EVALUATION OF THE JOHN DAY DAM SOUTH FISH LADDER MODIFICATION 2003

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EXECUTIVE SUMMARY

Adult salmonids have been jumping in the ladders of John Day Dam since initial construction. This behavior has led to mortalities through stranding and delayed migration. Tests indicated that modification of ladder hydraulics reduced jumping, so during the 2002 – 2003 winter maintenance season, the Corps of Engineers modified the south ladder flow-control section by installing slot and orifice weirs. This report presents the results of the post-construction evaluation conducted to determine whether adult salmonids continue to jump in the new flow-control section.

Our objectives were: 1. Determine if adult salmonid jumping behavior was reduced or eliminated in the re-designed portion of the south ladder and 2. Determine the passage times of adult salmonids through the flow-control section, comparing these with the passage times from a similar study conducted in 1993.

No jumping was observed in the flow-control section during 214 hours of observation in September and October of 2003. Adult salmonids took less time to pass through the re-designed flow-control section than they did through the same section in 1993. Steelhead that exited the flow-control section on the same day they entered it took an average of 24 minutes to swim through the section in 2003, compared to 51 minutes in 1993. Passage times for steelhead, in all passage categories (day, night, next day, etc.), were less in 2003 than in 1993.

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INTRODUCTION

BACKGROUND

Adult salmonids, primarily steelhead *(Oncorhynchus mykiss),* have been jumping in the fishways of John Day Dam (JDA) since initial construction in 1968. This has led to mortality from both stranding on catwalks and netting, and exiting the ladder to the ground below. Hard strikes against metal and concrete as well as possible depletion of energy reserves have been additional concerns. A brief history of work done at the John Day ladders from 1968 to 2003, addressing the jumping problems is in Appendix A.

Photo 1: A still from video shot during the 2000 slot, orifice, and control test (Jonas and Madson 2001). Depicted is a steelhead jumping in an area where the frequency of jumping was high. This image was captured while the gates were in the control position.

Photo 2: Holes in the netting commonly developed in areas of heavy jumping activity. Jumping steelhead were able to get through the gaps and became stranded on top of the net. While netting reduced the probability of salmonids jumping out of the ladder, it also prevented them from getting back in the ladder.

The flow-control sections at JDA were designed to create a serpentine flow pattern, forcing upstream migrants to swim in a continuous series of arcs, alternating between clockwise and counter-clockwise turns (Figure 1). Observers noted that jumping occurred most frequently on the south side of the ladder (Cordie 1993, Wright 1996, Jonas 1997). The Fisheries Field Unit (FFU) proposed using a surface slot or a submerged orifice to provide salmonids a direct route into the upstream pools. In 2000, the FFU tested both a surface slot and a submerged orifice in the south ladder; a significant reduction in jumping was observed with each treatment [slot $P<0.05$, orifice $P<0.05$ (Jonas and Madson 2001)]. In 2001, the slot and orifice were tried in combination; a significant reduction in jumping was also observed with this treatment [$P \leq 0.001$ (Jonas and Madson 2002)].

