

BENEFITS OF AN ADVANCED QUANTITATIVE PRECIPITATION INFORMATION SYSTEM - SAN FRANCISCO BAY AREA CASE STUDY

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NOAA Hydrometeorology Testbed

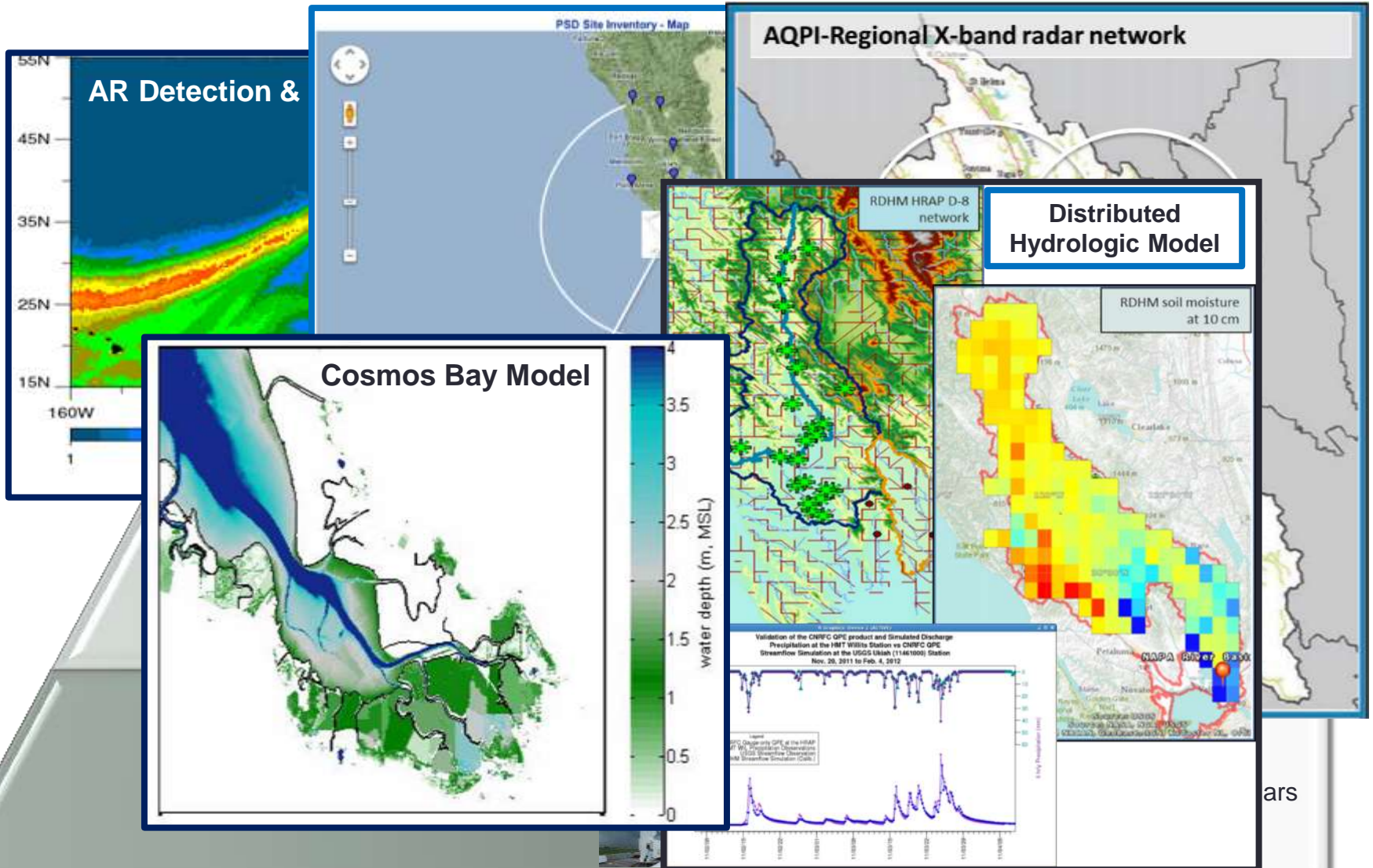
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Phased Approach for Improved Observations, Forecasts, and Decision Support Tools for the Bay Area



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Contributors & Collaborators

