RECLAMATION

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Folsom Dam- Selective Withdrawal Analysis for a Proposed Temperature Control Device for the Municipal Water Supply Intake

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MEMORANDUM

To: Bob Sund, Team Leader, D-8410

From: Tracy Vermeyen
Research Hydraulic Engineer

Subject: Folsom Dam - Selective Withdrawal Analysis for a Proposed Temperature Control Device for the Municipal Water Supply Intake

Per your request, I have completed the selective withdrawal analysis for the temperature control device (TCD) at Folsom Dam. I have enclosed a report entitled "Folsom Dam - Selective Withdrawal Analysis for a Proposed Temperature Control Device for the Municipal Water Supply Intake." This document serves as the final product of our service agreement. The document was peer reviewed by Tony Wahl (D-8560). If you have any questions or comments concerning the report, please contact me at (303) 236-2000, extension 451.

Attachment

PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

Project Name Folsom Dam WOID FLTCD

Document Folsom Dam - Selective Withdrawal Analysis for a Proposed Temperature Control Device for the Municipal Water Supply Intake

Document Date 5/29/97 Date Transmitted to Client 5/29/97

Team Leader Bob Sund, D-8410 Leadership Team Member ____________
(Peer Reviewer of Peer Review/QA Plan)

Peer Reviewer Tony L. Wahl Document Author(s)/Preparer(s) Tracy B. Vermeyen

Peer Reviewer ____________

Peer Reviewer ____________

REVIEW REQUIREMENT

Part A: Document Does Not Require Peer Review

Explain ____________

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Part B: Document requires Peer Review : SCOPE OF PEER REVIEW

Peer Review restricted to the following Items/Section(s): Reviewer:

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REVIEW CERTIFICATION

Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Tony L. Wahl Review Date: 5/18/97
Signature

Preparer: I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Member: Tracy B. Vermeyen Date: 5/30/97
Signature

FOLSOM DAM - SELECTIVE WITHDRAWAL ANALYSIS FOR A PROPOSED TEMPERATURE CONTROL DEVICE FOR THE MUNICIPAL WATER SUPPLY INTAKE

PURPOSE

The U.S. Bureau of Reclamation has proposed a temperature control device (TCD) for a municipal and industrial water intake at Folsom Dam. The intake supplies water to an 84-inch diameter pipeline that conveys water to a pumping plant which serves several water purveyors. The TCD is needed to conserve the cold water resources in Folsom Lake because the intake is normally positioned in the reservoir's coldwater pool. The TCD will be used to divert water from elevations above the coldwater pool during the summer and fall when the reservoir is thermally stratified. Operation of the TCD would conserve the reservoir's coldwater storage by reducing the volume of water diverted from the coldwater pool. As a result, more cold water would be available for release into the lower American River. Lower river temperatures are needed to improve habitat for fall-run chinook salmon and steelhead during July through October. Another advantage associated with the TCD is the ability to divert water from elevations other than the existing intake elevation of 317 ft (M.S.L.). This flexibility in withdrawal elevation will allow Reclamation to improve the quality of water delivered to the water purveyors throughout the year.

CONCLUSIONS

Calibration of the SELECT model with respect to temperatures measured at the San Juan Water Treatment Plant (WTP) was acceptable.

Both gate and weir intake configurations provide effective selective withdrawal for the proposed temperature control structure for a wide range of reservoir levels. Both intakes would allow conservation of the coldwater pool in Lake Folsom.

The gate configuration provides a narrower withdrawal zone when compared to the weir. However, this is only true when the intake is positioned above the thermocline. When below the thermocline, the thermocline is a physical barrier to the upper limit of withdrawal; therefore, both weir and gate intakes would perform nearly identically.

For submergences of 20- and 30-ft, the difference between release temperatures for the gate and weir configurations was usually less than 2 °F. The release temperatures associated with the gate were usually warmer than the weir, which is indicative of a narrower withdrawal zone.

For high reservoir levels and uncontrolled submergence, the release temperatures for the weir were about 1 °F warmer than the gate.

As the reservoir level drops, the potential to control release temperatures via selective withdrawal is reduced because the warm surface layer thickens and extends down to the existing intake elevation, 317 ft (M.S.L.).

The potential for vortex formation may be slightly greater with the weir because the top on the gate configuration may afford a small degree of vortex suppression. As a result, the weir configuration may require an additional few feet of submergence to prevent vortex formation.

For 20 ft of submergence, the headloss associated with the proposed structure was estimated to be about 1 ft of additional headloss for either of the two intake configurations. The headloss prediction is a rough estimate using previous studies for similar structures. A model study is recommended if headloss is a major concern.

SELECTIVE WITHDRAWAL MODELING

Selective withdrawal characteristics for the proposed TCD were mathematically modeled using SELECT, a program developed by the US Army Engineer Waterways Experiment Station (USAE-WES). The numerical model SELECT (version 1.33) was used to predict the release water quality from Lake Folsom for several outlet operating conditions and measured water quality profiles. SELECT was run using a personal computer with DOS. A user's guide for this model can be found in the USAE-WES Instruction Report E-87-2 entitled "SELECT: A Numerical One-Dimensional Model for Selective Withdrawal." This user's manual was revised and republished in July 1992.

SELECT is a one-dimensional numerical model that predicts the vertical extent and distribution of withdrawal from a reservoir of known density and water quality distribution for a given release flowrate from a specified outlet(s). Using this prediction for the withdrawal zone, SELECT computes the quality of the release water for user-specified parameters (such as temperature, dissolved oxygen, turbidity, heavy metals) which are treated as conservative substances. The release constituents are assumed to be conservative through the TCD because the detention time in the structure is short compared with the time required for the constituents to physically or chemically degrade. For example, there would be no time for the water temperature to change significantly.

It is important to understand the purpose of the SELECT model. SELECT was developed so that project operators would have a tool to estimate the withdrawal and release water quality characteristics of a structure for a given temperature stratification, outlet geometry, and discharge. SELECT is not a water quality or thermal simulation model. SELECT does not consider all the hydrodynamic and biochemical processes which take place in a reservoir. Its purpose is to compute withdrawal and release water quality characteristics for one set of reservoir releases and limnological characteristics. SELECT cannot predict the long-term impacts of the reservoir operations on the reservoir limnology.

SELECT was used in this study to estimate withdrawal characteristics for a wide range of reservoir operations. According to personal communication with Mr. Stacy Howington from USAE-WES, SELECT's algorithm was based on empirical relationships developed using physical model studies. In addition, Howington said there has been very little field verification of SELECT's ability to predict velocity and flow distribution characteristics. However, predictions of release temperatures and other water quality constituents have been verified at numerous Corp of Engineers reservoirs, which is an indirect or integrated measure of the model's performance. More recently, the Corps of Engineers has used a 3-D flow simulation of an intake port withdrawing water from a linearly stratified reservoir to verify the governing equations used in the SELECT model. The results of the study showed that the SELECT model was able to predict the withdrawal limits to within +/- 10 percent of withdrawal limits predicted by the more sophisticated 3-D model.

SELECT Input Data

The input data for the modeling were provided by Beak Consultants, Inc., from Sacramento, California (916/565-7900). Beak Consultants have a contract with Reclamation to collect monthly temperature and dissolved oxygen profiles in Folsom Lake. Mr. Neil Nikirk from Beak Consultants provided data for the years 1987 and 1990-1996. Jack Rowell (MP-710) supplied historical temperature profile data for 1957 through 1977. A record (1991-1996) of average daily water temperatures entering the San Juan WTP was provided by Mike Bryan from Surface Water Resources, Inc., from Sacramento, California (916/325-4043). Data and drawings on the water supply intake and records of historic lake elevations were provided by Bill Sanford and Rod Hall from Reclamation's Central California Area Office (CC-400). Design drawings of the proposed TCD were provided by the designer, Bob Sund (D-8410), and are included in the appendix.

The years of 1993 and 1994 were selected for analysis because they represent wet and dry water years, respectively. In addition, these years reflect current reservoir operations which have a significant impact on the reservoir stratification. In recent years, reservoir operations have changed to meet a variety of environmental objectives which may not be reflected in temperature data collected in the 1970's.

TCD Design and Operation

The proposed TCD will provide three telescopic gates which allow the intake crest to travel between elevations 331- and 401-ft. The hoist-operated gate system will be attached to the face of Folsom Dam in front of the existing water supply intake. Each interconnecting gate panel is 30 ft long and 10 ft wide. Two options are being considered for the intake configuration: 1) A 10-ft-wide uncontrolled overflow weir, and 2) a rectangular orifice gate that is 17 ft high and 9.5 ft wide. The top of the rectangular orifice would extend to elevation 418 when fully raised.

For this analysis, the allowable submergence for this structure was set at a minimum of 20 ft. During dry years when the water surface drops below elevation 351 ft, the submergence criteria would not be met and the gates would be hoisted to the surface and the existing intake (at elevation 317 ft) would be used. The potential for vortex formation may be slightly greater with the weir because the top on the gate configuration may afford a small degree of vortex suppression. As a result, the weir may require an additional few feet of submergence to prevent vortices from developing. Potential for vortex formation should be evaluated during the first few months of the TCD operation.

An assessment of headloss associated with the proposed structure indicates that about 1 ft of additional headloss could be expected for either of the two intake configurations. However, based on field tests conducted for the Hungry Horse selective withdrawal structure, the weir configuration may create a slightly higher headloss than the gate. However, these are rough estimates and a model study is recommended if headloss is a major concern.

The operation of the structure would allow the withdrawal of warm surface water during the spring and summer months in an effort to conserve the coldwater pool in Folsom Lake. Then in October, November, and December, cold water reserves would be released through the Folsom powerplant to reduce temperatures in the lower American River. The TCD may also be used at other times to improve the water quality delivered to the water treatment plants.

