

WECC HMTF

Aug 7, 2013

Historic PS Operation in WSCC

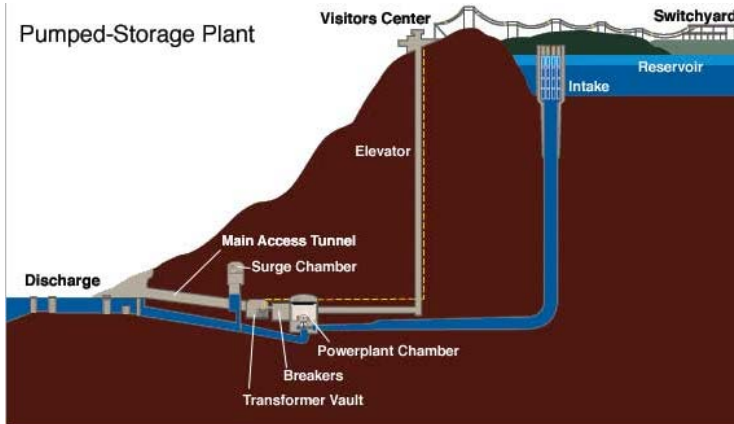


Overview

- PS Configuration
- Expected PS Operation
- Expected PS CF
- Review Historic Operation of PS Units in WECC:
 - Typical PS
 - Cabin Creek (PSC), Mount Elbert, Lake Hodges
 - PS with inflow Operation:
 - Horse Mesa (SRP), Mormon Flat (SRP), Eastwood (SCE) and Castaic (LADWP)
 - Helms (PS Efficiency issue)
 - Seasonal Water Storage:
 - W R Gianelli (San Luis) and O’Neill
- Appendix
 - PS Plants not operated in PS Mode?
 - Hyatt, Thermalito, Flatiron, Grans Coulee, Waddell, North Hollywood
 - Generic PS Efficiency
 - Data Source

