Colorado River Water Availability Study

Study Overview for the

Colorado Water Conservation Board

March 17, 2009

Consulting Team

Boyle - AECOM Water

AMEC Earth & Environmental

Canyon Water Resources

Leonard Rice Engineers

Stratus Consulting

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Study Team – Technical

Blaine Dwyer	Project Manager
Matt Brown	Assistant Project Manager
Ben Harding	Paleo, Stochastic, and Big River hydrology / operations
Erin Wilson	CDSS applications
Meg Frantz	StateMod refinements / execution
Jim Pearce	Review - Water Management issues
Joel Smith	Guidance - Climate Change approaches

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Agenda

1. Study Progress
2. BRT Workshops and CDSS Refinements
3. Technical Approaches
    a) Paleo-Hydrology
    b) Climate Change
4. Comments and Questions?

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1. Study Progress

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Study Team – Management

CWCB Board of Directors

Ray Alvarado
Ross Bethel
Eric Hecox
Veva Deheza
CWCB & DWR Staff

Department of Natural Resources

Attorney General's Office

IBCC - Basin Roundtables

Boyle Management

Blaine Dwyer, P.E.
Project Manager

Matt Brown, P.E.
Assistant P.M.

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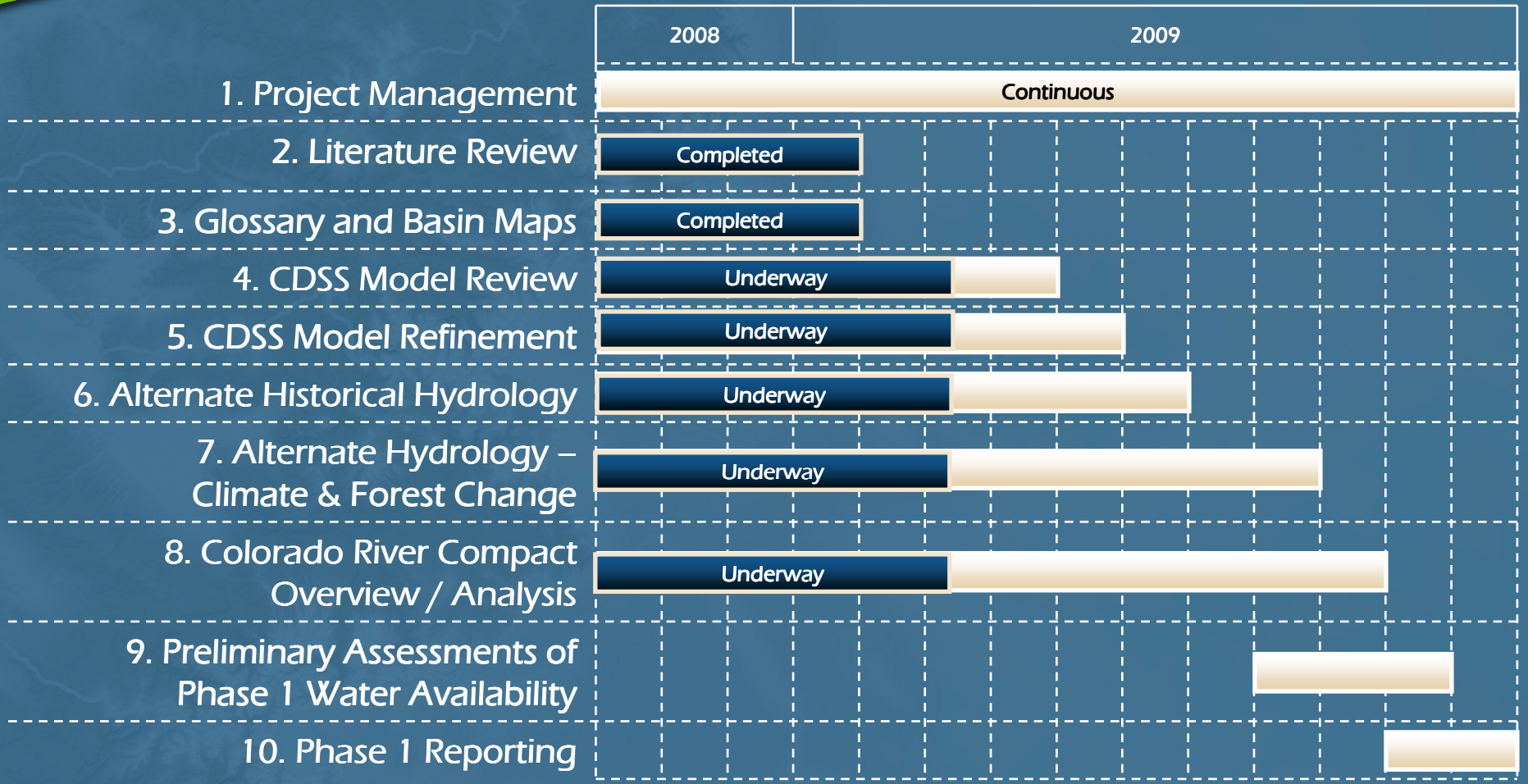
Study Status – Phase I



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Interim Work Products

Completed deliverables:

- Public Information - Newsletter - Volume 1 (Task 1.3)
- 6 CDSS Model Briefs - CDSS Overview, Yampa, White, Upper Colorado, Gunnison, San Juan/Dolores (Task 4.1)
- BRT Workshops - Yampa/White, Colorado, Gunnison, Southwest (Task 4.2)
- Alternate Historical Hydrology - Literature Review, Method Evaluation, Analysis of Tree-Ring Data, and Recommendations (Task 6.1-6.3)
- Climate and Forest Change - Hydrologic Approach and Model Selection (Task 7.5)

Draft CRWAS deliverables:

