Report of Mine Inundation
Jefferson Island Mine
Diamond Crystal Salt Company

By

Marvin W. Nichols, Jr.
Subdistrict Manager
Dallas, Texas

Kelvin K. Wu
Chief, Mine Waste and Geotechnical Engineering Division
Bruceton, Pennsylvania

Jeffery H. Kravitz
Chief, Mine Emergency Operations
Hopewell, Pennsylvania

Frank E. O'Gorman
Public Information Specialist
Arlington, Virginia

John S. Risbeck
Supervisory Mining Engineer
Rolla, Missouri

Jay W. Durfee
Supervisory Mining Engineer
Baton Rouge, Louisiana

William R. Wilcox
Supervisory Mine Specialist
Dallas, Texas

Richard D. Feehan
Mine Specialist
Dallas, Texas

David P. Lilly
Mine Specialist
Topeka, Kansas

Division of Audio Visual Resources
Education and Training

Name	Title
William A. Stone	Motion Picture Production Specialist
Earl F. Mazzeo	Audio Visual Production Specialist
Timothy W. Kirby	Television Production Specialist

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INTRODUCTION

This is an investigative report of a mine inundation that occurred November 20, 1980, at Jefferson Island Mine, Diamond Crystal Salt Company, New Iberia, Louisiana, MSHA I.D. No. 16-00508. The investigation was made pursuant to the provisions of the Federal Mine Safety and Health Act of 1977, Public Law 91-173, as amended by Public Law 95-164 (30 USC 801 et. seq.).

In conducting the inquiry into possible causes of the Jefferson Island Mine inundation, the MSHA investigation team was compelled to investigate the actions of Diamond Crystal and Texaco, Inc. In the case of Diamond Crystal, MSHA had jurisdiction in the matters of health and safety on the mine site, with a history of inspections that made MSHA familiar with the operation of the mine. In the case of Texaco's oil and gas drilling operations, however, MSHA had no jurisdiction whatsoever, nor any records prior to the inundation. MSHA was compelled to examine the activities of Texaco in the vicinity of Lake Peigneur because those activities might have been significant in this inundation accident.

The immediate purpose of the mine emergency response by MSHA was to ensure the safety of both miners and residents in the area who might be affected by the inundation of the mine and any related subsidence.

At the same time, an investigation into the entire accident was pursued. The purpose of that investigation was to determine, if possible, the causes of the mine inundation.

The objective of the investigation, and the publication of this report, is to prevent similar accidents.

In order for the reader to better visualize the destruction caused by the inundation, photographs have been added to the report as Appendix EE.

SUMMARY

Jefferson Island Mine, owned and operated by the Diamond Crystal Salt Company, was located approximately 12 miles west of New Iberia, La. Lake Peigneur was above part of the mine workings in the salt dome.

The inundation was first observed at approximately 0800 hours CST on November 20, 1980. Before the accident, there were two Texaco drill rigs in operation, one on the lake shore and one on the surface of the lake. Their work proceeded concurrently with the mining below.

Shortly after the day shift went underground to commence work, an inrush of water was detected, and emergency evacuation

was carried out immediately. Because mine emergency evacuation procedures were immediately followed, there were no injuries or loss of life. This mine inundation meant the loss of the mine, the loss of employment for the miners, and a substantial financial loss to all concerned.

The MSHA mine emergency team was mobilized rapidly and arrived at the mine site on the same day. Priorities were set as follows:

1. Ensure that all miners were evacuated safely and that no miners were missing;

2. Establish safeguards to preclude unnecessary risk of life;

3. Provide assistance to the mine operators for safely obtaining records and material, and securing the mine facilities;

4. Assist State and local law enforcement officials to provide maximum safeguards for the public; and

5. Investigate the cause of the inundation.

These efforts permitted MSHA to determine that the salt dome was relatively stable under the immediate post-inundation conditions. The residents were allowed to return to their homes and the workers to the mine site and surrounding properties. MSHA's mine emergency operation was concluded on November 30, 1980. An inspection program was established to ensure the continued safety of the personnel at the mine site. This program was continued until January 16, 1981.

The investigation into the cause of the inundation continued. In making its study for this report, the investigating committee considered the significant factors that might have contributed to the cause of the mine inundation. Among the factors considered were:

<u>The Jefferson Island Mine</u>

- Subsidence rate on the mine site;
- Mine maps and other studies;
- Rock mechanics studies of the mine;
- Underground closure rates of mine openings;
- Type of mining on all levels;
- Problems which might have developed on each level;

- Integrity of the structure of the salt mine;
- Stress conditions.
- Any abnormal fracture zones;
- Previous water problems; and
- Possible outbursts.

The Texaco Drill Rig

- Presence and the location of the drill rig on the lake;
- Possibility that the drilling operation penetrated the salt mine;
- Possibility that the drilling operation did not penetrate the mine but came in close proximity of the mine openings in the dome;
- Possibility that lake or ground water entered the well;
- Possible dissolution of salt and resulting cavities;
- Possible causes of the jamming of the drill string;
- Possible causes of the loss of the drilling mud;
- Effect of high pressure drilling mud on an existing fracture zone;
- Effect of a high hydrostatic head at the bottom of the well;
- Actions of the drill crew when the drill encountered difficulties prior to the inundation;
- Drill logs and other records; and
- Coordination between Texaco and Diamond Crystal.

Additional factors considered were the involvement of the following principal agencies:

Local Agencies

- Iberia Parish Police Jury

State of Louisiana Agencies

- Louisiana Stream Control Commission
- Department of Wildlife and Fisheries
- Department of Transportation and Development, Office of Public Works
- Office of Conservation
- Louisiana State Mineral Board

Federal Agencies

- Department of the Army, Corps of Engineers (COE)
- Department of the Interior, Fish and Wildlife Service (FWS)
- Environmental Protection Agency (EPA)
- National Maritime Fisheries Service, National Oceanic and Atmospheric Administration (NOAA)
- U. S. Coast Guard
- Department of Labor
  - Mine Safety and Health Administration (MSHA)
  - Occupational Safety and Health Administration (OSHA)

THE JEFFERSON ISLAND MINE

Background History

The Diamond Crystal Salt Company's Jefferson Island Mine was located about 12 miles west of New Iberia, Iberia Parish, La. At the time of the inundation, the mine employed 297 persons in both the underground workings and the mill facility. The mine operated three eight-hour shifts per day, seven days per week. Mining was accomplished by a room-and-pillar method.

Jefferson Island was the northernmost of five salt dome islands that are prominent landmarks along the central coast of Louisiana. The islands were spaced in a line beginning with Belle Isle, south of Morgan City, La., and extending northwest to Jefferson Island. The locations are shown in Appendix A.

Each of the five islands was the result of an uplifting of landscape by a rising salt stock from bedded salt perhaps as deep as 50,000 feet. Depth to the salt beneath the five islands varied from several hundred feet at Belle Isle to virtual surface penetrations on Avery Island, about 10 miles south of Jefferson Island.

Jefferson Island had a maximum elevation of 75 feet and included approximately 300 acres of area. The island was on a spine of salt that rose above the landscape on the south side of the salt dome. The Jefferson Island salt dome was irregular in shape and roughly elliptical in plan (Appendix B). Its major diameter was about 6,300 feet on the 800-foot contour and oriented north and south. The major portion of Jefferson Island's salt dome lay beneath Lake Peigneur, a nearly circular shallow depression approximately 1-1/2 miles in diameter. The lake had an area of approximately 1,000 acres and, prior to the inundation, ranged from 4 to 15 feet deep.

At Jefferson Island, the major portion of the salt dome beneath Lake Peigneur had a cap rock that was 275 feet thick in some areas. The cap rock dipped gently toward the west and thinned in places to about 100 feet in thickness. Sulphur in the cap rock, derived from insoluble sulphates in the salt, had been mined by the Frasch process in the past.

Jefferson Island was named after Joseph Jefferson, a noted actor who owned the island prior to 1900. The island had been formerly called Orange Island. In 1894, Jefferson contracted to have a water well drilled near his home on the island. Rock salt was encountered at 334 feet in the summer of 1895. Drilling continued to a depth of 2,090 feet without leaving the salt. A surface contour map of Jefferson Island may be found in Appendix C and a map of the mined out area in Appendix CC, with a cross section of these areas in Appendix DD.

Mining Development

In July 1919, Lawrence Jones and D. L. Bayless drilled 36 holes and mapped the contours of the salt around the island portions of the salt dome. In October of 1919, Jones and Bayless organized the Jefferson Island Salt Mining Company. A shaft was begun which was lost. During March of 1920, another shaft was begun; but because of problems with sealing off ground water, the shaft was not completed until February 1922. The 900-foot shaft did not encounter cap rock. It contacted the salt at 104 feet below the collar. The shaft was 25 feet in diameter and divided into four compartments with timber sets. The concrete shaft walls were extended 76 feet beyond the salt contact. Mining was begun on the 800-foot level.

Early mining on the 800-foot level was done by a shrinkage mining method. Rooms 65 feet wide and 90 feet high were developed, resulting in a room-and-pillar layout, the pillars approximately 75 feet square (Appendix D). An undercut was first drilled and blasted. Several slices were then blasted from the back, with fallen salt from previous slices serving as a working floor for subsequent slices. Broken salt was loaded into rail cars with an electric shovel, crushed underground and stored in holding bins. Five-ton capacity skips brought the salt to the surface. By 1930, annual production had reached 218,300 tons.

In 1940, a decline was driven to the 1,000-foot level (Appendix E). This decline was steep, and salt was hoisted up a track on the decline to the shaft at the 800-foot level. Eventually the shaft was deepened to 1,030 feet so that salt could be hoisted directly to the surface from that level. The shrinkage mining method was used on the 1,000-foot level, and 75-foot square pillars were aligned directly beneath the pillars on the 800-foot level. The rooms were mined to a height of about 100 feet and a width of 65 feet.

In 1957, the mine was sold to the Diamond Crystal Salt Company. Diamond Crystal continued mining on the 1,000-foot level until 1964. Diamond Crystal changed the method of mining to a bench system. Room and pillar sizes remained the same. Salt was extracted by driving headings 26 to 28 feet high, several pillar lines ahead, and then advancing a bench to remove 50 feet of floor. An additional 20 feet of floor was mined in several places.

In mid 1963, a 92-inch air shaft that is currently known as "the old air shaft" was begun to the 1,000-foot level. This shaft was sunk on a small peninsula just west of the present barge loading facility. Salt was contacted at 180 feet. A 3/4-inch thick steel liner from the collar extended 20 feet into the salt. The shaft was completed to the 1,000-foot level in September 1964.

In 1963, a decline was driven to the 1,300-foot level (Appendix F) and for several years a belt conveyor was used to transport the salt to the 1,000-foot level for hoisting to the surface. The main shaft was extended to 1,370 feet between 1968 and 1970. The design of the mine at the 1,300-foot level was changed.

The mine design on the 1,300-foot level and the 1,500-foot level (Appendix G) was conceived with the consulting services of Serata Geomechanics, Inc. of Berkley, Cal. At the 1,300-foot level, larger rooms and larger pillars were developed and the orientation was changed with respect to the 800-foot and the 1,000-foot levels. By mid 1974 two declines had been completed to the 1,500-foot level and the mine development on the 1,500-foot level permitted the main salt production to be shifted to that level. Salt was transported via a belt conveyor up the return air decline to the 1,300-foot level for hoisting. On the 1,500-foot level, rooms were developed 160 feet wide and 75 feet high and were oriented significantly different from the rooms on the level above. The large span between pillars was a considerable departure from the more conventional spans utilized on the levels above or in similar mines of the region. Pillars 240 feet square were left. Roof bolts were used extensively throughout the 1,500-foot level.

The room and pillar size for each level was as follows:

Mining Level Ft.	Floor Level Ft.*	Roof Elevation Ft.*	Room Height Ft.	Room Width Ft.	Pillar Size Ft.	Sill Thickness Ft.
800	-726	-636	90	65	75 x 75	92
1,000	-907	-818	99	65	75 x 75	304
1,300	-1,286	-1,211	75	100	100 x 75	167
1,500	-1,528	-1,453	75	160	240 x 240	

*Based on mean sea level data.

On the 1,500-foot level some localized roof control problems developed as the level was mined, but occurrences were not chronic and none was severe. At the time of the inundation, mining on the 1,500-foot level had neared completion. To begin lower development of the mine, two declines had been driven almost to the 1,800-foot level.

In a letter dated December 27, 1971, discussing the design of the mine at the 1,500-foot level, Serata Geomechanics, Inc. noted: "The entire structure of the salt dome above the 1,300-foot elevation is not stable. As the result, the surface is subsiding at the rate of about 10 inches per year. The instability is caused by the creep deformation of all the narrow pillars created in the three levels of the mine openings."

In another letter dated November 7, 1972, discussing a report and field studies, Serata Geomechanics, Inc. stated: "This may indicate that the salt formation above the 1,000-foot level is deforming excessively along its western perimeter."

In March 1975, water leaks developed in the shaft liners of the old air shaft. On the advice of a consultant, the shaft was sealed from the 1,000-foot level to the surface with layers of saltcrete and concrete (Appendix H). The sealing was completed on March 30, 1975. No leakage from the old air shaft was reported after sealing. Diamond Crystal reported that the area on the 1,000-foot level was checked visually on November 20, 1980, during the evacuation and no leakage was observed.

An air shaft, located approximately 675 feet southeast of the main shaft, was begun in May 1975. Salt was contacted 134 feet below the collar. The shaft was concrete lined to a depth of 323 feet with an inner diameter of 8 feet. Below the concrete liner an aluminum liner 24 feet long was positioned to prevent erosion around the concrete. Below the aluminum the shaft was 10 feet in diameter and not lined. A two-stage 500 H.P. fan over the shaft collar furnished 180,000 cfm of air to the mine. The shaft was downcast. The new air shaft was completed to the 1,300-foot level in November 1977 and an emergency hoist was installed. In the interim between closing of the old air shaft and completion of the new air shaft, a refuge chamber for emergencies was maintained on the 1,300-foot level. A borehole from the surface served the refuge chamber.

On November 9, 1976, at heading H right, in the 1,500-foot level, a water leak occurred at the face (Appendix I). To restrict the flow of water, the room was backfilled with broken salt, then stabilized by grouting. The resulting plug reduced the undetermined flow rate to a seepage of approximately five to seven gallons per hour. In salt mine operations any water leakage without remedial action could result in serious consequences.

In January 1980, a research program was begun by Louisiana State University (L.S.U.) in the Diamond Crystal salt mine under contract with the United States Department of Energy. L.S.U. was conducting experiments in the mine with high pressure air to measure the performance of the salt under pressure. These experiments were being conducted on the 1,300-foot level in SE 2 between SW 2 and 5. The project consisted of drilling several series of 20-foot long holes slanted at approximately 45 degrees into the floor under the pillars. This project was part of the Department of Energy's study of the feasibility of storing energy in the form of compressed air in the mines.

In a report submitted to Diamond Crystal on January 10, 1980, Serata designated a portion of the salt dome as a "critical creep deformation zone." The area designated was at the western end of the dome, in the area above the section of the mine where the inundation was first observed.

Past MSHA Inspection Records

The first regular inspection conducted under section 8 (enforcement provision) of the Federal Metal and Nonmetallic Mine Safety Act was in January 1971. To the date of the mine's inundation there had been 43 complete safety and health (regular) inspections, 38 other (spot) inspections and one accident investigation. The inspections, on an annual basis, are listed below:

YEAR	REGULAR INSPECTIONS	SPOT INSPECTIONS	ACCIDENT INVESTIGATION
1971	2	-	-
1972	1	1	-
1973	4	3	-
1974	1	1	1
1975	5	3	-
1976	9	1	-
1977	8	-	-
1978	3	3	-
1979	4	13	-
1980	6	13	-

The last regular inspection was conducted on October 2-16, 1980. On November 18, 1980, a spot inspection was carried out. The increase in the number of inspections per year in 1975 through 1980 was directly related to the establishment of the Baton Rouge, La., field office in the last half of 1974 with an increase in the number of authorized inspection personnel.

On June 25, 1979, on the basis of three air samples taken by MSHA on the 1,500-foot level in 11-right of J-heading, the Jefferson Island Mine was classified gassy. Sample number 1965 contained 0.359 percent flammable gas, sample number 1986 contained 0.283 percent flammable gas, and sample number 1994 contained 0.397 percent flammable gas.

Diamond Crystal's Mine Emergency Evacuation Program

The mine's evacuation program was developed in 1973, the year MSHA's predecessor--the Mining Enforcement and Safety Administration (MESA)--issued standards governing this aspect of safety in mining.

Under Title 30 of the Code of Federal Regulations, Section 57.11-53, the operator was required, among other things, to do the following:

> "A specific escape and evacuation plan...shall be set out in written form...Copies of the plan and revisions thereof shall be posted at locations convenient to all persons on the surface and underground...Such a plan shall be updated as necessary and shall be reviewed jointly by the operator and the Secretary or his authorized representative at least once every six months...The plan shall include: (a) Mine maps posted at all shaft stations and in underground shops, lunchrooms and elsewhere in working areas where men congregate; (b) Procedures to show how the miners will be notified of emergency; (c) An escape plan for each working area in the map to include instructions showing how each working area should be evacuated... (d) A fire fighting plan; (e) Subsurface procedure to follow in an emergency; (f) A statement of the availability of emergency communication and transportation facilities..."

Section 57.4-73 requires:

> "Mine evacuation drills shall be held for each shift once every six months. These evacuation drills shall involve all employees on each shift..."

Section 57.11-51 states:

> "Escape Routes shall be: (a) Inspected at regular intervals and maintained in safe, travelable condition; and (b) Marked with

conspicuous and easily read direction signs that clearly indicate the ways of escape."

Diamond Crystal held the evacuation drills once every six months. The last drill, covering all underground personnel on each of the three daily work shifts, was conducted on August 4 through 7, 1980. On November 17, three days before the inundation, the evacuation plan was reviewed during an underground safety meeting.

The performance of Diamond Crystal's miners on the morning of November 20 speaks both for the excellence of their evacuation plan and the training of the miners who followed it.

During the MSHA regular inspection of the mine in October 1980, as a standard inspection practice, an inspector walked from the deepest face of the two declines from the 1,500-foot level to the escape shaft on the 1,300-foot level to determine an escape time, to make certain that the route was maintained properly, and that there were no obstructions along the escape route. The walking time was 30 minutes. The route was properly maintained. Evacuation procedures included the use of all available mobile equipment. This mobile equipment was used in the actual evacuation on November 20.

THE TEXACO DRILLING OPERATION

Introduction

The sequence of events leading up to and immediately following the accident was developed from statements by eyewitnesses, employees and officials of the involved companies, and from data and other physical evidence provided by various companies and from Parish, State, and Federal agencies. MSHA was informed that various drilling logs, records, and instrumentation charts were lost in the crater with the well-drilling equipment.

The investigation of the Texaco drilling operation centered upon the following elements:

1. The planning phase of Texaco's State of Louisiana Lease No. 124, Lake Peigneur No. 20 exploratory oil well, commonly referred to as P-20.

2. The implementation of this plan, including initial drilling activity.

3. Detailed sequence of events experienced in drilling P-20 during the 12 hours preceding the inundation.

The Planning Phase

Texaco was the major oil and gas producer in the Jefferson Island Field. Texaco's State of Louisiana Lease No. 124 included the entire area underlying Lake Peigneur as delineated to six feet above mean-tide level. The Texaco wells and the Diamond Crystal mine were partly on state land and partly on private land. At the time of the inundation Texaco was drilling two oil exploration wells, P-20 and No. 35, in the area adjacent to the mine. P-20 was on Lake Peigneur approximately 2,150 feet southwest of the mine's main shaft, and No. 35 was located approximately 1,200 feet southeast of P-20 along the lake's south shore. The latter drilling site was approximately 400 feet inland from the Lake Peigneur south shore in a wooded portion of a tourist-oriented tropical garden and commercial nursery, known as Live Oak Gardens. The gardens, and the private residences incorporated within it, extended southward along the lake from the southern perimeter of Diamond Crystal's surface installations. A generalized view of Lake Peigneur prior to November 20 is depicted in Appendix J. The relationship of the various working levels within the salt dome at the southwest extremity of the mine is shown in Appendix J'.

Texaco's extensive work history, in and around Lake Peigneur, included an agreement with the State of Louisiana to remove an accumulation of wooden pilings from the lake bed. This activity was an integral part of local efforts to convert Lake Peigneur into a recreational area, in addition to its role as a mineral producing site and a marine and wildlife preserve.

Texaco's wells in the immediate area of Lake Peigneur were drilled by commercial drilling companies under contract, usually on a daywork basis. Texaco designed and located the proposed well sites, obtained the necessary drilling permits, supplied additional services, and managed drilling through the use of on-site Texaco drilling foremen, drilling mud engineers and other technical and administrative personnel. The contractor, usually a local well drilling service, provided the drilling rig, the crews requisite to its operation, and the supervisory and management team required to drill the well.

The P-20 well was being drilled by Wilson Drilling Corporation of Lafayette, La. The adjacent No. 35 well was under contract to Grafton Drilling Co. of New Iberia, La. Both operations were the responsibility of Texaco's district office located in New Iberia. Both wells were similar in design and were to be drilled to approximately 8,000 feet in depth. They differed significantly in that well No. 35, being drilled on land, could be served entirely by trucks and other vehicles. Conversely, P-20 was located on the lake and was dependent upon water-borne transportation.

The bulk of Diamond Crystal's salt product was shipped from the mine by tugboat-propelled barges via Lake Peigneur, the Delcambre Canal, and the Intercoastal Waterway. The lake itself is a shallow body of water which could not accommodate industrial traffic without dredging done by Diamond Crystal. In addition to serving as an outlet to the Gulf coastal waters, the Delcambre Canal acts as a harbor facility for a fleet of commercial shrimp boats, the fishing industry being an important element in the local economy. Vessels serving the area's oil and natural gas industry also utilize the canal.

The P-20 well was designed to intersect three targeted production formations at depths of 3,050 feet, 7,368 feet, and 7,950 feet (Appendix K). The well bottom was to be at a depth of 7,990 feet. The Texaco staff planned the well to vertically parallel the south flank of the Jefferson Island salt dome at a distance of approximately 50 to 165 feet. It was to change from a vertical to a directional drill hole at a depth of 3,300 feet (Appendix L). This apparently was intended to permit intersecting the targeted upper production sands and the two lower target formations at the highest possible levels of their dip-structures immediately adjacent to their salt dome contacts.

(The surface location of P-20 was dependent upon the relationship of the producing formations to the salt dome. The configuration of the dome was a significant element in the planning. According to Texaco's New Orleans Geological Department's plan map showing the contours delineating the salt dome, the contour interval was 1,000 feet (Appendix M). There was no geologic information on the plan above the minus 1,000-foot contour. A Texaco official stated that these data had been developed by Texaco from publications of the New Orleans Geological Society.) This map, in conjunction with seismographic surveys and logs of previously drilled wells, was used by Texaco to locate and design P-20. The Texaco designers had indicated that the surface location of P-20 could be staked with a 150-foot tolerance east or west of the specific location, should surface obstructions be encountered which would interfere with drilling procedures. If any relocation of the surface site were done, it would be along an east-west centerline, which would tend to parallel the salt dome, as contoured. The average planned horizontal distance from the salt dome to the proposed P-20's centerline was about 115 feet, based on 1,000-foot contour intervals. Texaco management approved the proposed location of the drill hole for P-20.

The physical elements of the P-20 design are shown in Appendix N. A 16-inch diameter conductor pipe was to be driven into the lake bottom to the maximum depth possible. Actual drilling was to be initially conducted with a 14 3/4-inch diameter drill bit to the 2,200-foot depth. The average hole diameter calculated for cementation purposes was 20 inches, using this bit. A 10 3/4-inch diameter surface casing would then be cemented in place. Drilling would then resume with an 8½-inch bit. At a depth of 3,300 feet, the drill hole would be diverted from the vertical to strike the targeted area. Production casing of 5½-inch diameter would then be set, followed by 2 3/8-inch tubing, should the well prove productive.

Texaco engineers had calculated the data needed to locate the P-20 well site and had provided the necessary information to a Texaco field survey crew. This site was located and staked in October 1979, utilizing transit and intersection methods. The instrument sighting stations used in the surveys were previously drilled wells whose coordinates had been determined. Verifying check angles were turned at this time to confirm the original calculations. Resulting field notes were processed by Texaco engineers and a drill hole location plan was prepared.

At the time P-20 was staked, the survey crew inspected the area around the site for obvious physical interferences, such as uncharted pipe lines, wells, or similar obstructions which would hinder the drilling of the proposed well.

Texaco planners had indicated that the well could be relocated a maximum of 150 feet east or west of the designed location without detriment to the project. No interferences were observed and the well apparently was staked as planned.

An important element in the planning of P-20 was its intended location on Lake Peigneur. All drilling equipment, auxiliaries, and related support activity, including men and supplies, would have to be transported by water. The size limitation imposed by the Delcambre Canal, including the vehicular and rail lift bridges at the town of Delcambre, dictated the type of drilling equipment which could be utilized. Barge-mounted or other floating rigs could not be used because of their size. A sectionalized land-type drilling rig was, therefore, to be erected upon a wooden drilling platform to be built on the lake. The dismantled rig would be loaded onto barges and transported to the site via the Intercoastal Waterway and the Delcambre Canal.

Texaco planned to use the existing salt-barge channel along the south shore of the lake to get to the vicinity of the P-20 site, then dredge a channelway to the drill site. Additional dredging was planned to accommodate a tug and barge turnaround and to provide a ditch for an oil flowline to connect with existing onshore bulk oil storage facilities, should the well prove productive. On October 26, 1979, Texaco officials applied to the Corps of Engineers for a permit authorizing this work.

Section 10 of the River and Harbor Act of 1899 and Section 404 of the Clean Water Act require prior permission from the Corps of Engineers when work, such as that proposed by Texaco, is to be conducted "on navigable waters, wetlands, interstate waters, and

...isolated lakes...where degradation or destruction of such waters would affect interstate commerce." The Corps of Engineers is responsible for regulating the discharge of dredged materials or pollutants into navigable waters. Lake Peigneur was identified as a navigable body of water utilized in interstate commerce. In addition, it was classed as a spawning and breeding area for shellfish and fish, a wildlife refuge, and a recreational area. The Corps is also responsible to review the practicality of approach as proposed by the permit applicant and to act as a clearing-house to inform interested parties of the applicant's intentions.

Certain Federal agencies, including the Fish and Wildlife Service, the Environmental Protection Agency and the National Oceanic and Atmospheric Administration, are required by law to be advised of the permit application. Various State of Louisiana agencies, including Office of Conservation, Departments of Transportation, Storm Control and Wildlife and Fisheries Commissions, parish officials, and other potentially interested parties must also be given public notice of the work proposed. Protests must be presented in writing and the principals are expected to attempt to resolve their differences. The Corps issues a finding of fact or official evaluation of the application and any objections, resolved or not. This document indicates whether the requested permit will be granted.

Texaco's permit application received only one objection, when Diamond Crystal expressed concern that their salt barge channel might suffer accelerated silting. Their protest also addressed the future of the proposed "levee" should P-20 prove to be a dry hole. The precise location of the drill hole was referenced on sheet No. 2 of the application's attached data as being "S 49° 48' W, 7,282 feet from Coast and Geodetic Survey I-4099." The site was not contested by any party. Texaco was issued the permit without modification, effective June 11, 1980 (Appendix O). They proceeded with arrangements for the equipment, materials and services required to drill P-20 and dredging and platform construction were begun. Texaco had previously applied to the Louisiana Department of Natural Resources' Office of Conservation for permission to drill P-20. This permit was granted on November 13, 1980, in keeping with Statewide Orders No. 29B and 29E. These orders regulate the design of a well, its casing and cementing, well spacing, production criteria, and required tests and logs. Pollution controls, wildlife and fisheries protection, and maintenance of navigable waters are also included. These regulations do not contain language relating to either surface or underground mining. As in the Corps of Engineers' permit procedures, public notice was given various agencies, local landowners and other potentially interested parties. There were no objections of significance received concerning this permit application (Appendix P).

P-20 Exploratory Oil Well Plan Implementation

Texaco proceeded with the dredging to the P-20 site during the period June 7 through June 20, 1980. On July 11 the company began to drive a piling series on which to construct a drilling platform designed for the rig. Preliminary to this work, the survey crew which had originally located and staked P-20 had already returned and confirmed that the staking was proper and undisturbed. At this time they set markers to facilitate the driving of the pilings.

A total of 166 wooden pilings averaging 45 feet in length were driven approximately 30 feet into the lake bed. The drilling platform was built on top of these pilings using 2-inch by 10-inch planks. A dragline base was built to handle material and supplies. This work was completed on July 30, 1980. Texaco had contracted for various services and equipment needed to drill P-20, including a drilling company and a well-cementing contractor, as well as for barges, a tugboat, and a dragline. dragline.

The Wilson Drilling Corporation was to drill this well on a daywork basis using their No. 1 rig. On November 11, 1980, Wilson crews began dismantling the No. 1 rig at a completed well site, transporting it to the Ivanhoe docking facility near Louisa for barge loading and travel to Lake Peigneur (Appendix Q). This land rig was capable of effective drilling to a depth of 12,000 feet. Major components included a 130-foot jackknife derrick of 700,000 pounds capacity, draw works, a 15-foot substructure, multiple diesel drive engines, a pair of high pressure mud pumps and mud mixing pumps, tanks and screens. Auxiliaries included blowout preventors, electric generators, air compressors, indicating and recording instrumentation, and mobile homes for living and office quarters. Barges secured to the platform would hold the drill pipe, casing sections, and the drilling mud system, including vibrating screens, the mobile homes and other equipment. A leased tugboat would move the supply barges. Drilling personnel would be transported by crew boats to an adjacent landing referred to as the Texaco Dock.

The Wilson drilling crews were scheduled to work a 12-hour tour and then go ashore for 24 hours. They were supervised by a toolpusher who lived and worked on the rig for four consecutive days, followed by four off-duty days. Two toolpushers were assigned to the rig. They received routine direction from a Wilson drilling superintendent, but all critical decisions were made by the Texaco drill foremen. The two foremen relieved each other on a seven days work and seven days ashore basis.

A marine radio was provided for the Texaco drill foremen to communicate with their New Iberia district office. A telephone was provided Wilson's toolpushers. The respective company offices were contacted by their on-site supervisors prior to 0600 hours each morning to give the drilling progress highlights for incorporation into daily reports. These reports were not based on the preceding calendar day, but on the 24 hours preceding the designated morning reporting time. Wilson's daily report corresponded to the tour change times of 0600 hours and 1800 hours, while Texaco's report day began and ended at approximately 0430 hours. Correlation of the two daily reports with drill log information could not be done with complete reliability.

P-20 well drilling progress was recorded on drill logs in terms of footage drilled, measured from one foot above the rig's rotary table (Appendix R). A Texaco representative stated that this measuring point, or zero, was at an elevation of 27.9 feet (rounded to 28 feet) above mean sea level. A drilling log entry of 725 feet, for example, would represent a depth of 725 feet minus 28 feet, or a depth of 697 feet below mean sea level.

The rigging up of the No. 1 rig to the P-20 location was nearing completion on November 17, 1980. On that date, the 16-inch conductor pipe was driven through the lake bed and 91 feet into the earth below. On the following day, spud-in drilling mud was mixed and the conductor pipe washed out, using the nozzles of the 14 3/4-inch drill bit to hydraulic the sediments from the pipe. The spud-in of drill hole P-20 was logged at 1800 hours on November 18.

(The drill crews and their supervisors had drilled near other salt mines and buildings in the past without problems. They were not concerned with their proximity to the surface installations of the Jefferson Island salt mine. They were given no indication that the salt dome might be contacted during the drilling, nor that the mine might be beneath their platform. It was mentioned that small bodies of salt, but not the salt dome itself, had been encountered in previous drilling in this field. The Texaco foreman on tour on the rig at the time of the accident stated that he had been given no reason to believe that salt would be drilled. He said that should salt be encountered it would be abnormal; that he would pull the drill string from the hole and radio his office for instructions.) He indicated that surface drilling mud is light in weight and not thick in order to maintain the hole free of sands and gravel. Drilling into salt would noticeably thicken the mud, due to a clay-salt solution reaction. A drilling rate of 20 feet per hour and a drilling mud circulation cycle of 30 minutes would make it possible to detect salt after approximately only 10 feet of drilling. Salt-thickened drilling mud returns would pass over the system's vibrating screen and prevent insoluble drill products from being separated from the mud. A typical oil well drilling mud system is pictured in Appendix S.

Drilling was routine during the first tour from 1800 hours November 18 to 0600 hours November 19. Sixty-one feet of hole per hour was averaged over a 10.5 hour period. A survey made at 497 feet indicated that the hole was within one degree of being vertical. The formation was reported as consisting of sand, gravel and gumbo. Without explanation being logged, it was indicated that only one mud pump was being used, which developed 600 pounds per square inch (psi) of pressure at 155 pump strokes per minute. On the morning of November 19 the Texaco drilling foreman reported drilling with only one mud pump, and that the No. 2 unit drive V-belts were being replaced. He continued drilling, but progress averaged only 20 to 25 feet per hour. The drilling string was pulled from the hole at 820 feet in order to check the drill bit for balling. This is the condition experienced when the cutter and nozzle become fouled with clay and mud to the point where the bit is not effective. The drill log indicates that they also checked for, but found no evidence of a washout condition. The foreman stated that two pumps are normally used during the surface phase of drilling but that he had continued drilling with one pump while the No. 2 unit's V-belt was being repaired.

Texaco had contracted with B J Hughes, Inc.'s New Iberia office to provide the men, equipment and materials to cement P-20's surface pipe in place as required by Statewide Order No. 29B and Texaco's drilling program. The location of P-20 on Lake Peigneur, and the difficulty in accurately predicting when the hole would be at the proper depth with casing in place, necessitated that B J's equipment be loaded onto barges and the cementing crews placed on stand-by status to await notification to proceed. Three cement haulage tractor-trailer trucks and a specialized cement pumping truck had been loaded onto barges and moved to Lake Peigneur preparatory to the tentative cementing date of Friday, November 21.

P-20 Drilling During the 12 Hours Preceding the Inundation

The night tour reported for duty at 1800 hours November 19, and found that both mud pumps were operational. The depth of the hole at that time was 992 feet. A short time later the No. 1 pump experienced a burned out clutch, and a mechanic was sent to the rig to supervise its repair. The derrickman assisted in this work. His responsibilities included the entire drilling mud circulation system. These included checking the pumps, mixing mud, maintaining tank levels, observing the nature and volume of mud returning from the drill hole over the vibrating screens, and cutting and processing mud samples. Higher drilling rates are often experienced in salt. Salt cuttings are not visible in the returns because they go into solution. The result is a significant thickening of the mud, readily visible on the screens. The amount of time the derrickman spends checking the returns depends upon drilling rates. As drilling rates increase, he must spend more time at the screens and adjust the drilling mud's specifications accordingly. The drilling foreman indicated that during the early morning hours of November 20 the derrickman apparently had the time to watch the mud returns and to assist with the mud pump repair. The driller also oberves the returns from his work area.