Aerial image are from Google Earth

PS Configuration



Mount Elbert PS: 39.094162, -106.352297

Configuration

- Upper reservoir
- Lower reservoir
- PS Power Plant
- Pipeline/tunnel

Technical Issue

- Number of PS unit per pipeline/ tunnels

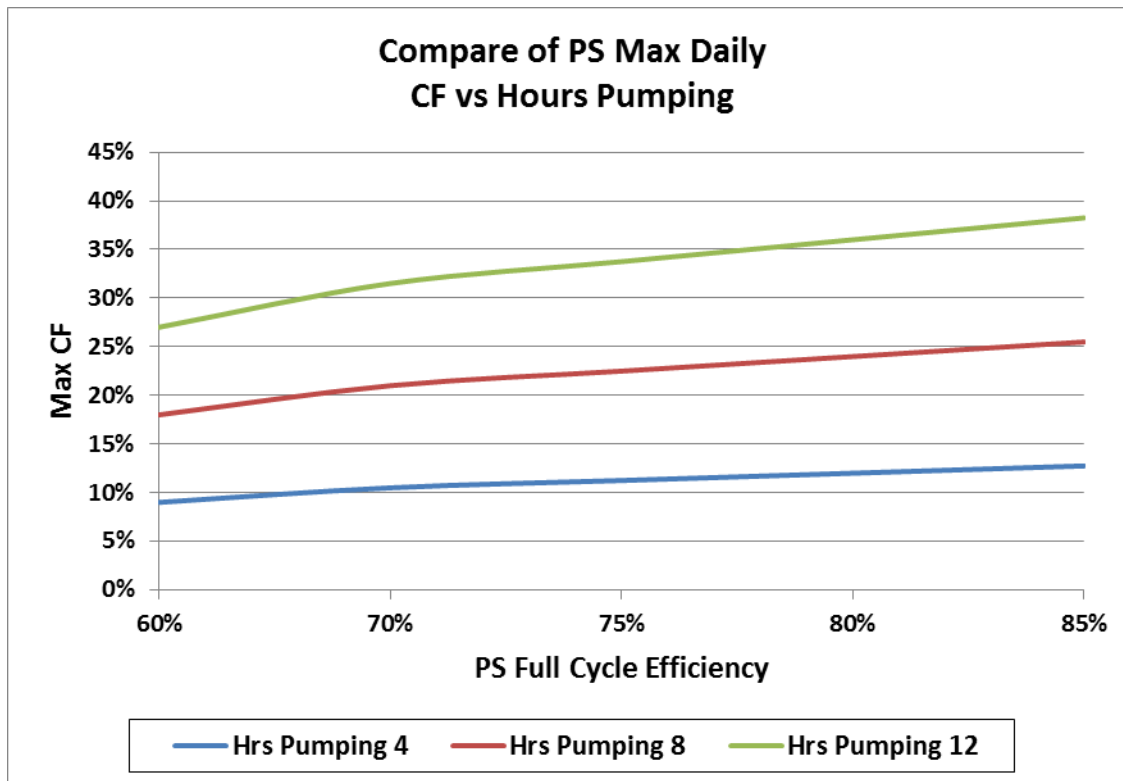
Expected PS Operation

- [Gen] – [Pumping] = [Net Gen]
 - [Pumping] > [Gen]
 - [Net Gen] < 0 (negative number)
 - If its positive implies nature inflow
 - Operational PS Efficiency:= [Gen]/[Pumping]
- PS Efficiency cannot be greater than ~86%
 - [Gen Eff]*[Pumping Eff]:= 0.935*0.925:= 86.5%
 - If its greater than 86% implies nature inflow
- PS efficiency lower than ~70%
 - Operated for spinning reserve
 - Implies seasonal operation
 - Refilling upper reservoir
- PS Efficiency:= The break even point for the ratio of Off-Peak/On-Peak pricing
 - My generic Off-Peak/On-Peak bid for CCGT is 82% (1.22)

Note: Blue font indicates EIA-923 data

Expected PS CF

- Working spreadsheet contains:
 - Break Even
 - Two tabs that calculate daily and weekly maximum PS CF:
 - Tabs: “Daily Theoretical CF” and “Weekly Theoretical CF”



- Mount Elbert

- Located: 39.094162, -106.352297
- Modeled 2022 PS Efficiency:= 75%
- Operational PS Efficiency:= 75%
- Historic CF:= 15%
- Little natural inflow

- Lake Hodges

- Started operation Sept-2012
- Under contract with SDGE
- Modeled 2022 PS Efficiency:= 76%
- Model as 1 units 40 MW unit (not 2x20 MW)



Cabin Creek

- Located: 39.655089. -105.712373
- Modeled 2022 PS Efficiency:= 75%
- Operational PS Efficiency:= 65%
- Historic CF:= 7%
- The low operational PS efficiency implies plant is operated for spin
- In early 1990's PSC operated Plant for spinning reserves.
- I'm talking with Jeff Hein at Excel regarding current operations.
- Alternative modeling approach for Spin:
 - Hard wire pumping load with one unit.
 - Hard wire gen to operate between defined hour at min generation with some surplus generation.

PS with Inflow - SRP

- A four reservoir system: Roosevelt, Horse Mesa (PS), Mormon Flat (PS) and Stewart Mountain.

