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HYDRAULIC MODEL STUDIES OF SCOGGINS DAM FISHTRAP AERATION AND SUPPLY STRUCTURE

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Engineering and Research Center
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16. ABSTRACT

Laboratory studies were made of the Scoggins Dam fishtrap aerator and supply structure with a 1:3.33 scale model to aid the development of the hydraulic design. A horizontally mounted fixed-cone valve discharging into a containment structure, followed by a stilling basin, was used to aerate the flow and to dissipate the flow energy before releasing it to the constant-head-orifice flow measurement structure. All of these features are part of the fishtrap supply structure. Results showed that the valve containment structure and stilling basin perform very well as an aerator and energy dissipator to provide quiet, oxygenated flow that could be measured and regulated in the constant-head-orifice structure.

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by

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July 1972

Hydraulics Branch
Division of General Research
Engineering and Research Center
Denver, Colorado

UNITED STATES DEPARTMENT OF THE INTERIOR * BUREAU OF RECLAMATION
Rogers C. B. Morton, Secretary
Ellis L. Armstrong, Commissioner

ACKNOWLEDGMENT

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PURPOSE

The purpose of the study was to aid in the development of the hydraulic design of the aerator and supply structure for the fishtrap.

CONCLUSIONS AND RECOMMENDATIONS

1. The aerator, which includes the horizontally mounted fixed-cone valve discharging into a containment structure followed by a covered stilling basin, satisfactorily performed its function of mixing the water with a very large amount of air.

2. The containment structure and stilling basin, both part of the aerator structure, performed very well as an energy dissipator and aerator. One baffle block on the floor of the basin was found to be adequate.

3. The basin should be kept free of heavy debris that might circulate in the turbulence and cause abrasion of the concrete.

4. The hanging baffle in the supply structure was effective in smoothing the water surface in the upstream compartment of the constant head-orifice-flow-measurement structure and in keeping the water surface free of foam on the downstream side of the baffle.

5. It was recommended that the weir gages in the compartments supplying the pipes to the fishtrap and fishway be placed on the upstream wall for better view of the gage and to be in a slightly more stable water surface area.

6. Air vents were needed immediately downstream from the gates in the supply structure to provide stable, steady flow in the pipes to the fishtrap. The air vents also prevent accidental overflow of the supply structure if orifice gates are adjusted improperly. For this reason, the air vents were increased to 18 inches (in.) (45.72 centimeters (cm)) in diameter after completion of the model study.

APPLICATIONS

The principle, whereby discharge is at a moderate head from a fixed-cone valve into a containment structure following by a stilling basin, proved to be a good one in this installation, both for the aeration process and for energy dissipation. It can probably be adapted for use at other structures without the need for an additional model study. The model in this study was used on a 1:1 scale basis to verify a proposed design of an outlet for the China Meadows Dam.

INTRODUCTION

Scoggins Dam, situated on Scoggins Creek about 7 miles (11.27 kilometers (km)) southwest of Forest Grove, Oregon, Figure 1, is part of the Tualatin Project. It is an earth embankment approximately 2,700 feet (ft) (822.96 meters (m)) long with a maximum height of approximately 116 ft (35.36 m) above the bed of Scoggins Creek. Maximum reservoir water surface elevation 305.7 ft (93.18 m) is 92.9 ft (28.22 m) above the maximum tailwater.

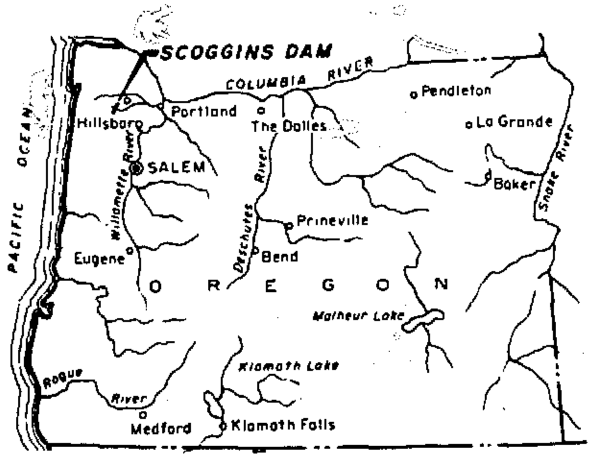


Figure 1. Location map.

The fishtrap supply structure, Figure 2, takes water from deep in the reservoir and supplies measured quantities to two different locations in the holding tank and to three locations in the fish ladder leading to the tank. The 16-in. (40.64-cm) supply line on the left to be used most frequently is designed for 10 cubic feet per second (cfs) (0.28 cubic meter per second (cu m/sec); the next is an 18-in. (45.72-cm) supply line designed for 15 cfs (0.43 cu m/sec); the next is a 24-in. (60.96-cm) supply line designed for 30 cfs (0.85 cu m/sec); and the one on the right is another 24-in. (60.96-cm) line designed for 23 cfs (0.65 cu m/sec).

