Warm Water Species Fish Passage in Eastern Montana Culverts

Dr. Joel Cahoon

Dr. Thomas McMahon

Leo Rosenthal

Dr. Robert Bramblett

Matt Blank

serving you with pride

MONTANA STATE UNIVERSITY

Are prairie systems so different?

- Culvert crossings are common in this setting.
- Many and diverse fish species.
- Different life history and mobility needs.

Probably, but we know less about them!

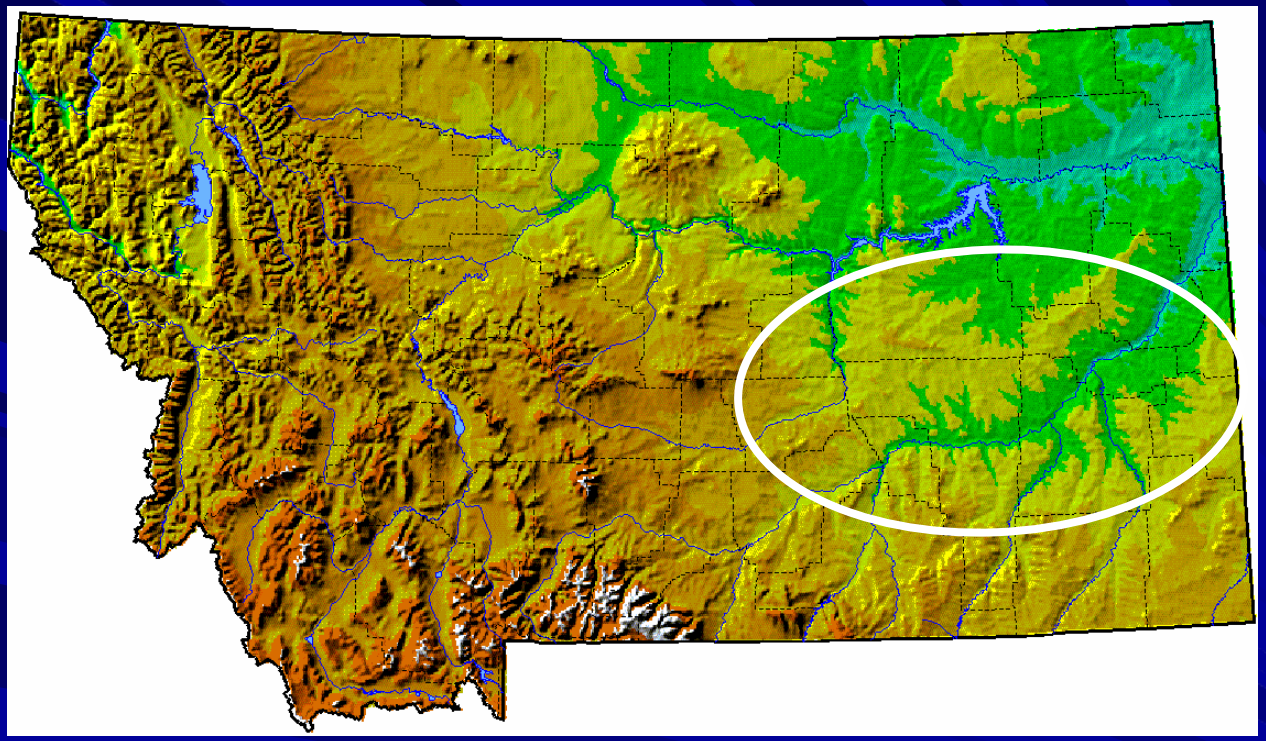
We don’t want culverts to result in:

- Local extirpation
- Loss of diversity
- Deny recolonization

Study Objectives

1. Know more about the interactions between culverts, fish, hydraulics and hydrology in prairie settings.
2. Know more about the capabilities of prairie fish species to navigate streams with culverts.

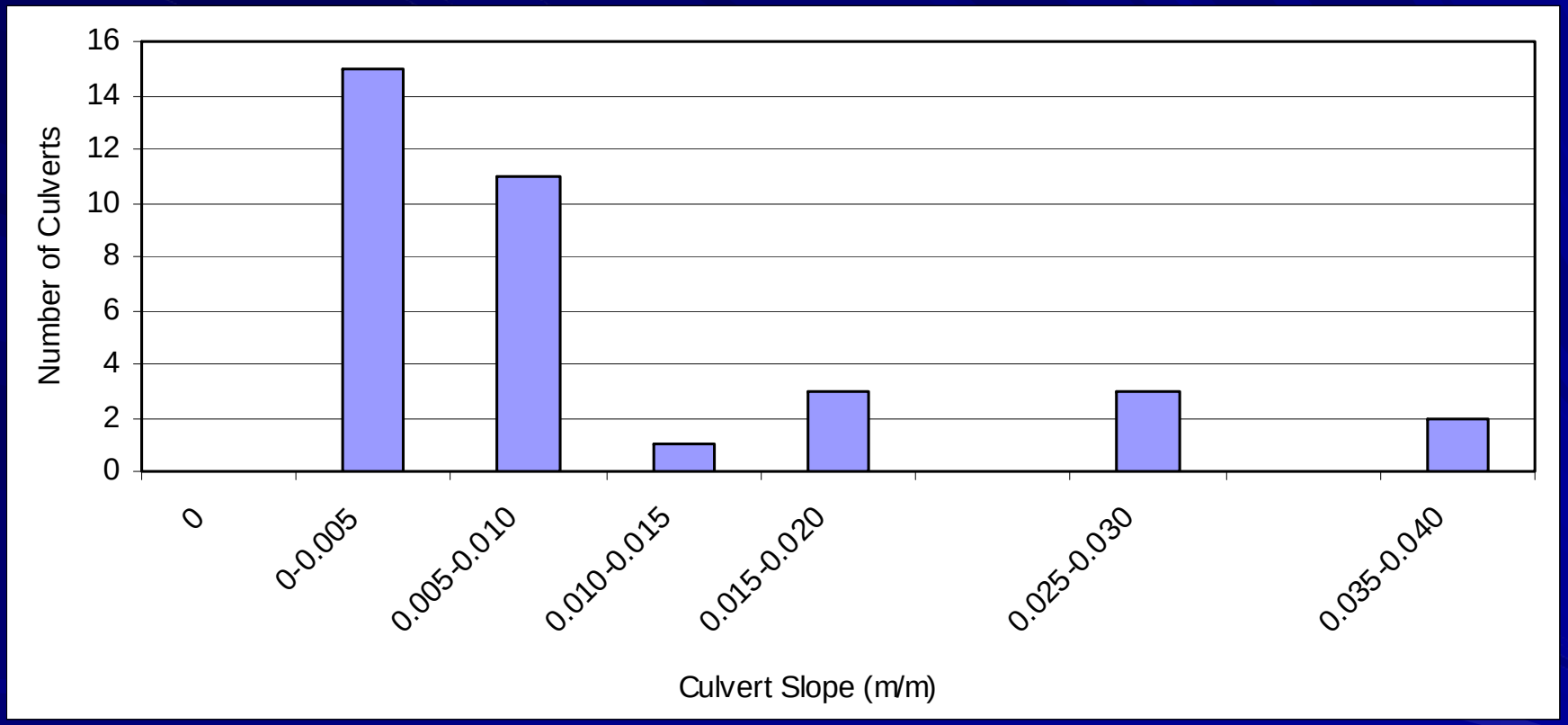
Tour of Existing Culverts



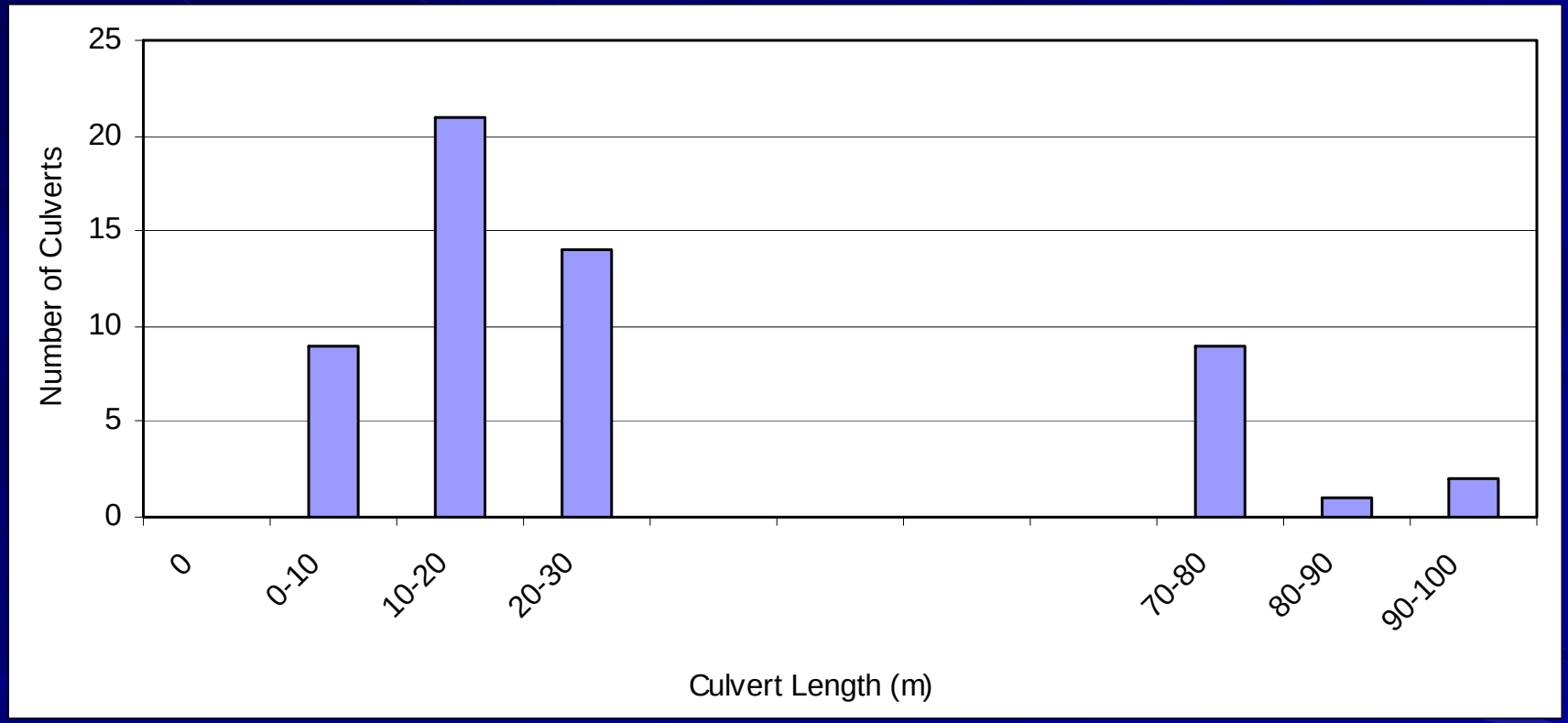
- Cataloged 34 road crossings
- County, state, or interstate road crossings
- Photos and physical measurements, including culvert dimensions, slope, material, outlet drop...