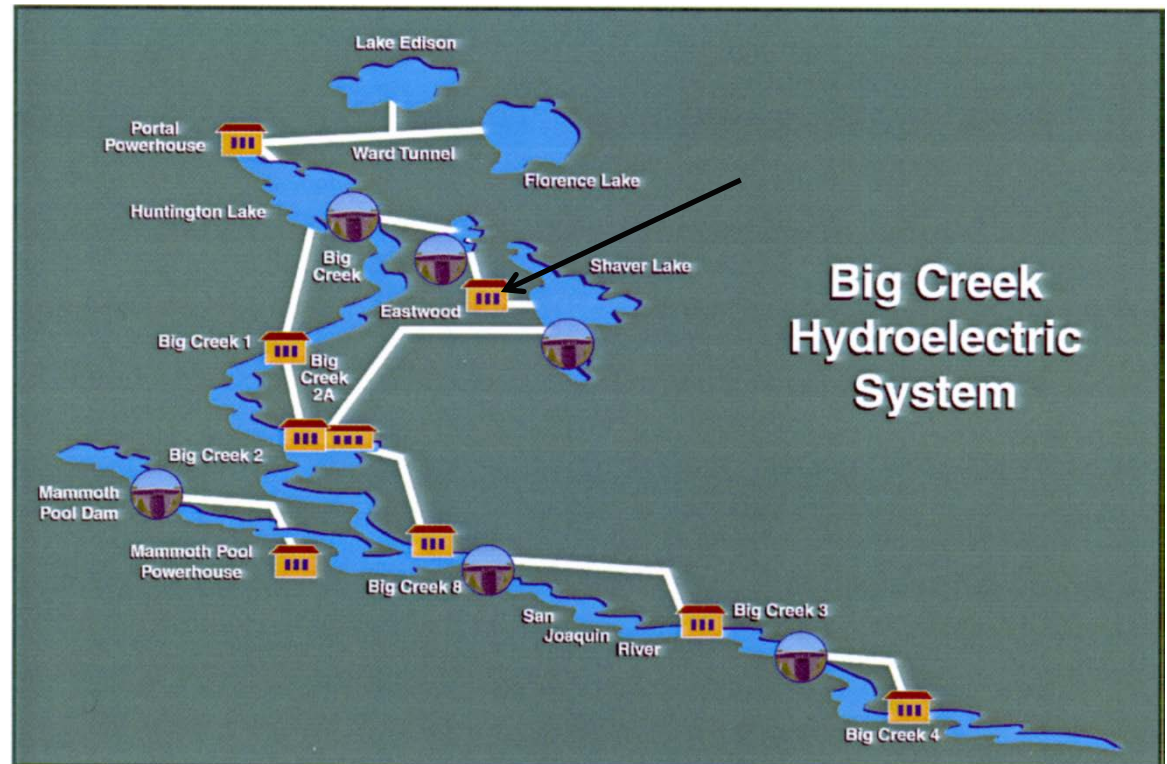


- SRP Horse Mesa and Mormon Flat
 - Historic data indicates monthly PS operation with inflow from the upper reservoirs.
 - Horse Mesa (PS 119 MW & HY 30 MW)
 - Modeled PS Efficiency in 2022:= 86%
 - Operational PS Efficiency Assume:= 65.0%
 - PS Eff has to be $\leq 67\%$ to prevent negative inflow
 - Historic Net CF 15.3%: Inflow 8.1% & PS Operation:= 7.2%
 - Shift PS Inflow to Conv Hydro
 - Mormon Flat (PS 57.3 MW and HY 11 MW)
 - Modeled PS Efficiency in 2022:= 86%
 - Operational PS Efficiency Assume:= 64.0%
 - PS Eff has to be $\leq 66\%$ to prevent negative inflow
 - Net Historic CF 17.7%: Inflow 9.6% & PS Operation:= 8.1%
 - Shift PS Inflow to Conv Hydro
 - Some PCM support monthly inflow

PS with Inflow - Eastwood

Eastwood is part of SCE's Big Creek Project

- PS Eff Assumed:= 75%
- Historic PS CF:= 8.1%
- Inflow CF:= 9.6%



- One Penstock with three PS units
 - Head losses increases as a function of flow
 - Operation of each additional unit lowers efficiency (Pumping or generating)
- This results in five modes of operation
 - Mode 1: 1 unit gen & 1 unit pumping
 - Mode 2: 2 unit gen & 1 unit pumping
 - Mode 3: 2 unit gen & 2 unit pumping
 - Mode 4: 3 unit gen & 2 unit pumping
 - Mode 5: 3 unit gen & 3 unit pumping

