Susitna Hydro Evaluation Project

Seminar on the Development of Large Hydroelectric Projects with a Focus on the Susitna Project

presented to

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HDR Alaska

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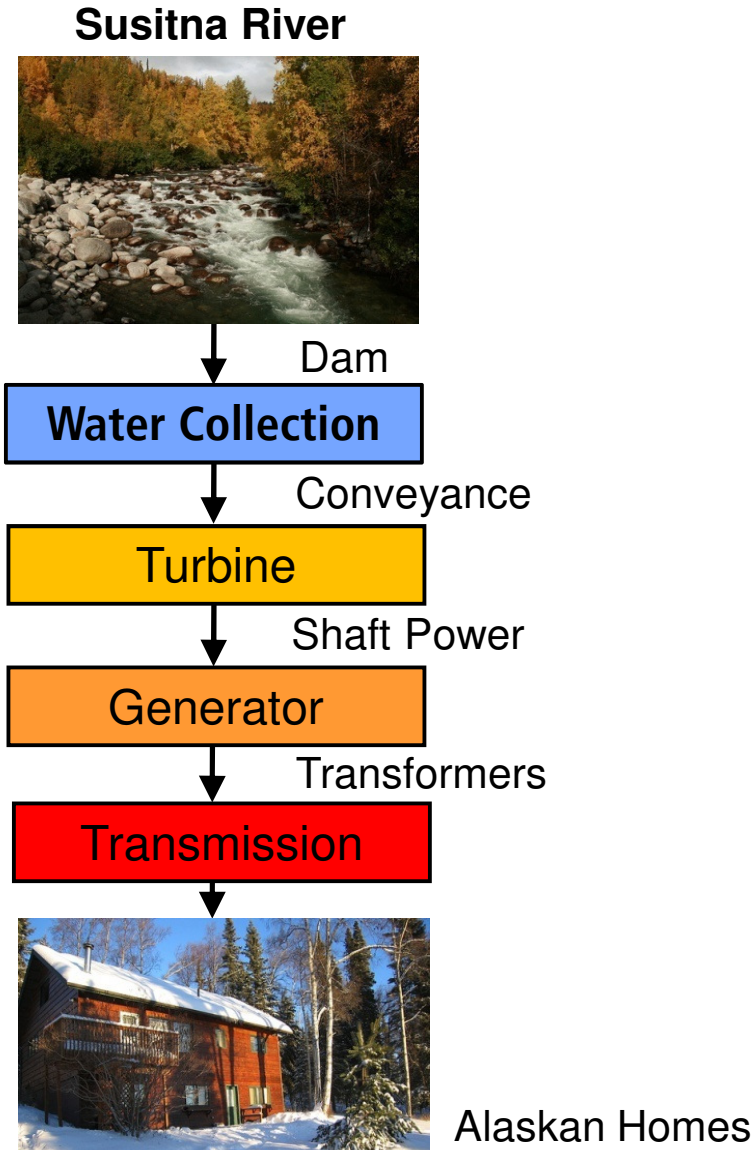
Hydroelectric Equipment, Hydrology, and Energy Production

