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PHYSICAL MODEL STUDIES OF THE GCID PUMPING PLANT FISH SCREEN STRUCTURE ALTERNATIVES

Progress Report No. 2

1:30 Scale Model Investigations: Alternative A - Multiple Bay "V" Screens

April 1998

U.S. DEPARTMENT OF THE INTERIOR
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This report was peer reviewed by the Glenn-Colusa Irrigation District Technical Advisory Group.

PURPOSE

This report presents the results of the A alternative, multiple-bay "V" shaped positive barrier fish screen physical model investigations for Glenn-Colusa Irrigation District (GCID). The flat plate screen modeled for alternative D (Mefford and Kubitschek, 1997) was removed from the model and replaced with a four-bay "V" screen design. The "V" screen option was installed in the GCID river model to evaluate its performance when located near the site of the existing screen structure and pumping plant.

APPLICATION

The information included in this report is provided to the GCID Technical Advisory Group (TAG) to assist in the evaluation of proposed screen alternatives and to provide design data for the selected alternative.

INTRODUCTION

The Glenn-Colusa Irrigation District Pumping Plant is located in north-central California, approximately 100 miles north of Sacramento, on an oxbow of the Sacramento River. Figure 1 is a general location map. The pumping plant exports water from the Sacramento River to the west side of the Sacramento River Valley for irrigation purposes.

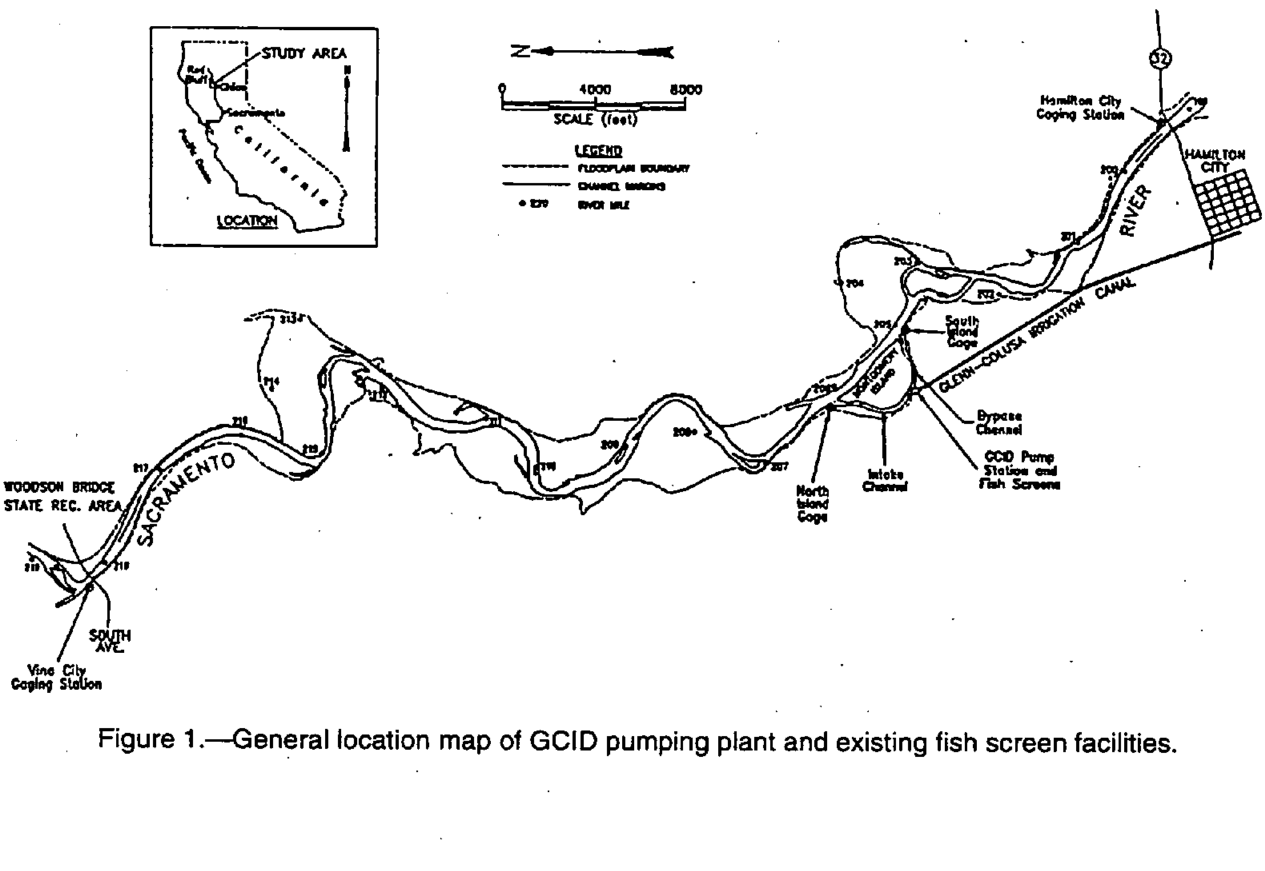


Figure 1.—General location map of GCID pumping plant and existing fish screen facilities.

In 1972, a rotary drum screen facility was constructed to provide fish protection from pumping plant entrainment. The facility originally consisted of 40 drum screens 8-ft wide and 17-ft in diameter. In 1970, the Sacramento River experienced the largest flooding since the construction of Shasta Dam. The result was a meander cutoff downstream from Montgomery Island that caused a decrease in river length of almost 1-1/2 miles. The consequence of this meander cutoff was a drop in water surface elevations of approximately 3 ft at the north end of Montgomery Island. These changes occurred over several years as the river stabilized. Lower water surface elevations resulted in lower than desired water depths in front of the drum screens. As a result, through-screen velocities exceeded resource agency fish screening criteria during high diversions. In 1991, the National Marine Fisheries Service (NMFS) filed an injunction against the irrigation district to restrict pumping during the peak winter-run Chinook salmon downstream migration period.

An aggressive program was initiated by the district in conjunction with resource agencies to identify options for both short- and long-term resolutions of the screening problem. To improve interim screen performance, flat panel wedge wire screens were placed in front of the drum screens in 1993. In 1995, the drum screens were removed from service.

Pursuit of a long-term solution has generated a number of screening alternatives which have, in turn, been subjected to detailed evaluation. In 1994, HDR Engineering, Inc., prepared a draft feasibility report which reviewed eight alternatives for replacement or modification of the existing screen facilities. Since then, these alternatives have been reduced to two.

The two best alternatives, labeled "A" and "D," are shown as figures 2 and 3, respectively.

Each of these alternatives was model studied. Alternative A consists of a new screen facility located just upstream from the existing facility. The A screen concept is a four-bay, multiple-V structure with bypass and evaluation facilities. Screen alternative D, Progress Report No. 1, March 1997, increases the length of the existing flat panel screen structure. The proposed flat plate screen is about 1,000 ft long, extending approximately 500 ft upstream from the existing structure.

Each of the previously described alternatives was initially evaluated and optimized using a 1:30 scale physical model. Following these investigations, one or both alternatives will be modeled at a larger scale to provide additional design on screen performance, screen baffling, and operation data for the prototype facility. A report series will be generated for documentation of the physical modeling of the screen alternatives. This report covers the 1:30 scale model investigations of the A alternative and constitutes the second report in the series.

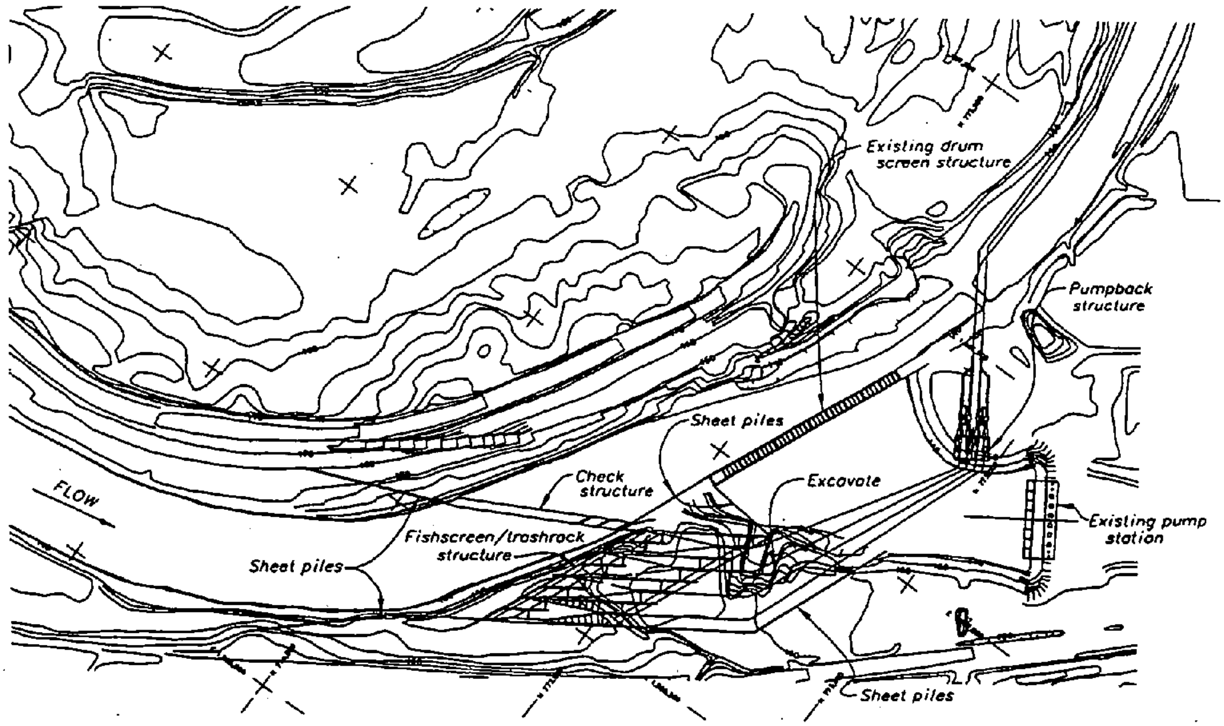


Figure 2.—Conceptual layout: Plan view of proposed A alternative.

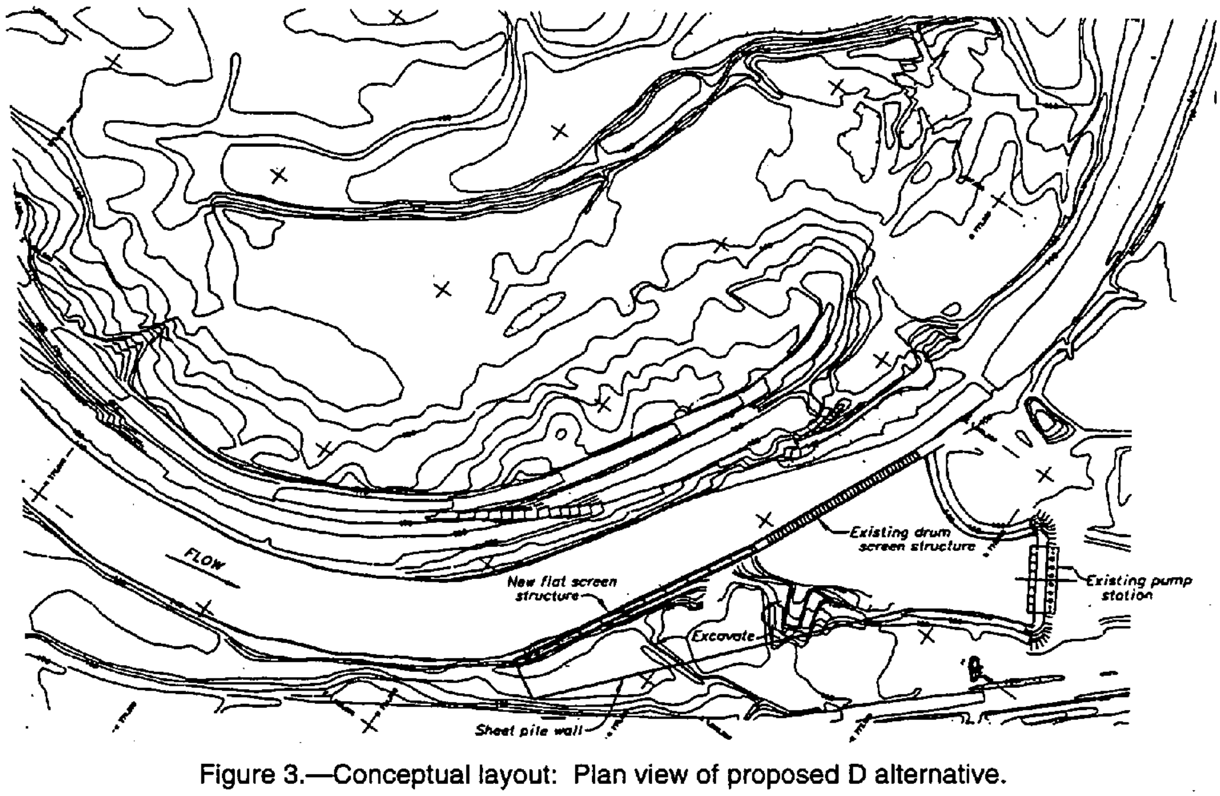


Figure 3.—Conceptual layout: Plan view of proposed D alternative.

DESCRIPTION OF ALTERNATIVE A - MULTIPLE BAY "V" SCREEN DESIGN

The fish screen structure is shown in figure 4. There are four V-shaped screen bays with a total screen length of 912 feet. The length of screen on each side of a "V" is 114 feet. The invert of the screens is set at elevation 125, which is approximately 3 feet below the currently dredged intake channel invert. The top of the deck is set at elevation 160.0, which is approximately 1.5 feet above the previous known high water mark, but 1.0 foot lower than the anticipated 100-year flood event water surface elevation. The minimum water depth at the screens would be 10 feet for the river flow of 7,000 ft^3/s upstream from the oxbow and 3,256 ft^3/s into the oxbow. The top of the fish screens is at elevation 137.0. A false wall (metal plate) extends from the top of the fish screens to the operating decks. Baffles are located behind the fish screens to provide for flow adjustment to achieve a uniform flow distribution through the screens. A fish bypass bay is located at the apex of each V-screen bay.

The weir wall adjacent to the fish screen structure prevents flow from passing down the lower oxbow channel during non-flood flow conditions and serves to guide flow into the fish screen structure. The weir wall is designed with a top elevation of 139.0. The weir contains three gates, a 35-foot wide river flood gate located near the weir's upstream end, a sediment sluice gate, and a trash sluice gate located next to the screen structure. The trash gate and sluice gate are operated only when needed to sluice material. The river flood gate is opened to pass a minimum of 500 ft^3/s flow when the river stage exceeds the top of the weir wall, elevation 139.0. When the river flood gate is closed, no flow is passed down the lower oxbow channel.

There are four 108-inch-diameter screw pumps (one for each bypass) in the pump back structure. Three pumps raise the bypass flow to elevation 145.0, and one pump raises the bypass flow to elevation 155.0. All pumps can operate for river flows are up to 30,000 ft^3/s. When the river flows are between 30,000 and 60,000 ft^3/s, only the single screen bay with pumped bypass flow to elevation 155.0 can be operated. Fish are bypassed back to the main river channel through two 78-inch pipelines. The bypass pipes terminate in the river thalweg.

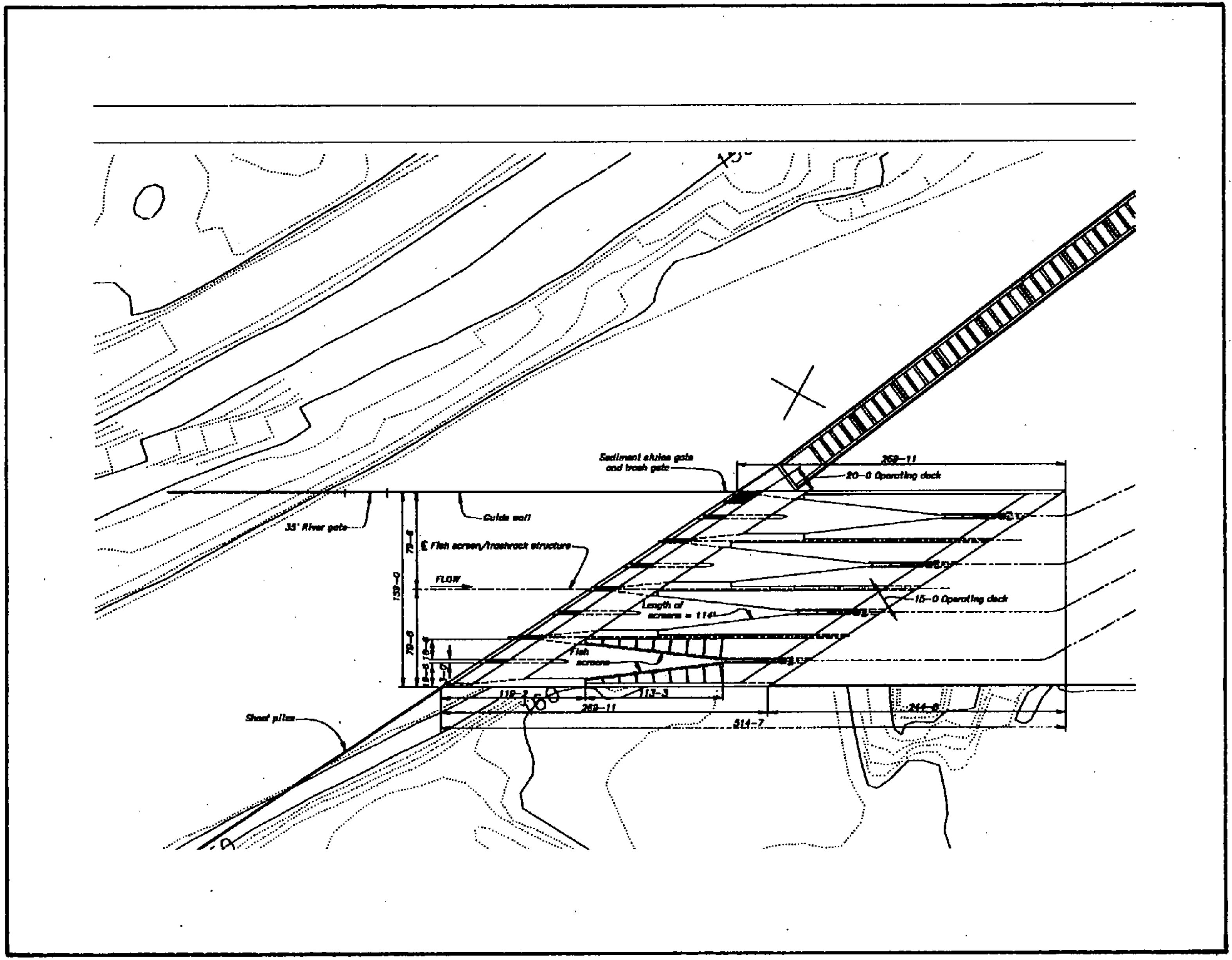


Figure 4.—Plan view of the "V" screen structure and weir wall.

OBJECTIVES OF THE MODEL STUDIES

The objectives of the river model study are to evaluate and determine the best site, structure orientation, and screen structure design for a "V" screen alternative based on approach flow conditions and screen flow performance. The major flow performance objectives are:

- The screen design should allow diversion of up to 3,000 ft^3/s of flow at 7,000 ft^3/s river flow.

- The approach channel should provide a nearly uniform distribution of flow into the screen bay entrances for all flows.

- For all flow conditions, the velocity normal to the screen face, measured 3 inches in front of the screen, should not exceed 0.33 ft/s.

- The flow velocity component parallel to the screen face, termed sweeping velocity, should be twice the normal component. Similar to the D-alternative screen structure, a design objective of 2 ft/s minimum sweeping velocity was chosen.

- The screen exposure time should not exceed 60 seconds.

- Each fish bypass should provide a flow of 64 ft^3/s at an average bypass entrance velocity of about 2 ft/s.

- The upper oxbow channel, screen forebay, and screen bays should be designed to minimize or eliminate areas of reverse flow or slack water. These conditions should be achieved for all pumping flows up to 3,000 ft^3/s. Between one and four bays may be operated to accommodated GCID canal flow diversion.

- The structure must allow for upstream migrants to move through the oxbow when flood flows are passed down the lower oxbow channel. This would occur when the river stage at the screen structure exceeds elevation 139.0.

CONCLUSIONS

The results of these investigations demonstrate that the A-alternative must be properly aligned relative to the oxbow channel and pumping plant to achieve desirable flow conditions. The study results show the multiple bay "V" screen concept can be designed to operate over the wide range of diverted flows. As part of this conclusion, we assume the screens would be baffled to further improve the velocity distribution approaching the screen faces. A series of modifications to the screen design were undertaken as part of the model study to improve performance. The screen modifications were largely related to structure positioning. A brief summary of screen performance for the A-alternative screen configuration is given below.

- Diversion capacity.—The A alternative requires no maintenance of down oxbow flow during non-flood flow conditions. Therefore, diversion capacity is controlled by the water surface drawdown provided by the GCID pumping plant. RCE (1993) (Resource Consultants and Engineers, Inc., "Riverbed Gradient Restoration Glenn-Colusa Irrigation District Configuration Data Report," U.S. Army Corps of Engineers contract DACW05-90-C-0168, September 1993) found the maximum flow that could be pumped at 7,000 ft^3/s river flow with the lower oxbow closed off is 2,600 ft^3/s. Operation of the existing pumping plant has a minimum forebay water surface elevation restriction of 135.1. Below this level, the pump motors overheat and must be shut down. Replacement of the existing pumps/motors allowing increased forebay drawdown would enable the screen structure to meet the desire diversion criteria. However, the impacts of increased oxbow channel drawdown on environmental issues or channel dredging have not been evaluated.

- Approach flow conditions.—Two orientations of the screen structure to the approach channel were model tested. These are referred to in this report as screen structure configurations 1 and 2. Configuration 1 (figure 5) was aligned with the approach channel to maximize the length of straight approach to the structure. Test data for configuration 1 shows good uniformity of flow approaching and along the screens for four-bay operation. However, closing bays during reduced pumping resulted in large slackwater areas forming in front of the closed bays and increased non-uniformity of screen approach flow.

For configuration 2, the screen structure entrance was positioned at a 4° angle to the existing structure, figure 6. The alignment of the screen bay entrances was set the same as that chosen for the D alternative flatplate screen. Flow approaches the structure parallel to the screen bay entrances, then turns about 30° as it passes into the screen structure. Configuration 2 showed improved sweeping velocity across the entrance to the screen structure. Starting with the bay fartherst upstream, bays could be closed without adversely affecting the approach flow. However, turning the flow approximately 30° as it entered the screen structure resulted in added non-uniformity of screen approach velocities.

Flow velocities in the upper oxbow channel are a function of river stage and GCID pumping. As shown in Table 1, the average flow velocity in the upper oxbow can be very low during periods of low pumping. This condition is present for river flows less than about 20,000 ft^3/s when the lower oxbow is closed.

- Normal approach velocity to the screens.—The screen structure is sized to meet 0.33 ft/s screen approach flow velocity (velocity component measured normal to the screen) at peak pumping. However, the flow distribution on the screens for unbaffled conditions was highly skewed. Non-uniformity of screen approach velocities were found to occur both along the screen and across screen bays.

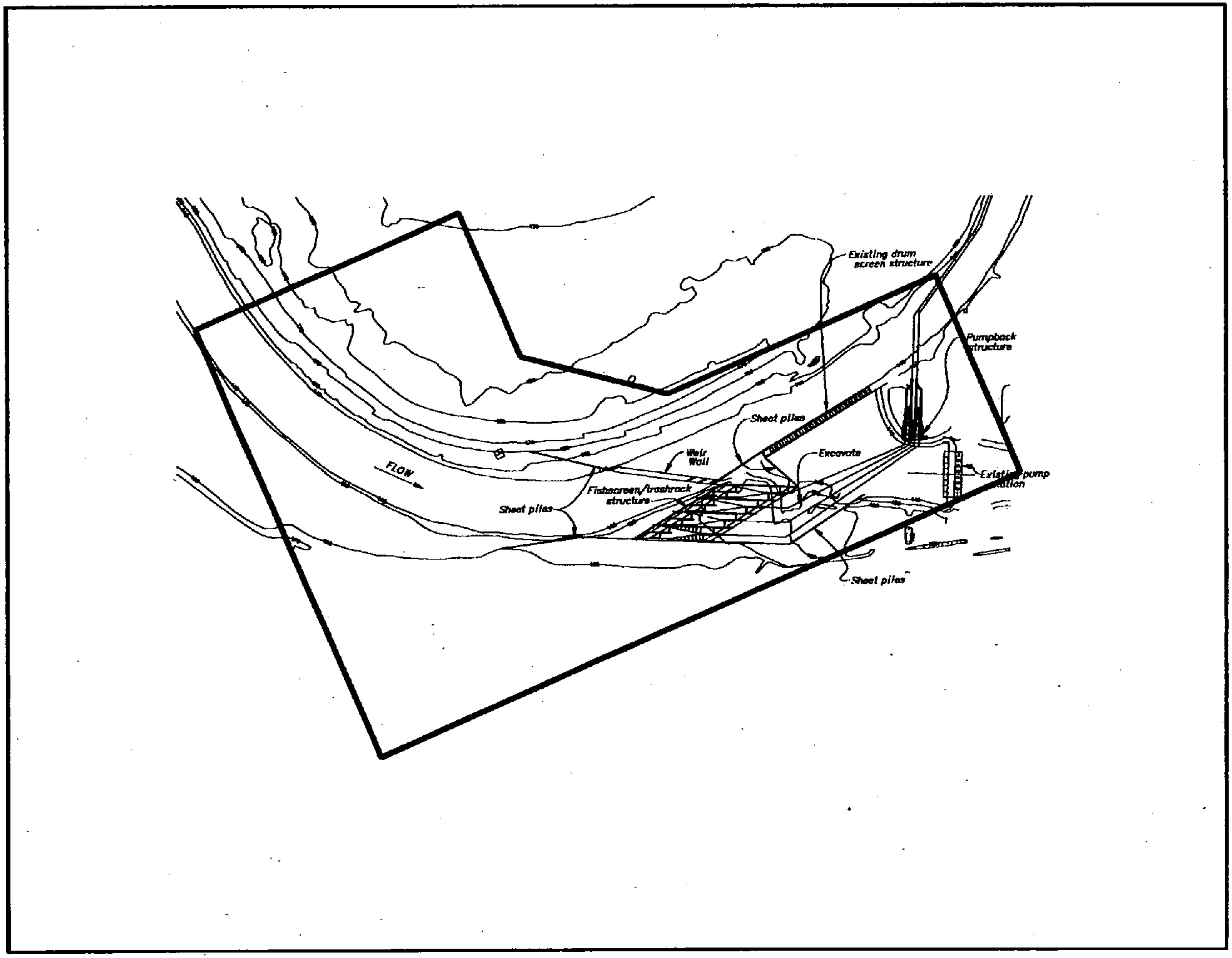


Figure 5.—Plan view showing location of screen configuration 1 and model limits.

