Analyses of California's Water Problems

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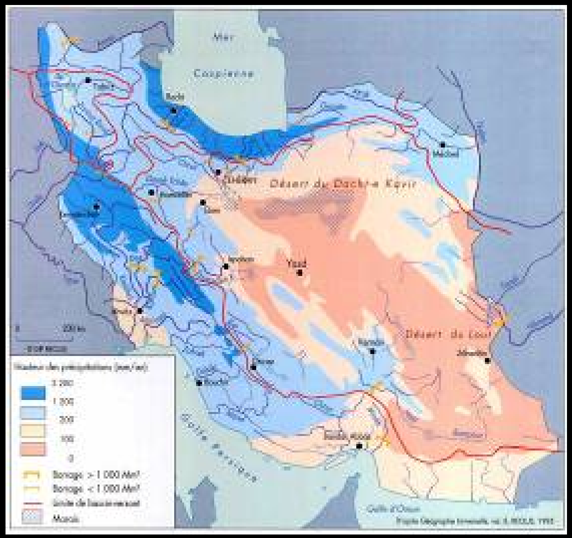

“Still Wrong, but Sometimes Useful”: Adventures with CALVIN

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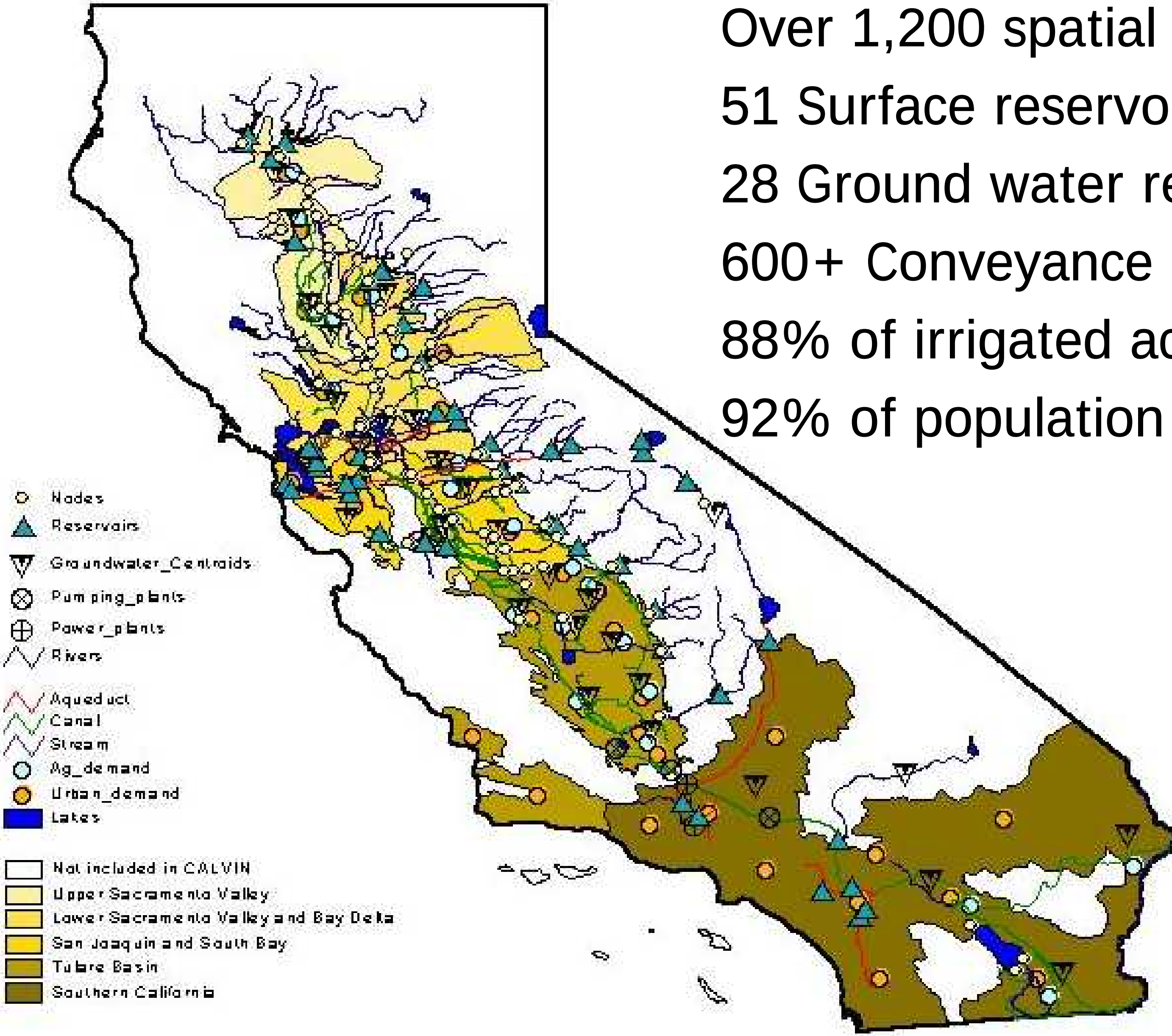
http://cee.engr.ucdavis.edu/faculty/lund/CALVIN/

What is CALVIN?

- Entire inter-tied California water system
- Surface and groundwater systems
- Supply and demand management options
- Economics-driven engineering optimization model
    - Economic Values for Agricultural, Urban, & Hydropower Uses
    - Flow Constraints for Environmental Uses
- Prescribes monthly system operation over a 72-year representative hydrology

Forces quantitative understanding of the system

CALVIN Model Coverage



Over 1,200 spatial elements

51 Surface reservoirs

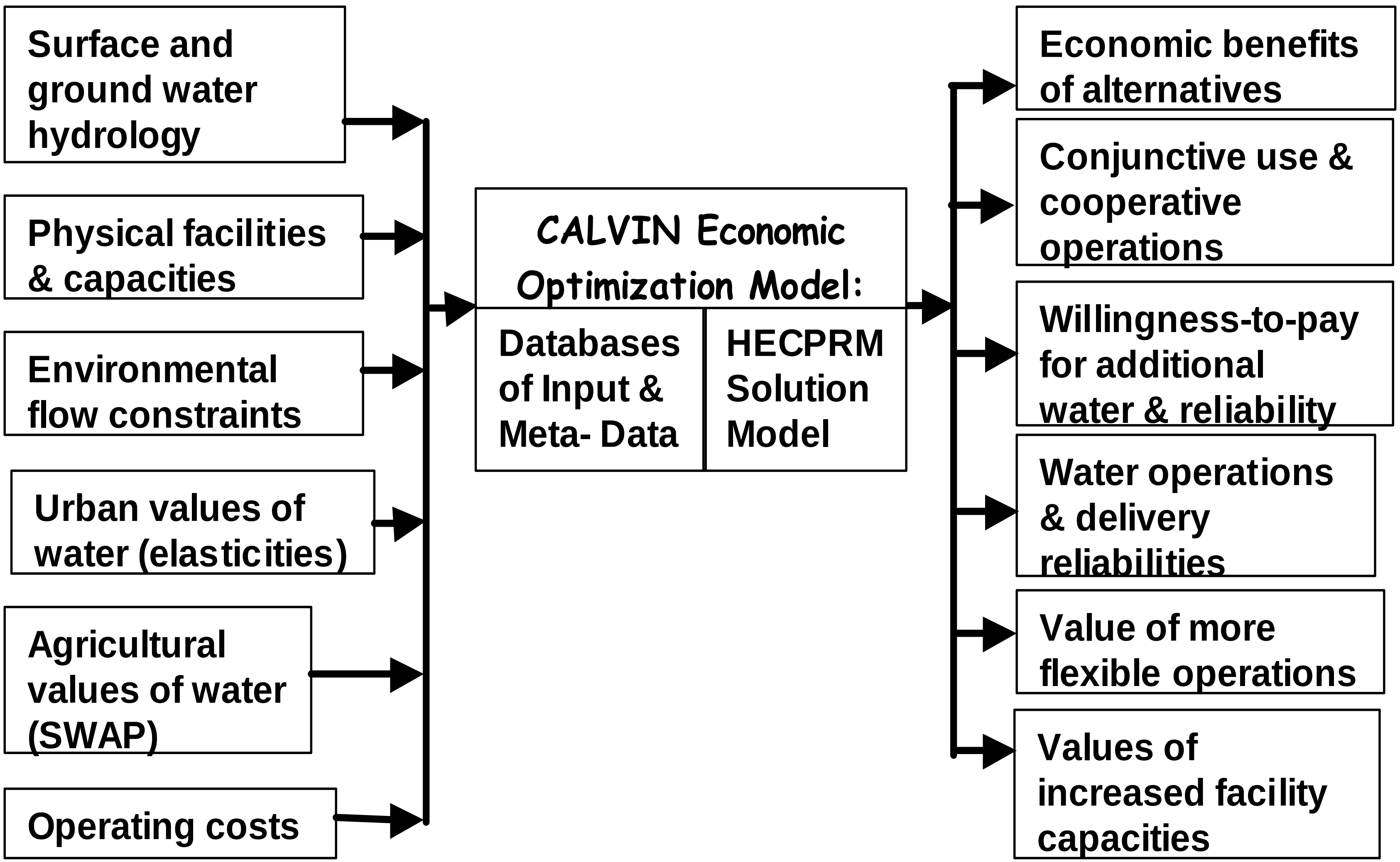
28 Ground water reservoirs

600+ Conveyance links

88% of irrigated acreage

92% of population

Data Flow for the CALVIN Model



Applications of CALVIN

- Regional and statewide water markets & values of new facilities (2001)
- Conjunctive use in S. California (2002)
- Restoring Hetch Hetchy (2003)
- Climate warming & adaptation (2003, 2005, now)
- Paleodrought (2005)
- Groundwater overdraft (2006)
- Baja California & Colorado R. Delta (2006 - now)
- Delta water supply impacts (2002, 2007- now)
- Sacramento Valley Conjunctive Use (now)

