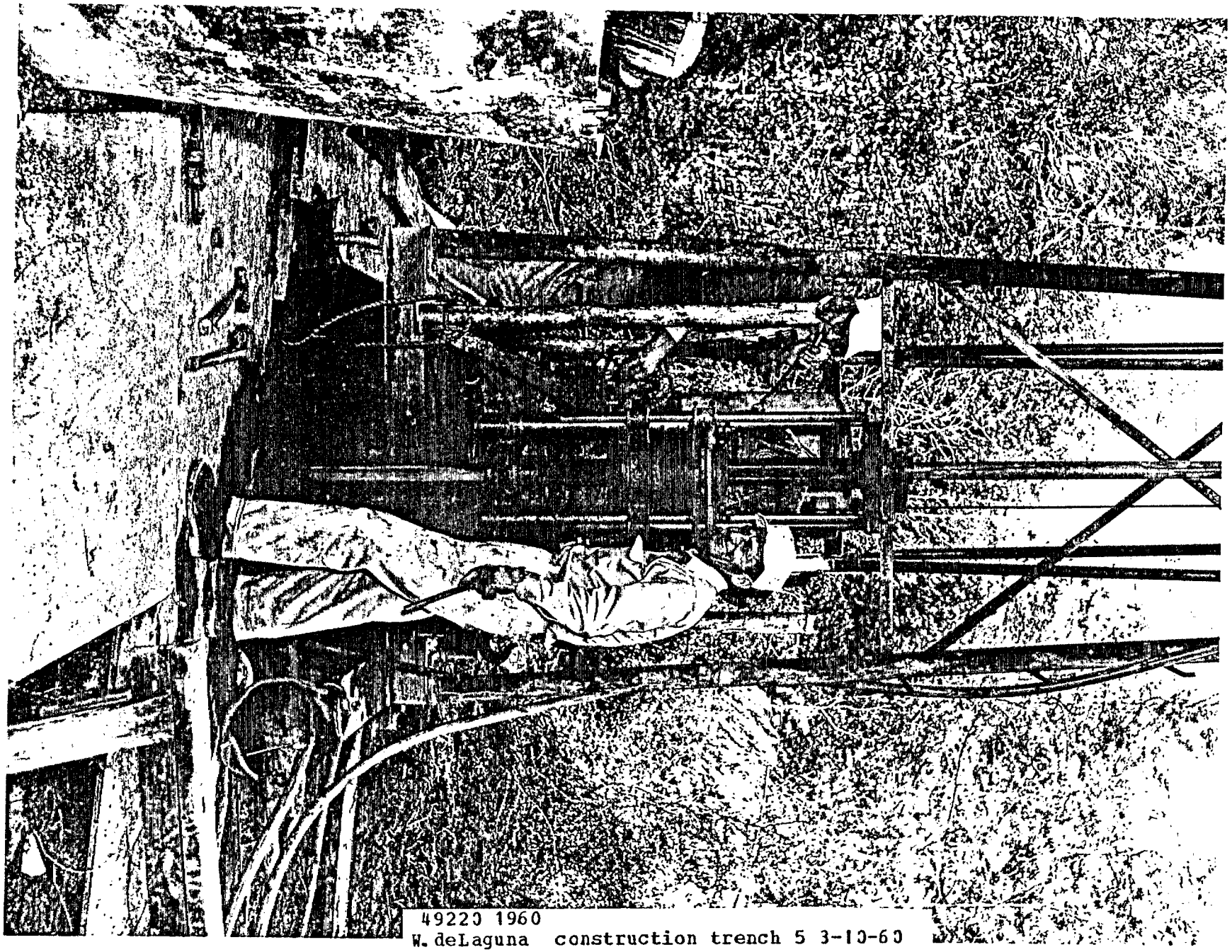
49012 1960
H. Wyrick Pit 4 eastern seep interceptor trench 1-28-60



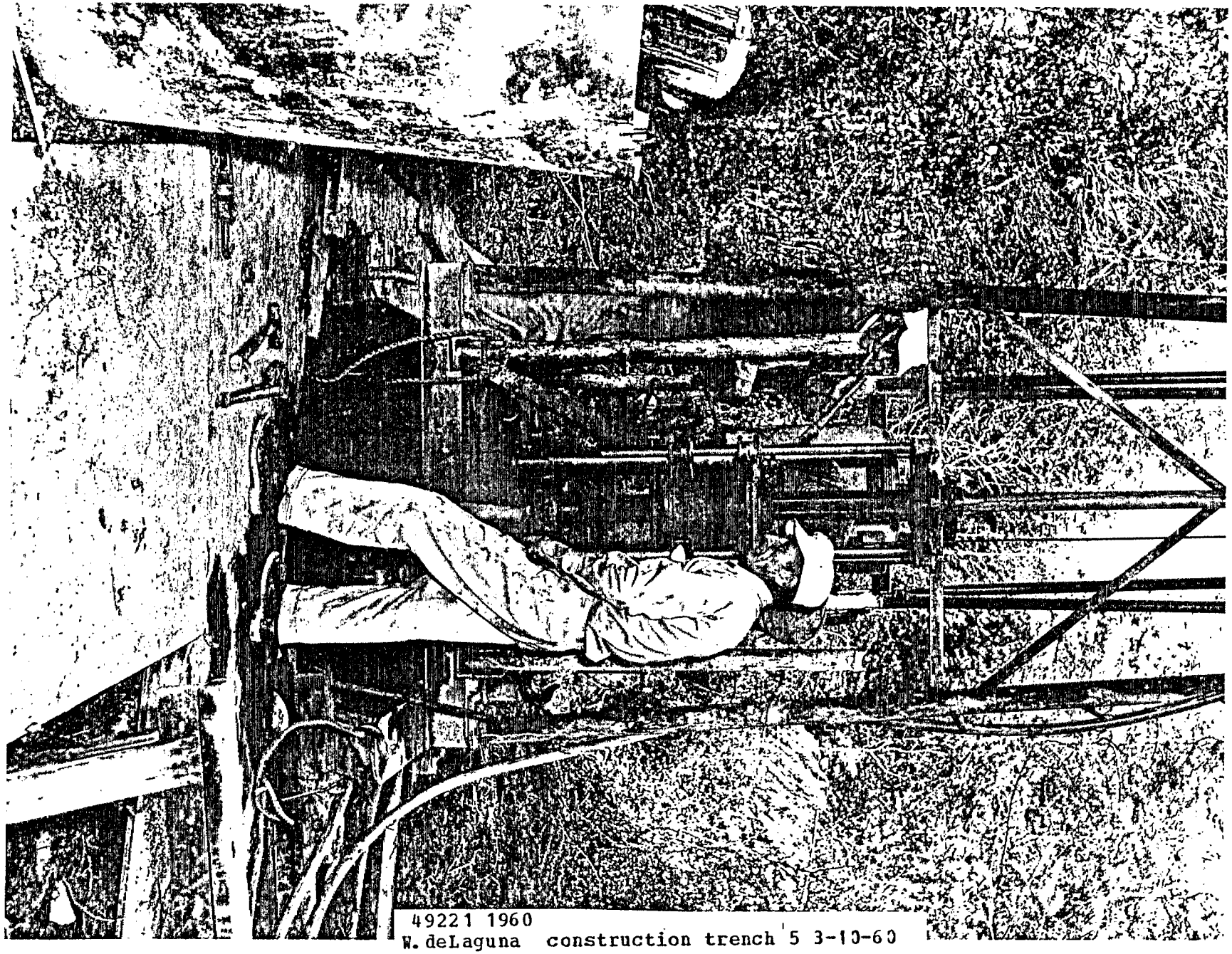
49013 1960
H. Wyrick Pit 4 site groundwater seep 1-28-60