The valve discharging into the aerator structure is a 20-in. (50.80-cm) horizontally mounted fixed-cone valve. This valve was chosen because it sprays the jet in a 360^{o} arc, thus exposing a large flow surface to the atmosphere for maximum aeration. However, to contain the cone-shaped jet in a relatively small space, a containment structure is needed. Much of the advantage of spraying into the atmosphere is lost by use of the containment structure but a very large

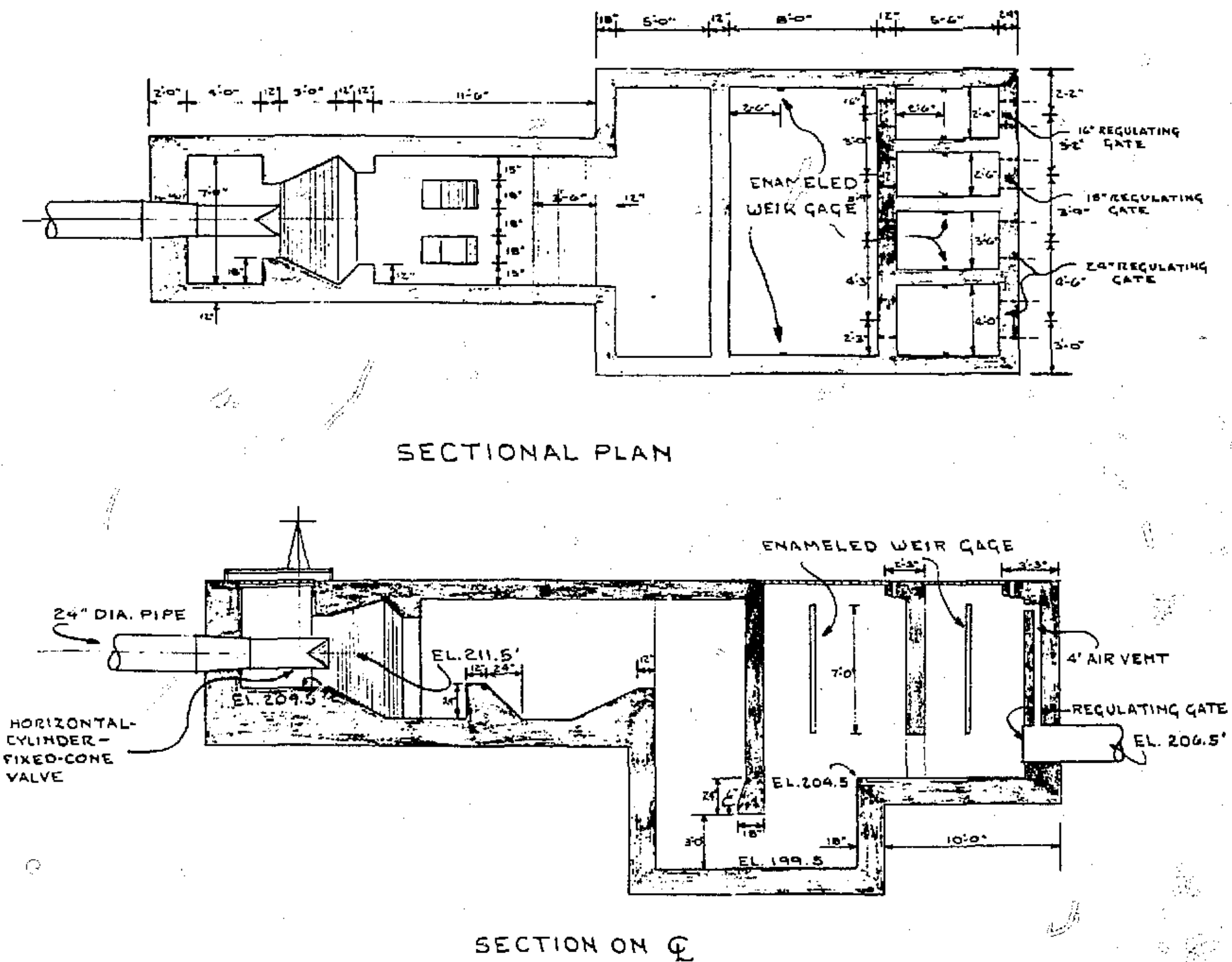


Figure 2. Fishtrap and supply structure.

amount of air is entrained in the flow in the containment structure and stilling basin that follows.

The valve, containment structure, and stilling basin arrangement is similar to that provided for the outlet works at Ute Dam[1] which is used only as an energy dissipator. From the stilling basin the flow discharges over the end sill into the constant-head-orifice flow measurement structure. In the Scoggins structure the flow is regulated and measured through four separate compartments from which it is discharged into four pipelines to different areas of the fishtrap as required.