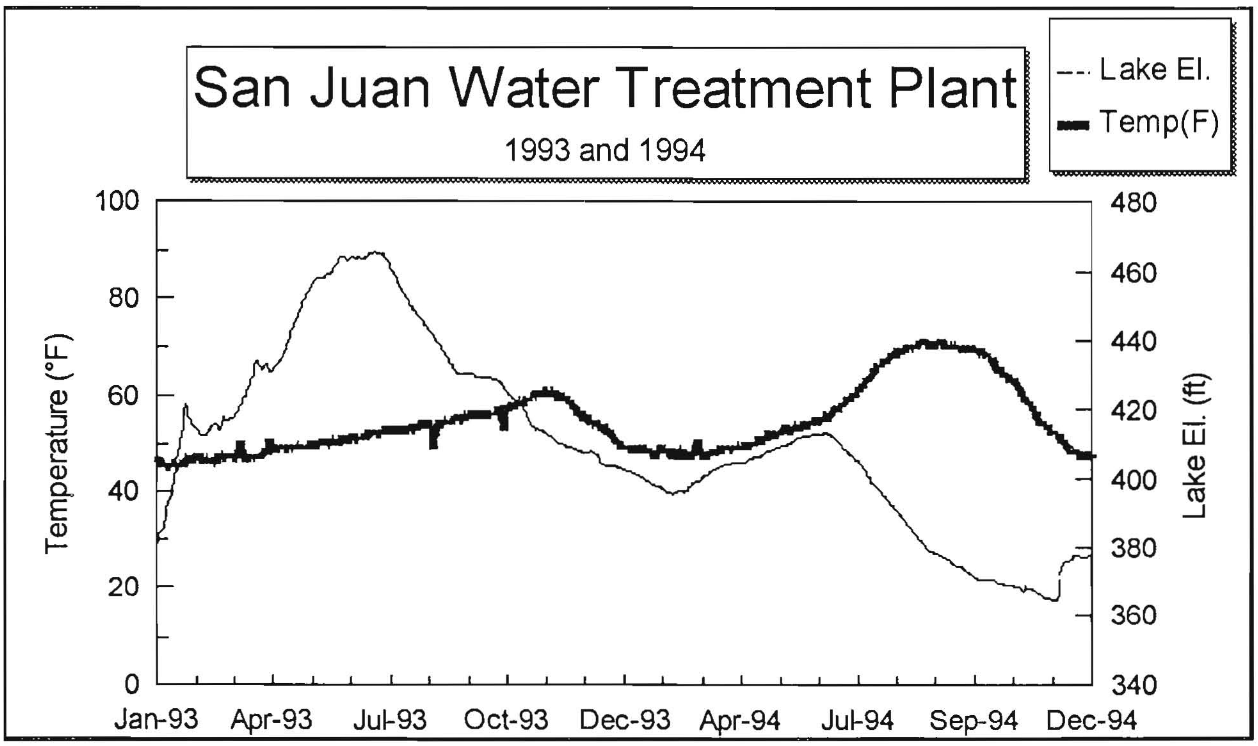


Figure 1. Lake elevation and water supply temperatures measured at the San Juan WTP for the years 1993 and 1994. The water temperatures increase dramatically in July 1994 as the reservoir is drawn down below elevation 400.

SELECT Model Calibration

The SELECT model was used to predict the selective withdrawal characteristics for the proposed TCD using temperature profiles measured near Folsom Dam. The period of study was 1993 and 1994. Water temperature data collected at the San Juan WTP located about 1 mile from the pumping plant were used to calibrate the model for the existing intake configuration. Figure 1 is a plot of the reservoir elevation and water temperature entering the San Juan WTP during the period of study.

Using monthly temperature profiles for input, SELECT was used to predict the upper and lower limits of withdrawal, withdrawal zone flow distribution, and the release water temperatures. SELECT was also used to predict the dissolved oxygen concentration in the release water. The selective withdrawal characteristics predicted by the SELECT model for the baseline or existing intake structure are presented in table 1. A comparison of predicted and actual release temperatures produced a very good correlation as is shown in figure 2. A linear regression analysis of the data in figure 2 had a coefficient of determination (R^2) equal to 0.98 with a standard error of $\pm$ 1.2 °F. The San Juan WTP water temperatures were consistently higher than SELECT's predictions, which may result from a temperature gain during the conveyance to the WTP or a result of a deficiency in the model's empirical equations. A sample of SELECT output data for baseline conditions on September 23, 1993, is illustrated in figure 3. The vertical flow distribution (flow in each 10-ft water layer) describes the withdrawal zone extent for this temperature profile and flow rate. Several other plots similar to figure 3 are included in the appendix and they illustrate the performance of the TCD's gate and weir intake configuration.

Selective Withdrawal Characteristics for the Proposed Structure

Two control structures were proposed for the TCD: 1) a 10-ft-wide uncontrolled overflow weir, and 2) a rectangular orifice that is 17 ft high and 9.5 ft wide. For this report, they will be referred to as a weir and gate. Reservoir stratifications measured in 1993 and 1994 were very different as shown in figure 4. To facilitate the most direct comparison of the design alternatives, we chose to analyze selective withdrawal performance for both variable and fixed submergence conditions. Note that 1993 profiles were used for the fixed submergence analysis even though the reservoir levels were too high to allow submergence control for May through August. So the reservoir elevation, rather than the gate position, was adjusted to model various degrees of submergence when using 1993 temperature profiles. In addition, selective withdrawal performance was determined for uncontrolled submergence using 1993 data.

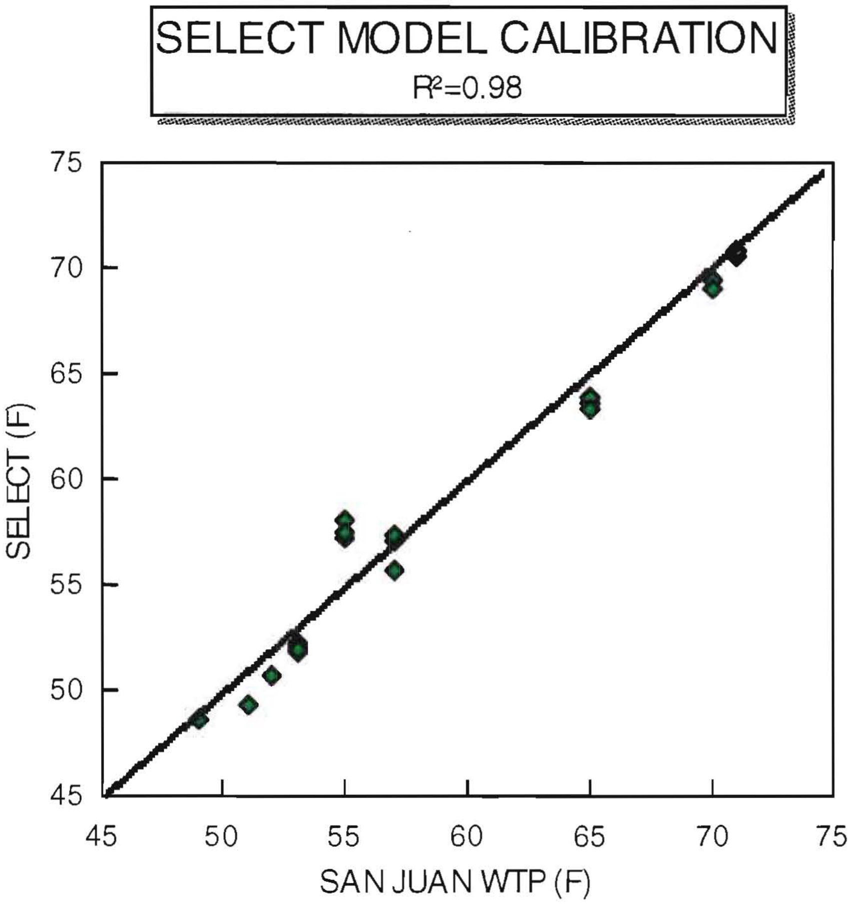


Figure 2. Comparison of SELECT and San Juan WTP release water temperatures. The linear regression correlation coefficient (R^2) was 0.98 which indicates a very good calibration of the SELECT model.

Table 1. A comparison of the release water temperatures measured at the San Juan WTP and the water temperature predicted using SELECT for the existing intake configuration (*August profile had some bad data points).

MONTH	YEAR	WSEL (ft)	SJ WTP TEMP (F)	SELECT TEMP (F)
APRIL	1993	446.9	49	48.7
MAY	1993	464.0	51	49.4
JUNE	1993	465.5	52	50.8
JULY	1993	450.9	53	52.3
AUGUST*	1993	432.4	55	58.1
SEPTEMBER	1993	428.2	57	55.7
MAY	1994	412.0	53	52.2
JUNE	1994	411.1	57	57.3
JULY	1994	398.7	65	63.9
AUGUST	1994	386.5	70	69.5
SEPTEMBER	1994	378.1	71	70.9

SELECT Results for the Gate and Weir Options - SELECT was used to evaluate the TCD's selective withdrawal characteristics for the gate and weir options for several conditions:

- Twenty feet of submergence on the gate and weir, see tables 2 and 5.
- Thirty feet of submergence on the gate and weir, see tables 3 and 6.
- Fifty feet of submergence on the gate, see table 4 (weir could not be analyzed for this submergence).
- Variable submergence for 1993 reservoir levels which represents operation at high reservoir levels, see table 7.

Figure 5 and tables 2 through 7 cover the months of April through September for years 1993 and 1994. Information presented in the tables include the temperature recorded at the San Juan WTP, the release temperature predicted using SELECT, the release dissolved oxygen concentration, the upper and lower limits of the withdrawal layer predicted by SELECT, and the withdrawal zone thickness.

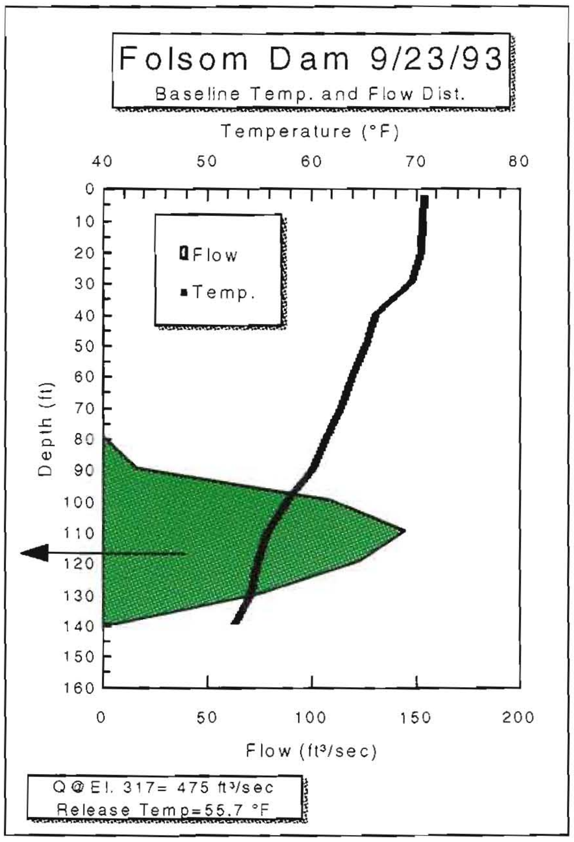


Figure 3. Plot of the temperature profile and vertical flow distribution for a discharge of 475 ft^3/sec through the existing intake. The arrow indicates the level of the existing intake.

