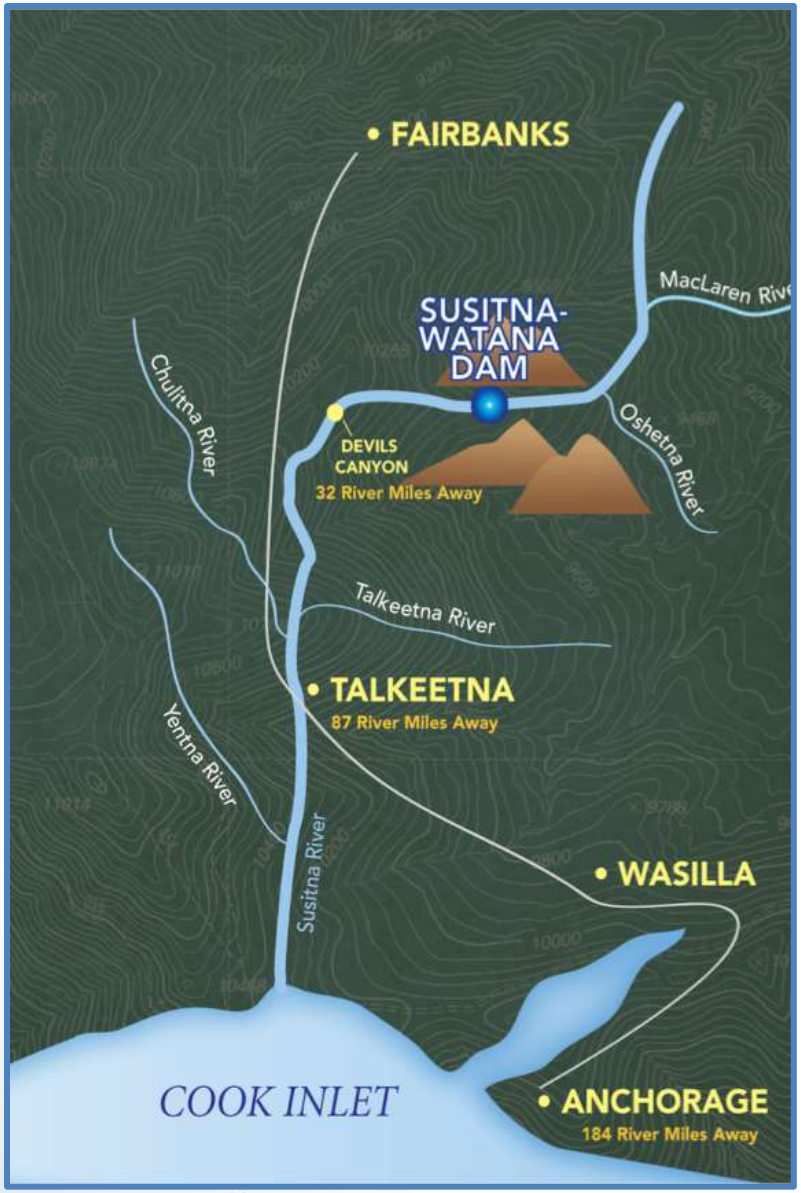

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Fisheries Technical Meeting

Study 9.12 Fish Passage Barriers

March 19, 2014

Prepared by
R2 Resource Consultants, Inc. & Tetra Tech, Inc.

Fish Passage Barrier Assessment Topics

- Target/priority fish species selection (Study 9.12; FSP Section 9.12.4.1)
- Species-specific passage criteria (depth, velocity and leaping ability) for individual fish species (Study 9.12; FSP, 9.12.4.2)
- Application of passage criteria in Focus Areas to evaluate current limits of fish habitat access and potential changes with Project conditions (Study 9.12; FSP Section 9.12.4.5 - 9.12.4.7)
- Geomorphological assessment and modeling in support of barrier assessment (Studies 6.5 and 6.6).
- Selection of tributaries to be studied within the Upper and Middle River segments (Study 9.12; FSP Section 9.12.4.3)

9.12 Fish Passage Barriers – Objectives

- *Locate and categorize existing barriers in selected Middle and Upper River tributaries*
- *Evaluate potential changes to existing barriers within the influence of the Project*
- *Evaluate potential Project-induced creation of barriers*

Susitna Fish Species
Arctic grayling
Dolly Varden
Humpback whitefish
Round whitefish
Burbot
Longnose sucker
Sculpin
Eulachon
Bering cisco
Threespine stickleback
Arctic lamprey
Chinook salmon
Coho salmon
Chum salmon
Pink salmon
Sockeye salmon
Rainbow trout
Northern pike
Lake trout

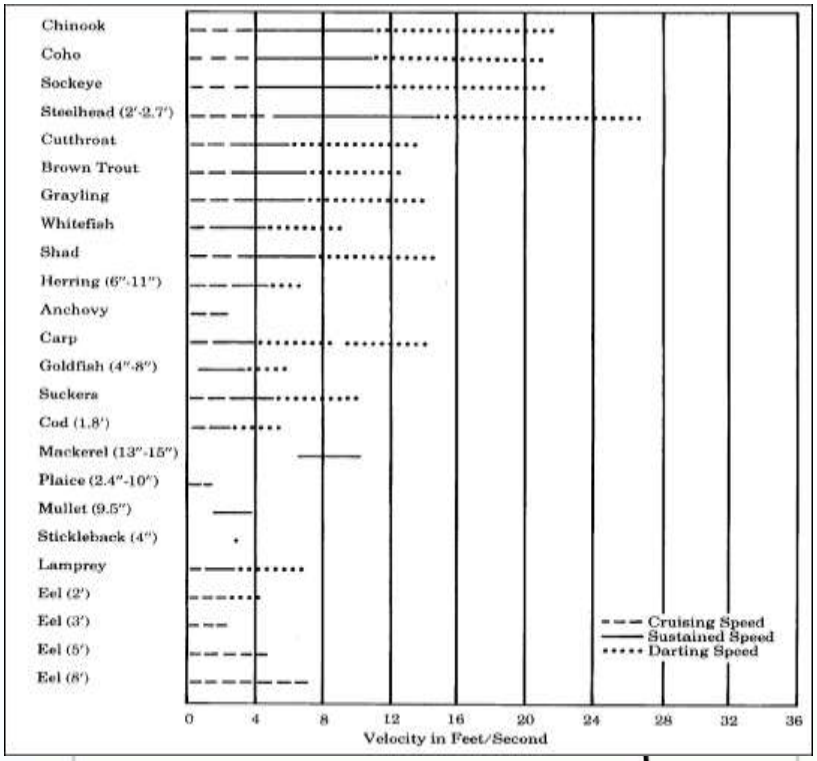
Target Species Selection

- 9.12 Study Plan - select same species or a sub-set of those selected for IFS Study 8.5
- Apply same 3 criteria for target fish species selection from Study 9.11 (Fish Passage Feasibility Study):
  - ***Exhibits migratory and/or anadromous behavior*** most significant for species for which migration is necessary to complete its life cycle.
  - ***High relative abundance***
  - ***Important to commercial, sport, or subsistence fisheries***

Proposed Fish Passage Species List

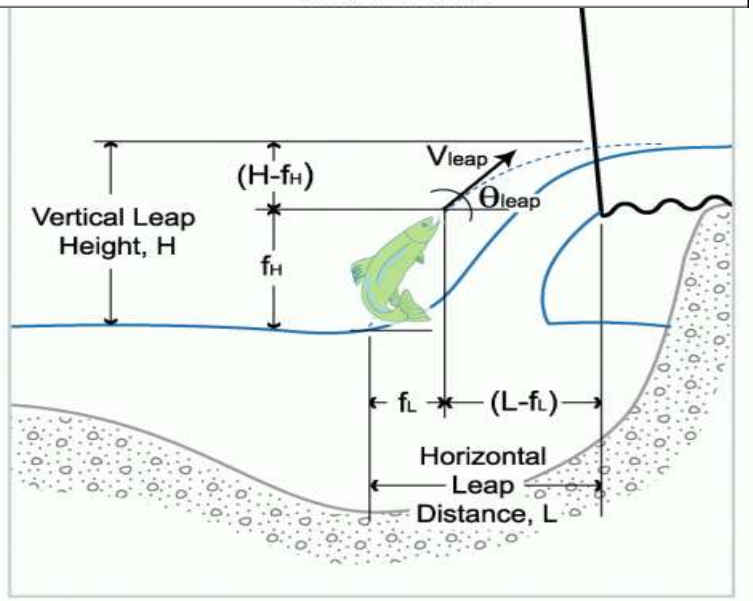
Susitna Fish Species
Arctic grayling
Dolly Varden
Humpback whitefish
Round whitefish
Burbot
Longnose sucker
Sculpin
Eulachon
Bering cisco
Threespine stickleback
Arctic lamprey
Chinook salmon
Coho salmon
Chum salmon
Pink salmon
Sockeye salmon
Rainbow trout
Northern pike
Lake trout

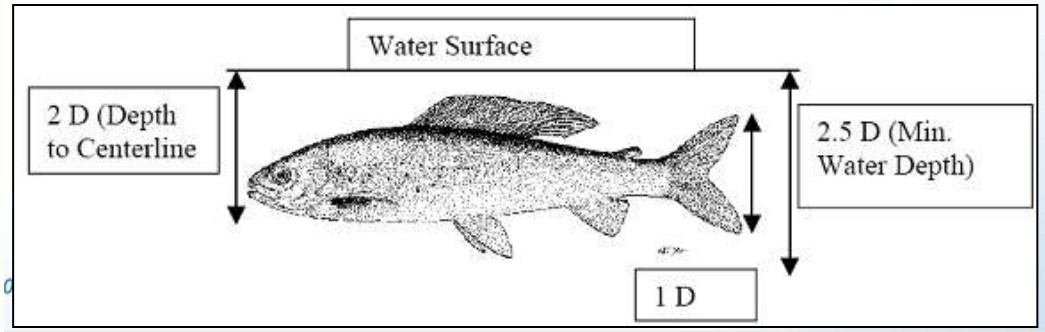
Arctic grayling
Dolly Varden
Burbot
Chinook salmon
Coho salmon
Chum salmon
Pink salmon
Sockeye salmon
Rainbow trout



