PART A - APPENDIX C: PHYSICAL, HYDROLOGICAL, AND ENGINEERING INFORMATION

PART A - APPENDIX D: DETAILED STUDY SCHEDULE UPDATED JULY 10, 2013

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Study of Fish Passage Feasibility at Watana Dam (9.11)

Part A - Appendix C
Physical, Hydrological, and Engineering Information

Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

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Prepared by

[R2 Resource Consultants Inc. &

LGL Alaska Research Associates, Inc.]

June 2014

Table C-1. List of physical, hydrologic and engineering information needs. The available information as of January 8, 2014 follows in this appendix. Except where the noted initial compilation of information was provided to the FPTWG prior to Workshop #1 (April 9 and 10, 2013) and updates provided prior to the Site Visit (September 18 and 19, 2013).

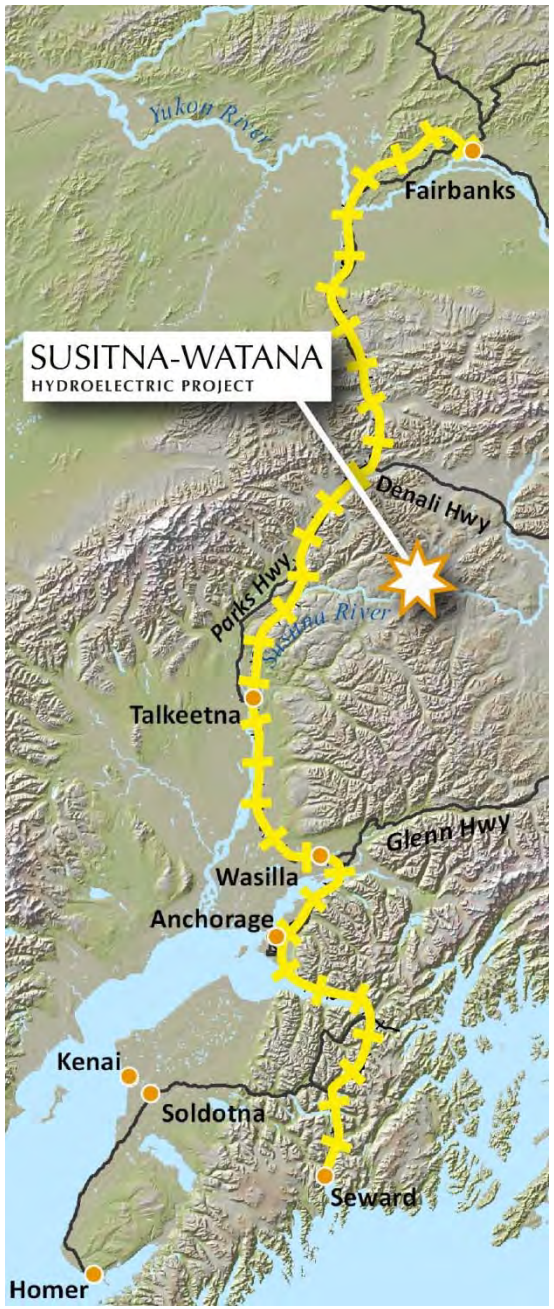
No.	Item	Comments
P1	Water quality & water temperature under existing conditions, main stem & tributaries	1980 data exists. New data is being collected. Results from field data collection and model selection in 2012 report summary, see web for report and 2 appendices (http://www.susitna-watanahydro.org/wp-content/uploads/2013/03/2012_WaterQuality_TM.pdf). 2012-2013. Review data from Gold Creek. Note significant milestones from 2013 field season data. See current study plan (RSP 5.5 – Baseline Water Quality Study). Confirm with R. Plotnikoff that we can get modeled velocity data for reservoir, understand what info will be provided. Currents through reservoir, confirm data and presentation.
P2	Water quality & water temperature above & below proposed dam	Same as above. Look for surrogate sites, similar lakes, smaller tributaries, etc. D. Schmidt will investigate and report on status (exists, or no data). Goal by January 8, 2014.
P3	Tailwater Rating curves at dam and expected trap location	Forebay rating information is in Item P5 below. 1980's data. Use to start. Updates with new survey data will likely available by December, 2013. Draft tailwater rating curve provided to FPTWG on April 22, 2013.
P4	Flow duration by month, through turbines, spillways, other outlets	From operations modeling. J. Haapala provided summary of all duration flows with spreadsheet; presented May 21, 2013. Data provided for Operational Scenario (OS) OS-1. AEA to provide feedback on other run scenarios (i.e., run of river). When can we get other runs to fill in sideboards? (note action item for AEA).
P5	Reservoir elevation duration curves by month	From operations modeling. Have data for OS-1. Could have other data for other Operational Runs, see P4 also. Draft curves provided to FPTWG on April 22. To be posted to web.
P6	Other project operations data (rule curve, expected operating restrictions)	See Items P4 and P5 – relates to what operational scenarios are going to be run. Need input from AEA.
P7	Ice cover on river and tributaries in project area before project	Ice conditions annually Oct-May. See RSP 7.6 - Ice Processes in the Susitna River Study. Request more of an annual summary of typical seasonal ice issues, access, etc. at the tributaries of interest. Biological component to correlate with life cycle by species.
P8	Ice cover on reservoir and in river below dam	Dana S. to search for analogous reservoirs for Kokanee, etc. Will have ice model from WQ study, R. Plotnikoff will give update on model study, see action items. Pending.
P9	Water temperatures during upstream migration period	See WQ Study (P1), more data will be coming. Coordinate with climate change studies. Goal is to define range potentials in the future to assure fish passage design is flexible, can be expanded, can function over range, etc. So design won't be obsolete, etc. Add this item to several items, revisit off line.
P10	Water temperatures during downstream migration period	See WQ Study (P1), more data will be coming.
P11	Air temperature, wind, light, MET station info information by month (max, min, average)	Estimate fetch, etc. from available data. Some data likely available in the fall of 2013.

No.	Item	Comments
P12	Sediment information (transport rates, sediment gradation, sediment sources & their location)	2012 Report on Project website – Documents – 2012 Environmental Studies (http://www.susitna-watanahydro.org/wp-content/uploads/2013/03/SuWa-2012-Sediment-Report.pdf). Tributaries: modeling potential for perching and barrier potential at mouths. Model scheduled to be completed 2014. Sediment data being collected this summer. Be aware of ISR/USR, quarterly data updates. Ask B. Fullerton to send provisional data to this group. Prioritize tributary data.
P13	River morphology trends after project operation	Model results in 2014. Fluvial Geomorphology Modeling below Watana Dam Study (6.6) RSP (http://www.susitna-watanahydro.org/wp-content/uploads/2012/12/02-RSP-Dec2012_2of8-Sec-6-Geomorphology-v2.pdf).
P14	Topographic mapping of the project site and along river downstream. Tsusena Creek.	Fish passage will be sketched on these sheets. D. Dorratcague, D. Postlewait, D. Turner – to refine this data need. Request centerline profiles for any available tributaries upstream and downstream of dam. Use best available data. Check with J. Zablotney, GIS. Get available cross section data – D. Dorratcague.
P15	Current dam layout drawings, plans, elevations, and cross sections (include details of outlet works and spillways)	Fish passage will be sketched on these sheets. Prefer simplified, scale drawings with a plan, section, and elevation suitable for brainstorm sketching in 11x17 format. Any 3D drawings showing general arrangement would also be helpful. This is CEII information. FPTWG participants were asked to sign CEII forms for access to copies of this data. Data presented at this point in time, note overall dam design schedule.
P16	Makeup of project components – turbines (number & type), outlet valves & gates	See Aled Hughe's (MWH) presentation and updated plan view of Watana Dam provided by MWH on 9/4/2013. This is CEII information. FPTWG participants were asked to sign CEII forms for access to copies of this data.
P17	Projected operation of project turbines, gates, & valves	Turbines operate to meet Railbelt loads and minimum flow requirements. Fixed-cone valves operate to control floods up to about the 1 in 50 year event. The gated spillway operates for floods greater than about the 1 in 50 year event. Refinements to this operation are to be determined. Operations data presented based on 3 turbine arrangement.
P18	Site access or restrictions to access for operation and maintenance. Include entire project area at dam, along reservoir, and into tributaries (i.e., existing or planned access roads)	Three potential corridors are under study for access to the dam.
P19	Electrical power availability	FPTWG can provide more info later on load requirements. Substation will be on hill, right abutment.
P20	Amounts and types of debris expected in the reservoir	The Large Woody Debris component of the Geomorphology Study (RSP Section 6.5.4.9) will be assessing large woody debris loading in the Susitna River, including estimated input to the reservoir during project operation. Additional information can be provided as needed from Kathy Dubé.
P21	Amounts and types of debris expected below the dam	Same as Item P20. Potential for passing from reservoir above. LWD, etc. Potential to move LWD below dam, burn management, etc.

No.	Item	Comments
P22	Location downstream of any barrier and trap & haul locations, stress release ponds, adult release locations, etc.	Review mapping and identify any additional needs. Ask MWH dam designers for their opinions.
P23	Other data which you feel are important to fish passage	Possibility of establishing a natural fishway at Tsusena creek.
P24	Tributary flow data	Tributary stage data will be collected in 2013 field season. Rating curves to convert stage to flow will be developed in 2014 as part of RSP 8.5 Instream Flow.
P25	Tributary trap access data. Consider also for Adult release sites.	No roads or plans for roads exist. Understand planned roads at this point in time. This group can advise more on needs concurrent with brainstorm session.
P26	Seepage study, right abutment	Groundwater-related Aquatic Habitat Study (7.5) RSP - http://www.susitna-watanahydro.org/wp-content/uploads/2012/12/03-RSP-Dec2012_3of8-Sec-7-8-HydrologythroughInstreamFlowStudies-v2.pdf
P27	Glacier outburst floods	Glacial and Runoff Changes Study (7.7) RSP - http://www.susitna-watanahydro.org/wp-content/uploads/2012/12/03-RSP-Dec2012_3of8-Sec-7-8-HydrologythroughInstreamFlowStudies-v2.pdf
P28	Foundation condition, bank stability near ladders, etc.	Coordinate with geotechnical studies

INFORMATION ITEM P1:

WATER QUALITY AND WATER TEMPERATURE CURRENT CONDITIONS



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Fish and Aquatics TWG

Fish Passage Workshop 1

April 9, 2013

Water Quality

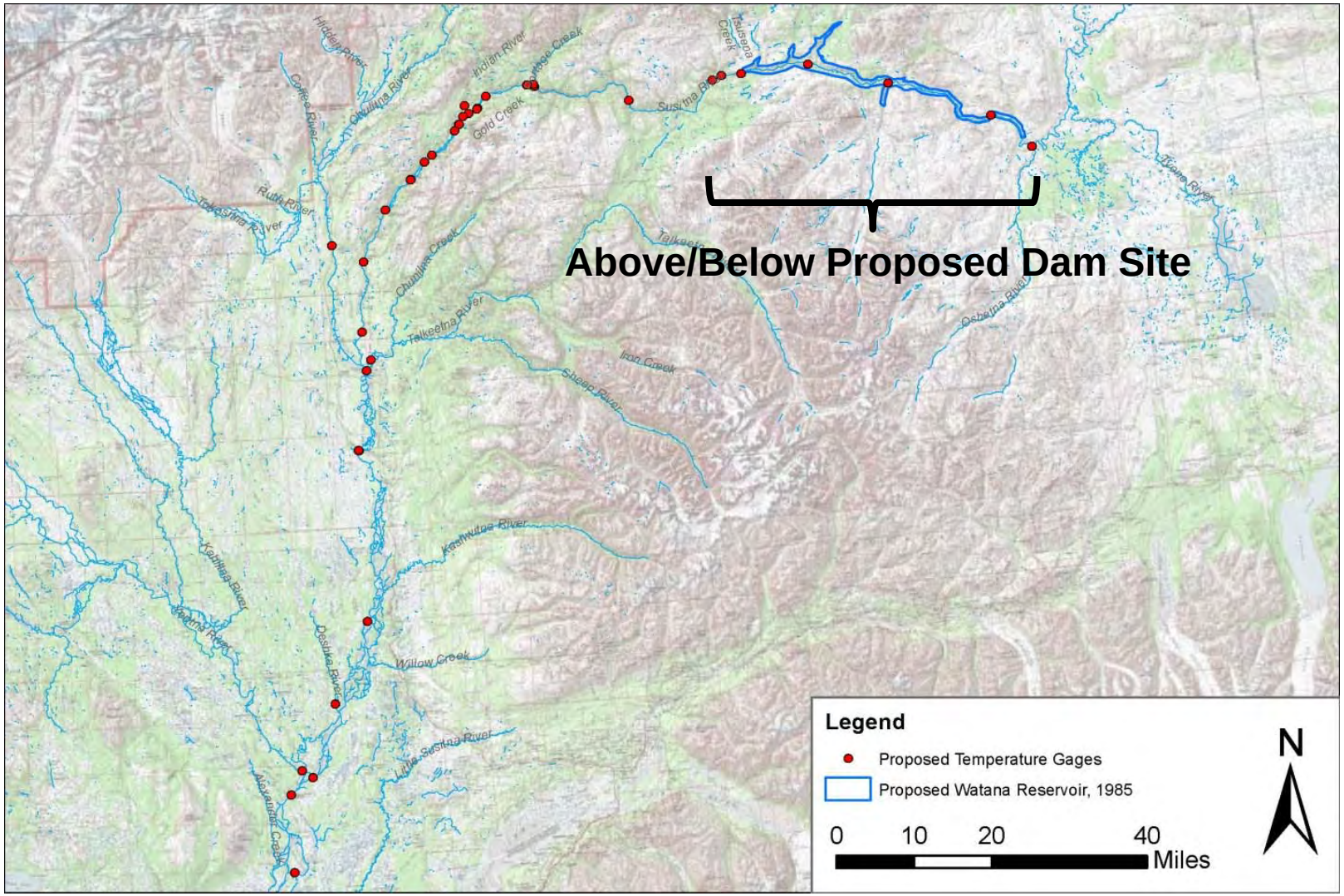
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Water Resources Proposed Studies

- Section 5.5 Baseline Water Quality Study
- Section 5.6 Water Quality Modeling Study
- Section 5.7 Mercury Assessment and Potential for Bioaccumulation Study

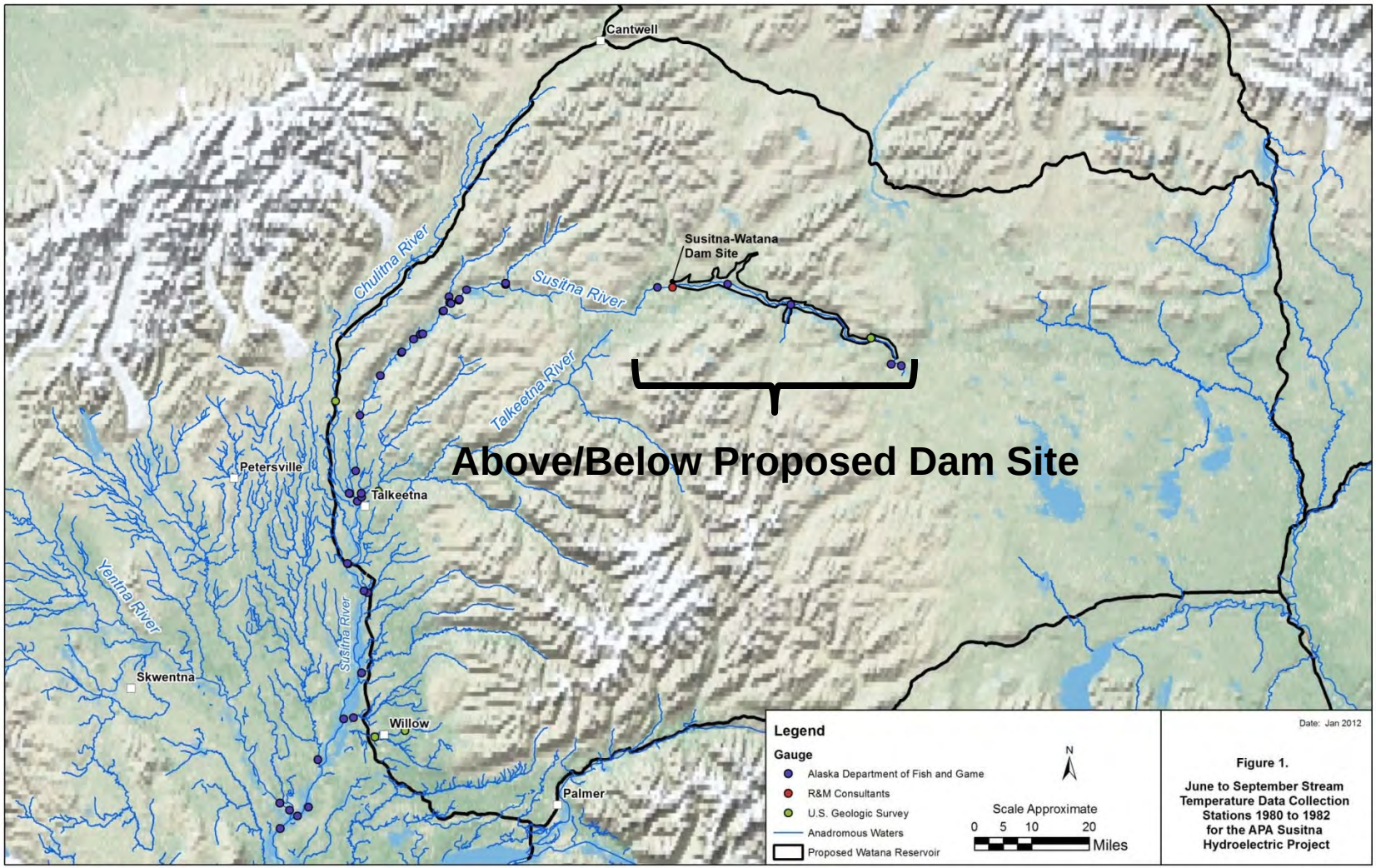
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Water Quality Study Area 2012/2014



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Water Quality Study Area 1980/1982



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Historic Water Quality

Station Name	Station Susitna River Mile	Most Recent Sample Date	Years of Record	Season	Temp (°C)	Suspended Sediment Discharge (ton/day)
Main stem Susitna at Watana Dam Site	184.2	10/16/85	1	Winter	NA	NA
	184.2	10/16/85	1	Spring	3.7-9.0	NA
	184.2	10/16/85	1	Summer	1.9-14.4	NA
	184.2	10/16/85	1	Fall	0-4.0	NA
Vee Canyon	223.1	7/30/86	24	Winter	0	19
	223.1	7/30/86	24	Spring	0-10	up to 175,000
	223.1	7/30/86	24	Summer	4.0-13	up to 196,000
	223.1	7/30/86	24	Fall	1-5.5	up to 2,070

ALASKA ENERGY AUTHORITY

Current Water Quality

- Water Quality Monitoring Strategy
  - 39 sites from RM 15.1 to RM 233.4
  - Monthly site visits: June 2013- September 2013, December 2013, and March 2014
  - Parameter groups include: continuous temperature, in-situ, general water quality, and one-time surveys (e.g., bacteria, petroleum hydrocarbons, sediment, radionuclides, and toxic metals).
  - Media analyzed will include: surface water, sediment, and fish tissue

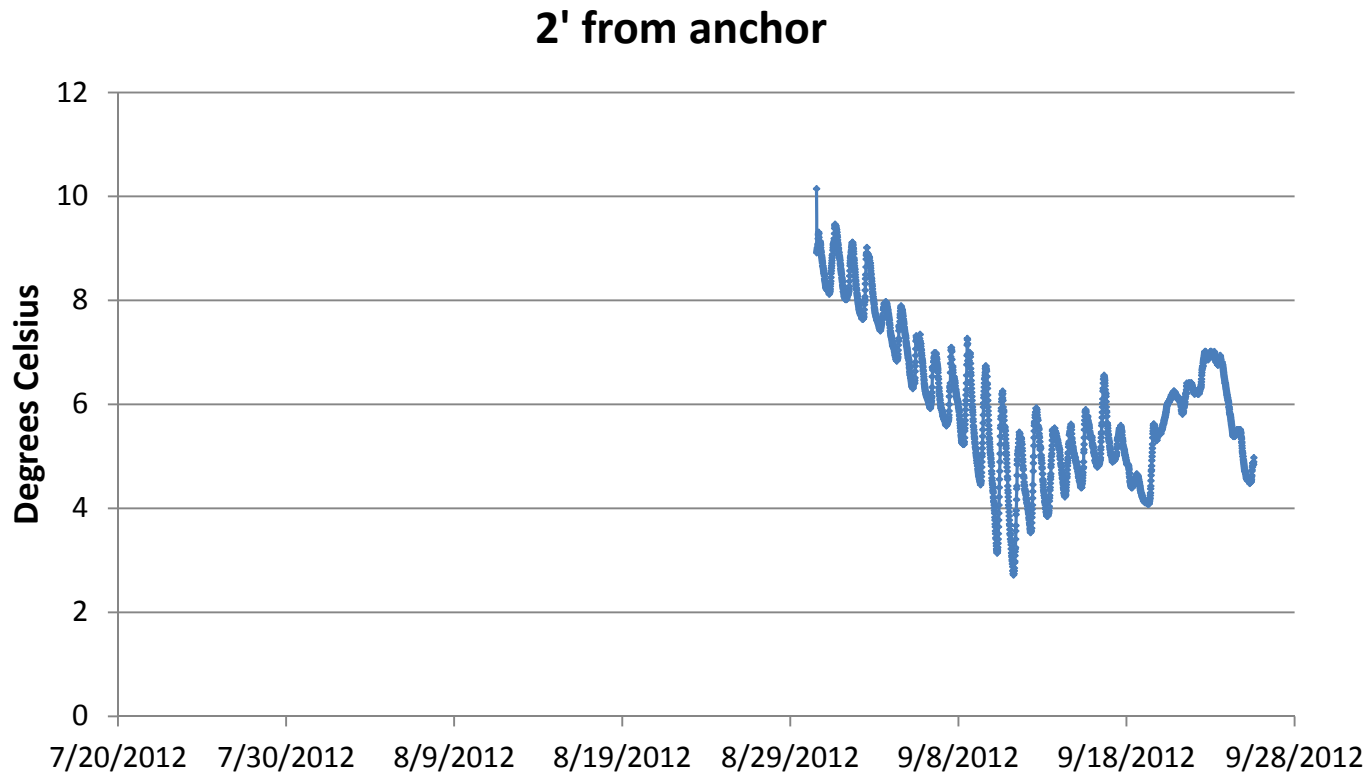
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2012 Temperature Data: Above/Below Proposed Dam Site

Susitna River Mile	Site Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
180.3[1]	Susitna below Tsusena Creek	NA	62.8134	-148.6568
181.3[3]	Tsusena Creek	NA	62.8217	-148.6068
184.5[1]	Susitna at Watana Dam site	NA	62.8226	-148.533
194.1	Watana Creek	NA	62.8296	-148.259
206.8	Kosina Creek	NA	62.7822	-147.94
223.7[3]	Susitna near Cantwell	NA	62.7052	147.538
233.4	Oshetna Creek	NA	62.6402	-147.383

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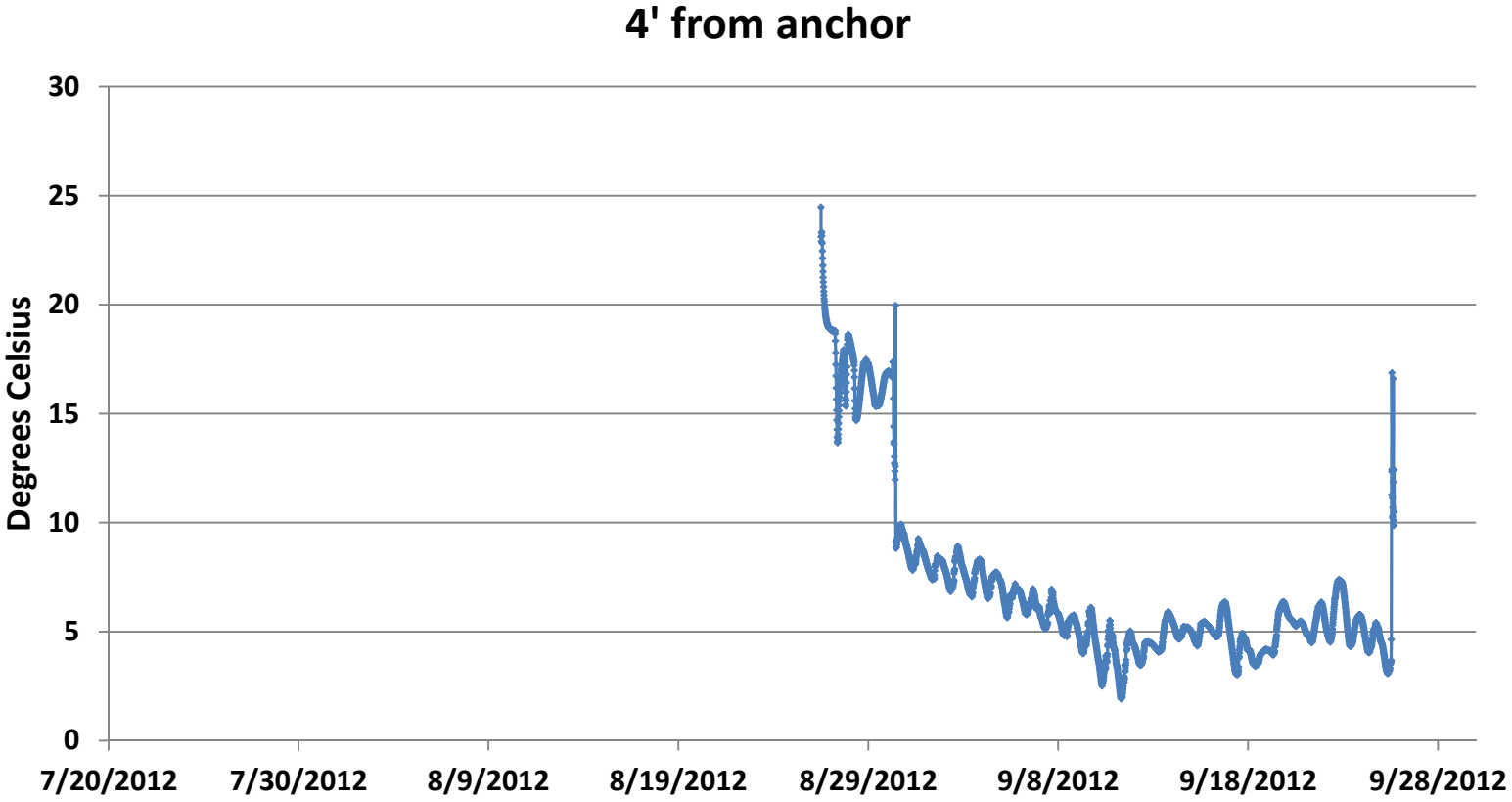
Tributaries: RM206.8 Kosina Creek 2012 Temperature Data



RM206.8 Kosina Creek



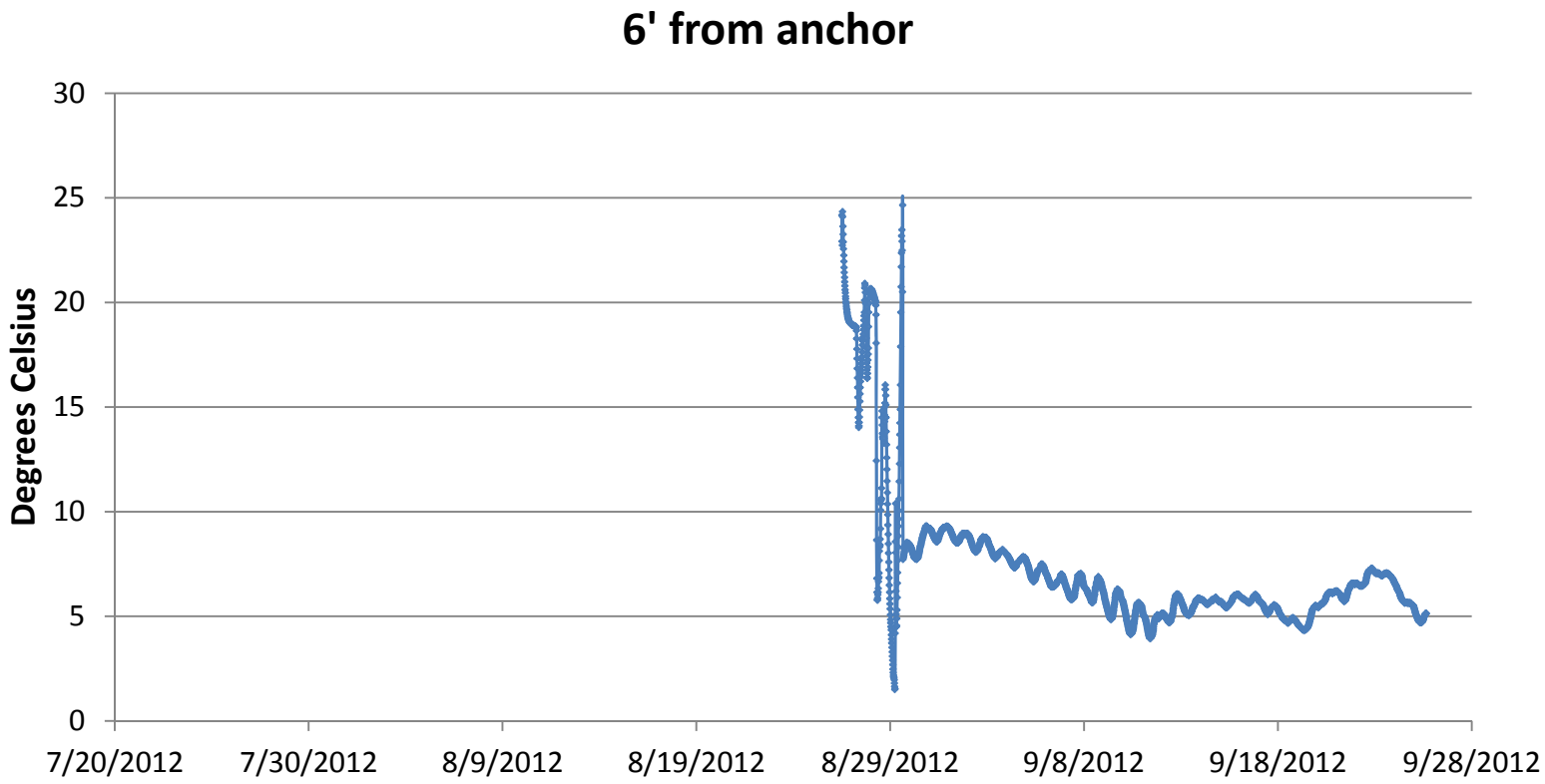
Tributaries: RM233.4 Oshetna Creek



RM233.4 Oshetna Creek



Mainstem: RM180.3 Susitna River below Tsusena Creek



RM180.3 Susitna River below Tsusena Creek



Water Quality Modeling: Approach and Output

- Reservoir Water Quality Model (EFDC)
  - 3-Dimensional Model
  - Prediction of vertical stratification in the reservoir when the dam is present
  - Nutrient and algae representation
  - Sediment transport (erosion, transport, settling/deposition)
  - Ability to represent metals concentrations
  - Integration between temperature and ice dynamics models

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Water Quality Modeling: Approach and Output

- Riverine Water Quality Model (EFDC)
  - 2-Dimensional Model
  - Tightly coupled with the Reservoir Model
  - Boundary conditions of the Reservoir Model initial conditions for the Riverine Model
  - Riverine Model constructed/calibrated with and w/o the Reservoir Model
  - Output used by the following:
    - Ice Processes;
    - Productivity; and
    - Instream Flow studies

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INFORMATION ITEM P2:

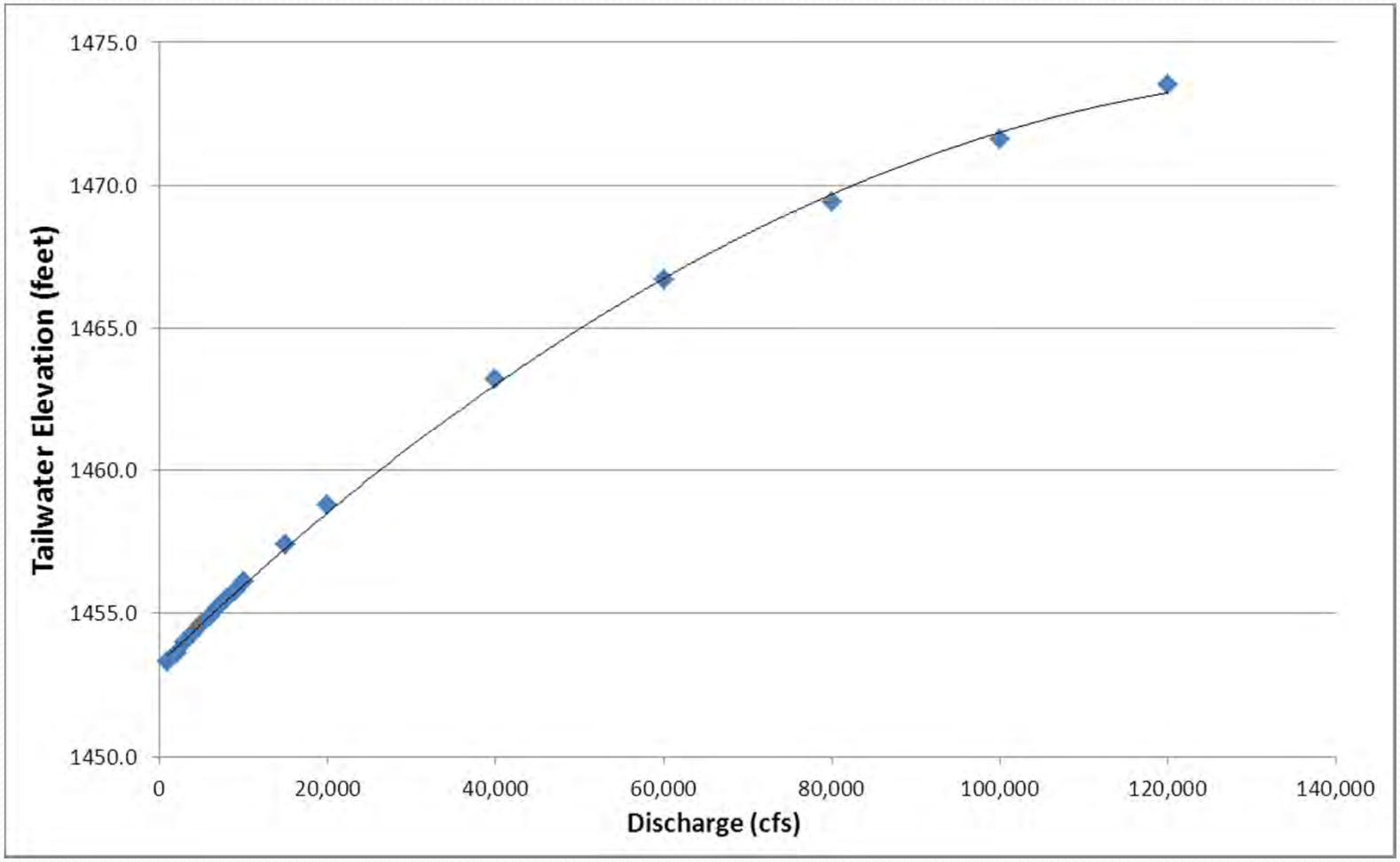
WATER QUALITY AND WATER TEMPERATURE FUTURE CONDITIONS ABOVE AND BELOW WATANA DAM

INFORMATION ITEM P3:

TAILWATER RATING CURVES AT DAM AND EXPECTED TRAP LOCATION

PRELIMINARY DATA

P3 – Tailwater Rating Curve Chart



From: March 2013, Fish Passage Workshop #1 Powerpoint by MWH

INFORMATION ITEM P4:

FLOW DURATION BY MONTH THROUGH TURBINES SPILLWAYS, AND OTHER OUTLETS

Table 34: Calculated Flood Frequency for the Susitna River at Susitna Station

Return Period (Years)	Flow (cfs)
2	187,000
5	223,000
10	247,000
25	280,000
50	305,000
100	331,000
200	357,000
500	393,000
1,000	419,000
10,000	508,000

Peak flows were estimated for return periods up to 10,000 years at the Watana dam site by transposing peak flow analysis results at Gold Creek to Watana according to the following equation:

$$Q_{Watana} = Q_{Gold\ Creek} \times \left(\frac{A_{Watana}}{A_{Gold\ Creek}}\right)^{0.86}$$

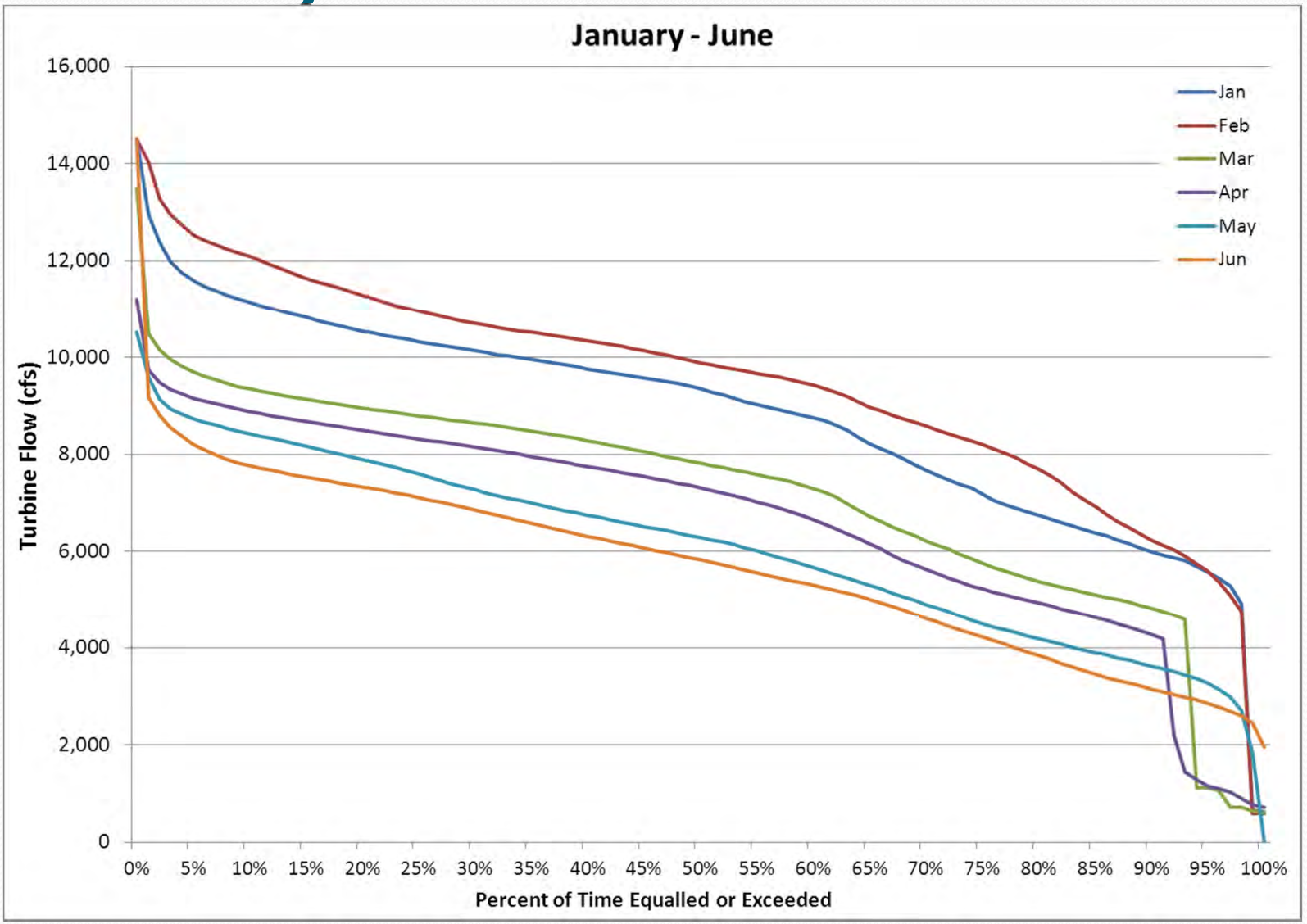
where A is the drainage area for each site. The exponent in this equation was selected as the value that minimized the percent error between the calculated peak flows at Cantwell presented in Table 27 and the estimated peak flows that resulted from transposing the calculated peak flows at Gold Creek to Cantwell.

Table 35: Estimated Peak Annual Flows in the Susitna River at Watana

Return Period (Years)	Peak Flow (cfs)
2	37,900
5	49,200
10	57,400
25	68,500
50	77,400
100	86,600
200	96,300
500	110,000
1,000	120,000
10,000	155,000

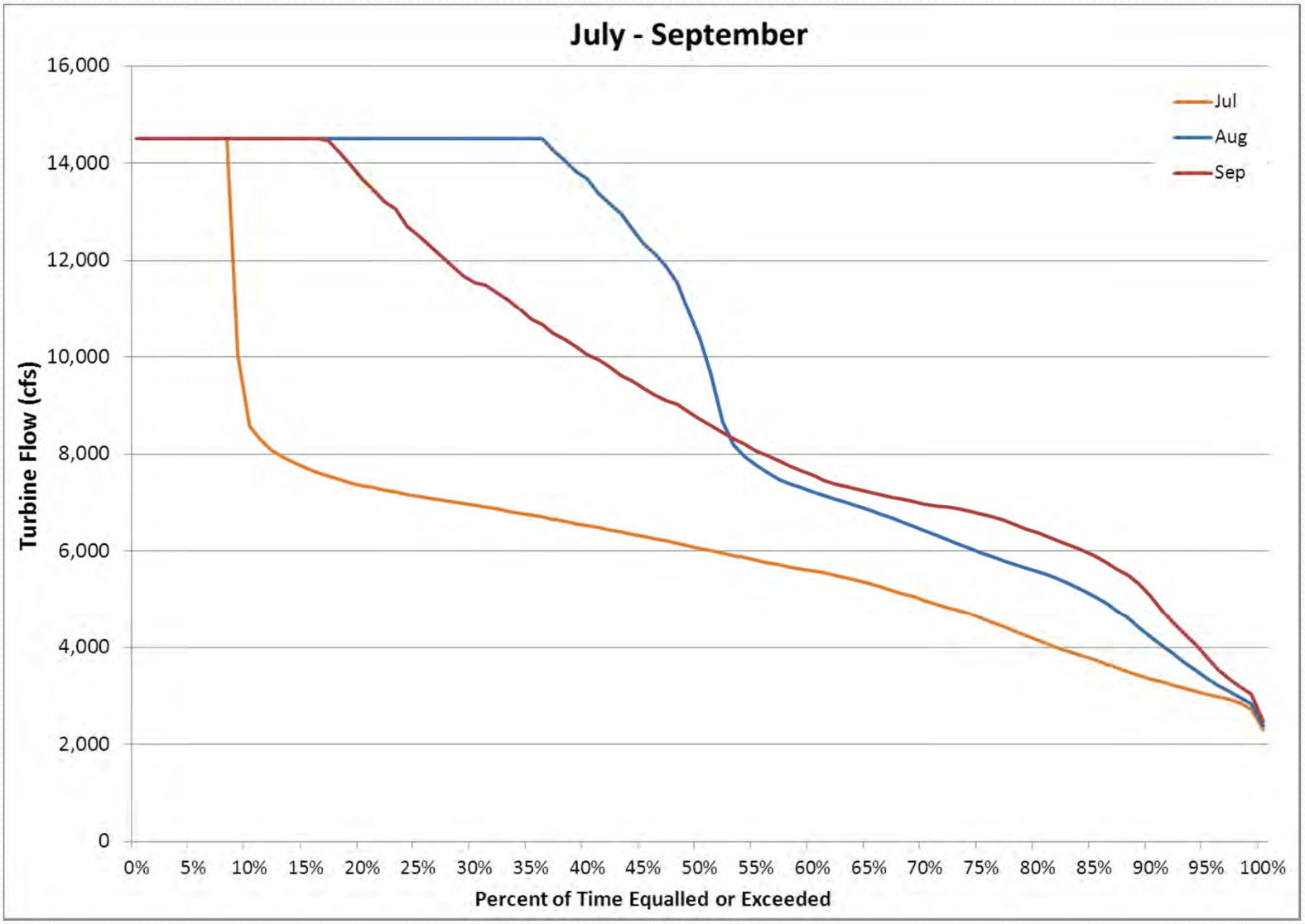
PRELIMINARY DATA

P4 – Monthly Flow Duration Curves – Turbines



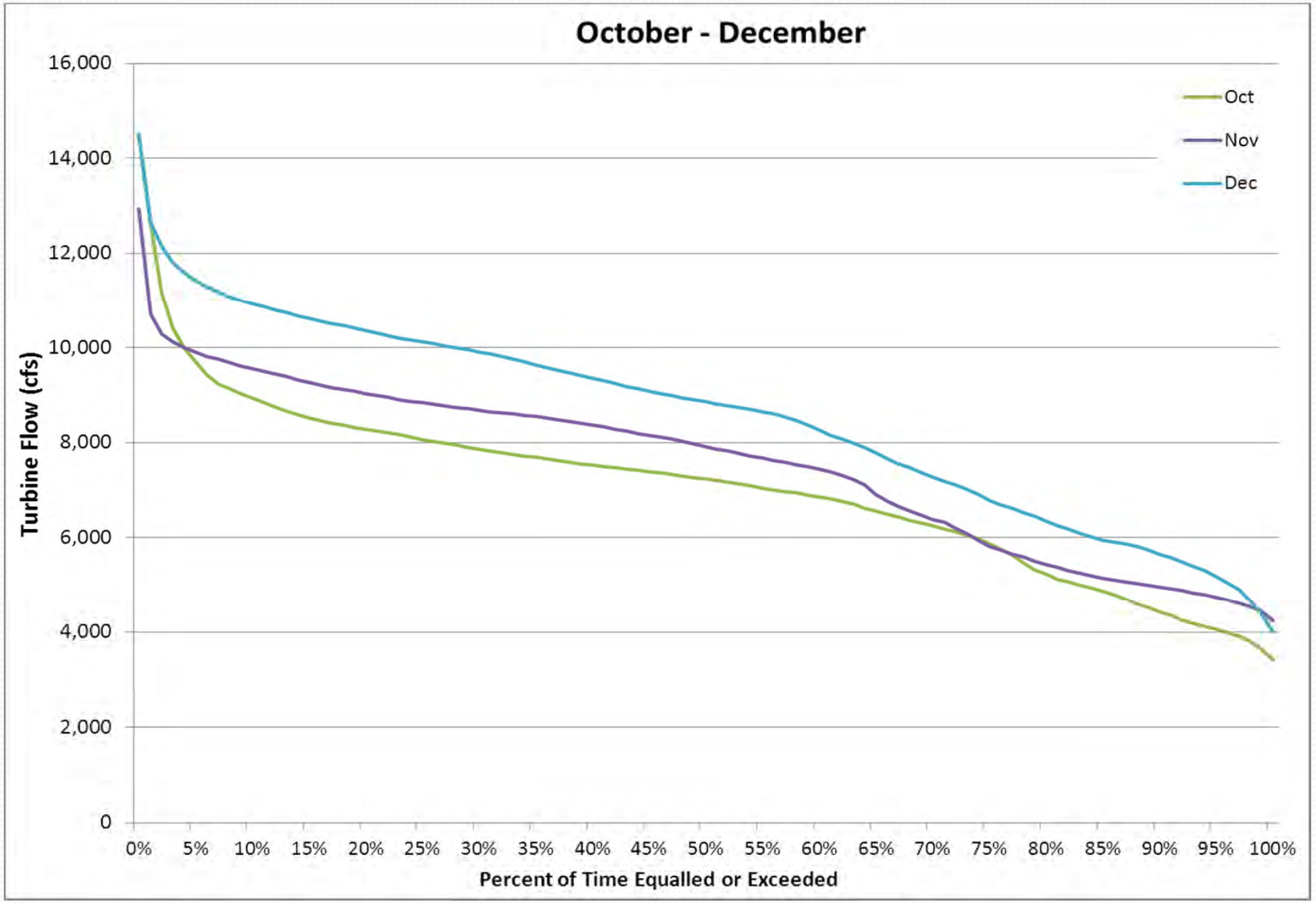
PRELIMINARY DATA

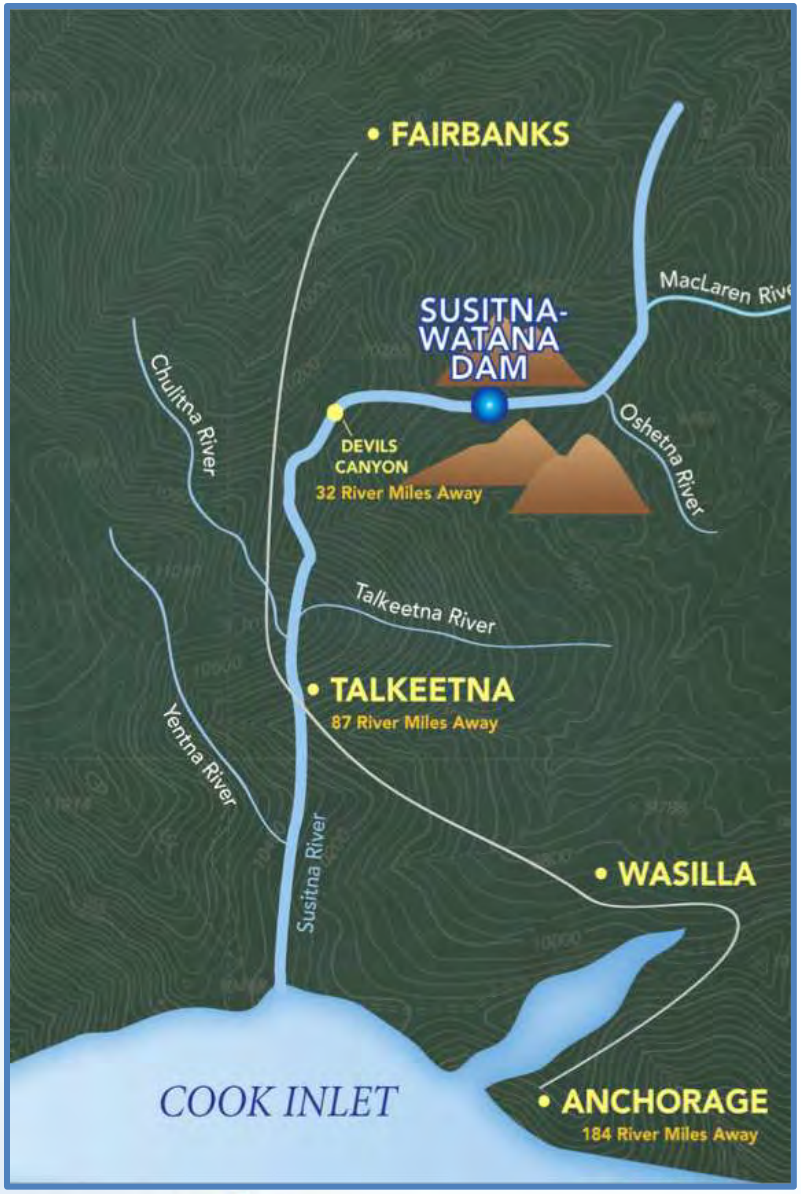
P4 – Monthly Flow Duration Curves- Turbines



PRELIMINARY DATA

P4 – Monthly Flow Duration Curves - Turbines





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Response to FERC Order

Susitna River Pre-Project and Maximum Load Following Operational Scenario 1 Stages

Open Water HEC-RAS Flow Routing Model

Version 1

1 February 2013

Prepared by: R2 Resource Consultants, GW Scientific, Brailey Hydrologic, and Geovera

DRAFT – FOR DISCUSSION PURPOSES ONLY

Background

- A hydrologic routing model (HEC-ResSim) was previously developed to analyze stages in the Susitna River between Devils Canyon and Sunshine Gage .
- The HEC-ResSim model was used to analyze Pre-Project and Maximum Load Following Operational Scenario 1 (OS-1) conditions during calendar year 1984.
- Input to the HEC-ResSim model included hourly flow releases from the proposed Watana Dam site (Project River Mile (PRM) 187.2.
- Results were presented at the October 23-25, 2012 Technical Workgroup meetings.

Maximum Load Following OS-1

- Based on the assumption that the load fluctuation of the entire Railbelt would be provided by the Susitna-Watana Project, and that all other sources of electrical power in the Railbelt would be running at base load.
- This assumed condition is not realistic for an entire year, and the results of this condition should be conservative with respect to assessing downstream stage changes.

Current Update

- A hydraulic flow routing model (HEC-RAS) was developed of the Susitna River from the proposed Watana Dam site downstream to PRM 80.0 (7 miles downstream from Sunshine Gage).
- Version 1 of the HEC-RAS model was developed and calibrated using data collected in 2012.
- Results of the HEC-RAS model are shown using same 1984 Pre- and Post-Project dam release hydrographs that were used in the previous HEC-ResSim study.

Hydrologic Versus Hydraulic Flow Routing

- Hydrologic flow routing (as is used in HEC-ResSim) is used to route flows through a river and predict downstream flow hydrographs. A corresponding stage hydrograph can be developed at a particular location if a stage/discharge rating curve is available.
- Hydraulic flow routing (as is used in HEC-RAS) uses the momentum equation to route flows through a river and directly predict both flow and stage hydrographs at downstream locations of interest.

Limitations

- The HEC-RAS flow routing model is appropriate for analyzing stage and flow fluctuations under ice-free conditions.
- An ice processes flow routing model is currently being developed to analyze stage and flow fluctuations under ice-affected conditions.
- Actual results during the winter may differ from those presented herein as a result of ice formation on the river.

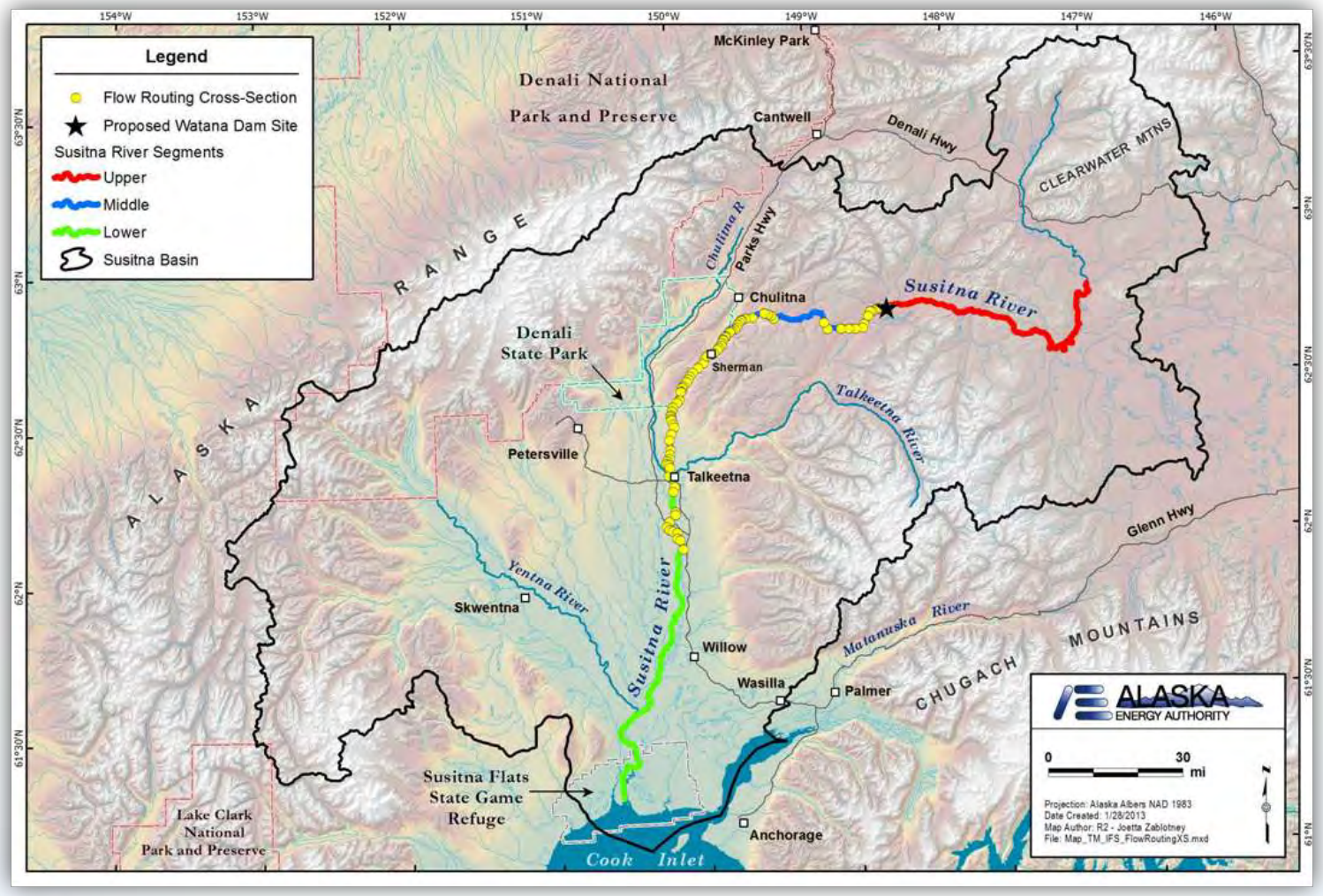
Downstream Stages with 15-Minute Flow Routing Basis and Assumptions

- HEC-RAS model developed from 88 cross-sections surveyed on the Susitna River in 2012 from PRM 187.2 to PRM 80.0.
- Steady-state calibration focused on matching 170 pairs of flows and water surface elevations measured in 2012.
- Unsteady-state calibration focused on matching flow hydrographs during the week of August 11 to 17, 2012.
- Unsteady-state validation performed during the period from June 4 to October 14, 2012.