Gate and Weir Performance at 20 ft of Submergence - For the case of 20 ft of submergence on the gate (table 2) and the weir (table 5), the withdrawal characteristics varied somewhat depending on the year (figure 5). In 1993, the gate configuration consistently had a narrower withdrawal zone, which was between 44- and 50-ft thick, but there was less than 1 °F difference between the release water temperatures for the gate and weir configurations. The withdrawal zone thickness for the weir was between 55- and 83-ft. In 1994, the gate configuration consistently had a narrower withdrawal zone, between 44- and 52-ft thick, but there was less than 0.5 °F difference between release temperatures for the gate and weir configurations. The withdrawal zone thickness for the weir was between 59- and 80-ft.

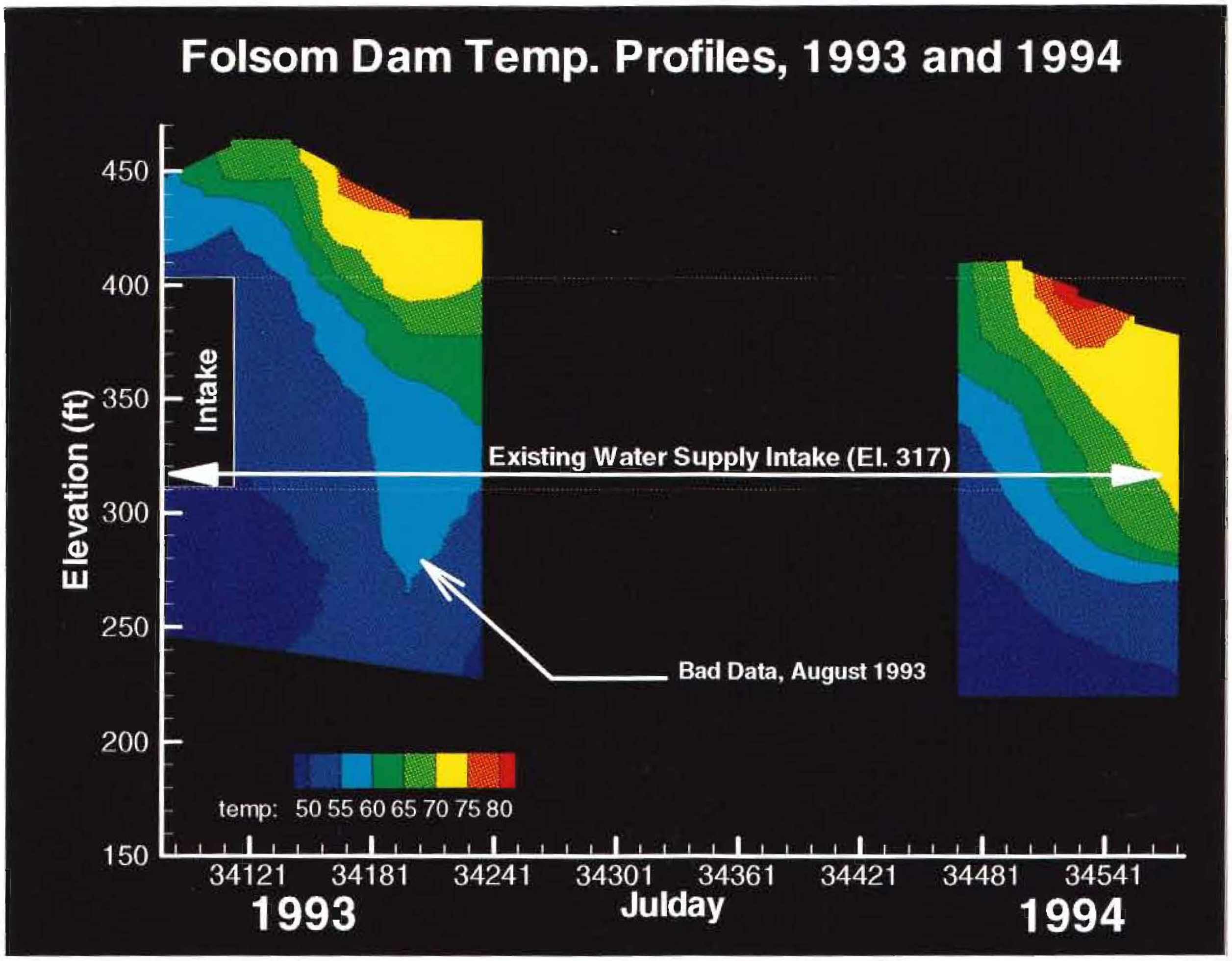


Figure 4. Temperature profiles collected upstream of Folsom Dam for the months May through September 1993 and 1994. These data illustrate the lower reservoir levels and thicker warm surface water layer that existed in 1994.

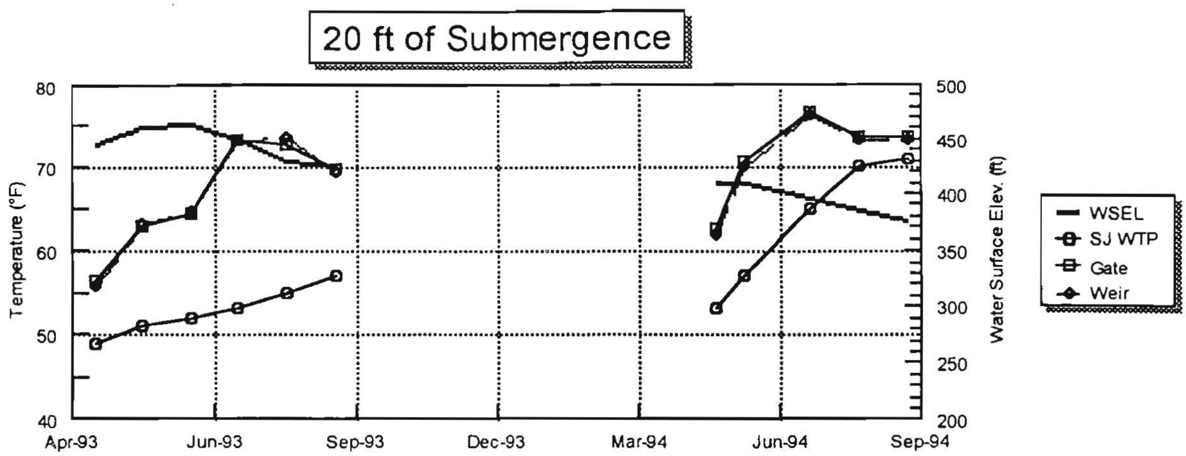
In summary, the gate configuration provides a narrower withdrawal zone, but because the withdrawal was from the well mixed surface water there was very little difference in release temperatures. For all months analyzed, the withdrawal zone extended to the water surface for both intake configurations. Using selective withdrawal, the release water temperatures for both intake configurations were increased by 9 to 20 °F from May to July, respectively.

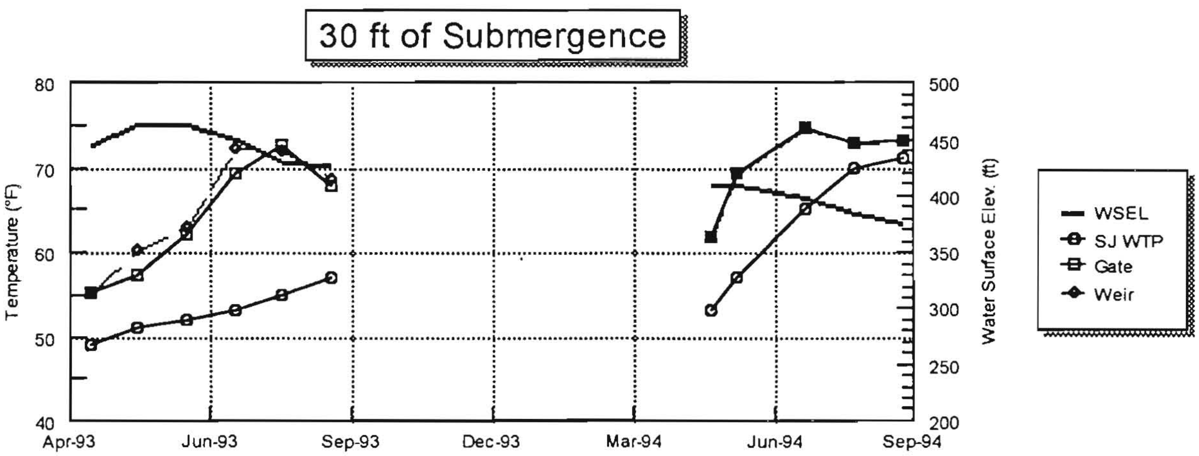
Gate and Weir Performance at 30 ft of Submergence - For the case of 30 ft of submergence on the gate (table 3) and the weir (table 6) configurations, the withdrawal characteristics varied depending on the year (figure 5). In 1993, the gate configuration consistently had a narrower withdrawal zone, which was between 50- and 59-ft thick, and the gate's release temperatures were 1 to 3 °F cooler than the weir. Lower release temperatures for the gate occurred because the withdrawal zone did not extend to the surface once a strong temperature stratification was established. The withdrawal zone thickness for the weir configuration ranged between 60- and 90-ft and always extended to the water surface. In 1994, the gate configuration consistently had a narrower withdrawal zone, between 54- and 60-ft thick, but there was less than 1 °F difference between the gate and weir configurations. The small temperature difference between the two intakes was attributed to the warm surface water layer which was much thicker than in 1993. The withdrawal zone thickness for the weir configuration was between 65- and 82-ft.

Like the 20-ft submergence condition, the gate configuration provided a narrower withdrawal zone, but when the withdrawal was from the well mixed surface water there was a small difference in release temperatures when comparing the weir and gate options. The release water temperatures for both intake configurations were increased using selective withdrawal by 6 to 19 °F from May to July, respectively.

