RECLAMATION

Managing Water in the West

Natural Flow And Salt Computation Methods

Fall 2005 meeting
Colorado River Forecasting Service
November 22, 2005

U.S. Department of the Interior
Bureau of Reclamation

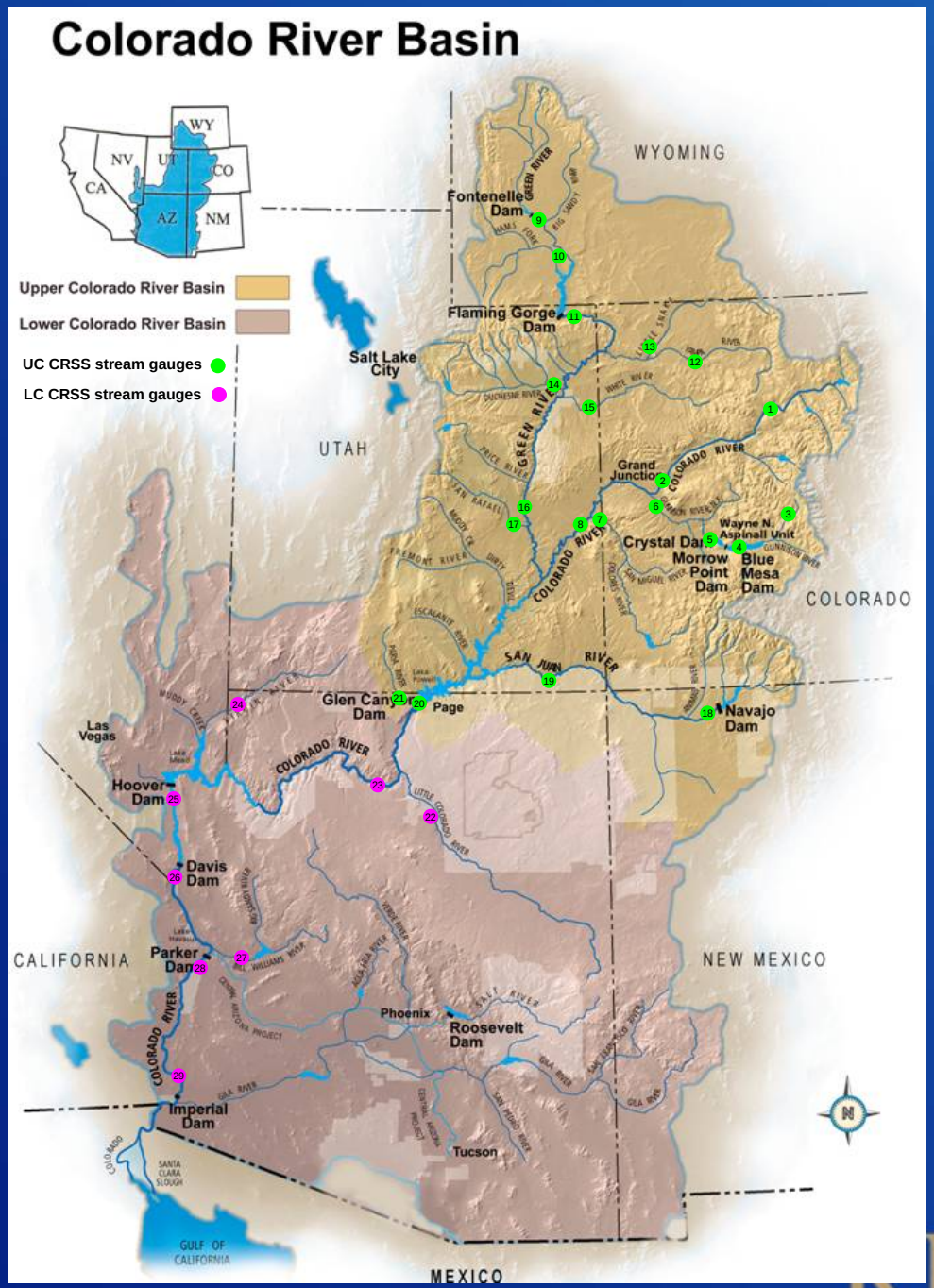
Why Recompute Natural Flow ?

- Natural flow is required input for CRSS
- Addressing Data Inconsistencies
  - Recomputing natural flow from 1971-03

    Natural Flow = Historic Flow

    + Consumptive Uses and Losses

    +/- Reservoir Regulation
- Addressing Methodological Inconsistencies
  - RiverWare model computes natural flow
    - Ensures consistency
- Limited Documentation



Natural Flow Nodes

- CRSS inputs
- 29 inflow locations
  - 20 Upper Basin
  - 9 Lower Basin

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Natural Flow Nodes – Upper Basin

Site	Gauge Number	Gauge Name
1	09072500	Colorado River near Glenwood Springs, Colorado
2	09095500	Colorado River near Cameo, Colorado
3	09109000	Taylor River below Taylor Park Reservoir, Colorado
4	09124700	Gunnison River below Blue Mesa Reservoir, Colorado
5	09127800	Gunnison River at Crystal Reservoir
6	09152500	Gunnison River near Grand Junction, Colorado
7	09180000	Dolores River near Cisco, Utah
8	09180500	Colorado River near Cisco, Utah
9	09211200	Green River below Fontenelle Reservoir, Wyoming
10	09217000	Green River near Green River, Wyoming
11	09234500	Green River near Greendale, Utah
12	09251000	Yampa River near Maybell, Colorado
13	09260000	Little Snake River near Lily, Colorado
14	09302000	Duchesne River near Randlett, Utah
15	09306500	White River near Watson, Utah
16	09315000	Green River at Green River, Utah
17	09328500	San Rafael River near Green River, Utah
18	09355500	San Juan River near Archuleta, New Mexico
19	09379500	San Juan River near Bluff, Utah
20	09380000	Colorado River at Lees Ferry, Arizona