- NOAA Earth System Research Laboratory
 - Hydrometeorology Testbed (HMT)
 - Water Cycle Branch
 - Global System Division
- NWS
 - Office of Hydrologic Development
 - California-Nevada River Forecast Center
 - San Francisco Weather Forecast Office
- California Department of Water Resources
- Sonoma County Water Agency
- San Francisco Wastewater Enterprise
- Scripps Research Institute

AQPI BENEFITS ASSESSMENT

- **ECONOMICS OF HYDROMET INFORMATION**
 - **FLOOD MITIGATION**
 - Avoid damages by early warning
 - **WATER SUPPLY**
 - Capture storm runoff in reservoirs
 - **ECOSYSTEM SERVICES**
 - Maintain flows for fisheries and recreation
 - **TRANSPORTATION**
 - Avoid Delays and Dangers on Roads, Air, Rail and Ports
- **REGIONAL ACCOUNTING APPROACH**
 - Reconnaissance-level tabulation
 - Expected annual value estimates
 - Most estimates low to moderate confidence



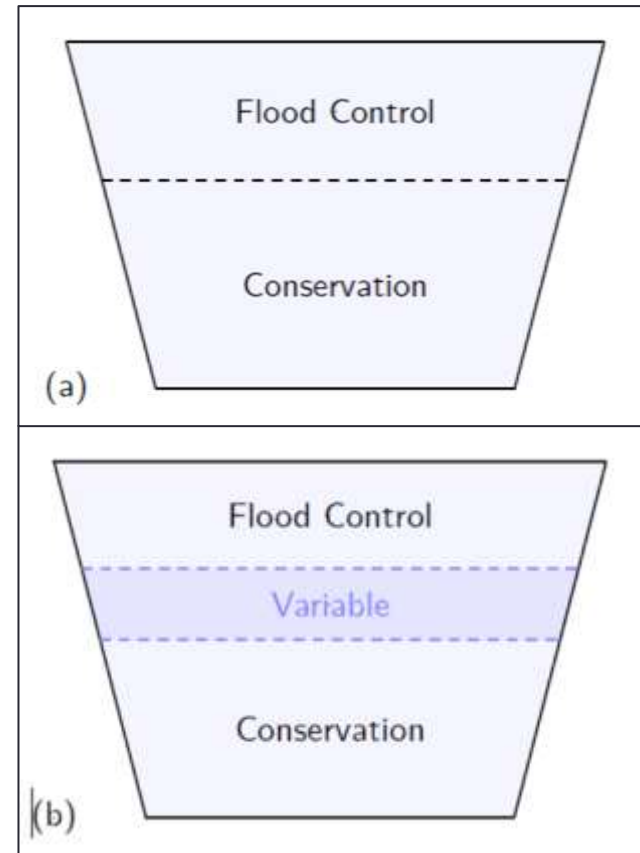
TIME FRAMES AND WATER MANAGEMENT PURPOSES

Time Frame / Purpose	Nowcast (0 min – 6 hrs)	Near Real-time (6 hr – 1 day)	Short-term (1 day – 1 week)	Near-term (1 wk – 3 mon)	Mid-term (6 mon – 2 yrs)	Long-term (5 years+)
Flood Mitigation	Flood status assessment	FF warning; Response deploy; System opt.	Flood warning; Response deploy; Reservoir FBO	Flood warning; Response deploy; Reservoir FBO	Over-year storage allocation	Flood frequency; Capacity devel; Climate adapt.
Water Supply	Status assessment; Intake operations	Intake and outlet operations	Reservoir FBO; Emergency conservation	Delivery sched.; Reservoir FBO; Conservation	Over-year drought mit.; Conservation	Capacity devel; Demand mana; Climate adapt.
Hydro-Power	Release operations	Reservoir FBO	Reservoir FBO; Demand sched.	Reservoir FBO; Demand sched.	Over-year drought mit.	Capacity devel.; Climate adapt.
Ecosystem Enhancement	Status assessment	Threat assess; River & Reservoir FBO	Threat assess; River & Reservoir FBO	Threat assess; River & Reservoir FBO	Threat assess; Capacity devel; Drought mit.	Ecosystem & Capacity devel; Climate adapt.
Water Quality	Status assess; Real-time control	WW capture & treatment	Threat assess; Sys. optimize	Threat assess; Capacity devel; Sys. optimize	Threat assess; Capacity devel; Sys. optimize	Capacity devel; Climate adapt.
Recreation	Weather status; Warning	Event scheduling	Reservoir FBO	Reservoir FBO	Capacity development	Capacity development