Passage Criteria for Identified Fish Species

- Upstream ***Velocity*** Criteria
- ***Leaping*** Criteria for Adult Upstream Migration
- ***Depth*** Criteria for *Upstream* Adult Migration and *Downstream* juvenile and resident seasonal movement





Velocity Criteria

Category	Period	Definitions
Sustained speed	> 200min	Maintained indefinitely w/o fatigue, purely aerobic
Prolonged speed	20s to 200min	Short periods of travel at high speeds, aerobic to anaerobic
Burst speed	< 20s	Max swimming speed or jumping, inducing fatigue, anaerobic

U_{crit} (critical swimming speed) max swimming speed a fish can maintain for a period of time (e.g. 10min, 20min, …) under laboratory conditions. Top end of prolonged speed/aerobic range. Useful for understanding fish passage through culverts

- **Prolonged** swimming and **U_{crit}** indicative of fish ability to travel long distances upstream and how fish condition may change in upper reaches of Susitna
- **Burst** swimming speed useful to understand fish movement across discrete rapids/riffles or high velocity areas

Fish Swimming Performance

COMMON NAME		PROLONGED SPEED		BURST SPEED	
		ft/s	References	ft/s	References
Arctic grayling	*adult*	1.4 - 4.1	Katapodis (1992)	6.9 - 13.9	Bell (1991)
	juvenile	0.5 - 0.8	Deegan et al. (2005)	NA	
Dolly Varden	*adult*	2.0 - 3.3	Jones et al. (1974), Beamish (1980)	3.6 - 4.4	Beamish 1980
	juvenile	0.5-1.6*	Mesa (2004) *for Bull Trout*	NA	
Chinook salmon	*adult*	2.9 - 11.0	Bell (1991)	11.0 - 22.1	Bell (1991)
	juvenile	0.5 - 0.9	Furniss et al. (2008)	2.0 - 2.3	Randall et al. (1987)
Coho salmon	*adult*	3.1 - 10.9	Lee et al. (2003)	11.7 - 21.0	Bell (1991)
	juvenile	0.4 - 2.1	Bell (1991)		
Chum salmon	*adult*	1.7 - 5.1	Aaserude/Orsborn (1986), Smith/Carpenter (1987)	6.0 - 12.6	Powers and Orsborn 1985
	juvenile	0.4 - 0.6	Smith and Carpenter (1987)	NA	
Pink salmon	*adult*	2.9 - 11.0	Lee et al. (2003), Bell (1991)	11.0 – 21.0	Bell (1991)
	juvenile	0.4 - 0.5	Smith & Carpenter 1987	7.7 – 11.0	Powers & Orsborn (1985); Hawkins & Quinn (1996)
Sockeye salmon	*adult*	4.0 – 8.8	Bell (1991)	10.0 - 21.9	Bell (1991), Bainbridge (1960)
	juvenile	1.4 - 2.1	Bell (1991)		
Rainbow trout	*adult*	2.1 - 2.6	Furniss (2008)	14.0 - 20.3	Bell (1991)
	juvenile	1.0 - 2.0	Bainbridge 1960	2.4 - 7.2	Bainbridge 1960

Velocity Criteria (cont)

- Swimming speed proportional to fish length

  Adult speed > Juvenile speed
- Gradients or channel constrictions at entrances to sloughs and side channels not sufficient to create velocity barriers for adult or juvenile fish
- Velocity barriers most likely a factor in tributaries where steep gradients create uniform, high velocity flows in chutes and waterfalls and at tributary mouths before entering the main channel *(Devils Canyon velocity not measured due to safety concerns)*
- Which swimming speed category best represents limitations for fish passage in Susitna River and its tributaries?

Criteria Suggestion - high-end prolonged speed and burst speed represent the fish speeds required to attain chutes and waterfalls in major tributaries

Hunter and Mayor (1998)
Swim Speed Equation

$$V = aL^{b}t^{-c}$$

V = swim speed of fish relative to the water
L = length of the fish
t = time to exhaustion
a,b,c = regression constants

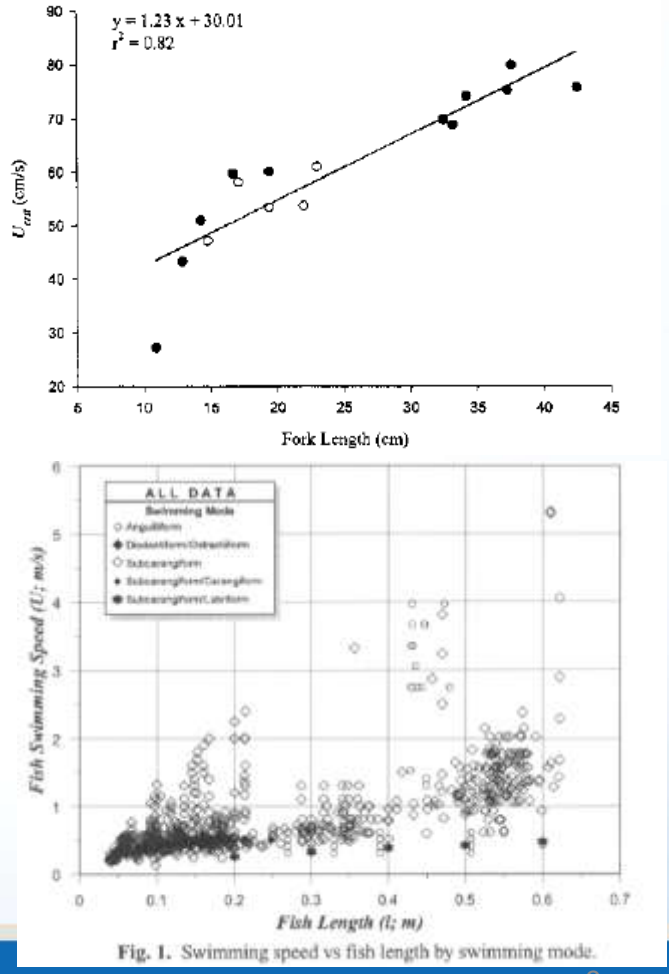
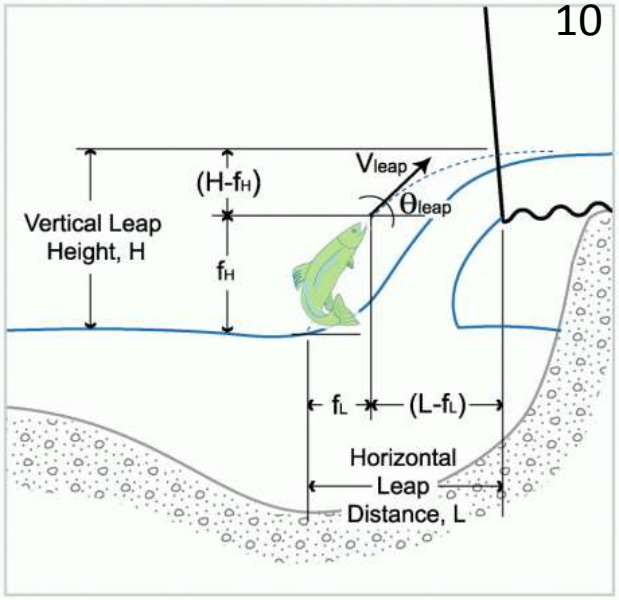


Fig. 1. Swimming speed vs fish length by swimming mode.

Leaping Criteria

- Ability of fish to pass a vertical barrier is determined by:
  - species- and life stage-specific factors such as burst speed, swimming form, and leaping capability.
  - water depth, stream flow, and barrier geometry
- Leaping curves and jumping equations assume pool depth below barrier is adequate
  - 1:1.25 barrier height/leaping pool depth (Powers Orsborn 1985)
  - Pool depth at least 2.5m (Reiser and Peacock 1985)
- Other barrier considerations – stream gradient
  - 8% sustained slope (CA Habitat Restoration Manual)
  - >20% for 30ft (OR Dept of Forestry)
  - w/o pools >12% for 30ft adult salmon
  - >20% for 160m (WA Dept F&W)



USFS Fish Xing
Leaping equations

$$H = V_{leap}(\sin\theta_{leap})\ t + \frac{1}{2} g\, t^2$$

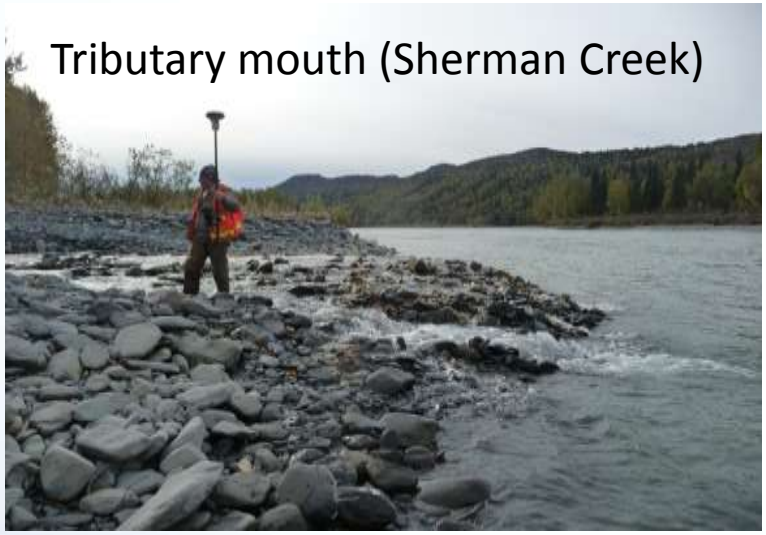
$$L = V_{leap}(\cos\theta_{leap})\ t$$

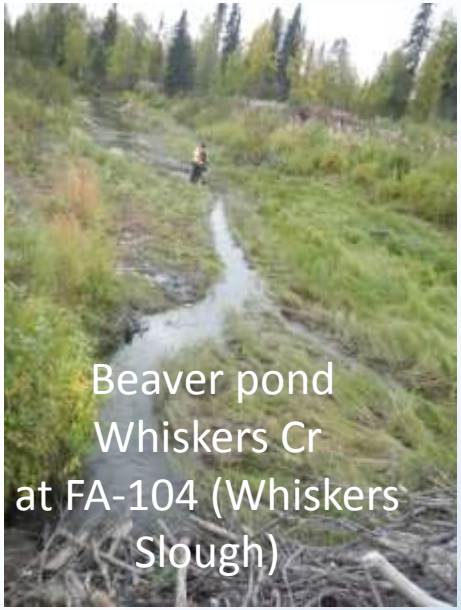
Where:
H = Vertical leap distance
L = Horizontal leap distance
Vleap = Leap velocity
θleap = Leap angle
g = Gravitational acceleration
t = Time

