CZES Coastal Zone and Estuarine Studies

EVALUATION OF FISH PROTECTIVE FACILITIES AT LITTLE GOOSE AND LOWER GRANITE DAMS

AND

REVIEW OF NITROGEN STUDIES RELATING TO PROTECTION OF JUVENILE SALMONIDS IN THE COLUMBIA AND SNAKE RIVERS, 1976

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George A. Swan, Earl M. Dawley
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March 1977

Final Report of Research
Financed By
U.S. Army Corps of Engineers
(Contract No. DACW68-75-C-0111)

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Northwest and Alaska Fisheries Center
Division of
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2725 Montlake Boulevard East
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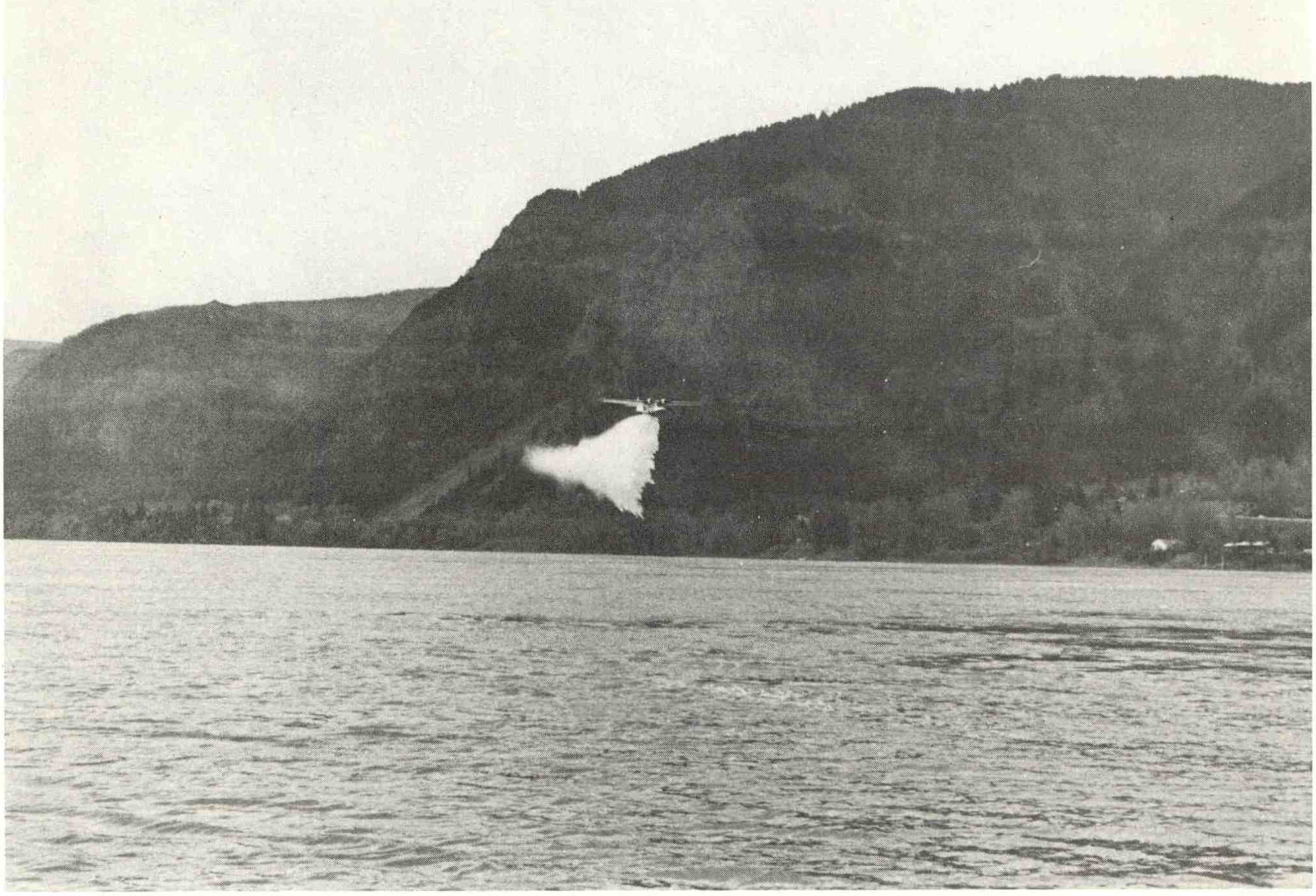


Air release of juvenile chinook salmon from PBY aircraft into Columbia River (5 miles below Bonneville Dam) after 1-½ hour flight from Lower Granite Dam.

CONTENTS

INTRODUCTION

During 1976, the National Marine Fisheries Service (NMFS), under contract to the U.S. Army Corps of Engineers, continued to evaluate the following: (1) fish protective facilities for juvenile salmonids at Lower Granite and Little Goose Dams, (2) a mass transportation system for increasing survival of downstream migrant salmonids, and (3) dissolved gas abatement procedures in the Columbia and Snake Rivers.

At Lower Granite Dam, emphasis was placed on traveling screen research and collection of smolts and their transportation by truck and aircraft. It is important to determine if transportation, found to be successful at Little Goose Dam, can be successfully employed further upstream nearer the smolt rearing areas. Experiments were also designed to determine if salt water is beneficial in alleviating stresses during transport, thereby increasing survival to the sea. Traveling screen research involved tests with the standard traveling screen and an adjustable angle traveling screen designed by the Corps of Engineers. Tests were made with the standard screen located in the bulkhead slot, and the adjustable angle screen located in the bulkhead slot and the fish screen slot.

At Little Goose Dam, emphasis was placed on evaluating the mass transportation of juvenile salmonids. A portion of the smolts transported to Bonneville Dam were marked and some groups were hauled in salt water. We also continued to recover adults returning upriver from juvenile migrations marked and transported from Little Goose Dam in 1973 and from Lower Granite Dam in 1975.

Throughout the study area, we also conducted research relating to the following: (1) the effects of stress on chinook salmon--includes data on descaling, gas bubble disease, and contagious diseases and (2) the levels of dissolved gasses in the Columbia and Snake Rivers especially as related to spillway flow deflectors at Little Goose and McNary Dams.

MASS TRANSPORT OF SMOLTS

Mass transportation of smolts continues to be a practical way to reduce losses of juvenile salmonids during their downstream migration. Emergency mass transport of 549,000 juvenile steelhead was initiated at Little Goose Dam in 1975. In 1976 the fishery agencies approved mass hauling of up to 50% of the total outmigration of both juvenile chinook salmon and steelhead trout from Lower Granite and Little Goose Dams to release locations below Bonneville Dam.

To evaluate the success of mass transport in 1976, a sample of the total number of hauled fingerlings from each dam was tagged with coded wire tags, branded, and adipose fin clipped. Each test group was marked with a distinctive tag code and brand symbol. Subsequent returns of marked adults to the fishery, the adult separator at Lower Granite Dam, and to hatcheries will provide data on the contribution of transported fish to the total run.

Approximately 1.2 million fingerlings collected at Lower Granite and Little Goose Dams were transported to the river below Bonneville Dam in 1976. The 751,000 chinook salmon and 435,000 steelhead trout smolts represented about 15% of the total outmigration from the Snake River. High runoff, as in 1975, reduced our collection capability. Most of the outmigration passed over the spillways rather than through the screened turbine intakes. A summary of the numbers of smolts transported and the percent of the total outmigration hauled each year since 1971 is given in Table 1. Specifics on numbers of marked and unmarked fish hauled from each dam may be found in the respective sections of the report titled, "Research - Lower Granite Dam" and "Research - Little Goose Dam."

RESEARCH - LOWER GRANITE DAM

FINGERLING TRANSPORTATION EXPERIMENTS - TRUCK

Prior to the beginning of the downstream migration period, modifications and changes were made to the collection and marking facility that improved operations. Collection and subsequent marking of juveniles was enhanced by operation of six standard traveling screens strategically placed in three operating units. This was the first year that collection was available from three units in service throughout the fingerling migration. Last year we had only three screens, and they were used in a single operating unit. Modifications were made to the fingerling sorter assembly which permitted a consistent automatic operation for sorting and removing debris. Modifications were also made at the marking facility which permitted a smooth gravity flow of fish from the dam to the facility and from the facility to the transport trucks.

Table 1.--Number of smolts and percent of total Snake River outmigration transported below Bonneville Dam 1971-76.

	Chinook Smolts			Steelhead Smolts		
	No. at upper dam (1,000)	No. hauled (1,000)	% hauled	No. at upper dam (1,000)	No. hauled (1,000)	% hauled
1971	4000	109	3%	5500	154	3%
1972	5000	360	7%	2500	227	9%
1973	5000	247	5%	5500	176	3%
1974	3500	0	0	5000	0	0
1975	4000	414	10%	3200	549	17%
1976	5000	751	15%	3200	435	14%

This years research began at Lower Granite Dam on April 14 when the first fingerlings became available for marking. The objective of the research was to determine whether large numbers of juvenile salmonids could be transported from Lower Granite Dam to locations below Bonneville Dam without extensive mortality or loss of homing ability--thus increasing survival and subsequent returns to parent streams. It is especially important to test the transport concept at Lower Granite Dam because of its proximity to nearby rearing areas. If smolts are collected and transported too soon after they begin their seaward migration, it is conceivable that homing could be destroyed or impaired, resulting in increased straying as adults.

Experimental Design

Data from studies initiated in 1975 indicated a potential benefit from hauling chinook fingerlings in a mild saline solution (5 ppt). To measure actual benefits in terms of adult returns, half of the fish marked and transported below Bonneville Dam in 1976 were hauled in 5 ppt salt water and half in fresh water. Through May 5, test groups were released at the Washington Department of Game boat launch site one mile below Bonneville Dam. After May 5, the boat launch site was inaccessible and truck releases were made near the powerhouse. Control groups, all hauled in fresh water, were released near Clarkston, Washington, at the Port of Clarkston barge facility on the south shore of the Snake River. Separate brands and coded tags were used to identify fish by specific release site and whether they were hauled in fresh or salt water.

Evaluation of the survival and homing ability of each group will be based on adult returns to the following: (1) various Columbia River commercial fisheries, (2) the sport fishery, (3) the adult separator at Little Goose or Lower Granite Dams, (4) hatcheries, and (5) native spawning grounds.

Procedures

Fish were diverted, collected, and handled in the same manner as last year. All fingerlings used in our tests were tagged with coded magnetic wire tags, branded, and adipose fin clipped. Each test group was marked with a distinctive tag code and brand symbol.

At the marking facility we monitored descaling daily as an indicator of injury to smolts passing through the bypass-collection system. Descaling rate in the marking building provided a total injury factor. An injury factor for the bypass and collection facility could be established by subtracting the descaling noted in the gatewells from the descaling rate observed in the marking building.

Steelhead trout and chinook salmon were hauled simultaneously but in separate compartments in both 3500 and 5000-gallon tankers. Fish transported in fresh water were treated in a disinfectant bath of Malachite green prior to leaving the marking building. A mild anesthetic (1 ppm quinaldine) was added to all freshwater hauls. When hauls were made in salt water (5 ppt), the saline solution was maintained during marking and loading operations. Routine water quality observations were made after transport, and samples of fish were taken from the truck for delayed mortality observations (45-hour).

Diversion, collection, marking, and transportion all place a degree of stress on fingerlings. Measures of descaling and delayed mortality provide criteria for assessment of this stress. Monitoring these parameters on smolts hauled each year from both Lower Granite and Little Goose Dams provides an index of fish condition in relation to efforts to reduce stress.

Number and Condition of Smolts Transported

About 650,000 smolts were handled at the fingerling collection facility in 1976. Of these, 238,974 chinook salmon and 165,828 steelhead trout were marked for various transportation experiments (Table 2). The remaining 140,637 chinook salmon and 101,875 steelhead trout were transported unmarked to below Bonneville Dam (Table 3). Appendix Tables 1 through 4 contain a detailed summary of all transportation releases.

The condition of smolts hauled from Lower Granite Dam in 1976 was much better than the condition of those hauled from Lower Granite Dam in 1975 or from Little Goose Dam in 1976. Average descaling rate measured for chinook salmon at the fish marking facility was 7% (range 4 to 13%). Half, or 3.5%, was attributable to traveling screens and half to the bypass and collection facility. Measurements in 1975 were nearly double these figures--13% total, (6.4% traveling screens and 6.6% bypass and collection facility).

Delayed mortality on marked chinook salmon hauled in fresh water averaged 4.7% in 1976, down considerably from the 11.5% measured in 1975. Delayed mortality on marked steelhead trout was negligible in both years.

Table 2.--Summary of fingerlings collected and marked at Lower Granite Dam and transported to Bonneville Dam and estuary release sites (test) or released near Clarkston, Washington (control), 1976.

Release site and transport conditions	Chinook No.	Steelhead No.
Bonneville - Boat Ramp (Truck)		
Salt water	45,476	16,504
Fresh water	47,507	7,304
Bonneville - Powerhouse (Truck)		
Salt water	15,970	52,641
Fresh water	25,421	47,392
Beacon Rock (Airplane)		
Fresh water	37,118	--
Tongue Point (Airplane)		
Fresh water	38,796	--
Clarkston, WA (Truck)		
Fresh water	28,686	41,987
Total Marked	238,974	165,828

Table 3.--Summary of salmonid fingerlings collected at Lower Granite Dam and transported unmarked to release sites below Bonneville Dam, 1976.

Release site and transport conditions	Chinook No.	Steelhead No.
Bonneville - Boat Ramp (Truck)		
Salt water	54,328	29,211
Fresh water	45,335	10,473
Bonneville - Powerhouse (Truck)		
Salt water	12,452	34,235
Fresh water	28,522	27,956
Total hauled unmarked	140,637	101,875

Delayed mortality of marked and unmarked chinook salmon was reduced significantly when 5 ppt salt water was used during transport (Table 4). It is apparent that hauling fingerling chinook salmon in 5 ppt salt water is beneficial for short-term survival. Further experiments are planned to evaluate the effect of salt on long-term survival.

Disease Monitoring

During the smolt outmigration, research was conducted at Lower Granite Dam to determine if fish disease was of sufficient magnitude to influence survival of transported chinook salmon smolts in 1976. Even a small percentage of diseased fish could adversely affect others when all are closely confined in a tanker for 6 to 8 hours.

Thirty freshly dead or moribund smolts were examined for fish diseases. The procedure consisted of microscopically examining wet mounts of material from the fish's external surface, gills, internal organs and intestinal contents. In addition, kidney stabs were streaked onto TSA and cytophaga agar. Gram stains from the kidney and other suspect organs were prepared and examined under oil immersion. The external examination and agar slants were negative for all fish. However, the Gram stains revealed the presence of a Gram-positive diplobacillus in various internal organs of 9 of the 30 fish examined. This bacteria was determined to be the causative agent of bacterial kidney disease and most likely was a factor in the deaths of these fish.

Table 4.--Delayed mortality of marked and unmarked chinook salmon and steelhead trout held 48 hours after transport from Lower Granite Dam in fresh water or salt water (5 ppt).

	Mortality range (average)	
	Salt water %	Fresh water %
Marked chinook	0 to 10.4 (1.5)	0 to 31.6 (4.7)
Unmarked chinook	0 to 5.8 (2.8)	0 to 12.5 (4.1)
Marked steelhead	0 to 1.8 (0.12)	0
Unmarked steelhead	0	0

In a separate study, a total of 90 chinook salmon smolts were randomly obtained from the fish population in an attempt to determine what percentage of the live fish population was infected with fish diseases. The examination procedure was the same as previously described. Again, all external observations and agar slants were negative. Bacterial kidney disease was found in only 1 of the 90 fish examined. Several fish were harboring various nematodes and trematodes in their intestinal tracts (including pyloric caeca), but the infestations were light and considered of no consequence.

A third study was conducted to determine if any freshwater fish diseases were contributing to delayed mortality after the fish reached salt water. In this experiment, 3 different groups of 400 chinook salmon fingerlings each were transported to the NMFS Mariculture Station at Manchester, Washington, where they were transferred directly to seawater and held in net pens for 3 months. In all three groups a mortality of approximately 20% was experienced within the first 24-hour period. This mortality was attributed to osmoregulatory problems due to the immediate transition from fresh water to full strength seawater. For the duration of the study, all three lots of fish were observed daily and dead fish were preserved for later examination. When the experiment was terminated after approximately 3 months, a 50% mortality had occurred in each of the three groups. Subsequent examination of the survivors and the preserved dead for the presence of freshwater disease was negative. Some of the dead examined on site showed infections with *Vibrio anguillarum*, a saltwater bacterial disease, while others simply showed symptoms of dehydration.

The combined results of the disease studies indicate that contagious diseases were not a serious factor influencing survival among transported chinook salmon in 1976. It is noteworthy, however, that the causative agent of kidney disease was found in about 30% of the dead fish examined.

FINGERLING TRANSPORTATION EXPERIMENTS - AIR

Experiments were initiated this year to determine if increased benefits could be obtained by transporting fingerlings by airplane. Even though transportation of fingerlings by truck around dams is clearly emerging as a positive means of increasing survival of chinook salmon and steelhead trout from the Snake River there is room for improvement. Air lifting will reduce transport time from Lower Granite Dam to Bonneville Dam by 6 hours (road time of 7.5 hours vs air time of 1.5 hours). With this reduction in transportation time, we hope for a proportionate reduction in stress and a corresponding increase in survival. Furthermore, truck access for release sites on the lower Columbia River is limited; with air transport, release sites are virtually unlimited.

This experiment had the following objectives: (1) compare survival of fingerlings transported by air with those hauled by truck, and (2) determine if survival can be further enhanced by transporting fish the additional 127 miles from Bonneville Dam to the estuary.

Fish to be transported by air were handled and marked in the same manner as those hauled by truck. Separate brands and wire codes identified each release group. (See Appendix Table 4 for details.)