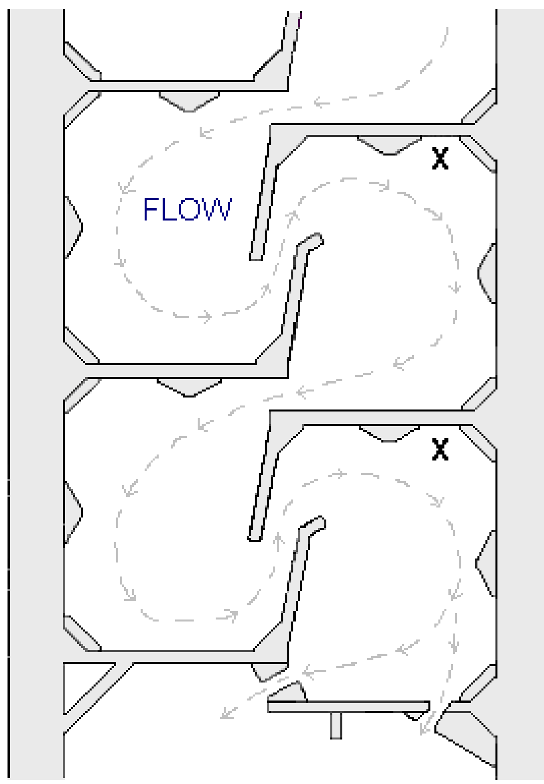

Figure 1: Drawing of the original serpentine design in the John Day Dam south ladder flow-control section, 2002. "X" s show where the majority of jumping occurred.

Based on these findings, the Portland District Corps of Engineers developed a design for the south ladder derived from the slot and orifice configuration at Ice Harbor Dam and The Dalles Dam's north ladder (U.S. Army Corps. of Engineers 2002). This design included a full depth vertical slot near the center of the fishway directing flow toward the south fishway wall. It also included an 18″ x 18″ submerged orifice on the floor of the fishway near the north fishway wall (Figure 2). During the 2002 – 2003 winter maintenance season, contractors removed the old style serpentine weirs and replaced them with the vertical slot style of weirs. In the fall of 2003, the FFU conducted a post-construction evaluation of the re-designed flow-control section.

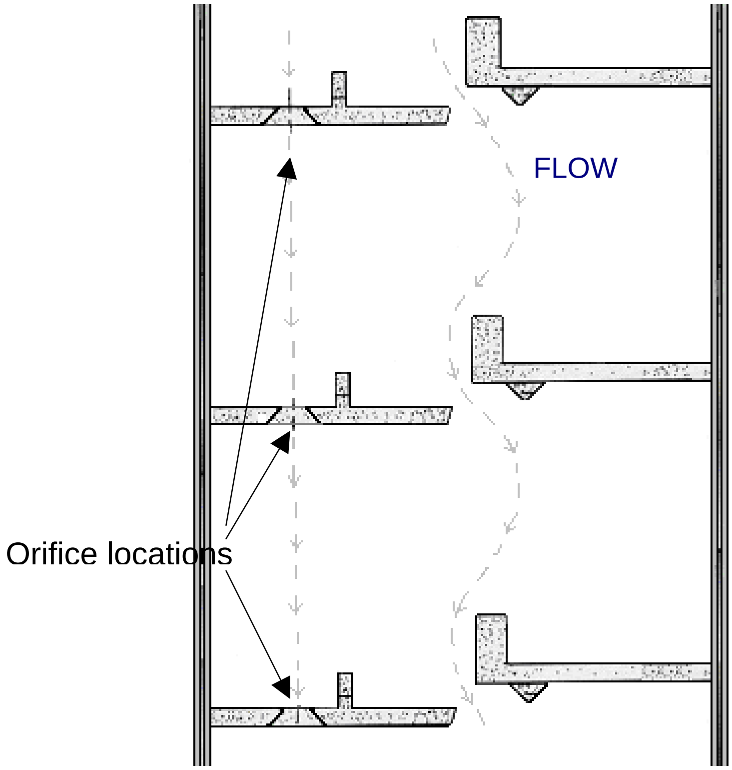

Figure 2: Drawing of the vertical slot and orifice design for the John Day Dam south ladder flow-control section, 2003.

OBJECTIVES

1. Determine if adult salmonid jumping behavior was reduced or eliminated in the re-designed flow-control section of the south ladder.

2. Determine the passage times of adult salmonids through the flow-control section; compare 2003 passage times with passage times calculated from data collected in 1993.

SITE DESCRIPTION

John Day Dam is located on the Columbia River at river mile 215.6 (346.9 km). The project has two fish ladders to accommodate adult fish passage, one on the south (Oregon) side of the river and one on the north (Washington) side. The flow-control section of the south ladder begins upstream of the diffuser pool and ends at the ladder exit (Figure 3). The re-construction of this section of the ladder is documented below in photos 3-6.

3. 

4. 

