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System Operator

Transmission Expansion Plan to Minimize Congestion Between Arizona, Nevada, and California

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California ISO

January 18, 2005



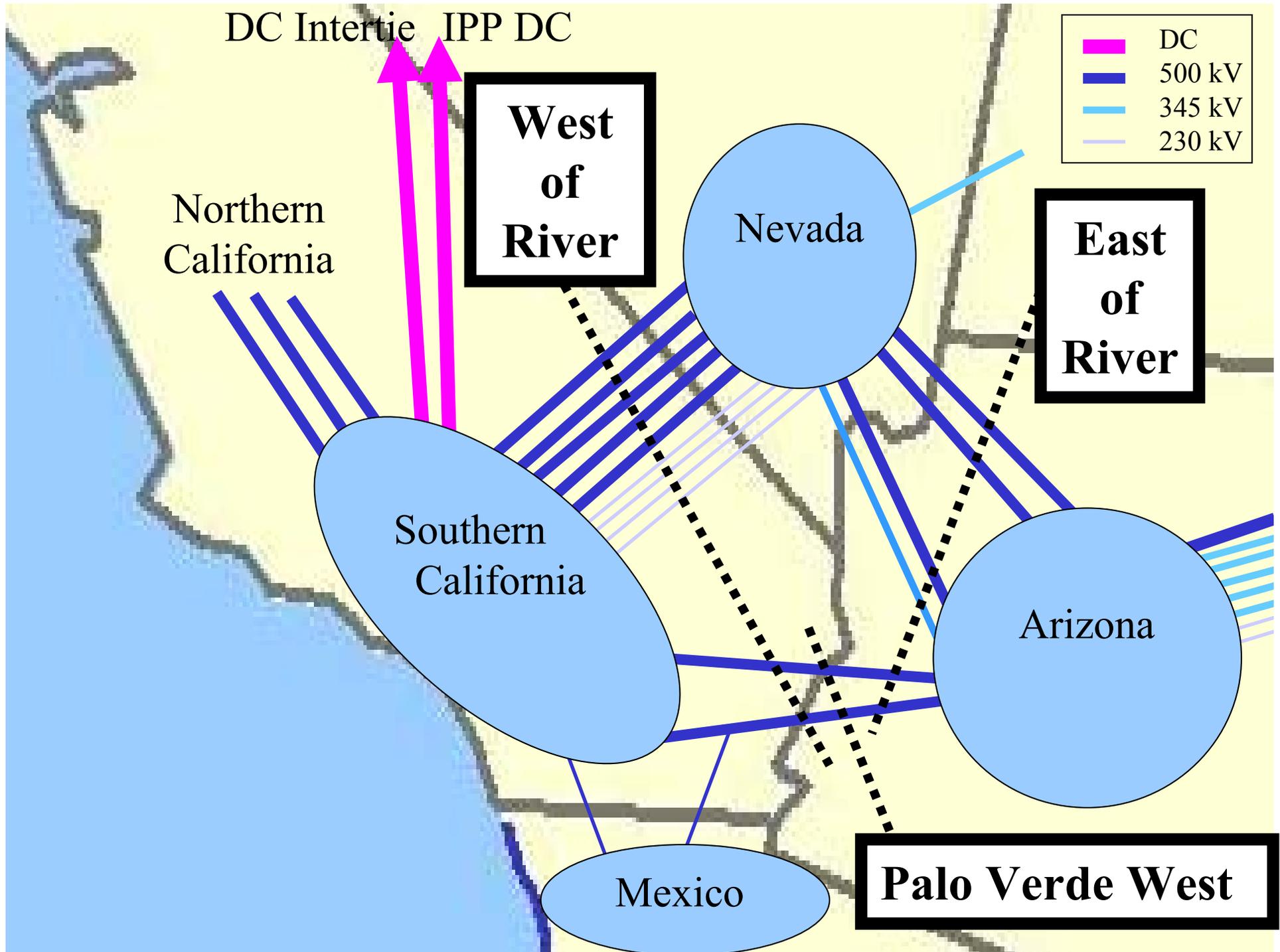
Methodology

- PLEXOS Production Cost Program
 - Conducts an hour by hour simulation for an entire year
 - Models the full network using a DC powerflow
 - Assumes that the nonlinear system is linear
 - No vars, just MW so all ratings are in MW
 - Voltage and stability limits have to be translated to MW limits
 - Goal is to minimize production cost (fuel and variable O&M)
- Many simplifying assumptions - no wheeling rates, no losses, no unit commitment
- To ease analysis, chronological line flows are reordered by magnitude to create flow duration curves



What Can We Learn From Flow Duration Curves

- Able to view an entire year of operation rather than a snapshot like in a power flow case
- Provides useful insight into the ratings that planners study and achieve
- Provides useful insights into the interaction between different projects and different interfaces (i.e., the effect on WOR of an increase in EOR)
- Useful for planning projects (line ratings, series comp levels, etc.)
- Helps in understanding economic study results





Assumptions

- 2008 SSG-WI assumptions with increased renewables in California
- Path 49 Upgrades
 - Palo Verde-Devers #1 Series Capacitors Upgraded
 - Hassayampa-North Gila-Imperial Valley Series Capacitors Upgraded
 - 2nd Devers 500/230 kV Transformer added
 - SVC added at Devers
- Miguel-Mission 230 kV line added
- East of River limited to 8,055 MW
- West of River Unconstrained



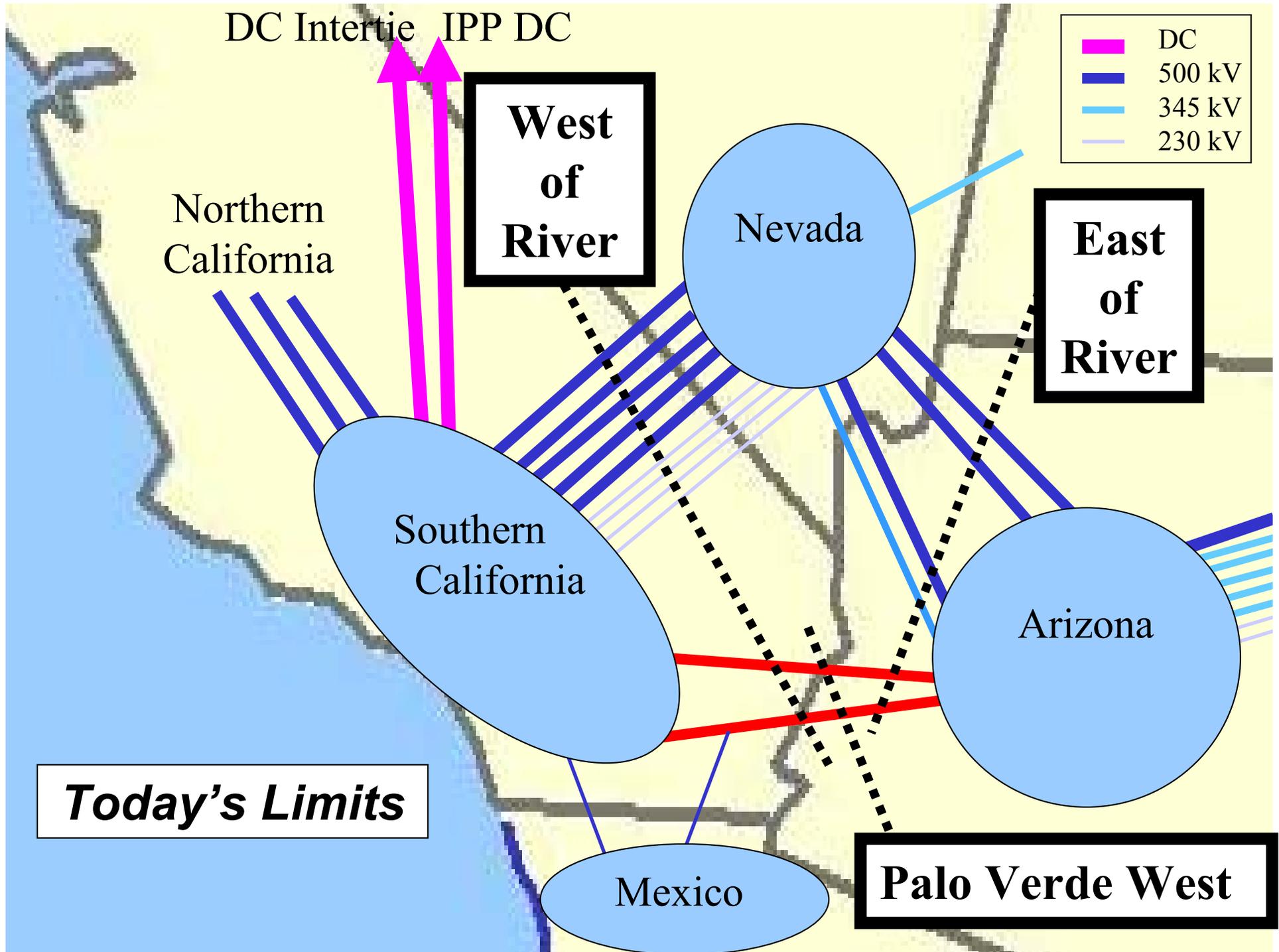
Assumptions (continued)

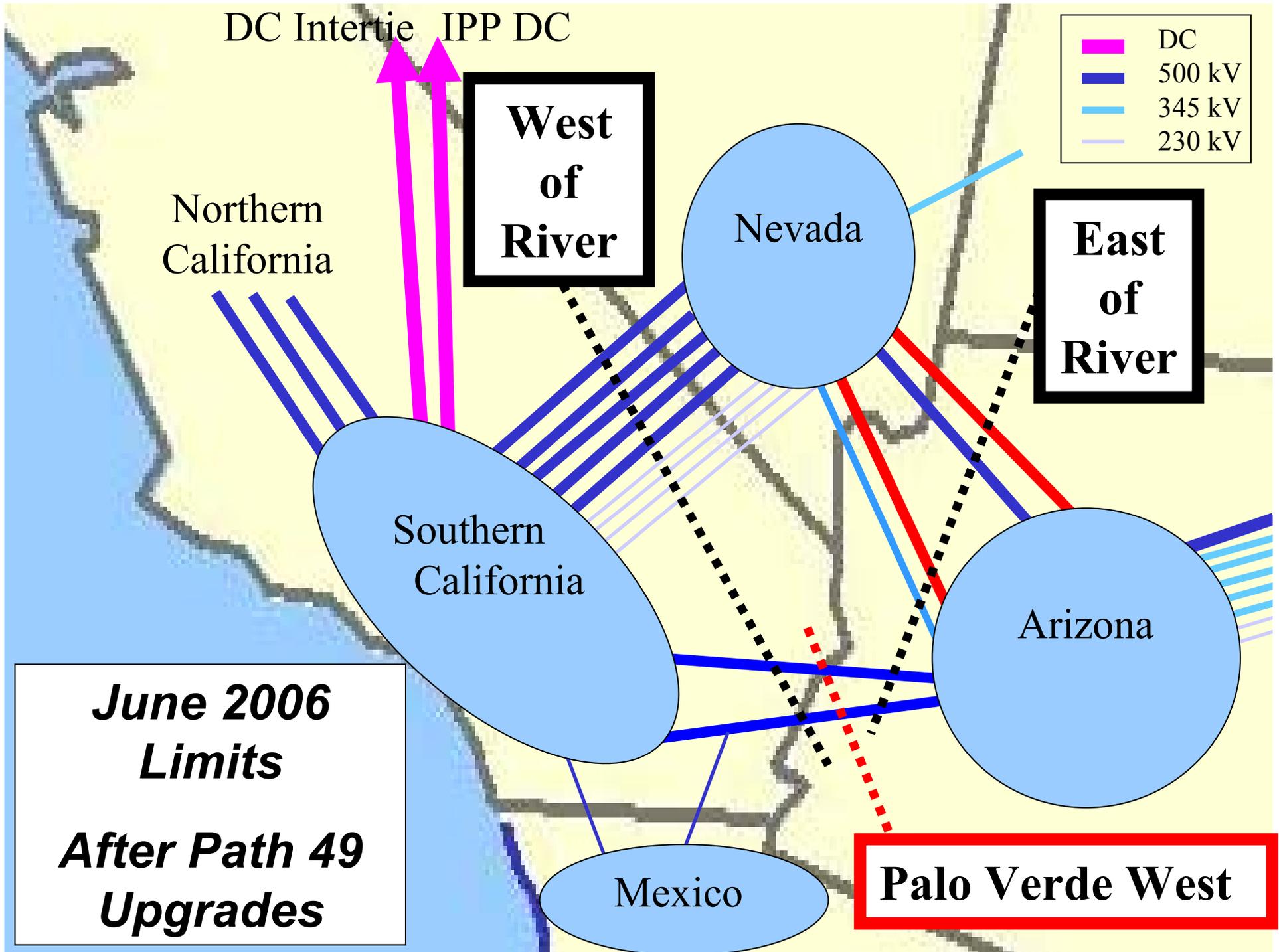
- Palo Verde West limited to 3600 MW
- All 500 kV line ratings are respected
- Mohave out of service
- Mountainview, Palomar, and Otay Mesa in-service
- Additional renewables in California to meet Renewable Portfolio Standard of 20%