THE MODEL

A 6-in. (15.24-cm) fixed-cone valve was used to simulate a 20-in. (50.8-cm) prototype valve, thereby fixing the model scale at 1:3.33. Included in the model, Figure 3, in addition to the valve was the containment structure and stilling basin, the constant-head-orifice flow measurement structure, and 24-in. (60.96-cm) lengths of the pipes leading away from each of the four compartments in the flow measurement structure to the fishtrap.

[1] REC-OCE-70-11, "Hydraulic Model Studies of an Energy Dissipator for a Fixed-Cone Valve at the Ute Dam Outlet Works," G. L. Beichley, U.S. Bureau of Reclamation, March 1970.

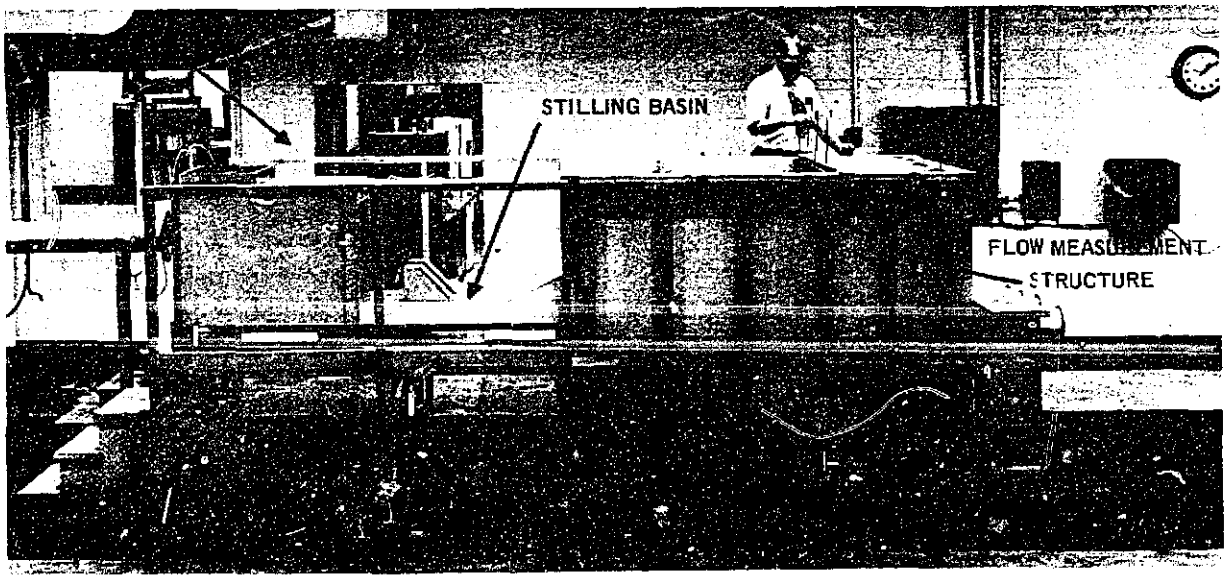


Figure 3. The 1:3.33 scale model. Photo P417-D-71883

A piezometer tap was installed on each side of the pipe one valve diameter upstream of the valve. The two piezometers at centerline elevation were connected together and used with a U-tube mercury manometer to adjust the valve opening for the required head and discharge combination.

THE INVESTIGATION

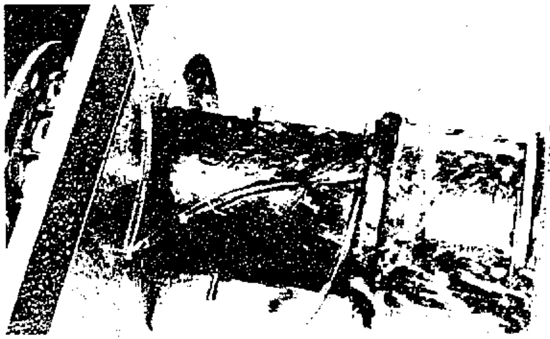
The Requirement

The minimum requirement of the fishtrap aeration and supply structure was to discharge a flow of 10 cfs (0.28 cu m/sec) through the left pipe plus 4 cfs (0.11 cu m/sec) through each of the two center pipes for a total of 18 cfs (0.51 cu m/sec) at a reservoir elevation ranging between 263.68 ft (80.37 m) and 303.68 ft (92.56 m). The maximum requirement was to be able to deliver a flow of 10 cfs (0.28 cu m/sec) through the left pipe, 15 cfs (0.43 cu m/sec) through the next one and 30 cfs (0.85 cu m/sec) through the next with an additional 23 cfs (0.65 cu m/sec) through the right pipe. This is a total of 55 or 78 cfs (1.56 or 2.21 cu m/sec) depending upon whether the right-hand pipe discharging an additional 23 cfs (0.65 cu m/sec) is in operation. This flow can come from any reservoir elevation at or above that specified for the minimum requirement. The maximum total head at the valve was computed to be 75.13, 70.10, and 63.18 ft (22.90, 21.37, and 19.26 m) for the three discharges of 18, 55, and 78 cfs (0.51, 1.56, and 2.21 cu m/sec), respectively.

