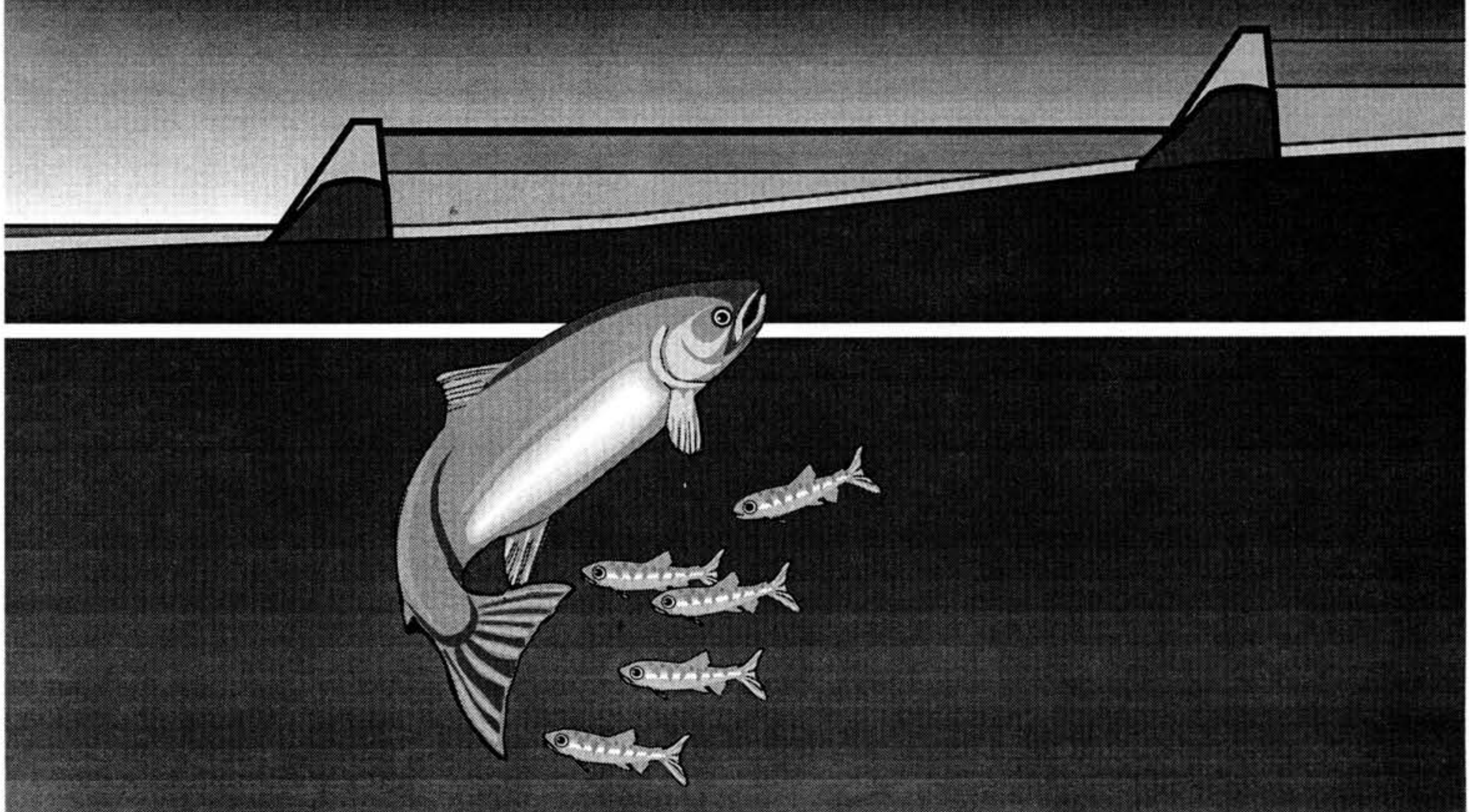
1992 Reservoir Drawdown Test

Lower Granite and Little Goose Dams

US Army Corps of Engineers
Walla Walla District

Appendix A

Hydraulic Evaluation



December 1993

APPENDIX A

HYDRAULIC EVALUATION

1992 Reservoir Drawdown Test

Lower Granite and Little Goose Dams

Hydraulic Design Section
Engineering Division
Walla Walla District
U.S. Army Corps of Engineers

LOWER GRANITE AND LITTLE GOOSE 1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
(Hydraulic Design Section, CENPW-EN-DB-HY, July 1993)

TABLE OF CONTENTS

ENCLOSURES

SECTION 1 INTRODUCTION

1.1 GENERAL

The following report presents the results of hydraulic design related monitoring and evaluations that took place as part of a test drawdown of Lower Granite and Little Goose reservoirs on the Snake River (see Enclosure A-1) during March 1992. The test was completed to allow the Corps of Engineers and others to gather information to assist in evaluating the concept of reservoir drawdown for long-term usage to speed the spring out-migration of the juvenile salmon.

Monitoring and hydraulic-related evaluations of the operation of the Lower Granite spillway, stilling basin, and miscellaneous other features were conducted before, during, and after the March 1992 test period. The primary reasons for the hydraulic design related activities were to:

(1) Insure that the major structural related components of the system were not damaged during the testing.

(2) Evaluate the effectiveness of the spillway flow deflectors (flip-lips) as it pertains to dissolved gas levels for different combinations of spillway flow, forebay elevations, and tailwater elevations.

(3) Observe spillway flow patterns to document impacts related to adult fishway entrances and related features.

(4) Evaluate the operation of the fish ladder and emergency exit at different forebay elevations.

Flow conditions which required forebay levels to be dropped below juvenile fish collection orifice elevations (centerline elevation 729.0) made the juvenile fish collection facilities inoperable. Thus, no hydraulic design related evaluations of these features during the testing were performed.

1.2 OTHER REPORTS AND APPENDICES

The Hydraulic Evaluation After-Action-Report will be included as an appendix to the main drawdown report entitled, Lower Granite and Little Goose Projects, 1992 Reservoir Drawdown Test Report, Walla Walla District Corps of Engineers, October 1992. A listing of other appendices is included in the main report.

SECTION 2 DESCRIPTION OF KEY FEATURES AND BACKGROUND INFORMATION

2.1 GENERAL

Since all of the hydraulic design related monitoring and evaluations occurred at Lower Granite Dam, a brief description of the key hydraulic design related features for this project are presented in the following paragraphs and are shown on Enclosures A-2 and A-3.

2.2 STILLING BASIN AND RELATED DESCRIPTIONS

The Lower Granite spillway has a total length of 512 feet between abutment centerlines, including 7 intermediate piers, and consists of 8 gate-controlled bays, each 50-feet-wide. Piers 14-feet-wide separate the bays. Elevation of the spillway crest is 681 feet mean sea level (fmsl). Spillway discharges are controlled by 8 tainter gates each 50-feet-wide by 60.15-feet-high. The design capacity of the spillway is 850,000 cubic feet per second (cfs), with a corresponding maximum pool of 746.5 fmsl. At normal pool elevation 738 fmsl, the spillway will pass a maximum of 678,000 cfs. (Note: These design flows pertain to the spillway itself and do not mean that other portions of the project could pass these high discharges without sustaining possible damage.)

Energy of the water discharging through the spillway is dissipated by a hydraulic jump in a horizontal apron type stilling basin. The stilling basin has been designed to contain the jump for all discharges up to 850,000 cfs. Nitrogen related flow deflectors, 12.5-feet-long, located at elevation 630 fmsl were installed in bays 1 through 8 of the 8-bay spillway. See Enclosure A-4 for a profile view of the spillway and related features.

2.3 JUVENILE FISH FACILITIES

Lower Granite's juvenile facilities consist of a bypass system and juvenile transportation facilities. The bypass system contains 18 traveling screens, a gatewell orifice system, a bypass channel running the length of the powerhouse, and a bypass pipe to transport the fish to the transportation facilities or to the river. The transportation facilities include an upwell and separator structure to separate the juveniles from the excess water and adult fish, raceways for holding fish, a distribution system for distributing the fish among the raceways, a sampling and marking building, truck and barge loading facilities, and associated water supply lines. Each of the turbine gatewells contain two 10-inch orifices of which one operates under normal operating conditions. The centerline of the orifices is at elevation 729.0 fmsl and discharges through the orifices range from approximately 10.5 cfs at full pool (elevation 738 fmsl) to 6.7 cfs at low pool (elevation 733 fmsl).

2.4 ADULT FISH FACILITIES

The adult fish passage facilities at Lower Granite are made up of one fish ladder on the south shore, two south shore entrances, a powerhouse collection system, north shore entrances with a transportation channel underneath the spillway to the powerhouse collection system, and an auxiliary water supply system.

The fishway system has a pool and weir/orifice fish ladder with a vertical slot water control section at the top of the ladder, a forebay fed gravity flow diffuser at the bottom of the water control section for maintaining a specific flow down the fish ladder, an alternate exit and water supply system, and a vertical slot fish counting station. The fish ladder operates with a flow of approximately 75 cfs. The invert on the fish ladder exit into the forebay is at elevation 727.0 fmsl. During times of extremely high river flow when the Lower Granite pool must be lowered to prevent over topping the levees protecting the City of Lewiston, the alternate fish ladder exit and water supply system is used.

The alternate water supply system is comprised of three pumps located in the forebay, which pump water into the top of the ladder through the diffuser at the bottom of the water control section and through an overflow weir at the alternate exit. The alternate exit is an overflow weir with an 18-inch discharge pipe and chute set at a 15 degree angle leading from the ladder to the lowered pool. The alternate exit is a closed pipe from elevation 735 fmsl to 719 fmsl and a half pipe/chute from elevation 719 fmsl to 710 fmsl. The half pipe allows the system to operate over a pool range from elevation 710 fmsl to 719 fmsl.

The powerhouse collection system is comprised of 10 floating orifices, 2 downstream entrances, and 1 side entrance into the spillway basin on the north end of the powerhouse, and a common transportation channel. Four of the floating orifices and the two downstream entrances at the north end of the collection system are normally used. The north shore entrances are made up of two downstream entrances and a side entrance into the spillway basin with the two downstream entrances normally used. The auxiliary water is supplied by three electric pumps that pump water from the tailrace to the diffusers with two pumps normally used to provide the required flows. The attraction water pumps have a pumping capacity of 1,050 cfs each. The sills of the two south shore entrances and the north shore entrances are at elevation 625 fmsl. The north powerhouse entrance sills are at elevation 628 fmsl.

The adult fish collection facilities were designed to attract and collect migrating adult fish during project operating conditions which included powerhouse operation. Fishway entrances were located where fish should be able to find them under spill conditions (approximately 100,000 cfs) with an operating powerhouse. Under normal conditions when a project spills, the powerhouse discharge maintains a downstream flow from the powerhouse area and forces the spillway discharge to remain in a channel below the spillway.

2.5 DISSOLVED GAS RELATED DISCUSSION

A. Summary of Research and Impacts to Projects.

In general, highly aerated water flowing over standard spillways and plunging into deep stilling basins of dams increases the nitrogen levels of rivers to a supersaturated condition. In contrast, water passing through turbines and navigation locks contributes little or none to gas supersaturation levels reached in forebays. Consequently, flows through these structures, when completely mixed with spillway flow, will reduce the gas supersaturation level in the tailwater downstream from the dam.

On the Lower Snake and Columbia River Dams, several methods have been used to help reduce nitrogen supersaturation of the rivers by spillway operations. These methods include reducing spillway flows by the use of upstream storage to control spring freshets, installation of additional powerhouse units, and structurally modifying the spillway by construction of spillway deflectors to prevent normal spillway flows from plunging deep into the stilling basin.

The unknown effects of spillway deflectors on flow conditions in stilling basins, at existing fishway entrances, and in the channel downstream from the spillway made the use of hydraulic model studies necessary. Each project has individual characteristics related to channel configurations, location of fishway entrances, and stilling basin design which required individual model studies to determine the location and geometry of deflectors and the spillway operation needed to provide optimum fish-passage conditions. Prototype development of the deflectors would have been time consuming and extremely costly. Numerical modeling, which had been used to study the action of dissolved nitrogen in the Lower Columbia and Snake Rivers, could not model the behavior of the deflectors.

Model studies for developing suitable deflectors for the spillways were conducted for several Corps of Engineers Dams including the Lower Snake Rivers projects. Deflectors were installed at each of the Lower Snake River projects except Ice Harbor.

It was found during model tests that if the deflectors are placed at optimal elevations, they would produce the greatest range of stable, skimming flow which would provide the most desirable condition for preventing supersaturation. If the deflector was placed too low, the deflector created standing waves in the basin which drew air into the flow. If the deflector was placed too high, the flow nappe lacked sufficient submergence and plunged near the center of the basin increasing air entrainment.

Upon completion of installation of the deflectors on the structures, it was found (in general) that the deflectors have resulted in lowering of the nitrogen levels during average water years from the 130-140 percent range prior to installation to a range of about 115-120 percent. During high water years, it is estimated that the reduction is generally from the range of 140-150 percent to about 120-125 percent.

B. Observations/Measurements Made During the Lower Granite Spillway Test on 1 June 1991.

A spillway test was conducted at Lower Granite Dam on 1 June 1991. For this test, approximately 100,000 cfs (with average forebay and tailwater elevations equal to 733.5 and 633.7 fmsl, respectively) was discharged over the spillway with no flow passed through the powerhouse. The test was conducted for four hours with three different spillway operation modes. The purpose of the test was to observe conditions comparable to those expected during some of the proposed pool lowering options. The primary focus on the tests were related to adult fish passage conditions and gas supersaturation conditions.

Prior to the test, nitrogen readings in the tailrace area equaled about 101 percent. After the test, the nitrogen readings in the tailrace area equaled about 138 percent. The tailrace water surface elevation only dropped about 1-foot as compared to pretest conditions. The reason for the increase in the nitrogen level can be explained by:

a. For the present normal operating mode with a river flow of about 100,000 cfs, the powerhouse would be operating with no spill occurring. Thus, for operations with full powerhouse flow and 100,000 cfs spill, the river flow could be as high as about 230,000 cfs with a resulting normal tailwater elevation ranging from about 638 to 643 fmsl. For this 230,000 flow condition, based on hydraulic model study data (see Enclosure D-4), the minimum tailwater required to obtain a stable, skimming flow into the stilling basin would equal about elevation 636; therefore, for the 1 June 1991 spill test with an average tailwater elevation at 633.7 fmsl, the tailwater was about 2.3-feet below that required to keep it out of a zone of unstable flows in the basin.

b. Since there was no powerhouse operation during the test, there was no benefit in reducing gas supersaturation levels in the river because of a mixing action of powerhouse flows with spillway flows.

2.6 PRE-DRAWDOWN SPILL TESTS

Tests of 100 percent spill at normal forebay and tailwater conditions were conducted on February 26 and 28 1992, prior to the start of the drawdown. The reason for these tests were:

(1) To walk through the testing procedure,

(2) To determine appropriate locations for instrumentation in addition to calibratation of several instruments, and

(3) To gather baseline data for instrumentation where possible.

SPILLWAY RELATED TEST DESCRIPTIONS

3.1 GENERAL DRAWDOWN INFORMATION

A. General.

The lowering of the Lower Granite and Little Goose pools were completed in four phases starting on March 1 and ending on April 1. A total of nine spillway related tests were completed between March 15 and March 28 with base condition tests completed prior to March 1. Enclosure B-1 shows a graph of forebay elevations versus time for Lower Granite and Little Goose Dams that occurred during the testing. Enclosures B-2 and B-3 shows in tabular form a summary of the test data (discharge, reservoir elevations, dissolved gases) that occurred during each test. Test objectives and operational procedures that were completed are discussed in the following paragraphs.

The drawdown test was scheduled to be completed within the month of March in order to minimize potential negative impacts to migrating fish. (It was anticipated that few juvenile and adult fish would be migrating in the river during this period.) The pool levels that could be reached and the duration of the individual tests were governed by river inflow amounts and by restrictions on how quickly the pools could be lowered. The limits on pool lowering rates were set to minimize damage that might occur to embankments and other structures if the pools were dropped too quickly. The time required to refill the reservoirs to their normal minimum operating pools (MOP) by 1 April was controlled by the river inflow amounts.

B. Lower Granite Pool Related Test Objectives and Restraints.

It was desired to drop the Lower Granite pool as close to the spillway crest as possible given the test time frame while monitoring and evaluating a wide variety of biological, operational, and engineering features.

The pool lowering during the first phase of the test (see paragraph 3.3.B) was limited to no more than two feet over a 24-hour period.

The pool lowering during the spillway and powerhouse surge tests phases of the test (see paragraphs 3.3.C. and 3.3.D.) was initially limited to no more that two feet over a relatively short duration (say a few hours) with the restriction that the pool should not be lowered further until a 24-hour period had elapsed. This limitation was later changed (after Tests 1 and 2) to allow a quick 3-foot-drop while still maintaining the overall 24-hour period requirement. This change allowed additional testing time to facilitate collecting dissolved gas data. See paragraph 3.3.C(2)(a)(2) for additional information.

C. Little Goose Pool Related Test Objectives and Restraints.

The Little Goose forebay was targeted to drop to an elevation which would create a tailwater elevation at Lower Granite that would be close to that if spillway freeflow conditions were occurring at Little Goose. The reason the Little Goose pool did not have to drop to an actual spillway freeflow condition was because it was estimated that natural river conditions [i.e. out of the effect of the backwater from Little Goose] could approximately be reached at the Lower Granite tailrace by dropping the Little Goose pool to about elevation 618. By not having to drop the Little Goose pool to an actual spillway freeflow condition, it would allow the collection of a maximum amount of information with a minimal effect on the upstream pool plus it would reduce the time to refill the pool after the test was complete.

The pool lowering was limited to two feet over a 12-hour daylight period with the restriction that the pool should not be dropped further until a 24-hour period had elapsed. The daytime limitation on the Little Goose pool lowering was used to allow personnel a chance to inspect the shoreline of the Little Goose reservoir in case the drawdown uncovered any Chinook Redd nests that were suspected to be present.

One reason that the Little Goose pool was started at Elevation 638.0 fmsl (Maximum Normal Operating Pool) rather than at Elevation 633.0 fmsl (MOP) was so data on dissolved gases could be obtained over the entire normal range of tailwater conditions given current flow levels. This would provide information that might help determine when the flow deflectors on the spillway become less effective. In addition, starting Little Goose pool at Elevation 638.0 fmsl would provide a high tailwater for the start of the spillway-related tests in order to insure safe conditions with respect to dam safety issues. A high tailwater elevation would start the testing with stilling basin conditions that would be within current operating limits of the project.

The tailwater elevation at Lower Granite Dam would vary depending on the starting pool elevation at Little Goose Dam and on the flow in the river versus backwater effect from Little Goose to Lower Granite. As discussed in the previous paragraph, at some point the tailwater elevation at Lower Granite could shift from a backwater effect from Little Goose to a run-of-river natural flow condition. In addition, during the actual spillway tests, flow conditions in the tailrace area at Lower Granite would be very turbulent with substantial wave action occurring downstream and adjacent to the spillway.

3.2 RIVER DISCHARGE AND PROJECT RELEASE INFORMATION

Snake River inflows during the nine spill test portions of the March 1992 test averaged around 29,000 cfs with daily average inflows reaching as low as about 26,000 cfs and high as about

35,000 cfs (see Enclosures B-2 and B-3). This compared to historical average inflows during the March timeframe equaling around 60,000 cfs with daily average inflows reaching as low as 25,000 cfs and as high as 166,000 cfs.

The juvenile fish season occurs from April through July with the peak fish runs coming in May and June. The historical average inflows during the May and June time period average around 100,000 cfs with the daily average inflows reaching as low as 20,000 cfs and as high as 245,000 cfs. In order to observe and monitor the spillway and stilling basin under flow conditions that would be more typical during the juvenile fish season (i.e. May and June), special surge tests were conducted using reservoir storage to simulate spillway discharges of about 100,000 cfs. A discussion of the special surge tests is presented in paragraph 3.3.

3.3 POOL LOWERING AND SPILL RELATED TEST DESCRIPTIONS

A. General.

The pool lowering and raising was accomplished in four phases. Within these test phases (except for Phase 1), various spill and powerhouse related tests were conducted. The general test procedures are outlined in the following paragraphs.

B. Phase 1 (March 1 to March 15) - Drawdown Lower Granite Pool from Elevation 733.0 fmsl (Minimum Operating Pool - [MOP]) to Elevation 705 fmsl.

Starting Lower Granite pool at Elevation 733.0 fmsl (MOP) and Little Goose pool at Elevation 638.0 fmsl (Maximum Normal Operating pool), the Lower Granite pool was dropped, passing river discharges through the turbines at a steady constant rate of two feet per day until elevation 705.0 fmsl was reached. This took 15 days to accomplish.

The significance of elevation 705.0 fmsl (and for elevations 703.0 fmsl and 706.0 fmsl that is discussed later) is that for a spillway flow of about 100,000 cfs, control of the forebay elevation could be reliably maintained at these elevations with the spillway gates. For water surface elevations less than elevation 703 fmsl, control of the forebay water surface elevation might have shifted between the spillway gates and the spillway crest possibly causing undesirable flow surges and instabilities.

c. Phase 2 (March 15 to March 23) - Spillway and Combination Spillway and Powerhouse Tests: Periodically Conducted Surge Tests with Lower Granite Pool Ranging Initially Between Elevations 705 and 703 fmsl (and Later Between Elevations 706 and 703 fmsl) with Little Goose Pool Dropping Between Elevations 638 and 621 fmsl to Provide Low Tailwater Conditions at Lower Granite.

(1) General.

A total of seven spill related tests during Phase 2 were conducted between March 15 and March 23. Control of the spillway flows was maintained by use of the spillway gates. The tests conducted on March 15, 17, 19, 21, and 23 involved spilling natural river flows for about two-hours before doing a spillway surge test to pass for a short period of time, average discharges slightly in excess of 100,000 cfs over the spillway. (The test on March 23 also included a surge test to pass for a short period of time discharges averaging about 65,000 cfs.) The test conducted on March 16 involved spilling natural flows for about two hours before doing a combination spillway and powerhouse surge test to pass about 23,000 cfs and 81,000 cfs over the spillway and through the powerhouse, respectively. The test conducted on March 22 involved spilling natural flows for about two hours before doing a combination spillway and powerhouse surge test to pass about 84,000 cfs and 23,000 cfs over the spillway and through the powerhouse, respectively. Results of these test are presented in Section 5. A more detailed description of how these tests were conducted are presented in the following paragraphs.

(2) Phase 2 Test Procedure.

(a) Standard Spill Tests.

(1) Test 1 (March 15).

(a) With Lower Granite and Little Goose forebays initially set at elevations 705.0 fmsl and slightly less than 638.0 fmsl, respectively, natural river inflows passing through the turbines were directed over the gate controlled spillway. After about a 2-hour period, a spillway surge test providing gated flows slightly exceeding 106,000 cfs was produced by quickly dropping the Lower Granite forebay from elevation 705.0 to 703.0 fmsl. The length of the test was limited by the 2-foot-drop restriction set on the Lower Granite forebay.

(b) After this surge test was complete, the spillway gates were closed and all river flows were shifted to pass water back through the turbines. The forebay was raised back to elevation 705.0 fmsl while the Little Goose forebay, which had begun to be lowered earlier, continued to steadily drop at the 2-feet per day (over a 12-hour period) rate.

(2) Tests 3, 4, 5, and 7 (March 17, 19, 21, and 23, respectively).

(a) Four additional natural river and 103,000 cfs plus spillway surge tests were conducted in a manner similar to that previously described for Test 1, except that the Lower Granite pool was quickly dropped from elevation 706.0 to 703.0 fmsl rather than from elevation 705.0 to 703.0 fmsl. (See paragraph 3.1.B for a discussion of why a change from a 2-foot to a 3-foot drop was allowed and desirable.) In addition, Test 7 had (besides the 104,000 cfs spill surge test) a 66,000 cfs spill surge test. The length of the tests were limited by the revised 3-foot drop restriction set on the Lower Granite forebay. Each of these tests were conducted with a different pool elevation at Little Goose with the Little Goose forebay dropping to a different level for each test (between about elevation 634 and 621 fmsl - see Enclosure B-1). As previously mentioned, these tests were conducted in a process similar to the standard spill Test 1 previously described; except after Test 7 on March 23, the Lower Granite forebay was allowed to continue to drop while the Little Goose pool was allowed to start to rise (see paragraph 3.3.D.).

(b) Combination Spill and Powerhouse Tests.

(1) Test 2 (March 16).

(a) With Lower Granite and Little Goose forebays at about elevations 705.0 fmsl and slightly less than 636.0 fmsl, respectively, natural river inflows passing through the turbines were directed over the gate controlled spillway. After about a 2-hour period, a combination gated spillway and powerhouse surge test providing flows of about 104,000 cfs (about 23,000 cfs through the powerhouse and about 81,000 cfs over the spillway) was produced by quickly dropping the Lower Granite forebay from elevation 705.0 to 703.0 fmsl. The length of the test was limited by the original 2-foot-drop restriction set on the Lower Granite forebay.

(b) After this surge test was complete, the spillway gates were closed and all river flows were shifted to pass water back through the turbines. The forebay was raised back to elevation 706.0 fmsl while the Little Goose forebay, which had begun to be lowered earlier, continued to steadily drop at the 2-feet (over a 12-hour period) rate.

(2) Test 6 (March 22).

(a) With Lower Granite and Little Goose forebays at about elevations 706.0 fmsl and slightly less than 623.0 fmsl, respectively, natural river inflows passing through the turbines were directed over the gated spillway. After about a 2-hour period, a combination gated spillway and powerhouse surge test providing flows of about 107,000 cfs (about 84,000 cfs through the powerhouse and about 23,000 cfs over the spillway) was produced by quickly dropping the Lower Granite forebay from elevation 706.0 to 703.0 fmsl. The length of the test was limited by the modified 3-foot-drop restriction set on the Lower Granite forebay.

(b) After this surge test was complete, the spillway gates were closed and all river flows were shifted to pass water back through the turbines. The forebay was raised back to elevation 706.0 fmsl while the Little Goose forebay, which had begun to be lowered earlier, continued to steadily drop at the 2-feet per day (over a 12-hour period) rate.

D. Phase 3 - Drop and Hold Lower Granite Forebay to Near Spillway Crest and Raise Little Goose Forebay (and therefore Lower Granite Tailwater) Back to within Normal Operating Levels.

1. General.

After the Phase 2 tests were completed (i.e. after Test 7 on March 23), the Lower Granite pool continued to be steadily dropped using the turbines at a 2-foot per day rate until a near spillway freeflow elevation (elevation 700.0 fmsl which was about 19 feet above spillway crest elevation 681.0 fmsl) was reached on March 26. The Little Goose forebay had been raised steadily back to reach about elevation 635.0 fmsl. At this point, a natural river and spillway freeflow test was completed.

2. Test 8 (March 26).

After Lower Granite forebay had reached elevation 700.0 fmsl, natural river inflows that had been passing through the turbines were first directed over the gated spillway. After about a 2-hour period, a spillway surge test with the gates fully out of the water (i.e. spillway freeflow) provided flows ranging from about 114,000 cfs at the start of the test to about 87,000 cfs by the end of the test. These flows were generated by quickly dropping the Lower Granite forebay from elevation 700.0 to 697.0 fmsl. The length of the test was limited by the 3-foot-drop restriction set on the Lower Granite forebay.

(b) After this surge test was complete, the spillway gates were closed, and the process to begin refilling the Lower Granite pool began. See paragraph 3.3.E. for a discussion related to refill.

E. Phase 4 - Refill Lower Granite Pool to MOP.

1. General.

After completion of the March 26 spillway freeflow test in Phase 3, the spillway gates were closed and river inflows were either passed through the turbines or were temporarily held behind Lower Granite (i.e. zero project releases) depending on the time of day. The only exception to this refill process was the completion of a final spill-related test that was conducted on March 28. The Lower Granite pool refill was temporarily stopped at about elevation 713.0 fmsl to allow final spill related testing at a forebay elevation at which the alternate adult fish ladder exit and water supply system could operate.

2. Test 9 (March 28).

a. Spill Only Test Segment.

Once the Lower Granite pool reached about elevation 712.9 fmsl, natural river inflows passing through the turbines were directed over the gate controlled spillway. After about a 2-hour period, a spillway surge test providing gated flows of about 66,000 cfs was produced by quickly dropping the Lower Granite forebay from about elevation 712.9 fmsl to about 711.8 fmsl. The time duration of this portion of the test was limited to about 2-hours (which resulted a in pool drop of about 1.1-feet) in order to allow for a combination spill and powerhouse test during the next portion of this test.

b. Combination Spill and Powerhouse Test Segment.

After completion of the previously described full spill portion of the test, a combination gated spillway and powerhouse surge test providing flows of about 77,000 cfs (about 24,000 cfs through the powerhouse and about 53,000 cfs over the spillway) was produced by quickly dropping the Lower Granite forebay from about elevation 711.8 to about 710.4 fmsl. The length of the test was set for 2-hours making sure that the full test did not exceed the 3-foot-drop limitation set on the Lower Granite forebay.

After this surge test was complete, the spillway gates were closed and river inflows were either passed through the turbines or were temporarily held behind Lower Granite (i.e. zero project releases) depending on the time of day. The process to refill the Lower Granite pool then continued until the forebay reached MOP conditions on April 1.

SECTION 4 METHODS TO MONITOR AND EVALUATE TESTS

4.1 GENERAL

A variety of methods were used to monitor and evaluate the drawdown test before, during, and after the test. These methods are discussed in the following paragraphs.

4.2 HYDRAULIC SECTIONAL MODEL OF THE LOWER GRANITE SPILLWAY.

A. General.
A 1:55-scale sectional model of the Lower Granite spillway reproducing one full bay width, two piers, and two partial bays was constructed to evaluate, prior to the actual field test, flow conditions related to both normal and special reservoir drawdown conditions. (See Enclosure E-1, page 3 of 4, for a photograph of the model.)

The normal condition tests were used to:

a. Compare new model study flow conditions to original project model study conditions.

b. Provide base conditions to compare model drawdown related tests to normal model conditions.

c. Compare past spillway flows and existing stilling basin and related physical conditions to new model study tests.

d. Observe flow patterns related to the flow deflectors on the spillway as it pertains to original dissolved gas evaluations.

A complete description of the model study describing the model can be found in a memorandum from the Waterways Experiment Station (WES) to the Walla Walla District dated 3 March 1992 with the subject heading, "Data Report, Lower Granite Spillway on the Snake River Hydraulic Sectional Model."

B. Overview of Model Study Tests.
Specific tests that were conducted included:

a. Conducting a series of tests that were used to obtain a quick comparison between normal project conditions and special drawdown conditions.

b. Operating the spillway and stilling basin with constant minimum normal forebay elevations assuming varying flow rates and tailwater elevations in order to establish base conditions for which to compare the model drawdown tests results.

c. Evaluating the spillway and stilling basin for conditions that would be encountered during the drawdown tests assuming several different combinations of spillway flows with varying forebay and tailwater elevations.

d. Observing spillway and stilling basin discharge conditions for various combinations of inflows, forebay elevations, and tailwater elevations. These observations, in addition to comparisons to the original spillway deflectors model study tests, could give an indication of how the drawdown tests might impact dissolved gas levels in the river.

4.3 HYDROGRAPHIC WORK

A. General.

Hydrographic surveys were performed to monitor and evaluate the underwater topography (or bathymetry) of the Lower Granite stilling basin and surrounding area prior to, during, and after the spill tests. In particular, the surveys were performed to monitor any material volume changes or movements both inside and outside of the stilling basin and to evaluate the stilling basin for any structural damage that might result from the testing.

B. Stilling Basin Bathymetry.

Detailed bathymetric surveys of the stilling basin and the surrounding downstream and adjacent tailrace area (see Enclosure A-2) was conducted before and after the March 1992 test period. Additional detailed sonic mapping in selected areas of the basin was also obtained after each individual spillway surge test.

The bathymetric surveys were conducted utilizing an integrated system giving automated data collection as well as processing. A brief description of the operational components of this system is presented below:

(a) Survey Vessel.

The survey vessel was a thirty-foot aluminum V-hull powered boat with an inboard engine equipped with a jet pump propulsion system and a sea chest which enclosed a 200 Khz-3 degree beam transducer. The positioning mast was located directly over the transducer, radar, electronic fluxgate compass, "E" size plotter, left-right monitor, and printer.

(b) Navigation System.

The positioning system utilized was the Lasertrak Range-Azimuth positioning system. An NEC computer running Coastal Oceanographics software processed the navigation and bathymetric data, accepting from the positioning system acoustic fathometer and radio tide gage, and then provided the output to the monitor, plotter, printer, event box, and to computer memory for post-processing.

(c) **Precision Fathometer.**

This instrument was designed to transmit and receive high frequency (200 Khz) acoustic signals to reflect off the bottom. These reflected acoustic signals provided detailed measurements of subsurface variations and existing contours during specific phases of the drawdown testing. A 3 degree, 200 Khz transducer with an Innerspace 448 thermal printing depth sounder was utilized during all phases of the hydrographic surveying process.

The pre-test and post-test stilling basin and adjacent area profile mapping was accomplished at 100 foot intervals with actual data collection made at lesser spans. The profile mapping after each spill test was completed in selected regions of the stilling basin in order to cover smaller areas of the basin in the short time allowed between some of the spill tests. The areas picked for the detailed survey was based on quick side-scan sonic data (see later paragraphs) done immediately after the spill test. Narrower intervals were utilized at selected locations when greater detail was needed.

The accuracy for positioning the survey boat was judged to be within 1 meter (plus or minus 3.28 feet). The accuracy for determining the bottom depths was judged to be 0.1-foot within the main stilling basin. For areas outside of the main basin such as along the sloped portions of the endsill, next to the curved portion of the spillway, and at certain areas outside of the stilling basin, the accuracy was judged to be within about 0.2 feet.

C. **Side-Scan.**

Side-scan sonar data was obtained immediately after each spillway surge test in order to provide a quick, relative change comparison of the stilling basin and channel bottom conditions between tests. In addition, the side-scan data allowed optimizing the bathymeteric survey profile lines so that detailed bottom information could be collected in the areas of most interest during the short time between some of the spill tests.

The side-scan system provided a high-resolution method to obtain descriptive mapping of both sides normal to the survey vessel's path. This method provided acoustical "pictures" (sonographs) of the surface areas which were then printed on a paper surface. These high-frequency sound pulses, emitted from transducers faced in opposite directions perpendicular to the survey vessel's track, provided a plan view or image of the stilling basin floor and adjacent areas.

The side-scan equipment consisted of the Model SMS 260 Image Correcting Side-Scan Sonar System which was a small, portable, digital sonar system. The Model 260 provided sonar images fully corrected for slant range, ship speed, and amplitude. This device derives its information from reflected acoustic energy with its operation very similar to radar in that it provides a continuous plan view of a broad scanned area. Transducer emitted pulses spread in a thin fan-shaped pattern outward on either side of the vessel in a plane perpendicular to its path. This beam can scan a bottom section ranging as far as 600 meters on each side. At the vessel, this acoustic energy reflected from the bottom, amplified and transmitted as electrical energy, is processed and converted to a paper medium by the side-scan recorder.

4.4 DIVERS.

Divers were used before the drawdown tests to inspect areas of the stilling basin just downstream of the end sills where previous field survey information indicated that portions of the downstream channel have eroded away from the structure. The divers at this time examined and collected samples of materials that had been deposited in piles at various locations in the stilling basin. Divers were also used to inspect a portion of the stilling between one of the tests in order to inspect the basin for possible damage.

4.5 HYDRAULIC MEASUREMENTS.

A. General.

Measurements at selected locations were made to evaluate the hydraulic conditions in and around the stilling basin throughout the drawdown testing. These measurements included direct measurements of deflector (flip-lip) pressures, water-surface elevations, and water velocities across the end sill. Also, indirect assessments of turbulent conditions within the stilling basin were made using accelerometers. Enclosures A-2 and A-3 show the general location of key hydraulic related gages that were used to monitor the drawdown test.

B. Water Surface Elevations.

1. General Information.

(a) The official stages monitored during testing were the existing gages installed by the Walla District. The headwater gage was on the upstream face of the dam and the tailwater gage was downstream of the dam on the left bank in the vicinity of the visitor center. These gages had their ranges extended to function over the entire span of the drawdown test.

(b) The Waterways Experiment Station (WES) also recorded stage data during the drawdown testing at Lower Granite Dam. WES installed temporary gages downstream of the dam to during spillway releases.

(c) Pressure transducers and data loggers were used to record the water surface elevations at one minute intervals. The pressure transducers were vented transducers that eliminated the effects of atmospheric pressure changes. Each pressure transducer was secured to a structure and frequently calibrated based on a measured water surface elevation at the transducer site. Due to mounting difficulties, the elevation of some of the transducers was adjusted during the test program as the downstream pool was lowered. The data loggers were secured in accessible areas near the pressure transducer. Data from the data logger was downloaded to ASCII files and the water surface profile was plotted for each location and averages were calulated. Water surface elevations were plotted for each test for the five different gage locations beginning at 0700 hours until after the conclusion of testing.

2. Locations of WES Gages.

Water surface elevations were recorded at five locations during the test program. The gage locations were as follows:

a. Downstream Guide Wall.

A gage was located about 70 feet from the end of the downstream guide wall on the navigation side of the wall. (Away from the stilling basin.) The guide wall protected this gage from most of the turbulent wave action. Measurements made by this gage would be easy to duplicate in the general hydraulic model.

b. Curved Guide Wall.

A gage was located on the navigation side of the curved guide wall. This gage would have measured any tendency for eddies to form in the area behind the navigation lock.

c. Fish Loading Facility.

A gage was located on the bank side of the fish loading facility on the left descending bank. The water surface at this location reflected the waves in the main downstream channel. The structure seemed to have little effect on surface waves.

d. Right Training Wall.

A gage was located between the navigation lock and the right spillway training wall. This gage tended to reflect the water surface elevations at the downstream end of the training wall. The gage was located in an extremely turbulent location. The data reflects this turbulence.

e. Right Bank Downstream.

This gage was located on the right bank in the downstream channel. The gage was 3280 feet downstream of the station 41+64 of the original dam construction baseline. The transducer at this site was attached to a weight placed on the channel bottom. This transducer was moved several times during testing as the water level dropped.

C. Pressure Transducers.

Pressure transducers were installed along the spillway deflectors (flip-lips) to help determine when the deflectors had become fully aerated. Flow instabilities could have occurred during the transition from non-aerated to fully aerated discharges, possibly creating unacceptable flow instabilities over the spillway. Two sets of pressure gages were attached to the vertical face of the flip-lip along the centerline of spillway bays 3 and 6. Each set consisted of one upper and one lower gage.

D. Endsill Water Velocities.

Two-directional electromagnetic velocity meters were installed along the top of the endsill downstream of gate bays 1, 7, and 8. The purpose of these velocity measurements was to determine the magnitude and direction of the flow just above the endsill. Preliminary physical model data clearly showed that under certain combinations of discharge and tailwater elevation, reverse flows (upstream direction) created across the endsill were able to transport debris, such as rocks and boulders, into the stilling basin.

E. Accelerometers.

Accelerometers mounted on the structure in the vicinity of the spillway and stilling basin were used to indirectly assess turbulence conditions by measuring relative levels of the magnitude and frequency of structural vibration. The accelerometers were located on the right training wall near the pier, at the midpoint of the right training wall, at the end of the left training wall, and on the center pier. The gages were located to also detect possible vibrations caused by cavitation in the vicinity of the deflectors in the event the low tailwater elevations created non-aerated flow conditions.

F. Data Acquisition.

The data from all sensors were simultaneously recorded using digital data acquisition equipment developed by WES. The individual sensors were connected by signal cable to the recording equipment housed in a fully equipped instrumentation vehicle parked on the dam at the north end of the spillway. Basic data analysis was accomplished immediately post-test to assess any possible unfavorable conditions occurring in the basin. These analysis included time history plots, pertinent statistical analysis (average, maximum, minimum, and rms), and limited spectrum analysis. For endsill velocities, the magnitude and direction of the flow was determined.

Data was collected for finite sampling windows on the order of 4 to 6 minutes duration. Therefore, five test series were conducted for each drawdown event. These included:

(a) Pretest no flow condition to calibrate instruments.

(b) Spillway gate openings from 0 cfs to natural river inflows (averaging about 30,000 cfs).

(c) Spillway gates set approximately for natural inflows (averaging about 30,000 cfs).

(d) Spillway gate openings from about 30,000 cfs to about 100,000 cfs (natural inflows to target spillway surge test discharge).

(e) Spillway gates set approximately for target spillway surge test discharge (about 100,000 cfs).

4.6 VISUAL AND PHOTOGRAPHIC OBSERVATIONS

Visual observations were constantly made throughout the actual spill tests to observe any changing flow patterns in the stilling basin and surrounding areas.

Videos were taken both from the south shore, from a helicopter, and from other locations in order to document the test.

4.7 DISSOLVED GAS MONITORING

Dissolved gas related information discussed within this appendix presents and discusses dissolved-gas data collected during the Lower Granite and Little Goose 1992 Drawdown Tests as it relates to the operation of the spillway flow deflectors. A complete discussion of the raw dissolved gas data and how it relates to water quality issues is presented in the main drawdown report.

Dissolved gas sampling stations were located in the forebay of Lower Granite Dam (stationary and boat transects) and approximately one-half mile downstream of the dam (stationary and boat transects). (See Enclosures A-2 and A-3). Additional dissolved gas sampling stations were located approximately four miles downstream of the dam across from Port of Almota (boat transects) and at the forebay and tailrace of Little Goose Dam (both stationary instruments). Boat transects were run in the forebay on two occasions, but most of the time background levels were measured in the tailrace prior to the opening of the spill gates or before the spilled water had reached the first sampling station.

Measurements were taken at the surface and at a depth of approximately 10 to 15 feet (throughout the rest of the document will be noted as "deep") with a Common Sensing, Inc. tensionometer. Attempts were made to keep the surface probe under water at all times, but periodically, turbulent conditions resulted in a brief exposure to the air; although, this should not have affected readings. Turbulent conditions are also what resulted in varying depths for the lower probe, as well as shallow tailwater conditions during the Little Goose drafting forcing a reduction in depth.

SECTION 5 TEST OBSERVATIONS, EVALUATIONS, and CONCLUSIONS

5.1 GENERAL

Hydraulic related drawdown observations, evaluations, and conclusions are presented in the following paragraphs. Potential additional test evaluations, in light of future results from an ongoing hydraulic three-dimensional general physical model of the Lower Granite project and from possible future numerical dissolved gas modeling of the system, will be completed as new information becomes available. See Section 7 for possible future related studies.

5.2 HYDRAULIC SECTIONAL MODEL TESTS: RESULTS AND INFLUENCES ON DRAWDOWN TEST

A complete description of the model study describing the model and test results can be found in a memorandum from the Waterways Experiment Station (WES) to the Walla District dated 3 March 1992 with the subject heading, "Data Report, Lower Granite Spillway on the Snake River Hydraulic Sectional Model." A portion of this report showing velocities, photos, and air-entrainment related sketches for the 30,000 cfs and 100,000 spill conditions (which is comparable to some of the actual drawdown field tests completed in 1992) is presented in Enclosure E.

Items that were closely examined and evaluated during the model testing included:

a. The extent of energy dissipation in reference to the end sill which would be an indication of potential erosion within or downstream of the basin.

b. The direction and magnitude of model velocities which would be an indication of the tendency to pull downstream material into the basin.

c. The roller action from plunging spillway flows under lower tailwater conditions which would be an indication of damage that might occur if rock materials were allowed to continually grind and pound the basin floor.

d. The potential for nitrogen supersaturation which would be indicated by the amount of aeration observed during the testing.

Conclusions and judgments made from the model prior to the actual drawdown tests were as follows:

a. It appeared hydraulically safe to spill for all test flows up to 60,000 cfs under all test conditions. Additional testing would be needed to evaluate conditions under extended flow periods. Items that would have to be evaluated for extended flow situations include testing different combinations of flows, tailwater elevations, and stilling basin conditions.

b. It appeared unsafe to spill for 100,000 cfs once tailwater elevations approached the deflectors (flip-lips) if existing rock material were not removed prior to the start of the test.

c. If substantial amounts of new larger material were pulled into the basin during testing, this might also lead to limiting the test.

d. It appeared there would be a potential for increased dissolved gases when the tailwater elevation approaches the deflectors (flip-lips) top elevation.

e. It appeared that spillway freeflow might increase the potential of nitrogen problems because of the tendency to plunge deeper.

Because of the concern raised during the model study of the potential damage that might be caused by churning rock in the stilling during lower tailwater test conditions, the stilling basin was dredged of over 1100 cubic yards (see Enclosures C-6 and C-7) prior to the start of the test to remove most of the existing materials within the basin . (It should be noted that it is believed that this dredged material was originally brought into the basin during spill conditions from previous years.) This allowed spill amounts to safely go as high as the 100,000 cfs levels. As previously noted, if substantial amounts of new larger material had been pulled into the basin during testing, this could have lead to limiting the test.

5.3 STILLING BASIN RELATED EVALUATIONS AND CONCLUSIONS

A. General.

The following information presents data and test results of the various hydraulic evaluations that were completed in and around the stilling basin as it pertains primarily to physical measurements and impacts to the basin. A discussion of test data, evaluations, and conclusions as it pertains to dissolved gases and to the operation of the adult fishway is presented in paragraphs 5.4 and 5.5.

B. Hydrographic Work.

(1) Side-Scan Information.

The side-scan acoustical "pictures" that were obtained immediately after each spillway surge test proved to be very valuable in terms of providing a quick evaluation (typically within about one hour after the test was completed) of what was happening to the debris piles, to the stilling basin floor, and to the areas adjacent to stilling basin. It was also very useful in helping to optimize the use of the bathymeteric surveys between the tests. A typical side-scan print is shown on Enclosure C-1.

The side-scan data indicated that considerable movement of materials occurred both inside and outside of the stilling basin during the spill tests. Since the bathymetery surveys discussed in the next paragraph document in more detail the changes that were occurring in and around the stilling basin during the tests, no further discussion on the side-scan information will be presented at this time. A report forth coming from WES will present additional side-scan related prints and information .

(2) Stilling Basin Bathymetry.

Results of the detailed bathymetric surveys are shown in several different formats in Enclosure C. Enclosures C-2 through C-5 show isometric views of the pre- and post-test hydrographic surveys for both within and adjacent to the stilling basin. Enclosures C-6 through C-15 show the changing locations and volume amounts of the material piles within the basin during the testing. Enclosure B-5 is a table showing material volume changes between the tests based on data from Enclosures C-6 through C-15. Enclosures C-16 and C-24 show profile sections of the pre- and post-test conditions through the stilling basin and adjacent areas.

The data from the previously mentioned enclosures indicated the following items:

a. During the initial phases of the spill testing with tailwater elevations above the deflectors (flip-lips), computed material volumes increased from about 70 cubic yards (Enclosure C-7) to more than 322 cubic yards (Enclosures C-9 and C-10). As the tailwater continued to drop to and then below the deflectors, the amount of material within the basin was reduced to about 122 cubic yards (Enclosure C-12). Finally, as the tailwater elevations were elevated back to normal, the amount of material volumes increased again to a level equaling about 363 cubic yards (Enclosure C-15). Significant material movements within the basin occurred during the lower tailwater conditions under the plunging flow conditions as indicated by Enclosures C-10 through C-13. (Note: As previously discussed in the earlier paragraphs, the tendency to pull materials back into the basin under high tailwater conditions and to shift materials within and out of the basin under low tailwater conditions was also observed in the hydraulic sectional model of the stilling basin.)

b. The pre- and post-test profiles of the stilling basin and adjacent areas indicate that a significant amount of material movement downstream of the basin did occur. For example, towards the south end of the stilling basin (see Station 34+00, Enclosure C-21), it shows approximately 10 feet and 45 feet downstream of the endsill that about 8 feet and 5 feet of material, respectively, had been vertically removed over the test period. As another example, towards the middle section of the stilling basin (see Station 36+00, Enclosure C-22), it shows approximately 20 feet and 170 feet downstream of the endsill that about 5 feet of material was vertically removed and about 19 feet of material was vertically added, respectively.

c. Diver Inspections.

(1) Dive on 6 February 1992.