After marking, the fish were placed in a tank truck and taken to the air strip at Lower Granite Dam for transfer by hose to a Super PBY airplane. The plane has a built in, 1600-gallon water tank originally designed for carrying fire retardant. The tank was altered to our specifications by insulating with polyurethane foam. The insulation controlled temperature variation and minimized vibrations due to engine noises. The tank was also fitted with fish life-support systems consisting of aeration pumps and metered, high-pressure oxygen. Because these were initial tests with several unknowns, the aircraft was loaded with only 1000 gallons of fresh water.

Chinook salmon smolts were chosen for initial air transportation studies. Previous studies showed that chinook are more vulnerable to the stresses and shock of transport than are steelhead trout and should, therefore, benefit most from the reduced transportation time. Moreover, chinook salmon smolts are only one-fourth as large as steelhead trout smolts; thus, many more fish could be hauled per gallon of water.

Air transport of fingerling chinook salmon started from Lower Granite Dam on April 21. Eight flights were made during the 17-day period ending on May 7. In four flights, a total of 37,118 fingerlings were air lifted to a release point about 5 miles below Bonneville Dam. An additional four flights air lifted 38,796 fingerlings to Tongue Point, about 4 miles upstream from Astoria, Oregon. The average "payload" for each flight was almost 9,500 fish.

The transported fish appeared to arrive at the release site in good condition. Water temperatures and dissolved oxygen levels (monitored by remote readout equipment) were maintained at desirable levels during each flight. The behavior of the fish was monitored by watching through portholes in each compartment, and no abnormal behavior was observed. In addition, careful observations were made in the drop area, and no dead fish were seen.

Economic feasibility of an air transport system cannot be fully evaluated until adult returns are analyzed. The capacity of present truck units is about 50,000 chinook salmon fingerlings per haul. Although not fully tested, it is expected that an airplane could haul about 20,000 fingerlings per flight. It presently costs more to haul the 20,000 fish by air than to haul the 50,000 fish by truck--therefore, air-transported fingerlings must survive at a greater rate than truck-hauled fingerlings to make the air system pay.

Present plans call for repeating the experiment in 1977. Over the 2-year period there will be enough releases of marked fish to provide a sound basis for evaluating the air transport system. Jack returns from the air lift releases will appear in 1977. More meaningful returns of adults during 1978-80 should indicate the true value of the airlift as a viable solution to the survival problems of chinook salmon in the Snake River.

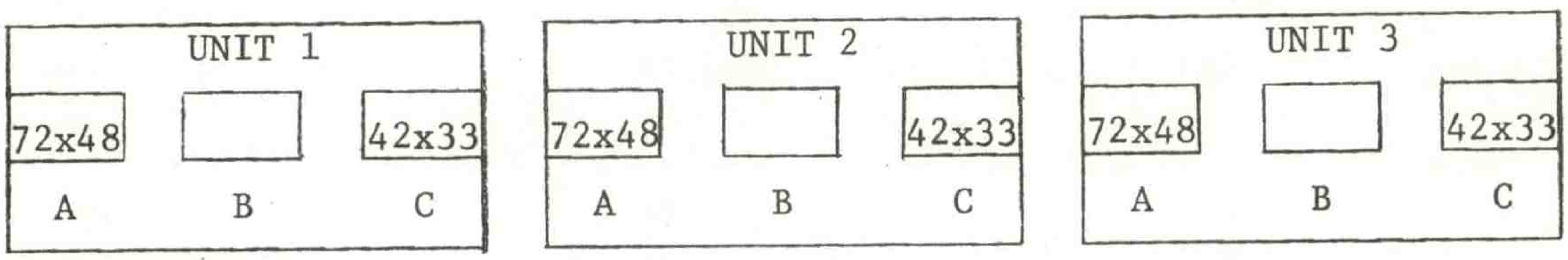
TRAVELING SCREEN AND ORIFICE BYPASS STUDIES

Research on traveling screens and orifice bypasses for 1976 had the following objectives: (1) test the prolonged operation of standard traveling screens in the A and C bulkhead slots of units 1, 2, and 3 to provide diversion of fingerlings for collection and transportation; (2) monitor the condition of fingerlings after they enter the bulkhead slots; (3) test and evaluate the new experimental traveling screen; and (4) determine orifice size and location for best passage of fingerlings from gate slots.

Standard Traveling Screen

Spring Tests and Results

The six standard traveling screens operated satisfactorily with a minimum of mechanical problems. Two mesh and perforated plate combinations were used in the bulkhead slots: (1) intermediate mesh (72 x 36 x 16 mesh per foot) with 48% perforated plate (abbreviated 72 x 48), and (2) regular mesh (42 x 36 x 16 mesh per foot) over 33% perforated plate (42 x 33). Screens were placed in intakes in the following pattern:



We attempted to place the available screen and plate combination which was most effective in reducing descaling (72 x 48) in the highest flow areas (A slots). Since the 42 x 33 combination was the least effective at reducing descaling, we placed it in the lowest flow area (C slots). We also believed a limited degree of guiding might be accomplished by leaving the B slots vacant thus "channeling" some fingerlings to that slot if they refused to enter adjacent A or C slots.

Descaling and injury of fingerlings in gatewells where traveling screens were operating was monitored daily throughout the season. Fish with more than 10% of their scales missing were classified as descaled. A descaling rate was calculated by dividing the number of fish classified as descaled by the total number of fish counted in any particular test. Average descaling rate for chinook salmon was 3.5% in the A slots and 3.8% in the C slots (Table 5). The total average descaling for chinook salmon was about 3.6%--down from the 6.4% we reported in 1975. For the first time, descaling among steelhead trout was higher than among chinook salmon although the overall percent descaling was considerably lower for both species than in past seasons. Apparently the placement pattern for traveling screens that we selected was useful in controlling descaling of chinook salmon because descaling rates in all slots were uniformly low and within acceptable limits.

In June a special test was designed to measure the average descaling rate for fall chinook salmon in the gatewell when a conventional traveling screen equipped with the 42 x 33 mesh-plate combination was operating in the bulkhead slot. Tests were conducted with fall chinook

Table 5.--Average descaling rate measured for naturally migrating chinook salmon and steelhead trout collected in gatewells at Lower Granite Dam after diversion by standard traveling screens - 1976.

	Screens Placed in Bulkhead Slots			
Species	Location/descaling rate %	Location/descaling rate %	Location/descaling rate %	Average %
Chinook	1A - 3.87	2A - 3.70	3A - 2.98	3.51
Chinook	1C - 4.52	2C - 3.89	3C - 2.84	3.75
Steelhead	1A - 5.24	2A - 6.83	3A - 5.91	5.99
Steelhead	1C - 5.63	2C - 6.03	3C - 4.68	5.44

salmon obtained from the Priest Rapids spawning channel. Although tests were limited to hatchery fish ranging in length from 50 to 80 mm, the descaling rate was nil with the turbine operating at full load (155 megawatts).

Fall Tests and Results

During the fall testing period, four combinations of screen mesh and plate (72-33, 72-48, 42-33, and 42-48) were tested on a standard traveling screen operating in the bulkhead slot. Turbine loading (155 megawatts) and lighting (lights off) were kept constant throughout the tests.

Insufficient time and numbers of experimental fish limited the number of tests we could conduct and the data we could obtain (Table 6). The combination of intermediate mesh (72) and 33% plate gave the best guidance (78%) and descaling was nil. The poorest guidance (55%) and some descaling occurred with the combination of regular mesh (42) and 48% plate. Further tests were planned for the spring of 1977.

Adjustable Angle Traveling Screen

Spring Tests and Results

A new screen designed to operate with monofilament nylon mesh belts and at adjustable angles from 45 to 65^{o} by 5^{o} increments (Figure 1) was completed and delivered in time to be tested in the spring of 1976. Limited testing took place with the screen placed at various angles and operating in either the fish screen slot or the bulkhead slot. However, problems with the hydraulic

Table 6.--Results of tests using standard traveling screens with various combinations of mesh and perforated plate.

Order of results	Average recovery (%)	Screen mesh and plate	Turbine load (megawatts)	Light condition	Slot	Average descaling (%)
1	78.2	72-33	155	OFF	BHS	0
2	74.2	72-48	"	"	"	0.3
3	69.8	42-33	"	"	"	0
4	55.1	42-48	"	"	"	2.4

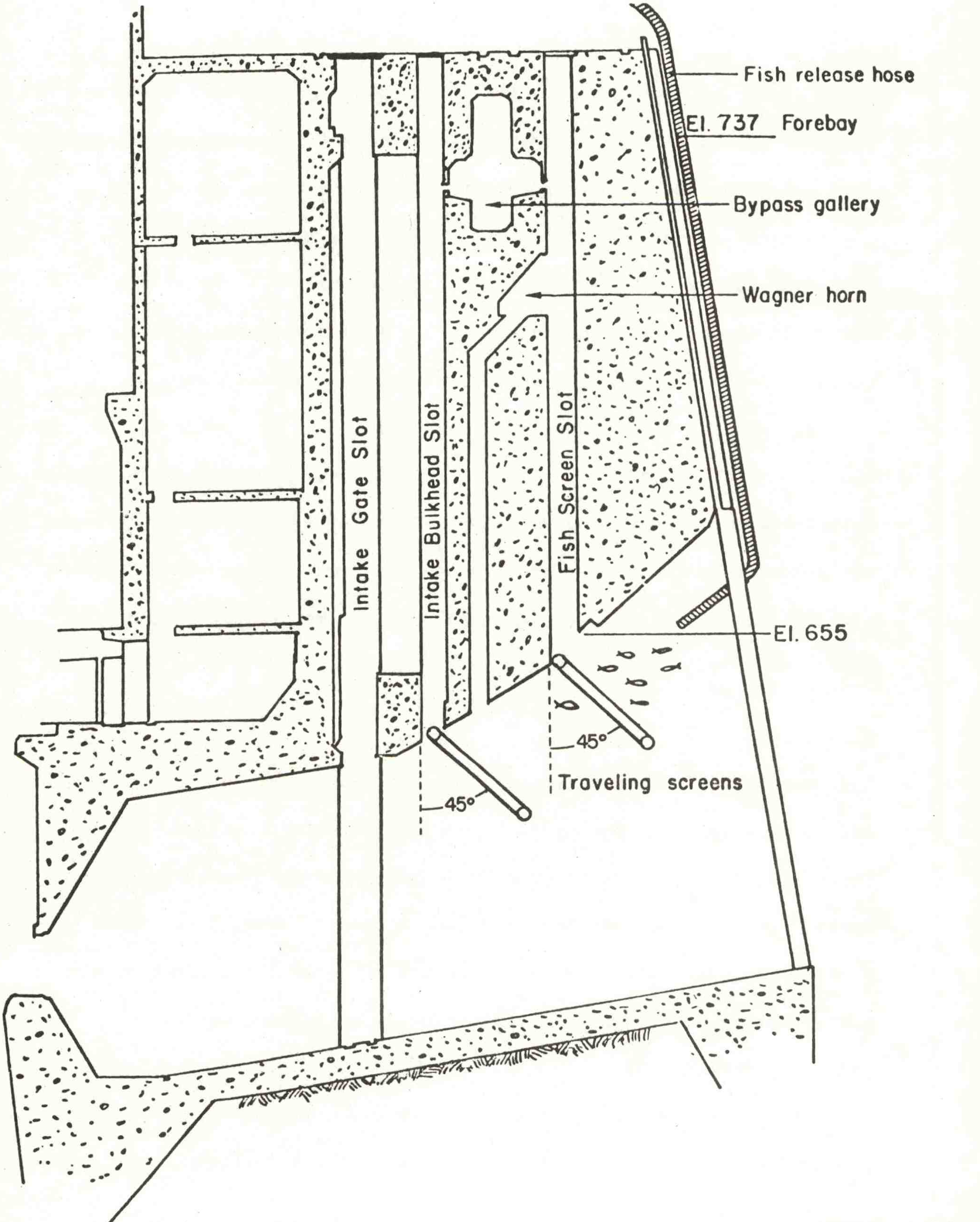


Figure 1.--Schematic drawing of traveling screen placement in the turbine intake at Lower Granite Dam. Traveling screens were tested in either the intake bulkhead slot or the fish screen slot at various angles from vertical (a screen angle of 45° is illustrated).

drive system prevented completion of any phase of the scheduled test program. Despite the problems, some valuable information was obtained:

1. With the new screen operating in the fish screen slot at angles greater than 45^{o}, descaling was significantly reduced below the 20% or greater descaling rate measured with the standard screen in the fish screen slot in 1975. In three of the four angles tested (50^{o}, 55^{o} , and 65^{o}) the descaling rate was less than 2%.

2. While insufficient data were obtained to determine the optimum conditions for maximum guiding with minimum descaling, we did determine that the average descaling rate for chinook salmon and steelhead trout was lowest when the new screen was operated in the fish screen slot.

3. Mechanical problems must be resolved before significant tests can be accomplished.

Fall Tests

Mechanical problems that were prevalent throughout the spring test period were resolved during the summer by Corps of Engineers personnel. Therefore, a full-scale program to evaluate the new screen was undertaken during October and November (See Appendix Tables 5 and 6 for experimental design). The objective was to determine optimum screen placement and configuration to minimize descaling and maximize guidance of fingerlings.

Test fish recovered from groups released in the turbine intakes provided data on descaling and guiding during the following test conditions:

1. New screen backed with 48% open area perforated plate--variables tested included screen angle, turbine load, screen lighting (on or off), and area of operation (bulkhead or fish screen slot).

2. New screen, modified with 33% open area perforated plate--turbine load (155 megawatts), light condition (On), and area of operation (BHS) were held constant, but the screen angle was varied from 45 to 65^{o} in 5^{o} increments.

Procedures.--Test fish were hatchery-reared pre-smolt spring chinook salmon tattooed in lots of 150 fish each. Each release (replicate) was made up of one lot; three replicates totaling 450 fish made up a test group.

Each lot of fish was introduced into the turbine intake through a 3-inch hose placed behind the trash rack and held in place (by cable) about 15 feet upstream from the traveling screen and 4 to 6 feet from the intake ceiling (Figure 1). Video observations were made by placing the camera and its light source on the truss near the top center of the screen. (In previous tests the camera was mounted near the center of the screen; however, clearance was reduced in the new design so that this was not practical.) Direct observations were made via a remote monitor, and observations were also taped for later analysis. Video observations were made only on selected tests when screen lights were on so the TV light source would have minimal influence on fish behavior.

Lighting for the new adjustable angle screen was provided by an array of twelve 500 watt incandescent bulbs attached to a framework welded to the back side of the screen. Lights were spaced so that the entire screen was illuminated. No illumination was provided at the slot entrance.

During tests, the orifices in the test slot were closed to prevent egress of fish. Tests were evaluated by dipnetting the slot after each test group (3 lots) was released. The number recovered compared to number released provided the guiding efficiency. All fish recovered were examined for descaling and the standard descaling rate was determined.

Results--adjustable angle screen modified with 48% plate.--From the outset of the tests it was apparent that the test fish were good quality, healthy animals. Consequently, recoveries were high and fish responded to various conditions presented to them.

A composite of 30 test results ranked by average percent recovery is given in Table 7. Pertinent findings include the following:

1. Best guidance and least descaling occurred with a lighted screen in the bulkhead slot at screen angles of 50 to 65^{o} (rankings 1 to 8). Recovery rate averaged 85% and descaling rate was nil.

2. In the bulkhead slot, guidance was independent of turbine load but depended on lighting condition and screen angle. With screen lights off, guidance declined to 75% and descaling increased slightly (rankings 9, 10, 12 to 14, 17 to 20, 23, and 25). There were no significant differences among screen angles from 50 to 65^{o}, but guidance at 45^{o} (the traditional angle of operation for standard screens) was significantly less effective--68% vs 85% (rankings 11, 20, 23, and 25).

3. Poorest guidance occurred when the screen was in the fish screen slot. With lights off, average recovery rate was 64% (rankings 16, 21, 22, 24, 26, and 27). When screen lights were on, guidance declined significantly to 48% (rankings 28, 29, and 30).

Table 7.--Results of tests using a modified adjustable angle traveling screen with a 48% perforated plate at a wide range of operating conditions.

Order of results	Average recovery (%)	Average descaling (%)	Screen angle (degree)	Turbine load (megawatts)	Light condition	Slot
1	87.55	0	50	155	ON	BHS
2	87.35	0	65	155	ON	BHS
3	86.51	0	60	155	ON	BHS
4	85.33	0	55	125	ON	BHS
5	84.67	0	60	125	ON	BHS
6	84.22	0	50	125	ON	BHS
7	83.56	0	65	125	ON	BHS
8	78.89	0.6	55	155	ON	BHS
9	78.67	0	60	125	OFF	BHS
10	77.78	0	60	155	OFF	BHS
11	77.68	0	45	125	ON	BHS
12	76.89	0	50	125	OFF	BHS
13	75.78	0.3	50	155	OFF	BHS
14	74.80	0.7	65	125	OFF	BHS
15	73.77	0	65	125	OFF	FSS
16	73.55	1.2	45	125	OFF	FSS
17	73.3	1.2	65	155	OFF	BHS
18	71.3	0.43	55	125	OFF	BHS
19	70.17	1.9	55	155	OFF	BHS
20	69.33	1.8	45	155	ON	BHS
21	66.65	0.3	60	155	OFF	FSS
22	66.4	1.6	55	125	OFF	FSS
23	64.66	1.3	45	125	OFF	BHS
24	59.97	0	45	155	OFF	FSS
25	59.5	4.3	45	155	OFF	BHS
26	59.1	0	55	155	OFF	FSS
27	57.79	0	65	155	OFF	FSS
28	49.99	0.5	45	155	ON	FSS
29	48.22	0	55	155	ON	FSS
30	46.09	0.5	65	155	ON	FSS

4. Video observations indicated that fish were capable of swimming in all directions near the screen; suggesting that the prolonged activity in the vicinity of the screen could ultimately lead to fish being descaled or perhaps swimming back to the forebay.

