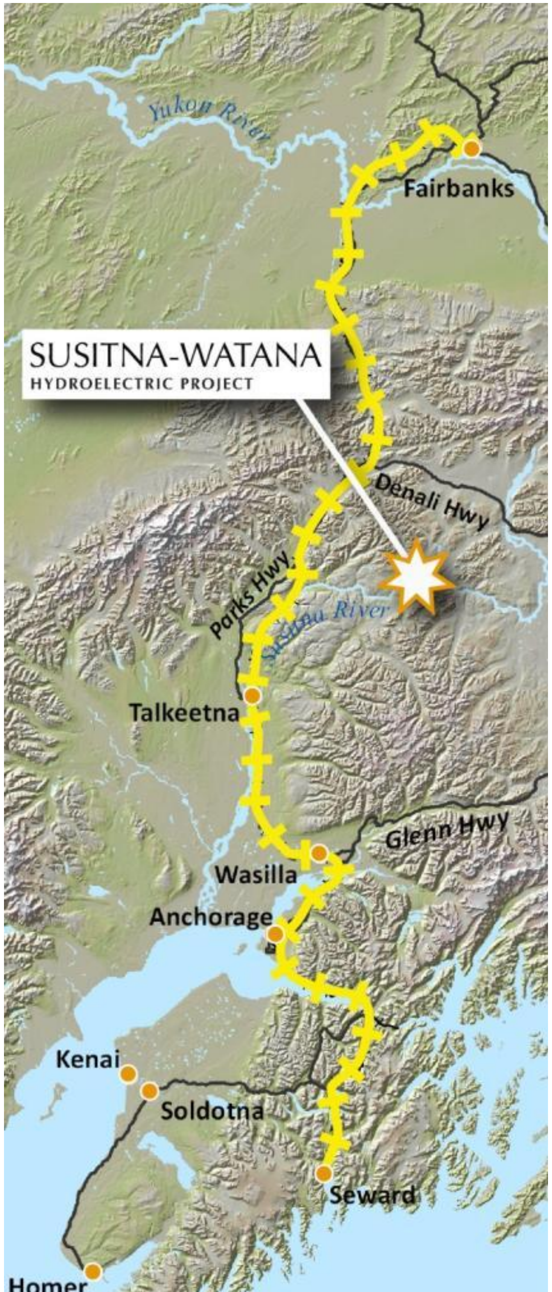

SUSITNA-WATANA
HYDROELECTRIC PROJECT

Technical WorkGroup Meeting
Instream Flow-Fish
Instream Flow Methods Review
October 2-4, 2012

Prepared by R2 Resource Consultants

Draft Version - September 27, 2014

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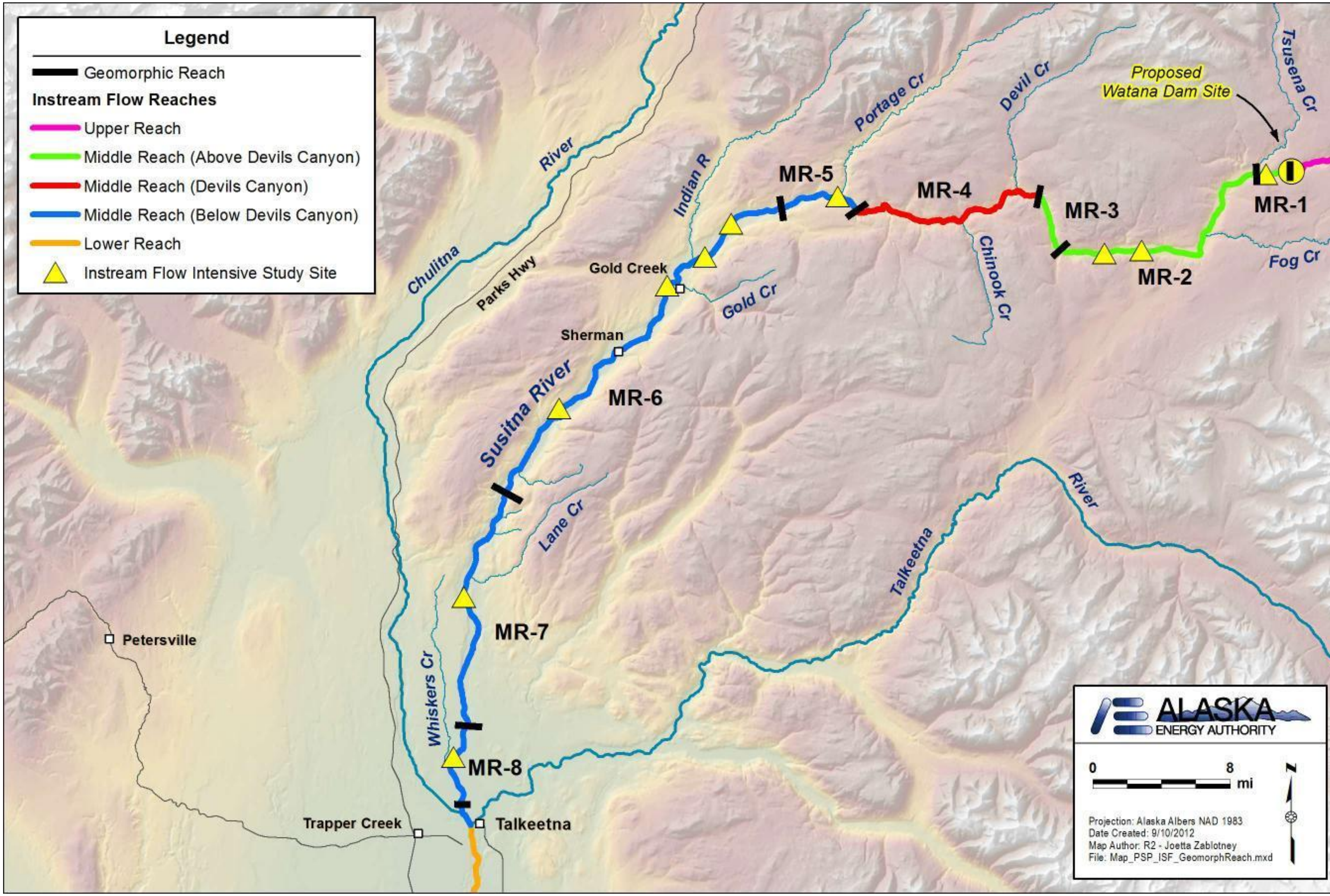
Susitna IFS Site Selection Process
Follow-up to 9-14 TWG meeting

- Identify potential Focus Area study sites for planning purposes (Sep 2012)
- Use mapping results to evaluate habitat variability, conduct statistical power analysis, refine intensive sites and identify supplementary sites (Dec 2012)
- TWG confirmation of sites (Feb/Mar 2013)
- Collect data during summer 2013
- Evaluate summer 2013 data and modify/add sites as needed in collaboration with TWG (Nov 2013)
- Collect additional data as needed summer 2014

Focus Area Study Sites



SUSITNA-WATANA HYDROELECTRIC PROJECT

Instream Flow Study (IFS)– Objectives

(from PAD)

- Intent: to evaluate effects of Project operations on habitat quality and availability.

- Study objective: to characterize aquatic and riparian habitat as a function of flow using site-specific data, ecological principles, and modeling methodologies as needed. *The information developed from this study, in combination with other resource studies (e.g., water temperature, fish abundance and distribution, geomorphology, and riparian), will provide a basis for streamflow-related resource management decisions and impact analyses.*

- Specific objective: provide habitat versus flow relationships necessary to quantify the potential effects of the Project and other alternative flow scenarios on aquatic and riparian habitat.

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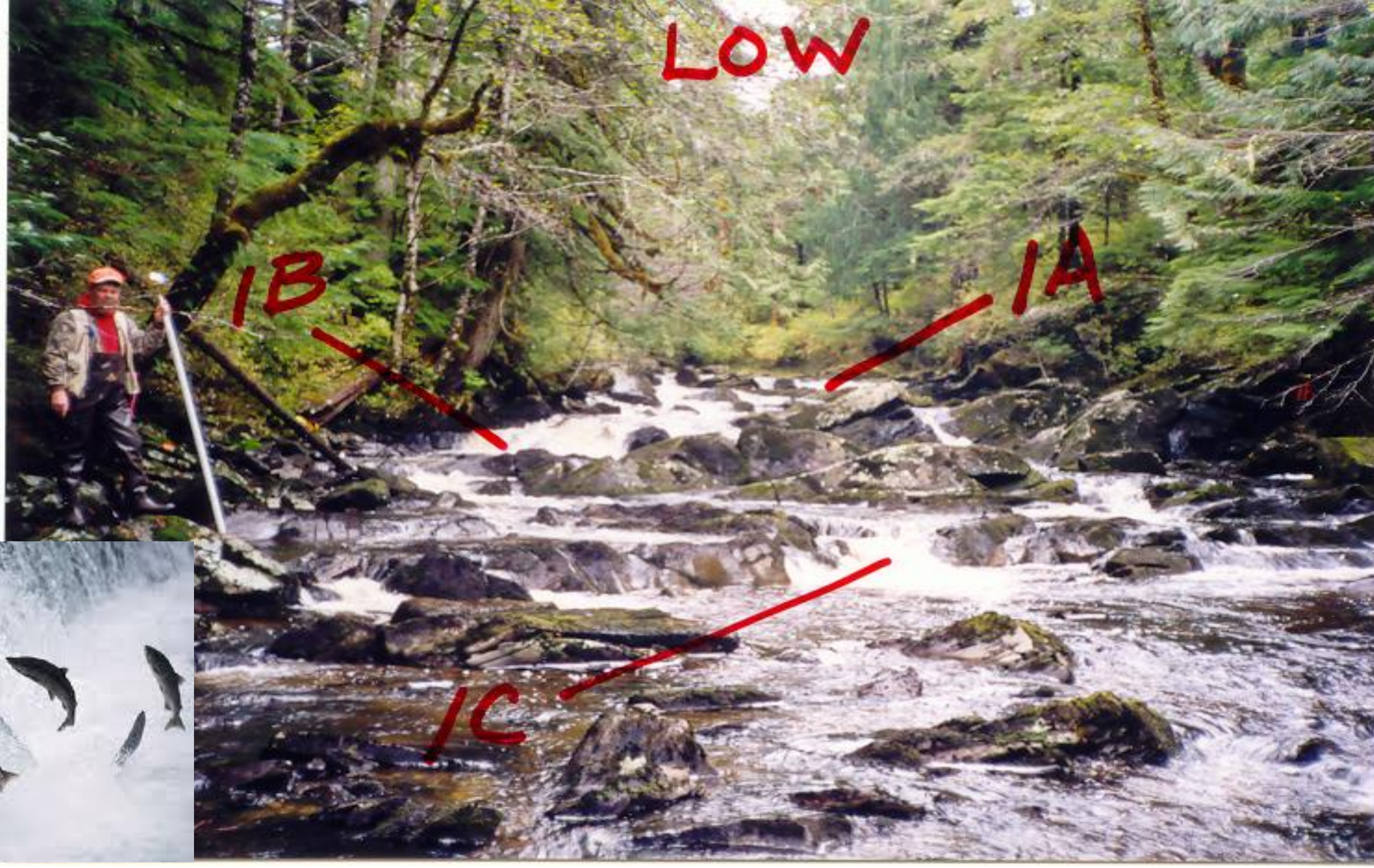
Agenda

- Quick Review of Fish-habitat flow requirements
- Review of 1980s Methods
- Contemporary Methods Review
  - Office based
  - Field based
  - Varial zone modeling
- Methods Selection Process and Criteria
- Tying it all together – Operations Modeling and Decision Support System (DSS)
- Pilot Winter Studies
- TWG Schedule
- Itinerary for Site Reconnaissance

Potential Flow Related Project Effects

- Temporal changes in flow magnitude and habitat availability
- Variable flow effects due to load following:
  - Stranding/Trapping
  - Varial zone development - effects on invertebrate productivity
  - Disruption of spawning
  - Redd dewatering/egg incubation
- Alteration in the frequency and timing of side channel and side slough connectivity
- Changes in channel geometry due to alteration in sediment balance and transport functions
- Changes in flood frequency and magnitude and associated effects on riparian ecosystems
- Changes in temperature regime and associated ecological effects
- Changes in water quality characteristics – DO, TDG, etc….



UPSTREAM MIGRATION

Streamflow influenced parameters: physical barriers, turbidity, water depth – minimum, water velocity - maximum, water temperature.

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SPAWNING

Streamflow influenced parameters: water depth, water velocity, substrate, water temperature, dissolved oxygen, cover, groundwater upwelling

