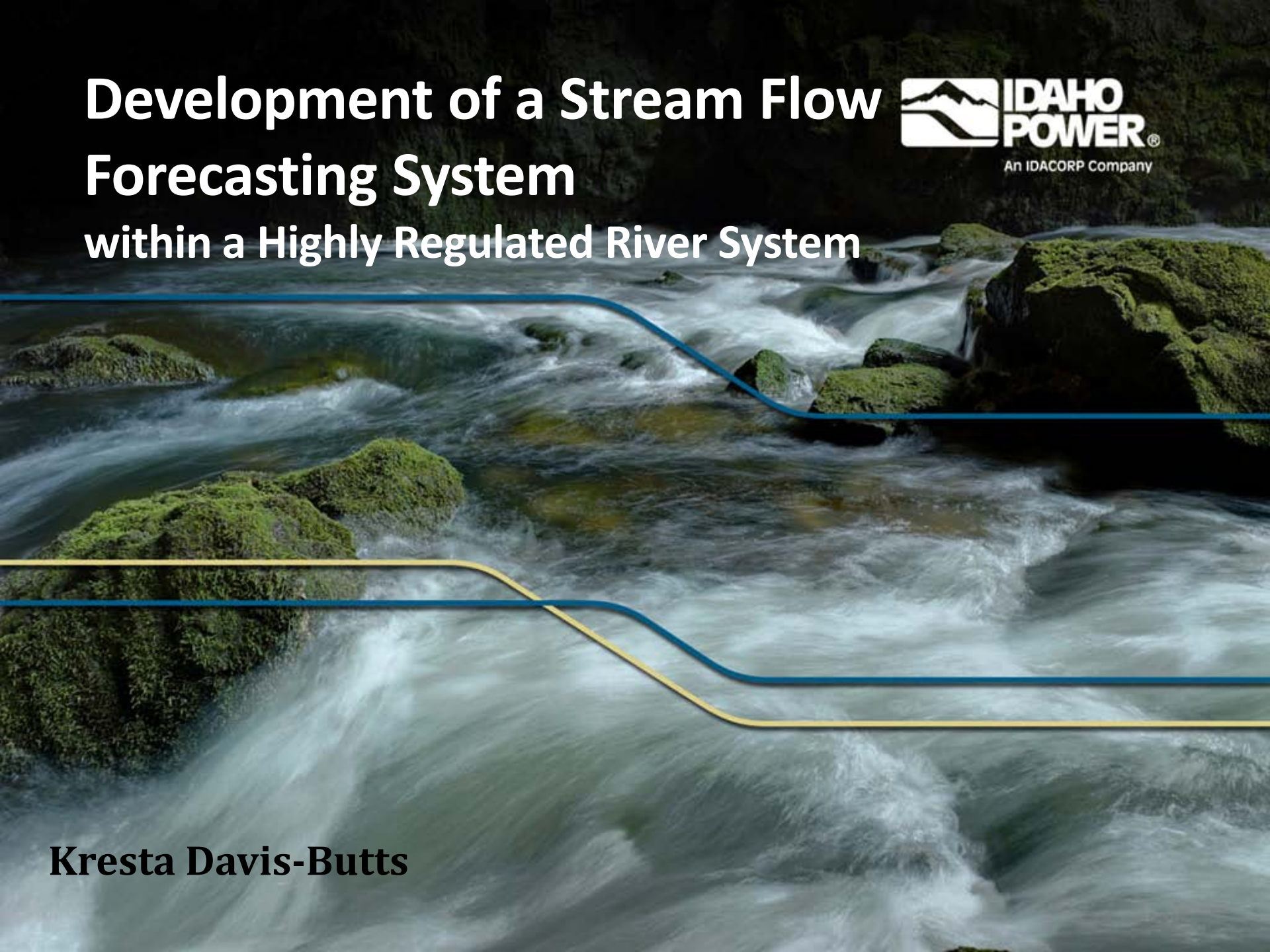
Development of a Stream Flow Forecasting System

within a Highly Regulated River System



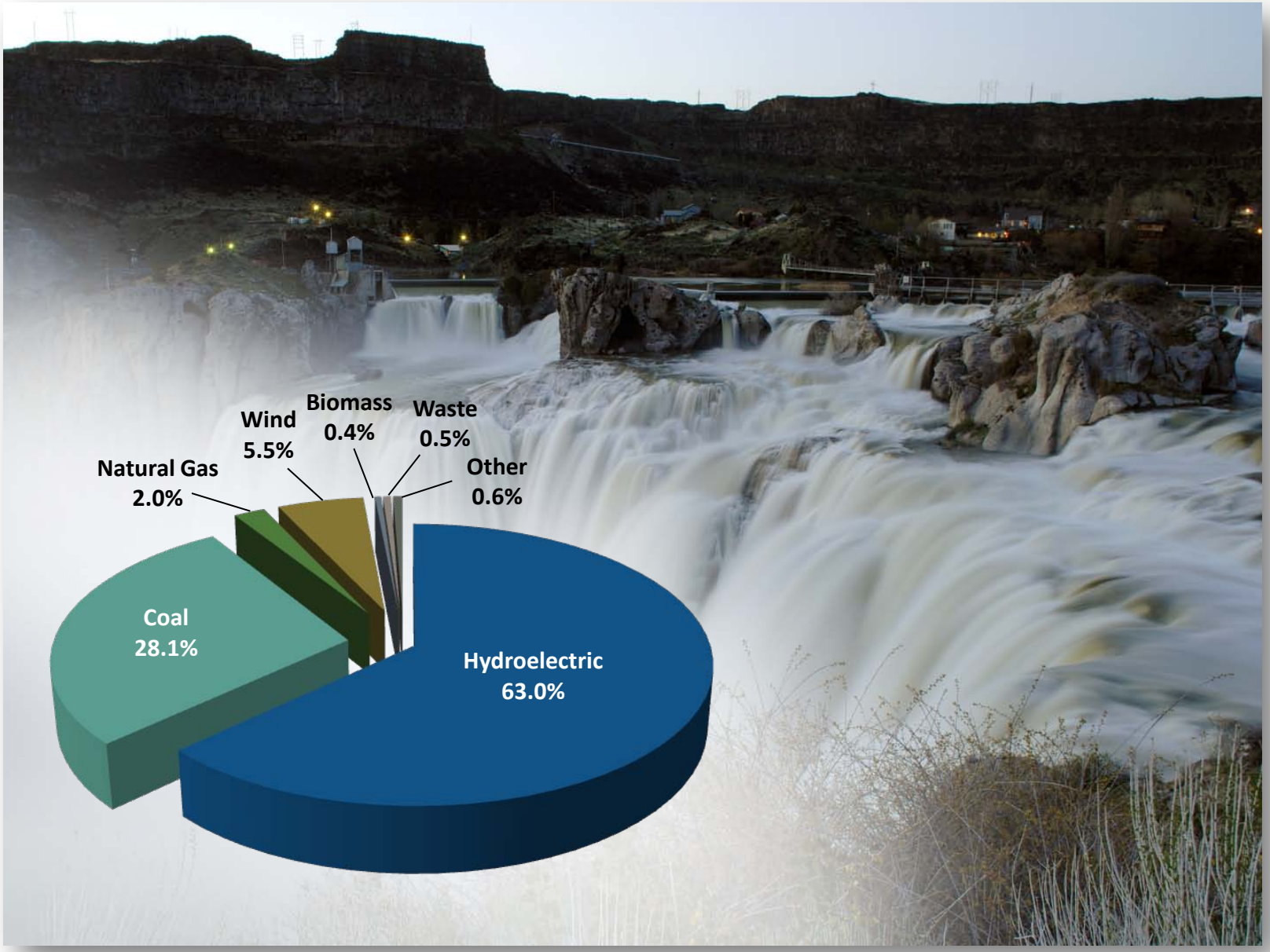
IDAHO POWER®
An IDACORP Company

Kresta Davis-Butts

Outline

- Introduction to Idaho Power's Hydroelectric Resources
- Stream Flow Forecasting
  - Customers
  - Cooperators
  - History
  - Products
- Development of the NWSRFS to meet Idaho Power's needs
- Challenges
- Integration of RFS and RiverWare

