Memorandum for the Files

11/14/12

Subject: Bonneville Adult Collection and Monitoring Facility (Bonn AFF):
Proposed Improvements for Small Project work in the Fiscal Year (FY) 13 In-Water Work Period

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1) Problem:

A number of both sampled and bypassed adult fish have experienced mortality in past fish passage seasons in the Bonn AFF operations.

2) Probable causes of Problem
   a) Fast surface velocity in the main exit channel may pin salmon against trashrack
   b) Proximity of exit opening between the brail pool and main exit channel is located too near to the fast moving water surface and too close to trashrack
   c) Leakage or inflow from Valve 3, or other sources may be contributing excessive flow in the main exit channel
   d) Bypass flumes have pipe exits more than 2.5 feet above the water surface in the main exit channel at a location where the flow depth is only 1.9 feet deep and very fast.
   e) Insufficient recovery time in the brail pool

3) Goals of the Small Project Improvements to the Bonn AFF:
   a) Create more uniformly distributed velocities in the exit channel
   b) If possible, reduce flow in Exit Channel
   c) No increase in velocities in brail pool
   d) Recovery tanks for fish prior to sending to brail pool
   e) Improve the outlet conditions for the bypass flumes

4) Description of Current Operation:

The system generally consists of the following in the direction of water flow:

   a) Fish Recovery & Exit System
      i) Main exit channel from Pool 49 to main trashrack and Valve 15 pit
      ii) Brail pool and Anesthesia Tank
   b) Flume system
      i) False Weir to Sort Flume,
      ii) Flume to Anesthesia Tank
      iii) Bypass Flumes to Exit Channel
   c) Collection System
      i) Collection Pool

ii) Collection Channel flows to Pool 37

A general plan view of the Bonn AFF is shown in Figure 1.

d) Fish Exit and Fish Recovery System:

The main exit channel flow discharges (estimated 37 cfs at one foot ladder head) from the main ladder (pool 49) down a series of half-ice harbor weirs: 8-feet wide channel with 5 feet overflow weirs and single 18-inch square orifices. Valve 2 feeds water from the forebay to a floor diffuser in pool 49 to augment the flow down the exit channel and maintain ladder head criteria at weir 37 in the main ladder.

Downstream of the half-ice harbor weirs, the AFF exit channel is very shallow (~ 1.9 feet) and makes a 180° bend goes about 40 feet and then bends 90°. After the last bend, there is the final 30 feet of exit channel (still 8 feet wide) in which the last 20 feet is deeper again (~ 4.9 feet).

The 20-foot long deeper section passes the 10-foot wide brail pool and terminates with a sloping 8-foot wide trashrack. There is an16-inch wide x 1.9 feet deep exit opening from the brail pool into the main exit channel, located about 7 feet upstream of the main trashracks. This is where recovered fish (previously sampled) return to the main exit channel and main ladder system. A detailed schematic plan view of this area under existing operation in shown in **Figure 2**.

Valve 3 (from the Forebay) is used to augment initial water-up of the brail pool and exit channel, but is normally closed during sampling operations.

All exit channel flow is currently discharged through both an 8-foot long terminating trashrack and an adjacent 5-foot long vertical side wall trashrack. All outflow then discharges over a system of stoplog weirs surrounding the drainage pit for Valve 15. The sum (clear) opening length of the weirs is 12.5 feet and the stoplogs are about 4 feet above the invert. The stoplogs consist of 4 x 4-inch wood members and there is noticeable leakage through them. The weirs tend to control the discharge and maintain water surface elevation in the exit channel and brail pool. Valve 15 is set at 75% open to assure drainage behind the weirs and prevent them from becoming submerged. In the previous years, the valve was set at 55% to maintain essentially the same water level elevation. This indicates there is more outflow going through valve 15 than in previous years (unless there is some new impedance in the drainage system).

There is also Valve 14 located off to the side in the NE corner of the sump area, which could be used to augment drainage capacity. It is currently kept closed.