Sequence Studied

- Step 1: Add EOR 9000 project (Mead-Perkins and Navajo-Crystal Upgrade)
- Step 2: Add Moenkopi-Eldorado series capacitor upgrade
- Step 3: Add Palo Verde-Devers #2





DC Intertie IPP DC

- DC
- 500 kV
- 345 kV
- 230 kV

**West
of
River**

**East
of
River**

Northern
California

Nevada

Southern
California

Arizona

***June 2006
Limits
After Path 49
Upgrades***

Mexico

Palo Verde West

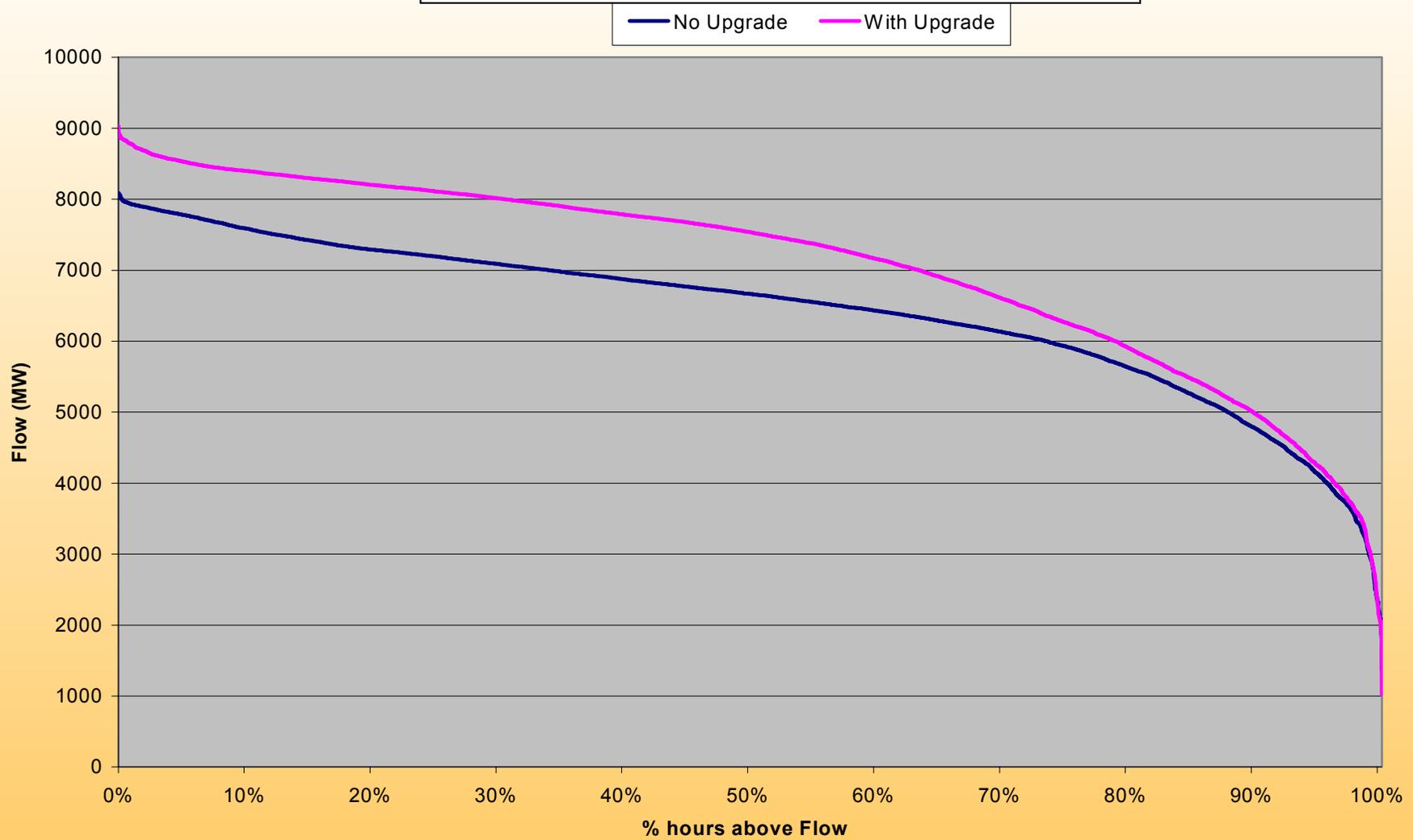


Step 1 - Implement EOR 9000

- Increased capability of Mead-Perkins from 1238 MW to 1905 MW
- Increased capability of Navajo-Crystal from 1411 MW to 1808 MW
- Increased East of River path rating from 8055 MW to 9300 MW