Drilling continued to be slow, repairs continued on the No. 1 pump, and a survey at 1,059 feet indicated 0.5 degree deviation from vertical. At approximately 0440 hours the driller awakened the Texaco drill foreman and gave him information for his daily report. The driller said that the derrickman had whistled to him, and he had returned to the drilling floor to find that the drill pipe was stuck and could not be restarted. The toolpusher and drill foreman were summoned to the floor. Circulation had also been lost. The depth of the hole was stated to have been between 1,228 and 1,248 feet. Daily drilling reports place the depth at 1,248 feet. The drill string could not be raised or lowered and no rotation was possible. Approximately 30 barrels of mud were reportedly pumped into the annulus while rotation of the drill steel was attempted. Mud circulation was not achieved. The foreman instructed the crew to thicken the mud, then radioed his daily report to his office and advised them of his problem. The time was approximately 0500 hours. Mud pump No. 1 repairs were completed and the pump was available to operate at this time. It was anticipated that the thickened mud as pressurized by both pumps would solve the problem. The hook load indicator climbed slowly beyond the 78,000 pound actual weight of the drill string. It indicated a weight of 200,000 to 240,000 pounds but was returned to a normal 40,000 pounds by slacking off on the wire rope. However, it would promptly climb again to the 100,000 pound level to the amazement of the crew. At this point the relieving drill crew reported for work at approximately 0545 hours. The driller stated that he then heard unidentifiable, popping sounds from below the rig. The hook load indicator had climbed to above 400,000 pounds and the crews were baffled by what was happening. Crewmen observed that the drill rig was beginning to tilt. Both Texaco and Wilson offices were notified and a contractor was instructed to report to the site to level the rig, on the assumption that the platform supporting pilings had given way--not an uncommon event, it was claimed. As the listing became more pronounced, the foreman decided that something far more serious was taking place and ordered the crewmen to evacuate. The rig platform had "dropped 2 or 3 feet on one corner," and the foreman, toolpusher, and the driller began releasing the barges from the platform in an effort to save the equipment they contained. The tugboat "Charlie" was used to move them clear of the platform area as they were freed. Two Texaco assistant district superintendents arrived in time to see the rig overturn at 0725 hours. The witnesses were dumbfounded to see the substructure itself disappear in what they knew was water less than 11 feet in depth. The top of the derrick landed atop the barge containing the mud tanks and vibrating screens and gradually slipped off, causing the barge to tilt and equipment to fall into the lake. Wilson officials arrived at about this time via seaplane. Between 0815 and 0830 hours "the tugboat 'Charlie' came alongside my trailer house barge and told us the mine was taking water," the toolpusher said.

INUNDATION

Just before 0700 hours on Thursday, November 20, 1980, 48 miners and three visitors from L.S.U. entered into the Jefferson Island Mine. A few stopped at the 1,300-foot level. Most continued down to the 1,500-foot working level of the mine.

By 0810, most of the day shift workforce had descended to the 1,500-foot level. At that time, Junius Gaddison, the mine's master electrician, was working on the 1,300-foot level where diesel fuel, electrical equipment and other supplies were stored. While Gaddison collected electrical equipment to be moved down to the 1,500-foot level, a nearby work crew unloaded ammonium nitrate from the mancage and stacked it on pallets. As he checked on wire supplies near the electrical office, Gaddison abruptly stopped his work. An unusual banging noise caught his attention. As he looked up the drift, he could see a muddy stream more than two feet deep advancing toward the station. The sound he had heard was made by fuel drums striking against each other as they were carried along by the stream. The sight left no doubt in Gaddison's mind that a large volume of water was coming into the mine from the outside.

Gaddison shouted a warning to the supply crew and to the shift foreman, Earl Dundas, who was also on the 1,300-foot level. Gaddison then reached for the disconnect switch that controlled power to the lower level where most of the miners were working and flashed the switch on and off three times - the evacuation signal.

Those on the 1,300-foot level phoned the hoistman to lower the cage and notified foremen on the 1,500-foot level to lose no time in getting the men out of the mine. Dundas meanwhile went down the decline to help lead those on the 1,500-foot level to safety. En route, he met Wilfred Johnson, who continued up to the 1,300-foot level where he assumed charge of evacuation activities at that level. By the time the cage was lowered to the 1,300-foot level, Gaddison and eight others were standing ankle-deep in muddy water. They quickly entered the cage and belled it to the surface.

During the next few minutes, Johnson tried to determine the source and extent of the flooding but was forced back by the oncoming flow. Following standard evacuation procedures, he checked the incline to the 1,000-foot level to make sure it was clear. When the regular phone system went dead, he made his way to the refuge chamber to use an emergency phone. He called the surface and asked that the cage be spotted at the 1,000-foot level. He doubted that the remaining miners could be safely evacuated from the shaft station at the 1,300-foot level.

On the surface, Gaddison also advised sending the cage to the higher level as he told Jim Frith, safety director, and others about the situation underground. Stratton Love, mine superintendent told the hoistman to send the cage to the 1,000-foot level. Meanwhile, the surface construction foreman was told to take his crew to the air shaft, move the fan, and have the emergency hoist stand by--also a part of the mine's evacuation procedures. When this was accomplished, John Vice, captain of Diamond Crystal's rescue team, and Louis Babin were sent down the air shaft to the 1,300-foot level to see whether anyone was at the refuge chamber. They waited there for several minutes, but found no one and returned to the surface. They made one more trip to the 1,300-foot level, searched the immediate area and, seeing no one, again returned to the surface.

With Earl Dundas and other supervisors in charge on the 1,500-foot level, the evacuation proceeded smoothly. Using a truck, Randy La Salle, the maintenance foreman, drove to several remote areas and picked up four miners who had been working beyond the lights and had not seen the flashing evacuation signal. All the miners and the three visitors had then walked or ridden mobile equipment to the assembly area at the rescue chamber on the 1,300-foot level, where a careful head count showed that those who had been on the lower level were present.

From this point, the group proceeded to the shaft station at the 1,000-foot level. Reaching the 1,000-foot level, they found the mancage waiting for them. Between 0840 hours and 0900 hours, all persons who had been in the mine were taken to the surface in four trips. No one was injured in the evacuation. There were no fatalities. All persons underground and on the surface had performed exactly as they should have performed.

Diamond Crystal officials initiated efforts to identify the causes of the inundation while it was in progress. They associated the P-20 drilling rig with the accident and a project engineer was ordered to locate the P-20 drill site with a surveyor's transit. The instrument was reportedly set-up at several survey monuments and sighted on the tip of the drill platform's dragline, the only piece of well-site equipment still visible above the lake's surface. The drill rig had disappeared into the lake and the dragline itself was sinking from view. Diamond Crystal stated that the results of this rough check indicated that the drill had pierced the mine.

Several hours later, Diamond Crystal and Texaco officials met at the emergency command post established at the mine rescue training station located adjacent to the mine site. Texaco officials provided survey data and calculated the bearing and distance from the mine's main shaft to the P-20 drill hole. This information was plotted and marked with an X on a Diamond Crystal mine map of the 1,300-foot mine working level (Appendix T). A Diamond Crystal official stated that the plotted location of the drill hole fell just within a mined out area at the southwest area of the mine.

While the miners were escaping, the inundation rapidly became a torrent as water from Lake Peigneur drained into the mine at the 1,300-foot level. As the lake began emptying into the mine, a vast whirlpool approximately one-fourth of a mile in diameter developed in the lake. It caught in its grip a tugboat, a string of barges, and two Texaco oil rigs. Two boaters on the lake managed to power their boat to shore. Within the next three hours, the entire lake disappeared into the mine. Normally, water from the lake flowed out through the Delcambre Canal to Vermillion Bay in the Gulf of Mexico. With the emptying of the lake, however, the water was flowing from the Delcambre Canal into the crater. This reverse flow continued for the next two days until the lake was once again filled with water, and the normal flow out into the canal recommenced. Approximately 30 shrimp boats in the canal, which was lined with seafood companies, were beached when the water level dropped as the canal was refilling Lake Peigneur. They were later refloated when the lake stabilized and the canal rose to its normal level.

At approximately 0820 hours on November 20, the MSHA Baton Rouge office was notified of the emergency when Richard Krueger, manager of production for Diamond Crystal, called Jay Durfee, supervisory mining engineer. Durfee immediately notified Marvin Nichols, Dallas subdistrict manager. Durfee then set out to the mine site with Jerry Millard, mine inspector from the Baton Rouge office who had often inspected the mine. They arrived at 1055 hours and Durfee, after consultation with headquarters, Wayne D. Kanack, Dallas district manager, and the subdistrict manager, issued a 103(j) order to restrict activities in the mine area. See Appendix U for a restatement of the order, as amended, up to April 13, 1981. (Under Section 103(j) of the Federal Mine Safety and Health Act of 1977, Durfee - an authorized representative of the Secretary of Labor - was empowered to take whatever action he deemed appropriate to protect lives and to direct any recovery activities at the mine.) The order was later modified to include evacuation of the residents from the island. Durfee remained in charge until the arrival of Nichols at approximately 2200 hours of the same day. Nichols directed the operation until he was relieved on November 30 by Terry Phillips, Rolla, Mo., subdistrict manager.

When Durfee and Millard arrived at the mine site, a whirlpool and a smaller eddy had formed on the lake. Over the next two hours, a vast whirlpool developed that carried a tugboat, barges, and two oil rigs down into the crater.

The air in the mine, compressed by the inrush of water, was exhausting violently from the air shaft and the main shaft. At the air shaft, at approximately 1300 hours, a shower of mud and water sprayed the area. The cage in the air shaft was battered by the force of the air, its metal frame twisted by the impact. No such mud shower came out of the main shaft, but the violent outpouring of air damaged the head-frame enclosure above the shaft.

The terrain bordering the lake was affected by the emptying of the water into the mine. The land on which Live Oak Gardens was located suffered the most damage. About 65 acres of land, including a part of Live Oak Gardens, slumped below the normal lake level. The home of D. L. (Jack) Bayless was also partially submerged when the earth movement occurred and the lake refilled. Several greenhouses were demolished, and a sizeable portion of Live Oak Gardens slumped below the level of the waters of the lake. Gas from a Texaco well damaged by the landslide became ignited and burned on the surface of the water about 200 feet from shore.

Utilities in the area were shut off rapidly, and all residents of the island were evacuated. Personnel from the Iberia Parish Sheriff's office, the Louisiana State Police, the Vermillion Parish Sheriff's Office, Delcambre Police, and the State Wildlife and Fisheries Department arrived on the island to assist in maintaining order, to help in the evacuation of the residents, and to prevent unauthorized people from entering the island. One week later, when most of these personnel were withdrawn, a smaller group of deputies from the office of the U. S. Marshal assumed the task of providing security.

By the end of the first day, Nichols was in charge of MSHA activities. Dr. Kelvin K. Wu, Chief, Mine Waste and Geotechnical Engineering Division, and Jeff Kravitz, Chief, Mine Emergency Operations (MEO), had arrived at Jefferson Island to assist Nichols. The island had been secured by law enforcement and other personnel.

Over the course of the next week, the work of MSHA was centered around monitoring the area surrounding the mine for any further subsidence or ground movements. Geophone sensors were implanted in the earth to register any unusual ground movements. Seismic activity was recorded within the dome but no correlated additional surface movement was detected. A team of surveyors measured for any unusual shifts in the terrain. None was detected. A communications system was established by MSHA's MEO operation and work was permitted in the affected areas under the supervision of Steve Risbeck, supervisory mining engineer of MSHA's Rolla office, with the approval of Nichols. When the fire on the lake burned out, but the gas continued to bubble on the water, Texaco was given permission to surround the well with a pollution boom, to trap any oil that might be rising with the escaping gas.

Over the course of that same week, the area media concern was enormous. By November 26, most of the law enforcement personnel were being withdrawn. The residents were informed at an evening meeting with MSHA personnel that they could return to their homes. Some returned on the following day, Thanksgiving, but because of lack of utilities, they did not remain.

On Friday, November 21, the day following the inundation, Diamond Crystal filed suit in Federal Court against Texaco for an unspecified amount of damages. On the following Tuesday, November 25, Texaco filed a countersuit against Diamond Crystal in the Federal Court, estimating Texaco's loss at $10 million worth of equipment. In addition, mine workers filed a class action suit against Texaco in the aftermath of the inundation that terminated their employment at Diamond Crystal.

Five days after the inundation, Diamond Crystal gave out awards for heroism to Earl Dundas, Junius Gaddison, Wilfred Johnson, Louis Babin, and John Vice for their cool-headed actions and leadership during the successful evacuation. When officials found out later about Randy La Salle's search by truck for miners in remote areas of the 1,500-foot level, they also cited him for heroism.

DECISIONS AND DAILY ACTIVITIES

November 20, 1980

Richard Krueger telephoned Jay Durfee in Baton Rouge at 0820 hours on November 20, 1980, and informed him that water was coming into the mine. Krueger also said the mine was being evacuated. Durfee notified Marvin Nichols, and then he and Jerry Millard drove to Jefferson Island.

When Durfee and Millard arrived at the mine at 1055 hours, they were informed that all miners had been safely evacuated from the mine. Eight Diamond Crystal personnel remained at the mine site; everyone else had been sent home.

Millard went to the main shaft to collect gas samples. Air was exhausting so violently from the mine that he decided against sampling there because he would have to open the shaft enclosures to collect a good sample and might expose himself to some unforeseen hazard. He then walked to the air shaft, but the exhaust air was so violent there that Millard could only sample from an 8-inch borehole leading to the refuge chamber at the 1,300-foot level. The methanometer indicated no methane. Several bistable samples were taken and later analysis showed a trace of methane (Appendix V).

The Diamond Crystal plant site is located on a small peninsula on the eastern shore of Lake Peigneur. Durfee, who had met with Richard Sieferman, the Jefferson Island plant manager, near the plant office, could see the lake was calm except for two swirling areas. One area was about 2,500 feet southwest of the plant where a Texaco drilling platform had just disappeared. The other swirl was west of the plant, off the peninsula near the abandoned air shaft. Later it was determined that this second swirl was only a current circling a small depression as the lake water was drawn into the first swirl.

Conditions were so uncertain that at 1115 hours Durfee issued a 103(j) order of withdrawal, to control operations at the mine. His first directive was that all personnel were to leave the plant site. He had consulted with Nichols, Wayne D. Kanack, and John Waxvik, Acting Administrator, Metal and Nonmetal, at MSHA's headquarters in Arlington, Va. The Iberia Parish Sheriff's Department and the Louisiana State Police set up roadblocks about a mile from the mine to keep nonessential personnel away.

One of the swirls that Durfee had seen turned into a whirlpool. A large crater, about 1,500 feet in diameter, formed in the lake. As the water emptied into the mine below, the adjacent land was also affected. About 65 acres of land along the southeast shore of the lake slumped below the normal lake level.

Because of the ground movement in the lake and along the southeast shore, and the inability to predict how much more extensive it might become, at 1330 hours Durfee modified the 103(j) order to evacuate the residents of the island above the salt dome to ensure their safety.

At 2200 hours, Nichols arrived at Jefferson Island and Durfee turned over the direction of MSHA's activities to him. Dr. Kelvin Wu and Jeff Kravitz flew from Pittsburgh, Pa., and arrived at Jefferson Island at 2400 hours.

November 21, 1980

An inspection of the mine site by Nichols, Wu and Kravitz started at 0030 hours on November 21. The cage at the air shaft had been battered against the headframe and hung suspended about 10 feet above the collar. A layer of wet silt lay in about a 50-foot radius of the shaft. The entire inspection was hampered by darkness. Specific areas could be illuminated with cap lamps, but a comprehensive assessment could not be made. At this time, it was decided to maintain the restrictions already placed on the mine site.

The inspection group next went to the Bayless property on the southeast shore of the lake and made a preliminary survey of the damage there. There was still some limited ground movement, but nothing approaching the dimensions of what had occurred throughout the preceding day.

At 0945 hours, Steve Risbeck arrived to assist the emergency team.

Because of the uncertainty of conditions resulting from the accident and the inaccessibility of some of the affected areas, a helicopter was leased from Industrial Helicopters of Lafayette, Louisiana. An aerial survey by Wu, Nichols, Risbeck and Kravitz began at 1000 hours. At this time, the water level in the crater was 40 to 50 feet below the normal lake level. A waterfall poured water from the Delcambre Canal into the partially empty crater of the lake.

Texaco's Number 8 producing gas well had been located on the southeast shore of the lake. The ground movement caused by the inundation had damaged the casing of the well below the water level. The gas had become ignited--possibly by friction as the casing sheared--and a fire burned in about a 50-foot radius on the surface of the lake. There was agitation in the water from the escaping gas, but the lake was otherwise calm.

At the Bayless property, about midway between the gas well and the plant site, several large greenhouses were destroyed and a commercial botanical garden was partially lost. Out in the lake, a grouting truck was stuck, nose first, in the mud.

The main buildings of the plant appeared stable. There was no observable ground movement at the time of this survey and there was no evidence that movement had occurred. The guy wires attached to a smoke stack at the mine's power house had a normal amount of slack.

Between 1130 and 1300 hours, the group walked to the Bayless property at the lake's newly established shoreline. This was the area of the most obvious destruction. The Bayless home had dropped about 20 feet below its former elevation and rested with approximately a 4 percent incline toward the cavity in the lake. The house was dry at this time, but through the day and night, as the lake returned to its normal level, the water rose to within two or three feet of the second floor.

The nursery had about 20 greenhouses of various sizes. Several near the Bayless home had been reduced to rubble. Others on higher ground that had moved only a few feet had still shifted enough to break the glass into shards and twist the buildings' framework. Several hundred yards of roadway had slumped; utility poles were tilted and power lines drooped.

Numerous cracks were forming within 30 feet of the new shoreline. During the inspection, there was continued localized movement; a tree snapped and fell into the lake at one point. A safety zone was then established 150 feet from the lake's new edge.

At the plant site, the inspection affirmed what had been seen from the air. Everything appeared normal except the scattered debris at the main shaft, the damaged cage at the air shaft, and the layer of silt that covered that area. The silt in the area was physical evidence that a slurry mixture was in the mine. Sampling of the material in the shafts was planned as soon as it was feasible. The inspection included visual checks for any deviation from plumb, ground cracks, paint that might have recently peeled at structural joints, cracked walls, or any sign of damage or movement to structural foundations and to the railroad tracks.

Despite the apparent stability of the area, it was decided at this time not to permit any access to the plant site until MEO established a radio communications system. With exceptions, the recurring problems facing the emergency team became defined:

1. Was the surface above the salt dome only temporarily stable?

2. In view of the localized ground movement, was the area on the lake's southeast perimeter safe?

3. What could be done to control or extinguish Texaco's Number 8 gas well fire?

As far as the stability of the surface was concerned, reliable and immediate information was needed to begin a systematic evaluation of the conditions. A routine, annual subsidence survey of the dome had been completed seven months before the inundation. A daily survey was planned to determine the present degree of subsidence and monitor changes in the rate and magnitude of surface movement as it occurred. After a meeting between MSHA and Diamond Crystal, the company started a survey party to work that afternoon. Portable radios could not be obtained in time for the surveyors, but the survey results were judged to be sufficiently important that permission was given for the survey to be taken. In order to safeguard the surveyors, the extent of the survey was limited to the east side of the plant--the area farthest from the crater.

In order to more precisely monitor additional ground movement if it were to occur, Kravitz directed that seismic monitoring equipment be sent from the MEO Hopewell facility. A daily walk-around inspection of critical stress points on structures was established as a routine.

There was no immediate solution to the Texaco Number 8 gas well fire. A meeting with Texaco was scheduled for November 22 to evaluate proposals for the resolution of the problem.

<u>November 22, 1980</u>

An aerial survey of the area began at 1020 hours. The lake had returned to its normal level and the water was flowing from the lake into the canal. The fire was unabated on the surface of the lake at Texaco's Number 8 gas well. The second floor of the Bayless home showed above the water. The mine site appeared stable with no visible evidence of ground movement.

The survey party, checking points from the annual survey for vertical movement, completed its work in the morning. The company engineer reported insignificant amounts of subsidence consistent with the mine site's history. This was the best information to date on the conditions of the dome. Although it was clearly a positive sign, it could not be interpreted as assurance that the stability was permanent.

On this day, two new and puzzling conditions came to light--a difference in the slurry levels of the two shafts and a roaring noise in the main shaft.

An attempt to measure slurry levels in both the air shaft and the main shaft failed. It was clear, however, that there was a significant difference between the levels in the two shafts. The air shaft could be measured and had slurry about 75 feet below the collar. At the main shaft, however, the line became entangled and a reliable measurement was impossible at the time. The level was at least 150 feet below the collar. The air shaft collar was 34 feet above sea level and the main shaft collar was 54 feet above sea level. Calculations showed that there was at least 55 feet of difference between the slurry levels in the two shafts.

There was also a roaring noise coming from the main shaft. The noise had first been noticed by Durfee the previous evening, but he had attributed the noise to the wind reverberating in the headframe. It was calm on the 22nd, but the noise persisted. No convincing theory was advanced to explain the roar and as a result, MSHA's Television Probe System was ordered by Kravitz from the MEO Hopewell facility. It was expected that an explanation would be revealed by a view down the shaft with the television camera.

It was necessary to clear away the debris in the vicinity of the main shaft to permit the approach of the MEO truck on which the camera would be mounted. A work party was designated to prepare the area and the shaft for the television probe. An MSHA supervisor accompanied the work party at all times.

An inspection of the mine site and the southeast shore of the lake showed no evidence of additional ground movement. Texaco officials walked with MSHA representatives to the southeast portion of the lake to observe the fire at the Number 8 gas well. It was decided that Texaco would return on November 23 to brief MSHA and to submit a proposal for putting out the fire.

A trailer was obtained in the afternoon by Kravitz to be used as MSHA headquarters for the emergency team. MSHA had previously used a portion of Diamond Crystal's office space at the company's mine rescue meeting house.

November 23, 1980

The MEO radio communications system arrived, was put into operation under MSHA's direction, and a work party was permitted to enter the mine site at 0900 hours. The company barricaded the main shaft and went into predetermined buildings to retrieve personnel records needed to expedite unemployment claims for hourly workers whose employment was terminated as a result of the inundation. Risbeck accompanied the work group and maintained communications with emergency headquarters. An inspection of the area beforehand had indicated that the conditions were stable, and that there had been no new ground movement related to the inundation. The trip for the records was completed at 1022 hours.

The difference in the slurry levels of the two shafts was about 222 feet. The measurement at the air shaft showed slurry to be six feet above sea level and the slurry at the main shaft was about 216 feet below sea level. The roaring sound at the main shaft continued. An attempt to obtain a sample of the slurry in the main shaft was unsuccessful.

Between Diamond Crystal and MSHA, several theories were developed to explain the slurry level difference. Two were generally favored. One depended on different specific gravities of the slurries in the shafts. There would be no discernible hazard if this theory proved correct. It was difficult to understand why the specific gravity should be different in each shaft but, at this point, the question was academic. A slurry sample could not be obtained in the main shaft and the theory could not be verified.

The alternate theory envisioned wood, steel and other debris from the mine combined with mud from the inundation blocking the main shaft. There was implied in this theory the possibility that slurry under 200 feet of hydrostatic head could suddenly erupt. The sheeting that enclosed the headframe and the wood and steel that caused the blockage would become missiles. If people were working near the shaft when it erupted, injuries could result. Before the level of the water became known, it was even suspected that an entire level of the mine might be blocked off. If that were true, and if the blockage were to burst, the lake could partially drain again, filling the empty level of the mine, and additional subsidence could result.

A Texaco engineer met with Nichols and Wu in the morning and proposed drilling a relief well to shut off the Texaco Number 8 gas well. After the conference a survey party contracted by Texaco began layout work for the relief well. The engineer also expressed Texaco's concern that the Number 8 gas well might begin to discharge oil. The oil pollution could cause serious environmental problems and could harm the fish, shrimp, and other aquatic life downstream from the lake unless measures were taken to contain the oil. The engineer did not believe the problem to be imminent, but reported that a Texaco geologist viewed it as a genuine possibility. Another conference with Texaco was scheduled for November 24 to discuss the full range of Texaco's proposed work in the Lake Peigneur area.

Audiovisual specialists from the Pittsburgh Audio Visual Service Division recorded television and still pictures of the mine site and lake areas.

Geophone subarrays, part of the MEO seismic monitoring equipment, were installed in the ground at the air shaft, the main shaft and the water tower. A visicorder portion of the equipment that would print the readout from the sensors was delayed in transit to the site. It was expected to arrive and to be operating the following morning.

At 1600 hours, MSHA and Diamond Crystal personnel inspected to the water's edge on the peninsula west of the mine site, but found no signs of ground movement. The limits of the daily subsidence survey were extended to include two silos which had been constructed on a concrete foundation on pilings. It was hoped that these structures would provide information about any ground movement in that area.

In a morning conference with Nichols and Wu, Texaco asked permission to place a pollution boom around their Number 8 gas well. The boom, a 24-inch floating vinyl collar reaching 16 inches below the water and 8 inches above, would minimize environmental damage if the well started to discharge oil. The alternative--drilling a relief well--might take five weeks: two or three weeks to set up the drill and one or two additional weeks for the actual drilling. Texaco believed their best immediate solution was the pollution boom. To clear the debris so that the boom could be installed, Texaco would be required to spend an entire day on the lake, almost directly above the crater.

It was explained to Texaco that too little was known to make a responsible judgment. MSHA was still uncertain of the dome's stability and the full implications of the slurry level difference in the two shafts. As it was viewed at this time, there was a lingering possibility that part of the mine was empty, with the related possibility that the lake could drain again. MSHA suggested that cables be laid by helicopter and the pollution boom installed from land. The Texaco officials said they would look into the feasibility of such a plan. In the meantime, it was agreed that a pollution boom across the Delcambre Canal would at least restrict damage to the lake. Permission for Texaco to go onto the surface of the lake to float the pollution boom near the well was denied.

A string of Texaco barges that had serviced the drilling operation had become grounded and stuck in the bottom of the crater during the inundation. They had floated to the surface after the lake refilled and Texaco wanted to retrieve them. Although this would not require an entire day's exposure on the lake, the request was also denied for the same reasons.

Seismic monitoring began at 1130 hours. The subsidence survey, which had been expanded to include the entire mine site, showed no significant vertical movement. The survey point at the silos, in an area that had been restricted from even the surveyors until this time, also showed no movement.

The difference in the slurry levels of the two shafts was about 220 feet. This was two feet less difference than on November 23. The slurry at the air shaft was about 4 feet above sea level. The slurry elevation at the main shaft was 216 feet below sea level. Samples were taken of the slurry from both shafts, but the analyses would not be completed until November 25. The roaring noise had diminished somewhat, but could still be heard.

At 1300 hours, the MEO television camera probe began a survey of the main shaft. When it reached the slurry level at minus 216 feet elevation, there was intense surface agitation observed, and the slurry appeared very muddy. The television survey ended at about 2230 hours.

November 25, 1980

After unusual seismic activity was recorded in the morning, MSHA and Diamond Crystal personnel went to the mine site and inspected for ground movement. No new surface cracks were observed. The geophone activity may have been caused by localized ground stress adjustment. The daily subsidence survey showed no significant movement.

The roaring noise in the main shaft had stopped. The difference in the slurry levels was approximately 202 feet, which was 18 feet less than it had been on November 24. The slurry in the air shaft was at 7 feet elevation; the measurement at the main shaft was at 195 feet below sea level. The levels appeared to be equalizing gradually.

Diamond Crystal finished analyzing the samples from the two shafts. The specific gravity was 1.542 at the main shaft and 1.236 at the air shaft. The calculation anticipated 258 feet of difference between the two shafts. The actual difference was 220 feet. These data supported the specific gravity theory. If the theory were true, the slurry levels should gradually equalize if the specific gravities became the same.

In the afternoon, the MEO television camera probe was lowered in the shaft for pictures on a horizontal plane. The camera showed a slowly boiling or rolling turbulence. It was later decided that the bubbles were caused by trapped air escaping from the mine. Thi[s] release of air would also explain the puzzle of the roaring noise.

Because of the results of the specific gravity derived from the sampling, the images from the television camera probe and the tendency of the slurry levels to equalize, it was felt that Texaco could reasonably be allowed on the lake to place their pollution boom. Nichols explained to Texaco that MSHA would prefer to monitor the mine for a little longer, but Texaco would not be stopped if they wanted to place the boom. A proposed activity list would have to be submitted in advance to assure that all necessary safety precautions had been taken: the lake's water level would be monitored; the shortest possible route would be used to lay the boom; a helicopter would stand by for an emergency evacuation. Texaco reported back in the afternoon that they had misgivings of their own and would prefer to wait before installing the boom. The fire at the Number 8 gas well continued to burn.

The Iberia Parish Sheriff's Department and the Louisiana State Police had maintained roadblocks, checked identification, and generally secured the area for five days. Both these agencies felt the need to return to their routine duties. The parish and state police were scheduled to be relieved by U. S. Marshals from the Justice Department's Baton Rouge office on November 25.

<u>November 26, 1980</u>

The salt dome appeared to remain stable. Seismic monitoring equipment and the daily subsidence survey indicated no significant ground movement.

The slurry levels in the two shafts had 13 feet less difference than on November 25. The difference on this date was 187 feet. The main shaft level was at minus 183 feet elevation; the air shaft was at 4 feet elevation.

A single stage sampler from MEO collected three gas samples above the slurry level in the main shaft. The analysis showed that only air was present (Appendix W). The gas sampling eliminated flammable gas as a possible source of both the roaring noise and the bubbling in the main shaft.

The main shaft was again viewed through the television camera probe. The camera showed more bubbles than on November 25. They were of no greater amplitude on this date, but appeared to be boiling faster. The camera was also used to inspect for leakage in the main shaft liner. None was observed. At the bottom of the liner, a lengthy inspection of the margin between the concrete and the salt revealed no apparent seepage. The roaring noise at the main shaft resumed in the morning, but did not seem as loud as it had been.

Texaco informed Nichols and Wu that an activity plan was being prepared to place the pollution boom around the Number 8 gas well. The intensity of the gas fire on the lake had noticeably diminished.

November 27, 1980 (Thanksgiving Day)

The Number 8 gas well fire had gone out during the preceding night. Texaco decided to place their pollution boom. They fired flares into the area in an attempt to reignite the fire, but could not. This indicated that the gas well pressure was very low and did not present a hazard. Texaco wanted to assure itself that the gas fire would not reignite while its employees were working in the area.

The difference of the slurry levels in the two shafts had lessened by 45 feet. The slurry level in the main shaft was minus 161 feet. The slurry level in the air shaft was measured at minus 19 feet. This was a difference of 142 feet. Since both shafts' slurry levels were below sea level, there was a tentative indication that the failed areas of the mine had been at least temporarily sealed.

There was no detectable subsidence at the dome. Seismic records indicated that the area was relatively stable. Diamond Crystal's survey party did not work on this date.

At 1300 hours, an inspection was conducted at the mine site. The central area of the site appeared stable. There was no evidence of cracks at critical structural points. The loading dock, the part of the plant nearest to the area of greatest subsidence, showed no evidence of recent movement. Apparently, on November 20, pilings had sunk several inches. The floor had dropped and the paneling had sprung from the wall in a control shed at the south end of the loading dock. This was the first inspection of this part of the mine site.

The residents of Jefferson Island, who were evacuated after the initial ground movement, were allowed to return to their homes on this date. The marshals had removed their roadblock, but would stay at MSHA headquarters until November 30, to be available in the event of any emergency.

By November 30, all the evidence at the mine site--the daily subsidence surveys, the visual inspections, the slurry elevation measurements, the seismic monitoring data (with one morning's exception)--indicated that the dome structure was stable. The roaring noise had stopped at the main shaft. There had been no detectable new ground movement on the southeast shore.

For three days after the residents had been allowed to return to their homes, the monitoring was continued by the MSHA group who originally comprised the mine emergency team. On November 30, 1980, most of this group was relieved. Under the direction of Terry Phillips, monitoring continued on the same schedule for another week. With no change in conditions, the evidence of stability was heavily predominant.

MINE EMERGENCY OPERATIONS (MEO)

At approximately 0930 hours on Thursday, November 20, 1980, John J. Mulhern, Assistant Director of Safety, MSHA Technical Support, notified Dr. Kelvin K. Wu, Chief, Mine Waste and Geotechnical Engineering Division, and Jeff Kravitz, Chief, Mine Emergency Operations, that an inundation accident had occurred at the Jefferson Island Mine. There were no reports of miners entrapped and both were told to stand by.

At 1430 hours, Mulhern directed Wu and Kravitz to proceed to Jefferson Island to assist the MSHA emergency team, and at 1730 hours both departed the Greater Pittsburgh Airport. At approximately 2400 hours, Kravitz and Wu arrived at the mine site and met with Marvin Nichols at the Diamond Crystal mine rescue meeting house.

At 1045 hours on November 21, Kravitz directed MEO personnel to ship surface communications equipment by air freight to Jefferson Island. James Moore, Westinghouse MEO program manager, arrived at the emergency site from Baltimore at about 2400 hours to assist with logistics operations. Kravitz arranged for Ron Dartez of Rowan Drilling Co., Houston, Tex., to be available to consult with MSHA officials regarding drilling procedures. Raymond Rouiller and George Keeney, two additional members of the Westinghouse MEO team, departed Pittsburgh for the mine at 1400 hours with surface communications equipment and arrived at the mine site about 2400 hours, November 21.

During the morning of November 21, Kravitz chartered a helicopter for MSHA personnel to conduct surveillance flights over the lake, to survey the surface damages and maintain security. Additional flights were conducted on November 22, 23, 24, 25, and 30.

On November 22, Kravitz rented a trailer to be used as MSHA headquarters at the mine. Telephones, a copy machine, radio communications and a telefax machine were installed. The most serious question facing the MSHA emergency team at this time was the stability of the salt dome and the surface above it. The decision was made to use MEO seismic monitoring equipment on the surface of the mine to monitor ground activity. A second problem arose out of the unexplained noise in the main shaft of the mine where the slurry surface was too far below the collar for visual inspection. It was therefore decided to conduct a TV survey of the main shaft by use of the MEO TV probe system. Kravitz directed that the seismic equipment be dispatched from the Hopewell facility by air, while the MEO TV probe system was dispatched by highway.

The first 12 hours of seismic monitoring was used to establish a data base from which to determine activity trends on the mine site and in the subsurface strata of Jefferson Island. The seismic monitoring was performed on a 24-hour basis commencing on November 24.

When the MEO TV equipment arrived at the mine site on the morning of November 24, a modification was made to permit the camera to look vertically into the main shaft as it was lowered. The first video pictures taken on that day showed the possibility of flowing water at a depth of 270 feet below the collar in the main shaft. It was then determined that a better picture could be obtained by removing the modification, which would permit the camera to function normally on a horizontal plane. On the following day the camera was lowered into the main shaft and gave a precise picture of the bubbling slurry within the shaft.

MEO equipment for obtaining gas samples was shipped to the mine site from the Hopewell facility. The results of the sampling removed the concern of the MSHA emergency team that some form of flammable gas or an explosive mixture might be present in the main shaft.

The MEO communications equipment accompanied all official parties leaving headquarters, allowing immediate coordination of all activities at the mine site and providing a greater measure of safety for MSHA personnel and others working on Jefferson Island.

When a TV survey of the main shaft on November 27 showed no significant changes in the slurry, a decision was made to return the MEO TV equipment to the Hopewell facility. It was decided to leave the seismic equipment in place for monitoring by the senior resident MSHA official. It was also decided that John Hartman from the Westinghouse MEO team would remain in temporary residence to maintain the seismic monitoring as directed, to maintain the surface communications equipment and to assist with surface surveillance. Seismic monitoring activities were suspended on December 11. Hartman departed Jefferson Island on the following day.

ENGINEERING EVALUATION

Survey

Surveys of the horizontal and vertical movement of the ground surface above the Jefferson Island salt dome have been conducted annually since 1971. These surveys have monitored the movement both in magnitude and direction. The latest regular annual measurement was done in April of 1980. The points monitored for movement were located throughout an area encompassing the mine's surface facilities (Appendix X). These annual surveys were conducted by C. H. Fenstermaker and Associates. The data evaluated here consist of the final annual magnitude and direction of movement only, and not the survey notes or calculations. The horizontal movement was generally in the westerly direction and oscillated from north to south over the 10-year period. The magnitude of this movement varied from a low of 0.3 inches to a high of 13.7 inches annually. The vertical movement ranged from 2.6 inches to 7.5 inches of downward movement annually with an average annual movement of about 6 inches.