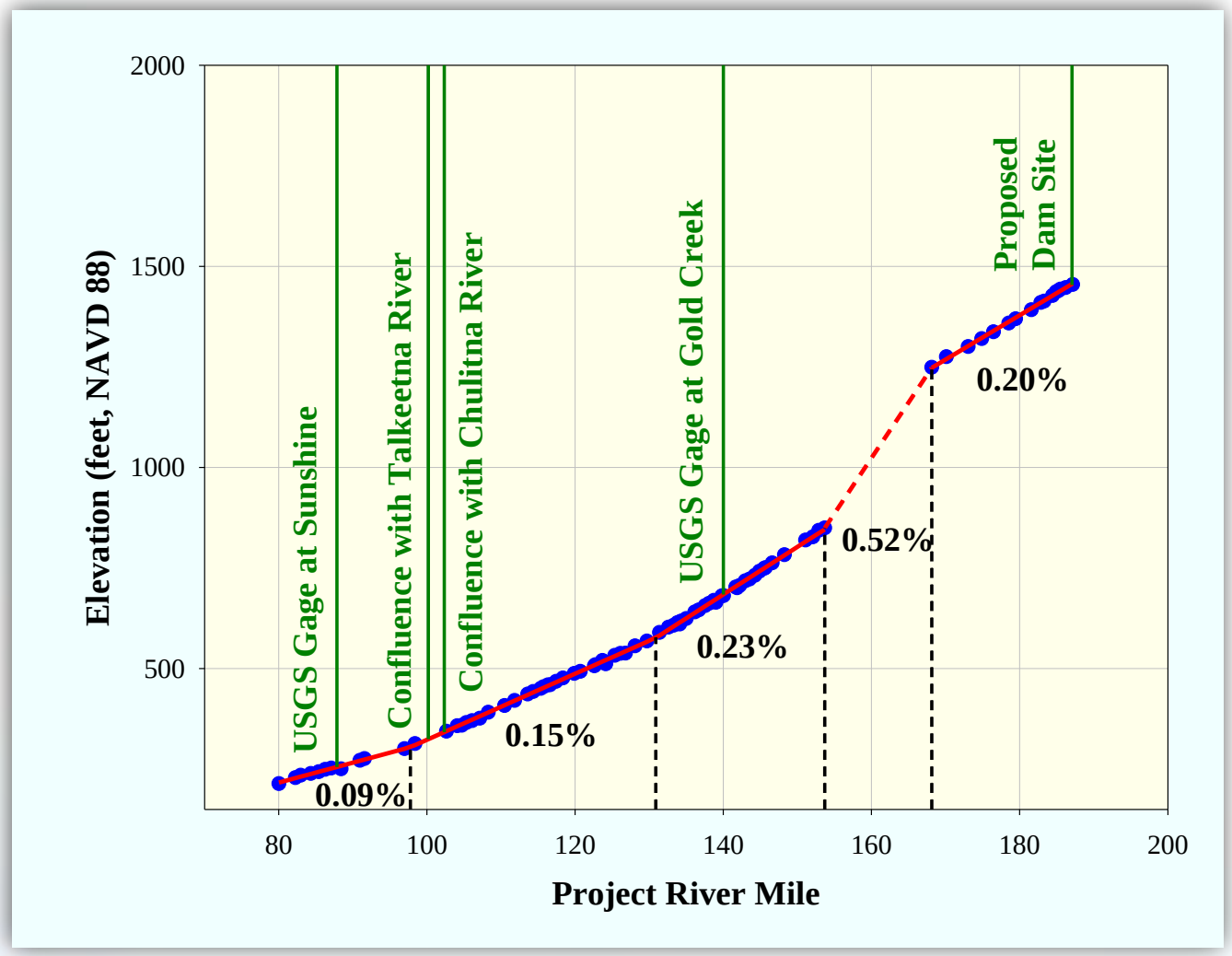
Open Water Flow Routing Model

- HEC-RAS model developed from 88 cross-sections surveyed on the Susitna River in 2012 from PRM 187.2 to PRM 80.0.
- Additional river cross-sections were interpolated for reasons of numerical stability under unsteady flows conditions (especially through Devils Canyon).

Cross-Sections Surveyed in 2012



Longitudinal Thalweg Profile

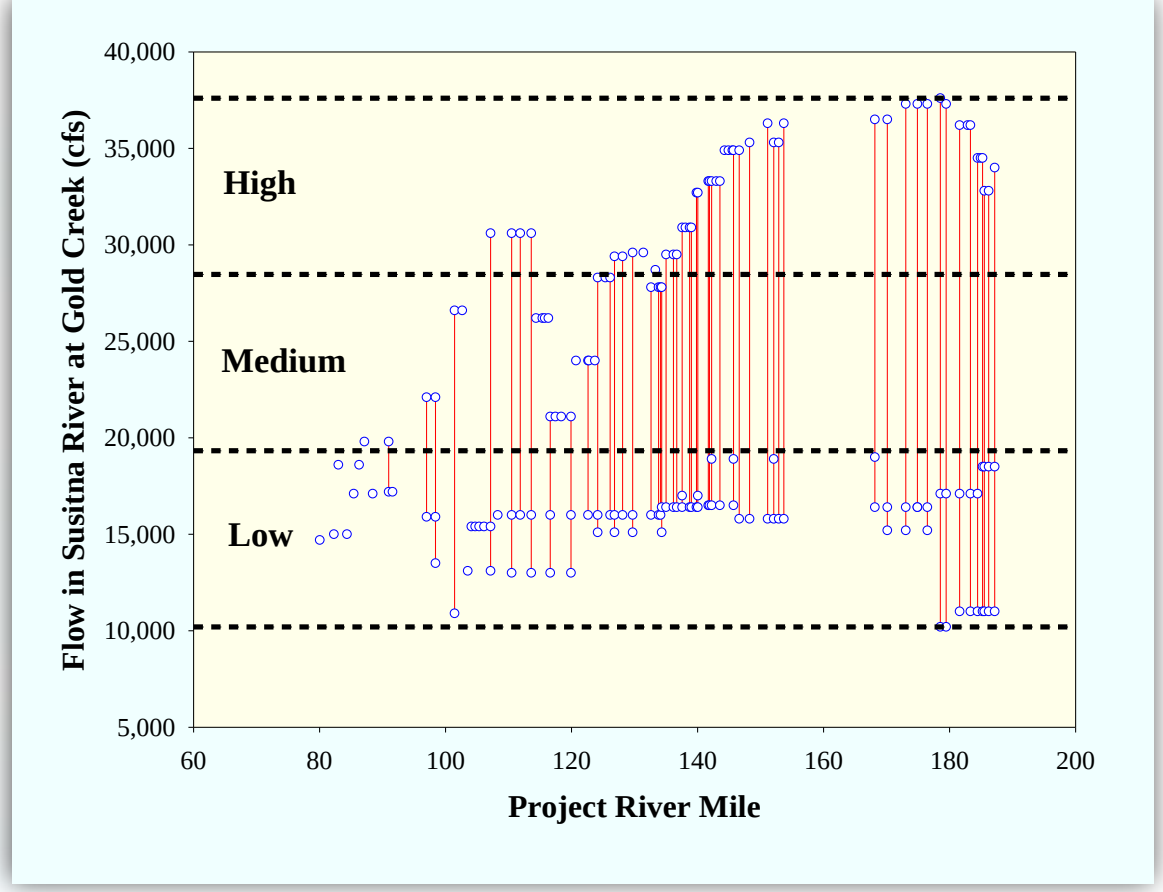


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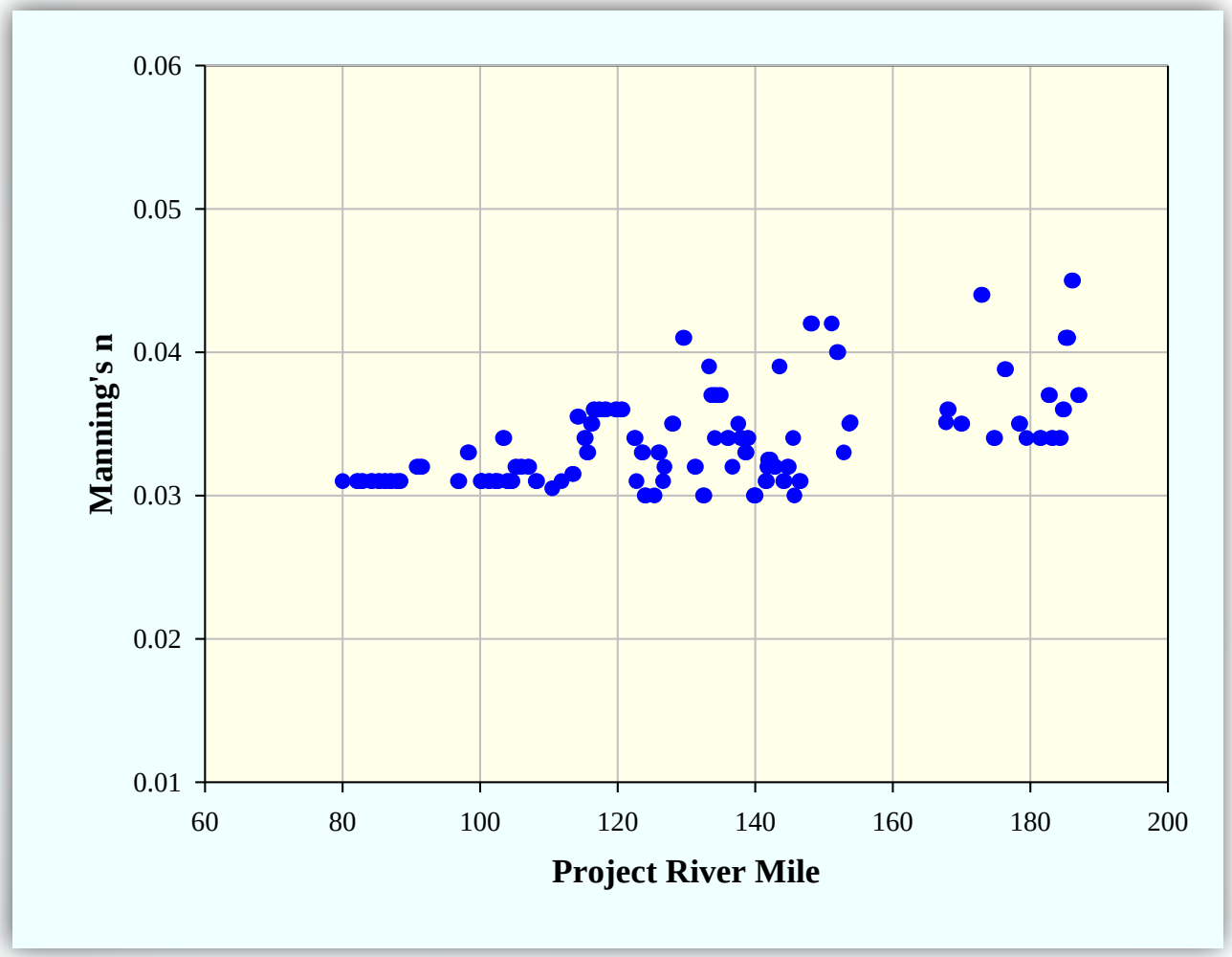
Steady-State Calibration

- Steady-state calibration focused on matching 170 pairs of flows and water surface elevations measured in 2012.
- Calibration was performed by selecting reasonable values of Manning's "n" and by adjusting the morphology of interpolated cross-sections.
- Predicted water surface elevations matched observed water surface elevations to within plus or minus 0.2 feet.

Flows Measured in 2012 Classified as Low, Medium, or High Based on Concurrent Flows at Gold Creek



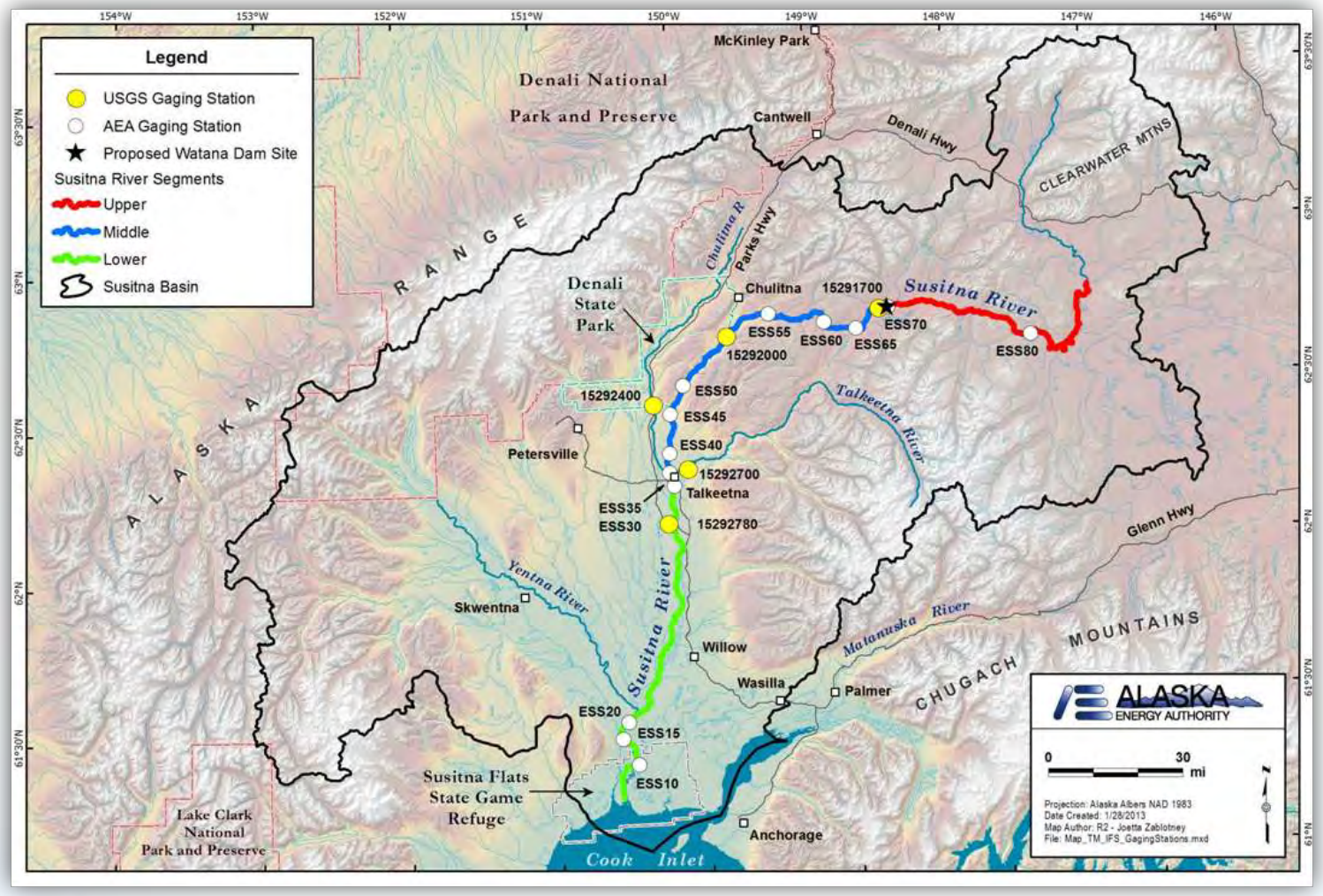
Steady State Calibration
Hydraulic Roughness



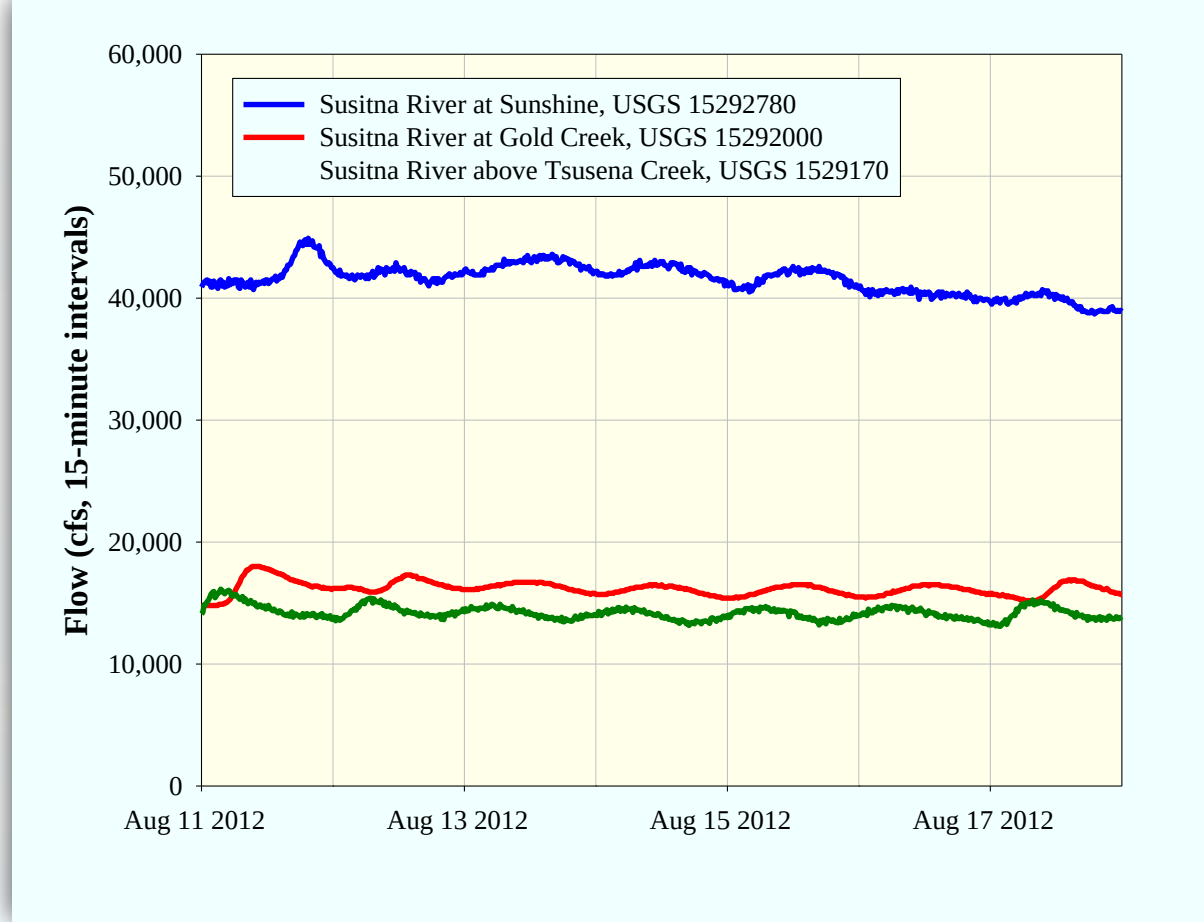
Unsteady-State Calibration

- Focused on week of August 11 to 17, 2012 when diurnal pulses occurred as a result of glacial melt
- Calibration relied on flows measured by the US Geological Survey
- Calibration was focused on matching the arrival time of pulses at Gold Creek and Sunshine
- To accelerate the arrival of pulses, upstream interpolated cross-sections were made narrower.
- To decelerate the arrival of pulses, upstream interpolated cross-sections were made wider.

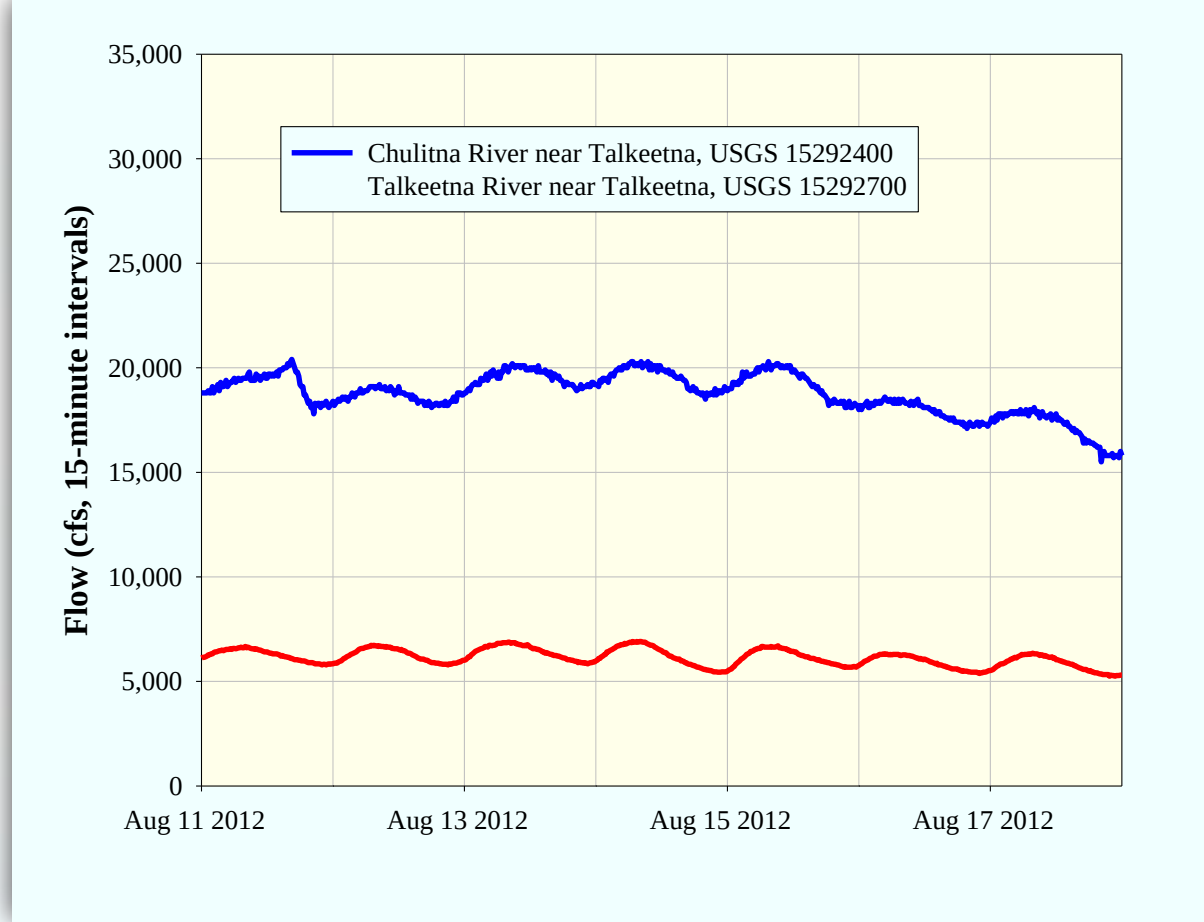
Gaging Station Locations



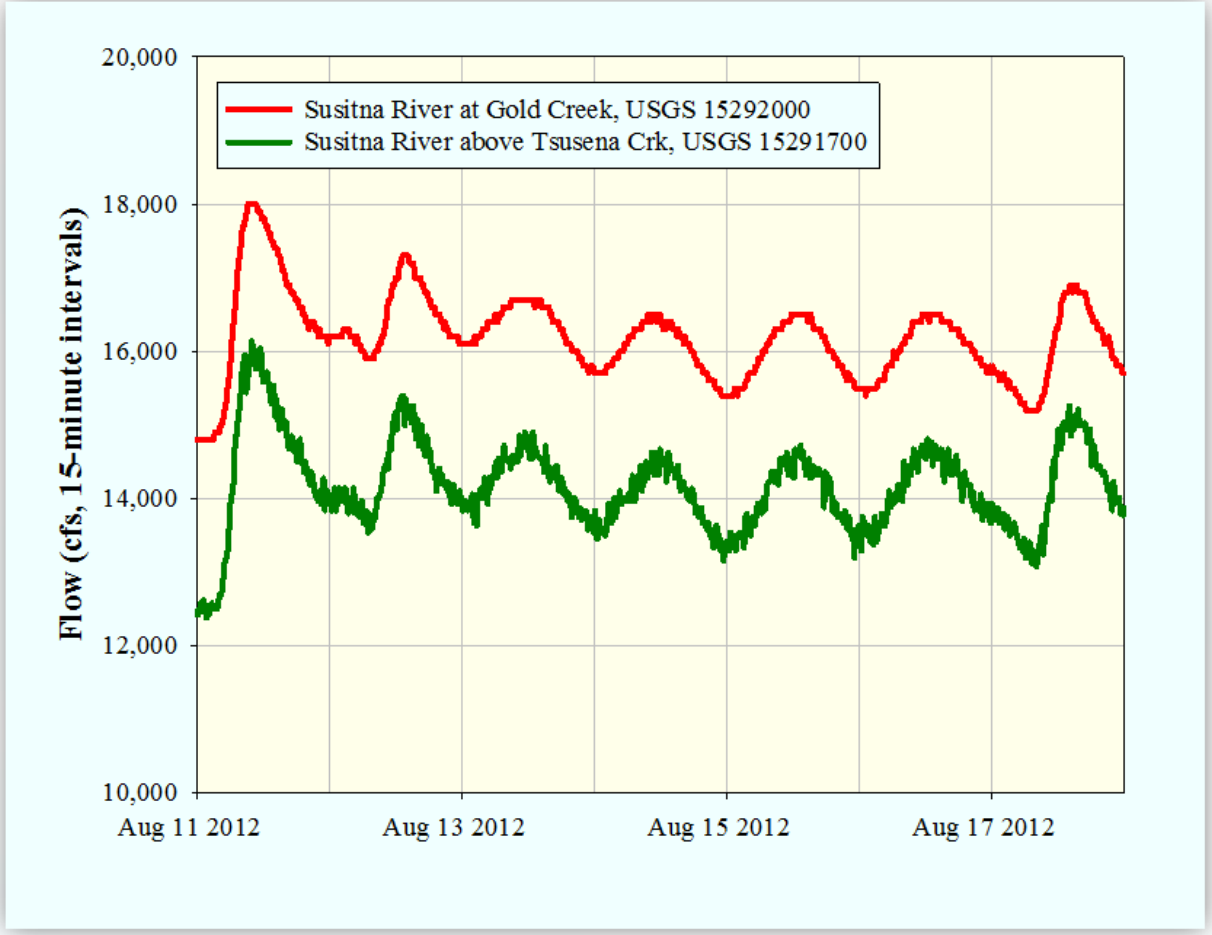
Unsteady-State Calibration
15-Minute Flows in Susitna River
August 11 to 17, 2012



Unsteady-State Calibration
15-Minute Flows in Tributaries of the Susitna River – August 11 to 17, 2012



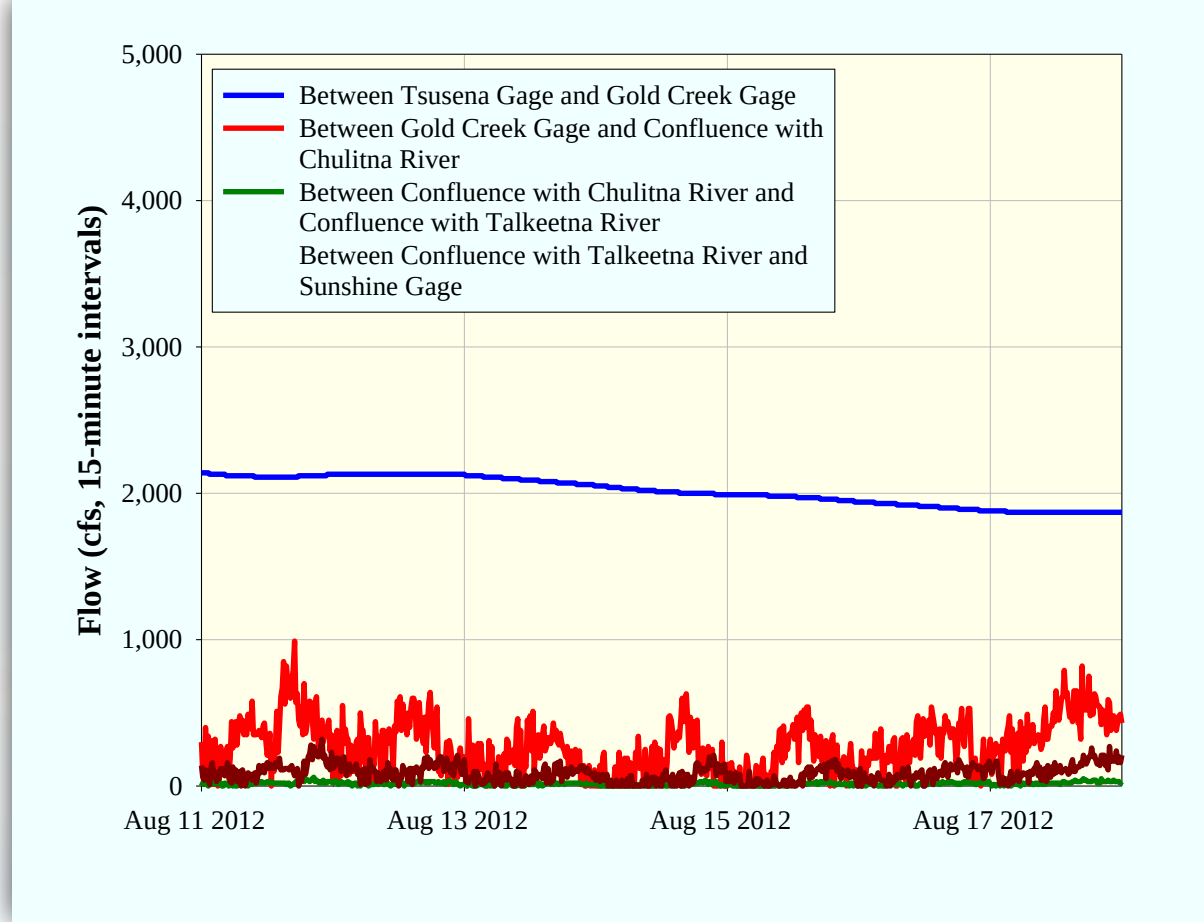
Unsteady-State Calibration
Flows above Tsusena Creek
Shifted Forward by 6.4 Hours



Propagation of Diurnal Pulses Between Tsusena Creek and Gold Creek

- Pulses traveled 47.2 miles in 6.4 hours
- Speed of propagation, or celerity, was 7.4 miles per hour or 10.8 feet per second
- Celerity should be 1.25 to 1.50 times the channel flow velocity (Linsley 1975)
- Equivalent to average flow velocity of 7 to 9 feet per second, consistent with what was measured in 2012

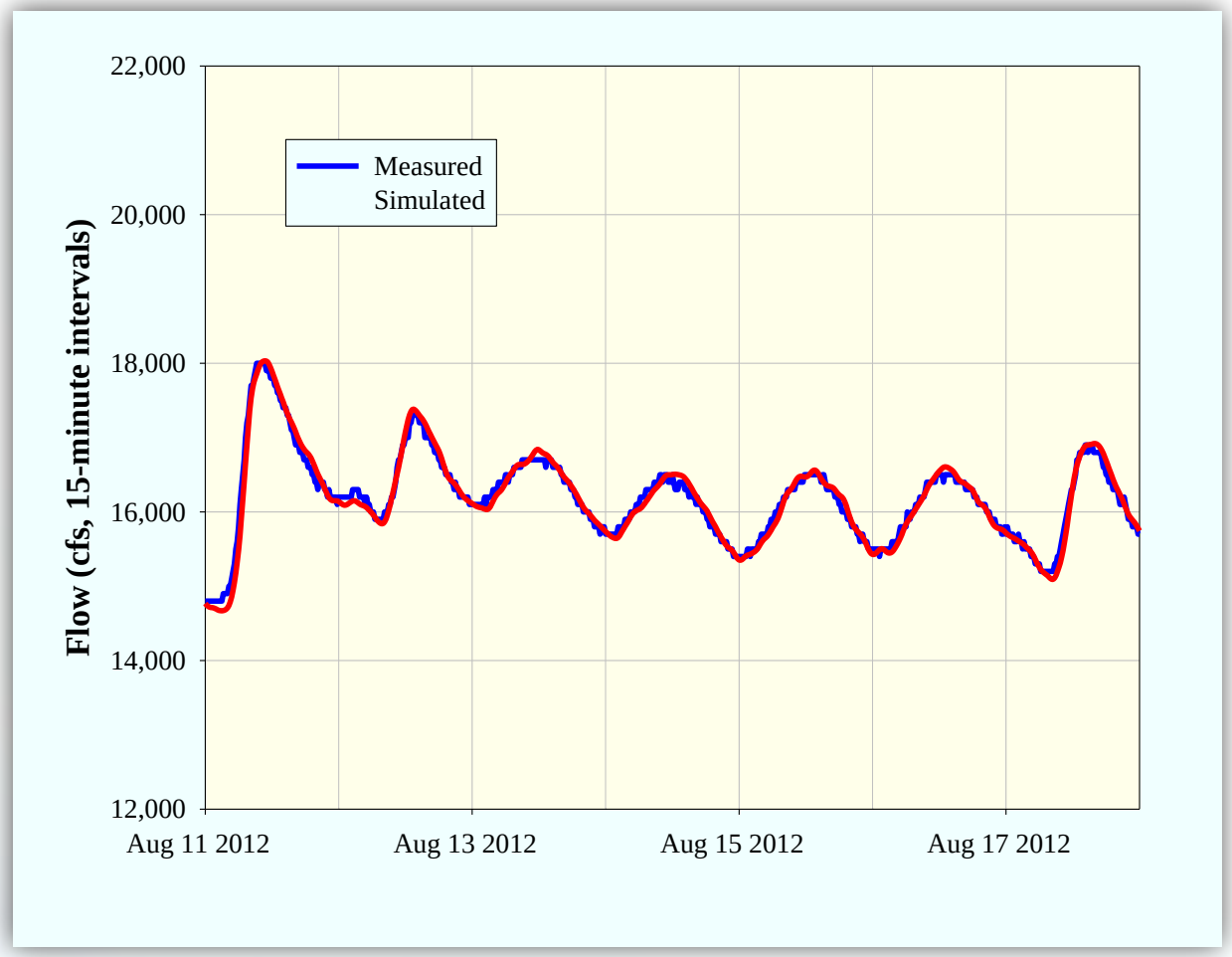
Unsteady-State Calibration
15-Minute Ungaged Accretion Flows to the Susitna River – August 11 to 17, 2012



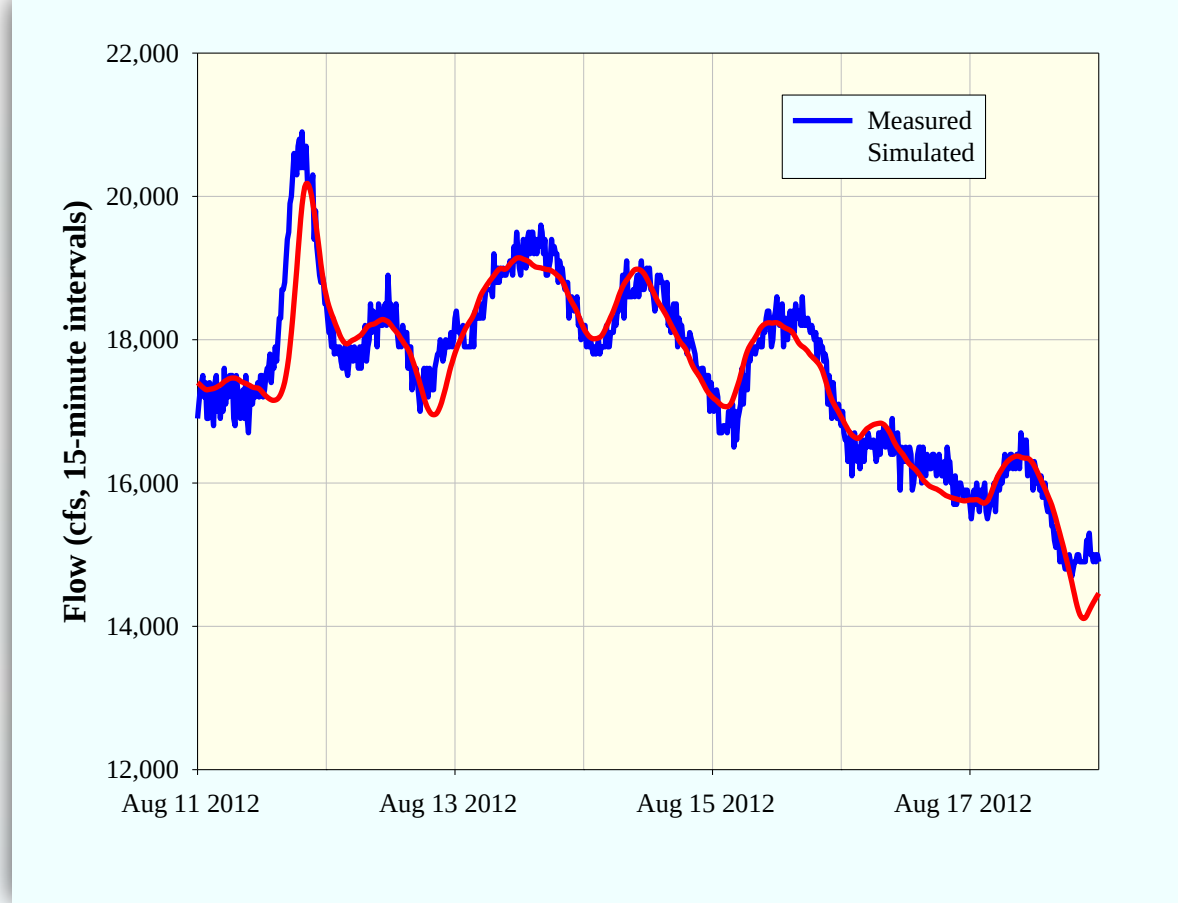
Selection of Computational Time Step

- For numerical stability and accurate results the computational time step should be less than the distance between cross-sections divided by the celerity
- Distance between cross-sections = 1,000 feet
- Celerity = 10.8 feet per second
- Time step should be less than 93 seconds
- Time step of one minute (60 seconds) was selected

Unsteady Flow Calibration Results
Susitna River at Gold Creek
August 11 to 17, 2012



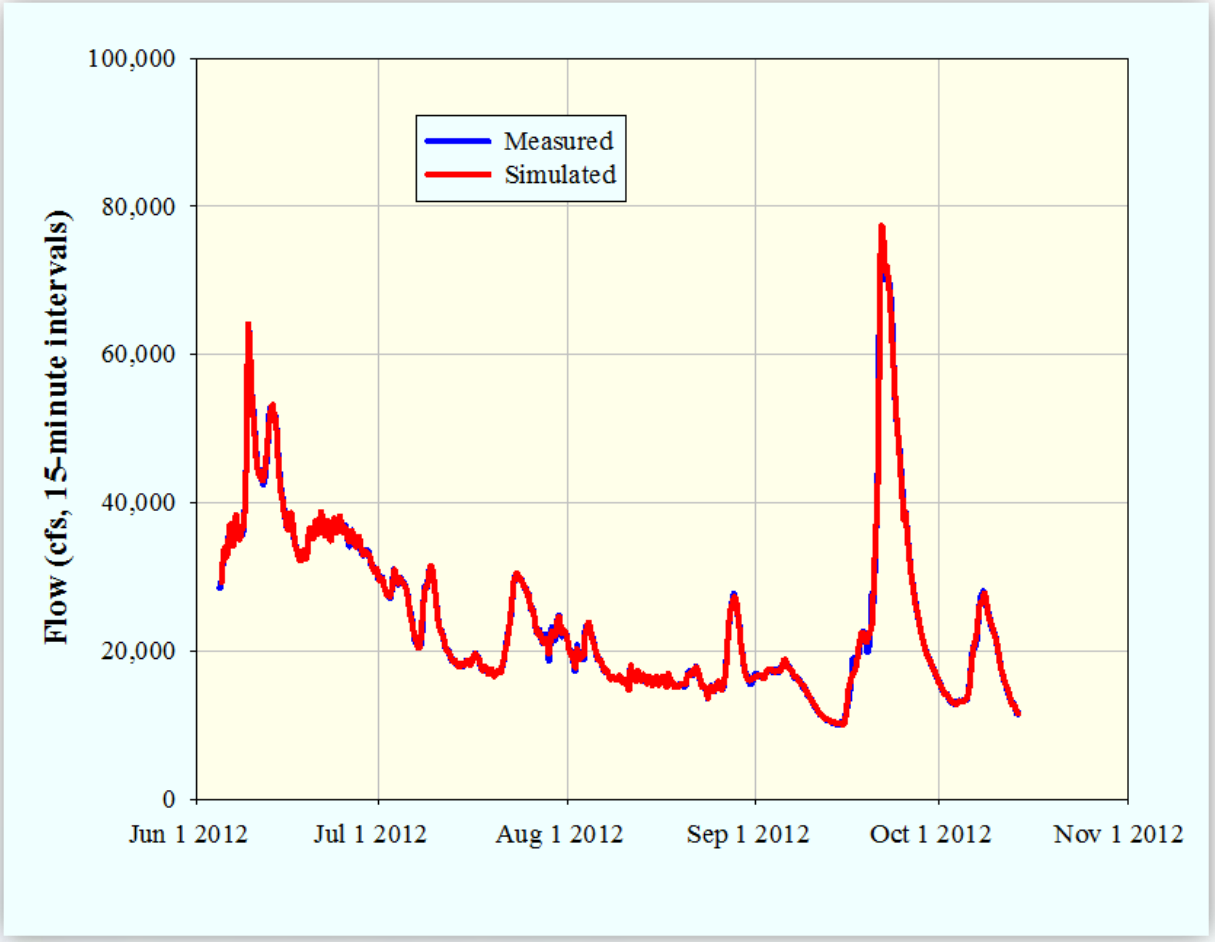
Unsteady Flow Calibration Results
Susitna River at Sunshine
August 11 to 17, 2012



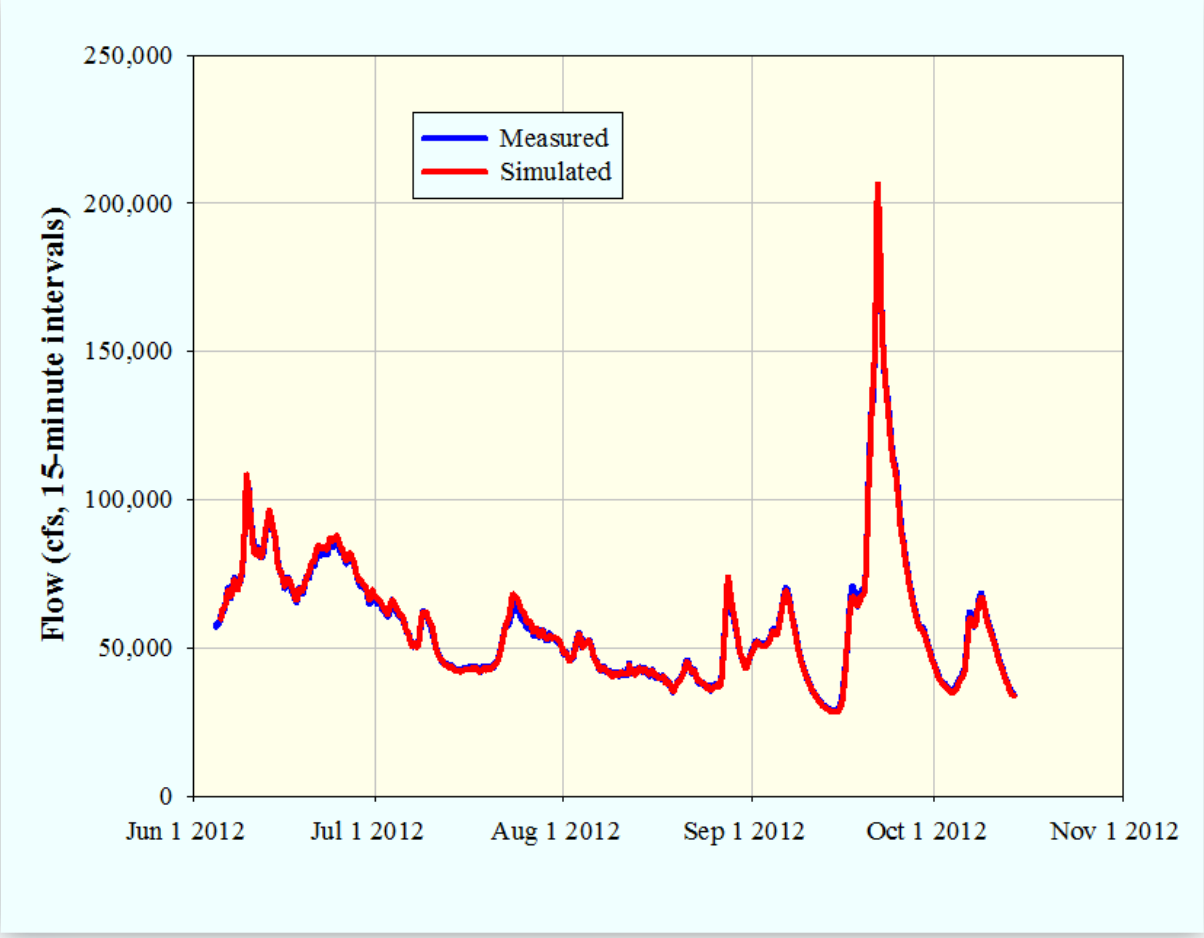
Model Validation

- The calibrated HEC-RAS model was then run for the period from June 4 to October 14, 2012.
- Good agreement between measured and simulated flow hydrographs was found for the Susitna River at Gold Creek Gage and Sunshine Gage over a wide range of flows (up to 200,000 cfs at Sunshine).

Model Validation
Susitna River at Gold Creek
June 4 to October 14, 2012



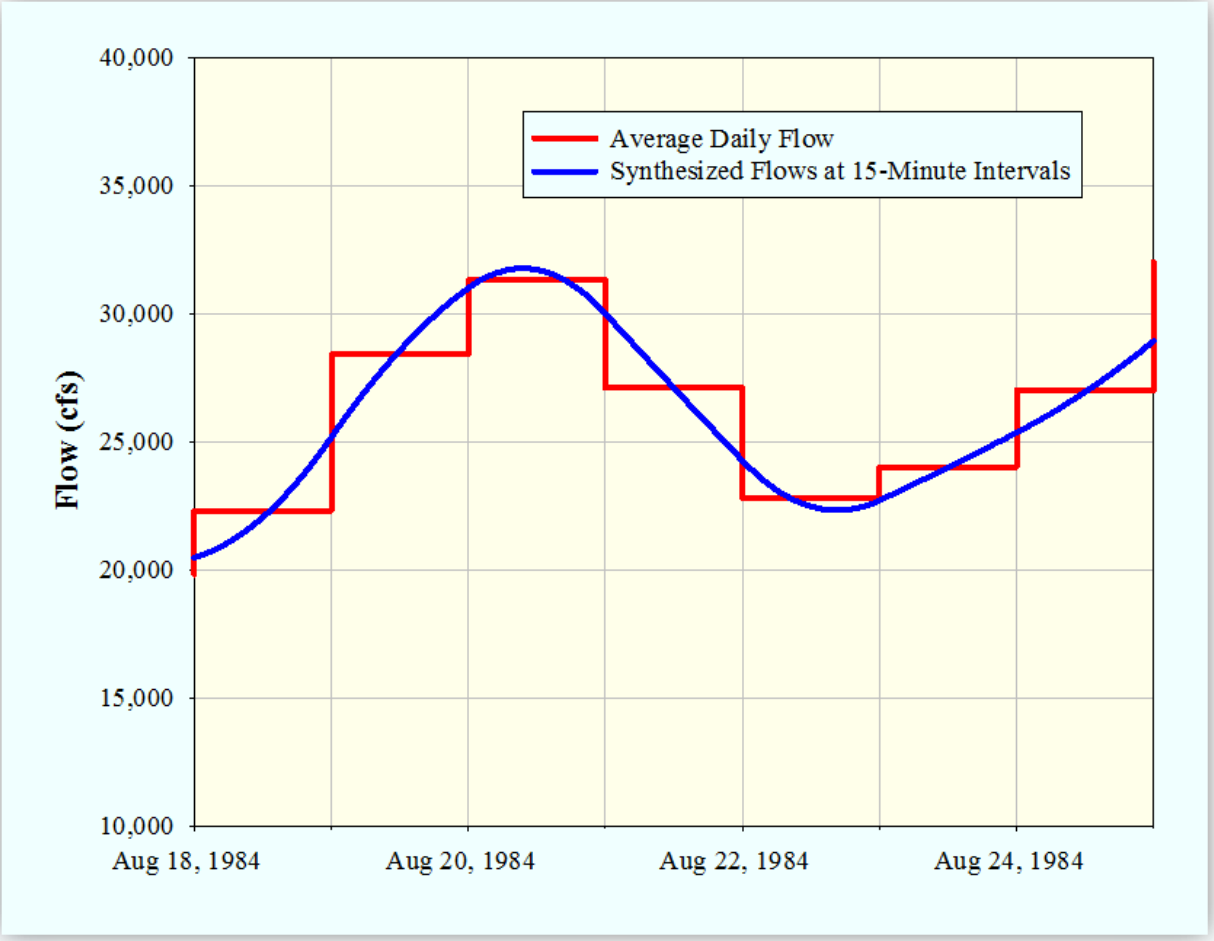
Model Validation
Susitna River at Sunshine
June 4 to October 14, 2012



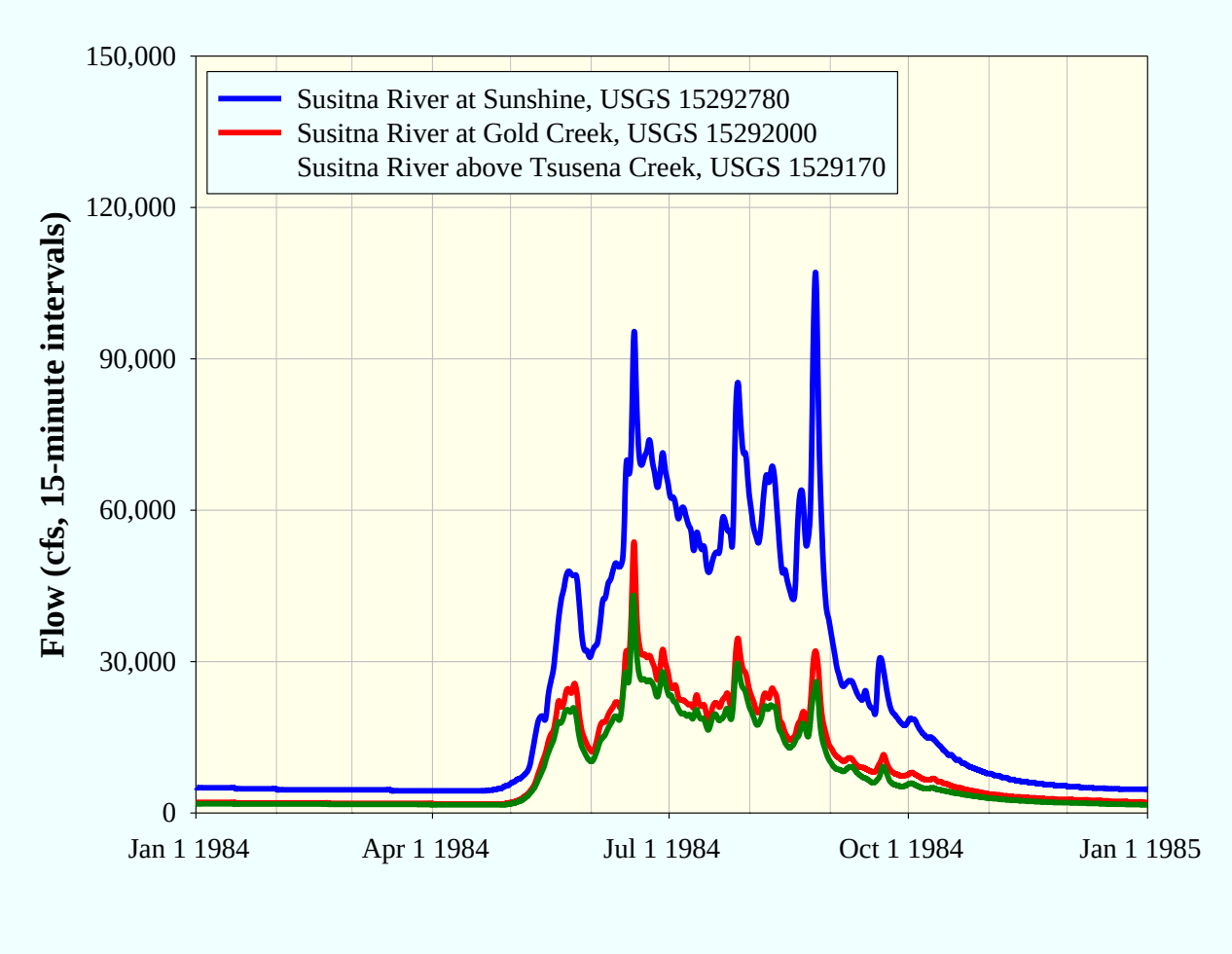
Effects of Proposed Project Operations

- The calibrated HEC-RAS model was then used to analyze Pre-Project and Maximum Load Following OS-1 conditions for calendar year 1984.
- Accretion flows downstream from the proposed dam site were derived from daily flows reported by the USGS.
- The daily flow hydrographs were converted to 15-minute flow hydrographs.
- The 15-minute flow hydrographs did not account for diurnal glacial melt fluctuations.
- During the winter, actual results may differ from those reported herein as a result of ice formation on the river

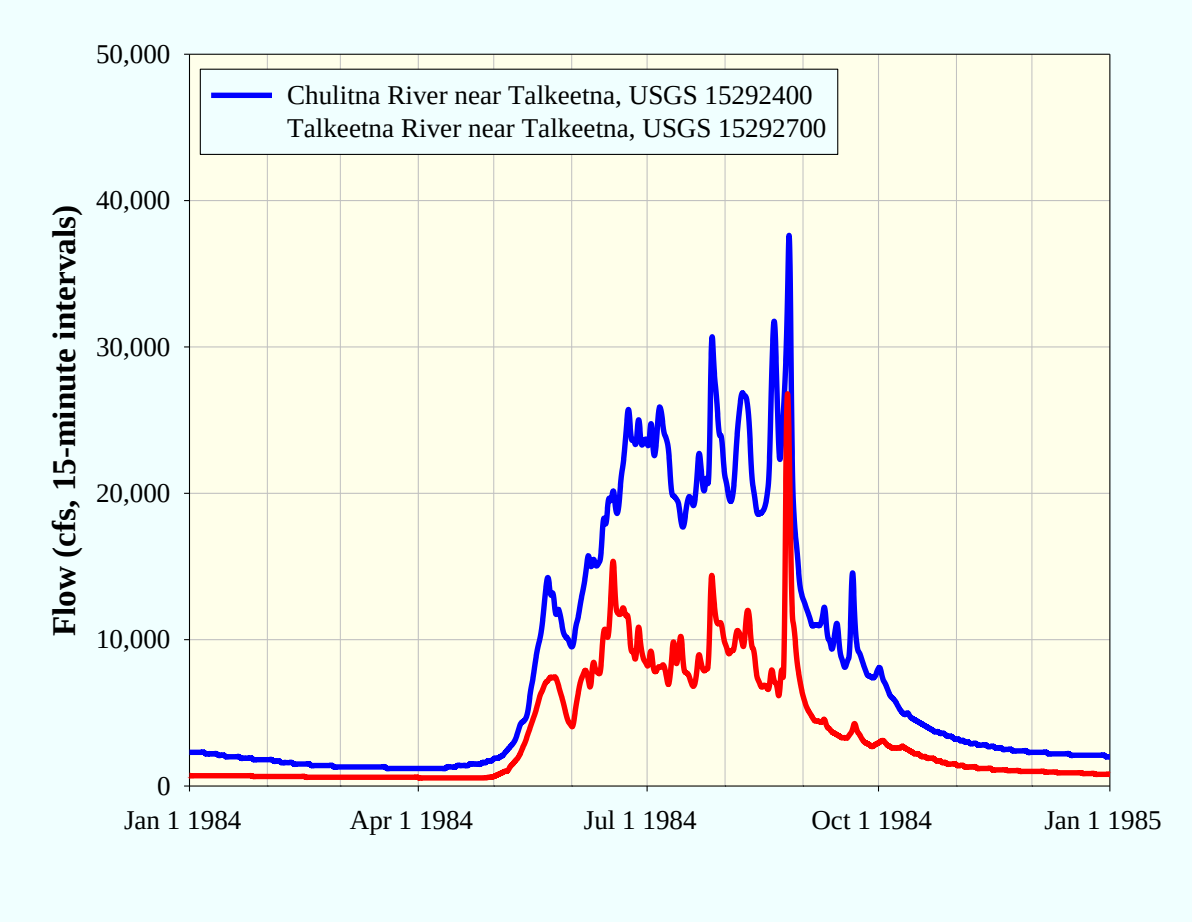
Derivation of 15-Minute Hydrograph from Daily Flows Reported for Chulitna River