49219 1960
W. deLaguna construction trench 5 3-13-60

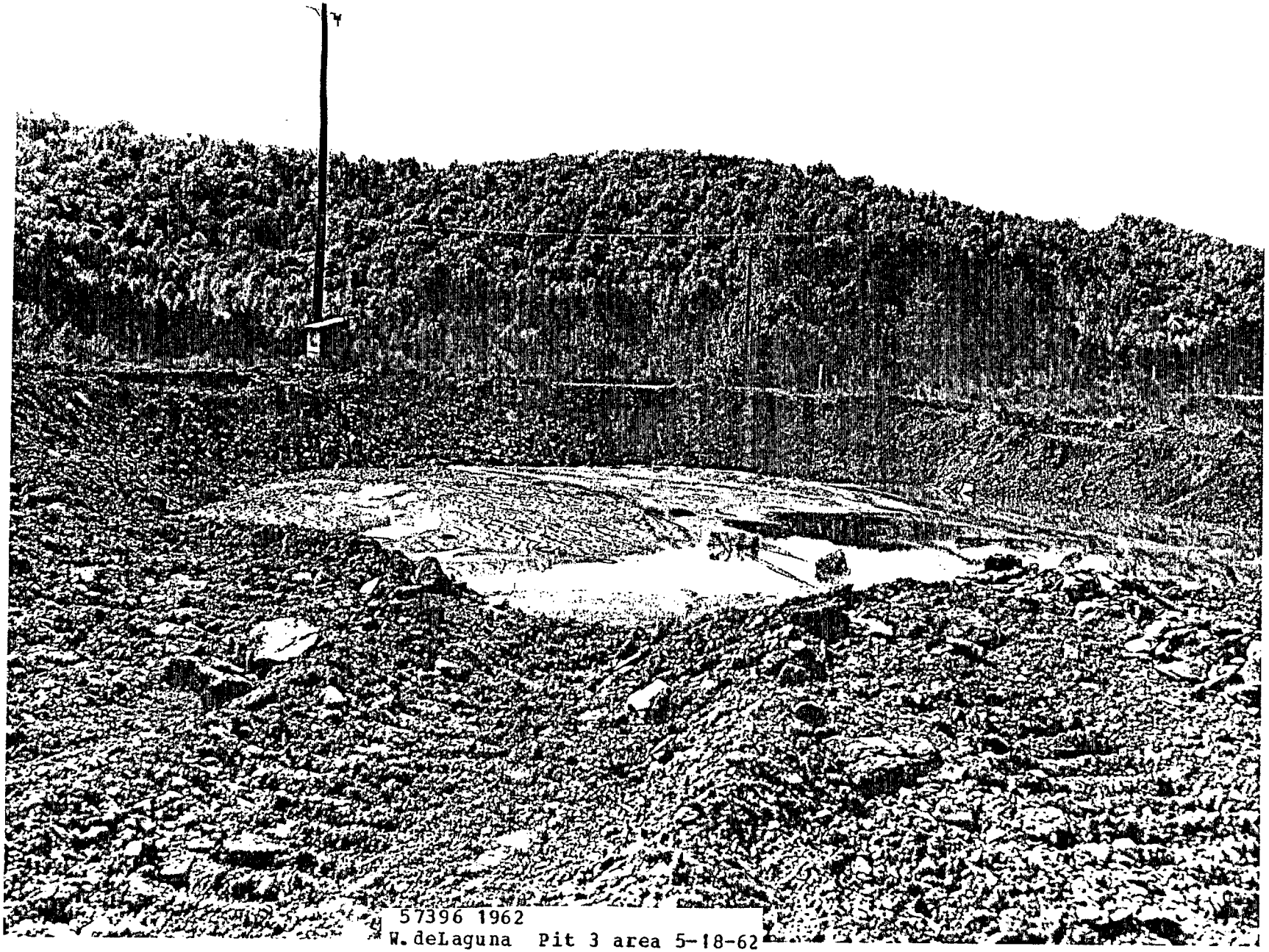


49220 1960
W. deLaguna construction trench 5 3-10-60

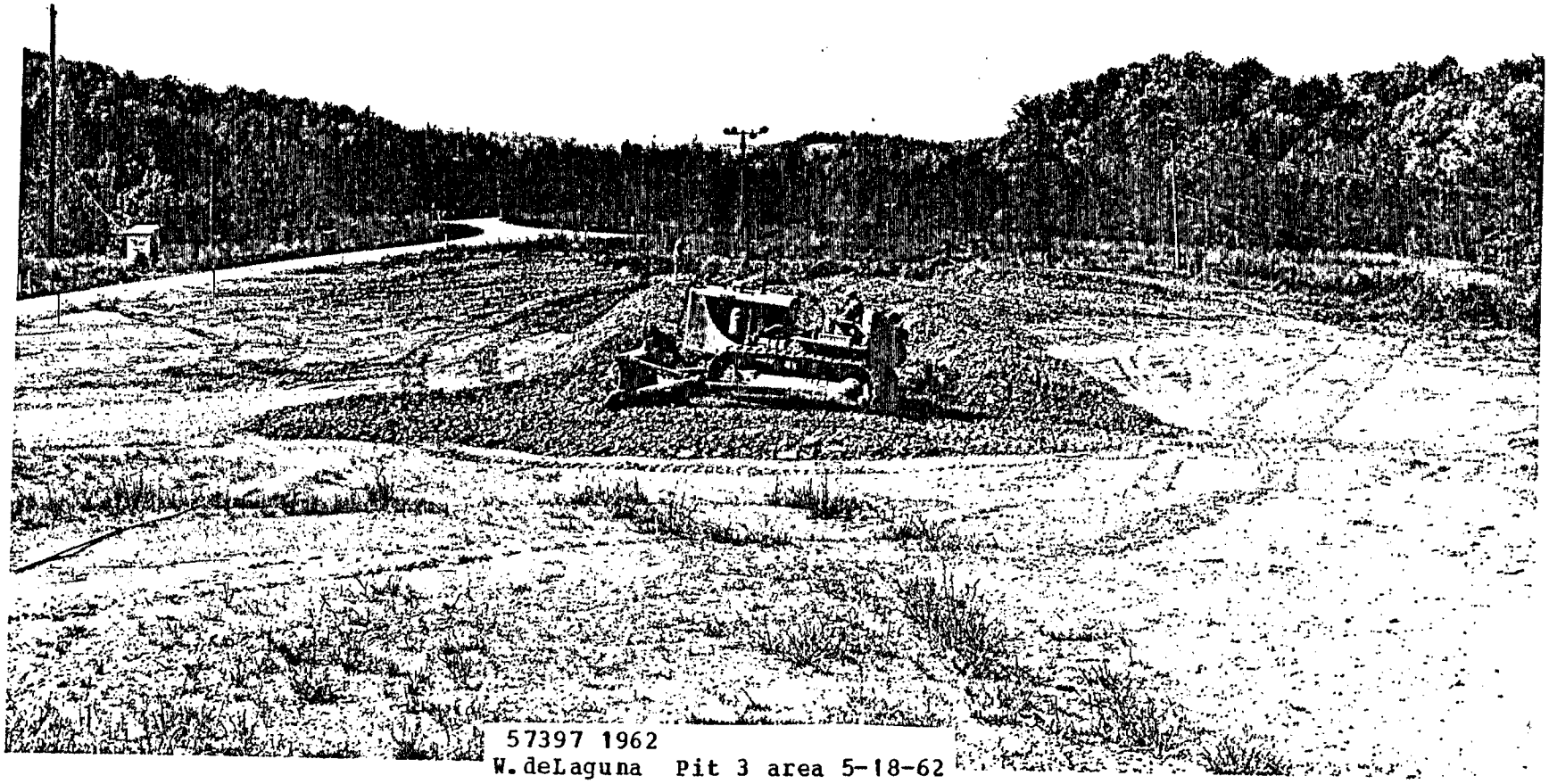


49221 1960
W. deLaguna construction trench 5 3-10-60

57395 1962