On 6 February 1992, divers inspected several areas of the stilling basin and adjacent areas. Underwater visibility for the divers was limited to just a few feet in front of their lights and video camera because of the turbidity level in the water. On their first dive, they examined portions of the stilling basin starting at the south training wall near the deflectors and then ending at about half-way across the width of the basin in order to check for material types and sizes within the basin and to look at the general condition of the basin floor. On their second dive, they looked at the basin endsill and adjacent downstream areas in the vicinity of the north training wall to check if any undermining of the endsill might have occurred over the years. (Previous underwater surveys showed deep holes directly downstream of the endsill in this area.) On their third and final dive, they completed a sweep of the area downstream of the endsill to look at the material types and sizes to check if there was any source material available that could get pulled into the basin during normal spill conditions.

Divers found various size rocks that ranged from several inches in diameter to fist sized and larger (see Enclosure C-1). The basin floor had in some areas very light surface scarring, but did not look widespread or significant.

The inspection of the endsill towards the north training wall did confirm very deep scour holes downstream of the endsill. However, the divers were unable to dive into the deep holes because of safety reasons to check if any actual undermining of the structure endsill had occurred. There were some portions of the downstream side of the concrete endsill structure that had exposed rebar and broken pieces of concrete. It is not known, though, if this was actual damage that had been caused from previous spills or if this part of the structure had been left this way from the original construction. Future dam safety inspections will investigate this area further.

An inspection of the area downstream of the endsill toward the north half of the stilling basin did show that source materials (i.e. loose rocks and gravels) were still present which meant that materials could possibly be drawn into the basin during normal spill conditions.

2. Dive on 18 March 1992.

Divers were used on 18 March 1992 to re-install some WES instrumentation that had broken loose during parts of the spill tests. In addition to this work, divers were used to examine areas toward the north end of the stilling basin (just downstream of the deflectors) which appeared in the side-scan prints to have shown possible significant scarring. As was the case for the previous dive, visibility for the divers was poor and observations were limited to just a few feet in front of their light and video camera.

Divers did not detect anything during the dive that would indicate any serious structural damage in terms of threatening the integrity of the basin. However, areas of the basin floor did show substantial surface erosion with widespread areas of exposed aggregate and pitting that was several inches deep . This part of the basin floor looked considerably more scarred than the south part of the basin that had been inspected prior to the start of the drawdown test.

D. Hydraulic Measurements.

1. Water Surface Elevations.

Tailwater and forebay water surface elevations recorded during the tests are shown in several different forms on the following enclosures:

a. Enclosure B-1 shows Lower Granite and Little Goose forebay elevations (project gages) versus time for the entire testing period.

b. Enclosure B-2 shows Lower Granite forebay (project gage) and tailwater (WES gages) summary information. The tailwater elevations shown are the average values, excluding sharp rises and drops during transition phases of the tests, from several key WES gaging stations located in the tailrace area.

c. Enclosure B-3 shows the maximum, minimum, and average Lower Granite forebay and tailwater elevations (project and WES gages) for each spill test condition.

Average tailwater elevations, accurate to within a tenth of a foot, from key WES gages were used when analyzing data related to the spillway and to dissolved gas considerations. The project south shore gage was typically from 0.5 feet to 1.5 feet lower than the WES tailwater gages due the location of this gage with respect to powerhouse and spillway operations.

2. Deflector (Flip-Lip) Pressure Transducers.

Pressure measurements obtained during the spill tests are shown on Enclosure B-4. Some of the gages became inoperable or temporarily disconnected during the testing because of the high velocity and turbulent conditions that occurred on the deflectors. (It should also be mentioned that some of the gages were made inoperable because of some biological testing within the stilling basin that resulted in "electro-shocking" some of the gages.) Thus, data was not collected for all phases of the tests. However, for the gages that were operational, it provided insight as to when the discharge over the deflectors became aerated and when free plunging versus skimming flow had occurred.

3. Endsill Water Velocities.

All three water velocity meters located on the end sill became inoperable during the early stages of the first spill test on 15 March. It was suspected prior to the testing that there would be a chance of loosing these gages because large rocks being carried by high velocity water might either hit the gages or tear up the cables leading to the gages. Prior to loosing these instruments, though, velocities reaching as high as 20 fps with reverse flow conditions back into the basin were recorded. These flow conditions were comparable to those that were observed with the hydraulic sectional model of the stilling basin.

4. Accelerometers.

Vibration levels measured on the structures around the spillway and stilling basin during the tests were always within acceptable levels as it pertains to the structural integrity of the facilities. It was interesting to note that as the tailwater elevations dropped during the tests, the "noise levels" picked up by the measurements increased, which could have been an indication of the increased rock movement within the basin.

E. Evaluation of Data.

Under normal tailwater project operations with spillway flows greater than about 60,000 cfs, materials downstream of the stilling basin were drawn into the basin. This finding is based on side-scan and detailed sounding profile data, on changes in computed volumes of material within the basin, and on measured endsill flow directions and velocities showing reverse inflow back into the basin. This information correlates well with the results obtained from the hydraulic sectional model of the spillway and stilling basin.

It appears under normal tailwater project operations, materials already within the basin remained relatively stable. However, as tailwater elevations dropped closer to the top of the flip-lip, side-scan and detailed sounding data indicated increasing material movement within the basin. The movement of this material can be explained by a greater tendency for water discharging over the flip-lip at lower tailwater elevations to plunge rather than to skim across the surface. The side-scan and sounding information, in addition to a diver inspection of portions of the basin between tests, showed that substantial surface pitting of the stilling basin floor had occurred either prior to or during the testing. It is not known how much of the surface damage might have been covered by materials prior to the tests exposing these areas. It is believed, however, that some surface damage did occur during the testing. This judgment is based on the amount of material movement that was observed during the lower tailwater tests, on the size of the material (fist size and larger rocks) within the basin discovered during a mid-test diver inspection, and on the spillway hydraulic sectional model study that demonstrated substantial churning material movement during lower tailwater conditions.

Based on preceding paragraphs, it is believed that it would be unacceptable to operate the spillway and stilling basin for an extended time under lowered tailwater conditions unless a method to keep rock material out of the basin is devised.

An important item was identified as result of the testing that is applicable to projects with deflectors installed on just a portion of the spillway (for example, Lower Monumental). Flow patterns created within these basins could be pulling material into the basin while at the same time causing a churning action of some of the materials that might be damaging the basin floors. Future analysis will be completed to explore this potential problem for other projects.

5.4 ADULT FISHWAY RELATED OBSERVATIONS

A. Flow Patterns in the Vicinity of the Adult Fishway Entrances.

1. Sketches of Tailrace Surface Flow Patterns.

Enclosure F shows sketches developed by observing video tapes of the different tailrace surface flow patterns resulting from the spill tests. The purposes of the sketches are not to precisely define surface flowlines, but to instead provide a general overview of typical flow patterns observed during the testing. The view point for these particular tapes was from a location just downstream of the dam on the south shore hillside.

2. Evaluation of Observations.

Surface flow patterns observed in the vicinity of the main adult fishway entrances for all the tests with either no or two units operating appeared to be undesirable for adult fish passage. Some type of surface eddy was always apparent downstream of the powerhouse which would probably make it difficult for fish to locate the powerhouse and south shore related entrances. Very turbulent flow conditions with high velocities were also apparent at the fishway entrance located just north of the spillway.

The only test that appeared to have acceptable flow conditions at the adult fishway entrances was the test with full powerhouse operation and the low spill discharge (Test 6B on 22

March). This condition appeared similar to normal operating conditions which does successfully pass adult fish through the project.

Additional information related to the effects of spill on flow patterns can be found in the main drawdown report.

B. Emergency Adult Fishway Exit System.
The emergency adult fishway exit system, operational down to forebay elevation 710, appeared to pass fish although flow conditions at the false weir appeared to be very turbulent. It might be possible to modify the flow conditions at the false weir if it is ultimately judged to be a serious concern.

Additional information related to adult fish passage as it relates to the emergency alternate fish ladder exit can be found in the main report.

5.5 DISSOLVED GAS LEVEL RELATED EVALUATIONS

A. General.
Factors related to the spillway that influenced what level of dissolved gases were generated during the testing involved items such as the quantity and distribution of spillway discharges, forebay elevations, tailwater elevations, and combination powerhouse and spillway operations. How each of these factors impacted the dissolved gas levels is discussed in the following paragraphs.

It was observed that dissolved gas levels, during the testing, generally continued to rise until the spill test was complete. It is presently theorized that after the powerhouse is either shutoff or significantly reduced and the spillway is opened, a substantial amount of non-supersaturated water initially remains in the pool immediately downstream of the powerhouse. As the spill continues, this water is slowly replaced with supersaturated water from the spillway flows as the upstream eddy, downstream of the powerhouse, continues to circulate. Based on initial estimates from the Lower Granite general physical model using information related to how long it takes dye to be removed from the eddy, it might take up to eight hours or more for the entire volume of water to be replaced. The non-supersaturated water dilutes the water downstream from the spillway in the area where the drawdown test measurements were taken; thus this would explain why the dissolved gas measurements continued to rise until a spill test was complete.

A more complete discussion related to dissolved gas supersaturation as it pertains to water quality issues as well as hydraulic related features is presented in the main 1992 Reservoir Drawdown Test Report. This information includes a discussion related to dissolved gas instrumentation, data collection, and data analysis.

Summary project discharge, reservoir water levels, and dissolved gas data is shown on Enclosure B-2. The dissolved gas level values shown, which are considered to be representative averages of measurements taken at a depth of approximately 10 to 15 feet deep, were taken roughly in the center of the river at a locations typically about one-half mile downstream of the dam.

B. Evaluation of Test Data.

1. Impact of Spill Levels on Dissolved Gas Saturation. Enclosure D-1 shows a plot of spillway discharge versus percent dissolved gas saturation. For these spill conditions with no powerhouse operations, it was confirmed that the higher the spill level, the higher the dissolved gas saturation amounts. Although forebay and tailwater elevations in addition to powerhouse operations are also components in determining what the dissolved gas levels will be (see the following paragraphs), the overriding factor is the spill level. For example, as can be seen on Enclosure B-2, page 2 of 3, for the low flow tests with spill levels ranging from 27.2 to 35.2 kcfs, the dissolved gas levels ranged from 113.9 to 118.3 percent. In contrast, for the high flow tests with spill levels ranging from 100.0 to 106.8 kcfs, the dissolved gas levels ranged from 126.5 to 132.4 percent. It should be noted that for all of these tests (in addition to considering some pre-reservoir drawdown tests), there were sometimes a wide variation in forebay and tailwater elevations. Even with these variations, the strong trend of higher the discharge, the higher dissolved gas saturation, remained the same.

2. Impact of Lowered Forebay Elevations on Dissolved Gas Levels. It was uncertain what impact substantially lowering the forebay would have on dissolved gas saturation levels. Lowering the head on the spillway would lower the amount of energy entering the stilling basin from the spillway discharge. However, it was also believed that other factors such as the spill amounts and tailwater elevation would probably be more significant in terms of impacting dissolved gas levels.

Average dissolved gas levels taken in late February 1992 during pre-reservoir drawdown tests in the center of the river ranged from approximately 123 to 125 percent. With comparable spill levels (approximately 100 kcfs) and with a 28 to 30 foot lowered forebay, the dissolved gas values for the actual drawdown tests averaged about 127 percent (at similar tailwater elevation), indicating that lowering the forebay does not reduce dissolved gas levels.

3. Impact of Lowered Tailwater Elevations on Dissolved Gas Levels.

(a) Low Spill Discharge Tests.

(1) It was observed during the low level spill tests that there was a difference in the visual appearance of the hydraulic characteristics of the flows in the stilling basin between high and low tailwater elevations. For tailwater elevations above deflector top elevation 630.0 fmsl, discharges coming off the spillway seemed to carry downstream with surface turbulence readily apparent. In contrast, for tailwater elevations in the vicinity and below deflector top elevation 630.0 fmsl, the flows coming off the spillway seemed to plunge with less surface turbulence being observed downstream as compared to the high tailwater tests. These surface observations with respect to energy dissipation within the basin matched relatively well with what was observed in the hydraulic sectional model of the spillway and stilling basin. The model data (see Enclosure D-4) showed the higher tailwater flows having a skimming action and the lower tailwater flows having a plunging action.

(2) Enclosure D-2 shows a plot of tailwater elevation versus percent dissolved gas supersaturation for low spill test conditions. This data, which shows two curves with spill level groups averaging about 28 and 35 kcfs each, indicate that dissolved gas saturation levels are minimally impacted by reducing the tailwater under the lower spill amounts.

(b) High Spill Discharge Tests.

(1) It was observed during the high level spill tests that there was a significant difference in the visual appearance of the hydraulic characteristics of the flows in the stilling basin between high and low tailwater elevations. For tailwater elevations a few feet and higher above deflector top elevation 630.0 fmsl, discharges coming off the spillway seemed to carry considerably downstream with a great deal of surface turbulence. In contrast, for tailwater elevations in the vicinity and below deflector top elevation 630.0 fmsl, the flows coming off the spillway seemed to plunge with significantly less turbulence being observed downstream as compared to the high tailwater tests. It was also interesting to note that the appearance of the downstream water with the low tailwater tests had an almost dull mildly color while the high tailwater tests had a more whitish appearance. These surface observations with respect to energy dissipation within the basin matched well with what was observed in the hydraulic sectional model of the spillway and stilling basin. As was the case for the low spill tests, the model data (see Enclosure D-4) showed the higher tailwater flows having a skimming action and the lower tailwater flows having a plunging action.

(2) Enclosure D-3 shows a plot of both tailwater elevation and spillway deflector pressures versus percent dissolved gas supersaturation for high spill test conditions. The plot of tailwater elevation versus percent dissolved gas does show a definite trend that the lower the tailwater elevation, the higher the dissolved gas level. This information alone doesn't seem to indicate that there was any substantial change in dissolved gas levels that occurred once tailwater elevations dropped below the top of the deflectors except that there was a relatively constant downward trend. (Dissolved gas levels increased from 126.5 to 132.4 percent when the tailwater elevations were dropped from 638.9 to 628.3 fmsl, respectively.) However, a closer look at the data provided some interesting insights.

(a) The plot on Enclosure D-3 of spillway deflector pressures versus percent dissolved gas supersaturation for high spill test conditions show that actual pressures measured below the deflectors were from 4 to 6 feet below tailwater elevations measured a short distance downstream. This graph indicates that as tailwater elevations dropped from higher elevations to closer to the top of the deflectors, there was relatively minor reductions in the dissolved gas levels. However, as tailwater elevations continued to lower and the pressure readings dropped to below the top of the deflectors, dissolved gas levels appeared to significantly rise. For example, from Test 4B to test 7C on the graph, there was roughly a 4 to 5 percent dissolved gas level increase for about a one-foot pressure reduction. This indicates that once hydraulic conditions within the basin clearly allow for plunging action versus skimming conditions, dissolved gas levels substantially rise.

(b) For test 5B on March 21 when the minimum tailwater elevation prior to the test was at about 624.6 fmsl (see Enclosure B-3, page 10 of 20), dissolved gas levels quickly jumped to about 135 percent. Once flows had somewhat stabilized and the tailwater elevations had risen to an average of about 629.8 fmsl, dissolved gas readings tended to drop and level off to about 130.5 percent. (The reason the tailwater elevation increased was because of the higher backwater effect caused by the higher river discharge.) This information suggests that dissolved gas levels would probably be significantly higher for situations where a strong plunging action versus an unstable skimming condition over the spillway could be maintained for a longer period of time.

(3) In the case for Lower Granite, the physical layout of the downstream river channel may not allow tailwater elevations (and therefore pressure readings) under high spill conditions to drop significantly below the top of the deflector. This may cause the Lower Granite tailwater and resulting deflector pressures to remain high enough to partially counter the effects of the pool lowering.

4. Impact of Powerhouse Operations on Dissolved Gas Levels.

It appears discharges from combination powerhouse and spillway operations do not mix significantly within the first few miles of the dam. This may mean that any dilution effect (i.e., reductions in dissolved gas levels) caused by low dissolved gas levels from powerhouse discharges mixing with high dissolved gas levels generated by spill may be minimal over a sizable length of river. Thus, unless powerhouse discharges are a majority of the total river flow (as was the case for test 6B), there may be no real effect on reducing dissolved gas levels. Data showing dissolved gas level test values for different combinations of spill and powerhouse operations is shown for tests 2B, 6B, and 9C on Enclosure B-2, page 2 of 3. (Note: See the main drawdown report for additional discussion and supporting information related to combination spill and powerhouse operational tests.)

SECTION 6 **SUMMARY**

The following information summarizes the main hydraulic related drawdown observations and conclusions based on both hydraulic sectional model data in addition to actual drawdown test results:

A. Stilling Basin Related Conclusions.

1. Material from downstream of the stilling basin was brought back into the basin during normal spill conditions for spill levels in excess of about 60,000 cfs.

2. Under normal spill conditions, material already within the stilling basin remained relatively stable. However, as tailwater conditions dropped closer to the top of the spillway deflectors, there was an increasing amount of movement of the material. The movement of material can be explained by a greater tendency for water discharging over the spillway deflector at lower tailwater elevations to plunge rather than to skim across the surface.

3. Areas of the basin floor showed substantial surface erosion with widespread areas of exposed aggregate and pitting that were several inches deep. It is not known how much of the surface damage might have been covered by material prior to the test exposing these areas. It is believed, however, that some surface damage did occur during the testing. This judgment is based on the amount of material movement that was observed during the lower tailwater tests, on the size of the material found during diver inspections within the basin, and on the spillway hydraulic section model study that demonstrated substantial churning material movement during lower tailwater conditions.

4. Based on the preceding paragraphs, it is believed that it would be unacceptable to operate the spillway and stilling basin for an extended time under lowered tailwater conditions unless a method to keep rock material out of the basin is devised.

5. An important item was identified as result of the testing that is applicable to projects with deflectors installed on just a portion of the spillway (for example, Lower Monumental). Flow patterns created within these basins could be pulling material into the basin while at the same time causing a churning action of some of the materials that might be damaging the basin floors. Future analysis will be completed to explore this potential problem for other projects.

B. Adult Fishway Related Conclusions.

1. Flow Patterns in the Vicinity of the Adult Fishway Entrances.

Surface flow patterns observed in the vicinity of the main adult fishway entrances for all the tests with either no or two units operating appeared to be undesirable for adult fish passage. Some type of surface eddy was always apparent downstream of the powerhouse which would probably make it difficult for fish to locate the powerhouse and south shore related entrances. Very turbulent flow conditions with high velocities were also apparent at the fishway entrance located just north of the spillway.

2. Emergency Adult Fishway Exit System.

The emergency adult fishway exit system, operational down to forebay elevation 710, appeared to pass fish although flow conditions at the false weir appeared to be very turbulent. It might be possible to modify the flow conditions at the false weir if it is ultimately judged to be a serious concern.

C. Dissolved Gas Level Related Conclusions.

1. The higher the spill level, the higher the dissolved gas saturation amount.

2. A lowered forebay elevation during spillway operation, as compared to normal pool levels, did not reduce dissolved gas amounts. In addition, going to spillway freeflow conditions did not improve dissolved gas levels.

3. Dissolved gas saturation levels are minimally impacted by reduced tailwater elevations under lower spill discharge conditions (say at about 30,000 cfs).

4. Dissolved gas saturation levels are significantly impacted by reduced tailwater elevations under higher spill discharge conditions (say at about 100,000 cfs), once the tailwater elevation approaches or drops below the top of the deflector.

5. It appears that discharges from combination powerhouse and spillway operations do not mix significantly within the first few miles of the dam. This may mean that reductions in river dissolved gas levels caused by a dilution effect of powerhouse discharges on high dissolved gas levels generated by spill may be minimal over a sizable length of the river.

SECTION 7 FUTURE STUDIES

A. General.

Currently no hydraulic studies, besides the ongoing study using the Lower Granite general model to evaluate various drawdown alternatives, are being conducted to obtain additional insights into the stilling basin, adult fishway system, or dissolved gas related problems previously identified. However, depending on future actions related to the overall study to evaluate the reservoir drawdown options, several steps might be taken in the future to increase our knowledge of what was observed during the Lower Granite drawdown tests.

B. Potential Future Hydraulic Models that Might Improve Our Understanding of the Spillway and Stilling Basin.

Construction of a hydraulic sectional model of the spillway and stilling basin, or possibly even a general model, for either Little Goose or Lower Monumental Dam might be done at some point to evaluate other projects under reservoir drawdown conditions. Information from these models might offer additional insights related to both structural and operational questions that have been identified during the Lower Granite drawdown tests.

C. Potential Future Actions That Might Improve Our Understanding and Predictive Capabilities Related to Dissolved Gas Supersaturation.

A variety of actions have been discussed that might be used to increase our knowledge related to the dissolved gas supersaturation items previously discussed. It appears that we are presently a long way from developing a numerical model that would predict dissolved gas levels associated with the various drawdown alternatives. However, some steps that might be taken in the future include the following items:

1. Statistical Analysis of Existing Data. Complete a "broad-brushed" statistical analysis of existing dissolved gas and related project data to establish/discover relationships that might prove helpful in numerical modeling of the existing system.

2. Field Work. Work with WES to optimize future dissolved gas related data collection for both normal and possible special project operations. This might include using a methane gas sample analysis method to use as a tracer and to calculate oxygen related information.

3. <u>Hydraulic Models</u>.

(a) <u>Lower Granite Sectional Model</u>.

Use the sectional model (possibly in conjunction with the general model) to develop operational criteria to minimize dissolved gas levels for the existing system.

(b) <u>Lower Granite General Model</u>.

(1) Time how quickly dye deposited in the eddy areas disperse in order to estimate how soon downstream dissolved gas levels during the drawdown tests might have reached steady state conditions assuming that the spill levels could have been maintained.

(2) Use fluorescent dyes or tracer materials to evaluate the mixing effect of the eddies with flow from the spillway. This information would indicate, over the range of the model, how far downstream discharges from the spillway travel before becoming significantly intermixed with side flows from the eddies.

(3) Obtain hydraulic information for miscellaneous test conditions that could be used for data input for a numerical dissolved gas model.

4. <u>Investigation of Other Projects with Features Similar to the Lower Snake River Projects</u>. Evaluate other projects, in both the U.S. and worldwide, that are similar to potential operational or structural changes proposed for the Lower Snake River system. This might help in developing relationships that could be used for predicting dissolved gas levels.

5. <u>Numerical Models</u>.

(a) Based on what information can be found or developed from the previously discussed statistical analysis of historical data and on the drawdown field tests, possibly compute what dissolved gas levels in the tailrace area would be using dissolved gas levels measured in the forebay of the downstream dam.

(b) Using the data that can be judged applicable for a numerical model developed for normal project operations and using other applicable information from the hydraulic models and from other similar projects (if any), possibly develop a numerical model that would be capable of estimating dissolved gas levels for various operating and design conditions.

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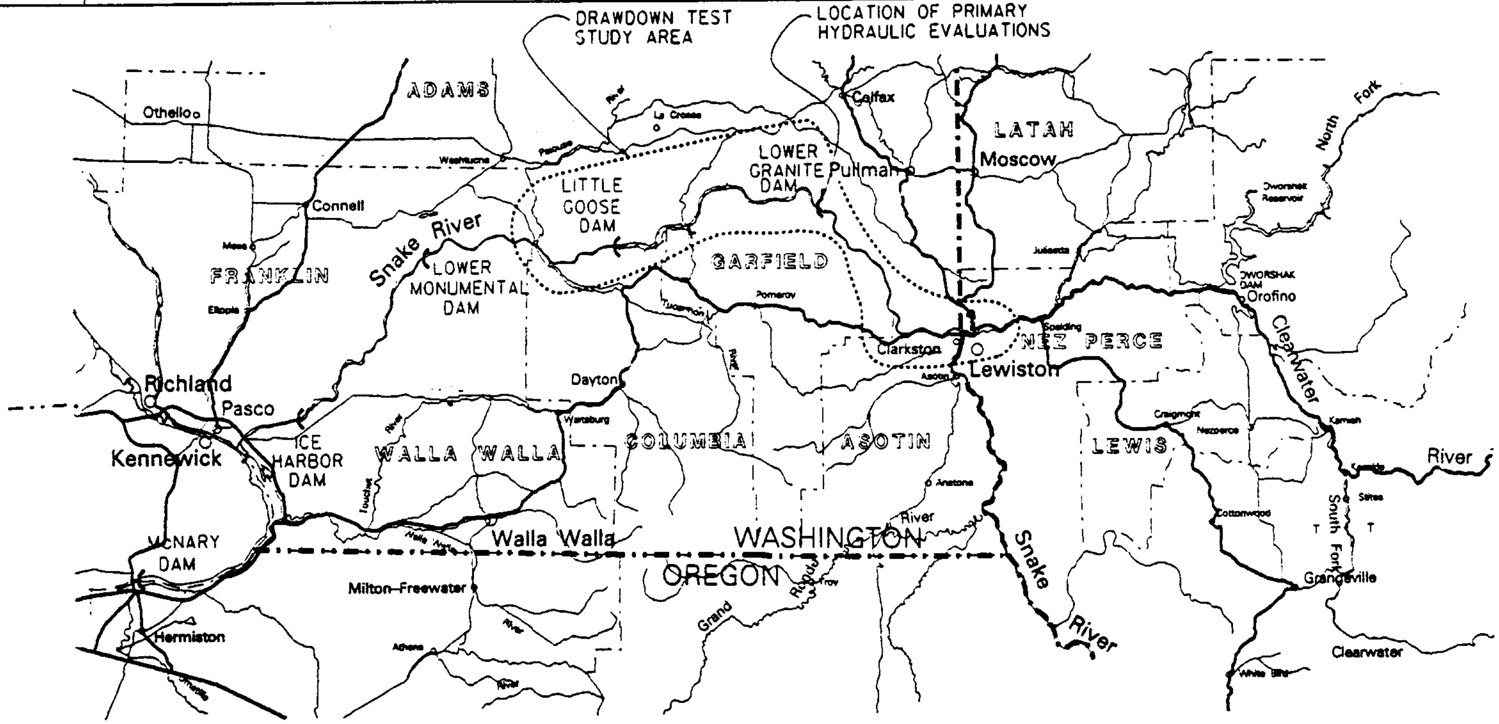
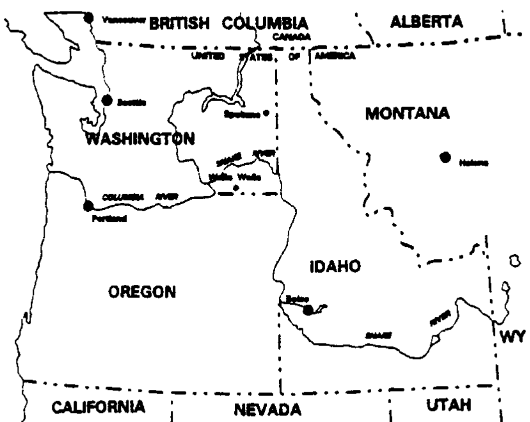


LOWER SNAKE RIVER AREA MAP



VICINITY MAP

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LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT

AREA AND VICINITY MAPS

LEIGH
LEIGH

SCALE AS SHOWN INV. NO.

ENCLOSURE A-1

VALUE ENGINEERING PAYS

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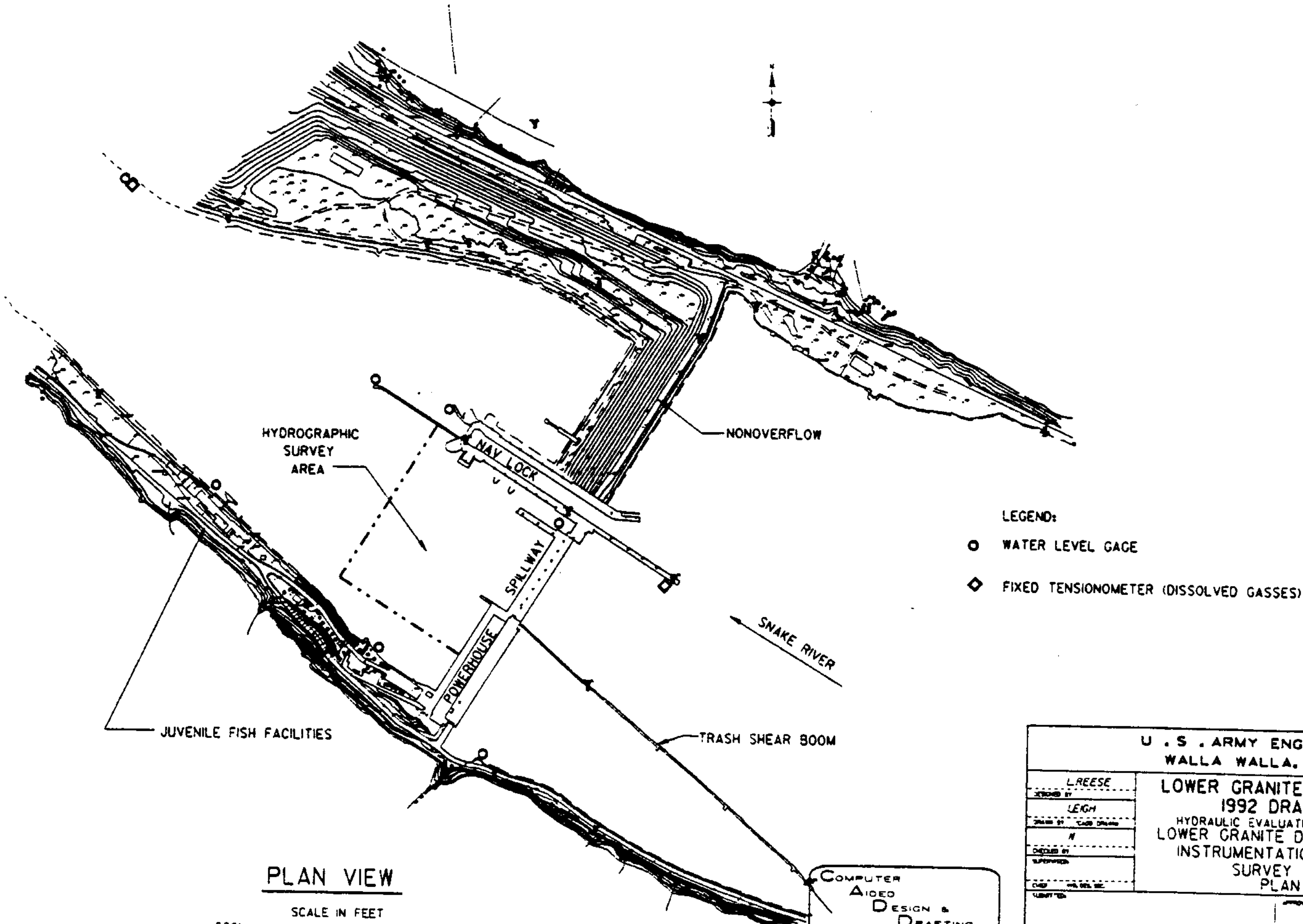

PLAN VIEW

SCALE IN FEET

600' 0 600'

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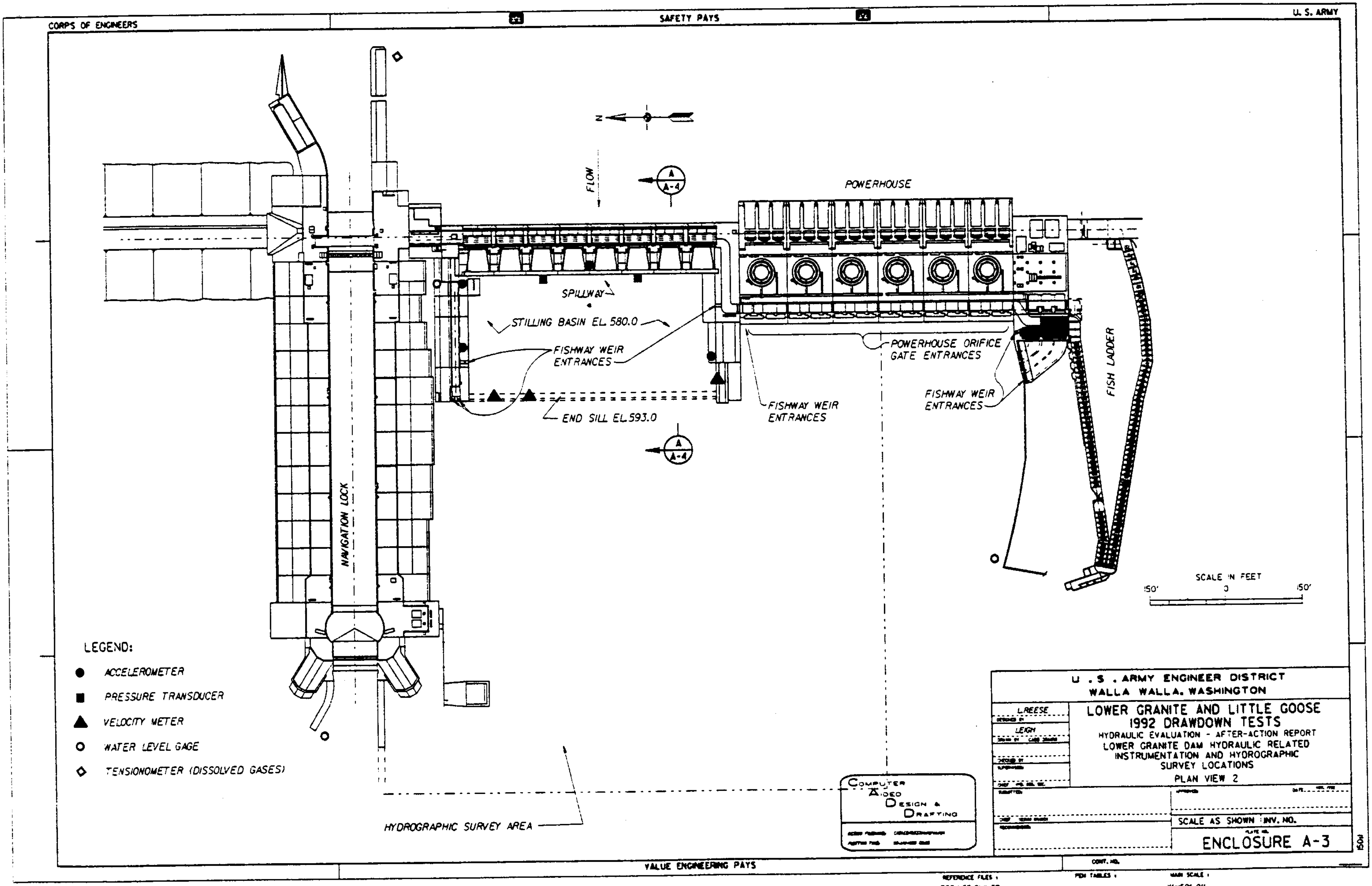
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
LOWER GRANITE DAM HYDRAULIC RELATED
INSTRUMENTATION AND HYDROGRAPHIC
SURVEY LOCATIONS
PLAN VIEW 1

SCALE AS SHOWN | INV. NO.

ENCLOSURE A-2

VALUE ENGINEERING PAYS

REFERENCE FILES : PEN TABLES : MAIN SCALE :



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INSTRUMENTATION AND HYDROGRAPHIC
SURVEY LOCATIONS
PLAN VIEW 2

SCALE AS SHOWN INV. NO.

ENCLOSURE A-3

REFERENCE FILES: SCS&LSO.BLK.TB
PEN TABLES: NO
MAIN SCALE: 1"=50'-0"

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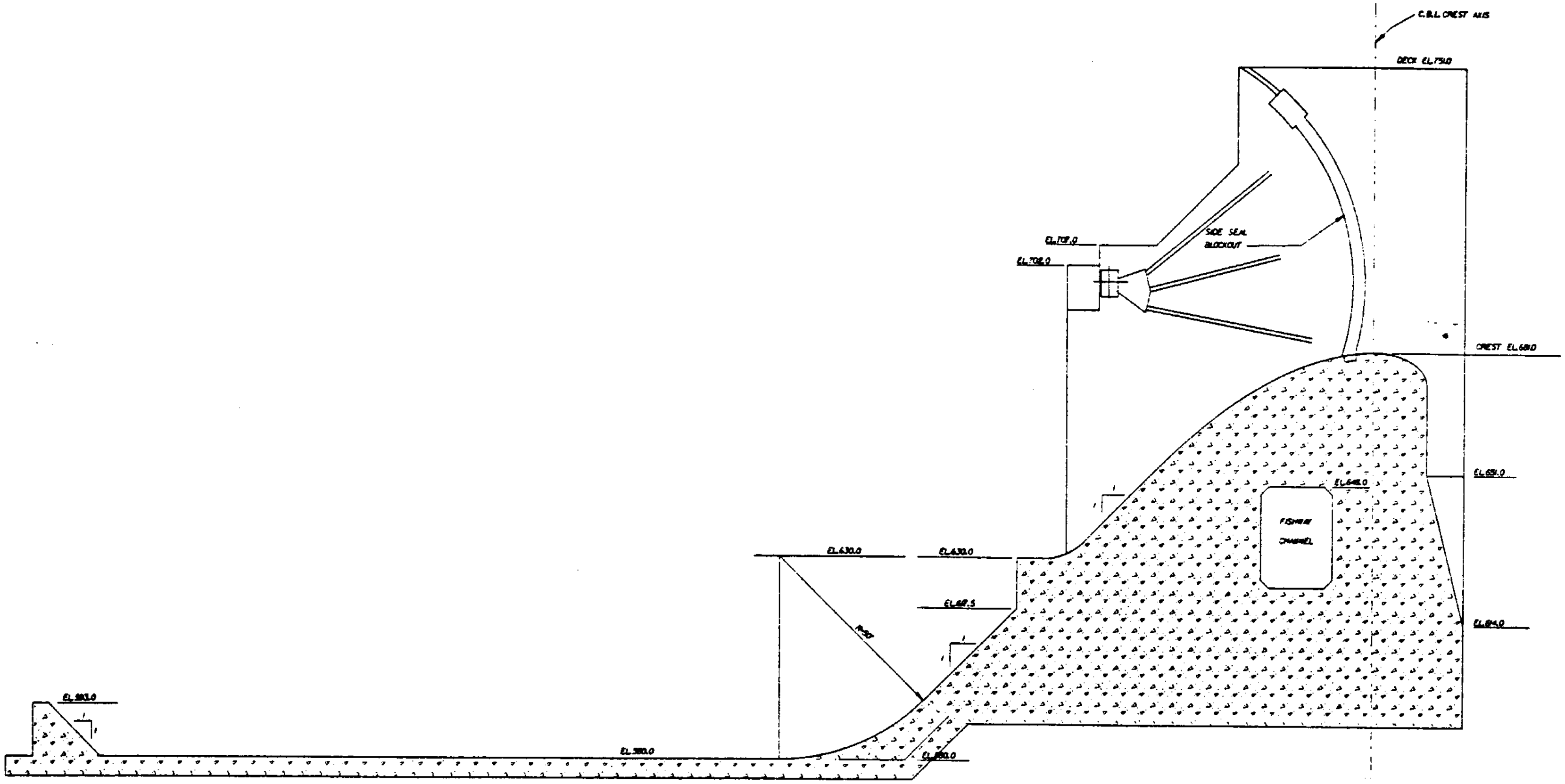

SECTION A / A-3

SCALE IN FEET

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LOWER GRANITE AND LITTLE GOOSE 1992 DRAWDOWN TESTS

HYDRAULIC EVALUATION - AFTER-ACTION REPORT

LOWER GRANITE DAM

SPILLWAY & STILLING BASIN PROFILE

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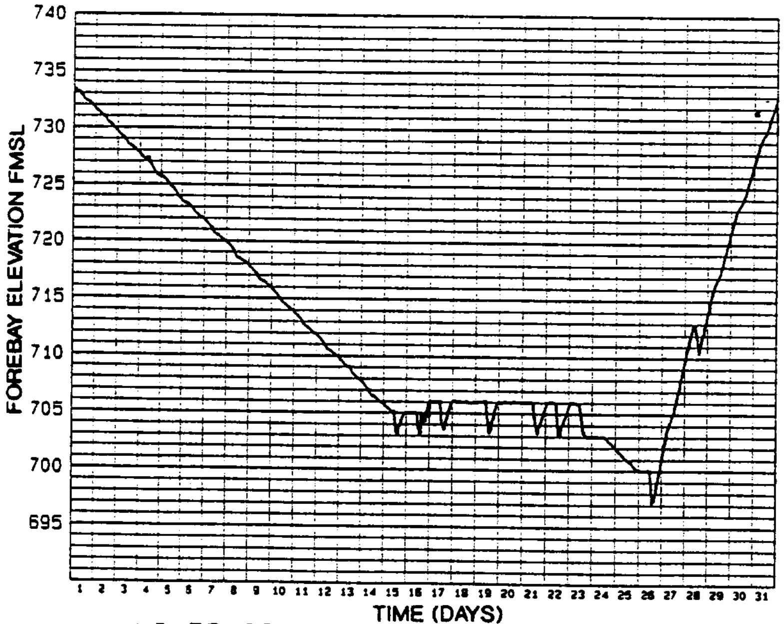
ENCLOSURE A-4

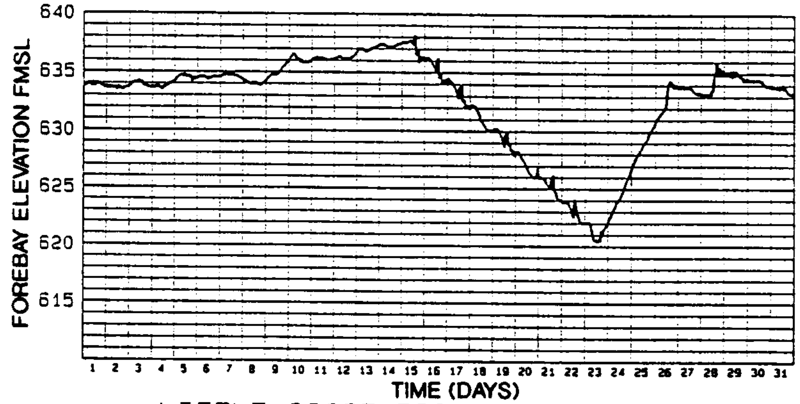
VALUE ENGINEERING PAYS

CONT. NO.

REFERENCE FILES : PEN TABLES : MAIN SCALE :



LOWER GRANITE POOL - MARCH 1992



LITTLE GOOSE POOL - MARCH 1992

NOTE:

1. "FMSL" MEANS "FEET MEAN SEA LEVEL."

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LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT

PROJECT FOREBAY ELEVATION VERSUS TIME

MARCH 1992

NOV. 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE B-1

LOWER GRANITE AND LITTLE GOOSE 1992 DRAWDOWN TESTS-HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Test Summary Data - Project Discharge, Reservoir Elevations, and Dissolved Gases

Table 1 of 2

DATE	TEST #	Main Project Release			Reservoir Elevations		Dissolved Gas Levels (%) *4
		Powerhouse (kcfs)	Spill (kcfs) *1	Total (kcfs)	Forebay (fmsl) *2	Tailwater (fmsl) *3	
15 Mar 92	1A	0.0	28.5	28.5	705.1	637.3	115.1
15 Mar 92	1B	0.0	106.5	106.5	704.4	638.9	126.5
16 Mar 92	2A	0.0	28.5	28.5	705.0	635.0	115.0
16 Mar 92	2B	23.0	81.4	104.4	704.0	637.2	124.9
17 Mar 92	3A	0.0	35.2	35.2	706.0	633.3	118.3
17 Mar 92	3B	0.0	106.8	106.8	704.5	635.4	127.0
19 Mar 92	4A	0.0	35.2	35.2	706.0	629.2	118.1
19 Mar 92	4B	0.0	106.7	106.7	704.6	632.4	127.9
21 Mar 92	5A	0.0	29.0	29.0	706.0	625.6	113.9
21 Mar 92	5B	0.0	106.7	106.7	704.5	630.4	130.3
22 Mar 92	6A	0.0	29.0	29.0	706.0	624.0	114.1
22 Mar 92	6B	84.0	23.3	107.3	704.5	630.7	111.3
23 Mar 92	7A	0.0	27.8	27.8	706.0	622.3	113.4
23 Mar 92	7B	0.0	65.6	65.6	704.9	626.2	119.4
23 Mar 92	7C	0.0	103.6	103.6	703.4	628.3	132.4
26 Mar 92	8A	0.0	26.3	26.3	700.0	631.7	113.4
26 Mar 92	8B	0.0	100.0	100.0	698.5	634.9	128.1
28 Mar 92	9A	0.0	27.2	27.2	712.9	633.3	114.7
28 Mar 92	9B	0.0	65.5	65.5	712.4	634.6	122.5
28 Mar 92	9C	24.1	53.4	77.5	711.1	635.4	121.3

ABBREVIATIONS:

kcfs = thousands of cubic feet per second
fmsl = feet mean sea level

* Notes on page 3 of 3

Lower Granite Spill Test Summary Data-
Project Discharge, Reservoir Water Levels, Dissolved Gases
(Table 2 of 2)

Test #	Reservoir Elevations			Dissolved Gas Levels (%) *4
	Spill (kcfs) *1	Forebay (fmsl) *2	TW (fmsl) *3	
Low (Inflow) Spill Tests:				
1A	28.5	705.1	637.3	115.1
2A	28.5	705.0	635.0	115.0
3A	35.2	706.0	633.3	118.3
4A	35.2	706.0	629.2	118.1
5A	29.0	706.0	625.6	113.9
6A	29.0	706.0	624.0	114.1
7A	27.8	706.0	622.3	113.4
8A	26.3	700.0	631.7	113.4
9A	27.2	712.9	633.3	114.7
Medium Spill Tests:				
7B	65.6	704.9	626.2	119.4
9B	65.5	712.4	634.6	122.5
High Spill Tests:				
1B	106.5	704.4	638.9	126.5
3B	106.8	704.5	635.4	127.0
4B	106.7	704.6	632.4	127.9
5B	106.7	704.5	630.4	130.3
7C	103.6	703.4	628.3	132.4
8B	100.0	698.5	634.9	128.1
Combination Spill and Powerhouse Tests:				
2B	81.4	704.0	637.2	124.9
6B	23.3	704.5	630.7	111.3
9C	53.4	711.1	635.4	121.3

Abbreviations:
Kcfs = thousands of cubic feet per second
fmsl = feet mean sea level

*Notes on page 3 of 3

NOTES

1. Spill values are computed based on average forebay elevations during the tests.

2. Forebay elevations are the average values for the tests.

3. Tailwater elevations are average values, excluding sharp rises and drops during transition phases of tests, of several key tailwater gages located in the tailrace area.

4. Dissolved gas level values were measurements taken at a depth of approximately 10 to 15 feet roughly in the center of the river at a location about one-half mile downstream of the dam. Values are considered representative averages over the testing period. (These values were within about 3 percent of peak surface and deep dissolved gas measurements obtained during the tests).

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 1A (Test 1 of 2 - 28.5 Kcfs Natural Flow Spill Test)

DATE AND TIME PERIOD OF TEST: 15 March 92 (0900 to 1115 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	28.3	28.1	28.2
. Project Releases:	28.5	28.5	28.5
. Spillway Flows:	28.5	28.5	28.5
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	705.0
- Elevation at End of Test:	705.1
- Average Elevation:	705.1

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	637.1	636.1	636.7
- Fish Loading Facility	637.7	636.8	637.3
- Downstream on Right Bank	637.6	636.8	637.8
- Downstream Guide Wall	637.7	636.9	637.3
- Curved Guide Wall	637.8	636.2	637.3
- Behind Right Training Wall	637.4	635.6	636.4

COMMENTS:
- All spillway gates set to 3 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 1B (Test 2 of 2 - 106.5 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 15 March 92 (1115 to 1315 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	28.3	28.1	28.2
. Project Releases:	108.6	102.4	106.5
. Spillway Flows:	108.6	102.4	105.5
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	705.1
- Elevation at End of Test:	703.0
- Average Elevation:	704.4

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	638.0	636.8	637.4
- Fish Loading Facility	640.0	637.9	639.0
- Downstream on Right Bank	639.6	637.9	638.7
- Downstream Guide Wall	639.8	637.9	638.9
- Curved Guide Wall	639.7	638.4	639.0
- Behind Right Training Wall	638.1	635.0	636.6

COMMENTS:
- All spillway gates set to 12 stops.

