Exhibit O

Underwater Inspection and Velocity Survey

UNDERWATER INSPECTION AND VELOCITY SURVEY OF THE DOS AMIGOS PUMPING PLANT TRASHRACKS AND FOREBAY

February 21 and 22, 2007

U.S. Bureau of Reclamation
March 2007

REPORT PREPARED BY:

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March 17, 2007

To: Dave Gutierrez, Team Leader
DWR Accident Inspection Team

From: Joel F. Sturm, Member
DWR Accident Inspection Team

Subject: Underwater Inspection and Velocity Survey of the
Dos Amigos Pumping Plant Trashracks and Forebay
February 21 and 22, 2007

I. BACKGROUND AND INTRODUCTION,

On February 7, 2007, two California Department of Water Resources (DWR) inspection divers lost their lives while engaged in the underwater inspection of Dos Amigos Pumping Plant. The divers were looking specifically for evidence of Quaaga Mussels on the Unit 1, 2 and 3 intake trashracks. At the time of the inspection dive, Units 1, 2, 3, 4 and 6 were shut down and Unit 5 was operating at approximately full capacity (2600 cfs).

Dos Amigos Pumping Plant is located on the California Aqueduct/San Luis Canal, 9 miles south of the City of Los Banos, California and 16 canal-miles downstream of O'Neal Forebay. The pumping plant was designed and constructed by the U.S. Bureau of Reclamation (Reclamation) and construction was completed in 1968. Dos Amigos Pumping Plant is currently operated and maintained by DWR with Reclamation paying approximately 45% of the cost of operation and maintenance.

As part of the investigation into this accident, Reclamation personnel with experience in underwater inspections of structures and the measurement of flow velocities were requested to conduct an underwater inspection and velocity survey of the unit trashracks and forebay.

The underwater inspection and velocity survey were completed over a two-day period on February 21 and 22, 2007. Reclamation participants are listed in Table 4; DWR participants and Dos Amigos plant personnel are listed in Table 5 (Appendix F).

II. PURPOSE

The main objectives of the underwater inspection were:

1. Inspect the trashracks in front of operating and non-operating units for evidence of water weed/debris plugging or damage.

2. Inspect the forebay invert immediately beneath the trashracks for evidence of debris and entanglement hazards.
3. Inspect the forebay invert to a point at least 50 feet upstream of the trashracks for evidence of debris and entanglement hazards.

The main objectives of the velocity survey were:

1. Measure point velocities and velocity profiles upstream of the trashracks in front of operating and non-operating units.
2. Measure velocities along the trashracks of non-operating units located immediately adjacent to an operating unit (ie. Determine the existence and strength of sweeping currents)

All objectives were achieved.

III. UNDERWATER AND SURFACE CONDITIONS

U/W Visibility:	1 to 2 feet
Water Temperature:	60 degrees F
Current:	Absent or very low upstream of Units 1, 2, 3, 4 and 6 (non-operating units) and throughout forebay. High upstream of Unit 5 (operating unit)
Water Surface:	El. 220 (average)
Forebay Invert:	El. 192.2
Max. Water Depth:	28 feet
Weather:	2/21: Cloudy and mild to cool 2/22: Rainy to cloudy and cool.

IV. OPERATION SCHEDULE

The operation schedule for Dos Amigo Pumping Plant on February 21 and 22, 2007, before and during each day's underwater inspection activities is shown in Table 2 (Appendix E). The operation schedule for February 7, 2007, before and at the time of the diving accident on 2/7/07 is shown in Table 3 (Appendix E). The operation schedule for the 2/21, 22/07 underwater inspection was intended to be close to the operation schedule that was in effect at the time of the diving accident on 2/7/07. The intent was to produce similar underwater conditions and a similar degree of water weed/debris plugging of the trashracks upstream of operating Unit 5.

V. UPSTREAM CONDITIONS

Water weed plugging of the trashracks is a chronic operational problem for Dos Amigos Pumping Plant. Water weed grows in abundance in the relatively warm, shallow water around the edges of O'Neill Forebay located 16 canal-miles upstream of the pumping plant, and is carried to Dos Amigos Pumping Plant Forebay via the California Aqueduct/San Luis Canal. During the underwater inspection, water weed and miscellaneous floating debris were observed floating at the surface throughout the forebay and accumulating against the trashracks of operating units at and below the water surface.

VI. SHUT DOWN OF UNITS

Units 1, 3 and 4 were shut down just prior to starting the ROV inspection and velocity survey at 08:00 on February 21 and 22. Prior to shut down, a substantial accumulation of water weed and floating debris was evident at the water surface on the trashracks upstream of each operating unit. Shut down of each unit produced a dramatic return flow or surge that was characterized by surface turbulence, flow in an upstream direction and purging or flushing of the accumulated water weed from the trashracks. Once flushed from the trashracks, floating water weed moved about the forebay water surface and was eventually drawn to the single operating unit, Unit 5, where it continued to accumulate throughout the inspection.

VII. INSPECTION PROCEDURE

Two separate underwater inspections were conducted. An underwater video and sonar inspection employed a Remotely Operated Vehicle (ROV) to conduct a video (visual) and sonar inspection of the unit trashracks and the intake basin invert. The ROV inspection was conducted by Reclamation's Lower Colorado Region Underwater Inspection Team whose members are based in Boulder City, Nevada, 25 miles southeast of Las Vegas and Phoenix, Arizona. The flow velocity survey utilized two separate flow velocity measuring devices, a single-point velocimeter and an acoustic profiler to measure flow velocities in front of the unit trashracks. The velocity survey was conducted by Tracy Vermeyen, a Civil Engineer with Reclamation's Technical Service Center, Water Resources Research Lab in Denver, Colorado. Both inspection efforts received substantial assistance from DWR's Dos Amigos Pumping Plant staff.

ROV Inspection

Non-Operating Units 1, 2, 3, 4 and 6

Initially, the ROV was "flown" laterally across the trashracks in front of each unit at 5-foot depth intervals at depths of 5, 10, 15, 20 and 25 feet. The vertical spacing between depth intervals was increased when it became apparent that all non-operating units were clean and free of water weed and debris. Full control of the ROV was maintained at all times. The ROV video camera was typically no more than 1 foot upstream of the tashrack bars.

Operating Unit 5

Unit 5 was inspected at spot locations by a series of crash landings by the ROV. While inspecting Unit 5, the ROV was unable to be controlled by its onboard thrusters due to the high velocity flow encountered. A small degree of control of the ROV was maintained by a 3- to 4-person team pulling on the ROV umbilical in an upstream left direction. During the inspection of Unit 5, control of the ROV would be suddenly and completely lost when the ROV approached to within about 2 feet of the trashracks at which point the pull of the operating unit overcame the pulling power of the 3- to 4-man team. The ROV would then be slammed against the trashracks where it remained pinned while its onboard video was able to provide views of the water weed mat and high velocity flow. Eventually, the ROV was unable to be pulled free by four men pulling very hard. At 13:26, Unit 5 was shut down and the ROV was pulled free with no serious damage.

Forebay

The forebay invert was surveyed for its entire width from the trashracks to a distance of approximately 200 feet upstream. The forebay was inspected mainly through the use of side-scan sonar and continuous depth measurements supplemented by spot video observations.

Velocity Survey

The flow velocity survey was performed with a point-source velocimeter and a velocity profiler. The velocimeter was attached to a trolley (trailer) and lowered down the upstream faces of the trashracks of non-operating units by a boom truck. The velocimeter trolley was not lowered in front of operating Unit 5 due to concerns that it might become pinned to the trashracks. While lowering the velocimeter trolley along the pier separating Units 4 and 5, sweeping flows caused the trolley to become unstable and tip toward Unit 5. The trolley weighed approximately 1220 lbs. in air and approximately 1075 lbs. in water.

The velocity profiler, contained in a small boat that floats at the water surface, was used to measure vertical velocity profiles upstream of all units. See Appendix H, *Dos Amigos Pumping Plant – Trash Rack Velocity Survey, Tracy Vermeyen, PE, Technical Service Center, U.S. Bureau of Reclamation, Denver, Colorado,* for a complete discussion of the velocity survey.

VIII. INSPECTION EQUIPMENT

Remotely Operated Vehicle (ROV)

The ROV employed in the underwater inspection is a Phantom 500 XTL manufactured by Deep Ocean Engineering with a 550 foot umbilical and depth rating. The ROV is the property of Reclamation's Lower Colorado Region Underwater Inspection. The ROV is equipped with a high resolution color video camera capable of variable focus, zoom and vertical tilt that is designed for use in low light and low visibility conditions (5 to 7 lux minimum). Video images are viewed on a surface monitor along with an on-screen heading, date, time, depth and temperature display. Lighting is provided by a two-lamp, fixed intensity lighting system. An auxiliary low light, black and white fixed zoom and focus video camera is also mounted on the ROV for use in light of 0.1 lux minimum. The color video provides optical resolution that slightly exceeds that of the human eye. A combined, side- scan and oblique angle imaging sonar system provides both profile imaging and navigational capabilities. The ROV is maneuvered or "flown" using lateral, forward/reverse and vertical thrusters operated by a topside control panel. The ROV umbilical provides electric power (supplied by a portable generator) to the on-board thrusters, cameras, lights, sonar system and cables to the onboard depth and temperature sensors.

Flow Velocity Instruments
The point-source velocimeter and velocity profiler employed in the velocity survey are described in Appendix H.

IX. FINDINGS

ROV INSPECTION

Units 1, 2, 3, 4 and 6

The condition of the trashracks of each of the five inactive units was remarkably similar with respect to the condition of the trashracks and the degree of debris plugging. Trashracks were in satisfactory condition for a 50-year-old structure. Most trashrack panels show a pervasive rust coating and only a few, localized instances of minor damage. A number of trashracks are in like-new condition as a result of having been recently rebuilt.

All trashracks on inactive units were clean and almost completely free of debris of all kinds: pond weed, tumble weed, plastic bags, fishing line. Minor, localized accumulations of water weed and debris were observed as approximately 1- to 2-foot square, widely spaced patches at random locations on some trashracks. Water weed was observed as a 1- to 2-foot high pile along the bases of the Unit 1, 2, 3 trashracks; the left and middle Unit 4 trashrack panels and the right and middle Unit 6 trashracks. The forebay invert was clean at the bottom of the right Unit 4 trashrack panel and the left Unit 6 trashrack panel (the panels closest to operating Unit 5).

Flow direction and relative velocity was evident in the movement of suspended particles as observed by the video camera onboard the ROV. No flow or very low flow was observed at the Unit 1, 2 and 3 trashracks; at the left and middle panels Unit 4 trashrack panels; and at the middle and right Unit 6 trashrack panels. Flow toward Unit 5 (the operating unit) was evident at the right Unit 4 trashrack panel (the panel closest to Unit 5) and at the left Unit 6 trashrack panel (the panel closest to Unit 5). This “sweeping flow” moved along or parallel to the faces of the trashracks toward the operating unit. Sweeping flow was most evident along the forebay invert at the base of the trashracks.

Trashracks are removable and are separated by fixed trashrack guides.

Unit 5

Based on ROV video images, the trashracks upstream of Unit 5, the single operating unit, were plugged over much of their area by a dense mat of green water weed. Water weed was tightly wrapped in an approximately horizontal direction, parallel to flow, around all trashrack bars (similar to the way tinsel hangs on the branches of a Christmas tree only horizontal). The gaps between trashrack bars were apparent as depressions in the water weed mat or as localized, 2- to 6-inch diameter “windows” or holes in the water weed mat. Linear openings oriented parallel to the trashrack bars were present along the trashrack guides adjacent to the trashrack panels. Videography from the ROV showed bits of water weed or floating debris to be drawn into these "windows" and openings at extremely high rates of speed, clear evidence that extremely high velocity flow was concentrated at small openings that amount to only a small fraction of the open area that would be available on trashracks that are free of debris.

At 13:00 on February 21, a head differential of 4.5 feet was measured across the heavily water weed-plugged trashracks of Unit 5, the only operating unit.

Forebay

Invert at Bottom of Trashracks - Video and sonar from the ROV showed the forebay invert to be covered by a few inches to 2 to 3 feet of fine sediment, clam shells, water weed and tumbleweeds at the bottoms of the Unit 1, 2 and 3 trashracks and at the bases of the middle and right Unit 4 trashrack panels and the middle and left Unit 6 trashrack panels. The forebay invert at the bottoms of the right Unit 4 trashrack panel, the left Unit 6 trashrack panel and the Unit 5 trashracks was clean; video showed bare concrete.

Upstream Area – Side-scan sonar images, spot video observations and depth measurements showed the invert to be flat, free of debris and covered by less than one foot of fine sediment and clam shells.

VELOCITY SURVEY

Velocities measured in front of the non-operating units were less than 0.65 ft/sec. The highest velocity of 5.0 ft/sec was measured in front of the operating unit. See Appendix G, *Dos Amigos Pumping Plant – Trash Rack Velocity Survey, Tracy Vermeyen, PE, Technical Service Center, U.S. Bureau of Reclamation, Denver, Colorado,* for a complete discussion of the velocity survey.

X. SUMMARY AND CONCLUSIONS

1. Water weed plugging of the unit trashracks is a chronic operational problem at Dos Amigos Pumping Plant.

2. Water weed plugging affects the trashracks of any operating unit.

3. Maximum plugging occurs when only one unit is operating and all water weed in the forebay is drawn to the single operational unit.

4. Heavy water weed plugging produced a differential head of 4.5 feet across the Unit 5 trashracks on February 21. Unit 5 was the only operating unit at the time.

5. Exceptionally high velocity flow occurs where water weed plugging of trashracks has reduced the available area of the trashracks to much less than the area normally available with a clean trashrack.

6. The highest velocity flows were observed and measured at the trashracks of operating Unit 5 where a dense mat of water had plugged the trashracks. High velocity flow is concentrated along the trashrack guides between trashracks and at localized "windows" or thin spots in the mat of water weed.

7. Shut down of a unit produces a strong return surge which flushes accumulated water weed and debris from the unit trashracks resulting in a "self cleaning" effect.

8. The trashracks of recently shut down, non-operating units are clean and free of debris.

APPENDICES

A. Photographs

B. Table 1. ROV Video Log and Video Images of Trashracks

C. Sonar Records - Figures 1 and 2.

D. Drawings

E. Operation Schedules – Tables 3 and 4

F. Participants – Table 4. Reclamation; Table 5. DWR

G. Water Surface Elevations

H. Dos Amigos Pumping Plant – Trash Rack Velocity Survey, Tracy Vermeyen, PE, Technical Service Center, U.S. Bureau of Reclamation, Denver, Colorado

1. PHOTOGRAPHS

Photo 1 Dos Amigos Pumping Plant
Underwater Inspection

AERIAL VIEW

Aerial oblique view of Dos Amigos Pumping Plant and Forebay.

R. Tang February 20, 2007

Photo 2

Dos Amigos Pumping Plant
Underwater Inspection

TRASHRACKS

View of the tashracks looking toward canal right (west). Units are numbered 1 to 6 from left to right. Water weed and floating debris has accumulated on the Unit 1, 3 and 4 trashracks indicating that these three units are operating.

R. Tang

February 21, 2007

Photo 3

Dos Amigos Pumping Plant
Underwater Inspection

TRASHRACKS

Return surge and clearing of water weed from the Unit 1trashracks following shut down of the unit.