Photos: 3. View toward the ladder exit shows the original serpentine design in the flow-control section of the John Day Dam south ladder with protective padding around slot used for tests in 2000 and 2001. 4. View looking down the ladder from the forebay deck shows weir construction in the upper section of the south ladder. (FFU Photos)

5. 

6. 

Photos: 5. A view from inside the ladder looking upstream shows a completed weir with the new slot and orifice configuration. 6. The completed John Day Dam south ladder remodel with netting reattached. (FFU Photos)

METHODS

JUMP EVALUATION

Previous study data (Jonas and Madson 2001) was employed to determine the required sample size for achieving a 95% confidence interval (38 observation days). Observations, four days per week, began on September 15, 2003 and were to continue until November 21, 2003. After three weeks of inactivity, observations were reduced to two days per week. Sampling was stopped on October 28, 2003 (after 20 observation days) due to lack of fish activity. By viewing pools in pairs, it was possible to sample all 22 pools in the entire modified upper section of the John Day south ladder for one full hour during each sample day (Appendix B). A jump was considered to occur when a fish completely exited the water. Any above-water activity, such as nosing or lunging out of the water was also noted.

RADIO TRACKING ANALYSIS

The Idaho Cooperative Fish & Wildlife Research Unit (ICFWRU) provided the FFU with radio tracking data collected on the John Day south ladder during the 1993 and 2003 fish passage seasons. This data was used to compare fish behavior in 1993 to fish behavior in 2003 at three sites in the upper half of the John Day Dam south ladder. The antennas were located at: 1) mid-ladder just upstream of the 180° bend, 2) the diffuser pool at the base of the flow-control section, and 3) the last pool of the flow-control section, one pool down from the exit (Figure 3).

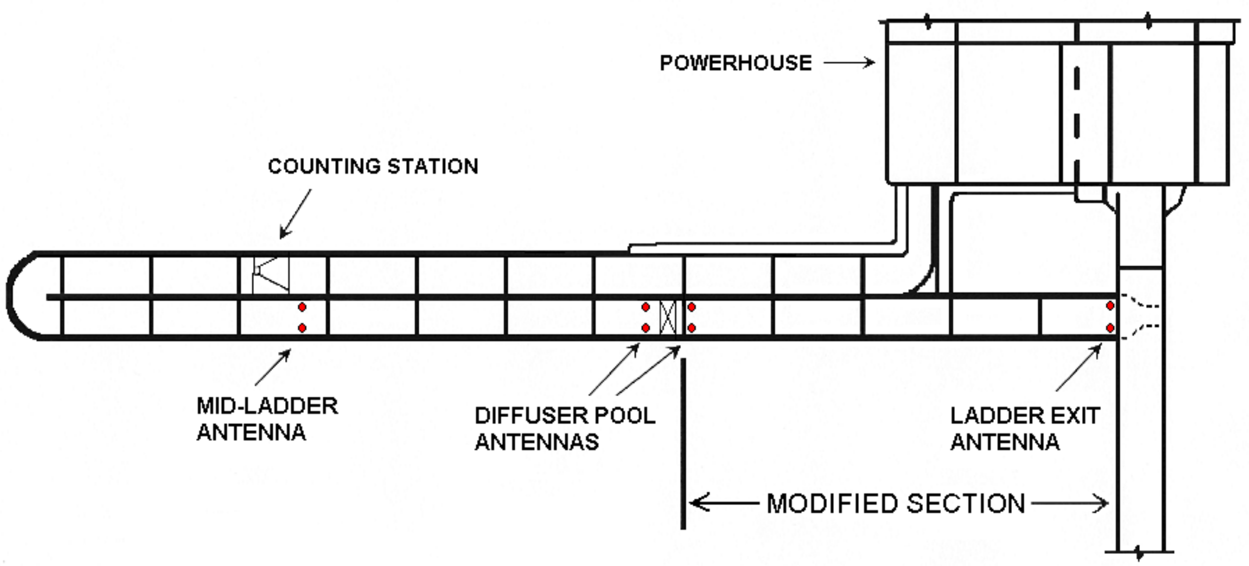

Figure 3: Top view of John Day Dam south ladder radio telemetry monitoring sites, and modified flow-control section where fish jumping observations were made in 2003. Individual pools are not illustrated in this figure.

