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REPORT OF PHASE 3 HYDROGEOLOGIC SERVICES
PROPOSED SPRING CHINOOK SATELLITE FACILITY
WINTHROP, WASHINGTON
FOR
DOUGLAS COUNTY PUBLIC UTILITY DISTRICT

GeoEngineers

March 6, 1990

Consulting Geotechnical
Engineers and Geologists

Sverdrup Corporation
1200 - 112th Avenue Northeast
P.O. Box 369
Bellevue, Washington 98009

Attention: Mr. Glen Aurdahl

We are submitting six copies of our report of Phase 3 hydrogeologic studies for ground water supply at the proposed Spring Chinook Satellite Facility near Winthrop, Washington. The initial scope of our services for this project is listed in our proposal dated July 29, 1988. The scope and budget for our services were expanded in accordance with our letter of September 1, 1989. Our Phase 3 services were performed under the terms of our technical services agreement with the Sverdrup Corporation dated July 29, 1988.

We appreciate the opportunity to be of service on this project and look forward to assisting the Sverdrup Corporation and the Douglas County P.U.D. during continuing studies of this site. Please call if you have questions regarding this report.

Yours very truly,

GeoEngineers, Inc.

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Principal

JAM:cs

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REPORT OF PHASE 3 HYDROGEOLOGIC SERVICES
PROPOSED SPRING CHINOOK SATELLITE FACILITY
WINTHROP, WASHINGTON
FOR
DOUGLAS COUNTY PUBLIC UTILITY DISTRICT

INTRODUCTION

The results of our Phase 3 hydrogeologic services at the site of the proposed Spring Chinook Satellite Facility near Winthrop, Washington are presented in this report. The site is located adjacent to the Methow River, within the northwestern quarter of Section 3, Township 34 North, Range 21 East. The proposed facility will be located about 4000 feet west (upstream) of the existing Winthrop National Fish Hatchery (NFH). The location of the site relative to regional topographic conditions is shown on the Vicinity Map, Figure 1.

Surface water and ground water are to be used for water supply at the proposed facility. We understand that a ground water supply of 10 cubic feet per second (cfs) is needed for operation of the facility. The general layout of the proposed facility is shown on the Site Plan, Figure 2.

GeoEngineers conducted Phase 1 and Phase 2 studies at the site during 1988. The purpose of our earlier studies was to explore the feasibility of developing a ground water supply of 5 to 6 cfs from an infiltration gallery and to provide information for the preliminary design of an infiltration gallery. The results of Phase 1 and Phase 2 studies are presented in separate reports dated October 5, 1988.

The Phase 1 study included the excavation of six test pits (TP-1 through TP-6) to explore shallow subsurface conditions and the installation of an observation well in each test pit. The Phase 2 study included conducting a pumping test in Well TP-1 and evaluating shallow aquifer characteristics based on the results of the pumping test. Bedrock was observed in the river channel adjacent to the site during our previous studies. Bedrock was not encountered in the test pits at the site.

We understand that, after completion of our Phase 1 and 2 studies, the desired supply of ground water for the facility increased to 10 cfs from the original needed supply of 5 to 6 cfs. We also understand that the U.S. Fish and Wildlife Service expressed concern that pumping from an infiltration gallery or production wells may reduce ground water seepage into the Foghorn Ditch and potentially increase ice formation in the ditch during the winter months.

PURPOSE AND SCOPE

The purpose of our Phase 3 services is to determine the feasibility of obtaining the 10 cfs ground water supply from production wells and/or an infiltration gallery. Specific issues of concern which were evaluated include: (1) the possibility of reduced yield from the production wells or an infiltration gallery due to the presence of shallow bedrock near the site and to the potential presence of shallow bedrock beneath the site, (2) whether production wells or an infiltration gallery would be more economical for ground water supply at the proposed facility, (3) the potential for the reduction of ground water seepage into the Foghorn Ditch due to pumping from wells or an infiltration gallery, and (4) the potential for infiltration of cold river water into the aquifer beneath the site due to pumping from the aquifer. Our specific scope of services completed during Phase 3 includes the following:

1. Subcontract the drilling of a test well (TW-10) to a depth of 127 feet. The test well was drilled as a 12-inch-diameter bore to a depth of 95 feet and as a 6-inch-diameter bore from 95 feet to 127 feet.
2. Subcontract the drilling of five additional 6-inch-diameter borings to depths ranging from 28 feet to 52 feet. Two-inch-diameter observation wells were installed in four of the borings.
3. Observe drilling activities and prepare a log of each boring.
4. Develop recommendations for well screen location, length and slot size in the 6-inch-diameter and 12-inch-diameter portions of the test well. The recommendations were based on our field observations and soil grain-size analyses.
5. Observe and evaluate well screen development activities.
6. Subcontract the rental, installation and maintenance of pump equipment for two pumping tests which were conducted in the 6-inch-diameter and 12-inch-diameter portions of the test well.

7. Observe and record time-drawdown data in the test well and observation wells during the pumping and recovery phases of the aquifer pumping tests.
8. Monitor the pH, temperature and electrical conductivity of ground water at the site during the pumping tests.
9. Measure water levels in the existing NFH infiltration galleries and the Spring Branch Spring Ditch during the pumping tests.
10. Submit two water samples that were obtained from the test well during the pumping tests for chemical analyses of water quality.
11. Evaluate the pumping test data to determine aquifer hydraulic conductivity, specific capacity and well yield.
12. Evaluate the pumping test data to determine if the presence of bedrock would result in a reduced yield from the proposed gallery or production wells.
13. Evaluate the pumping test data to determine if the temperature of the ground water produced from a gallery or wells will be adversely affected by the infiltration of river water into the aquifer.
14. Assess whether an infiltration gallery or production wells would be more economical for water supply at the site.
15. Provide preliminary design parameters and locations for production wells or an infiltration gallery that would be capable of supplying 10 cfs ground water.
16. Develop recommendations for using the test well as a production well.

SITE CONDITIONS

SURFACE CONDITIONS

Wolf Creek Road is located along the southern border of the site and relatively undeveloped pasture land is located adjacent to the eastern and western borders of the site. The Methow River flows along the northern boundary of the site. Water is diverted from the Methow River into Foghorn Ditch at a location west (upstream) of the site. Foghorn Ditch crosses the central portion of the site and is located as shown in Figure 2. Foghorn Ditch supplies surface water for use at the existing NFH facility.

Site topography consists of three relatively level terraces. The lower terrace, located adjacent to the Methow River, has ground surface elevations of about 1766 to 1770 feet. The middle terrace, located north of Foghorn Ditch, generally has ground surface elevations of about 1773 feet. The elevation of the upper terrace, located between the Foghorn Ditch and Wolf Creek Road, is generally about 1782 to 1784 feet. The general locations of the lower, middle and upper terraces are shown in Figure 2.

A house and a barn are located on the upper terrace and a shed and another barn are located on the middle terrace. Vegetation consists mainly of grass, low brush and cottonwood trees on the lower terrace. Grass and weeds are present on the middle and upper terraces at the site.

SUBSURFACE SOIL CONDITIONS

Shallow subsurface conditions were explored by excavating six test pits (TP-1 through TP-6) during our Phase 1 study. Test pit locations are shown in Figure 3. The logs of the test pits are given in our report of Phase 1 services, dated October 5, 1988. Soil encountered in the shallow test pit explorations generally consists of gravel with sand, cobbles and occasional boulders.

Subsurface conditions were further explored during our Phase 3 studies by drilling six borings (OW-7, B-8, OW-9, TW-10, OW-11 and OW-12) to depths of 28 to 127 feet. The boring locations are shown in Figure 3. Details of the field exploration program and logs of each boring are presented in Appendix A of this report.

Soil encountered in the borings generally consists of medium to coarse sand with gravel and fine to coarse gravel with sand and occasional cobbles. Fine to medium sand with a trace of silt was encountered between the depths of about 84 to 92 feet in the test well boring (TW-10). The fine to medium sand flowed into the well casing during drilling due to a greater hydraulic pressure in the sand unit as compared to the well casing. We estimate that approximately 50 cubic yards of fine sand was discharged from the well as drilling progressed between the depths of 84 and 92 feet. About 10 cubic yards would have been expected to be discharged through this depth interval in the absence of the flowing sand. Gravel with sand and sand with gravel was encountered between the depths of 92 and 119 feet in TW-10.

Bedrock consisting of black shale was encountered at a depth of 27 feet in OW-7, 43 feet in B-8, 48 feet in OW-11 and 119 feet in TW-10. A surface outcrop of the shale is exposed in the channel of the Methow River (Figure 3). It appears that the depth to bedrock increases toward the southwest portion of the property based on our field explorations. Generalized subsurface cross-sections of the site and the Methow Valley are presented in Figures 4 and 5.

GROUND WATER CONDITIONS

Ground water conditions at the site were explored by constructing wells in 5 of the 6 borings (OW-7, OW-9, TW-10, OW-11 and OW-12) completed during our Phase 3 studies. Well TW-10 was constructed as a test well for evaluation of aquifer yield. The remaining wells were constructed as observation wells for the pumping tests and for future collection of ground water samples for analytical testing. A well was not constructed in B-8. Construction details for the wells are included in Appendix A. Wells TP-1 through TP-6, installed during our Phase 1 studies, were included in our field measurements to provide additional information with respect to ground water conditions.

The static water table depth and elevation were measured in the wells during our Phase 3 field studies on September 13 and October 10, 1989. Ground water elevations generally increased slightly between September and October. The depth to ground water in the observation wells located on the lower terrace ranged from about 5 to 7 feet. Ground water was encountered at depths of about 3 to 5 feet below ground surface in the wells located on the middle terrace. The depth to ground water was about 12 feet below ground surface on the upper terrace. The elevation of the water table appears to decrease by about 9 feet from the location of OW-12 on the upper terrace to the location of OW-11 on the lower terrace. This is equivalent to a water table slope (gradient) of approximately 0.0093.

Ground water elevations at the well locations and water table contours for measurements made on October 10, 1989 are shown in Figure 3. The general direction of ground water flow appears to be northeastward toward the river based on our September 1989 and October 1989 measurements.

The river water surface elevation adjacent to the site was slightly lower than ground water elevations in nearby wells during our measurements in September 1989 and October 1989. Site measurements during September 1989 and October 1989 indicated that the Methow River was gaining water from the aquifer beneath the site. Site measurements during August 1988 indicated that the Methow River was losing water into the aquifer beneath the site. It appears that the portion of the aquifer immediately adjacent to the river is recharged by river water during the drier summer season and during periods when the river surface elevation is greater than adjacent ground water elevations. However, for most of the year the aquifer appears to discharge to the river in the site vicinity.

AQUIFER TESTING

GENERAL

A relatively high degree of hydraulic connection appears to exist between the sand and gravel deposits above and below the fine sand layer encountered between the depths of 84 to 92 feet in the test well (TW-10) based on the results of the pumping tests. For discussion purposes, however, we have designated the soils above and below the fine sand layer the "upper" and "lower" aquifers, respectively.

A pumping test of the lower aquifer was conducted during September 1989 to evaluate the potential for production of ground water from the sand and gravel deposit that was encountered between the depths of 92 to 119 feet in TW-10.

A pumping test of the upper aquifer was conducted during October 1989 to evaluate the potential for production of ground water from the sand and gravel deposit that was encountered above the depth of 84 feet in TW-10.

Water levels in the pumping well and observation wells (including wells constructed during our Phase 1 study) were monitored on a periodic basis during the each of the pumping tests and as water levels recovered after pumping was terminated. Water levels in the Methow River, the Winthrop National Fish Hatchery (NFH) infiltration galleries and the Spring Branch Spring Ditch were also monitored during the pumping tests. Spring Branch Spring Ditch, which flows into Foghorn Ditch, is located as shown in Figure 1.

LOWER AQUIFER

Six-inch-diameter telescoping stainless steel well screen with a slot size of 0.040 inches was installed in the test well (TW-10) between the depths of 98 to 118 feet. The well screen was developed by surging with air lift methods on September 11, 1989. A pumping test of the lower aquifer was conducted for a period of about 27 hours between September 13 and 14, 1989. Water was pumped from the well at a rate of about 650 to 700 gallons per minute (gpm) during the pumping test and discharged to the Methow River. A maximum drawdown of about 3 feet was recorded in TW-10 during the test. Drawdown in TW-10 appeared to stabilize after about 10 to 12 hours of pumping. Plots of the water level versus time in TW-10, OW-9 and OW-12 are shown in Figures 6 and 7. Water levels in the Methow River were relatively stable during the pumping test.

Analysis of the pumping test data indicates that the hydraulic conductivity of the lower aquifer is about 0.70 feet per minute. The specific capacity of the lower aquifer is about 240 gpm per foot of drawdown based on the results of the pumping test.

The wells at the site, with the exception of the test well (TW-10), are completed in the sand and gravel deposits of the upper aquifer. Drawdown of water levels was observed in the wells completed in the upper aquifer during the pumping test conducted in the lower aquifer. A relatively high degree of hydraulic connection appears to exist between the upper and lower aquifers based on the observed drawdowns in the upper aquifer during the lower aquifer pumping test.

The 6-inch-diameter well casing and screen were removed from the test well after the pumping test of the lower aquifer was completed.

UPPER AQUIFER

Twelve-inch-diameter telescoping stainless steel well screen with a slot size of 0.150 inches was installed in the test well (TW-10) between the depths of 60 to 80 feet after the 6-inch-diameter casing and screen were removed from the boring. The 12-inch well screen was developed by surging with air lift methods between September 25 and 26, 1989. The 12-inch screen was redeveloped using air lift methods between October 4 and 7, 1989 after an initial pumping test attempt yielded excessive sand in the discharge water. We estimate that 150 to 175 cubic yards of fine sand were discharged from the well during development of the 12-inch well screen. A pumping test of this aquifer was conducted for a period of about 48 hours between October 10 and October 12, 1989. The test well was pumped initially at a rate of 1500 gpm; after four hours the discharge was increased to a rate of about 2000 gpm. Water was discharged to the Methow River during the pumping test. A maximum drawdown of about 13 feet was recorded in the pumping well during the test. Drawdown in the test well appeared to stabilize after about 28 hours of pumping. Plots of the water level versus time in TW-10, OW-7, OW-9 and OW-12 are shown in Figures 8 through 10, respectively. Water levels in the Methow River were relatively stable during the pumping test.

Analysis of the pumping test data indicates that the hydraulic conductivity of the upper aquifer is about 0.35 feet per minute. The specific capacity of the upper aquifer is about 156 gpm per foot of drawdown.

We estimate that the combined hydraulic conductivity and specific capacity of the lower and upper aquifers is about 0.42 feet per minute and 173 gpm per foot of drawdown, respectively.

The drawdown observed in OW-9, located approximately 200 feet north of the pumping well, was about 3 feet during the pumping test of the upper aquifer. Observed drawdown in OW-12, located approximately 100 feet south of the pumping well and near Foghorn Ditch, was about 1.6 feet during this pumping test. Generally, a greater drawdown is expected in the observation well which is located closest to the pumping well. The lesser amount of drawdown in OW-12 appears to result primarily from a compressed cone of depression in the upgradient direction from the test well. The drawdown observed in OW-12 may have also been affected, to a lesser degree, by seepage of surface water from Foghorn Ditch.

This pattern of reversed drawdown in Wells OW-12 and OW-9 was not observed during the pumping test of the lower aquifer. Similar observations may have resulted, however, if a greater pumping rate was attempted during testing of the lower aquifer.

GROUND WATER QUALITY

The temperature, pH and electrical conductivity of ground water from the test well were measured periodically during each pumping test. The temperature and electrical conductivity of ground water from the observation wells were also measured periodically during each pumping test. The results of these measurements are summarized in Tables 1 and 2.

The temperatures of ground water from the test well and observation wells were nearly identical during the pumping tests of the lower and upper aquifers. Ground water temperatures from the test well varied between 47°F and 48°F during the pumping tests. The temperature of ground water in the relatively shallow observation wells ranged between 47°F and 57°F and generally showed a slightly greater temperature fluctuation as compared to water pumped from the test well. The lowest temperatures in the shallow observation wells were generally recorded in the early morning hours and the highest temperatures recorded in the late afternoon. The temperature of ground water in the shallow observation wells appeared to be affected by atmospheric temperature fluctuations and warming of the above-grade portions of the well casings. River water did not appear to be infiltrating to the shallow aquifer beneath the site during the pumping tests based on our water table measurements. Ground water temperatures from the September and October 1989 pumping tests were generally slightly lower than the temperatures measured during the August 1988 (Phase 2) pumping test.

The electrical conductivity of the ground water in the test and observation wells ranged from 60 to 180 µhmos/cm during the pumping tests. The pH of ground water from the test well ranged from 6.8 to 7.0 during the test of the lower aquifer and from 6.9 to 7.5 during the test of the upper aquifer. The pH of ground water from in the observation wells was not measured during the pumping tests.

A ground water sample was collected from the test well (TW-10) near the end of each pumping test and submitted for laboratory chemical analyses. The results of the analyses are summarized in Table 3. The laboratory reports are presented in Appendix B. State of Washington Department of Fisheries (WDF) recommended water quality standards for fish production are also shown in Table 3 for comparison. Analytical results indicate that the ground water from each aquifer would be suitable for fishery-related purposes. The analytical results also indicate that ground water from the upper and lower aquifers are chemically similar.

GROUND WATER SUPPLY FOR THE PROPOSED FACILITY

GENERAL

Our evaluations of the results obtained during our field studies at the site indicate that production wells would be preferable to an infiltration gallery for the purpose of obtaining the needed 10 cfs ground water supply at the site. We recommend that three production wells located as shown in Figure 2 be used to provide the needed ground water supply for the proposed facility. Factors considered during development of our recommendation to use production wells for water supply are described in the following sections of this report.

GROUND WATER TEMPERATURE

The temperature of ground water pumped from the test well was relatively stable during our Phase 3 pumping tests. We expect that ground water obtained from production wells located in the southern portion of the site would not be significantly affected by the temperature of the river or by atmospheric temperature. We estimate that the temperature of ground water from the proposed production wells would be relatively constant at about 47°F to 48°F based on measurements during the pumping tests.

The temperature of ground water from a shallow infiltration gallery located near the river may be adversely affected by infiltration of cold river water and by atmospheric temperature variations. We understand that ground water would be used to supply the proposed facility during the winter season. We expect that the temperature of ground water from the proposed production wells would be more stable and warmer than ground water from an infiltration gallery.

POTENTIAL REDUCED YIELD FROM BEDROCK

We estimate that an infiltration gallery would have to be about 500 feet in length to obtain the needed 10 cfs ground water supply, assuming that the gallery was located on the lower terrace and near the river. The length of the property boundary parallel to the river is slightly greater that 500 feet. In our opinion, the presence of relatively shallow bedrock beneath the lower terrace in the northwestern portion of the site and the presence of bedrock within the river channel increases the potential for reduced long-term yield from an infiltration gallery. An infiltration gallery located on the middle or upper terraces (areas where the bedrock was encountered at a greater depth) would need to be longer than 500 feet to obtain the needed 10 cfs ground water supply. As discussed below, an infiltration gallery longer than 500 feet would cost significantly more than the construction of production wells.

The presence of shallow bedrock in the northwestern portion of the site did not appear to reduce well yield or increase the observed water level drawdown during the pumping tests in the Phase 3 test well. We understand that the ground water supply may be needed for periods of up to 90 days per year. In our opinion, the potential for reduced yield from production wells constructed on the upper terrace due to the presence of bedrock is significantly less than the potential for reduced yield from an infiltration gallery located near the river.

Although the potential appears to be relatively low, it is possible that the presence of the bedrock could adversely affect the long-term yield from production wells. We recommend, prior to construction of the facilities, that the production wells be installed and pumped for a period of at least 60 days to confirm that the bedrock has little or no affect on the long-term yield from the proposed production wells.

CONSTRUCTION COSTS

Our estimated costs for construction of the production wells are less than construction costs for an infiltration gallery. We estimate that the cost of constructing an infiltration gallery at the DCPUD site to be about $300 per lineal foot (not including pumps, controls and distribution piping) or about $150,000 for a gallery with a length of 500 feet. We estimate that the cost for construction of three production wells drilled to a depth of 125 feet would be approximately $95,000 to $110,000 (not including pumps, controls and distribution piping).

POTENTIAL INTERFERENCE WITH NFH WATER SUPPLIES

GeoEngineers measured water levels in the existing NFH galleries during the two pumping tests of the upper and lower aquifers. The water levels in the galleries increased during the pumping test in the upper aquifer. The rise in water level is attributed to a decrease in the rate of pumping from 2700 to 700 gpm in the existing NFH Gallery No. 1 during the upper aquifer pumping test. Water levels were stable in the existing NFH galleries during the pumping test of the lower aquifer. The data from Phase 3 pumping tests indicates that the radius of influence for the proposed production wells will be about 1,000 feet. The Winthrop NFH galleries are located about 4,000 feet from the DCPUD site. Our evaluations indicate that withdrawal of ground water at a rate of 10 cfs will not interfere with the infiltration galleries at the existing Winthrop NFH.

