EXHIBIT F.

PROTOTYPE TESTING PROGRAM AND INSTRUMENTATION

Exhibit F

PROTOTYPE TESTING PROGRAM AND INSTRUMENTATION

Because of the high head and complicated design of the structure, a model study was conducted at the U.S. Army Engineer Waterways Experiment Station (ERDC-WES) to evaluate the hydraulic design by measuring dynamic hydrostatic pressures in the outlet structure. In this study, zones of potential cavitation and air demand at the mid-tunnel were determined. At the same time, the adequacy of the intake tower, the outlet plunge pool, and the exit channel design was also evaluated, extent of scour and the need for protection downstream of the structure, and the discharge characteristics of the regulation outlet (RO) gates with various operating scenarios were determined from the model.

As a result of this model study, a prototype testing program was developed and is to be implemented during operations to monitor the actual performance of Seven Oaks Dam and verify the design parameters derived form the model study. Hydraulic instrumentation has been installed for testing the entire outlet works. The instrumentation is listed defined in Table F-1 and shown on Plate 2-24 of this Water Control Manual. The instrumentation measures piezometric head, pressure fluctuations, and air demand. Data collected from the testing instrumentations will be used to evaluate the hydraulic performance of the project, analyze potential operation problems, and design repairs and/or project modifications, if necessary. The instrumentation for piezometric head and pressure fluctuations are concentrated at critical areas located in the vicinity of the offsets, of the jet impact, and along the curves in the roof and walls in the transition downstream of the intake tower and in the transition upstream of the gate chamber. The pressure instrumentation will allow early detection upstream of high positive or negative pressure as well as extreme fluctuations in pressure, conditions which could damage the concrete surfaces. The air demand instrumentation will determine the quantity of air supplied to aerate the flow.

During the implementation of the Water Control Plan, an opportunity may arise allowing the collection of data for the prototype-testing program. This testing program involves five types of tests which will be carried out in three phases: 1) The installation

of the operation and prototype test instrumentation, purchased by U.S. Army Engineer Research and Development Center, Waterways Experiment Station (WES) prior to impoundment of water; 2) Testing of the performance of the main tunnel during the first significant flow period; 3) Project design flood testing. Phase 1 has been completed. Testing Phases 2 and 3 can only be performed when there is a significant impoundment behind the dam to accommodate larger releases through the LF and the RO gates.

The OCPF&RD water control managers have the responsibility of contacting the Los Angeles District, Corps of Engineers, Reservoir Regulation Section, so that WES can be notified when dam have the potential of meeting pre-established testing conditions. Such conditions could include key or new maximum water surface elevations, and new maximum releases, etc. Since these conditions will change as new maximum elevations and releases are achieved, continuous coordination between the water control managers and WES is necessary. It is advisable that such coordination be made prior to the start of every flood season in order to establish the test conditions, to update phone numbers, POC's, and other pertinent information. All new information should be included in the notifications list that is updated by the water control mangers prior to the start of every flood season.

A complete documentation of the model study for the prototype testing program is contained in the technical report (HL-92-14) titled, Outlet Works for Seven Oaks Dam, Santa Ana River, San Bernardino County, California, dated October 1992. Table F-1 lists and defines the prototype instrumentation facilities (Types A, B, C, CC, D, E, F, G, and H) at Seven Oaks Dam outlet works. The following discusses the five types of tests to be performed:

1) <u>Test Type 1: Head Loss Determinations</u>. Head losses are determined by measuring piezometric head throughout the project during steady-state flow conditions. These tests are to be performed for both low flow and main tunnel discharges. The primary measurements are with the Type G facilities, however, measurements are also

needed for Type C and F. Test results will provide much needed model-prototype correlation and overall evaluation of project performance.

2) Test Type 2: Entrance Geometry Evaluation. Pressures in the tunnel entrances of both the intake and the mid-tunnel outlet works are measured to evaluate the entrance geometry performance. Any flow separation combined with micro-turbulence at the surface could result in excessive pressure fluctuations and cavitation/erosion problems. This is most critical at the intake tower due to this concrete lined surface, whereas the mid-tunnel section has a steel liner extending from the entrance to the aerator offsets. Measurements are to be obtained from the Type F facilities for the intake tower and Types D and E for the main tunnel and low-flows tunnels, respectively. Results will provide model-prototype correlation and prototype performance evaluation.

3) Test Type 3 and 4: Cavitation Monitoring and Air Demand. Providing aeration along the flow boundaries downstream of the regulating gates is critical to the prevention of cavitation damage. Analysis has shown the cavitation index to be well below incipient just downstream of the gates. Horizontal and vertical offsets have been designed to draw air into the flow to cushion the very low pressures. Air is supplied to the main tunnel aerators through a bifurcated vertical airshaft. Air to the low-flow tunnel is supplied by interconnected shafts tapped into the main shaft just below the bifurcation of the primary airshaft. Airflow measurements are to be obtained at the very top of the airshafts to quantify actual air demand.