- Abbreviations:
Kcfs = thousands of cubic feet per second
fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 2A (Test 1 of 2 - 28.5 Kcfs Natural Flow Spill Test)

DATE AND TIME PERIOD OF TÉST: 16 March 92 (0900 to 1115 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	29.0	29.1	29.0
. Project Releases:	28.5	28.5	28.5
. Spillway Flows:	28.5	28.5	28.5
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	705.0
- Elevation at End of Test:	705.0
- Average Elevation:	705.0

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	635.2	634.1	634.4
- Fish Loading Facility	635.4	634.6	634.9
- Downstream on Right Bank	635.5	634.8	635.0
- Downstream Guide Wall	635.7	634.1	635.1
- Curved Guide Wall	635.8	635.0	635.2
- Behind Right Training Wall	635.6	633.4	633.8

COMMENTS:
- All spillway gates set to 3 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 2B (Test 2 of 2 - Combination 23.0 Kcfs Powerhouse & 81.4 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 16 March 92 (1100 to 1250 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	29.1	29.2	29.1
. Project Releases:	106.4	102.3	104.4
. Spillway Flows:	83.4	79.3	81.4
. Powerhouse Flows:	23.0	23.0	23.0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	705.0
- Elevation at End of Test:	703.0
- Average Elevation:	704.0

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	636.6	634.2	636.4
- Fish Loading Facility	637.8	636.9	637.3
- Downstream on Right Bank	637.5	636.5	637.0
- Downstream Guide Wall	637.6	636.8	637.2
- Curved Guide Wall	637.7	635.3	637.3
- Behind Right Training Wall	636.5	633.9	635.0

COMMENTS:
- Units 1 and 2 operating
- All spillway gates set to 9 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

Lower Granite Spill Tests- Discharge and Reservoir Elevation Variations

TEST NUMBER: 3A (Test 1 of 2 - 35.2 Kcfs Natural Flow Spill Test)

DATE AND TIME PERIOD OF TEST: 17 March 92 (0900 to 1100 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	35.4	34.5	35.0
. Project Releases:	35.2	35.2	35.2
. Spillway Flows:	35.2	35.2	35.2
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	706.0
- Elevation at End of Test:	706.1
- Average Elevation:	706.0

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	633.0	632.3	632.6
- Fish Loading Facility	633.7	632.5	633.0
- Downstream on Right Bank	634.0	633.1	633.5
- Downstream Guide Wall	633.9	633.0	633.3
- Curved Guide Wall	633.9	632.9	633.2
- Behind Right Training Wall	633.0	630.9	631.5

COMMENTS:
- Three southern most spillway gates set to 3 stops.
- Five northern most spillway gates set to 4 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 3B (Test 2 of 2 - 106.8 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 17 March 92 (1100 to 1352 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	33.7	31.6	32.7
. Project Releases:	111.1	102.4	106.8
. Spillway Flows:	111.1	102.4	106.8
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test: 706.1
- Elevation at End of Test: 703.0
- Average Elevation: 704.5

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	634.3	632.3	633.9
- Fish Loading Facility	636.2	634.7	635.5
- Downstream on Right Bank	636.1	634.9	635.5
- Downstream Guide Wall	636.0	634.4	635.3
- Curved Guide Wall	635.9	633.0	635.1
- Behind Right Training Wall	636.3	631.0	634.1

COMMENTS:
- All spillway gates set to 12 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

Lower Granite Spill Tests- Discharge and Reservoir Elevation Variations

TEST NUMBER: 4A (Test 1 of 2 - 35.2 Kcfs Natural Flow Spill Test)

DATE AND TIME PERIOD OF TEST: 19 March 92 (0900 to 1100 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	35.4	35.4	35.4
. Project Releases:	35.2	35.2	35.2
. Spillway Flows:	35.2	35.2	35.2
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	706.0
- Elevation at End of Test:	706.1
- Average Elevation:	706.0

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	629.94	628.12	629.0
- Fish Loading Facility	629.7	628.9	629.2
- Downstream on Right Bank	629.7	628.9	629.3
- Downstream Guide Wall	629.6	628.9	629.2
- Curved Guide Wall	629.5	628.8	629.1
- Behind Right Training Wall	629.3	626.7	627.7

COMMENTS:
- Three southern most spillway gates set to 3 stops.
- Five northern most spillway gates set to 5 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 4B (Test 2 of 2 - 106.7 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 19 March 92 (1100 to 1353 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	35.5	35.3	35.4
. Project Releases:	111.4	102.4	106.7
. Spillway Flows:	111.4	102.4	106.7
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test: 706.1
- Elevation at End of Test: 703.0
- Average Elevation: 704.6

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	631.6	628.1	631.3
- Fish Loading Facility	633.3	631.7	632.6
- Downstream on Right Bank	632.7	631.6	632.2
- Downstream Guide Wall	632.7	631.9	632.3
- Curved Guide Wall	632.8	628.8	632.0
- Behind Right Training Wall	634.1	626.7	631.7

COMMENTS:
- All spillway gates set to 12 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

Lower Granite Spill Tests- Discharge and Reservoir Elevation Variations

TEST NUMBER: 5A (Test 1 of 2 - 29.0 Kcfs Natural Flow Spill Test)

DATE AND TIME PERIOD OF TEST: 21 March 92 (0900 to 1100 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	28.9	28.8	28.9
. Project Releases:	29.0	29.0	29.0
. Spillway Flows:	29.0	29.0	29.0
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	706.0
- Elevation at End of Test:	706.0
- Average Elevation:	706.0

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	625.7	624.6	625.1
- Fish Loading Facility	625.9	625.0	625.5
- Downstream on Right Bank	625.8	625.0	625.6
- Downstream Guide Wall	625.8	625.0	625.6
- Curved Guide Wall	625.7	624.8	625.4
- Behind Right Training Wall	625.4	623.4	624.1

COMMENTS:
- All spillway gates set to 3 stops

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 5B (Test 2 of 2 - 106.7 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 21 March 92 (1100 to 1343 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	28.8	28.7	28.8
. Project Releases:	111.1	102.4	106.7
. Spillway Flows:	111.1	102.4	106.7
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	706.0
- Elevation at End of Test:	703.0
- Average Elevation:	704.5

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	630.0	624.6	629.8
- Fish Loading Facility	631.1	629.7	630.6
- Downstream on Right Bank	630.6	629.1	630.1
- Downstream Guide Wall	630.9	629.9	630.5
- Curved Guide Wall	630.9	625.2	630.0
- Behind Right Training Wall	632.2	623.4	630.0

COMMENTS:
- All spillway gates set to 12 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 6A (Test 1 of 2 - 29.0 Kcfs Natural Flow Spill Test)

DATE AND TIME PERIOD OF TEST: 22 March 92 (0900 to 1100 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	28.0	28.0	28.0
. Project Releases:	29.0	29.0	29.0
. Spillway Flows:	29.0	29.0	29.0
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	706.0
- Elevation at End of Test:	705.9
- Average Elevation:	706.0

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	624.0	623.1	623.6
- Fish Loading Facility	624.4	623.8	624.0
- Downstream on Right Bank		NO DATA	
- Downstream Guide Wall	624.3	623.8	624.0
- Curved Guide Wall	624.2	623.6	623.9
- Behind Right Training Wall	624.4	622.7	622.9

COMMENTS:
- All spillway gates set to 3 stops

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 6B (Test 2 of 2 - Combination 84.0 Kcfs Powerhouse and 23.3 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 22 March 92 (1100 to 1310 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	28.0	27.8	27.9
. Project Releases:	108.0	106.6	107.3
. Spillway Flows:	24.0	22.6	23.3
. Powerhouse Flows:	84.0	84.0	84.0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	705.9
- Elevation at End of Test:	703.0
- Average Elevation:	704.5

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	631.5	623.1	631.0
- Fish Loading Facility		NO DATA	
- Downstream on Right Bank	630.8	630.0	630.6
- Downstream Guide Wall	631.2	630.0	630.8
- Curved Guide Wall	631.1	624.0	630.0
- Behind Right Training Wall	631.6	623.2	630.4

COMMENTS:
- Two outside spillway gates (four total) set to 2 stops.
- Four interior spillway gates (four total) set to 3 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 7A (Test 1 of 3 - 27.8 Kcfs Natural Spill Test)

DATE AND TIME PERIOD OF TEST: 23 March 92 (0900 to 1100 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	27.2	27.2	27.2
. Project Releases:	27.8	27.8	27.8
. Spillway Flows:	27.8	27.8	27.8
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	706.0
- Elevation at End of Test:	706.0
- Average Elevation:	706.0

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	622.6	621.3	622.2
- Fish Loading Facility	622.6	621.6	622.1
- Downstream on Right Bank	622.6	621.6	622.3
- Downstream Guide Wall	622.9	622.0	622.5
- Curved Guide Wall	622.8	621.7	622.3
- Behind Right Training Wall		NO DATA	

COMMENTS:
- Northern most spillway gate (1 gate) set at 2 stops.
- All other spillway gates (7 gates) set at 3 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 7B (Test 2 of 3 - 65.6 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 23 March 92 (1100 to 1450 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	27.4	27.1	27.2
. Project Releases:	67.3	63.9	65.6
. Spillway Flows:	67.3	63.9	65.6
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	706.0
- Elevation at End of Test:	703.8
- Average Elevation:	704.9

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	625.5	621.8	625.3
- Fish Loading Facility	626.7	625.9	626.4
- Downstream on Right Bank	626.5	625.8	626.0
- Downstream Guide Wall	626.5	626.0	626.3
- Curved Guide Wall	626.4	622.2	625.8
- Behind Right Training Wall	628.0	622.7	625.0

COMMENTS:
- All spillway gates set to 7 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 7C (Test 3 of 3 - 103.6 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 23 March 92 (1450 to 1518 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	28.1	28.1	28.1
. Project Releases:	104.7	102.4	103.6
. Spillway Flows:	104.7	102.4	103.6
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	703.8
- Elevation at End of Test:	703.0
- Average Elevation:	703.4

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	628.9	625.3	628.2
- Fish Loading Facility	629.0	628.1	628.6
- Downstream on Right Bank	628.3	627.6	628.0
- Downstream Guide Wall	628.7	628.0	628.4
- Curved Guide Wall	628.6	626.0	627.7
- Behind Right Training Wall	630.4	624.9	628.2

COMMENTS:
- All spillway gates set to 12 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests- Discharge and Reservoir Elevation Variations

TEST NUMBER: 8A (Test 1 of 2 - 26.3 Kcfs Natural Flow Spill Test)

DATE AND TIME PERIOD OF TEST: 26 March 92 (0900 to 1100 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	26.2	26.2	26.2
. Project Releases:	26.4	26.3	26.3
. Spillway Flows:	26.4	26.4	26.3
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	700.0
- Elevation at End of Test:	700.1
- Average Elevation:	700.0

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	631.5	631.1	631.3
- Fish Loading Facility	631.9	631.2	631.7
- Downstream on Right Bank	631.9	631.4	631.7
- Downstream Guide Wall	632.0	631.4	631.7
- Curved Guide Wall	632.1	631.6	631.9
- Behind Right Training Wall	631.4	630.0	630.5

COMMENTS:
- Fourth spillway gate from north set to 4 stops.
- All other spillway gates (7 gates) set to 3 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 8B (Test 2 of 2 - 100.0 Kcfs Spillway Freeflow Test)

DATE AND TIME PERIOD OF TEST: 26 March 92 (1100 to 1337 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	26.2	26.2	26.2
. Project Releases:	114.4	87.2	100.0
. Spillway Flows:	114.4	87.2	100.0
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	700.1
- Elevation at End of Test:	697.0
- Average Elevation:	698.5

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	634.0	631.1	633.7
- Fish Loading Facility	635.7	634.8	635.2
- Downstream on Right Bank	635.3	633.9	634.7
- Downstream Guide Wall	635.4	634.1	634.8
- Curved Guide Wall	635.6	632.0	634.7
- Behind Right Training Wall	635.8	630.4	633.6

COMMENTS:
- All spillway gates set to 15 stops (Freeflow).

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 9A (Test 1 of 3 - 27.2 Kcfs Natural Spill Test)

DATE AND TIME PERIOD OF TEST: 28 March 92 (0900 to 1100 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	26	26	26
. Project Releases:	27.2	27.2	27.2
. Spillway Flows:	27.2	27.2	27.2
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	712.9
- Elevation at End of Test:	712.9
- Average Elevation:	712.9

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	632.9	632.2	632.5
- Fish Loading Facility	634.0	632.8	633.3
- Downstream on Right Bank		NO DATA	
- Downstream Guide Wall	633.8	632.8	633.2
- Curved Guide Wall		NO DATA	
- Behind Right Training Wall		NO DATA	

COMMENTS:
- Two outside spillway gates (four total) set to 2 stops.
- four interior spillway gates (four total) set to 3 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 9B (Test 2 of 3 - 65.5 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 28 March 92 (1100 to 1300 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	27	26	26.5
. Project Releases:	66.1	64.9	65.5
. Spillway Flows:	66.1	64.9	65.5
. Powerhouse Flows:	0	0	0

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	712.9
- Elevation at End of Test:	711.8
- Average Elevation:	712.4

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	633.6	632.2	633.3
- Fish Loading Facility	635.2	632.9	634.5
- Downstream on Right Bank		NO DATA	
- Downstream Guide Wall	635.2	633.7	634.6
- Curved Guide Wall		NO DATA	
- Behind Right Training Wall		NO DATA	

COMMENTS:
- All spillway gates set to 6 stops.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE/LITTLE GOOSE 1992 DRAWDOWN TEST
HYDRAULIC EVALUATION: AFTER-ACTION REPORT

Lower Granite Spill Tests-
Discharge and Reservoir Elevation Variations

TEST NUMBER: 9C (Test 3 of 3 - Combination 24.1 Kcfs Powerhouse and 53.4 Kcfs Spill Test)

DATE AND TIME PERIOD OF TEST: 28 March 92 (1300 to 1500 hrs)

PROJECT DISCHARGES (kcfs):	Maximum	Minimum	Average
- Total River Discharge:	27	27	27
. Project Releases:	78.2	76.9	77.5
. Spillway Flows:	54.1	52.8	53.4
. Powerhouse Flows:	24.1	24.1	24.1

LOWER GRANITE FOREBAY ELEVATION (FMSL):
(Project Gage)

- Elevation at Start of Test:	711.8
- Elevation at End of Test:	710.4
- Average Elevation:	711.1

LOWER GRANITE TAILWATER ELEVATIONS(FMSL):	Maximum	Minimum	Average
- South Shore Project Gage (Short Distance Downstream of Powerhouse)	634.9	633.6	634.4
- Fish Loading Facility	636.0	634.4	635.1
- Downstream on Right Bank		NO DATA	
- Downstream Guide Wall	636.0	635.1	635.6
- Curved Guide Wall		NO DATA	
- Behind Right Training Wall		NO DATA	

COMMENTS:
- All spillway gates set to 5 stops.
- Units 1 and 2 operating.

- Abbreviations:
  Kcfs = thousands of cubic feet per second
  fmsl = feet mean sea level

LOWER GRANITE AND LITTLE GOOSE 1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION: AFTER-ACTION REPORT
Pressure Measurements on Spillway Deflectors (Flip-Lip) During Spill Tests

Date	Test	Spill Levels (Kcfs)	Gage Pressure Prior to Test (fmsl)	Gage Name	Deflector (Flip-Lip) Pressures [fmsl] Average	Minimum	Maximum	Peak to Peak
15 Mar 92	1A	0 to 28.5	637.40	FL3T	636.90	636.39	637.43	1.04
				FL3B	637.13	636.52	637.71	1.19
				FL6T	----	----	----	--
				FL6B	636.80	635.96	637.72	1.77
19 Mar 92	4A	0 to 35.2	629.75	FL6T	----	625.17	630.21	5.04
				FL6B	----	624.59	630.17	5.58
	4A	35.2		FL6T	626.74	624.80	628.43	3.63
				FL6B	626.77	625.09	628.29	3.20
	4A	35.2		FL6T	626.49	625.17	627.69	2.52
				FL6B	626.46	624.71	627.60	2.89
	4B	35.2 to 106.7		FL6T	625.50	621.54	630.21	8.67
				FL6B	625.35	620.01	630.17	10.16
	4B	106.7		FL6T	625.42	618.50	630.13	11.63
				FL6B	624.69	615.62	630.04	14.42
	4B	106.7		FL6T	625.38	617.98	628.95	10.97
				FL6B	625.56	616.18	629.86	13.68

Notes:

1. Pressure transducers were located on the vertical portions of the deflectors at the centerline of bay 3 (FL3T and FL3B) and bay 6 (FL6T and FL6B). The "T" and "B" designation on the gage name indicate "Top Gage" and "Bottom Gage". See Enclosures A-2 and B-3 for site locations of gages.

2. The abbreviation "Kcfs" means "thousands of cubic feet per second."

3. The abbreviation "fmsl" means "feet mean sea level."

Date	Test	Spill Levels (Kcfs)	Gage Pressure Prior to Test (fmsl)	Gage Name	Deflector (Flip-Lip) Pressures [fmsl] Average	Minimum	Maximum	Peak to Peak
21 Mar 92	5A	0 to 29.0	626.50	FL3T	626.41	625.80	627.34	1.54
				FL6T	626.39	625.71	627.33	1.62
	5B	29.0 to 106.7		FL3T	625.63	623.83	629.24	5.40
				FL6T	625.43	622.17	628.81	6.64
	5B	106.7		FL3T	624.91	619.06	629.73	10.66
				FL6T	623.90	619.95	628.14	8.19
	5B	106.7		FL3T	624.70	618.57	629.10	10.52
				FL6T	628.50	619.51	628.29	8.78
	5B	106.7 to 0		FL3T	625.75	619.84	629.03	9.19
				FL6T	624.89	619.88	628.01	8.13
22 Mar 92	6A	29.0	626.50	FL3T	626.16	625.75	626.87	1.12
				FL6T	626.00	625.26	627.10	1.84
	6B	29.0 to 23.3		FL3T	626.12	624.84	626.94	2.10
				FL6T	625.91	624.01	628.05	4.05
	6B	23.3		FL3T	628.92	625.82	629.95	4.13
				FL6T	629.07	625.48	629.89	4.41

Date	Test	Spill Levels (Kcfs)	Gage Pressure Prior to Test (fmsl)	Gage Name	Deflector (Flip-Lip) Pressures [fmsl] Average	Minimum	Maximum	Peak to Peak
23 Mar 92	7A	27.8	626.50	FL3T	626.31	625.53	627.31	1.78
				FL6T	626.22	624.17	628.51	4.34
	7B	65.6		FL3T	625.80	624.12	627.31	3.19
				FL6T	625.27	621.59	629.99	8.39
	7C	103.6		FL3T	624.60	621.41	627.25	5.83
				FL6T	624.17	621.00	626.50	5.50
26 Mar 92	8A	26.3	631.66	FL3T	629.35	627.74	630.50	2.76
				FL6T	629.98	629.15	630.64	1.48
	8B	26.3 to 114.4 (Start of Freeflow)		FL3T	629.31	625.72	631.97	6.26
				FL6T	629.42	626.78	632.12	5.34
	8B	114.4 to 102.4 (Free Flow)		FL3T	629.05	625.53	631.11	5.58
				FL6T	628.05	624.26	629.97	5.71
	8B	102.4 to 90.4		FL3T	629.32	627.07	630.87	3.80
				FL6T	627.97	622.18	631.08	8.90

Material Volume Changes Measured Within the Lower Granite Stilling Basin Between Spill Tests (See Notes 1 and 2)

Date of Hydrographic Survey	Total Volume of Measured Material (cubic yards)	Volume Change from Previous Hydrographic Survey (cubic yards)	Comments
28 Feb	1,182	--------	----------
14 Mar	70	-1112	See note 3
15 Mar	281	+ 211	----------
17 Mar	329	+ 48	----------
19 Mar	322	- 7	See note 4
21 Mar	267	- 55	----------
22 Mar	122	- 145	----------
24 Mar	243	+ 121	See note 5
26 Mar	294	+ 51	----------
1 Apr	363	+ 69	----------

NOTES:

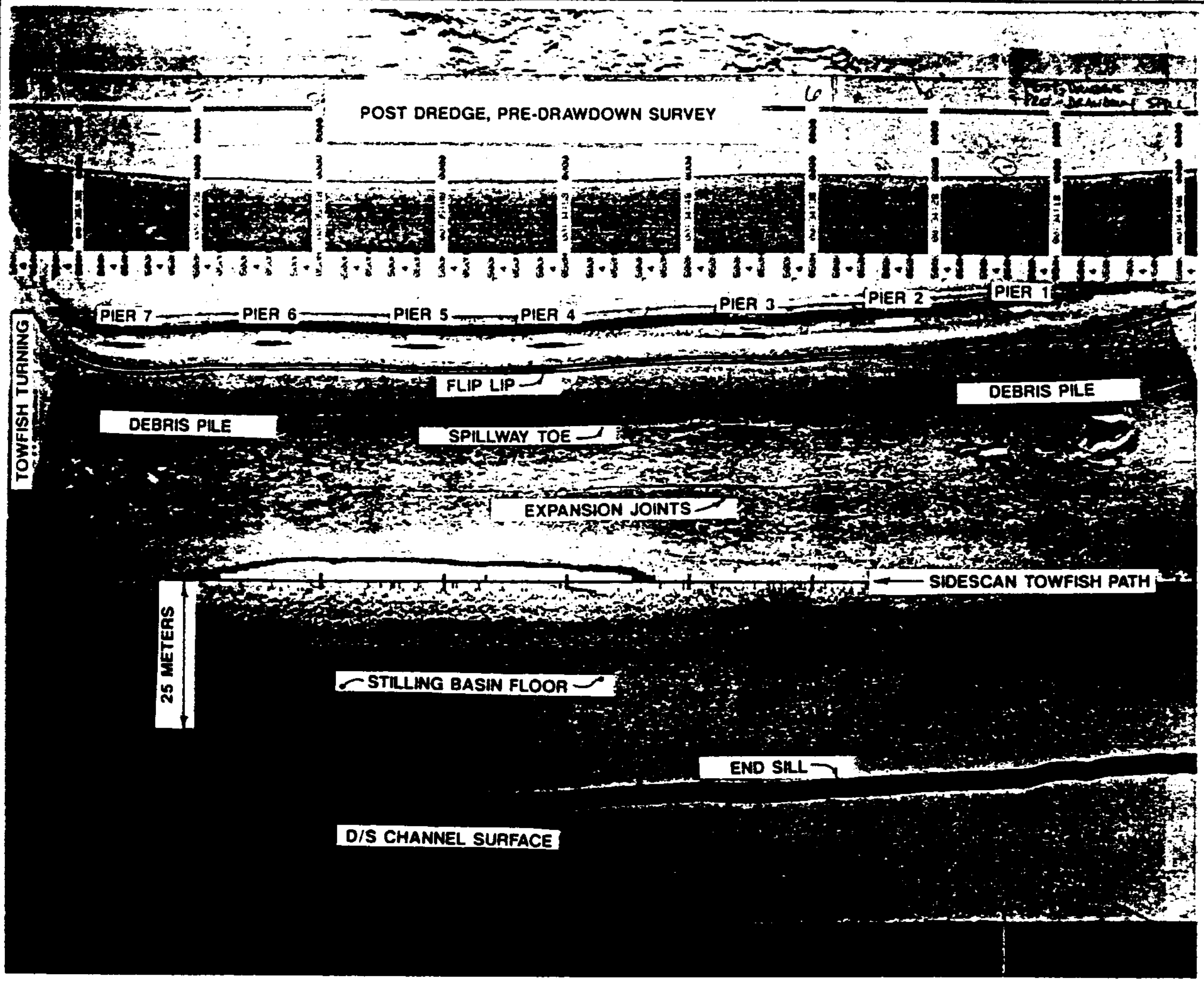
1. See Enclosures C-6 through C-15 for material thickness contour information relating to the hydrographic surveys. Data was collected after completion of the corresponding spill test.

2. Volumes of material indicates what was computed based on the debris piles shown on Enclosures C-6 through C-15. Additional material may have been within the basin in smaller debris piled located throughout the basin.

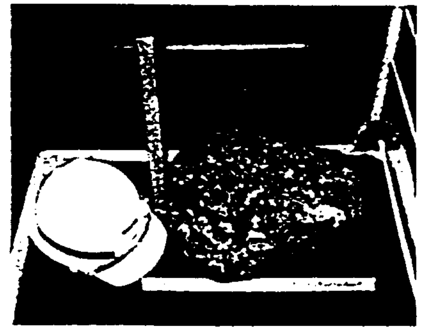
3. Stilling basin dredged between 28 February and 14 March.

4. Tailwater elevation dropped below the top of the spillway deflector between 17 and 19 March.

5. Tailwater elevation raised above the top of the spillway deflector between 23 and 26 March.



LOWER GRANITE STILLING BASIN SIDE SCAN RECORD



PICTURE OF ROCK MATERIAL REMOVED FROM LOWER GRANITE STILLING BASIN ON 6 FEBRUARY 1992

NOTES:

1. EXAMPLE SHOWN WAS TAKEN ON 14 MARCH 1992 AFTER MATERIAL PILES WITHIN THE BASIN HAD BEEN DREDGED. THIS RECORD WAS TAKEN ONE DAY PRIOR TO THE START OF THE DRAWDOWN RELATED SPILL TESTS.

COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH

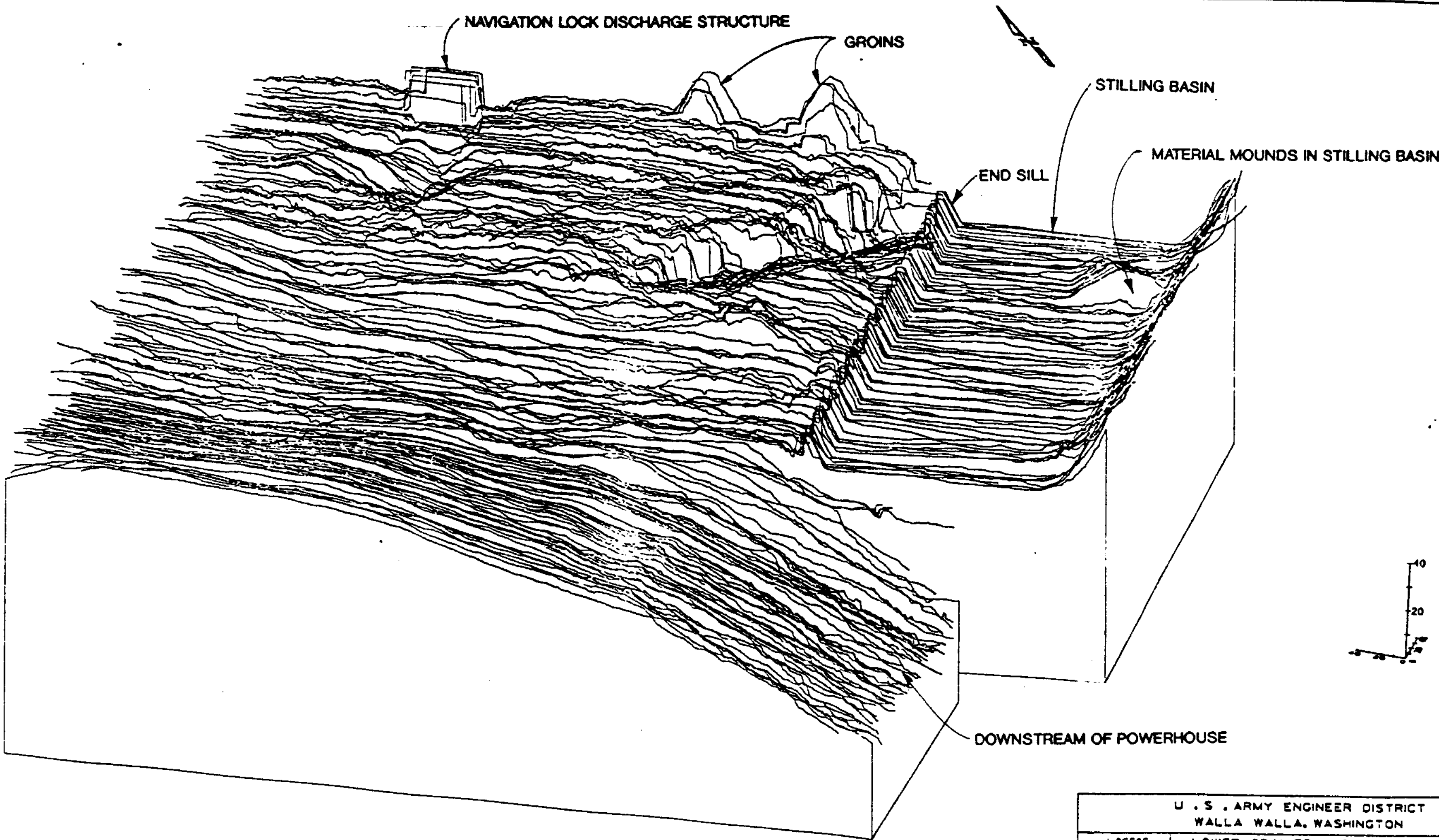
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TYPICAL STILLING BASIN SIDE SCAN RECORD AND ROCK SAMPLE PHOTO

NOV. 1992

SCALE AS SHOWN INV. NO.

ENCLOSURE C-1

CORPS OF ENGINEERS — SAFETY PAYS — U. S. ARMY



NOTES:

1. DATA PROVIDED BY DAVID EVANS AND ASSOCIATES, INC.
   2828 S.W. CORBIT AVE. PORTLAND OR.
2. SURVEY COMPLETED PRIOR TO DREDGING OF THE STILLING BASIN.

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE

J.LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
PRE-DRAWDOWN HYDROGRAPHIC SURVEY
ISOMETRIC VIEW 1
FEBRUARY 28, 1992

NOV. 1992

SCALE AS SHOWN | INV. NO.

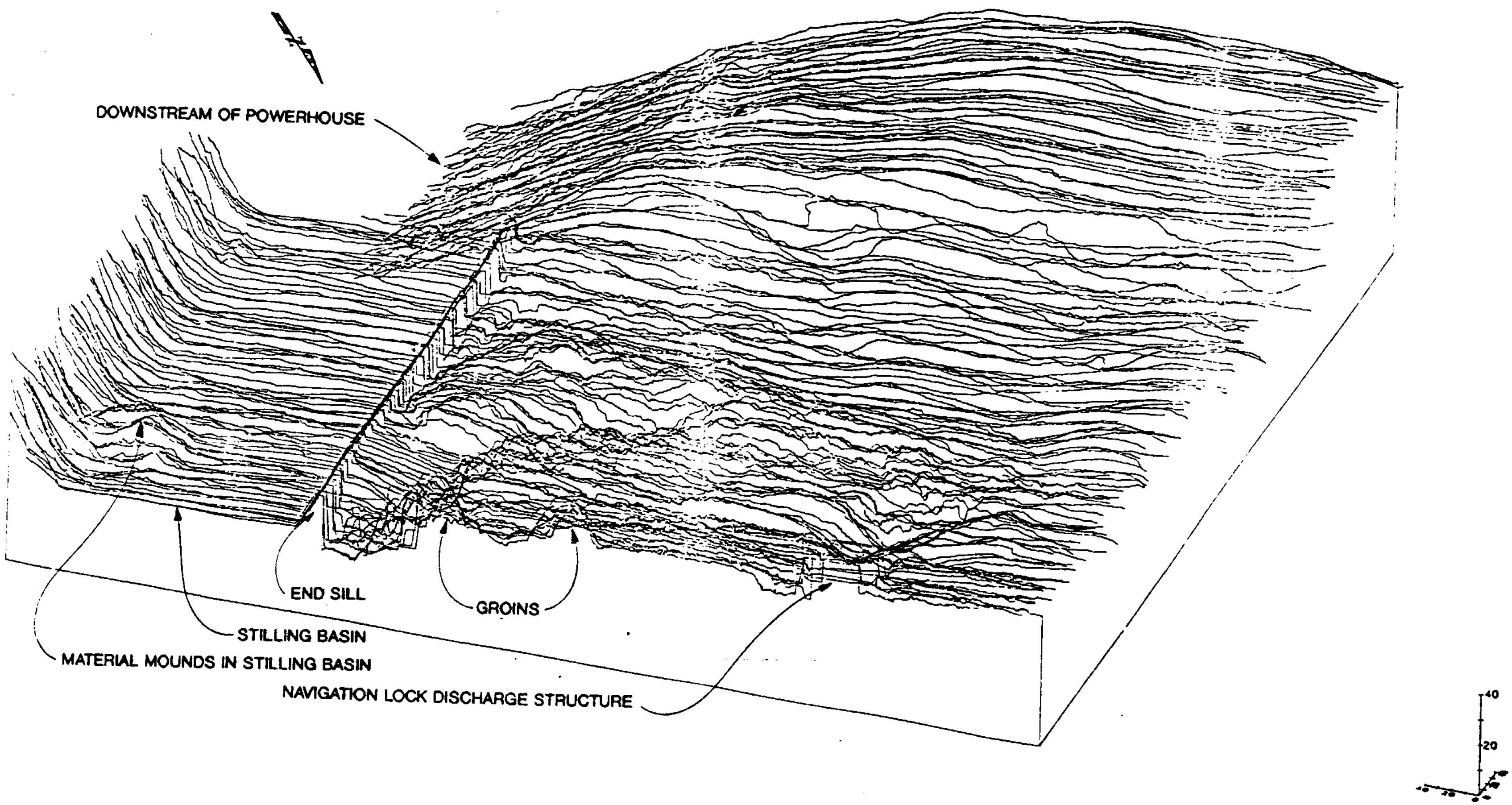
ENCLOSURE C-2

VALUE ENGINEERING PAYS

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



NOTES:

1. DATA PROVIDED BY DAVID EVANS AND ASSOCIATES, INC. 2828 S.W. CORBIT AVE. PORTLAND OR.
2. SURVEY COMPLETED PRIOR TO DREDGING OF THE STILLING BASIN.

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE

J.LEIGH

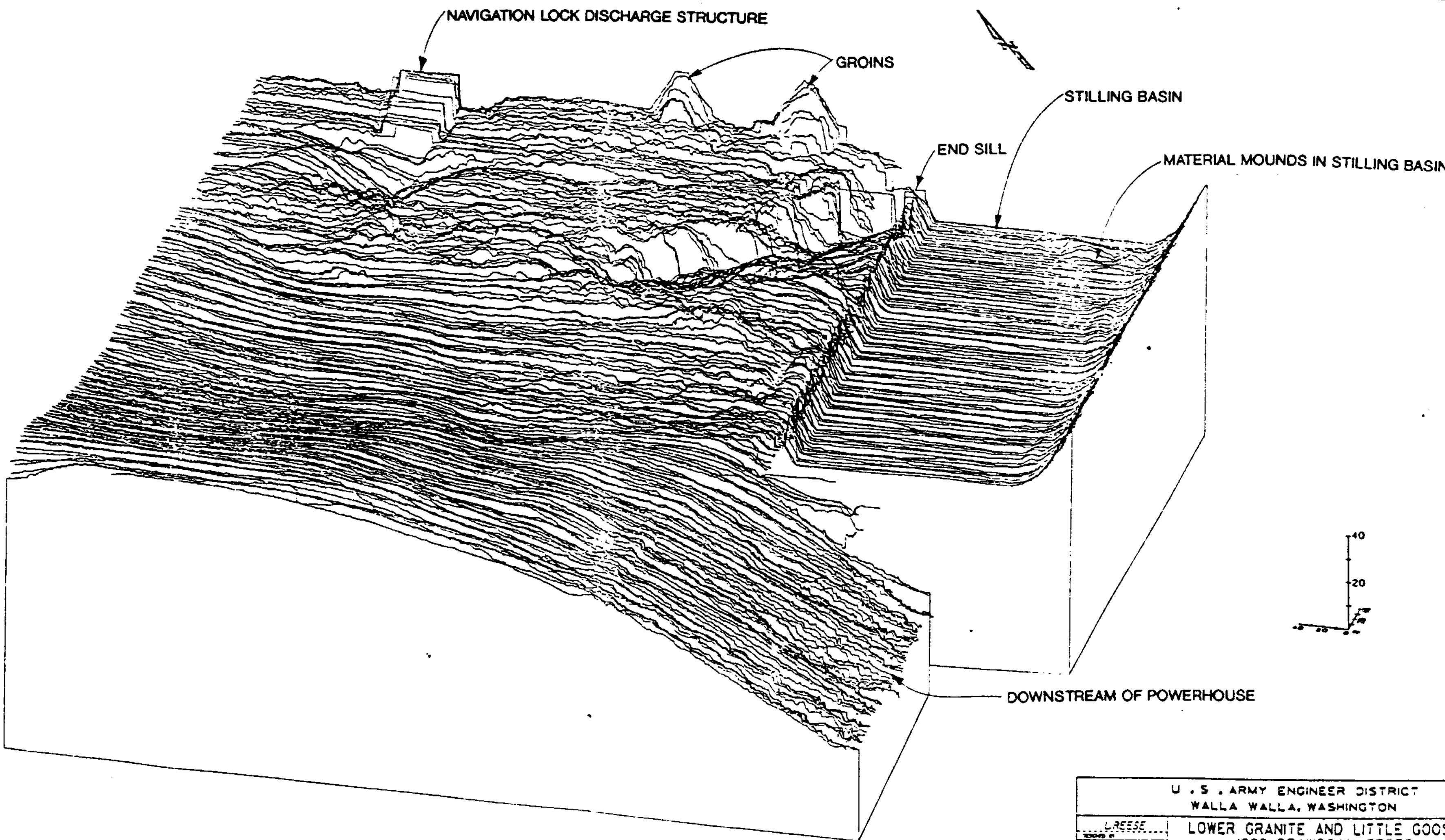
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
PRE-DRAWDOWN HYDROGRAPHIC SURVEY
ISOMETRIC VIEW 2
FEBRUARY 28, 1992

NOV 1992

SCALE AS SHOWN INV. NO.

ENCLOSURE C-3

VALUE ENGINEERING PAYS



NOTES:

1. DATA PROVIDED BY DAVID EVANS AND ASSOCIATES, INC.
   2828 S.W. CORBIT AVE. PORTLAND OR.

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
L.LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT

POST-DRAWDOWN HYDROGRAPHIC SURVEY

ISOMETRIC VIEW 1

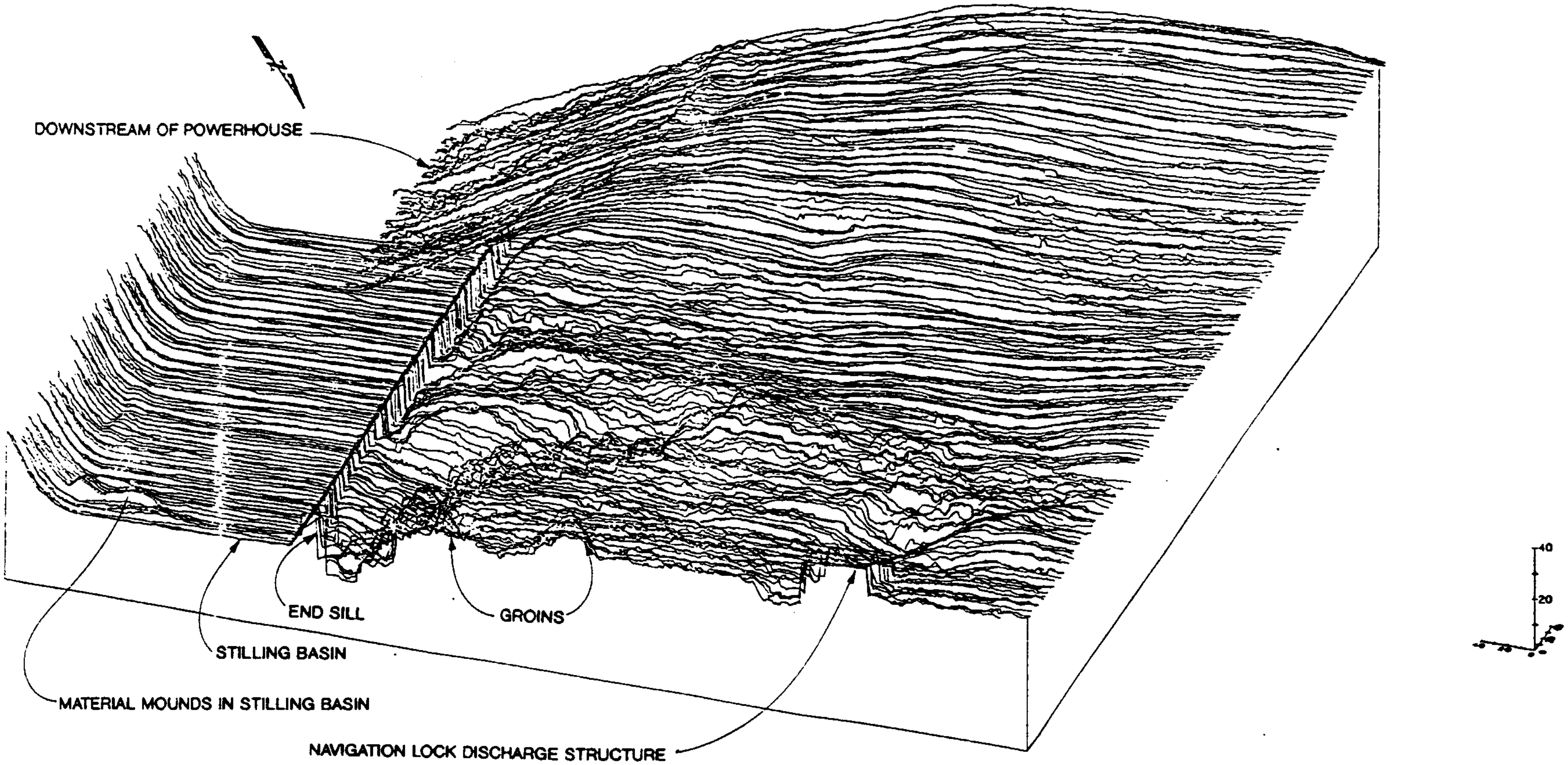
APRIL 1, 1992

NOV. 1992

SCALE AS SHOWN INV. NO.

ENCLOSURE C-4

CORPS OF ENGINEERS SAFETY PAYS U. S. ARMY



NOTES:

1. DATA PROVIDED BY DAVID EVANS AND ASSOCIATES, INC.

2828 S.W. CORBIT AVE. PORTLAND OR.

COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH

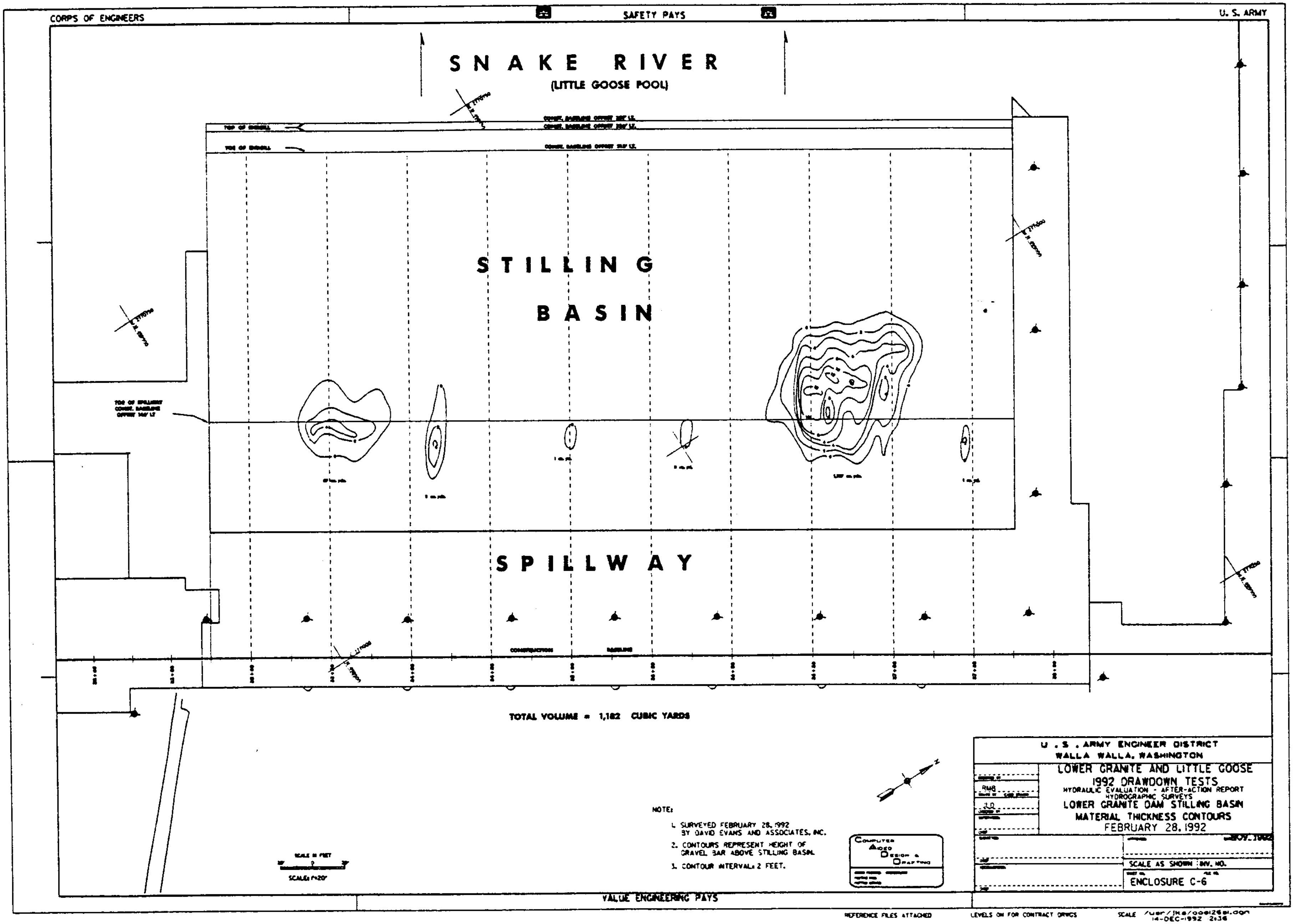
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
POST-DRAWDOWN HYDROGRAPHIC SURVEY
ISOMETRIC VIEW 2
APRIL 1, 1992

NOV. 1992

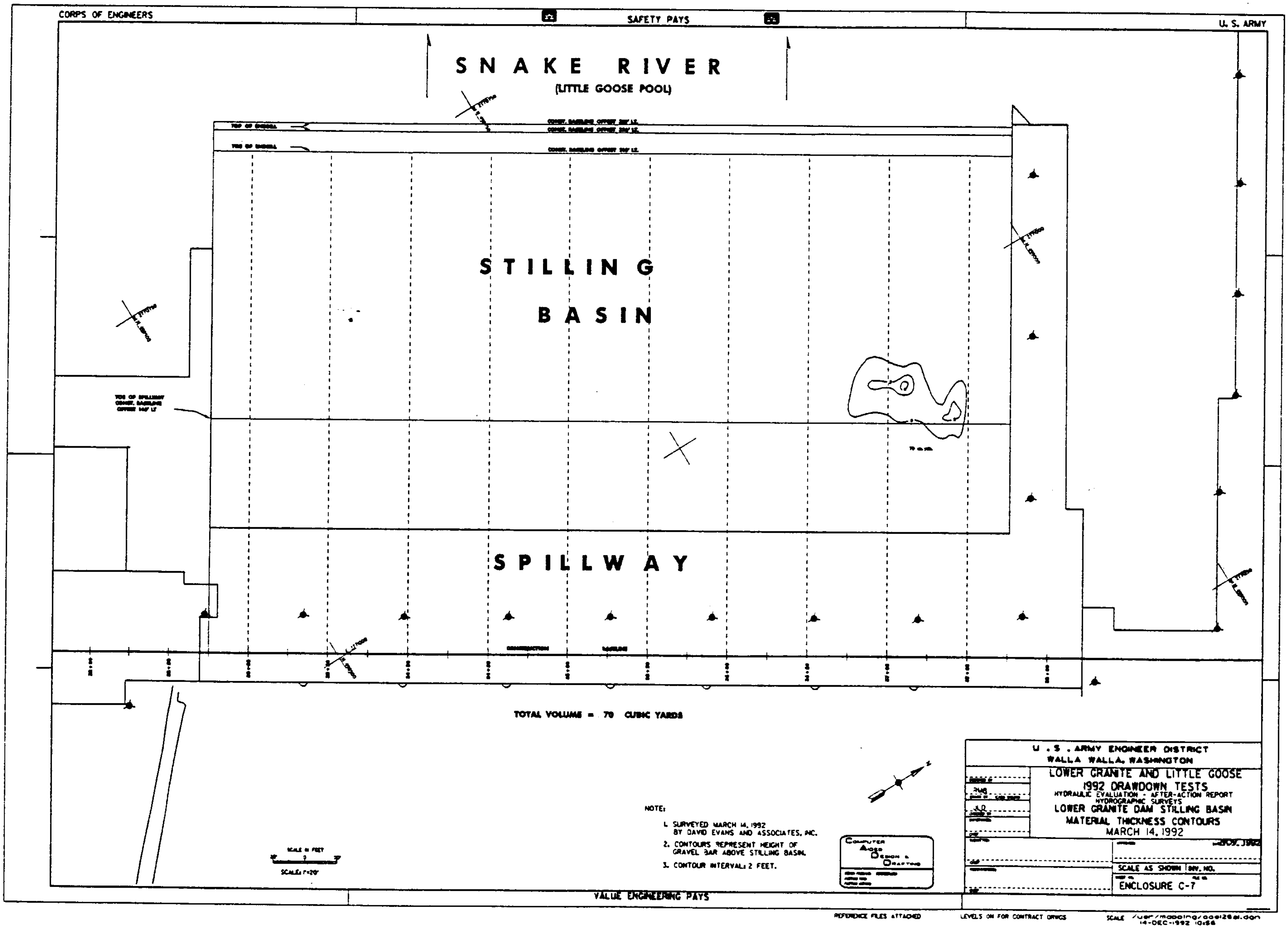
SCALE AS SHOWN INV. NO.

