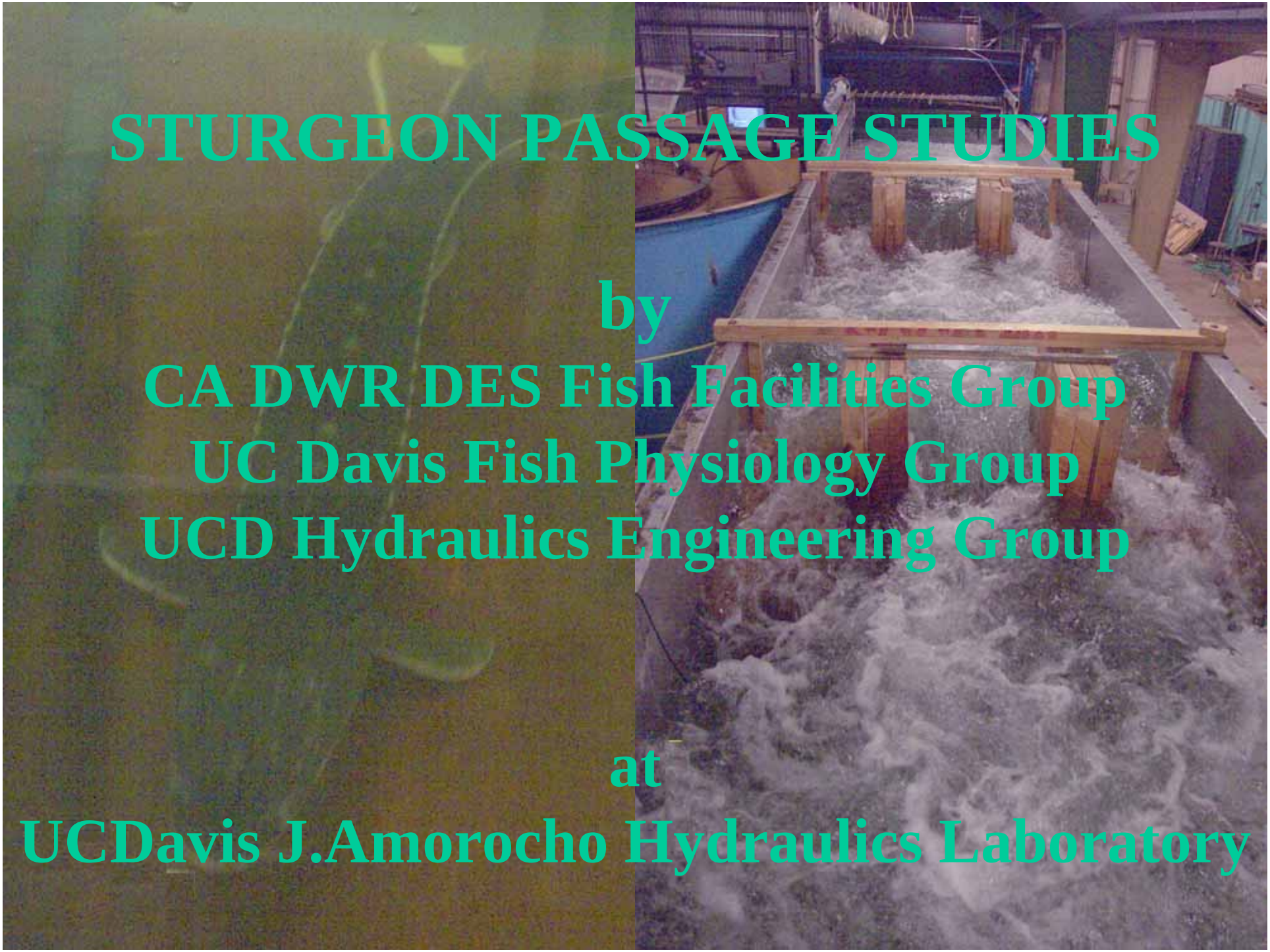


STURGEON PASSAGE STUDIES

by

CA DWR DES Fish Facilities Group

UC Davis Fish Physiology Group

UCD Hydraulics Engineering Group

at

UCDavis J.Amorocho Hydraulics Laboratory

Major Objective of the Study:

To research, evaluate, design, and implement sturgeon passage by observing and quantifying baffles for use in a DCC/TDF facility.

Swimming performance tests will be used to quantify the swimming capabilities of adult white sturgeon, and to identify the physiological and behavioral parameters in order to design a feasible sturgeon passage structure.

•This study has been a coordinated effort with UCD and DWR with both engineers and biologists actively involved from both agencies. Oversight and review has been provided by the DCC/TDF, North Delta Technical Team and CVFFRT. Results of this study may also be applicable to other situations where sturgeon passage is an issue, such as Red Bluff Diversion Dam in the Sacramento River, or the Columbia River.

•This has been a three year pilot study previously recommended by the DCC/TDF Team.

•The first 2 years of the study evaluated swimming performance and behavior of white sturgeon. The third and last year of the study took the information learned and applied it to a prototype sturgeon passage.

•The Final Report on the 3 years of study will start circulation for review in August 2005.

Current Sturgeon Flume Circulation System

Total Length of Sturgeon Flume Apparatus : 120 ft

Testing Section Length: 80 ft

Height of the Flume Wall: 4.5 ft

Width of the Flume Interior: 6.92 ft

Flume Bed Slope: 4 %

Pump Capacity: 60 cfs at 13 ft above ground level

- Several major modifications to the flume has occurred over the last 3 years, including adding and improving the pumps and sloping the flume.

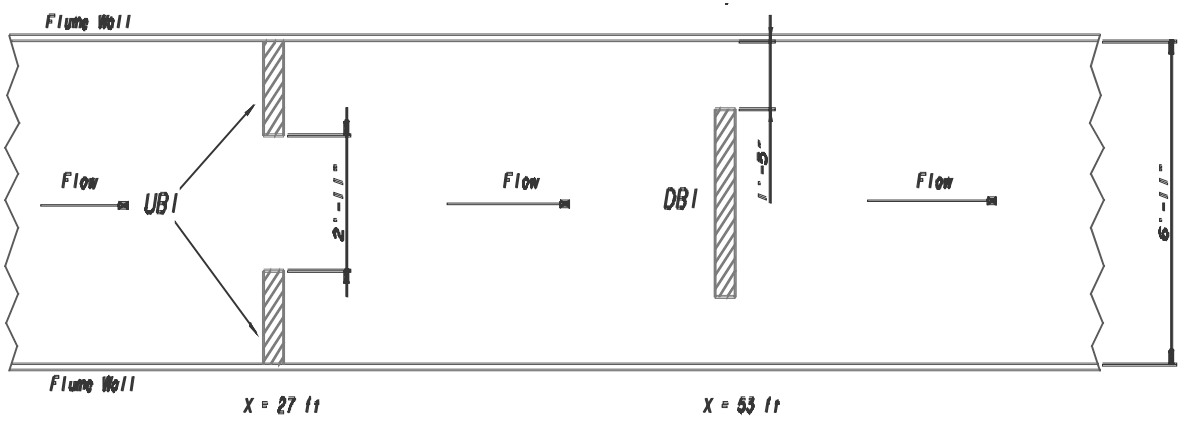
- In the first two years different types of baffles were inserted to develop an understanding of how white sturgeon responded to different flow conditions.