Proof of concept for innovations

1) ems

ons

2) n

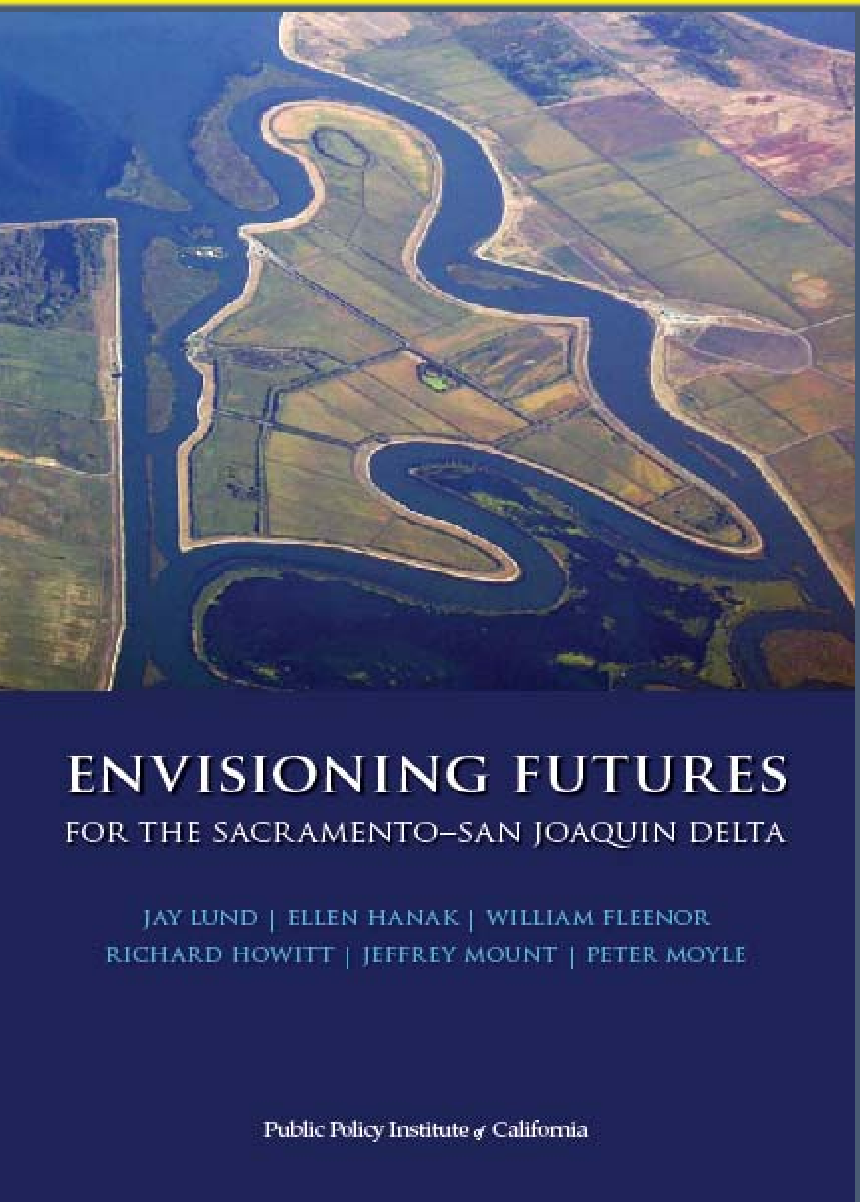
3)

4)

Lesson taught by CALVIN

1. Integrated modeling is possible
2. Integrated modeling produces more insightful results
3. Documentation is possible
4. System data bases are possible

Beyond the Peripheral Canal



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Biologist:
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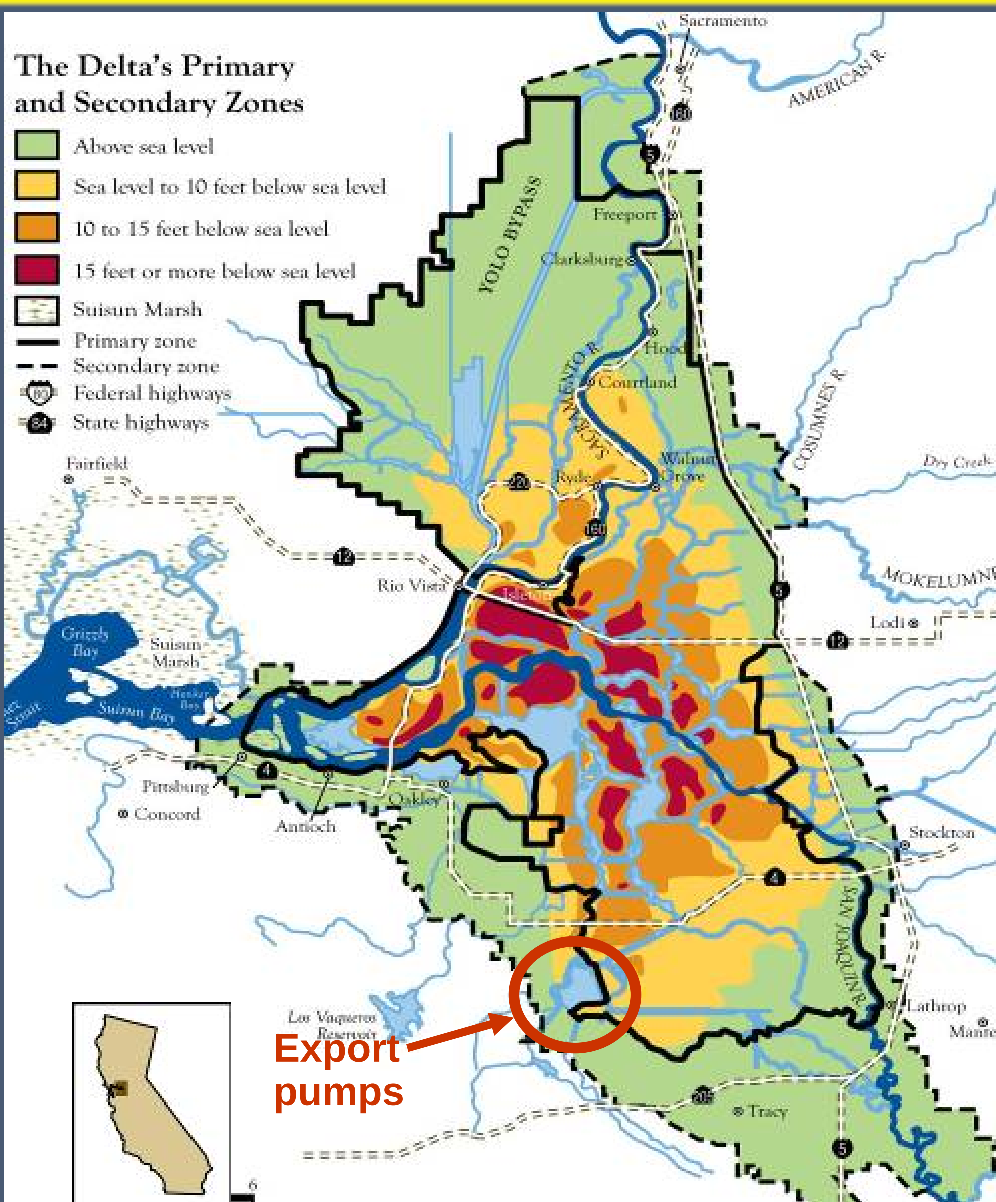
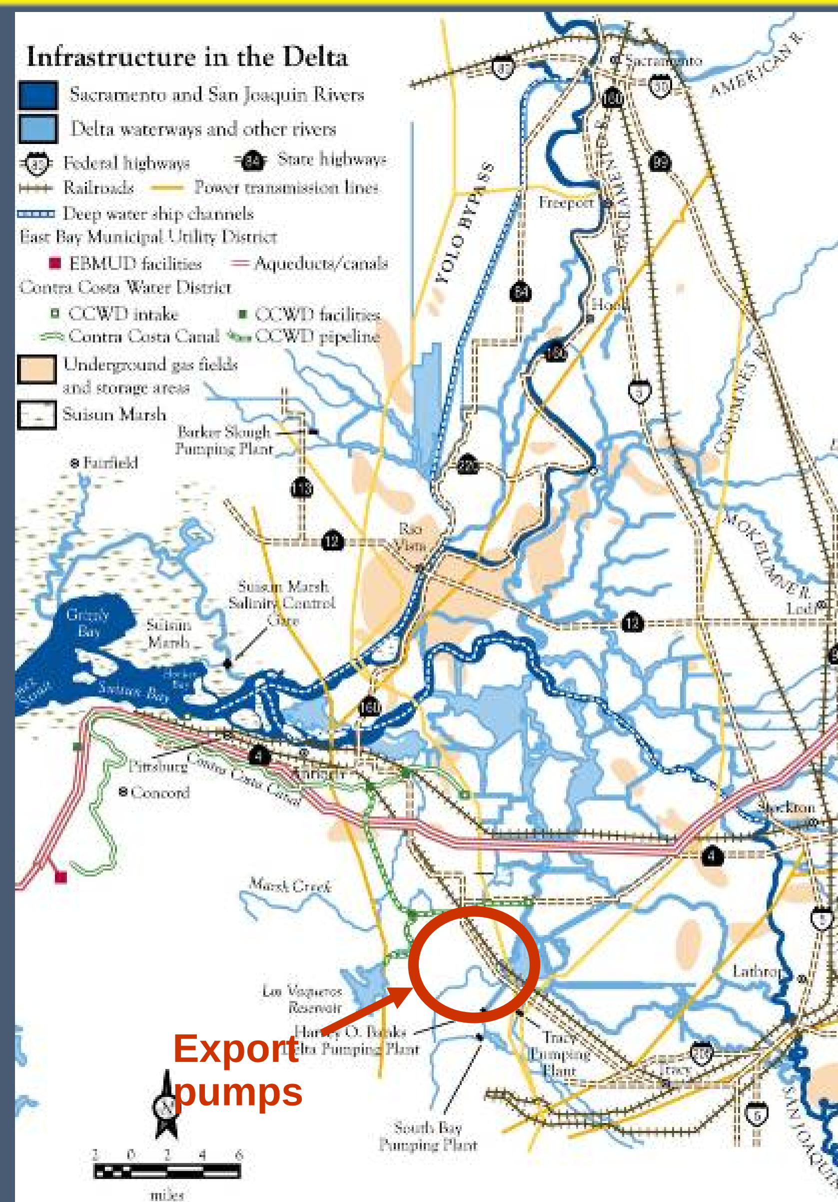
The Sacramento-San Joaquin Delta