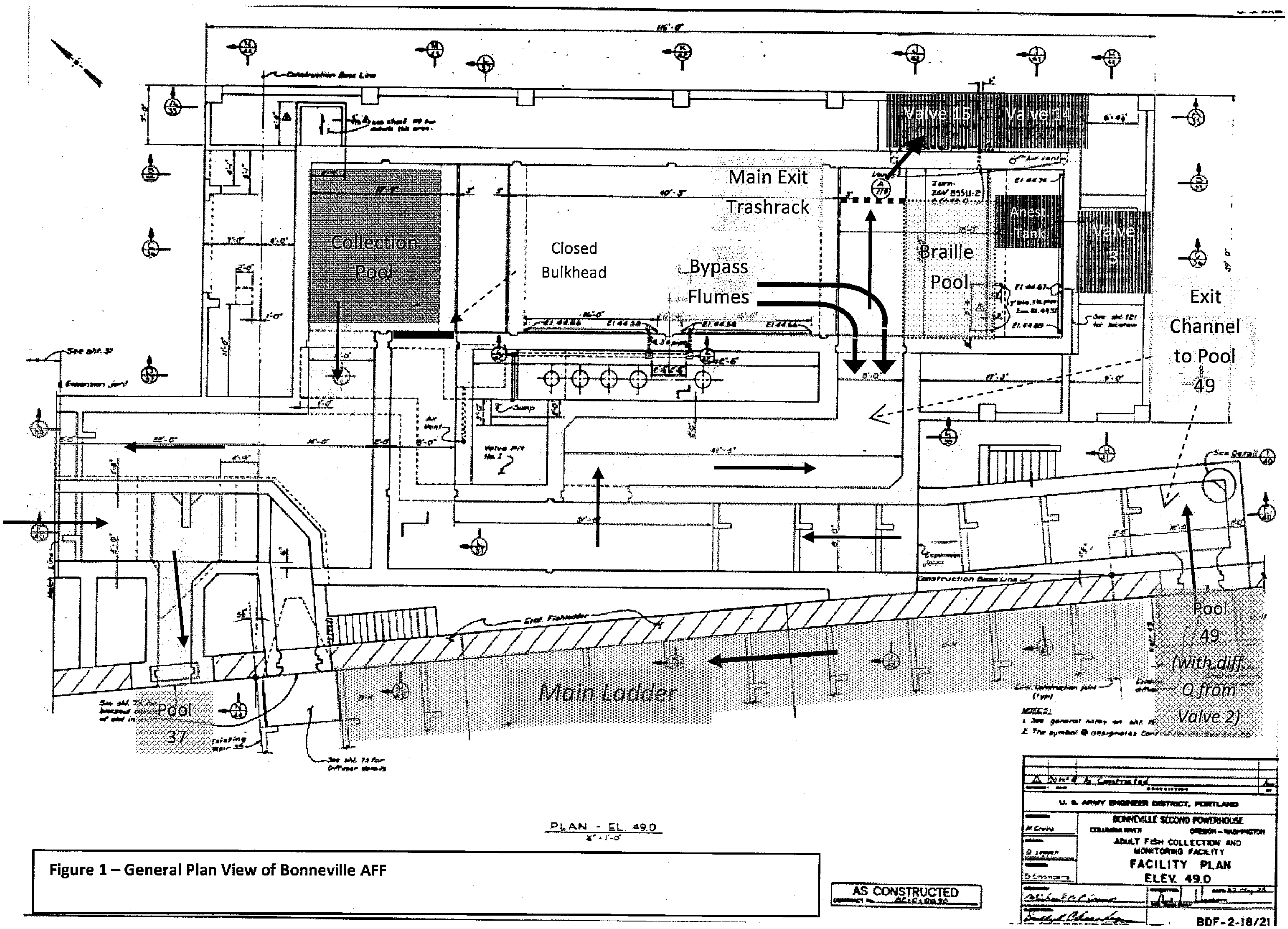


Figure 1 – General Plan View of Bonneville AFF

EXISTING OPERATION WITH DIMENSIONS AND DEPTH AVERAGED VELOCITIES

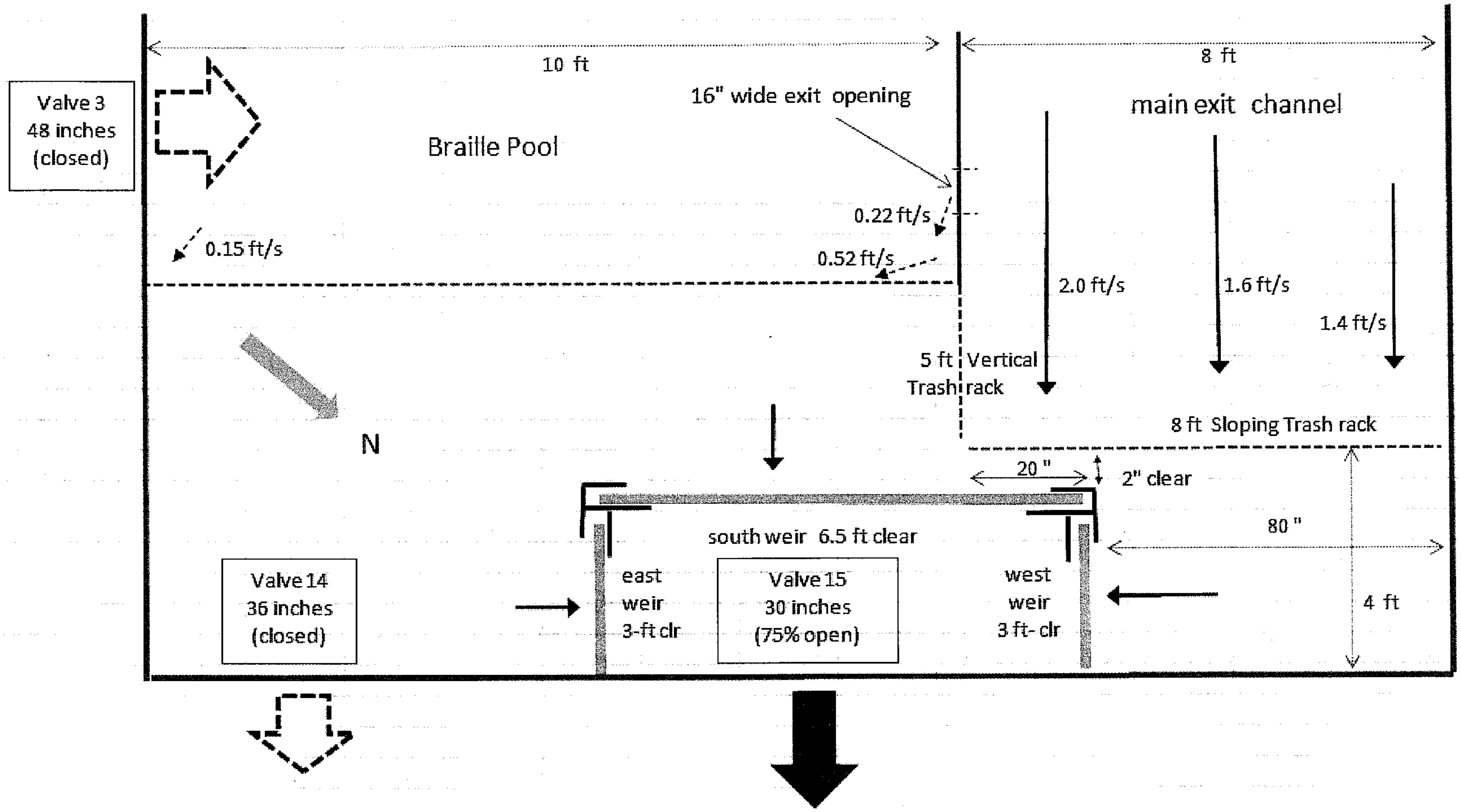


Figure 2 – Schematic of Existing Braille Pool and Exit Channel area under Existing Operation (with depth-averaged velocities).

e) Fish Collection System:

This is another side of the AFF which pertains to the collection of fish from the downstream Pool 37 in the main ladder. In normal operations, this is hydraulically separated from the exit system by means of a closed bulkhead (see upper left in **Error! Reference source not found.**). Water drains from the collection pool through a similar system of half ice harbor weirs as in the exit channel. The collection pool is supplied by Valve 12 from the forebay.

f) Fish Flume System:

Fish volitionally leave the collection pool over a false weir into a rectangular flume. The flume has bifurcations and switch gates that direct fish to either the anesthesia tank(s) or bypass to the main exit channel. The anesthesia tank is located on the east side of the brail pool, so the rectangular flume to the anesthesia tank must cross over both the exit channel and brail pool.