5. Turbine load did not have a significant effect on either guiding or descaling with screens in the bulkhead slot. For example, when operating in the bulkhead slot with screen lights on, the average recovery was 82% and 83% at 155 and 125 megawatts, respectively. Descaling was negligible at both loads. The effect of turbine load on guidance in the fish screen slot was not clear.

Results--adjustable angle screen modified with 33% plate.--Results from the five conditions tested are summarized in Table 8. Guidance was good (average 82%) at all angles tested, and no significant difference could be measured when the results were compared to results obtained while using the 48% plate under similar conditions.

Orifice Bypass

At Lower Granite Dam the bypass normally functions with two 8-inch lighted orifices open from each gatewell slot. The orifices are located near each corner of the upstream side of the bulkhead slot and near each corner of the downstream side of the fish screen slot. Observations in 1975-76 indicated that egress from the gatewell slots was excellent and no accumulation of fingerlings occurred.

In 1976, in a series of replicated experiments, we tested orifice passage efficiency for lighted vs unlighted 8-inch orifices and lighted

Table 8.--Results of tests using a modified adjustable angle traveling screen with a 33% perforated plate at selected operating conditions.

Order of results	Average recovery (%)	Average descaling rate (%)	Screen angle (degree)	Turbine load (megawatts)	Light condition	Slot
1	86.1	0.3	55	155	ON	BHS
2	84.0	0.3	50	"	"	"
3	82.9	0	60	"	"	"
4	79.9	0.3	45	"	"	"
5	78.9	0	65	"	"	"

vs unlighted 6-inch orifices in the bulkhead slot of unit 2A. Inserts were used to reduce the diameter of existing orifices to 6 inches, and a special trap was designed to capture fish for enumeration. Operations were conducted at night when most fingerlings move out of the gatewells. The objective was to determine which conditions should be used for future operations at Lower Granite Dam. In addition, the information obtained may be applicable to future design criteria for orifices at other dams.

Our tests indicated that 8-inch diameter orifices were more efficient at passing fish than were 6-inch diameter orifices. We also found that lighted orifices were more efficient than unlighted orifices. We concluded that for future work at Lower Granite Dam, two lighted 8-inch diameter orifices should be used for maximum passage.

Recommendations

Traveling Screens

1. Further tests should be scheduled to determine the optimum screen angle and perforated plate backing for adjustable angle screens operating in both the bulkhead slot and the fish screen slot.

2. Adjustable angle screens (3) and standard screens (1) should be fitted with lights, and tests should be scheduled to determine if they enhance guiding of naturally migrating juvenile chinook salmon and steelhead trout.

3. We should continue to monitor the descaling rate for all juvenile salmonids associated with traveling screens at the dam.

Orifice Bypass

1. For maximum fish passage efficiency, orifices, regardless of their size, should be lighted.

2. Additional research is needed to optimize orifice configuration under a variety of conditions.

RESEARCH - LITTLE GOOSE DAM

MASS TRANSPORTATION EXPERIMENTS

Mass hauling of juvenile salmonids was begun in 1975 but only as an emergency measure. Transported fish were not marked, thus preventing any assessment of their contribution to the ensuing adult runs. Further research was scheduled for the 1976 outmigration period. The objective of the transport research at Little Goose Dam in 1976 was to initiate a mark and release study to evaluate the potential of mass hauling juvenile chinook salmon and steelhead trout to increase their survival.

Experimental Design and Procedures

In 1976, mass transportation research began at Little Goose Dam on April 16. Transportation of fingerlings throughout the migration period was limited because only units 2 and 3 had vertical and traveling screens in place for diverting fish into the bypass collection system. Both juvenile chinook salmon and steelhead trout were marked and released in three lots: one lot (a control) was transported to and released at Central Ferry above Little Goose Dam, and the other two lots (test) were transported to and released at the sites below Bonneville

Dam--one lot hauled in fresh water and one lot hauled in 10 ppt salt water. Fish that were not a specific part of the mass transport evaluation were transported and released unmarked. Different wire codes and brands identified time and location of release.

Handling, marking, and transport operations were similar to those used at Lower Granite Dam; however, loading operations were significantly different. Fingerlings were transferred either from the raceways into a transport truck or into the marking building via a fish loading hopper. The hopper held 175 gallons of water and fish (about 2000 fish), and was lifted from the raceway and emptied in about 30 seconds. This transfer method appeared to work better than the pumping system previously used; but a gravity flow system, such as employed at Lower Granite Dam, is definitely superior to either system used at Little Goose Dam.

Rate of descaling, incidence of gas bubble disease, and the amount of delayed mortality were the criteria used to evaluate the quality of fingerlings hauled from Little Goose Dam.

Numbers and Condition of Smolts Transported

About 850,000 salmonids were counted at the fingerling facility at Little Goose Dam in 1976: 561,907 chinook salmon, 280,686 steelhead trout, 4,324 sockeye salmon and 168 coho salmon. Of these, 188,088 chinook salmon, 129,710 steelhead trout, 1,506 sockeye salmon and 168 coho salmon were marked for the mass transportation experiment (Table 9). (See Appendix Tables 7 and 9 for more details of marking

Table 9.--Summary of fingerlings collected at Little Goose Dam, marked, and then transported to Bonneville Dam (test) or released at Central Ferry (control), 1976.

Release site	Transport medium	Chinook	Steelhead
Bonneville - Boat Ramp	Salt water	45,244	11,677
Bonneville - Boat Ramp	Fresh water	36,239	10,667
Bonneville - Powerhouse	Salt water	31,311	41,446
Bonneville - Powerhouse	Fresh water	32,366	32,514
Central Ferry (control)	Fresh water	42,928	33,406
Total Marked		188,088	129,710

by test group.) The following numbers of fingerlings were transported unmarked: 255,295 chinook salmon, 112,872 steelhead trout, 2,818 sockeye salmon. Table 10 shows the release locations and transport conditions for the unmarked juveniles.

At Little Goose Dam, descaling, gas-bubble disease, and stresses placed on juveniles because of the inefficient orifice bypass system continued to thwart collecting fish in good condition. As a result, delayed mortality was considerably higher among fingerlings hauled from Little Goose Dam than among those hauled from Lower Granite Dam. Average rate of descaling for chinook was 11.5% and ranged from 0.0 to 34.6%. Assuming descaling of 3.5% by screens, there was 8% descaling from the gatewell to the marking facility; this rate was more than double the 3.5% rate measured at Lower Granite Dam. Delay in exiting from the gatewell contributed substantially to the higher descaling rate as well as to the high incidence of gas bubble disease symptoms (average 51.7%, range 12 to 80.5%) for chinook salmon. On April 26, near the peak chinook migration, the dissolved N_2 level was 118% in the forebay at Little Goose Dam. Poor passage through gatewell orifices coupled with N_2 levels in excess of 115% apparently created a potential gas bubble disease problem for chinook salmon at Little Goose Dam.

Mortality during transport to the Bonneville boat ramp showed a marked difference between saltwater and freshwater hauls. Average transport mortality for chinook salmon hauled in salt water was 0.04% compared to 0.56% in freshwater hauls. Average transport mortality for steelhead trout was 0.06% for saltwater and 0.47% for freshwater hauls. This is lower than the mortality observed last year for

Table 10.--Summary of fingerlings collected at Little Goose Dam and transported unmarked below Bonneville Dam, 1976.

Release site	Transport medium	Chinook	Steelhead
Bonneville - Boat Ramp	Salt water	59,866	5,463
Bonneville - Boat Ramp	Fresh water	57,658	13,641
Bonneville - Powerhouse	Salt water	61,478	34,037
Bonneville - Powerhouse	Fresh water	76,293	58,731
Total hauled unmarked		255,295	111,872

both chinook salmon (4.7%) and steelhead trout (1.1%), when all fingerlings were transported in fresh water.

Delayed mortality of fish was compared among the following: (1) marked and unmarked chinook salmon, (2) marked and unmarked steelhead trout, and (3) freshwater and saltwater loads. Samples of fish obtained from loads transported to Bonneville Dam were held for 45 hours to determine delayed mortality.

Delayed mortality of marked chinook salmon hauled in salt water ranged from 0 to 14.7% with an overall average of 4.1%; while delayed losses of marked chinook hauled in fresh water ranged from 0 to 10.0%, with an overall average of 6.1%. Delayed losses of unmarked chinook salmon hauled in salt water ranged from 0 to 19.0%, with an overall average of 4.3%; while delayed losses from unmarked chinook salmon hauled in fresh water ranged from 0 to 17.8%, with an average of 3.2%.

Delayed mortality of steelhead trout occurred in only one load during the season. In that load (a saltwater haul) the delayed loss of marked steelhead was 3.3% and the delayed loss of unmarked steelhead was 6.0%. The overall average was 0.29% for marked steelhead and 0.13% for unmarked steelhead.

Among both species, losses from unmarked fish were the same or slightly less than losses from marked fish. These small differences are probably significant since unmarked fish were loaded from raceways without inspection and included substantial numbers of descaled fish; whereas, the marked groups were inspected individually and descaled fish were not marked. The delayed mortality rates of 3 to 6% for chinook salmon and 0.1 to 0.3% for steelhead trout are much lower than the delayed losses for chinook salmon (14.4%) and steelhead trout (0.6%) mass-hauled last year. These data indicate that the changes in loading procedures from a fish pump to a fish loading hopper system were beneficial in reducing stresses. Even so, the rate is still more than double the delayed mortality measured on fish hauled from Lower Granite Dam.

Fingerlings hauled from Little Goose Dam will continue to be of poorer quality than those hauled from Lower Granite Dam until the fingerling bypass is brought up to the quality of the bypass at Lower Granite Dam and a gravity flow system to load fish is provided.

The Corps of Engineers is funding research in 1977 to examine methods of improving the bypass at Little Goose Dam. A modified bypass with a gravity fish loading system is scheduled to be in operation by the spring of 1978.

RETURN OF ADULTS FROM THE 1975 OUTMIGRATION

The adult collection facility at Lower Granite Dam was tested in the fall of 1975 and the spring of 1976. Although some fish were trapped, the system did not function as planned (a proposal for modification has been forwarded to the Corps). Therefore, adult chinook salmon and steelhead trout originally transported from Lower Granite Dam as juveniles and returning after one year at sea were collected and evaluated at the trapping facility at Little Goose Dam.

Only a preliminary evaluation of the benefits of transporting juveniles from Lower Granite Dam is possible at this time. To date, 75 chinook salmon and 260 steelhead trout have returned. The transport benefit ratio is 3.0 to 1 for chinook salmon and 2.5 to 1 for steelhead trout. It should be emphasized that returns are preliminary as only one-ocean fish have returned.

Although the transport benefit ratio for jack chinook salmon isn't as great as was the benefit ratio based on jack returns from the 1973 release (ratio 16 to 1), the percentage of jack return from the 1975 transported groups is about double the return of the best previous return (1973 release-Little Goose experiments). See Figure 2.

It appears that transportation of juveniles from Lower Granite Dam will be at least as effective as transportation from Little Goose Dam. In fact, because the fish are collected in better condition and new techniques such as air transportation (chinook salmon only) and hauling in salt water are available, survival will probably be increased.

RETURN OF ADULTS FROM THE 1973 OUTMIGRATION

Returns to the adult trap at Little Goose Dam from the 1973 control and transport releases of chinook smolts marked at Little Goose Dam are complete with the exception of a few 4-ocean age fall chinook salmon. The combined adult returns from the 1973 release indicate a much higher survival from transport releases than from control releases. Returns from the fish released at the Bonneville site indicated a transport to control benefit of 1187% (ratio 12.8 to 1); returns from the fish released at the Dalton Point site indicated a benefit of 1637% (ratio 17.4 to 1) (Table 11).

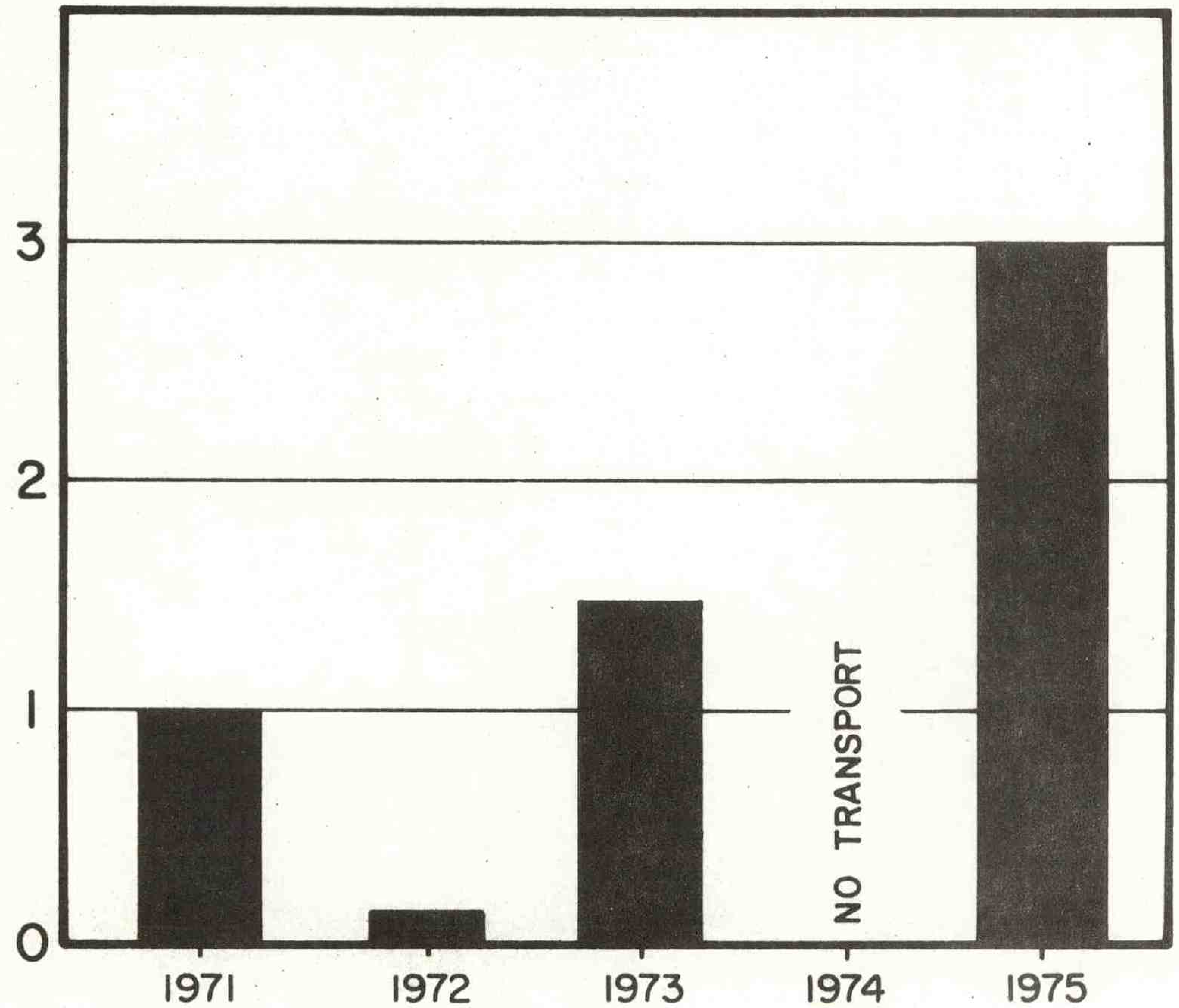


Figure 2.--Relative rate of return of 1-ocean chinook salmon transported as smolts from Little Goose Dam (1971-73), and from Lower Granite Dam (1975).

Table 11.--Returns to Little Goose Dam of 1, 2 and 3-ocean chinook salmon from control and transport releases of smolts in 1973. Recovery period April 1974 to August 1976.

Release site and experimental groups	Number of juveniles released 1/	Number of adults recaptured				Observed adult return in % of juveniles released	Transport benefits 2/ (%)
		1-ocean age	2-ocean age	3-ocean age	Total (1+2+3's)		
Little Goose Dam (control)	88,170	3	11	7	21	.024	
Bonneville Dam (transport)	83,606	34	142	82	258	.309	1187
Dalton Point (transport)	57,758	35	130	76	241	.417	1637
TOTAL	229,534	72	283	165	520		

1/ Adjusted for initial tag loss.

2/ Based on observed return

Returns of chinook salmon to Little Goose Dam were also compared by seasonal migrations: spring, summer, and fall run chinook salmon. Returns from the Bonneville Dam release showed a transport benefit of 1800% for spring chinook salmon, 709% for summer chinook salmon, and 1000% for fall chinook salmon. Similarly, returns from the Dalton Point releases showed a transport benefit of 2327% for spring chinook salmon and 1272% for summer chinook salmon. Due to the timing of the fall chinook salmon smolt migration past Little Goose Dam, it is doubtful that any were transported to the Dalton Point release site.

Returns to Little Goose Dam of 1, 2, and 3-ocean age adult steelhead trout from control and transport releases of smolts in 1973 are complete, and a total of 1279 steelhead trout have been identified. Only 84 adults returned in 1976; therefore, the major analysis was presented in last year's report. Benefits from transportation continued to remain high for the returning 2-ocean age steelhead trout. Total returns from the 1973 releases showed a transportation benefit of 1231% (or about a 13.3 to 1 ratio) for the Bonneville releases and 1237% (or about 13.4 to 1 ratio) for the Dalton Point releases.

DISSOLVED GAS (N_2) STUDIES - 1976

The program for bi-weekly monitoring of dissolved gas concentrations in the lower Snake and Columbia Rivers was similar to last years. In addition, intensive N_2 sampling was carried out to evaluate the effectiveness of newly installed spill deflectors on the spillways of Little Goose and McNary Dams.