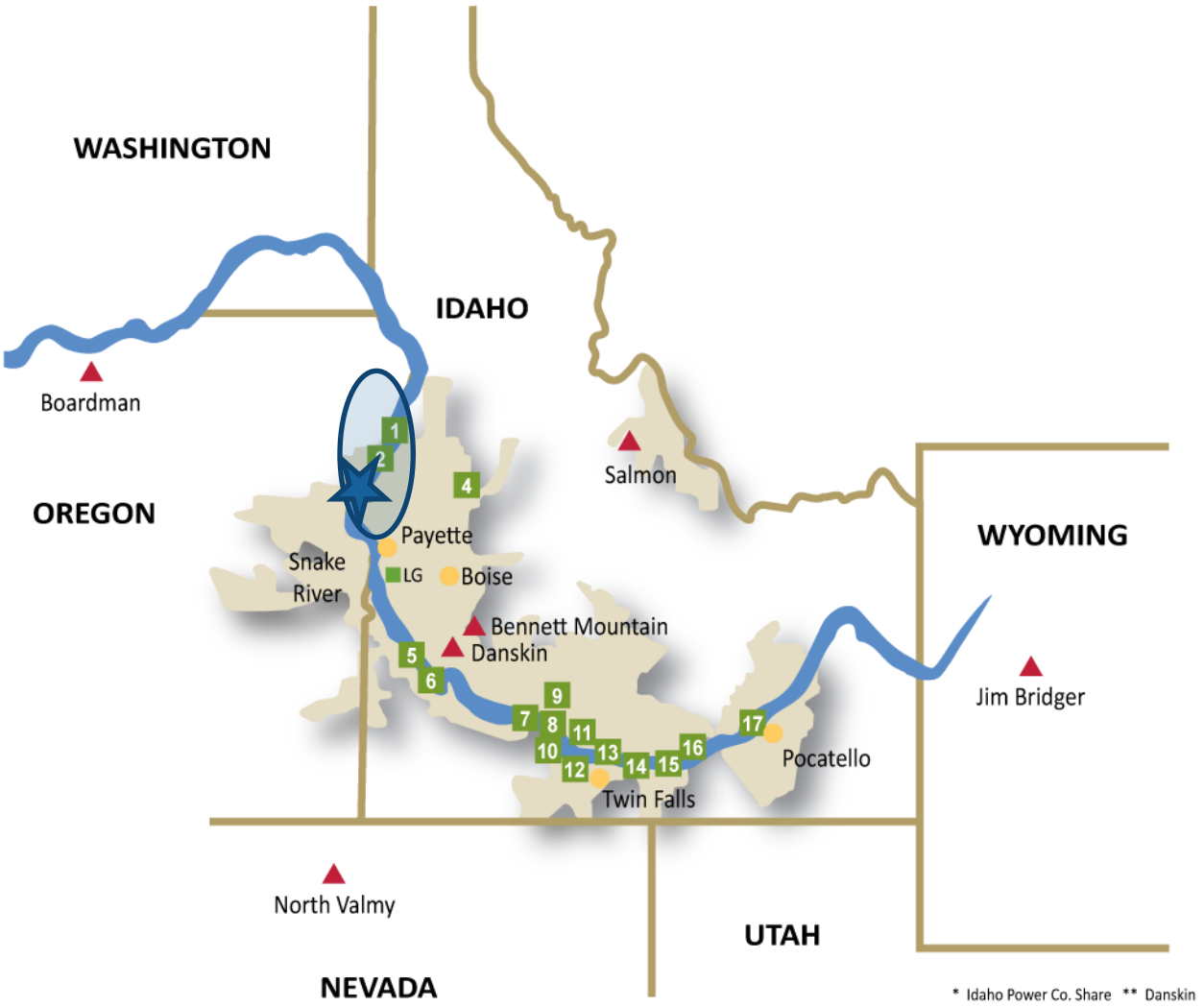
2011 Fuel Mix



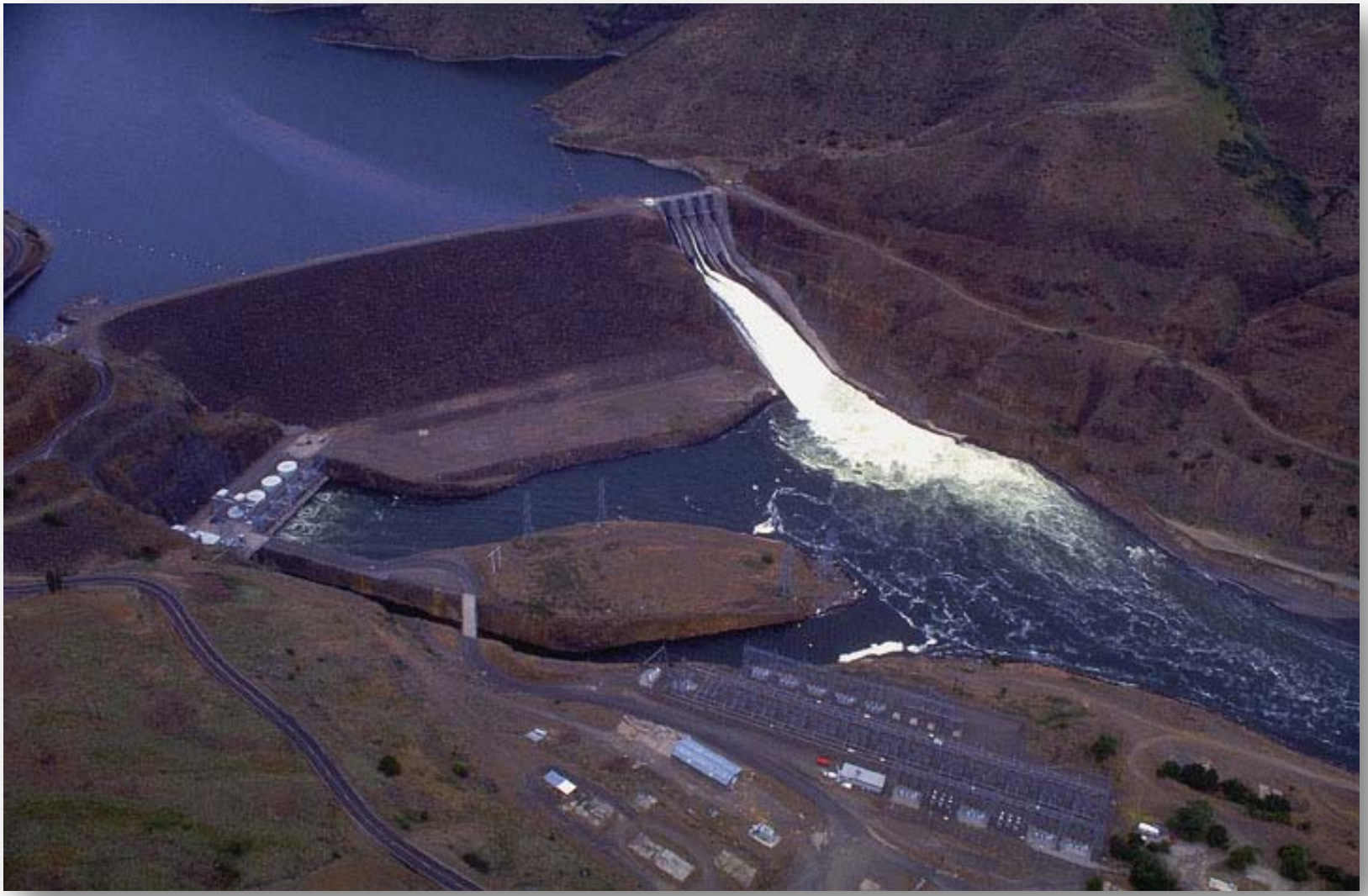
Hydroelectric Resources

Hydroelectric Facilities and Nameplate Capacities

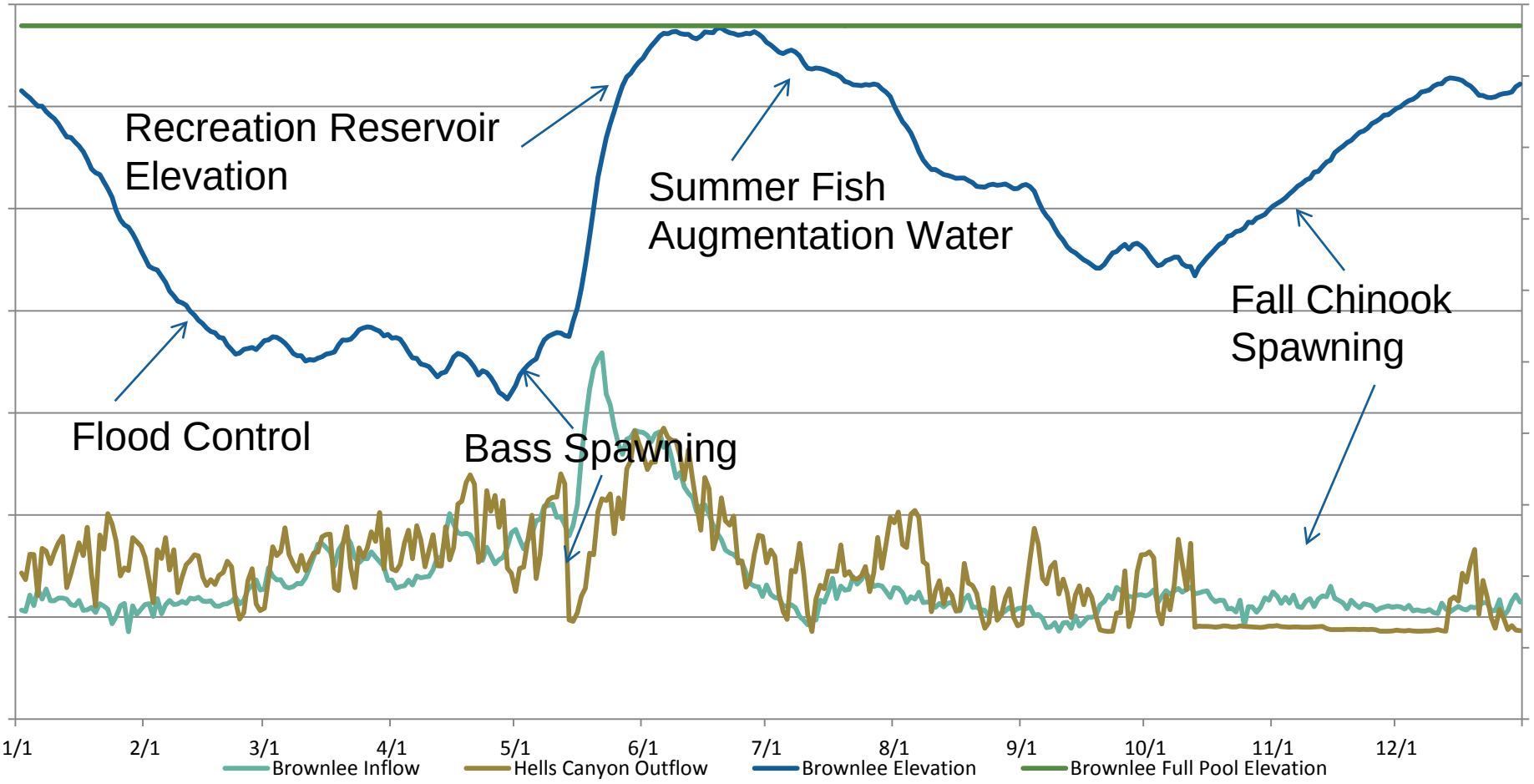
1	Hells Canyon	391,500 kW
2	Oxbow	190,000 kW
3	Brownlee	585,400 kW
4	Cascade	12,420 kW
5	Swan Falls	27,170 kW
6	C. J. Strike	82,800 kW
7	Bliss	75,000 kW
8	Lower Malad	13,500 kW
9	Upper Malad	8,270 kW
10	Lower Salmon	60,000 kW
11	Upper Salmon	34,500 kW
12	Thousand Springs	8,800 kW
13	Clear Lake	2,500 kW
14	Shoshone Falls	12,500 kW