J. Sturm

February 21, 2007

Photo 4

Dos Amigos Pumping Plant
Underwater Inspection

TRASHRACKS

Floating water weed following shut down of Units 1, 3 and 4.

J. Sturm

February 21, 2007

Photo 5

Dos Amigos Pumping Plant
Underwater Inspection

TRASHRACKS

Return surge and clearing of water weed from the Unit 5 trashracks following shut down of the unit at 13:26 in order to free the ROV.

J. Sturm

February 21, 2007

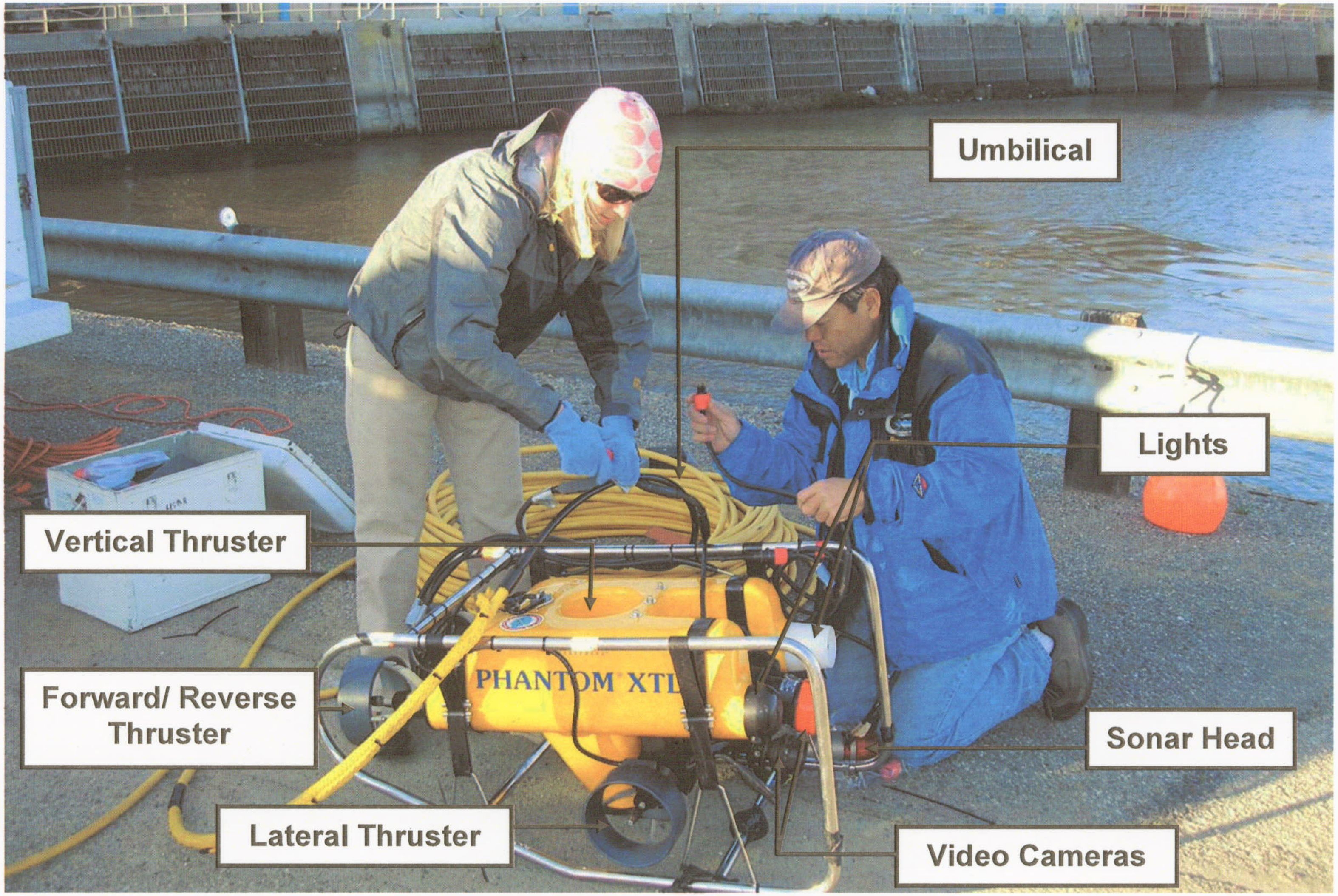


Photo 6

Dos Amigos Pumping Plant
Underwater Inspection

ROV

Preparing the ROV to inspect the trashracks. The main components of the ROV are the lateral, forward/reverse and vertical thrusters, video cameras, lights, sonar head and umbilical. The umbilical provides electrical power (supplied by a portable generator) and control to the thrustors, lights, cameras and sonar system and cables to the depth and temperature sensors.

J. Sturm

February 21, 2007

Photo 7 Dos Amigos Pumping Plant
Underwater Inspection

ROV

ROV and Reclamation's Lower Colorado Region Dive Team truck containing the video monitor and ROV controls.

J. Sturm February 21, 2007

Photo 8. Dos Amigos Pumping Plant
Underwater Inspection

ROV

Close-up view of the video monitor and ROV controls. The labtop computer displays the sonar image.

J. Sturm February 21, 2007

Photo 9. Dos Amigos Pumping Plant
Underwater Inspection

ROV

View looking upstream and left (northwest) at the ROV, umbilical and dive truck containing the video monitor and ROV controls.

J. Sturm February 22, 2007

Photo 10.

Dos Amigos Pumping Plant
Underwater Inspection

ROV

ROV is just upstream of Unit 6. The small floats attached to the ROV umbilical kept the umbilical at the surface in order to avoid entanglement with any debris on the forebay invert.

J. Sturm

February 22, 2007

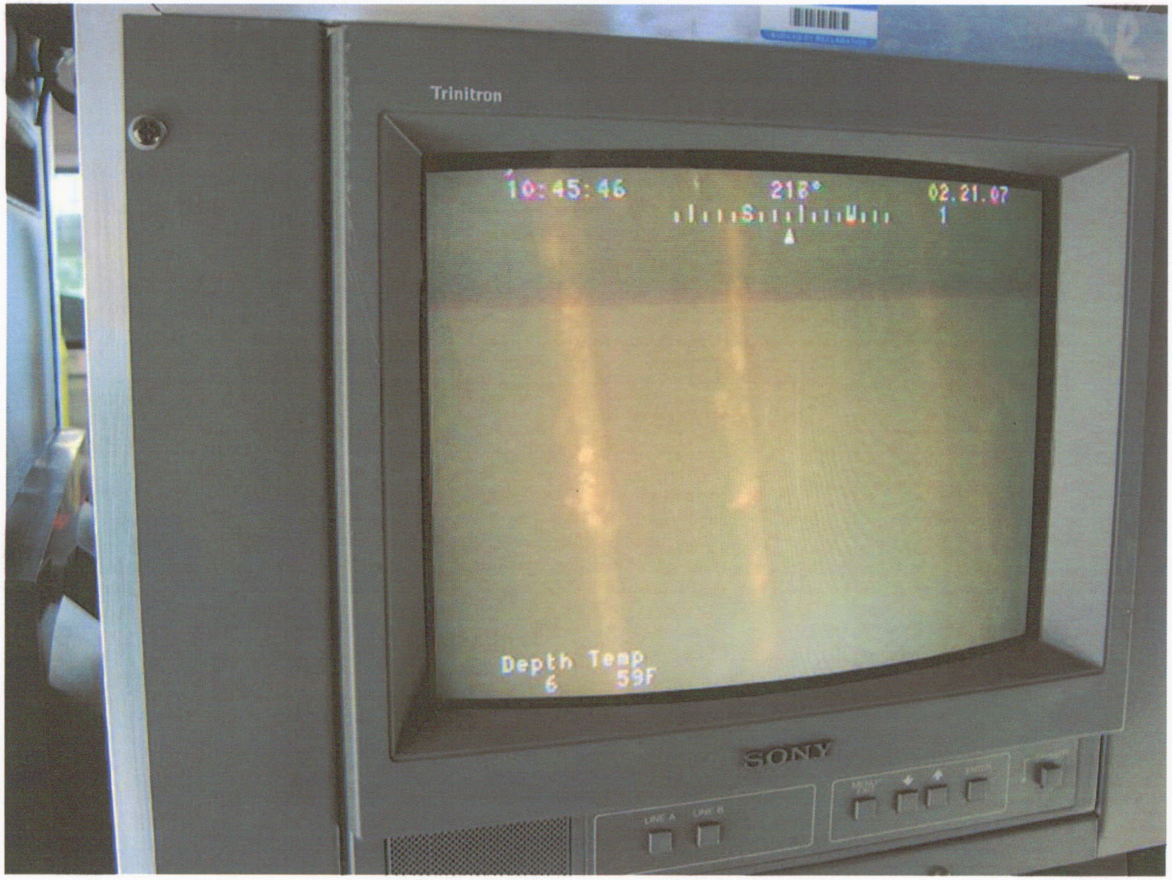


Photo 11.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 2 trashrack bars at a depth of 6 feet. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo 12.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of minor damage to the Unit 2 trashrack bars at a depth of 1 foot. The bar was probably bent by the excavator used for trash removal.

J. Sturm

February 21, 2007

Photo 13

Dos Amigos Pumping Plant
Underwater Inspection

TRASHRACKS

View of the water weed and floating debris that accumulated in front of Unit 5 over a 2-hour period during the underwater inspection.

J. Sturm

February 22, 2007

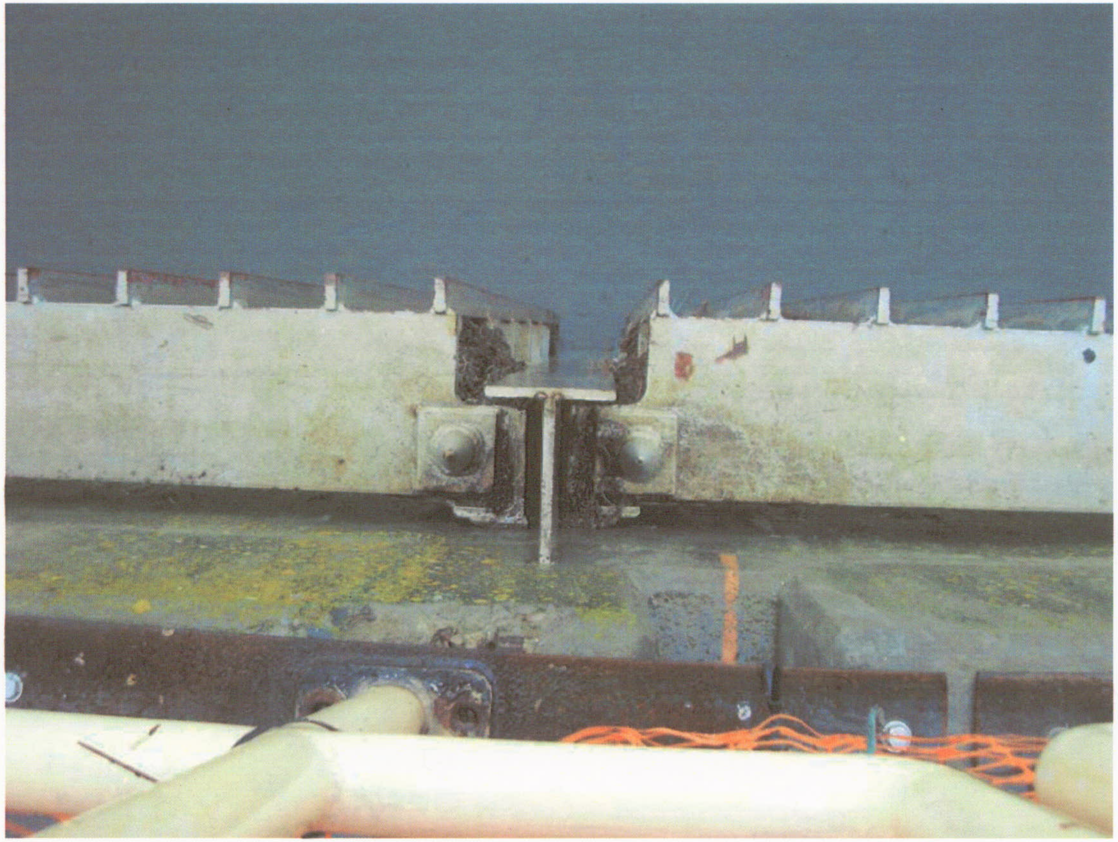


Photo 14 — Dos Amigos Pumping Plant, Underwater Inspection

TRASHRACKS

View looking directly down on the top of two tashrack panels showing a trashrack guide at photo center.

J. Sturm — February 22, 2007

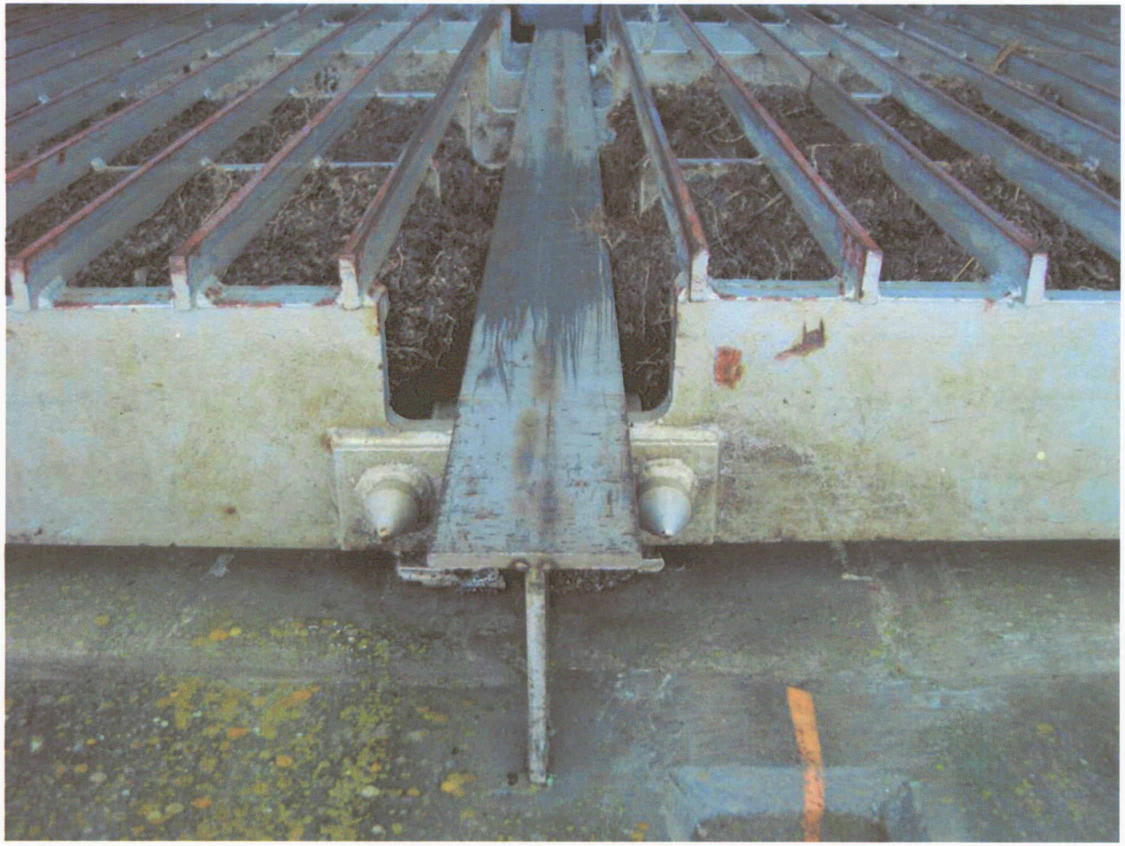


Photo 15

Dos Amigos Pumping Plant
Underwater Inspection

TRASHRACKS

View looking down and toward the two tashrack panels shown in Photo 14. The upper 4 feet of each trashrack panel is thoroughly plugged with water weed.