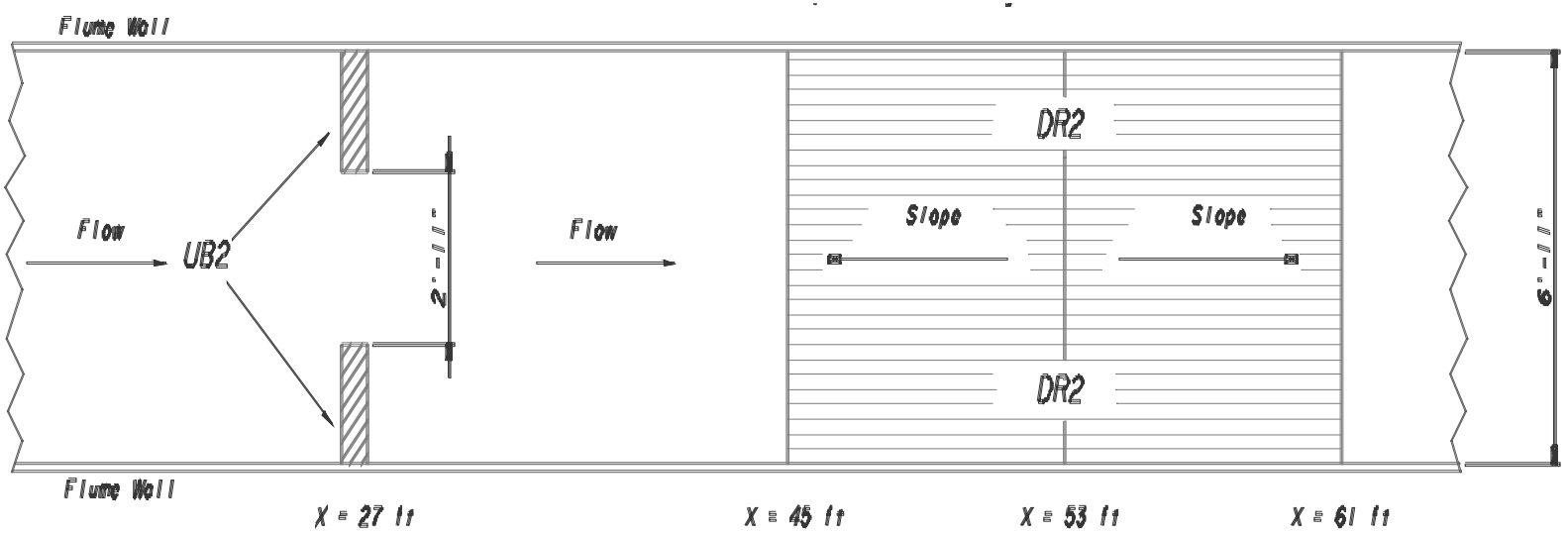
- Also in the first year preliminary swimming performance tests were conducted that were limited by the pump capacity of the flume.

- The different configurations included: vertical, horizontal and slopping baffles, an orifices and a sloping floor up to 8%

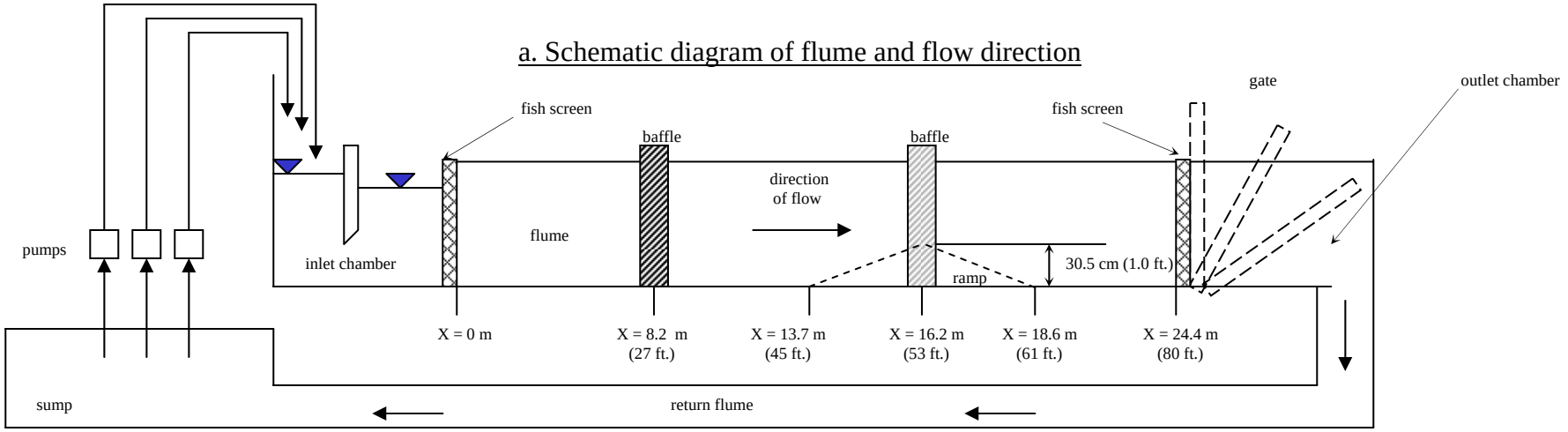
- These different configurations provided flow conditions that a sturgeon may encounter in a fish passage and allowed us to evaluate fish behavior as it relates to hydraulic conditions.

Preliminary behavior and swimming configurations

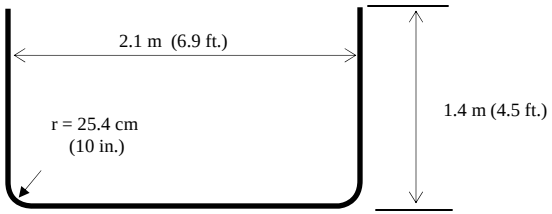


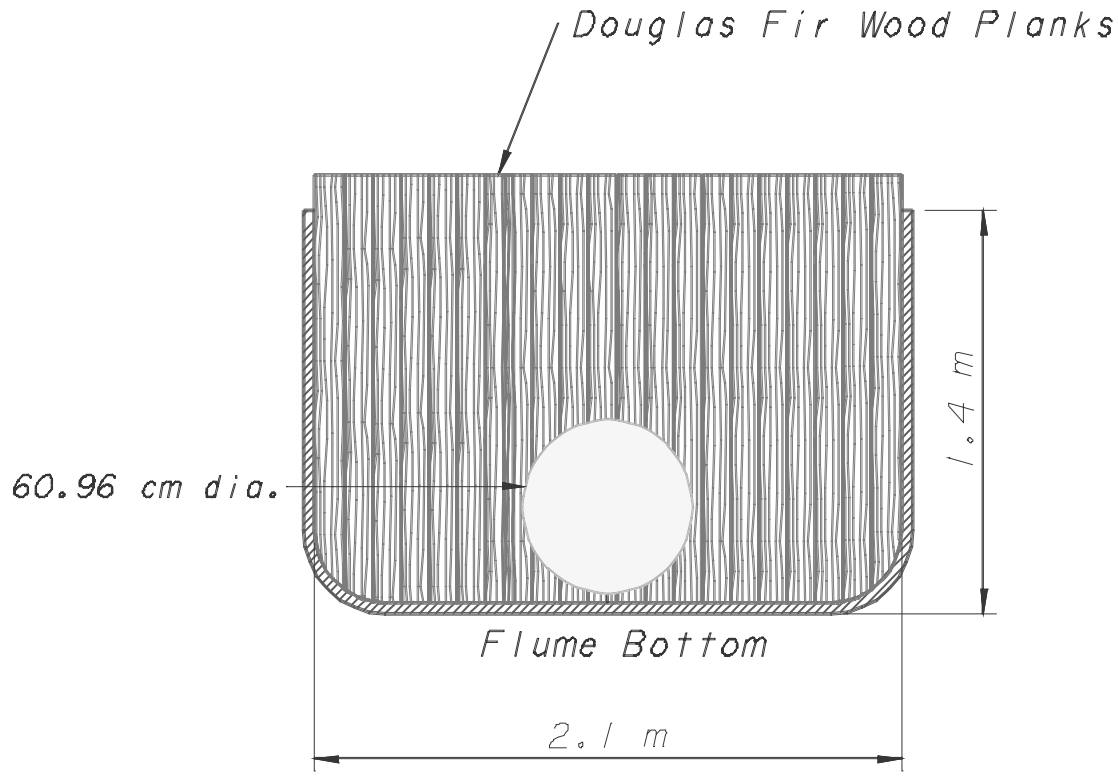

Flume Wall
Flow
UB2
2"-//"
Flow
DR2
Slope
Slope
DR2
6"-//"
Flume Wall
X = 27 ft
X = 45 ft
X = 53 ft
X = 61 ft

a. Schematic diagram of flume and flow direction



c. Flume body cross-section





Orifice Baffle that was tested in the flume during 2004

Fish Collection

- White adult sturgeon have been collected for this study from both the Bay and from the Yolo Bypass. The length requirement has been fish over 4 feet.
- In 2003, 32 Sturgeon were collected
- In 2004, 51 Sturgeon were collected
- In 2005, 46 Sturgeon were collected
- Collection occurs from the end of January to the middle of April

Fish used in the study have been collected, primarily, from the Bay and, to a lesser extent, the Yolo Bypass and the Sacramento River.
The primary method used to collect fish has been hook and line with a smaller number of fish collected each year from a fyke trap operated by DWR in the Yolo Bypass. In 2004 and 2005, set lines were also used to collect some fish in the Bay.