Examples from Tour

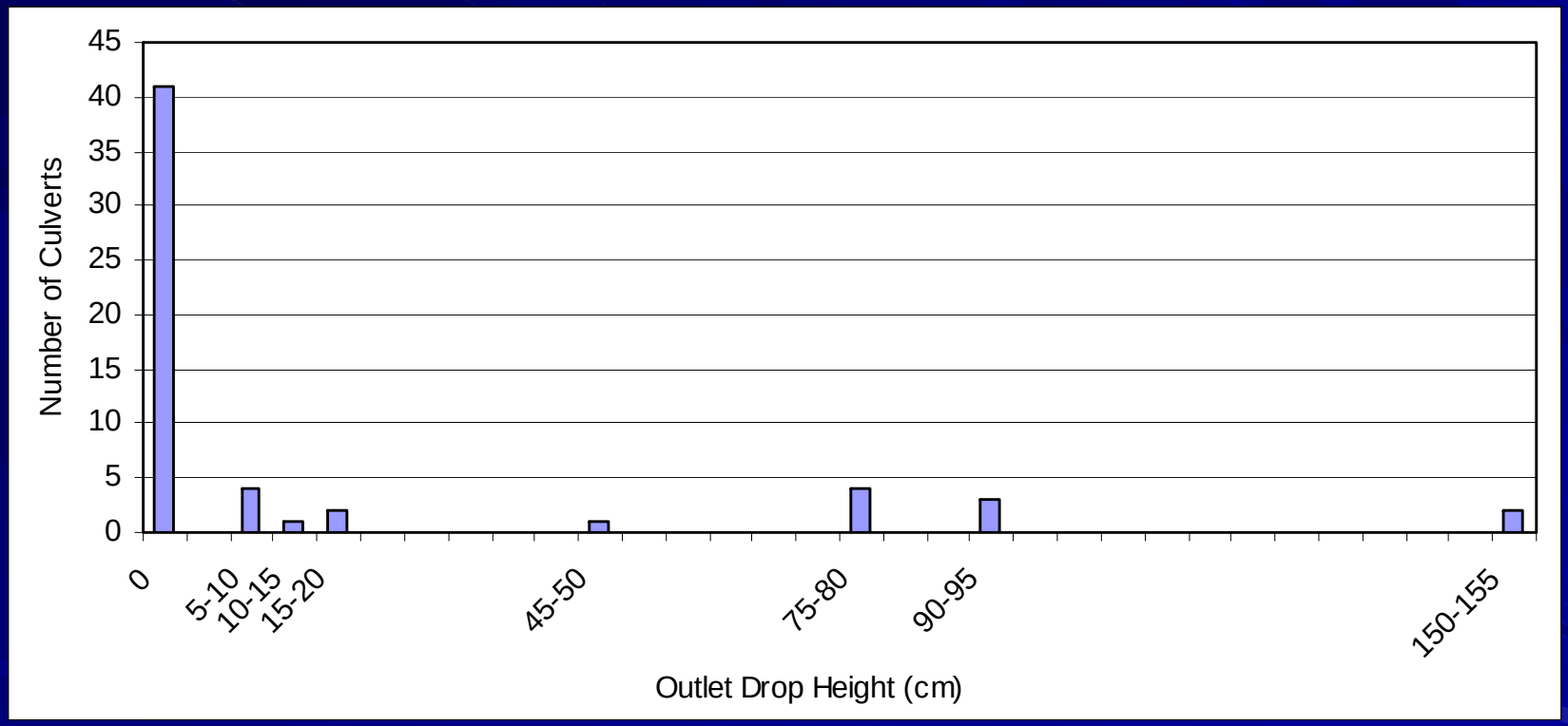
Summary of Tour Culverts



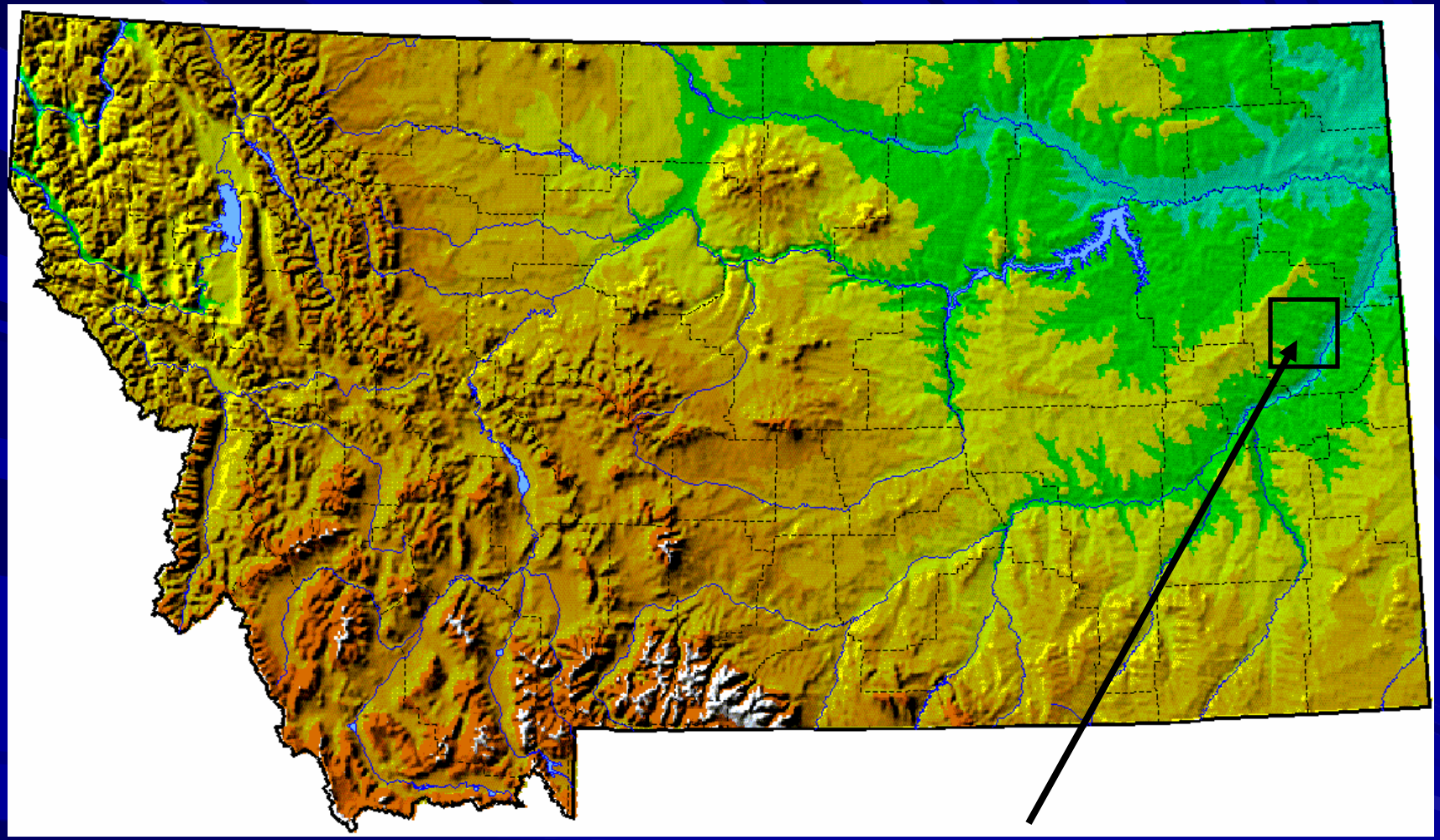
Summary of Tour Culverts



Summary of Tour Culverts



Intensive Study Culverts

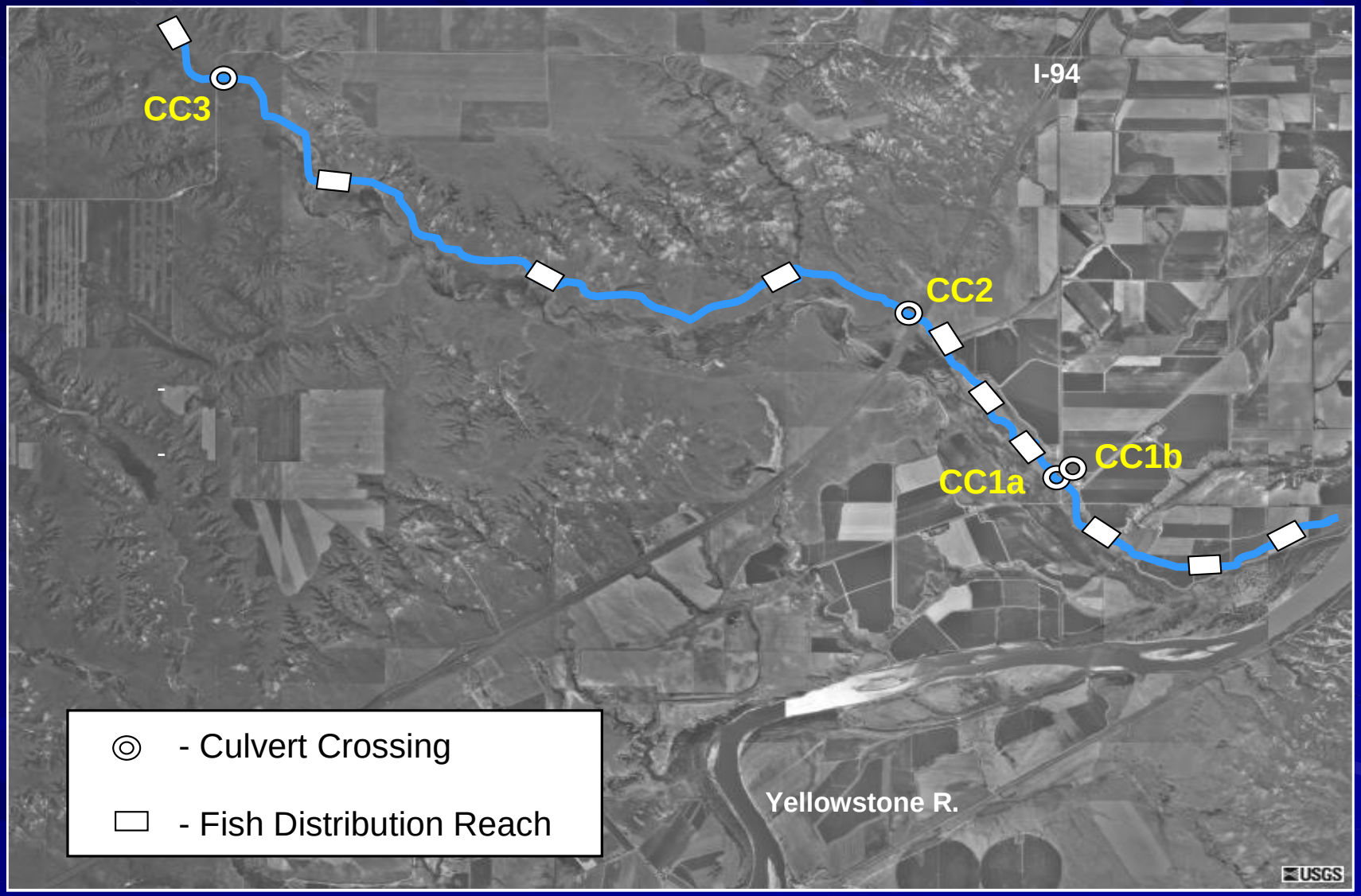


Sand and Clear Creek Drainages

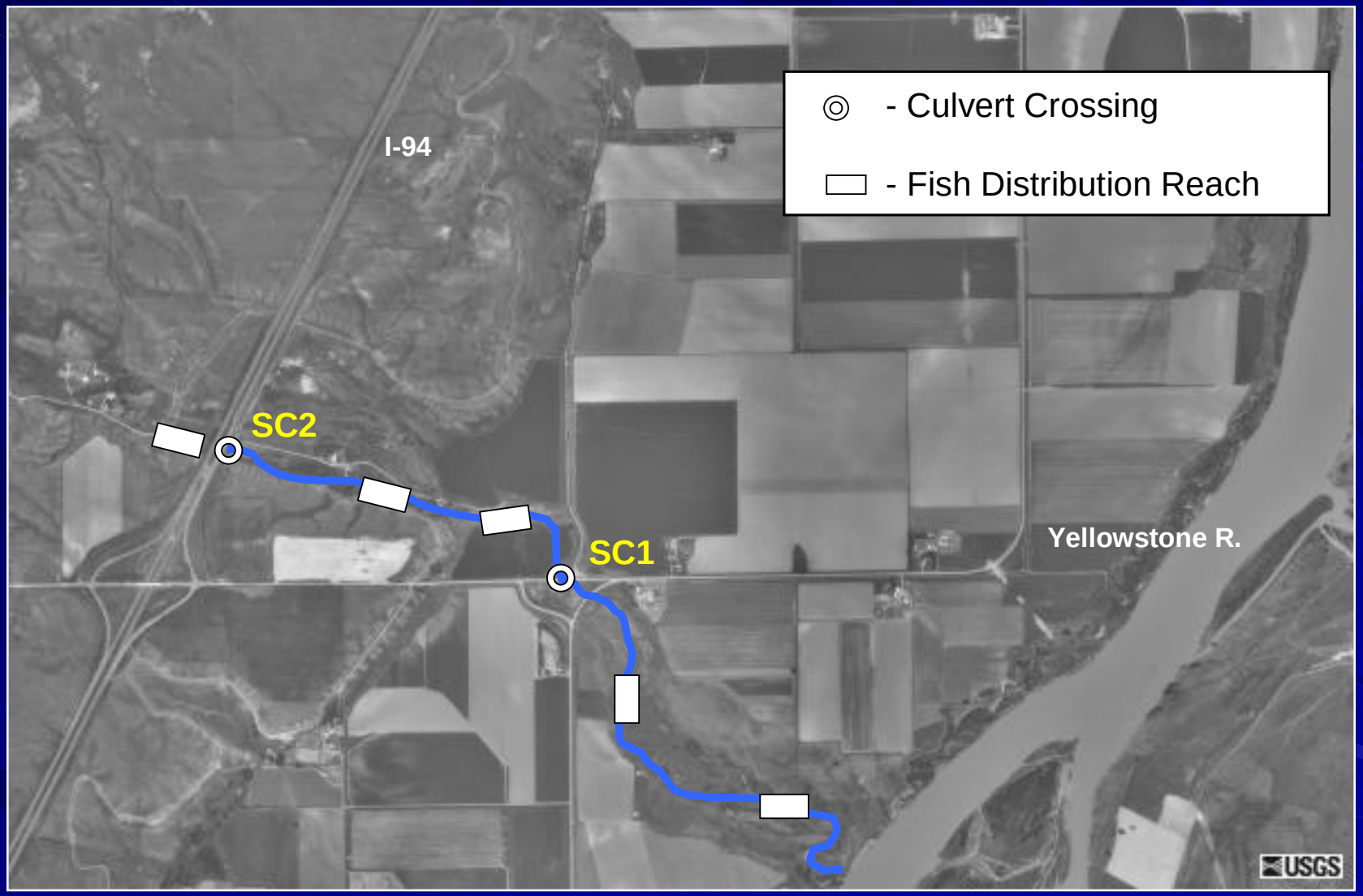
Sand Creek and Clear Creek

- Multiple stream crossings (4 single, 1 multiple)
- Substantial in-stream flow
- Good landowner cooperation

Clear Creek


CC3
I-94
CC2
CC1b
CC1a
Yellowstone R.
- Culvert Crossing
- Fish Distribution Reach
USGS

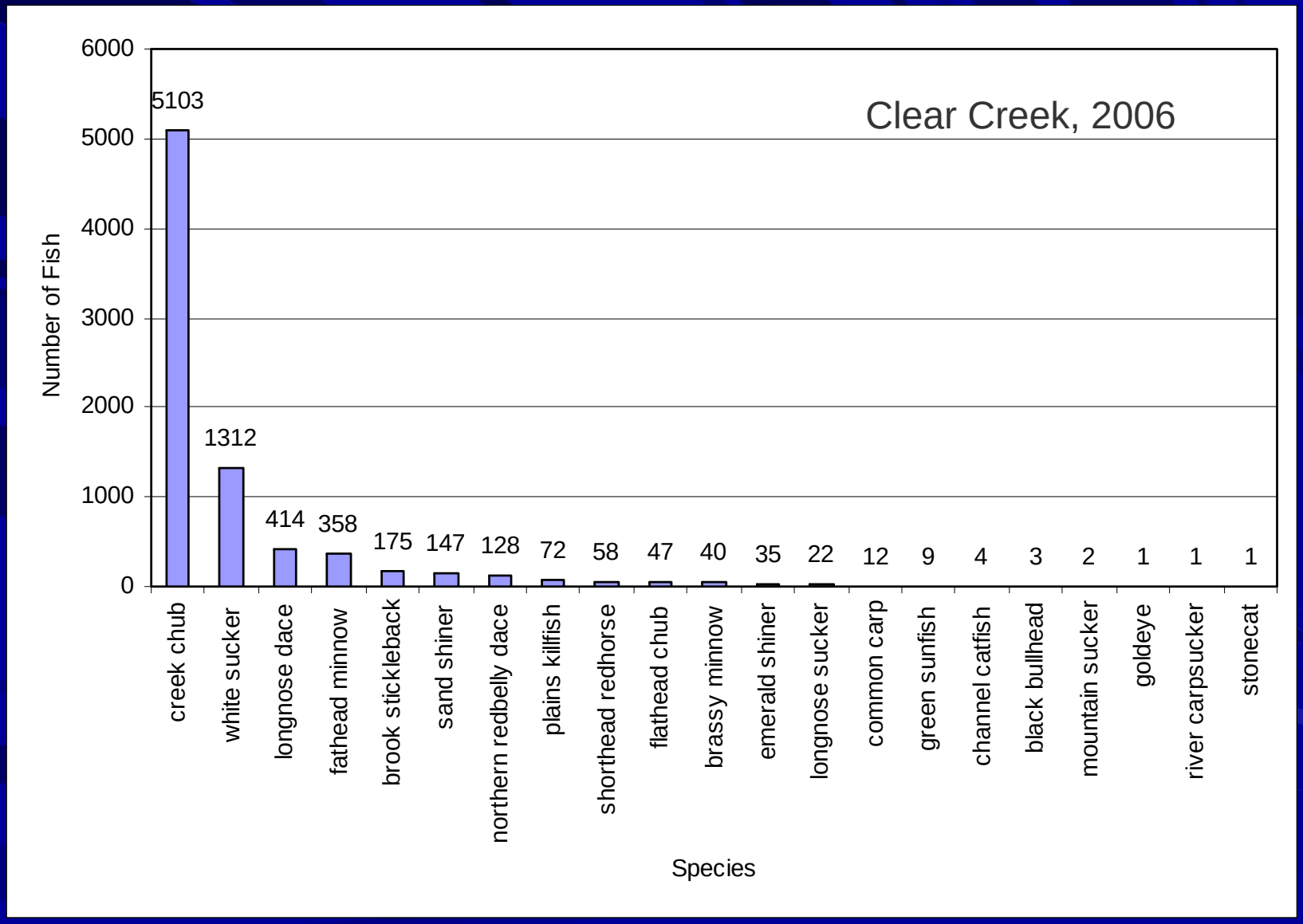
Sand Creek


◎ - Culvert Crossing