The U.S. Fish and Wildlife Service has expressed concern that pumping during the winter months would increase the potential for ice formation in Foghorn Ditch by reducing the seepage of "warm" ground water into the ditch in the vicinity of the DCPUD site. NFH personnel indicated during our Phase 3 field studies that ground water seepage into the ditch occurs in the vicinity of the DCPUD site; however, the specific locations of seepage were not identified. Obvious indications of seepage of ground water into the ditch were not observed by GeoEngineers during our visual reconnaissance of the ditch during September and October 1989.

Water level measurements at the site during our Phase 3 pumping tests indicated that ground water elevations in the vicinity of Foghorn Ditch were approximately 1.0 to 1.5 feet higher than the elevation of the base of the ditch. Surface water elevations in Foghorn Ditch were about 2 feet higher than ground water elevations in the vicinity of the ditch. Measurements of ground water elevations at the site suggest that Foghorn Ditch was losing water to the aquifer beneath the site both before and during the Phase 3 pumping tests.

It appears that the effects of pumping at a rate of 10 cfs will extend along the ditch approximately 800 feet west and 500 feet east of the site boundaries based on our analysis of the pumping test data. We estimate that the withdrawal of ground water from the proposed production wells would cause a maximum drawdown in ground water elevations beneath the ditch of between 2.5 to 3.5 feet. In our opinion, withdrawal of ground water at a rate of 10 cfs from production wells at the locations shown in Figure 2 will induce additional seepage from the ditch.

Although seepage of ground water into Foghorn Ditch did not appear to be occurring during our Phase 3 field studies, ground water seepage into Foghorn Ditch could potentially occur during periods when the ground water elevation exceeds the surface water elevations in the ditch. Pumping from the proposed production wells could reduce the rate of seepage into Foghorn Ditch during periods of high ground water elevations.

We recommend that assessment of water loss in Foghorn Ditch during pumping from the proposed production wells be evaluated by measuring flow volumes in the ditch at locations upstream and downstream of the area affected by pumping. The possible loss of water due to the seepage from the ditch could be mitigated by diverting a relatively small percentage of water from the production wells to Foghorn Ditch.

Water from the Spring Branch Spring Ditch is also used by the NFH. NFH personnel expressed concerns regarding the potential for reduced flow volumes from the Spring Branch Spring Ditch during pumping for the proposed facilities. GeoEngineers measured water levels in the Spring Branch Spring Ditch during the October 1989 pumping test of the upper aquifer. The water level in Spring Branch Spring Ditch increased by 0.02 feet during the pumping test. The minimum distance between Spring Branch Springs Ditch and proposed production wells is about 1500 to 2000 feet. The data from Phase 3 pumping tests indicates that the radius of influence for the proposed production wells will be about 1000 feet. In our opinion, withdrawal of ground water at a rate of 10 cfs from the proposed production wells will not interfere with the Spring Branch Springs Ditch.

GROUND WATER FLUX

Water level measurements in the wells at the site indicate a ground water flow direction toward the Methow River (Figure 3). Under normal conditions, a considerable flux of ground water passes beneath the proposed DCPUD site. Assuming a flow path width of 2000 feet (twice the radius of influence of the pumping wells), an aquifer thickness of 100 feet, a mean hydraulic conductivity for the aquifer of 0.42 feet per minute, and a water table slope of 0.0093, the ground water flux is calculated at approximately 13 cfs. This flux is greater than the anticipated ground water withdrawal rate of 10 cfs. Therefore, a measurable loss of base flow in the Methow

River due to ground water withdrawal at the proposed DCPUD facility is not expected. Furthermore, because significant reversals of ground water flow direction (from the river toward the wells) are not expected, we anticipate relatively stable ground water temperatures in the new production wells.

DISCUSSION AND RECOMMENDATIONS

We recommend that three production wells be constructed south of the Foghorn Ditch, located approximately as shown in Figure 2, to obtain the desired 10 cfs ground water supply. We estimate that the maximum drawdown will be about 14 to 16 feet in the three proposed production wells during simultaneous pumping of ground water at a rate of 3.33 cfs from each well (combined rate of 10 cfs). We recommend that the proposed production wells withdraw ground water from both aquifers to take advantage of the greater specific capacity of the lower aquifer. Our recommended design of the proposed production wells is based on conditions encountered in the Phase 3 test well. We recommend that the final design of the proposed production wells be based on conditions encountered during drilling of the wells. On a preliminary basis, we recommend that each production well be drilled as a 16-inch-diameter bore to a depth of about 125 feet. We estimate that the production capacity of each well will range between 1600 gpm and 1900 gpm. The 16-inch-diameter bore is needed to allow the installation of a pump capable of supplying 1600 gpm to 1900 gpm supply of ground water.

On a preliminary basis, we recommend that 30 feet of 16-inch-diameter stainless steel telescoping well screen be installed in each well. We expect that the screens will consist of one 10-foot section of screen and one 20-foot section of screen separated by a length of blank pipe. The 10-foot section of screen will be placed in the lower aquifer and the 20-foot section of screen will be placed in the upper aquifer. The section of blank pipe will be placed to correspond to the fine sand deposit. The length of the blank section will be determined by the thickness of the fine sand deposit. We recommend that the well screen slot size be selected based on the results of soil grain-size testing conducted during drilling of the proposed wells.

We recommend that the production wells be pumped at a combined rate of 10 cfs for a duration of 60 days prior to starting construction of the remaining facilities at the site. The purpose of a 60-day test is to fully assess any potential aquifer boundary conditions, such as bedrock, which may affect long-term well yield. The production wells, observation wells, NFH galleries, Spring Branch Spring Ditch and Foghorn Ditch should be monitored frequently during the first week of the test and on a weekly basis thereafter. We recommend that the ground water be discharged directly to the Methow River during the 60 day test. The USF&WS and the State of Washington Departments of Fisheries and Ecology will require notification of discharge to the river during the long-term pumping test. We recommend that the pumps intended for permanent use at the site be installed in the wells before the long-term pumping test. A short-term pumping test using rental equipment should be conducted prior to installing the permanent pumps to evaluate well yield and to ensure that the well screens have been adequately developed. We further recommend that improvements to the well heads such as concrete pads be constructed prior to the 60 day test.

We recommend that the Phase 3 test well (TW-10) be maintained as presently constructed for use as a backup for the proposed production wells. Well TW-10 could be used to supply water to the facility during potential mechanical failure or maintenance of pumping equipment in one of the proposed production wells. We recommend that the maximum pumping rate from Well TW-10 be limited to 1500 gpm. Well TW-10 could also be used for domestic water supply for the proposed facilities.

We estimate that a total of about 200 to 225 cubic yards of soil were discharged from TW-10 during the drilling and well screen development activities. The soil discharged during drilling was primarily from between the depths of 60 to 95 feet. Approximately 150 to 175 cubic yards of fine to medium sand was discharged during development of the 12-inch well screen that was placed between the depths of 60 to 80 feet. In our opinion there is the potential for settlement of the ground surface in the vicinity of TW-10 because of the volume of soil discharged from TW-10. If settlement of the ground surface occurs, we expect that it would be limited to a radius of less than 50 feet from TW-10. We recommend that the proposed facility structures be located at least 50 feet from TW-10 and the three proposed production wells.

We recommend that additional Phase 4 services be conducted at the site. The purpose of the Phase 4 services is to (1) observe production well drilling, well development and pumping test activities, (2) provide final recommendations for long-term pumping rates in the production wells, and (3) provide recommendations for mitigating potential seepage losses from Foghorn Ditch. Our recommended scope of services for Phase 4 includes the following:

1. Observe production well drilling activities and prepare a geologic log of each boring.
2. Develop recommendations for well screen location(s), length and slot size based on field observations and soil grain-size analyses.
3. Observe and evaluate well screen installation and development activities.
4. Observe and record time-drawdown data during short-term (24-hour) pumping tests in the production wells.
5. Monitor the temperature, pH and electrical conductivity of ground water at the site during the pumping tests.
6. Submit a ground water sample collected from each production well for detailed chemical analyses of water quality parameters.
7. Provide estimates of drawdown during production pumping, based on the 24-hour pumping tests.
8. Development recommendations for production well pumps and related equipment.
9. Develop recommendations for a 60 day aquifer pumping test, and coordinate with regulatory agencies concerning discharge of ground water to the Methow River during the test.
10. Observe and record time-drawdown data during the initial portion of the 60-day pumping test.
11. Monitor Foghorn Ditch, the Spring Branch Spring Ditch and the NFH galleries for potential interference affects during the initial portion of the pumping test.
12. Develop recommendations for continued monitoring of the 60-day test by DCPUD personnel.

13. Evaluate the results of the 60-day test to provide final recommendations on long term ground water supply, pumping rates, and mitigation of potential interference affects in Foghorn Ditch.
14. Summarize the findings and recommendations of the Phase 4 studies in a final written report.

LIMITATIONS

We have prepared this report for use by the Sverdrup Corporation and the Douglas County Public Utility District for their evaluation of the ground water supply potential for the proposed Spring Chinook Satellite Facility by pumping from an infiltration gallery or production wells. Our recommendations are based on our review and interpretation of the results of our subsurface explorations. The potential for development of an adequate ground water supply using production wells appears to be favorable at the site. Our interpretations, however, should not be construed as a warranty of favorable long-term ground water supply conditions at the site. A more detailed study of long-term ground water withdrawal conditions is necessary to fully assess potential limitations to ground water supply at the site.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No other conditions, express or implied, should be understood.

- o O o -

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We appreciate the opportunity to be of service. Please call if you have questions regarding our report.

Respectfully submitted,

GeoEngineers, Inc.

Terry T. Fisk
Geologist

John H. Biggane
Associate

James A. Miller, P.E.
Principal

TTF:JHB:JAM:sd

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TABLE 1

GROUND WATER TEMPERATURE, pH AND ELECTRICAL CONDUCTIVITY PUMPING TEST OF LOWER AQUIFER

Well Number	Temperature (degrees Fahrenheit)	pH	Electrical Conductivity (uhmos/cm)
TP-1	49 to 52		107 to 148
TP-2	51 to 52		102 to 107
TP-3	52 to 54		102 to 105
TP-4	55 to 57		90 to 96
TP-5	52 to 54		100 to 103
TP-6	51 to 54		105 to 110
OW-7	48 to 52		99 to 160
OW-9	53		98 to 104
TW-10	47 to 48	6.8 to 7.0	60 to 120
OW-11	47 to 49		65 to 69
OW-12	52 to 55		98 to 138

Note: Data was collected between September 13 and 14, 1989.

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TABLE 2

GROUND WATER TEMPERATURE, pH AND ELECTRICAL CONDUCTIVITY PUMPING TEST OF UPPER AQUIFER

Well Number	Temperature (degrees Fahrenheit)	pH	Electrical Conductivity (umhos/cm)
OW-7	50		140
OW-9	53 to 54		158
TW-10	48	6.9 to 7.5	123 to 140
OW-11	48		180
OW-12	51 to 53		110 to 123

Note: Data was collected between October 10 to 12, 1989.

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TABLE 3
SUMMARY OF GROUND WATER CHEMISTRY DATA

Water Quality Parameter(1)	Well TW-10(2)	WDF(3) Standards
Arsenic	<0.01	<0.05
Barium	<0.25	<5.0
Cadmium	<0.002	<0.0002
Chromium	<0.01	<0.01
Iron	<0.05	<0.1
Lead	<0.01	<0.02
Manganese	<0.01	<0.01
Mercury	<0.001	<0.002
Selenium	<0.005	<0.002
Silver	<0.010	<0.0003
Sodium	<10	<75
Hardness (as CaCO3)	80	10 to 400
Conductivity	118	NA
Turbidity (NTU)	0.3	NA
Fluoride	<0.2	<0.5
Nitrate	<0.2	<1
Chloride	<10	<4
pH	7.2	6.5 to 8.0
Dissolved Oxygen	10.8	>7

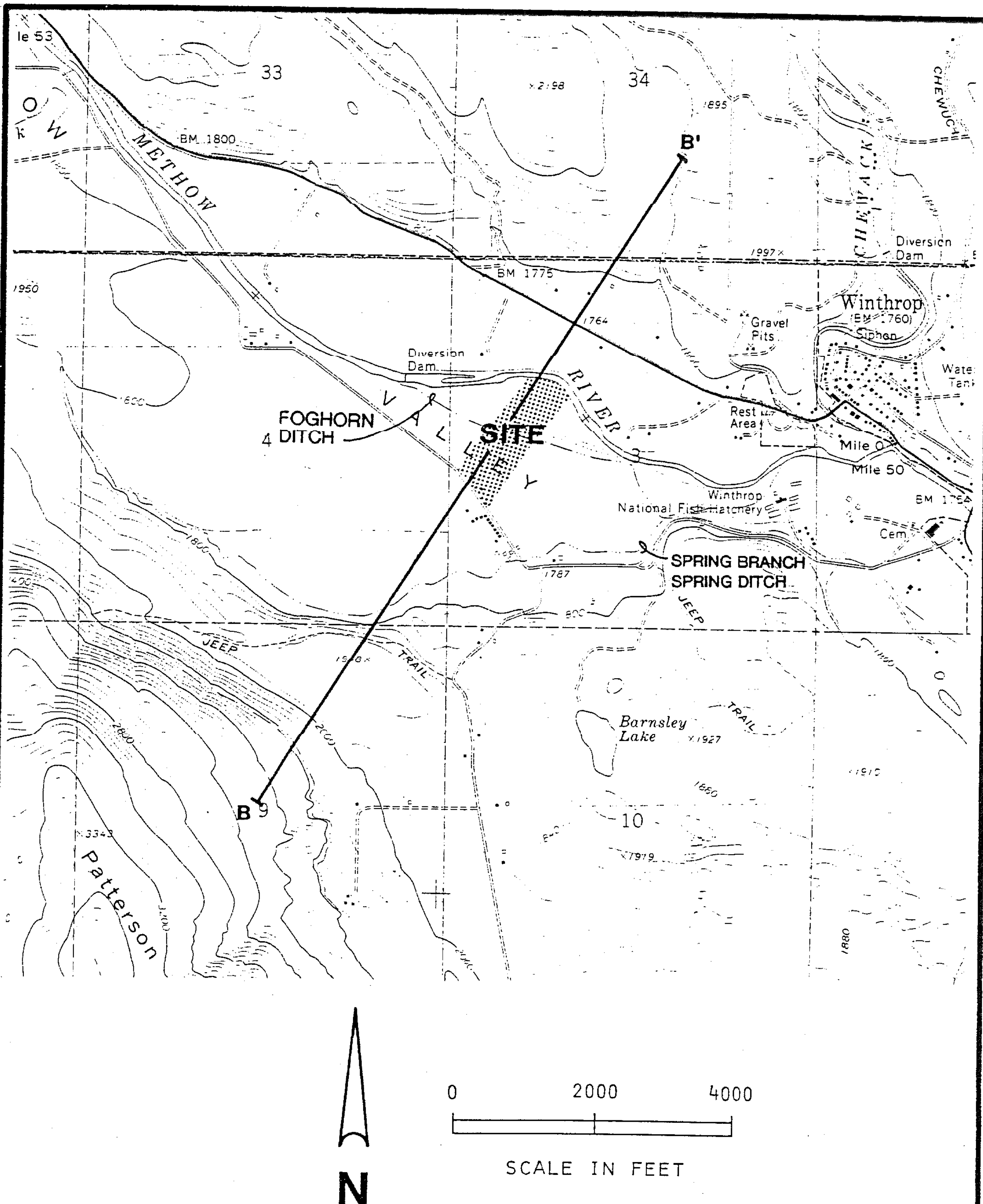
Notes:

(1) Concentrations in mg/l unless noted.

(2) Results shown are for a ground water sample collected from the upper aquifer on October 12, 1989. Chemical data for a ground water sample collected from the lower aquifer on September 14, 1989 was identical except for the following parameters: Nitrate = 0.4 mg/l, Hardness = 78 mg/l, Conductivity = 110 and pH = 7.33.

(3) Washington Department of Fisheries recommended water quality standards for fish production.

"NA" indicates "not available"



REFERENCE: USGS 7.5' TOPOGRAPHIC QUADRANGLE MAP "WINTHROP, WASH."

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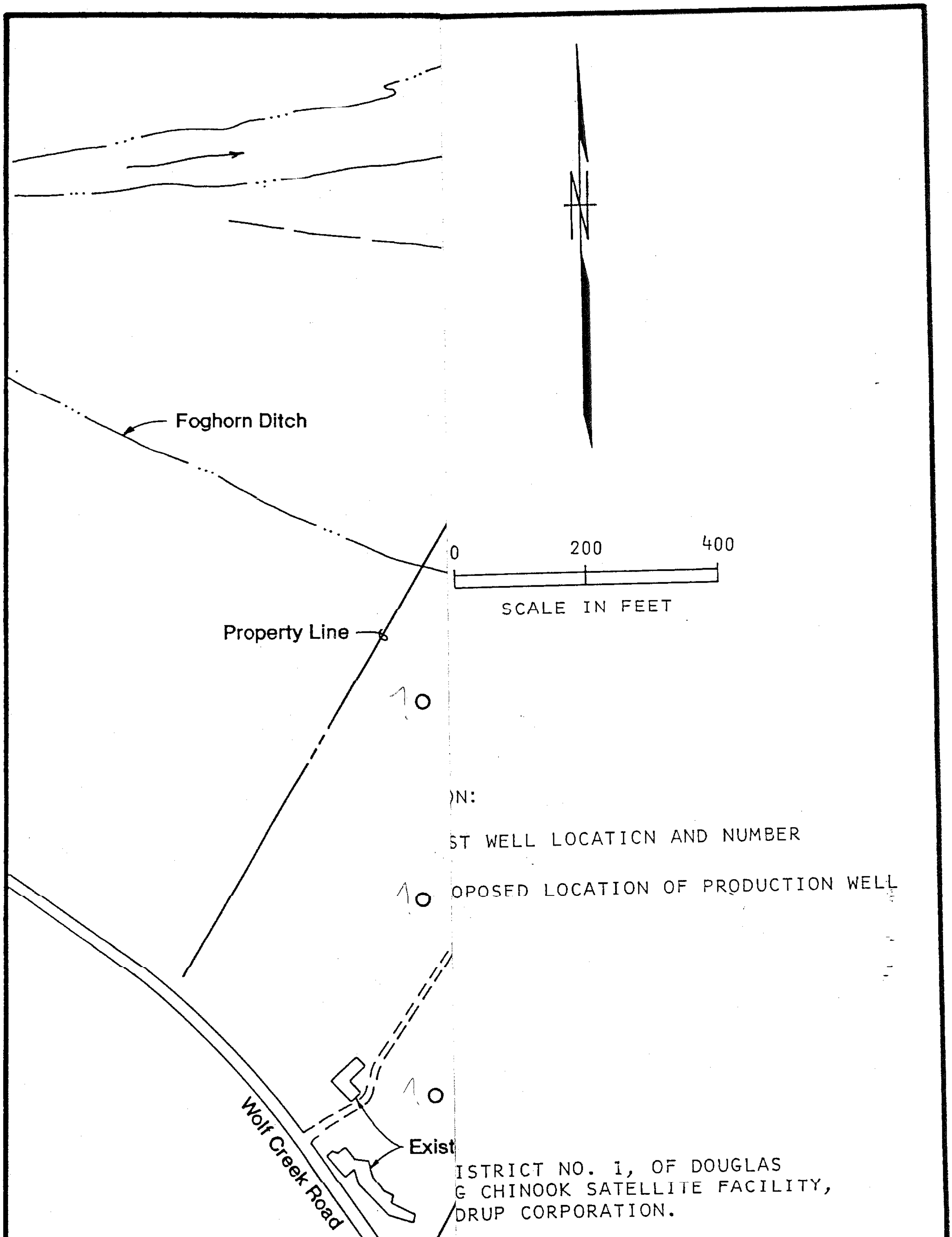
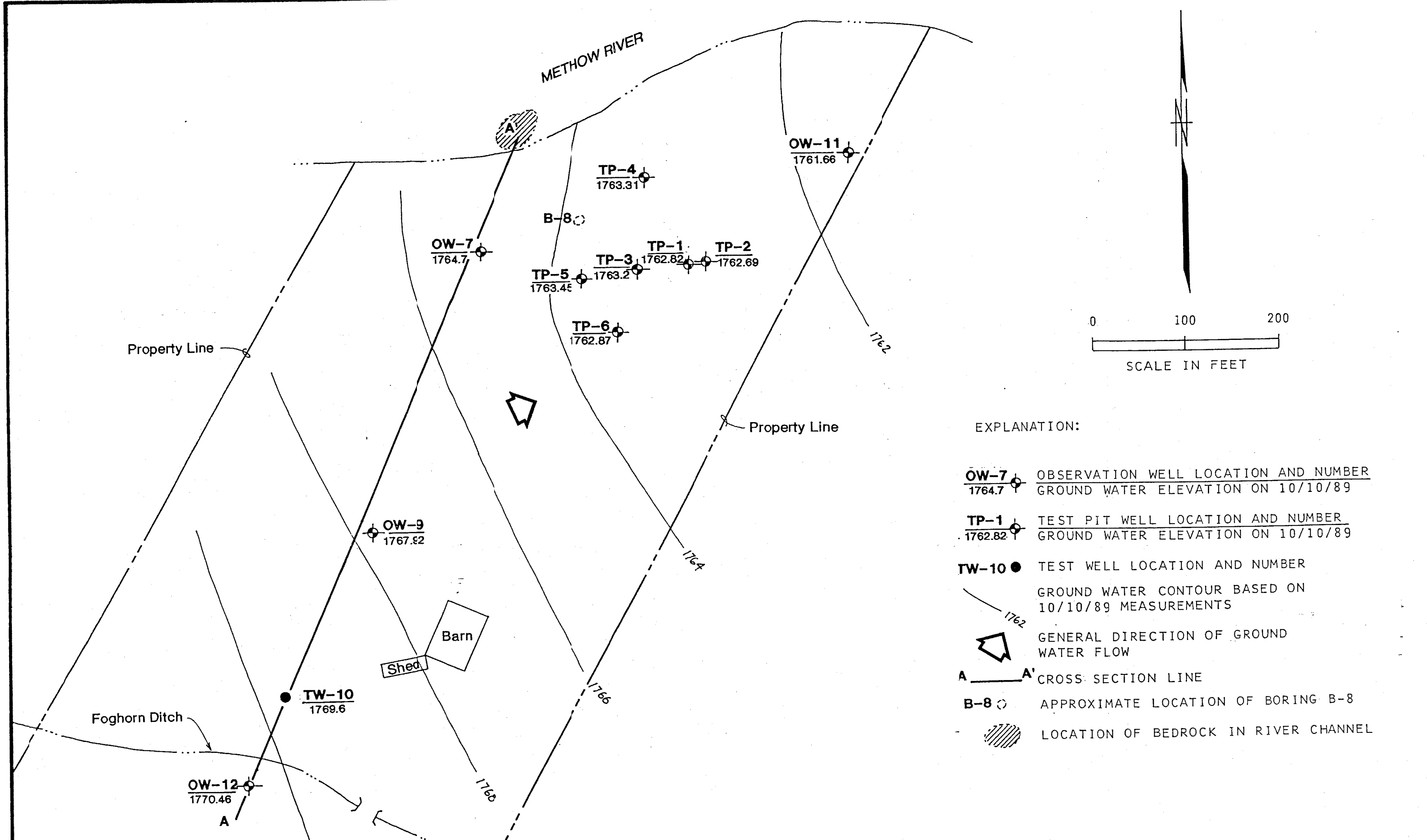
VICINITY MAP