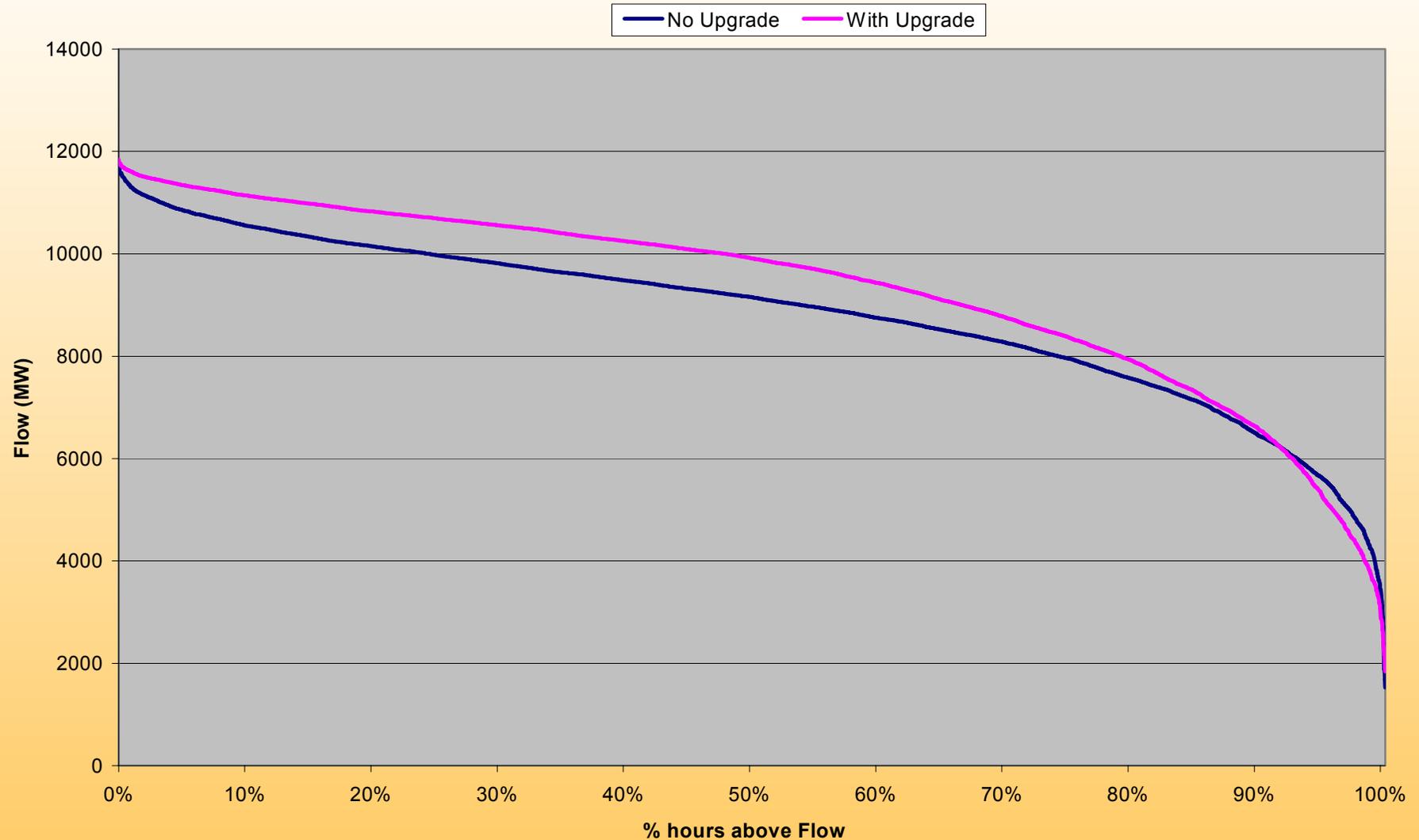


East of River





West of River



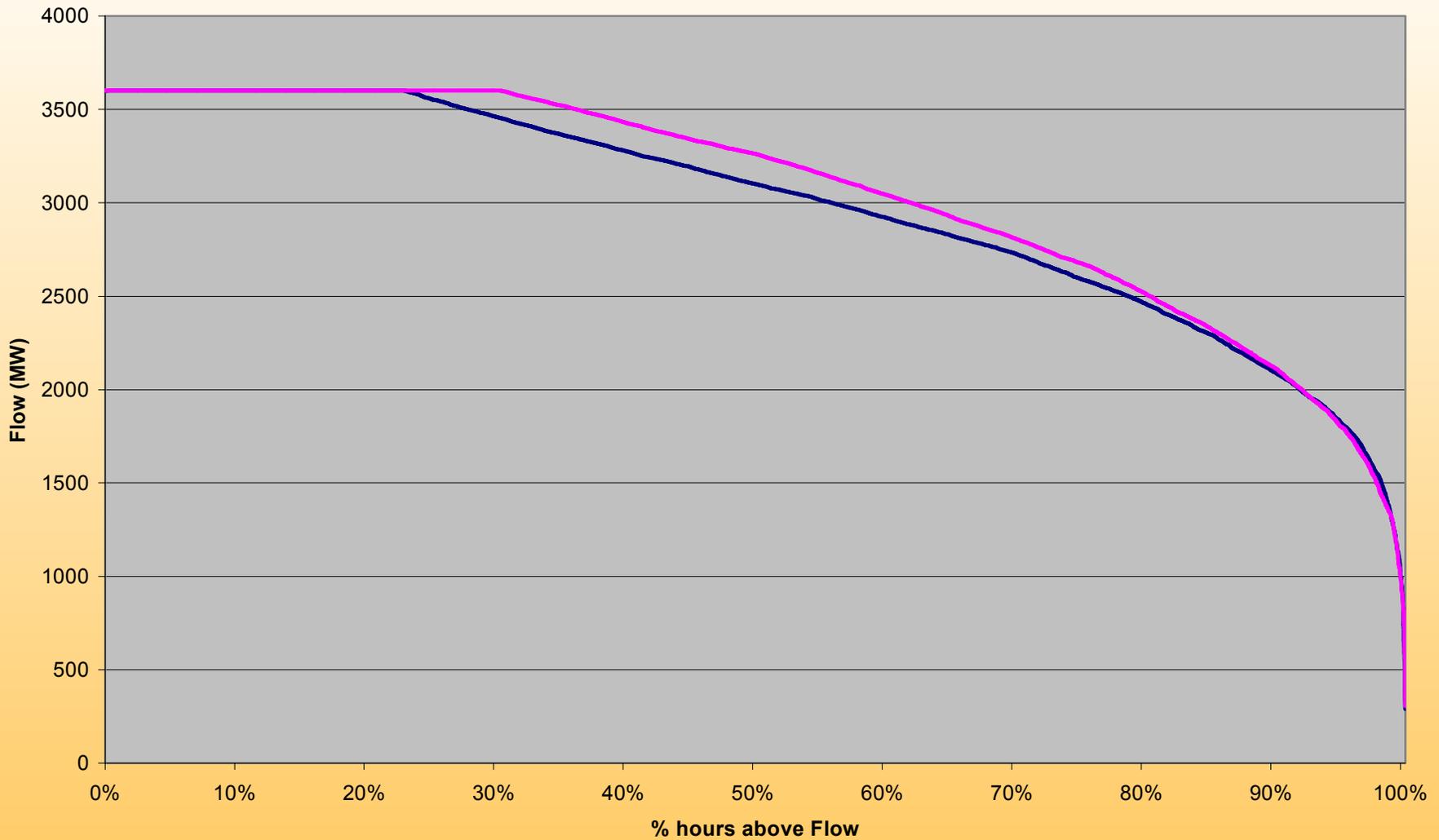


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Palo Verde West

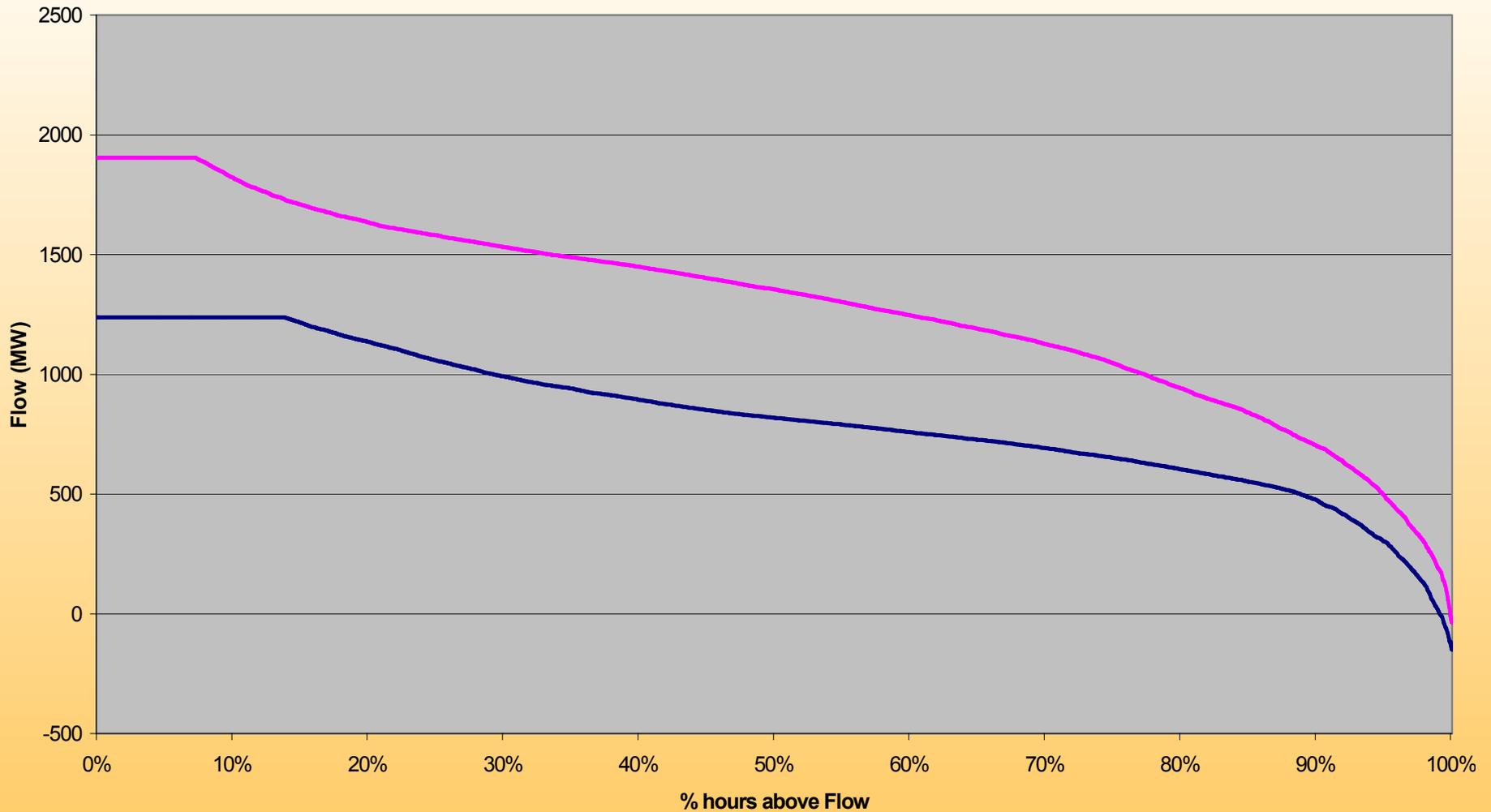
— No Upgrade — With Upgrade





Perkins-Mead 500 kV

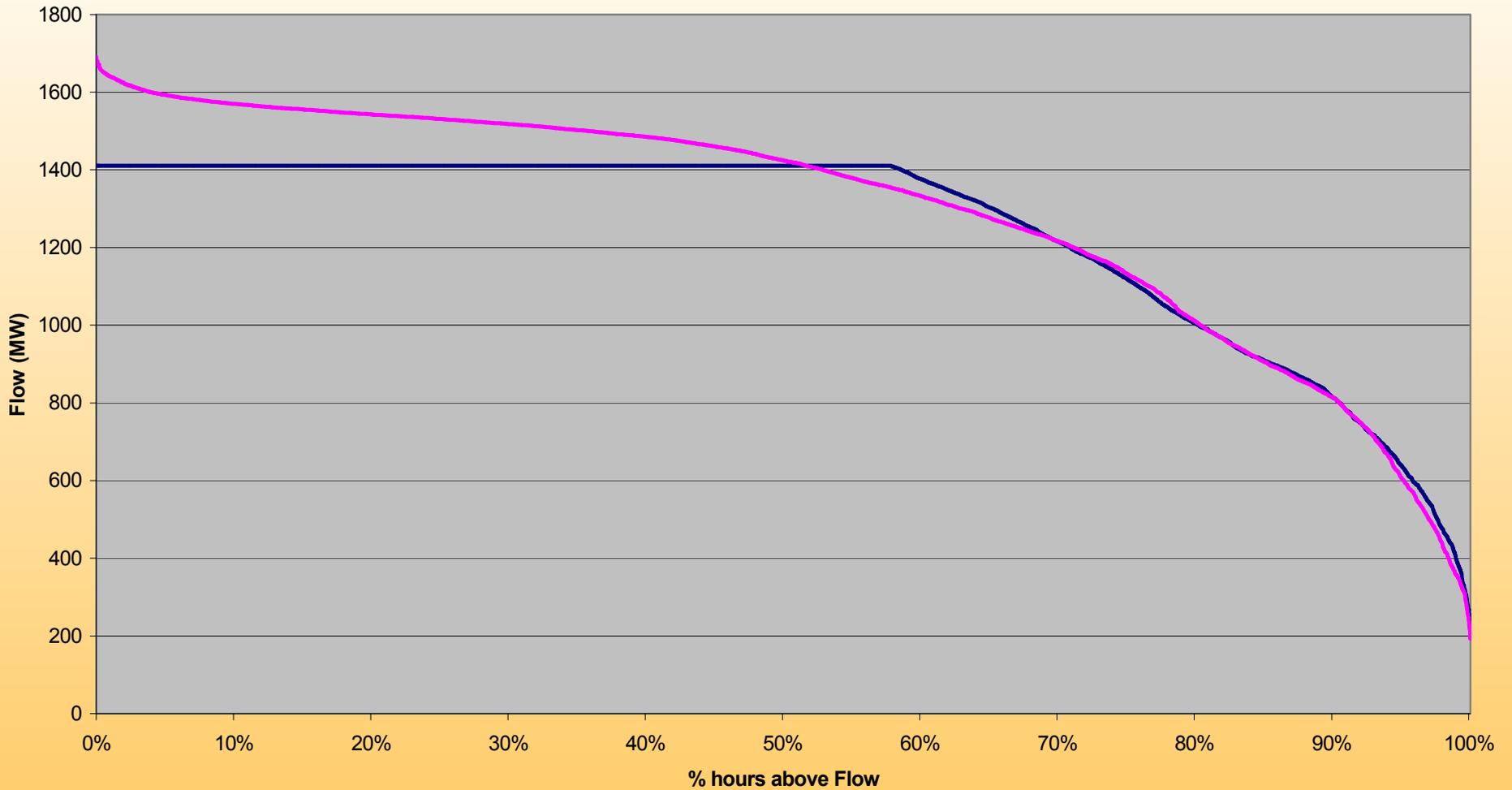
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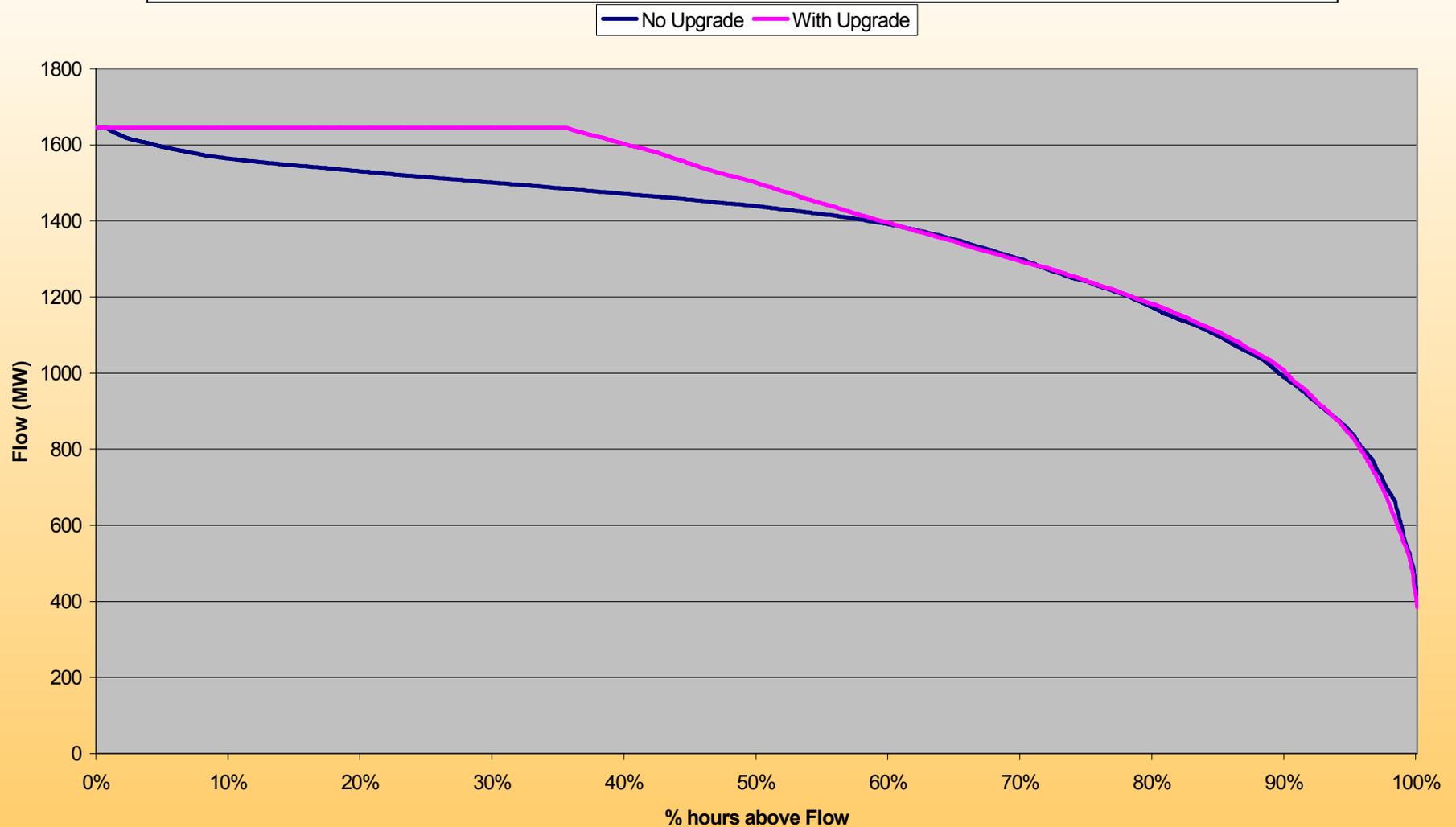
Navajo-Crystal 500 kV

