EVALUATION OF A WEIR DESIGNED TO REDUCE ENTRAINMENT OF ENDANGERED COLORADO RIVER FISH IN CANALS

Mark McKinstry

US Bureau of Reclamation, Salt Lake City, UT

Chris Cheek

The Navajo Nation, Farmington, NM

Peter MacKinnon

Biomark, Boise, ID

Robert Norman

US Bureau of Reclamation, Grand Junction, CO

Scott Durst

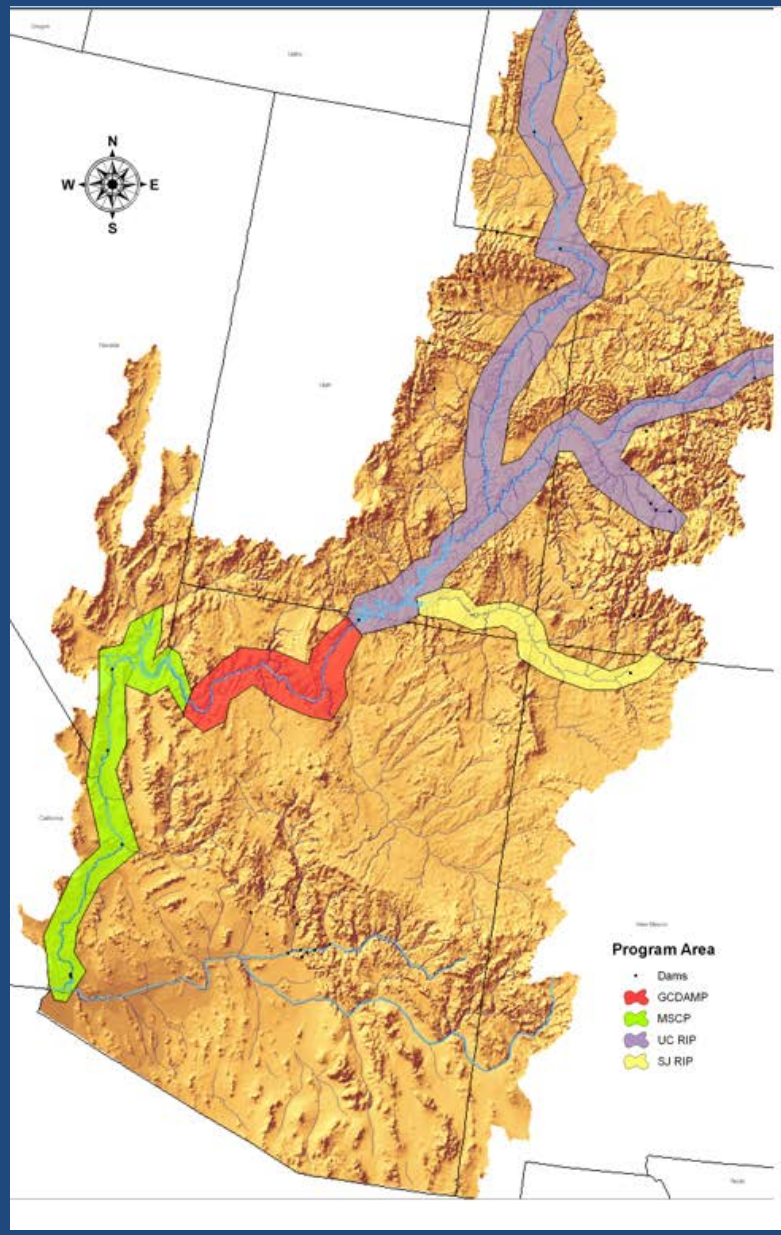
US Fish and Wildlife Service, Albuquerque, NM

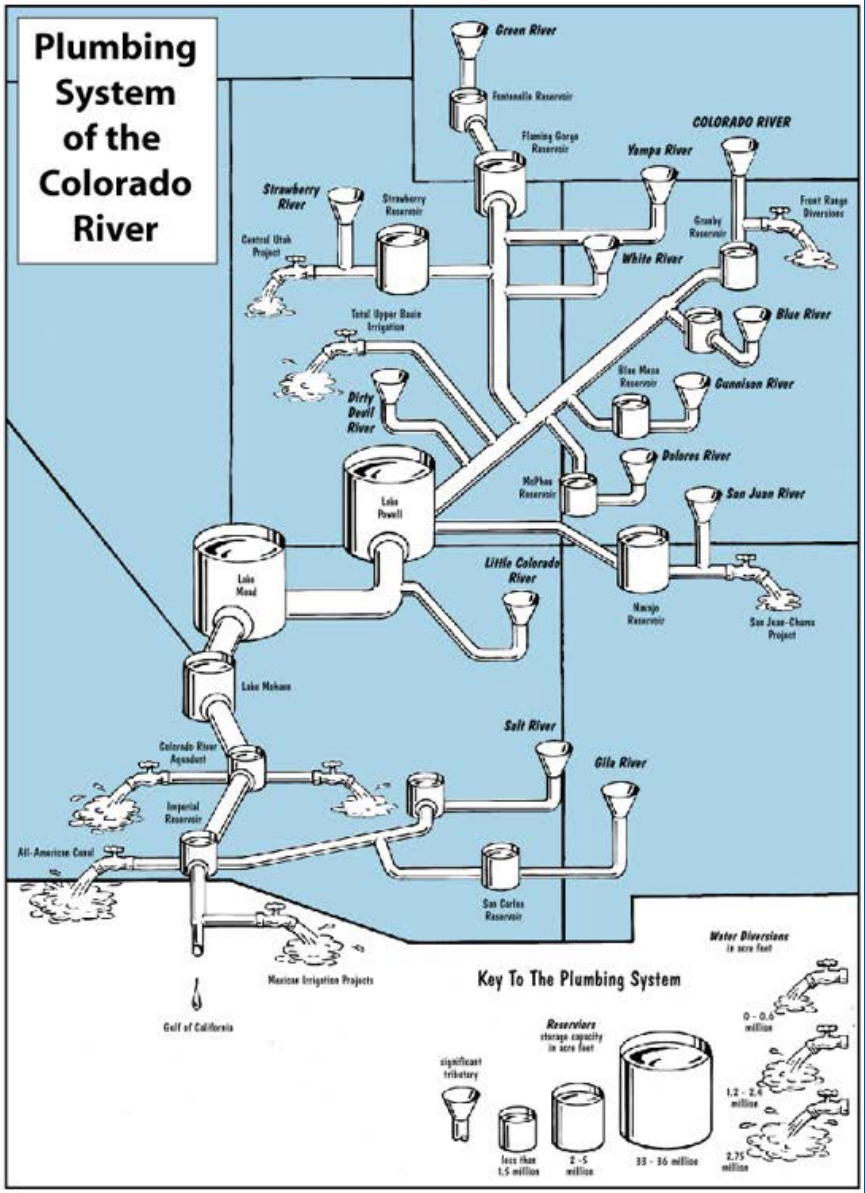
Howard Brandenburg, Robert Dudley, & Steven Platania

American Southwest Ichthyological Researchers, Albuquerque, NM

Kevin Bestgen

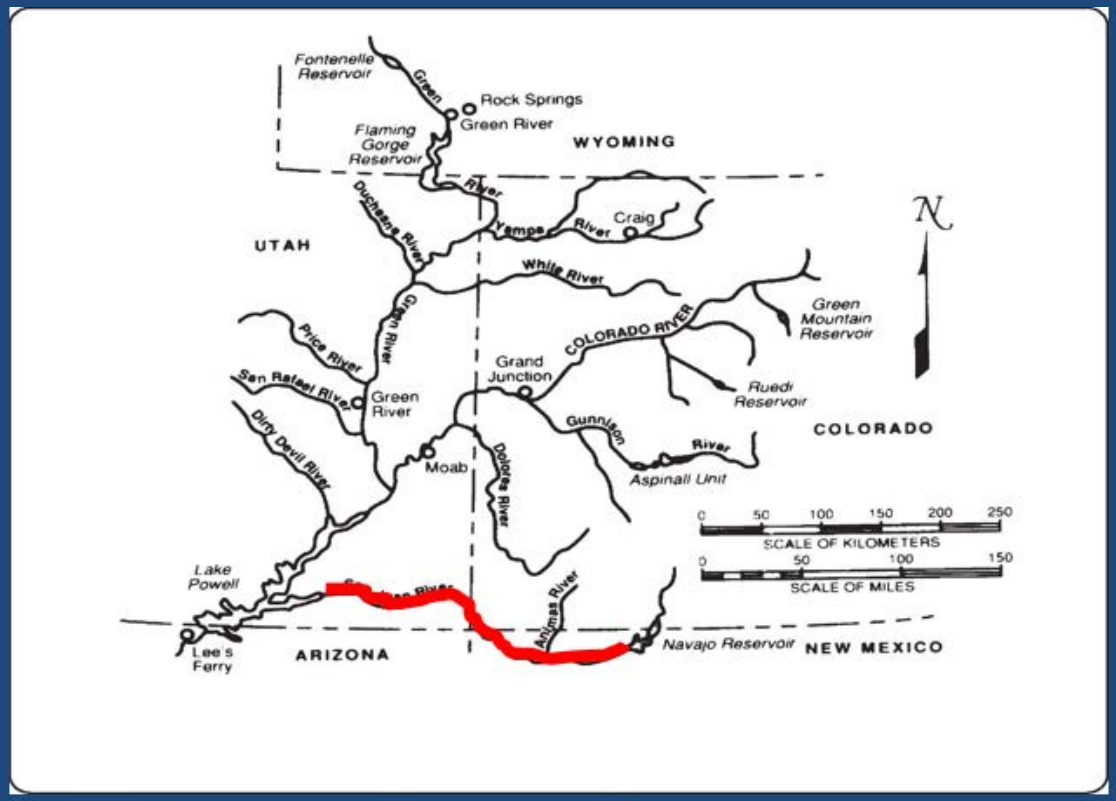
Colorado State University, Ft. Collins, CO