- Coordination with Front Range Vulnerability Study (Task 7.1)
- Climate Change - Literature Review and Methods Evaluation (Task 7.2)
- Forest Change Literature Review and Suggested Methods (Task 7.3)
- Colorado River Compact Overview Summary of Key Issues (Task 8.1)

2. BRT Workshops & Input to Date

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Study Purpose – State-Wide Sponsorship

Interstate Issues

Information for the entire state to use in relation to current and future water management

Intrastate Issues

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Phases and Limitations

- Phase I – Water Availability under current water supply infrastructure, currently perfected water rights, and current levels of consumptive and non-consumptive water demands

- Phase II – Water Availability under projected demands from existing, conditional, and new water rights and for additional consumptive and non-consumptive water demands

- Limitation - No assessment of compact call administration or potential for curtailments

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Basin Roundtable Involvement

- BRT Workshops on Model Briefs for each Basin
  - Colorado – February 23 in Glenwood Springs
  - Gunnison – March 2 in Montrose
  - White/Yampa – March 4 in Craig
  - Southwest – March 11 in Durango
- BRT suggestions for CDSS Model Refinements by end of March
- Encouraged to provide input on other Study products as developed

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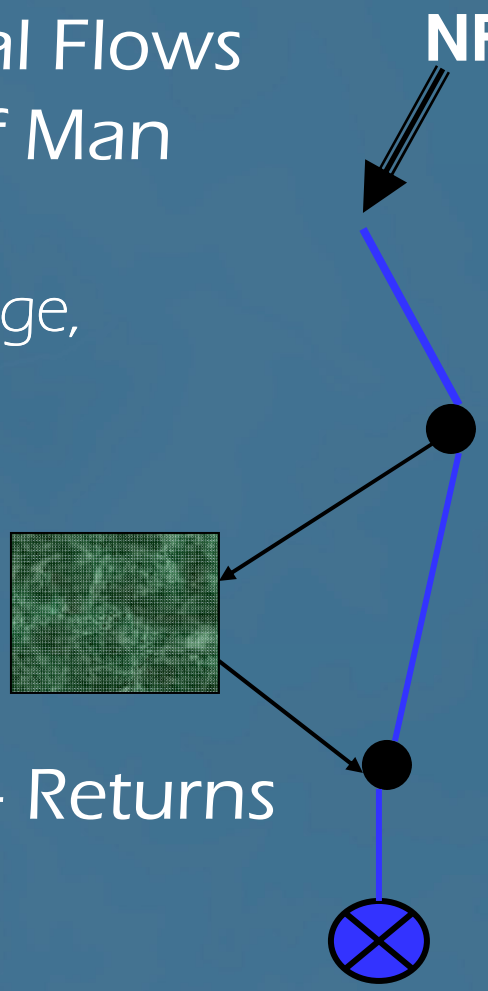
Inflow Hydrology – Natural Flow Development

- StateMod estimates Natural Flows by Removing the Effects of Man
  - Diversions, Return Flows, Changes in Reservoir Storage, Evaporation



- NF = Gaged + Diversions – Returns +/- change in storage

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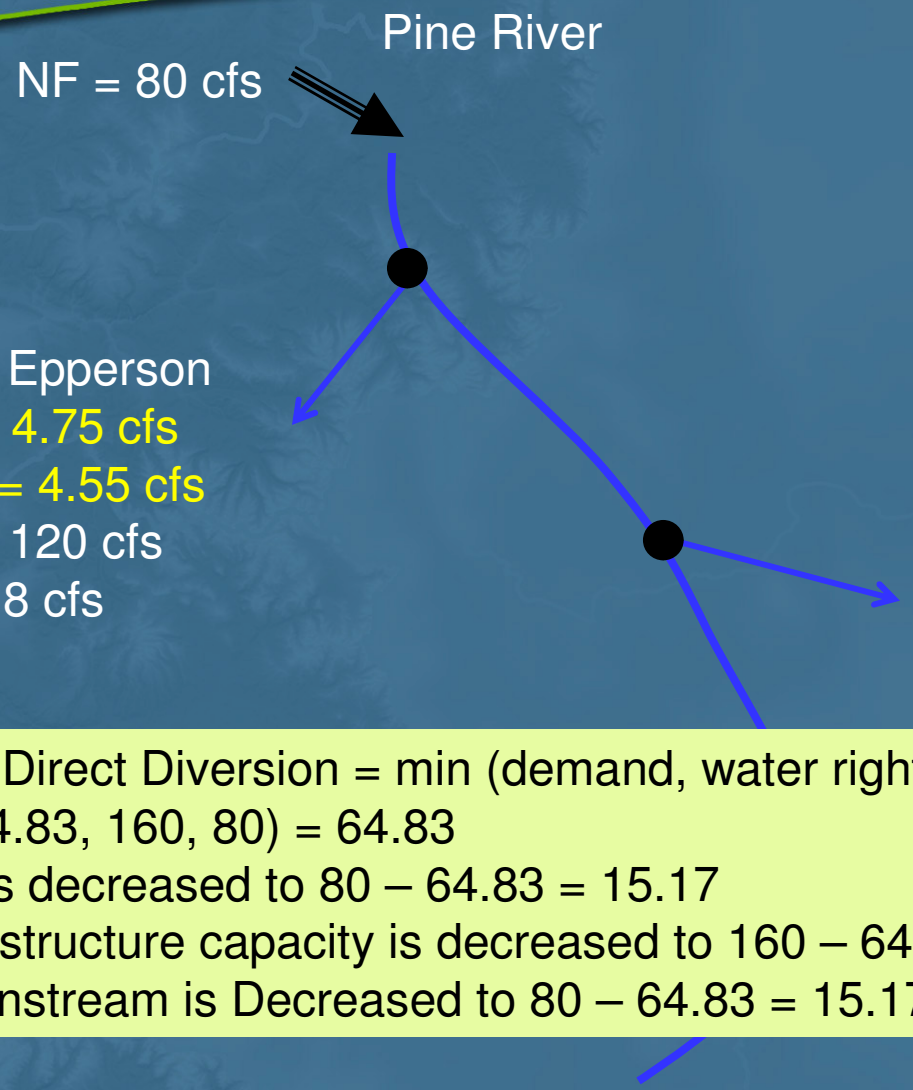
Model Operations