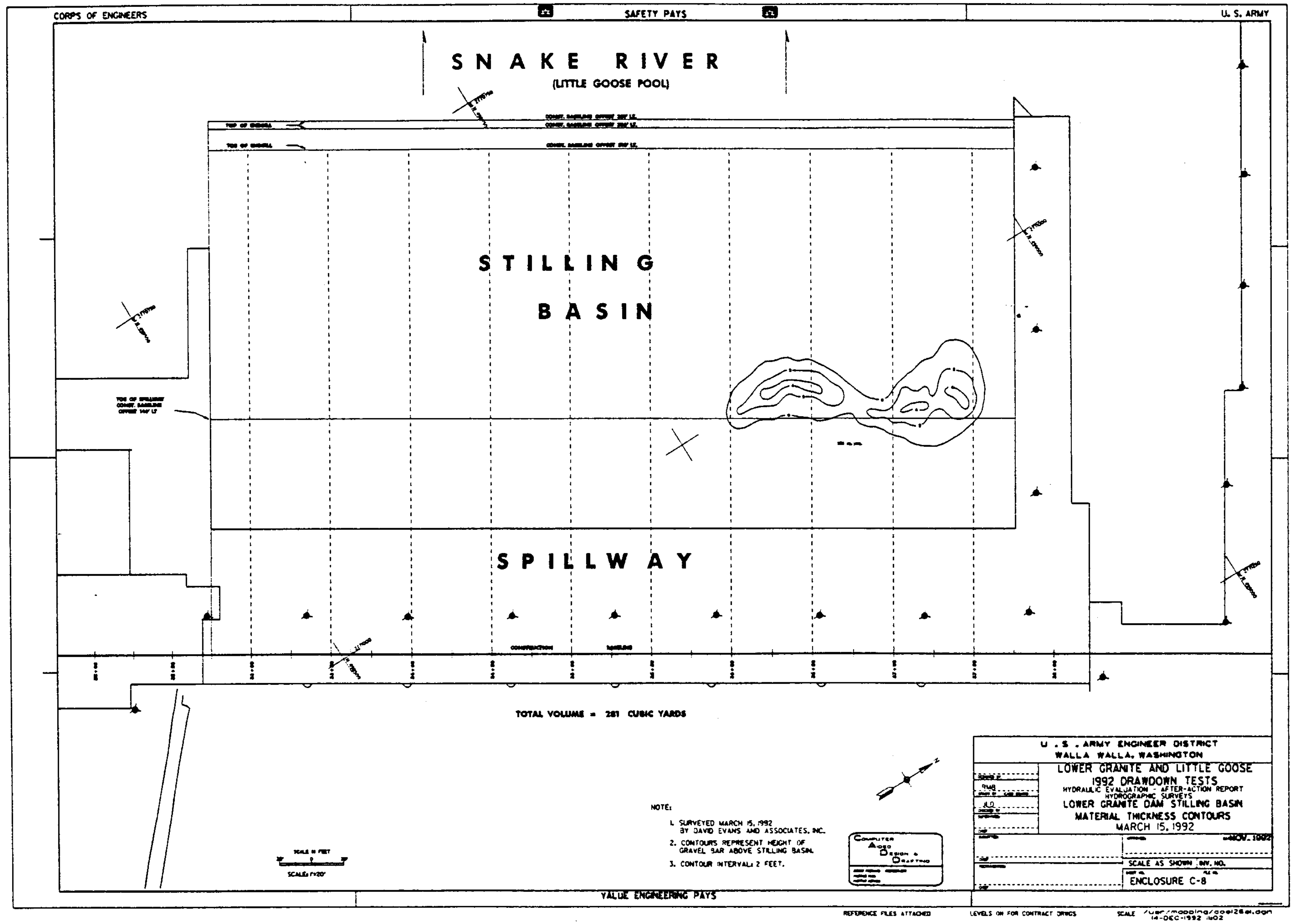
ENCLOSURE C-5

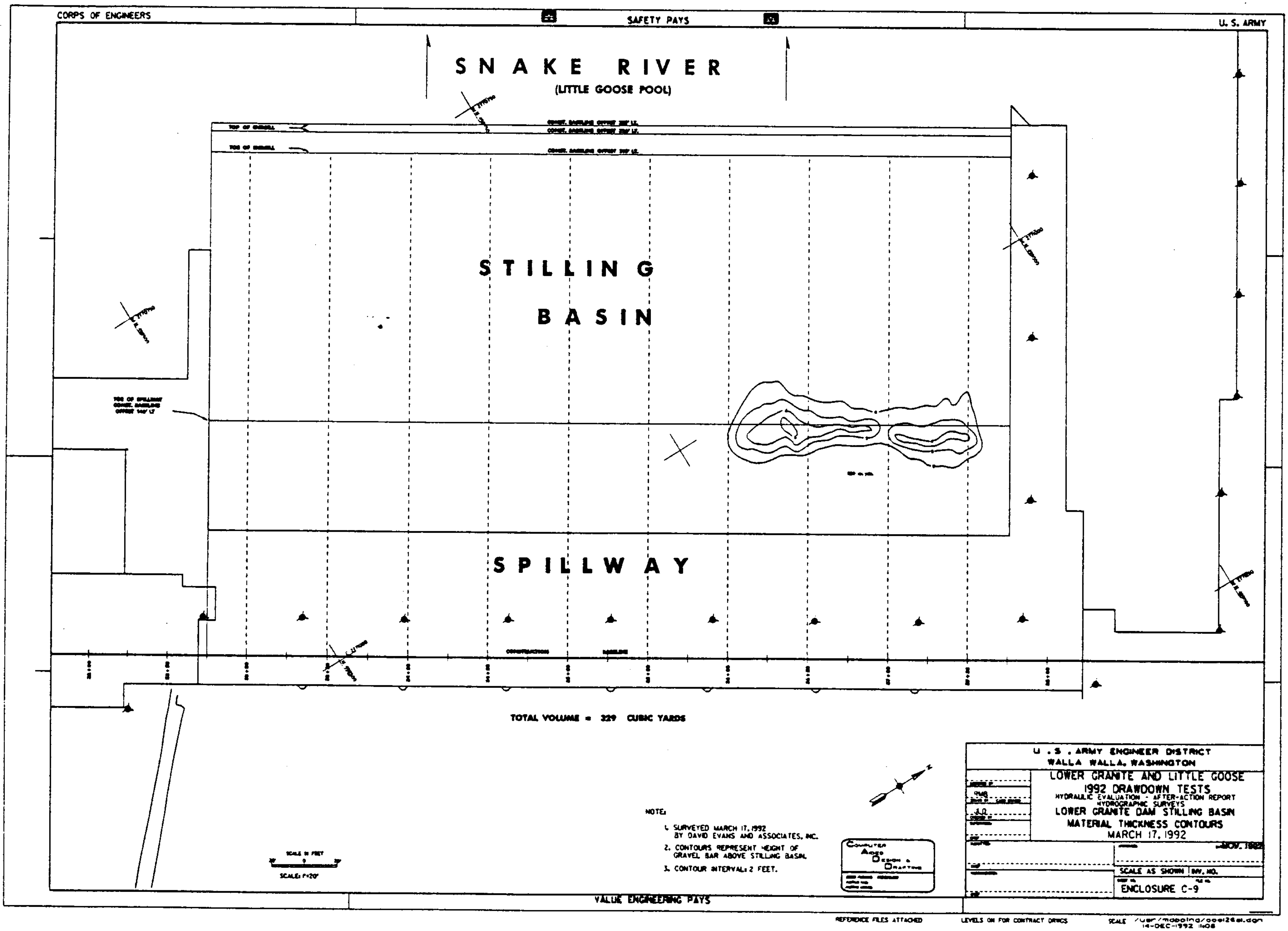
VALUE ENGINEERING PAYS

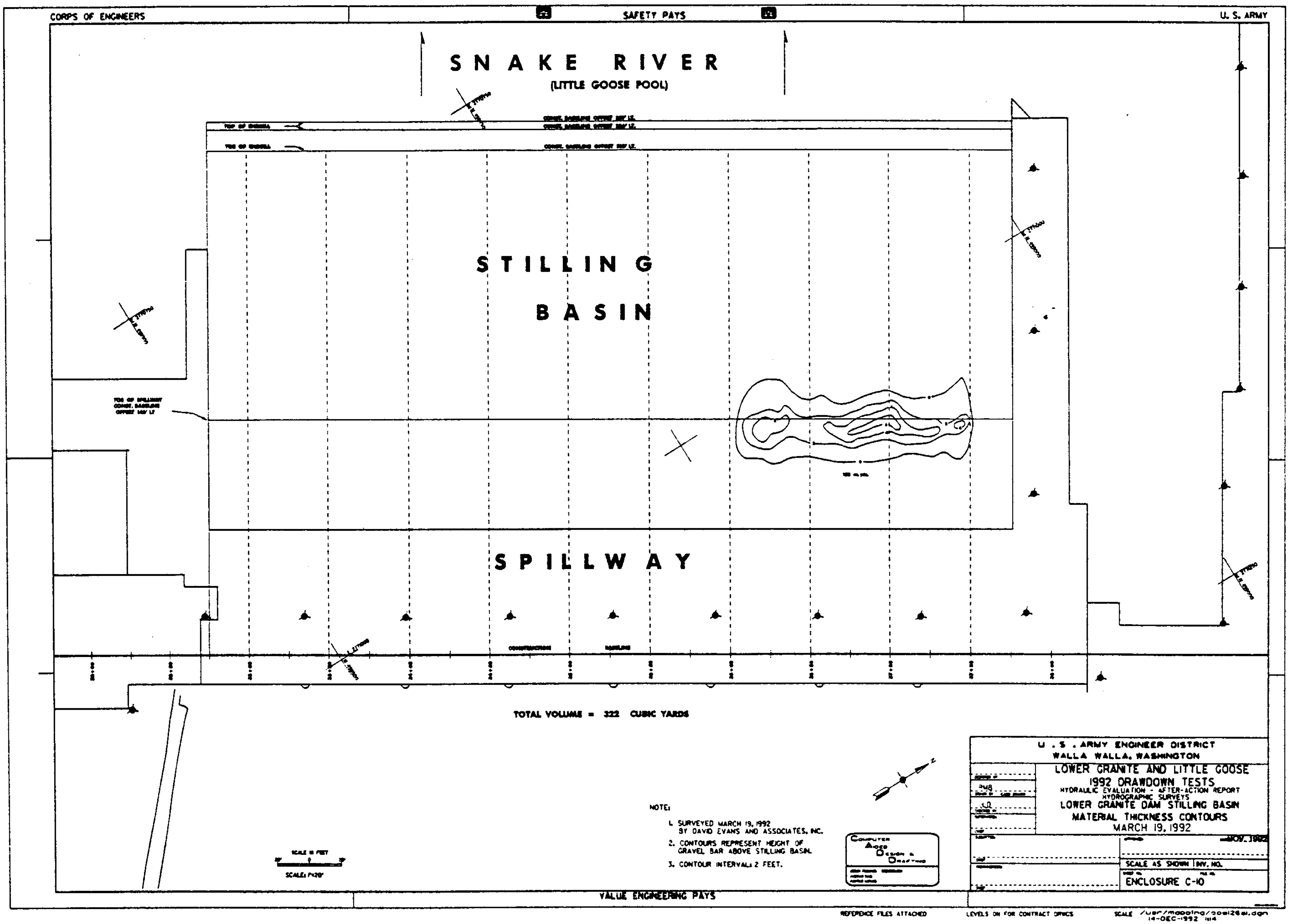


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING
BASIN
SPILLWAY
TOTAL VOLUME = 1,182 CUBIC YARDS
NOTE:
1. SURVEYED FEBRUARY 28, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
SCALE: 1"=20'
COMPUTER AIDED DESIGN & DRAFTING
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
FEBRUARY 28, 1992
RMB
JLD
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-6
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
14-DEC-1992 2:36

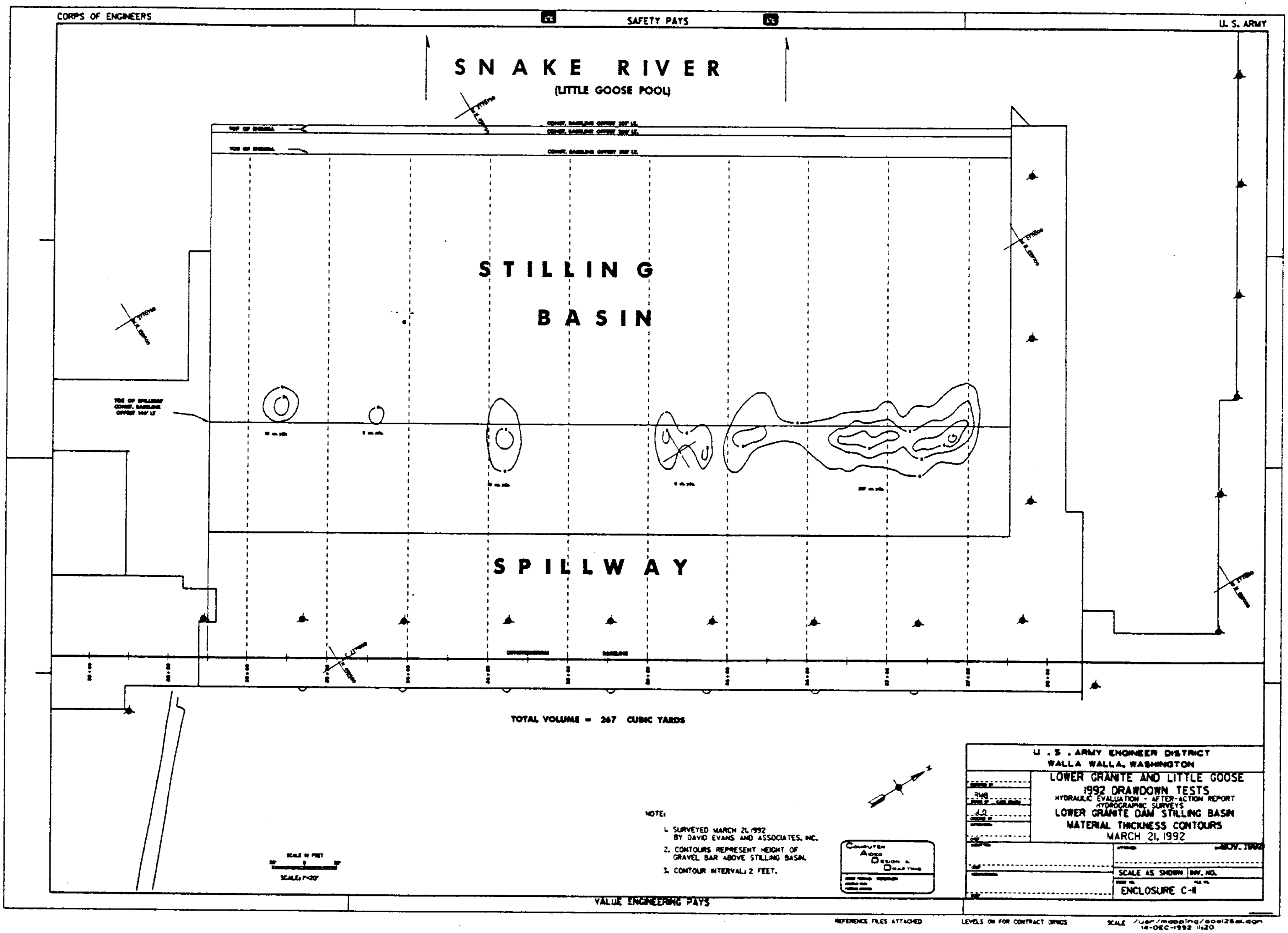

CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING BASIN
SPILLWAY
TOTAL VOLUME = 70 CUBIC YARDS
NOTE:
1. SURVEYED MARCH 14, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
COMPUTER AIDED DESIGN & DRAFTING
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
MARCH 14, 1992
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-7
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
14-DEC-1992 10:56

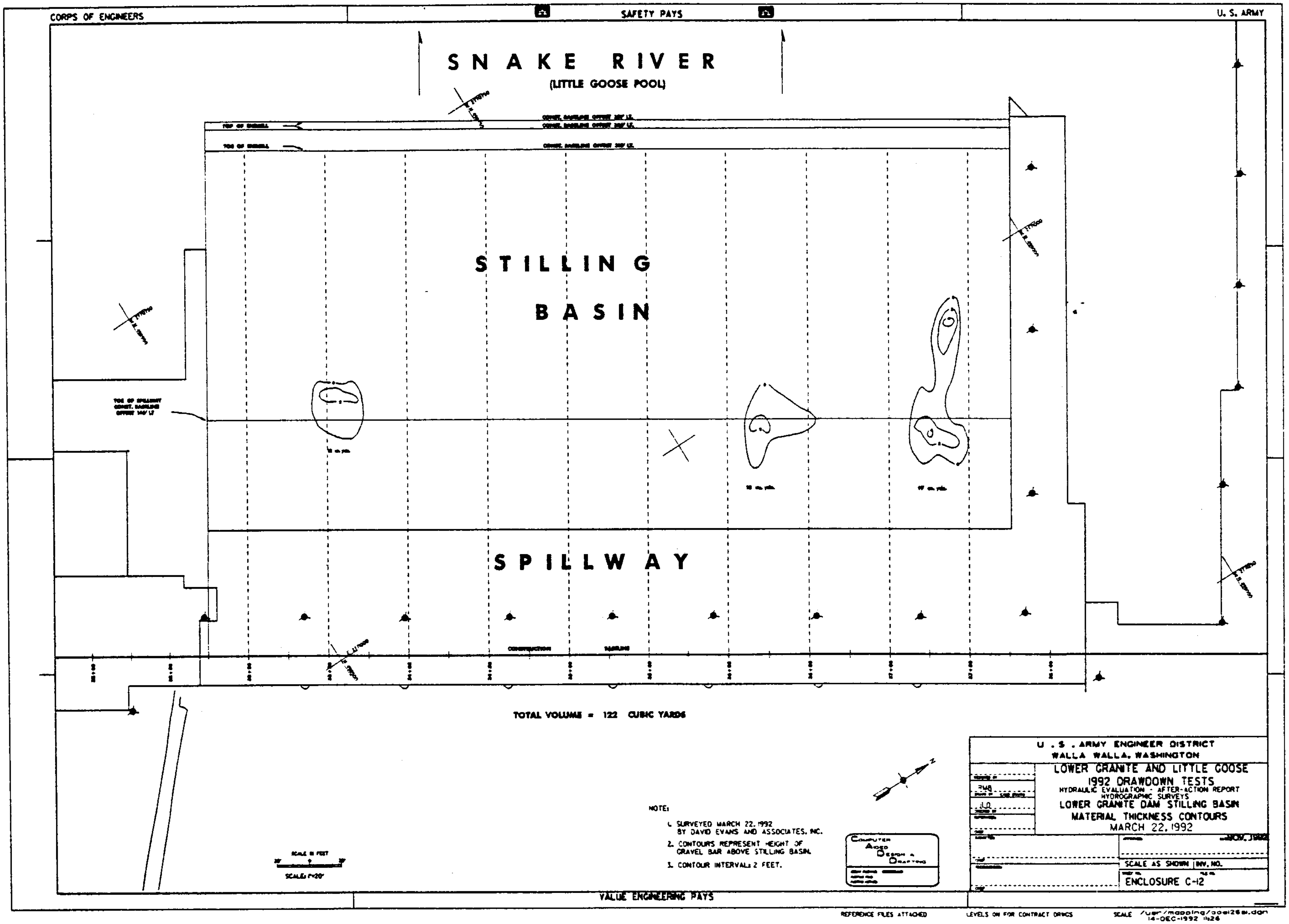

CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING
BASIN
SPILLWAY
TOTAL VOLUME = 281 CUBIC YARDS
NOTE:
1. SURVEYED MARCH 15, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
COMPUTER AIDED DESIGN & DRAFTING
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
MARCH 15, 1992
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-8
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
14-DEC-1992


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING BASIN
SPILLWAY
TOTAL VOLUME = 329 CUBIC YARDS
NOTE:
1. SURVEYED MARCH 17, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
SCALE: 1"=20'
Computer Aided Design & Drafting
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
MARCH 17, 1992
NOV. 1992
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-9
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
14-DEC-1992 11:08



CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING BASIN
SPILLWAY
TOTAL VOLUME = 322 CUBIC YARDS
NOTE:
1. SURVEYED MARCH 19, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
MARCH 19, 1992
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-10
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DWGS


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING
BASIN
SPILLWAY
TOTAL VOLUME = 267 CUBIC YARDS
NOTE:
1. SURVEYED MARCH 21, 1992
BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF
GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
MARCH 21, 1992
RMB
JLQ
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-11
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
14-DEC-1992 11:20


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING
BASIN
SPILLWAY
TOTAL VOLUME = 122 CUBIC YARDS
NOTE:
1. SURVEYED MARCH 22, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
SCALE: 1"=20'
COMPUTER AIDED DESIGN & DRAFTING
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
MARCH 22, 1992
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-12
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
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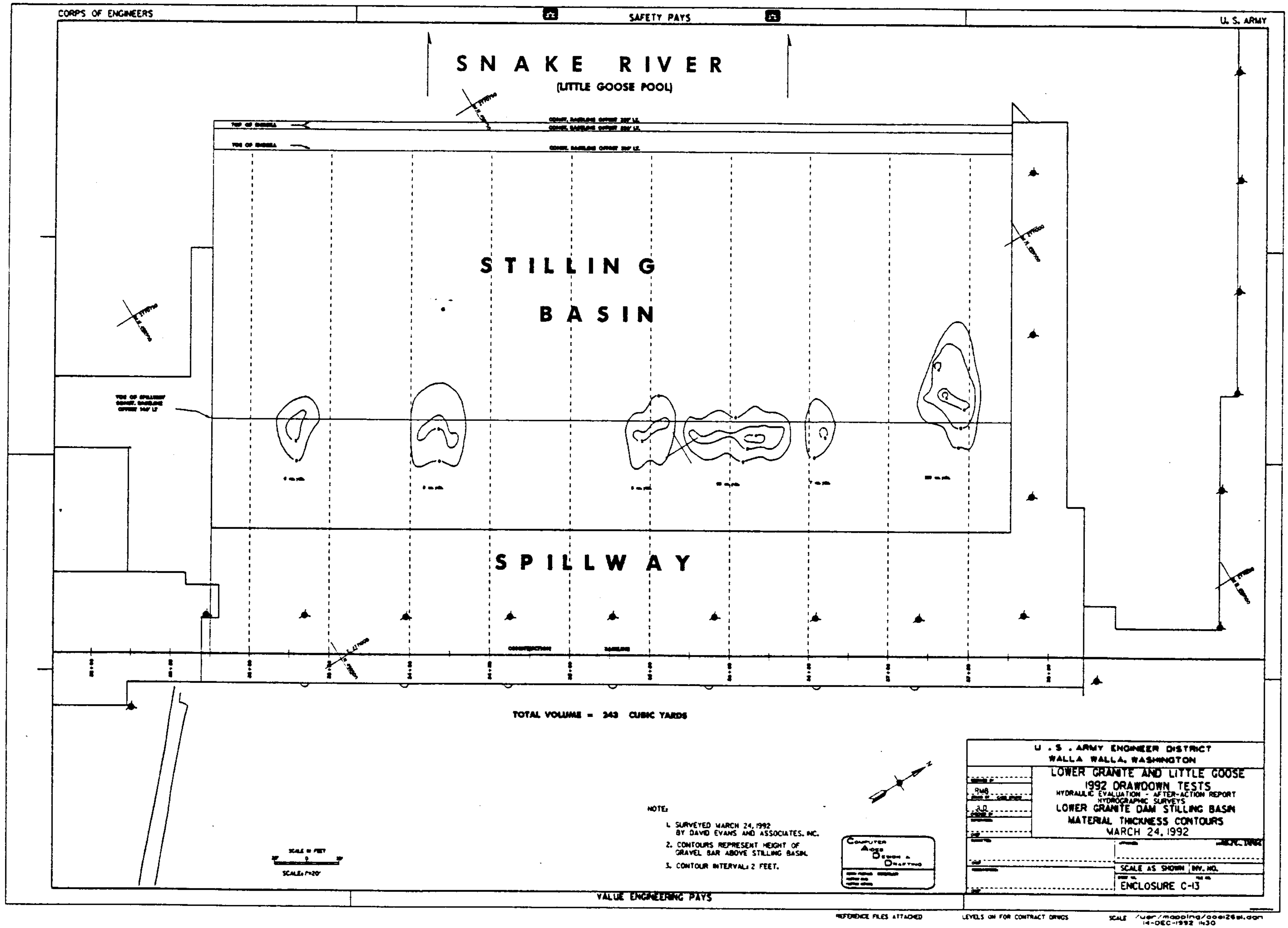
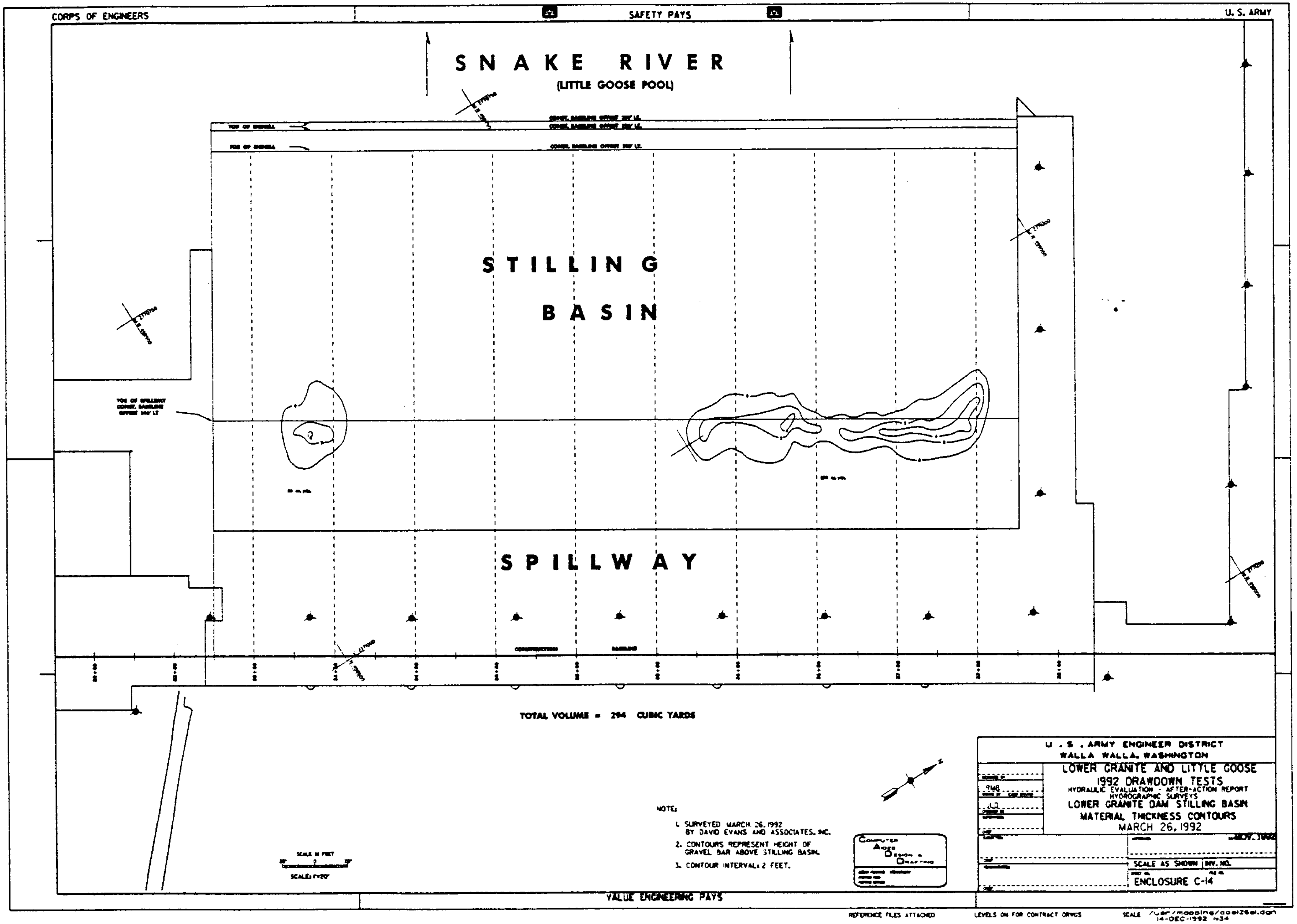
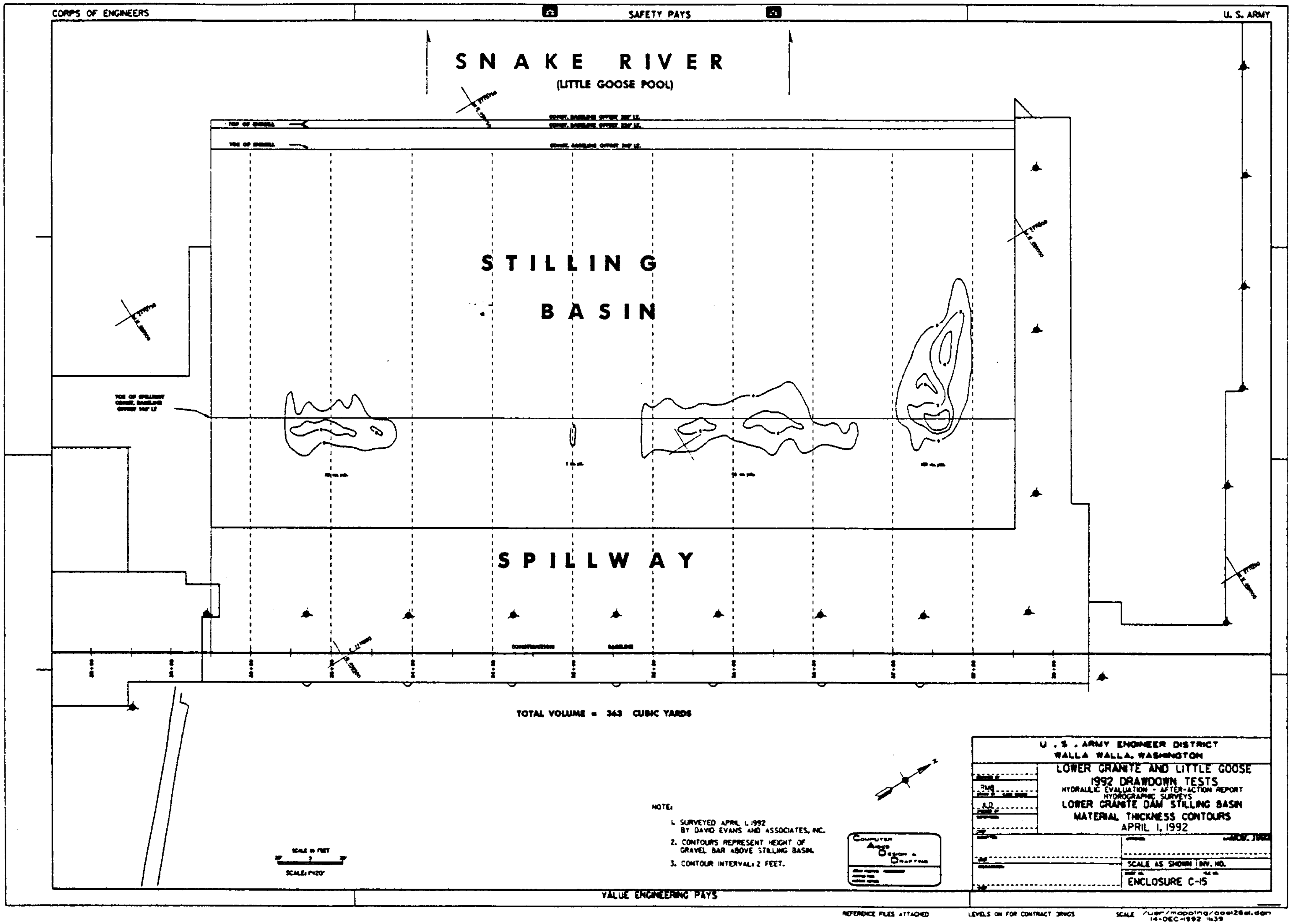
14-DEC-1992 11:26


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING BASIN
SPILLWAY
TOTAL VOLUME = 243 CUBIC YARDS
NOTE:
1. SURVEYED MARCH 24, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
SCALE: 1"=20'
U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
MARCH 24, 1992
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-13
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
14-DEC-1992 14:30

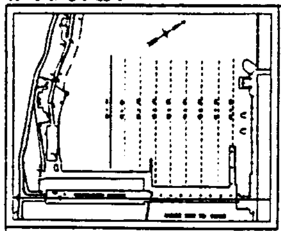

CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING BASIN
SPILLWAY
TOTAL VOLUME = 294 CUBIC YARDS
NOTE:
1. SURVEYED MARCH 26, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
SCALE: 1"=20'
COMPUTER AIDED DESIGN & DRAFTING
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
MARCH 26, 1992
NOV. 1992
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-14
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
14-DEC-1992


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
SNAKE RIVER
(LITTLE GOOSE POOL)
STILLING BASIN
SPILLWAY
TOTAL VOLUME = 363 CUBIC YARDS
NOTE:
1. SURVEYED APRIL 1, 1992 BY DAVID EVANS AND ASSOCIATES, INC.
2. CONTOURS REPRESENT HEIGHT OF GRAVEL BAR ABOVE STILLING BASIN.
3. CONTOUR INTERVAL: 2 FEET.
SCALE: 1"=20'
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
HYDROGRAPHIC SURVEYS
LOWER GRANITE DAM STILLING BASIN
MATERIAL THICKNESS CONTOURS
APRIL 1, 1992
RMG
JLD
SCALE AS SHOWN
INV. NO.
ENCLOSURE C-15
VALUE ENGINEERING PAYS
REFERENCE FILES ATTACHED
LEVELS ON FOR CONTRACT DRWGS
SCALE
14-DEC-1992 11:39

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY

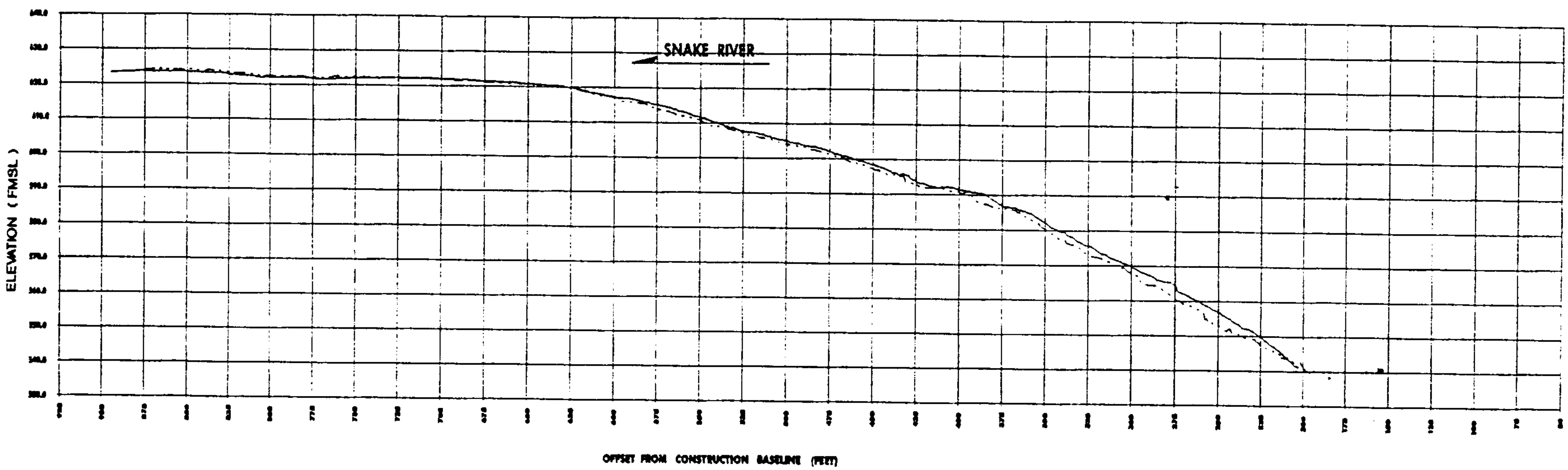


LEGEND

FEBRUARY 28, 1992

APRIL 1, 1992

STATION 30+00 (Line 11)



VERTICAL SCALE

HORIZONTAL SCALE

NOTE:

SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.

PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 28, 1992.

POST DRAWDOWN SURVEY CONDUCTED ON APR. 1, 1992.

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 30+00

NOV. 1992

SCALE AS SHOWN

ENCLOSURE C-16

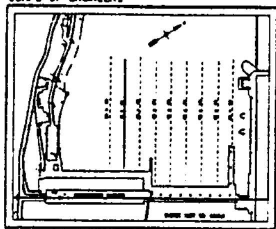
VALUE ENGINEERING PAYS

REFERENCE FILES ATTACHED LEVELS ON FOR CONTRACT DRWGS SCALE FILE

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY

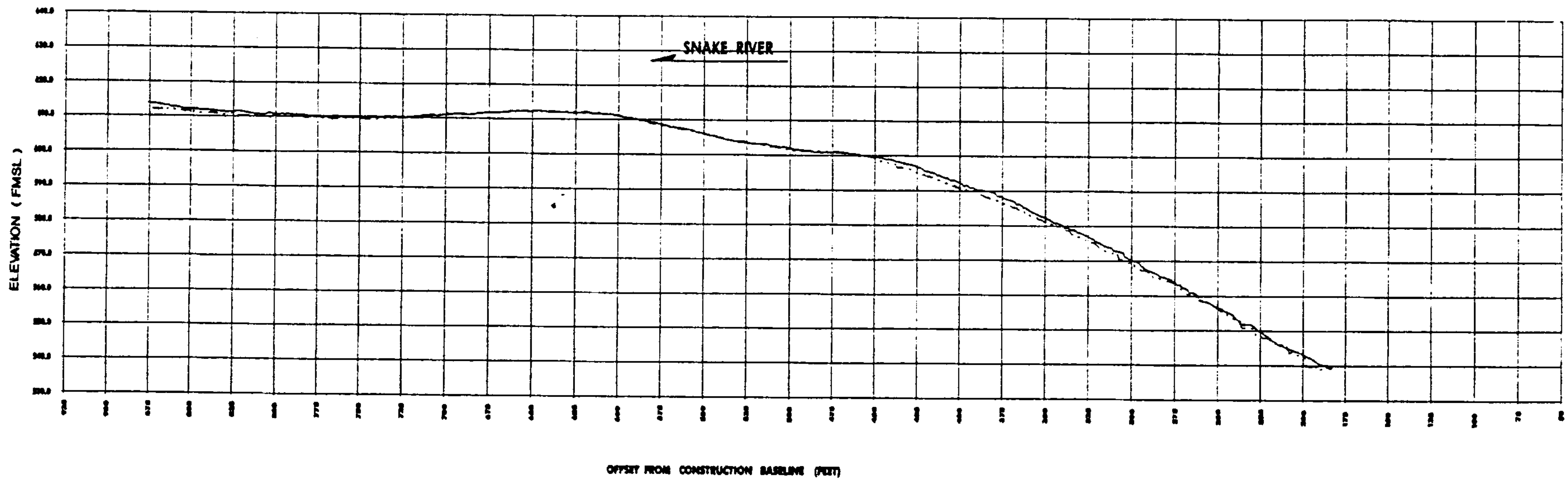


LEGEND

—— FEBRUARY 28, 1992

-·-·- APRIL 1, 1992

STATION 31+00 (Line 31)



NOTE:

SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.

PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 28, 1992.

POST DRAWDOWN SURVEY CONDUCTED ON APRIL 1, 1992.

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 31+00

NOV. 1992

SCALE AS SHOWN

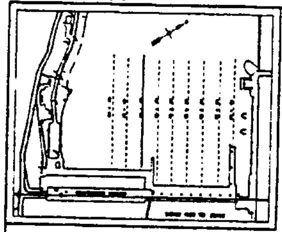
ENCLOSURE C-17

VALUE ENGINEERING PAYS

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY

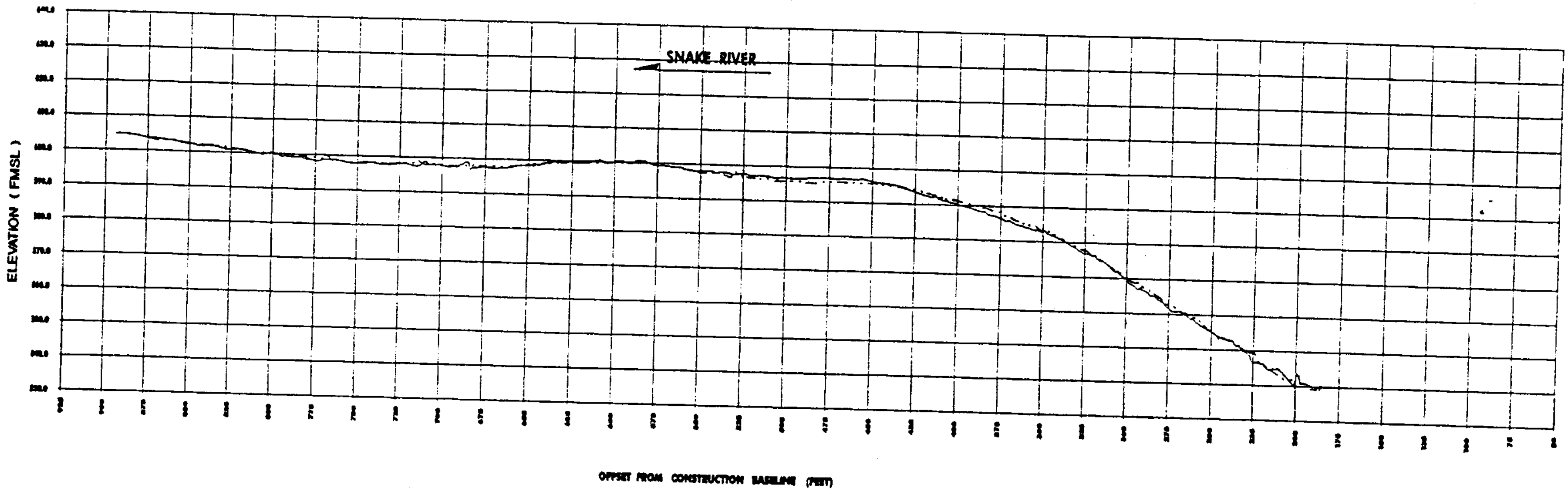


LEGEND

—— FEBRUARY 28, 1992

-·-·- APRIL 1, 1992

STATION 32+00 (Line 51)



VERTICAL SCALE

HORIZONTAL SCALE

NOTES:

SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.

PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 28, 1992.

POST DRAWDOWN SURVEY CONDUCTED ON APRIL 1, 1992.

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 32+00

NOV. 1992

SCALE AS SHOWN

ENCLOSURE C-18

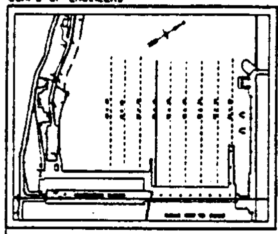
VALUE ENGINEERING PAYS

REFERENCE FILES ATTACHED   LEVELS ON FOR CONTRACT DRWGS   SCALE   FILE

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY

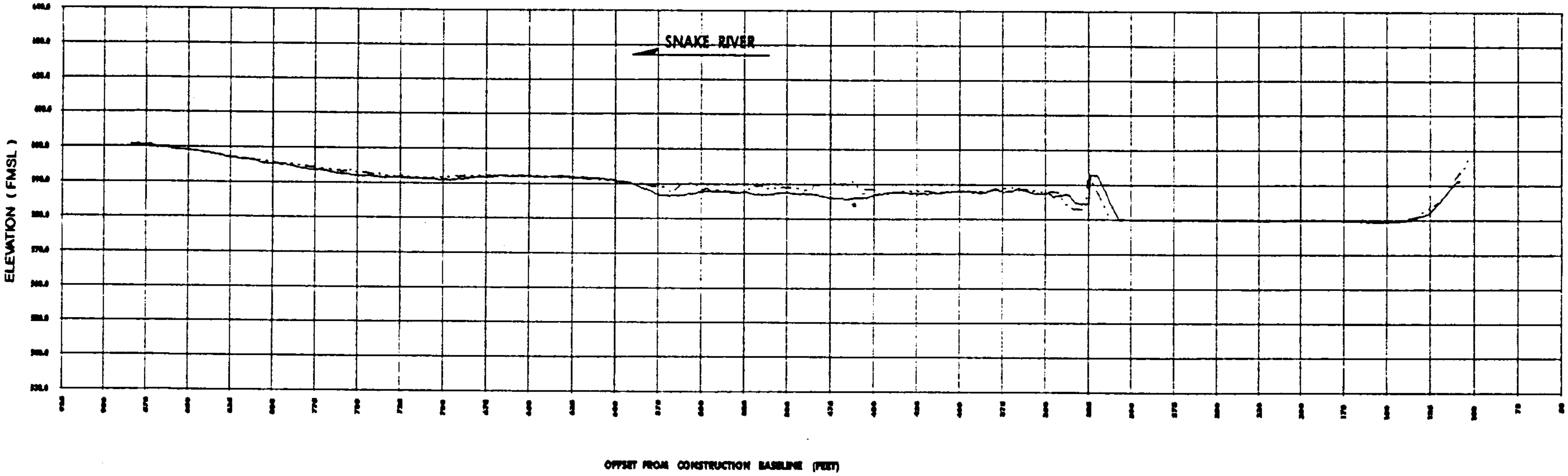


LEGEND

FEBRUARY 28, 1992

APRIL 1, 1992

STATION 33+00 (Line 71)



VERTICAL SCALE

HORIZONTAL SCALE

NOTES:

SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.

PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 28, 1992.

POST DRAWDOWN SURVEY CONDUCTED ON APRIL 1, 1992.