In 1993, the ICFWRU trapped, tagged, and released spring and summer chinook[1] (19 April through 29 July) and steelhead[2] (7 July through 5 November) in the lower portion of the John Day Dam south ladder (Bjornn et al. 1998). At Bonneville in 2003, the same operation occurred with spring, summer, and fall chinook, coho, pink, and steelhead from 20 February through 15 October in the lower portion of the Bonneville Dam Washington shore ladder (Table 1). Because of significant differences in tagging procedures and data sets, statistical methods were not employed to compare 1993 with 2003. We compared descriptive data for 1993 and 2003 spring/summer chinook and steelhead. Delayed passage by steelhead in 1993 was also evaluated.

Table 1: Number, species, and location of salmonids radio tagged in 1993 and 2003.

	1993*		2003	
Location tagged	South ladder at John Day Dam		Washington shore ladder at Bonneville Dam	
Spring Chinook	713	(19Apr–	806	(27Mar–31May)
Summer Chinook	459	(1Jun–29Jul)	378	(1Jun–30Jul)
Fall Chinook			666	(2Aug–15Oct)
Coho			25	(27Aug–18Sep)
Pink			6	(24Sep–13Oct)
Early run Steelhead			26	(20Feb–20Mar)
Steelhead	899	(7Jul–5Nov)	615	(2Jun–15Oct)
Total	**2,071**		**2,522**	

***** The 1993 ICFWRU tagging record shows 2,082 rather than 2,071 salmonids tagged. It further indicates that eleven fish, all spring/summer chinook, were each re-tagged with the same channel/code combination on the day following their initial tagging.

Detections were noted for the first and last contact each fish made at each location monitored: mid-ladder, the diffuser pool, and the ladder exit (Figure 3). Passage times were calculated for: 1) passage through the study area (mid-ladder to the exit) and 2) through the flow-control section (diffuser pool at the base of the modified section to the exit). Passage time through the entire study area was calculated by subtracting the time of the first contact at mid-ladder from the time of the first contact at the exit. Passage time through the flow-control section was calculated by subtracting the time of first contact at the diffuser pool from the time of first contact at the exit (only contacts made after contacts at the mid-ladder site had ceased were used for calculating passage times through the flow-control section). The first contact at the exit site was used rather than the last contact because the exit site antenna was capable of detecting tagged fish in the forebay. Average and median passage times are presented for all passage categories.

[1] Chinook salmon (*Oncorhynchus tshawytscha*) are labeled spring chinook if they first appear in the fish ladders in the Columbia Basin before May 31 each year. They are labeled summer chinook if they appear in the fish ladders from June 1 through July 31.

[2] In this report, steelhead (*Oncorhynchus mykiss*) refers to the steelhead that migrate upstream through the fish ladders from June through November.

A contact that occurred after a three-minute loss of signal at a given site was considered a new detection (re-appearance) at that site. Downstream movement percentages were calculated by dividing the number of new detections at a site by the total number of contacts at the site and multiplying by 100.

The 1993 tagging operation at JDA blocked the ladder for several hours each day, shifting passage toward the nighttime, when passage normally slows or stops. To prevent a time-of-day bias due to a shift toward nighttime passage, passages were grouped according to the time of day a fish entered and left the study area (day → same day, or night → same night, etc.).

RESULTS

JUMP EVALUATION

From September 15 to October 28, 2003, during 214 hours of observation, there was no jumping in any of the modified pools of the John Day Dam south ladder. No fish were observed nosing above the water's surface or holding in any pools as seen before the modification. No above-water activity of any kind was observed in the flow-control section.