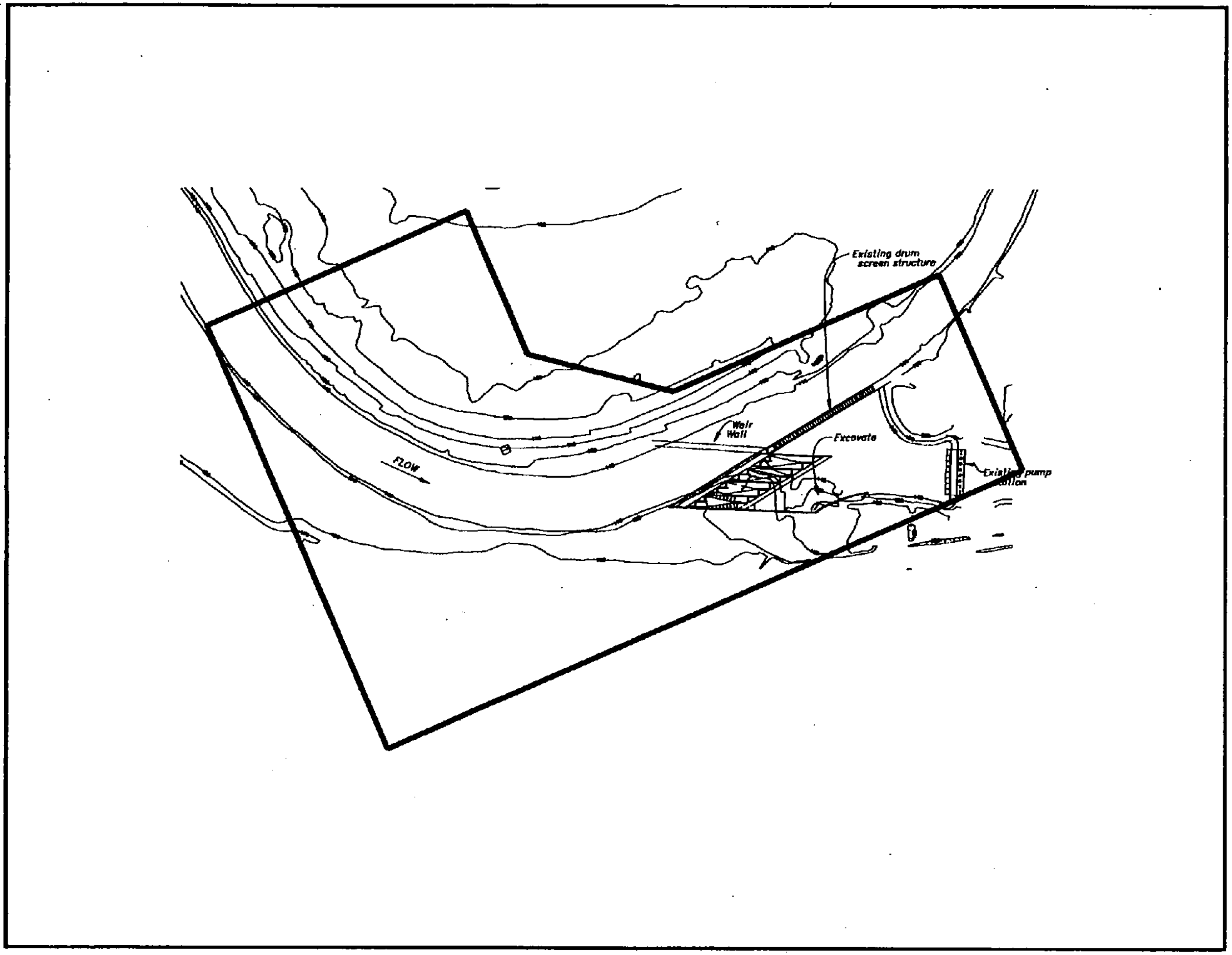


Figure 6.—Plan view showing location of screen configuration 2 and model limits.

Table 1.—Calculated values of approach channel flow velocity and screen hydraulics

Run No.	Average Upper Oxbow Velocity, ft/s	Average Screen Sweeping Velocity, ft/s	Average Screen Approach Velocity, ft/s	Screen Exposure Time, seconds
16	0.93	1.8	0.21	54
17	1.80	2.5	0.27	45
18	0.25	1.4	0.11	87
19	2.40	2.6	0.29	44
20	2.20	2.2	0.24	51
21	1.70	1.9	0.22	58

Increases in normal screen velocity from the head of the screen bay to the "V" apex or fish bypass entrance are typical of "V" shaped screen bays. This trend was evident for all configurations tested and varied in magnitude with operation. In addition to streamwise variations, screen approach velocity varied across screen bays for all conditions where the flow made a significant turn at the entrance to the screen structure. Screen approach velocities were typically highest on the downstream side of each screen bay as referenced to the screen bay centerline. Flow passing through the downstream side of the "V" bays follows the outside of the turn into the structure and the inside of the turn when exiting the structure and approaching the pumping plant. The across bay approach velocity distribution is probably skewed by the screen structure downstream alignment with the pumping plant and by turning the flow into the screen structure. However, attempts to improve the velocity distribution by extending the straight length of the screen structure by 120 ft and aligning the screens with the pumping plant provided little improvement. Across bay approach velocity differences were evident for all conditions tested. Configuration 1 with all bays open (see figure 9) showed the least across bay non-uniformity of flow. The test results indicate a greater length of straight approach to the screens and/or full baffling of the screen bays is needed to achieve the targeted magnitude and uniformity of screen approach velocity. Screen baffling was not tested in this study.

- An average sweeping velocity along the screen of 2.0+ ft/s is achieved for the design condition of 750 ft^3/s per screen bay. The velocity decreases for reduced pumping rates as shown in Table 1.

- Screen exposure time is inversely proportional to both screen sweeping velocity and screen approach velocity. Screen exposure times are generally less than the 60 second design objective. However, low pumping rates will result in screen exposure approaching 120 seconds.

- Flood flows require the weir gate be opened to pass a minimum of 500 ft^3/s flow down the lower oxbow whenever the water surface exceeds elevation 139.0. Operation of the gate for these conditions does not adversely affect flow into the screen structure. During flood flows, the weir gate design should allow for upstream migrants to pass through the oxbow channel. This conclusion is based on flow conditions predicted for 20,000 ft^3/s river flow with the weir gate fully open. This condition was numerically modeled to establish the water surface drop across the weir wall and was physically modeled to evaluate flow conditions. Twenty thousand cubic feet per second river flow corresponds to about the river stage at which the weir gate would be opened and lower oxbow flow established. For this condition, a water surface drop across the weir of about 1.0 ft occurs. Although higher river flows were not modeled, the differential across the weir is expected to diminish with increased river stage. This assumption should be checked with additional numerical simulations if further development of the design is pursued. Issues of lower oxbow channel flushing and fish blockage during non-flood flows were not addressed as part of the model investigation.

PHYSICAL MODEL

The fish screen model was constructed at Reclamation's Water Resources Research Laboratory in Denver, Colorado, using the same model facility used for the D-alternative studies. The 1:30 scale model included approximately 3,000-ft of the oxbow channel, the A alternative screen structure, the pumping plant, and the downstream bypass pipes. Figure 7 is a photograph of the river model for the A alternative, as constructed in the laboratory.

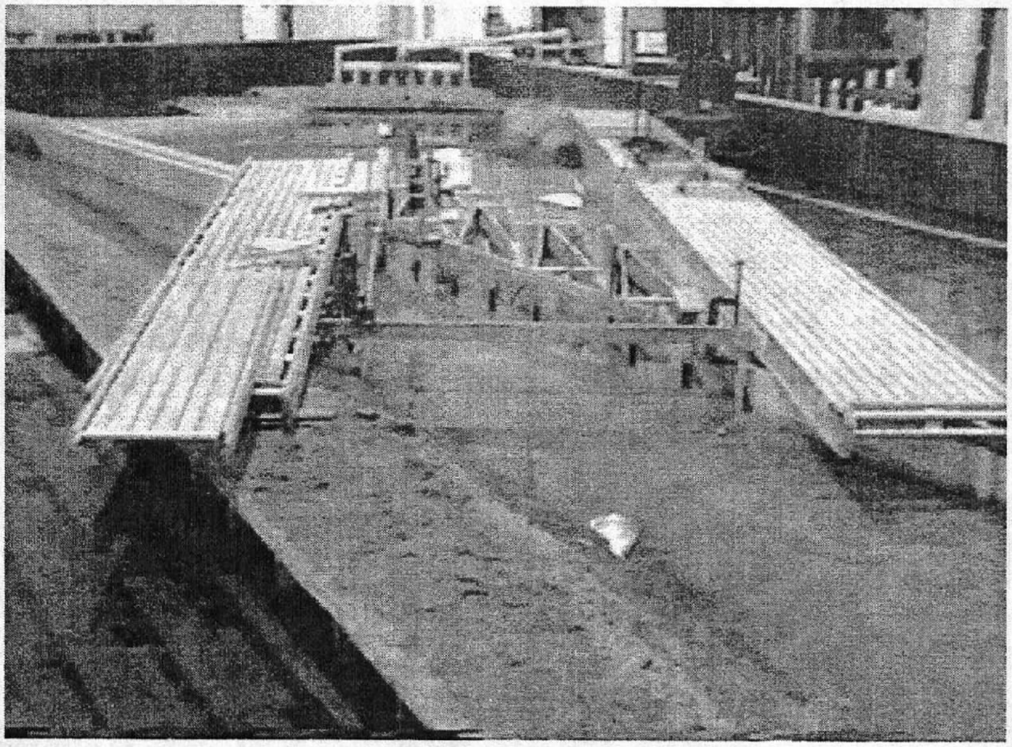


Figure 7.—Photograph of the Alternative A fish screen model.

Similar to the D-alternative model, 3/16-in perforated aluminum plate having a 56 percent open area was used as screen in the model. Screen bypasses were controlled by a pump and valve system. Downstream from the screen structure, the four bypass pipes were valved and then manifolded into a single pipe. The single pipe was connected to the suction side of a small pump to provide the necessary head for bypass flow. A valve and flow meter were placed on the discharge side of the pump to regulate bypass discharge.

The pumping plant was simulated using three separate pump and manifold systems in the model. Pump intakes 1 and 2, 3 to 8, and 9 and 10 were manifolded to separate pumps. Pumped discharges for pumps 3-8 were measured using a Controlotron ultrasonic flowmeter, and discharges for pumps 1 and 2 and 9 and 10 were measured using paddle wheel type flowmeters.

Discharge delivered to the model was measured using a permanent bank of laboratory venturi meters. The system is equipped with a flow controller to maintain the desired flow rate. Water surface elevations were monitored throughout the model using point gages set within the oxbow channel and screen structure forebay.

MODEL TEST PLAN

The major objective of model study was determining the impact on screen performance of screen structure location and alignment. The position and orientation of the screens relative to the curved oxbow channel and the existing pumping plant were assumed to be critical factors to achieving the desired flow conditions through the screen structure. Two positions for the screen structure were evaluated. Initially, the centerline of the structure was aligned with the centerline of the upstream oxbow channel. The screen structure was positioned on the outside of the channel bend at approximately the center of the bend (figure 5). This alignment is referred to in the test results as configuration 1. The structure was aligned with the approach channel to maximize the length of straight channel upstream from the screen bays.

For the second screen configuration tests, the screen structure was moved just upstream from the existing flatplate screen structure. The entrance to the screen bays was aligned at a 4° angle to the existing structure (figure 6). A similar alignment of the flat plate in the D alternative model was used to produce good sweeping flow along the face of the screen. For the A alternative the same alignment was chosen to provide sustained sweeping flow in front of the trashracks when the bays are closured.

Each screen configuration was tested for a range of river flows and GCID pump flows. The specific operating conditions tested were adjusted during the testing program based on data results and input from the Technical Advisory Group. Baseline water surface data for the physical model was again determined using a numerical model.

The numerical model developed for the D-alternative screen was modified to the A alternative screen design. The major changes were to the screen structure location, the screen entrance length, and the addition of the lower oxbow channel weir wall.

Ayers and Associates were contracted to run six flow combinations, table 2. The run numbering includes the previous 15 runs conducted as part of the D-alternative screen study. Runs 16 through 19 and run 21 were selected to represent conditions similar to those modeled in the D-alternative study. Comparable model run numbers for the D-alternative screen are shown in parentheses in table 2. Run 20 was added to show the impact of reduced pumping under river conditions similar to those of Run 19. In addition to these simulations, simulations conducted by Ayers in 1993 using a closed oxbow screen scenario were used to identify water surface and flow datums for the A-alternative design. Table 1 gives calculated average approach channel velocities and screen velocities for each of the numerical runs.

Table 2.—GCID screening Alternative A, 2D numerical simulation results

n=.025 for the River Channel and Oxbow Channel
(No Gradient Restoration Structure)

Run No.	Q_{river}	Q_{pump} (Input)	$Q_{Hamilton\ City}$	$Q_{Flood\ bypass\ to\ lower\ oxbow}$	Q_{intake}	Q_{bypass}	Water Surface Elevation (ft) North Gage (Output)	South Gage	GCID Screens
16 (13)	5,000	1,000	4,000	0	1,128	128	135.7	134.2	135.6
17 (1)	7,000	2,000	5,000	0	2,192	192	136.1	134.6	135.7
18 (12)	8,000	300	7,700	0	364	64	137.5	135.4	137.3
19 (7)	10,000	3,000	7,000	0	3,258	256	136.9	135.3	136.3
20	10,000	2,000	8,000	0	2,192	192	137.4	135.6	137.1
21 (9)	20,000	3,000	17,000	500	3,756	256	140.1	138.2	139.9

TESTING

Hydraulic testing of each structure configuration was limited to evaluating flow patterns and velocities in the approach channel and within the fish screen structure. Dye and confetti were added to the flow field upstream from the screen structure to observe the general flow pattern associated with each operating condition. Velocity measurements were made in the approach channel, along the trashracks, and along each fish screen.

Flow Visualization

Dye tests were particularly valuable for identifying the presence of slackwater and eddy zones in the screen forebay. Dye was injected approximately 200 ft upstream from the screen structure, starting near the right bank and moving across to the left bank. Visual observations and video tape were made of the dye flow path as it moved down the oxbow and into the screen structure.

Velocity Measurements

Velocity measurements were conducted to quantify approach flow and near-screen hydraulic conditions. A three dimension acoustic doppler velocity meter was used to make all velocity measurements. The meter has a velocity range of 0.003 to 8 ft/s, with a resolution of 0.001 ft/s. Velocity measurements were taken along the first 80 ft of screen along each side of each screen bay. The remaining 34 ft of screen approaching the bypass could not be measured in the model due to the narrow width of the "V" apex. Approach flow velocities were measured across the channel at the upstream point farthest upstream from the screen structure and at the center between trashrack piers upstream from the screens. Point velocities were measured at the 0.6-ft depth, thus representing the approximate vertical average velocity.

TEST RESULTS

Approach channel and screen bay entrance velocities are plotted in plan view relative to the screen structure as velocity vectors. The screen velocity results of the model study are presented as X-Y velocity plots for each configuration tested. The X-axis is given as the measurement location along the screen structure and the Y-axis as velocity magnitude. Both sweeping and normal components of velocity have been presented on the same plot for each test. Complete tabular data are given following each plot.

Screen Structure Configuration 1

Table 3 lists the test series conducted for configuration 1. For all tests, the screen bays and screens are numbered from downstream to upstream. Each screen bay is considered to contain two screens, one either side of the flow centerline.

Numeric model results given in table 2 were not available for the configuration 1 tests. Therefore, the screen structure was tested starting at maximum flow and then stepping the flow down in 750 ft^3/s increments. Each reduction in flow was associated with the closure of a screen bay. A water surface elevation at the screens of 135.0 was used for tests 1 through 4. This water surface elevation was selected based on 1993 Ayers numerical data reported for a 7,000 ft^3/s river flow and 3,000 ft^3/s GCID diversion flow condition. The same water surface was used for tests 2, 3, and 4 because it is currently the lowest possible water surface for pumping and the worst case for screen velocity. Water surface elevations of 139.0 and above represented operation of the weir wall flood gate and flow down the lower oxbow.

Table 3.—Fish screen Alternative A physical model testing summary.

Configuration 1:					
Test No.	Qintake	Qpp (cfs)	Qbypass (cfs)	w.s.el. (ft)	Comments
1	3,275	3,000	240	134.8	4 bay operation
2	2,430	2,250	180	135	3 bay operation (bay 4 - closed)
3	1,620	1,500	120	135	2 bay operation (bays 3 & 4 - closed)
4	810	750	60	135	1 bay operation (bays 2, 3 & 4 - closed)
5	4,275	3,000	240	139	4 bay operation (bay entrance velocities)

Configuration 2:					
Test No.	Qintake (cfs)	Qpp (cfs)	Qbypass (cfs)	w.s.el. (ft)	Comments
1	3,256	3,000	256	136.3	4 bay operation
2	2,192	2,000	192	135.7	3 bay operation (bay 4 - closed)
3	1,128	1,000	128	135.6	2 bay operation (bays 3 & 4 - closed)
4	364	300	64	137.3	1 bay operation (bays 2, 3 & 4 - closed)
5	3,756	3,000	256	139.9	4 bay operation

Configuration 3:					
Test No.	Qintake (cfs)	Qpp (cfs)	Qbypass (cfs)	w.s.el. (ft)	Comments
1	3,256	3,000	256	136.3	4 bay operation
2	2,192	2,000	192	135.7	3 bay operation (bay 4 - closed)
3	1,128	1,000	128	135.6	2 bay operation (bays 3 & 4 - closed)
4	364	300	64	137.3	1 bay operation (bays 2, 3 & 4 - closed)
5	3,756	3,000	256	139.9	4 bay operation

Configuration 4:					
Test No.	Qintake (cfs)	Qpp (cfs)	Qbypass (cfs)	w.s.el. (ft)	Comments
1	1,128	1,000	128	135.6	2 bay operation (bays 3 & 4 - closed)

Test 1 - 3,000 ft^3/s pumped flow and four-bay operation.—Four bay operation produced reasonably good flow conditions in the screen forebay (figure 8). Flow moved smoothly into the screen structure. Dye tests showed good flow distribution with no slackwater areas. Internal to each bay, the normal screen velocity components were consistently high on the downstream screen and low on the upstream screen (figure 9 and table 4). The difference in approach screen velocity relative to bay centerline was assumed to be caused by the offset orientation between the screen structure and the pumping plant. In general, normal velocities also increased from upstream to downstream along the screen face. A velocity increase toward the screen bypass is typical of "V" shaped screen structures. Sweeping velocities measured along the screen were relatively constant, averaging between 2.5 ft/s and 3.0 ft/s.

Test 2 - 2,250 ft^3/s pumped flow and three-bay operation.—Bay 4, the bay farthest upstream, was closed. A smooth plate was placed in front of the trashrack structure. Again the alignment of the structure with the oxbow channel provided good flow uniformity upstream from the screen structure (figure 10). Note, bay entrance velocities were not measured for this test. Closure of bay 4 created a significant reduction in the overall performance of the structure. Dye tests revealed the flow immediately in front of the closed bay was predominately slackwater and therefore potentially predator fish habitat. Internal to the operating bays, flow was increasingly skewed (figure 11 and table 5). In bay 3, the difference in normal screen velocity between similar positions on screens 5 and 6 increased substantially. This was probably caused by the eddy in front of bay 4 pushing the approach flow to the downstream side of bay 3.

Test 3 - 1,500 ft^3/s pumped flow and two-bay operation.—Closing bays 3 and 4 resulted in a further increase in the slackwater area in front of bay 4 (figure 12). Again, screen normal velocities were high on the downstream screens within each bay (figure 13 and table 6). Similar to test 2, the bay farthest upstream displayed the greatest across bay deviation of normal velocity.

Test 4 - 750 ft^3/s pumped flow and 1 bay operation.—Dye tests and screen forebay velocity measurements showed a large slackwater area in front of bay 4 and a smaller slackwater area in front of bay 3 (figure 14). The difference between across bay normal screen velocity increased in bay 1, following the previously cited trend (figure 15 and table 7).

Test 5 - 3,000 ft^3/s pumped flow and four-bay operation, screen water surface elevation 139.0: For test 5, the weir flood gate in the screen structure weir wall was opened to pass 500 ft^3/sec bypass flow. This test was conducted to evaluate the influence of weir flood gate operation on the flow distribution entering the screen bays. Screen bay entrance velocities are shown in figure 16. No other velocities were measured for this condition. No significant skewing in the bay entrance flow distribution was noted due to weir flood gate operation.

Following test 5, a number of tests were conducted to determine if the slackwater zone that forms by closure of a screen bay could be altered by closing bays in a different sequence, for example, closing bay 3 or bay 2 instead of bay 4 during three-bay operation. In a similar pattern, several combinations of bay closures were also tried for two bay operation. Altering the bay closure patterns proved ineffective for improving screen forebay flow conditions. Test data derived during experimenting with gate closure sequencing are not included in this report.

Screen Structure Configuration 2

The entire screen structure was moved downstream and aligned with the bay entrances at a 4° angle to the existing screen structure. The alignment of the trashracks was nearly parallel to the main approach flow direction (figure 6). The shape of the chevron bays was not changed between test configurations. Test conditions, flows, and water surfaces used for configuration 2 are shown in table 3. The results of numerical simulations were again used to establish baseline water surfaces.

Test 1 - 3,000 ft^3/s pumped flow and 4 bay operation.—Approach velocities were found to be highest near the right bank and lowest near the opposite bank (figure 17). It was evident a better transition between the opposite bank and the weir wall was needed to eliminate a local slack water zone located along the opposite bank. The effect on the general approach flow pattern was deemed small, and further work to improve the transition to the weir wall was set aside for future refinement. The study emphasis continued to focus on flow conditions in front of the trashracks and screens. Moving the screen structure downstream and aligning it approximately normal to the approach flow created high sweeping velocities in front of the trashracks. Velocities decreased from about 3.5 ft/s at the upstream bay entrance to about 1.5 ft/s at the bay farthest downstream.

Flow conditions around the trashrack piers were investigated visually. Dye was injected upstream from each pier and observed as it moved downstream into the screen structure. These tests revealed no areas of strong separation as flow turned into the screen structure. The convergence of the downstream pier walls and pumping plant flow demand appeared sufficient to move flow smoothly into the screen structure.

Velocities measured on the screen are given in figure 18 and table 8. A large difference in the normal screen components across each screen bay are evident. Velocities normal to the screen were high on the downstream side of each bay and low on the upstream side. Normal velocities also varied along the screens, increasing as flow approached the apex of the screen bay. The sweeping component of the flow velocity was fairly uniform in all screen bays, averaging between 3 to 4 ft/s.

Test 2 - 2,000 ft^3/s pumped flow and three-bay operation.—Bay 4 was closed for this test. Good sweeping velocity was sustained across the entrance to the closed bay (figure 19). Approach flow velocities were fairly uniform, varying between about 2.0 and 1.5 ft/s. The slackwater zone previously noted near the intersection of the opposite bank guide wall and the check structure was evident. However, dye tests and velocity data indicated this area had little influence on the flow distribution entering the screen bay structure. Dye injected upstream from bay 4 along the right bank moved smoothly past the closed bay and into bay 3. No slackwater or eddy zones were noted.

Screen velocities were similar to those measured for four-bay operation (figure 20 and table 9). Substantial differences were measured for normal velocity components both as a function of screen bay side and position along the screen length.

Test 3 - 1,000 ft^3/s pumped flow and two-bay operation.—Approach flow velocities are given in figure 21. These velocities show good uniformity of flow entering the screen structure. Flow swept past the closed bays at a velocity similar to that of the average approach channel velocity. Dye tests also showed a good transition of flow into the screen bays.