J. Sturm

February 22, 2007

Photo 16

Dos Amigos Pumping Plant
Underwater Inspection

VELOCITY SURVEY

Velocity profiler (red boat) being deployed by the DWR boom truck. The same boom truck was used to lower the trolley holding the single-point velocimeter (Photo 19) down the trashracks.

J. Sturm

February 22, 2007

Photos 17 and 18

Dos Amigos Pumping Plant
Underwater Inspection

VELOCITY SURVEY

Close-up views of the velocity profiler.
R. Tang

February 22, 2007

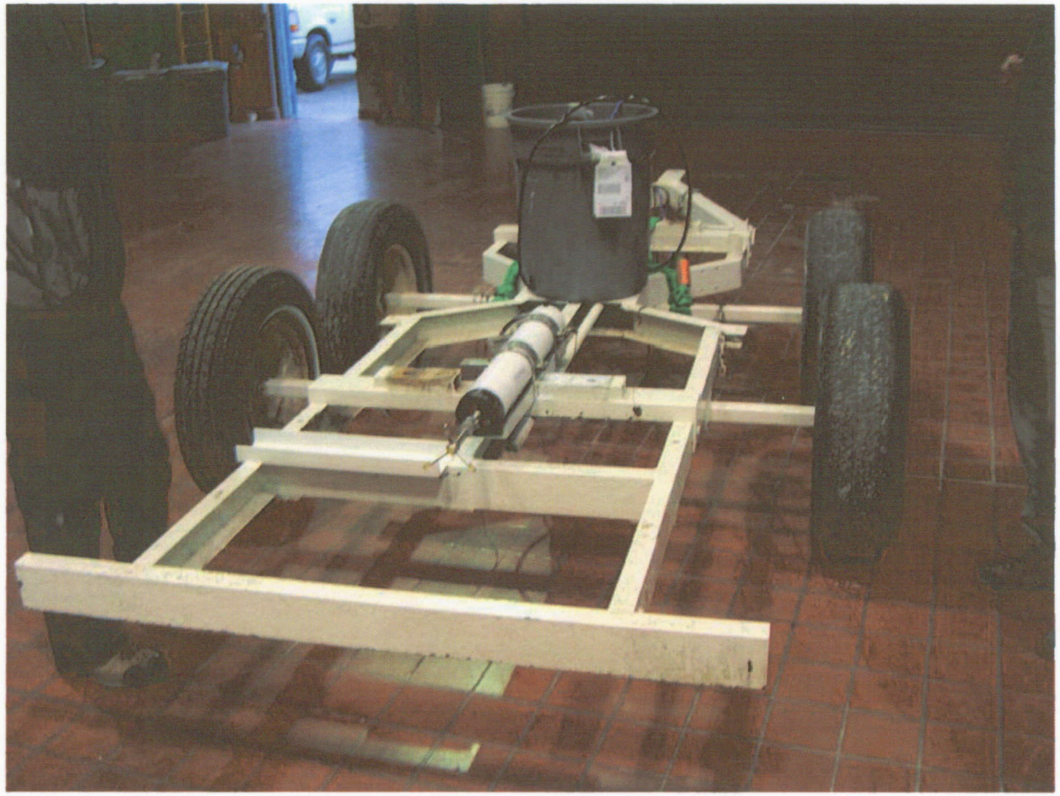


Photo 19

Dos Amigos Pumping Plant
Underwater Inspection

VELOCITY SURVEY

Trolley and single-point velocimeter (white cylinder with stainless steel, 3-pronged “antenna”. The trolley and velocimeter were lowered down the trashracks of each non-operating unit by a DWR boom truck and crew. Velocimeter cable is stored in the gray barrel.

R. Tang

February 22, 2007

2. Video Records

TABLE 5. VIDEO LOG OF UNDERWATER INSPECTION
DOS AMIGOS PUMPING PLANT
FEBRUARY 21 & 22, 2007

TIME INTERVAL	UNIT	OBSERVATIONS
DVD #1		**UNITS 1 and 2** **2/21/07**
10:07:30 to 10:33:06	1	Trashracks clean and free of debris. Some trashrack panels in "like new" condition. No current observed.
10:36:36 to 11:06:55	2	
DVD #2		**UNITS 3, 4 and 5** **2/21/07**
11:26:34 to 11:40:48	3	Trashracks clean and free of debris. No current observed.
11:47:20 to 12:33:44	4	Trashracks clean and generally free of debris. Localized bunches of water weed. 12:30:02 -12:30:44: Sweeping current toward Unit 5 observed at forebay invert. 12:33:00 to 12:33:45: High velocities at 4/5 pier
12:34:00 to 12:52:30	5	Dense water weed mat. High velocity current. Highest velocities are concentrated at localized "windows" and along edges of trashrack guides. 12:34:46 to 12:34:56: High velocities at "window" 12:35:10 to 12:35:38: High velocities at edges of trashrack guide 12:36:06 to 12:36:28: "Window" or hole in water weed mat. 12:36:38 to 12:36:40: "Window" or hole in water weed mat. 12:48:00 to 12:48:40: High velocities at edges of trashrack guide 12:51: to 12:52:30: High velocities at "windows" between trashrack bars
DVD #3		**UNITS 5 and 6** **2/22/07**
9:53:12 to 10:05:15 10:06:11 to 10:08:06	6	Trashracks clean and free of debris. Sweeping current toward Unit 5 observed.
10:52:30 to 10:53:00 11:04:20 to 11:05:16 11:18:55 to 11:19:07	5	High velocity current concentrated at "windows" or holes in dense water weed mat. Fine sediment and shells on forebay invert. Few useable images due to difficulty controlling ROV and concern that ROV would become pinned to trashrack or damaged by high velocity current.

Photo V1.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 1 trashrack bars at a depth of 19 feet. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo V2.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 2 trashrack bars at a depth of 21 feet. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo V3.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 3 trashrack bars at a depth of 15 feet. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo V4.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 4 trashrack bars at a depth of 23 feet. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo V5.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 4 trashrack at a depth of 26 feet at the bottom right corner of trashrack panel C, next to the right trashrack guide (visible in photo) and the Unit 4/5 pier. A moderately strong sweeping current toward Unit 5, the only unit operating, was observed. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo V6.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 5 trashrack at a depth of 17 feet showing a “window” or hole through the dense water weed mat that covered and severely plugged most of the Unit 5 trashrack at the time of the inspection. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo V7.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 5 trashrack and guide at a depth of 19 feet. Very high velocity flow was observed at this location. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo V8.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 5 trashrack at a depth of 15 feet showing a "window" or hole through the dense water weed mat where very high velocity flow was observed. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 21, 2007

Photo V9.

Dos Amigos Pumping Plant
Underwater Inspection

UNDERWATER INSPECTION

Video image of the Unit 6 trashrack bars at a depth of 21 feet. The information on the screen includes: time (top left), heading (top center), date (top right), depth (feet of sea water, fsw) and water temperature (lower left).

J. Sturm

February 22, 2007

3. Sonar Records

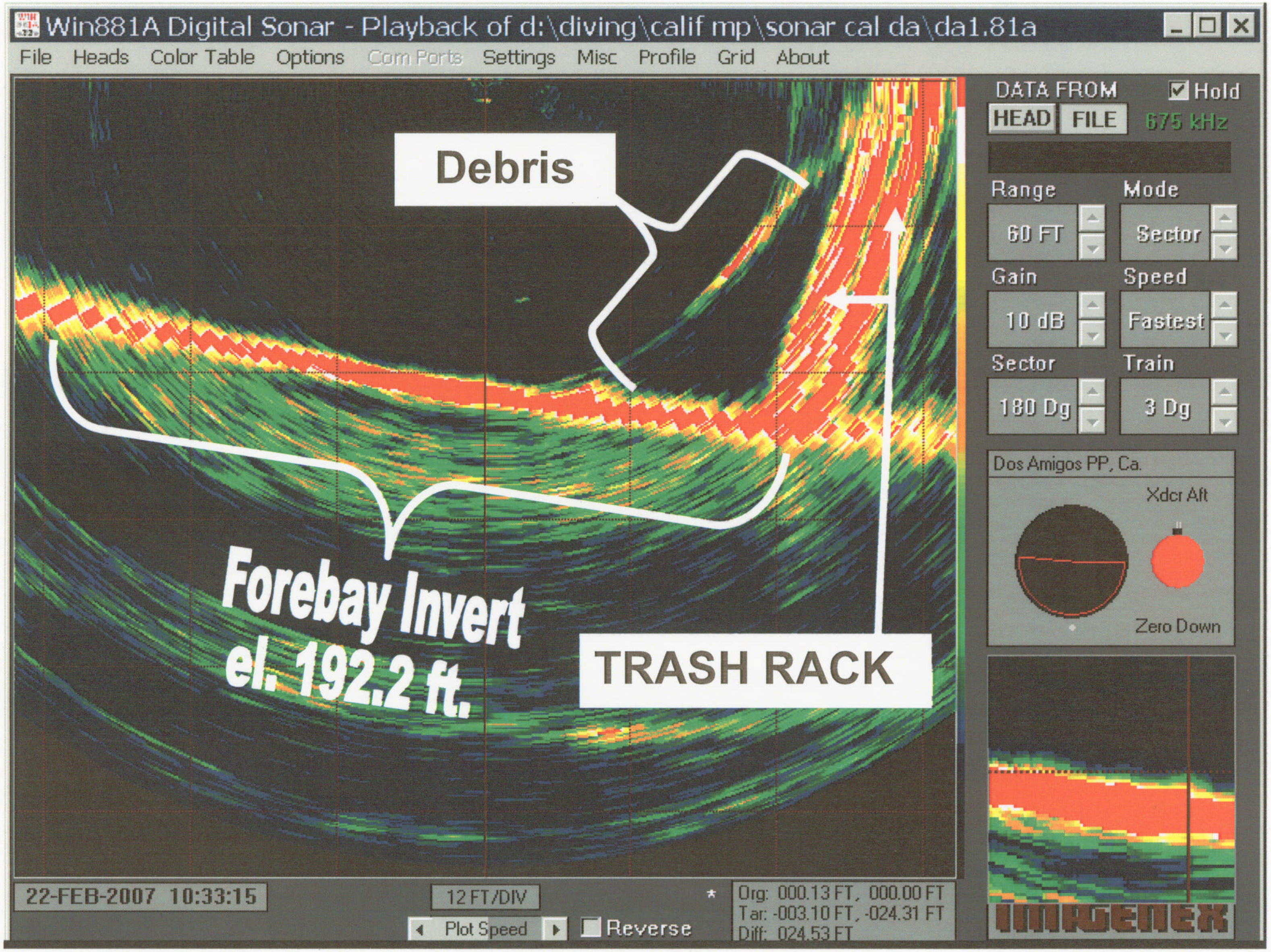


FIGURE 1. Sonar Cross-Section of Trashracks and Forebay Invert
Sonar image looking east at the trashracks and forebay invert upstream of a non-operating unit. The conditions shown are typical of all non-operating units. Debris is limited to a small "wedge" of water weed at the base of the trashracks. The forebay invert is horizontal. The apparent slope of the forebay invert is due to the angle of the sonar head on the ROV.

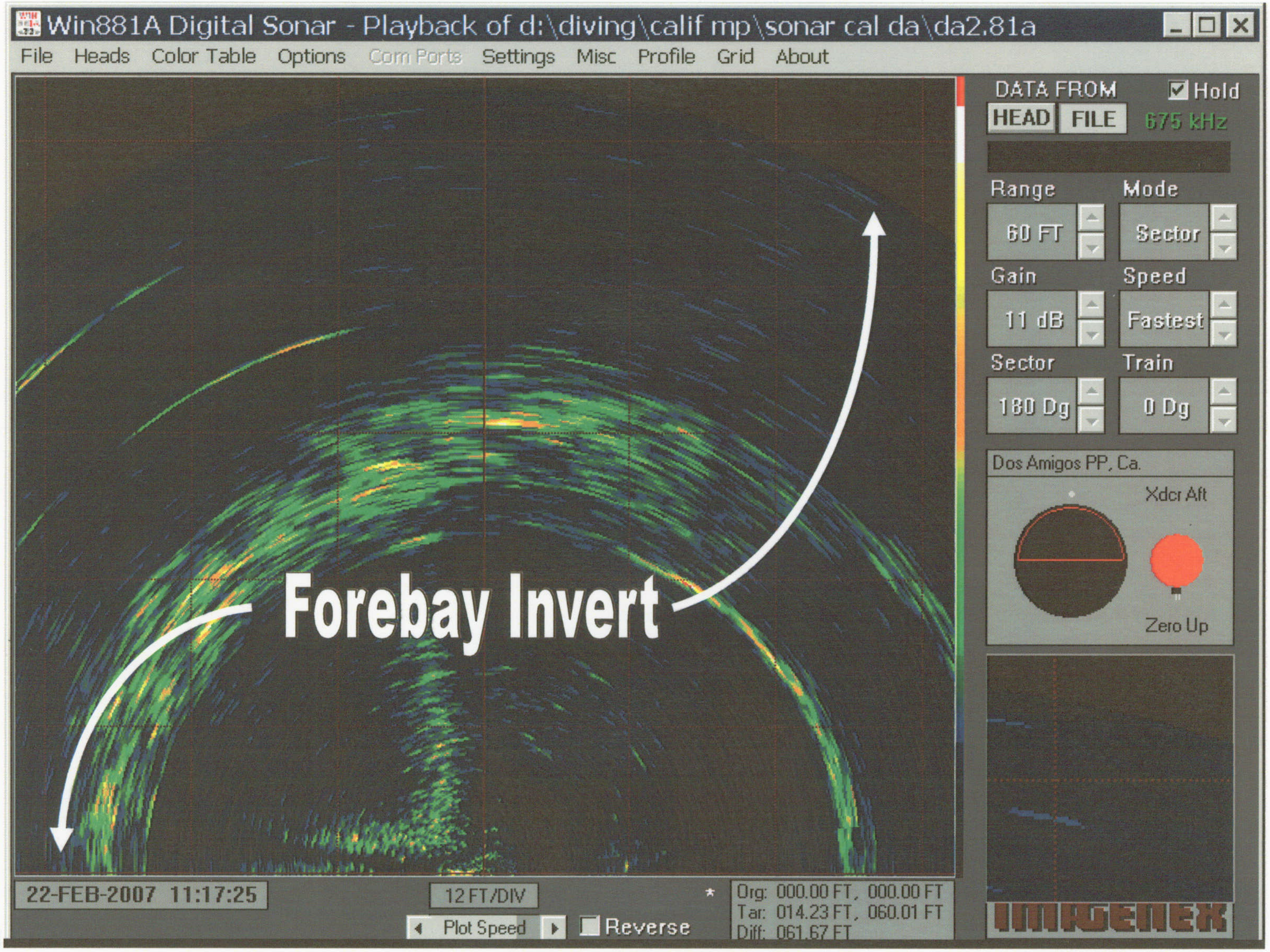
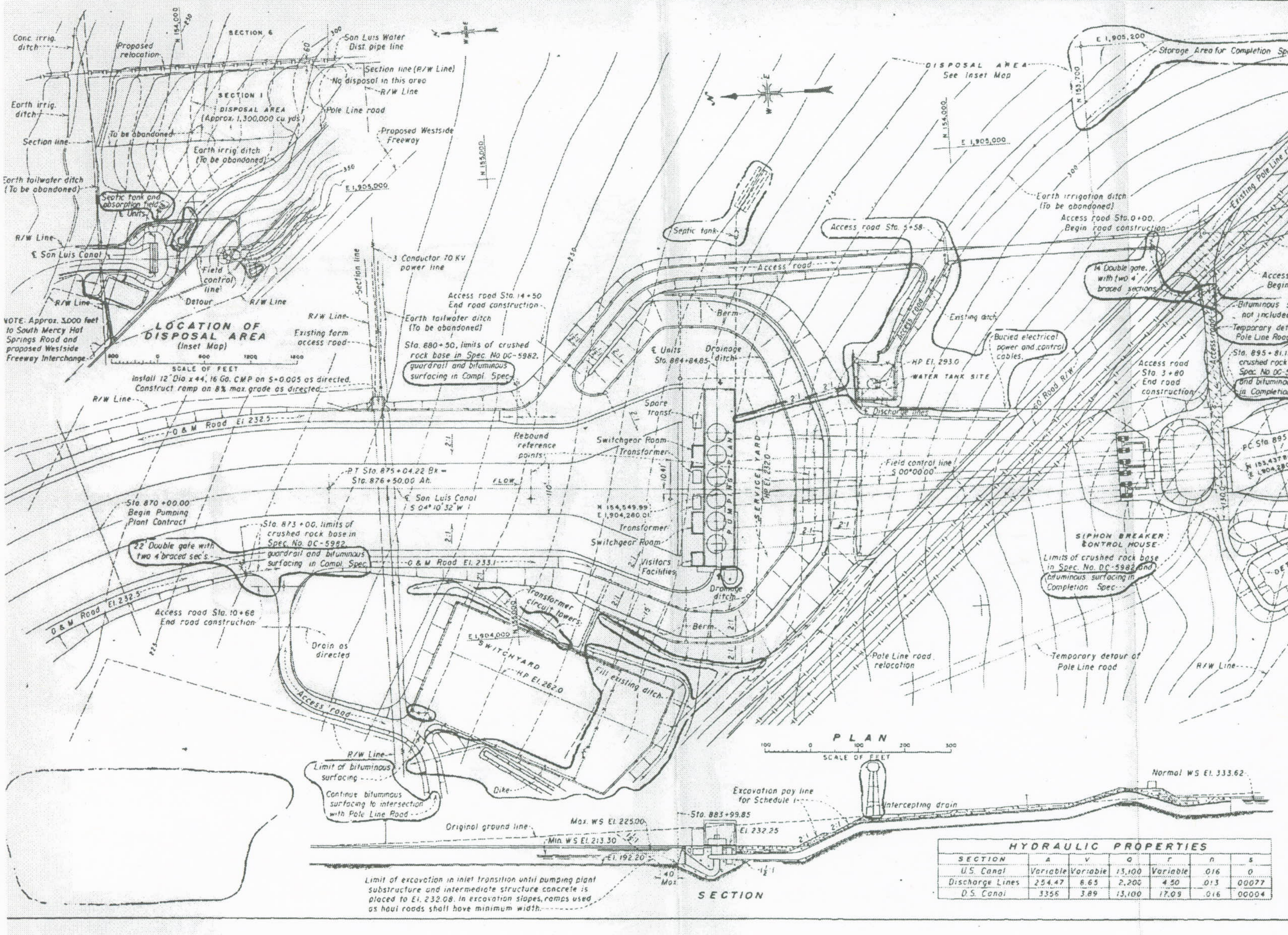