W. deLaguna well northeast of pit 3 5-18-62



57396 1962
W. deLaguna Pit 3 area 5-18-62



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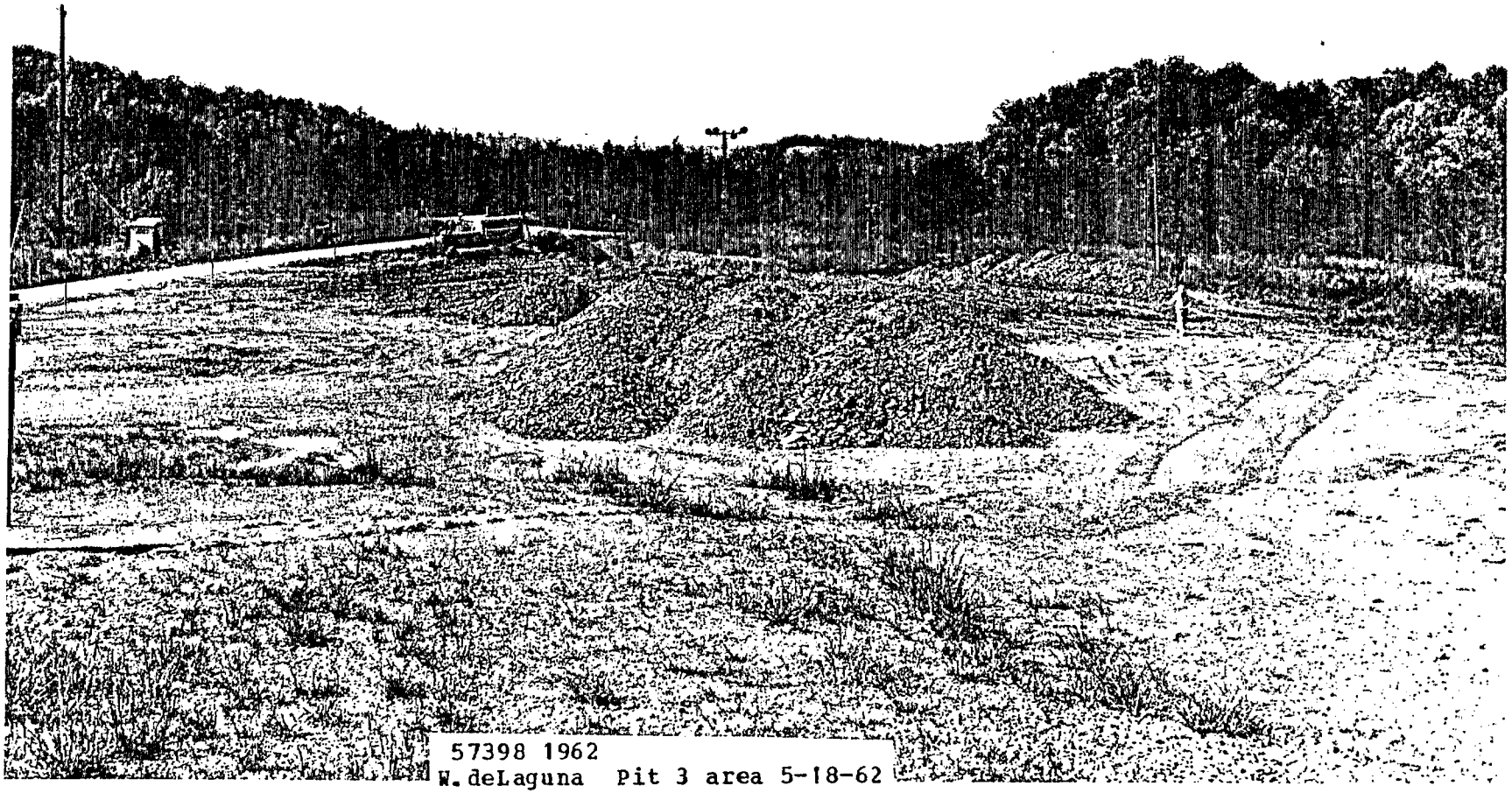
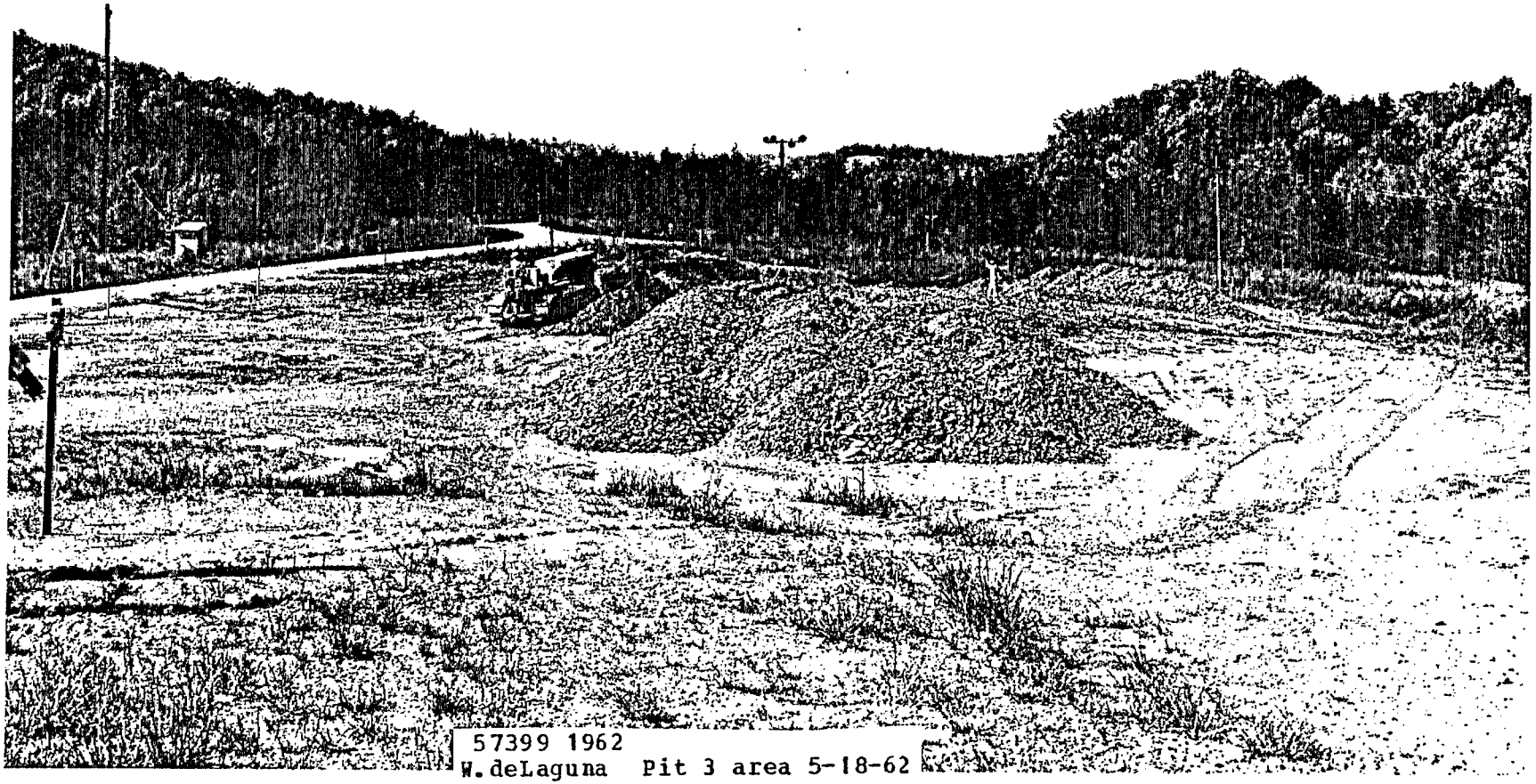
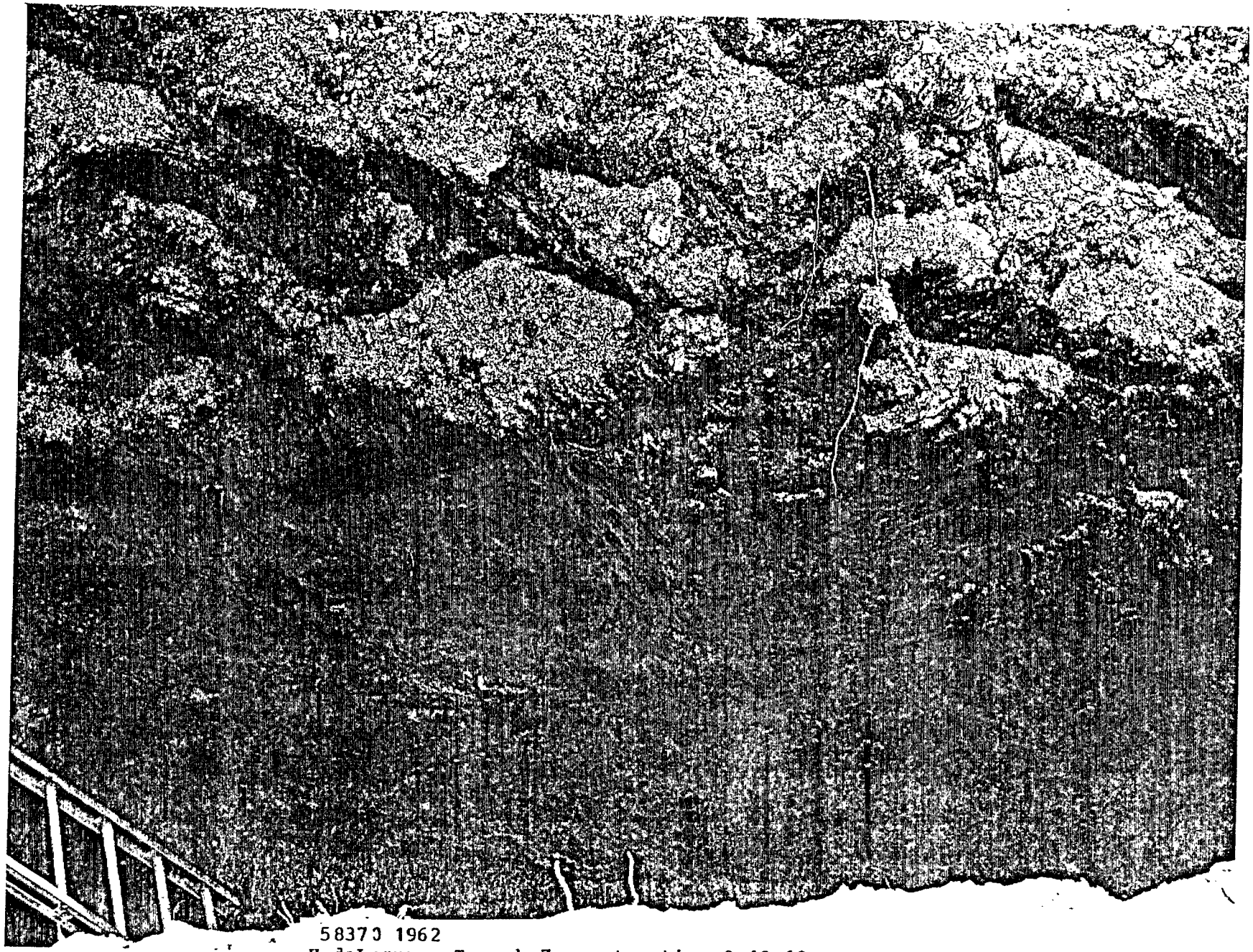
W.deLaguna Pit 3 area 5-18-62