Fish were transported from field locations in a trailer-mounted tank, and held at the UC Davis Hydraulics Lab in circular flow-through tanks at 13 to 17°C, and salinity: 0 ppt.

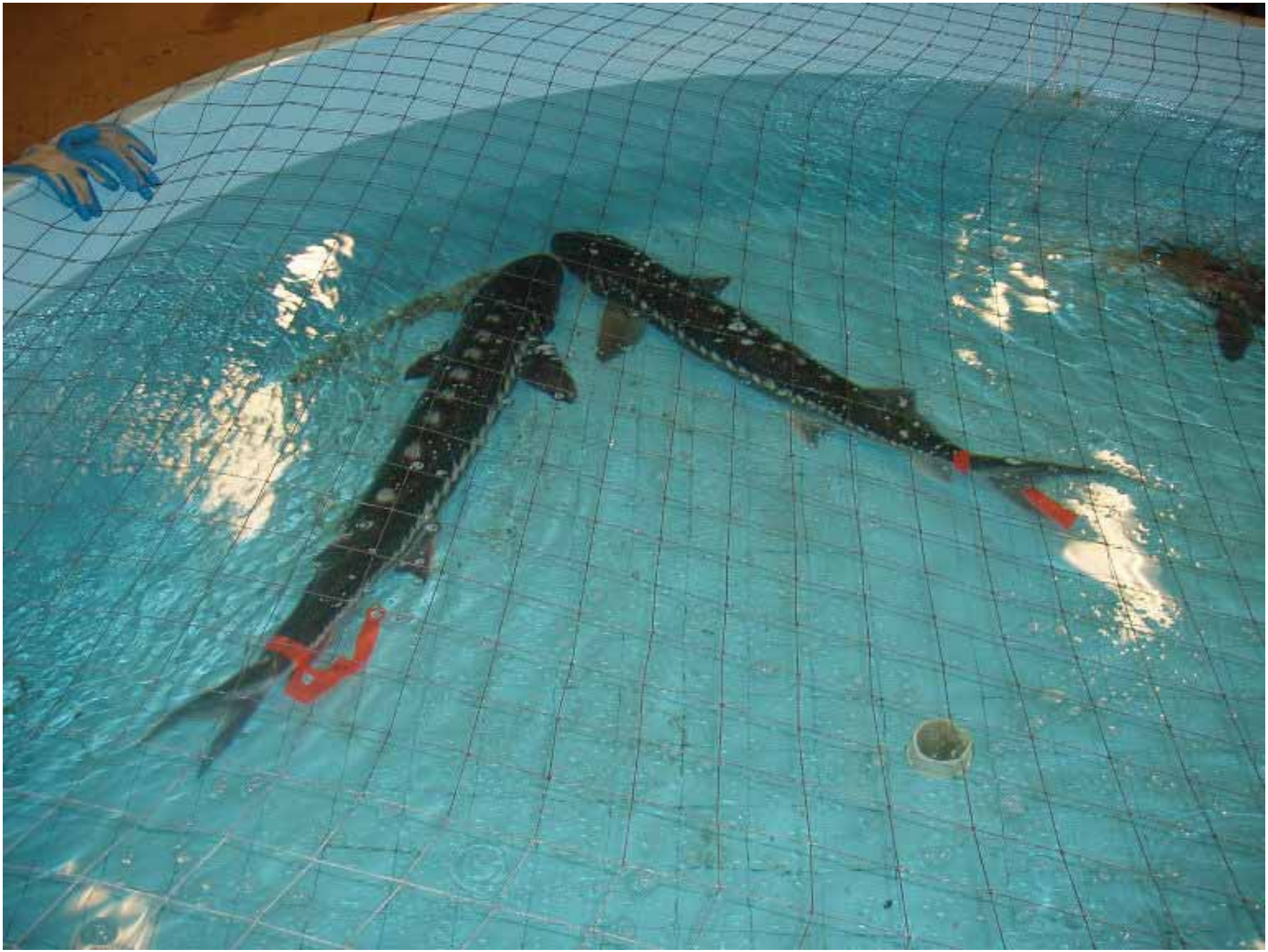
In 2003, fish were held in three, 3-m diameter tanks for 2-28 days (mean = 11) without feed before use in swimming experiments; some fish were used as many as three times, with at least two days between experiments.
In 2004, fish were held in three 3-m diameter tanks and one 3.7-m diameter tank for 3-26 days (mean = 9) without feed; some fish were used in as many as two experiments with at least two days between experiments.


Certificate of Participation
HAPPY HOOKER
BERKELEY, CA
HEAD
NEWS

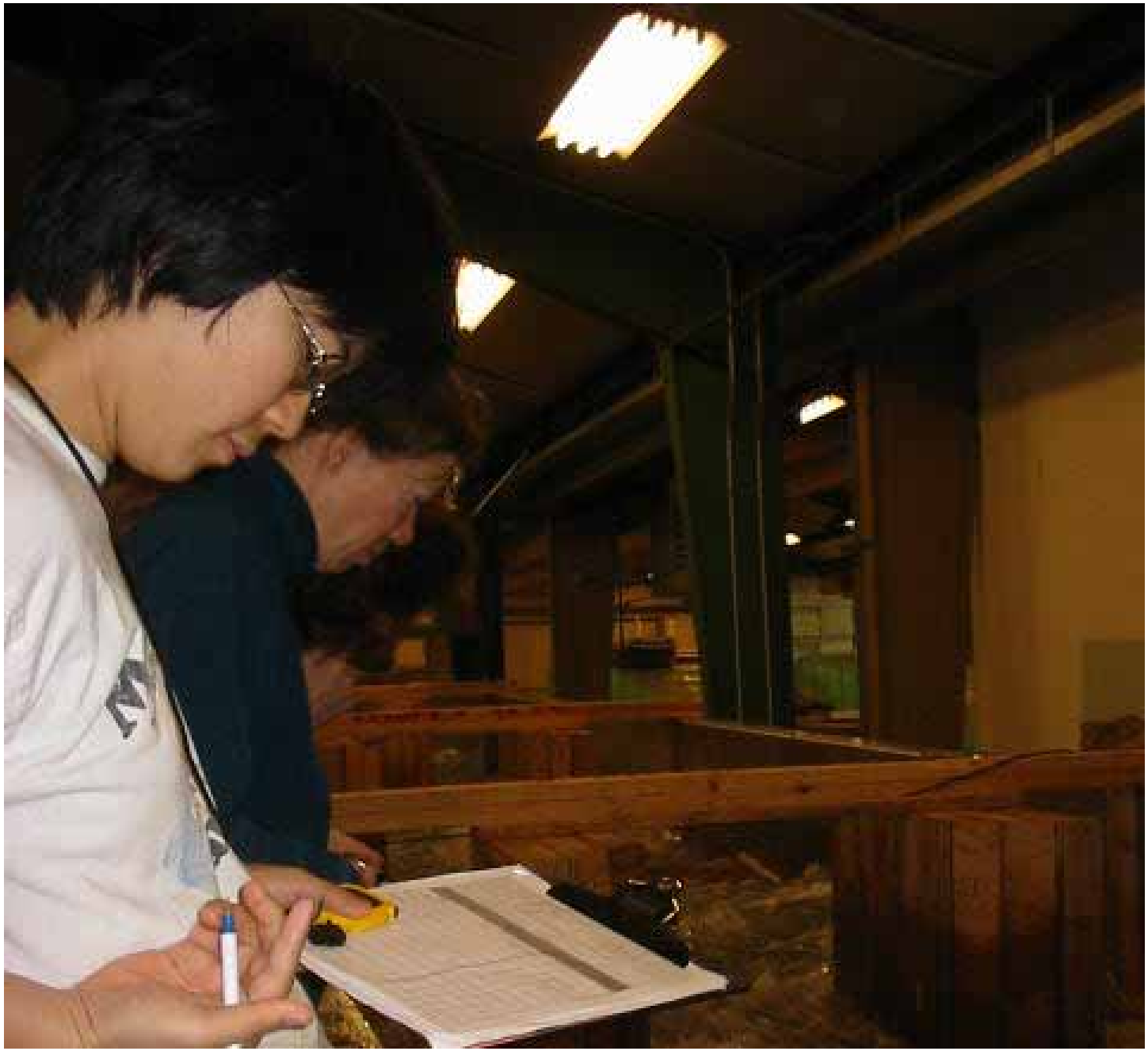

BILLABONG

Picture borrowed from California Department of Water Resources – Aquatic Ecology Section