Gate and Weir Performance at 50 ft of Submergence - For the case of 50 ft of submergence on the gate configuration (table 4), the withdrawal characteristics varied depending on the year analyzed (figure 5, see variable submergence plot). The weir configuration was not tested for 50 ft of submergence because the SELECT model requires the weir crest elevation be above the thermocline and this criterion could not be satisfied. In 1993, the gate configuration had a withdrawal zone which was between 48- and 64-ft thick. The release temperatures were 2 to 8 °F warmer than the existing intake release temperatures measured at the San Juan WTP. The withdrawal zone did not extend to the surface for this level of submergence, and the upper limit of withdrawal was 20- to 27-ft below the water surface. In 1994, the gate configuration had a withdrawal zone which was between 51- and 61-ft thick. The release temperatures for the gate were 0.4 to 6 °F warmer than the existing intake releases as measured at the San Juan WTP. The withdrawal zone did not extend to the surface for this level of submergence, and the upper limit of withdrawal was 20- to 26-ft below the water surface. It is interesting that the TCD's effectiveness is very limited in August and September 1994. The limited performance can be attributed to the very thick warm water layer which developed in 1994; the warm water layer extended below the existing intake elevation.

Variable Submergence on the Gate and Weir - For the proposed TCD, elevation 401 is the upper limit of the gate invert position. As a result, when the reservoir water surface is above elevation 421 (20 ft of submergence) the gate cannot be adjusted upward to control the submergence. An analysis of 1993 data with uncontrolled submergence was conducted to determine the selective withdrawal performance for high reservoir levels (figure 5). The model results for this scenario are summarized in table 7. For gate submergences of 56 ft in June, the release temperatures were 5 °F warmer than the existing intake and the upper limit of withdrawal was 29 ft below the water surface. This compares to a 12 to 14 °F difference when submergence was held at 20 ft. In general, this type of operation, while not optimum, does help conserve the coldest water in the reservoir. For high reservoir levels and uncontrolled submergence, the release temperatures for the weir were about 1 °F warmer than the gate. Over the course of the summer, the reservoir level drops and the selective withdrawal performance improves as the submergence decreases. In August and September 1993, the reservoir drops to a submergence of 20- to 30-ft and the gate release temperatures are about 0.6 and 1 °F warmer than the weir.





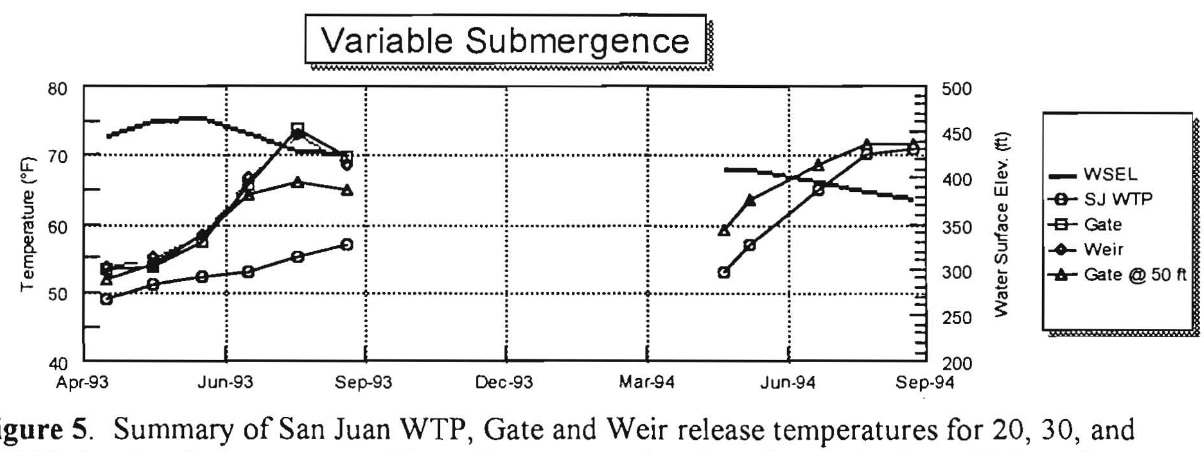


Figure 5. Summary of San Juan WTP, Gate and Weir release temperatures for 20, 30, and variable levels of submergence. These Plots summarize the TCD's selective withdrawal performance (tables 2-7) and illustrates the dependence of TCD release water temperatures on the water surface elevation.

Table 2. Twenty feet of submergence on the GATE for 1993 and 1994 temperature profiles.

MONTH	YEAR	WSEL (ft)	Gate Elev. (ft)	SJ WTP TEMP (F)	SELECT TEMP (F)	SELECT DO (mg/L)	SELECT U/L of W/D	SELECT L/L of W/D	W/D Zone (ft)
APRIL	1993	446.9	426.9	49.0	56.3	9.8	SURFACE	397.7	62.4
MAY	1993	464.0	444.0	51.0	62.8	8.7	SURFACE	419.2	63.3
JUNE	1993	465.5	445.5	52.0	64.4	8.5	SURFACE	418.3	57.4
JULY	1993	450.9	430.9	53.0	73.2	n/a	SURFACE	406.8	47.8
AUG.*	1993	432.4	412.4	55.0	72.8	7.9	SURFACE	387.9	46.3
SEPT.	1993	428.2	408.2	57.0	69.8	7.7	SURFACE	382.7	45.5
MAY	1994	412.0	392.0	53.0	62.3	9.2	SURFACE	360.5	51.5
JUNE	1994	411.1	391.1	57.0	70.6	8.0	SURFACE	366.4	44.7
JULY	1994	398.7	378.7	65.0	76.7	8.4	SURFACE	354.8	43.9
AUG.	1994	386.5	366.5	70.0	73.5	4.9	SURFACE	336.0	50.5
SEPT.	1994	378.1	358.1	71.0	73.6	4.7	SURFACE	328.8	49.3

*** August had some bad data points**

Table 3. Thirty feet of submergence on the GATE for 1993 and 1994 temperature profiles.

MONTH	YEAR	WSEL (ft)	Gate Elev. (ft)	SJ WTP TEMP (F)	SELECT TEMP (F)	SELECT DO (mg/L)	SELECT U/L of W/D	SELECT L/L of W/D	W/D Zone (ft)
APRIL	1993	446.9	416.9	49.0	55.1	9.8	SURFACE	388.1	58.8
MAY	1993	464.0	434.0	51.0	57.4	8.7	457.5	403.8	53.7
JUNE	1993	465.5	435.5	52.0	62.1	8.4	460.8	408.8	52.0
JULY	1993	450.9	420.9	53.0	69.3	n/a	448.1	397.6	50.5
AUG.*	1993	432.4	402.4	55.0	72.7	7.9	SURFACE	378.8	53.6
SEPT.	1993	428.2	398.2	57.0	67.9	6.4	428.9	372.0	56.9
MAY	1994	412.0	382.0	53.0	61.7	9.0	SURFACE	353.5	58.5
JUNE	1994	411.1	381.1	57.0	69.0	7.8	SURFACE	356.5	54.6
JULY	1994	398.7	368.7	65.0	73.8	6.9	SURFACE	344.2	54.5
AUG.	1994	386.5	356.5	70.0	73.2	4.4	SURFACE	328.0	58.5
SEPT.	1994	378.1	348.1	71.0	73.3	4.0	SURFACE	318.5	59.6

*** August had some bad data points**

Table 4. Fifty feet of submergence on the GATE for 1993 and 1994 temperature profiles.

MONTH	YEAR	WSEL (ft)	Gate Elev. (ft)	SJ WTP TEMP (F)	SELECT TEMP (F)	SELECT DO (mg/L)	SELECT U/L of W/D	SELECT L/L of W/D	W/D Zone (ft)
APRIL	1993	446.9	396.9	49.0	51.8	9.7	425.8	362.3	63.5
MAY	1993	464.0	414.0	51.0	54.0	8.4	439.8	379.7	60.1
JUNE	1993	465.5	415.5	52.0	58.3	8.2	442.8	386.0	56.8
JULY	1993	450.9	400.9	53.0	64.2	n/a	423.6	375.0	48.6
AUG.*	1993	432.4	382.4	55.0	66.0	6.1	406.6	356.0	50.6
SEPT.	1993	428.2	378.2	57.0	64.8	5.4	404.0	349.7	54.3
MAY	1994	412.0	362.0	53.0	59.3	8.2	392.5	334.6	57.9
JUNE	1994	411.1	361.1	57.0	63.6	6.9	385.2	332.7	52.5
JULY	1994	398.7	348.7	65.0	68.8	5.8	372.9	321.9	51.0
AUG.	1994	386.5	336.5	70.0	71.6	3.1	366.9	307.8	59.1
SEPT.	1994	378.1	328.1	71.0	71.4	1.4	357.0	295.7	61.3

*** August had some bad data points**

Table 5. Twenty feet of submergence on the WEIR for 1993 and 1994 temperature profiles.

MONTH	YEAR	WSEL (ft)	Weir Elev. (ft)	SJ WTP TEMP (F)	SELECT TEMP (F)	SELECT DO (mg/L)	SELECT U/L of W/D	SELECT L/L of W/D	W/D Zone (ft)
APRIL	1993	446.9	426.9	49.0	55.7	9.8	SURFACE	363.9	83.0
MAY	1993	464.0	444.0	51.0	63.0	8.7	SURFACE	397.3	66.7
JUNE	1993	465.5	445.5	52.0	64.5	8.5	SURFACE	398.5	67.0
JULY	1993	450.9	430.9	53.0	73.4	n/a	SURFACE	395.7	55.2
AUG.*	1993	432.4	412.4	55.0	73.7	8.2	SURFACE	371.7	60.7
SEPT.	1993	428.2	408.2	57.0	69.4	7.4	SURFACE	360.2	68.0
MAY	1994	412.0	392.0	53.0	61.8	9.1	SURFACE	338.8	73.2
JUNE	1994	411.1	391.1	57.0	70.1	7.9	SURFACE	348.4	62.7
JULY	1994	398.7	378.7	65.0	76.3	8.2	SURFACE	339.5	59.2
AUG.	1994	386.5	366.5	70.0	73.3	4.6	SURFACE	309.1	77.4
SEPT.	1994	378.1	358.1	71.0	73.4	4.5	SURFACE	298.5	79.6

*** August had some bad data points**

Table 6. Thirty feet of submergence on the WEIR for 1993 and 1994 temperature profiles.