— No Upgrade — With Upgrade

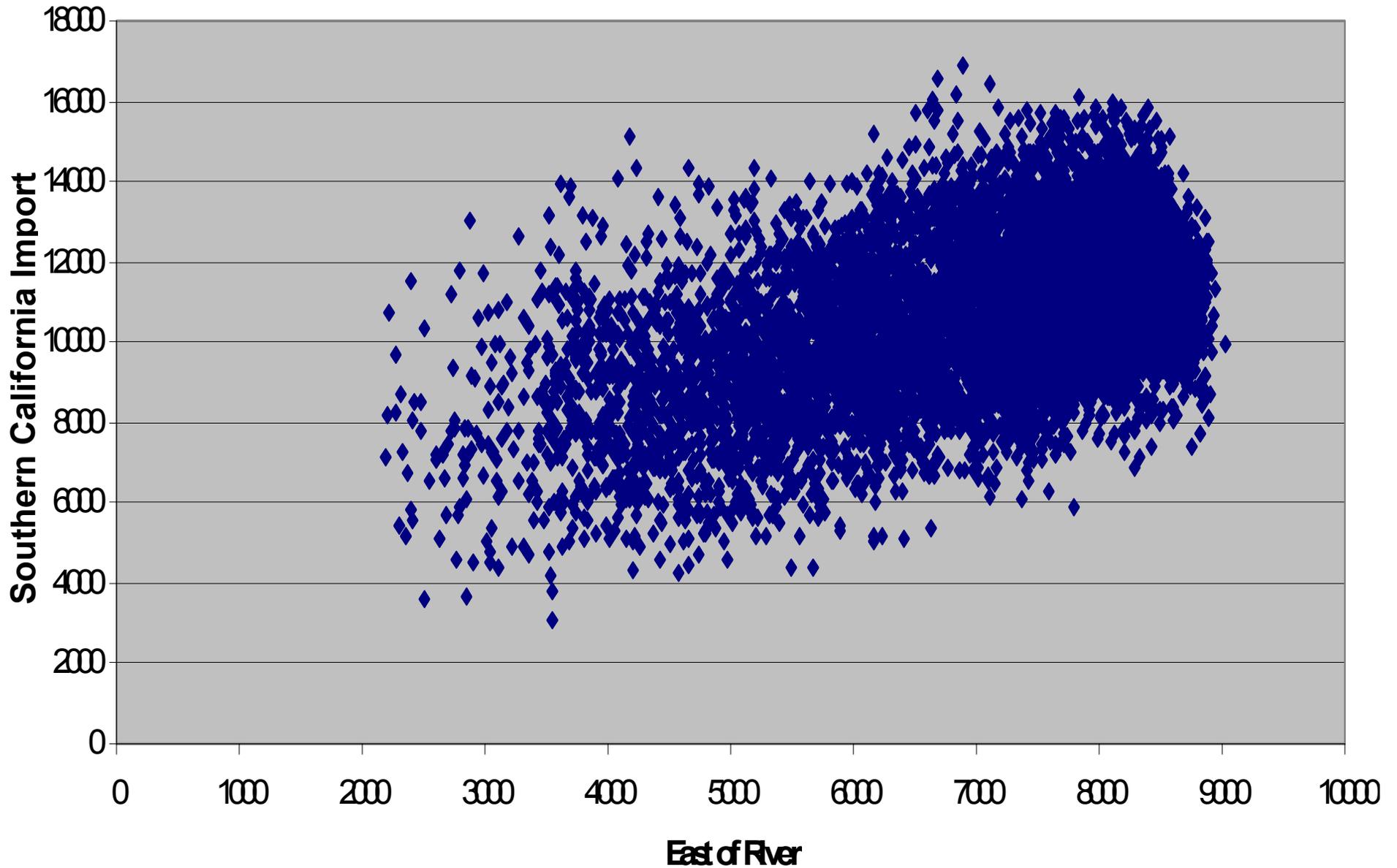




Moenkopi-Eldorado 500 kV



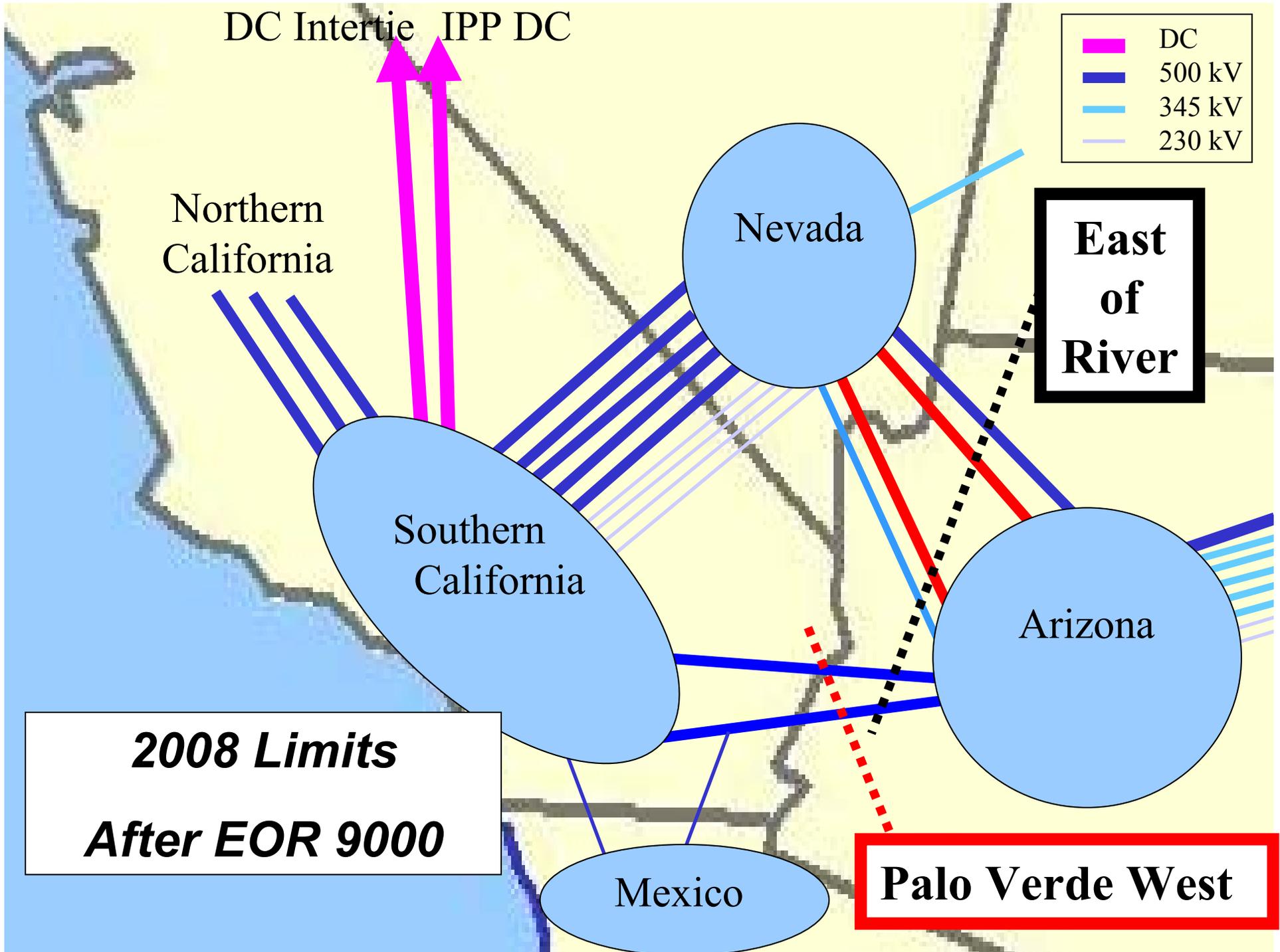
SCIT Nomogram Flows





EOR 9000 Observations

- EOR flows increase by approximately 1000 MW to 9000 MW
- WOR reaches 11,800 MW
- PV West is heavily congested (30% of the time)
- Perkins-Mead remains congested even after the upgrade to 1905 MW (8% of the time)
- Moenkopi-Eldorado is heavily congested (35% of the time)