- Modeled PS Efficiency for 2022:= 70%
- Based on historic monthly data implied PS efficiency ranges from 18%-274%
- Average monthly:= 70%
- For ECAC proceeding in the early 1990 Helms was modeled as: 3 PS units with Eff of: 86%, 75% and 64%
 - ECAC proceedings: CPUC review of non-standard contracts with QFs for the Independent Energy Producers Association.
- Proposed model as 3 PS units with PS Eff of: 73%, 63% and 53%
- Work with Tom Miller for current operations

PS with Inflow - Castaic

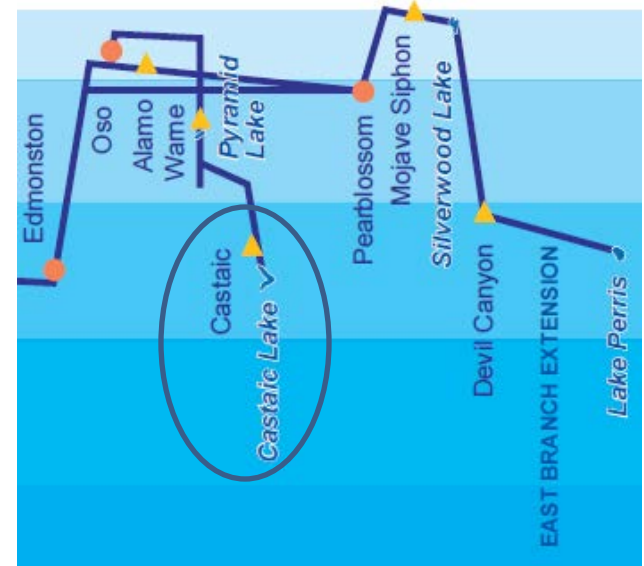
- Castaic is part of the water conveyance system from the Northern California to the LA Basin, via California Aqueduct.
- DWR refers to this part of the system as the West Branch

<http://www.water.ca.gov/swp/facilities/>



Castaic Configuration

- Upper reservoir Pyramid Lake
- Lower reservoir Elderberry Forebay
 - North west corner if Castaic Lake
- 1,575 MW plant (6 x 262.5 MW)



PS with Inflow - Castaic

- Castaic PS Operation
 - Modeled 2022 PS Eff:= 70%
 - PS Eff Assumed:= 70% (Avg Op Eff)
 - Historic PS CF:= 2.3%
 - Inflow CF:= 3.2%
- Note: A single tunnels feeds seven generator feed pipes
 - Single tunnel is ~6 miles long with 410 feet of head (39% of head)
 - Generator feed pipes is ~0.5 miles with 650 feet of head (61% of head)

Proposed Modeling of Castaic (Conv Hydro & PS)

- Spit Castaic into two types of units
 - EIA 1,575 MW PS & 56 MW Hydro
 - Modeled PS 2022: 1,175 MW
 - PS Plant: 3x392 MW units (1,175 MW)
 - PS Eff Assumed:= 70% (72%, 64%, & 57%)
 - Run-of-River Hydro Unit: 150 MW
 - Historic Gen:= 47 aMW (Annual average)