15	Twin Falls	52,897 kW
16	Milner	59,448 kW
17	American Falls	92,340 kW
	Total	1,709,045 kW



Brownlee Dam

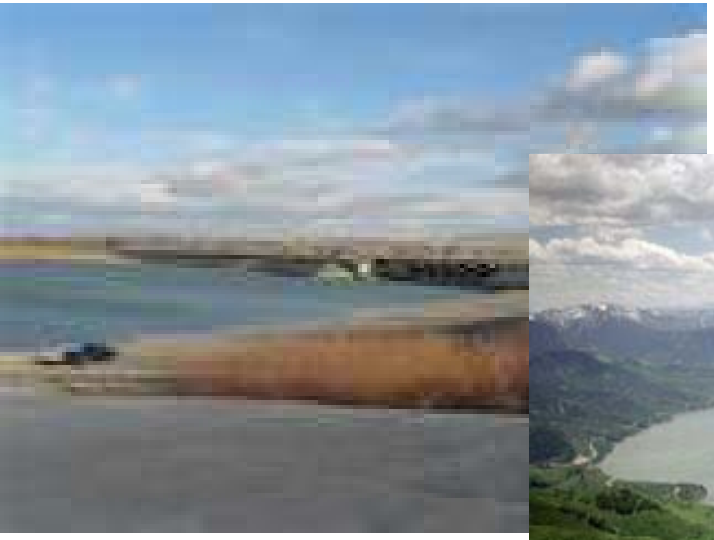


Brownlee Operations



Upstream Regulation

- **Upper Snake River**
  - Reservoirs include: Jackson, Palisades, and American Falls Reservoirs



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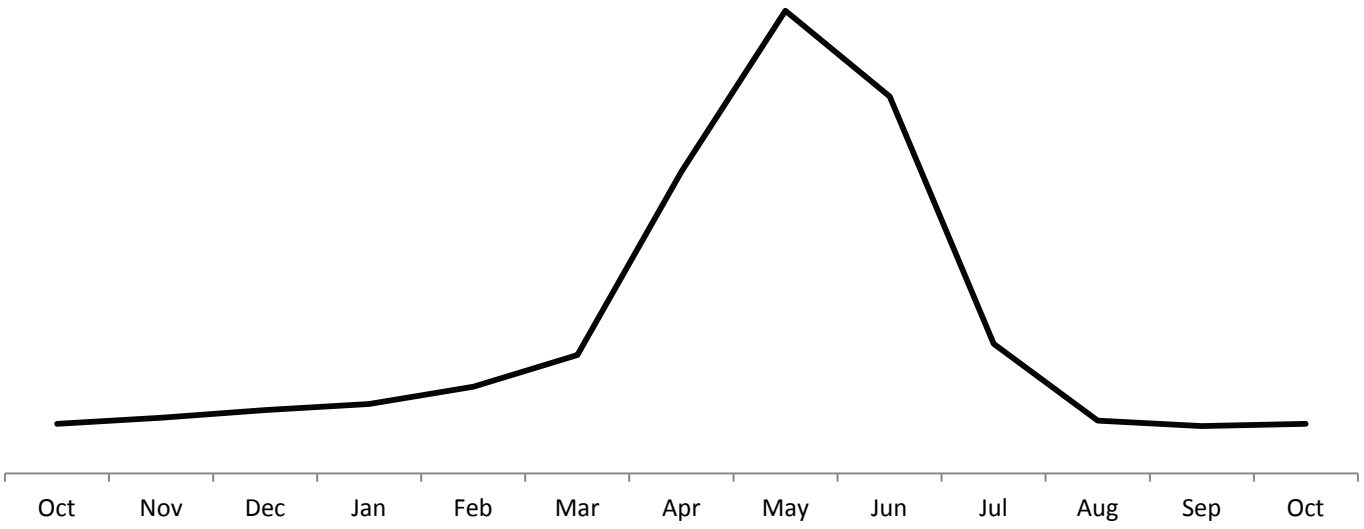
Upstream Regulation

- **Payette and Boise**
  - Reservoirs include: Cascade, Payette, Deadwood, Black Canyon, Anderson, Arrowrock, and Lucky Peak Reservoirs