57398 1962
W. deLaguna Pit 3 area 5-18-62

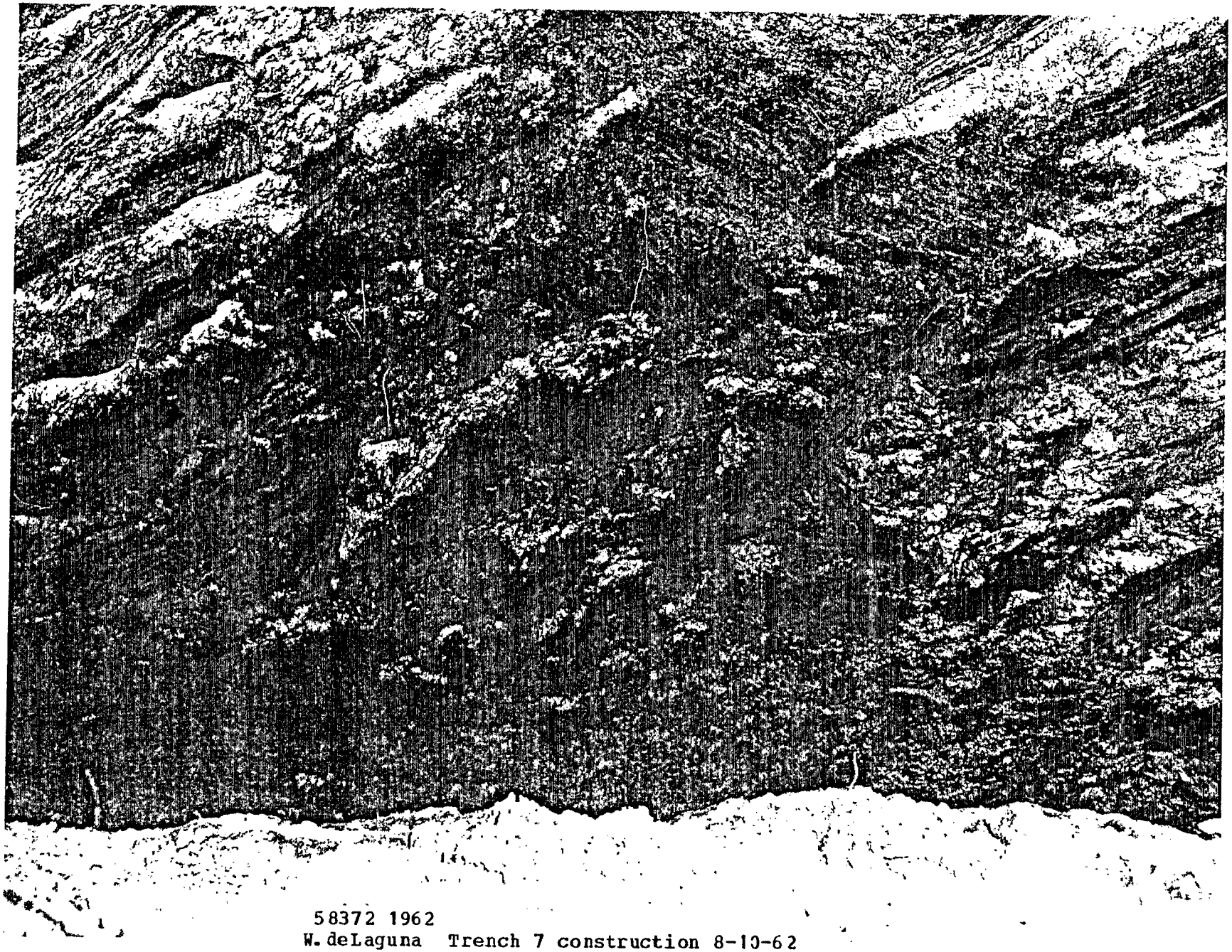


57399 1962
W. deLaguna Pit 3 area 5-18-62

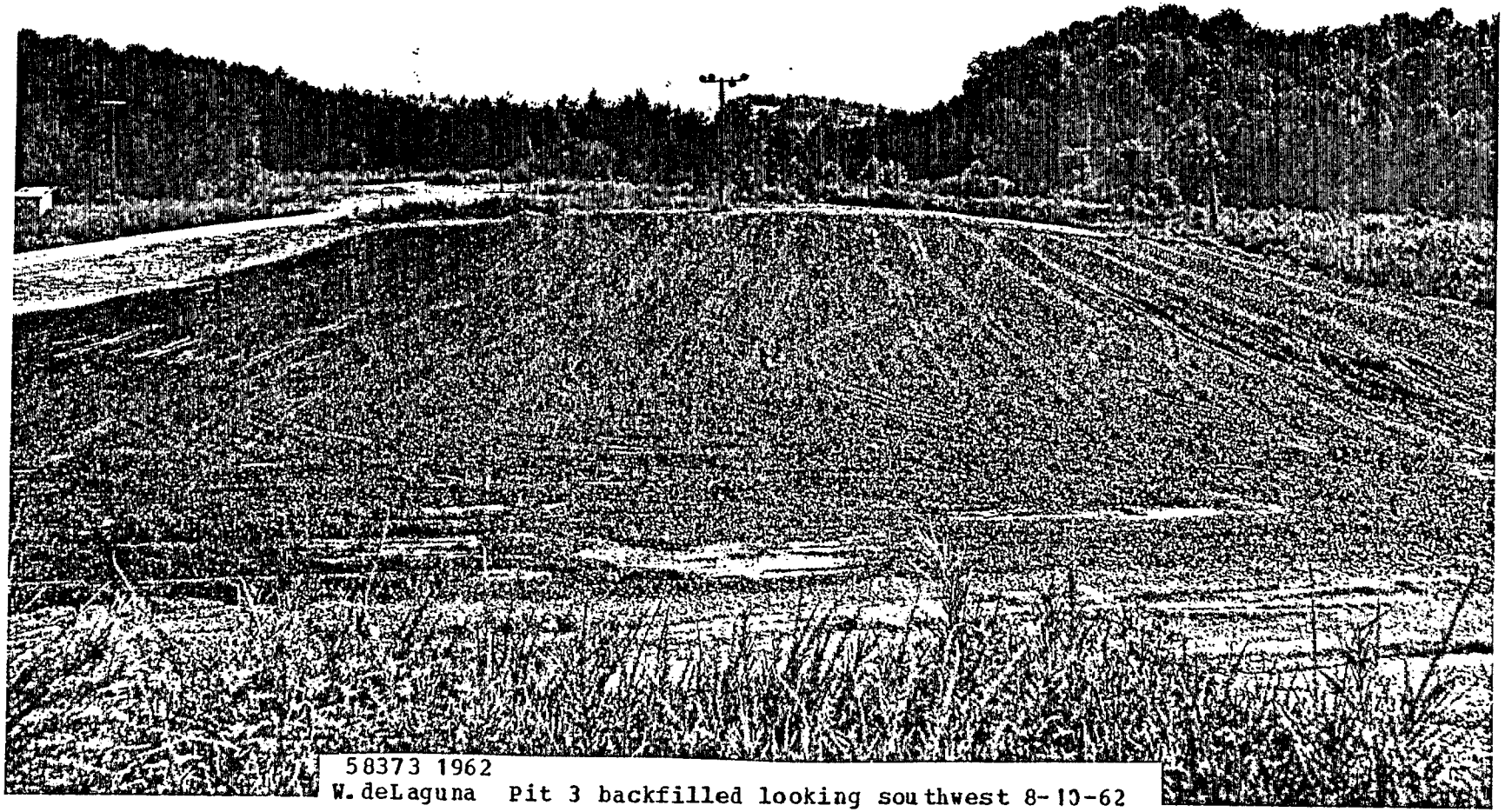