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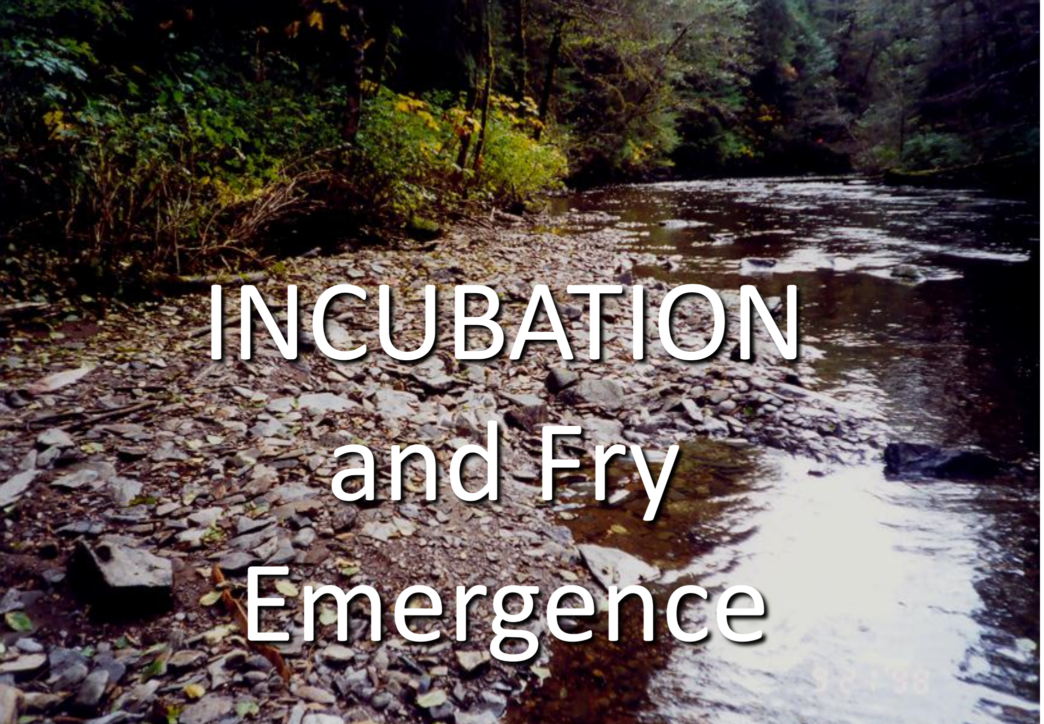
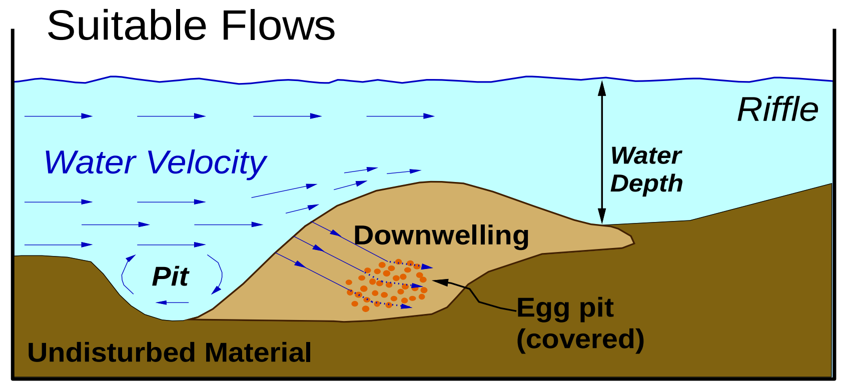
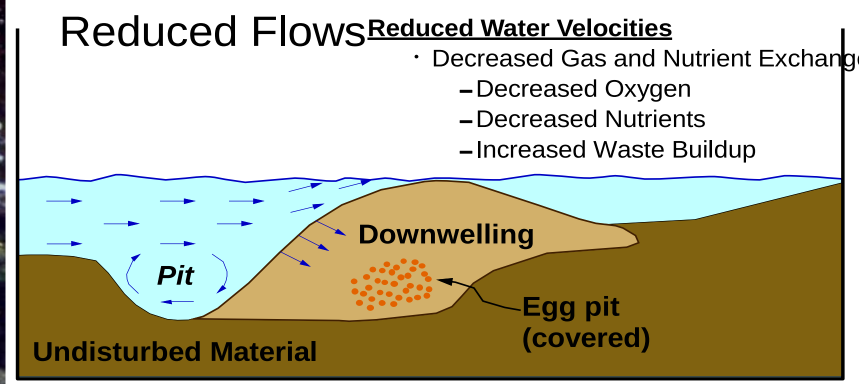
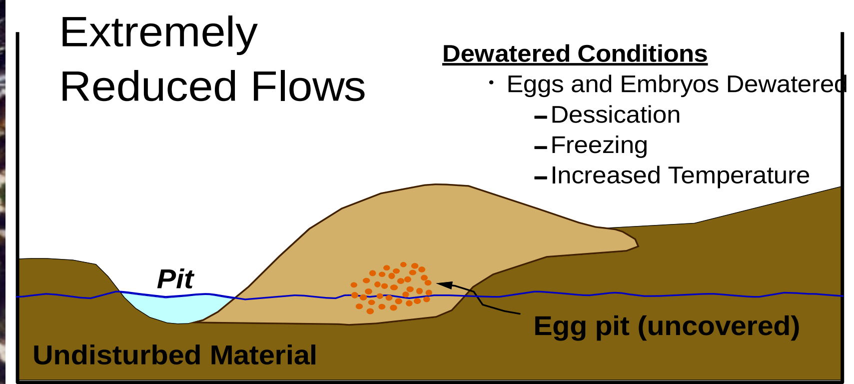
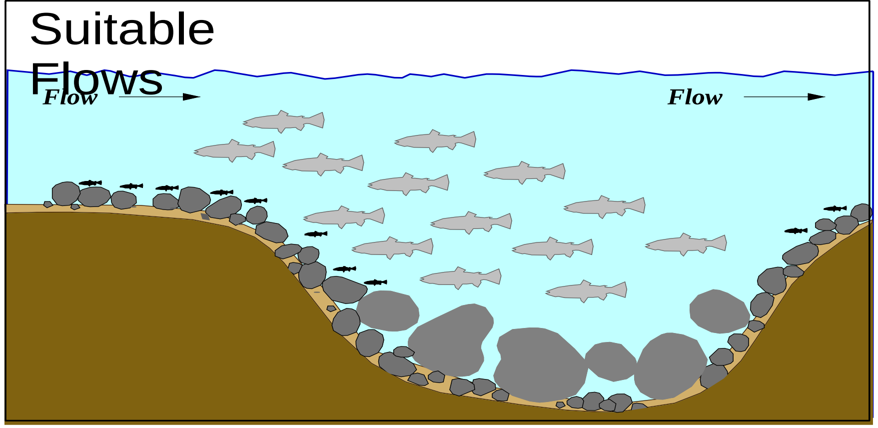
INCUBATION and Fry Emergence

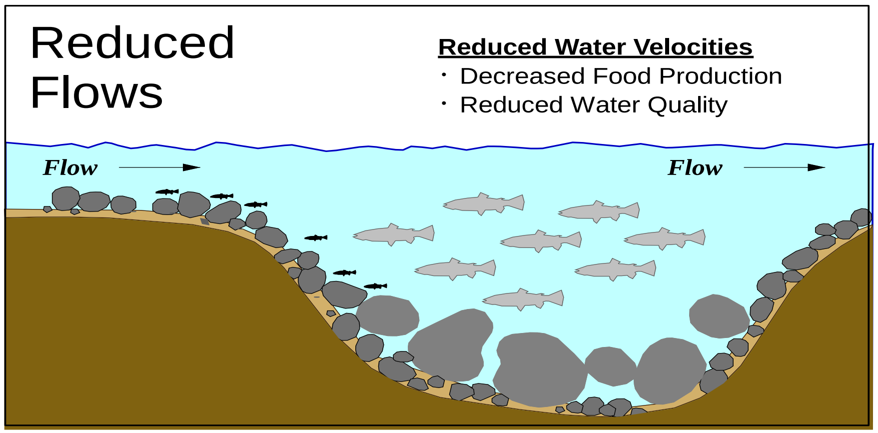


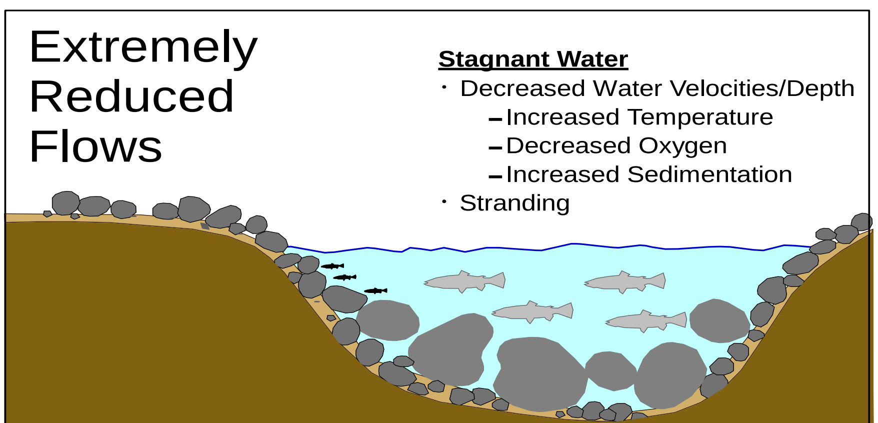




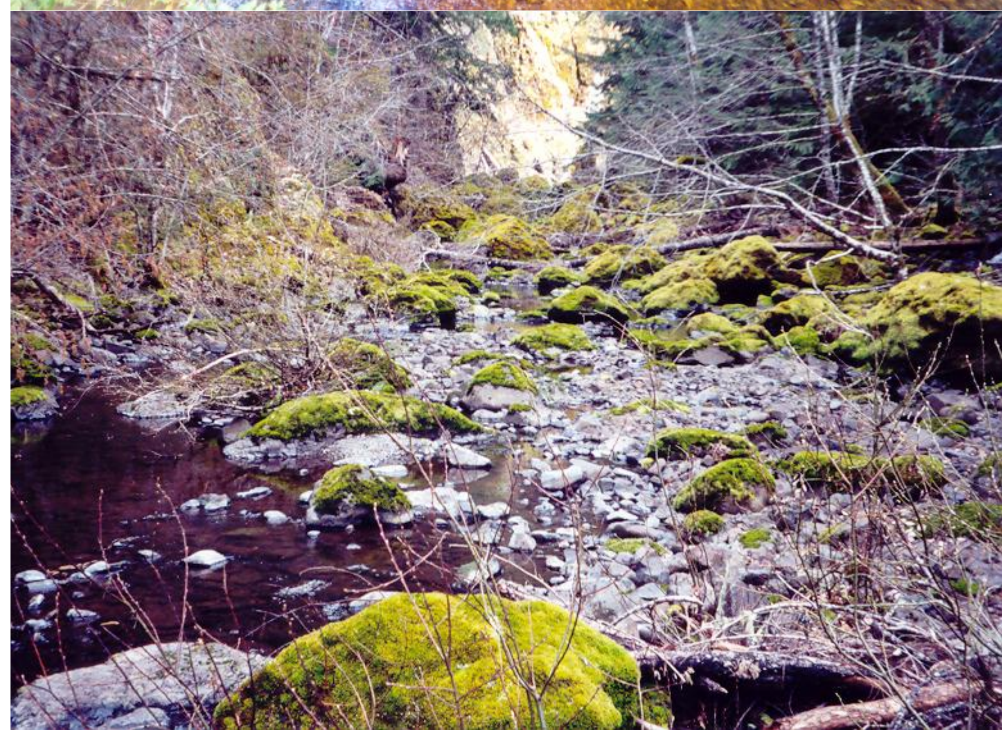


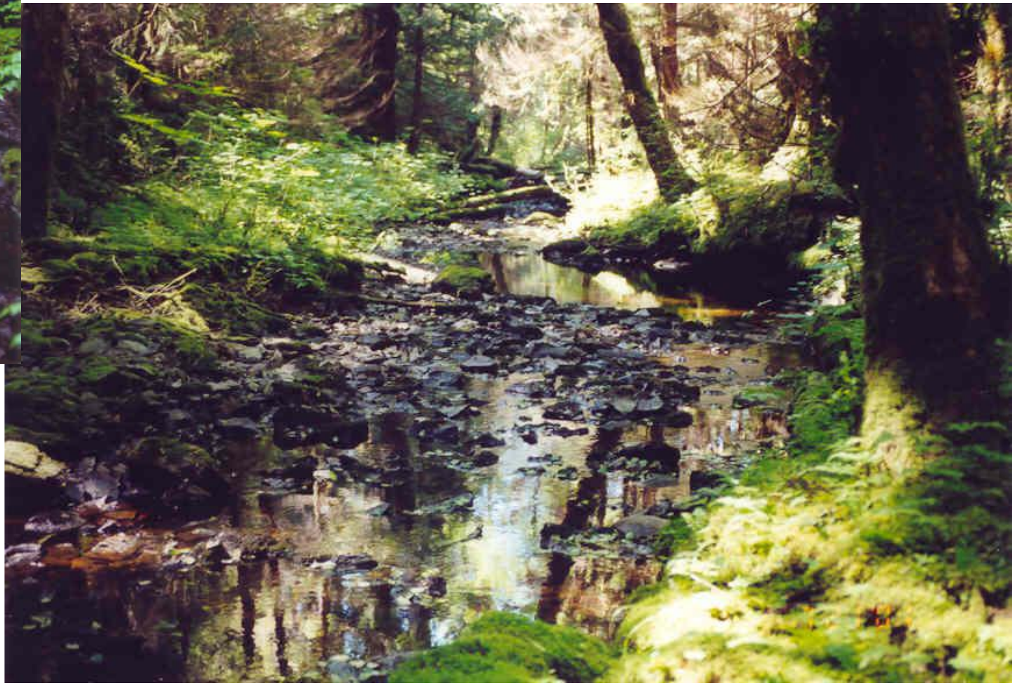

Suitable Flows
Flow
Flow


Reduced Flows
Reduced Water Velocities
• Decreased Food Production
• Reduced Water Quality
Flow
Flow


Extremely Reduced Flows
Stagnant Water
• Decreased Water Velocities/Depth
– Increased Temperature
– Decreased Oxygen
– Increased Sedimentation
• Stranding


REARING
9 21 '98





Side Channel and Slough Habitat Connectivity

Fry nursery habitat, juvenile rearing habitat, velocity and thermal refuge habitats, spawning habitat, gravel and wood recruitment.

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DOWNSTREAM PASSAGE

Movement typically synchronous with runoff; turbidity, freshets, water temperature

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HABITAT FORMATION AND FUNCTION

Sediment transport – pools/riffles, riparian habitat, substrate quality, aquifer recharge ,hyporheic zone.

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ICE FORMATION AND FUNCTION

Channel formation, sediment transport, side channel and off-channel connectivity, overwintering habitat conditions.

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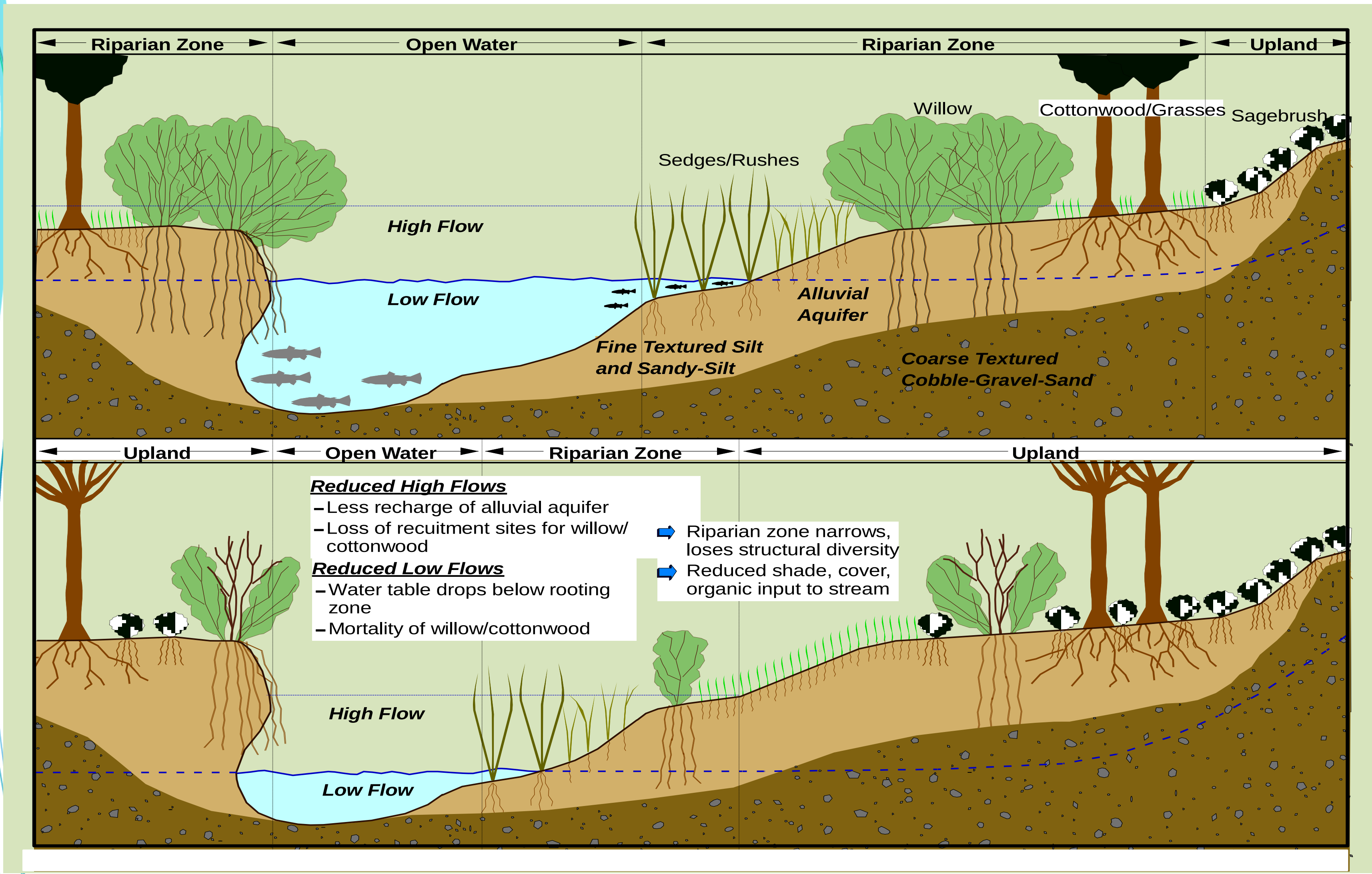
Channel – Riparian-Q Interactions



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Factors Involved in Assessing Instream Flows

- Basin Hydrology
  - perennial or intermittent
  - base/ peak flows
  - flow duration (daily, monthly, annual)
  - surface flow connectivity
- Fish Use
  - resident, anadromous, both
  - life stage use (e.g., spawning, rearing)
- Channel Morphology
  - bankfull width depth
  - local slope and confinement
  - disturbance regime and sensitivity
- Project Operating Conditions
  - baseline
  - proposed