Why the Delta Matters to Californians

Water Supply

Agriculture

Ecosystem

Infrastructure

Recreation

Housing

Major Themes

- Current Delta is unsustainable for almost all stakeholders
- Improved understanding of the Delta provides opportunities for new solutions
- Promising alternatives exist
- Most Delta users have ability to adapt
- Promising solutions are unlikely to arise from a stakeholder-only process

A Three-pronged Crisis

- Levees at increasing risk
  - Sea level rise and sinking land
  - Floods and earthquakes
- Steep declines in many fish species
  - Many are "listed"
  - Culprits: invasive species, habitat loss, pumps
- Governing institutions lacking
  - Resurgence of legal actions

Why We Need a New Delta Policy

- Existing Delta policy is unsustainable
  - All interests are getting worse together
- Delta failure would be disastrous for state, regional, and local interests
- Better ecosystem understanding points to promising new solutions
- Stakeholders can better adapt to new solutions than continue with the current high-risk policy
- Promising alternatives exist

Fluctuating Delta Alternatives Are Most Promising

Alternatives	Environmental Performance	Annual Water Exports	Economic and Financial Costs
1. Levees as Usual	Poor	0 – 6+ maf	~$2 Billion + failures
2. Fortress Delta	Poor	6+ maf	> $4 Billion + lost islands
3. Saltwater Barrier	Poor		$2 – 3 Billion + lost islands
4. Peripheral Canal Plus	Promising - allows Delta to fluctuate		$2 – 3 Billion + < $70 M/year
5. South Delta Aqueduct			$2 – 3 Billion + < $41 M/year
6. Armored-Island Aqueduct	Mixed		$1 – 2 Billion + < $30 M/year
7. Opportunistic Delta	Promising	2 – 8 maf	$0.7 – 2.2 Billion + < $170 M/year
8. Eco-Delta	Best?	1 – 5 maf	Several $ Billion + < $600 M/year
9. Abandoned Delta	Poor	0	$500 Million + ~$1.2 Billion/year

Hydropower and Climate Warming in California

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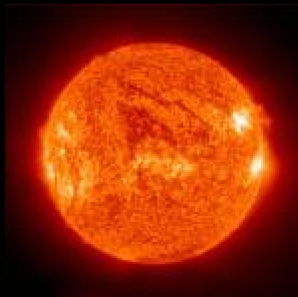
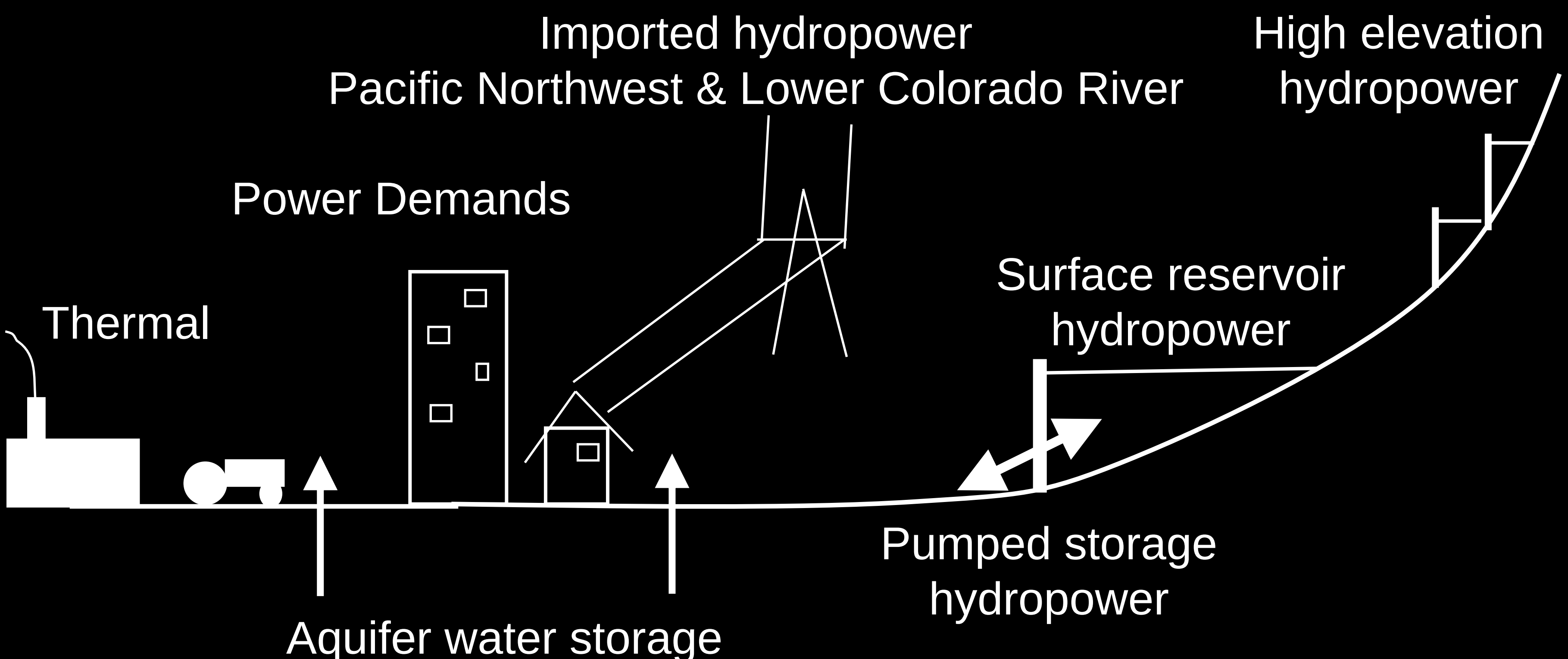


Hydropower Systems



Hydropower and California

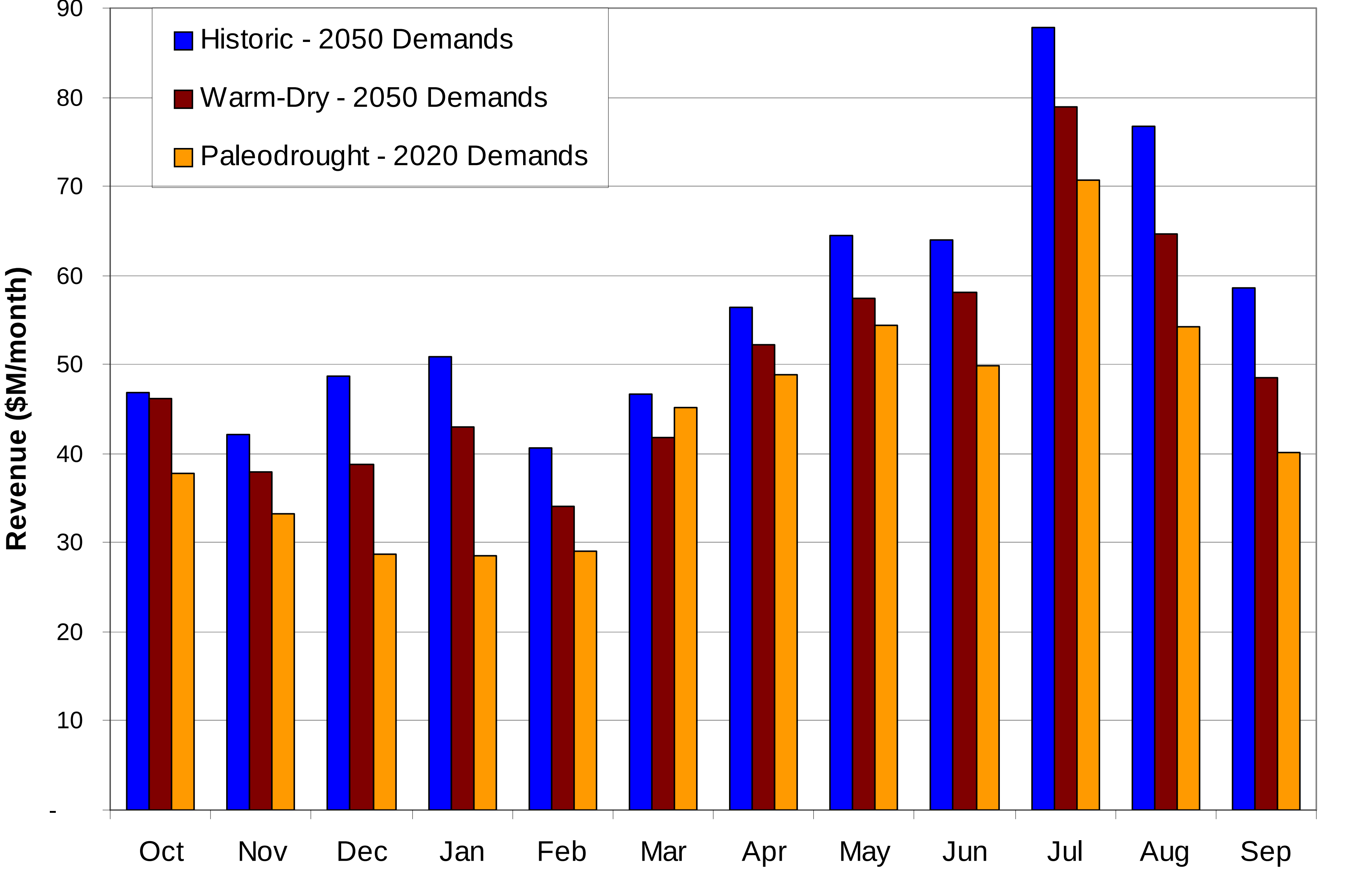
	1,000 GWH/yr, 2004
Hydropower Total	45.4
In-state Hydropower	*34.4*
High Elevation*	25.3
Low Elevation*	9.1
Pumped Storage	?
Imported Hydropower	*11*
PNW	9.5
LCR	1.5
Thermal	205.2
Other renewables	24.5
Total	**275.1**