FIGURE 1



SITE PLAN

FIGURE 2



REFERENCE: DRAWING ENTITLED "DOUGLAS COUNTY P.U.D. NO.1, SPRING & SUMMER CHINOOK REARING FACILITY, WINTHROP, WASHINGTON", DATED 9/26/89 BY ERLANDSEN & ASSOCIATES.

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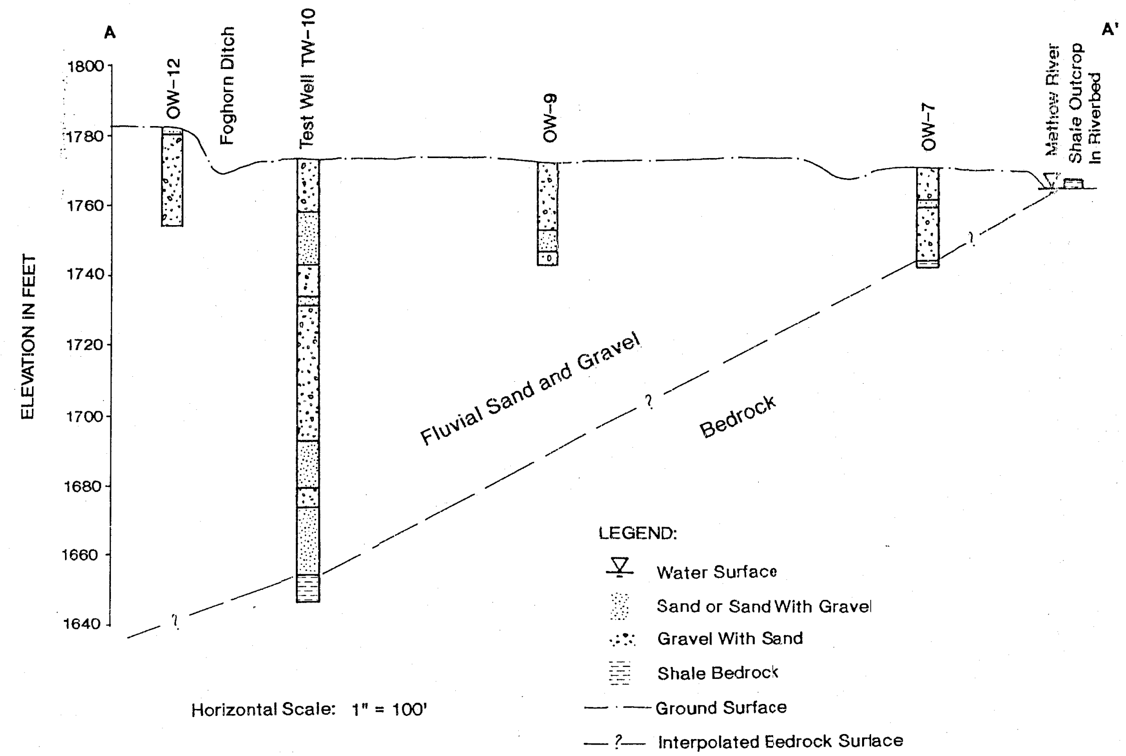
WELL LOCATIONS AND GROUND WATER CONTOURS

FIGURE 3



NOTE: CROSS SECTION A - A' IS LOCATED AS SHOWN IN FIGURE 3.

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CROSS SECTION A–A'

FIGURE 4

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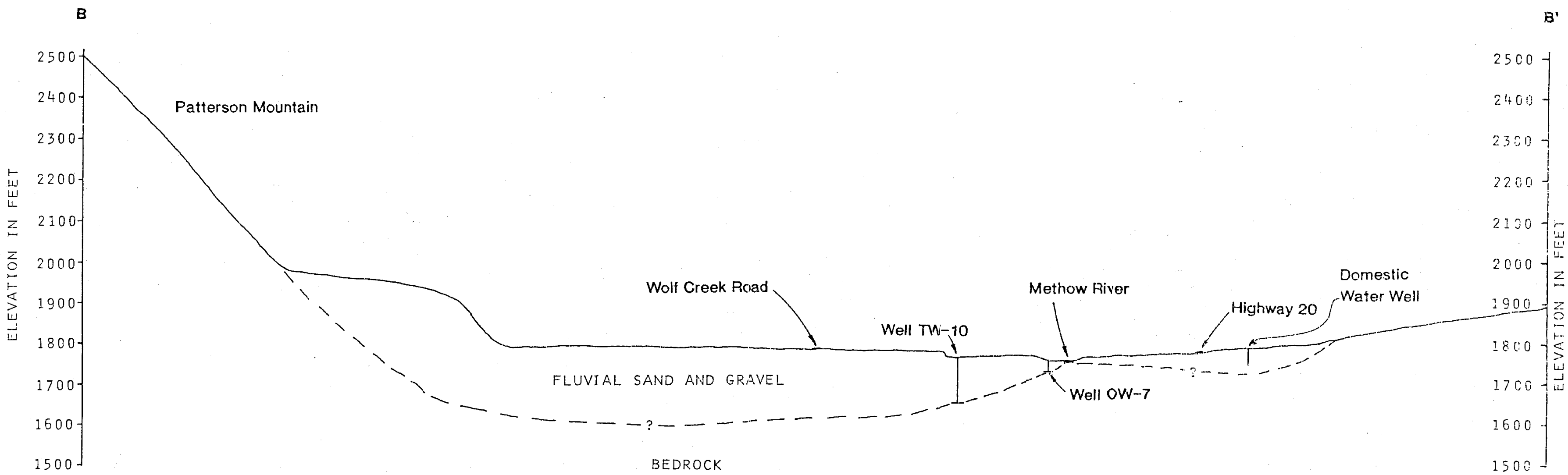

HORIZONTAL SCALE: 1"=750'
VERTICAL SCALE: 1"=250'

NOTE: CROSS SECTION B - B' IS LOCATED AS SHOWN IN FIGURE 1.

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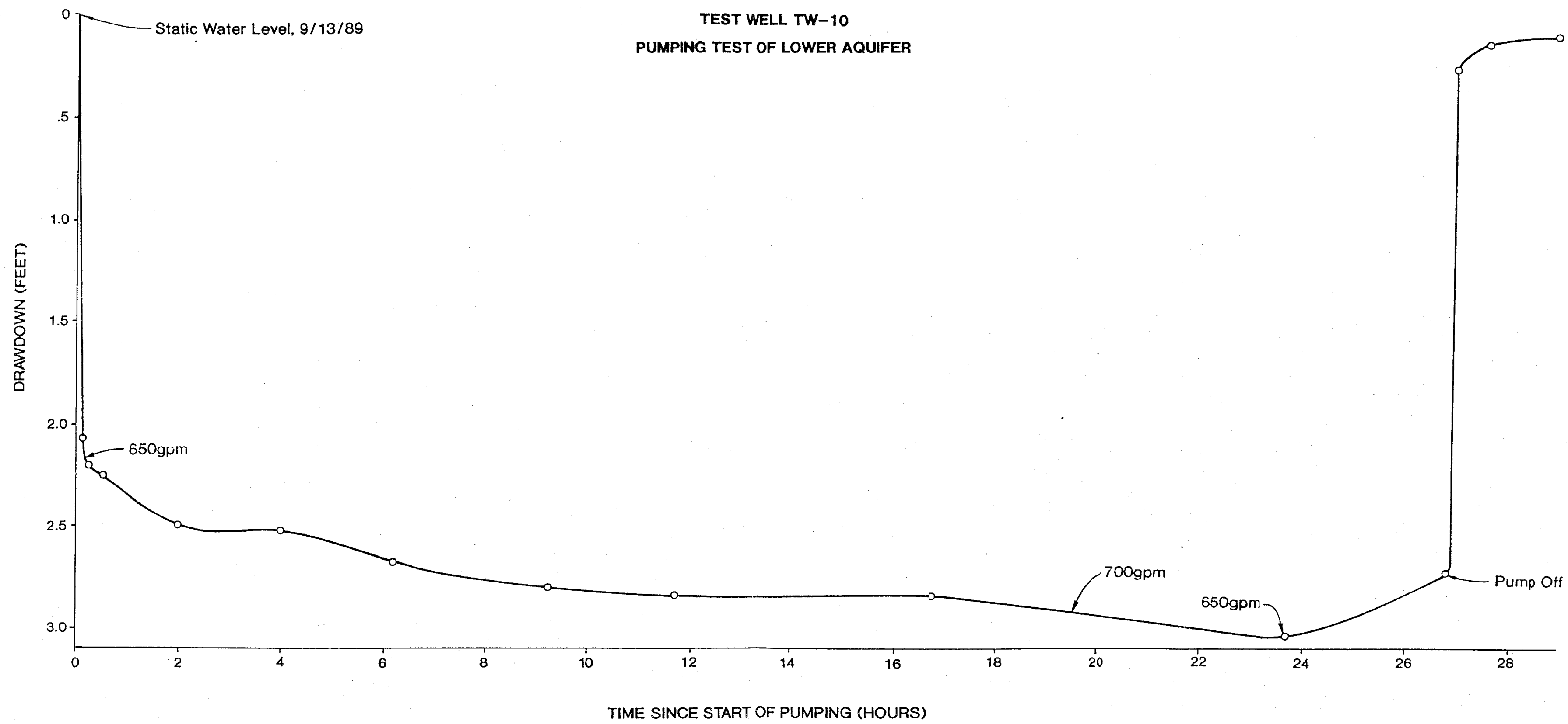
CROSS SECTION B–B'

FIGURE 5



NOTE: SIX-INCH WELL SCREEN SET BETWEEN THE DEPTHS OF 98 AND 118 FEET.

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TEST WELL TW-10
WATER LEVEL VS. TIME, 6" PUMPING TEST

FIGURE 6

1317-006-B04 JGR:KKT 11-27-89

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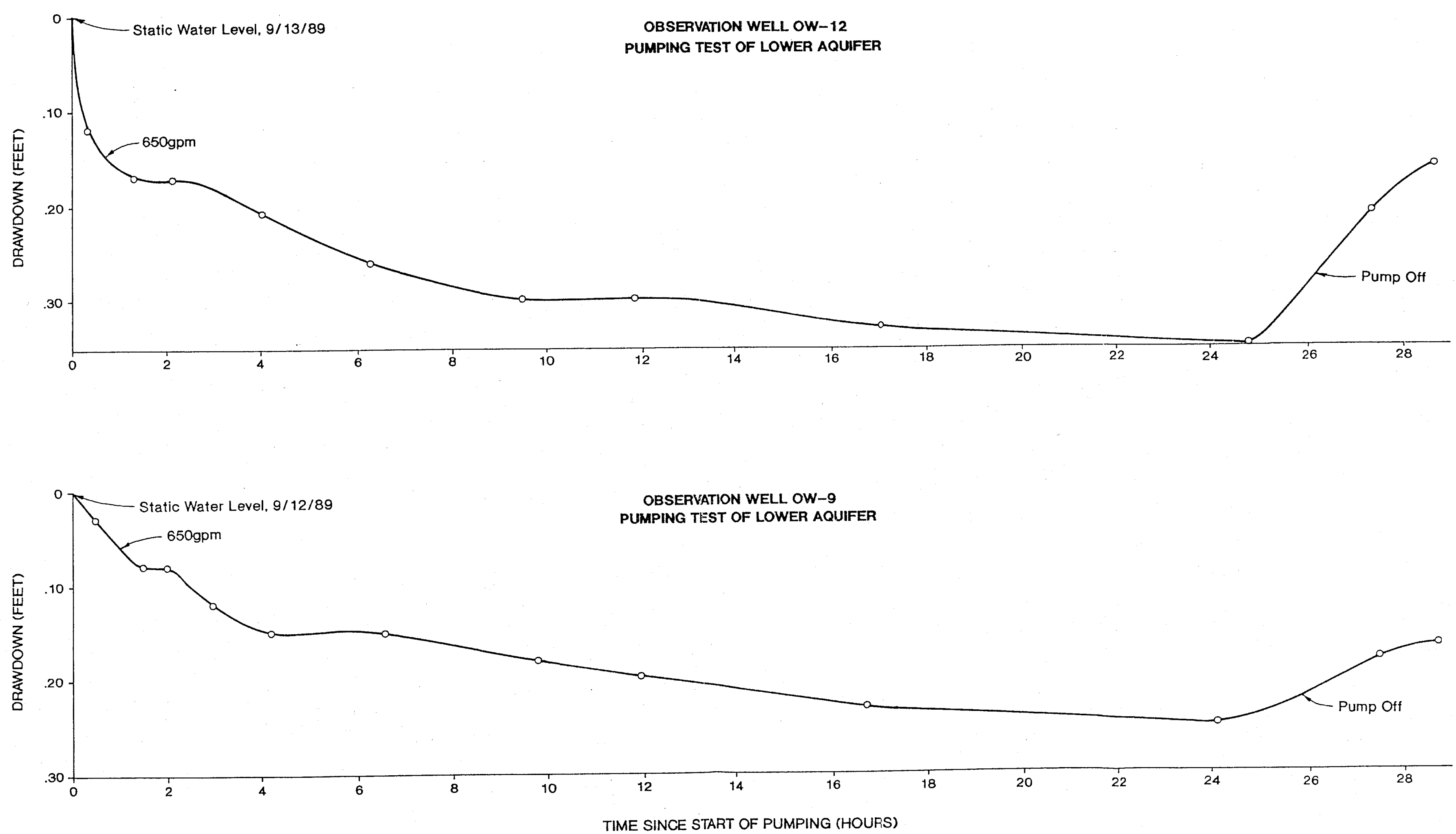

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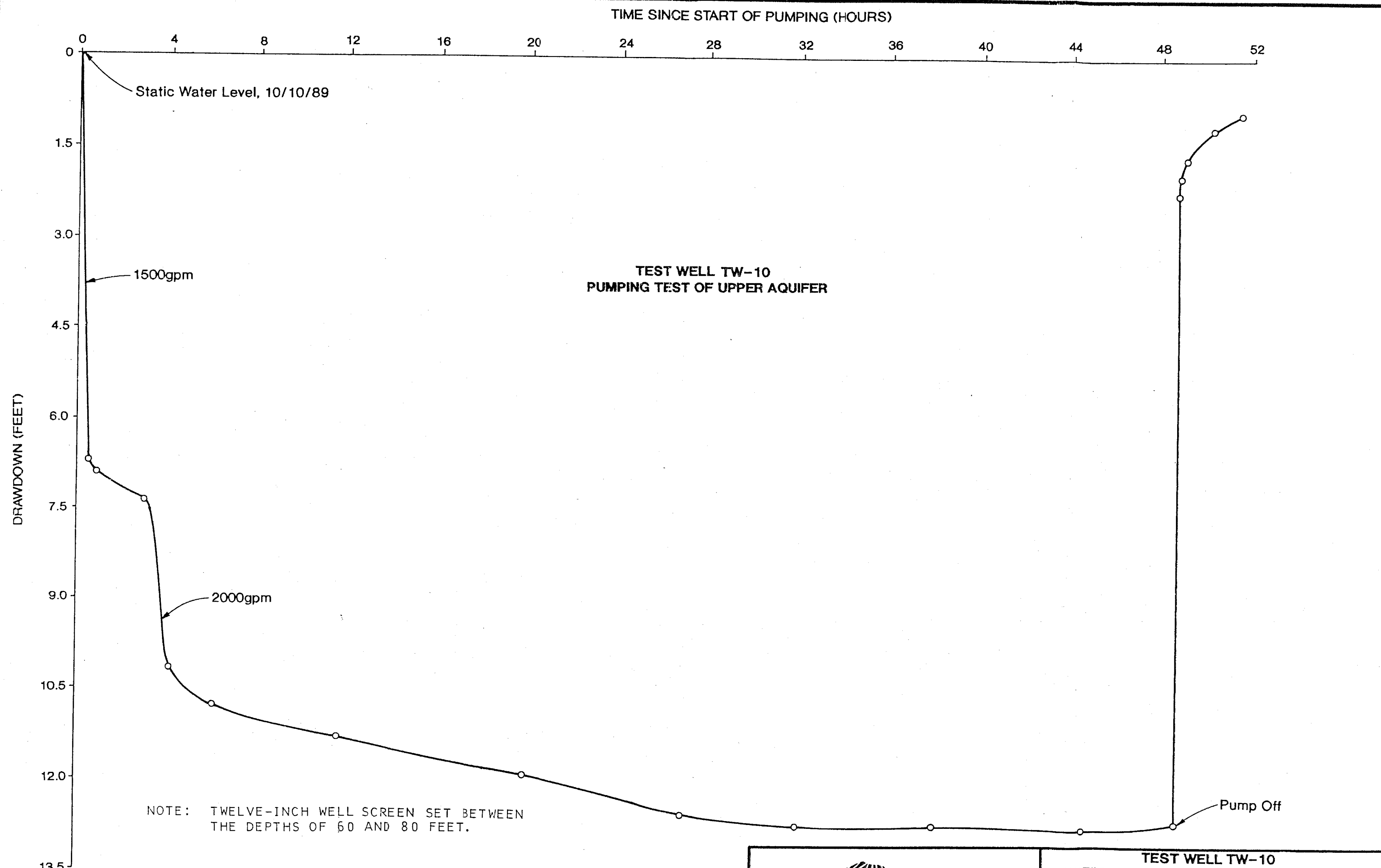
WELLS OW–12 & OW–9
WATER LEVEL VS. TIME, 6" PUMPING TEST