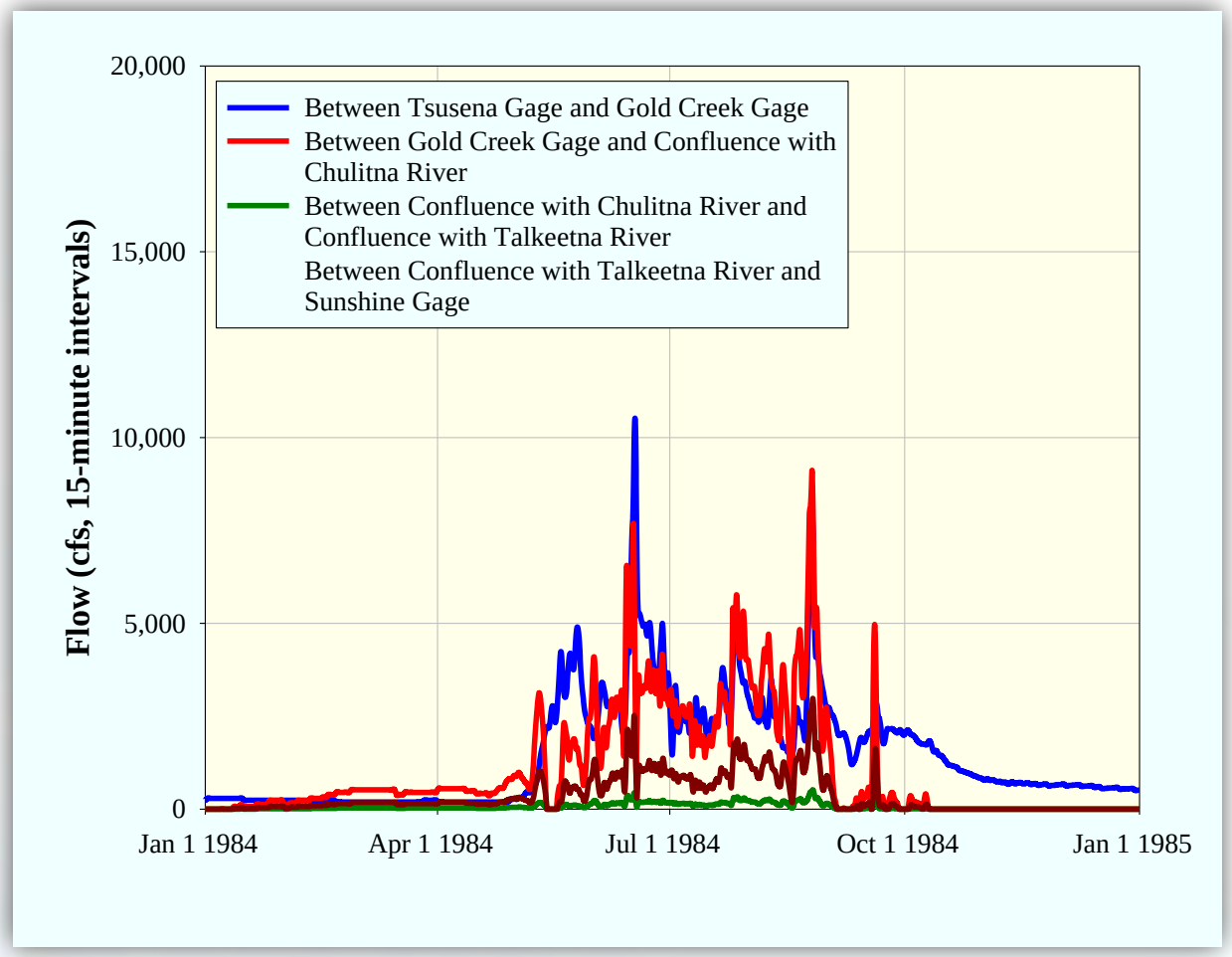
15-Minute Flows in Susitna River - 1984



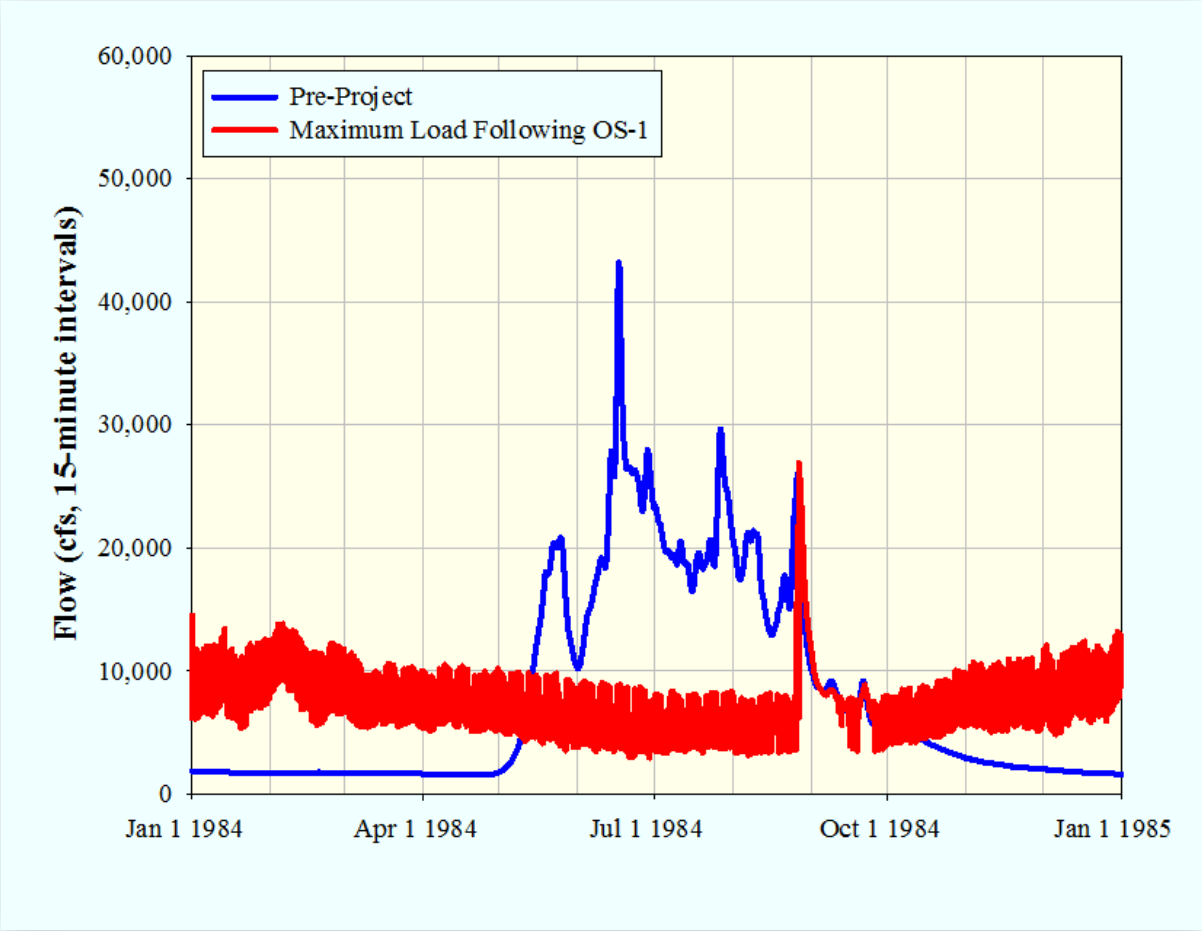
15-Minute Flows in Tributaries of the Susitna River - 1984



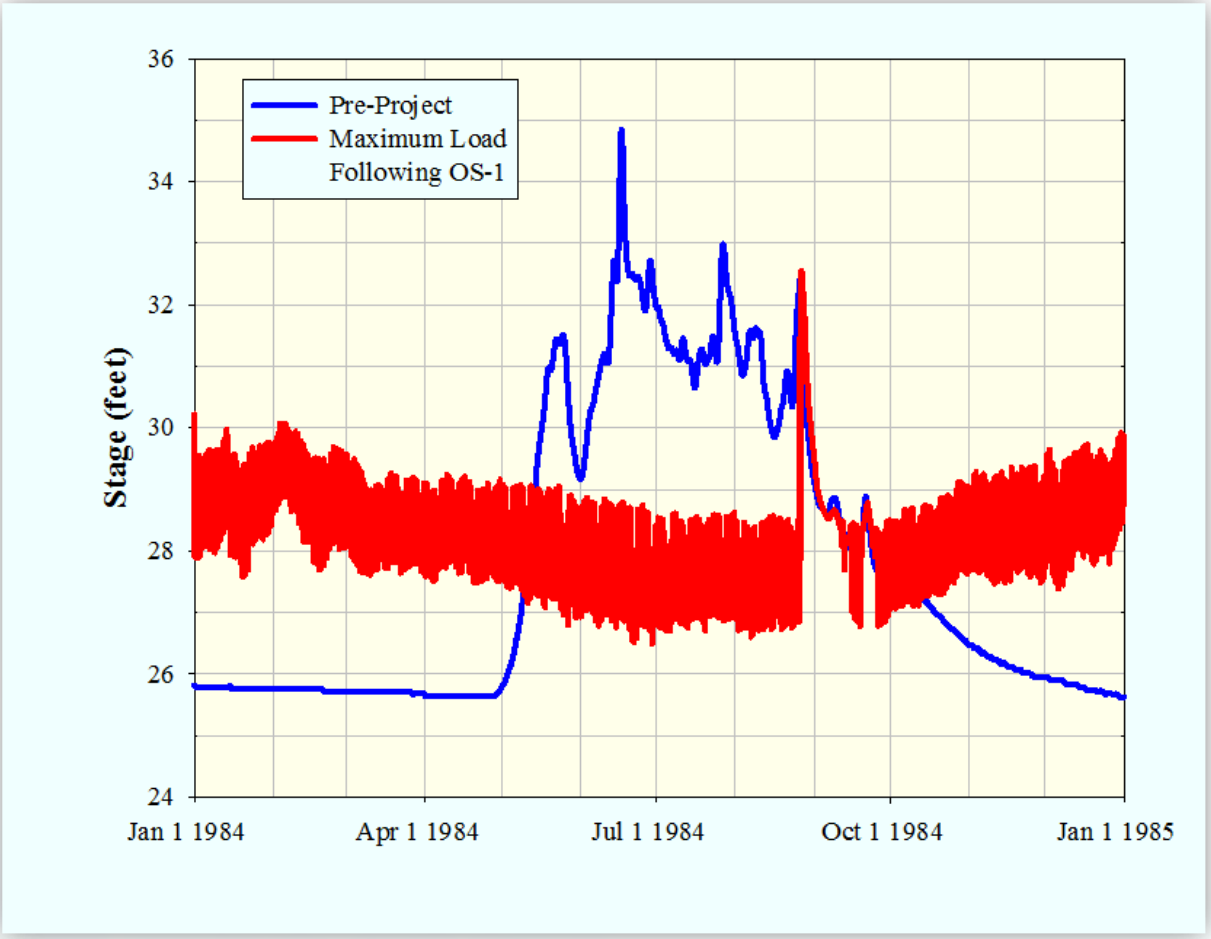
15-Minute Ungaged Accretion Flows to the Susitna River - 1984



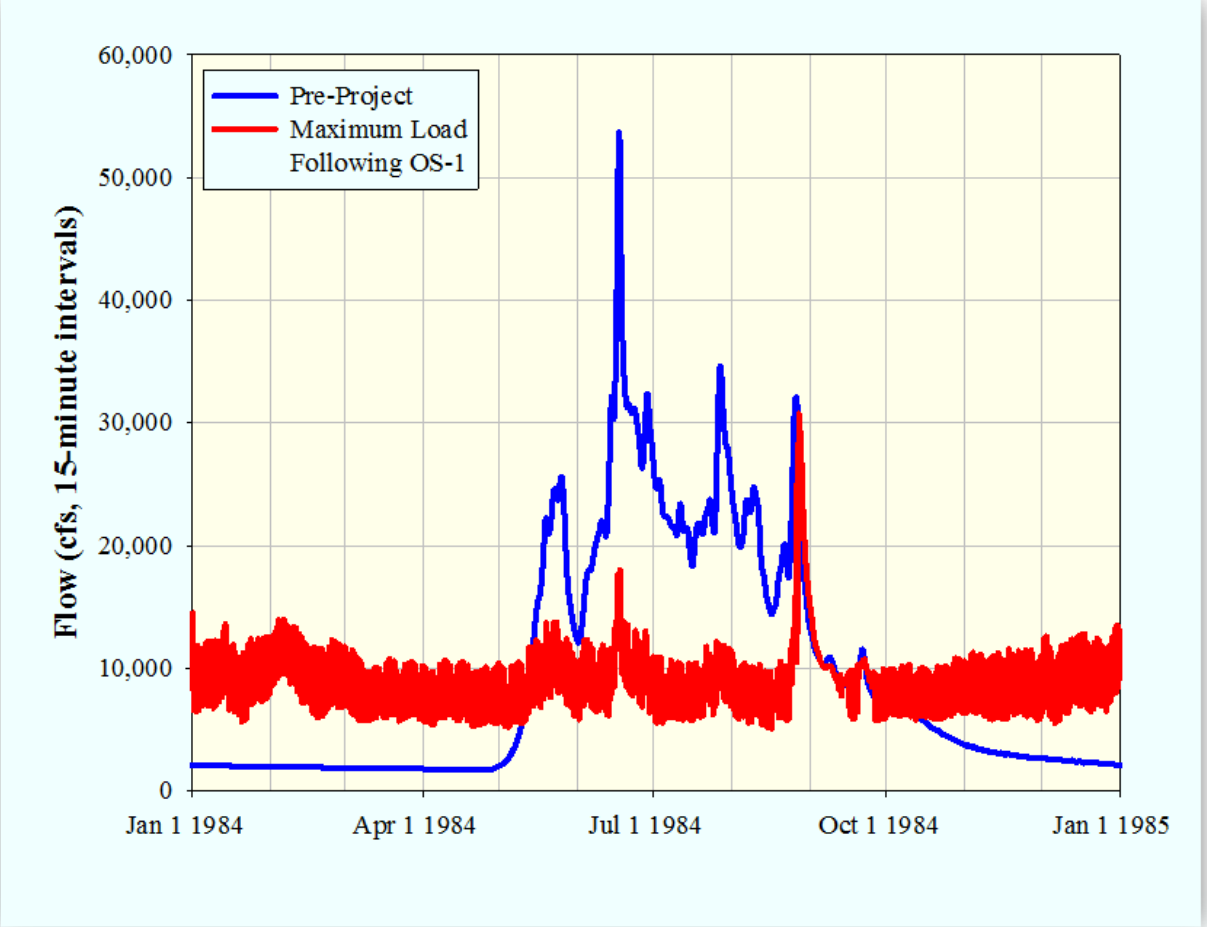
Effects of Proposed Project
15-Minute Flows in Susitna River Below Proposed Dam Site - 1984



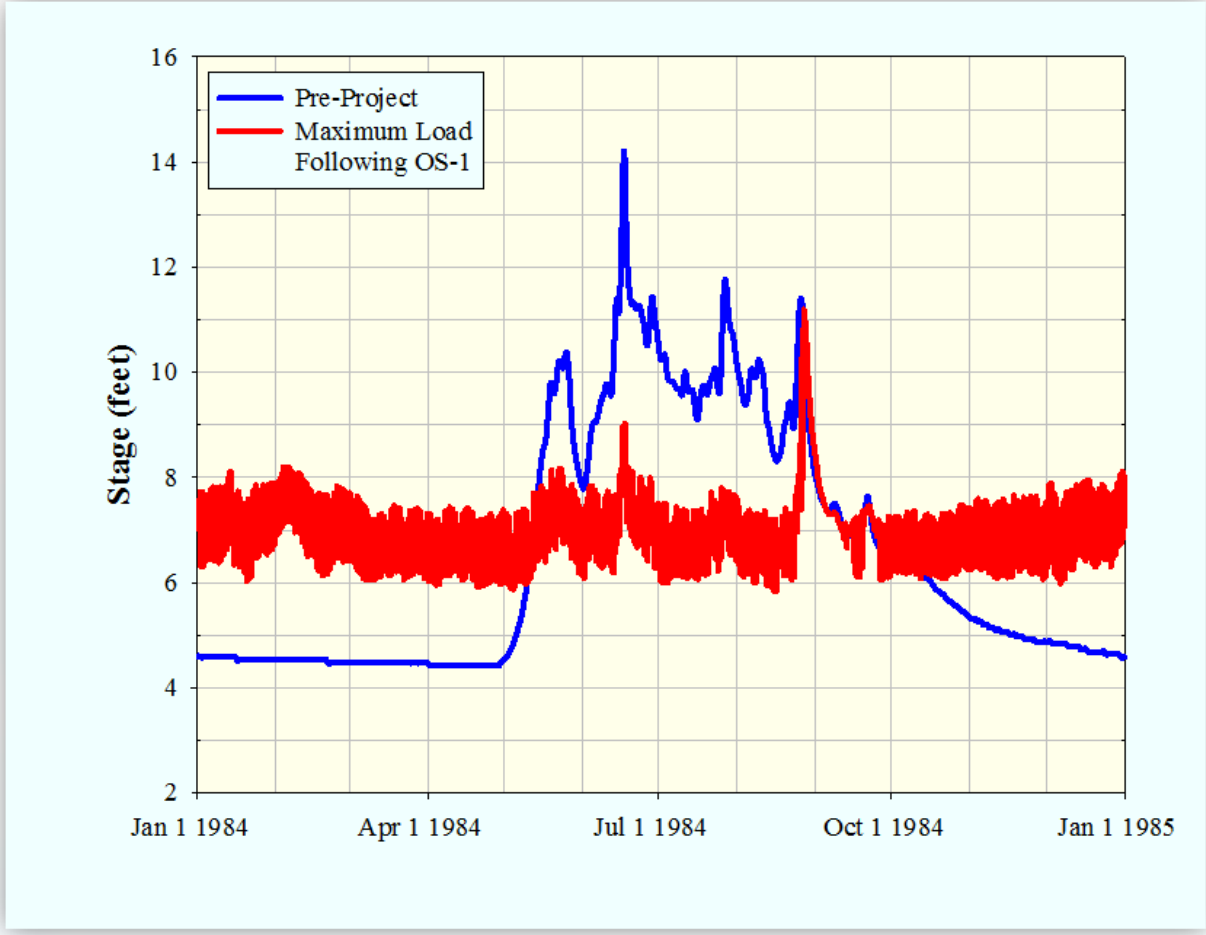
Effects of Proposed Project
15-Minute Stages in Susitna River Below Proposed Dam Site - 1984



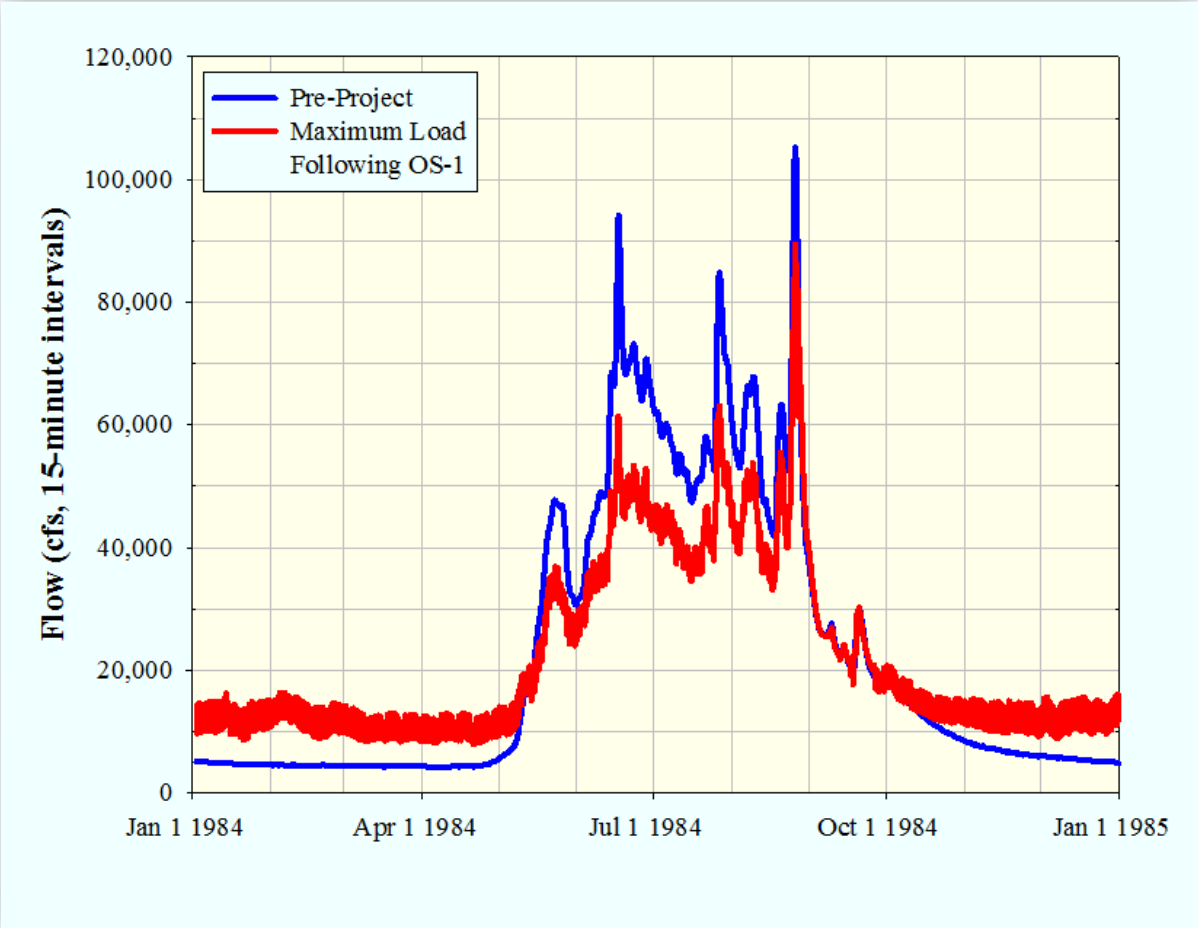
Effects of Proposed Project (HEC-RAS results)
15-Minute Flows in Susitna River at Gold Creek Gage - 1984



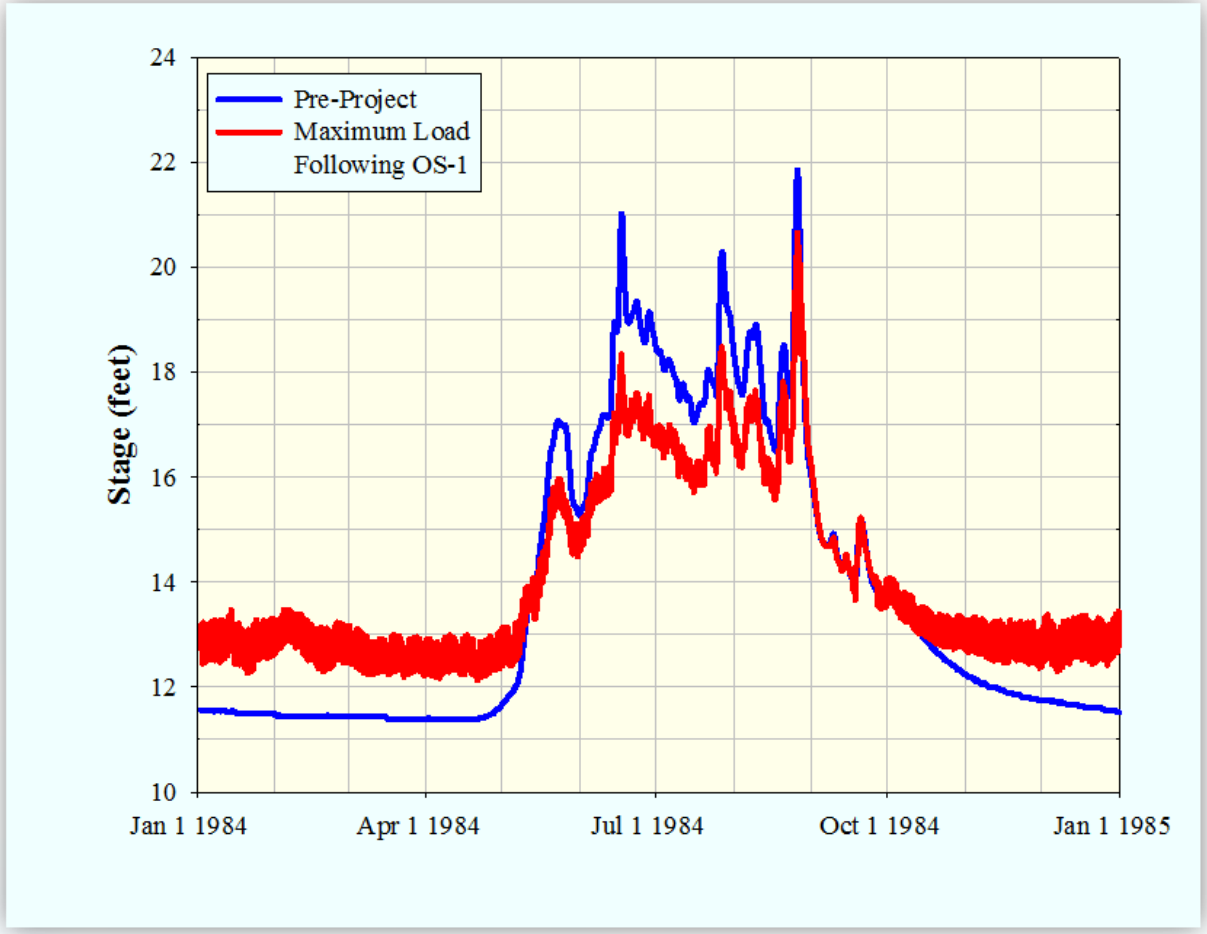
Effects of Proposed Project (HEC-RAS results)
15-Minute Stages in Susitna River at Gold Creek Gage - 1984



Effects of Proposed Project (HEC-RAS results)
15-Minute Flows in Susitna River
at Sunshine Gage - 1984

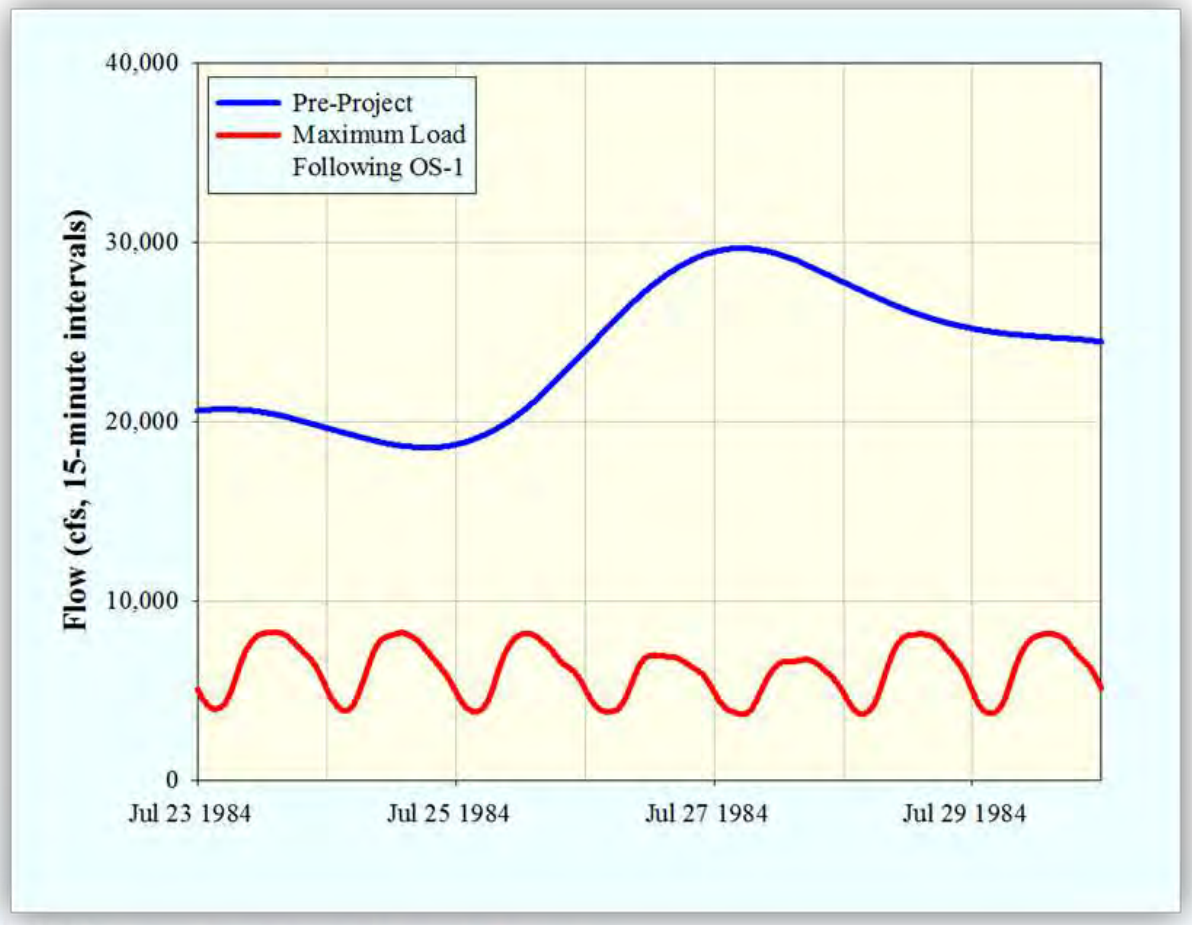


Effects of Proposed Project (HEC-RAS results) 15-Minute Stages in Susitna River at Sunshine Gage - 1984



Effects of Proposed Project
15-Minute Flows in Susitna River Below Proposed Dam Site – July, 1984

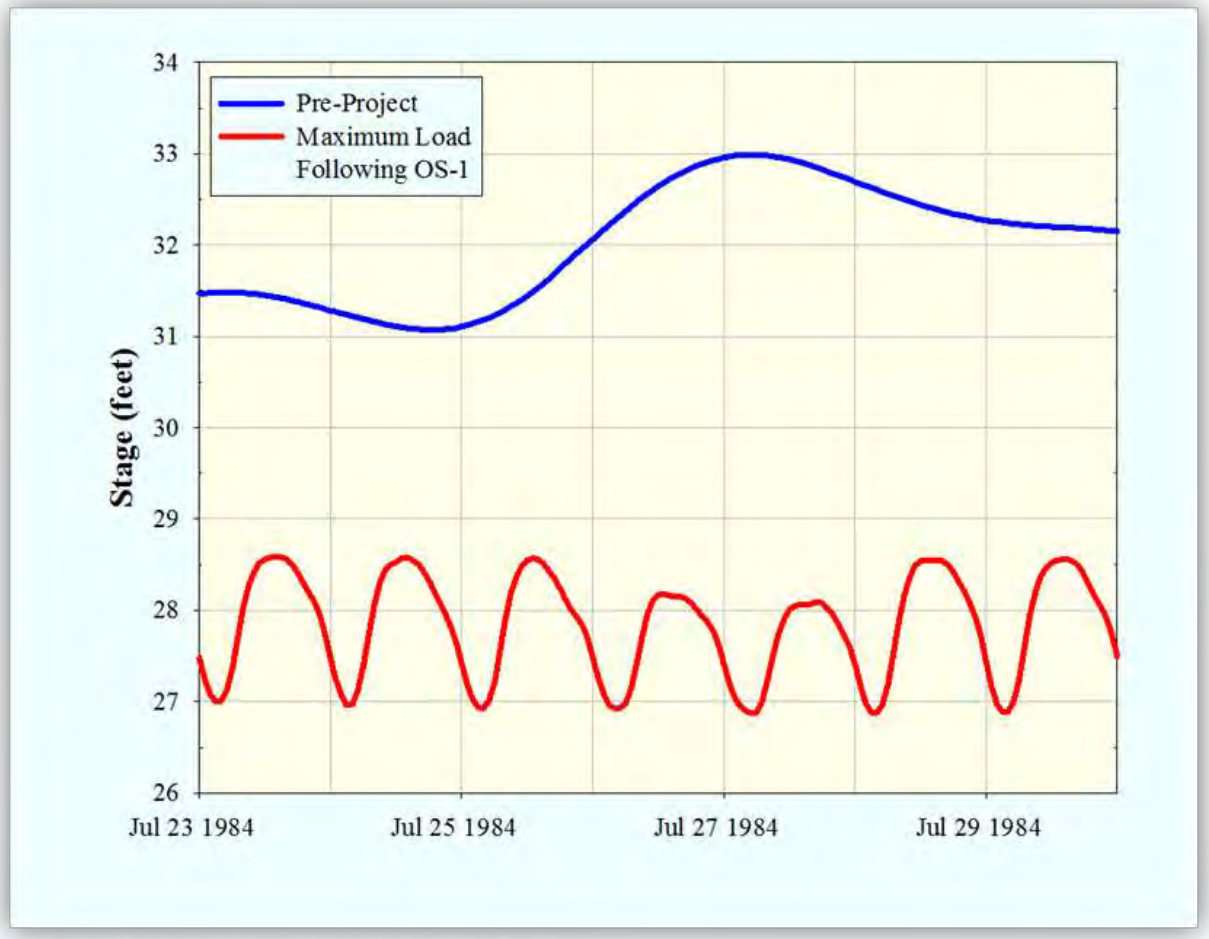
(Pre-Project conditions do not account for diurnal glacial melt fluctuations)



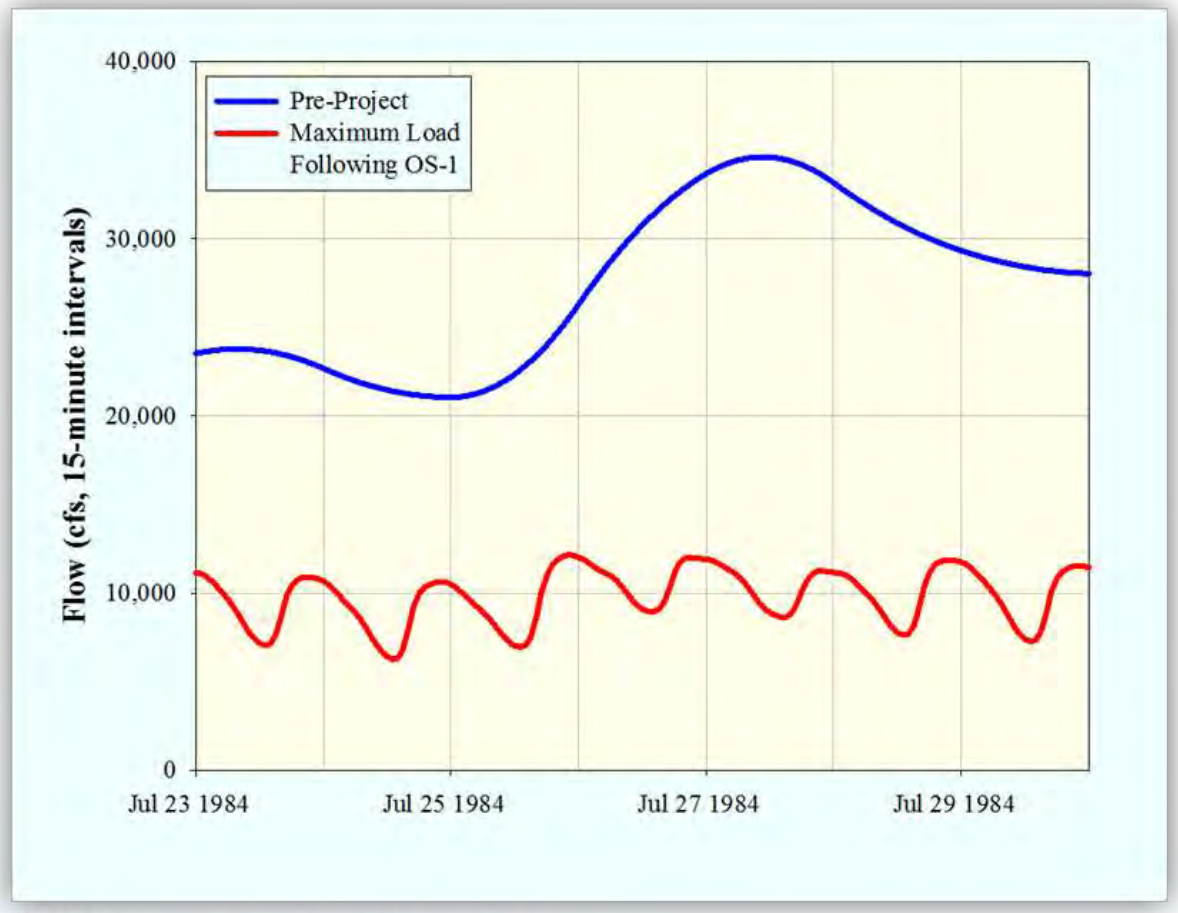
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Effects of Proposed Project
15-Minute Stages in Susitna River Below Proposed Dam Site – July, 1984

(Pre-Project conditions do not account for diurnal glacial melt fluctuations)

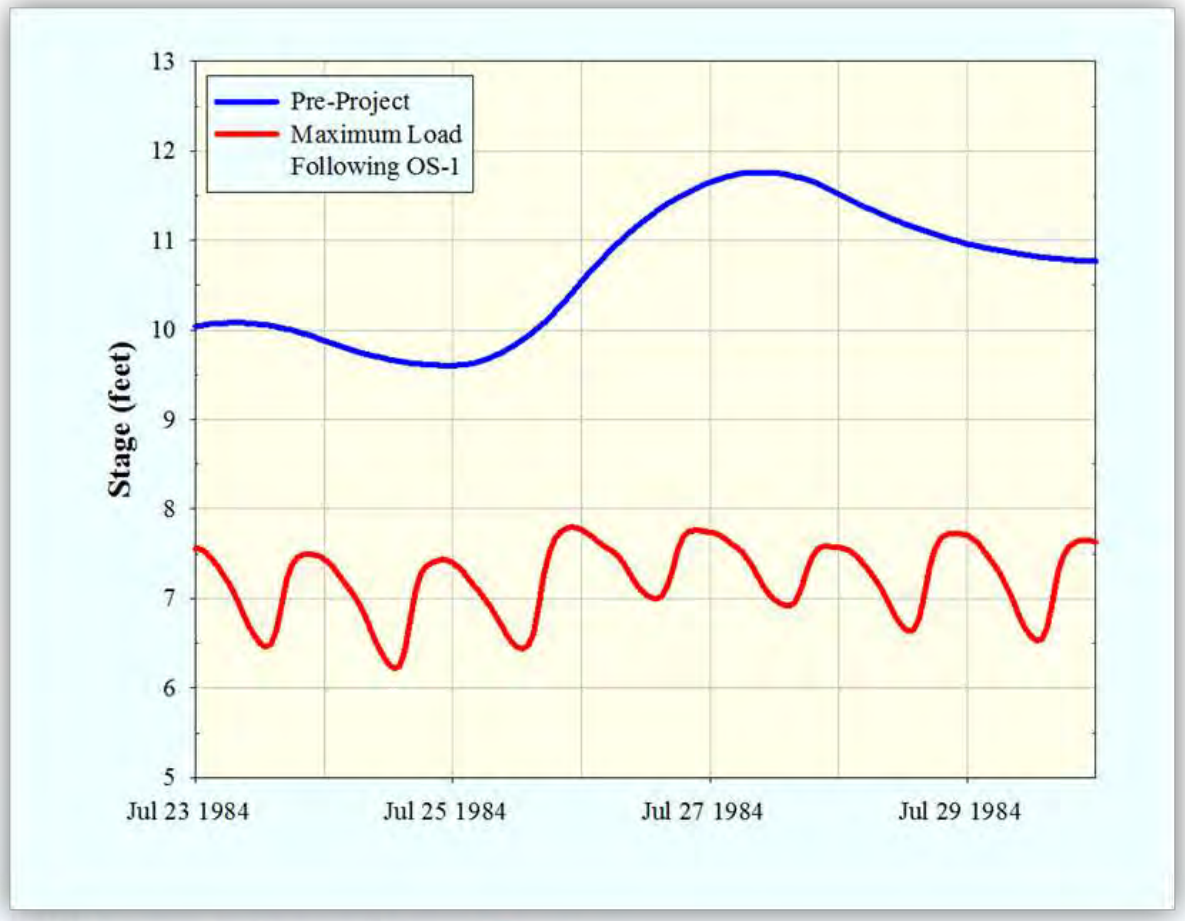


Effects of Proposed Project (HEC-RAS results)
15-Minute Flows in Susitna River at Gold Creek Gage – July, 1984
(Pre-Project conditions do not account for diurnal glacial melt fluctuations)



Effects of Proposed Project (HEC-RAS results) 15-Minute Stages in Susitna River at Gold Creek Gage – July, 1984

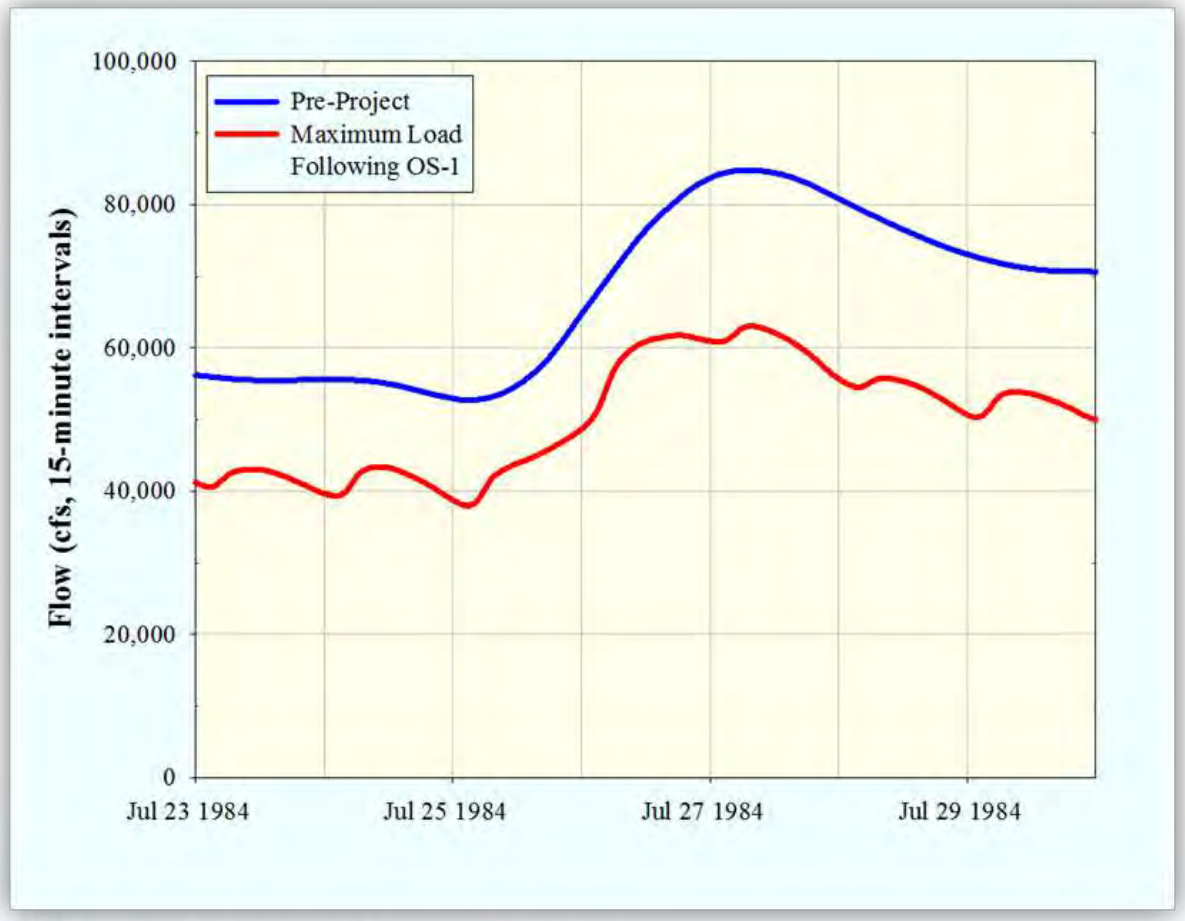
(Pre-Project conditions do not account for diurnal glacial melt fluctuations)



SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

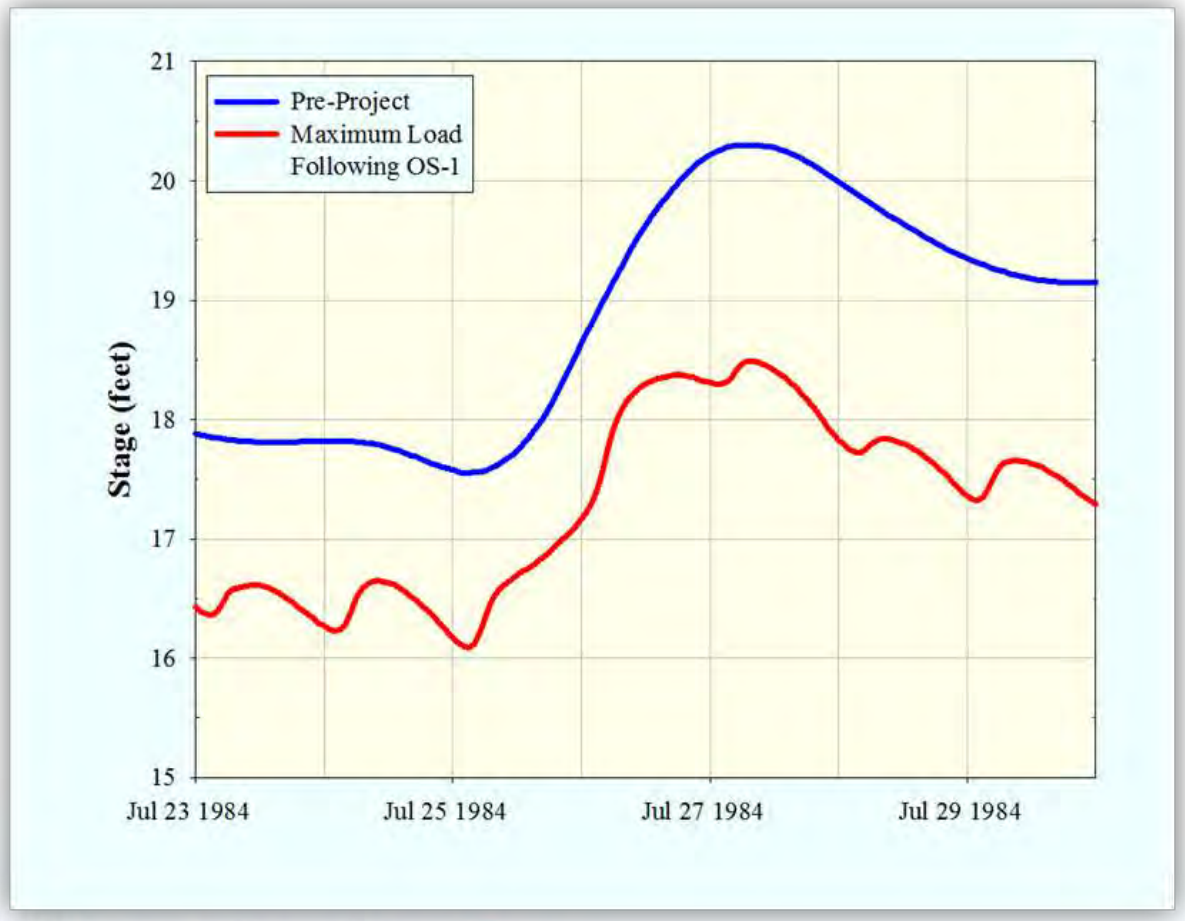
Effects of Proposed Project (HEC-RAS results) 15-Minute Flows in Susitna River at Sunshine Gage – July, 1984

(Pre-Project conditions do not account for diurnal glacial melt fluctuations)



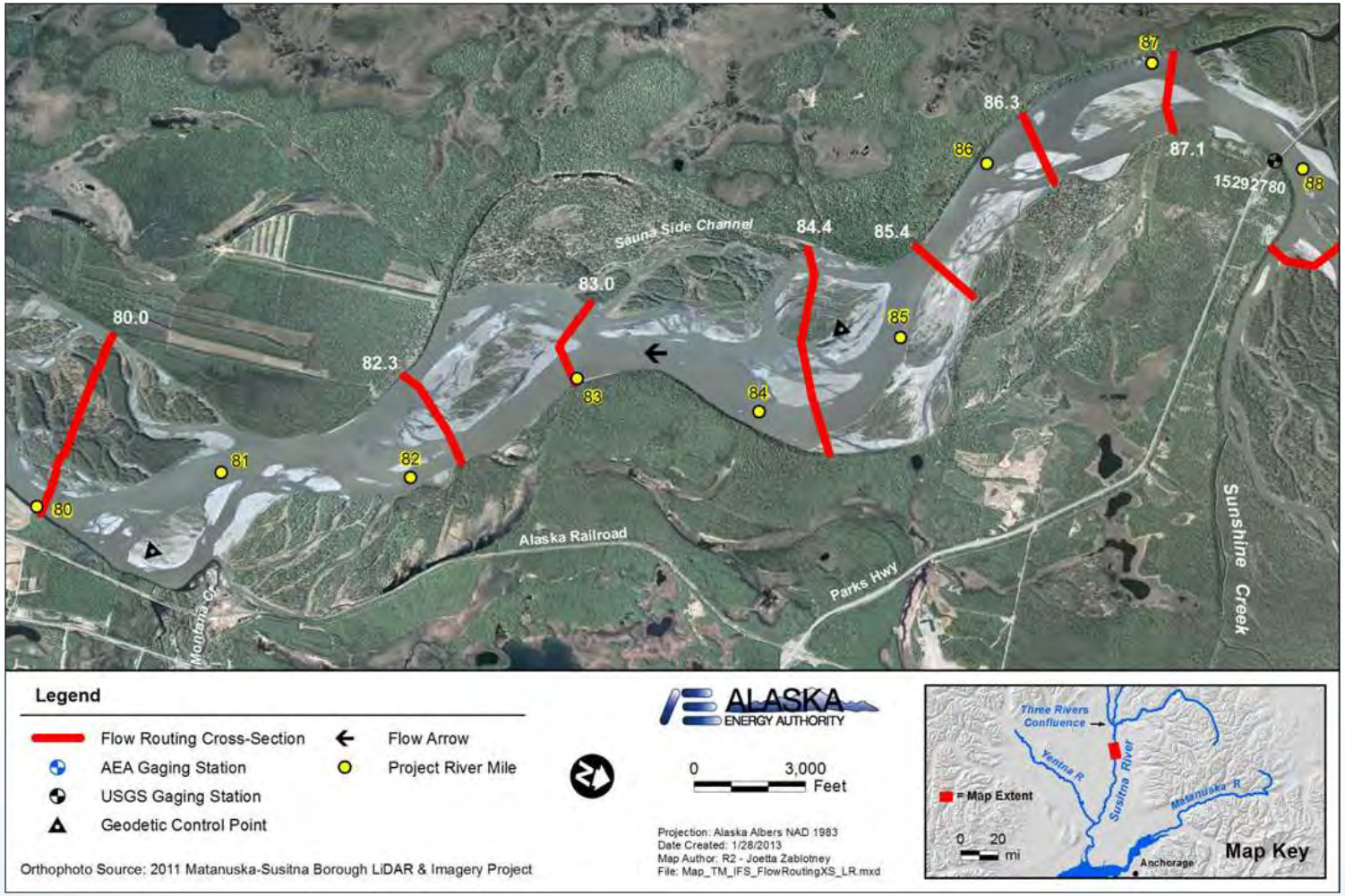
Effects of Proposed Project (HEC-RAS results) 15-Minute Stages in Susitna River at Sunshine Gage – July, 1984

(Pre-Project conditions do not account for diurnal glacial melt fluctuations)



SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

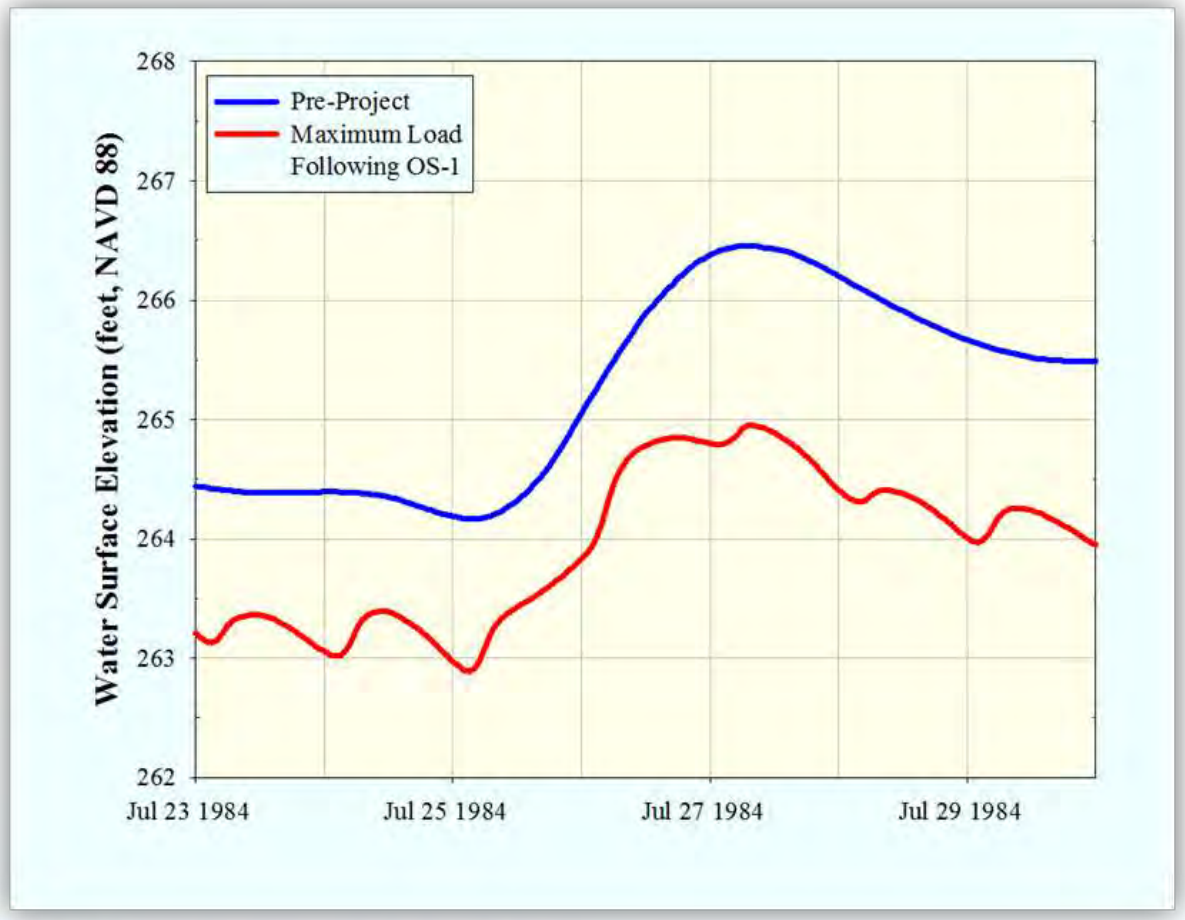
Sunshine Gage is Located at a Confined Single Channel - Not Representative of Local Conditions



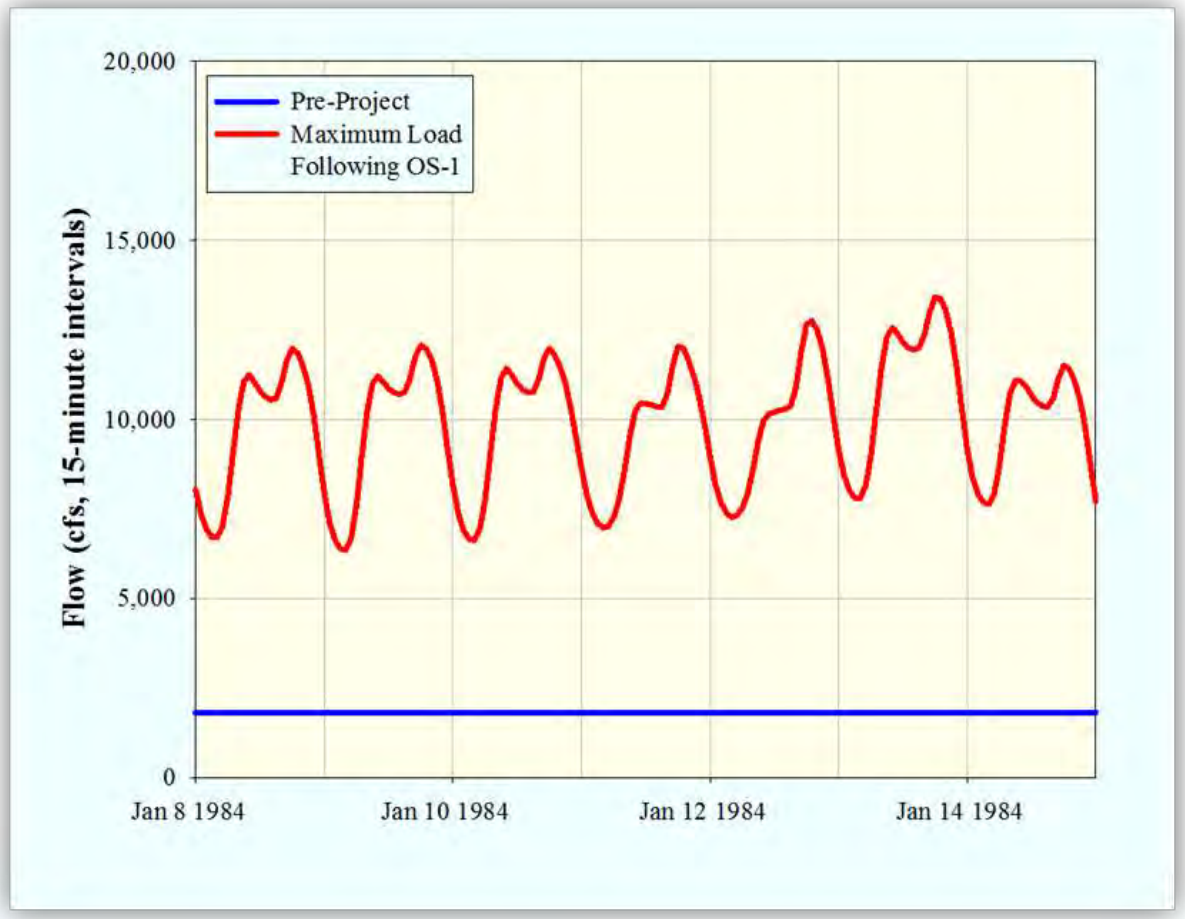
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Effects of Proposed Project (HEC-RAS results) 15-Minute Stages in Susitna River at PRM 87.1 (below Sunshine gage) – July, 1984

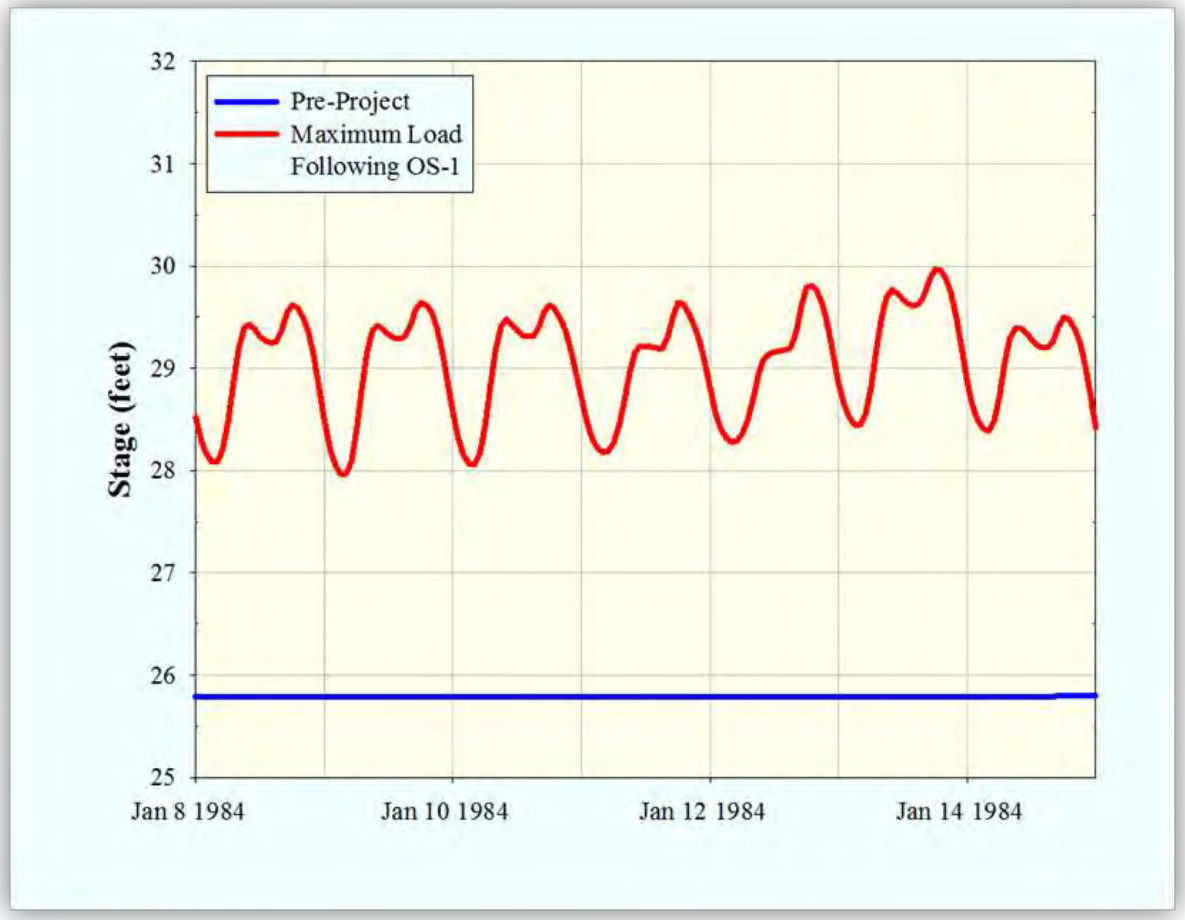
(Pre-Project conditions do not account for diurnal glacial melt fluctuations)