The mine inundation at Jefferson Island occurred on November 20, 1980. An immediate decision was made by the MSHA investigation team and Diamond Crystal to initiate daily ground movement monitoring on November 21. Due to the time-consuming process for horizontal surveying, it was agreed by MSHA and Diamond Crystal that only vertical surveying would be conducted during the initial stage. This was carried out on November 21 through 28, and on December 1 and 3. The vertical movement was close to that expected, based on the 10-year annual survey.

On November 26, the horizontal survey was initiated. Due to the great amount of time needed to complete this work, it was agreed that fewer surveys would be required. The data submitted indicated a maximum horizontal movement of approximately 7.2 inches. The horizontal measurements were made using triangulation. The survey was started and closed over a point which lies off the dome, reportedly not subject to dome movements. Each horizontal measurement was done several times, and these surveys were found to vary by as much as one-half inch. The day-to-day horizontal distance increased and decreased in an apparently random fashion and no trend could be established. It was difficult to draw any conclusion based on the limited data taken over a short period of time.

Diamond Crystal agreed to continue monitoring for vertical and horizontal movement and to submit the data to MSHA for continued evaluation.

Seismic Monitoring

On November 24 continuous seismic monitoring at the Jefferson Island Mine began at 1130 hours, using equipment provided by MEO. The purpose of the seismic monitoring was to provide an added safety measure by using the equipment as a seismic activity trend monitor. When unusually high periods of activity occurred, visual inspections of the monitored area were required to check for additional ground movement. During these periods, personnel in the area were instructed to proceed with caution.

The seismic monitoring of the activity after the flooding produced signals that were probably generated by underground hydraulic activity or rockmass movement. The monitoring was accomplished using vertical velocity seismic sensors placed in the ground at the main shaft, the air shaft and the water tower

(Appendix Y). These locations formed a triangular array approximately 400 feet on a side, with a bandpass of approximately 10 to 20 Hertz (Hz). The signals were produced during periods of time when peak to peak ground velocity was approximately 6,000 micro-inches per second (MIPS). This level is approximately 600 times greater than natural background noise. Signals greater than background signals were observed a number of times. In each case, the signal would start impulsively--a rise time of less than .5 seconds, the limit of resolution of the records. The signal lasted for periods up to 6 minutes, when it would stop impulsively. In each instance, the signal would start and stop simultaneously on all sensors. At times when the signal was not present, the noise was approximately 2,000 MIPS, 200 times above the average natural noise.

Subsurface ground movement associated with the mine failure was the likely source of the seismic signals; however, other sources had to be considered. Activities associated with cars, planes, helicopters, or boats were ruled out by the impulsive start at the three separate sensors. The impulsive start also ruled out such a source as a person located near one of the sensors. Machinery in the area could not generate a signal because the power to the mine area was off. It was postulated that a drill operating at a distance of several miles from the sensors caused the signal. A calibration of signal levels from such drills was not available. However, drill noise from a rotating drill at a drill-to-sensor distance of 500 feet observed by Greenfield (1977) was on the order of 20 MIPS. This was far below the observed signal level. A second point tending to exclude a drill as a possible source was the irregular pattern of the recorded signal.

Slurry Evaluation

On November 21, 1980, a decision was made to continue monitoring the slurry elevation in the main shaft and the air shaft for the following reasons:

1. To establish a data base for future decision making;

2. To determine the comparative movement of the slurry in the air and main shafts (Appendix Z);

3. To take slurry samples for engineering laboratory testing; and

4. To establish the reasons for the slurry elevation difference between the air and main shafts.

Due to the great difference between the elevations of the slurry in the air shaft and the main shaft, and the roaring noise heard in the main shaft, there was a serious concern that some type of high pressure existed in the main shaft. Different theories were discussed, and the members of the investigation team hypothesized at that time that the two most likely causes were as follows:

1. Some type of blockage existed in the main shaft. This shaft intersects the 800-foot, 1,000-foot, and 1,300-foot levels. Mine supplies, timber sets, or a combination of these could have collected and a bulkhead could have developed. If this were true, any failure of the blockage could have resulted in a release of tremendous pressure, creating a safety hazard; and

2. The specific gravities of the slurries in the air shaft and the main shaft were different. If this were true, then there would have been no sudden pressure release and therefore a safety hazard would not have existed.

Slurry Sampling

Samples of slurry were taken from the air shaft and the main shaft. The specific gravities of the two samples were 1.236 and 1.542 respectively. These values seemed reasonable.

Elevation data for November 24 showed that the air shaft was +4 feet and the main shaft was -216 feet with respect to sea level.

Assuming the specific gravities are G1 and G2 and the total depths 1,266 feet and 1,246 feet below sea level for the air and main shafts, the following calculation showed:

$$(1266+4)\ G1 = (1246-216)\ G2$$

$$1270\ G1 = 1030\ G2$$

$$\frac{G1}{G2} = \frac{1030}{1270} = 0.81$$

Measured reading:

$$\frac{G1}{G2} = \frac{1.236}{1.542} = 0.80$$

As the calculated and measured results indicated, the theory of the specific gravity causing the difference of elevation between the air and main shafts became more acceptable as the logical explanation. The trend of continued reduction of the slurry elevation difference in the air and main shafts indicated stability. These favorable results offered a chance for the investigation team to eliminate a major safety hazard consideration.

Gas Sampling

Based on the TV monitoring results, it was clearly indicated that there was either air or a dangerous gas being released from the turbulent slurry in the main shaft. The possible source of this was discussed by the members of the investigation team. Four possible sources were hypothesized:

1. Mine air had been trapped in the workings;

2. Additional air had been drawn into the mine by the inrush of lake water;

3. Gas intrinsically trapped in the salt crystals had been released by the dissolving action of the water on the salt; and

4. A gas pocket in the rock salt had been released due to the inundation.

The immediate concern was that the shaft might contain toxic or explosive gases, creating a health or safety hazard. In order to eliminate this concern, gas samples were taken and sent to a laboratory for analysis. The results indicated that the samples were air, eliminating items 3 and 4 as areas of concern. Based on the available videotapes and photos, the so-called whirlpool did not develop a vortex when the water drained into the mine, indicating that a vacuum had not developed. The failure zone filled with water instead of air, eliminating item 2. The only remaining source was item 1. Air that became trapped in the mine was being released.

Visual Inspection

A visual inspection of all of Jefferson Island was carried out daily. The following areas received major attention:

1. Any obvious evidence of ground movement, such as tension cracks and land slides on the surface area;

2. The structural integrity of the mill buildings;

3. The railroad track; and

4. The water tower, silo, and headframe.

Throughout the period, no significant visible changes were detected.

Slope Indicator

The most effective instrumentation used to detect any subsurface movement was the slope indicator installation. There were three slope indicator wells installed by Diamond Crystal around the air shaft in September 1980. This information was not known by the MSHA investigation team on November 20. It was not until November 30, on a list submitted for work approval, that Diamond Crystal requested permission to take slope indicator readings. The MSHA investigation team perceived the importance of this installation and requested that these readings be carried out immediately. At the same time, a formal request for the past data and plots was presented to Diamond Crystal. Unfortunately, Diamond Crystal had not established any data base; only three readings had been taken with no attempt to plot and analyze the data. MSHA's investigation team took the three sets of readings and sent them to the Bruceton Safety Technology Center for evaluation. Additional readings, as required by MSHA, were taken and forwarded to Bruceton for continued monitoring. These readings were taken at boreholes located northeast, northwest, and southeast of the air shaft, approximately 20 feet apart. Readings were taken by Dave Stevenson, Diamond Crystal plant engineer, using a Terra-Probe Indicator in the grooved borehole linings in holes that had previously been used to freeze the ground for air shaft sinking purposes. The first readings had been taken on September 26, 1980, and indicated a general northward tilting in all three holes. At the southeast and northeast holes, the tilting seemed to increase in an eastward direction below approximately 100 feet in depth. At the northwest hole, however, the tilting trend seemed to increase westward with depth. All three holes reached a depth of 190 feet to 200 feet below the ground surface and approximately 100 feet into the salt dome.

Cumulative readings taken on September 26, compared with those on October 30, November 29, December 2, and December 3 showed no movement in the southeast hole (Appendix AA). At the northern holes, however, readings of horizontal movement varied within a two-inch range, showing an oscillating rather than a steadily increasing movement. The minimal changes in the readings gave additional assurance that the Jefferson Island salt dome, after the inundation, was relatively stable.

Because of problems with the lining of the borehole, the northwest slope indicator was considered suspect.

In a modification of the 103(j) order, currently in effect, Diamond Crystal was required to continue monitoring the ground movement with slope indicator readings to be submitted to MSHA for evaluation.

Rock Mechanics

Serata Geomechanics, Inc. was retained by Diamond Crystal Salt Company as their rock mechanics consultant to improve the stability of the dome structure. The information provided by Diamond Crystal to MSHA included only the correspondence and reports submitted to Diamond Crystal by Serata Geomechanics, Inc. covering the period from December 27, 1971, to June 17, 1980.

In early 1971, Serata Geomechanics, Inc. indicated that the entire structure of the salt dome above the 1,300-foot elevation was not stable. On November 7, 1972, Serata Geomechanics, Inc. indicated that the pillar yielding in the room closure on the 1,000-foot level might indicate that the salt formation above the 1,000-foot level was deforming excessively along its western perimeter. In the subsequent years, the consultant evaluated the conditions and, based on its rock mechanics study, a new mine design was proposed and implemented. The information available to MSHA indicated that the new mine design for the 1,500-foot level had performed as the plan called for, and the stability of the structure had been improved.

According to the surface survey data, the annual subsidence rate had been fairly consistent and no substantial reduction was noted. Based on the available information from Diamond Crystal and MSHA's inspection records, the ground condition at the 1,500-foot level had indeed been an improvement over the conditions on the levels above. It would be reasonable to assume that the subsidence rate would eventually be reduced. The area of most pertinence during the investigation was under the lake. There were no subsidence data for this area available for detailed engineering evaluation.

Additional Safety Questions

In addition to the previously discussed items, there were four other safety questions considered:

1. Was there any leakage from the old air shaft?

The old air shaft had been sealed with saltcrete and concrete. The sealing had been completed on March 30, 1975. No leakage had been reported since that date up to the morning of the inundation. On that morning the route taken by miners evacuating from the 1,500-foot and 1,300-foot levels to the 1,000-foot level took them past the old air shaft. They observed no leakage. This eliminated the old air shaft as the possible source of the inundation.

2. What was the possibility of the lake water continuing to dissolve the salt pillars and causing an unstable condition?

Calculations submitted by Diamond Crystal (Appendix BB)--and concurred in by MSHA--postulated the maximum possible dissolution at the various levels of the pillar, roof, and floor:

Level	Salt Dissolved (Pillar, Roof and Floor)
800	3.078 feet
1,000	3.078 feet
1,300	3.869 feet
1,500	4.600 feet

These figures were based on an assumption that the saturated brine in the mine would not be replaced by fresh water. This assumption was supported by the fact that the slurry elevation had rapidly fallen below sea level in both the air and main shafts. It could be reasonably assumed that the failure zone where the lake drained into the mine was being sealed through natural processes. The fresh lake water would not continue to seep into the mine to dissolve additional salt.

3. Could ground failure in the immediate vicinity of the main shaft cause ground water to seep into the mine, providing a new source of fresh water to dissolve salt, thereby creating a serious safety problem?

When the MEO television camera was lowered into the main shaft to study the slurry below, a careful inspection was made of the shaft liner and the contact of the liner with rock salt to the slurry level of the main shaft. No seepage was observed.

4. Could an outburst have initiated the mine structure failure?

Past experience indicates that an outburst will generally occur in an area of active workings, immediately following blasting (see Appendix T). For an outburst to cause the type of failure which occurrred in the Jefferson Island Mine, it would have to have been of such magnitude that an immediate pressure differential would have been detected by personnel working underground. No miner reported experiencing such a pressure change. The possibility of an outburst, therefore, was eliminated.

Hypothetical Failure Modes

During the course of the investigation, the investigation team considered certain failure modes to determine, if possible, the cause of the inundation. These modes are as follows:

1. The Drilling Operation

(a) Assume that the drilling operation on the lake entered the salt dome close to the mine, but did not actually penetrate it. The investigation team considered the effect of lake water or ground water entering the well, the dissolution of the salt by the water, and the possible formation of a cavity which caused the difficulties encountered on the drilling operation on the lake. Within this same framework, they also considered the efforts of the drill crew to free the drill string, the pumping of additional drill mud under high pressure into the well and the possibility of these actions damaging the mine structure.

(b) Assume that the drilling operation on the lake did penetrate the mine. In this mode, the investigation team again considered the possible effects of lake and ground water entering the well with the drilling mud under high pressure. Also considered was whether the flow of water and drilling mud could, in themselves, cause the catastrophic failure. Further considered was the effect of this flow becoming uncontrollable and the progressive damage this might do to the mine structure, bringing about the total structural failure.

2. <u>The Mining Operation</u>

Assume that the salt dome had experienced and developed excessive creep deformation. The investigation team considered both surface and subsurface ground movement. They considered the new developments below the 800-foot and 1,000-foot levels and the possibility that these had brought about additional stress changes. They considered whether these changes might have brought the mine structure to a condition where the structure could no longer support itself.

3. <u>The Drilling and Mining Operation</u>

Assume that the salt dome had experienced and developed excessive creep deformation which had seriously weakened the structure, and assume that the drill rig penetrated the dome in the proximity of the mine or into the mine itself. The investigation team considered whether an abnormal fracture zone existed, but in itself was not sufficient to cause a total collapse of the structure. Also considered was the effect of the drill rig entering the fracture zone. They considered the effects of the effort to free the drill string and the additional effects of pumping drilling mud under high pressure. They considered whether this total picture would bring about the ground failure.

In considering the possible failure modes, the investigation team evaluated all the available information which might have contributed to a determination of which, if any, failure modes might have explained what occurred.

POSSIBLE CAUSES

Because it was impossible to inspect the flooded mine workings, and because of the circumstantial nature of the information available, it would be extremely difficult to determine the precise cause of the inundation. However, based on the information in this report, some possible causes have been proposed.

1. The mining operation had experienced subsidence on the surface and stress change underground. These developments had been monitored for at least the past 10 years. It would have been expected from the mining that the stress redistribution could have caused the weakening of the salt dome and the overburden. As early as 1971, an engineering study stated "the entire structure of the salt dome above the 1,300-foot elevation is not stable." In the following year, an engineering study indicated that "the salt formation above the 1,000-foot level is deforming excessively along its western perimeter." In 1980, an engineering study noted a "critical creep formation zone" in the general area of the mine where the inundation was first observed. During that period of time, the inspection of the mine did not disclose any visible major structural failure problems. However, the possibility of a weakened structure developing into a catastrophic failure through continual mining activities can not be ruled out as a possible cause of the inundation.

2. As noted elsewhere in this report, approximately two-and-one-half hours before the inundation was first observed, the Texaco drill string became stuck and could not be restarted. There was a loss of circulation of the drilling mud. The depth of the hole was reported to have been between 1,228 and 1,248 feet, which would have been in the approximate range of the 1,300-foot level of the salt mine. Efforts were continued to restart the drill, but to no avail. The inundation of the mine was detected shortly after the entire drilling rig capsized and disappeared into Lake Peigneur.

Additionally, an attempt was made by Diamond Crystal to place the exact location of the Texaco oil rig immediately following the inundation. Later that same day, Diamond Crystal was joined by Texaco, and Texaco provided its own survey data to calculate the bearing and distance from the mine's shaft to the P-20 drill hole. The information supplied by Texaco was plotted on a Diamond Crystal mine map of the 1,300-foot level. A Diamond Crystal official stated that the plotted location of the drill hole fell just within a mined out section in the southwest area of the mine. An X was placed on the map during this joint meeting to indicate that spot (Appendix T).

The sequence of events on the drill rig and the inundation of the mine shortly thereafter can not be ignored. Unfortunately, it is also not possible to determine whether the problems encountered on the rig signified that it was the rig that caused the mine failure or that the mine failure caused the trouble.

If the plotting on the mine map were correct, then serious thought must be given to the Texaco drill rig as the triggering action for the sudden failure. It would not have been necesssary for the drill to puncture the mine itself. Proximity to the mine could have brought about the failure. To make a determination of the facts in this matter, it would be necessary to examine the mine's interior. Obviously, this is not possible at this time.

3. As a third possible cause of the collapse of the mined out section of the salt dome and the resultant inundation of the mine, the coincidence of both the above possible explanations must be considered. If indeed a continuing excessive creep deformation caused the mine structure to weaken, principally in the area where the inundation was suspected, and if the Texaco drilling operation either penetrated or came near the mine in that area, then the combination could have caused a collapse of the mined out section that progressed to a catastrophic failure and, finally, the total inundation of the mine.

CONCLUSION

Based on the evidence and information which the investigation team was able to obtain, it was not possible to determine the exact cause of the inundation.

RECOMMENDATIONS

The following recommendations apply to mines where the possibility of an inundation exists.

1. Responsible parties representing drilling and mining interests should meet to discuss all proposed drilling which may adversely affect mining. The parties should jointly prepare a map showing a proposed hole's location in relation to the mine and its workings. A copy of this map should be submitted to the MSHA district office.

2. The mine operator should maintain current surface and underground maps. These should be updated semi-annually and submitted to each respective district office, and made available to any drilling operator in the immediate vicinity.

3. Salt domes should be contoured as accurately as possible at all elevations where mining is conducted or intended.

4. Whenever the mine design is changed significantly from standard practice, the reason for the change and its supporting background data should be submitted to MSHA in advance.

5. Whenever abandoned areas of salt mines are isolated from active workings, water detection equipment should be installed.

6. Barriers that are constructed in a mine to prevent entry should be provided with a positive means to prevent accumulation of water without detection.

7. When mine development headings are advanced to within 400 feet of the edge of the dome, and in mines where seepage is detected, the headings should be preceded by horizontal exploratory drill holes. The distance from the face to the end of the drill holes should not be less than 100 feet.

8. An emergency plan should be jointly developed by drilling and mining interests. Communications should be stressed.

9. Mine evacuation plans and drills should be continually emphasized at all underground mines. The successful evacuation of all personnel at the Jefferson Island Mine is ample proof that intelligent planning may save many lives.

GLOSSARY

<u>annulus</u>

- The space surrounding pipe suspended in the well bore.

<u>back</u>

The roof or ceiling in any underground mine cavity.

<u>back sight</u>

The initial observation used to reference a transit or other instrument before measuring or establishing horizontal angles during surveying procedures.

<u>balling</u>

To collect a mass of sticky, consolidated material - usually shale cuttings on the drill bit. Condition frequently caused by inadequate drilling mud pump pressure or an insufficient volume of drilling fluid.

<u>bench mining</u>

A system of mining in which the floor is removed in a series of vertical slices, following the initial room-and-pillar configuration.

<u>bistable</u> (sampler)

A hand operated sampling device used to sample mine atmospheres for analytical purposes.

<u>blowout preventor</u>

Equipment installed on surface or intermediate casing for the purpose of controlling pressure in the annular space between the casing and the drill pipe or in an open hole during drilling and complete operations.

<u>cage</u>

The mining term for an elevator, normally used to convey men/materials within a shaft.

<u>cap rock</u>

Barren rock and/or soil covering an ore deposit.

<u>casing</u>

Steel pipe used to isolate a section of open drill holes or to isolate producing zones from one another.

cementing

Cement slurry pumped down through a well casing and out at the lower end in such a way that it fills the space between the casing and the sides of the well bore to a predetermined height above the bottom of the well. Used to secure the casing in place and to exclude water and other fluids from the well bore.

circulation

To pump drilling fluid (mud) down through the drill pipe and back to the surface.

conductor pipe

A short casing string of large diameter used in marshy locations or under other conditions to keep the top of the well bore open, prevent washing out, and to provide a means of conveying the upflowing drilling fluid to the surface.

contour interval

The difference in elevation between two adjacent contour lines.

contour line

A line connecting points of equal value on a map; usually points of equal elevation.

daywork

The basis for payment in which a contractor is paid by the operator at an agreed upon daily rate, regardless of footage drilled.

decline

A sloping tunnel leading from one mine level downward to another level.

derrick

The load-bearing, structural portion of a drilling rig which supports the crown block. Present practice is to use a mast which may be raised or lowered without disassembly in place of a derrick.

dip

The angle at which a lead or stratum is inclined from the horizontal.

directional

Purposely deviating a well being drilled, from the vertical, in a controlled direction and angle.

downcast

The downward flow of air in a mine shaft, raise, or stope.

draw works

The hoisting mechanism on a drilling rig. It is essentially a large winch which raises or lowers the drill string and bit.

drill string

The bit, drill collars, drill pipe, Kelly joint and Kelly when assembled for drilling.

drilling log

A tour by tour account of progress made in drilling. Usually written on standardized record forms.

drilling mud

A mixture of water or other fluids and one or more mud-making materials such as clay, weighting materials or chemicals. It removes cuttings from the bottom of a drill hole and carries them to the surface. Muds also lubricate and cool the bit, exert hydrostatic pressure to contain high formation pressures, and build a filter cake lining the bore to reduce mud fluid losses into potentially producing formations.

drilling platform

The fabricated base upon which the substructure of a drilling rig is mounted.

drilling rig

The derrick, draw works and attendant surface equipment of a drilling unit.

dry hole

A well found incapable of producing oil or gas economically.

face

The solid surface of unbroken material at the advancing end of a mine working.

floor

The part of an underground working upon which a person walks or on which mine vehicles travel.

Frasch process

The mining of sulfur by means of forcing superheated water into the deposit to melt the sulfur, which is then pumped to the surface.

gumbo

Soils yielding a sticky mud when wet, often a type of clay.

headframe

The steel or timber frame at the top of a mine shaft which carries the sheaves for the hoisting rope.

hook lead indicator

A scalar instrument indicating the suspended weight of the drill string and/or casing expressed in pounds.

intersection

A surveying procedure used to physically locate a desired point on the earth's surface from multiple points of known location.

mean tide level

The average level of a body of water affected by tides; the median between high and low tide.

mud engineer

An oil/gas well drilling specialist concerned with controlling chemical, rheological and wall building properties of drilling fluids.

mud pump

A single or double acting piston type pump used to circulate drilling fluids down the drill pipe and up the annulus under normal operations.

production casing

The pipe casing which maintains the integrity of the well bore. It is perforated where it passes through producing strata to permit entrance of oil/gas to its interior. It houses the production tubing.

production formation

Rock stratum which is the reservoir rock of gas/oil.

production tubing

Tubing used inside of the production casing to bring well product to the surface.

refuge chamber

A facility in an underground mine which can be isolated from contaminants in the mine atmosphere. It either contains its own or is supplied with a source of uncontaminated air. In some instances it may be supplied with food, water and other necessities to sustain life for extended periods.

return air

Air which has circulated in the underground mine workings and is flowing toward a point of discharge at the surface.

returns

Drilling fluids and contained drill cuttings discharging from a well bore at the surface.

rigging up

Assembling the components of a drilling rig at well site preparatory to initiating drilling.

roof bolts (rock bolts)

Long steel bolts driven or anchored into the wall or roof of an underground excavation and used to support the roof, preventing and limiting the extent of roof falls.

roof control

The methods of stabilizing rock movement in underground mines.

room-and-pillar

A mining method in which the ore is mined in rooms separated by pillars of unmined ore or rock which support the roof.

saltcrete

An especially compounded cementation material mixed with saturated salt water to enhance cementing procedures in salty environments.

salt dome

A roughly circular plug resulting from upward movement of a salt mass. In the Gulf Coast area the surface topography is uplifted locally by the intrusions, referred to as islands.

shaft

An excavation of limited area compared with its depth made for mining ore; raising of ore, water, or rock; the hoisting or lowering of men and materials; or ventilating underground workings.

shaft collar

The beginning point of a shaft or drill hole; the surface.

shrinkage mining

A system of mining where the roof is removed in successive slices, a portion of the broken ore from previous slices serving as a working floor to mine succeeding slices.

skip (hoist)

A conveyance for hoisting ore or rock from a mine.

slope indicator

An indicating instrument utilizing a pendulum and electric signals to show changes of slope at various points along a pipe inserted into the earth.

spudding in

The very beginning of drilling operations of a well.

substructure

The foundation on which the derrick and engines sit.

surface pipe

The first string of casing to be set in a well, generally to isolate fresh water formations.

survey

A test to indicate the amount of deviation of a well bore from the vertical as measured in degrees. Louisiana state regulations require such tests to be made every 500 feet when drilling. The results must be recorded and made available to state officials.

timber sets

A timber frame to support the roof, sides, and sometimes the floor of mine roadways or shafts.

toolpusher

A foreman in charge of one or more drilling rigs; the supervisor of drilling operations.

topographic mapping

The representation, to a predetermined scale, of selected features of a portion of the surface of the earth. This map type may show land features by means of contour lines.

tour

The word designating the work shift of a drilling crew, often pronounced t-o-w-e-r.

undercut

To remove a horizontal section or kerf in the bottom of face of rock (in this case, salt) to ease its removal by blasting.

vibrating screen (shale shaker)

A screening device which removes coarse drill cuttings from drilling muds circulated to the surface prior to reentry into the mud pump(s).

washout

An excessive well bore enlargement caused by solvent and erosional action of the drilling fluid.

ACKNOWLEDGEMENTS

The courtesy, cooperation, and assistance extended by all individuals and organizations is appreciated.

Respectfully submitted,

Marvin W. Nichols
Subdistrict Manager

Kelvin K. Wu
Chief, Mine Waste & Geotechnical Engineering Division

Jeffery H. Kravitz
Chief, Mine Emergency Operations

John S. Risbeck
Supervisory Mining Engineer

Jay W. Durfee
Supervisory Mining Engineer

William R. Wilcox
Supervisory Mine Specialist

Richard D. Feehan
Mine Specialist

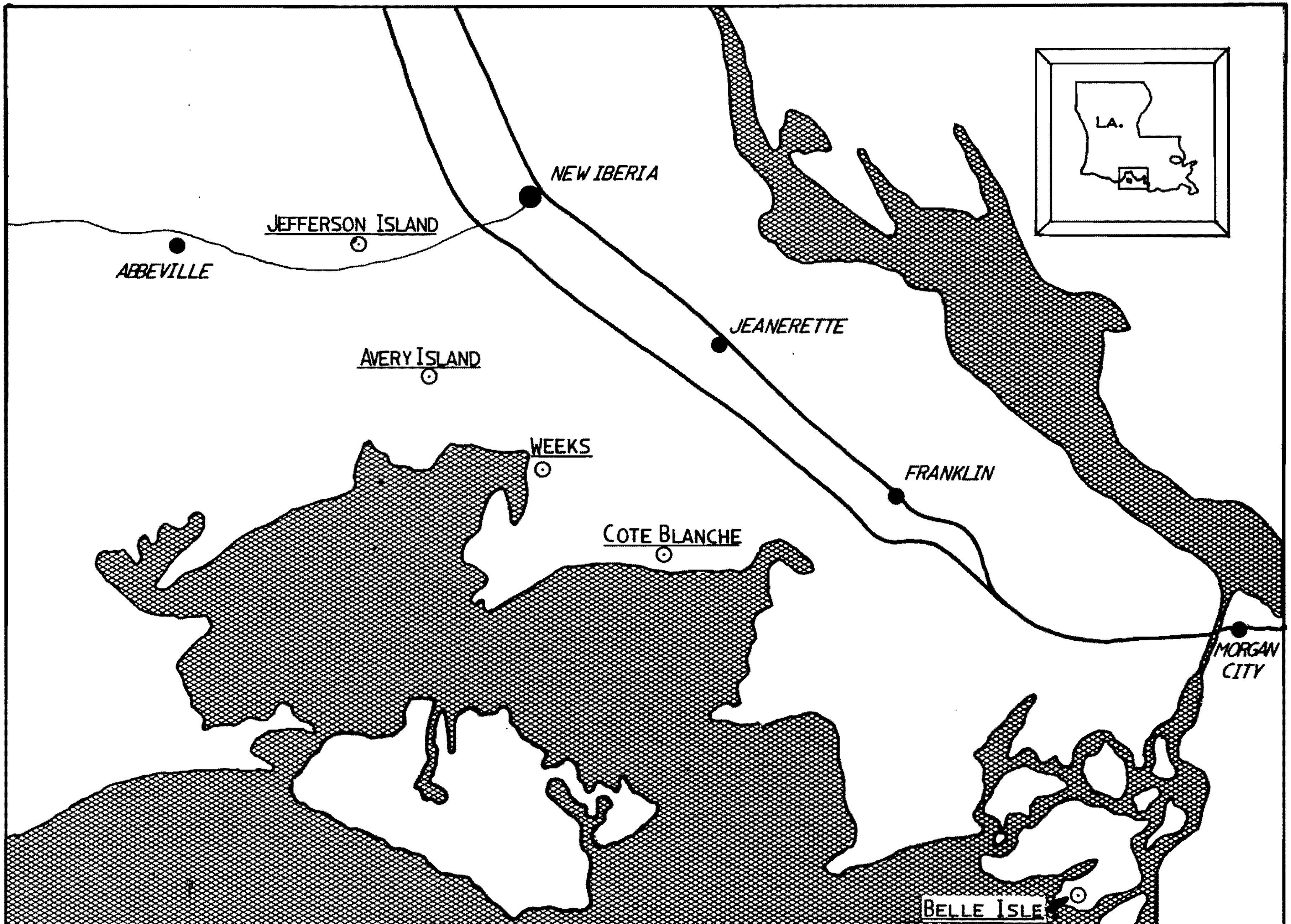
David P. Lilly
Mine Specialist

Frank E. O'Gorman
Public Information Officer

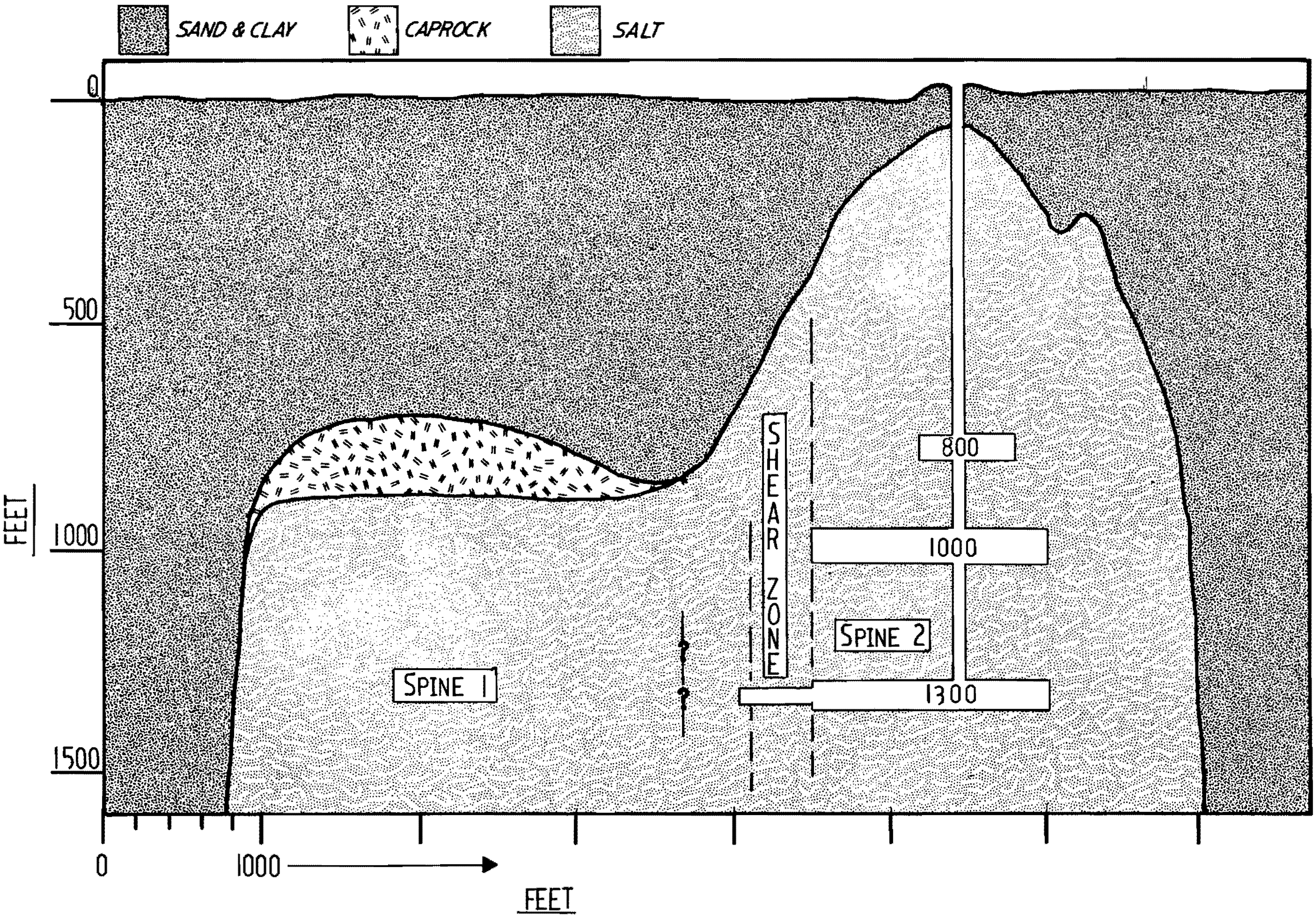
Approved by:

Acting Deputy Administrator
for Metal and Nonmetal

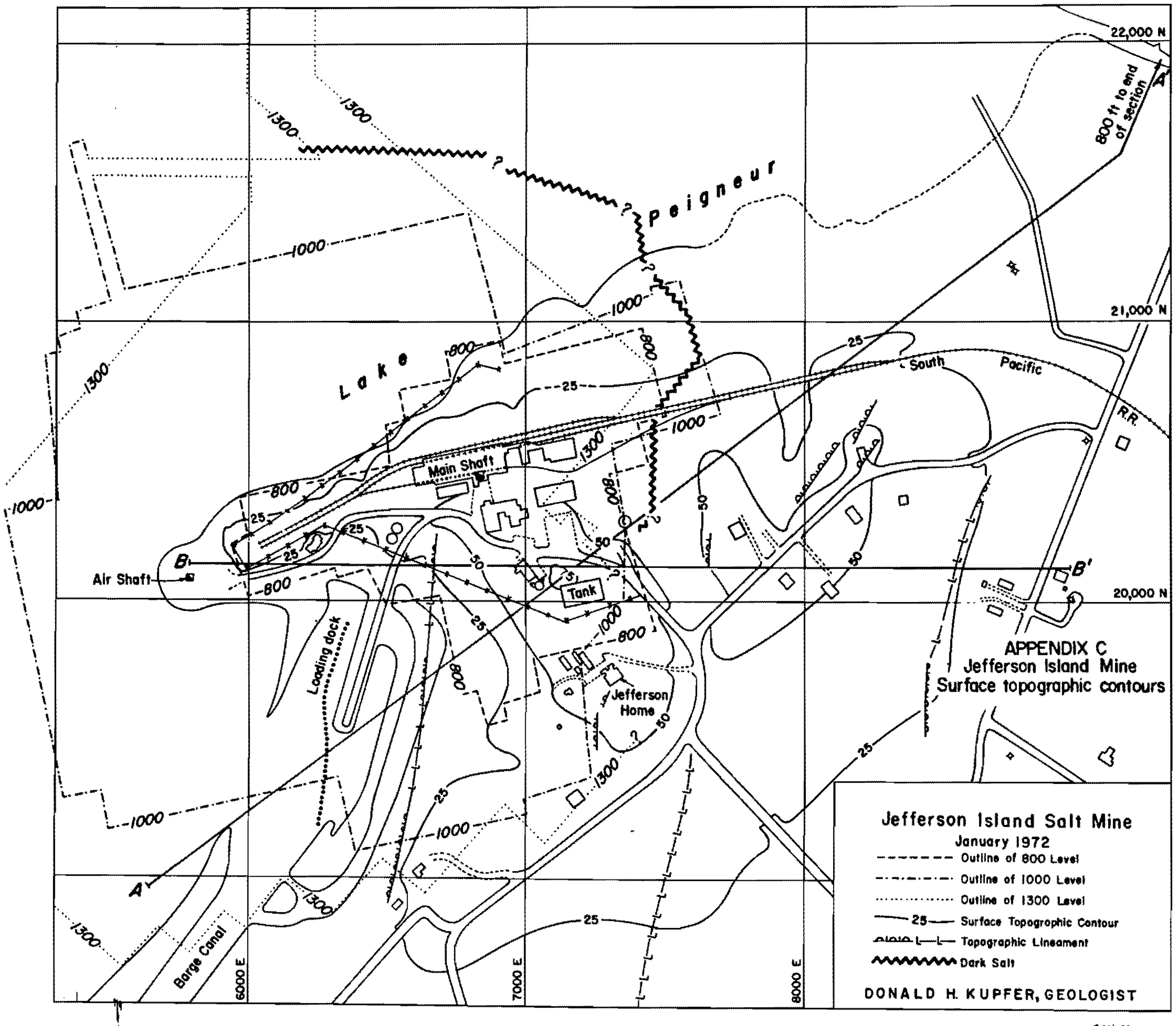
APPENDIX



APPENDIX A: JEFFERSON ISLAND MINE LOCATION

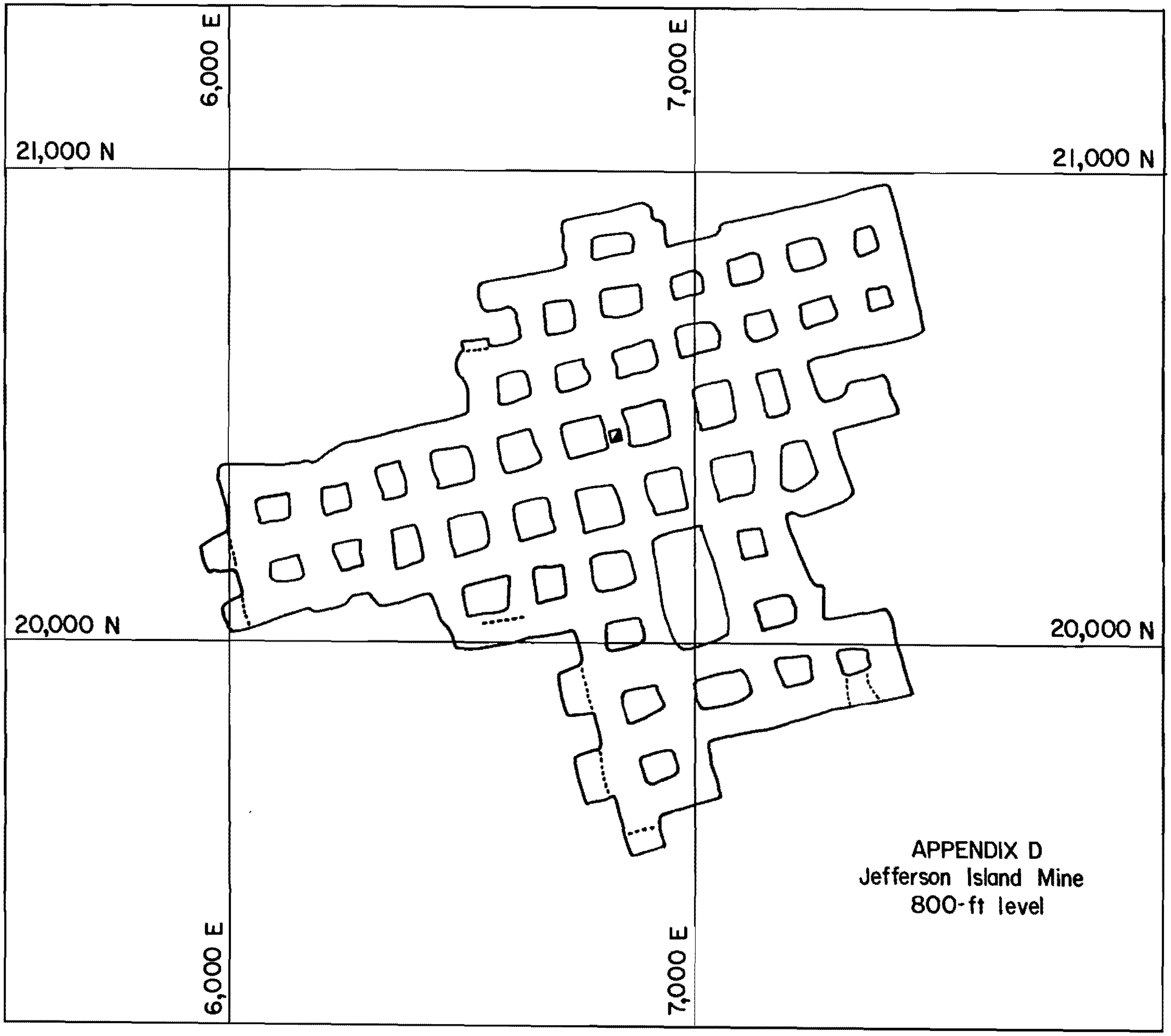


APPENDIX B: Cross-Section of Jefferson Island Salt Dome

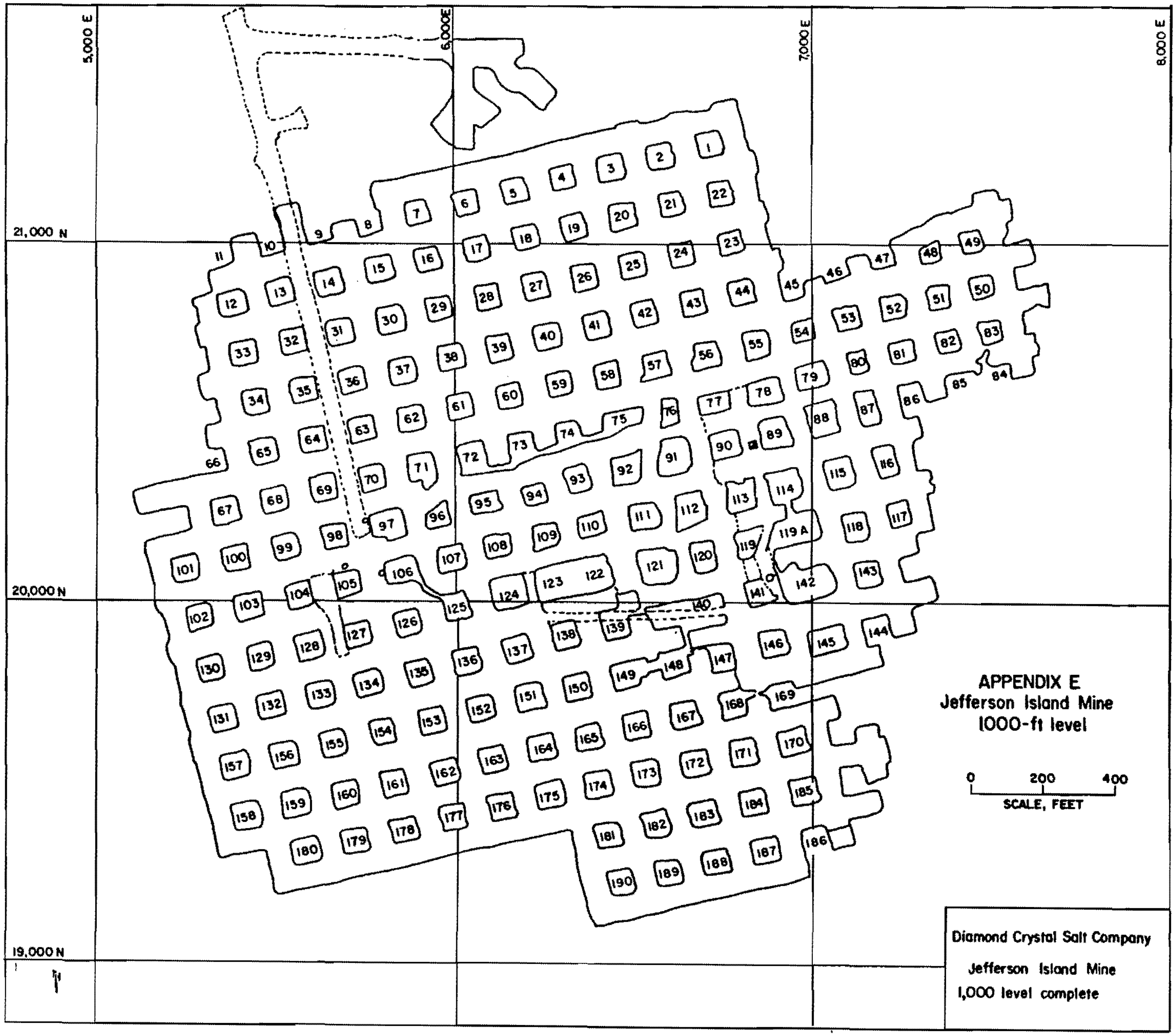


22,000 N
21,000 N
20,000 N
6000 E
7000 E
8000 E
800 ft to end of section
A'
A
B
B'
Lake Peigneur
South Pacific R.R.
Main Shaft
Air Shaft
Tank
Loading dock
Jefferson Home
Barge Canal
APPENDIX C
Jefferson Island Mine
Surface topographic contours
Jefferson Island Salt Mine
January 1972
Outline of 800 Level
Outline of 1000 Level
Outline of 1300 Level
25 Surface Topographic Contour
L L Topographic Lineament
Dark Salt
DONALD H. KUPFER, GEOLOGIST

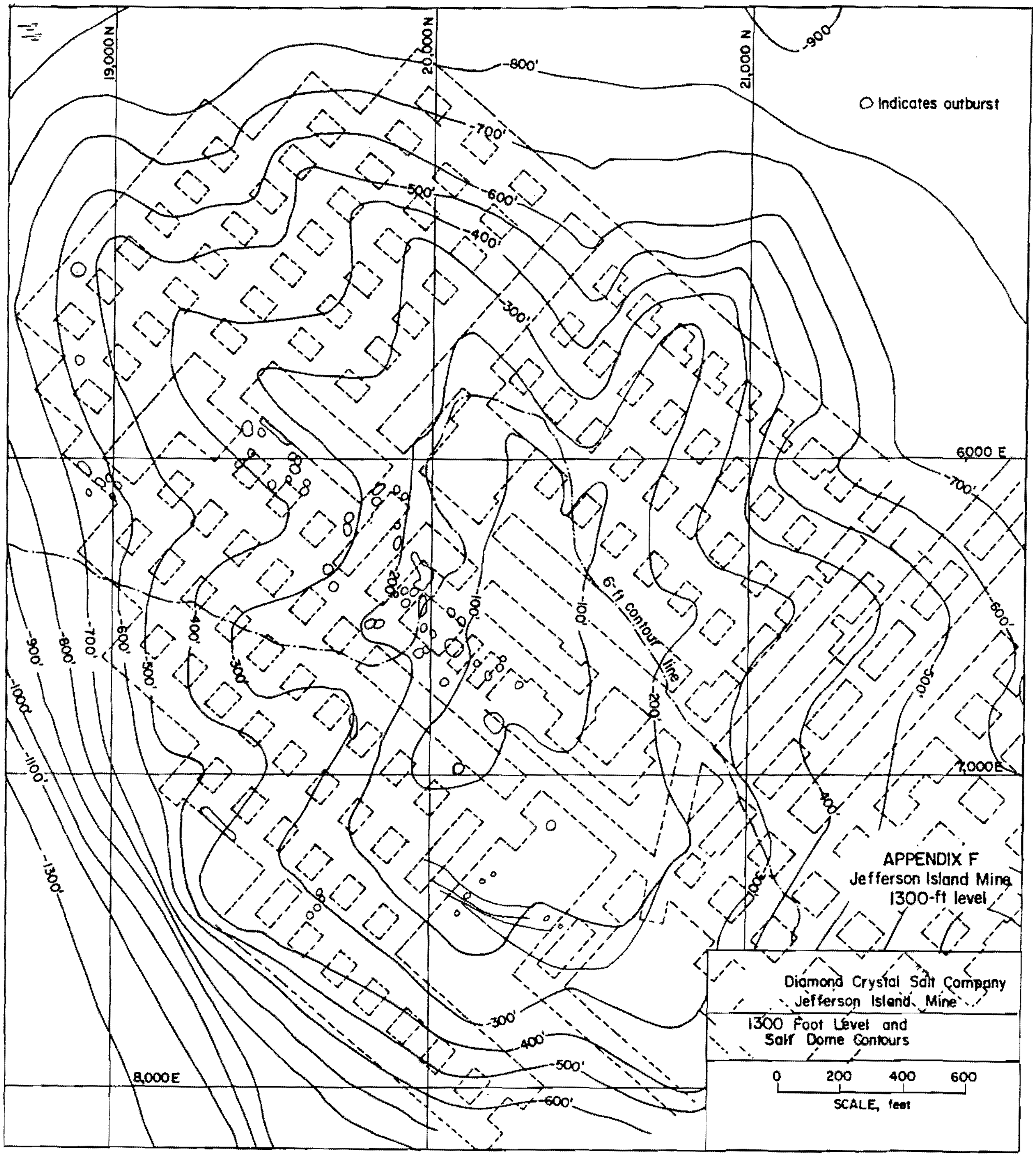
PGH-81
219



APPENDIX D
Jefferson Island Mine
800-ft level

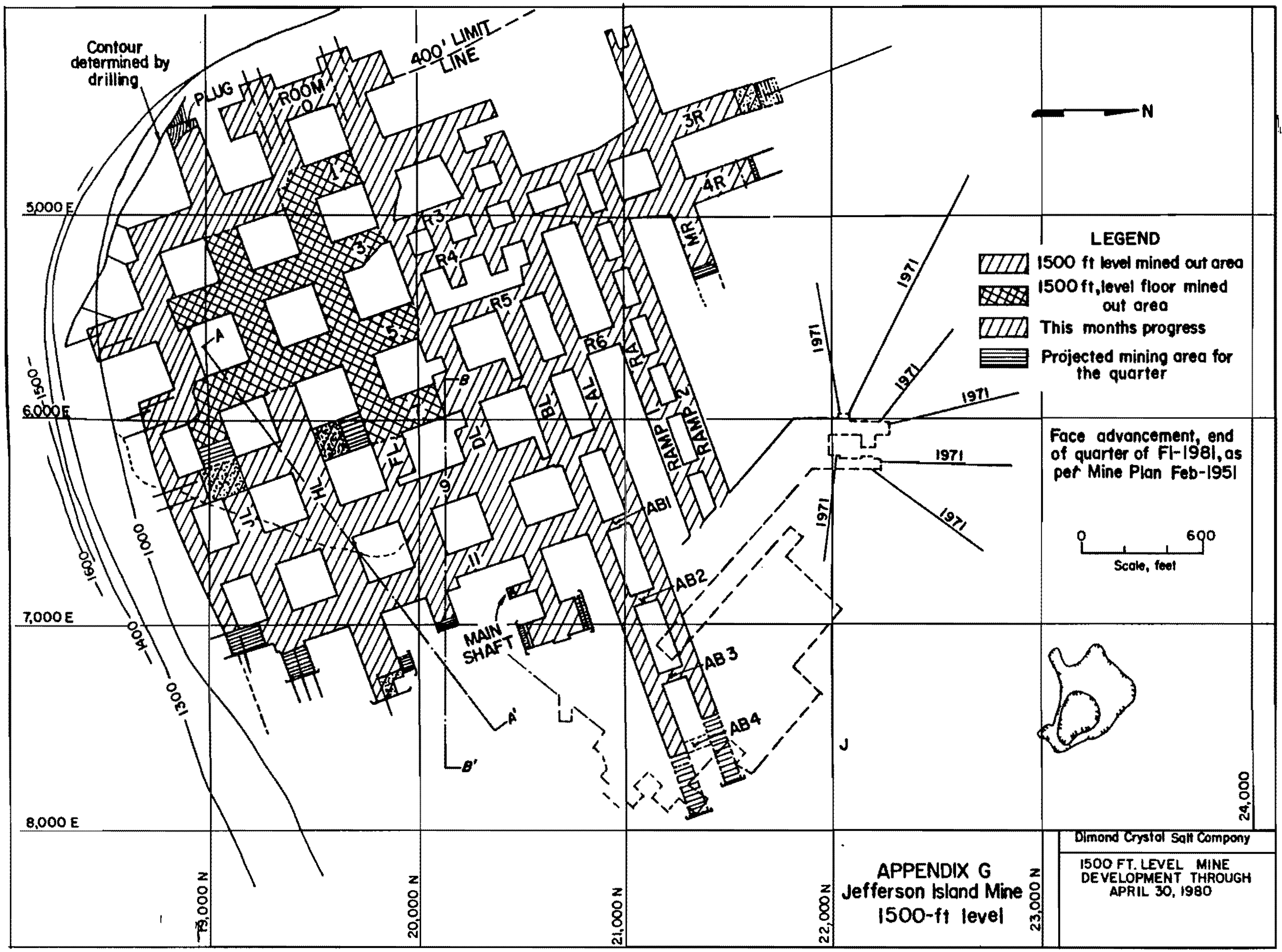

APPENDIX E
Jefferson Island Mine
1000-ft level
0 200 400
SCALE, FEET
5,000 E
6,000E
7,000 E
8,000 E
21,000 N
20,000 N
19,000 N
Diamond Crystal Salt Company
Jefferson Island Mine
1,000 level complete

PGH-BL
221



19,000 N
20,000 N
21,000 N
○ Indicates outburst
6000 E
7,000E
8,000E
-800'
-900'
-700'
-600'
-500'
-400'
-300'
-200'
-100'
-1000'
-1100'
-1300'
6-ft contour line
APPENDIX F
Jefferson Island Mine
1300-ft level
Diamond Crystal Salt Company
Jefferson Island Mine
1300 Foot Level and
Salt Dome Contours
0 200 400 600
SCALE, feet

PGH-81
222



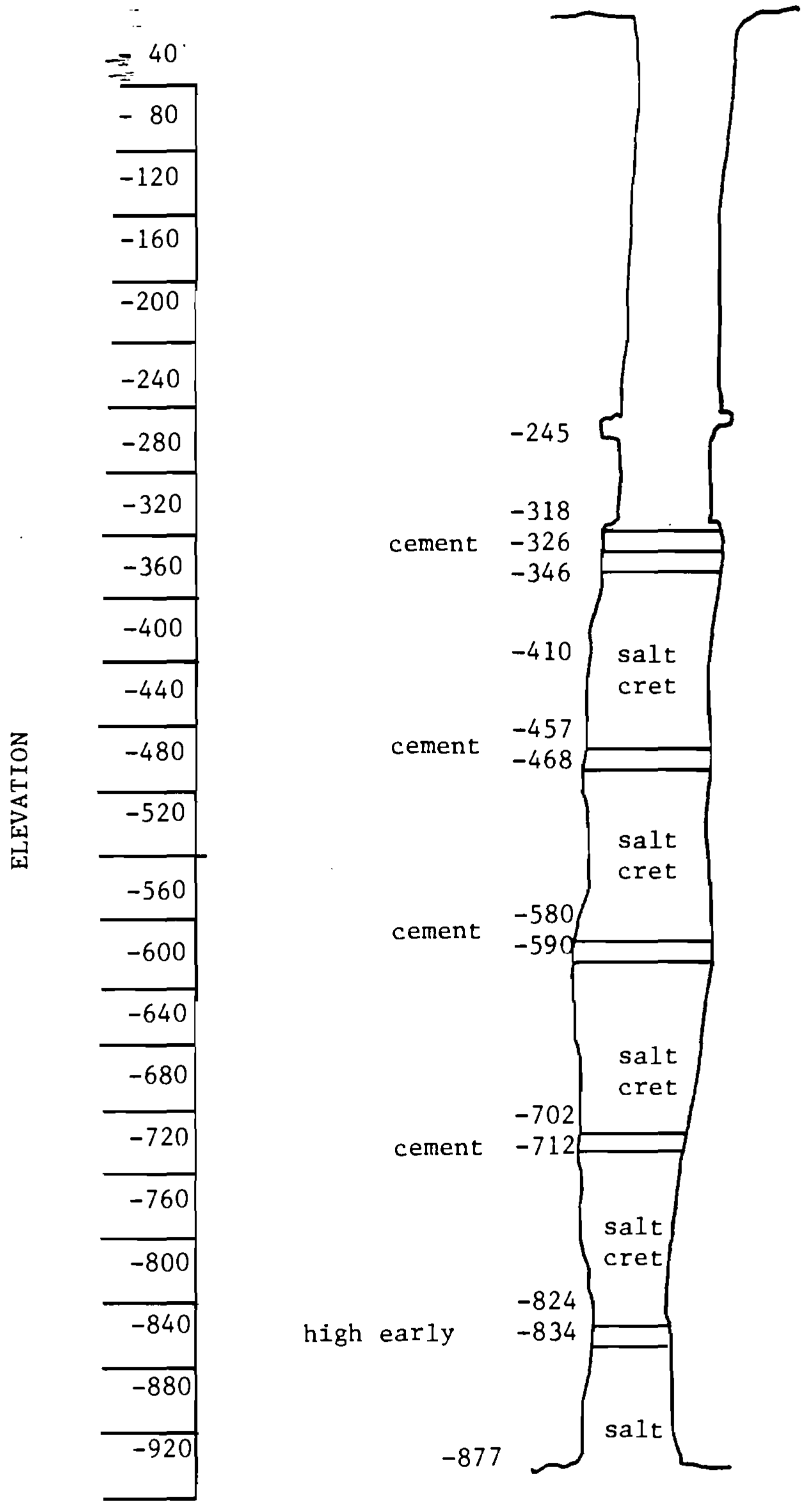
APPENDIX G
Jefferson Island Mine
1500-ft level

Dimond Crystal Salt Company

1500 FT. LEVEL MINE
DEVELOPMENT THROUGH
APRIL 30, 1980

PGH-81
223

DIAMOND CRYSTAL SALT COMPANY
Jefferson Island, Louisiana

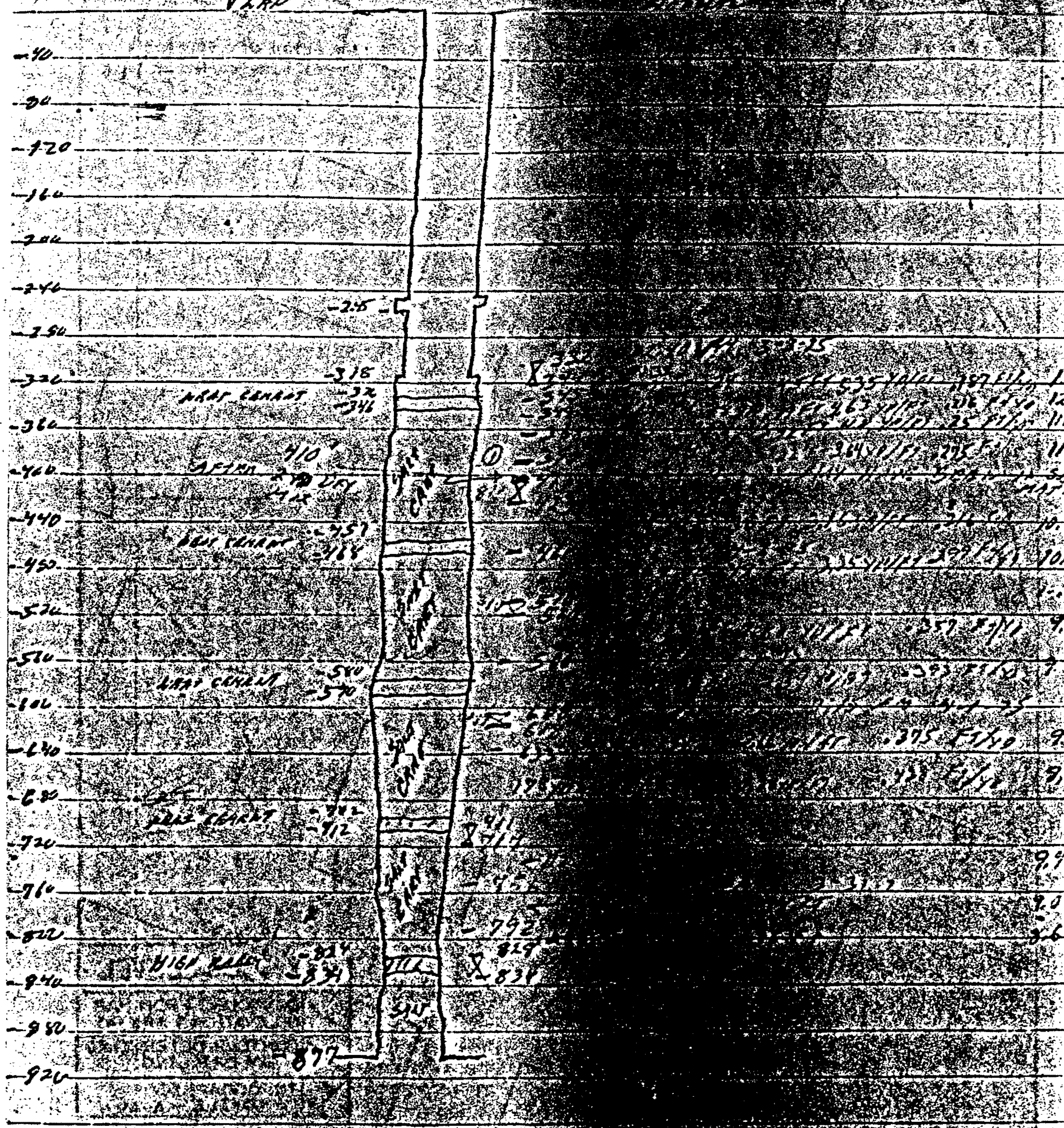


APPENDIX H: Old Air Shaft Seal (from Diamond Crystal Plan)