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Methods Used in 1980s

- IFG4 and IFG2 (1-Dimensional Modeling): Instream Flow Incremental Methodology – IFIM and Physical Habitat Simulation (PHABSIM) Models
- DIHAB – (Direct Habitat analysis)
- RJHAB – (Resident Juvenile Habitat Model)
- Aerial Imagery and Habitat Mapping (Digitization)
- Other

(See List and Map for Locations)

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IFG4 and IFG2

- IFG4 – individual models developed for each transect: site evaluation based on composited WUA
- IFG2 (aka WSP) – model developed for entire study site: transects tied together
- 1980s Studies used for developing habitat-flow relationships for spawning and juvenile life stages

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DIHAB

- Focused on chum spawning habitats
- Designed to capture parameters/features not readily addressed in PHABSIM type models (i.e. upwelling, turbidity)

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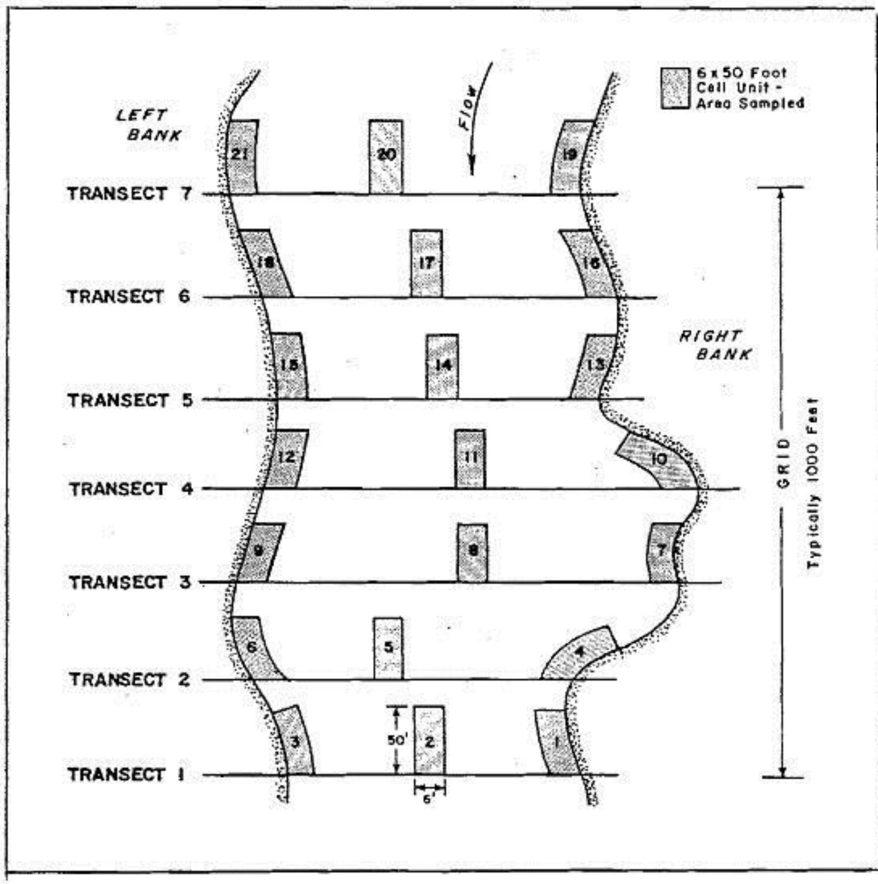
RJHAB

- Applied Grid network to assess juvenile habitat-flow relationships
- Incorporated fish sampling in effort to relate habitats to flow and fish abundance



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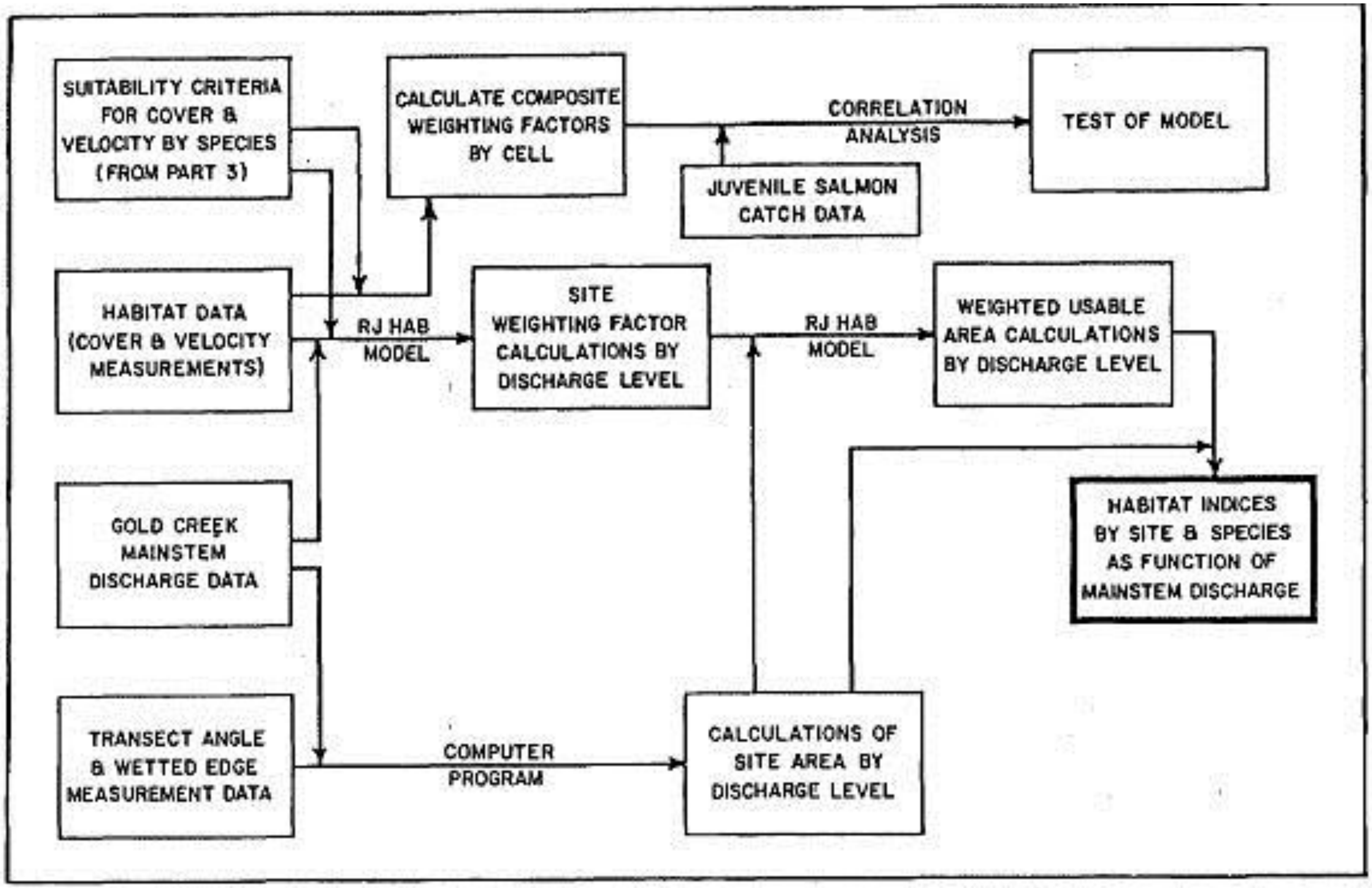

Figure 3. Data analysis flow chart for juvenile salmon rearing habitat models.

Placeholder – refer to PPT with 1980s Study Sites

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Contemporary Methods to Assess Effects

- Upstream Fish Passage Issues
  - Powers and Orsborn (1984) – physical obstacles (falls, cascades and chutes)
  - Thompson (1974) - flow related (minimum depth and maximum velocity)
- Spatial Habitat Requirements and Impacts
  - Many different methods
  - Hydrologic Based
  - IFIM PHABSIM1D- and 2D- modeling -
  - Effective Spawning Habitat/Varial Zone Analysis
  - others

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Contemporary Methods to Assess Effects

- Side Channel/off-channel Connectivity
  - Side channel – main channel stage/discharge relationships: define functionality of channel
  - Aerial Photography/Habitat mapping
  - GIS mapping
- Downstream Passage
  - Hydrologic modeling - define project operational effects
  - Species periodicities

Contemporary Methods to Assess Effects

- Fluvial Geomorphology Issues
  - Sediment transport modeling
  - Substrate characterization
  - RTK/GPS Topographic surveys
- Temperature Effects
  - Temperature monitoring and modeling
    - SNTEMP – surface flow method
    - River1D – under ice method
    - FLIR/TIR imaging

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Tennant Method

Hydrology based - % of Average Annual Flow

Table 1. Instream flow regimes for fish habitat (Tennant, 1976).

Narrative Descriptions of Flows	Recommended Base Flow Regimes (QAA)	
	Oct. – Mar.	Apr.-Sept.
Flushing Flow	200%	200%
Optimal Range	60 – 100%	60 – 100%
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair	10%	30%
Poor or Minimum	10%	10%
Severe Degradation	10%	10%

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Indicators of Hydrologic Alteration and Environmental Flow Components (Richter et al. 1996)

Hydrological Based

Comparison of 67 hydrological parameters relative to unaltered vs. altered conditions

IHA Parameters

Parameter Group	Number of parameters	Example parameter(s)
Magnitude of monthly water conditions	12	• Mean or median value for each calendar month
Magnitude & duration of annual extreme water conditions	12	• Annual minima / maxima for 1-, 3-, 7-, 30-, and 90-day means • Number of zero-flow days
Timing of annual extreme water conditions	2	• Julian date of each annual 1-day maximum / minimum
Frequency & duration of high & low pulses	4	• Mean or median duration of low / high pulses (days) • Number of low / high pulses per yr.
Rate & frequency of water condition changes	3	• Rise rates • Fall rates • Number of hydrologic reversals

Total of 33 parameters

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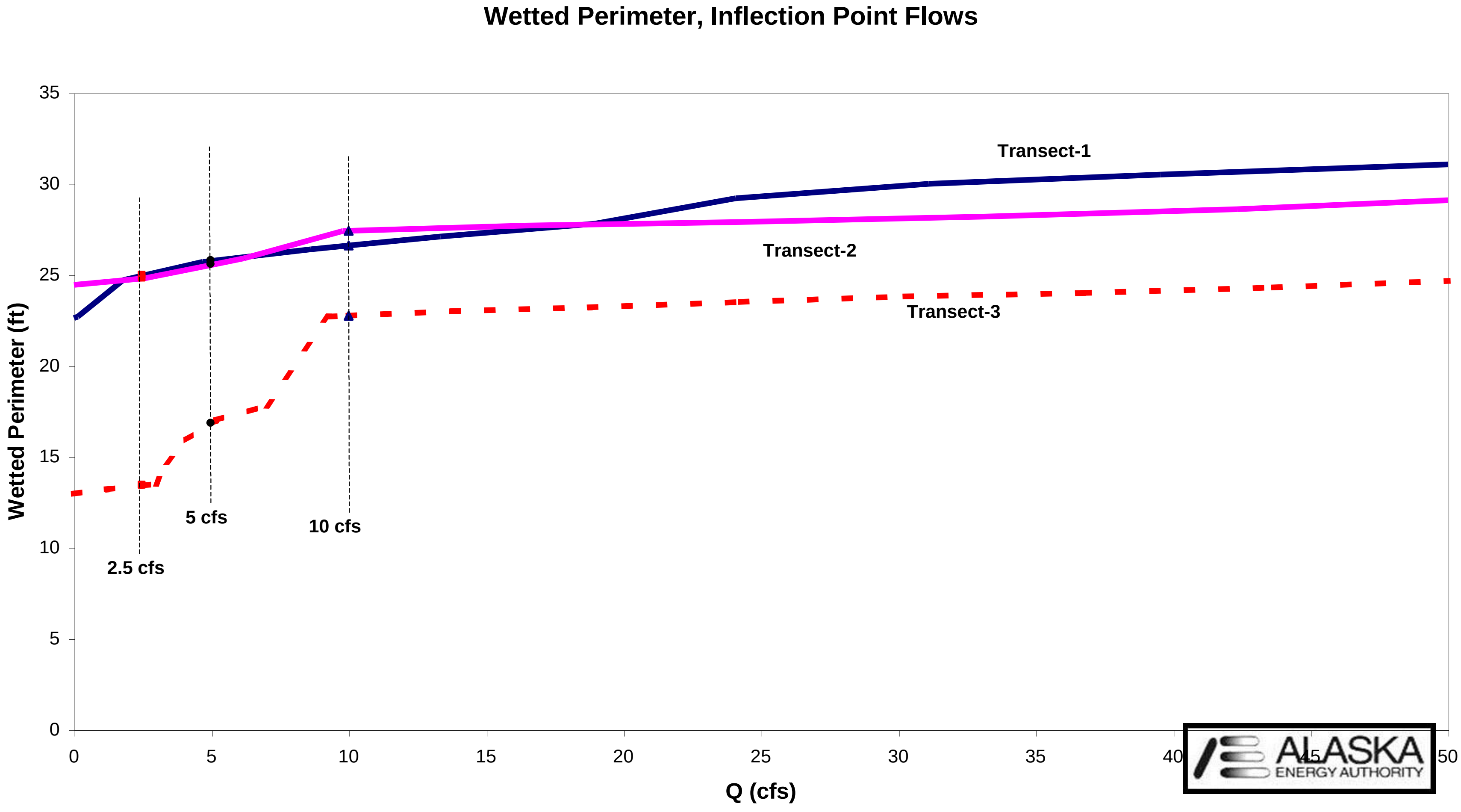
EFC Parameters

EFC Type	Number	Example parameter(s)
Monthly low flows	12	• Mean or median values of low flows during each calendar month
Extreme low flows	4	• Frequency of extreme low flows during each water year or season • Mean or median values of extreme low flow event (duration, peak flow, timing)
High flow pulses	6	• Frequency of high flow pulses during each water year or season • Mean or median values of high flow pulse event (duration, peak flow, timing, rise and fall rates)
Small floods	6	• Frequency of small floods during each water year or season • Mean or median values of small flood event (duration, peak flow, timing, rise and fall rates)
Large floods	6	• Frequency of large floods during each water year or season • Mean or median values of large flood event (duration, peak flow, timing, rise and fall rates)