The flow distribution of normal screen velocities was similar to previous tests. Normal velocity varied across bay and along the bay length (figure 22 and table 10). Sweeping screen velocities were fairly uniform, averaging about 1.8 ft/s.

Test 4 - 300 ft^3/s pumped flow and one-bay operation.—Approach flow velocities are low during conditions of low pumping and water surface elevations below 139.0. For 300 ft^3/s pumped flow, approach channel velocity measured upstream from the screen structure was about 0.5 ft/s (figure 23). Flow in front of the closed bays continued at about 0.5 ft/s, indicating a good alignment of the structure. Screen approach velocities were not repeated for the 139.0 water surface elevation.

Test 5 - 3000 ft^3/s pumped flow and four-bay operation, screen water surface elevation 139.9 ft.—This condition represented about 20,000 ft^3/s river flow. In addition to pipe bypass flow, 500 ft^3/s flow was passed down the lower oxbow. The majority of the flow passed through the weir gate, with only a shallow skimming flow passing over the weir wall. The higher water surface improved overall screen performance as compared to test 1. The approach flow velocity distribution is shown on figure 24. Passing flow through the weir gate increased opposite bank velocities reducing the slackwater area previously noted. The screen data, figure 25 and table 11, shows less deviation of normal velocity between upstream and downstream sides of screen bays.

Screen Structure Configurations 3 and 4

Screen bay configurations 3 and 4 were modifications to the configuration 2 screen structure. The position and alignment of the screen structure relative to the oxbow channel were not changed.

Configuration 3 is shown in figure 26. The screen bay entrances were lengthened by 120 ft to increase the straight distance between the screens and the turn at the entrance to the trashracks. This configuration was tested to determine if the longer approach length would improve flow uniformity approaching the screens and reduce the side to side differences in normal screen flow velocities documented in configurations 1 and 2. The same test conditions, flows, and water surfaces used for configuration 2 were used for configuration 3 testing (table 3).

Lengthening the straight approach to the screens by 120 ft was not found to significantly improve the uniformity of screen normal velocities. The downstream side of screen bays again showed higher normal velocity values than their upstream side counterparts. The data for configuration 3 tests are given in figures 27 to 35 and tables 12 to 16. In addition to velocity measurements, several dye tests were made to observe flow through the structure. Dye injected in the middle of a bay tended to flow largely into the downstream side of the screen bays, verifying the flow patterns indicated by the velocity measurements.

Flow leaving the screen structure makes a mild turn as it approaches the pumping plant. This turn also favors the downstream screens and likely contributed to the across bay differences in normal velocity. Configuration 4 modeling consisted of a single test to evaluate the impact of downstream alignment of the screens and pumping plant. To evaluate the importance of downstream alignment with the pumping plant the weir wall was extended through the forebay to the pumping plant (figure 36). This modification yielded a straight alignment to the pumping plant for bays 1 and 2. The modification was placed in the model as a quick method to evaluate downstream alignment and did not reflect a proposed feasibility design. The temporary modification was tested with two-bay operation, bays 3 and 4 closed and 1,000 ft^3/s pumped flow. Only pumps on the forebay side of the temporary wall were operated. Figure 37 and table 17 give measured screen velocities for the conditions of a 120 ft straight approach and straight exit. With similar operation, a comparison of configuration 2 data with configuration 4 data (figure 20) shows only a small improvement. Also, flow conditions were checked again by injecting dye into the screen structure ahead of the screens. Dye injected along the bay centerline again moved largely into the downstream screen showing the stronger demand evident in the velocity data. No additional tests were conducted to further investigate improving the across bay flow velocity uniformity problem. It was decided that this issue should be addressed in the larger scale screen model which would include screen baffles.

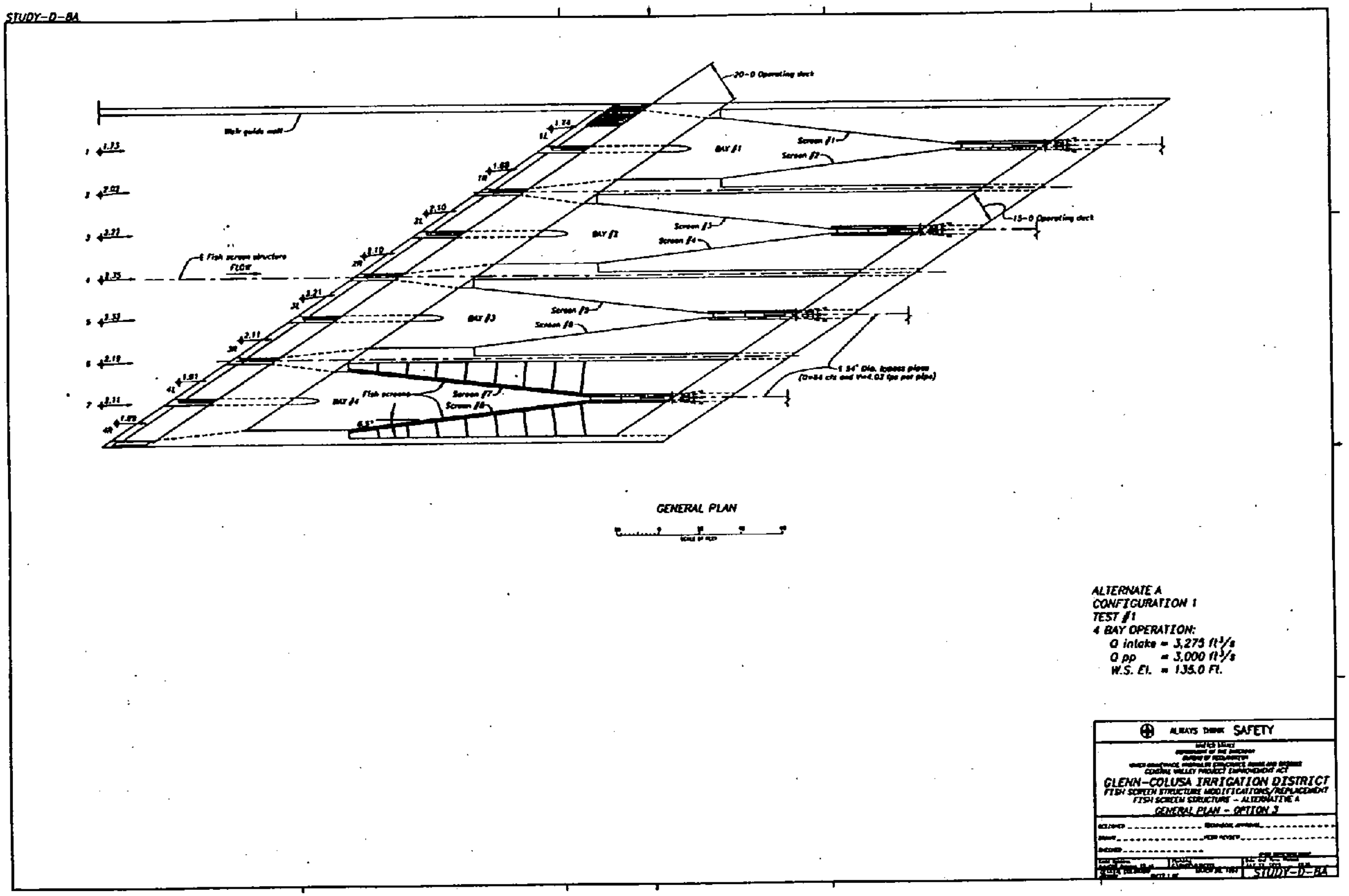


Figure 8.—Approach channel velocities for screen configuration 1, test 1.

GCID Alternative A 1:30 Scale Model Testing - Configuration 1
21 February 1996
fn=c1t2sd.wk4
TEST # 1 - 4 bay operation

Qintake =	3,275	cfs
Qpumping	3,000	cfs
Qbypass =	275	cfs (Total)
w.s.el. =	135	ft (@ screens)

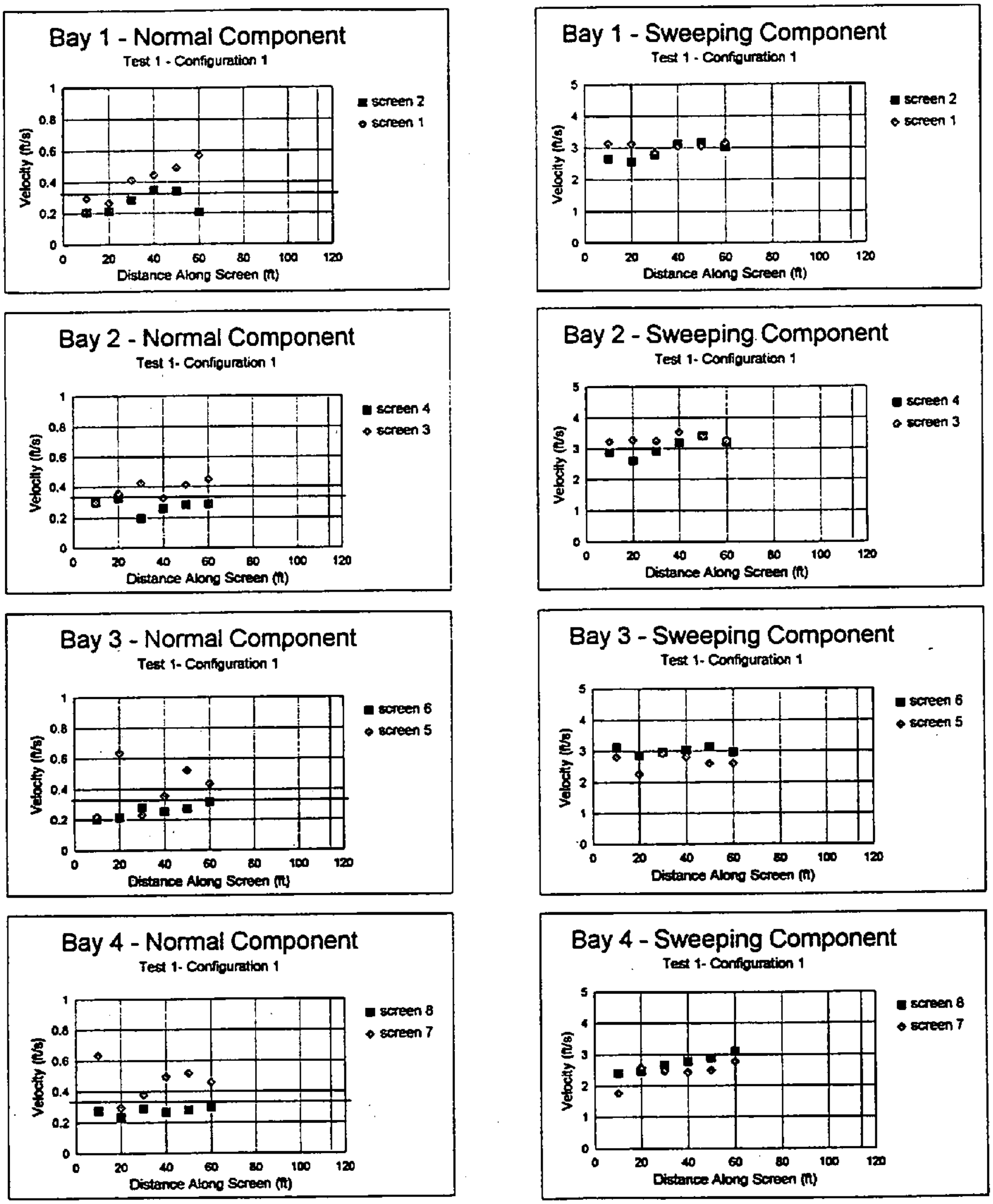


Figure 9.—Normal and sweeping flow velocities for screen configuration 1, test 1.

Table 4.—Screen approach velocity data for configuration 1, test 1.

GCID Alternative A 1:30 Scale Model Testing - Configuration 1
21 February 1996
fn=c1t2sd.wk4
TEST #1 - 4 bay operation:
Qintake = 3,275 cfs
Qpumping 3,000 cfs
Qbypass = 275 cfs (Total)
w.s.el. = 135 ft (@ screens)

Screen Velocity Data Summary:

Distance (ft)	Screen No.	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
10	1	0.29	3.14	5.32	3.16			
20		0.26	3.13	4.83	3.14			
30		0.41	2.85	8.25	2.88			
40		0.44	3.04	8.30	3.08			
50		0.49	3.04	9.17	3.08			
60		0.57	3.16	10.24	3.21	0.41	470.1	33.3
10	2	0.20	2.66	4.37	2.67			
20		0.21	2.57	4.72	2.57			
30		0.29	2.79	5.87	2.81			
40		0.35	3.13	6.36	3.15			
50		0.34	3.16	6.18	3.18			
60		0.21	3.03	3.93	3.04	0.27	304.4	
10	3	0.29	3.23	5.18	3.24			
20		0.36	3.28	6.19	3.30			
30		0.42	3.24	7.47	3.27			
40		0.33	3.53	5.30	3.54			
50		0.41	3.39	6.95	3.42			
60		0.45	3.27	7.82	3.30	0.38	430.1	32.0
10	4	0.30	2.88	5.88	2.90			
20		0.33	2.61	7.12	2.63			
30		0.19	2.93	3.80	2.94			
40		0.26	3.20	4.63	3.21			
50		0.29	3.41	4.78	3.42			
60		0.29	3.20	5.16	3.21	0.28	313.5	
10	5	0.22	2.81	4.48	2.82			
20		0.64	2.26	15.75	2.35			
30		0.23	2.93	4.49	2.94			
40		0.36	2.82	7.20	2.84			
50		0.52	2.61	11.31	2.66			
60		0.44	2.61	9.46	2.65	0.40	456.0	32.2
10	6	0.20	3.12	3.71	3.13			
20		0.21	2.86	4.25	2.87			
30		0.28	2.98	5.42	3.00			
40		0.26	3.03	4.81	3.05			
50		0.27	3.15	4.98	3.16			
60		0.32	2.97	6.09	2.99	0.26	293.4	
10	7	0.64	1.76	19.90	1.87			
20		0.29	2.57	6.47	2.59			
30		0.38	2.47	8.72	2.50			
40		0.49	2.43	11.49	2.48			
50		0.52	2.50	11.70	2.55			
60		0.46	2.77	9.44	2.80	0.46	527.7	36.1
10	8	0.27	2.40	6.47	2.41			
20		0.23	2.47	5.40	2.48			
30		0.29	2.65	6.26	2.67			
40		0.27	2.79	5.49	2.80			
50		0.28	2.89	5.52	2.90			
60		0.30	3.11	5.45	3.13	0.27	311.7	

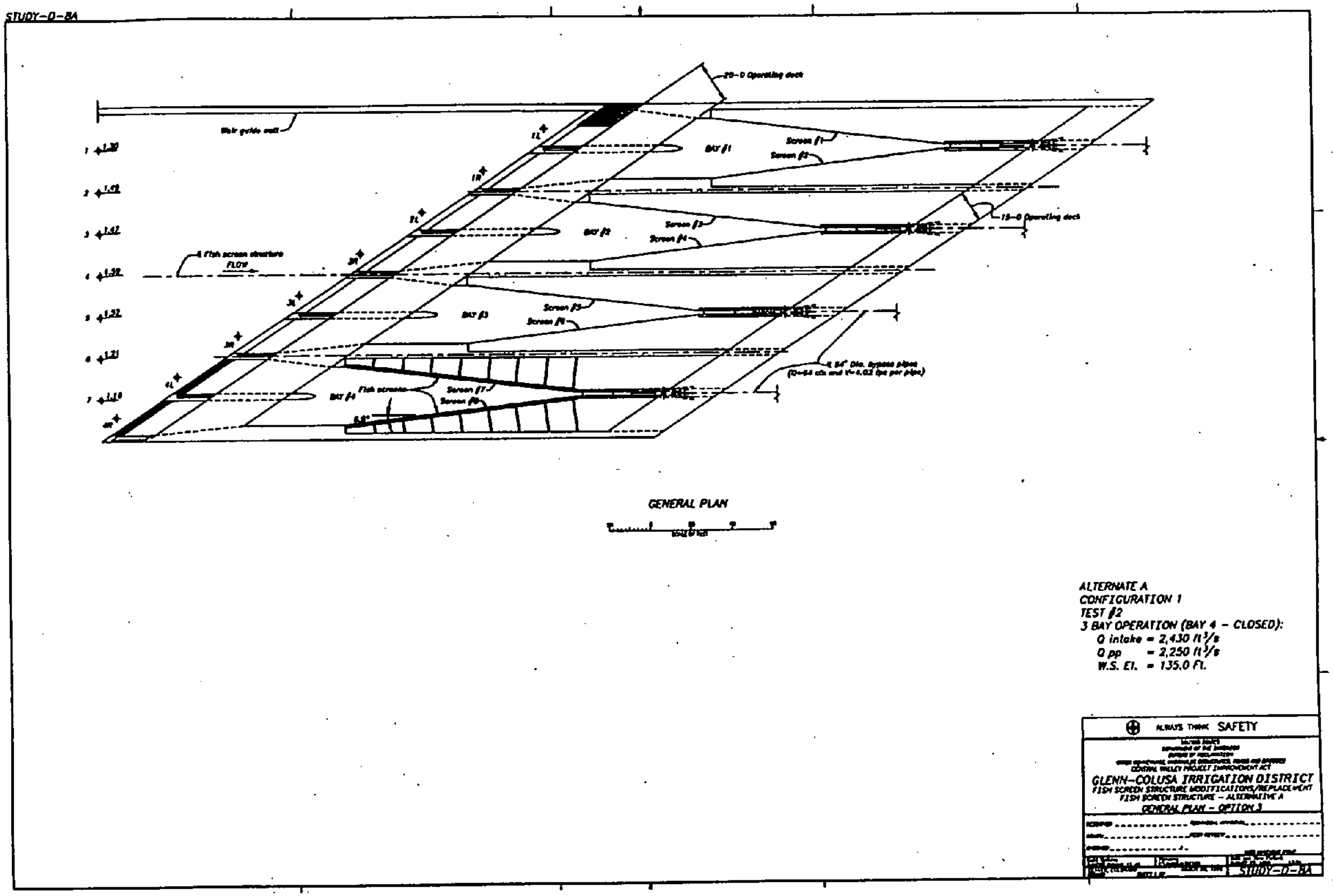


Figure 10.—Approach channel velocities for screen configuration 1, test 2.

GCID Alternative A 1:30 Scale Model Testing - Configuration 1
8 March 1996
fn = c1t3sd.wk4
TEST #2 - (3 bay operation (bay 4 closed))

Qintake =	2,430 cfs
Qpumping	2,250 cfs
Qbypass =	180 cfs (Total)
w.s.el. =	135 ft (@ screens)

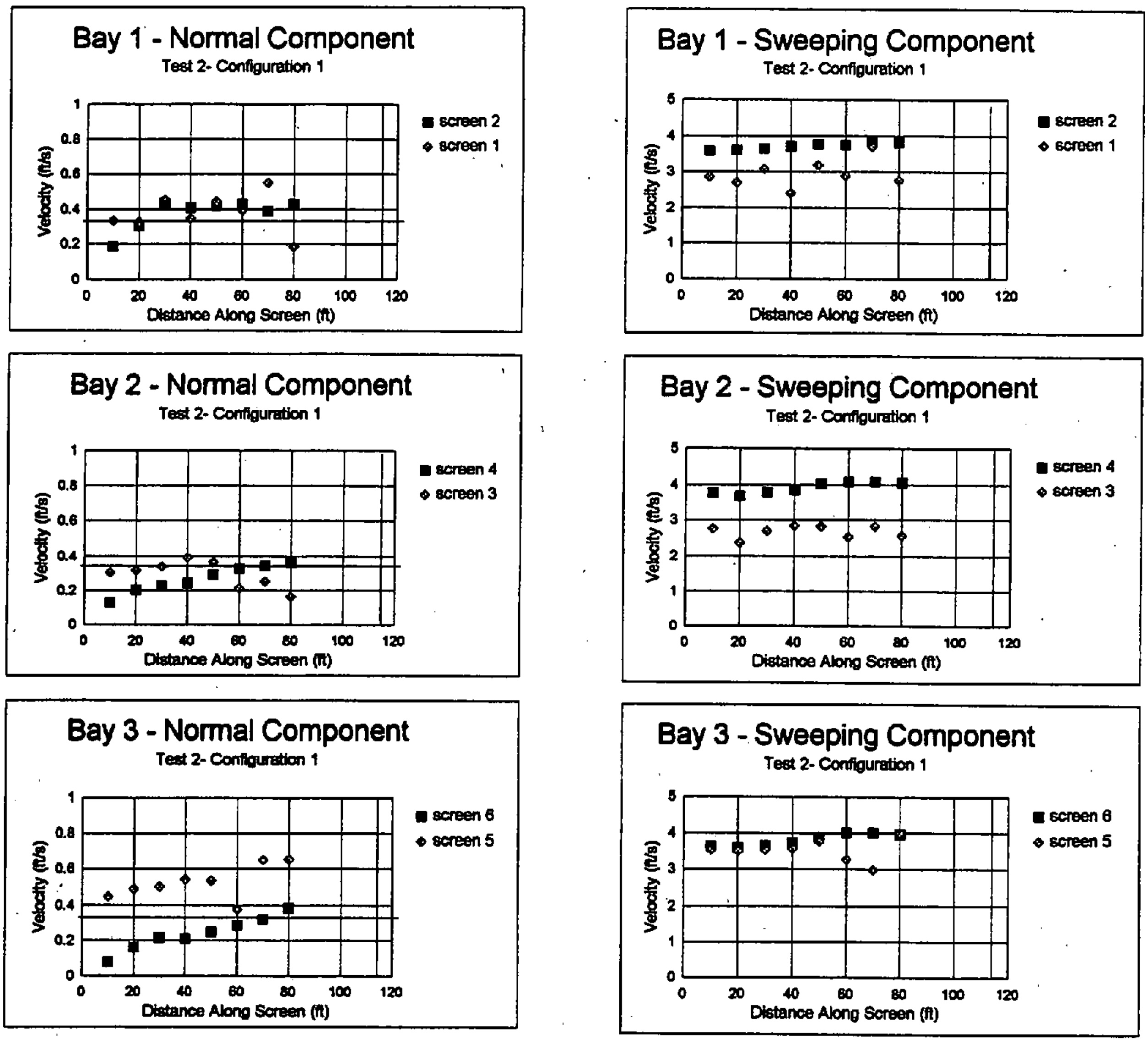


Figure 11.—Normal and sweeping velocities for screen configuration 1, test 2.

Table 5.—Screen approach velocity data for configuration 1, test 2.