The bypass flumes are a 14-inch outside diameter (OD) Schedule 40 PVC pipe. The two Bypass flumes bend 90 ° southward into the main exit channel and exit about 20 -25 feet upstream of the main trashrack in the shallow portion of the channel. The drop from the bypass flume inverts to the exit channel water surface was measured to be about 2.6 feet. The depth is flow is 1.9 feet in this area of the exit channel (see **Error! Reference source not found.** for approximate location of bypass flume outfalls).

5) Hydraulic Data and Evaluation:

Hydraulic data were collected in the Bonn AFF on Oct 24 and Oct 31, 2012. A Marsh McBirney velocity meter was used in the first trip, and a more reliable Price Meter was used in the second trip. Other than low velocity (< 0.5 to 1 ft/s) measurements (in which the price meter detected velocities and Marsh Mc Birney did not), the differences between meter results were small.

In both visits, the velocity in the main exit channel was measured at a location about 5 feet upstream of the main trashrack (coincident with the north side of the Brail Pool). In the second visit, the velocities were also measured in the brail pool. During both trips, the valve 15 and valve 14 settings were altered to see if the surface velocity could be reduced in the exit channel.

a) Main exit channel measurements:

The average velocity (as a function of depth below water surface) is shown **in Figure 3**. The velocities were averaged across the channel (8 foot width) at different depths (flow depth = 4.9 feet). The Price Meter data (red curve) is more reliable. The velocities are over 2.8 ft/s near the surface and less than 1 ft/s below 3.5 feet. The velocities are much faster near the surface because the outflow and water surface level is mainly controlled by stoplog weirs, and the weirs primarily draw water from the surface (there is also leakage through the stoplogs). The overall average velocity was 1.7 ft/s with an estimated total flow rate of 66 cfs.

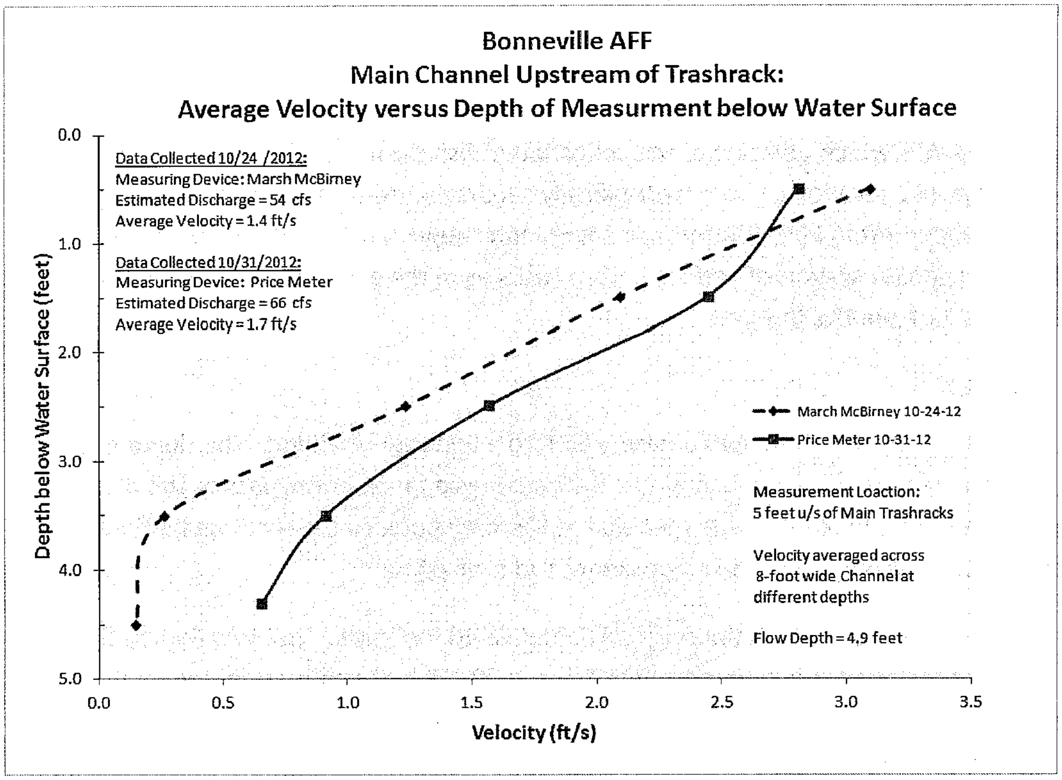


Figure 3 – Average Velocity versus Depth below Water Surface in Exit Channel (5 feet U/S of Trashracks)

For the same exit channel measurements, the depth averaged velocity as a function of lateral location is shown in **Figure 4**. The velocity was averaged over the full depth (4.9 feet) at different lateral location. The Price Meter data (red curve) is more reliable. The velocities are higher on the right (east) side of the channel, adjacent to the Brail Pool. The reason is that there are multiple flow paths towards the stoplog weirs from the right side of the channel in the complicated non-symmetrical weir and valve pit geometry (See **Figure 2**).