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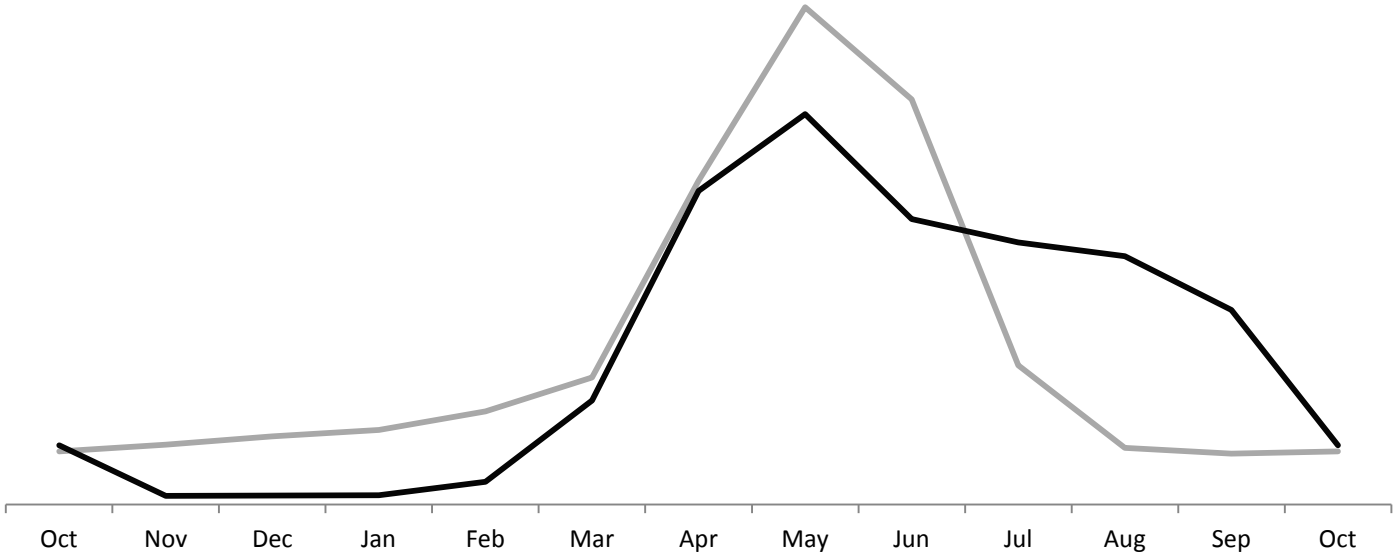
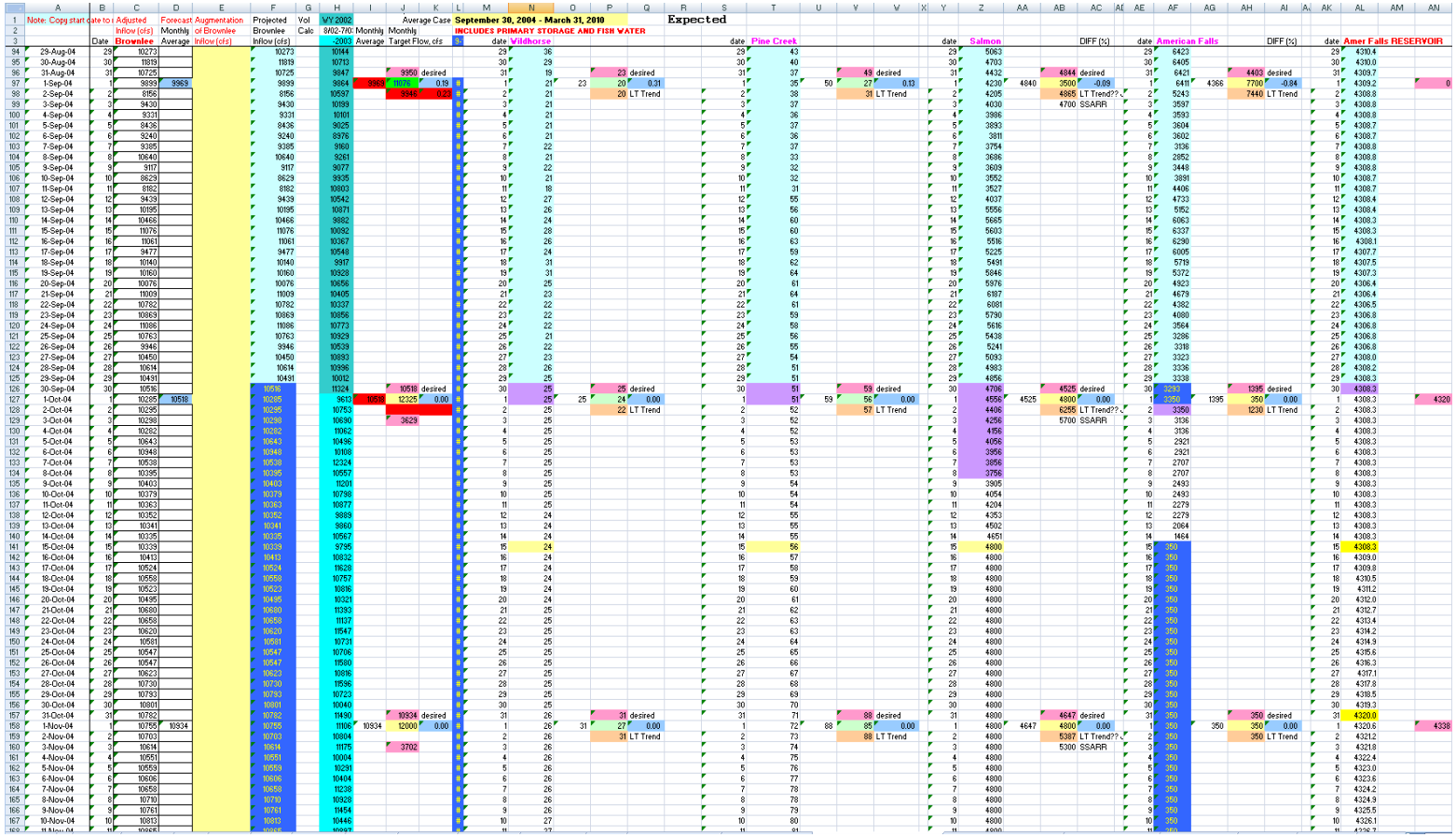


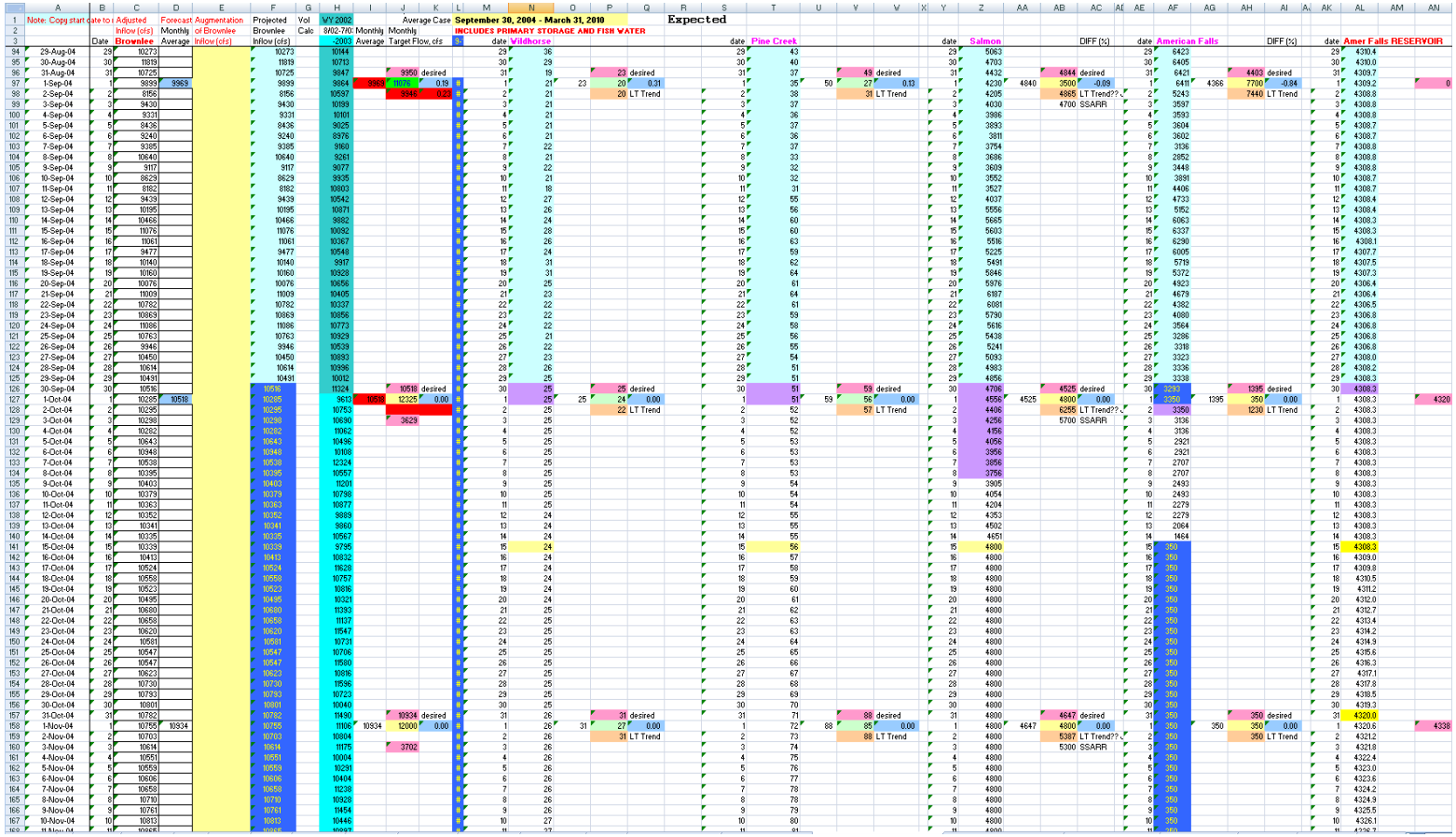
Customers

- Short- and long-term traders
- Long term resource planners
- Plant operators
  - Plant maintenance
  - License obligations
- Risk management team
- Finance
  - PCA
- Others

Stream Flow Forecasting History



Stream Flow Forecasting History

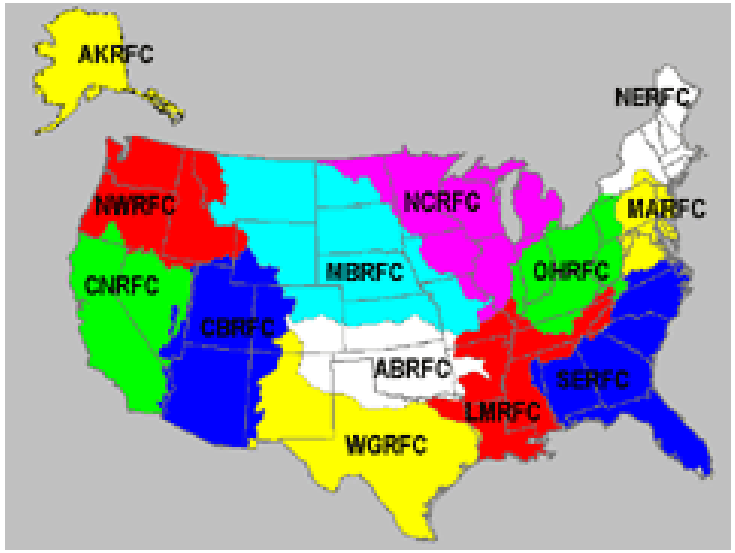


Finding a forecasting tool to meet Idaho Power's needs

- Account for snow accumulation and timing of runoff
- Track water moving through the soil
- Modify routed stream flow using irrigation information and return flows
- Allow for flood control operations using forecasted inflow