* Estimated   Sources: CEC; McCann 2005

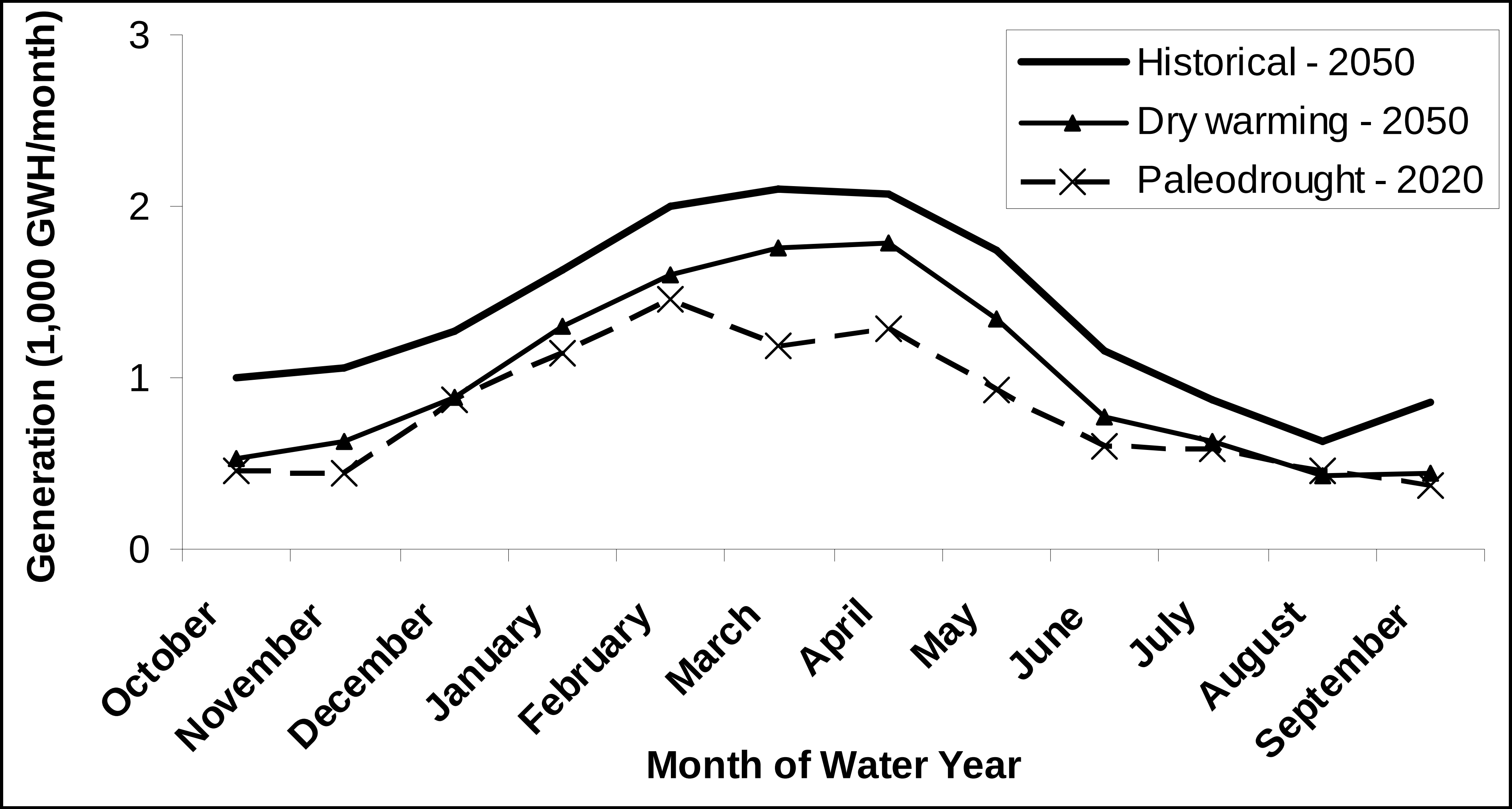
Climate Effects on Hydropower

1. Energy demand
2. Timing of water availability
3. Quantity of water available
4. Availability of hydropower to import
5. Thermal generation efficiency
6. Sensitivity of environment to hydro operations

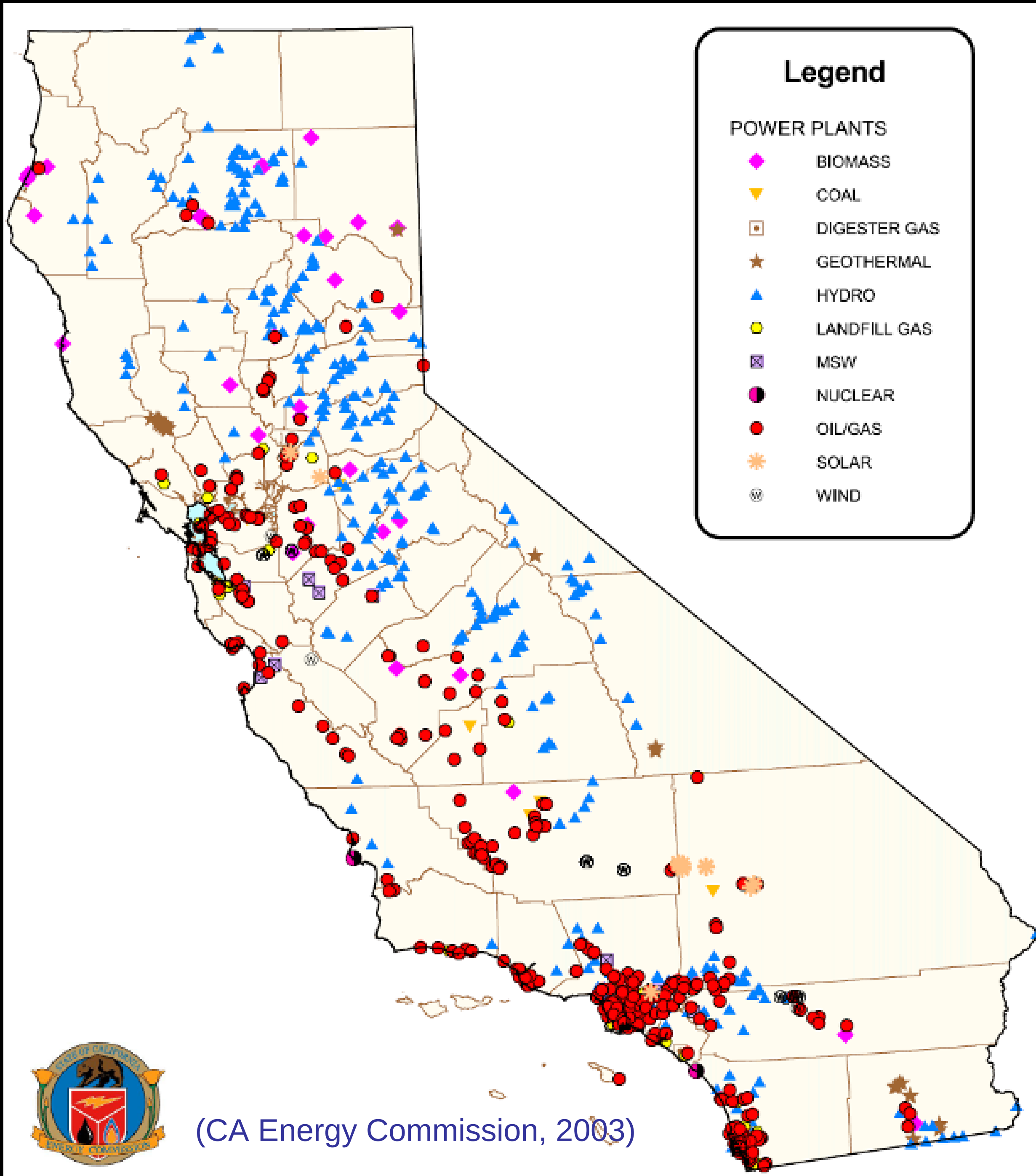
Average Water Supply Reservoir Hydropower Benefits ($M/year)