- Fish Distribution Reach
I-94
SC2
SC1
Yellowstone R.
USGS

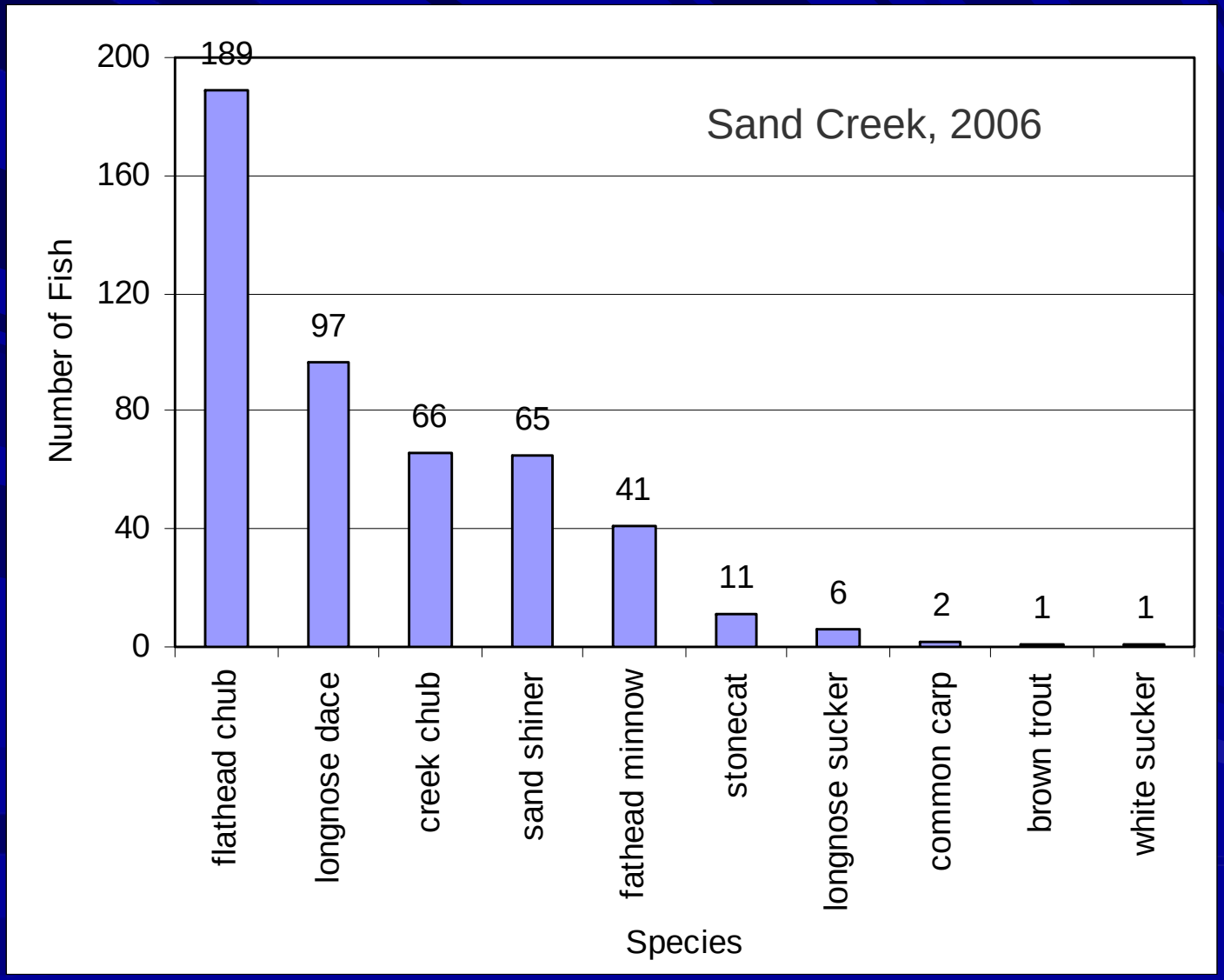
Intensive Study Culverts

Stream	Crossing	Type	Length (m)	Width (m)	Height (m)	Slope (m/m)	Corrugation dimensions (cm x cm)	Outlet drop height (cm)
Clear Creek	CC1a	SSP	19.7	3.4	2.1	0.0037	16.5 x 5.1	0.0
Clear Creek	CC1b	CMP	14.0	1.5	1.5	0.0000	7.6 x 1.3	0.0
Clear Creek	CC2	SSP	70.7	4.6	3.0	0.0055	15.2 x 5.1	5.1
Clear Creek	CC3 left	CMP	18.4	1.2	1.2	0.0166	7.6 x 1.3	0.0
Clear Creek	CC3 center	CMP	18.4	1.2	1.2	0.0159	7.6 x 1.3	0.0
Clear Creek	CC3 right	CMP	18.4	1.2	1.2	0.0185	7.6 x 1.3	0.0
Sand Creek	SC1	CMP	27.1	2.4	2.4	0.0158	8.5 x 2.5	0.0