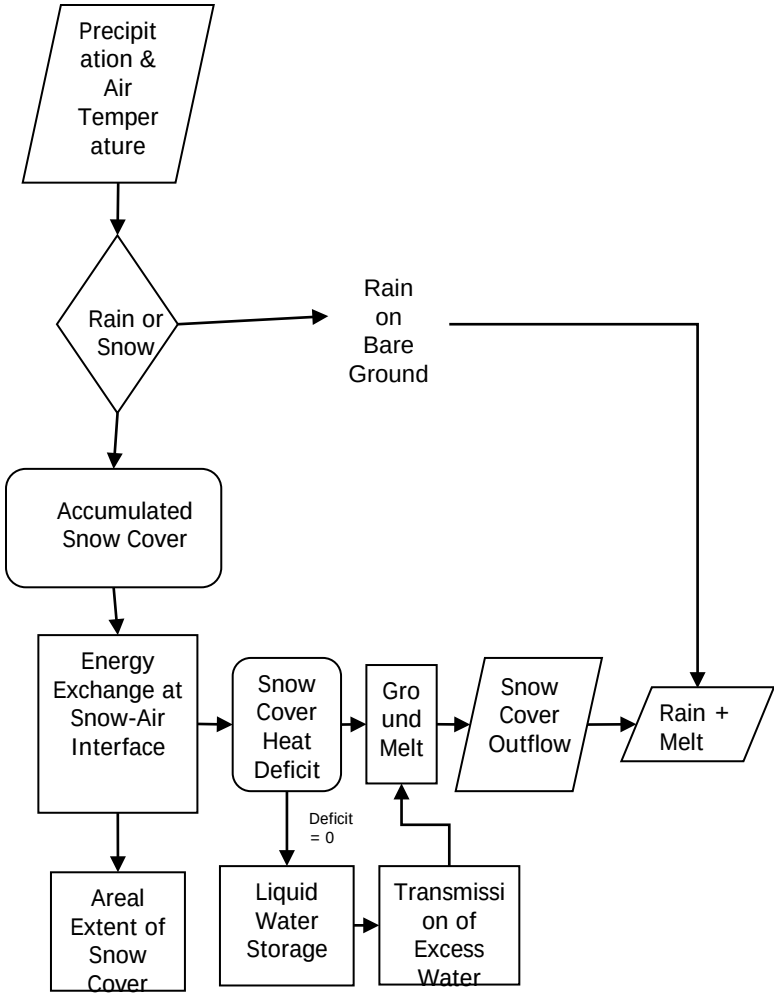
Nation Weather Service River Forecast System (RFS)

- Total river and hydrologic forecast system.
- Real-time, Short-Range, Medium-Range & Long-Range Forecast Components.
- Used at all thirteen River Forecast Centers.



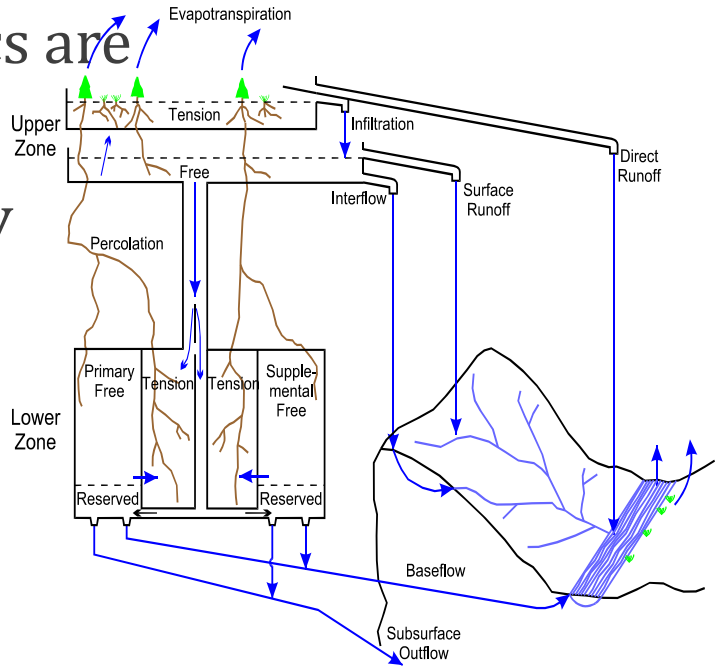
SNOW Model

- Conceptual Model
  - Simplified Heat Balance During Rainfall Events
  - Degree-Day Melt Factor During Non-Rain Events
- Input: Air Temperature & Precipitation
- Output: **RAIN+MELT**, SWE, Depth, Areal Extent
- Processes: Snow Accumulation, Surface Energy Exchange
- Watershed Areal Application: Areal Extent of Snow Cover



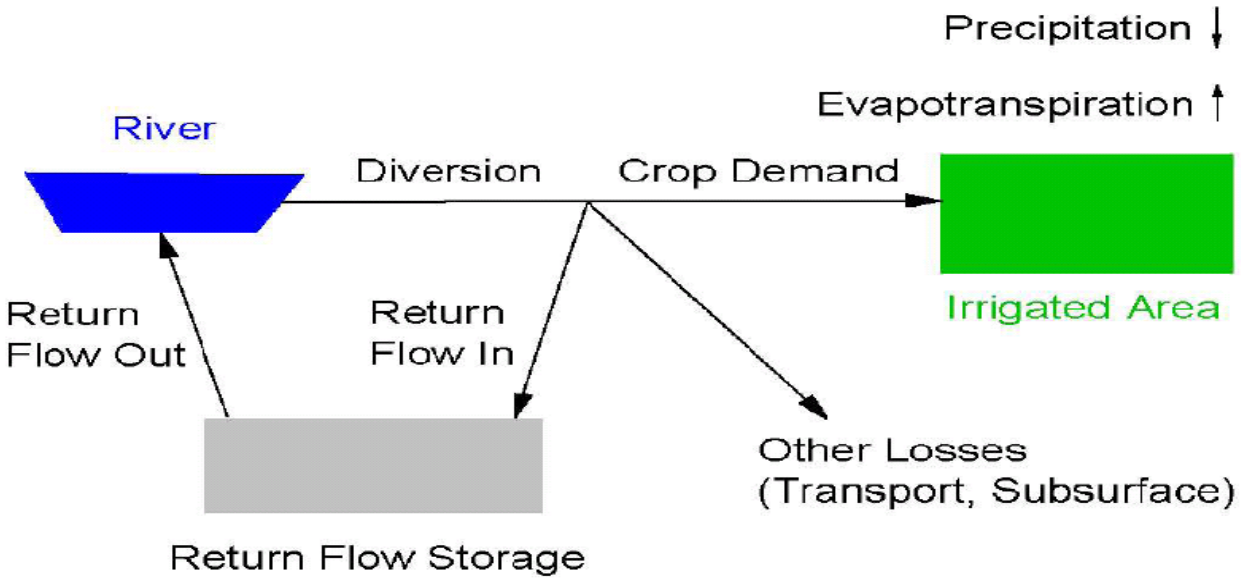
Sac-SMA

- Conceptual Model
  - Represents soil moisture characteristics such that:
    - Applied moisture is distributed properly in various depths and energy states in soil
    - Rational percolation characteristics are maintained
    - Streamflow is simulated effectively
- Input: RAIN + MELT
- Output: RUNOFF