Leaping Criteria – literature values

COMMON NAME		LEAPING CRITERIA	
		ft	**References**
Arctic grayling	*adult*	NA	
	juvenile		
Dolly Varden	*adult*	NA	
	juvenile		
Chinook salmon	*adult*	7.5, 7.9, 11.0	Powers and Orsborn (1984), Reiser and Peacock (1985), USFS (2001)
	juvenile		
Coho salmon	*adult*	7.5, 7.3, 11.0	Powers and Orsborn (1984), Reiser and Peacock (1985), USFS (2001)
	juvenile		
Chum salmon	*adult*	3.5, 4.0, 4.0	Powers and Orsborn (1984), Reiser and Peacock (1985), USFS (2001)
	juvenile		
Pink salmon	*adult*	3.5, 4.0, 4.0	Powers and Orsborn (1984), Reiser and Peacock (1985), USFS (2001)
	juvenile		
Sockeye salmon	*adult*	7.5, 6.9, 10.0	Powers and Orsborn (1984), Reiser and Peacock (1985), USFS (2001)
	juvenile		
Rainbow trout	*adult*	NA	
	juvenile		

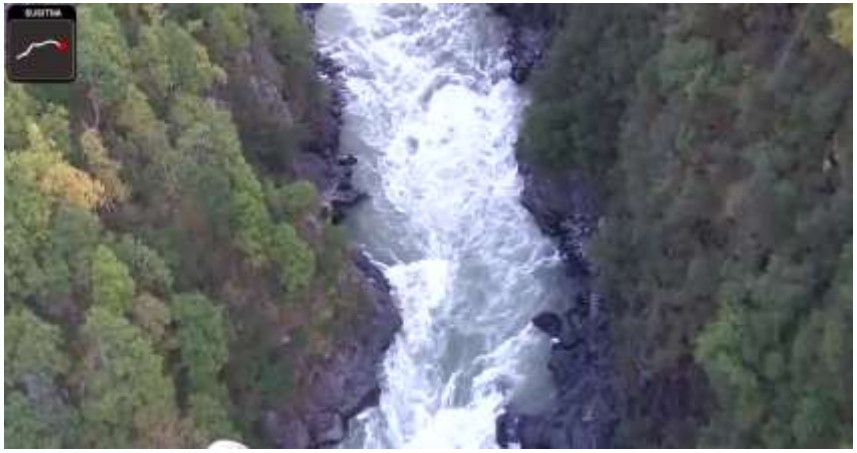
Dynamic Barriers





Velocity Barriers – Devils Canyon

passage of adult salmon addressed by Study 9.7 (Salmon Escapement)



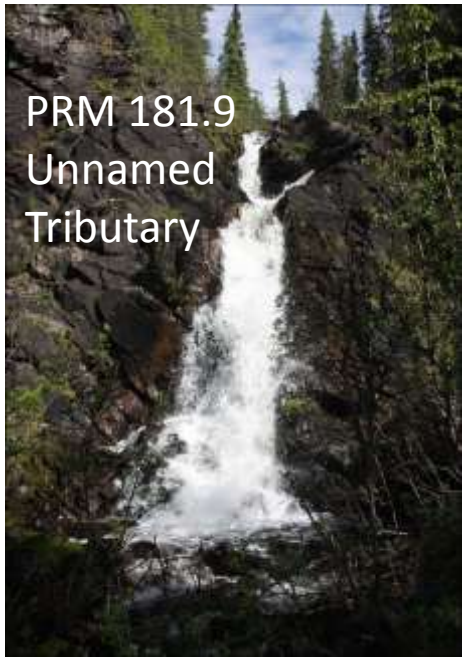
Impediment 1 (PRM 154.8) – Sept 11, 2012
11,600 cfs at Gold Creek
8,840 cfs at Tsusena

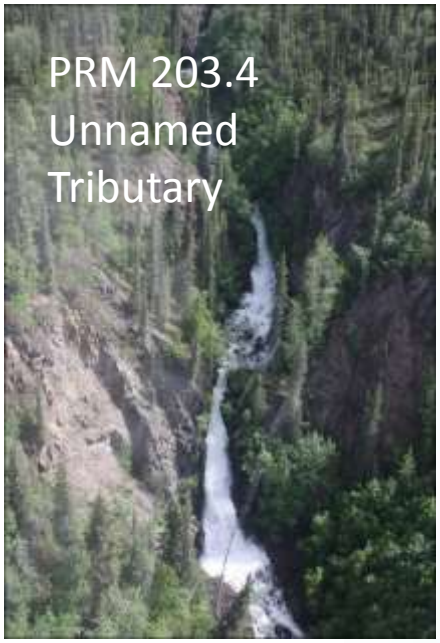
Impediment 3 (PRM 164.5) - Sept 7, 2012
16,500 cfs at Gold Creek
11,800 cfs at Tsusena

- Movement of radio tagged fish will be compared to discharge during spawning period by the Salmon Escapement Study 9.7
- *2012 results – of 313 Chinook salmon radio tagged in Middle River, four passed through impediment 3*
- *2013 results – of 449 large Chinook salmon radio tagged in Middle River, three passed through impediment 3*

Permanent Barriers

Waterfall >12ft





Depth Criteria

- Water depth required to fully submerge the fish species

- Body depth of the fish plus some additional depth to account for a number of factors that could affect passage, such as:
  - Variation in individual size, behavior, and performance;
  - Possible obstacles that must be passed like debris or sediment deposits;
  - The ability to move to some degree in a vertical plane for predator avoidance, or injury prevention (i.e., no contact with solid surfaces)

- "the minimum water depth necessary to minimize wave induced swimming forces is two and one half times the height of the caudal fin" (ADF&G and AKDT&PF 2001).

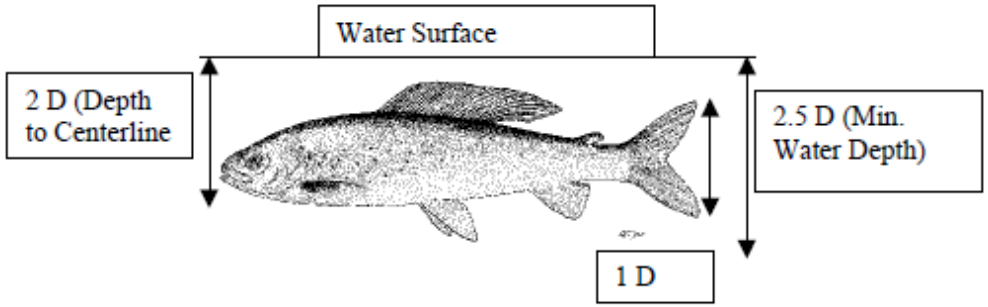


Figure A-2. Minimum water depths for fish passage (D = height of caudal fin).

Depth Criteria – literature values

COMMON NAME		DEPTH CRITERIA	
		Ft	References
Arctic grayling	*adult*	0.6	ADFG (2001)
	juvenile	0.4	ADFG (2001)
Dolly Varden	*adult*	0.2 - 1.0	ADFG (1985)
	juvenile	0.2	Bugert et al. (1991)
Chinook salmon	*adult*	0.8 - 0.9	OSGC (1963), R2 CDFG 2013
	juvenile	0.3	R2 CDFG (2013)
Coho salmon	*adult*	0.6 - 0.7	R2 CDFG (2013)
	juvenile	0.3	R2 CDFG (2013)
Chum salmon	*adult*	0.6 - 0.8	Thompson (1972), Bates et al. (2003)
	juvenile	0.3	Young, C. (2009)
Pink salmon	*adult*	0.6 - 0.8	Thompson (1972), Bates et al. (2003)
	juvenile	0.3	Nordlund, B. (2008)
Sockeye salmon	*adult*	0.6 – 0.7	Bates et al. (2003)
	juvenile	0.3	Nordlund, B. (2008)
Rainbow trout	*adult*	0.5 - 0.7	Snider (1985), R2 CDFG (2013)
	juvenile	0.3	R2 CDFG (2013)

Potential Depth Barrier

Whisker Slough Mouth
at FA-104 (Whiskers Slough)

upstream view

downstream view

July 18 2013, Susitna R at Gold Creek 16,000-20,000 cfs

Passage Criteria and Fish Abundance/Habitat Use

- Fish **abundance** and **habitat** use considerations
  - Upper River
    - Arctic Grayling (all habitats; MC,SC,BW, CWP, SS)
    - Chinook and Dolly Varden - less abundant
  - Middle River
    - Tributaries – Chinook, Coho, Chum, Pink
    - Sloughs – Chum, Sockeye, some Pink
    - Side Channel/Mainstem - limited use by Chum, Coho, Sockeye

- **Periodicity** – adult anadromous migration, and resident/juvenile migrations

- ***Leaping*** and ***Velocity*** criteria –tributary vertical barriers and mouths