Transporting fish back to the Lab



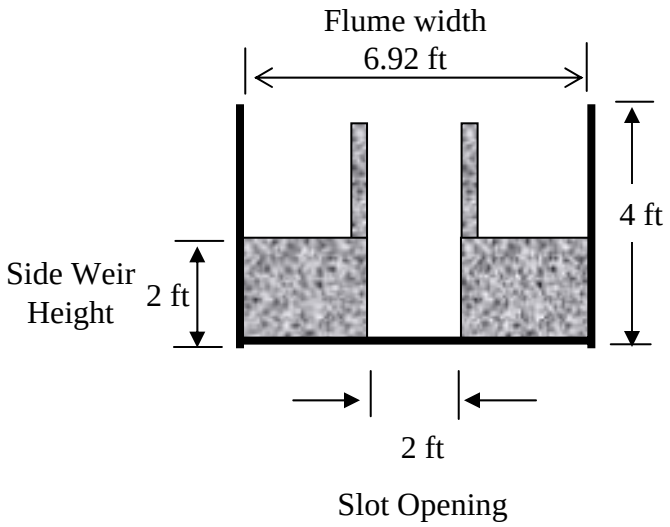
Start of an experiment

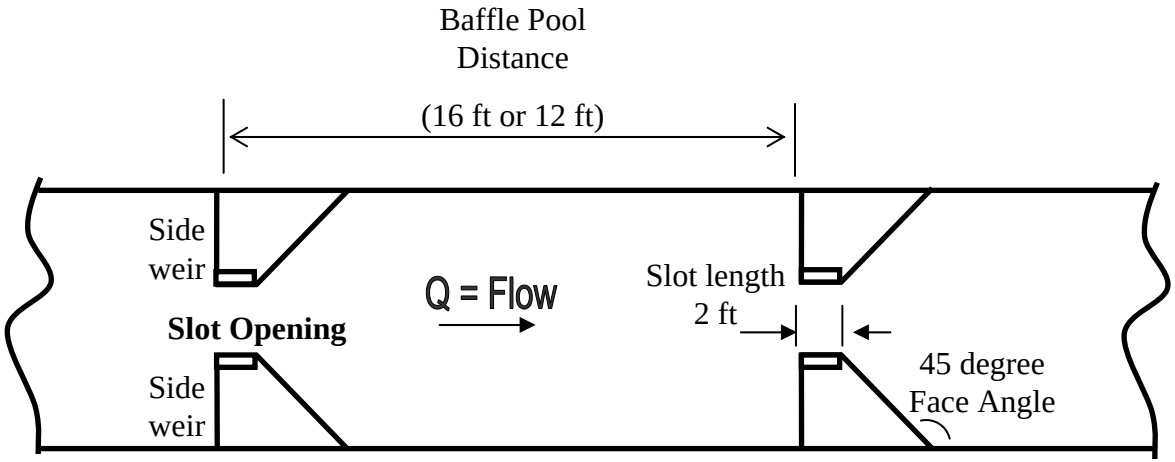


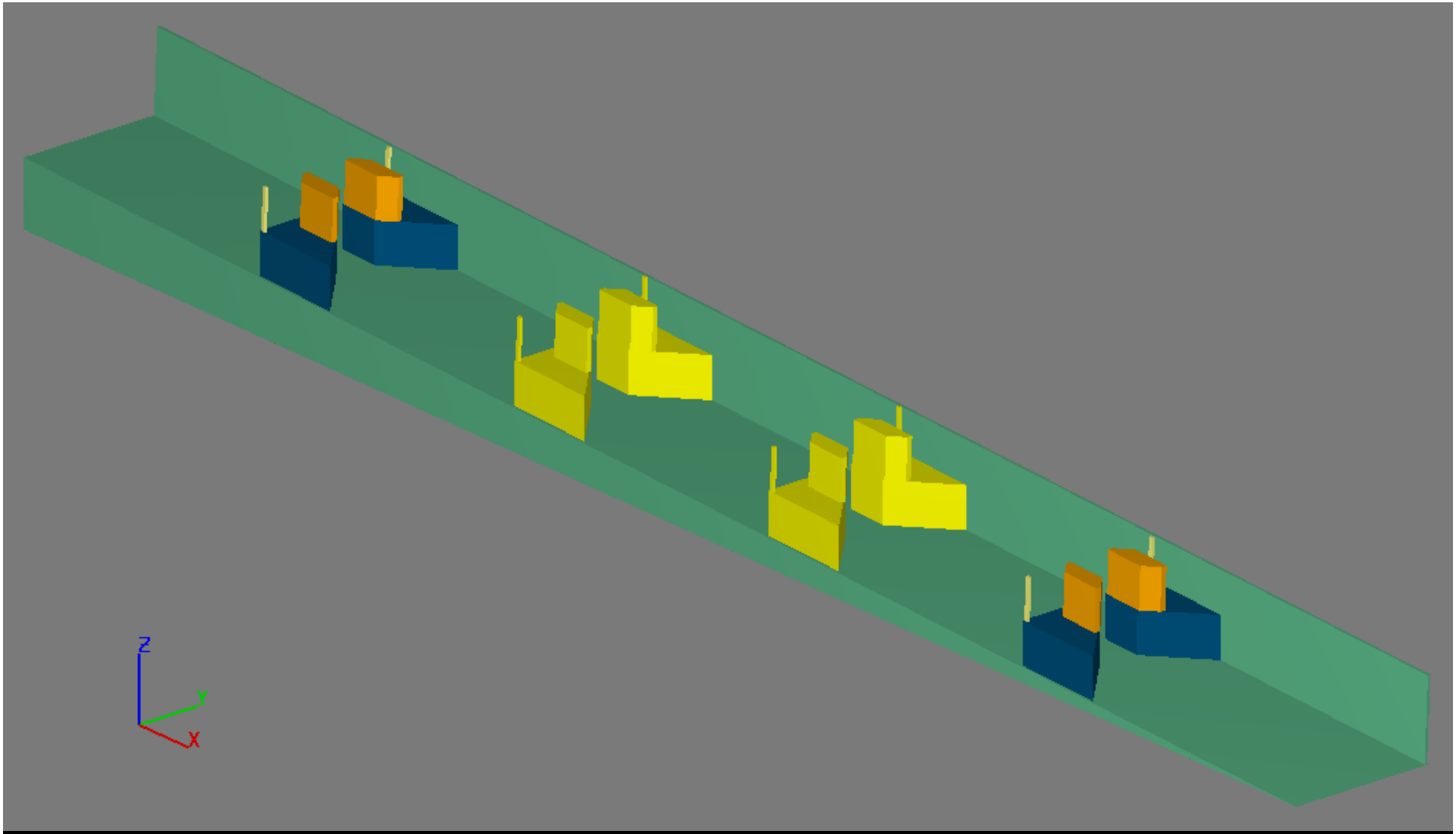
3rd Year of Testing

- DWR/Fish Facilities Section provided the prototype passage design. The process of developing the prototype included an evaluation of existing types of passage and why these passages are not favorable to sturgeon passage. And from the information learned from the two previous years of work at UCD a baffle design was developed.
- The passage was fabricated and implemented by UCDJA Hydraulics Laboratory.