FIGURE 7



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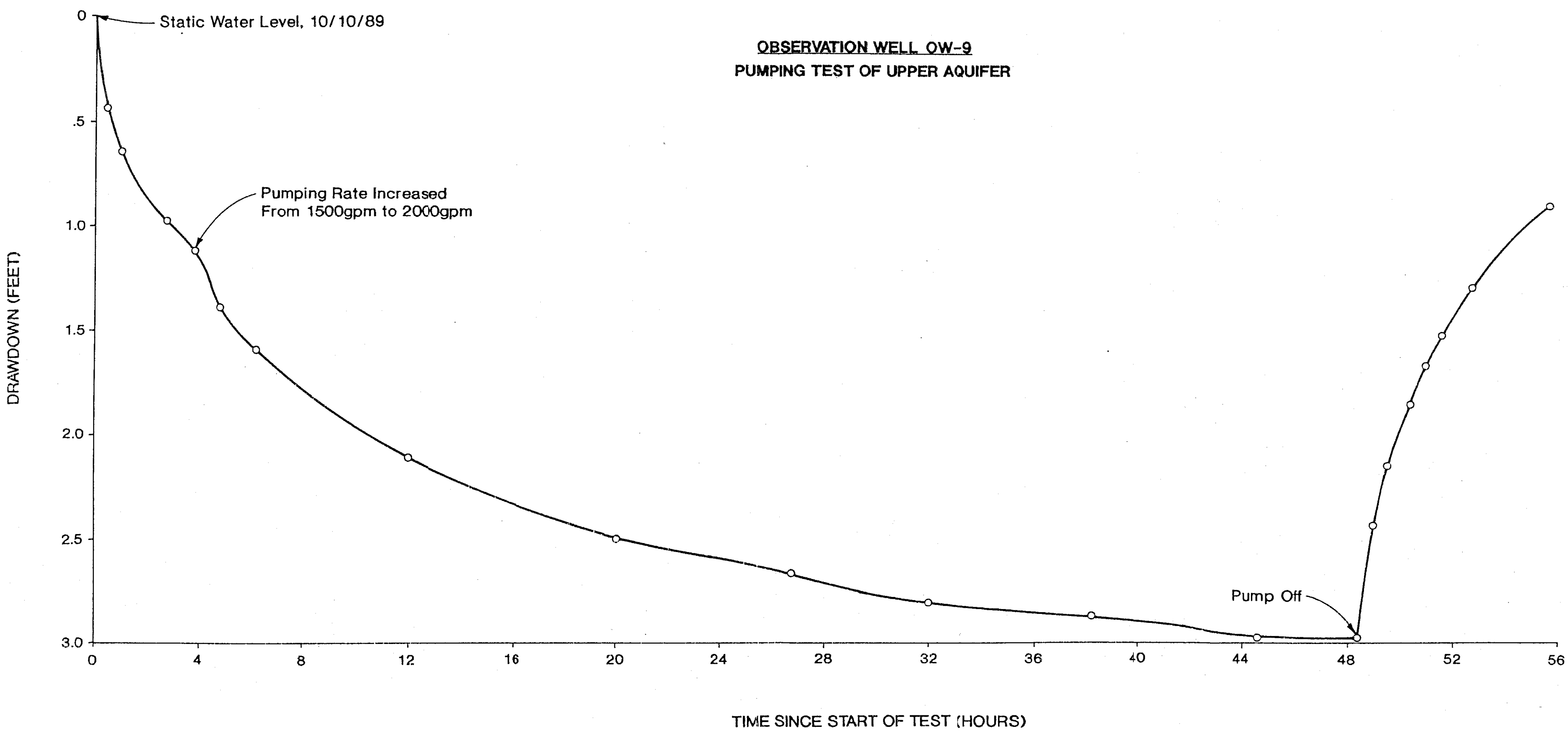
TEST WELL TW-10
WATER LEVEL VS. TIME, 12" PUMPING TEST

FIGURE 8



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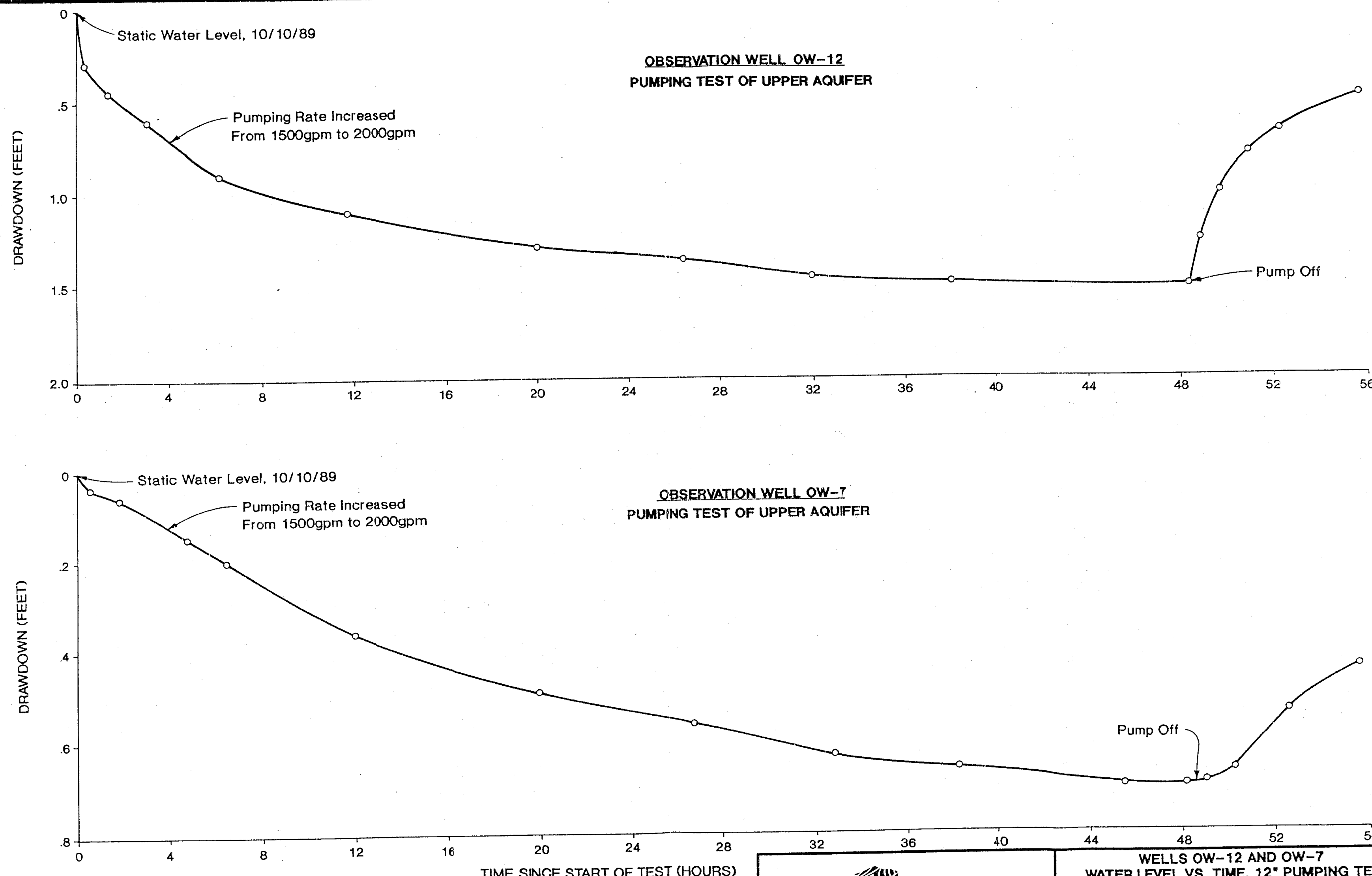
WELL OW-9
WATER LEVEL VS. TIME, 12" PUMPING TEST

FIGURE 9



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WELLS OW-12 AND OW-7
WATER LEVEL VS. TIME, 12" PUMPING TEST

FIGURE 10

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

DRILLING AND SOIL SAMPLING PROGRAM

Subsurface conditions at the proposed Spring Chinook Satellite Facility were explored during our Phase 3 studies by drilling six borings using a Porta-Drill air rotary drilling rig at the locations indicated in Figure 3. The borings were drilled between July 27 and August 12, 1989 to depths ranging from 28 to 127 feet using drilling equipment owned and operated by Methow Valley Drilling of Twisp, Washington. The borings include: (1) one test well (TW-10), (2) three observation wells (OW-7, OW-9 and OW-12), (3) one observation/ground water sampling well (OW-11) and (4) one exploration boring (B-8). The test well (TW-10) was drilled as a 12-inch-diameter bore to a depth of 95 feet and as a 6-inch-diameter bore from 95 to 127 feet. The remaining Phase 3 explorations were drilled as 6-inch-diameter bores. Well OW-7 was drilled to determine the depth to bedrock west (upstream) of the proposed infiltration gallery area. Boring B-8 was drilled in the vicinity of the proposed gallery after bedrock was encountered at a relatively shallow depth of 27 feet in OW-7. Well OW-11 was drilled at the request of the DCPUD in anticipation of future regulatory requirements for ground water quality monitoring.

A geologist from our staff determined the boring locations, examined and classified the soils encountered, and prepared a detailed log of each boring. Soils encountered were classified visually in general accordance with ASTM D-2488-83, which is described in Figure A-1. The boring logs are presented in Figures A-2 through A-16.

Soil samples were obtained from the test well at 10-foot intervals using a down hole steel sediment bailer. The soil grain-size distributions of the samples obtained from the test well were determined by dry sieving in the field. Plots of grain-size distribution are shown in Figures A-17 through A-22. Soils from the five additional borings were classified by visual examination of the drill cuttings.

OBSERVATION WELL CONSTRUCTION

Observation wells were constructed in four of the 6-inch-diameter borings (OW-7, OW-9, OW-11 and OW-12). Two-inch-diameter, Schedule 40 PVC casing was installed in each boring at the completion of drilling. The lower 5 feet of the PVC pipe is machine slotted (0.02-inch slot width) to allow the entry of water. Native soil was used to fill the borehole annulus surrounding the slotted portion of the wells. The observation wells were finished above-grade and are protected within six-inch steel well casings. Observation well construction is indicated in Figures A-2 and A-5 through A-16. A well was not installed in B-8.

TEST WELL CONSTRUCTION

Well TW-10 was drilled and cased as a 12-inch-diameter bore to a depth of about 95 feet. Six-inch-diameter steel casing was installed from the ground surface to the base of the 12-inch bore prior to resumption of drilling below a depth of 95 feet. Six-inch-diameter telescoping stainless steel well screen with a slot size of 0.040 inches was installed in TW-10 between the depths of 98 to 118 feet. The six-inch-diameter well casing and screen were removed from the well after the pumping test of the lower aquifer was completed. Twelve-inch-diameter telescoping stainless steel well screen with a slot size of 0.150 inches was then installed in TW-10 between the depths of 60 to 80 feet. Test well construction is indicated in Figures A-5 and A-6.

The test well was developed using air lift methods after the installation of each length of well screen. Well development was conducted using air-rotary drilling equipment owned and operated by Methow Valley Drilling.

PUMPING TESTS

Pumping tests of the upper and lower aquifers at the site were conducted in TW-10 using vertical line-shaft turbine pumps powered by a truck-mounted engine. The pumping tests were conducted in September 1989 and October 1989 using equipment owned and operated by Wells and Wade of Wenatchee, Washington.

The pumping test of the lower aquifer was conducted for a period of about 27 hours between September 13 and September 14, 1989. The pumping test of the upper aquifer was conducted for a period of about 48 hours between October 10 and October 12, 1989. An initial pumping test of the upper aquifer was attempted on September 27, 1989. This test was terminated because of excessive sand in the discharge water and the well screen was redeveloped prior to the October pumping test.

WATER CHEMISTRY ANALYSES

Ground water samples were collected from the test well on September 14 and October 12, 1989. The samples were submitted to AM Test, Inc. for chemical analyses. The ground water samples were analyzed for drinking water quality parameters plus other selected parameters. The laboratory reports are presented in Appendix B and summarized in Table 3.

WATER TEMPERATURE, pH AND ELECTRICAL CONDUCTIVITY

The temperature and electrical conductivity of the ground water from the test well and observation wells were measured with a YSI meter during each of the pumping tests. The pH of ground water from the test well was measured with a Whatman meter during the pumping tests. The YSI and Whatman meters are designed for measuring field water quality parameters. The YSI meter consists of a down-well sensor, which is immersed in the water, and an analog dial readout. The Whatman meter consists of a sensor, which is immersed in a water sample obtained from the well, and a digital readout. The calibration of the meters was checked prior to each round of measurements. The field data are summarized in Tables 1 and 2.

GROUND AND SURFACE WATER ELEVATIONS

The elevation of the ground water table during the pumping tests was measured with an electric sounder relative to the steel casing rim of the test well and the PVC casing rims of the observation wells. The water elevation of the Methow River was measured relative to temporary benchmarks placed in the river channel. Ground surface elevations and the elevations of the steel and PVC casing rims were determined by Erlandsen and Associates, professional surveyors. The elevations are shown on the boring logs (Figures A-2 through A-8).

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS MORE THAN 50% PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-83.
2. Soil classification using laboratory tests is based on ASTM D2487-83.
3. Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry – Absence of moisture, dusty, dry to the touch

Moist – Damp, but no visible water

Wet – Visible free water or saturated, usually soil is obtained from below water table

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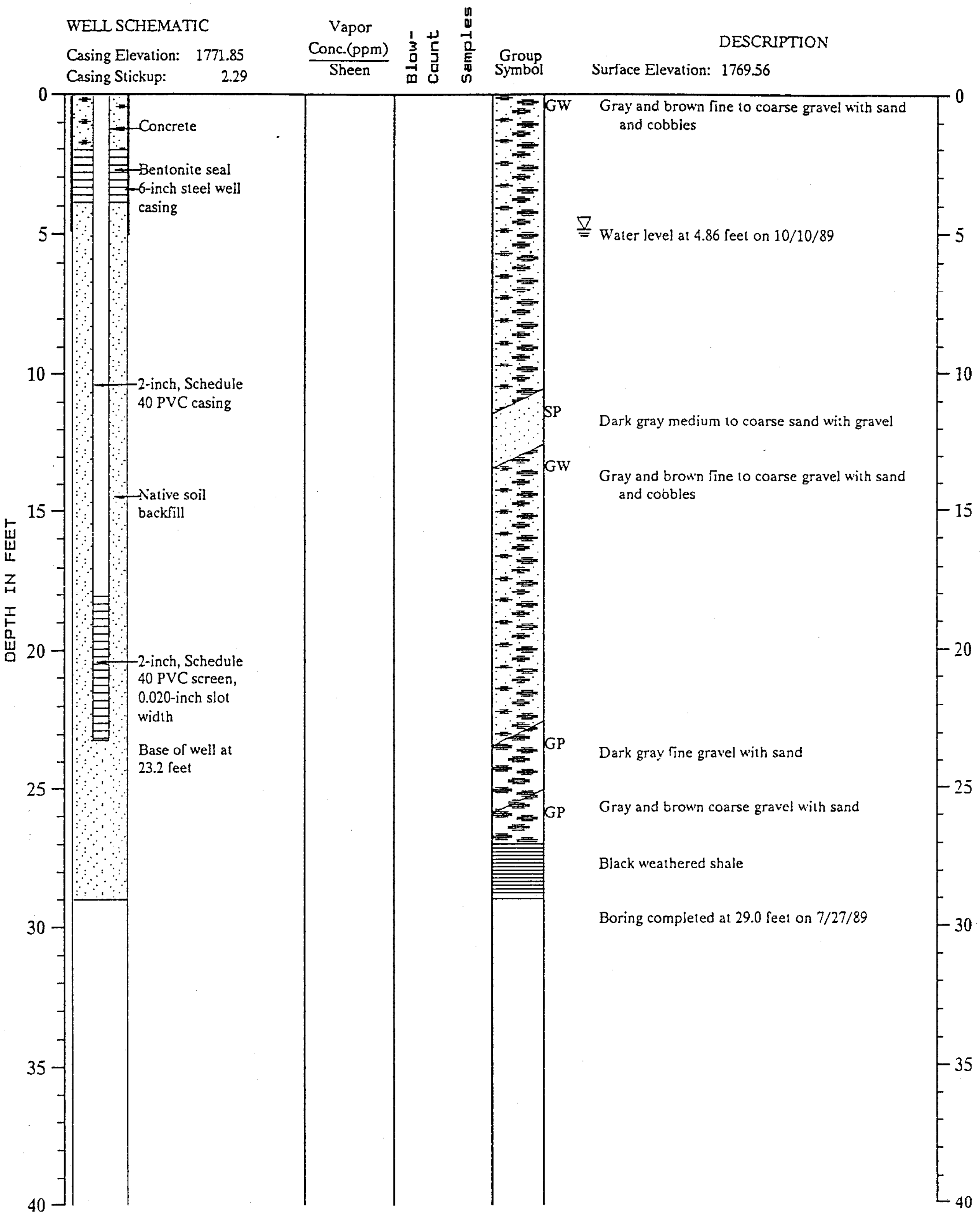
SOIL CLASSIFICATION SYSTEM

FIGURE A-1

OBSERVATION WELL NO. OW-7



Note: See Figure A-2 for explanation symbols

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Log of Observation Well

Figure A-2

1317-006-B04 TTF:CDO 11/30/89

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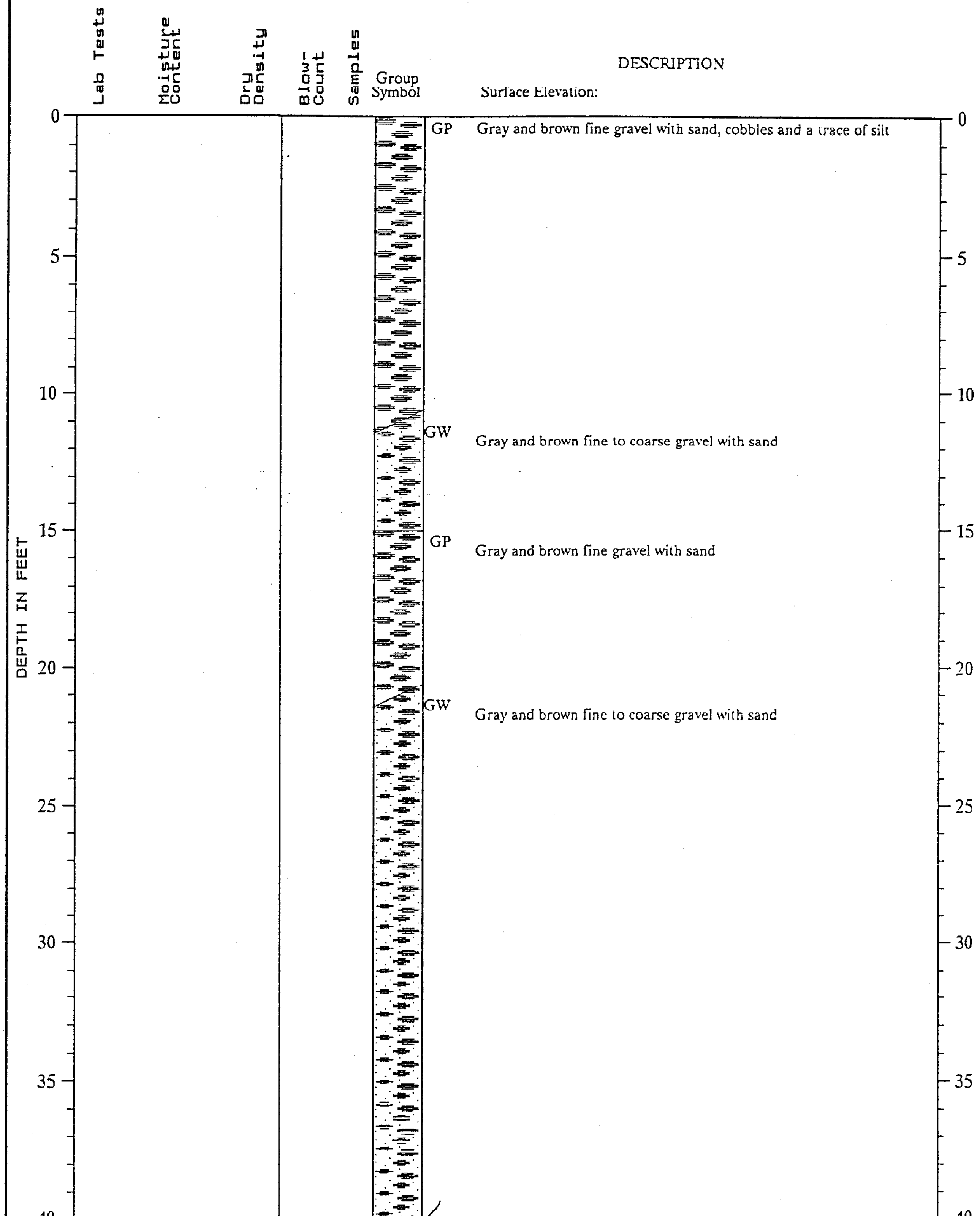
EXPLORATION BORING B-8

TEST DATA



Note: See Figure A-2 for explanation of symbols

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Log of Exploration Boring

Figure A-3

1317-006-B04 TTF:CDO 11/30/89

TEST DATA

EXPLORATION BORING B-8 (Continued)

Lab Tests	Moisture Content	Dry Density	Blow-Count	Samples	Group Symbol	DESCRIPTION
						Black weathered shale
						Boring completed at 50.0 feet on 7/28/89 Note: The purpose of this boring was to determine the depth to bedrock. A well was not constructed in the boring.