Total of 34 parameters

Wetted Perimeter

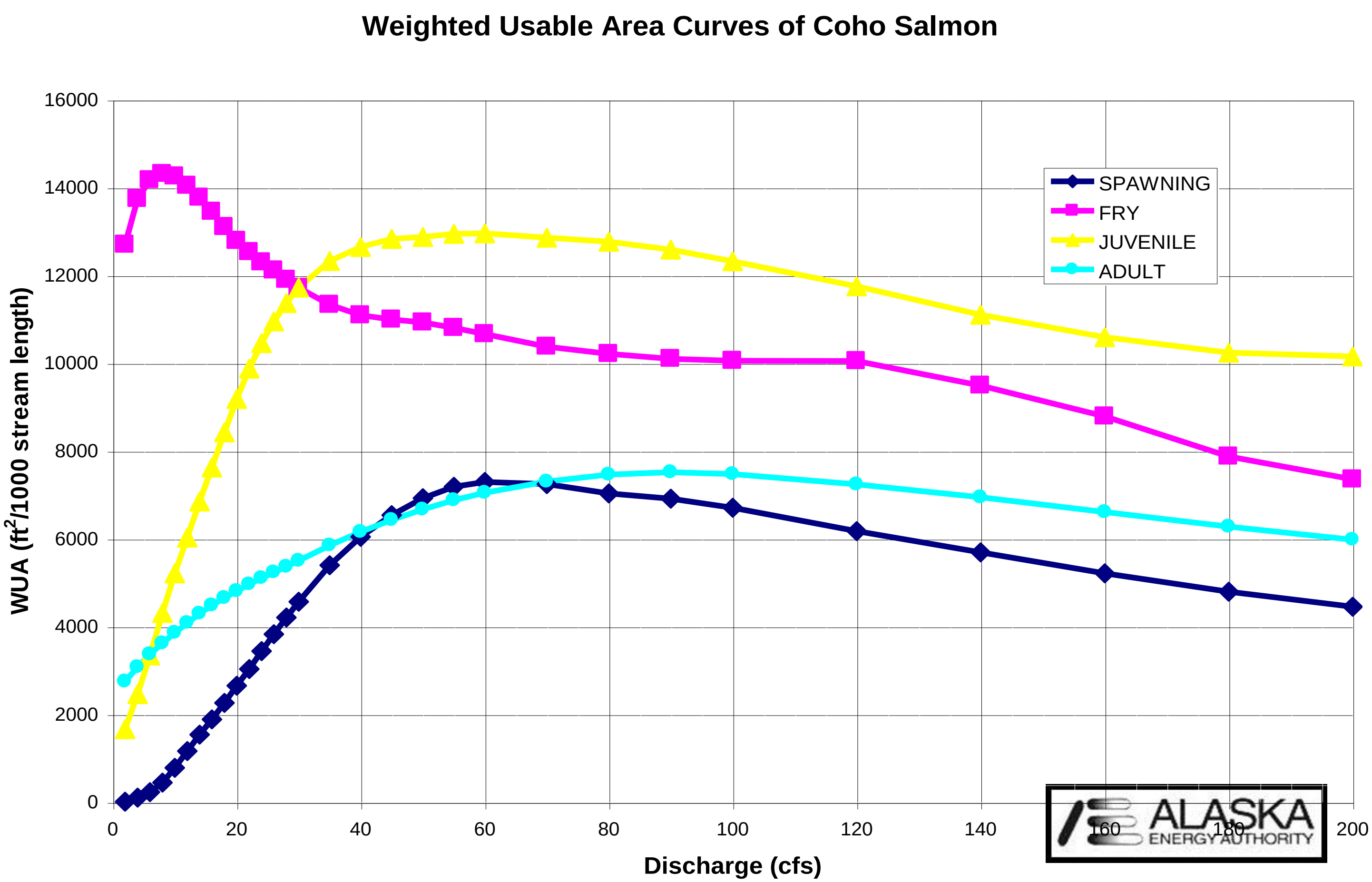
WP – "inflection points" = minimum flow



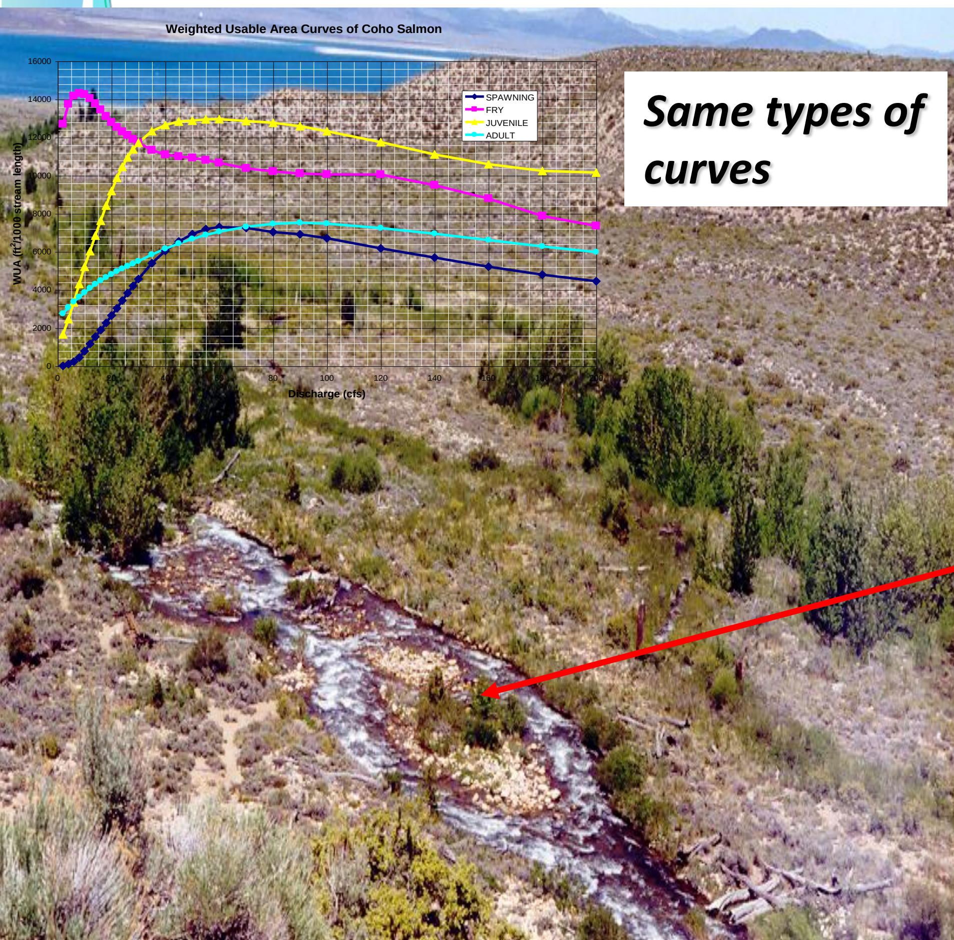
PHABSIM – 1-dimensional modeling Habitat:Q

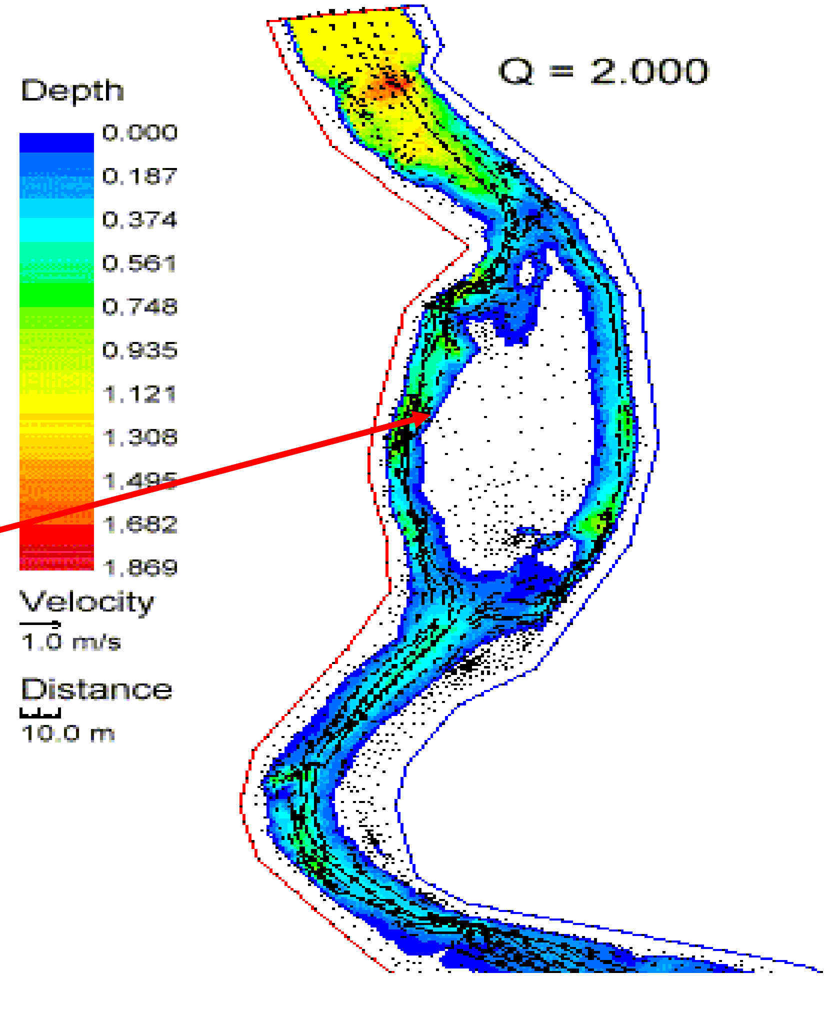
Weighted usable area (WUA) v Q – <u>starting point</u>

Incremental method – evaluate tradeoffs

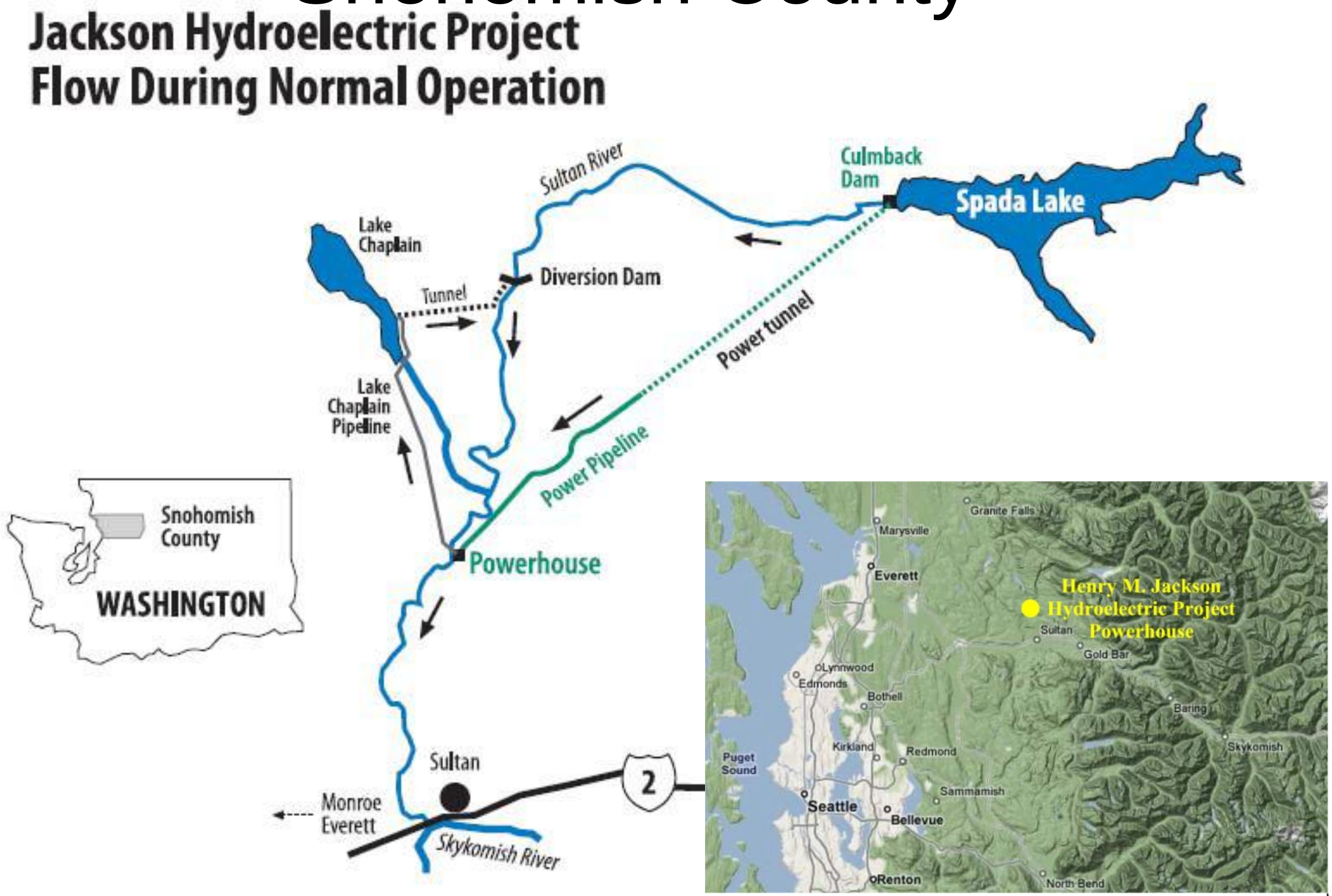


PHABSIM -2-dimensional modeling





Henry M. Jackson Hydroelectric Project (FERC 2157) Public Utilities District No. 1 of Snohomish County



VATANA
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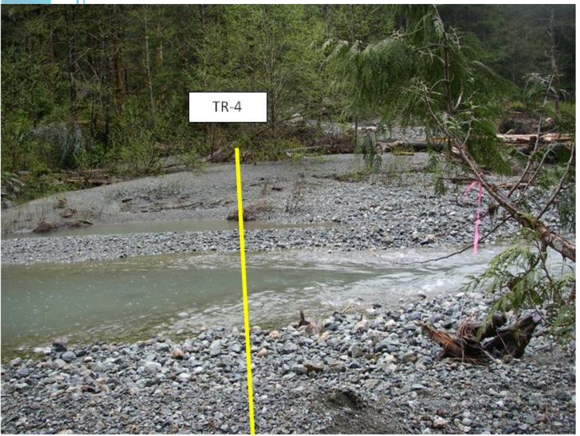
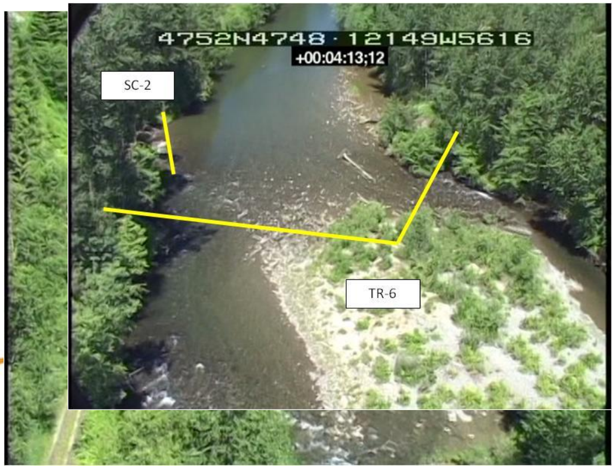
Project Objectives – Methods

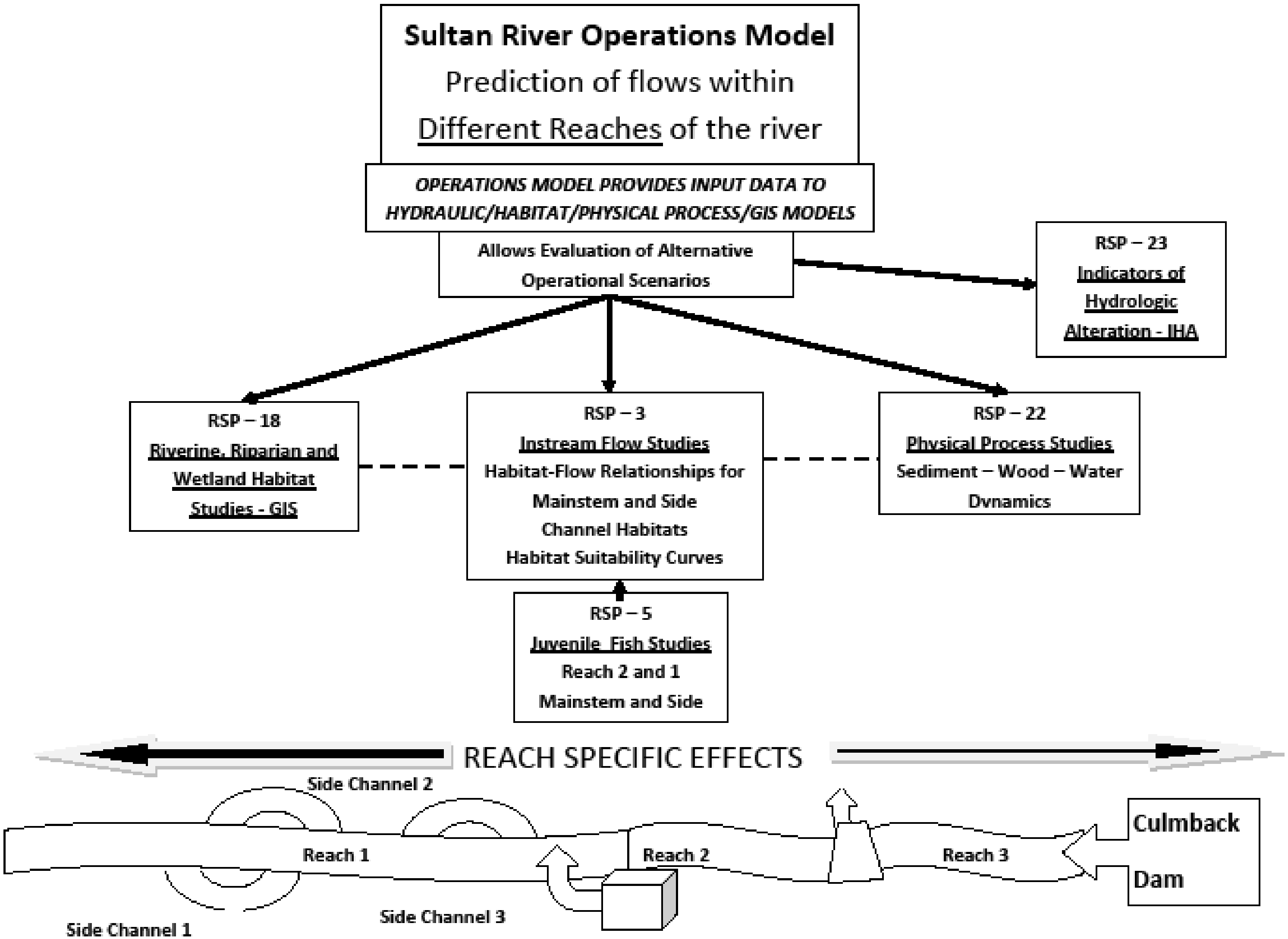
- Develop reach-specific habitat:flow relationships for target species/lifestages – Apply 1-D PHABSIM modeling.