- ***Depth*** Criteria – Focus Areas and Tributary Mouths
  - Upstream – adult anadromous migration
  - Downstream – anadromous juvenile and migratory resident movement between summer rearing and overwintering habitats

Study 9.5/9.6 FDA Adult and Juvenile Resident Fish Counts by Macrohabitat 2013

Macrohabitat	Dolly Varden	Burbot	Arctic grayling	Rainbow trout
	Upper River			
Black River		11	108	
Clearwater Plume		18	17	
Goose Creek			1502	
Jay Creek	137	3	42	
Kosina Creek			180	
Main Channel		58	270	
Oshetna River		16	227	
Side Channel		3	17	
Side Slough	15		29	
Tsisi Creek			198	
Unnamed Tributary 194.8	71		16	
Upland Slough		1	19	
Watana Creek	520		1008	
	Middle River Above Devils Canyon			
Backwater	1	5	110	
Chinook Creek	63			
Clearwater Plume	2	3	299	
Fog Creek	256			
Main Channel	3	13	141	
Side Channel		6	150	
Side Slough	11	13	727	
Tributary Mouth	2	4	42	
Tsusena Creek	4		74	

Macrohabitat	Dolly Varden	Burbot	Arctic grayling	Rainbow trout
	Middle River Below Devils Canyon			
Backwater	4	38	21	4
Clearwater Plume		4	33	13
Main Channel	4	52	41	24
Side Channel	7	35	16	6
Side Slough	3	39	49	22
Side Slough Beaver Complex		19	2	6
Tributary	16	37	101	141
Tributary Mouth	27	4	49	17
Upland Slough		39	1	12
Upland Slough Beaver Complex	8	82	2	26

Preliminary data, may not contain all data sources, subject to QC

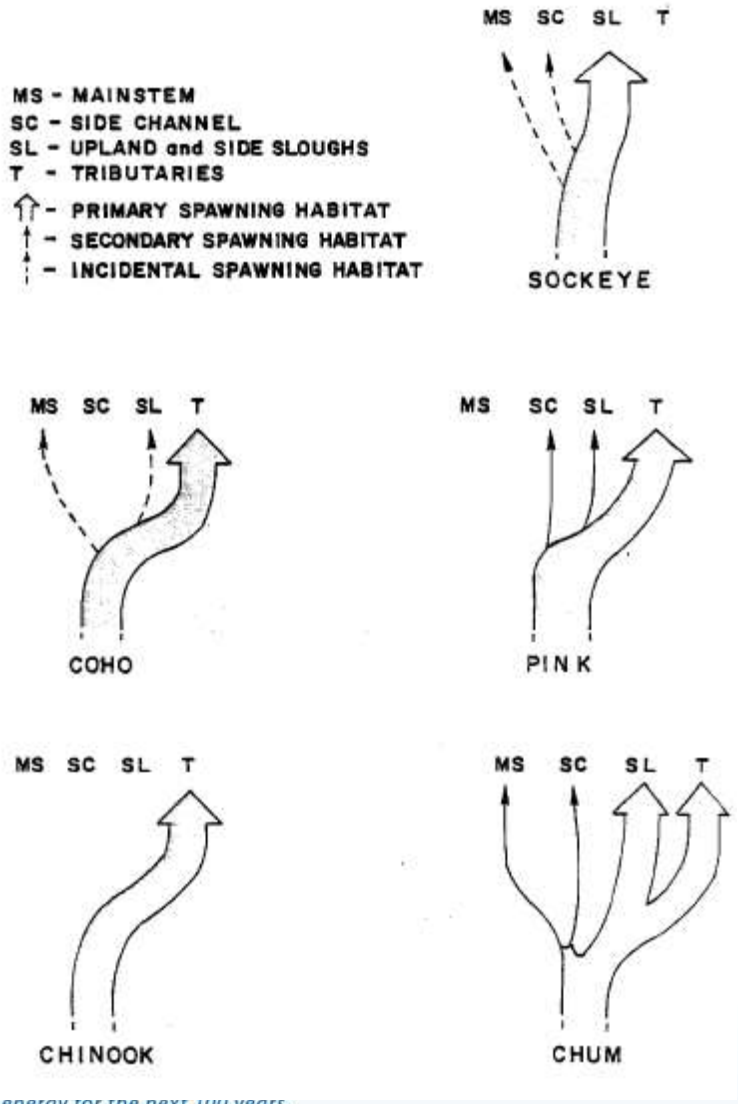
Study 9.5/9.6 FDA Juvenile Anadromous Fish Counts by Macrohabitat 2013

Macrohabitat	Chinook	Chum	Coho	Pink	Sockeye
	Upper River				
Black River	69				
Clearwater Plume					
Goose Creek					
Jay Creek					
Kosina Creek	116				
Main Channel					
Oshetna River	2				
Side Channel					
Side Slough					
Tsisi Creek					
Unnamed Tributary 194.8					
Upland Slough					
Watana Creek					
	Middle River Above Devils Canyon				
Backwater	1				
Chinook Creek					
Clearwater Plume					
Fog Creek					
Main Channel					
Side Channel					
Side Slough					
Tributary Mouth					
Tsusena Creek					

Macrohabitat	Chinook	Chum	Coho	Pink	Sockeye
	Middle River Below Devils Canyon				
Backwater	30		104	4	98
Clearwater Plume	5		49		8
Main Channel	6		5		1
Side Channel	121	17	321		174
Side Slough	77		412	1	235
Side Slough Beaver Complex	62	4	217		992
Tributary	170	1	880		40
Tributary Mouth	12	6	309		17
Upland Slough	22		205		10
Upland Slough Beaver Complex	543	1	2947		29

Preliminary data, may not contain all data sources, subject to QC

Adult Anadromous Spawning by Macrohabitat 1980s



1980s periodicity and habitat observations

Common Name	Presence (p 101, Table 8.1-1)					Peak Use Period (All River) (p 83, Table S-1)					Spawning Habitat (Primary and/or Secondary) (p 105, Fig. S-1)			
	Lower River	Lower Middle	Upper Middle	Upper River	Tribs	June	July	Aug.	Sept	Oct.	Main-stem	Side Channel	Side Slough	Trib
Arctic grayling	X	X	X	X	X									
Dolly Varden	X	X	X		X									
Chinook salmon	X	X	X	X	X									1
Chinook salmon, Spawning														
Coho salmon	X	X			X									1
Coho salmon, Spawning														
Chum salmon	X	X			X						2	2	1	1
Chum salmon, Spawning														
Pink salmon	X	X			X							2	2	1
Pink salmon, Spawning														
Sockeye salmon	X	X			X	A	A B			B			1	
Sockeye salmon, Spawning						A		A B		B				
Rainbow trout	X	X			X									

Key
Off-Peak Use, Adult
Peak Use, Adult Migration
Off-Peak Use, Spawning
Peak Use, Spawning

Notes: 1st (A) and 2nd (B) run Sockeye exhibit distinct timing of adult migration and spawning, and use separate areas for spawning.

Passage Criteria Application

- **Depth Criteria** application
  - 1980s depth x distance curves for uniform and non-uniform substrate with Chum as surrogate for salmonids 0.41 ft uniform, 0.54 ft non-uniform
  - Lang et al. (2004) determined the limiting depth to be the shallowest point over a riffle following the thalweg in the stream wise direction
  - Min depth for 25% total, full 10% of transect width (Thompson 1972)

Passage Criteria Application

- **Integration with modeling**
  - Fluvial Geomorphology Study 6.5 - depth threshold magnitude and frequency with 2-D model runs including upstream/downstream velocity, hydraulic dynamics and sediment aggradation/degradation, channelization and tributary mouth barriers, formation and removal of barriers under project conditions
  - Ice Processes Study 7.6 - address juvenile fish passage during ice-cover periods with 1-D and 2-D models including ice formation and breakup; ice thickness, elevation, and blockage of off-channels and tributary deltas; passageways beneath ice and changes in ice-free at slough entrances