1) Priority 1: Direct Diversion = min (demand, water right, capacity, physical flow) = min(80, 64.83, 160, 80) = 64.83
2) Demand is decreased to 80 – 64.83 = 15.17
3) Diversion structure capacity is decreased to 160 – 64.83= 95.17
4) Flow Downstream is Decreased to 80 – 64.83 = 15.17

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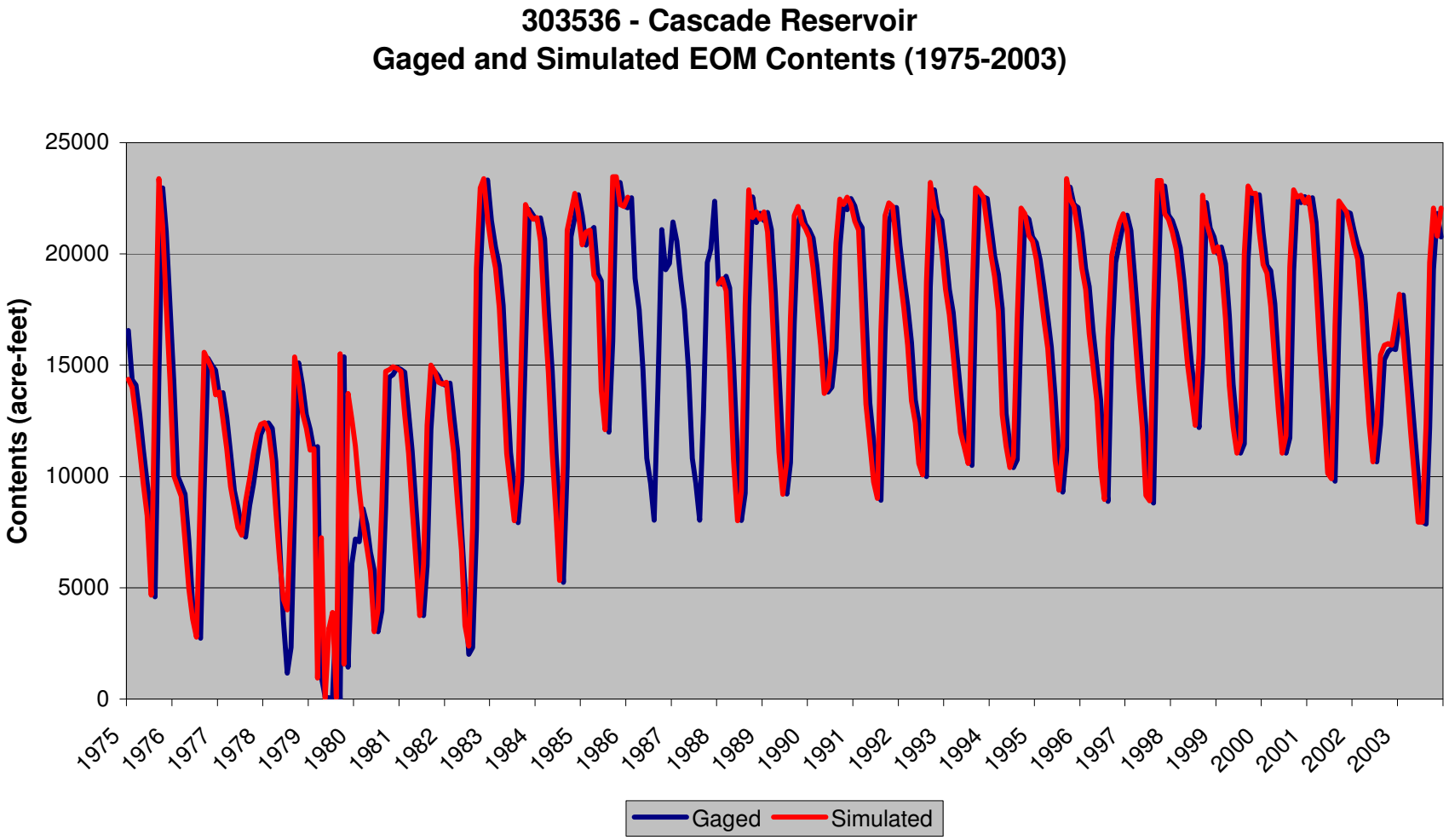
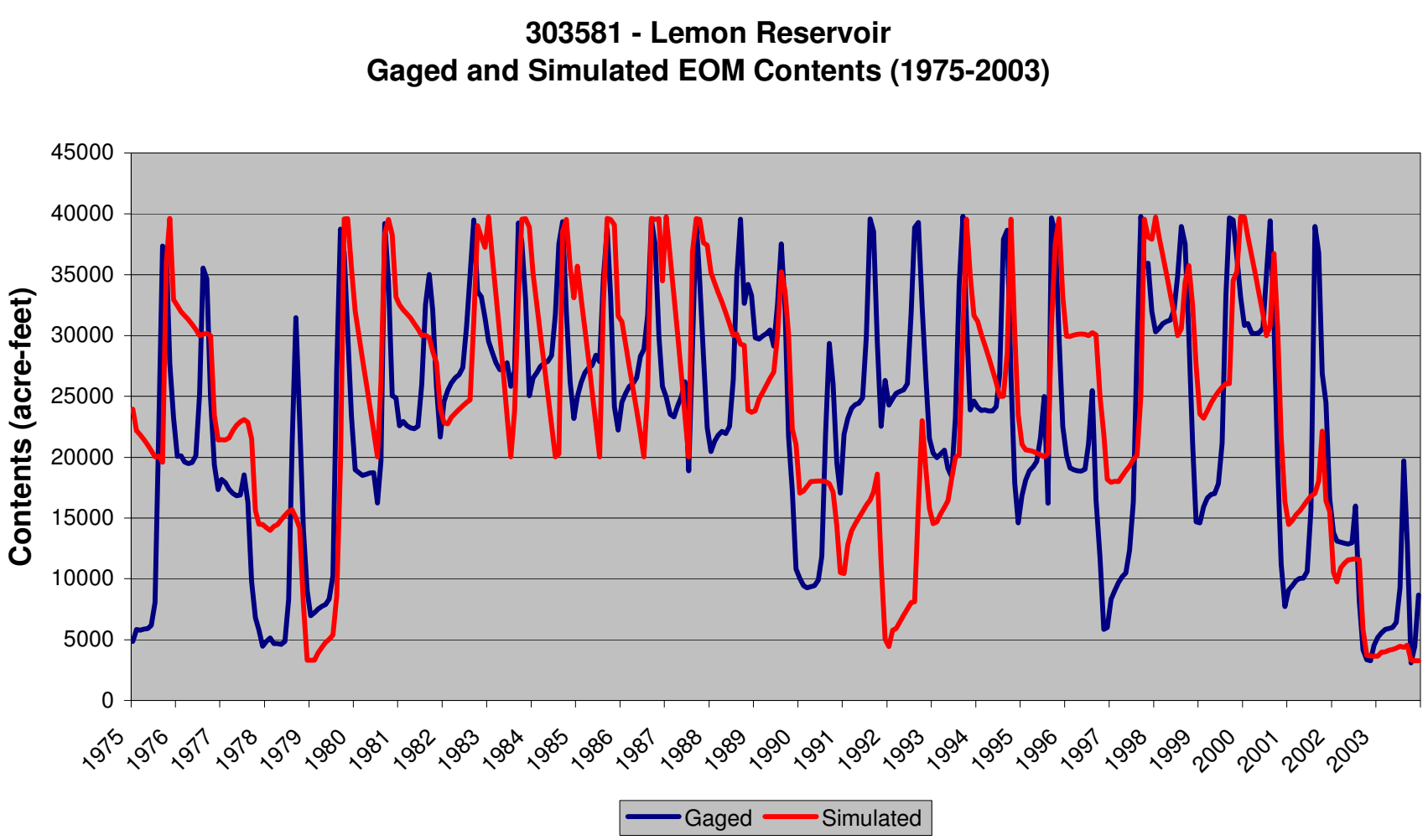
Model Calibration