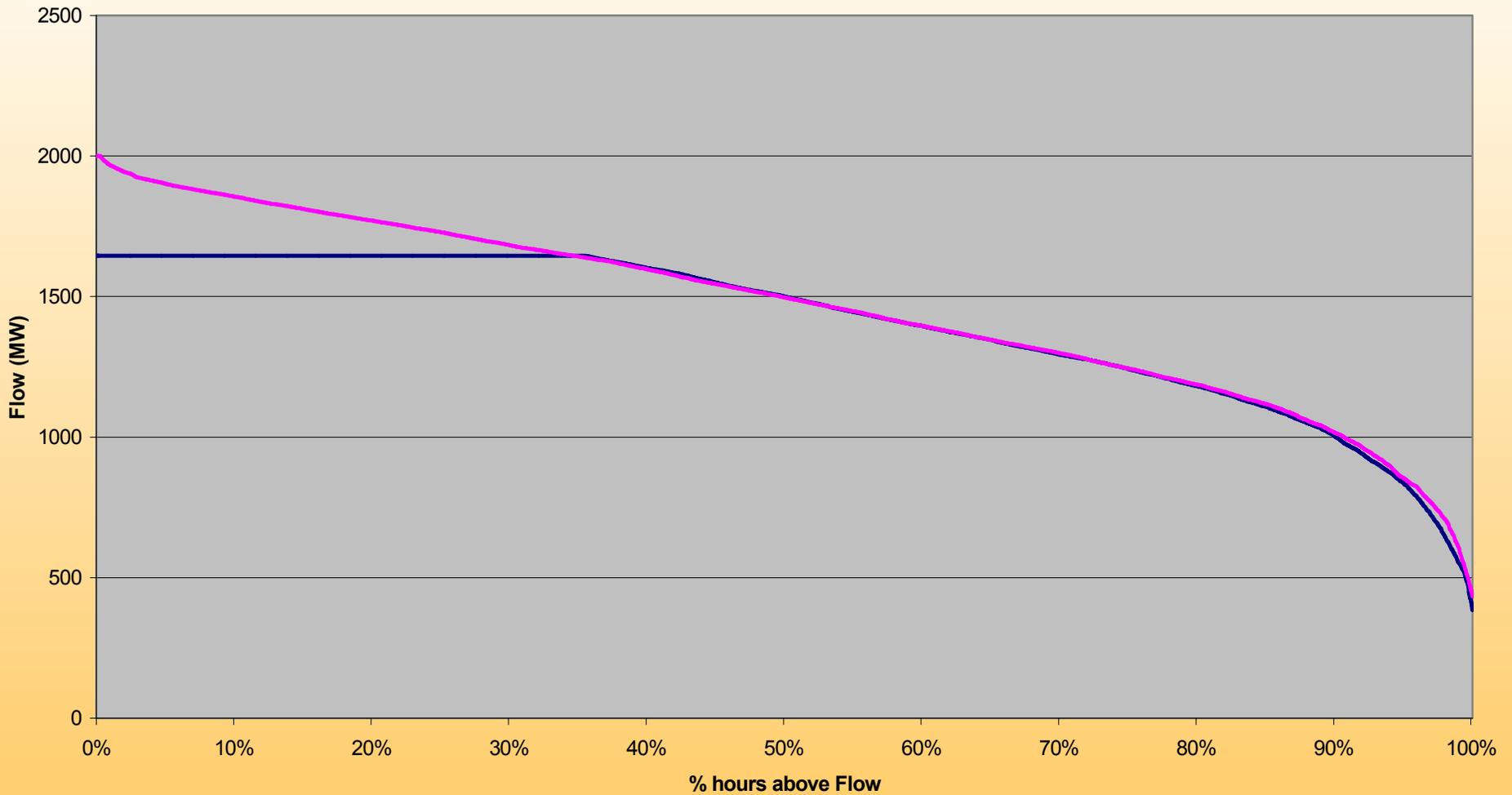
Step 2 – Upgrade Moenkopi-Eldorado

- Increase capability of Moenkopi-Eldorado from 1645 MW to 2000 MW



Moenkopi-Eldorado 500 kV

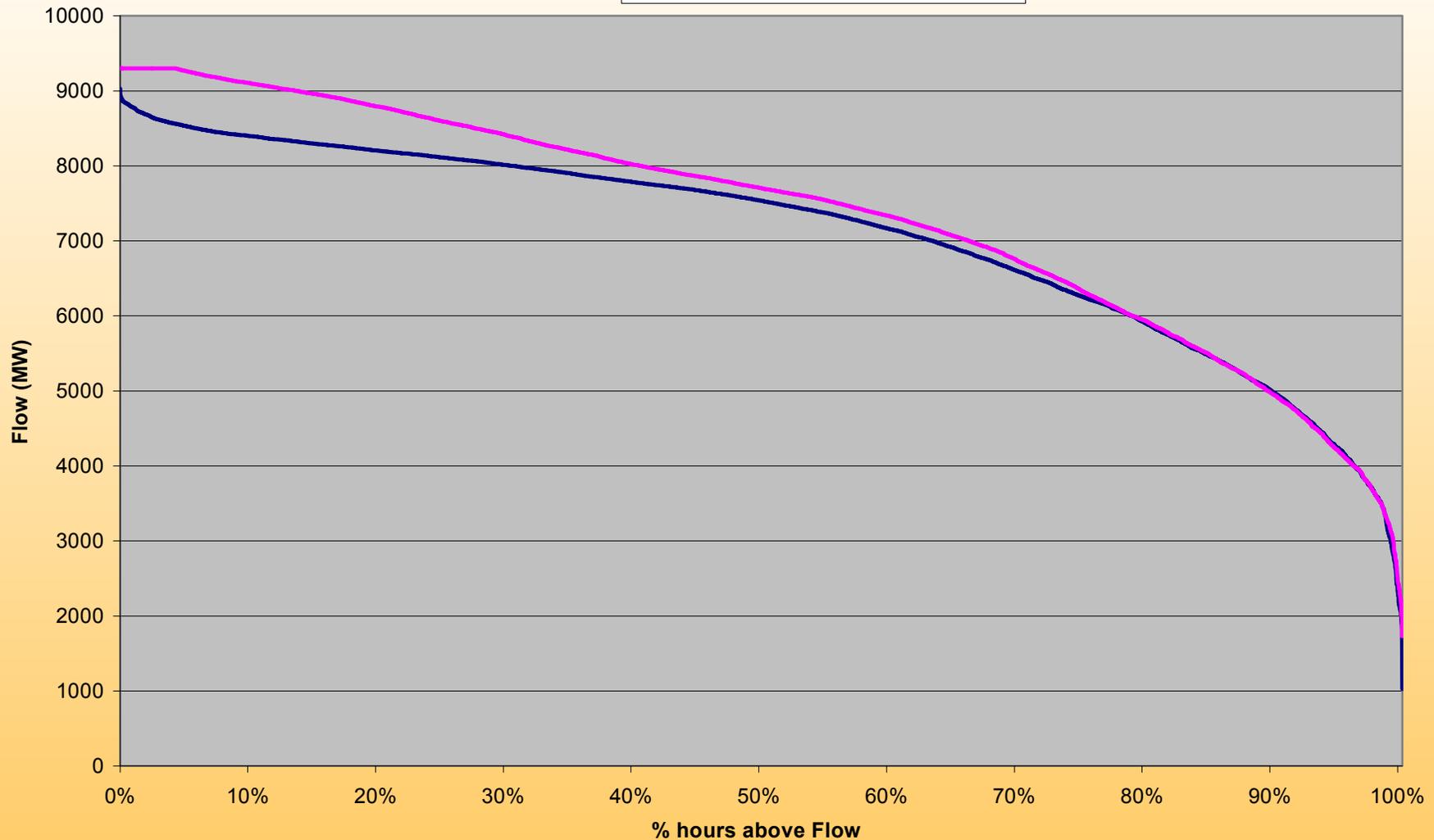
— No Upgrade — With Upgrade





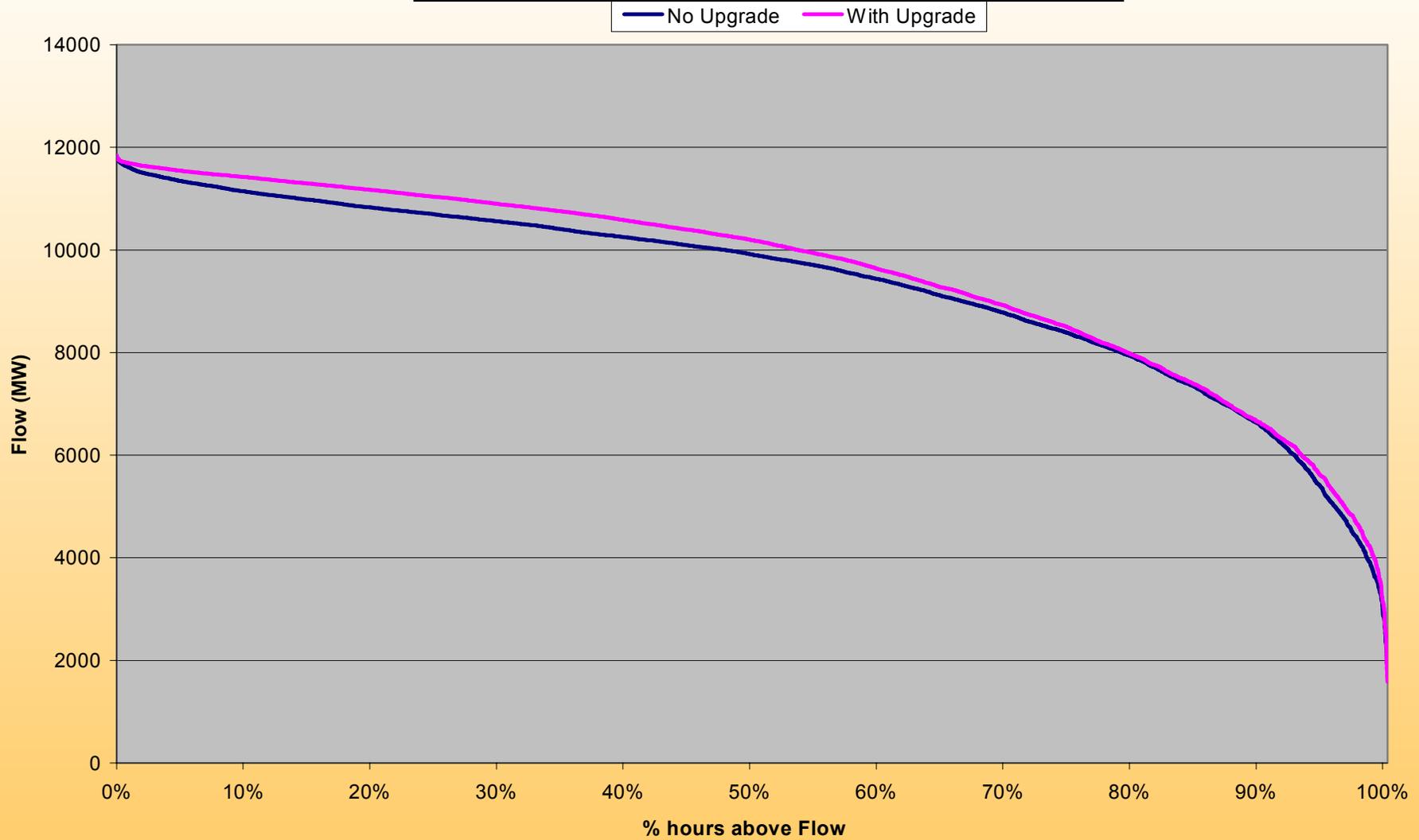
East of River

— No Upgrade — With Upgrade





West of River



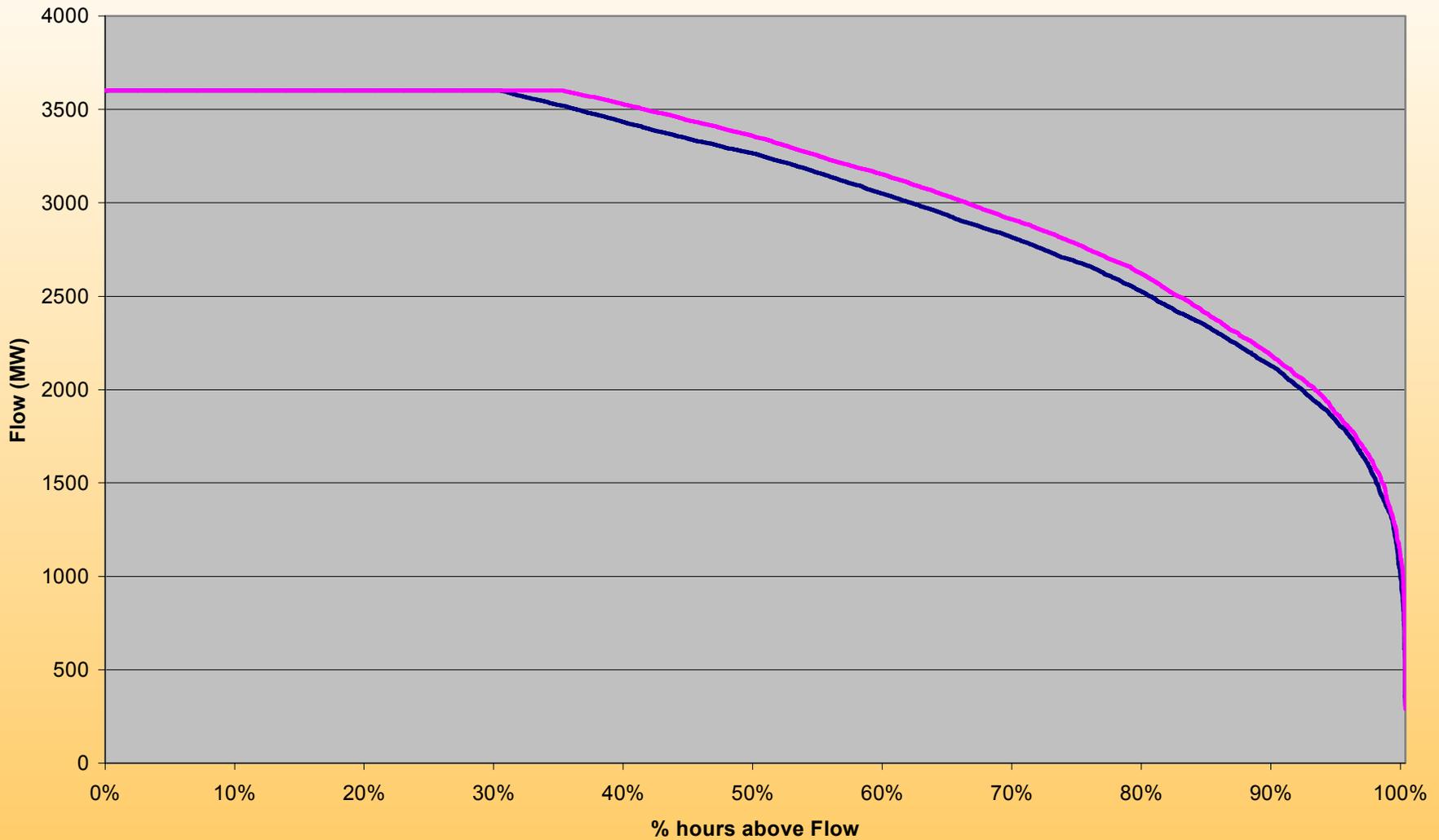


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Palo Verde West