The minimum water surface elevation in the upstream compartment of the flow measurement structure to discharge the maximum flow requirement was computed to be at elevation 209.5 ft (63.86 m). This is only 2 ft (0.61 m) below the centerline elevation of the fixed-cone valve but is required to provide the minimum head differential between the upstream and downstream compartments in the flow measurement structure plus enough head to overcome the losses in the most critical of the four pipelines to the fishtrap. The 24-in. (60.96 cm) line discharging 30 cfs (0.85 cu m/sec) was the critical line that governed the minimum head requirement.

Performance at Minimum Requirement

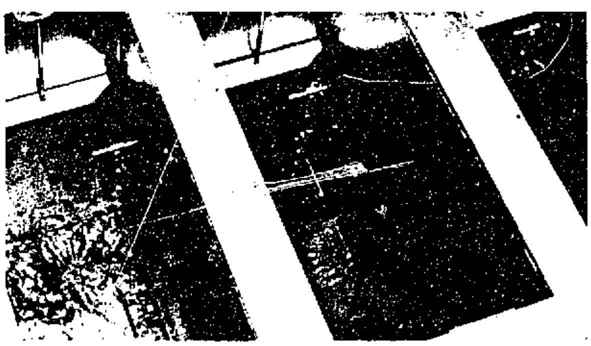
At 18 cfs (0.51 cu m/sec) in the aerator and supply structure, either from maximum reservoir elevation 305.70 ft (93.18 m) or from minimum elevation 263.68 ft (80.37 m), Figures 4 and 5, respectively, the air entrainment in the stilling basin portion of the aerator structure appeared to be sufficient to cause good aeration of the flows as judged by the disintegration of the jet in the containment structure and the air entrainment observed in the stilling basin. At maximum head, Figure 4, a considerable amount of water from the roof and walls of the containment structure portion of the aerator deflected upstream over the valve; however, other than appearance, this was not a hydraulic performance problem and, actually, was probably a benefit to the aeration process.



a. Flow from the fixed-cone valve into the containment structure. Photo P417-D-71892

b. Flow from the containment structure into the stilling basin. Photo P417-D-71893

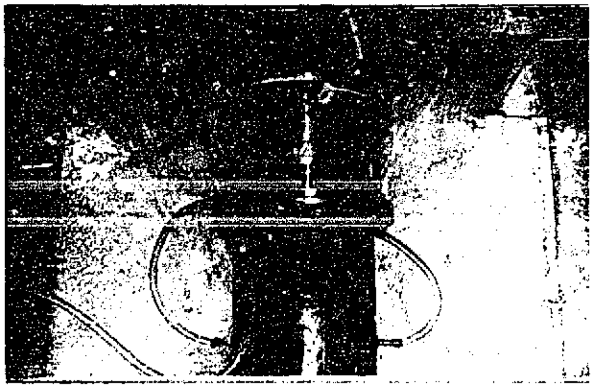
c. Flow from the stilling basin into the constant-head-orifice-flow-measurement structure. Photo P417-D-71894



d. Flow in constant-head-orifice structure to fish trap pipelines. Photo P417-D-71895

e. Flow in pipes to fish trap. Photo P417-D-71896

Figure 4. Aeration and supply structure discharging 18 cfs (0.51 cms) from maximum reservoir elevation 305.70 feet (93.18 m).



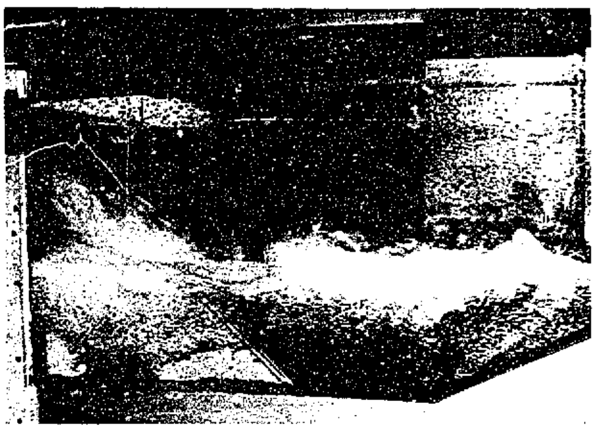


Figure 5. Aeration structure discharging 18 cfs (0.51 cms) from minimum reservoir elevation 263.68 feet (80.37 m). Photos P417-D-71890 and P417-D-71891

Gravel placed in the stilling basin swirled around to some extent and did not wash out of the basin. Therefore, it was recommended that the basin be kept free of debris.

Flow on the downstream side of the hanging baffle in the flow measurement structure, Figure 4c, provided a very quiet water surface for measurement by the wall-mounted weir gage.