GCID Alternative A 1:30 Scale Model Testing - Configuration 1
8 March 1996
fn = c1t3sd.wk4
TEST #2 - 3 bay operation (bay 4 - closed):

Qintake =	2,430	cfs
Qpumping	2,250	cfs
Qbypass =	180	cfs (Total)
w.s.el. =	135	ft (@ screens)

Screen Velocity Data Summary:

Distance (ft)	Screen No.	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degreees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
10	1	0.33	2.86	6.68	2.88			
20		0.33	2.70	6.93	2.72			
30		0.46	3.07	8.43	3.11			
40		0.35	2.41	8.21	2.43			
50		0.44	3.19	7.94	3.22			
60		0.39	2.88	7.79	2.91			
70		0.55	3.70	8.48	3.74			
80		0.18	2.76	3.81	2.77	0.38	433.3	
10	2	0.18	3.59	2.94	3.60			
20		0.31	3.61	4.84	3.62			
30		0.44	3.66	6.81	3.68			
40		0.41	3.72	6.30	3.74			
50		0.42	3.78	6.35	3.80			
60		0.43	3.77	6.55	3.79			
70		0.39	3.83	5.80	3.85			
80		0.43	3.82	6.47	3.85	0.38	429.4	36.4
10	3	0.30	2.77	6.24	2.78			
20		0.32	2.38	7.60	2.40			
30		0.34	2.69	7.21	2.71			
40		0.39	2.85	7.83	2.87			
50		0.37	2.82	7.37	2.84			
60		0.21	2.54	4.77	2.55			
70		0.25	2.83	5.10	2.84			
80		0.16	2.57	3.63	2.58	0.27	334.0	
10	4	0.13	3.76	1.95	3.77			
20		0.20	3.67	3.16	3.68			
30		0.23	3.79	3.42	3.79			
40		0.24	3.85	3.61	3.86			
50		0.29	4.02	4.11	4.03			
60		0.33	4.10	4.58	4.11			
70		0.34	4.09	4.79	4.11			
80		0.36	4.07	5.09	4.08	0.27	302.5	26.9
10	5	0.45	3.54	9.28	4.05			
20		0.49	3.52	12.28	3.05			
30		0.50	3.55	6.55	3.31			
40		0.54	3.59	8.07	3.82			
50		0.54	3.78	8.62	3.63			
60		0.38	3.28	8.07	3.58			
70		0.65	2.98	7.91	3.55			
80		0.65	4.00	7.20	3.57	0.52	598.5	
10	6	0.08	3.65	1.19	3.65			
20		0.16	3.60	2.59	3.61			
30		0.22	3.66	3.37	3.67			
40		0.21	3.75	3.23	3.76			
50		0.25	3.88	3.67	3.89			
60		0.29	4.02	4.06	4.03			
70		0.32	4.01	4.58	4.02			
80		0.38	3.96	5.53	3.98	0.24	271.5	36.7

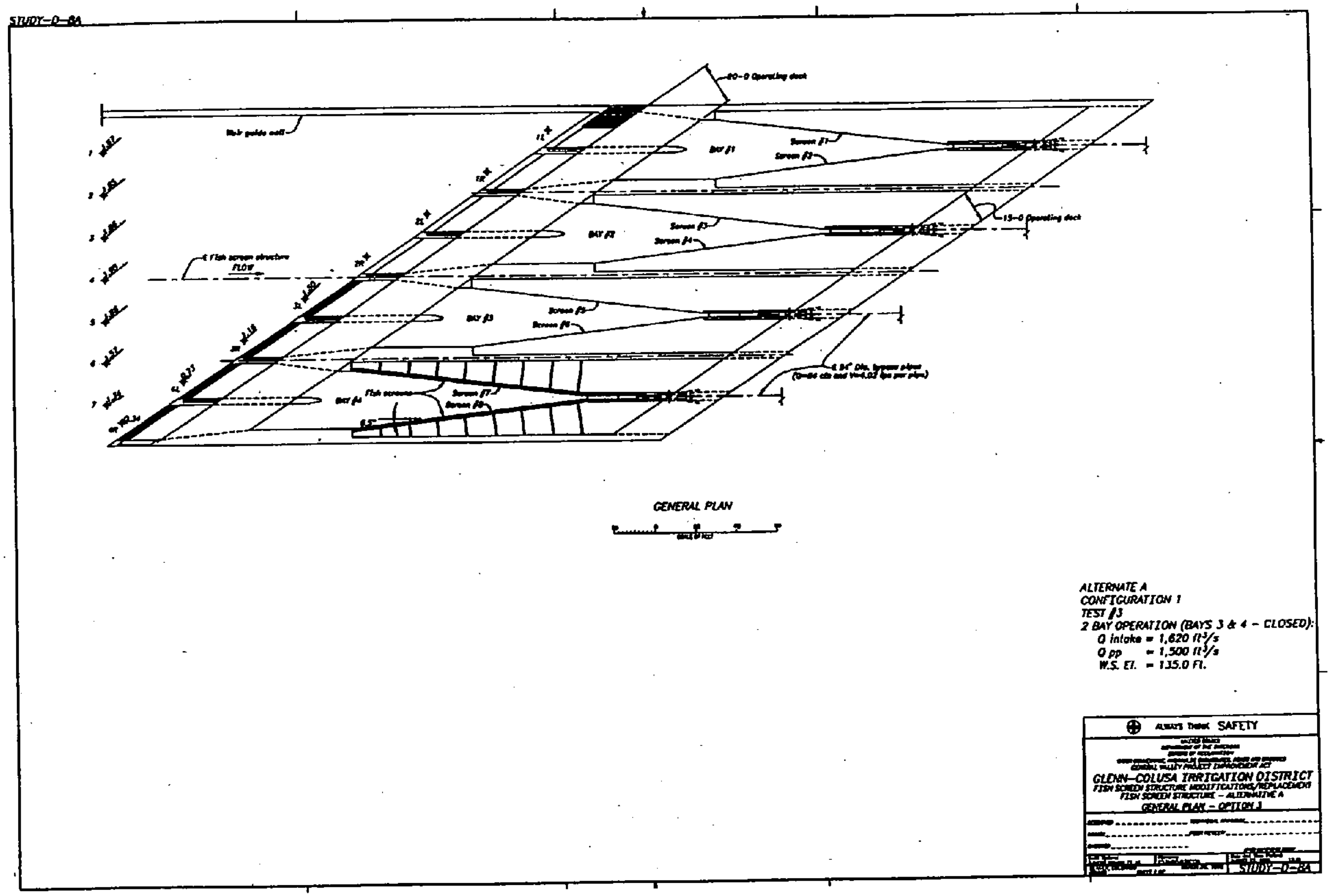


Figure 12.—Approach channel velocities for screen configuration 1, test 3.

GCID Alternative A 1:30 Scale Model Testing - Configuration 1
8 March 1996
fn = c1t4sd.wk4
TEST #3 = 2 bay operation (bay 3&4 = closed)

Qintake =	1,620 cfs
Qpumping	1,500 cfs
Qbypass =	120 cfs (Total)
w.s.el. =	135 ft (@ screens)

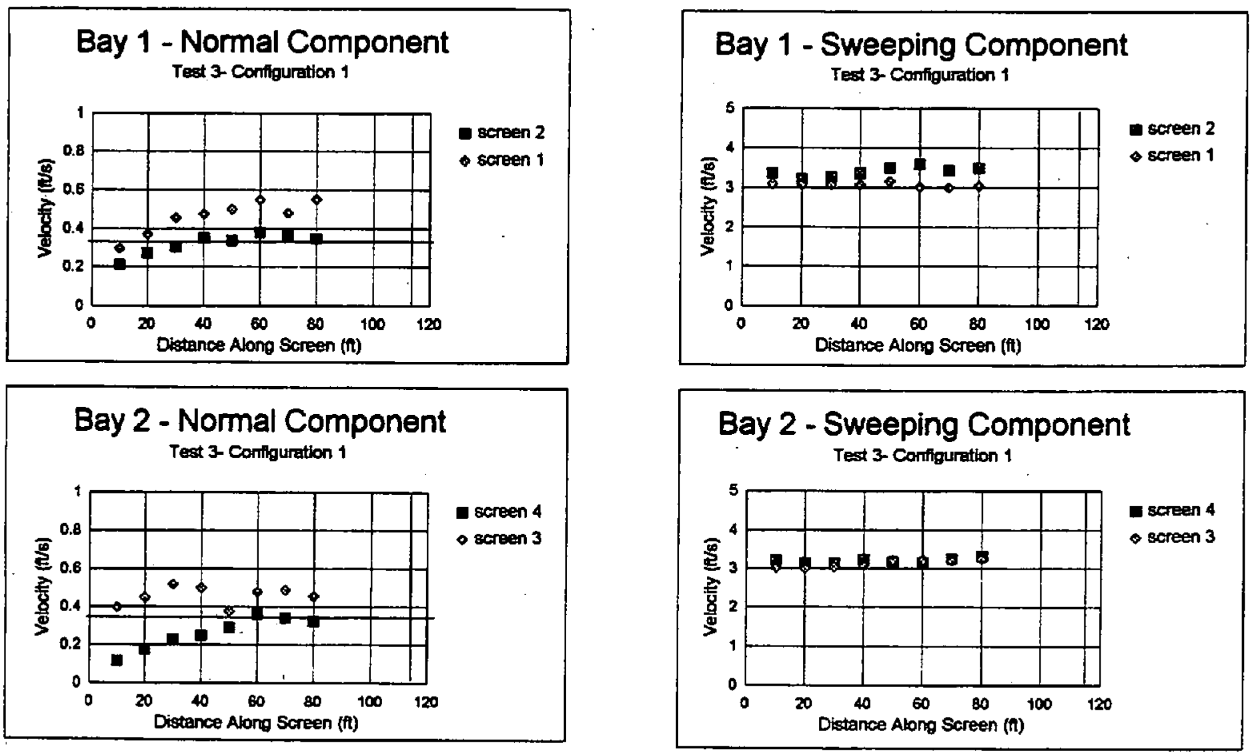


Figure 13.—Normal and sweeping velocities for screen configuration 1, test 3.

Table 6.—Screen approach velocity data for configuration 1, test 3.

GCID Alternative A 1:30 Scale Model Testing - Configuration 1
8 March 1996
fn = c1t4sd.wk4
TEST #3 - 2 bay operation (bay 3&4 - closed):

Qintake =	1,620 cfs	
Qpumping	1,500 cfs	
Qbypass =	120 cfs	(Total)
w.s.el. =	135 ft	(@ screens)

Screen Velocity Data Summary:

Distance (ft)	Screen No.	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
10	1	0.29	3.10	5.42	3.12			
20		0.37	3.07	6.87	3.10			
30		0.46	3.09	8.42	3.12			
40		0.47	3.08	8.76	3.12			
50		0.50	3.15	9.02	3.19			
60		0.55	3.02	10.31	3.07			
70		0.48	3.00	9.10	3.04			
80		0.55	3.04	10.28	3.09	0.46	524.0	52.2
10	2	0.21	3.37	3.59	3.37			
20		0.27	3.23	4.85	3.24			
30		0.31	3.27	5.36	3.28			
40		0.35	3.36	5.95	3.38			
50		0.34	3.49	5.52	3.51			
60		0.38	3.59	6.04	3.61			
70		0.37	3.43	6.11	3.45			
80		0.35	3.49	5.71	3.51	0.32	366.9	
10	3	0.39	3.02	7.45	3.04			
20		0.45	3.00	8.46	3.03			
30		0.52	3.04	9.64	3.08			
40		0.50	3.10	9.09	3.14			
50		0.38	3.21	6.67	3.23			
60		0.48	3.23	8.40	3.27			
70		0.49	3.22	8.64	3.25			
80		0.45	3.25	7.93	3.29	0.46	519.9	47.8
10	4	0.12	3.20	2.06	3.21			
20		0.18	3.14	3.24	3.14			
30		0.23	3.14	4.14	3.15			
40		0.25	3.23	4.36	3.24			
50		0.29	3.18	5.24	3.19			
60		0.36	3.16	6.52	3.18			
70		0.34	3.25	5.95	3.27			
80		0.32	3.32	5.59	3.34	0.26	297.0	

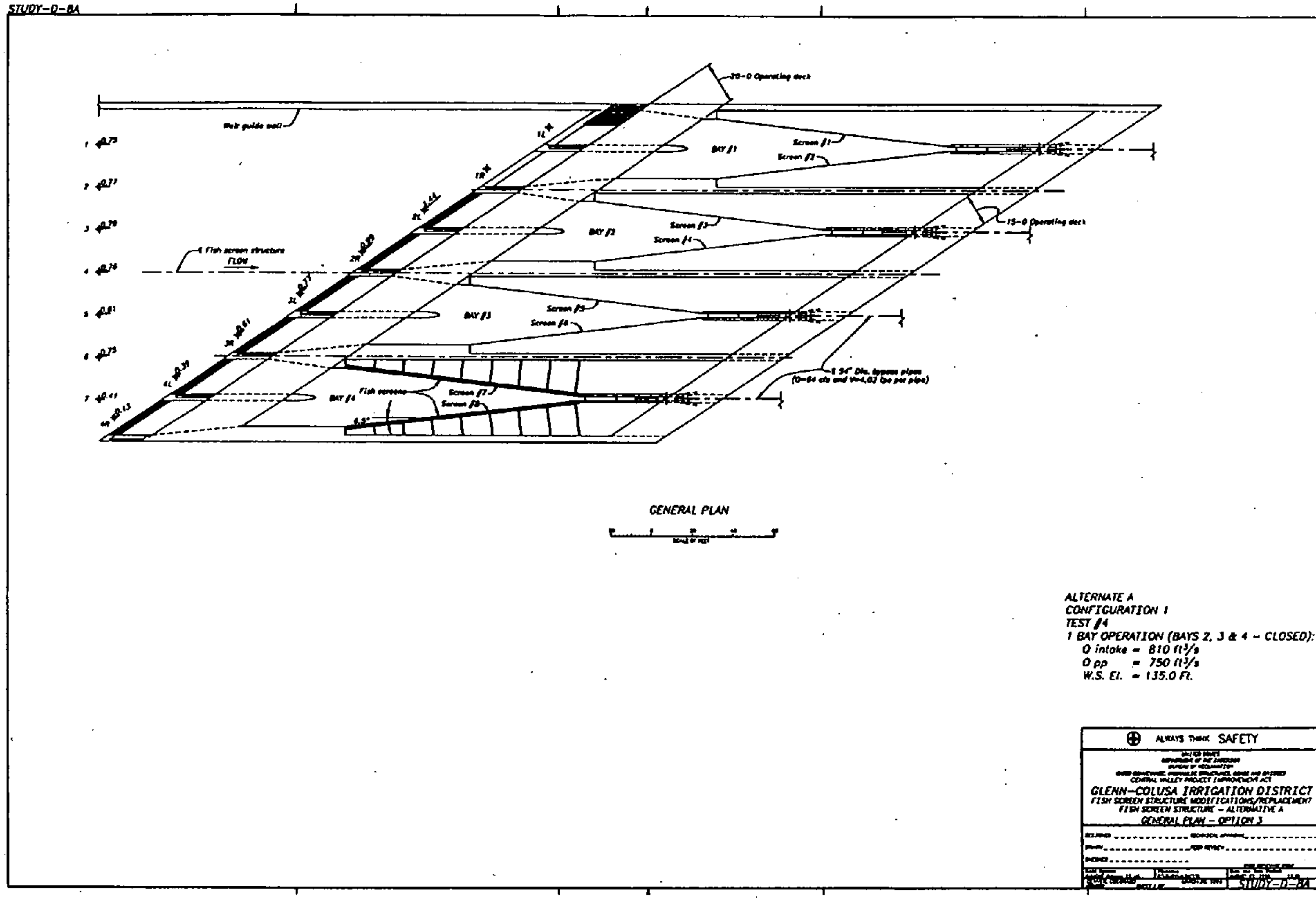
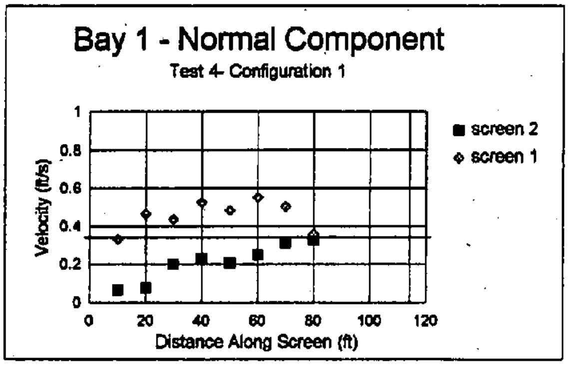


Figure 14.—Approach and sweeping velocities for screen configuration 1, test 4.

GCID Alternative A 1:30 Scale Model Testing - Configuration 1
8 March 1996
fn = c1t5sd.wk4
TEST 4 - 1 bay operation (bay 2,3&4 closed)

Qintake =	810	cfs
Qpumping	750	cfs
Qbypass =	60	cfs (Total)
w.s.el. =	135	ft (@ screens)



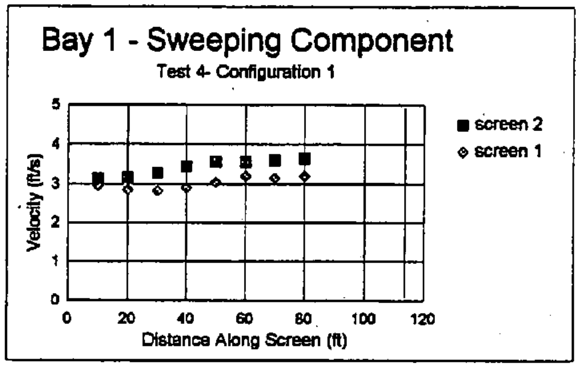


Figure 15.—Normal and sweeping velocities for screen configuration 1, test 4.

Table 7.—Screen approach velocity data for configuration 1, test 4.

TEST #4 - 1 bay operation (bay 2,3&4 - closed):

Qintake =	810 cfs
Qpumping	750 cfs
Qbypass =	60 cfs (Total)
w.s.el. =	135 ft (@ screens)

Screen Velocity Data Summary:

Distance (ft)	Screen No.	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)
10	1	0.33	2.96	6.43	2.97
20		0.47	2.86	9.28	2.89
30		0.44	2.82	8.82	2.85
40		0.53	2.90	10.31	2.95
50		0.48	3.05	8.99	3.09
60		0.55	3.21	9.76	3.25
70		0.50	3.17	9.03	3.21
80		0.36	3.20	6.39	3.22
10	2	0.06	3.16	1.14	3.16
20		0.08	3.18	1.41	3.18
30		0.20	3.29	3.53	3.29
40		0.23	3.46	3.81	3.47
50		0.21	3.58	3.35	3.59
60		0.25	3.58	3.99	3.59
70		0.31	3.61	4.94	3.62
80		0.33	3.65	5.15	3.67

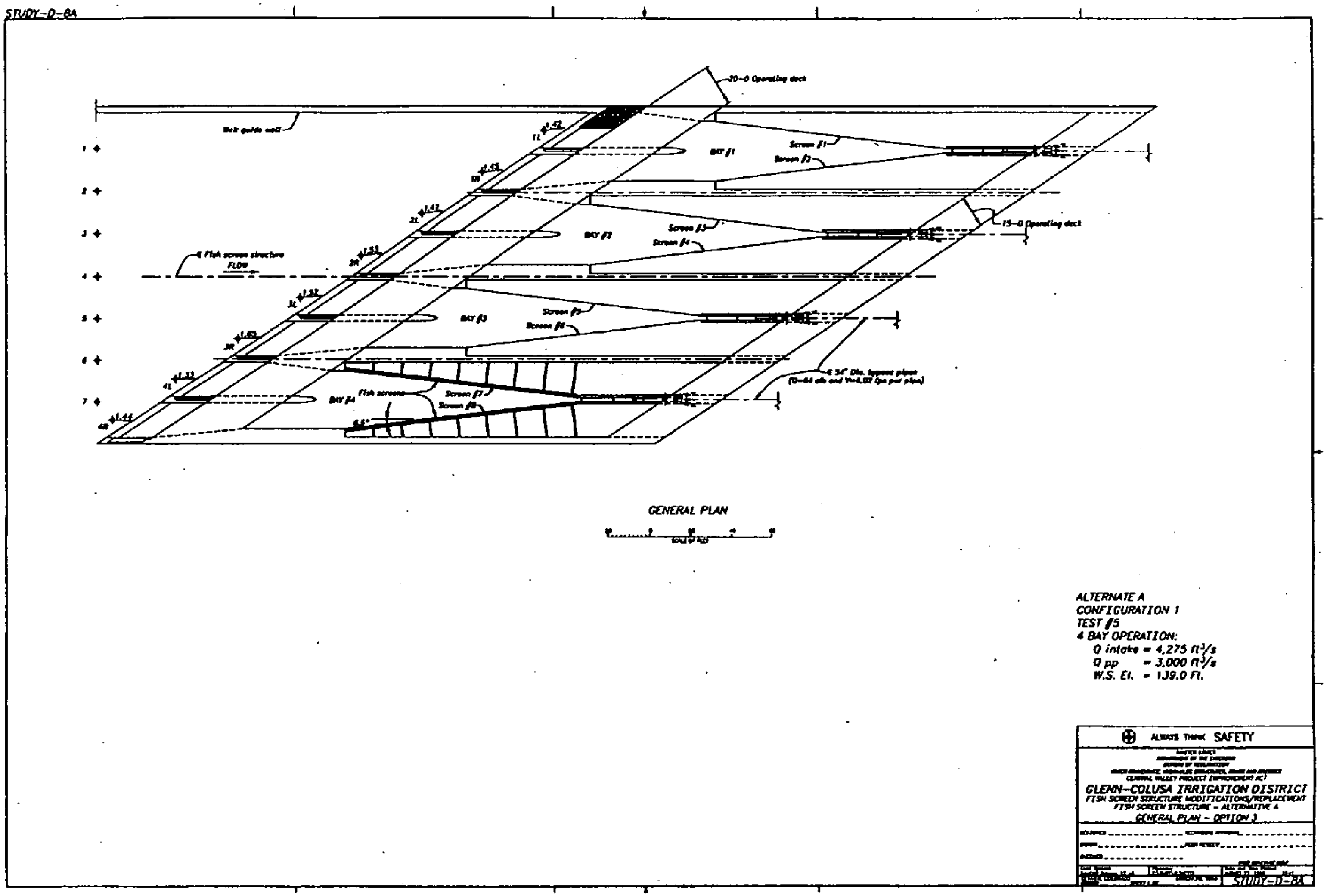


Figure 16.—Approach channel velocities for screen configuration 1, test 5.

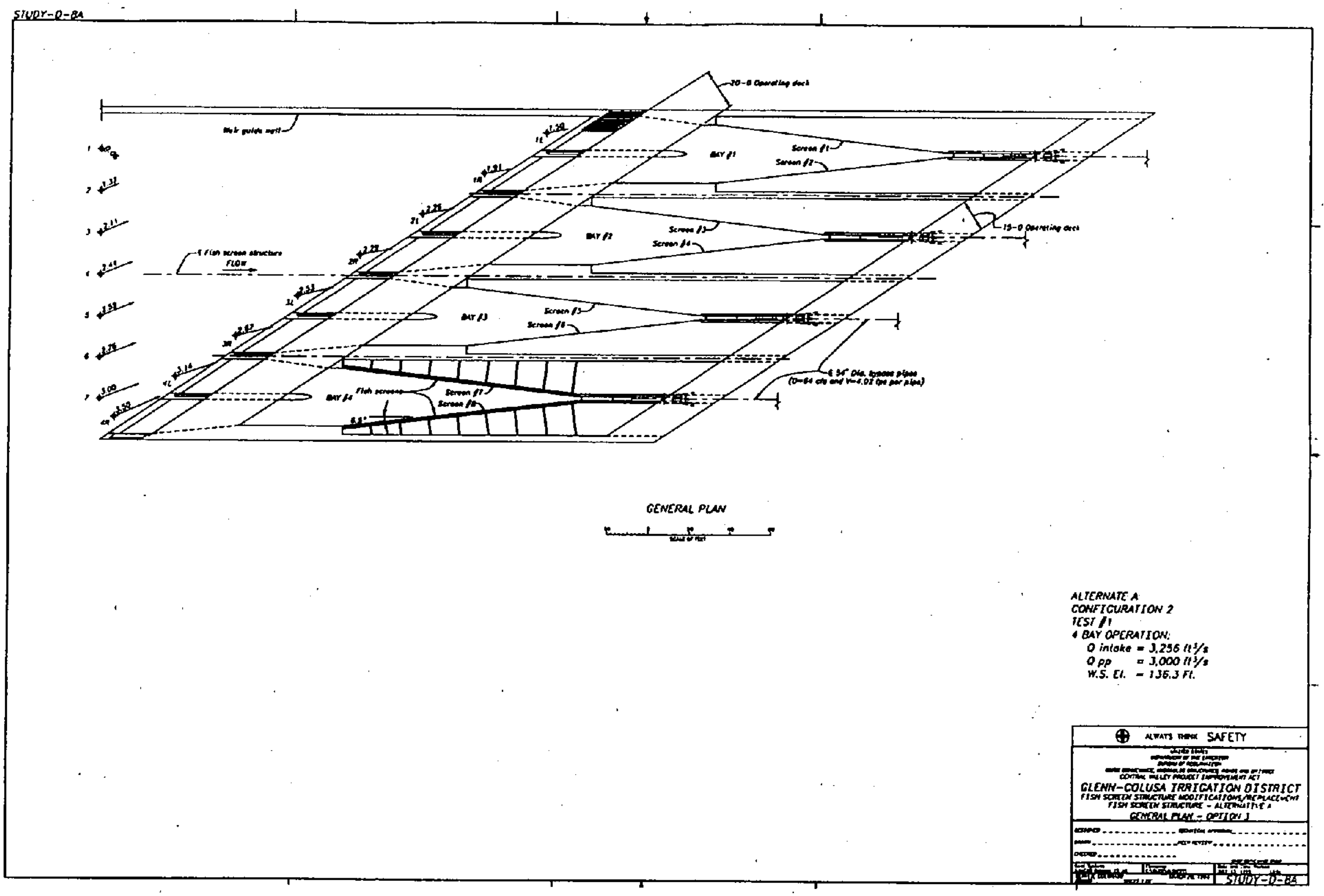


Figure 17.—Approach channel velocities for screen configuration 2, test 1.