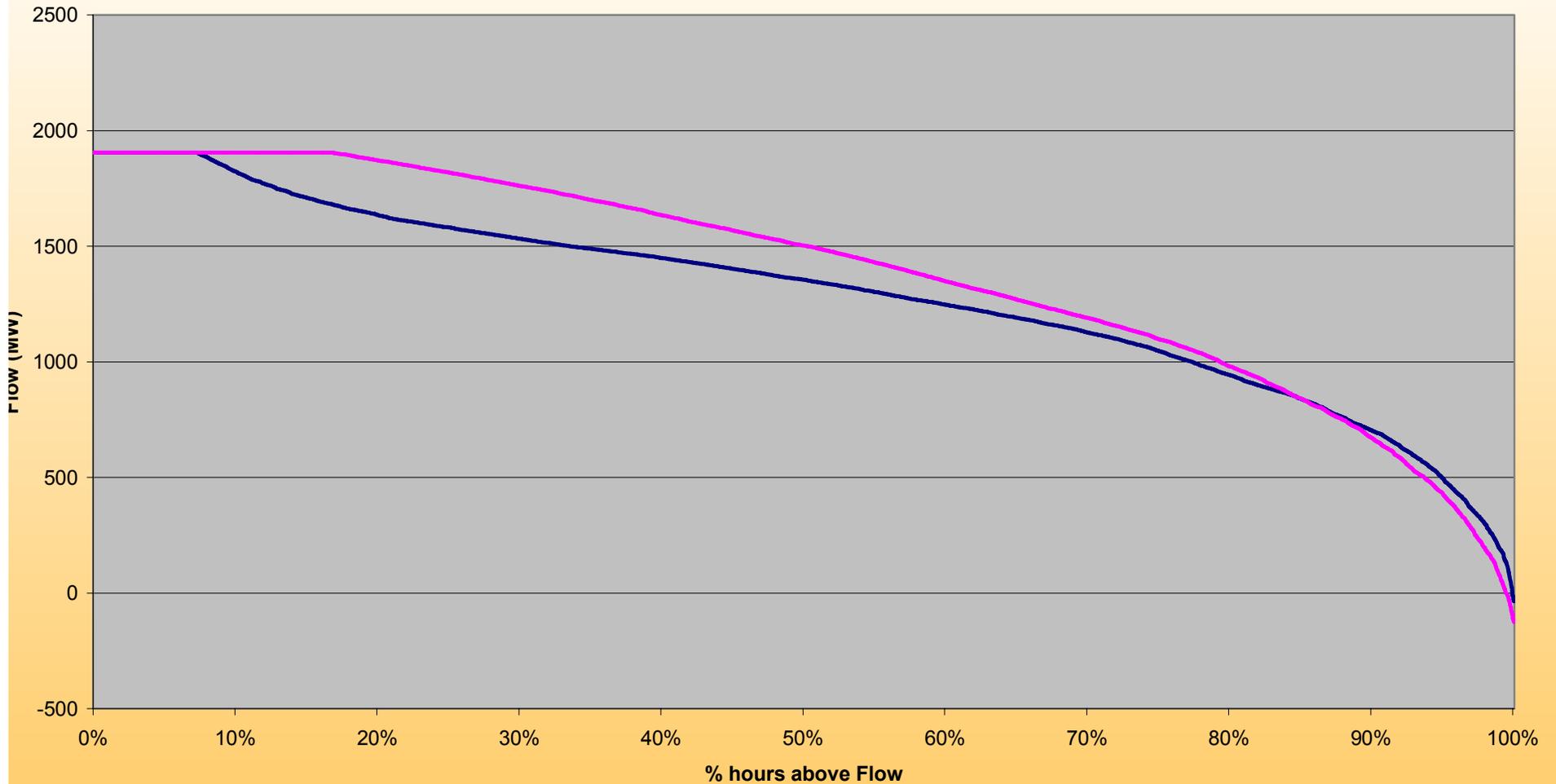
— No Upgrade — With Upgrade



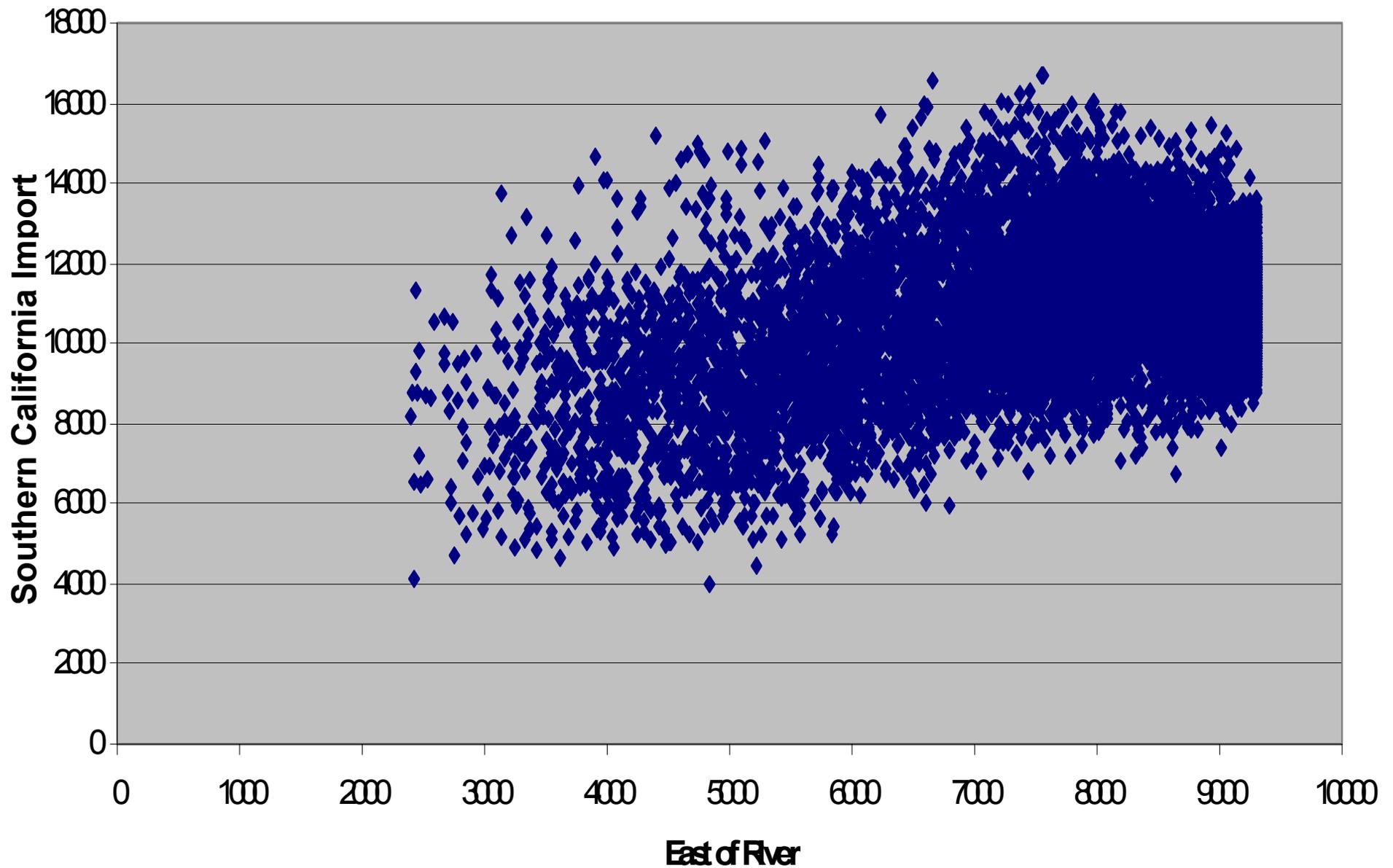


Perkins-Mead 500 kV

— No Upgrade — With Upgrade



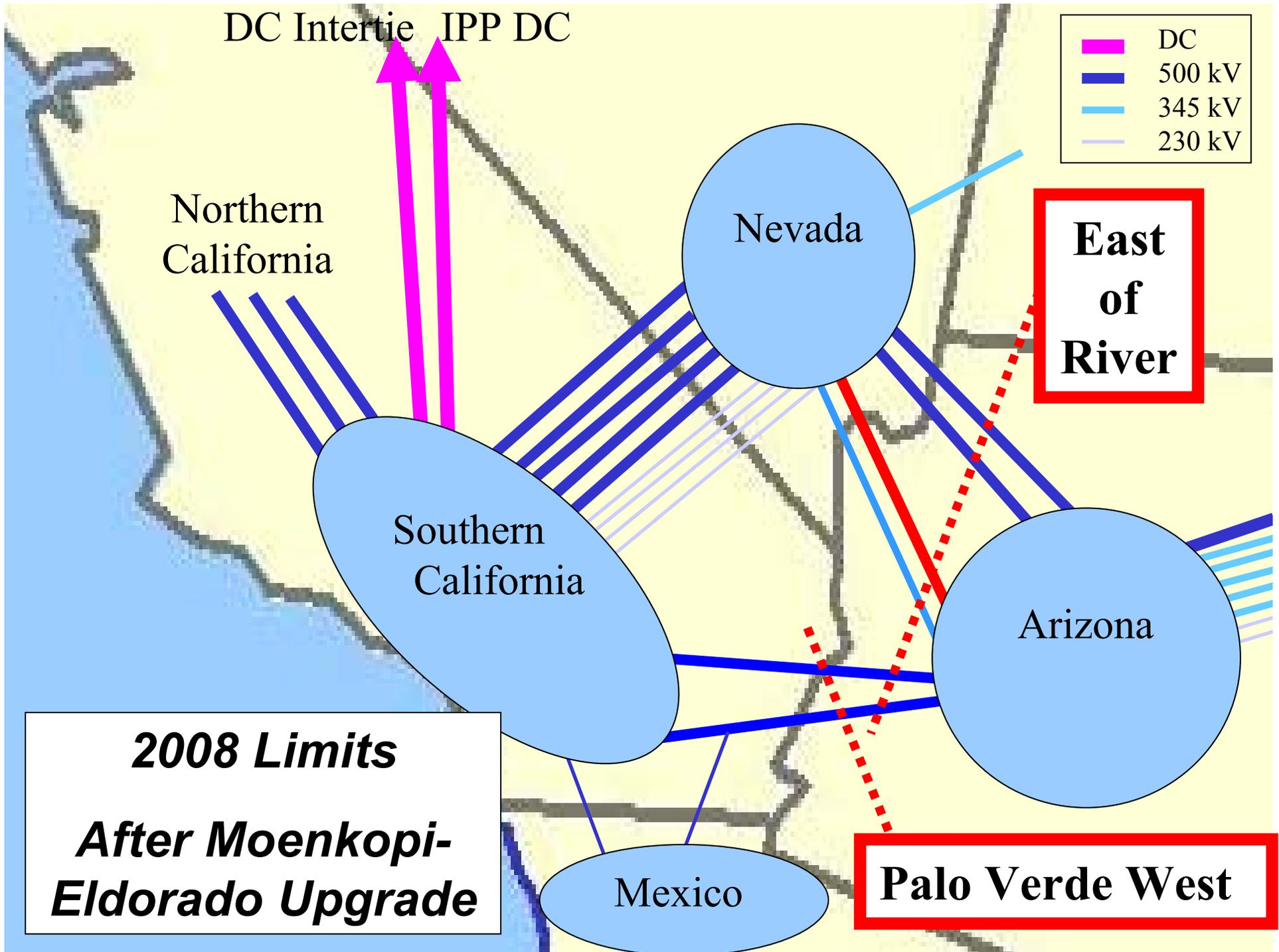
SCIT Nomogram Flows





Moenkopi-Eldorado Upgrade Observations

- EOR flows increased from 9000 MW to 9300+ MW
- WOR not significantly changed (11,800 MW)
- Palo Verde West is heavily congested (35% of the time)
- Perkins-Mead is heavily congested (20% of the time)





