Research to Develop an Improved Fingerling-Protection System for John Day Dam, 1981

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CONTENTS

INTRODUCTION

In 1981, the National Marine Fisheries Service (NMFS), under contract to the U.S. Army Corps of Engineers (CofE), continued research to develop improved methods for protecting fingerling salmon and steelhead from losses associated with hydroelectric dams operated by the CofE on the Columbia and Snake Rivers. Development of fingerling protection facilities for John Day Dam is currently considered the number one priority by the Columbia River Fisheries Council. The CofE acknowledged this need and provided funding for the NMFS to conduct research in 1981 for developing a fingerling bypass for John Day Dam.

The primary focus of the research was on developing fingerling protection facilities at John Day Dam and included solving problems in the present bypass. The research was conducted at McNary Dam instead of John Day Dam for economic and practical reasons. Much of the needed test equipment was already on site at McNary Dam, and the operating gate could be raised from the stored position to simulate gatewell flow conditions found at John Day Dam (demonstrated in a model study). With the exception of no stored gates, the basic configurations of the two dams are similar. Therefore, the results of the research obtained at McNary Dam should be applicable to John Day Dam.

Objectives of the research at McNary Dam were as follows: (1) determine the fish-guiding efficiency (FGE) of the submersible traveling screen (STS) with and without an airlift system in place, (2) evaluate the effectiveness of an airlift system for lifting juvenile fish out of the gatewell slot, (3) measure fish-passage efficiency (FPE) of a gatewell orifice submerged 2.4 and 5.2 m (8 or 17 feet), (4) evaluate the feasibility of an orifice cycling operation to reduce water consumption and construction costs, and (5) determine the best vertical barrier screen configuration.

A secondary aspect of this year's research pertained to potential predation in the forebay of John Day Dam. Present fingerling bypasses do not intercept juvenile salmonids until they are into the turbine intake. There is no protection from mortalities incurred by predation in the forebay immediately upstream from the dam. Skimmer devices in the forebay have been proposed to alleviate potential problems. Before proceeding further with the design of such a device for John Day Dam, information on the extent of the predation at the dam was needed. The objective of research initiated in 1981 was to sample the forebay for evidence of predation.

FINGERLING PROTECTION FACILITIES

Materials and Methods

Dam and Experimental Equipment

Experimental and handling equipment are shown in Figure 1. The frames below the STS supported the fyke nets used for estimating the number of unguided fish. The airlift system tested was the "funnel" airlift pump system described by Sims et al. (1981) (Figures 2 and 3). The dip basket used to sample the gatewells was similar to the device used by the NMFS at various hydroelectric dams on the Snake and Columbia Rivers (Swan et al. 1979) (Figure 4).

The turbine intakes of McNary and John Day Dams are basically similar. One major difference is the presence of a stored operating gate in the