Natural Flow Nodes – Lower Basin

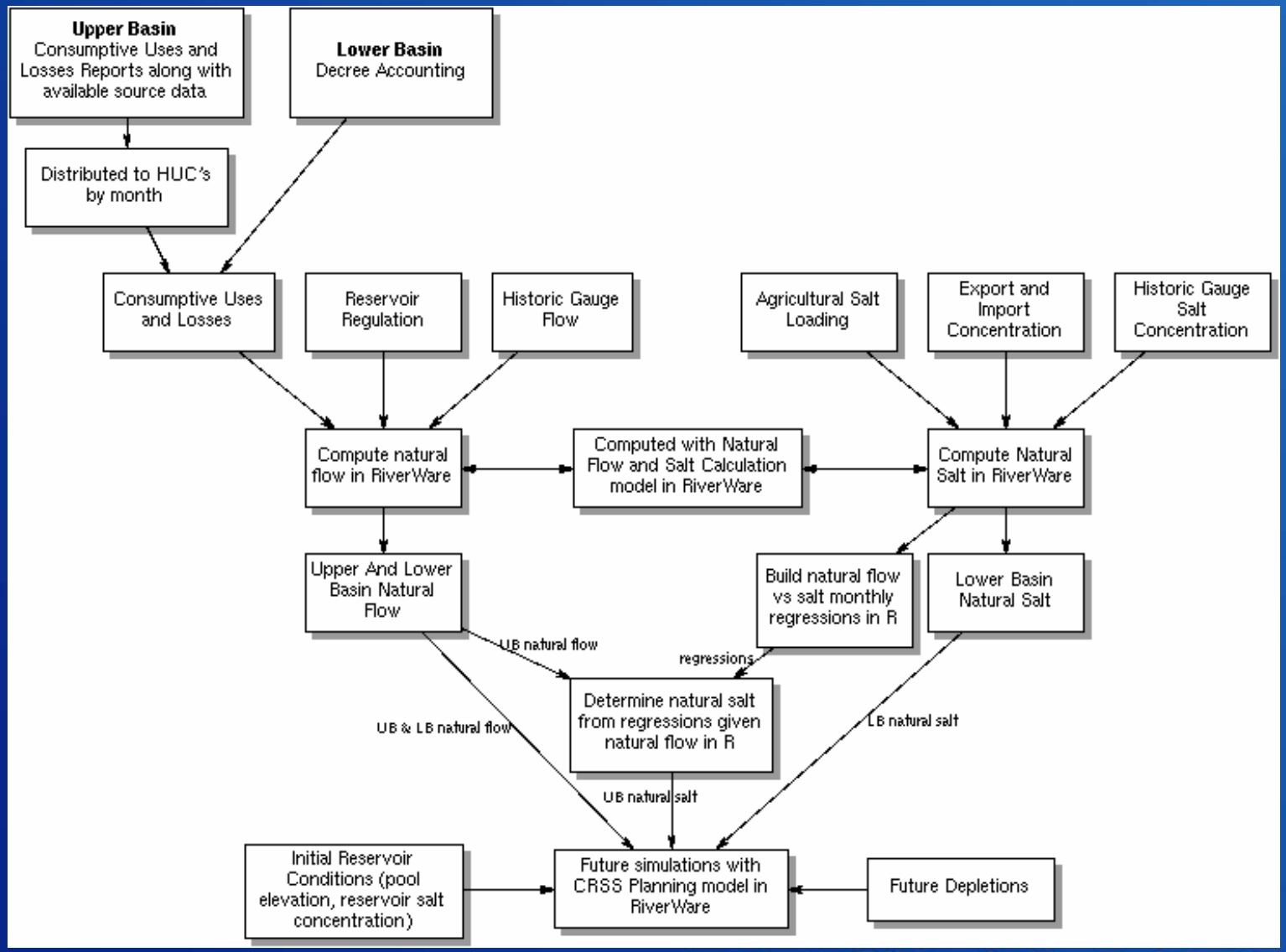
- Computed Gains

Site	Reach Number	Gauge Number	Gauge Name
23	1	09402500	Colorado River Near Grand Canyon, AZ
25	2	09421500	Colorado River Below Hoover Dam, AZ-NV
26	3	09423000	Colorado River Below Davis Dam, AZ-NV
28	4	09427520	Colorado River Below Parker Dam, AZ-CA
29	5	09429490	Colorado River Above Imperial Dam, AZ-CA

- Historic Inflows

Site	Reach Number	Gauge Number	Gauge Name
21	1	09382000	Paria River at Lees Ferry, AZ
22	1	09402000	Little Colorado River Near Cameron, AZ
24	2	09415000	Virgin River at Littlefield, AZ
27	4	09426000	Bill Williams River Below Alamo Dam, AZ

Computing Natural Flow Scheme



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Basic Model Inputs

- Historic USGS gauge data
  - 29 gauges
- Historic main-stem reservoir outflow and pool elevations
  - 12 main-stem reservoirs
- Historic off-stream reservoir change in storage
  - 25 off-stream reservoirs
- Consumptive uses and losses
  - 9 categories in Upper Basin
  - Decree Data in Lower Basin

Main-stem reservoirs

- Fontenelle
- Flaming Gorge (includes bank storage)
- Taylor Park
- Blue Mesa
- Morrow Point
- Crystal
- Navajo
- Lake Powell (includes bank storage)
- Lake Mead (includes bank storage)
- Lake Mohave
- Lake Havasu

Off-stream reservoirs

Reservoir Name	HUC	State
Shadow Mountain	14010001	Colorado
Granby	14010001	Colorado
Willow Creek	14010001	Colorado
Williams Fork	14010001	Colorado
Wolford	14010001	Colorado
Dillon	14010002	Colorado
Green Mountain	14010002	Colorado
Homestake	14010003	Colorado
Reudi	14010004	Colorado
Vega	14010005	Colorado
Silver Jack	14020002	Colorado
Paonia	14020004	Colorado
Fruitgrowers	14020005	Colorado
McPhee	14030002	Colorado
Meeks Cabin	14040107	Wyoming
Moon Lake	14060002	Utah
Steinaker	14060002	Utah
Starvation	14060004	Utah
Strawberry[1]	14060004	Utah
Solider Creek[2]	14060004	Utah
Scofield	14060007	Utah
Joes Valley	14060009	Utah
Vallecito	14080101	Colorado
Lemon	14080104	Colorado
Jacksons Gulch	14080107	Colorado

[1] This became Solider Creek in the 1980's.

[2] Starts in September 1983. This was Strawberry before the expansion.

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Upper Basin

- Consumptive Uses and Losses
  - Irrigated Agriculture
  - Reservoir Evaporation
  - Stock ponds
  - Livestock
  - Thermal Power
  - Minerals
  - Municipal and Industrial
  - Exports/Imports
- Required data files
  - 823 diversion points

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Lower Basin

- Decree Accounting
  - Records complied in accordance with Article V of the Decree of the Supreme Court of the United States in Arizona v. California dated March 9, 1964
  - Total diversion
  - Total consumptive use
    - We account for unmeasured returns
- Required data files
  - 52 diversion points

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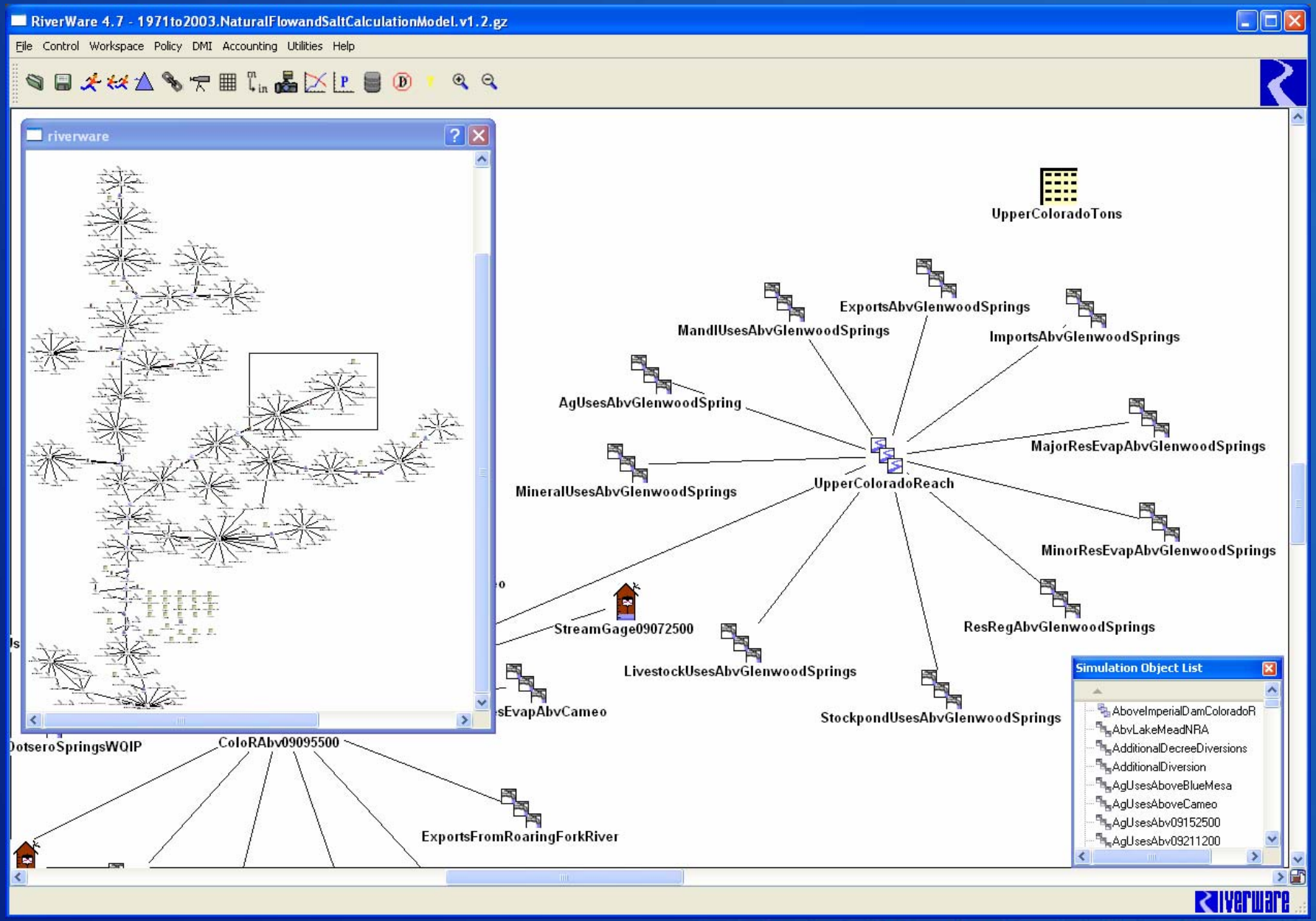