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

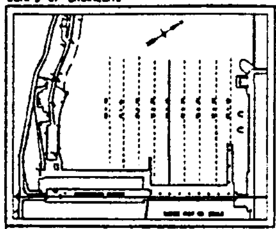
STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 33+00

NOV 1992

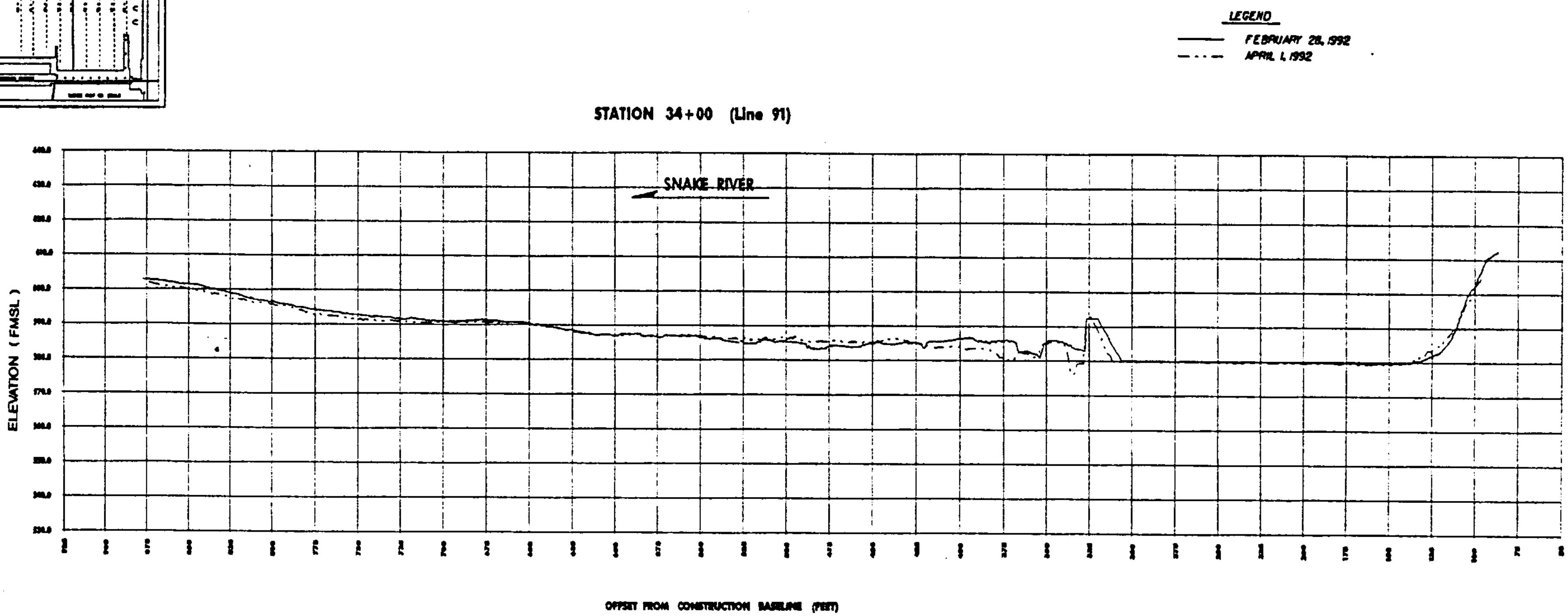
SCALE AS SHOWN

ENCLOSURE C-19

VALUE ENGINEERING PAYS



STATION 34+00 (Line 91)



NOTE:

SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.

PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 28, 1992.

POST DRAWDOWN SURVEY CONDUCTED ON APRIL 1, 1992.

Computer Aided Design & Drafting

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

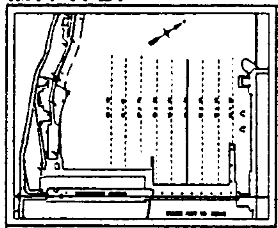
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

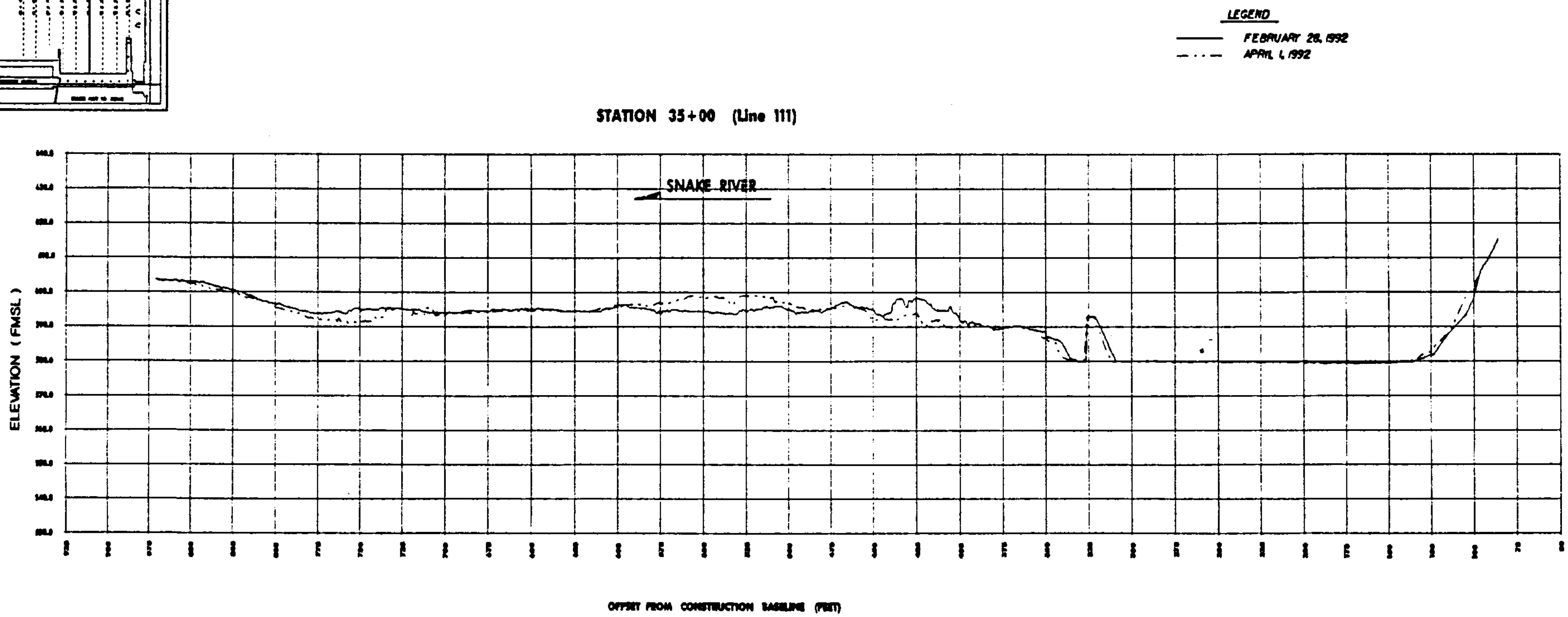
STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 34+00

NOV 1992

SCALE AS SHOWN

ENCLOSURE C-20





NOTE:
SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.
PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 28, 1992.
POST DRAWDOWN SURVEY CONDUCTED ON APRIL 1, 1992.

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 35+00

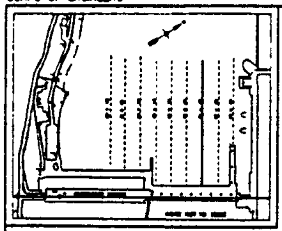
NOV. 1992

ENCLOSURE C-21

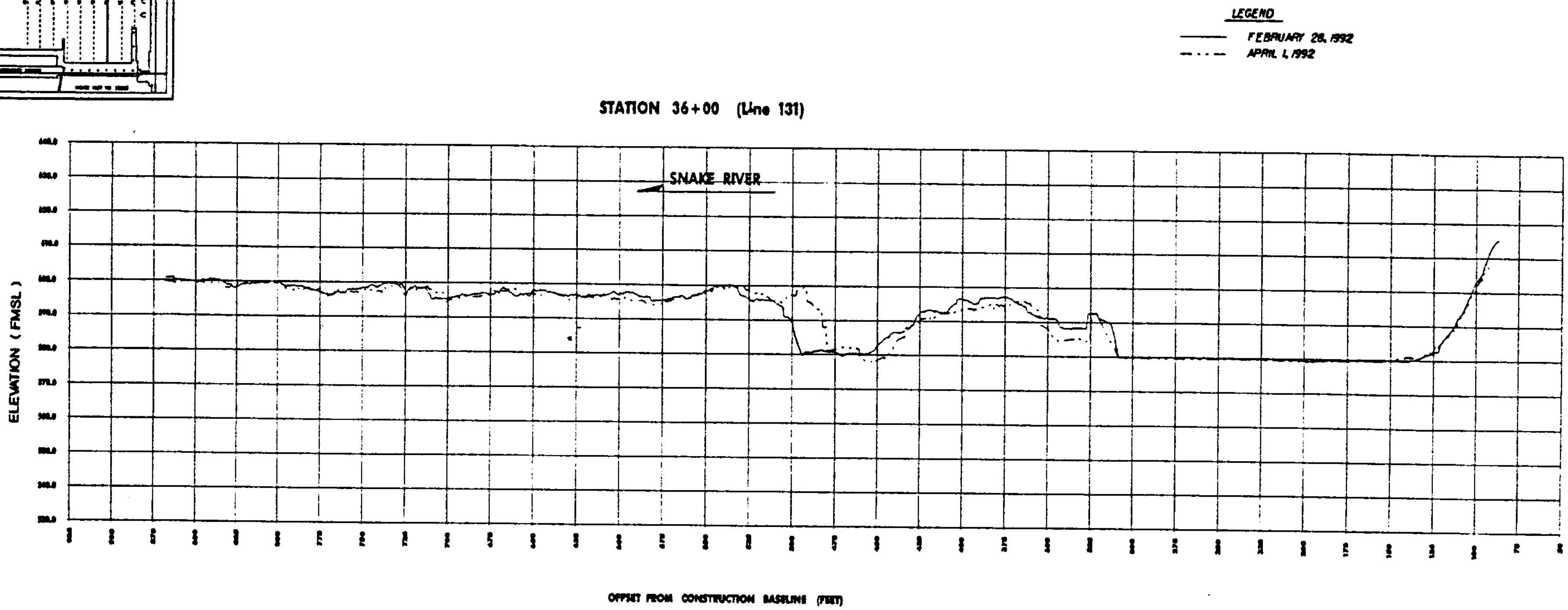
CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



STATION 36+00 (Line 131)



NOTE:

SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.

PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 28, 1992.

POST DRAWDOWN SURVEY CONDUCTED ON APRIL 1, 1992.

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 36+00

NOV. 1992

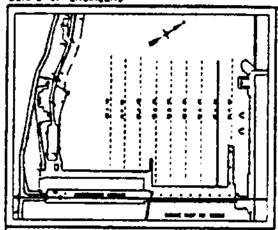
SCALE AS SHOWN

ENCLOSURE C-22

VALUE ENGINEERING PAYS

REFERENCE FILES ATTACHED LEVELS ON FOR CONTRACT DWGS SCALE FILE SYTIME

CORPS OF ENGINEERS — SAFETY PAYS — U. S. ARMY



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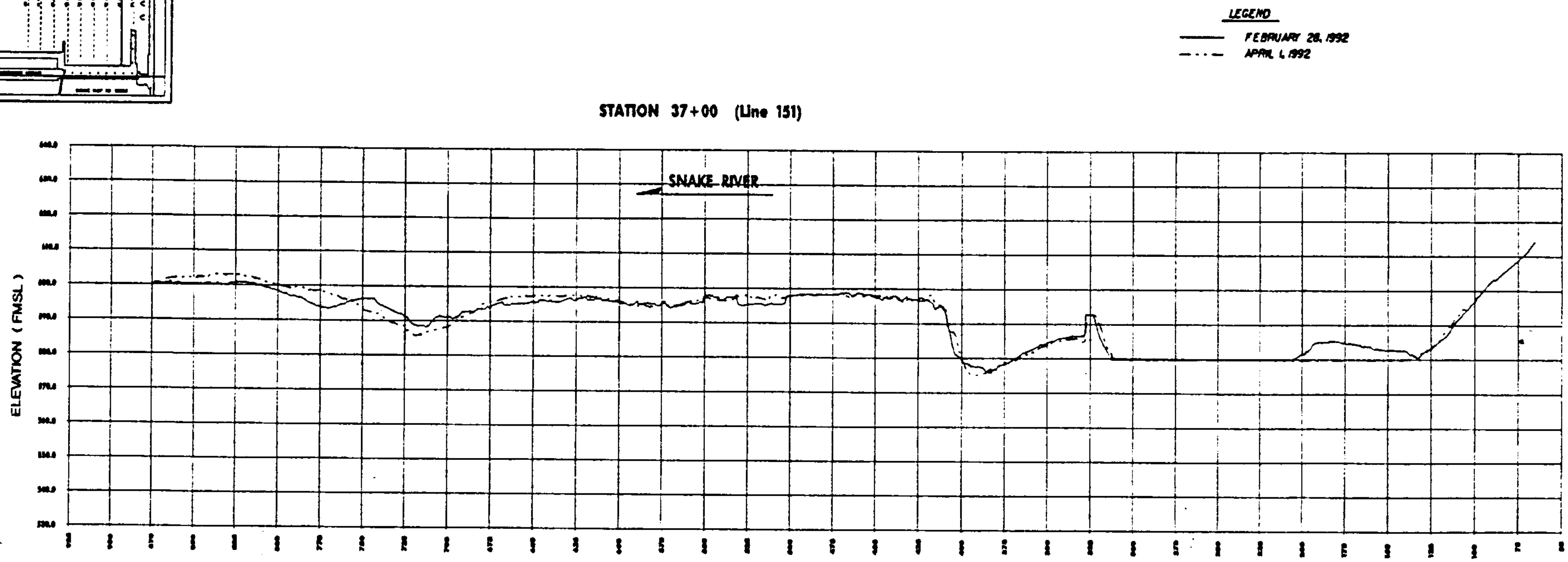


NOTE:

SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.

PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 24, 1992.

POST DRAWDOWN SURVEY CONDUCTED ON APRIL 1, 1992.

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 37+00

NOV. 1992

SCALE AS SHOWN

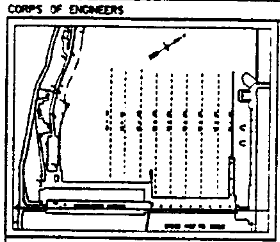
ENCLOSURE C-23

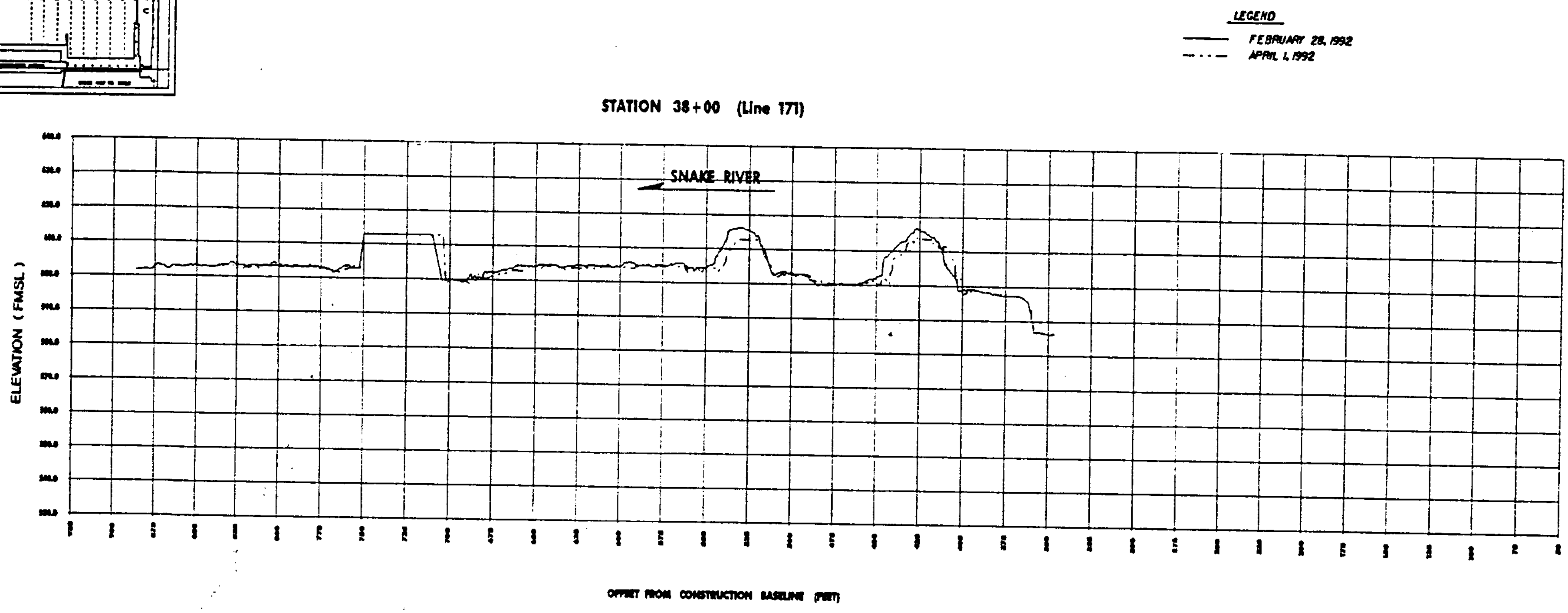
VALUE ENGINEERING PAYS

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY





NOTE:

SURVEYED BY DAVID EVANS AND ASSOCIATES, INC.

PRE DRAWDOWN SURVEY CONDUCTED ON FEBRUARY 28, 1992.

POST DRAWDOWN SURVEY CONDUCTED ON APRIL 1, 1992.

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS

STILLING BASIN AND ADJACENT AREAS
PRE AND POST DRAWDOWN PROFILES
STA. 38+00

NOV. 1992

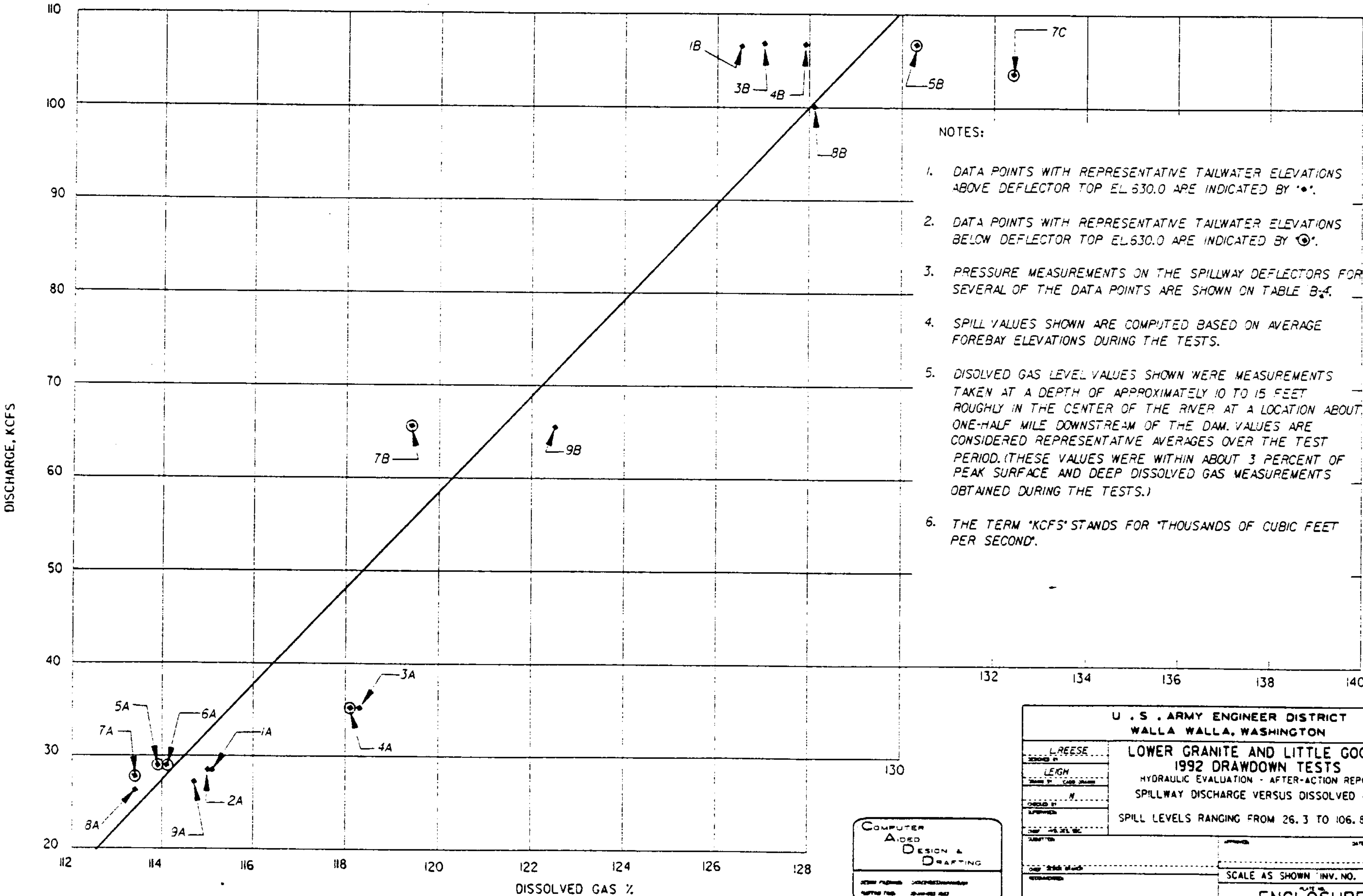
SCALE AS SHOWN

ENCLOSURE C-24

VALUE ENGINEERING PAYS

REFERENCE FILES ATTACHED LEVELS ON FOR CONTRACT DRWGS SCALE FILE

CORPS OF ENGINEERS — SAFETY PAYS — U. S. ARMY



NOTES:

1. DATA POINTS WITH REPRESENTATIVE TAILWATER ELEVATIONS ABOVE DEFLECTOR TOP EL 630.0 ARE INDICATED BY "•".
2. DATA POINTS WITH REPRESENTATIVE TAILWATER ELEVATIONS BELOW DEFLECTOR TOP EL 630.0 ARE INDICATED BY "⊙".
3. PRESSURE MEASUREMENTS ON THE SPILLWAY DEFLECTORS FOR SEVERAL OF THE DATA POINTS ARE SHOWN ON TABLE B-4.
4. SPILL VALUES SHOWN ARE COMPUTED BASED ON AVERAGE FOREBAY ELEVATIONS DURING THE TESTS.
5. DISOLVED GAS LEVEL VALUES SHOWN WERE MEASUREMENTS TAKEN AT A DEPTH OF APPROXIMATELY 10 TO 15 FEET ROUGHLY IN THE CENTER OF THE RIVER AT A LOCATION ABOUT ONE-HALF MILE DOWNSTREAM OF THE DAM. VALUES ARE CONSIDERED REPRESENTATIVE AVERAGES OVER THE TEST PERIOD. (THESE VALUES WERE WITHIN ABOUT 3 PERCENT OF PEAK SURFACE AND DEEP DISSOLVED GAS MEASUREMENTS OBTAINED DURING THE TESTS.)
6. THE TERM "KCFS" STANDS FOR "THOUSANDS OF CUBIC FEET PER SECOND".

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L. REESE
LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
SPILLWAY DISCHARGE VERSUS DISSOLVED GAS
SPILL LEVELS RANGING FROM 26.3 TO 106.8 KCFS

SCALE AS SHOWN — INV. NO.

ENCLOSURE D-1

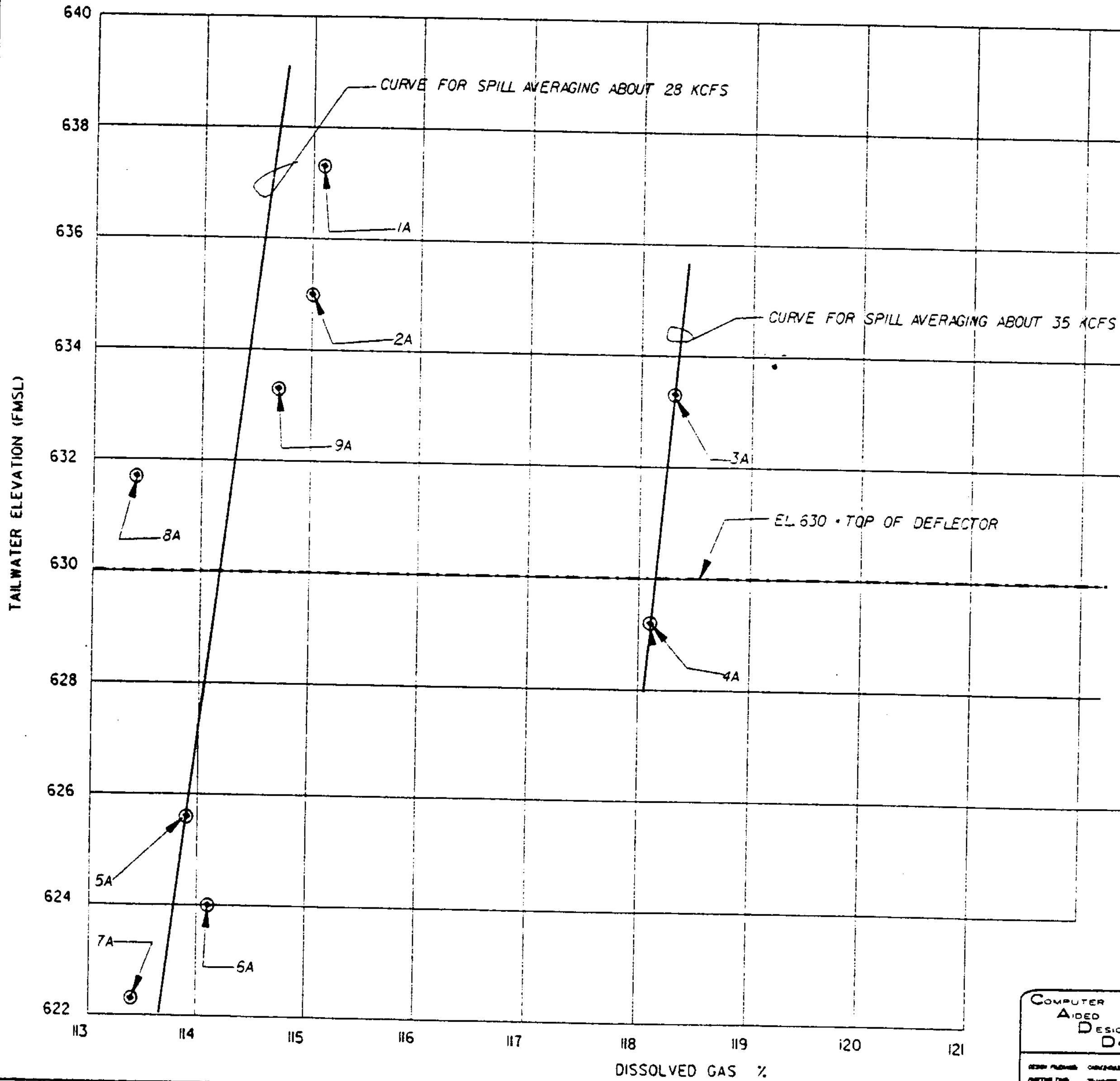
VALUE ENGINEERING PAYS

LV=2 OFF

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



NOTES:

1. TAILWATER ELEVATIONS ARE THE AVERAGE VALUES (EXCLUDING SHARP RISES AND DROPS DURING TRANSITION PHASES OF TESTS) OF SEVERAL KEY TAILWATER GAGES LOCATED IN THE TAILRACE AREA.

2. DISOLVED GAS LEVEL VALUES SHOWN WERE MEASUREMENTS TAKEN AT A DEPTH OF APPROXIMATELY 10 TO 15 FEET ROUGHLY IN THE CENTER OF THE RIVER AT A LOCATION ABOUT ONE-HALF MILE DOWNSTREAM OF THE DAM. VALUES ARE CONSIDERED REPRESENTATIVE AVERAGES OVER THE TEST PERIOD. (THESE VALUES WERE WITHIN ABOUT 3 PERCENT OF PEAK SURFACE AND DEEP DISSOLVED GAS MEASUREMENTS OBTAINED DURING THE TESTS.)

3. THE TERM "KCFS" STANDS FOR "THOUSANDS OF CUBIC FEET PER SECOND".

4. THE TERM "FMSL" STANDS FOR "FEET MEAN SEA LEVEL".

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L. REESE
LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT

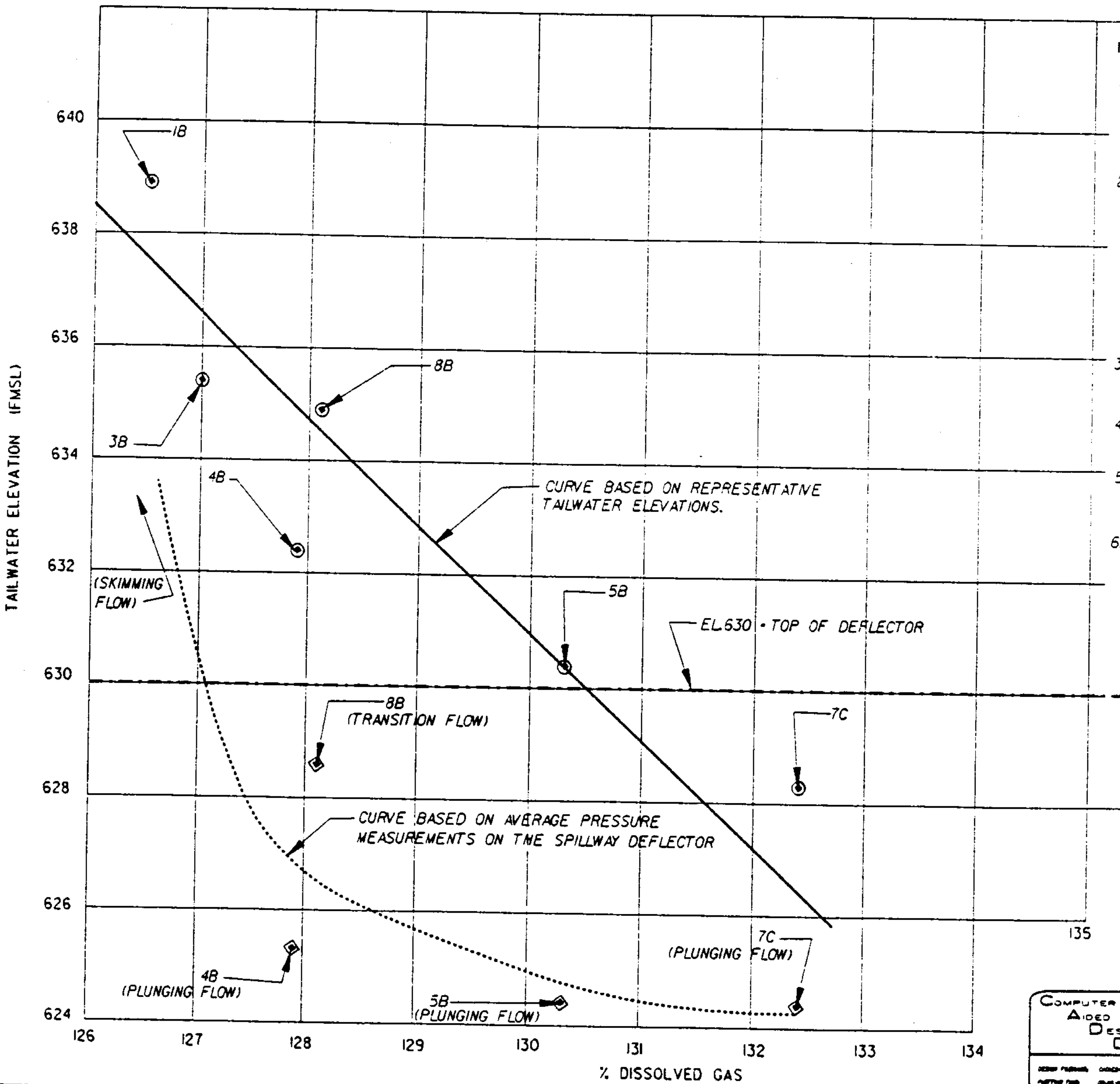
TAILWATER ELEVATION VERSUS DISSOLVED GAS
SPILL LEVELS RANGING FROM 26.3 TO 35.2 KCFS

SCALE AS SHOWN | INV. NO.

ENCLOSURE D-2

VALUE ENGINEERING PAYS

CORPS OF ENGINEERS — SAFETY PAYS — U. S. ARMY



NOTES:

1. TAILWATER ELEVATIONS ARE THE AVERAGE VALUES (EXCLUDING SHARP RISES AND DROPS DURING TRANSITION PHASES OF TESTS) OF SEVERAL KEY TAILWATER GAGES LOCATED IN THE TAILRACE AREA.
2. DISOLVED GAS LEVEL VALUES SHOWN WERE MEASUREMENTS TAKEN AT A DEPTH OF APPROXIMATELY 10 TO 15 FEET ROUGHLY IN THE CENTER OF THE RIVER AT A LOCATION ABOUT ONE-HALF MILE DOWNSTREAM OF THE DAM. VALUES ARE CONSIDERED REPRESENTATIVE AVERAGES OVER THE TEST PERIOD. (THESE VALUES WERE WITHIN ABOUT 3 PERCENT OF PEAK SURFACE AND DEEP DISSOLVED GAS MEASUREMENTS OBTAINED DURING THE TESTS.)
3. THE TERM "KCFS" STANDS FOR "THOUSANDS OF CUBIC FEET PER SECOND".
4. THE TERM "FMSL" STANDS FOR "FEET MEAN SEA LEVEL".
5. DATA POINTS SHOWN WITH REPRESENTATIVE TAILWATER ELEVATIONS ARE INDICATED BY "⊙".
6. DATA POINTS SHOWN WITH AVERAGE SPILLWAY DEFLECTOR PRESSURES ARE INDICATED BY "◈".

COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

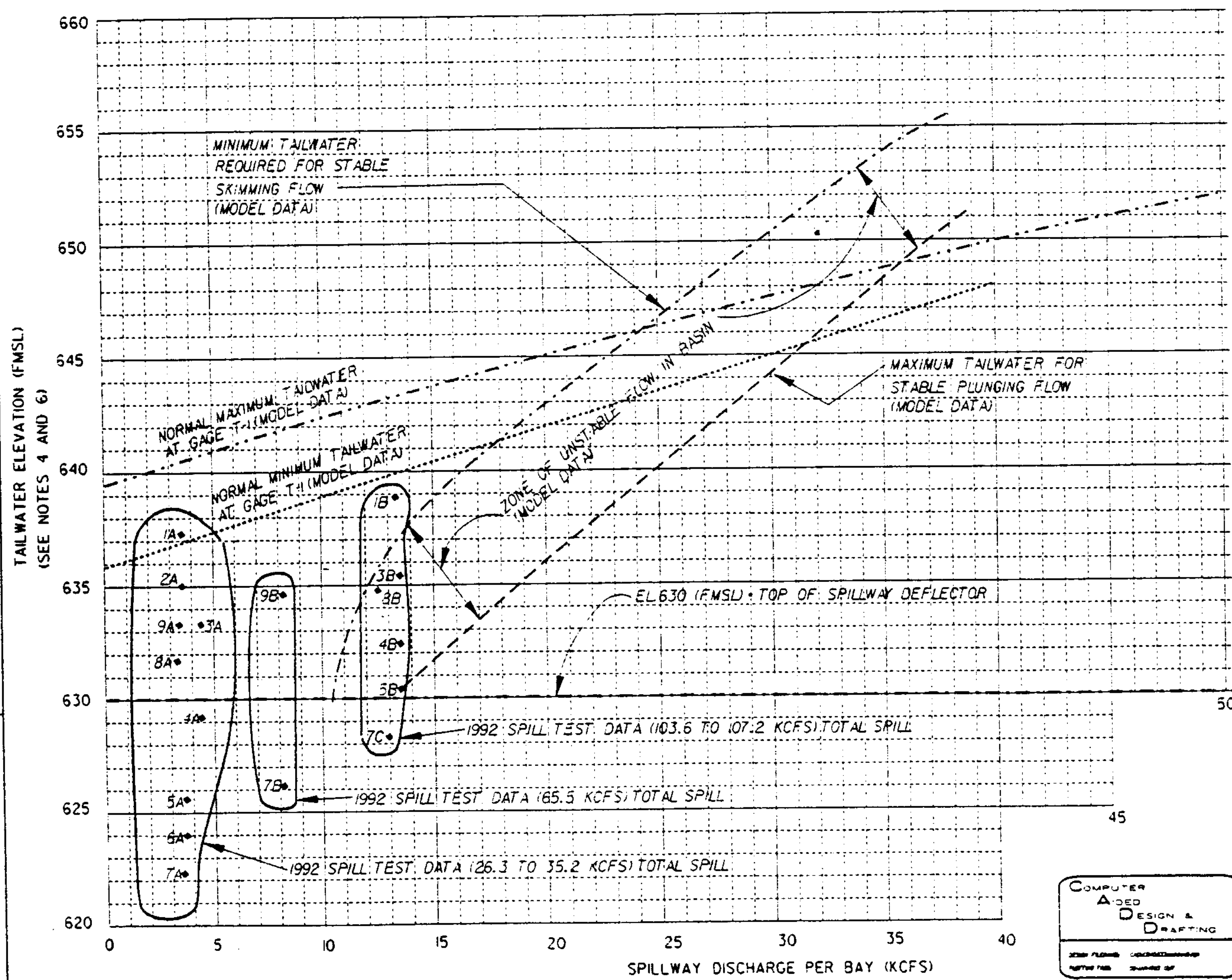
L. REESE
LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILWATER AND SPILLWAY DEFLECTOR PRESSURES VERSUS DISSOLVED GAS
SPILL LEVELS RANGING FROM 103.6 TO 106.8 KCFS

SCALE AS SHOWN INV. NO.

ENCLOSURE D-3

VALUE ENGINEERING PAYS



NOTES:

1. SOURCE OF ORIGINAL MODEL STUDY SHOWING STILLING BASIN FLOW CONDITIONS IS: LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON, TR NO.121-1, AUGUST 1984.
2. THE NORMAL TAILWATER WAS SET FOR A TOTAL RIVER FLOW INCLUDING SIX POWERHOUSE UNITS.
3. MODEL OPERATION USED A UNIFORM SPILLWAY OPERATION.
4. GAGE T-1 IN THE MODEL WAS LOCATED APPROXIMATELY 1000 FT. DOWNSTREAM FROM THE SPILLWAY AXIS.
5. MODEL STUDY FLOW DATA REFLECTS THE 12.5 FT. DEFLECTORS INSTALLED AT THE PROJECT.
6. SPILL TEST TAILWATER ELEVATIONS ARE THE AVERAGE VALUE (EXCLUDING SHARP RISES AND DROPS DURING TRANSITION PHASES OF TESTS) OF SEVERAL KEY TAILWATER GAGES LOCATED IN THE TAILRACE AREA.
7. MODEL STUDY DATA COLLECTED DOWN TO EL 630 (TOP OF SPILLWAY DEFLECTOR).
8. THE TERM "KCFS" STANDS FOR "THOUSANDS OF CUBIC FEET PER SECOND".
9. THE TERM "FMSL" STANDS FOR "FEET MEAN SEA LEVEL".

COMPUTER AIDED DESIGN & DRAFTING

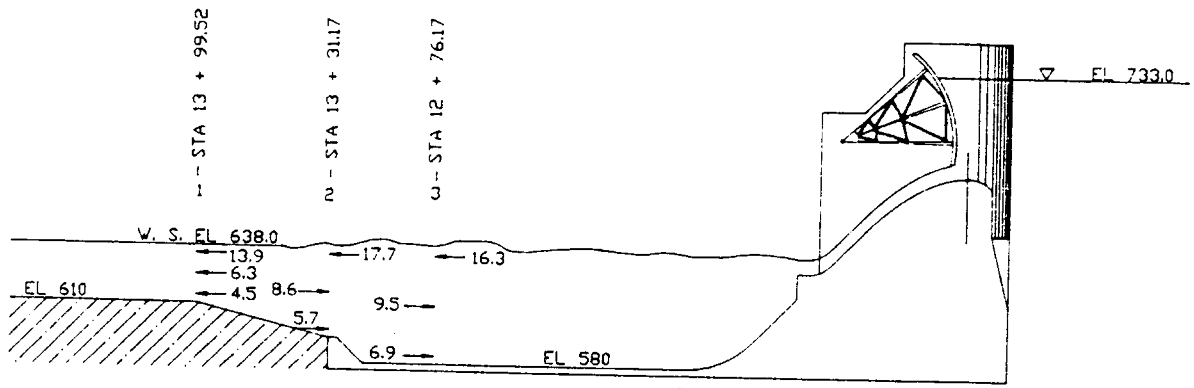
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L. REESE
LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
FLOW CONDITIONS IN STILLING BASIN
ORIGINAL MODEL STUDY INFORMATION
SHOWING DATA POINTS FROM SPILL TESTS

SCALE AS SHOWN | INV. NO.

