UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket Nos. 50-329 OM
	)	50-330 OM
CONSUMERS POWER COMPANY	)	
	)	Docket Nos. 50-329 OL
(Midland Plant, Units 1 and 2)	)	50-330 OL

TESTIMONY

OF

WILLIAM C. PARIS, JR.

ON BEHALF OF THE APPLICANT

REGARDING PERMANENT DEWATERING SYSTEM

FOR THE MIDLAND SITE

SS: STATE OF MICHIGAN
COUNTY OF WASHTENAW

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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AFFIDAVIT OF WILLIAM C. PARIS, JR

William C. Paris, Jr., being duly sworn, deposes and says that he is the author of the "Testimony of William C. Paris, Jr. concerning the Permanent Dewatering System for the Midland Site," and that such testimony is true and correct to the best of his knowledge and belief.

W. C. Paris (signature)
W.C. Paris, Jr.

Sworn and Subscribed Before Me this 15 Day of October, 1982

Beverly A. Bross (signature)
Notary Public
Washtenaw County, Michigan

My Commission Expires November 30, 1982

BEVERLY A. B[illegible]OSS
NOTARY [illegible] CO. [illegible]
MY COMMISSION [illegible]

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1.0 INTRODUCTION

This is the testimony of William C. Paris, Jr. concerning the permanent dewatering system for the Midland site. That system - a part of the proposed soils remedial action for the Midland site - is designed to remove water from the granular plant fill materials underlying certain Seismic Category I structures and components, precluding the possibility of liquefaction during a design basis earthquake (FSAR Figure 2.4-47).

I have directly participated in the design of the permanent dewatering system. Based on my knowledge and analysis of that design, as well as the construction methodology, I conclude that the dewatering system will provide an acceptable method of removing water from the granular plant fill material thereby preventing liquefaction of soils beneath certain Category I structures at Midland in the event of a design basis earthquake.

1.1 QUALIFICATIONS AND EXPERIENCE

My detailed educational and professional record is presented in Appendix A. The following is a summary:

I completed the requirements for a Bachelor of Arts degree in Geology from Bowling Green State University in 1968.

Following graduation, I began work as a geologist with consulting engineering companies in Pennsylvania and Maryland. My work was primarily in the area of engineering geology, which is the application of geologic data, techniques and principles to the study of rock, soil, and groundwater. Some of the projects upon which I worked include the following: design and construction of highways and bridges, building foundations, municipal water supplies, pipelines, and solid waste disposal facilities.

Starting in 1974, I served as a geologist in the Bechtel Gaithersburg (Maryland) office. I became supervisor of the engineering geology group of the Bechtel Ann Arbor office in June 1979. My experience with Bechtel includes project geologist for the Boston Redline Extension Tunnels, geotechnical coordinator for additional facilities constructed at the Dickerson (Maryland) Generating Station, and resident field geologist at the Grand Gulf (Mississippi) Nuclear Station. I also have provided technical support for feasibility, siting, design and construction of other nuclear and fossil fueled facilities.

I am a registered geologist in Georgia, and a certified geologist in Maine. I am listed in Who's Who in Technology Today, Volume 2, Civil and Earth Sciences, 1982. I am a member of the International Association of Engineering Geologists, and Geological Society of America. I am the immediate past president of the 3,000-member Association of Engineering Geologists and recently served on the governing board of the American Geological Institute. I am currently on the U.S. National Committee of the International Association of Engineering Geologists. I am also an Associate Member of the American Society of Civil Engineers and a member of the National Water Well Association.

1.2 BACKGROUND INFORMATION

Areas of the site subject to possible liquefaction are described in the liquefaction testimony of Dr. Woods. Facilities affected include the diesel generator building, auxiliary building electrical penetration areas, auxiliary building railroad bay, the cantilevered section of the service water pump structure, and a portion of the service water lines adjacent to the service water pump structure.

Basically, the underpinning proposed for the auxiliary building electrical penetration wings and service water pump structure and rebedding of a portion of the service water lines eliminates liquefaction as a potential problem in those areas. A slight potential for liquefaction in the event of the design basis earthquake would still exist in the granular plant fill lying above elevation 610 beneath the diesel generator building and in the uppermost layers of fill beneath the railroad bay area of the auxiliary building. With regard to the diesel generator building, the preload program was designed to consolidate clay soils, but was not designed to and did not, eliminate the possibility of liquefaction of granular materials beneath the structure if a design basis earthquake were to occur.

2.0 SUMMARY OF DESIGN OF PERMANENT DEWATERING SYSTEM

Section 2.4.12 of the Standard Review Plan including Branch Technical Position HGEB-1 has been reviewed and was used as a guide in designing the dewatering system. The design of the permanent dewatering system meets or commits to meet all the provisions of the Regulatory Guide.

The design of the permanent dewatering system is based on an evaluation of design drawings and construction records, test boring information, field and laboratory test results, observation well and piezometer data and pumping test results. The data obtained from these activities include type, distribution and permeability of materials, zones of recharge, zones of drawdown, recharge rates and pumping rates. This information has been used to determine the location, spacing, size, and depth of the dewatering wells.

The design of the system further includes protection against system malfunction and ensures that sufficient time is available for implementation of remedial measures before the groundwater level can rise to an unacceptable level. More specifically, a groundwater monitoring program has been developed to provide early detection of system failure at critical locations; an evaluation of system component failures (pumps, timers, screens and headers) on the performance of the entire system has been completed; provision has been made for the repair of any system failure which may occur; and a regularly scheduled inspection program will be carried out during both construction and operation of the system.

Last, the design of the system is such that following a total system failure, the groundwater level recharge time is sufficiently slow to allow other forms of dewatering to be implemented before the design basis groundwater level is exceeded at the diesel generator building or auxiliary building railroad bay. To verify that conclusion, a full-scale test was performed by shutting off all operating wells after the groundwater levels had been lowered to elevation 595, or as low as practical and with the cooling pond at operating elevation 627. During this test, groundwater level versus time curves were plotted to determine the actual recharge time at the diesel generator building and auxiliary building train bay. The results of this test indicate there is sufficient time to initiate corrective action before the groundwater levels can reach elevation 610 beneath either the diesel generator building or auxiliary building railroad bay.

3.0 EXPLORATION PROGRAM

The design of the permanent dewatering system is based on evaluation of over 300 exploratory borings including 56 borings designated by the "PD" prefix drilled specifically for the dewatering investigation. The objective of this program was to develop a clear understanding of the hydraulic characteristics of the materials to be dewatered. Information collected from the PD series borings includes:

a. Areal extent of the lacustrine sand (Unit c), lacustrine clay (Unit d), and till (Units b and e)

b. In situ soil permeability data and degree of hydraulic connection between lacustrine sand (Unit c) and sand backfill

c. Grain size analysis of lacustrine sand (Unit c) and sand backfill

3.1 AREAL EXTENT OF SANDS

The PD series boring program and other site borings were evaluated to determine the areal extent and thickness of the granular materials.

Clay and silty clay are the predominant backfill materials. However, sand backfill was placed adjacent to the structures, with the largest concentration of sand backfill in the main excavation around the containment and auxiliary building structures. The borings show that sand backfill placed elsewhere is predominantly at or near the base of the plant fill.

The natural material underlying the site is primarily Unit c lacustrine sand or Unit d clay, and Unit e till. The Unit c lacustrine sand is found beneath the eastern and southern portions of the site. This sand is thickest east of the plant structures and decreases in thickness to the west (FSAR Figure 2.4-39). The bottom of the Unit c sand is generally below elevation 590 over the entire plant site as shown in FSAR Figure 2.4-49.

4.0 HYDRAULIC CHARACTERISTICS OF MATERIALS

The hydraulic characteristics of the natural and backfill sands and their degree of hydraulic interconnection* were obtained through pumping tests, in-situ falling head tests, grain size analyses and observations of changes in site water levels as a result of changes in cooling pond elevation (Appendix B) and construction dewatering (Appendix C).

*The term hydraulic interconnection refers to the ability of water to freely flow from one unit or strata of soil to another.

Pumping tests were performed by pumping a well for a period of time at a constant rate while observing the change in water level in the pumping well and in nearby observation wells. From these tests permeabilities and transmissivities are determined. (Permeability is the rate water will move through a material of unitized dimensions under a given pressure, whereas transmissivity is the permeability of the material multiplied by its saturated thickness. Thus, the transmissivity gives an indication of the rate water will flow through a given saturated material.)

Permeability may also be determined through the use of field falling head permeability tests, which are performed by measuring the rate of water level decline in a cased borehole which has been filled with water. Evaluation of the test results indicate the permeability of materials at the open bottom of the casing.

A third method of approximating permeability is by grain size analyses. Theoretically, permeability varies with the square of a particular particle diameter. The controlling particle diameter is the size where 10% of the material is finer by weight, and 90% is coarser by weight, which is referred to as the D_{10} size.

4.1 FIELD FALLING HEAD TESTS

Field falling head permeability tests were performed in selected borings to evaluate the permeabilities of the Unit c lacustrine sand, Unit d lacustrine clay, Unit e till, sand backfill, and clay backfill. The results of these tests were analyzed using Hvorslev's variable head formula (Reference 1). These tests were performed in the PD Series borings and shown in plan in FSAR Figures 2.5-17, 2.5-17A, and 2.5-17B. The average permeability for the lacustrine sand (Unit c) is 840 ft/yr. The average permeability of the lacustrine clay (Unit d) is 15 ft/yr. The glacial till (Unit e) also has an average permeability of 15 ft/yr. The sand backfill has an average permeability of 3,600 ft/yr and the clay backfill has an average permeability of 20 ft/yr. The results of these permeability tests are presented in FSAR Table 2.4-11A.

The falling head permeability tests that were performed in clay are subject to error due to leakage around the casing. Because the clays have such low permeability, the water added to the casing could run up between the casing and the wall of the boring if the casing is not seated properly in the clay. However, this error is conservative because it results in higher permeability values.

4.2 PERMEABILITY ESTIMATED FROM GRAIN SIZE

Grain size information was also used to estimate permeabilties of the lacustrine sand (Unit c) and sand backfill. Grain size information was taken from gradation analysis of selected samples from numerous site borings. The range of permeabilities determined for the Unit c sand are from less than 5,700 to 50,000 ft/yr and the backfill sand from less than 5,700 to 55,000 ft/yr.

The permeabilities determined from grain size analyses represent only relative permeability values. The Hazen formula (Reference 2) was used, which is an empirical derivation relating permeability to grain size and may be subject to error when applied to sands with different gradations. The use of this method was intended only to provide a range of relative permeabilities that can be compared to field and laboratory permeability tests.

4.3 PUMPING TESTS

Eight constant rate pumping tests were performed during the site investigation to evaluate the permeability and degree of hydraulic connection in the lacustrine sand (Unit c) and sand backfill. The results obtained from these tests indicate that:

a. Shallow backfill sands near the containment structures are in hydraulic contact with the deeper backfill sands; thus the shallow backfill sands will respond to pumping from the deeper backfill sands. The clay intervals in the backfill are not effective barriers to drainage.

b. Backfill sands surrounding the circulating water discharge lines are in direct contact with the underlying lacustrine (natural) sand, and the two sands are hydraulically connected. However, these sands are not directly connected to the cooling pond.

c. Hydraulic connection exists throughout the combined Unit c and backfill sands. These sands are directly connected to the cooling pond in the area of the circulating water intake and service water pump structures.

Calculated transmissivities from pumping tests in the lacustrine sand (Unit c) and sand backfill range from 28 to 1,103 ft^2/day. The average permeability is 3,527 ft/yr (FSAR Table 2.4-11B).

The pumping test method is accepted as one of the most accurate methods of determining aquifer permeability. Because observations of water levels are made some distance from the pumping well, permeability values can be obtained for a sizable portion of the aquifer. Additionally, the aquifer materials are not disturbed as they are in a laboratory permeability test (Reference 3).

5.0 AREAS OF RECHARGE

The backfill materials are placed within the limits of the plant dike which encompasses the cooling pond as well as the plant area backfill. The plant dike contains a clay cutoff or slurry wall (Reference 4) which effectively reduces movement of groundwater toward or away from either the plant backfill material or underlying natural sand from sources outside the dike.

There is, however, no impervious cutoff between the cooling pond and the plant fill. Therefore, the primary source of recharge to the plant backfill materials is the cooling pond. Two potential areas for the recharge were considered: south of the diesel generator building, and around the circulating water intake and service water pump structures.

An analysis of the results of pumping tests, permeability measurements, changes in plant groundwater levels due to pond raising or lowering, and construction dewatering indicates only slight hydraulic connection between the pond and soils south of the diesel building (Appendix B). Instead, seepage from the cooling pond enters the plant site at the circulating water intake structure, and travels to other portions of the plant site. This conclusion was verified by the rate at which site water levels rose during the recharge test. Examination of the hydrographs of site observation wells (Reference 16) measured during the recharge test indicates that the water levels rose much faster in the area of the circulating water intake structure than in the area south of the diesel generator building (Appendix D).

6.0 DEWATERING SYSTEM DESIGN

The design of the permanent dewatering system accounts for the two basic findings of the exploration and testing program: 1) The granular backfill materials are hydraulically connected to the underlying natural sands, and 2) The cooling pond, at elevation 627, is the main source of recharge, and seepage from the pond is occurring primarily at the circulating water intake structure and service water pump structure.

The first component of the permanent dewatering system is a line of interceptor wells around the intake and pump structure area (FSAR Figure 2.4-46). This line of wells is designed to prevent cooling pond water from moving through the backfill and natural sands toward the diesel generator building and auxiliary building railroad bay areas. These wells will also aid in lowering groundwater levels in the backfill and Unit c sands near the cooling pond. Thus, should the dewatering wells become inoperable, the groundwater will be low enough so that the rate of groundwater level rise in the plant area is sufficiently slow to allow activation of the backup dewatering system before the groundwater level reaches elevation 610 at the diesel generator building or auxiliary building railroad bay.

The interceptor well system analysis utilized the combined gravity-artesian flow method presented in the Army, Navy, and Air Force dewatering manual (Reference 5). This method of analysis was selected to account for the confining nature of the concrete foundation of the circulating water intake and service water pump structures.

The calculation is based on an approximation of inflow from a line source (cooling pond) into a slot (interceptor well system) 110 feet from the cooling pond. This hypothetical slot extends along the entire length of the circulating water intake/service water pump structures and continues in a straight line to the condensate tanks for a total length of 380 feet. The results of the analysis indicated that 20 wells, with a 20-foot well spacing, are required to intercept flow and maintain pumping levels of elevation 585 in these wells (FSAR Figure 2.4-46). Each well should produce approximately 10 gpm with the water levels between the interceptor wells at elevation 590 and downstream of the wells at elevation 589. This calculation conservatively ignores the Seismic Category I concrete wall that will be installed to support the cantilevered portion of the service water pump structure. This wall will effectively cut off any seepage from beneath the structure for a length of 57 feet.

Design of the interceptor well system also requires a duplicate or backup interceptor well system to provide nearly uninterrupted service should the primary interceptor well system be shut down for maintenance or repair. Therefore, a total of 40 (interceptor and backup interceptor) wells are provided in the vicinity of the circulating water intake and service water pump structures (FSAR Figure 2.4-46).

The second component of the system consists of area dewatering wells designed to fulfull two objectives: first, to remove groundwater from storage to elevation 595 within the plant site; and, second to intercept rain water and pipe leakage. The average annual rainfall at the site is 29.6 inches (Reference 6). Normal leakage from pipes during plant operations is estimated to be no greater than 1 gpm. The total number of area wells required for area dewatering is estimated to be 24 (FSAR Figure 2.4-46). The area wells are expected to operate only a small percentage of the time.

The optimum maximum groundwater level during operation was determined by the use of an analytical model. The model is a linearized form of the Boussinesq equation (Reference 7) and utilized data from observed groundwater fluctuations as a result of changes in cooling pond level. The optimum maximum operating groundwater level was selected to provide sufficient time to repair the system, in the event of a complete failure, before groundwater levels would reach elevation 610 at the critical areas. The optimum operating groundwater level was determined to be elevation 595. The most conservative recharge time, as determined from the model, is approximately 60 days.

6.1 AREAS OF PERMANENT DEWATERING INFLUENCE

The area of influence of drawdown created by the permanent dewatering system over the life of the plant will not extend beyond the plant fill area because of the cutoff and slurry trench, which was constructed around the perimeter of the site (Reference 4). This cutoff effectively limits any movement of groundwater toward or away from the plant backfill material or underlying Unit c sand.

FSAR Figure 2.4-41 presents the predicted groundwater levels during the permanent dewatering system operation. This figure shows that within the plant area fill, the groundwater levels are contained within the plant boundaries.

Dewatering has no effect on the integrity of the soil straca, and the lower confined aquifer will not be affected because of the presence of 135 feet of essentially impervious soil between the upper Unit c sand and the lower confined aquifer.

6.2 DESCRIPTION OF COMPONENTS

The components of the dewatering system include the permanent well, filter pack, pumping equipment, well discharge and header piping, timers, switches, and monitoring devices. These components have been or will be installed in accordance with industry or manufacturer's standards under the owner's QA/QC inspection plan.

6.2.1 Description of Permanent Well

Each permanent dewatering well is constructed of the following materials (FSAR Figure 2.4-60):

a. Well casings are 6 inches nominal diameter SDR-21 polyvinyl chloride (PVC).

b. Well screens are No. 18 (0.018 inch) continuously-slotted, plastic wire wrapped.

c. Caps placed at the bottom of each well are PVC.

d. Piezometers are porous stone, Casagrande type. The connecting riser pipe is 1/2-inch diameter PVC.

e. Each well is equipped with a filter pack as described in Section 6.2.2.

f. The seal above the filter pack consists of nonshrink grout.

6.2.2 Description of Filter Pack

A filter pack is required to provide a transition zone between the natural sand to be dewatered and the well screen to prevent the movement of soil particles into the well. The filter pack design for the monitoring wells and interceptor, backup, and area dewatering wells was based on grain size data from the PD series borings (Reference 8). A composite of Unit c natural sand grain size curves is presented in FSAR Figure 2.4-54. From this figure, a composite Unit c sand grain size curve was selected and utilized for the filter pack design (FSAR Figure 2.4-55). The filter pack gradation curve was determined from grain size of the composite curve using industry accepted methods (Reference 9). The width of the well screen slot was selected to retain 90% of the filter pack (Reference 9). Verification of the range of grain sizes for the Unit c sand was performed by sampling from pilot holes drilled at selected permanent dewatering and monitoring well locations (Reference 10). In order to ensure that the filter pack is functioning properly, a soil particle monitoring program will be in effect during plant operation (Section 11.2.2).

Each filter pack is composed of clean, well-rounded, noncalcareous sand, containing no clay, organic matter, or other deleterious materials. The filter pack meets the following requirements:

Sieve Size Designation (No.)	Acceptable Range of % Retained
4	0- 10
6	0- 24
8	6- 22
12	14- 31
16	24- 40
20	35- 51
30	51- 67
40	87-100

(Particle size analysis was performed by the contractor's testing representative prior to shipment of filter pack material.)

6.2.3 Description of Permanent Pumping Equipment

Each individual permanent well will be equipped with a waterproof submersible pump of sufficient capacity to control and lower the groundwater within its zone of influence. The pumping equipment will be manufactured from material capable of resisting the effects of substandard groundwater quality (Reference 11), and will be supplied with remote motor starters and controls (Reference 12). Pumping equipment will be connected to the piping discharge system with a quick disconnect pitless adaptor to allow pumping equipment to be easily removed from the well for inspection, cleaning, or replacement.

6.2.4 Description of Permanent Well Discharge and Header Piping

Groundwater quality samples were obtained and tested during the permanent dewatering exploration program and the initial operation of the backup dewatering system. Evaluation of chemical analyses presented in FSAR Tables 2.4-12B, 2.4-12C, and 2.4-12D indicates that the groundwater at the site is not scale forming. However, all buried discharge and header piping will be reinforced thermosetting vinylester resin pipe which minimizes concentration of dissolved solids and mineral deposits or deterioration caused by chemical reaction (Reference 13).

Each individual well will be equipped with a three-way valve to divert the discharge flow from the header to the water quality sample tap (Reference 13) or emergency riser discharge pipe (Reference 14). An automatic drain valve will be provided at each individual well sampling tap to prevent freezing.

Each subsystem will be divided into one or more separate header sections to provide monitoring control and minimize the dependence on a single system header. Each header will be provided with a 5-foot minimum cover or freeze protection. The headers will be routed to a meter pit equipped with a header water quality sampling point and remote readout flowmeter. Water quality samples and flow measurements will be taken in accordance with the operating technical specification.

The discharge from one or more headers will be combined after the monitoring points and conveyed to a catch basin for discharge back to the cooling pond.

6.2.5 Description of Timers and Level Switches

Each individual well will be controlled by its own timer and/or automatic self-contained level switches located within the well casing.

Wells for the primary interceptor subsystem will be controlled by individual timers and low level shut off safety switches. Timer settings will be determined after the system is in operation or sufficient construction dewatering activities have been performed to determine the correct cycling duration. Timing will be adjusted periodically to meet the limiting conditions of the operating technical specification. In addition to the timers, these wells will be provided with low level cutoff switches to prevent pump damage if unexpected low flow occurs.

The backup interceptor subsystem wells are operated by high/low level switches. This subsystem will automatically activate if abnormal amounts of groundwater pass the primary interceptor subsystem causing the groundwater to rise to a predetermined elevation. The area subsystems are controlled by high/low level switches and will activate if the local water level rises to a predetermined elevation. Each motor control unit will be supplied with an automatic/off/and manual on cycle for emergency and testing use.

Electrical wiring of the dewatering pump system will be designed so that a temporary outage of one or more wells will have no effect on the remainder of the wells. If any disruption in the electrical power supply occurs, a backup diesel generator will be available to supply power to the primary interceptor well and backup well pumps on a temporary basis until the normal power supply is restored. At a given time, this temporary backup power can feed either the primary interceptor or backup interceptor well pumps.

6.2.6 Description of Permanent Monitoring Wells

Six permanent groundwater level monitoring wells will be installed as part of the dewatering system. These wells, as shown in FSAR Figure 2.4-46, are located to provide groundwater level data at the two critical structures and between the critical structures and the cooling pond.

The monitoring wells were installed using the same construction techniques, materials and soil particle test criteria as the dewatering wells. The only exception is that no pumping equipment or pitless adapters will be installed in these wells. A typical section of a monitoring well is shown in FSAR Figure 2.4-48.

Ultrasonic level transmitting devices will be installed in each monitoring well. This level transmitter sends water level data from the monitoring wells to a continuous reading strip chart recorder located in the evaporator building. Additionally, alarms are connected to this system which are activated when a significant water level rise occurs in any of the wells. The high level alarm is located in the main control room.

Because the monitoring wells are constructed in the same way as the dewatering wells, in the event of an emergency situation, temporary pumping equipment can be installed in these wells with the discharge being diverted to a catch basin. Additional observation wells are also available at the site to monitor various depths within the backfill and natural sands (FSAR Figure 2I-1). A select number of these wells will be maintained for measurement over the life of the plant.

7.0 INSTALLATION OF PERMANENT DEWATERING WELLS

After pilot holes were drilled to obtain information as to filter pack design, the permanent dewatering wells were installed between August 1981 and August 1982. Bechtel's geologists/hydrogeologists prepared as-built drawings of each well installation, including well number, location, diameter of hole, total length, and description of each type of casing; a log of subsurface materials encountered; and a complete compilation of all field data obtained during drilling, installation and development of the wells, including the data requested by the NRC (Reference 15).

The bored hole for each dewatering and monitoring well was drilled by the cable tool drilling method, using water as a drilling fluid. The subcontractor was required to take bailer samples from the drill cuttings from each 5-foot interval of drilling and at every formation change. Strata were classified by Bechtel's geologist/hydrogeologist during the drilling operation (Reference 15). Each hole was 17 inches in diameter to the elevations indicated in Table 1. During the drilling operation, thee subcontractor was required to keep the water level in the drive casing 5 feet above the static groundwater level. The subcontractor was restricted to drilling only 5 feet below the end of the drive casing in sand and 10 feet below in clay.

Each dewatering well was constructed as a filter pack well (FSAR Figure 2.4-60). The filter pack material was delivered in bags and wetted to prevent particle segregation. Centering devices were installed on the casing and screen to locate and hold the casing and screen in position. Casagrande-type, porous stone piezometers were placed just below the well screen within the filter pack of each well. After the assembled casing, screen, piezometer, tips, and tubing were located in the drilled hole, the filter pack was installed from the bottom of the well to the planned bottom of the grout seal. As the steel casing was being withdrawn, at all times the filter pack was maintained at least 2 feet above the bottom of the steel casing.

The filter pack was placed by two tremie pipes arranged 180 degrees apart. While placing the filter pack, clear water was circulated continuously through the tremie pipes.

Following installation of the filter pack or grout seal each well was developed by intermittent pumping with a submersible pump. The 20 permanent backup wells were developed prior to grout seal placement, while the remaining 44 permanent dewatering wells were developed after placement of the grout seal. Each well was developed for approximately 8 hours after which a soil particle test (0.05 mm size) was performed. If the quantity of soil particles was less than 10 ppm, the well was accepted and development discontinued. If the quantity of soil particles was greater than 10 ppm, the subcontractor was directed to develop the well for another 8 hours and a second test performed. If the second test exceeded 10 ppm, the subcontractor was directed to develop the well for another 8 hours and a third test was taken. If the third test failed, the well was required to be abandoned. During the installation of the permanent wells, all wells passed the soil particle test. Only one well (E-7) required three tests and two wells (H-3 and E-5) required two tests; all others passed the soil particle monitoring after the initial development period. As required by the NRC, during development an estimate of quantity of material removed was made by the Bechtel geologist/hydrogeologist. The results are indicated on the Well Installation Data Sheets (Reference 15).

Upon completion of development or gravel pack installation, the wells were grouted using a minimum thickness of 12 feet of nonshrink grout. The grout was introduced by a tremie pipe into the annulus between the PVC well casing and the steel drive casing. When the grout was brought to the design level, the tremie pipe and steel drive casing were withdrawn from the hole. Removal of the steel drive casing would cause the grout level to drop slightly. Therefore, after removal of the steel drive casing, the tremie pipe was reinserted into the hole and grout was added to bring the grout level in the hole back to the design elevation. A minimum set time of 24 hours for the grout to attain maximum strength was allowed following grout placement.

Following the grout curing period, temporary backfill or a steel casing was placed from the top of the grout seal to ground surface. A PVC cap was placed on the well for protection. The details of construction and as-built conditions of the wells are presented on the Well Installation Data Sheets and Well Construction Summaries (Reference 15).

All work was completed under supervision of Bechtel's geologist/hydrogeologist and inspected by the owner's QA/QC inspection plan.

8.0 TEMPORARY OPERATION OF 20 PERMANENT BACKUP DEWATERING WELLS

Following installation of the 20 permanent backup dewatering wells, temporary pumping equipment was installed. The pumping equipment consisted of either a standard submersible pump or eductor unit(s). Selection of the type of pumping equipment was based on estimates of individual well yields during development. Temporary steel header lines were placed above ground to allow all wells to discharge to a common point. Soil particle monitoring sample points were placed on individual well discharge lines and on the system discharge line.

By November 20, 1981, all 20 permanent backup dewatering wells were pumping as part of the drawdown-recharge test (Appendix D). Pumping rates versus time for the total system production are shown graphically in FSAR Figure 2.4-64 and 2.4-65. During operation of this system, biweekly soil particle sampling was performed on the system overflow and monthly sampling was performed on individual well discharge lines. As per request of the NRC, these soil particle samples were tested using a 0.005 mm (5 micron) filter medium. Throughout the majority of the system operation period, the soil particle results remained well below (less than 2 ppm) the maximum 10 ppm by weight of soil particles.

During initial system start-up, September 17, 1981, a test failure was reported. This failure is thought to be due to the presence of foreign material in the temporary header lines, eductor pipes, and drop pipes. No subsequent test failures have occurred. The pumping in these wells was terminated on February 4, 1982.

These wells were made operational again on May 6, 1982, to provide dewatering for the underpinning activities.

To evaluate the effectiveness of interceptor system design, actual field measurements were compared to the design information presented in Section 6.0. The comparison of design versus actual information is as follows:

Parameter	Design	Actual
Average Elevation of Bottom of Sand	el 580'	el 572'
Average Thickness of Sand	16'	28'
Total Head at Cooling Pond	47'	55'
Average Well Spacing	20'	24'
Average Distance From Cooling Pond	110'	124'
Length of Slot	380'	365'
Pumping Level	el 585'	el 579'
Average Pumping Rate (per well)	10 gpm	12 gpm
Average Soil Particle Removal (per well)	10 ppm 1.0 cy (max)	0.2 ppm < 1.0 cy (projected)

Examination of this information shows that, even though the sand thickness and total head at the cooling pond is greater and the pumping level is lower than the design assumptions, the pumping rate per well is essentially the same. This indicates that the true permeability of the sand at the dewatering slot is lower than the design permeability value of 17 feet per day.

Figure 1 shows the groundwater level contours before startup of the 20 permanent dewatering well system and FSAR Figure 2.4-58 shows the groundwater level contours at the conclusion of the drawdown portion of the drawdown-recharge test. It can be seen that the 20 permanent backup dewatering wells, in conjunction with construction and temporary dewatering wells (Appendix D) effectively lowered groundwater levels below elevation 595 throughout most of the plant site. Further, FSAR Figures 2.4-52 and 2.4-63, showing the flowrates for the construction dewatering system, shows that following startup of the 20 permanent backup dewatering wells, the flowrate of the construction dewatering system declined rapidly to less than 2 gallons per minute. This indicates that the permanent backup wells form an effective system for intercepting seepage from the cooling pond.

9.0 RECHARGE TIME

To verify the recharge time derived from the mathematical model (Section 6.0), a full-scale recharge test was performed at the site. Groundwater levels were lowered as close to predicted operating groundwater levels as possible, using the 20 backup interceptor wells, construction dewatering system, and miscellaneous wells around the site (Appendix D). FSAR Figure 2.4-56 shows the locations of these wells. The sequence of pumping operations is shown in FSAR Figure 2.4-57. FSAR Figures 2.4-50, 2.4-52, 2.4-63, 2.4-64, and 2.4-65 show pumping rates for the construction and permanent backup dewatering systems. FSAR Figure 2.4-58 is a groundwater level countour map showing levels before the start of the recharge test. The recharge test began February 4, 1982, and was conducted for 60 days. Hydrographs (Reference 16) show the responses of individual observation wells around the site. The groundwater contours at the completion of the test are shown in Figure 2. The results of this test indicate that there is sufficient recharge time available to repair or perform maintenance (FSAR Table 2.4-16) on the dewatering system before groundwater levels would reach elevation 610 at the diesel generator building (Figure 3).

10.0 EFFECTS OF MALFUNCTIONS OR FAILURES

The dewatering system is not a safety related Seismic Category I system; it is not required to operate during or after an SSE. Instead, the system design is based on the conclusion that, following natural circumstances that may cause total or partial failure of the system, sufficient time exists to make necessary repairs before the potential for liquefaction develops. A worst case assumption (the total failure of all pumping capacity in the system) would still permit sufficient time to repair or replace the system before the water level in liquefiable soils in the diesel generator building and auxiliary building train bay areas reaches elevation 610. This conclusion was verified by the full scale recharge test described in Appendix D. A summary of well failure mechanisms and repair times is presented in FSAR Table 2.4-16.

Less severe accident conditions (e.g., a partial break in the dewatering header system, breaks of lines outside the dewatering system, or power outages) have also been accounted for in the system design.

10.1 POWER OUTAGES

Electrical wiring of the system will be designed such that the temporary outage of one or more wells will have no effect on the remaining wells. In addition, should any disruption in the overall power supply occur, backup diesel generator power will be available for temporary backup power and can feed either the primary interceptor or backup interceptor well pumps.

10.2 UNINTERRUPTED SERVICE

Assurance of uninterrupted service in the event of a partial loss of system wells is also provided by a number of redundancies built into the dewatering system. Twenty backup wells located at the cooling water intake structure and service water pump structure will provide standby pumping capacity for the 20 interceptor wells in this area. Another 24 area wells are available to remove any water not collected by the interceptor wells. Thus, 64 wells have been incorporated into the dewatering system design, each with a submerislbe pump having the capacity of at least 10 gpm. Of the 64 wells incorporated, it is estimated that only 20 interceptor wells and 2 area wells will be required to maintain the groundwater at the level shown in FSAR Figure 2.4-41.

10.3 PIPE BREAKS

The dewatering system design also accounts for pipe breaks, both at the interceptor wells and at the critical areas. Pipe breaks that would immediately impact the interceptor well system include breaks of a dewatering system header line, concrete pipe cooling pond blowdown line, or service water discharge line. Also a nonmechanistic failure of both the Unit 2 circulating water discharge pipe and the 20-inch diameter condensate water pipe near the diesel generator building was analyzed.

10.3.1 Damage to the Dewatering System Header Line

Damage to the dewatering system header line could result in return flow to the dewatering wells in the vicinity of the broken line. In that event, the combination of groundwater recharge and surface water inflow could exceed the capacity of the affected pump, producing a rise in groundwater level. To account for this, flexible hose would be attached to each well to temporarily divert the flow to the system's catch basins until the header line is repaired. In the case of an interceptor well header failure, the backup wells would automatically be activated and they are on a separate header system. This arrangement will prevent an overload of the pumping capacity of an individual well or of a group of wells.

10.3.2 Break of 66-Inch Concrete Cooling Pond Blowdown Line

A break of the 66-inch concrete cooling pond blowdown line at the service water pump structure could result in damage to two dewatering wells if the break were to occur at the point where the line crosses the interceptor wells while the line is in service. The impact of such a pipe break on the entire dewatering system, however, would be minimal. The total amount of water released by a break in this low-pressure line would not produce a significant rise in overall plant groundwater levels, even if all the released water entered the groundwater system.

Following a pipe break, the flow of the water would be shut off and the backup interceptor wells would automatically activate. The backup interceptor wells and remaining primary wells will have sufficient capacity to remove recharge from the cooling pond until the damaged wells can be replaced. Excess water introduced into the area by the pipe break would be removed by the area dewatering system.

10.3.3 Nonmechanistic Failure of the Unit 2 Circulating Water Pipe

Potential hazards from the nonmechanistic failure of the circulating water discharge pipe near the diesel generator building were assessed by determining the time necessary for the rise in water lev to activate a permanent area dewatering well. It was determined that groundwater levels would be significantly below the critical elevation when the permanent area dewatering wells would be activated.

10.3.4 Nonmechanistic Failure of the 20-Inch Condensate Pipe

A nonmechanistic failure of the 20-inch diameter condensate water pipe, which is located directly beneath the diesel generator building, was analyzed. Using a simplified analysis, it was assumed that the entire contents of the condensate water tank (300,000 gallons) were spilled directly beneath the diesel generator building. Further, it was conservatively assumed that all the water would be contained beneath the building. From this analysis, it was determined that the groundwater elevation would not rise above elevation 610.

11.0 MONITORING SAFEGUARDS

Groundwater quality, pumping rates, drawdown levels, and hours of operation will be monitored frequently during the initial operating period so that a complete operating history of each well is established prior to plant operation. By comparision of the data collected, any decrease in production efficiency will be detected. The six basic causes of declines in production which result in groundwater level increases include: 1) inefficient pump operation due to worn, corroded or plugged parts; 2) defective or failed timers or high-level switches; 3) deposits of scale, corrosion and microorganisms on the well screen; 4) clogging of the well screen by clay, silt or fine sand; 5) pump motor burnout; and 6) failure or corrosion of discharge piping in well.

In order to assure that the gravel pack and screen are functioning properly, a monitoring program has been implemented to measure soil particle content in the discharge water during system operation. The estimated maximum permissible amount of soil particles that can be produced by any one well has been established as 10 ppm by weight. Normally, only sand-sized particles are measured in water (Reference 17). Sand is technically defined as any nonorganic solid material coarser than 0.06 mm. However, for conservatism, the NRC has requested that we monitor particle sizes larger than 0.005 mm which corresponds to fine silt-sized particles (Reference 18).

11.1 PLANT OPERATION

During plant operation, all monitoring procedures will be performed under a quality assurance program as operating technical specifications. When it is determined by analysis of available data that a well or group of wells is no longer functioning properly, appropriate remedial measures will be taken. These measures may include cleaning of the well screens, repair of replacement of screens or any mechanical parts, or installation of a new dewatering well, if necessary.

A complete set of replacement parts will be stored on site for any repair, replacement or installation which may be required. As a result of monitoring the well system, any significant rise in the groundwater level will be detected in sufficient time to take remedial actions before the critical groundwater elevation is reached.

During plant operation the permanent dewatering system will be monitored in accordance with operating technical specifications. The operating technical specifications cover groundwater level, soil particle, and chemical quality monitoring.

11.1.1 Groundwater Level Monitoring

The groundwater level monitoring program ensures that groundwater levels do not rise above elevation 610 at the diesel generator building or auxiliary building railroad bay. Groundwater levels in monitoring wells, selected area dewatering wells, and observation wells will be monitored monthly to verify groundwater level elevations. In addition to monthly readings, continuous water level records are maintained for monitoring wells by use of ultrasonic level transducers and strip chart recorders.

In the event of a groundwater level rise, measurements are increased to once weekly between elevation 595 (system operating level) and elevation 605 and daily above elevation 605. If a groundwater level rise continues, plant shutdown will be initiated at elevation 606.5. Based on the drawdown-recharge test, groundwater levels will take at least 8.5 days to rise from elevation 606.5 to elevation 610 (Figure 4). To bring the plant to a cold shutdown requires 36 hours; this allows 7 days to install offsite power to the plant.

11.1.2 Soil Particle Monitoring

The soil particle removal monitoring program ensures that a single dewatering will not produce more than 1 cubic yard (3,375 pounds) of soil particles over its operating life. Soil particles are defined herein as inorganic, nonmetallic particles greater than 0.005 mm in size and having a dry unit weight of 125 pounds per cubic foot.

Soil particle monitoring will be performed once a month for all producing dewatering wells. The soil particle monitoring activity involves taking a water sample from a well and filtering it through a filter medium having 0.005 mm openings. The filter medium is dried and weighed to determine the concentration of soil particles. The flowrate of each dewatering well is monitored once every 6 months. The monthly soil particle concentration and the last semiannual flow reading are used to determine the amount of soil particles removed over the month. This value is then added to the cumulative amount of soil particles removed from the well. In the unlikely event that a well produces 3,375 pounds (1 cubic yard) of soil particles the well will be grouted and a new well drilled.

11.1.3 Chemical Quality Monitoring

To prevent a decrease in dewatering efficiency due to incrustation of well screens, a groundwater quality monitoring program will be implemented.

Groundwater samples from the dewatering header lines will be taken annually. These samples will be analyzed to determine the concentrations of compounds associated with incrustation. The results of the analyses will be used to calculate Langelier and Ryzner Indexes (References 19 and 20). These indexes indicate whether or not an incrustation potential exists. If an incrustation potential exists in a group of wells, then these wells are cleaned with acid to remove any incrustation. This treatment is repeated once every 3 years for the life of the wells or until results of the chemical analyses indicate that an incrustation potential no longer exists.

12.0 CONCLUSION

The foregoing testimony describes, in detail, the design and construction of the permanent dewatering system for the Midland nuclear plant site. As previously stated, based on my knowledge and analysis of that design, as well as the construction methodology, I conclude that the dewatering system will provide an acceptable method of removing water from the granular plant fill material, thereby preventing liquefaction of soils beneath certain Seismic Category I structures at Midland plant in the event of a design basis earthquake.

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APPENDIX A

WILLIAM C. PARIS, JR. - EDUCATIONAL AND PROFESSIONAL RECORD

WILLIAM CHARLES PARIS, JR. ENGINEERING GEOLOGIST
GROUP SUPERVISOR

EDUCATION: B.A. Geology 1968
Bowling Green State University

REGISTRATIONS: Geologist, State of Maine 1974
Geologist, State of Georgia 1976

SUMMARY: 13 1/2 Years: Engineering geology applied to planning, design, construction and operation of engineered structures; supervising, conducting and interpreting results of exploration and testing programs for preparation of geotechnical reports for ground water development and control, tunnels, nuclear and fossil fueled power plants, pipelines, roads and other civil work projects and Safety Analysis Reports for nuclear power plant licensing.

EXPERIENCE: June 1979- Present: Geology group supervisor in the Bechtel Ann Arbor Office. Responsible for all geologic and geohydrologic studies. Specific duties include design, construction, and testing of a permanent dewatering system, ground water control for construction, design and construction of monitoring wells, subsidence studies, and preparation of the FSAR for the Midland Nuclear Plant. Other studies have included caisson inspection for Goodyear Aerospace, aquifer investigation for City of Boston, coal mine feasibility in Alaska, construction claims for Boston Redline Tunnel and geologic data reduction for planned nuclear power plant in Taiwan.

1975 - 1979: Project geologist in the Bechtel Gaithersburg Office for the Boston Redline Extension Tunnel. His responsibilities included supervision of subsurface investigations, office coordination, and preparation of geotechnical reports and specifications for design and construction of the rock tunnel portions of the project. As geotechnical coordinator for the additional facilities at the Dickerson Generating Station, responsible for investigation and evaluation of subsurface data, design of foundations on rock, and preparation of specifications and geologic reports. Also served as the resident field geologist at the Grand Gulf Nuclear Power Plant. Duties included geologically mapping foundations, providing geotechnical assistance during construction of the tie back walls, deep excavations, heavy haul road, radial collector wells, structural backfill operations, and preparation of the FSAR.

1968 - 1974: Previously employed as a geologist by consulting engineering companies in the Eastern United States. Work included investigation and development of ground water resources for municipal water systems; evaluation of geologic conditions for dams, tunnels, pipelines, highways and bridge foundations; conducting studies for regional solid waste disposal; foundation design for buildings; preparation of geotechnical reports and project siting and feasibility determinations.

ORGANIZATIONS: Association of Engineering Geologists

Geological Society of America

American Society of Civil Engineers

National Water Well Association

International Association of Engineering Geologists

NATIONAL POSITIONS: President, Association of Engineering Geologists 1981-82.

Member of Governing Board, American Geological Institute, 1981-82.

U.S. National Committee of International Association of Engineering Geologists

ACHIEVEMENTS: Who's Who in Technology Today, Volume 4, Third Edition, 1982

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"Suggested Method for Determining Rock-Loads for Moderately Sized, Shallow-Depth Rock Tunnels," William C. Paris, Jr., presented at Geotechnology in Massachusetts Conference, Boston, Massachusetts, March 1980.

10/82

APPENDIX B

DETAILED ANALYSIS OF AREAS OF RECHARGE

APPENDIX B

DETAILED ANALYSIS OF AREAS OF RECHARGE

The following is a detailed analysis of data and test results in support of the conclusion that recharge occurs primarily around the service water pump/circulating water intake structure areas rather than in the area south of the diesel generator building.

The backfill materials south of the diesel generator building consist predominantly of clay (FSAR Figure 2.4-53). Backfill sand is present only adjacent to the circulating water discharge lines and is a possible recharge route from the cooling pond. However, where the discharge lines terminate at the cooling pond, concrete facing covers the sand backfill, thereby preventing hydraulic connection with the cooling pond. Examination of the relationship of the natural sands to the cooling pond shows that the natural sands do not extend to the cooling pond in this area (FSAR Figure 2.4-53).

Examination of the time drawdown graphs for observation wells PD-3 and PD-5 (Figures 24-14 and 47-5), during the PD-20 pumping test show that significant drawdown occurred in these wells. These observation wells are much closer to the cooling pond than to the pumping wells as shown in FSAR Figure 2.4-42. If recharge from the cooling pond had occurred, there would have been no drawdown or the drawdown would have stabilized rapidly. Further, the static water levels in these observation wells were below the cooling pond level prior to and after the pumping test.

A second test performed in test well PD-20 between October 2 and November 13, 1980, substantiated the findings of the first pumping test. During this test, water levels south of the diesel generator building were lowered over 4 feet with a constant pumping rate of only 2.4 gpm (FSAR Figures 2.4-43 and 2.4-44).

Review of the data from another pumping test, PD-5C, indicates that if recharge from the cooling pond had occurred south of the diesel generator building, the drawdown determined for observation well PD-5B would be less than the drawdowns determined from observation wells PD-6, PD-3 and PD-20B (Figures 5 and 6). That is not the case. The relative differences in drawdown between these wells is significant when taking into account the proximity of the cooling pond and the pumping rate (0.83 gpm). The lack of hydraulic connection is also suggested by the imcomplete recovery of the static water level following the completion of the PD-5C pumping test. The time drawdown graph for observation well PD-5 during the PD-5C pumping test is shown in Figure 47-10.

Permeability measurements also support the conclusion that clay soils in the area south of the diesel generator building are an effective barrier to water flow. The results of the PD-5C pumping test indicate that the adjacent natural and backfill sands have an average permeability of 1,400 ft/yr (FSAR Table 2.4-11B). Falling head permeability tests in the natural and backfill sands as shown in FSAR Table 2.4-11A indicate an average permeability of 1,275 ft/yr. In contrast, the falling head permeability tests in the backfill and natural clays indicate an average permeability of 15 ft/yr. Therefore, the natural and backfill clays are over 85 times less permeable than the natural and backfill sands.

The second area of potential recharge, around the service water pump and circulating water intake structures, is underlain by natural sand. The cantilevered portion of the service water pump structure and the areas behind the retaining walls are backfilled primarily with sand. These backfill sands were designed to be in hydraulic contact with the cooling pond to protect the stability of the retaining wall. Based on exploration and testing programs, the spatial distribution of natural and backfill sands around the circulating water intake and service water pump structures indicate that this is the area of recharge.

Examination of time drawdown data from observation wells measured during the PD-15A pumping test indicates the area of influence for that test was asymmetrical. This may be observed by comparing drawdowns in wells SW-1 and AX-12 (Figures 7 and 8).

At 8,550 minutes after the start of pumping AX-12, located 247 feet northwest of the pumping well, had a drawdown of 3.52 feet, while SW-1, located 172 feet south of the pumping well, had a drawdown of 0.85 feet (FSAR Figure 2.4-42). The observation wells south of the pumping well had less drawdown per unit distance from the pumping well than the observation wells north of the pumping well. The asymmetrical area of influence with a steeper gradient toward the pond is indicative of recharge from the cooling pond in the area of the circulating water and service water pump structures.

The response of observation wells south of the diesel generator building and near the service water pump and circulating water intake structures to raising and lowering of the cooling pond level supports the above conclusions. The response to lowering the level of the cooling pond in December of 1979 throughout the plant area can be viewed by comparing FSAR Figures 2.4-40 and 2.4-59. FSAR Figure 2.4-40 shows that south of the diesel generator building groundwater levels were a minimum of one foot below the cooling pond level prior to lowering of the pond level. Groundwater levels south of the diesel generator building were a minimum of one foot above the cooling pond a month and a half after the pond was lowered four feet, showing a lack of response to changes in pond levels (FSAR Figure 2.4-59).

Another specific comparision between the area south of the diesel generator building and the area around the service water pump and circulating water intake structures can be made by examining the hydrographs of observation wells PD-3, PD-9 and PD-16, during the cooling pond lowering (Figure 47-6). The water levels in observation well PD-9, located in the vicinity of the cirulating water intake structure, responded closely to the variations of the level of the cooling pond. In contrast, water levels in observation wells PD-3 and PD-16, located south of the diesel generator building, remained above the level of the cooling pond for several months. The lag in response of these two observation wells to cooling pond lowering further indicates lack of direct hydraulic connection with the cooling pond in this area.

The cooling pond level was raised in January 1981. The hydrographs from observation wells around the site for that period are presented in Reference 16. The observation wells in the circulating water intake and service water pump structures area responded to changes in the cooling pond level much more rapidly than the observation wells south of the diesel generator building (Figures 9 and 10). The rapid response at the service water pump and circulating water intake structures indicates a direct hydraulic connection with the cooling pond, while the slow response south of the diesel generator building indicates an indirect hydraulic connection with the cooling pond. This effect is further demonstrated by the drawdown obtained during the construction dewatering and the response resulting from the recharge test (Appendixes C and D).

APPENDIX C

RESULTS OF CONSTRUCTION DEWATERING

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RESULTS OF CONSTRUCTION DEWATERING

The temporary construction dewatering system was installed by a dewatering subcontractor between August and October 1979 to dewater the feedwater valve pit and the electrical penetration wings of the auxiliary building before underpinning. Subsequently, additional dewatering wells were installed to dewater for repair of a ductbank and for installation of metering pits on the service water lines (FSAR Figure 2.4-45). The data obtained from the operation of the construction dewatering system were used to verify the design of the permanent dewatering system including estimated flowrates, degree of hydraulic continuity between backfill and Unit c sands, zones of recharge, rates of drawdown, soil particle monitoring criteria, and areas of influence. The operation of the temporary construction dewatering system was also used to aid in lowering site groundwater levels prior to the recharge test (Appendix D).

The construction dewatering system is composed of five subsystems. These subsystems are defined by 100, 200, TEW, 300, and 400 series dewatering wells. The dewatering subcontractor also installed the LOW Series of observation wells. Locations of these five dewatering subsystems and subcontractor installed observation wells are shown in FSAR Figure 2.4-45. The wells are typically 2, 3, and 6 inch size. Typical sections of the construction dewatering wells are presented in FSAR Figure 2.4-51.

Groundwater levels were measured at selected observation wells for several months prior to any dewatering (Reference 16). In November 1979, the groundwater levels around the plant site were between elevations 620 and 627 (FSAR Figure 2.4-40). The cooling pond at that time was elevation 627. In December 1979, the cooling pond was lowered 4 to elevation 623. As a result of lowering the cooling pond level, the groundwater levels declined in the plant area to between elevations 618 and 624 as shown in FSAR Figure 2.5-59.