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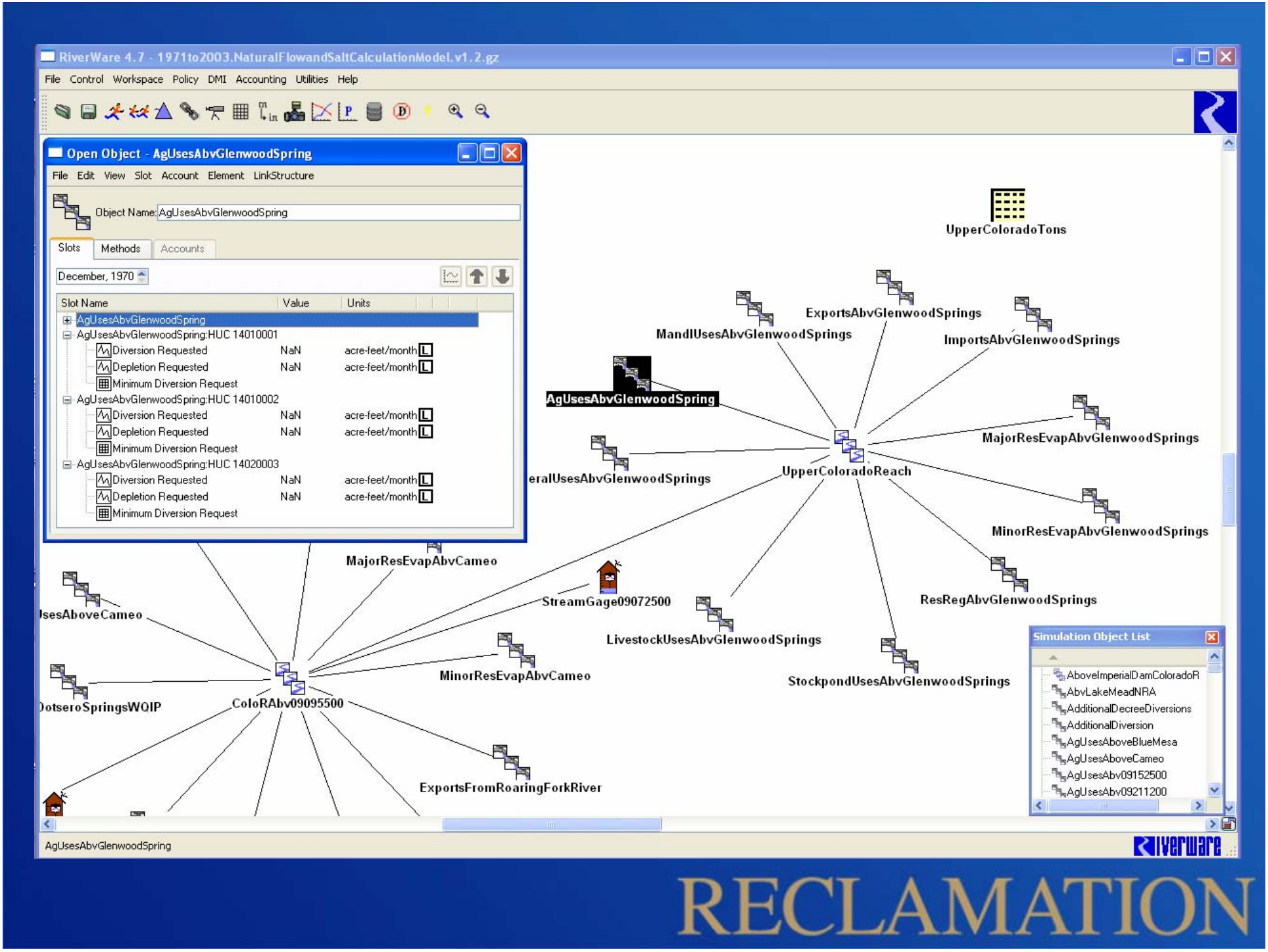

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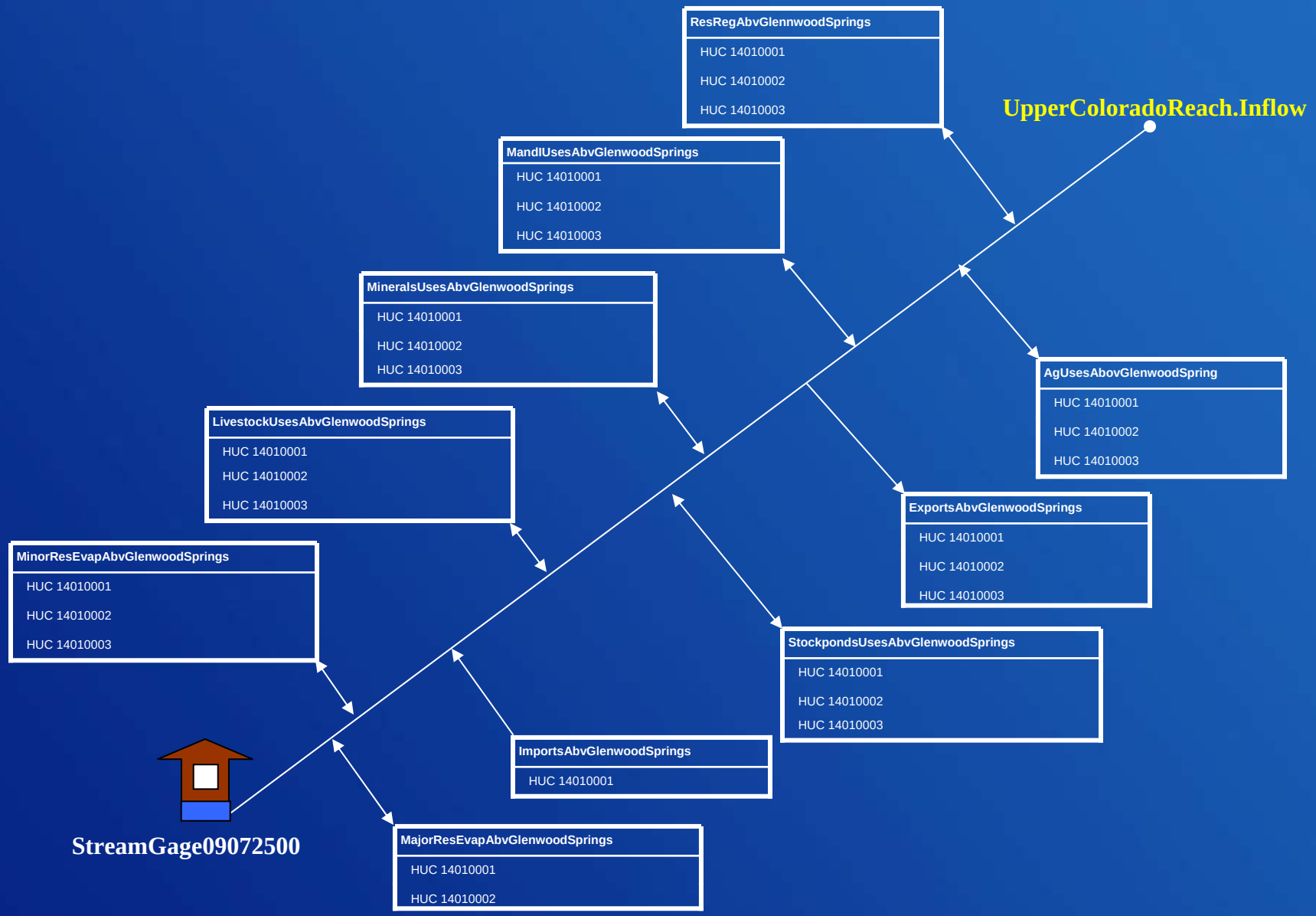
Above Glenwood Springs Reach