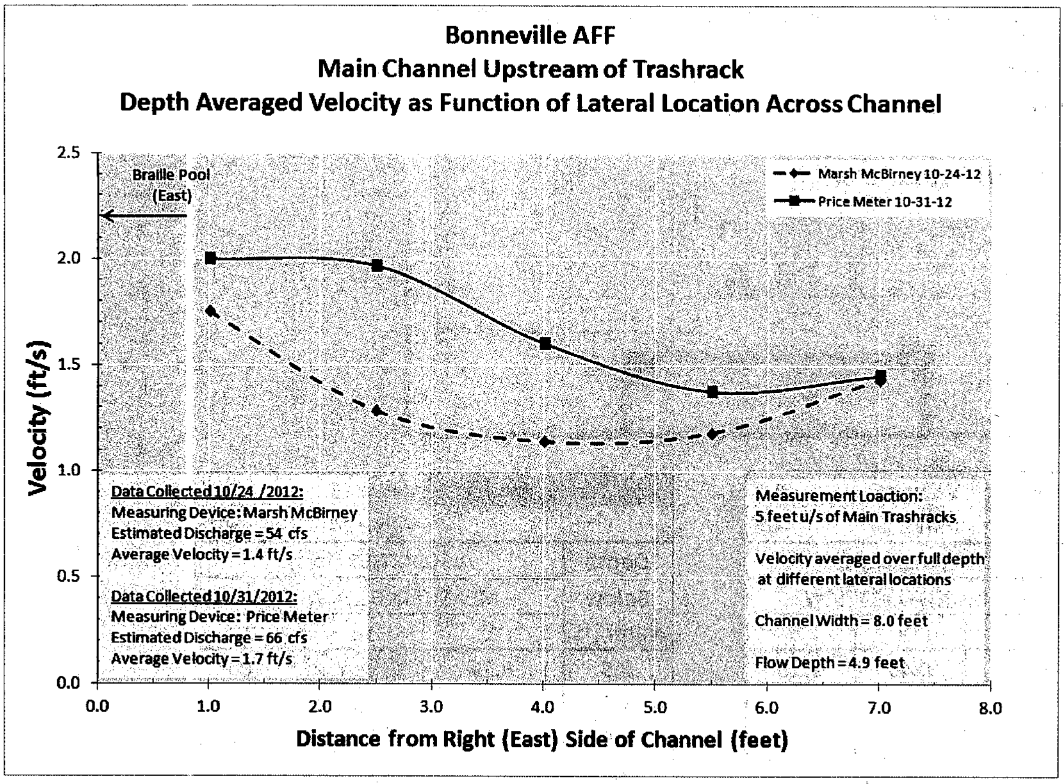


Figure 4 – Depth Averaged Velocity versus Lateral Location in Cross-section of Exit Channel

Velocities in the centerline of main exit channel were also measure under different valve operations. The velocities could not be improved in the exit channel without submerging the weirs. More will be discussed on this in the section under valve settings.

b) Brail Pool measurements:

Velocities were measured at different locations along the north (or NE) edge of the brail pool (which was most assessable and showed the most visible flow. The measurement locations and depth averaged velocities are shown in **Figure 2** (presented earlier). The highest velocities (0.5 ft/s) are in the far north (or NW) corner of the brail pool, adjacent to the main exit channel and exit opening. Velocities at the exit opening were notably lower at 0.2 ft/s with the direction of the flow parallel to the opening and west sides of the brail pool.

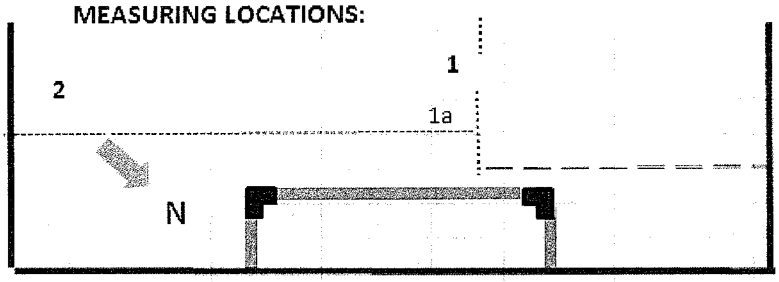
The velocities as a function of depth in the pool are shown at each location in Table the measurement locations are shown numbered in the upper schematic. The data for the current operation (valve 15 at 75% open) is shown in the lower left. The lower right has data from a modified operation (valve 15 @ 70% and Valve 14 @ 30 %). The velocities changed negligibly in the Brail Pool between these operations (but the velocities in the exit channel increased significantly under the modified operation.)

The higher surface velocities at location 1 and 1A indicate the influence of the adjacent exit channel and the downstream weirs. The velocities are faster in the lower depths at location 2 because the sides below water are blocked in the upper 2 feet and the bottom 2 feet have open grating.

Table 1 – Braille Pool Measurement Locations and Velocities as a function of Depth

Braille Pools Data

Depth of Pool at North end = 4 feet



CURRENT Operation		Valve 15	75%
		Valve 14	0%
Depth Below Water (ft)	VELOCITIES (ft/s)		
	MEASURING LOCATION		
	1	1a	2
0.5	0.29	0.46	0.10
1.5	0.27	0.56	0.10
2.5	0.10		0.20
3.2	0.21		0.20
Average V	0.22	0.51	0.15
Average direction	↓	←	↙

Modified Operation		Valve 15	70%
		Valve 14	30%
Depth Below Water (ft)	VELOCITIES (ft/s)		
	MEASURING LOCATION		
	1	1a	2
0.5	0.29		0.00
1.5	0.23		0.19
2.5	0.19		0.22
3.2	0.17		0.29
Average V	0.22		0.18
Average direction	↓	←	↗

c) Alternative Valve Operations:

Alternative valve settings (Valve 14 & 15) were investigated during the two different site visits. The question was could velocities be reduced in the exit channel by changing the distribution of valve settings. However caution had to be exercised to avoid raising the velocities in the brail pool, where fish are still recovering from anesthesia.

During the Oct 24 trip, the following operations (Table 1) were investigated with head measurements upstream and downstream of the weir and without velocity measurements. Visually, the slower velocities occurred when the weirs were submerged (rows with pink cells), but these are unstable operations and the tests were not of sufficient duration to assure the water levels has stabilized. The brail pool did not appear to be affected much but the different valve operations.