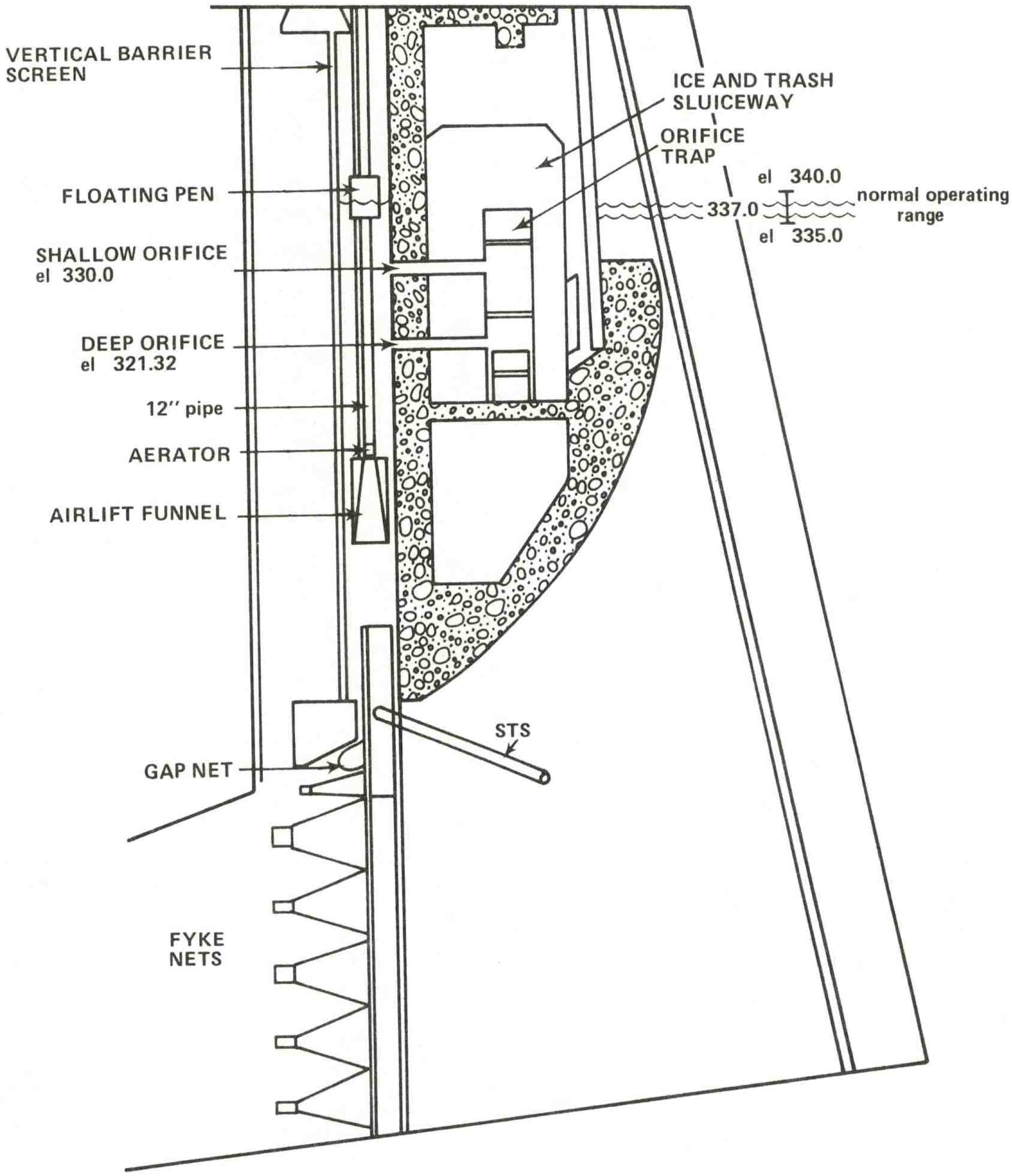


Figure 1.--Transverse section through Unit 6-B of McNary Dam showing experimental and handling equipment used for research in 1981.