DIAMOND CRYSTAL

JEFFERSON ISLAND

3-30-75



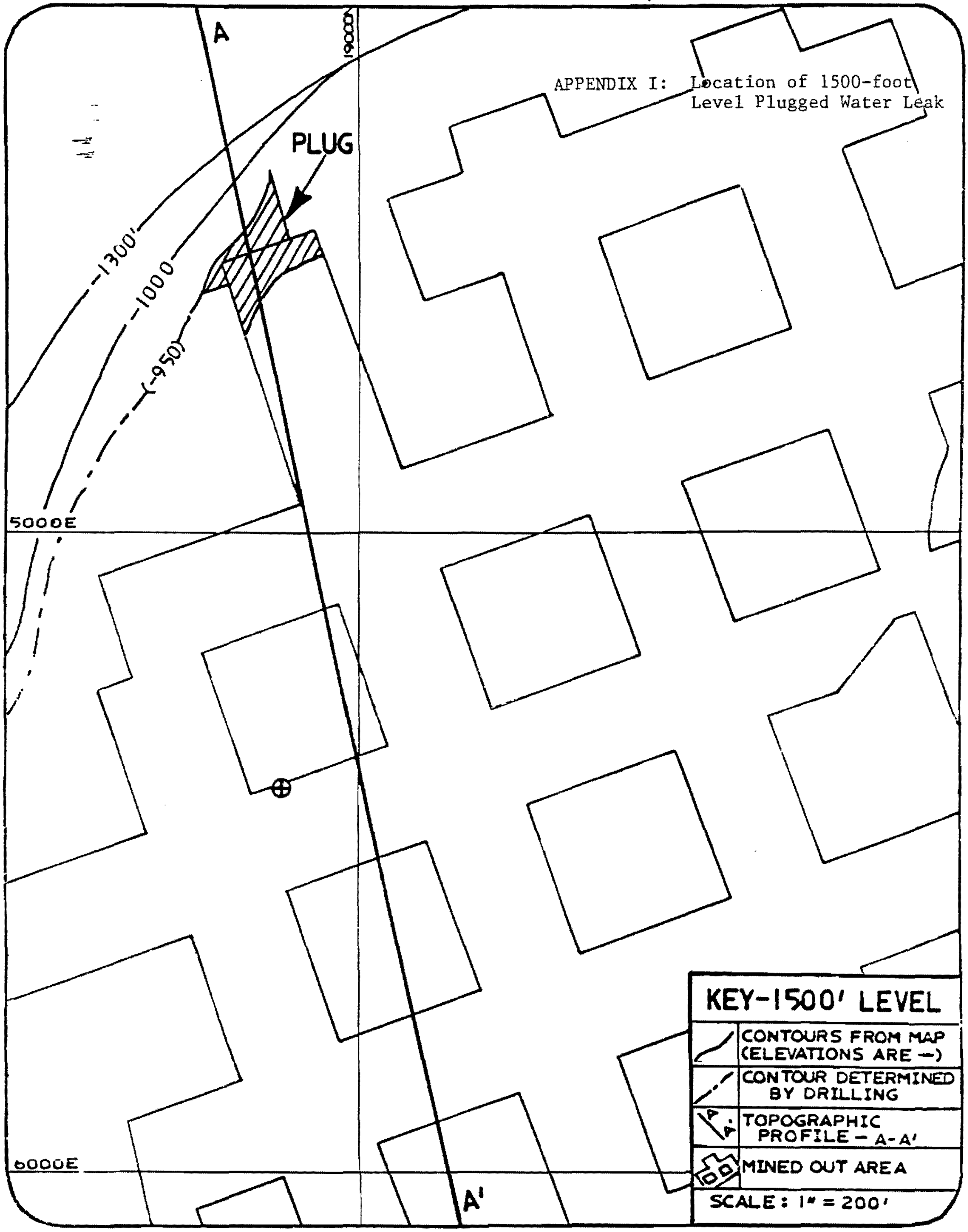
10 Ft of New Cement (1) ... 257

Vol Based on Average 11 Ft

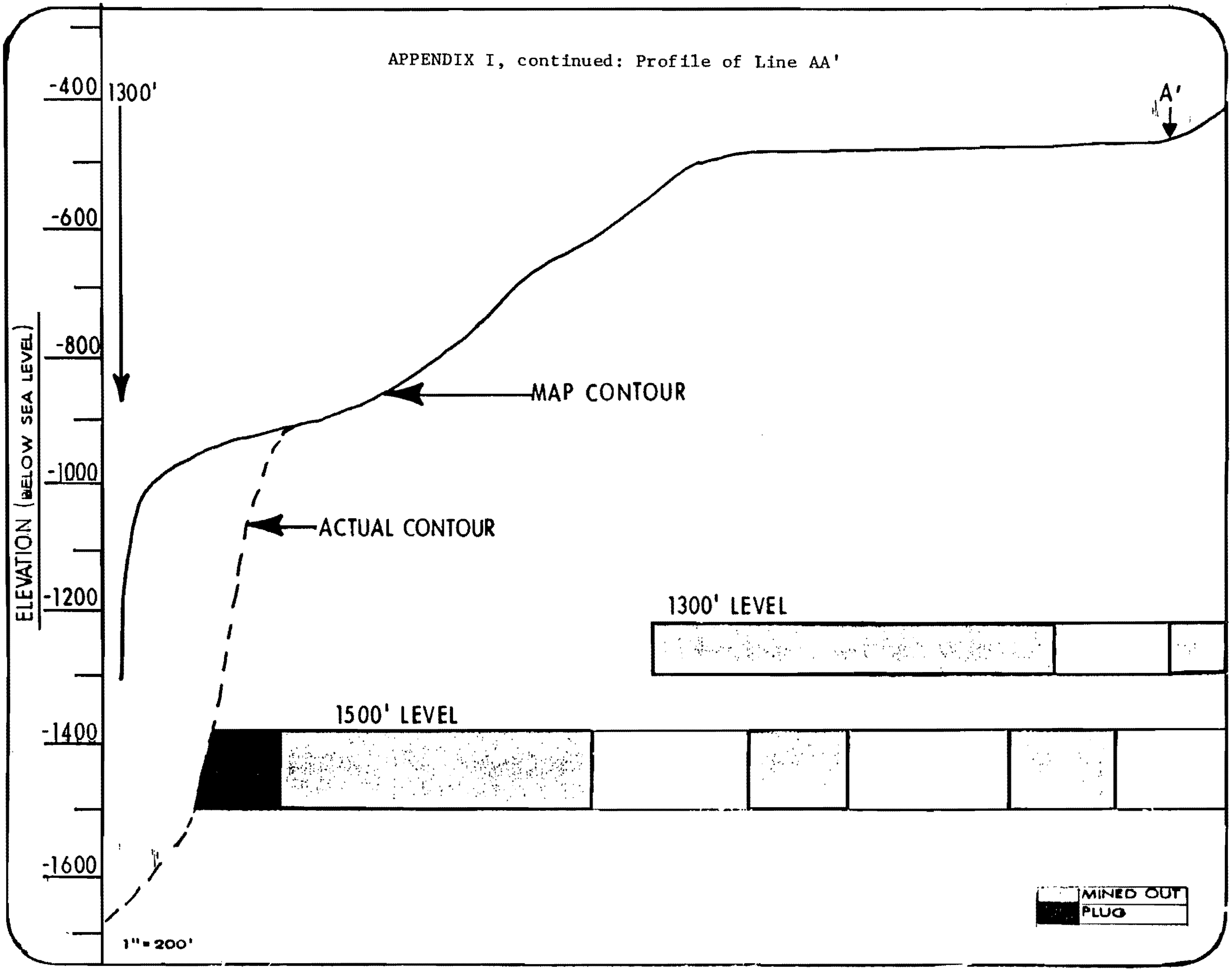
Dia Height May Be More

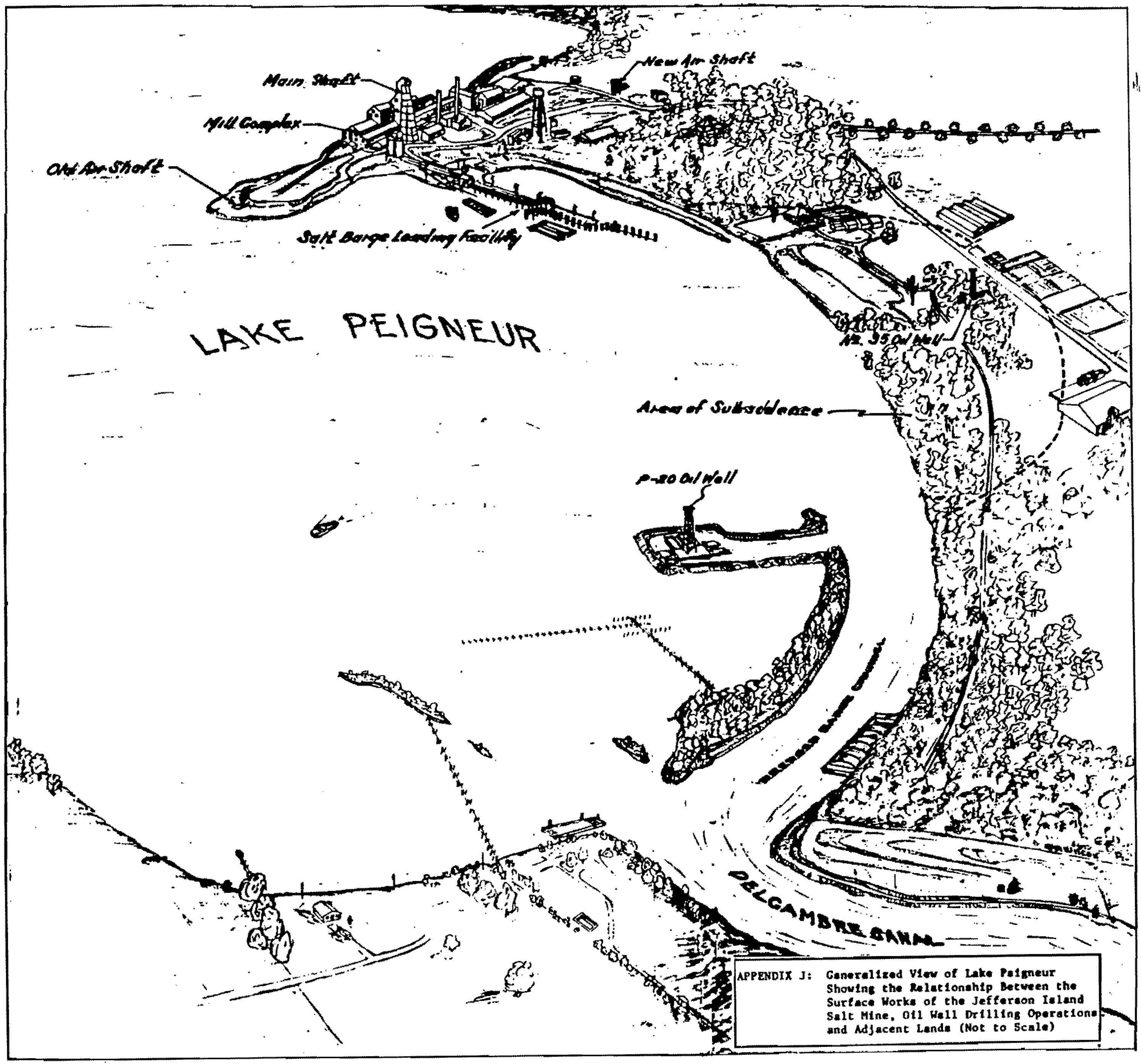
or Less Depending on Dia

APPENDIX I: Location of 1500-foot Level Plugged Water Leak

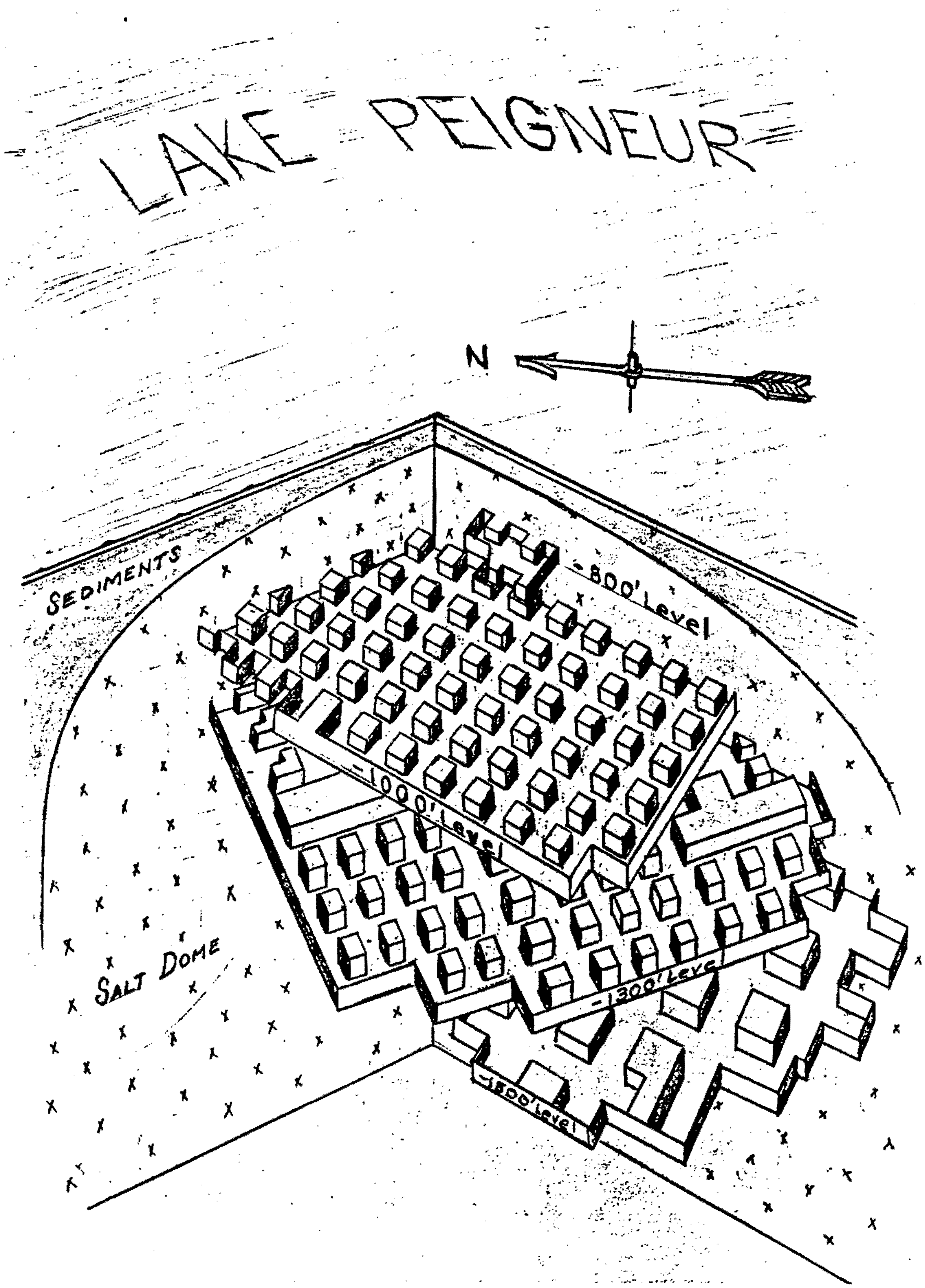


APPENDIX I, continued: Profile of Line AA'

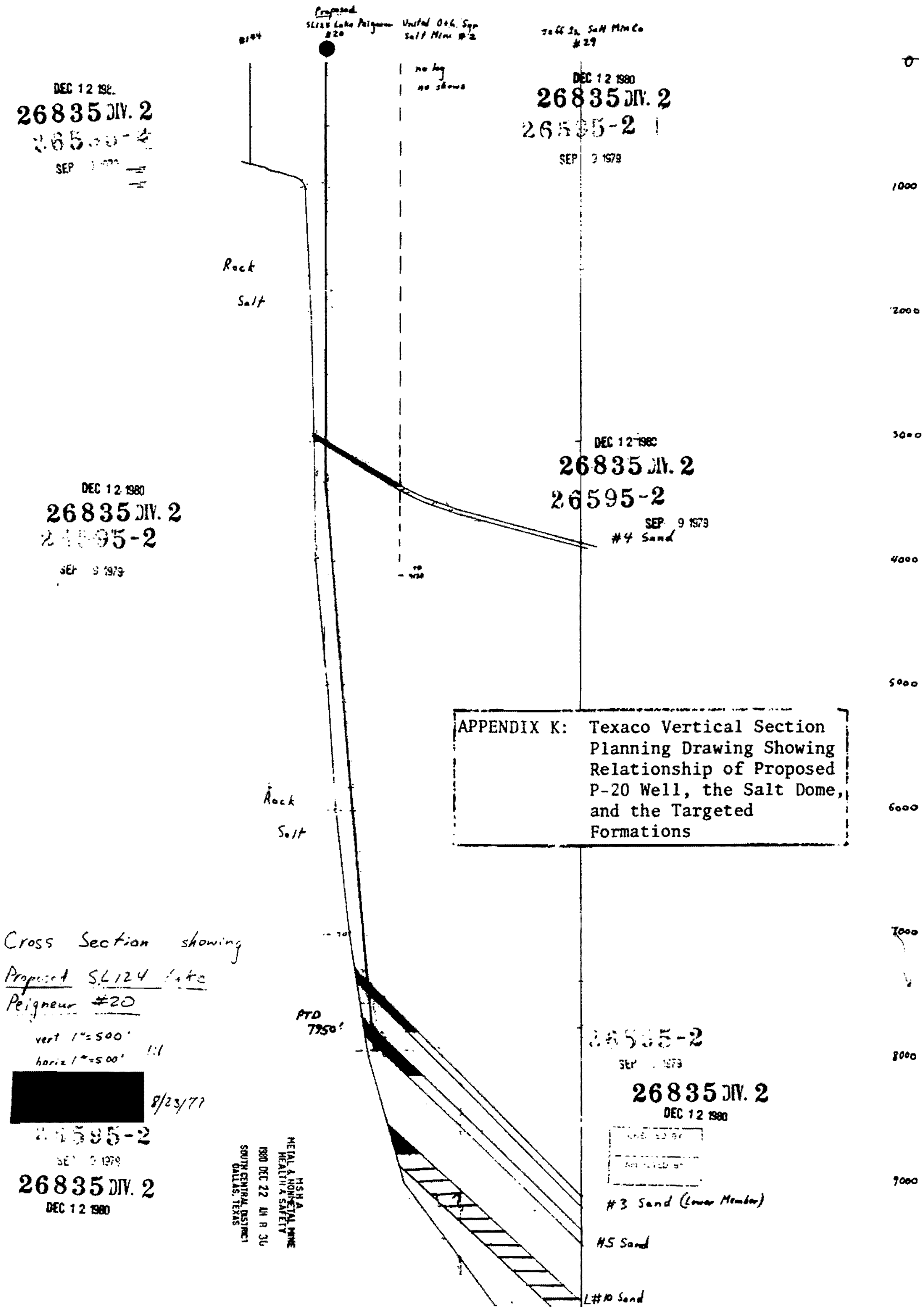




APPENDIX J: Generalized View of Lake Peigneur Showing the Relationship Between the Surface Works of the Jefferson Island Salt Mine, Oil Well Drilling Operations and Adjacent Lands (Not to Scale)

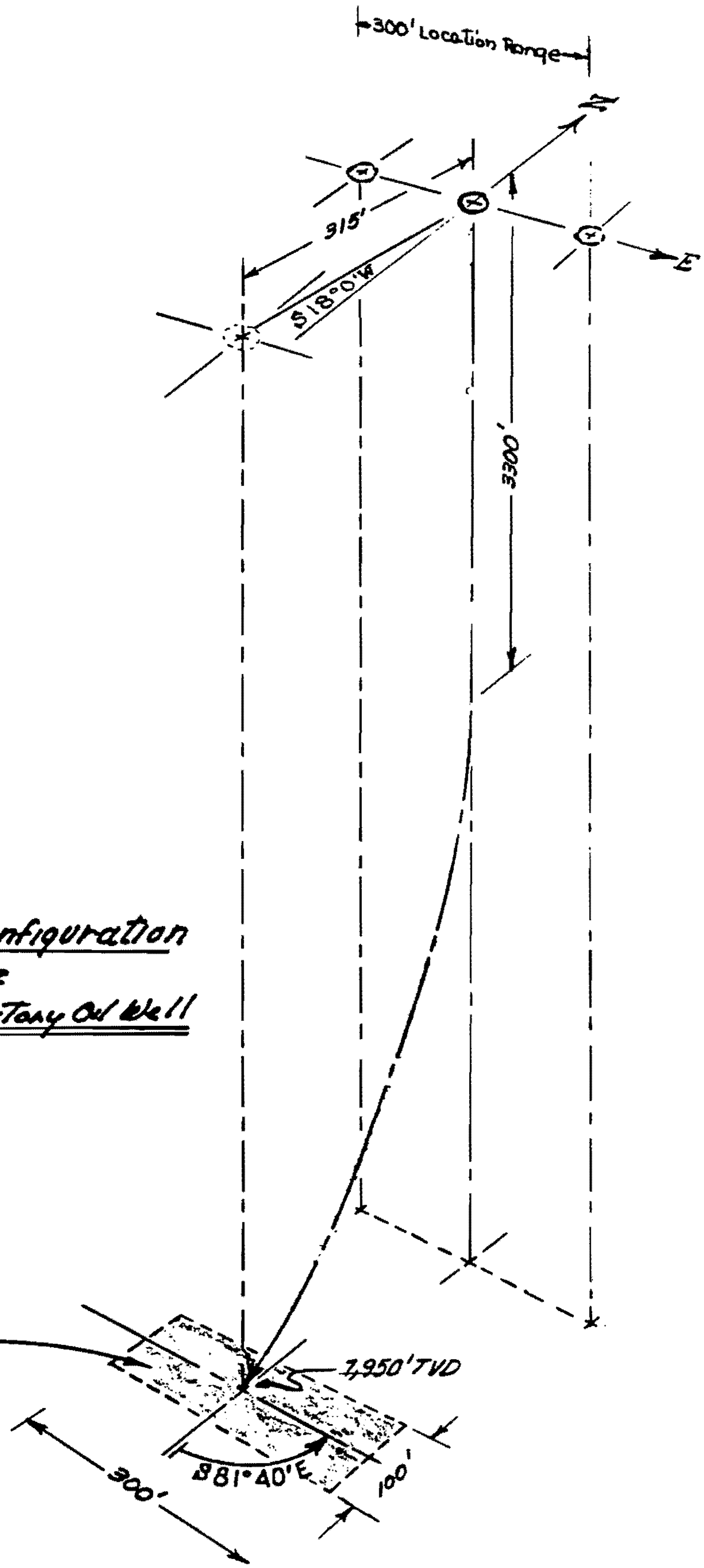


APPENDIX J': General relationship of the various working levels within the salt dome at the southwest extremity of the mine. (View toward the surface plant location.)

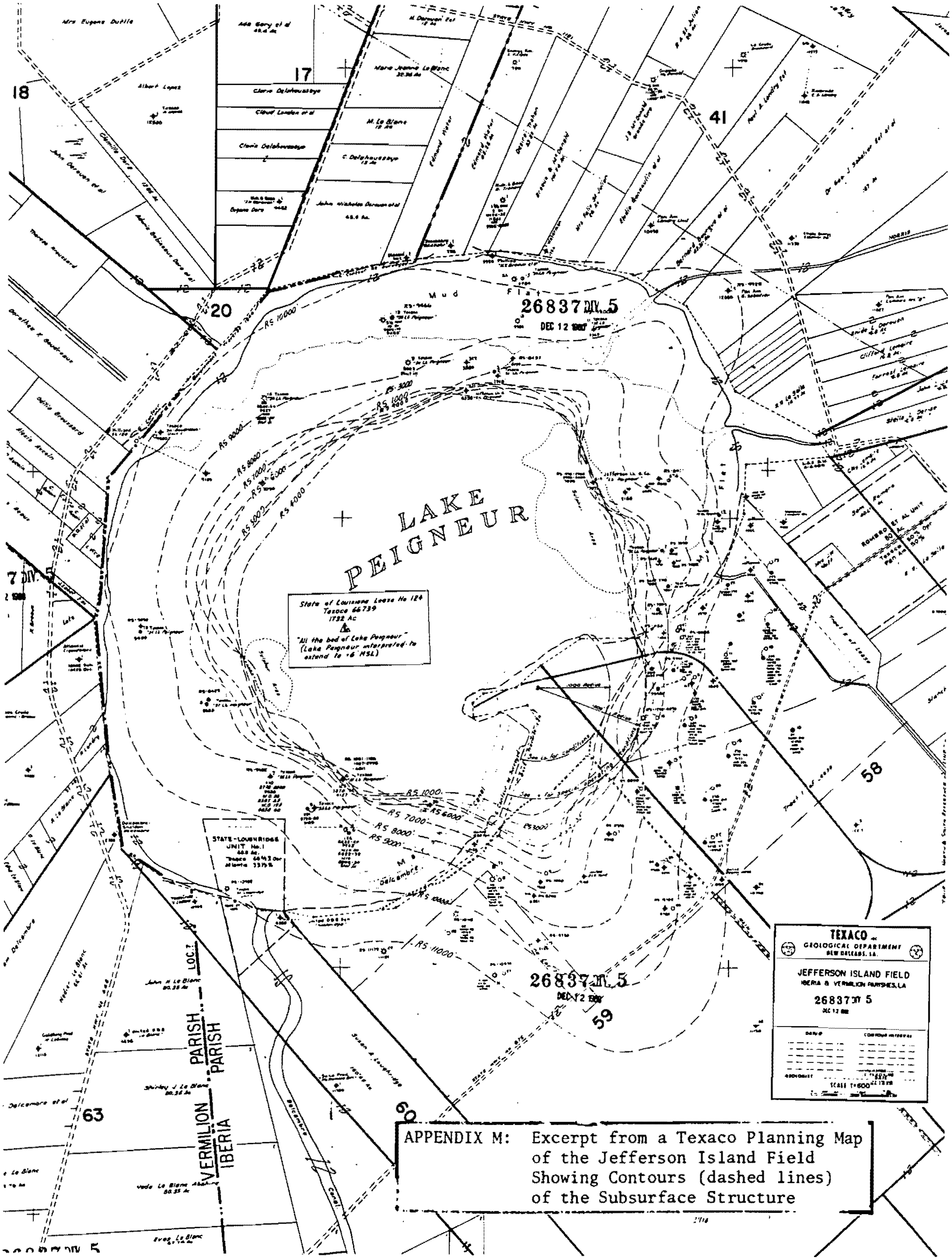


APPENDIX K: Texaco Vertical Section Planning Drawing Showing Relationship of Proposed P-20 Well, the Salt Dome, and the Targeted Formations

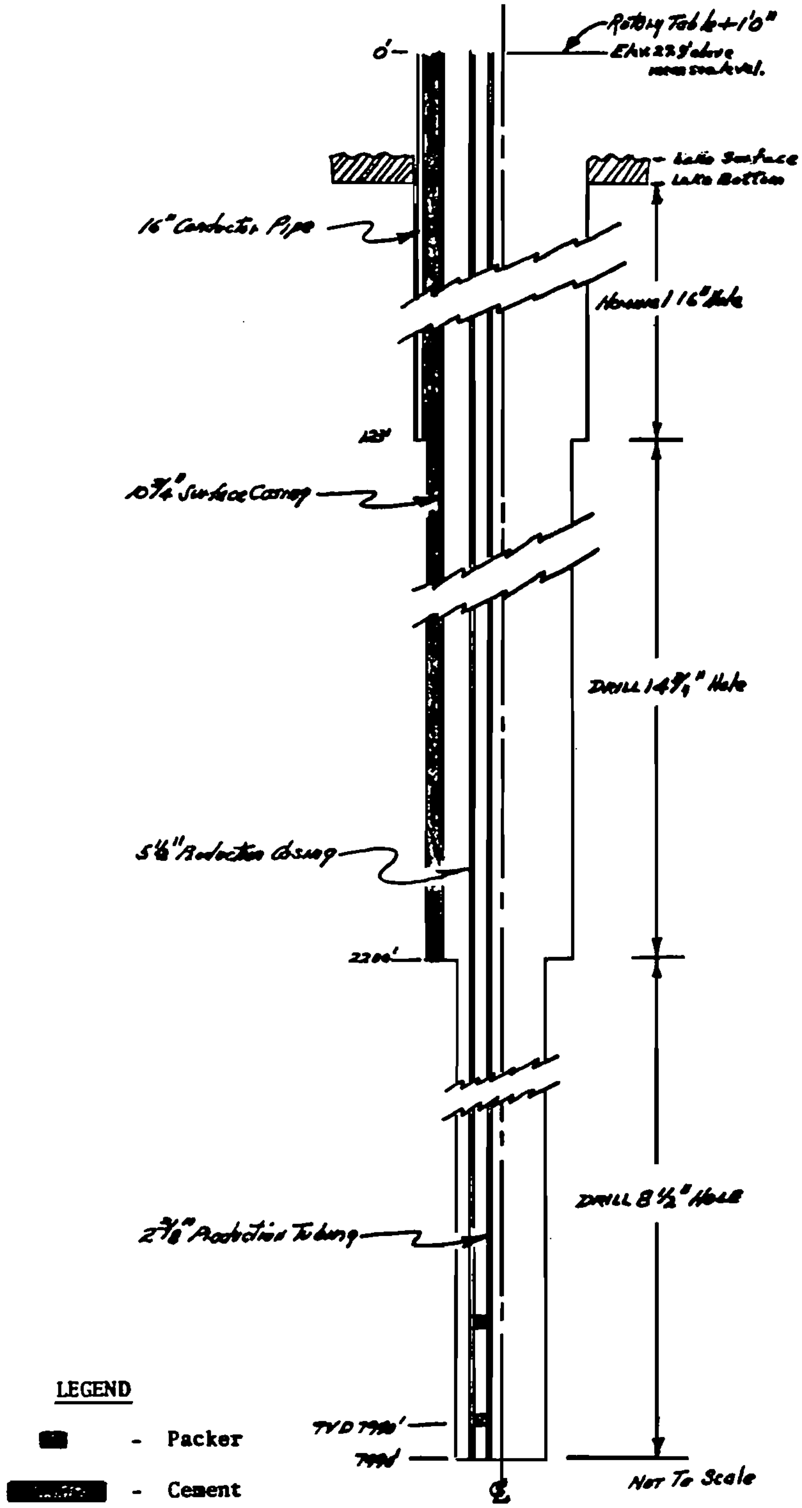
Designed Configuration of the A-20 Exploratory Oil Well



APPENDIX L



APPENDIX M: Excerpt from a Texaco Planning Map of the Jefferson Island Field Showing Contours (dashed lines) of the Subsurface Structure



APPENDIX N: P-20 Oil Well Casing and Cementing Schedule (Directional Drilling Not Shown)

Application No. LMNOD-SP(Lake Peigneur)8

Name of Applicant Texaco Inc.

Effective Date 11 June 1980

Expiration Date (If applicable) •

Miss Nelson/srd
#61 [redacted]

FILE COPY

LMNOD-SP
1522-15
Lake Peigneur
8/2
P-80-A-137

404

DEPARTMENT OF THE ARMY
PERMIT

Referring to written request dated 26 October 1980 for a permit to:

(X) Perform work in or affecting navigable waters of the United States, upon the recommendation of the Chief of Engineers, pursuant to Section 10 of the Rivers and Harbors Act of March 3, 1899 (33 U.S.C. 403);

(X) Discharge dredged or fill material into waters of the United States upon the issuance of a permit from the Secretary of the Army acting through the Chief of Engineers pursuant to Section 404 of the Federal Water Pollution Control Act (86 Stat. 816, P.L. 92-500);

( ) Transport dredged material for the purpose of dumping it into ocean waters upon the issuance of a permit from the Secretary of the Army acting through the Chief of Engineers pursuant to Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (86 Stat. 1052; P.L. 92-532);

Texaco Inc.
P.O. Box 60252
New Orleans, Louisiana 70160

is hereby authorized by the Secretary of the Army:

to dredge and maintain a channel and install and maintain a drilling rig, platform, pipeline and appurtenant structures for oil operations on state lease 124, well No. 20,

in Lake Peigneur and adjacent wetlands,

at central to a point about 1.5 miles northerly from Delcambre, Louisiana, in Iberia Parish,

in accordance with the plans and drawings attached hereto which are incorporated in and made a part of this permit (on drawings: give file number or other definite identification marks.) in four sheets, titled, "Dredging, Oil Well Structures, and Pipeline in Lake Peigneur * * *," dated 26 October 1979,

COPY TO U S C G 16 JUN 1980

COPY TO INSPECTOR 16 JUN 1980

CF: w/encl
U.S. Department of Commerce, NOAA
National Ocean Survey
ATTN: C-323
Washington, Science Center
Rockville, Md. 20852

subject to the following conditions:

I. General Conditions:

a. That all activities identified and authorized herein shall be consistent with the terms and conditions of this permit; and that any activities not specifically identified and authorized herein shall constitute a violation of the terms and conditions of this permit which may result in the modification, suspension or revocation of this permit, in whole or in part, as set forth more specifically in General Conditions j or k hereto, and in the institution of such legal proceedings as the United States Government may consider appropriate, whether or not this permit has been previously modified, suspended or revoked in whole or in part.

ENG FORM 1 JUL 77 1721 EDITION OF 1 APR 74 IS OBSOLETE. (ER 1145-2-303)

APPENDIX O: A Copy of the Corps of Engineers Permit Issued to Texaco Approving the Requested Work Involving the P-20 Well

FILE COPY

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

NOTICE OF AUTHORIZATION

11 June 19 80

A PERMIT TO dredge and maintain a channel and install and maintain a drilling rig, platform, pipeline and appurtenant structures for oil operations on state lease 124, well No. 20, in Lake Peigneur and adjacent wetlands,

/AT central to a point about 1.5 miles northerly from Delcambre, Louisiana, in Iberia Parish,

HAS BEEN ISSUED TO Texaco Inc. ON 11 June 19 80

ADDRESS OF PERMITTEE P.O. Box 60252
New Orleans, Louisiana 70160

PERMIT NUMBER LMNOD-SP(Lake Peigneur)8

HENRY R. SCHORR
For the District Engineer

ENG Form 4336
Jul 70

THIS NOTICE MUST BE CONSPICUOUSLY DISPLAYED AT THE SITE OF WORK.

*GPO: 1977 232-984

APPENDIX O, Continued: A Copy of the Notice of Authorization Required to be Posted at the P-20 Well Site

ORIGINAL TO OPERATOR

... OF LOUISIANA
... CONSERVATION

PERMIT TO DRILL FOR MINERALS

PERMIT $100.00
Multiple Zone Processing

REPERMIT

Att: Lafayette/17 Date: November 13, 1980
Ser #172187 API API#1704520638
Iberia 023 Field: Jefferson Island 4746

Operator: Texaco, Inc. 5878
Address: POBOX 60252
City & State: New Orleans LA 70160
Well Name: SL 124 Lake Peigneur No 20
Location: Sec. — T12S, R5E
N 4416' & W 7104' fr most E/ly corn irregular sec.59, being N 71 Deg. 41' E 1140' fr "SL 214 LAKE PEIGNEUR" #6. BHL: S 18 Deg. W 315' fr surf. falling in Lake Peignuer. (REPERMIT 168655 Expired) PTD 7950
Reservoir of Proposed Completion: No. 4
Applicable Department of Conservation Order: 29B E

COMMISSIONER ISSUING AUTHORITY

156723

State of Louisiana

R.T. SUTTON
COMMISSIONER

DEPARTMENT OF NATURAL RESOURCES
OFFICE OF CONSERVATION
November 17, 1980

P.O. BOX 44275
BATON ROUGE, LA. 70804

RE: Iberia Parish
Jefferson Island Field
SL 124 Lake Peigneur
#20, Ser #172187

SOUTH CENTRAL DIVISION
DALLAS, TEXAS
DEC 22

Texaco, Inc.
P.O. Box 60252
New Orleans LA 70160

Gentlemen:

We are issuing Permit to Drill for the above referenced well with the understanding that you will furnish the appropriate District Manager with a Directional Survey as proof that the well has been drilled in compliance with the provisions of the Statewide Order No. 29-B, Section XVIII, Paragraph 3 dated March 1, 1967.

In addition, completion of said well cannot be in any pool in which the location does not conform with the provisions of Statewide Order No. 29-E.

Very truly yours,

R. T. SUTTON, COMMISSIONER
OFFICE OF CONSERVATION

BY

Joseph W. Hecker
Chief Engineer

NEW ORLEANS DIVISION
C. E. DEPT.

APPENDIX P: A Copy of the P-20 Well Drilling Permit Issued to Texaco by Louisiana Department of Natural Resources' Office of Conservation

cc: Mr. F. J. Fava, Jr.
District Manager

SEQUENCE OF EVENTS

Drilling of SL-124, Lake Peigneur No. 20 Oil Well

The following chronology is an approximation of the sequence of events arrived at by compositing available drilling logs, daily drilling reports and statements by eyewitnesses.

11-11-80	Rigging-down of the Wilson No. 1 drilling rig at its previous drilling location (Stansbury No. 2 Well).
11-12-80	Rigging-down and transporting rig components to Ivanhoe Dock facilities (near Louisa, Iberia Parish) and began barge loading.
11-13-80	Continued barge loading and began movement of rig to Lake Peigneur.
11-14-80	(No drilling log.) Four barges at site.
11-15-80	Began rigging-up Wilson No. 1 rig on the P-20 site.
11-16-80	Continued rigging up; derrick assembled.

APPENDIX Q

	11-17-80	Continued rigging-up; derrick up at 0930 hours.
		Welding mud tanks to barges. Drove 123 feet of 16-inch conductor pipe with 1 foot penetration at 123 blows/foot hammer rate.
	11-18-80	
Day Tour	0600 Hours	Rigging-up completed; began mixing spud-mud, washing out conductor pipe.
Night Tour	1800 Hours	-Spudded-in at 1800 hours using 14 3/4-inch H.T.C. bit with three 5/8-inch nozzles.
		-Circulated and built mud volume at 300 foot depth.
		-Conducted survey at 497 feet, 1 degree inclination from vertical.
		-Drilled to 765 feet (765'-123' ÷ 10.5 hours = 61.1 feet/hour average).
		-Mud: 190 gel, 20 caustic, viscosity 38.
		-Rotary: 150 r/m.

Night Tour	-Using 1 pump (No. 1) @ 600 psi and 155 strokes/minute.
	-Formation: Sand, gravel, gumbo.
11-19-80	
0600 Hours	-Drilled to 992 feet (992'-765' ÷ 10 hours = 22.7 feet/hour average).
Day Tour	-Pulled drill string out of hole at 820 foot depth; checked bit for balling, found no wash-out.
	-Replaced V-belts on No. 2 mud pump drive.
	-Repairing No. 1 mud pump drive (clutch burned out).
	-1 mud pump only available for the day; pressures reported as 1300 psi.
	-Formation: Sand, gravel, gumbo.
1800 Hours	-No. 1 mud pump repairs completed at 0530 hours (11-20-80).
Night Tour	-Drilled to 1,248 feet (1,248'-992' ÷ 20.25 hours = 12.7 feet/hour average for the 256 feet drilled).

	-Conducted survey at 1,059 feet, 0.5 degree inclination from vertical.
	-0515 Hours - lost mud circulation and stuck bit at 1,248 feet.
	-Added 30 barrels of mud to drill hole at 0600 Hours.
Night Tour	-Tool string actual weight 78,000 pounds.
	-Rig listing approximately 3 feet at one corner.
	-Pipe taking weight to 250,000 pounds, plus.
	-Drill floor tilting.
	-Day tour crew arrived.
	-Rig tilting an estimated 20 degrees.
11-20-80 0600 Hours	-Piling continues to sink; rig tilting continues.
	-Abandoned rig.
Day Tour	-Releasing barges from rig to salvage equipment; tugboat moves them into the clear.

-Rig overturned at 0725 hours, taking mud barge.

Day Tour

-Drilling platform with dragline disappeared at approximately 1030 hours.

-1200 Hours - "Barges with drill pipe, trailer house, and rest of equipment disappeared, presumably into the Jefferson Island salt dome."

APPENDIX R: A Sample Page from the P-20 Well Drilling Log Showing Daily Progress

No. 15034

DAILY DRILLING REPORT   REPORT NO.

LEASE	WELL NO.	API WELL NUMBER	WATER DEPTH	DATE
[illegible]	[illegible]			11/19/80

OPERATOR	CONTRACTOR	RIG NO.
[illegible]	Wilson Bros.	1

SIGNATURE OF OPERATOR'S REPRESENTATIVE

SIGNATURE OF CONTRACTOR'S TOOL PUSHER: [illegible signature]

D.P. SIZE	WT./FT.	GRADE	TOOL JT O.D.	TYPE THREAD	STRING NO.	PUMP NO.	(PUMP MANUFACTURER)	TYPE	STROKE LENGTH
4½	16.60	—	[illegible]	X.H.	1	1	[illegible]	P 7 14	8"
						2	[illegible]	[illegible]	[illegible]

FIELD OR DIST.	COUNTY	STATE
[illegible]	[illegible]	LA

LAST CASING, TUBING OR LINER	SIZE	MAKE	WT. & GR.	NO. JOINTS	FEET	RKB. TO CSG. HD.	SET AT
	16"	[illegible]		3	172		71

WIRE LINE RECORD · REEL NO. · SIZE · NO. LINES · FT. SLIPPED · FT. CUT OFF · PRESENT LENGTH · TON MI. OR TRIPS SINCE LAST CUT · CUMULATIVE TON MI. OR TRIPS

Time Distribution – Hours

CODE NO. – OPERATION	NIGHT	DAY
1. RIG UP AND TEAR DOWN		
2. DRILL ACTUAL		
3. REAMING		
4. CORING		
5. CONDITION MUD & CIRCULATE		
6. TRIPS		
7. LUBRICATE RIG		
8. REPAIR RIG		
9. CUT OFF DRILLING LINE		
10. DEVIATION SURVEY		
11. WIRE LINE LOGS		
12. RUN CASING & CEMENT		
13. WAIT ON CEMENT		
14. NIPPLE UP B.O.P.		
15. TEST B.O.P.		
16. DRILL STEM TEST		
17. PLUG BACK		
18. SQUEEZE CEMENT		
19. FISHING		
20. DIR. WORK		
21.		
22.		
COMPLETION A. PERFORATING		
B. TBG TRIPS		
C. TREATING		
D. SWABBING		
E. TESTING		
F. ADDITIONAL		
G.		
TOTALS		

DAY WORK TIME SUMMARY (OFFICE USE ONLY): HRS. W/CONTR. D.P. · HRS. W/OPR. D.P. · HRS. NO/DP · HRS. STANDBY · TOTAL DAY WORK

NO. OF DAYS FROM SPUD: 1 · CUMULATIVE ROTATING HRS. · TOTAL MUD COST

Night Tour

NO.	DRILLING ASSEMBLY (At end of tour)	FT.
1	BIT	
	STB. REAM	
	D.C. I.D.	
	STB. REAM	
	D.C. I.D.	
	STB. REAM	
	STANDS DP	
	SINGLES DP	
	KELLY DOWN	10
	TOTAL	765
	WT. OF STRING	LBS.

BIT RECORD	
BIT NO.	1
SIZE	14¾
MFG.	[illegible]
TYPE	[illegible]
JETS 1/32"	[illegible]
SER. NO.	FE 932
DEPTH OUT	[illegible]
DEPTH IN	0
TOTAL FTG.	765
TOTAL HRS. RUN	10½
COND. T.B. GAGE	
GPM/PD-PM	

MUD RECORD	
TIME	
WEIGHT	
PRESSURE GRADIENT	
VISC.-SEC.	35
PV/YP	
GELS	
WL-CC'S	
pH	
SOLIDS %	

MUD & CHEMICALS ADDED – TYPE	AMT.
GEL	120
CAUSTIC	20

REMARKS

FOOTAGE FROM	TO	DR.D RM.R CORE.C	CORE NO.	FORMATION (SHOW CORE RECOVERY)	ROTARY RPM	WT. ON BIT 1000#	PUMP PRESS	PUMP NO. 1 LINER SIZE	S.P.M.	PUMP NO. LINER SIZE	S.P.M.	METHOD RUN
123	765 (642)	D		Sd, Gumbo & Gravel	150	0/15	600	6	155	[illegible]		Sl. (pump only)

DEVIATION RECORD – DEPTH	DEV.	DIRECTION
497	1°	

TIME LOG FROM	TO	ELAPSED TIME	CODE NO.	DETAILS OF OPERATIONS IN SEQUENCE AND REMARKS
6:00	9:00	3		Spud in @ 600 pm 11-18-80 — Drilling
900	1000	1		Circulating and [illegible] drilling mud [illegible]
10:00	11:30	1½		Drilling
1130	1200	½		Survey @ 497' 1°
12:00	6:00	6		Drlg
		Σ drilling: 10½		

Day Tour

NO.	DRILLING ASSEMBLY (At end of tour)	FT.
1	BIT	1.00
2	STB. REAM	7.85
18	D.C. I.D.	
	STB. REAM	
	D.C. I.D.	
30	STB. REAM / HW.	
9	STANDS DP	
	SINGLES DP	
	KELLY DOWN	10
	TOTAL	992
	WT. OF STRING	65000 LBS.