Model Calibration



CDSS - BRT Workshops

- CDSS information specific to each basin
- Increased comfort with CDSS models and procedures
- Key input to-date:
  - Reliability of tree-ring and climate change
  - Specific project operations
  - High elevation crop coefficients
  - Incorporation of non-consumptive needs
  - Importance of Phase 2

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3. Technical Approaches

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Three Step Hydrologic Analysis

1) **Historical Hydrology**

- To be used for comparative analysis
- 1950's forward (most reliable data)

2) **Alternate Historical: Paleo -Hydrology** | Extend Records with Tree-Rings & Stochastic Methods

3) **Climate Change and Forest Change**

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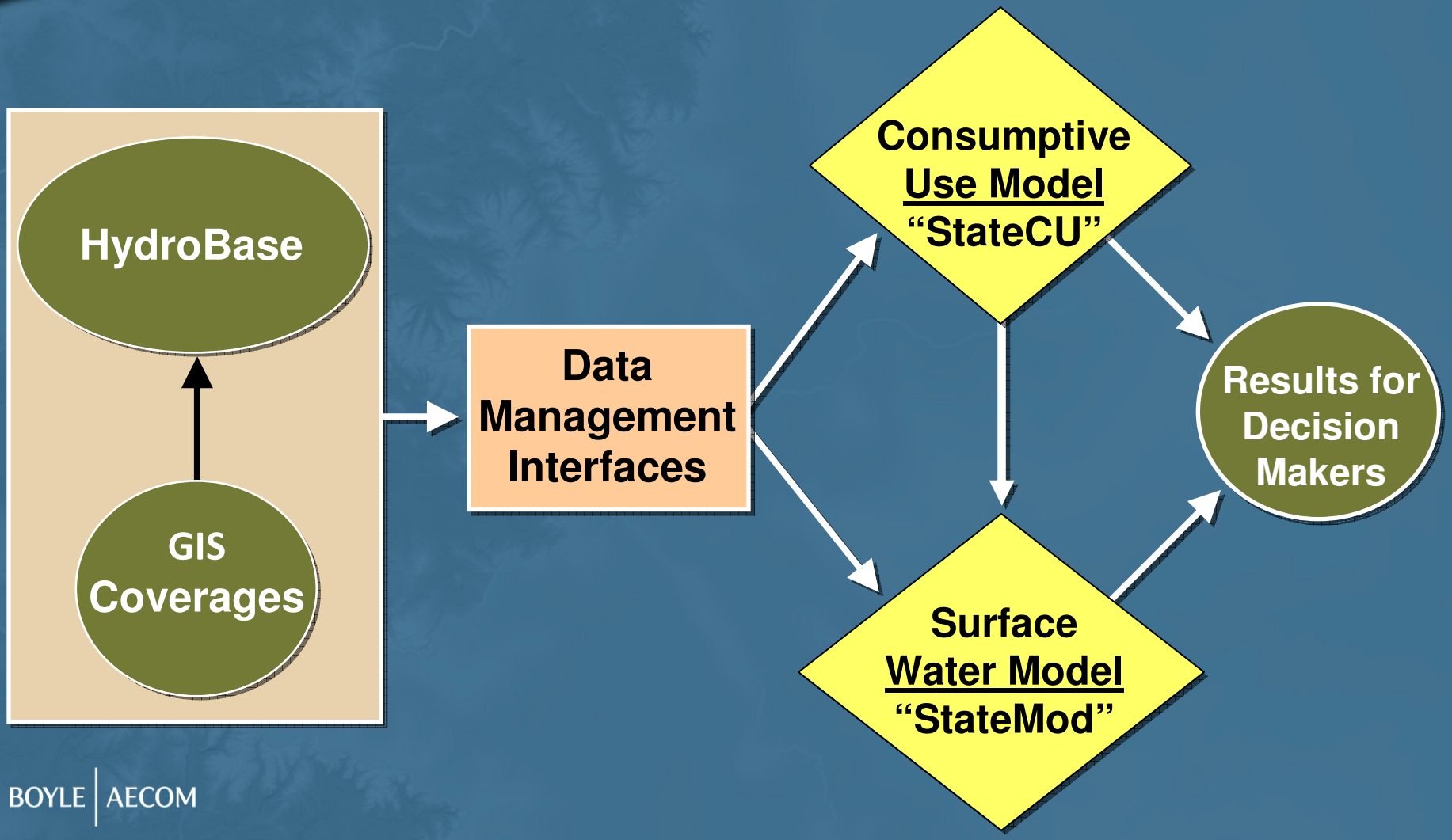
1) Historical Hydrology – Data-Centered CDSS