FIGURE 2. Sonar Image of the Forebay Invert.
Minor scattered debris or areas of rough concrete are evident as yellow, orange or red areas. No major debris is evident.

4. Drawings



HYDRAULIC PROPERTIES

SECTION	A	V	Q	r	n	s
U.S. Canal	Variable	Variable	13,100	Variable	.016	0
Discharge Lines	254.47	8.65	2,200	4.50	.013	00077
D.S. Canal	3356	3.89	13,100	17.09	.016	00004

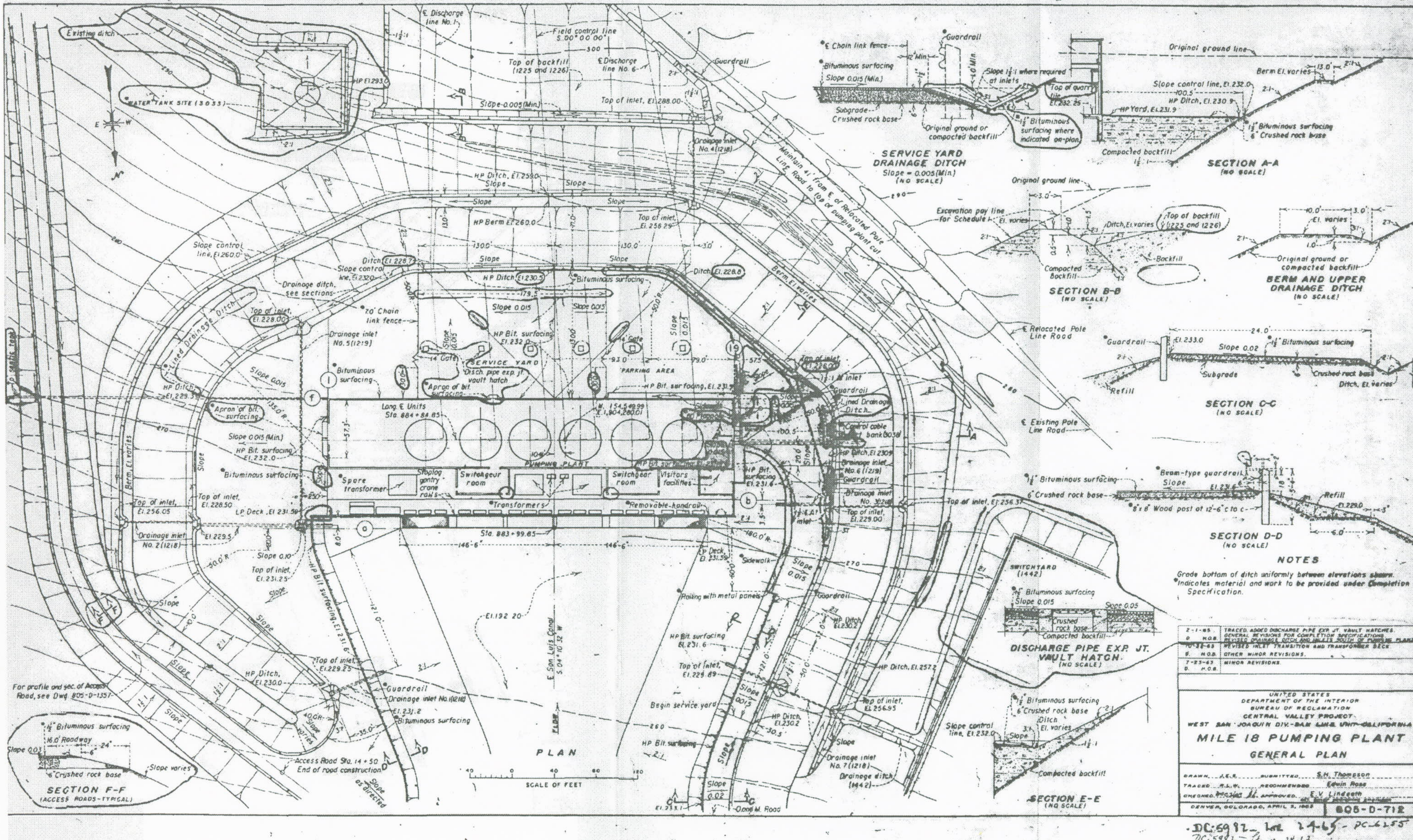
2-19-65 D- H.O.B.	TRACED. REV. VISITORS ACCESS ROAD. GENERAL REVISIONS FOR COMPLETION SPECIFICATIONS.
8-28-63 D- H.O.B.	ADDED RAMP TO EXISTING ACCESS ROAD AND SPARE TRANSFORMER. REV. STA'S. AND INLET TRANSITION.
7-30-63 D- H.O.B.	REV. DISPOSAL AREA, SLOPE LINES, DRAINAGE, BERM IN INTAKE CHANNEL. OTHER MINOR REVISIONS.
3-29-63 D- H.O.B.	GENERAL REVISIONS.
1-21-63 D- H.O.B.	REV. DISPOSAL AREA, DISCH. LINES, ROAD EL. RELOCATED ACCESS RD. ADDED DRAINAGE DITCHES AND R/W.

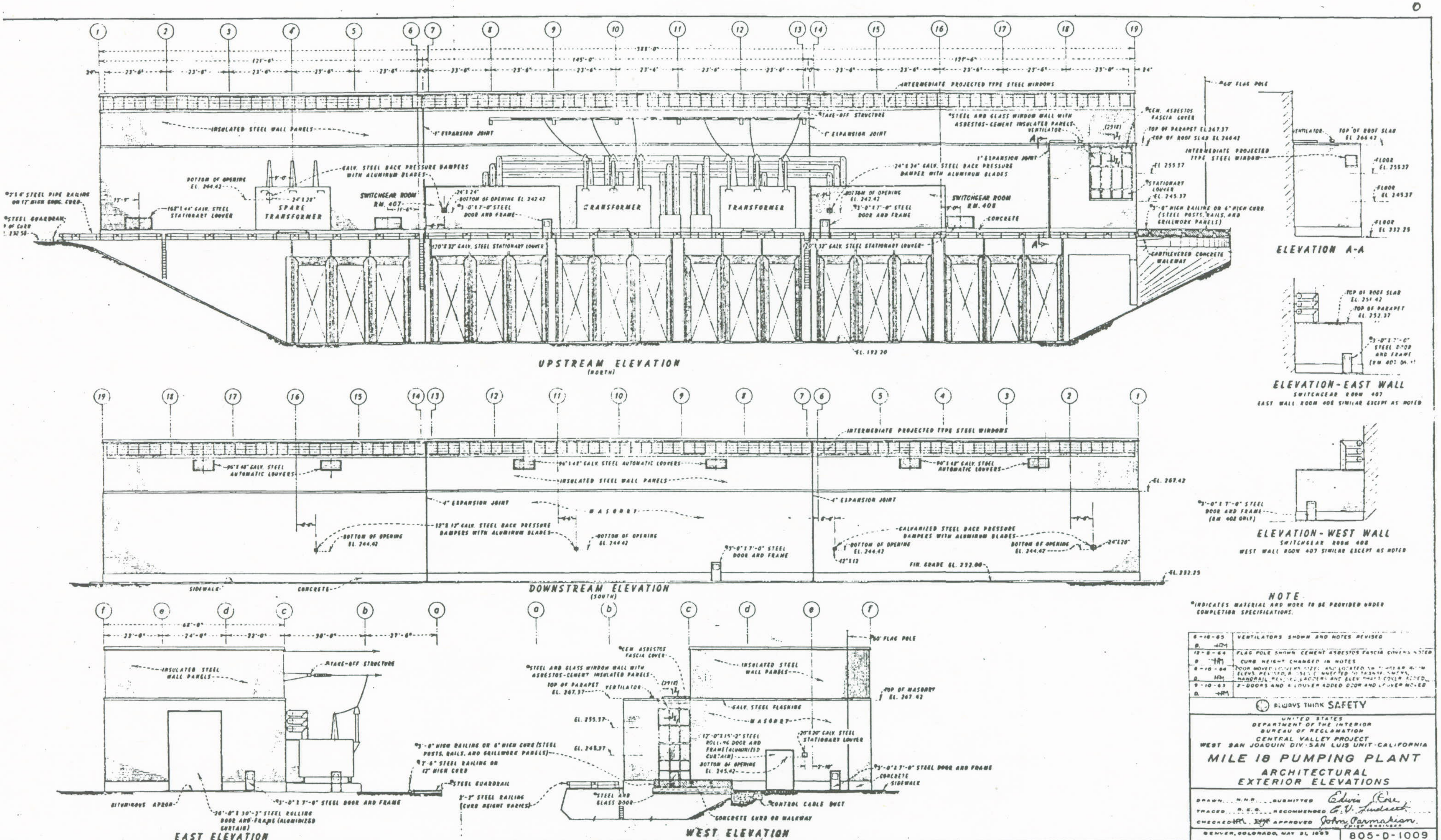
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA

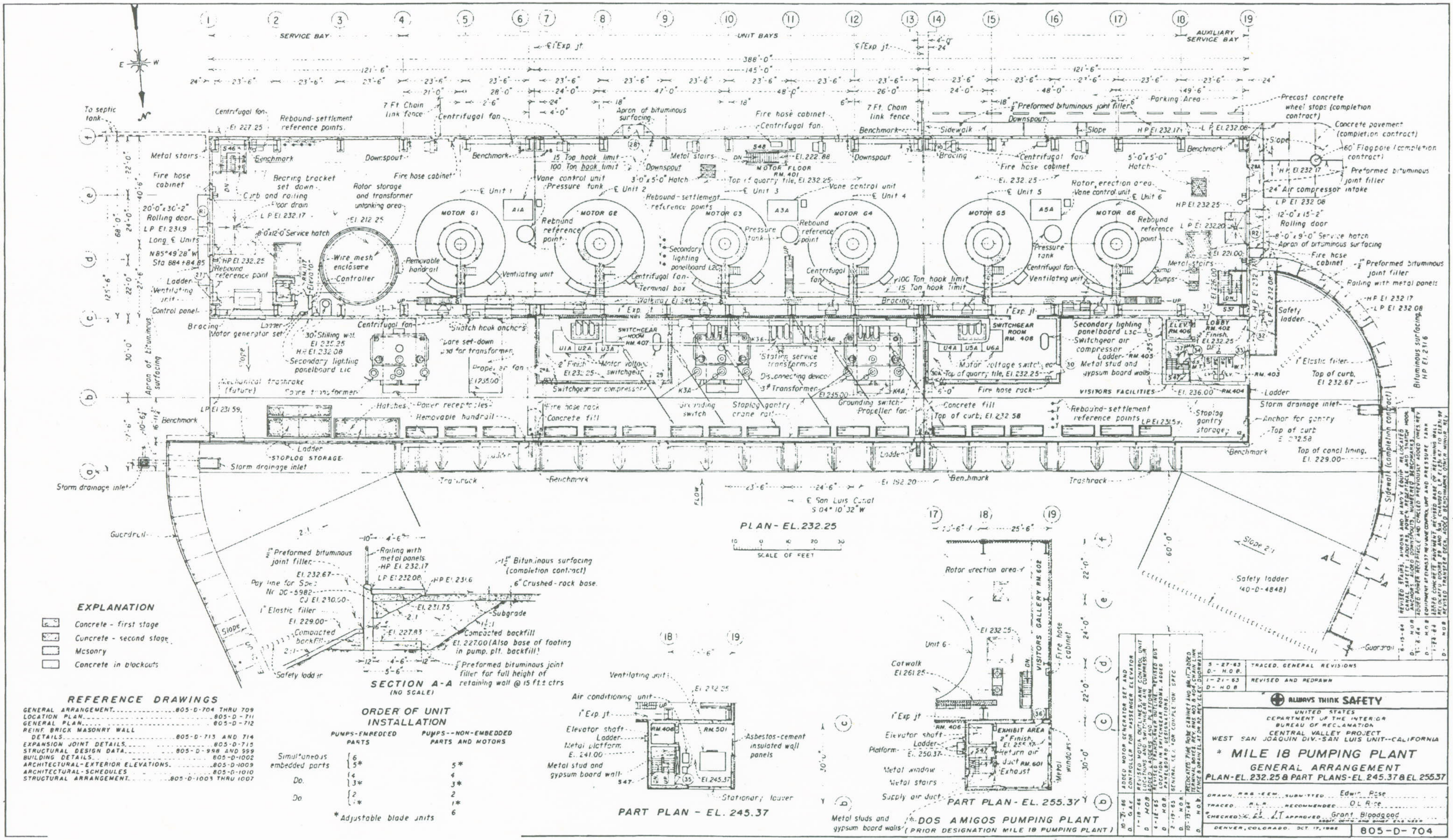
MILE 18 PUMPING PLANT
LOCATION PLAN

DRAWN H.W.B. SUBMITTED Edwin Rose
TRACED K.E.G. RECOMMENDED O.L. Rice
CHECKED H.O.B. S.J. APPROVED B.P. Bellport
DENVER, COLORADO, DEC. 13, 1962 — 805-D-711