Performance at Maximum Requirement

At design capacity of 78 cfs (2.21 cu m/sec) including 23 cfs (0.65 cu m/sec) from the right compartment of the flow measurement structure discharging from maximum or minimum reservoir elevation and at 55 cfs (1.56 cu m/sec) without the 23 cfs (0.65 cu m/sec), Figures 6 through 9, the aeration process appeared to be excellent as determined by observing the very large amount of entrained air in the flow.

At the higher heads a considerable amount of flow deflected upstream from the containment structure over the valve and the valve was partially submerged; but no vibration of the valve could be detected. Because the prototype is to be only 3.33 times larger than the model it was believed that vibration would definitely not be a problem in the prototype.

The stilling basin portion of the aerator appeared to perform well as an energy dissipator as well as for the aeration process. Two baffle blocks were originally anticipated for the stilling basin; however, only one was installed and this was found to be sufficient.

The hanging baffle in the flow measurement structure performed very satisfactorily in keeping the foam created by the air-entrained water on the upstream side of the baffle, and in providing a smooth water surface at the weir staff gage mounted on the left wall downstream from the baffle. The water surface in each of the downstream compartments of flow measurement structure that supplied water to each of the four pipelines to the fishtrap was less smooth. This water surface elevation could not be measured as accurately as in the upstream compartment but it was sufficiently accurate for the prototype requirements.

In operation at design capacity the upstream gates to the four downstream compartments were set fully open while the downstream gates to the pipelines were regulated to provide the proper differential as determined from the flow measurement handbook.[2] It was found important that air vents be installed in the crown of the pipes immediately downstream of the gates, Figures 2 and 8, to provide a stable flow condition in the pipes to the fishtrap; otherwise, the pipes carrying near full capacity alternately flowed full and part full.

The positions of the gates discharging into the pipes were not calibrated in the model since this could and should be done more accurately in the prototype. It was suggested that the weir staff gages mounted on the side walls of the compartments, Figure 2, be mounted on the upstream wall to provide a better view of the gage from above and to be in a slightly more stable water surface area.

To determine the maximum capacity of the aerator supply structure the fixed-cone valve was fully opened

[2] U.S. Department of the Interior, Bureau of Reclamation "Water Measurement Manual."