DEPTH IN FEET: 40, 45, 50, 55, 60, 65, 70, 75, 80

Note: See Figure A-2 for explanation of symbols

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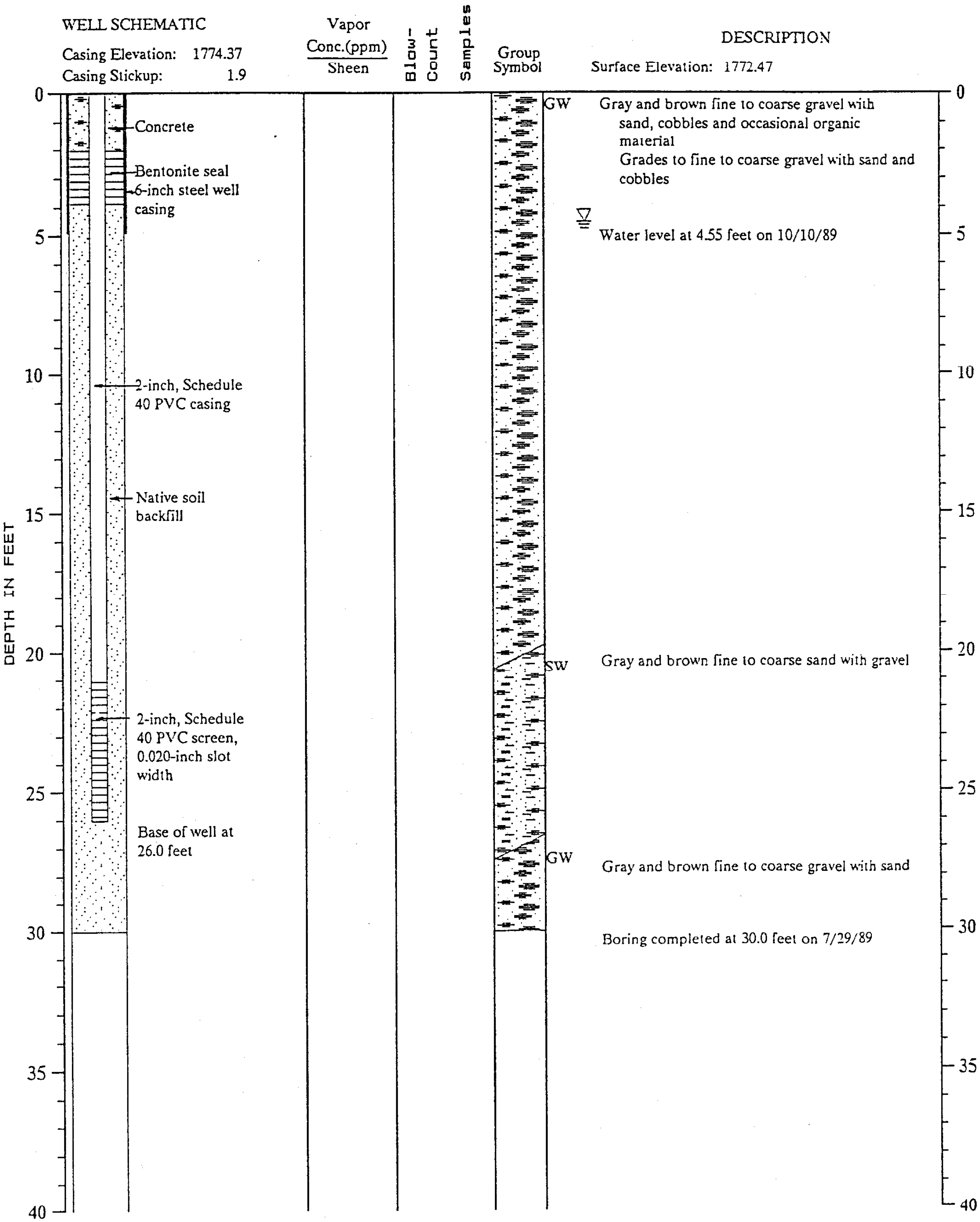
Log of Exploration Boring

Figure A- 4

1317-006-B04

:CDD -1/3

OBSERVATION WELL NO. OW-9



Note: See Figure A-2 for explanation symbols

Log of Observation Well

Figure A-5

1317-006-B04 TTF:CDO 11/30/89

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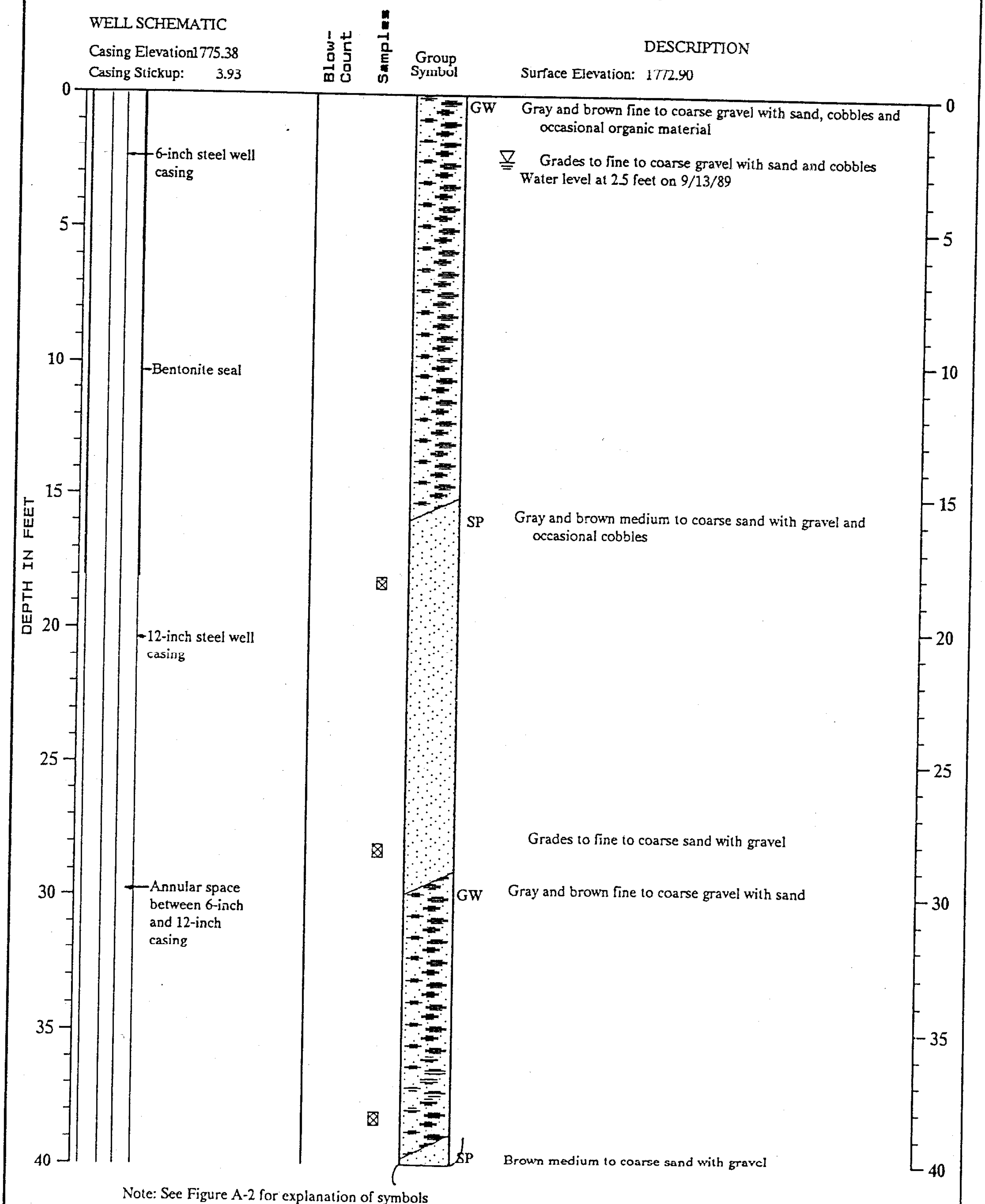
TEST (PRODUCTION) WELL NO. TW-10

6-inch Screen Construction



Note: See Figure A-2 for explanation of symbols

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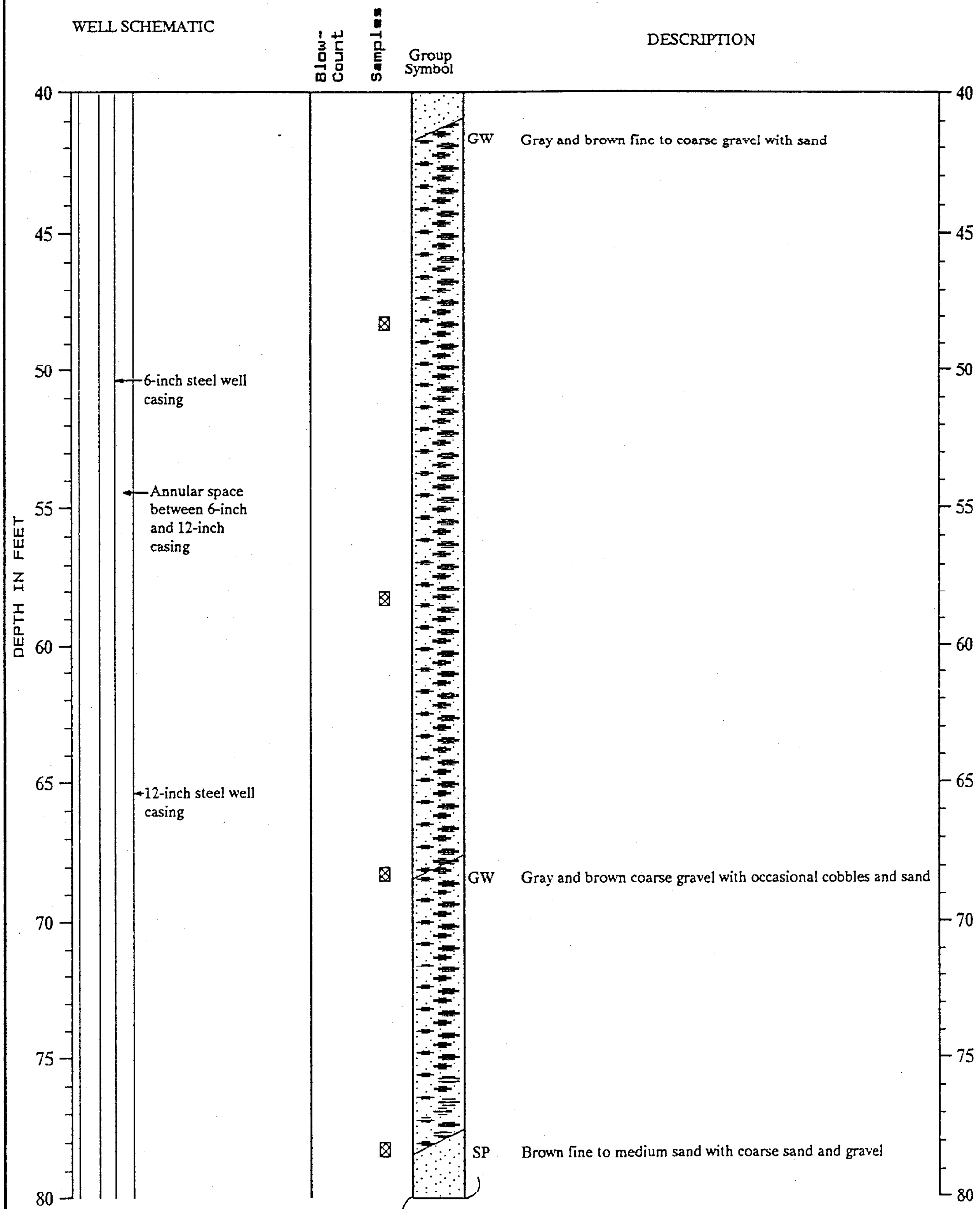
Log of Test (Production) Well

Figure A-6

1317-006-B04 TTF:CDO 12/28/89

TEST (PRODUCTION) WELL NO. TW-10 (Continued)
6-inch Screen Construction



Note: See Figure A-2 for explanation of symbols

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Log of Test (Production) Well

Figure A-7

1317-006-B04 TTF:CDO 12/28/89

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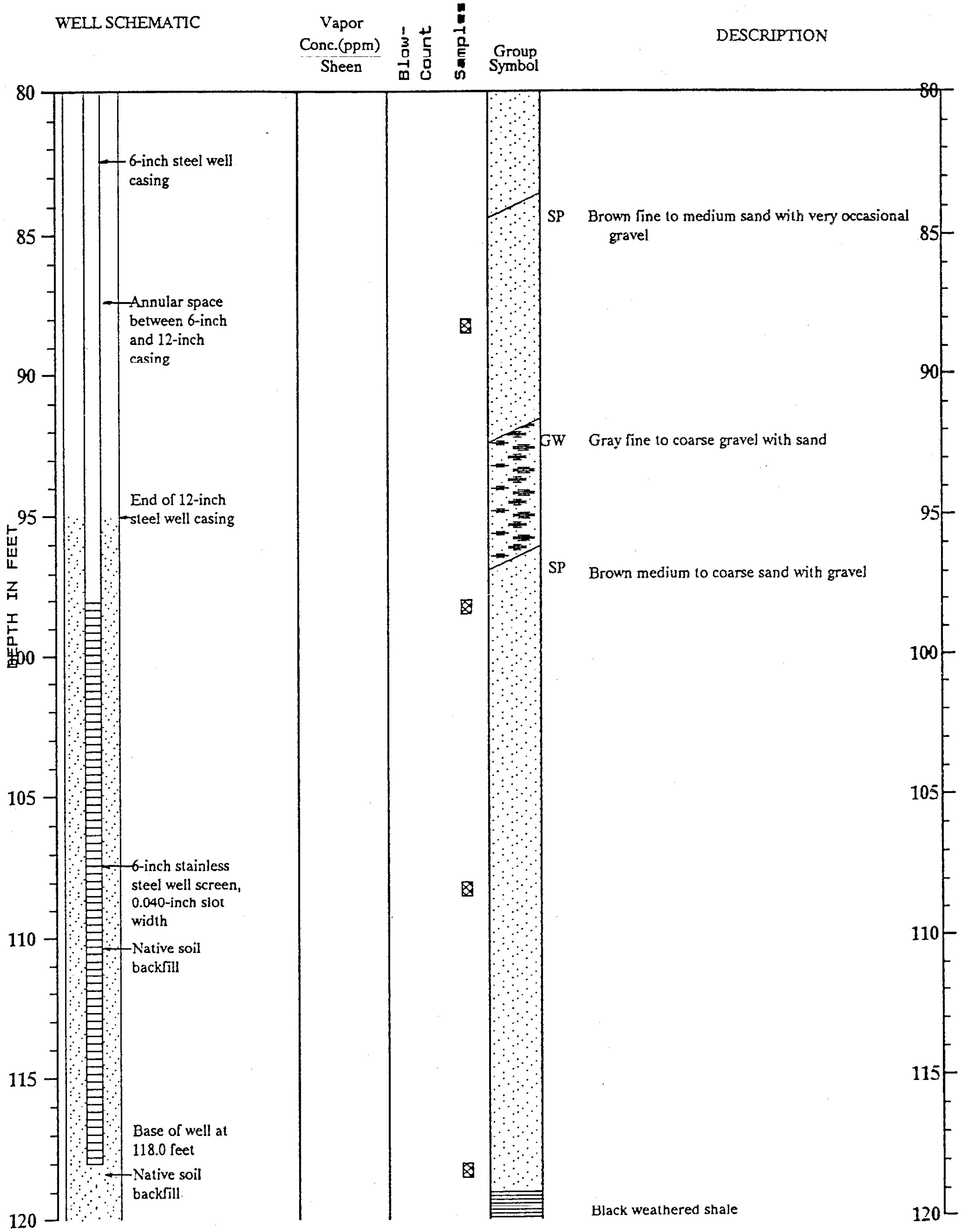
TEST (PRODUCTION) WELL NO. TW-10 (Continued)

6-inch Screen Construction



Note: See Figure A-2 for explanation of symbols

TTF:CDO 1/9/90

1317-006-B04

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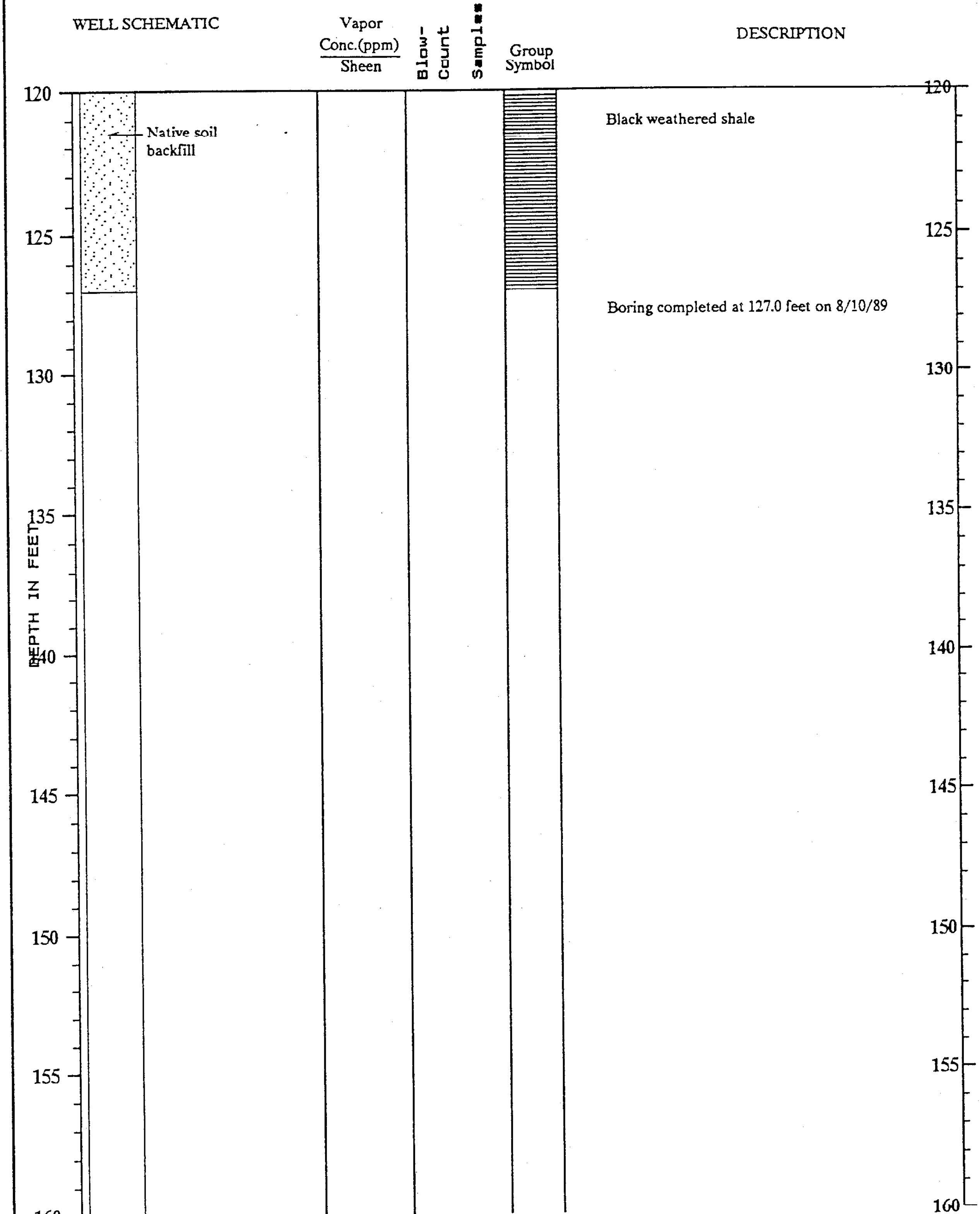
Log of Test (Production) Well

Figure A-8

TEST (PRODUCTION) WELL NO. TW-10 (Continued)
6-inch Screen Construction



Note: See Figure A-2 for explanation of symbols

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Log of Test (Production) Well