Water Supply Dam Hydropower Seasonal Generation Changes

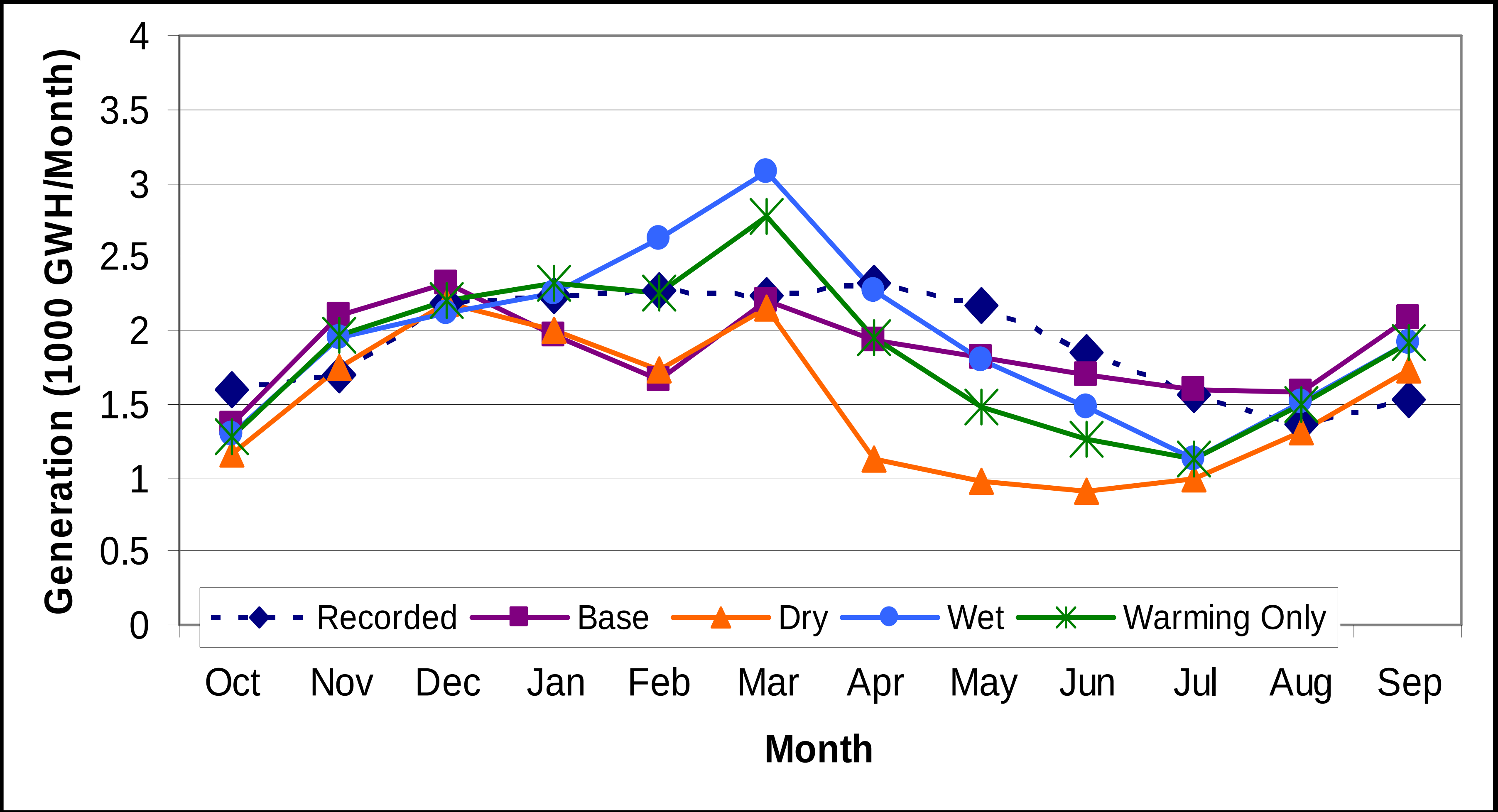


Major water supply reservoirs in CALVIN system optimization model



- 156 High-elevation power plants
- Varied ownership
- Snowpack dependant
- High-head, little head-storage effect
- Limited storage or flow data!!

Monthly Generation



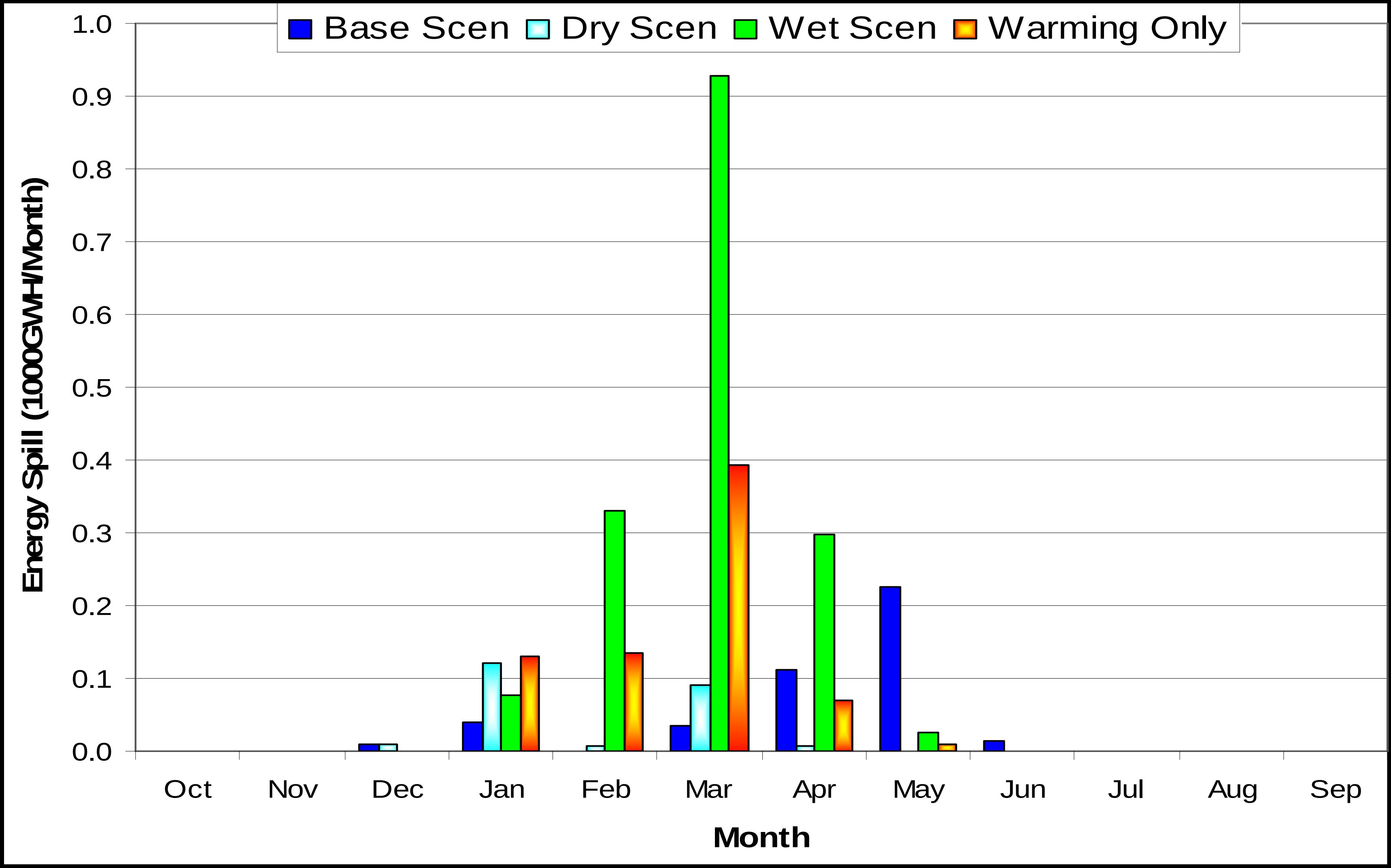
EBHOM's Results

Model Results

	Scenario			
	Base	***Dry***	***Wet***	***Warming-Only***
Generation (1000 GWH/yr)	22.3	18.0	23.4	22.0
Generation Change with Respect to the Base Case (%)		- 19.3	+ 4.8	- 1.4
Spill (MWH/yr)	433	224	1,661	735
Spill Change with Respect to the Base Case (%)		- 46.0	+ 283.9	+ 58.8
Revenue (Million $/yr)	1,449	1,271	1,483	1,435
Revenue Change with Respect to the Base Case (%)		- 12.3	+ 2.3	- 0.9

average of results over 1984-1998 period under four climate scenarios

Average monthly energy spill (1984-1998)



Overall Conclusions

- Sierra loses snowpack, the natural reservoir.
- Storage works. Generation changes more with total runoff than seasonal runoff shift.
- Problems for smaller high-elevation reservoirs - more spills even without change in total runoff
- Drier climate causes more problems than wetter climate causes benefits.
- Revenue reduction may be economically insufficient to justify expanding storage or generation capacity.

The Next Step in Central Valley Flood Management: Connecting Costs and Benefits

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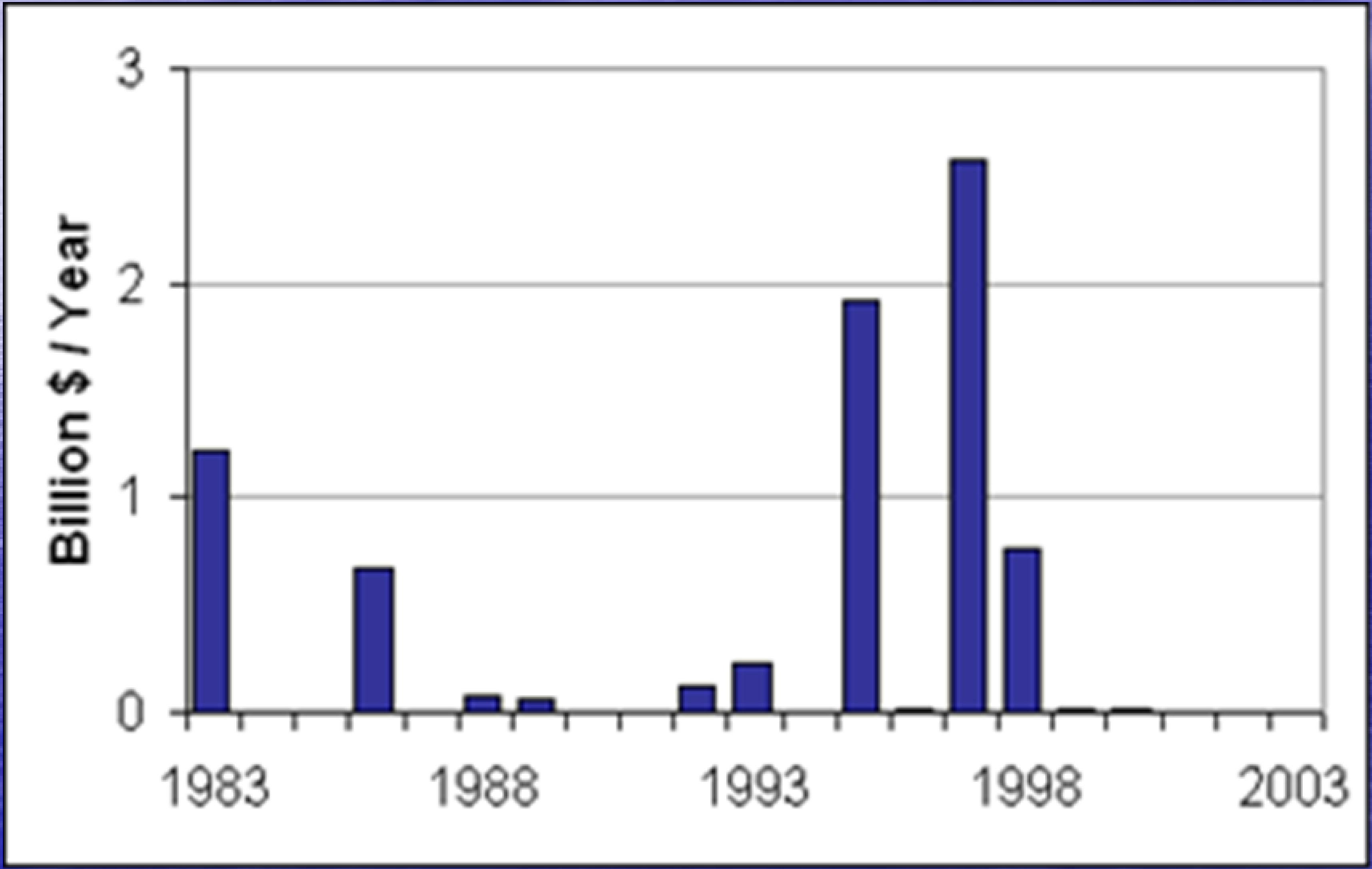
Central Valley Flood System