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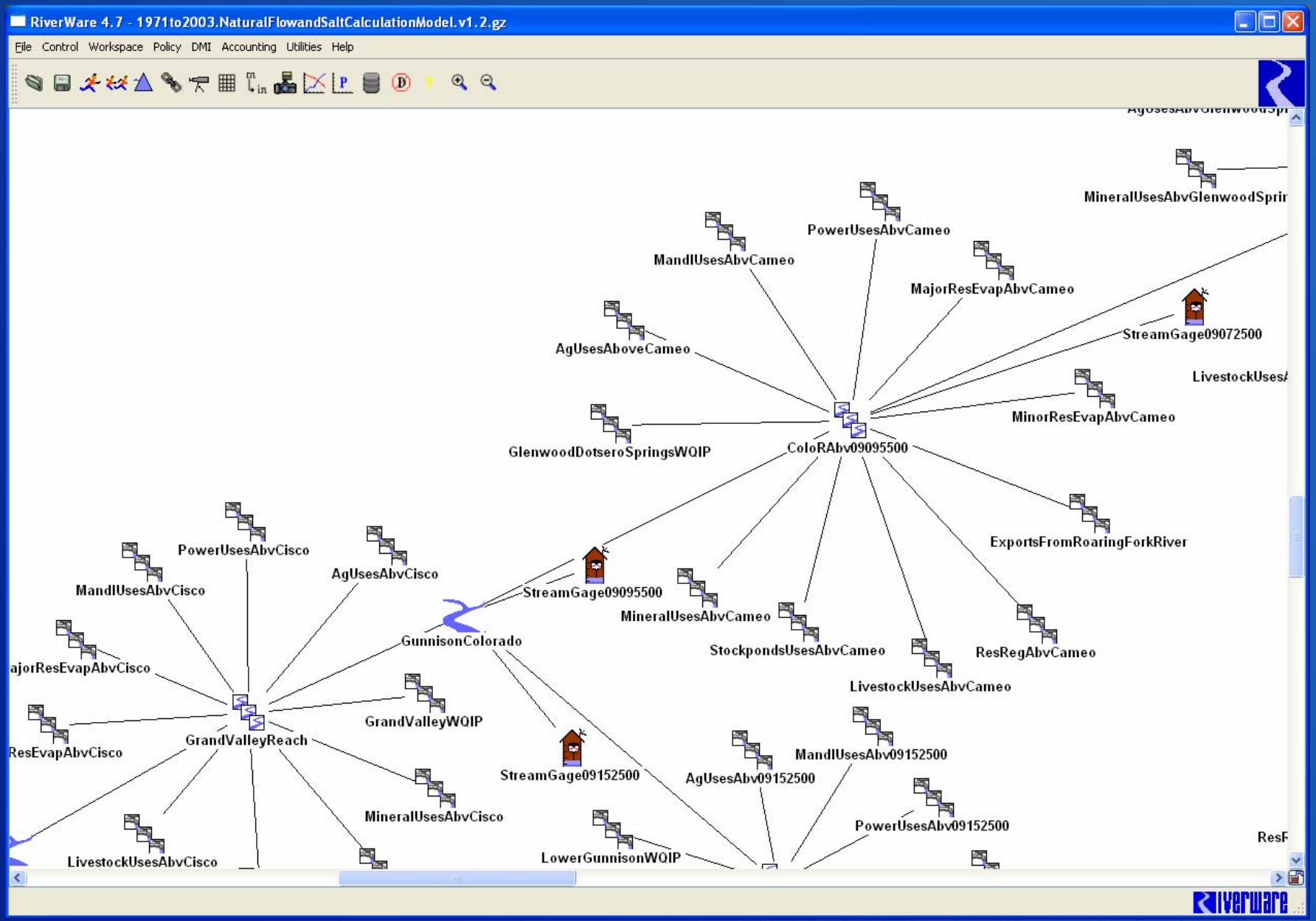
Glenwood Springs to Cameo Reach



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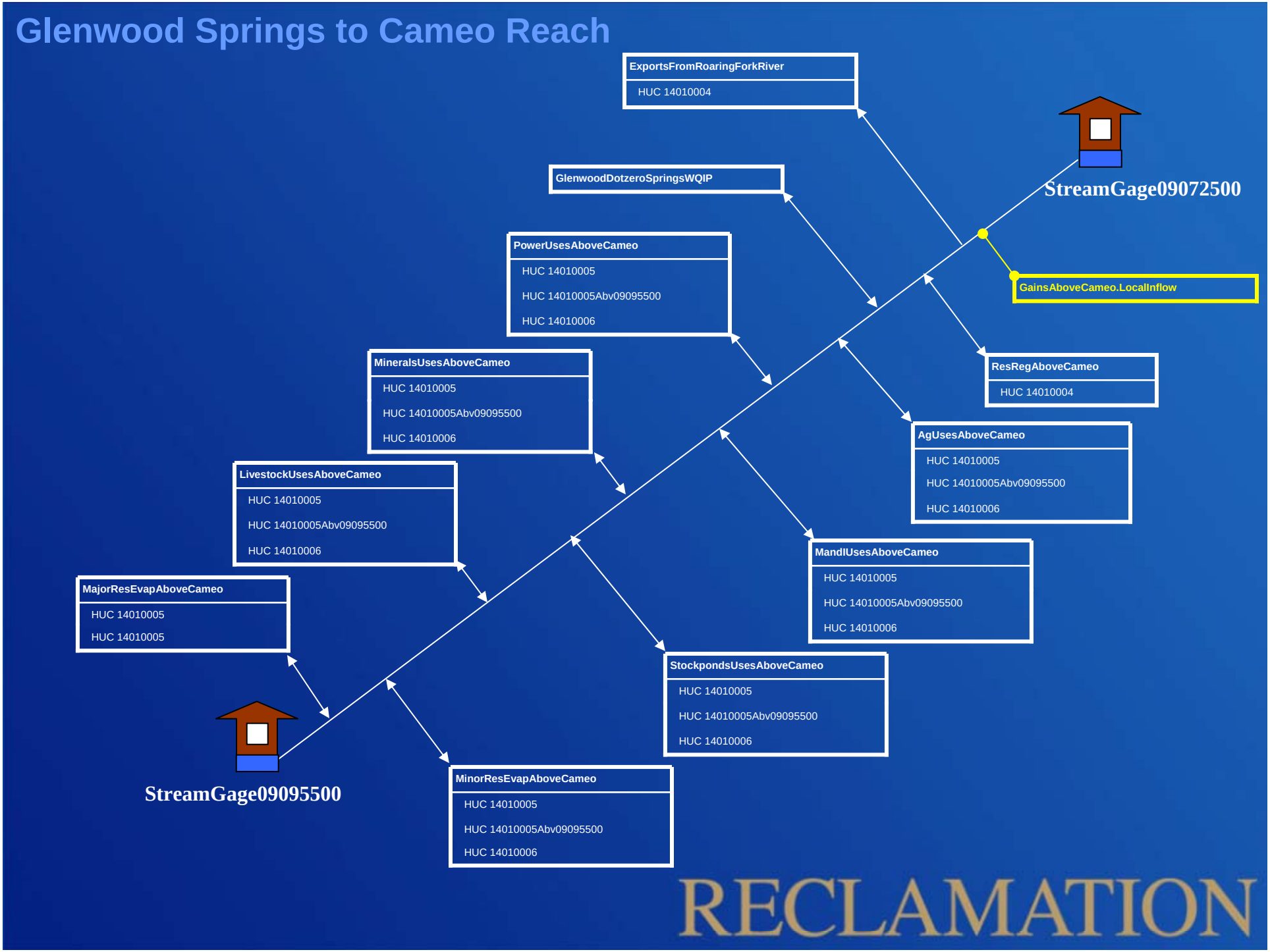
Glenwood Springs to Cameo Reach



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Calculating Natural Flow in the Lower Basin