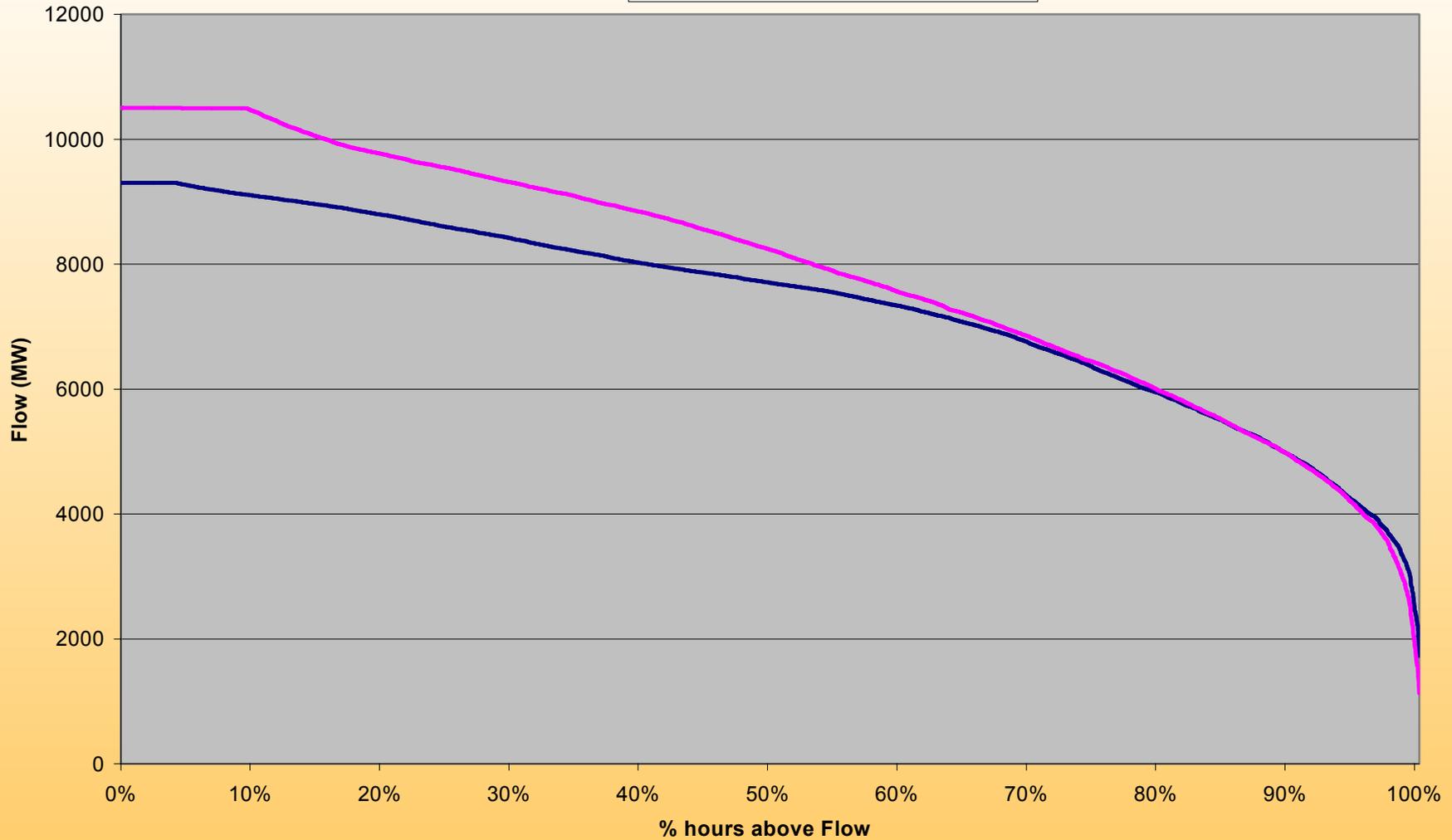
Step 3 – Add Palo Verde-Devers #2

- Add project line with 2338 MW rating and associated upgrades
- Increased EOR path rating by 1200 MW (from 9300 MW to 10,500 MW)
- Increased PV West by 1800 MW (from 3600 MW to 5400 MW)