Consumptive Use

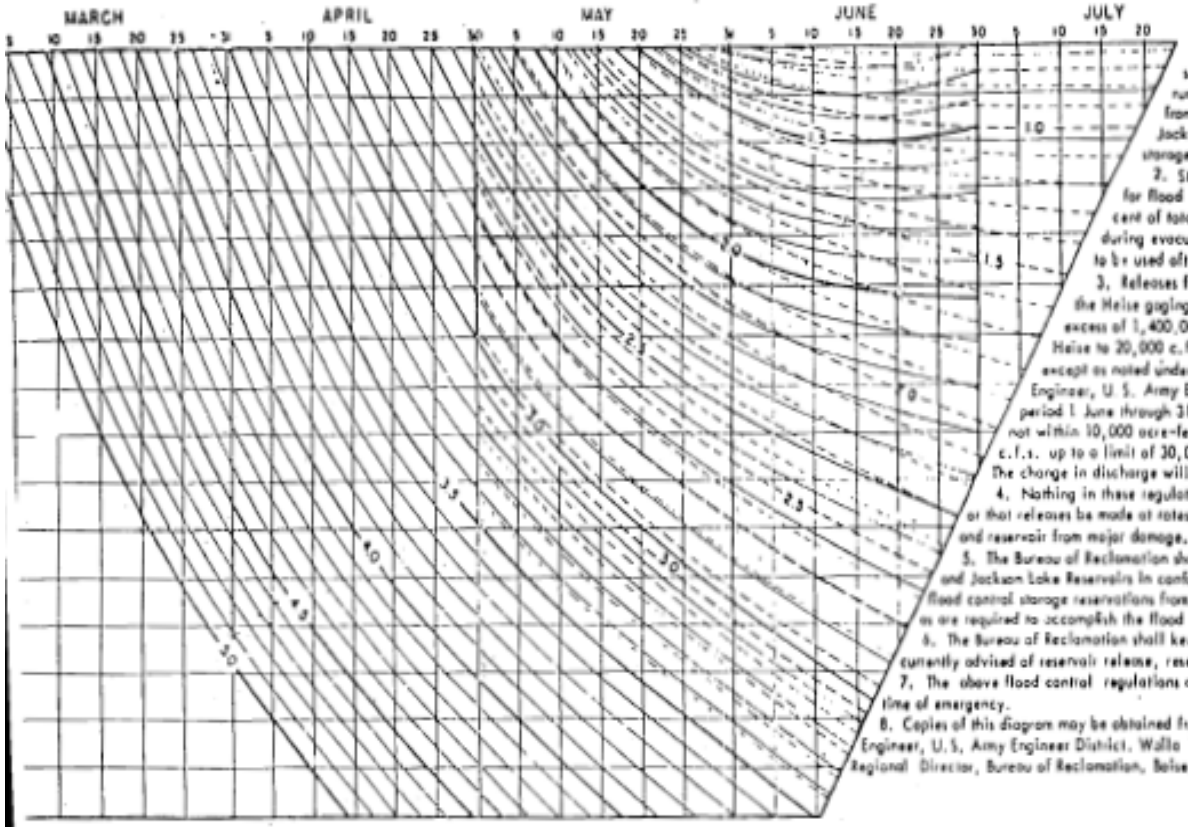
- Consumptive Use Models (Seasonal)
  - Diversions
  - Return Flows
  - Out-of-Basin Diversions
  - Local Inflow to Irrigated Areas



Joint Reservoir Operations

- Rules and Parameters
  - Irrigation Withdrawal
    - Average historical withdraws at diversion dams
    - Minimum flow requirements
  - Reservoir Evaporation
  - Fish Augmentation
  - Turbine Capacity
  - Ramp Rates
  - Flood Management
    - USBR and COE Flood Control Rule Curve (WatSup)

Flood Management



NOTES

1. The minimum flood control storage reservation required on any day of the flood season is as indicated by the diagram. Parameter values are forecasted natural flood run-off of Snake River at Heise in millions of acre-feet for the remainder of the season from any given date to 31 July. A minimum of 200,000 acre-feet of storage space in Jackson Lake will be held vacant until 1 May every year unless the forecast indicates that storage should begin earlier to insure filling that space.

2. Storage space in Palisades Reservoir and Jackson Lake combined shall be kept available for flood control purposes in accordance with this diagram. However, not less than 75 per cent of total storage space will be made available in Palisades Reservoir. Solid lines to be used during evacuation and until natural inflow to Palisades first exceeds 20,000 c.f.s. Dashed lines to be used after natural inflow exceeds 20,000 c.f.s.

3. Releases from Palisades Reservoir shall be restricted to 20,000 c.f.s. or less as measured at the Heise gaging station except: (A) when the forecasted run-off indicates that storage capacity in excess of 1,400,000 acre-feet in Palisades and Jackson Lake combined is required to control flows at Heise to 20,000 c.f.s., releases in excess of 20,000 c.f.s. will be made but not to exceed 30,000 c.f.s. except as noted under Item 7 or as may be agreed upon by the Bureau of Reclamation and the District Engineer, U. S. Army Engineer District, during extremely large floods and; (B) when the forecasted run-off for period 1 June through 31 July exceeds 7,500,000 acre-feet, and, when after 1 June the available space is not within 10,000 acre-feet of the space required by this diagram, the release may be increased above 20,000 c.f.s. up to a limit of 30,000 c.f.s. to the extent of 1,000 c.f.s. for each 5,000 acre-feet of deficient storage. The change in discharge will be made in such manner as to minimize the adverse downstream effects.

4. Nothing in these regulations shall be construed to require dangerously rapid changes in magnitudes of releases, or that releases be made at rates or in a manner that would be inconsistent with requirements for protecting the dam and reservoir from major damage.

5. The Bureau of Reclamation shall procure current basic hydrologic data necessary for forecasting inflows to Palisades and Jackson Lake Reservoirs in conformance with procedures mutually agreed to, make current determinations of required flood control storage reservations from the diagram and make current calculations of permissible releases from the reservoirs as are required to accomplish the flood control objectives.

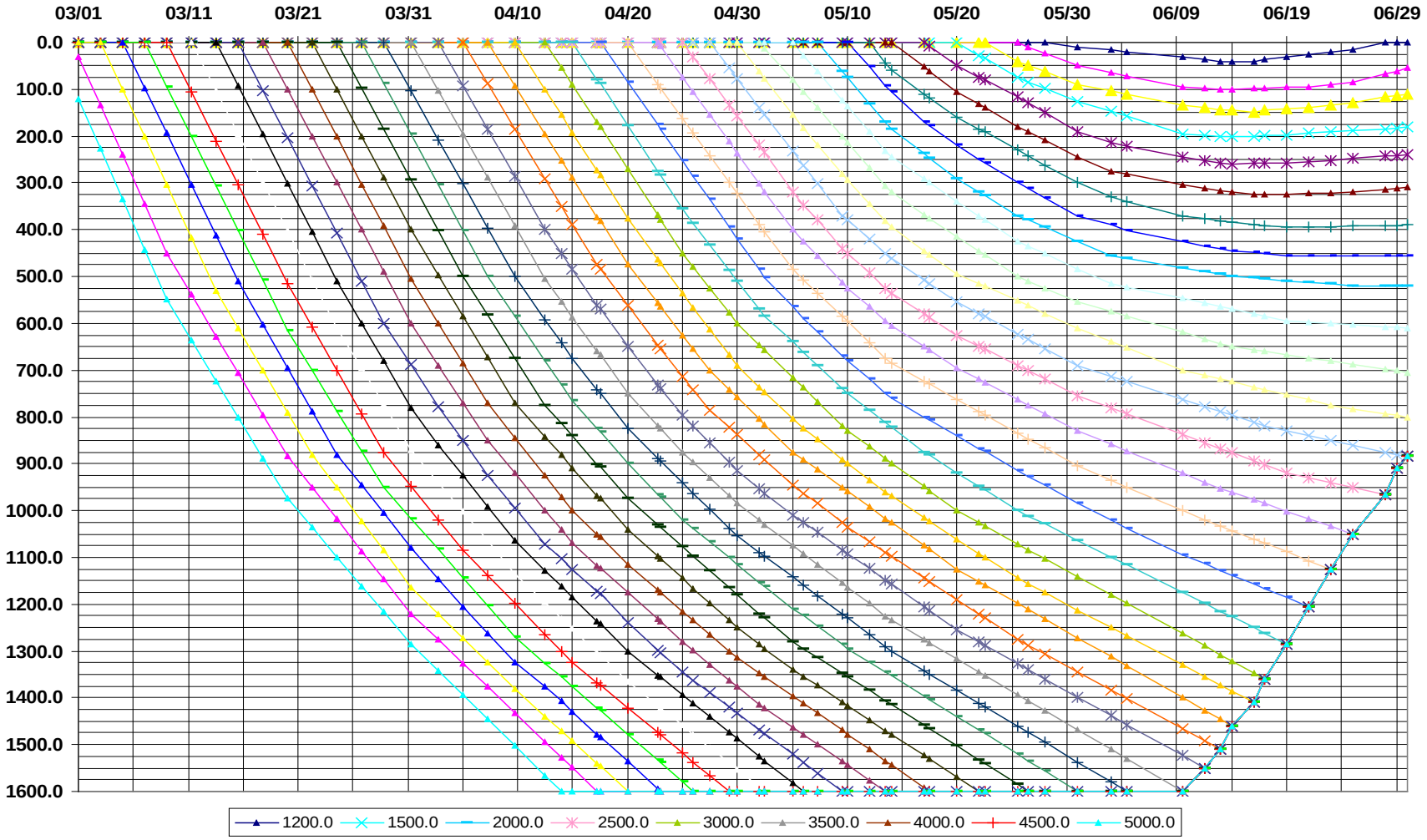
6. The Bureau of Reclamation shall keep the District Engineer, U.S. Army Engineer District, in charge of the locality currently advised of reservoir release, reservoir storage and such other operating data as the District Engineer may request.