Application of Depth Criteria – 1980s depth/distance

Chum as surrogate for salmonids

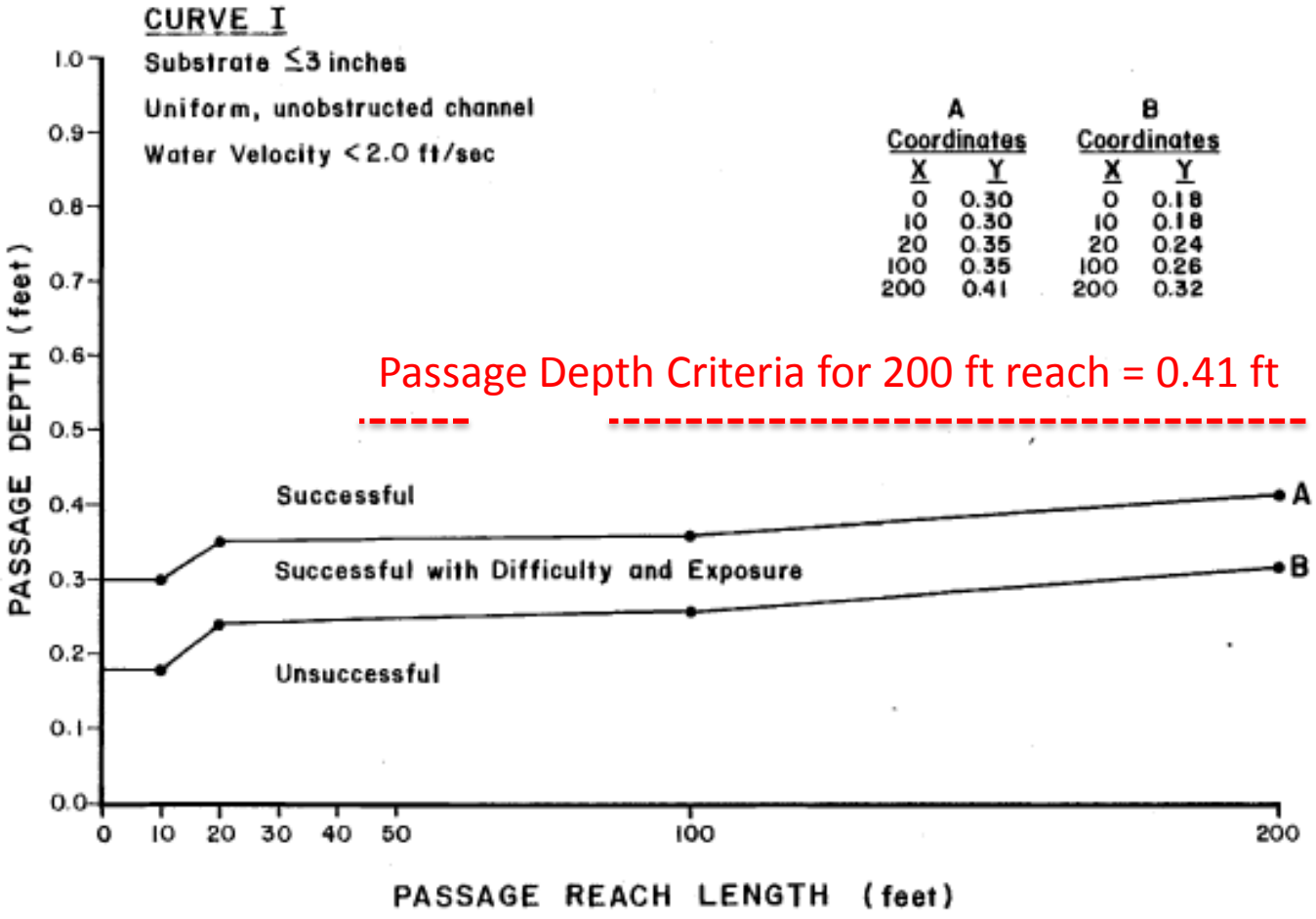


Figure 6-4. Passage depth requirements for chum salmon as a function of passage reach length within sloughs and side channels having substrates less than 3.0 inches in diameter, uniform morphology and water velocities less than 2.0 ft/sec.

Application of Depth Criteria – 1980s depth/distance

Chum as surrogate for salmonids

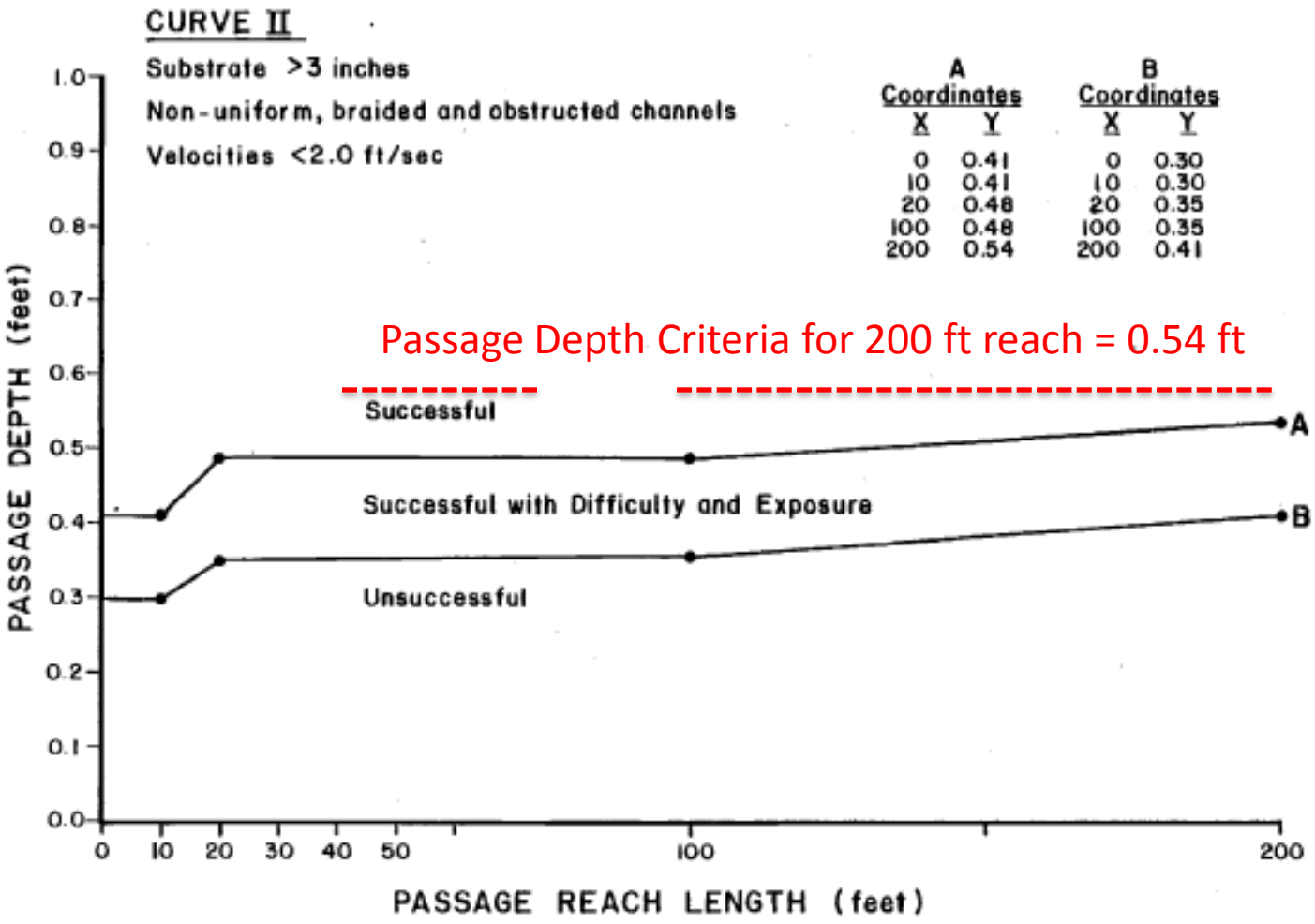


Figure 6-5. Passage depth requirements for chum salmon as a function of passage reach length within sloughs and side channels having substrates greater than 3.0 inches in diameter, non-uniform, braided and obstructed channels and velocities less than 2.0 ft/sec.

Application Depth Criteria – slough and SC habitats

Breaching, backwater, local flows

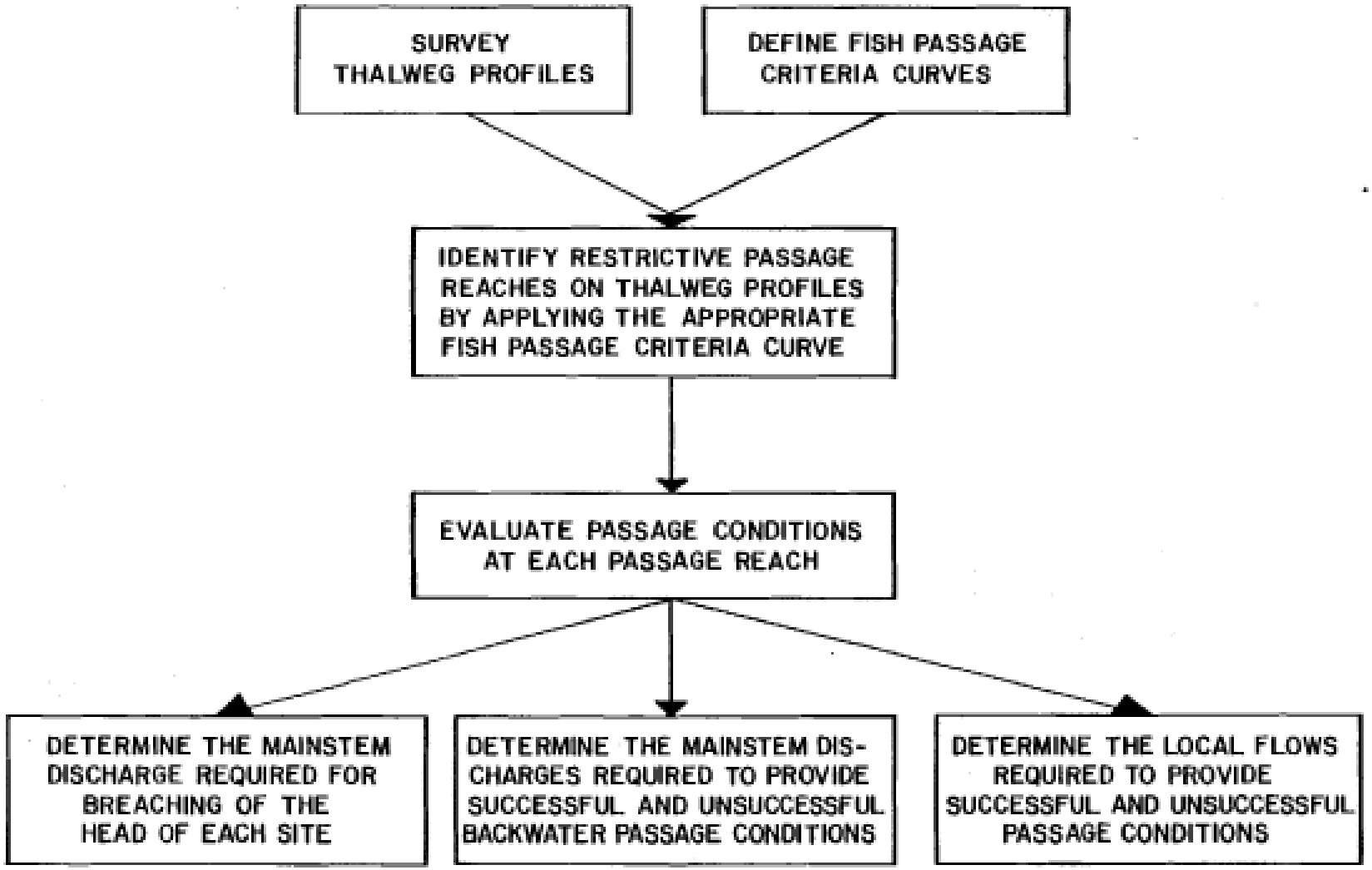


Figure 6-3. Flow chart displaying the methods employed to evaluate passage reach conditions.