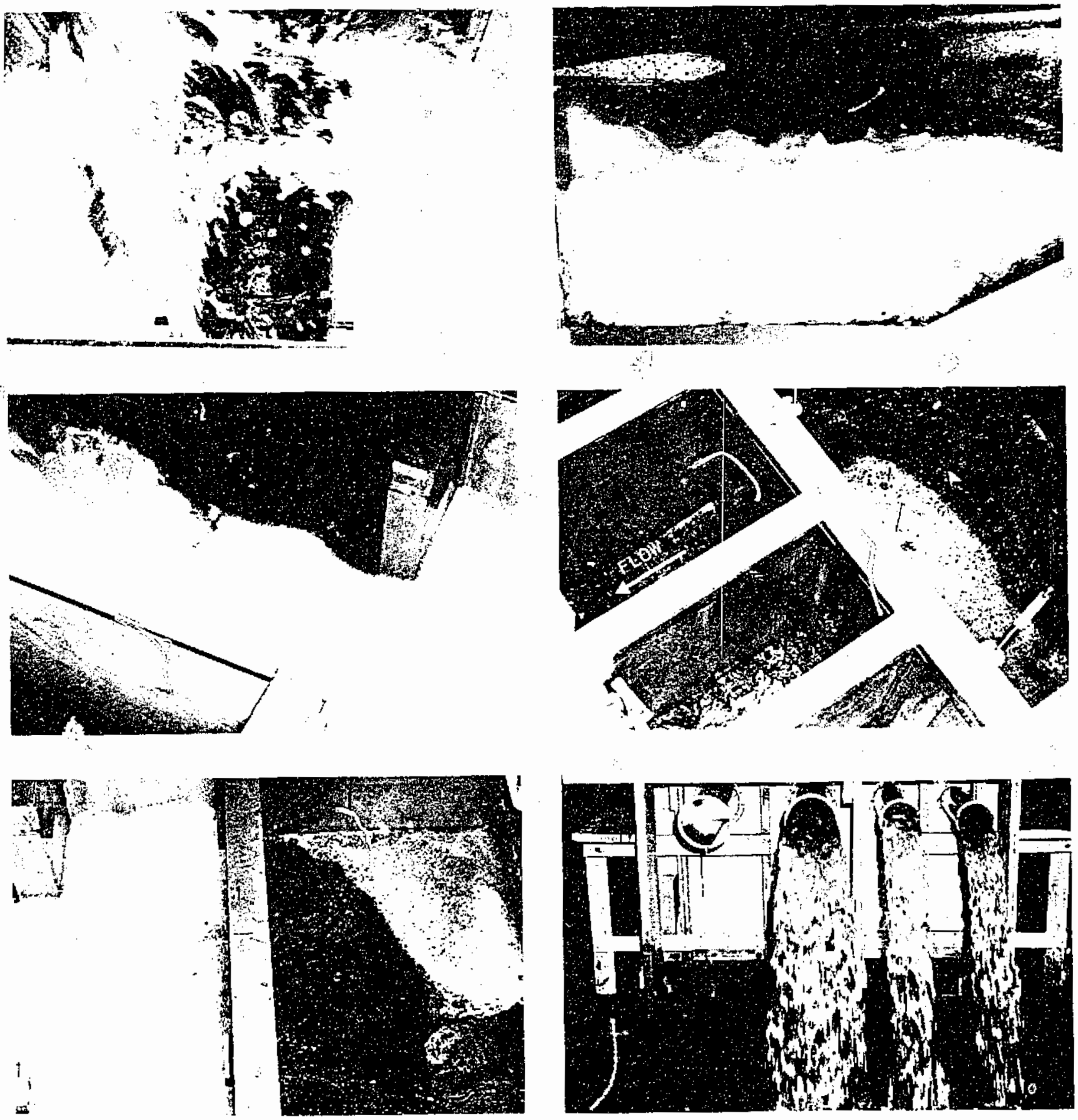


Figure 6. Aeration and supply structure discharging 55 cfs (4.56 cms) from reservoir elevation 305.70 feet (93.18 m). Photos from left to right P417-D-71897, -71900, -71898, -71901, -71899, and -71902

and the flow increased until the foamy water surface was roughly a foot from the ceiling of the stilling basin over the end sill. From this test it was determined that the structure could probably discharge up to approximately 110 cfs (3.12 cu m/sec), Figure 10. It was noted that the flow through the basin created a strong breeze blowing foam from under the cover out the sides between the stilling basin and hanging baffle. This was an indication of the very large amount of air that was being drawn into the aerator around the valve at the upstream end; and, therefore, it was believed that the aerator was doing a good job in performing its function.

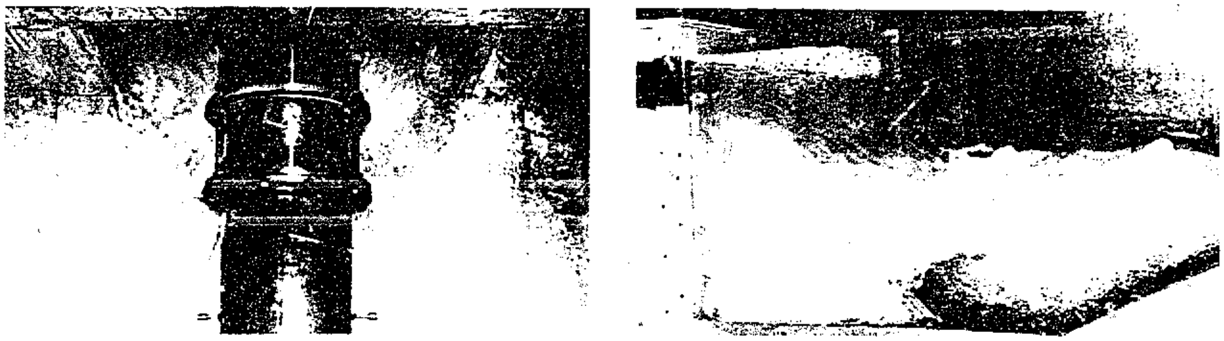


Figure 7. Aeration structure discharging [illegible] cfs (1.56 cms) from reservoir elevation 263.68 feet (80.37 m). Photos P417-D-71903 and P417-D-71904

Figure 8. Aeration and supply structure discharging 78 cfs (2.21 cms) from reservoir elevation 305.70 feet (93.18 m). Photos P417-D-71886, -71887, and -71888

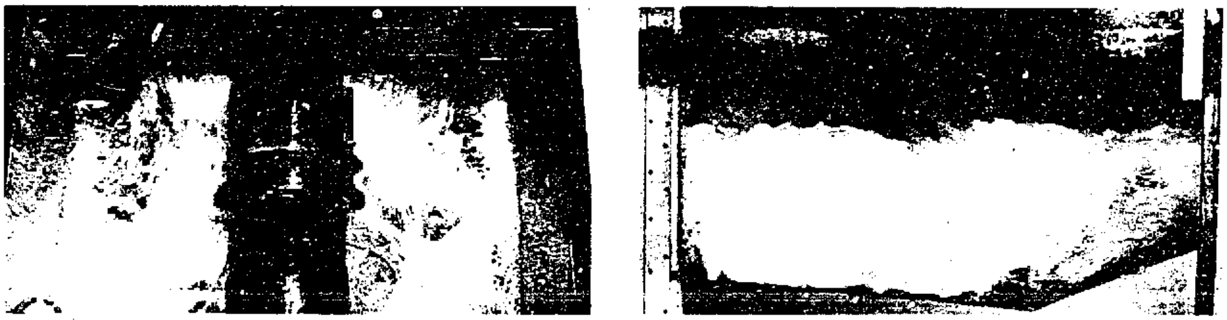


Figure 9. Aeration structure discharging 78 cfs (2.21 cms) from reservoir elevation 263.68 feet (80.37 m). Photos P417-D-71884 and P417-D-71885

Figure 10. Aeration and supply structure discharging 110 cfs (3.12 cms) at full open valve—1:3.33 scale model. Photo P417-D-71889

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CONVERSION FACTORS—BRITISH TO METRIC UNITS OF MEASUREMENT

The following conversion factors adopted by the Bureau of Reclamation are those published by the American Society for Testing and Materials (ASTM Metric Practice Guide, E 380-68) except that additional factors (*) commonly used in the Bureau have been added. Further discussion of definitions of quantities and units is given in the ASTM Metric Practice Guide.