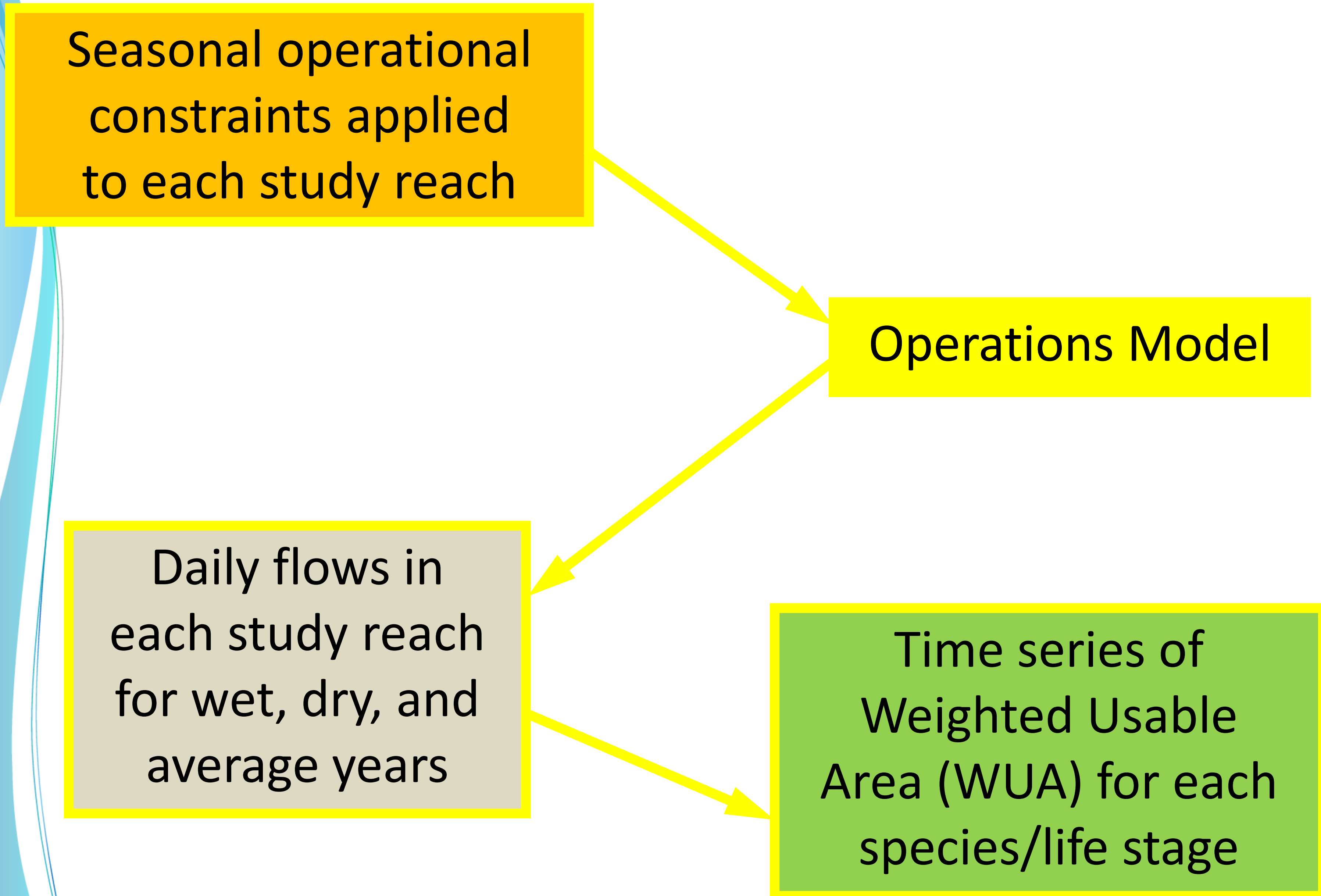
** Develop integrated <u>aquatic habitat model</u> that produces <u>a time series</u> of data over a range of flow conditions and under select alternative <u>operational scenarios</u>.*





STUDY INTEGRATION

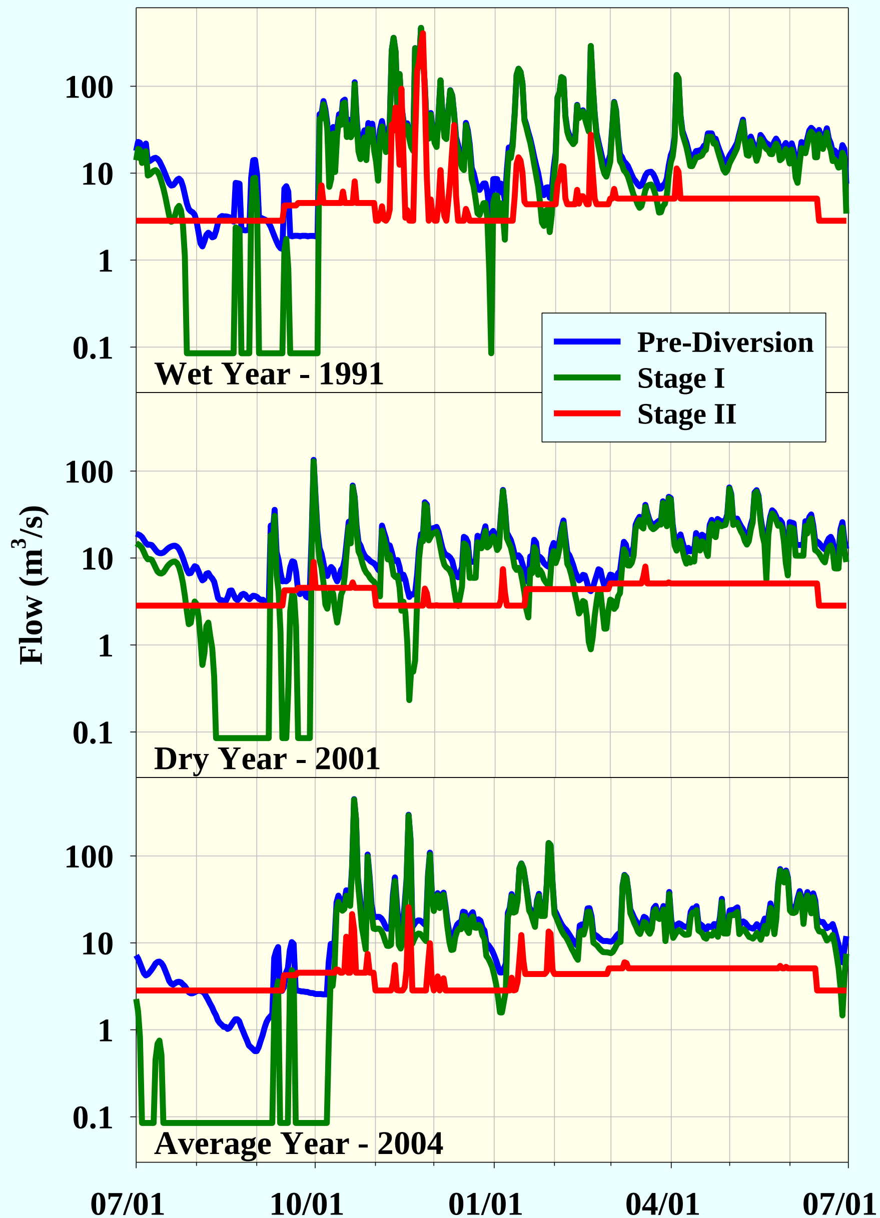




SUSITNA-WATANA
HYDROELECTRIC PROJECT

Operations Model

Daily flows at upstream end of Reach 2



Link to ➔

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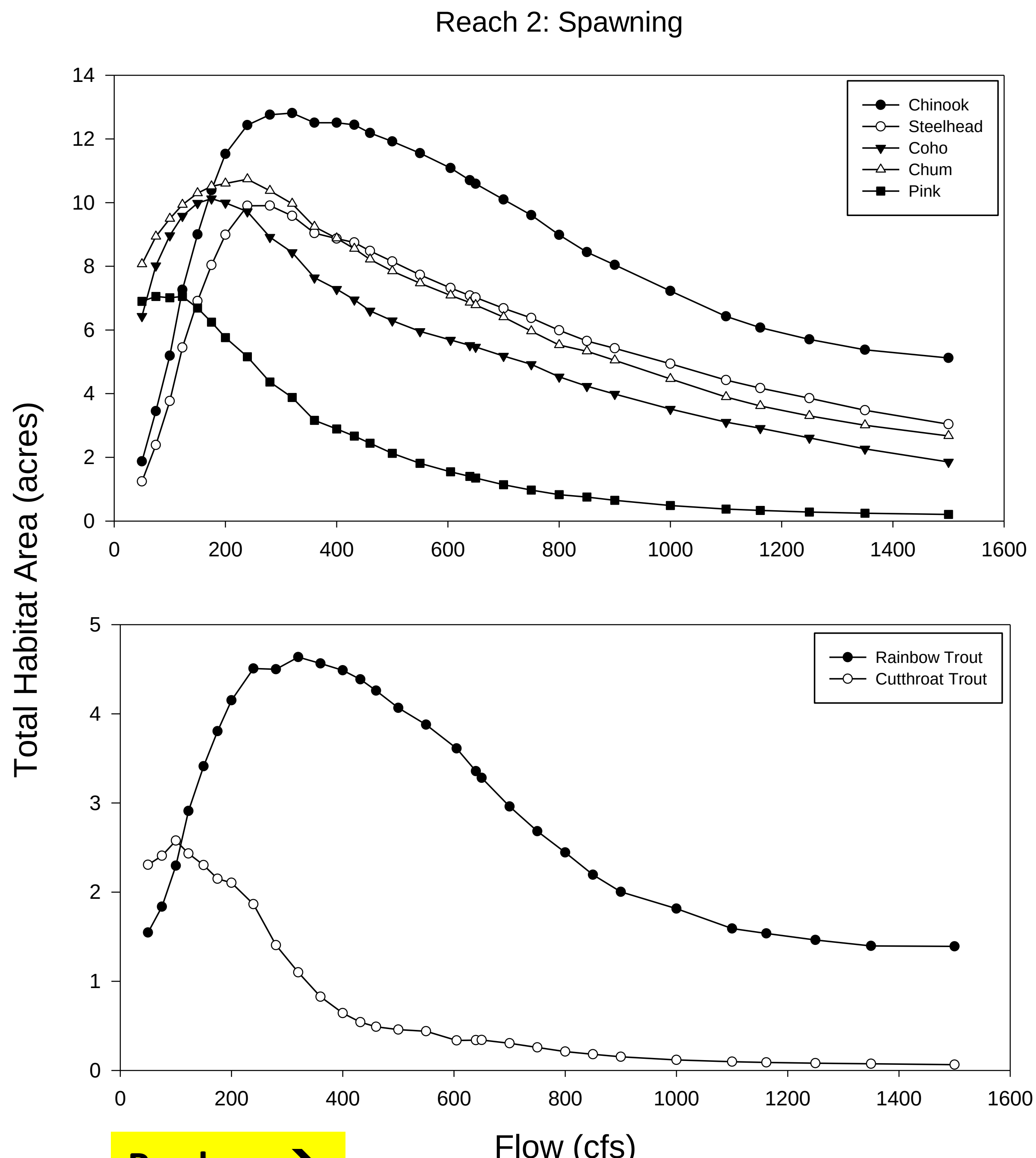
PHABSIM Analysis