RADIO TRACKING ANALYSIS

Several differences were noted between the 1993 and 2003 data sets. If a fish was contacted at only two of the three monitored sites, the passage was considered "partial path". Twenty-five percent of the passages in the south ladder were "partial path" in 1993 compared to two percent in 2003. In 1993, these were primarily steelhead passages (327 of the 396). Tagged fish holding in the diffuser area overloaded the receiver and caused a loss of data from September 19 to September 21, 1993. In order to prevent another loss, the diffuser pool antennas were disconnected on September 23, 1993 and remained out-of-service for the rest of the fish passage season. In 2003, data was lost during two groups of dates, May 8 – 15 and September 5 – 9. The loss of data from May 8 – 15 May was the result of receiver failure; the loss of data from September 5 – 9 appeared to be the result of another overload of data in the receiver.

Substantial behavioral differences were found between the two years. In 2003, only one passage ended at mid-ladder; in contrast, 124 passages in 1993 ended at mid-ladder. In 2003, repeat detections (re-appearances) were relatively rare. In 1993, fish re-appeared repeatedly before finally departing the ladder. One fish made 2,365 re-appearances, another 1,199, and 12 made more than 100 re-appearances. The time spent making repeated appearances in 1993 ranged from 36 minutes to 4 months, 24 days. In 1993, approximately 43% of steelhead movements were downstream at the mid-ladder site compared to 8% in 2003.

The passage times of fish through the entire study area are shown in Table 2; these fish were detected at both the mid-ladder and ladder exit monitors. Most passages occurred entirely within one day, during daylight hours. Some fish stopped moving upstream during the night and completed their passage the next morning. Steelhead exiting the ladder the same day they entered the study area, took an average of 52 minutes to swim from the mid-ladder monitor to the exit in 2003, compared to one hour and 22 minutes in 1993 (Table 2).

Table 2: Numbers of 1993 and 2003 passages, average passage times (h:mm:ss), and median passage times (m) starting from the first contact at mid-ladder and ending at the first contact at the exit of the John Day Dam south ladder. Average and median times for groups of four or less passages are not shown.

Enter	Exit	1993 Spring/Summer Chinook	1993 Steelhead	2003 Spring/Summer Chinook	2003 Steelhead
Day	Same Day	687 1:28:41 1:22:58 m	392 1:22:13 1:14:12 m	458 1:10:34 1:01:26 m	220 0:51:59 0:48:17 m
Day	That Night	60 2:01:12 1:57:53 m	32 3:06:12 1:31:43 m	23 1:41:23 1:06:20 m	14 1:33:16 0:52:37 m
Night	Same Night	15 2:00:53 1:38:16 m	20 2:21:24 1:46:13 m	9 1:58:16 1:25:48 m	41 1:55:16 1:15:32 m
Night	Next Day	34* 9:23:03 9:39:38 m	12 9:40:49 9:57:58 m	25* 8:02:12 8:39:22 m	7* ** 3:30:57 3:13:37 m
Day	Next Day	21* 12:02:46 10:37:50 m	30 *** 17:50:21 18:12:23 m	3	2
Day	Days Later	7 223:59:53 216:05:32 m	33 **** 277:36:35 144:55:46 m	1	1
	Totals:	***824***	***519***	***519***	***285***

*Left the south ladder early in the morning.
** Arrived at the mid-ladder monitor late at night.
*** Approximately 46% downstream movements.
**** Approximately 49% downstream movements.

The passage times of fish through the flow-control section are shown in Table 3; these fish were detected at both the diffuser pool and the ladder exit. Steelhead that exited the ladder the same day they entered the flow-control section took an average of 24 minutes to swim through that section in 2003, compared to 51 minutes in 1993 (Table 3).

Table 3: Numbers of 1993 and 2003 passages, average passage times (mm:ss or h:mm:ss), and median passage times (m) starting from the first contact at the diffuser pool and ending at the first contact at the exit of the John Day Dam south ladder. Average and median times for groups of four or less passages are not shown.