W R Gianelli Complex

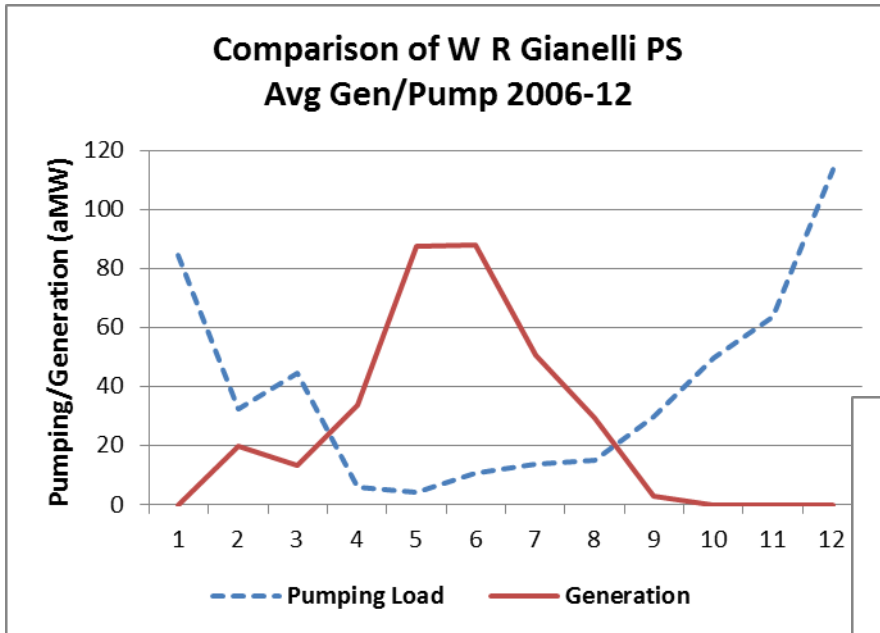


<http://www.water.ca.gov/swp/facilities/sanluis.cfm>



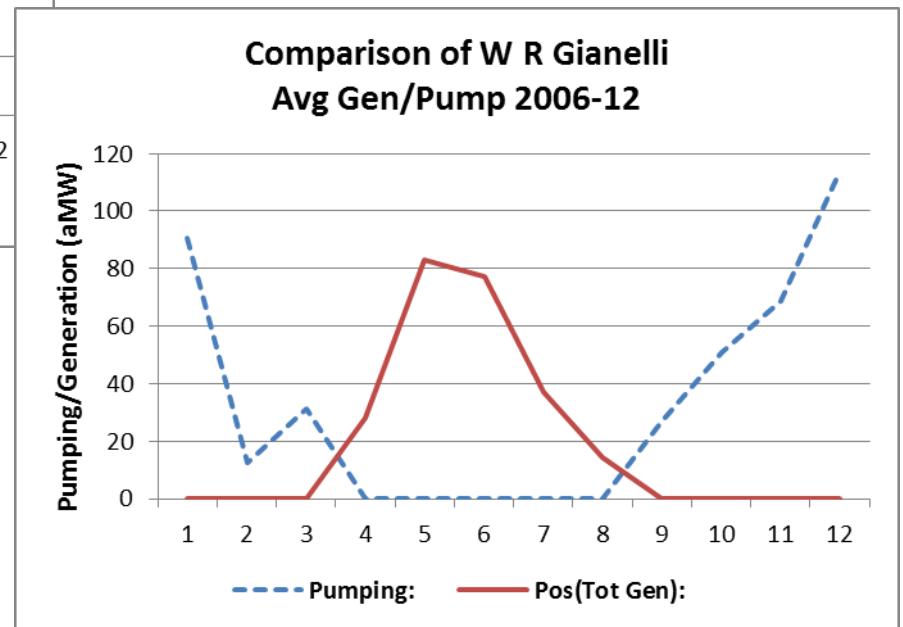
W R Gianelli (San Luis)

San Luis Reservoir stories 2.1 MAF of Winter/Spring run-off for summer delivery



Historic Operation of W R Gianelli

Proposed Modeling of W R Gianelli



- Configuration
 - Upper reservoir: San Luis reservoir
 - Lower reservoir: O'Neill Forebay/California Aqueduct
 - Primary used for seasonal water storage
 - Reservoir has no natural watershed
 - Surplus winter/spring run-off is stored for summer deliveries
 - Approximately 2.1 MAF of storage
 - Ownership DWR 55% USBR 45%
- Proposed Modeling of W R Gianelli - Split into two components:
 - Flat pumping load Jan-Mar & Sep-Dec (Hourly shape if available)
 - Hydro Generator Apr-Aug (Base load or Hourly shape?)