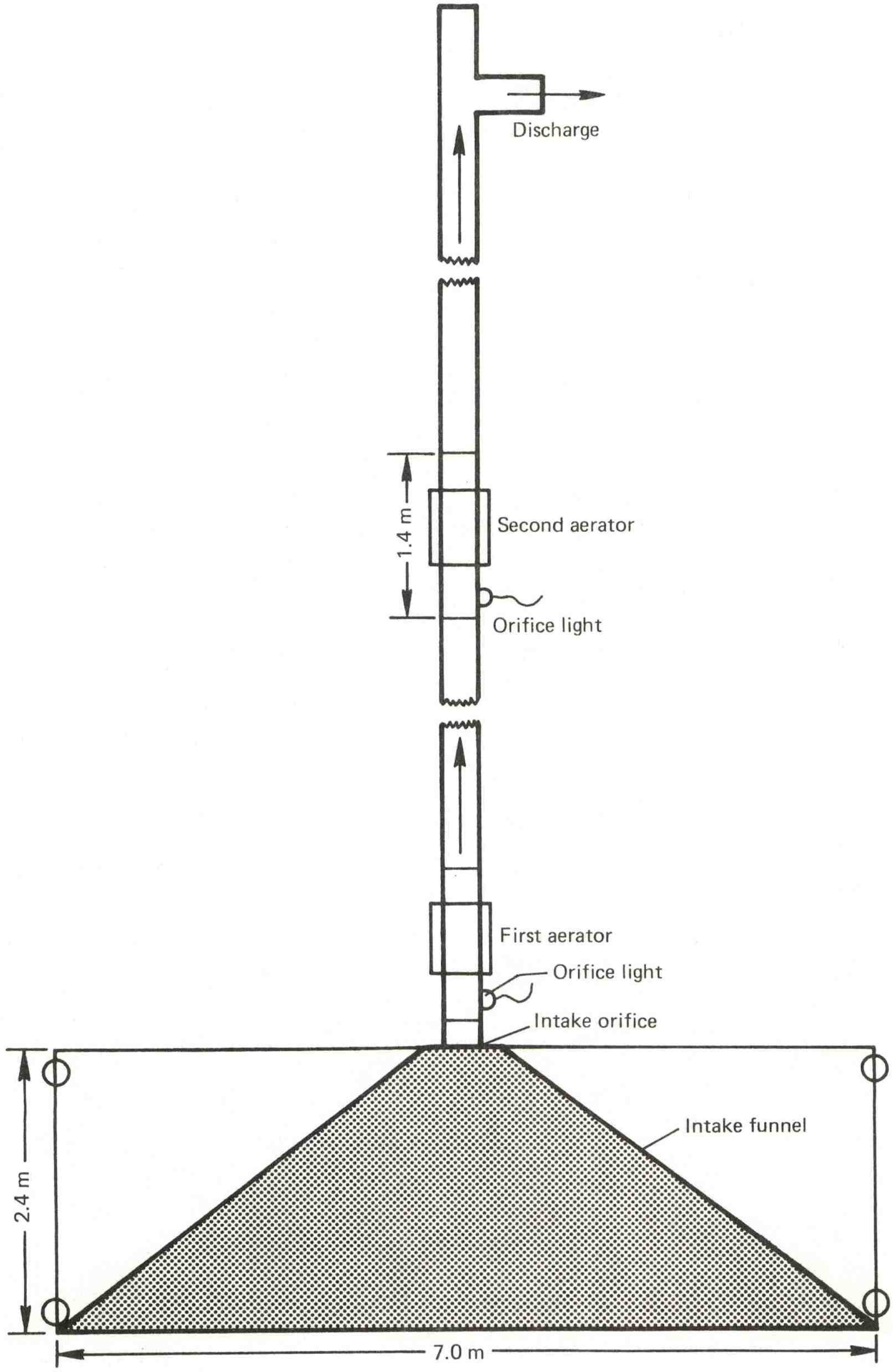


Figure 2.--The "funel" airlift pump system tested at McNary Dam in 1981.