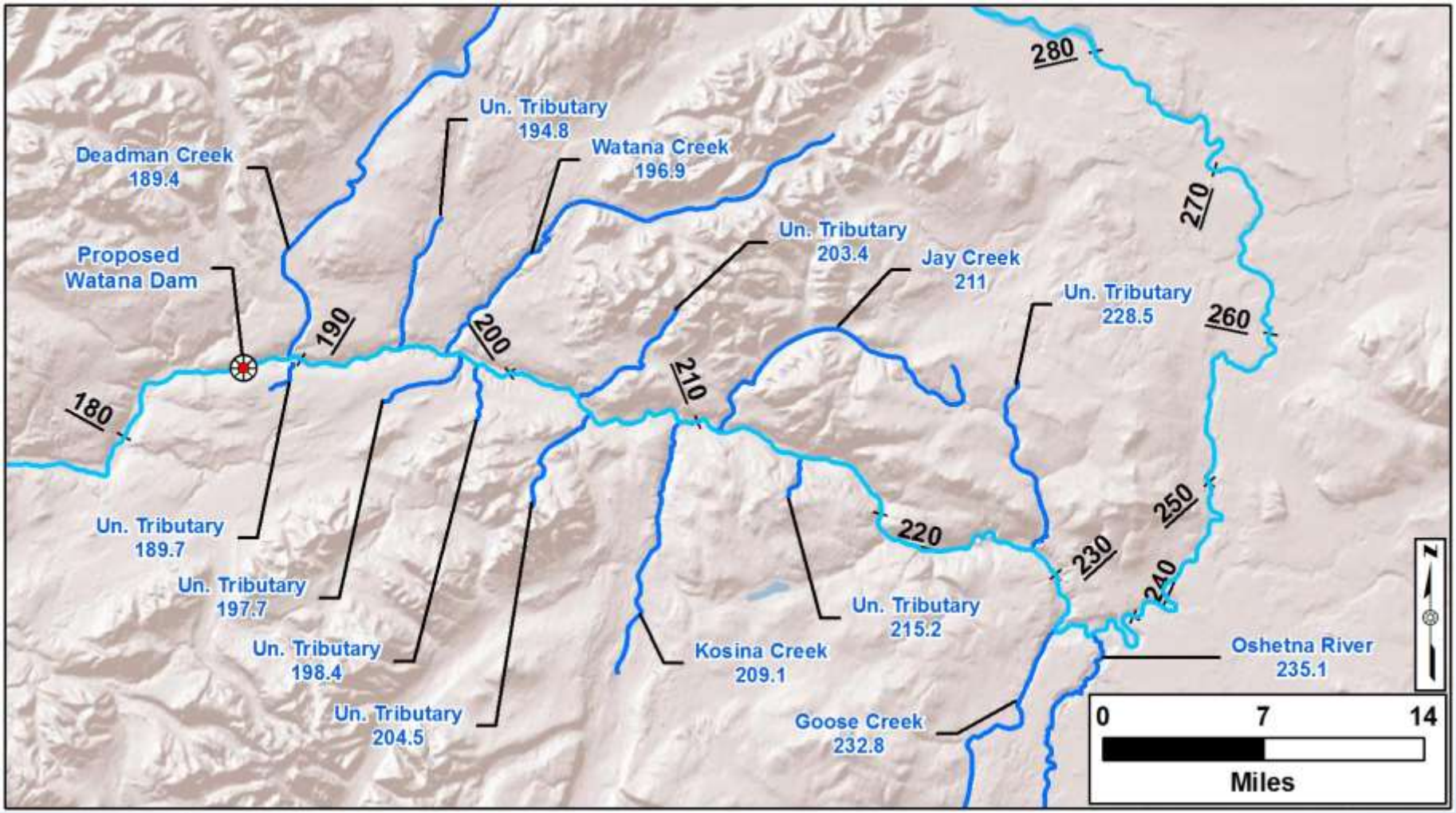
Study 6.5 Geomorphology – Objectives

- *Estimate formation of deltas at reservoir inflows to evaluate potential effects on upstream fish passage*
  - *Study area: proposed Watana Dam (PRM 187.1) to 5 miles upstream max pool (PRM 238)*

Study 6.6 Fluv. Geo. Modeling – Objectives

- *Develop sediment inflows for tributaries*
  - *Couple sediment rating curves with flow series at surveyed tributaries*
  - *Apply regional relationships or regression equations (from surveyed tributaries) at non-surveyed tributaries*
  - Model sediment transport and deposition processes at select tributary mouths

Upper River Tributaries



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Recommended Selection of Upper River Tributaries

Tributary	PRM	D.A. (mi^2)	Bank	2012/2013 Fish Distribution					Barriers Eliminated by Reservoir[1]			Rationale for Exclusion
				Chinook	Burbot	Dolly Varden	Round Whitefish	Arctic Grayling	Type	Trib RM	Elevation[2]	
Oshetna R.	235.1	556.4	L	x		x	x	x				
Goose Cr.	232.8	106.5	L	x	x		x	x				
Un. Tributary	228.5	46.9	R									TOB @ 2,375'
Un. Tributary	215.2	2.3	L									TOB @ 2,200'
Jay Cr.	211.0	62.4	R		x	x	x	x				
Kosina Cr.	209.1	402.5	L	x	x	x	x	x				
Un. Tributary	204.5	12.3	L						cmpd.	0.4 & 0.6	1830&1925	Steep ch.
Un. Tributary	203.4	19.5	R									TOB @ 2,030'
Un. Tributary	198.4	1.8	L			x						Small D.A.
Un. Tributary	197.7	8.1	L						falls	1.3	1990	Steep ch.
Watana Cr.	196.9	176.4	R	x	x	x	x	x				
Un. Tributary	194.8	23.2	R			x		x				
Un. Tributary	189.7	1.9	L						chute	0.4	1990	Small D.A.
Deadman Cr.	189.4	175.4	R		x	x	x	x	falls	0.6	1760	

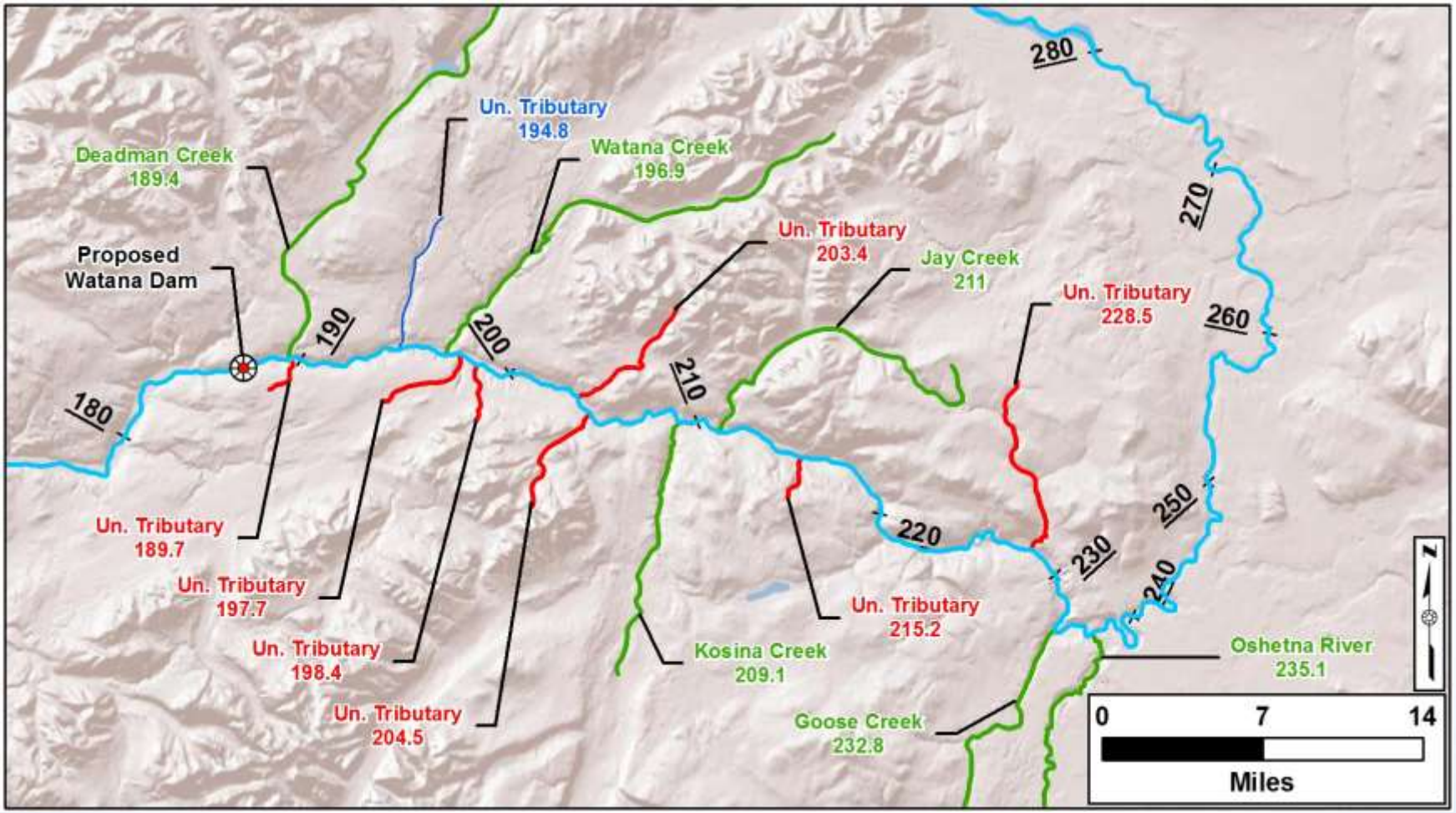
[1] Identified fish passage barriers potentially inundated by the proposed Watana Reservoir
Reservoir max pool = 2,050 feet (NAVD88) with upper extent at PRM 232.5,
Reservoir low pool = 1,850 feet (NAVD88) with upper extent at PRM 222.5