HMT Focus
<http://hmt.noaa.gov/>

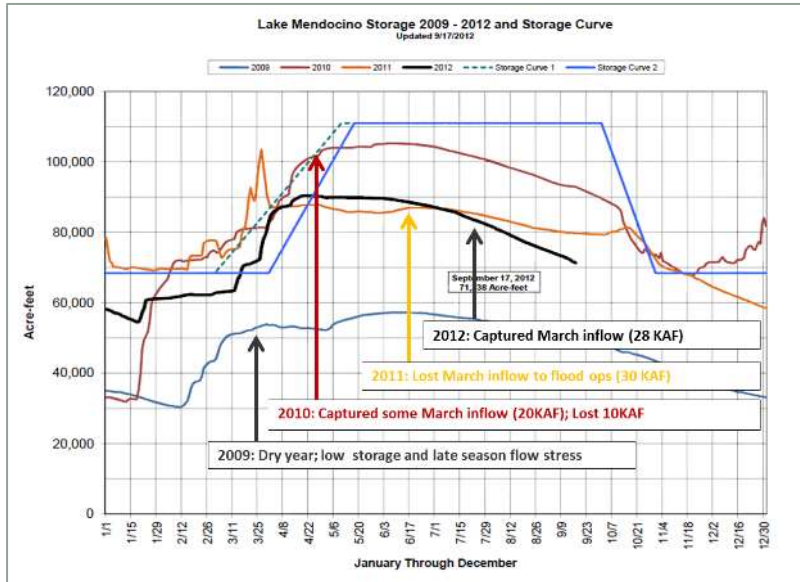
FORECAST INFORMED RESERVOIR OPERATIONS

- Storage management to maximize benefits for all users
- Water supply
 - Municipal and industrial
 - Irrigation
- Flood damage mitigation
- Ecosystem enhancement
 - Water Quality
 - Water-Related Recreation
- Hydropower generation

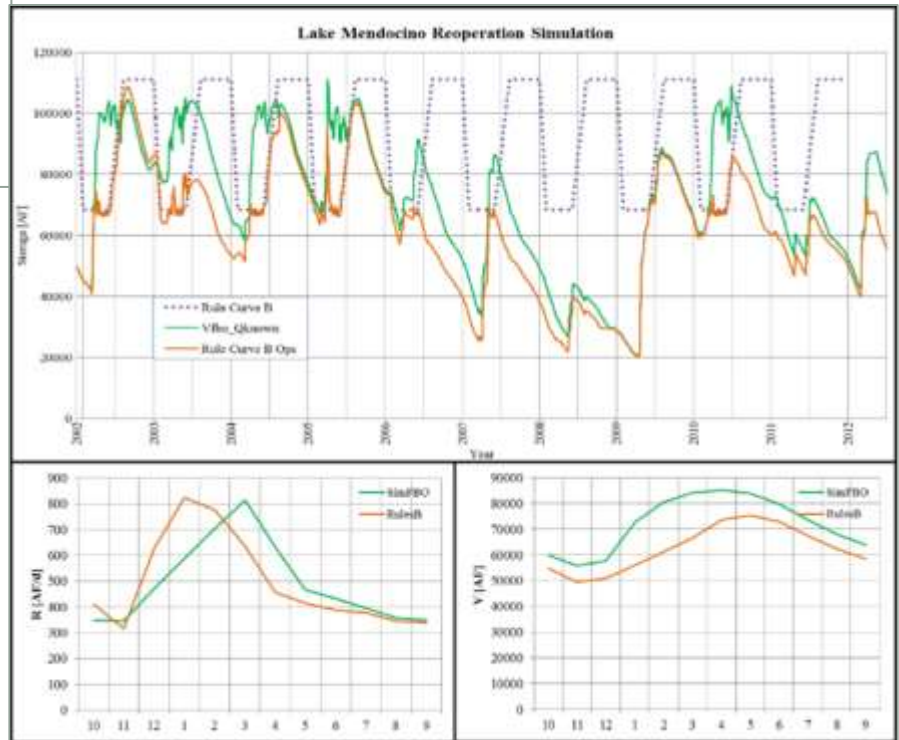


Depiction of reservoir space allocations under (a) typical operating paradigm and (b) forecast-based operation. (MBK Engineers 2014)