GCID Alternative A 1:30 Scale Model Testing - Configuration 2
15 April 1996
fn = c2t1sd.wk4
[redacted]

Qintake =	3,256 cfs
Qpumping	3,000 cfs
Qbypass =	256 cfs (Total)
w.s.el. =	136.3 ft (@ screens)

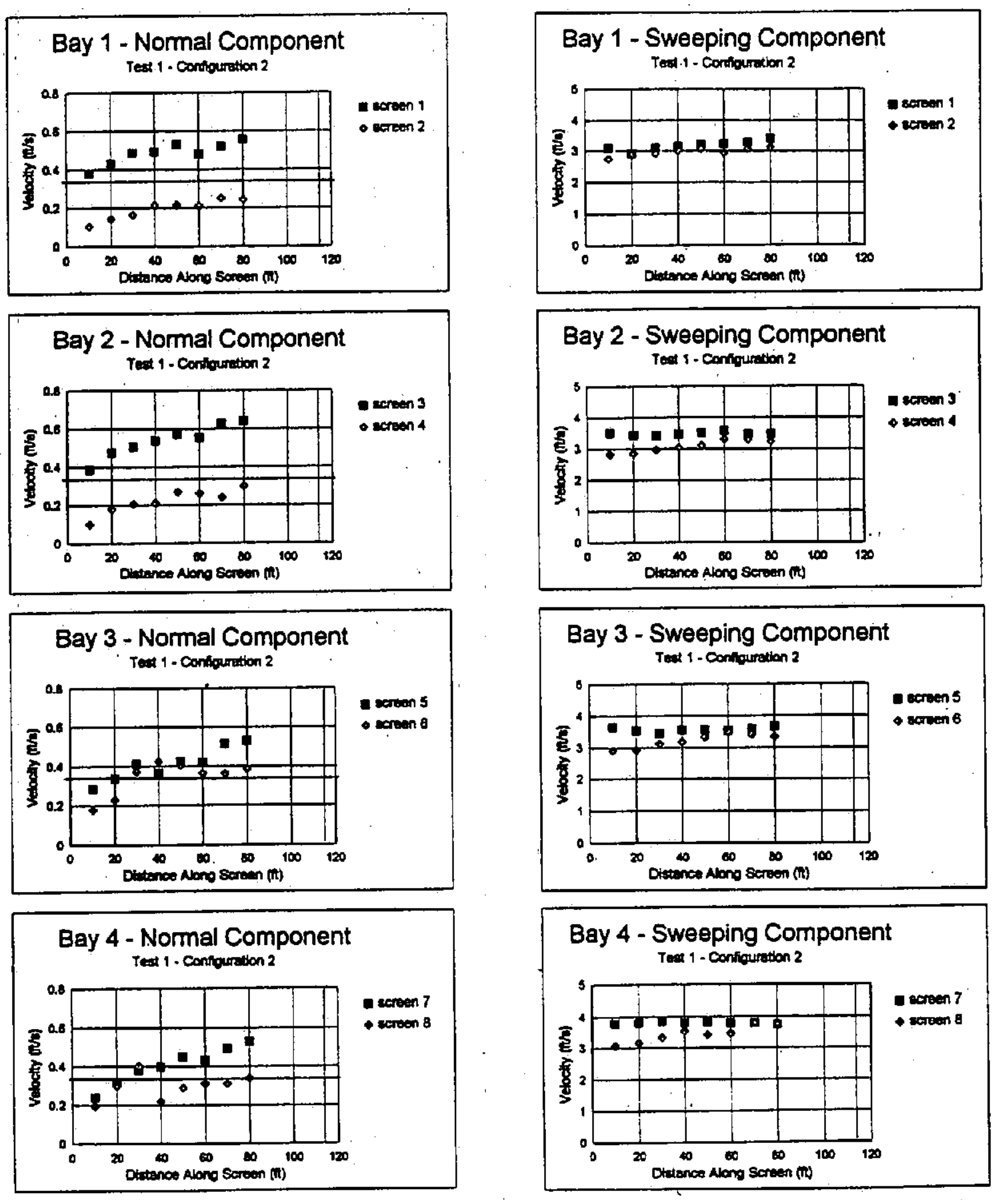


Figure 18.—Normal and sweeping velocities for screen configuration 2, test 1.

Table 8.—Screen approach velocity data for configuration 2, test 1.

GCID Alternative A 1:30 Scale Model Testing - Configuration 2
15 April 1996
fn = c2t1sd.wk4
TEST #1 - 4 bay operation

Qintake =	3,256 cfs
Qpumping	3,000 cfs
Qbypass =	256 cfs (Total)
w.s.el. =	136.3 ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)
1	10	0.38	3.10	6.96	3.12
	20	0.43	2.93	8.35	2.96
	30	0.49	3.10	8.94	3.13
	40	0.49	3.16	8.85	3.20
	50	0.53	3.21	9.37	3.25
	60	0.48	3.24	8.39	3.28
	70	0.52	3.29	8.93	3.33
	80	0.55	3.42	9.19	3.46
2	10	0.11	2.76	2.21	2.76
	20	0.14	2.87	2.86	2.87
	30	0.16	2.92	3.21	2.93
	40	0.21	3.01	4.06	3.02
	50	0.21	3.07	3.99	3.08
	60	0.21	2.95	4.06	2.96
	70	0.25	3.08	4.63	3.09
	80	0.24	3.13	4.43	3.14
3	10	0.39	3.51	6.29	3.53
	20	0.47	3.45	7.83	3.48
	30	0.51	3.42	8.40	3.46
	40	0.54	3.47	8.79	3.51
	50	0.57	3.52	9.23	3.57
	60	0.55	3.58	8.77	3.62
	70	0.63	3.48	10.21	3.53
	80	0.64	3.48	10.39	3.54
4	10	0.10	2.82	2.11	2.82
	20	0.18	2.85	3.60	2.85
	30	0.20	2.96	3.95	2.97
	40	0.21	3.04	3.95	3.05
	50	0.27	3.10	4.91	3.12
	60	0.26	3.31	4.47	3.32
	70	0.24	3.31	4.12	3.31
	80	0.30	3.24	5.25	3.25
5	10	0.28	3.63	4.49	3.64
	20	0.34	3.52	5.46	3.54
	30	0.41	3.45	6.82	3.48
	40	0.37	3.56	5.87	3.58
	50	0.43	3.57	6.80	3.59
	60	0.42	3.54	6.76	3.57
	70	0.51	3.60	8.13	3.64
	80	0.53	3.67	8.23	3.71
6	10	0.18	2.90	3.51	2.90
	20	0.23	2.92	4.47	2.93
	30	0.37	3.12	6.77	3.14
	40	0.42	3.18	7.59	3.21
	50	0.40	3.33	6.94	3.35
	60	0.36	3.48	5.96	3.49
	70	0.36	3.40	6.05	3.42
	80	0.39	3.35	6.56	3.37
7	10	0.24	3.80	3.64	3.80
	20	0.32	3.80	4.85	3.81
	30	0.38	3.85	5.64	3.86
	40	0.40	3.80	5.98	3.83
	50	0.45	3.82	6.75	3.84
	60	0.43	3.79	6.55	3.82
	70	0.49	3.79	7.39	3.83
	80	0.53	3.74	8.05	3.78
8	10	0.19	3.09	3.59	3.10
	20	0.30	3.16	5.43	3.17
	30	0.40	3.34	6.91	3.36
	40	0.22	3.53	3.55	3.54
	50	0.29	3.41	4.89	3.43
	60	0.31	3.46	5.15	3.47
	70	0.31	3.79	4.69	3.81
	80	0.34	3.76	5.17	3.77

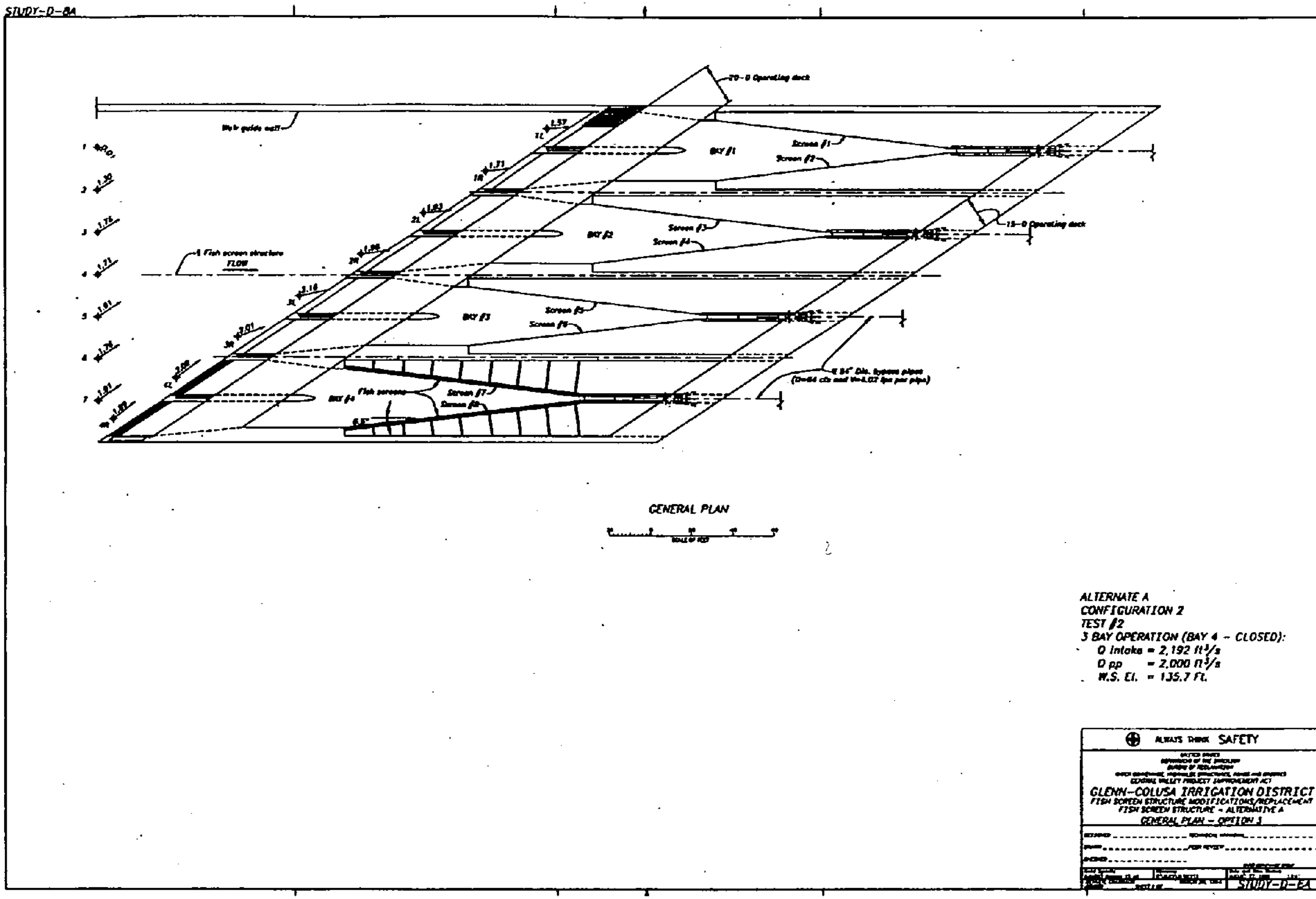


Figure 19.—Approach channel velocities for screen configuration 2, test 2.

GCID Alternative A 1:30 Scale Model Testing - Configuration 2
25 April 1996
fn = c2t3sd.wk4
TEST #2 - 3 bay operation (bay 4 - closed)

Qintake =	2,192 cfs
Qpumping	2,000 cfs
Qbypass =	192 cfs (Total)
w.s.el. =	135.7 ft (@ screens)

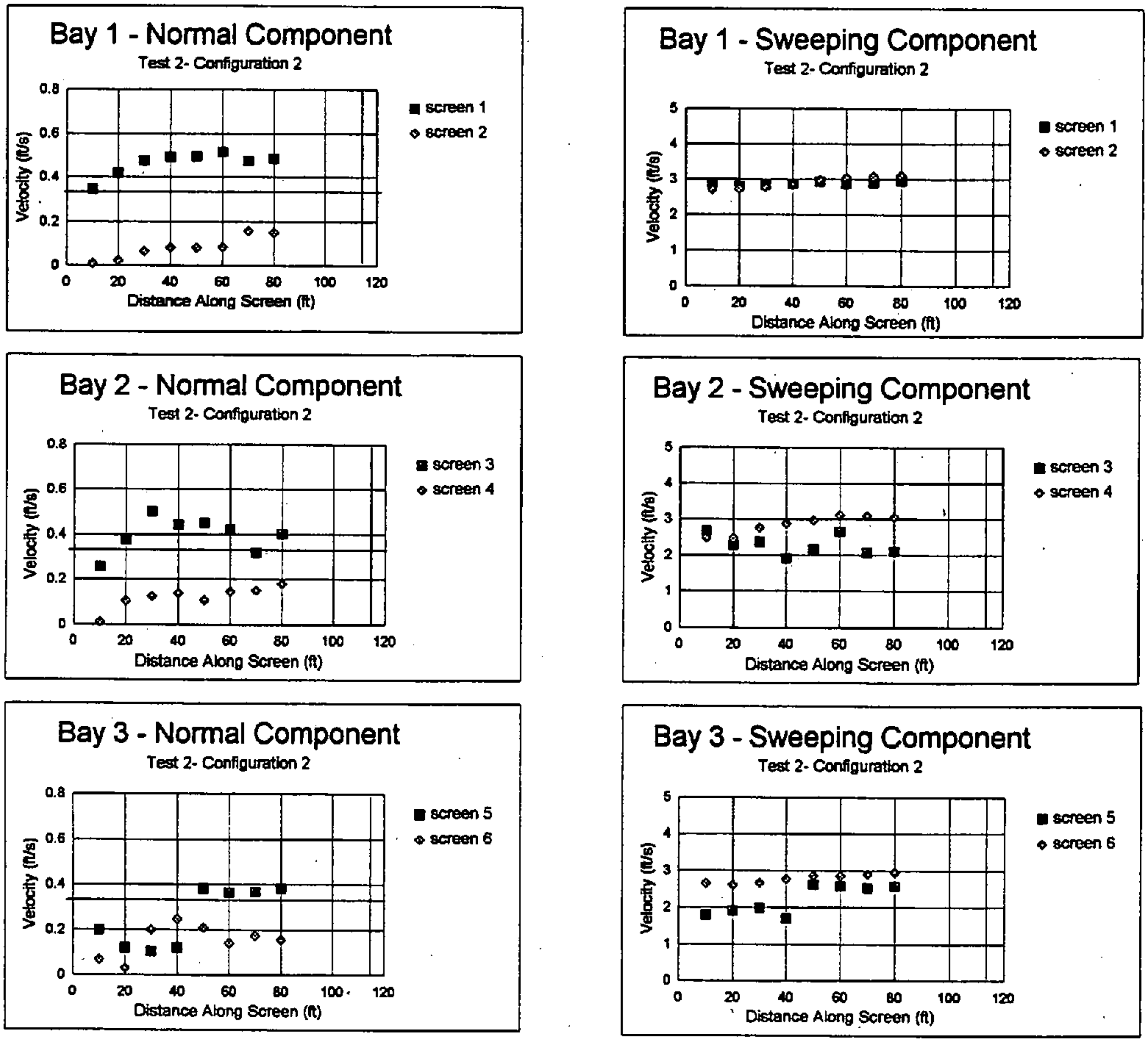


Figure 20.—Normal and sweeping velocities for screen configuration 2, test 2.

Table 9.—Screen approach velocity data for configuration 2, test 2.

GCID Alternative A 1:30 Scale Model Testing - Configuration 2
25 April 1996
fn = c2t3sd.wk4
TEST #2 - 3 bay operation (bay 4 - closed):

Qintake =	2,192 cfs
Qpumping	2,000 cfs
Qbypass =	192 cfs (Total)
w.s.el. =	135.7 ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.35	2.88	6.83	2.90			
	20	0.42	2.81	8.48	2.84			
	30	0.47	2.83	9.46	2.87			
	40	0.49	2.87	9.70	2.91			
	50	0.49	2.93	9.54	2.97			
	60	0.52	2.86	10.20	2.91			
	70	0.47	2.89	9.27	2.93			
	80	0.48	2.95	9.30	2.99	0.46	562.6	
2	10	0.01	2.70	0.24	2.70			
	20	0.02	2.71	0.50	2.71			
	30	0.07	2.79	1.36	2.79			
	40	0.08	2.85	1.62	2.85			
	50	0.08	2.98	1.58	2.99			
	60	0.08	3.05	1.60	3.05			
	70	0.16	3.08	2.90	3.08			
	80	0.15	3.11	2.73	3.11	0.08	99.6	37.0
3	10	0.26	2.68	5.46	2.69			
	20	0.38	2.29	9.34	2.33			
	30	0.50	2.37	11.94	2.43			
	40	0.44	1.92	12.89	1.97			
	50	0.45	2.17	11.72	2.22			
	60	0.42	2.66	8.99	2.69			
	70	0.32	2.08	8.77	2.10			
	80	0.40	2.12	10.72	2.15	0.40	483.5	
4	10	0.01	2.48	0.27	2.48			
	20	0.10	2.48	2.36	2.48			
	30	0.12	2.77	2.54	2.78			
	40	0.14	2.89	2.69	2.89			
	50	0.11	2.98	2.03	2.98			
	60	0.14	3.12	2.63	3.12			
	70	0.15	3.10	2.77	3.11			
	80	0.18	3.06	3.35	3.07	0.12	145.1	35.1
5	10	0.20	1.79	6.32	1.80			
	20	0.12	1.90	3.64	1.90			
	30	0.10	1.99	2.98	1.99			
	40	0.12	1.70	3.99	1.71			
	50	0.38	2.63	8.29	2.66			
	60	0.37	2.58	8.07	2.61			
	70	0.37	2.52	8.26	2.55			
	80	0.38	2.57	8.44	2.60	0.25	310.8	
6	10	0.07	2.65	1.52	2.65			
	20	0.03	2.60	0.68	2.60			
	30	0.20	2.67	4.24	2.68			
	40	0.25	2.79	5.09	2.80			
	50	0.21	2.86	4.21	2.87			
	60	0.14	2.87	2.80	2.87			
	70	0.17	2.91	3.42	2.91			
	80	0.16	2.95	3.01	2.96	0.15	187.0	27.8

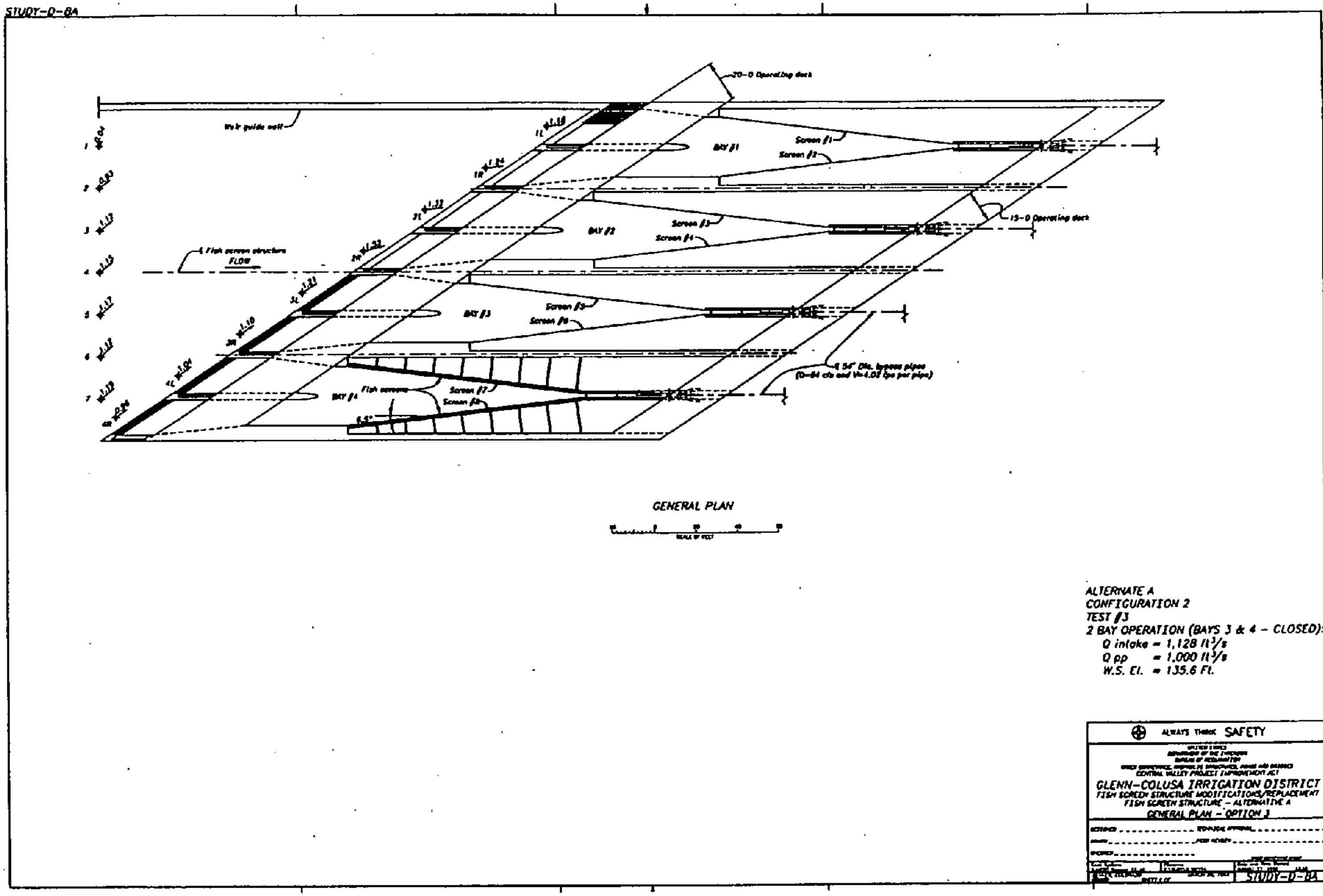


Figure 21.—Approach channel velocities for screen configuration 2, test 3.

GCID Alternative A 1:30 Scale Model Testing - Configuration 2
25 April 1996
fn = c2t4sd.wk4
TEST #3 - 2 bay operation (bays 3&4 - closed)

Qintake =	1,128 cfs
Qpumping	1,000 cfs
Qbypass =	128 cfs (Total)
w.s.el. =	135.6 ft (@ screens)

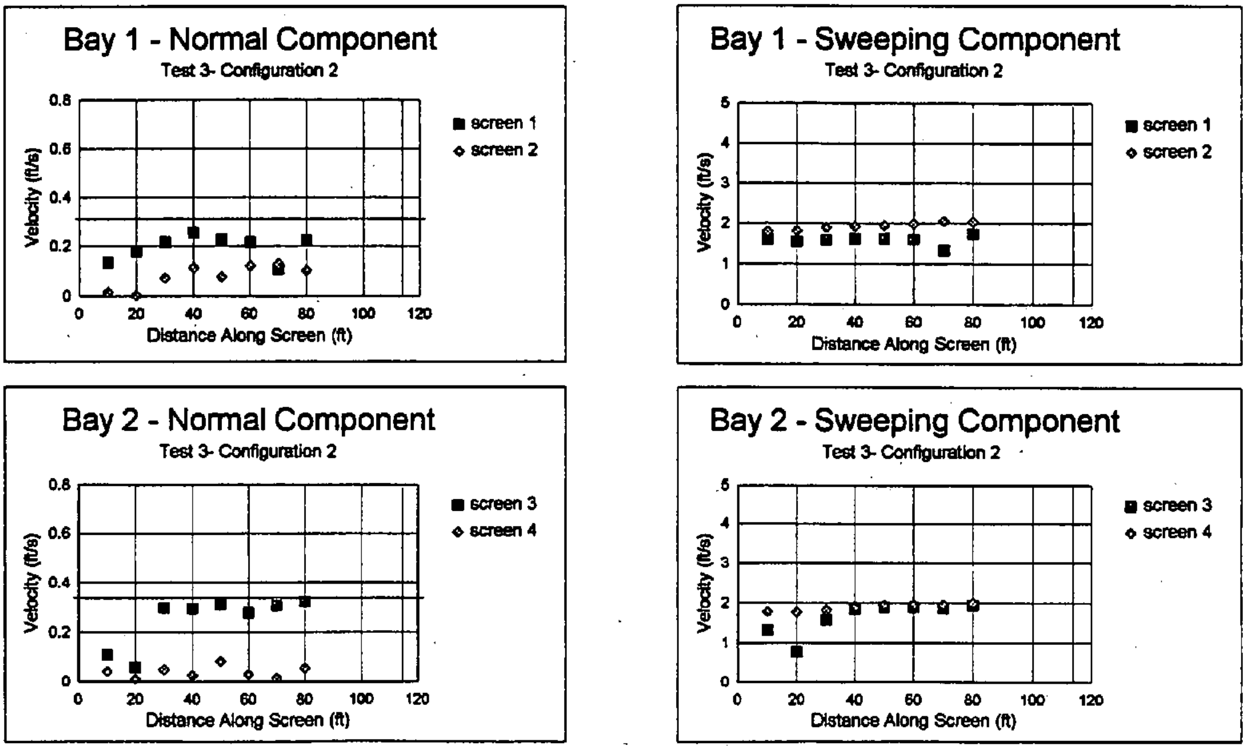


Figure 22.—Normal and sweeping velocities for configuration 2, test 3.

Table 10.—Screen approach velocity data for configuration 2, test 3.