7. The above flood control regulations are subject to temporary modification by the District Engineer, if found necessary in time of emergency.

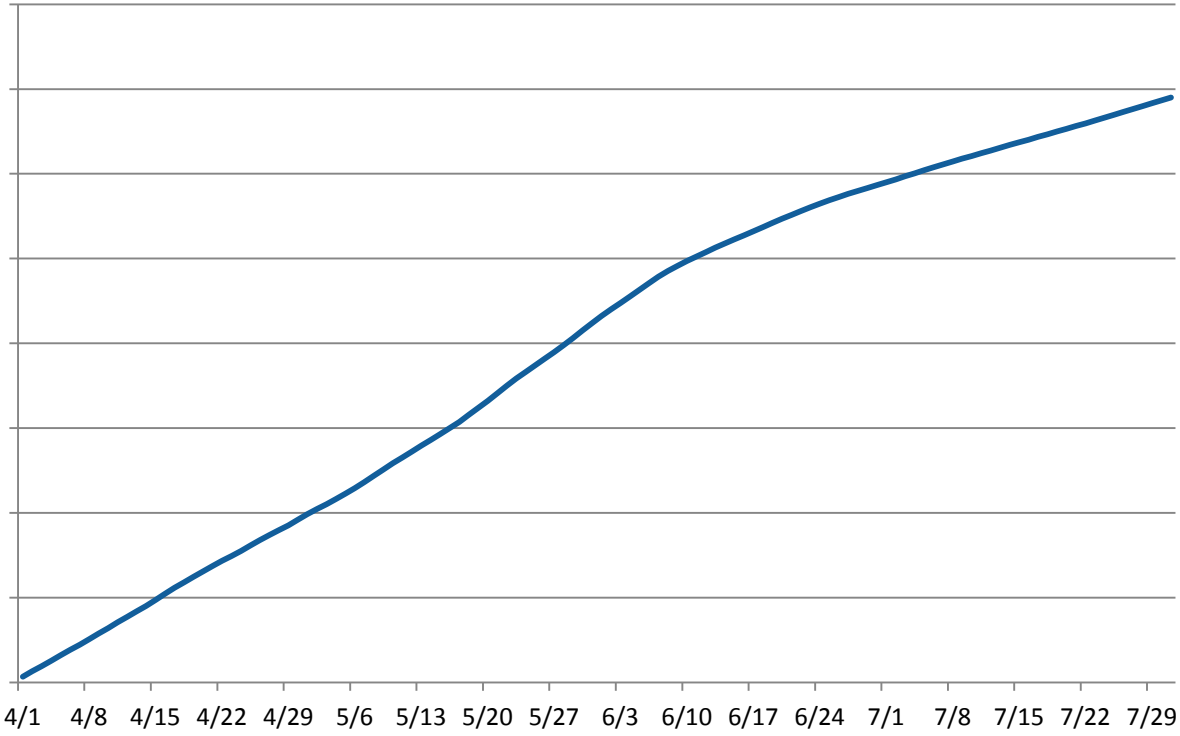
8. Copies of this diagram may be obtained from the offices of the District Engineer, U.S. Army Engineer District, Walla Walla, Washington, and the Regional Director, Bureau of Reclamation, Boise, Idaho.

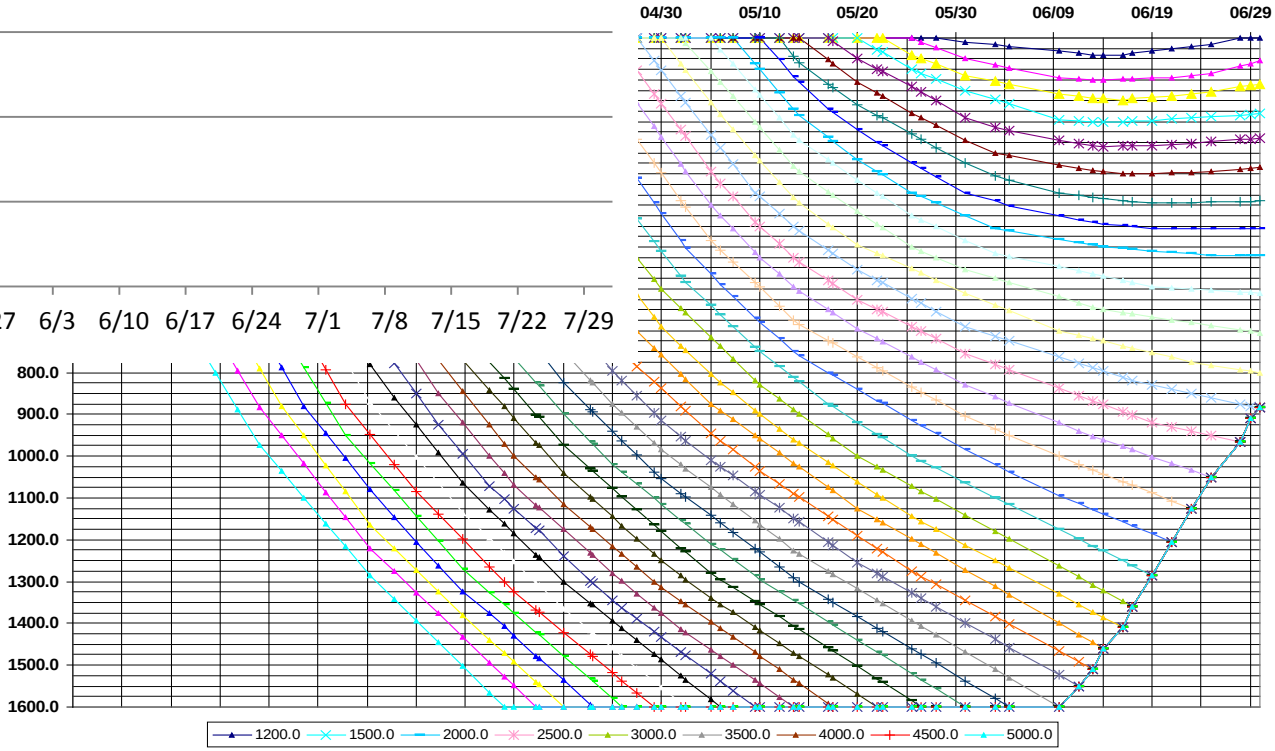
PALISADES DAM AND RESERVOIR
Snake River, Idaho
FLOOD CONTROL STORAGE RESERVATION DIAGRAM
Prepared Pursuant to Flood control Regulations for Palisades Dam and Reservoir 33 CFR 208.1
APPROVED W. A. Dexheimer
Commissioner of Reclamation
APPROVED E. C. Itschner
Major General, Chief of Engineers
Effective Date May 12, 1958 File No. [illegible]

Flood Management



Flood Management

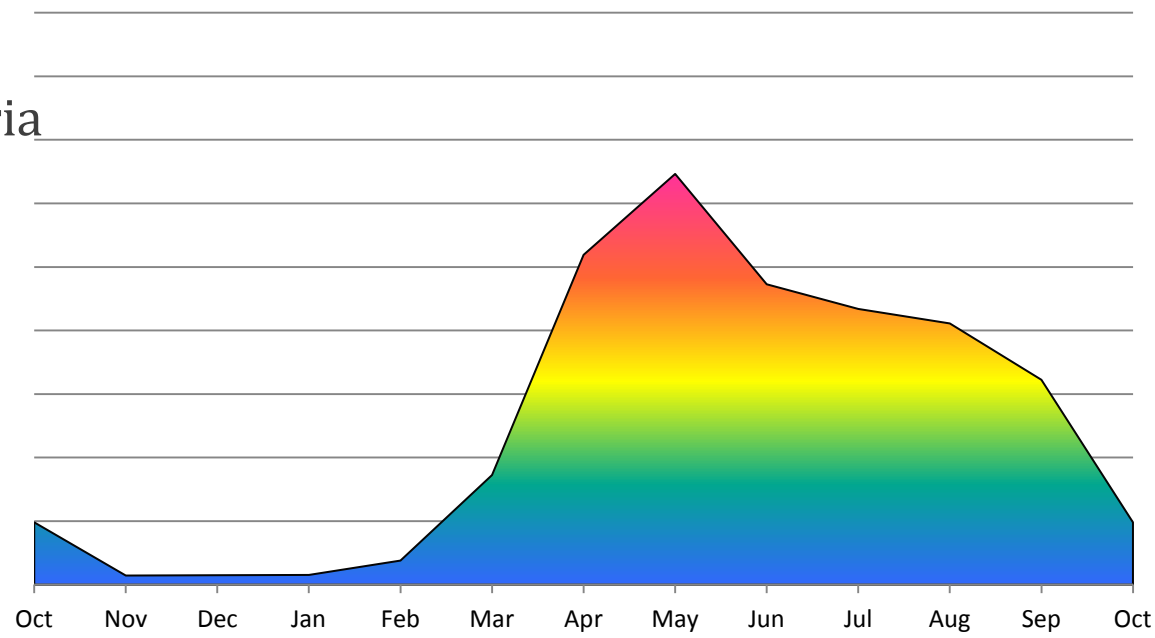




Challenges

- Flood control operations that include more than one reservoir
  - Iteration
  - Increased run time