ENCLOSURE D-4

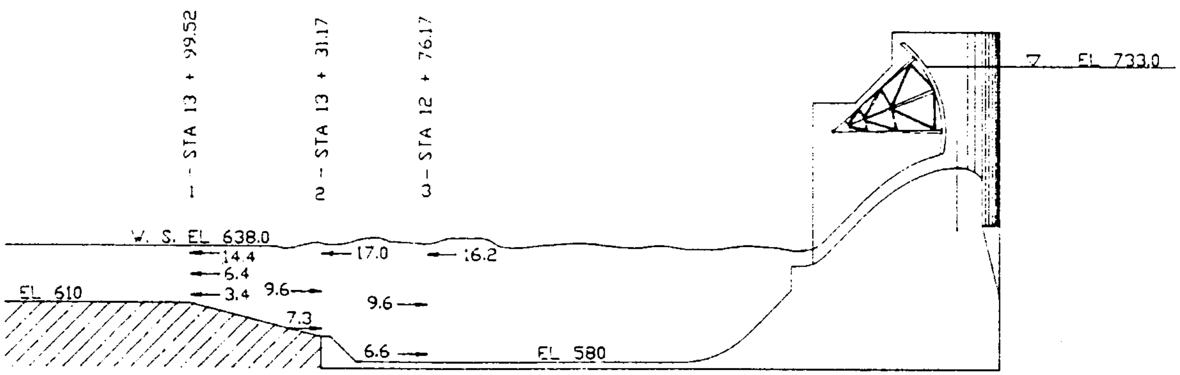


NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS
STATION 1
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 733
TAILWATER EL 638.0

MARCH 1992



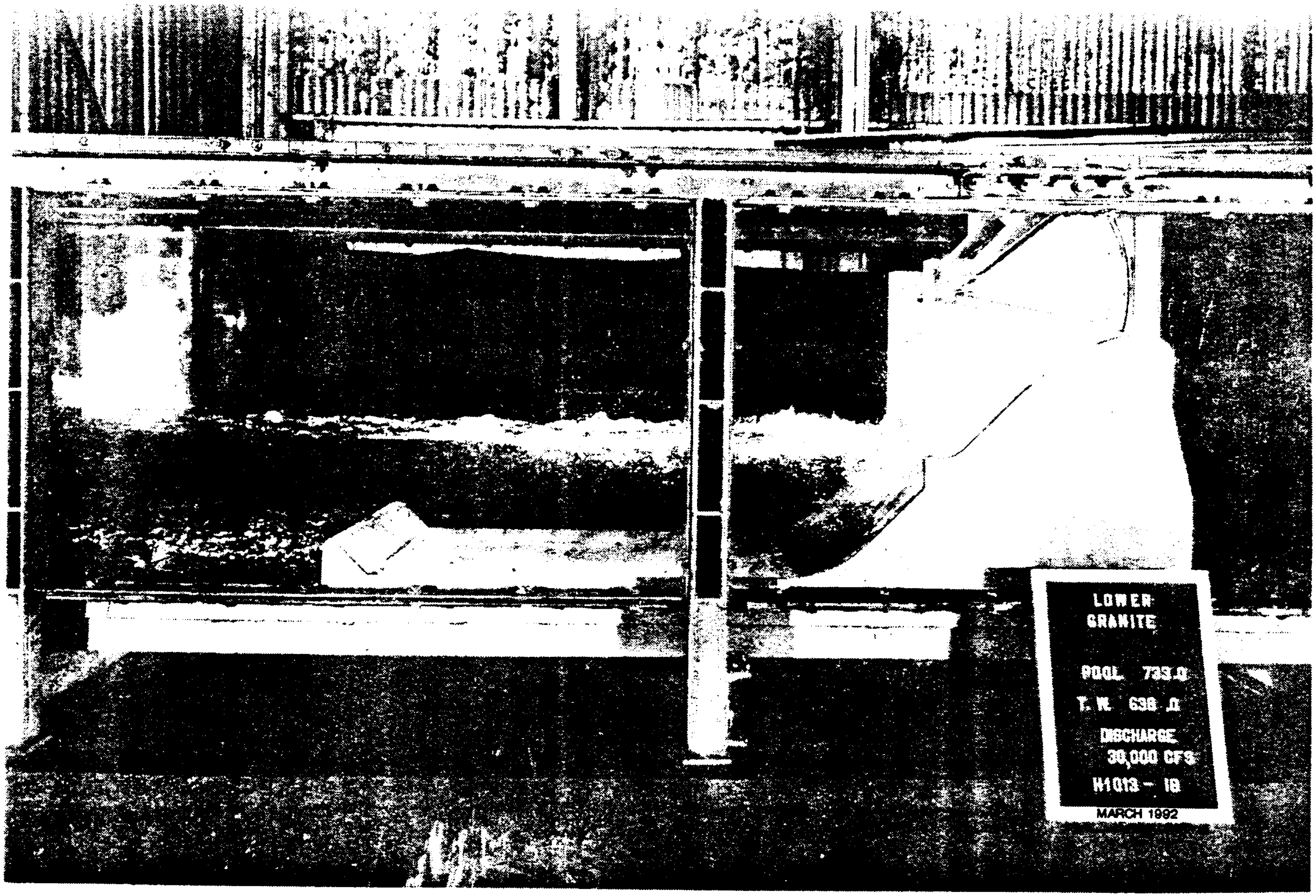
NOTES:

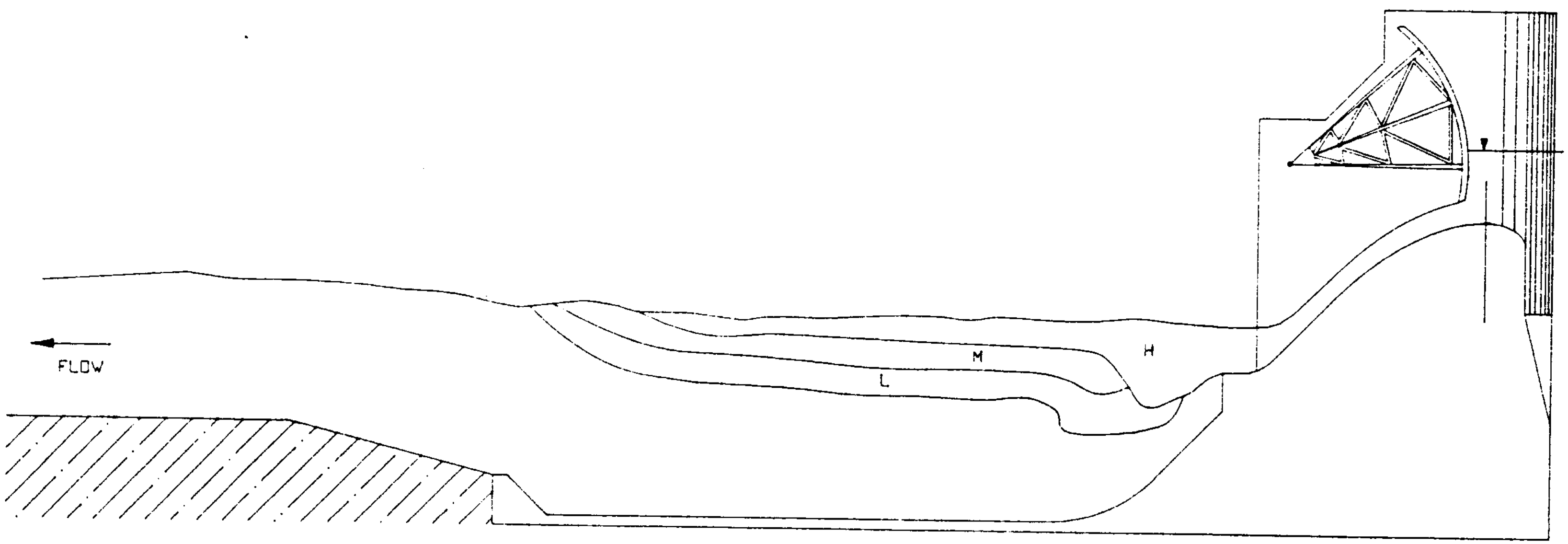
1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 2
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 733
TAILWATER EL 638.0

MARCH 1992

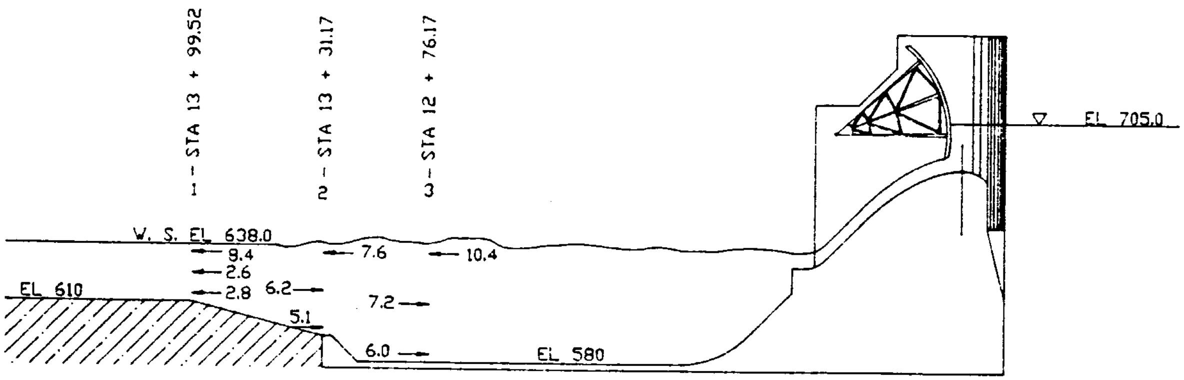

LOWER
GRANITE
POOL 733.0
T. W. 638.0
DISCHARGE
30,000 CFS
MARCH 1992



H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 733.0
TAILWATER EL 638.0

MARCH 1992



NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

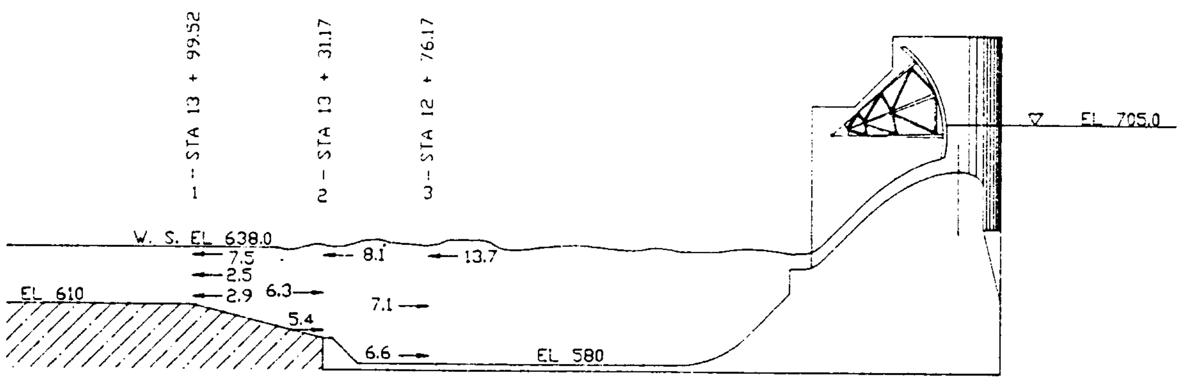
STATION 1

SPILLWAY DISCHARGE 30,000 CFS

POOL EL 705.0

TAILWATER EL 638.0

MARCH 1992



NOTES:

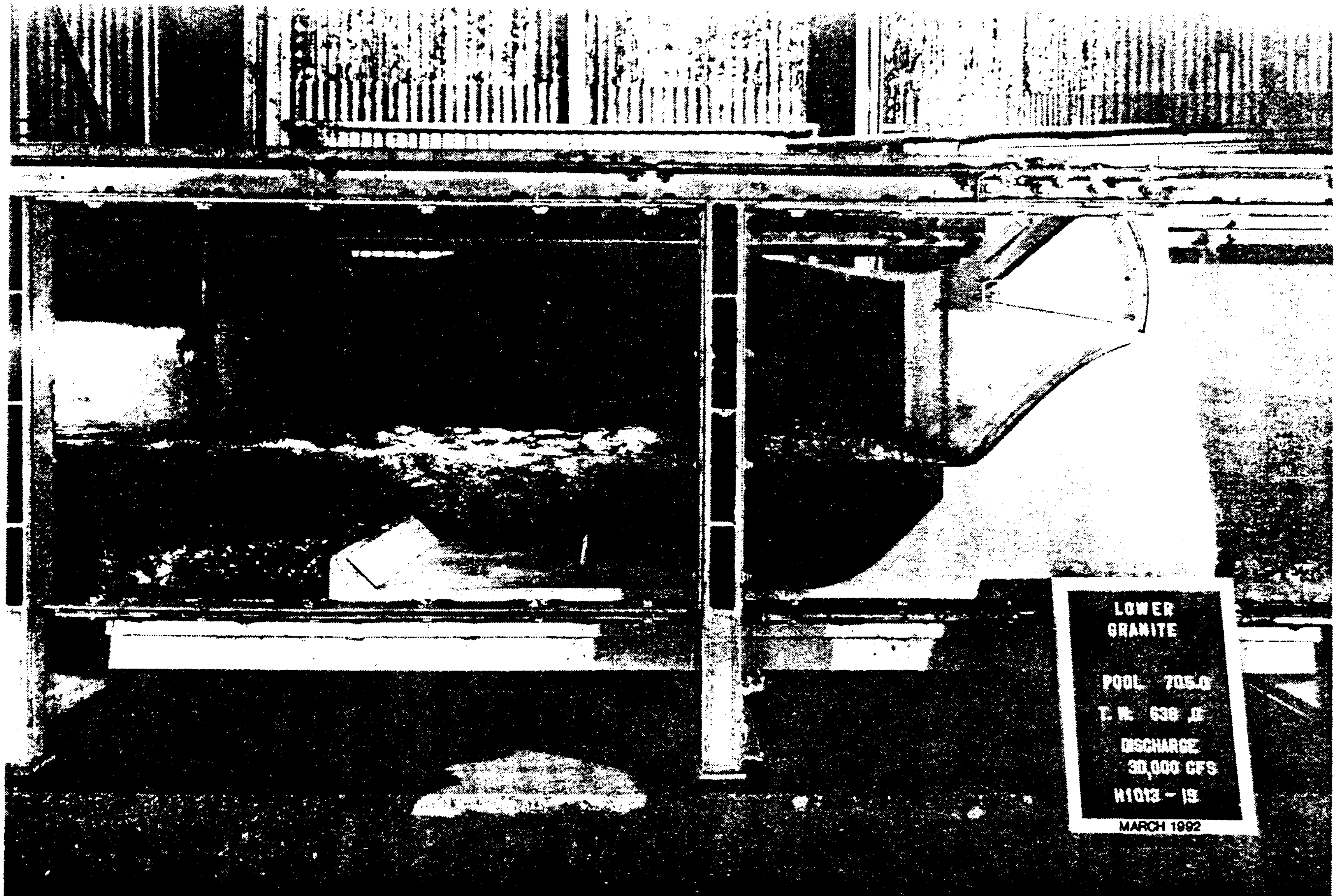
1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

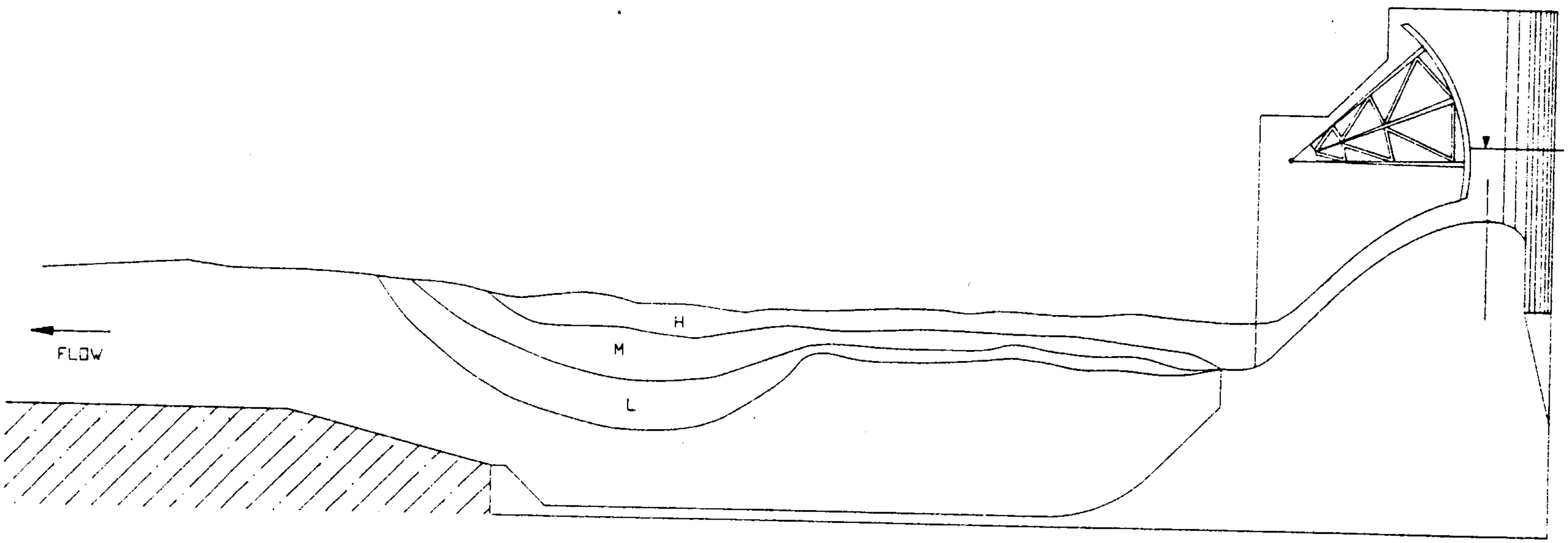
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 2
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 705.0
TAILWATER EL 638.0

MARCH 1992

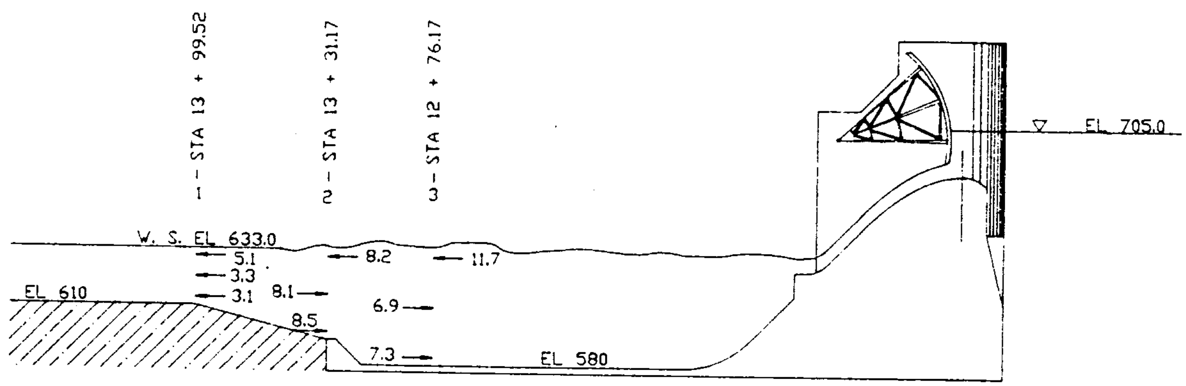

LOWER
GRANITE
POOL 705.0
T. W. 638 .0
DISCHARGE
30,000 CFS
H1013 - 19
MARCH 1992



H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 705.0
TAILWATER EL 638.0

MARCH 1992



NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

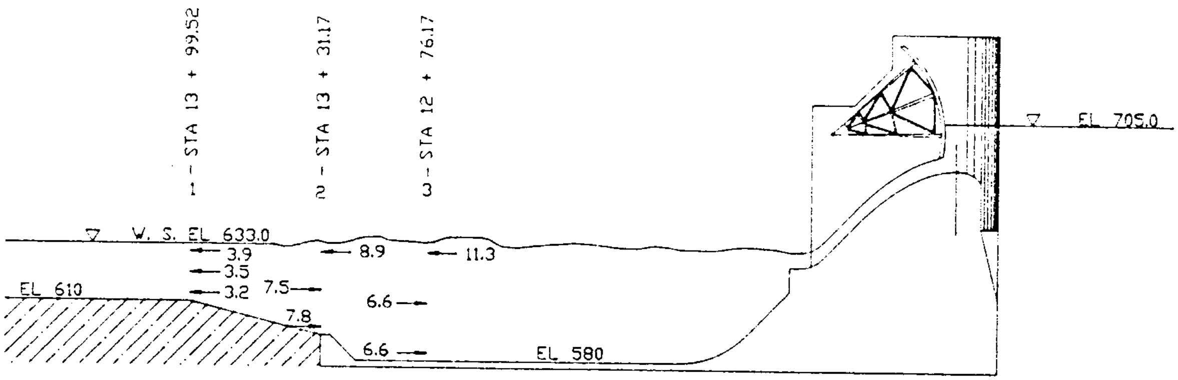
STATION 1

SPILLWAY DISCHARGE 30,000 CFS

POOL EL 705.0

TAILWATER EL 633.0

MARCH 1992



NOTES:

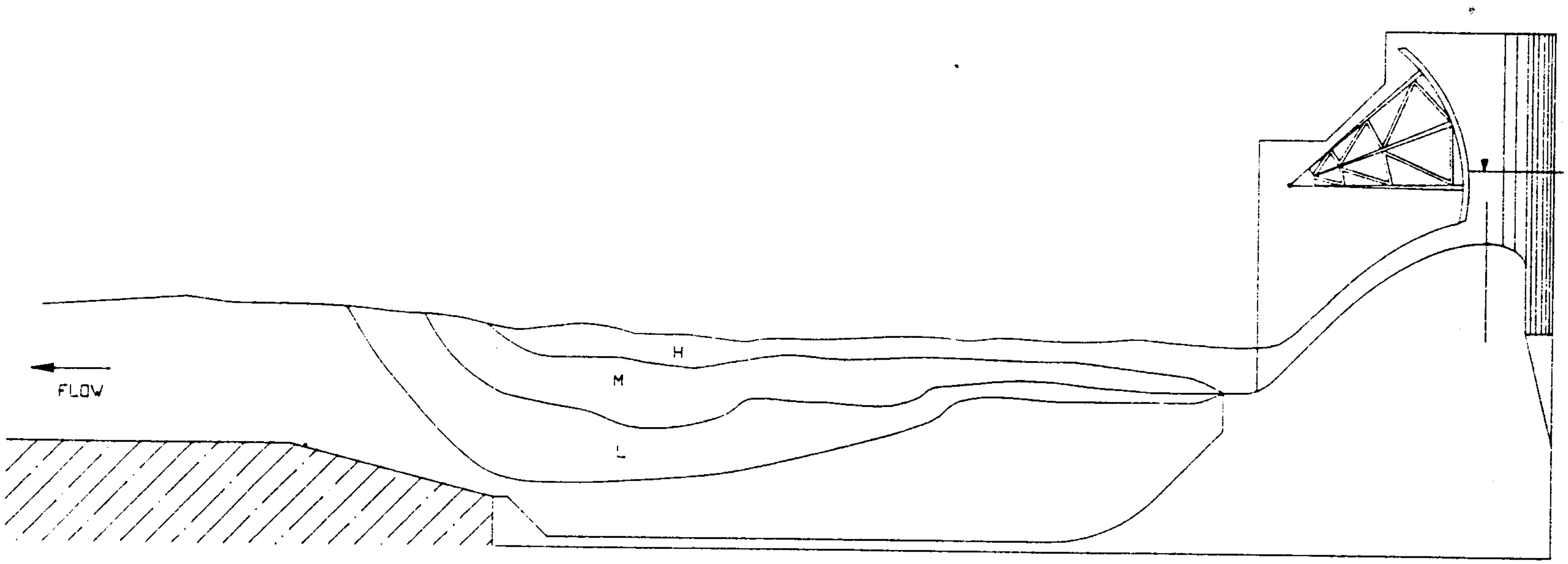
1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 2
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 705.0
TAILWATER EL 633.0

MARCH 1992

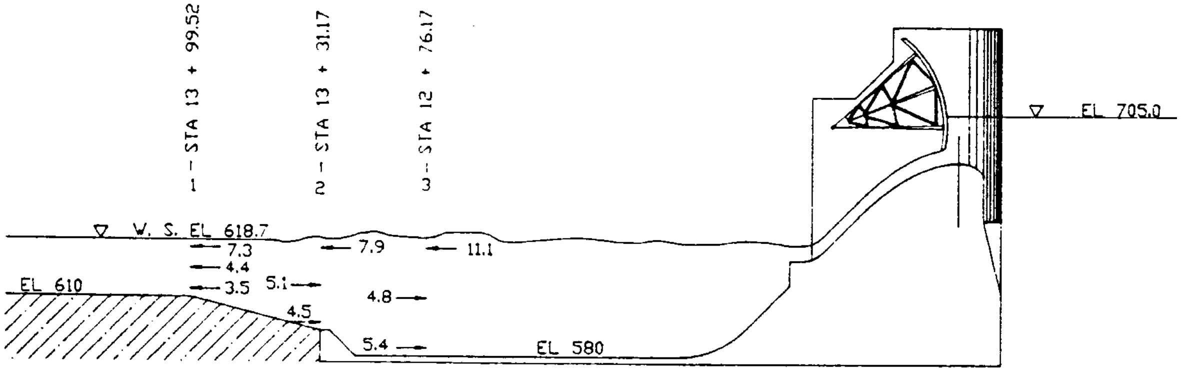

LOWER
GRANITE
POOL 705.0
T.W. 633.0
DISCHARGE
30,000 CFS
H1013 - 20
MARCH 1992



H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 705.0
TAILWATER EL 633.0

MARCH 1992

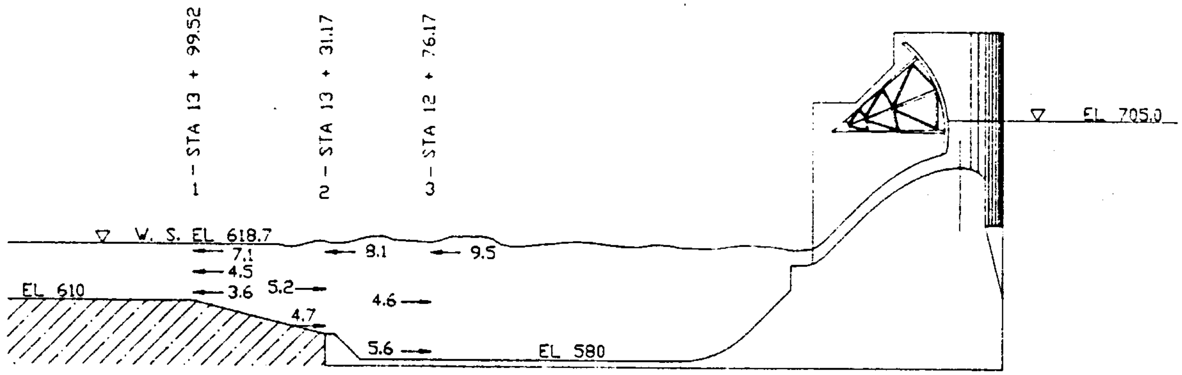


NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS
STATION 1
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 705.0
TAILWATER EL 618.7

MARCH 1992



NOTES:

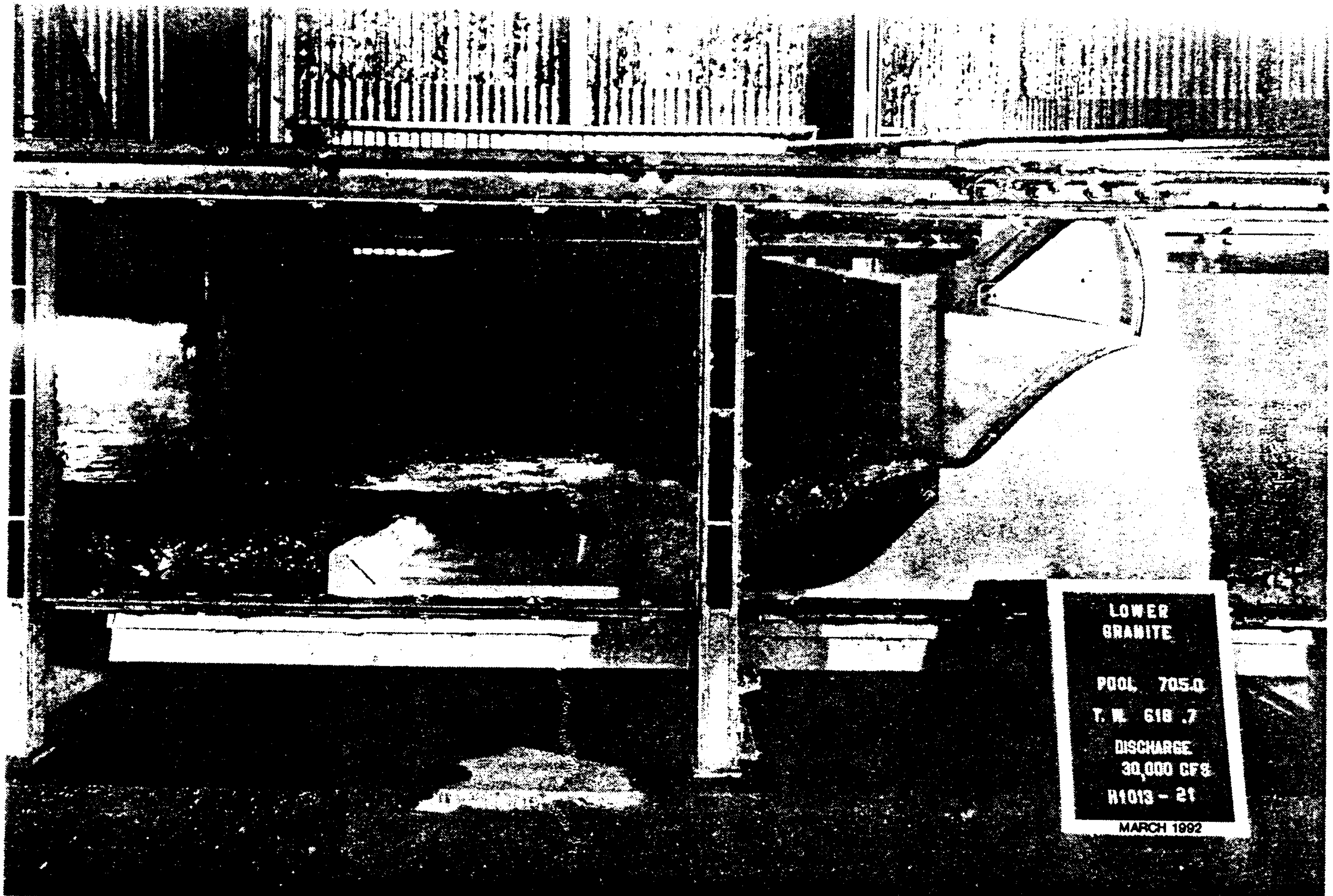
1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

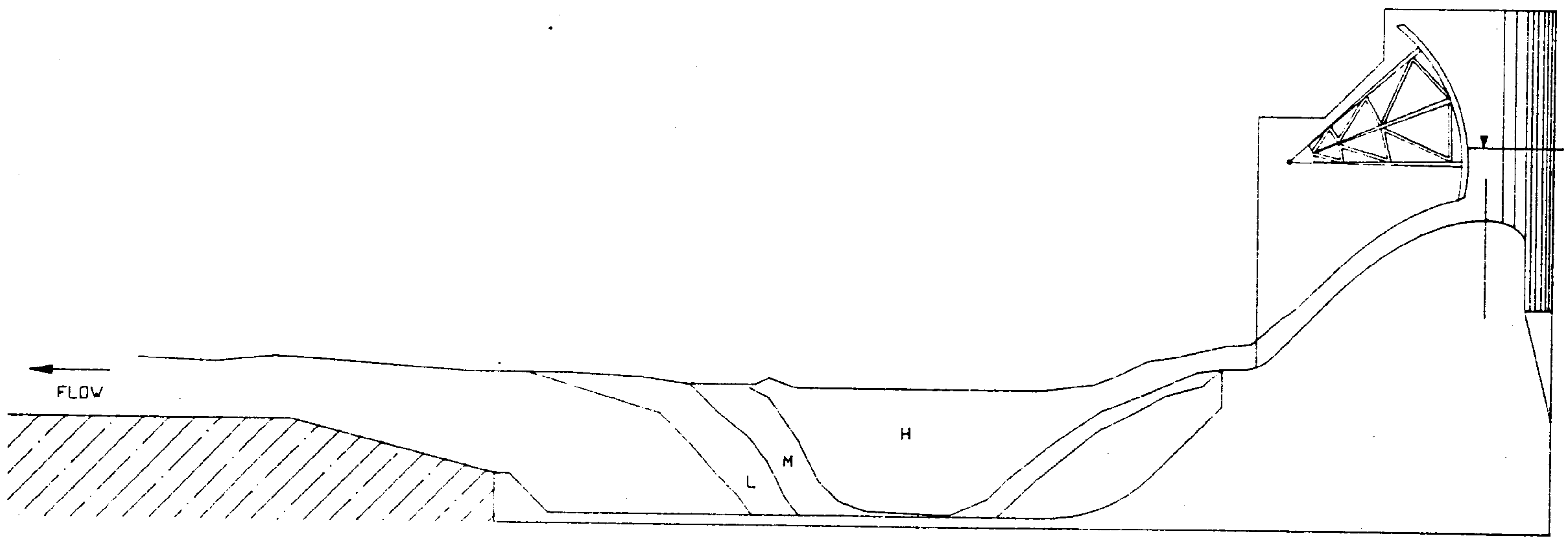
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 2
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 705.0
TAILWATER EL 618.7

MARCH 1992

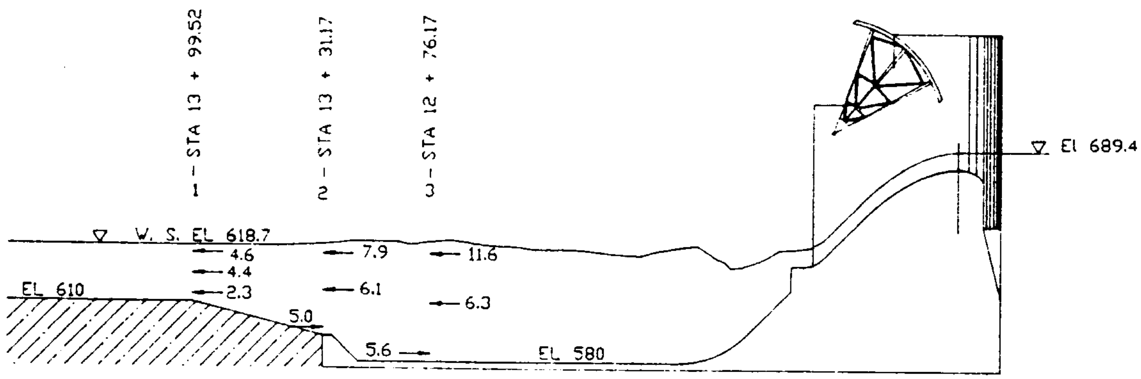

LOWER
GRANITE
POOL 705.0
T.W. 618.7
DISCHARGE
30,000 CFS
H1013 - 21
MARCH 1992



H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 705
TAILWATER EL 618.7

MARCH 1992



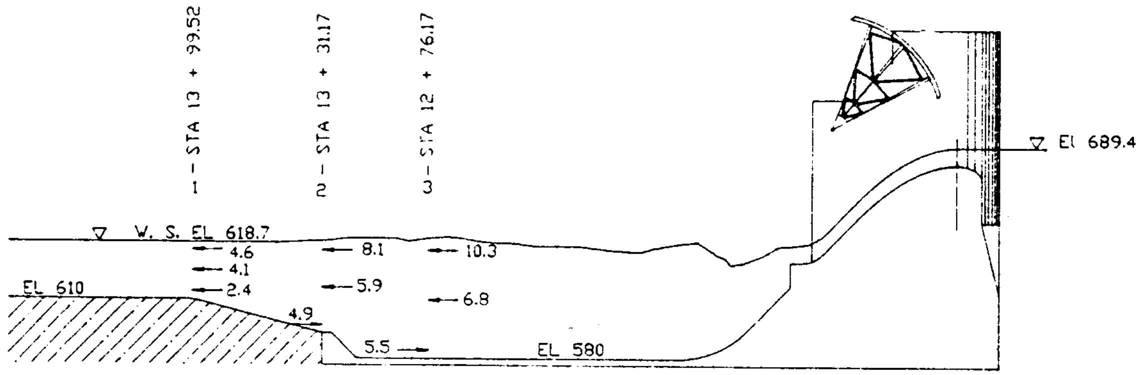
NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 1
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 689.4
TAILWATER EL 618.7

MARCH 1992



NOTES:

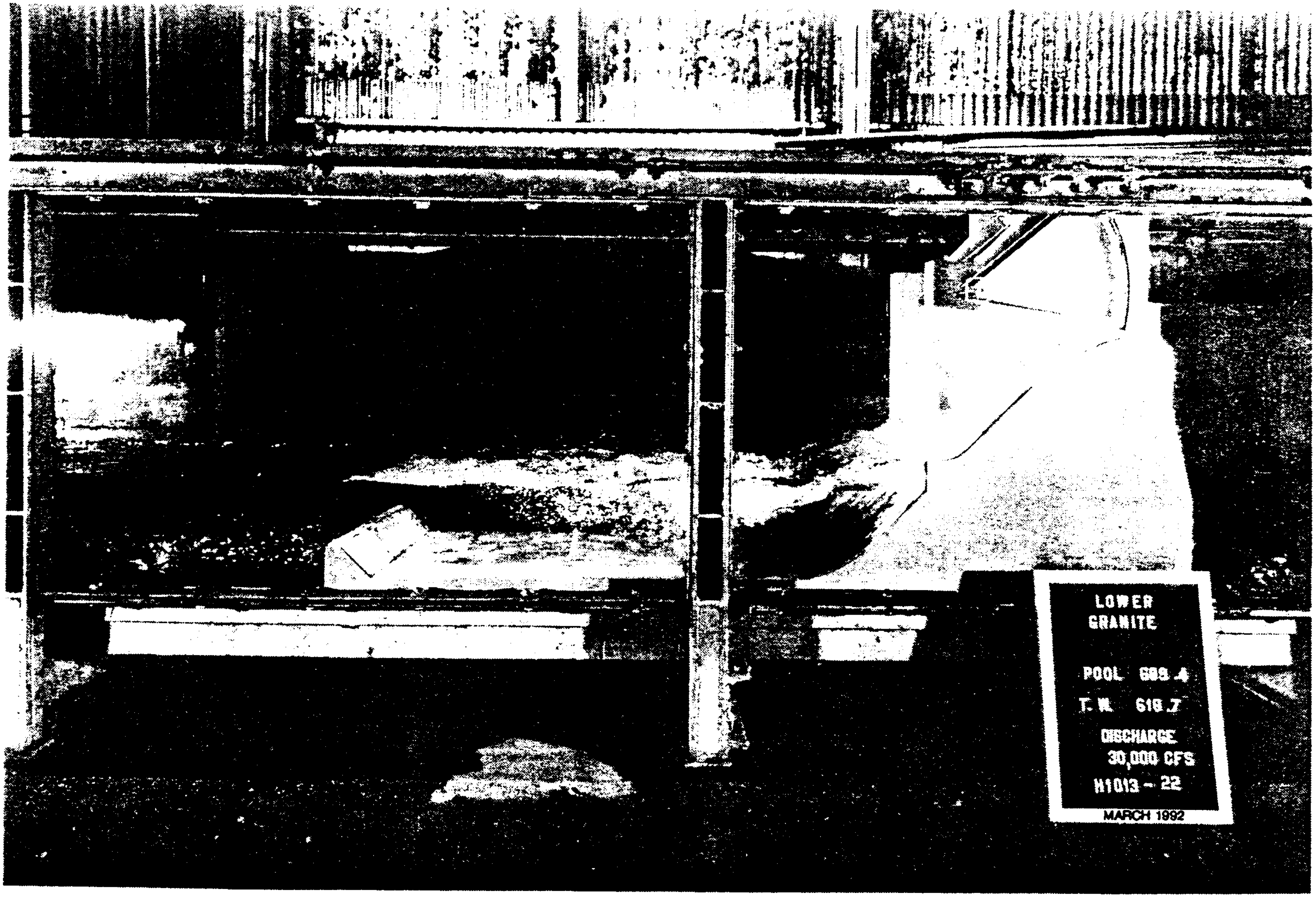
1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

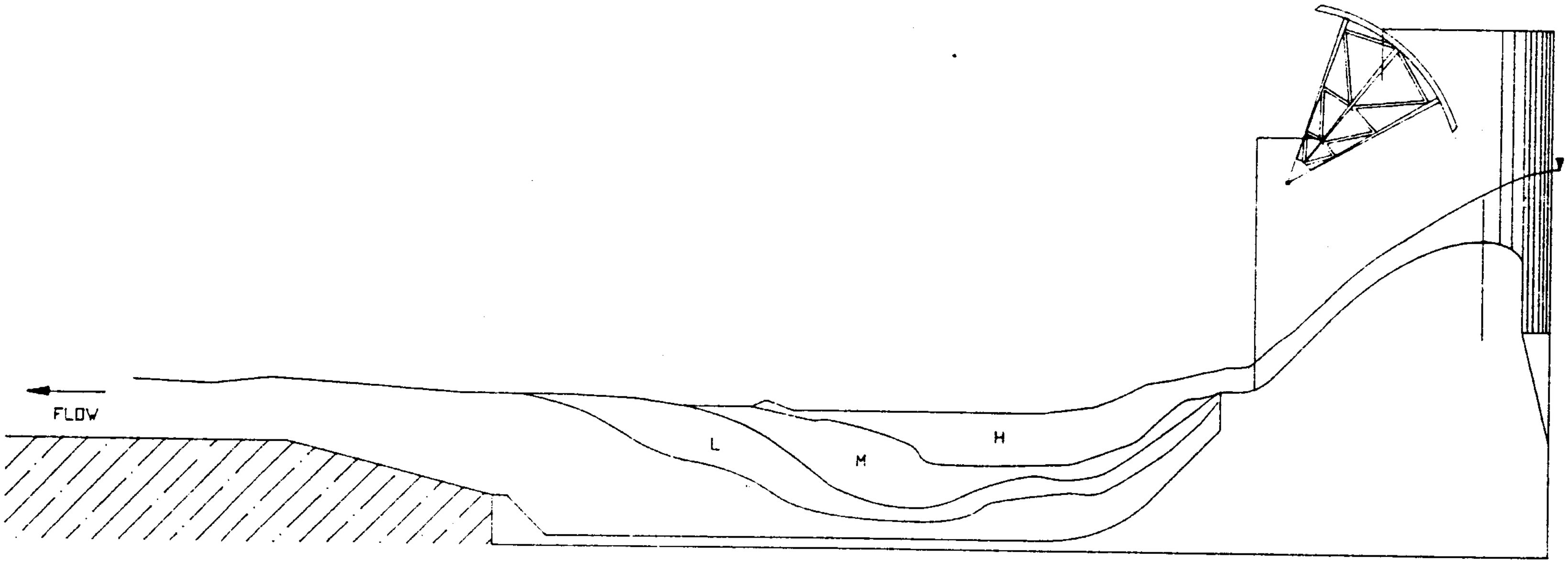
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 2
SPILLWAY DISCHARGE 30,000 CFS
POOL EL 689.4
TAILWATER EL 618.7

MARCH 1992


LOWER
GRANITE
POOL
T. W.
DISCHARGE
30,000 CFS
H1013 - 22
MARCH 1992

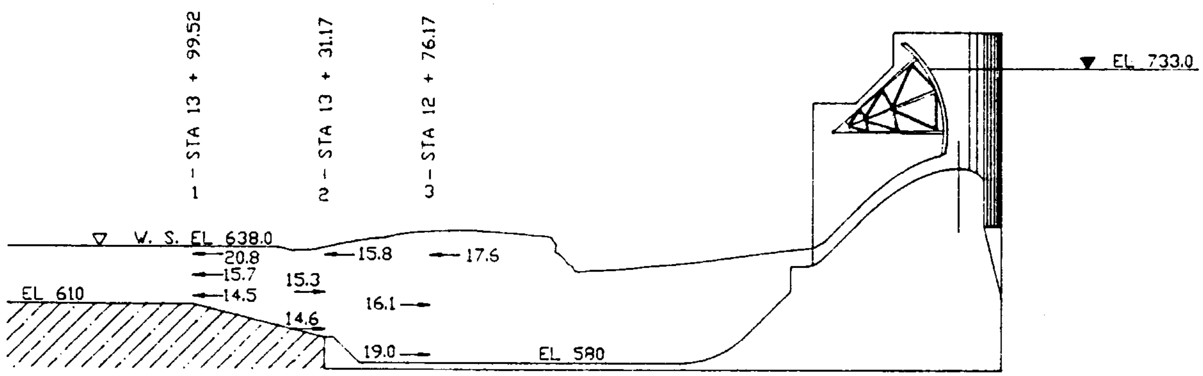


H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT

SPILLWAY DISCHARGE 30,000 CFS
POOL EL 689.4
TAILWATER EL 618.7
FREE FLOW

MARCH 1992



NOTES:

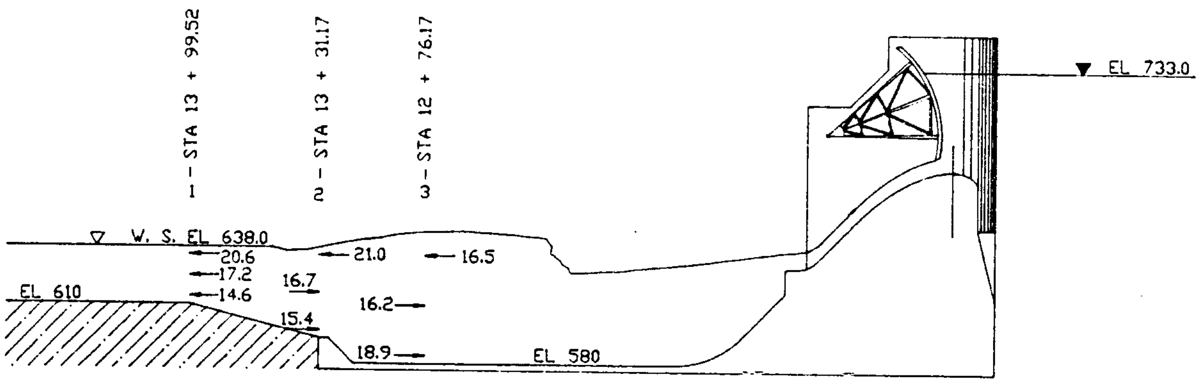
1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 1
SPILLWAY DISCHARGE 100,000 CFS
POOL EL 733
TAILWATER EL 638.0

MARCH 1992



NOTES:

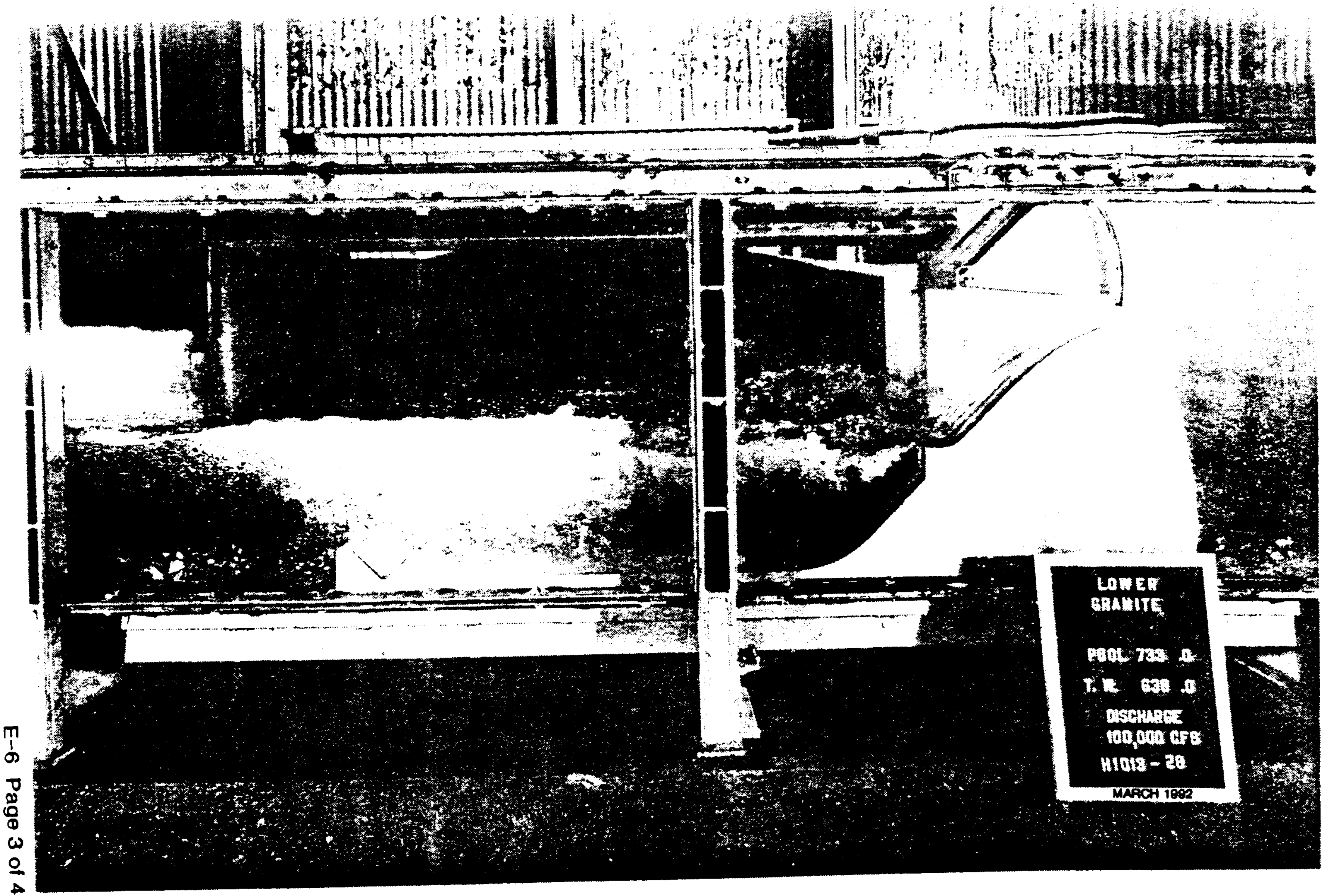
1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

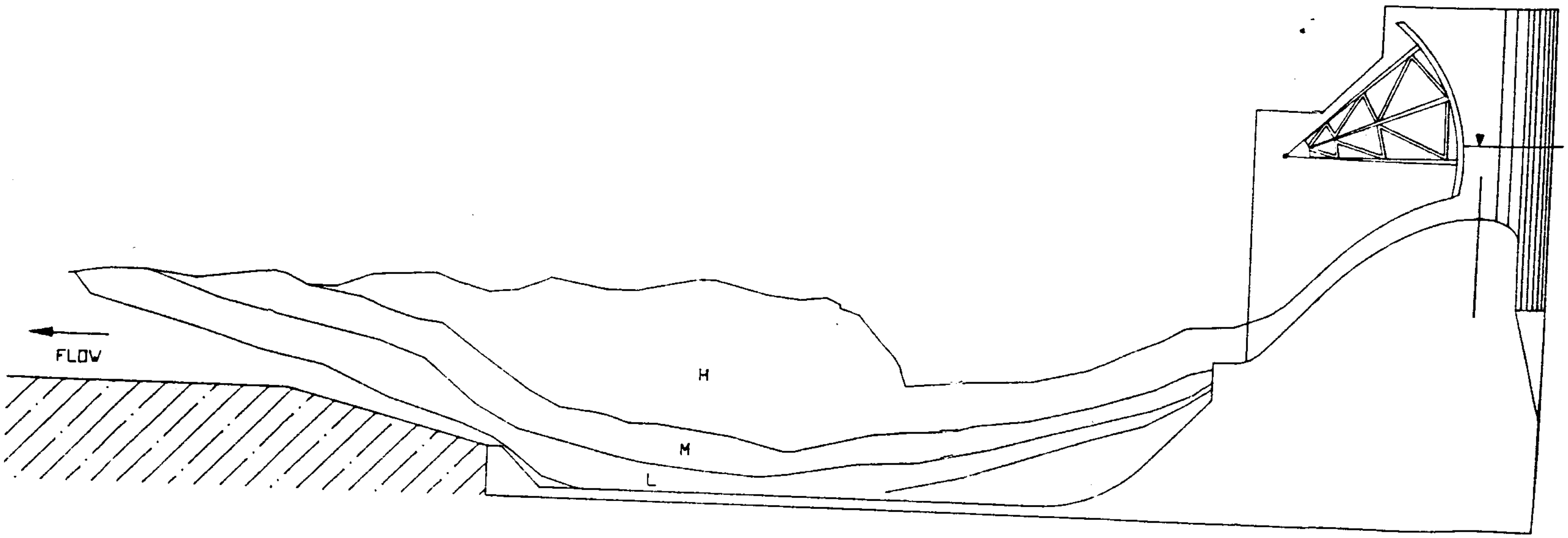
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 2
SPILLWAY DISCHARGE 100,000 CFS
POOL EL 733
TAILWATER EL 638.0