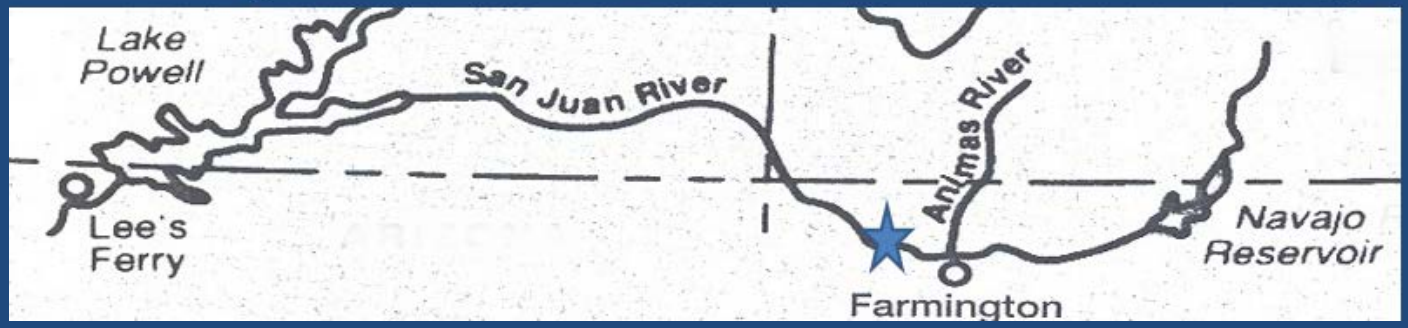

N
W
E
S
Program Area
Dams
GCDAMP
MSCP
UC RIP
SJ RIP


Plumbing System of the Colorado River
Green River
Fontenelle Reservoir
Flaming Gorge Reservoir
COLORADO RIVER
Yampa River
Strawberry River
Strawberry Reservoir
Central Utah Project
Granby Reservoir
Front Range Diversions
White River
Total Upper Basin Irrigation
Blue River
Blue Mesa Reservoir
Gunnison River
Dirty Devil River
Dolores River
McPhee Reservoir
San Juan River
Lake Powell
Little Colorado River
Lake Mead
Navajo Reservoir
San Juan-Chama Project
Lake Mohave
Salt River
Colorado River Aqueduct
Gila River
Imperial Reservoir
All-American Canal
San Carlos Reservoir
Mexican Irrigation Projects
Gulf of California
Key To The Plumbing System
Water Diversions in acre feet
0 - 0.6 million
1.2 - 2.4 million
2.75 million
Reservoirs storage capacity in acre feet
significant tributary
less than 1.5 million
2 - 5 million
33 - 36 million

Entrainment

Study Area


Fontenelle Reservoir
Green
Rock Springs
Green River
Flaming Gorge Reservoir
WYOMING
Duchesne River
River
Yampa
River
Craig
UTAH
White River
Green River
Price River
San Rafael River
Green River
Grand Junction
COLORADO RIVER
Green Mountain Reservoir
Ruedi Reservoir
Gunnison
River
Aspinall Unit
COLORADO
Dirty Devil River
Moab
Dolores River
Lake Powell
Lee's Ferry
ARIZONA
Animas River
Navajo Reservoir
NEW MEXICO
N
0 50 100 150 200 250
SCALE OF KILOMETERS
0 50 100 150
SCALE OF MILES


Lake Powell
San Juan River
Animas River
Lee's Ferry
Navajo Reservoir
Farmington

Hogback Canal, San Juan River, NM April—November

Hogback Fish Entrainment Study

Renfro, Platania & Dudley (2006)

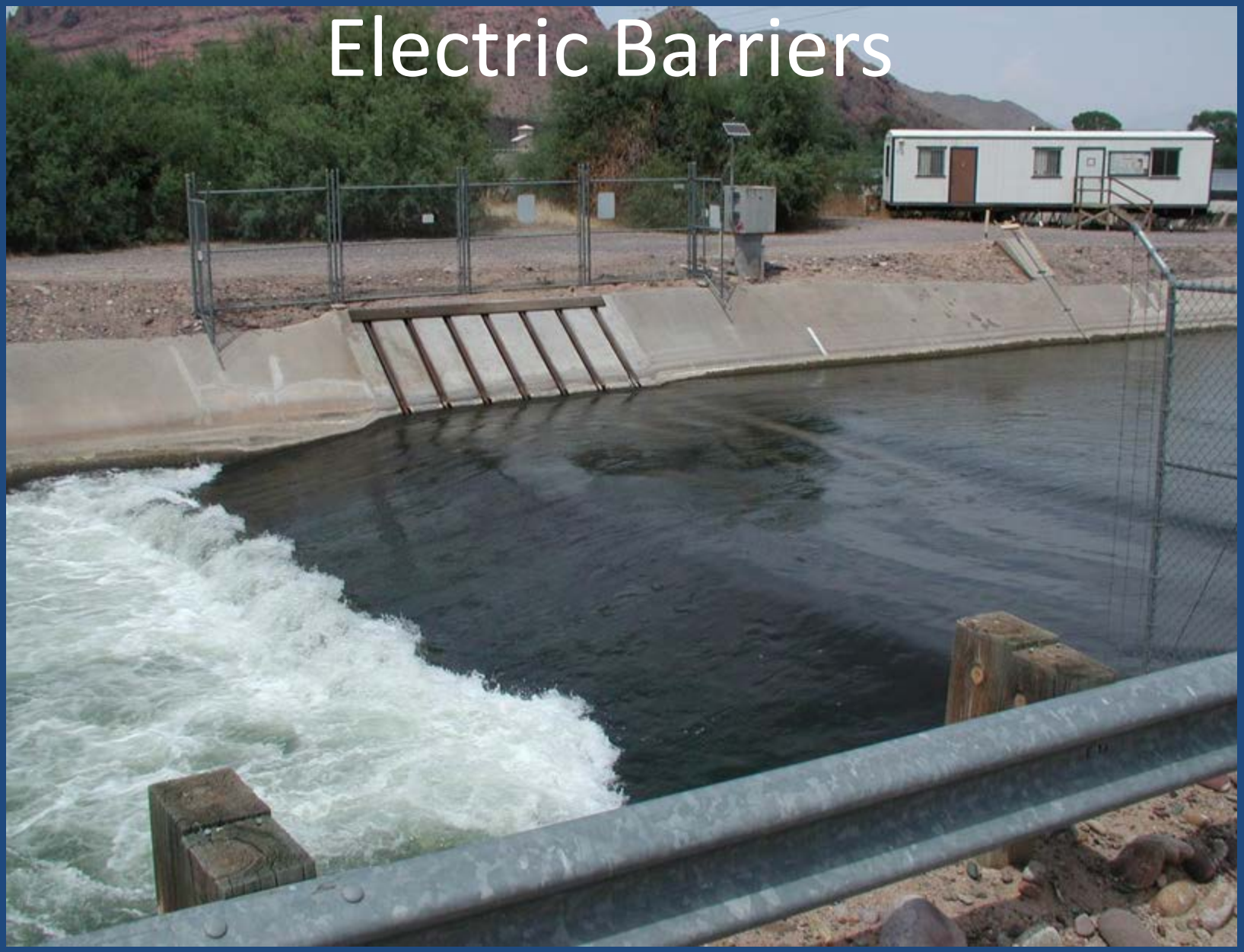
- 2004-2005 sampling in Hogback Canal
- 11,400 fish
- 201 Colorado Pikeminnow (Endangered)
- COPM were 42-315 mm
- Green River Canal, Green River, UT > 600 PIT-tagged endangered fish in 2013

What to Do?

- Deliver irrigation water
- Eliminate or reduce entrainment = screening

RECLAMATION

Electric Barriers



RECLAMATION

Value Engineering study (2007)

Constructed and operational by March 2013

$3.5 million

2 more planned in CO River Basin + more interest

RECLAMATION

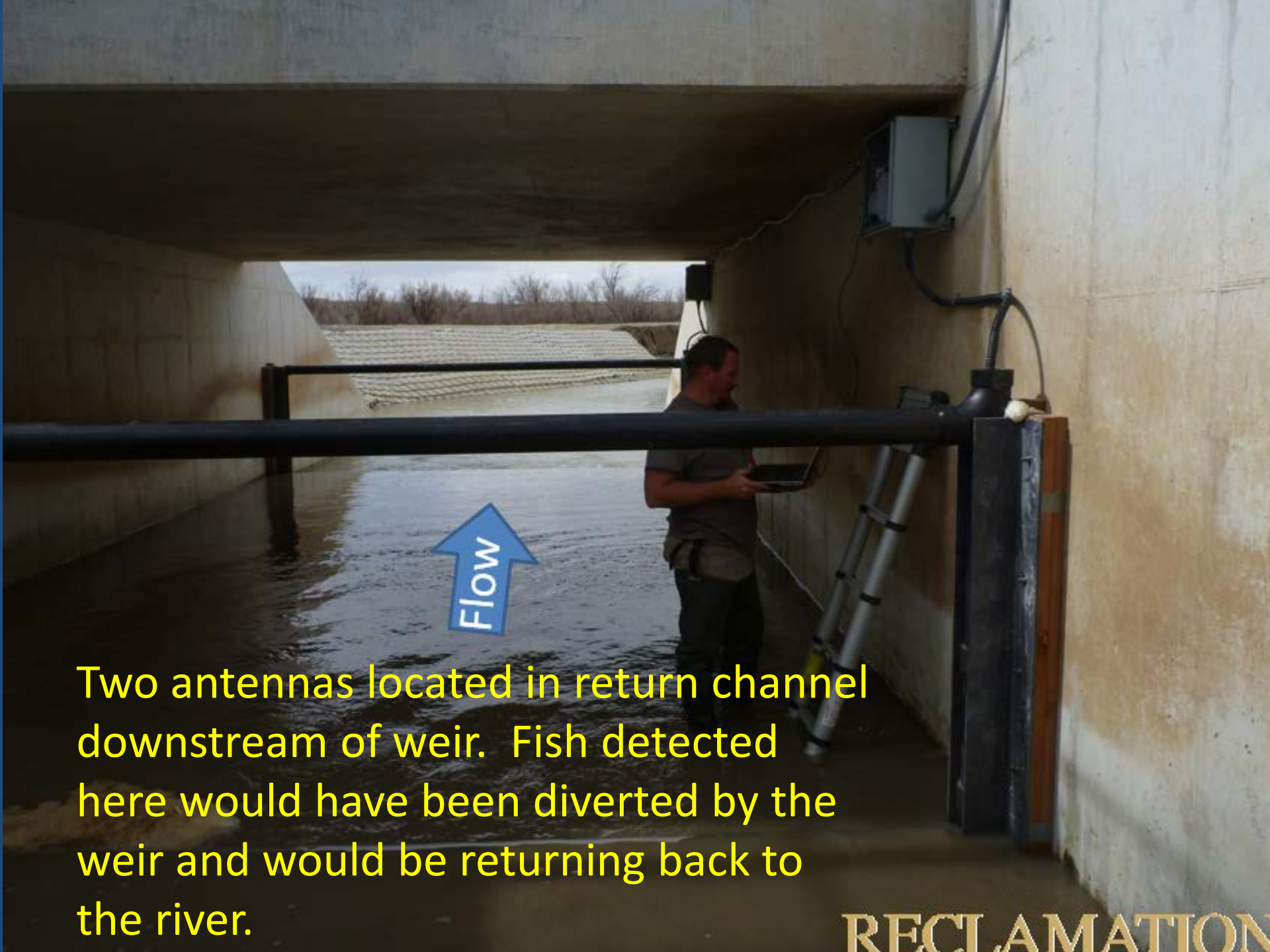
Flow
Fish Path
2 antennas upstream!!
Weir
NO!!
YES!!
7 antennas total
Canal
Antenna Locations in BLACK
Return Flow
RECLAMATION