MONITORING OF N_2 SUPERSATURATION

Dissolved gases (N_2 and O_2) and water temperatures were measured every two weeks from April 12 to August 2. Water samples were collected at reservoirs from Lower Granite Dam on the Snake River downstream to Bonneville Dam and at lower river sampling sites near Washougal, WA, and Prescott, OR, on the Columbia River. Collections were also made immediately downstream from Ice Harbor, McNary and Bonneville Dams. Samples were collected by aircraft in a one-day period, and gas analysis was accomplished the following day. Total dissolved gas pressure measurements were also taken by saturometer at 3 or 4 of the sampling sites for comparison with gas chromatograph values.

Water flows this spring were moderately high (up to 192 kcfs in the Snake River and 404 kcfs on the Columbia River), yet N_2 supersaturation was less than observed in previous years with similar river conditions (Appendix Table 10). N_2 concentrations in the Snake River seldom reached 130% of saturation, and averaged only 123% during the freshet (April 26 - June 21); whereas, in comparable years before installation of spill deflectors, nitrogen concentrations were near 140% of saturation. Concentrations of dissolved gasses in the Columbia River were also less than in years past with gas concentrations throughout most of the lower river seldom going above 115% of saturation. Concentrations in the Bonneville Dam tailrace were slightly less than observed before spill deflectors were installed, but saturation percentages were still in the 130's during heavy spill conditions.

EFFECT OF SPILL DEFLECTORS AT LITTLE GOOSE DAM

N_2 measurements were made on March 22 below the spillway at Little Goose Dam during spill discharges of 30, 60, 85, and 120 kcfs. Six spill bays with deflectors were used at uniform gate openings for each discharge level. N_2 saturation values obtained during these tests ranged from 110% to 133% of saturation depending on spill discharge (Appendix Table 11). Prior to installation of deflectors, with spill of 30 to 120 kcfs, N_2 saturation values would have been 121% to >145% (data from 2/12 and 5/15/72)--about 10 to 15% higher.

N_2 values from the forebay of Lower Monumental Dam were also compared. These values represent mixed spillway and powerhouse discharges from Little Goose Dam. At river flows of 123 to 169 kcfs (spill discharge approximately 57 to 100 kcfs) deflectors reduced N_2 values about 10% (138% to 128%).

When saturation values obtained below spillway deflectors at Lower Monumental and Lower Granite Dams were compared to values obtained below Little Goose Dam, we found that the values at Little Goose Dam were slightly higher (2 to 8%) throughout the range of flows tested. This difference is probably due to a deeper stilling basin below the spillway at Little Goose Dam and smaller spill deflectors (8 feet in length compared to 12 feet at Lower Monumental and Lower Granite Dams).

EFFECT OF SPILL DEFLECTORS AT MCNARY DAM

An extensive N_2 analysis program was carried out at McNary Dam from April thru July to define the effects of the block of spill deflectors installed on 18 of the 22 spill bays. The wide range of conditions tested included the following: (1) single vs multiple bay spill discharges; (2) light, moderate, and heavy spill; (3) uniform vs non-uniform gate opening patterns; (4) low and high N_2 concentrations in the forebay; and (5) cold and warm water temperatures.

The following discussion is based on averaged N_2 values measured under specific conditions (Table 12). Individual datum points can be observed in Appendix Table 12.

Comparison of N_2 measurements between deflector and standard single bay discharges showed a 10 to 16% benefit from the deflector, but as observed previously all values were lower than observed during multiple bay spill discharges with the same flow per bay (Table 12). N_2 measurements from single bay discharges have provided a relative measure of the effects of deflectors for each dam tested except Bonneville Dam. However, efforts to extrapolate single bay measurements to accurately predict benefits from multiple bays with deflectors have not been successful.

Supersaturation increased with volume of flow during all tests and the highest saturation value recorded (128%) was measured during the highest spillway flow tested (249 kcfs). In years prior to installation of deflectors, nitrogen concentrations in the tailrace were commonly 140% of saturation at discharges near 250 kcfs. Comparisons of bi-weekly sampling data collected below the McNary spillway this year with previous years data shows a decrease of 16 to 20% through the spill discharge range of 97 to 200 kcfs.

Table 12.--Spill deflector tests, including dates, test conditions, and average N_2 values for forebay and spillway tailrace at McNary Dam - 1976.

Date Mo/Day	Water temp. (°C)	Forebay N_2 (% sat)	No. of bays spilling	Gate opening pattern	Spill flow rate (kcfs)	Tailrace N_2 avg. (% sat)
4/ 7	7.0	107	1	Bay w/ deflector	5	108.2
4/ 7	7.0	107	1	"	7	109.2
4/ 7	7.0	107	1	"	9	110.2
4/ 7	7.0	107	1	"	14	112.3
7/15	17.0	114	1	"	4	114.5
7/15	17.1	114	1	"	7	116.8
7/16	17.2	113	1	"	9	113.4
7/16	17.2	113	1	"	14	114.8
4/ 7	7.0	107	1	Bay w/o deflector	5	124.3
4/ 7	7.0	107	1	"	7	122.6
4/ 7	7.0	107	1	"	9	121.6
4/ 7	7.0	107	1	"	14	125.1
7/15	17.0	114	1	"	4	126.0
7/15	17.1	114	1	"	7	126.5
7/16	17.3	113	1	"	9	125.7
7/16	17.3	113	1	"	14	126.9
4/14	8.8	110	18	Uniform gate opening	72	114.1
4/13	9.0	117	18	"	160	121.1
4/14	8.8	110	18	"	248	126.1
4/14	8.8	110	22	ODFW 1/	72	112.8
4/13	8.9	110	22	ODFW	165	121.6
6/ 9	13.6	119	22	ODFW	75	117.1
6/ 9	13.7	119	22	ODFW	163	123.2
6/10	13.6	118	22	ODFW	249	128.3
7/15	17.3	114	22	ODFW	72	114.4
7/15	17.3	114	22	ODFW	165	118.8
7/15	17.3	114	22	ODFW	249	123.8
5/10	11.8	115	22	ODFW	143	117.3 2/
5/24	12.4	112	22	ODFW	186	121.0 2/
6/21	15.1	115	22	ODFW	97	117.7 2/
7/ 5	16.2	116	22	ODFW	103	122.2 2/

1/ ODFW = gate openings set by Oregon Department of Fish and Wildlife for best water flows to attract adult fish to fish ladder.

2/ Data from bi-weekly monitoring selected for spill flows >90 kcfs. Sampling site 1 mile downstream and near the shore on the spill side of the river.

Uniform gate openings using only bays with spill deflectors created slightly less supersaturation (0 to 2%) than non-uniform gate openings using all spillbays (Table 12). The non-uniform patterns were set using O.D.F.W. operational criteria for the best flows to attract adult fish to entrances of fish ladders.

Comparison of effects between low and high forebay concentrations when spill discharge was constant indicates that N_2 levels in the tailrace increased up to 4% when forebay N_2 increased from 110 to 119%.

Differences associated with water temperature variations were undefinable due to increases in forebay N_2 levels.

As indicated by these data and data from prior testing at Lower Monumental and Lower Granite Dams, spill deflectors have significantly decreased the level of supersaturation in the Snake and Columbia Rivers and should increase the survival of migrating juvenile salmonids.

SUMMARY

1. The mass transport concept was broadened to include hauling from Lower Granite Dam. A total of 1.2 million salmonids were hauled from Lower Granite and Little Goose Dams to Bonneville Dam or the estuary (air transport) in 1976.

2. Transportation from Lower Granite Dam included a continuing investigation of trucking to provide a means of increasing survival of smolts collected at the upper dam. A new concept of transporting fingerling chinook salmon by air was begun. Testing the two transport systems resulted in marking 238,974 chinook salmon and 165,828 steelhead

trout which were released in various locations. About one-half of the fish released below Bonneville Dam were transported in 5 ppt salt water. A significant reduction of delayed mortality after transport was achieved by using salt water.

3. Research was conducted at Lower Granite Dam to determine if fish disease was of significant magnitude to influence survival of transported chinook salmon smolts in 1976. In addition, about 1200 chinook salmon fingerlings were transported to and held directly in seawater to determine if any freshwater diseases were contributing to delayed mortality after the fish reached salt water. The combined results of the studies indicate that contagious diseases were not a serious factor influencing survival among transported chinook salmon in 1976.

4. Descaling or injury of chinook salmon smolts was monitored at the marking buildings at Lower Granite and Little Goose Dams. The descaling rate was 7% and 11.5%, respectively, indicating that steps need to be taken to reduce descaling--especially at Little Goose Dam.

5. Descaling attributed to standard traveling screens was monitored at Lower Granite Dam. The descaling rate was about 3.5%, which is down from the 6.4% reported last year.

6. A new adjustable angle traveling screen was tested at Lower Granite Dam. Spring tests were limited because of mechanical problems, but full-scale tests were accomplished in October-November. Best guidance and least descaling (hatchery-reared spring chinook) occurred

with a lighted screen in the bulkhead slot at screen angles 50 to 65°. Average recovery was 85% and descaling was nil. With screen lights off, guidance decreased to 75% and descaling increased slightly. Guidance at 45°, the angle used on the standard screens, was significantly less effective than the other angles tested (50 to 65°). Poorest guidance occurred with the screen in the fish-screen slot. Turbine load (155 vs 125 megawatts) did not have a significant impact on guidance in the bulkhead slot. In the fish screen slot, better guidance was noted at 125 megawatts, but significance is doubtful since fewer tests were made.

7. Tests were conducted to determine the best orifice operating condition to provide egress of fingerlings from the gatewells at Lower Granite Dam. We concluded that both 8-inch orifices should be used with the orifice light on.

8. At Little Goose Dam mass transportation of smolts was emphasized. Further testing of transportation of fingerlings in salt water (10 ppt) was accomplished. About 850,000 fingerlings were counted, of which 188,000 chinook salmon and 129,000 steelhead trout were marked for mass transport (truck) experiments. The overall delayed mortality was down significantly from the 12% delayed mortality reported last year. Average delayed mortality of chinook salmon hauled in fresh water was 3 to 6% vs 4% for smolts hauled in salt water; no significant reduction of delayed mortality could be detected for smolts hauled in salt water. However, average transport mortality for chinook salmon and steelhead trout was noticeably lower in saltwater hauls than in freshwater hauls (<.1% mortality in salt water vs about .5% in fresh water).

9. Adults returning from smolts released from tests at Lower Granite Dam in 1975 and from similar studies at Little Goose Dam in 1973 were captured at the trap facilities at Little Goose Dam. Returns of one-ocean chinook salmon and steelhead trout (75 and 200, respectively) from smolts transported from Lower Granite Dam in 1975 indicate a transport benefit ratio of 3.0 to 1 for chinook salmon and 2.5 to 1 for steelhead trout. Return of adults from releases of smolts from Little Goose Dam in 1973 are virtually complete. The transport benefit ratio for chinook salmon is 12.8 to 1 and 13.3 to 1 for steelhead trout. Transport from Lower Granite and Little Goose Dams is continuing to be encouraging as a solution for smolt passage problems on the lower Snake River.

10. Dissolved gas concentrations in the lower Snake and Columbia Rivers were monitored again this year. In addition, intensive N_2 sampling was carried out to evaluate the effectiveness of newly installed spill deflectors at Little Goose and McNary Dams. Concentrations of dissolved gasses in the Snake and Columbia Rivers were generally less than observed in previous years with similar river conditions. The spillway deflectors installed at Little Goose and McNary Dams were effective at reducing dissolved gas concentrations over a wide range of flows.

Appendix Table 1 .--Date, brand position, wire tag code, release location, and number of chinook salmon and steelhead trout released as controls above Lower Granite Dam, 1976.

Date	Brand position 1/ and symbol	Wire 2/ tag color	Release site	Chinook salmon	Steelhead trout
4-13	LA-P	W-O-LtGr	Clarkston, WA	4,181	689
4-14	LA-P	W-O-LtBl	"	4,274	856
4-15	LA-P	W-O-LtGr	"	1,420	559
4-16	LA-P	W-O-LtGr	"	2,909	795
4-20	LA-P	W-O-LtGr	"	2,266	1,943
4-23	LA-P	W-O-LtGr	"	1,747	1,492
4-24	LA-P	W-O-LtGr	"	1,515	1,589
4-28	LA-ᑫ	W-O-LtGr	"	2,725	1,046
4-30	LA-ᑫ	W-O-LtGr	"	2,486	1,912
5-4	LA-ᑫ	W-O-LtBl	"	124	3,197
5-5	LA-ᑫ	W-O-LtGr	"	1,317	4,375
5-10	LA-ᑫ	W-O-LtGr	"	--	2,744
5-11	LA-ᑫ	W-O-LtGr	"	2,934	1,502
5-12	LA-ᑫ	W-O-LtBl	"	129	3,242
5-13	LA-ᑫ	W-O-LtBl	"	527	2,670
5-14	LA-ᑫ	W-O-LtBl	"	76	3,081
5-17	LA-d	W-O-LtBl	"	56	4,031
5-21	LA-d	W-O-LtBl	"	--	3,388
5-24	LA-d	W-O-LtBl	"	--	2,876
			TOTALS	28,686	41,987

1/ LA indicates brand position; left anterior

2/ Colors on wire tags; W-White, O-Orange, LtGr-Light Green, LtBl-Light Blue

Appendix Table 2.--Date, brand position, wire tag code, release location, and number of juvenile chinook salmon and steelhead trout marked and transported by truck in 5 ppt salt water from Lower Granite Dam, 1976.

Date	Brand position and symbol1/	Wire tag color2/	Release site	Chinook salmon	Steelhead trout
4-15	RA-L	W-O-Bl-LtBl	Bonneville boat launch	8,674	14
4-19	RA-L	W-O-Bl-LtBl	"	3,088	5,119
4-27	RA-L	W-O-Bl-LtBl	"	4,063	3,579
4-29	RA-L	W-O-BL-LtBl	"	9,136	--
4-30	RA-L	W-O-Bl-LtBl	"	4,042	--
5-1	RA-L	W-O-Bl-LtBl	"	5,116	--
5-2	RA-⊣	W-O-Bl-LtBl	"	9,248	--
5-5	RA-⊣	W-O-Gr-LtGr	"	2,109	7,792
5-7	RA-9	W-O-L-O	Near ice and trash sluice at Bonneville Dam	1,363	8,006
5-10	RA-9	W-O-L-O	"	--	12,288
5-12	RA-9	W-O-L-O	"	6,505	3,608
5-14	RA-9	W-ROX	"	3,219	5,865
5-15	RA-9	W-ROX	"	2,565	5,418
5-18	RA-ɞ	W-ROX	"	329	6,540
5-24	RA-ɞ	W-ROX	"	1,989	6,287
5-28	RA-ɞ	W-ROX	"	--	4,629
			TOTALS	61,446	69,145

1/ RA indicates brand position; right anterior

2/ Colors on wire tags; W-White, O-Orange, Bl-Blue, LtBl-Light Blue, GR-Green LtGr-Light Green, R-Red, ROX-Red Oxide, L-Lavender

Appendix Table 3.--Date, brand position, wire tag code, release location, and number of juvenile chinook salmon and steelhead trout marked and transported by truck in fresh water from Lower Granite Dam, 1976.

Date	Brand position[1/] and symbol	Wire[2/] tag color	Release site	Chinook salmon	Steelhead trout
4-12	RA-W	W-O-R-ROX	Bonneville boat launch	4,140	177
4-13	RA-W	W-O-R-ROX	"	8,772	788
4-16	RA-W	W-O-R-ROX	"	4,979	2,065
4-22	RA-W	W-O-R-ROX	"	2,789	2,889
4-26	RA-≤	W-O-R-ROX	"	11,800	--
4-28	RA-≤	W-O-R-ROX	"	8,384	1,385
5-3	RA-≤	W-O-Y-YOX	"	6,643	--
5-6	RA-2	W-O-O-O	Near ice and trash sluice at Bonneville Dam	2,405	5,323
5-8	RA-2	W-O-O-O	"	398	7,491
5-11	RA-2	W-O-O-O	"	9,949	1,919
5-13	RA-2	W-O-O-O	"	4,591	4,008
5-17	RA-∾	W-O-O-O	"	2,872	2,656
5-17	RA-∾	W-Pur-Br-ROX	"	56	2,972
5-19	RA-∾	W-BL-ROX	"	359	5,148
5-21	RA-∾	W-BL	"	2,173	5,311
5-26	RA-∾	W-BL	"	870	7,680
6-1	RA-Z	W-BL	"	1,738	4,884
			TOTALS	72,918	54,696

1/ RA indicates brand position; right anterior

2/ Colors on Wire Tags; W-White, O-Orange, R-Red, ROX-Red Oxide, Y-Yellow, YOX-Yellow Oxide, Pur-Purple, Br-Brown, BL-Blue

Appendix Table 4.--Date, brand position, wire tag code, release location, and number of juvenile chinook salmon and steelhead trout transported in 5 ppt salt water by airplane from Lower Granite Dam, 1976.

Date	Brand position[1/] and symbol	Wire[2/] tag color	Release site	Chinook salmon	Steelhead trout
4-21	RA-H	Orange	Beacon Rock	6,822	
4-23	RA-S	White	Near Tongue Point (Estuary)	8,067	
4-27	RA-4	W-Y-Y-LtGr	"	10,341	
4-29	RA-H	W-Pur-Y-Gr	Beacon Rock	10,507	
5-1	RA-H	W-Pur-Y-P	"	10,074	
5-3	RA-ᚦ	W-Pur-Y-YOX	Near Tongue Point (Estuary)	10,727	
5-4	RA-⌶	W-Pur-LtBl-P	Beacon Rock	9,715	
5-6	RA-ᚦ	W-Y-Y-LtBl	Near Tongue Point (Estuary)	9,661	
5-7	RA-⌶	W-Pur-YOX-YOX	Beacon Rock		4,961
			TOTALS	75,914	4,961

1/ RA indicates brand position; right anterior

2/ Colors on wire tags; W-White, O-Orange, Y-Yellow, YOX-Yellow Oxide, LtBl-Light Blue, Pur-Purple, Gr-Green, LtGr-Light Green, P-Pink

Appendix Table 5.--Experimental design covering a wide range of conditions for adjustable angle traveling screens.