Velocities measures were taken in the centerline of the exit channel (and brail pool) during the Oct 31 site visit for the current operation and two other alternative operations. The end result was the velocities in the exit channel were simply made worse by the adjustment s (19% increase), even if the brail pool did not appear to be affected.

In short alternative valve operations don't help.

Table 2 - Valve Operations Tested on Oct 24

Valve 15	Valve 14	Visual on exit Cha.	Water level below weir (inches) U/s Weir	D/s Weir
75%	0%	fast	10.5	-4
75%	10%	fast	11	-6
75%	20%	fast	10	-12
75%	30%	fast	9	-14
50%	30%	slower	17	12
60%	30%	slower	15	15
65%	30%	slower	14	13
65%	40%	fast	9	-12

Table 3 - Valve Operations Tested on Oct 31 with Velocities measured in Centerline of Exit Channel

Depth Below Water (ft)		Current OP		Mod. OP 1		Mod. OP 2
	Valve 15	75%	Valve 15	70%	Valve 15	60%
	Valve 14	0%	Valve 14	40%	Valve 14	50%
0.5		3.44		4.12		3.99
1.5		2.20		2.63		2.60
2.5		1.01		1.33		1.34
3.5		0.68		0.67		1.01
4.3		0.62		0.70		0.51
Average Velocity (ft/s)		1.59		1.89		1.89
Percent Above Normal		0.00		19%		19%

One alternative valve operation (not listed for Oct 31) was closing Valve 15 and opening Valve 14 to 75%. Valve 14 is larger (36 inch vs. 30 inch) and does not have weirs surrounding its pit. Hence the water level was drawn down below the crest of the weirs. It was at this time we discovered that there is significant leakage around, under and between a number of stoplogs. This is probably due to the gradually rotting and wearing of the 4 x 4 inch wooded stop logs.

d) Probable Cause of Increase Flow though Valve 15

In past years, Valve 15 has been operated at 55% open. Currently in order to avoid submerging the weirs, the valve 15 must be open to 75% to avoid submerging the stoplog weirs. The increased opening in Valve 15 indicates more flow is passing through Valve 15 and the exit channel.

Referring to Fig 4.3 in 'Hydraulics of Pipelines" (Tullis, 1989), the discharge coefficient (CD) in a typical butterfly valve will be 0.5 for 75% open and 0.35 for 55% open. Using a simplifying assumption of equivalent head differential across the partially closed butterfly valve, the flow rate would be 30% lower (46 cfs) in the previous operation (55%) than in the current valve setting (75% with 66 cfs discharge). In actuality, percent difference in flow rate will be lower when factoring in the increased downstream conduit head losses with the greater flow, so the previous outflow was probably more along the lines of 50 cfs.

An additional piece of evidence is that the Project biologists have had to open Valve 2 from a previous long term setting of 50% to as high as 70% in the past year to assure correct ladder head down at Pool 37 in the main ladder. Valve 2 feeds the diffuser in pool 49 to augment the ladder head in the main ladder.

It is probable that the observed leakage through the stoplogs has grown over time, such that it lowered the water level upstream of the weirs under the 55% valve operation. A lower water level upstream of the weirs in exit channel would raise the head differential in the exit channel half ice harbor weirs so that more flow would be pulled into the exit channel from pool 49 (which act as a junction between the main ladder and the AFF exit channel). This increase in flow into the exit channel would take water away from the portion that goes down the main ladder. The ladder head at Weir 37 would become too low and the Project would need to open Valve 2 to compensate. This would bring in yet more water into the exit channel and Valve 15 would need to be opened to the current 75% to prevent submerging the stop log weirs.

While there may be other factors yet undetected, this appears to be at least a partial cause for why there is more flow in the exit channel and the increased Valve 15 setting.

6) Recommended Design Changes for Bonn AFF:
   The following improvements are recommended for 2012-13 in-water work to be performed under Small Projects:
   - Replace 4.5 feet of stop lop weirs (out of 12.5 feet total) with low porosity perforation plate, replace existing stoplog weirs with new members and add u/s blockage plywood to reduce leakage.
   - Add two recovery tanks to hold up to 4 fish for duration of 20-30 minutes, as a transition for fish between the anesthesia tank and the brail pool.
   - Extend the existing bypass flumes approximately 30 feet at 5% to bend around corner in exit channel and reduce drop between invert and water level in exit channel to about 6 inches.

   a) Replace 4.5 feet of Stoplog weir with porosity plate and improve sealing around remainder of weirs.

The proposed improvements are illustrated in the schematic shown in **Figure 2**Figure 5 .
The porosity plates will be designed to both assure more even distribution of flow in the exit channel and reduce the overall flow in the exit channel. The holes will need to be larger than 1 inch diameter (to avoid plugging and spaced dispersedly to reduce porosity and discharge rate. At the location where the

porosity plate is replacing 1.5 feet of the main 6-5-foot weir, the plate above 4 feet depth will be solid due to the proximity of the upstream main trashrack (i.e. minimize hot spots on trashrack). A new vertical guide will need to be added for this new perf plate section. To augment schedule, it is possible to use solid wood members for the perf plates and have the 1.5-inch holes drilled into them. The perf plates will extend above the water surface.

The old stoplogs will need to be replaced and an additional section of plywood should be place upstream of each weir section to further reduce leakage in the remaining weirs.

The valve setting will need to be readjusted after the improvement. The valve setting should be reduced from the current 75%.

b) Bypass Flumes Extension

The 14-inch OD Bypass Flumes exit at a level has been measured to be about 2.6 feet above the water surface elevation in exit channel. This is in a fast, shallow (1.9 feet depth) location. There is vertical and lateral space to extend the flumes (at 5% slope) to at least 32 feet downstream and bend the pipes (per criteria: Radius = 5 x OD) to a location upstream that would reduce the drop from the flumes to about 6 inches. A plan view of the proposed extension is shown in Figure 6.