		1993		2003	
Enter	**Exit**	**Spring/Summer Chinook**	**Steelhead**	**Spring/Summer Chinook**	**Steelhead**
Day	Same Day	733 48:04 42:58 m	204 51:15 42:49 m	461 31:59 26:26 m	229 24:06 21:22 m
Day	That Night	47 1:14:17 57:47 m	16 3:54:17 1:04:40 m	9 27:38 26:16 m	7 22:48 22:28 m
Night	Same Night	32 1:09:11 55:44 m	12 1:40:27 1:25:14 m	23 1:21:41 47:02 m	47 59:53 33:38 m
Night	Next Day	36* 8:34:42 8:34:58 m	8 9:49:00 9:33:17 m	23* 7:24:41 7:51:05 m	5* 2:57:23 3:36:36 m
Day	Next Day	3	15** 16:13:1 15:42:50 m	1	2
Day	Days Later		1		1
	***Totals*:**	***851***	***256***	***517***	***291***

*Left the south ladder early in the morning.
** Approximately 42% downstream movements.

DISCUSSION

In the fall of 2003, the FFU evaluated fish behavior in the newly modified ladder. In nine years of observations prior to the rebuild, fish were frequently seen jumping in the flow-control section including multiple jumps by individual fish. During the 2001 – 2002 test of the surface slot and submerged orifice, the FFU observed single-pool mean jump rates as high as 13.6 jumps per hour. In 2003, no jumps were observed in the rebuilt flow-control section. Nosing, lunging, and other above-water activity observed during previous years, was not observed in the flow-control section during the study. The only above-water activity observed was a single pool-to-pool jump located downstream of the diffuser pool in the overflow section of the ladder. Holding by adult salmonids was not observed, even in the diffuser pool where it was evident during past observations. In previous years, adult salmonids were found stranded on the netting or catwalk; no fish mortalities were observed along the flow-control section during the evaluation. An analysis of radio tracking data showed that salmonids took less time to pass through the flow-control section than they did prior to the rebuild; however, this comparison is based on the only data currently available, two single-year samples (1993, 2003). To determine whether the difference in passage rates was unique to John Day Dam, additional analysis would be required; the data for such an analysis is not available at this time. There seemed to be a correspondence between months when radio tagged steelhead were delayed and when the FFU observed jumping and holding in the upper south ladder. The nature of the stimulus that triggered the delay is still unknown. On December 3, 2003, although two adult steelhead were seen by the dewatering crew, no steelhead, or other adult salmonids, were handled during the fishway dewatering (Jonas 2003); it is unknown whether this paucity of fish is a result of the ladder rebuild.

Ten brief observations were made on the upper section of the John Day north ladder during the fall of 2003. Jumping and holding activity was noted, reflecting the same pattern as seen during previous years. At the annual fishway dewatering on January 12, 2004, eighty steelhead were moved to tailwater (personal communication, Project Biologist, Robert Cordie). The north ladder employs a serpentine flow-control section similar to the one replaced at the south ladder. Problems have been documented with jumping, holding, and excessive downstream movement past the count station. Replacing the flow-control section with a slot-and-orifice design may address these on-going problems.