WATER SUPPLY BENEFITS



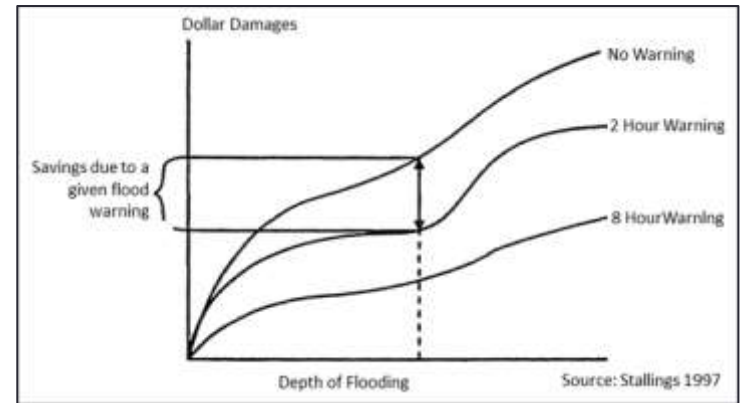
- » Fixed rule curve operations lose water
- » Examples show historic operations
- » Current 2014 drought exacerbates flow conditions for water supply and fish
- » Forecast-based operations can capture and hold 10 KAF additional water; @ \$1K/AF get \$10M benefit



- » FldOps simulation model
- » Rule curves relaxed for a) flood pre-release if large rain forecast, and b) flood zone capture and hold if no rain forecast
- » 10-day inflow volume look ahead
- » Overall increase in storage levels
- » Increases in release flows to later in Spring and Summer

Flood Lead Time Benefits

- NWS inflow forecasts to USACE reservoirs have benefits ~5% of average annual flood damages prevented by flood storage
- Actions
 - Short-term flood events
 - Little lead time but life threats greatly reduced by restricting exposure
 - Reductions in flood damages ~10% of average annual flood damages
 - Long-term flood events
 - Enough lead time for community flood fight actions
- Expected annual damages (EAD) reductions estimated
- Benefits only accrue if flood response actions are taken

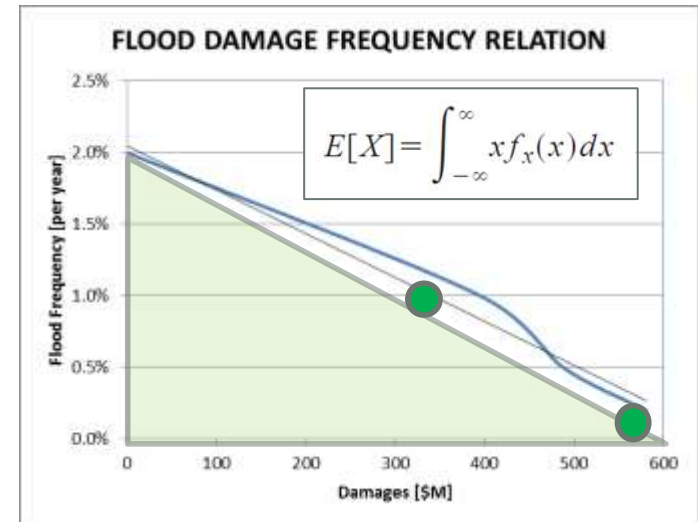


ARkStorm Scenario Damages
(Porter et al 2011)

County	Flood	Wind
Alameda	\$ 14,000,000	\$ 270,000
Contra Costa	\$ 16,000,000	\$ 430,000
Marin	\$ 8,500,000	\$ 72,000
Napa	\$ 2,000,000	\$ 33,000
San Francisco	\$ 990,000	\$ 180,000
San Mateo	\$ 11,000,000	\$ 380,000
Santa Clara	\$ 40,000,000	\$ 59,000
Solano	\$ 7,000,000	\$ 130,000
Sonoma	\$ 5,500,000	\$ 86,000
Total	\$ 104,990,000	\$ 1,640,000