Another area of concern is at the tunnel boundary in the vicinity of the jet impact zone. Preliminary analyses indicate that this is to be in the vicinity of Station 22+23 through 22+50 in the main tunnel (see Plate 2-24 of this Water Control Manual). High pressure fluctuations could result, thus affecting the long term stability of the tunnel lining. Pressure along the invert centerline and lower walls are measure so as these conditions can be monitored.

Types 3 and 4 tests are to be performed with the Type A, B, C, and CC measurement facilities. As stated above, the main tunnel is the most critical and these tests would have to be performed during flood events. A prototype evaluation of the performance of the aeration system will be used so as model-prototype comparisons can be made. These comparisons will provide valuable information that can be used to for improving present Corps design guidance of aeration systems.

4) <u>Test Type 5: MDL Head Loss and Orifice Losses</u>. Pressure measurements in the MDL tunnel intake and outlet pipe are necessary as the MDL performance can be evaluated. Head losses and orifice losses are best determined by measuring piezometric head throughout the MDL during steady-state flow conditions. These tests are to be performed for both low flow and high flow discharges. Test results will provide much needed model-prototype correlation and overall evaluation of project performance.

Table F-1. Prototype Instrumentation Facilities, Seven Oaks Dam Outlet Works

Prototype Location No.	Model Location [4]	Instrument Type [2]	Location [4]			Type			Comment
						Flush-Mount Pitot-			
			Code [3]	Station	Elev.	Piez	Gage	Static	
T-1		A	AR1	22+12	2077.5		X		Instrument Type A measures Pressures for the main tunnel Low Flow Tunnel wall and floor offsets.
T-2		A	AR2	22+12	2074.4		X		
T-3		A	AR3	22+05	2075.9		X		
T-4		A	AR4	22+05	2074.1		X		
T-5		B	AVR					X	Instrument Type B measures Air Velocities for the left and right airshafts and the tunnel.
T-6		B	AVL					X	
T-7		B	AVRC					X	
T-8		B	AVLC					X	
T-9		B	AVT					X	
T-10		C	TPF1	22+27	Invert		X		Instrument Type C measures Pressures for the tunnel invert and wall.
T-11		C	TPW1	22+27	Invert + 2-ft		X		
T-12		C	TPF2	22+42	Invert		X		
T-13		C	TPW2	22+42	Invert + 2-ft		X		
T-14		C	TPF3	22+57	Invert		X		
T-15		C	TPW3	22+57	Invert + 2-ft		X		
T-16		CC	LPF1		Invert		X		Instrument Type CC measures Pressures for the Low Flow tunnel invert and wall.
T-17		CC	LPW1		Invert + 2-ft		X		
T-18		CC	LPF2		Invert		X		
T-19		CC	LPW3		Invert + 2-ft		X		
T-20		CC	LPF3		Invert		X		
T-21		CC	LPW3		Invert + 2-ft		X		
T-22	X	D	PR1	21+75.5	2082.9	X			Instrument Type D measures Pressures at the roof and wall Entrance
T-23	X	D	PW1	21+75.5	2078.4	X			
T-25	X	D	PW2	21+78.5	2078.4	X			
T-27	X	D	PW3	21+81.5	2078.4	X			
T-28	X	D	PR4	22+03.0	2082.9	X			
T-32	X	E	PL4	22+00.5	2077.4	X			Instrument Type E measures the Low flow tunnel roof pressure between emergency and operating gates
T-33	X(5)	F	IP0	Tower	2180	X			Instrument Type F measures Pressures at the Intake Tower entrance
T-34	X(7)	F	IP1	11+33.01	2212.54	X			
T-35	X(8)	F	IP2	11+37.41	2116.03	X			
T-36	X(9)	F	IP3	11+45.91	2113.76	X			
T-37	X(10)	F	IP4	11+50.41	2113.75	X			
T-38	X(11)	F	IP5	11+27.01	2106.88	X			
T-39	X(12)	F	IP6	11+30.26	2106.88	X			
T-40	X(13)	F	IP7	11+34.01	2106.88	X			
T-41	X(16)	F	IP8	11+67.91	Roof	X			
T-42	X	G	HGL1	14+00	Roof	X			Instrument Type G provides the Piezometric head elevations.
T-43	X	G	HGL2	16+00	Roof	X			
T-44	X	G	HGL3	19+00	Roof	X			
T-45	X	G	HGL4	21+00	Roof	X			
T-46	X	G	HGL5	24+00	Invert + 2-ft	X			
T-47	X	G	HGL6	25+00	Invert + 2-ft	X			
T-48	X	G	HGL7	26+00	Invert + 2-ft	X			
T-49	X	G	HGL8	27+00	Invert + 2-ft	X			
T-50	X	G	HGL9	28+00	Invert + 2-ft	X			

1. Numbers in parentheses identify model numbers.
2. Denotes measurement type.
3. Transducer code names used in as-built drawings.
4. Refer to Plate 2-24 of this Water Control Manual to show the locations of these piezometers.