MONTH	YEAR	WSEL (ft)	Weir Elev. (ft)	SJ WTP TEMP (F)	SELECT TEMP (F)	SELECT DO (mg/L)	SELECT U/L of W/D	SELECT L/L of W/D	W/D Zone (ft)
APRIL	1993	446.9	416.9	49.0	55.3	9.8	SURFACE	356.7	90.2
MAY	1993	464.0	434.0	51.0	60.3	8.7	SURFACE	374.6	89.4
JUNE	1993	465.5	435.5	52.0	63.0	8.4	SURFACE	392.3	73.2
JULY	1993	450.9	420.9	53.0	72.4	n/a	SURFACE	390.7	60.2
AUG.*	1993	432.4	402.4	55.0	72.1	8.0	SURFACE	370.0	62.4
SEPT.	1993	428.2	398.2	57.0	68.6	7.0	SURFACE	355.6	72.6
MAY	1994	412.0	382.0	53.0	61.7	9.0	SURFACE	336.8	75.2
JUNE	1994	411.1	381.1	57.0	69.4	7.7	SURFACE	345.4	65.7
JULY	1994	398.7	368.7	65.0	74.8	7.5	SURFACE	333.6	65.1
AUG.	1994	386.5	356.5	70.0	73.1	4.4	SURFACE	308.4	78.1
SEPT.	1994	378.1	348.1	71.0	73.1	3.9	SURFACE	296.5	81.6

*** August had some bad data points**

Table 7. Variable submergence on the GATE and WEIR for 1993 temperature profiles. This analysis reflects the upper limit of Gate and Weir operations for the TCD design. The submergence varies from 54 ft in May to 20 ft in September.

MONTH	YEAR	WSEL (ft)	Gate Elev. (ft)	SJ WTP TEMP (F)	SELECT TEMP (F)	SELECT DO (mg/L)	SELECT U/L of W/D	SELECT L/L of W/D	W/D Zone (ft)
APRIL	1993	446.9	409.5	49.0	53.5	9.7	441.6	379.2	62.4
MAY	1993	464.0	409.5	51.0	53.8	8.4	437.6	374.3	63.3
JUNE	1993	465.5	409.5	52.0	57.4	8.2	436.6	379.2	57.4
JULY	1993	450.9	409.5	53.0	65.9	n/a	433.5	385.7	47.8
AUG.*	1993	432.4	409.5	55.0	73.7	8.2	432.4	386.1	46.3
SEPT.	1993	428.2	408.2	57.0	69.9	7.8	428.2	382.7	45.5
WEIR DATA			**Weir elev.**						
APRIL	1993	446.9	401.0	49.0	53.7	9.7	446.9	332.7	114.2
MAY	1993	464.0	401.0	51.0	55.2	8.4	464.0	332.7	131.3
JUNE	1993	465.5	401.0	52.0	58.4	8.3	465.5	338.9	126.6
JULY	1993	450.9	401.0	53.0	66.9	n/a	450.9	360.9	90.0
AUG.	1993	432.4	401.0	55.0	73.0	8.0	432.4	365.7	66.7
SEPT.	1993	428.2	401.0	57.0	68.8	7.1	428.2	356.2	72.0

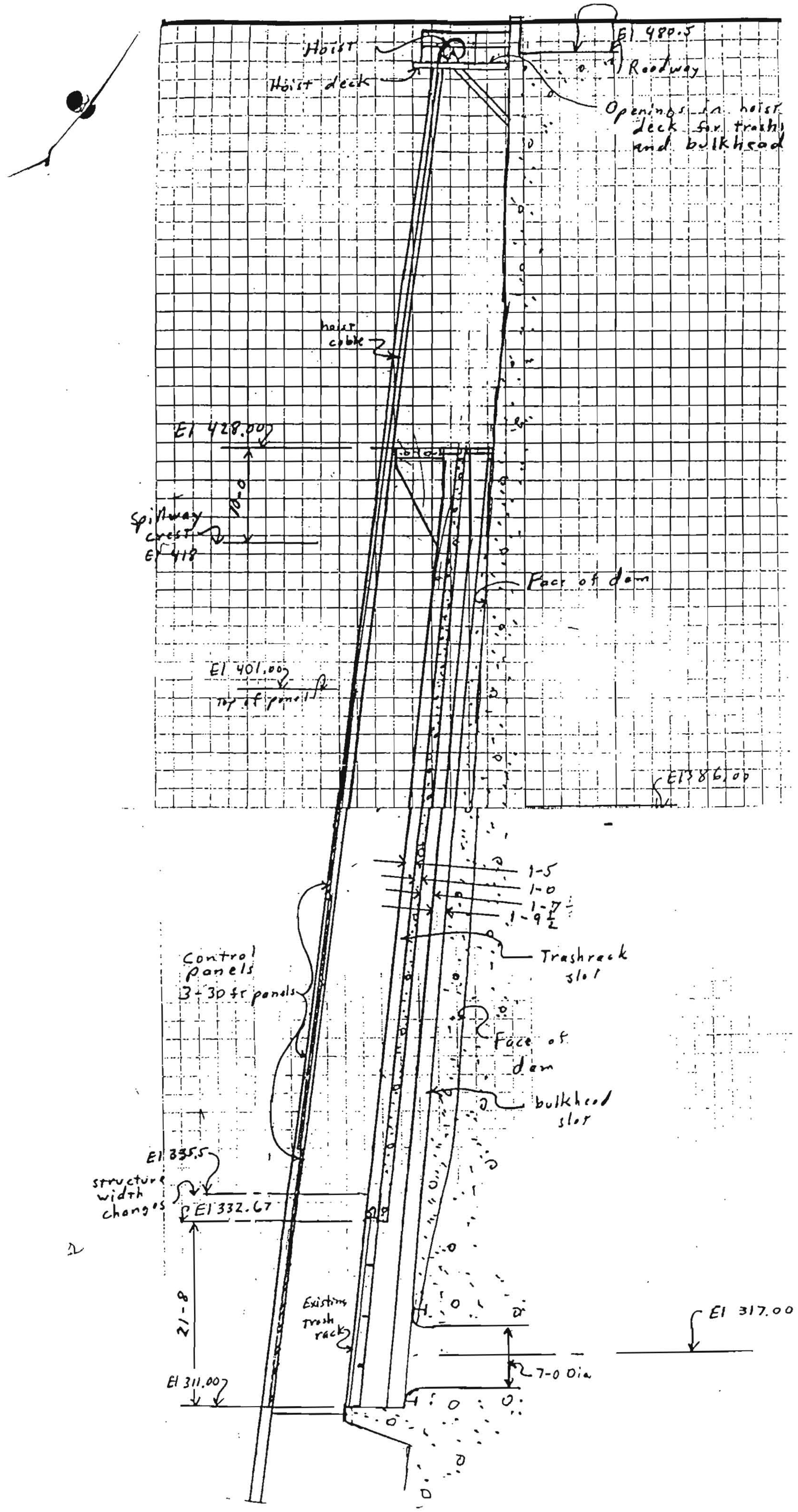
*** August had some bad data points**

Appendix

Contents

1) Preliminary Design Drawings

2) Fax Transmittal to Bill Sanford and Rod Hall, CC-400

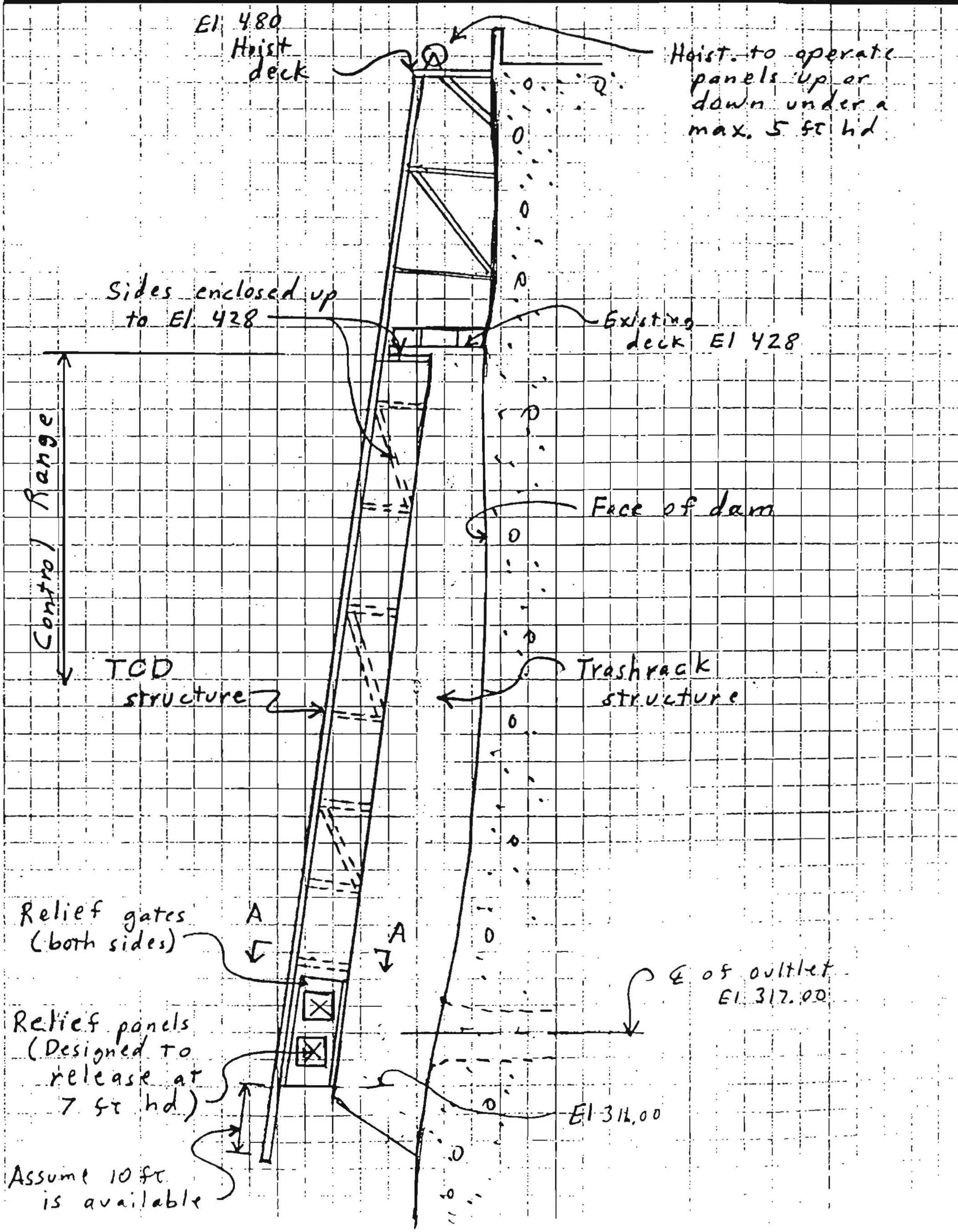


El 480.5
Hoist
Roadway
Hoist deck
Openings in hoist deck for trash and bulkhead
hoist cable
El 428.00
10-0
Spillway crest
El 418
Face of dam
El 401.00
top of panel
El 386.00
1-5
1-0
1-7
1-9 1/2
Trashrack slot
Control panels
3-30 ft panels
Face of dam
bulkhead slot
El 335.5
structure width changes
El 332.67
21-8
Existing Trash rack
El 317.00
7-0 Dia
El 311.00