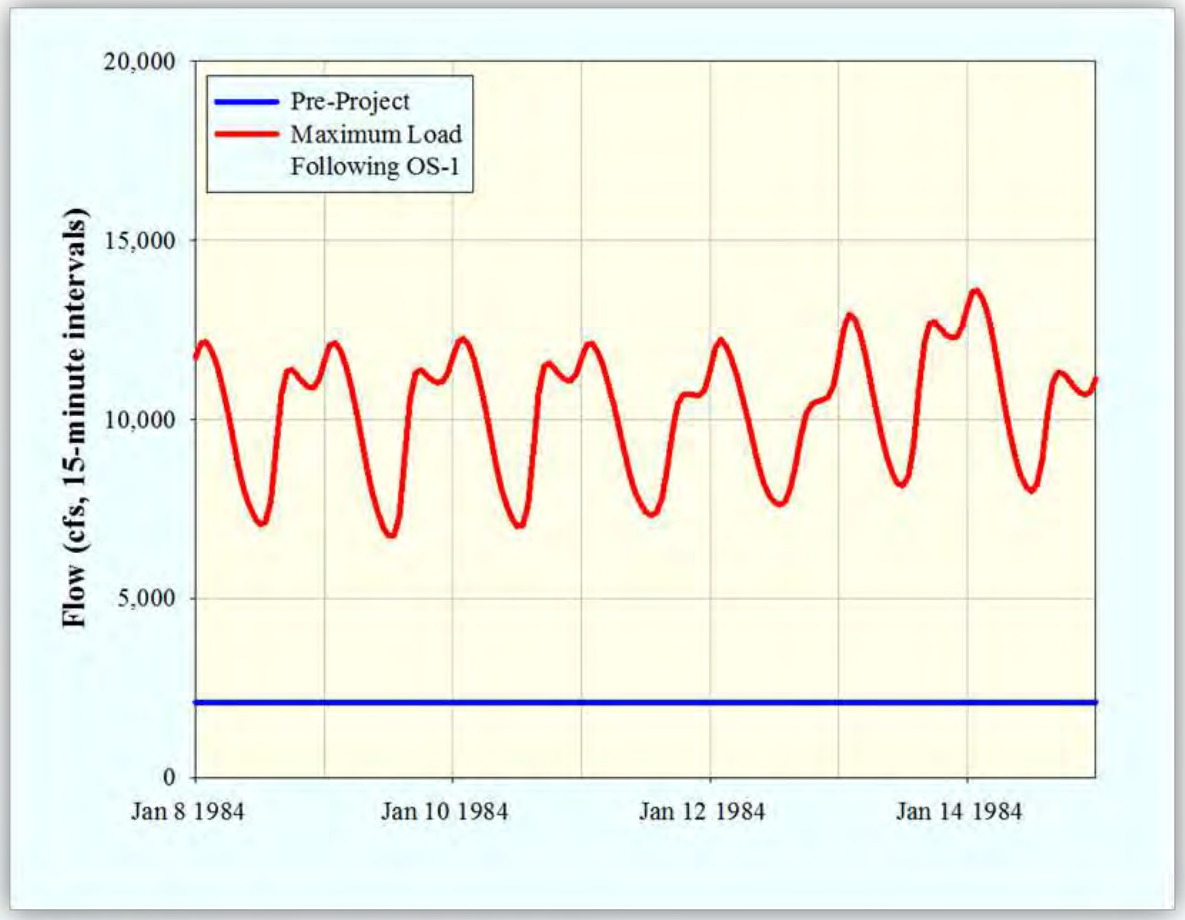
Effects of Proposed Project
15-Minute Flows in Susitna River Below Proposed Dam Site – January, 1984



Effects of Proposed Project
15-Minute Stages in Susitna River Below Proposed Dam Site – January, 1984



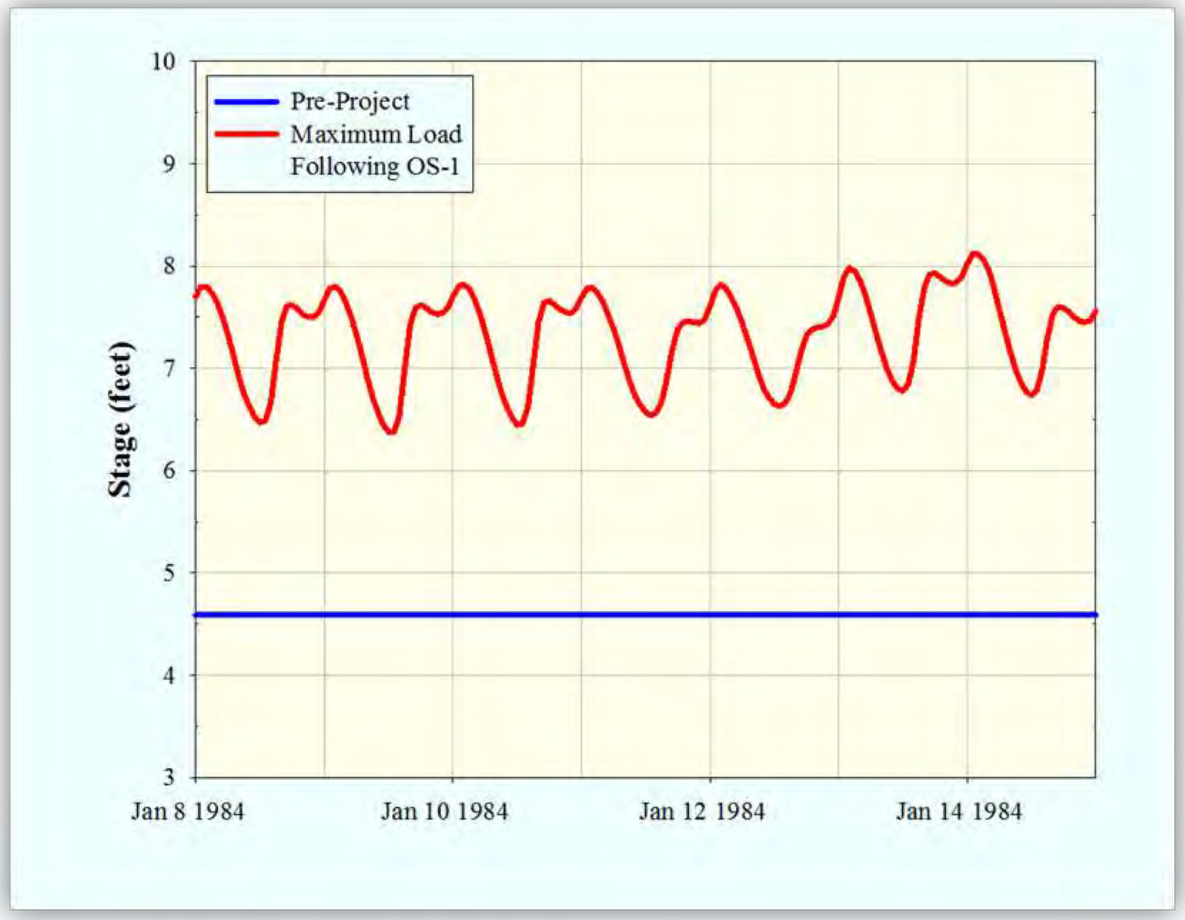
Effects of Proposed Project (HEC-RAS results)
15-Minute Flows in Susitna River at Gold Creek Gage – January, 1984
(Actual results may differ as a result of ice formation on the river)



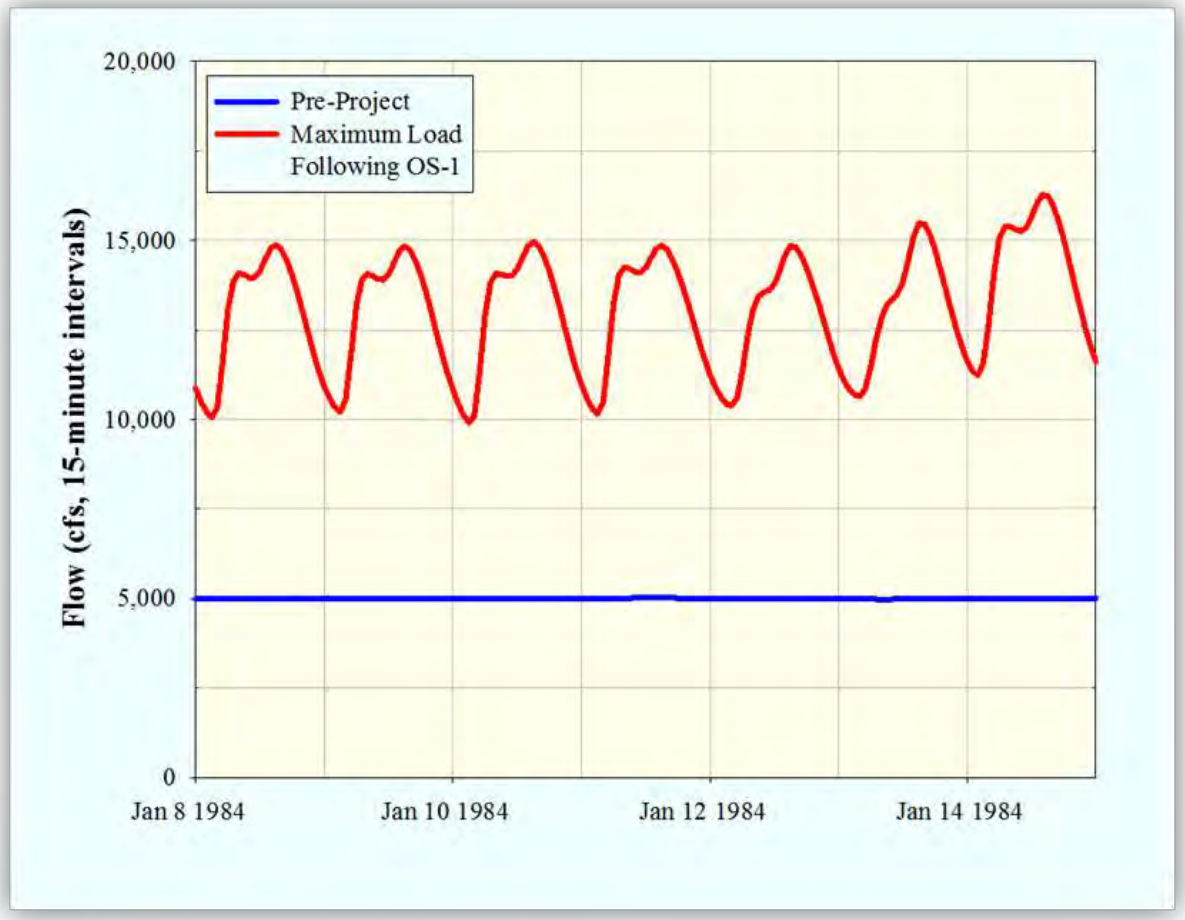
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Effects of Proposed Project (HEC-RAS results) 15-Minute Stages in Susitna River at Gold Creek Gage – January, 1984

(Actual results may differ as a result of ice formation on the river)



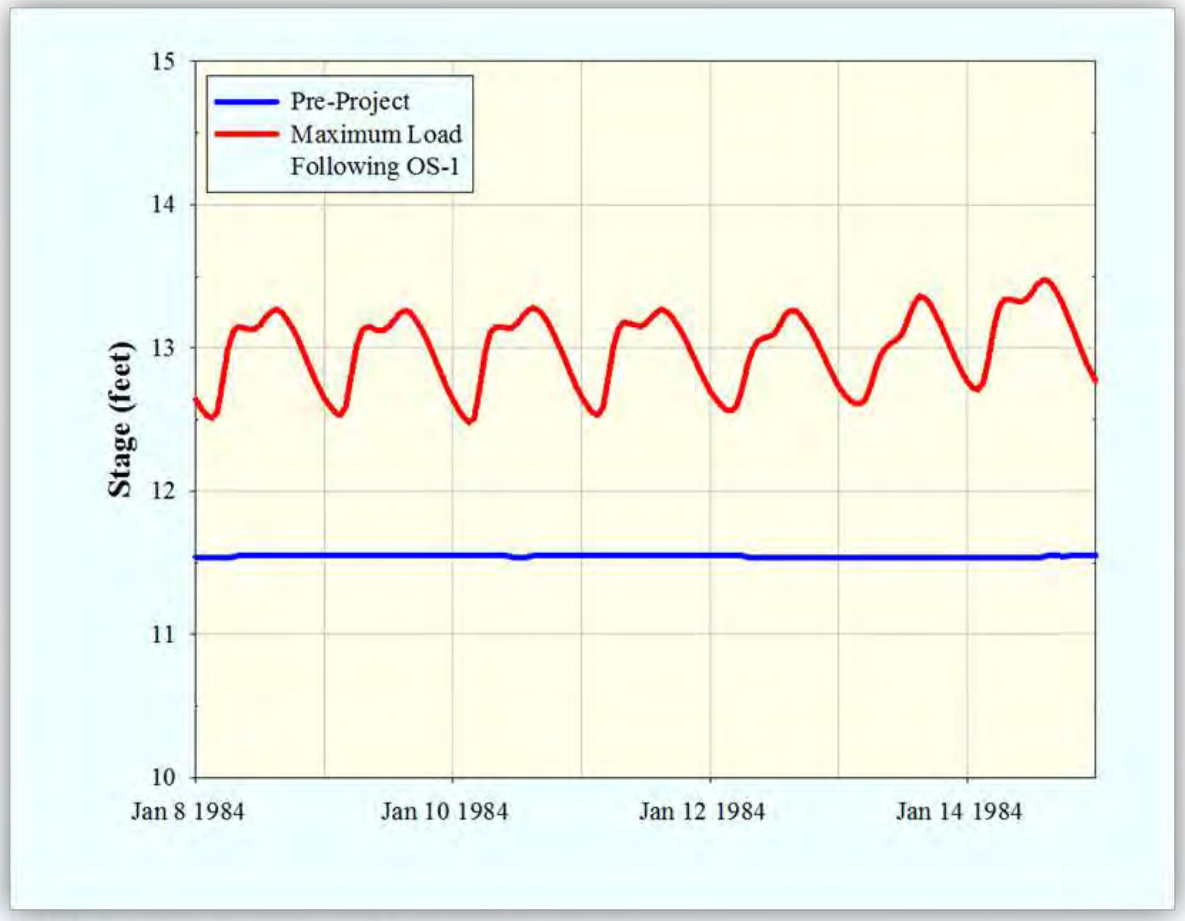
Effects of Proposed Project (HEC-RAS results)
15-Minute Flows in Susitna River at Sunshine Gage – January, 1984
(Actual results may differ as a result of ice formation on the river)



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Effects of Proposed Project (HEC-RAS results)
15-Minute Stages in Susitna River at Sunshine Gage – January, 1984

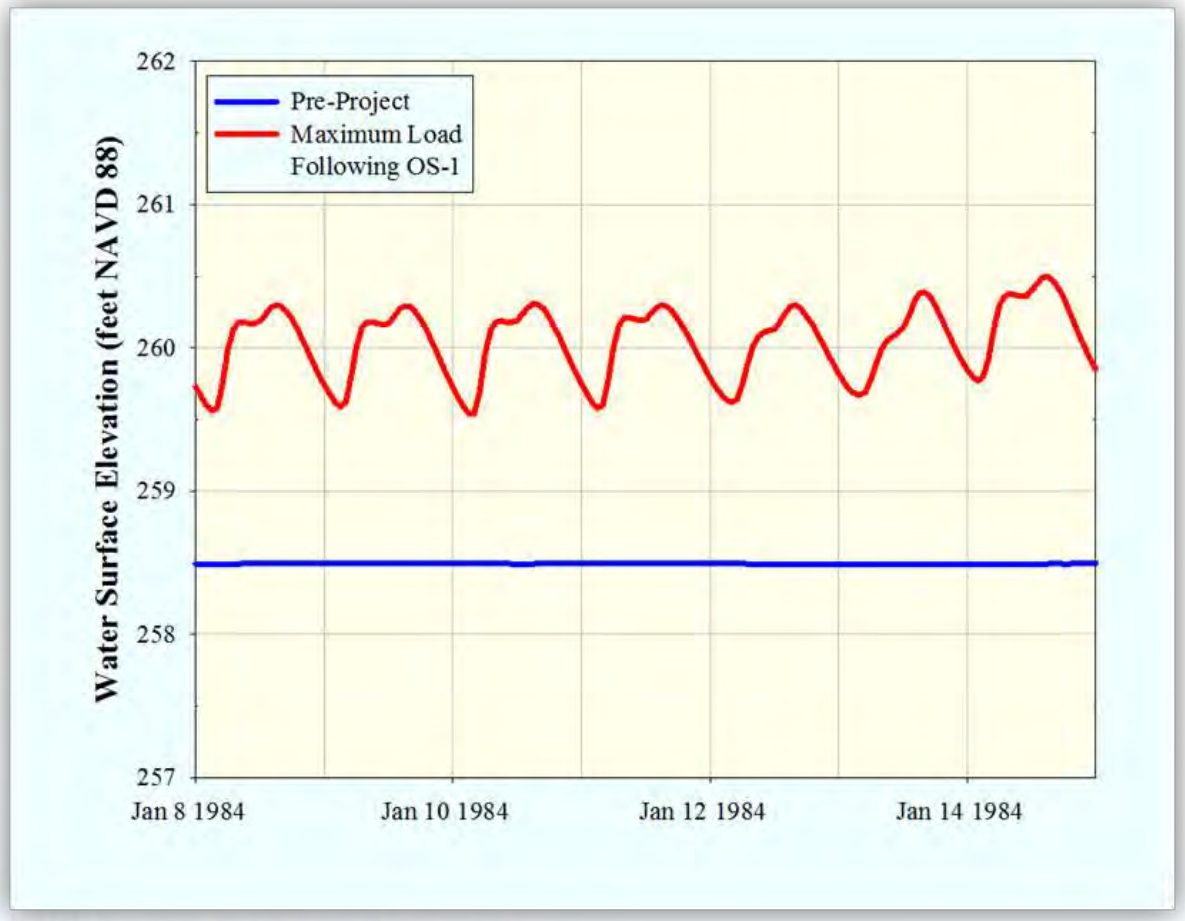
(Actual results may differ as a result of ice formation on the river)



SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Effects of Proposed Project (HEC-RAS results)
15-Minute Stages in Susitna River
at PRM 87.1 (below Sunshine Gage) – January, 1984

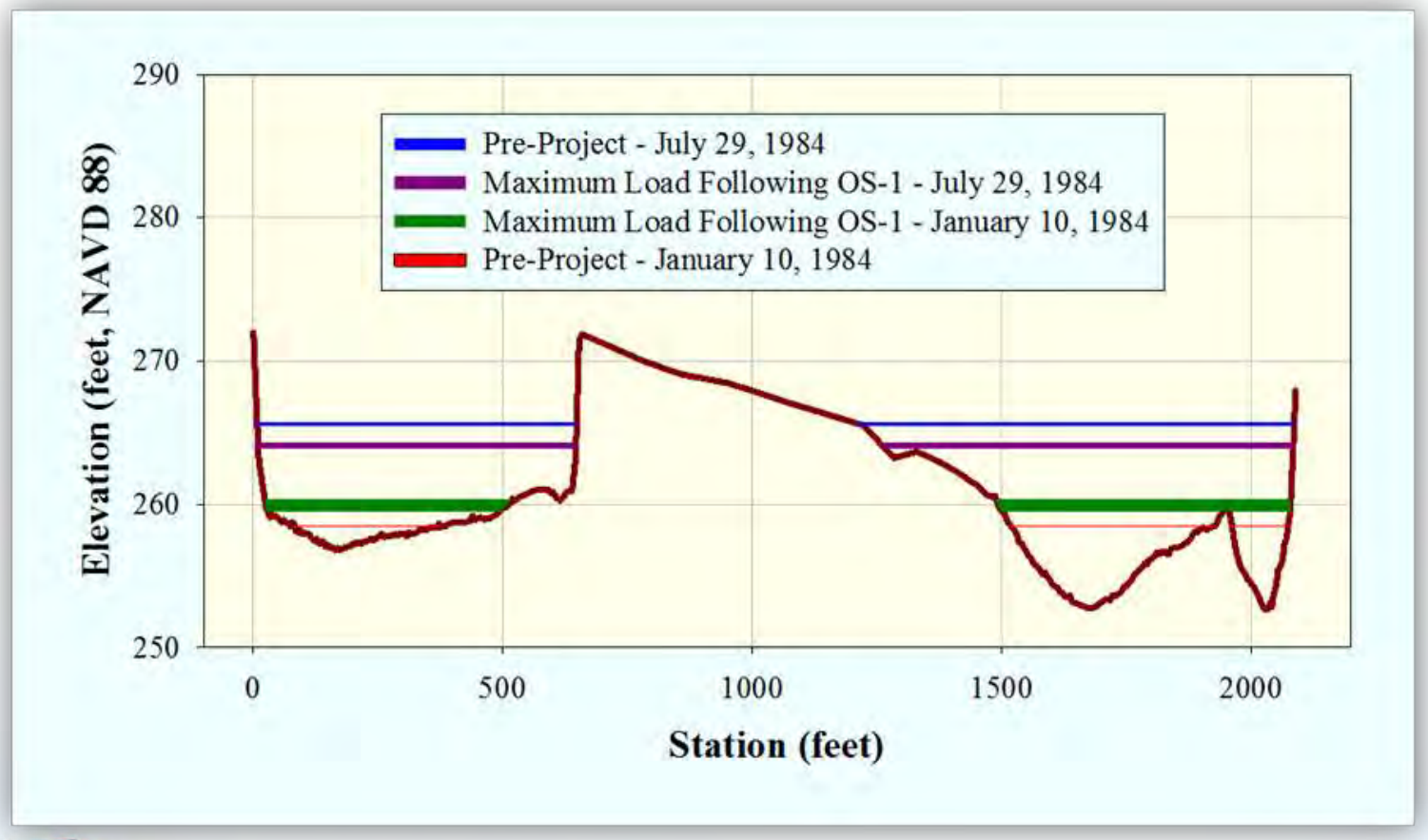
(Actual results may differ as a result of ice formation on the river)



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Effects of Proposed Project (HEC-RAS results) Surveyed Cross-Section of Susitna River at PRM 87.1

(Actual results may differ as a result of ice formation on the river)



Planned Improvements to Open-Water Flow Routing Model

- HEC-RAS: Version 2 will extend cross-section profiles to higher elevations using LiDAR, and ground-based RTK GPS surveys.
- Additional pairs of flow/water surface elevations will be measured and used in the model.
- Measured flows in tributaries will improve estimates of accretion flows.
- The model will include additional cross-sections surveyed in geomorphology study.
- Diurnal glacial melt fluctuations will be incorporated into summer hydrographs.

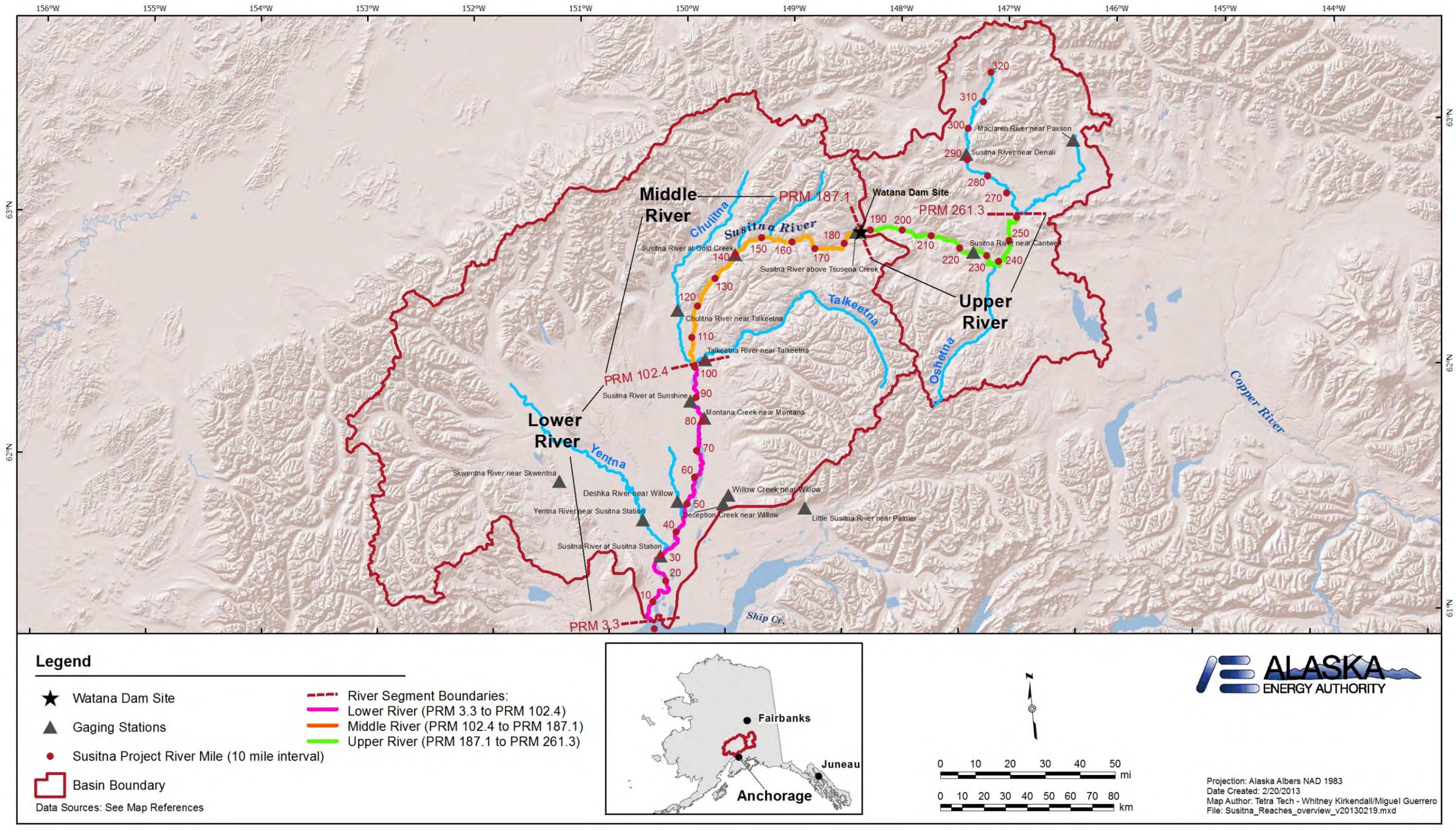
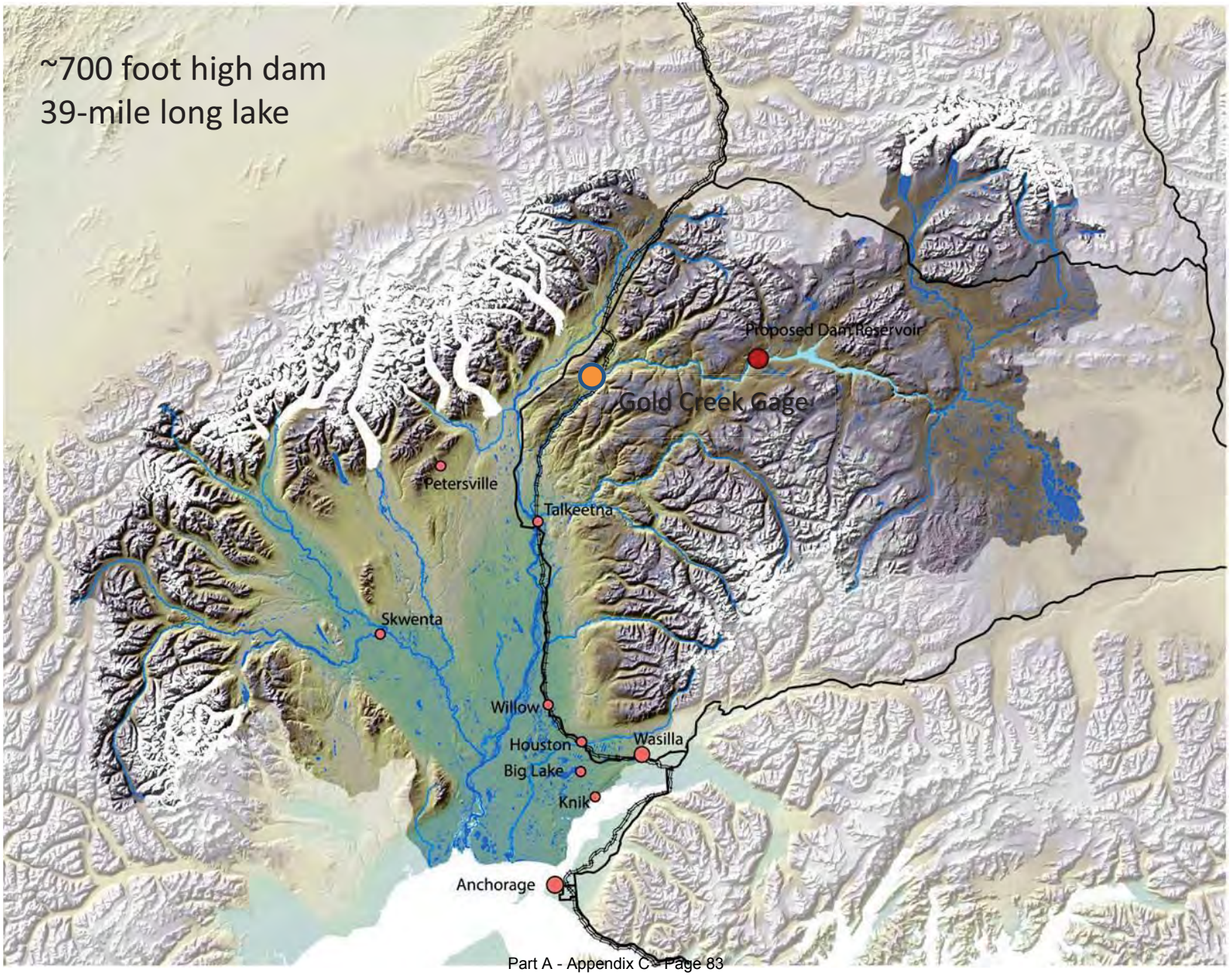
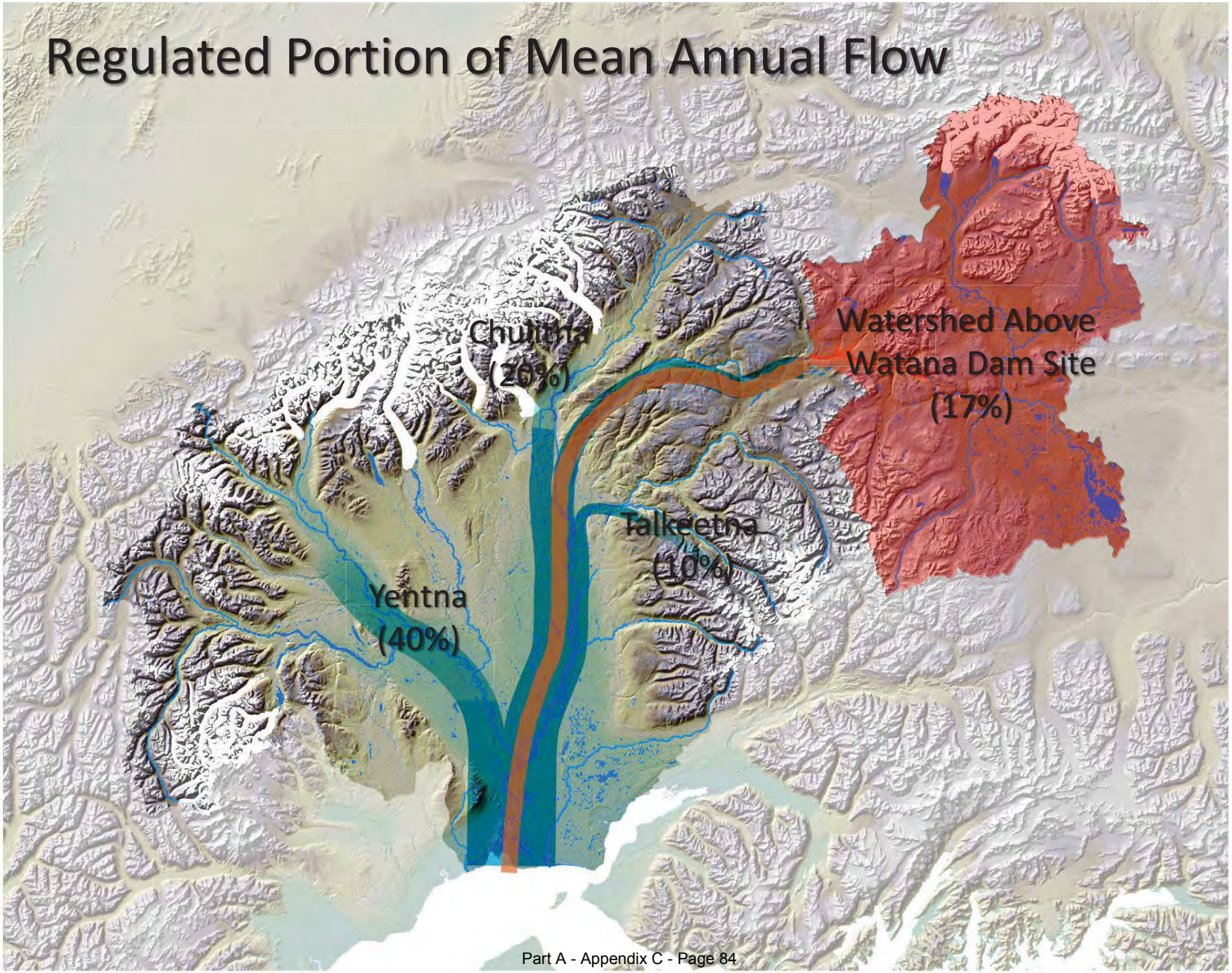
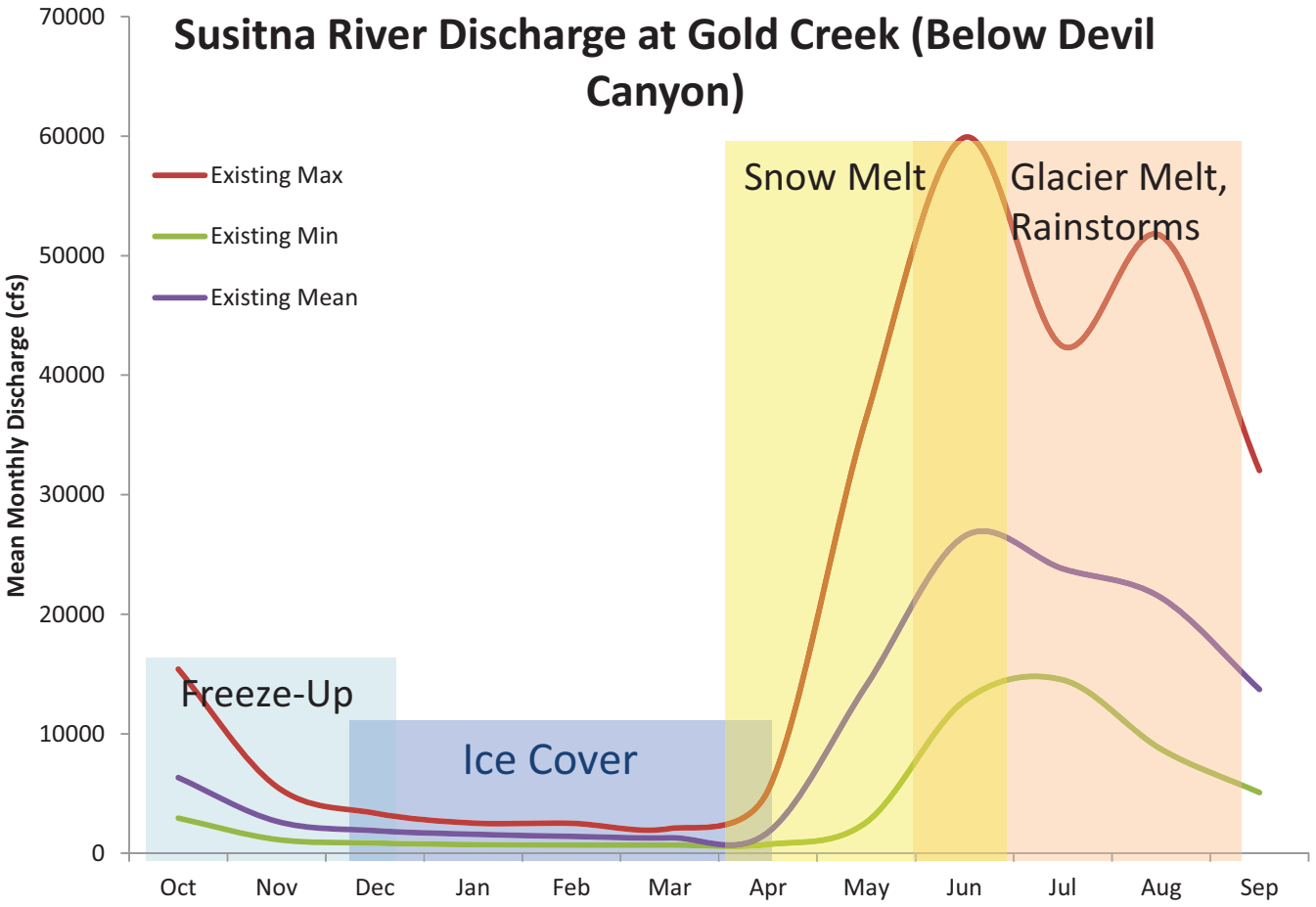


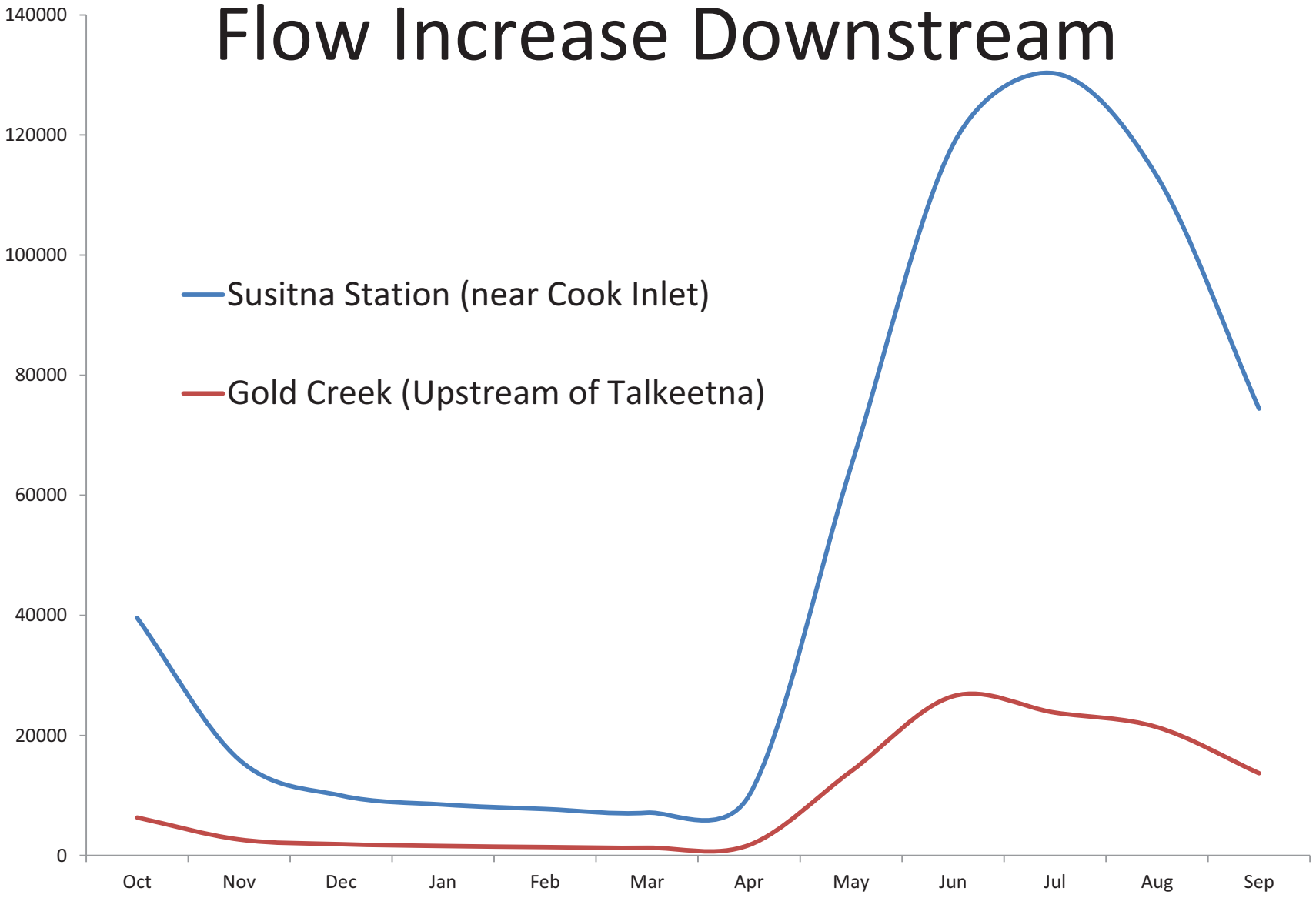
Figure 3.2-1. Susitna River study area and large-scale river segments.


~700 foot high dam
39-mile long lake
Proposed Dam, Reservoir
Gold Creek Gage
Petersville
Talkeetna
Skwenta
Willow
Houston
Wasilla
Big Lake
Knik
Anchorage

Regulated Portion of Mean Annual Flow

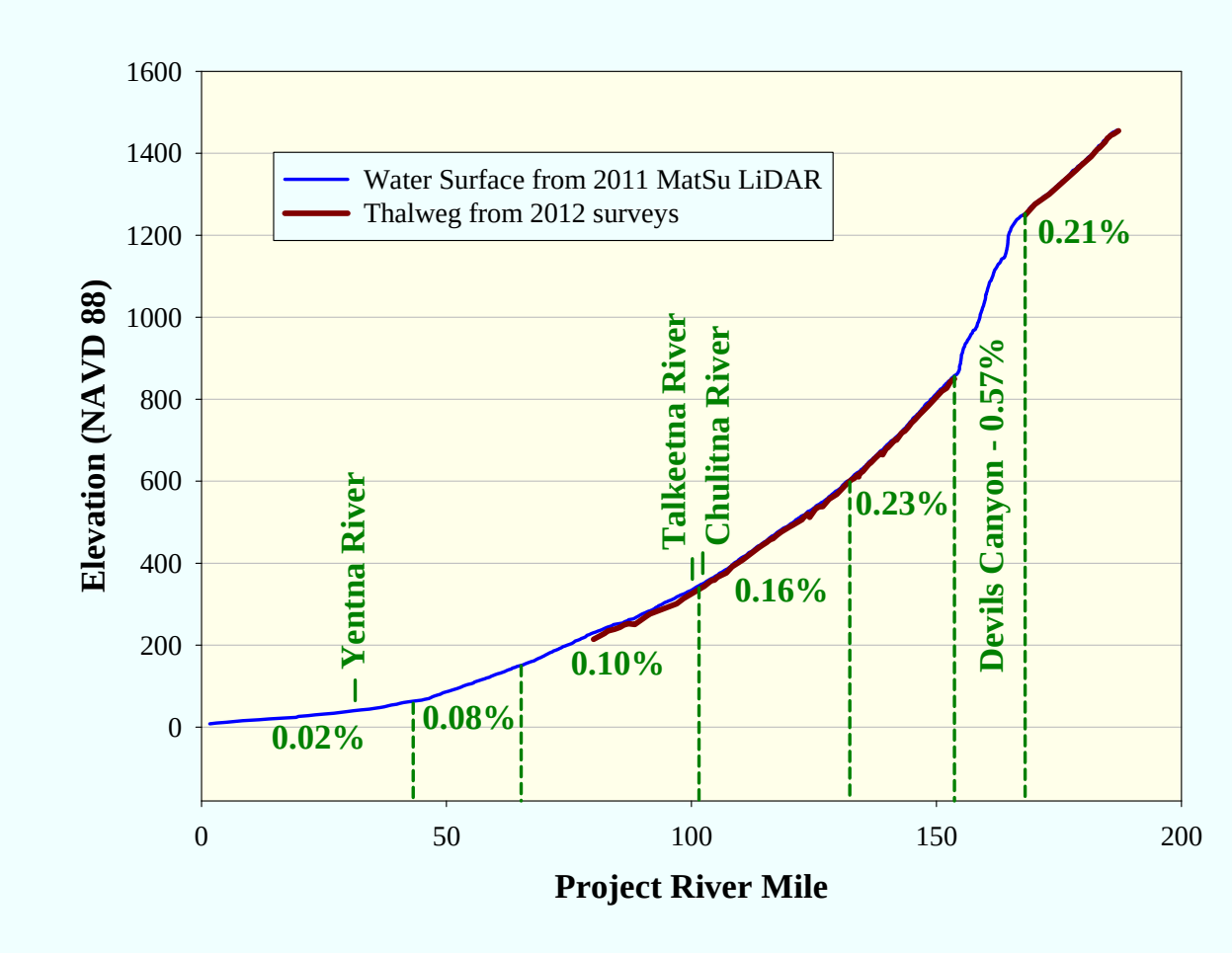


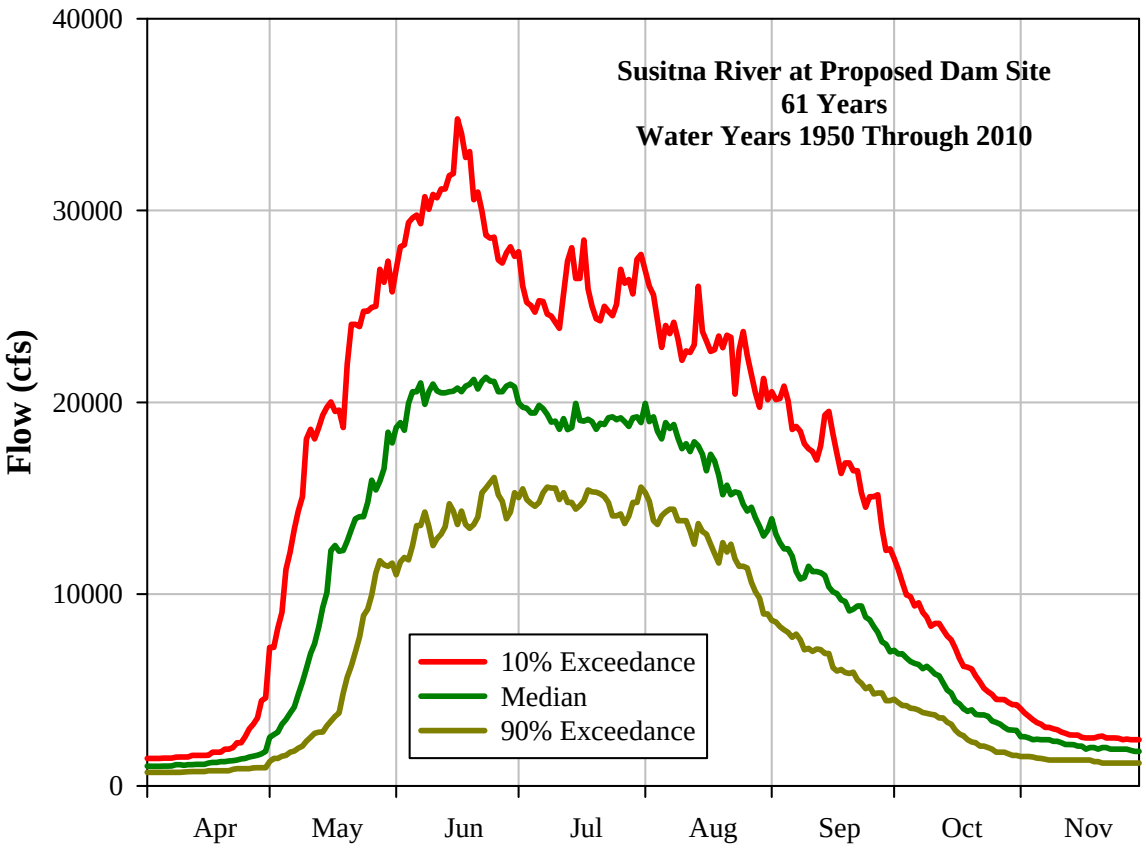

Susitna River Discharge at Gold Creek (Below Devil Canyon)
Mean Monthly Discharge (cfs)
70000
60000
50000
40000
30000
20000
10000
0
Existing Max
Existing Min
Existing Mean
Snow Melt
Glacier Melt, Rainstorms
Freeze-Up
Ice Cover
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

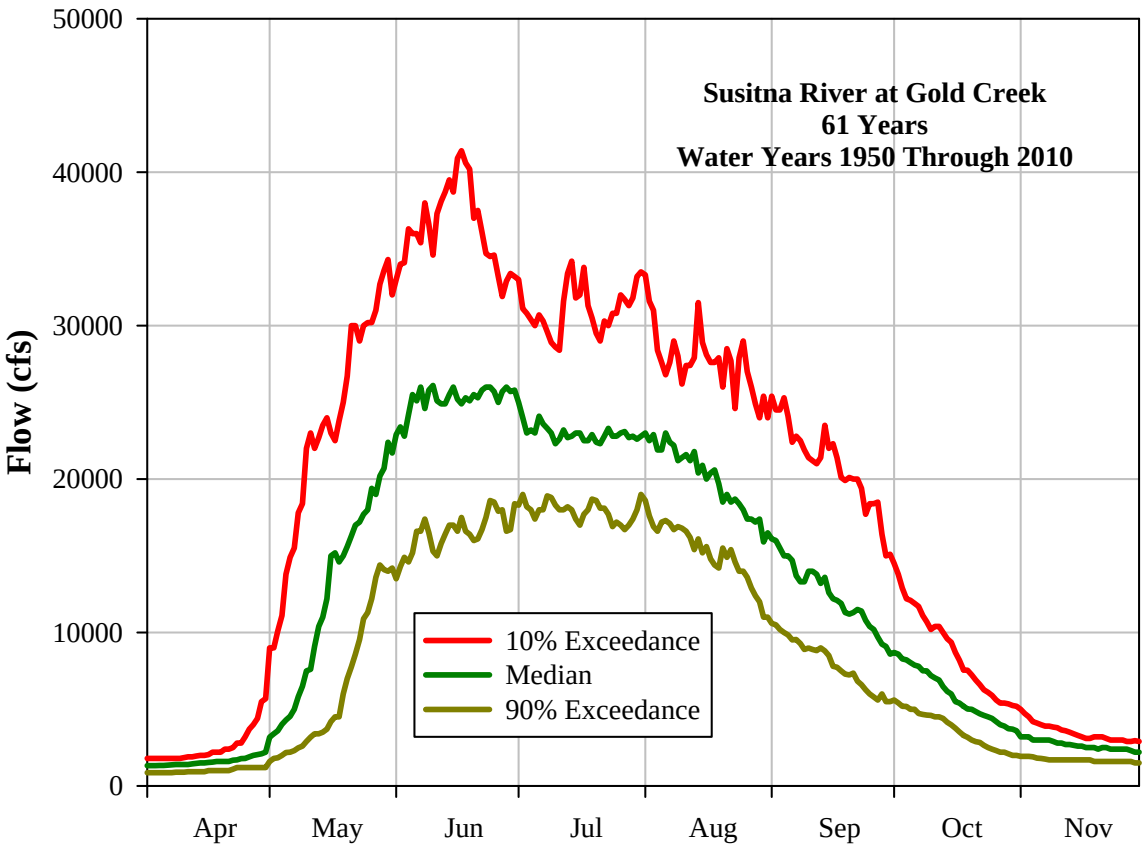

Flow Increase Downstream
140000
120000
100000
80000
60000
40000
20000
0
Susitna Station (near Cook Inlet)
Gold Creek (Upstream of Talkeetna)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

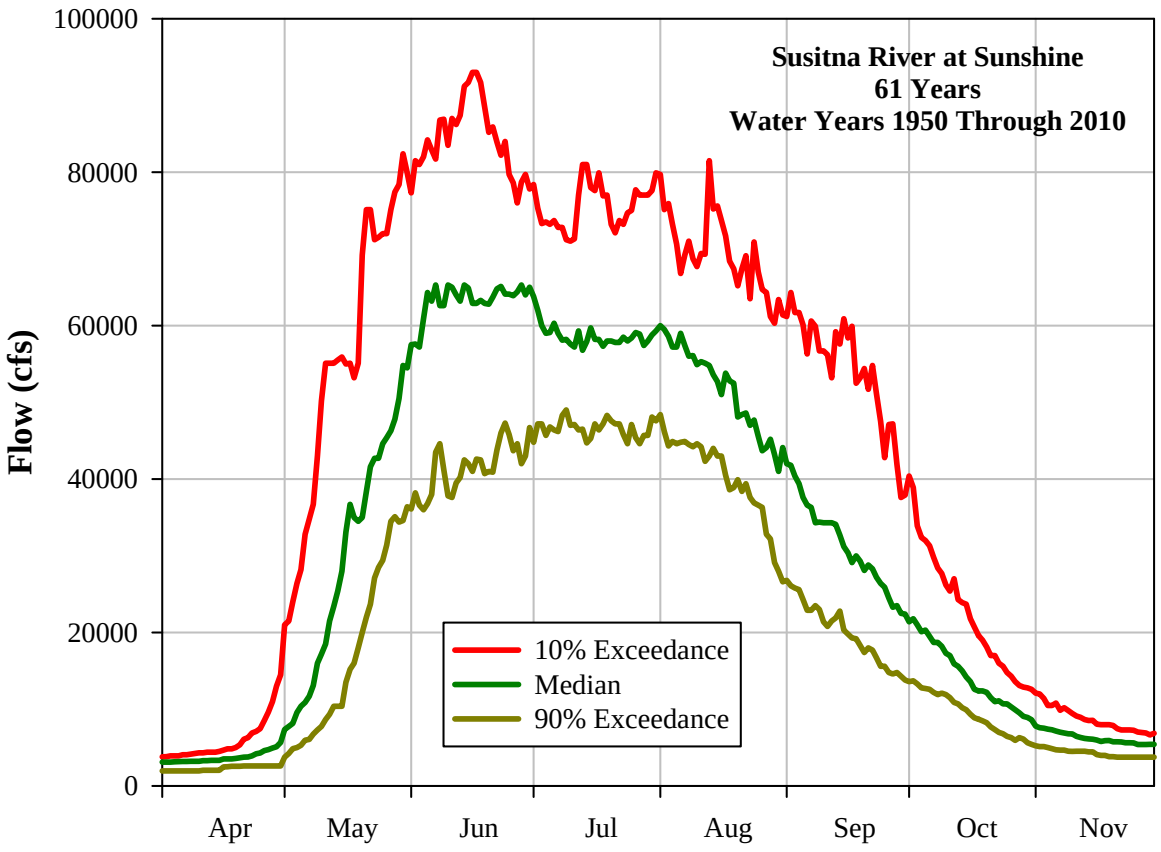
Average Monthly and Annual Flows (cfs)

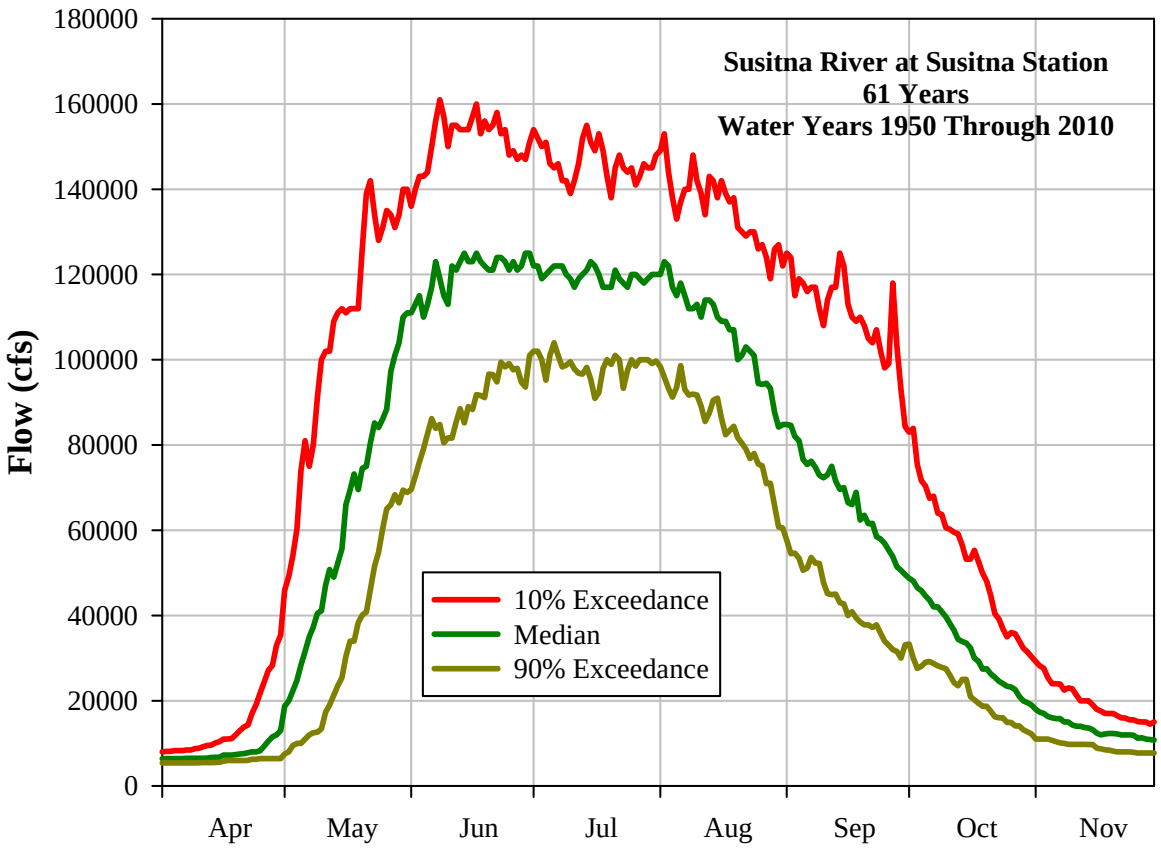
Period	Watana Dam (PRM 187)		Susitna River at Gold Creek (PRM 140)		Susitna River at Sunshine (PRM 87.9)		Susitna River at Susitna Station (PRM 29.9)	
	Pre-Project	Max LF OS-1	Pre-Project	Max LF OS-1	Pre-Project	Max LF OS-1	Pre-Project	Max LF OS-1
JAN	1,280	8,840	1,590	9,140	3,720	11,300	7,910	15,500
FEB	1,130	9,450	1,420	9,750	3,260	11,600	7,080	15,400
MAR	1,040	7,170	1,300	7,460	2,960	9,190	6,510	12,700
APR	1,400	6,650	1,740	6,950	4,030	9,160	8,990	14,100
MAY	11,300	6,090	13,800	8,490	33,200	27,400	66,100	60,200
JUN	21,700	5,680	26,300	10,200	63,700	47,500	120,000	104,000
JUL	20,000	6,980	24,000	10,800	60,500	47,200	122,000	108,000
AUG	17,800	11,900	21,400	15,400	54,200	48,400	109,000	103,000
SEP	11,300	10,100	13,700	12,700	34,900	34,100	72,800	72,000
OCT	5,100	7,020	6,320	8,240	15,900	18,000	36,000	38,100
NOV	2,150	7,520	2,670	7,990	6,490	11,900	14,400	19,800
DEC	1,520	8,540	1,890	8,750	4,490	11,300	9,510	16,300
Annual	**8,010**	**7,990**	**9,720**	**9,660**	**24,100**	**24,000**	**48,600**	**48,500**