- Lower Basin split into five (5) reaches
- A natural intervening flow gain (Reach Gain) is calculated in each reach to account for:
  - historic streamflow gained or lost
  - error associated with the calculation
- Reach Gain =

  + End of Reach Gauged Flow

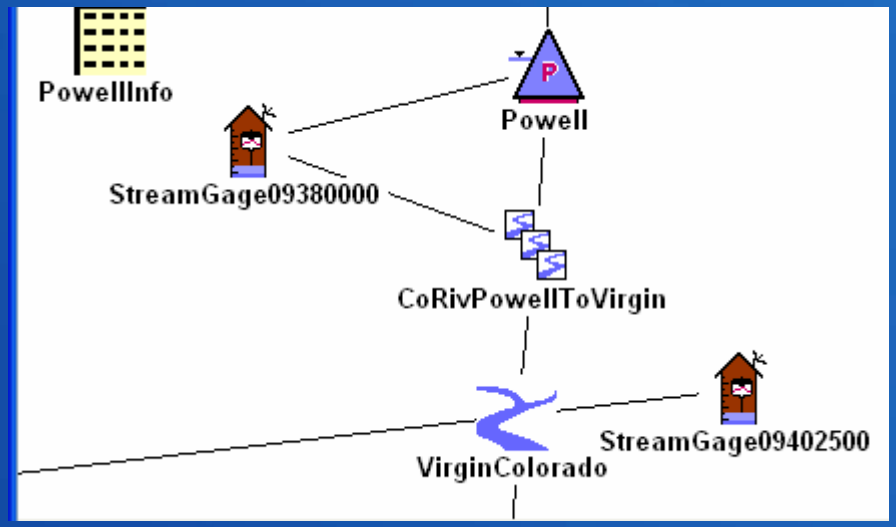
  - Beginning of Reach Gauged Flow

  - Tributary Inflow

  + Depletions

  + / - Reservoir Regulation

Lees Ferry to Grand Canyon Reach



StreamGage09380000

PariaGains.LocalInflow

LittleCoR.LocalInflow

GainsAboveGC.LocalInflow

StreamGage09402500

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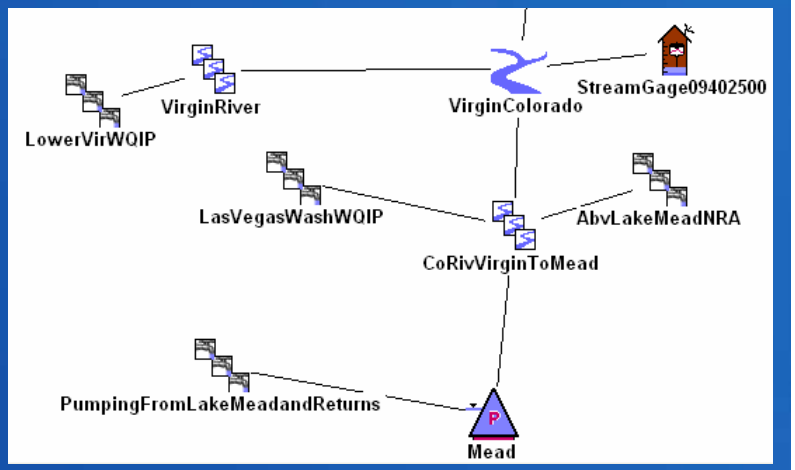
Grand Canyon to Hoover Reach



StreamGage09402500

VirginRiver
- VirginRiver.Inflow
- LowerVirginWQIP

LasVegasWashWQIP

PumpingFromLakeMeadandReturns
- BoulderCanyonProject
- RoberBGriffithWaterProject
- LasVegasValleyWaterDistSaddleIsle
- BasicManagementInc
- CityofHendersonDivatSaddleIsle
- NVDeptofFishAndGame
- CityofBoulderCityDivatHoover
- PacificCoastBuildingProductsInc
- NellisAirForceBaseDivSaddleIsle
- CityofNorthLasVegasDivSaddleIsle
- LasVegasWashReturnFlows

AbvLakeMeadNRA
- TempleBarAZ
- LakeMeadNV

GainsAboveHoover.LocalInflow

Lake Mead
- Change in storage
- Change in bank storage
- Evaporation

Hoover Dam

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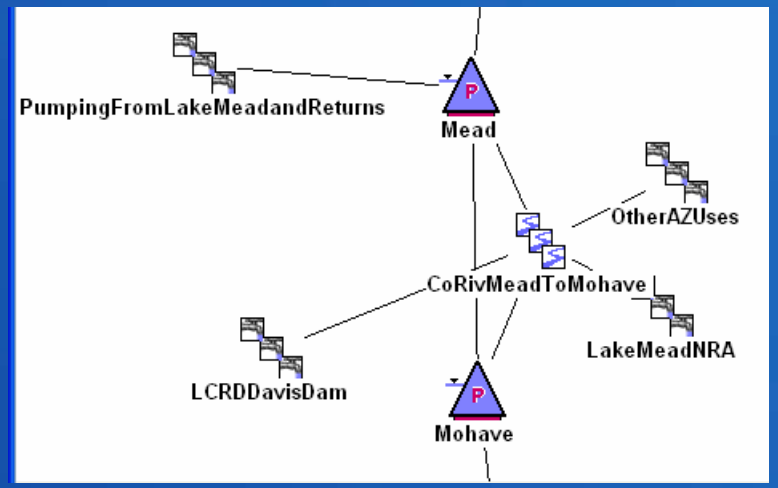
Hoover to Davis Reach