58370 1962
W. deLaguna Trench 7 construction 8-10-62

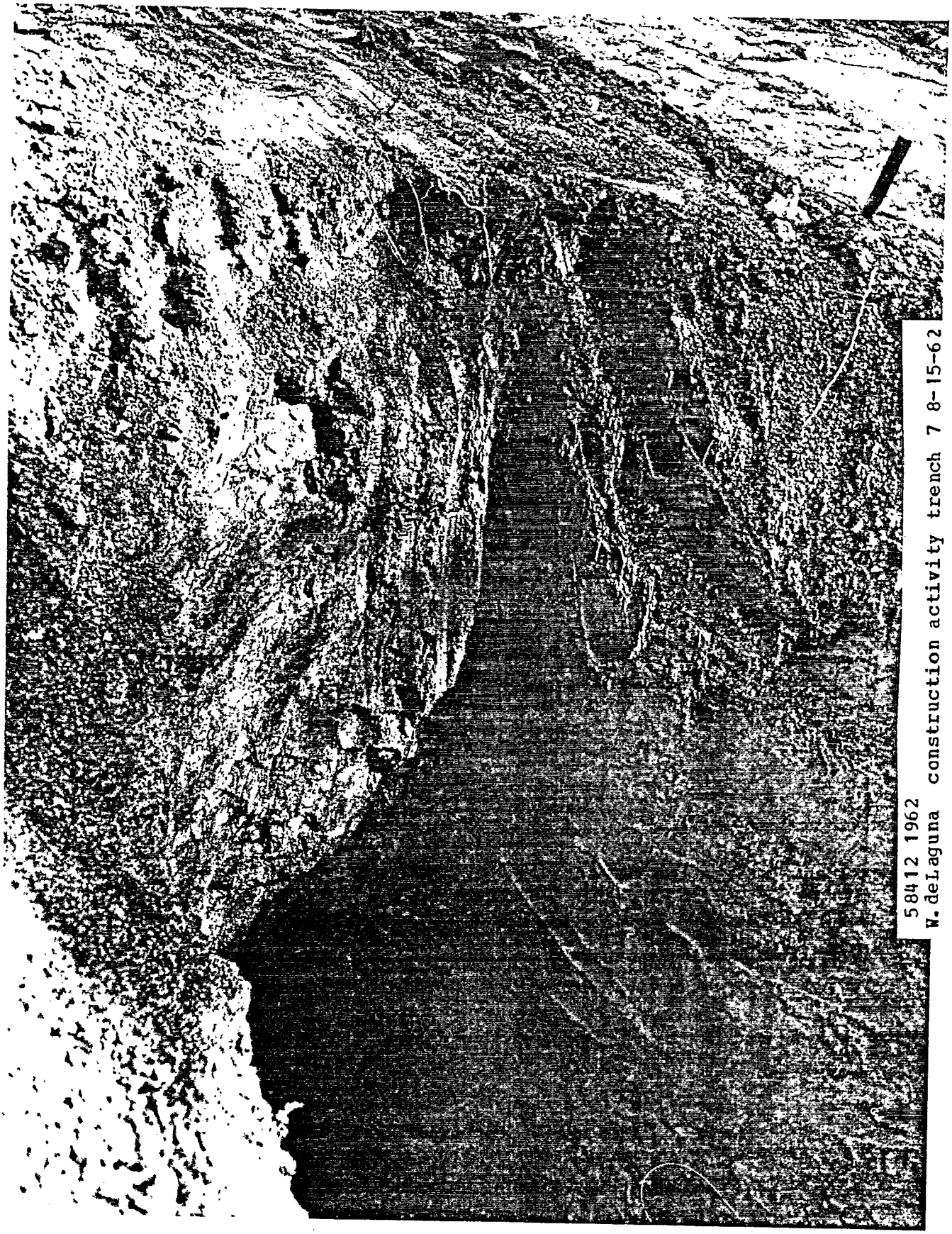
58371 1962
W. deLaguna Trench 7 construction 8-10-62