- Sacramento and San Joaquin Rivers
- Composed of Levees, weirs, reservoirs, and bypasses
- Designed mainly to protect farmland and navigation

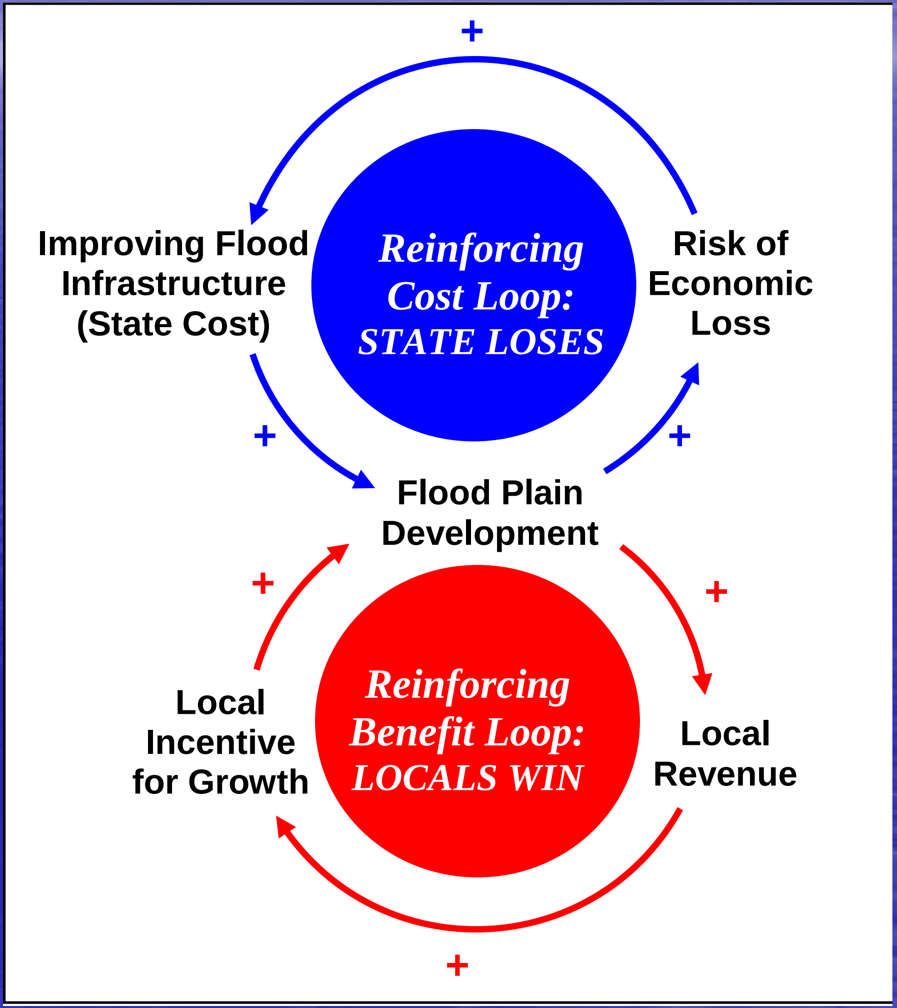
Recent CA Flood Damages
(Pielke et al., 2002)



Weaknesses of the System

1. Disconnect Between Costs and Benefits

- Who makes land-use decisions?
- Who is responsible for protecting public?
- Should we stop development in floodplains?!



Weaknesses of the System

2. Poor Understanding of Risks

- Decision makers and residents poorly understand flood risks and liabilities
- Homeowners are not notified unless in 100-year flood plain
- Inaccurate and outdated FEMA maps which were developed for insurance purposes, not for land use planning and disaster response

Weaknesses of the System

2. Poor Understanding of Risks

- 100-year protection does not clearly convey the risks
- Residual risks neglected
- False sense of security

Floodplain	***Chance of Flood during a 30-year Mortgage***
50 year	45%
100 year	***26%***
200 year	14%
500 year	6%
1000 year	3%

Weaknesses of the System

3. No Long-term Comprehensive Program

- Short-term plans
- Fluctuating & irregular funding
- Can the $4.9 billion bond fund solve the problem? Well-planned bond expenditure is important, but insufficient
- Are we prepared for climate change?

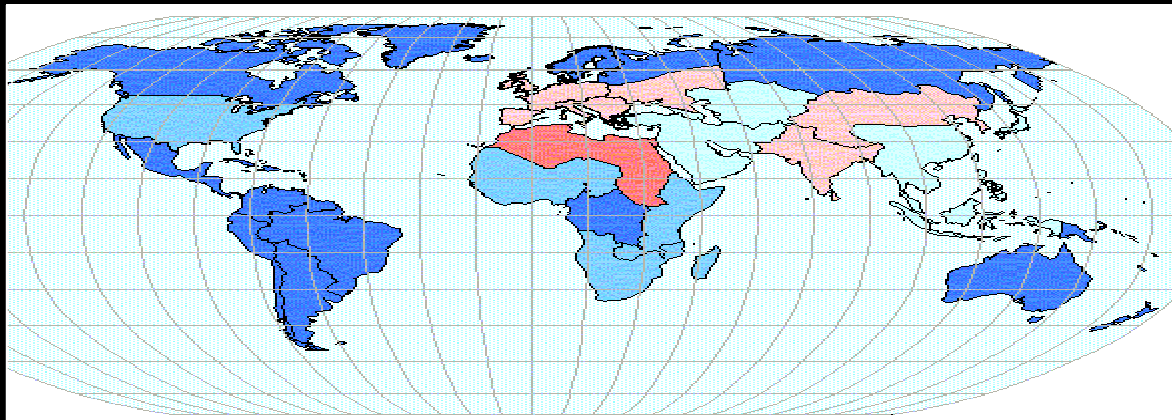
Flood Control vs. Management

- Floods cannot always be prevented (residual risk) but threats can be minimized
- Managing floodwaters (historic) vs. managing flood risks
- Structural (keeping water away from people) vs. non-structural methods (minimizing the damage potential of floods)

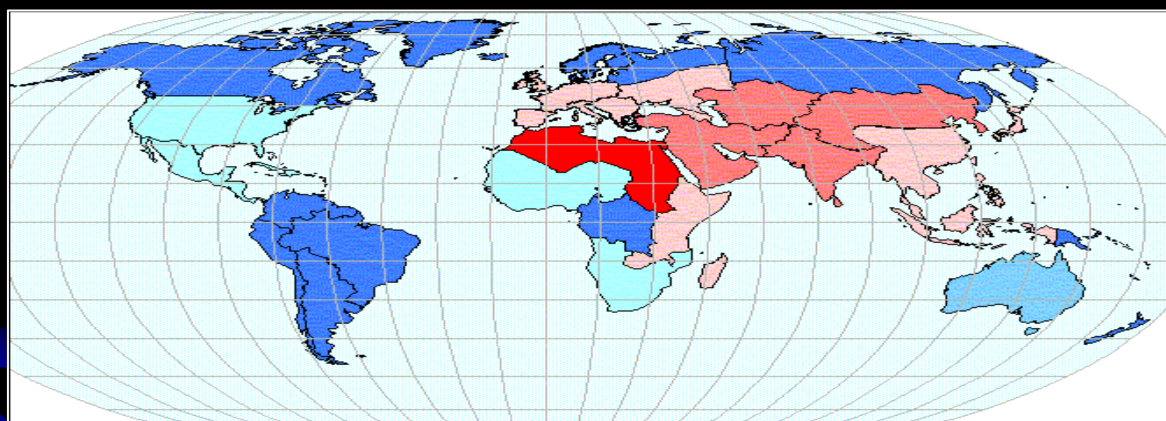
Conclusions

- California has always flooded and always will
- California can pay for flood management or it can pay more for mismanagement
- Improving Infrastructure alone will not eliminate flood risks
- A combination of approaches is needed
- Flood systems must provide land and water use services for most years, not just flood years