During 1980 and 1981, each construction dewatering subsystem was activated separately so that the effects of dewatering on the site groundwater levels could be evaluated. The staging of the operation of each construction dewatering subsystem is shown in FSAR Figure 2.4-57. The impact of pumping from the various dewatering subsystems on the site groundwater levels is presented on hydrographs (Reference 16).

As each subsystem was made operational, groundwater levels throughout the plant responded, indicating hydraulic connection between materials. The flowrates of the various subsystems were also monitored and these results are shown in FSAR Figures 2.4-50, 2.4-52, and 2.4-63. The flowrates indicate the the quantity of water entering the plant fill is moderate and can be controlled by a conventional well system. During operation of the construction dewatering system, individual dewatering wells were sampled for chemical analyses. These chemical analyses were used to evaluate the effects of the groundwater chemistry on the permanent wells and associated piping (Section 6.2.4). Soil particle monitoring was also conducted during operation of the construction dewatering wells. During operation, biweekly sampling was performed on the system overflow and monthly sampling was performed on the individual well discharge lines. The soil particle samples were tested using a 0.05 mm (50 micron) filter medium. Throughout the system operation, the soil particle results remained below the maximum 10 ppm by weight of soil particles.

APPENDIX D

DETAILS OF DRAWDOWN-RECHARGE TEST

APPENDIX D

DETAILS OF DRAWDOWN-RECHARGE TEST

Drawdown

The drawdown test began on November 20, 1981 and continued until February 4, 1982.

The purpose of the test was to lower the site groundwater level to as close to the design operation level (elevation 595) as practical prior to conducting the recharge test. The site groundwater levels prior to the drawdown test are shown in Figure 1. The test was performed using only the 20 permanent backup dewatering wells, the existing Unit 1 (100 Series) and Unit 2 (200 Series) construction dewatering wells, selected individual observation wells equipped with self-contained eductors, and temporary dewatering wells (DD Series). The locations of these wells are shown in FSAR Figure 2.4-56.

After the permanent backup wells were drilled and installed as described in Section 7.0, temporary pump units were installed for the drawdown test. Submersible and eductor type pumps were used. Submersibles were installed in wells F-1 through F-4A, G-1 through G-6, G-8, G-9, and H-1. The remaining wells, F-5 through F-7, G-7, and H-2 through H-4, were equipped with eductors.

The construction dewatering wells, selected individual observation wells and temporary wells utilized were 2-inch, 3-inch, and 6-inch sizes as shown in FSAR Figure 2.4-56.

Additional temporary dewatering wells DD-1 through DD-5 were installed between December 22, 1981, and January 4, 1982, to replace selected individual observation wells PD-5C, PD-20, COE-13A, COE-12A, and A-45. The DD Series wells were installed with eductors and submersible pumps. These wells provided more pumping capacity than the selected individual observation wells, and accelerated the rate of drawdown in the diesel generator building area. The length of time each well was pumped is shown in FSAR Figure 2.4-57.

Monitoring

Flow rates were monitored at each discharge location shown in FSAR Figure 2.4-56. The flow rates of the construction dewatering wells (100 and 200 Series) and 20 permanent backup wells are shown in FSAR Figures 2.4-52, 2.4-63, 2.4-64, and 2.4-65, respectively.

Groundwater levels were monitored by Bechtel Geotechnical Personnel at the observation well locations shown in Figure 11. The level of the cooling pond was recorded each time the observation wells were measured, unless the pond was frozen. A groundwater contour map at the start of the drawdown test is shown in Figure 1. The rate of groundwater level decline at each observation well was plotted on a hydrograph (Reference 16).

The drawdown test was terminated on February 4, 1982, when the groundwater level had been lowered to elevation 595 or as low as practical throughout the plant site. The only levels above elevation 595 were at fringe areas of the site (PD-3, PD-5, T-27, PD-24, PD-42, PD-39 and at observation wells COE-10 and WB-1 located along the north side of the diesel generator building (FSAR Figure 2.4-58).

Recharge Test

The recharge test commenced on February 4, 1982, and was conducted for a period of 60 days.

The objective of the recharge test was two-fold; first, to substantiate that the analytical model used to determine the rise of groundwater level is appropriate (Section 6.0); and second, to establish that sufficient time is available for repair of the permanent dewatering system before the groundwater levels rise above the design operating level (elevation 595) at the diesel generator building and auxiliary building train bay to elevation 610. Elevation 610 has been established as the groundwater level at which liquefaction could occur under the diesel generator building and auxiliary building railroad bay if a design basis earthquake were to occur (Dr. Woods' testimony).

Groundwater levels were monitored under a Quality Control Program by Bechtel Geotechnical personnel at the observation well locations shown in Figure 10. The level of the cooling pond was recorded each time the observation wells were measured, unless the cooling pond was frozen. The cooling pond level was at elevation 627 (operating level) or above. The level in the Tittabawassee River fluctuated between elevation 590 and elevation 593. The rate of groundwater level rise at each observation well was plotted on a hydrograph (Reference 16). The groundwater level at completion of the recharge test is shown in Figure 2.

The locations of the monitored observation wells at the critical structures are shown in Figure 12 and the responses are shown in Figure 3. The response of observation wells in the diesel generator building area is representative of the recharge rate from the cooling pond in the event of a complete well shutdown. However, in the auxiliary building railroad bay area, a high-pressure construction water line was broken between March 11 and March 17, 1982, which resulted in flooding of the railroad bay floor including observation well AX-2. Therefore, the water level indicated in AX-2 on March 15, 1982, does not represent a true groundwater level within the backfill. As can be seen in Figure 3, the water level began dropping prior to the water line being shut off. Observed water level readings for observation wells AX-13A, CH-9A and T-21A also may have been influenced by the broken water line. Nevertheless, there is still considerably more than 60 days recharge time available at the auxiliary building railroad bay area based on groundwater level obtained during the drawdown portion of the test, and at least 40 days recharge time from elevation 595.

Evaluation of the data from the full scale recharge test indicates the following:

a. A permanent dewatering system can lower groundwater levels below elevation 610 at the two critical structures.

b. From elevation 595 (design operating level), a minimum of 40 days is available for maintenance, repair or replacement of the system before groundwater levels at the two critical structures exceed elevation 610 prior to the SSE. Under normal operating conditions it is expected that the groundwater levels will be maintained somewhat below elevation 595, which will provide greater than 40 days recharge time.

TABLE 1

PERMANENT DEWATERING AND MONITORING WELL SCHEDULE[2]

Well Number	Elevation of Top of Gravel Pack	Elevation of Top of Well Screen	Elevation of Bottom of Well Screen	Elevation of Bottom of Gravel Pack	Well Type[1]
A-1	607.7	600.0	591.5	576.2	A
A-2	610.7	605.2	590.2	578.8	A
A-3	609.2	602.9	587.9	577.9	A
A-4	610.0	603.7	594.7	579.1	A
A-5	604.7	599.9	576.8	570.2	A
B-1	608.0	602.3	588.8	578.4	A
B-2	608.7	601.6	590.4	587.7	A
B-3	608.5	595.5	586.6	571.5	A
B-4	605.5	600.0	581.0	570.8	A
B-5	610.7	601.0	585.0	573.7	A
C-1	608.4	601.9	582.8	576.5	I
C-2	609.0	601.8	588.7	574.7	I
C-3	607.8	601.4	585.8	574.8	I
C-4	608.8	604.2	589.1	580.9	I
D-1	610.4	586.8	565.1	559.3	I
D-2	604.1	588.3	565.0	559.9	I
D-3	603.5	592.0	563.4	558.4	I
D-4	604.5	589.2	565.1	559.5	I
D-5	606.5	588.4	573.3	565.0	I
D-6	606.2	586.0	578.0	570.1	I
D-7	611.2	593.8	578.8	571.6	I
E-1	613.3	595.4	576.1	565.9	I
E-2	607.7	591.4	576.4	569.1	I
E-3	606.2	593.1	576.1	571.1	I
E-4A	607.6	597.2	572.3	560.2	I
E-5	609.4	598.8	569.5	560.8	I
E-6	609.8	596.4	572.3	565.0	I
E-7	611.7	595.4	586.4	579.0	I
E-8A	605.8	593.7	581.2	570.2	I
E-9	607.5	596.5	577.5	567.5	I
F-1	610.2	584.4	565.2	560.2	B
F-2	608.8	590.3	565.3	559.4	B
F-3	610.1	592.3	565.0	560.0	B
F-4A	607.6	589.2	564.8	558.8	B
F-5	608.0	588.4	571.4	565.5	B
F-6	608.9	585.6	578.5	573.5	B
F-7	605.9	594.1	579.3	570.8	B

TABLE 1 (Continued)

Well Number	Elevation of Top of Gravel Pack	Elevation of Top of Well Screen	Elevation of Bottom of Well Screen	Elevation of Bottom of Gravel Pack	Well Type[1]
G-1	611.5	600.2	578.1	572.7	B
G-2	610.3	591.5	574.4	569.3	B
G-3	607.6	592.5	577.4	572.2	B
G-4	611.4	601.1	573.7	563.3	B
G-5	605.6	602.4	568.7	563.7	B
G-6	609.6	596.8	571.8	566.5	B
G-7	608.9	597.0	587.9	576.1	B
G-8	610.1	590.4	581.5	574.5	B
G-9	608.1	596.2	574.0	568.8	B
H-1	607.9	601.6	583.1	576.2	B
H-2	608.9	603.9	587.9	580.6	B
H-3	610.8	603.9	594.9	584.9	B
H-4	610.0	604.1	597.4	581.1	B
J-1	609.3	599.2	586.2	573.1	A
J-2	605.9	590.6	574.6	567.6	A
J-3	608.6	599.6	573.6	568.8	A
M-1	609.1	594.8	569.1	564.0	A
M-2	606.9	572.4	553.2	549.1	A
M-3	607.0	579.0	570.1	565.1	A
M-4A	611.2	594.8	573.3	568.3	A
M-5	603.3	596.5	571.9	566.9	A
N-1	603.6	590.6	583.0	582.0	A
N-2A	604.3	596.4	573.4	564.2	
N-3	609.7	592.4	573.3	567.3	A
N-4	609.8	597.9	572.9	566.2	A
N-5A	614.0	596.1	573.1	563.9	A
N-6	605.7	589.0	566.4	561.4	A

TABLE 1 (Continued)

Well Number	Elevation of Top of Gravel Pack	Elevation of Top of Well Screen	Elevation of Bottom of Well Screen	Elevation of Bottom of Gravel Pack	Well Type[1]
OBS-1	613.0	604.0	599.0	579.4	M
OBS-1A	609.0	601.9	593.7	578.4	M
OBS-2	613.4	602.0	590.0	578.7	M
OBS-3	608.4	596.0	569.7	563.1	M
OBS-4[3]	607.0	602.0	588.0	578.0	M
OBS-5	602.5	590.8	582.0	581.0	M
OBS-6	609.6	596.5	577.4	570.2	M

[1] Well types:

A - Area well
B - Backup interceptor well
I - Interceptor well
M - Monitoring well

[2] Elevations in feet above sea level

[3] Design elevations (not yet installed)

TABLE 2.4-11A

FALLING HEAD PERMEABILITY TEST SUMMARY

Boring	Depth (ft)	Coordinates	Permeability (ft/yr)	Material
Lacustrine sand (Unit c)				
PD-3	34.0	S5337.5 E185	819	Sand
PD-4	33.5	S5335 E250	883	Sand
PD-5	35.0	S5336 E315	4,397	Sand
PD-5	36.5	S5336 E315	22.7	Sand
PD-9	36.5	S5260 E600	698	Sand
PD-15	41.5	S4870 E699	14.6	Sand
PD-16	36.0	S5145.3 E230	57,0	Sand
PD-17	34.0	S5266.5 E202	4,229	Sand
PD-18	34.0	S5110 E570	730	Sand
PD-20A	37.5	S5194.2 E343.8	816	Sand
PD-21	36.5	S4970 E630	552	Sand
PD-22	36.5	S4920 E755	1,960	Sand
PD-22	63.0	S4920 E755	98.0	Sand
PD-23	32.8	S4845 E580	300	Sand
PD-25	55.5	S4640 E560	33.0	Sand
PD-26	54.0	S4765 E715	450	Sand
PD-28	48.5	S4605 E515	1,807	Sand
PD-28	71.5	S4605 E515	370	Sand
PD-29	42.5	S4695 E690	403	Sand
PD-29	81.5	S4695 E690	22.0	Sand
PD-30	46.5	S4775 E800	26.0	Sand

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Table 2.4-11A (continued)

Boring	Depth (ft)	Coordinates	Permeability (ft/yr)	Material
PD-31	41.5	S4850 E810	1,730	Sand
PD-32	41.5	S4930 E795	1,608	Sand
PD-32	67.5	S4930 E795	42.0	Sand
PD-33	46.5	S4846 W96	24.0	Sand
PD-34	41.5	S4918 W101	384	Sand
PD-35	41.5	S4884 W126	214	Sand
PD-38	41.5	S5108 E630	283	Sand
PD-38	55.5	S5108 E630	331	Sand
PD-42	46.5	S4695 E800	1,947	Silty sand
Lacustrine clay (Unit d)				
PD-2	29.3	S5335 E110	6.9	Silty clay
PD-12	40.0	S5195 E50	21.0	Silty clay
PD-17	56.5	S5266.5 E202	0.5	Silty clay
PD-19	51.5	S5192 E159	51.0	Silty clay
PD-21	79.0	S4970 E630	1.6	Silty clay
PD-24	40.0	S4550 E420	1.9	Silty clay
PD-25	97.5	S4640 E560	8.5	Silty clay
PD-26	100.0	S4765 E715	<0.5	Silty clay
PD-28	96.5	S4605 E515	<0.4	Silty clay
PD-30	56.5	S4775 E800	12.0	Silty clay

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Table 2.4-11A (continued)

Boring	Depth (ft)	Coordinates	Permeability (ft/yr)	Material	
PD-32	101.5	S4930 E795	<0.5	Silty clay	
Till (Units b and e)					
PD-14	36.5	S4980	21.2	Sandy clay	
PD-26	44.0	S4765 E715	2.6	Silty clay	
PD-27	41.5	S5008.75 E751.50	<0.6	Silty sand	
Sand backfill					
PD-3	21.5	S5337.5 E185	13,345	Sand	
PD-19	21.5	S5192 E159	476	Sand	
PD-20A	12.2	S5194.2 E343.8	8,998	Sand	
PD-20A	22.5	S5194.2 E343.8	970	Sand	44
PD-27	16.5	S5008.75 E751.5	331	Sand	
PD-33	31.5	S4846 W96	137	Sand	
PD-37	41.5	S5015 E804	897	Sand	
Clay backfill					
PD-5	16.5	S5336 E315	1.4	Silty clay	
PD-8A	21.5	S5335 E515	25.0	Silty clay	
PD-12	20.1	S5195 E50	0.2	Silty clay	
PD-13	19.0	S5098 E497	1.5	Silty clay	
PD-14	24.0	S4980 E960	2.1	Silty clay	
PD-15	18.5	S4870 E699	4.1	Silty clay	
PD-16	19.0	S5145.3 E230	21.0	Silty clay	

Table 2.4-11A (continued)

Boring	Depth (ft)	Coordinates	Permeability (ft/yr)	Material	
PD-17	16.5	S5266.5 E202	0.6	Silty clay	
PD-18	21.5	S5110 E570	0.8	Silty clay	
PD-19	51.5	S5192 E159	51.0	Silty clay	
PD-21	21.5	S4970 E630	7.1	Silty clay	
PD-22	19.0	S4920 E755	2.0	Silty clay	
PD-23	20.0	S4845 E580	17.0	Silty clay	44
PD-24	40.0	S4550 E420	<1.0	Silty clay	
PD-25	20.5	S4640 E560	120	Silty clay	
PD-26	19.0	S4765 E715	3.4	Silty clay	
PD-27	26.5	S5008.75 E751.50	27.0	Silty clay	
PD-29	21.5	S4695 E690	<0.5	Silty clay	

TABLE 2.4-11P

SUMMARY OF PUMPING TESTS

Observation Well	Material Tested	Sand Thickness Tested (ft)	Distance to Pumping Well (ft)	Drawdown at End of Pumping Period (ft)	Monitored[1] Interval (elevation in ft)	Transmissivity (ft^2/d) Drawdown[2]	Transmissivity (ft^2/d) Recovery[3]	Permeability (ft/year)
Well TW-1 pumped at 9 gpm for 230 min								
TW-1	Backfill sand	6.0	0.16[4]	19.67	585-595	28	50	1,825
OW-1	Backfill sand	13.4	7.0	7.77	578-603	65	50	1,460
OW-3	Backfill sand	6.5	2.0	11.33	583-603	56	50	3,285
AX-11	Backfill sand	10.0	15.0	6.00	575-611	71	50	2,555
OW-4	Backfill sand	11.7	2.0	0.58	609-633	[5]	[5]	[5]
(OW-1, OW-3, AX-11)						99[6]		
Well TW-2 pumped at 9 gpm for 301 min								
TW-2	Backfill sand	10.0	0.08[4]	[7]	609-614	[7]	[7]	[7]
OW-4	Backfill sand	11.7	5.1	3.08	609-633	159	258	6,570
TW-1	Backfill sand	6.0	3.77	0.60	582-598	[5]	[5]	[5]
TW-3	Backfill sand	7.0	2.34	0.69	587-634	[5]	[5]	[5]
AX-11	Backfill sand	10.0	17.2	0.56	575-611	[5]	[5]	[5]
OW-1	Backfill sand	13.4	10.2	0.70	578-603	[5]	[5]	[5]
OW-3	Backfill sand	6.5	3.1	0.77	583-603	[5]	[5]	[5]
Well TW-3 pumped at 6.5 gpm for 320 min								
TW-3	Backfill sand	7.0	0.08[4]	[7]	587-592	[7]	[7]	[7]
OW-3	Backfill sand	6.5	0.75	9.50	583-603	56	54	2,920
TW-1	Backfill sand	6.0	2.32	9.36	582-598	55	54	3,285
OW-1	Backfill sand	13.4	7.00	6.41	578-603	64	54	1,460
AX-11	Backfill sand	10.0	16.00	4.63	575-611	70	54	2,190
TW-2	Backfill sand	10.1	2.34	0.58	609-634	[5]	[5]	[5]
OW-4	Backfill sand	11.7	2.70	0.82	609-633	[5]	[5]	[5]
OW-2	Backfill sand	1.5	7.80	0.54	608-632	[5]	[5]	[5]

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TABLE 2.4-11B (continued)

Observation Well	Material Tested	Sand Thickness Tested (ft)	Distance to Pumping Well (ft)	Drawdown at End of Pumping Period (ft)	Monitored[1] Interval (elevation in ft)	Transmissivity (ft^2/d) Drawdown[2]	Transmissivity (ft^2/d) Recovery[3]	Permeability (ft/year)
Well TW-4 pumped at 10 gpm for 520 min								
TW-4	Backfill sand Natural sand	10.0	0.08[4]	[7]	579-634	[7]	[7]	[7]
AX-12	Backfill sand Unit C sand	27.0[8]	5.00	1.91	582-624	239[9]	330	5,110
OW-5	Backfill sand	12.0	8.83	0.97	609-634	[5]	[5]	[5]
TW-5	Backfill sand	12.0	7.20	1.02	611-634	[5]	[5]	[5]
Well TW-5 pumped at 11 gpm for 321 min								
TW-5	Backfill sand	12.0	0.08[4]	[7]	611-616	[7]	[7]	[7]
OW-5	Backfill sand	12.0	2.55	3.63	609-634	441	299	11,315
TW-4	Backfill sand Unit C sand	10.0	7.20	0.90	579-634	[5]	[5]	[5]
AX-12	Backfill sand Unit C sand	27.0[8]	4.89	1.60	582-624	[5]	[5]	[5]
Well PD-5C pumped at 0.83 gpm for 4,959 min **Note: (fluctuations in pumping rate)**								
PD-5C	Unit C sand	11.2	0.16[4]	15.88	593-603	[10]	[10]	[10]
PD-5D	Unit C sand	10.0	5.00	1.18	590-603	[10]	29	1,095
PD-5	Unit C sand	11.0	7.60	0.96	592-602	[10]	[10]	[10]
PD-3	Unit C sand	22.5	109.2	0.49	591-602	84	[10]	1,460
PD-20A	Unit C sand	20.0	147.3	0.29	590-614	[10]	[10]	[10]
PD-6	Backfill sand	2.0	86.4	0.55	592-614	84	[10]	[10]
PD-20B	Backfill sand	20.0	144.8	0.47	600-629	84	[10]	1,460
PD-5B	Backfill sand	2.5	35.6	0.54	587-604	93	[10]	[10]
(PD-5D, PD-5, PD-3, PD-20A)						102[6]		

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TABLE 2.4-11B (continued)

Observation Well	Material Tested	Sand Thickness Tested (ft)	Distance to Pumping Well (ft)	Drawdown at End of Pumping Period (ft)	Monitored[1] Interval (elevation in ft)	Transmissivity (ft^2/d) Drawdown[2]	Transmissivity (ft^2/d) Recovery[3]	Permeability (ft/year)
Well PD-20 pumped at 7 gpm for 4,495 min Note: (response at PD-20, A, B, and C probably affected by partial penetration effects)								
PD-20	Unit C and backfill sand	19.0	0.16[4]	13.65	600-605		202	4,015
PD-20B	Unit C and backfill sand	20.0	3.5	2.93	600-629	229	260	4,380
PD-20C	Unit C and backfill sand	28.0	9.56	0.48	596-628	252	433	4,015
PD-20A	Unit C and backfill sand	20.0	4.6	2.91	590-614	145	187	2,920
PD-3	Unit C sand	22.5	210.0	1.31	591-602	263	101	2,920
PD-5	Unit C sand	11.0	140.0	2.01	592-602	154	206	5,840
W-2	Unit C sand	4.0[11]	283.0	No response	601-634			
CL-1	Unit C sand	4.0[11]	250.0	No response	598-634			
Well PD-20 pumped for 7 gpm for 4,495 min								
PZ-33	Backfill sand	[11]	82.0	No response	618-622			
PZ-30	Backfill sand	[11]	193.0	0.67	600-605	[10]	[10]	[10]
PZ-18	Clay backfill	[11]	214.0	No response	611-613			
PZ-2	[11]	[11]	108.0	1.44	603-608	[10]	[10]	[10]
Well PD-15A pumped at 12.5 gpm for 8,610 min								
PD-15A	Unit C sand	40.0	0.16[4]	11.33	564-579		180	1,460
PD-15	Unit C sand	36.5	11.0	6.52	553-598	1,103	173	6,205
LOW-10	Unit C sand	40.0	140.0	5.04	590-598	384	245	2,420
PD-15C	Backfill clay	NA	15.0	No response	610-615			
PD-15B	Unit C sand	40.0	18.0	5.08	564-604	679	221	4,015

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TABLE 2.4-11B (continued)

Observation Well	Material Tested	Sand Thickness Tested (ft)	Distance to Pumping Well (ft)	Drawdown at End of Pumping Period (ft)	Monitored[1] Interval (elevation in ft)	Transmissivity (ft^2/d) Drawdown[2]	Transmissivity (ft^2/d) Recovery[3]	Permeability (ft/year)
Note: (boundary effect preclude analysis of following wells)								
AX-12	Backfill and Unit C sand	27.0[8]	247.0	3.52	582-624			
Q-1	Unit C sand	40.0[8]	163.0	4.18	595-634			
SW-4	Backfill clay	NA	139.0	0.66	596-616			
SW-1	Backfill sand	19.0	172.0	0.85	608-633			
PD-20A	Unit C and backfill sand	6.0 14.0	583.0	0.56	590-614			
PD-20B	Backfill sand	20.0	581.0	0.40	600-629			
OW-3	Backfill sand	6.5	615.0	0.42	583-603			

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[1] Monitored intervals: screened interval of pumping well or interval between bottom of hole and observation well/piezometer seal
[2] Jacob modified nonequilibrium time drawdown method
[3] Jacob modified nonequilibrium residual drawdown method
[4] Pumping well radius
[5] Completed in different sand interval than pumping well; drawdown used to evaluate interconnections to sands
[6] Jacob modified nonequilibrium distance drawdown method
[7] No access to measure drawdown
[8] Unit C sands not completely penetrated
[9] The nonequilibrium time drawdown method
[10] Not determined: insufficient drawdown or complex response
[11] Observation well/piezometer record incomplete

TABLE 2.4-12B

CHEMICAL ANALYSES OF GROUNDWATER SAMPLES FROM PUMPING TESTS

(Constituents in ppm Except Where Noted)

Well No.	pH (pH Units)	Ca	Mg	Na	Alk'y	Hard-ness	HCO_3	SO_4	Cl	Fe	Turbidity	Date Sampled
TW-2[1]	7.4	212	49[2]	160	260	730	317[2]	380	300	0.4	3.2 Ntu	06/19/79
TW-3[1]	7.2	212	49[2]	150	250	730	305[2]	340	320	12.0	5.3 Ntu	06/18/79
TW-4[1]	7.3	220	58[2]	140	220	790	268[2]	405	320	0.3	2.2 Ntu	06/14/79
TW-5[1]	7.1	276	46[2]	28	305	880	372[2]	535	300	3.6	3.4 Ntu	06/12/79
PD-20[3]	7.2	65.6[2]	94[2]	115	342	553	417[2]	440	227	6.3	22.0 Ftu	11/26/79
PD-5C[3]	7.[illegible]	72.4[2]	69[2]	40	278	464	339[2]	140	136	0.1	0.8 Ftu	11/26/79
PD-15A[3]	7.1	167	34[2]	78	69	512	84[2]	160	114	0.2	16.0 Ftu	12/06/79

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[1] Analyses performed by Midland Water Department
[2] Calculated values
[3] Analyses performed by Consumers Power Company

TABLE 2.4-12C

CHEMICAL ANALYSIS OF GROUNDWATER SAMPLES FROM CONSTRUCTION DEWATERING WELLS[1] (CONSTITUENTS IN PPM, EXCEPT WHERE NOTED)

Well No.	pH (pH Units)	Ca	Mg	Na	Alk'y	Hardness	HCO_3[2]	SO_4	Cl	Fe (Total)	Fe (Dissolved)	Turbidity	Date Sampled	Langlier Index[2]	Ryznar Index[2]
223A	7.2	280	56.0	166.0	277	929[2]	337	400.0	300	3.48	<0.10	-	03/05/80	0.06	7.08
213A	7.0	679	99.0	271.0	330	2,102[2]	402	510.0	480	0.32	<0.10	-	03/05/80	-	-
111	7.2	286	57.0	231.0	240	949[2]	293	410.0	400	2.1	<0.10	-	03/05/80	-0.04	7.28
330	7.7	112[2]	7.3[2]	58.0	169	310	206	-	110	6.0	1.43	6.0	06/26/80	0.525	-
301	7.8	110[2]	8.7[2]	52.0	162	312	197	-	102	0.32	0.38	3.0	06/26/80	0.457	-
307	7.7	124[2]	13.0[2]	54.0	172	364	210	-	90	0.76	0.65	3.0	06/26/80	0.506	-
315	7.7	121[2]	9.7[2]	55.0	164	342	200	-	118	0.42	0.49	2.0	06/26/80	0.497	-
408	7.6	120[2]	12.0[2]	55.0	169	350	206	-	110	0.71	0.67	4.0	06/26/80	0.455	-
448	7.5	106[2]	11.0[2]	48.0	157	310	191	-	102	0.42	0.39	1.0	06/26/80	0.209	-
448	7.1	144[2]	12.0[2]	69.0	169	410	207	-	137	0.70	0.62	3.0	06/26/80	-0.015	-
422	7.3	125[2]	2.4[2]	55.0	165	322	201	-	110	0.25	0.25	2.0	06/26/80	0.128	-
202	7.7	144[2]	41.0[2]	93.0	234	528	285	-	236	0.31	<0.1	2.2 FTU	10/02/80	0.58	6.54
212A	7.7	147[2]	37.0[2]	81.0	237	522	289	-	196	0.34	<0.1	1.6 FTU	10/02/80	0.59	6.51
225B	7.5	156[2]	29.0[2]	78.0	223	508	272	-	192	0.32	<0.1	2.1 FTU	10/02/80	-	-
301	7.2	116[2]	27.0[2]	24.2	179	402	218	-	132	<0.1	<0.1	1.0 NTU	01/06/81	-0.34	7.88
332	7.4	102[2]	27.0[2]	21.0	172	366	210	-	160	<0.1	<0.1	1.0 NTU	01/06/81	-0.21	7.82
438	7.6	126[2]	33.0[2]	63.3	192	450	234	-	140	0.15	<0.1	1.5 NTU	01/06/81	0.13	7.35
422	7.4	123[2]	33.0[2]	68.7	196	444	239	-	120	0.38	0.11	2.0 NTU	01/06/81	-0.07	7.55
202	7.7	132[2]	33.0[2]	68.3	200	466	244	-	200	0.14	<0.1	1.5 NTU	01/06/81	0.26	7.18
225B	7.7	97[2]	48.0[2]	64.1	199	438	243	-	180	0.10	<0.1	1.5 NTU	01/06/81	0.13	7.45
117	7.5	125[2]	32.0[2]	66.0	195	442	238	-	120	0.11	<0.1	1.5 NTU	01/06/81	0.03	7.45
103A	7.7	126[2]	33.0[2]	67.0	197	450	240	-	140	<0.1	<0.1	1.5 NTU	01/06/81	0.23	[illegible]
103A	7.6	104[2]	17.0[2]	39.4	174	332	212	127.2	115	0.39	0.27	1.0 NTU	08/05/81	0.29	7.01
202	7.7	96[2]	27.0[2]	42.1	170	352	207	124.7	115	0.30	0.16	1.1 NTU	08/05/81	0.37	6.99
117	7.8	93[2]	26.0[2]	40.5	166	340	202	122.6	77	0.32	0.22	1.0 NTU	08/05/81	0.47	6.91
438	7.9	83[2]	28.0[2]	38.7	159	324	194	110.7	134	0.11	0.08	1.2 NTU	08/05/81	0.46	6.98
422	7.8	80[2]	35.0[2]	41.2	162	344	198	112.8	86	0.33	0.14	1.3 NTU	08/05/81	0.35	7.09
332	7.7	86[2]	21.0[2]	34.6	153	304	187	90.1	67	0.18	0.09	0.8 NTU	08/05/81	0.29	7.11
301	7.8	77[2]	30.0[2]	38.4	155	316	189	108.7	67	0.14	0.03	1.0 NTU	08/05/81	0.32	7.16
225B	7.7	98[2]	33.0[2]	38.5	166	[illegible]	202	114.4	96	0.28	0.11	0.9 NTU	08/05/81	0.34	7.01

44

[1] All analyses performed by Consumers Power Company
[2] Calculated values

TABLE 2.4-12D

CHEMICAL ANALYSES OF GROUNDWATER SAMPLES FROM PERMANENT DEWATERING WELLS[1]

(Constituents in ppm, Except Where Noted)

Well No.	pH (pH UNits)	Co[2]	Ng[2]	Na	Alk'y	Hardness	HCO_3	SO_4	Cl	Fe (total)	Fe (dissolved)	Turbidity	Date Sampled	Langler Index[2]	Ryznar Index[2]	
F-1	7.5	83	20	91	227	290	277	111	120	0.95	0.78	8.0 NTU	01/12/82	-0.05	7.59	
F-2	7.4	97	26	52	210	348	256	141	60	1.34	0.89	13.0 NTU	01/12/82	-0.11	7.63	
F-3	7.5	78	21	33	166	284	202	91	80	0.67	0.50	5.0 NTU	01/12/82	-0.16	7.83	
F-4	7.5	78	25	27	173	296	211	81	60	1.17	0.81	8.3 NTU	01/12/82	-0.12	7.74	
F-5	7.7	69	27	30	184	282	224	87	100	0.49	0.21	2.9 NTU	01/12/82	0.13	7.43	
F-6	7.6	82	24	31	174	304	212	102	100	0.54	0.24	4.6 NTU	01/12/82	-0.06	7.71	
F-7	7.7	77	23	31	157	286	192	86	60	0.43	0.18	3.0 NTU	01/12/82	-0.03	7.75	
G-1	7.7	62	21	23	151	242	184	78	60	0.34	0.17	1.0 NTU	01/12/81	-0.02	7.74	44
G-2	7.2	62	23	24	83	250	101	85	80	0.49	0.25	2.0 NTU	01/12/82	-0.94	9.08	
G-4	7.7	65	22	24	150	252	183	89	80	0.73	0.49	2.8 NTU	01/12/82	-0.11	7.92	
G-5	7.7	66	22	25	150	254	183	84	80	0.92	0.57	3.4 NTU	01/12/82	-0.16	8.03	
G-6	7.6	71	25	25	163	280	199	88	80	0.93	0.81	2.5 NTU	01/12/82	-0.11	7.82	
G-7	7.8	71	23	31	168	274	205	86	120	0.51	0.16	2.8 NTU	01/12/82	-0.08	7.65	
G-8	7.7	62	18	27	137	228	167	82	60	0.32	0.22	1.4 NTU	01/12/82	-0.17	8.03	
G-9	7.5	64	31	29	168	286	205	91	80	0.64	0.56	0.9 NTU	01/12/82	-0.14	7.77	
H-1	7.7	57	24	33	154	242	198	58	60	0.24	0.12	0.4 NTU	01/12/82	-0.02	7.74	
H-2	7.7	70	24	29	162	272	198	84	100	0.55	<0.10	2.3 NTU	01/12/82	0.09	7.53	
H-3	7.7	70	28	31	164	290	200	101	80	0.63	0.13	2.8 NTU	01/12/82	0.07	7.56	
H-4	7.7	73	25	31	164	286	200	95	80	0.54	0.13	2.7 NTU	01/12/82	0.11	7.49	

NOTES:

[1]All analyses performed by Consumers Power Company
[2]Calculated values

TABLE 2.4-16

WELL FAILURE MECHANISMS AND REPAIR TIMES

Event	Repair Time
1. Electrical Failure	
a. Single well (wired in parallel)	Less than 1 day
b. Multiple wells due to power outage	1 day to initiate operation of backup diesel power to interceptor wells. Operate until normal power can be restored. Backup interceptor wells automatically begin pumping if water levels exceed el 595'.
2. Failure of timers/pumps/check valves	Less than 1 day; replacement parts onsite.
3. Header pipe break	1 day to attach flexible hose to each well affected and pump water to storm drains. In case of interceptor well header failure, initiate backup wells (on separate header system).
4. Well screen encrustation	2 days to acidize well.
5. Complete loss of well	4 days to replace one well using cable tool rig. 1 day if other drilling method used. If well or wells need to be replaced, there is enough redundancy and pumping capacity to prevent water levels from rising in plant fill, while the replacement wells are being installed.

44

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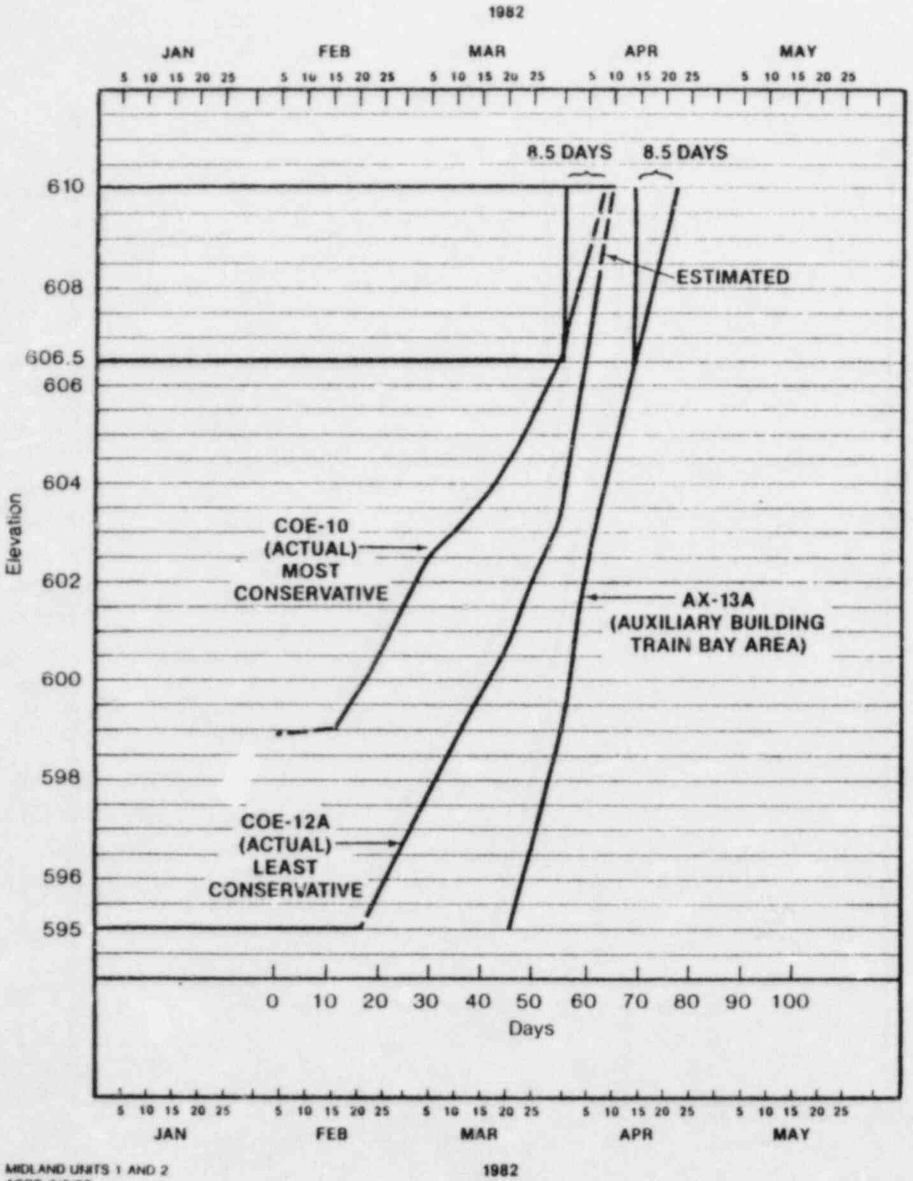


MIDLAND UNITS 1 AND 2
ACRS 8/5/82

ASSUMPTIONS:

1. 1½ DAYS TO COLD SHUTDOWN
2. 7 DAYS TO OPERATE DIESELS AFTER COLD SHUTDOWN
3. WELL OR WELLS CANNOT BE REPAIRED OR REPLACED IN SUFFICIENT TIME

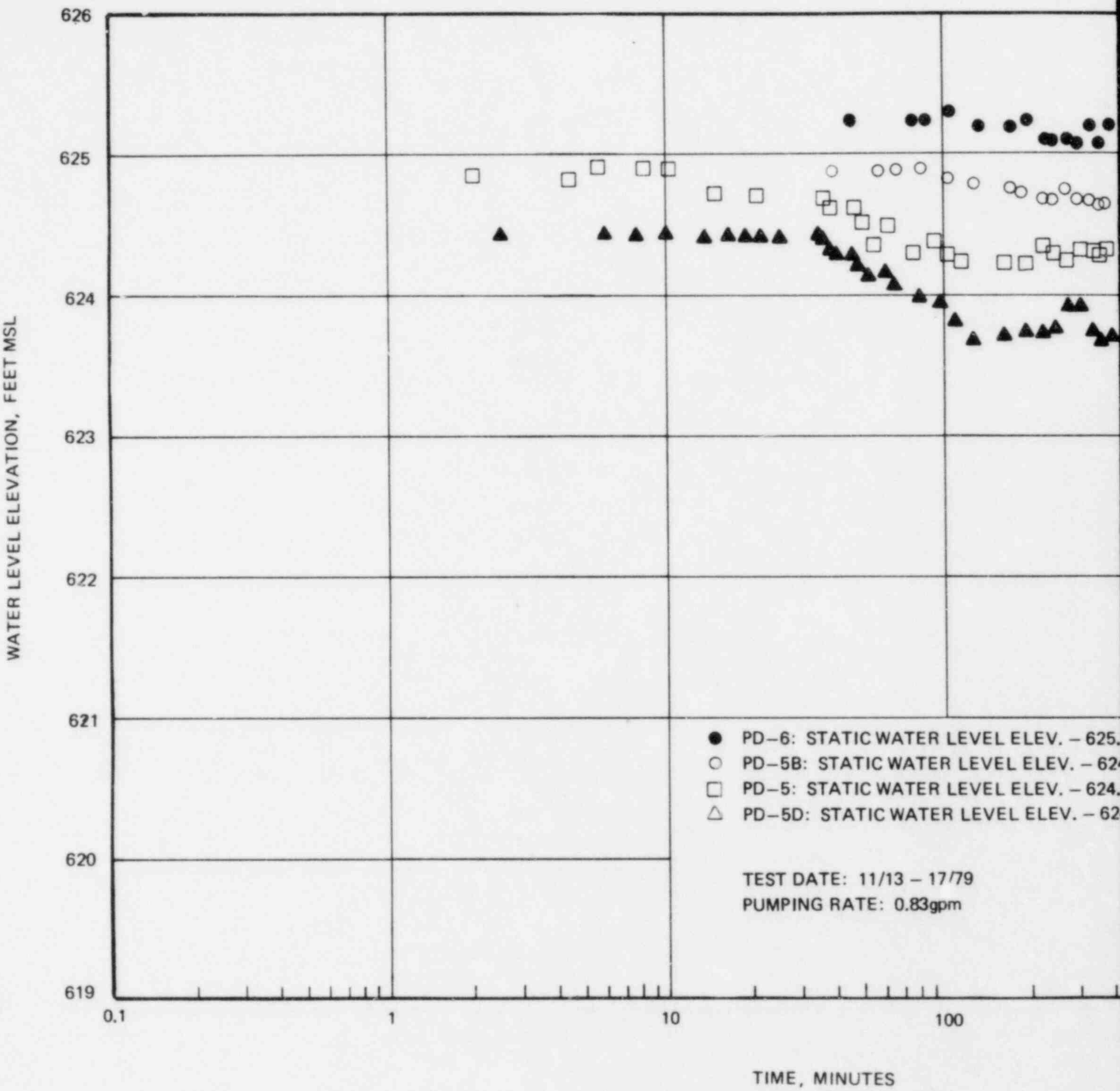
CRITERIA:

IF GROUND WATER LEVEL EXCEEDS ELEVATION 606.5 AT ANY OBSERVATION WELL AT THE DIESEL BUILDING OR AUXILIARY BUILDING RAILROAD BAY THE PLANT WILL BE SHUT DOWN.

NOTE: FOR LOCATION OF OBSERVATION WELLS AND AREAS COMMITTED TO PERMANENT DEWATERING, SEE FIGURE 2

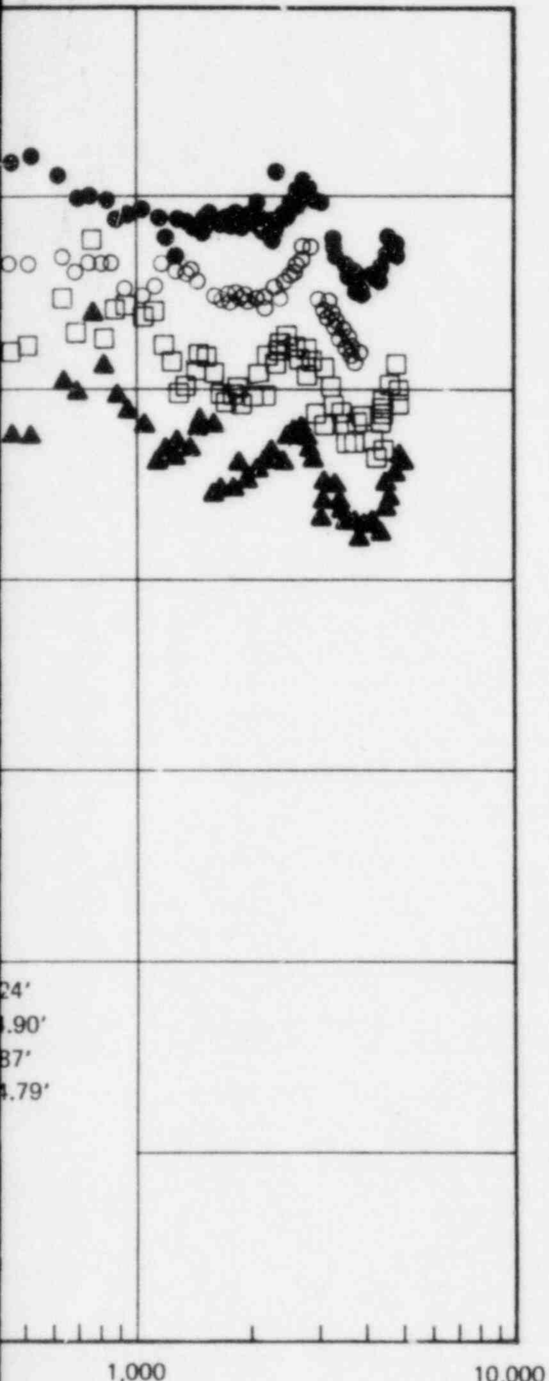
CONSUMERS POWER COMPANY MIDLAND UNITS 1 AND 2
DEWATERING CRITERIA FOR PLANT SHUTDOWN
FIGURE 4

34-G-1986-15



NOTE:

See Figure 2.4-42 for well locations.



WELL NO.	Δs (FEET)	t_o (MIN)	r (FEET)
PD–5C	*	*	NA
PD–6	0.35	120	86.40
PD–5B	0.32	60	35.60
PD–5	*	*	7.60
PD–5D	*	*	5.00

FORMULAE

$$T = \frac{264\,Q}{\Delta s} \qquad S = \frac{0.3\ t_o T}{r^2}$$

WHERE :

T = TRANSMISSIVITY (GPD/FT)

Q = PUMPING RATE (GPM)

Δs = DRAWDOWN OVER ONE LOG CYCLE OF TIME (FT)

S = STORAGE COEFFICIENT

t_o = ZERO DRAWDOWN INTERCEPT (DAYS)

r = DISTANCE TO PUMPING WELL (FT)

WELL NO.	TRANSMISSIVITY (GPD/FT)	STORAGE COEFFICIENT
PD–5C	NA	NA
PD–6	626	0.002
PD–5B	685	0.007
PD–5	NA	NA
PD–5D	NA	NA

* SEE TABLE 2.4–11B

NO.	DATE	REVISIONS	BY	CK'D	GROUP SUPV.	ENG'R	PROJ. ENG'R	MICRO FILM
0	10-14-82	ISSUED FOR PROJ USE	RVO		X		X	

SCALE NONE | DESIGNED LEY | DRAWN MJM

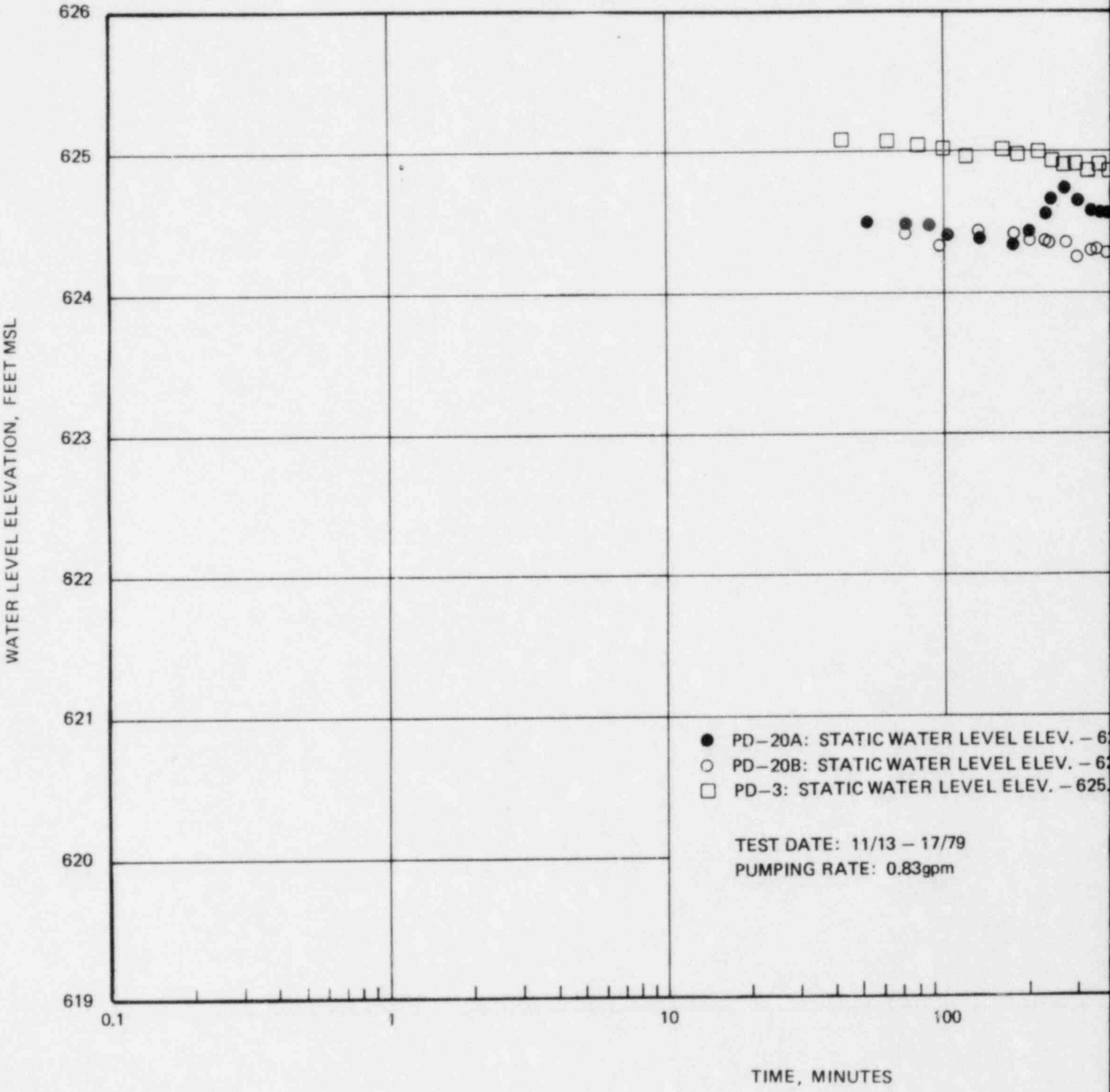
BECHTEL
ANN ARBOR

MIDLAND POWER PLANT

TIME – DRAWDOWN GRAPH
FOR PD–5C PUMPING TEST
(SHEET 1)

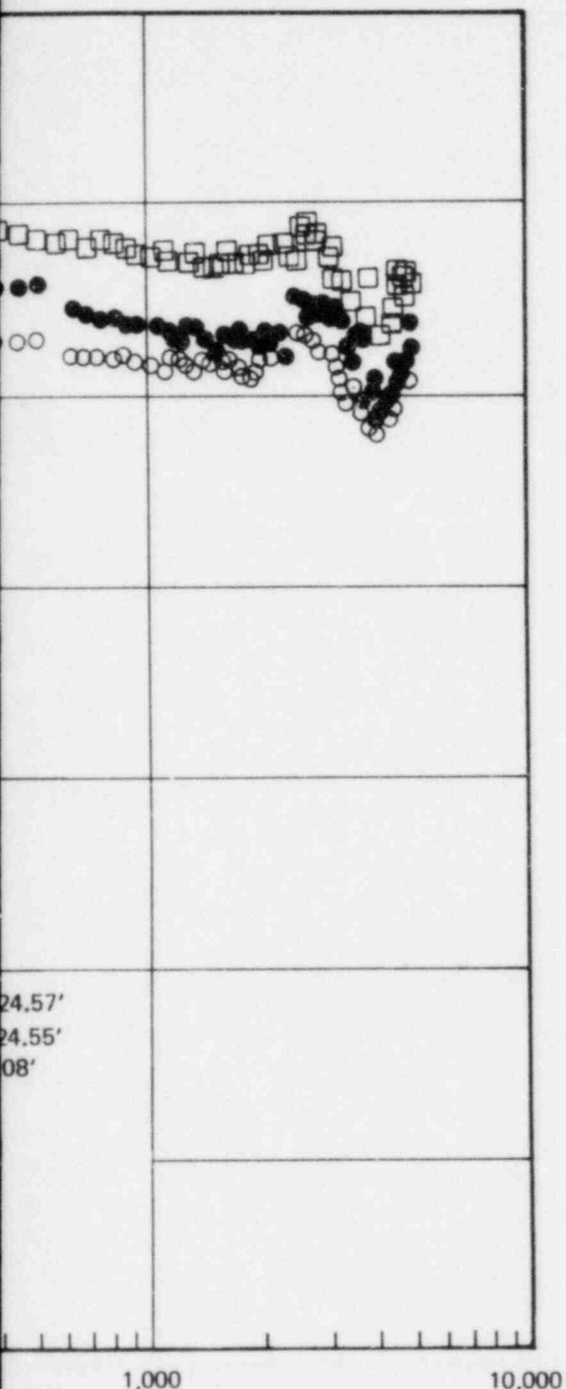
JOB NO.	DRAWING NO.	REV.
7220	FIGURE 5	0

SK-G-767



NOTE:

See Figure 2.4-42 for well locations.