Baffles Configurations







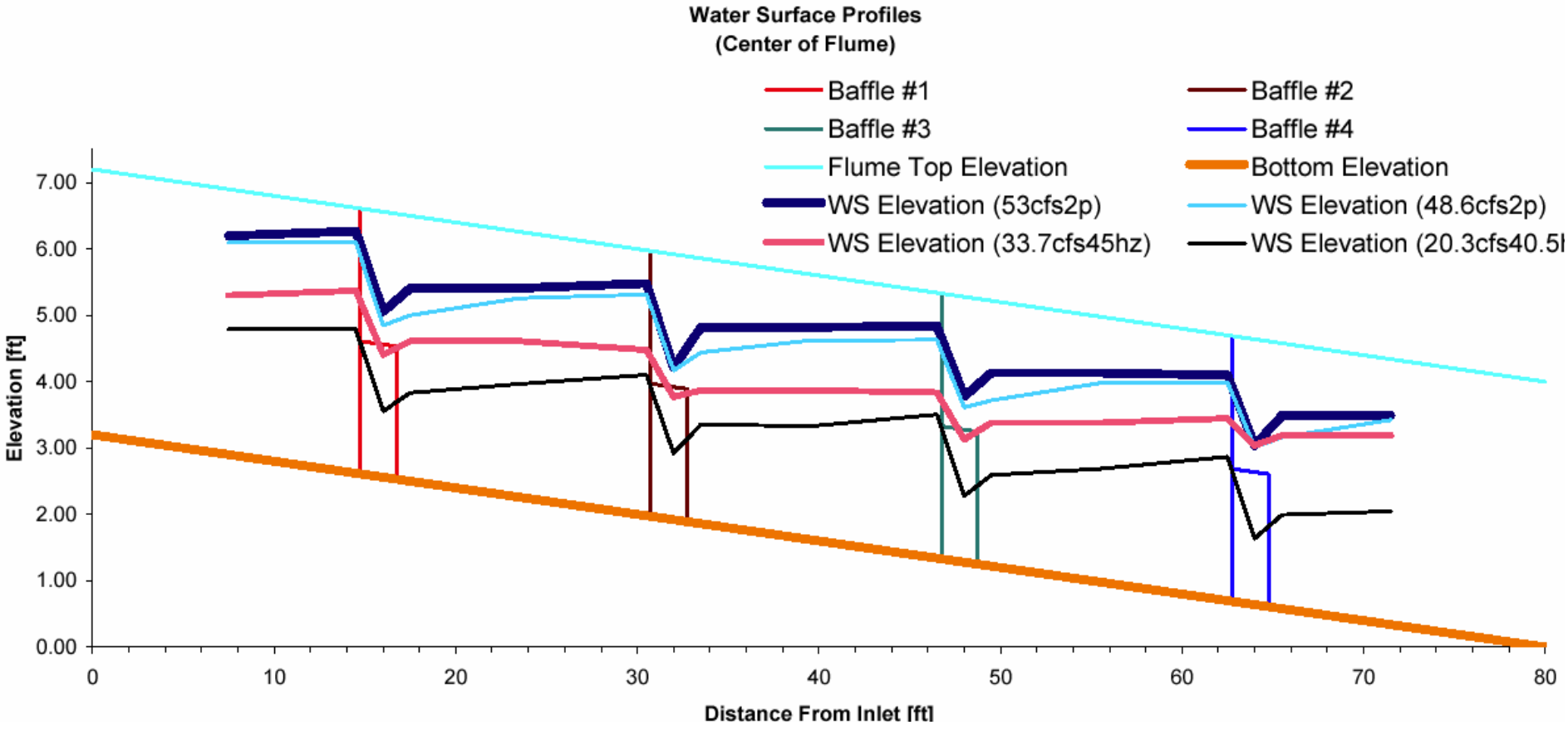
Sturgeon Flume Configuration #1: 4 % bed slope,
Four Baffles & Pool length of 16 ft

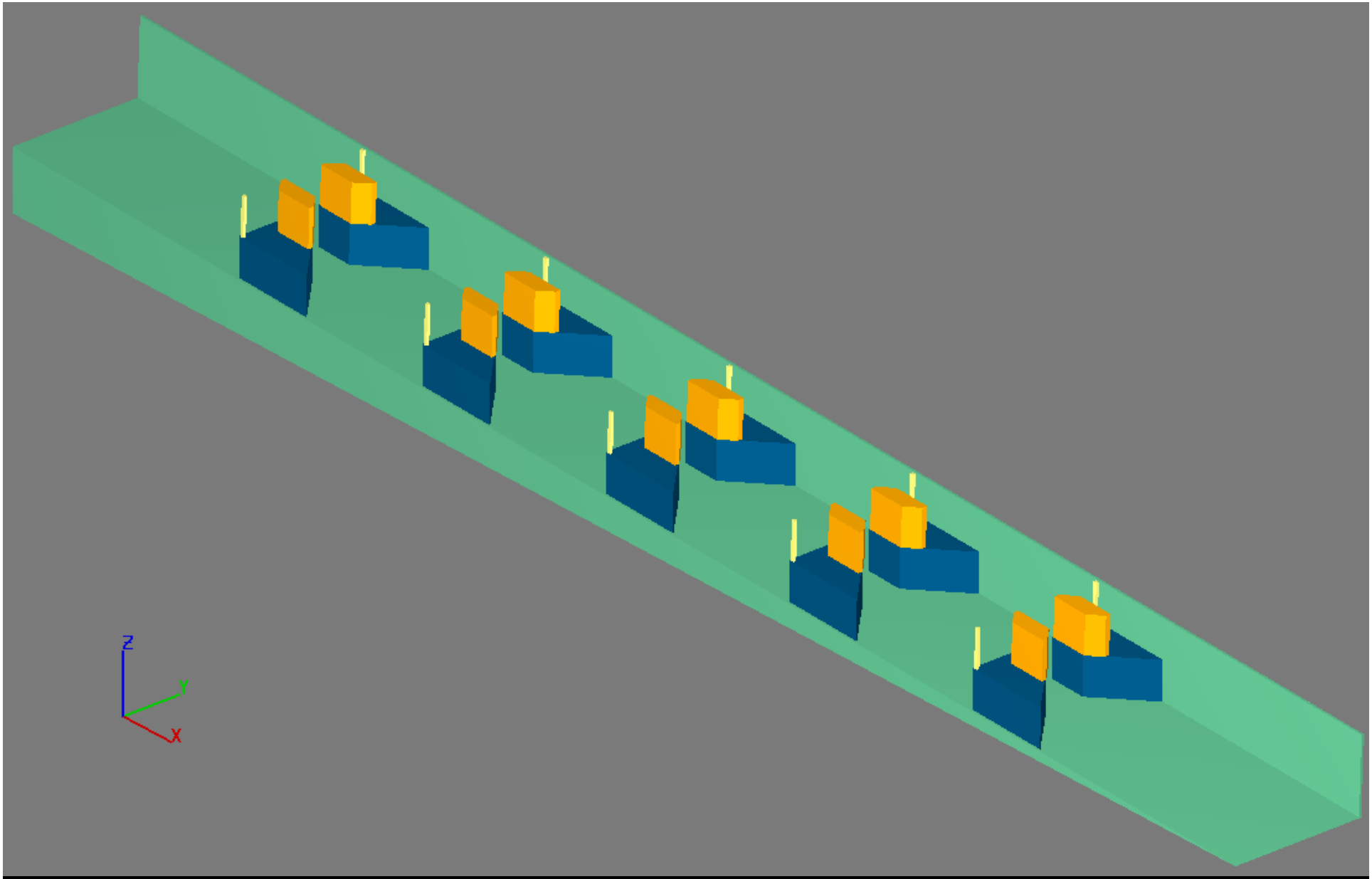

03 04 2005

03 04 2005

Flume Configuration: 4 baffles, sideweir open

Discharge Condition		53cfs 2pumps	48.6cfs 2pumps	33.7 cfs 45Hz	20.3cfs 40.5Hz	53cfs 2pumps	48.6cfs 2pumps	33.7 cfs 45Hz	20.3cfs 40.5Hz
Location	**Distance**	**Velocity [ft/sec]**				**Depth [ft]**			
1	8	2.70	1.65	1.48	1.41	3.30	3.20	2.40	1.89
2	16	7.96	7.45	7.41	7.54	3.08	2.99	2.30	1.75
3	24	5.31	1.76	4.17	1.56	3.15	3.00	2.35	1.71
4	32	7.99	7.59	7.36	7.18	2.90	2.79	2.18	1.56
5	40	6.72	1.76	6.31	1.56	3.20	3.00	2.25	1.71
6	48	8.66	7.32	7.25	7.44	3.00	2.81	2.18	1.58
7	56	4.57	1.76	4.66	1.56	3.15	3.00	2.40	1.71
8	64	8.76	7.19	5.46	7.35	2.90	2.83	2.58	1.58
9	72	4.91	1.71	3.48	1.56	3.15	3.08	2.85	1.71