Produce →

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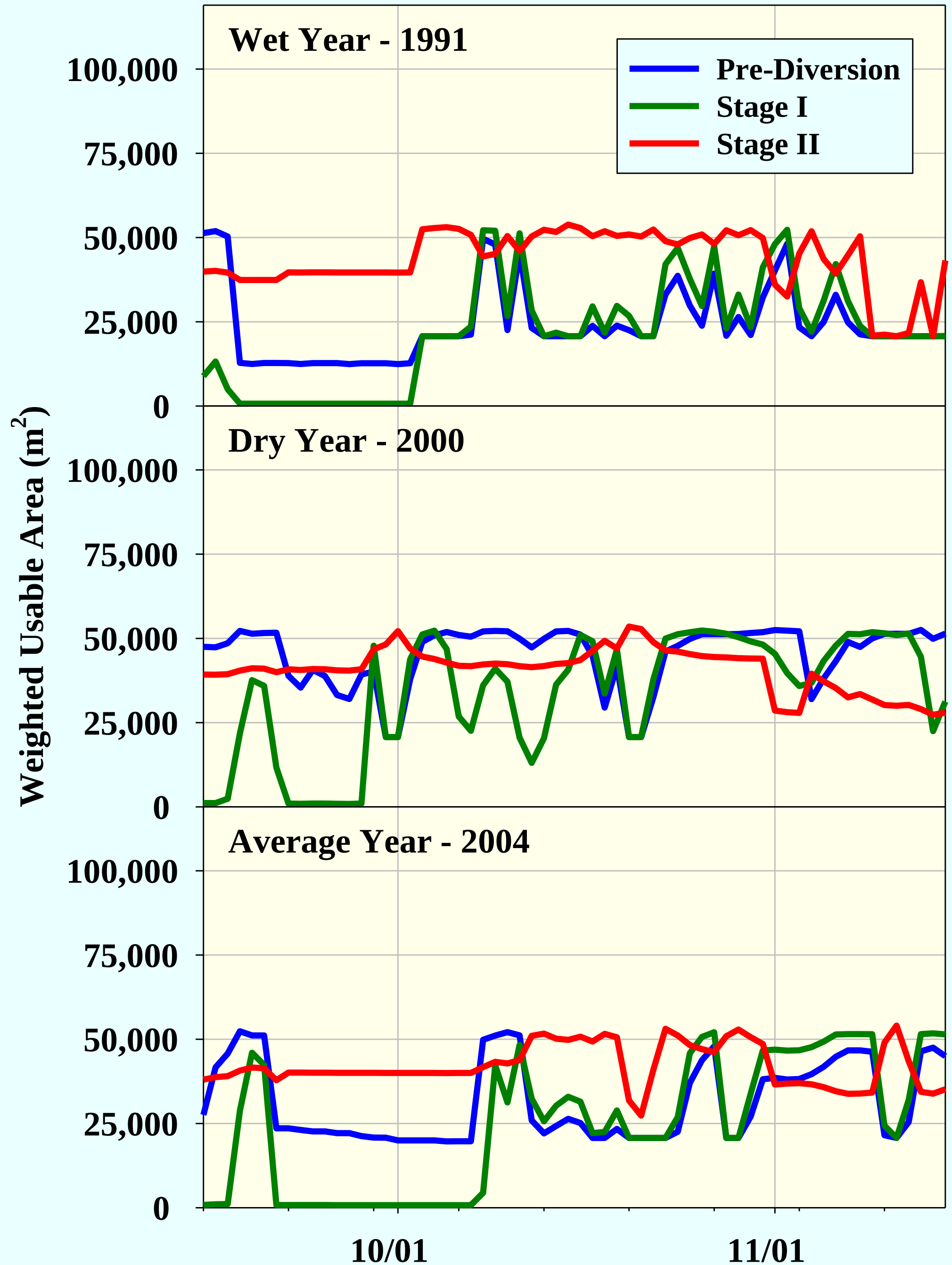
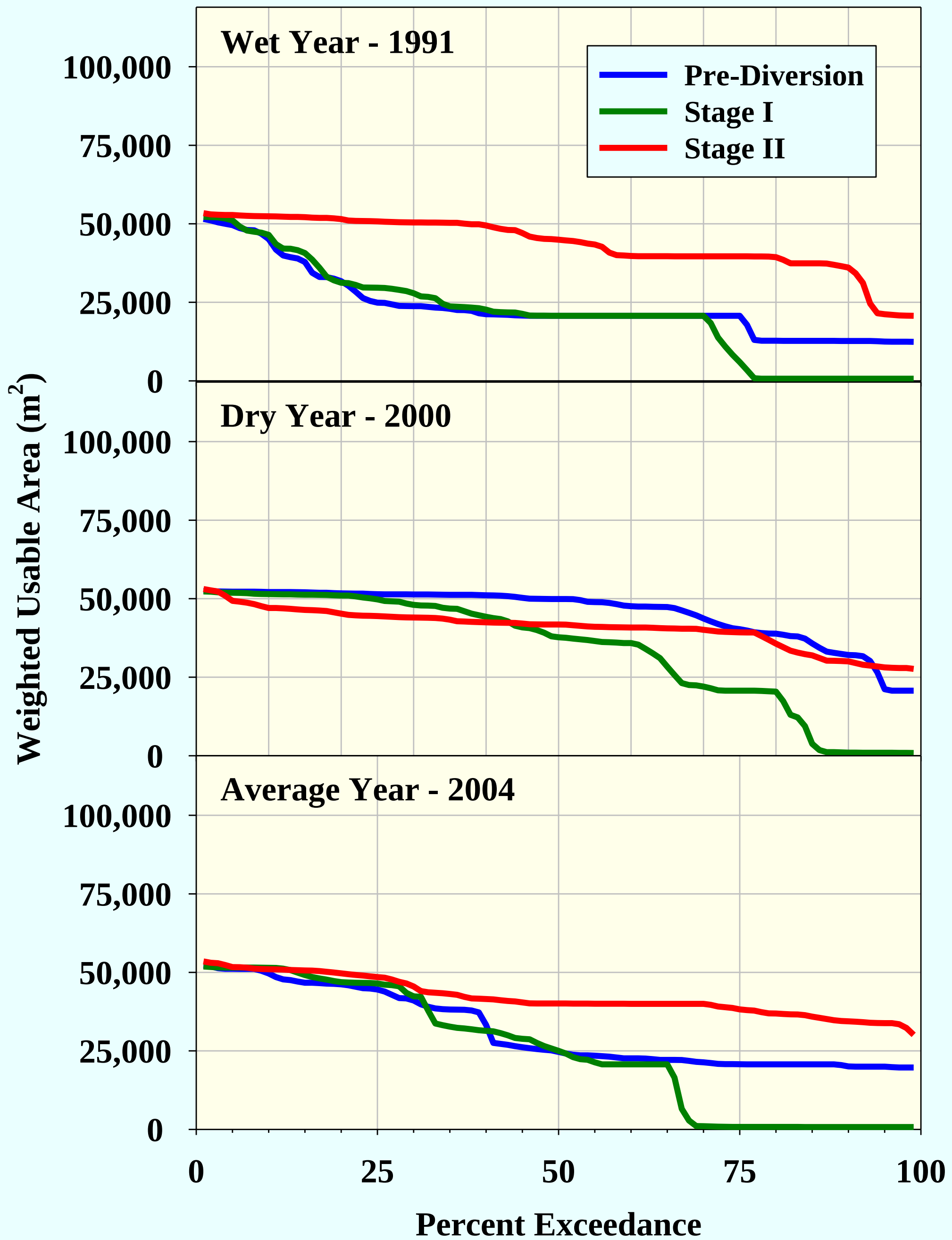
Time Series of Chinook spawning Weighted Usable Area in Reach 2

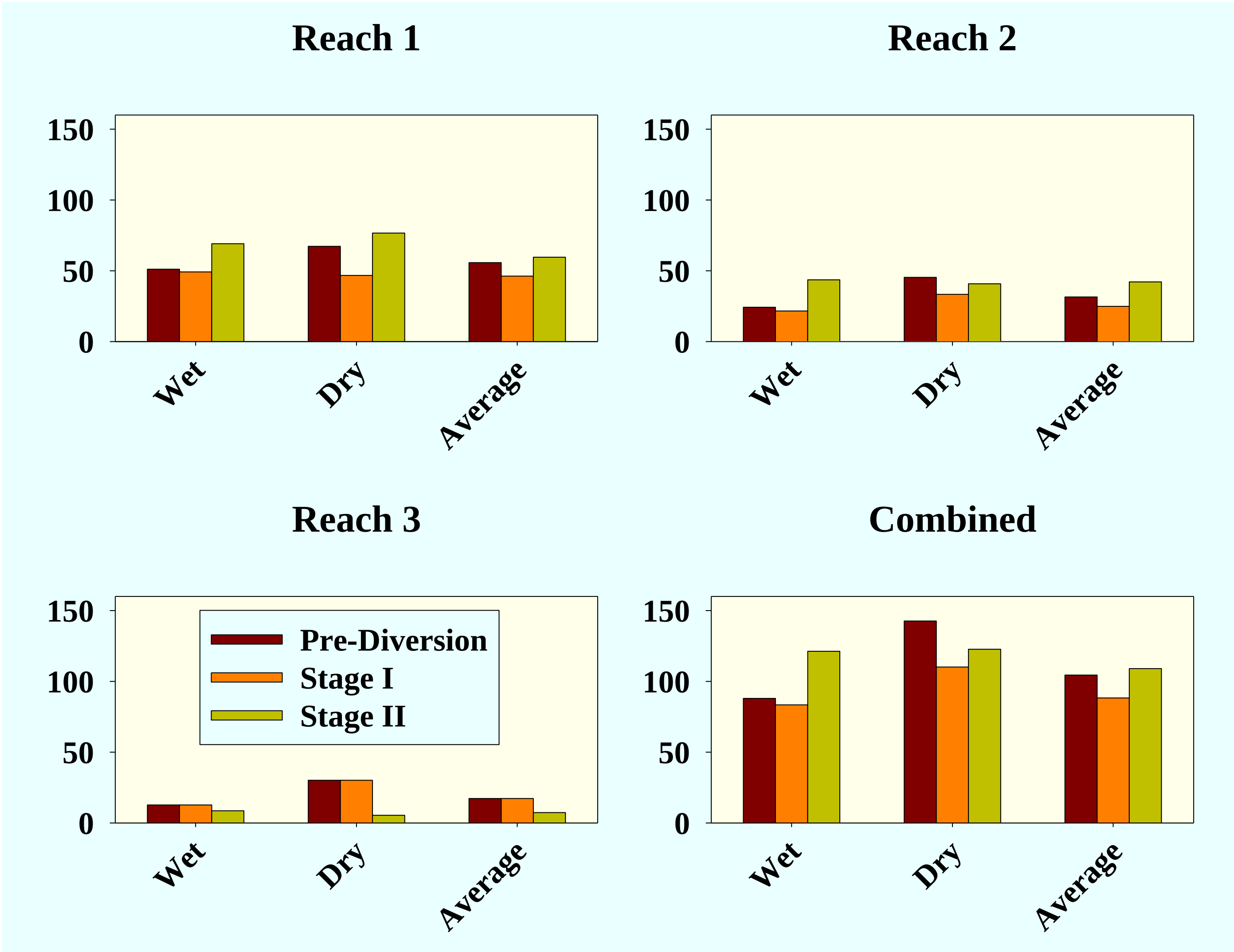


Habitat Duration

Chinook
spawning
in Reach 2



Chinook Spawning Habitat Summary
Average Weighted Usable Area (1,000 m²)



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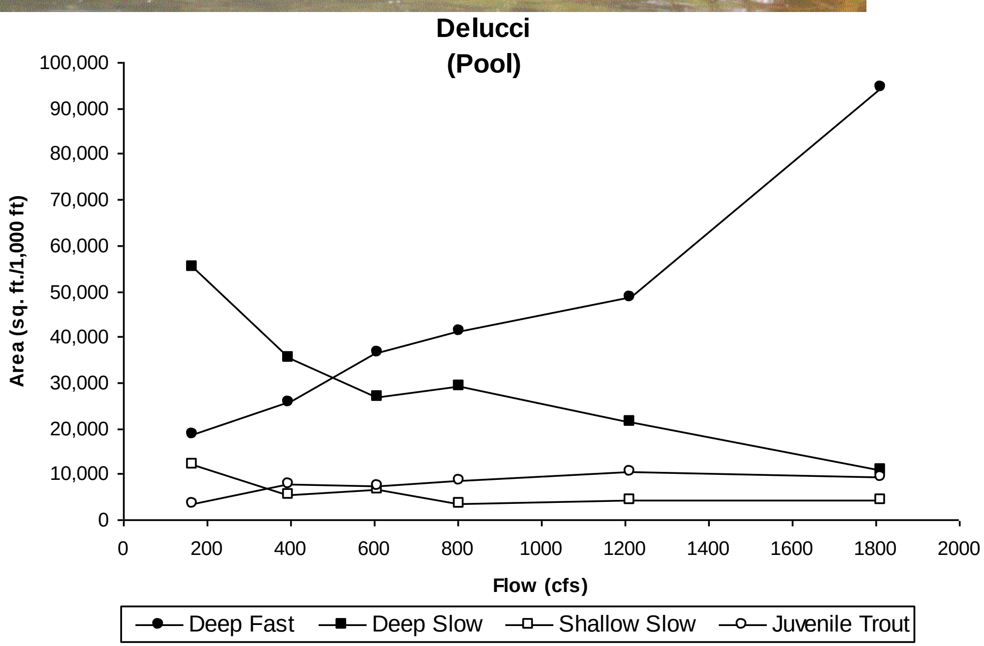
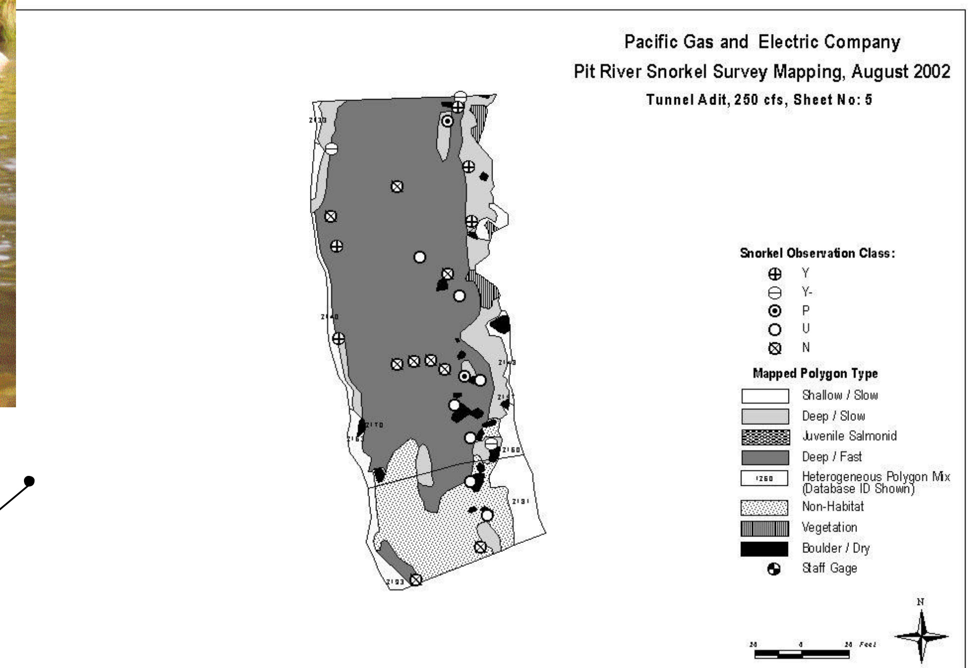
HABITAT MAPPING AT MULTIPLE FLOWS - PGandE Pitt 3,4,5





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Habitat Mapping Spring Flow Releases / Aerial Photography

- Base, 250, 400, 600, 800, 1200 cfs
- Photograph Entire Pit 3, 4, 5 Reach
- 1:7200 Scale, 10 cm Pixel
- Goal: Produce Photographs That Could be Used to Map Microhabitat Polygons and Riparian Vegetation

ps

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Digitized, QA/QC'd Maps

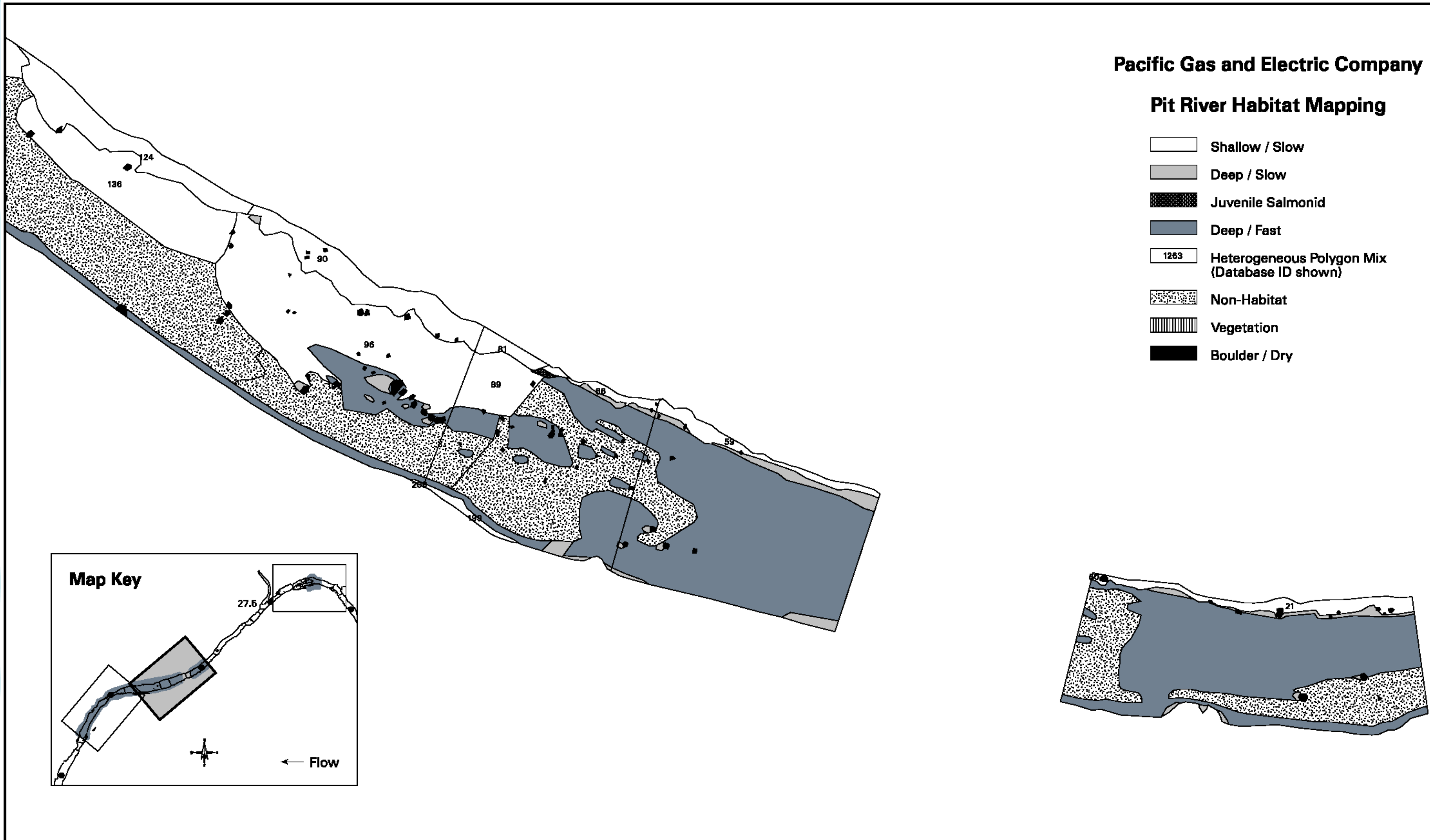

Figure C-47. Digitized microhabitat polygons for the Pit 3, 4, 5 Project (Kosk Creek, 800 cfs, Map 1 of 2)