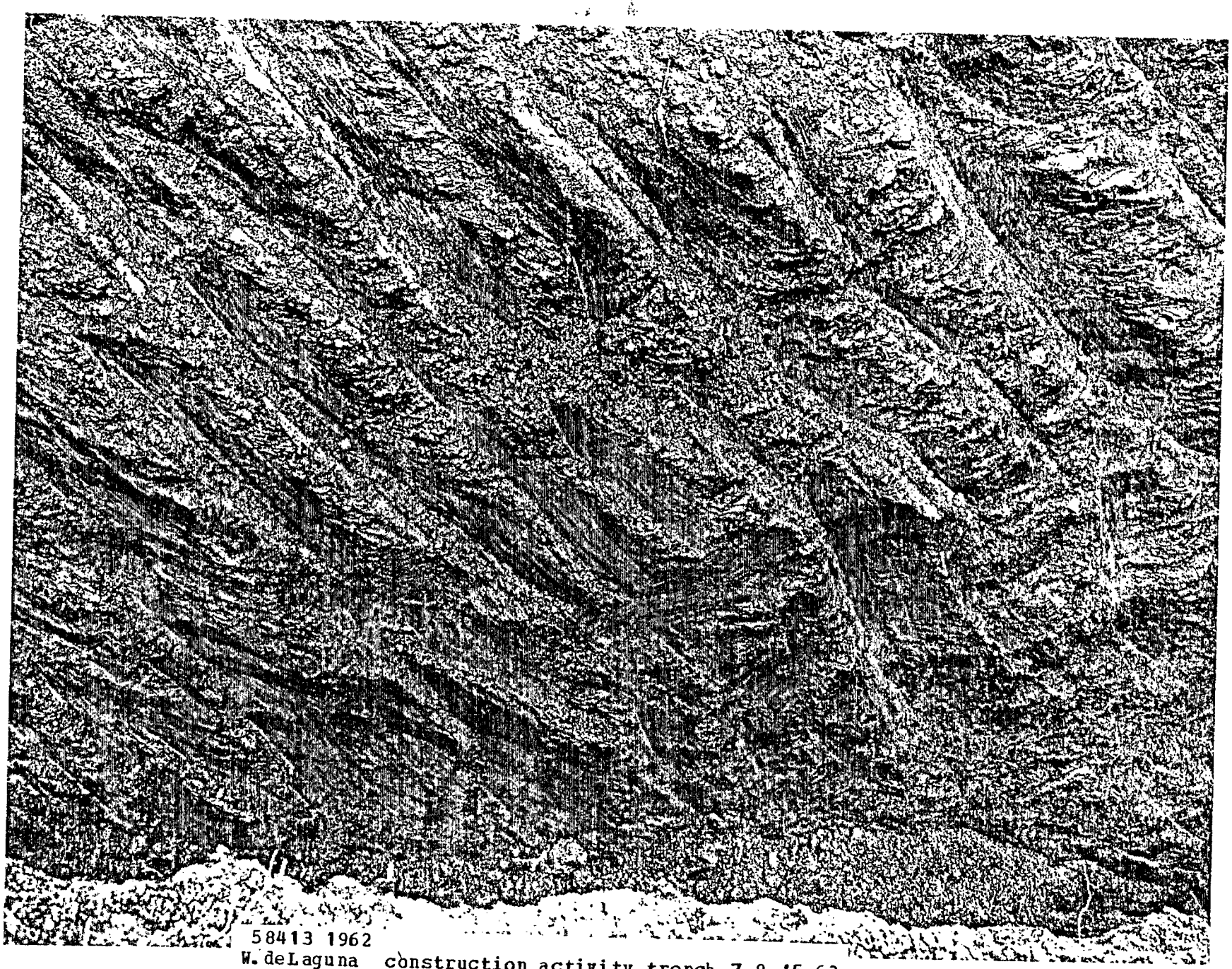


58372 1962
W. deLaguna Trench 7 construction 8-10-62

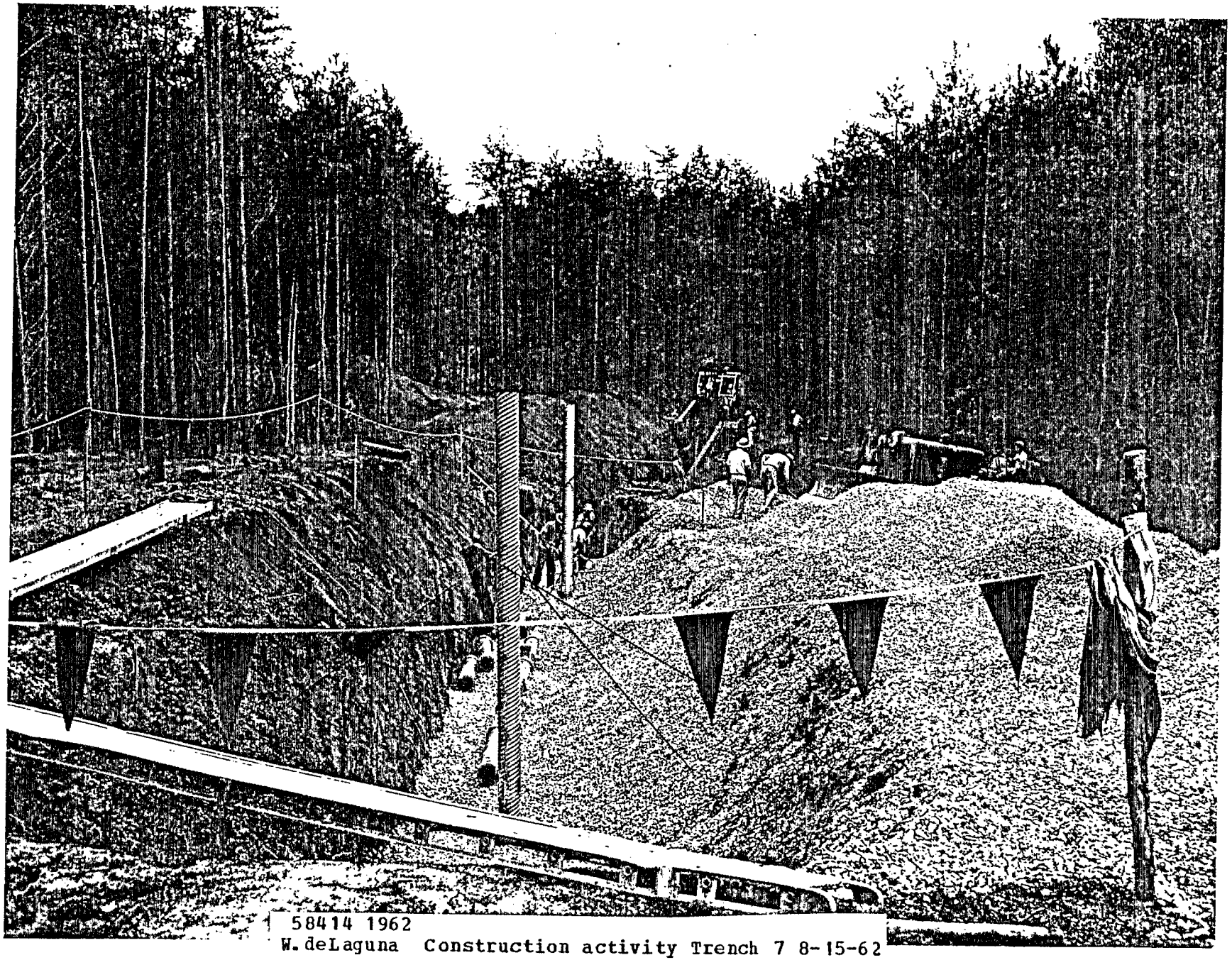


58373 1962
W. deLaguna Pit 3 backfilled looking southwest 8-10-62

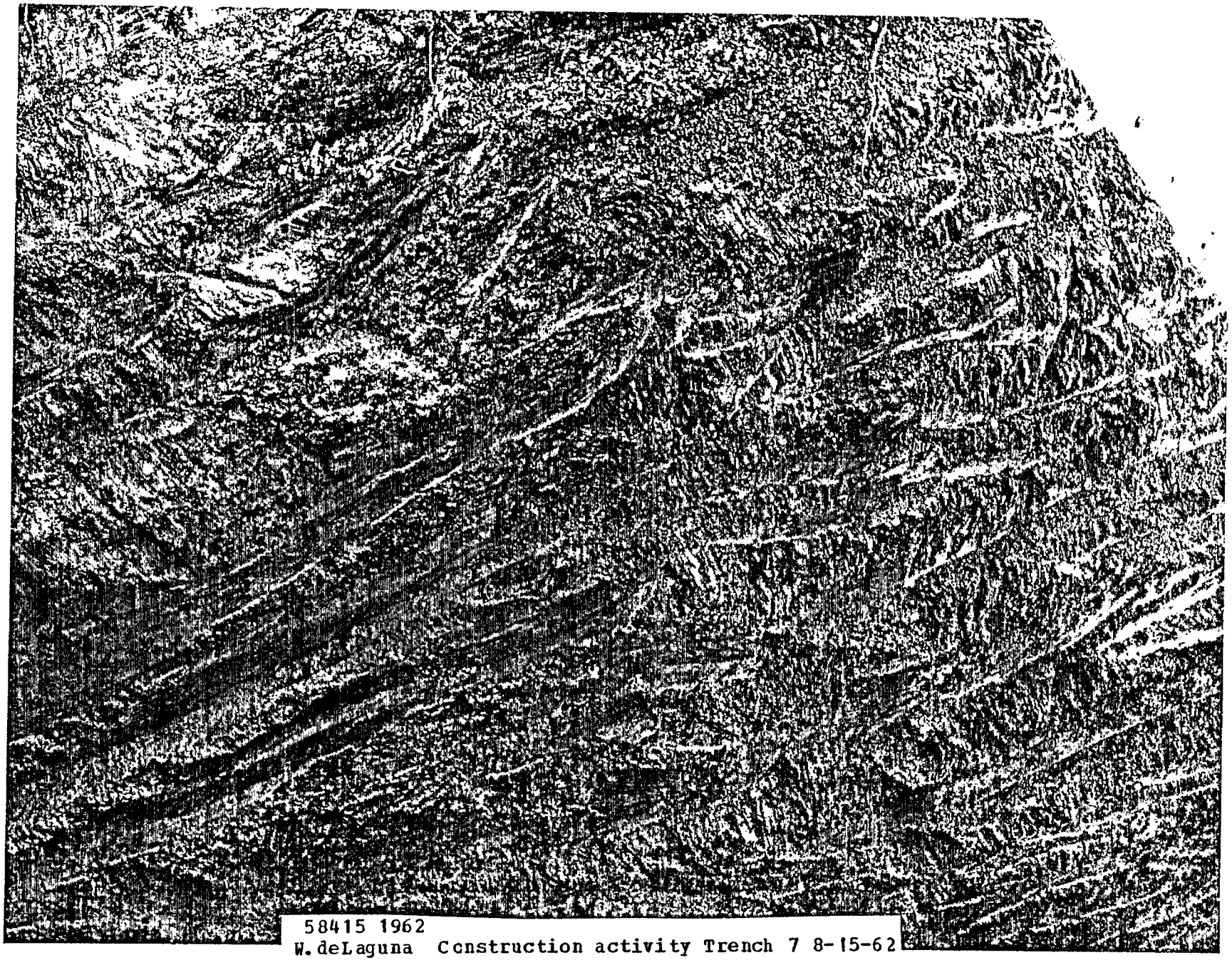

58412 1962
W. deLaguna construction activity trench 7 8-15-62



58413 1962