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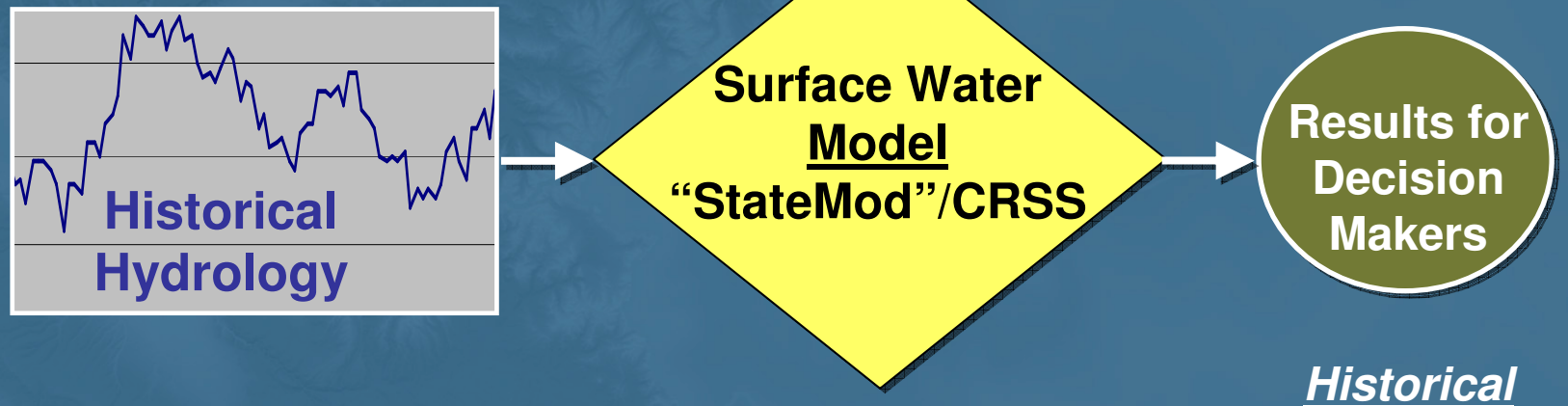
1) Historical Hydrology → Water Availability



Historical

Water Availability

Reservoir Conditions

Instream Flows

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3a) Paleo-hydrology

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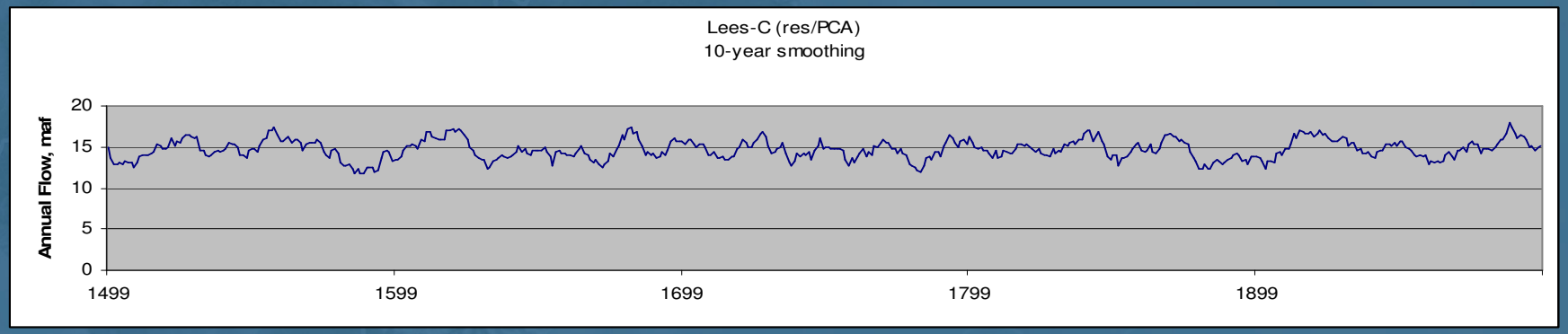
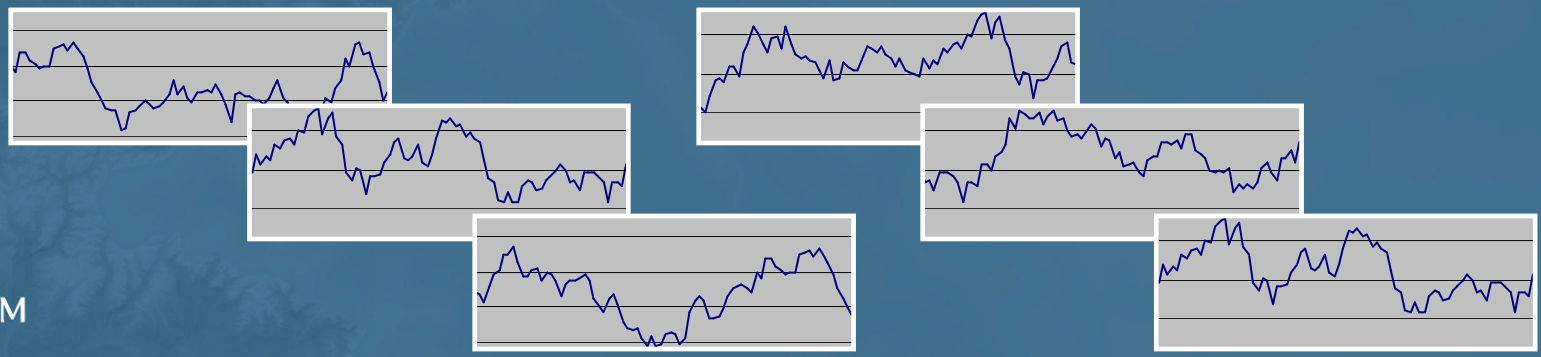
2) Alternate Historical Hydrology (Paleo-hydrology)