GCID Alternative A 1:30 Scale Model Testing - Configuration 2
25 April 1996
fn = c2t4sd.wk4
TEST #3 - 2 bay operation (bays 3&4 - closed)

Qintake =	1,128 cfs
Qpumping	1,000 cfs
Qbypass =	128 cfs (Total)
w.s.el. =	135.6 ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.14	1.60	4.86	1.61			
	20	0.18	1.55	6.57	1.56			
	30	0.22	1.58	7.77	1.60			
	40	0.25	1.60	8.99	1.62			
	50	0.22	1.61	7.95	1.62			
	60	0.21	1.59	7.68	1.60			
	70	0.11	1.33	4.70	1.33			
	80	0.22	1.74	7.26	1.76	0.19	234.8	
2	10	0.01	1.80	0.45	1.80			
	20	0.00	1.81	0.09	1.81			
	30	0.07	1.89	2.25	1.89			
	40	0.12	1.92	3.45	1.92			
	50	0.08	1.94	2.34	1.94			
	60	0.12	1.98	3.51	1.99			
	70	0.13	2.04	3.64	2.05			
	80	0.11	2.03	2.96	2.04	0.08	97.1	48.9
3	10	0.11	1.31	4.88	1.31			
	20	0.06	0.78	4.38	0.78			
	30	0.30	1.57	10.68	1.60			
	40	0.29	1.84	9.05	1.87			
	50	0.31	1.88	9.37	1.91			
	60	0.28	1.90	8.32	1.92			
	70	0.31	1.86	9.37	1.88			
	80	0.32	1.93	9.47	1.96	0.25	298.8	
4	10	0.04	1.77	1.33	1.77			
	20	0.01	1.77	0.35	1.77			
	30	0.05	1.82	1.53	1.82			
	40	0.03	1.90	0.81	1.90			
	50	0.08	1.94	2.49	1.94			
	60	0.03	1.95	0.97	1.95			
	70	0.02	1.95	0.50	1.95			
	80	0.06	2.00	1.63	2.00	0.04	48.2	51.1

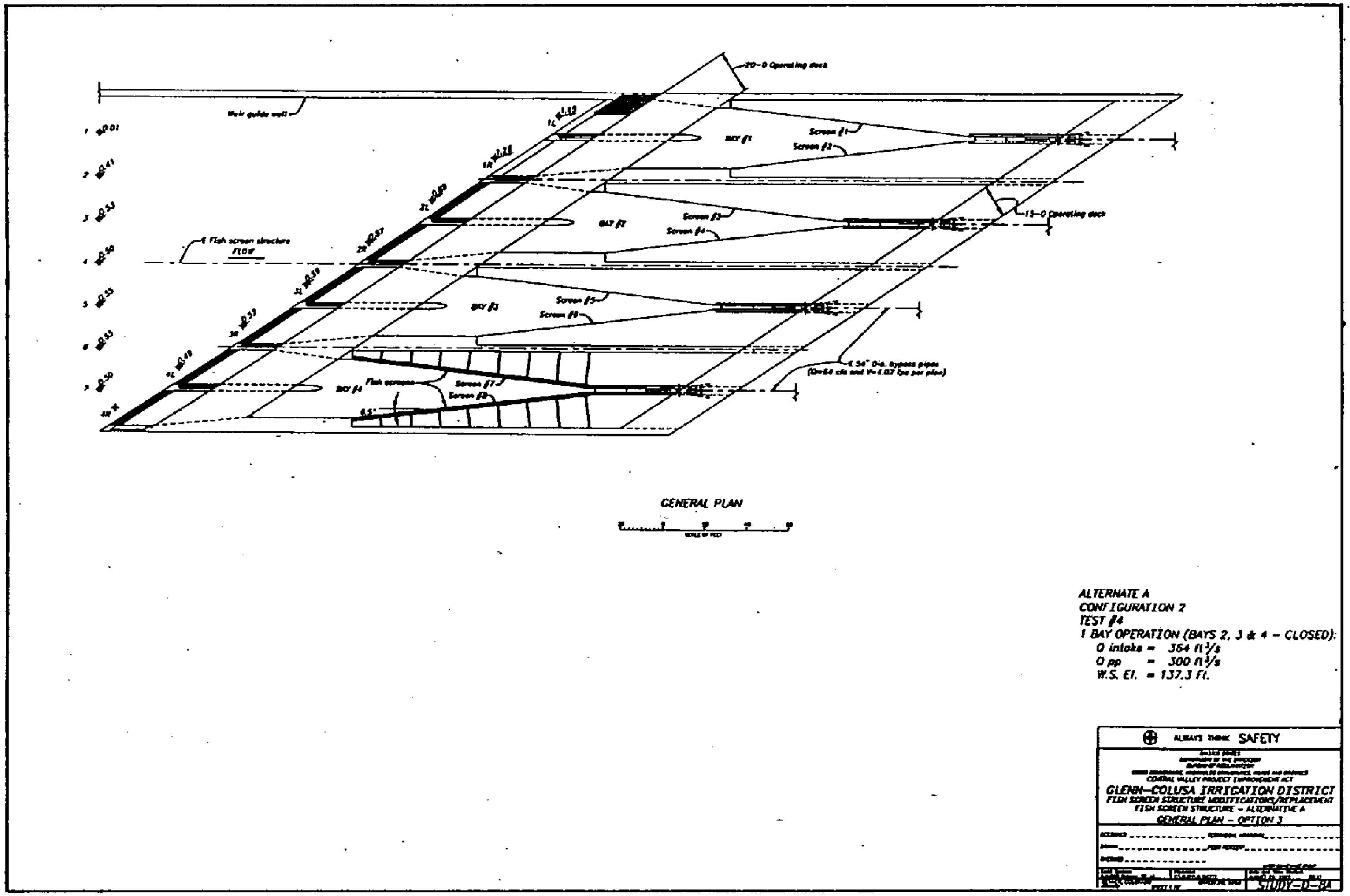


Figure 23.—Approach channel velocities for screen configuration 2, test 4.

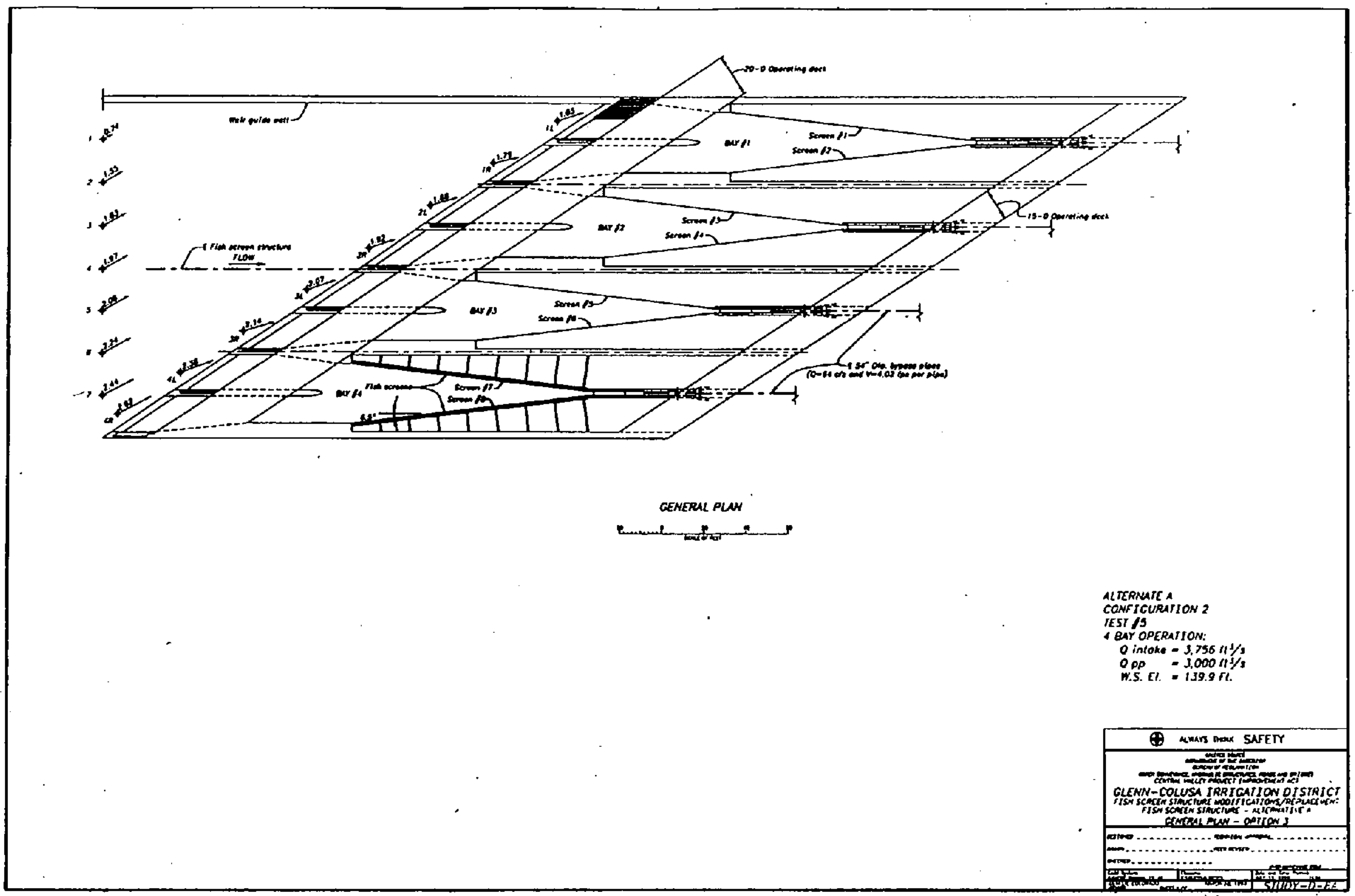


Figure 24.—Approach channel velocities for screen configuration 2, test 5.

GCID Alternative A 1:30 Scale Model Testing - Configuration 2
25 April 1996
fn = c2t5sd.wk4
TEST #5 - 4 bay operation

Qintake =	3,756 cfs
Qpumping	3,000 cfs
Qbypass =	256 cfs (Total)
w.s.el. =	139.9 ft (@ screens)

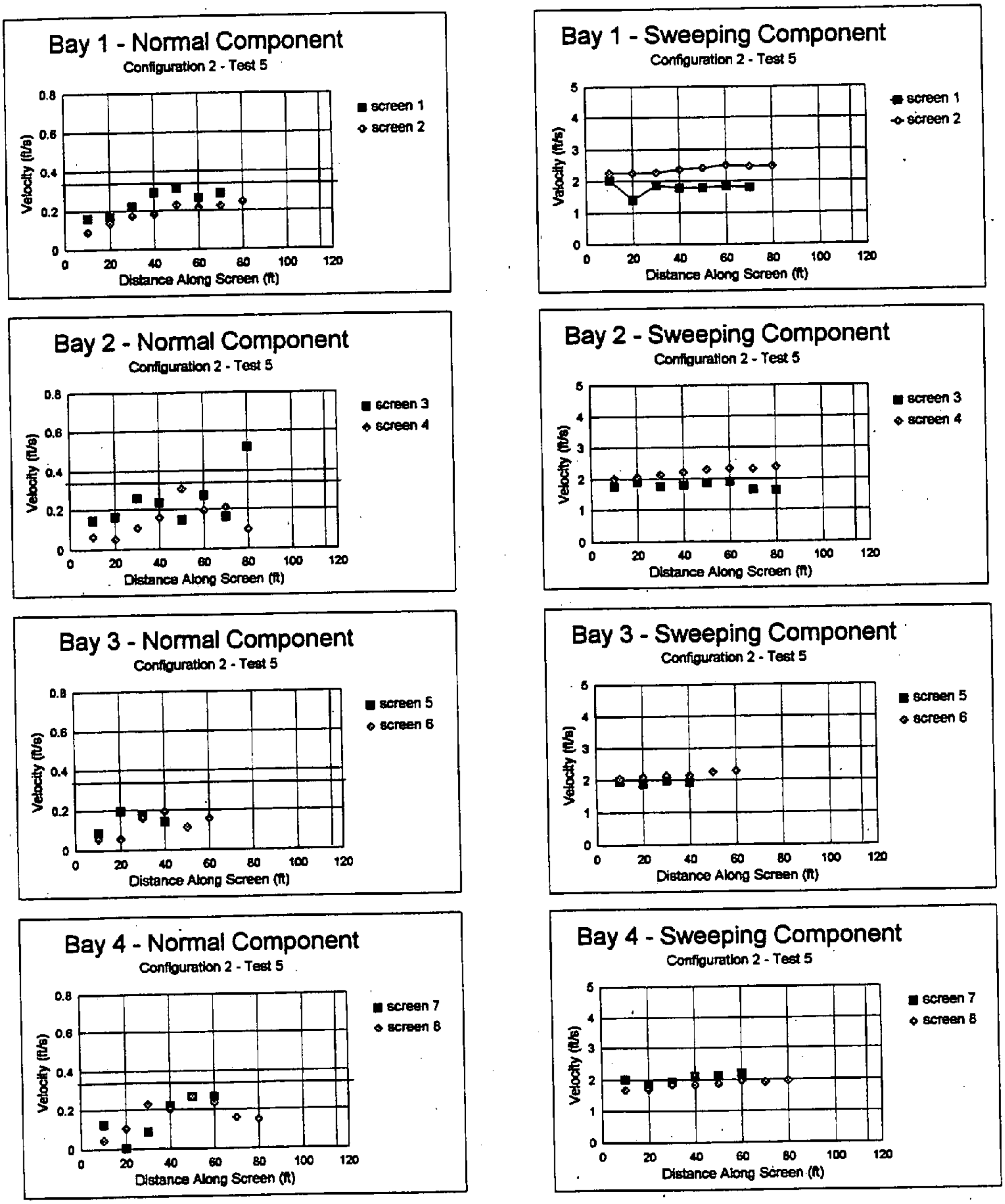


Figure 25.—Normal and sweeping velocities for configuration 2, test 5.

Table 11.—Screen approach velocity data for configuration 2, test 5.

GCID Alternative A 1:30 Scale Model Testing - Configuration 2
25 April 1996
fn = c2t5sd.wk4
TEST #5 - 4 bay operation
Qintake = 3,756 cfs
Qpumping 3,000 cfs
Qbypass = 256 cfs (Total)
w.s.el. = 139.9 ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.16	2.03	4.57	2.04			
	20	0.17	1.41	6.86	1.42			
	30	0.22	1.86	6.77	1.87			
	40	0.29	1.77	9.32	1.80			
	50	0.31	1.78	9.98	1.80			
	60	0.26	1.82	8.23	1.84			
	70	0.29	1.80	9.07	1.82			
	80					0.24	414.0	
2	10	0.09	2.26	2.25	2.26			
	20	0.14	2.25	3.48	2.25			
	30	0.17	2.27	4.34	2.28			
	40	0.18	2.37	4.38	2.37			
	50	0.23	2.41	5.40	2.42			
	60	0.21	2.50	4.91	2.51			
	70	0.22	2.45	5.17	2.46			
	80	0.24	2.48	5.60	2.49	0.19	315.6	30.2
3	10	0.15	1.76	4.78	1.77			
	20	0.17	1.91	4.95	1.92			
	30	0.26	1.77	8.36	1.78			
	40	0.24	1.81	7.40	1.83			
	50	0.15	1.87	4.46	1.88			
	60	0.27	1.90	8.16	1.92			
	70	0.16	1.66	5.59	1.67			
	80	0.52	1.64	17.59	1.72	0.24	405.1	
4	10	0.07	2.02	1.86	2.02			
	20	0.05	2.07	1.46	2.07			
	30	0.11	2.14	2.93	2.15			
	40	0.16	2.23	4.10	2.24			
	50	0.30	2.30	7.53	2.32			
	60	0.19	2.34	4.71	2.34			
	70	0.21	2.32	5.17	2.33			
	80	0.10	2.39	2.39	2.39	0.15	253.4	27.2
5	10	0.09	1.95	2.57	1.95			
	20	0.19	1.88	5.88	1.89			
	30	0.18	1.98	5.07	1.98			
	40	0.14	1.92	4.17	1.92			
	50							
	60							
	70							
	80					0.15	253.3	
6	10	0.06	2.04	1.62	2.04			
	20	0.06	2.09	1.53	2.09			
	30	0.16	2.13	4.23	2.14			
	40	0.19	2.13	5.14	2.14			
	50	0.11	2.25	2.88	2.25			
	60	0.16	2.28	3.93	2.29			
	70							
	80					0.12	207.3	19.0
7	10	0.13	2.01	3.61	2.02			
	20	0.00	1.85	0.15	1.85			
	30	0.09	1.93	2.63	1.94			
	40	0.22	2.11	6.00	2.12			
	50	0.27	2.13	7.13	2.14			
	60	0.27	2.19	6.93	2.20			
	70							
	80					0.16	275.9	
8	10	0.04	1.68	1.51	1.68			
	20	0.11	1.70	3.56	1.70			
	30	0.23	1.83	7.11	1.85			
	40	0.20	1.84	6.30	1.85			
	50	0.27	1.87	8.09	1.89			
	60	0.23	1.96	6.83	1.97			
	70	0.16	1.91	4.69	1.92			
	80	0.15	1.96	4.29	1.97	0.17	294.3	23.6

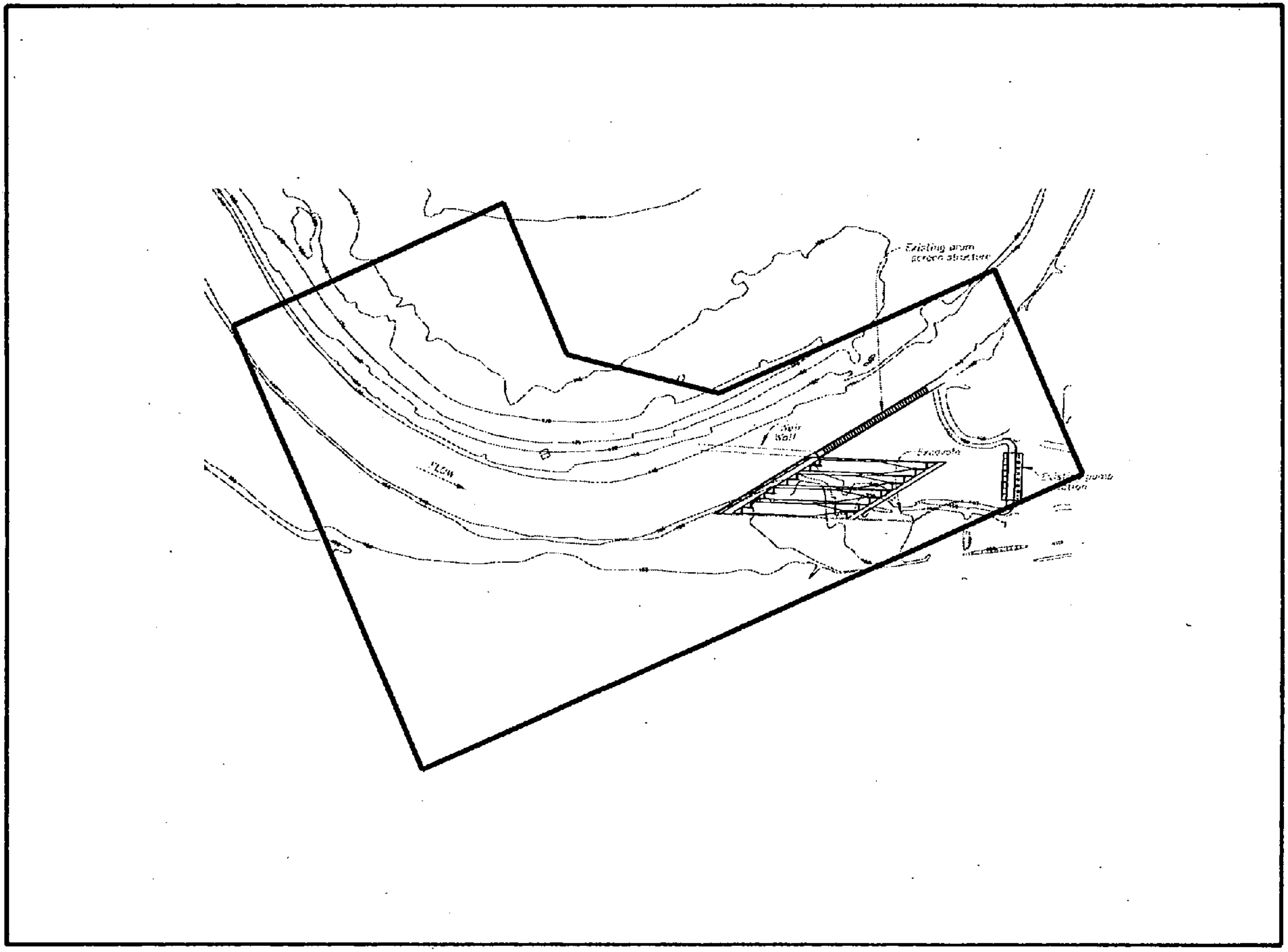


Figure 26.—Plan view of screen model configuration 3 showing the screens set back 120 ft from the trashrack structure.

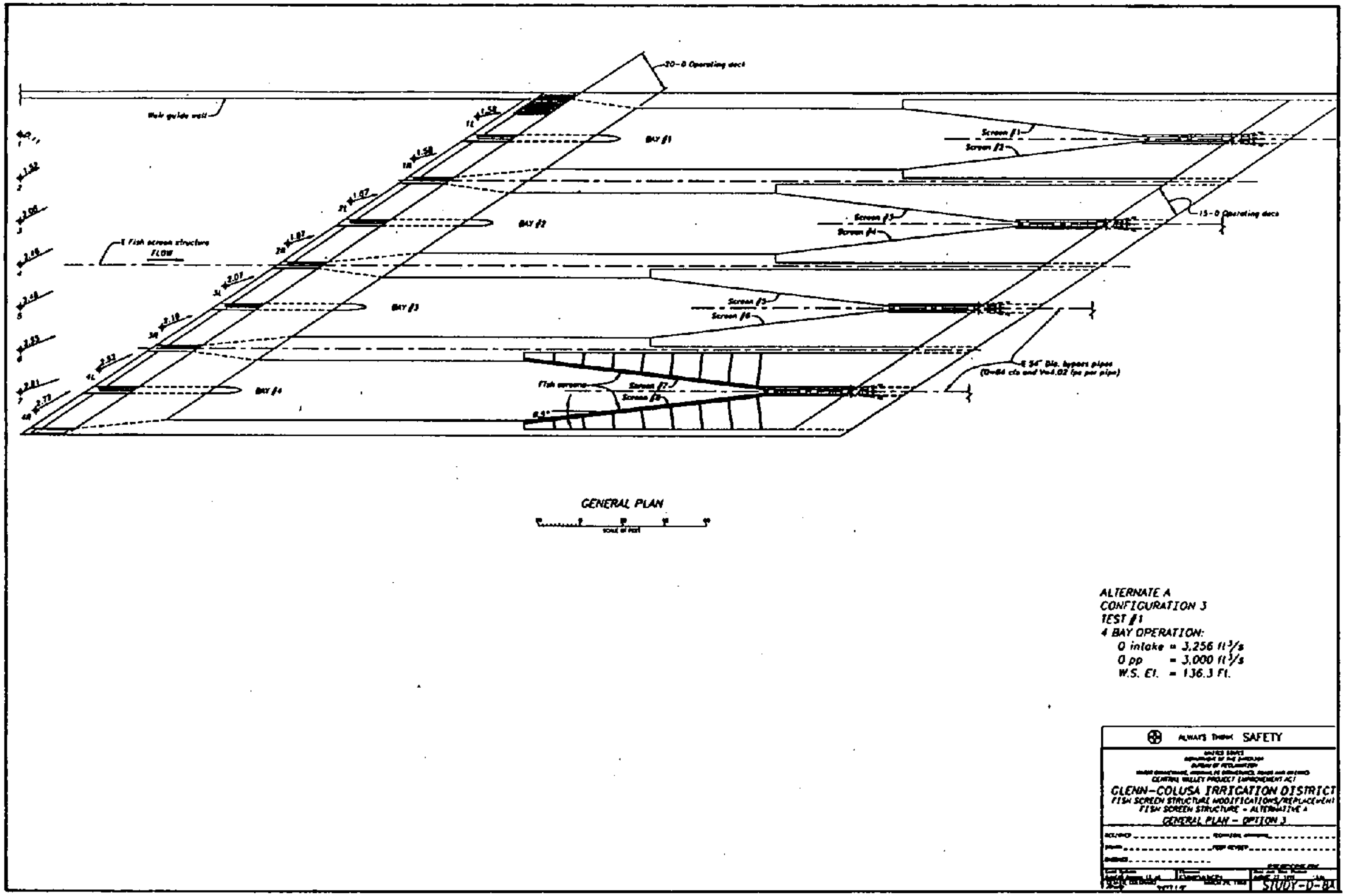


Figure 27.—Approach channel velocities for screen configuration 3, test 1.