[2] Elevation at the top of the barrier, as estimated using 2011 MatSu LiDAR (feet, NAVD88)

Indicates candidate tributary recommended for delta modeling

Indicates candidate tributary recommended for exclusion from delta modeling

Recommended Selection of Upper River Tributaries



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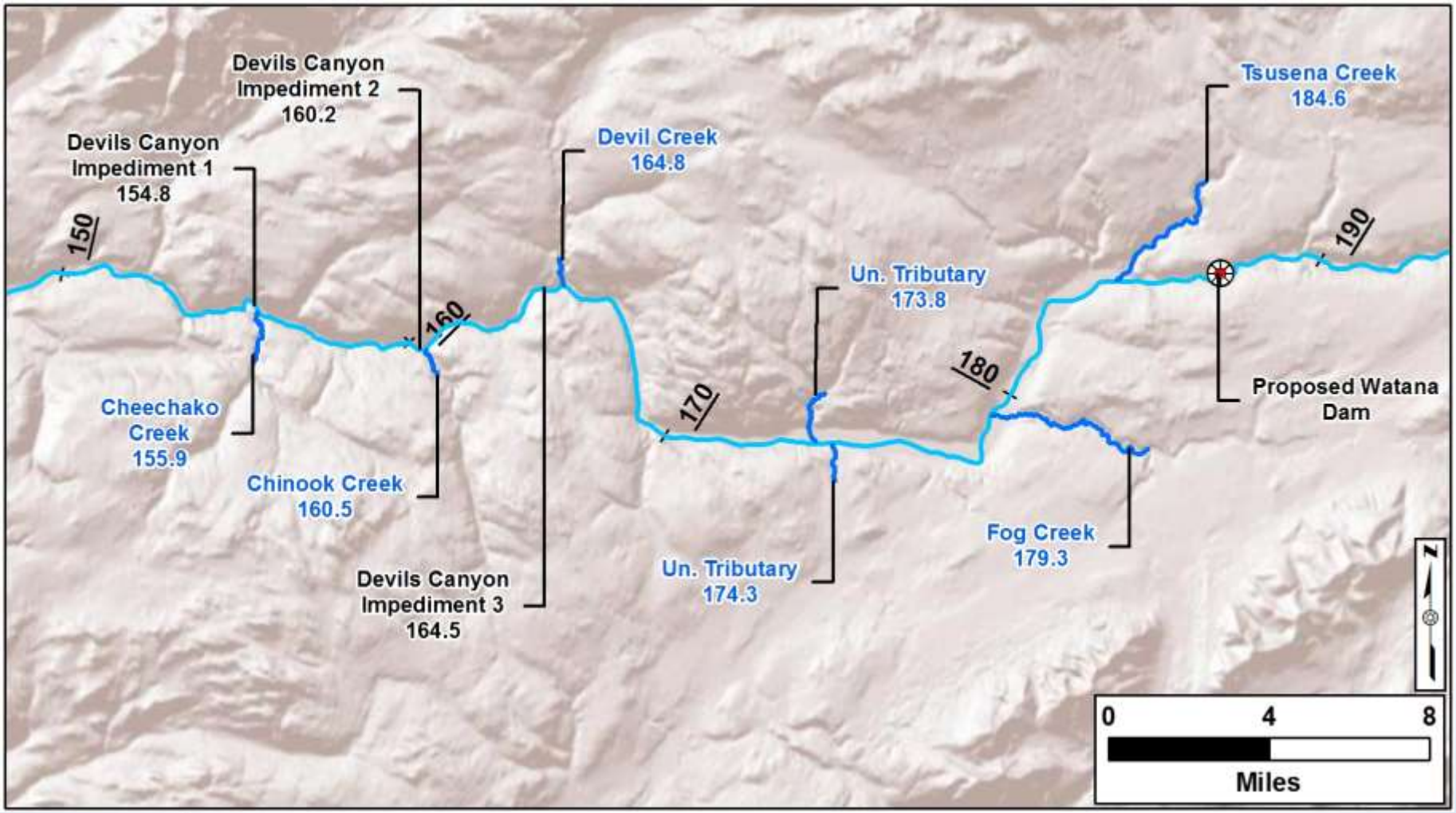
Middle River Tributaries Upstream and Within Devils Canyon



Recommended Selection of Middle River Tributaries Upstream and Within Devils Canyon

Tributary	PRM	D.A. (mi^2)	Lake Presence[1]		Focus Area	Evidence of ActiveFan	2012/2013 Fish Distribution		Interest[2]
			Trib RM	Area (ac)			No. of Resident Species	No. of Salmon Species	
Upstream of Devils Canyon									
Tsusena Cr.	184.6	145.4			184	Yes	4	1	S,B,F
Fog Cr.	179.3	149.7				Yes	4	1	S,B,F
Un. Tributary	174.3	4.4	1.0 & 1.8	62.3 & 235	173	No			S
Un. Tributary	173.8	8.6			173	Yes	4		S,F
Within Devils Canyon									
Devil Cr.	164.8	74.4				No		1	B
Devils Canyon Impediment 3 (PRM 164.5)									
Chinook Cr.	160.5	24				Yes	2	1	S,B,F
Devils Canyon Impediment 2 (PRM 160.2)									
Cheechako Cr.	155.9	34.4				No		1	B
Devils Canyon Impediment 1 (PRM 154.8)									

[1] Large lakes near the tributary mouth trap sediment and prevent formation of fans

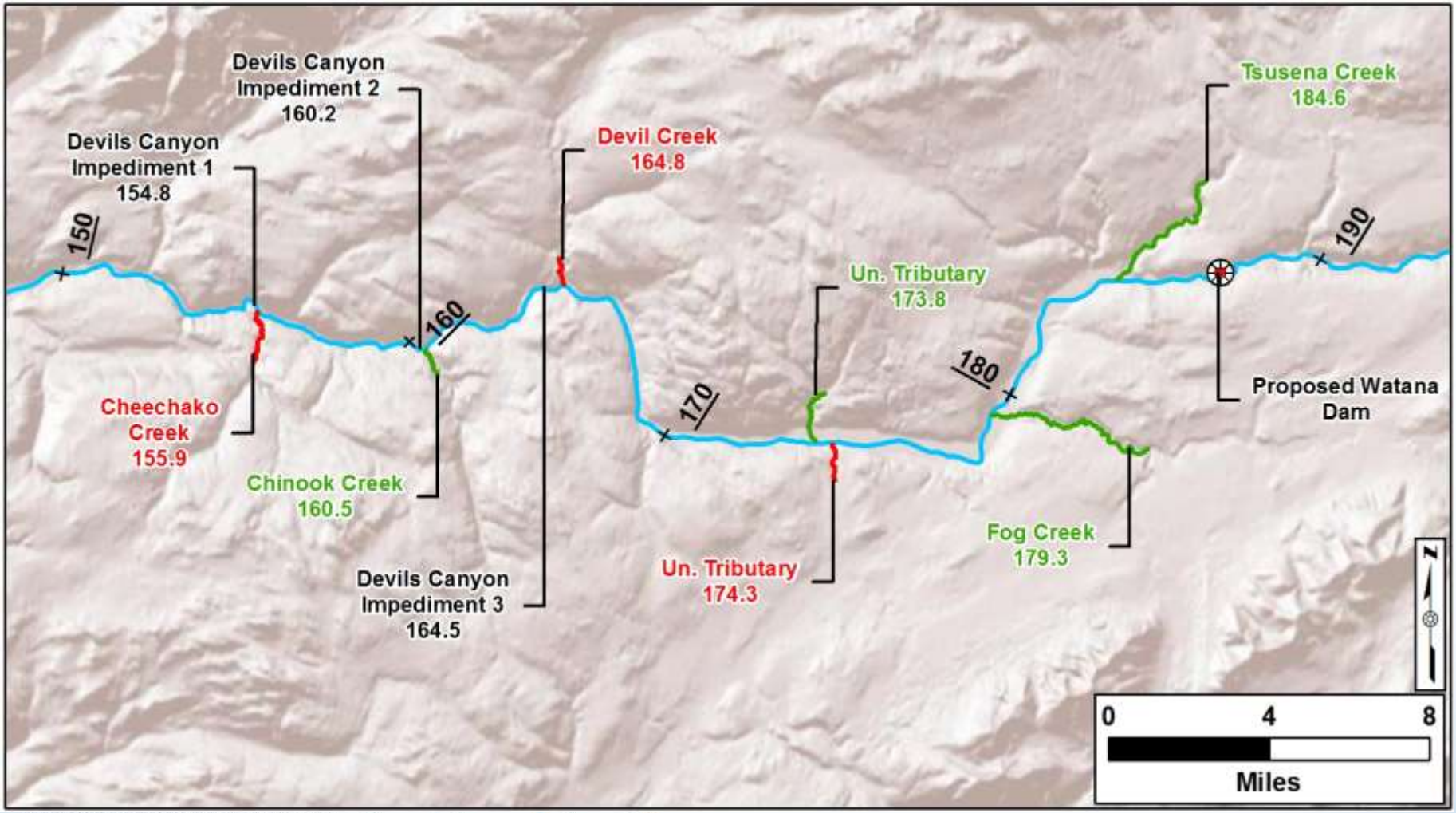
[2] S = sediment supply (Study 6.6); B = fish passage barrier (Study 9.12); F = depositional fan (Study 6.5)