Reconstructed Flows



"Ensemble" of "Traces"



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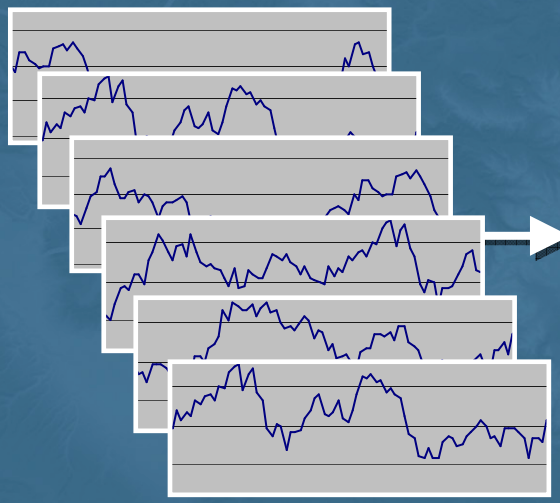
2) Alternate Historical Hydrology ➔ Water Availability

"Ensemble" of "Traces"



Surface Water Model "StateMod"/CRSS

Results for Decision Makers

Alternate Historical

Water Availability

Reservoir Conditions

Instream Flows

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Alternate Historical Hydrology

- Considered 3 methods involving regression- and re-sequencing techniques
- Two have been previously applied to Colorado River basin
- Selected the re-sequencing approach:
  - *Efficiency/ automated validation processes*
  - *Can be applied to both "Big River" (CRSS) and CDSS models*
  - *Spatial correlations and seasonal patterns maintained*

3b) Climate Change

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3) Climate Change & Down - Scaling

Earth

- Emissions Scenarios
- Global Climate Models

Result: *Altered Temperature and Precipitation*

Colorado River Basin

- "Down-Scaled" Projections
- Revised Basin-Wide Hydrology

Result: *Altered Stream Flows*

State of Colorado

- CDSS Modeling

Result: *Water Availability*

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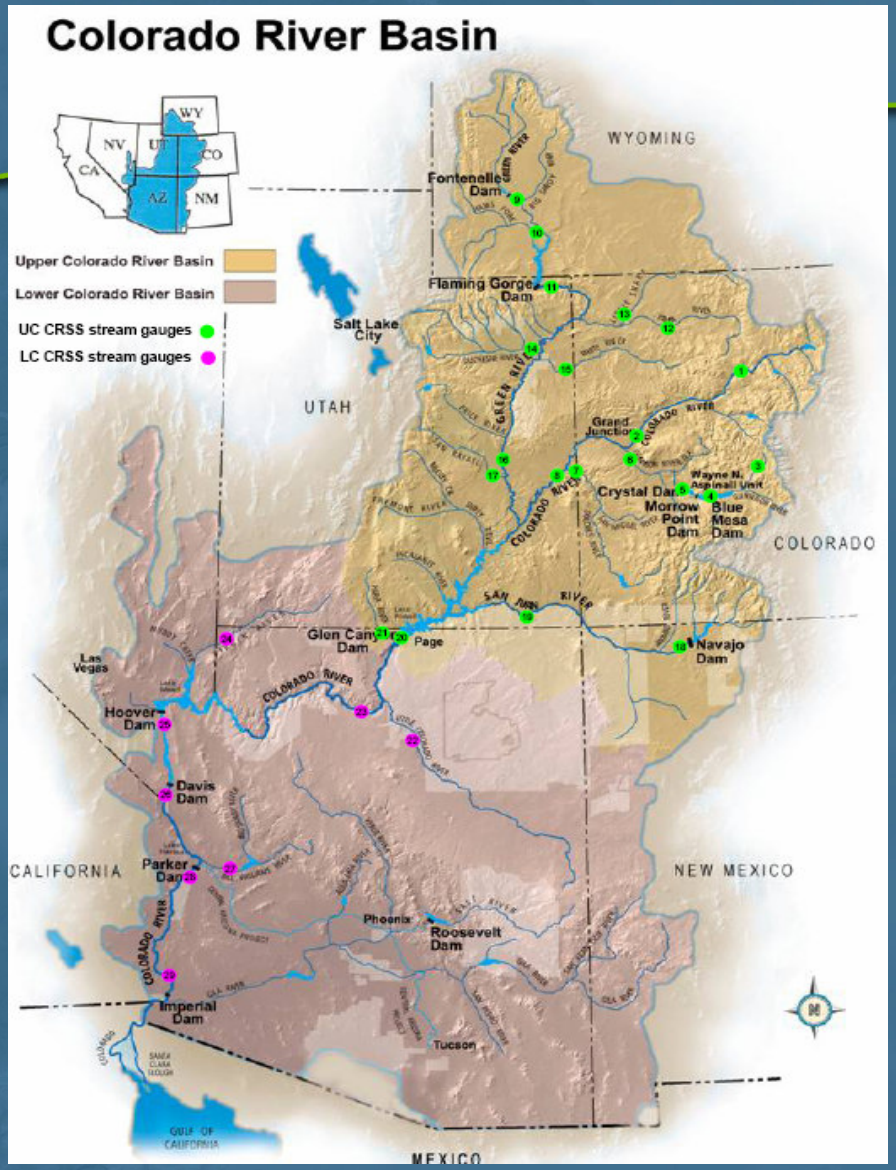
Basin-wide Hydrology Models