W. deLaguna construction activity trench 7 8-15-62



58414 1962
W. deLaguna Construction activity Trench 7 8-15-62



58415 1962
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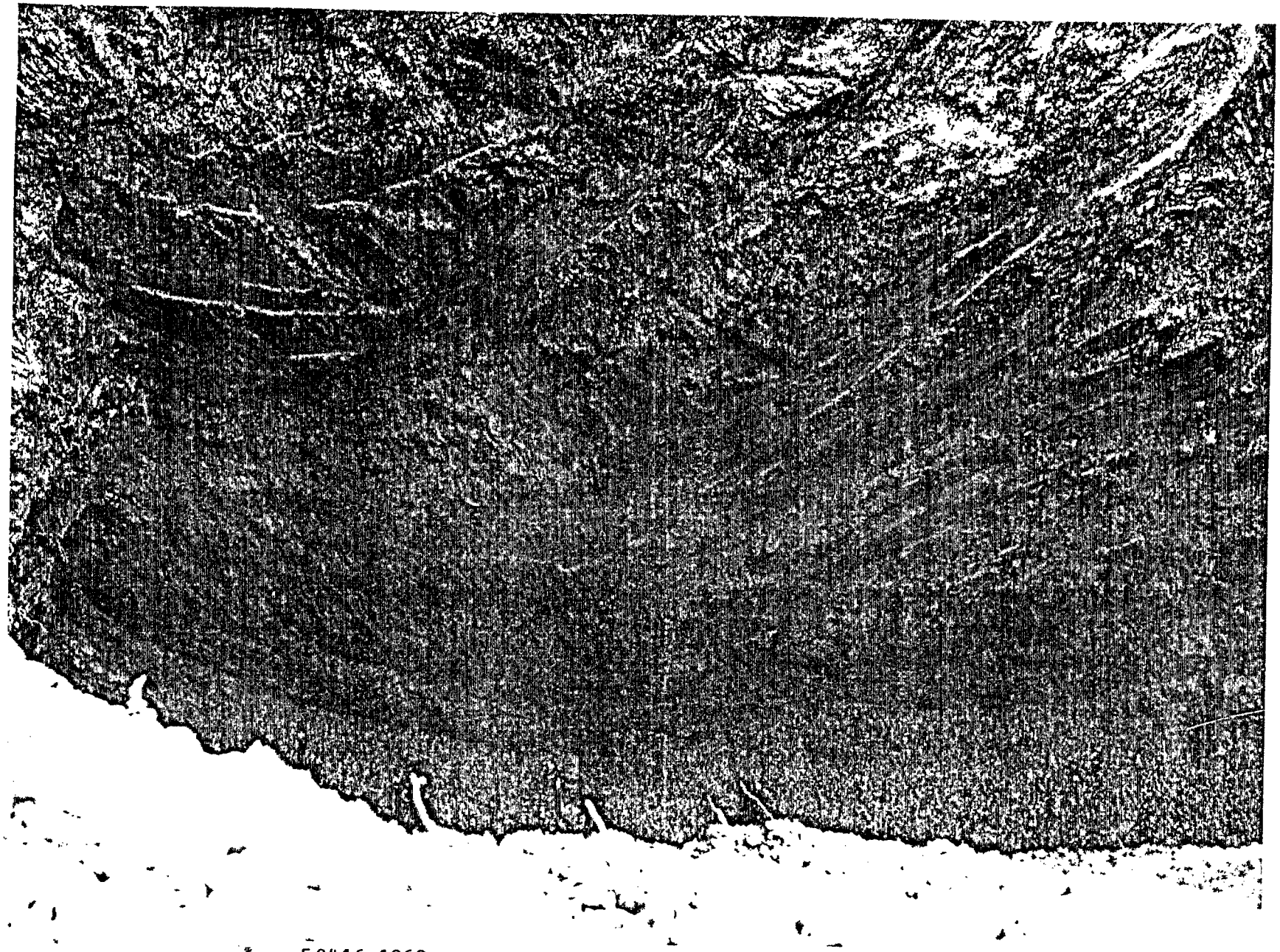

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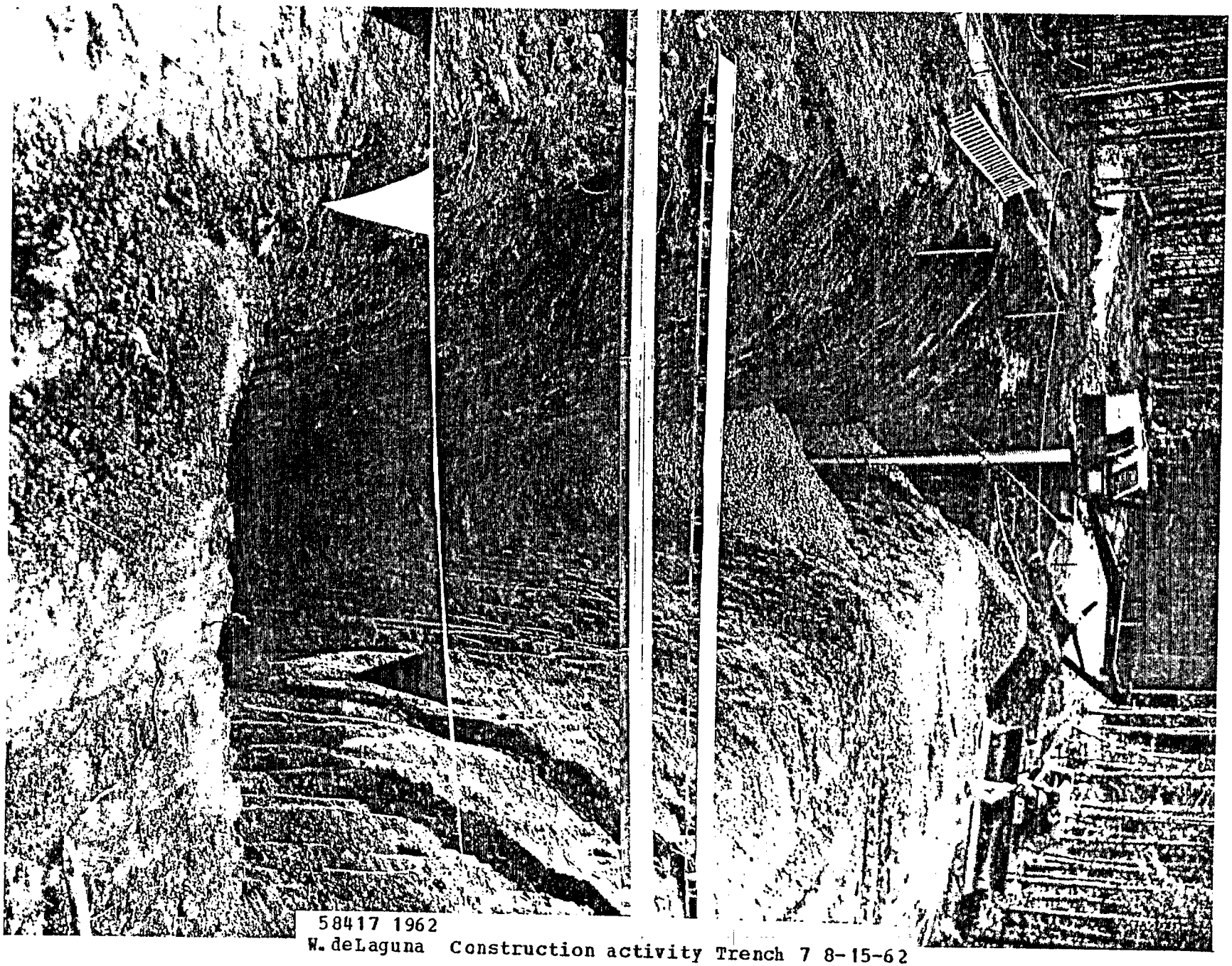
W. deLaguna Construction activity Trench 7 8-15-62