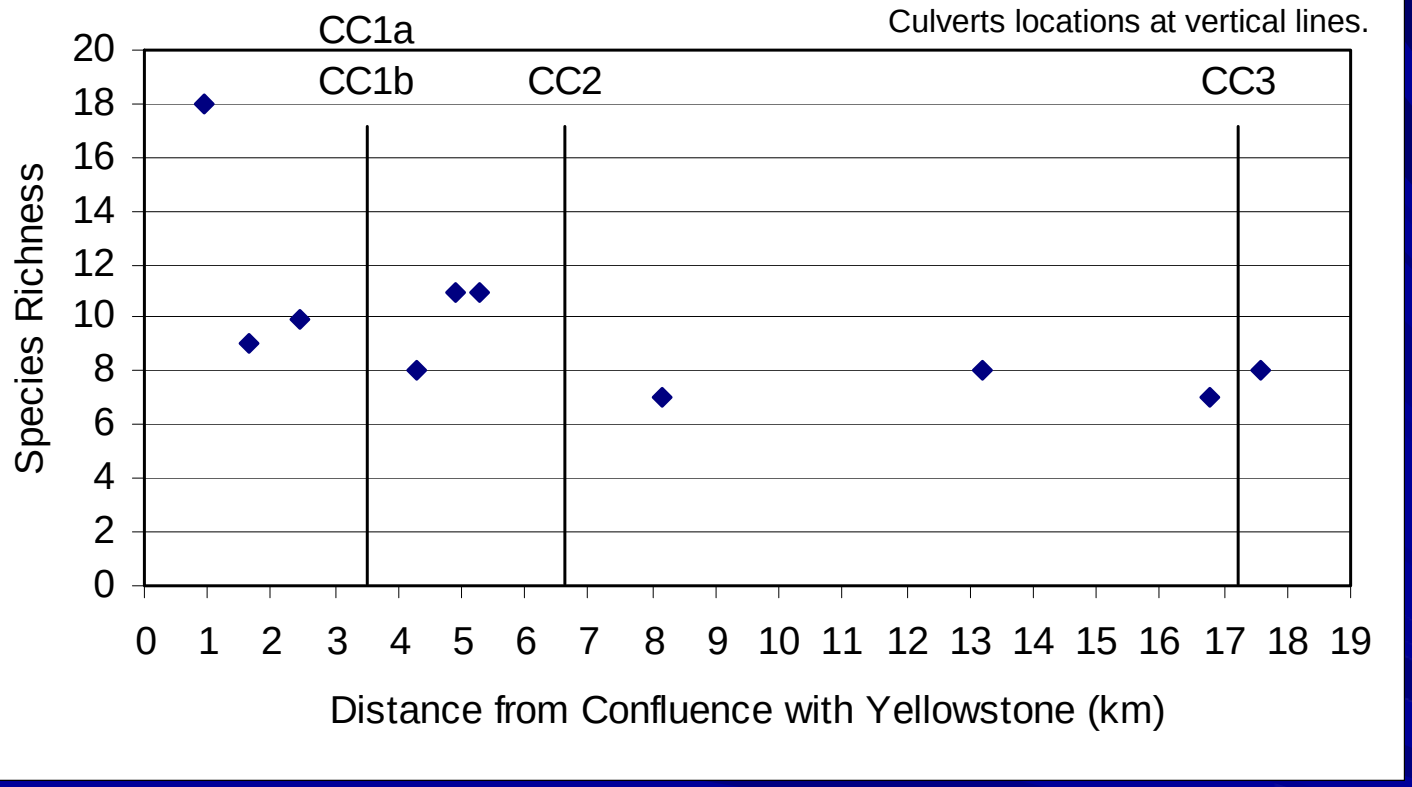
Species and Abundance



Species and Abundance



Species and Abundance

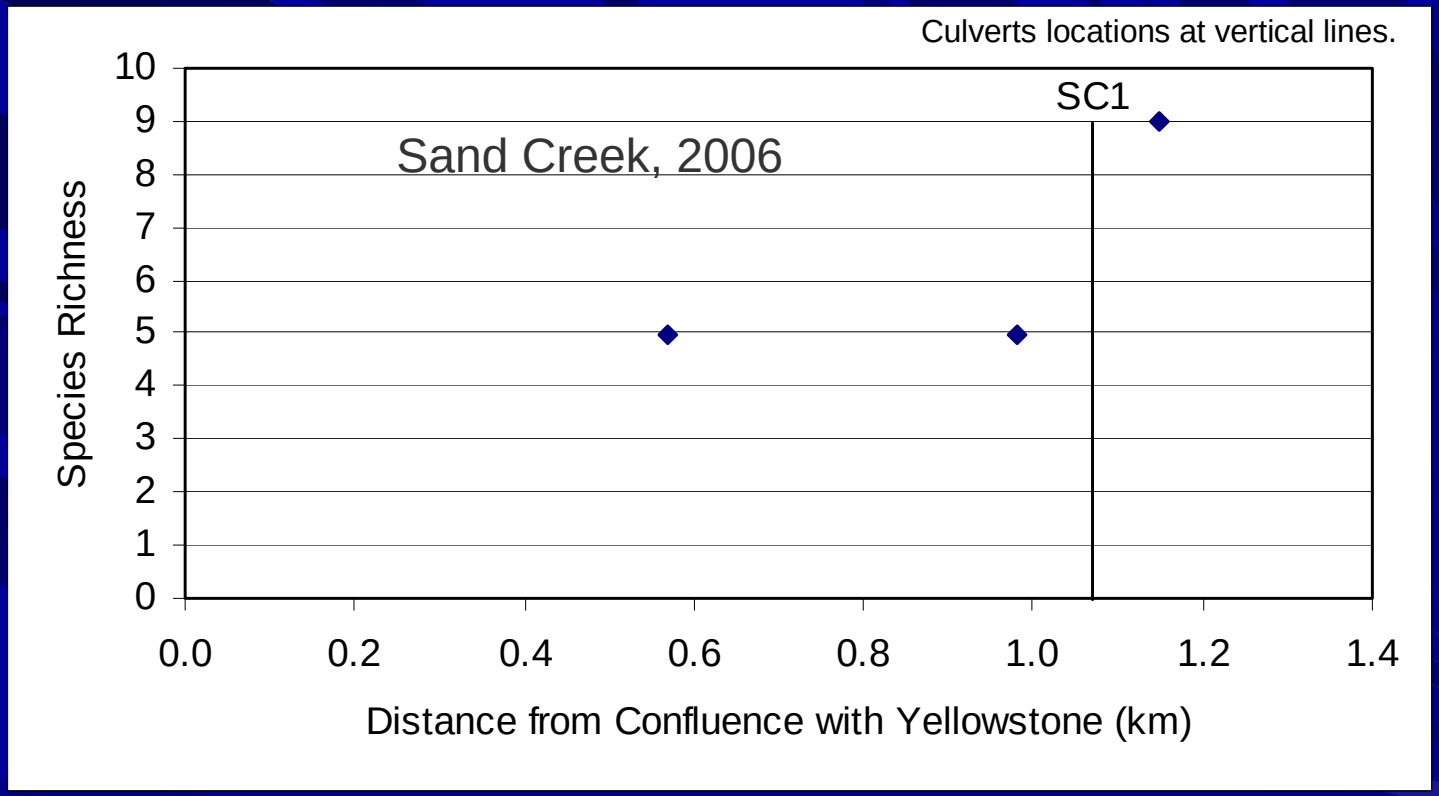


Clear Creek

2006

Species	CC1a and CC1b	CC2	CC3
Creek chub	no difference	no difference	no difference
White sucker	no difference	no difference	no difference
Longnose dace	**higher upstream**	no difference	no difference
Fathead minnow	no difference	**lower upstream**	no difference
Sand shiner	no difference	**lower upstream**	no difference