MARCH 1992


LOWER
GRANITE
POOL 733 .0
T. W. 638 .0
DISCHARGE
100,000 CFS
H1013 - 28
MARCH 1992

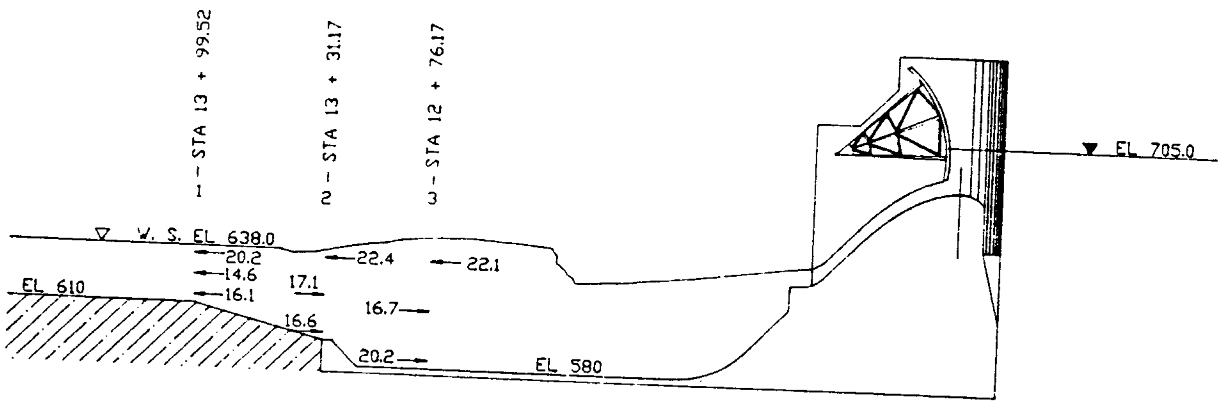


H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT

SPILLWAY DISCHARGE 100,000 CFS
POOL EL 733.0
TAILWATER EL 638.0

MARCH 1992



NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

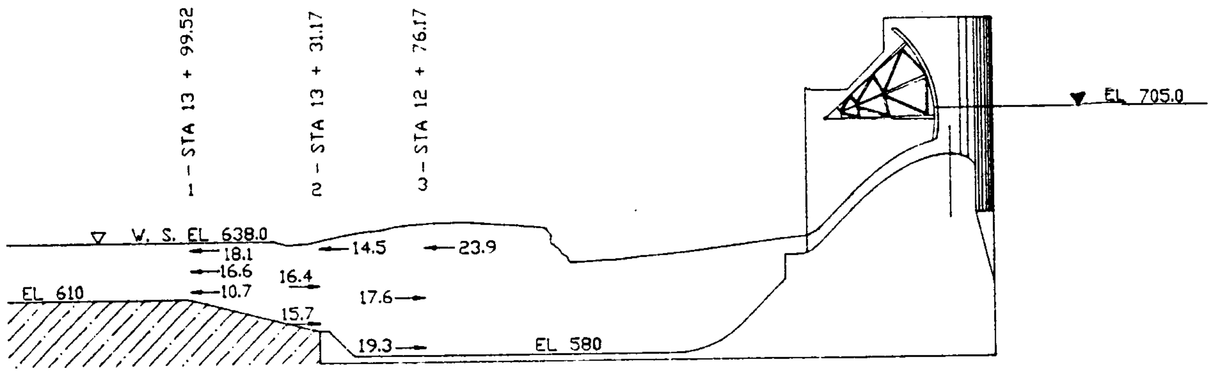
STATION 1

SPILLWAY DISCHARGE 100,000 CFS

POOL EL 705.0

TAILWATER EL 638.0

MARCH 1992



NOTES:

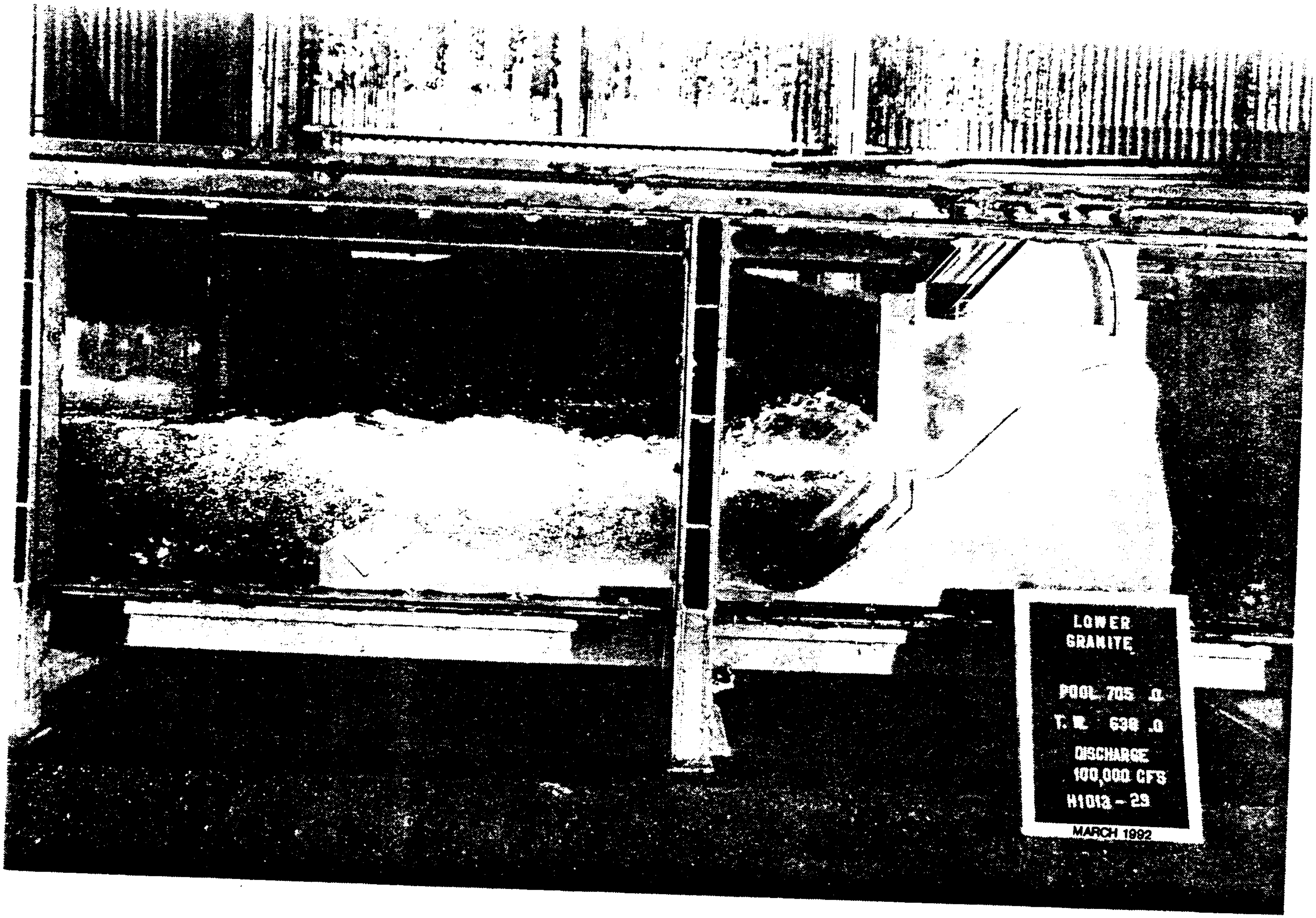
1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

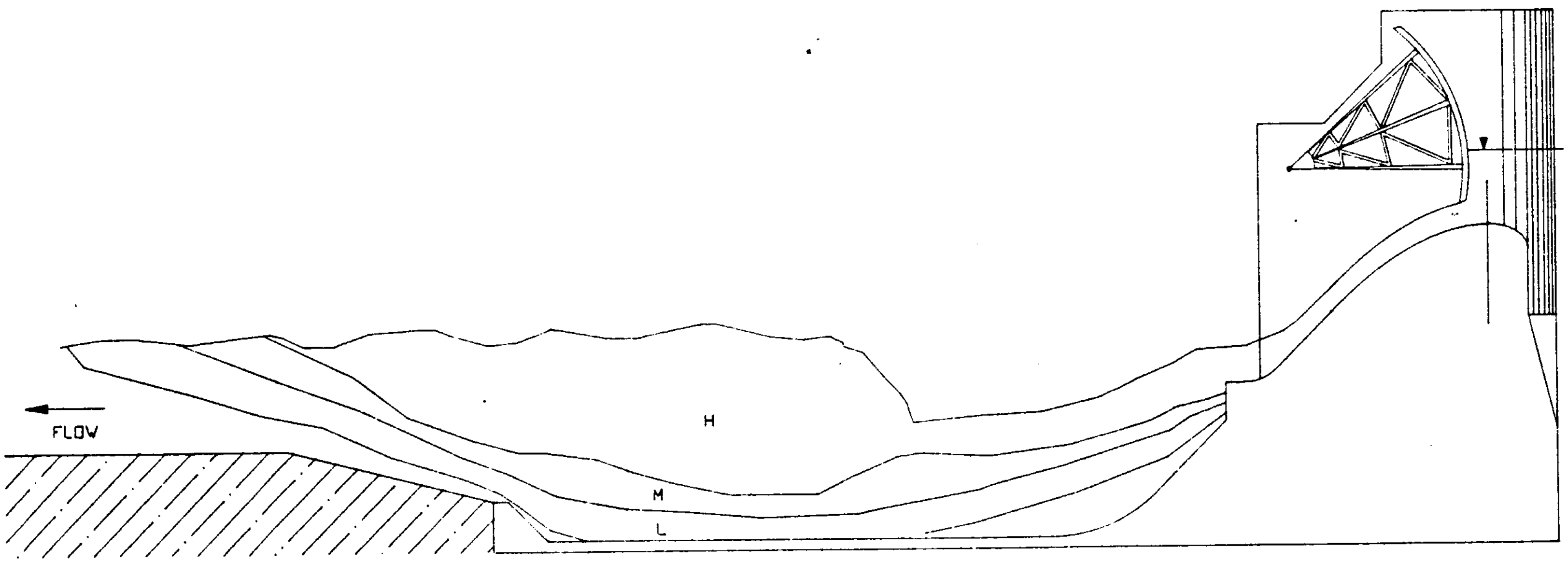
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 2
SPILLWAY DISCHARGE 100,000 CFS
POOL EL 705.0
TAILWATER EL 638.0

MARCH 1992


LOWER
GRANITE
POOL 705 .0
T.W. 638 .0
DISCHARGE
100,000 CFS
H1013 - 29
MARCH 1992

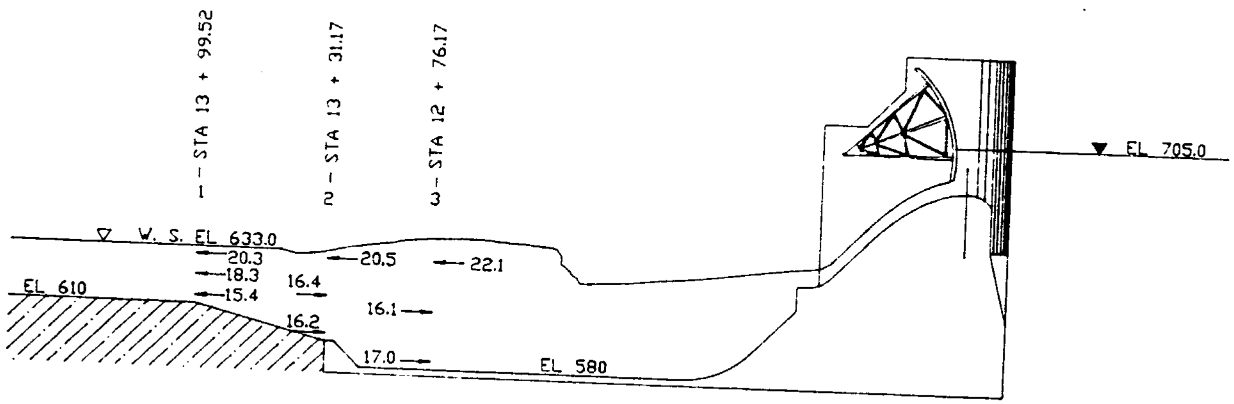


H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT

SPILLWAY DISCHARGE 100,000 CFS
POOL EL 705.0
TAILWATER EL 638.0

MARCH 1992



NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

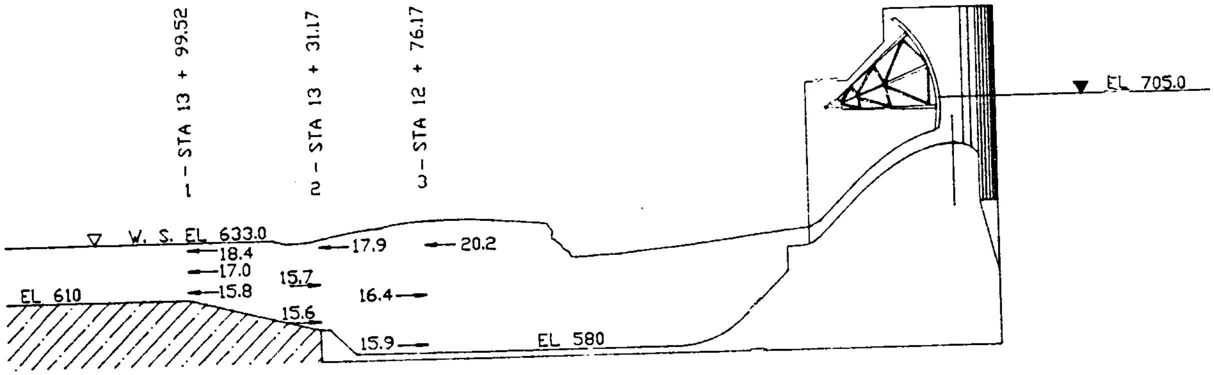
STATION 1

SPILLWAY DISCHARGE 100,000 CFS

POOL EL 705.0

TAILWATER EL 633.0

MARCH 1992



NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

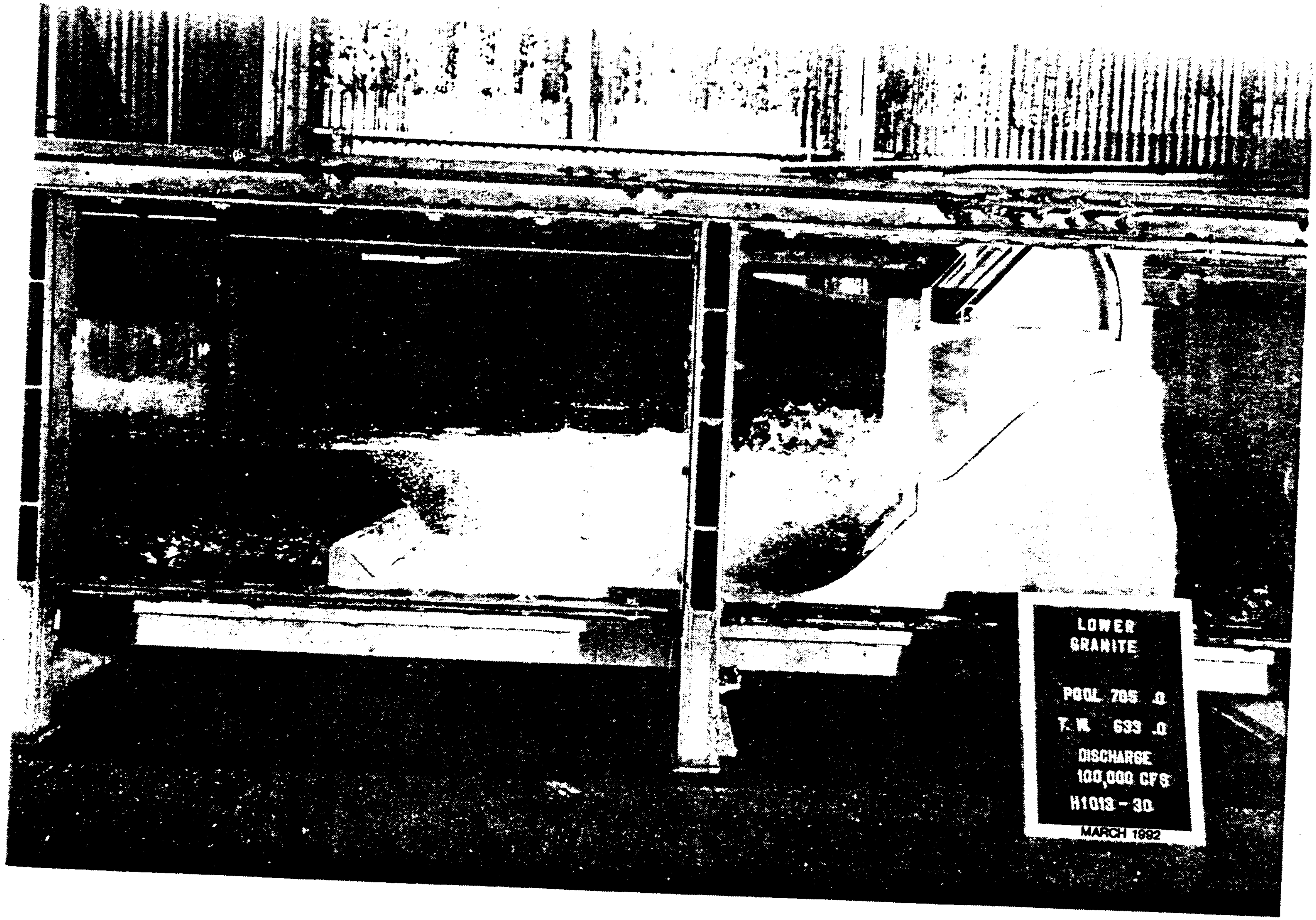
STATION 2

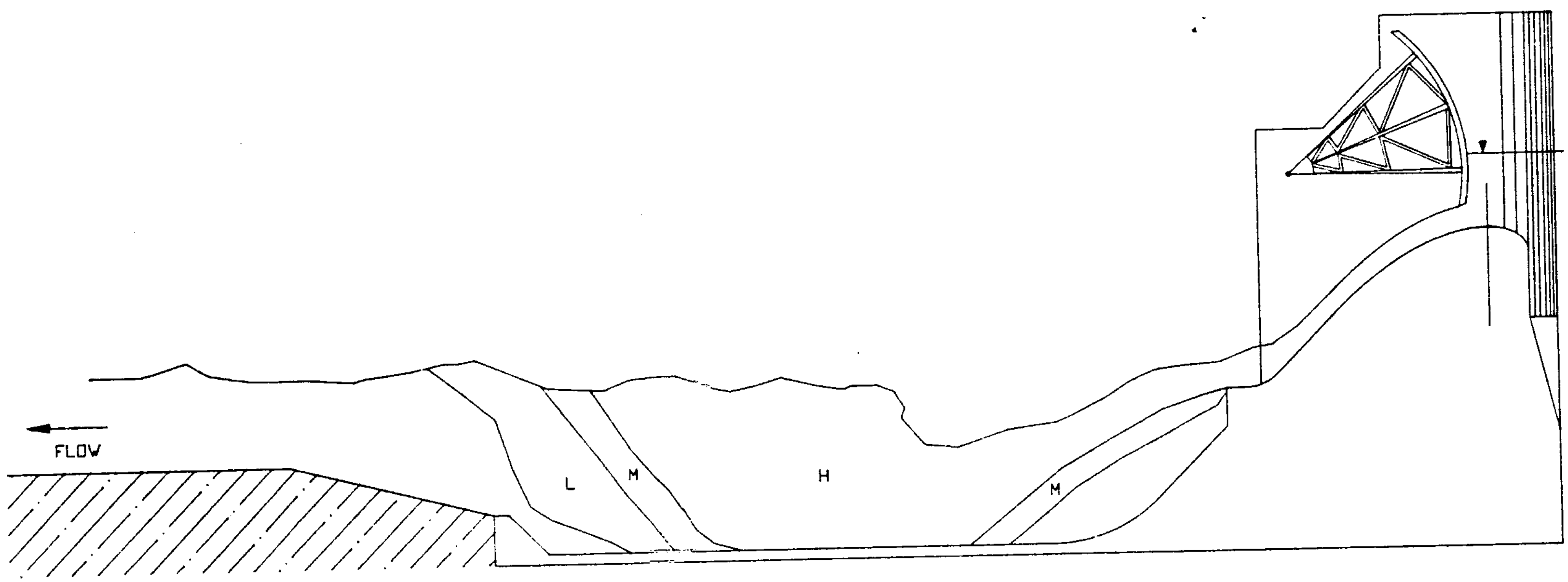
SPILLWAY DISCHARGE 100,000 CFS

POOL EL 705.0

TAILWATER EL 633.0

MARCH 1992


LOWER
GRANITE
POOL 705 .0
T.W. 633 .0
DISCHARGE
100,000 CFS
H1013 - 30
MARCH 1992

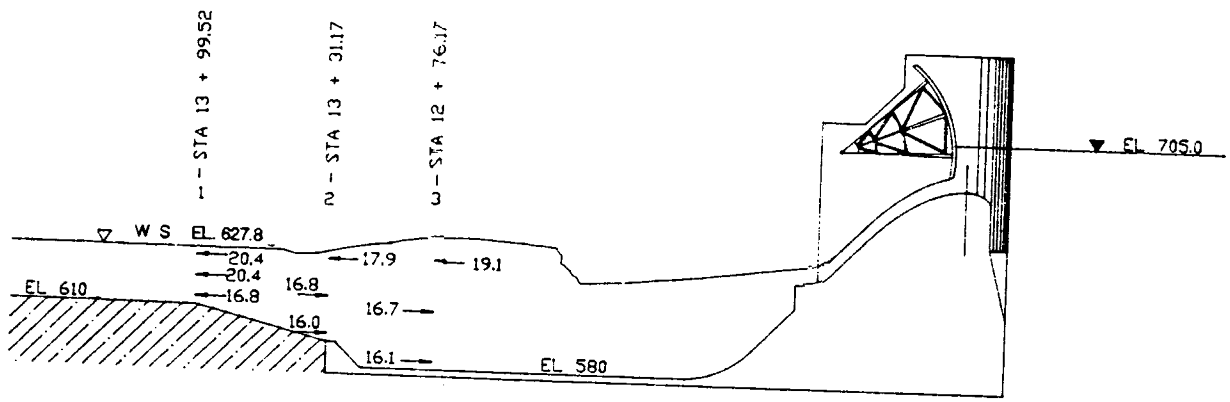


H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT

SPILLWAY DISCHARGE 100,000 CFS
POOL EL 705.0
TAILWATER EL 633.0

MARCH 1992



NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

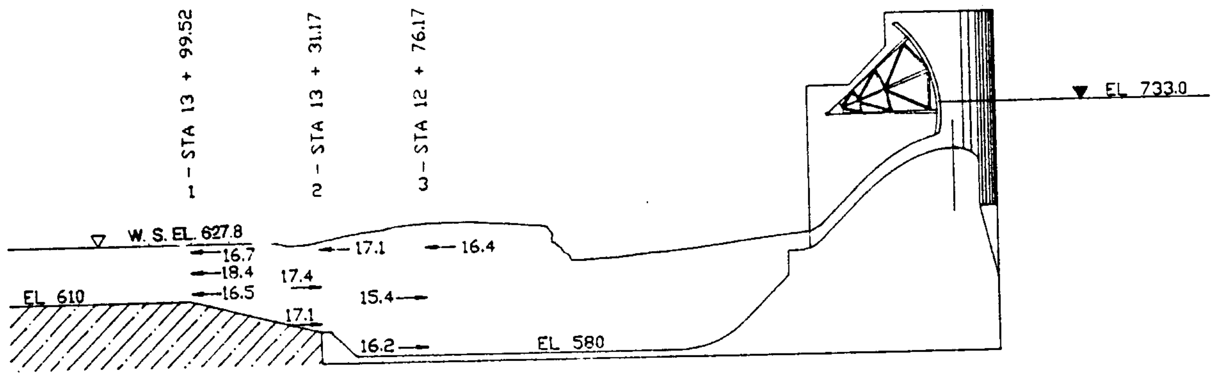
STATION 1

SPILLWAY DISCHARGE 100,000 CFS

POOL EL 705.0

TAILWATER EL. 627.8

MARCH 1992



NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.

2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

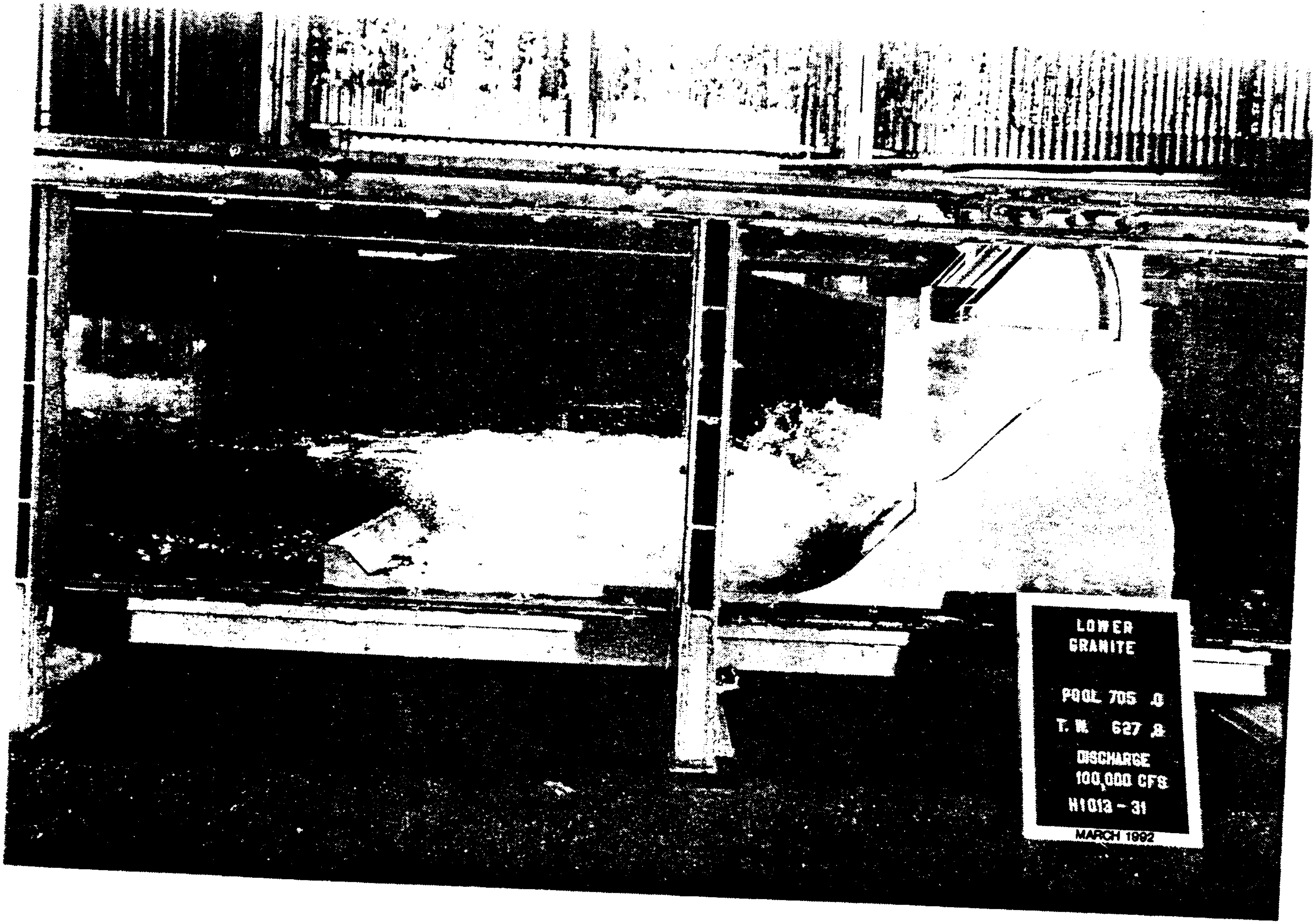
STATION 2

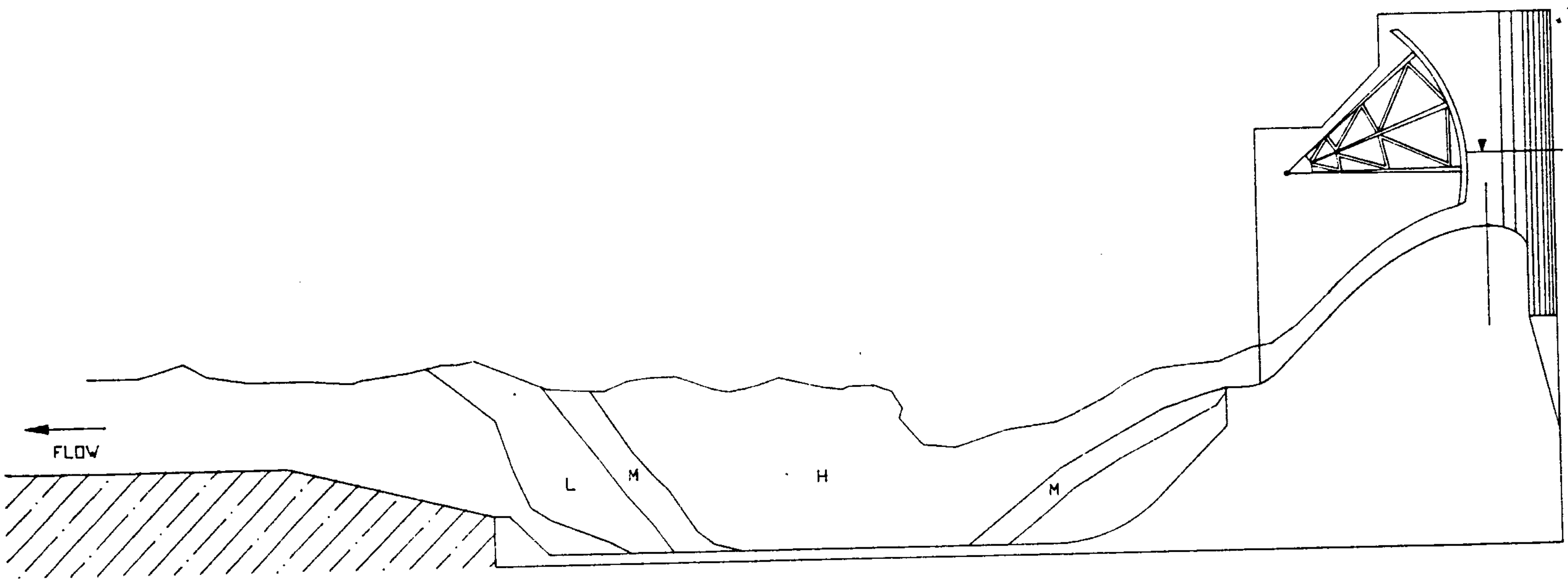
SPILLWAY DISCHARGE 100,000 CFS

POOL EL 705.0

TAILWATER EL. 627.8

MARCH 1992

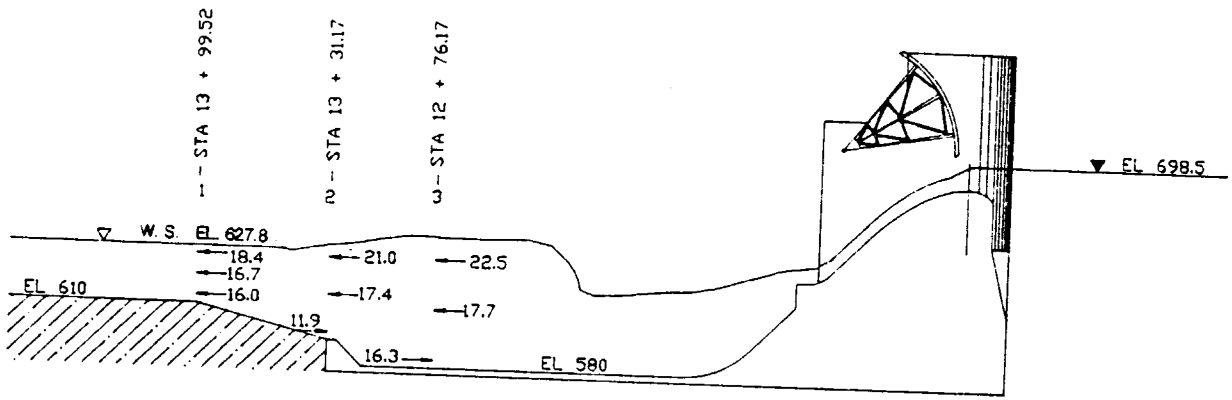

LOWER
GRANITE
POOL 705 .0
T. W. 627 .8
DISCHARGE
100,000 CFS
H1013 - 31
MARCH 1992



H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

AIR ENTRAINMENT
SPILLWAY DISCHARGE 100,000 CFS
POOL EL 705.0
TAILWATER 627.8

MARCH 1992



NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS

STATION 1

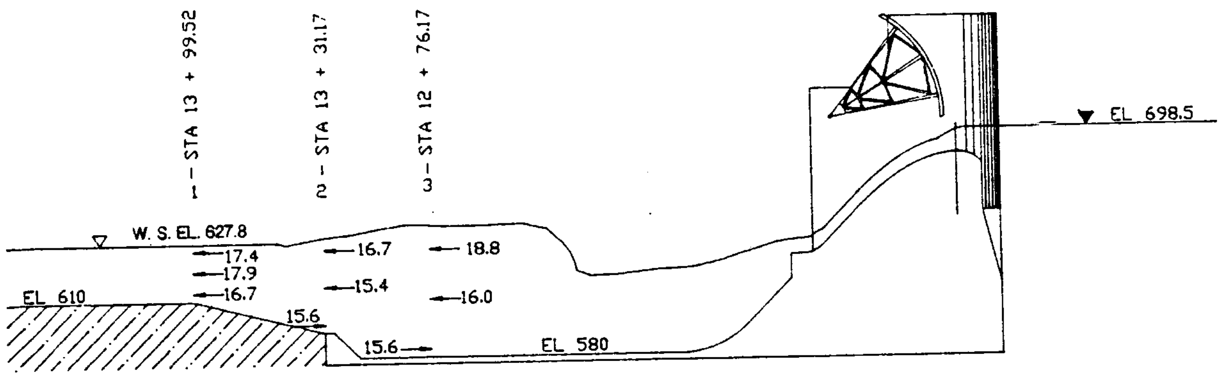
SPILLWAY DISCHARGE 100,000 CFS

POOL EL 698.5

TAILWATER EL. 627.8

FREE FLOW

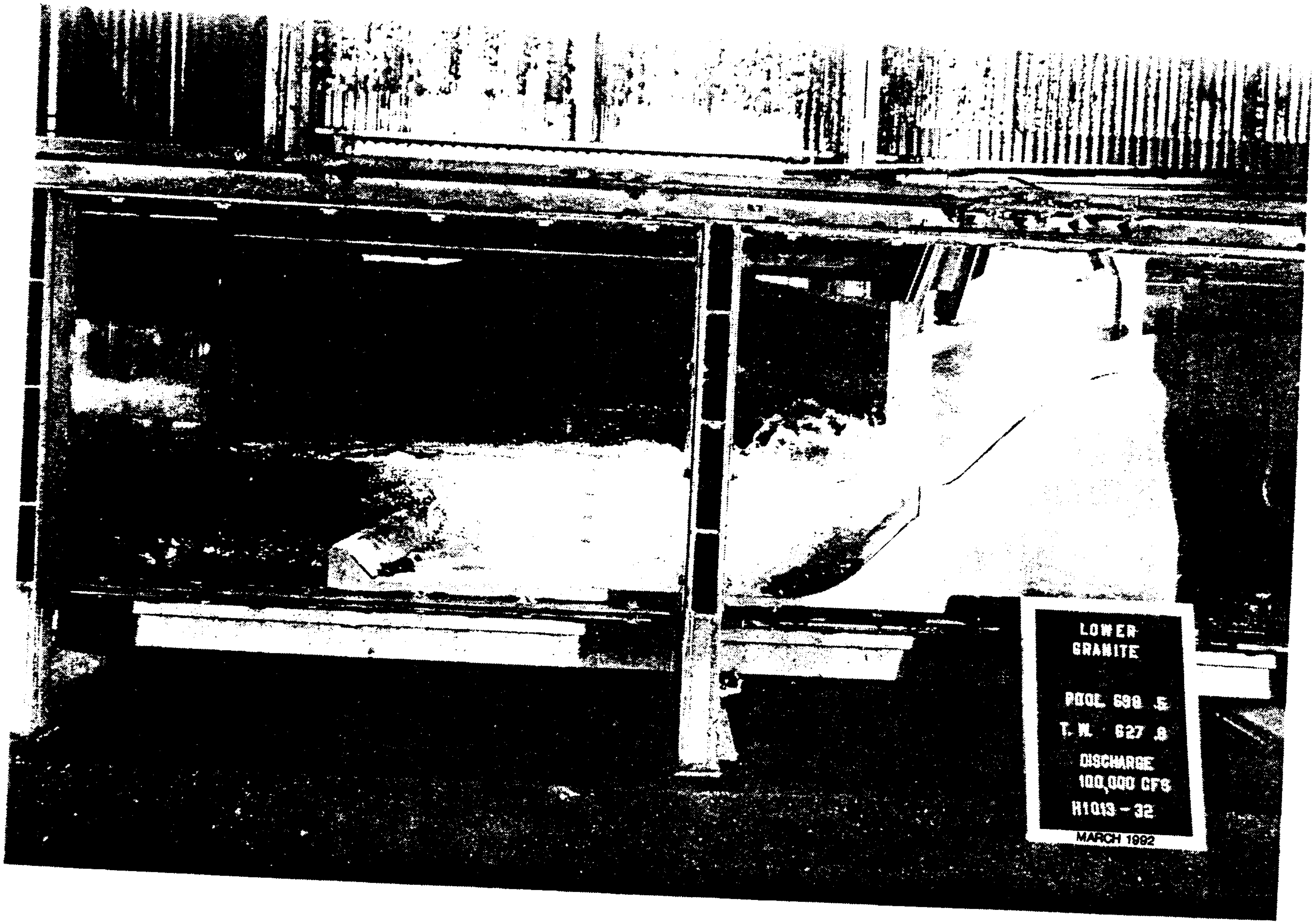
MARCH 1992

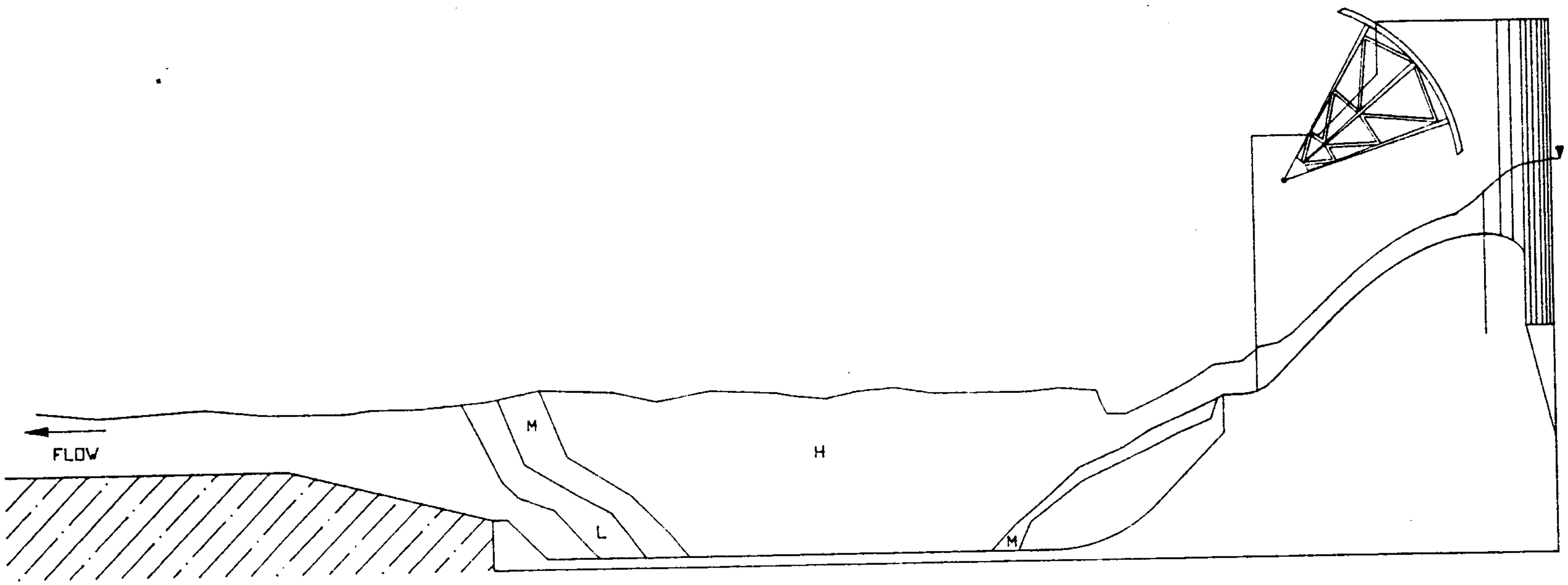


NOTES:

1. VELOCITIES IN FEET PER SECOND AND LOCATED 4 FEET BELOW THE SURFACE, MIDDEPTH, AND 4 FEET ABOVE THE BOTTOM.
2. VELOCITIES AND FLOW PATTERNS SHOWN INDICATE AVERAGE VALUES AND DIRECTIONS. FLOW CONDITIONS WITHIN THE BASIN ARE ACTUALLY HIGHLY UNSTABLE WITH FLUCTUATING VELOCITIES AND CHANGING FLOW DIRECTIONS.

VELOCITY MEASUREMENTS
STATION 2
SPILLWAY DISCHARGE 100,000 CFS
POOL EL 698.5
TAILWATER EL. 627.8
FREE FLOW
MARCH 1992


LOWER
GRANITE
POOL 698 .5
T.W. 627 .8
DISCHARGE
100,000 CFS
H1013 - 32
MARCH 1992



H - HIGH CONCENTRATION OF AIR
M - MEDIUM CONCENTRATION OF AIR
L - LIGHT CONCENTRATION OF AIR

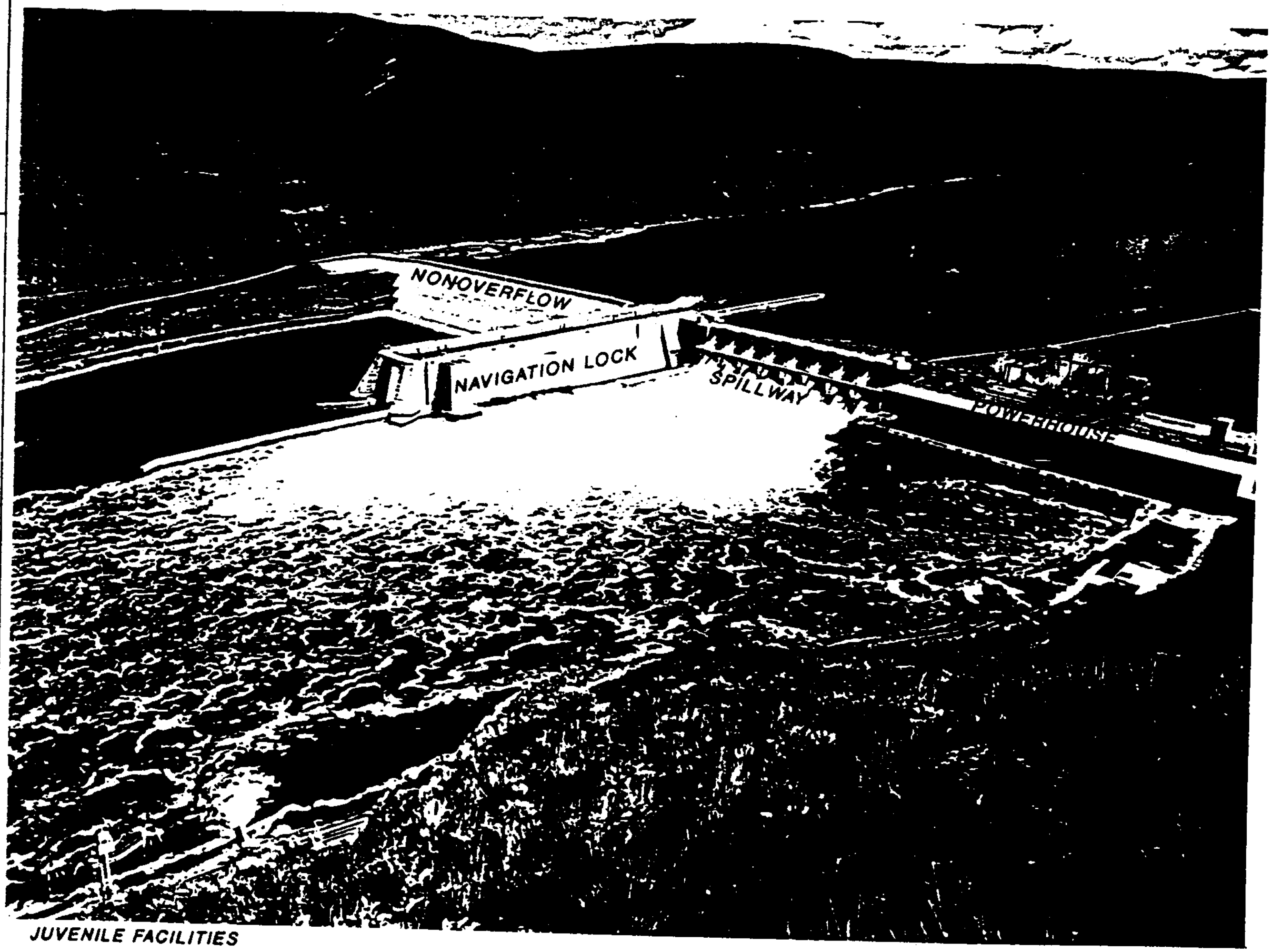
AIR ENTRAINMENT
SPILLWAY DISCHARGE 100,000 CFS
POOL EL 698.5
TAILWATER EL 627.8
FREE FLOW

MARCH 1992

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



JUVENILE FACILITIES

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE

L.LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
PHOTO

COMPUTER AIDED DESIGN & DRAFTING

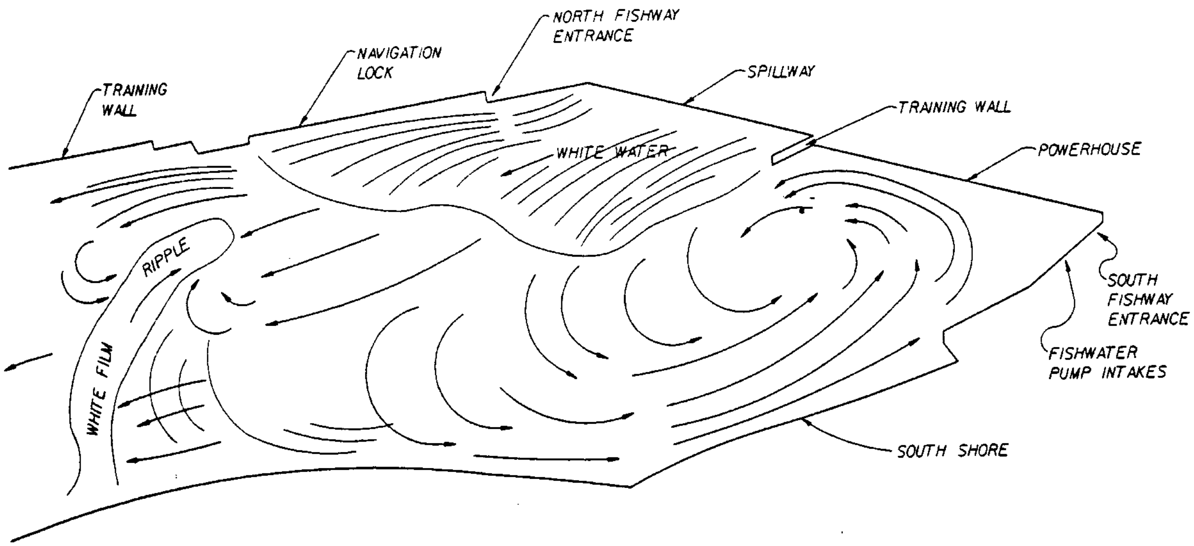
NOV. 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-1

VALUE ENGINEERING PAYS

CORPS OF ENGINEERS | SAFETY PAYS | U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 28.5 KCFS

REPRESENTATIVE TAILWATER EL. = 637.3 FMSL
FOREBAY EL. = 705.1 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED BY: L.REESE
DRAWN BY: J.LEIGH

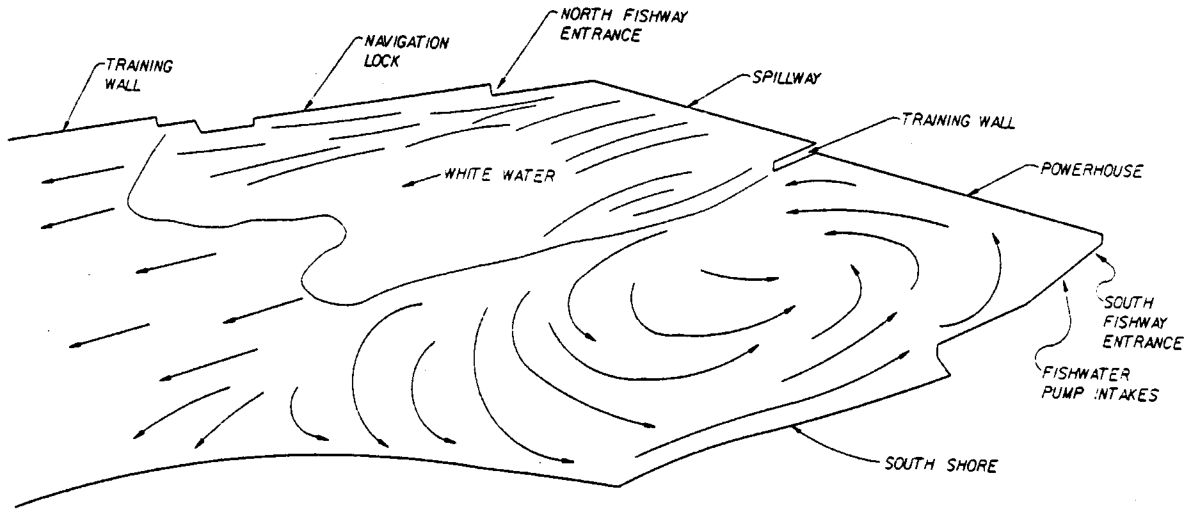
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 1-A, 15 MARCH 1992

DATE: NOV. 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-2

VALUE ENGINEERING PAYS



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES. BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 106.5 KCFS

REPRESENTATIVE TAILWATER EL. = 638.9 FMSL
FOREBAY EL. = 704.4 FMSL

COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 1-B, 15 MARCH 1992

NOV. 1992

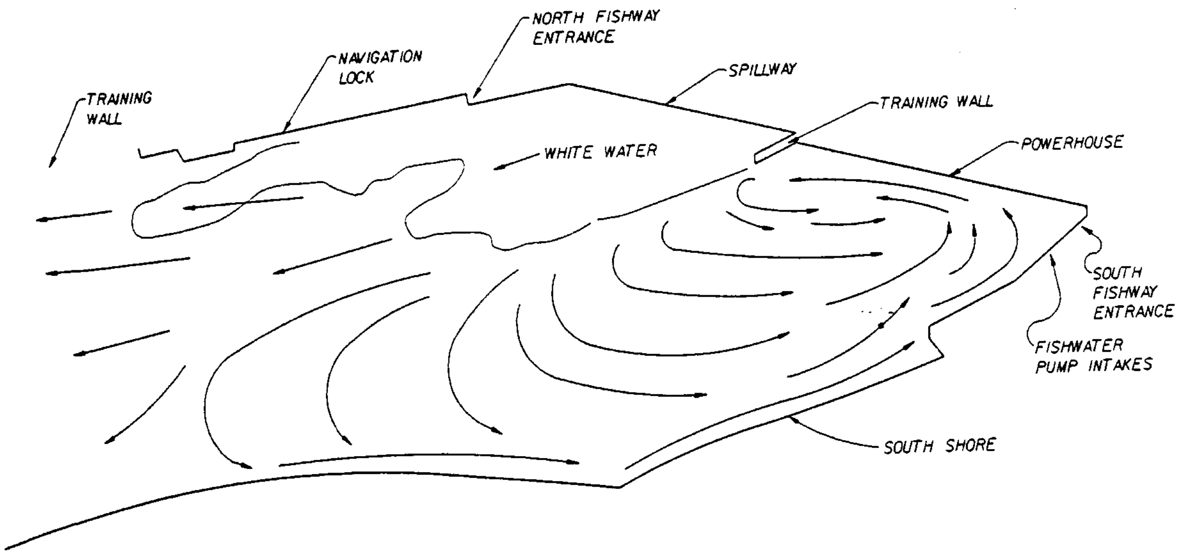
SCALE AS SHOWN | INV. NO.