Other Defined PS Plants

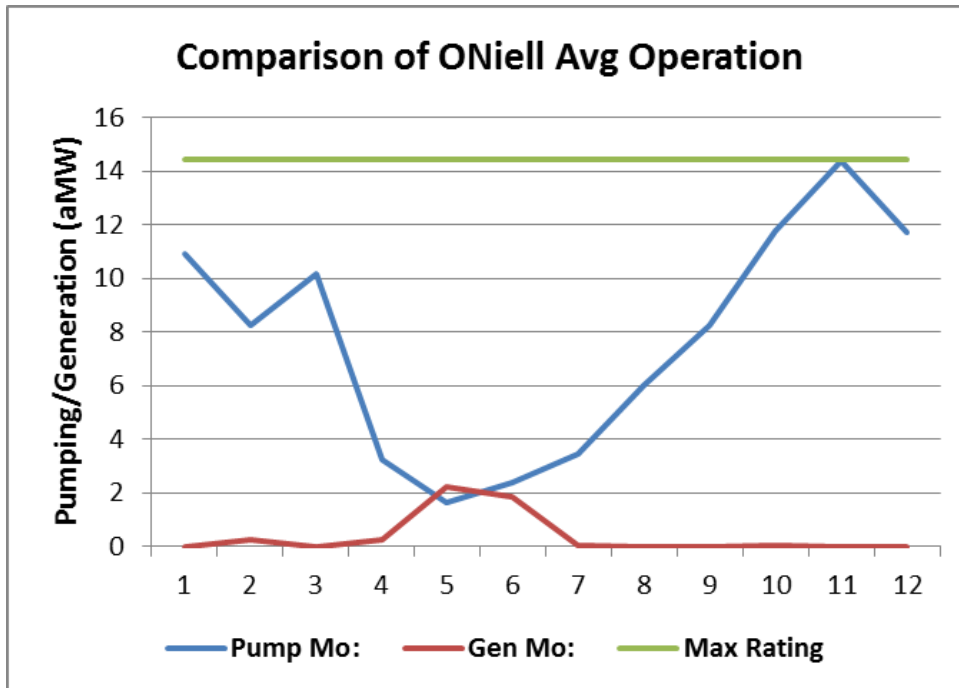
- O'Neill: Model as pumping load
- Hyatt (Lake Oroville) & Thermalito: Model as Hydro plant
- Flatiron: Model as pumping load
- Waddell: Model as Hydro plant
- Grand Coulee PS: Don't model
 - Seven year avg CF 1.8%
 - Project current under going its first upgrading
 - Evaluate yearly