The metric units and conversion factors adopted by the ASTM are based on the "International System of Units" (designated SI for Systeme International d'Unites), fixed by the International Committee for Weights and Measures; this system is also known as the Giorgi or MKSA (meter-kilogram (mass)-second-ampere) system. This system has been adopted by the International Organization for Standardization in ISO Recommendation R-31.

The metric technical unit of force is the kilogram-force; this is the force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 9.80665 m/sec/sec, the standard acceleration of free fall toward the earth's center for sea level at 45 deg latitude. The metric unit of force in SI units is the newton (N), which is defined as that force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 1 m/sec/sec. These units must be distinguished from the (inconstant) local weight of a body having a mass of 1 kg, that is, the weight of a body is that force with which a body is attracted to the earth and is equal to the mass of a body multiplied by the acceleration due to gravity. However, because it is general practice to use "pound" rather than the technically correct term "pound-force," the term "kilogram" (or derived mass unit) has been used in this guide instead of "kilogram-force" in expressing the conversion factors for forces. The newton unit of force will find increasing use, and is essential in SI units.

Where approximate or nominal English units are used to express a value or range of values, the converted metric units in parentheses are also approximate or nominal. Where precise English units are used, the converted metric units are expressed as equally significant values.

Table I

QUANTITIES AND UNITS OF SPACE

Multiply	By	To obtain
	LENGTH	
Mil	25.4 (exactly)	Micron
Inches	25.4 (exactly)	Millimeters
Inches	2.54 (exactly)*	Centimeters
Feet	30.48 (exactly)	Centimeters
Feet	0.3048 (exactly)*	Meters
Feet	0.0003048 (exactly)*	Kilometers
Yards	0.9144 (exactly)	Meters
Miles (statute)	1,609.344 (exactly)*	Meters
Miles	1.609344 (exactly)	Kilometers
	AREA	
Square inches	6.4516 (exactly)	Square centimeters
Square feet	*929.03	Square centimeters
Square feet	0.092903	Square meters
Square yards	0.836127	Square meters
Acres	*0.40469	Hectares
Acres	*4,046.9	Square meters
Acres	*0.0040469	Square kilometers
Square miles	2.58999	Square kilometers
	VOLUME	
Cubic inches	16.3871	Cubic centimeters
Cubic feet	0.0283168	Cubic meters
Cubic yards	0.764555	Cubic meters
	CAPACITY	
Fluid ounces (U.S.)	29.5737	Cubic centimeters
Fluid ounces (U.S.)	29.5729	Milliliters
Liquid pints (U.S.)	0.473179	Cubic decimeters
Liquid pints (U.S.)	0.473166	Liters
Quarts (U.S.)	*946.358	Cubic centimeters
Quarts (U.S.)	*0.946331	Liters
Gallons (U.S.)	*3,785.43	Cubic centimeters
Gallons (U.S.)	3.78543	Cubic decimeters
Gallons (U.S.)	3.78533	Liters
Gallons (U.S.)	*0.00378543	Cubic meters
Gallons (U.K.)	4.54609	Cubic decimeters
Gallons (U.K.)	4.54596	Liters
Cubic feet	28.3160	Liters
Cubic yards	*764.55	Liters
Acre-feet	*1,233.5	Cubic meters
Acre-feet	*1,233,500	Liters