- Use changes in temperature and precipitation to generate new streamflows and evaporative conditions
- Evaluated 5 existing models: a) VIC; b) MMS-PRMS; c)NWSRFS/SAC-SMA; d) TWB; and e) WEAP
- Selected "VIC" *(for the Colorado River):*
  - Practicality and previous wide-ranging & CC applications
  - Compatible spatial resolution (vs downscaled GCM's)
  - Soil moisture dynamics, snow dynamics, & evapotranspiration



29 Natural Inflow Stations in CRSS

1	Colorado River at Glenwood Springs, CO
2	Colorado River near Cameo, CO
3	Taylor River below Taylor Park Reservoir, CO
4	Gunnison River below Blue Mesa Reservoir, CO
5	Gunnison River at Crystal Reservoir, CO
6	Gunnison River near Grand Junction, CO
7	Dolores River near Cisco, UT
8	Colorado River near Cisco, UT
9	Green River below Fontenelle Reservoir, WY
10	Green River near Green River, WY
11	Green River near Greendale, UT
12	Yampa River near Maybell, CO
13	Little Snake River near Lily, CO
14	Duchesne River near Randlett, UT
15	White River near Watson, UT
16	Green River at Green River, UT
17	San Rafael River near Green River, UT
18	San Juan River near Archuleta, NM
19	San Juan River near Bluff, UT
20	Colorado River at Lees Ferry, AZ
21	Paria River at Lees Ferry, AZ
22	Little Colorado River near Cameron, AZ
23	Colorado River near Grand Canyon, AZ
24	Virgin River at Littlefield, AZ
25	Colorado River below Hoover Dam, AZ-NV
26	Colorado River below Davis Dam, AZ-NV
27	Bill Williams River below Alamo Dam, AZ
28	Colorado River below Parker Dam, AZ-CA
29	Colorado River above Imperial Dam, AZ

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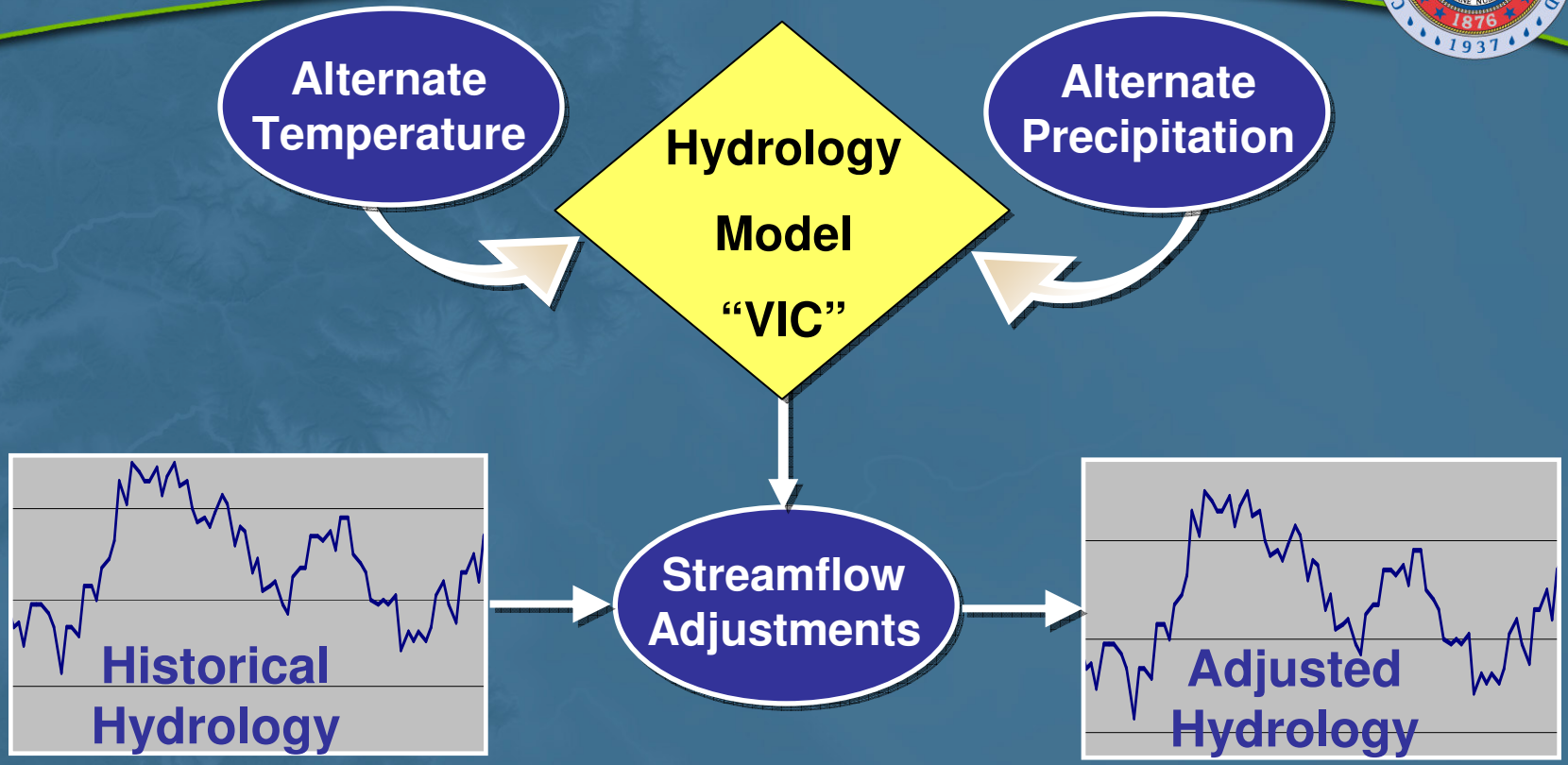
(Source: U.S. Bureau of Reclamation)