The new location would still be in a fast shallow location, however the added distance upstream plus reduced drop should help the bypassed fish.

c) Recovery Boxes

Biologists have suggested the addition of two recovery tanks as a transition from anesthesia tank to brail pool. The boxes would hold up to two fish per tank, or four total—the same number as the anesthesia tan.

Draft drawings of the tanks are shown in Figure 7and Figure 8. However, there are changes intended since these drawings were developed:

1) The tanks are more intended to be aluminum instead of wood if possible.

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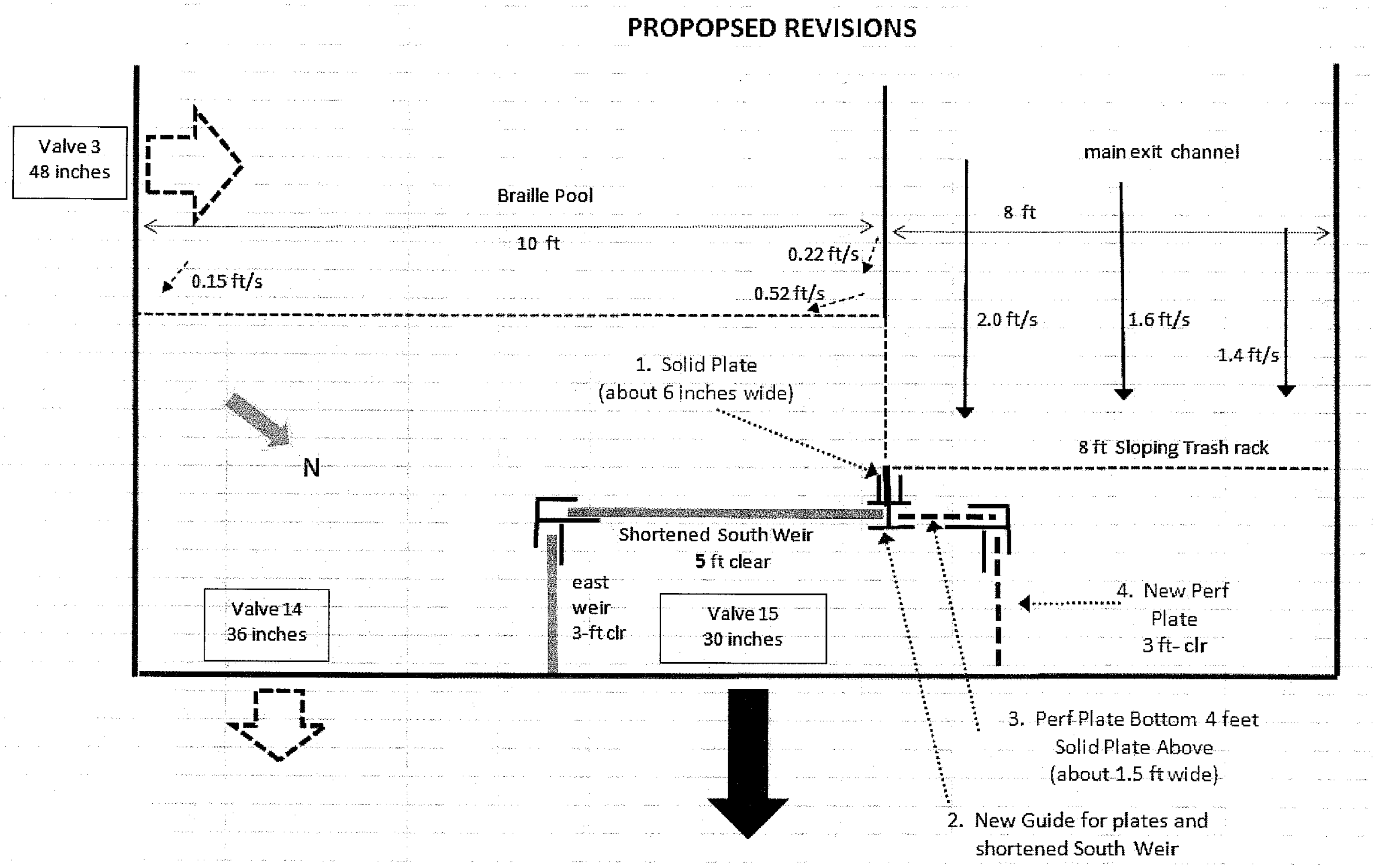

Figure 5 – Proposed Changes in Exit Channel to improve velocity distribution and reduce overall flow.