Introduction

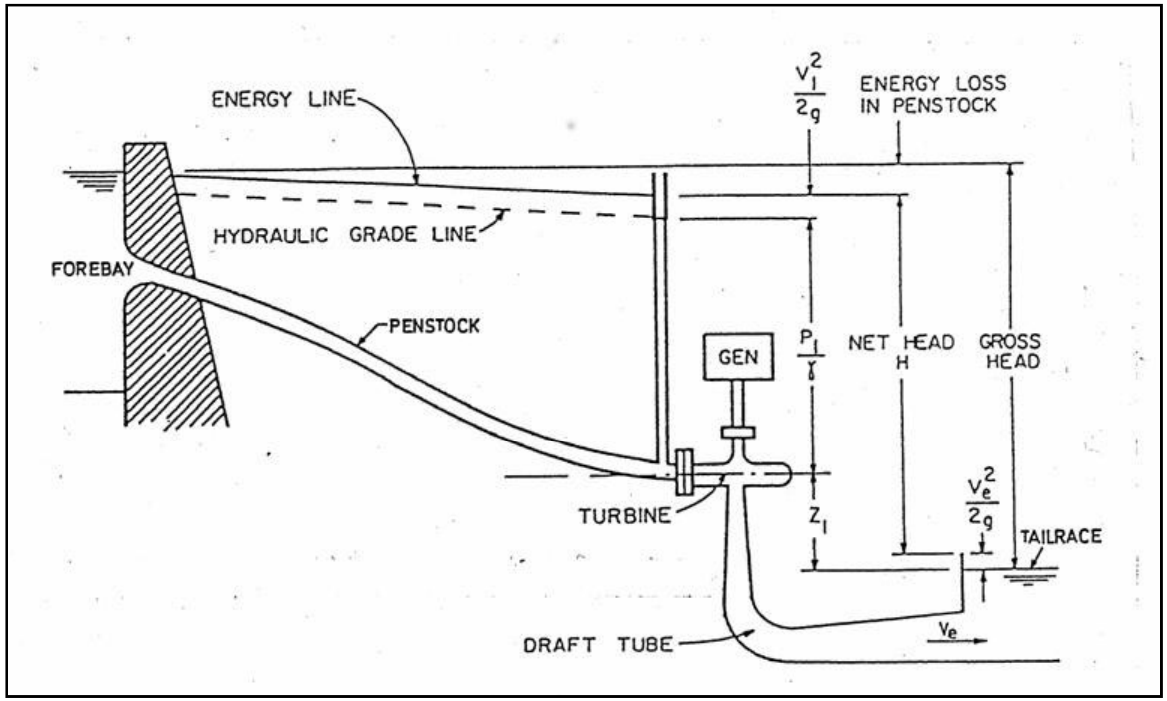
- Physics: water flow times gravity head equals power, integrated over time equals energy
- Static head is developed by dams, in this case 885 feet at Watana and 647 feet at Devil Canyon
- River flow captured by dams routed to turn turbines-generators to produce 1,880 MW of renewable power
- Power over time is energy, which annually is 6,900,000 MWh

Energy Process



- Dams
- Powerhouses
- Hydroelectric machinery
  - Turbines
  - Generators
  - Controls
  - Transformers
  - Transmission
- Hydrology
- Energy production

Water Flows Downhill



$$P = \eta\gamma QH$$

P = Power

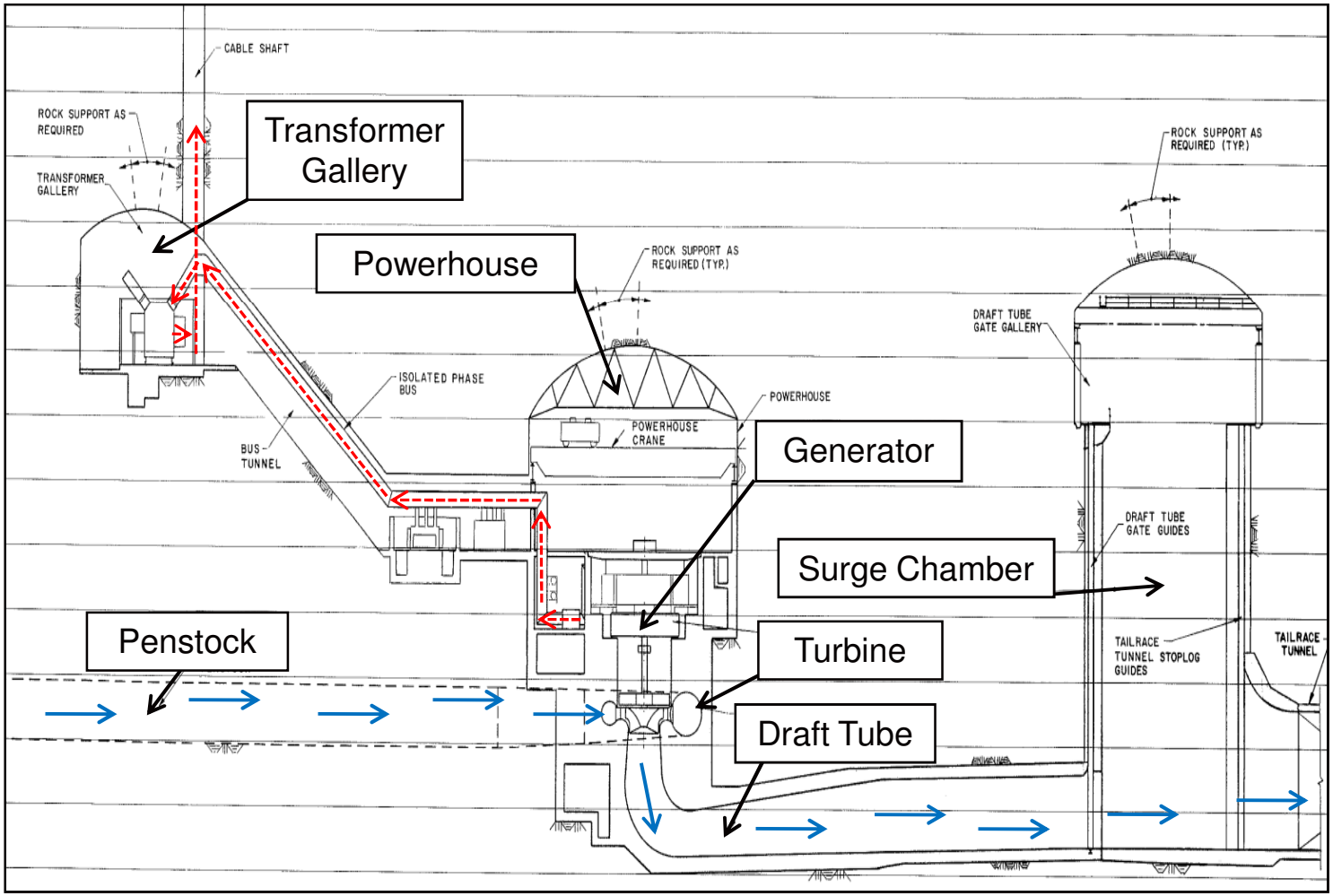
H = Hydraulic Head (ft)