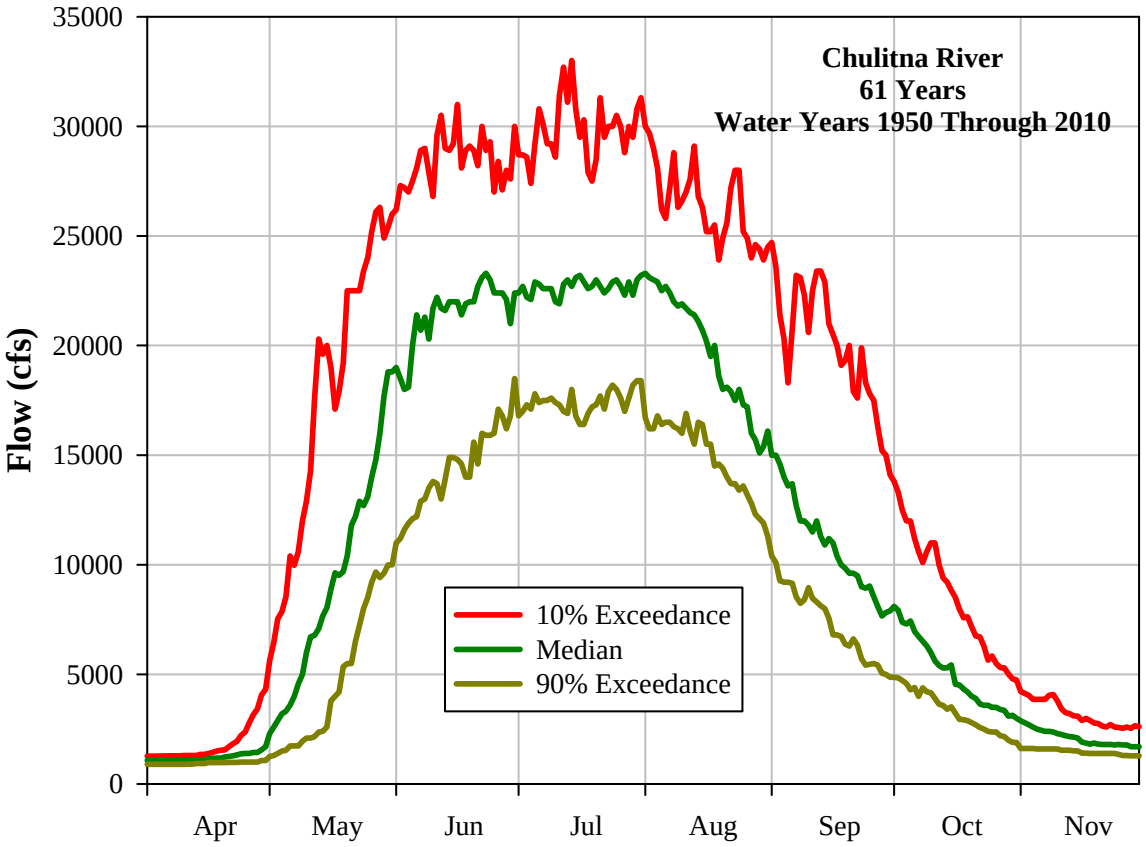

Water Surface from 2011 MatSu LiDAR
Thalweg from 2012 surveys
Elevation (NAVD 88)
Project River Mile
1600
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
Yentna River
Talkeetna River
Chulitna River
Devils Canyon - 0.57%
0.02%
0.08%
0.10%
0.16%
0.23%
0.21%

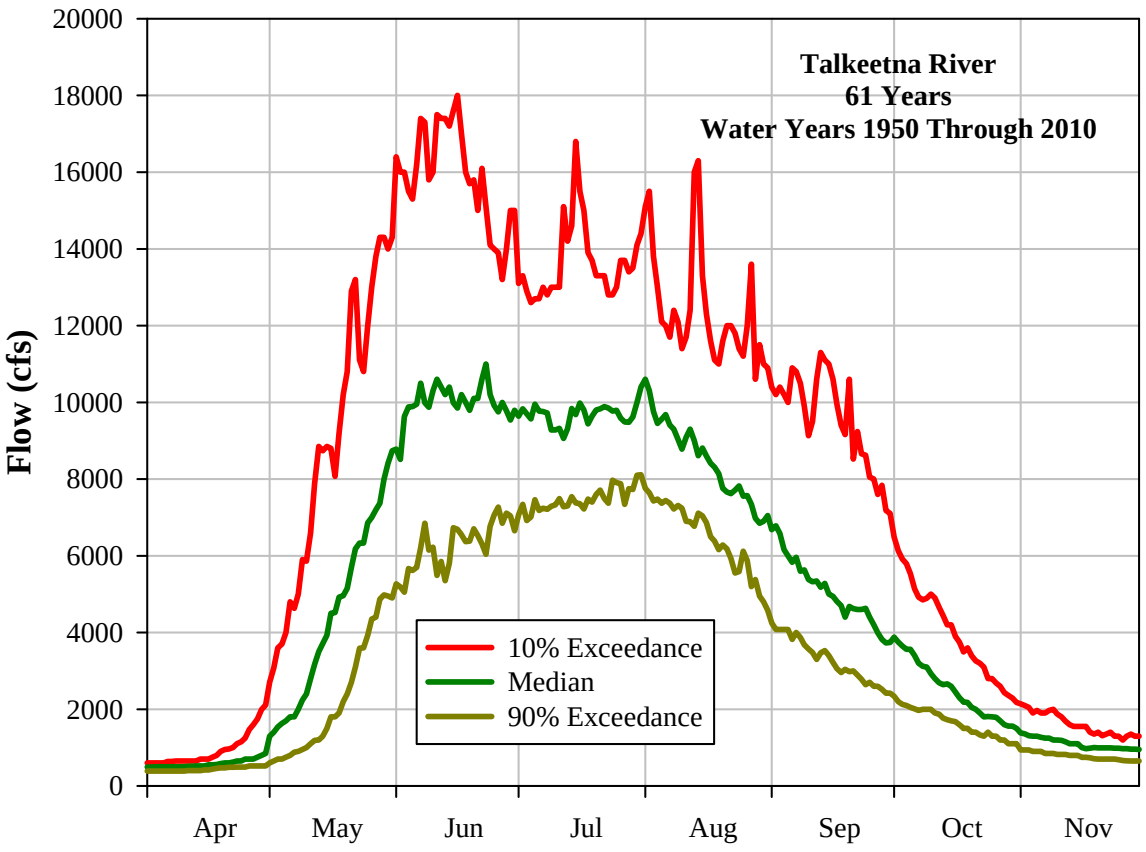

Susitna River at Proposed Dam Site
61 Years
Water Years 1950 Through 2010
Flow (cfs)
40000
30000
20000
10000
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
10% Exceedance
Median
90% Exceedance

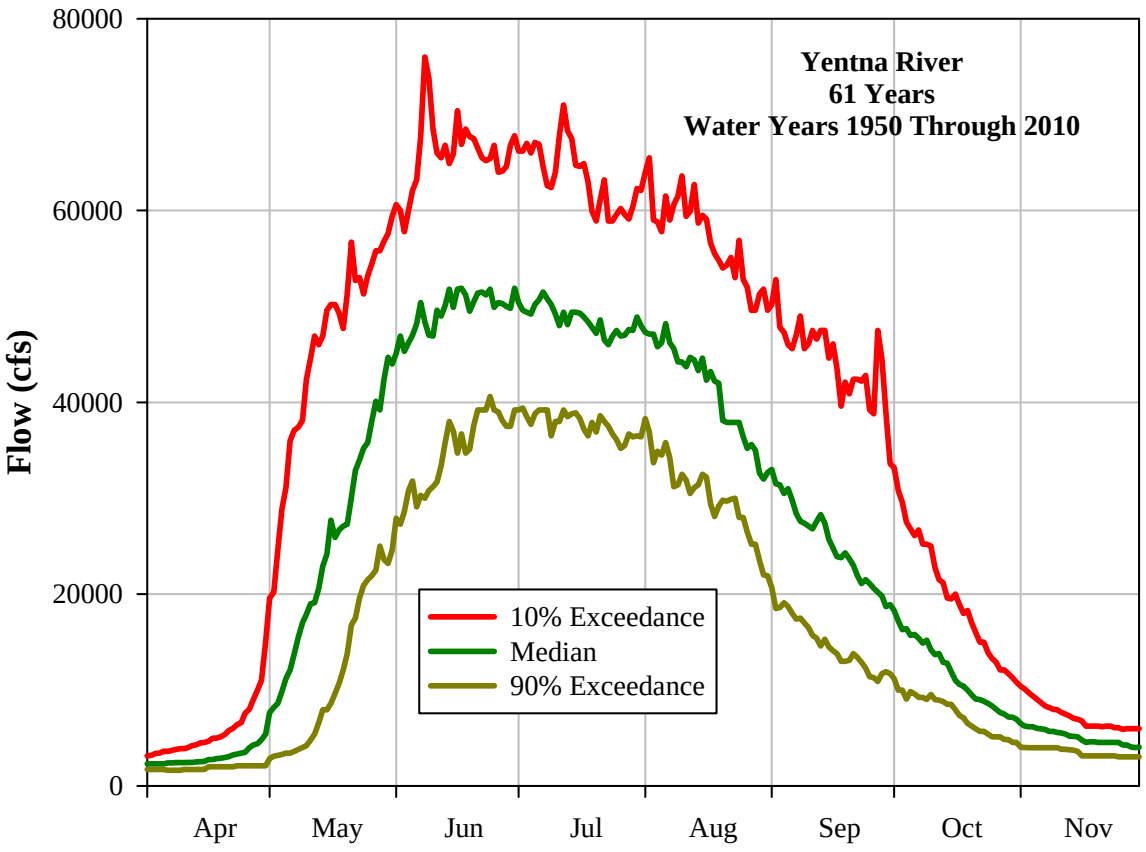

Susitna River at Gold Creek
61 Years
Water Years 1950 Through 2010
Flow (cfs)
50000
40000
30000
20000
10000
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
10% Exceedance
Median
90% Exceedance


Susitna River at Sunshine
61 Years
Water Years 1950 Through 2010
Flow (cfs)
100000
80000
60000
40000
20000
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
10% Exceedance
Median
90% Exceedance


Susitna River at Susitna Station
61 Years
Water Years 1950 Through 2010
Flow (cfs)
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
10% Exceedance
Median
90% Exceedance


Chulitna River
61 Years
Water Years 1950 Through 2010
Flow (cfs)
35000
30000
25000
20000
15000
10000
5000
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
10% Exceedance
Median
90% Exceedance


Talkeetna River
61 Years
Water Years 1950 Through 2010
Flow (cfs)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
10% Exceedance
Median
90% Exceedance

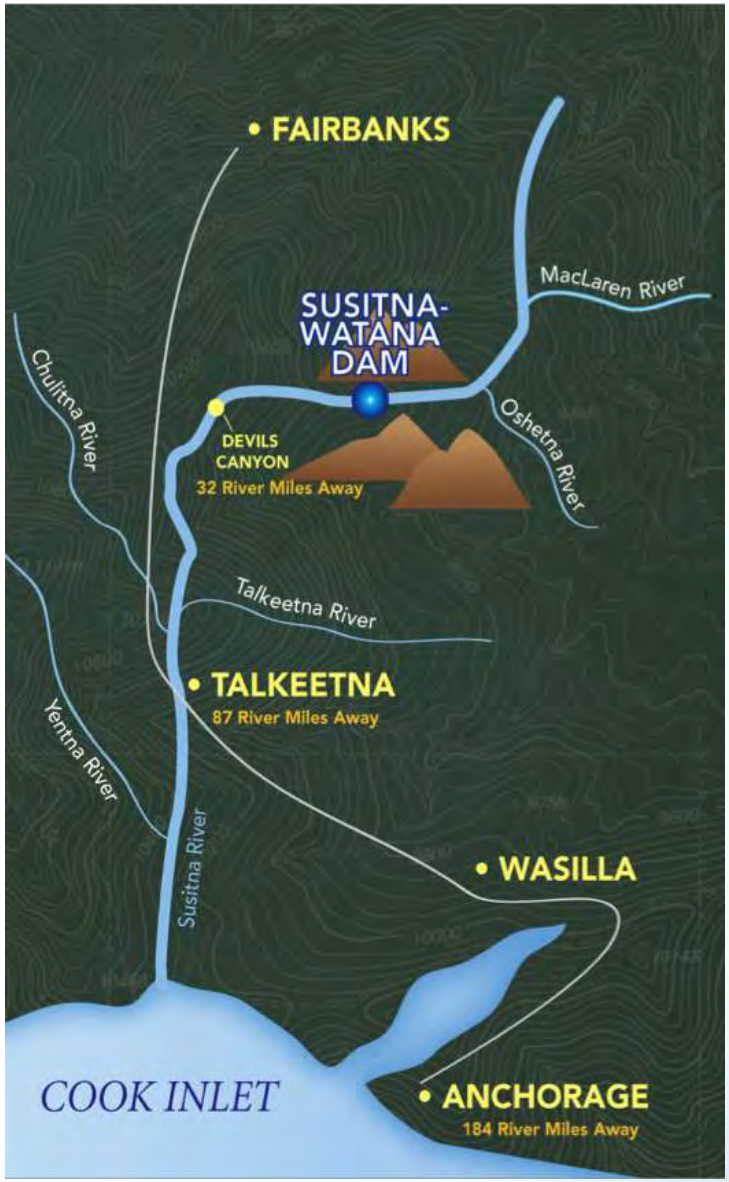

Yentna River
61 Years
Water Years 1950 Through 2010
Flow (cfs)
80000
60000
40000
20000
0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
10% Exceedance
Median
90% Exceedance

Hydrology Presentation: Existing and with-Project Hydrology

Technical Workgroup Meeting
February 14, 2013

Prepared by: Tetra Tech

Prepared for: Alaska Energy Authority



SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Background

- USGS developed 61 year extended discharge record
- HEC-ResSim model used to simulate operations for a maximum load following “bookend” scenario to develop hourly with-Project outflows (“Maximum Load Following Operation Scenario 1”)
- HEC-ResSim Muskingum-Cunge procedure with 1980s cross-sections used to route the flows downstream to Sunshine
- Both Pre-Project and Maximum Load Following OS-1 conditions analyzed
- Flow duration and peak flow analysis performed to provide initial comparison of the Maximum Load Following OS-1 scenario and Pre-Project conditions

Basis and Assumptions

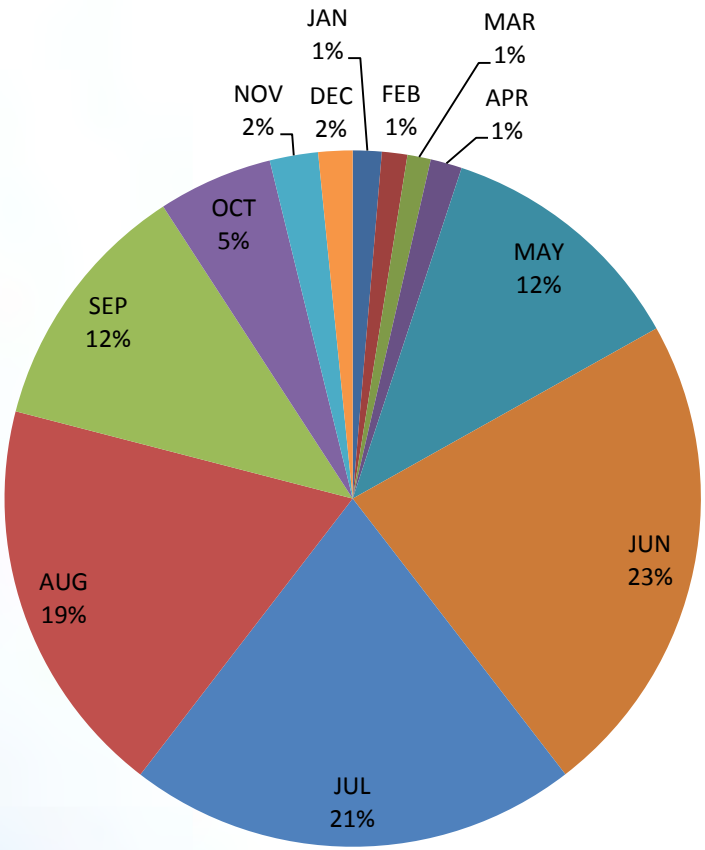
- Maximum Load Following OS-1 scenario assigns load fluctuation of the entire Railbelt to Watana
- Prepared for planning purposes – **Watana load is very conservative for any period of time and not realistic for an entire year**
- Hourly open-water flow routing results from HEC-ResSim
- Uses 1980s cross-sections and HEC-2 rating curves
- Railbelt generation loads from the 2010 Railbelt Integrated Resources Plan

Average Monthly and Annual Flows (cfs)

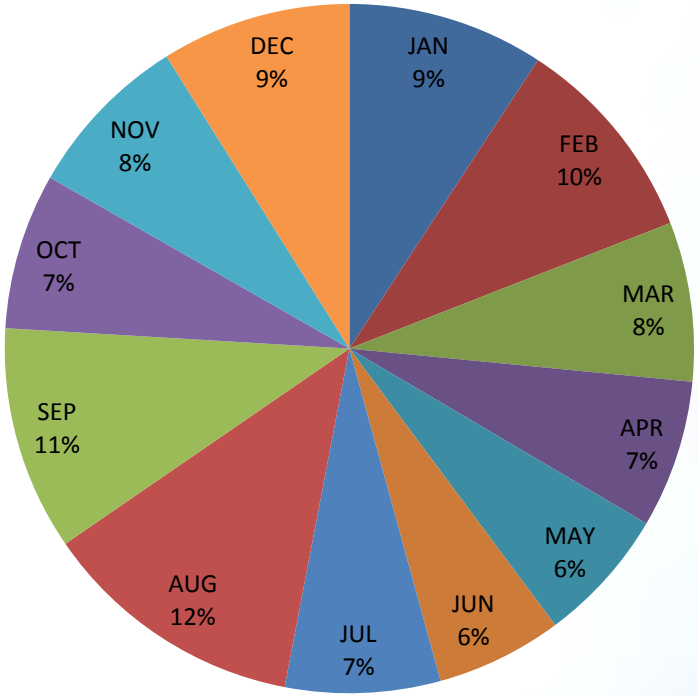
Period	Watana Dam (PRM 187)		Susitna River at Gold Creek (PRM 140)		Susitna River at Sunshine (PRM 87.9)		Susitna River at Susitna Station (PRM 29.9)	
	Pre-Project	Max LF OS-1	Pre-Project	Max LF OS-1	Pre-Project	Max LF OS-1	Pre-Project	Max LF OS-1
JAN	1,280	8,840	1,590	9,140	3,720	11,300	7,910	15,500
FEB	1,130	9,450	1,420	9,750	3,260	11,600	7,080	15,400
MAR	1,040	7,170	1,300	7,460	2,960	9,190	6,510	12,700
APR	1,400	6,650	1,740	6,950	4,030	9,160	8,990	14,100
MAY	11,300	6,090	13,800	8,490	33,200	27,400	66,100	60,200
JUN	21,700	5,680	26,300	10,200	63,700	47,500	120,000	104,000
JUL	20,000	6,980	24,000	10,800	60,500	47,200	122,000	108,000
AUG	17,800	11,900	21,400	15,400	54,200	48,400	109,000	103,000
SEP	11,300	10,100	13,700	12,700	34,900	34,100	72,800	72,000
OCT	5,100	7,020	6,320	8,240	15,900	18,000	36,000	38,100
NOV	2,150	7,520	2,670	7,990	6,490	11,900	14,400	19,800
DEC	1,520	8,540	1,890	8,750	4,490	11,300	9,510	16,300
Annual	**8,010**	**7,990**	**9,720**	**9,660**	**24,100**	**24,000**	**48,600**	**48,500**

Monthly Average Flow Comparison (cfs) [5]

Watana Dam (Pre-Project)



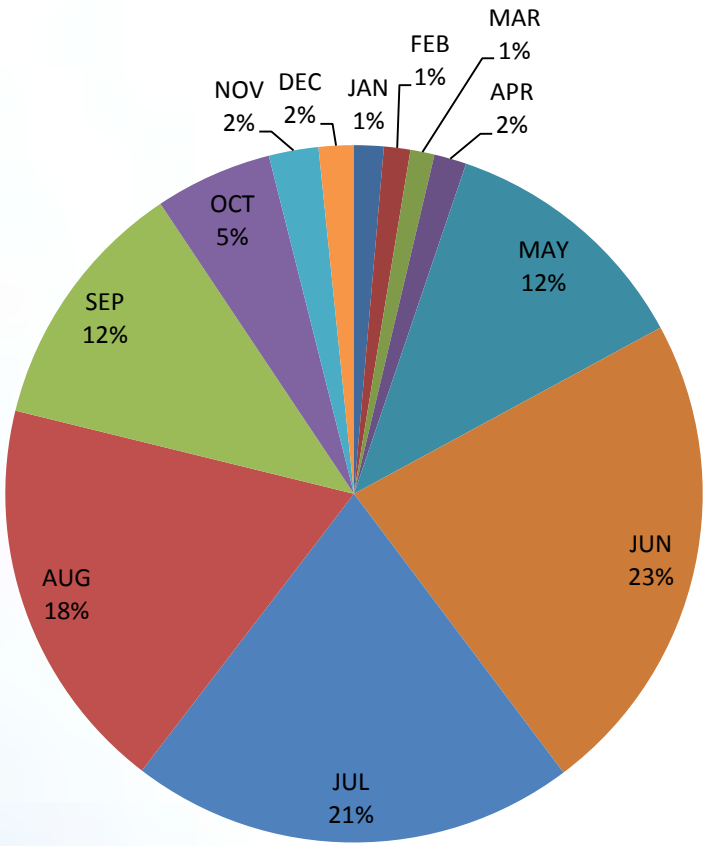
Watana Dam (Max LF OS-1)



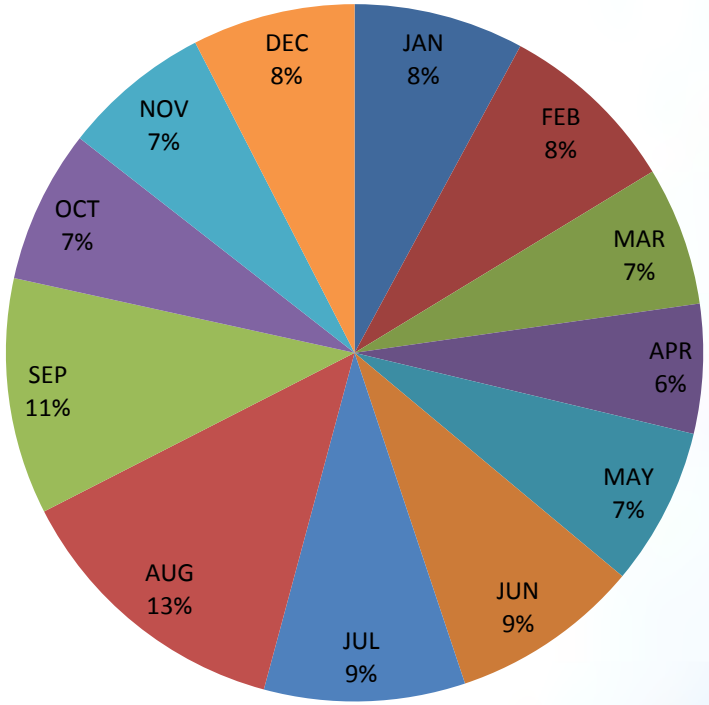
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Monthly Average Flow Comparison (cfs) 6

Gold Creek (Pre-Project)



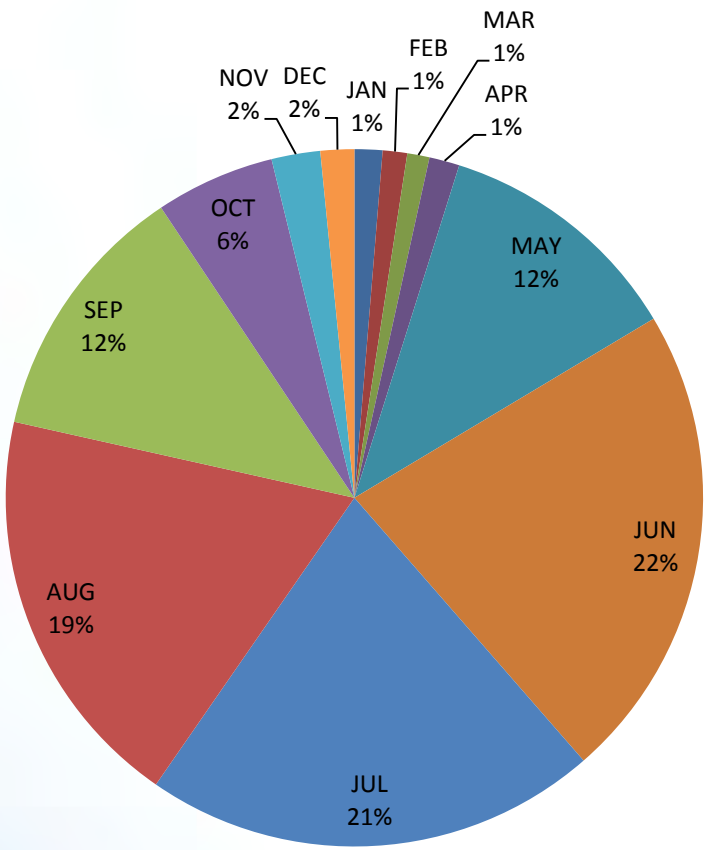
Gold Creek (Max LF OS-1)



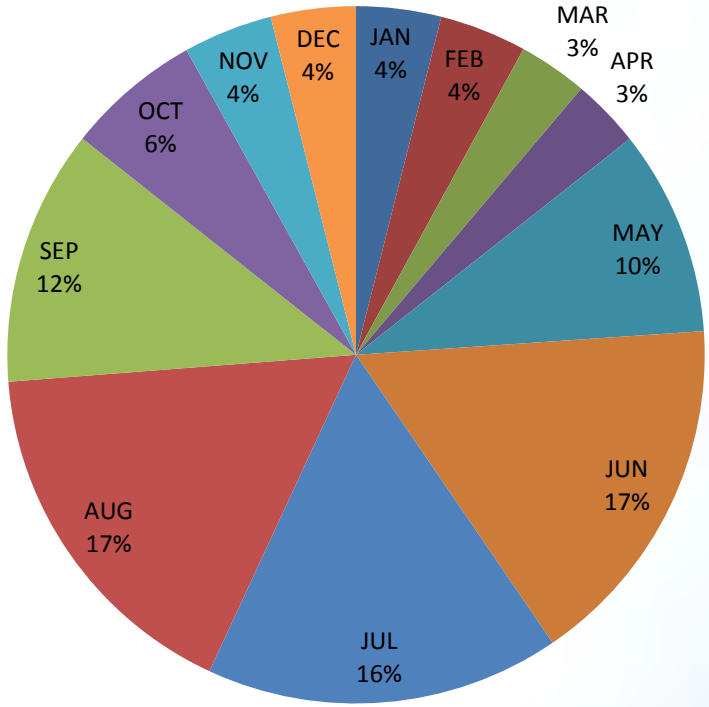
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Monthly Average Flow Comparison (cfs) [7]

Sunshine (Pre-Project)



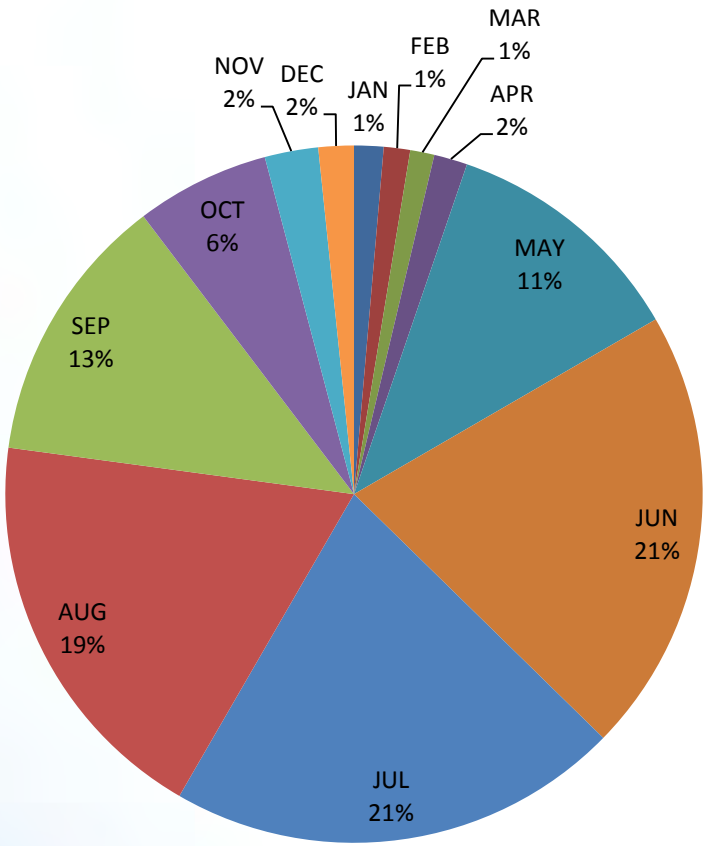
Sunshine (Max LF OS-1)



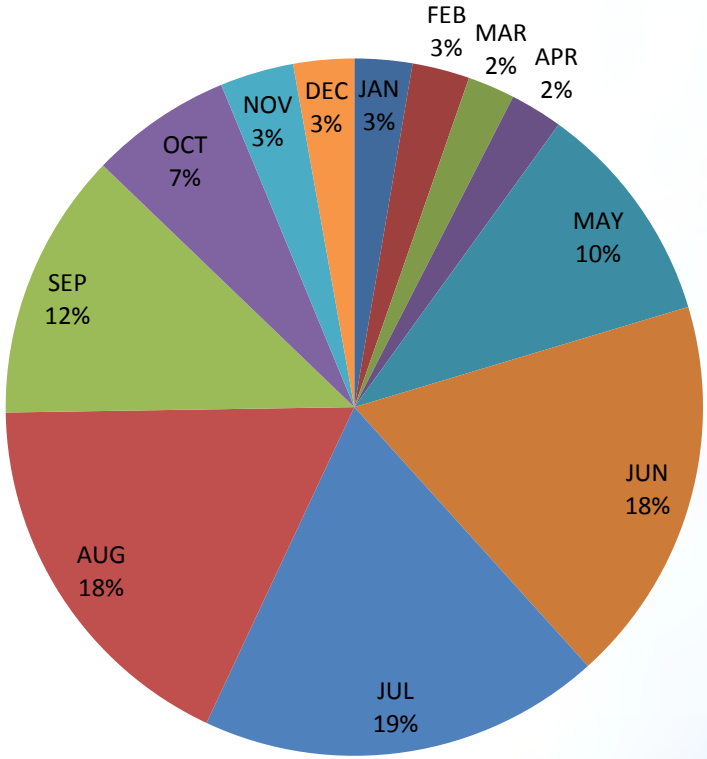
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Monthly Average Flow Comparison (cfs) [8]

Susitna Station (Pre-Project)



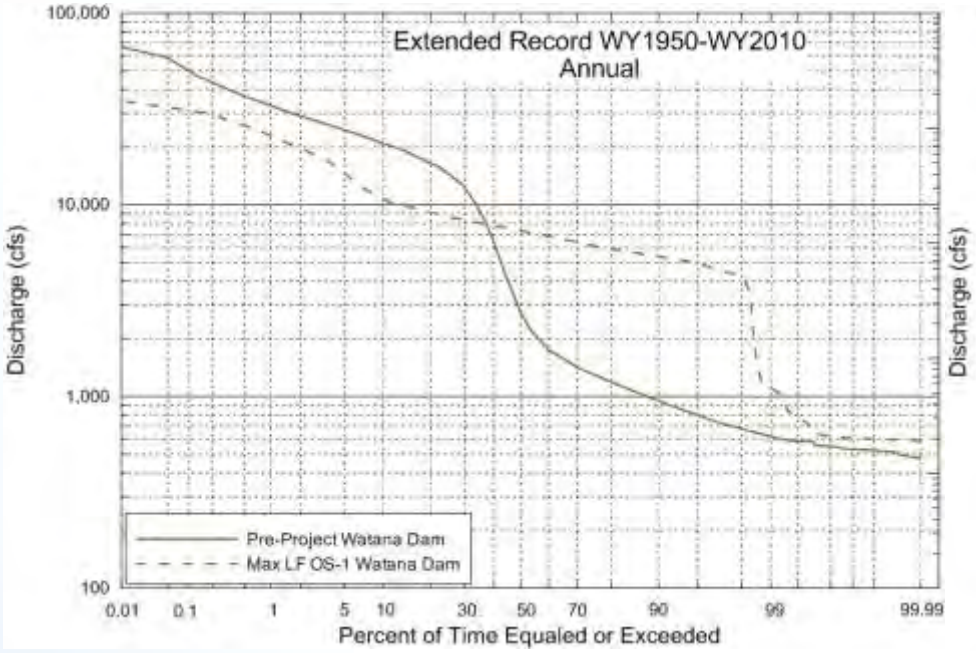
Susitna Station (Max LF OS-1)



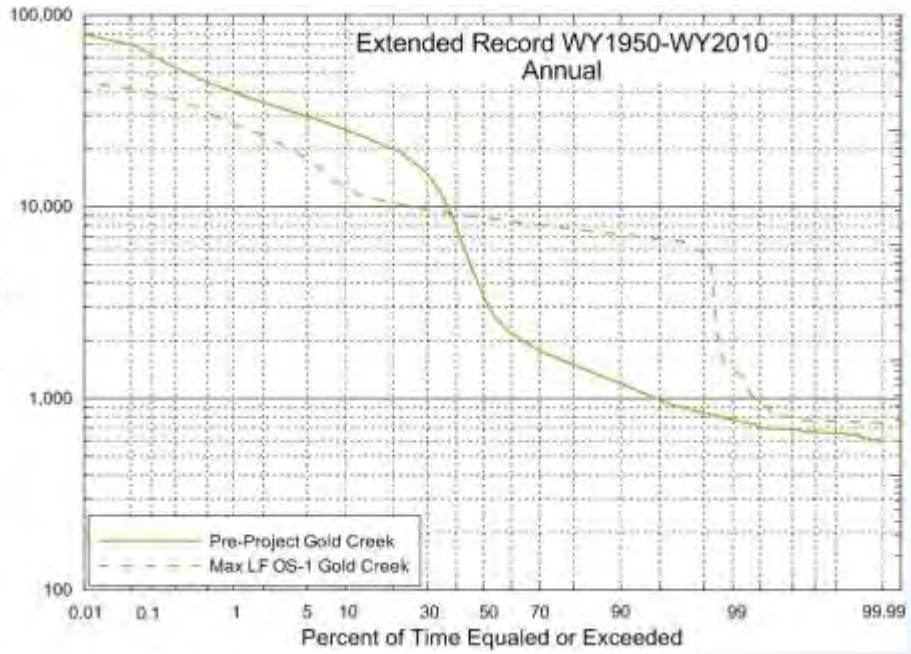
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Annual Flow Duration

Watana Dam (PRM187)

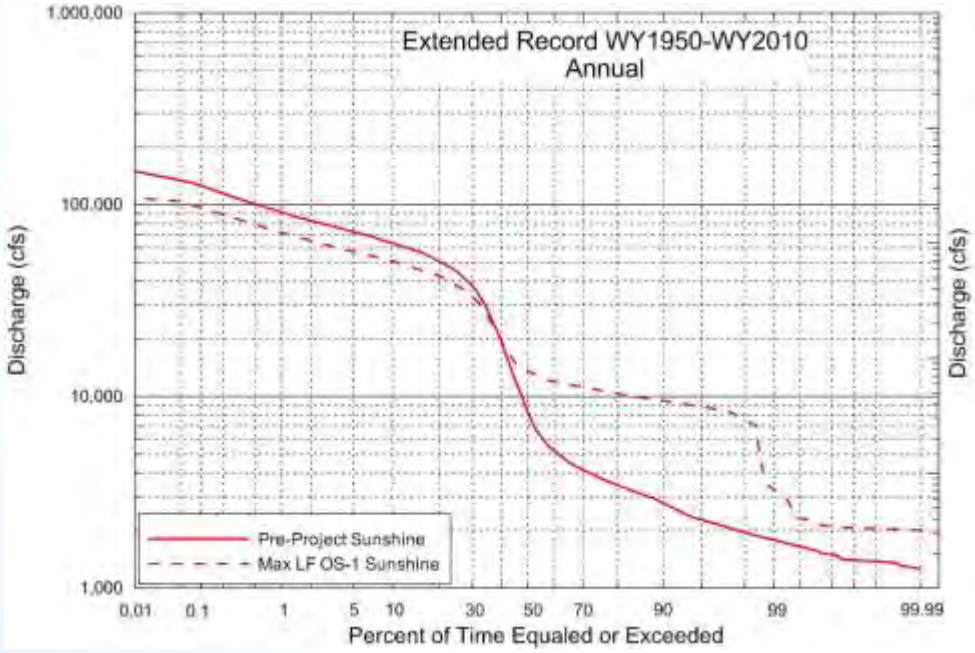


Gold Creek (PRM 140)

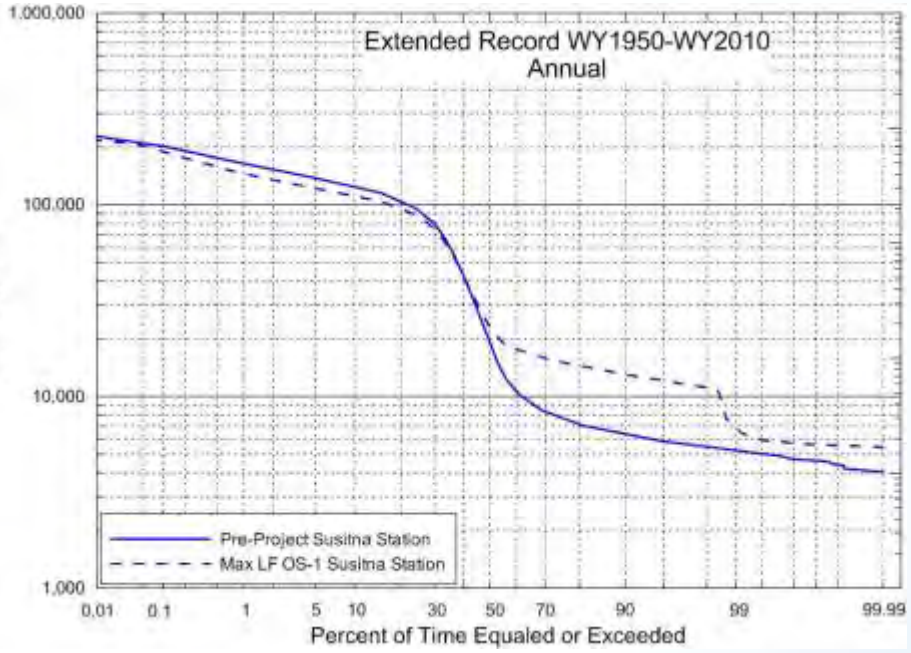


Annual Flow Duration

Sunshine (PRM 87.9)



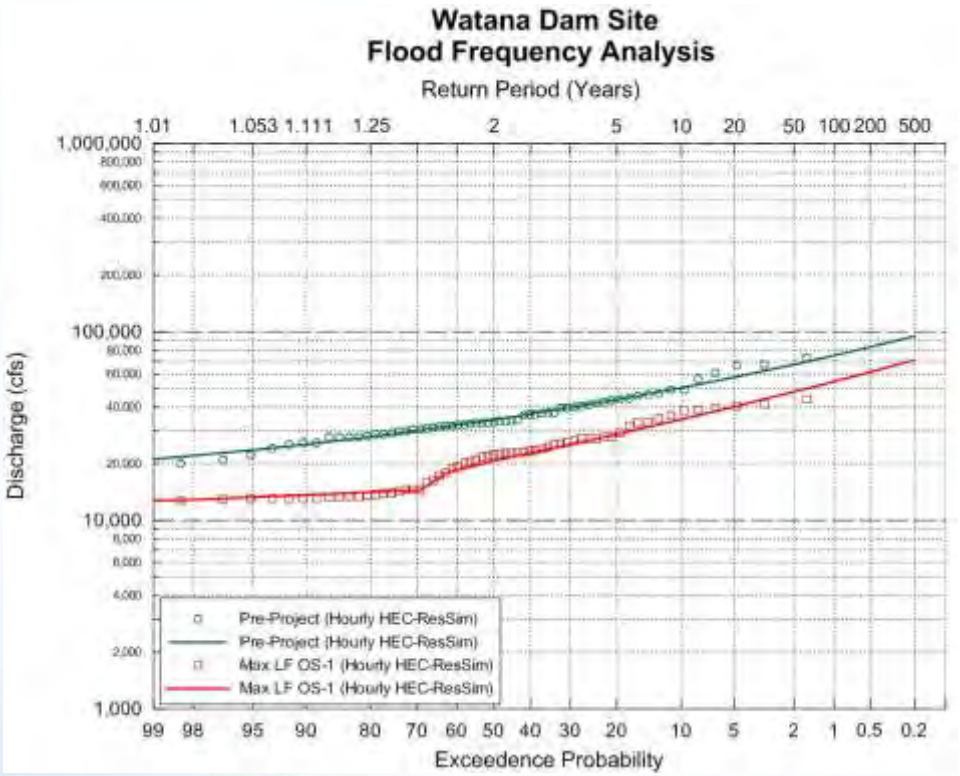
Susitna Station (PRM 29.9)



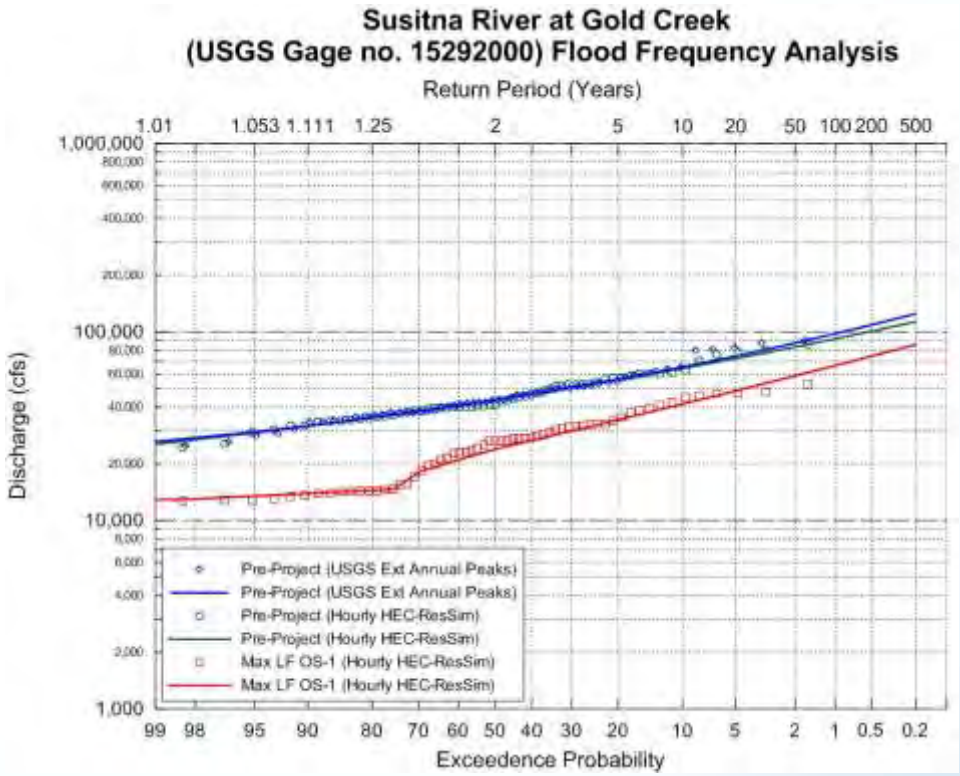
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Flood Frequency
Pre-Project and Max LF OS-1

Watana Dam (PRM 187)

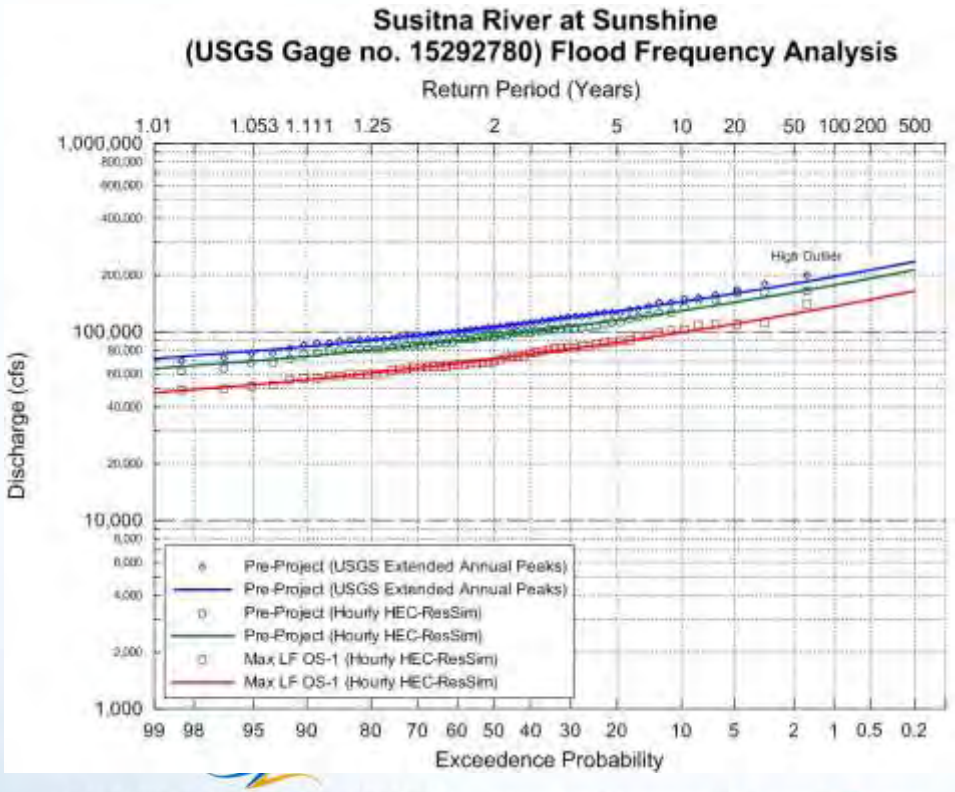


Gold Creek (PRM 140)

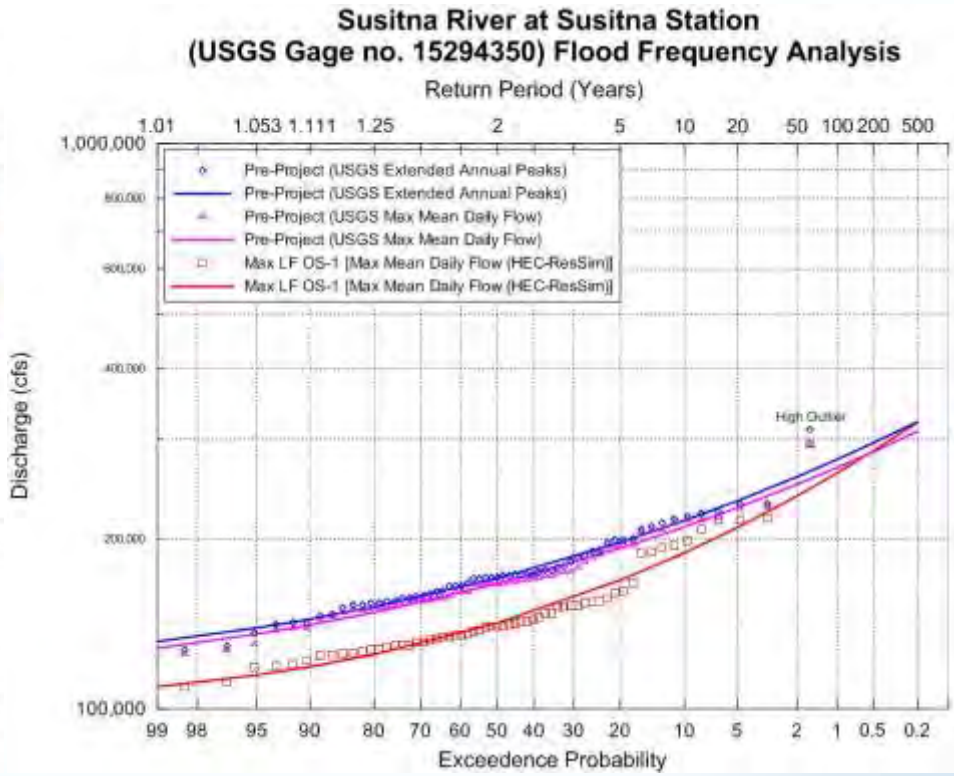


Flood Frequency
Pre- Project and Max LF OS-1

Sunshine (PRM 87.9)



Susitna Station (PRM 29.9)



Annual Peak Flow Comparison: Watana Dam Site (PRM 187)

Return Period (Years)	Watana Dam Site			
	Pre-Project Flow (cfs)	Max LF OS-1 Flow (cfs)	Difference (cfs)	Difference (%)
1.01	21,100	12,800	-8,300	-39%
1.25	27,800	14,100	-13,700	-49%
1.5	30,700	15,800	-14,900	-49%
2	34,200	20,700	-13,500	-39%
5	43,700	28,700	-15,000	-34%
20	57,600	40,200	-17,400	-30%
50	67,300	48,200	-19,100	-28%
100	75,100	54,600	-20,500	-27%

Annual Peak Flow Comparison: Gold Creek (PRM 140)

Return Period (Years)	Gold Creek			
	Pre-Project Flow (cfs)	Max LF OS-1 Flow (cfs)	Difference (cfs)	Difference (%)
1.01	25,400	12,900	-12,500	-49%
1.25	35,100	14,400	-20,700	-59%
1.5	39,000	19,100	-19,900	-51%
2	43,700	23,900	-19,800	-45%
5	55,800	34,300	-21,500	-39%
20	72,300	48,800	-23,500	-33%
50	83,400	58,600	-24,800	-30%
100	92,100	66,400	-25,700	-28%

Annual Peak Flow Comparison: Sunshine Station (PRM 87.9)

Return Period (Years)	Sunshine			
	Pre-Project Flow (cfs)	Max LF OS-1 Flow (cfs)	Difference (cfs)	Difference (%)
1.01	64,000	47,600	-16,400	-26%
1.25	80,200	60,500	-19,700	-25%
1.5	87,000	65,800	-21,200	-24%
2	94,700	72,000	-22,700	-24%
5	115,400	88,200	-27,200	-24%
20	143,600	110,400	-33,200	-23%
50	162,500	125,100	-37,400	-23%
100	177,300	136,700	-40,600	-23%

Annual Peak Flow Comparison: Susitna Station (PRM 29.9)

Return Period (Years)	Susitna Station			
	Pre-Project Flow (cfs)	Max LF OS-1 Flow (cfs)	Difference (cfs)	Difference (%)
1.01	131,700	109,500	-22,200	-17%
1.25	151,600	124,900	-26,700	-18%
1.5	160,400	132,900	-27,500	-17%
2	170,300	141,900	-28,400	-17%
5	197,000	168,900	-28,100	-14%
20	233,500	209,400	-24,100	-10%
50	257,600	238,200	-19,400	-8%
100	276,300	261,400	-14,900	-5%

Shift in Return Period of Peak Flows Pre-Project vs. Max LF OS-1

Watana Dam Site (187)			Gold Creek (PRM 140)		
Discharge (cfs)	Pre-Project Return Period (years)	Max LF OS-1 Return Period (years)	Discharge (cfs)	Pre-Project Return Period (years)	Max LF OS-1 Return Period (years)
21,100	1.01	2	25,400	1.01	2
27,800	1.25	4	35,100	1.25	5
30,700	1.5	6	39,000	1.5	8
34,200	2	10	43,700	2	12
43,700	5	30	55,800	5	39
57,600	20	136	72,300	20	166

Shift in Return Period of Peak Flows Pre-Project vs. Max LF OS-1

Sunshine (PRM 87.9)			Susitna Station (PRM 29.9)		
Discharge (cfs)	Pre-Project Return Period (years)	Max LF OS-1 Return Period (years)	Discharge (cfs)	Pre-Project Return Period (years)	Max LF OS-1 Return Period (years)
64,000	1.01	1.4	131,700	1.01	1.5
80,200	1.25	3	151,600	1.25	3
87,000	1.5	5	160,426	1.5	4
94,700	2	7	170,300	2	5
115,400	5	27	197,000	5	13
143,600	20	149	233,500	20	43

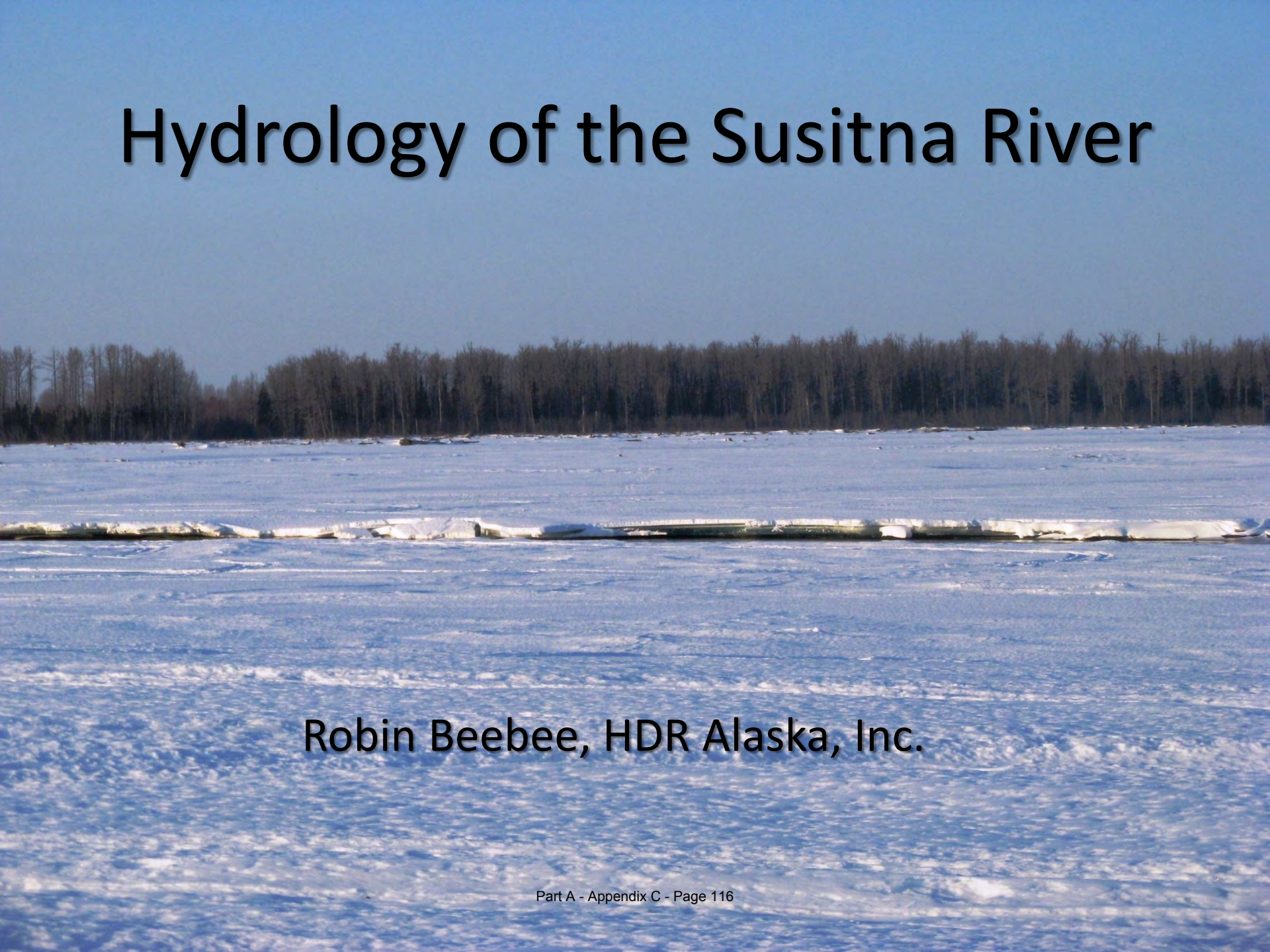
Ratio 100-year to 2-year Peak Flows

Location	Pre-Project Ratio	Max LF OS-1 Ratio
Watana Dam (PRM 187	2.2	2.6
Gold Creek (PRM 140)	2.1	2.8
Sunshine (PRM 87.9)	1.9	1.9
Susitna Station (PRM 29.9)	1.6	1.8

The Analysis is an Initial Assessment

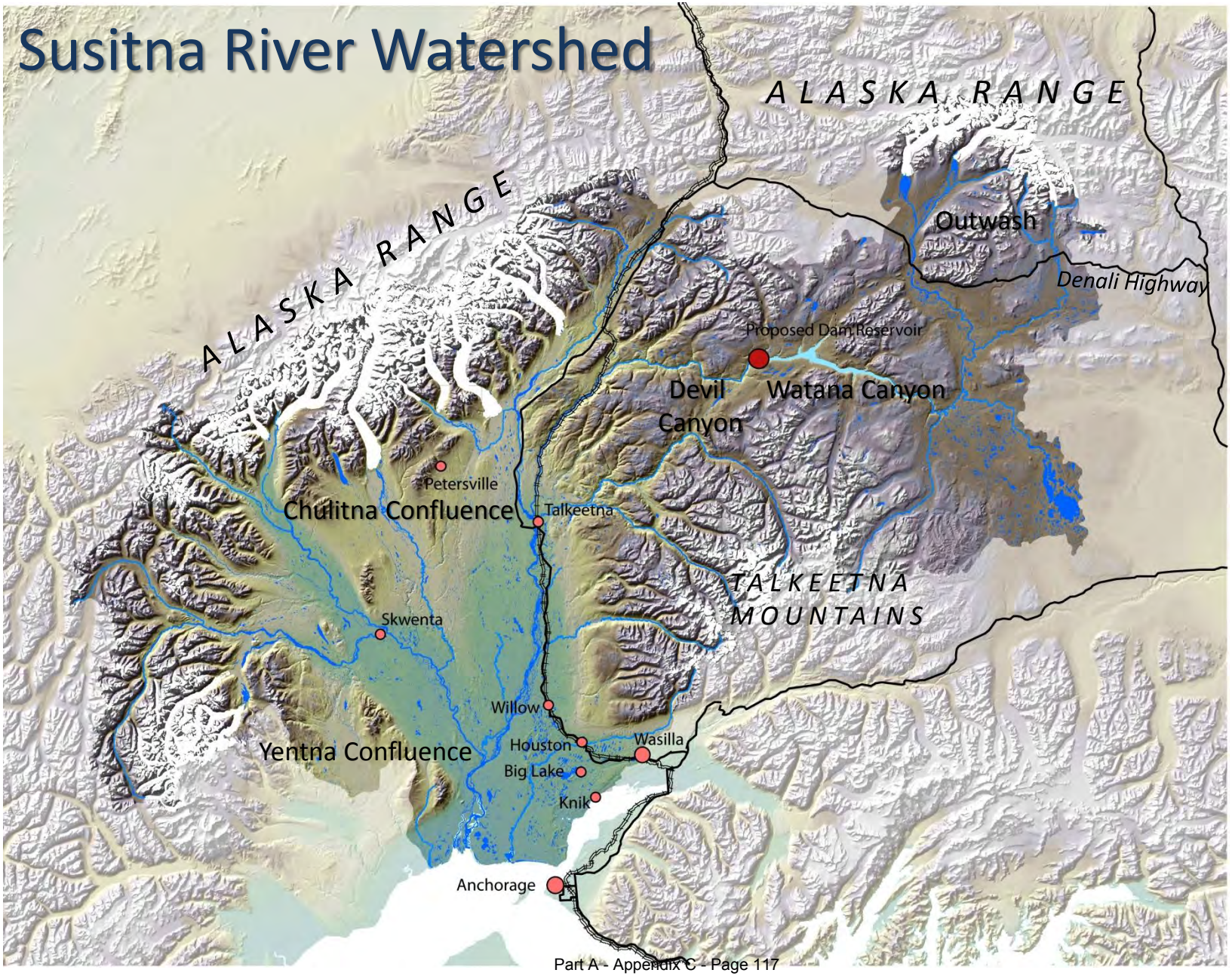
- Performed to assist in study planning
- **Watana load is very conservative for any period of time & not realistic for an entire year**
- Models will be upgraded in 2013
  - Replace HEC-ResSim Muskingum-Cunge routing
  - 2012 X-sections, additional 2013 X-sections
  - Refine tributary inflows and accretion flows
  - Additional calibration

Hydrology of the Susitna River



Robin Beebee, HDR Alaska, Inc.