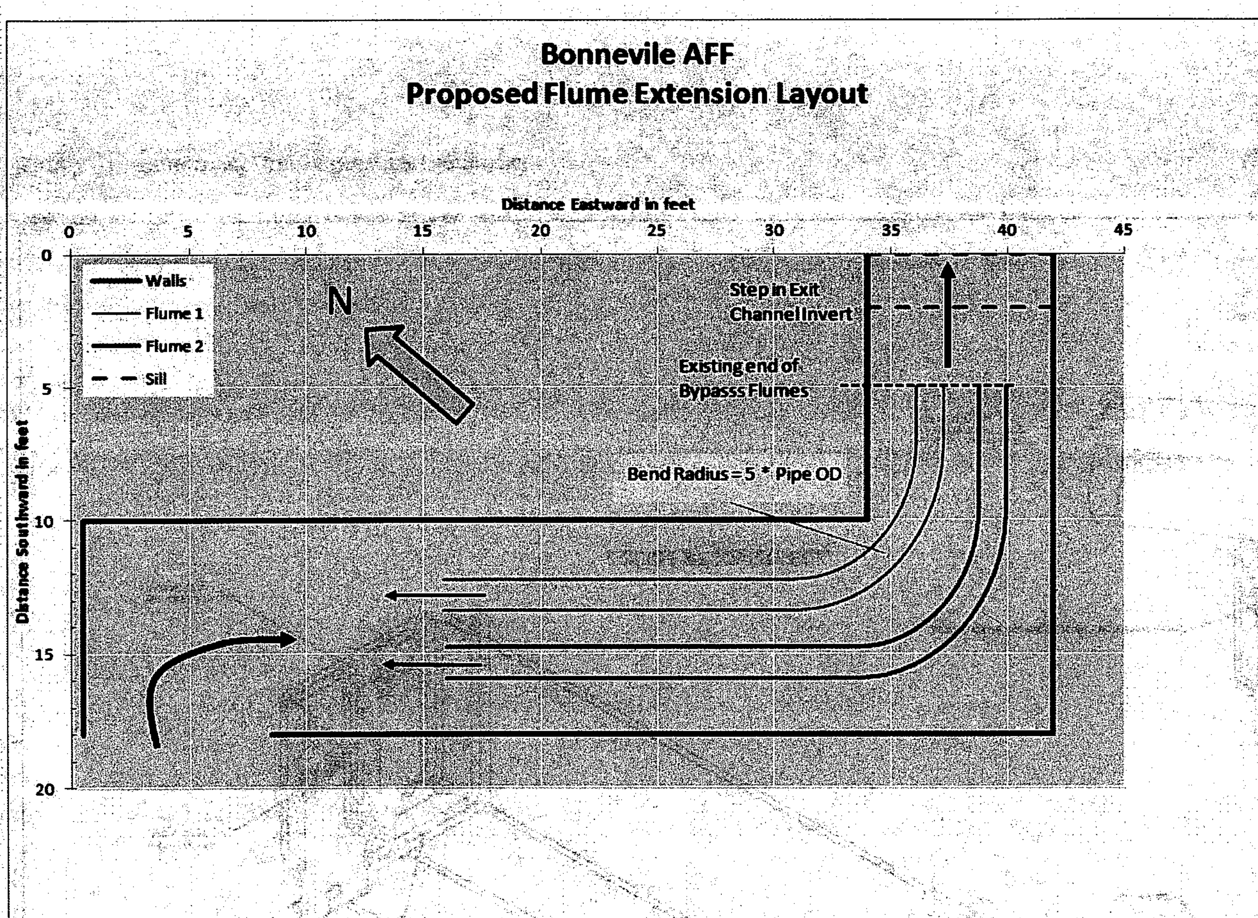

Figure 6 – Proposed Extension to Bypass Flumes at 5% Slope (Plan View).

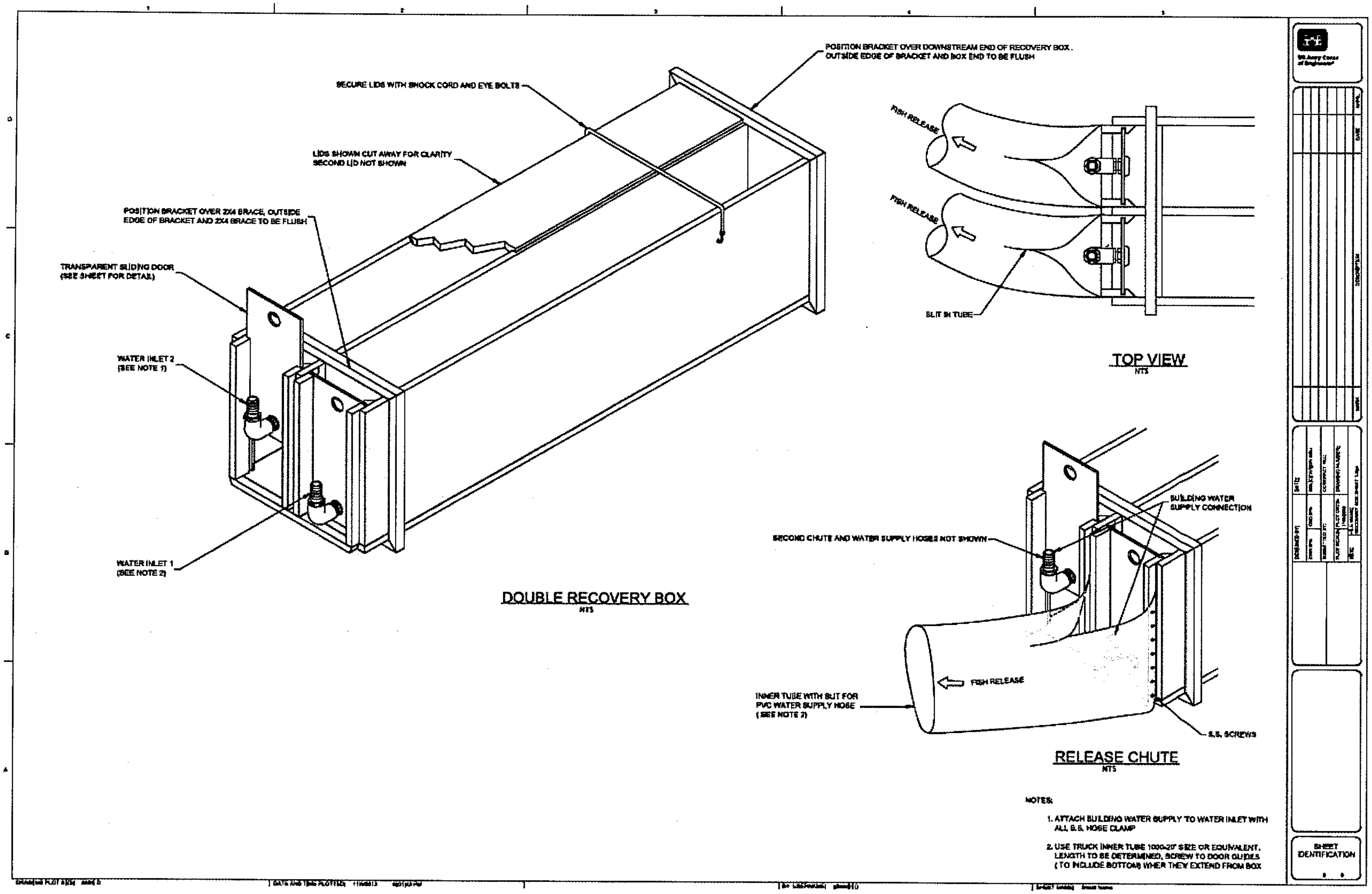

Figure 7 – Draft Recovery Tanks Drawing (Isometric).