GCID Alternative A :30 Scale Model Testing - Configuration 3
10 May 1996
fn = c3t4sd.wk4
TEST #1 - 4 bay operation

Qintake =	3,256	cfs
Qpumping	3,000	cfs
Qbypass =	256	cfs (Total)
w.s.el. =	136.3	ft (@ screens)

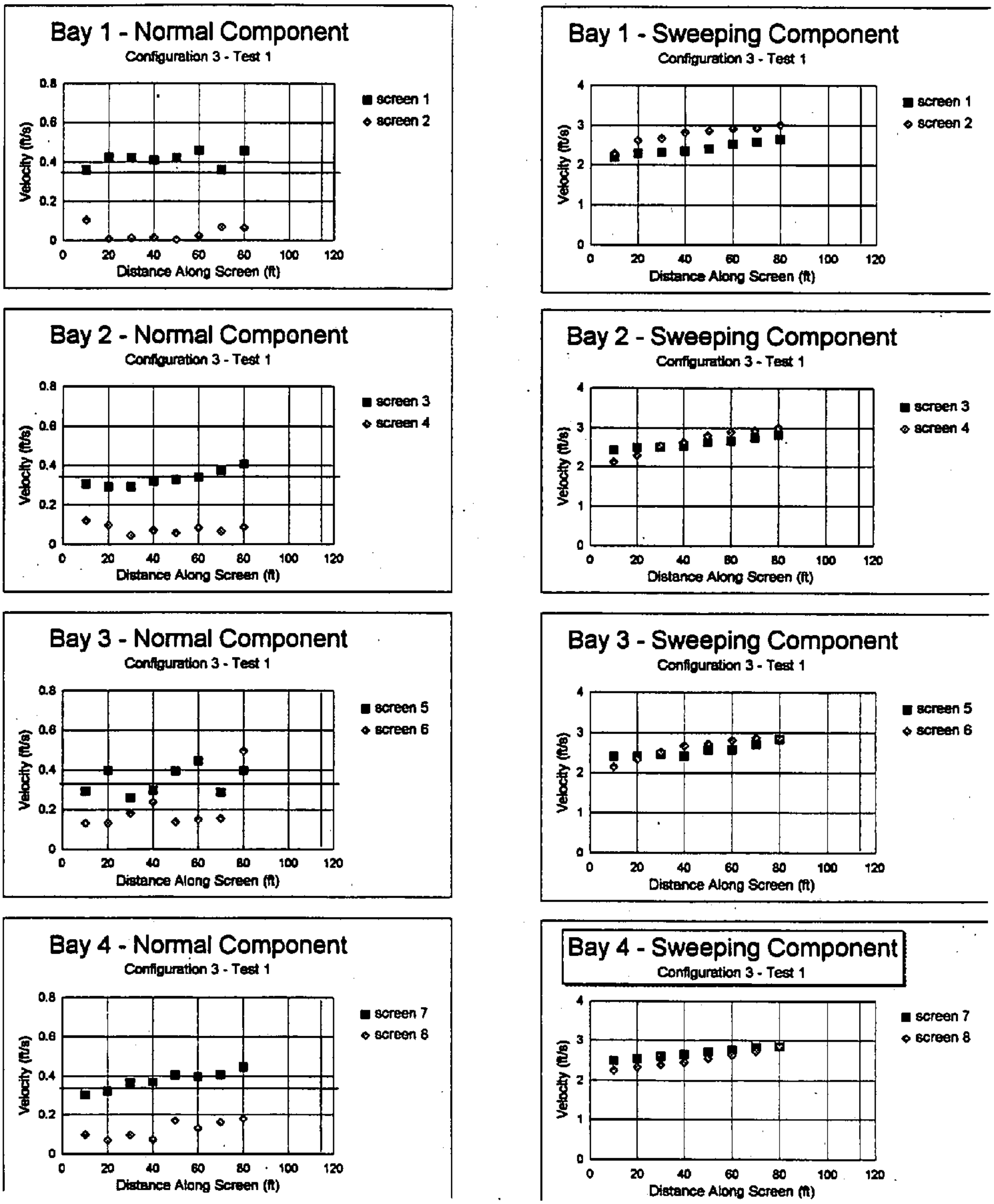


Figure 28.—Normal and sweeping velocities for screen configuration 3, test 1.

Table 12.—Screen approach velocity data for configuration 3, test 1.

GCID Alternative A :30 Scale Model Testing - Configuration 3
10 May 1996
fn = c3t4sd.wk4
TEST #1 - 4 bay operation

Qintake =	3,256 cfs
Qpumping	3,000 cfs
Qbypass =	256 cfs (Total)
w.s.el. =	136.3 ft (@ screens)

Screen Velocity Data Summary

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.36	2.20	9.31	2.23			
	20	0.43	2.29	10.53	2.33			
	30	0.42	2.32	10.32	2.36			
	40	0.41	2.36	9.83	2.40			
	50	0.42	2.40	9.95	2.44			
	60	0.46	2.53	10.29	2.57			
	70	0.36	2.58	7.97	2.60			
	80	0.46	2.65	9.78	2.69	0.41	534.0	
2	10	0.11	2.29	2.73	2.29			
	20	0.01	2.61	0.26	2.61			
	30	0.01	2.67	0.28	2.67			
	40	0.02	2.82	0.33	2.82			
	50	0.01	2.86	0.11	2.86			
	60	0.03	2.91	0.54	2.91			
	70	0.07	2.92	1.42	2.92			
	80	0.07	3.01	1.27	3.01	0.04	51.9	23.4
3	10	0.31	2.44	7.23	2.46			
	20	0.29	2.50	6.67	2.52			
	30	0.29	2.51	6.69	2.53			
	40	0.32	2.55	7.18	2.57			
	50	0.33	2.64	7.14	2.66			
	60	0.34	2.68	7.29	2.70			
	70	0.37	2.75	7.75	2.78			
	80	0.41	2.83	8.21	2.86	0.33	430.7	
4	10	0.12	2.14	3.24	2.14			
	20	0.10	2.29	2.45	2.29			
	30	0.05	2.53	1.05	2.53			
	40	0.07	2.64	1.53	2.64			
	50	0.06	2.80	1.21	2.80			
	60	0.08	2.89	1.67	2.89			
	70	0.07	2.94	1.31	2.94			
	80	0.09	2.99	1.67	3.00	0.10	130.2	22.4
5	10	0.30	2.41	6.99	2.43			
	20	0.40	2.41	9.33	2.44			
	30	0.26	2.46	6.09	2.48			
	40	0.30	2.42	7.07	2.44			
	50	0.39	2.58	8.68	2.61			
	60	0.45	2.58	9.83	2.62			
	70	0.29	2.71	6.12	2.73			
	80	0.40	2.84	7.96	2.87	0.35	447.9	
6	10	0.13	2.15	3.53	2.15			
	20	0.13	2.34	3.21	2.34			
	30	0.18	2.51	4.10	2.51			
	40	0.24	2.67	5.10	2.68			
	50	0.14	2.72	2.86	2.73			
	60	0.15	2.81	3.06	2.81			
	70	0.16	2.87	3.11	2.88			
	80	0.50	2.85	9.89	2.89	0.20	260.8	28.3
7	10	0.30	2.48	6.99	2.50			
	20	0.32	2.54	7.23	2.56			
	30	0.36	2.60	7.98	2.63			
	40	0.37	2.66	7.93	2.68			
	50	0.41	2.71	8.52	2.74			
	60	0.40	2.76	8.20	2.79			
	70	0.41	2.84	8.22	2.87			
	80	0.45	2.85	8.91	2.88	0.38	486.5	
8	10	0.10	2.25	2.49	2.26			
	20	0.07	2.33	1.72	2.33			
	30	0.10	2.39	2.31	2.39			
	40	0.07	2.45	1.72	2.45			
	50	0.17	2.53	3.83	2.54			
	60	0.13	2.63	2.86	2.63			
	70	0.16	2.73	3.40	2.73			
	80	0.18	2.86	3.61	2.86	0.12	158.0	25.8

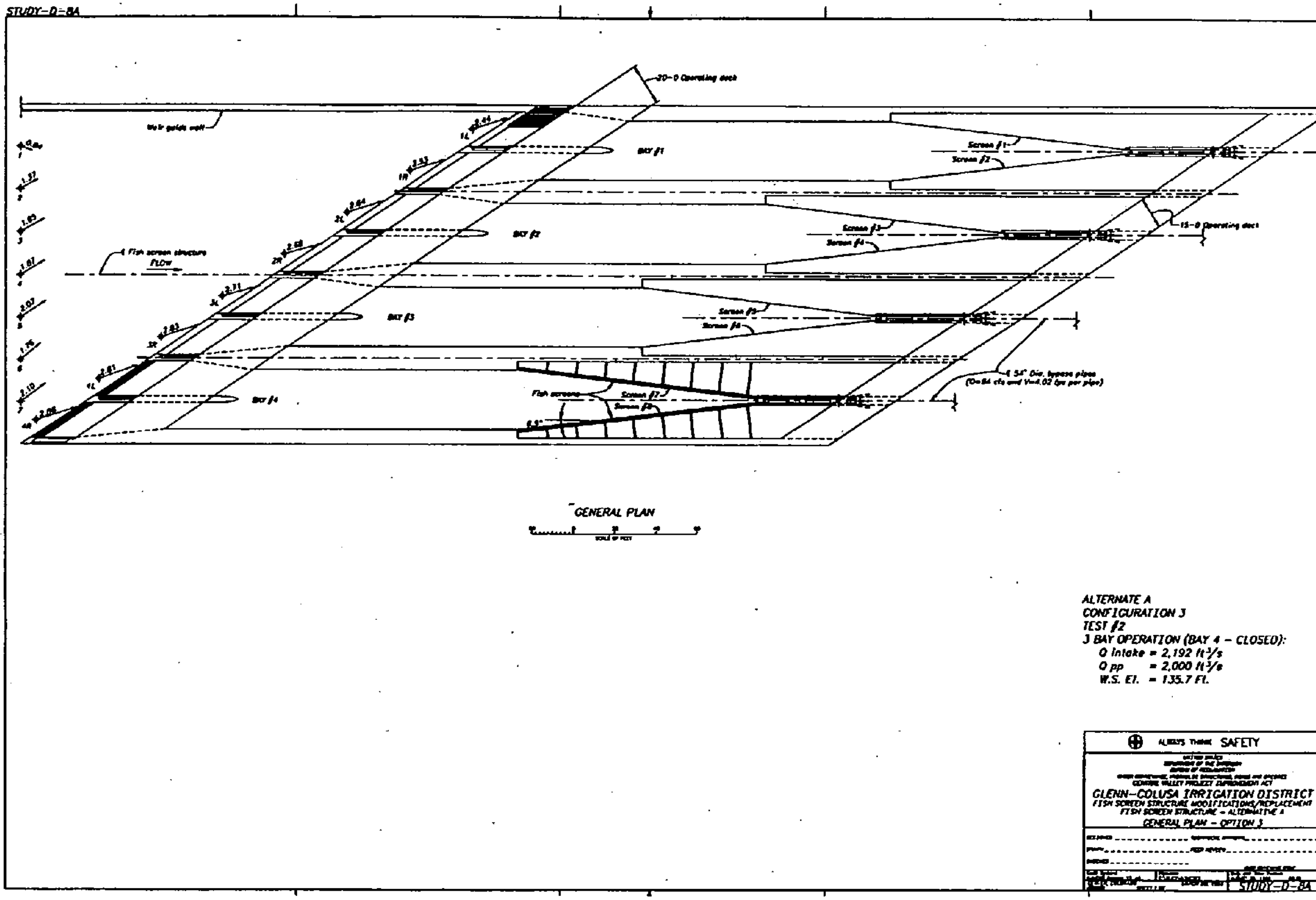


Figure 29.—Approach channel velocities for screen configuration 3, test 2.

GCID Alternative A 1:30 Scale Model Testing - Configuration 3
6 May 1996
fn = c3t3sd.wk4
TEST #2 3 bay operation (bay 4 - closed)

Qintake =	2,192 cfs
Qpumping	2,000 cfs
Qbypass =	192 cfs (Total)
w.s.el. =	135.7 ft (@ screens)

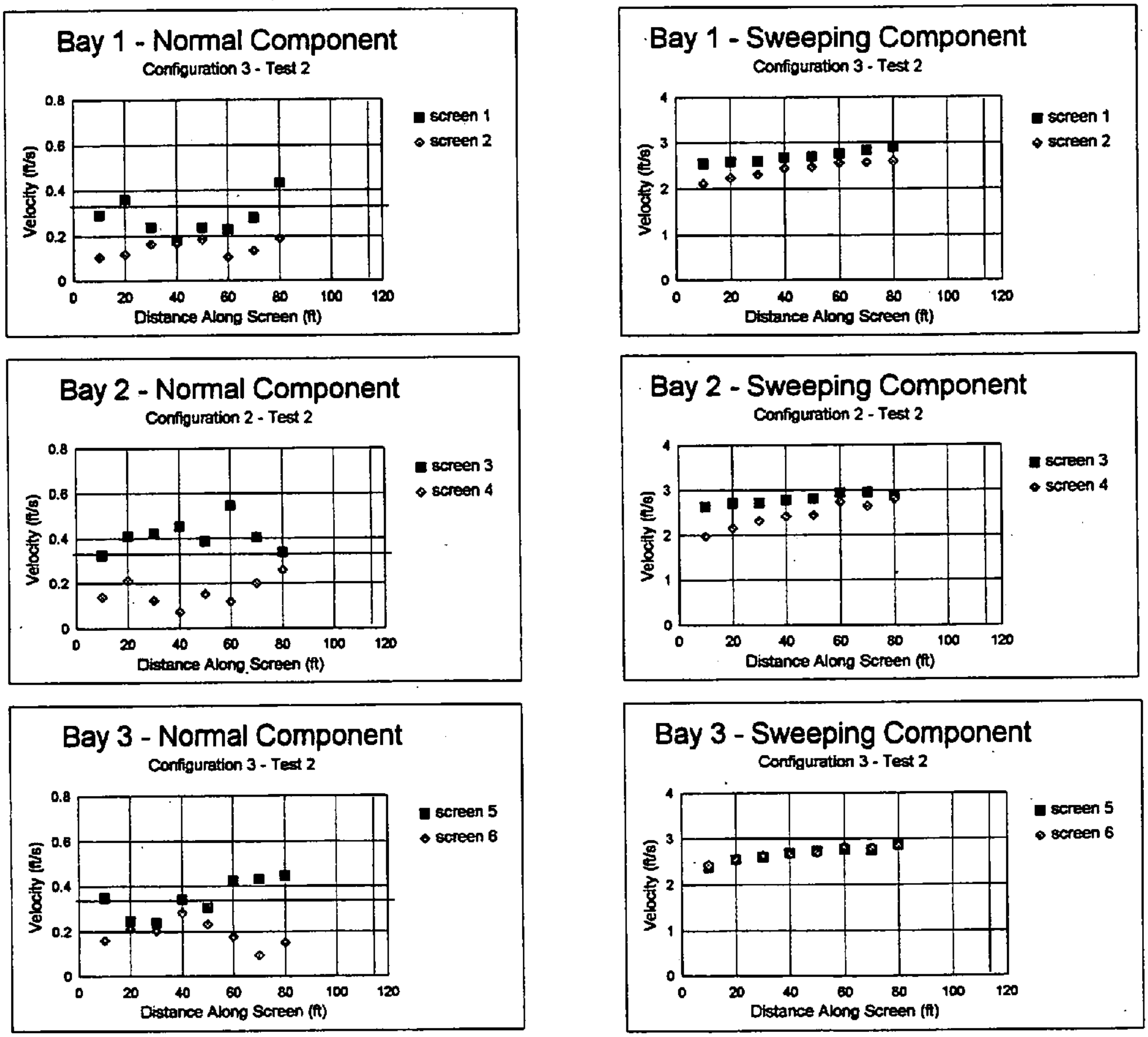


Figure 30.—Normal and sweeping velocities for configuration 3, test 2.

Table 13.—Screen approach velocity data for configuration 3, test 2.

GCID Alternative A 1:30 Scale Model Testing - Configuration 3
6 May 1996
fn = c3t3sd.wk4
TEST #2 - 3 bay operation (bay 4 - closed)

Qintake =	2,192 cfs
Qpumping	2,000 cfs
Qbypass =	192 cfs (Total)
w.s.el. =	135.7 ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.29	2.56	6.54	2.57			
	20	0.36	2.59	7.83	2.62			
	30	0.24	2.61	5.29	2.62			
	40	0.18	2.70	3.84	2.70			
	50	0.24	2.71	5.04	2.72			
	60	0.23	2.76	4.77	2.77			
	70	0.28	2.85	5.64	2.86			
	80	0.43	2.91	8.46	2.94	0.28	344.6	
2	10	0.11	2.11	2.86	2.12			
	20	0.12	2.24	3.02	2.25			
	30	0.16	2.32	4.03	2.32			
	40	0.17	2.46	3.85	2.46			
	50	0.18	2.48	4.26	2.48			
	60	0.10	2.56	2.34	2.56			
	70	0.13	2.57	2.94	2.58			
	80	0.19	2.61	4.13	2.61	0.15	177.2	27.8
3	10	0.32	2.63	7.04	2.65			
	20	0.41	2.72	8.59	2.75			
	30	0.42	2.72	8.84	2.75			
	40	0.45	2.79	9.24	2.83			
	50	0.39	2.82	7.79	2.84			
	60	0.55	2.94	10.54	2.99			
	70	0.40	2.95	7.81	2.98			
	80	0.34	2.89	6.67	2.91	0.41	501.3	
4	10	0.14	1.97	4.04	1.97			
	20	0.21	2.14	5.66	2.16			
	30	0.12	2.32	3.09	2.32			
	40	0.07	2.42	1.75	2.42			
	50	0.15	2.44	3.58	2.44			
	60	0.12	2.74	2.51	2.74			
	70	0.20	2.64	4.36	2.65			
	80	0.26	2.80	5.27	2.82	0.16	195.7	37.2
5	10	0.35	2.38	8.39	2.40			
	20	0.25	2.55	5.54	2.56			
	30	0.24	2.60	5.29	2.61			
	40	0.34	2.69	7.23	2.71			
	50	0.31	2.74	6.37	2.76			
	60	0.42	2.77	8.70	2.80			
	70	0.43	2.75	8.94	2.78			
	80	0.45	2.87	8.82	2.90	0.35	425.0	
6	10	0.16	2.44	3.80	2.44			
	20	0.21	2.52	4.83	2.53			
	30	0.20	2.63	4.41	2.64			
	40	0.28	2.67	6.05	2.68			
	50	0.23	2.70	4.90	2.71			
	60	0.18	2.83	3.55	2.83			
	70	0.10	2.81	1.94	2.81			
	80	0.15	2.86	3.04	2.86	0.19	230.9	35.0

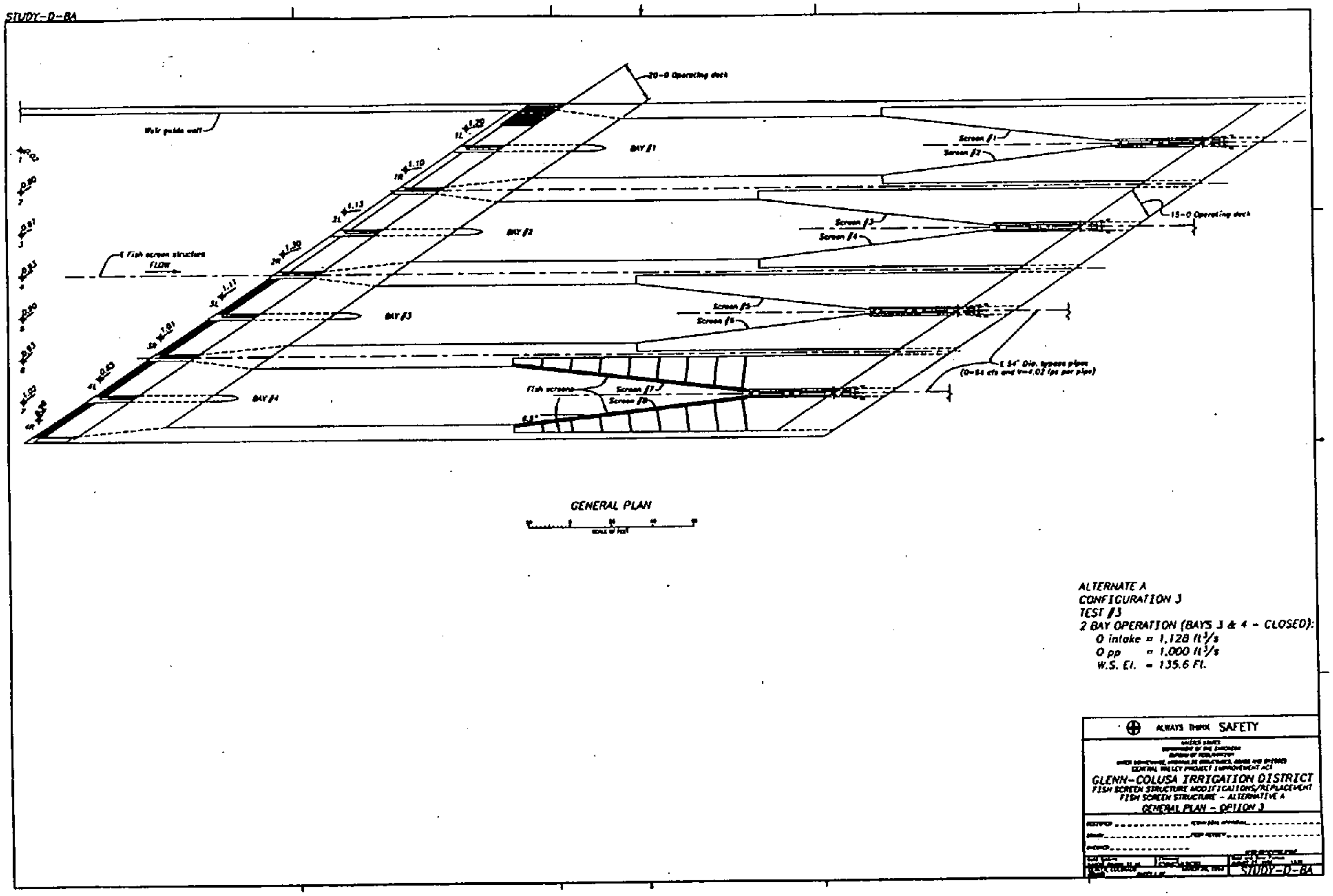


Figure 31.—Approach channel velocities for screen configuration 3, test 3.

GCID Alternative A 1:30 Scale Model Testing - Configuration 3
3 May 1996
fn = c3t2sd.wk4
TEST #3 - 2 bay operation (bays 3 & 4 - closed)

Qintake =	1,128	cfs
Qpumping	1,000	cfs
Qbypass =	128	cfs (Total)
w.s.el. =	135.6	ft (@ screens)

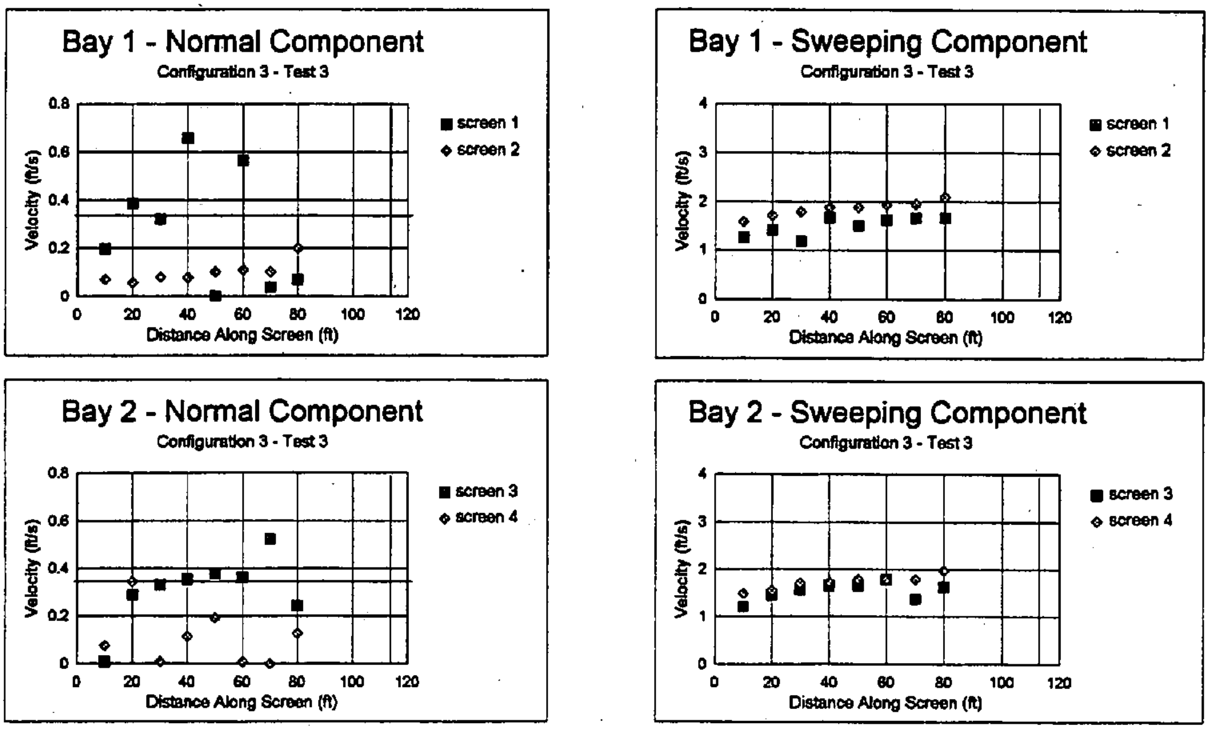


Figure 32.—Normal and sweeping velocities for screen configuration 3, test 3.

Table 14.—Screen approach velocity data for configuration 3, test 3.