WELL NO.	Δs (FEET)	t_o (MIN)	r (FEET)
PD–20A	*	*	147.30
PD–20B	0.35	70	144.80
PD–3	0.35	100	109.20

FORMULAE

$$T = \frac{264\,Q}{\Delta s} \qquad S = \frac{0.3\ t_o T}{r^2}$$

WHERE :

T = TRANSMISSIVITY (GPD/FT)

Q = PUMPING RATE (GPM)

Δs = DRAWDOWN OVER ONE LOG CYCLE OF TIME (FT)

S = STORAGE COEFFICIENT

t_o = ZERO DRAWDOWN INTERCEPT (DAYS)

r = DISTANCE TO PUMPING WELL (FT)

WELL NO.	TRANSMISSIVITY (GPD/FT)	STORAGE COEFFICIENT
PD–20A	NA	NA
PD–20B	626	0.0004
PD–3	626	0.001

* SEE TABLE 2.4–11B

NO.	DATE	REVISIONS	BY	CK'D	GROUP SUPV.	ENGR	PROJ. ENGR	MICRO FILM
0	10-14-82	ISSUED FOR PROJ USE	RV					

SCALE NONE | DESIGNED LEY | DRAWN MJM

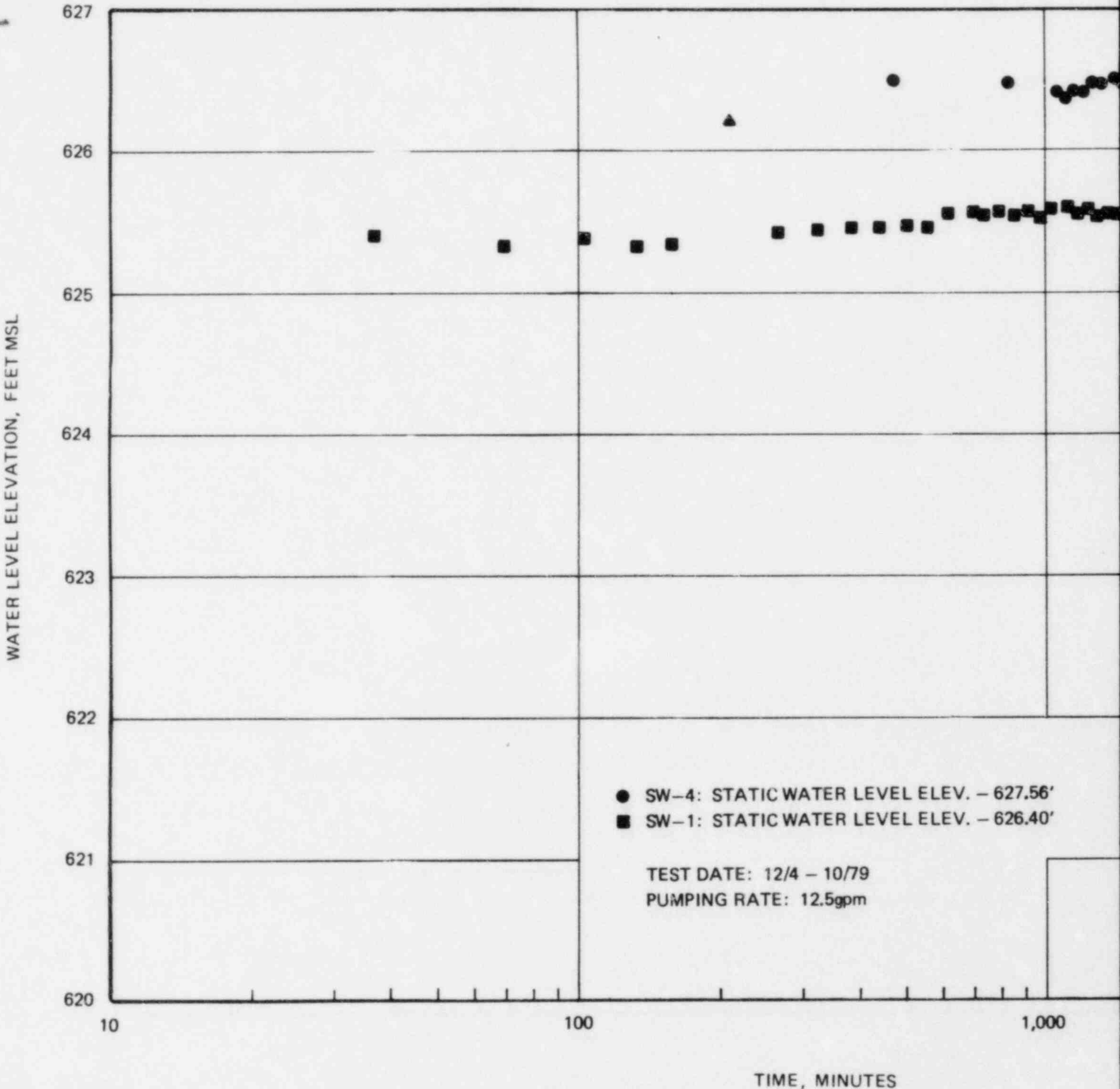
BECHTEL
ANN ARBOR

MIDLAND POWER PLANT

TIME – DRAWDOWN GRAPH
FOR PD–5C PUMPING TEST
(SHEET 2)

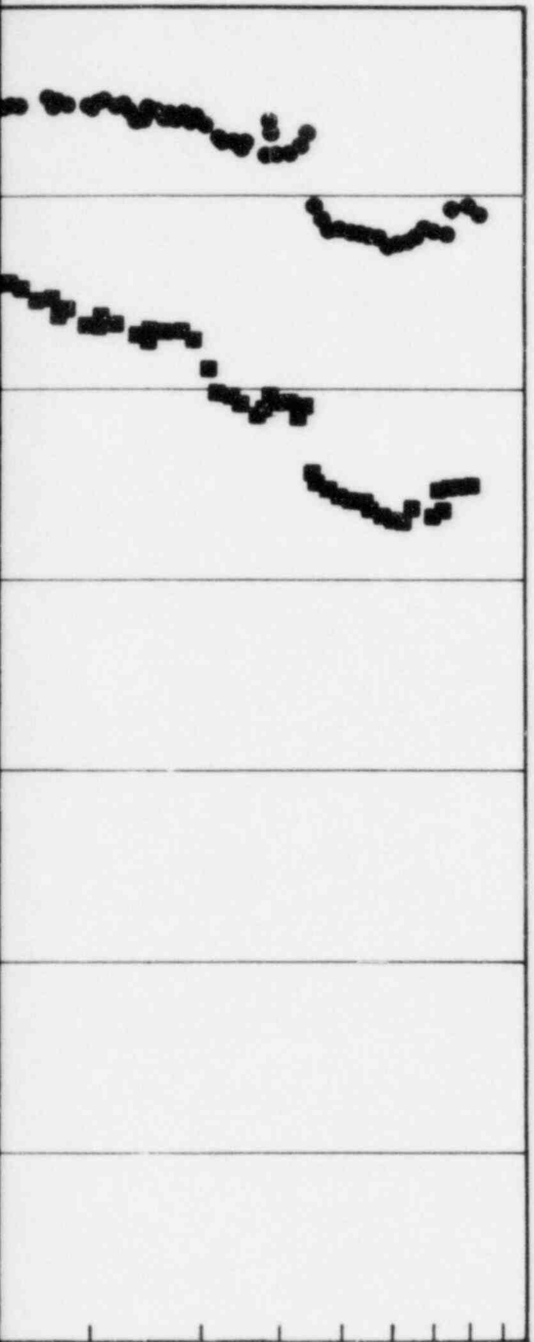
JOB NO.	DRAWING NO.	REV.
7220	FIGURE 6	0

SK-G-765



NOTE:

See Figure 2.4-42 for well locations.



WELL NO.	Δs (FEET)	t_o (MIN)	r (FEET)
SW-4	•	•	139.0
SW-1	•	•	172.0

FORMULAE

$T = \frac{264\ Q}{\Delta s}$ $S = \frac{0.3\ t_o T}{r^2}$

WHERE :

T = TRANSMISSIVITY (GPD/FT)

Q = PUMPING RATE (GPM)

Δs = DRAWDOWN OVER ONE LOG CYCLE OF TIME (FT)

S = STORAGE COEFFICIENT

t_o = ZERO DRAWDOWN INTERCEPT (DAYS)

r = DISTANCE TO PUMPING WELL (FT)

WELL NO.	TRANSMISSIVITY (GPD/FT)	STORAGE COEFFICIENT
SW-4	NA	NA
SW-1	NA	NA

NO.	DATE	REVISIONS	BY	CK'D	GROUP SUPV.	ENG'R	PROJ. ENG'R	MICRO FILM
0	10-14-82	ISSUED FOR PROJ USE	RJO		X		X	

SCALE NONE | DESIGNED LEY | DRAWN MJM

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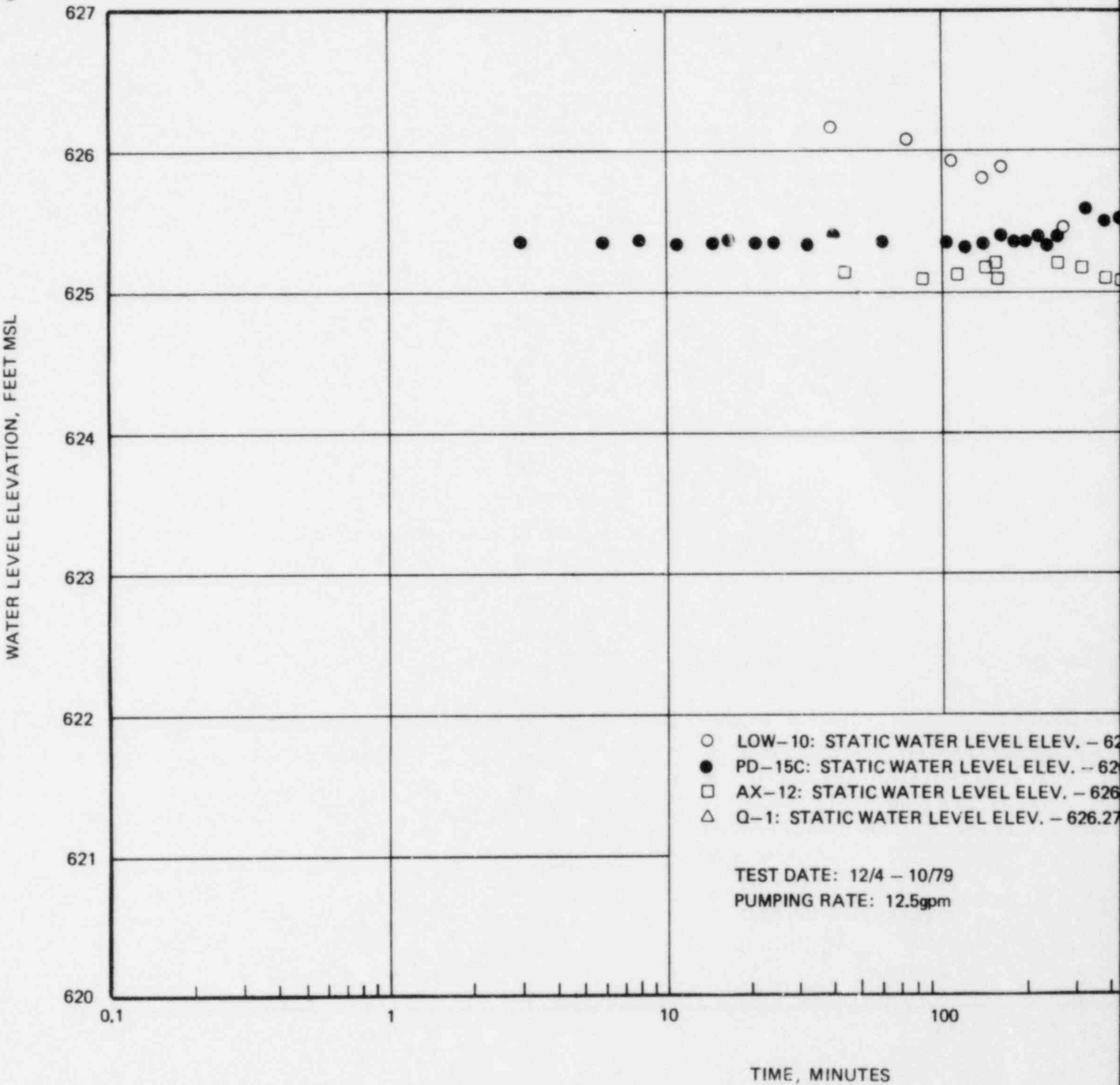
ANN ARBOR

MIDLAND POWER PLANT

TIME – DRAWDOWN GRAPH
FOR PD–15A PUMPING TEST
(SHEET 1)

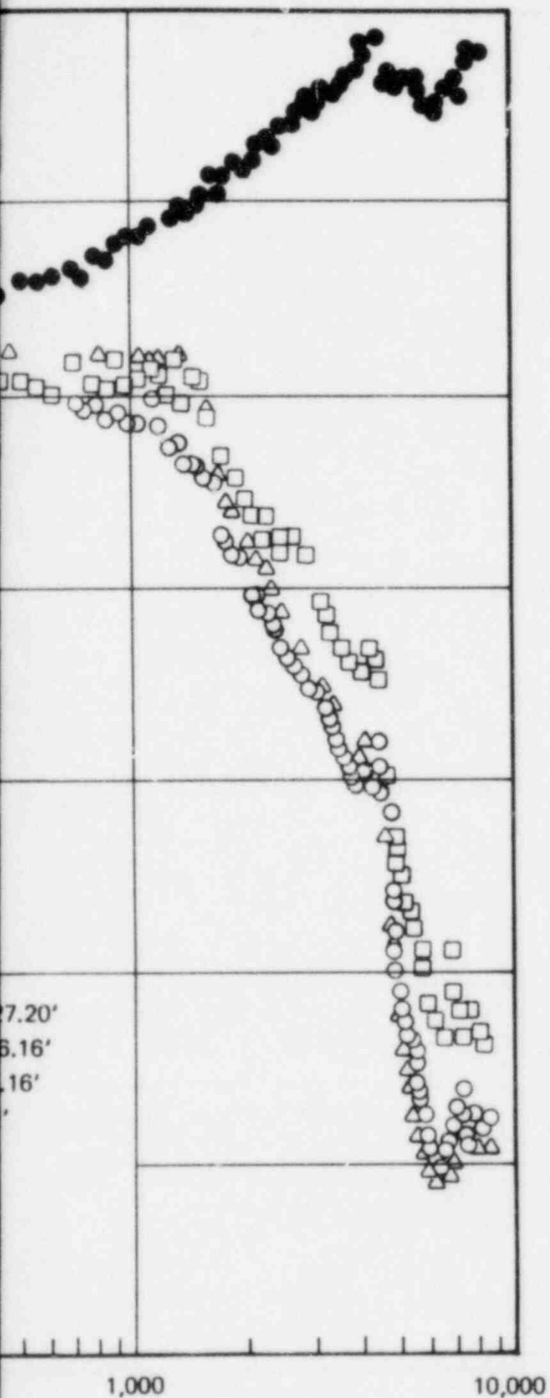
JOB NO.	DRAWING NO.	REV.
7220	FIGURE 7	0

SK-G-768



NOTE:

See Figure 2.4-42 for well locations.



WELL NO.	Δs (FEET)	t_o (MIN)	r (FEET)
LOW–10	1.15	62.0	140.0
PD–15C	*	*	15.0
AX–12	*	*	247.0
Q–1	*	*	163.0

FORMULAE

$$T = \frac{264\,Q}{\Delta s} \qquad S = \frac{0.3\ t_o T}{r^2}$$

WHERE :

T = TRANSMISSIVITY (GPD/FT)

Q = PUMPING RATE (GPM)

Δs = DRAWDOWN OVER ONE LOG CYCLE OF TIME (FT)

S = STORAGE COEFFICIENT

t_o = ZERO DRAWDOWN INTERCEPT (DAYS)

r = DISTANCE TO PUMPING WELL (FT)

WELL NO.	TRANSMISSIVITY (GPD/FT)	STORAGE COEFFICIENT
LOW–10	2869	0.002
PD–15C	NA	NA
AX– 12	NA	NA
Q–1	NA	NA

* SEE TABLE 2.4–11B

NO.	DATE	REVISIONS	BY	CHK'D	GROUP SUPV.	ENG'R	PROJ. ENG'R	MICRO FILM
△								
△								
0	10-14-82	ISSUED FOR PROJ USE						

SCALE NONE | DESIGNED LEY | DRAWN MJM

BECHTEL
ANN ARBOR

MIDLAND POWER PLANT

TIME – DRAWDOWN GRAPH
FOR PD–15A PUMPING TEST
(SHEET 2)

JOB NO.	DRAWING NO.	REV.
7220	FIGURE 8	0

SK-G-770

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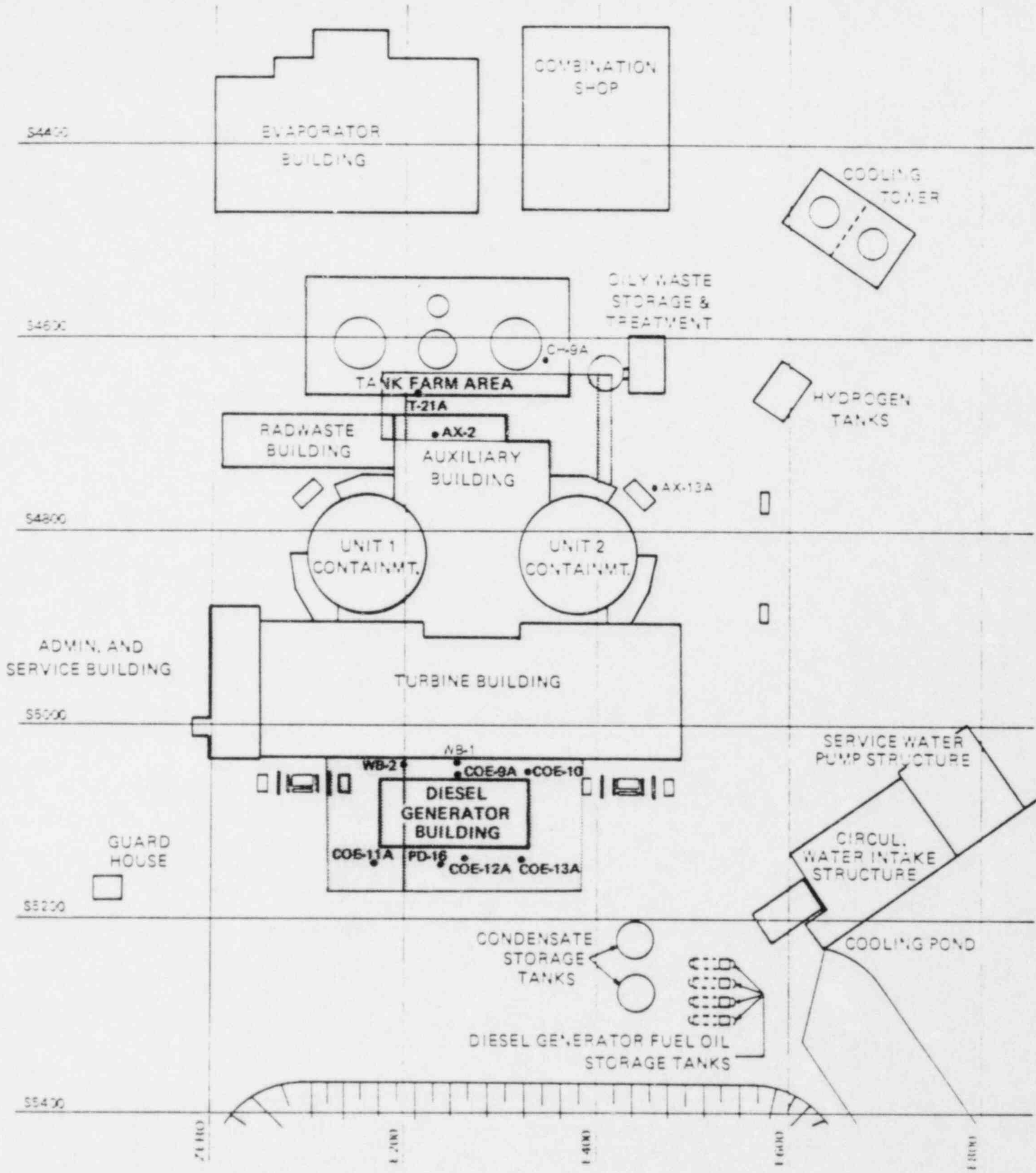


EXPLANATION

- • OBSERVATION WELLS USED FOR RECHARGE TIME DETERMINATION
- ▭ AREAS COMMITTED TO PERMANENT DEWATERING

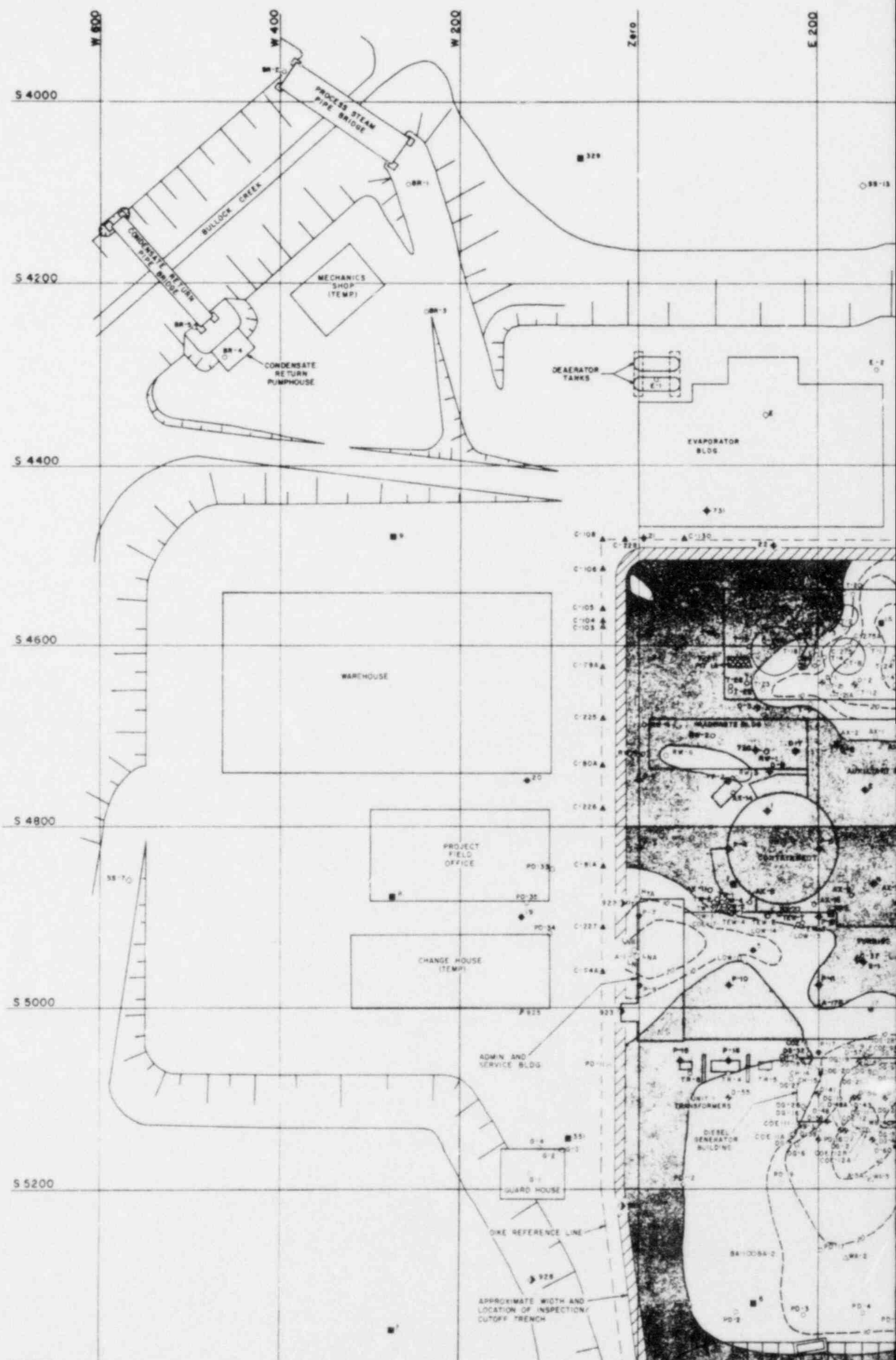
0 50 100 150 200
SCALE IN FEET

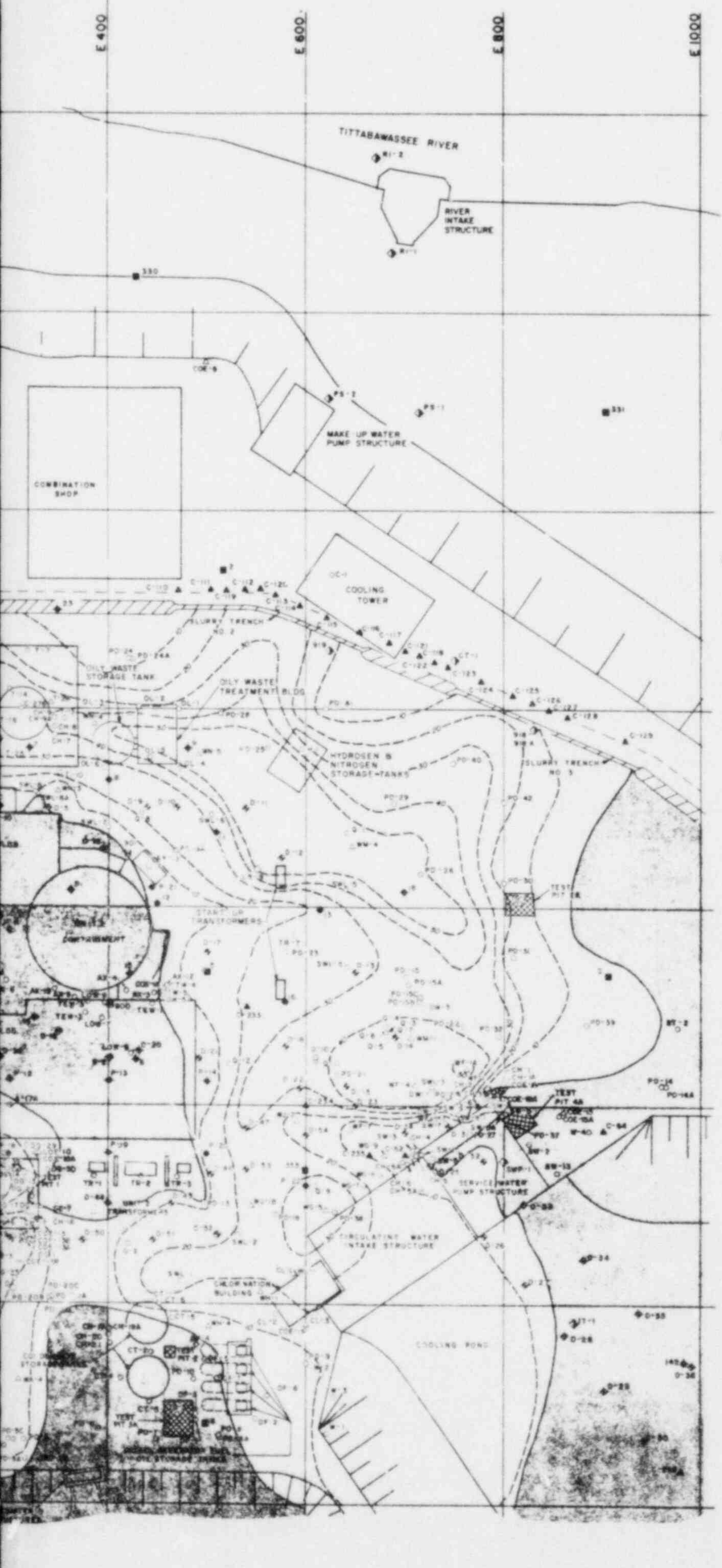
BECHTEL
ANN ARBOR

MIDLAND POWER PLANT

OBSERVATION WELLS AT CRITICAL STRUCTURES MONITORED DURING RECHARGE TEST

JOB NO.	DRAWING NO.
7220	FIGURE 12


W 600
W 400
W 200
Zero
E 200
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
BULLOCK CREEK
CONDENSATE RETURN PIPE BRIDGE
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BLDG
WAREHOUSE
PROJECT FIELD OFFICE
CHANGE HOUSE (TEMP)
ADMIN AND SERVICE BLDG
CONTAINMENT
DIESEL GENERATOR BUILDING
TRANSFORMERS
GUARD HOUSE
DIKE REFERENCE LINE
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/ CUTOFF TRENCH



NOTES:

1. The remaining natural sands are described as Unit c in the FSAR.
2. Thickness of natural sands based on interpretation of boring logs and construction records.

EXPLANATION

EXPLORATION PROGRAM - PRECONSTRUCTION

- ■ MICHIGAN DRILLING COMPANY BORINGS; 1956 & 1968
- ◆ DAMES & MOORE BORINGS; 1967, 1968 & 1969

EXPLORATION PROGRAM - CONSTRUCTION PERIOD

- ▲ WALTER FLOOD COMPANY BORINGS, 1969 & 1970
- ◆ BECHTEL BORINGS, 1970
- ■ SOIL & MATERIALS ENGINEERING INC. BORINGS, 1973 & 1974
- ◗ BECHTEL BORINGS, 1973 & 1974
- ○ BECHTEL BORINGS, 1977 & 1978
- ○ BECHTEL BORINGS, 1978, 1979, 1980 & 1981
- △ WOODWARD-CLYDE CONSULTANTS BORINGS, 1981
- ▩ BECHTEL TEST PITS, 1978 & 1979
- ▭ BACKFILL AREAS INSIDE THE DIKE INSPECTION/CUTOFF TRENCH UNDERLAIN BY CLAY
- ▭ BACKFILL AREAS INSIDE THE DIKE INSPECTION/CUTOFF TRENCH UNDERLAIN BY NATURAL SAND
- -20- CONTOUR REPRESENTS THICKNESS OF REMAINING NATURAL SANDS. CONTOUR INTERVAL IS 10 FEET

N

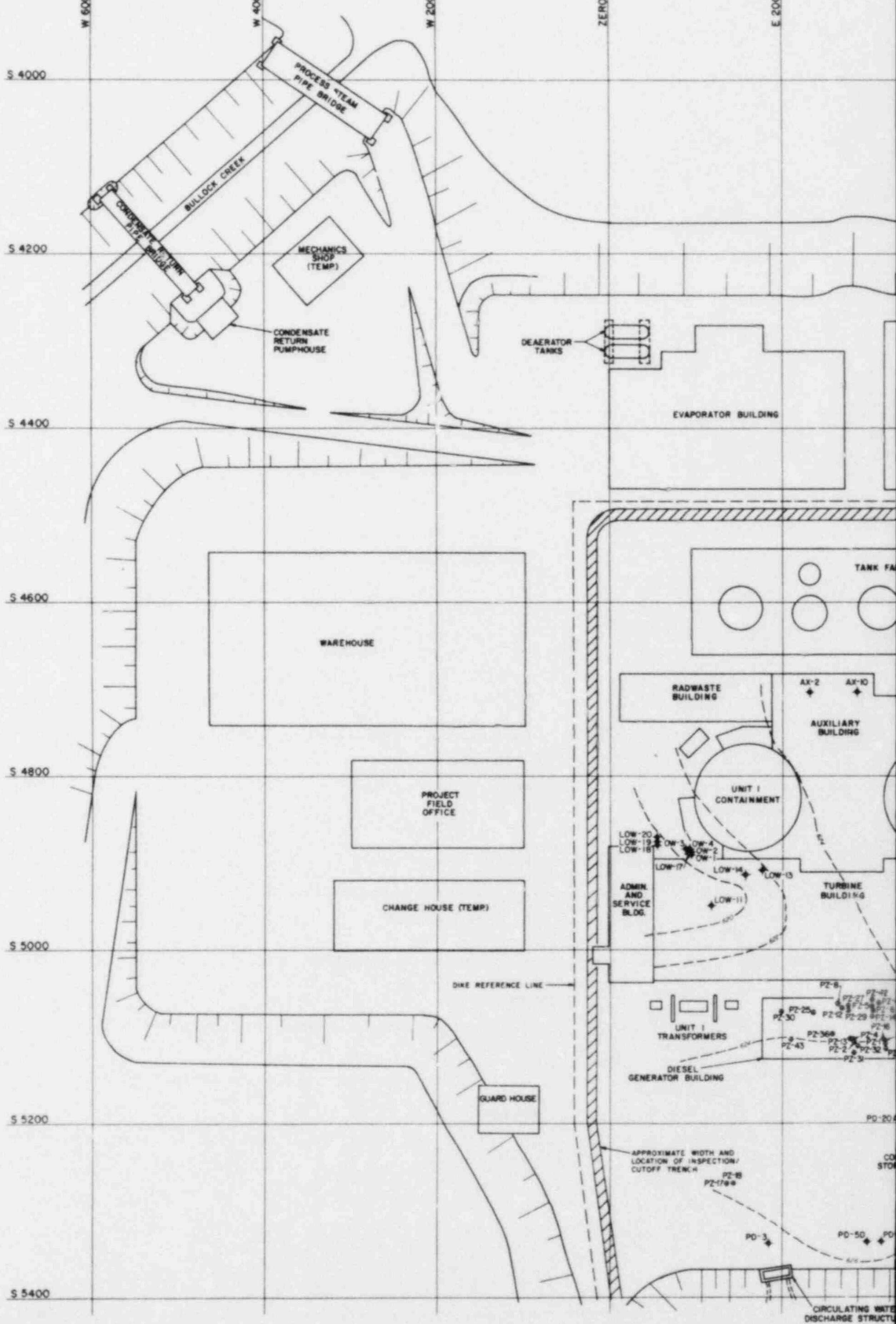
0 25 50 100 150 200
SCALE IN FEET

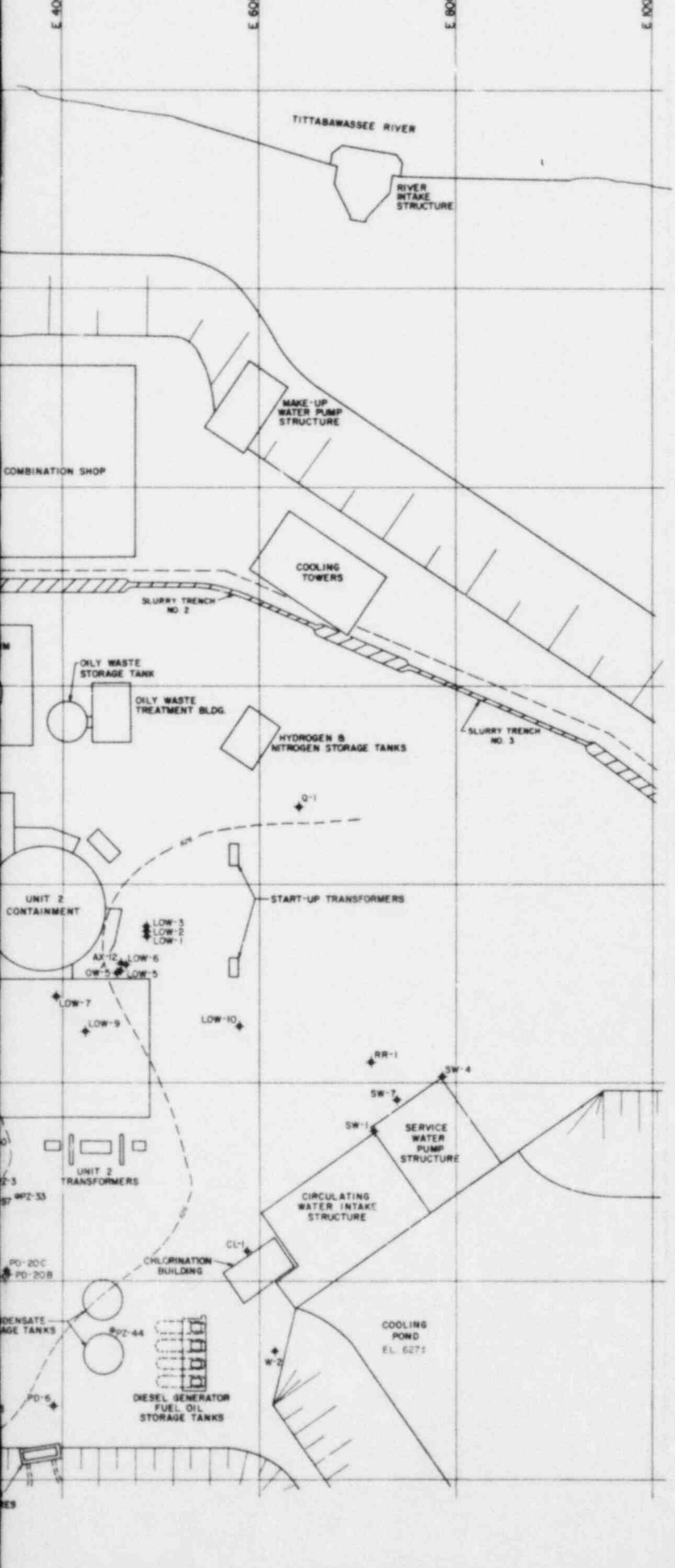
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Isopach of Remaining Natural Sands

(SK-G-598, Rev 0)

FSAR Figure 2.4-39


W 600
W 400
W 200
ZERO
E 200
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
BULLOCK CREEK
CONDENSATE RETURN PIPE BRIDGE
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BUILDING
WAREHOUSE
RADWASTE BUILDING
AX-2
AX-10
AUXILIARY BUILDING
UNIT I CONTAINMENT
PROJECT FIELD OFFICE
CHANGE HOUSE (TEMP)
ADMIN. AND SERVICE BLDG.
TURBINE BUILDING
DIKE REFERENCE LINE
UNIT I TRANSFORMERS
DIESEL GENERATOR BUILDING
GUARD HOUSE
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/ CUTOFF TRENCH



EXPLANATION

AX-2 ✦ LOCATION OF MEASURED OBSERVATION WELLS

PZ-6 ● LOCATION OF MEASURED PIEZOMETERS

APPROXIMATE ELEVATION OF GROUND WATER LEVEL. CONTOUR INTERVAL IS 2 FEET.

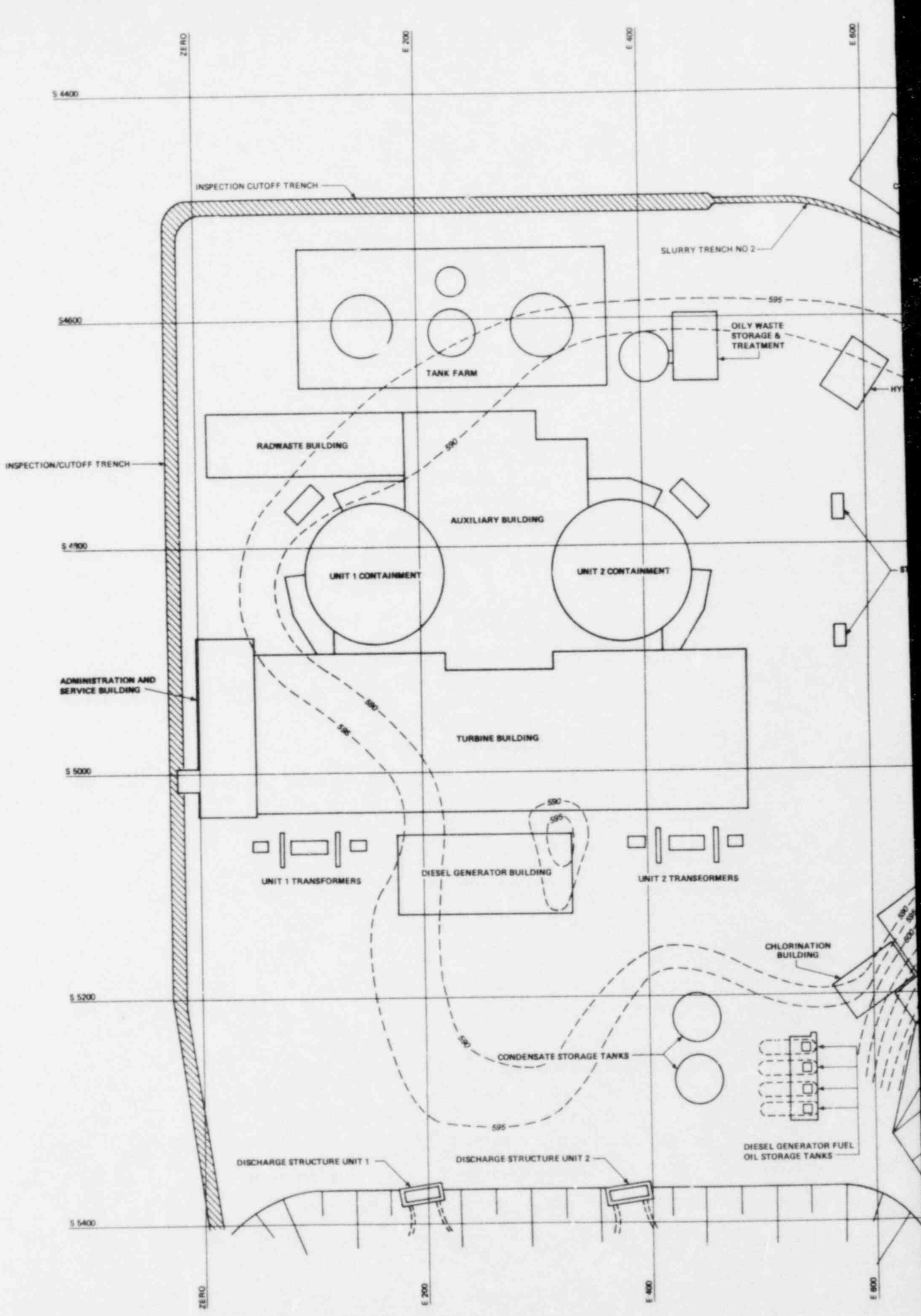
NOTE:
Only observation wells and piezometers screened through pervious material were used to prepare this figure.

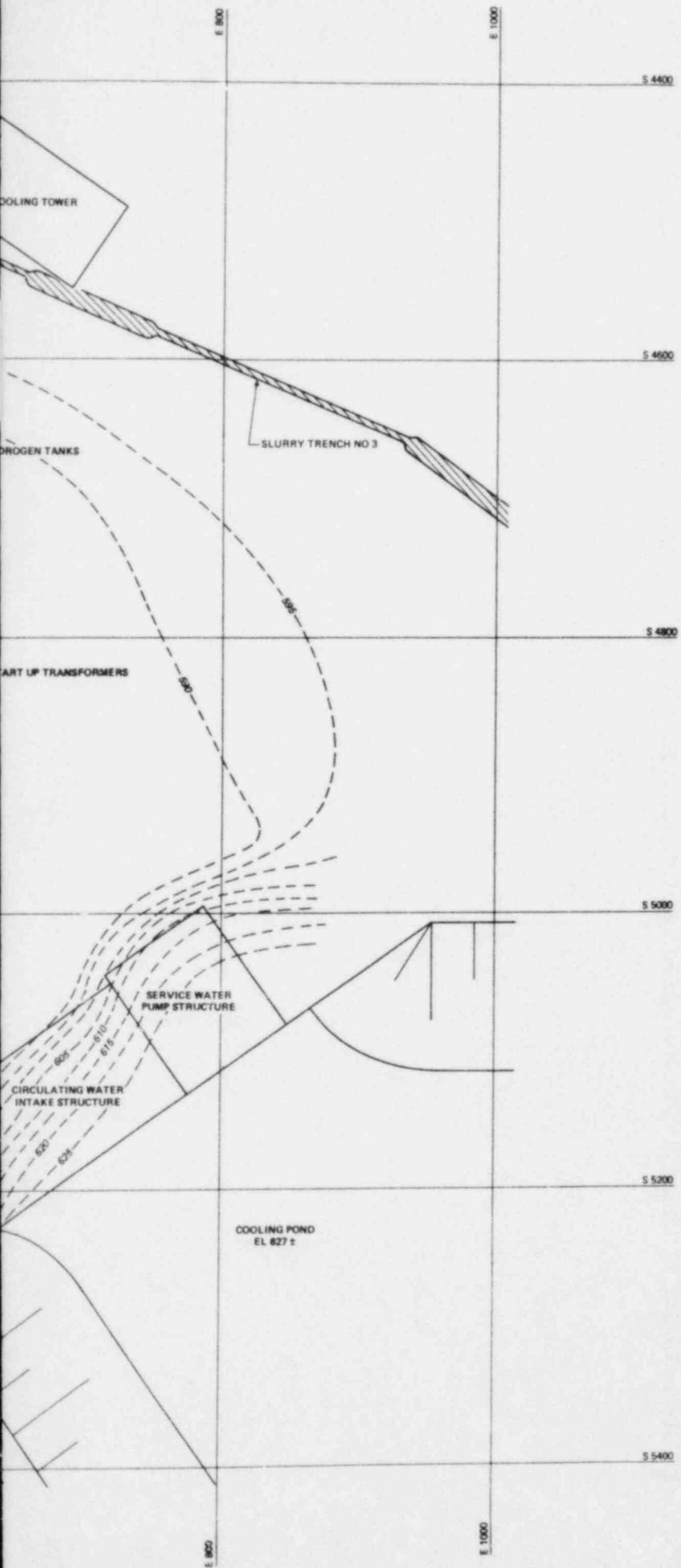
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Groundwater Levels Prior to Pond Lowering (11-27 to 11-29-79)

(SK-G-457, Rev 1)

FSAR Figure 2.4-40


ZERO
E 200
E 400
E 600
S 4400
S4600
S 4800
S 5000
S 5200
S 5400
INSPECTION CUTOFF TRENCH
SLURRY TRENCH NO 2
TANK FARM
OILY WASTE STORAGE & TREATMENT
RADWASTE BUILDING
INSPECTION/CUTOFF TRENCH
AUXILIARY BUILDING
UNIT 1 CONTAINMENT
UNIT 2 CONTAINMENT
ADMINISTRATION AND SERVICE BUILDING
TURBINE BUILDING
UNIT 1 TRANSFORMERS
DIESEL GENERATOR BUILDING
UNIT 2 TRANSFORMERS
CHLORINATION BUILDING
CONDENSATE STORAGE TANKS
DIESEL GENERATOR FUEL OIL STORAGE TANKS
DISCHARGE STRUCTURE UNIT 1
DISCHARGE STRUCTURE UNIT 2
595
590
600
E 600



EXPLANATION

— 610 — PREDICTED ELEVATION OF GROUNDWATER LEVEL. CONTOUR INTERVAL IS 5 FEET.