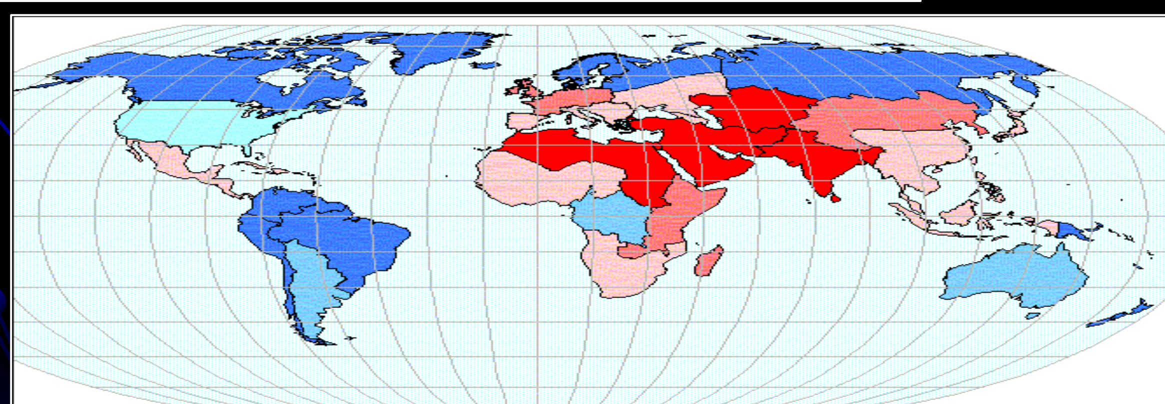
World ARWA per capita



1950



1995

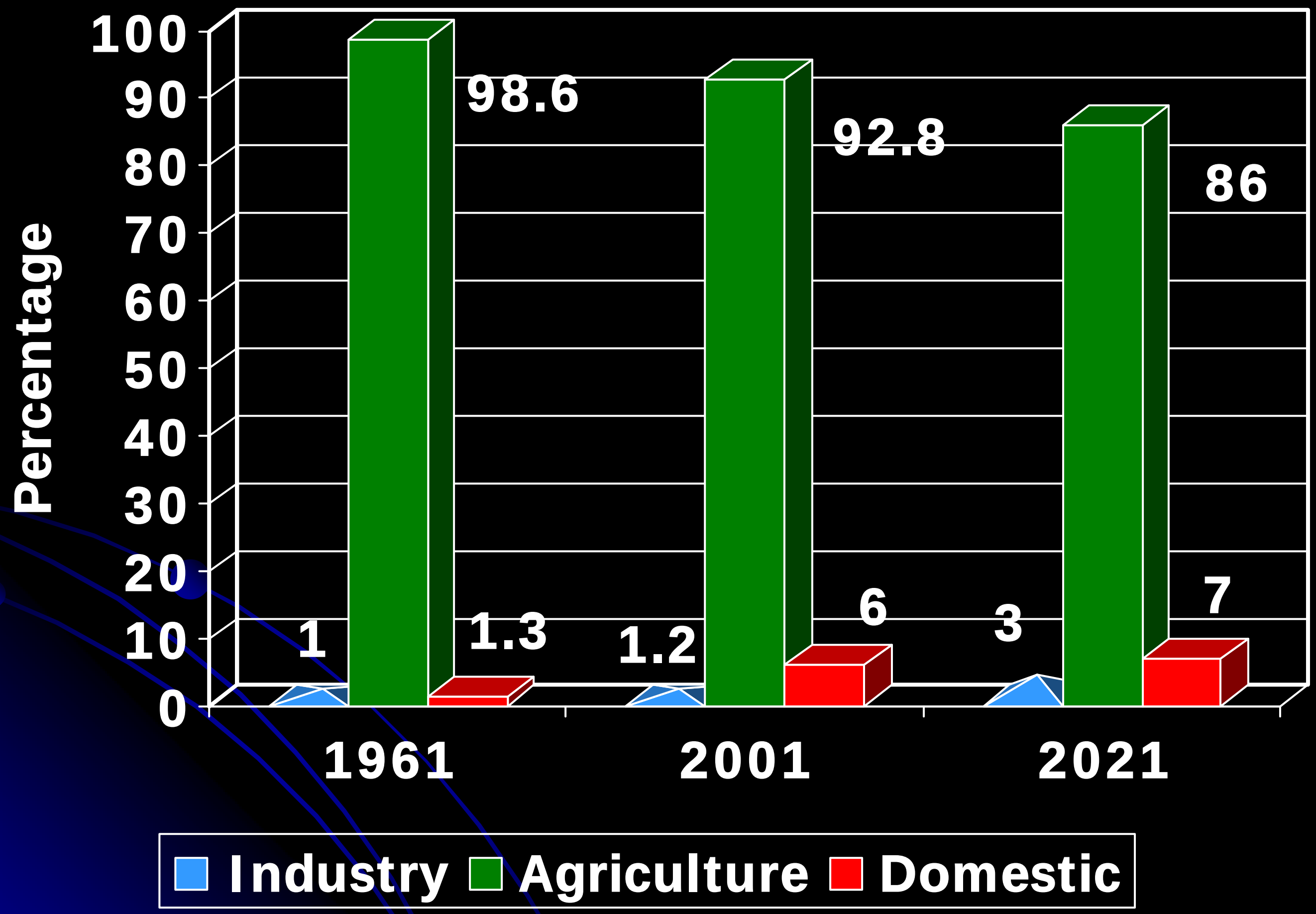


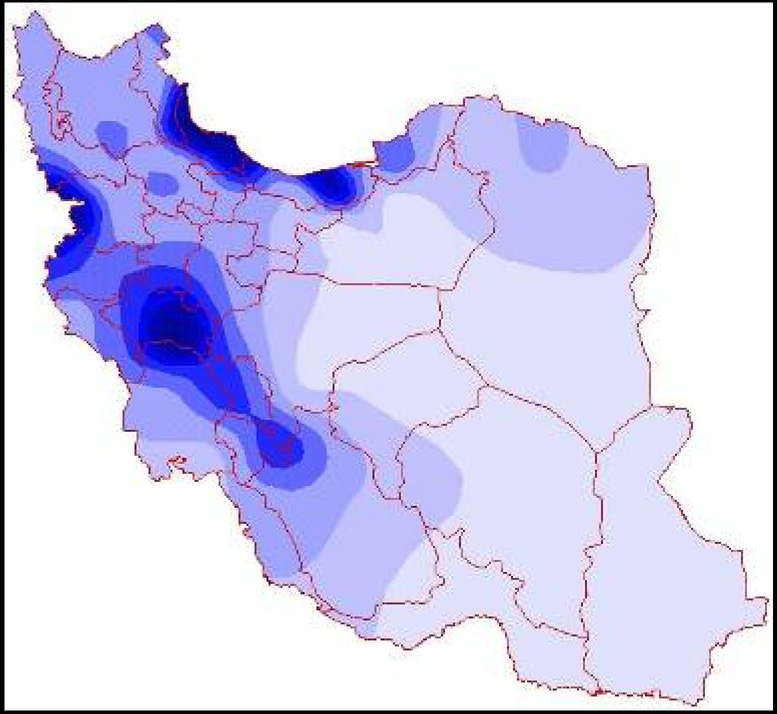
2025

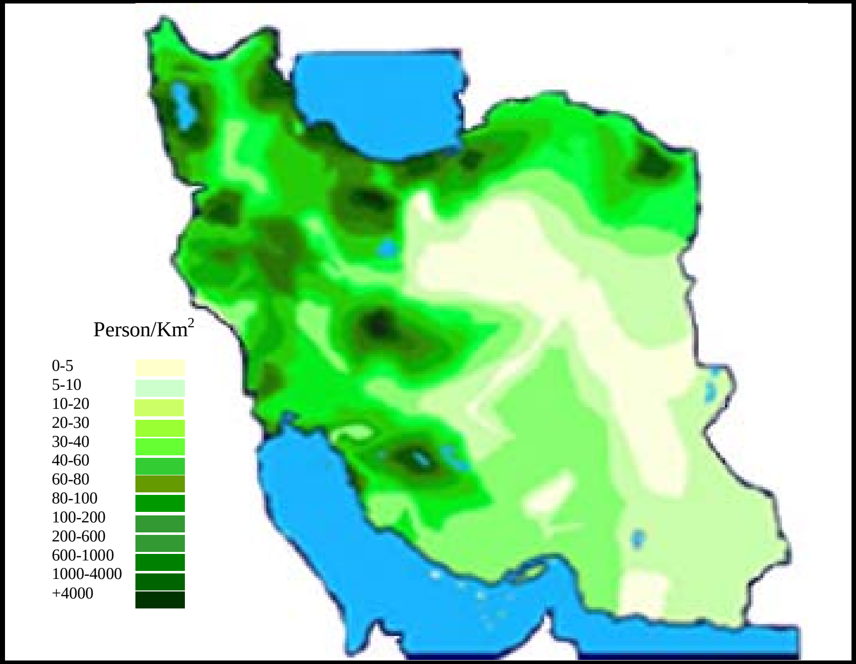
Renewable Fresh Water

Year	Annual Renewable Water availability (cubic meters/capita)
1956	7000
2001	2000
2021	1300

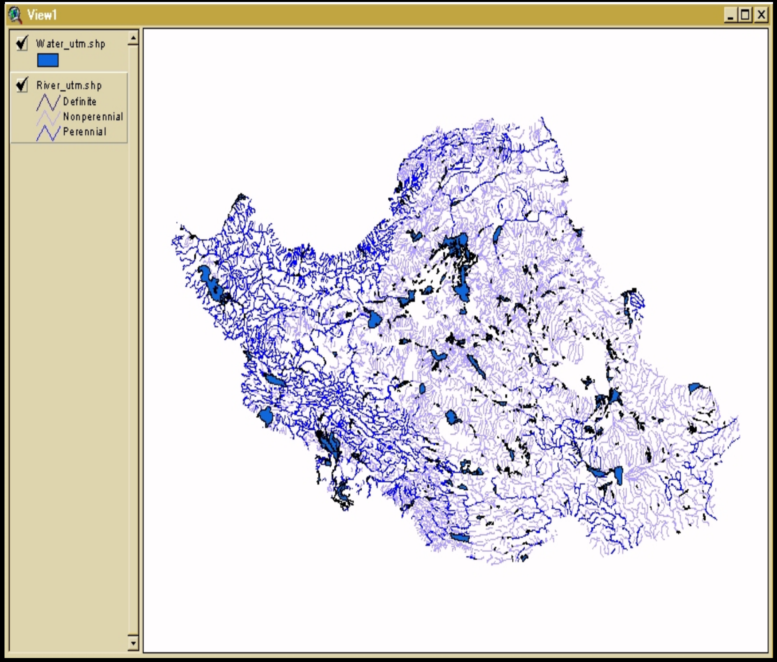
Water Consumption at a Glance







Person/Km^2
0-5
5-10
10-20
20-30
30-40
40-60
60-80
80-100
100-200
200-600
600-1000
1000-4000
+4000