GCID Alternative A 1:30 Scale Model Testing - Configuration 3
3 May 1996
fn = c3t2sd.wk4
TEST #3 - 2 bay operation (bays 3 & 4 - closed)

Qintake =	1,128 cfs
Qpumping	1,000 cfs
Qbypass =	128 cfs (Total)
w.s.el. =	135.6 ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.20	1.27	8.85	1.28			
	20	0.39	1.42	15.22	1.47			
	30	0.32	1.18	15.19	1.23			
	40	0.66	1.68	21.35	1.80			
	50	0.00	1.51	0.17	1.51			
	60	0.56	1.62	19.23	1.71			
	70	0.04	1.66	1.40	1.66			
	80	0.07	1.67	2.48	1.67	0.28	339.0	
2	10	0.07	1.59	2.63	1.59			
	20	0.06	1.71	1.94	1.71			
	30	0.08	1.80	2.60	1.80			
	40	0.08	1.88	2.47	1.88			
	50	0.10	1.88	3.16	1.89			
	60	0.11	1.94	3.30	1.94			
	70	0.10	1.95	3.06	1.95			
	80	0.20	2.08	5.47	2.09	0.10	122.8	47.6
3	10	0.01	1.21	0.47	1.21			
	20	0.29	1.46	11.20	1.49			
	30	0.33	1.57	11.91	1.60			
	40	0.35	1.65	12.11	1.69			
	50	0.38	1.66	12.89	1.70			
	60	0.36	1.79	11.50	1.83			
	70	0.52	1.37	20.91	1.46			
	80	0.24	1.64	8.46	1.65	0.31	376.5	
4	10	0.08	1.48	2.92	1.49			
	20	0.34	1.55	12.55	1.59			
	30	0.01	1.71	0.29	1.71			
	40	0.12	1.72	3.82	1.73			
	50	0.19	1.78	6.19	1.79			
	60	0.01	1.79	0.26	1.79			
	70	0.00	1.79	0.04	1.79			
	80	0.13	1.98	3.69	1.98	0.11	132.0	52.4

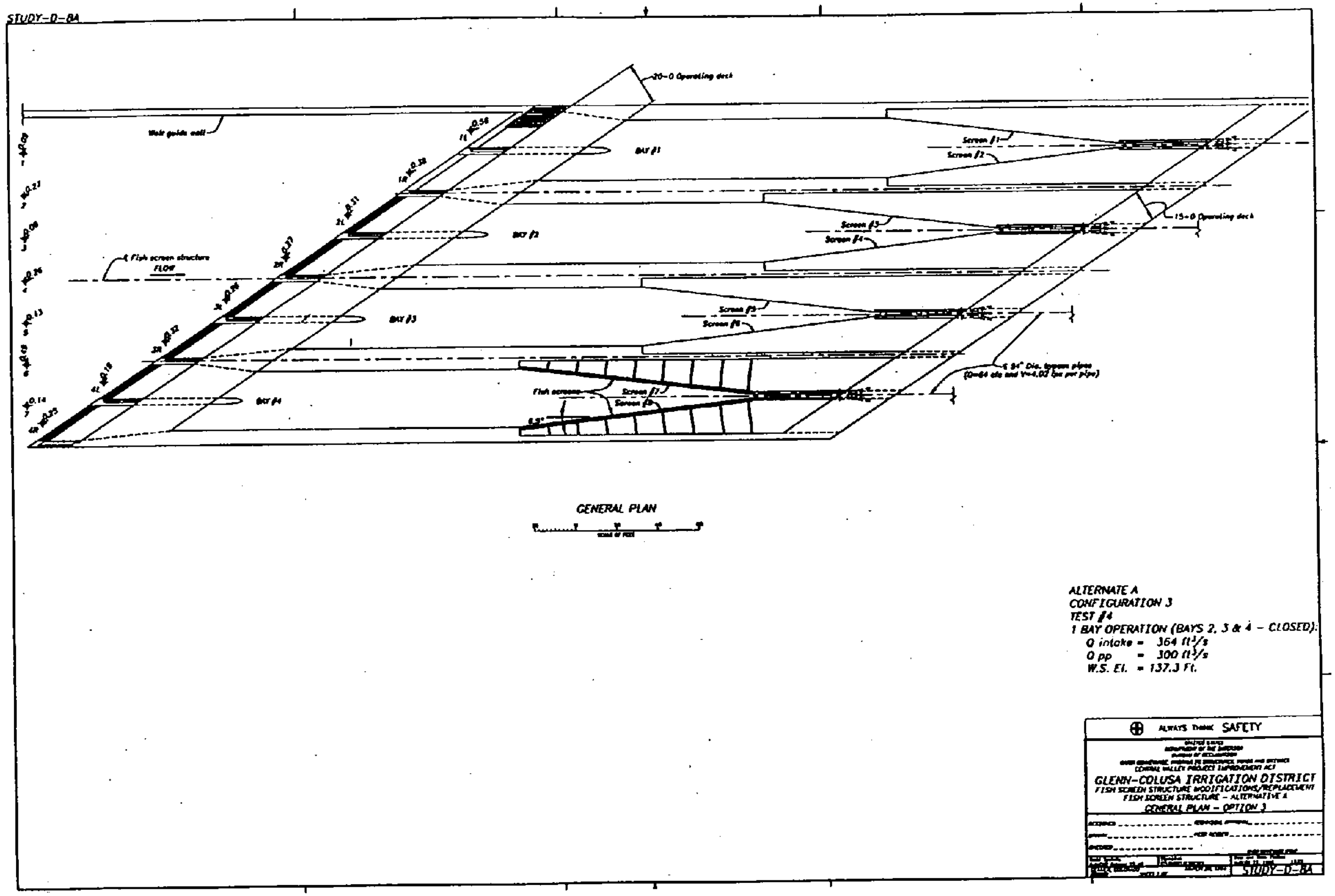
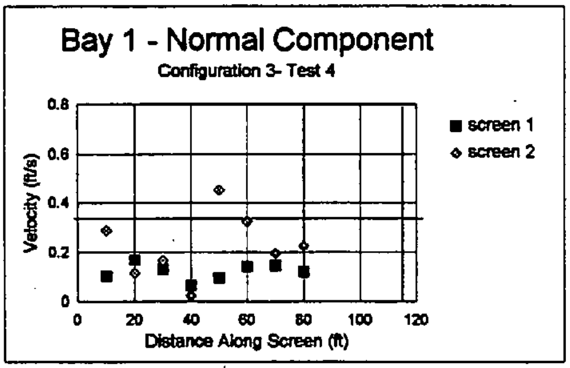


Figure 33.—Approach channel velocities for screen configuration 3, test 4.

GCID Alternative A 1:30 Scale Model Testing - Configuration 3
3 May 1996
fn = c3t1sd.wk4
TEST #4 - 1 bay operation (bays 2, 3 &4 - closed)

Qintake =	364	cfs
Qpumping	300	cfs
Qbypass =	64	cfs (Total)
w.s.el. =	137.3	ft (@ screens)



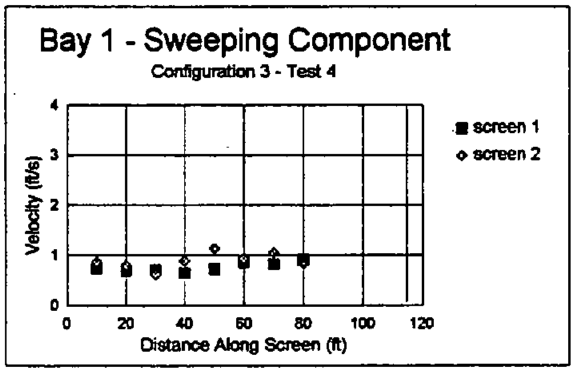


Figure 34.—Normal and sweeping velocities for screen configuration 3, test 4.

Table 15.—Screen approach velocity data for configuration 3, test 4.

GCID Alternative A 1:30 Scale Model Testing - Configuration 3
3 May 1996
fn = c3t1sd.wk4
TEST #4 - 1 bay operation (bays 2, 3 &4 - closed)

Qintake =	364	cfs
Qpumping	300	cfs
Qbypass =	64	cfs (Total)
w.s.el. =	137.3	ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.10	0.74	7.96	0.74			
	20	0.17	0.69	13.77	0.71			
	30	0.13	0.71	10.40	0.72			
	40	0.06	0.65	5.62	0.65			
	50	0.09	0.72	7.37	0.73			
	60	0.14	0.86	9.25	0.87			
	70	0.15	0.82	10.07	0.84			
	80	0.12	0.91	7.48	0.92	0.12	145.8	
2	10	0.29	0.86	18.54	0.91			
	20	0.12	0.79	8.37	0.80			
	30	0.17	0.60	15.49	0.63			
	40	0.02	0.88	1.46	0.88			
	50	0.45	1.13	21.68	1.22			
	60	0.32	0.94	19.01	0.99			
	70	0.19	1.05	10.46	1.07			
	80	0.23	0.84	15.10	0.87	0.22	270.4	100.0

TEST #5 - 4 bay operation

Qintake =	3,756 cfs
Qpumping	3,000 cfs
Qbypass =	256 cfs (Total)
w.s.el. =	139.9 ft (@ screens)

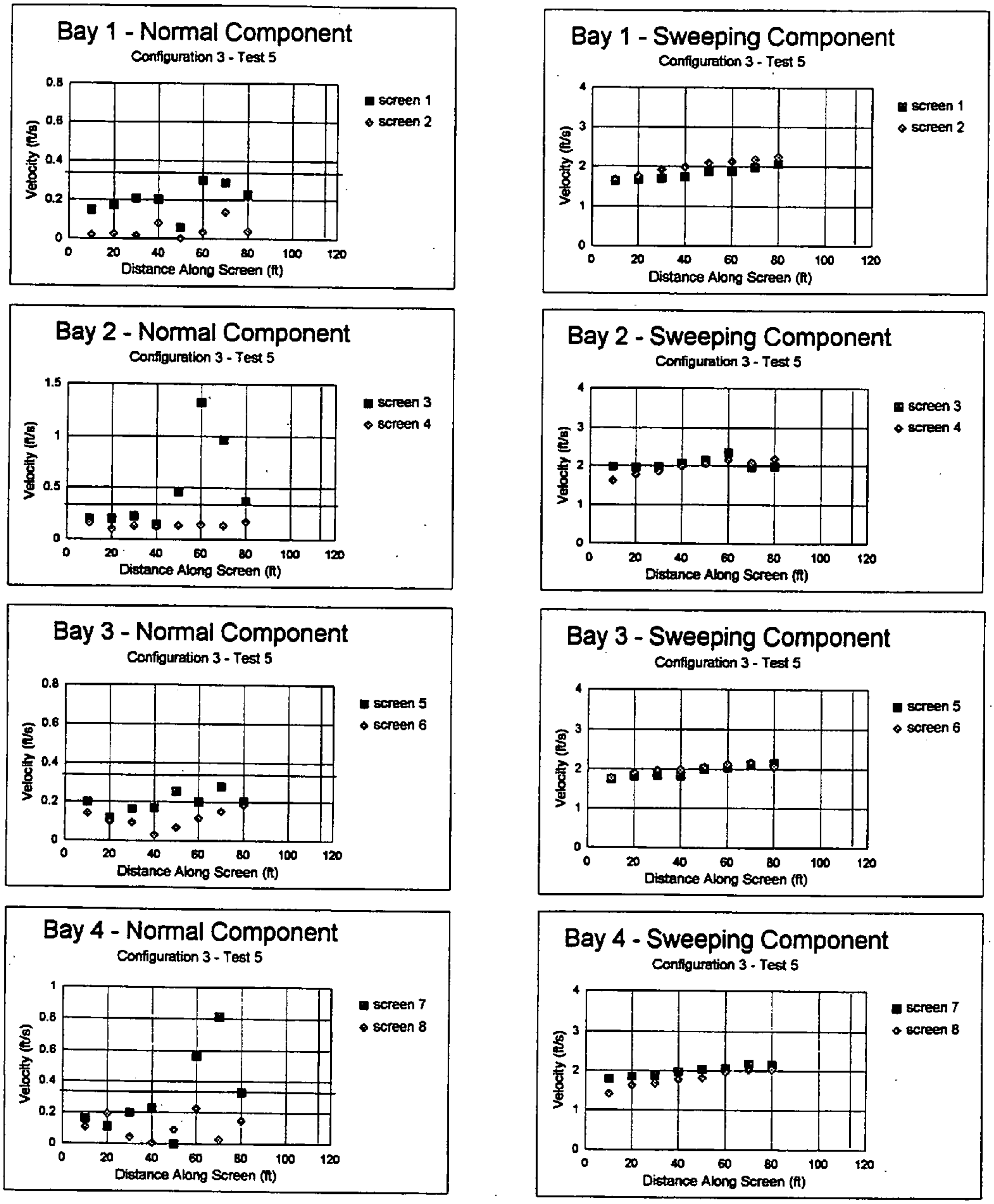


Figure 35.—Normal and sweeping velocities for screen configuration 3, test 5.

Table 16.—Screen approach velocity data for configuration 3, test 5.

GCID Alternative A 1:30 Scale Model Testing - Configuration 3
15 May 1996
fn = c3t5sd.wk4
TEST #5 - 4 bay operation
Qintake = 3,756 cfs
Qpumping 3,000 cfs
Qbypass = 256 cfs (Total)
w.s.el. = 139.9 ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.15	1.64	5.18	1.65			
	20	0.17	1.67	5.93	1.68			
	30	0.21	1.71	6.96	1.72			
	40	0.20	1.75	6.60	1.76			
	50	0.06	1.88	1.82	1.88			
	60	0.30	1.88	9.13	1.90			
	70	0.29	1.98	8.27	2.00			
	80	0.23	2.07	6.27	2.08	0.20	335.5	
2	10	0.02	1.66	0.72	1.66			
	20	0.03	1.75	0.90	1.75			
	30	0.02	1.91	0.59	1.91			
	40	0.08	1.99	2.41	1.99			
	50	0.00	2.09	0.08	2.09			
	60	0.04	2.13	1.02	2.13			
	70	0.14	2.18	3.68	2.18			
	80	0.04	2.24	1.01	2.24	0.05	79.0	17.0
3	10	0.20	1.98	5.67	1.99			
	20	0.20	1.95	5.75	1.96			
	30	0.23	1.98	6.49	2.00			
	40	0.14	2.07	3.94	2.07			
	50	0.46	2.14	12.10	2.19			
	60	1.32	2.35	29.41	2.69			
	70	0.96	1.96	26.21	2.18			
	80	0.37	1.98	10.60	2.02	0.48	823.7	
4	10	0.16	1.63	5.62	1.63			
	20	0.10	1.78	3.23	1.78			
	30	0.13	1.85	4.04	1.86			
	40	0.12	1.99	3.59	2.00			
	50	0.13	2.04	3.74	2.05			
	60	0.15	2.16	3.86	2.16			
	70	0.13	2.10	3.60	2.10			
	80	0.17	2.19	4.51	2.20	0.14	233.5	43.2
5	10	0.20	1.75	6.53	1.76			
	20	0.12	1.82	3.64	1.83			
	30	0.16	1.83	5.14	1.84			
	40	0.17	1.83	5.29	1.84			
	50	0.26	1.99	7.30	2.01			
	60	0.20	2.03	5.62	2.04			
	70	0.28	2.11	7.57	2.12			
	80	0.20	2.15	5.41	2.16	0.16	276.3	
6	10	0.14	1.77	4.57	1.77			
	20	0.10	1.91	2.94	1.91			
	30	0.09	1.97	2.71	1.97			
	40	0.03	1.98	0.89	1.98			
	50	0.07	2.05	1.94	2.05			
	60	0.12	2.12	3.12	2.12			
	70	0.15	2.18	3.99	2.18			
	80	0.19	2.04	5.18	2.05	0.09	155.2	17.7
7	10	0.16	1.78	5.19	1.79			
	20	0.11	1.85	3.51	1.85			
	30	0.20	1.87	6.09	1.88			
	40	0.23	1.97	6.60	1.99			
	50	0.00	2.03	0.03	2.03			
	60	0.56	2.07	15.27	2.14			
	70	0.81	2.17	20.51	2.32			
	80	0.33	2.15	8.81	2.18	0.21	359.3	
8	10	0.11	1.41	4.32	1.42			
	20	0.20	1.63	6.85	1.64			
	30	0.04	1.67	1.48	1.67			
	40	0.01	1.77	0.27	1.77			
	50	0.09	1.81	2.94	1.82			
	60	0.23	1.96	6.71	1.97			
	70	0.03	2.03	0.82	2.03			
	80	0.15	2.04	4.23	2.05	0.11	182.1	22.1

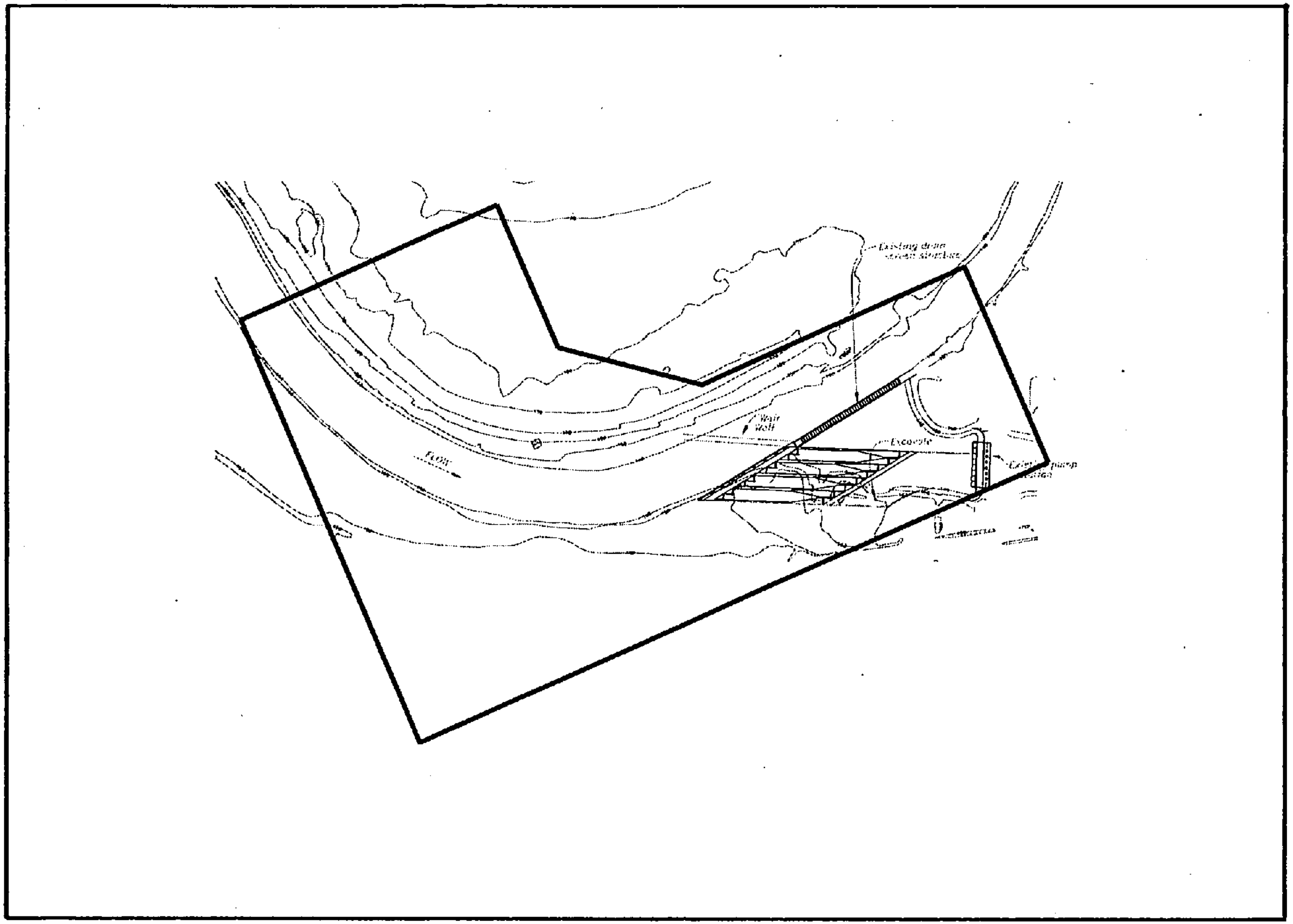


Figure 36.—Plan view of configuration 4 screen model showing the temporary extension of the weir wall to the pumping plant.

GCID Alternative A 1:30 Scale Model Testing - Configuration 4
14 May 1996
fn = c4t1sd.wk4
TEST #1 - 2 bay operation (bays 3 & 4 = Closed)

Qintake =	1,128 cfs	
Qpumping	1,000 cfs	
Qbypass =	128 cfs	(Total)
w.s.el. =	135.6 ft	(@ screens)

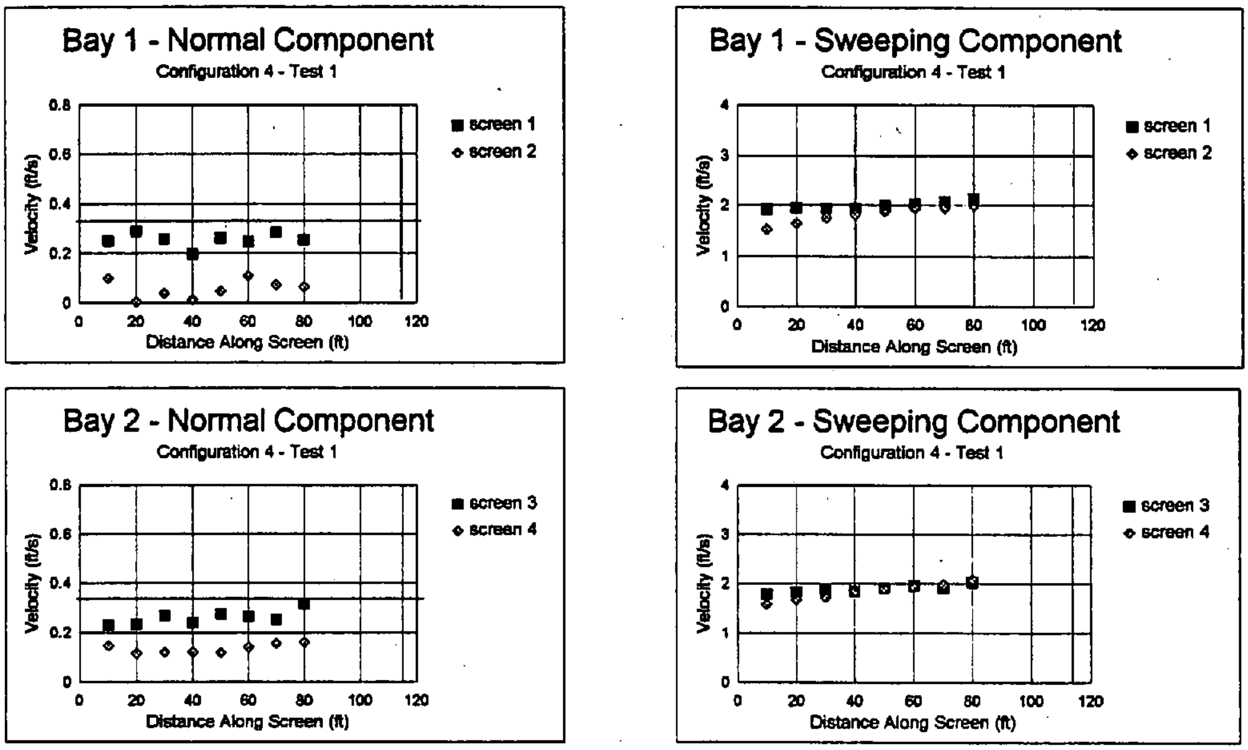


Figure 37.—Normal and sweeping velocities for screen configuration 4, test 1.

Table 17.—Screen approach velocity data for configuration 4, test 1.

GCID Alternative A 1:30 Scale Model Testing - Configuration 4
14 May 1996
fn = c4t1sd.wk4
TEST #1 - 2 bay operation (bays 3 &4 - closed)
Qintake = 1,128 cfs
Qpumping 1,000 cfs
Qbypass = 128 cfs (Total)
w.s.el. = 135.6 ft (@ screens)

Screen Velocity Data Summary:

Screen No.	Distance (ft)	Vn (ft/s)	Vs (ft/s)	Angle of Attack (degrees)	Vr (ft/s)	Vn (average)	Discharge (cfs)	%Discharge
1	10	0.25	1.93	7.41	1.95			
	20	0.29	1.96	8.52	1.98			
	30	0.26	1.95	7.59	1.96			
	40	0.20	1.95	5.80	1.96			
	50	0.26	2.00	7.52	2.02			
	60	0.25	2.03	6.97	2.04			
	70	0.29	2.08	7.83	2.10			
	80	0.26	2.14	6.84	2.16	0.26	310.7	
2	10	0.10	1.54	3.68	1.54			
	20	0.01	1.66	0.23	1.66			
	30	0.04	1.75	1.33	1.75			
	40	0.01	1.82	0.41	1.82			
	50	0.05	1.88	1.47	1.88			
	60	0.11	1.95	3.19	1.95			
	70	0.07	1.94	2.11	1.94			
	80	0.06	1.99	1.86	1.99	0.06	68.3	44.3
3	10	0.23	1.79	7.30	1.80			
	20	0.24	1.84	7.33	1.85			
	30	0.27	1.87	8.15	1.89			
	40	0.24	1.86	7.39	1.87			
	50	0.27	1.91	8.18	1.93			
	60	0.27	1.97	7.70	1.98			
	70	0.25	1.92	7.50	1.94			
	80	0.32	2.02	8.88	2.05	0.26	314.6	
4	10	0.15	1.59	5.22	1.59			
	20	0.12	1.68	3.96	1.68			
	30	0.12	1.72	3.96	1.72			
	40	0.12	1.84	3.72	1.84			
	50	0.12	1.90	3.52	1.90			
	60	0.14	1.96	4.11	1.96			
	70	0.16	1.99	4.47	1.99			
	80	0.16	2.08	4.39	2.09	0.13	162.0	55.7

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13. ABSTRACT *(Maximum 200 words)*

This report covers physical modeling of a multiple bay "V" shaped positive barrier fish screen. "V" shaped fish screens are among several concepts under study for the Glenn Colusa Irrigation District (GCID) diversion on the Sacramento River near Hamilton, California. A 1:30 scale model of the diversion intake and proposed screen structure was modeled in Reclamation's Water Resources Research Laboratory in Denver, Colorado.

The study investigated screen hydraulics for a staggered screen array of "V" screens downstream from a short approach channel. Measurements of screen approach and sweeping velocity were made to evaluate major design performance.

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