~ 1/3 flow
50-75 CFS
~ 2/3 flow
175-200 CFS
04/23/2013
RECLAMATION

~ 2/3 flow
Weir Wall—8'
~ 1/3 flow
RECLAMATION

Hogback Weir Facility

Dual Leaf Gates
Flow
Slide and
Flapper Gates
Dual Leaf
Gates
RECLAMATION



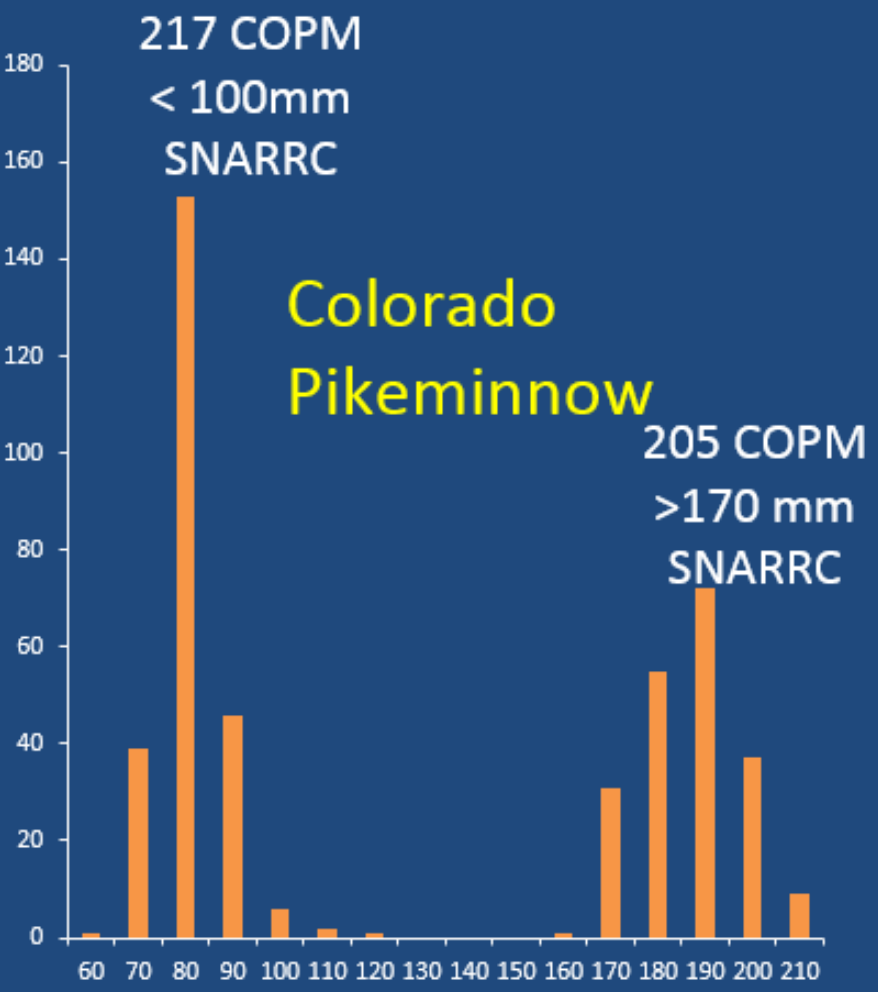
Two antennas located in return channel downstream of weir. Fish detected here would have been diverted by the weir and would be returning back to the river.

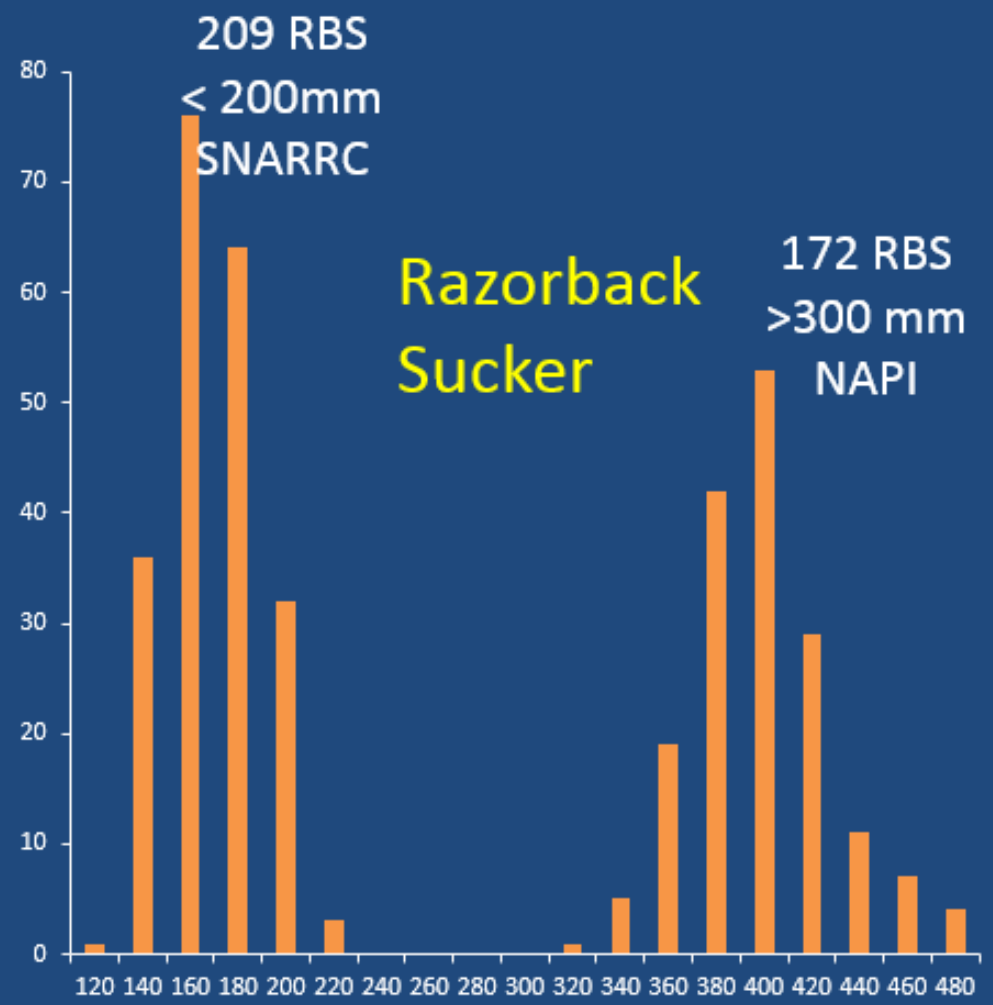
Two antennas located at flume in canal downstream of weir. Fish detected here would be entrained.

Hogback Fish Weir Test

1) Facility run according to specifications entire time of test—normal operations can have problems
2) Fish test was 5 days--stocking started at 1pm on Wednesday 11/5, ended Monday 11/10 8am with headgates closing and dewatering the canal
3) All fish, except >300mm RBS, were conditioned to flow
4) Stocked small numbers (~20) of fish ~ every hour—avoid tag collision
5) Spring 2015
    1) 194 Adult Flannelmouth Sucker--natural
    2) 58 Adult Bluehead Sucker--natural