7-1654 (11-94)
Bureau of Reclamation

COMPUTATION SHEET

BY	DATE	PROJECT	SHEET 5 OF 7
CHKD BY	DATE	FEATURE	
DETAILS			

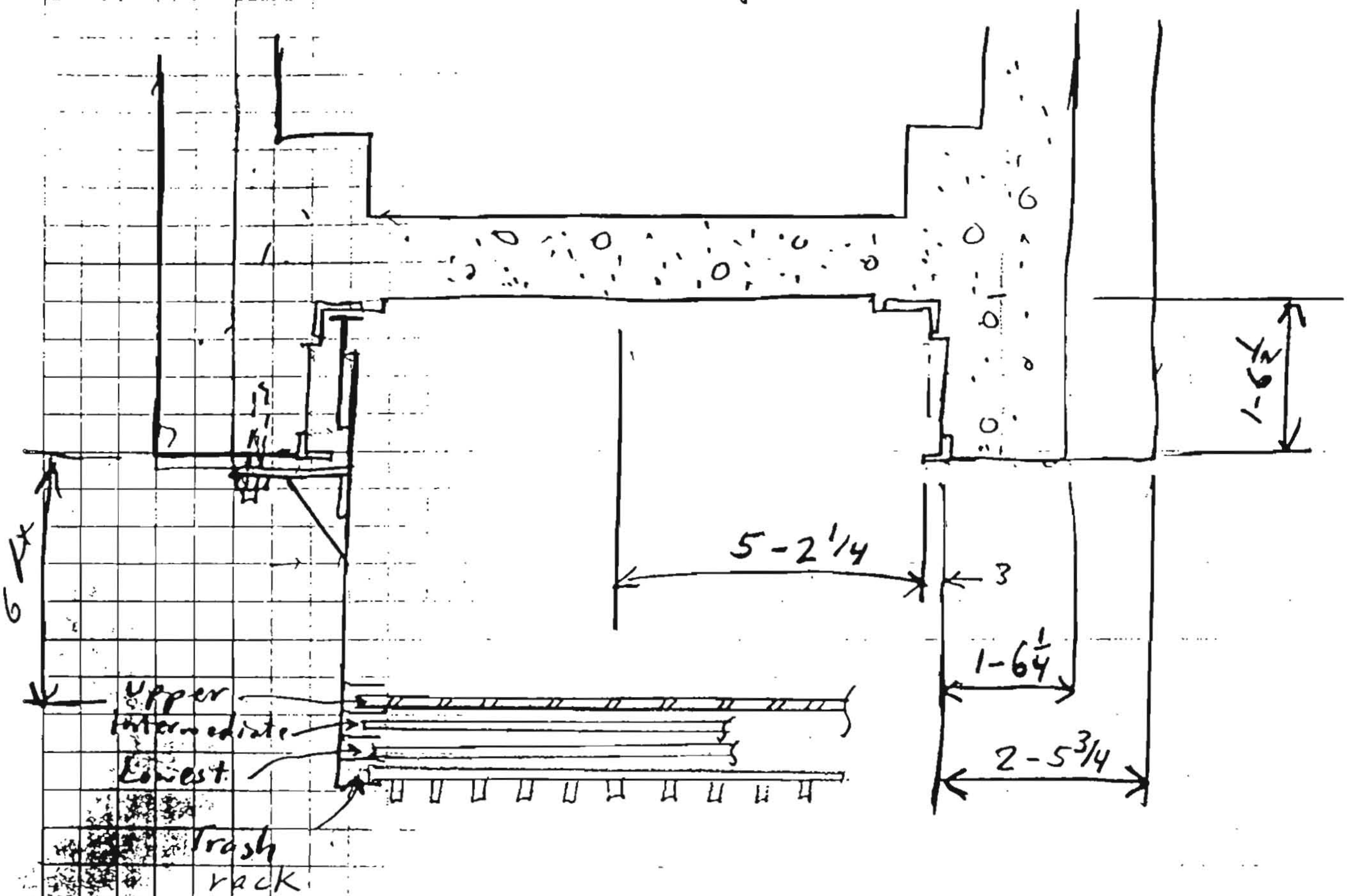


7-1654 (11-94)
Bureau of Reclamation

COMPUTATION SHEET

BY	DATE	PROJECT	SHEET 1 OF
CHKD BY	DATE	FEATURE	
DETAILS			

$$H_L = K\frac{v^2}{2g}$$



Determine maximum Q

From conversation on Jan 8 '97, Bill said to figure max Q at 7' dia pipe at 12 ft/sec

$$A = \pi r^2 = \pi(3.5)^2 = 38.48\ ft^2$$

$$Q = 38.48(12) = 461.8\ ft^3 \quad \text{say } 475\ ft^3/sec$$

Down the chute

$$A = 10.00(7.5) = 75\ ft^2$$

$$V = \frac{475}{75} = 6.33\ ft/sec$$

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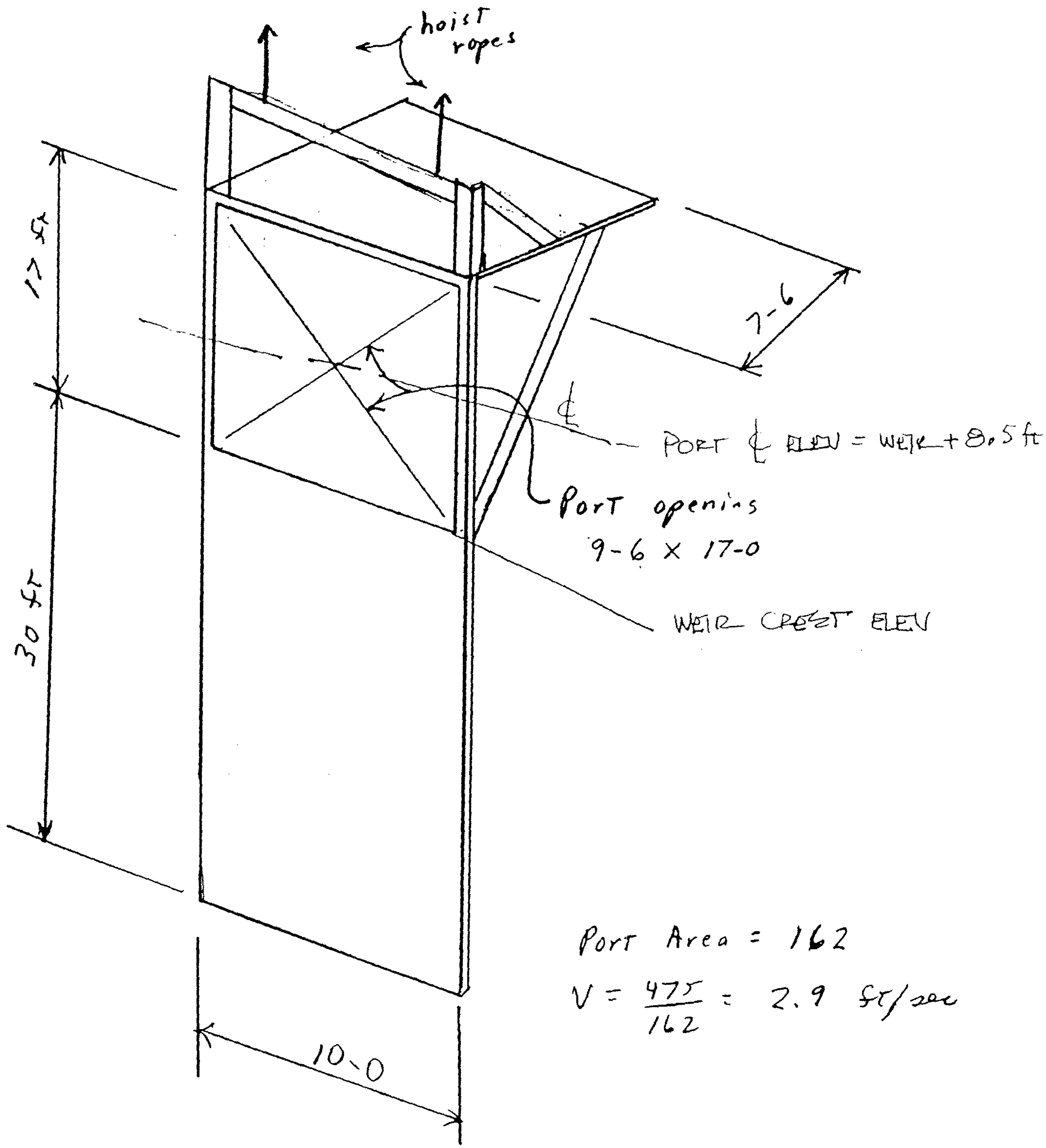
Bureau of Reclamation

COMPUTATION SHEET

BY	DATE	PROJECT	SHEET ____ OF ____
CHKD BY	DATE	FEATURE	
DETAILS			

Upper Gate



Port Area = 162

$V = \frac{475}{162} = 2.9$ ft/sec

FAX

T R A N S M I T T A L

To: BILL SANFORD and ROD HALL (CC-400)

Fax: 916 989-7208

Tel:

From: TRACY VERMEYEN

Date: April 23, 1997

Pages: COVER + 8

Re: SELECTIVE WITHDRAWAL ANALYSIS

Bill and Rod, I've included several figures which should illustrate the selective withdrawal characteristics of the TCD structure Bob Sund has proposed. Here is a summary of some of my observations related to the attached figures:

- Figure 1 is a plot of Lake Elevation and Water Temperature at the San Juan WTP and it shows that for low reservoir conditions (1992 and 1994) warm water (70 F) is available for withdrawal at El. 317. As a result, the TCD will not be effective during low reservoir levels.

- Figure A is a plot of the predicted release temperatures using the SELECT model and the water temperatures reported at the San Juan WTP. This figure shows a very good correlation between the known and estimated temperature, in fact, the linear regression coefficient is 0.98. These results validate the SELECT model calibration.