EXPECTED ANNUAL DAMAGES AVOIDED

- Flood damage frequency relation
- Expected annual damages computation
- EAD reductions
 - Household content value
 - 5% - 10% rule gross estimate
 - 1% - 2% incremental estimate



County	Structures in 100-yr Floodplain	Structures in 500-yr Floodplain	100-Yr Contents Damages* [\$M]	500-Yr Contents Damages* [\$M]	Exp. Annual Contents Damages [\$M/yr]
Alameda	10,100	38,500	\$505	\$1,925	\$11.5
Contra Costa	15,300	25,300	\$765	\$1,265	\$11.7
Marin	13,300	22,100	\$665	\$1,105	\$10.2
Napa	4,900	6,500	\$245	\$325	\$3.5
San Francisco	0	0	\$0	\$0	\$0.0
San Mateo	30,300	44,700	\$1,515	\$2,235	\$22.2
Santa Clara	37,100	201,600	\$1,855	\$10,080	\$52.9
Solano	7,200	23,100	\$360	\$1,155	\$7.5
Sonoma	7,900	11,600	\$395	\$580	\$5.8
Total	126,100	373,400	\$6,305	\$18,670	\$125.3

* Assuming contents at \$50K per structure

Ref: CaDWR 2013: California's Flood Future: Attachment D - Summary of Exposure and Infrastructure - Inventory by County

ECOSYSTEM SERVICES BENEFITS

- Fishery and boating flows enhanced by maintaining releases anticipating reservoir capture
- Weather information informs on safety of water conditions (flow velocities, waves)
- Reductions in beach closures due to WQ issues reduces lost visitor days.



TRANSPORTATION BENEFITS

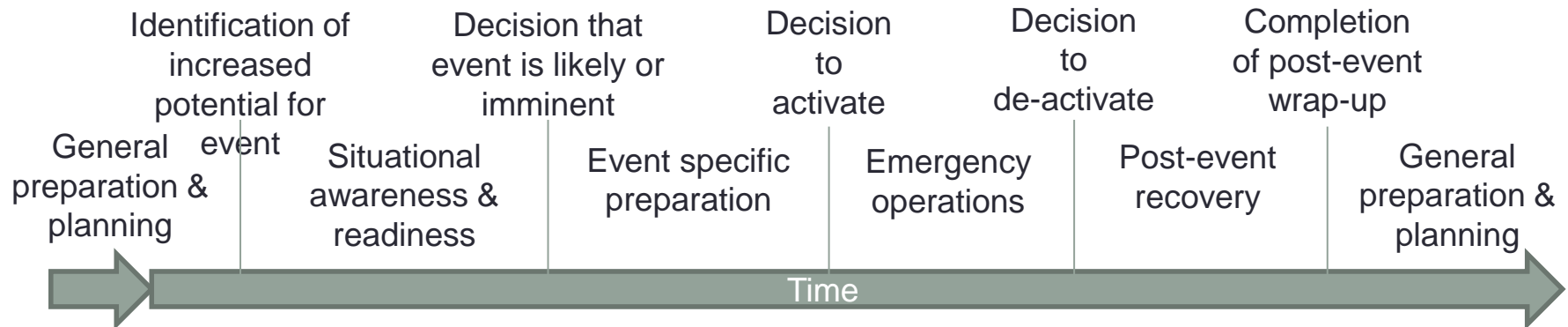
- Improved safety
- Improved efficiency (e.g. travel time)
- Improved environmental protection
- Improved recreational experiences
- Enhanced wx forecasts may guide road travel choices on timing and routes; although most drivers do not change.
- Aviation travel scheduling is enhanced by timely and accurate wx reports at hourly time scales.
- Shipping benefits based on avoided shipping delays and grounding and spills.