Test slot	Turbine load	Screen angle	Light condition	Number fish
Bulkhead slot	155	45°	ON	600
"	155	45°	OFF	600
"	155	50°	ON	450
"	155	50°	OFF	600
"	155	55°	ON	450
"	155	55°	OFF	600
"	155	60°	ON	450
"	155	60°	OFF	450
"	155	65°	ON	450
"	155	65°	OFF	450
"	125	45°	ON	450
"	125	45°	OFF	600
"	125	50°	ON	450
"	125	50°	OFF	450
"	125	55°	ON	450
"	125	55°	OFF	600
"	125	60°	ON	450
"	125	60°	OFF	450
"	125	65°	ON	450
"	125	65°	OFF	600
Fish screen slot	155	45°	ON	450
"	155	45°	OFF	450
"	155	55°	ON	450
"	155	55°	OFF	450
"	155	60°	OFF	450
"	155	65°	ON	450
"	155	65°	OFF	450
"	125	45°	OFF	450
"	125	55°	OFF	450
"	125	65°	OFF	450

Appendix Table 6 .--Experimental design for selected conditions testing the modified adjustable angle screen and various standard screens in the bulkhead slot.

Screen	Screen angle	Turbine load	Light condition	Number fish
New-33% pl	45^{o}	155	ON	450
New-33% pl	50^{o}	155	ON	450
New-33% pl	55^{o}	155	ON	450
New-33% pl	60^{o}	155	ON	450
New-33% pl	65^{o}	155	ON	450
Standard 72-33	45^{o}	155	OFF	450
Standard 72-48	45^{o}	155	OFF	450
Standard 42-33	45^{o}	155	OFF	450
Standard 42-48	45^{o}	155	OFF	450

Appendix Table 7.--Date, brand, brand position, wire tag code, release location, and number of chinook salmon and steelhead trout released as controls above Little Goose Dam, 1976.

Date	Brand position[1/] and symbol	Wire[2/] tag color	Release site	Chinook salmon	Steelhead trout
April 13-26	LA- [illegible]	W-Y-Y-Y	Central Ferry	12,215	4,368
April 27	LA- [illegible]	Solid Lavender	Central Ferry	3,231	--
April 28 - May 7	LA - [illegible]	W-PU-Y-R	Central Ferry	20,443	5,425
May 13 - June 4	LA- [illegible]	Pink stripe	Central Ferry	5,524	21,103
June 6	LA- [illegible]	Pink stripe	Central Ferry	633	2,044
			TOTALS	42,046	32,940

1/ LA indicates brand position; left anterior

2/ Colors on wire tags: W-White, Y-Yellow, PU-Purple, R-Red.

Appendix Table 8 .--Date, brand, brand position, wire tag code, release location, and number of chinook salmon and steelhead trout marked and transported by truck in fresh water from Little Goose Dam, 1976.

Date	Brand position[1/] and symbol	Wire tag[2/] color	Release site	Chinook salmon	Steelhead trout
April 14-27	RA-J	Solid green	Bonneville boat ramp	19,131	5,520
April 28-29	RA-J	W-Y-P-G	"	4,705	1,657
April 30-May 4	RA-ᓚ	Solid green	"	12,403	3,489
			SUB-TOTAL	36,239	10,666
May 6 - June 2	RA-ʃ	Green stripe	Bonneville powerhouse	28,145	29,798
June 9-21	RA-ᓗ	Green stripe	"	4,221	2,823
			SUB-TOTAL	32,366	32,621
			TOTAL	68,605	43,287

1/ RA indicates brand position; right anterior

2/ Colors on wire tags; W-White, Y-Yellow, P-Pink, G-Green

Appendix Table 9 .--Date, brand, brand position, wire tag code, release location, and number of chinook salmon and steelhead trout marked and transported by truck in 10 ppt salt water from Little Goose Dam, 1976.

Date	Brand position[1/] and symbol	Wire tag[2/] color	Release site	Chinook salmon	Steelhead trout
April 15-26	RA-V	Solid yellow	Bonneville boat ramp	16,694	7,114
April 28-30	RA- ⊲	W-Y-PU-G	"	12,731	384
May 1-3	RA- ⊲	Solid yellow	"	12,490	1,796
May 5	RA- ⊲	Yellow stripe	"	4,329	2,383
			SUB-TOTAL	46,244	11,677
May 7-June 3	RA-Λ	Yellow stripe	Bonneville powerhouse	29,755	35,912
June 7-18	RA- ⊳	Yellow stripe	"	6,083	6,285
			SUB-TOTAL	35,838	42,197
			TOTAL	82,082	53,874

1/ RA indicates brand position; right anterior

2/ Color on wire tag; W-White, Y-Yellow, PU-Purple, G-Green.

Appendix Table 10.--Bi-weekly measurements of dissolved gas saturation and temperature for the Columbia and Snake Rivers April-August, 1976

April 12, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1600	0	7.8	11.70	101.1	15.92	104.5	768.0	103.7	7	0.0	0.0	740	0	0
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1605	33	7.8	11.47	99.0	15.67	102.8	755.1	102.0	7	85.0	155.0	740	84	153
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1515	0	8.9	13.17	116.4	17.96	120.4	886.5	119.3	7	0.0	0.0	638	0	0
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1520	33	8.9	13.43	118.7	18.33	122.9	904.5	121.7	7	84.0	149.0	638	84	149
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1435	0	8.4	13.97	121.5	18.89	124.7	923.0	123.7	8	0.0	0.0	540	0	0
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1440	33	8.4	14.03	122.0	18.89	124.7	923.8	123.8	8	81.0	147.0	540	79	145
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1400	0	9.0	13.30	117.0	18.05	120.4	893.9	119.4	9	0.0	0.0	440	0	0
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1405	33	9.1	13.57	119.6	18.42	123.2	914.0	122.1	9	60.0	143.0	440	74	152
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1330	0	8.7	13.17	114.6	17.13	113.1	850.2	113.2	13	43.0	242.0	340	69	238
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1335	33	8.5	13.30	115.2	17.03	112.0	844.7	112.4	13	43.0	242.0	340	69	238
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1320	0	9.0	12.77	111.9	17.13	113.8	850.6	113.2	13	43.0	242.0	340	69	238
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1325	33	9.0	12.89	113.0	17.50	116.3	866.6	115.4	13	43.0	242.0	340	69	238
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1310	0	8.7	13.01	112.9	17.25	113.6	852.7	113.2	13	43.0	242.0	270	69	238
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1300	0	8.7	12.77	110.8	17.03	112.2	841.3	111.7	13	43.0	242.0	270	69	238
JOHN DAY FOREBAY 1/4 MI UP CNTR	1030	0	8.1	11.70	100.1	15.55	101.0	759.1	100.8	0	0.0	256.0	265	31	239
JOHN DAY FOREBAY 1/4 MI UP CNTR	1035	33	8.1	11.84	101.3	15.83	102.8	771.5	102.4	0	0.0	256.0	265	31	239
THE DALLES FOREBAY 1/4 MI UP CENTER	1000	0	7.9	12.24	103.8	16.11	103.8	783.9	103.7	0	0.0	217.0	160	64	225
THE DALLES FOREBAY 1/4 MI UP CENTER	1005	33	8.1	12.24	104.3	16.01	103.7	783.9	103.7	0	0.0	217.0	160	64	225
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	925	0	8.0	11.97	101.5	15.83	101.9	771.6	101.7	18	88.0	223.0	74	98	231
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	930	33	8.1	12.24	104.0	16.11	103.9	787.5	103.8	18	88.0	223.0	74	98	231
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	915	0	8.3	14.23	121.3	19.31	125.0	940.5	123.8	18	88.0	223.0	18	98	231
COLUMBIA RIVER PRESCOTT CENTER	830	0	8.7	12.72	109.4	16.85	110.0	833.4	109.7	0	0.0	0.0	14	0	0

April 26, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1546	0	10.0	10.87	99.0	15.22	104.9	767.1	103.6	8	60.0	118.0	740	59	117
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1546	33	9.9	10.83	98.3	15.23	104.7	765.0	103.3	8	60.0	118.0	740	59	117
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1510	0	9.9	12.03	108.9	16.76	114.8	842.6	113.4	8	77.0	116.0	638	62	116
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1510	33	9.7	12.03	108.4	17.16	117.1	854.8	115.0	8	77.0	116.0	638	62	116
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1440	0	9.7	12.98	116.5	18.03	122.6	902.4	121.0	8	55.0	112.0	540	61	113
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1440	33	9.8	12.81	115.2	18.09	123.3	904.6	121.3	8	55.0	112.0	540	61	113
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1406	0	10.2	13.08	118.4	17.96	123.0	911.1	121.7	9	29.0	114.0	440	40	117
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1406	33	9.5	12.98	115.5	18.15	122.4	903.1	120.6	9	29.0	114.0	440	40	117
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1209	0	9.0	13.08	114.7	17.49	116.3	869.2	115.7	20	44.0	273.0	340	73	265
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1209	33	8.8	12.87	112.3	17.49	115.8	862.4	114.8	20	44.0	273.0	340	73	265
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1209	0	9.0	13.29	116.5	17.36	115.4	866.8	115.4	20	44.0	273.0	340	73	265
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1209	33	8.8	12.87	112.3	17.02	112.7	844.2	112.4	20	44.0	273.0	340	73	265
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1149	0	9.0	13.08	114.4	17.23	114.2	858.7	114.0	20	44.0	273.0	270	73	265
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1149	0	9.0	12.87	112.6	17.43	115.5	863.7	114.7	20	44.0	273.0	270	73	265
JOHN DAY FOREBAY 1/4 MI UP CNTR	1105	0	9.1	11.92	104.5	16.42	109.1	813.4	108.0	16	32.0	313.0	265	46	266
JOHN DAY FOREBAY 1/4 MI UP CNTR	1105	33	9.1	11.85	103.8	16.42	109.1	812.3	107.8	16	32.0	313.0	265	46	266
THE DALLES FOREBAY 1/4 MI UP CENTER	1038	0	8.8	12.03	104.3	16.56	108.9	814.6	107.7	0	0.0	265.0	160	29	242
THE DALLES FOREBAY 1/4 MI UP CENTER	1038	33	8.8	11.82	102.5	16.29	107.1	801.3	106.0	0	0.0	265.0	160	29	242
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1002	33	8.9	11.70	101.3	15.83	104.0	783.4	103.3	16	119.0	252.0	74	113	246
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1002	0	9.1	14.01	121.7	19.24	126.7	951.7	125.3	16	119.0	252.0	20	113	246
COLUMBIA RIVER WASHOUGAL CNTR	932	0	9.1	12.45	108.2	17.36	114.4	857.2	112.8	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	852	0	9.4	12.17	106.4	16.69	110.6	832.6	109.6	0	0.0	0.0	14	0	0

May 10, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1000	0	11.6	10.82	102.2	14.82	105.7	776.6	104.9	8	105.0	167.0	740	111	174
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1000	33	11.6	10.48	99.0	14.43	102.9	755.6	102.0	8	105.0	167.0	740	111	174
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1053	0	12.5	12.71	122.2	17.29	125.2	923.2	124.2	8	98.0	164.0	638	112	173
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1053	33	11.5	12.40	116.5	17.37	123.1	902.5	121.4	8	98.0	164.0	638	112	173
LWR MCNUMENT FOREBAY 1/4 MI UP CENTER	1132	0	11.6	13.03	122.2	18.02	127.6	940.4	126.1	8	78.0	146.0	540	105	169
LWR MCNUMENT FOREBAY 1/4 MI UP CENTER	1132	33	11.7	13.03	122.5	18.24	129.4	951.4	127.6	8	78.0	146.0	540	105	169
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1216	0	12.0	12.50	118.0	17.44	124.1	916.6	122.4	10	51.0	143.0	440	84	166
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1216	33	12.1	12.61	119.2	17.44	124.3	920.0	122.9	10	51.0	143.0	440	84	166
SNAKE RIVER-MOUTH MOUTH	1237	10	12.3	13.05	123.5	18.38	131.2	969.8	129.1	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1430	0	12.5	13.13	124.9	16.05	115.0	877.5	116.8	22	143.0	349.0	340	194	397
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1430	33	12.0	12.92	121.5	16.27	115.4	874.4	116.4	22	143.0	349.0	340	194	397
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1430	0	12.2	13.03	123.1	16.86	120.0	903.8	120.3	22	143.0	349.0	340	194	397
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1430	33	11.8	12.71	119.0	17.07	120.6	900.7	119.9	22	143.0	349.0	340	194	397
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1500	0	12.3	12.18	115.1	16.49	117.3	877.9	116.6	22	143.0	349.0	270	194	397
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1500	0	12.3	12.29	116.1	16.42	116.9	876.6	116.4	22	143.0	349.0	270	194	397
JOHN DAY FOREBAY 1/4 MI UP CNTR	1600	0	12.0	12.08	113.3	15.98	113.0	850.0	112.8	20	113.0	403.0	265	116	398
JOHN DAY FOREBAY 1/4 MI UP CNTR	1600	33	12.2	12.32	116.0	16.05	114.0	860.0	114.2	20	113.0	403.0	265	116	398
THE DALLES FOREBAY 1/4 MI UP CENTER	1625	0	12.4	12.18	114.9	16.49	117.2	880.0	116.4	22	88.0	409.0	160	132	385
THE DALLES FOREBAY 1/4 MI UP CENTER	1625	33	12.3	12.18	114.6	16.56	117.4	881.2	116.6	22	88.0	409.0	160	132	385
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1650	0	12.4	11.97	112.6	16.35	115.8	870.8	114.8	18	253.0	387.0	74	249	383
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1650	33	12.5	11.97	112.8	16.35	116.0	872.7	115.1	18	253.0	387.0	74	249	383
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1703	0	12.3	13.33	124.8	18.49	130.5	78.1	128.8	18	253.0	387.0	27	240	383
COLUMBIA RIVER WASHOUGAL CNTR	1736	0	12.4	12.82	120.3	17.74	125.4	941.3	123.9	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1800	0	12.6	12.50	117.8	17.15	121.7	915.8	120.5	0	0.0	0.0	14	0	0

May 24, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1627	0	12.1	10.32	98.7	14.03	101.2	745.1	100.6	8	96.0	146.0	740	93	155
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1627	33	11.7	10.64	100.8	14.84	106.0	776.4	104.8	8	96.0	146.0	740	93	155
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1600	0	12.2	12.08	115.3	16.75	120.5	885.4	119.1	8	104.0	163.0	638	96	155
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1600	33	12.0	12.08	114.8	17.01	121.9	892.6	120.1	8	104.0	163.0	638	96	155
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1524	0	12.2	12.66	120.5	17.71	127.0	934.1	125.2	8	84.0	151.0	540	84	147
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1524	33	11.9	12.69	119.9	17.97	128.1	939.4	125.9	8	84.0	151.0	540	84	147
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1500	0	12.3	12.43	118.1	17.18	123.0	910.7	121.7	10	66.0	134.0	440	70	149
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1500	33	12.0	12.43	117.3	17.18	122.3	905.0	120.9	10	66.0	134.0	440	70	149
SNAKE RIVER-MOUTH MOUTH	1445	0	12.5	12.78	121.6	17.71	126.9	941.7	125.4	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1240	0	12.9	12.43	119.3	16.48	119.1	892.5	118.8	22	186.0	371.0	340	200	357
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1240	33	12.3	12.06	114.1	15.70	112.0	843.1	112.2	22	186.0	371.0	340	200	357
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1235	0	12.6	12.31	117.4	16.92	121.5	903.6	120.3	22	186.0	371.0	340	200	357
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1235	33	12.3	12.31	116.6	16.92	120.7	898.0	119.5	22	186.0	371.0	340	200	357
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1208	0	12.4	12.43	117.7	16.97	121.0	903.4	120.0	22	186.0	371.0	270	200	357
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1225	0	12.4	12.31	116.5	16.75	119.4	892.5	118.5	22	186.0	371.0	270	200	357
JOHN DAY FOREBAY 1/4 MI UP CNTR	1124	0	13.4	11.37	110.1	15.17	110.4	829.8	110.2	19	40.0	356.0	265	81	354
JOHN DAY FOREBAY 1/4 MI UP CNTR	1124	33	12.5	11.54	109.4	15.70	112.2	839.0	111.4	19	40.0	356.0	265	81	354
THE DALLES FOREBAY 1/4 MI UP CENTER	1046	0	12.6	12.66	119.9	17.53	125.1	934.5	123.6	22	69.0	337.0	160	102	339
THE DALLES FOREBAY 1/4 MI UP CENTER	1046	33	12.6	12.66	119.9	17.80	127.0	945.5	125.1	22	69.0	337.0	160	102	339
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1025	0	12.5	11.84	111.6	16.13	114.5	861.9	113.7	18	208.0	345.0	74	208	345
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1025	33	12.5	11.84	111.5	15.61	110.8	839.6	110.7	18	208.0	345.0	74	208	345
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1013	0	12.6	13.25	124.9	19.15	136.0	0.0	133.1	18	208.0	345.0	26	208	345
COLUMBIA RIVER WASHOUGAL CNTR	943	0	12.8	12.55	118.8	17.62	125.6	940.3	123.8	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	848	0	13.0	12.19	116.0	17.10	122.4	916.8	120.6	0	0.0	0.0	14	0	0