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58418 1962
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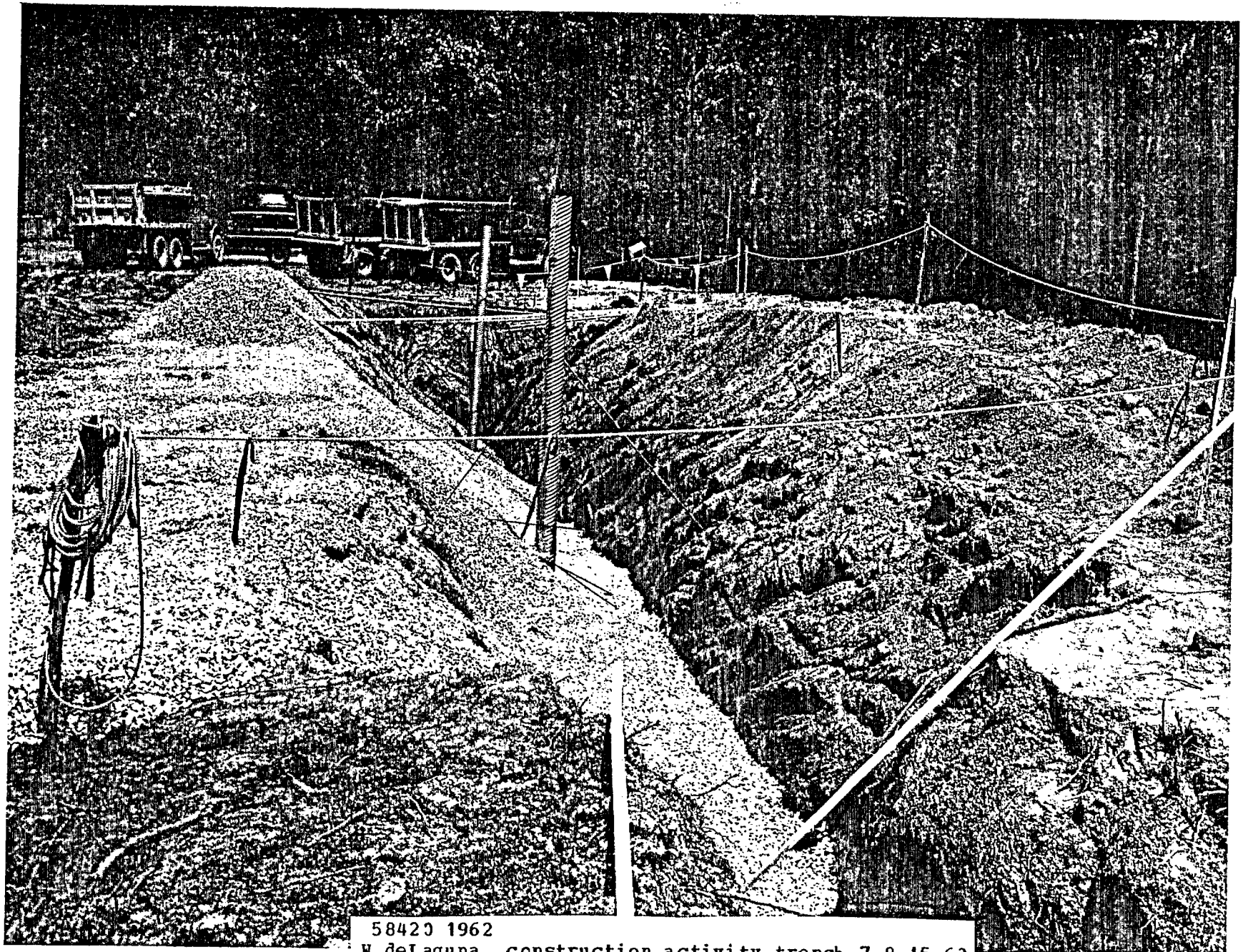
58419 1962
W. deLaguna construction activity trench 7 8-15-62



58420 1962
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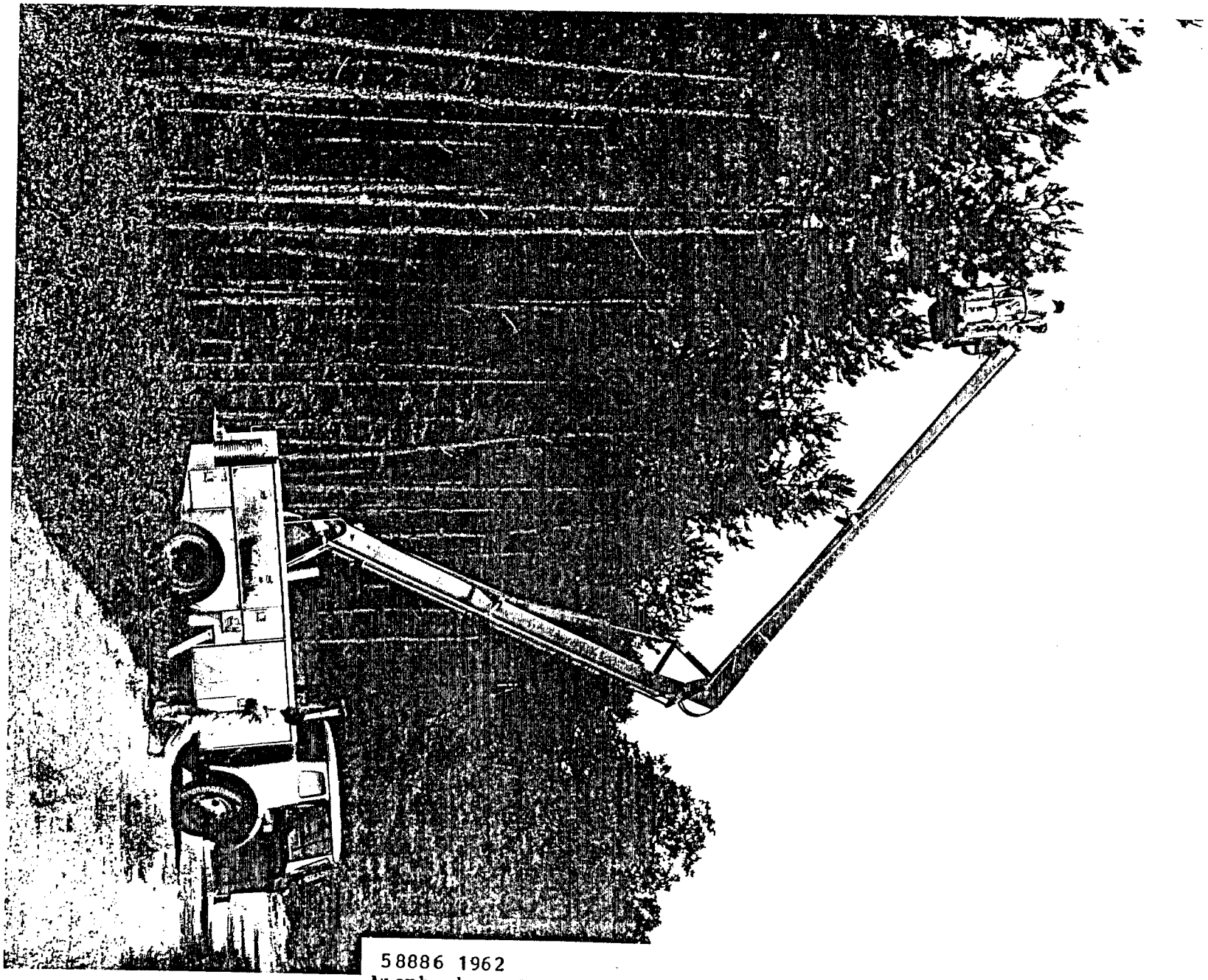
58421 1962
W. deLaguna construction activity trench 7 8-15-62



58886 1962
Auerbach Vegetation sampling at Trench 5

Distribution

Baldwin, J. S.	1505
Bates, L. D.	3047
Boegly, W. J. (5)	1505
Cannon, J. B.	4500N,D32
Cutshall, N. H.	1505
Davis, E. C.	1505
Dreier, R. B.	3504
Durfee, N. W.	1000,128C
Furth, W. F.	1000,203A
Garten, C. T.	1505
Haase, C. S.	3504
Homan, F. J.	3047
Huff, D. D.	1505
Jugan, M. R.	DOE/ORO
Lee, D. W.	2001,C100
Lee, S. Y.	3504
McNeese, L. E.	4500N,145
Mezga, L. J.	1505
Mulholland, P. J.	1505
Myrick, T. E.	3047
Olsen, C. R.	1505
Rohwer, P. S.	4500S,H252
Row, T. H.	4500N,C36
Sealand, O. M.	1505
Spalding, B. P. (15)	1505
Stansfield, R. G.	3504
Stow, S. H.	1505
Stratton, L. E.	3504
Tamura, T.	1505
Trabalka, J. R.	1505

Laboratory Records (2)

ORNL Patent Section