BIT RECORD	
BIT NO.	1
SIZE	14¾
MFG.	HTC
TYPE	OSC-3AJ
JETS 1/32"	3/3/34
SER. NO.	FE932
DEPTH OUT	SIH
DEPTH IN	-0-
TOTAL FTG.	992
TOTAL HRS. RUN	22½
COND. T.B. GAGE	
GPM/PD-PM	

MUD RECORD	
TIME	
WEIGHT	8.8
PRESSURE GRADIENT	
VISC.-SEC.	34
PV/YP	
GELS	
WL-CC'S	
pH	
SOLIDS %	

MUD & CHEMICALS ADDED – TYPE	AMT.
Gel	65
Caustic	6

REMARKS

FOOTAGE FROM	TO	DR.D RM.R CORE.C	CORE NO.	FORMATION (SHOW CORE RECOVERY)	ROTARY RPM	WT. ON BIT 1000#	PUMP PRESS	PUMP NO. 1 LINER SIZE	S.P.M.	PUMP NO. 2 LINER SIZE	S.P.M.	METHOD RUN
765	992 (227)	D		sd - Gumbo & Gravel	150	30	1300	6½	157	6½	63	B

FOOTAGE 227.

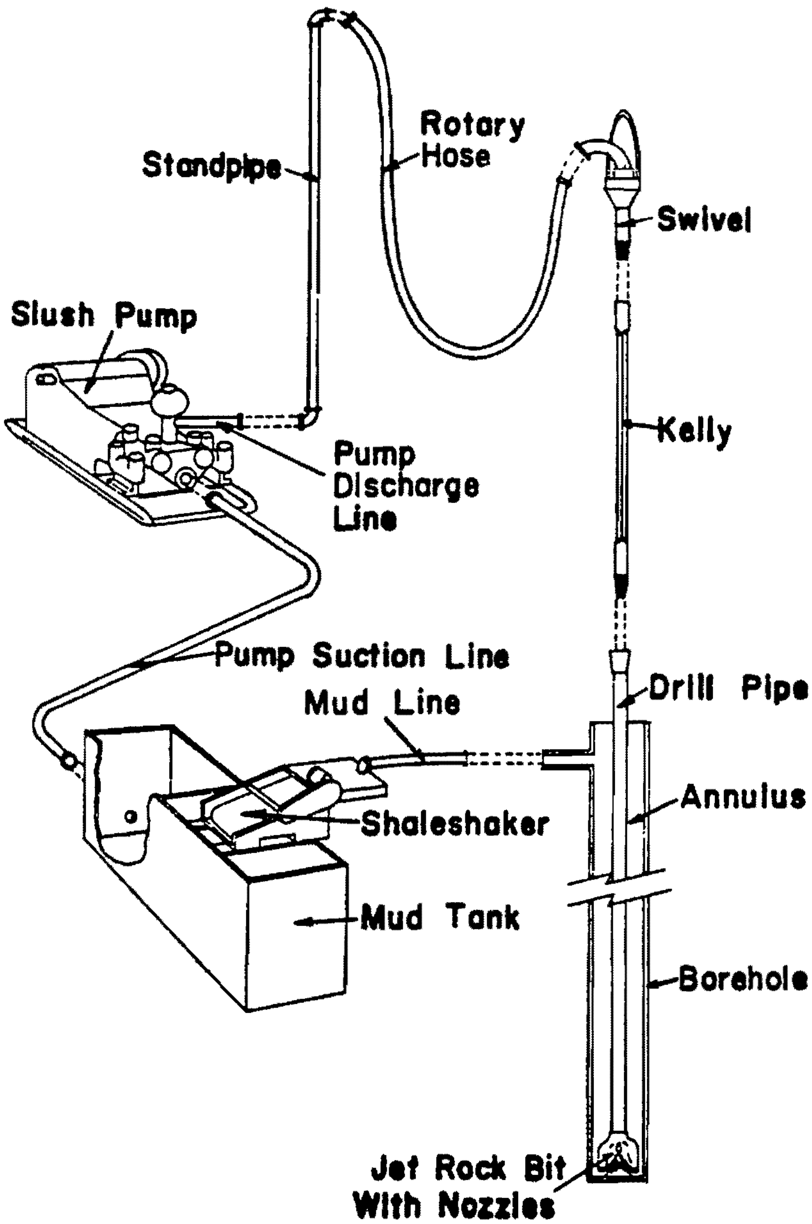
DEVIATION RECORD – DEPTH · DEV. · DIRECTION

TIME LOG FROM	TO	ELAPSED TIME	CODE NO.	DETAILS OF OPERATIONS IN SEQUENCE AND REMARKS
6:00	11:00	5		Drilling
11:00	1:00	2		Trip pipe to ck. bit
1:00	6:00	5.		Drilling
		Σ drilling = 10		

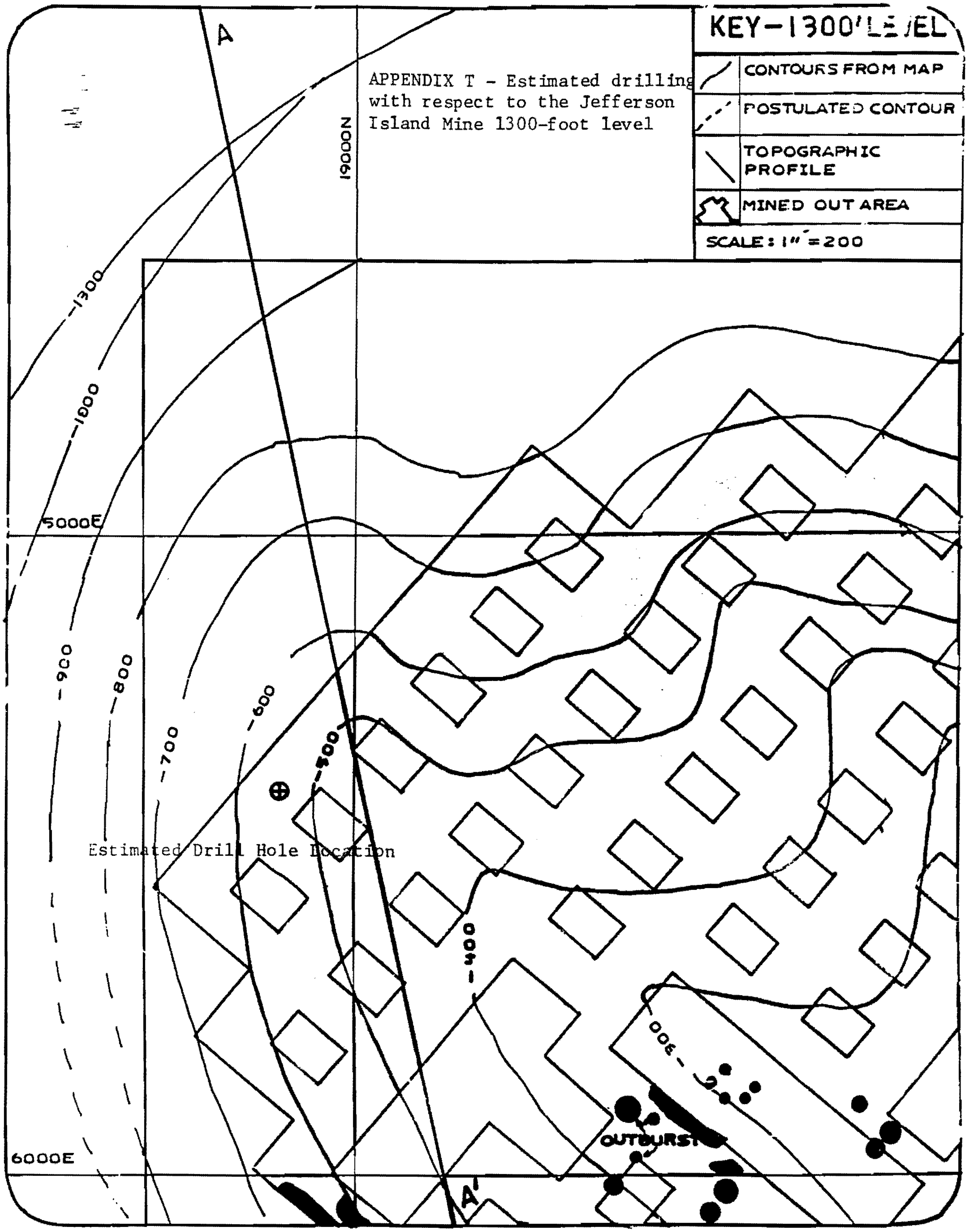
DRILLER: Herman J. Rider

Form 21-4 · Printed in U. S. A. · APPROVED · APPROVED

IADC – API OFFICIAL DAILY DRILLING REPORT FORM



APPENDIX S: Typical Oil Well Drilling Mud System



APPENDIX T - Estimated drilling with respect to the Jefferson Island Mine 1300-foot level

ORDER OF WITHDRAWAL

The following order and modifications were issued during this investigation, under section 103(j) of the Act.

Order No. 156940 103(j)

Issued November 20, 1980, at 1115 hours.

The mine is flooding with water, all persons have been evacuated and accounted for. There are visible swirling water motions in the nearby bay at two locations. All persons are to be evacuated from all company surface buildings, and stay off the immediate mine property. This order will remain in effect until the situation has been fully assessed and plans are presented as to what company officials plan, and these plans are fully assessed by MSHA officials.

Modification No. 156940-1

Issued November 20, 1980, at 1339 hours.

This is to modify the order to state that all persons, including residents that are within the boundary of the Jefferson Island Salt Mine, are to be evacuated until the flooding of the mine is further assessed, and the surface area above the dome's periphery is found not to be unstable and not subject to subsidence.

APPENDIX U: Section 103(j) Order of Withdrawal and Subsequent Modifications

Modification No. 156940-2

Issued November 23, 1980, at 0800 hours.

Order No. 156940 issued on 11/20/80 is hereby modified to allow retrieval of records from the personnel office and mill office within the time frame as indicated on the activity proposal. All future work plans must be submitted in writing to MSHA for approval at least 8 hours before work is to commence. Benchmark surveys must be conducted daily until 11/25/80. At that time, MSHA will reevaluate the survey schedule.

Modification No. 156940-3

Issued December 4, 1980, at 1530 hours.

Order No. 156940 issued on 11/20/80 is further modified to allow salvage work to continue, providing that a walk-around inspection is conducted by an MSHA inspector at the beginning of each shift before salvage work commences. Work plans must continue to be submitted in writing to MSHA for approval at least 8 hours before work is to commence. The following monitoring requirements will remain in effect until further notice.

(1) Vertical surveys will be conducted every Monday and survey data submitted to the MSHA on-site inspector by the beginning of the Tuesday work shift.

(2) Horizontal surveys will be conducted the first and third Monday of every month. Survey data will be submitted to the on-site MSHA inspector no later than one week after survey is completed.

(3) Slope indicator readings will be conducted every Tuesday and survey data will be submitted to the on-site MSHA inspector by the beginning of the Wednesday work shift.

(4) Water level measurements in the production and air shafts will be conducted daily and the results submitted to the on-site MSHA inspector by the end of the work day.

Modification No. 156940-4

Issued January 9, 1981, at 1500 hours.

Order No. 156940 issued on 11/20/80 at 1115 hours is further modified to revise monitoring requirements as follows:

(1) Water measurements in the air and production shafts shall be conducted weekly.

(2) Slope indicator surveys will be conducted weekly.

(3) Vertical surveys will be conducted every two weeks.

(4) Horizontal surveys will be conducted monthly. MSHA will reevaluate these monitoring requirements again on 2/16/81. Daily work schedules will no longer be required, but weekly plans must be discussed with the on-site MSHA inspector.

Modification No. 156940-5

Issued February 17, 1981, at 0800 hours.

Order No. 156940 issued on 11/20/80 at 1115 hours is further modified to revise monitoring requirements as follows:

(1) Water measurements in the air and production shafts will be conducted weekly.

(2) Slope indicator surveys will be conducted every two weeks.

(3) Vertical and horizontal surveys will be conducted monthly.

<u>Modification No. 156940-6</u>

Issued April 4, 1981, at 0900 hours.

Order No. 156940 issued on 11/20/80 at 1115 hours is hereby modified to be made pursuant to 103(k) and to further specify that the brine operation shall not be started until a detailed plan of the operation is submitted to MSHA for approval. Any future modification concerning the brine operation or other areas of the mine site shall also be submitted to MSHA for approval. No work shall commence before approval from MSHA is obtained.

<u>Modification No. 156940-7</u>

Issued April 13, 1981, at 0800 hours.

Order No. 156940 issued on November 20, 1980, at 1115 hours is further modified to allow the brine operation to commence providing that the following monitoring requirements are followed. Vertical and horizontal surveys are conducted every six months. Since these surveys were just completed, the next survey data will be due October 1, 1981. Slope indicator surveys will be conducted monthly. Water measurements in the air and production shafts will be conducted weekly. Results of these surveys will be mailed to the Dallas Subdistrict Office of MSHA. MSHA must be notified in advance of any attempt to reenter the mine.

Air Sample Record — *ATT: RUSH - A.S.A.P.*

U.S. Department of Labor
Mine Safety and Health Administration

Check if Needed:
☐ Mailers ☐ Plastic Vials ☐ Vacuum Bottles ☐ Bistables ☐ Forms Sheet of

1. Mine/Mill: *Jefferson Island Mine*	2. Company: *Diamond Crystal Salt Co.*
3. Mine ID Number: *16-00508*	4. Commodity: *Salt*
5. Collector: *Jerry A. Millard*	6. AR Number: *368*
7. Field Office: *Baton Rouge, La.*	8. Subdistrict Office: *Dallas, Tx.*

DEC 0 8 1980

• SAMPLING DATA

	1	2	3	4	5	6
9. Pre-seal Number						
10. Sample Number	52263	52264	52265	52266	52267	
11. Sample Type	GAS	GAS	GAS	GAS	GAS	
12. Date Collected	11-20-80	11-20-80	11-20-80	11-20-80	11-20-80	
13. Time Collected	1305	1305	1305	1305	1305	
14. Sample Location	MINE	MINE	MINE	MINE	MINE	
15. Methane (est. %)	0	0	0	0	0	
16. Flow Rate (lpm)						
17. Analysis Desired	Reg.	Reg.	Reg.	Reg.	Reg.	

Note: These samples were collected as the mine was being flooded. Samples taken from an exhausting 8-inch vent pipe.

• WEIGHING DATA

	1	2	3	4	5	6
18. Received By and Date						
19. Post-seal Number						
20. Sample Weight (mg)						
21. Weighed By and Date						
22. Fiber Count						
23. Counted By and Date						

• LABORATORY ANALYSIS

	1	2	3	4	5	6
Received By and Date	[illegible] 12-1-80	→	→	→	→	
Seal Number	None	→	→	→	→	
Laboratory Number	2731	2732	2733	2734	2735	
☐ Quartz (mg)						
☐ Fiber Count (f/ml)						
☐ Fiber ID						
☐ Elemental						
☐ Oxygen (%)	19.86	19.89	19.86	19.80	19.79	
☐ Methane (%)	.288	.279	.289	.310	.321	
☐ Carbon Monoxide (%)	.0005	.0004	.0006	.0005	.0005	
☐ Carbon Dioxide (%)	.41	.40	.41	.43	.44	
TWA						
TLV						
Analysis Completed By & Date	[illegible] 12-1-80	12-1-80	12-1-80	12-1-80	12-1-80	
Analysis Mailed By & Date						

Informed Tom Lloyd (?) of analysis results 10:45 A, 12-1-80. Lloyd, TC (?)

MSHA Form 4000-29, Mar 80

APPENDIX V: Analysis of Air Samples Taken At the 8-Inch Vent Pipe Exhausting from the Refuge Chamber

SOUTHERN PETROLEUM LABORATORIES, INC.

P.O. BOX 20807
HOUSTON, TEXAS 77025
(713) 668-4448

P.O. BOX 52768
LAFAYETTE, LOUISIANA 70601
(318) 984-2374

Certificate of Analyses Nos. L-884, L-885, L-886

Company: U. S. Department of Labor
Location: Mine Facility
Field: Jefferson Island
Sample Of: Air
Submitted By: M. S. H. A. Personnel
Sample Date: 11-26-80

For: U. S. Department of Labor
Mine Safety & Health Admin.
1100 Commerce St., Rm. 4C50
Dallas, Texas 75242

ATTENTION: MARVIN NICKOLS

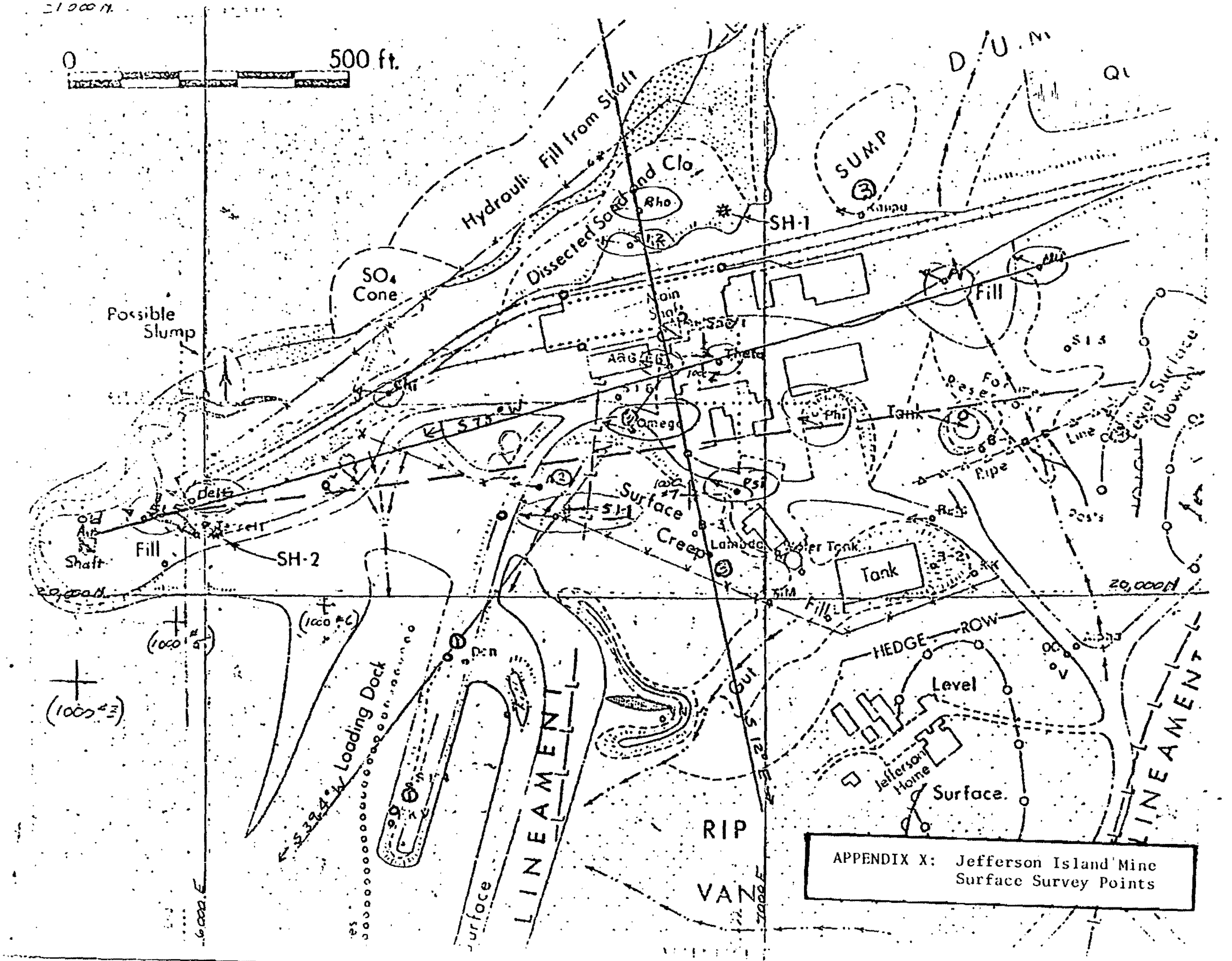
26 November 1980

Analysis #	Sample #	Date	Time	Sample Point	Results
886	1	11-26-80	11:05 AM.	222' Prod. Shaft	Total Sample was air, no Hydrocarbons
884	2	11-26-80	11:13 AM.	Production Shaft	Total Sample was air, no Hydrocarbons
885	3	11-26-80	11:31 AM.	Production Shaft	Total Sample was air, no Hydrocarbons

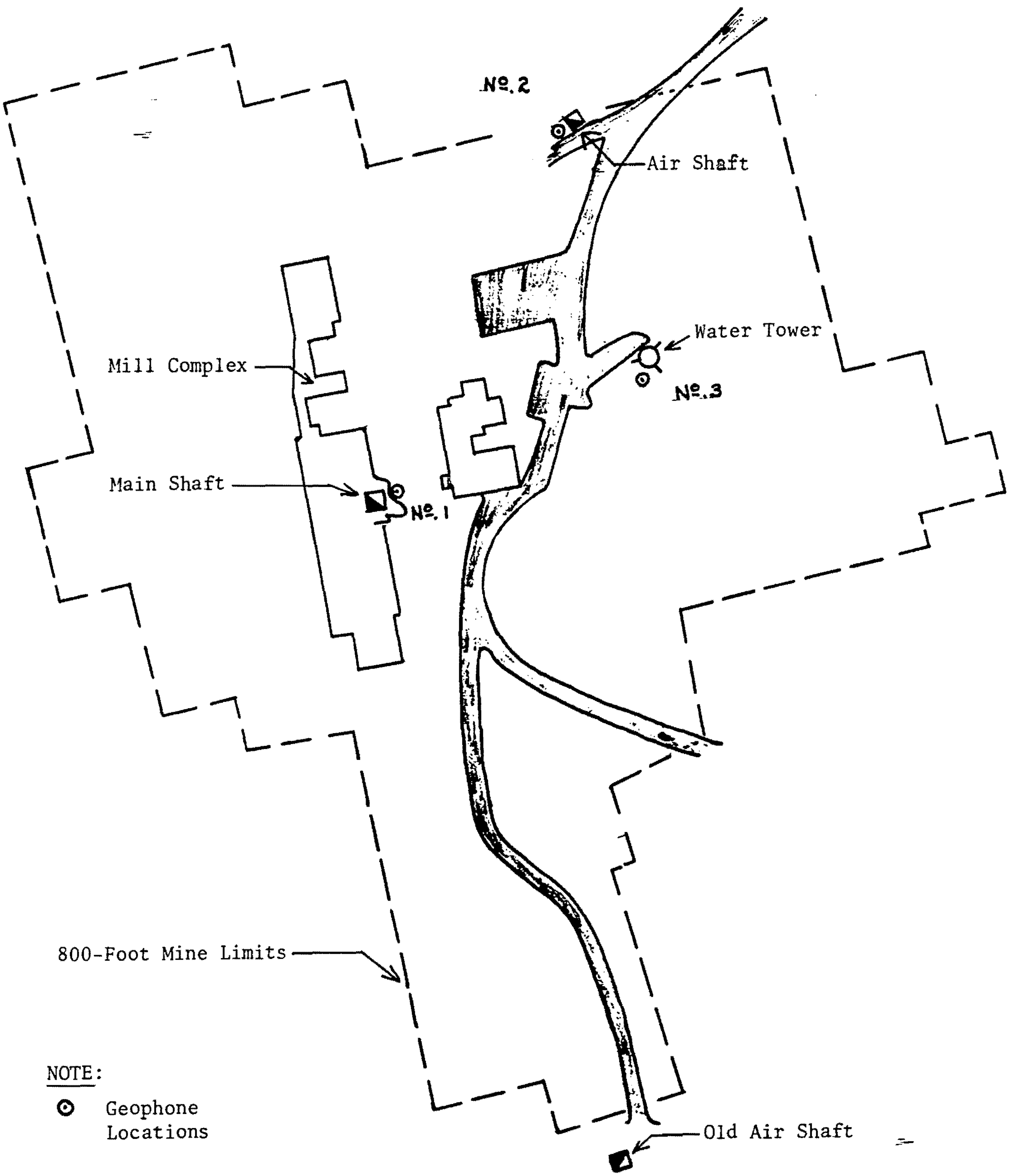
SOUTHERN PETROLEUM LABORATORIES, INC.

BY Wayne Boling
Wayne Boling

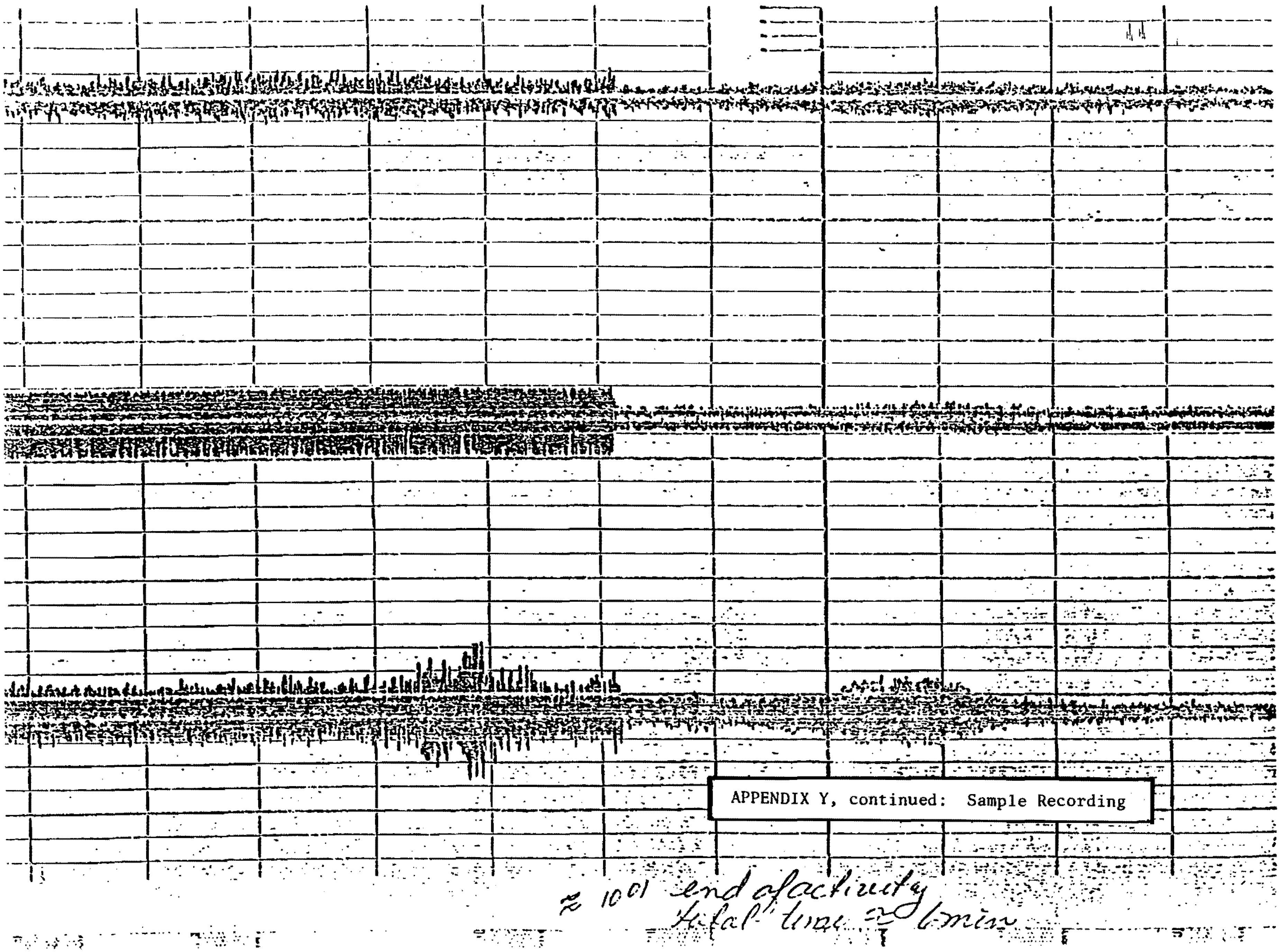
APPENDIX W: Main Shaft Gas Sampling Analysis



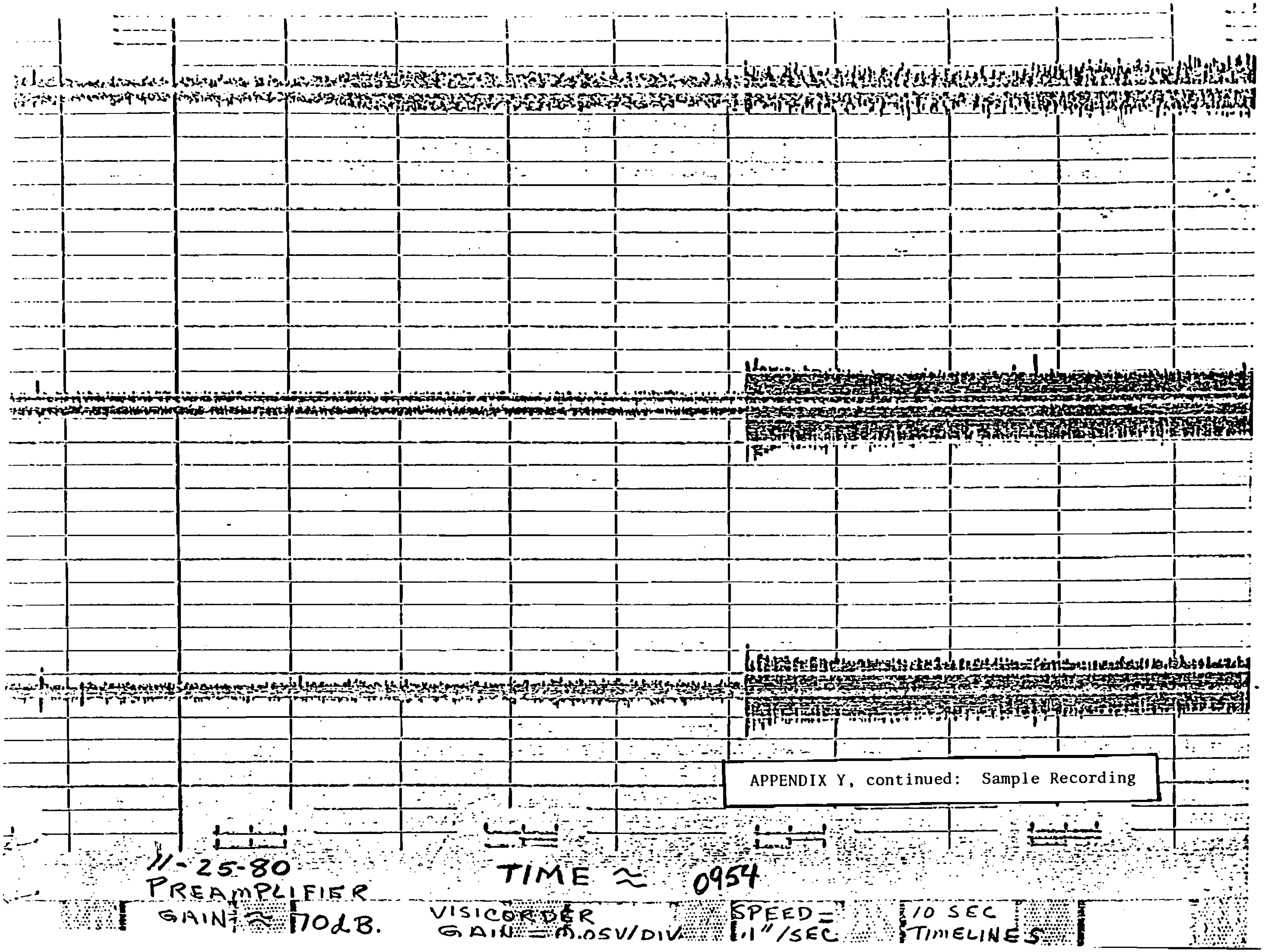
APPENDIX X: Jefferson Island Mine
Surface Survey Points