Q = Flow Rate (cfs)

γ = Specific weight of water (62 lb/ft^3)

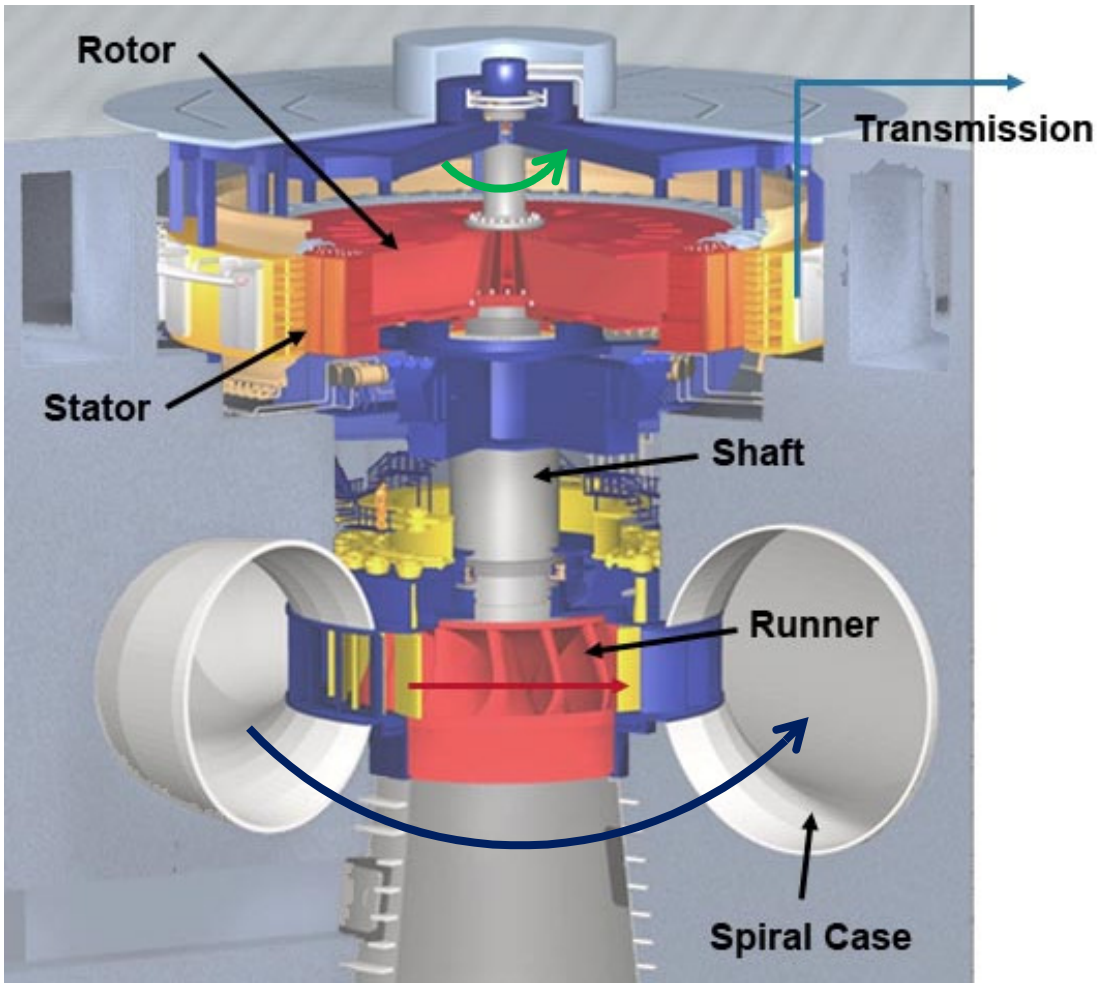
η = Overall efficiency of facility (90 Turbine Efficiency-95 Generator Efficiency)%