- Question on PS

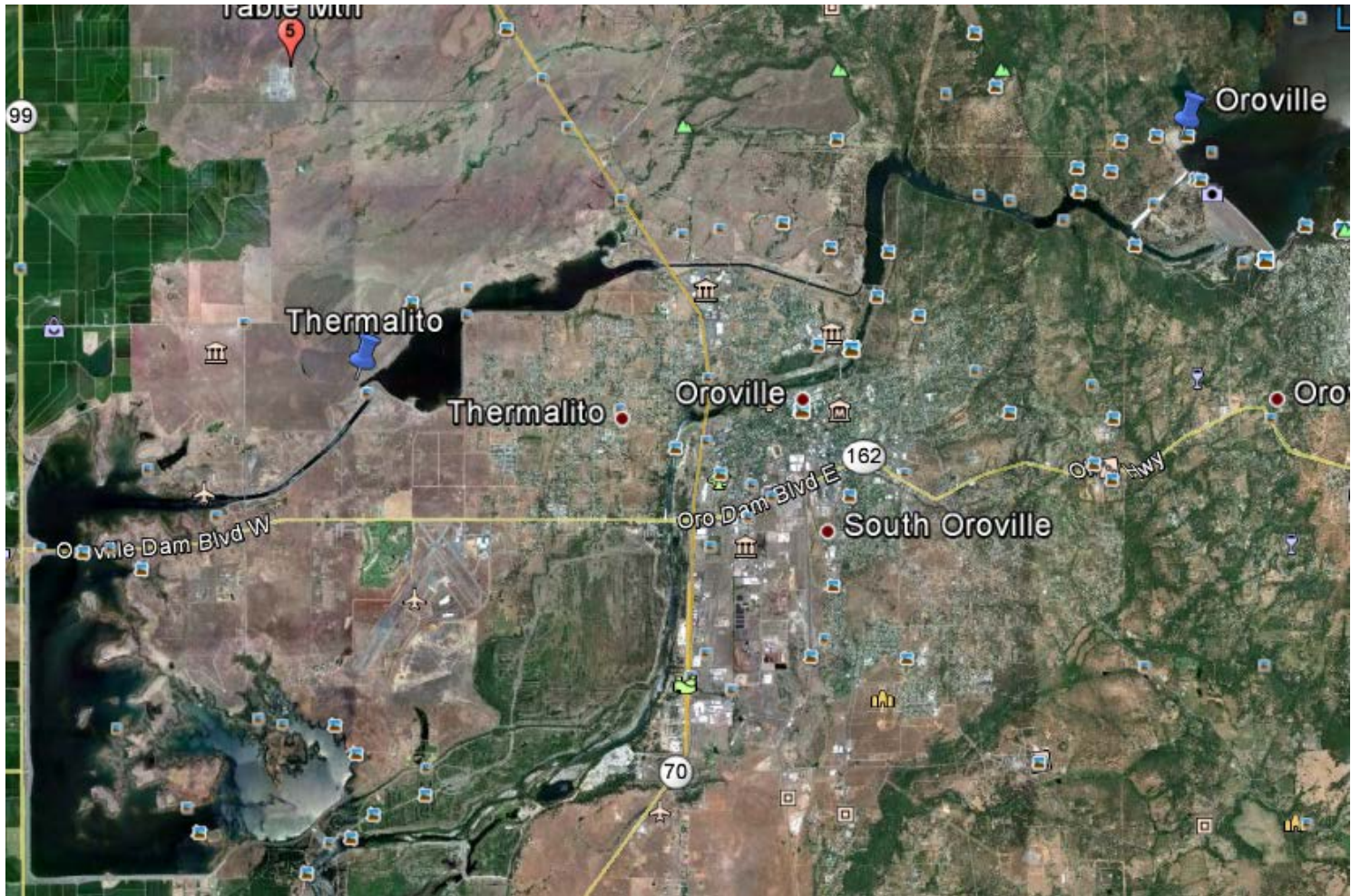
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Appendix

- Historic CF
 - Pumping: 53.4%
 - Generation: 2.7%



Hyatt/Thermalito



Not Operated as PS #1

- Hyatt (Lake Oroville)
 - Over the last 9 years the of operation Hyatt average 4,000 MWh of pumping load per year
 - Average pumping load is equal to about 13 hours of pumping/year
 - PS units are operated as conventional Hydro units to manage peak flow
- Thermalito
 - Over the last 9 years the of operation Thermalito average 3,600 MWh of pumping load per year
 - Average pumping load is equal to about 12 hours of pumping/year
- Model Hyatt and Thermalito as Hydro facilities

Not Operated as PS #2

- Flatiron – In CO operated by USBR
 - 2006-12 average pumping load 34,909 MWh (47% CF)
 - 2006-12 average generation 1,782 MWh (2.4% CF)
 - Always positive value with little to no pumping
 - Model as a pumping load
- Waddell (Central Arizona Water Conservation)
 - No pumping load from 2006-12 or net negative generation
 - Model as a Hydro plant with 13.2% CF