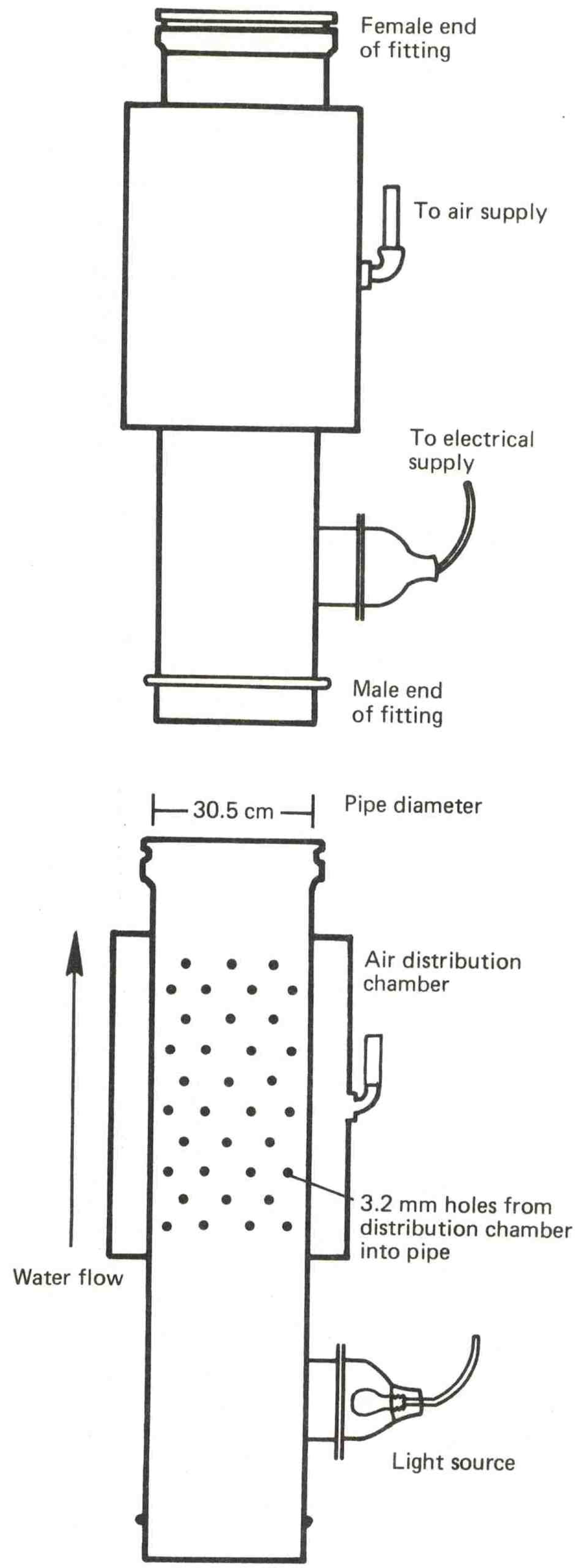
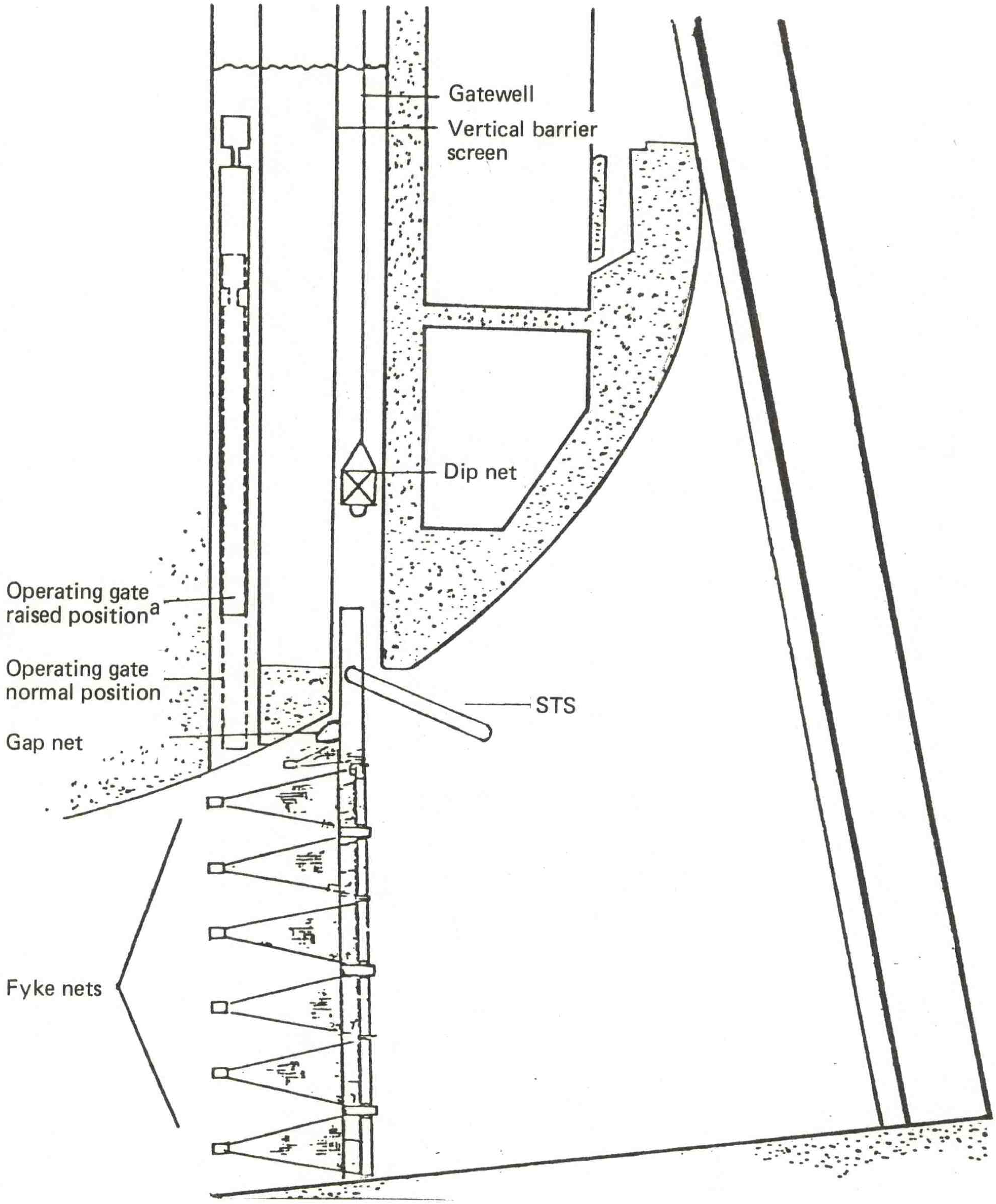