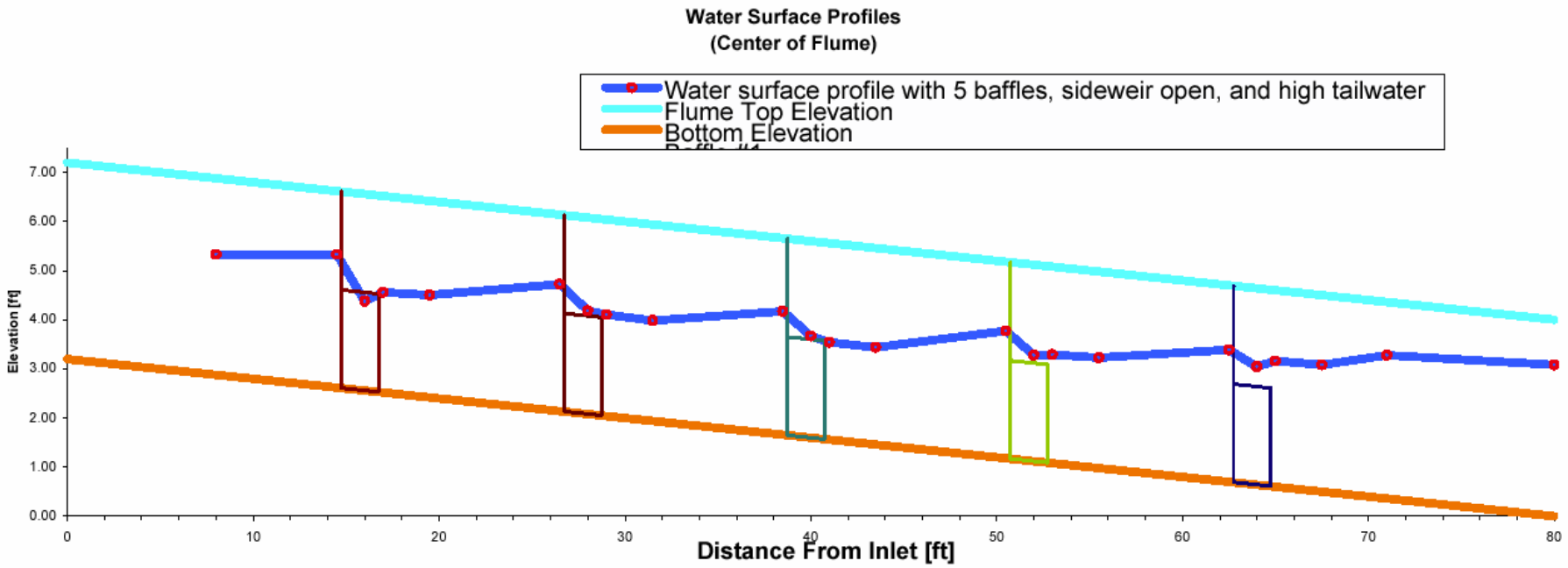


Sturgeon Flume Configuration #2: 4 % bed slope,
Five Baffles & Pool length of 12 ft


03 16 2005


03 16 2005

Setting: Water surface profile with 5 baffles, sideweir open, and high tailwater **50hp+35Hz** 31 cfs

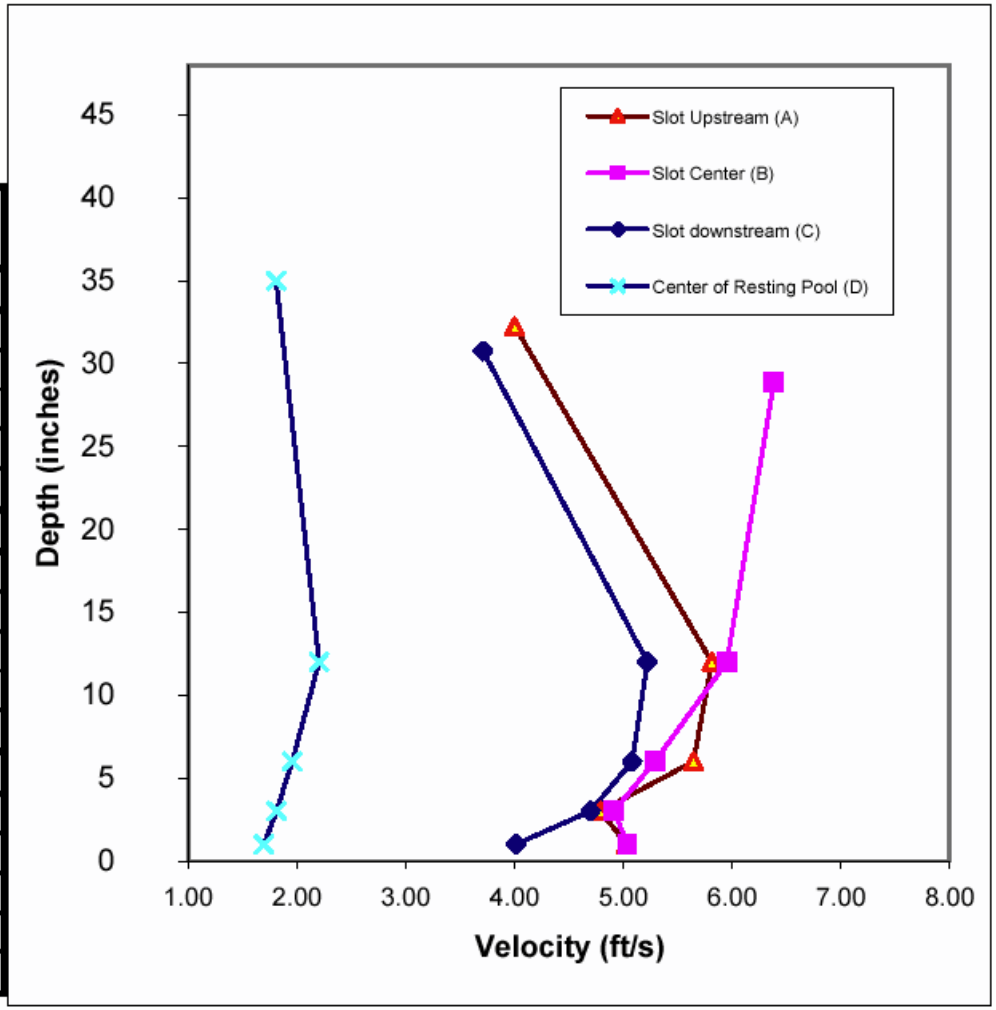


Xmark [ft]	8	14.5	16	17	19.5	26.5	28	29	31.5	38.5	40	41	43.5	50.5	52	53	55.5	62.5	64	65	67.5	71	80
WS Elev (ft)	5.33	5.33	4.37	4.56	4.50	4.72	4.18	4.10	3.98	4.18	3.67	3.54	3.44	3.77	3.28	3.29	3.23	3.39	3.05	3.16	3.08	3.28	3.08
Depth [inches]	29.4	32.5	21.8	24.5	25.0	31.0	25.3	24.8	24.5	30.2	24.9	23.8	23.8	31.1	25.9	26.5	27.0	32.3	28.9	30.8	31.0	35.0	37.0

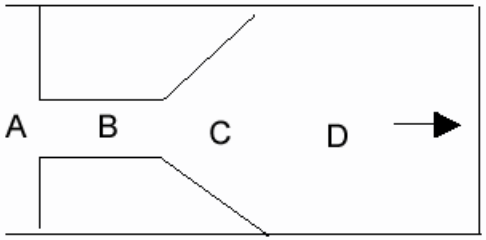
X Locastion(ft)	16	23	28	35	40	47	52	59	64
Mean Velocity (ft/s)	5.38	4.40	7.04	5.81	6.30	5.69	6.27	4.68	5.38

Configuration: 5 baffles, sideweir open, and high tailwater
Discharge Setting: pump50hp + 35 Hz
Head over Weir: 0.548
Discharge (cfs): 31
Tailgate Setting: High Tailwater
Date: 3/14/2005