Table II

QUANTITIES AND UNITS OF MECHANICS

Multiply	By	To obtain
MASS		
Grains (1/7,000 lb)	64.79891 (exactly)	Milligrams
Troy ounces (480 grains)	31.1035	Grams
Ounces (avdp)	28.3495	Grams
Pounds (avdp)	0.45359237 (exactly)	Kilograms
Short tons (2,000 lb)	907.185	Kilograms
Short tons (2,000 lb)	0.907185	Metric tons
Long tons (2,240 lb)	1,016.05	Kilograms
FORCE/AREA		
Pounds per square inch	0.070307	Kilograms per square centimeter
Pounds per square inch	0.689476	Newtons per square centimeter
Pounds per square foot	4.88243	Kilograms per square meter
Pounds per square foot	47.8803	Newtons per square meter
MASS/VOLUME (DENSITY)		
Ounces per cubic inch	1.72999	Grams per cubic centimeter
Pounds per cubic foot	16.0185	Kilograms per cubic meter
Pounds per cubic foot	0.0160185	Grams per cubic centimeter
Tons (long) per cubic yard	1.32894	Grams per cubic centimeter
MASS/CAPACITY		
Ounces per gallon (U.S.)	7.4893	Grams per liter
Ounces per gallon (U.K.)	6.2362	Grams per liter
Pounds per gallon (U.S.)	119.829	Grams per liter
Pounds per gallon (U.K.)	99.779	Grams per liter
BENDING MOMENT OR TORQUE		
Inch-pounds	0.011521	Meter-kilograms
Inch-pounds	1.12985×10^6	Centimeter-dynes
Foot-pounds	0.138255	Meter-kilograms
Foot-pounds	1.35582×10^7	Centimeter-dynes
Foot-pounds per inch	5.4431	Centimeter-kilograms per centimeter
Ounce-inches	72.008	Gram-centimeters
VELOCITY		
Feet per second	30.48 (exactly)	Centimeters per second
Feet per second	0.3048 (exactly)*	Meters per second
Feet per year	*0.965873×10^{-6}	Centimeters per second
Miles per hour	1.609344 (exactly)	Kilometers per hour
Miles per hour	0.44704 (exactly)	Meters per second
ACCELERATION*		
Feet per second^2	*0.3048	Meters per second^2
FLOW		
Cubic feet per second (second-feet)	*0.028317	Cubic meters per second
Cubic feet per minute	0.4719	Liters per second
Gallons (U.S.) per minute	0.06309	Liters per second
FORCE*		
Pounds	*0.453592	Kilograms
Pounds	*4.4482	Newtons
Pounds	*4.4482×10^5	Dynes

Table II—Continued

Multiply	By	To obtain
WORK AND ENERGY*		
British thermal units (Btu)	*0.252	Kilogram calories
British thermal units (Btu)	1,055.06	Joules
Btu per pound	2.326 (exactly)	Joules per gram
Foot-pounds	*1.35582	Joules
POWER		
Horsepower	745.700	Watts
Btu per hour	0.293071	Watts
Foot-pounds per second	1.35582	Watts
HEAT TRANSFER		
Btu in./hr ft^2 degree F (k, thermal conductivity)	1.442	Milliwatts/cm degree C
Btu in./hr ft^2 degree F (k, thermal conductivity)	0.1240	Kg cal/hr m degree C
Btu ft/hr ft^2 degree F	*1.4880	Kg cal m/hr m^2 degree C
Btu/hr ft^2 degree F (C, thermal conductance)	0.568	Milliwatts/cm^2 degree C
Btu/hr ft^2 degree F (C, thermal conductance)	4.882	Kg cal/hr m^2 degree C
Degree F hr ft^2/Btu (R, thermal resistance)	1.761	Degree C cm^2/milliwatt
Btu/lb degree F (c, heat capacity)	4.1868	J/g degree C
Btu/lb degree F	*1.000	Cal/gram degree C
Ft^2/hr (thermal diffusivity)	0.2581	Cm^2/sec
Ft^2/hr (thermal diffusivity)	*0.09290	M^2/hr
WATER VAPOR TRANSMISSION		
Grains/hr ft^2 (water vapor) transmission)	16.7	Grams/24 hr m^2
Perms (permeance)	0.659	Metric perms
Perm-inches (permeability)	1.67	Metric perm-centimeters

Table III

OTHER QUANTITIES AND UNITS

Multiply	By	To obtain
Cubic feet per square foot per day (seepage)	*304.8	Liters per square meter per day
Pound-seconds per square foot (viscosity)	*4.8824	Kilogram second per square meter
Square feet per second (viscosity)	*0.092903	Square meters per second
Fahrenheit degrees (change)*	5/9 exactly	Celsius or Kelvin degrees (change)*
Volts per mil	0.03937	Kilovolts per millimeter
Lumens per square foot (foot-candles)	10.764	Lumens per square meter
Ohm-circular mils per foot	0.001662	Ohm-square millimeters per meter
Millicuries per cubic foot	*35.3147	Millicuries per cubic meter
Milliamps per square foot	*10.7639	Milliamps per square meter
Gallons per square yard	*4.527219	Liters per square meter
Pounds per inch	*0.17858	Kilograms per centimeter

GPO 844-376

ABSTRACT

Laboratory studies were made of the Scoggins Dam fishtrap aerator and supply structure with a 1:3.33 scale model to aid the development of the hydraulic design. A horizontally mounted fixed-cone valve discharging into a containment structure, followed by a stilling basin, was used to aerate the flow and to dissipate the flow energy before releasing it to the constant-head-orifice flow measurement structure. All of these features are part of the fishtrap supply structure. Results showed that the valve containment structure and stilling basin perform very well as an aerator and energy dissipator to provide quiet, oxygenated flow that could be measured and regulated in the constant-head-orifice structure.

ABSTRACT

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