DC-6455 – Drawn. K-1-65

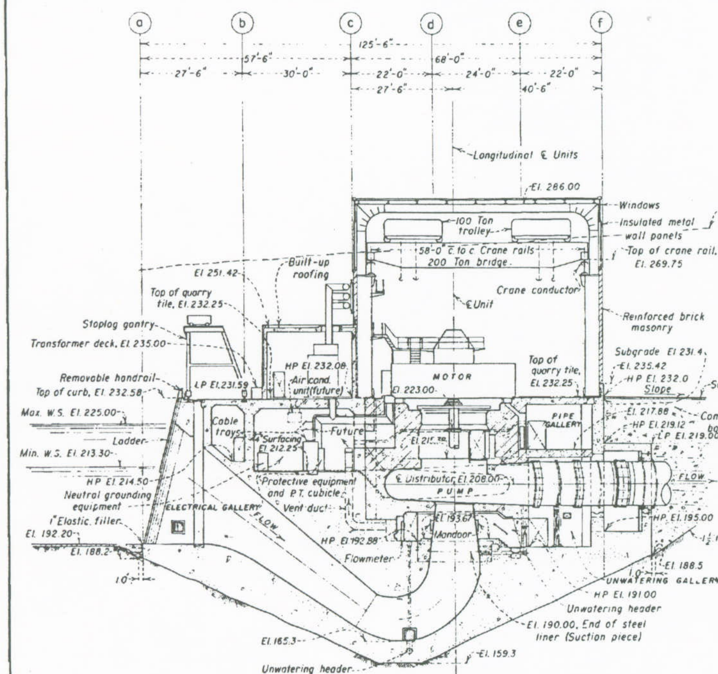

3
SERVICE YARD DRAINAGE DITCH
Slope = 0.005 (Min.)
(NO SCALE)
SECTION A-A
(NO SCALE)
SECTION B-B
(NO SCALE)
BERM AND UPPER DRAINAGE DITCH
(NO SCALE)
SECTION C-C
(NO SCALE)
SECTION D-D
(NO SCALE)
NOTES
Grade bottom of ditch uniformly between elevations shown.
Indicates material and work to be provided under Completion Specification.
DISCHARGE PIPE EXP. JT. VAULT HATCH
(NO SCALE)
SECTION E-E
(NO SCALE)
SECTION F-F
(ACCESS ROADS-TYPICAL)
PLAN
SCALE OF FEET
PUMPING PLANT
SERVICE YARD
PARKING AREA
Spare transformer
Switchgear room
Visitors facilities
Transformers
Removable handrail
SWITCHYARD (1442)
WATER TANK SITE (3033)
Existing ditch
For profile and sec. of Access Road, see Dwg. 805-D-1357
Access Road Sta. 14+50 End of road construction
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA
MILE 18 PUMPING PLANT
GENERAL PLAN
S.H. Thompson
Edwin Rose
E.V. Lindseth
DENVER, COLORADO, APRIL 5, 1963
805-D-712
DC-5982 - LR 2-4-65 - PC-6255
DC-5982 - Ltr 10-24-63


UPSTREAM ELEVATION
(NORTH)
DOWNSTREAM ELEVATION
(SOUTH)
EAST ELEVATION
WEST ELEVATION
ELEVATION A-A
ELEVATION-EAST WALL
SWITCHGEAR ROOM 407
EAST WALL ROOM 408 SIMILAR EXCEPT AS NOTED
ELEVATION-WEST WALL
SWITCHGEAR ROOM 408
WEST WALL ROOM 407 SIMILAR EXCEPT AS NOTED
TRANSFORMER
TRANSFORMER
SPARE TRANSFORMER
SWITCHGEAR ROOM RM. 407
SWITCHGEAR ROOM RM. 408
INTERMEDIATE PROJECTED TYPE STEEL WINDOWS
INSULATED STEEL WALL PANELS
MASONRY
NOTE
*INDICATES MATERIAL AND WORK TO BE PROVIDED UNDER COMPLETION SPECIFICATIONS.
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA
MILE 18 PUMPING PLANT
ARCHITECTURAL
EXTERIOR ELEVATIONS
DENVER, COLORADO, MAY 21, 1963
805-D-1009

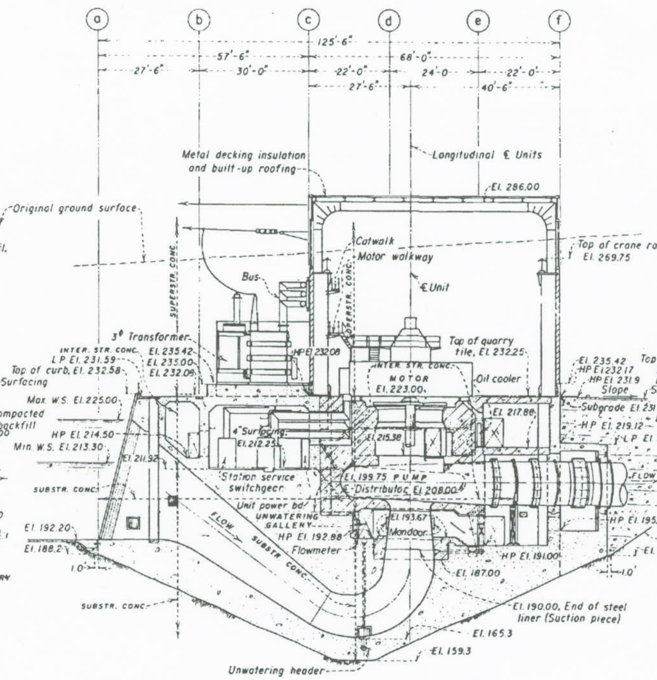


SERVICE BAY
UNIT BAYS
AUXILIARY SERVICE BAY
PLAN - EL. 232.25
SCALE OF FEET
SECTION A-A (NO SCALE)
PART PLAN - EL. 245.37
PART PLAN - EL. 255.37
MOTOR G1
MOTOR G2
MOTOR G3
MOTOR G4
MOTOR G5
MOTOR G6
MOTOR FLOOR RM. 401
SWITCHGEAR ROOM RM. 407
SWITCHGEAR ROOM RM. 408
VISITORS FACILITIES
VISITORS GALLERY RM. 602
EXHIBIT AREA
STOPLOG STORAGE
Storm drainage inlet
Trashrack
Benchmark
Rotor erection area
Wire mesh enclosure
Controller
Safety ladder (40-D-4848)
EXPLANATION
Concrete - first stage
Concrete - second stage
Masonry
Concrete in blockouts
REFERENCE DRAWINGS
GENERAL ARRANGEMENT .... 805-D-704 THRU 709
LOCATION PLAN 805-D-711
GENERAL PLAN 805-D-712
REINF. BRICK MASONRY WALL DETAILS .... 805-D-713 AND 714
EXPANSION JOINT DETAILS 805-D-715
STRUCTURAL DESIGN DATA .... 805-D-998 AND 999
BUILDING DETAILS 805-D-1002
ARCHITECTURAL-EXTERIOR ELEVATIONS 805-D-1009
ARCHITECTURAL-SCHEDULES 805-D-1010
STRUCTURAL ARRANGEMENT .... 805-D-1003 THRU 1007
ORDER OF UNIT INSTALLATION
PUMPS--EMBEDDED PARTS
PUMPS--NON-EMBEDDED PARTS AND MOTORS
Simultaneous embedded parts
Do.
Do.
*Adjustable blade units
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT--CALIFORNIA
* MILE 18 PUMPING PLANT
GENERAL ARRANGEMENT
PLAN-EL. 232.25 & PART PLANS-EL. 245.37 & EL. 255.37
* DOS AMIGOS PUMPING PLANT
(PRIOR DESIGNATION MILE 18 PUMPING PLANT)
DENVER, COLORADO. OCT. 17, 1962
805-D-704

20

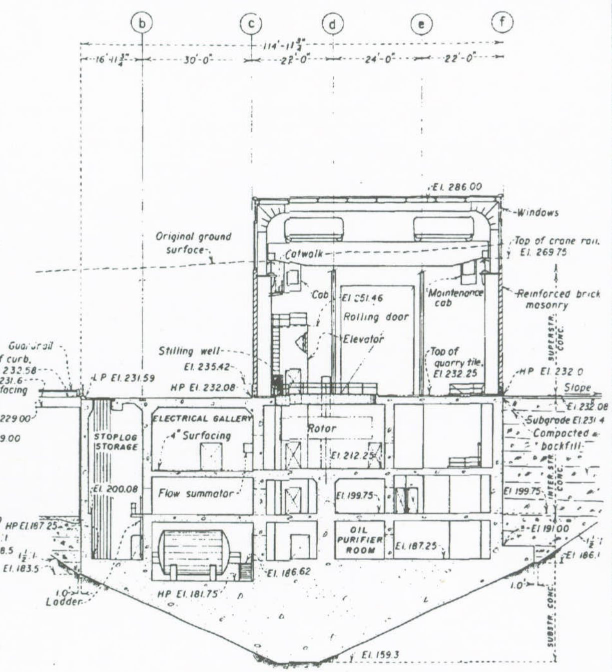


TRANSVERSE SECTION THRU ℄ UNITS 2, 4, & 6



TRANSVERSE SECTION THRU ℄ UNITS 1, 3, & 5

SCALE OF FEET



TRANSVERSE SECTION THRU SERVICE BAY

NOTE

For symbols, see Dwg 805-D-704

PUMP DATA

Rated Q = 2,200 cfs each unit @ total head 125 feet, 120 rpm.
Plant Q = 13,100 cfs (maximum)
Range of total heads = 107 to 125 feet.
Best efficiency head = 117 feet.
Units No. 1, 3, and 5 ---- Variable pitch impeller, mixed-flow type pumps. (Adjustable vanes positioned by vane control unit.)
Units No. 2, 4, and 6 ---- Centrifugal type pumps. (Fixed flow)

1-3-67	D. U.A.T.	LOCATED FLOWMETER AND SUMMATOR EQUIPMENT, AND SHOWED DOORS BEYOND ROTOR IN SERVICE BAY.
5-13-66	D. G.A.E.	REVISED BUS, PROTECTIVE EQUIPMENT, P.T. CUBICLE, AND MOTOR VOLTAGE SWITCHGEAR OUTLINES.
1-18-66	D. H.O.B.	REVISED MOTOR OUTLINE. REVISED BUS OPENING TO MOTOR. ADDED RECESS FOR WATER-OIL COOLER PIPING.
4-12-65	D. H.O.B.	REVISED TRANSFORMER OUTLINE. REVISED LOCATION OF BUS OPENING THROUGH SWITCHGEAR ROOM ROOF.
2-19-65	D. H.O.B.	GENERAL REV. FOR COMPLETION SPEC.

*** DOS AMIGOS PUMPING PLANT**
(PRIOR DESIGNATION MILE 18 PUMPING PLANT)

10-13-64	D. H.O.B.	ADDED FUTURE AIR CONDITIONING UNIT. REVISED CABLE TRAYS. OTHER MINOR REVISIONS.
6-15-64	D. H.O.B.	REV. STAIRWELL IN SERV. BAY. FILLETS UNDER TRANSF. DECK, DOORWAYS IN PIPE GALLERY, SUCTION TUBE LINERS AND VENT DUCT UNITS 2, 4 & 6. ADDED VENT. DUCT UNITS 1, 3 & 5.
3-6-64	D. H.O.B.	ADDED FLOW TRANSDUCER INTAKE. REV. VENT. DUCT IN ELECTRICAL GALLERY.
1-24-64	D. H.O.B.	REVISED PUMPS, PUMP PIT, SUCTION TUBE ACCESS, STOPLOG STORAGE, OIL STORAGE TANK, C AND F LINE WALLS. ADDED CABLE TRAYS, WATER INTAKES AND VENT-DUCT. OTHER MINOR REVISIONS.
8-27-63	D. H.O.B.	TRACED. GENERAL REVISIONS.
1-21-63	D. H.O.B.	GENERAL REVISIONS.