Figure A-9

1317-006-B04 TTF:CDO 1/9/90

TEST (PRODUCTION) WELL NO. TW-10
12-inch Screen Construction

WELL SCHEMATIC

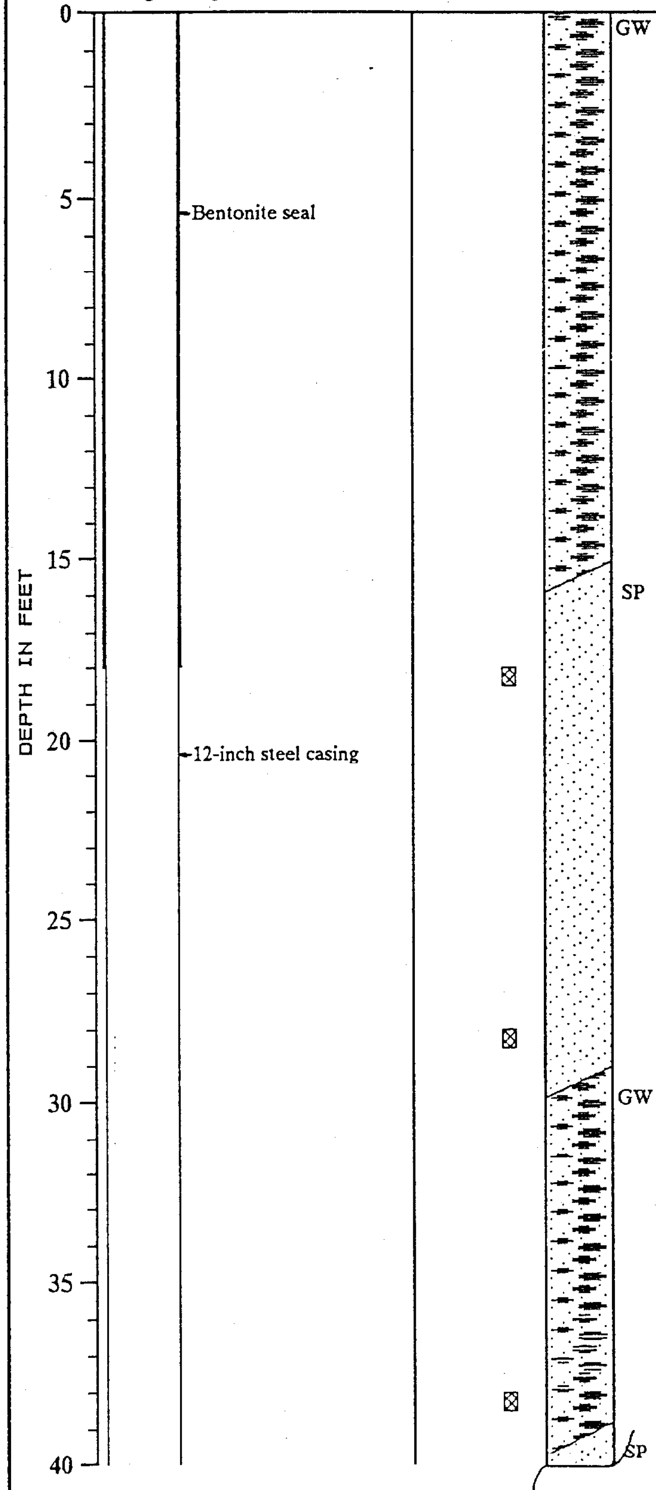
Casing Elevation: 1775.38

Casing Stickup: 2.45

Blow-Count | Samples | Group Symbol

DESCRIPTION

Surface Elevation: 1772.90



GW — Gray and brown fine to coarse gravel with sand, cobbles and occasional organic material

Grades to fine to coarse gravel with sand and cobbles

Water level at 3.3 feet on 10/10/89

SP — Gray and brown medium to coarse sand with gravel and occasional cobbles

Grades to fine to coarse sand with gravel

GW — Gray and brown fine to coarse gravel with sand

SP — Brown medium to coarse sand with gravel

Note: See Figure A-2 for explanation of symbols

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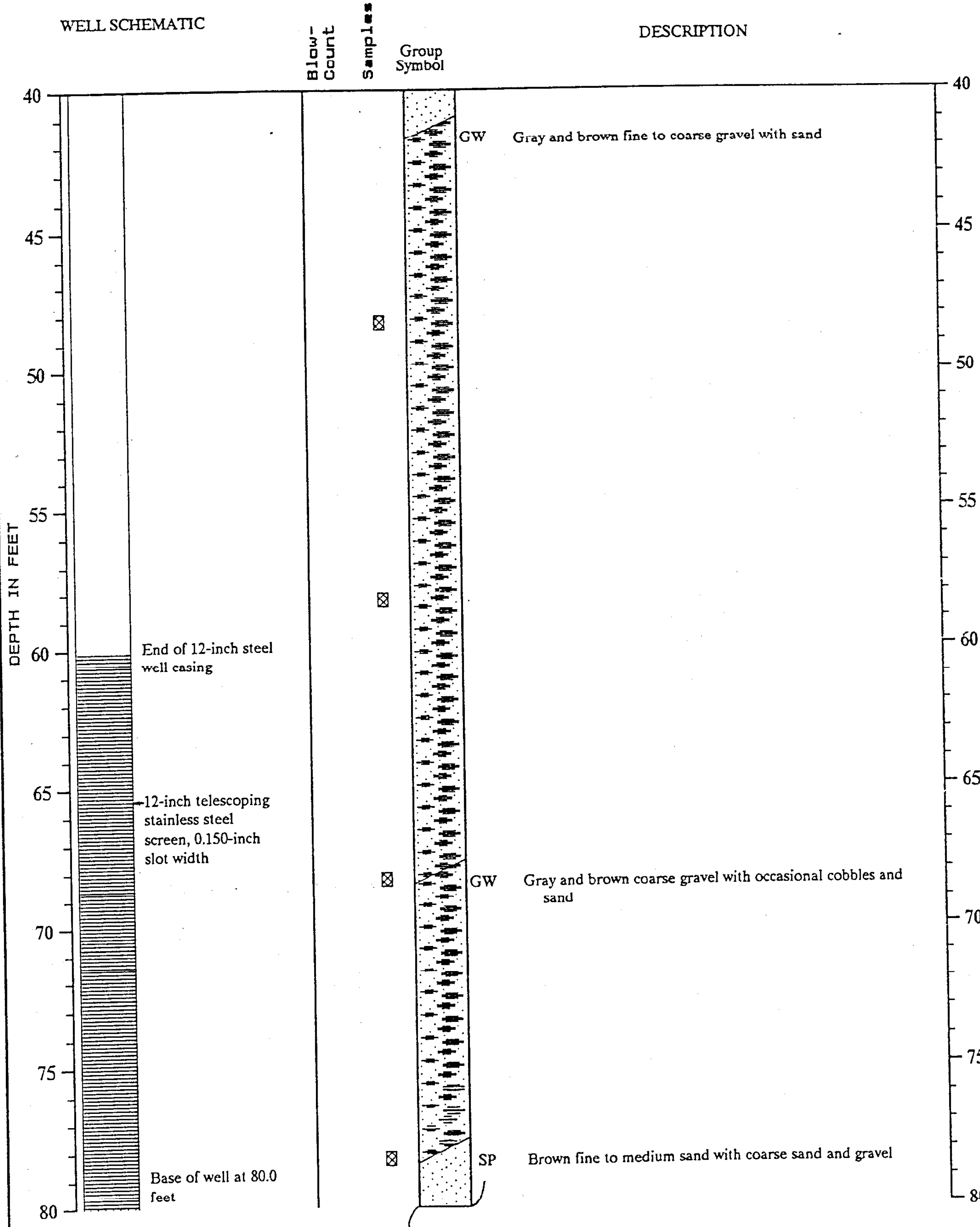
Log of Test (Production) Well

Figure A-10

1317-006-B04 TTF:CDO 12/28/89

TEST (PRODUCTION) WELL NO. TW-10 (Continued)
12-inch Screen Construction



Note: See Figure A-2 for explanation of symbols

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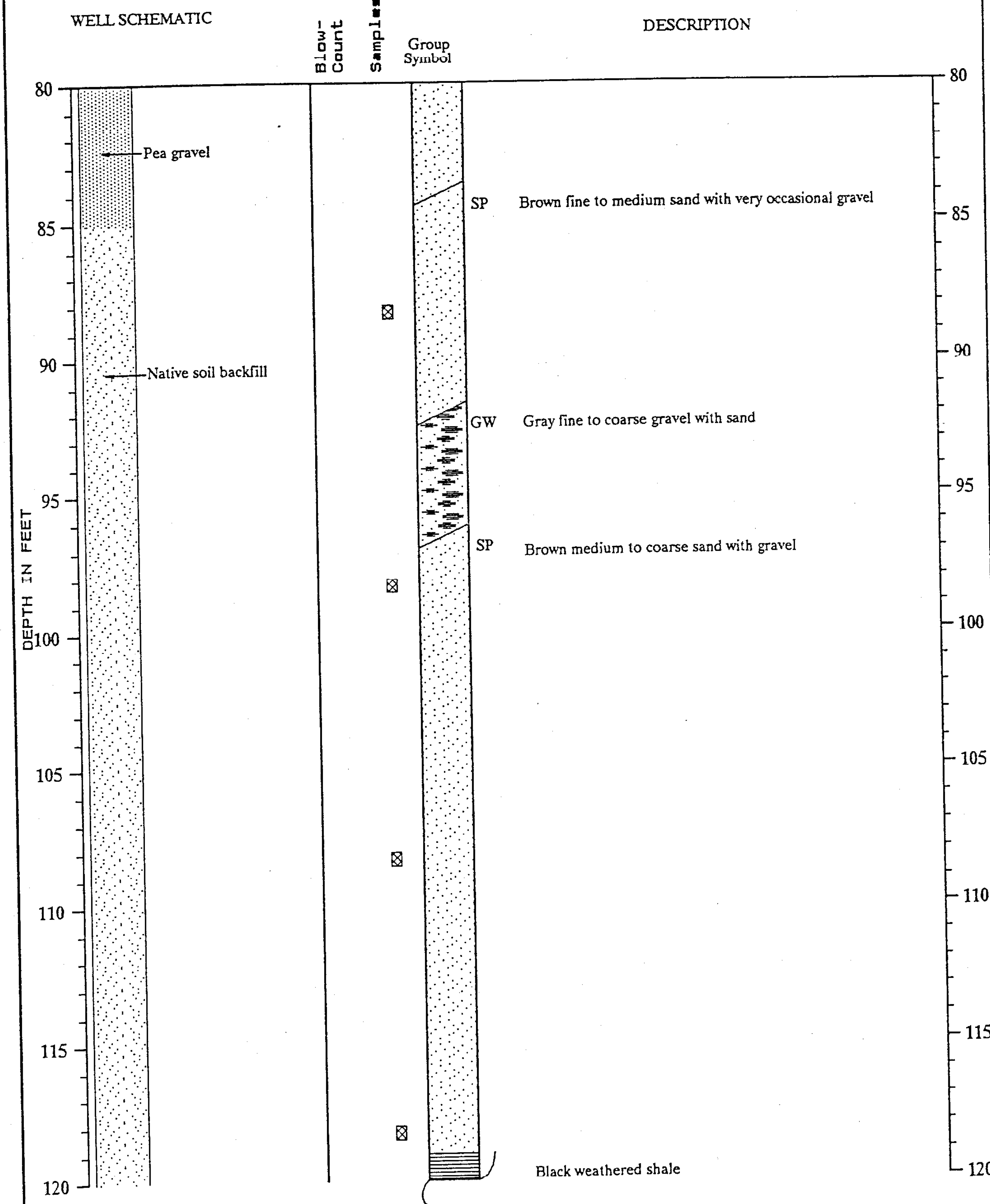
Log of Test (Production) Well

Figure A-11

TEST (PRODUCTION) WELL NO. TW-10 (Continued)

12-inch Screen Construction



Note: See Figure A-2 for explanation of symbols

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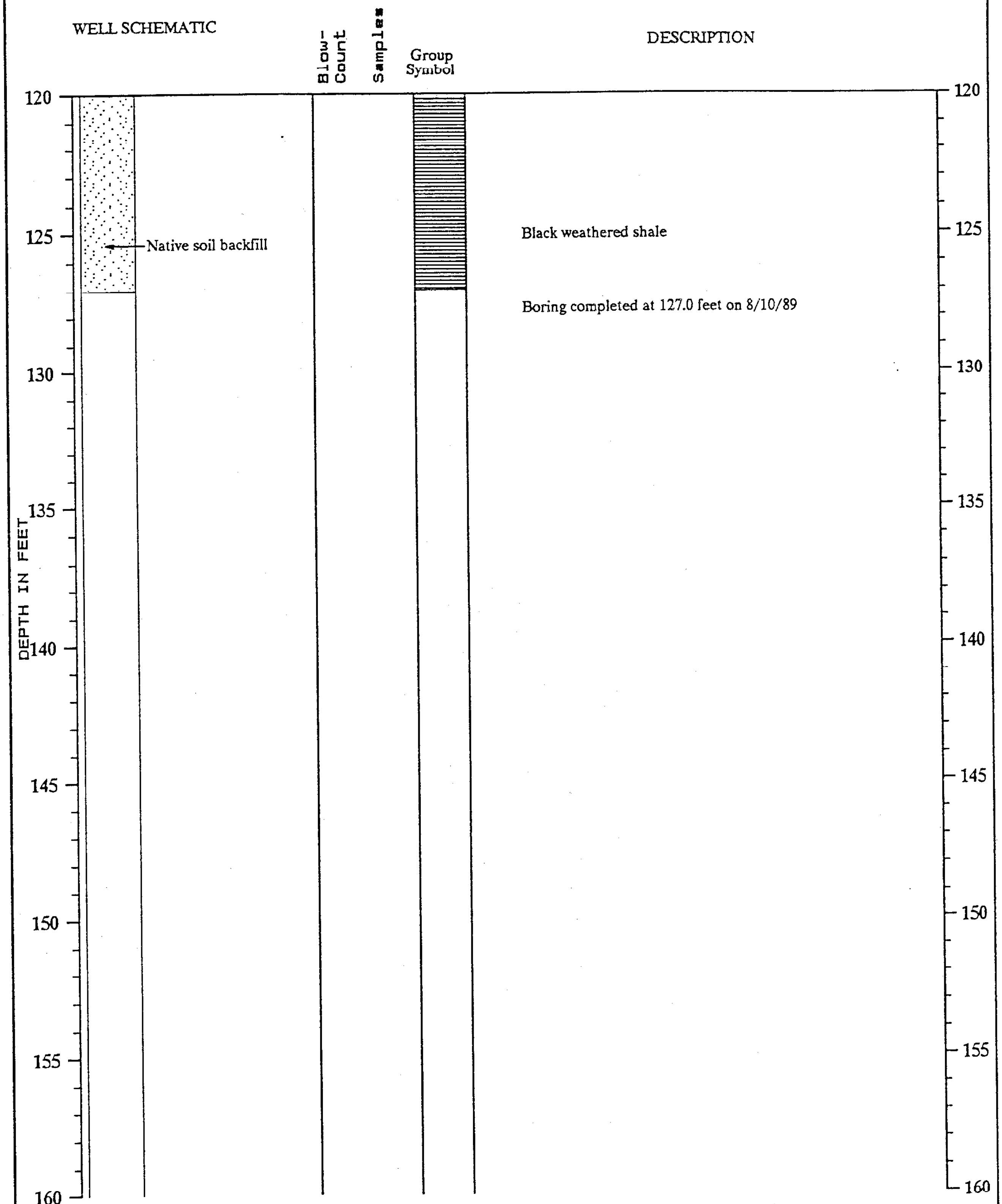
Log of Test (Production) Well

Figure A-12

TEST (PRODUCTION) WELL NO. TW-10 (Continued)
12-inch Screen Construction



Note: See Figure A-2 for explanation of symbols

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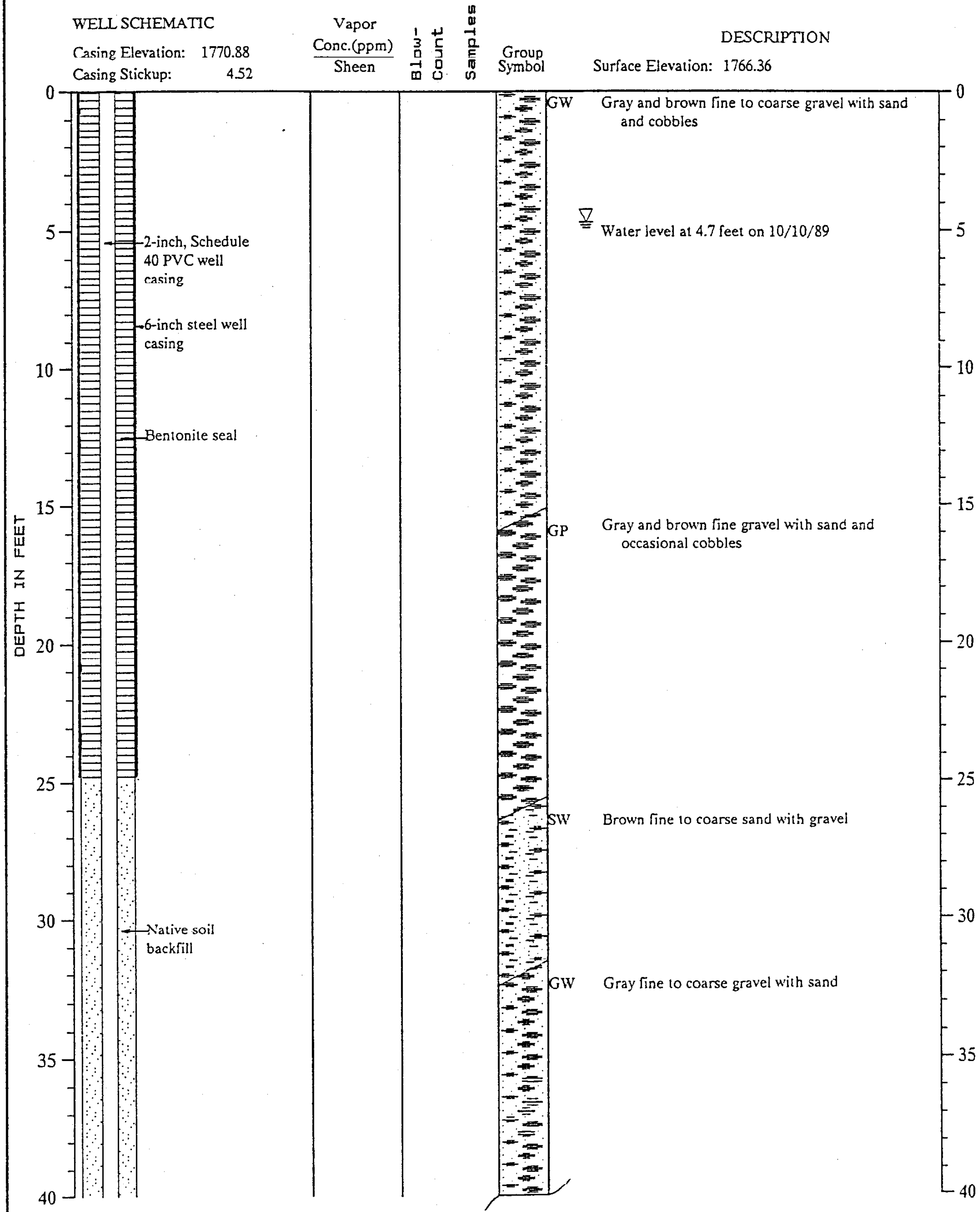
Log of Test (Production) Well