Hoover Dam

LakeMeadNRA
- LakeMohaveNV
- LakeMohaveAZ

GainsAboveDavis.LocalInflow

OtherAZUses
- OtherAZUsersBelowHooverDam

LCRDDavisDam

Lake Mohave
- Change in storage
- Evaporation

Davis Dam

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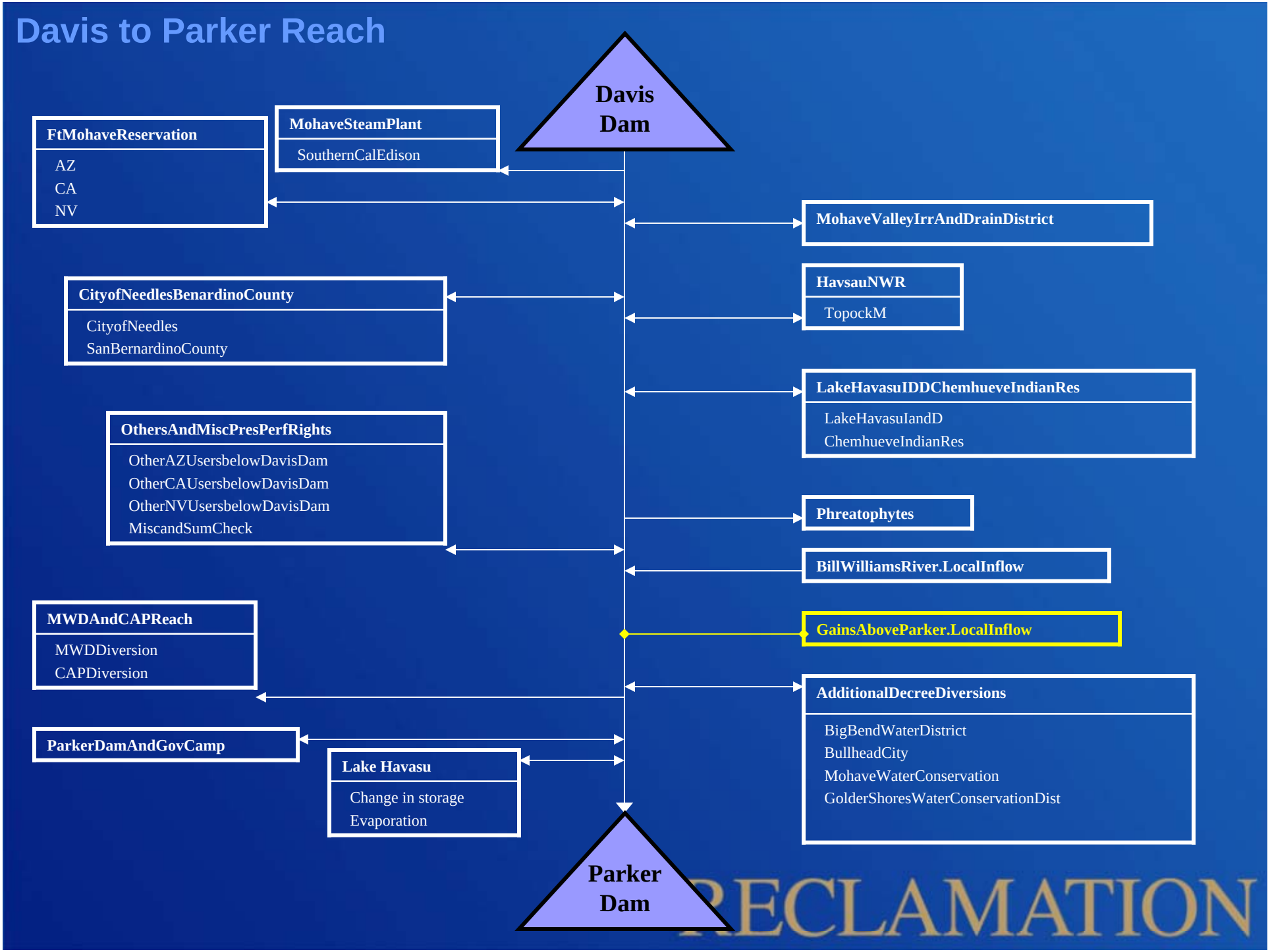
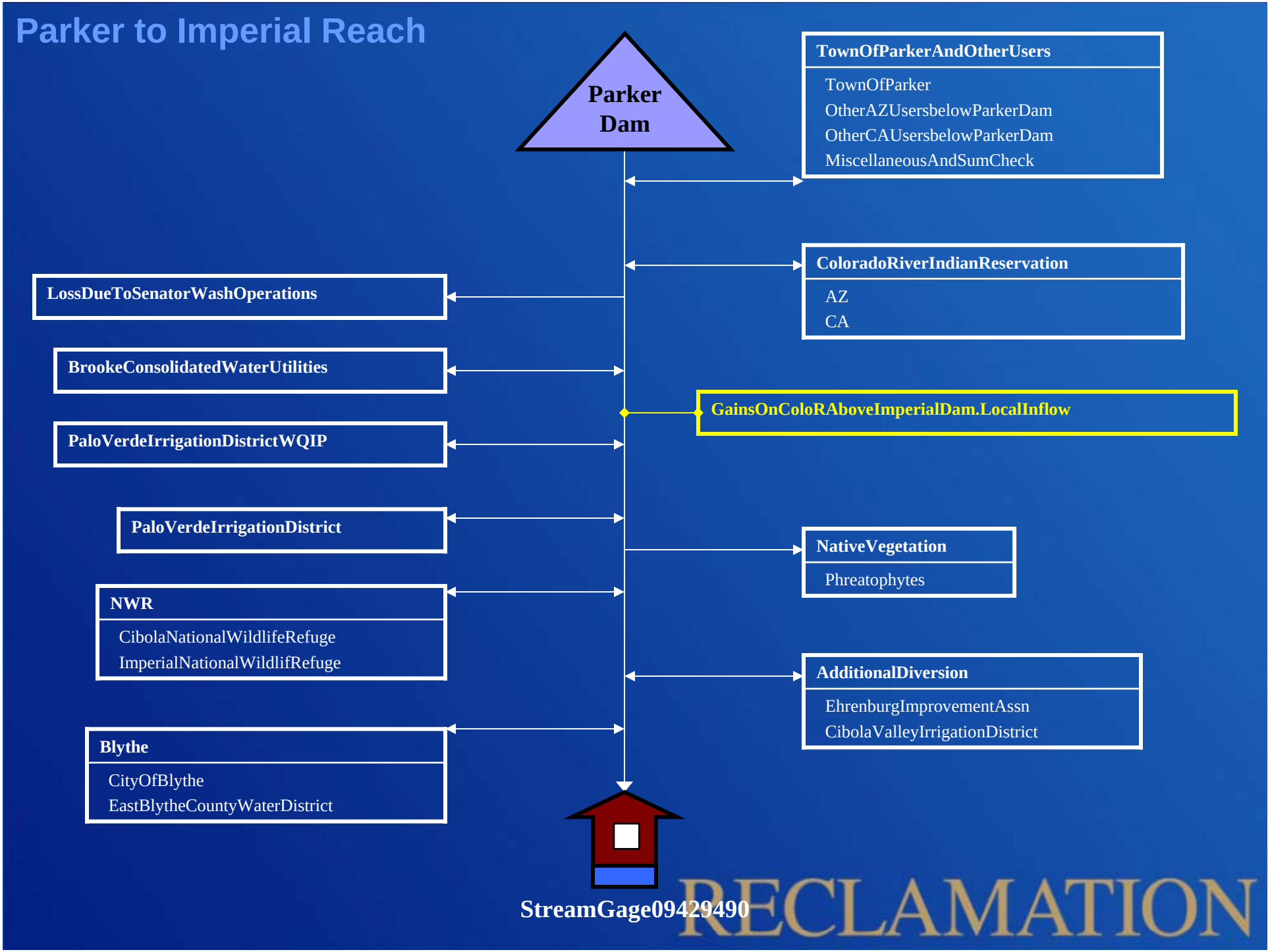
Davis to Parker Reach