Figure 3.--Construction detail of the aerators used in the airlift pump system tested at McNary Dam in 1981.



a/ Simulated John Day Dam condition.

Figure 4.--Cross section of a turbine intake and associated structures in the McNary Dam powerhouse.

downstream slot at McNary Dam. To simulate gatewell flow conditions found in the gatewells at John Day Dam, the operating gate in the B-Slot of Unit 6 was raised and dogged off at the intake deck (Figure 4).

The operating depth of the standard bypass orifices in each gatewell at McNary Dam ranges from 1.5 to 3.0 m (5 to 10 feet) during the spring season. The standard orifice tests were conducted at an average depth of 2.4 m (8 feet). To simulate the John Day condition, an additional deep submerged orifice was drilled through the concrete wall between Gatewell 6-B and the ice and trash sluiceway. The deep orifice located directly underneath the existing north orifice was 5.2 m (17 feet) below the surface during the tests. The diameter of both orifices was 30.5 cm (12 inches). The existing orifice and the deep orifice of Unit 6-B were connected to a trap facility (Figure 5) in the sluiceway by separate 30.5 cm (12-inch) diameter pipes with valves for opening and closing the orifice.

Measurements and Procedures

STS Fish Guiding Efficiency.--The FGE of the STS was measured during a series of tests with fyke nets mounted below the STS to provide information on numbers of fish passing under the STS (unguided) and through the turbine. The number of fish guided was obtained by dipnetting the gatewell. The number of fish guided divided by the total number of fish guided and unguided provided the FGE. Effects of the airlift system on the FGE of the STS were determined by comparision of FGEs with and without the airlift system in place.