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APPENDIX A

JOHN DAY SOUTH LADDER HISTORY OF SALMONID JUMPING PROBLEM

YEAR	ACTION TAKEN	REFERENCE
1968	initial construction	
1969	jumping in ladders noted	Donaldson 1969
1970-71	upper section of S ladder reconfigured with vertical slots	AFPR 1971
1971-72	upper section of N ladder reconfigured with vertical slots	AFPR 1972
1982?	protective netting installed in ladders	Beck 1989
1982-84	Fluoride concentration research upstream of JD Dam	Damkaer & Dey 1984
1985	FFU radio-tracked adult salmonids in S ladder	Shew et al. 1988
1987	more spring steelhead moving down than up in ladders	AFPR 1987
1989	jump observations-memo and recommendations	Rawding 1989; NMFS memo 1990
1990	mitred corners installed, netting replaced & coverage expanded	Rife 1990
	NMFS preliminary jump observations	Cordie 1995
1991	NMFS preliminary removable sills test	Nordlund 1991
	NMFS rudimentary water tests (temperature & conductance)	Nordlund 1991
1992	upper ladder diffuser pool picketed barriers installed,	
	mitred corners, vertical deflectors & slot in upper ladder	Wright 1996
1993	radio-tracking analysis & jumping observations.	Jonas et al. 1994
	Fluoride sampling - John Day N and S fishladders	Cordie 1994
1994	literature search - water quality affects on salmonid behavior	Cordie 1994
	jump observations and water quality investigations	Cordie 1995
1995	NMFS BiOp requires continued investigation of jumping, delay	NMFS 1995
	preliminary pH, conductivity and conductance water quality tests	Jonas 1996
	plywood-shaded railing test	Wright 1996
	water temperature monitoring in the ladder	Dalen & Jonas 1995; Dalen et al. 1995
1995-96	permanent concrete mitred corners installed by JDA project	Jonas, 1997
1996	netting replaced & coverage extended toward ladder exit	
	dissolved Oxygen monitoring	Langeslay 1997
	jump observations	Jonas 1997
	ladder water temperature monitoring	Dalen et al. 1997
1997	removable sills tests,	Dresser & Stansell 1998
	literature search on salmonid jumping behavior	ibid.
	ladder water temperature monitoring	Dalen & Stansell 1998
1998	effect of shading upon jumping behavior & jump observations	Jonas 1999
	ladder water quality data collection (temp,do,conductivity,pH)	Langeslay 1998
	NMFS night jumping observations	FFU files
	protective padding installed - selected areas of N & S ladders	FFU
1999	diffuser settings test	Jonas & Madson 2000
	protective padding installed - selected areas of N & S ladders	FFU
2000	vertical slot cut into south side weir wall	JDA project
	slot,orifice control jump comparisons	Jonas & Madson 2001
2001	slot/orifice vs. control test	Jonas & Madson 2002
2002-03	rebuild of upper JDA south ladder	
2003	evaluation of rebuilt upper south ladder	

APPENDIX B

Samples taken, JDA south ladder, 2003: numbers (0 – 11) following each date represent sites sampled for one hour, each site views two flow-control pools, site 0 views 6 pools in the overflow section including the diffuser pool. Observer's #1 and #2 sample simultaneously, enabling all pools to be viewed during daylight hours.

	Observer #1						Observer #2					
	A	B	C	D	E	F	A	B	C	D	E	F
15-Sep	11	3	5	9	0	10	2	6	4	7	1	8
16-Sep	2	7	10	1	8	11	6	5	9	3	4	0
17-Sep	0	7	1	5	11	4						
18-Sep	9	4	3	10	1	11	2	7	6	5	0	8
22-Sep	11	8	0	10	6	7	5	2	9	1	3	4
23-Sep	4	7	3	0	11	5	6	10	9	1	8	2
24-Sep	3	9	0	11	7	6	1	5	10	8	4	2
25-Sep	11	2	7	0	3	8	10	5	4	1	9	6
29-Sep	9	5	6	7	3	10	0	11	1	8	4	2
30-Sep	7	8	11	10	6	0	4	1	3	5	9	2
1-Oct	7	2	8	11	9	3	5	10	0	6	1	4
2-Oct	0	2	11	3	6	9	5	7	8	4	1	10
6-Oct	4	6	10	8	7	11	5	1	0	3	9	2
9-Oct	9	2	7	4	6	0	11	1	10	8	3	5
14-Oct	5	2	10	4	11	8	6	3	1	0	7	9
15-Oct	2	3	1	10	6	4	7	9	5	11	0	8
21-Oct	5	9	10	4	2	8	3	1	11	6	0	7
22-Oct	10	11	7	9	2	8	5	3	6	4	1	0
27-Oct	9	4	1	2	5	8	3	7	6	11	10	0
28-Oct	2	4	11	1	3	7	8	9	10	0	6	5