Susitna River Watershed



Upper Susitna River and Susitna Glacier





Alaska Energy Authority Photo

Watana Canyon of the Susitna



Alaska Energy Authority Photo

Devil Canyon of the Susitna



National Geographic Photo





Near Gold Creek



Chulitna Confluence Near Talkeetna







Photo from Jason Mouw

Lower Susitna River



Mark Meyers Photo

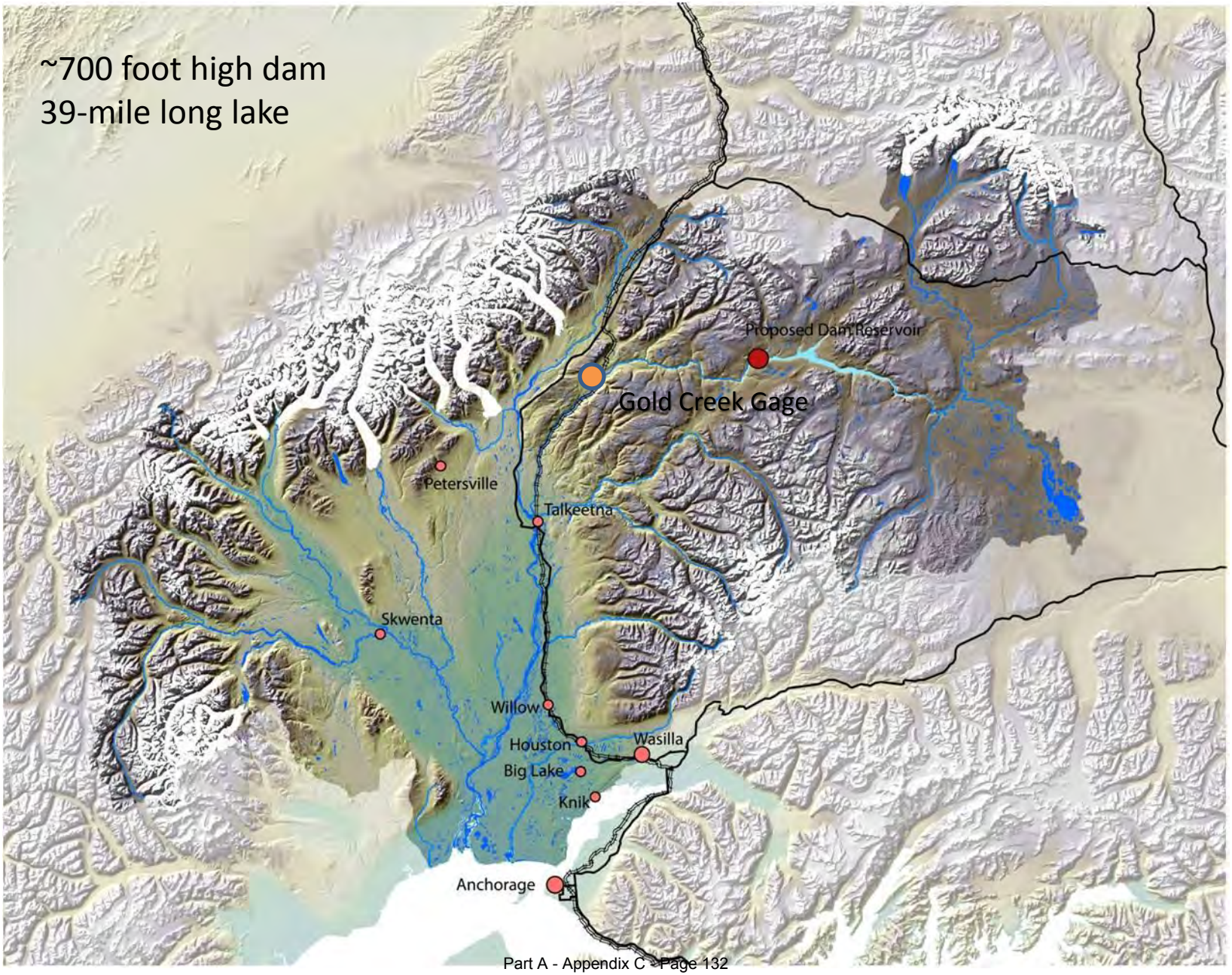


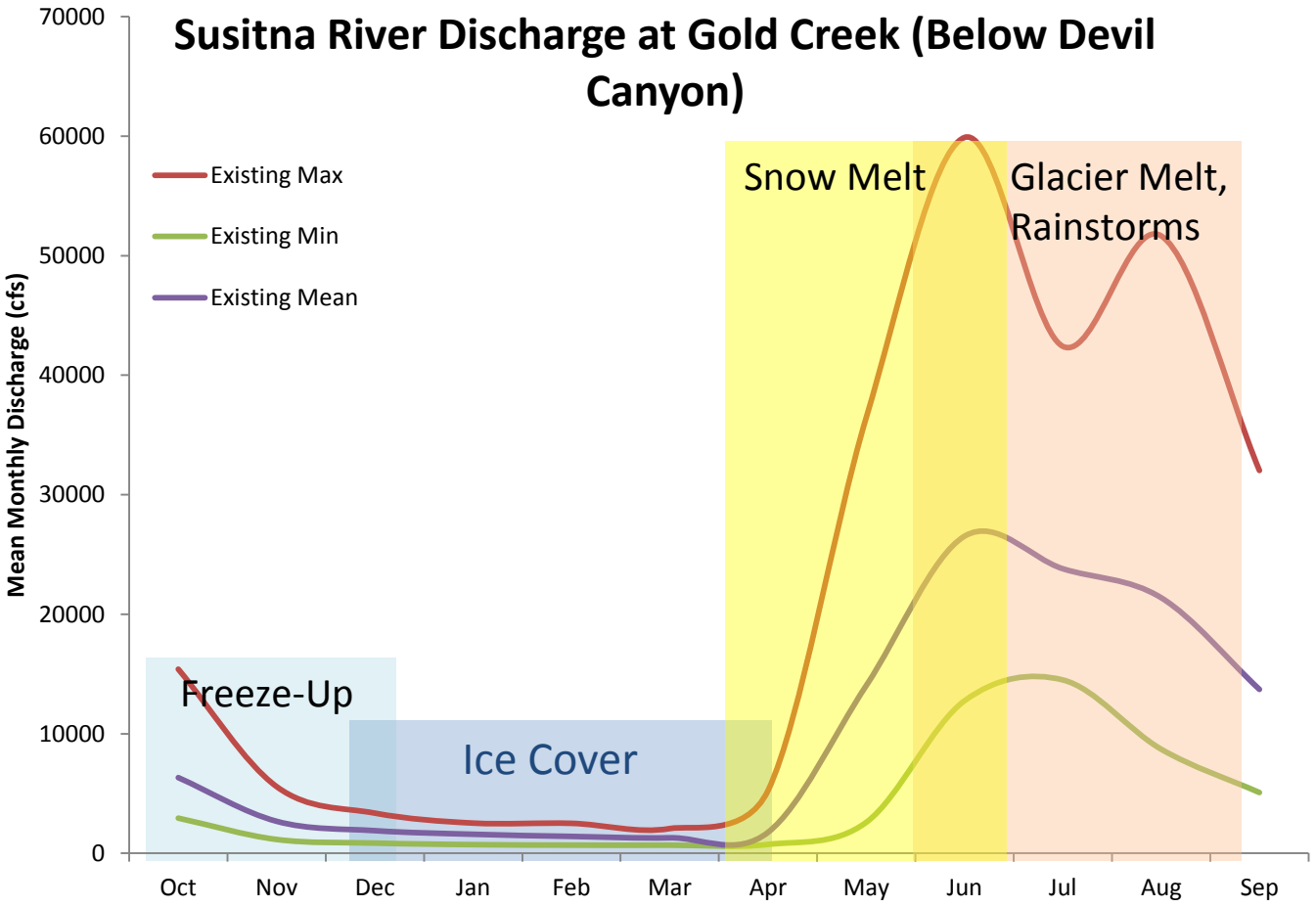
Near Yentna Confluence



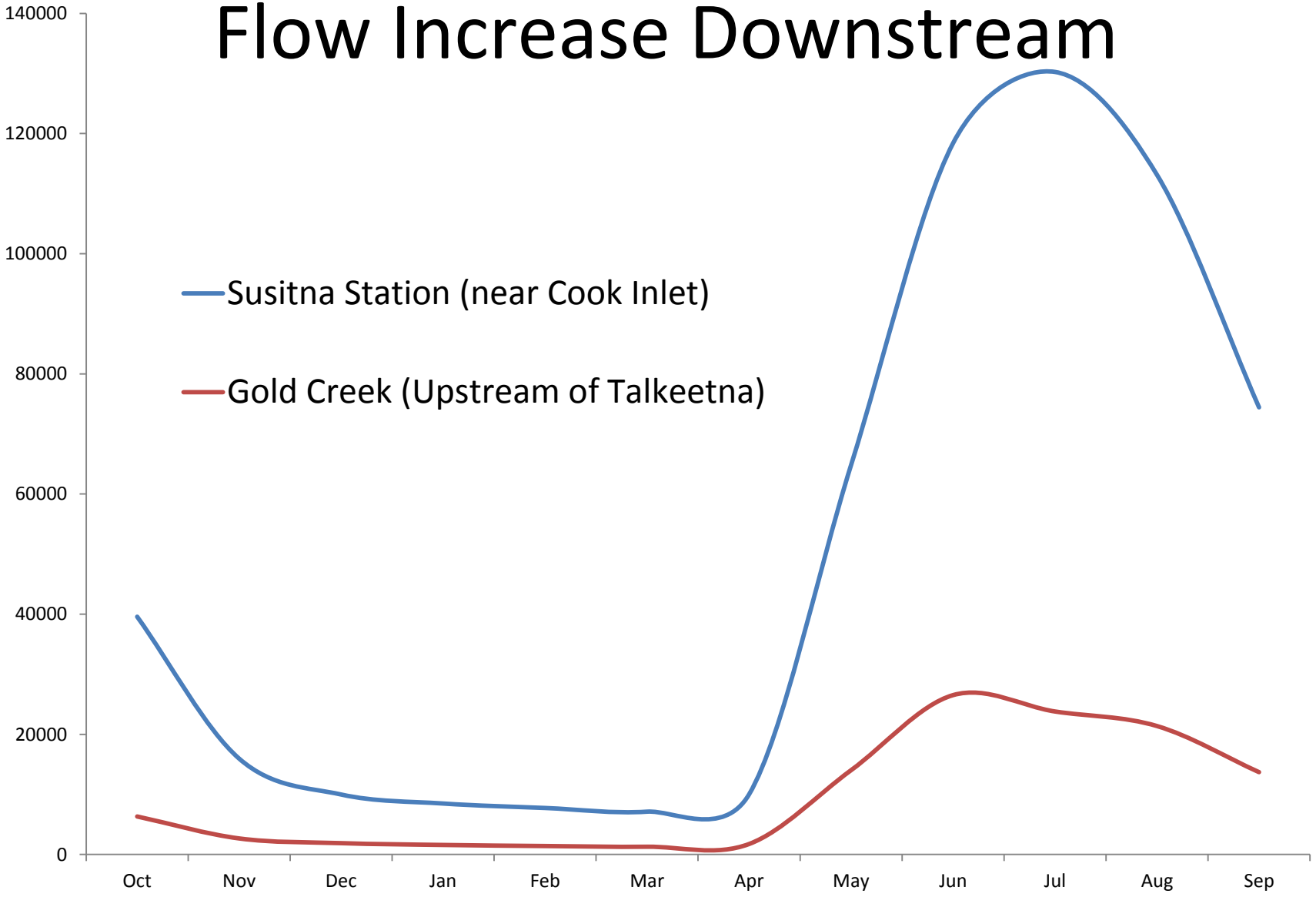


Jill Homer Photo

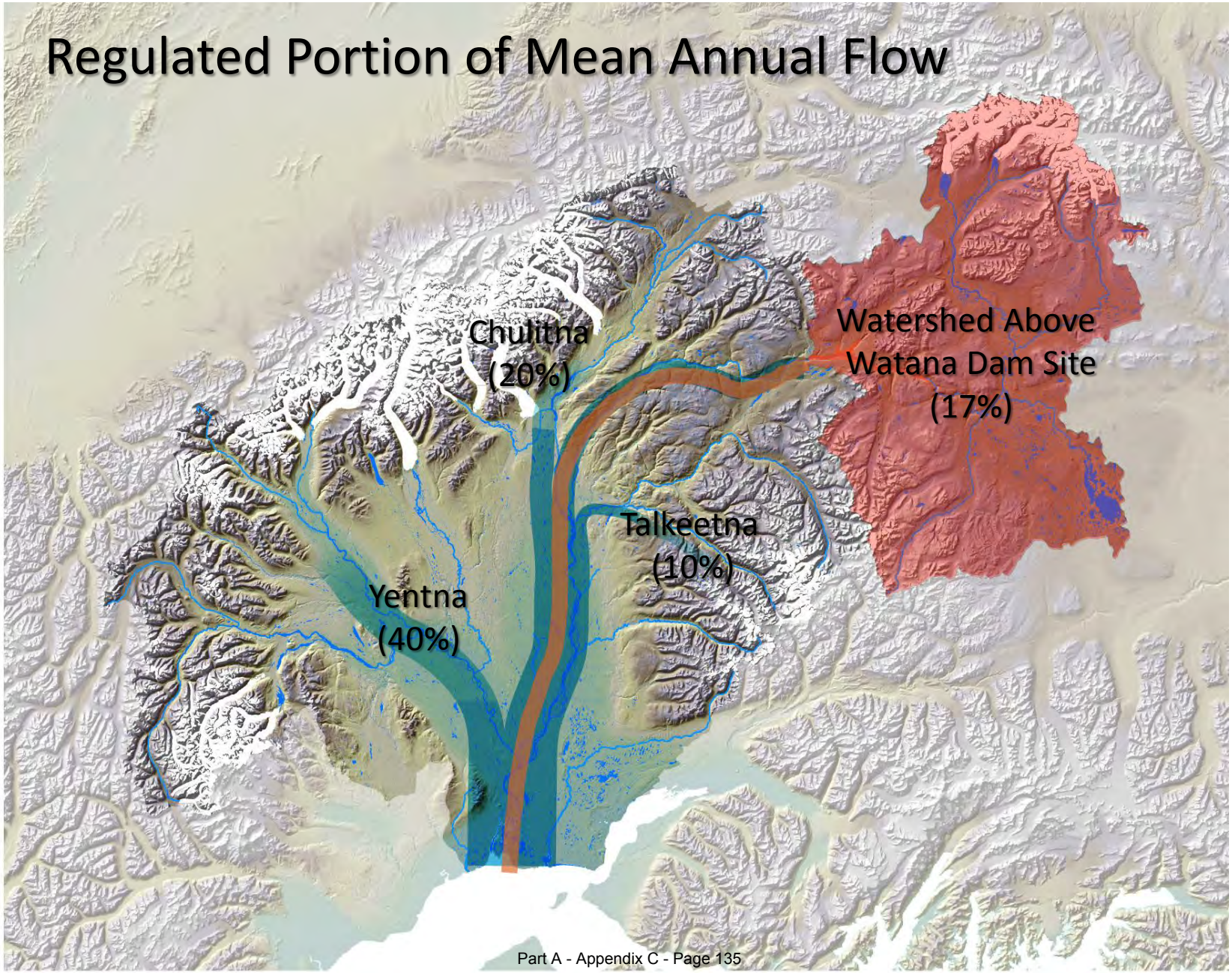

~700 foot high dam
39-mile long lake
Proposed Dam/Reservoir
Gold Creek Gage
Petersville
Talkeetna
Skwenta
Willow
Houston
Wasilla
Big Lake
Knik
Anchorage

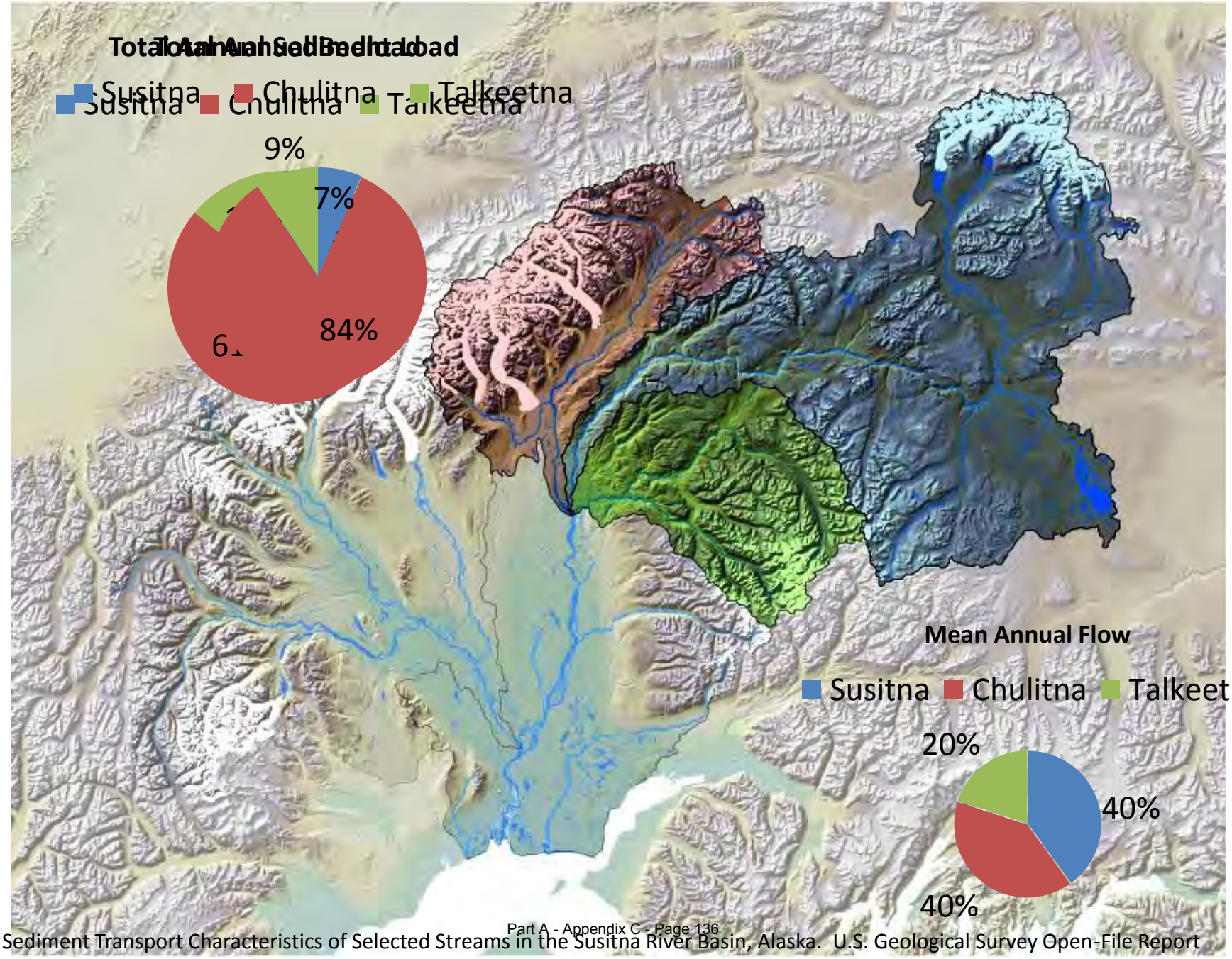

Susitna River Discharge at Gold Creek (Below Devil Canyon)
Mean Monthly Discharge (cfs)
70000
60000
50000
40000
30000
20000
10000
0
Existing Max
Existing Min
Existing Mean
Snow Melt
Glacier Melt, Rainstorms
Freeze-Up
Ice Cover
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

Flow Increase Downstream



Regulated Portion of Mean Annual Flow



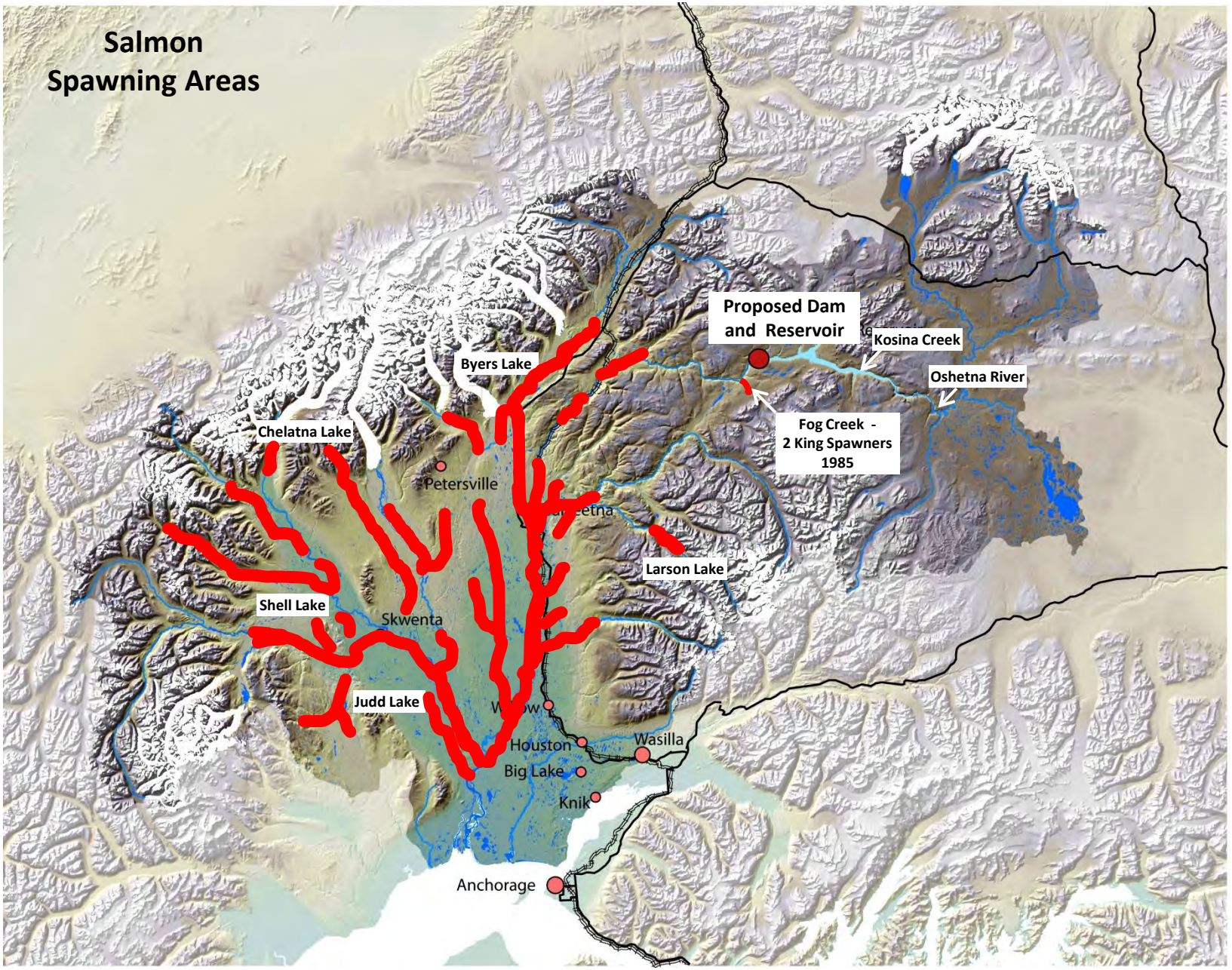


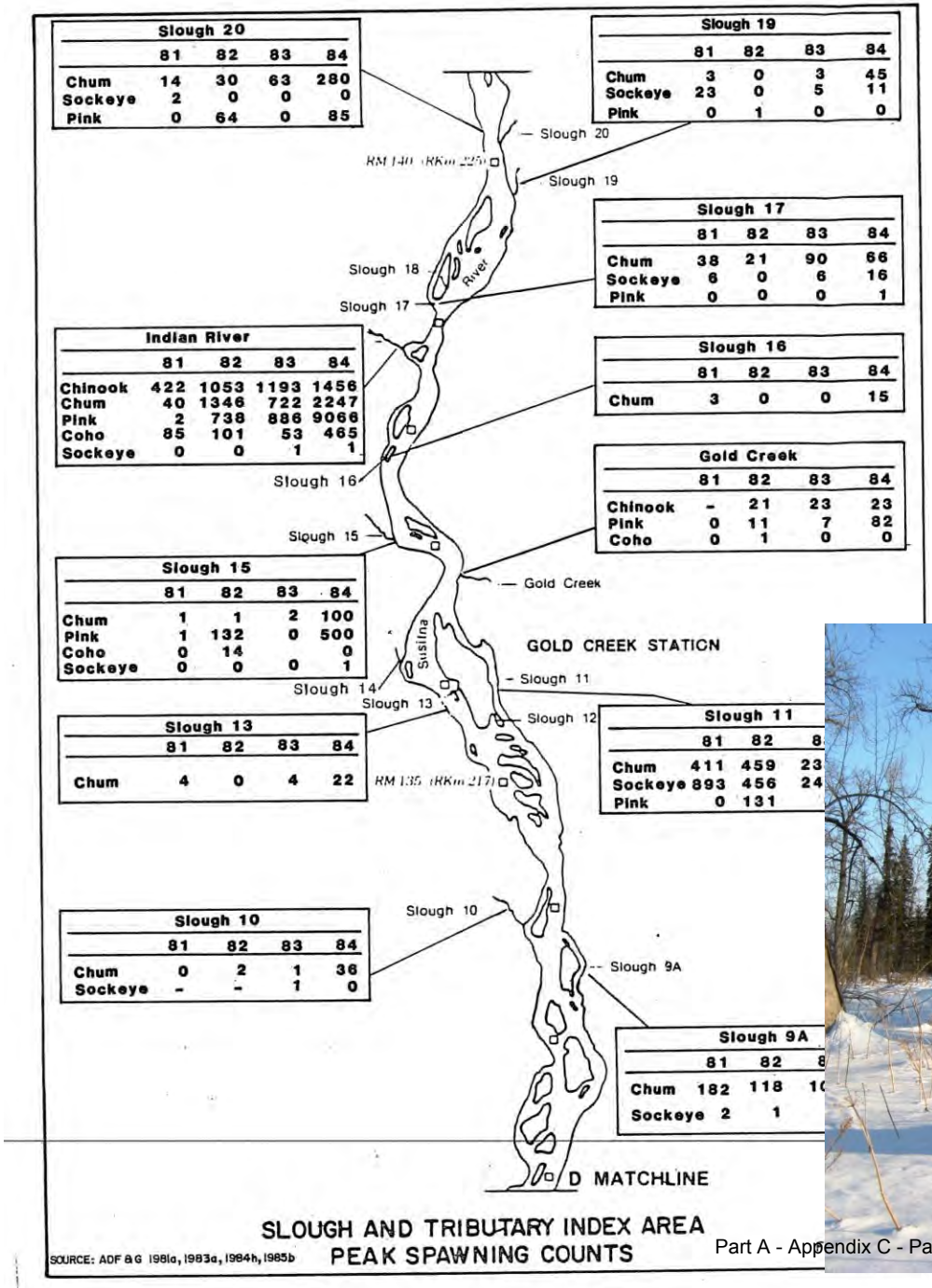
Sediment Transport Characteristics of Selected Streams in the Susitna River Basin, Alaska. U.S. Geological Survey Open-File Report 87-229








Salmon
Spawning Areas
Proposed Dam
and Reservoir
Kosina Creek
Oshetna River
Fog Creek -
2 King Spawners
1985
Byers Lake
Chelatna Lake
Petersville
Larson Lake
Shell Lake
Skwenta
Judd Lake
Houston
Wasilla
Big Lake
Knik
Anchorage

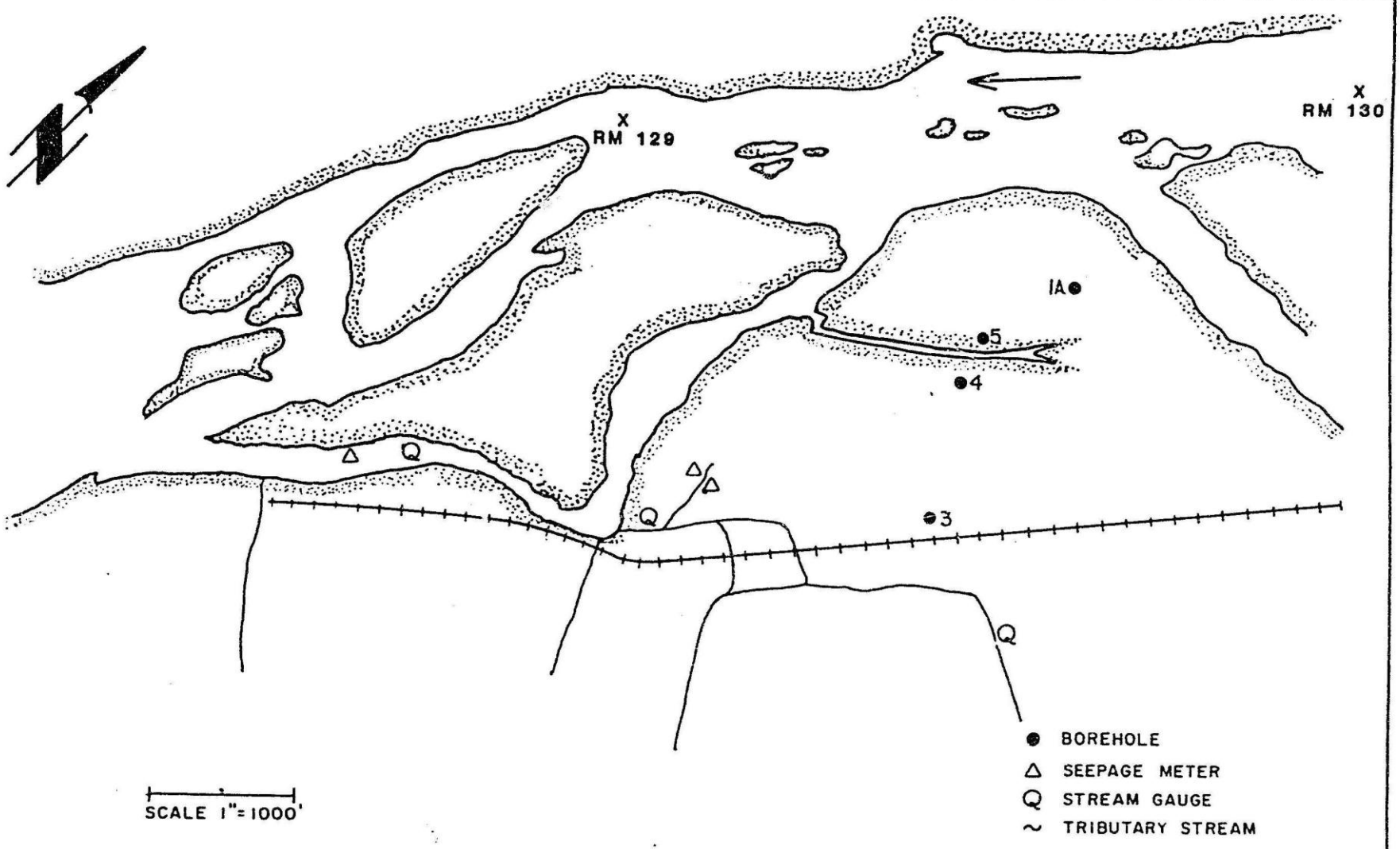


SLOUGH AND TRIBUTARY INDEX AREA
PEAK SPAWNING COUNTS

SOURCE: ADF&G 1981a, 1983a, 1984h, 1985b







PREPARED BY:
R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

Figure 3.3 SLOUGH 9

PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE



Potential Effects of the Dam – River Flow, Sediment Transport, Ice Processes



Learn More!





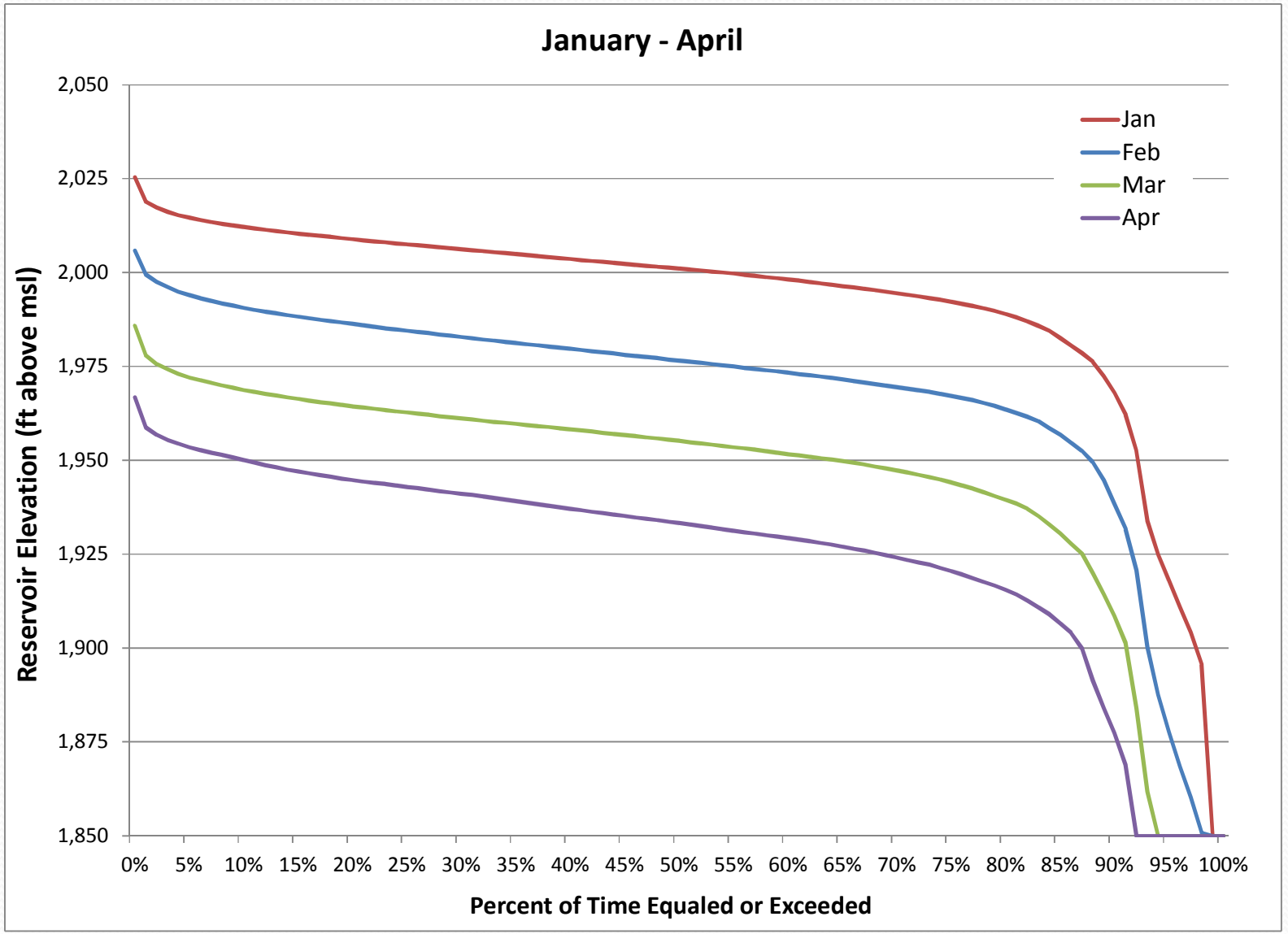
Acknowledgements

Information collected from numerous studies conducted by the Alaska Power Authority in the 1980s, from USGS mapping and streamflow records, and from studies conducted with funding from the Alaska Energy Authority and Alaska Department of Transportation and Public Facilities. Opinions are, of course, my own.

INFORMATION ITEM P5:
RESERVOIR ELEVATION DURATION CURVES BY MONTH

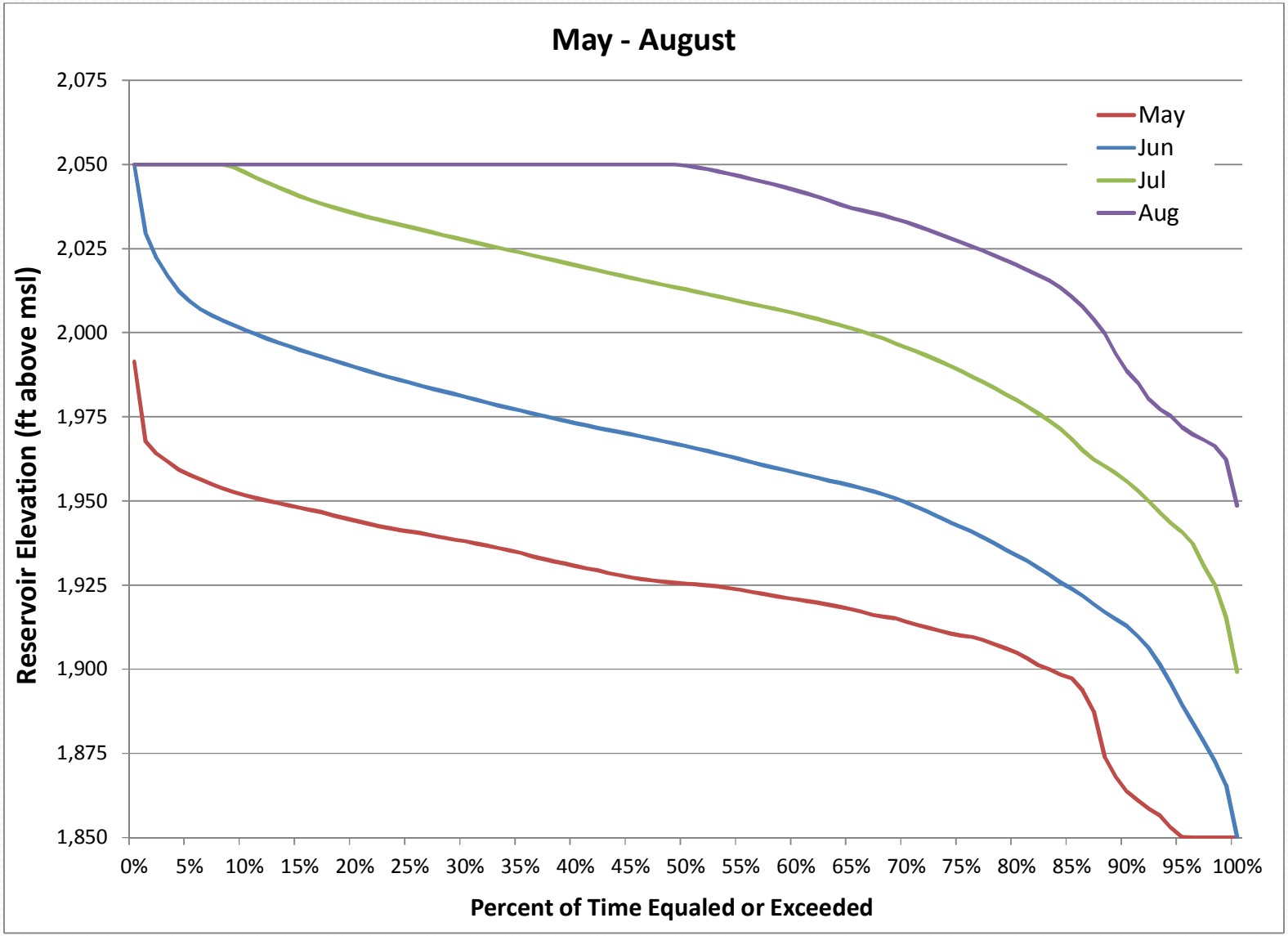
PRELIMINARY DATA

P5 – Monthly Elevation Duration Curves



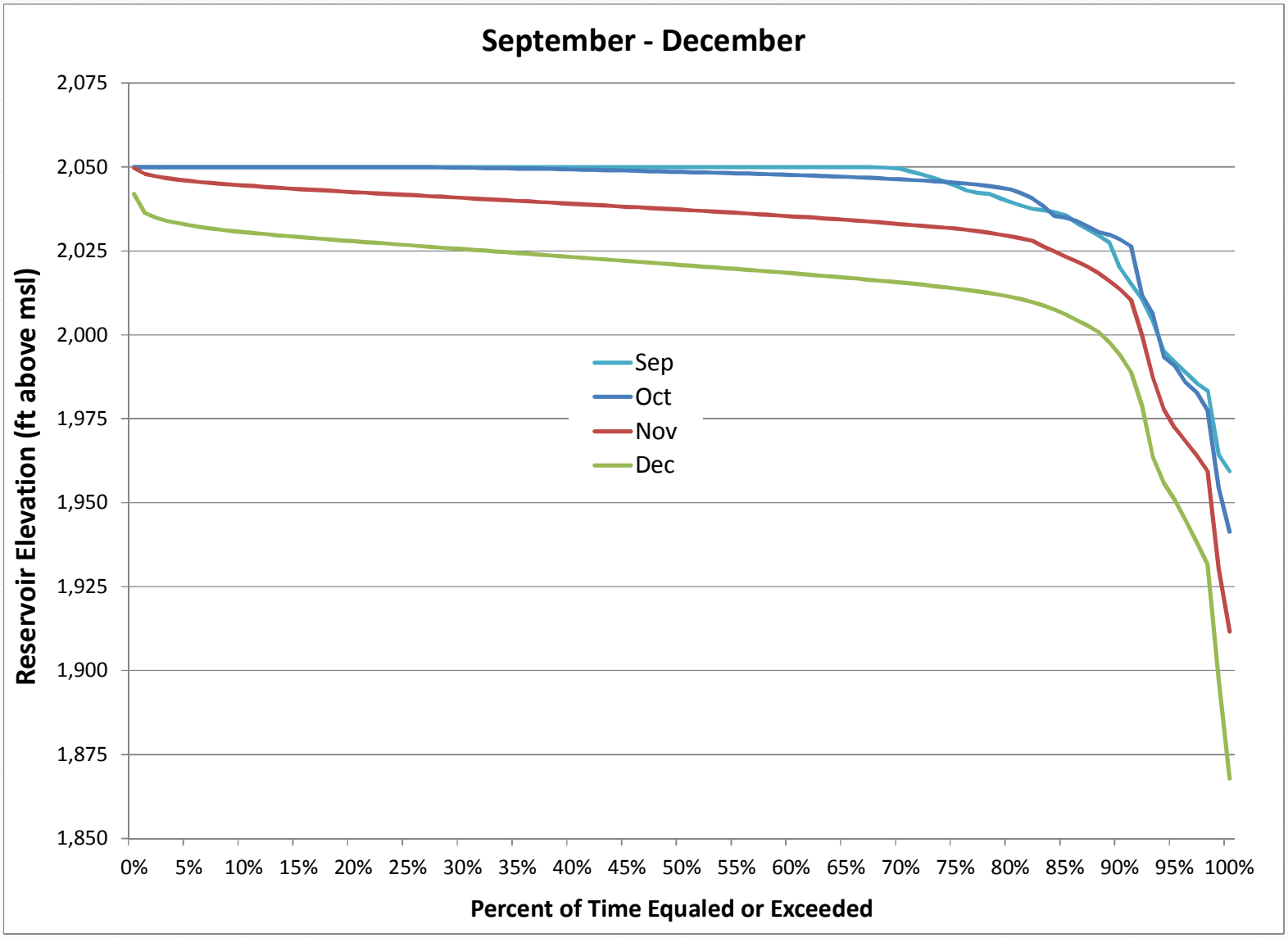
PRELIMINARY DATA

P5 – Monthly Elevation Duration Curves



PRELIMINARY DATA

P5 – Monthly Elevation Duration Curves



INFORMATION ITEM P6:
OTHER PROJECT OPERATIONS DATA

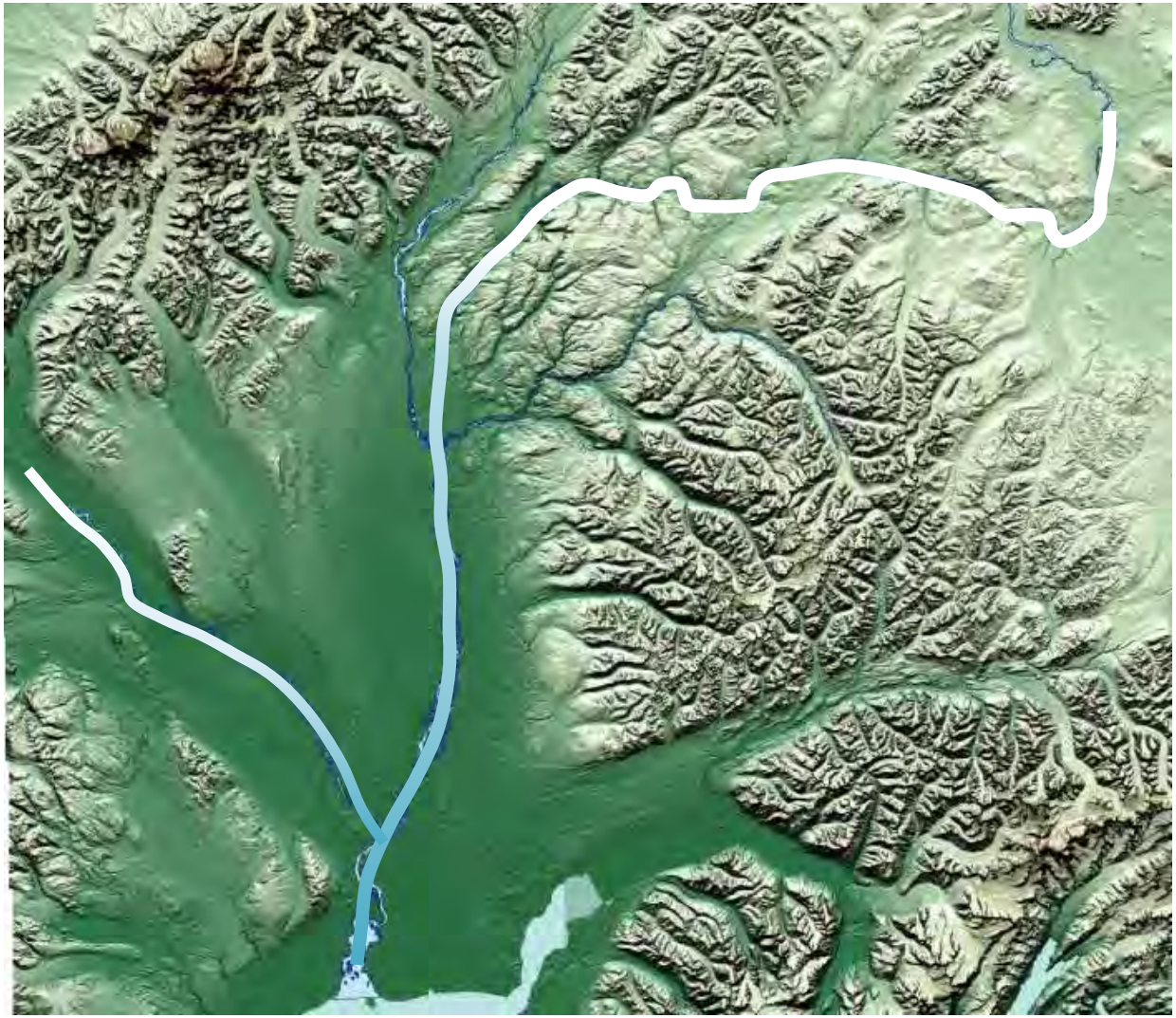
INFORMATION ITEM P7:
EXISTING ICE COVER ON RIVER AND TRIBUTARIES

Existing Information

- All measurements and observation locations are compiled into an Access database and are sorted by river mile.
  - Freeze-up and breakup progression observations, 1980-1985 (Upper River observed in 1980 and 1985)
  - Freeze-up bridging has occurred at RM 170, RM 186, RM 194. Freeze-up jam and breakout around RM 186.
  - Major breakup jam recurred near damsite.
  - 34 Ice thickness measurements between Devil Canyon and Vee Canyon – 2 ft – 4 feet average, maximum of 6-plus feet.
- Model predictions of post-project ice cover progression, ice thickness and elevation, and the open-water lead downstream of the dam site.

Susitna River Freeze Up Process – Frazil Production

- River cools to 32 degrees
- Frazil appears, flows downstream
- Border ice grows
- Significant anchor ice grows upstream of Devil Canyon, but is transient.



SUSITNA-WATANA
HYDROELECTRIC PROJECT

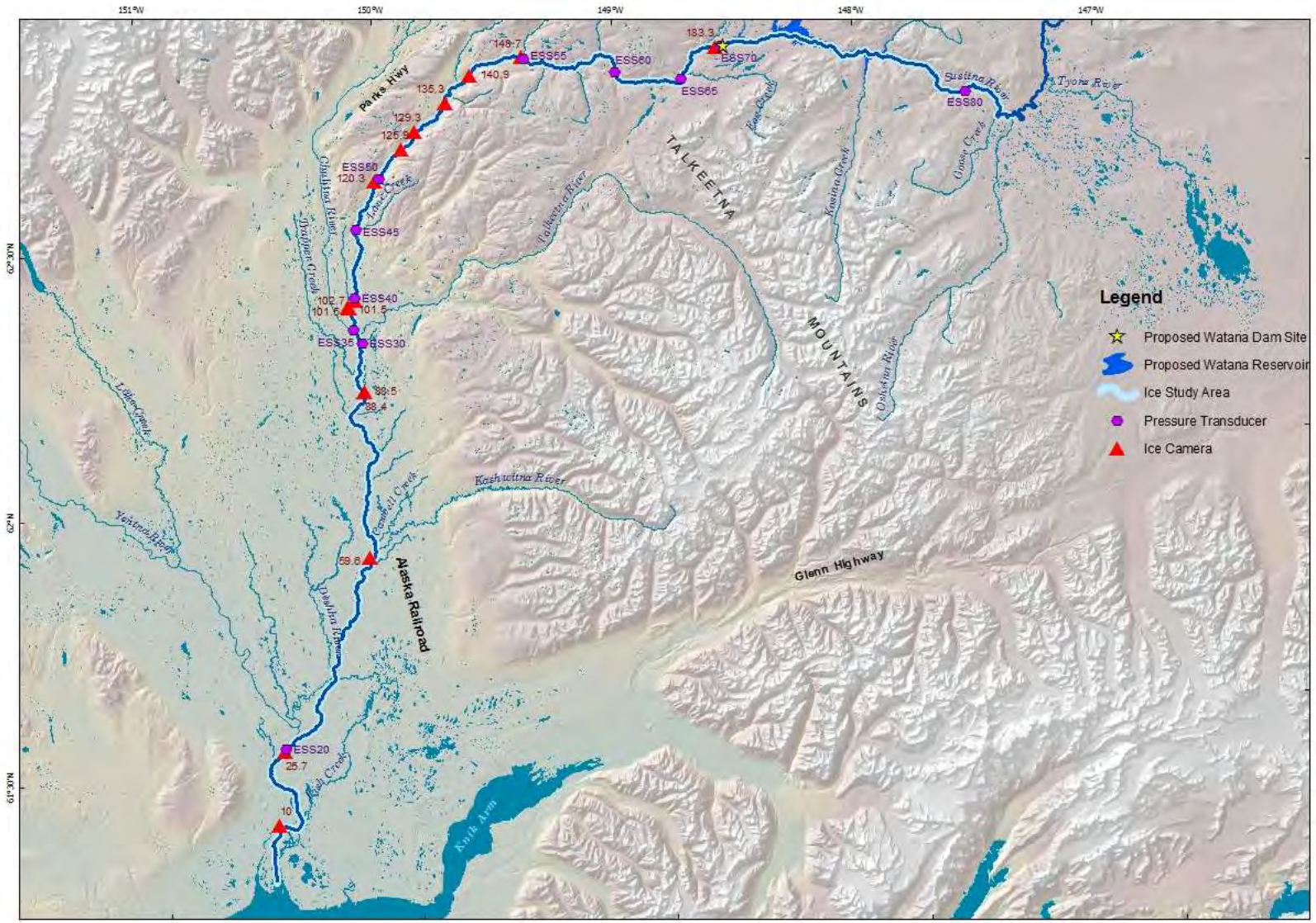
Susitna River Freeze Up Process – Frazil Production and Border Ice Growth



R&M 1984

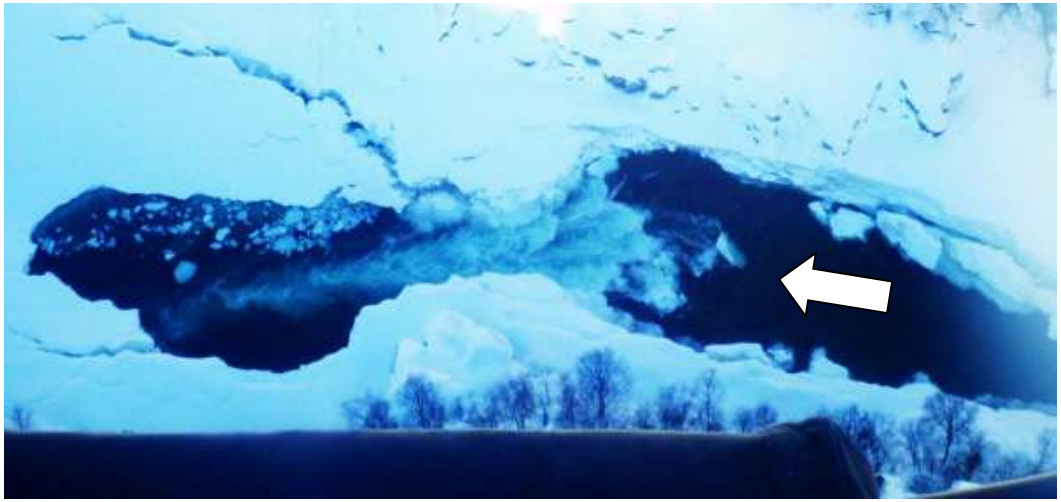
FIGURE 5.4
October 17, 1983. Low air temperatures and minimal solar radiation influence the water surface in the upper river canyons. These factors together with high turbulence generates large volumes of frazil slush in October. This is near the mouth of Jay Creek, looking downstream.

2012 Study Area



SUSITNA-WATANA
HYDROELECTRIC PROJECT

2012 Open Leads – Middle River Velocity



Devil Canyon, RM 152, PRM 156



SUSITNA-WATANA
HYDROELECTRIC PROJECT

2012 Open Leads – Middle River above Devil Canyon



RM 170 Velocity lead opening up, April 2012

2012 Open Leads – Upper River



Vee Canyon, RM 222, PRM 224

Oshetna Confluence, RM 232, PRM 234



SUSITNA-WATANA
HYDROELECTRIC PROJECT

2012 Breakup – Devil Canyon



Leads opening, April 27th





Remains of ice shelf, May 2. Ice cover Composed of rounded fine slush balls.

2012 Breakup – Upper River



Vee Canyon, RM 221.5, PRM 223.4 April 27th



RM 221, PRM 223, May 9th

SUSITNA-WATANA
HYDROELECTRIC PROJECT

2012 Breakup – Upper River



Kosina, May 9th



Oshetna, May 9th

SUSITNA-WATANA HYDROELECTRIC PROJECT

2012 Breakup – Watana Dam Site Area





Stranded ice chunks, above and "bulldozed" soil, right.
May 9, RM 183, PRM 186

SUSITNA-WATANA
HYDROELECTRIC PROJECT

2012 Freeze-up Conditions

- Much higher than average flows during early ice formation (October 12th flows were twice average at Gold Creek and Sunshine, and near proposed project flows)
- Colder than average November, warmer December and January
- Unusually high water as ice front reached Talkeetna
- Progression followed patterns observed in the 1980's.