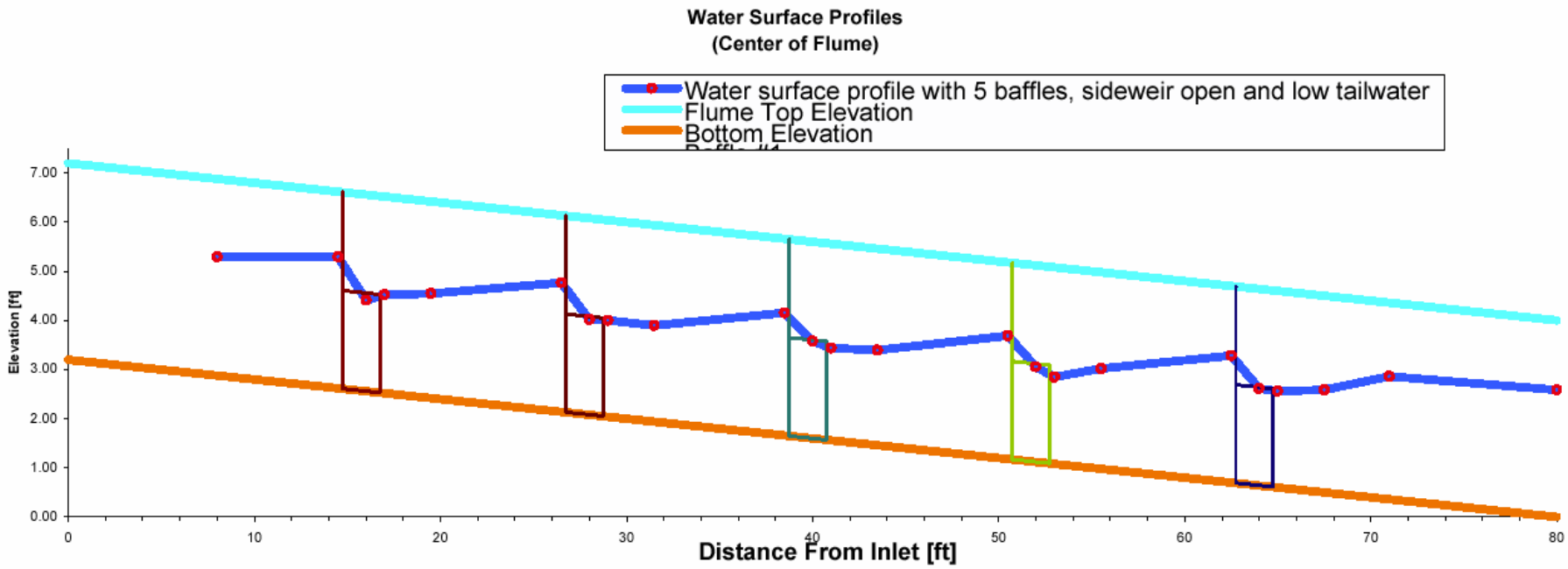
Longitudinal Location	Vertical depth		Velocity[(ft/sec]		
		Mean	left	center	right
Slot Upstream (A)	32 1/4			4.00	
	12			5.82	
	6			5.65	
	3			4.79	
	1			5.03	
		Mean	left	center	right
Slot Center (B)	28 7/8			6.39	
	12			5.95	
	6			5.29	
	3			4.92	
	1			5.04	
		Mean	left	center	right
Slot downstream (C)	30 3/4	3.71	3.48	4.73	2.92
	12	5.22	5.30	6.00	4.37
	6	5.08	5.25	5.20	4.80
	3	4.70	4.69	5.12	4.30
	1	4.01	3.98	4.37	3.70



	Vertical depth	Velocity[(ft/sec]					
		Mean	L2	L1	M	R1	R2
Center of Resting Pool (D)	35	1.81	0.62	2.72	3.59	1.51	0.60
	12	2.21	1.15	3.34	4.47	1.65	0.42
	6	1.96	0.56	1.46	4.44	2.86	0.48
	3	1.81	0.89	2.45	3.67	1.57	0.49
	1	1.70	0.75	2.23	3.07	2.06	0.38



Setting: Water surface profile with 5 baffles, sideweir open and low tailwater **50hp+35Hz** 31 cfs

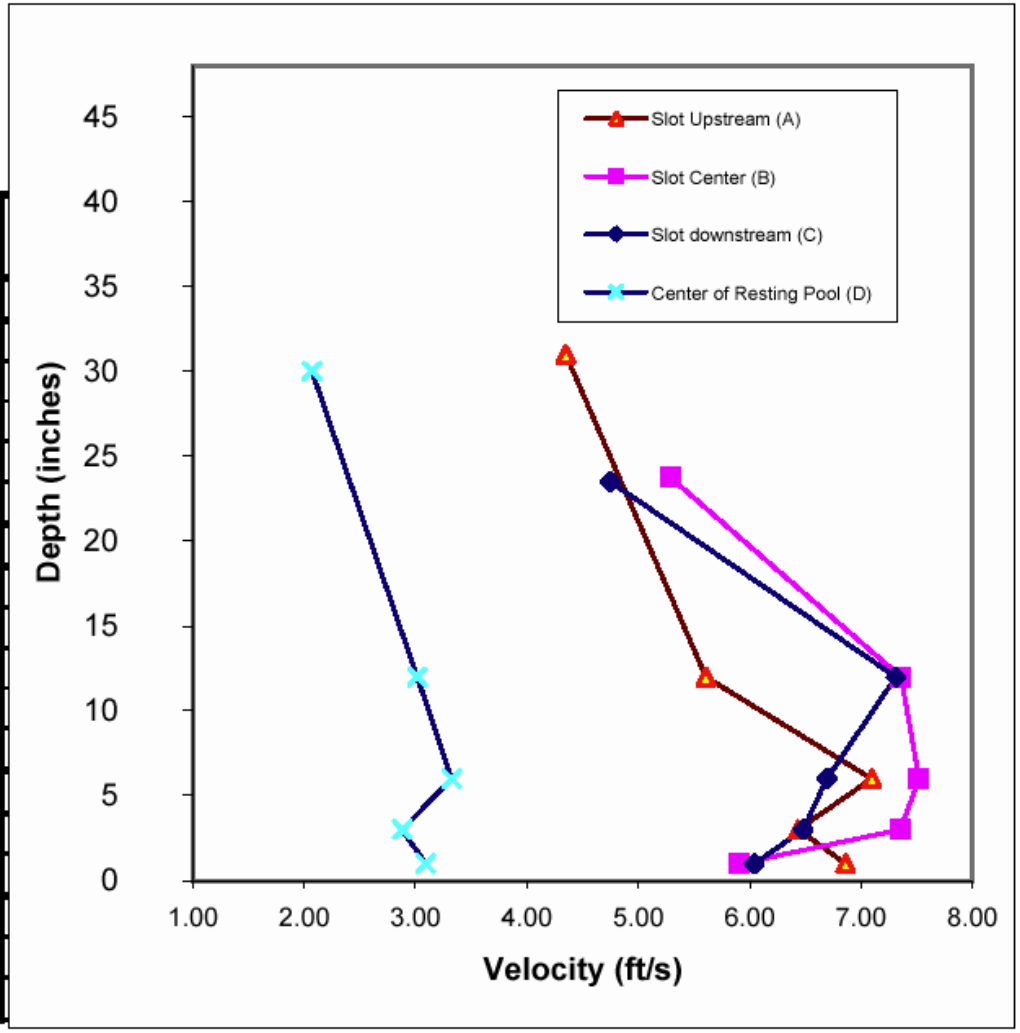


Xmark [ft]	8	14.5	16	17	19.5	26.5	28	29	31.5	38.5	40	41	43.5	50.5	52	53	55.5	62.5	64	65	67.5	71	80
WS Elev (ft)	5.30	5.30	4.41	4.52	4.55	4.77	4.02	4.00	3.90	4.15	3.58	3.44	3.40	3.69	3.06	2.85	3.02	3.28	2.62	2.56	2.58	2.86	2.58
Depth [inches]	29.0	32.1	22.3	24.0	25.5	31.5	23.3	23.5	23.5	29.9	23.8	22.5	23.3	30.1	23.3	21.3	24.5	31.0	23.8	23.5	25.0	30.0	31.0

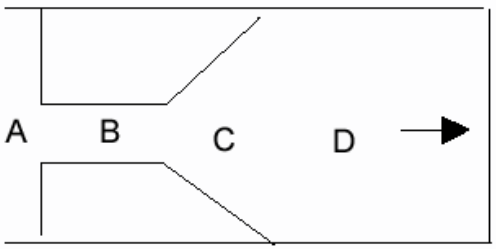
X Locastion(ft)	16	23	28	35	40	47	52	59	64
Mean Velocity (ft/s)	5.92	4.22	6.69	5.73	6.84	5.98	6.99	5.86	6.69