NOTES:

1. Contours represent ground water levels in pervious materials only
2. See Figure 2.4-47 for areas committed to permanent dewatering.

N

0 25 50 100 150 200

SCALE IN FEET

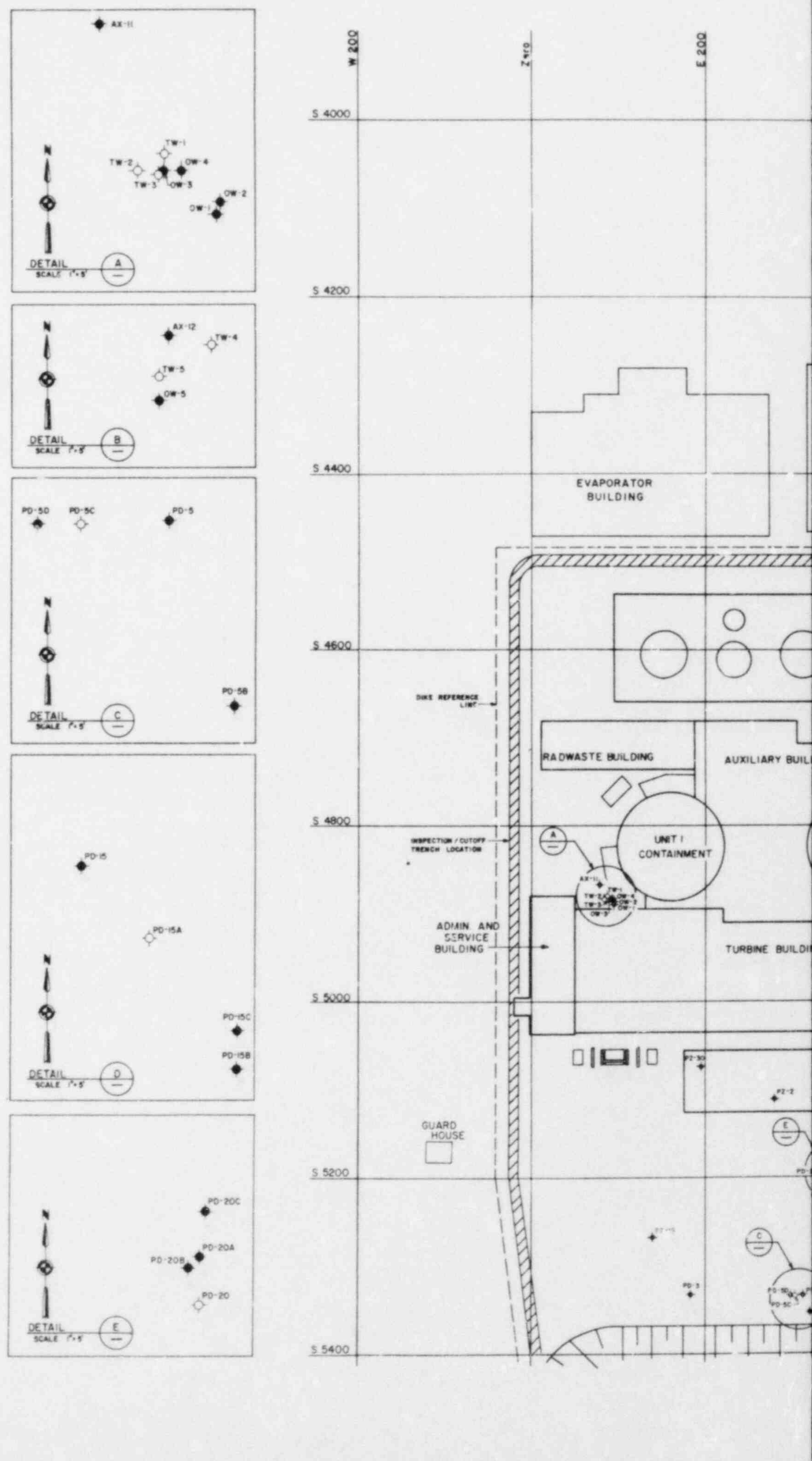
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Predicted Groundwater Levels
During Plant Operation

(SK-G-631, Rev 0)

FSAR Figure 2.4-41

6/82 Revision 44


AX-11
TW-1
TW-2
OW-4
TW-3
OW-3
OW-2
OW-1
N
DETAIL
SCALE 1"=5'
A
AX-12
TW-4
TW-5
OW-5
DETAIL
SCALE 1"=5'
B
PD-5D
PD-5C
PD-5
PD-5B
DETAIL
SCALE 1"=5'
C
PD-15
PD-15A
PD-15C
PD-15B
DETAIL
SCALE 1"=5'
D
PD-20C
PD-20A
PD-20B
PD-20
DETAIL
SCALE 1"=5'
E
W 200
Zero
E 200
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
EVAPORATOR BUILDING
DIKE REFERENCE LINE
RADWASTE BUILDING
AUXILIARY BUIL
INSPECTION / CUTOFF TRENCH LOCATION
UNIT 1 CONTAINMENT
ADMIN. AND SERVICE BUILDING
TURBINE BUILDI
GUARD HOUSE
PD-3

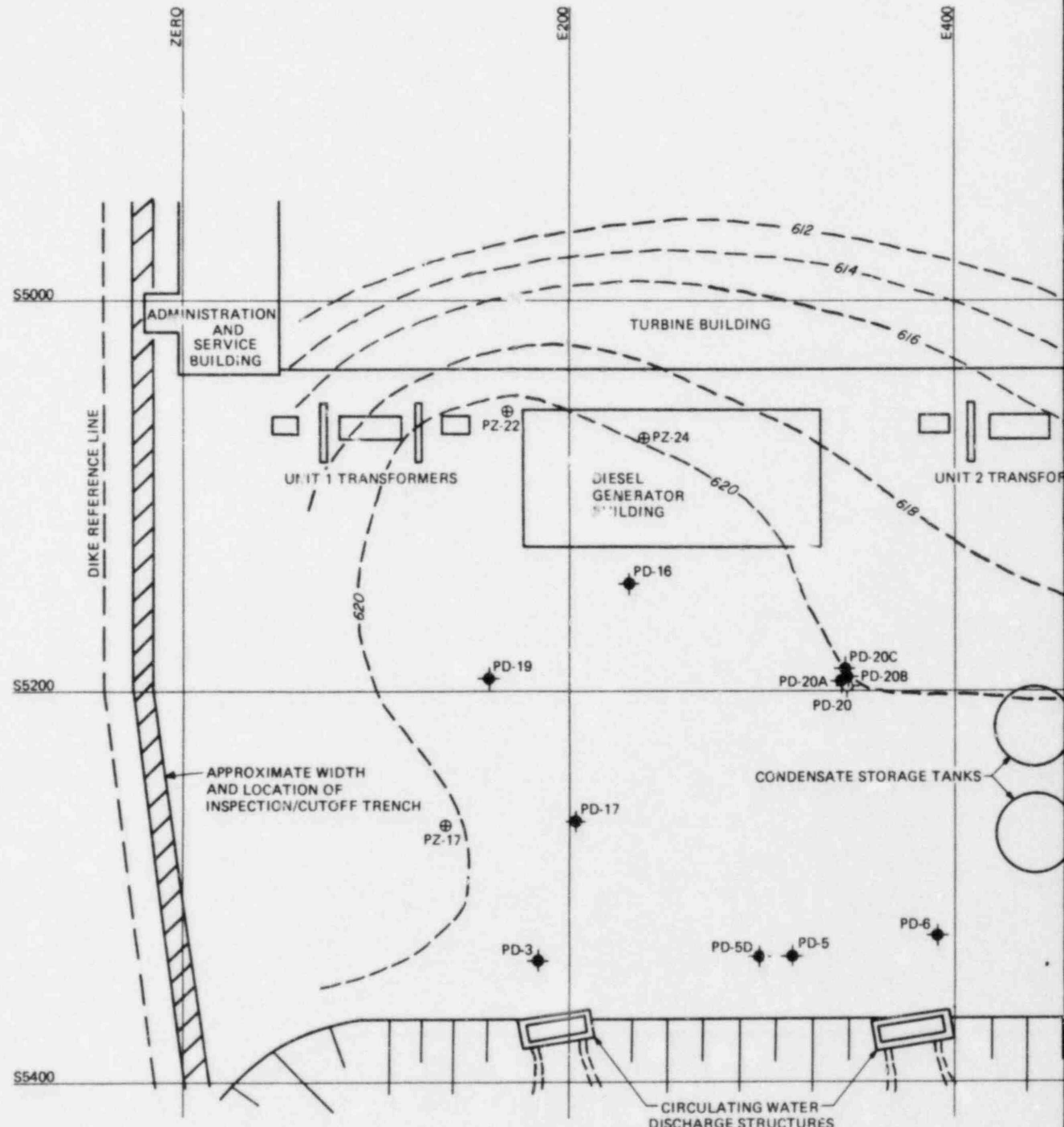
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Pumping Test Location Plan

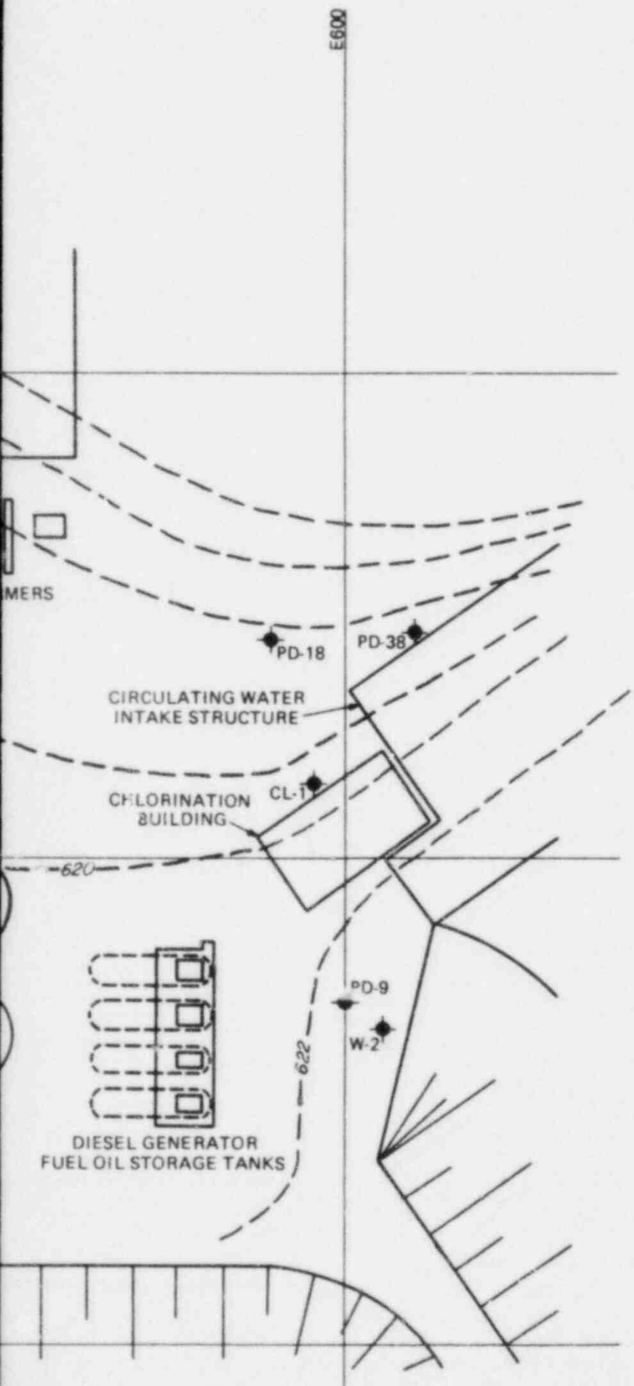
(SK-G-386, Rev 0)

FSAR Figure 2.4-42

6/82 Revision 44



ZERO
E200
E400
S5000
S5200
S5400
DIKE REFERENCE LINE
ADMINISTRATION AND SERVICE BUILDING
TURBINE BUILDING
612
614
616
618
620
PZ-22
PZ-24
UNIT 1 TRANSFORMERS
DIESEL GENERATOR BUILDING
UNIT 2 TRANSFOR
PD-16
PD-19
PD-20C
PD-20B
PD-20A
PD-20
CONDENSATE STORAGE TANKS
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/CUTOFF TRENCH
PZ-17
PD-17
PD-3
PD-5D
PD-5
PD-6
CIRCULATING WATER DISCHARGE STRUCTURES



EXPLANATION

PD-20 LOCATION OF TEST WELL

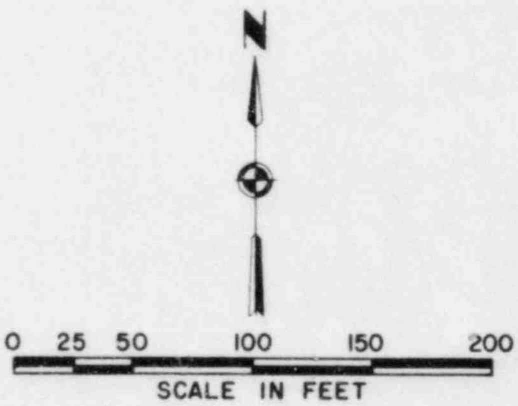
PD-3 LOCATION OF MEASURED OBSERVATION WELLS

PZ-17 LOCATION OF MEASURED PIEZOMETERS

--618-- APPROXIMATE ELEVATION OF GROUND WATER LEVEL. CONTOUR INTERVAL IS 2 FEET.

NOTES:

1. The duct bank/valve pit dewatering system was started 2/26/80.
2. The Unit 2 dewatering system was started 8/10/80.
3. Only observation wells and piezometers screened through pervious material were used to prepare this figure.
4. For detailed locations of the duct bank/valve pit and Unit 2 dewatering systems, see Figure 2.4-46
5. Test well PD-20 was pumped at 2.4 gpm between 10/2/80 and 11/13/80.

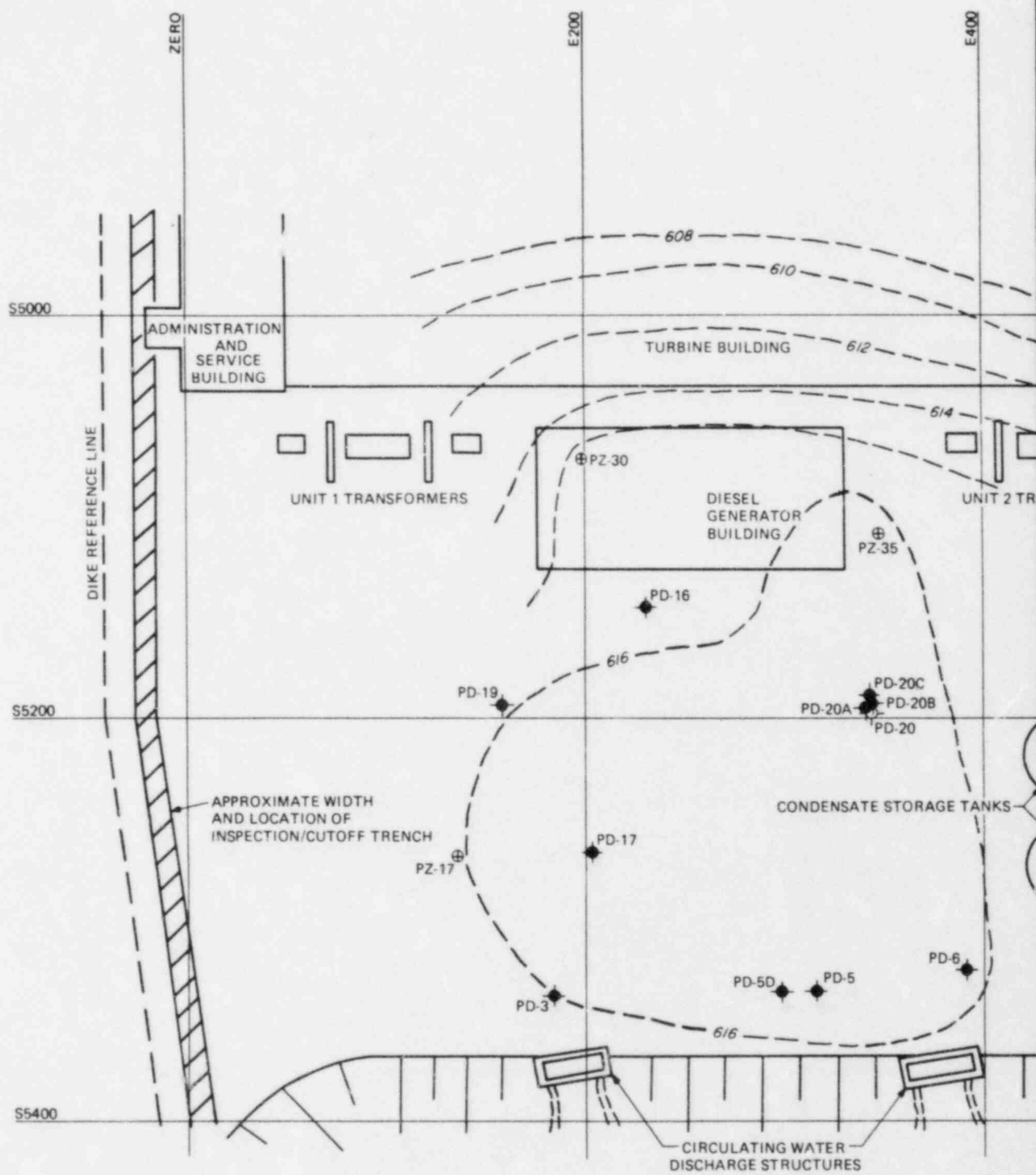


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

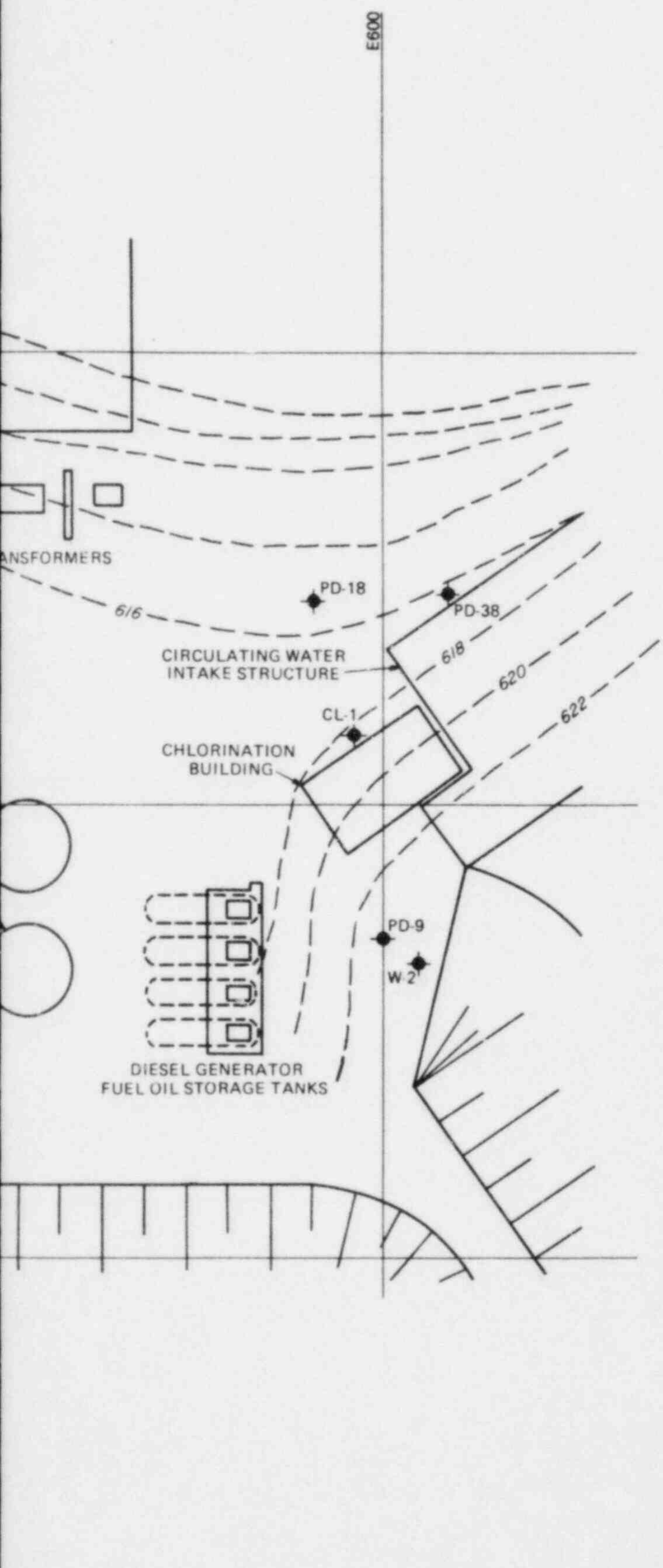
Groundwater Levels in the Vicinity of the Diesel Generator Building Prior to Pumping Test Well PD-20 (10/2/80)

(SK-G-516, Rev 0)
FSAR Figure 2.4-43

6/82 Revision 44



ZERO
E200
E400
S5000
S5200
S5400
DIKE REFERENCE LINE
ADMINISTRATION AND SERVICE BUILDING
TURBINE BUILDING
608
610
612
614
616
UNIT 1 TRANSFORMERS
DIESEL GENERATOR BUILDING
UNIT 2 TR
PZ-30
PZ-35
PD-16
PD-19
PD-20C
PD-20B
PD-20A
PD-20
CONDENSATE STORAGE TANKS
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/CUTOFF TRENCH
PZ-17
PD-17
PD-6
PD-5D
PD-5
PD-3
CIRCULATING WATER DISCHARGE STRUCTURES



EXPLANATION

PD-20 LOCATION OF TEST WELL

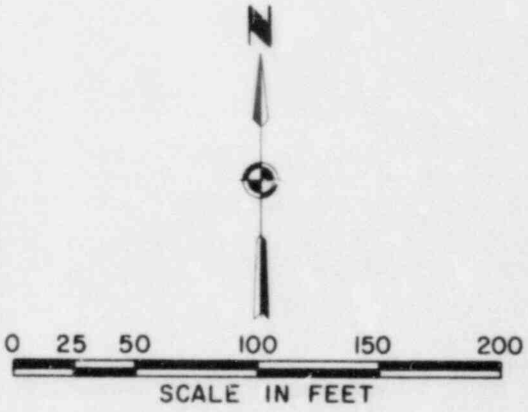
PD-3 LOCATION OF MEASURED OBSERVATION WELLS

PZ-17 LOCATION OF MEASURED PIEZOMETERS

--618-- APPROXIMATE ELEVATION OF GROUND WATER LEVEL. CONTOUR INTERVAL IS 2 FEET.

NOTES:

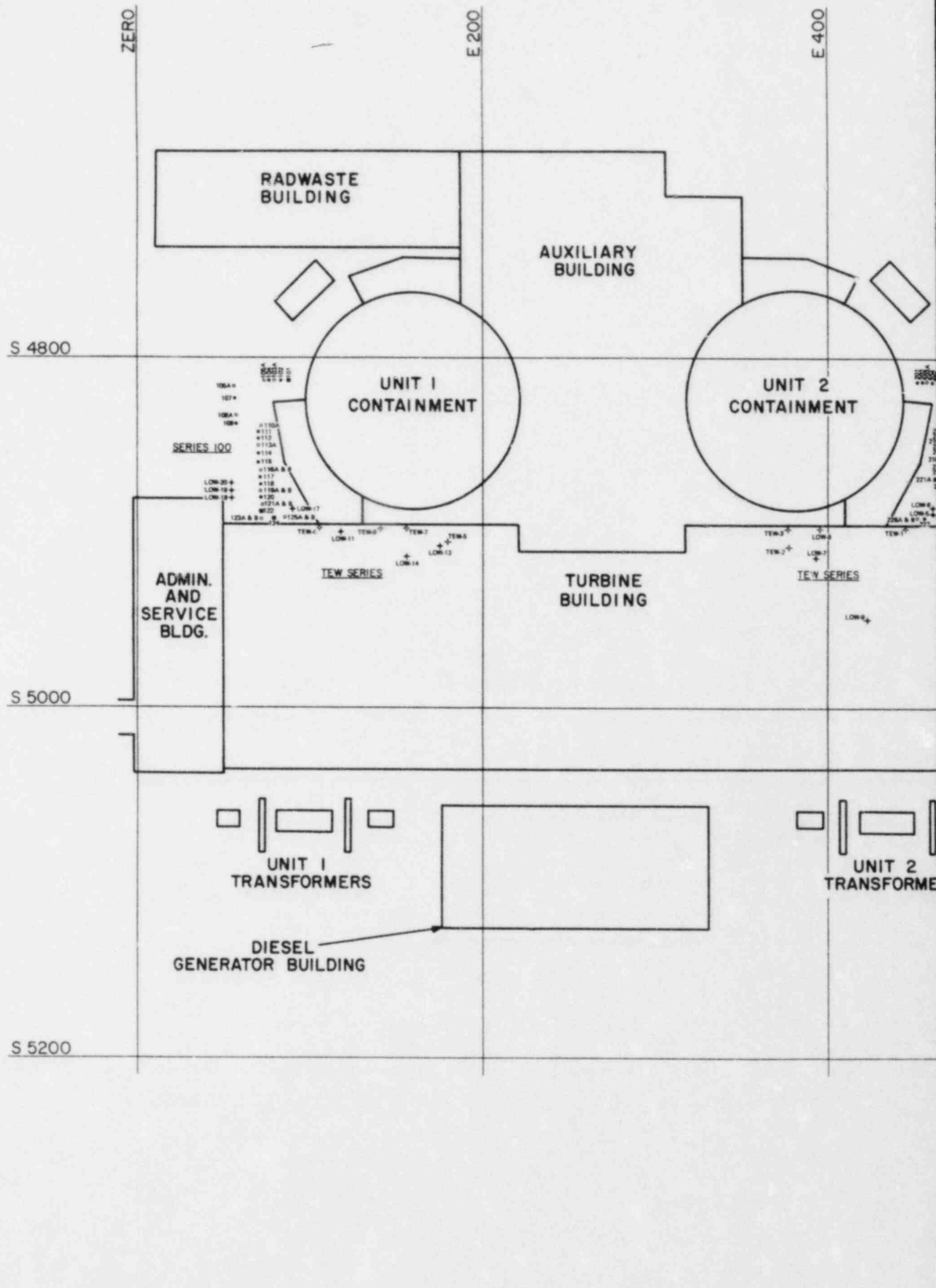
1. The duct bank/valve pit dewatering system was started 2/26/80.
2. The Unit 2 dewatering system was started 8/10/80.
3. Only observation wells and piezometers screened through pervious material were used to prepare this figure.
4. For detailed locations of the duct bank/valve pit and Unit 2 dewatering systems, see Figure 2.4-45
5. Test well PD-20 was pumped at 2.4 gpm between 10/2/80 and 11/13/80.

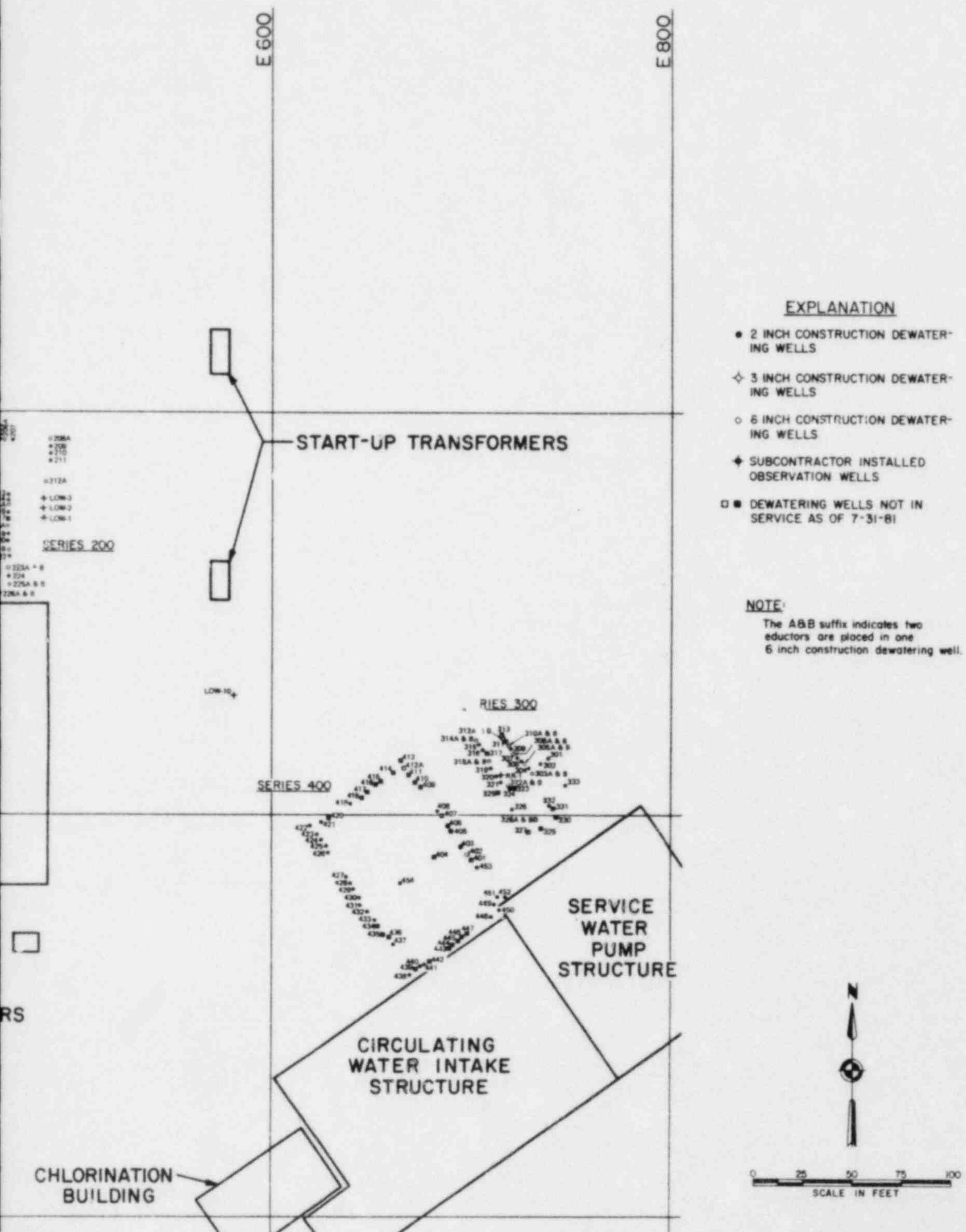


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Groundwater Levels in the Vicinity of the Diesel Generator Building Near the Completion of Pumping Test Well PD-20 (11/12/80)

(SK-G-517, Rev 0)
FSAR Figure 2.4-44


ZERO
E 200
E 400
S 4800
S 5000
S 5200
RADWASTE BUILDING
AUXILIARY BUILDING
UNIT 1 CONTAINMENT
UNIT 2 CONTAINMENT
SERIES 100
TEW SERIES
TEW SERIES
ADMIN. AND SERVICE BLDG.
TURBINE BUILDING
UNIT 1 TRANSFORMERS
UNIT 2 TRANSFORME
DIESEL GENERATOR BUILDING

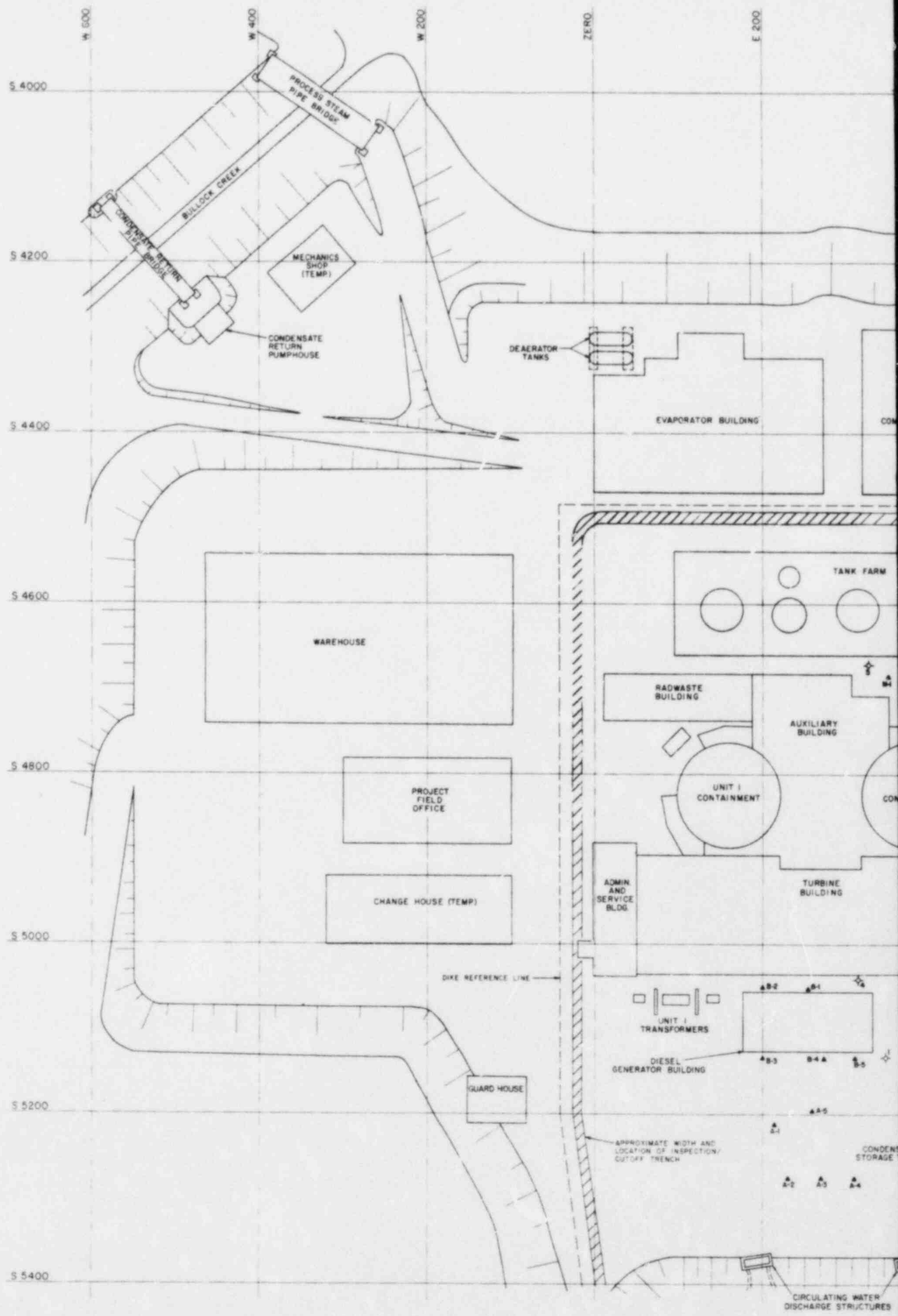


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

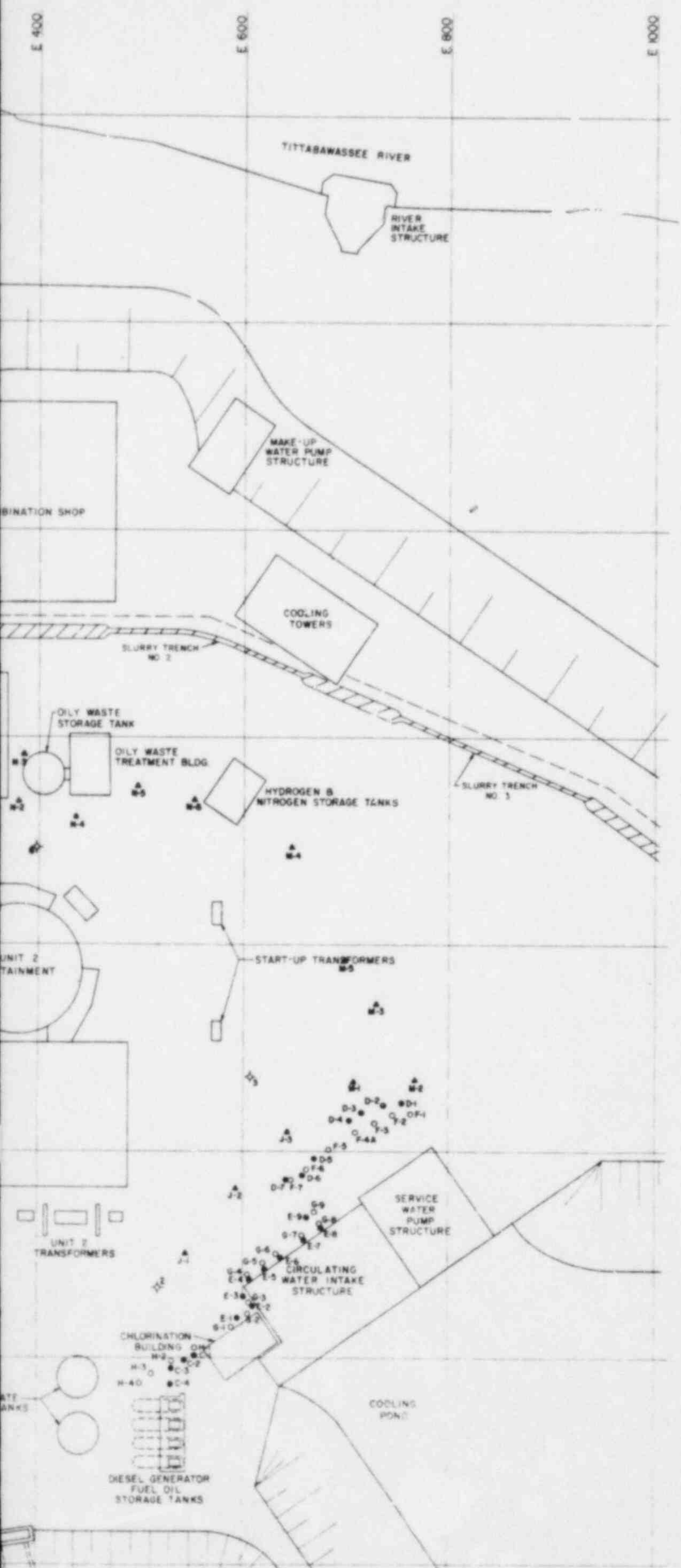
Location of Construction Dewatering Wells

(SK-G-455, Rev 2)

FSAR Figure 2.4-45

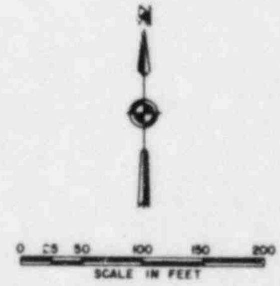


W 600
W 400
W 200
ZERO
E 200
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
BULLOCK CREEK
CONDENSATE RETURN PIPE BRIDGE
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BUILDING
TANK FARM
WAREHOUSE
RADWASTE BUILDING
AUXILIARY BUILDING
UNIT I CONTAINMENT
PROJECT FIELD OFFICE
CHANGE HOUSE (TEMP)
ADMIN. AND SERVICE BLDG.
TURBINE BUILDING
DIKE REFERENCE LINE
UNIT I TRANSFORMERS
DIESEL GENERATOR BUILDING
GUARD HOUSE
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/ CUTOFF TRENCH
CIRCULATING WATER DISCHARGE STRUCTURES



LEGEND

- ● PERMANENT INTERCEPTOR WELL
- ○ PERMANENT BACKUP INTERCEPTOR WELL
- ▲ PERMANENT AREA WELL
- ◇ PERMANENT MONITORING WELL

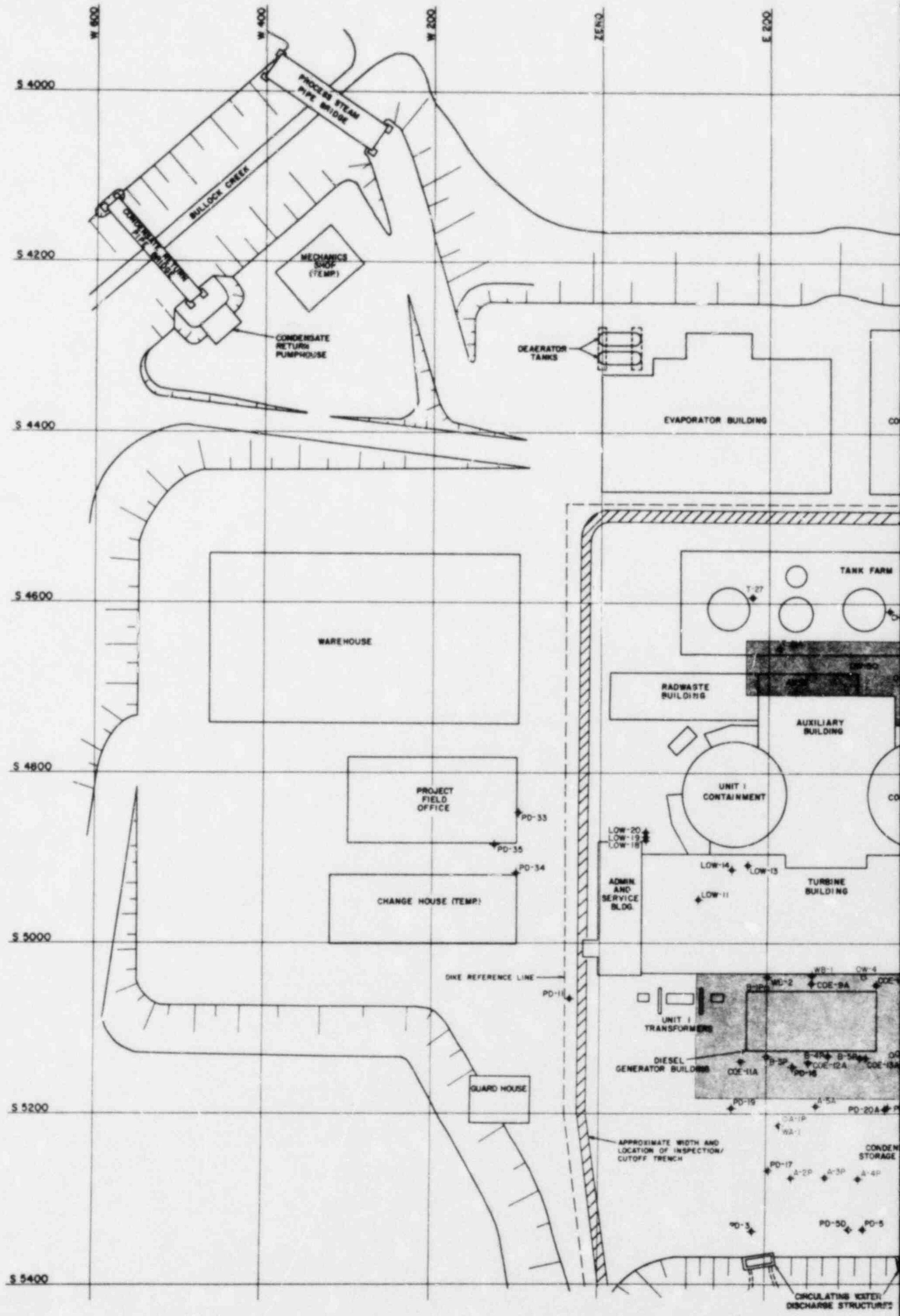


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

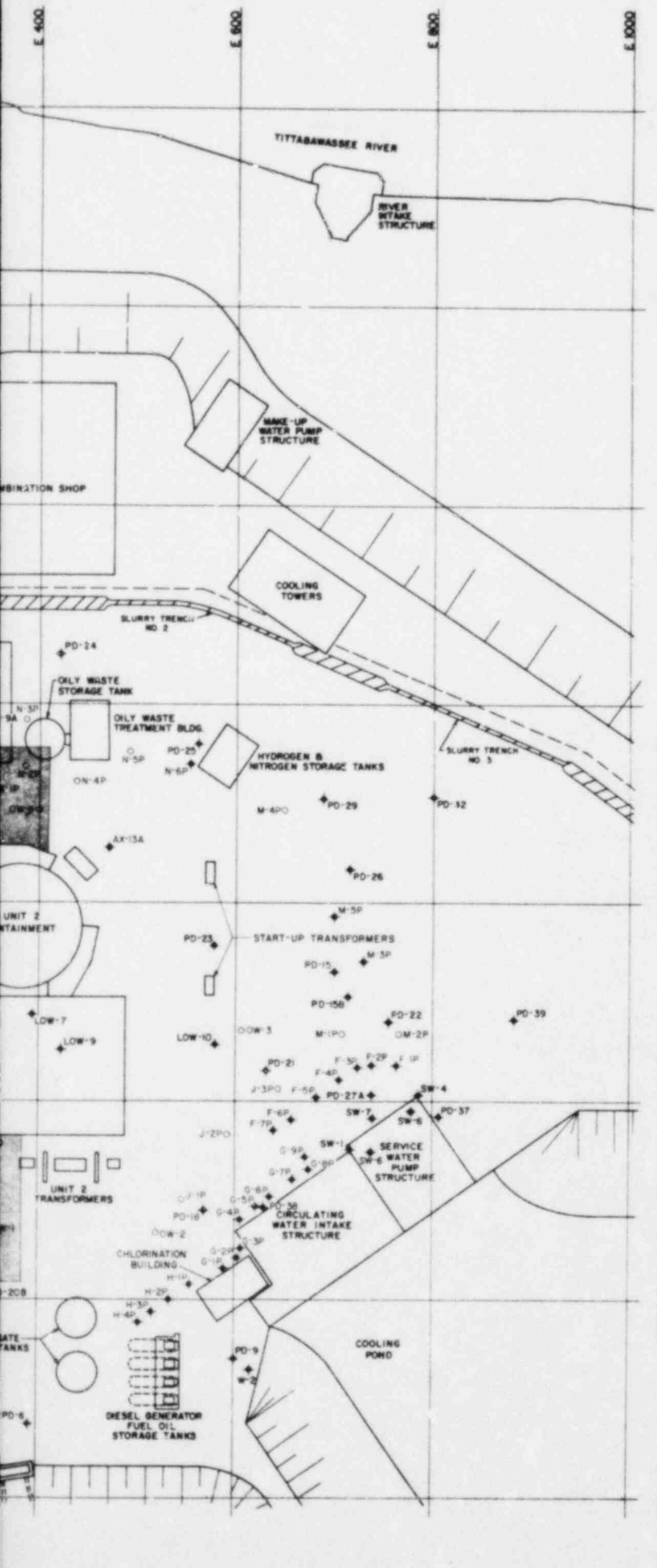
Permanent Dewatering and Monitoring Well Location Plan

(SK-G-454, Rev 1)

FSAR Figure 2.4-46



W 600
W 400
W 200
ZERO
E 200
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
BULLOCK CREEK
CONDENSATE RETURN PIPE BRIDGE
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BUILDING
WAREHOUSE
TANK FARM
T-27
RADWASTE BUILDING
AUXILIARY BUILDING
UNIT I CONTAINMENT
PROJECT FIELD OFFICE
PD-33
PD-35
PD-34
CHANGE HOUSE (TEMP)
LOW-20
LOW-19
LOW-18
ADMIN. AND SERVICE BLDG.
LOW-14
LOW-13
LOW-11
TURBINE BUILDING
DIKE REFERENCE LINE
PD-11
UNIT I TRANSFORMERS
DIESEL GENERATOR BUILDING
COE-11A
COE-9A
COE-12A
MD-2
WB-1
OW-4
B-4P
B-5P
B-9P
PD-16
PD-19
A-5A
PD-20A
GUARD HOUSE
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/ CUTOFF TRENCH
PD-17
A-2P
A-3P
A-4P
PD-3
PD-5D
PD-5
CIRCULATING WATER DISCHARGE STRUCTURE



EXPLANATION

◆ EXISTING OBSERVATION WELL
○ PLANNED OBSERVATION WELL
■ AREAS OF GRANULAR BACKFILL COMMITTED TO PERMANENT DEWATERING BELOW EL 610

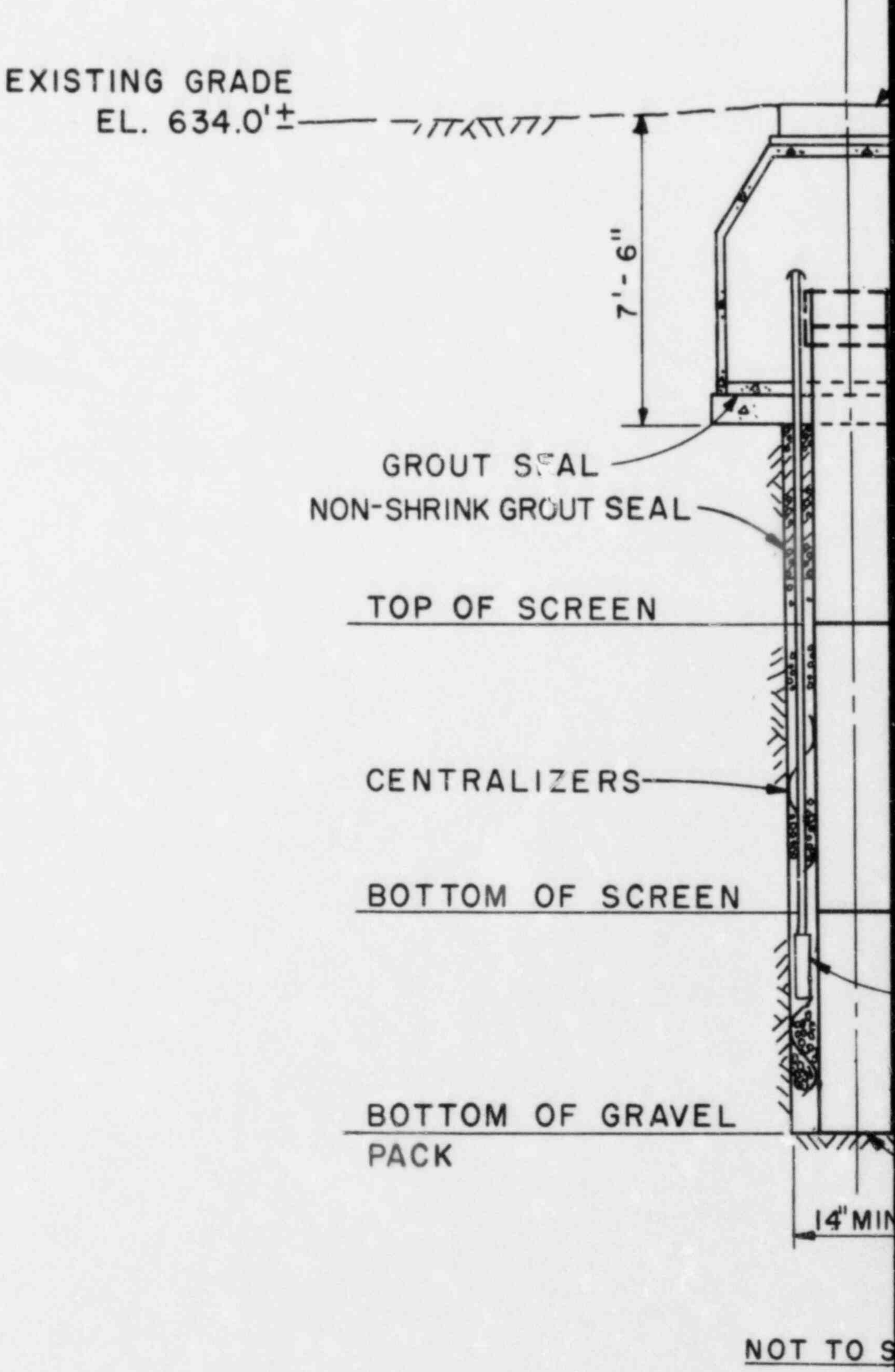
NOTE:
The C, D, and E Observation Wells planned adjacent to G, F, and H Observation Wells are not shown.