Species and Abundance

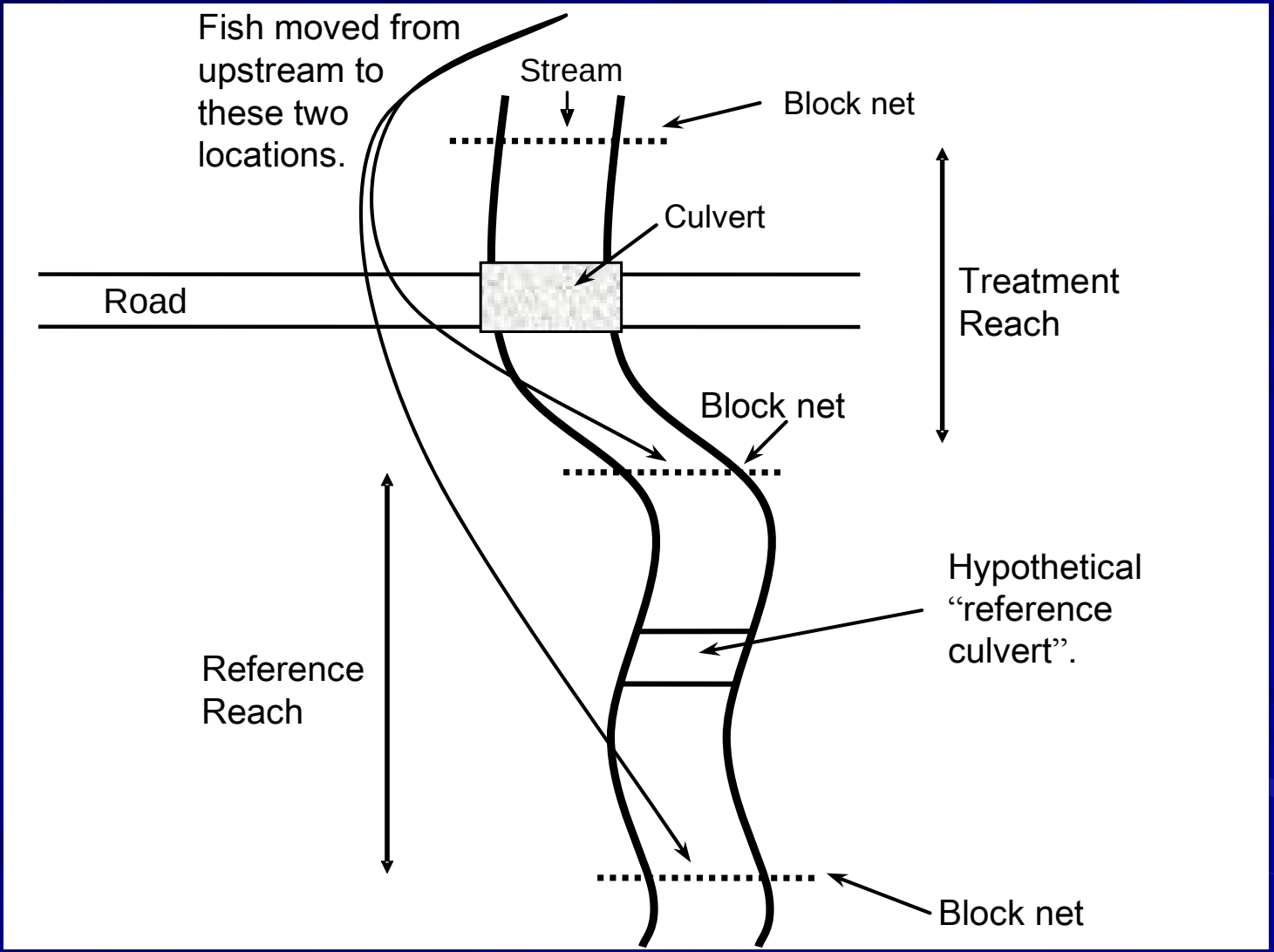


Direct Assessment of Fish Passage

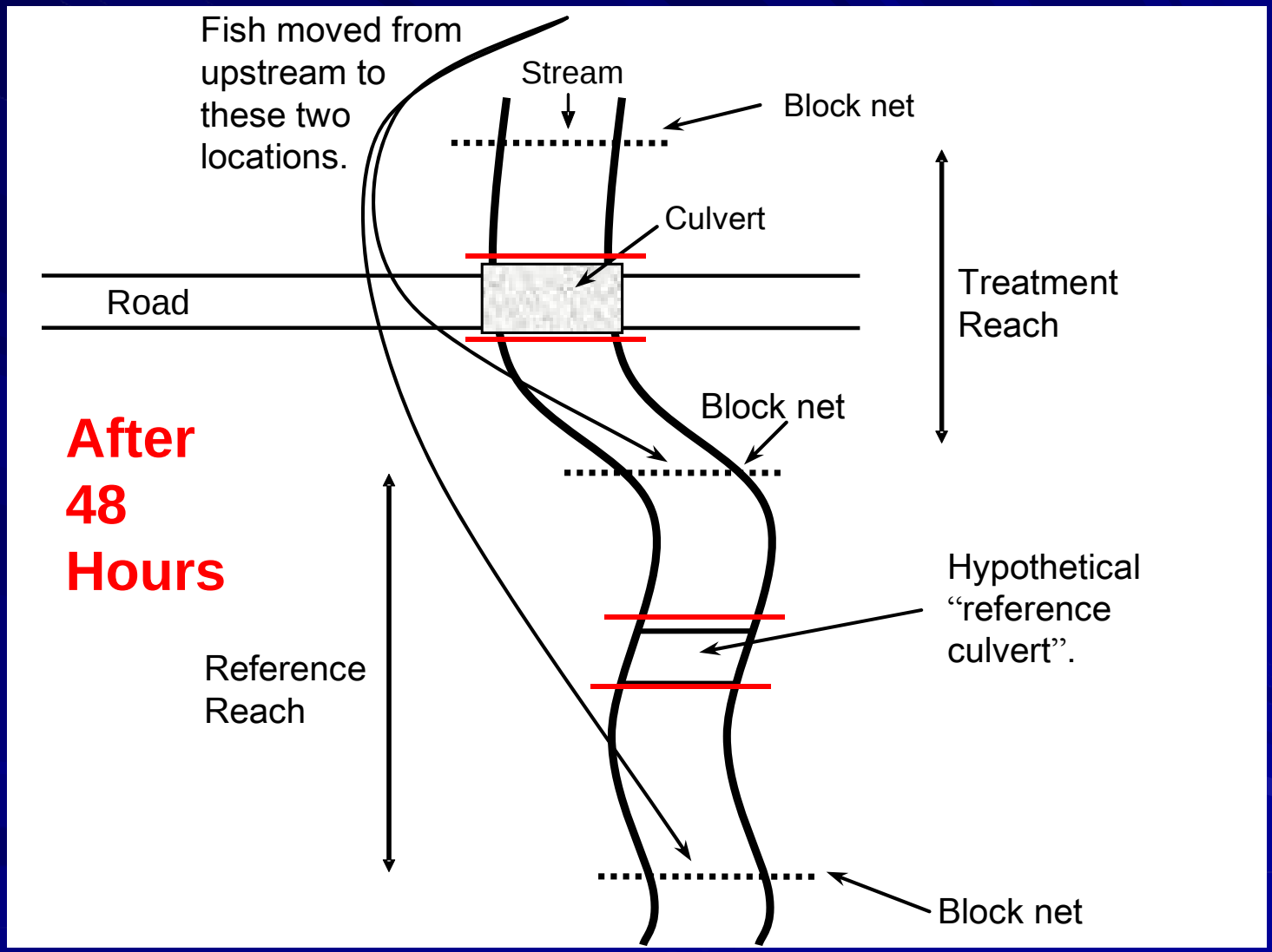
VIE Tag

- Used the dominant species collected
- Marked fish with visible implant elastomer (VIE) tags

Direct Assessment of Fish Passage



Direct Assessment of Fish Passage

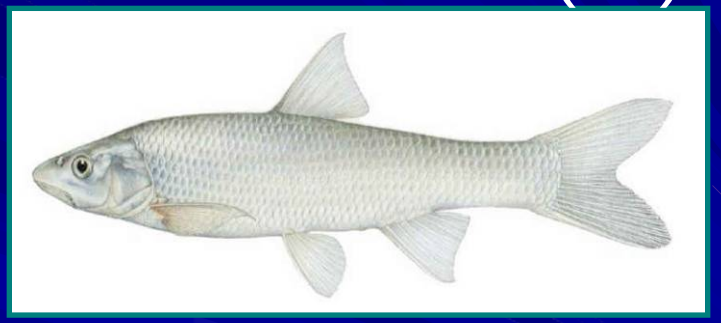


Direct Assessment of Fish Passage

- (5 crossings) x (2 experiments) = 10 experiments
- Flows ranged from 0.02 cms to 0.45 cms
- Marked ~1100 fish, four species:

Creek chub (620)

Flathead chub (63)



Longnose dace (164)

White sucker (200)

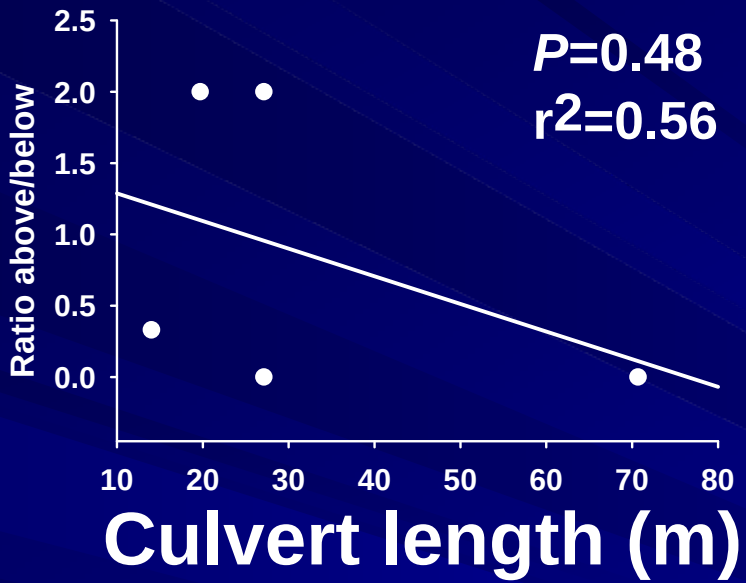
Direct Assessment of Fish Passage

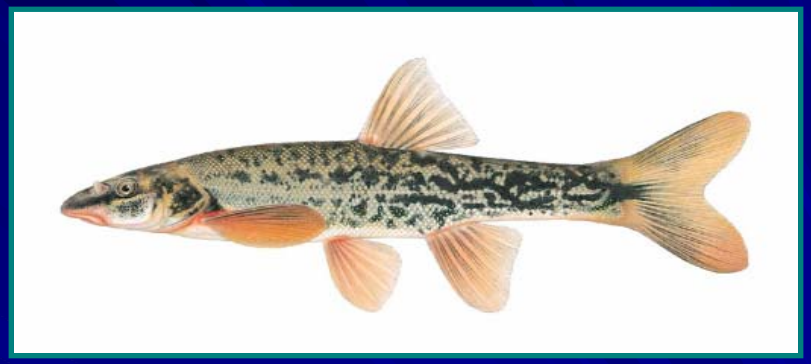
"Odds Ratio"

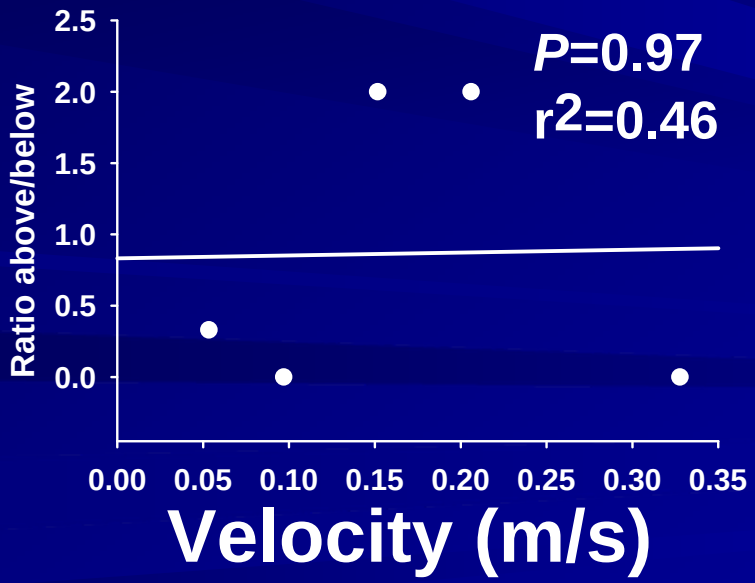
Species	OR	95% CI	
Creek chub	1.52	0.97 - 2.38	
White sucker	9.25	2.94 - 29.08	
Longnose dace	0.28	0.08 - 0.98	*P = 0.04
Flathead chub	3.00	0.49 - 18.25	
All species	1.81	1.27 - 2.59	

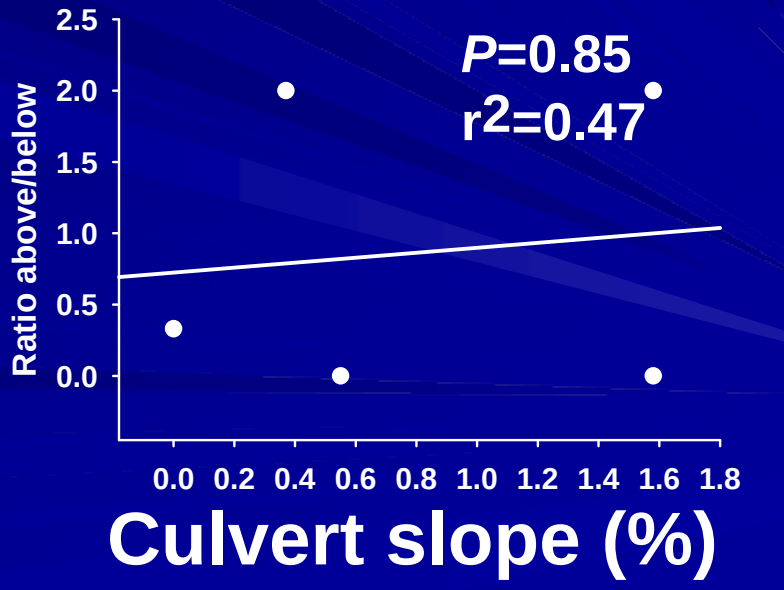
Fish were 1.81 times as likely to pass through a culvert than through the corresponding reference stream reach.