APPENDIX Y: Geophone Installations

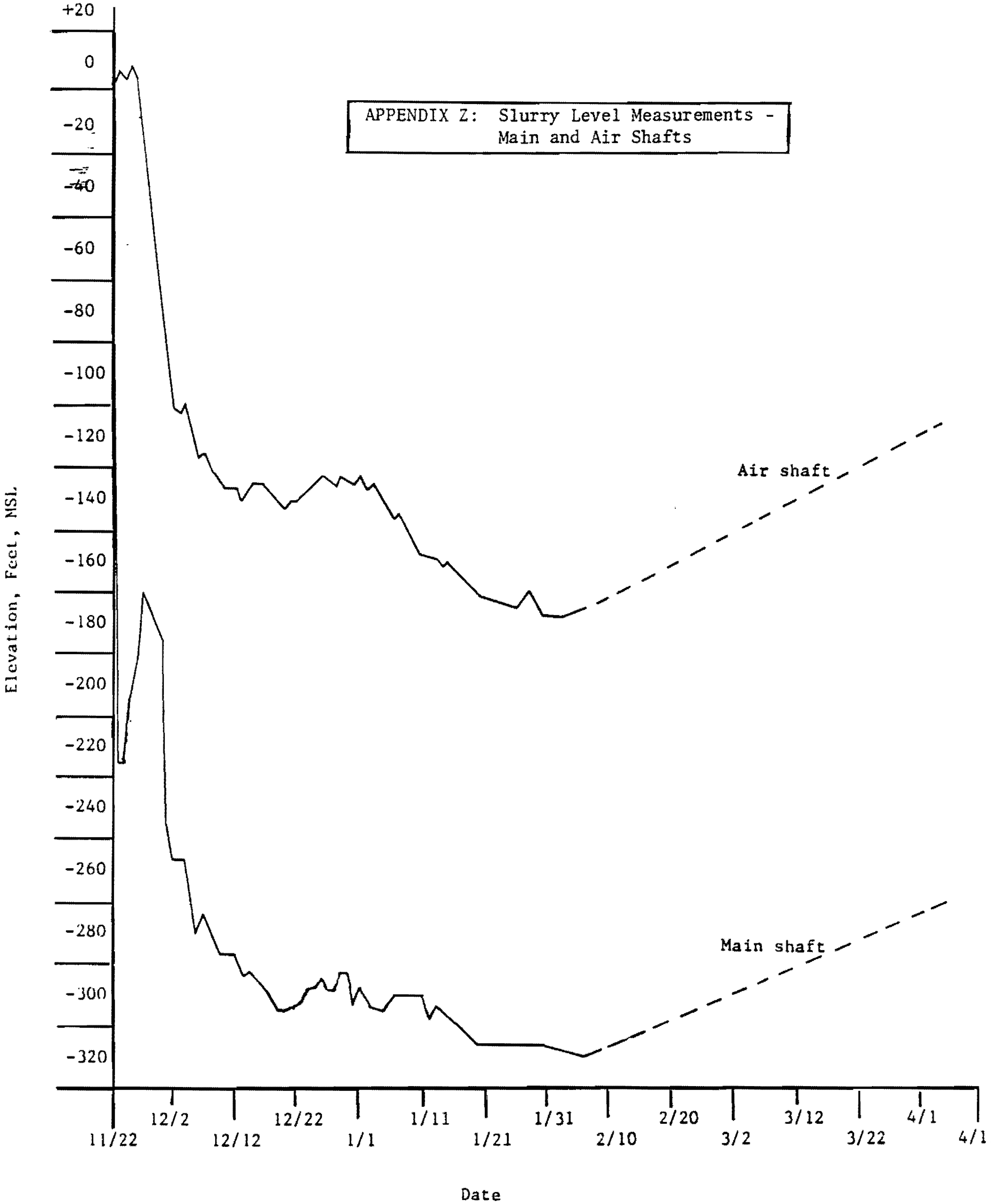


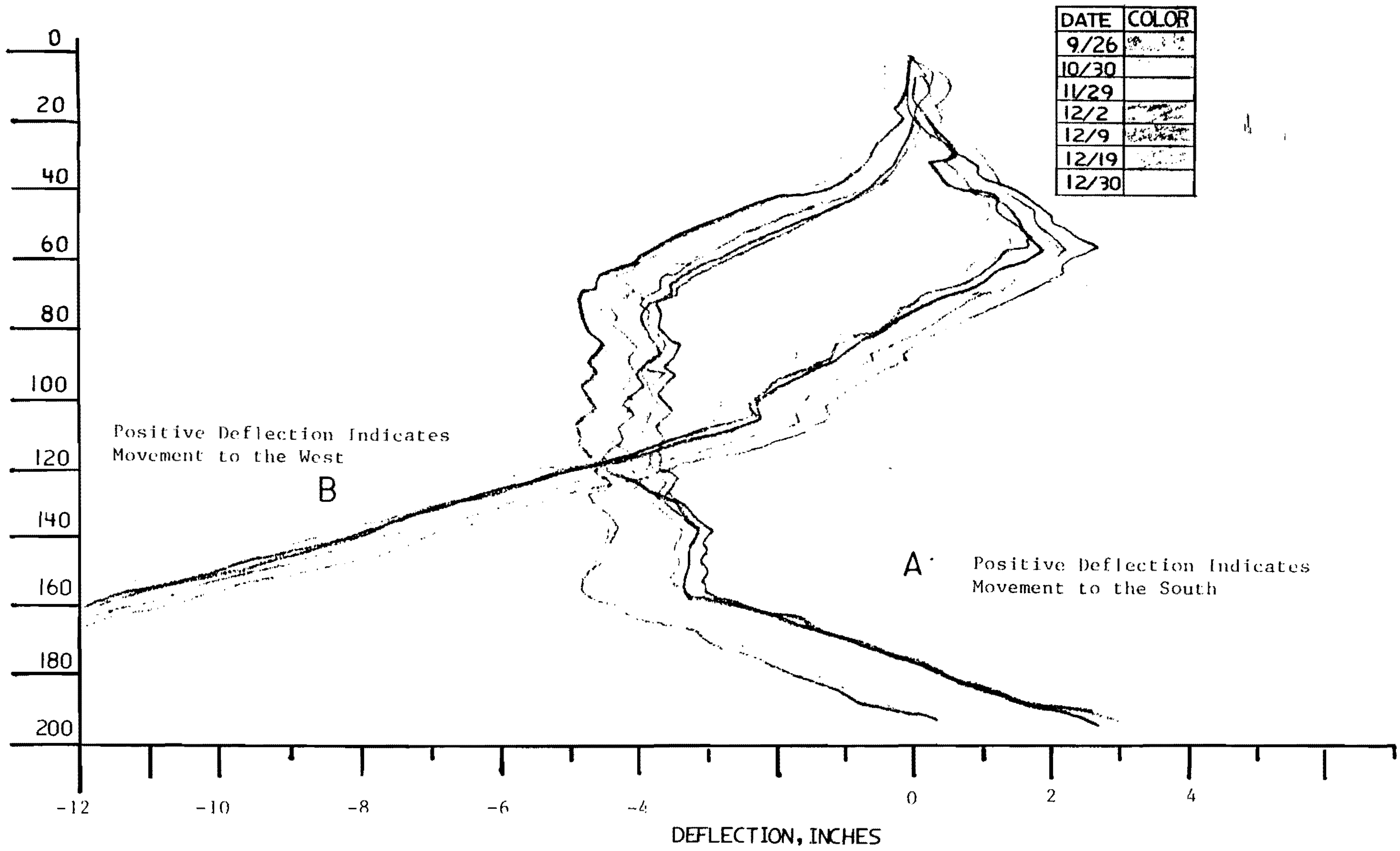
APPENDIX Y, continued: Sample Recording



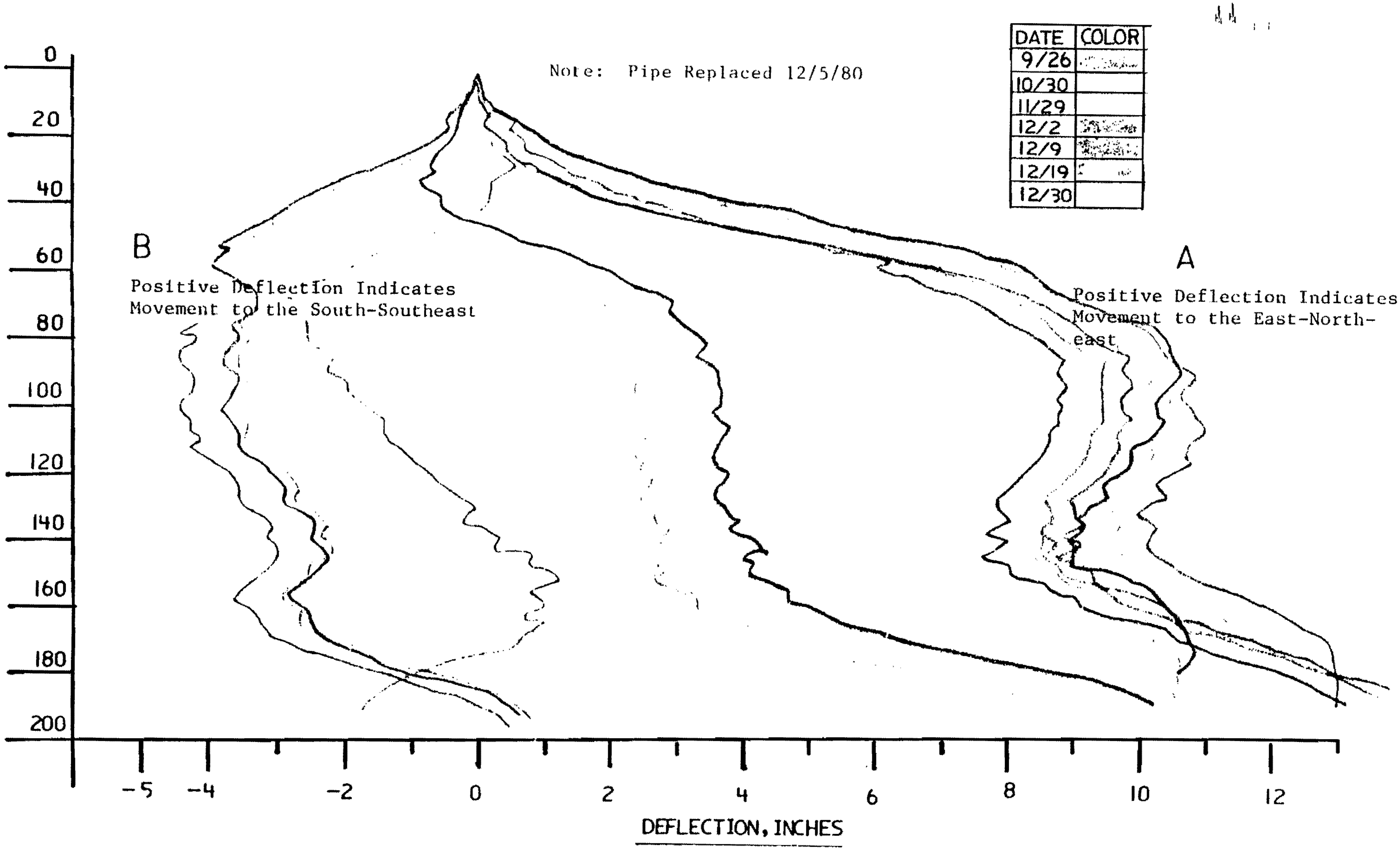
APPENDIX Y, continued: Sample Recording

APPENDIX Z: Slurry Level Measurements - Main and Air Shafts

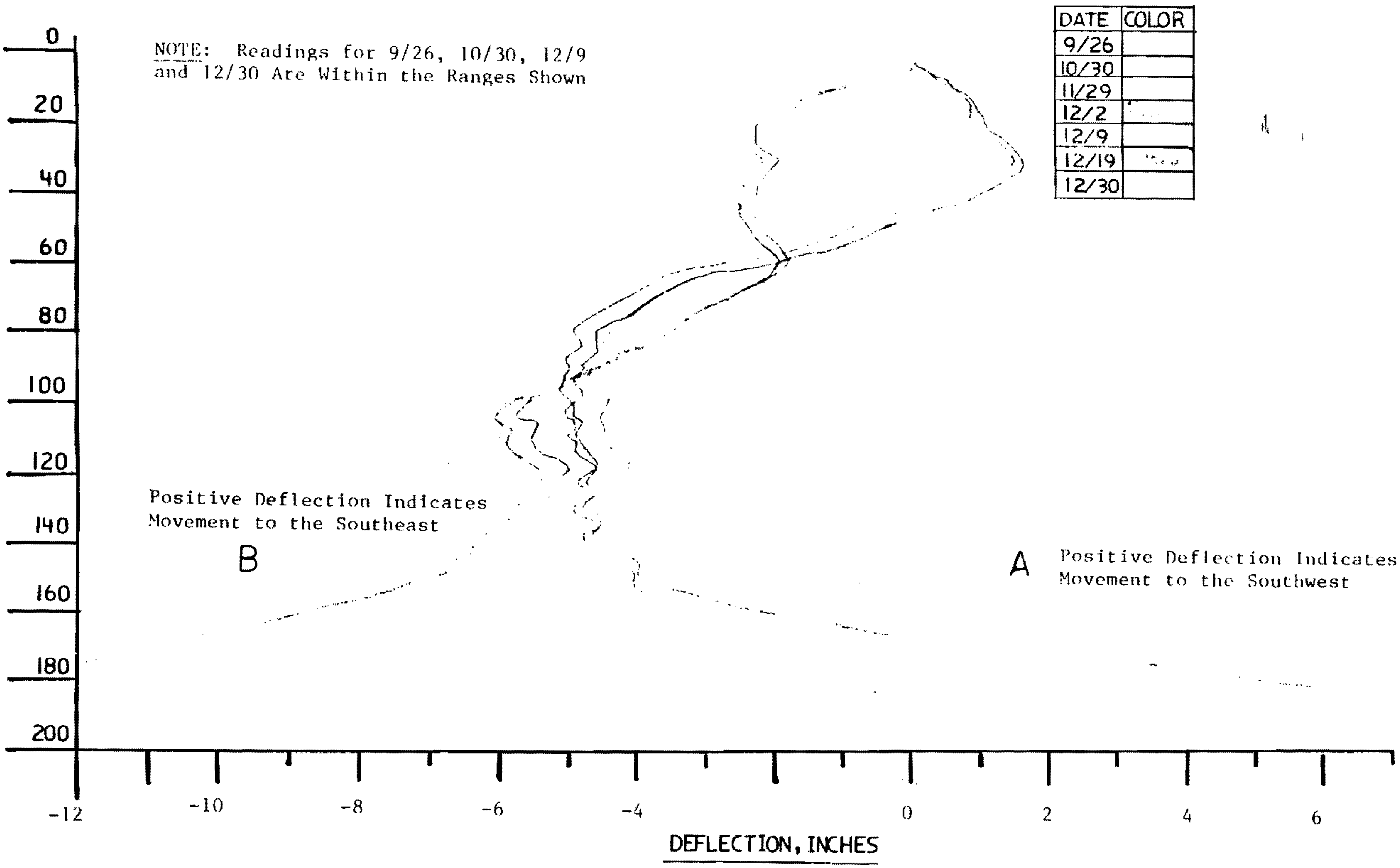




APPENDIX AA: Slope Indicator Readings - Northeast Borehole



APPENDIX AA, continued: Slope Indicator Readings - Northwest Borehole



APPENDIX AA, continued: Slope Indicator Readings - Southeast Borehole

Northeast Borehole

Positive deflection of the A line indicates movement to the southern direction.

Positive deflection of the B line indicates movement to the western direction.

Northwest Borehole

Positive deflection of the A line indicates movement to the east-northeast.

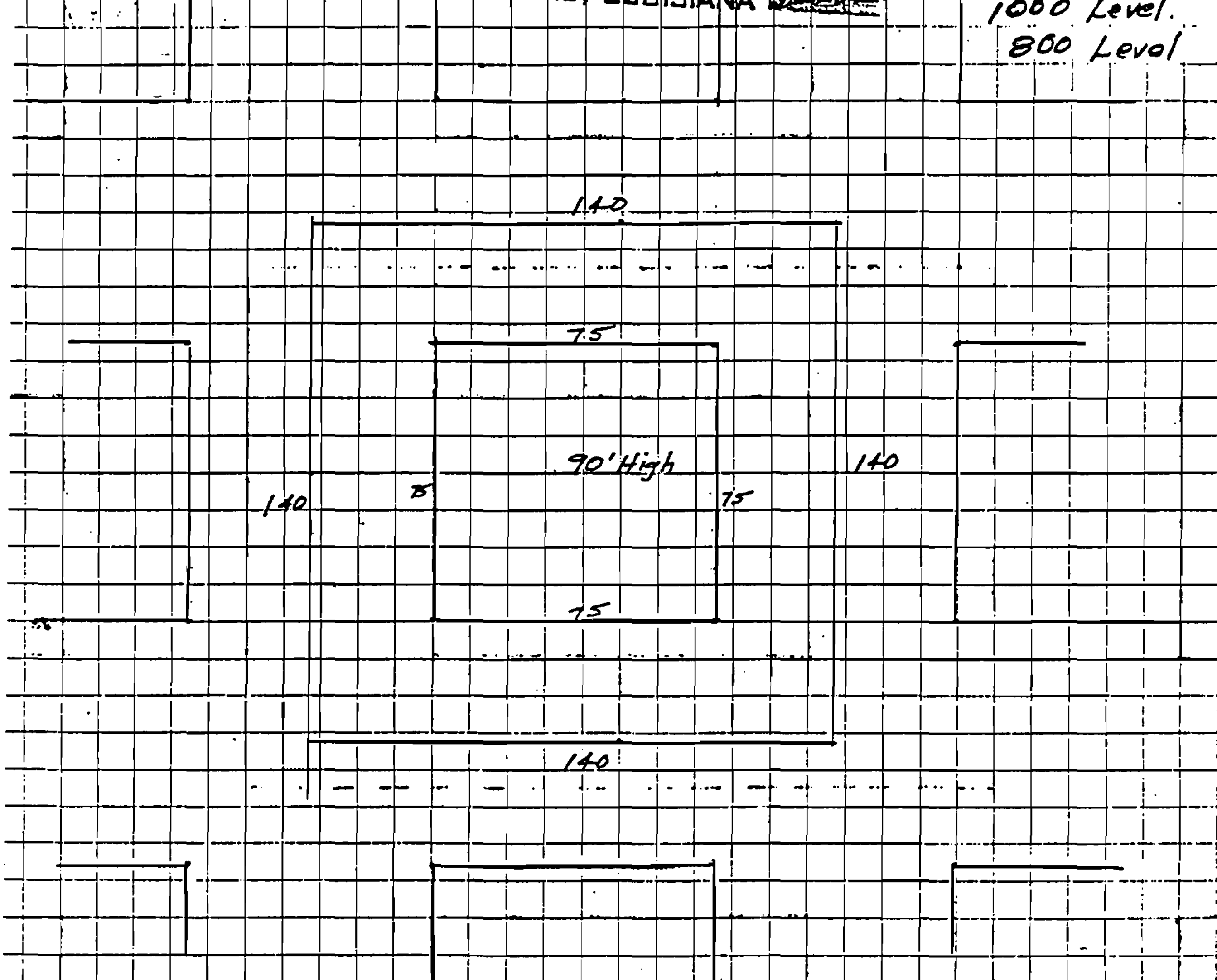
Positive deflection of the B line indicates movement to the south-southeast.

Southeast Borehole

Positive deflection of the A line indicates movement to the southeast.

Positive deflection of the B line indicates movement to the southwest.

DIAMOND CRYSTAL SALT COMPANY
JEFFERSON ISLAND, LOUISIANA



Surface Areas: Roof $(140)^2-(75)^2$ = 13,975 sq. ft
Floor $(140)^2-(75)^2$ = 13,975 sq ft
Pillar $75 \times 90 \times 4$ = 27000 sq ft
TOTAL 65,750 sq ft

Volume $[(140)^2-(75)^2] \times 90$ = 1,257,750 cu ft

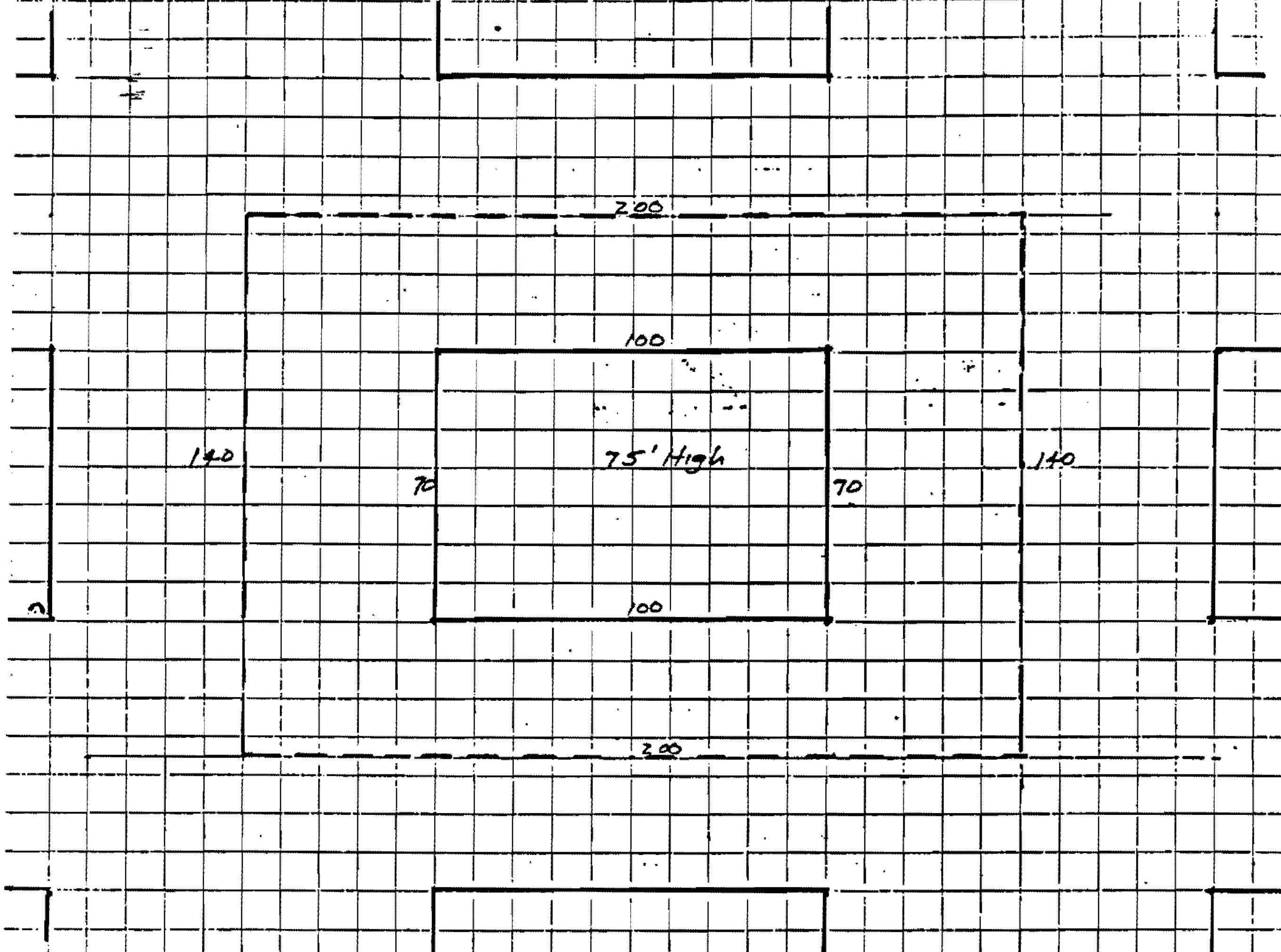
$0.1658 \times 1,257,750$ = 208,535 cu ft salt

208,535 / 67,750 = 3.078 ft

APPENDIX BB: Diamond Crystal's Calculations for Determining Limits of Salt Solvency

DIAMOND CRYSTAL SALT COMPANY
JEFFERSON ISLAND, LOUISIANA

13.00 Level



Surface Areas: Roof - (140 x 200) - (100 x 70) = 21,000 sq ft
Floor (140 x 200) - (100 x 70) = 21,000 sq ft
Pillar 2 (70 x 75) + 2 (100 x 75) = 25,500 sq ft
TOTAL = 67,500 sq ft

Volume of Fluid = [(140 x 200) - (100 x 70)] 75 = 1,575,000 cu ft

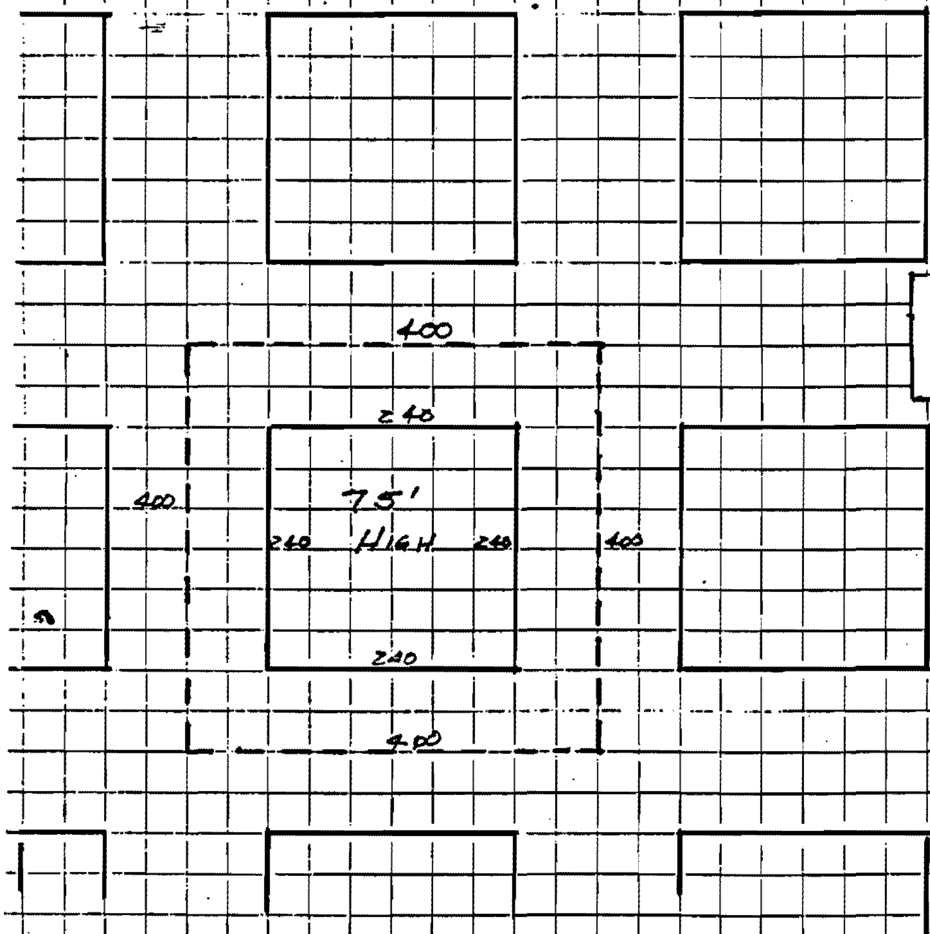
0.1658 x 1,575,000 cu ft = 261,135 cu ft salt.
261,135 / 67,500 = 3.869 ft

APPENDIX BB, continued: Diamond Crystal's Calculations for Determining Limits of Salt Solvency

DIAMOND CRYSTAL SALT COMPANY
JEFFERSON ISLAND, LOUISIANA

1500 Level

APPENDIX BB, continued:
Diamond Crystal's Calculations for Determining Limits of Salt Solvency



Surface Areas: 1) Roof $(400)^2 - (240)^2$ = 102,400 sq ft.
2) Floor $(400)^2 - (240)^2$ = 102,400 sq ft
3) Pillar 240 × 75 × 4 = 72,000 sq ft
TOTAL = 276,800 sq ft.

Volume of Fluid = $[(400)^2 - (240)^2] \cdot 75$ = 7,680,000 cu.ft.

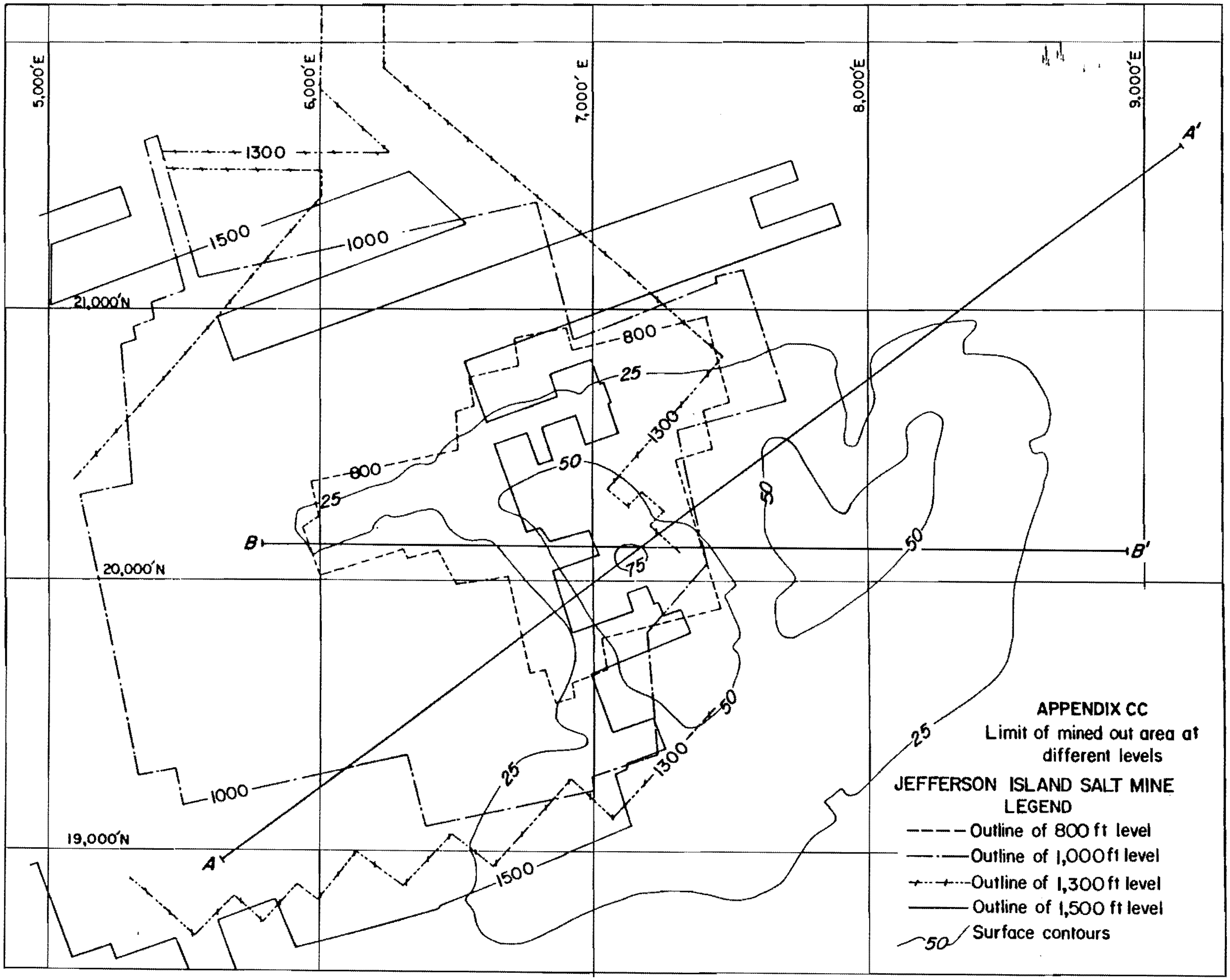
At saturation, (60°F), 1 gal. Brine contains 2.647 lb. Salt; 7.380 lb H_2O

2.647/7.380 = 0.3587 lb salt / lb water   .3587 × 62.4 $\left(\frac{lb\ H_2O}{cu\ ft}\right)$ = 22.38 lb. Salt / cu ft H_2O

@ 135 lb/cu ft salt in place, 22.38/135 =
0.1658 cu. ft salt / cu ft water

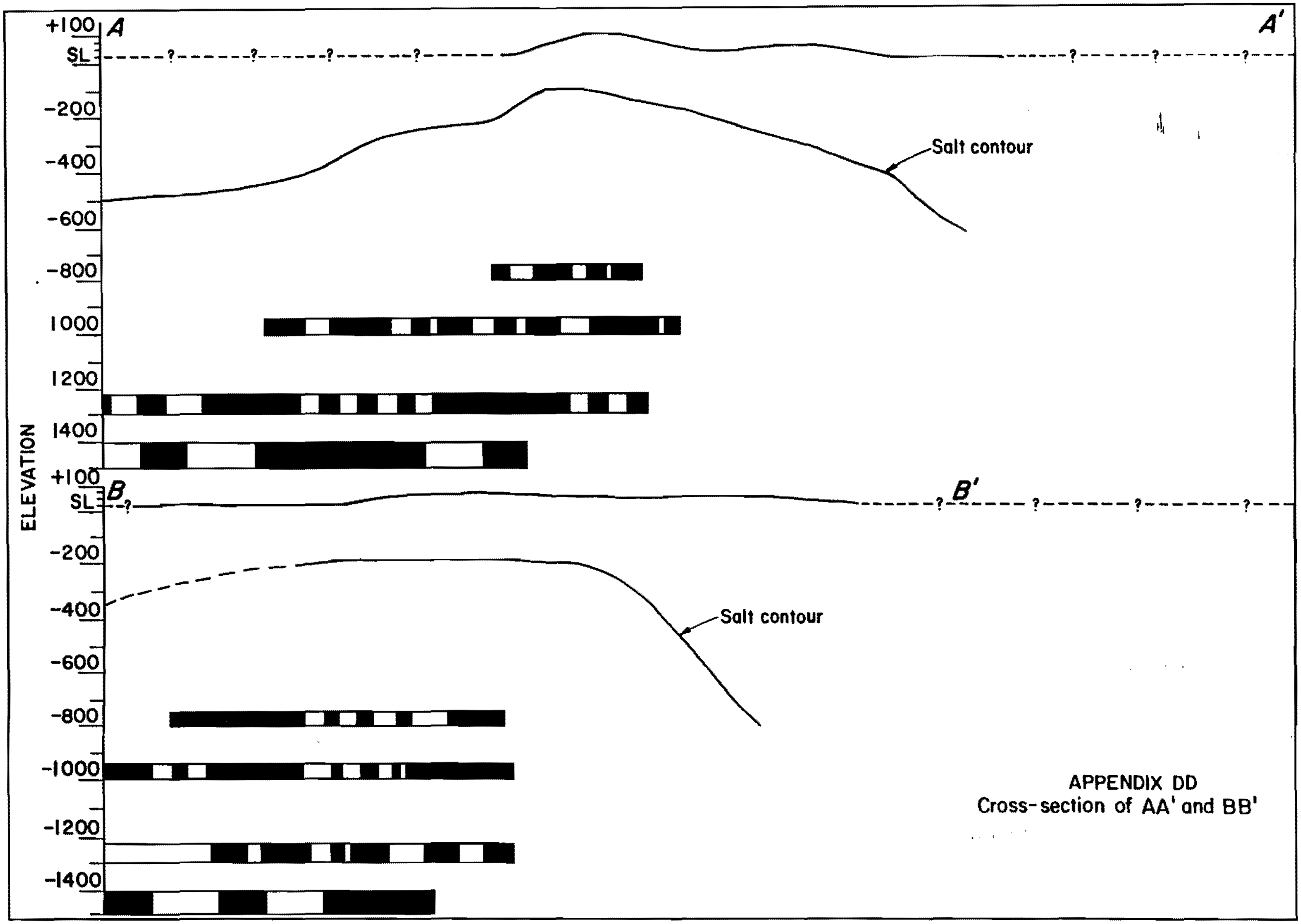
.1658 ft^3 salt / ft^3 water × 7,680,000 ft^3 water = 1,273,344 cu ft salt

1,273,344 ft^3 / 276,800 = 4.600 ft



APPENDIX CC
Limit of mined out area at different levels

JEFFERSON ISLAND SALT MINE

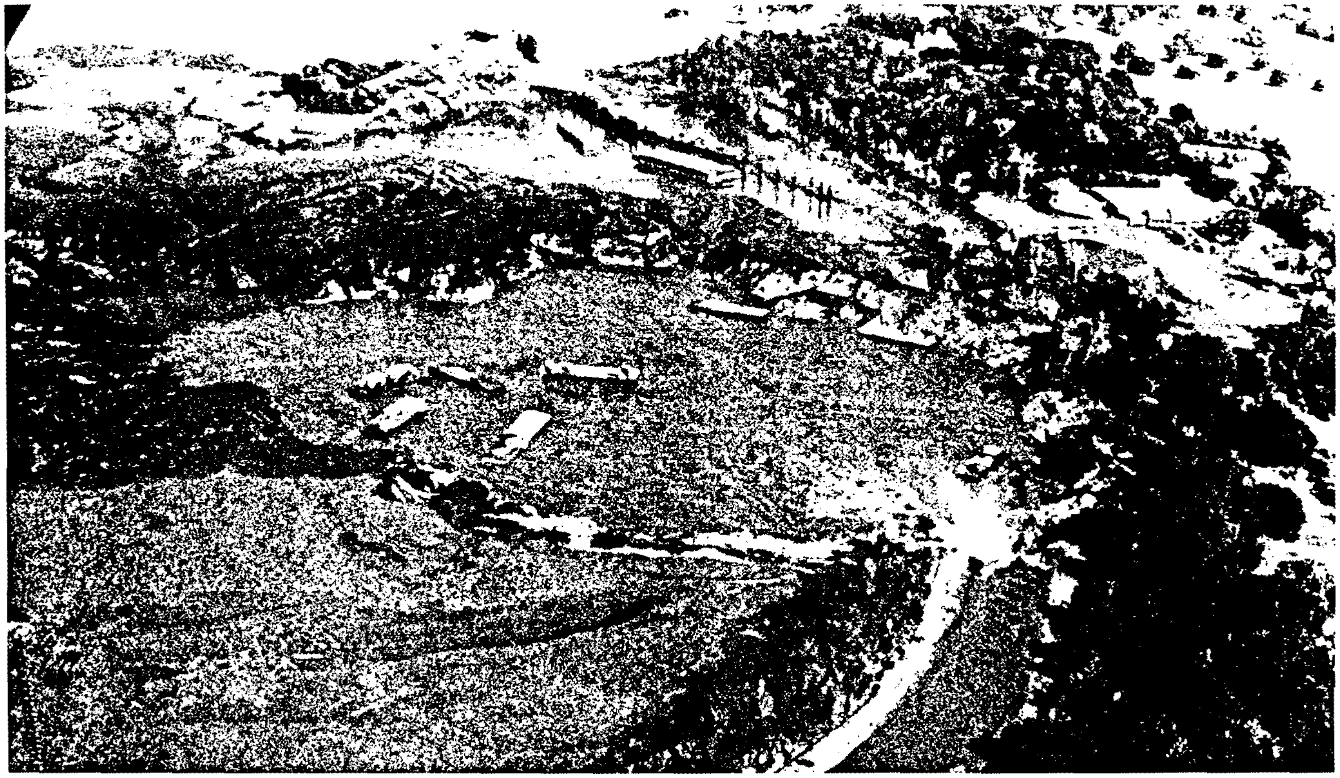


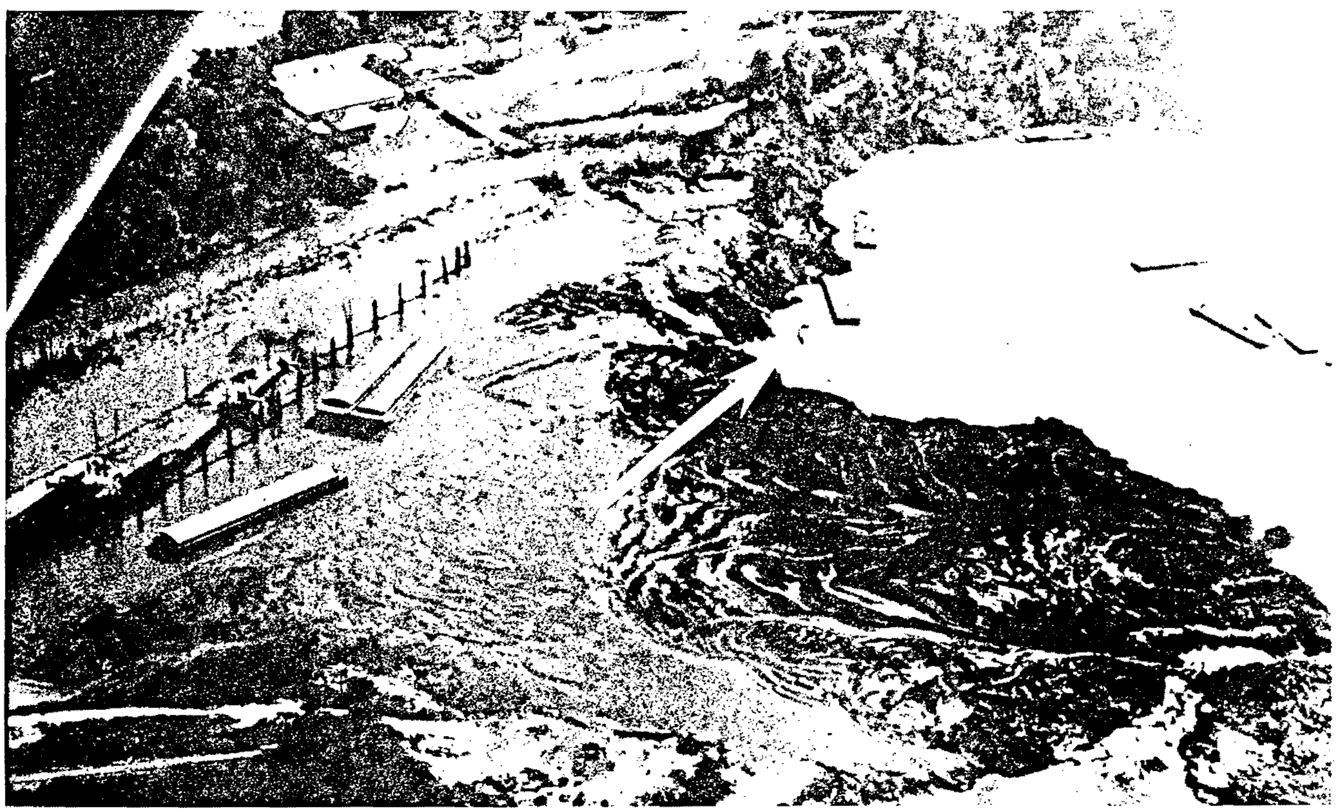
APPENDIX DD
Cross-section of AA' and BB'