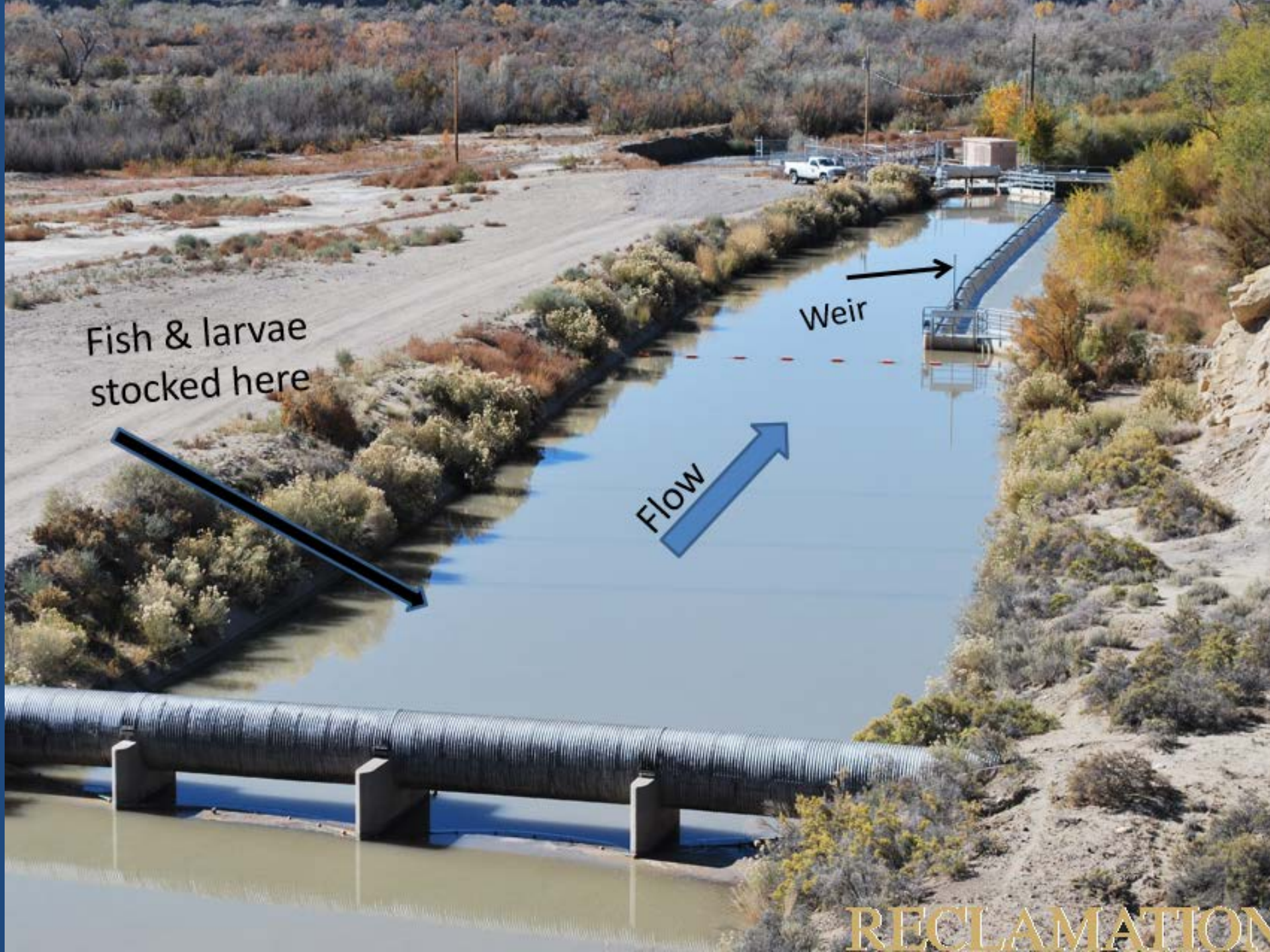
Size Classes of Stocked Fish





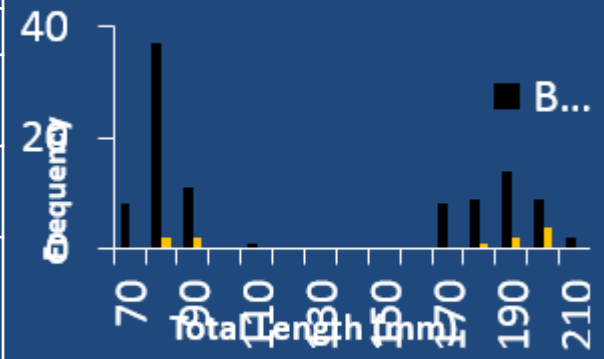
194 Adult Flannelmouth Sucker

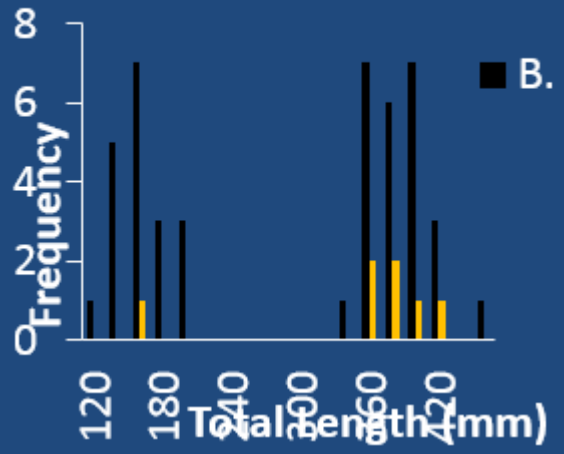
58 Adult Bluehead Sucker

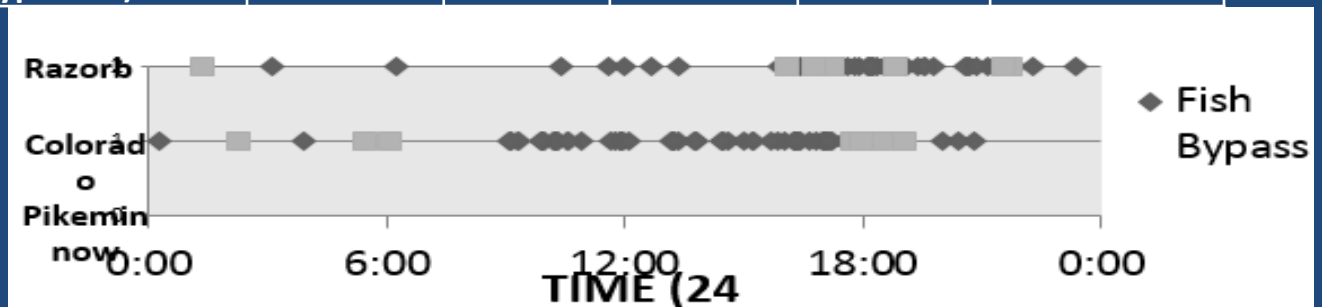

Fish & larvae
stocked here
Weir
Flow
RECLAMATION

Results

	CPM <100mm	CPM >150mm	RBS <200mm	RBS >300mm	Total
Number Stocked	217	205	209	172	803
1- Fish Bypassed during test	57	42	19	25	143
2-Fish Entrained during test	4	7	1	6	18
3- Undetected (upstream?)	127 58.5% (127/217)	135 65.8% (135/205)	68 32.5% (68/209)	78 45.3% (78/172)	408 50.8% (408/803)
% bypassed 1+2	93.4% (57/61)	85.7% (42/49)	95.0% (19/20)	80.6% (25/31)	88.8% (143/161)
% bypassed of total exiting facility 1+2+3	30.3% (57/188)	22.8% (42/184)	21.6% (19/88)	22.9% (25/109)	25.1% (143/569)
% entrained 1+2	6.6% (4/61)	14.3% (7/49)	5.0% (1/20)	19.4% (6/31)	11.2% (18/161)
% entrained of total exiting facility 1+2+3	2.1% (4/188)	3.8% (7/184)	1.1% (1/88)	5.5% (6/109)	3.2% (18/569)
Post Test Fish Remaining in Intake Canal (not entrained or bypassed)	29 13.4% (29/217)	21 10.2% (21/205)	121 57.9% (121/209)	63 36.6% (63/172)	234 29.1% (234/803)