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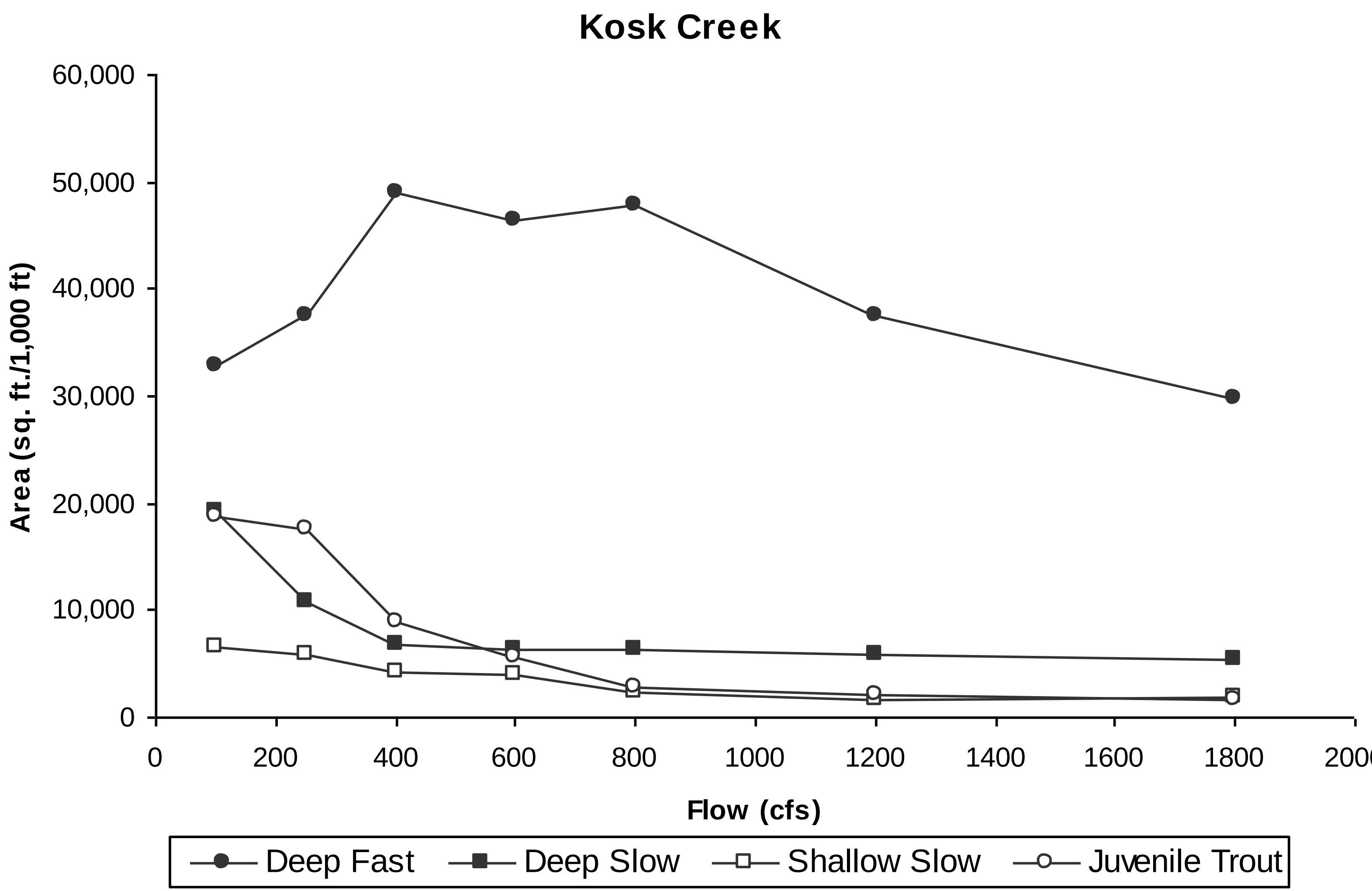
Microhabitat-Flow Curves: By Site



ANA
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Stranding/Trapping and Varial Zone Analysis

Susitna-Watana
Instream Flow Study – Fish
-Methods Selection -

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Susitna-Watana Instream Flow Study-Fish

- WUA for target species and lifestages
- Effective Spawning Habitat
  - dewatering
  - upwelling
  - water temperature and DO
  - sediment transport
  - ice processes
- Varial Zone (stranding and trapping)
- Ramping Rates
- Passage/habitat connectivity

IFS Program Goal is to:

identify existing, or develop new method(s) best suited for evaluating potential effects of flow regulation of the Susitana-Watana Dam Project and its operations on fish and aquatic resources of the Susitna River

SUSITNA-WATANA
HYDROELECTRIC PROJECT

Methods Selection

Process (coordinated with TWG):

- Review methods utilized in 1980s
- Review contemporary methods and models
- Identify habitat types and features warranting habitat- flow assessment
- Select one or more methods best suited to evaluate flow effects for each habitat type and feature
- Review with TWG and reach agreement on specific methods to be applied in 2013 – *Prepare TM describing Methods selection process*

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Methods Selection

Considerations/Criteria:

- The predictive capability of the method or model to extrapolate results over a range of flows.
- The ability of the method to depict flow and habitat changes incrementally.
- The applicability of the methodology to different fish species (and life stages), including anadromous and resident salmonids.
- The biological soundness of the methodology results (i.e., habitat-flow relationship curves and criteria that relate directly to the fish species present in the Susitna River system).
- The sensitivity of the method/model output to the individual user (i.e., ability to control bias).
- The reproducibility of results, both field data collection and modeling.
- Compatibility of model/methods results into operations modeling
- The acceptability of the method/model by TWG members.

SUSITNA-WATANA
HYDROELECTRIC PROJECT

Instream Flow – Fish

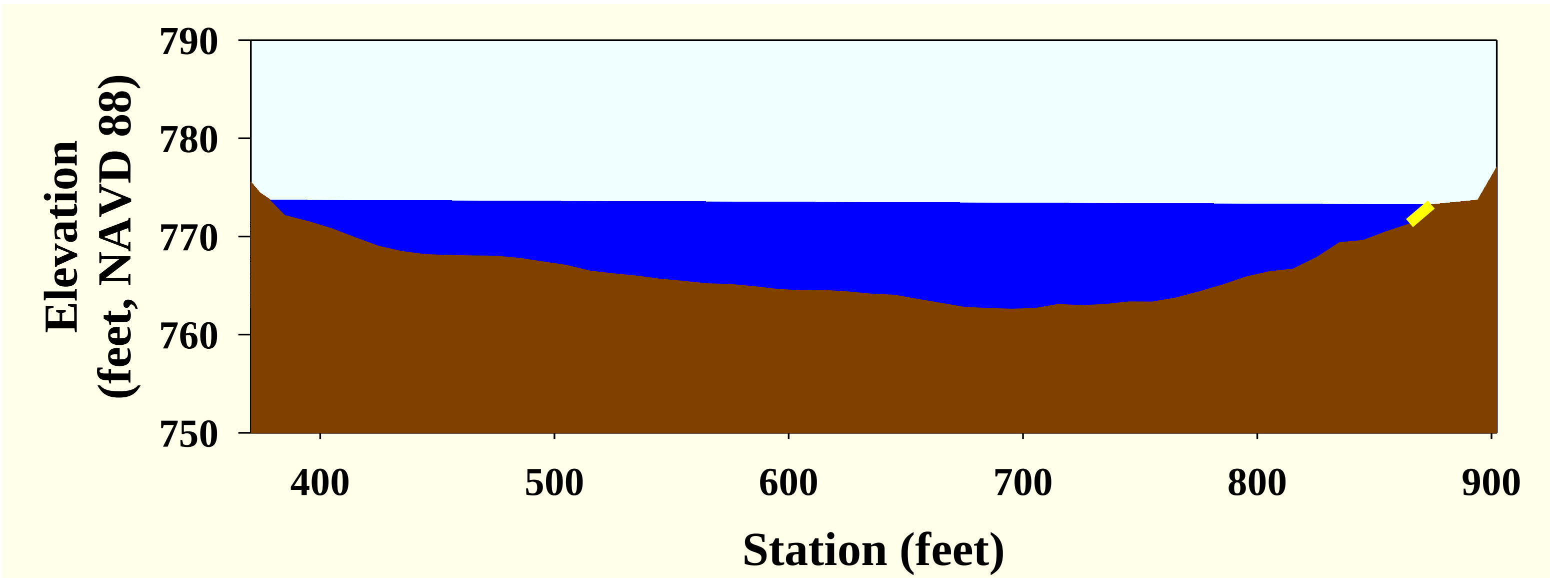
Proposed habitat modeling techniques at instream flow-fish study sites (primary/secondary)

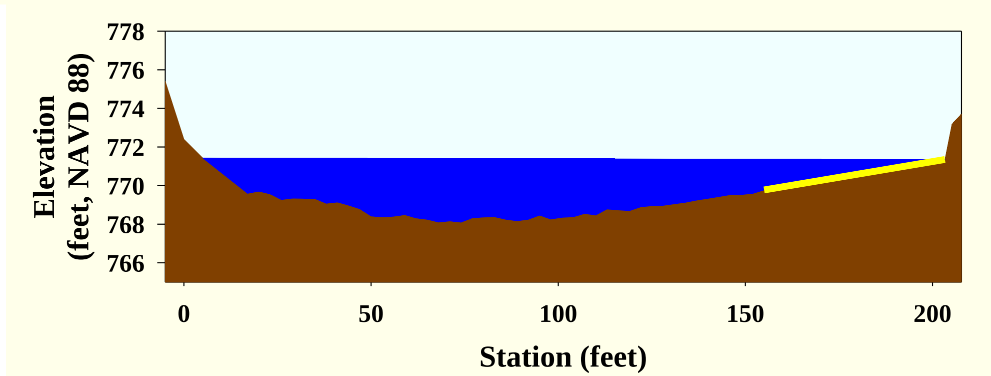
Physical & Biological Processes	Habitat Types			
	Mainchannel	Side Channel	Slough	Tributary Mouths
Spawning	ESH/PHAB(2D)	ESH/PHAB(2D)	ESH/PHAB(2D)	ESH/PHAB
Incubation	ESH	ESH	ESH	ESH
Juvenile Rearing	PHAB(2D)	PHAB(2D)	PHAB(2D)/HabMap	PHAB
Adult Holding	PHAB(2D)	PHAB(2D)	PHAB(2D)	PHAB/HabMap
Macroinvertebrates	VZM	VZM	VZM	VZM
Standing/Trapping	VZM	VZM	VZM	VZM
Upwelling/Downwelling	HabMap	HabMap	HabMap	HabMap
Temperature	WQ	WQ	WQ	WQ
Ice Formation	IPM/WQ/HabMap	IPM/WQ/HabMap	IPM/WQ/HabMap	NA

PHAB-Physical Habitat Simulation Modeling (2D, 1D, or empirical); ESH-Effective Spawning Habitat ; VZM-Varial Zone Modeling; HabMap-Surface Area Mapping; WQ-Water Quality Modeling; WP-Wetted Perimeter Modeling; IPM-Ice Processes Model

* Does not consider main-channel x-sections measured for Q routing model; 78 transects in Middle Reach: 16 above Devils Canyon/61 below; 19 transects in Lower Reach

"Brailey" RM 143.2 – Main/Side Channels
Total Q = 32,700 cfs – June 27, 2012





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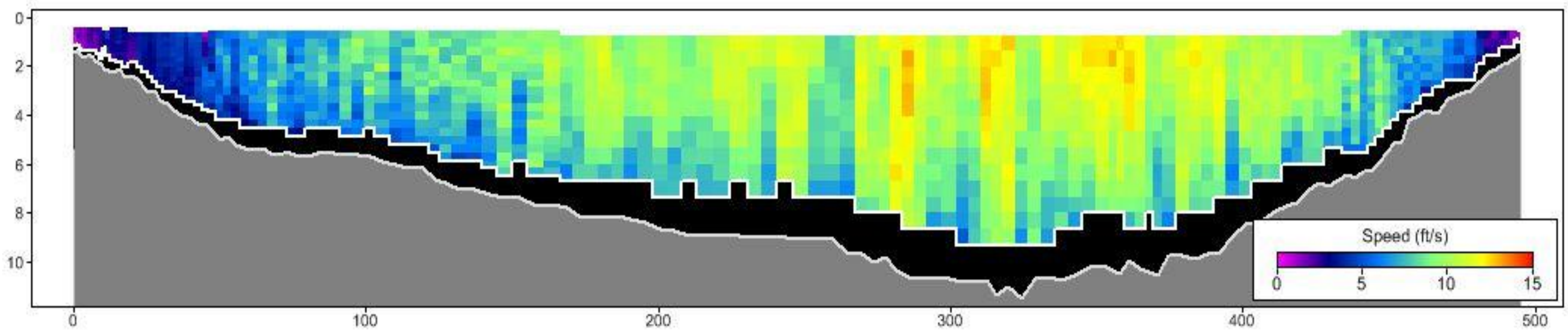
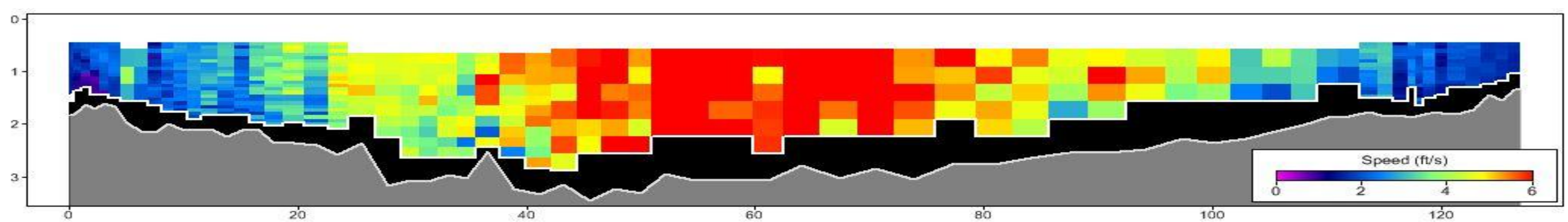
“Brailey” RM 143.2 – Main/Side Channels Total Q = 32,700 cfs – June 27, 2012