Direct Assessment of Fish Passage







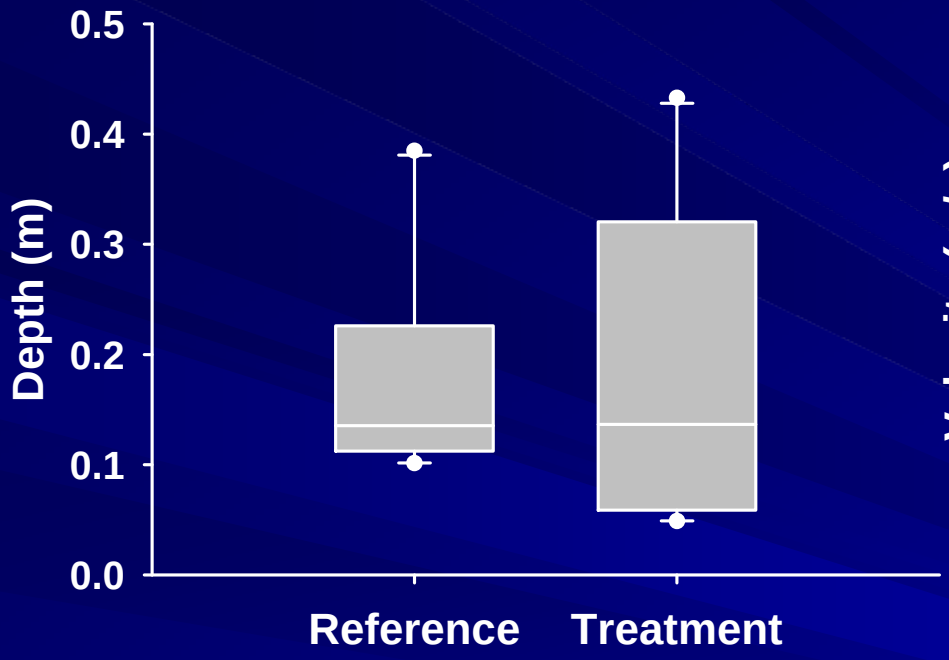


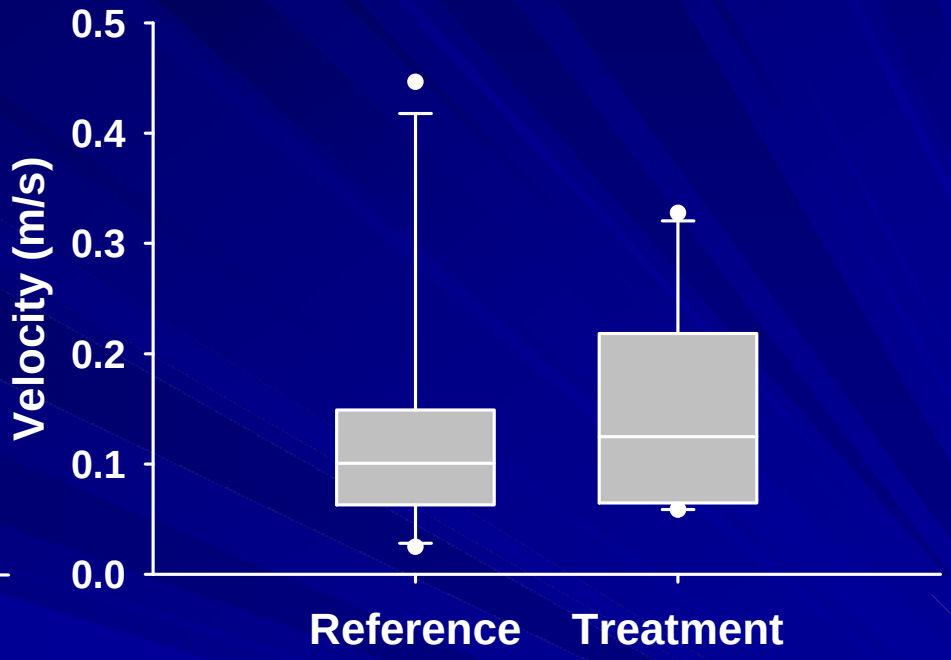
Direct Assessment of Fish Passage

Species	Total length (mm)	Chi-square value	Odds ratio	95% CI	P-value
Creek chub	≤ 80	0.09	1.10	0.59 to 2.05	0.76
Creek chub	> 80	4.92	2.10	1.09 to 4.05	0.03
White sucker	≤ 80	--.--	1.61	0.23 to 1.09	1.00
White sucker	> 80	18.50	18.12	3.78 to 86.91	< 0.0001

Small creek chub were not more restricted in passing culverts than large creek chub. Same holds for white sucker.

Direct Assessment of Fish Passage





Culverts had a lot of habitat similarities with the stream reference reaches.

Direct Assessment of Fish Passage

Crossing	Reach	Segment measurements: Mean thalweg depth (cm)	Segment measurements: Mean wetted width (m)	Culvert measurements: Mean water depth (cm)	Culvert measurements: Mean water velocity (m/s)
CC1a	Reference	29.4 (0.05)	3.2 (0.5)	11.8 (0.01)*	0.12 (0.02)
	Treatment	23.6 (0.04)	2.5 (0.6)	9.2 (0.01)	0.12 (0.02)
CC1b	Reference	30.5 (0.03)	1.5 (0.08)	28.5 (0.02)	0.07 (0.01)
	Treatment	27.0 (0.03)	2.1 (0.2)*	29.9 (0.03)	0.06 (0.01)
CC2	Reference	41.9 (0.08)*	3.3 (0.3)	15.0 (0.01)*	0.09 (0.01)
	Treatment	18.3 (0.04)	5.0 (0.04)*	5.0 (0.01)	0.14 (0.02)
CC3	Reference	30.8 (0.02)	3.5 (0.5)	11.8 (0.01)	0.08 (0.01)
	Treatment	49.4 (0.04)	9.2 (0.5)*	11.1 (0.01)	0.16 (0.03)
SC1	Reference	31.9 (0.05)	2.1 (0.2)	22.4 (0.02)	0.30 (0.03)
	Treatment	57.1 (0.07)*	3.3 (0.3)*	31.9 (0.03)*	0.27 (0.04)

Culverts had a lot of habitat similarities with the stream reference reaches.

Direct Assessment of Fish Passage

There are limitations of the experiment:

- Snapshot in time (flow)
- Problems with high flows

Blending FishXing with Direct Assessment

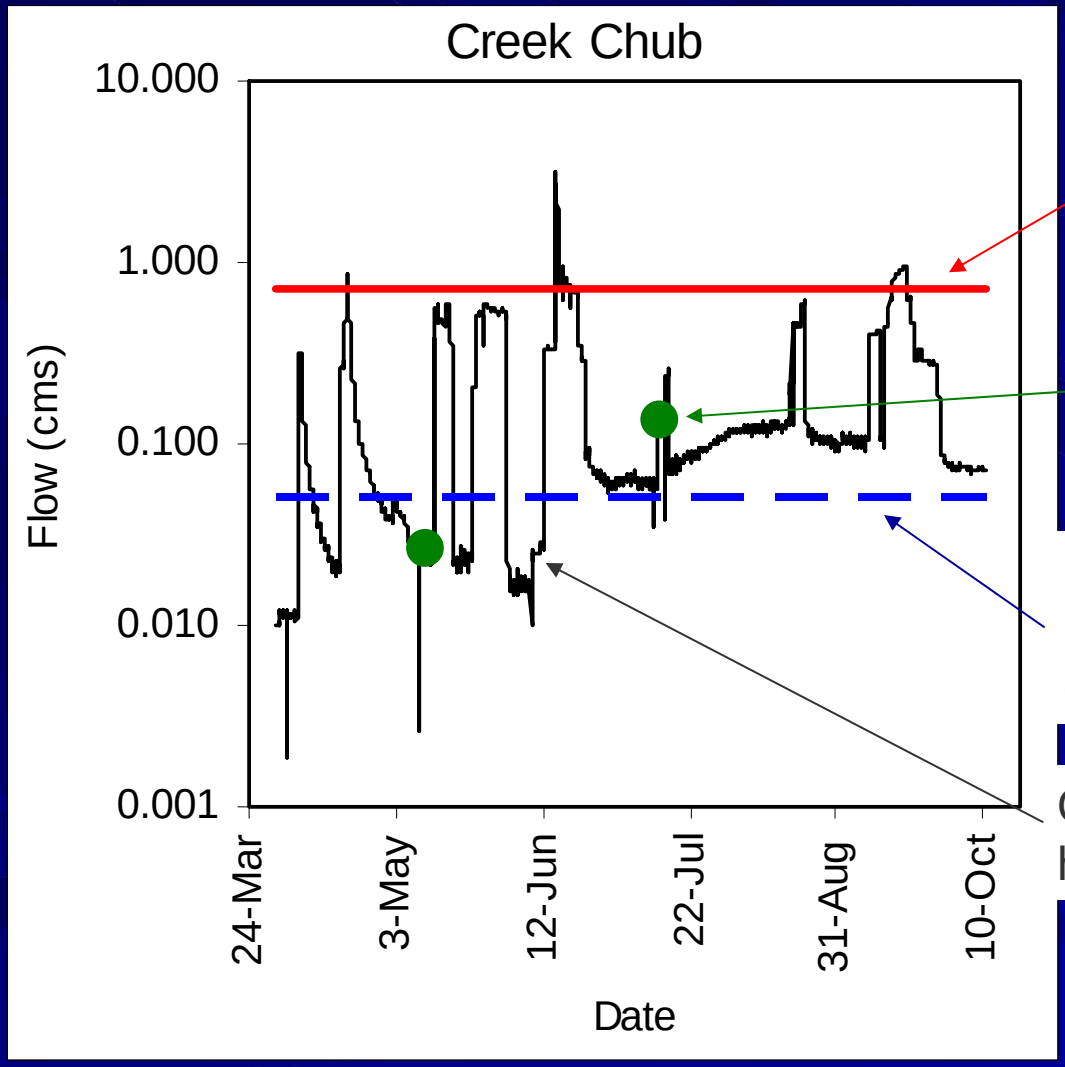
Physical and Hydraulic Data

+

Swimming and Leaping Ability

"Passage Windows"

Blending FishXing with Direct Assessment



Highest flow where FishXing labels culvert non-barrier.

Flow and date where fish observed to pass culvert in field trials.

Lowest flow where FishXing labels culvert non-barrier.

Observed hydrograph.

Flow and date where fish observed to NOT pass culvert in field trials.

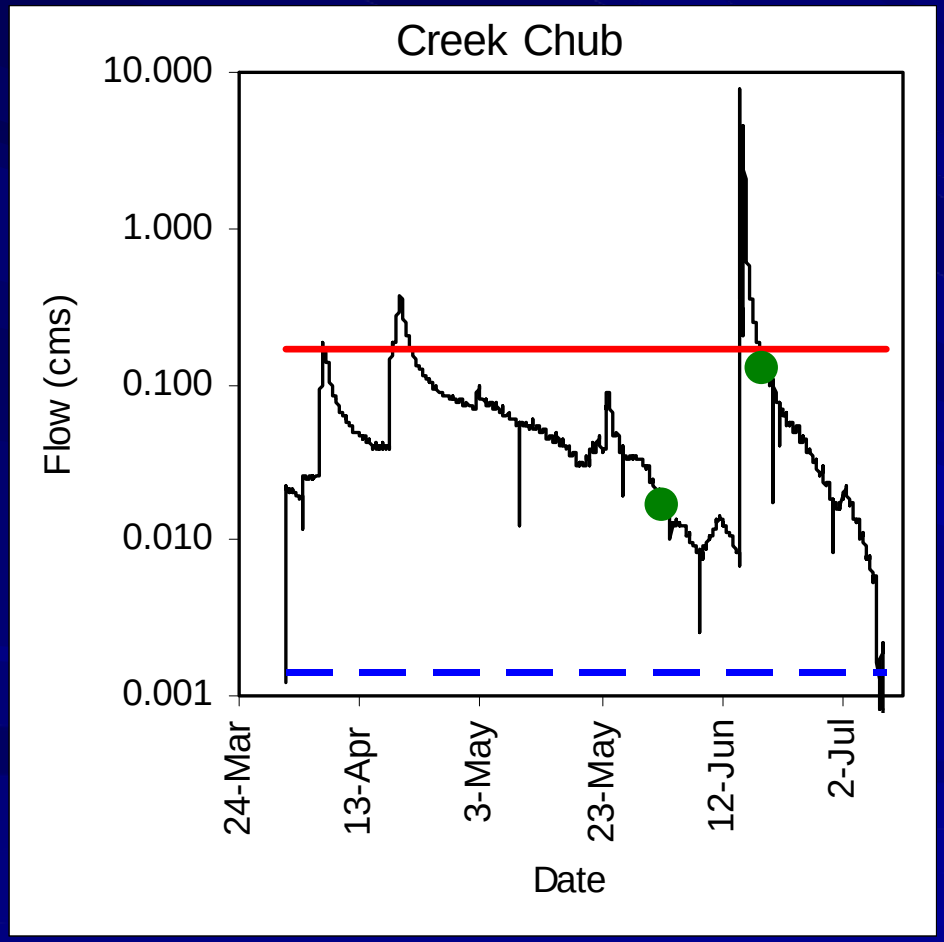
No horizontal lines – FishXing says always a barrier.