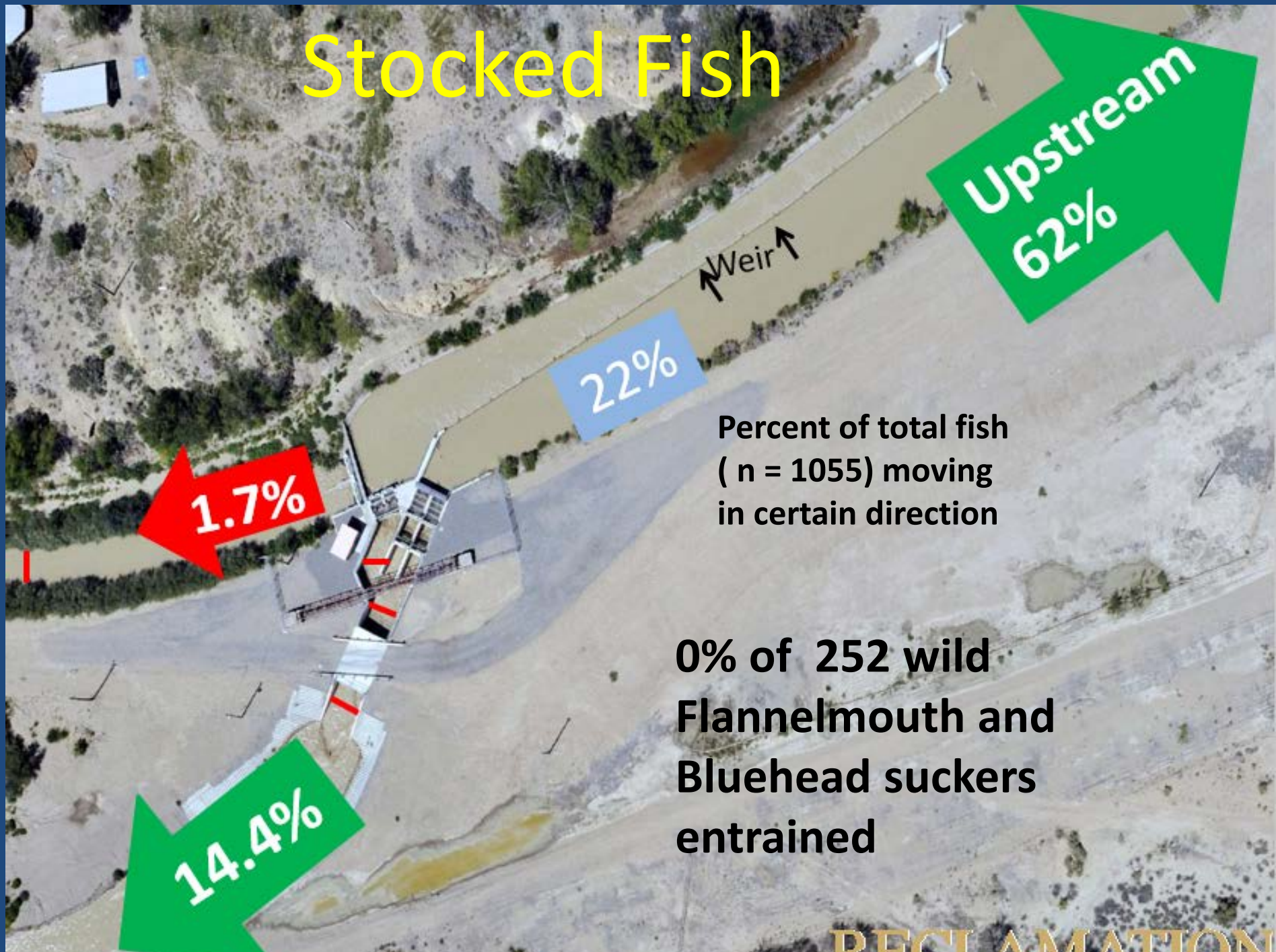






RECLAMATION

Stocked Fish



Percent of total fish (n = 1055) moving in certain direction

0% of 252 wild Flannelmouth and Bluehead suckers entrained

Future Directions

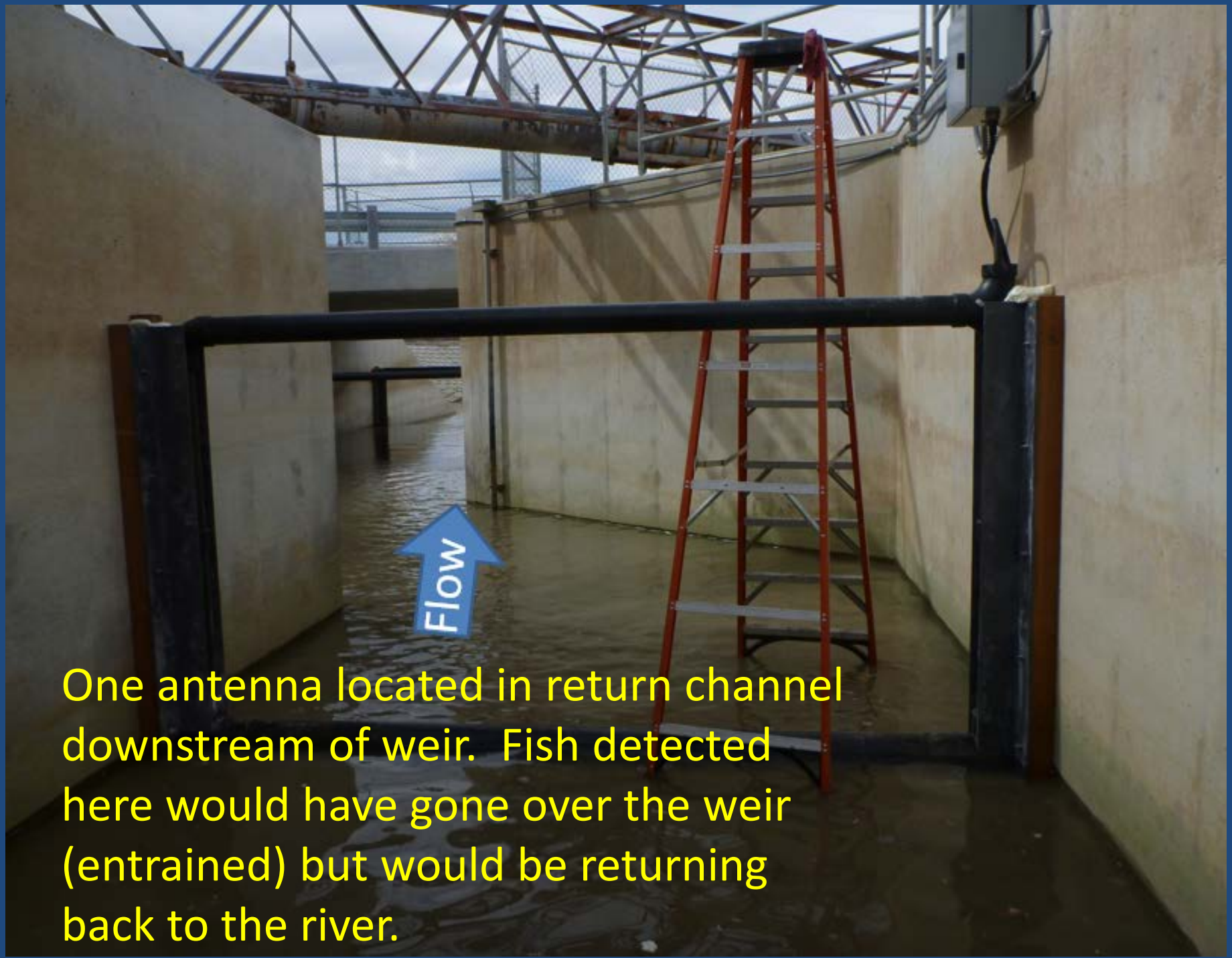
- Electrify weir wall??
- Lights or structure along inside bypass wall?
- Full test of weir during entire irrigation season
  - Detections during actual operations
  - Larvae test—additional life stages, natural larvae
  - Antenna efficiency

Thanks

- Mike Zobott (Biomark)
- Ernest Teller (USFWS)
- Manuel Ulibarri and staff @ SNARRC
- Marlin Saggboy (The Navajo Nation—Shiprock Irrigation)
- Ian Johnson, ACES Engineering

	Total
Number Stocked	803
1- Fish Bypassed during test	143
2-Fish Entrained during test	18
3- Undetected (upstream?)	408 50.8% (408/803)
% bypassed 1+2	88.8% (143/161)
% bypassed of total exiting facility 1+2+3	25.1% (143/569)
% entrained 1+2	11.2% (18/161)
% entrained of total exiting facility 1+2+3	3.2% (18/569)
Post Test Fish Remaining in Intake Canal (not entrained or bypassed)	234 29.1% (234/803)

	CPM <100mm	CPM >150mm	RBS <200mm	RBS >300mm	Total
Number Stocked	217	205	209	172	803
1- Fish Bypassed during test	57	42	19	25	143
2-Fish Entrained during test	4	7	1	6	18
3- Undetected (upstream?)	127 58.5% (127/217)	135 65.8% (135/205)	68 32.5% (68/209)	78 45.3% (78/172)	408 50.8% (408/803)
% bypassed 1+2	93.4% (57/61)	85.7% (42/49)	95.0% (19/20)	80.6% (25/31)	88.8% (143/161)
% bypassed of total exiting facility 1+2+3	30.3% (57/188)	22.8% (42/184)	21.6% (19/88)	22.9% (25/109)	25.1% (143/569)
% entrained 1+2	6.6% (4/61)	14.3% (7/49)	5.0% (1/20)	19.4% (6/31)	11.2% (18/161)
% entrained of total exiting facility 1+2+3	2.1% (4/188)	3.8% (7/184)	1.1% (1/88)	5.5% (6/109)	3.2% (18/569)
Post Test Fish Remaining in Intake Canal (not entrained or bypassed)	29 13.4% (29/217)	21 10.2% (21/205)	121 57.9% (121/209)	63 36.6% (63/172)	234 29.1% (234/803)

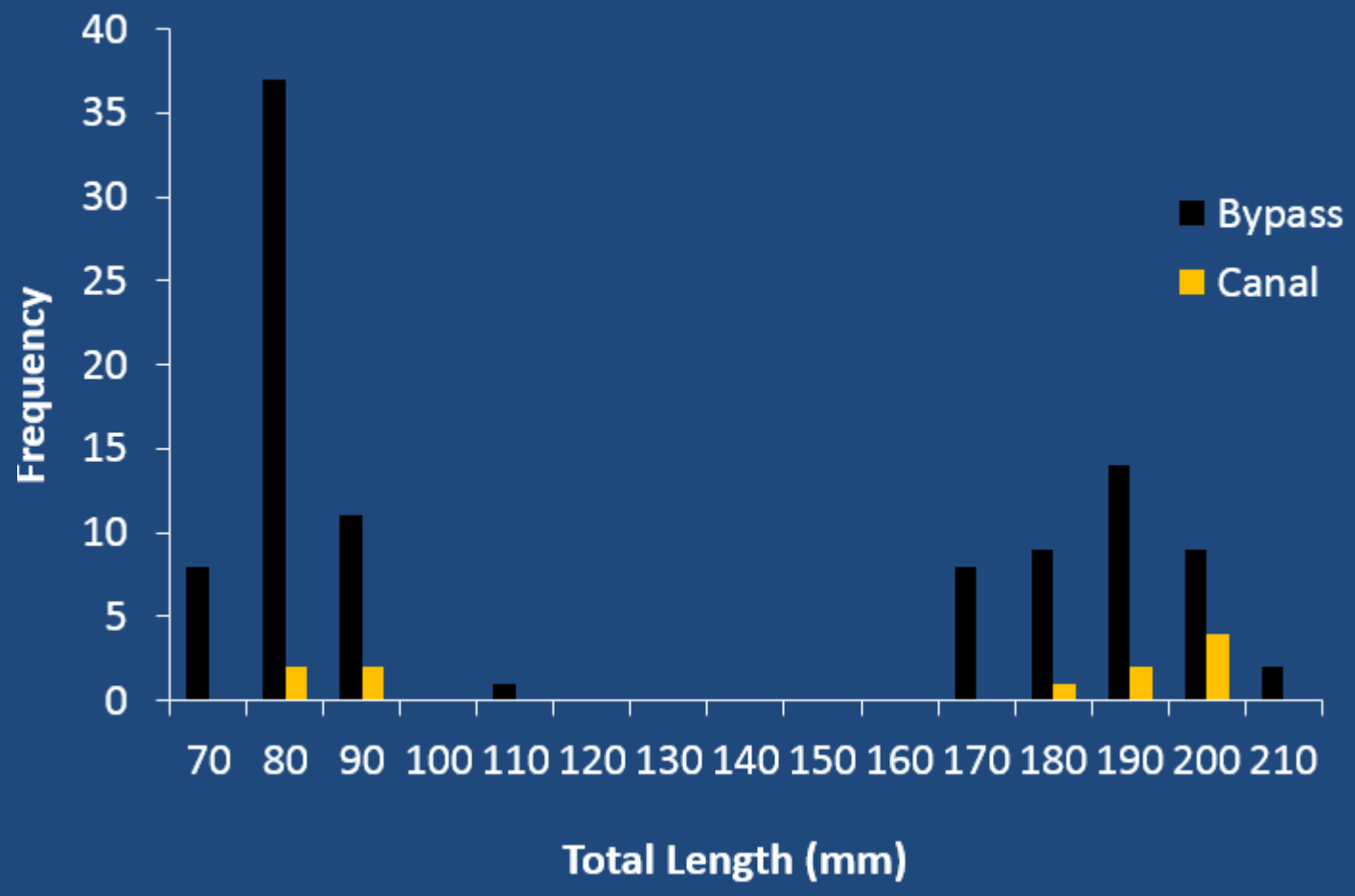


One antenna located in return channel downstream of weir. Fish detected here would have gone over the weir (entrained) but would be returning back to the river.