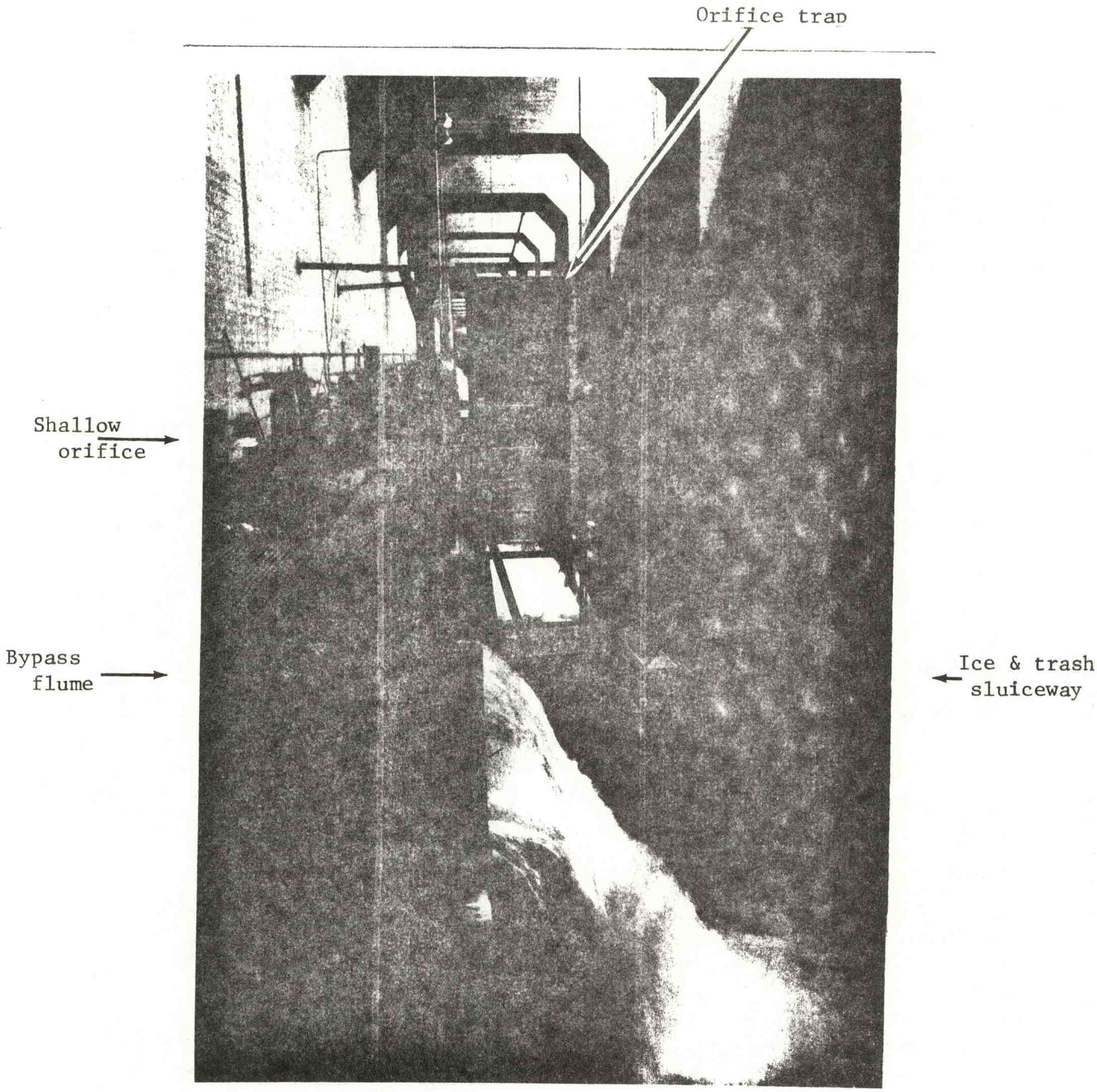


Figure 5.--Orifice trap facility.

Airlift Fish Passage Efficiency.--The FPE of the airlift pump was tested with the STS and simulated John Day Dam flow conditions in Turbine Intake 6-B. An inverted porous cone funneled all fish entering the gatewell to the airlift pump (Figure 2). To determine FPE, the number of fish passing through the airlift and collected in the floating pen was compared to the number of fish entering the gatewell expressed as:

$$FPE = \frac{a}{a+b} \times 100$$

a = number of fish in floating pen.

b = number of fish remaining in gatewell.

Procedures for a typical test of the FPE of the airlift system and its effect on the FGE of the STS were as follows:

1) Unit 6 was shut down.

2) The STS with attached fyke net frame was lowered into position.

3) The bypass orifices in Slot 6-B were closed, and the gatewell was dipped to remove all fish.

4) The airlift funnel and connecting pipe were lowered into place.

5) Unit 6 was returned to service and brought to peak efficiency speed.

6) A floating pen was lowered into the gatewell to receive the pumped fish, and the airlift system was started.

7) The airlift pump was turned on, and the test was conducted for a specified period of time.

8) The test was terminated by shutting down the unit and reversing the above procedures.

9) The fish in the pen and those dipped from the gatewell were kept

separate and sorted by species, counted, and examined for descaling and injury.

10) The STS with attached fyke nets and frames was brought to the surface, and the fish were removed from the nets for enumeration and identification.

Orifice Fish Passage Efficiency.--The FPEs through deep and shallow orifices were measured over periods of 24 h with the airlift cone removed. To determine FPE, the number of fish passing through the orifices and collected in the trap was compared to the total number entering the gatewell expressed as:

$$FPE = \frac{a}{a+b} \times 100$$

a = number of fish collected in orifice trap.

b = number of fish remaining in gatewell.

Tests were run with both continuous and cycled operations. Tests with continuous orifice operation compared FPE for both the McNary Dam (operating gate in place) and John Day Dam (operating gate raised) flow conditions. Tests with cycled orifice operation compared FPE for only the John Day Dam flow condition. Two orifice cycling time periods were tested: (1) 8 h off and 4 h on and (2) 5 h off and 2 h on.