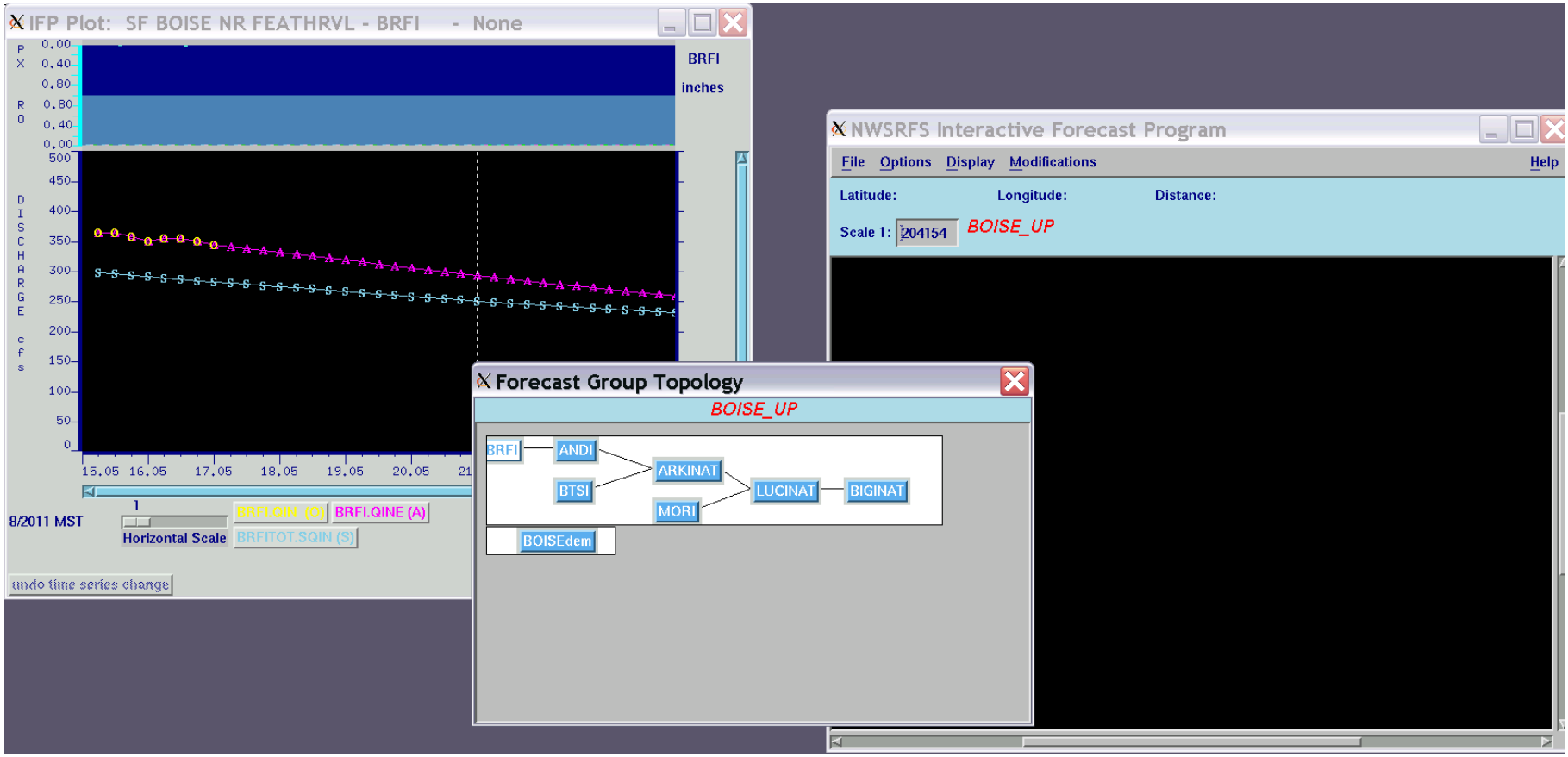
- "Coloring" the water
  - Fish augmentation
  - Minimum flow criteria
  - Flood control
  - Rental water
  - Storage water



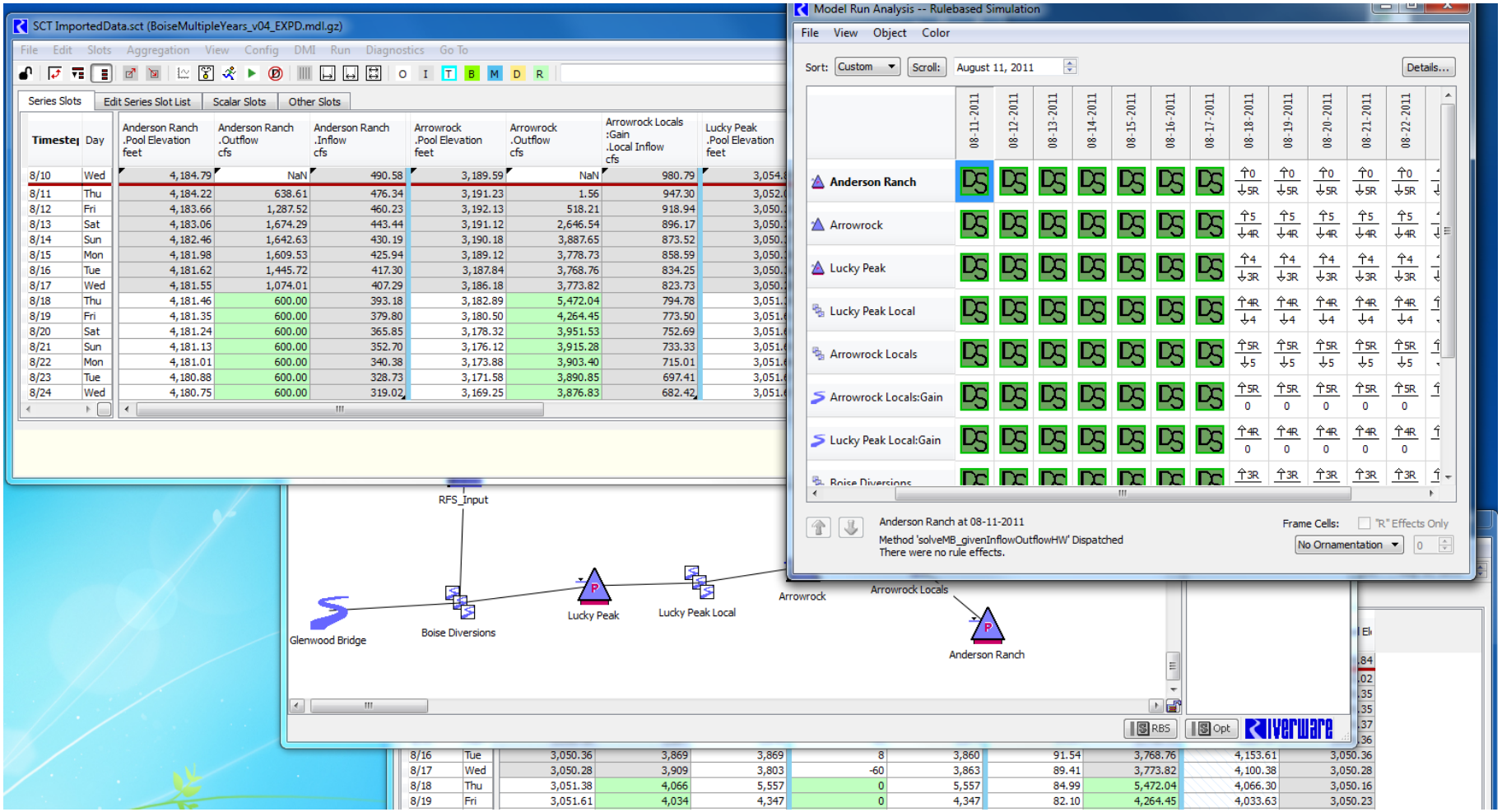
Integration of RFS and RiverWare

- RiverWare has the ability to solve bi-directionally (downstream to upstream and upstream to downstream)
- Using rulebase simulation may be a means to clearly interpret and account for modeled reservoir releases
- RiverWare has been used to handle flood control curves given accumulated inflow volumes
- TSTool readily available to convert timeseries between RFS and RiverWare
- RiverWare is used by many of our cooperators

Integration of RFS and RiverWare



Integration of RFS and RiverWare



Integration Issues

- Modification made within the short term in the RFS are not translated and routed by RiverWare
- Running true ESP has not been addressed
- Work remains to improve upon the efficiency in which the scripts run

Questions?