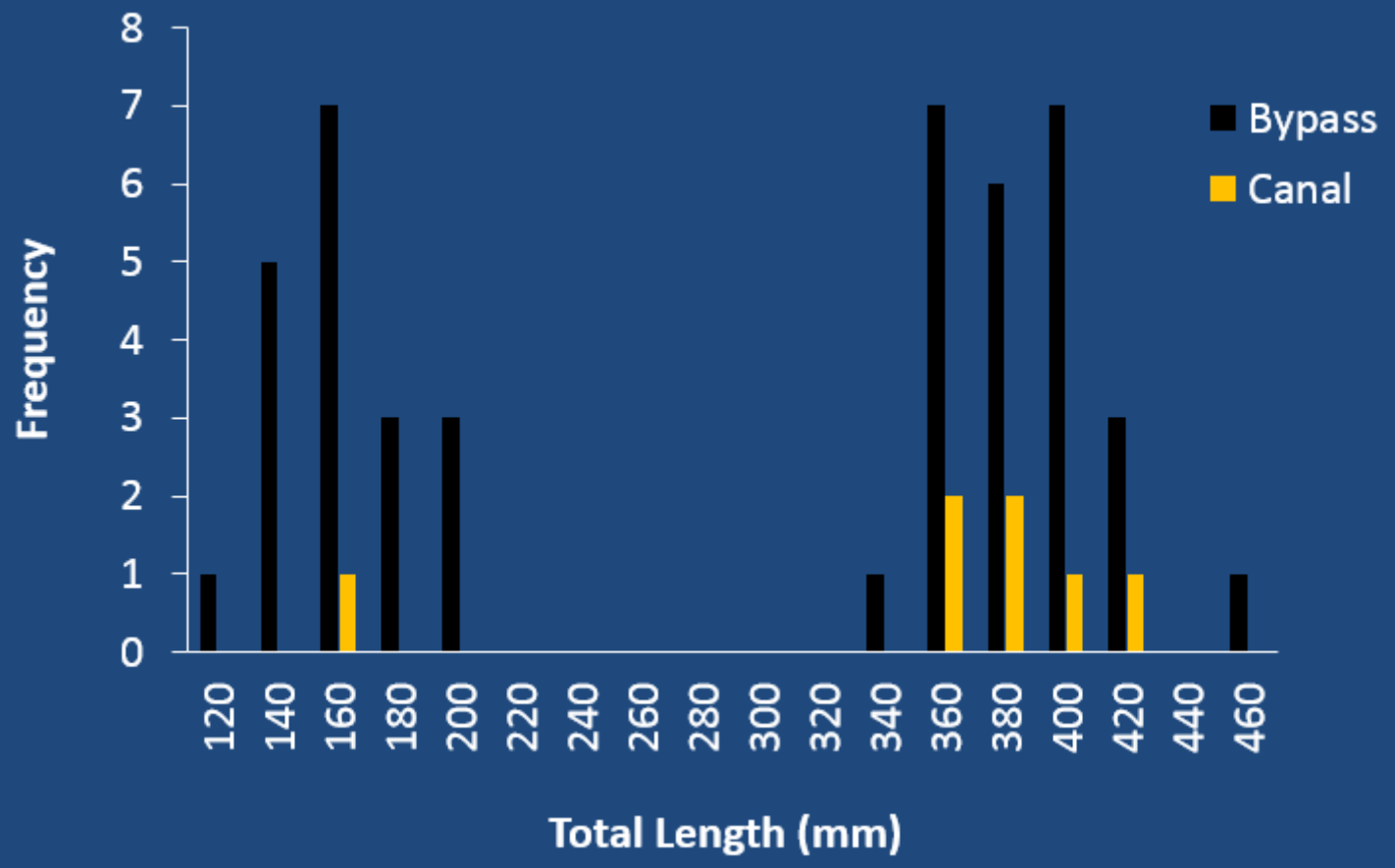
Dual Leaf Gates

Flow

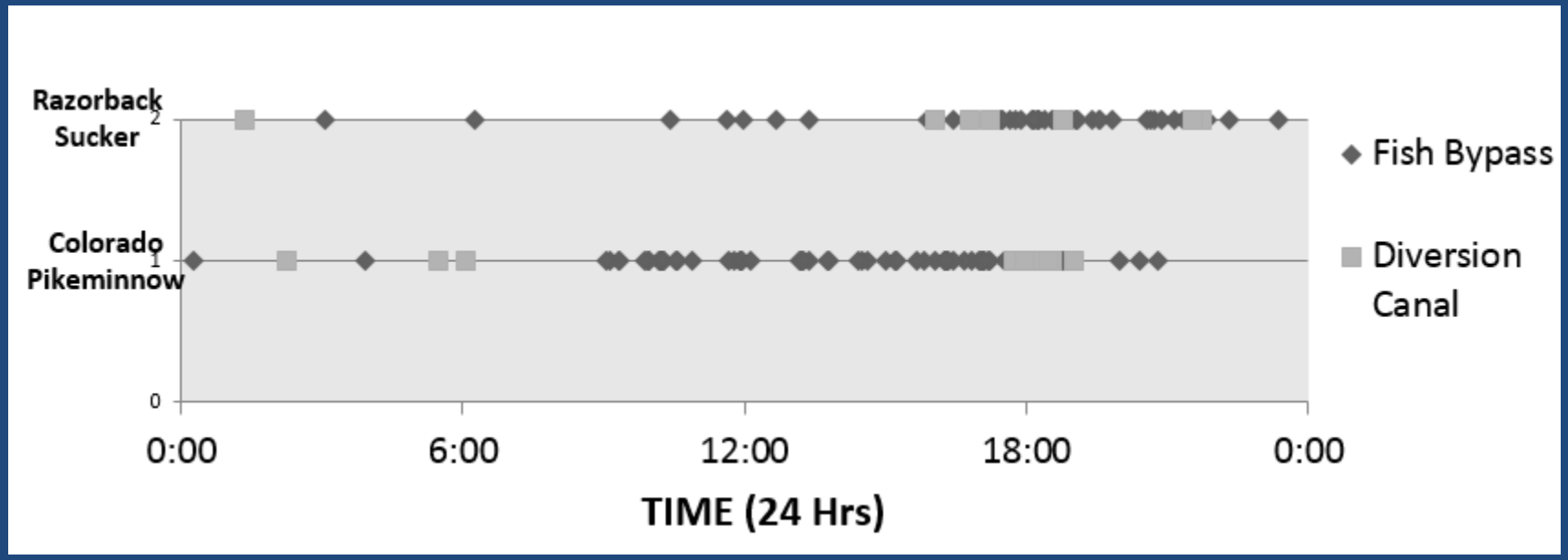
Colorado Pikeminnow



Razorback Suckers

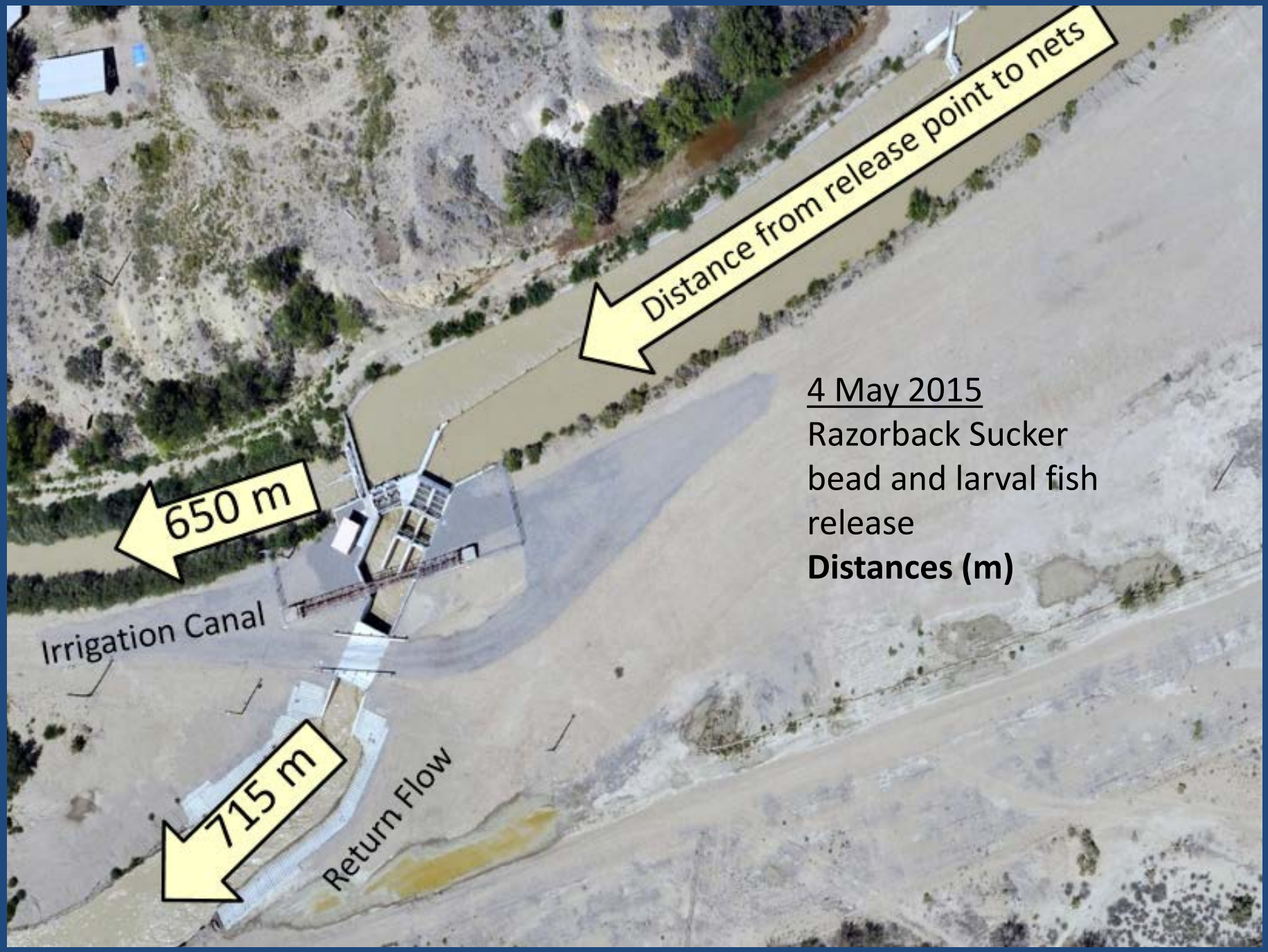


Detection Timeline

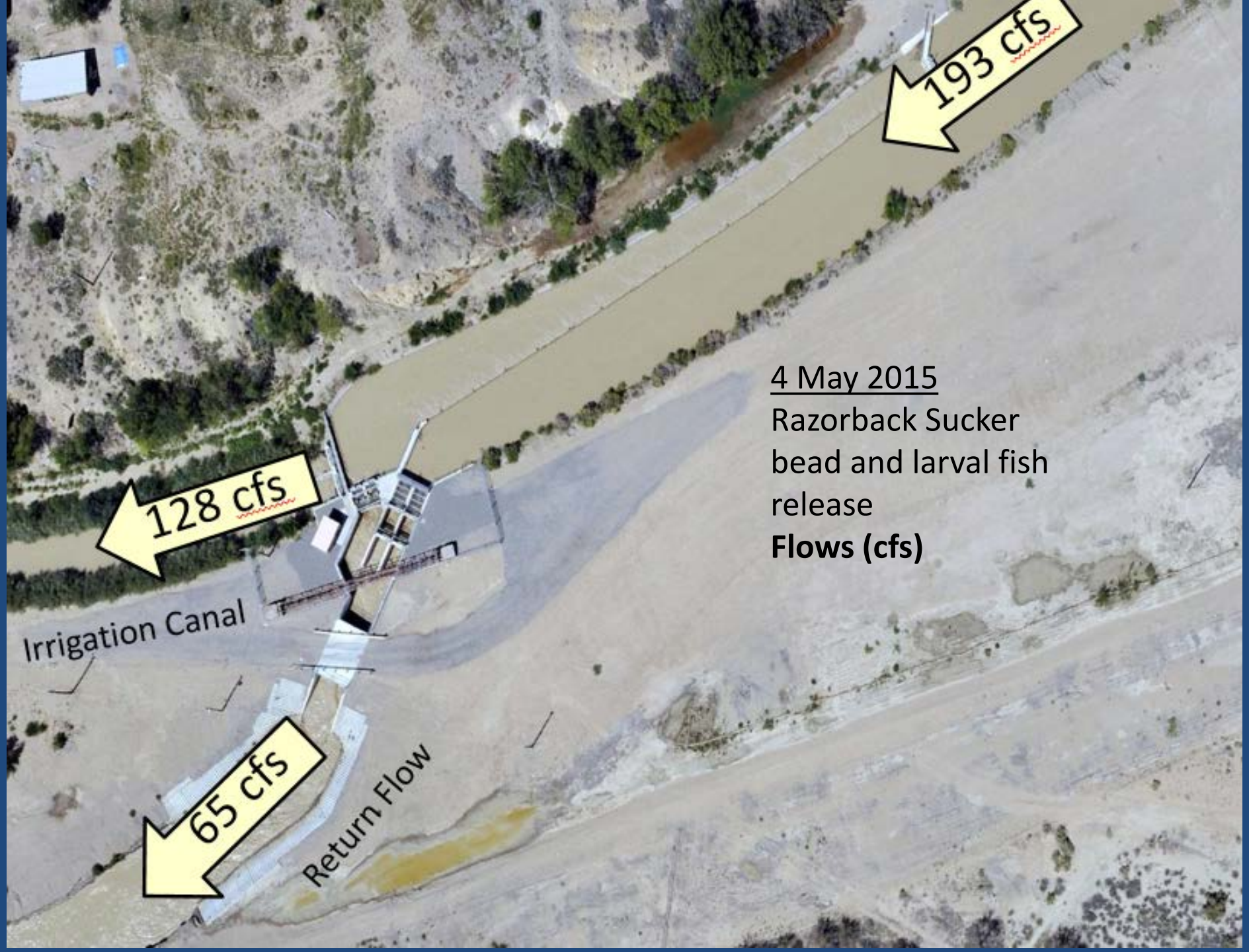


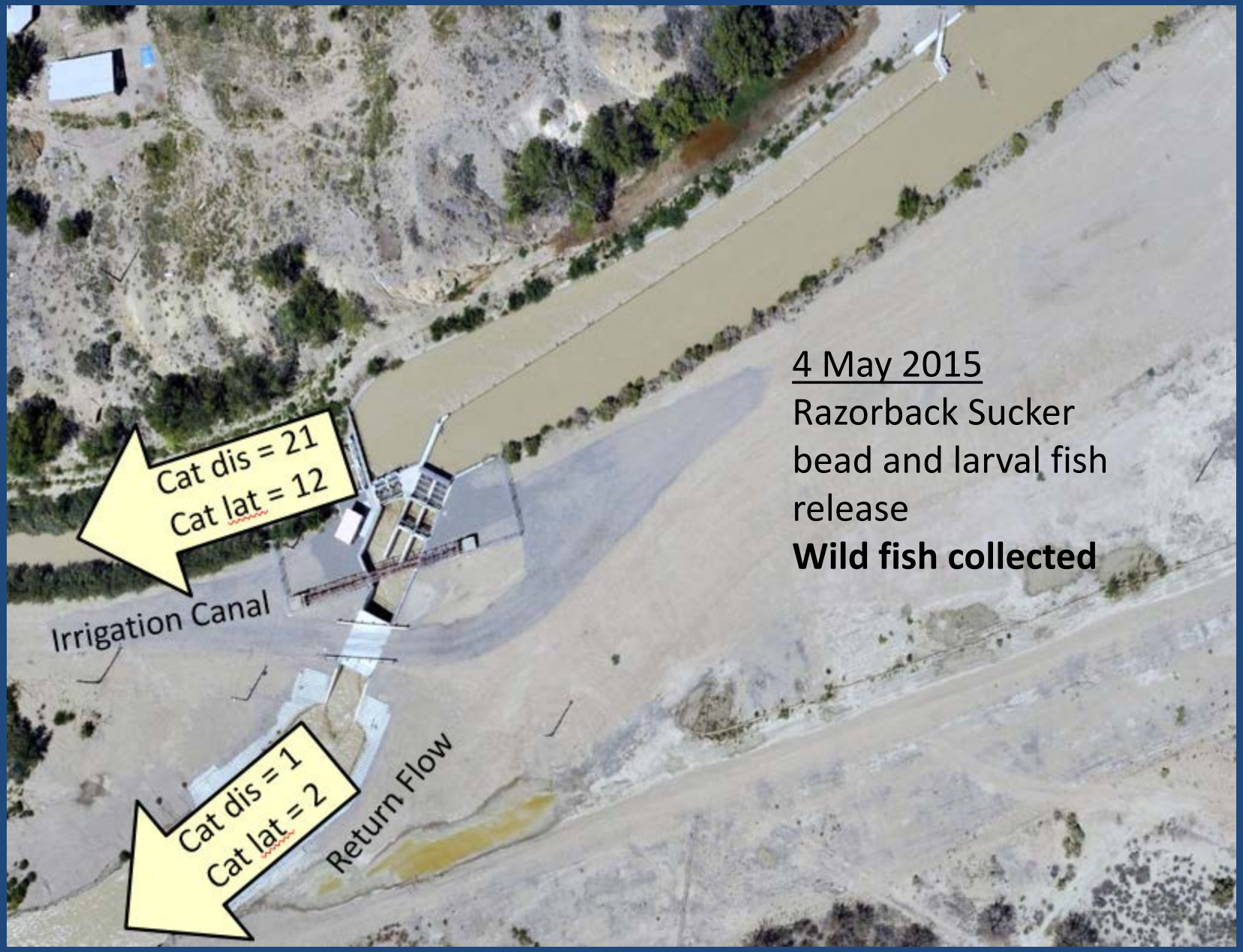
Intake to Hogback Canal

RECLAMATION

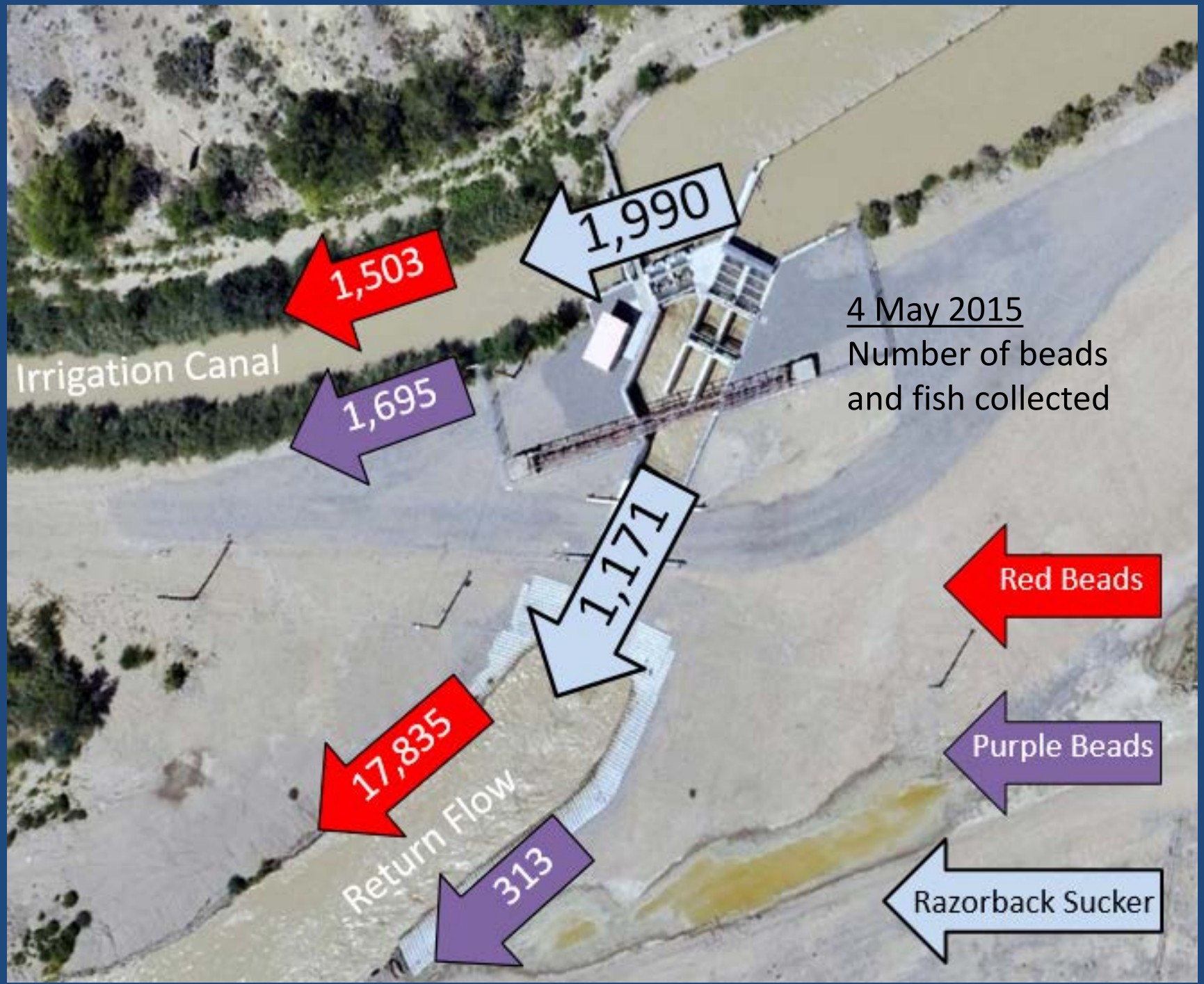