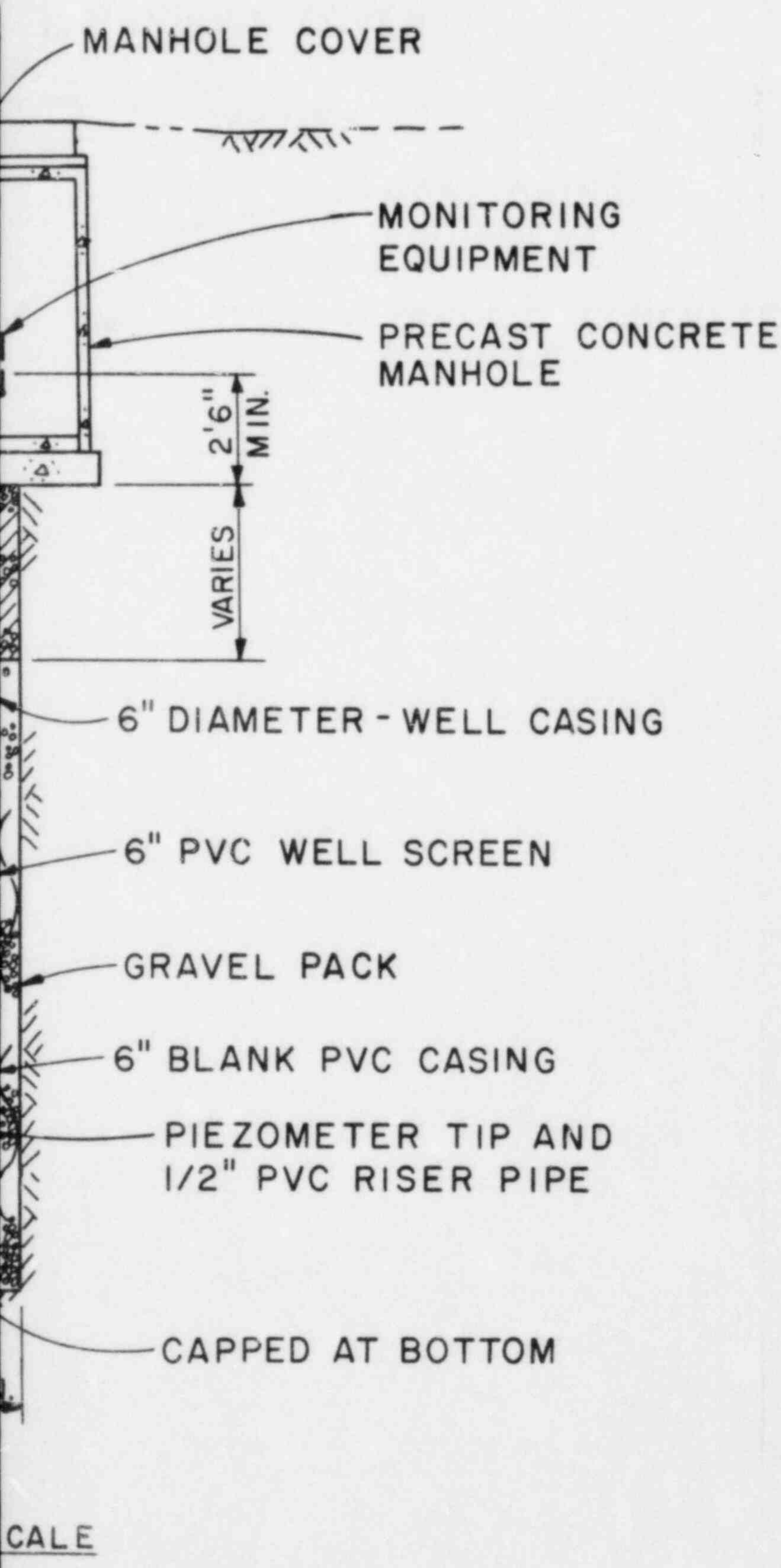
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Areas Committed to Permanent Dewatering

(SK-G-628, Rev 0)

FSAR Figure 2.4-47

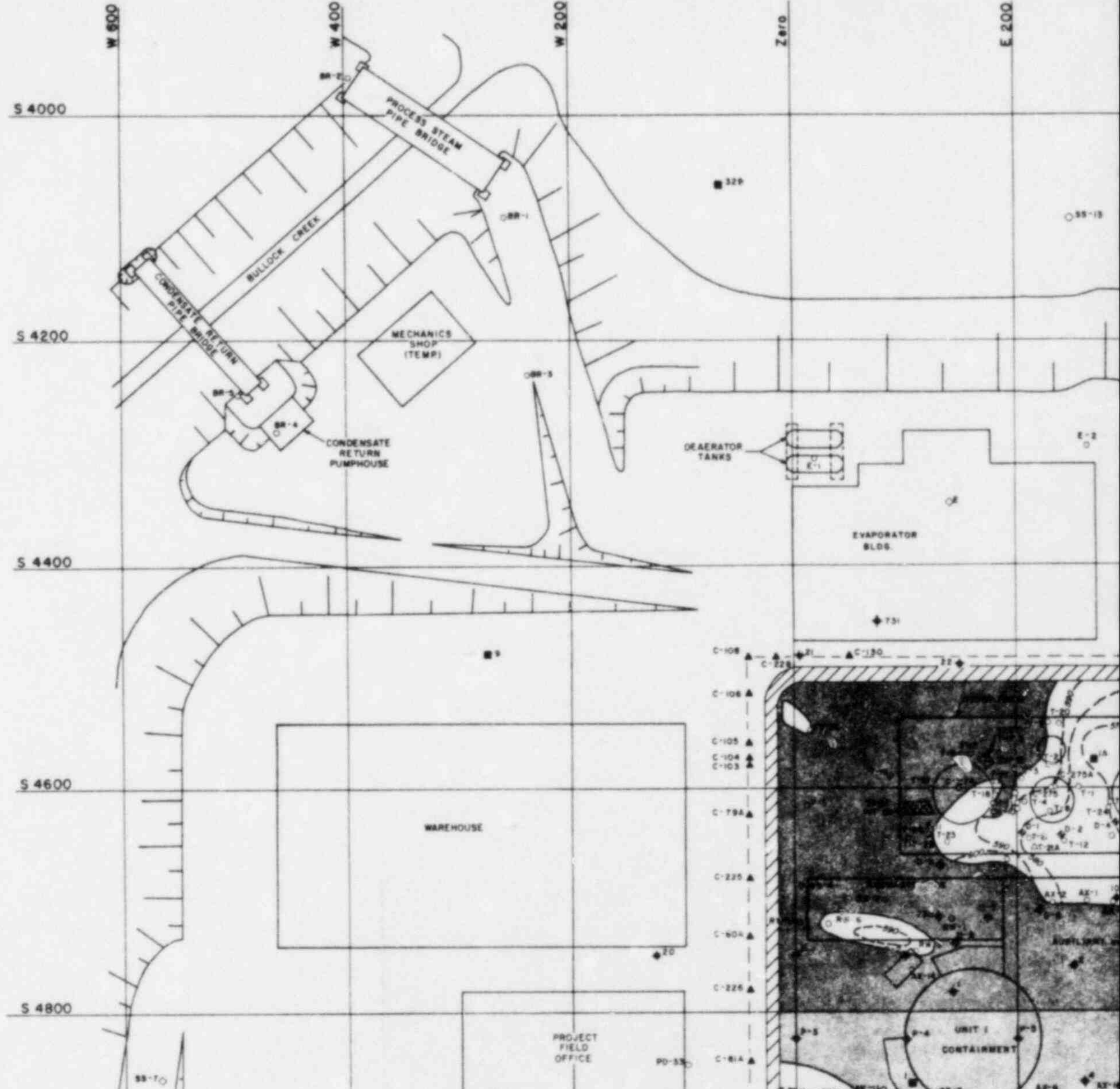

EXISTING GRADE
EL. 634.0'±
7'-6"
GROUT SEAL
NON-SHRINK GROUT SEAL
TOP OF SCREEN
CENTRALIZERS
BOTTOM OF SCREEN
BOTTOM OF GRAVEL PACK
14" MIN
NOT TO S



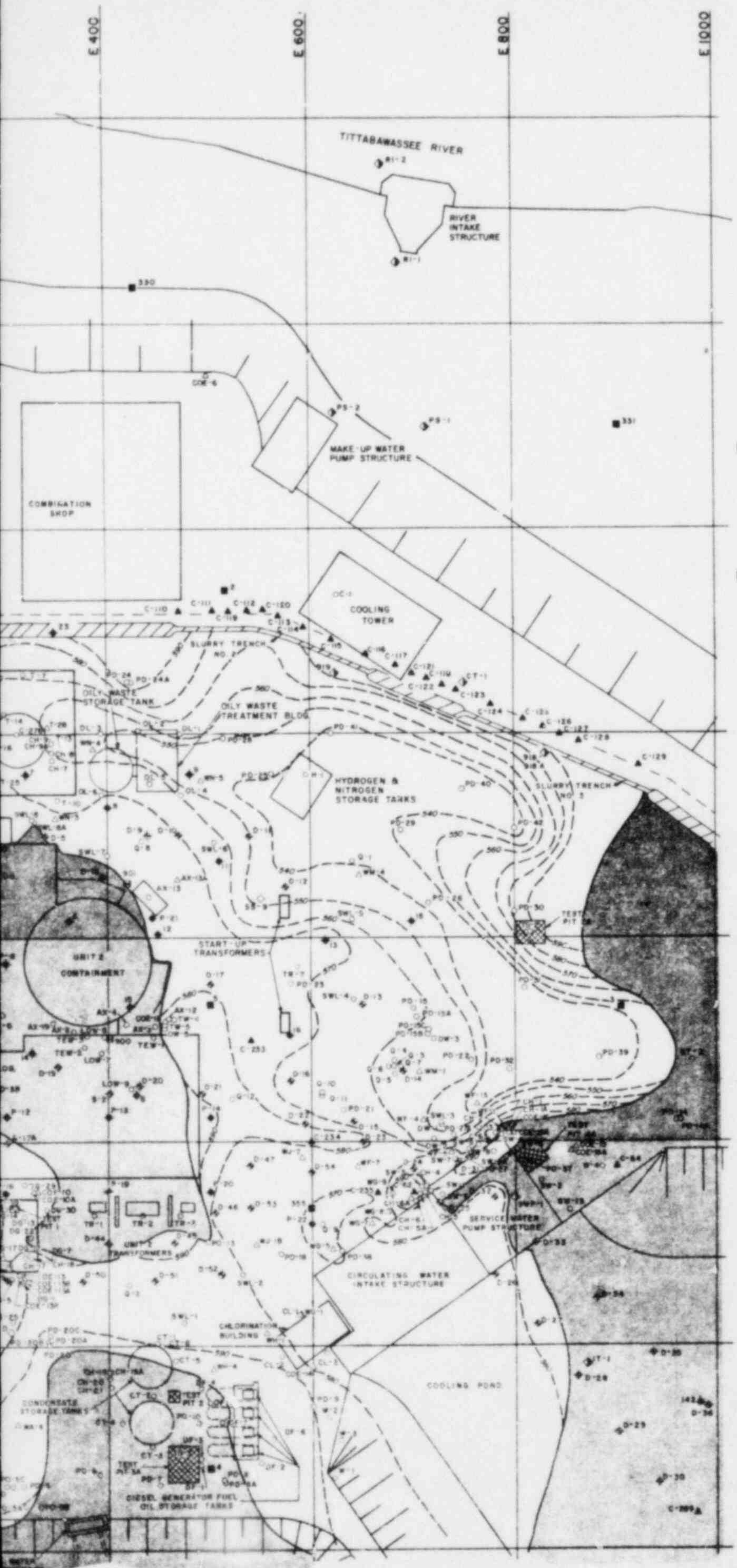
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Typical Permanent
Monitoring Well Section
(SK-G-450, Rev 1)

FSAR Figure 2.4-48



W 600
W 400
W 200
Zero
E 200
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
BULLOCK CREEK
CONDENSATE RETURN PIPE BRIDGE
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BLDG.
WAREHOUSE
PROJECT FIELD OFFICE
CHANGE HOUSE (TEMP)
ADMIN AND SERVICE BLDG.
UNIT 1 CONTAINMENT
UNIT 1 TRANSFORMERS
DIESEL GENERATOR BUILDING
GUARD HOUSE
DIKE REFERENCE LINE
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/ CUTOFF TRENCH



NOTES:

1. The remaining natural sands are described as Unit c in the FSAR.
2. Elevations on bottom of natural sands based on interpretation of boring logs and construction records.

EXPLANATION

EXPLORATION PROGRAM - PRECONSTRUCTION

- ■ MICHIGAN DRILLING COMPANY BORINGS; 1956 & 1968
- ◆ DAMES & MOORE BORINGS; 1967, 1968 & 1969

EXPLORATION PROGRAM - CONSTRUCTION PERIOD

- ▲ WALTER FLOOD COMPANY BORINGS; 1969 & 1970
- ◆ BECHTEL BORINGS, 1970
- ■ SOIL & MATERIALS ENGINEERING INC. BORINGS; 1973 & 1974
- ◐ BECHTEL BORINGS, 1973 & 1974
- ○ BECHTEL BORINGS, 1977 & 1978
- ◦ BECHTEL BORINGS; 1978, 1979, 1980 & 1981
- △ WOODWARD-CLYDE CONSULTANTS BORINGS; 1981
- ▩ BECHTEL TEST PITS; 1978 & 1979
- ■ BACKFILL AREAS INSIDE THE DIKE INSPECTION/CUTOFF TRENCH UNDERLAIN BY CLAY
- ☐ BACKFILL AREAS INSIDE THE DIKE INSPECTION/CUTOFF TRENCH UNDERLAIN BY NATURAL SAND
- 570 CONTOUR REPRESENTS APPROXIMATE BOTTOM OF NATURAL SAND AFTER CONSTRUCTION. CONTOUR INTERVAL IS 10 FEET

N

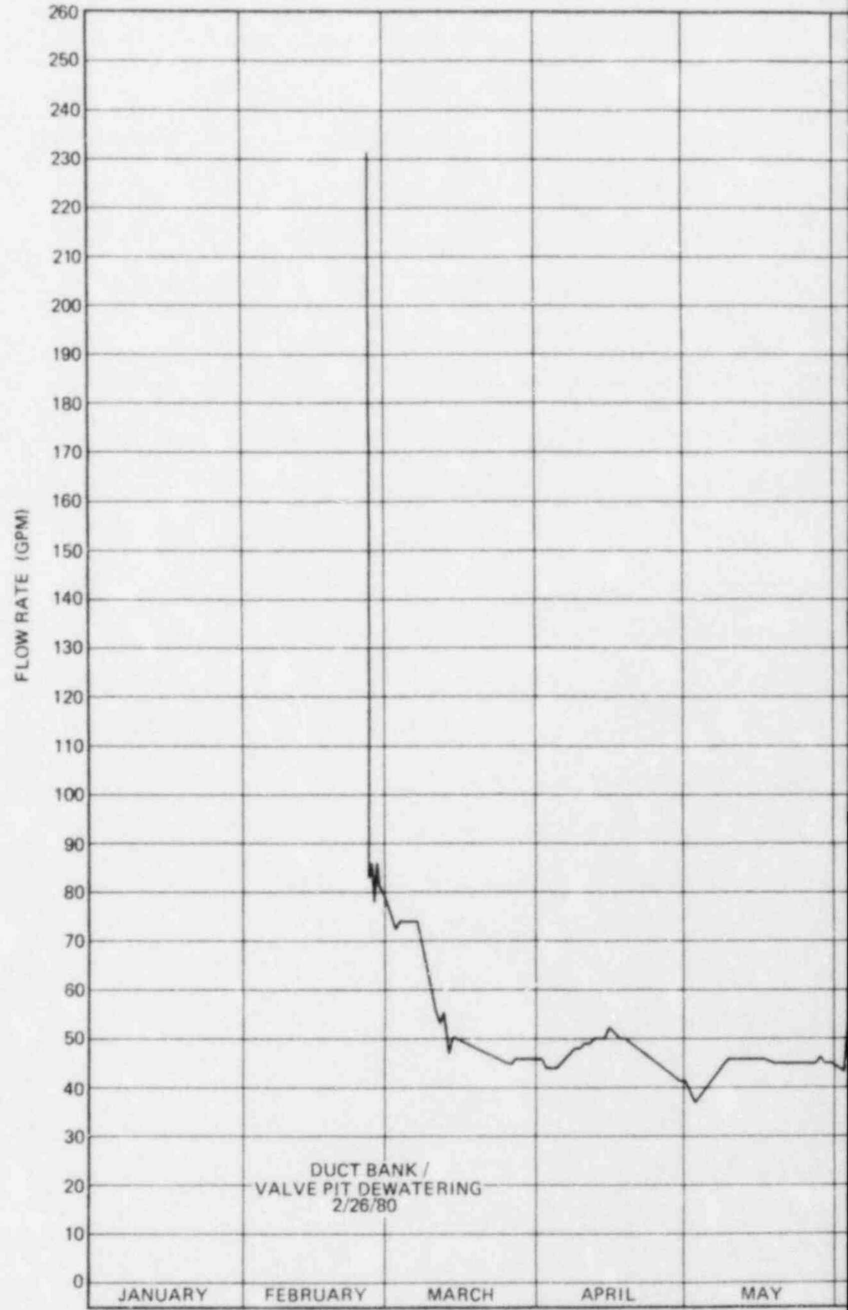
0 25 50 100 150 200
SCALE IN FEET

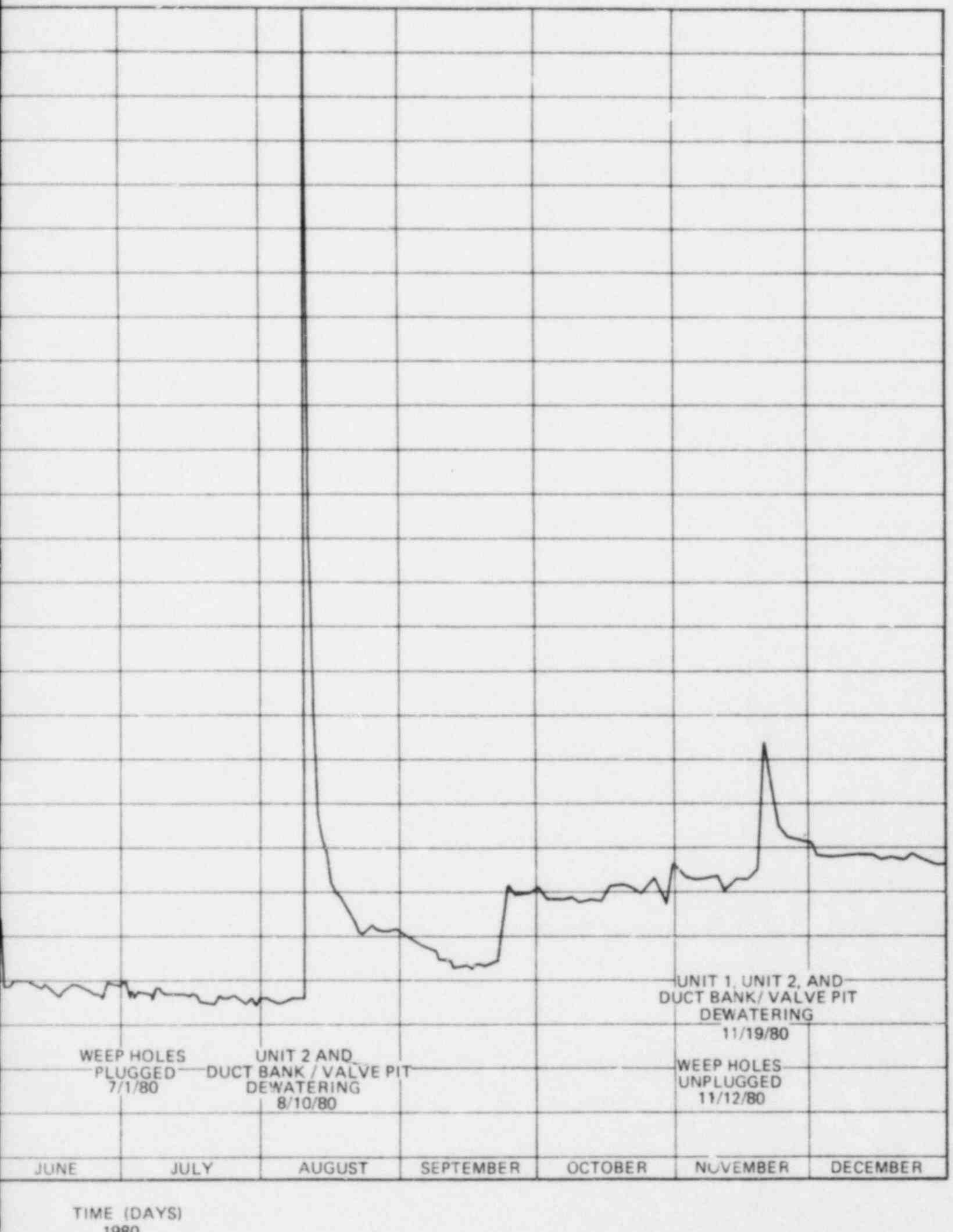
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Contours on Bottom of Natural Sand After Construction

(SK-G-599, Rev 0)

FSAR Figure 2.4-49

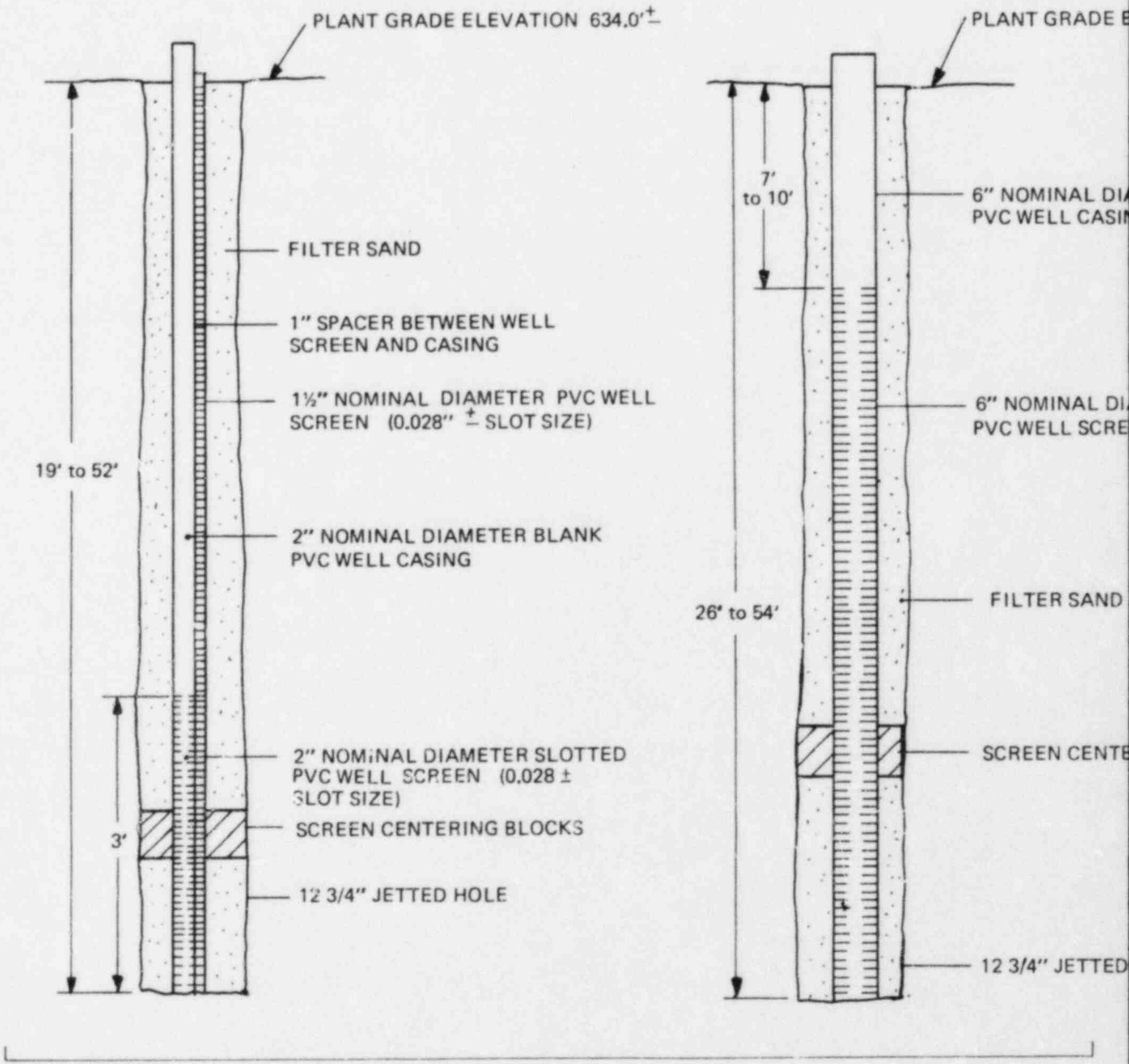

FLOW RATE (GPM)
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
DUCT BANK /
VALVE PIT DEWATERING
2/26/80
JANUARY
FEBRUARY
MARCH
APRIL
MAY



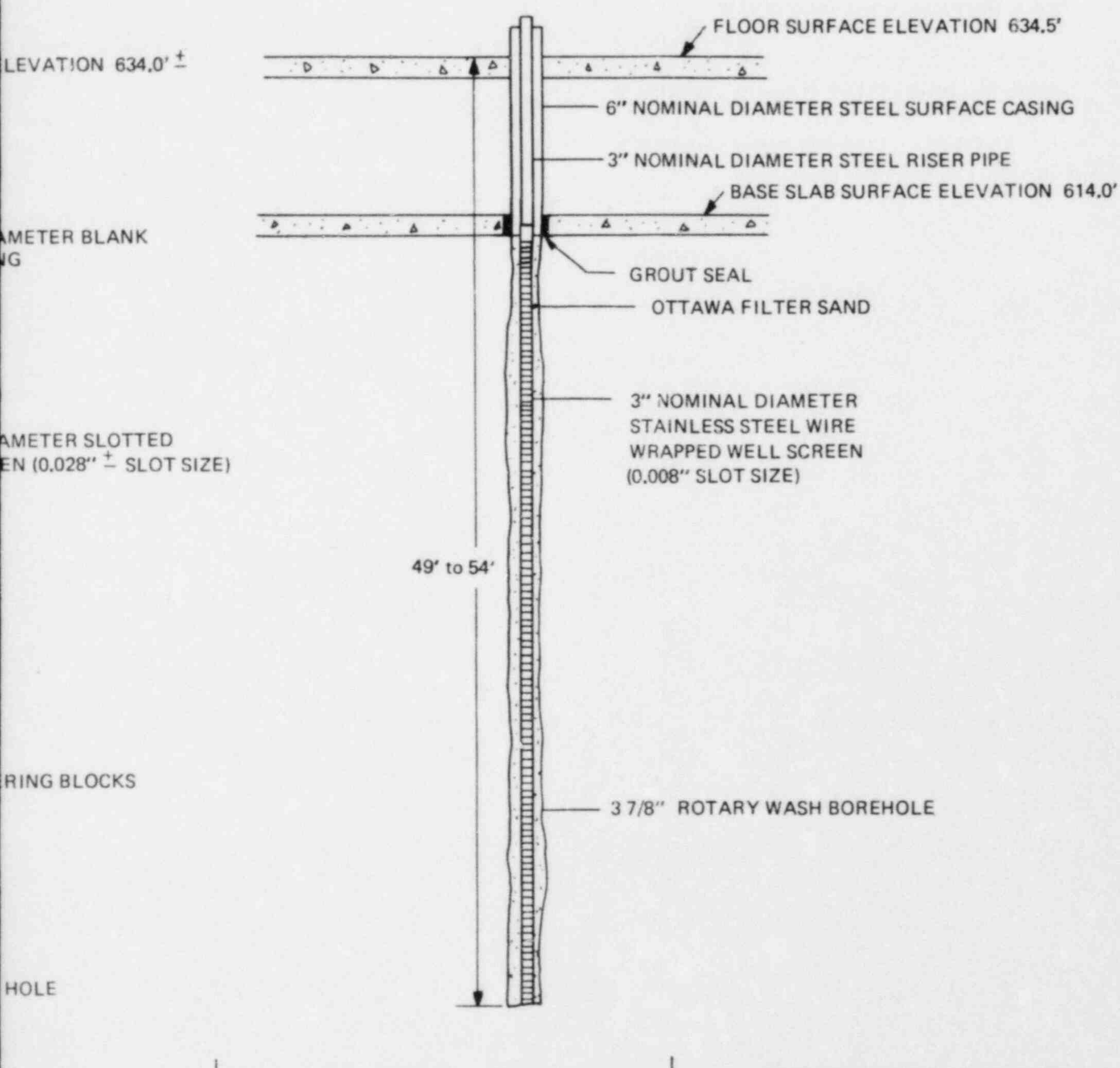
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Flowrate vs Time Construction Dewatering System 1980 (Sheet 1) (SK-G-446, Rev 0)

FSAR Figure 2.4-50



TYPICAL SECTIONS OF DEWATERING WELLS IN THE YARD AREA
NOT TO SCALE



TYPICAL SECTION OF DEWATERING WELLS
INSIDE THE TURBINE BUILDING

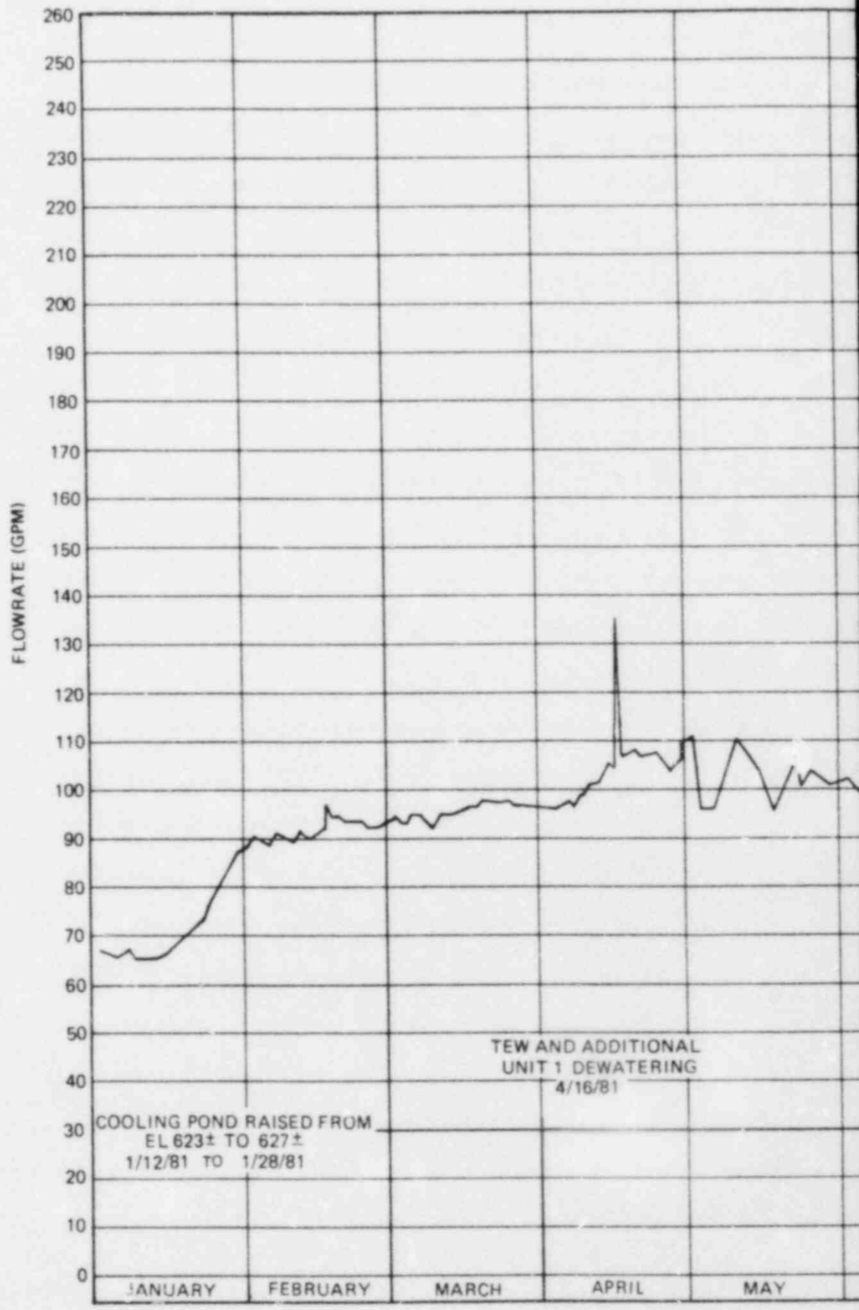
NOT TO SCALE

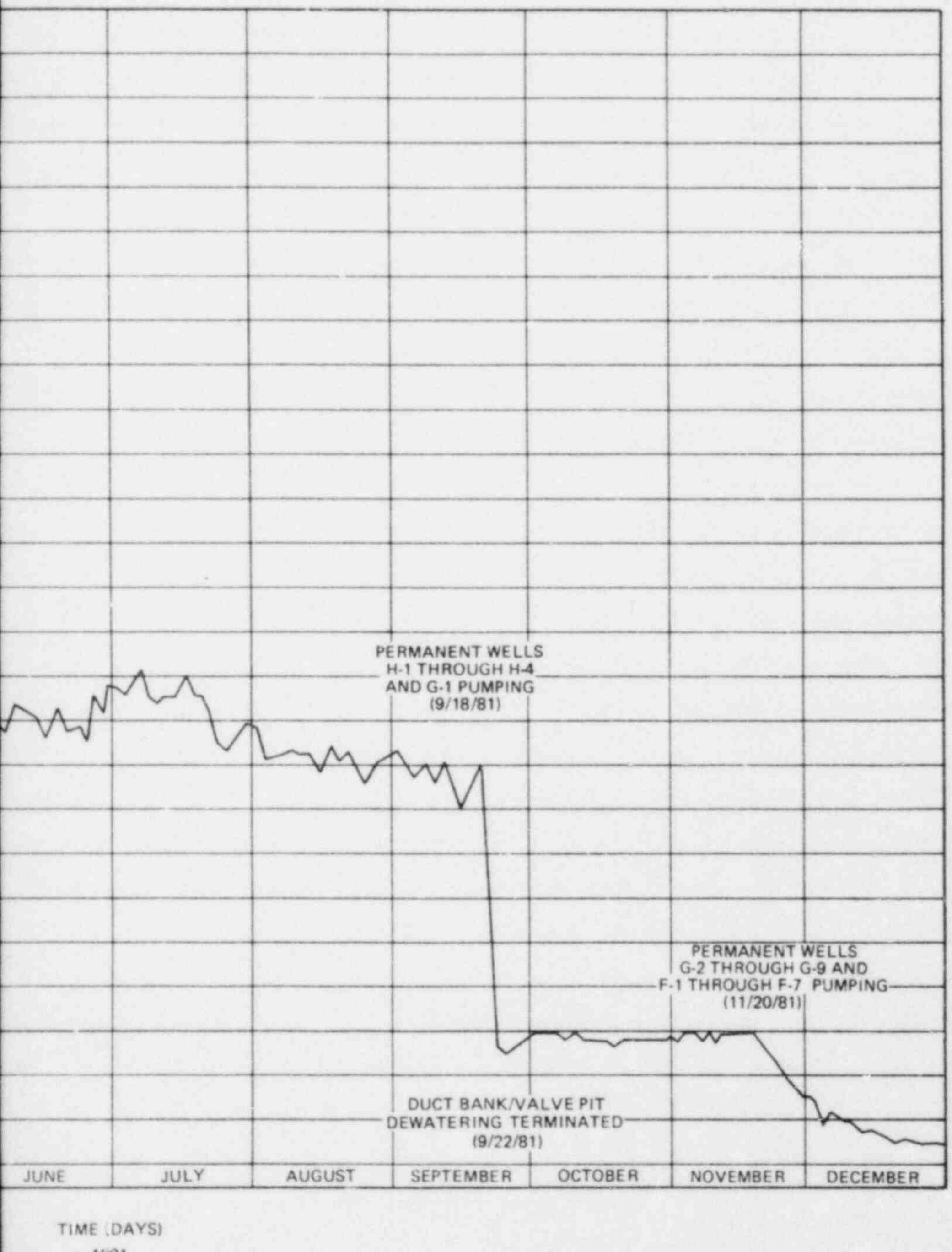
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Typical Sections of Construction
Dewatering Wells

(SK-G-442, Rev 0)

FSAR Figure 2.4-51

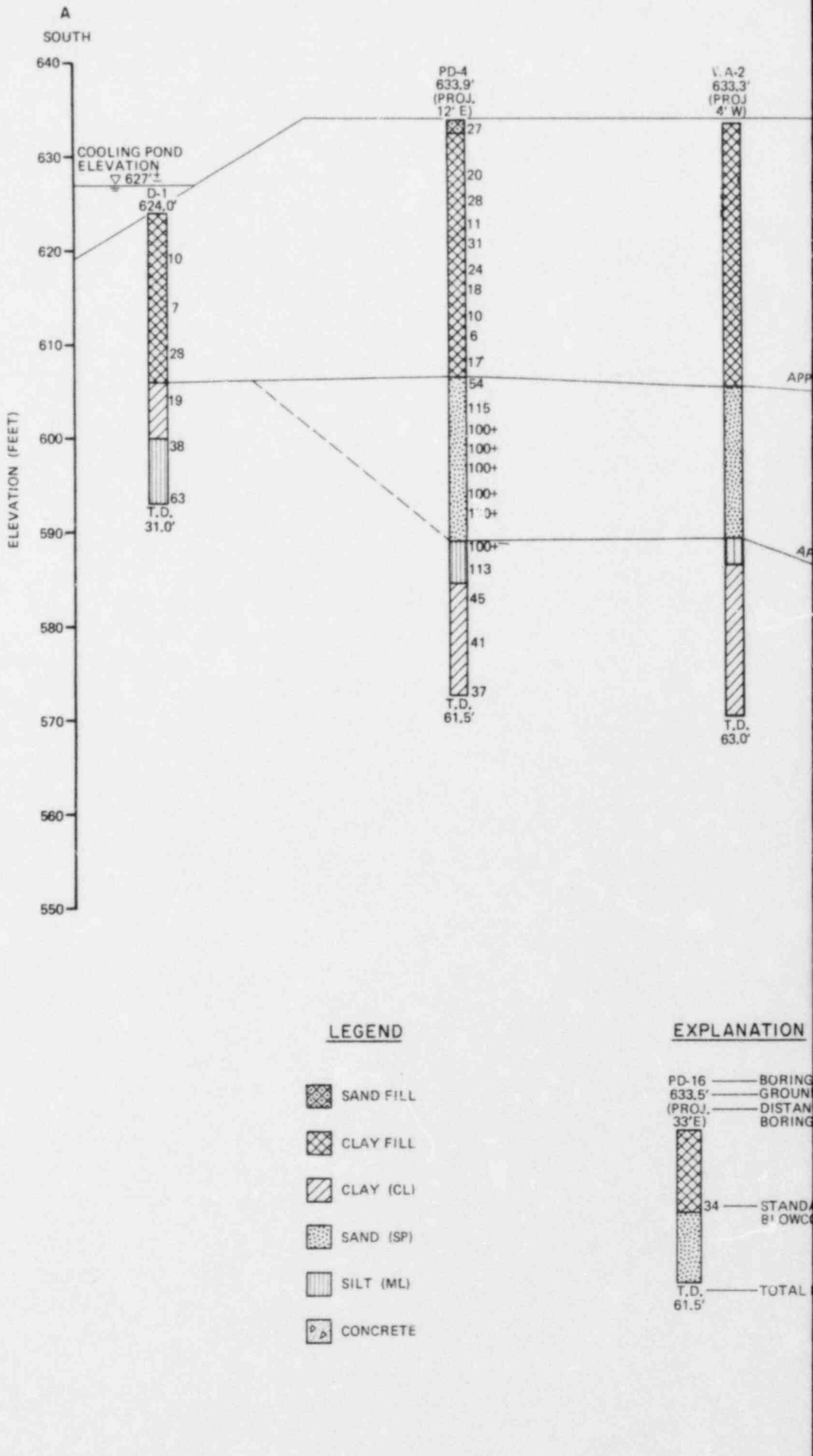

FLOWRATE (GPM)
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
JANUARY
FEBRUARY
MARCH
APRIL
MAY
TEW AND ADDITIONAL
UNIT 1 DEWATERING
4/16/81
COOLING POND RAISED FROM
EL 623± TO 627±
1/12/81 TO 1/28/81

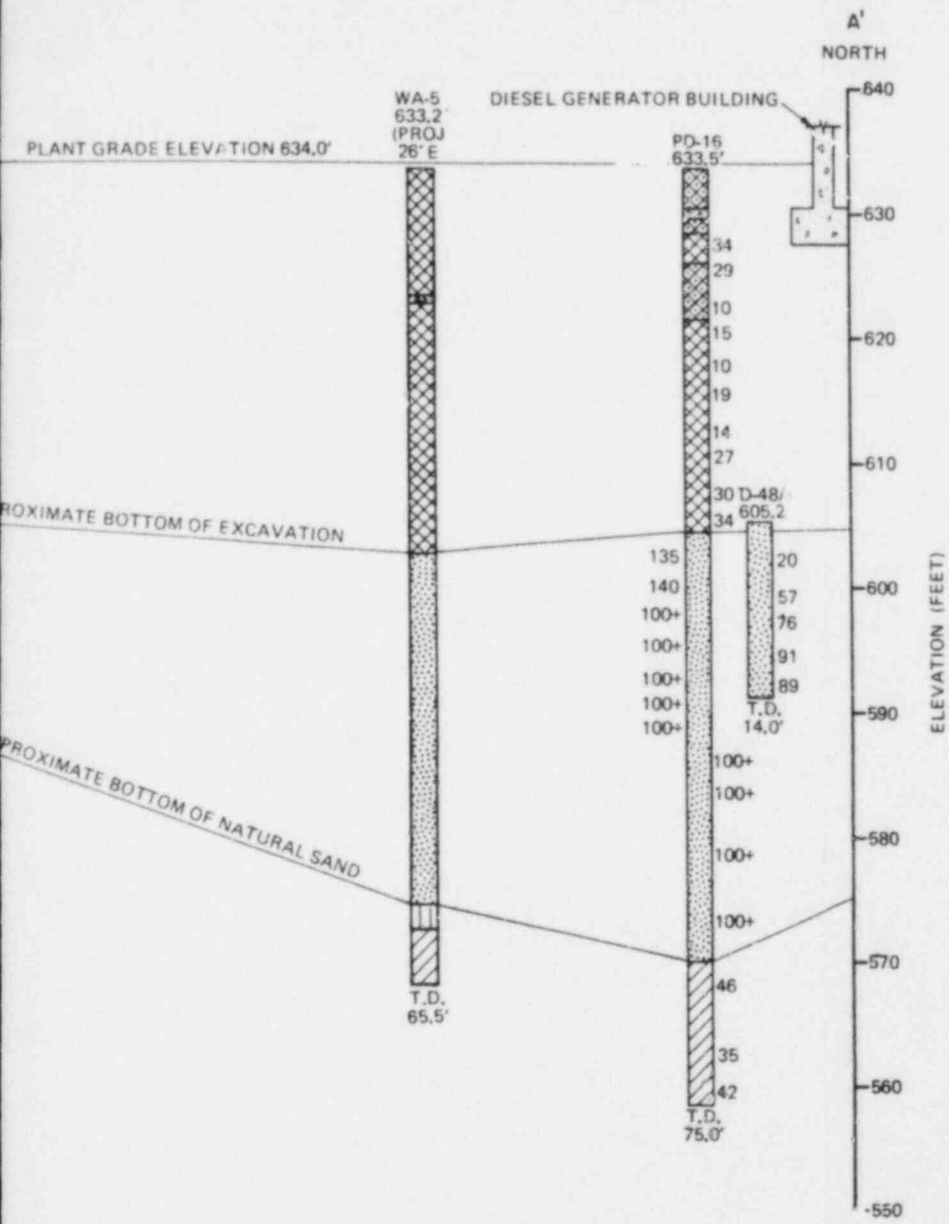


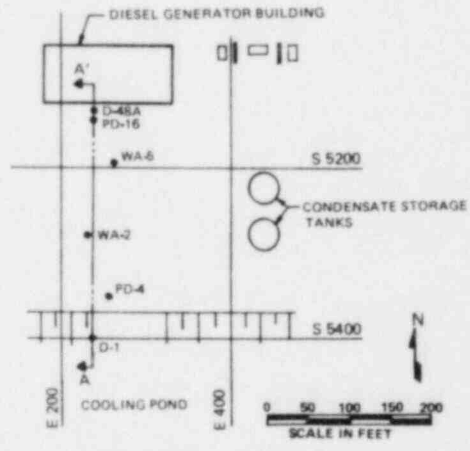
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Flowrate vs Time Construction
Dewatering System
1981 (Sheet 2)
(SK-G-522, Rev 0

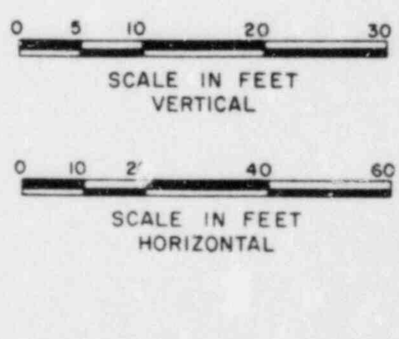
FSAR Figure 2.4-52


A
SOUTH
ELEVATION (FEET)
640
630
620
610
600
590
580
570
560
550
COOLING POND ELEVATION
▽ 627'±
D-1
624.0'
10
7
28
19
38
63
T.D.
31.0'
PD-4
633.9'
(PROJ.
12' E)
27
20
28
11
31
24
18
10
6
17
54
115
100+
100+
100+
100+
100+
113
45
41
37
T.D.
61.5'
633.3'
(PROJ
4' W)
T.D.
63.0'
LEGEND
SAND FILL
CLAY FILL
CLAY (CL)
SAND (SP)
SILT (ML)
CONCRETE
EXPLANATION
PD-16
633.5'
(PROJ.
33'E)
34
T.D.
61.5'





CROSS-SECTION LOCATION PLAN



NUMBER
SURFACE ELEVATION
E AND DIRECTION OF
TO SECTION LINE

RD PENETRATION
UNT (BLOWS/FOOT)

EPTH IN FEET

NOTES:

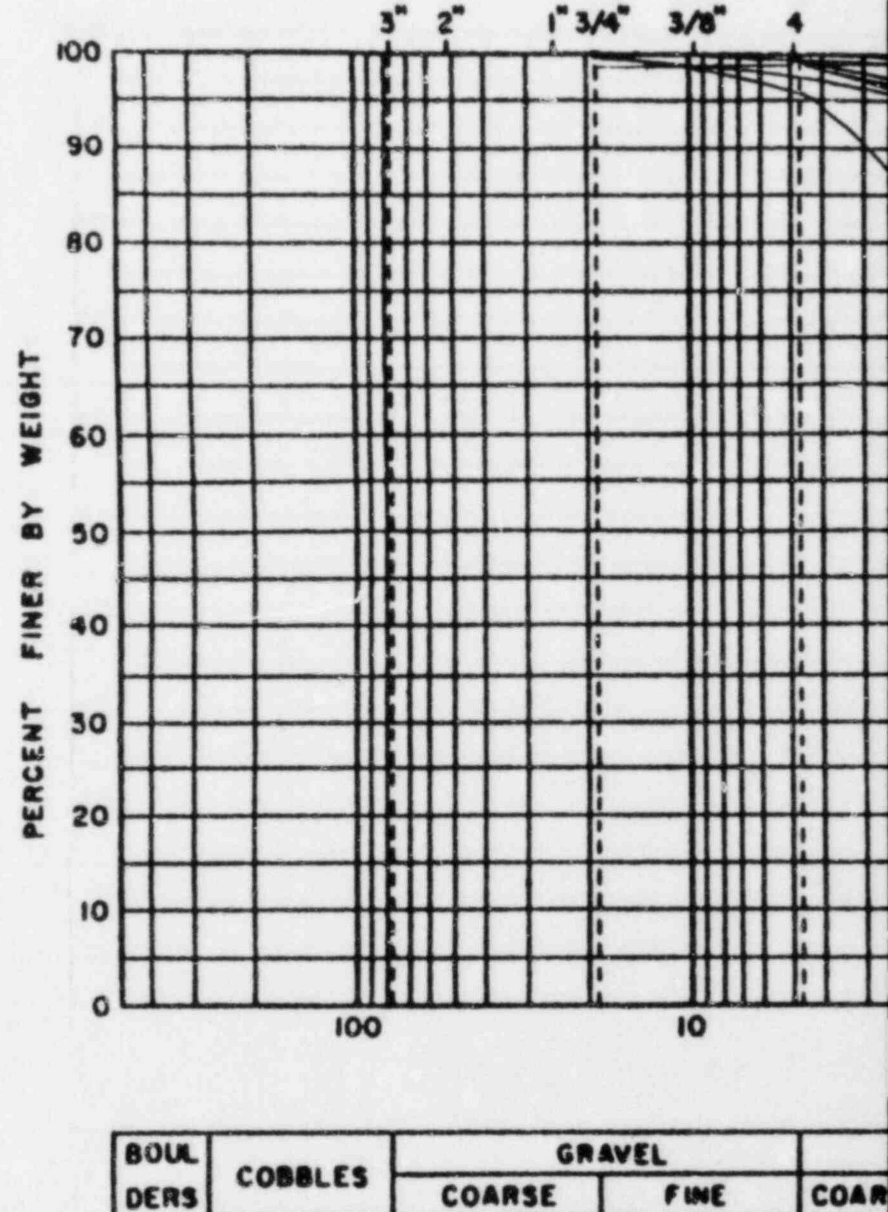
1. D-1 was drilled in 1978.
2. D-48A was drilled prior to construction.
3. Borings WA-2 and WA-5 were sampled using a pitcher tube sampler. No standard penetration blowcounts are available for these borings.
4. Natural sand is described as Unit C in the FSAR.