Profile View:
Watana and Devil Canyon Powerhouses



Turbine-Generator

1. Water in spiral case turns turbine runner.
2. Runner turns shaft.
3. Shaft turns generator rotor.
4. The rotating magnetic field due to the spinning rotor induces electrical current in the stationary stator.
5. Electrical current from the stator is sent through a transformer and then on to the utility grid.



1985 FERC Application Staged Development Plan

Watana Stage 1

- Install 700-foot dam at Watana
- Four turbine generator units.
- Total capacity: 440 MW

Full Devil Canyon

- Install 646-foot thin arch concrete dam
- Four 170MW turbine generator units.
- Total Devil Canyon capacity: 1,200 MW

Watana Stage 2

- Raise Watana dam by 185 feet
- Install two 200-MW turbine generator units.
- Total project capacity both plants: 1,880 MW

Turbines: Watana

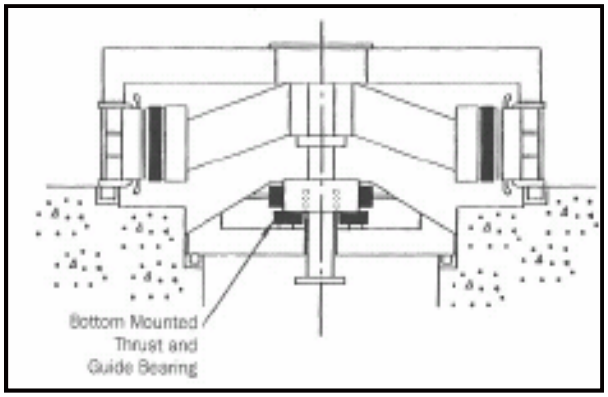
- Turbine - vertical-shaft, Francis type, with spiral case
- 3,500 cfs flow, 719 feet of head, 94 percent turbine and 97 percent generator efficiency
- Six turbines rated at 200 MW each equals total 1,200 MW

Turbines: Devil Canyon

- Vertical-shaft Francis turbine with spiral casing
- 600 feet of head with 3,800 CFS flow rate
- Four turbines rated at 170 MW each
- 680 MW total

Generator Specifications

- Approximate dimensions
  - 38-foot stator diameter
  - 24-foot rotor diameter
  - Rotor weight 385 tons
  - Total weight 740 tons