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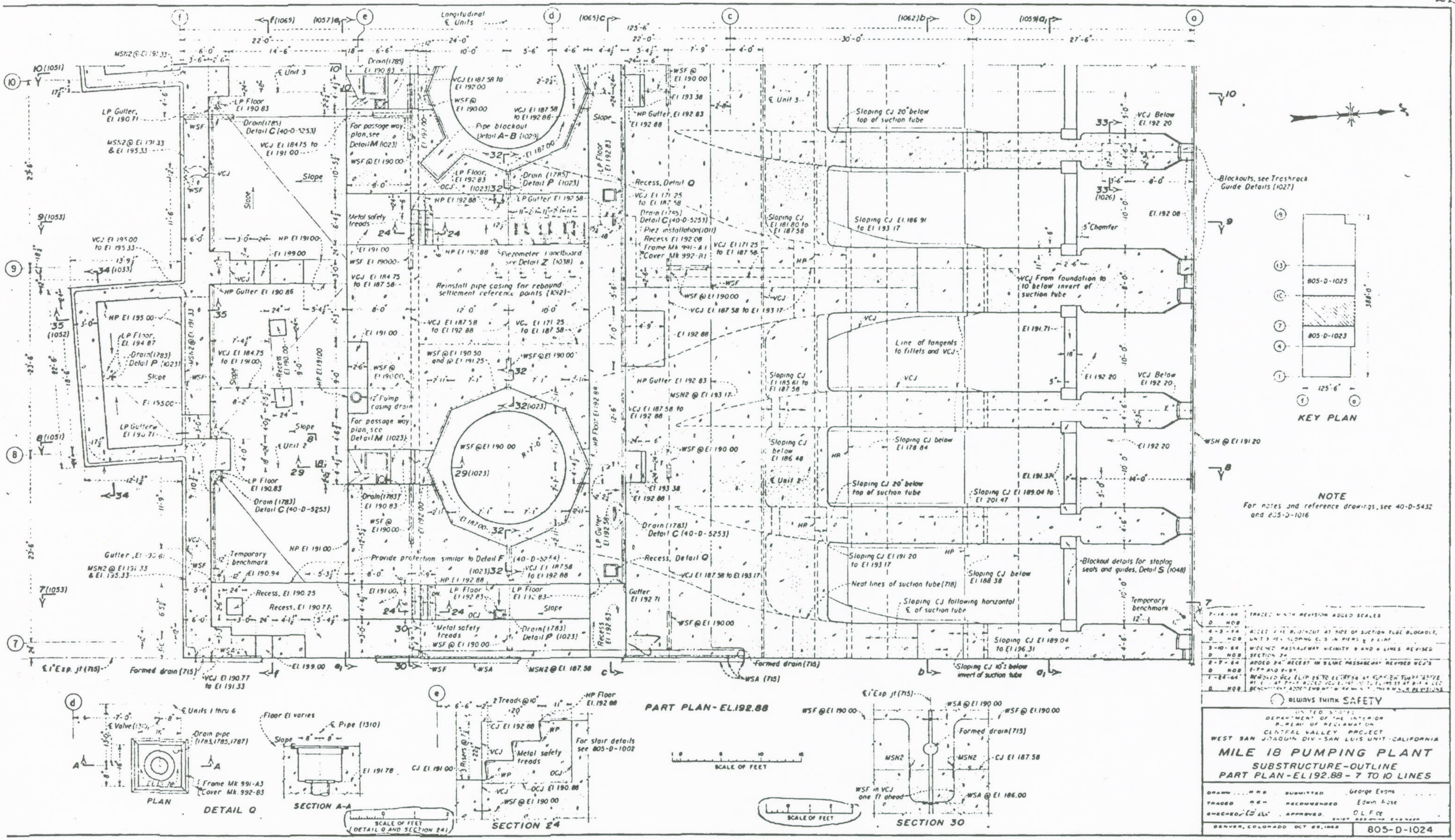
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA

*** MILE 18 PUMPING PLANT**
GENERAL ARRANGEMENT
TRANSVERSE SECTIONS

DRAWN J.W.H. SUBMITTED Edwin Rose
TRACED R.E.S. RECOMMENDED O. L. Rice
CHECKED H. L. APPROVED Grant Bloodgood
ASST. COMM. AND CHIEF ENGINEER
DENVER, COLORADO, OCT. 17, 1962 805-D-708


MILE 18 PUMPING PLANT
SUBSTRUCTURE-OUTLINE
PART PLAN-EL.192.88 - 7 TO 10 LINES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA
ALWAYS THINK SAFETY
DENVER, COLORADO
805-D-1024
PART PLAN-EL.192.88
KEY PLAN
NOTE
For notes and reference drawings, see 40-D-5432 and 805-D-1016
DETAIL Q
SECTION A-A
SECTION 24
SECTION 30
PLAN
SCALE OF FEET
Blockouts, see Trashrack Guide Details (1027)
Blockout details for stoplog seals and guides, Detail S (1048)
Temporary benchmark
Reinstall pipe casing for rebound settlement reference points (1012)
Provide protection similar to Detail F (40-D-5254)
For passage way plan, see Detail M (1023)
For stair details see 805-D-1002
Line of tangents to fillets and VCJ
Neat lines of suction tube (718)
Sloping CJ following horizontal ℄ of suction tube
Formed drain (715)

5. Operation Schedules

TABLE 2. OPERATION SCHEDULE – DOS AMIGOS PUMPING PLANT
FEBRUARY 21 AND 22, 2007

TIME INTERVAL	UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5	UNIT 6
FEBRUARY 21, 2007						
0000 to 0800	ON	OFF	ON	ON	ON	OFF
0801 to 1323	OFF (2)	OFF	OFF	OFF	ON	OFF
1323 to 2400	ON	OFF	ON	ON	OFF (2)	OFF
FEBRUARY 22, 2007						
0000 to 0800	ON	OFF	ON	ON	ON	OFF
0801 to 1400	OFF	OFF	OFF	OFF	ON	OFF

NOTES:

1) The underwater inspection by Remotely Operated Vehicle (ROV) was conducted between 0800 and 1400 on both 2/21 and 2/22.
2) During the inspection on 2/21, the ROV became pinned to the Unit 5 trashracks (Unit 5 was the only unit operating at the time). In order to free the ROV, pumping plant deliveries were transferred from Unit 5 to Unit 1. Unit 1 was turned ON (started up) at 1323 and Unit 5 was turned OFF (shut down) at 1326.

TABLE 3. OPERATION SCHEDULE – DOS AMIGOS PUMPING PLANT
FEBRUARY 7, 2007

TIME INTERVAL	UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5	UNIT 6
FEBRUARY 7, 2007						
0000 to 0650	OFF	OFF	OFF	OFF	ON (1)	ON
0650 to 1130	OFF	OFF	OFF	OFF	ON (1)	OFF
1130 to 1150	OFF	OFF	OFF	OFF	ON (2)	OFF
1150 to 1900	OFF	OFF	OFF	OFF	OFF	OFF
1900 to 2200	OFF	ON	ON	OFF	OFF	OFF

NOTES:

1) Operating at Full Capacity
2) Operating at Half Capacity
3) Divers entered the water at 1010.
4) Recovery operations were conducted between approximately 1200 and 1300.

6. Participants

TABLE 4. U.S. BUREAU OF RECLAMATION PARTICIPANTS
ROV INSPECTION AND FLOW VELOCITY SURVEY
DOS AMIGOS PUMPING PLANT -- FEBRUARY 21, 22, 2007

NAME	TITLE	OFFICE	PHONE
Gregory Finnegan	Chief, Marine and Diving Operations	Lower Colorado Regional Office, Boulder City, NV	(702) 528-3256
Caireen Ulepic	ROV Operator	Lower Colorado Regional Office, Boulder City, NV	(702) 293-8476
Rodney Tang	Civil Engineer / ROV Operator	Phoenix Area Office, Phoenix, AZ	(623) 773-6458
Tracy Vermeyen	Civil Engineer	Technical Service Center (TSC), Denver, CO	(303) 445-2154
Liz Partridge	Civil Engineer	Tracy Field Office, Tracy, CA	(209) 836-6278
Joel Sturm	Regional Geologist	Mid Pacific Regional Office, Sacramento, CA	(916) 978-5305

NOTES:

1) G. Finnegan, C. Ulepic and R. Tang are active members of the Lower Colorado Region (LCR) Dive Team.
2) J. Sturm is a former member of the LCR Dive Team with over 20 years of underwater inspection experience.
3) T. Vermeyen works in the TSC Water Resources Research Lab where he specializes in flow velocity measurement and analysis.
4) Liz Partridge is a Lead O&M Engineer in the Tracy Field Office.

TABLE 5. DWR PARTICIPANTS
ROV INSPECTION AND FLOW VELOCITY SURVEY
DOS AMIGOS PUMPING PLANT -- FEBRUARY 21, 22, 2007

Name	Classification	Branch	Assigned to
Mandeep Bling	Supervising Hydroelectric Power Engineer	Engineering	San Luis Field Division
Rob Dunlop	Senior Hydroelectric Power Engineer	Engineering	San Luis Field Division
Ron Rushing Sr.	Water Resources Engineering Associate II	Water Operations	Dos Amigos Pumping Plant
Scott Crist	Water Resources Engineering Associate II	Water Operations	Dos Amigos Pumping Plant
Dennis Migguel	Utility Crafts Worker	Civil Maintenance	San Luis Field Division
Ken Andrade	Utility Crafts Worker	Civil Maintenance	San Luis Field Division
Ron Souza	Utility Crafts Supervisor	Civil Maintenance	San Luis Field Division
Kevin Nelson	Utility Crafts Worker	Civil Maintenance	San Luis Field Division
Robert Adams	Utility Crafts Worker	Civil Maintenance	San Luis Field Division
Ron Pereira	HEP Mechanical Supervisor	Plant Maintenance	Gianelli Pumping/Generating Plant
Larry Carmo	HEP Electrical Supervisor	Plant Maintenance	Dos Amigos Pumping Plant
Bob Wirth	HEP Mechanical Supervisor	Plant Maintenance	Gianelli Pumping/Generating Plant
Brent Ingram	HEP Mechanic	Plant Maintenance	Gianelli Pumping/Generating Plant
Ron Rushing Jr.	HEP Mechanic	Plant Maintenance	Gianelli Pumping/Generating Plant
Adam Souza	HEP Mechanic	Plant Maintenance	Gianelli Pumping/Generating Plant
Barry Conlin	HEP Foreman	Plant Maintenance	Gianelli Pumping/Generating Plant
Rick Alamo	HEP Mechanic	Plant Maintenance	Gianelli Pumping/Generating Plant
John Morris	HEP Foreman	Plant Maintenance	Dos Amigos Pumping Plant
Ralph Zavala	HEP Mechanic	Plant Maintenance	Dos Amigos Pumping Plant
Rick Barton	HEP Mechanic	Plant Maintenance	Gianelli Pumping/Generating Plant
Skip Muir	HEP Mechanic	Plant Maintenance	Dos Amigos Pumping Plant
Israel Luna	HEP Mechanic	Plant Maintenance	Dos Amigos Pumping Plant
Sean Marsh	HEP Mechanic	Plant Maintenance	Dos Amigos Pumping Plant
Mike Cardoza	HEP Senior Operator	Plant Operations	Dos Amigos Pumping Plant
Anthony Ramirez	HEP Senior Operator	Plant Operations	Dos Amigos Pumping Plant
Dave Roberts	HEP Operator	Plant Operations	Dos Amigos Pumping Plant
David Gutierrez	Division Chief	Engineering	Division of Safety of Dams

7. Water Surface Elevations

Information Storage & Retrieval System

DWR

Feb 26 09:34:46

Active Users: 1

Hourly Values Inquiry Results

Abbrevations/ID					Average/Value of Hour Ending				Maximum/Minimum During the Hour				
Div	Sys	Station	Measure Description	Units	Average	Day/Hour	Value	Quality	Max RTUTime	Max Value	Quality	Min RTUTime	Min Value
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 16:00	220.338		02/22/2007 15:12	220.47		02/22/2007 15:29	220.27
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 15:00	220.223		02/22/2007 14:45	220.35		02/22/2007 14:14	220.1
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 14:00	219.982		02/22/2007 13:58	220.17		02/22/2007 13:12	219.79
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 13:00	219.7		02/22/2007 11:59	219.91		02/22/2007 12:20	219.49
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 12:00	219.586		02/22/2007 11:59	219.87		02/22/2007 11:27	219.51
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 11:00	219.563		02/22/2007 10:53	219.69		02/22/2007 10:09	219.46
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 10:00	219.381		02/22/2007 09:38	219.52		02/22/2007 09:03	219.24
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 09:00	219.336		02/22/2007 08:01	219.54		02/22/2007 08:57	219.24
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 08:00	219.539		02/22/2007 07:01	219.7		02/22/2007 07:58	219.42
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 07:00	219.719		02/22/2007 06:00	220.03		02/22/2007 06:43	219.48
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 06:00	219.882		02/22/2007 05:58	220.06		02/22/2007 05:49	219.78
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 05:00	220.014		02/22/2007 03:59	220.11		02/22/2007 04:59	219.94
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 04:00	220.158		02/22/2007 03:03	220.27		02/22/2007 03:59	220.1
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 03:00	220.308		02/22/2007 02:06	220.43		02/22/2007 02:56	220.21
SL	GI	GIPL	FOREBAY	FEET	Y	02/22/2007	220.48		02/22/2007	220.6		02/22/2007	220.33

			WTR LVL			02:00		01:14		01:59	
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 01:00	220.618	02/22/2007 00:23	220.81	02/22/2007 00:07	220.36
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/22/2007 00:00	220.693	02/21/2007 23:07	220.82	02/21/2007 23:17	220.63
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 23:00	220.676	02/21/2007 22:19	220.93	02/21/2007 22:02	220.33
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 22:00	220.637	02/21/2007 21:50	220.74	02/21/2007 21:58	220.36
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 21:00	220.604	02/21/2007 20:36	220.68	02/21/2007 20:26	220.56
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 20:00	220.552	02/21/2007 19:49	220.62	02/21/2007 19:01	220.49
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 19:00	220.445	02/21/2007 18:59	220.52	02/21/2007 18:40	220.36
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 18:00	220.372	02/21/2007 17:01	220.51	02/21/2007 17:08	220.27
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 17:00	220.342	02/21/2007 16:01	220.56	02/21/2007 16:19	220.2
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 16:00	220.415	02/21/2007 15:09	220.55	02/21/2007 15:58	220.33
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 15:00	220.448	02/21/2007 14:51	220.52	02/21/2007 14:57	220.36
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 14:00	220.309	02/21/2007 13:59	220.45	02/21/2007 13:08	220.19
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 13:00	220.167	02/21/2007 12:55	220.28	02/21/2007 12:19	220.06
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 12:00	220.137	02/21/2007 11:31	220.23	02/21/2007 11:47	220.08
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 11:00	220.11	02/21/2007 10:50	220.2	02/21/2007 10:19	219.97
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 10:00	219.935	02/21/2007 09:36	220.12	02/21/2007 09:05	219.76
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 09:00	219.905	02/21/2007 08:20	220.02	02/21/2007 08:55	219.82
SL	GI	GIPL	FOREBAY WTR LVL	FEET	Y	02/21/2007 08:00	220.068	02/21/2007 07:02	220.35	02/21/2007 07:44	219.93
SL	GI	GIPL	FOREBAY	FEET	Y	02/21/2007	220.197	02/21/2007	220.34	02/21/2007	220.1

8. Velocity Survey

Dos Amigos Pumping Plant – Trash Rack Velocity Survey

Purpose

To determine the near-field velocity fields along the pumping plant trash racks for hydraulic conditions similar to those when the diving accident occurred.

Objectives

To characterize the velocities experienced by the divers as they traveled from Unit 1 toward Unit 5. The following velocity data were considered important for the accident investigation:

- Water currents parallel and perpendicular to the trash racks for Unit's 1 through 4 measured a short distance upstream from the trash rack face.
- Water current profiles approaching the Unit 5 trash racks at several distances upstream from the face of the trash racks.
- Measure currents on the Unit 5 trash racks while operating to identify areas of high velocities caused by debris obstruction.
- Make observations of the flow fields approaching Unit 5 that may have contributed to the accident.

Site Description

The Dos Amigos Pumping Plant has 6 pump units, three of which have variable pitch impellers (units 1, 3, and 5). The pumping plant lifts water coming from the north 118 ft (36 m), to flow by gravity to the next pumping station located 164 miles (264 km) to the south. Each pump intake is served by three trash rack bays. Each trash rack bay is about 10 ft wide by 40 ft high. The trash racks are inclined about 14° from vertical. The trash racks extend from the forebay floor (El. 192.2 ft) to just below the transformer deck (El. 231.6). The units are numbered 1 to 6 from left to right when facing downstream. Each intake is protected by 3 trash rack panels which were identified by A, B, and C from left to right when facing downstream (figure 1).

Dos Amigos Pumping Plant Operations - February 21-22, 2007

During the velocity survey, the forebay water surface elevation was about 217.2 ft. All velocity data were collected when Unit 5 was operated alone and was pumping about 2600 ft^3/sec. Pumping rate was measured using the plant's Accusonic acoustic flowmeters. The velocity survey plan was to collected data for hydraulic conditions similar to those on February 7, 2007 - the date the accident occurred. For both days of data collection, pumping plant operations were set to the accident conditions at 8:00 a.m. and were held constant until 2:00 p.m.