Passage Windows

There are 6 possible combinations of the outcomes of field trials and the outcomes of FishXing models. In the following examples, these are labeled a) through f).

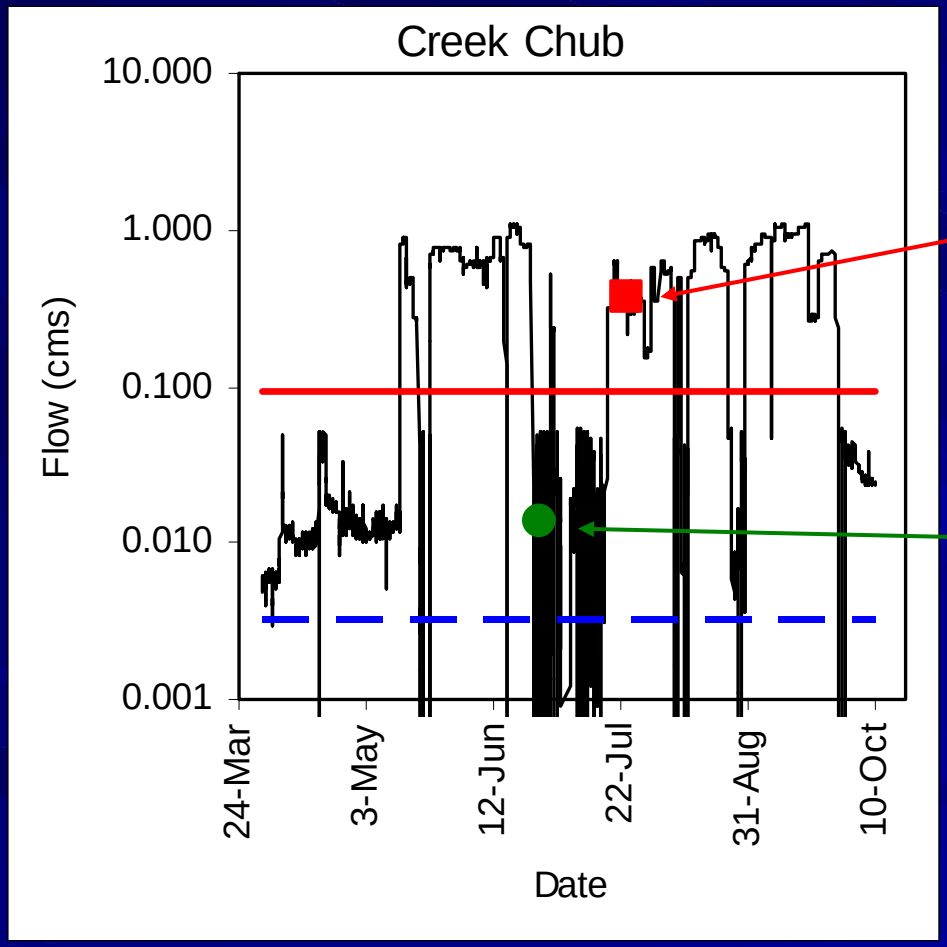
Passage Windows

a) FishXing indicated that a passage window exists and fish are observed to pass the culvert at flows in that window



Passage Windows

b) FishXing indicated that a passage window exists and fish are observed to not pass the culvert at flows outside that window

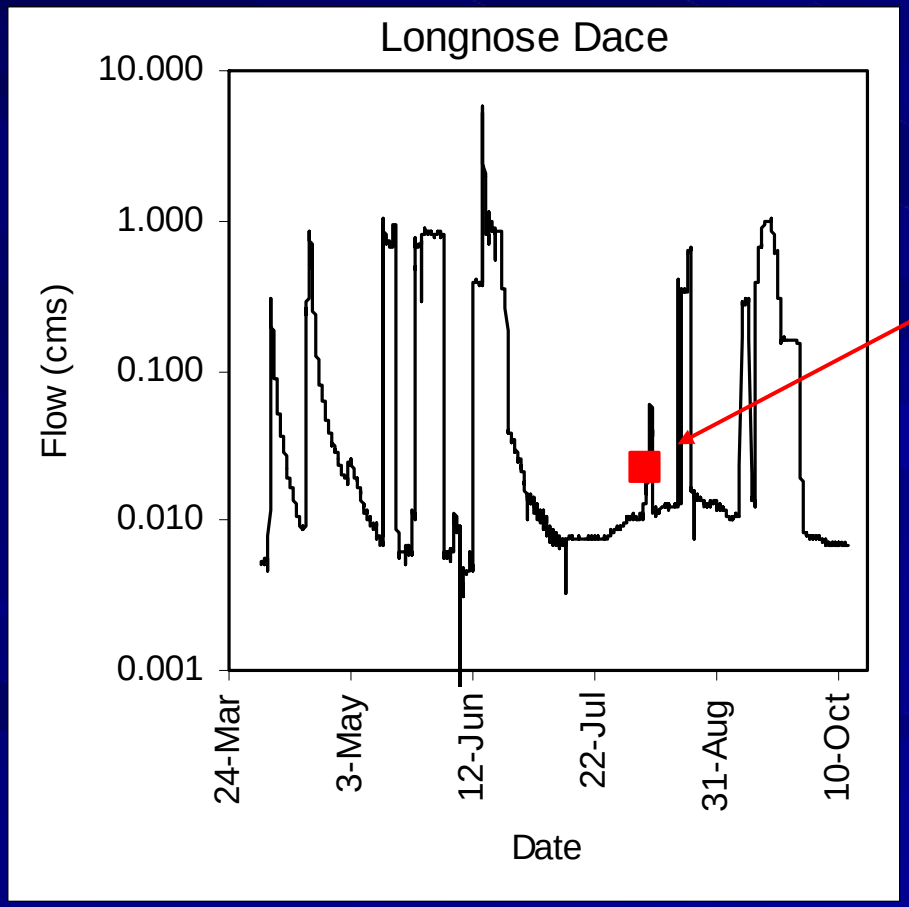


Here is an example of case b).

There's also a case a) here.

Passage Windows

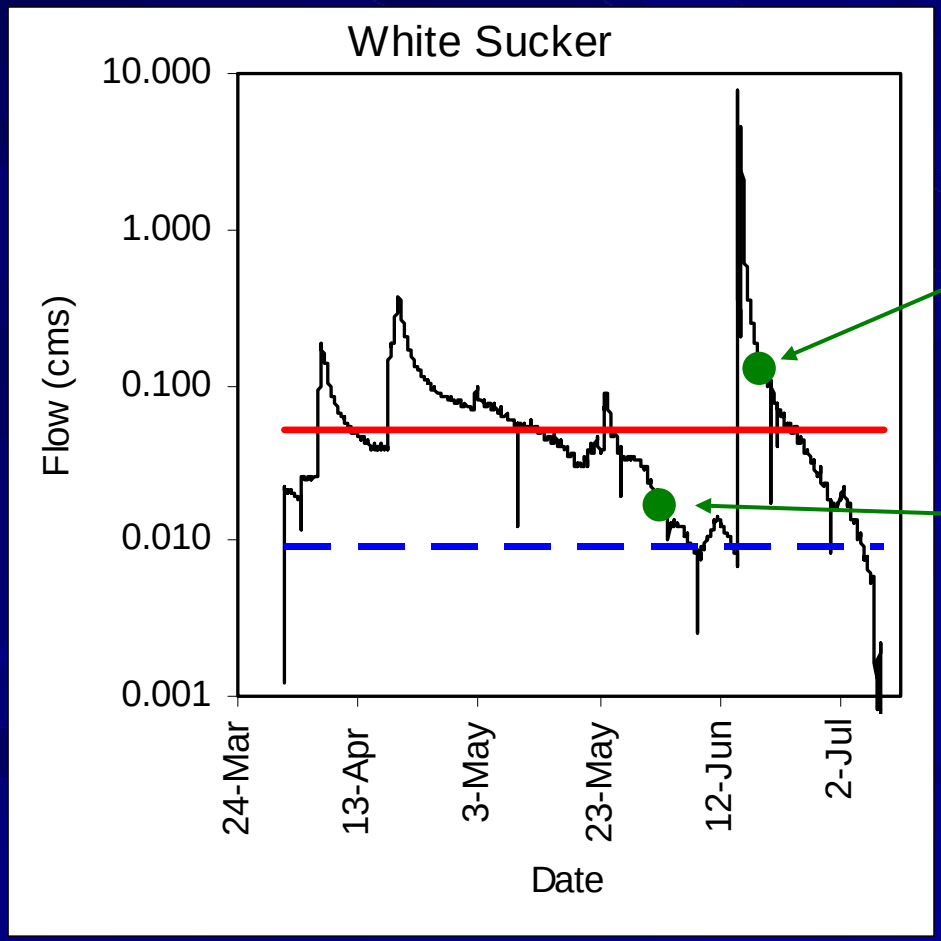
c) FishXing indicated that the culvert is not passable (no passage windows) and fish are observed to not pass the culvert during any field trials



No window and fish observed to not pass culvert, an example of case c)

Passage Windows

d) FishXing indicated that a passage window exists and fish are observed to pass the culvert at flows that are outside the window

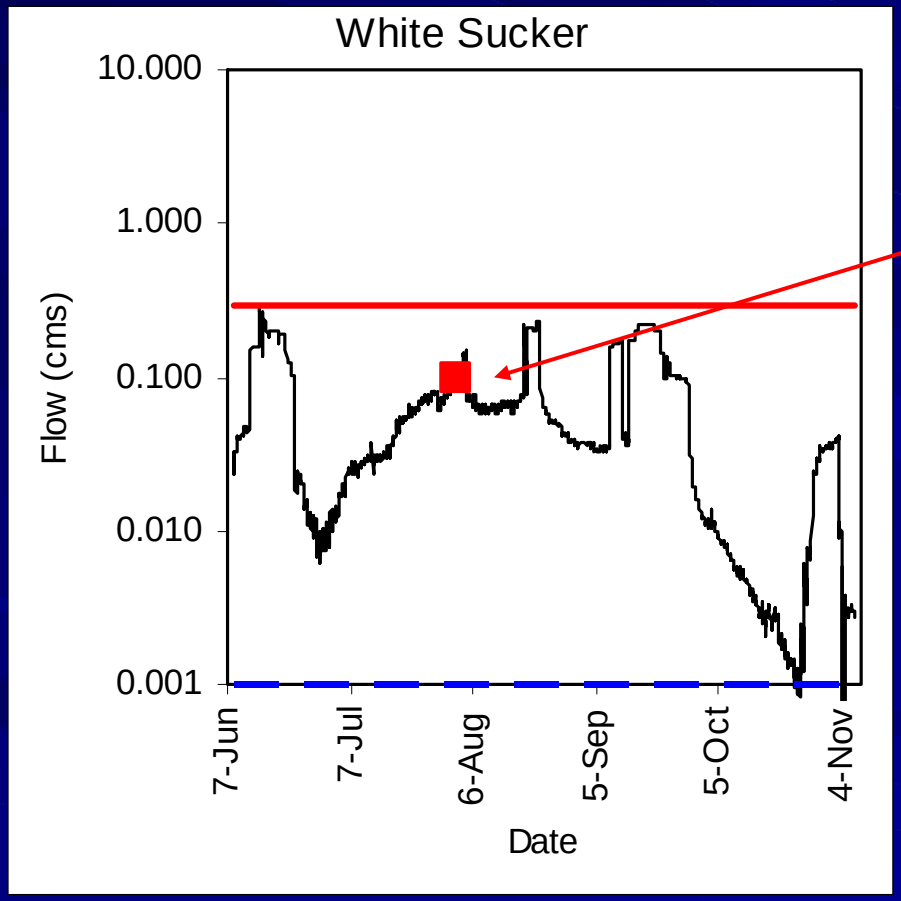


Here is an example of case d).