Umbrella Type

Generator Specifications, *continued*

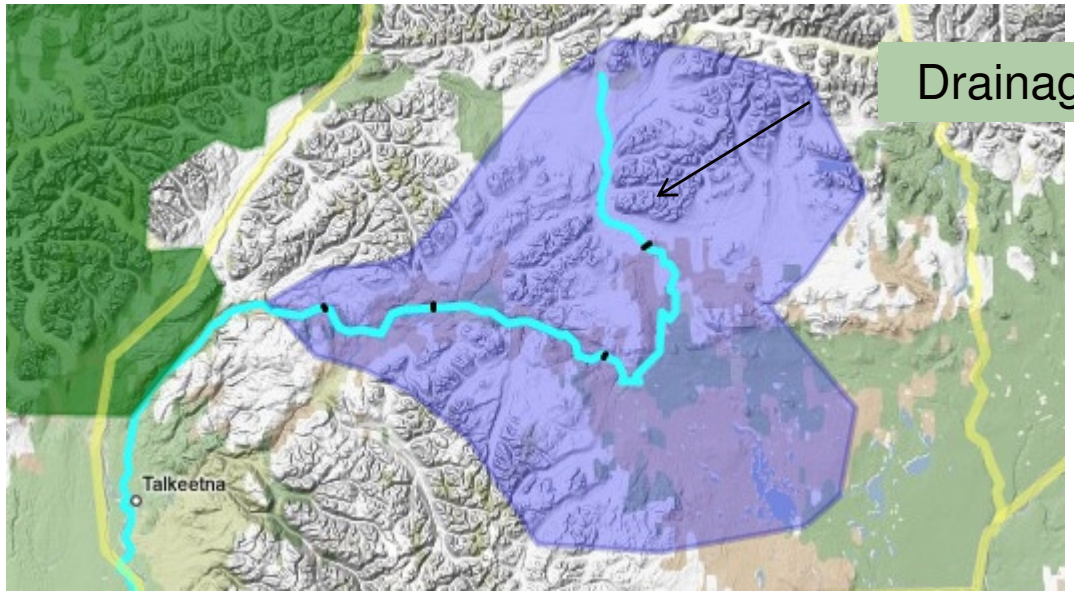
- Generator parameters
  - Watana: 200-MW max power
  - Devil Canyon: 170-MW max power
  - 15kV, 3-phase, 60 Hertz power
  - 225 rpm synchronous speed

Transformers

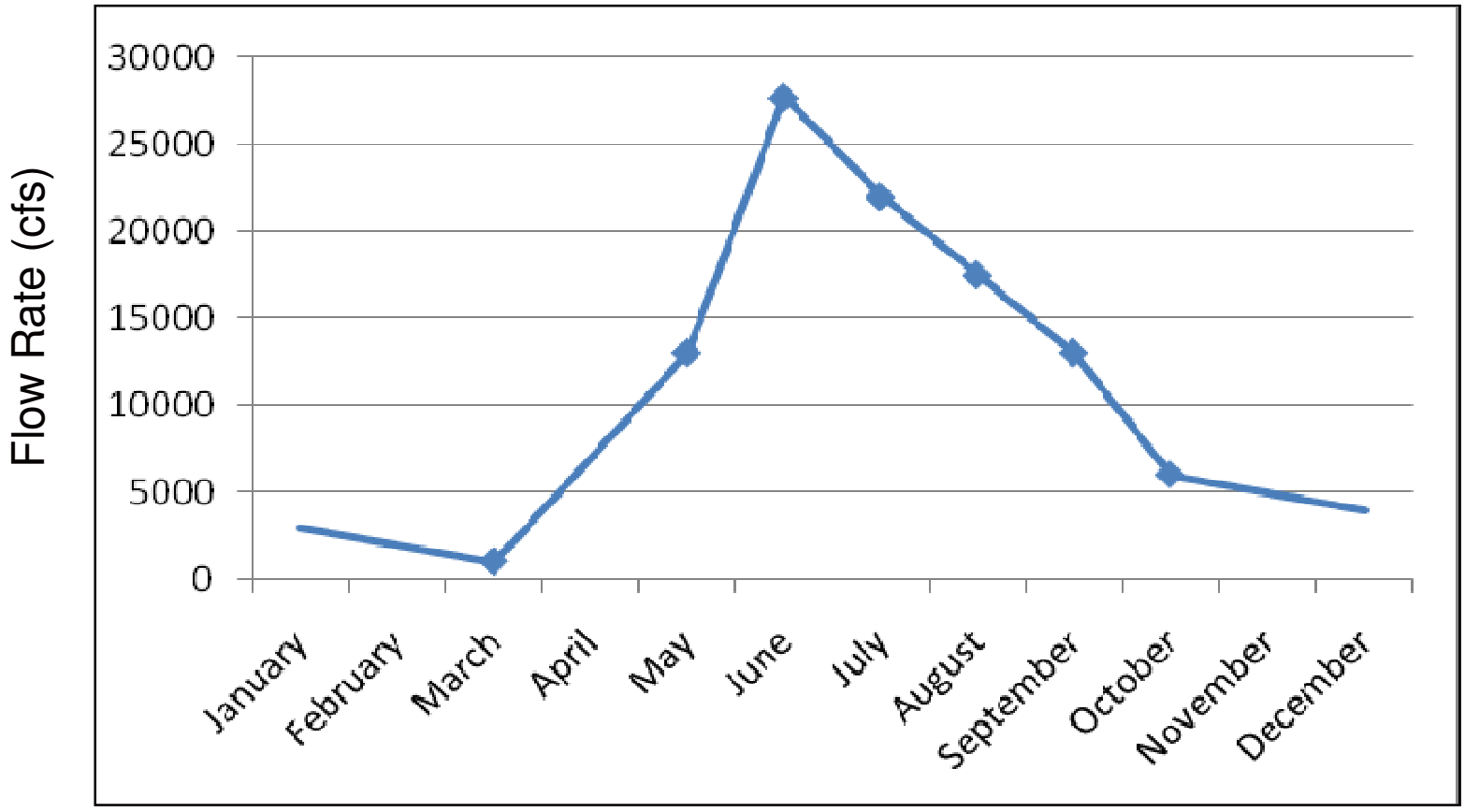
- Devil Canyon - three single-phase transformers per generator: 15 KV and 70MVA per phase
- Watana – three single-phase transformers per pair of generators: 15 KV and 150MVA per phase
- Maximum size limited by 150,000-lb load limit on Denali Highway
- Transmission line voltage – 345 KV/1,300 KV Voltage