For a pumping rate of 2600 ft^3/sec and the forebay water level (El. 217.2), the estimated gross approach velocity just upstream from a debris-free trash rack would be about 2.2 ft/sec.

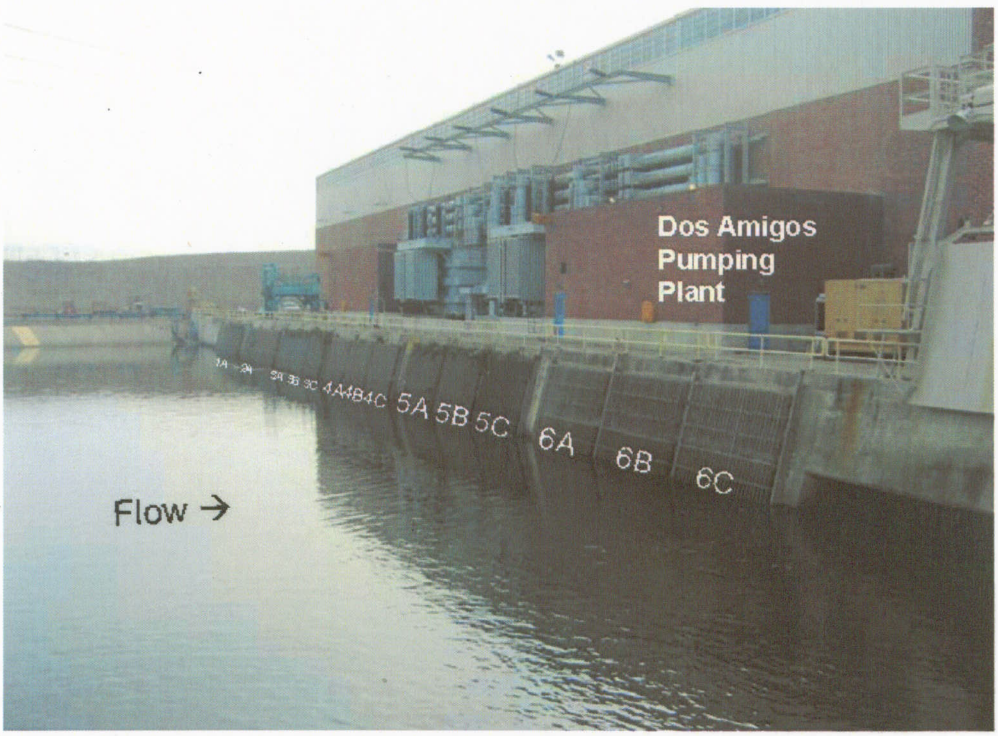


Figure 1. Photograph of the Dos Amigos Pumping Plant Forebay with the six trash rack bays with the identification scheme used in this report.

The pumping plant has an debris problem generated by aquatic weeds being transported from the O'Neill forebay reservoir. The aquatic debris accumulates on the Dos Amigos trash racks and causes significant head differential across the trash racks of operating units. On February 21, 2007 at 1:00 p.m. the head differential across the Unit 5 trash racks was 4.5 ft. The trash rake cleaning system was down for maintenance during our site visit. The project had been using a construction backhoe to remove floating debris from the pumping plant forebay. Aquatic debris was observed to accumulate on the operating pumps. When pumping was transferred from one unit to another, the back flow from the unit shutting down would wash debris 30 to 50 ft into the forebay. This debris would then migrate toward the operating unit(s). The back flow appeared to effectively remove all surface debris that had accumulated. It usually took about one hour for most of the available aquatic debris to accumulate on the Unit 5 trash racks (figure 2).

All velocity measurements were collected while working from the transformer deck. This limited the ability to measure approach velocities upstream of the trash racks. A truck-mounted crane was with a boom length of 30 ft was used.

Figure 2. View of aquatic debris and trash accumulated on the Unit 5 trash rack. This photograph was taken on February 22, 2007, at 10:00 a.m.

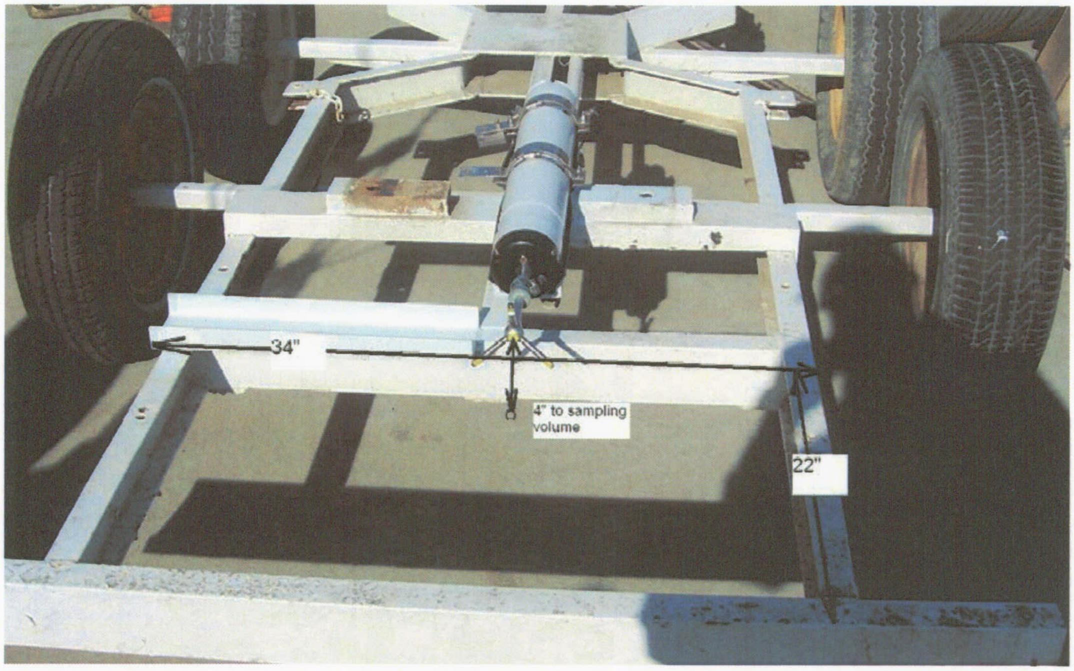


Figure 3. Photograph of Argonaut-ADV mounted within a 34" by 22" clear area in a dual-axle trailer. For this mount, the ADV sampling volume was offset about 22 inches above the roadway. The sampling volume is located about 4 inches below the acoustic transducer and about 11 inches from the end of the trailer.

Instrumentation and Methods

Two instruments were used to collect the velocity data necessary to describe the flow fields which existed during the accident. A Sontek/YSI® Argonaut-ADV (acoustic Doppler velocimeter) was used to measure three-dimensional point velocities around the trash racks. A Nortek Q-Liner was used to measure velocity profiles parallel to trash racks and profiles upstream from the Unit 5 trash racks.

Sontek/YSI® Argonaut-ADV

The SonTek/YSI® Argonaut-ADV is a single-point, high-resolution, 3-dimensional Doppler velocimeter. The Doppler processing techniques used by the ADV provide several advantages: accurate, fast, 3D velocity measurements in a remote sampling volume; no periodic calibration required; simple operation, and excellent low flow performance. The Argonaut-ADV is a *bistatic* sensor. Bistatic means that the Argonaut-ADV uses separate acoustic transducers for transmit and receive functions. Both the transmitter and receivers are constructed to generate very narrow beam patterns – the transmitter generates sound with the majority of the energy concentrated in a narrow cone, while the receiver is most sensitive to sound coming from a very narrow angular range. The transducers are mounted such that their beams intersect at a volume of water located about 4 inches below the sensor. This beam intersection determines the location of the sampling volume (the volume of water in which measurements are made). A single transmit/receive pair measures the projection of the water velocity onto its bistatic axis. The Argonaut-ADV uses one transmitter and three acoustic receivers to measure 3-dimensional velocities. The receivers are aligned to intersect with the transmit beam pattern at a common sampling volume. The Argonaut-ADV combines velocity measurements from each receiver, knowing the relative orientation of the three bistatic axes, to compute the 3-D water velocity vectors in the sampling volume. The sampling volume contains approximately 0.02 in^3 of water.

An Argonaut-ADV was used to collect three dimensional point velocities (x,y,z) a short distance upstream from the trash racks on the Dos Amigos Pumping Plant. This ADV is equipped with a pressure sensor along with a compass and tilt sensors that are used to determine the ADV's depth and orientation, respectively. Throughout velocity profiling, an integral temperature sensor was used to measure water temperature which is required to perform real-time speed-of-sound corrections. Data were collected and monitored using a laptop computer. Specifications for the Argonaut-ADV used for this project are summarized in table 1.

Table 1. Sontek/YSI® Argonaut-ADV specifications
Velocity
• Range: ±0.003 to 15 ft/sec
• Resolution: 0.0003 ft/sec
• Accuracy ±1% of measured velocity, ±0.003 ft/sec
• User programmable data output rate
• 3-D water velocity measurement
Temperature Sensor
• Resolution 0.01°C
• Accuracy ±0.1°C
Pressure Sensor
• Strain Gage (0.1 % accuracy)

The ADV was mounted to a dual-axle trailer provided by DWR. The ADV was mounted in a 22-in-high by 34-in-wide clear area on the trailer where the pumping plant inflows where minimally obstructed by the trailer frame (figure 3). The ADV was clamped to the trailer so the probe was offset a distance of 22 inches upstream from the trash rack. Unless specified differently, ADV measurements were collected down the centerline of the middle trash rack panel. The trailer was positioned on individual trash rack panels using a truck-mounted crane. The crane was provided and operated by DWR.

Argonaut-ADV Velocity Coordinate System

The ADV normally reports velocity data in a Cartesian (x,y,z) coordinate system relative to probe orientation. The definition of this coordinate system varies depending on the probe configuration. If a compass/tilt sensor is installed, velocity can be reported in Earth coordinates (east, north, and up). However, for this project a x,y,z coordinate system was more practical. For the 3-D down-looking configuration used for this project, the positive z-axis is defined upwards along the mounting stem (i.e. from the sensor towards the signal conditioning module) which is parallel to the trash rack face. The positive x-direction is defined from the acoustic transmitter to acoustic receiver no. 1 which was directed perpendicular to the trash rack face. For this probe orientation, velocities in the x-direction (or approach velocity) will be negative. The y-direction is parallel to the trash rack face and is positive for flow moving from Unit 1 towards Unit 6 (or left to right when facing downstream). For clarity, the coordinate system was sketched onto the photograph in figure 4.

Figure 4. Photograph of the truck-mounted crane, trailer, Argonaut-ADV, and the x,y,z coordinate system. The trailer is located near the center of rack 1B.

Nortek Q-Liner

A Nortek Q-Liner, an acoustic Doppler profiler, was used to collect current profiles parallel to the trash racks and approaching velocity profiles upstream from the Unit 5 trash racks. This instrument uses a multi-beam acoustic transducer to measure velocity in a two-dimensional plane and the channel depth (see inset photo, figure 5). The profiler is mounted to a light weight fiberglass float that was positioned along the trash racks using taglines. The Q-Liner uses wireless technology to transfer data between the profiler and a handheld computer. The PocketPC

Table 2. Nortek® Q-Liner (2.0 MHz) specifications

Velocity
- Range: ±32 ft/sec
- Accuracy: ±1% of measured velocity, ±0.16 ft/sec
- User programmable data output rate
- 2-D water velocity measurement
- Max sampling rate: 1Hz

Depth
- Range: 0.7 to 32 ft
- Cell size: 0.33 to 6.5 ft
- Maximum No. of depth cells: 50

Temperature Sensor
- Resolution 0.01°C
- Accuracy ±0.1°C

computer is used by the operator to control the measurements and to monitor system performance. To measure currents moving parallel to the trash racks, also known as sweeping velocity, the Q-Liner transducer was rotated about 14 degrees from vertical so the acoustic plane was parallel to the inclined trash racks. Q-Liner profiles where collected about 0.8 ft from the trash rack face. In this position, the Q-liner can measure sweeping velocities and velocities upward (or downward) along the trash rack. However, in this orientation, the Q-liner cannot measure currents moving perpendicular to the trash racks. Prior to measuring approach velocity profiles, the transducer was rotated back to its vertical position. For velocity profiles collected upstream from the Unit 5 trash rack, a crane and taglines were used to position the Q-Liner (figure 5). Approach velocity profiles were measured at several locations upstream from the Unit 5 trash racks. For this application, the bottom 5 ft of the profile was not measurable because of side lobe interference. Qmetrix describes side lobe interference in their user's manual as follows:

Profilers looking up or down typically lose data near the surface or bottom. This loss is caused by contamination of the near-surface data by side lobe echoes. The acoustic beams focus most of the energy in the centre of the beams, but a small amount leaks out in other directions. Because sound reflects much better from the water surface or the bottom than it does from the water, the small signals that travel straight to the surface can produce sufficient echo to contaminate the signal from the water. In general we use only data from cells up to 80-85 % of the total distance between the sensor and the possible reflector. In the case of the Q-Liner this means we only use data from cells up to 80% of the water depth.

Figure 5. Photograph of the Q-Liner and crane setup used to measure approach velocities toward Unit 5 trash racks. The Q-Liner was oriented perpendicular to the trash rack using tag-lines (not shown).

Results

The results of the velocity measurements collected near the Dos Amigos Pumping Plant trash racks are presented in separate sections for near-field approach and sweeping velocities measured with the ADV and approach velocity profiles collected upstream of the trash racks using the Q-Liner. Approach velocity is defined as water current moving towards and perpendicular to the trash rack, and sweeping velocity is defined as water current moving parallel to the trash rack. Sweeping velocities can be directed along the trash racks or up (or down) the racks. For this study, the sweeping velocity along the racks was of primary interest.

Velocity data were collected in close proximity to the trash racks to identify diver exposure to currents during their trash rack inspection. The data presented were collected when Unit 5 was operated alone and was pumping about 2600 ft^3/sec. The plan was to collected data for conditions similar to when the accident occurred. Plant operations were set to the accident conditions at 8:00 a.m. and were held constant until 2:00 p.m. It usually took about an hour for most of the available aquatic debris to accumulate on the Unit 5 trash racks.

Near-field Velocities

Near-field velocities were measured using two instruments: 1) Argonaut-ADV and 2) Q-Liner. The Q-Liner's profiling range, when positioned parallel to the trash rack, was limited to about 6 ft below the water surface because of debris accumulated on the trash racks. In general, Q-Liner data were in agreement with Argonaut-ADV data collected near the water surface. However, because of the limited Q-Liner range and that the highest velocities were measured below a depth of 7 ft, only Argonaut-ADV velocity data will be presented herein.

Table 3 contains the Argonaut-ADV data collected on February 21, 2007 at various trash rack panels from Unit 1 to Unit 5. Table 3 contains 3-dimensional velocities (Vx, Vy, Vz), the resultant magnitude of the Vx and Vy components (Vxy-mag) and the standard error of the three velocity components. Vxy-mag represents a resultant current which would impinge an object on the trash rack. Standard errors are the statistical uncertainty associated with each mean velocity component. For example, the standard error for Vx (-0.01 ft/sec) collected at 12:00 on February 21, 2007 is ±0.06 ft/sec. This means that this Vx is statistically insignificant because the uncertainty is greater than the measured Vx. However, measurements made closer to Unit 5 are much larger than the standard error, so they are statistically significant. Standard errors generally are a combination of acoustic noise, mechanical vibration, and natural velocity fluctuations commonly known as turbulence. For this project, it is reasonable to expect standard errors to increase with proximity to an operating pump unit.