3) Alternate Hydrology of Climate Change



CDSS Natural Flows
CRSS Natural Flows

CDSS Adjusted Flows
CRSS Adjusted Flows

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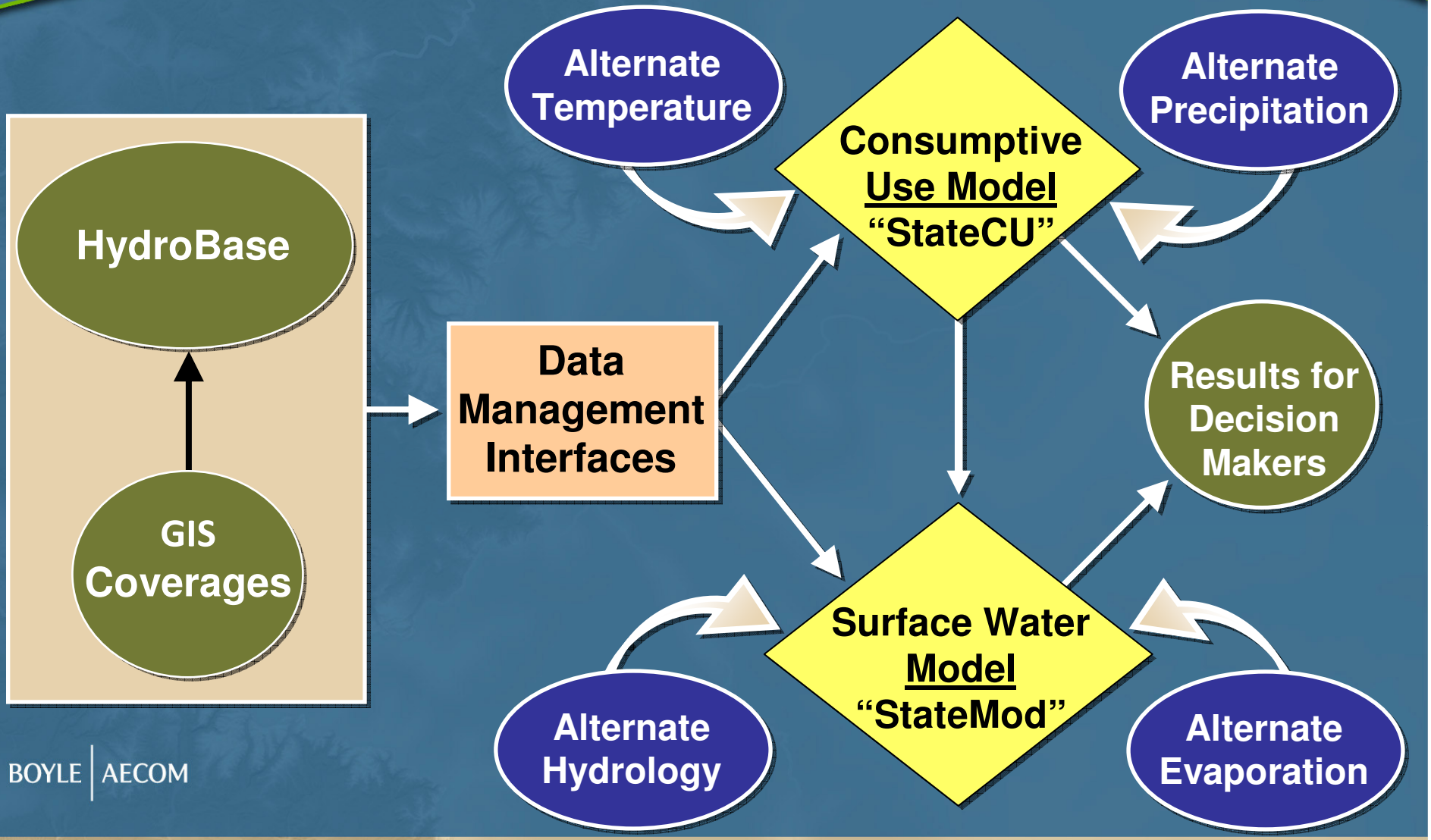
3) Alternate Historical Hydrology



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Status Summary

- Study is progressing well – key critical path activity is receipt of suggestions from the BRT's on CDSS Model refinements and the incorporation of the refinements

- On-going coordination with the FRVS will provide a more uniform approach to assessment of potential effects of climate change

Comments and Questions?

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