Parker to Imperial Reach

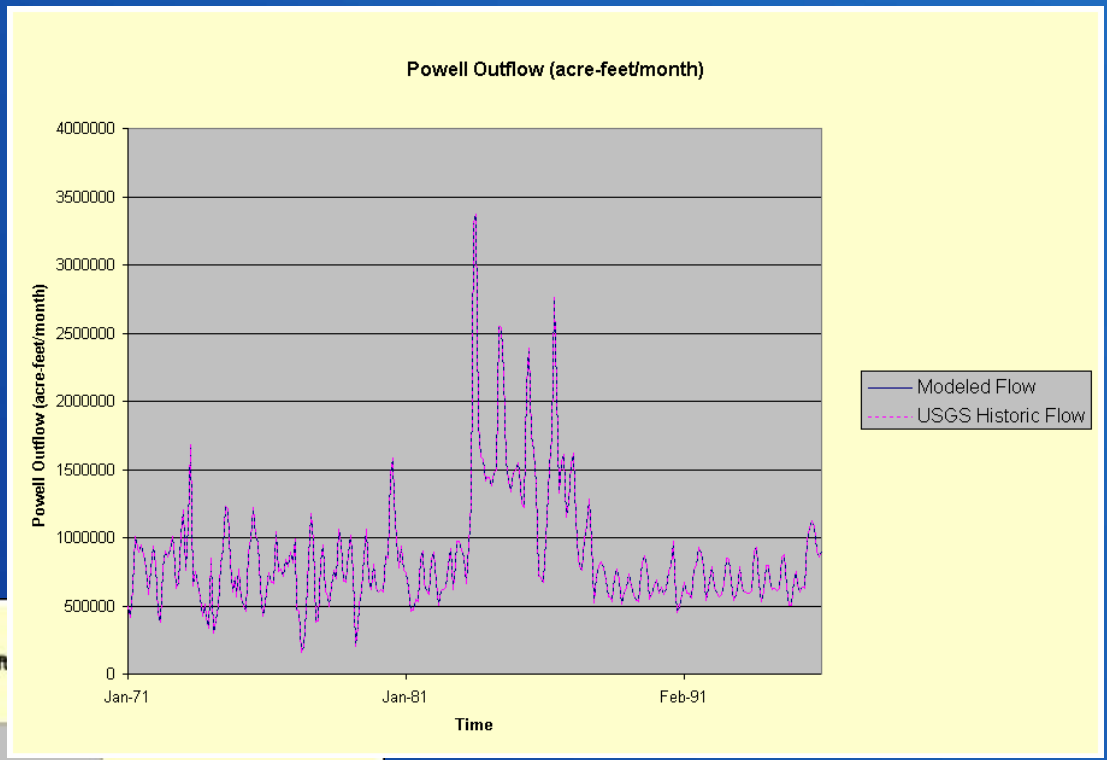


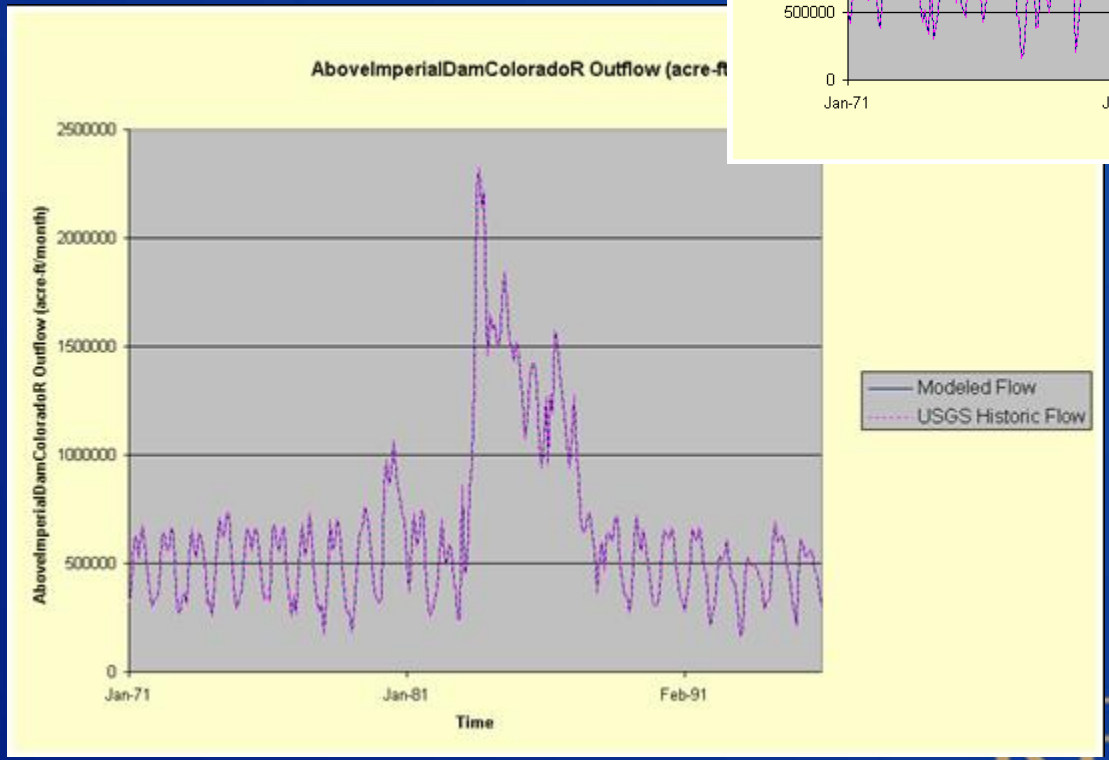
Model Outputs

- Natural flow for each reach
  - 20 reaches in the Upper Basin
  - 9 reaches in the Lower Basin
- Output from model via
  - DMI to HDB
  - .rdf file

Verifying Model Results

- After data input :Output following
  - Historic Gauges
  - CU and L data
  - Reservoir Regulation
- Verify data is same as that input
- Run natural flow model in reverse
  - Check that gauge data is simulated exactly





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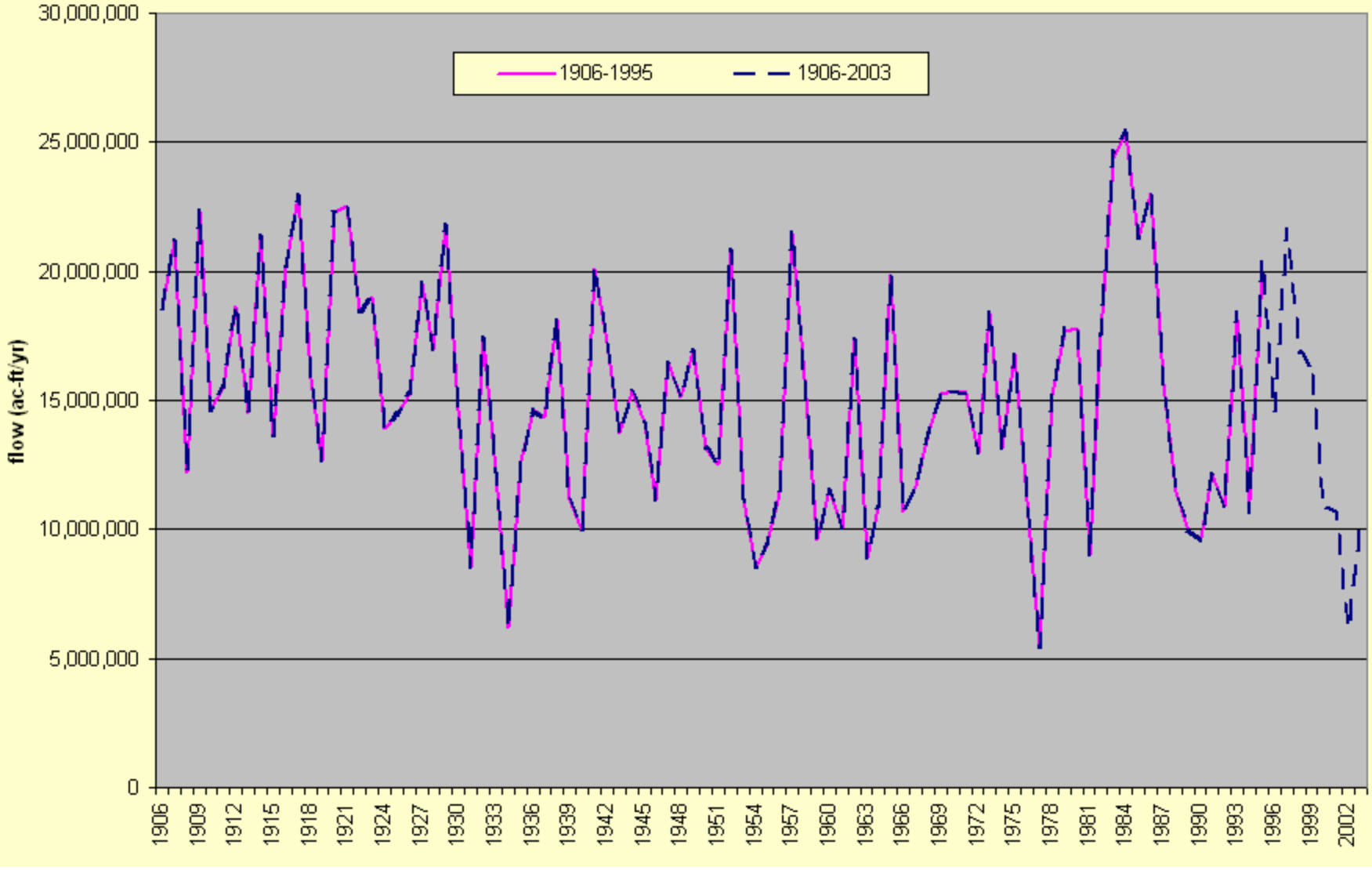

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Publications

- Clayton, R., (2004). “Upper Colorado River Consumptive Use Determination at CRSS Natural Flow Node Locations CY 1971-1995.”
- Prairie, J. et al., (2005). “Statistical Nonparametric Model for Natural Salt Estimation” ASCE Journal of Environmental Engineering, 131(1), 130-138.
- Prairie, J., and Callejo, R., (2005). “Natural Flow And Salt Computation Methods 1971-1995”
- Reclamation, (2004). “Colorado River System Consumptive Uses and Losses Report 1996-2000”
- Reclamation, (2005). “Upper Basin Consumptive Uses and Losses Report as Revised After Peer Review 1971-1995.”
- Reclamation, (2005). “PROVISIONAL Colorado River System Consumptive Uses and Losses Report 2001-2005”