- Figure 2 shows the temperature profiles and vertical flow distribution for temperature profiles collected in April and September 1993. The arrows indicate the intake position. This analysis was done to develop a baseline condition for comparison with TCD model runs. The April 1993 stratification is relatively weak (48-56 F), and as a result the withdrawal zone has a greater vertical extent than the withdrawal zone generated with a stronger stratification, like in September 1993. The withdrawal zone extents are also a function of discharge and local influences associated with nearby powerplant operations and the reservoir bottom. The reservoir bottom below the intake (El. 284) is an obstruction to the development of the withdrawal zone as is shown in the April 19, 1993 Baseline plot. Influences associated with powerplant withdrawals are beyond the capabilities of the SELECT model and were not evaluated.

Water Resources
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- Figure 3 shows the temperature profiles and vertical flow distribution using a gate or port configuration for temperature profiles collected in April and September 1993. The arrows on the plot indicate the gate position. This plot shows that for 20 ft of submergence the upper limit of withdrawal extends to the water surface and the lower limit extends to a depth of 45 and 60 ft for April and September, respectively. The release temperatures were 56.3 and 69.8 F for April and September.

- Figure 4 shows the temperature profiles and vertical flow distribution for temperature profiles collected in April and September 1993 using a weir configuration. The arrows indicate the weir crest elevation. This plot shows that for 20 ft of submergence the upper limit of withdrawal extends to the water surface and the lower limit extends to a depth of 75 and 63 ft for April and September, respectively. The weir's withdrawal zone for both April and September is larger than for the port configuration. The release temperatures were 55.7 and 69.4 for April and September, which is less than 1 degree F colder than the port release temperatures.

- Figures 5 and 6 are similar to figures 3 and 4, except the submergence on the port and weir was 30 ft. The withdrawal characteristics are similar to those described above. Again, the difference in release temperatures between the weir and the port configurations was less than 1 degree F.

- Figure 7 is an image taken from a Corp of Engineers 3-D flow simulation of a intake port withdrawing water from a linearly stratified reservoir. Note that the withdrawal zone expands vertically with distance away from the port. This 3-D model was used by the Corps of Engineers to verify the prediction equations used in the SELECT model. The results of the study showed that the 1-D SELECT model was able to predict the withdrawal limits to within +/- 10% of withdrawal limits predicted by the more sophisticated 3-D model.

I hope these figures and my comments help explain the selective withdrawal results obtained using the SELECT model. If you have any questions please call me at (303) 236-2000 extension 451.

I will be preparing a report summarizing the selective withdrawal characteristics of the proposed TCD and Bob Sund will include it in the design summary. If you would like an advance copy, please let me know and I will send you one.

Sincerely,

Tracy Vermeyen, P.E.
Research Hydraulic Engineer

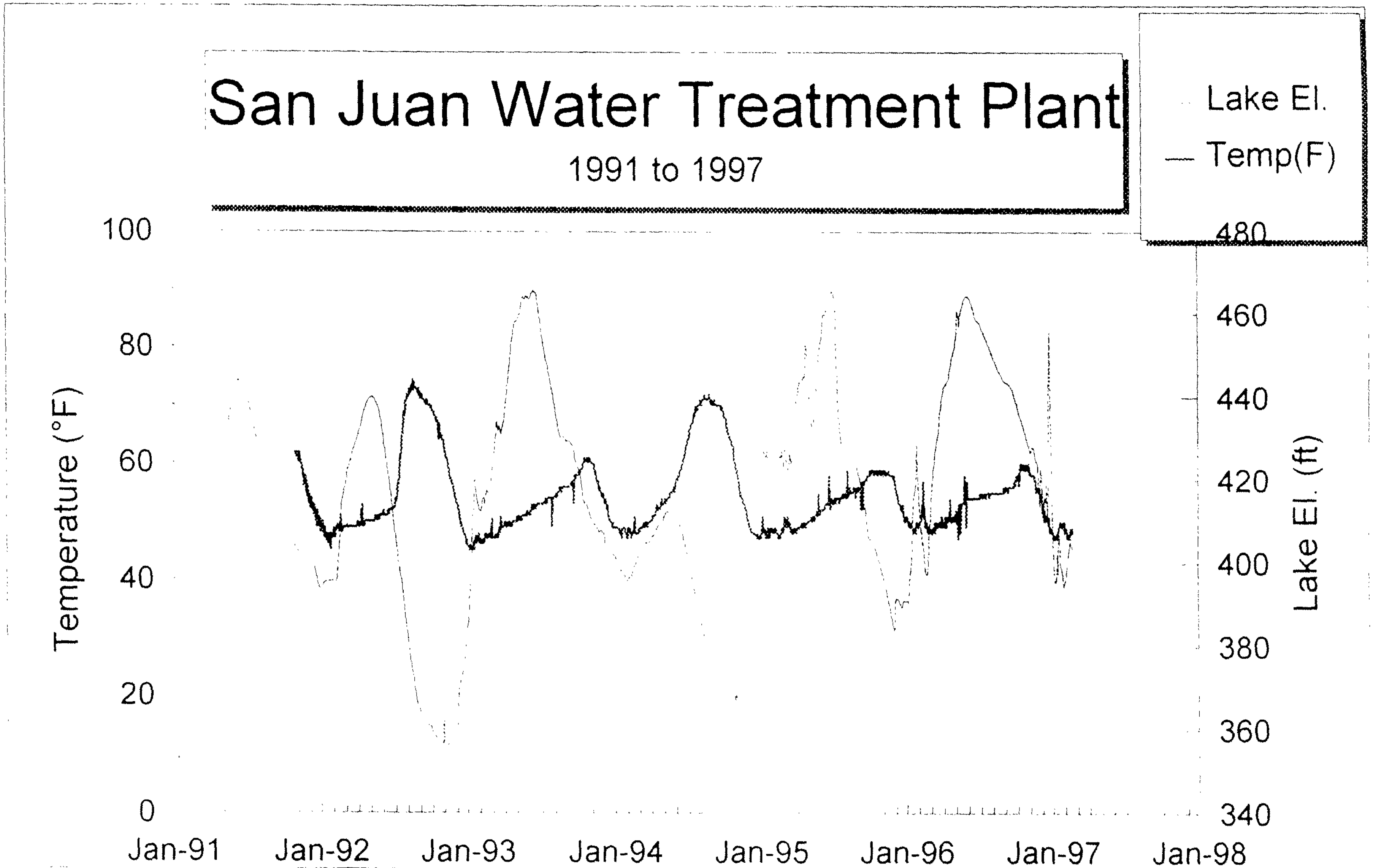

San Juan Water Treatment Plant
1991 to 1997
Lake El.
Temp(F)
Temperature (°F)
Lake El. (ft)
100
80
60
40
20
0
480
460
440
420
400
380
360
340
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98

FIG. 1

Regression Output:

Constant		-0.39181
Std Err of Y Est		1.173699
R Squared		0.976218
No. of Observations		33
Degrees of Freedom		31
X Coefficient(s)	0.997941	
Std Err of Coef.	0.027976	

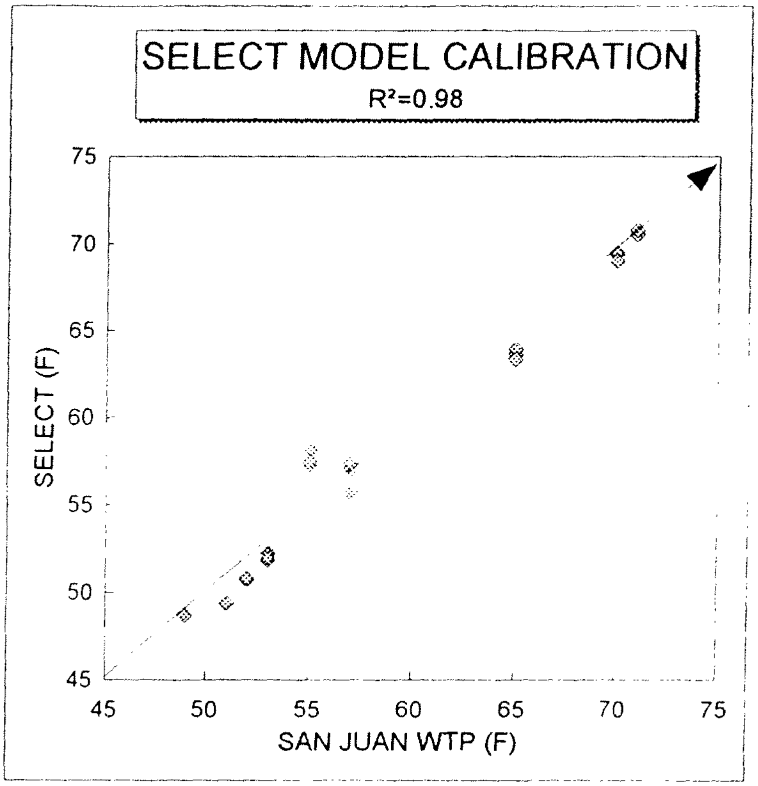


FIG A.