There's also a case a) here.

Passage Windows

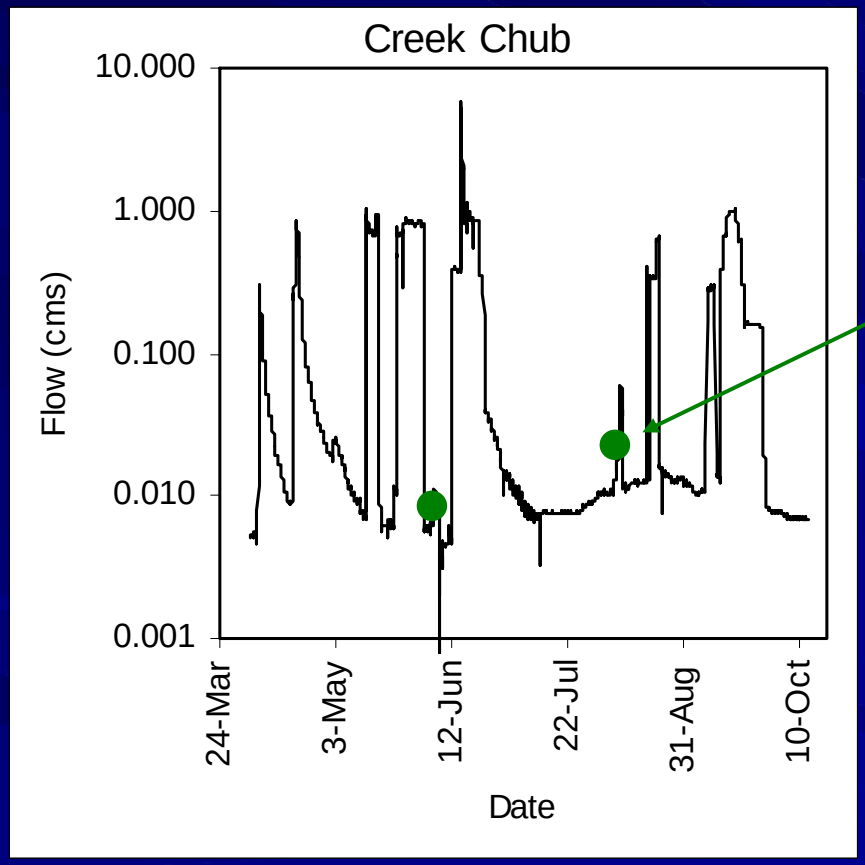
e) FishXing indicated that a passage window exists, but at flows within the passage window fish are observed to not pass through the culvert during field trials



Passage window predicted by FishXing, but fish observed to not pass culvert, an example of case e)

Passage Windows

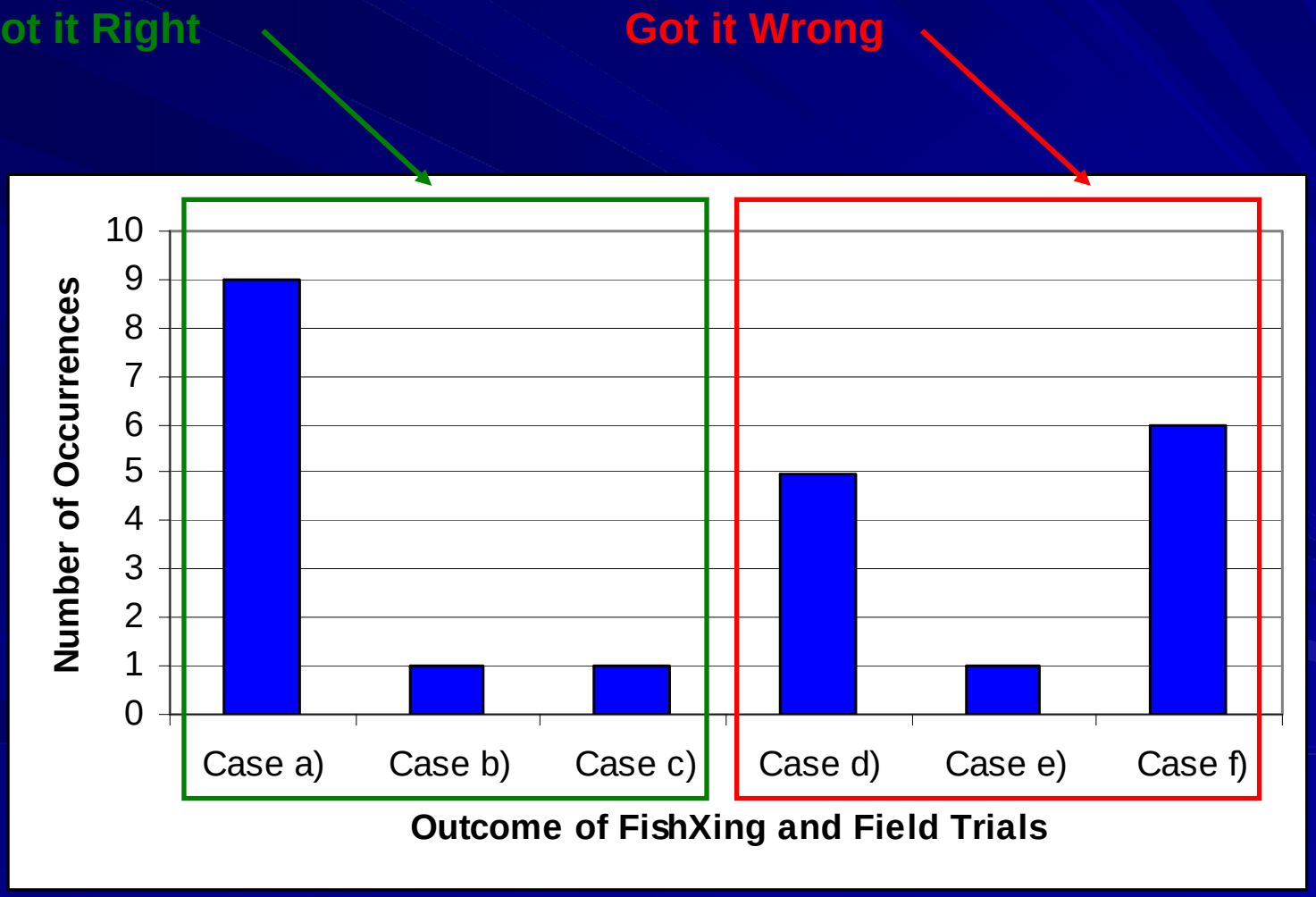
f) FishXing indicated that the culvert is not passable (no passage windows) and fish are observed to pass the culvert during field trials



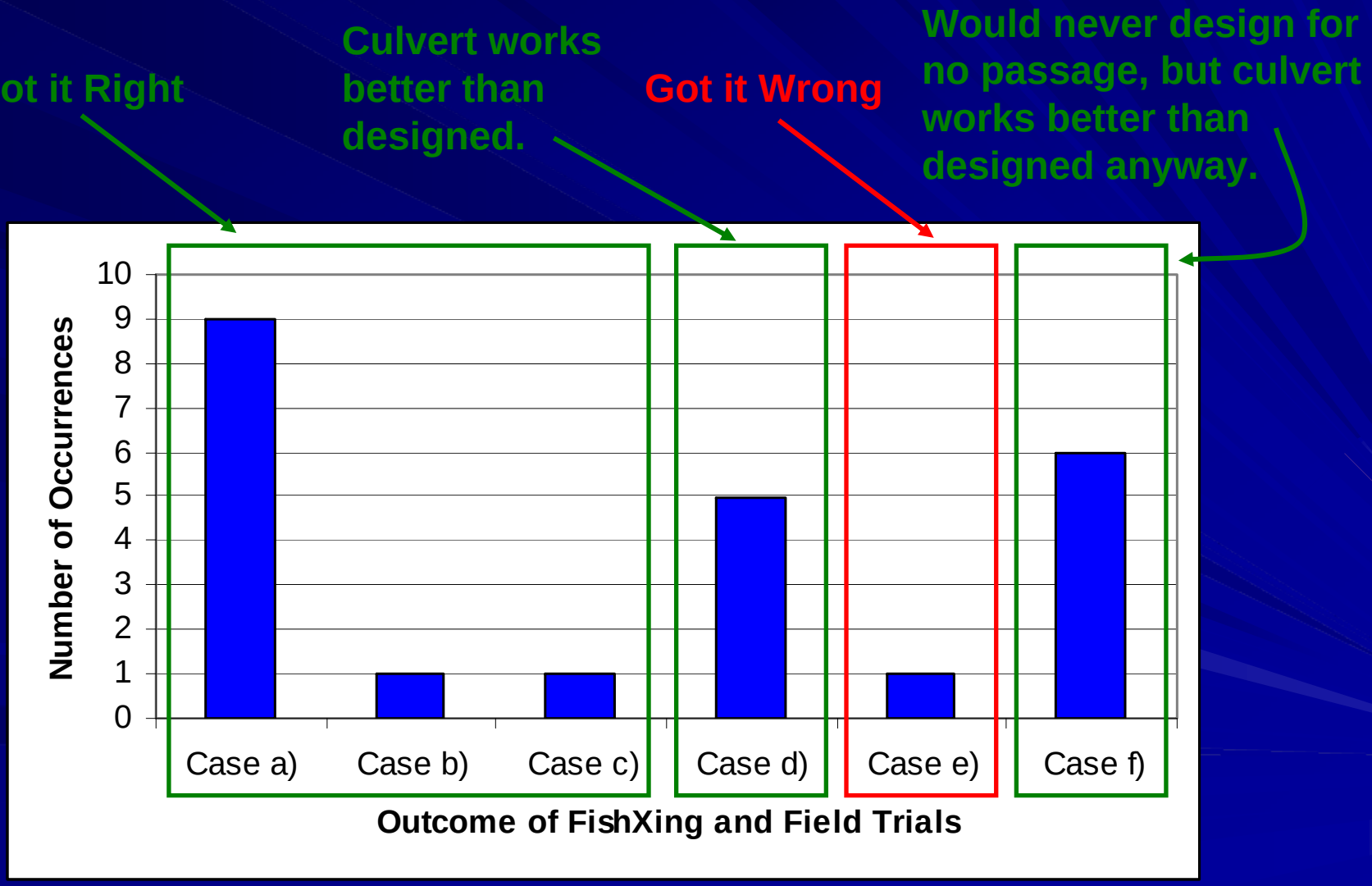
No passage window predicted by FishXing, and fish were observed to pass culvert.

Two examples of case f) shown here.

Using FishXing for Analyzing an Existing Culvert



Using FishXing for Designing a New Existing Culvert



Final Thoughts

1. Very diverse fisheries with good distribution of fish species in the systems.
2. Most of the more abundant species were fairly mobile, even through culverts. Possible exception is longnose dace?
3. FishXing good design tool and good for pointing out existing non-problem culverts. Not so good for pointing out problem culverts.

Acknowledgements

Technicians

- Ty Harrison
- Stephen Searles

MDT Contact

- Larry Sickerson

MT FWP Contacts

- Brad Schmitz
- Bill Wiedenheft

Questions?