Extra Slides follow

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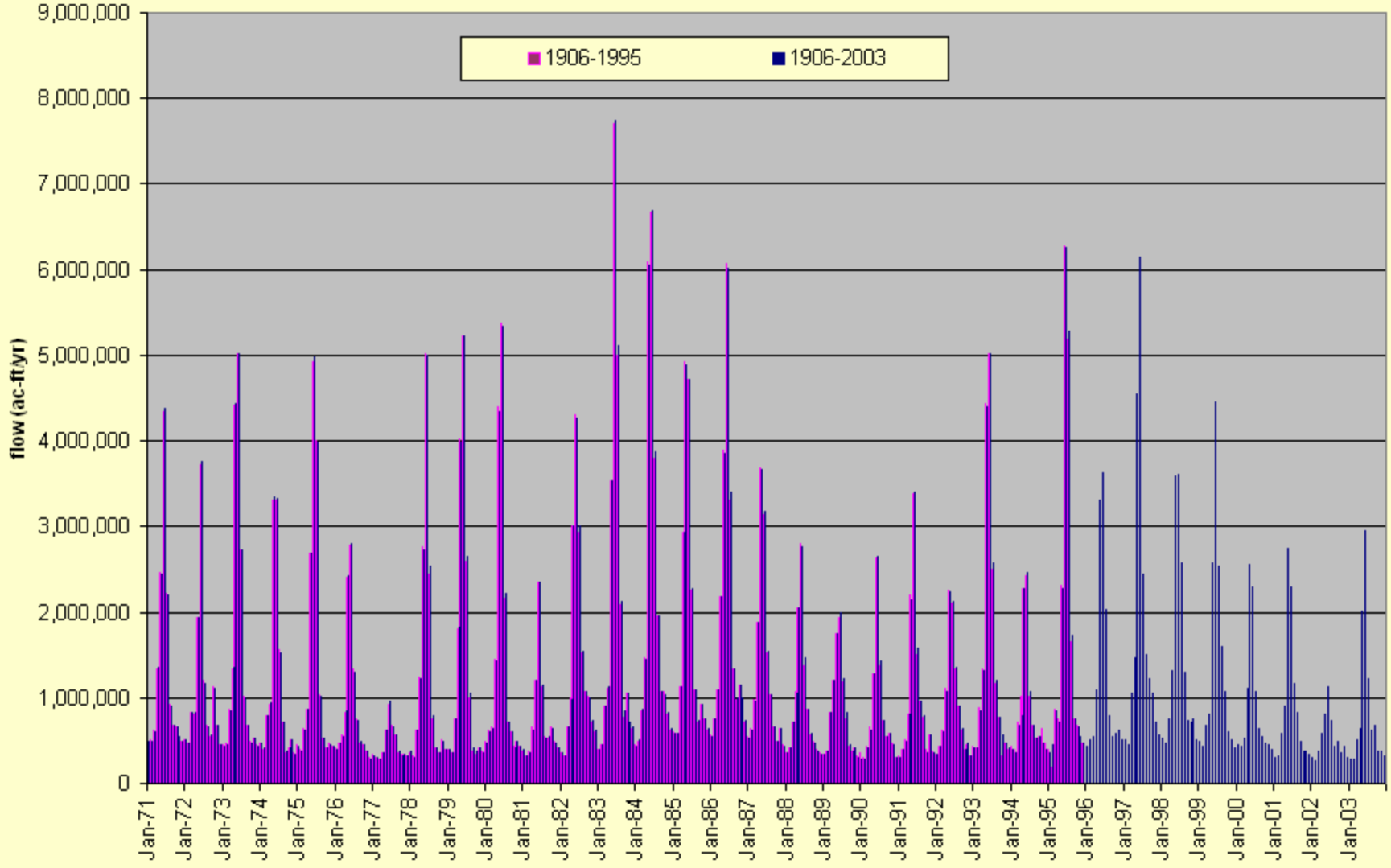

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Planning Model Assumptions

- Future water use (depletion) schedules:
  - Lower Basin at 7.5 maf per year for normal years; surplus schedules in effect for surplus years[1]
  - Upper Basin at 4.45 maf per year in 2005, ramping up to 4.93 MAF by 2025[1]
  - Republic of Mexico at 1.5 maf per year; up to 1.7 maf per year during flood control years

[1] Final Environmental Impact Statement for the Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions; available at www.usbr.gov/lc/region

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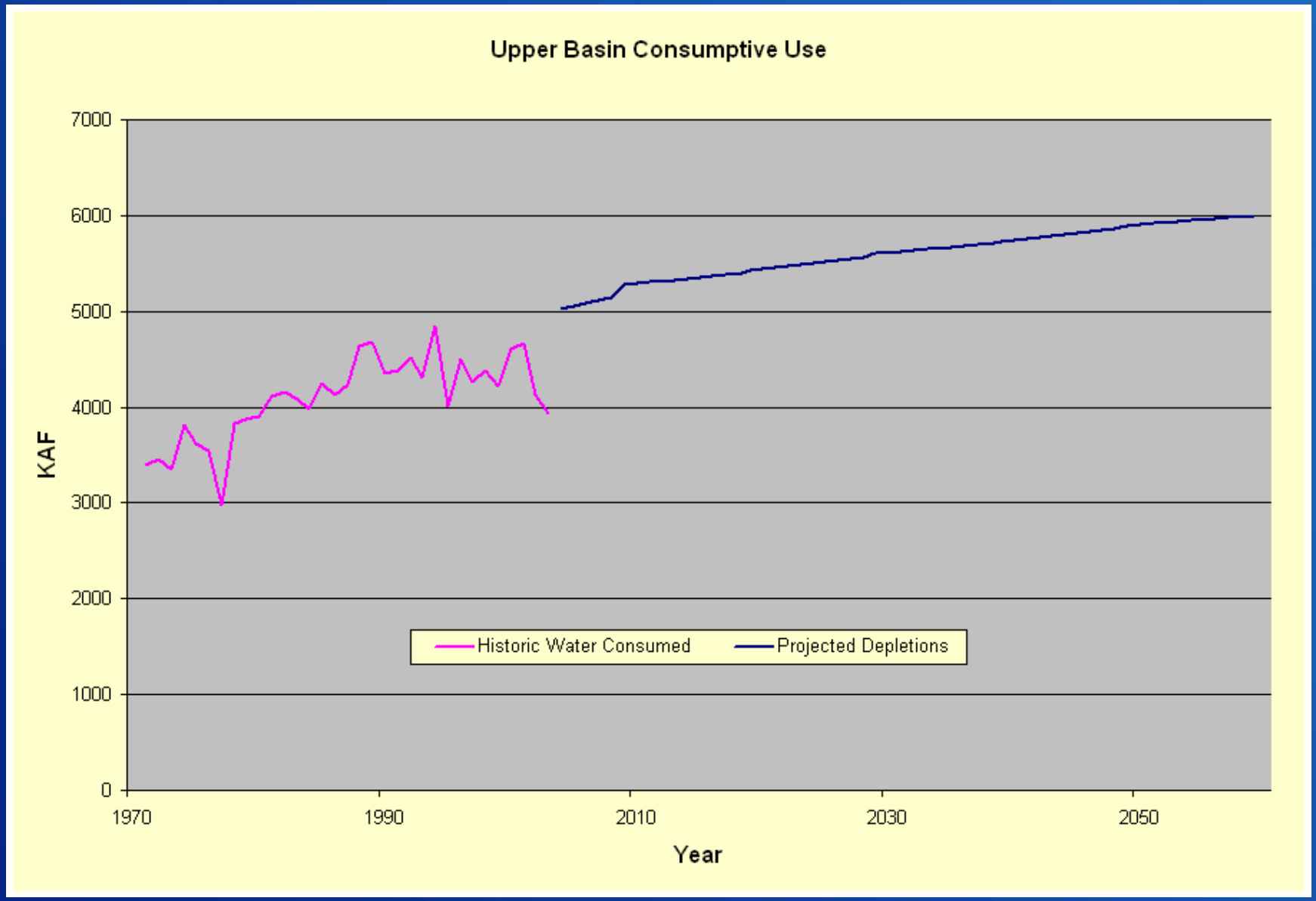

Consumptive Use includes CRSP reservoirs

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