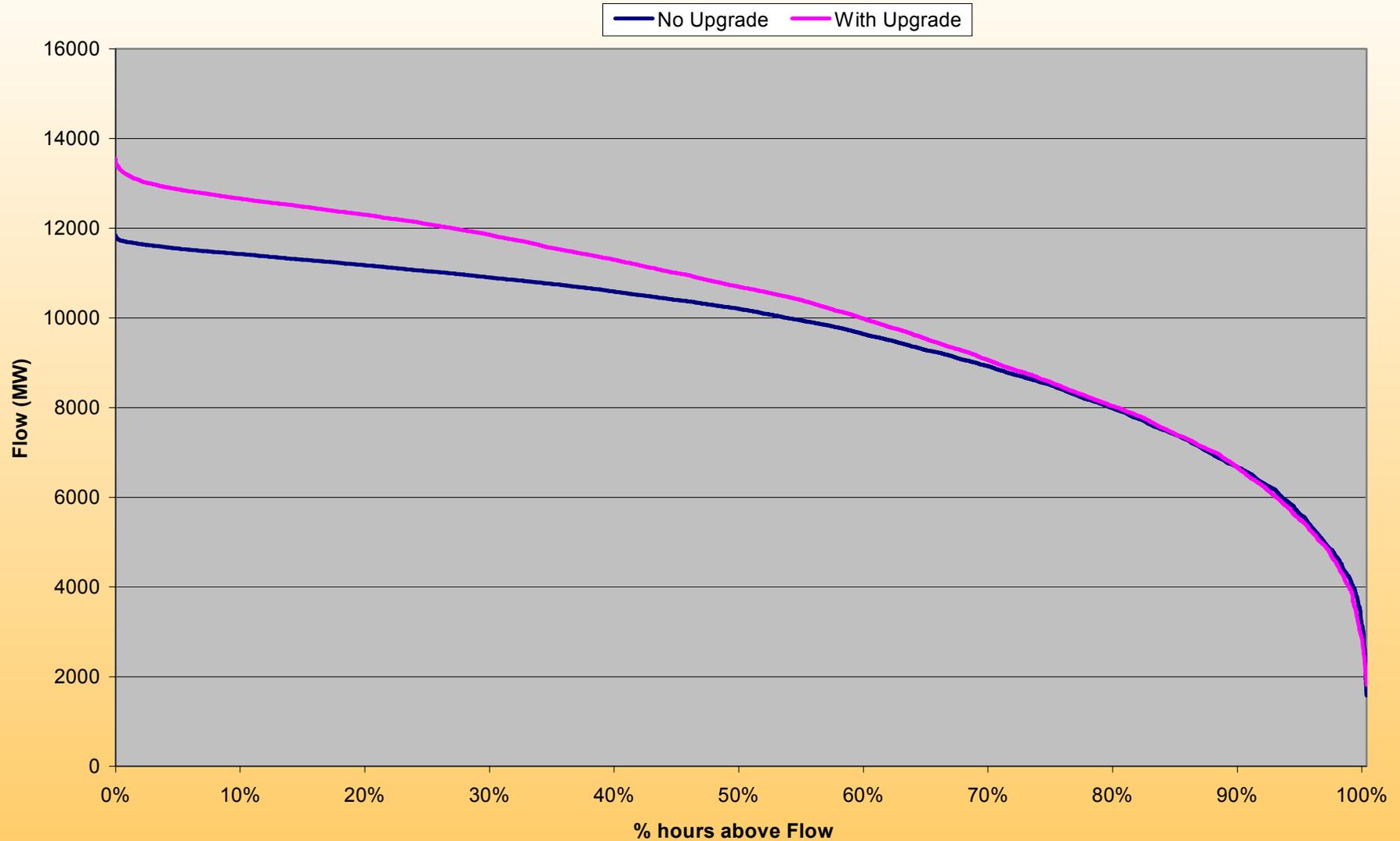
East of River

— No Upgrade — With Upgrade





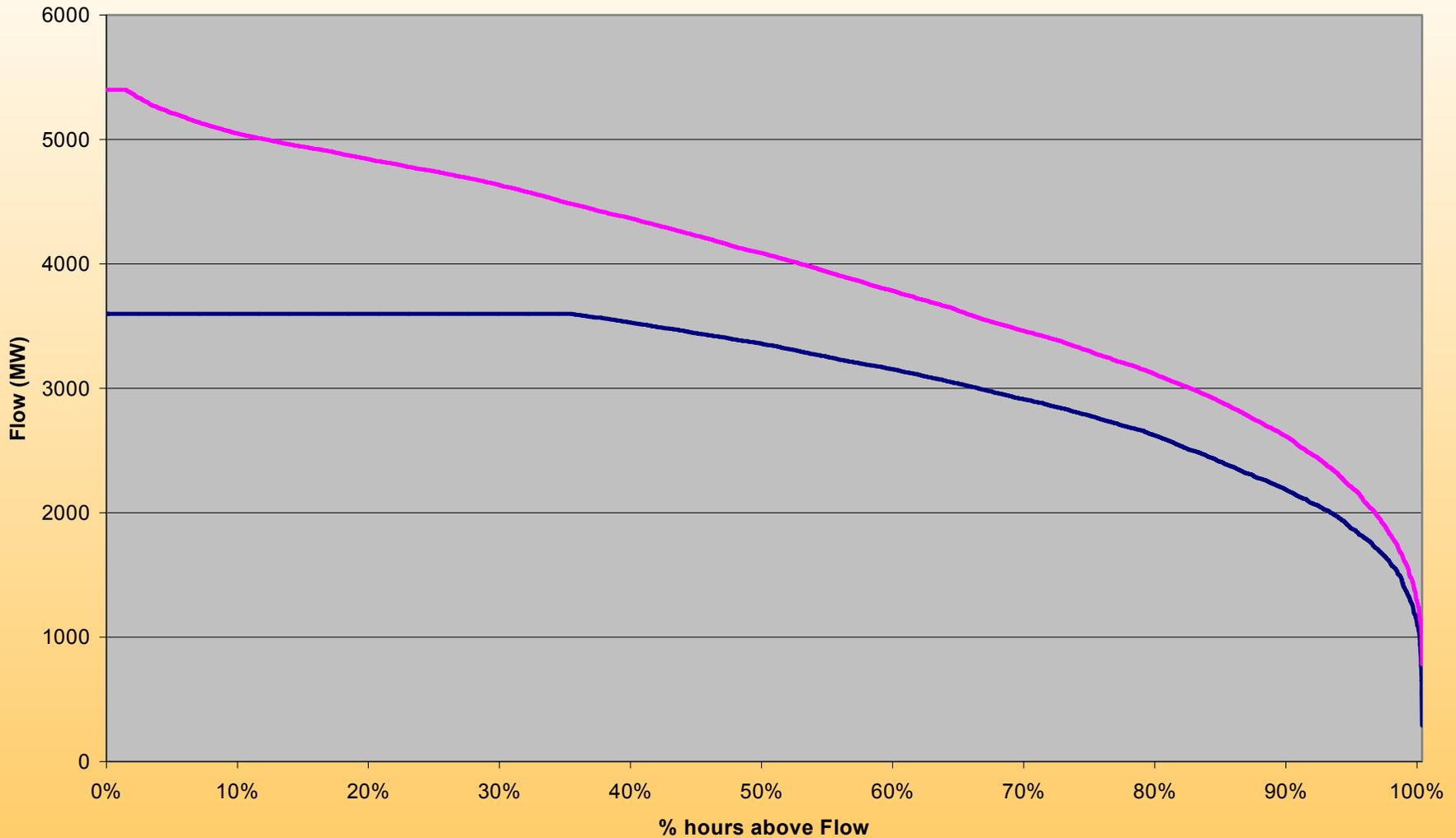
West of River





Palo Verde West

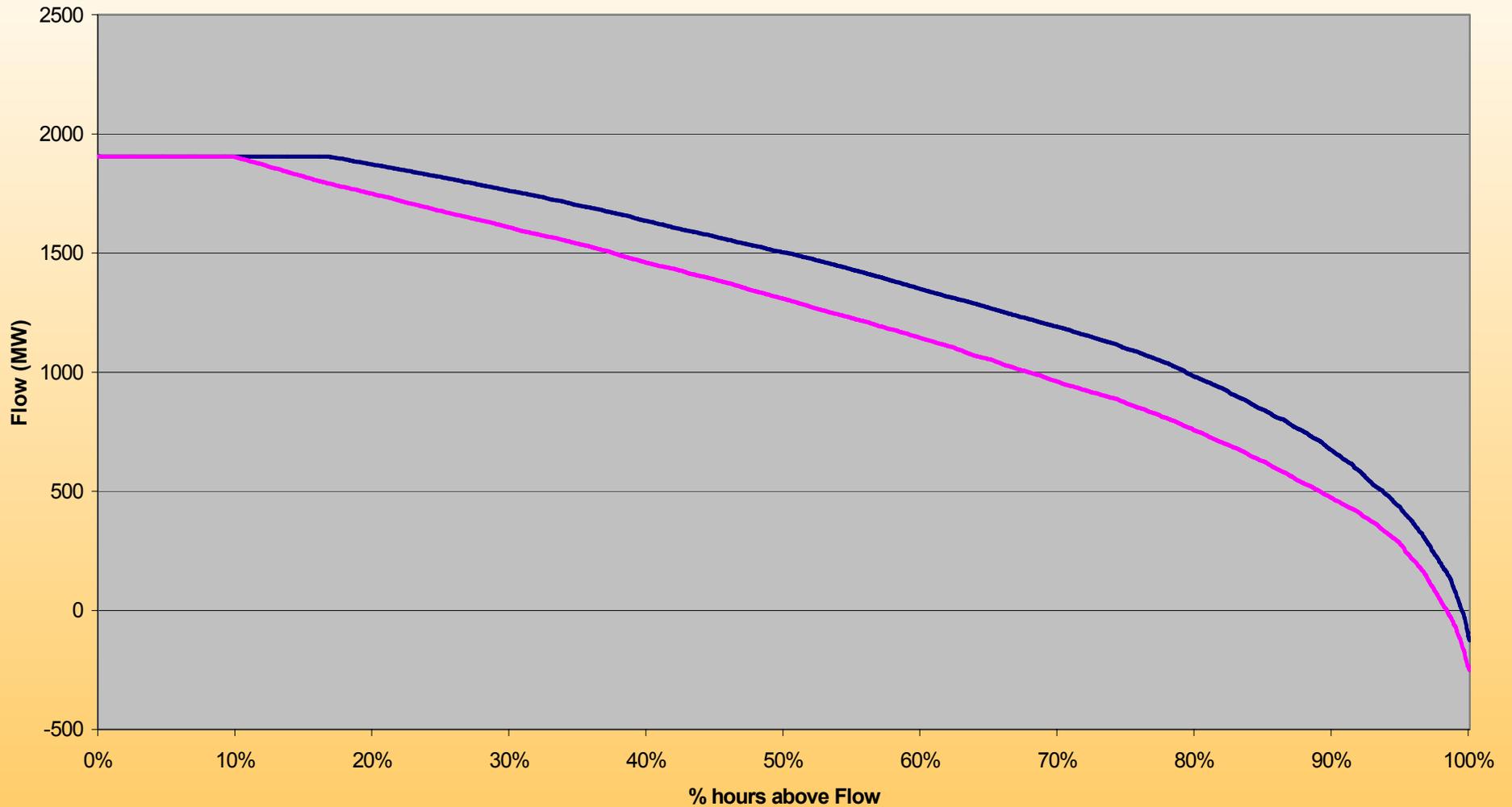
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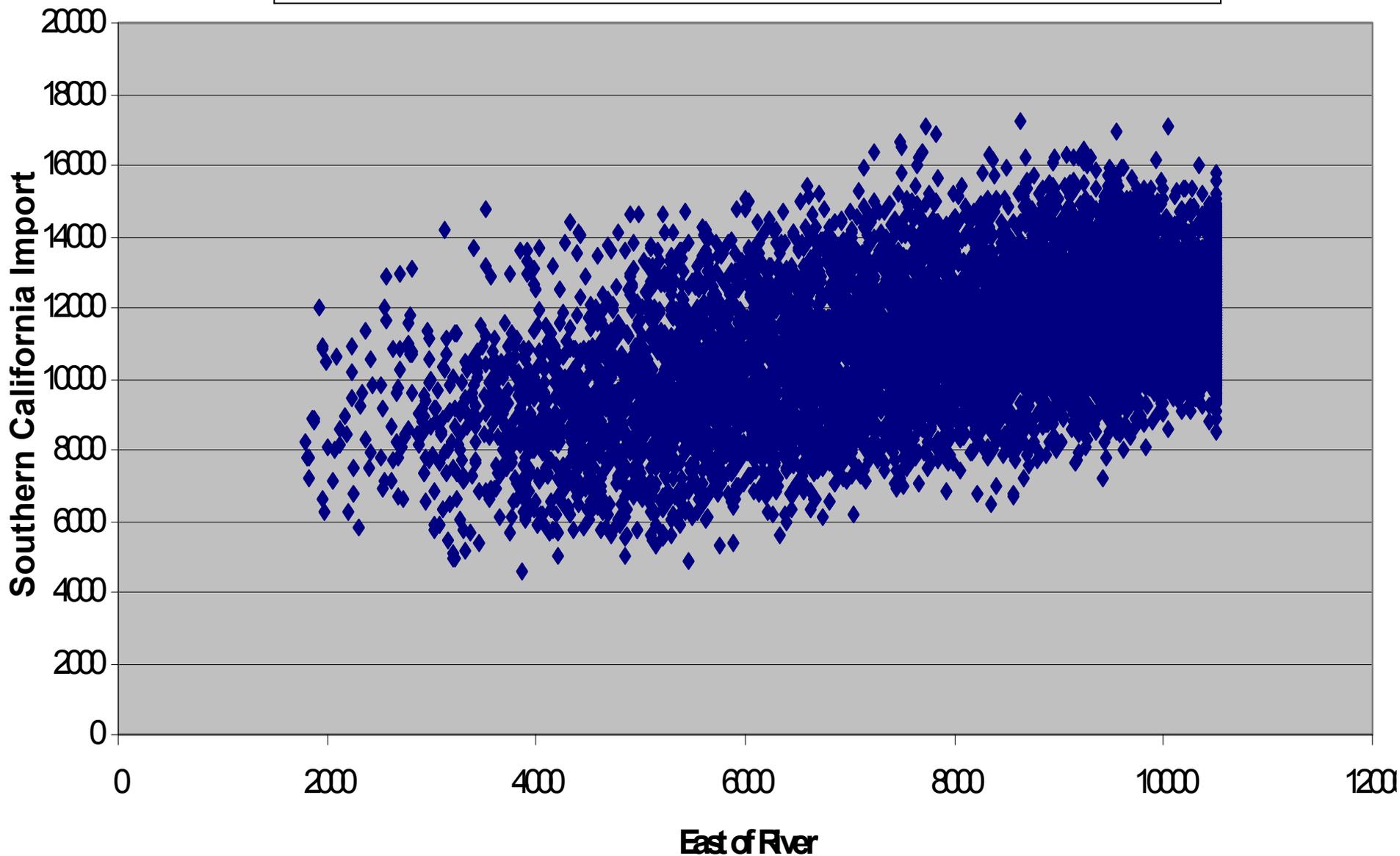


Perkins-Mead 500 kV

— No Upgrade — With Upgrade



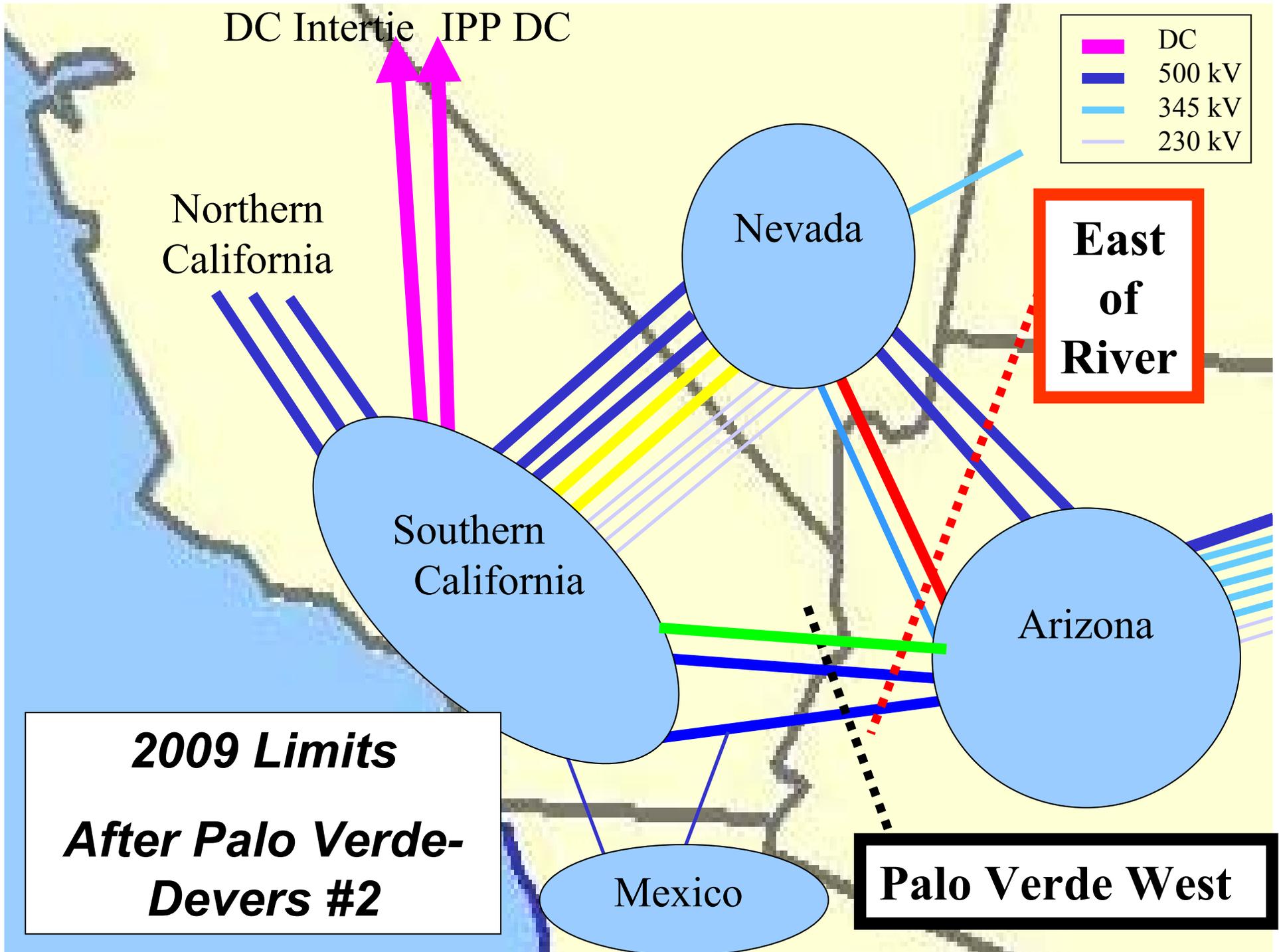
SCIT Nomogram Flows





Palo Verde-Devers #2 Observations

- EOR flows increased from 9300+ MW to 10,500+ MW
- EOR congestion increases from 5% to 10% of the time even after rating increase
- Palo Verde West is no longer congested
- Perkins-Mead congestion is reduced (15% to 20% of the time)





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Overall Observations



EOR 9000 Project Observations

- The EOR 9000 project should be expanded to include the upgrade of the Moenkopi-Eldorado 500 kV line
 - Without this addition, the Moenkopi-Eldorado line would be very heavily congested
 - Without this addition, the economic studies indicate that an EOR rating of approximately 9000 MW could be utilized
 - With this addition, the economic studies indicate that an EOR rating of approximately 9500 MW could be utilized
- The EOR 9000 project should investigate the potential for increasing the capability of the Perkins-Mead line beyond the present plan for 1905 MW (2200 amperes)



Palo Verde-Devers #2 Project Observations

- The PVD2 project could potentially increase the utilization of the EOR path by more than the proposed 1200 MW rating increase (potentially as much as 2000 MW).
 - Double line outage concerns (PV-Devers 1&2) may reduce PV West capability from 5400 MW to as low as 4500 MW and make this infeasible
- The EOR 9000 project and the Palo Verde-Devers #2 project are complimentary and function well together
- The addition of both the PVD2 project and the EOR 9000 project would eliminate the majority of the major path congestion in the STEP/SWAT area.



EOR Path Rating Observations

- A 9,000 MW EOR rating appears to be an appropriate objective after the EOR 9000 project
- With the addition of the Moenkopi-Eldorado upgrade to the EOR 9000 project, a 9,500 MW EOR rating appears to be an appropriate objective
- With the addition of the PVD2 project, a 11,500 MW EOR rating appears to be an appropriate objective (a 2,000 MW increase)
- **Qualification -- Achieving these path ratings may prove to be technically infeasible or uneconomic**



WOR Path Rating Study Observations

- After the addition of the Path 49 upgrades, a 11,800 MW WOR rating appears to be an appropriate objective (a 1,682 MW increase from the current 10,118 MW)
- This 11,800 MW WOR path rating would also be sufficient after the addition of the EOR 9000 project (with or without the Moenkopi-Eldorado upgrade)
- With the addition of the PVD2 project, a 13,800 MW WOR rating appears to be an appropriate objective (a 2,000 MW increase from 11,800 MW)
- **Achieving these path ratings may prove to be technically infeasible or uneconomic**



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Questions?