Vertical Barrier Screen Configuration.--Vertical barrier screen (VBS) model studies conducted at the CofE Hydraulics Laboratory at Bonneville Dam in 1981 indicated that a balanced flow vertical barrier screen (BFVBS) showed promise for increasing fish collection by increasing the amount of water entering a gatewell. Reduced turbulence and uniform water veolcities across the entire cross-section of the VBS were also indicated.

Since turbulence in gatewells does adversely affect FPE through orifices as well as fish condition, it was planned to install a prototype BFVBS at McNary Dam for testing in 1981. Because there was insufficient time to construct and install the prototype prior to the smolt migration, testing was postponed until 1982.

Criteria for Evaluation

An acceptable FGE was 70% or higher--about the proportion of fish that should have been guided by an STS based on previous vertical distribution studies.

An FPE of less than 75% was unacceptable; a lower FPE meant fish were delaying excessively in gatewells which can result in unacceptable injuries and descaling.

Fingerlings with 10% of their scales missing were considered descaled. Descaling of fish was considered unacceptable when there was a significant increase in descaling in test gatewells or orifice traps over that measured in the control gatewells. When this occured, it usually meant there was a problem such as delay in exiting the gatewell through the orifice.

Results

Fish Guiding Efficiency

Acceptable FGEs (above 75%) were measured for the John Day Dam condition (no stored gate) both with and without the airlift system in place for chinook salmon and steelhead (Tables 1 and 2). Insufficient numbers of fish of other species were collected for meaningful comparisons. Placement of the aerator at the 6.1 m (20-foot) depth did not adversely alter the FGE.

Table 1.--Fish guiding efficiency (%) of the STS with guided fish removed from the gatewell by dipping (no airlift system).

Replicate no.	Chinook salmon Guided (no.)	Chinook salmon Total (no.)	Chinook salmon FGE (%)	Steelhead Guided (no.)	Steelhead Total (no.)	Steelhead FGE (%)
1	339	486	70	49	55	89
2	70	85	82	16	25	64
3	126	186	68	32	44	73
4	173	185	94	49	61	80
Combined	708	942	75	146	185	79

Table 2.--Fish guiding efficiency (%) of the STS with an airlift system in place for lifting guided juvenile salmonids out of the gatewell.

		Chinook salmon			Steelhead		
Airlift position	Replicate no.	Guided (no.)	Total (no.)	FGE (%)	Guided (no.)	Total (no.)	FGE (%)
Shallow (20 ft deep)	1	180	204	88	9	15	60
"	2	193	208	93	12	15	80
"	3	41	53	77	128	149	86
	Combined	414	465	89	149	179	83
Mid-depth (30 ft deep)	1	99	120	83	74	95	78

Fish Passage Efficiency of Airlift System

The FPE with the airlift cone placed at the 6.1 m (20-foot) depth was considerably lower than desireable, whereas the FPE at the 9.1 m (30-foot) depth approached acceptable levels (Table 3). Neither the airlift system nor the STS appeared to increase descaling significantly (Table 4).

Orifice Fish Passage Efficiency

The overall FPE with continuously operated orifices was not acceptable. The only FPE greater than 75% was for steelhead (Table 5). In general, the FPE was better for the McNary Dam condition than for the John Day Dam condition. Mixed results were obtained on comparisons of shallow and deep orifice submergences. The condition of the fish generally reflected the poorer FPE of the John Day Dam condition. Highest descaling rates were for those fish passing through the deep orifice during the John Day Dam condition (Table 6).

The FPEs for cycled orifice operation were considerably lower than the unacceptable FPEs of continuously operated orifices (Table 7). The FPE for chinook salmon through the shallow orifice for the 8 h off-4 h on operation, for example, was only 17% compared to 59% for continuous operation. Measures of descaling rates were inconclusive.

PREDATOR STUDY

Materials and Methods

The schedule called for sampling in various locations of the forebay of John Day Dam at least one time each week from 1 April to mid-June 1981. Juvenile salmonids collected were to be counted by species. Squawfish collected were to be counted and a subsample marked and released for

Table 3.--Fish passage efficiency of the airlift system tested with a traveling screen and gatewell flow condition simulating John Day Dam.