ENCLOSURE F-3

U. S. ARMY

CORPS OF ENGINEERS

SAFETY PAYS



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 28.5 KCFS

REPRESENTATIVE TAILWATER EL. = 635.0 FMSL
FOREBAY EL. = 705.0 FMSL

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 2-A, 16 MARCH 1992

DESIGNED BY: L.REESE
DRAWN BY: J.LEIGH
CHECKED BY: M

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

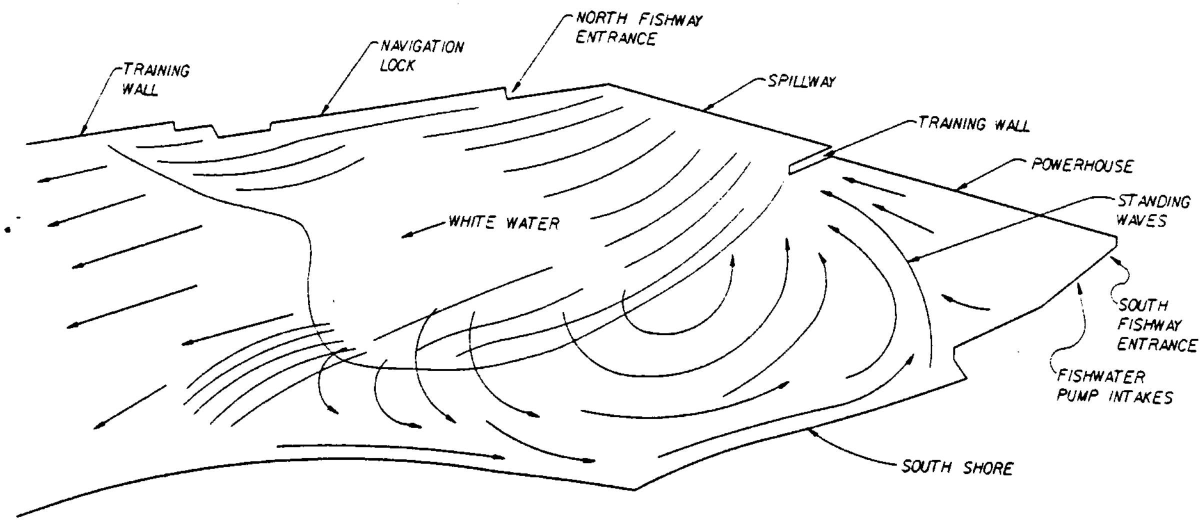
ENCLOSURE F-4

VALUE ENGINEERING PAYS

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 23.0 KCFS
SPILLWAY = 81.4 KCFS
(TOTAL = 104.4 KCFS)
REPRESENTATIVE TAILWATER EL. = 637.2 FMSL
FOREBAY EL. = 704.0 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.
4. POWERHOUSE UNITS 1 AND 2 OPERATING.

Computer Aided Design & Drafting

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

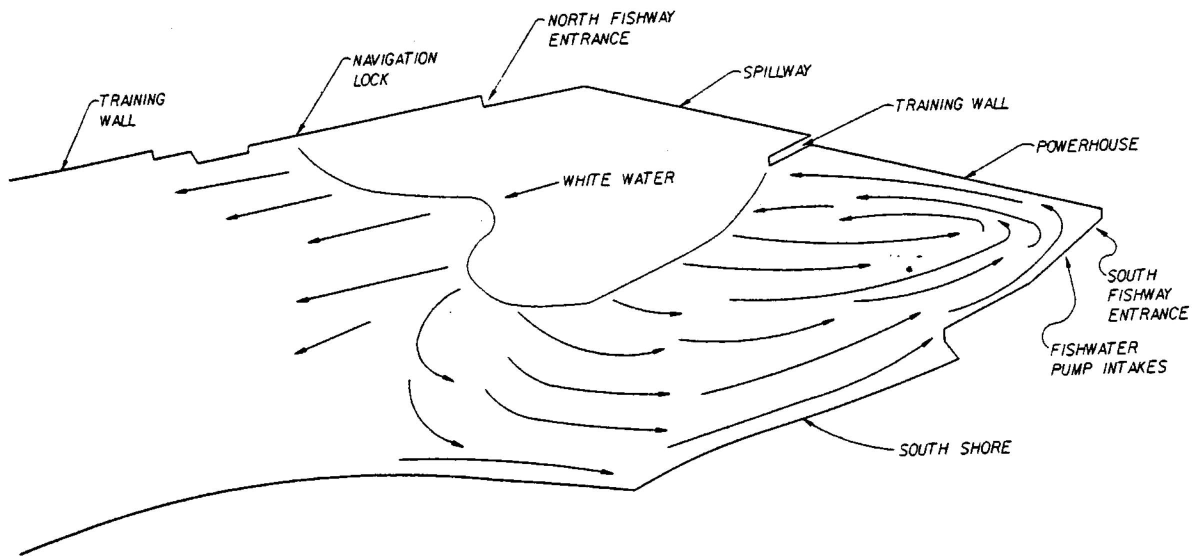
L.REESE
J.LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 2-8, 16 MARCH 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-5

VALUE ENGINEERING PAYS



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. THE THREE SOUTHERN MOST SPILLWAY GATES, 3 STOPS. THE FIVE NORTHERN MOST SPILLWAY GSTES, 4 STOPS.

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 35.2 KCFS

REPRESENTATIVE TAILWATER EL. = 633.3 FMSL
FOREBAY EL. = 706.0 FMSL

COMPUTER AIDED DESIGN & DRAFTING

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH
N

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 3-A, 17 MARCH 1992

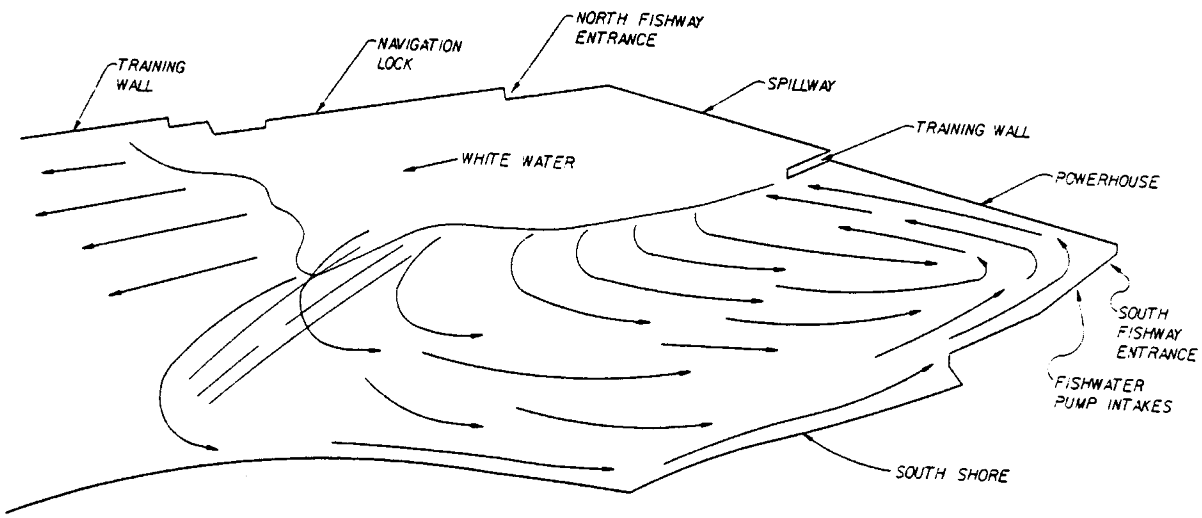
DATE NOV. 1992
SCALE AS SHOWN | INV. NO.

ENCLOSURE F-6

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)

POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 106.8 KCFS

REPRESENTATIVE TAILWATER EL. = 635.4 FMSL
FOREBAY EL. = 704.5 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH
N

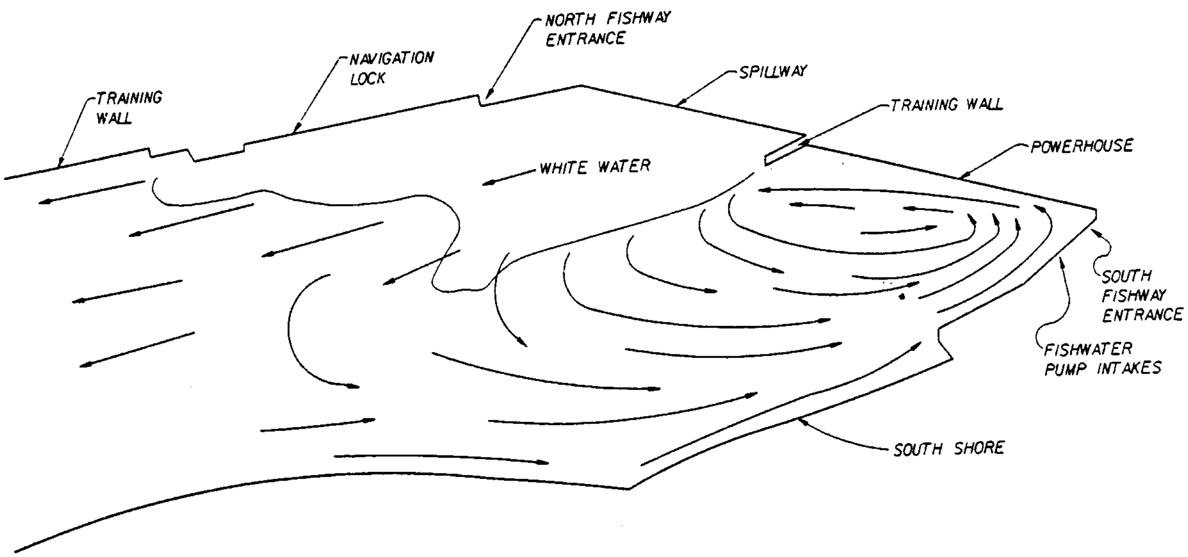
LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 3-B, 17 MARCH 1992

NOV. 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-7

VALUE ENGINEERING PAYS



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. THE THREE SOUTHERN MOST SPILLWAY GATES.3 STOPS. THE FIVE NORTHERN MOST SPILLWAY GATES.5 STOPS.

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 35.2 KCFS

REPRESENTATIVE TAILWATER EL. = 629.2 FMSL
FOREBAY EL. = 706.0 FMSL

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH
M

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 4-A, 19 MARCH 1992

Computer Aided Design & Drafting

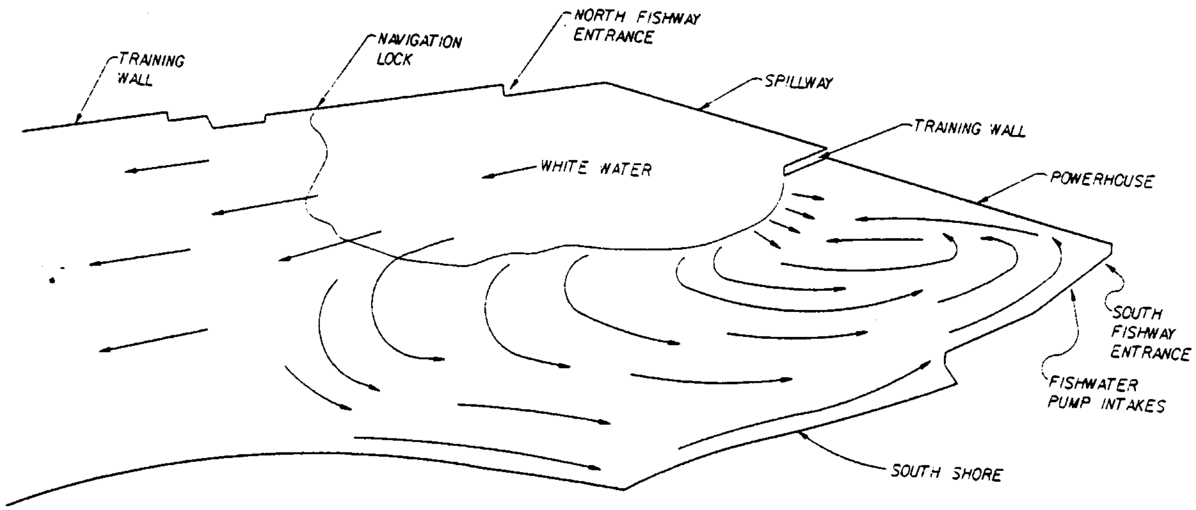
SCALE AS SHOWN | INV. NO.

ENCLOSURE F-8

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 106.7 KCFS

REPRESENTATIVE TAILWATER EL. = 632.4 FMSL
FOREBAY EL. = 704.6 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH
H

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPIONT FROM SOUTH SHORE HILLSIDE)
TEST 4-B, 19 MARCH 1992

SCALE AS SHOWN | INV. NO.

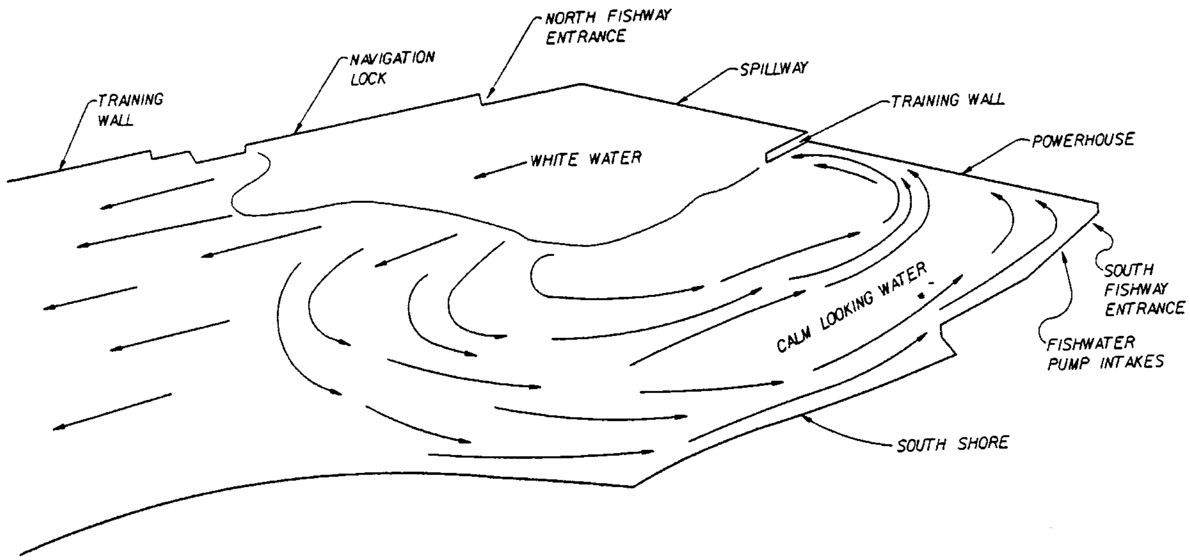
ENCLOSURE F-9

VALUE ENGINEERING PAYS

U. S. ARMY

SAFETY PAYS

CORPS OF ENGINEERS



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 29.0 KCFS

REPRESENTATIVE TAILWATER EL. = 625.6 FMSL
FOREBAY EL. = 706.0 FMSL

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPIONT FROM SOUTH SHORE HILLSIDE)
TEST 5-A, 21 MARCH 1992

DESIGNED BY: L.REESE
DRAWN BY: J.LEIGH
CHECKED BY: H
DATE: NOV. 1992

SCALE AS SHOWN | INV. NO.

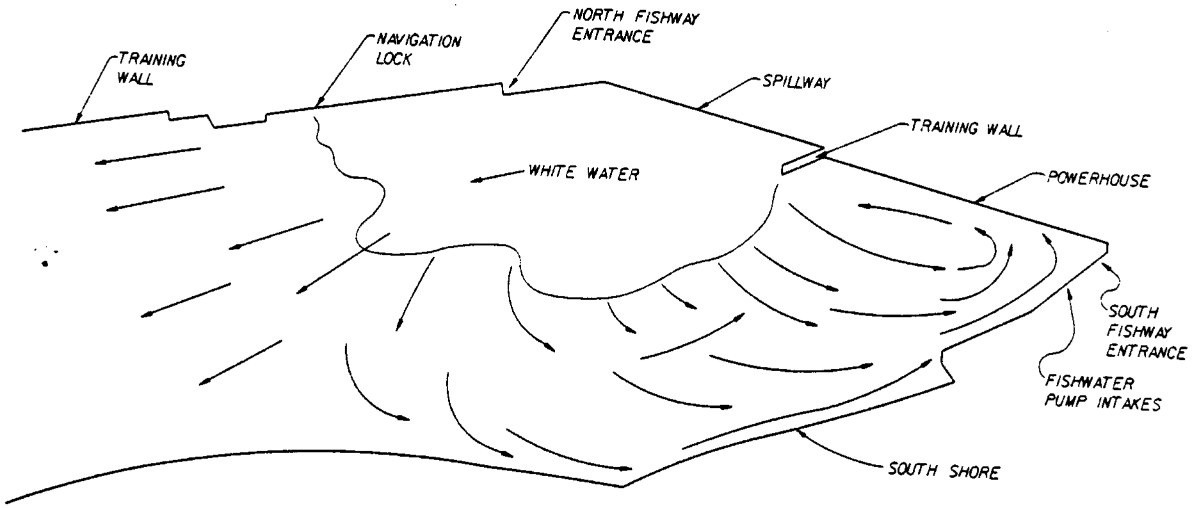
ENCLOSURE F-10

VALUE ENGINEERING PAYS

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 106.7 KCFS

REPRESENTATIVE TAILWATER EL. = 630.4 FMSL
FOREBAY EL. = 704.5 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES. BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH
N

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 5-8, 21 MARCH 1992

NOV. 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-11

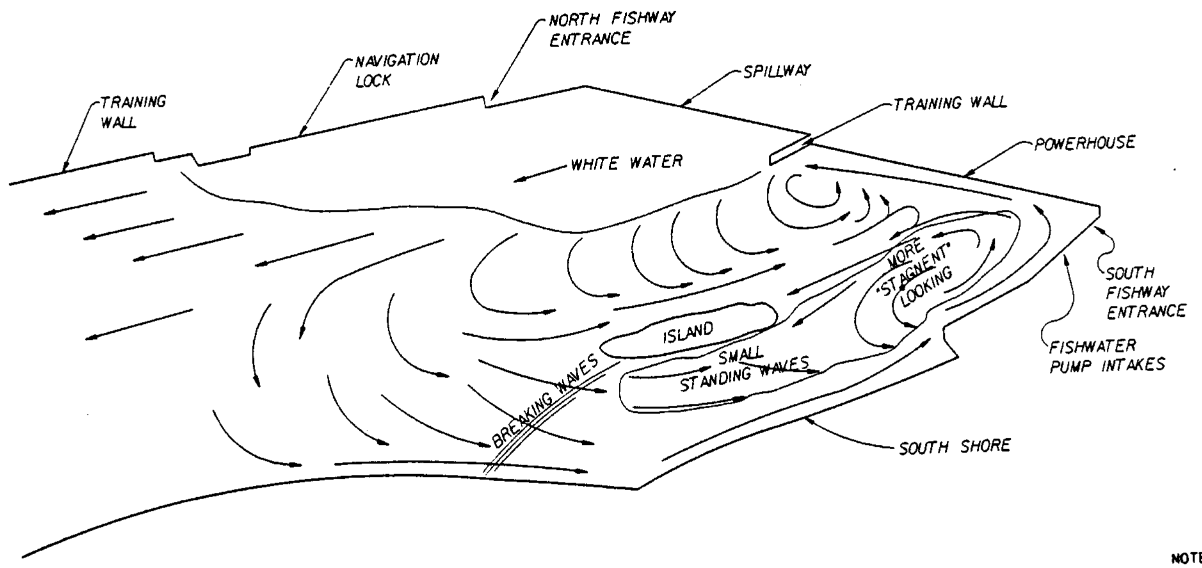
VALUE ENGINEERING PAYS

CONT. NO.

REFERENCE FILES :

PEN TABLES :

MAIN SCALE :



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 29.0 KCFS

REPRESENTATIVE TAILWATER EL. = 624.0 FMSL
FOREBAY EL. = 706.0 FMSL

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH
N

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPIONT FROM SOUTH SHORE HILLSIDE)
TEST 6-A, 22 MARCH 1992

NOV. 1992

COMPUTER AIDED DESIGN & DRAFTING

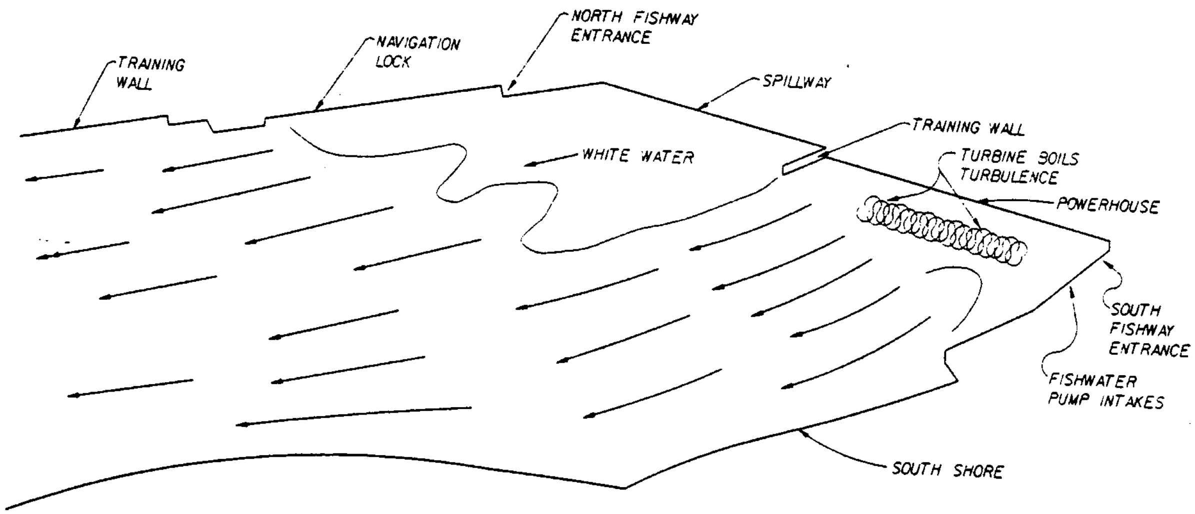
SCALE AS SHOWN | INV. NO.

ENCLOSURE F-12

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 84.0 KCFS
SPILLWAY = 23.3 KCFS
(TOTAL = 107.3 KCFS)
REPRESENTATIVE TAILWATER EL. = 630.7 FMSL
FOREBAY EL. = 704.5 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. THE TWO OUTSIDE SPILLWAY GATES (4 TOTAL) 2 STOPS. THE FOUR INTERIOR SPILLWAY GATES.3 STOPS
4. POWERHOUSE UNITS 1 AND 6 OPERATING.

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH

LOWER GRANITE AND LITTLE GOOSE 1992 DRAWDOWN TESTS

HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPIONT FROM SOUTH SHORE HILLSIDE)
TEST 6-8, 22 MARCH 1992

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-13

VALUE ENGINEERING PAYS

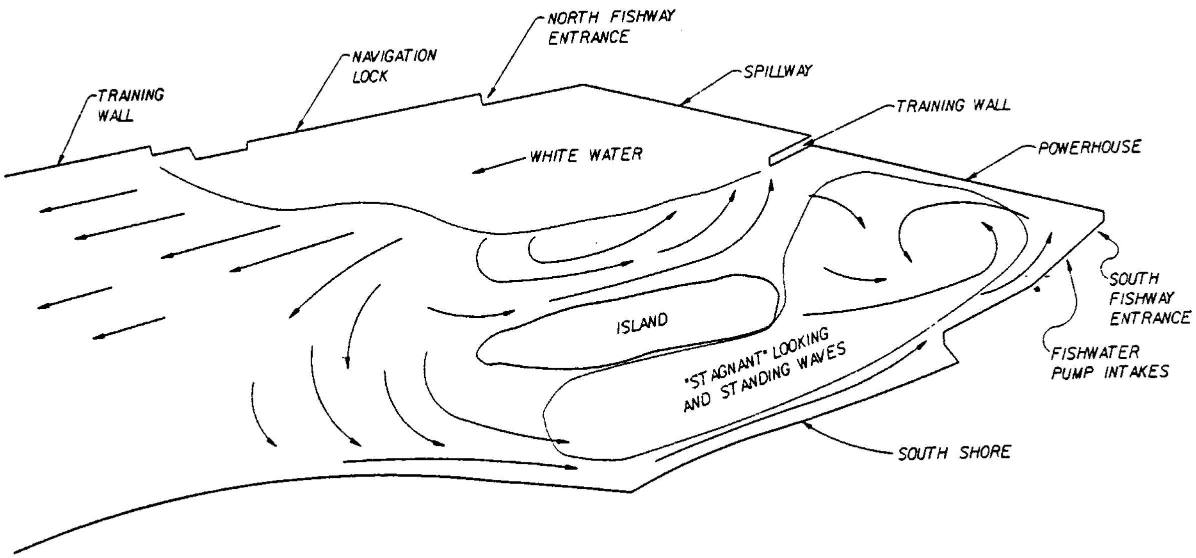
CONT. NO.

REFERENCE FILES :
PEN TABLES :
MAIN SCALE :

U. S. ARMY

CORPS OF ENGINEERS

SAFETY PAYS



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 27.8 KCFS

REPRESENTATIVE TAILWATER EL. = 622.3 FMSL
FOREBAY EL. = 706.0 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. THE NORTHERN MOST SPILLWAY GATE (1 TOTAL) 2 STOPS. ALL OTHER SPILLWAY GATES (7 TOTAL) 3 STOPS.

COMPUTER AIDED DESIGN & DRAFTING

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED BY: L.REESE
DRAWN BY: J.LEIGH
CHECKED BY: N

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPIONT FROM SOUTH SHORE HILLSIDE)
TEST 7-A, 23 MARCH 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-14

CONT. NO.

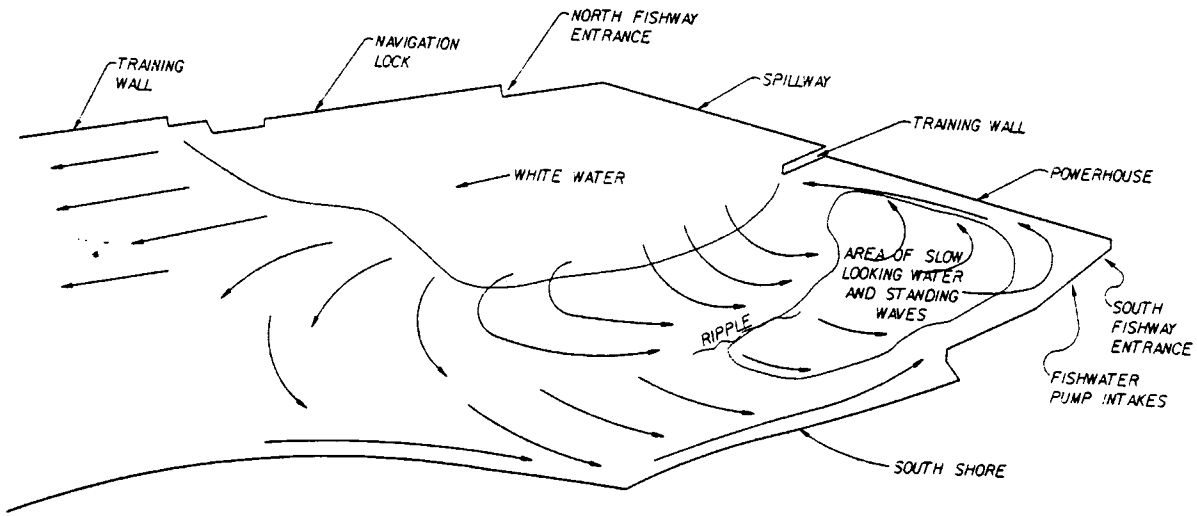
VALUE ENGINEERING PAYS

REFERENCE FILES : PEN TABLES : MAIN SCALE :

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)

POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 65.6 KCFS

REPRESENTATIVE TAILWATER EL. = 626.2 FMSL
FOREBAY EL. = 704.9 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

COMPUTER AIDED DESIGN & DRAFTING

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH
N

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPIONT FROM SOUTH SHORE HILLSIDE)
TEST 7-8, 23 MARCH 1992

NOV. 1992

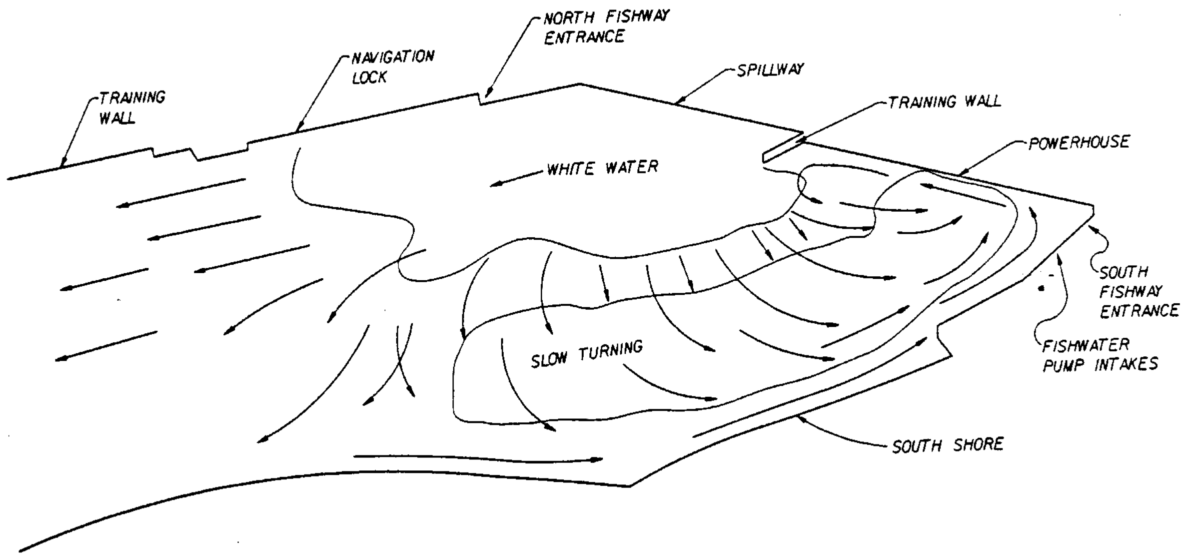
SCALE AS SHOWN | INV. NO.

ENCLOSURE F-15

VALUE ENGINEERING PAYS

CONT. NO.

REFERENCE FILES :
PEN TABLES :
MAIN SCALE :



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 103.6 KCFS

REPRESENTATIVE TAILWATER EL. = 628.3 FMSL
FOREBAY EL. = 703.4 FMSL

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE (DESIGNED BY)
J.LEIGH (DRAWN BY)
N (CHECKED BY)

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPIONT FROM SOUTH SHORE HILLSIDE)
TEST 7-C, 23 MARCH 1992

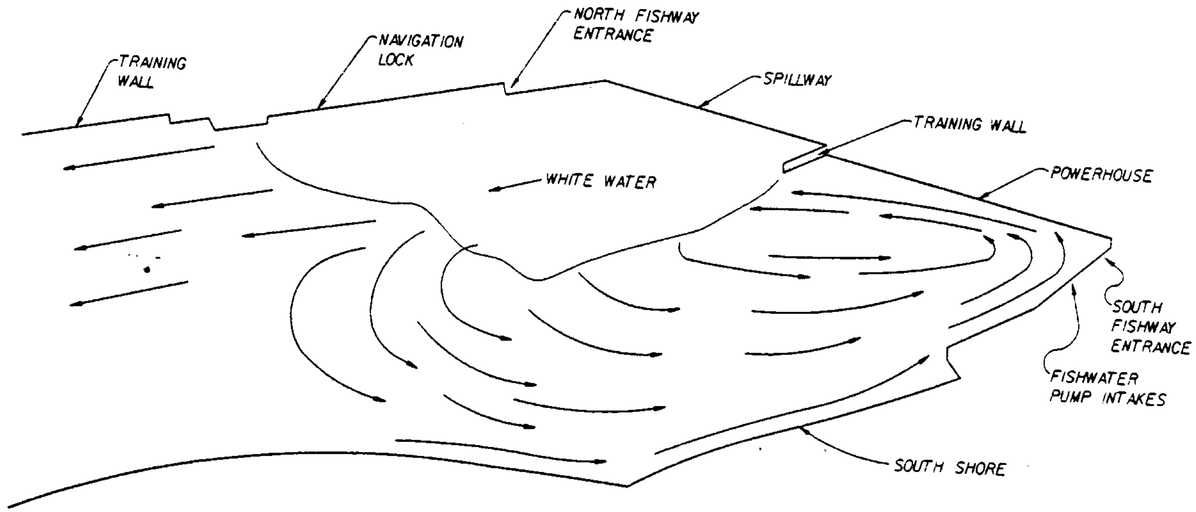
DATE NOV. 1992
SCALE AS SHOWN | INV. NO.
ENCLOSURE F-16

Computer Aided Design & Drafting

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 26.3 KCFS

REPRESENTATIVE TAILWATER EL. = 631.7 FMSL
FOREBAY EL. = 700.0 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1) VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES. BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. THE FOURTH SPILLWAY GATE FROM THE NORTH (1 TOTAL) 4 STOPS. ALL OTHER SPILLWAY GATES (7 TOTAL) 3 STOPS.

COMPUTER AIDED DESIGN & DRAFTING

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 8-A, 26 MARCH 1992

NOV. 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-17

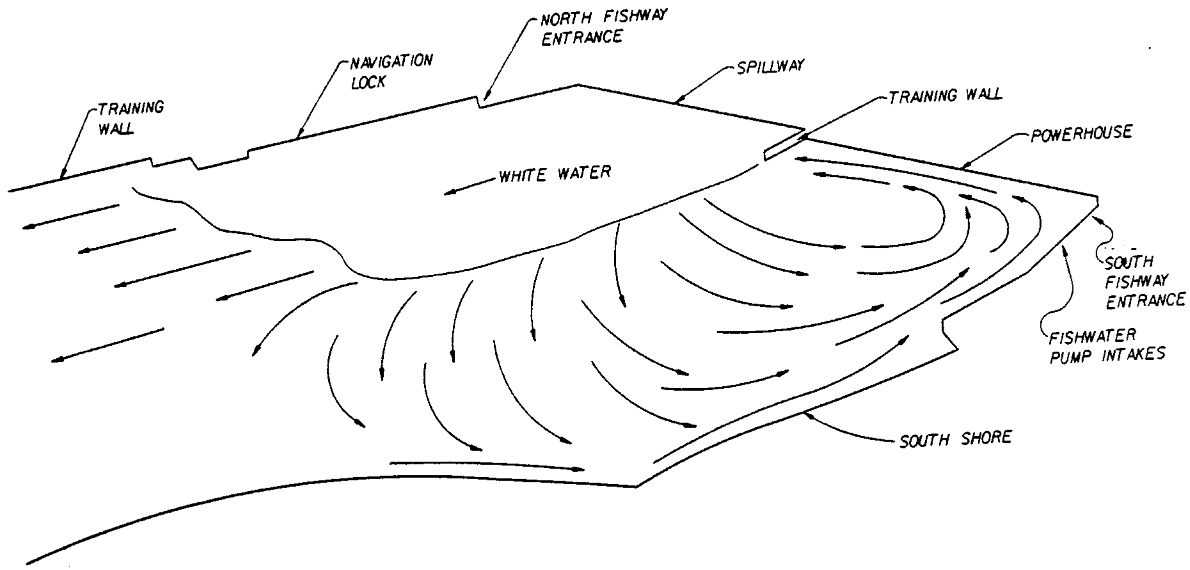
VALUE ENGINEERING PAYS

REFERENCE FILES : PEN TABLES : MAIN SCALE :

U. S. ARMY

SAFETY PAYS

CORPS OF ENGINEERS



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES. BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.(FREEFLOW)

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 100.0 KCFS

REPRESENTATIVE TAILWATER EL. = 634.9 FMSL
FOREBAY EL. = 698.5 FMSL

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 8-B, 26 MARCH 1992

L.REESE
J.LEIGH

DATE NOV. 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-18

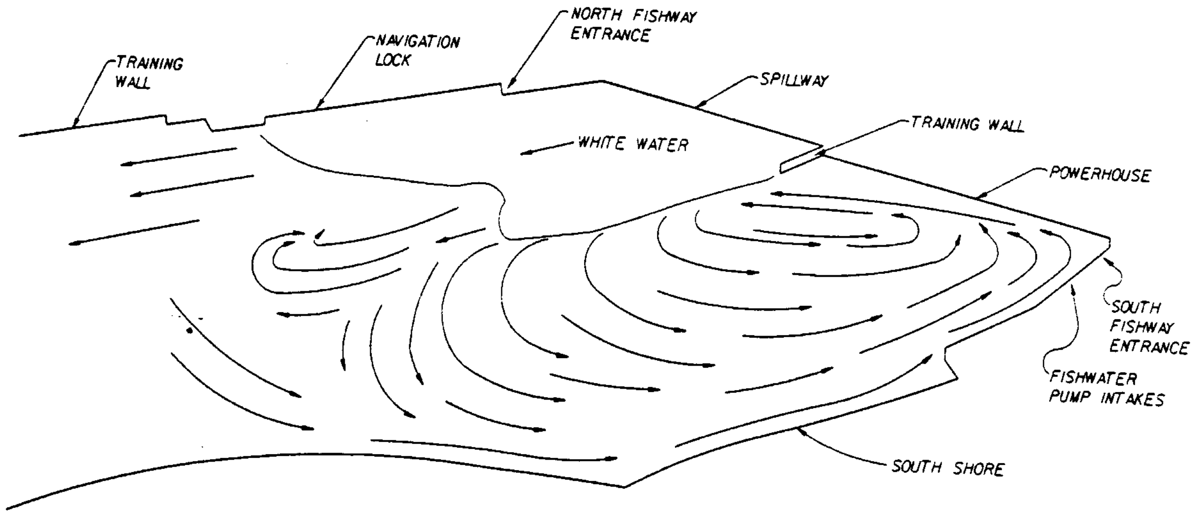
COMPUTER AIDED DESIGN & DRAFTING

VALUE ENGINEERING PAYS

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)

POWERHOUSE UNITS = 0 KCFS

SPILLWAY = 27.2 KCFS

REPRESENTATIVE TAILWATER EL. = 633.3 FMSL

FOREBAY EL. = 712.9 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES. BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. THE TWO OUTSIDE SPILLWAY GATES (4 TOTAL) 2 STOPS. THE FOUR INTERIOR SPILLWAY GATES (4 TOTAL) 3 STOPS.

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH
N

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 9-A, 28 MARCH 1992

DATE NOV. 1992

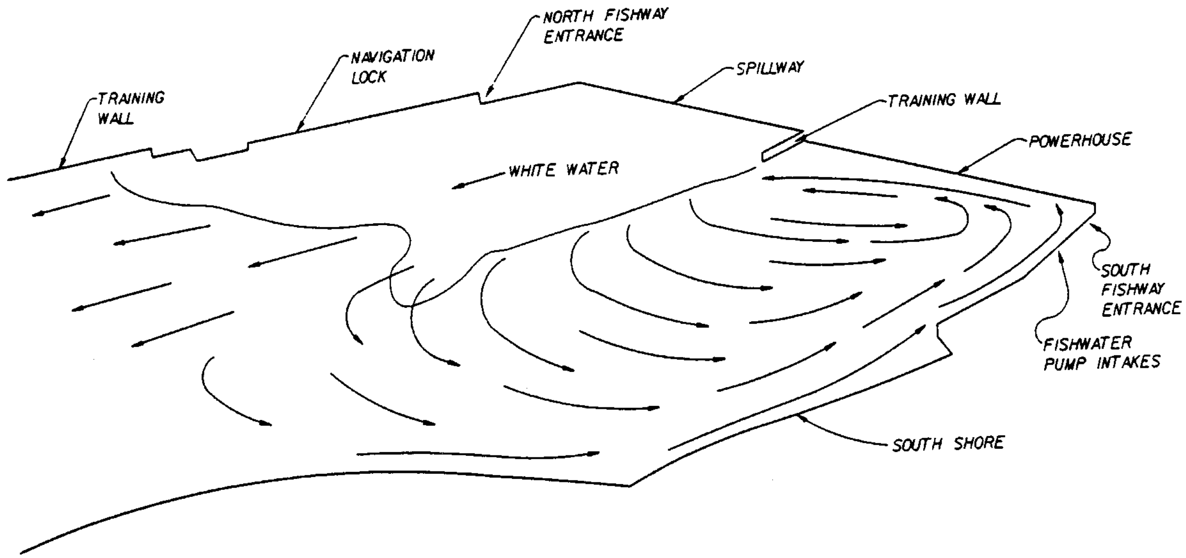
SCALE AS SHOWN | INV. NO.

ENCLOSURE F-19

CONT. NO.

VALUE ENGINEERING PAYS

REFERENCE FILES : PDI TABLES : MAIN SCALE :



NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.

OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)

POWERHOUSE UNITS = 0 KCFS
SPILLWAY = 65.5 KCFS

REPRESENTATIVE TAILWATER EL. = 634.6 FMSL
FOREBAY EL. = 712.4 FMSL

COMPUTER AIDED DESIGN & DRAFTING

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

L.REESE
J.LEIGH

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 9-8, 28 MARCH 1992

DATE NOV. 1992

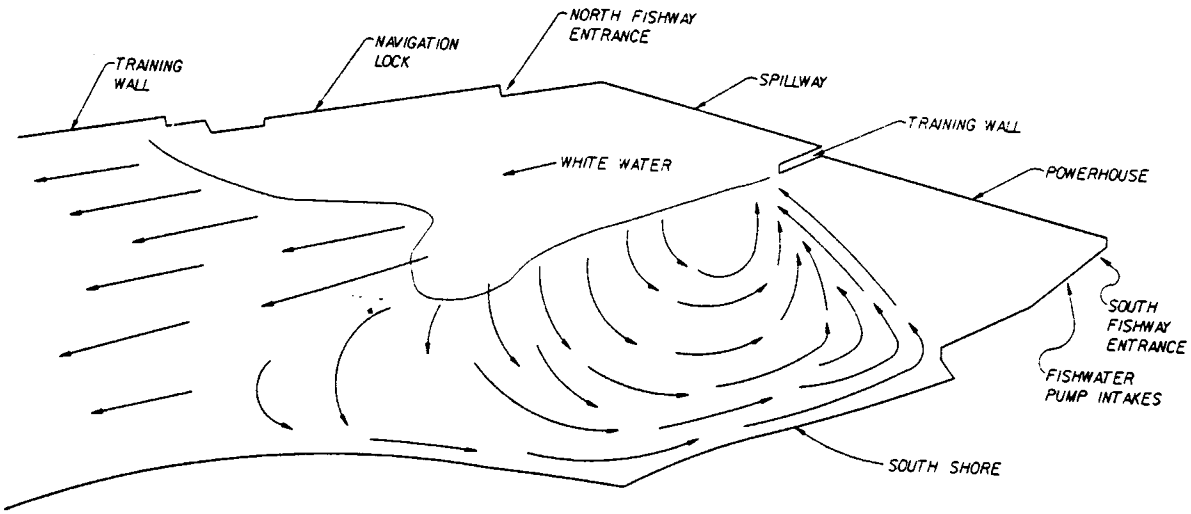
SCALE AS SHOWN | INV. NO.

ENCLOSURE F-20

CORPS OF ENGINEERS

SAFETY PAYS

U. S. ARMY



OPERATING CONDITIONS AND MAIN FLOW DISTRIBUTION
(ALSO SEE NOTES)
POWERHOUSE UNITS = 24.1KCFS
SPILLWAY = 53.4 KCFS
(TOTAL = 77.5 KCFS)
REPRESENTATIVE TAILWATER EL. = 635.4 FMSL
FOREBAY EL. = 711.1 FMSL

NOTES:

1. SKETCH IS DRAWN ASSUMING A VANTAGE POINT FROM THE SOUTH SHORE HILLSIDE.(SEE ENCLOSURE F-1)VIDEOTAPE FOOTAGE WAS USED IN DEVELOPING THE DRAWING.
2. THE PURPOSE OF THE SKETCH IS NOT TO PRECISELY DEFINE SURFACE FLOWLINES, BUT TO PROVIDE A GENERAL OVERVIEW OF TYPICAL FLOW PATTERNS OBSERVED DURING TEST.
3. ALL SPILLWAY GATES SET UNIFORMLY.
4. POWERHOUSE UNITS 1 AND 2 OPERATING.

Computer Aided Design & Drafting

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

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H

LOWER GRANITE AND LITTLE GOOSE
1992 DRAWDOWN TESTS
HYDRAULIC EVALUATION - AFTER-ACTION REPORT
TAILRACE SURFACE FLOW PATTERNS
(VIEWPOINT FROM SOUTH SHORE HILLSIDE)
TEST 9-C, 28 MARCH 1992

SCALE AS SHOWN | INV. NO.

ENCLOSURE F-21

VALUE ENGINEERING PAYS