A summary of the Argonaut-ADV velocities measured on the Dos Amigos trash racks on

February 21, 2007 are as follows:

- Velocities measured in the center of trash rack 1B showed low velocities with the Vy component moving away from Unit 5. These currents show a weak eddy flow moving eastward along the Unit 1 trash racks.
- Because of time constraints and the low velocities measured on rack 1B, measurements on trash rack 2B were skipped.
- Velocities measured on the center of trash rack 3B were still low with the maximum sweeping velocity (Vy) directed toward Unit 5 equal to 0.20 ft/sec at a depth of 25.9 ft.
- Velocities measured on the center of trash rack 4B were higher, with Vy (directed toward Unit 5) equal to 0.35 ft/sec at a depth of 8.6 ft. The maximum Vxy-mag was 0.44 ft/sec at a depth of 8.6 ft.
- Velocities measured on the center of trash rack 4C were higher, with the maximum Vy equal to 0.58 ft/sec at a depth of about 8.7 ft. The maximum Vxy-mag was 0.64 ft/sec at a depth of 8.7 ft. Vy at depths of 16 and 22 ft were also in the 0.5 ft/sec range. Vy measured near the bottom (depth = 25.9 ft) was 0.41 ft/sec.

Time	Trash Rack	Depth (ft)	Vx (ft/sec)	Vy (ft/sec)	Vz (ft/sec)	Vxy-mag (ft/sec)	StdErrorX (ft/sec)	StdErrorY (ft/sec)	StdErrorZ (ft/sec)
11:56	1B	0.49	-0.01	-0.16	0.00	0.16	0.02	0.00	0.01
11:58	1B	8.45	-0.02	-0.13	-0.02	0.13	0.02	0.00	0.01
12:00	1B	16.85	-0.01	-0.02	-0.05	0.02	0.06	0.02	0.06
12:01	1B	25.50	0.01	0.00	-0.02	0.01	0.02	0.01	0.01
12:24	3B	0.12	0.13	0.01	-0.01	0.13	0.02	0.01	0.01
12:26	3B	8.67	-0.13	-0.08	0.04	0.15	0.03	0.01	0.02
12:28	3B	16.49	-0.05	-0.03	-0.13	0.06	0.06	0.02	0.04
12:31	3B	25.91	0.20	0.03	-0.03	0.20	0.04	0.02	0.03
12:50	4B	0.78	0.10	0.19	0.05	0.22	0.10	0.02	0.07
12:54	4B	8.56	-0.26	0.35	0.07	0.44	0.05	0.01	0.04
12:58	4B	16.55	-0.17	0.32	-0.24	0.37	0.06	0.02	0.05
13:01	4B	22.00	0.11	0.18	-0.10	0.21	0.11	0.04	0.07
13:04	4B	27.18	0.19	0.10	-0.08	0.21	0.06	0.09	0.04
13:09	4C	0.99	0.04	0.35	0.03	0.35	0.15	0.08	0.07
13:11	4C	8.74	-0.27	0.58	-0.18	0.64	0.07	0.01	0.03
13:14	4C	16.66	-0.11	0.52	-0.32	0.54	0.09	0.04	0.07
13:16	4C	22.18	0.02	0.55	-0.19	0.55	0.18	0.08	0.10
13:19	4C	25.94	0.17	0.41	-0.06	0.44	0.18	0.06	0.10
13:44	1A - 1B	23.98	-0.51	0.08	0.61	0.52	0.16	0.03	0.07
13:48	1A - 1B	17.17	-1.82	0.10	1.34	1.82	0.08	0.01	0.04
13:50	1A - 1B	15.93	-2.33	0.04	1.26	2.33	0.07	0.01	0.03
13:53	1A - 1B	7.59	-2.73	0.03	0.03	2.73	0.05	0.01	0.03

Prior to the increase in pumping rates scheduled for 2:00 p.m., it was decided to measure velocity on a "clean" trash rack. The crane and ADV trailer were moved to the center of trash rack panel 1B. At approximately 1:30 p.m. Unit 5 was shut down and Unit 1 was started. The pumping rate was set to 2600 ft^3/sec. Measurements were started at 1:33 p.m. but the ADV transducer was quickly inundated with aquatic debris. As a result, no useable velocities were collected. The trailer was re-located between trash rack panels 1A and 1B and velocities were collected from the bottom to the surface. The velocity data in Table 3 show that there was a strong approach velocity component (Vx) at depths of 7.6, 15.9, and17.2 ft. The maximum Vx was 2.73 ft/sec and was measured at a depth of 7.6 ft. At this location, the Vz component was also relatively high because for this probe orientation horizontal approach flow is resolved into Vx and Vz components because the trash rack is inclined at a 14 degree angle.

Table 4 contains the Argonaut-ADV data collected on February 22, 2007 near trash rack panels on Unit 5. This second set of Argonaut-ADV data were collected in close proximity to Unit 5 for the same operations as the previous day. Unit 5 had operated through the night and its trash rack had accumulated a significant amount of surface debris. During data collection, the trailer could not be safely lowered below depths greater than 13 ft because sweeping velocities were strong enough to displace the trailer sideways toward the center of trash rack 5A. On a second attempt to measure velocities, the trailer was flipped over by the strong sweeping velocities. The loss of trailer control was considered unacceptable so data collection was stopped at 12:42 p.m.

Table 4. Near-field 3-D velocities measured on the Dos Amigos trash racks. Data were collected on February 22, 2007.

Time	Trash Rack	Depth (ft)	Vx (ft/sec)	Vy (ft/sec)	Vz (ft/sec)	Vxy-mag (ft/sec)	StdErrorX (ft/sec)	StdErrorY (ft/sec)	StdErrorZ (ft/sec)
12:26	4C - 5A	0.90	-0.66	1.17	-0.24	1.34	0.03	0.01	0.02
12:29	4C - 5A	4.29	-1.13	1.34	-0.44	1.75	0.06	0.01	0.05
12:31	4C - 5A	8.83	-1.35	2.45	-0.54	2.80	0.10	0.02	0.07
12:35	4C - 5A	11.26	-1.59	2.79	-0.48	3.21	0.13	0.01	0.08
12:39	5A	11.16	-4.62	1.91	-0.14	5.00	0.14	0.03	0.13
12:42	5A	13.58	-4.01	1.79	0.34	4.39	0.16	0.03	0.16

A summary of the Argonaut-ADV velocities measured on the Dos Amigos trash racks on February 22, 2007 are as follows:

- Velocities measured between trash rack 4C and 5A showed high velocities with the dominant component, Vy, moving toward Unit 5. The sweeping velocities greater than 2.4 ft/sec were measured between depths of 8.8 and 11.3 ft.
- Approach velocities, Vx, were significant and were also higher between depths of 8.8 and 11.3 ft.

- The maximum resultant of the Vx and Vy components, Vxy-mag, was 3.21 ft/sec at a depth of 11.3 ft.
- Velocities along the edge of trash rack 5A were the highest measured velocities with the dominant component, Vx, moving into Unit 5. The highest measured approach velocity, Vx equal to 4.62 ft/sec was located at a depth of 11.2 ft.
- At the edge of rack 5A, Vxy-mag was 5.00 ft/sec at a depth of 11.2 ft. This was the highest approach velocity measured near the Unit 5 trash racks during this survey.

Approach Velocity Profiles

On February 22, 2007, approach velocity profiles were measured using the Q-Liner. The Q-Liner's profiling range, when positioned perpendicular the trash rack, was the top 20 ft of the water column when positioned sufficiently upstream to prevent the aft beam from intersecting the trash rack.

Figures 6 and 7 contain the approach velocity profiles that were measured at positions located 24, 14, 9, and 2 ft upstream from the base of the Unit 5 trash racks. Figure 6 shows two profiles collected along the centerline of rack 5B and between racks 5A and 5B. The two profiles agree very closely. The highest approach velocities occurred between depths of 5 and 10 ft. It was observed by the ROV that there were higher velocities along the vertical edges of the trash rack panels because there was less debris accumulation. This observation was the rationale for moving the Q-Liner from the centerline of rack 5B to the location between panels 5A and 5B. The slightly higher approach velocities for the location between 5A and 5B support this observation.

The Q-Liner was incrementally moved toward the trash racks and multiple profiles were collected. The average approach velocity profiles at these locations are shown in figure 7. These profiles illustrate a trend of higher velocities with increasing proximity to the racks. The depth to the maximum velocity was also less for profiles collected closer to the rack. The maximum velocities (Vmax) for these three locations are summarized as follows:

- At 14 ft upstream, Vmax was 2.75 ft/sec at El. 206.5 ft.
- At 9 ft upstream, Vmax was 3.19 ft/sec at El. 206.5 ft.
- At 2 ft upstream, Vmax was 3.00 ft/sec at El. 209.5 ft.

Note on figure 7 how the velocity profiles are truncated (V=0) below where the aft acoustic beam hits a trash rack or concrete pier.

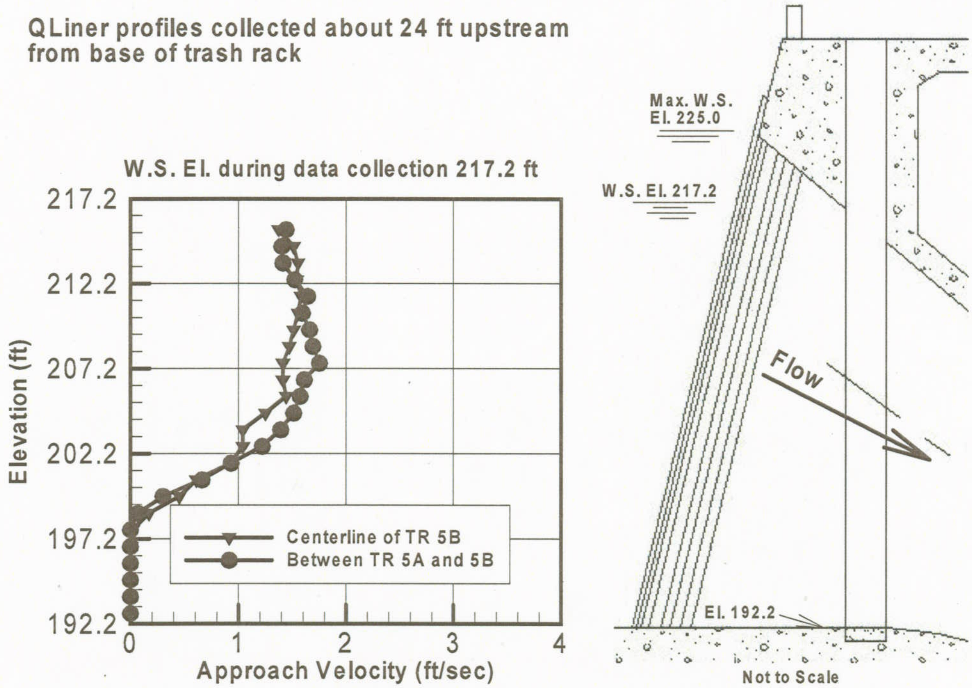


Figure 6. Approach velocity profiles collected by the Q-Liner 24 ft upstream from the base of trash rack 5B and between racks 5A and 5B. **prof24ftUS.wmf**

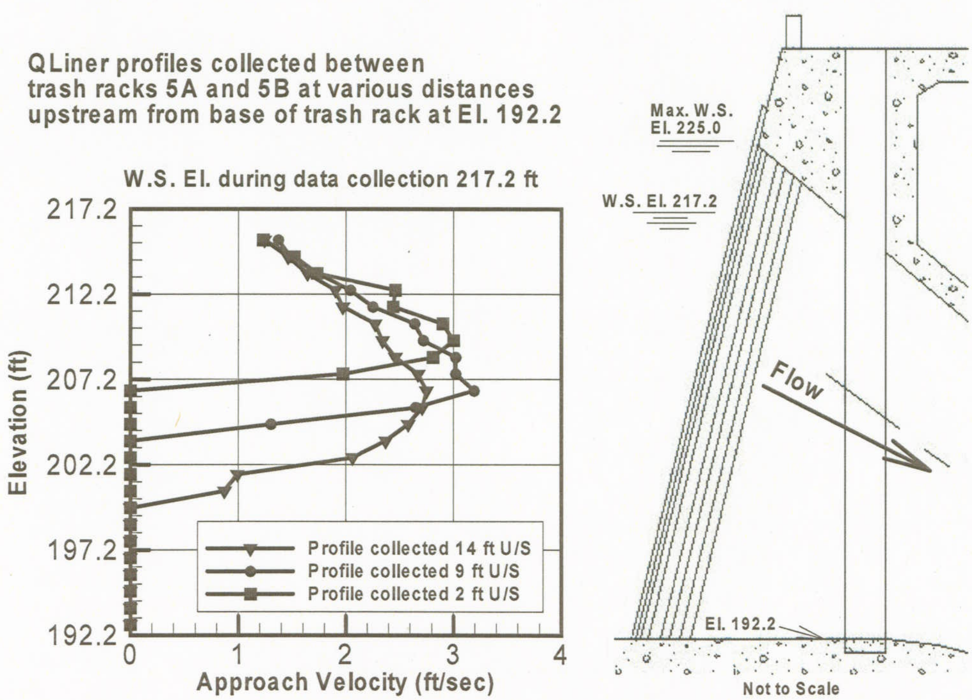


Figure 7. Approach velocity profiles collected by the Q-Liner at three distances upstream from pier between racks 5A and 5B. **ProfBtwn5A&5B.wmf**

Conclusions

Velocity measurements on the Dos Amigos Pumping Plant trash racks showed that approach, sweeping, and upward velocity components were less than 0.65 ft/sec from trash racks 1B to the center of trash rack 4C for pumping operations similar to when the diving accident occurred.

Argonaut-ADV velocity measurements collected 22 inches upstream from the trash racks and in close proximity to trash rack 5A revealed a maximum velocity (Vxy) of 5.00 ft/sec at a depth of 11.2 ft. It is reasonable to expect that velocities at the trash rack face would be higher than was measured by the ADV.

Sweeping velocities between trash racks 4C and 5A were large enough to move and even flip over the instrument trailer when Unit 5 was pumping 2600 ft^3/sec and the trash racks were clogged with debris.

Q-Liner velocity profiles showed that the highest approach velocities occurred between depths of 7 to 11 ft. Profiles collected closest to the trash racks showed a peak velocity at a depth of 7.7 ft (El. 209.5). This non-uniform velocity distribution indicates that the trash racks had more debris blockage near the water surface (El. 217.2) and near the forebay floor (El. 192.2).

There was close agreement between ADV and Q-Liner measurement in regards to the depths where peak velocities occurred, 7 to 11 ft.

During this velocity survey, trash rack debris blockage was indicative of aquatic debris accumulation for one operating pump. However, the quantity of debris available to collect on the trash rack was not known at the time of the accident and was not quantified at the time of the velocity survey. It is reasonable to expect higher velocities through open trash rack area as more and more cross sectional area is blocked by debris.

Peer Review

Technical Service Center policy requires all technical products be peer reviewed prior to be being transmitted to the client. Warren Frizell, mechanical engineer, performed the peer review on this report. Warren has extensive experience with both instruments used for this survey. His comments and suggestions were discussed and implemented into the report. Comments by Joel Sturm, team leader, were also addressed.