	FPE			
Duration of tests	Chinook (%)	Steelhead (%)	Sockeye (%)	Coho (%)
Shallow depth--20 ft				
4 hours (evening)	61	72	73	a/
24 hours (night termination)[b]	51	60	51	
24 hours (day termination)[c]	52	67	56	
Mid-depth--30 ft				
4 hours (evening) (Only one replicate)	75	68	80	a/

a/ Insufficient numbers of fish to validate tests.

b/ Tests started and stopped at about midnight.

c/ Tests started and stopped at about noon.

Table 4.--Condition of fish expressed as percent descaled.

Group	% descaled Chinook	Steelhead	Sockeye	Coho
Fish passed by the airlift system	7	9	11	6
Control--with STS	6	10	7	5
Control--without STS	6	6	4	3
Residual fish in test gatewell	8	8	9	7

Table 5.--Fish passage efficiency of the deep and shallow orifices tested for the McNary Dam gatewell flow condition and the simulated John Day Dam gatewell flow condition.

	FPE			
Test condition	Chinook (%)	Steelhead (%)	Sockeye (%)	Coho (%)
McNary condition				
Deep orifice	52	85	73	51
Shallow orifice	66	75	68	69
John Day condition				
Deep orifice	47	78	66	61
Shallow orifice	59	70	41	58

Table 6.--Condition of fish during orifice passage efficiency testing--expressed in percent descaling.

Group	% descaled Chinook	Steelhead	Sockeye	Coho
McNary condition				
Deep orifice				
Orifice trap	3	4	18	16
Gatewell residual	2	8	0	0
Control	7	6	20	9
Shallow orifice				
Orifice trap	5	1	20	17
Gatewell residual	2	3	0	20
Control	6	10	16	33
John Day condition				
Deep orifice				
Orifice trap	17	5	9	11
Gatewell residual	16	16	28	18
Control	6	4	10	8
Shallow orifice				
Orifice trap	5	5	13	6
Gatewell residual	1	10	6	3
Control	9	8	20	9

Table 7.--Fish passage efficiency of the deep and shallow orifice operated for two different time periods of orifice cycling for the John Day orifice.

	FPE			
Scenario	Chinook (%)	Steelhead (%)	Sockeye (%)	Coho (%)
5 h off-2 h on				
Deep orifice	46	64	21	98
8 h off-4 h on				
Deep orifice	36	67	59	48
Shallow orifice	17	38	15	33

recapture studies. At the conclusion of the sampling period, we were to estimate the occurrence of squawfish in the sampling area. The critical area of sampling was the so-called "zone of stagnation" or dead water area immediately upstream from the powerhouse. Previous sampling with hook and line had indicated that this area probably contained the greatest concentration of predators. Therefore, the first priority was to develop sampling gear that could provide sufficient samples of fish from the dead water area for analysis; purse seining and angling were tested. Because of high water velocities in the area, four units of the powerhouse were to be shut down during seining to avoid having the net sucked into a turbine.

Results

Even with four turbine units shut down, the current was so strong that on the first purse seining attempt, the net was almost sucked into the nearest operating turbine. The net was so badly damaged that no further attempts could be made to purse seine in the area. Limited purse seining with a shallow net was continued in the forebay approximately 1/2 mile upstream for several weeks, but catches of squawfish were not sufficient to provide adequate numbers of fish for marking. Angling in both areas also failed to provide enough fish to validate a marking experiment. The Oregon Department of Fish and Wildlife is scheduled to conduct predator population studies in 1982 with funds from the Bonneville Power Administration.

CONCLUSIONS AND RECOMMENDATIONS

1. The airlift system did not adversely affect the FGE of the STS, but passage of fish through the airlift system was unacceptable. Fish

passage through the system may be improved by placement of the airlift at a lower depth in the gatewell.

2. FPEs through either cycled or continuously operating orifices (John Day Dam condition) were unacceptable. Turbulence in the gatewell, caused by increased water flow due to the lack of a stored gate, was probably the main reason for the low FPEs. A BFVBS which would reduce turbulence, would probably enhance orifice FPE.

3. Additional studies are needed to develop the criteria necessary to efficiently operate the fish passage orifices in the fingerling bypass at John Day Dam.

4. Sampling gear needs to be developed that can efficiently sample the dead water area immediately in front of the powerhouse of John Day Dam for evidence of predation on juvenile salmonids.

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