Figure A-13

OBSERVATION WELL NO. OW-11



Note: See Figure A-2 for explanation symbols

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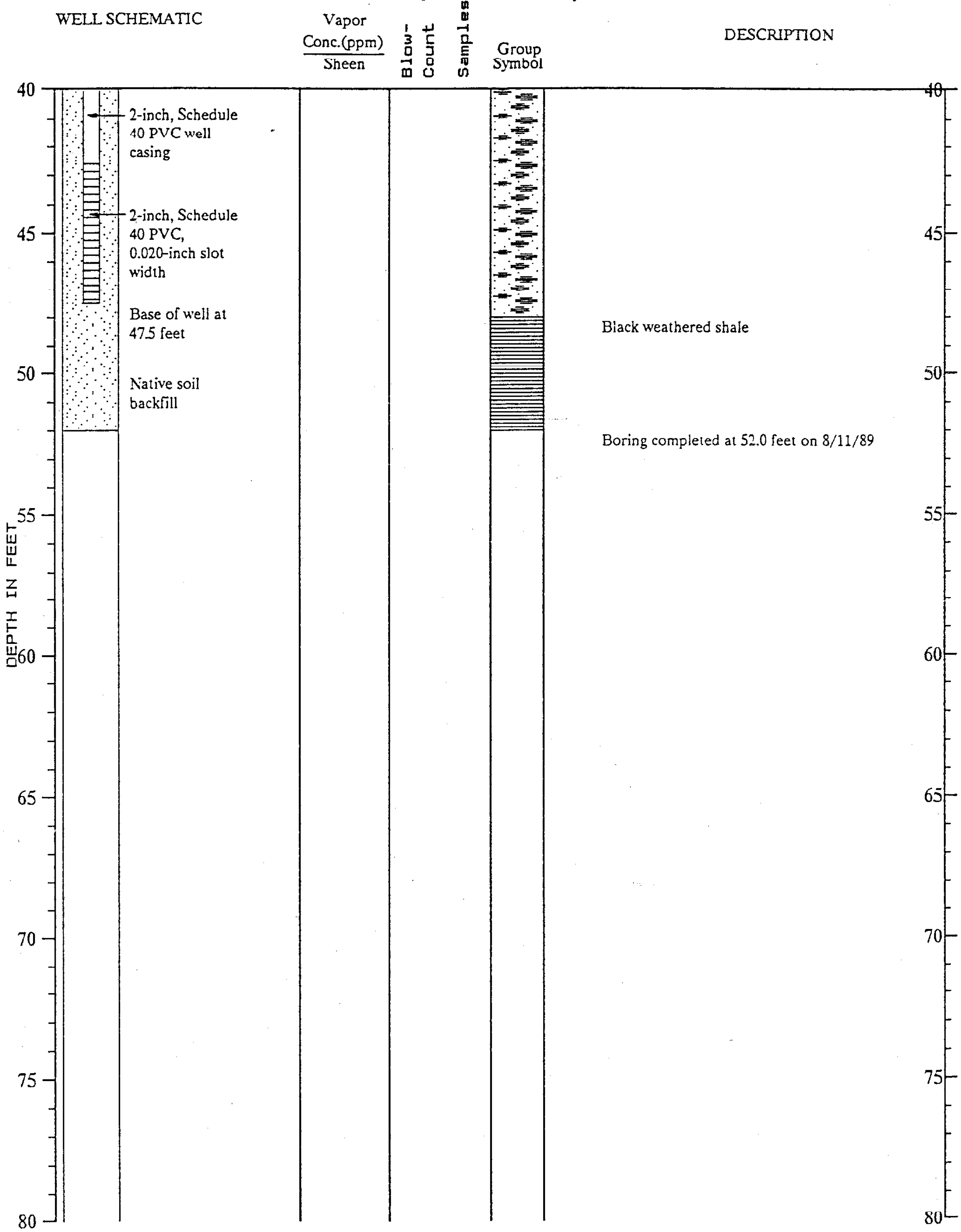
Log of Observation Well

Figure A-14

1317-006-B04 TTF:CDO 11/30/89

OBSERVATION WELL NO. OW-11
(Continued)



Note: See Figure A-2 for explanation of symbols

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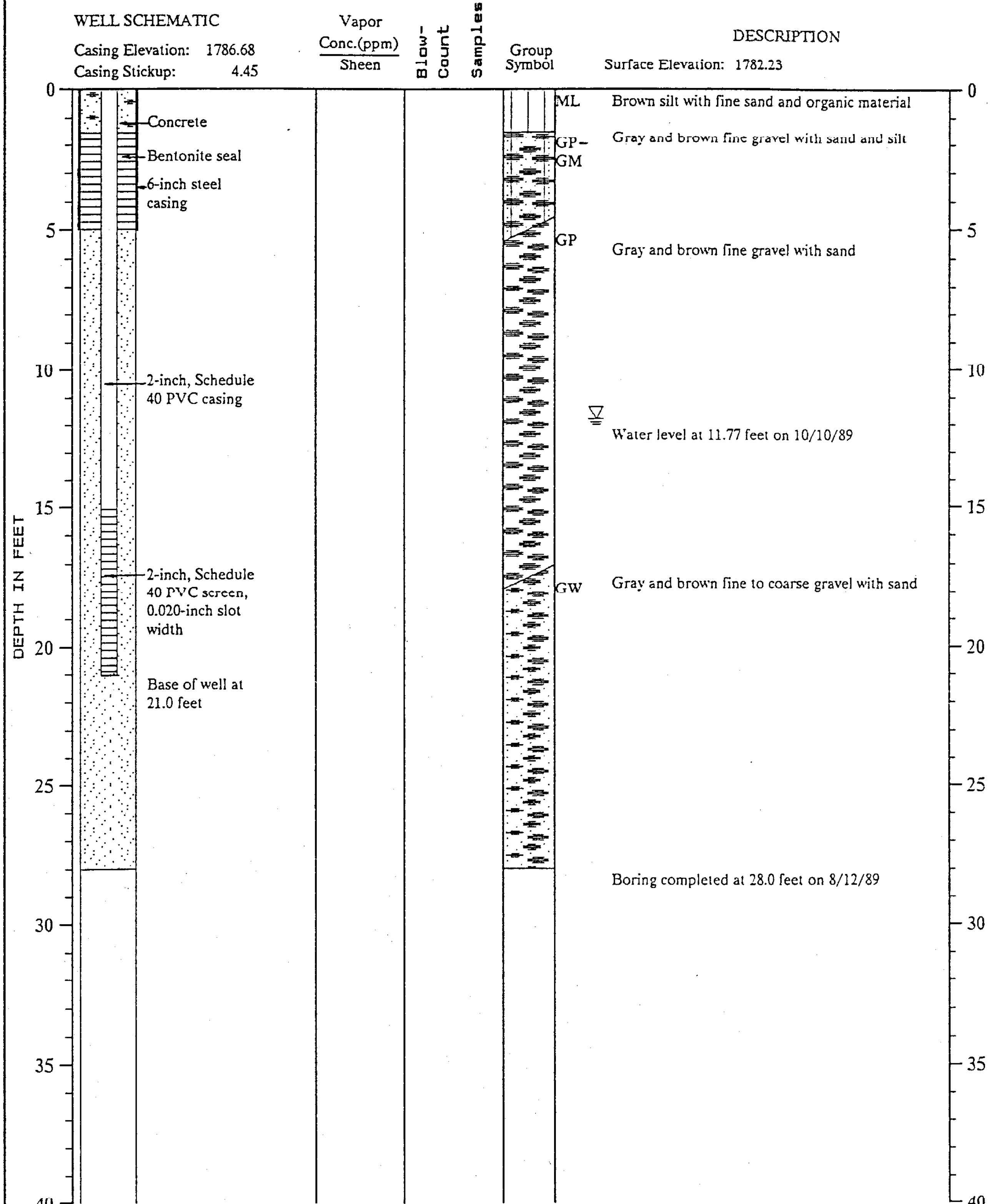
Log of Observation Well

Figure A-15

OBSERVATION WELL NO. OW-12



Note: See Figure A-2 for explanation symbols

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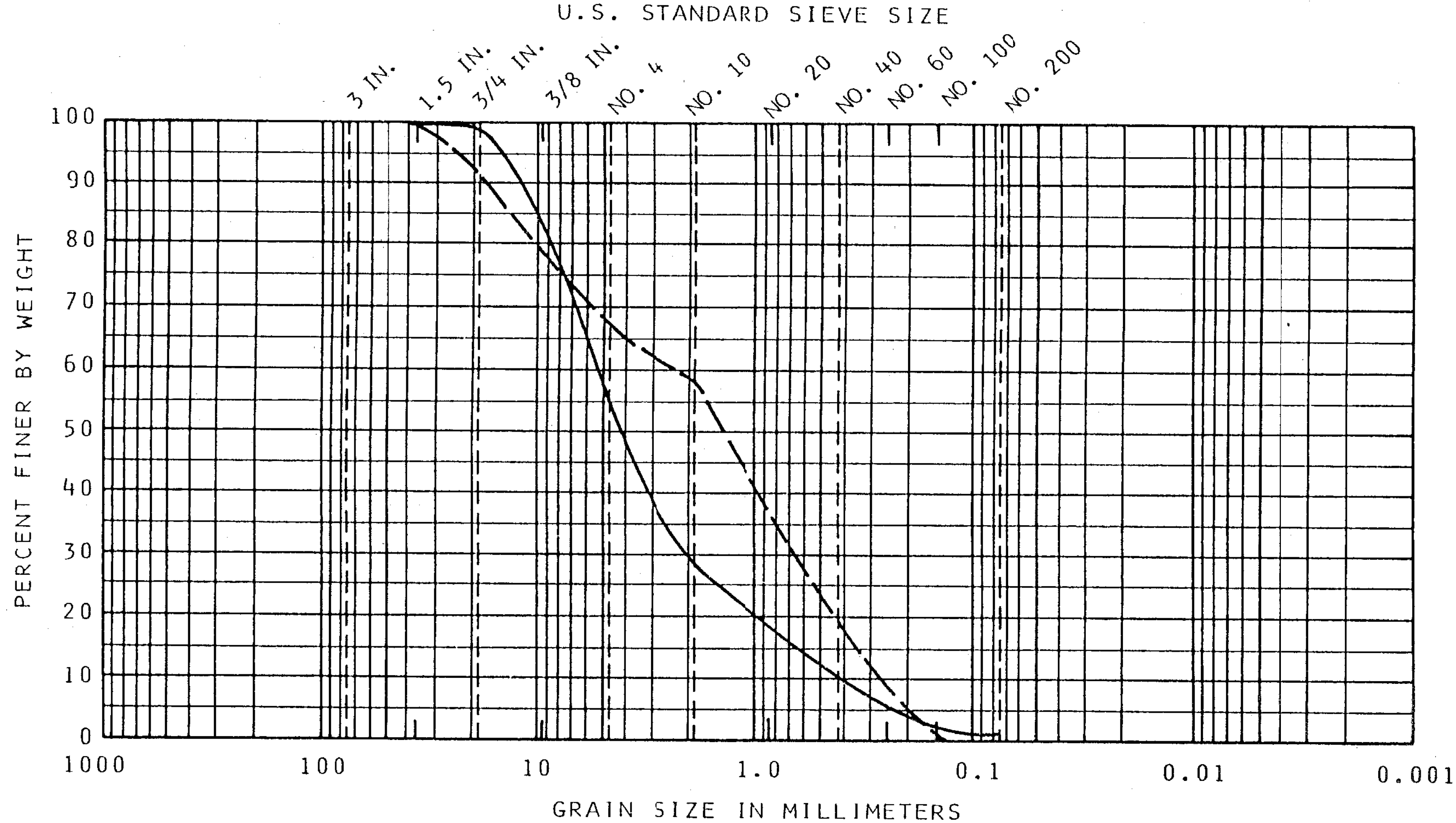
Log of Observation Well

Figure A-16

GEI 30-88

1317-006-B04 JGR:KKT 12/5/89



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——— (solid)	TW-10	18'	MEDIUM TO COARSE SAND WITH GRAVEL (SP)
— — — (dashed)	TW-10	28'	MEDIUM TO COARSE SAND WITH GRAVEL (SP)

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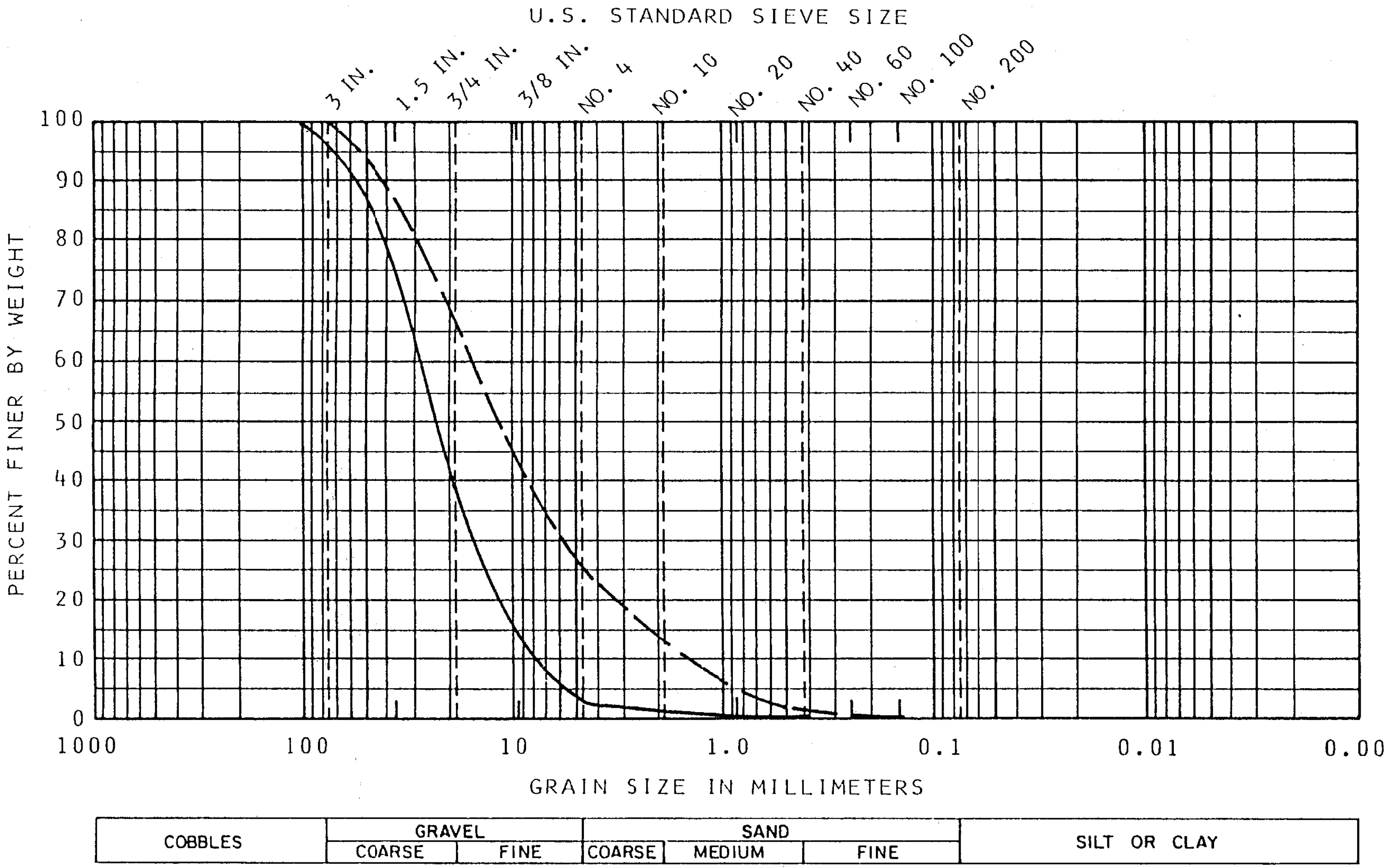
GRADATION CURVES

FIGURE A-17

GEI 30-88

1317-006-B04 JGR:KKT 12/5/89



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——————— (solid)	TW-10	38'	COARSE GRAVEL WITH FINE GRAVEL AND A TRACE OF SAND (GP/GW)
— — — — (dashed)	TW-10	48'	FINE TO COARSE GRAVEL WITH SAND (GW)

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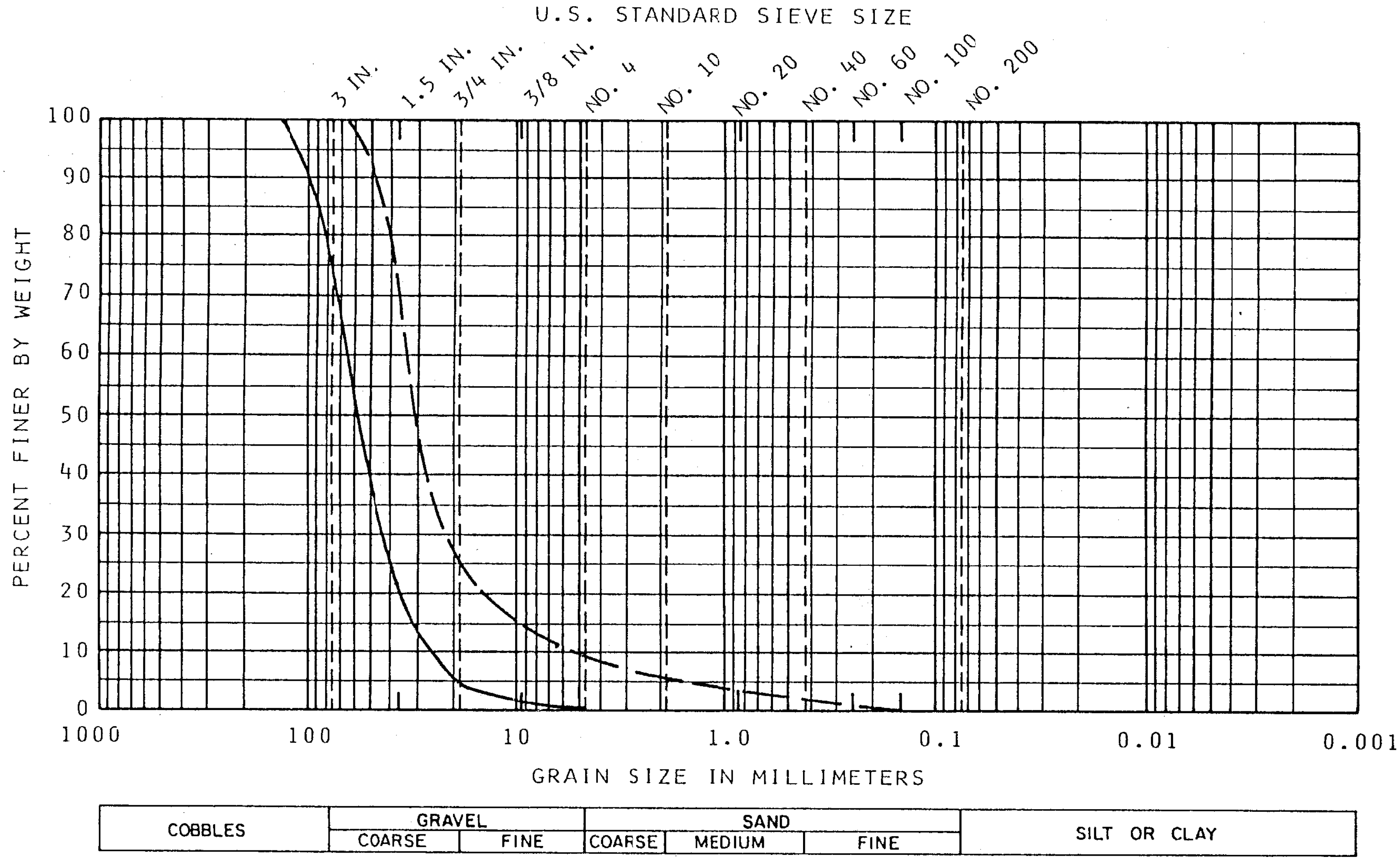
GRADATION CURVES

FIGURE A-18

GEI 30-88

1317-006-B04 JGR:KKT 12/5/89



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——————— (solid)	TW-10	58'	COARSE GRAVEL WITH FINE GRAVEL AND COBBLES (GP)
— — — — (dashed)	TW-10	68'	COARSE GRAVEL WITH SAND (GP)

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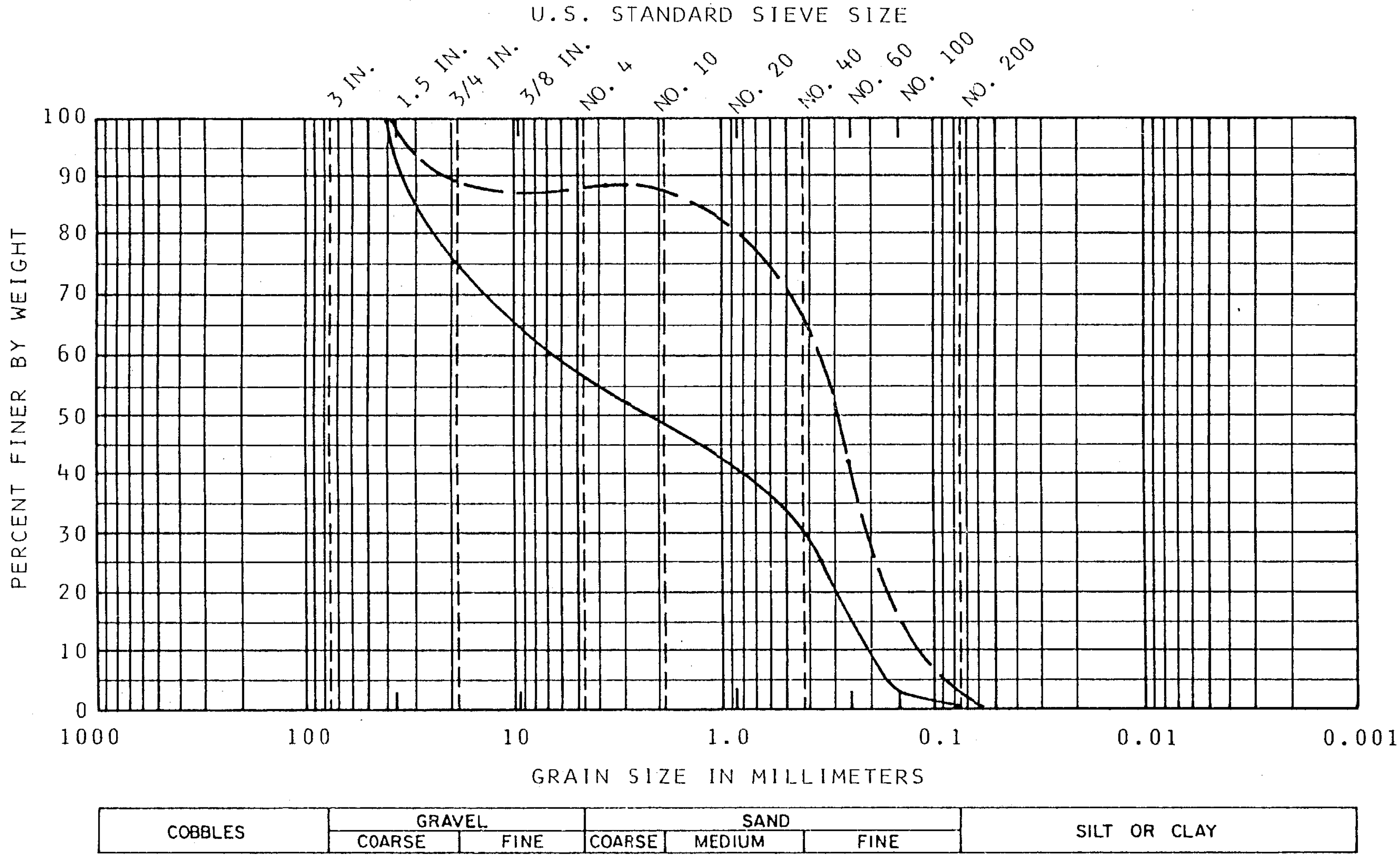
GRADATION CURVES