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

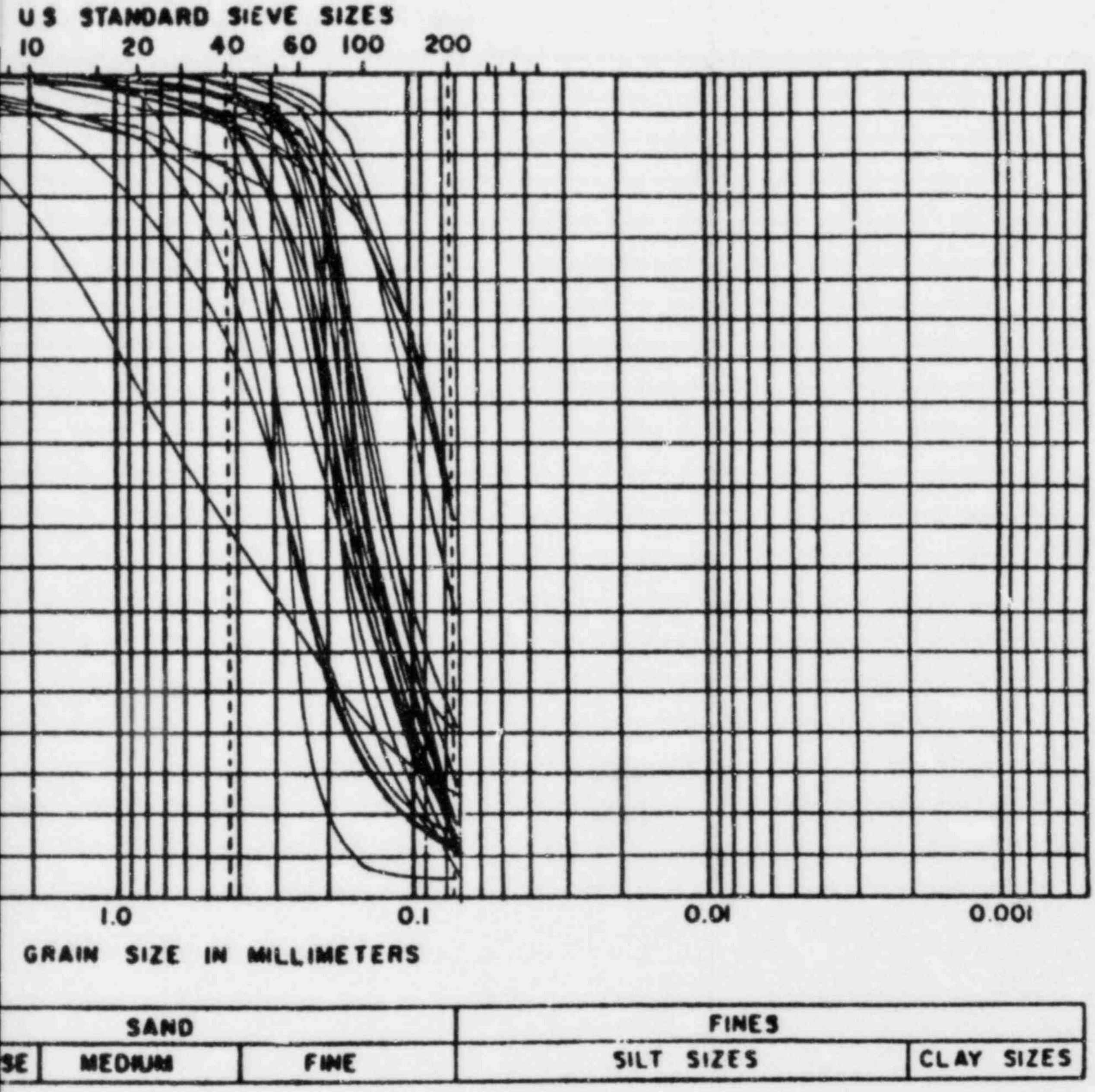
Geologic Cross-Section South of Diesel Generator Building (A-A')

(SK-G-447, Rev 0)

FSAR Figure 2.4-53



3"
2"
1"
3/4"
3/8"
4
100
90
80
70
60
50
40
30
20
10
0
PERCENT FINER BY WEIGHT
100
10
BOULDERS
COBBLES
GRAVEL
COARSE
FINE
COAR



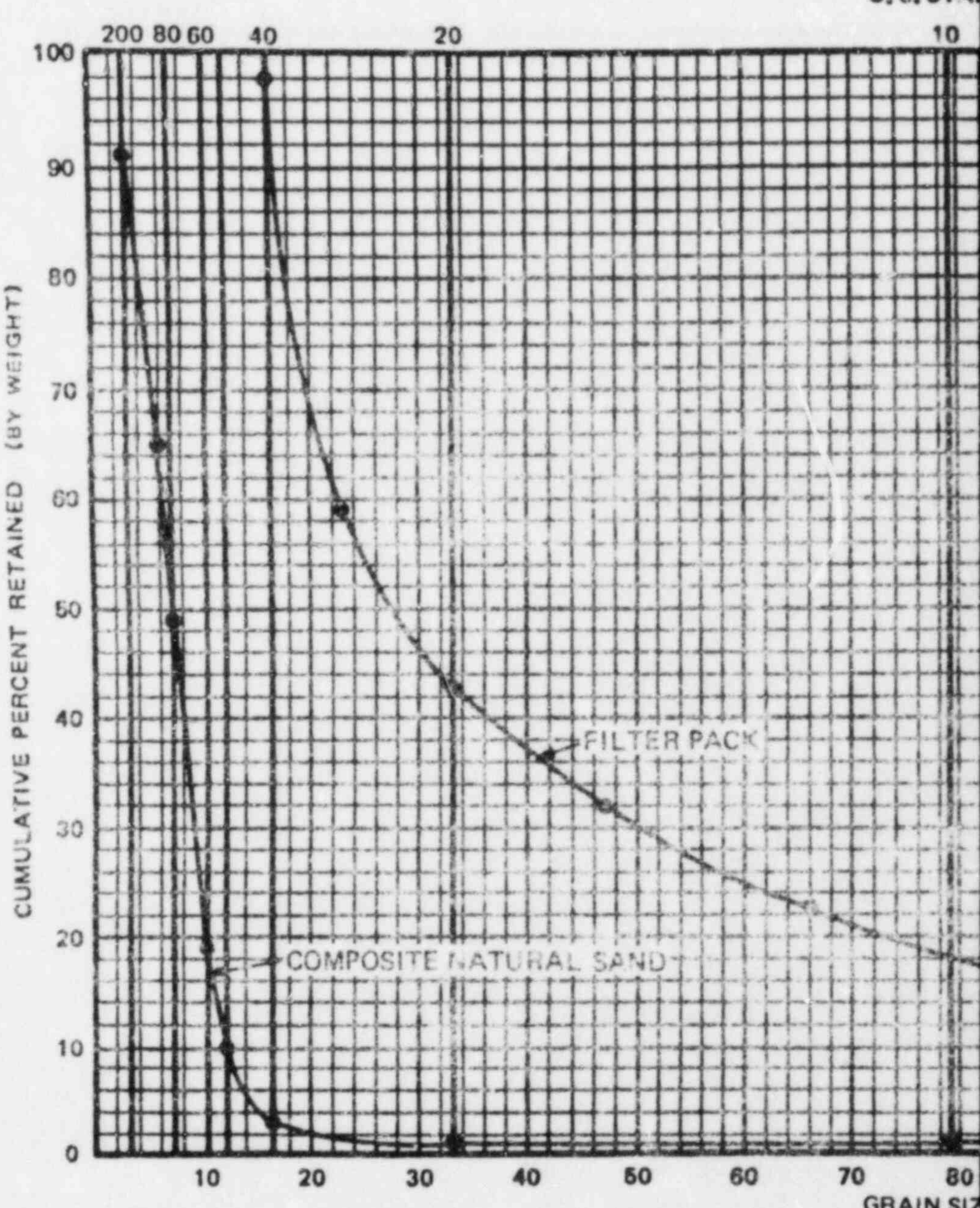
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Composite Grain Size Analyses
PD Borings - Natural Sand

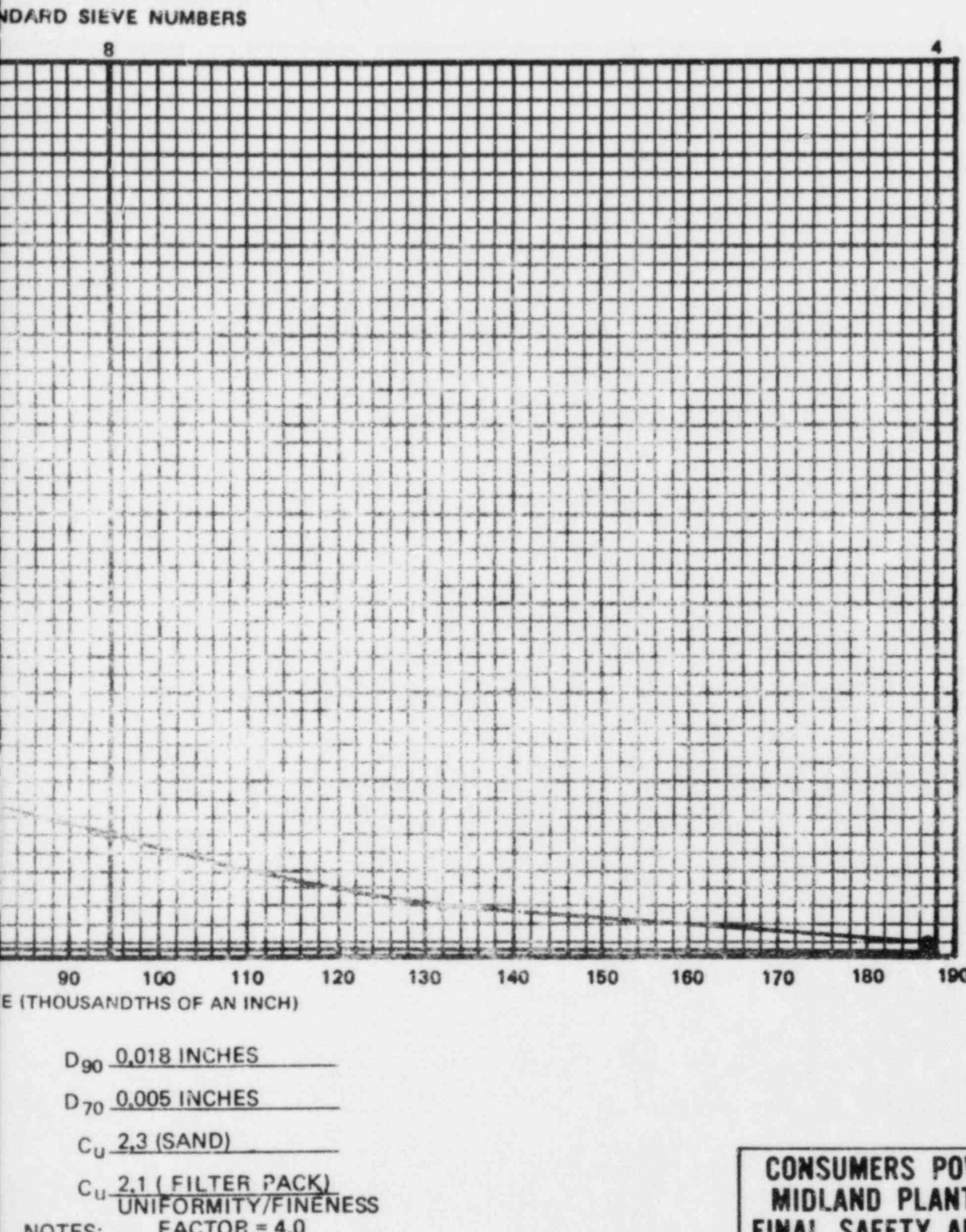
(SK-G-451, Rev 0)

FSAR Figure 2.4-54

6/82 **Revision 44**



U.S. SIEVE	SIEVE OPENING		FILTER PACK SPEC.		
NO.	INCHES	MM.	IDEAL	MIN.	MAX.
1/4	.250	6.35	0	0	0
4	.187	4.76	2.0	0	10
6	.132	3.36	6.0	0	14
8	.094	2.38	14.0	6	22
12	.066	1.68	22.5	14	31
16	.047	1.19	32.0	24	40
20	.033	0.84	43.0	35	51
30	.023	0.60	59.0	51	67
40	.016	0.42	98.0	90	100



D_{90} 0.018 INCHES

D_{70} 0.005 INCHES

C_u 2.3 (SAND)

C_u 2.1 (FILTER PACK)

NOTES: UNIFORMITY/FINENESS FACTOR = 4.0

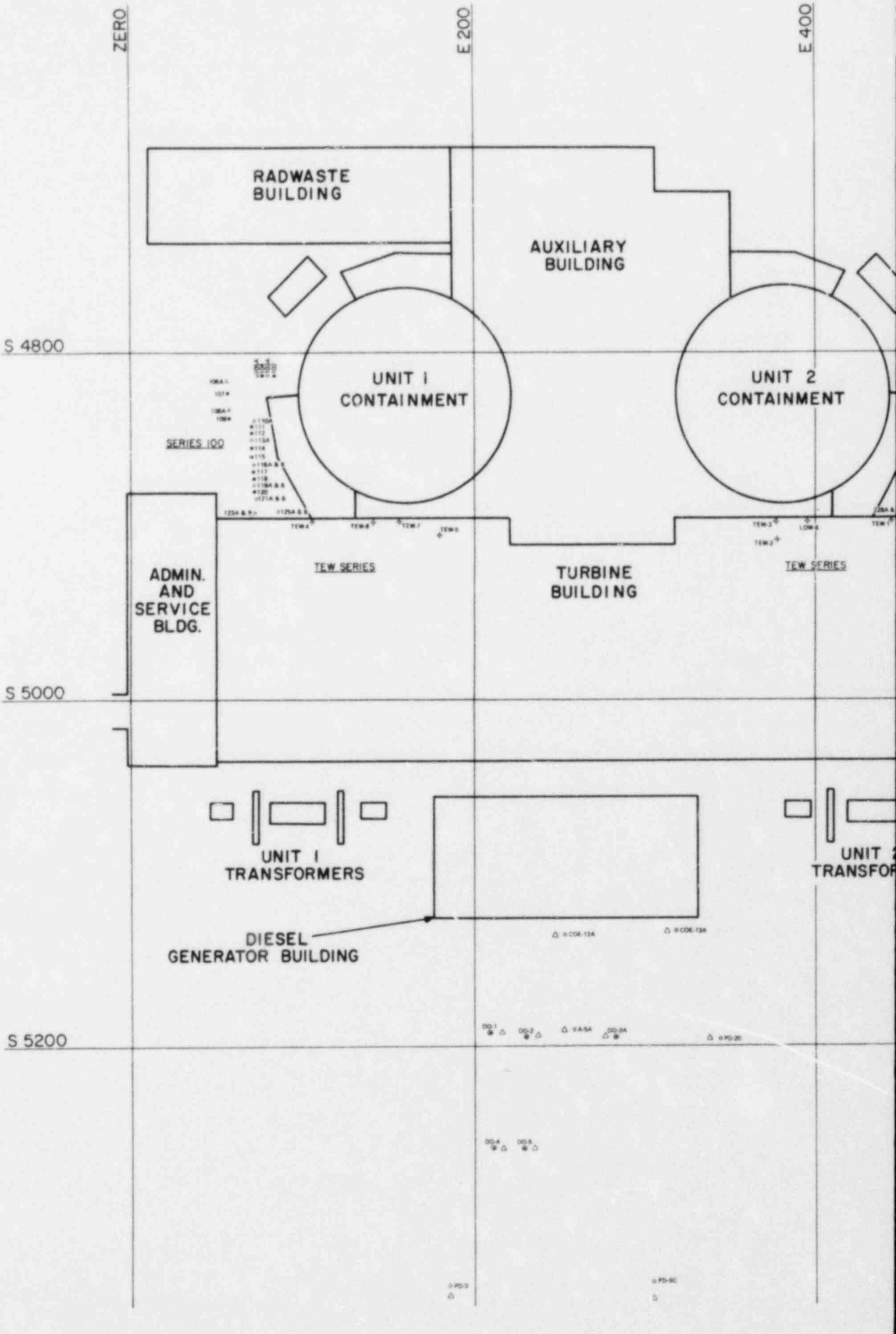
SLOT SIZE *18 (0.018 INCHES)

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

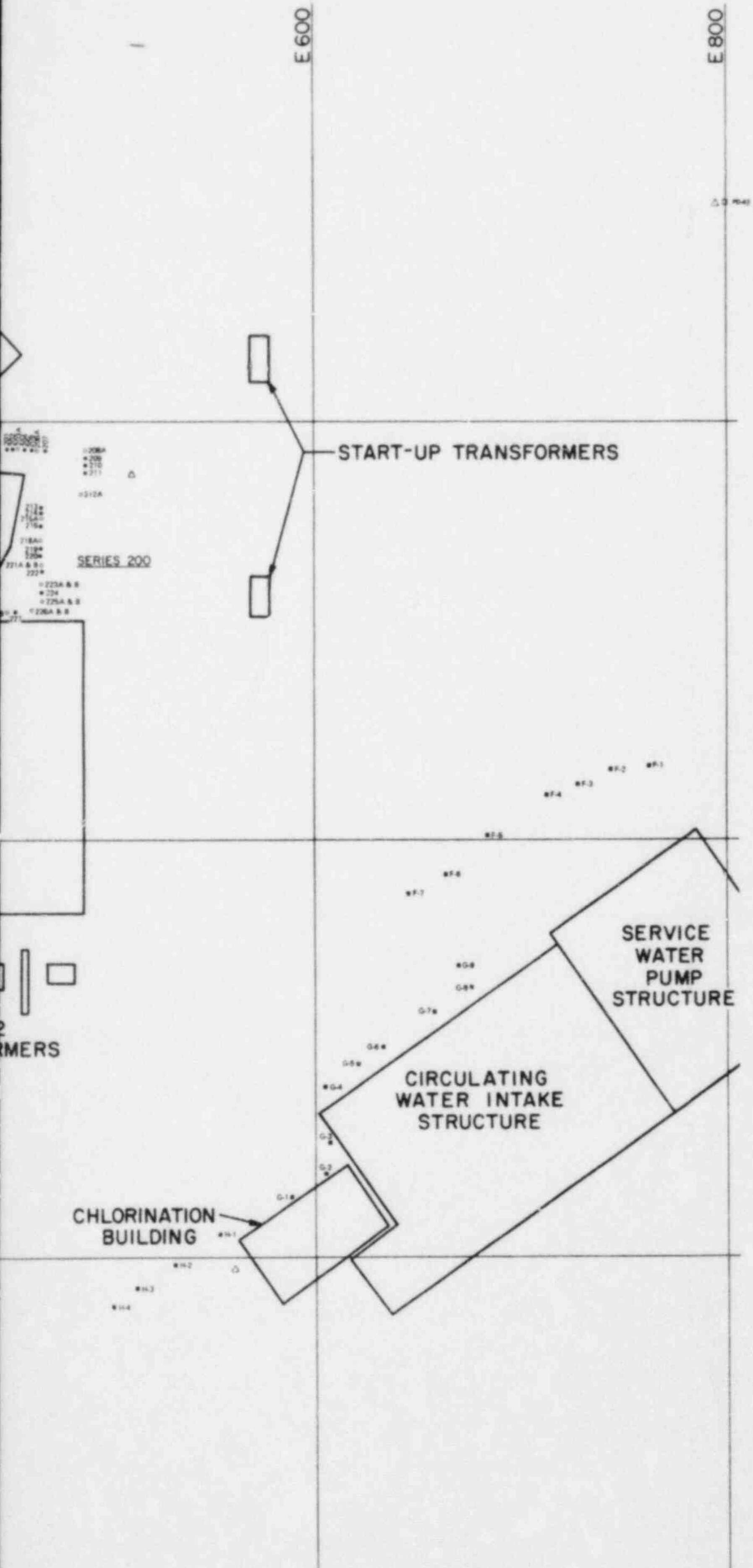
Design of Screen and Filter Pack

(SK-G-452, Rev 0)

FSAR Figure 2.4-55



ZERO
E 200
E 400
S 4800
S 5000
S 5200
RADWASTE BUILDING
AUXILIARY BUILDING
UNIT 1 CONTAINMENT
UNIT 2 CONTAINMENT
SERIES 100
TEW SERIES
TEW SERIES
ADMIN. AND SERVICE BLDG.
TURBINE BUILDING
UNIT 1 TRANSFORMERS
UNIT 2 TRANSFOR
DIESEL GENERATOR BUILDING

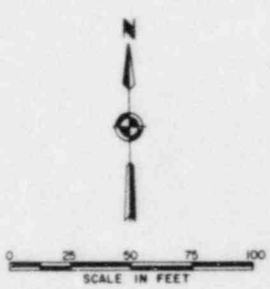


EXPLANATION

- 2 INCH CONSTRUCTION DEWATERING WELLS
- 3 INCH CONSTRUCTION DEWATERING WELLS
- 6 INCH CONSTRUCTION DEWATERING WELLS
- 6 INCH PERMANENT BACKUP WELLS
- 2 INCH INDIVIDUAL EDUCTOR WELLS
- LOCATION OF DISCHARGE
- 6 INCH TEMPORARY DEWATERING WELLS

NOTES:

1. The A&B suffix indicates two eductors are placed in one 6 inch construction dewatering well.
2. During the period December, 1981 to January, 1982, pumping from individual eductor wells PD-3, PD-5C, PD-20, PD-42, A-5A, COE-12A, and COE-13A was terminated and DD-1, DD-2, DD-3A, DD-4, and DD-5 were started.



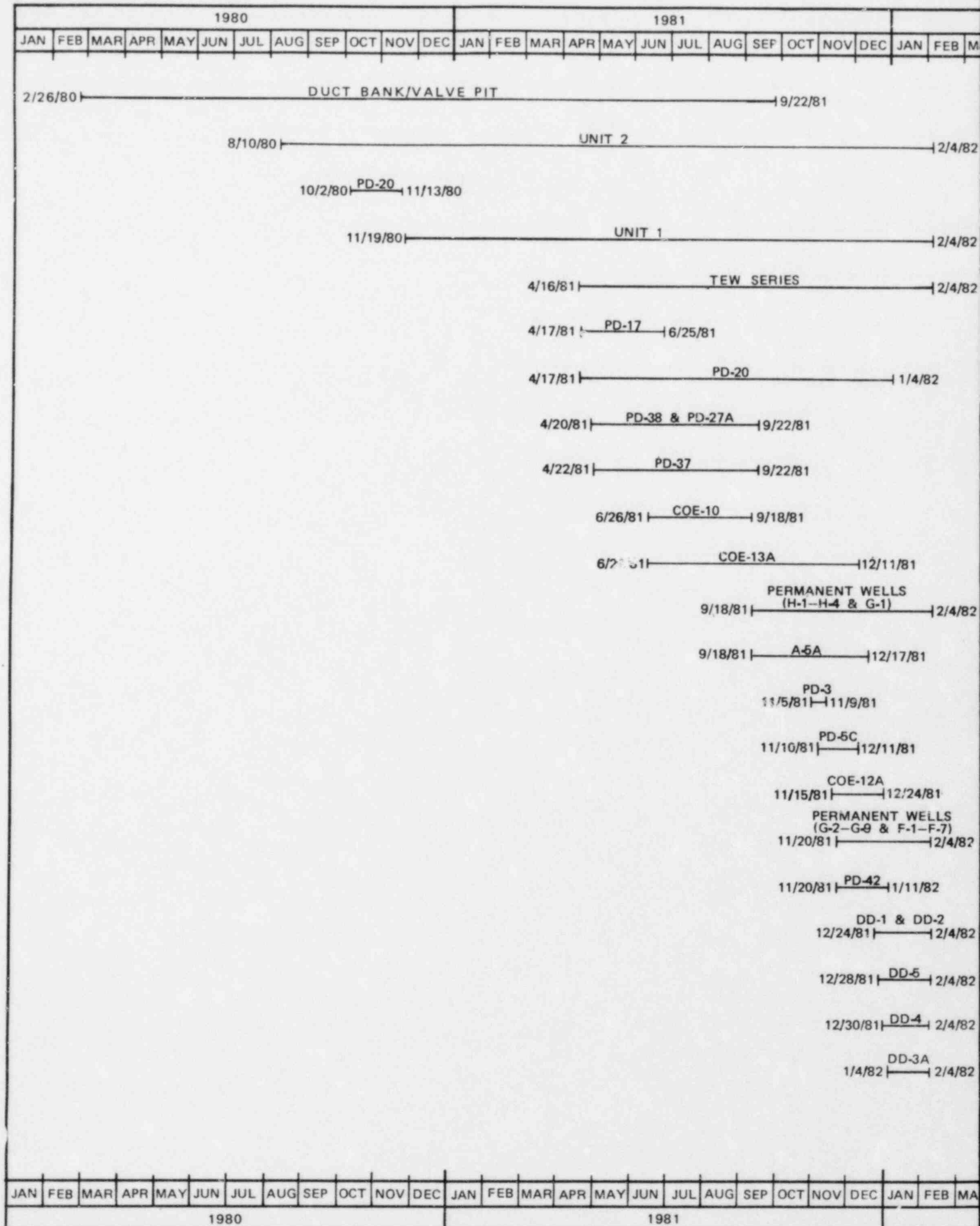
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

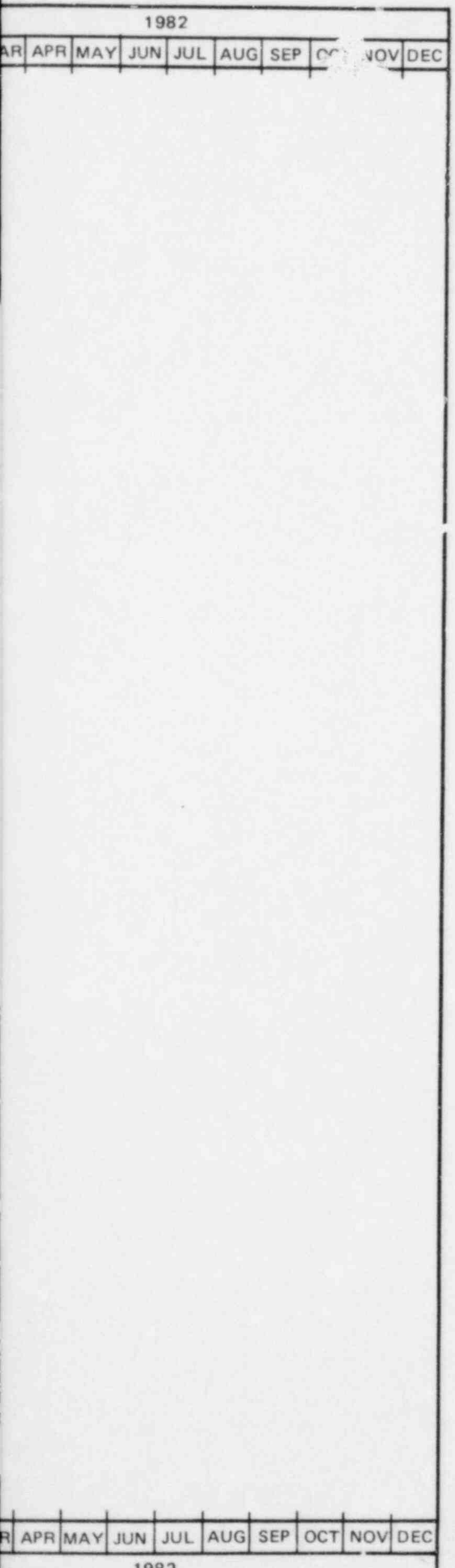
Wells Operating During Drawdown Test

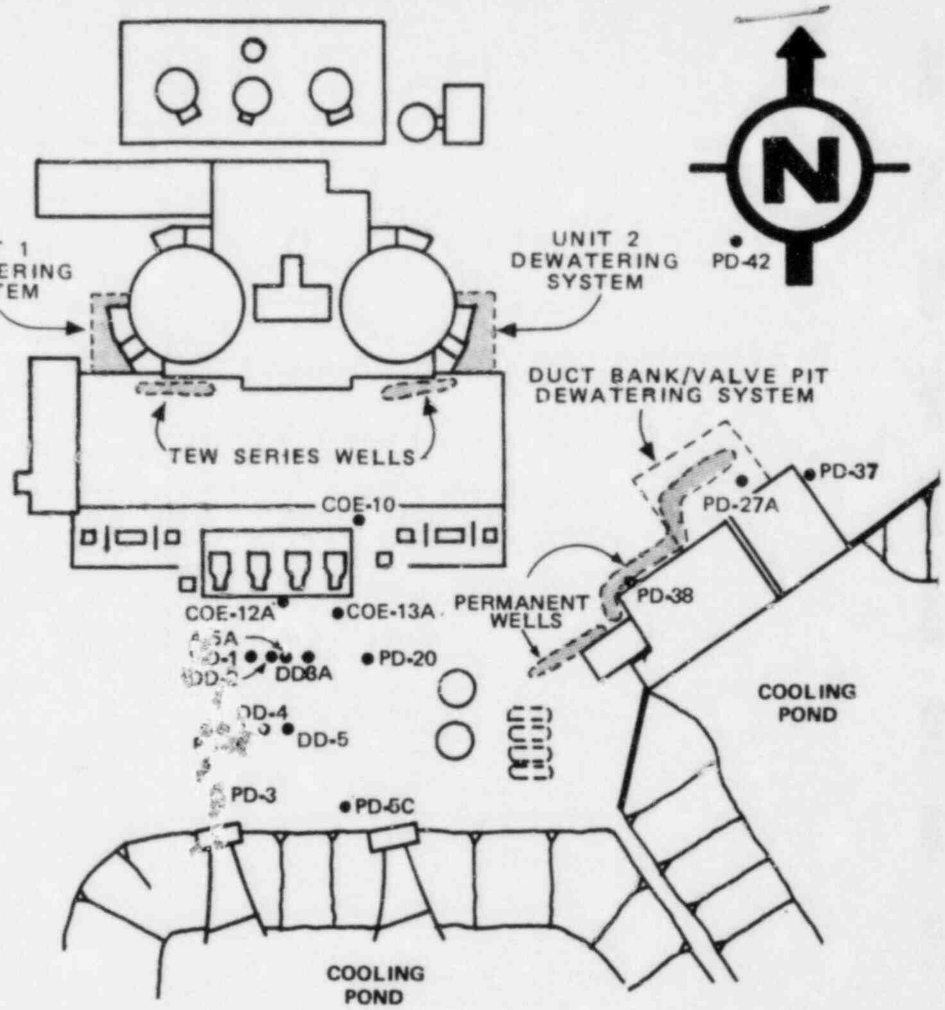
(SK-G-590, Rev 0)

FSAR Figure 2.4-56

6/82 Revision 44


1980
1981
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MA
2/26/80 DUCT BANK/VALVE PIT 9/22/81
8/10/80 UNIT 2 2/4/82
10/2/80 PD-20 11/13/80
11/19/80 UNIT 1 2/4/82
4/16/81 TEW SERIES 2/4/82
4/17/81 PD-17 6/25/81
4/17/81 PD-20 1/4/82
4/20/81 PD-38 & PD-27A 9/22/81
4/22/81 PD-37 9/22/81
6/26/81 COE-10 9/18/81
COE-13A 12/11/81
PERMANENT WELLS (H-1–H-4 & G-1)
9/18/81 2/4/82
9/18/81 A-5A 12/17/81
PD-3
11/5/81 11/9/81
PD-5C
11/10/81 12/11/81
COE-12A
11/15/81 12/24/81
PERMANENT WELLS (G-2–G-9 & F-1–F-7)
11/20/81
11/20/81 PD-42 1/11/82
DD-1 & DD-2
12/24/81 2/4/82
12/28/81 DD-5 2/4/82
12/30/81 DD-4 2/4/82
DD-3A
1/4/82 2/4/82





SITE PLAN
LOCATIONS OF DEWATERING WELLS
(NOT TO SCALE)

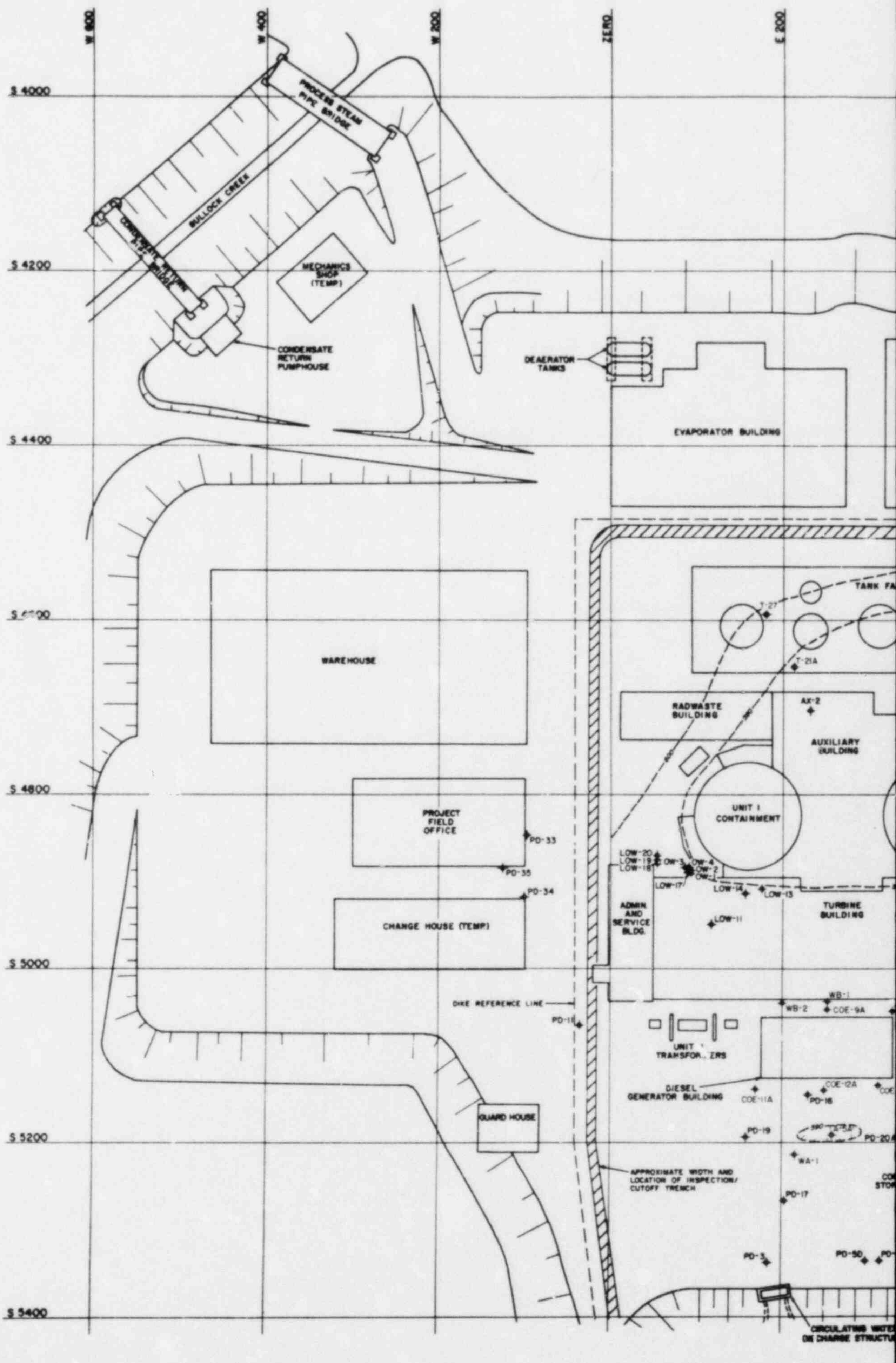
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Dewatering Events

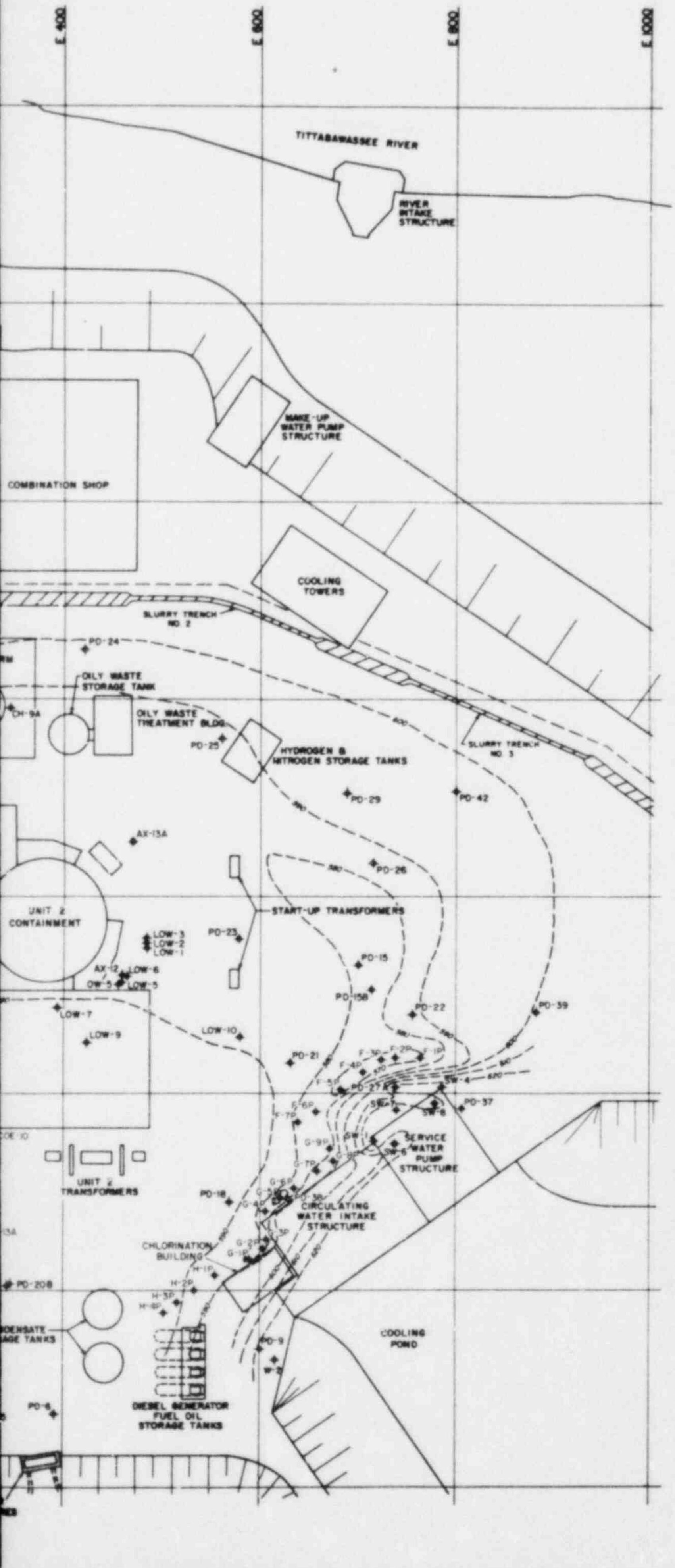
SK-G-613, Rev 0

FSAR Figure 2.4-57

6/82 Revision 44



W 600
W 400
W 200
ZERO
E 200
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
BULLOCK CREEK
CONDENSATE RETURN BRIDGE
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BUILDING
TANK FA
WAREHOUSE
T-27
T-21A
RADWASTE BUILDING
AX-2
AUXILIARY BUILDING
UNIT 1 CONTAINMENT
PROJECT FIELD OFFICE
PD-33
PD-35
PD-34
CHANGE HOUSE (TEMP)
LOW-20
LOW-19
LOW-18
LOW-17
LOW-14
LOW-13
LOW-11
ADMIN AND SERVICE BLDG.
TURBINE BUILDING
DIKE REFERENCE LINE
PD-18
WB-2
WB-1
COE-9A
UNIT TRANSFORMERS
DIESEL GENERATOR BUILDING
COE-11A
COE-12A
PD-16
GUARD HOUSE
PD-19
PD-20
WA-1
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/ CUTOFF TRENCH
PD-17
PD-3
PD-5D
CIRCULATING WATER DISCHARGE STRUCTURE



EXPLANATION

- LOCATION OF MEASURED OBSERVATION WELLS
- APPROXIMATE ELEVATION OF GROUND WATER LEVEL. CONTOUR INTERVAL IS 10 FEET.

NOTE:

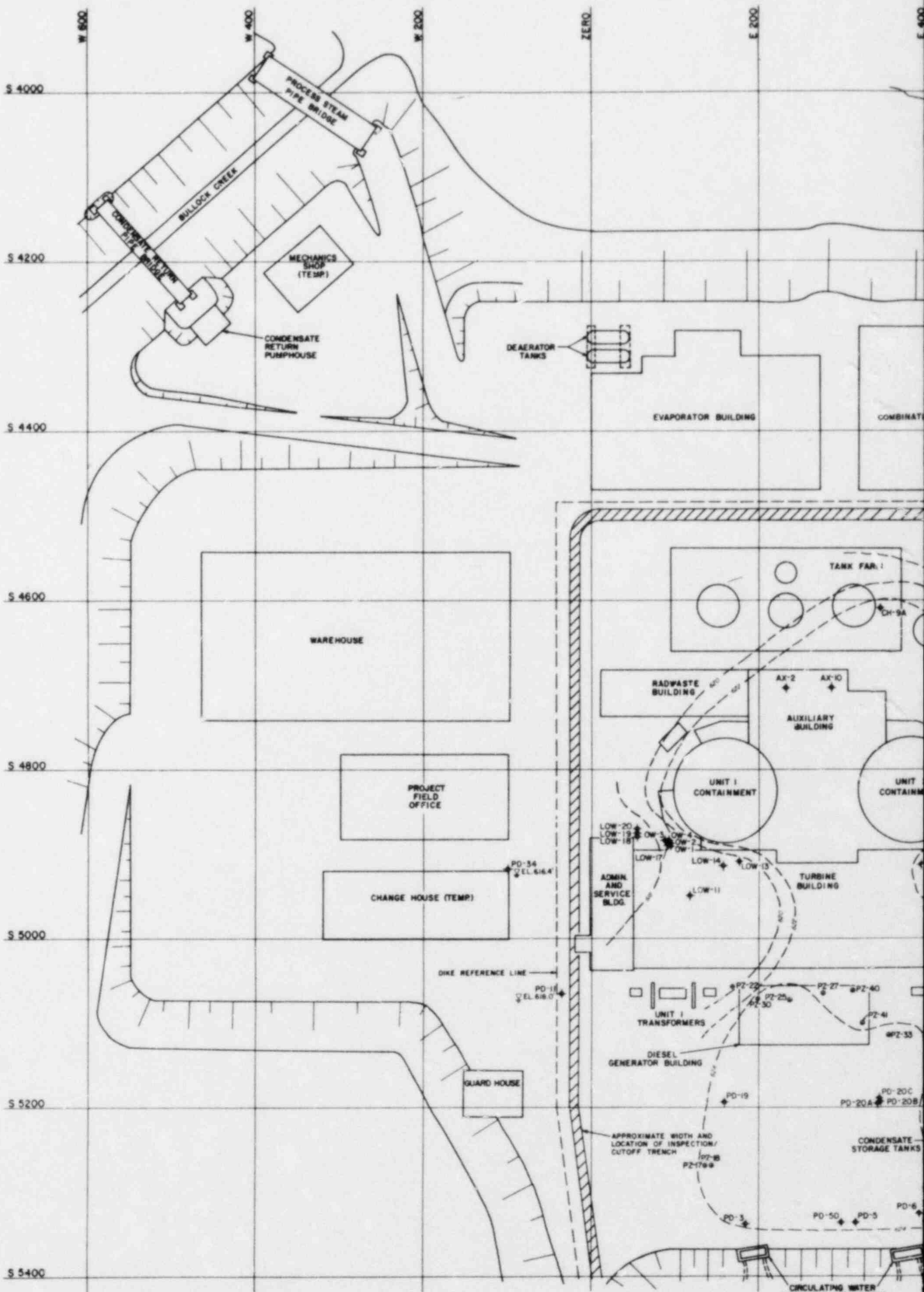
1. For complete history of dewatering activities, see Figure 2.4-57.

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

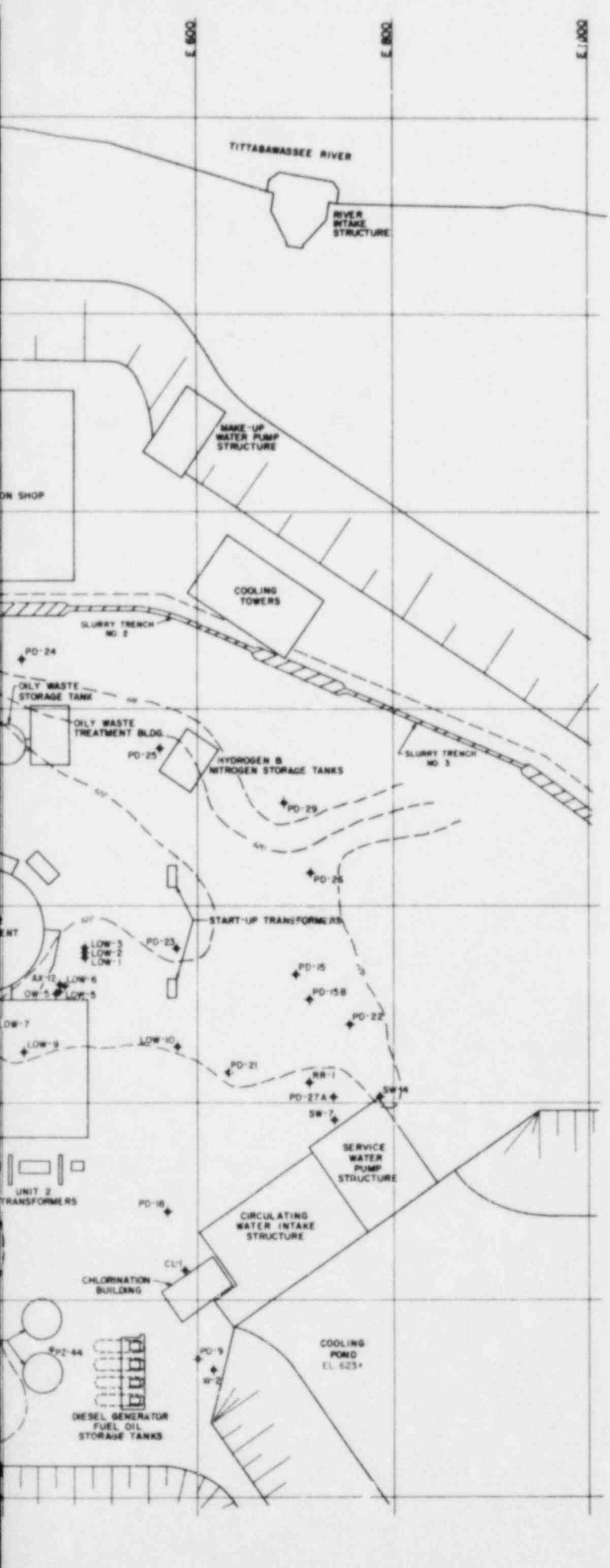
Groundwater Levels Prior to Start of Recharge Test (2-3-82)
SK-G-614, Rev 0

FSAR Figure 2.4-58

6/82 Revision 44



W 600
W 400
W 200
ZERO
E 200
E 400
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
BULLOCK CREEK
CONDENSATE RETURN PIPE BRIDGE
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BUILDING
COMBINATI
TANK FARM
WAREHOUSE
RADWASTE BUILDING
AUXILIARY BUILDING
UNIT 1 CONTAINMENT
UNIT CONTAINM
PROJECT FIELD OFFICE
CHANGE HOUSE (TEMP)
ADMIN. AND SERVICE BLDG.
TURBINE BUILDING
DIKE REFERENCE LINE
UNIT 1 TRANSFORMERS
DIESEL GENERATOR BUILDING
GUARD HOUSE
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/ CUTOFF TRENCH
CONDENSATE STORAGE TANKS
CIRCULATING WATER DISCHARGE STRUCTURES
PD-34 EL 616.4'
PD-11 EL 616.0'
AX-2
AX-10
CH-9A
LOW-20
LOW-19
LOW-18
LOW-17
LOW-14
LOW-13
LOW-11
PZ-22
PZ-25
PZ-30
PZ-27
PZ-40
PZ-41
PZ-33
PD-19
PD-20C
PD-20A
PD-20B
PZ-18
PZ-17
PD-3
PD-50
PD-5
PD-6



EXPLANATION

AX-2 ◆ LOCATION OF MEASURED OBSERVATION WELLS

PZ-33 ● LOCATION OF MEASURED PIEZOMETERS

APPROXIMATE ELEVATION OF GROUND WATER LEVEL. CONTOUR INTERVAL IS 2 FEET.