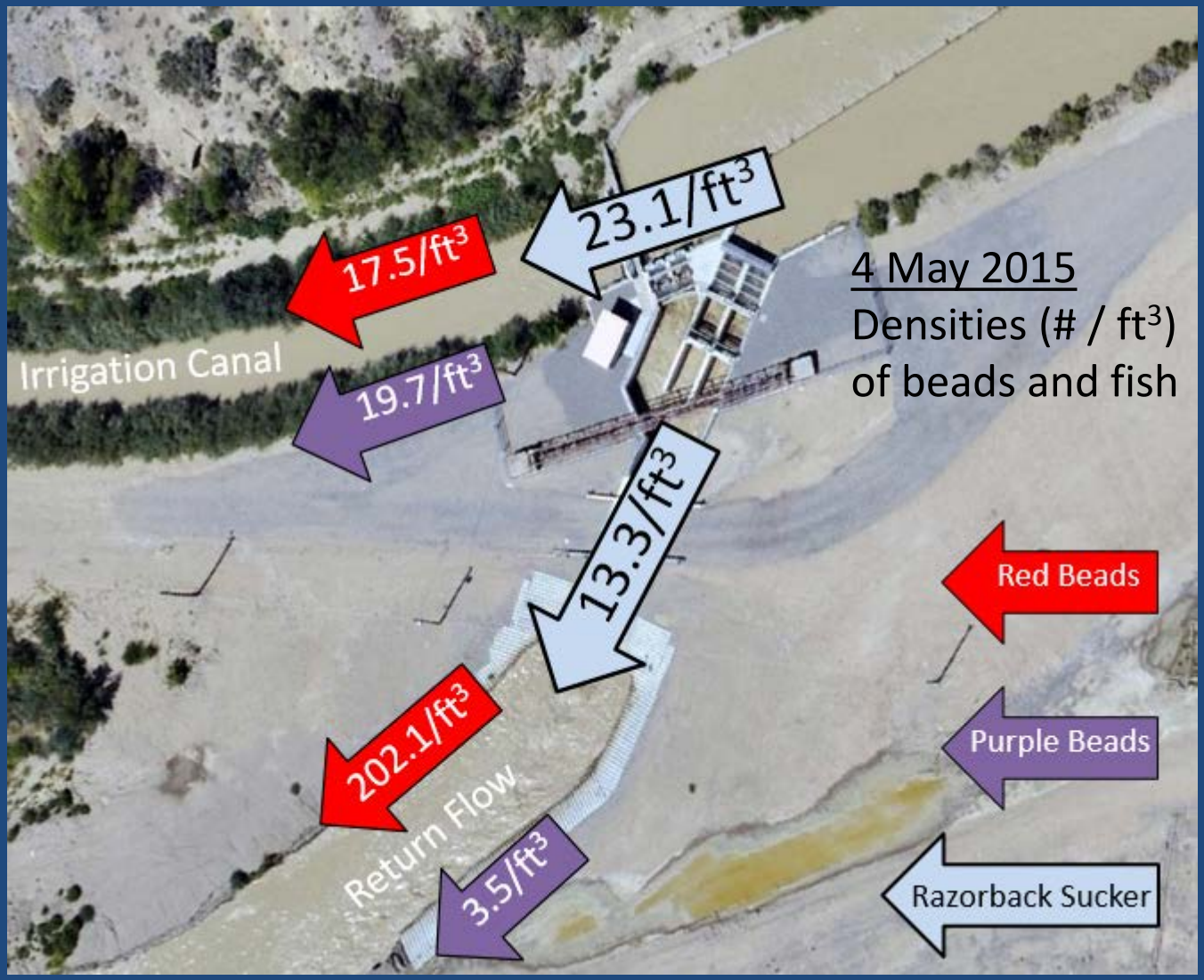
4 May 2015
Razorback Sucker bead and larval fish release
Distances (m)


193 cfs
128 cfs
Irrigation Canal
65 cfs
Return Flow
4 May 2015
Razorback Sucker
bead and larval fish
release
Flows (cfs)

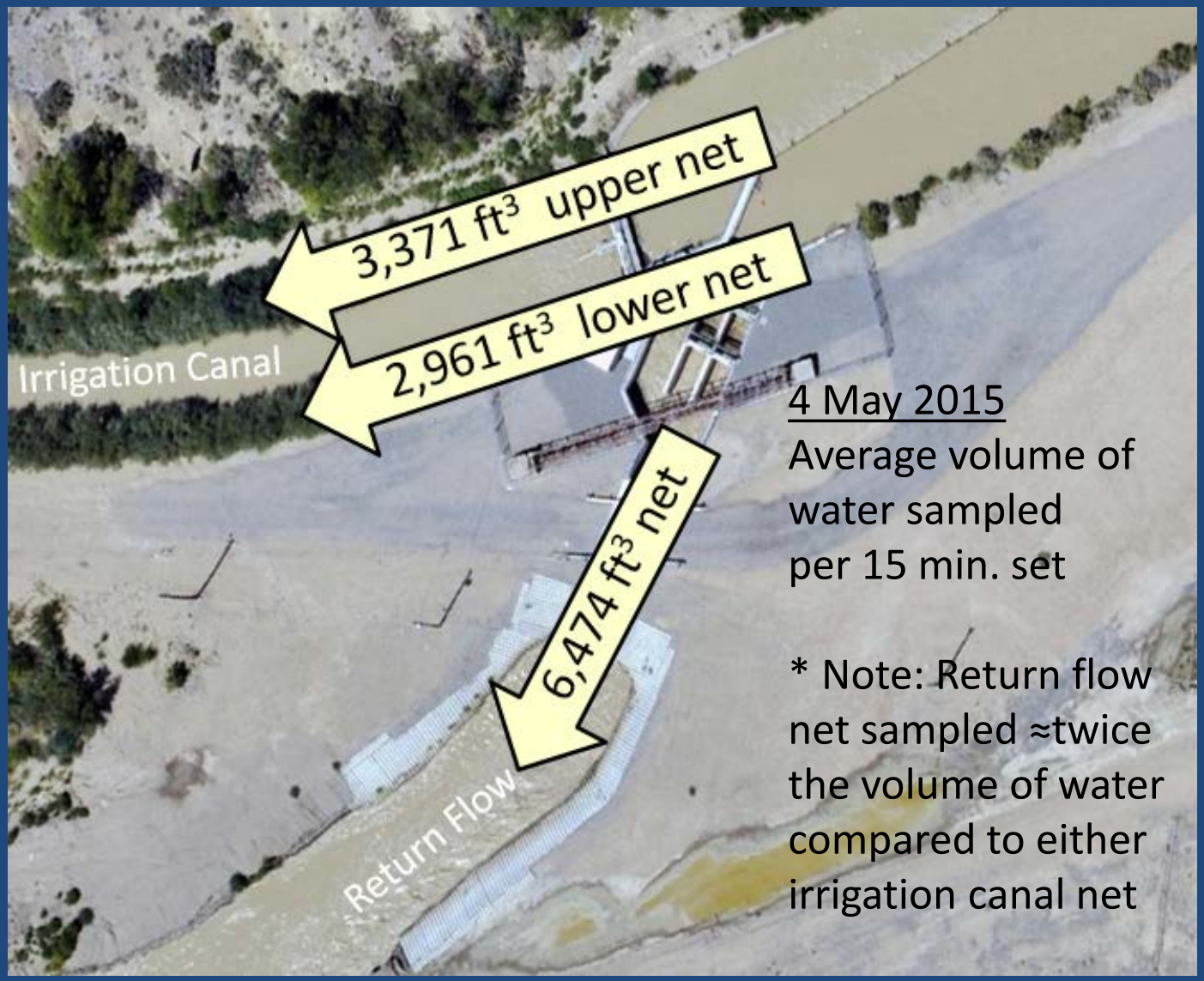


4 May 2015
Razorback Sucker bead and larval fish release
Wild fish collected


1,990
1,503
Irrigation Canal
1,695
4 May 2015
Number of beads
and fish collected
1,171
Red Beads
17,835
Purple Beads
Return Flow
313
Razorback Sucker



4 May 2015
Densities (# / ft^3) of beads and fish



4 May 2015
Average volume of water sampled per 15 min. set

* Note: Return flow net sampled ≈twice the volume of water compared to either irrigation canal net