BASELINE RESULTS

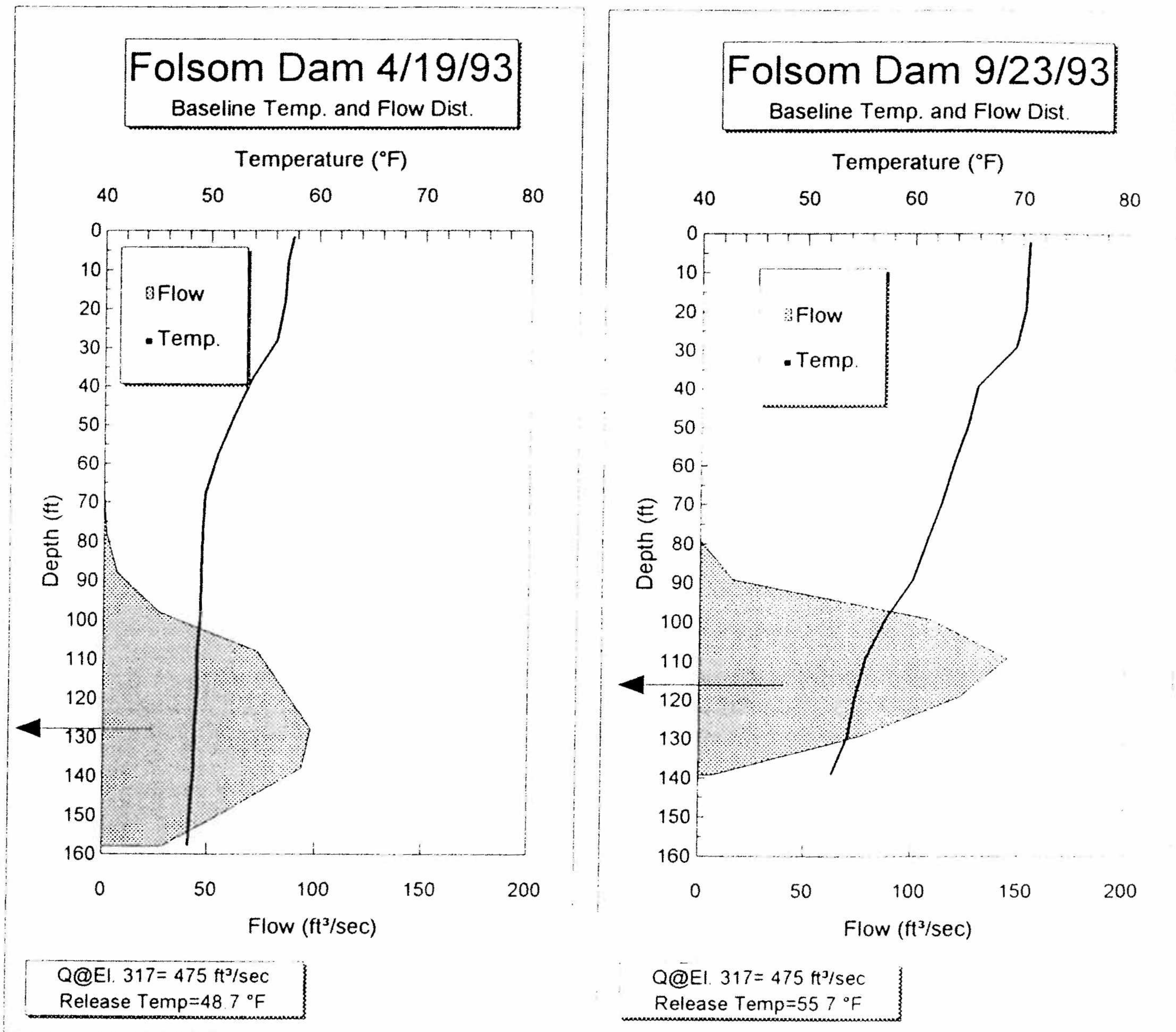
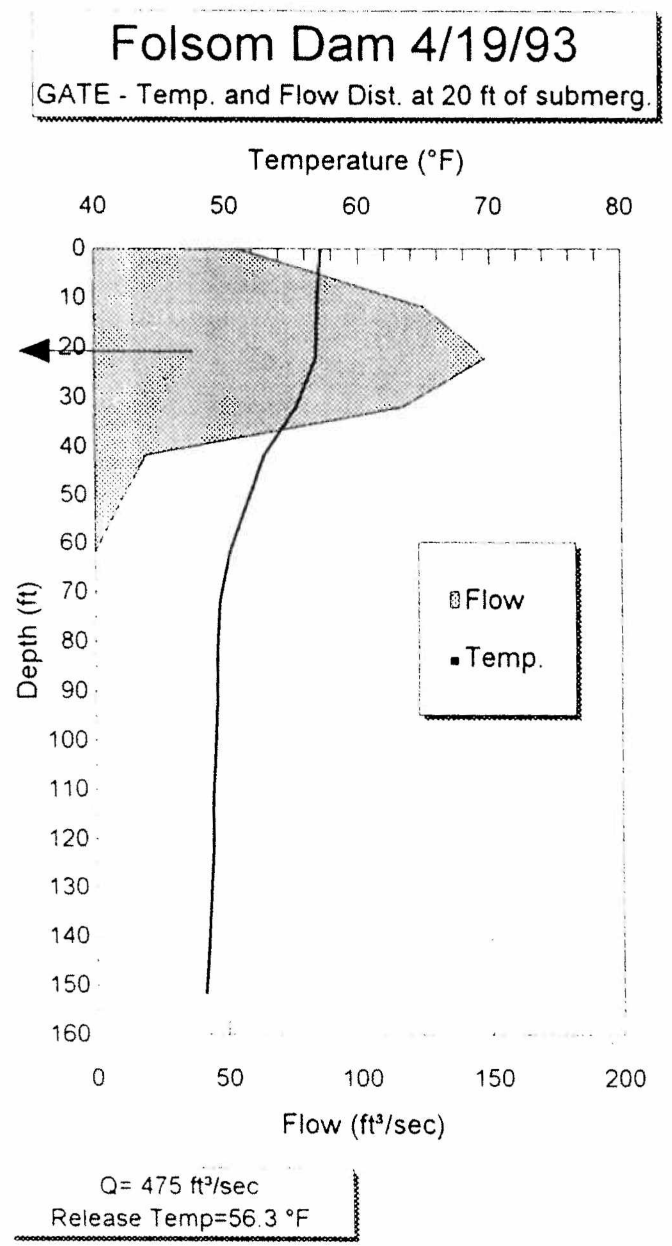
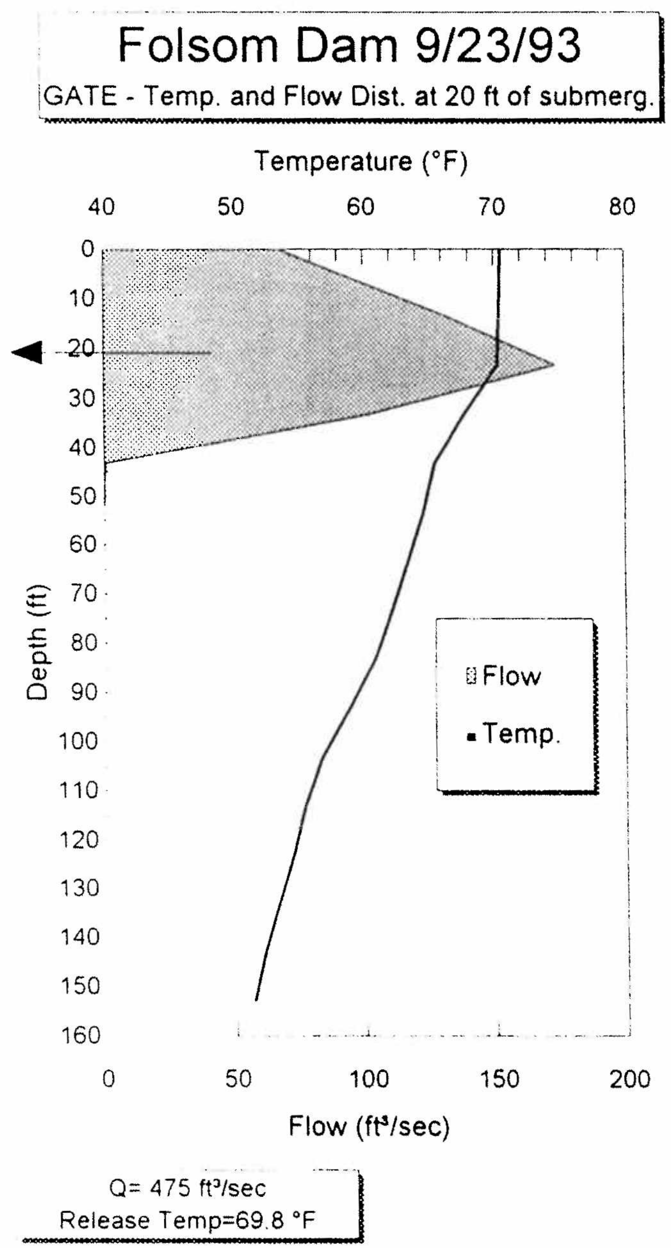


FIG 2.

WEAK STRATIFICATION

STRONG STRAT.

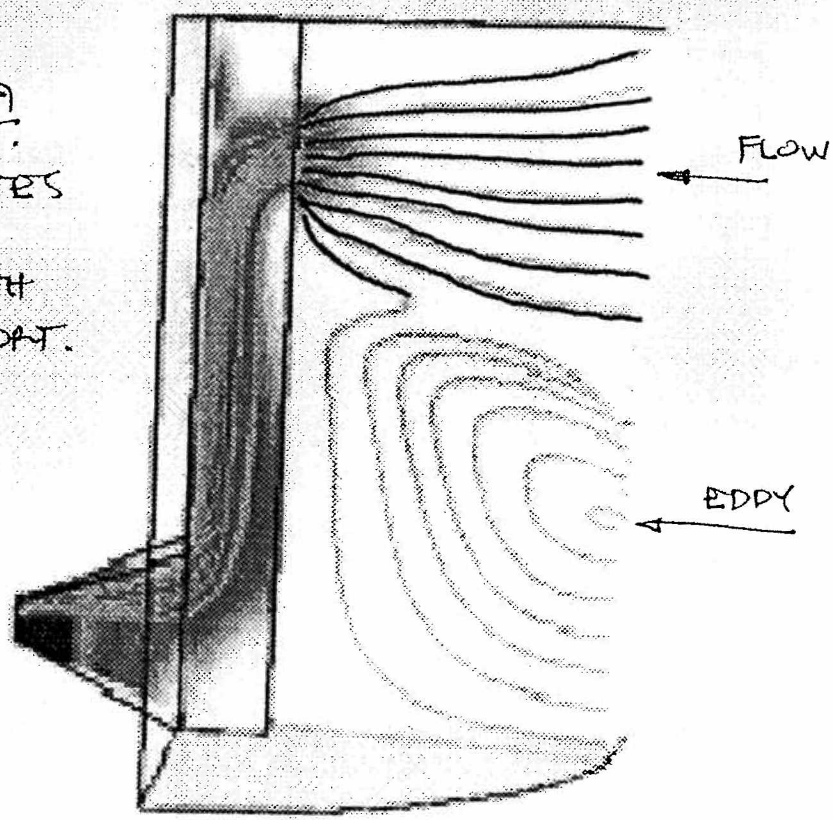


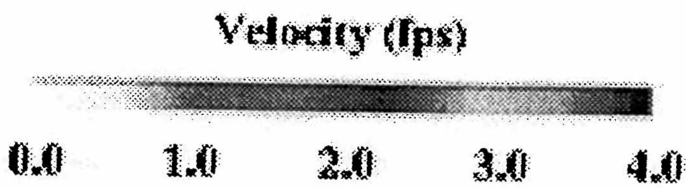


PORT CONFIG.
20 ft OF SUBMERG.

FIG. 3

EXAMPLE OF
FLOW FIELD ENTERING
A RECTANGULAR PORT.
THIS FIGURE ILLUSTRATES
THE EXPANSION OF THE
WITHDRAWAL ZONE WITH
DISTANCE FROM THE PORT.





SOURCE: CORP OF ENGINEERS, WATERWAYS EXP. STATION.

FIG. 7