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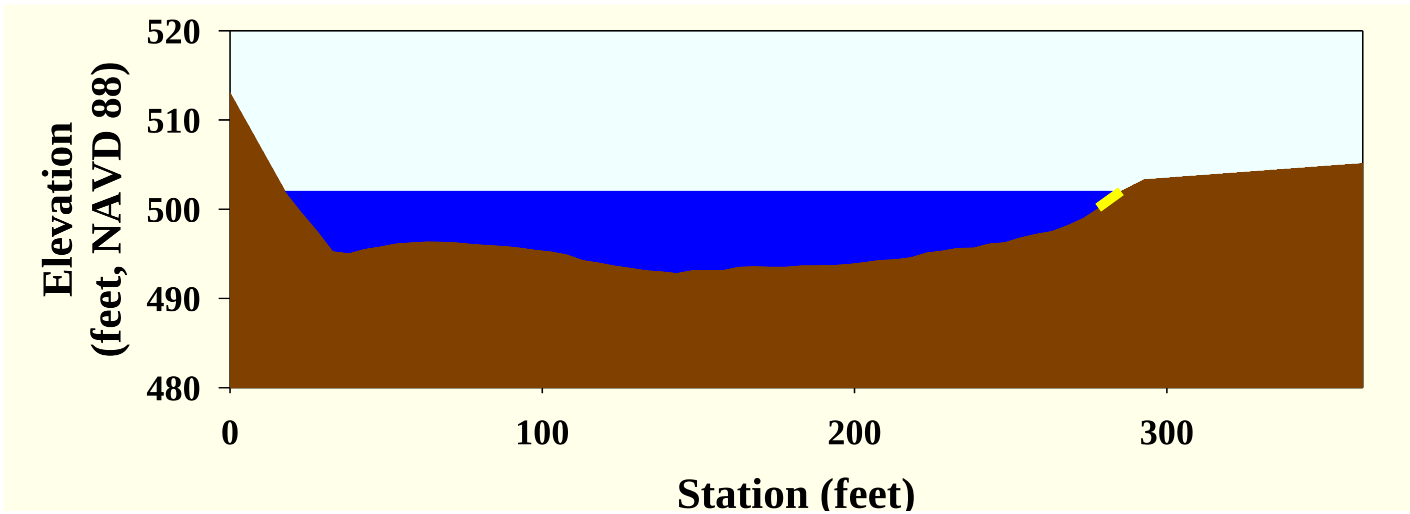
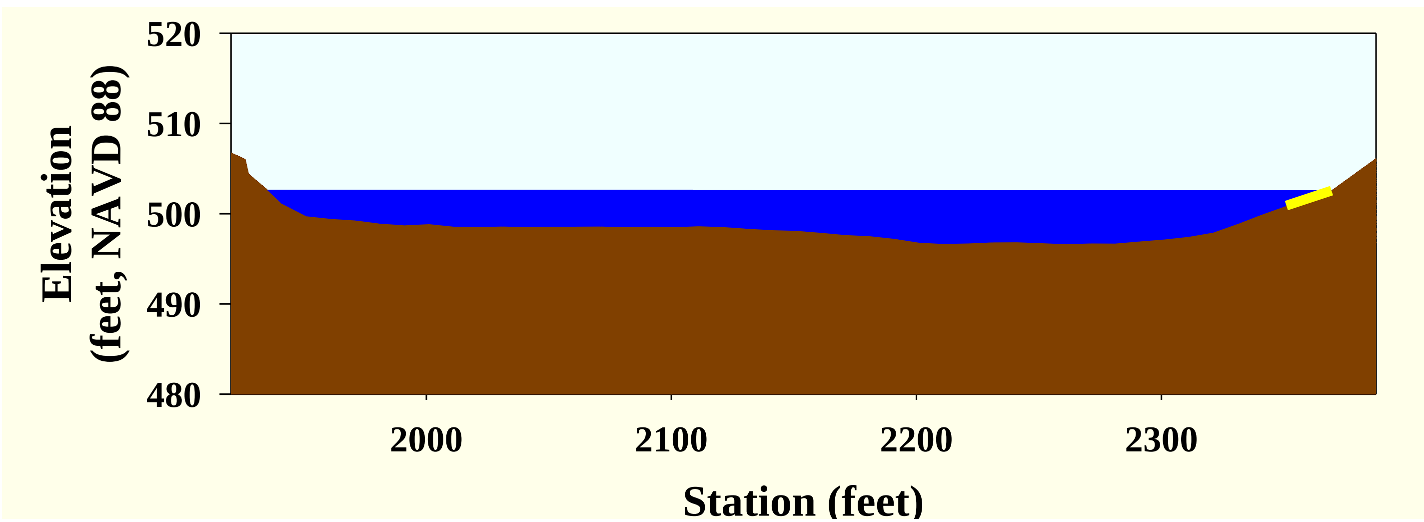
"Brailey" RM 117.2 – Left/Right Channel Total Q = 23,000 cfs – July 6, 2012





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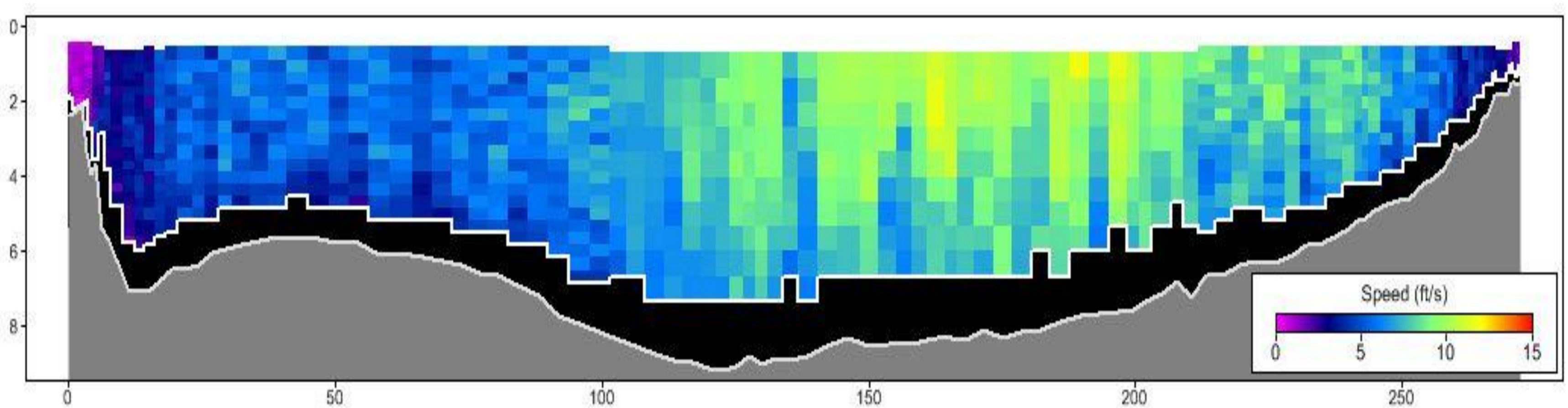
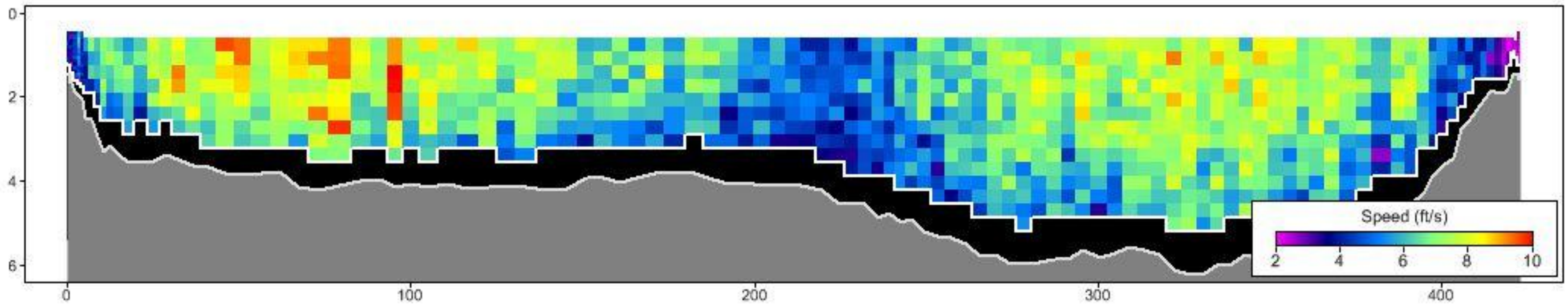
“Brailey” RM 117.2 – Left/Right Channel
Total Q = 23,000 cfs – July 6, 2012





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Tying It All Together
Decision Support System

Decision Support System (DSS)

Objectives

- Developed to assist in water management decisions regarding choices among different operating rules or scenarios (Auble et al. 2009)
- Goal of a DSS is to reduce the complexity of large data sets of simulated flow alternatives
- Basic approach is to array indicators of resources and responses
- Analyze and interpret water management and reservoir operations by focusing attention on tradeoffs among indicators

Decision Support System (DSS)

What are Indicators?

- Indicators are explicit and replicable calculations that describe the effects of alternate flow regimes

Caveats

- Indicators imperfectly represent physical and biological responses
- Balance between reducing complexity and oversimplification
- Decision support systems are not used to identify a preferred alternative, but to inform the evaluation of alternatives

Decision Support System (DSS)

Conceptual DSS Indicators

- Power
- Hydrologic
- Reservoir
- Ramping rates
- Varial Zone (stranding and trapping)
- Salmon Spawning and Incubation
- Riparian
- Recreation and Access
- Other Aquatic

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Decision Support System (DSS)

Refer to handout or MSProject file:

Conceptual Comparison of Multiple Resource Indicators of Alternate Operational Scenarios

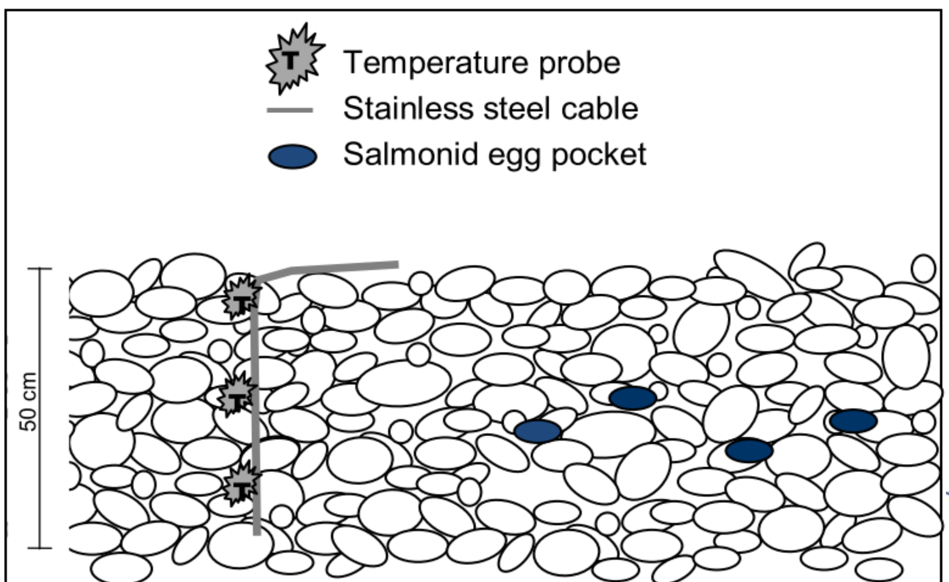
[SuWa_ScenarioCompExample_20120926.doc]

(Indicators and values are provided for illustration purposes only)

Pilot Winter Studies

Pilot Winter Studies

- Objectives:
  1. Monitor intergravel temperature and DO conditions in and near known spawning areas (determine egg incubation conditions (and estimate emergence times) and collect data that will assist in determining how these conditions may change relative to flow regulation)
     - *Information important for understanding spatially distinct patterns of egg incubation and fry emergence timing and duration that can be used in evaluating potential project operational effects*



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Pilot Winter Studies

- Objectives (continued):
  2. Monitor intergravel temperatures proximal to upwelling areas and within main channel
     - Useful for understanding groundwater/surface water interactions
  3. Define zones of groundwater influence – installation and monitoring of piezometers
  4. Evaluate juvenile fish behavior, habitat utilization, and relative abundance during winter conditions (under ice and open water threads)
     - *Information important for understanding current use patterns and potential project operational effects*

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Pilot Winter Studies

- Objectives (continued):

5. Pilot study - Test different monitoring devices and sampling approaches:
    - Temperature: Onset TidbiT v2, TinyTag, Remote, FLIR Handheld
    - DO: Onset Combination Temperature and DO recorder (HOBO Dissolved Oxygen Logger - U26-001; YSI, others)
    - UW Cameras, including DIDSON
    - Pressure transducers/stage recorders
    - Piezometers
    - Fish sampling approaches: minnow traps, trot lines, etc.
6. Expand studies in 2013 (other seasonal monitoring)

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Pilot Winter Studies

Two Study Sites:

* Whiskers Slough Complex
* Slough 8A

See Mock-ups of Study Sites

Habitat Suitability Criteria (HSC) 1980s Summary

ALASKA
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Microhabitat Study Sites from 1980s Susitna Studies

Study Site	RM*	Juvenile Salmon Rearing	Resident Adult	Salmon Spawning
Whiskers Cr. Slough	101	✓	✓	
Whiskers Cr.	101		✓	
Chase Cr.	107	✓		
Slough 5	108	✓		
Oxbow 1	110	✓		
Slough 6A	112	✓	✓	
Lane Cr.	114		✓	
Slough 8	114	✓		
Mainstem 2	114	✓		
Slough 8A	125	✓	✓	✓
Fourth of July Cr.	131		✓	✓
Slough 9	129	✓		✓
Slough 9A	133			✓
Sidechannel 10A	127	✓		
Sidechannel 10	134	✓		
Slough 11	135	✓	✓	✓
Indian River	139	✓	✓	✓
Slough 17	138			✓
Slough 20	140			✓
Jack Long Creek	145		✓	
Slough 21	142	✓		✓
Slough 22	144	✓		✓
Portage Creek	149	✓	✓	✓
Cheechako Cr.	153			✓

*Approximate river-miles based on 1980s reports

Preliminary Summary of Microhabitat Data Collected During 1980s Susitna Studies

(values indicate individual fish observations)

Species	Life Stage	Depth	Velocity	Substrate	Upwelling*	Cover	Turbidity*
Coho	Juvenile	2,020	2,020	2,020	0	2,020	0
Chinook	Juvenile	4,395	4,395	4,395	0	4,395	0
	Spawning	265	265	265	0	0	0
Sockeye	Juvenile	1,006	1,006	1,006	0	1,006	0
	Spawning	81	65	81	56	0	0
Chum	Juvenile	1,157	1,157	1,157	0	1,157	0
	Spawning	386	386	360	235	0	0
Pink	Spawning	8	8	8	0	0	0
Rainbow Trout	Adult	143	143	0	0	143	143
Dolly Varden	Adult	2	2	0	0	2	2
Arctic Grayling	Adult	140	140	0	0	140	140
Humpback Whitefish	Adult	15	15	0	0	15	15
Round Whitefish	Adult	384	384	0	0	384	384
Longnose Sucker	Adult	157	157	0	0	157	157
Burbot	Adult	18	18	0	0	18	18

*Binary data

HSC Curves Developed during 1980s Susitna Studies

Species	Life Stage	Depth	Velocity	Substrate	Upwelling	Cover	Turbidity[4]
Coho	Juvenile	✓[1]	✓			✓	
	Spawning	✓	✓	✓			
Chinook	Juvenile	✓[1]	✓			✓	✓
	Spawning	✓	✓	✓			
Sockeye	Juvenile	✓[1]	✓			✓	
	Spawning	✓	✓	✓	✓[3]		
Chum	Juvenile	✓[1]	✓			✓	
	Spawning	✓	✓	✓	✓[3]		
Pink	Spawning	✓	✓	✓			
Rainbow Trout	Adult	✓[2]	✓			✓	✓
Arctic Grayling	Adult	✓[2]	✓			✓	✓
Round Whitefish	Juvenile	✓	✓			✓	✓
	Adult	✓[2]	✓			✓	✓
Longnose Sucker	Adult	✓[2]	✓			✓	✓

[1, 2] Depth curves for multiple species combined
[3] Integrated with substrate suitability
[4] Separate curves developed for clear vs. turbid water for one or more parameters

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