2012 Freeze-up – Devil Canyon October 22



Lower Devil Canyon Ice Bridge, RM 151, PRM 155



Middle Devil Canyon Ice Bridge, RM 155, PRM 158.5

SUSITNA-WATANA
HYDROELECTRIC PROJECT

Anchor Ice, Middle River Above Devil Canyon

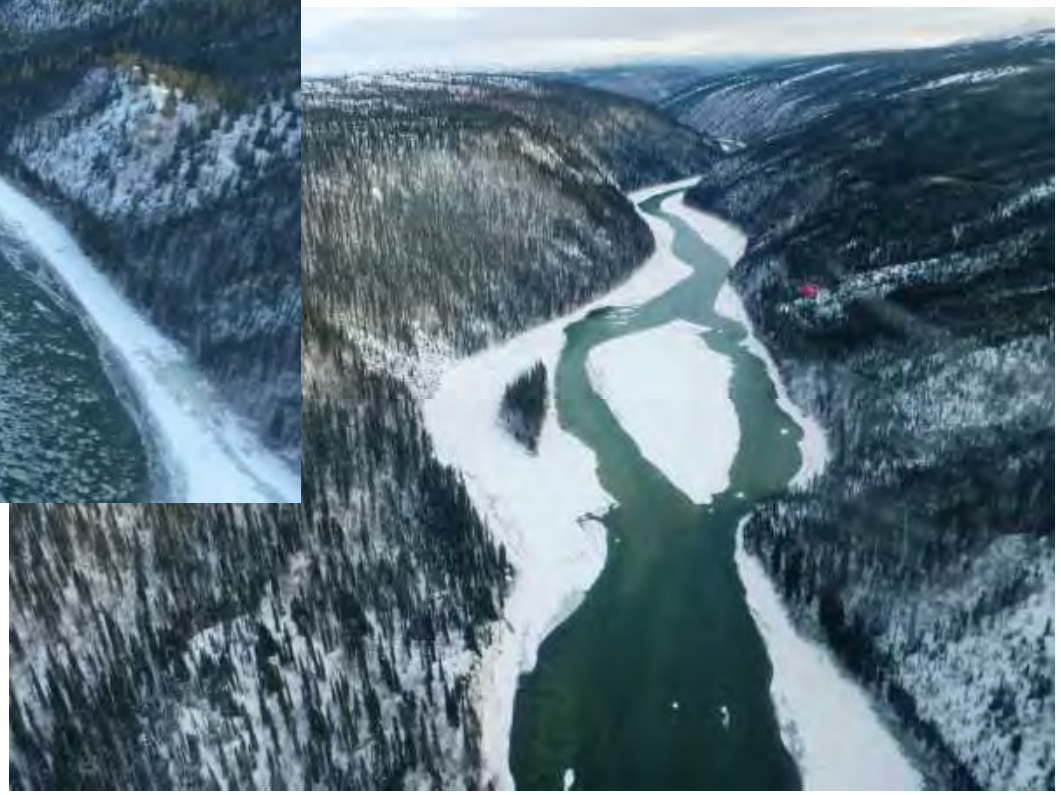


RM 172, PRM 175, November 15th , 2012

2012 Freeze-up – Dam Site



October 26



November 15

ALASKA ENERGY AUTHORITY

2012 Freeze-up – Dam Site



November 20



December 3

ALASKA ENERGY AUTHORITY

2012 Freeze-up – Dam Site



December 19

ALASKA ENERGY AUTHORITY

2012 Freeze-up Observations – Upper River





Above, Upper River ice bridge, RM 194, PRM 196.6, November 15th

Right, Upper River ice front, RM 215, PRM 217.5, November 15th

2012 Freeze-up Observations – Upper River Tributaries



Oshetna River breakout flood, November 15th

2012 Freeze-up Observations – Upper River Tributaries



Oshetna River frozen over, December 19th

2012 Freeze-up Observations – Upper River Tributaries



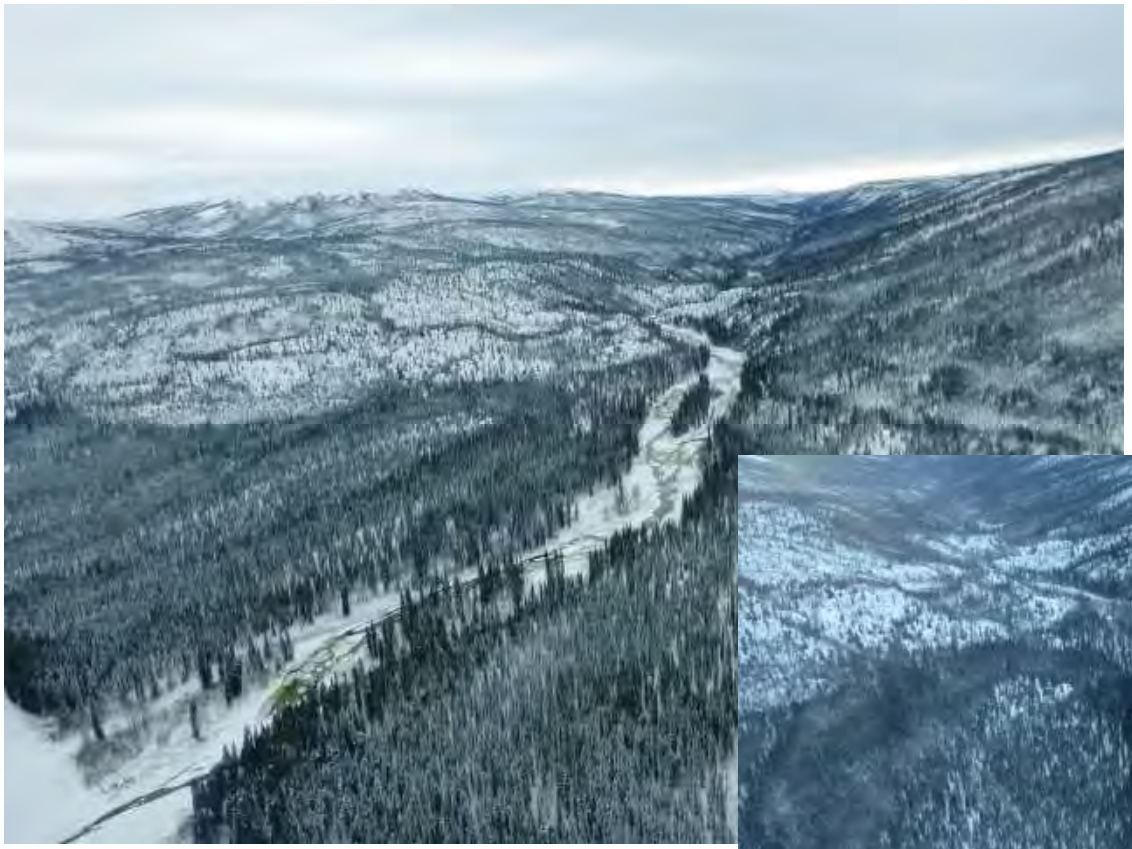
Jay Creek, November 15th



Deadman Creek, November 15th

SUSITNA-WATANA HYDROELECTRIC PROJECT

2012 Freeze-up Observations – Upper River Tributaries



Kosina Creek, November 15th



1985 Modeling Results and Predicted Project Effects (Middle River – Watana Only)

- The dam would release above-freezing water, creating an open reach extending 40-50 miles downstream of the dam (ice cover would end just downstream of Gold Creek in warm years, downstream of Portage Creek in cold years)
- The formation of an ice cover at Talkeetna would be delayed by 2-4 weeks (3 weeks on average).
- Within the open-water reach, stages would be lower than or equal to natural ice-covered conditions.
- Within the ice-covered reach, stages would be 2-7 feet higher than natural conditions.
- The increased stage may result in breaching of slough berms in the ice-covered reach of the Middle River.
- Breakup would occur 2-3 weeks earlier, and breakup jams in the Middle River would be decreased in severity.

INFORMATION ITEM P8:

ANTICIPATED ICE COVER ON RESERVOIR AND BELOW DAM FOLLOWING PROJECT CONSTRUCTION

INFORMATION ITEM P9:
WATER TEMPERATURES DURING UPSTREAM MIGRATION PERIOD

INFORMATION ITEM P10:

WATER TEMPERATURES DURING DOWNSTREAM MIGRATION PERIOD

INFORMATION ITEM P11:
AIR TEMPERATURE, WIND, LIGHT, AND MET STATION DATA

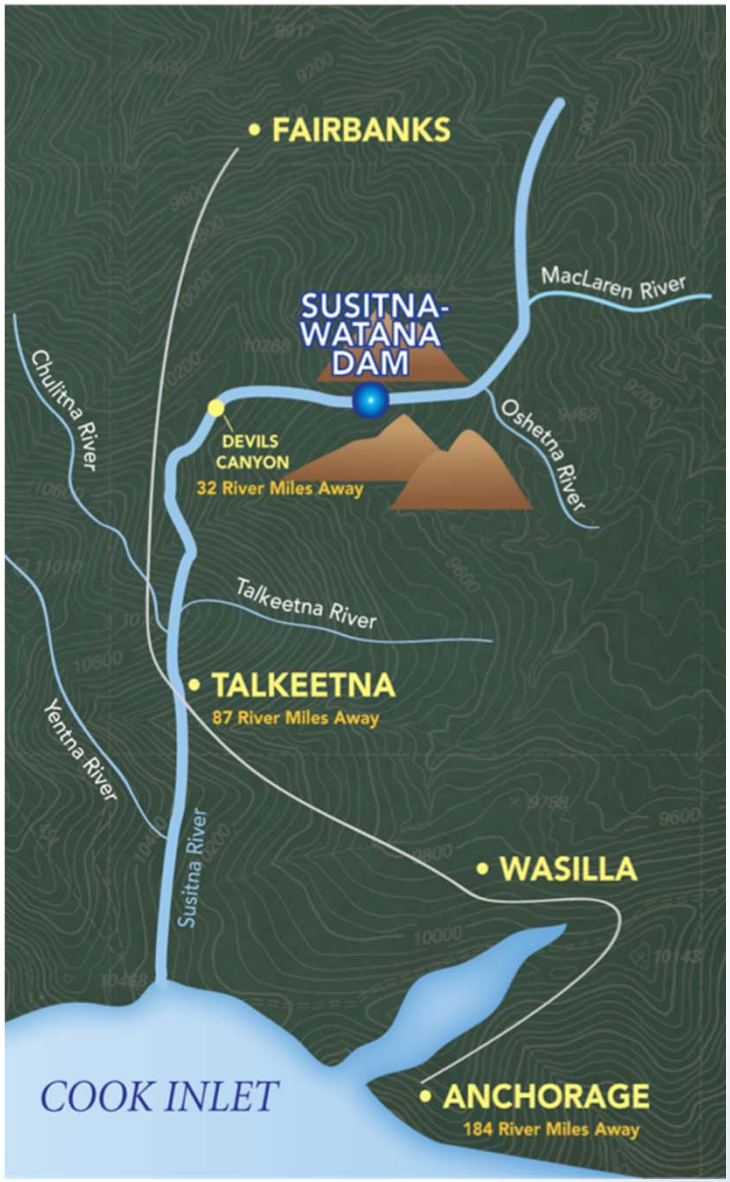
INFORMATION ITEM P12:
SEDIMENT INFORMATION

INFORMATION ITEM P13:
RIVER MORPHOLOGY TRENDS AFTER PROJECT CONSTRUCTION

Fish Passage Workshop 1:
Relevant Information form the Geomorphology Studies

Technical Workgroup Meeting
Fish and Aquatics
April 9, 2013

Prepared by: Tetra Tech
Prepared for: Alaska Energy Authority



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Overall Goal – Geomorphology Studies

- Two studies
  - Geomorphology Study
  - Fluvial Geomorphology Modeling Study
- The overall goal of the geomorphology studies is to assess the potential effects of the proposed Project on the fluvial geomorphology of the Susitna River, with particular focus on providing information to assist in predicting Project impacts to aquatic and terrestrial habitat.

2012 Geomorphology Study Tech Memos

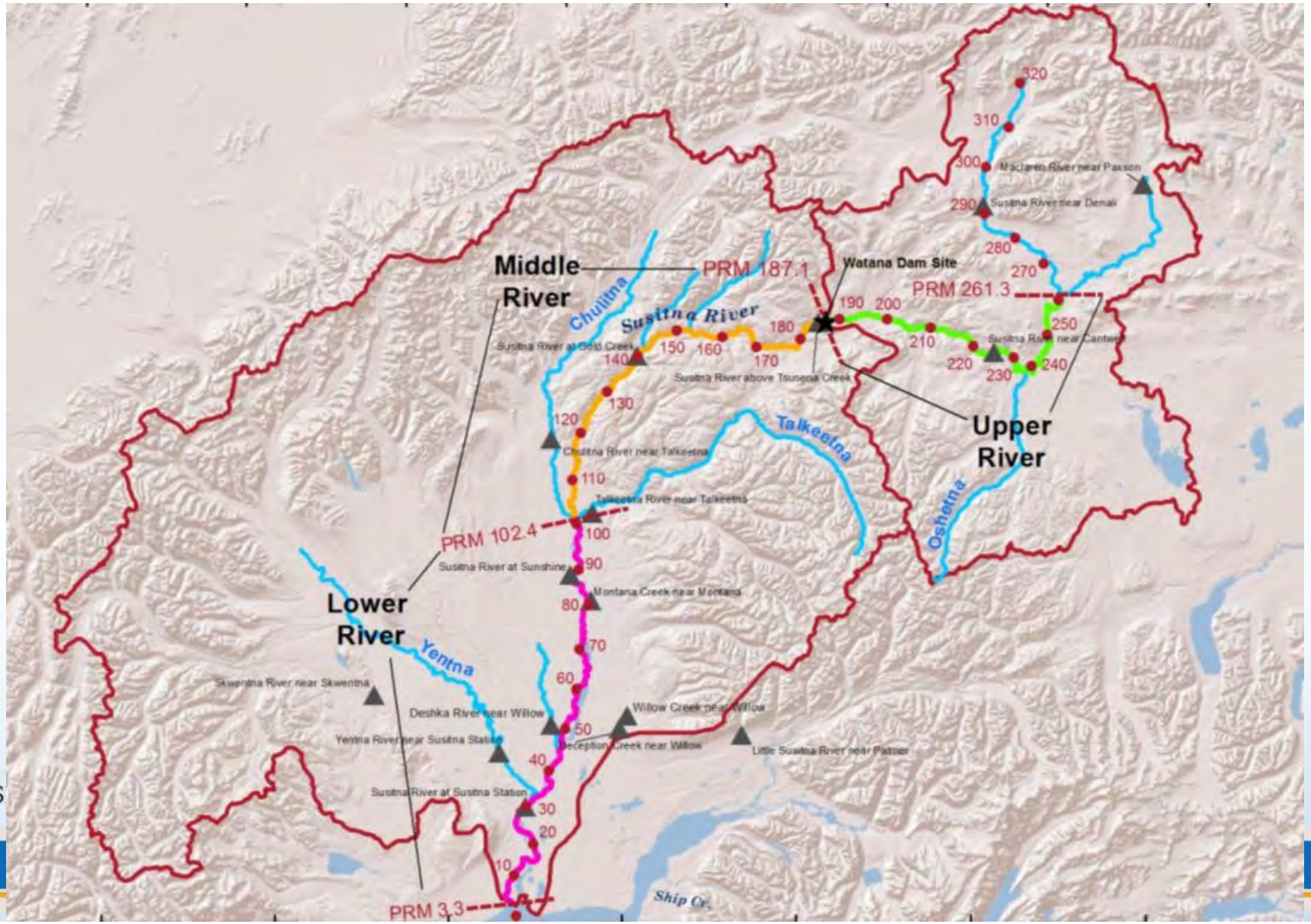
- *Stream Flow Assessment*
- *Initial Geomorphic Reach Delineation and Characterization, Middle and Lower Susitna River Segments*
- *Development of Sediment Transport Relationships and an Initial Sediment Balance for the Middle and Lower Susitna River Segments*
- *Reconnaissance Level Assessment of Potential Channel Change in the Lower Susitna River Segment*

2012 Geomorphology Study Tech Memos

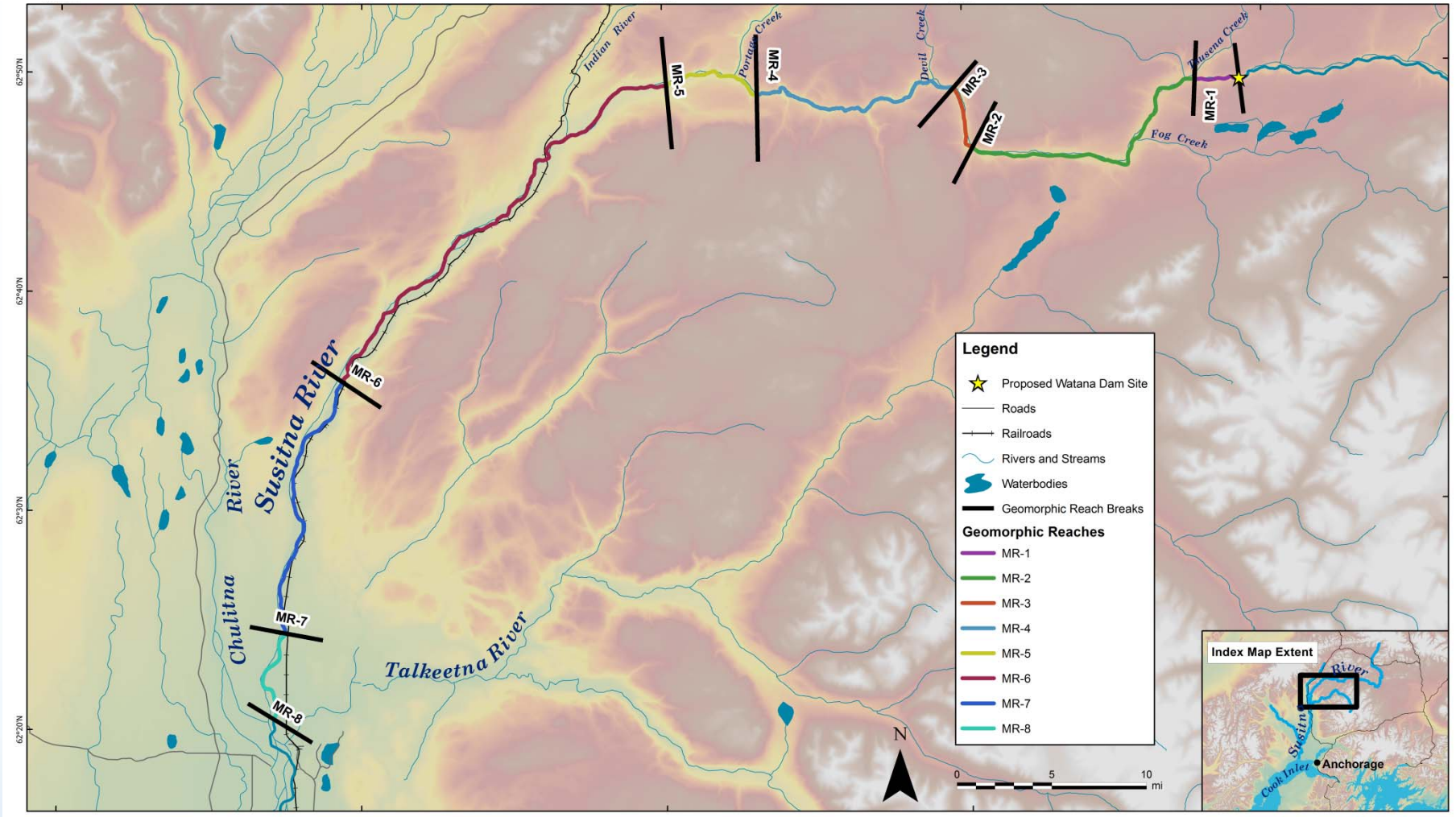
- *Mapping of Aquatic Macrohabitat Types at Selected Sites in the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials*
- *Mapping of Geomorphic Features within the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials*
- *Synthesis of the 1980s Lower Susitna River Segment Aquatic Habitat Information*

River Segments

Upper, Middle & Lower River Segments



Middle River Geomorphic Reaches



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Geomorphic Characteristics - MR

Reach	Length (mi)	Gradient (ft/mi)	Sinuosity	Average Width (feet)		Entrench-ment Ratio[1,3]	Median Bed Material Size (mm)	Number of Bed Material Samples	Channel Branching[4] (Average Number Channels)
				Active Channel	Valley Bottom[1]				
MR-1	2.5	9.4	1.03	655	782	1.2			1.2
MR-2	15.0	10.9	1.06	715	1,512	2.1			1.4
MR-3	3.5	11.0	1.02	594	781	1.3			1.1
MR-4	12.2	30.6	1.03	312	370	1.2			1.0
MR-5	5.5	12.1	1.03	512	851	1.7	70	NA	1.2
MR-6	25.7	10.8	1.09	985	2,350	2.4	50	17	2.4
MR-7	14.9	8.5	1.05	845	2,050	2.4	40	7	1.8
MR-8	5.4	7.3	1.19	1,132	8,960	7.9	63	18	2.7

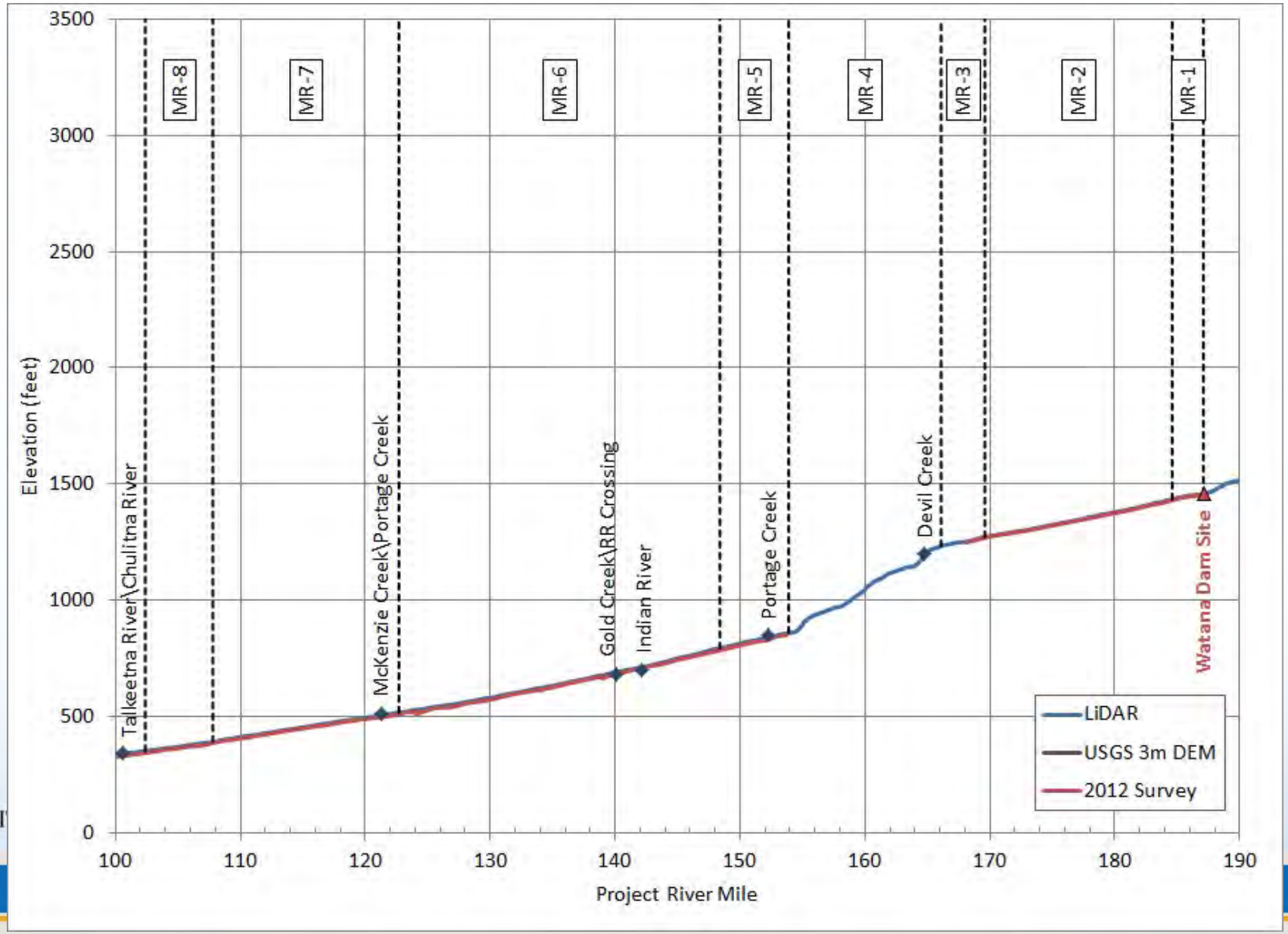
[1] Effects of manmade features, including railroad grade, levees, etc. not considered in valley bottom width.

[2] Valley bottom width reflects confining effects of manmade features, including railroad grade, levees, etc.

[3] Ratio of valley bottom width to active channel width.

[4] Number of channels separated by relatively stable, vegetated islands.

Bed Profile - Middle River



Middle River Geomorphic Reaches



Reach 1 (2.5 miles)

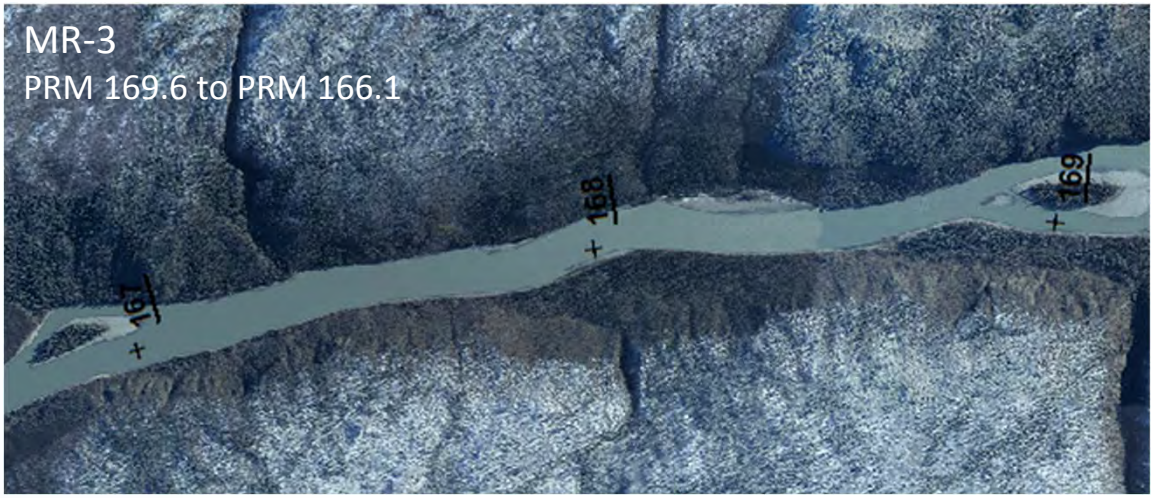
- Channel Type = SC2
- Gradient = 9.4 ft/mi
- Active channel width = 655 ft
- Entrenchment Ratio (ER) = 1.2
- Branching Index (BI) = 1.2



Reach 2 (15.0 miles)

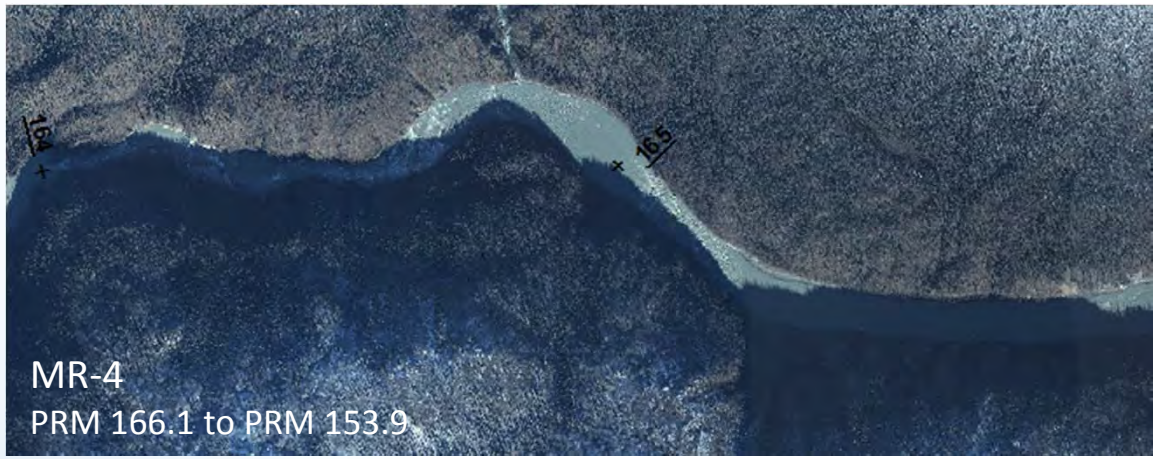
- Channel Type = SC2
- Gradient = 10.9 ft/mi
- Active channel width = 715 ft
- ER = 2.1
- BI = 1.4

Middle River Geomorphic Reaches



Reach 3 (3.5 miles)

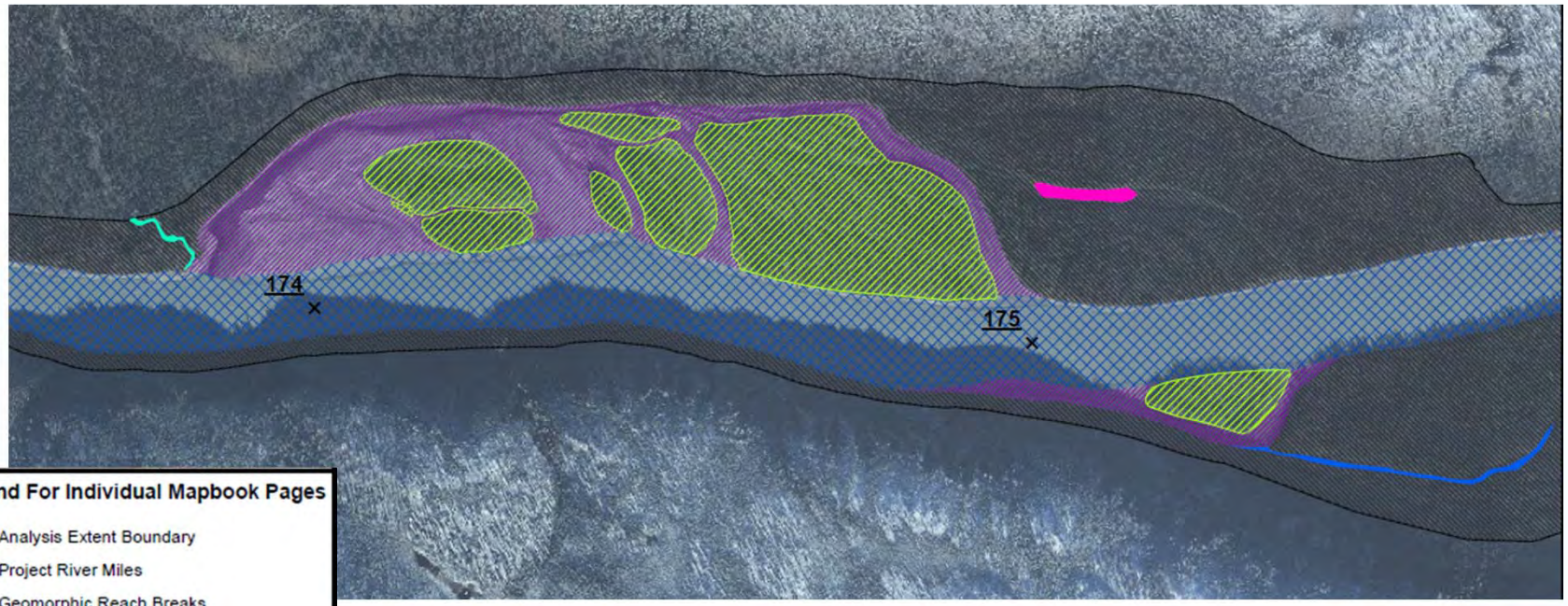
- Channel Type = SC2
- Gradient = 11.0 ft/mi
- Active channel width = 594 ft
- ER = 1.3
- BI = 1.1



Reach 4 (12.2 miles)

- Channel Type = SC1
- Gradient = 30.6 ft/mi
- Active channel width = 312 ft
- ER = 1.2
- BI = 1.0

Middle Susitna River Segment – MR-2
2012 Geomorphic Features



Legend For Individual Mapbook Pages

- Analysis Extent Boundary
- Project River Miles
- Geomorphic Reach Breaks

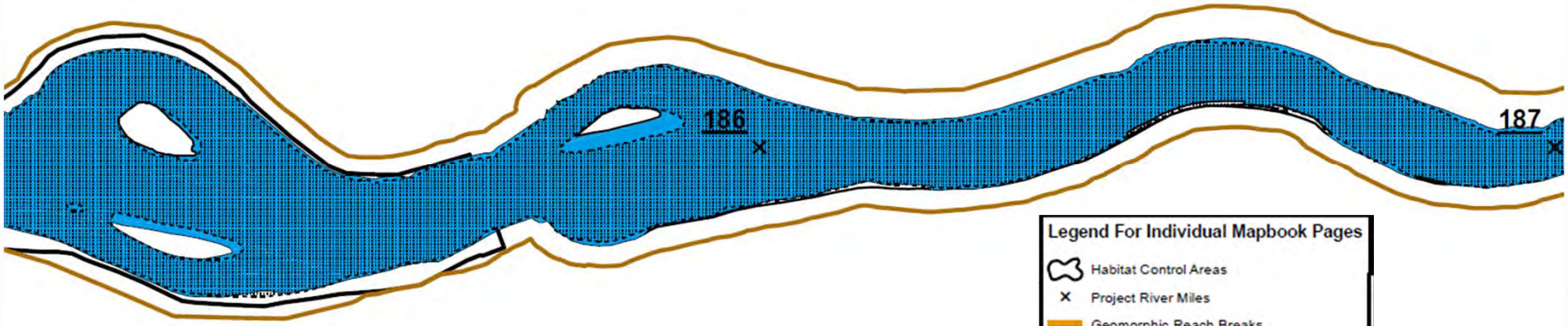
Geomorphic Features

- Main Channel (MC, MC TM, EXP MC)
- Side Channel (SC, SC TM, EXP SC)
- Side Slough (SS, EXP SS)
- Tributary (TR, TR TM, EXP TM)
- Upland Slough (US, EXP US)
- Additional Open Water (AOW)
- Vegetated Island (VI)
- Background (BG)

Location:	Imagery Date,	Discharge (Gold Creek)
PRM 102.4 - 143.6:	09/10/2012,	12,900 cfs
PRM 143.6 - 187.1:	09/30/2012,	17,000 cfs

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Middle Susitna River Segment – MR-1
1980's – 2012 Channel Change



Legend For Individual Mapbook Pages

- Habitat Control Areas
- Project River Miles
- Geomorphic Reach Breaks
- Analysis Extent Boundary

1980's Geomorphic Features

- Main & Side Channel Features
- Side Slough Features
- Tributary Features
- Upland Slough Features
- Additional Open Water

2012 Geomorphic Features

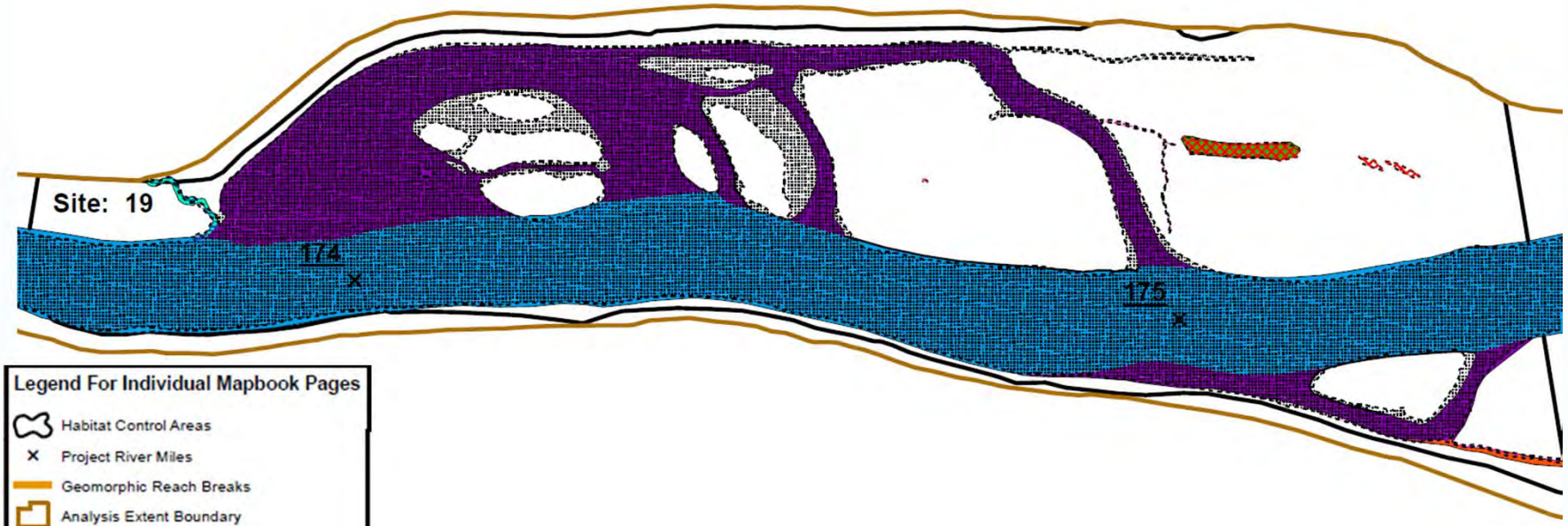
- Main & Side Channel Features
- Side Slough Features
- Tributary Features
- Upland Slough Features
- Additional Open Water

Location:	Imagery Date,	Discharge (Gold Creek)
PRM 102.4 - 143.6:	09/10/2012,	12,900 cfs
PRM 143.6 - 187.1:	09/30/2012,	17,000 cfs

Location:	Imagery Date,	Discharge (Gold Creek)
PRM 102.4 - 154.0	09/11/1983	12,500 cfs
PRM 154.0 - 187.1	07/19-20/1980	31,600 - 35,800 cfs

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Middle Susitna River Segment – MR-2
1980's – 2012 Channel Change



Legend For Individual Mapbook Pages

- Habitat Control Areas
- Project River Miles
- Geomorphic Reach Breaks
- Analysis Extent Boundary

1980's Geomorphic Features

- Main & Side Channel Features
- Side Slough Features
- Tributary Features
- Upland Slough Features
- Additional Open Water

2012 Geomorphic Features

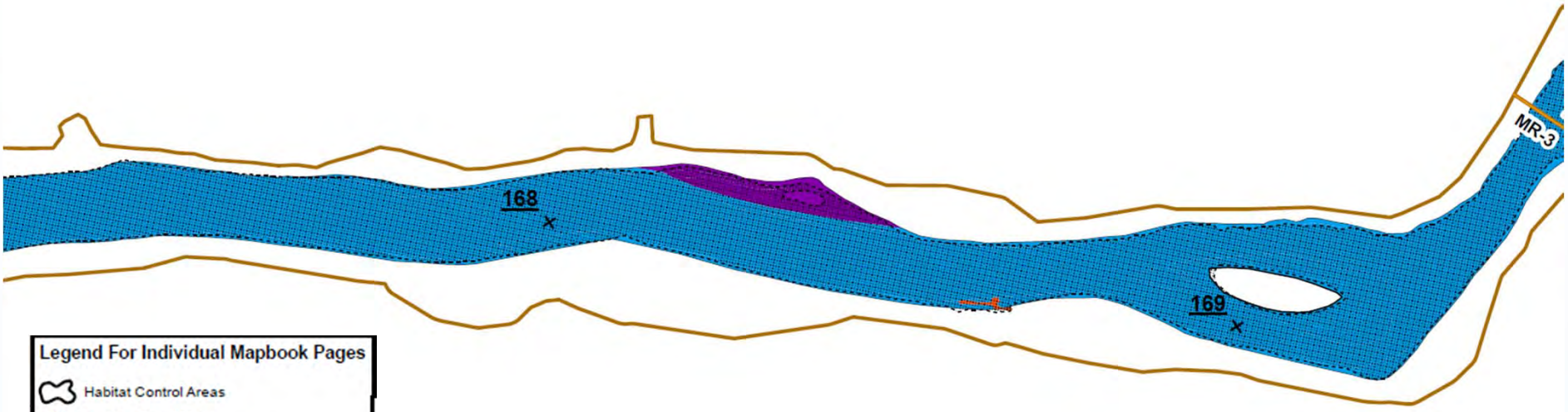
- Main & Side Channel Features
- Side Slough Features
- Tributary Features
- Upland Slough Features
- Additional Open Water

Location:	Imagery Date,	Discharge (Gold Creek)
PRM 102.4 - 143.6:	09/10/2012,	12,900 cfs
PRM 143.6 - 187.1:	09/30/2012,	17,000 cfs

Location:	Imagery Date,	Discharge (Gold Creek)
PRM 102.4 - 154.0	09/11/1983	12,500 cfs
PRM 154.0 - 187.1	07/19-20/1980	31,600 - 35,800 cfs

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Middle Susitna River Segment – MR-3
1980's – 2012 Channel Change



Legend For Individual Mapbook Pages

- Habitat Control Areas
- Project River Miles
- Geomorphic Reach Breaks
- Analysis Extent Boundary

1980's Geomorphic Features

- Main & Side Channel Features
- Side Slough Features
- Tributary Features
- Upland Slough Features
- Additional Open Water

2012 Geomorphic Features

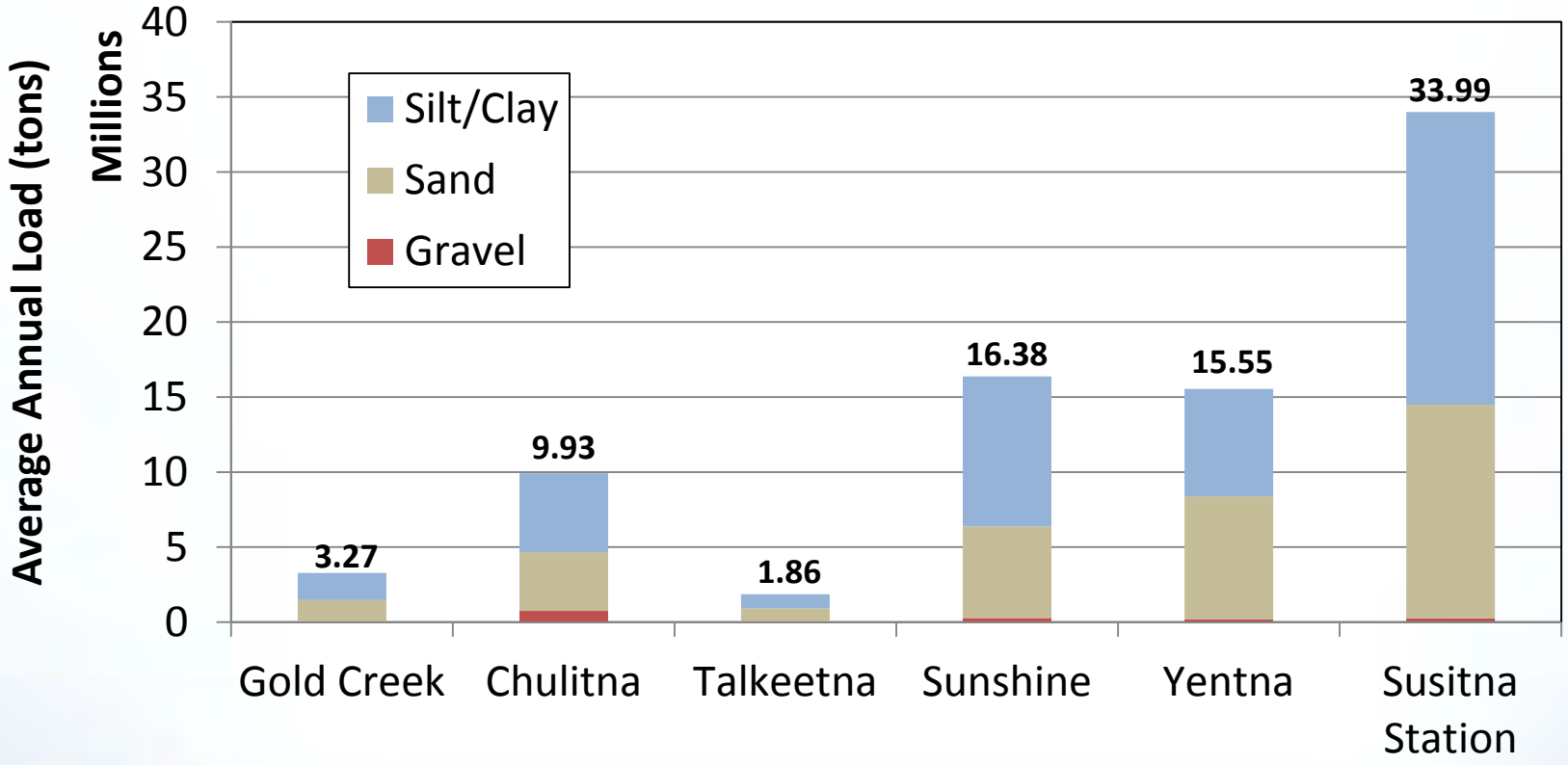
- Main & Side Channel Features
- Side Slough Features
- Tributary Features
- Upland Slough Features
- Additional Open Water

Location:	Imagery Date,	Discharge (Gold Creek)	Location:	Imagery Date,	Discharge (Gold Creek)
PRM 102.4 - 143.6:	09/10/2012,	12,900 cfs	**PRM 102.4 - 154.0**	09/11/1983	12,500 cfs
PRM 143.6 - 187.1:	09/30/2012,	17,000 cfs	**PRM 154.0 - 187.1**	07/19-20/1980	31,600 - 35,800 cfs

SUSITNA-WATANA HYDRO

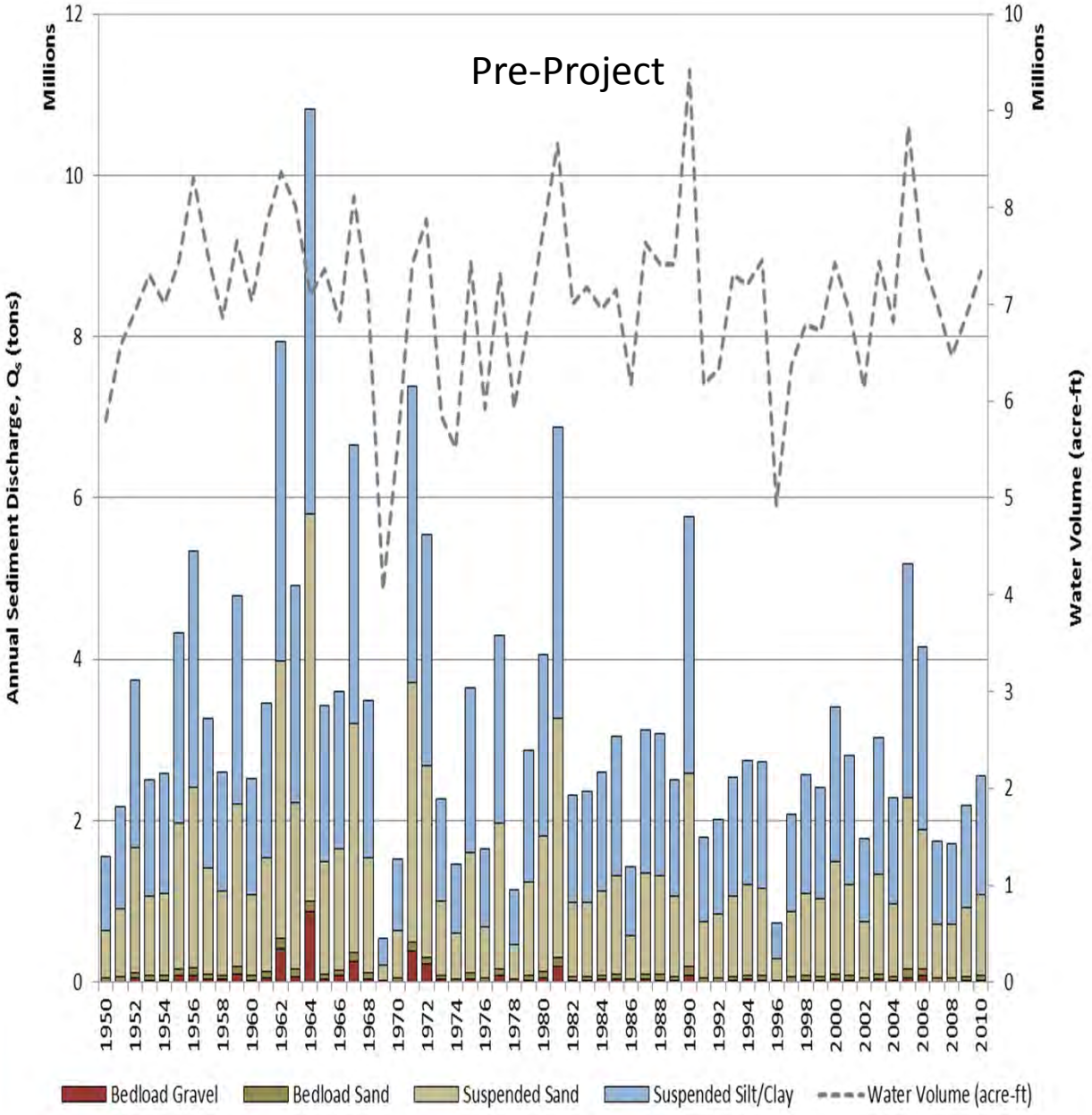
Clean, reliable energy for the next 100 years.

Average Annual Load
Pre-Project



SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Gold Creek Annual Sediment Load



SUSITNA-WATANA HYD

Overview of the Geomorphology Studies

Overall Goal – Geomorphology Studies

- Two studies
  - Geomorphology Study
  - Fluvial Geomorphology Modeling Study
- The overall goal of the geomorphology studies is to assess the potential effects of the proposed Project on the fluvial geomorphology of the Susitna River, with particular focus on providing information to assist in predicting Project impacts to aquatic and terrestrial habitat.

Geomorphology Study Objectives[19]

- Characterize the geomorphology of the Susitna River & define geomorphic reaches
- Determine sediment supply and transport
- Assess historical geomorphic stability/ change Middle and Lower Susitna River
- Conduct a reconnaissance-level geomorphic assessment of potential Project effects

Geomorphology Study Objectives[20]

- Watana Reservoir:
  - Trap efficiency
  - Shoreline erosion
  - Tributary delta development
- Conduct assessment of large woody debris recruitment, transport and their influence on geomorphic forms

Fluvial Geomorphology Modeling Study Objectives

- Develop calibrated models to predict the magnitude and trend of geomorphic response to the Project
  - 1-D (Middle and Lower River)
  - 2-D (Focus Areas)
- Apply the developed models to estimate the potential for channel change for with-Project operations compared to existing conditions

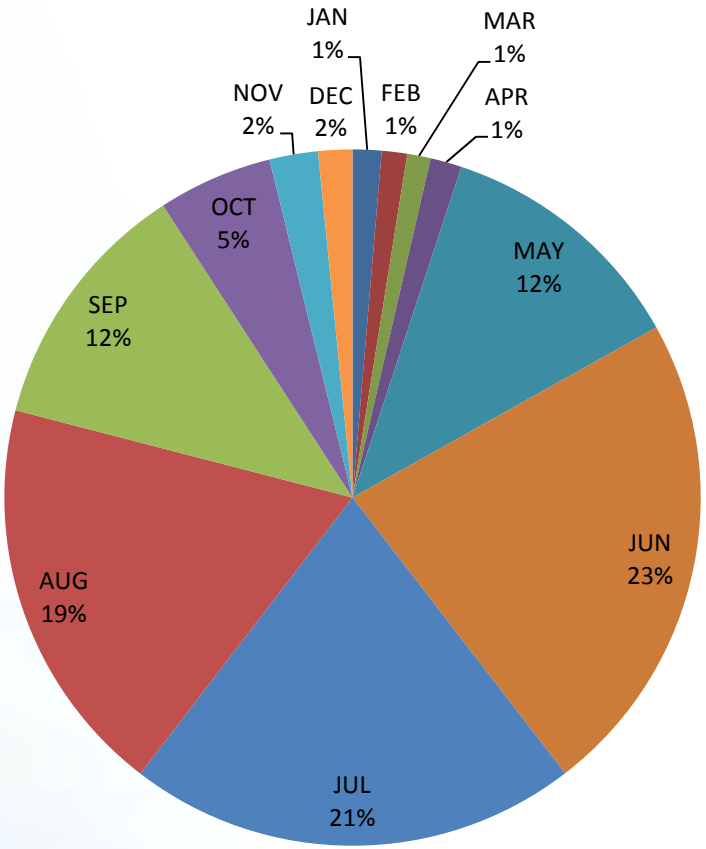
Fluvial Modeling Geomorphology Study Objectives

- Support the evaluation of Project effects by other studies by providing channel output data and assessment of potential changes in the geomorphic features that help comprise the aquatic and riparian habitats of the Susitna River

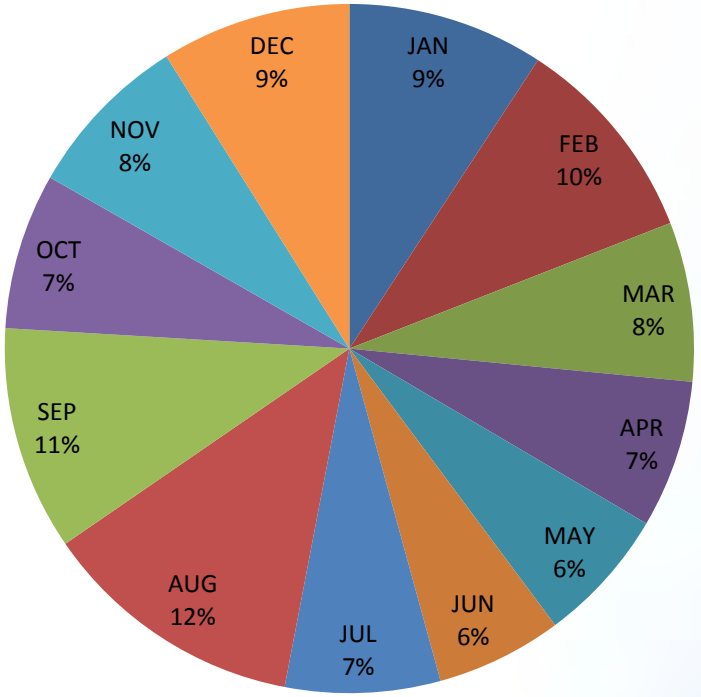
Post Project Conditions
Max LF OS-1

Monthly Average Flow Comparison (cfs) 24

Watana Dam (Pre-Project)

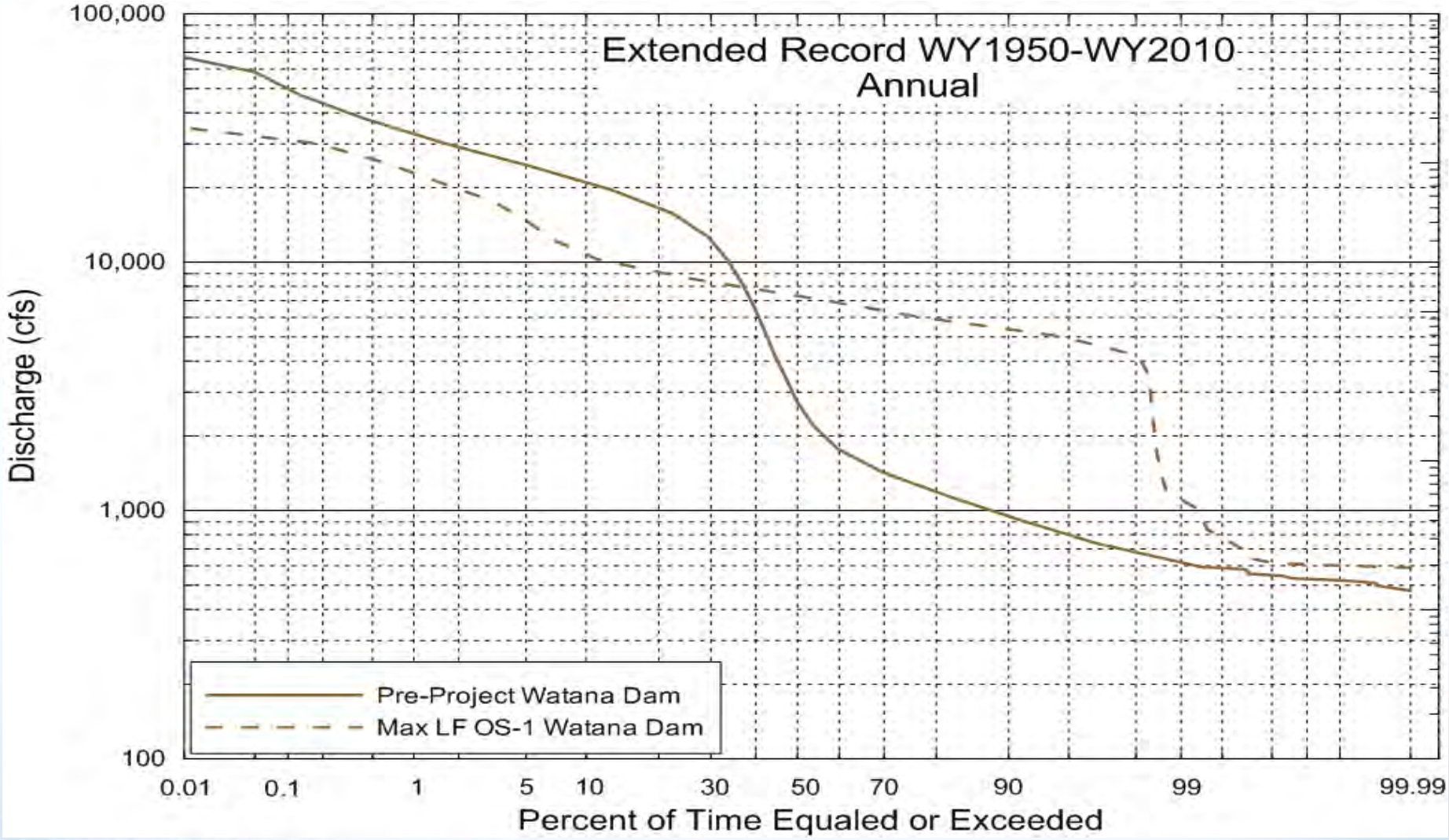


Watana Dam (Max LF OS-1)