Susitna River Hydrology

- 19,400 square mile drainage
- Peak flow in June
- Frozen October to March
- Glacial-fed, rainfall and storage project

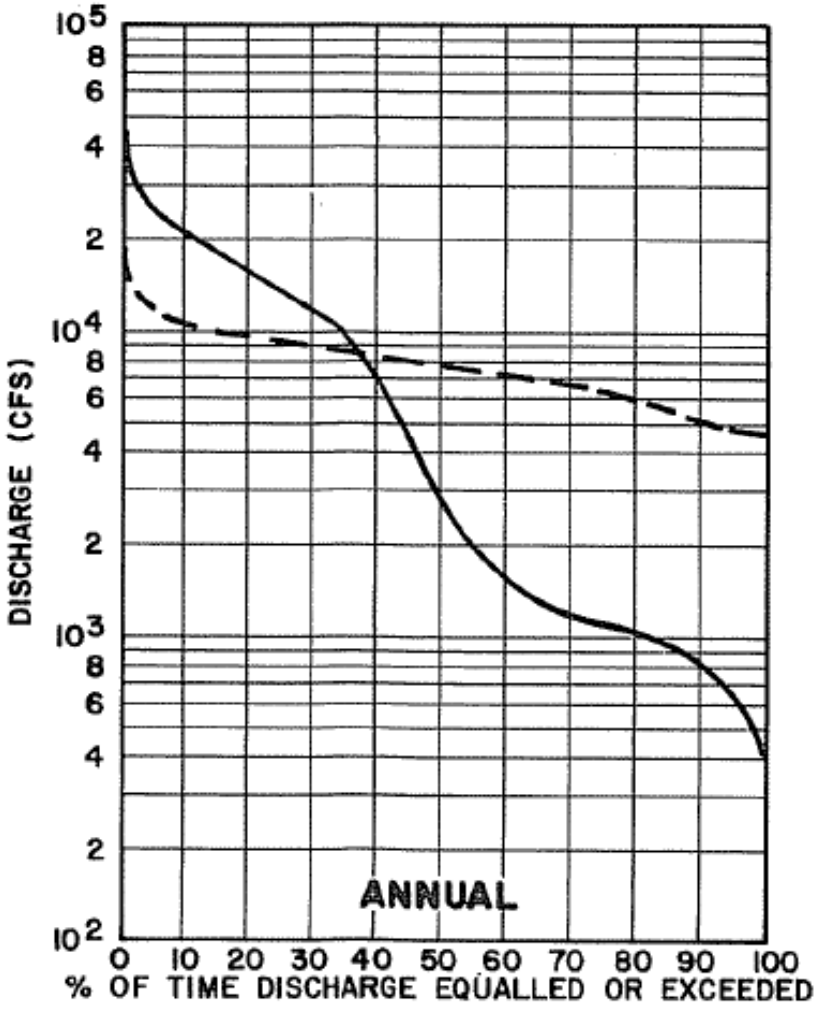


Susitna River Seasonal Flows



Gold Creek
USGS Gauge

Susitna Flow Duration Curve



Historical

Project

Hydrology: Influences and Trends

- Glacial Influences
  - Glaciers currently comprise from 5 to 25 percent of drainage areas contributing to the Susitna River (Water-Resources Investigations Report 01-4109)
  - Glaciers act to store and delay the seasonal runoff
  - Significant source of water during the summer season
- Preliminary Hydrological Review
  - Flows range from 400 to 40,000 cfs for 100 percent to 1 percent
  - Susitna Powerhouse turbine flow 14,400 to 21,000