FIGURE A-19

GEI 30-88

1317-006-B04 JGR:KKT 12/5/89



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———————	TW-10	78'	FINE TO MEDIUM SAND WITH COARSE SAND AND GRAVEL (SP/SW)
— — — —	TW-10	88'	FINE TO MEDIUM SAND WITH OCCASIONAL GRAVEL AND A TRACE OF SILT (SP)

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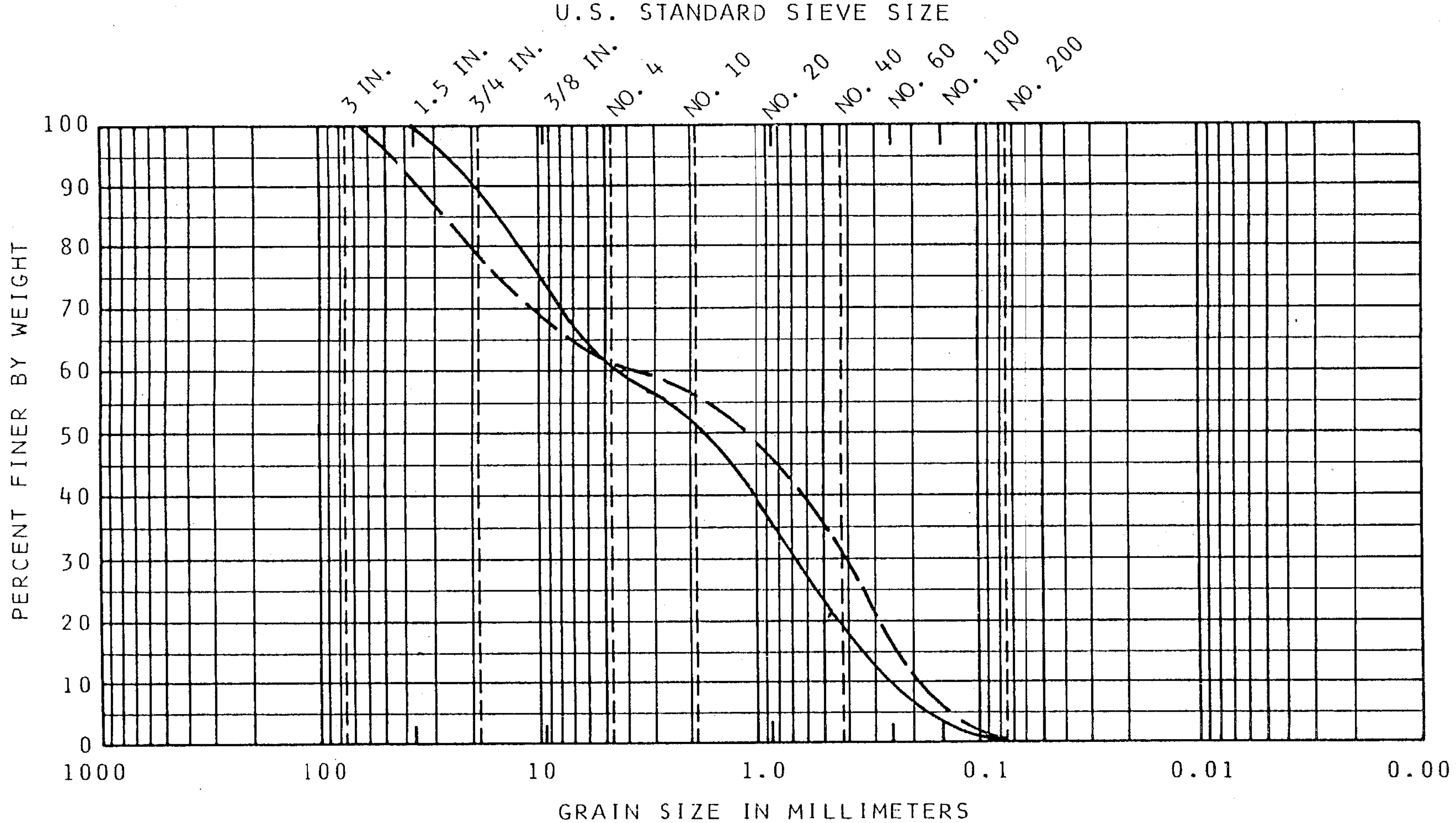
GRADATION CURVES

FIGURE A-20

GEI 30-88

1317-006-B04 JGR:KKT 12-5-89



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
——— (solid)	TW-10	98'	MEDIUM TO COARSE SAND WITH GRAVEL (SP)
— — — (dashed)	TW-10	108'	FINE TO MEDIUM SAND WITH COARSE SAND AND GRAVEL (SP)

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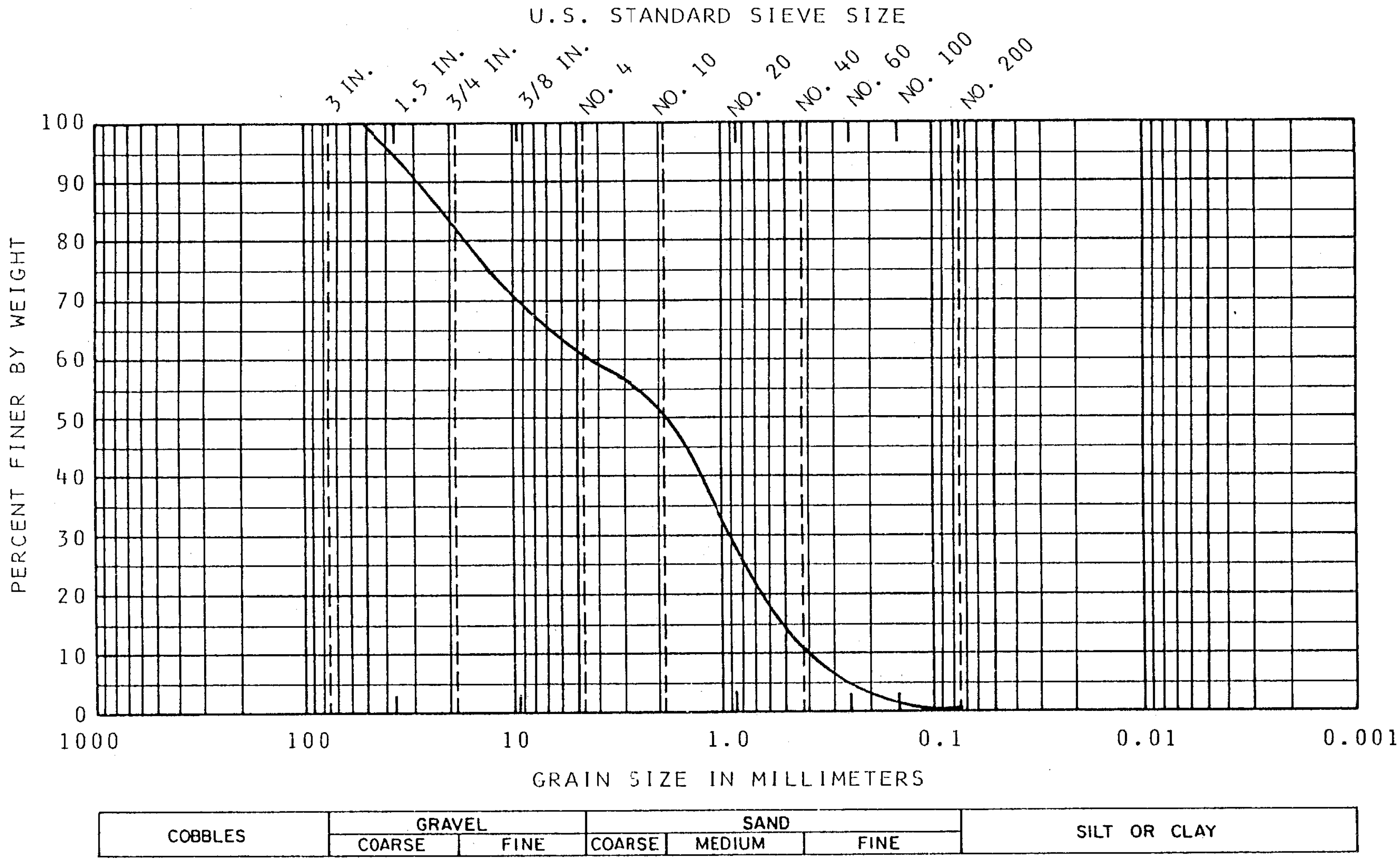
GRADATION CURVES

FIGURE A-21

1317-006-B04 JGR:KKT 12/5/89



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
————	TW-10	118'	MEDIUM TO COARSE SAND WITH GRAVEL (SP)

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GRADATION CURVES

FIGURE A-22

APPENDIX B

AMTEST

AmTest Inc.

Professional Analytical Services

14603 N.E. 87th St.
Redmond, WA
98052

Fax: 206 883 3495

Tel: 206 885 1664

GeoEngineers

DEC 21 1989

Routing JTB [illegible]

File

ANALYSIS REPORT

CLIENT: Geo Engineers

REPORT TO: John Biggane
2405 140th Avenue N.E.
Suite 105
Bellevue, WA 98005

DATE RECEIVED: 9/15/89

DATE REPORTED: 9/28/89

DATE REVISED: 12/19/89*

WATER SAMPLE INFORMATION FOR INORGANIC CHEMICAL ANALYSES

Laboratory Sample Number / Client Identification	916806 / 9-14 0800	Maximum Contaminant Level
Arsenic (mg/l)	<0.010	0.05
Barium (mg/l)	<0.25	1.0
Cadmium (mg/l)	<0.002	0.01
Chromium (mg/l)	<0.010	0.05
Iron (mg/l)	<0.05	0.3
Lead (mg/l)	<0.010	0.05
Manganese (mg/l)	<0.010	0.05
Mercury (mg/l)	<0.0010	0.002
Selenium (mg/l)	<0.005	0.01
Silver (mg/l)	<0.010	0.05
Sodium (mg/l)	<10.	-
Hardness (mg/l as $CaCO_3$)	78.	-
Conductivity (umhos/cm @ 25°C)	110.	700.
Turbidity (NTU)	0.3	1.0
Color	<5.0	15.0
Fluoride (mg/l)	0.2	2.0
Nitrate (mg/l)	0.4	10.0
Chloride (mg/l)	<10.	250.
pH	7.21	6.9
Dissolved Oxygen (mg/l)	10.8	-

< = Less than
*Request for typed report.

REPORTED BY: John T. Dailey

JTD/ja

...se Print Plainly
... HEAVY PENCIL
...O NOT WRITE IN SHADED AREAS

LABORATORY NAME
AM TEST, INC.
14603 NE 87TH STREET
REDMOND, WA 98052

44443

SEE BACK FOR INSTRUCTIONS

WATER SAMPLE INFORMATION FOR INORGANIC CHEMICAL ANALYSES 10-3

...B. NUMBER	CO.	CITY	DATE RECEIVED	DATE COLLECTED	COLLECTED BY:
616806	— —	—	9/15/89	[illegible]	GeoEngineers Telephone: [illegible]

...his a follow up of a previous out of compliance sample? Yes ☐ No ☐

OCT - 4 1989

...f yes, what was the laboratory number of the previous sample? — — — — — — — —

Routing 9H₂O ☐

...TEM I.D. NO.	SYSTEM NAME:	SYSTEM CLASS (circle one)	COUNTY
	9-14 0800	1 2 3 4	File

...PLE LOCATION: 1 — — —

THIS SAMPLE TAKEN BEFORE TREATMENT ☐ U AFTER ☐ T

IF TAKEN *AFTER* TREATMENT WAS IT __FILTERED __FLUORIDATED __CHLORINATED __WATER SOFTENER: TYPE USED ____

...OURCE ...E: __ 1. SURFACE __ 2. SPRING __ 3. WELL __ 4. PURCHASE

SOURCE NO. — —

IF SOURCE IS LAKE OR STREAM, ENTER NAME

IF SAMPLE WAS DRAWN FROM DISTRIBUTION SYSTEM IT WAS COLLECTED FROM SYSTEM AT: (ADDRESS)

DATE OF FINAL REPORT: 9/28/89

SEND REPORT TO: (PRINT FULL NAME & ADDRESS)

Name

Street

CITY , WA. ZIP CODE

Telephone: ( ) Area Code

REMARKS:

...7.33

LABORATORY REPORT
(DO NOT WRITE BELOW THIS LINE)

TESTS		*MCL	Less Than <	RESULTS		Compliance YES	Compliance NO	Chemist Initials	Laboratory Number (If different than above)
...senic	As	0.05 P	<	0.010	mg/l	/		JC	
...ium	Ba	1.0 P	<	0.25	mg/l	/		BT	
...admium	Cd	0.01 P	<	0.002	mg/l	/		BT	
...romium	Cr	0.05 P	<	0.010	mg/l	/		BT	
...on	Fe	0.3	<	0.05	mg/l	/		BT	
...d	Pb	0.05 P	<	0.010	mg/l	/		JC	
...anganese	Mn	0.05	<	0.010	mg/l	/		BT	
...cury	Hg	0.002 P	<	.0010	mg/l	/		JC	
...elenium	Se	0.01 P	<	0.005	mg/l	/		JC	
...er	Ag	0.05 P	<	0.010	mg/l	/		BT	
...odium	Na		<	10	mg/l	/		BT	
...rdness				78	mg/l As CaCO3	/		BT	
...nductivity		700		110	Micromhos/cm 25° C	/		KB	
...urbidity		1.0 P		0.3	NTU	/		KB	
...or		15.0	<	5.0	Color Units	/		KB	
...uoride	F	2.0 P		0.2	mg/l	/		JS	
...ate	as N	10.0 P		0.4	mg/l	/		JR	
...loride	Cl	250	<	10	mg/l	/		JS	
...ate—	SO_4	250			mg/l				

*MCL is the Maximum Contaminant Level Allowed

Laboratory Supervisor

AMTEST

AmTest Inc.
Professional Analytical Services
14603 N.E. 87th St.
Redmond, WA
98052
Fax: 206 883 3495
Tel: 206 885 1664

ANALYSIS REPORT

CLIENT: Geo Engineers

DATE RECEIVED: 10/16/89

REPORT TO: John Biggane
2405 140th Avenue N.E.
Suite 105
Bellevue, WA 98005

DATE REPORTED: 10/27/89

DATE REVISED: 12/19/89*

WATER SAMPLE INFORMATION FOR INORGANIC CHEMICAL ANALYSES

Laboratory Sample Number / Client Identification	918798 / None	Maximum Contaminant Level
Arsenic (mg/l)	<0.010	0.05
Barium (mg/l)	<0.25	1.0
Cadmium (mg/l)	<0.002	0.01
Chromium (mg/l)	<0.010	0.05
Iron (mg/l)	<0.05	0.3
Lead (mg/l)	<0.010	0.05
Manganese (mg/l)	<0.010	0.05
Mercury (mg/l)	<0.0010	0.002
Selenium (mg/l)	<0.005	0.01
Silver (mg/l)	<0.010	0.05
Sodium (mg/l)	<10.	-
Hardness (mg/l as $CaCO_3$)	80.	-
Conductivity (umhos/cm @ 25°C)	118.	700.
Turbidity (NTU)	0.3	1.0
Color	<5.0	15.0
Fluoride (mg/l)	<0.2	2.0
Nitrate (mg/l)	<0.2	10.0
Chloride (mg/l)	<10.	250.
pH	7.33	-

< = Less than
*Request for typed report.

REPORTED BY: John T. Dailey

JTD/ja

Please Print Plainly
USE HEAVY PENCIL
DO NOT WRITE IN SHADED AREAS

AM TEST Inc.
14603 N.E. 87th Street
Redmond, WA 98052

SEE BACK FOR INSTRUCTIONS

44840 10-30

WATER SAMPLE INFORMATION FOR INORGANIC CHEMICAL ANALYSES

LAB. NUMBER	CO.	CITY	DATE RECEIVED	DATE COLLECTED	COLLECTED BY:
6198798	— —	—	10/26/89	10/12/89	Jim Ril, GeoEngineers; Telephone: 746-5200

Is this a follow up of a previous out of compliance sample? Yes ☐ No ☑

If yes, what was the laboratory number of the previous sample? — — — — — — —

OCT 31 1989

SYSTEM I.D. NO.	SYSTEM NAME:	SYSTEM CLASS (circle one) 1 2 3 4	COUNTY Routing

SAMPLE LOCATION: 1 — — — — —

THIS SAMPLE TAKEN BEFORE TREATMENT ☐ U AFTER ☐ T

IF TAKEN AFTER TREATMENT WAS IT __ FILTERED __ FLUORIDATED __ CHLORINATED __ WATER SOFTENER: TYPE USED ____

SOURCE TYPE: __ 1. SURFACE __ 2. SPRING ✓ 3. WELL __ 4. PURCHASE

SOURCE NO. — —

IF SOURCE IS LAKE OR STREAM, ENTER NAME

IF SAMPLE WAS DRAWN FROM DISTRIBUTION SYSTEM IT WAS COLLECTED FROM SYSTEM AT: (ADDRESS)

DATE OF FINAL REPORT: 10/27/89

SEND REPORT TO: (PRINT FULL NAME & ADDRESS)
Name: [illegible] GeoEngineers
Street: 2405 140th Av NE [illegible]
CITY: Bellevue, WA. ZIP CODE: 98005
Telephone: ( ) 746-5200
Area Code

REMARKS:
[illegible]
[illegible]
T 10.8
pH = 7.21

LABORATORY REPORT
(DO NOT WRITE BELOW THIS LINE)

TESTS		*MCL		Less Than ≤	RESULTS		Compliance YES	Compliance NO	Chemist Initials	Laboratory Number (If different than above)
Arsenic	As	0.05	P	<	0.010	mg/l	✓		JC	
Barium	Ba	1.0	P	<	0.25	mg/l	✓		BT	
Cadmium	Cd	0.01	P	<	0.002	mg/l	✓		BT	
Chromium	Cr	0.05	P	<	0.010	mg/l	✓		BT	
Iron	Fe	0.3		<	0.05	mg/l	✓		BT	
Lead	Pb	0.05	P	<	0.010	mg/l	✓		JC	
Manganese	Mn	0.05		<	0.010	mg/l	✓		BT	
Mercury	Hg	0.002	P	<	.0010	mg/l	✓		JS	
Selenium	Se	0.01	P	<	0.005	mg/l	✓		JC	
Silver	Ag	0.05	P	<	0.010	mg/l	✓		BT	
Sodium	Na			<	10	mg/l	✓		BT	
Hardness					80	mg/l As $CaCO_3$	✓		BT	
Conductivity		700			118	Micromhos/cm 25° C	✓		KB	
Turbidity		1.0	P		0.3	NTU	✓		KB	
Color		15.0		<	5.0	Color Units	✓		KB	
Fluoride	F	2.0	P	<	0.2	mg/l	✓		JD	
Nitrate	as N	10.0	P	<	0.2	mg/l	✓		JD	
Chloride	Cl	250		<	10	mg/l	✓		JD	
Sulfate	SO_4	250				mg/l				

*MCL is the Maximum Contaminant Level Allowed
P Primary Standard

Laboratory Supervisor