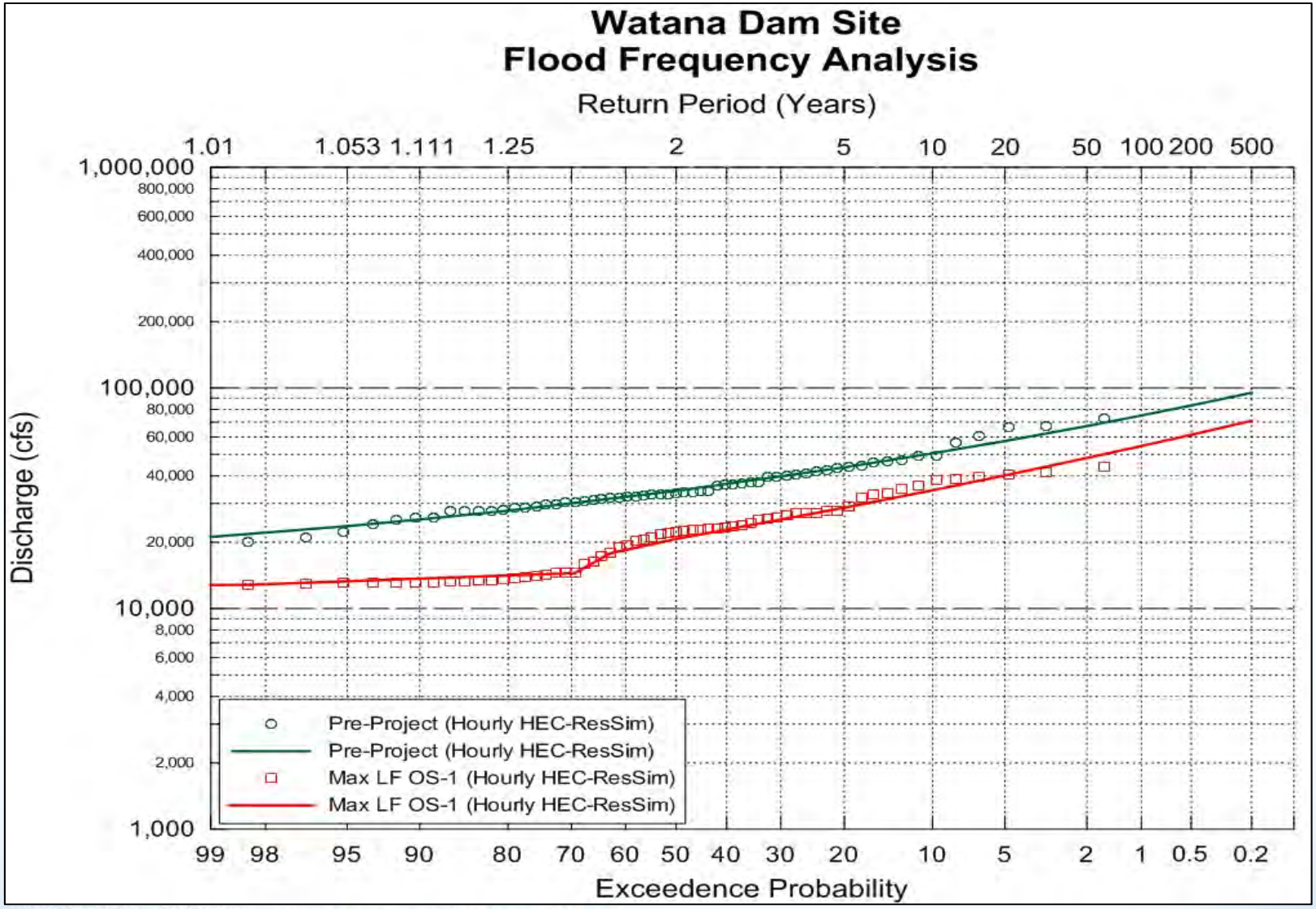


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Annual Flow Duration Watana Dam



Flood Frequency



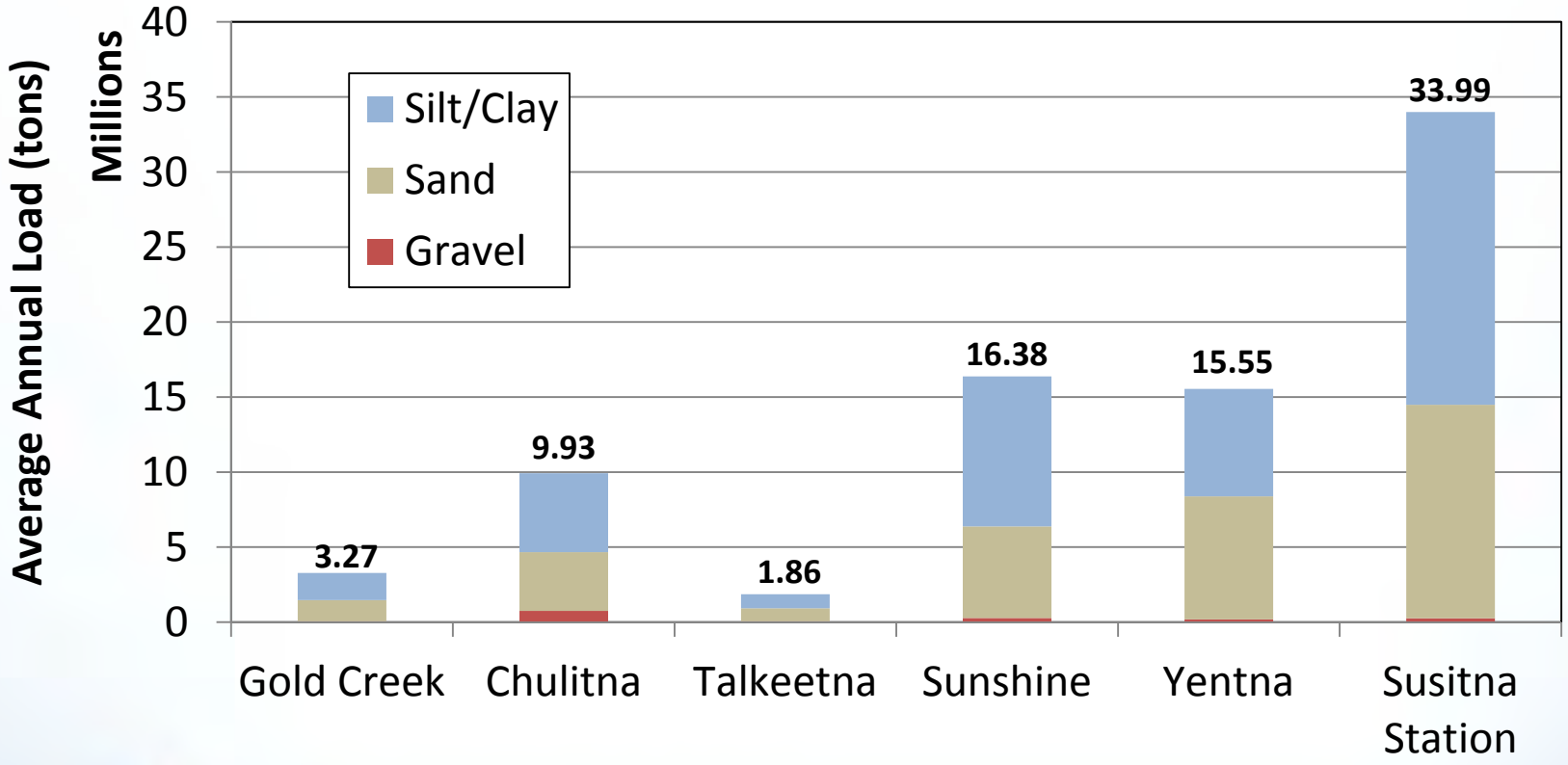
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Annual Peak Flow Comparison: Watana Dam Site (PRM 187)

Return Period (Years)	Watana Dam Site			
	Pre-Project Flow (cfs)	Max LF OS-1 Flow (cfs)	Difference (cfs)	Difference (%)
1.01	21,100	12,800	-8,300	-39%
1.25	27,800	14,100	-13,700	-49%
1.5	30,700	15,800	-14,900	-49%
2	34,200	20,700	-13,500	-39%
5	43,700	28,700	-15,000	-34%
20	57,600	40,200	-17,400	-30%
50	67,300	48,200	-19,100	-28%
100	75,100	54,600	-20,500	-27%

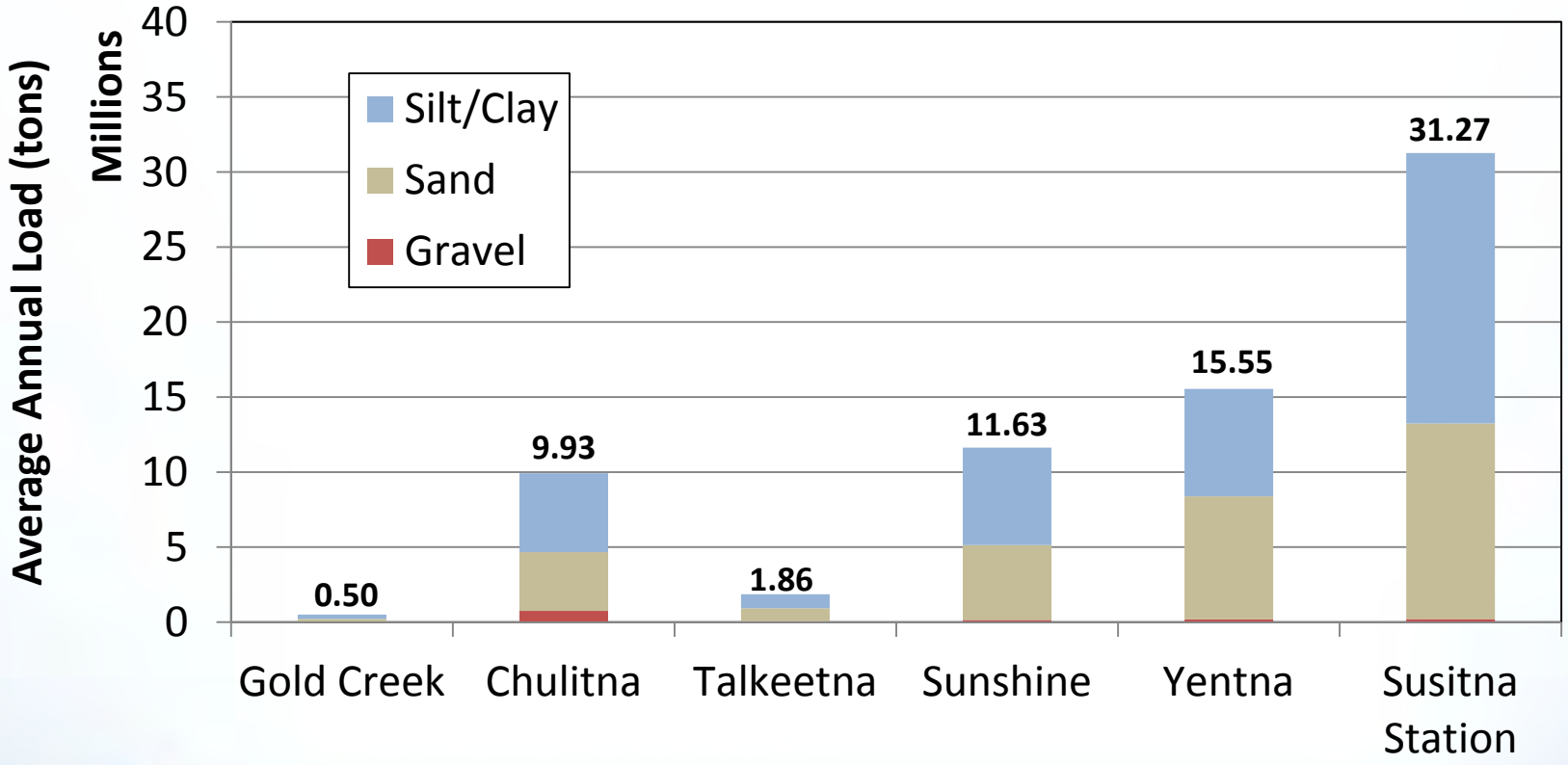
SUSITN

Average Annual Load
Pre-Project



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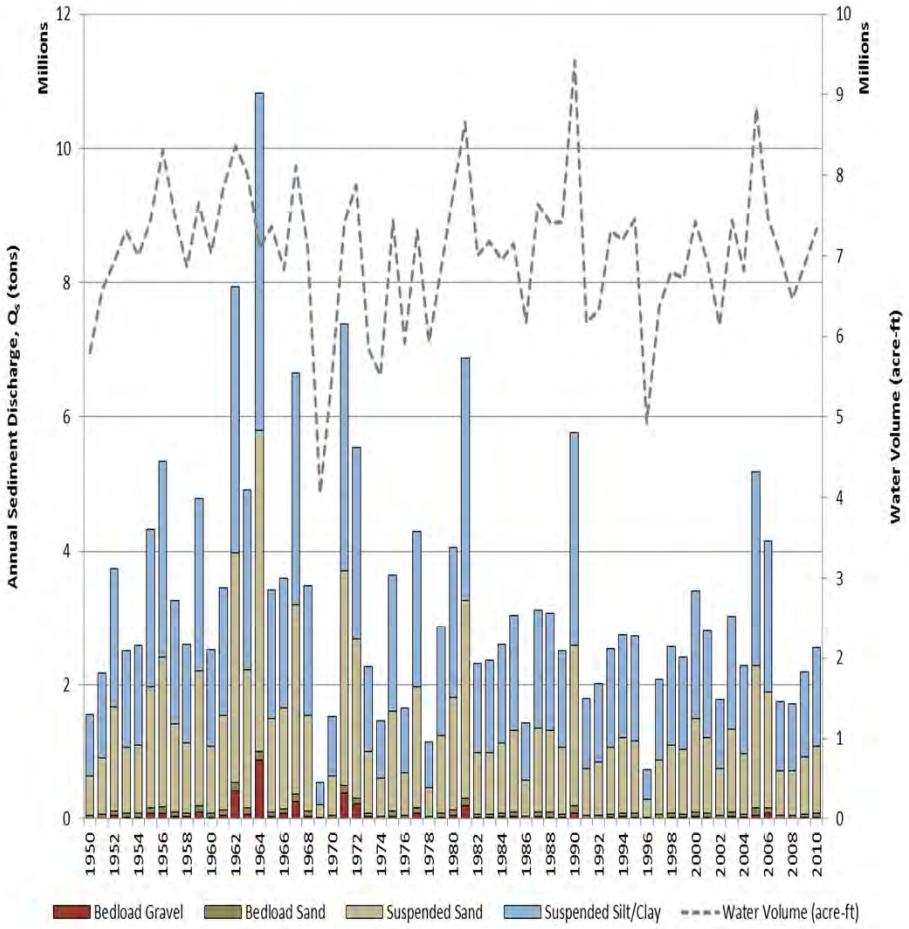
Average Annual Load
Max LF OS-1



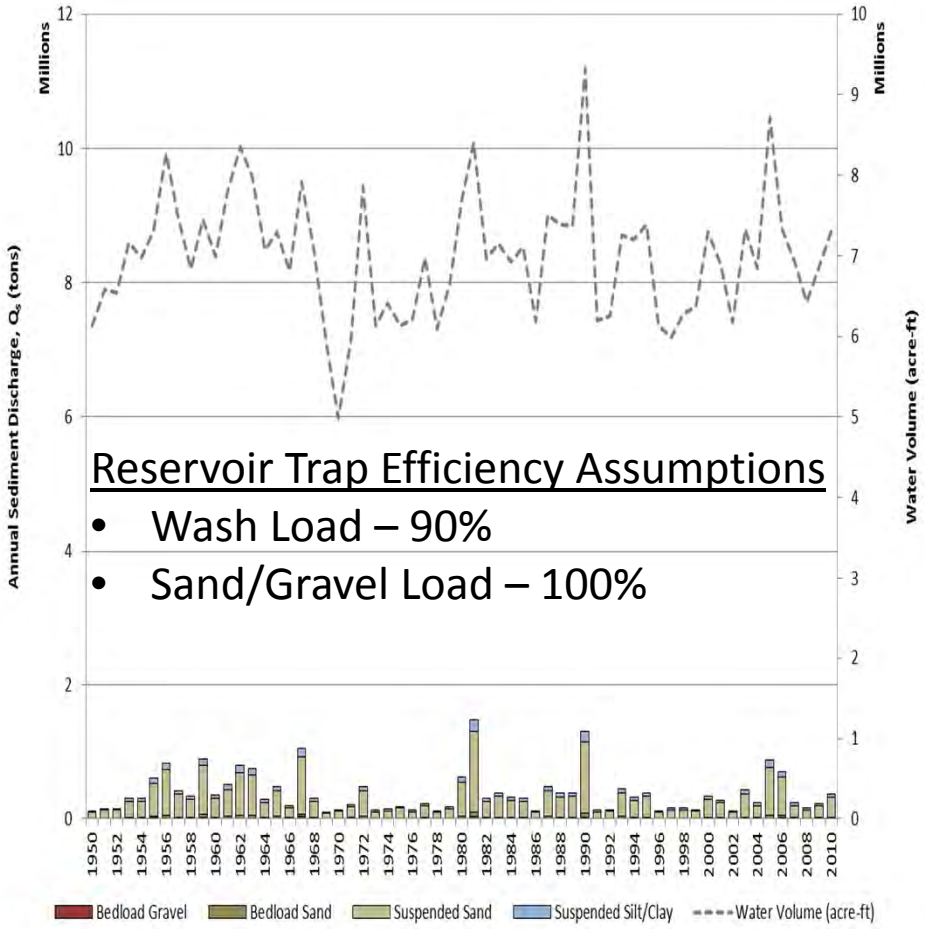
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Gold Creek Annual Sediment Load

Pre-Project



Max LF OS-1



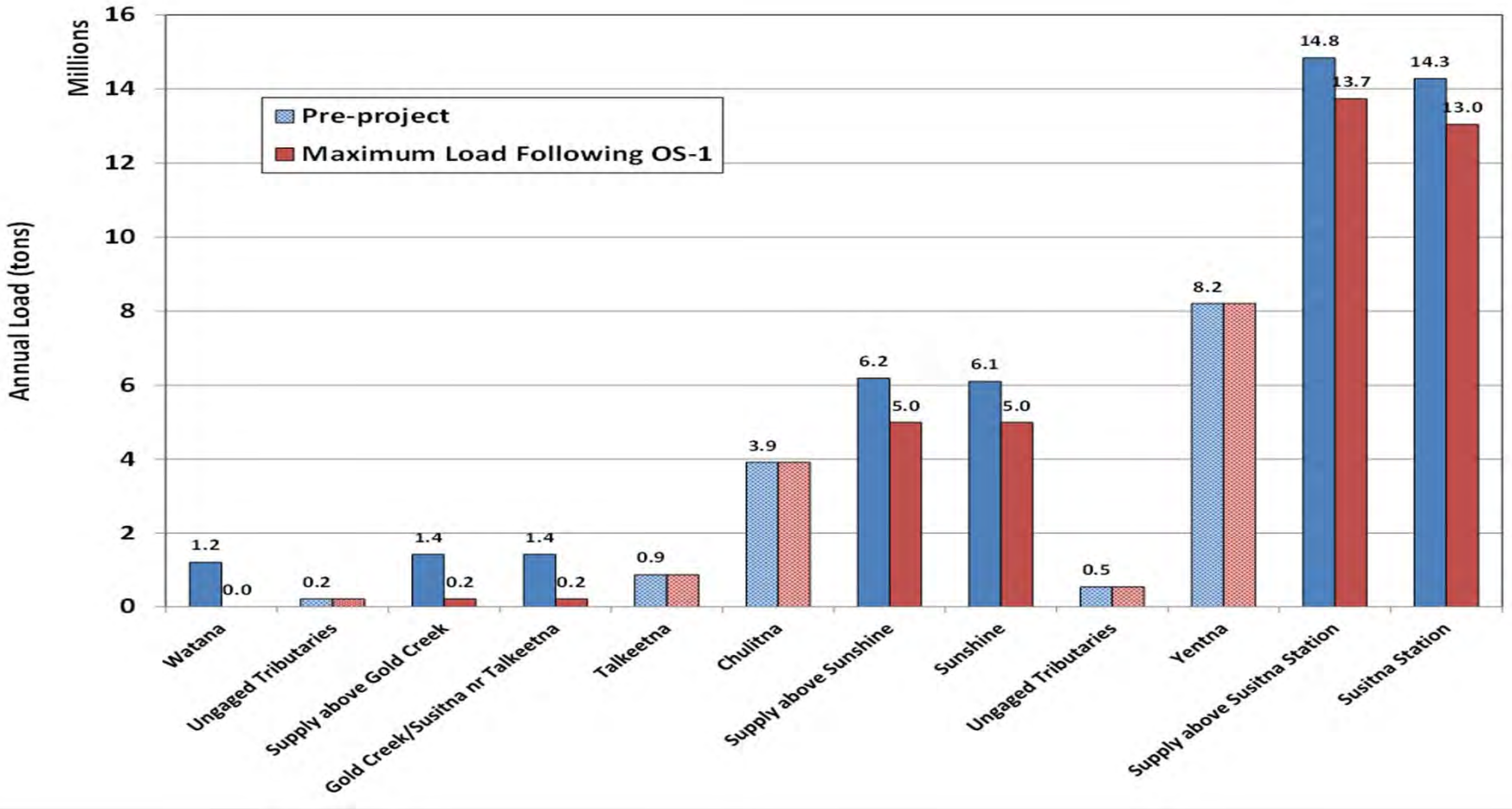
Reservoir Trap Efficiency Assumptions

- Wash Load – 90%
- Sand/Gravel Load – 100%

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Average Annual Sand Load

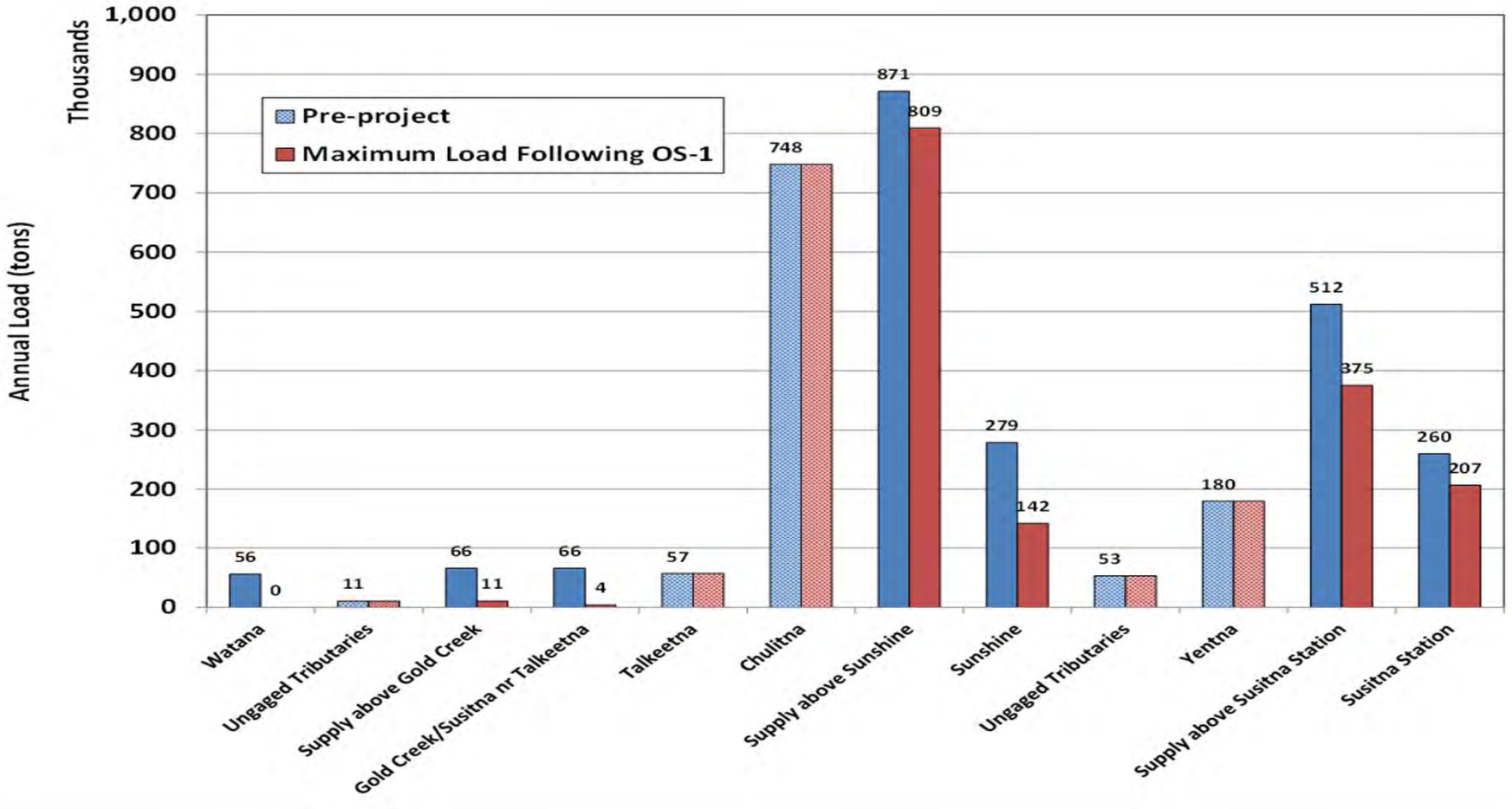
(Including estimated annual sand load from ungaged tributaries)



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Average Annual Gravel Load

(Including estimated annual gravel load from ungaged tributaries)



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Project Effects – Suspended Sediment[33] and Turbidity (1980s Docs)

- Reservoir Trap Efficiency
  - 80 to 90 percent of total sediment load
  - 100 percent of silt, sand and gravel
  - Only particles on the order of 3 to 10 microns or smaller pass through the reservoir

Project Effects – Suspended Sediment and Turbidity (1980s Docs)

- Suspended Sediment (typical)
  - Winter
    - Pre-Project: <10 mg/l
    - Post-Project: 30 to 70 mg/l
  - Summer
    - Pre-Project: 700 mg/l (over 2,500 mg/l occur)
    - Post-Project: 100 to 200 mg/l

Project Effects – Suspended Sediment and Turbidity (1980s Docs)

- Turbidity
  - Winter
    - Pre-Project: < 1 NTU
    - Post-Project: 10 NTU minimum
  - Summer
    - Pre-Project: 100 to 700 NTU
    - Post-Project: 50 NTU maximum

END

INFORMATION ITEM P14:
TOPOGRAPHIC MAPPING OF PROJECT SITE AND DOWNSTREAM

GIS\Proj\AEA\1010628 Susitna Hydro\MXD\Hydrology\Drainage_Basins_USGS_Topo.mxd



Susitna River

Susitna River at Gold Creek (15292000)

Susitna River near Cantwell (15291500)

Susitna River near Denali (15291000)

Maclaren River near Paxson (15291200)

Chulitna River near Talkeetna (15292400)

Chulitna River

Talkeetna River

Talkeetna River near Talkeetna (15292700)

Susitna River at Sunshine (15292780)

Montana Creek near Montana (15292800)

Yentna River

Skwentna River near Skwentna (15294300)

Deshka River near Willow (15294100)

Willow Creek Near Willow (15294005)

Deception Creek near Willow (15294010)

Little Susitna River near Palmer (15290000)

Yentna River near Susitna Station (15294345)

Susitna River at Susitna Station (15294350)

Cook Inlet

Anchorage

LEGEND:

- ★ Watana Dam Site
- ▲ Gaging Station
- Basin Boundary

NOTES:
1. Spatial Reference: NAD83 Alaska Albers, meters
2. Topography: USGS National Elevation Dataset (NED), 2-Arc Second
3. Basin boundary based on modified USGS HUCs 19020501-5

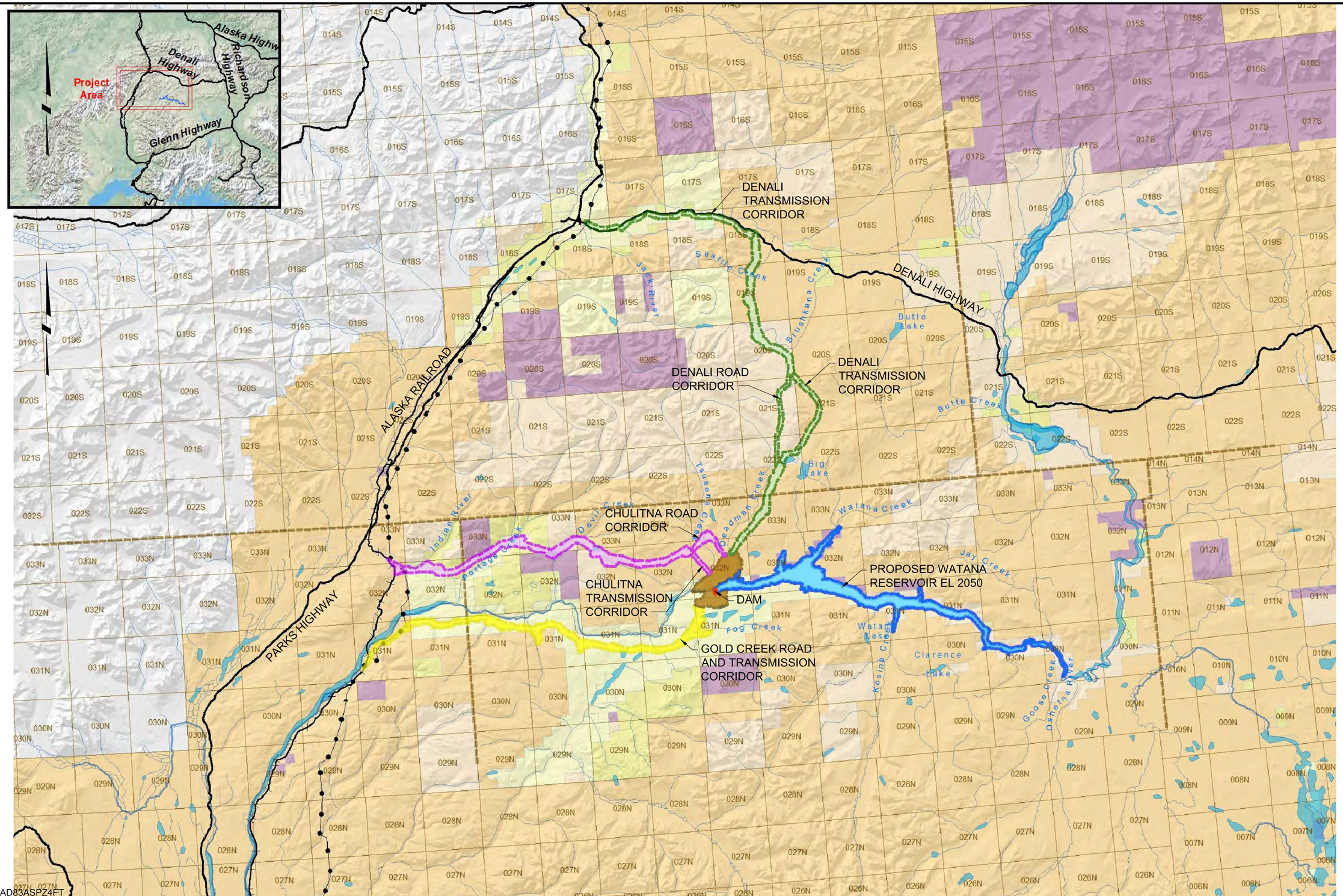
SUSITNA RIVER DRAINAGE BASIN BOUNDARY AND STREAMFLOW GAGE LOCATIONS

N

MWH

0 5 10 20 Miles

Date: May 12, 2011



NAD83ASPZ4FT

DRAFT

REV	DESCRIPTION	BY	DATE

SCALE
NO SCALE
ANSI D
FULL SIZE

WARNING
0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

Project No.	10500200
Date	12/21/2012
Designed	K GILBERT
Drawn	E ZIMMERMAN
Approved	B SADDEN

CONCEPTUAL DESIGN PHASE

NOT FOR CONSTRUCTION
This document is designated "interim" and not suitable for construction. As an interim document, it may contain data that is incomplete or define and locate structures that remain to be optimized.

MWH®

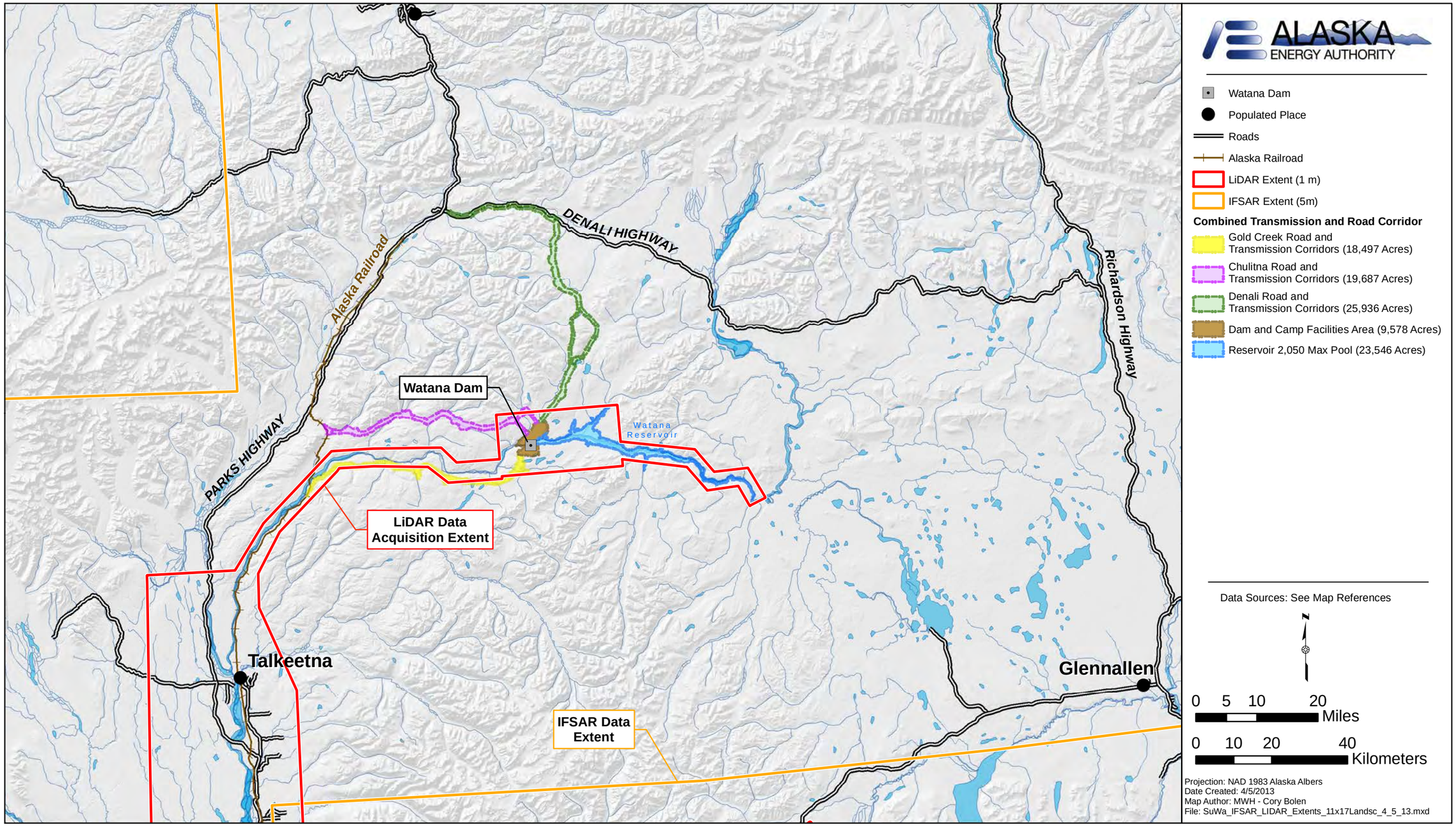
STATE OF ALASKA
ALASKA ENERGY AUTHORITY
ALASKA ENERGY AUTHORITY

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Clean, reliable energy for the next 100 years.

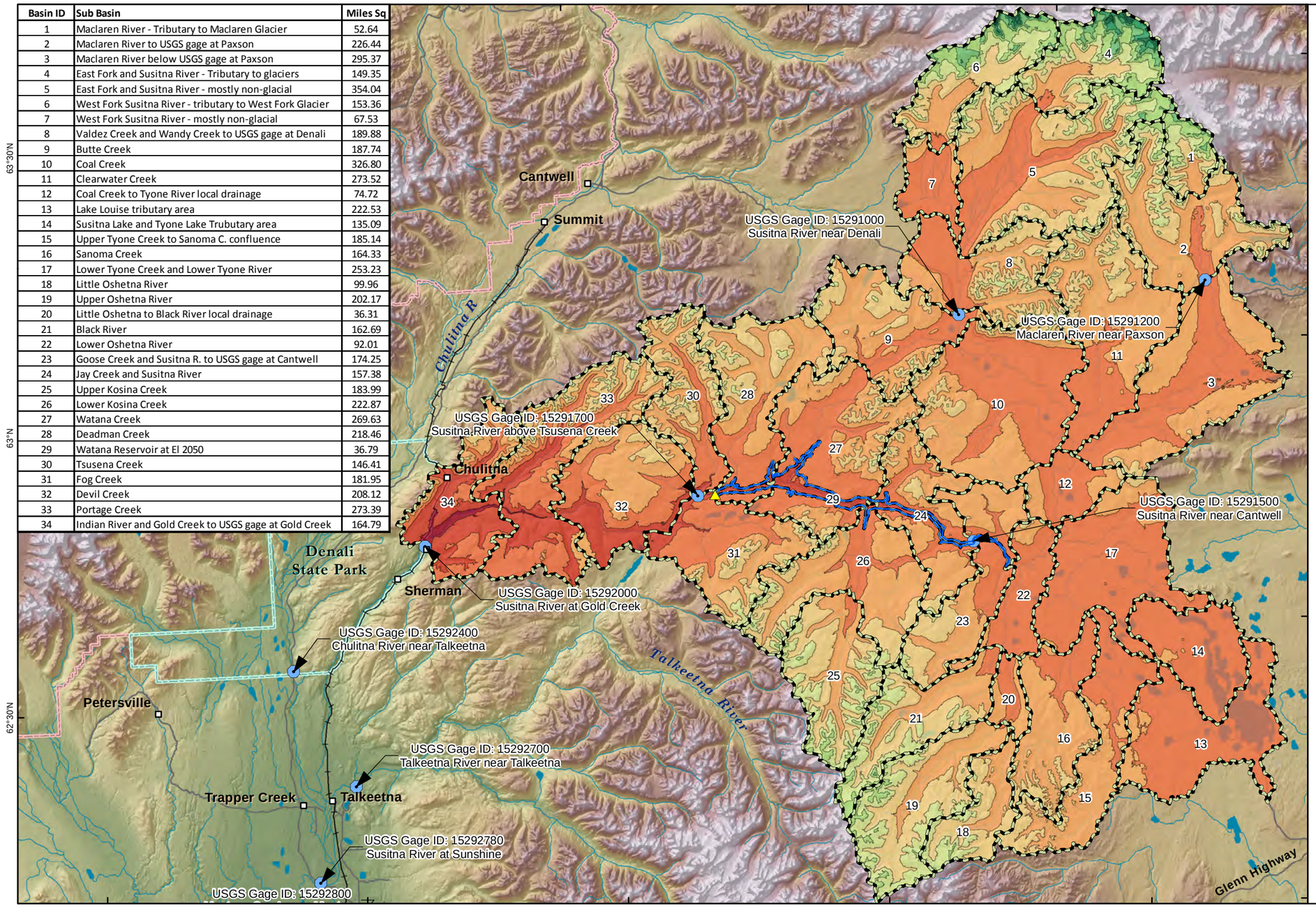
SUSITNA-WATANA HYDROELECTRIC PROJECT

GENERAL
OVERALL AREA
PLAN

Sheet No.
01-00G000
SHEET OF


DENALI HIGHWAY
Alaska Railroad
Richardson Highway
Watana Dam
Watana Reservoir
PARKS HIGHWAY
LiDAR Data Acquisition Extent
IFSAR Data Extent
Talkeetna
Glennallen
ALASKA ENERGY AUTHORITY
Watana Dam
Populated Place
Roads
Alaska Railroad
LiDAR Extent (1 m)
IFSAR Extent (5m)
Combined Transmission and Road Corridor
Gold Creek Road and Transmission Corridors (18,497 Acres)
Chulitna Road and Transmission Corridors (19,687 Acres)
Denali Road and Transmission Corridors (25,936 Acres)
Dam and Camp Facilities Area (9,578 Acres)
Reservoir 2,050 Max Pool (23,546 Acres)
Data Sources: See Map References
N
0 5 10 20 Miles
0 10 20 40 Kilometers
Projection: NAD 1983 Alaska Albers
Date Created: 4/5/2013
Map Author: MWH - Cory Bolen
File: SuWa_IFSAR_LIDAR_Extents_11x17Landsc_4_5_13.mxd

Basin ID	Sub Basin	Miles Sq
1	Maclaren River - Tributary to Maclaren Glacier	52.64
2	Maclaren River to USGS gage at Paxson	226.44
3	Maclaren River below USGS gage at Paxson	295.37
4	East Fork and Susitna River - Tributary to glaciers	149.35
5	East Fork and Susitna River - mostly non-glacial	354.04
6	West Fork Susitna River - tributary to West Fork Glacier	153.36
7	West Fork Susitna River - mostly non-glacial	67.53
8	Valdez Creek and Wandy Creek to USGS gage at Denali	189.88
9	Butte Creek	187.74
10	Coal Creek	326.80
11	Clearwater Creek	273.52
12	Coal Creek to Tyone River local drainage	74.72
13	Lake Louise tributary area	222.53
14	Susitna Lake and Tyone Lake Trubutary area	135.09
15	Upper Tyone Creek to Sanoma C. confluence	185.14
16	Sanoma Creek	164.33
17	Lower Tyone Creek and Lower Tyone River	253.23
18	Little Oshetna River	99.96
19	Upper Oshetna River	202.17
20	Little Oshetna to Black River local drainage	36.31
21	Black River	162.69
22	Lower Oshetna River	92.01
23	Goose Creek and Susitna R. to USGS gage at Cantwell	174.25
24	Jay Creek and Susitna River	157.38
25	Upper Kosina Creek	183.99
26	Lower Kosina Creek	222.87
27	Watana Creek	269.63
28	Deadman Creek	218.46
29	Watana Reservoir at El 2050	36.79
30	Tsusena Creek	146.41
31	Fog Creek	181.95
32	Devil Creek	208.12
33	Portage Creek	273.39
34	Indian River and Gold Creek to USGS gage at Gold Creek	164.79



ALASKA ENERGY AUTHORITY

- Proposed Watana Dam Site
- Proposed Watana Reservoir
- Susitna Gaging Stations
- Catchments

Elevation Bands in Feet

- 690 - 1,000
- 1,000 - 2,000
- 2,000 - 3,000
- 3,000 - 4,000
- 4,000 - 5,000
- 5,000 - 6,000
- 6,000 - 7,000
- 7,000 - 8,000
- 8,000 - 9,000
- 10,000 and Above

Data Sources: See Map References

0 5 10 mi

0 5 10 15 20 km

Projection: Alaska Albers NAD 1983
Date Created: 3/15/2013
Map Author: MWH - Eric Zimmerman
File: SuWa_Watersheds_Haap_11x17_Landsc_3_15_13.mxd

Upper Susitna Elevation Bands

Figure 4

INFORMATION ITEM P15:

WATANA DAM LAYOUT DRAWINGS, PLANS, ELEVATIONS AND CROSS SECTIONS (CEII PROTECTED INFORMATION FILED AS SEPARATE DOCUMENT)

INFORMATION ITEM P16:

PROJECT COMPONENT DETAILS (TURBINES, OUTLET VALVES, GATES, ETC.)
(CEII PROTECTED INFORMATION FILED AS SEPARATE DOCUMENT)

INFORMATION ITEM P17:
PROJECT OPERATIONS

INFORMATION ITEM P18:

SITE ACCESS OR CONSTRAINTS TO DAM, RESERVOIR, AND TRIBUTARIES

INFORMATION ITEM P19:
ELECTRICAL POWER AVAILABILITY

INFORMATION ITEM P20:
AMOUNTS AND TYPES OF DEBRIS EXPECTED IN RESERVOIR

INFORMATION ITEM P21:
AMOUNTS AND TYPES OF DEBRIS EXPECTED BELOW WATANA DAM

INFORMATION ITEM P22:

POTENTIAL LOCATIONS FOR ANY BARRIER, TRAP AND HAUL, STRESS RELEASE PONDS, ADULT RELEASE PONDS, OR OTHER FACILITIES

INFORMATION ITEM P23:
OTHER PERTINENT MISCELLANEOUS INFORMATION

INFORMATION ITEM P24:
TRIBUTARY FLOW DATA

INFORMATION ITEM P25:

TRIBUTARY ACCESS FOR JUVENILE COLLECTORS OR ADULT RELEASE SITES

INFORMATION ITEM P26:
SEEPAGE INFORMATION AT WATANA DAM SITE

INFORMATION ITEM P27:
GLACIER OUTBURST FLOODS

INFORMATION ITEM P28:

GEOTECHNICAL AND STREAM BANK INFORMATION NEAR POTENTIAL PASSAGE FACILITIES

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Study of Fish Passage Feasibility at Watana Dam (9.11)

Part A - Appendix D

Detailed Study Schedule Updated July 10, 2013

Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

[R2 Resource Consultants Inc. &

LGL Alaska Research Associates, Inc.]

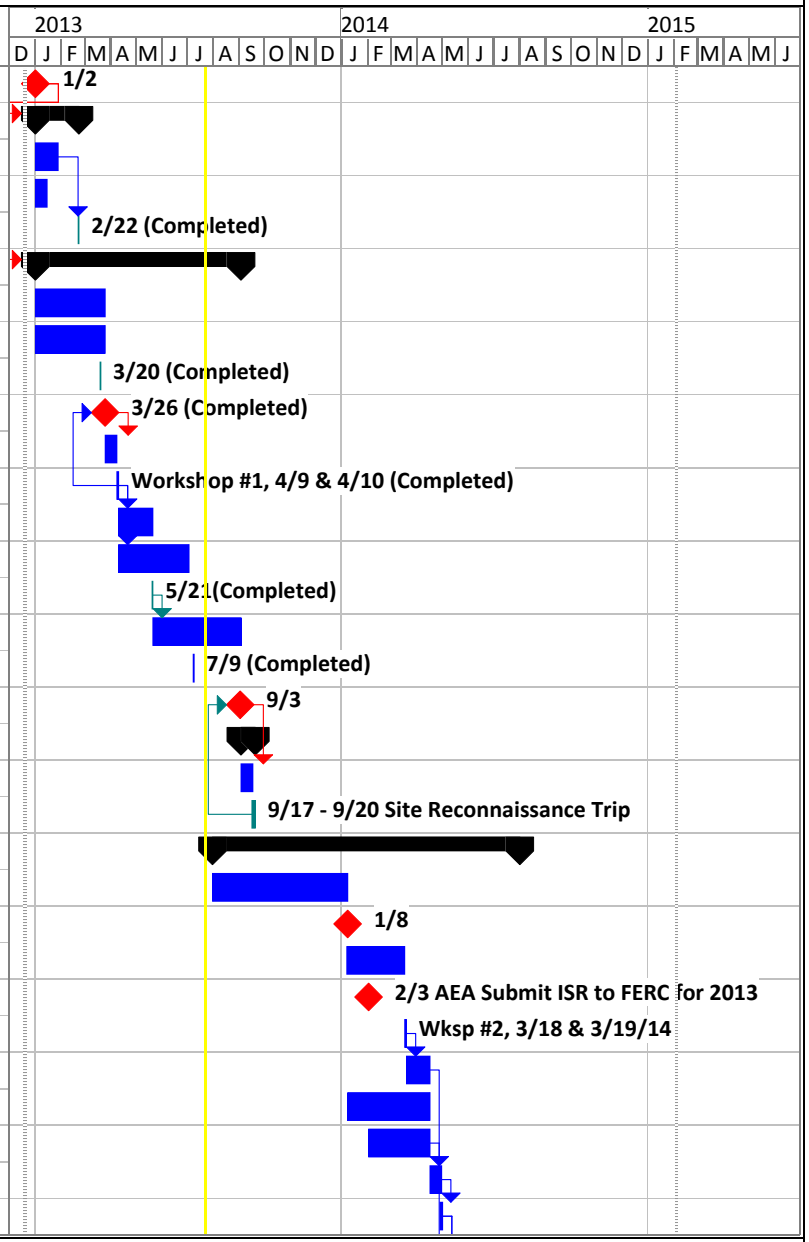
June 2014

Susitna-Watana - RSP 9.11 Study of Fish Passage at Watana Dam

Last Update: 7/10/13

Fish Passage Technical Work Group (FPTWG) Work Plan and Meeting/Workshop Schedule

ID	Task Name	Duration	Start	Finish
1	**Begin Study**	**0 days**	**Wed 1/2/13**	**Wed 1/2/13**
2	**Task 1 - Establish FPTWG, Input to Feasibility Assessm**	**39 days**	**Wed 1/2/13**	**Fri 2/22/13**
3	Prepare for FPTWG Meeting #1	19 days	Wed 1/2/13	Mon 1/28/13
4	Prepare list of information needs	10 days	Wed 1/2/13	Tue 1/15/13
5	FPTWG Meeting #1 - Kickoff	1 day	Fri 2/22/13	Fri 2/22/13
6	**Task 2 - Prepare for Feasibility Study**	**176 days**	**Wed 1/2/13**	**Tue 9/3/13**
7	Prepare Physical and operations data	60 days	Wed 1/2/13	Mon 3/25/13
8	Prepare Biological data	60 days	Wed 1/2/13	Mon 3/25/13
9	FPTWG Mt #2 - Regular update (web call)	1 day	Wed 3/20/13	Wed 3/20/13
10	Distribute background Info, 1st draft	0 days	Tue 3/26/13	Tue 3/26/13
11	Prepare for FPTWG Workshop #1	10 days	Tue 3/26/13	Mon 4/8/13
12	FPTWG Workshop #1 - Review background info	2 days	Tue 4/9/13	Wed 4/10/13
13	Update background material	29 days	Thu 4/11/13	Tue 5/21/13
14	Prepare draft criteria	60 days	Thu 4/11/13	Wed 7/3/13
15	FPTWG Mtg #3 - Regular update (web call)	1 day	Tue 5/21/13	Tue 5/21/13
16	Update background material as needed	75 days	Wed 5/22/13	Tue 9/3/13
17	FPTWG Mtg #3a - Regular update (web call)	1 day	Tue 7/9/13	Tue 7/9/13
18	Distribute update to backgnd info	0 days	Tue 9/3/13	Tue 9/3/13
19	**Task 3 - Conduct Site Reconnaissance**	**13 days**	**Wed 9/4/13**	**Fri 9/20/13**
20	Prepare for Site Recon FPTWG Mtg #4	10 days	Wed 9/4/13	Tue 9/17/13
21	FPTWG Mtg #4 - Site Recon (ANK)	4 days	Tue 9/17/13	Fri 9/20/13
22	**Task 4 - Develop Fish Passage Concepts**	**262 days**	**Thu 8/1/13**	**Fri 8/1/14**
23	Prep Bio Performance Tool & Update Info	115 days	Thu 8/1/13	Wed 1/8/14
24	Submit 2013 Information Updates	0 days	Wed 1/8/14	Wed 1/8/14
25	Prepare initial concepts for brainstorm	49 days	Wed 1/8/14	Mon 3/17/14
26	**AEA Submit ISR to FERC**	0 days	Mon 2/3/14	Mon 2/3/14
27	FPTWG Workshop #2 - Brainstorm Concept Alts	2 days	Tue 3/18/14	Wed 3/19/14
28	Organize and clarify concepts	20 days	Thu 3/20/14	Wed 4/16/14
29	Develop draft evaluation criteria	70 days	Thu 1/9/14	Wed 4/16/14
30	Update biological performance tool	53 days	Mon 2/3/14	Wed 4/16/14
31	Prep for FPTWG Mtg #5	10 days	Thu 4/17/14	Wed 4/30/14
32	FPTWG Mtg #5 - Reg update (1d, fatal flaw, ID alts)	3 days	Tue 4/29/14	Thu 5/1/14



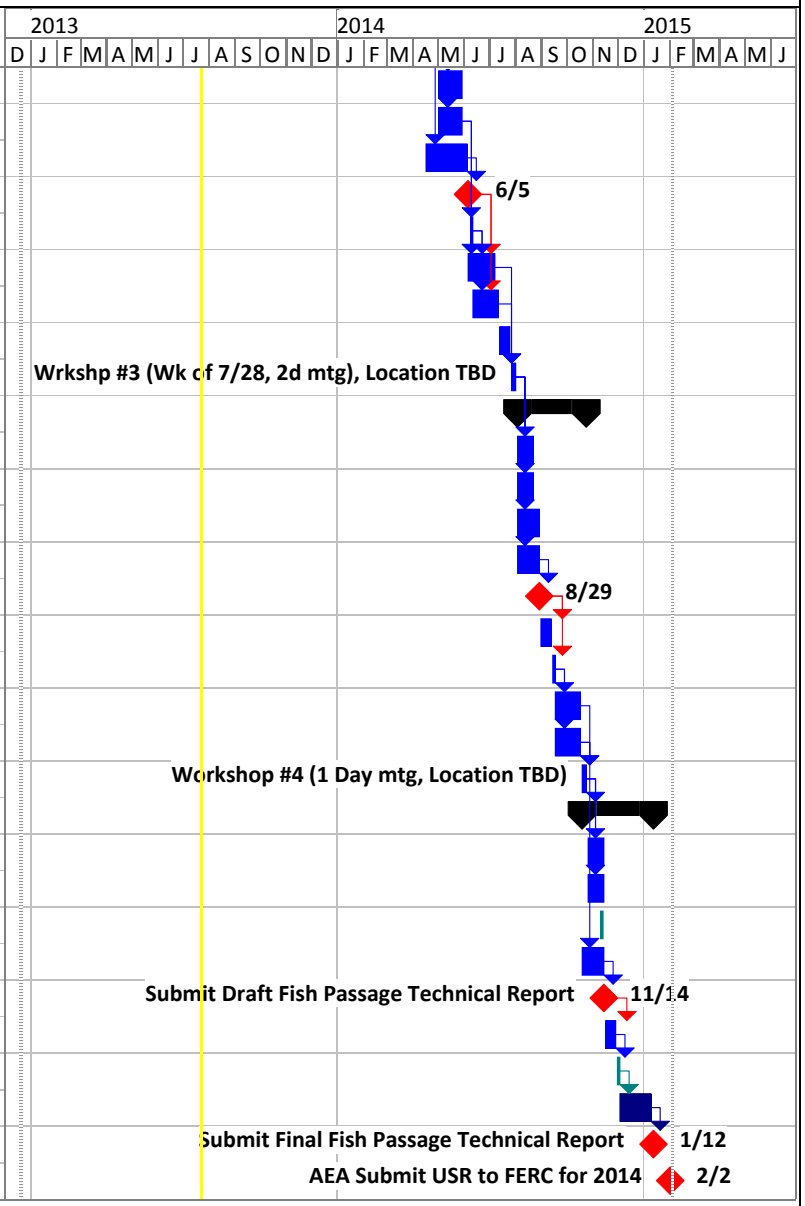
Note: Updated technical information will be provided to FPTWG members 2 weeks prior to each meeting.

File: 19.11 Schedule 2013-07-10 Update V3.1.mpp , Mon 7/22/13

Susitna-Watana - RSP 9.11 Study of Fish Passage at Watana Dam Last Update: 7/10/13

Fish Passage Technical Work Group (FPTWG) Work Plan and Meeting/Workshop Schedule

ID	Task Name	Duration	Start	Finish
33	Compile & Develop Fish Passage Alternatives	20 days	Fri 5/2/14	Thu 5/29/14
34	Evaluate Alts with Biological Performance Tool	20 days	Fri 5/2/14	Thu 5/29/14
35	Outline & draft Fish Passage Technical Report	35 days	Thu 4/17/14	Wed 6/4/14
36	Submit Prelim Draft Fish Passage Tech Report	0 days	Thu 6/5/14	Thu 6/5/14
37	FPTWG Mtg #6 - Regular update (web call)	3 days	Mon 6/9/14	Wed 6/11/14
38	Update Alts & Biological Performance Tool	22 days	Fri 6/6/14	Mon 7/7/14
39	Finalize evaluation criteria & Pugh matrix	22 days	Thu 6/12/14	Fri 7/11/14
40	Prepare for FPTWG Workshop #3	10 days	Mon 7/14/14	Fri 7/25/14
41	FPTWG Wrkshp #3 - Critique and Refine Alts (2 d)	5 days	Mon 7/28/14	Fri 8/1/14
42	**Task 5 - Evaluate Feasibility of Conceptual Alts**	**60 days**	**Mon 8/4/14**	**Fri 10/24/14**
43	Update Drawings and Descriptions	15 days	Mon 8/4/14	Fri 8/22/14
44	Update biological performance tool	15 days	Mon 8/4/14	Fri 8/22/14
45	Prepare Pugh Matrix	20 days	Mon 8/4/14	Fri 8/29/14
46	Update Draft Fish Passage Technical Report	20 days	Mon 8/4/14	Fri 8/29/14
47	Submit Draft Fish Passage Tech Report to FPTWG	0 days	Fri 8/29/14	Fri 8/29/14
48	Prepare for FPTWG Mtg #7 & review report	10 days	Mon 9/1/14	Fri 9/12/14
49	FPTWG Meeting #7 - Regular update (web call)	3 days	Mon 9/15/14	Wed 9/17/14
50	Address comments, Prep for FPTWG Workshop #4	22 days	Thu 9/18/14	Fri 10/17/14
51	Address comments and Update Pugh Matrix	22 days	Thu 9/18/14	Fri 10/17/14
52	FPTWG Workshop #4 - Alt Selection (1 d)	5 days	Mon 10/20/14	Fri 10/24/14
53	**Task 6 - Develop Refined Passage Strategies**	**61 days**	**Mon 10/20/14**	**Mon 1/12/15**
54	Refine Alts & Prep Opinions of Probable Costs	15 days	Mon 10/27/14	Fri 11/14/14
55	Finalize Biological performance tool	15 days	Mon 10/27/14	Fri 11/14/14
56	FPTWG Meeting #8 - Regular update (web call)	3 days	Tue 11/11/14	Thu 11/13/14
57	Prepare draft Fish Passage Tech Report	20 days	Mon 10/20/14	Fri 11/14/14
58	Submit draft Fish Passage Tech Report to FPTWG	0 days	Fri 11/14/14	Fri 11/14/14
59	Review Period	2 wks	Mon 11/17/14	Fri 11/28/14
60	FPTWG Mtg #9 - Last Scheduled Mtg (1 d)	3 days	Mon 12/1/14	Wed 12/3/14
61	Finalize FPTWG Fish Passage Tech Report	27 days	Thu 12/4/14	Fri 1/9/15
62	Submit Final Fish Passage Technical Report	0 days	Mon 1/12/15	Mon 1/12/15
63	**AEA Submit Updated Study Report (USR) to FERC**	**0 days**	**Mon 2/2/15**	**Mon 2/2/15**



Note: Updated technical information will be provided to FPTWG members 2 weeks prior to each meeting.

File: 19.11 Schedule 2013-07-10 Update V3.1.mpp , Mon 7/22/13