NOTES:

1. Only observation wells and piezometers screened through pervious material were used to prepare this figure.
2. For detailed location of the Duct/Bank Valve Pit dewatering system, see Figure 2.4-45

N

0 25 50 100 150 200

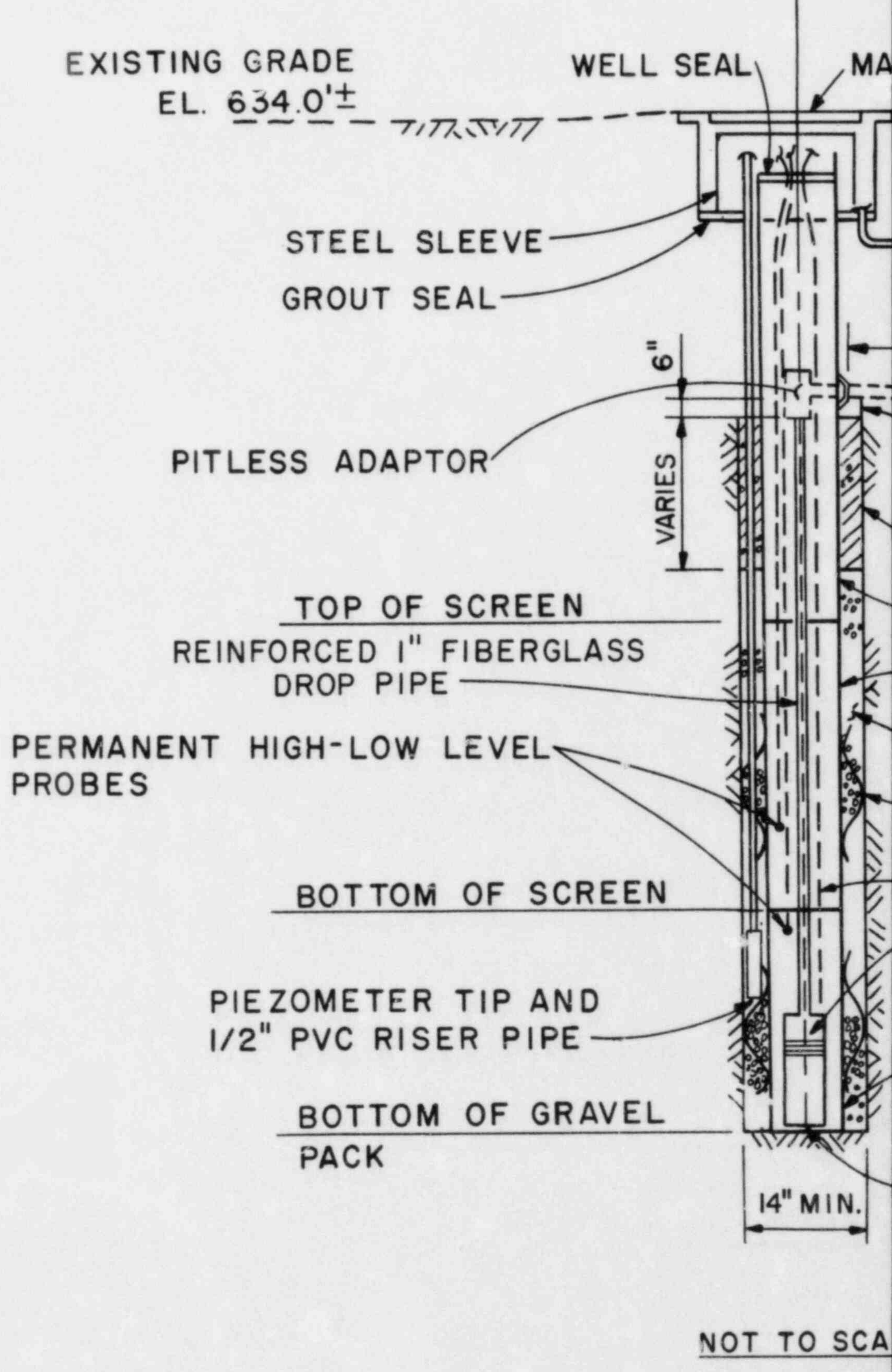
SCALE IN FEET

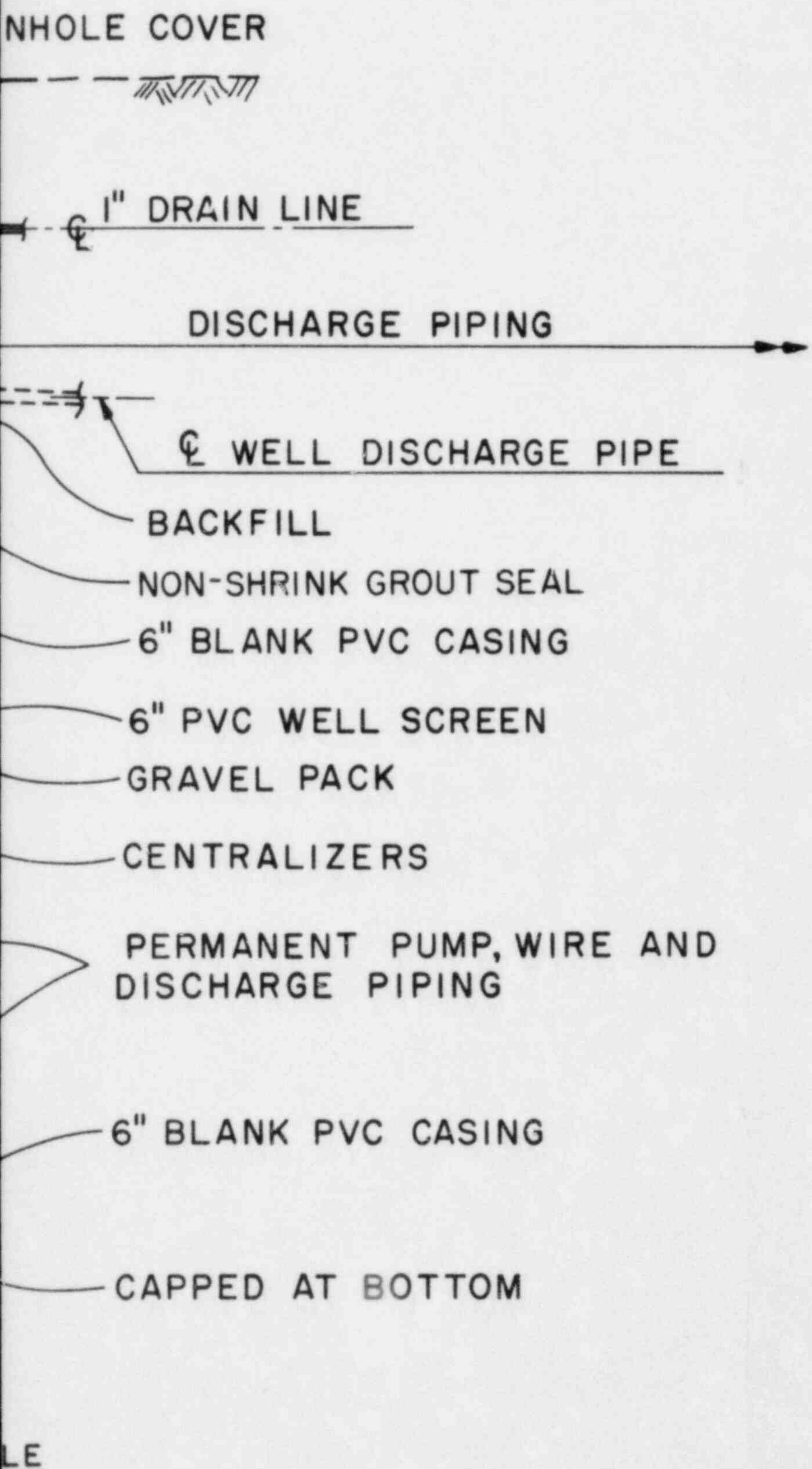
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Groundwater Levels After Pond Lowering (2-19 to 2-21-80)

SK-G-458, Rev 0

FSAR Figure 2.4-59


EXISTING GRADE
EL. 634.0'±
WELL SEAL
MA
STEEL SLEEVE
GROUT SEAL
6"
PITLESS ADAPTOR
VARIES
TOP OF SCREEN
REINFORCED 1" FIBERGLASS DROP PIPE
PERMANENT HIGH-LOW LEVEL PROBES
BOTTOM OF SCREEN
PIEZOMETER TIP AND 1/2" PVC RISER PIPE
BOTTOM OF GRAVEL PACK
14" MIN.
NOT TO SCA

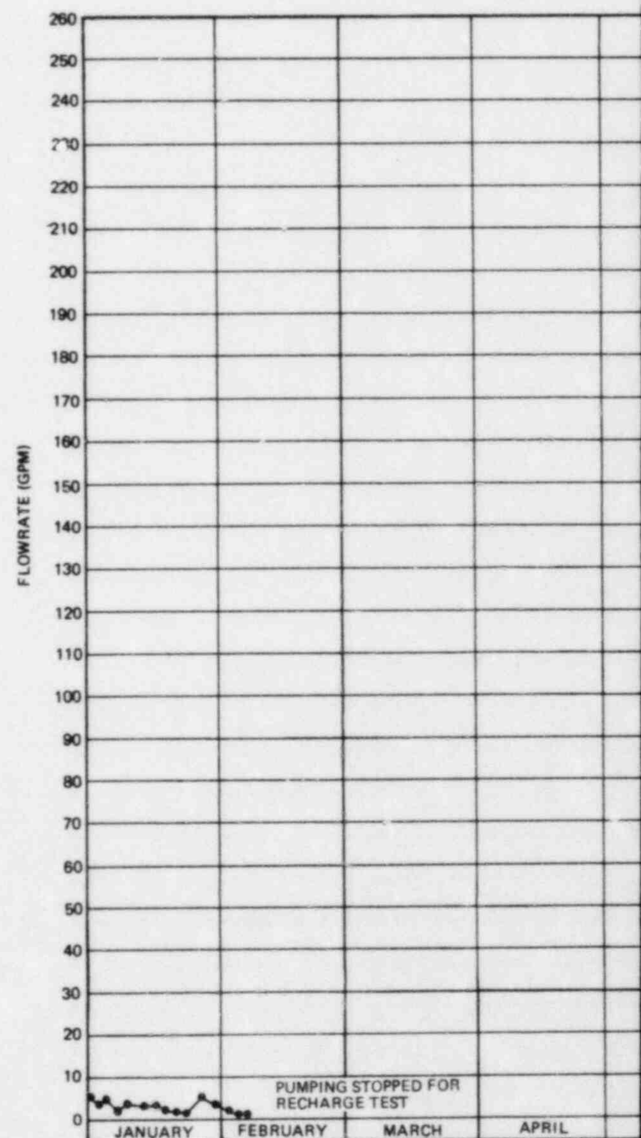


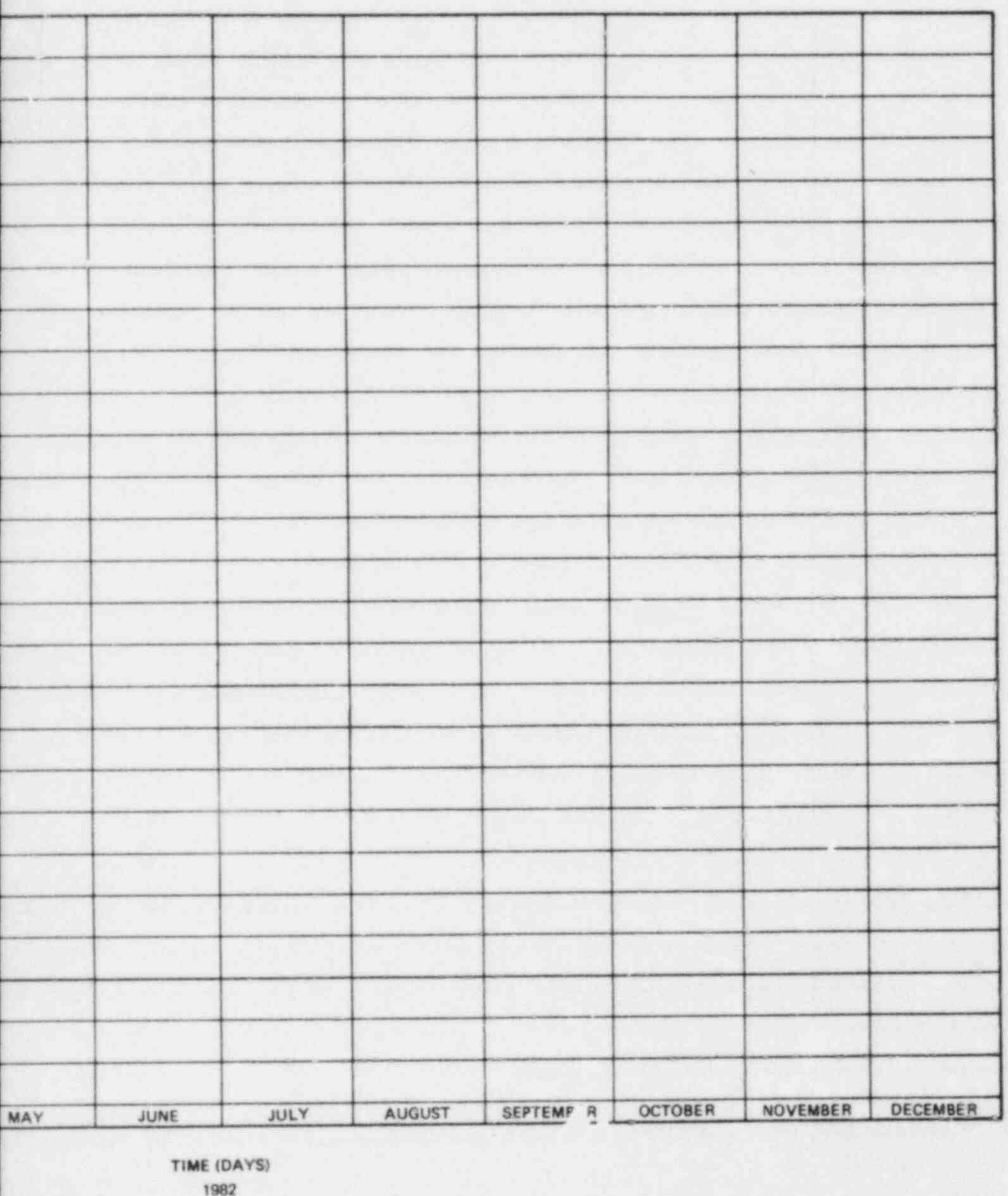
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Typical Permanent
Dewatering Well Section
(SK-G-449, Rev 1)

FSAR Figure 2.4-60

6/82 Revision 44


FLOWRATE (GPM)
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
PUMPING STOPPED FOR
RECHARGE TEST
JANUARY
FEBRUARY
MARCH
APRIL

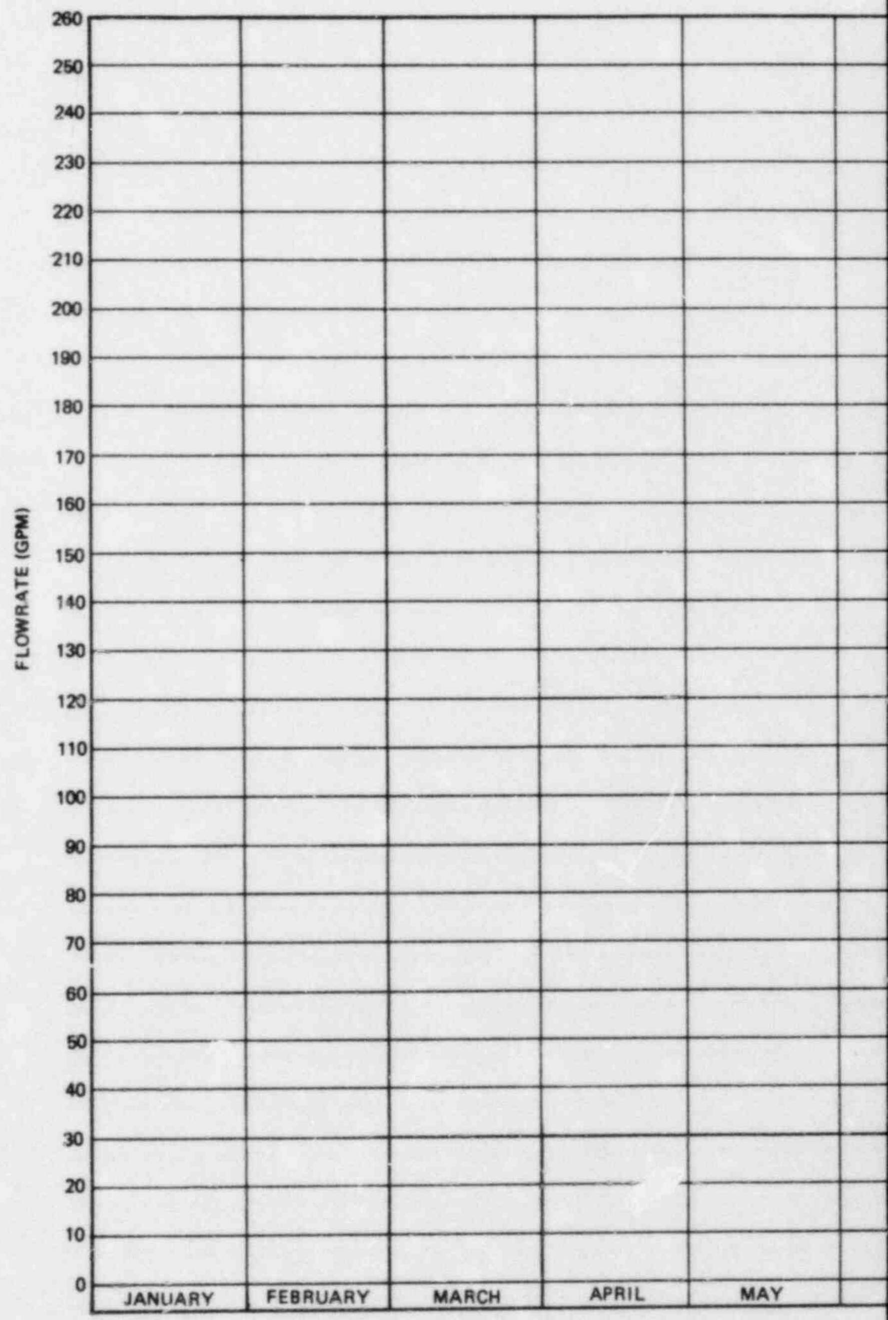


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

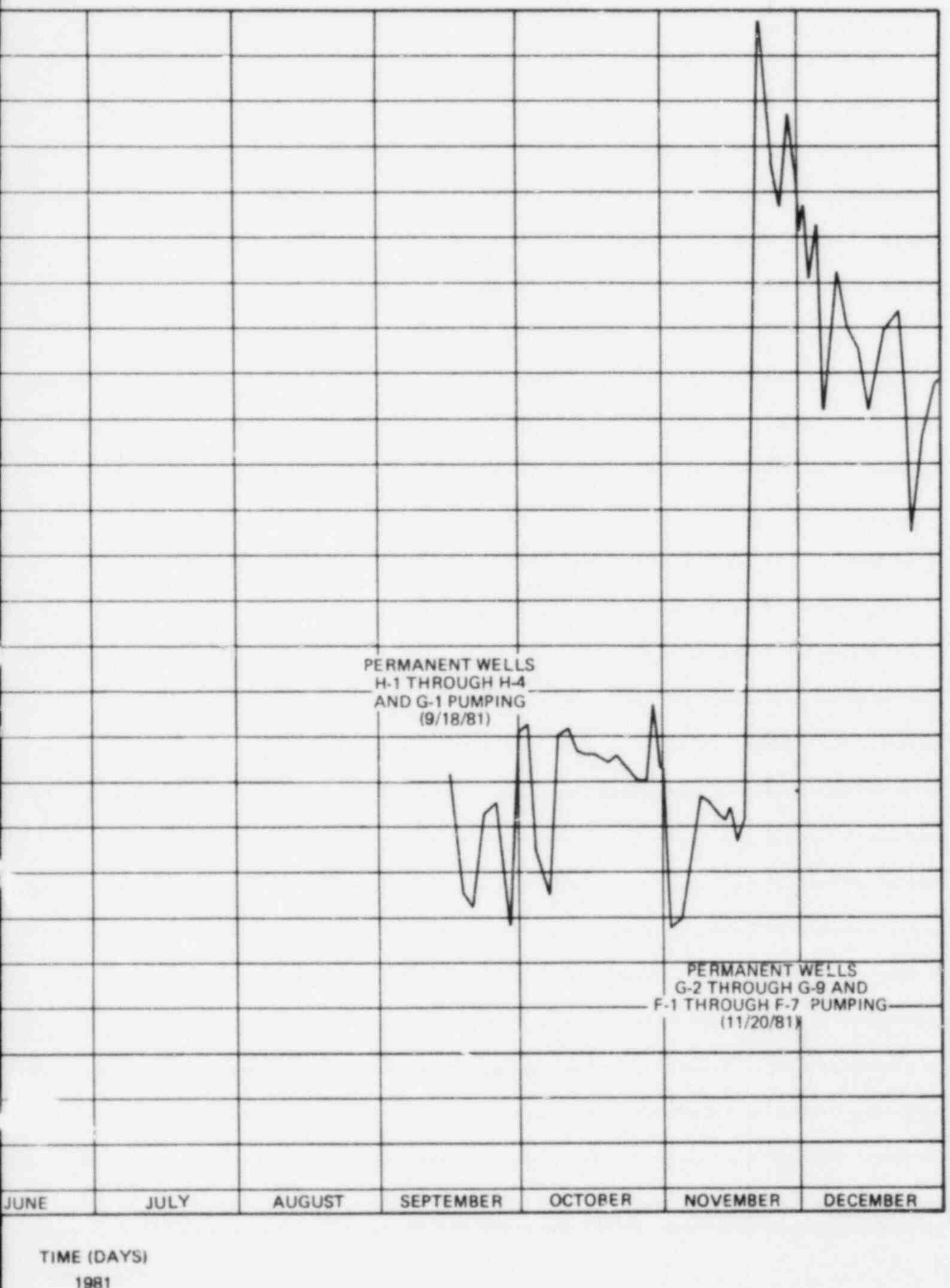
Flowrate vs Time
Construction Dewatering System
1982 (Sheet 3)
(SK-G-697, Rev 0)

FSAR Figure 2.4-63

6/82 Revision 44



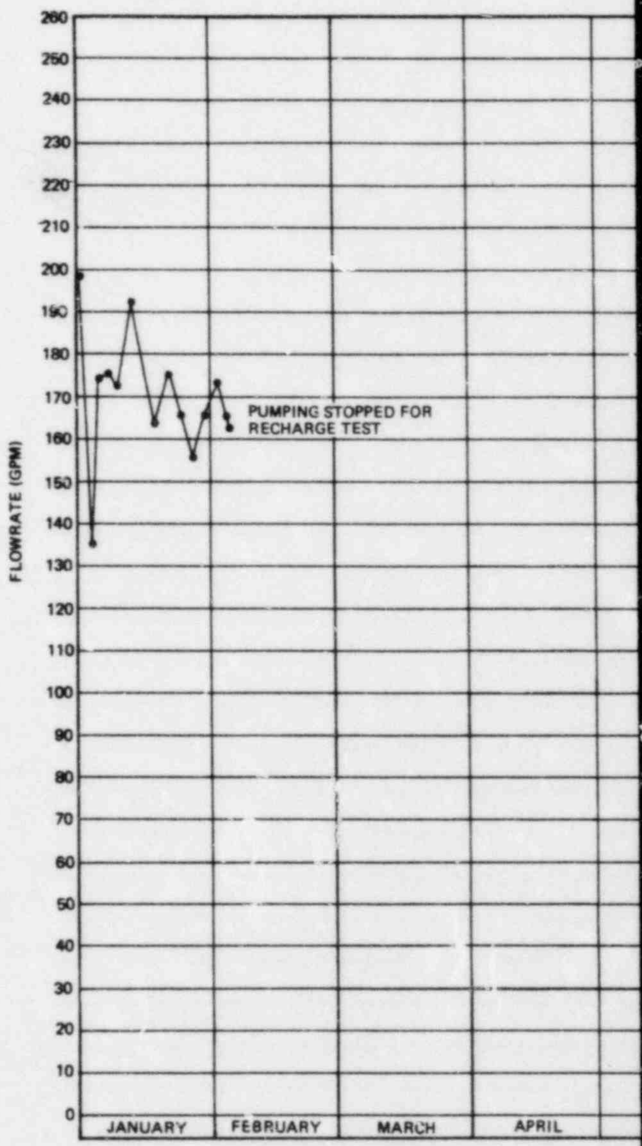
FLOWRATE (GPM)
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
JANUARY
FEBRUARY
MARCH
APRIL
MAY

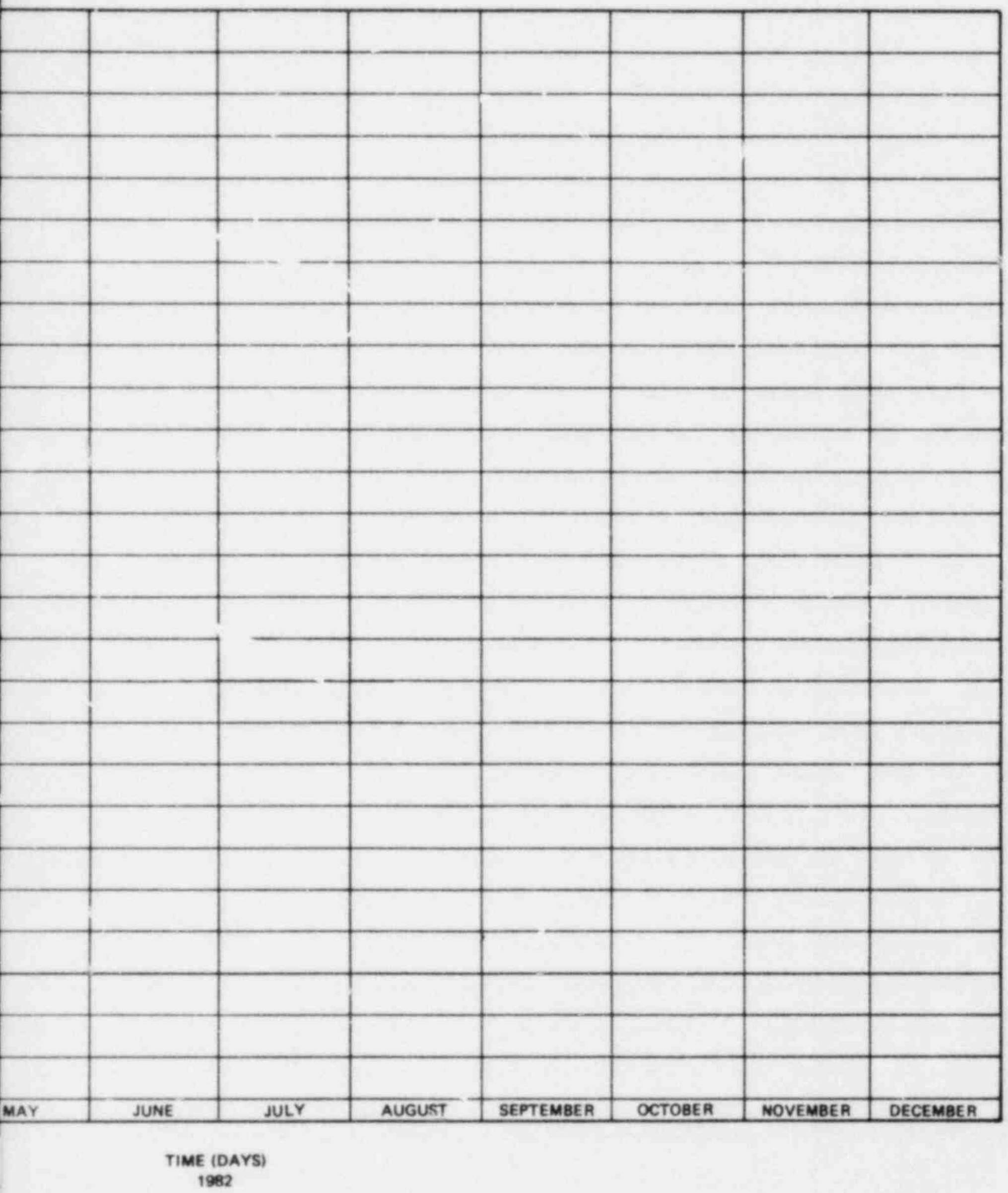


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Flowrate vs Time
Permanent Dewatering Wells G-1 Through G-9 F-1 Through F-7 and H-1 Through H-4 1981 (Sheet 1)

(SK-G-609, Rev 0)
FSAR Figure 2.4-64

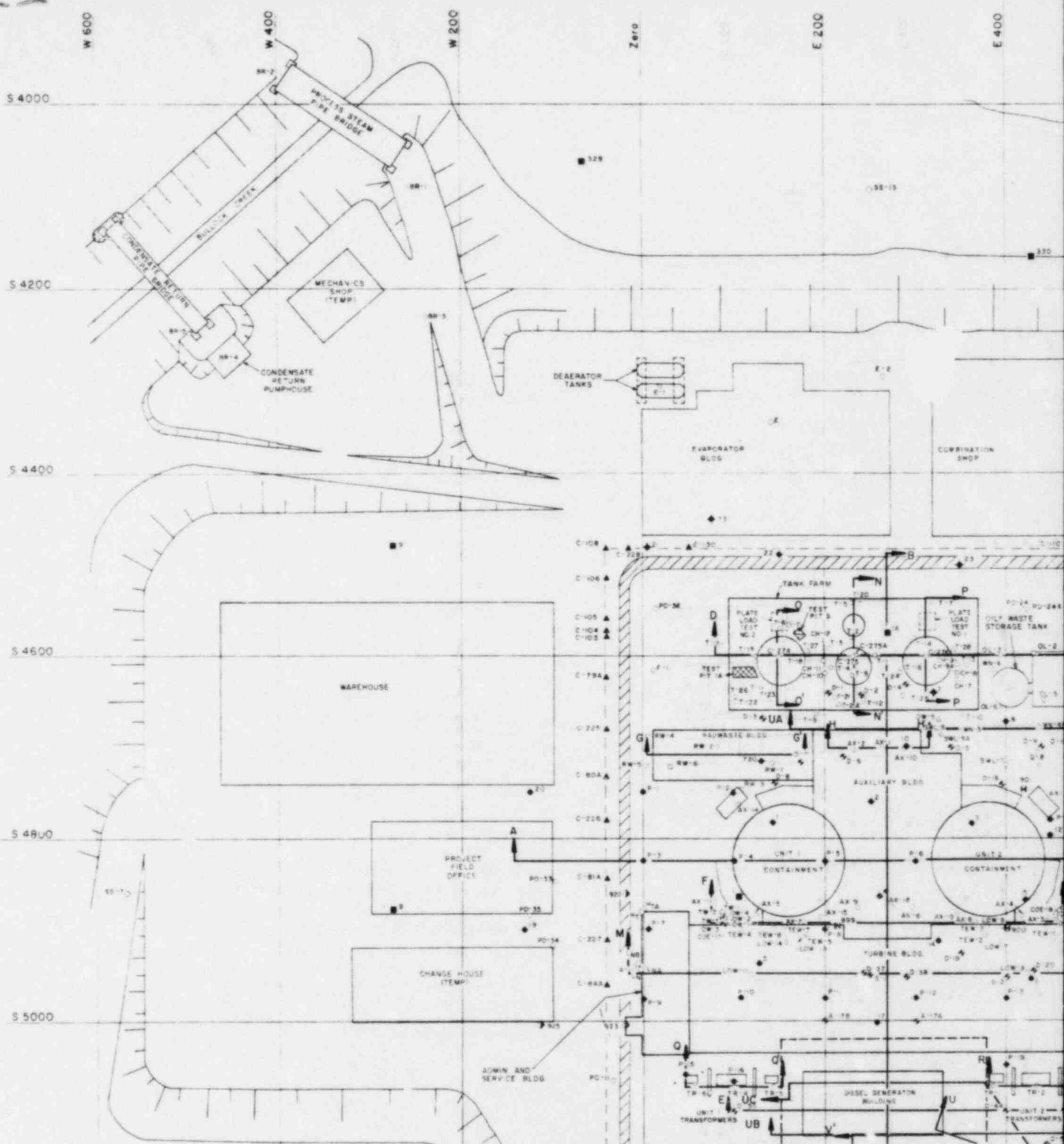

FLOWRATE (GPM)
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
PUMPING STOPPED FOR
RECHARGE TEST
JANUARY
FEBRUARY
MARCH
APRIL

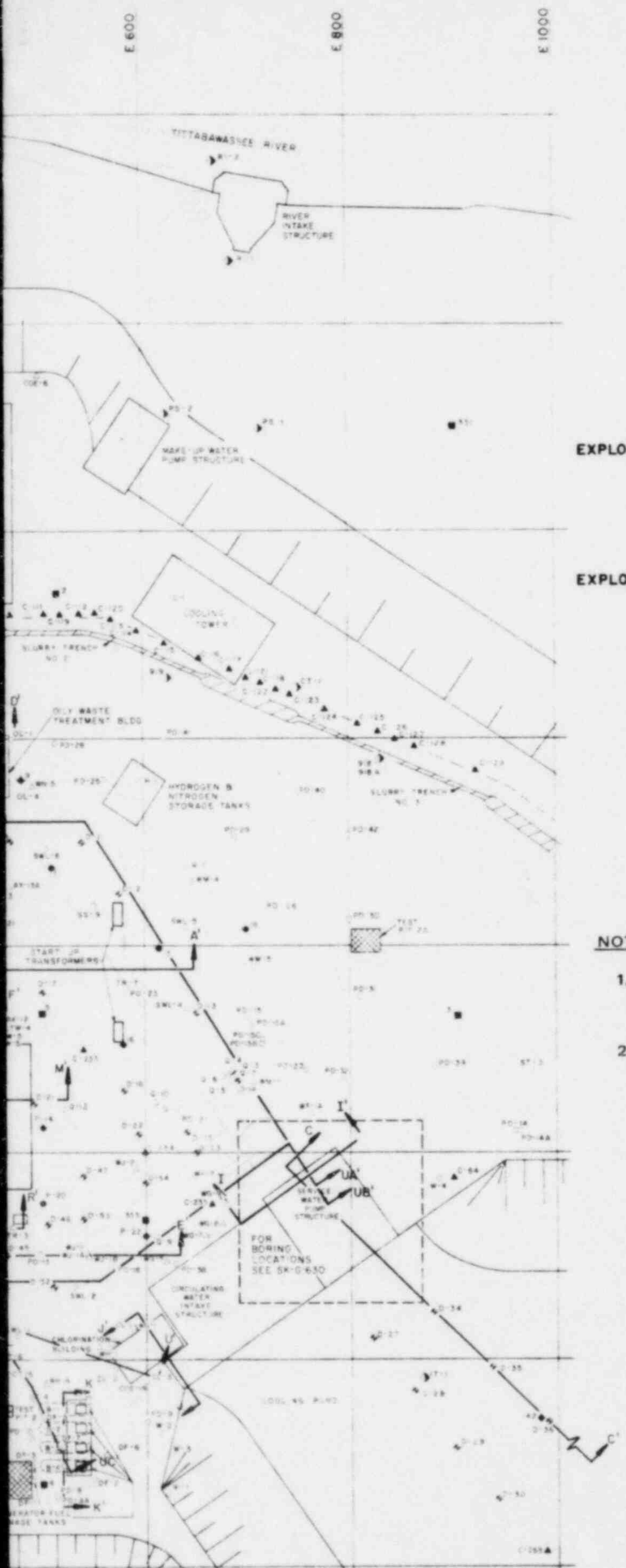


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Flowrate vs. Time Permanent Dewatering Wells G-1 Through G-9, F-1 Through F-7, and H-1 Through H-4 1982 (Sheet 2)

(SK-G-698, Rev 0)
FSAR Figure 2.4-65


W 600
W 400
W 200
Zero
E 200
E 400
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
CONDENSATE RETURN PIPE BRIDGE
BULLOCK CREEK
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BLDG
COMBINATION SHOP
WAREHOUSE
TANK FARM
OILY WASTE STORAGE TANK
RADWASTE BLDG
AUXILIARY BLDG
UNIT 1 CONTAINMENT
UNIT 2 CONTAINMENT
PROJECT FIELD OFFICE
CHANGE HOUSE (TEMP)
TURBINE BLDG
ADMIN AND SERVICE BLDG
DIESEL GENERATOR BUILDING
UNIT 1 TRANSFORMERS
UNIT 2 TRANSFORMERS
FOR BORING LOCATIONS SEE SK-D-653
GUARD HOUSE
DIKE REFERENCE LINE
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/CUTOFF TRENCH
CONDENSATE STORAGE TANKS
CIRCULATING WATER DISCHARGE STRUCTURES



EXPLANATION

EXPLORATION PROGRAM - PRECONSTRUCTION

- ■ MICHIGAN DRILLING COMPANY BORINGS; 1956 & 1968
- ✦ DAMES & MOORE BORINGS; 1967, 1968 & 1969

EXPLORATION PROGRAM - CONSTRUCTION PERIOD

- ▲ WALTER FLOOD COMPANY BORINGS; 1969 & 1970
- ◆ BECHTEL BORINGS, 1970
- ■ SOIL & MATERIALS ENGINEERS, INC. BORINGS; 1973 & 1974
- ◈ BECHTEL BORINGS; 1973 & 1974
- ◇ BECHTEL BORINGS; 1977 & 1978
- ○ BECHTEL BORINGS; 1978, 1979, 1980 & 1981
- △ WOODWARD-CLYDE CONSULTANTS BORINGS; 1981 & 1982
- ▩ BECHTEL TEST PITS; 1978 & 1979
- ⬚ BECHTEL PLATE LOAD TEST; 1979
- CROSS-SECTION LOCATION

NOTES:

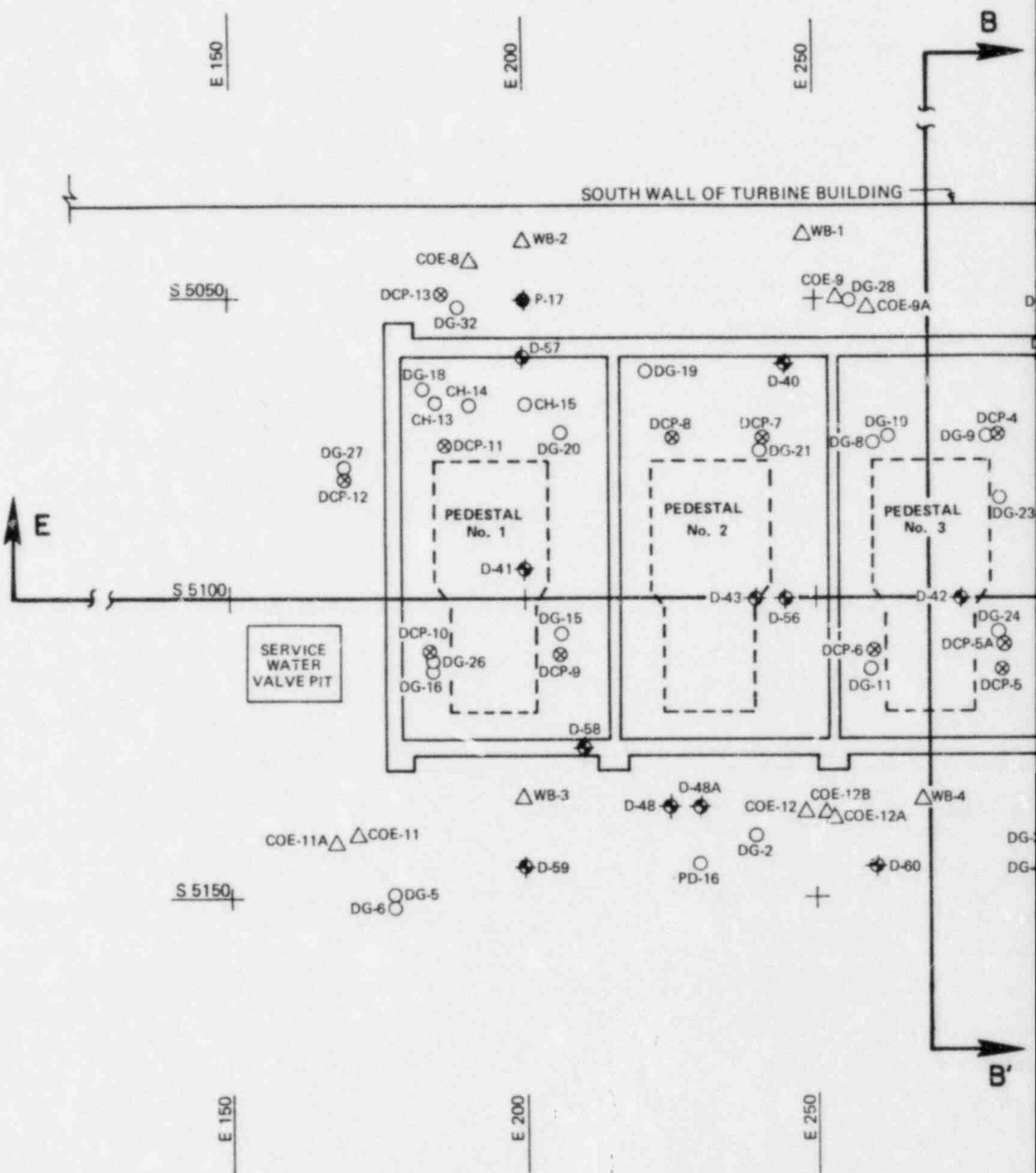
1. See Figure 2.5-20 thru 2.5-22 and 2.5-22A thru 2.5-22X for sections A-A' thru V-V'.
2. For the location of additional cross-sections in Emergency Cooling Water Reservoir, see Figure 2.5-160.