Original Energy Production Estimates

- Estimate Inputs: daily river flows; dam and water conveyances parameters; turbine, generator and transformer capacities and efficiencies; outages.
- Previous studies estimated 6,900GW hrs/yr (40 percent plant factor to theoretical 24 hour/365 day capacity)

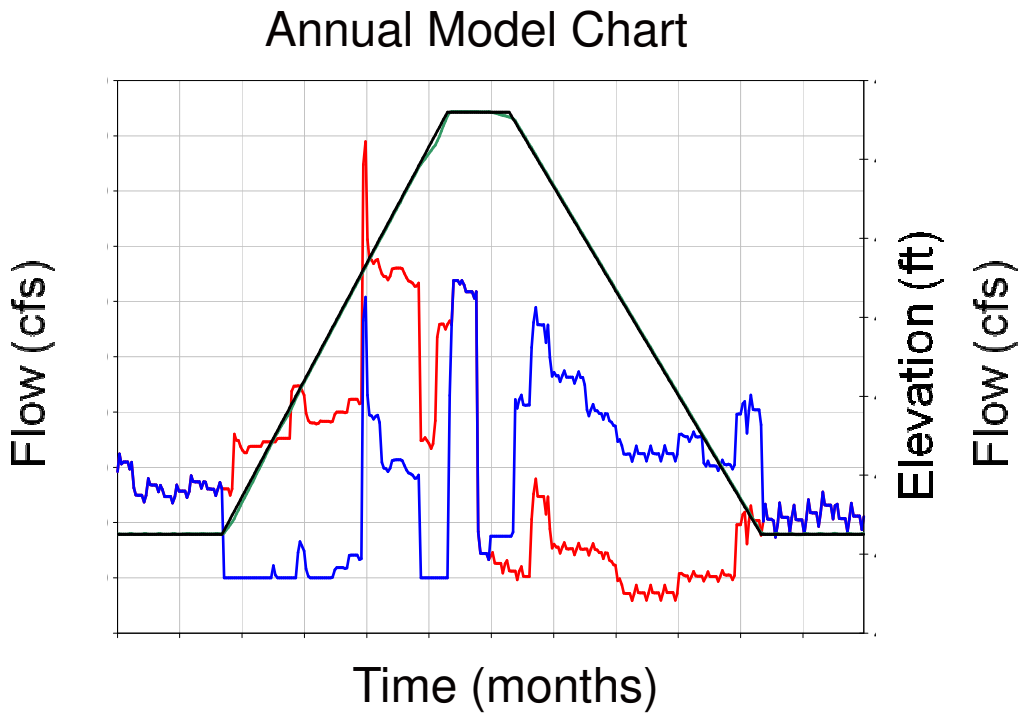
Modern Energy Modeling "CHEOPS"

- Daily calculation of generation based on reservoir, stream-flow and powerhouse operating constraints.
- Proprietary software:
  - Technical staff has the ability to modify code
  - Simulates unusual operating conditions or constraints such as cascading in-series dams such as Susitna
  - Solutions for flow, head, capacity optimization and environmental compliance.

Model Inputs and Outputs

- Inputs:
  - Daily flows
  - Headwater, tailwater, and acre-feet storage
  - Turbine generator capacities and efficiencies
  - License operating constraints, such as downstream flows
- Outputs:
  - Powerhouse discharge flow, head and power
  - Weekday and weekend generation shape for demand periods
  - Customizable output reporting detailed out in daily, weekly, annual and average long term flow, head and energy output.
  - Energy outputs used as inputs to financial models.

Energy : CHEOPS Model



KEY

Blue-Turbine Discharge

Red- Inflow to Project

Black/Green- Reservoir Elevation

Conclusions

- The Susitna Project would generate approximately 7 million MW hours per year
- Susitna would also provide Alaska electric security and system stability

Q&A