June 7, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1606	0	14.0	10.38	103.5	14.30	107.2	787.4	106.3	8	65.0	131.0	740	69	131
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1606	33	13.1	10.37	101.4	14.34	105.5	774.2	104.5	8	65.0	131.0	740	69	131
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1536	0	13.3	12.06	118.1	16.33	120.2	887.9	119.5	8	55.0	122.0	638	68	130
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1536	33	12.6	11.94	115.0	16.70	121.2	888.8	119.6	8	55.0	122.0	638	68	130
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1458	0	13.9	12.84	126.9	17.63	130.9	966.3	129.6	8	42.0	109.0	540	59	123
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1458	33	12.6	12.76	122.5	17.81	128.8	947.5	127.0	8	42.0	109.0	540	59	123
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1432	0	15.7	12.71	130.2	17.35	133.1	987.0	131.9	10	36.0	119.0	440	44	123
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1432	33	12.6	12.58	120.4	17.35	125.0	925.5	123.6	10	36.0	119.0	440	44	123
SNAKE RIVER-MOUTH MOUTH	1417	0	13.1	12.58	121.3	17.35	125.9	935.1	124.5	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1240	0	14.2	12.19	120.5	15.41	114.3	866.3	115.3	22	63.0	289.0	340	107	294
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1240	33	13.2	12.19	117.8	15.78	114.7	864.5	115.1	22	63.0	289.0	340	107	294
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1250	0	14.5	12.06	120.0	16.43	122.6	913.8	121.6	22	63.0	289.0	340	107	294
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1250	33	12.8	11.80	113.0	16.61	119.7	886.7	118.0	22	63.0	289.0	340	107	294
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1158	0	13.3	11.55	111.5	15.80	114.8	857.2	113.8	22	63.0	289.0	270	107	294
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1210	0	13.2	12.06	116.3	16.52	119.8	894.0	118.7	22	63.0	289.0	270	107	294
JOHN DAY FOREBAY 1/4 MI UP CNTR	1110	0	13.5	11.42	110.7	15.59	113.8	850.3	112.9	8	16.0	303.0	265	26	301
JOHN DAY FOREBAY 1/4 MI UP CNTR	1110	33	13.3	11.55	111.5	15.96	116.0	864.4	114.8	8	16.0	303.0	265	26	301
THE DALLES FOREBAY 1/4 MI UP CENTER	1045	0	13.2	11.29	108.3	15.50	112.0	839.2	111.0	0	0.0	313.0	160	37	294
THE DALLES FOREBAY 1/4 MI UP CENTER	1045	33	13.2	11.16	107.1	15.50	112.0	837.2	110.7	0	0.0	313.0	160	37	294
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1010	0	13.1	11.29	107.8	15.69	112.7	845.3	111.5	18	169.0	306.0	74	170	308
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1010	33	13.3	11.55	110.8	15.59	112.5	848.7	111.9	18	169.0	306.0	74	170	308
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1000	0	13.3	12.38	118.5	17.48	125.9	941.2	123.9	18	169.0	306.0	24	170	308
COLUMBIA RIVER WASHOUGAL CNTR	931	0	13.2	11.98	114.4	16.33	117.4	884.4	116.4	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	849	0	13.6	11.29	108.8	15.69	113.6	854.0	112.4	0	0.0	0.0	14	0	0

June 21, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR-- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1610	0	14.6	9.69	98.0	13.86	105.1	766.9	103.5	8	94.0	140.0	740	87	138
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	1610	33	14.3	9.75	97.9	14.16	106.7	776.0	104.8	8	94.0	140.0	740	87	138
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1531	0	13.9	11.19	111.0	16.16	120.4	878.0	118.1	8	92.0	137.0	638	78	136
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1531	33	13.5	11.19	110.0	16.32	120.6	877.8	118.1	8	92.0	137.0	638	78	136
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1500	0	14.1	12.05	119.6	17.43	129.9	949.5	127.3	8	64.0	129.0	540	62	127
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1500	33	13.6	12.26	120.3	17.61	129.9	950.7	127.5	8	64.0	129.0	540	62	127
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1437	0	13.9	11.83	116.6	16.95	125.4	922.0	123.2	10	51.0	133.0	440	58	127
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1437	33	13.6	11.73	114.7	17.03	125.2	918.2	122.7	10	51.0	133.0	440	58	127
SNAKE RIVER-MOUTH MOUTH	1411	0	13.9	11.73	115.1	16.70	123.1	909.3	121.0	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1215	0	15.4	11.73	118.9	15.29	116.1	874.4	116.4	21	97.0	337.0	340	154	320
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1215	33	15.1	11.51	116.0	15.21	114.8	862.4	114.8	21	97.0	337.0	340	154	320
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1230	0	14.9	11.30	113.3	15.92	119.8	887.0	118.1	21	97.0	337.0	340	154	320
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1230	33	14.8	11.41	114.2	15.92	119.5	886.9	118.1	21	97.0	337.0	340	154	320
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1154	0	15.4	11.46	115.9	15.54	117.7	881.2	117.0	21	97.0	337.0	270	154	320
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1200	0	15.0	11.19	112.2	15.68	117.9	876.7	116.4	21	97.0	337.0	270	154	320
JOHN DAY FOREBAY 1/4 MI UP CNTR	1111	0	15.8	10.87	110.9	14.49	110.7	832.3	110.5	10	23.0	288.0	265	87	298
JOHN DAY FOREBAY 1/4 MI UP CNTR	1111	33	15.8	10.87	110.9	14.41	110.1	828.7	110.0	10	23.0	288.0	265	87	298
THE DALLES FOREBAY 1/4 MI UP CENTER	1045	0	15.7	10.66	108.1	14.57	110.7	830.8	109.9	0	5.0	326.0	160	65	290
THE DALLES FOREBAY 1/4 MI UP CENTER	1045	33	15.7	10.55	107.0	14.65	111.3	832.7	110.1	0	5.0	326.0	160	65	290
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1015	0	15.4	10.44	104.9	14.65	110.3	826.1	108.9	18	157.0	296.0	74	161	300
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1015	33	15.4	10.55	106.0	14.73	110.9	831.3	109.6	18	157.0	296.0	74	161	300
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1003	0	15.5	12.20	122.6	18.30	138.4	0.0	134.5	18	1570.0	2960.0	23	161	300
COLUMBIA RIVER WASHOUGAL CNTR	933	0	15.4	10.87	109.0	15.36	115.4	864.4	113.8	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	850	0	15.7	10.85	109.4	15.44	116.7	872.7	114.8	0	0.0	0.0	14	0	0

July 5, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	950	0	17.5	10.05	108.0	13.56	108.9	803.8	108.5	8	18.0	69.0	740	24	65
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	950	33	16.2	9.44	98.7	13.66	106.9	778.3	105.1	8	18.0	69.0	740	24	65
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1025	0	17.7	10.92	117.5	14.63	117.5	870.5	117.1	0	16.0	66.0	638	24	66
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1025	33	16.2	10.27	107.0	14.77	115.2	841.9	113.3	0	16.0	66.0	638	24	66
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1045	0	16.5	11.14	116.5	15.42	120.5	889.9	119.3	1	0.0	64.0	540	21	61
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1045	33	15.4	10.92	111.6	15.77	120.7	883.3	118.4	1	0.0	64.0	540	21	61
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1115	0	16.7	10.92	114.3	15.56	121.7	896.2	119.7	0	0.0	61.0	440	0	61
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1115	33	15.6	10.81	110.5	15.63	119.6	878.7	117.4	0	0.0	61.0	440	0	61
SNAKE RIVER-MOUTH MOUTH	1130	0	17.8	11.78	125.6	16.89	134.4	990.4	131.8	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1300	0	17.6	12.35	131.2	15.20	120.5	918.5	122.3	21	103.0	261.0	340	81	231
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1300	33	15.5	11.47	116.6	15.27	116.3	871.6	116.0	21	103.0	261.0	340	81	231
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1310	0	19.3	11.58	127.4	14.85	121.5	917.9	122.2	21	103.0	261.0	340	81	231
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1310	33	15.4	11.36	115.2	15.34	116.6	871.3	116.0	21	103.0	261.0	340	81	231
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1320	0	16.2	11.28	116.0	15.88	122.2	907.4	120.5	21	103.0	261.0	270	81	231
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1330	0	15.7	11.14	113.4	15.34	117.0	872.9	115.9	21	103.0	261.0	270	81	231
JOHN DAY FOREBAY 1/4 MI UP CNTR	1415	0	18.4	10.71	115.3	14.35	115.2	865.0	114.8	14	42.0	203.0	265	33	201
JOHN DAY FOREBAY 1/4 MI UP CNTR	1415	33	16.4	10.16	104.9	14.49	112.0	830.5	110.3	14	42.0	203.0	265	33	201
THE DALLES FOREBAY 1/4 MI UP CENTER	1445	0	16.6	10.38	107.3	14.77	114.2	850.2	112.4	22	46.0	199.0	160	51	194
THE DALLES FOREBAY 1/4 MI UP CENTER	1445	33	16.3	10.39	106.7	14.63	112.4	839.0	111.0	22	46.0	199.0	160	51	194
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1515	0	16.6	10.49	108.1	14.49	111.6	839.0	110.6	18	82.0	218.0	74	86	221
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1515	33	16.6	10.49	108.1	14.49	111.6	839.0	110.6	18	82.0	218.0	74	86	221
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1520	0	16.7	11.10	114.4	15.75	121.4	907.4	119.5	18	82.0	218.0	19	86	221
COLUMBIA RIVER WASHOUGAL CNTR	1545	0	17.2	11.25	117.2	15.20	118.3	893.8	117.7	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1615	0	17.3	10.71	111.7	15.13	117.9	883.3	116.2	0	0.0	0.0	14	0	0

July 19, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	945	0	21.4	9.32	108.4	12.39	106.8	792.1	107.0	0	0.0	42.0	740	8	41
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	945	33	19.2	8.81	98.1	12.81	106.1	772.9	104.4	0	0.0	42.0	740	8	41
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1023	0	20.2	9.22	104.3	12.93	108.7	799.7	107.6	0	0.0	44.0	638	7	41
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1023	33	19.9	9.22	103.7	13.22	110.5	809.3	108.9	0	0.0	44.0	638	7	41
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1045	0	19.5	9.14	101.6	13.04	107.9	793.9	106.4	0	0.0	48.0	540	6	40
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1045	33	19.4	9.25	102.6	13.10	108.2	796.9	106.8	0	0.0	48.0	540	6	40
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1115	0	19.4	9.46	104.7	13.56	111.6	822.7	109.9	0	0.0	48.0	440	25	44
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1115	33	19.2	9.30	102.4	13.56	111.2	817.0	109.1	0	0.0	48.0	440	25	44
SNAKE RIVER-MOUTH MOUTH	1130	0	19.0	9.71	106.1	13.85	112.7	834.2	111.0	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1252	0	17.9	10.77	115.1	13.91	110.9	837.8	111.5	22	74.0	313.0	340	108	294
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1252	33	17.3	10.60	111.9	14.14	111.5	836.4	111.3	22	74.0	313.0	340	108	294
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1300	0	17.5	10.52	111.5	14.14	111.9	838.3	111.6	22	74.0	313.0	340	108	294
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1300	33	16.9	10.52	110.1	14.32	112.0	836.6	111.4	22	74.0	313.0	340	108	294
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1310	0	17.4	10.98	115.8	15.09	118.8	887.3	117.8	22	74.0	313.0	270	108	294
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1320	0	17.3	10.44	109.9	14.20	111.7	836.4	111.1	22	74.0	313.0	270	108	294
JOHN DAY FOREBAY 1/4 MI UP CNTR	1438	0	18.6	9.95	107.6	13.51	108.8	816.1	108.4	0	0.0	286.0	265	32	260
JOHN DAY FOREBAY 1/4 MI UP CNTR	1438	33	18.5	10.03	108.3	13.74	110.5	827.0	109.8	0	0.0	286.0	265	32	260
THE DALLES FOREBAY 1/4 MI UP CENTER	1510	0	18.3	9.87	105.7	13.97	111.5	831.9	110.0	0	0.0	256.0	160	43	253
THE DALLES FOREBAY 1/4 MI UP CENTER	1510	33	18.2	9.87	105.5	14.03	111.8	833.1	110.2	0	0.0	256.0	160	43	253
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1530	0	18.3	9.87	105.4	13.74	109.3	821.1	108.3	18	132.0	280.0	74	118	267
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1530	33	18.3	9.95	106.2	13.74	109.3	822.4	108.5	18	132.0	280.0	74	118	267
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1540	0	18.4	11.38	121.5	16.37	130.3	70.5	127.8	18	132.0	280.0	22	118	267
COLUMBIA RIVER WASHOUGAL CNTR	1600	0	18.8	10.28	110.7	13.97	112.0	846.5	111.4	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1630	0	19.1	9.91	107.3	13.91	112.1	842.2	110.8	0	0.0	0.0	14	0	0

August 2, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	---OXYGEN--- (SAT	ATMOSPHERIC --N2 + AR--- ML/L	ATMOSPHERIC --N2 + AR--- (SAT	TOTAL GAS PRESSURE MM HG	TOTAL GAS PRESSURE (SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	HOURLY FLOW KCFS TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	MEAN DAILY FLOW-KCFS TOTAL
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	950	0	21.9	8.30	97.5	12.26	106.7	774.9	104.6	0	0.0	40.0	740	0	31
LWR GRANITE FOREBAY 1/2 MI UP MID RESERVOIR	952	33	20.9	7.20	82.9	12.31	105.2	744.3	100.5	0	0.0	40.0	740	0	31
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1025	0	21.3	7.95	92.0	12.32	105.6	763.6	102.7	0	0.0	41.0	638	0	25
LITTLE GOOSE FOREBAY 1/4 MI UP CENTER	1030	33	20.9	7.69	88.3	12.62	107.4	768.1	103.3	0	0.0	41.0	638	0	25
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1053	0	21.9	8.13	94.8	12.50	107.9	783.6	105.1	0	0.0	43.0	540	0	25
LWR MONUMENT FOREBAY 1/4 MI UP CENTER	1056	33	20.9	7.60	87.0	12.32	104.5	752.1	100.8	0	0.0	43.0	540	0	25
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1113	0	21.7	8.56	99.1	12.80	109.7	803.3	107.3	0	0.0	43.0	440	0	33
ICE HARBOR FOREBAY 1/4 MI UP CENTER	1115	33	20.9	8.39	95.6	13.27	112.2	812.2	108.5	0	0.0	43.0	440	0	33
SNAKE RIVER-MOUTH MOUTH	1125	0	20.9	8.10	91.9	13.15	110.8	801.3	106.7	0	0.0	0.0	341	0	0
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1245	0	21.0	10.49	119.3	14.04	118.5	888.2	118.2	0	0.0	234.0	340	18	222
MCNARY DAM FOREBAY 1/4 MI UP SPILL SIDE WN.	1250	33	18.7	10.35	112.4	14.40	116.5	866.1	115.3	0	0.0	234.0	340	18	222
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1255	0	21.4	9.96	114.3	13.93	118.4	879.2	117.0	0	0.0	234.0	340	18	222
MCNARY DAM FOREBAY 1/4 MI UP POWER SIDE OR.	1257	33	18.7	10.05	109.2	14.22	115.1	853.0	113.5	0	0.0	234.0	340	18	222
MCNARY TAILRACE 1/4 MI DN SPILL SIDE WN.	1301	0	19.2	10.49	114.8	14.37	117.0	875.0	116.2	0	0.0	234.0	270	18	222
MCNARY TAILRACE 1/4 MI DN POWER SIDE OR.	1310	0	19.0	10.14	110.6	14.16	115.0	856.5	113.7	0	0.0	234.0	270	18	222
JOHN DAY FOREBAY 1/4 MI UP CNTR	1407	0	20.0	9.35	104.0	13.33	110.2	818.7	108.7	0	0.0	240.0	265	0	210
JOHN DAY FOREBAY 1/4 MI UP CNTR	1410	33	20.0	9.09	101.1	13.33	110.2	814.2	108.1	0	0.0	240.0	265	0	210
THE DALLES FOREBAY 1/4 MI UP CENTER	1438	0	19.9	9.35	103.4	13.81	113.5	839.9	111.1	0	0.0	270.0	160	0	214
THE DALLES FOREBAY 1/4 MI UP CENTER	1442	33	19.5	9.26	101.7	13.51	110.3	818.3	108.2	0	0.0	270.0	160	0	214
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1500	0	19.4	9.44	103.1	13.87	112.6	836.7	110.3	17	106.0	241.0	74	64	206
BONNEVILLE FOREBAY 1/2 MI UP SPILL SIDE	1503	33	19.4	9.18	100.2	13.45	109.2	812.4	107.1	17	106.0	241.0	74	64	206
BONNEVILLE TAILRACE 1/4 MI DN SPILL SIDE	1510	0	19.3	11.49	124.9	16.84	136.3	0.0	133.1	17	106.0	241.0	19	64	206
COLUMBIA RIVER WASHOUGAL CNTR	1530	0	19.5	9.53	104.0	13.57	110.2	825.6	108.7	0	0.0	0.0	26	0	0
COLUMBIA RIVER PRESCOTT CENTER	1550	0	19.7	9.29	101.8	13.51	110.1	821.6	108.1	0	0.0	0.0	14	0	0

Appendix Table 11.--Dissolved gas saturation and temperature data for Little Goose spill deflector test March 22, 1976.