APPENDIX EE: PHOTOGRAPHS

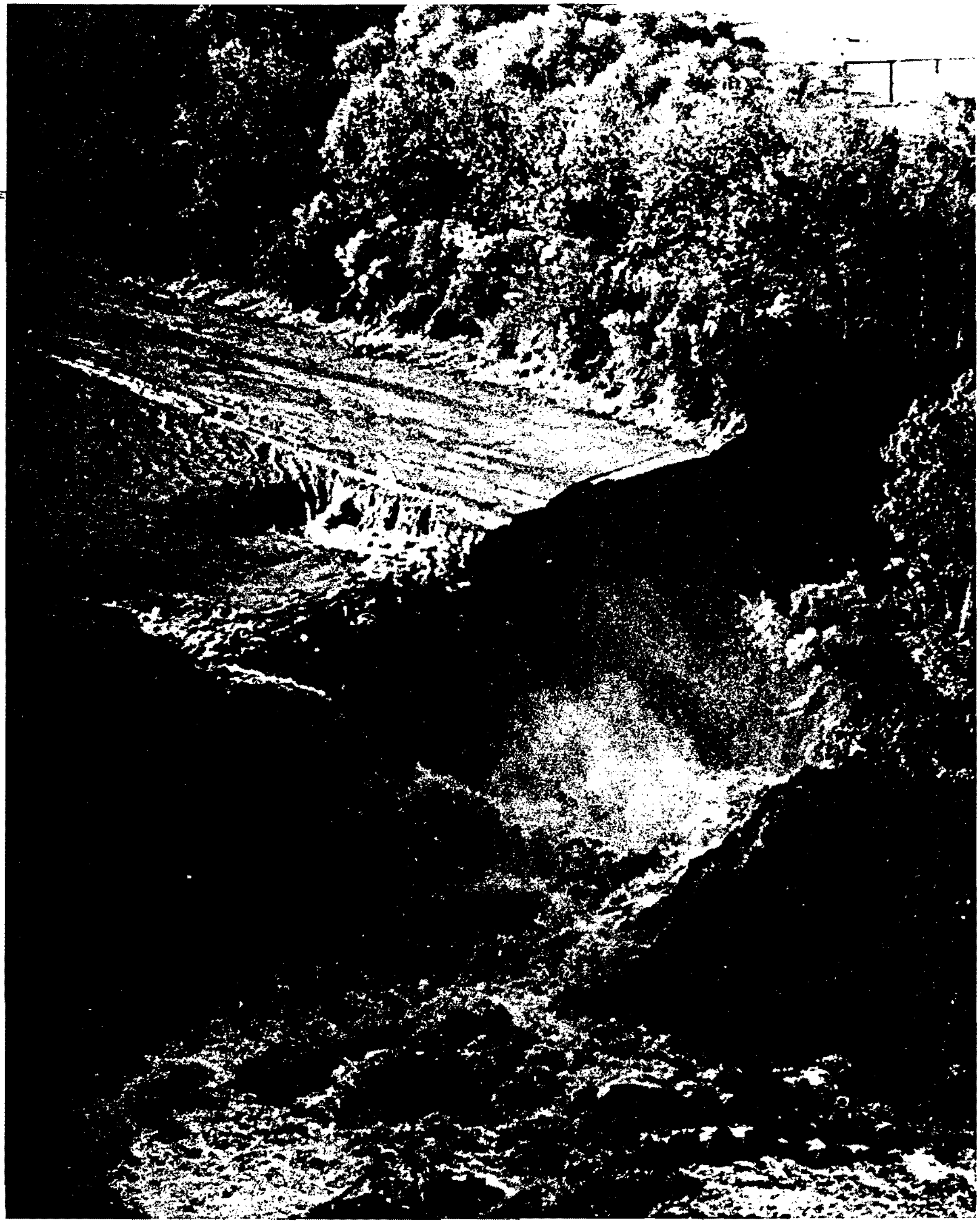
Early stage of crater development. (Barges in crater were between 120 - 200 feet in length.)

Bayless residence and greenhouses.



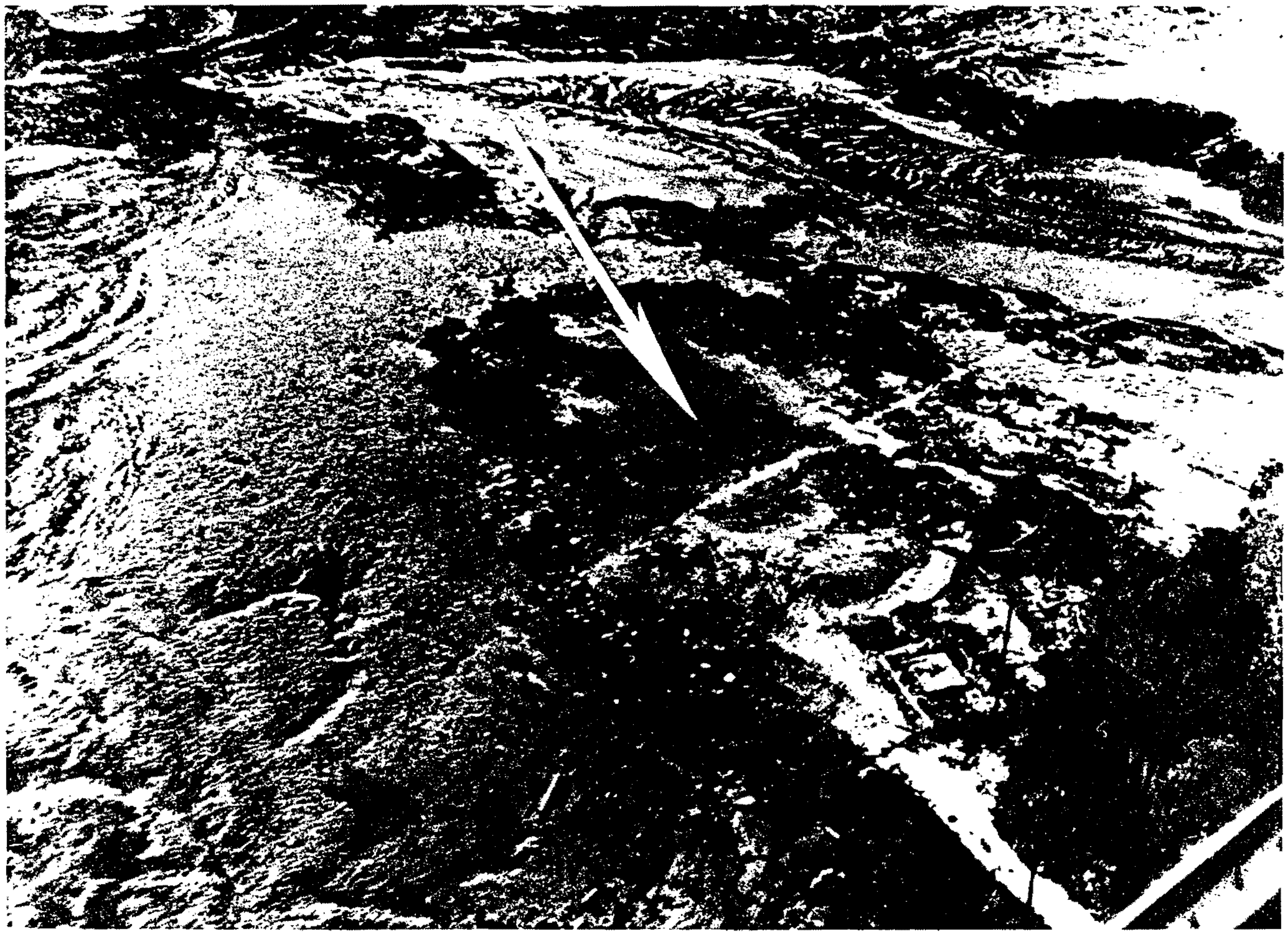


As the Delcambre Canal flowed into the lake, three barges temporarily remained at the loading dock. Small fishing boat (arrow) was in crater.

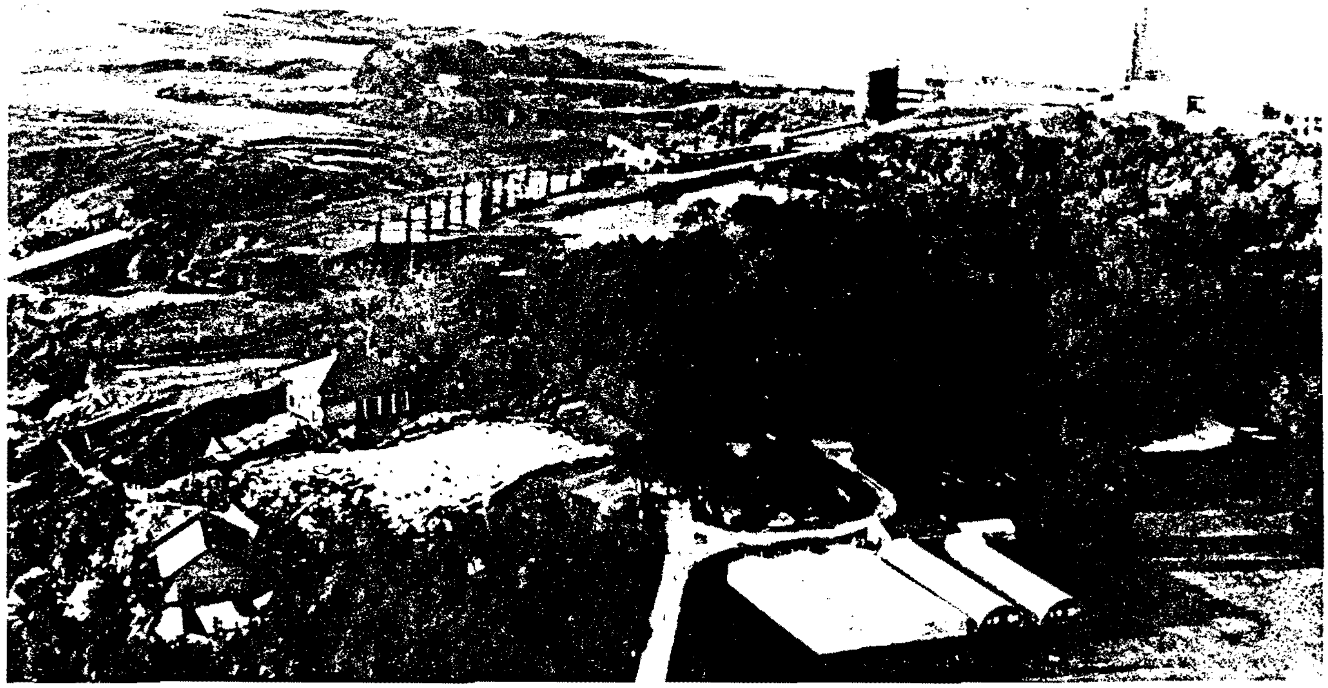


Closeup of Delcambre Canal feeding into Lake Peigneur.

Bayless guesthouse and greenhouses.

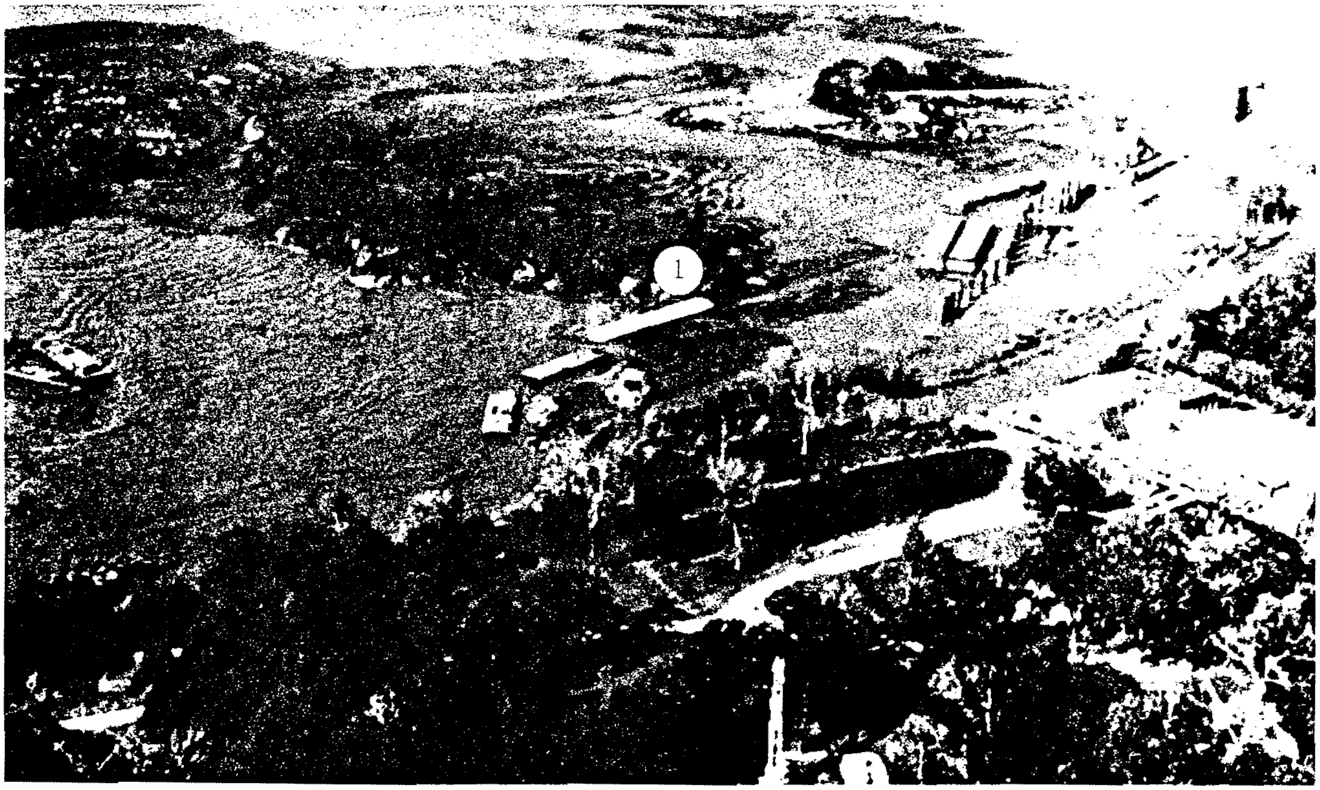


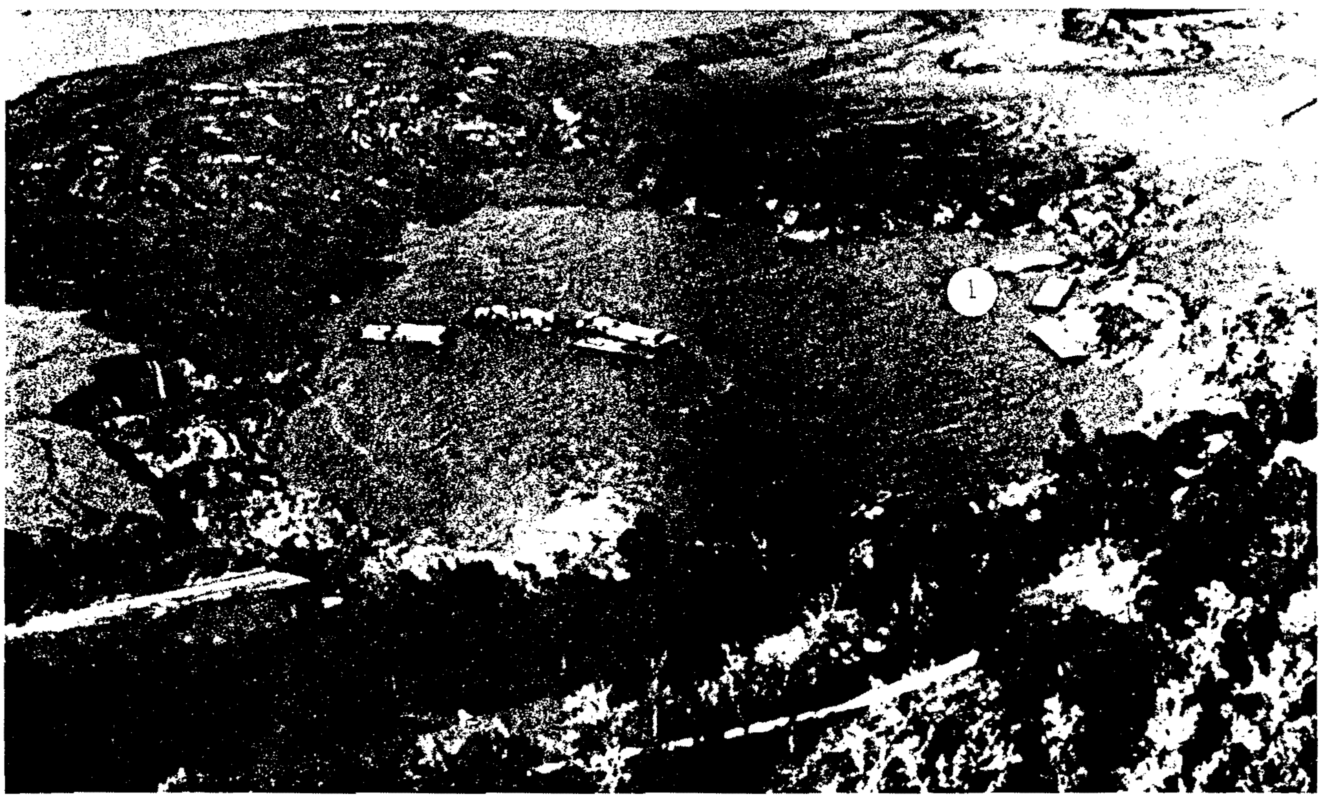
Old Air Shaft (arrow).



Conditions in the late afternoon,
November 20, 1981.

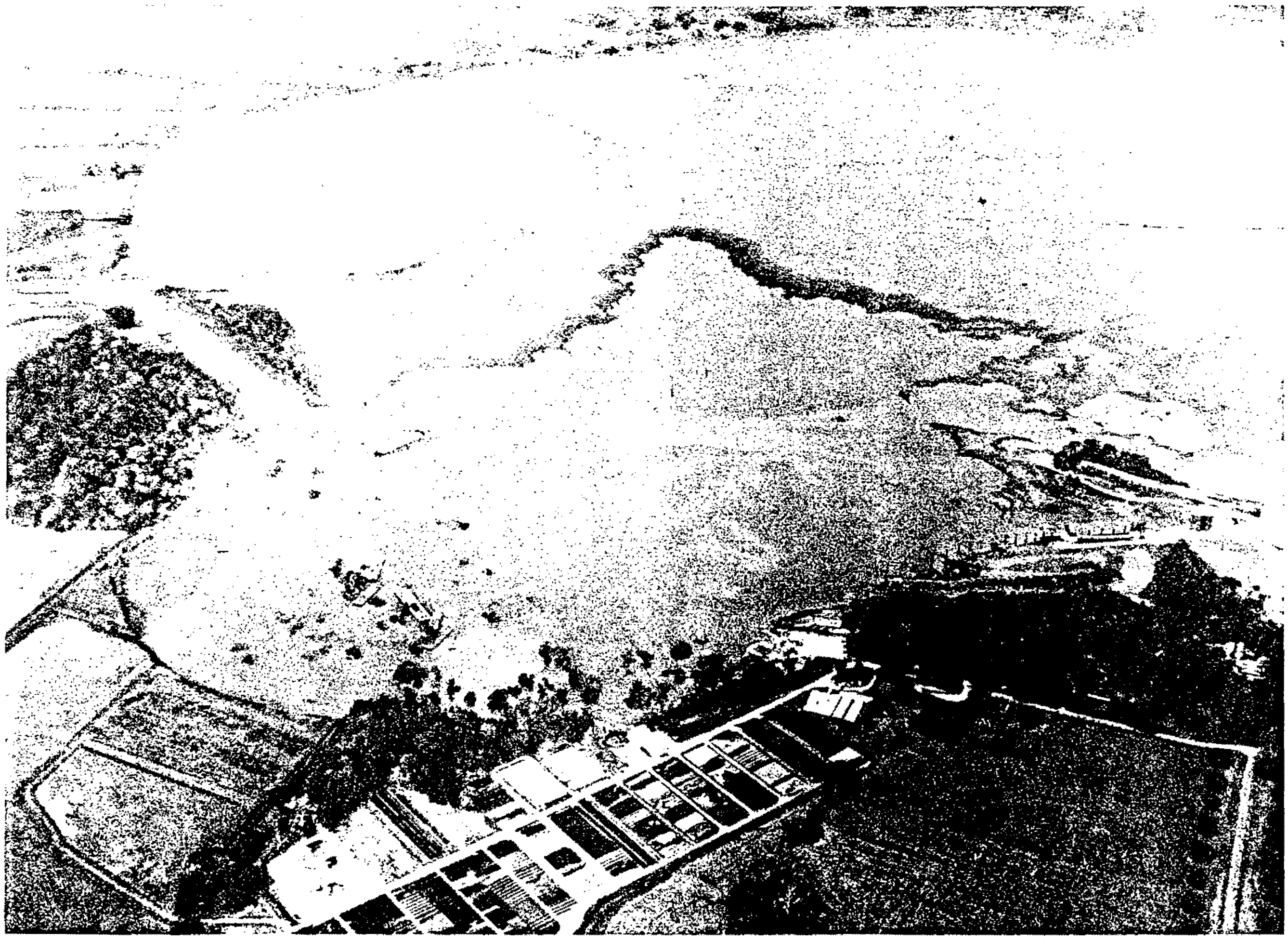
Bayless guesthouse.





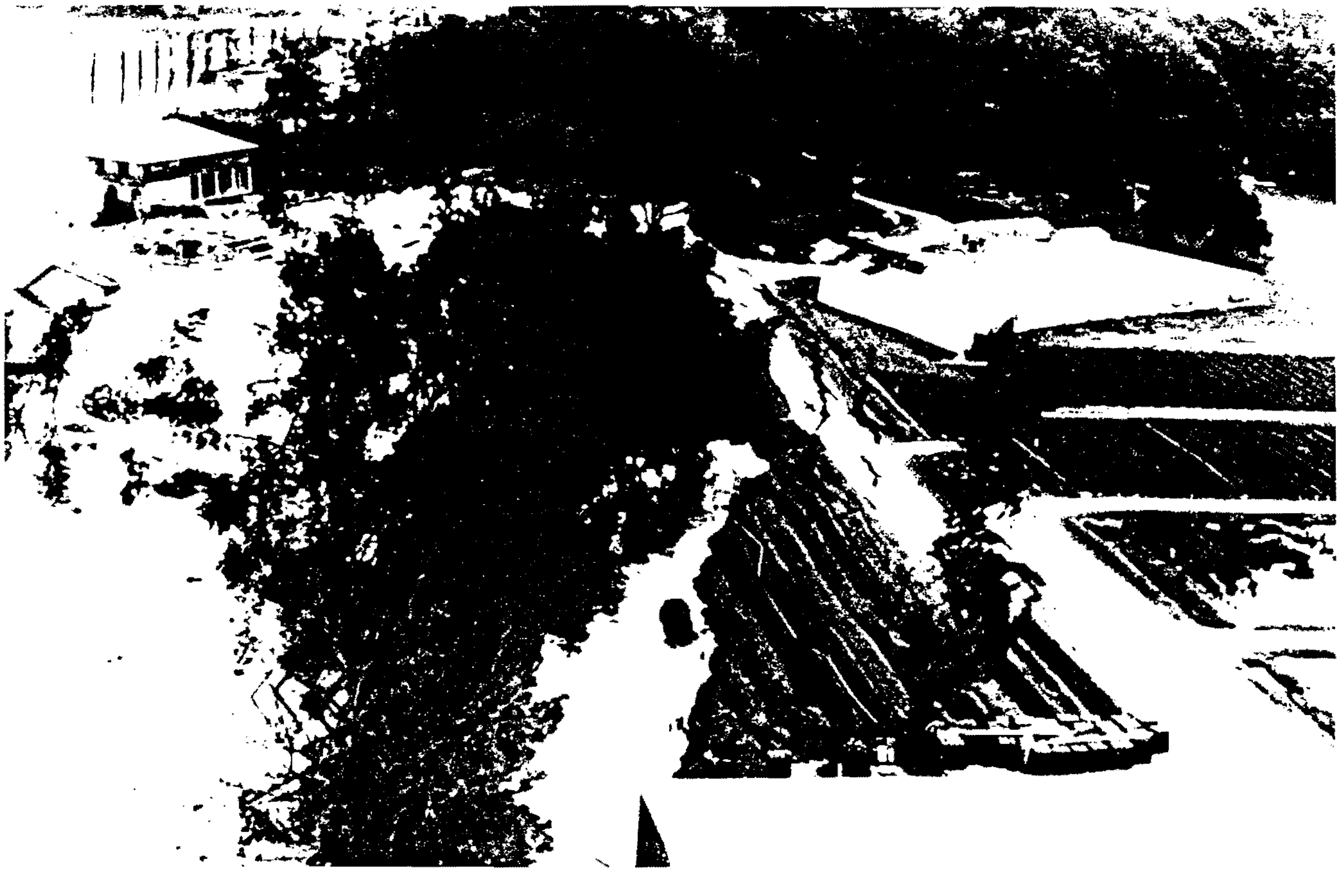
Water drained by crater exposed the lake's bed. (1) Note movement of salt barge from loading dock into crater.

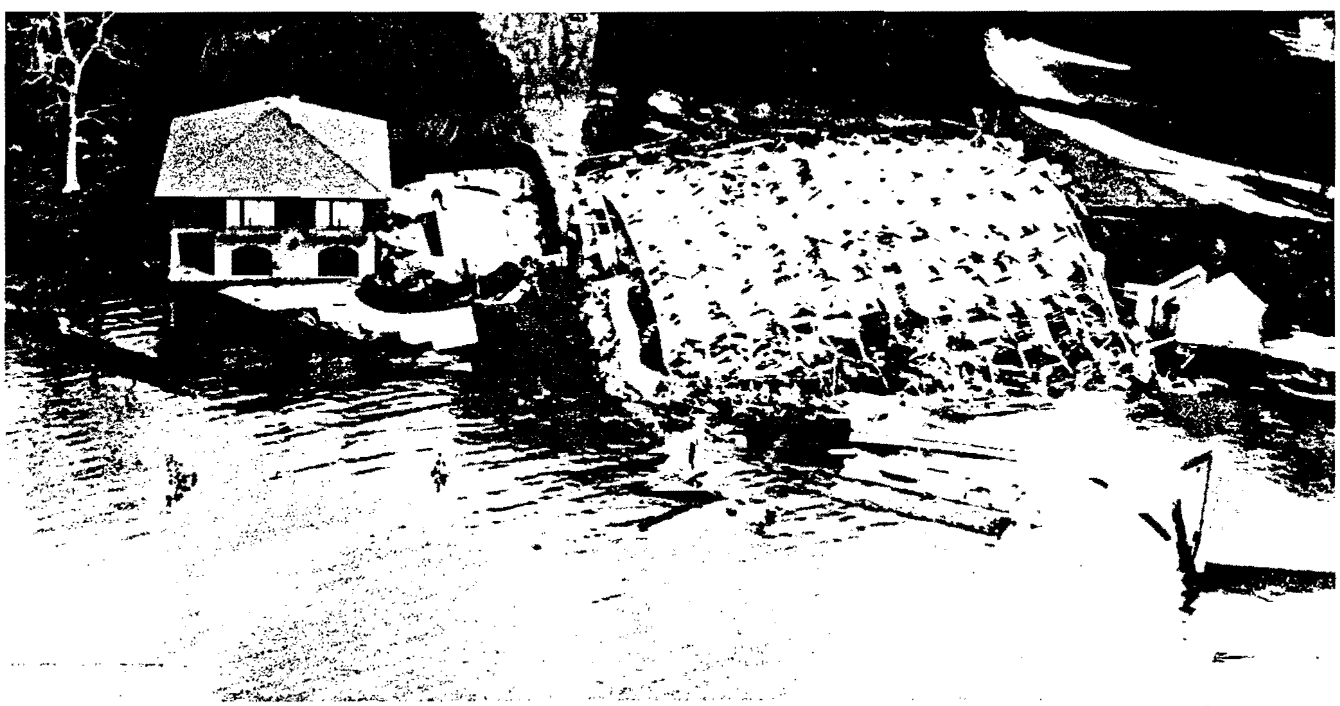
Additional subsidence developing.



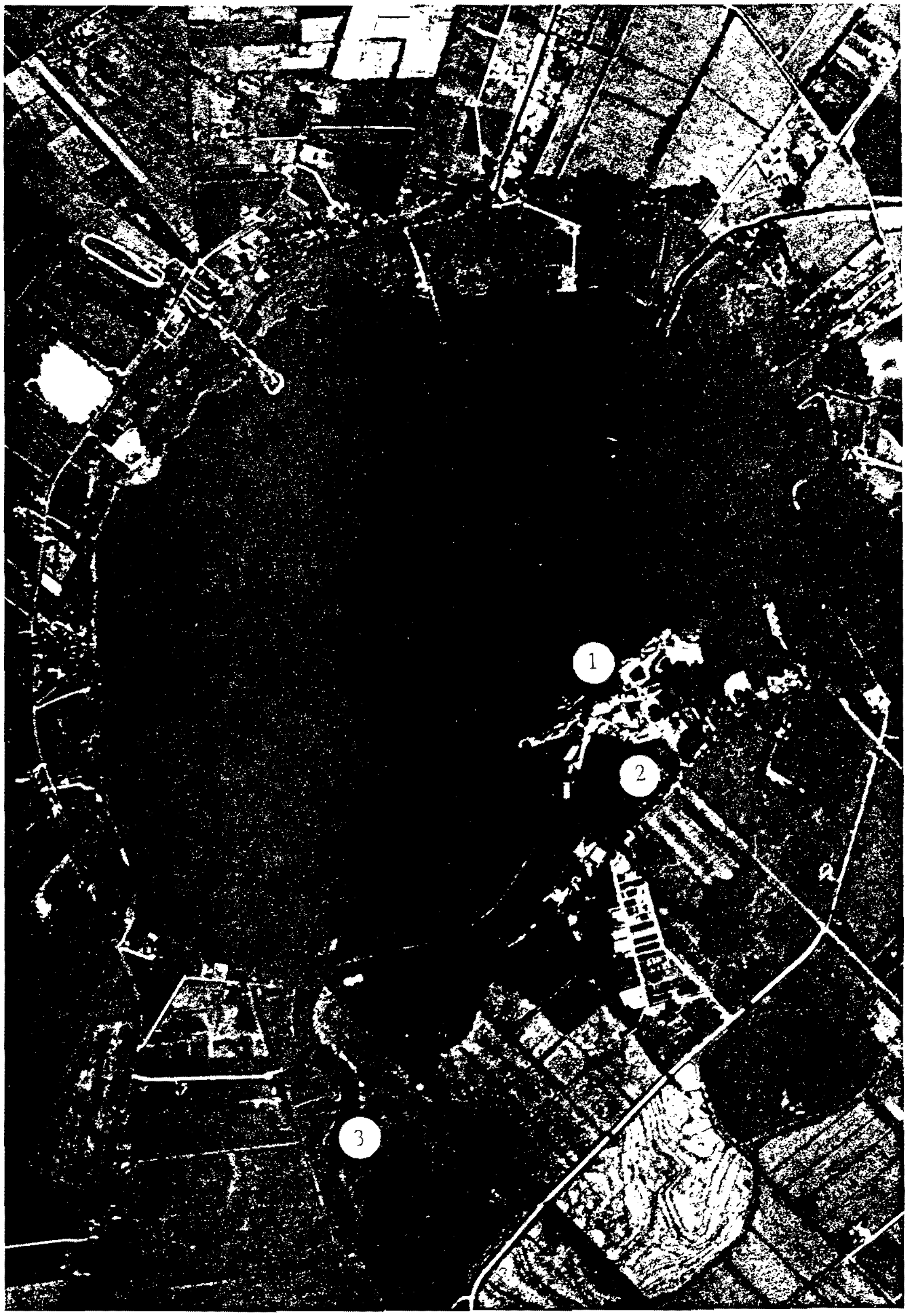
Texaco No. 8 gas well fire and
resurfaced barges.

LANDSAT Satellite Imagery of (1) Jefferson Island; (2) Avery Island; (3) Weeks Island; and (4) Cote Blanche





Subsidence damage at Bayless property.



Pre-inundation photograph of Lake Peigneur, Circa 1975. (1) Jefferson Islan
Mine Site; (2) Bayless property; and (3) Delcambre Canal.

Post-inundation photograph of Lake Peigneur, February 1981.
New lake area caused by subsidence.

P-20 servicing equipment disappearing into lake.

Security precautions at site.

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