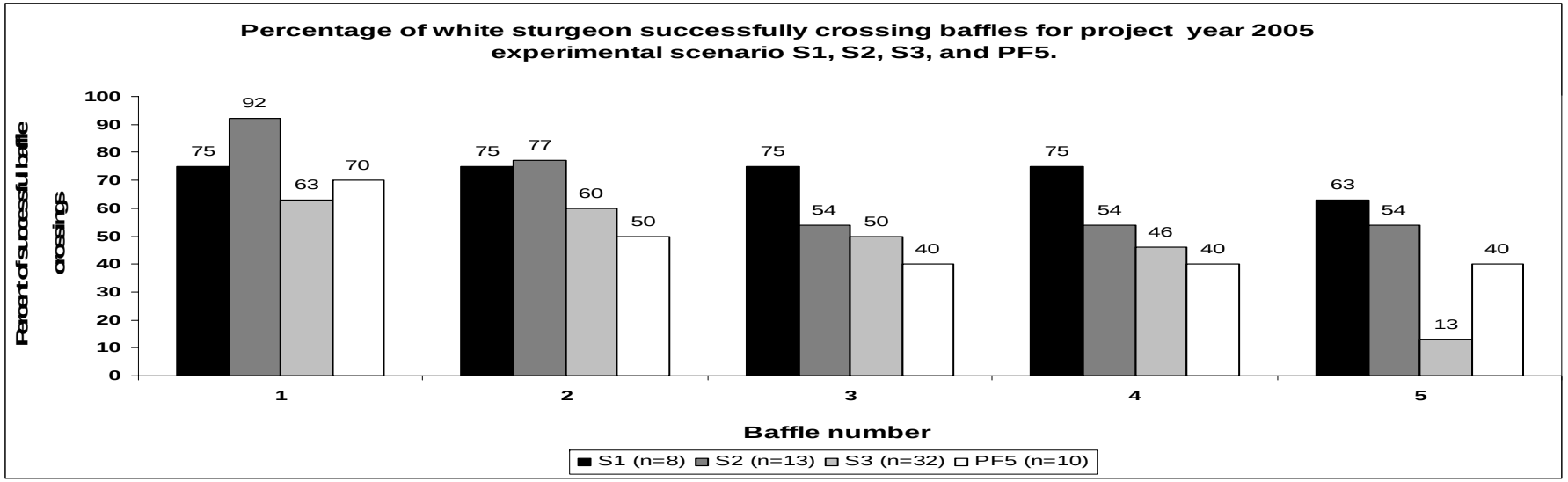
Configuration: 5 baffles, sideweir open and low tailwater
Discharge Setting: pump50hp + 35 Hz
Head over Weir: 0.548
Discharge (cfs): 31
Tailgate Setting: Low tailwater
Date: 3/15/2005

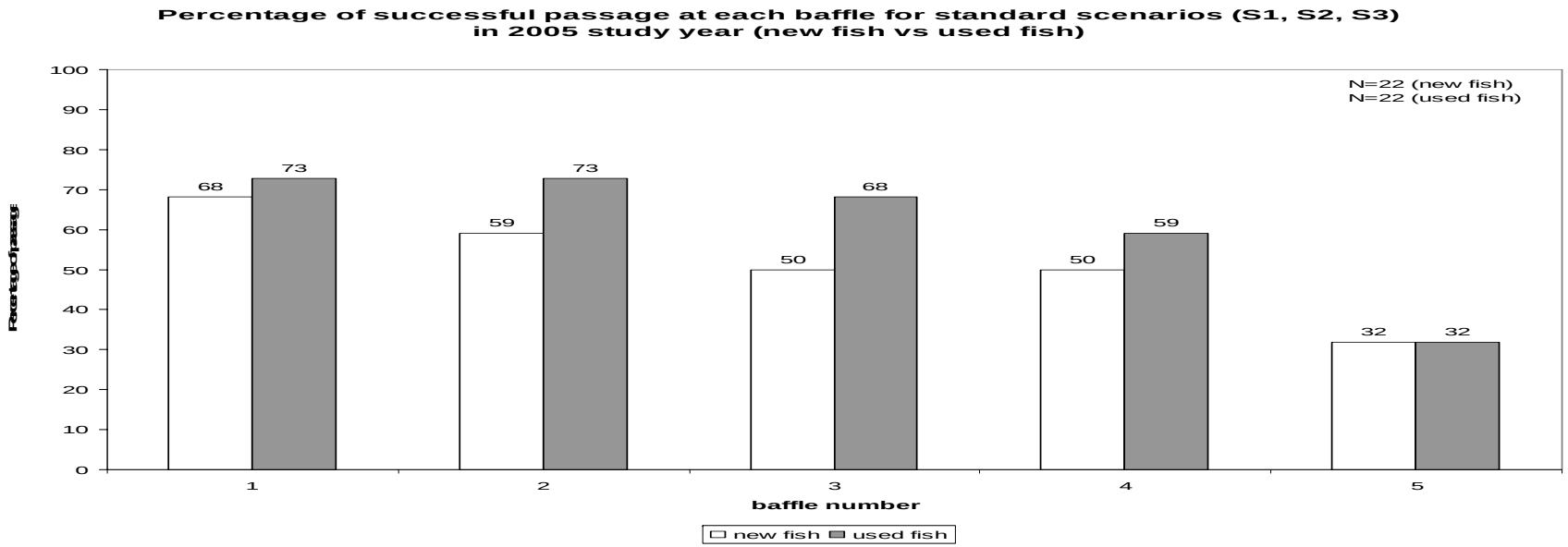
Longitudinal Location	Vertical depth		Velocity[(ft/sec]		
		Mean	left	center	right
Slot Upstream (A)	31			4.35	
	12			5.61	
	6			7.10	
	3			6.44	
	1			6.86	
		Mean	left	center	right
Slot Center (B)	23 3/4			5.29	
	12			7.36	
	6			7.52	
	3			7.35	
	1			5.91	
		Mean	left	center	right
Slot downstream (C)	23 1/2	4.75	4.56	5.83	3.86
	12	7.31	7.17	7.14	7.63
	6	6.69	7.10	6.12	6.85
	3	6.48	6.11	7.21	6.13
	1	6.04	5.90	6.24	6.00



	Vertical depth	Velocity[(ft/sec]					
		Mean	L2	L1	M	R1	R2
Center of Resting Pool (D)	30	2.07	0.68	1.62	3.94	3.43	0.68
	12	3.02	1.34	6.00	5.90	1.27	0.58
	6	3.32	2.47	5.61	6.29	1.67	0.58
	3	2.88	0.94	3.50	5.17	4.15	0.66
	1	3.09	2.33	5.93	3.96	2.55	0.68




Percentage of white sturgeon successfully crossing baffles for project year 2005
experimental scenario S1, S2, S3, and PF5.
Percent of successful baffle crossings
100
90
80
70
60
50
40
30
20
10
0
75
92
63
70
75
77
60
50
75
54
50
40
75
54
46
40
63
54
13
40
1
2
3
4
5
Baffle number
S1 (n=8)
S2 (n=13)
S3 (n=32)
PF5 (n=10)


Percentage of successful passage at each baffle for standard scenarios (S1, S2, S3)
in 2005 study year (new fish vs used fish)
Percentage of passage
100
90
80
70
60
50
40
30
20
10
0
N=22 (new fish)
N=22 (used fish)
68
73
59
73
50
68
50
59
32
32
1
2
3
4
5
baffle number
new fish
used fish

After the flume test

Returning fish back to wild

Outstanding Issues for Further Study:

1) What is the critical swimming velocity for adult white sturgeon? >>
   Swimming performance tests
2) How to improve the most recent baffle design/configuration in order to improve fish passage?
3) Using channel roughness to improve flow and what is the role of substrate (channel bottom roughness) in improving sturgeon passage.
4) Studies of the passage performance of other fish species for the current baffle design (green sturgeon, Chinook salmon, steelhead trout, Pacific lamprey, American shad, striped bass);
5) How do the fish swim downstream through the fish passage structure?
6) How do fish find the opening to the passage?
7) Transitions within the passage to complete movement through a passage.
8) The above issues would require a two year study to complete.

Note 3 year Pilot Study Report scheduled to be completed in August

Study Obstacles

- UCD has addressed all obstacles over this three year study to complete this work including equipment issues, funding and contracting delays.
- Timing is critical for this study to coincide with sturgeon migration.
- Funding for another study period and to address additional issues $1 to $2 million

Critical Issues

- IEP Coordinators are looking for the DCC/TDF to recommend if additional work should be conducted. If a recommendation is provided to proceed with additional work a study proposal will be developed that will meet the IEP and CalFed requirements.
- Timing
- Funding needs at UCD

What do we do next

- Continue with studies
- End the Studies
- Or