View1
Water_utm.shp
River_utm.shp
Definite
Nonperennial
Perennial

Caspian
Sea
TURKMENISTAN
TABRIZ
ARDABIL
Ahar
Marand
Lake Urmia
Maragheh
Mianeh
RASHT
Mahabad
Saqqez
ZANJAN
QAZVIN
Gorgan
Gondab-e Qabus
Bojnurd
Quchan
MASHHAD
Neyshabur
Sebzavar
Behshahr
Babol
Amol
Alborz
Mountains
KARAJ
TEHERAN
Semnan
SANANDAJ
HAMADAN
Tafresh
QOM
Great
Malayer
BUKHTARAN
Nahavand
ARAK
Kashan
Borujerd
Khomein
KHORRAMABAD
Salt
Torbat-e Heydariyeh
Kashmar
Gonabad
Ferdows
Birjand
Zagros
ESFAHAN
Najafabad
Shahr Kord
Ardakan
YAZD
Dezful
IRAQ
Masjed Soleyman
Qomsheh
Desert
AHVAZ
Abadeh
Eqlid
Yasuj
Khorramshahr
ABADAN
Mountains
KERMAN
Rafsanjan
Anar
Zabol
AFGHAN
STAN
Marv Dasht
SHIRAZ
Kazerun
Borazjan
KUWAIT
Khark
BUSHEHR
Fasa
Jahrom
Firuzabad
Sirjan
Saidabad
Nosratabad
ZAHEDAN
Bam
PAKI
SAUDI
Persian
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Hormoz
Bampur
Iranshahr
Sarbaz
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ARABIA
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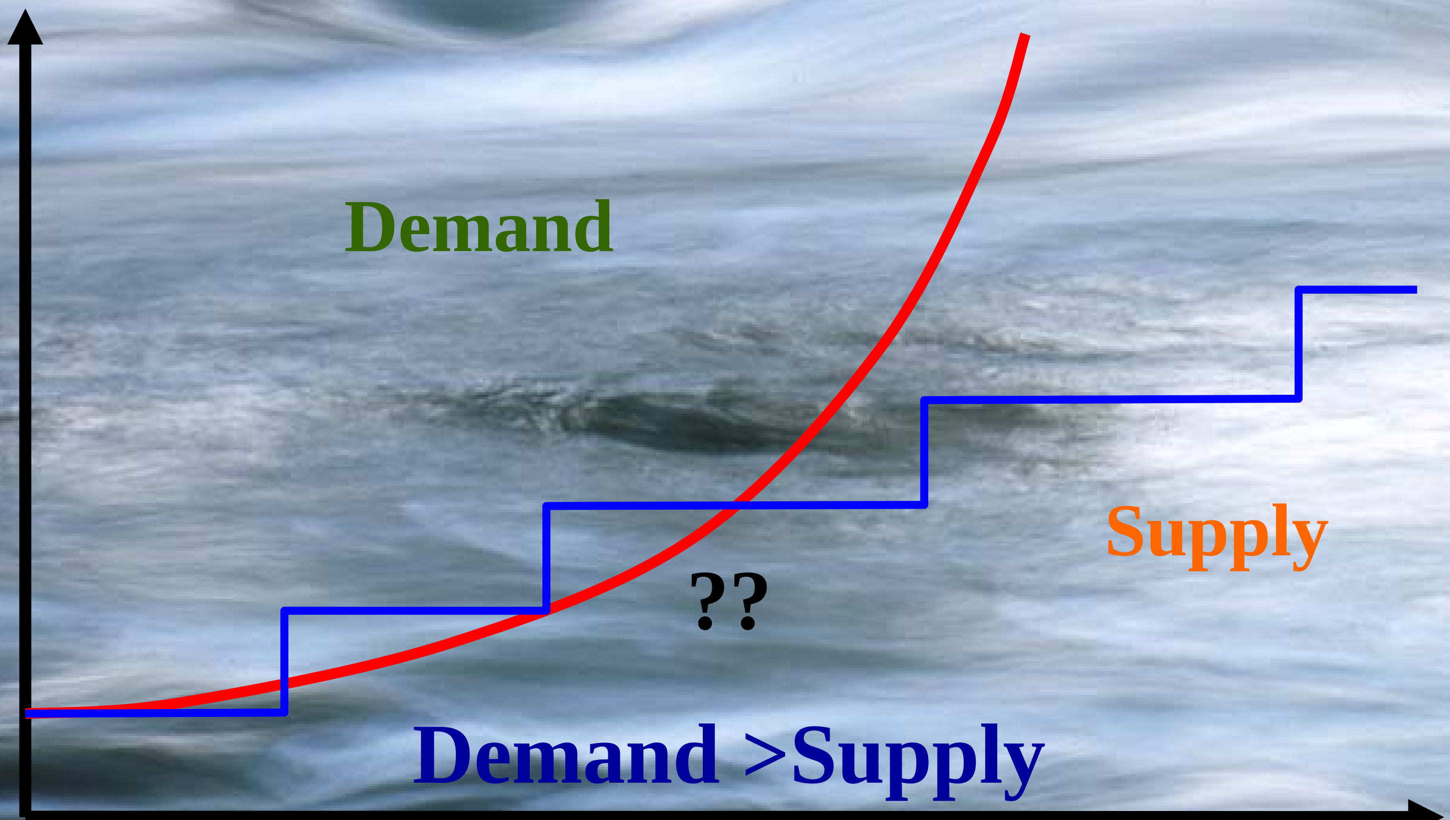
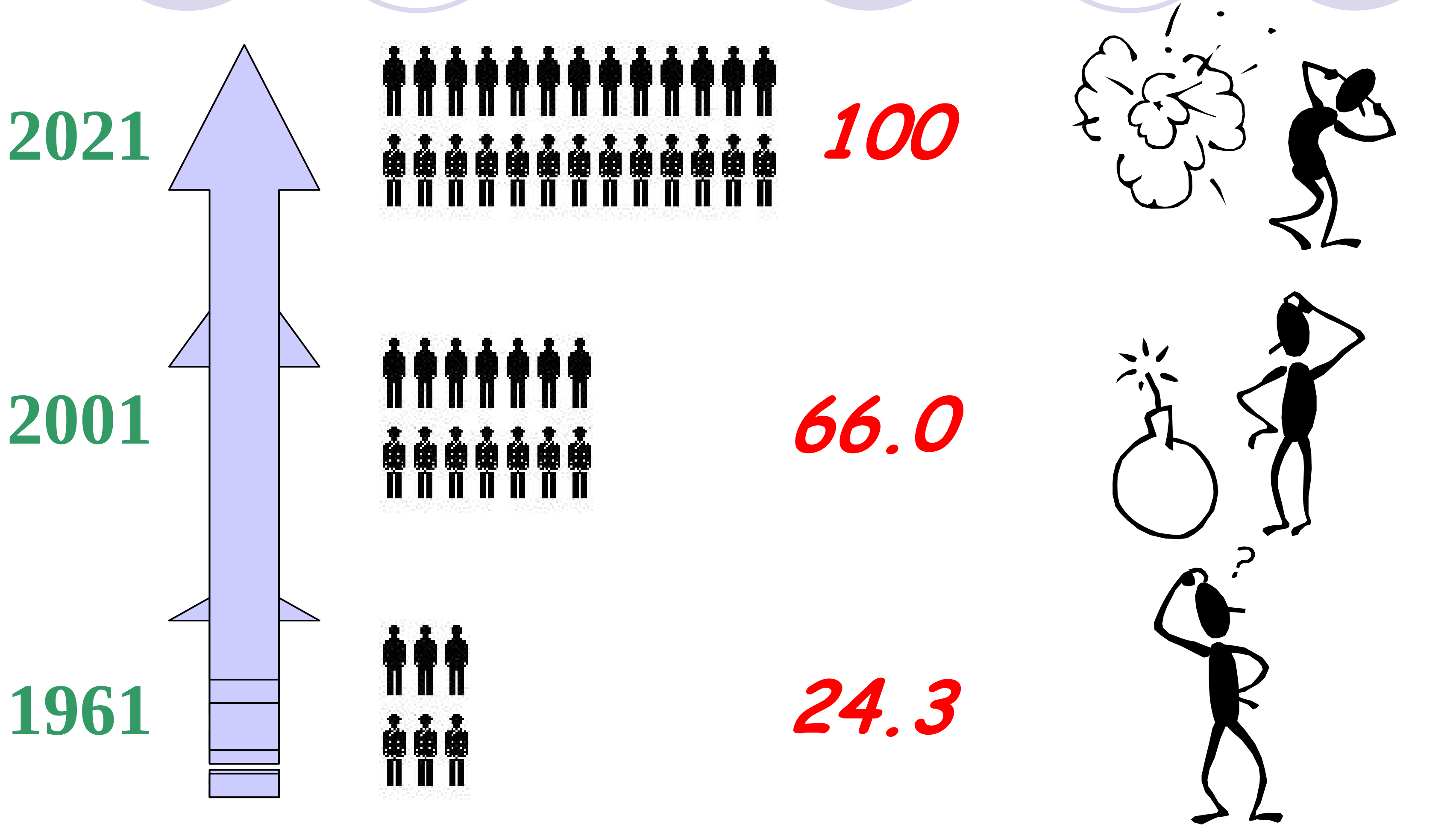
Chah Bahar
STAN

Long-term Challenges

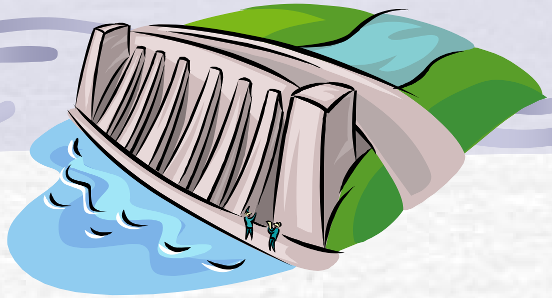
- Supply and Demand



1-Population Growth



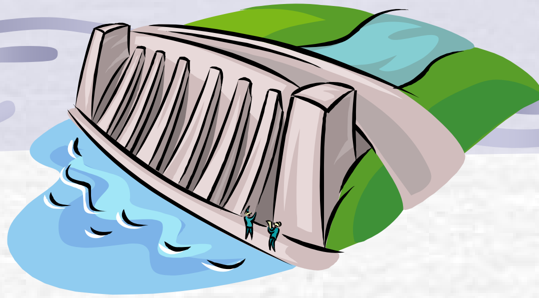
DAMS



Under Operation

No Major of Dams	85	75
Total Capacity (BCM)	25	30
Regulating Volume (BCM)	32.9	18.1

DAMS



Under Construction

No Major of Dams	**85**	**65**
Total Capacity (BCM)	**25**	**30**
Regulating Volume (BCM)	**32.9**	**18.1**

Mission

Understanding how the physical processes, information flows and managerial policies interact so as to create the dynamics of the variables of interest.

Water SISWEB

- Social Bookmarking Website dedicated to the Water Community
- SISWEB= Scientific Information Syndication WEBsite

www.watersisweb.org