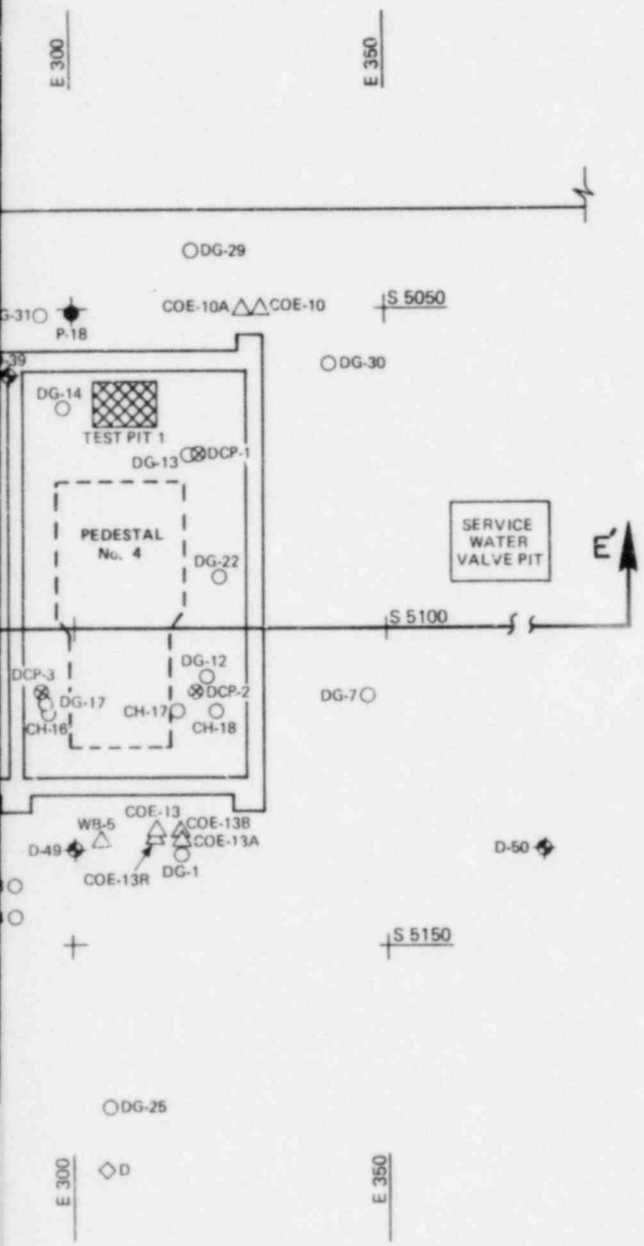
0 25 50 100 150 200
SCALE IN FEET

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Cross-Section and Boring Location Plan (SK-G-443, Rev 1)

FSAR Figure 2.5-17


E 150
E 200
E 250
B
SOUTH WALL OF TURBINE BUILDING
WB-2
WB-1
COE-8
COE-9
DG-28
COE-9A
S 5050
DCP-13
P-17
DG-32
D-57
DG-18
CH-14
CH-13
CH-15
DG-19
D-40
DCP-8
DCP-7
DG-21
DG-10
DG-8
DCP-4
DG-9
DG-27
DCP-11
DG-20
DCP-12
PEDESTAL No. 1
PEDESTAL No. 2
PEDESTAL No. 3
DG-23
E
D-41
S 5100
D-43
D-56
D-42
DG-15
DCP-10
DG-26
DG-16
DCP-9
DCP-6
DG-11
DG-24
DCP-5A
DCP-5
SERVICE WATER VALVE PIT
D-58
WB-3
D-48
D-48A
COE-12
COE-12B
COE-12A
WB-4
COE-11A
COE-11
DG-2
D-59
PD-16
D-60
S 5150
DG-5
DG-6
B'



EXPLANATION

- DAMES & MOORE BORINGS; 1969
- BECHTEL BORINGS; 1970
- BECHTEL BORINGS; 1977
- BECHTEL BORINGS; 1978, 1979 and 1980
- DUTCH CONE PENETROMETER; 1978
- WOODWARD-CLYDE CONSULTANTS BORINGS; 1981 and 1982
- BECHTEL TEST PIT; 1978

NOTE:

1. For the location of borings and subsurface profiles in adjacent areas, see Figure 2.5-17.

0 10 20 40 60

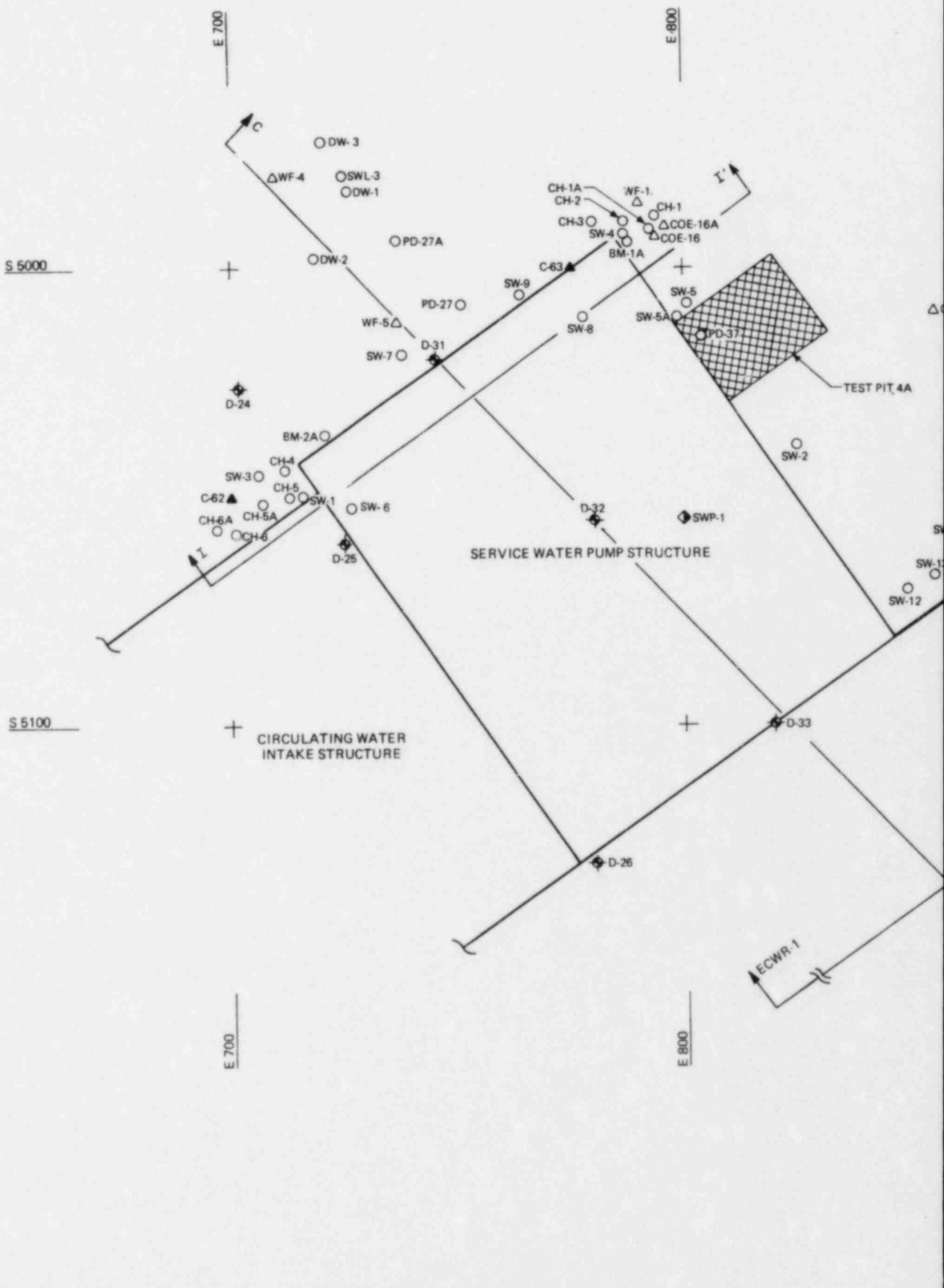
SCALE IN FEET

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

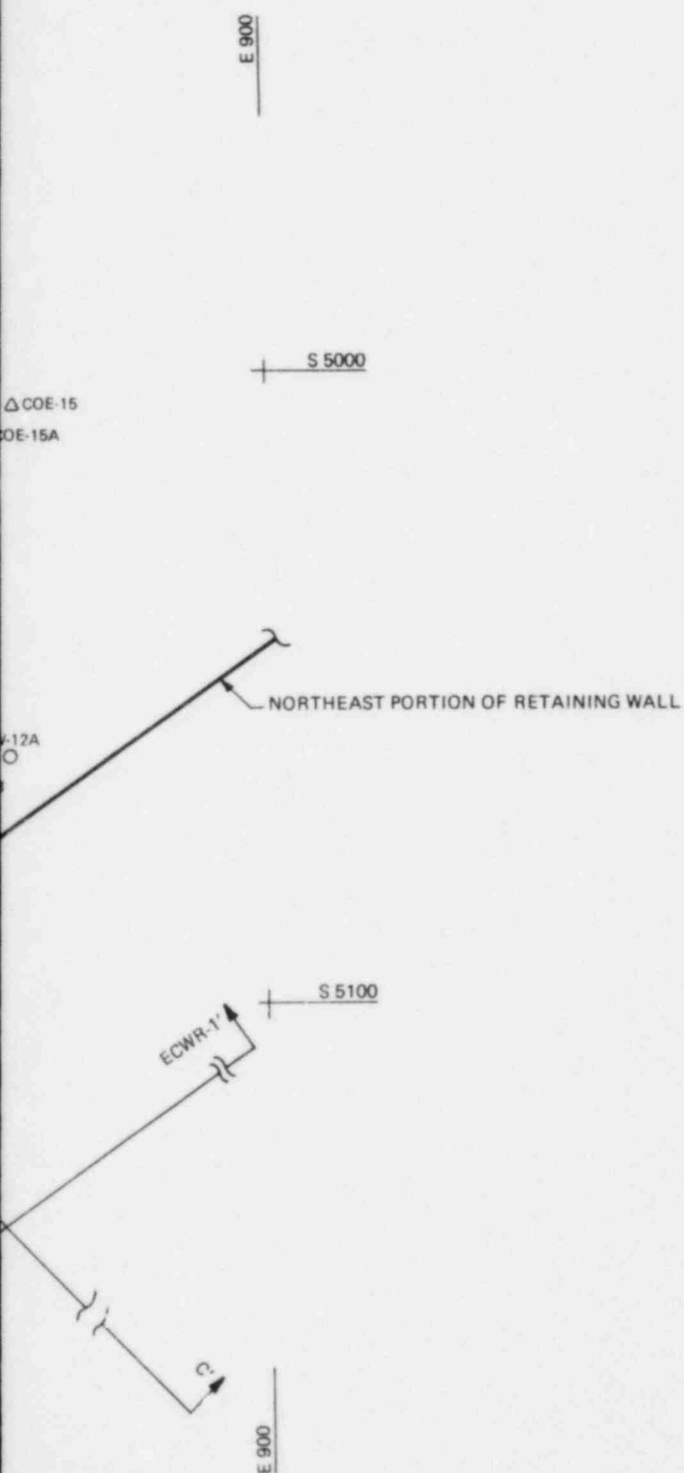
Cross-Sections, Borings and Test Pit Location Plan
Diesel Generator Building
(SK-G-653, Rev 0)

FSAR Figure 2.5-17A

6/82 Revision 44



E 700
E 800
S 5000
S 5100
C
I'
I
DW-3
WF-4
SWL-3
DW-1
PD-27A
DW-2
WF-5
PD-27
D-31
SW-7
D-24
BM-2A
CH-4
SW-3
CH-5
C-62
SW-1
SW-6
CH-6A
CH-5A
CH-6
D-25
C-63
SW-9
SW-8
CH-1A
CH-2
CH-3
SW-4
WF-1
CH-1
COE-16A
COE-16
BM-1A
SW-5
SW-5A
PD-37
TEST PIT 4A
SW-2
D-32
SWP-1
SERVICE WATER PUMP STRUCTURE
SW-12
D-33
CIRCULATING WATER INTAKE STRUCTURE
D-26
ECWR-1

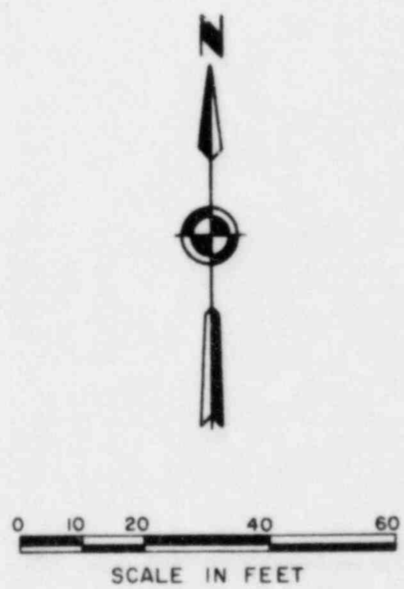


EXPLANATION

- ▲ — WALTER FLOOD COMPANY BORINGS 1969 & 1970
- ◆ — BECHTEL BORINGS; 1970
- ◆ — BECHTEL BORINGS; 1973 & 1974
- ○ — BECHTEL BORINGS; 1978, 1979, 1980 & 1981
- △ — WOODWARD–CLYDE CONSULTANTS BORINGS; 1981
- (crosshatched box) — BECHTEL TEST PIT; 1979
- (bracket) — LOCATION OF SUBSURFACE PROFILE

NOTE:

1. For the location of borings and subsurface profiles in adjacent areas, see Figure 2.5-17 and 2.5-160.

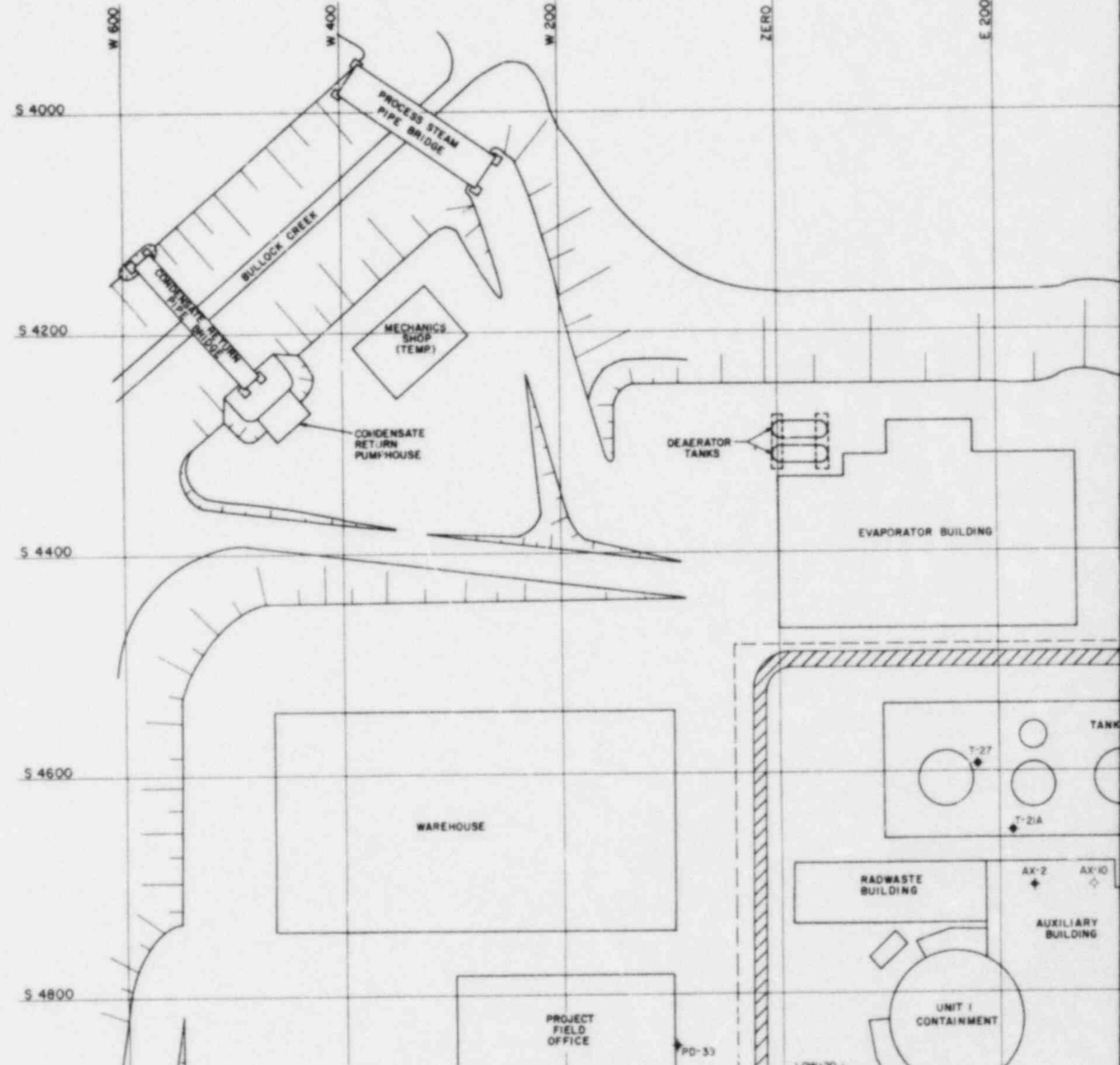


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

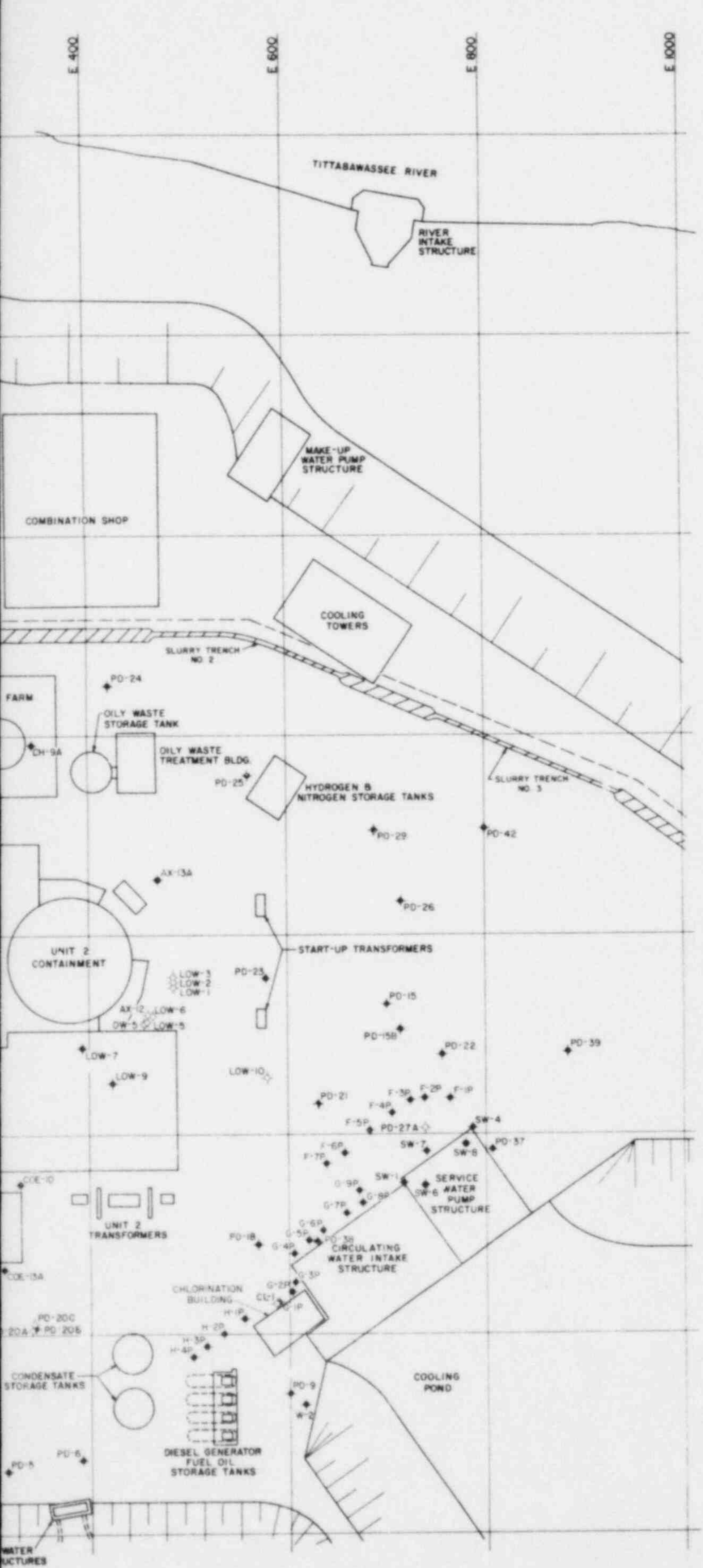
Boring and Test Pit Location Plan
Service Water Pump Structure
(SK-G-630, Rev 0)

FSAR Figure 2.5-17B

6/82 Revision 44



W 600
W 400
W 200
ZERO
E 200
S 4000
S 4200
S 4400
S 4600
S 4800
S 5000
S 5200
S 5400
PROCESS STEAM PIPE BRIDGE
BULLOCK CREEK
CONDENSATE RETURN PIPE BRIDGE
MECHANICS SHOP (TEMP)
CONDENSATE RETURN PUMPHOUSE
DEAERATOR TANKS
EVAPORATOR BUILDING
WAREHOUSE
RADWASTE BUILDING
AUXILIARY BUILDING
UNIT I CONTAINMENT
PROJECT FIELD OFFICE
CHANGE HOUSE (TEMP)
ADMIN. AND SERVICE BLDG.
TURBINE BUILDING
DIKE REFERENCE LINE
UNIT I TRANSFORMERS
DIESEL GENERATOR BUILDING
GUARD HOUSE
APPROXIMATE WIDTH AND LOCATION OF INSPECTION/ CUTOFF TRENCH
T-27
T-21A
AX-2
AX-10
PD-33
PD-35
PD-34
LOW-20
LOW-19
LOW-18
OW-3
OW-4
OW-1
LOW-17
LOW-14
LOW-13
LOW-11
WB-2
WB-1
COE-9A
COE-11A
COE-12A
PD-16
PD-19
A-5A
WA-1
PD-17
PD-3
PD-50



CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Plan of Observation Wells

(SKG-507)

FSAR Figure 2I-1

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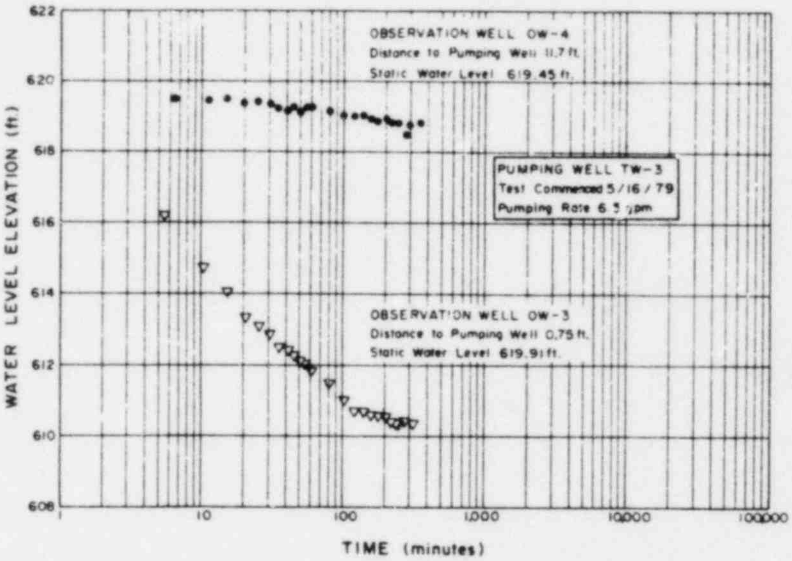
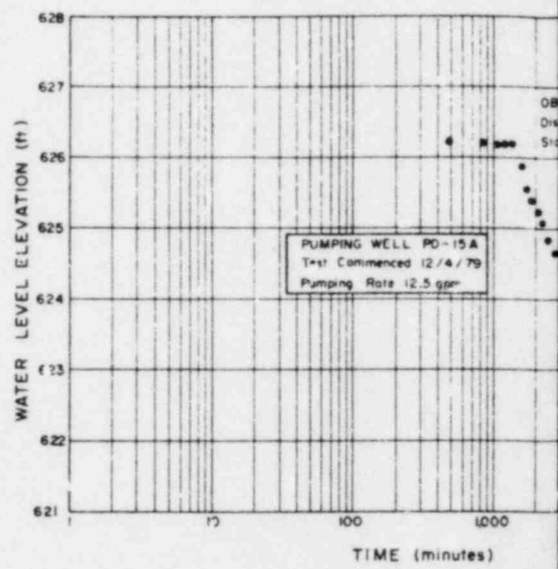
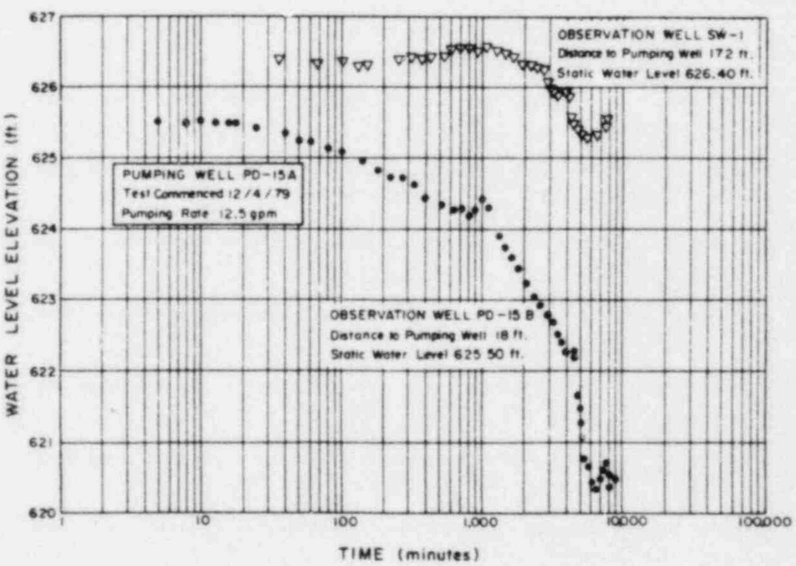
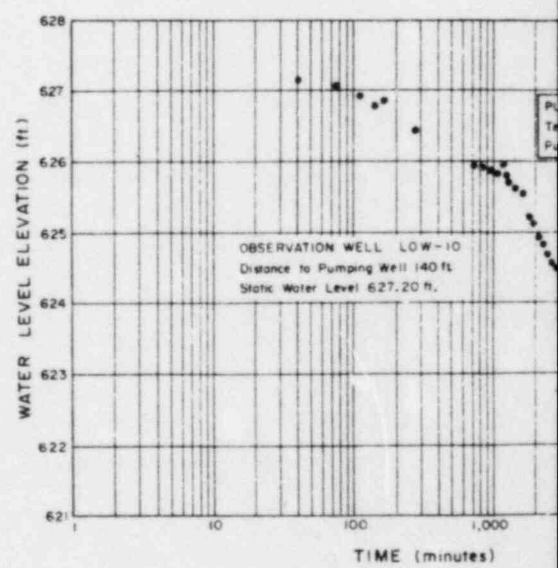
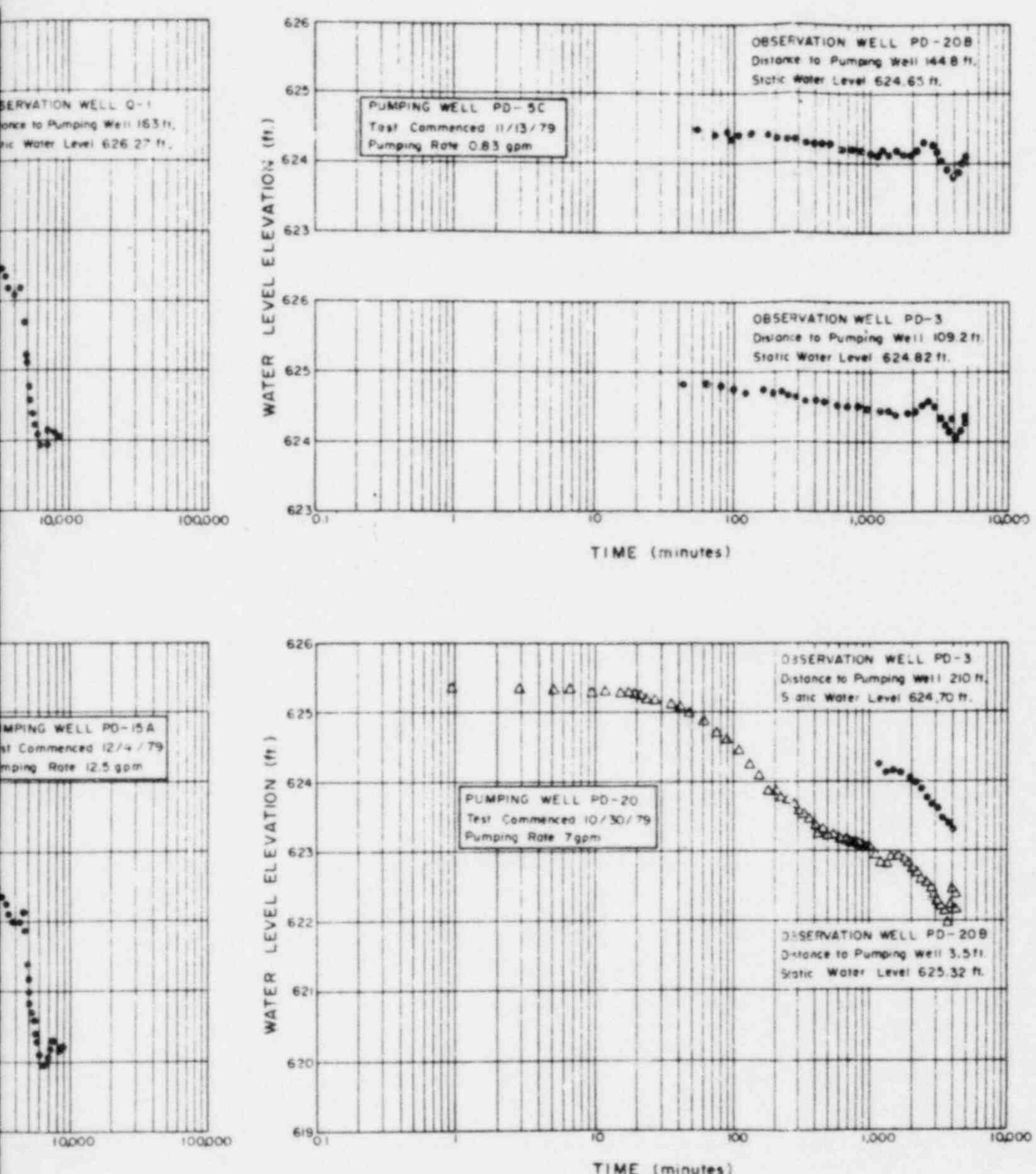

OBSERVATION WELL OW-4
Distance to Pumping Well 11.7 ft.
Static Water Level 619.45 ft.
PUMPING WELL TW-3
Test Commenced 5/16/79
Pumping Rate 6.5 gpm
OBSERVATION WELL OW-3
Distance to Pumping Well 0.75 ft.
Static Water Level 619.91 ft.
WATER LEVEL ELEVATION (ft)
TIME (minutes)


PUMPING WELL PD-15A
Test Commenced 12/4/79
Pumping Rate 12.5 gpm
WATER LEVEL ELEVATION (ft)
TIME (minutes)


OBSERVATION WELL SW-1
Distance to Pumping Well 172 ft.
Static Water Level 626.40 ft.
PUMPING WELL PD-15A
Test Commenced 12/4/79
Pumping Rate 12.5 gpm
OBSERVATION WELL PD-15B
Distance to Pumping Well 18 ft.
Static Water Level 625.50 ft.
WATER LEVEL ELEVATION (ft)
TIME (minutes)


OBSERVATION WELL LOW-10
Distance to Pumping Well 140 ft.
Static Water Level 627.20 ft.
WATER LEVEL ELEVATION (ft)
TIME (minutes)



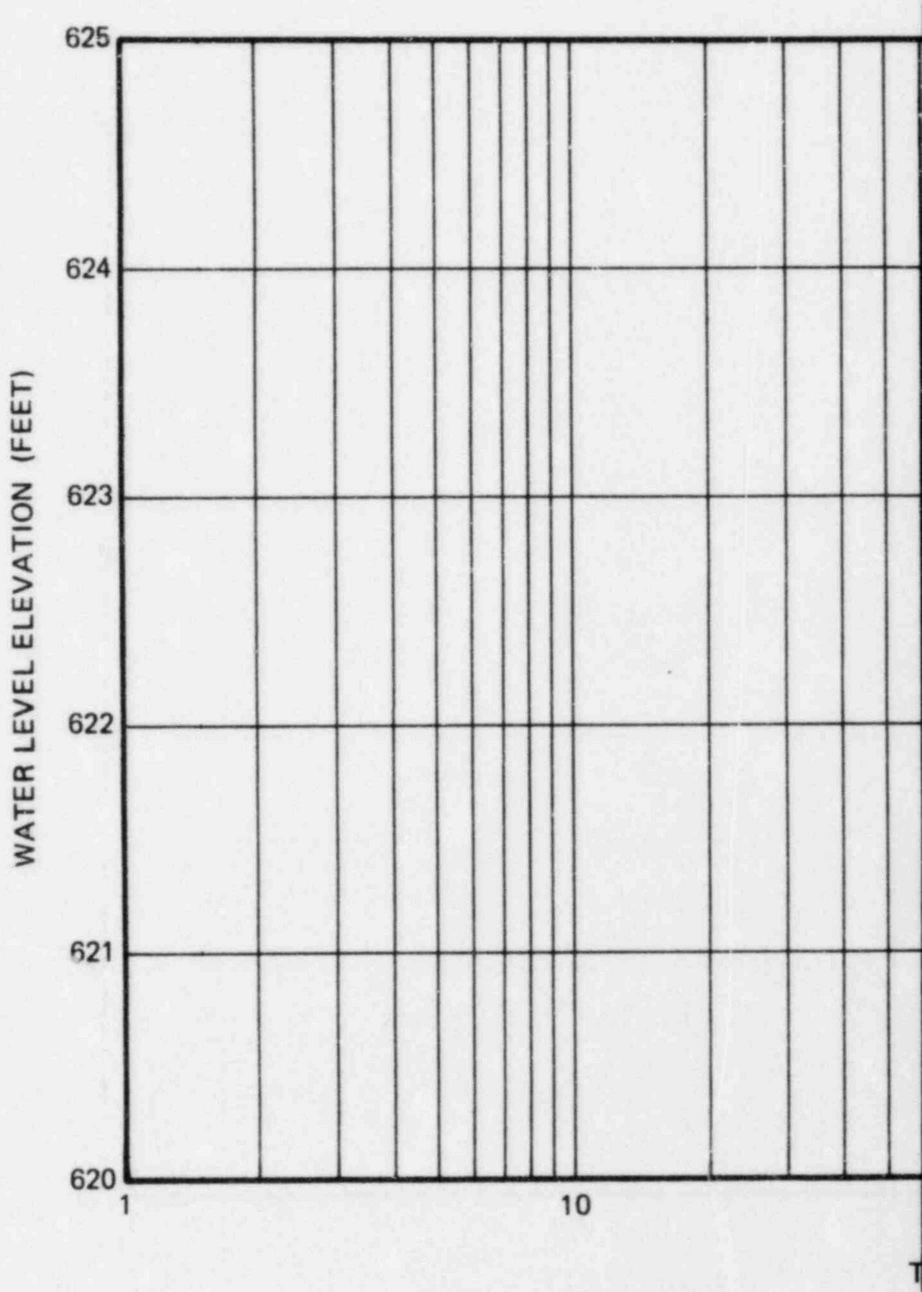
NOTE:

1. For location of pumping and observation wells, see Figure 2.4-42

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

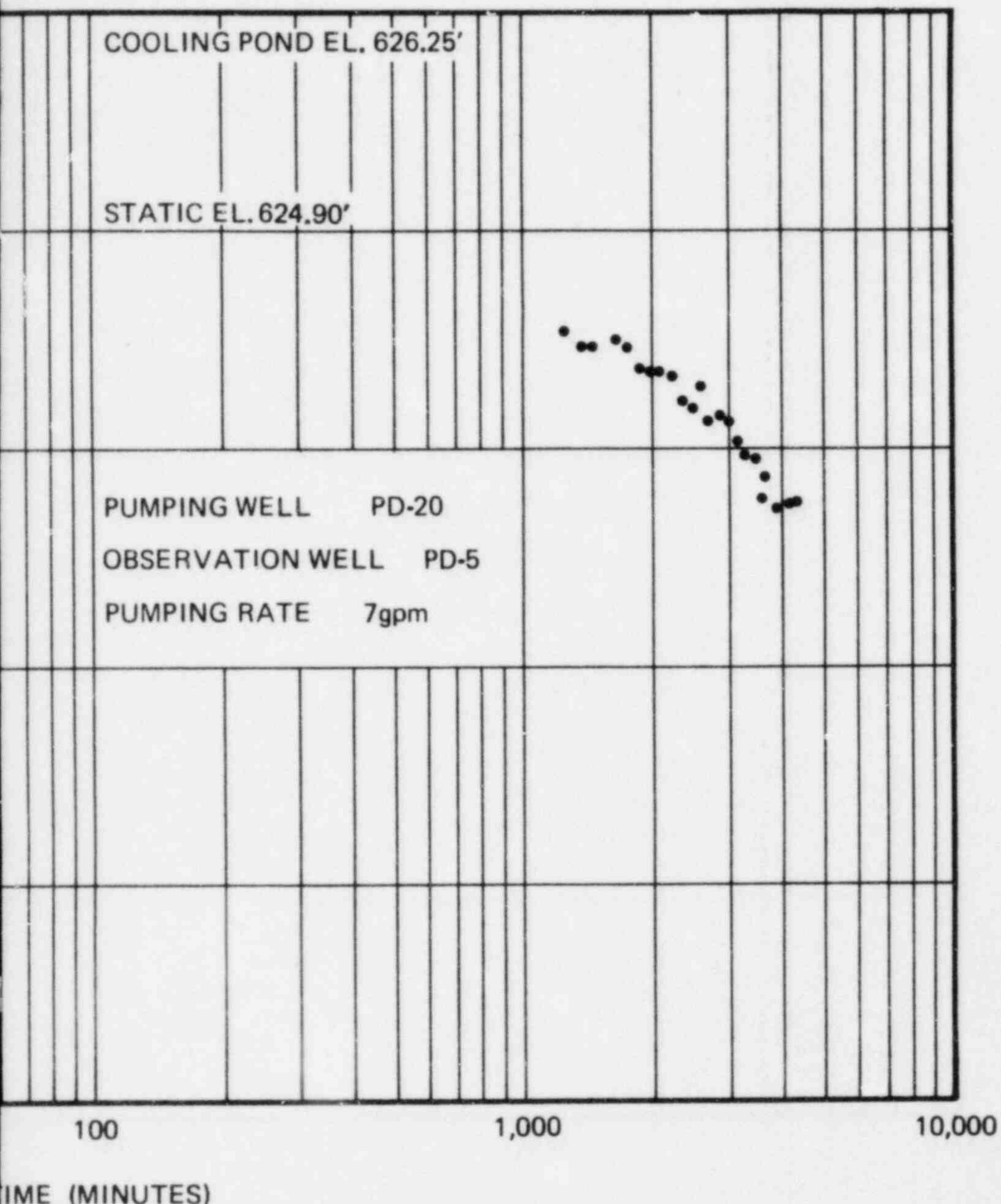
Pumping Tests Time-Drawdown Graphs

Figure 24-14



NOTE:

1. For the loca
PD-5, see F

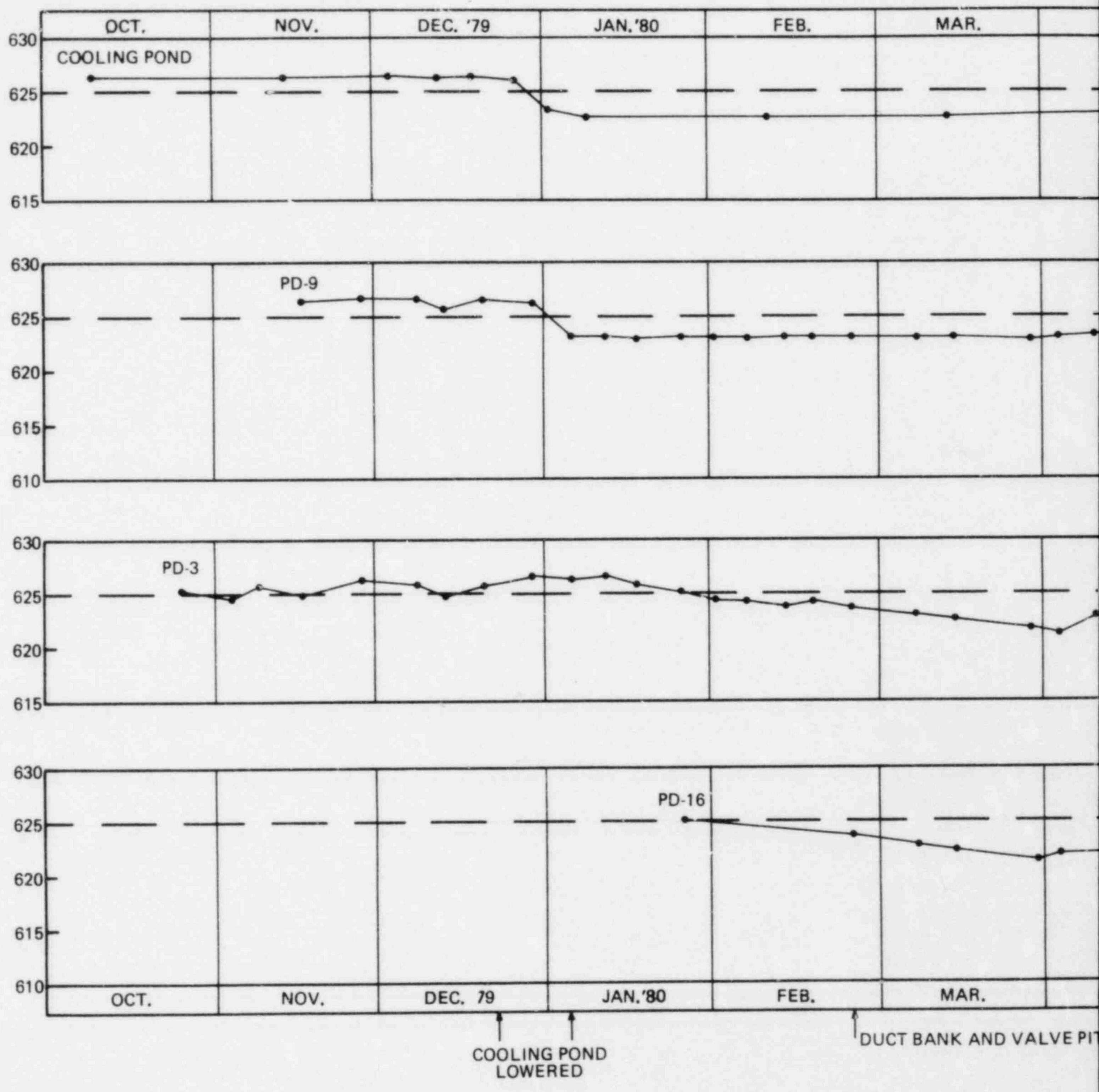


tion of observation well
gure 2.4-42

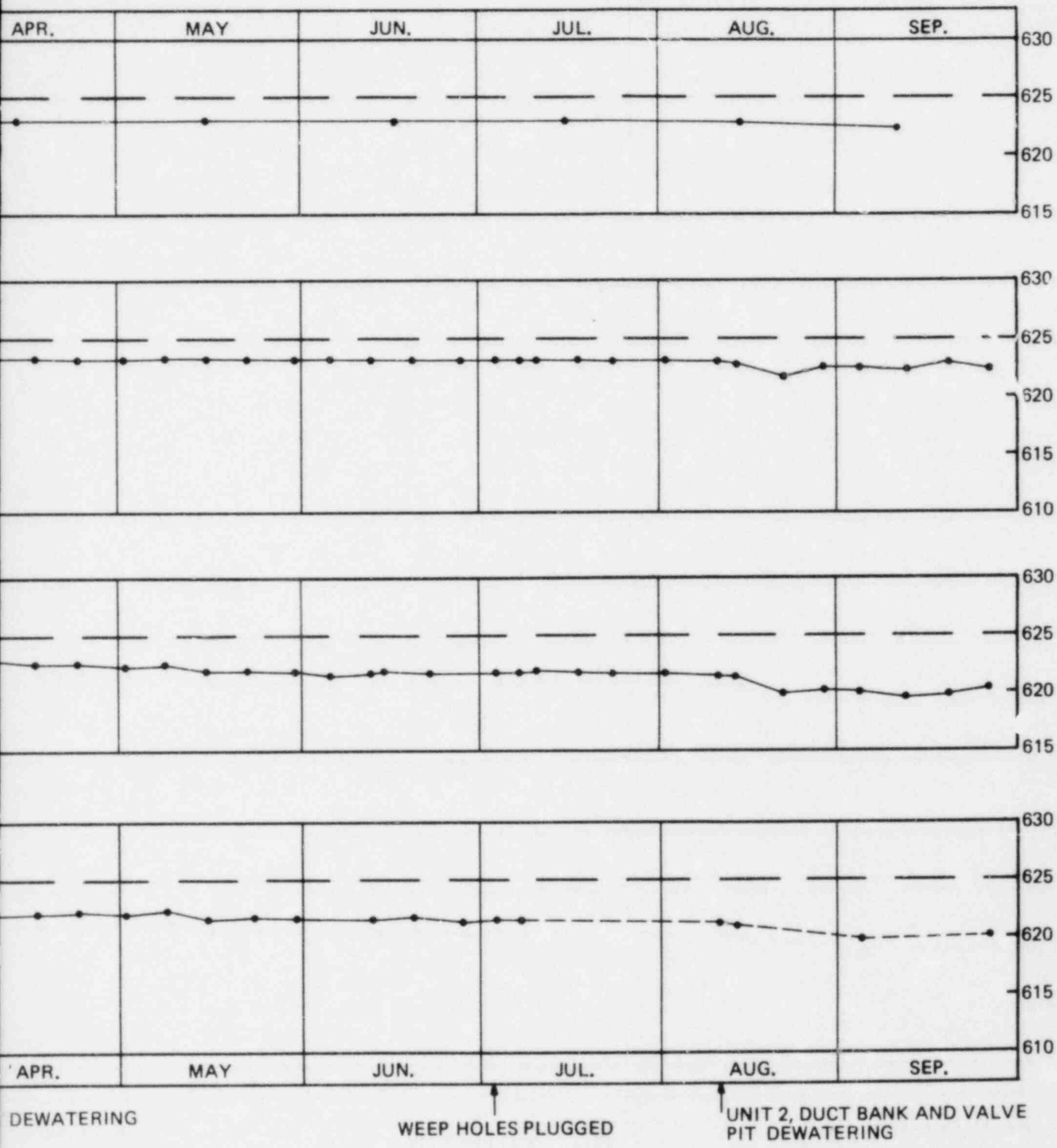
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

Time-Drawdown Graph Observation Well PD-5 Pumping Well PD-20 (Rev 0)

Figure 47-5



OCT.
NOV.
DEC. '79
JAN.'80
FEB.
MAR.
COOLING POND
PD-9
PD-3
PD-16
630
625
620
615
610
COOLING POND LOWERED
DUCT BANK AND VALVE PIT



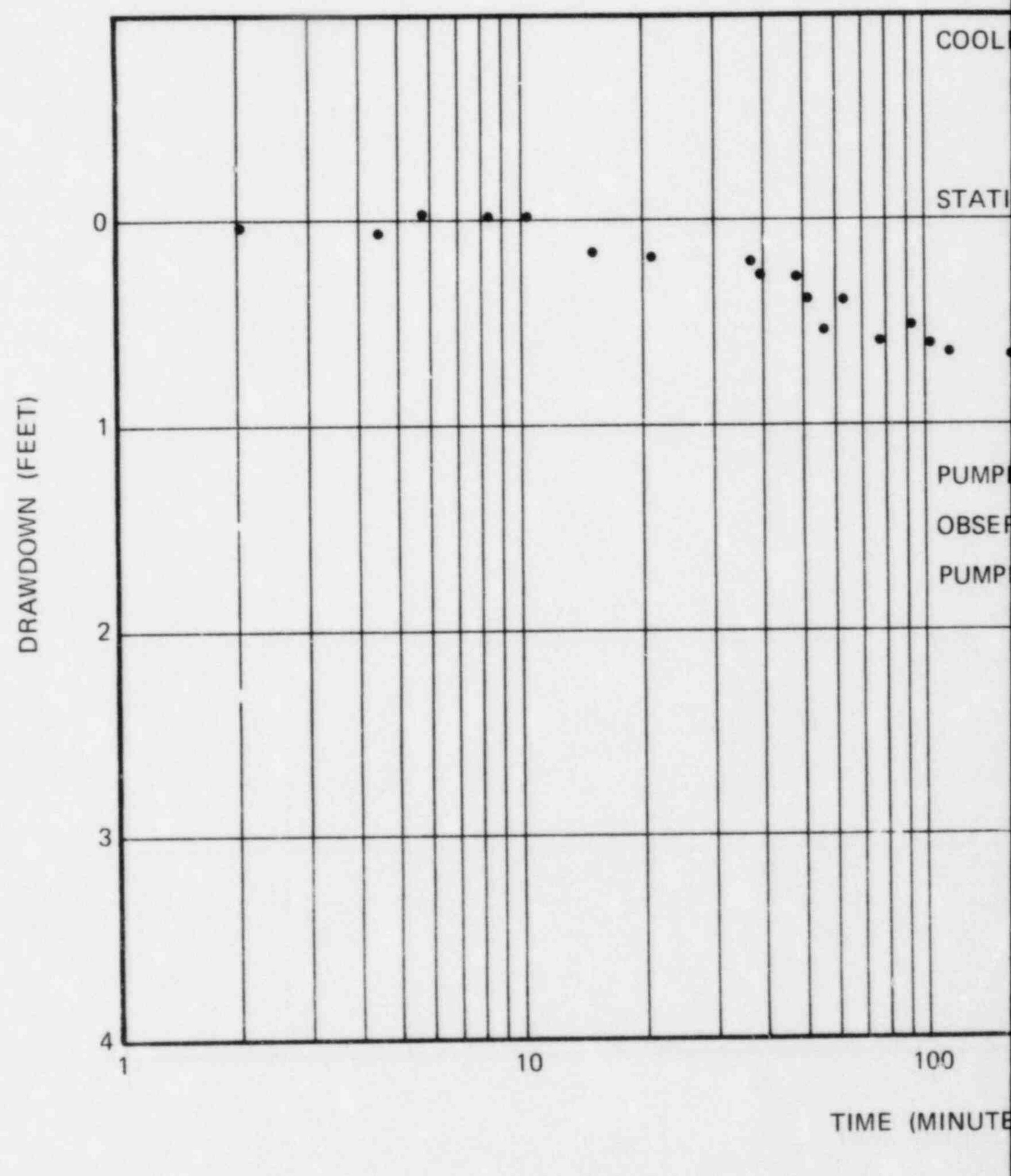
NOTE:

1. For location of observation wells, see Figure 21-1.

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

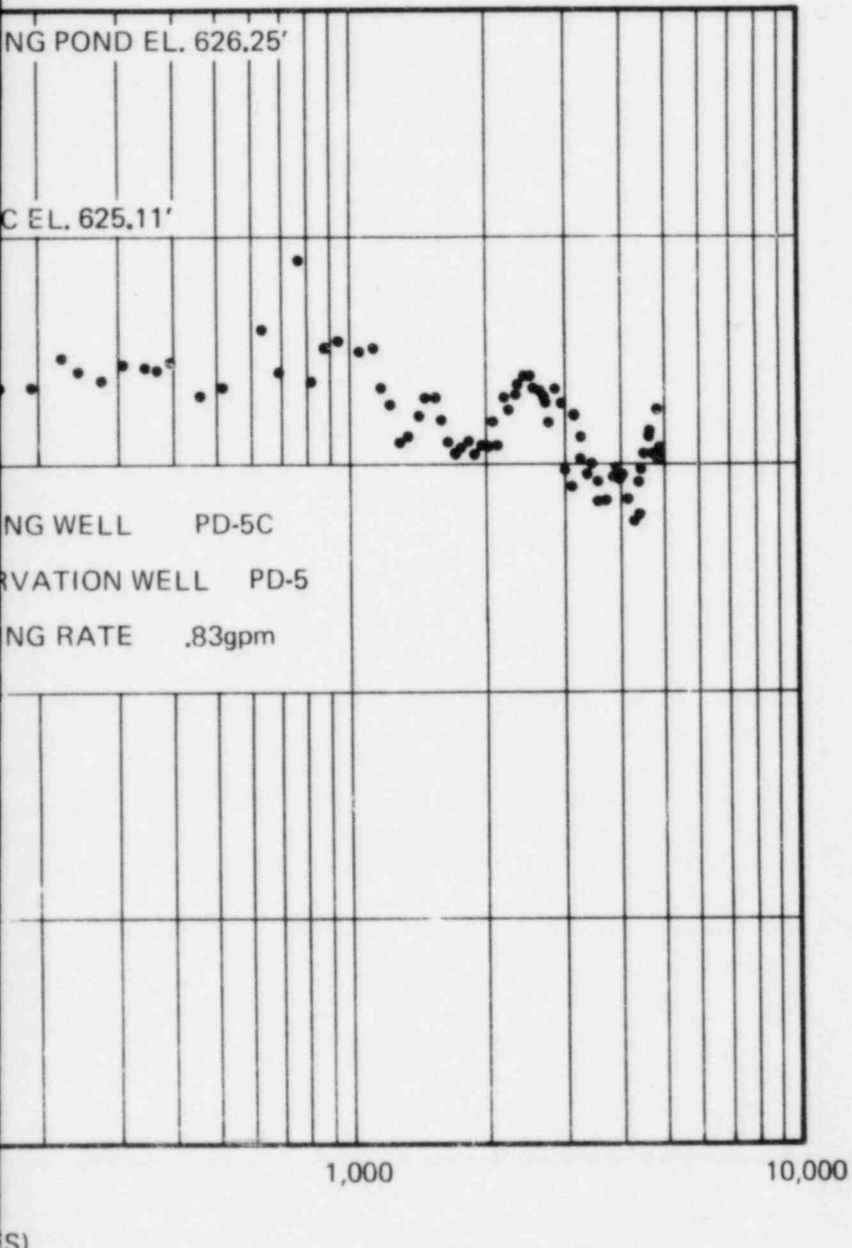
Hydrographs of Cooling Pond and Observation Wells PD-9, PD-3, and PD-16 (Rev 0)

Figure 47-6



NOTE:

1. For the location of observa
PD-5, see Figure 2.4-42



tion well

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

Time-Drawdown Graph Observation Well PD-5 Pumping Well PD-5C (Rev 0)

Figure 47-10