Indicates candidate tributary recommended for delta modeling

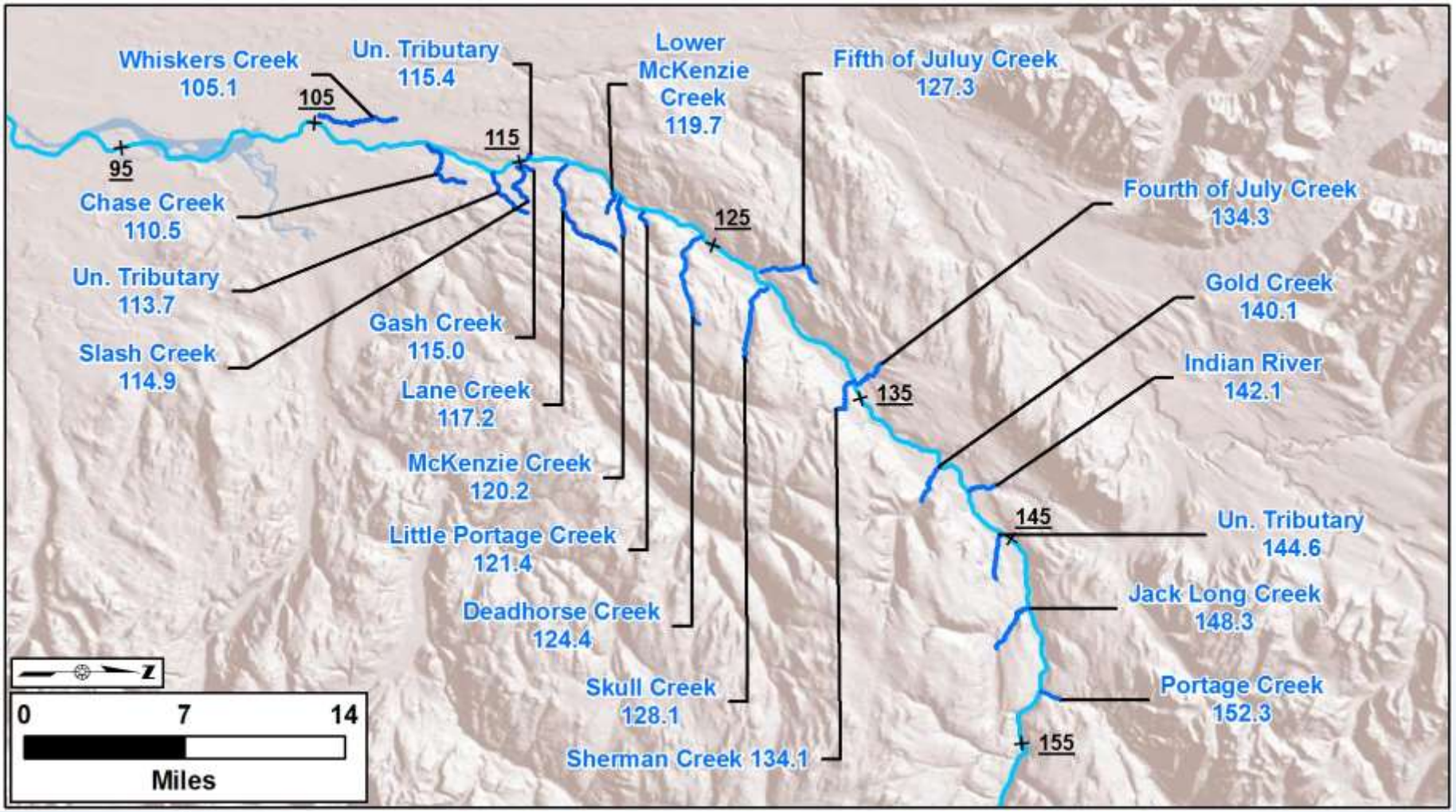
Indicates candidate tributary recommended for exclusion from delta modeling

Basis of recommendation for exclusion

Recommended Selection of Middle River Tributaries Upstream and Within Devils Canyon



Middle River Tributaries Downstream of Devils Canyon



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Recommended Selection of Middle River Tributaries Downstream of Devils Canyon

Tributary	PRM	D.A. (mi^2)	Lake Presence[1]		Focus Area	Evidence of ActiveFan	2012/2013 Fish Distribution		Interest[3]
			Trib RM	Area (ac)			No. of Resident Species	No. of Salmon Species	
Portage Cr.	152.3	179.1			151	Yes	2	5	S,F
Jack Long Cr.	148.3	19.1				No		2	B
Un. Tributary[4]	144.6	5.0			144	Yes			S,F
Indian River	142.1	81.9			141	Yes	9	5	S,F
Gold Cr.	140.1	24.6				Yes	1	3	S,B,F
Fourth of July Cr.	134.3	23.4				Yes	2	5	S,B,F
Sherman Cr.	134.1	7.1				Yes		1	S,B,F
Skull Cr.	128.1	4.3			128	Yes	4	4	S,F
Fifth of July Cr.	127.3	7.1				Minimal	3	4	S,B,F
Deadhorse Cr.	124.4	4.7				Yes			S,B,F
Little Portage Cr.	121.4	2.5	0.9	7.4		No			B
McKenzie Cr.	120.2	2.1				No			B
L. McKenzie Cr.	119.7	2.6	1.2 & 1.3	17.5 & 29.9		No			B
Lane Cr.	117.2	11.4				Yes	1	4	S,B,F
Un. Tributary	115.4	2.7			115	No	4	3	n/a
Gash Cr.	115.0	1.9	0.6	19.6	113	No	6	1	S
Slash Cr.	114.9	1.8			113	No			S
Un. Tributary	113.7	2.0			113	Yes	4	1	S,F
Chase Cr.	110.5	4.9	1.3	25.5		No	6	2	B
Whiskers Cr.	105.1	18.2			104	No	9	5	S

[1] Large lakes near the tributary mouth trap sediment and prevent formation of fans

[2] S = sediment supply (Study 6.6); B = fish passage barrier (Study 9.12); F = depositional fan (Study 6.5)

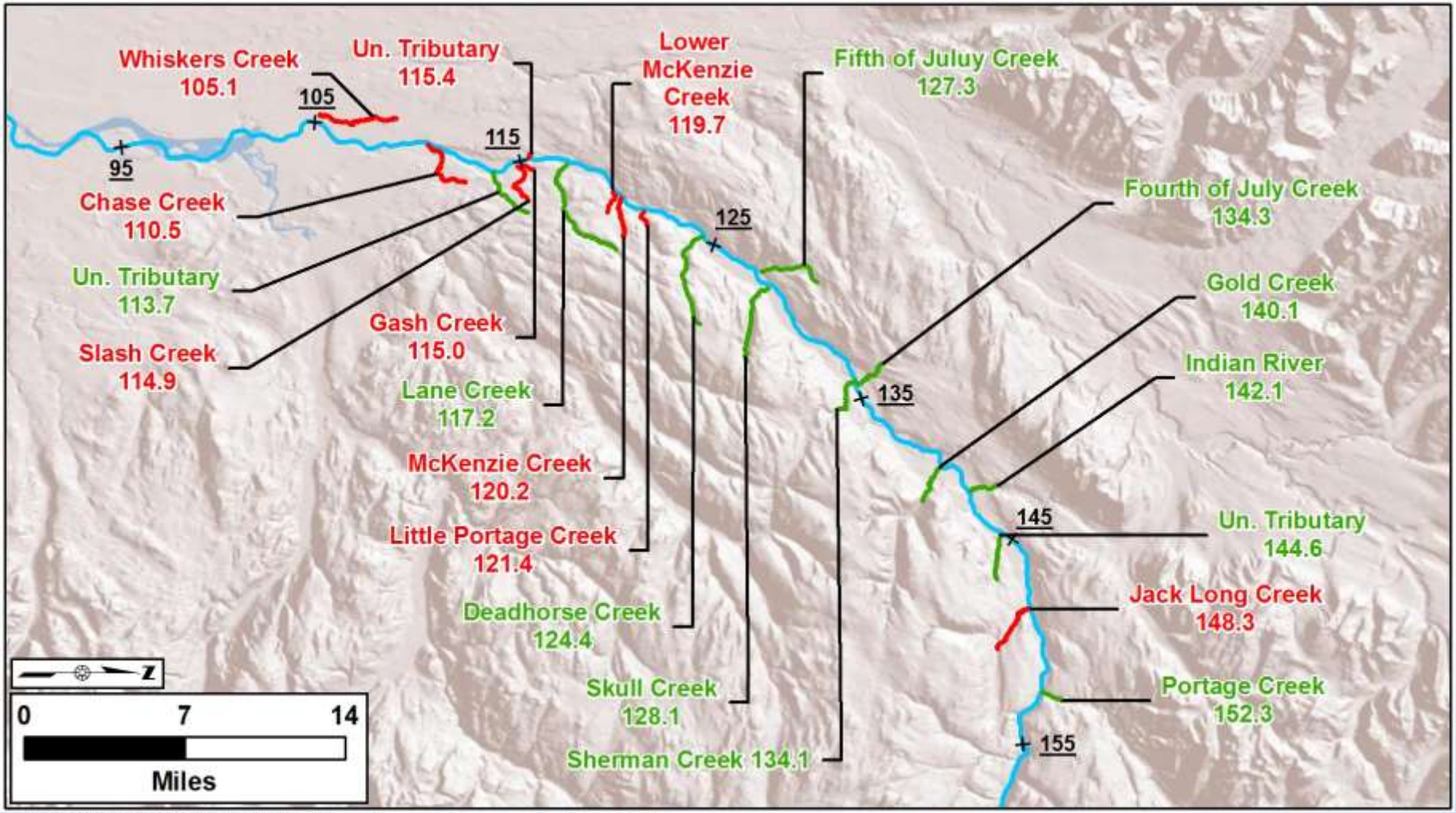
[3] No surface flow at mouth during July 2013 survey

Indicates candidate tributary recommended for delta modeling

Indicates candidate tributary recommended for exclusion from delta modeling

Basis of recommendation for exclusion

Recommended Selection of Middle River Tributaries Downstream of Devils Canyon



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DISCUSSION