March 22, 1976

Group	LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	---OXYGEN--- (SAT	ATMOSPHERIC --N2 + AR--- ML/L	ATMOSPHERIC --N2 + AR--- (SAT	TOTAL GAS PRESSURE MM HG	TOTAL GAS PRESSURE (SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	HOURLY FLOW KCFS TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	MEAN DAILY FLOW-KCFS TOTAL
	LITTLE GOOSE FOREBAY SPILL SIDE	1000	0	6.0	12.79	105.5	17.29	108.7	800.2	107.9	0	0.0	0.0	638	0	0
	LITTLE GOOSE FOREBAY SPILL SIDE	1715	0	5.4	12.52	101.8	17.11	106.1	779.3	105.1	0	0.0	0.0	638	0	0
	LITTLE GOOSE SPILL BAY 5 DEFLECTOR	1030	0	5.6	13.86	113.2	18.40	114.7	846.2	114.2	1	14.0	0.0	538	0	0
1	LITTLE GOOSE SPILL BAY 5 DEFLECTOR	1035	20	5.4	13.46	109.4	18.23	113.1	831.0	112.1	1	14.0	0.0	538	0	0
	LITTLE GOOSE SPILL BAY 8 STC. BAY	1110	0	5.4	15.73	127.8	20.79	129.0	951.8	128.4	1	14.0	0.0	538	0	0
2	LITTLE GOOSE SPILL BAY 8 STC. BAY	1115	20	5.4	15.86	128.9	21.22	131.6	968.9	130.7	1	14.0	0.0	538	0	0
	LITTLE GOOSE SPILL BAY 8 STC. BAY	1120	0	5.4	15.60	126.7	21.22	131.6	965.6	130.3	1	14.0	0.0	538	0	0
	LITTLE GOOSE SPILL BAY 2-7 SOUTH STA.	1508	0	5.4	13.86	112.6	18.74	116.2	854.5	115.3	6	35.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 SOUTH STA.	1508	20	5.4	13.86	112.6	18.83	116.8	857.6	115.7	6	35.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1520	0	5.4	13.59	110.4	18.40	114.1	838.9	113.2	6	35.0	0.0	539	0	0
3	LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1520	20	5.4	13.99	113.7	18.74	116.2	856.2	115.5	6	35.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 NORTH STA.	1526	0	5.4	13.59	110.4	18.40	114.1	838.9	113.2	6	35.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 NORTH STA.	1526	20	5.4	13.86	112.6	18.83	116.8	857.6	115.7	6	35.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1535	0	5.4	13.33	108.3	17.88	110.9	817.0	110.2	6	35.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 SOUTH STA.	1612	0	5.4	14.53	118.0	19.51	121.0	890.6	120.1	6	60.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 SOUTH STA.	1612	20	5.4	14.80	120.2	20.02	124.2	912.4	123.1	6	60.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1615	0	5.4	15.06	122.4	20.11	124.7	918.8	124.0	6	60.0	0.0	539	0	0
4	LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1615	20	5.4	13.86	112.6	18.74	116.2	854.5	115.3	6	60.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 NORTH STA.	1620	0	5.4	14.26	115.9	19.00	117.8	868.8	117.2	6	60.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 NORTH STA.	1620	20	5.4	13.86	112.6	18.57	115.2	848.4	114.4	6	60.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1627	0	5.4	14.80	120.2	19.77	122.6	903.2	121.8	6	60.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 SOUTH STA.	1658	0	5.4	14.93	121.3	19.94	123.7	911.0	122.9	6	85.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 SOUTH STA.	1658	20	5.4	15.06	122.4	20.28	125.8	925.0	124.8	6	85.0	0.0	539	0	0
5	LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1700	0	5.4	14.39	117.0	19.43	120.5	885.8	119.5	6	85.0	0.0	539	0	0
	LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1700	20	5.4	14.80	120.2	19.68	122.1	900.1	121.4	6	85.0	0.0	539	0	0

March 22, 1976 - Continued

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
1 LITTLE GOOSE SPILL BAY 2-7 NORTH STA.	1703	0	5.4	15.20	123.5	20.37	126.3	929.7	125.4	6	85.0	0.0	539	0	0
5 LITTLE GOOSE SPILL BAY 2-7 NORTH STA.	1703	20	5.4	14.53	118.0	19.34	120.0	884.4	119.3	6	85.0	0.0	539	0	0
LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1705	0	5.4	15.20	123.5	20.28	125.8	926.7	125.0	6	85.0	0.0	539	0	0
LITTLE GOOSE SPILL BAY 2-7 SOUTH STA.	1737	0	5.4	15.46	125.6	20.97	130.0	954.7	128.8	6	120.0	0.0	540	0	0
LITTLE GOOSE SPILL BAY 2-7 SOUTH STA.	1737	20	5.4	15.46	125.6	20.97	130.0	954.7	128.8	6	120.0	0.0	540	0	0
LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1742	0	5.4	15.20	123.5	20.71	128.4	942.1	127.1	6	120.0	0.0	540	0	0
6 LITTLE GOOSE SPILL BAY 2-7 CTR. STA.	1742	20	5.4	16.00	130.0	21.56	133.8	982.9	132.6	6	120.0	0.0	540	0	0
LITTLE GOOSE SPILL BAY 2-7 NORTH STA.	1747	0	5.4	15.20	123.5	20.45	126.9	932.8	125.8	6	120.0	0.0	540	0	0
LITTLE GOOSE SPILL BAY 2-7 NORTH STA.	1747	20	5.4	15.33	124.6	20.79	129.0	946.8	127.7	6	120.0	0.0	540	0	0

Six conditions were sampled:

1. Spill deflector Bay 5 at 14 kcfs
2. Standard Bay 8 at 14 kcfs
3. Spill Deflector Bays 2-7 at 6 kcfs each
4. Spill Deflector Bays 2-7 at 10 kcfs each
5. Spill Deflector Bays 2-7 at 14 kcfs each
6. Spill Deflector Bays 2-7 at 20 kcfs each

Appendix Table 12.--Dissolved gas saturation and temperature data for McNary spill deflector tests April-July, 1976.

April 7, 1976

	LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
	MCNARY FOREBAY SPILL SIDE	810	0	6.9	13.12	108.9	17.07	107.8	813.2	107.9	0	0.0	0.0	237	0	0
	MCNARY FOREBAY SPILL SIDE	810	60	6.7	13.20	108.9	16.97	106.7	807.0	107.0	0	0.0	0.0	237	0	0
	MCNARY FOREBAY SPILL SIDE	1405	50	7.0	13.06	109.0	16.97	107.8	810.9	107.9	0	0.0	0.0	337	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	820	0	7.0	13.04	108.5	16.88	107.0	807.2	107.2	1	5.0	242.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	820	10	6.9	12.99	107.9	16.97	107.3	808.1	107.3	1	5.0	242.0	269	0	0
1	MCNARY SPILLWAY DEFLECTOR BAY 5	830	0	6.9	12.99	107.9	17.07	107.9	811.5	107.8	1	5.0	242.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	835	0	6.9	13.12	109.0	17.34	109.7	823.6	109.3	1	5.0	242.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	835	10	6.9	13.25	110.1	17.25	109.1	821.8	109.1	1	5.0	242.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	932	0	7.1	13.25	110.6	17.34	110.2	829.1	110.1	1	7.0	241.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	932	0	7.1	13.38	111.7	17.56	111.5	838.7	111.4	1	7.0	241.0	269	0	0
2	MCNARY SPILLWAY DEFLECTOR BAY 5	945	0	7.0	13.33	111.0	17.25	109.3	824.7	109.5	1	7.0	241.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	950	10	7.0	12.86	107.1	17.07	108.2	811.8	107.8	1	7.0	241.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	954	0	7.0	12.86	107.1	16.88	107.0	804.9	106.9	1	7.0	241.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	1047	0	6.9	12.73	105.7	17.07	107.9	808.1	107.3	1	9.0	244.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	1050	10	6.9	13.25	110.1	17.53	110.8	832.1	110.5	1	9.0	244.0	269	0	0
3	MCNARY SPILLWAY DEFLECTOR BAY 5	1049	0	7.0	13.25	110.4	17.43	110.5	830.7	110.3	1	9.0	244.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	1055	10	7.0	13.25	110.4	17.53	111.1	834.1	110.8	1	9.0	244.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	1100	0	7.0	13.12	109.3	17.43	110.5	829.0	110.1	1	9.0	244.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	1155	0	7.0	13.38	111.4	17.90	113.4	849.6	112.8	1	14.0	252.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	1200	10	7.0	13.52	112.5	17.84	113.0	849.0	112.7	1	14.0	252.0	269	0	0
4	MCNARY SPILLWAY DEFLECTOR BAY 5	1203	0	7.0	13.38	111.4	17.80	112.8	846.1	112.4	1	14.0	252.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	1206	10	7.0	13.38	111.4	17.71	112.2	842.7	111.9	1	14.0	252.0	269	0	0
	MCNARY SPILLWAY DEFLECTOR BAY 5	1209	0	7.0	13.12	109.3	17.34	109.9	825.5	109.6	1	14.0	252.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1325	0	7.0	14.96	124.6	19.65	124.5	935.5	124.2	1	4.0	237.0	269	0	0
1	MCNARY SPILLWAY STANDARD BAY 21	1325	10	7.0	14.96	124.6	20.02	126.9	949.3	126.0	1	4.0	237.0	269	0	0

April 7, 1976 - Cont.

	LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
	MCNARY SPILLWAY STANDARD BAY 21	1330	0	7.0	14.43	120.2	19.37	122.8	918.3	121.9	1	4.0	237.0	269	0	0
1	MCNARY SPILLWAY STANDARD BAY 21	1330	10	7.0	14.30	119.1	19.37	122.8	916.6	121.7	1	4.0	237.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1334	0	7.0	14.70	122.4	19.65	124.5	932.1	123.8	1	4.0	237.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1432	0	7.0	14.30	119.1	19.10	121.0	906.3	120.3	1	7.0	241.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1436	10	7.0	14.57	121.3	19.56	123.9	926.9	123.1	1	7.0	241.0	269	0	0
2	MCNARY SPILLWAY STANDARD BAY 21	1436	0	7.0	14.96	124.6	20.02	126.9	949.3	126.0	1	7.0	241.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1440	10	7.0	14.17	118.0	18.91	119.9	897.7	119.2	1	7.0	241.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1443	0	7.1	14.30	119.4	19.10	121.3	908.3	120.6	1	7.0	241.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1538	0	7.0	14.56	121.2	20.20	128.0	950.9	126.3	1	9.0	244.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1542	0	7.0	14.57	121.3	19.40	122.9	920.9	122.3	1	9.0	244.0	269	0	0
3	MCNARY SPILLWAY STANDARD BAY 21	1546	10	7.0	14.57	121.3	19.56	123.9	926.9	123.1	1	9.0	244.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1550	10	7.1	14.30	119.4	19.19	121.9	911.8	121.1	1	9.0	244.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1552	0	7.0	13.38	111.4	17.53	111.1	835.8	111.0	1	9.0	244.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1650	0	7.0	14.51	120.8	19.37	122.8	919.3	122.1	1	14.0	248.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1654	10	7.0	15.09	125.7	20.20	128.0	957.9	127.2	1	14.0	248.0	269	0	0
4	MCNARY SPILLWAY STANDARD BAY 21	1656	10	7.0	14.83	123.5	20.04	127.0	948.2	125.9	1	14.0	248.0	269	0	0
	MCNARY SPILLWAY STANDARD BAY 21	1700	0	7.1	14.43	120.5	19.28	122.5	917.0	121.8	1	14.0	248.0	269	0	0

Four comparisons were made of single deflector vs standard bay flows at 5, 7, 9, and 14 kcfs each.

April 13, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
MCNARY FOREBAY	1615	50	8.9	13.04	114.1	17.80	118.0	878.5	116.9	0	0.0	0.0	339	0	0
SPILL SIDE															
MCNARY SPILLWAY DEFL 3-20 CTR 19	1320	10	8.9	13.83	120.7	18.42	121.9	913.5	121.3	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 19	1325	0	8.9	13.57	118.3	18.24	120.6	902.7	119.9	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 16	1328	0	8.9	13.44	117.2	18.01	119.1	891.9	118.4	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1330	0	8.9	13.70	119.5	18.33	121.3	908.1	120.6	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1332	0	8.9	14.10	123.0	18.79	124.3	931.6	123.7	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 10	1335	0	8.9	13.70	119.5	18.42	121.9	911.7	121.1	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 10	1337	20	8.9	14.10	123.0	18.70	123.7	928.0	123.2	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1340	0	8.9	13.97	121.8	18.51	122.5	919.0	122.0	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 4	1345	0	8.9	13.57	118.3	18.33	121.3	906.3	120.3	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 4	1346	20	8.9	13.57	118.3	18.14	120.0	899.1	119.4	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1350	0	8.9	13.70	119.5	18.24	120.6	904.5	120.1	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 10	1353	0	8.9	13.83	120.7	18.61	123.1	920.7	122.3	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1355	0	8.9	13.43	117.2	18.14	120.0	897.3	119.1	22	165.0	327.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 19	1506	0	9.0	13.43	117.5	18.14	120.3	899.4	119.4	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 19	1508	20	9.0	13.57	118.6	18.33	121.5	908.4	120.6	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 16	1510	0	9.0	13.70	119.8	18.24	120.9	906.6	120.4	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 16	1512	20	9.0	13.57	118.6	18.14	120.3	901.2	119.7	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1513	0	9.0	13.43	117.5	18.05	119.7	895.8	118.9	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 10	1516	20	9.0	13.70	119.8	18.33	121.5	910.2	120.9	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1520	0	9.0	13.43	117.5	18.14	120.3	899.4	119.4	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1522	20	9.0	13.43	117.5	18.61	123.4	917.4	121.8	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 4	1525	0	9.0	13.70	119.8	18.42	122.1	913.8	121.3	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 4	1528	20	9.0	13.70	119.8	18.33	121.5	910.2	120.9	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1532	0	9.0	13.43	117.5	18.14	120.3	899.4	119.4	18	160.0	325.0	269	0	0

April 13, 1976 - Cont.

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
MCNARY SPILLWAY DEFL 3-20 CTR 10	1534	0	9.0	13.43	117.5	18.35	121.7	907.5	120.5	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1536	0	9.0	13.43	117.5	18.35	121.7	907.5	120.5	18	160.0	325.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 16	1537	0	9.0	13.17	115.2	18.07	119.8	893.1	118.6	18	160.0	325.0	269	0	0

Two conditions sampled:

1. O.D.F.W. pattern of gate settings for best attraction flows to fish ladders. 22 bay discharge at 165 kcfs.

   Bays with Deflectors:
   - 5.6 kcfs thru bays 3, 5, and 18
   - 7.3 kcfs thru bays 4, 6, 7, 8, 9, 12, 15, 16, 17, 19, and 20.
   - 8.9 kcfs thru bays 10, 11, 13, and 14

   Standard Bays:
   - 7.2 kcfs thru bay 22
   - 8.3 kcfs thru bays 1, 2, and 21

2. Uniform discharge thru deflector bays (3-20) at 8.9 kcfs per bay, about 160 kcfs total.

April 14, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
MCNARY FOREBAY SPILL SIDE	1115	50	8.8	12.70	110.7	16.69	110.4	828.9	110.3	0	0.0	0.0	339	0	0
MCNARY FOREBAY SPILL SIDE	1500	50	8.8	12.58	109.7	16.40	108.5	815.7	108.6	0	0.0	0.0	339	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 19	1010	0	8.8	12.91	112.4	17.15	113.2	849.7	112.8	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 19	1015	10	8.8	12.85	111.8	17.06	112.6	845.2	112.2	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 16	1020	0	8.8	12.78	111.2	17.06	112.6	844.4	112.1	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 16	1025	10	8.8	12.78	111.2	17.06	112.6	844.4	112.1	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1030	0	8.8	12.91	112.4	17.24	113.8	853.3	113.3	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1035	20	8.8	12.52	109.0	16.88	111.4	833.7	110.7	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 10	1040	0	8.8	12.78	111.2	17.06	112.6	844.4	112.1	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 10	1045	20	8.8	12.74	110.8	16.97	112.0	840.2	111.6	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1050	0	8.8	12.78	111.2	17.06	112.6	844.4	112.1	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1055	10	8.8	12.78	111.2	17.06	112.6	844.4	112.1	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 4	1100	0	8.8	12.78	111.2	17.06	112.6	844.4	112.1	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 4	1102	20	8.8	12.78	111.2	17.06	112.6	844.4	112.1	22	72.0	305.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 19	1213	20	8.8	12.77	111.1	17.51	115.5	861.4	114.4	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 19	1216	0	8.8	12.78	111.2	17.06	112.6	844.4	112.1	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 16	1219	20	8.8	13.17	114.6	17.71	116.9	874.8	116.2	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 16	1221	0	8.8	13.04	113.5	17.34	114.4	858.7	114.0	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1225	20	8.8	13.04	113.5	17.52	115.7	865.8	115.0	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 13	1226	0	8.8	12.78	111.2	17.15	113.2	848.0	112.6	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 10	1228	20	8.8	12.78	111.2	17.00	112.2	841.9	111.8	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 10	1230	0	8.8	12.78	111.2	17.15	113.2	848.0	112.6	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1232	20	8.8	12.91	112.4	17.24	113.8	853.3	113.3	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 7	1236	0	8.8	12.91	112.4	17.24	113.8	853.3	113.3	18	72.0	302.0	269	0	0
MCNARY SPILLWAY DEFL 3-20 CTR 4	1238	20	8.8	12.78	111.2	17.24	113.8	851.5	113.1	18	72.0	302.0	269	0	0

April 14, 1976 - Cont.

	LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
	MCNARY SPILLWAY DEFL 3-20 CTR 4	1240	0	8.8	12.78	111.2	17.24	113.8	851.5	113.1	18	72.0	302.0	269	0	0
2	MCNARY SPILLWAY DEFL 3-20 CTR 19	1400	20	8.8	13.83	120.3	19.09	126.0	937.3	124.5	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 19	1402	0	8.8	13.57	118.0	18.63	123.0	915.9	121.6	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 16	1405	20	8.8	13.96	121.5	19.09	126.0	939.1	124.7	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 16	1408	0	8.8	13.96	121.5	19.27	127.2	946.3	125.6	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 13	1412	20	8.8	14.00	121.8	19.37	127.8	950.4	126.2	18	248.0	367.0	269	0	0
3	MCNARY SPILLWAY DEFL 3-20 CTR 13	1417	0	8.8	14.09	122.6	19.37	127.8	951.6	126.4	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 10	1420	20	8.8	13.96	121.5	19.27	127.2	946.3	125.6	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 10	1424	0	8.8	13.96	121.5	19.00	125.4	935.5	124.2	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 7	1426	20	8.8	14.09	122.6	19.18	126.6	944.2	125.4	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 7	1429	0	8.8	13.83	120.3	19.09	126.0	937.3	124.5	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 4	1432	20	8.8	13.96	121.5	19.00	125.4	935.5	124.2	18	248.0	367.0	269	0	0
	MCNARY SPILLWAY DEFL 3-20 CTR 4	1435	0	8.8	13.96	121.5	18.81	124.2	928.4	123.3	18	248.0	367.0	269	0	0

Three conditions sampled:

1. O.D.F.W. gate opening pattern--72 kcfs total

   Spill Deflector Bays { 2 kcfs thru bays 3, 5, 7, 9, 16, 18 and 20
   4 kcfs thru bays 4, 6, 8, 10, 11, 12, 13, 14, 15, 17, and 19.

   Standard Bays { 2.8 kcfs thru bays 1 and 22
   4 kcfs thru bays 2 and 21.

2. Uniform discharge thru deflector bays (3-20) at 4 kcfs--72 kcfs total.

3. Uniform discharge thru deflector bays (3-20) at 13.7 kcfs--248 kcfs total.

June 9, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	---OXYGEN--- (SAT	ATMOSPHERIC --N2 + AR--- ML/L	ATMOSPHERIC --N2 + AR--- (SAT	TOTAL GAS PRESSURE MM HG	TOTAL GAS PRESSURE (SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	HOURLY FLOW KCFS TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	MEAN DAILY FLOW-KCFS TOTAL
MCNARY FOREBAY	1310	50	13.5	12.40	120.6	16.22	118.6	891.6	118.7	0	0.0	0.0	338	0	0
SPILL SIDE															
MCNARY SPILLWAY BAYS 1-22 CTR 19	1207	0	13.6	12.11	117.8	16.43	120.1	898.2	119.3	22	75.0	296.0	269	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 19	1212	20	13.5	11.85	115.0	16.06	117.2	876.8	116.4	22	75.0	296.0	269	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 13	1220	0	13.6	11.72	114.0	15.87	116.0	868.6	115.3	22	75.0	296.0	269	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 10	1223	20	13.6	11.70	113.7	16.01	117.0	873.8	116.0	22	75.0	296.0	269	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 10	1225	0	13.6	11.72	114.0	15.78	115.4	864.6	114.8	22	75.0	296.0	269	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 13	1227	20	13.6	11.85	115.3	16.01	117.0	876.1	116.3	22	75.0	296.0	269	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 19	1310	0	13.7	12.24	119.3	16.80	123.0	917.9	121.9	22	163.0	384.0	269	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 13	1315	0	13.7	12.05	117.4	16.89	123.7	918.8	122.0	22	163.0	384.0	269	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 13	1325	20	13.7	12.07	117.6	16.80	123.0	915.1	121.5	22	163.0	384.0	269	0	0

Two conditions sampled with forebay N_2 at 119%:

1. O.D.F.W. gate opening pattern--75 kcfs total

Spill Deflector Bays
- 2.0 kcfs thru bays 3, 5, 7, 9, 16, 18, and 20
- 4.0 kcfs thru bays 4, 6, 8, 10, 11, 12, 13, 15, 17, and 19
- 7.3 kcfs thru bay 14

Standard Bays
- 2.8 kcfs thru bays 1 and 22
- 4.0 kcfs thru bays 2 and 21

2. O.D.F.W. gate opening pattern--163 kcfs total

Spill Deflector Bays
- 5.6 kcfs thru bays 3, 5, and 18
- 7.3 kcfs thru bays 4, 6, 7, 8, 9, 12, 15, 16, 17, 19, and 20
- 8.9 kcfs thru bays 10 and 11
- 10.4 kcfs thru bays 13 and 15

Standard Bays
- 7.2 kcfs thru bay 22
- 8.3 kcfs thru bays 1, 2, and 21

June 10, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
MCNARY FOREBAY SPILL SIDE	945	50	13.6	12.19	118.8	16.07	117.7	883.7	117.6	0	0.0	0.0	338	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 19	950	0	13.6	12.74	123.8	17.17	125.5	939.2	124.7	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 19	953	20	13.6	12.37	120.3	17.17	125.5	933.8	124.0	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 13	955	0	13.6	12.37	120.3	17.26	126.2	937.7	124.5	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 13	957	20	13.6	12.89	125.3	17.41	127.2	951.7	126.4	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 10	1000	0	13.6	12.24	119.1	16.89	123.5	919.9	122.2	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 10	1003	20	13.6	12.24	119.1	17.07	124.8	927.9	123.2	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 4	1004	0	13.6	12.40	120.5	16.80	122.8	918.3	121.9	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 4	1009	20	13.6	12.24	119.1	17.07	124.8	927.9	123.2	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 10	1012	0	13.6	12.64	122.9	17.35	126.9	945.6	125.6	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 13	1013	0	13.6	12.77	124.1	17.63	128.9	959.4	127.4	22	249.0	466.0	271	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 19	1015	0	13.6	12.50	121.6	17.26	126.2	939.7	124.8	22	249.0	466.0	271	0	0

One test with forebay N_2 at 119%

O.D.F.W. gate opening pattern--249 kcfs total

Spill Deflector Bays
- 7.3 kcfs thru bays 14
- 8.9 kcfs thru bays 3, 4, 5, 18, 19, and 20
- 10.6 kcfs thru bays 6, 7, 8, and 17
- 12.2 kcfs thru bay 9
- 13.8 kcfs thru bays 10, 11, and 16
- 15.2 kcfs thru bay 12
- 16.8 kcfs thru bays 13 and 15

Standard Bays
- 11.2 kcfs thru bays 1, 21, and 22
- 12.1 kcfs thru bay 2

July 15, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
MCNARY FOREBAY SPILL SIDE	830	50	17.1	10.66	112.0	14.42	113.2	846.6	112.7	0	0.0	0.0	339	0	0
MCNARY FOREBAY SPILL SIDE	1145	50	17.4	10.77	114.0	14.61	115.3	861.9	114.7	0	0.0	0.0	339	0	0
MCNARY FOREBAY SPILL SIDE	1605	50	17.9	11.25	120.2	14.21	113.2	859.3	114.4	0	0.0	0.0	338	0	0
1 MCNARY SPILLWAY DEFLECTOR BAY 5	817	0	17.0	10.58	110.7	14.56	113.8	850.1	112.9	1	4.0	234.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	820	20	17.0	10.54	110.3	14.56	113.8	849.6	112.8	1	4.0	234.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	823	0	17.0	10.66	111.5	14.77	115.5	861.1	114.3	1	4.0	234.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	826	0	17.0	10.66	111.5	14.58	113.9	852.2	113.2	1	4.0	234.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	828	0	17.0	10.66	111.5	14.77	115.5	861.1	114.3	1	4.0	234.0	269	0	0
2 MCNARY SPILLWAY DEFLECTOR BAY 5	935	0	17.1	10.77	113.0	14.91	116.8	871.0	115.6	1	7.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	938	20	17.1	11.00	115.4	14.98	117.3	877.9	116.6	1	7.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	940	0	17.1	10.89	114.2	15.05	117.9	879.3	116.8	1	7.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	942	20	17.1	10.74	112.6	14.91	116.8	870.4	115.6	1	7.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	945	0	17.1	10.66	111.8	14.70	115.1	859.4	114.1	1	7.0	239.0	269	0	0
1 MCNARY SPILLWAY STANDARD BAY 21	1132	0	17.2	11.82	124.2	16.11	126.4	944.4	125.4	1	4.0	237.0	269	0	0
MCNARY SPILLWAY STANDARD BAY 21	1135	0	17.2	11.69	122.9	16.04	125.9	939.2	124.7	1	4.0	237.0	269	0	0
MCNARY SPILLWAY STANDARD BAY 21	1137	20	17.2	11.69	122.9	16.18	127.0	945.6	125.6	1	4.0	237.0	269	0	0
MCNARY SPILLWAY STANDARD BAY 21	1140	0	17.1	11.81	123.8	16.11	126.2	942.5	125.1	1	4.0	237.0	269	0	0
MCNARY SPILLWAY STANDARD BAY 21	1141	20	17.1	11.58	121.4	15.90	124.5	929.1	123.4	1	4.0	237.0	269	0	0
2 MCNARY SPILLWAY STANDARD BAY 21	1238	0	17.3	11.81	124.4	16.19	127.3	949.6	126.1	1	7.0	240.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1240	20	17.2	11.69	122.9	15.83	124.2	929.5	123.4	1	7.0	240.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1242	0	17.2	11.81	124.1	16.32	128.1	954.0	126.7	1	7.0	240.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1244	20	17.2	11.69	122.9	16.25	127.5	948.9	126.0	1	7.0	240.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1247	0	17.1	11.58	121.4	16.04	125.6	935.5	124.2	1	7.0	240.0	270	0	0
3 MCNARY SPILLWAY BAYS 1-22 CTR 19	1348	0	17.1	11.12	116.6	14.70	115.1	866.9	115.1	22	72.0	310.0	270	0	0
MCNARY SPILLWAY BAYS 1-22 CTR 19	1350	20	17.3	11.00	115.9	14.77	116.1	871.6	115.7	22	72.0	310.0	270	0	0

July 15, 1976 - Cont.

	LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
	MCNARY SPILLWAY BAYS 1-22 CTR 13	1355	0	17.3	10.89	114.7	14.56	114.5	860.0	114.2	22	72.0	310.0	270	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1358	0	17.3	10.69	112.6	14.45	113.7	852.0	113.1	22	72.0	310.0	270	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1401	20	17.3	10.69	112.6	14.45	114.9	859.5	114.1	22	72.0	310.0	270	0	0
3	MCNARY SPILLWAY BAYS 1-22 CTR 4	1403	0	17.3	10.77	113.4	14.64	115.1	861.5	114.4	22	72.0	310.0	270	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 4	1405	20	17.3	10.69	112.6	14.70	115.6	863.2	114.6	22	72.0	310.0	270	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1407	0	17.3	10.69	112.6	14.54	114.3	855.7	113.6	22	72.0	310.0	270	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 13	1409	0	17.3	10.83	114.1	14.05	110.4	835.6	111.0	22	72.0	310.0	270	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 19	1453	0	17.3	10.69	112.6	14.45	113.7	852.0	113.1	22	165.0	401.0	272	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1456	20	17.3	10.83	114.1	14.45	113.7	854.3	113.5	22	165.0	401.0	272	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1502	0	17.3	11.41	120.1	15.19	119.4	897.4	119.2	22	165.0	401.0	272	0	0
4	MCNARY SPILLWAY BAYS 1-22 CTR 10	1503	20	17.3	11.41	120.1	15.51	122.0	912.3	121.2	22	165.0	401.0	272	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 4	1504	0	17.3	11.26	118.6	15.27	120.1	898.8	119.4	22	165.0	401.0	272	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1506	20	17.3	11.13	117.2	15.30	120.3	897.7	119.2	22	165.0	401.0	272	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1508	0	17.3	11.26	118.6	15.27	120.1	898.8	119.4	22	165.0	401.0	272	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 13	1510	0	17.3	11.26	118.6	15.27	120.1	898.8	119.4	22	165.0	401.0	272	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1550	20	17.1	11.41	119.6	15.51	121.5	908.9	120.7	22	249.0	485.0	273	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 13	1552	0	17.1	11.84	124.2	16.00	125.4	938.2	124.6	22	249.0	485.0	273	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 13	1553	20	17.3	11.69	123.2	15.92	125.2	935.7	124.3	22	249.0	485.0	273	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1555	0	17.3	11.55	121.6	15.68	123.3	922.2	122.5	22	249.0	485.0	273	0	0
5	MCNARY SPILLWAY BAYS 1-22 CTR 10	1557	20	17.3	11.58	121.9	15.76	123.9	926.3	123.0	22	249.0	485.0	273	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 4	1559	0	17.3	11.41	120.1	15.68	123.3	919.8	122.2	22	249.0	485.0	273	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 4	1601	20	17.5	11.55	122.2	15.68	123.8	925.7	122.9	22	249.0	485.0	273	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 10	1603	0	17.5	11.55	122.2	15.68	123.8	925.7	122.9	22	249.0	485.0	273	0	0
	MCNARY SPILLWAY BAYS 1-22 CTR 13	1605	0	17.5	11.55	122.2	15.76	124.4	929.5	123.4	22	249.0	485.0	273	0	0

July 15, 1976 - Cont.

Five tests with warm water temperatures. Two comparisons were made of single deflector vs standard bay flows, and 3 tests with O.D.F.W. gate opening patterns.

1. Single bay flows at 4 kcfs--Deflector and Standard Bay

2. Single bay flows at 7 kcfs--Deflector and Standard Bay

3. O.D.F.W. pattern--72 kcfs total

   Spill Deflector Bays
   - 2.0 kcfs thru bays 3, 5, 7, 9, 16, 18, and 20
   - 4.0 kcfs thru bays 4, 6, 8, 10, 11, 12, 13, 14, 15, 17, and 19

   Standard Bays
   - 2.8 kcfs thru bays 1 and 22
   - 4.0 kcfs thru bays 2 and 21

4. O.D.F.W. pattern--165 kcfs total

   Spill Deflector Bays
   - 4.0 kcfs thru bays 14
   - 5.6 kcfs thru bays 3, 5, and 18
   - 7.3 kcfs thru bays 4, 6, 7, 8, 9, 12, 16, 17, 19, and 20
   - 8.9 kcfs thru bays 10 and 11
   - 10.6 kcfs thru bays 15, 13

   Standard Bays
   - 7.2 kcfs thru bay 22
   - 8.3 kcfs thru bays 1, 2, 21

5. O.D.F.W. pattern--249 kcfs total

   Spill Deflector Bays
   - 4.0 kcfs thru bays 14
   - 8.9 kcfs thru bays 3, 4, 5, 18, 19, and 20
   - 10.6 kcfs thru bays 6, 7, 8, and 17
   - 12.2 kcfs thru bays 9
   - 13.8 kcfs thru bays 10, 11, and 16
   - 15.4 kcfs thru bays 12
   - 17.0 kcfs thru bays 13 and 15

   Standard Bays
   - 11.2 kcfs thru bays 1, 21, and 22
   - 12.1 kcfs thru bay 2

July 16, 1976

LOCATION	TIME	DEPTH M	TEMP FT	---OXYGEN--- MG/L	(SAT	ATMOSPHERIC --N2 + AR--- ML/L	(SAT	TOTAL GAS PRESSURE MM HG	(SAT	NO. GATE OPEN	HOURLY FLOW KCFS SPILL	TOTAL	SAMPLE ELEV FT	MEAN DAILY FLOW-KCFS SPILL	TOTAL
MCNARY FOREBAY SPILL SIDE	840	50	17.1	10.92	114.7	14.13	110.9	837.5	111.5	0	0.0	0.0	339	0	0
MCNARY FOREBAY SPILL SIDE	1200	50	17.5	11.12	117.9	14.45	114.4	862.4	114.8	0	0.0	0.0	339	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	742	0	17.2	10.83	113.8	14.70	115.3	863.9	114.7	7	9.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	745	20	17.2	10.83	113.8	14.62	114.7	860.2	114.2	1	9.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	748	0	17.2	10.69	112.3	14.37	112.8	846.6	112.4	1	9.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	750	20	17.1	10.83	113.6	14.21	111.3	839.9	111.5	1	9.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	753	0	17.1	10.83	113.6	14.37	112.6	847.4	112.5	1	9.0	239.0	269	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	904	0	17.2	10.98	115.4	14.70	115.4	866.3	115.0	1	14.0	248.0	270	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	906	20	17.2	10.83	113.8	14.62	114.7	860.2	114.2	1	14.0	248.0	270	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	908	0	17.1	10.98	115.1	14.70	115.1	864.6	114.8	1	14.0	248.0	270	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	910	20	17.1	11.01	115.4	14.54	113.9	857.6	113.9	1	14.0	248.0	270	0	0
MCNARY SPILLWAY DEFLECTOR BAY 5	912	0	17.2	10.83	113.8	14.62	114.7	860.2	114.2	1	14.0	248.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1006	0	17.3	11.84	124.7	15.60	122.6	923.1	122.6	1	9.0	238.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1009	20	17.3	12.13	127.7	16.09	126.5	950.2	126.2	1	9.0	238.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1010	0	17.3	12.13	127.7	16.09	126.5	950.2	126.2	1	9.0	238.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1012	20	17.3	12.06	126.9	16.17	127.1	952.8	126.5	1	9.0	238.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1014	0	17.3	12.13	127.7	16.00	125.8	946.5	125.7	1	9.0	238.0	270	0	0
MCNARY SPILLWAY STANDARD BAY 21	1105	0	17.4	11.98	126.4	16.17	127.4	953.4	126.6	1	14.0	242.0	269	0	0
MCNARY SPILLWAY STANDARD BAY 21	1107	20	17.3	12.27	129.2	16.25	127.8	960.0	127.5	1	14.0	242.0	269	0	0
MCNARY SPILLWAY STANDARD BAY 21	1109	0	17.4	11.69	123.4	16.00	126.1	941.2	125.0	1	14.0	242.0	269	0	0
MCNARY SPILLWAY STANDARD BAY 21	1111	20	17.3	12.15	127.9	16.46	129.4	967.5	128.5	1	14.0	242.0	269	0	0
MCNARY SPILLWAY STANDARD BAY 21	1114	0	17.3	11.84	124.7	15.76	123.9	930.6	123.6	1	14.0	242.0	269	0	0

Two comparisons with warm water temperatures.

1. Single bays flows at 9 kcfs--Deflector vs Standard

2. Single bay flows at 14 kcfs--Deflector vs Standard