Coulee PS

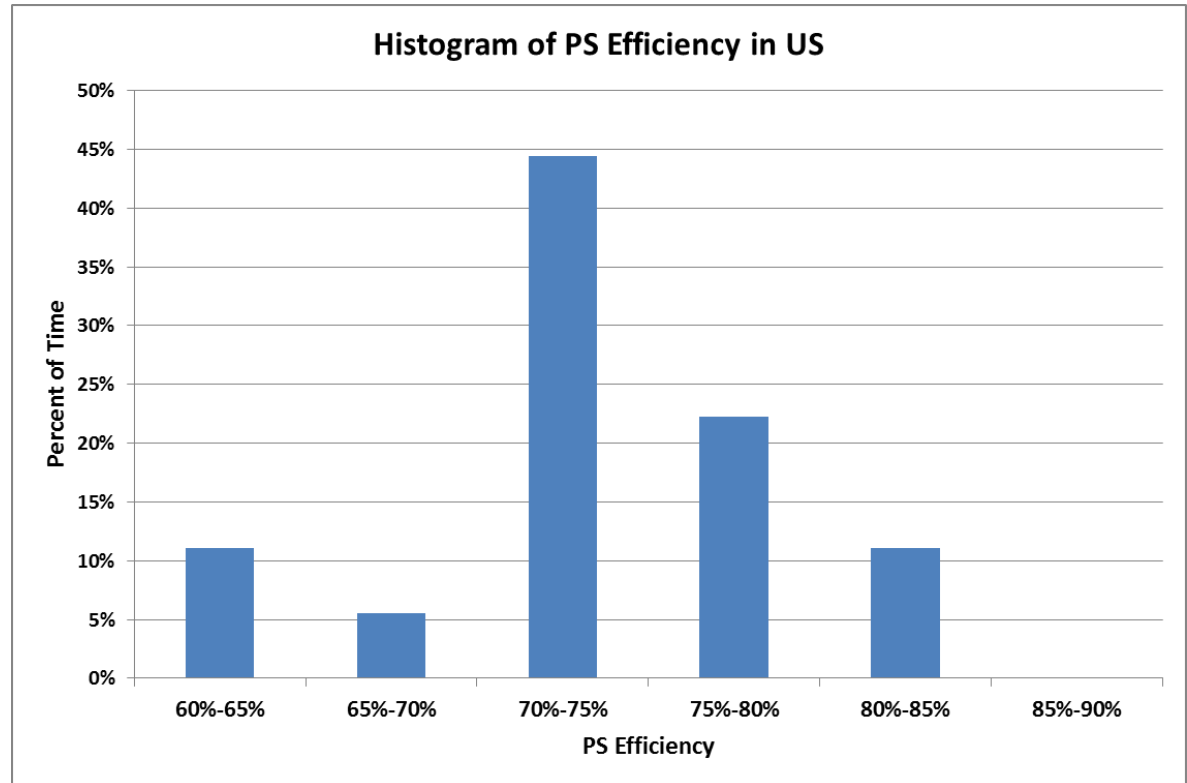
- Water is pumped from Grand Coulee reservoir to Banks Lake.
- Consist of 6xPumps and 6xPS Units (314 MW)
- Operated primary as pumping plant
- Generation of CF 1.8% (2006-12)
- Generation mode required manually switching & no pumping



Generic PS Efficiency

- Average 17 PS across the US to determine the generic operational PS efficiency

- Avg: 73.1%
- Median 73.5%
- StDev 6.2%
- Min 60.1%
- Max 80.8%



- EIA data can found at:
- <http://www.eia.gov/cneaf/electricity/page/data.html>
- Key report to be familiar with are
- EIA-860: Annual Electric Generator Report
 - Contains: Existing, Proposed and Retired plants (US Only).
- EIA-923: Utility, Non-Utility, and Combined Heat & Power Plant Data Files.

Data in file “EIA Schedules 2_3_4_5 Final”

- **Tab “Page 1 Generation and Fuel Data”**
 - Contains PS data
 - Cons: Plant level data only
 - Pros: Data by prime mover and fuel type by plant
- The first section of data contains PS Pumping energy
 - Header description “Total Quantity Consumed in Physical Units...”
- The last section of data contains Net PS generation
 - Header description “Electricity Net Generation (MWh)”