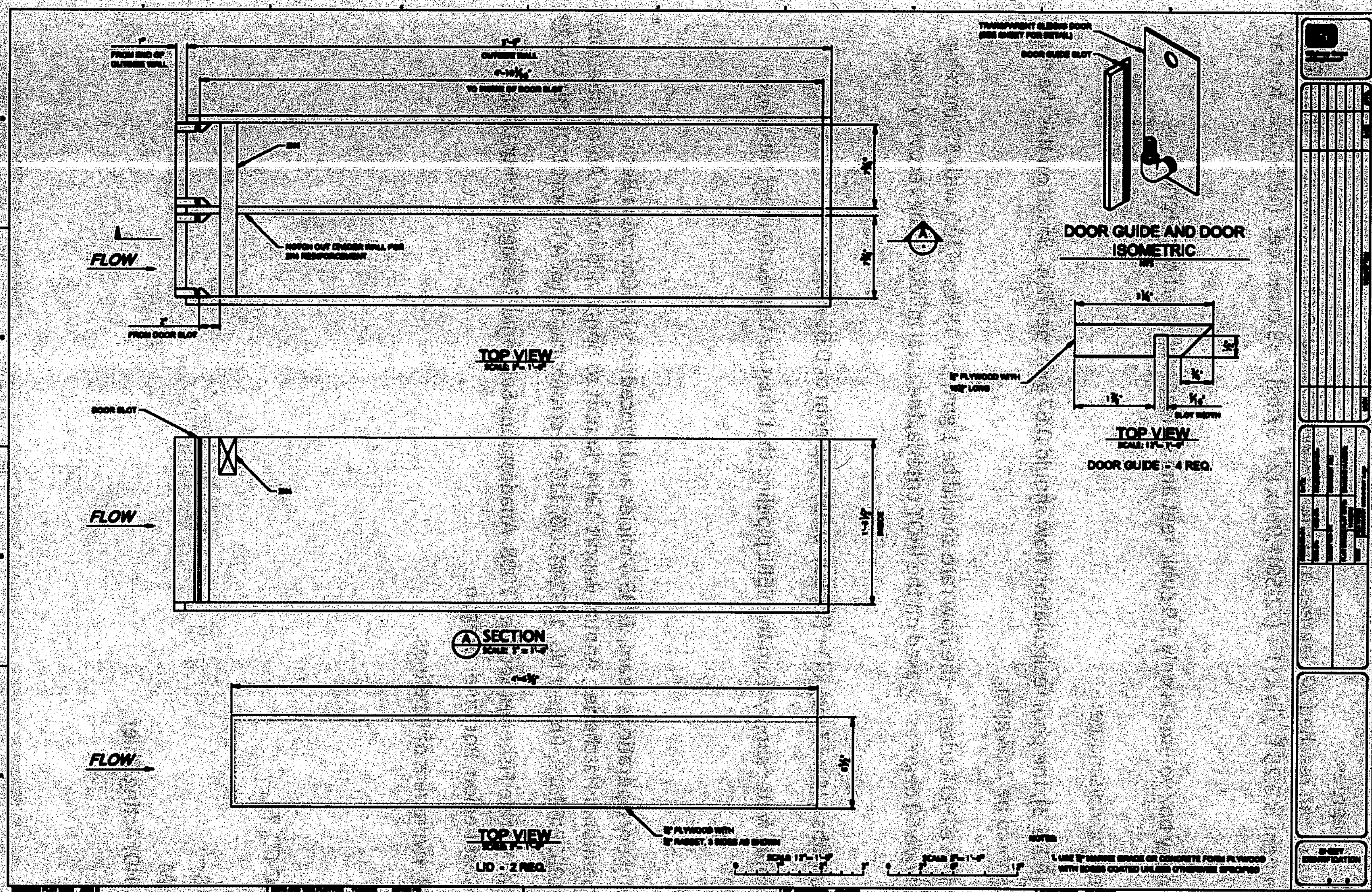

Figure 8 – Draft Recovery Tanks Drawing (Section Views).

i) Recovery box Volume:

Per NOAA Criteria (6.5.1.2), the pool volume should 0.25 cubic feet per pound of fish in 50 degree water during short term holding (less than 24 hours). If the water is warmer, it should be increased by 5% for each degree above 50 degrees.

At Bonneville the water can reached 72 degrees and the average poundage of fish is 37 lbs. Therefore the volume requirement is 0.25 ft^3/lb x {1 + (72-50)*.05} x (2 * 37lbs) = 38 cubic feet. (18.5 cubic feet at 50 degrees)

The proposed recovery box volume is only 5.9 cubic feet and will fall well short of criteria.

ii) Recovery box discharge:

Per NOAA Criteria (6.5.1.3), the pool recirculation flow should 0.67 gpm per fish. Based on this the total flow requirement should be 2.63 gpm.

Per the more restrictive IHOT criteria, the flow rate should be 1 gpm per 15 lbs of fish with 5% increase for every degree above 50 degrees. Based on the IHOT criteria, the total inflow to the recovery boxes should be:

Q = 1 gpm/15lbs x (4 x 37 lbs) x (1+ (72-50)*0.05) = 21 gpm or 0.05 cfs.

There should be ample water supply from the FERL pipeline that than be tapped to meet this water supply requirement.

7) References:

- Integrated Hatchery Operations Team, 1995, Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries, Annual Report 1994, Report to Bonneville Power Administration, Contract No. 1992BI60629, Project No. 199204300, 119 electronic pages (BPA Report DOE/BP-60629
- NMFS (National Marine Fisheries Service). 2008. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon
- J.P. Tullis 1989, Hydraulics of Pipelines.

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