Locations in the San Francisco Bay Area Projected to be Impacted by a 100-Year Extreme Storm Event without and with 1.4 m Sea-Level Rise. (Biging, et al 2012)

WATER MANAGEMENT DECISIONS SEQUENCE

- Generalized sequence of information gathering, assessment, decision making and follow-up
- Developed for flood response but applies to longer time frames for water supply and other purposes



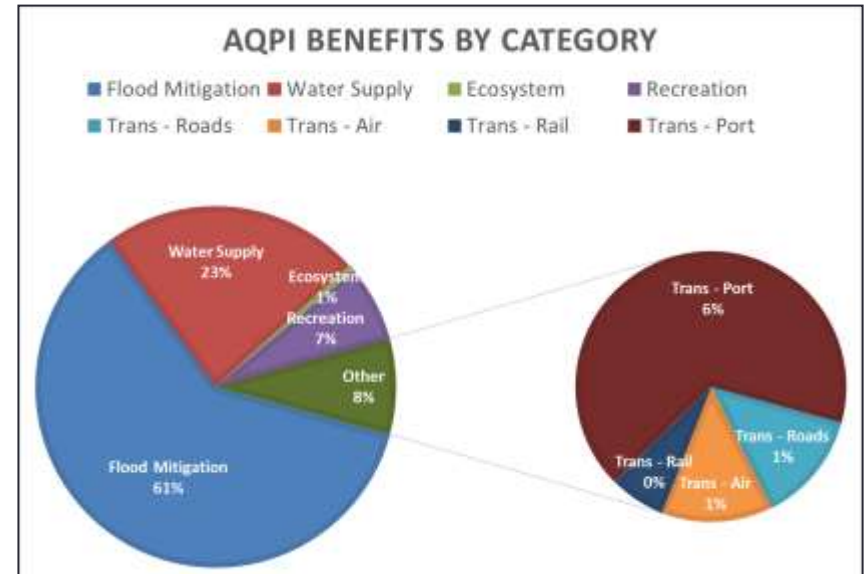
REGIONAL BENEFITS ACCOUNTING APPROACH

- Extensive literature review
- Identification of factors and metrics
 - “Concurrence of opinions”
- Data for all jurisdictions
- Bounding of estimates
- Conservative interpretations
- Uncertainty assessment
 - Base Case
 - Best case
 - Worst case
- Qualifications

Source of Benefits	Method
General Hydromet Value	1% rule on economic activity
	Per capita benefit
	Per capita benefit for early lead time
Flood Mitigation	Lead time for residential contents (EAD)
	ArkStorm property damages avoided (annualized)
Water Supply	Captured water; anticipation of AR event at 6 days lead time.
	Captured stormwater for aquifer recharge
Ecosystem Enhancement	Fishery flows enhanced by FBO reservoir capture.
Water-Related Recreation	Reservoir releases support canoeing and rafting trips, and fishing.
Transportation	Enhanced wx forecasts may guide road travel choices; although most drivers do not change.
	Aviation scheduling enhanced by wx information at hourly time scales.
	Rail operating efficiency, physical infrastructure and safe and timely travel are influenced by wx.
	Shipping benefits include safety, efficiency, lower insurance and higher customer satisfaction; including recreational boating.

AQPI BENEFITS SUMMARY

- Overall
 - Total Wx Benefits (\$240M/yr; \$34/person)
 - Incremental AQPI Benefits (\$62M/yr; \$9/person)
- By Category
 - Flood Mitigation (61%)
 - Water Supply (23%)
 - Ecosystem Services (8%)
 - Transportation (8% (Ports 6%))
- Benefit/Cost Estimates
 - Base Case – 5:1
 - Best Case – 13:1
 - Worst Case - 2:1
- Qualifications
 - AQPI system must work
 - Response actions must be taken



Benefit Category	Total Weather Forecast Benefits [\$ /yr]	AQPI Incremental Benefits [\$ /yr]	AQPI Incremental Benefits [PV(6%, 10 yr)]
General	\$1,120,154,000	\$35,480,000	\$261,135,889
Flood Mitigation	\$188,850,000	\$37,770,000	\$277,990,488
Water Supply	\$29,000,000	\$14,500,000	\$106,721,262
Ecosystem	\$1,875,000	\$375,000	\$2,760,033
Recreation	\$8,515,200	\$4,257,600	\$31,336,307
Trans - Roads	\$1,774,000	\$709,600	\$5,222,718
Trans - Air	\$3,552,500	\$710,500	\$5,229,342
Trans - Rail	\$1,064,400	\$354,800	\$2,611,359
Trans - Port	\$7,096,000	\$3,548,000	\$26,113,589
Total for categories	\$241,727,100	\$62,225,500	\$457,985,097

Thanks

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