

Simulation Modeling of River/Reservoir System Water Allocation and Management

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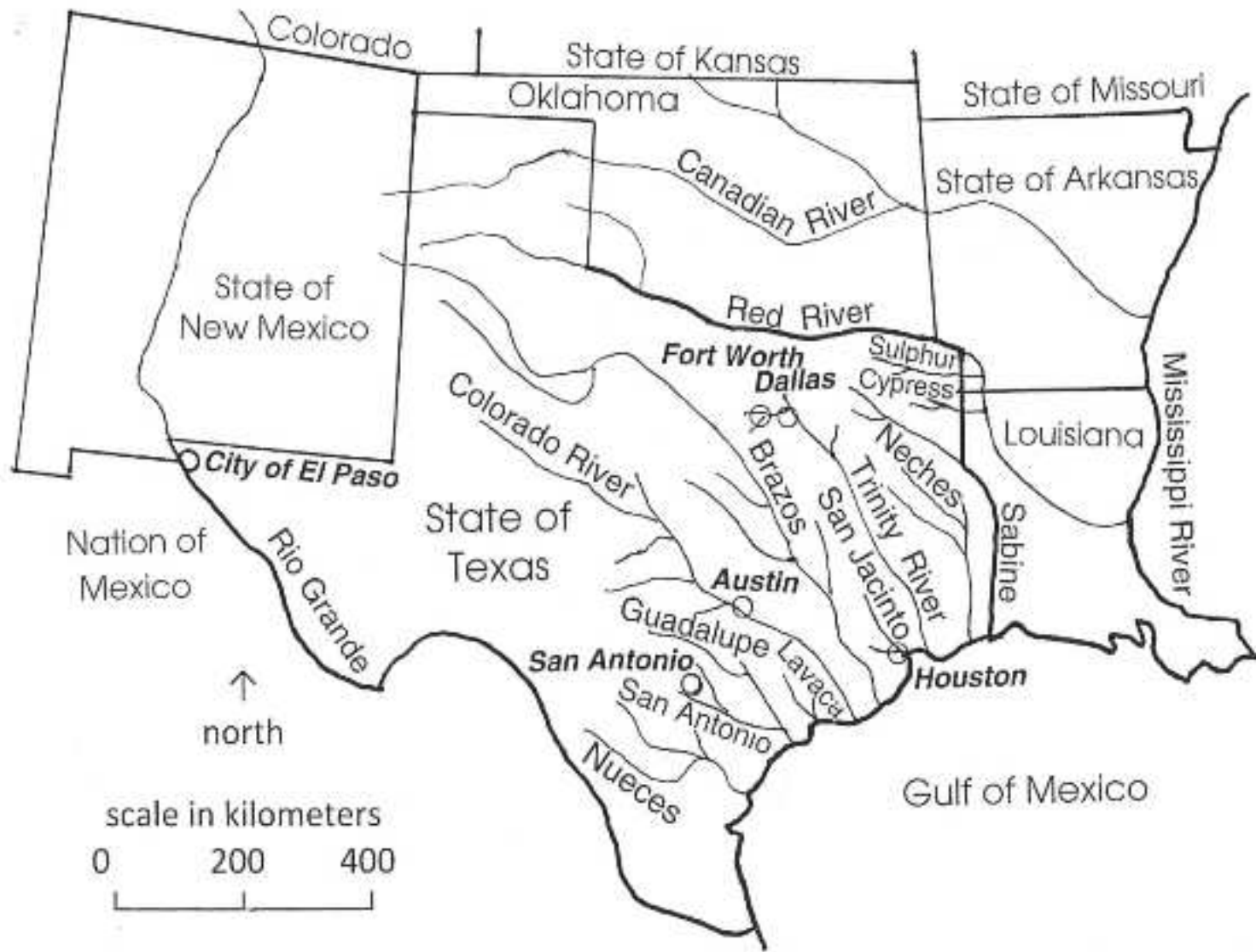
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Institutional Dimensions of River/Reservoir System Modeling

- Modeling complex institutional aspects of water resources development, management, allocation, and use.
- Partnership efforts of a water management community in developing and applying a modeling system.



WRAP and WAM Systems

Water Rights Analysis Package (WRAP) is a generalized modeling system developed at TAMU for simulating water development, management, allocation, and use that can be applied to any river basin.

Texas Water Availability Modeling (WAM) System developed by the Texas Commission on Environmental Quality and its partner agencies and contractors consists of *WRAP* and input datasets for the 23 river basins of Texas.

Applications of the WRAP/WAM Modeling System

- Preparation and evaluation of water right permit applications
- Regional and statewide planning studies
- Other applications by individual water management agencies and their consultants

Legislative Milestones in Texas Water Management

- Water Rights Adjudication Act of 1967
- 1997 Senate Bill 1, Brown-Lewis Water Management Plan
 - *Water Availability Modeling System*
 - *Regional Planning Process*
- 2001 Senate Bill 2 and 2007 Senate Bill 3, Texas Instream Flow Program

Internet Sites

<http://www.tceq.state.tx.us/>

WAM information including datasets
for Texas river basins

<http://ceprofs.tamu.edu/rwurbs/>

WRAP software and manuals

<http://twri.tamu.edu/>

Technical Reports

WRAP Documentation

*Water Rights Analysis Package (WRAP)
Modeling System Reference Manual,*
TWRI TR-255, 10th Ed., August 2013.

*Water Rights Analysis Package (WRAP)
Modeling System Users Manual,* TWRI
TR-256, 10th Edition, August 2013.

*Fundamentals of Water Availability
Modeling with WRAP,* TWRI TR-283,
7th Edition, August 2013.

WRAP Documentation (Continued)

WRAP Daily Modeling System, TWRI TR-430, August 2013.

WRAP River System Hydrology, TWRI TR-431, 2nd Edition, August 2013.

Salinity Features of WRAP, TWRI TR-317, July 2009.

Comparative Evaluation of Generalized Reservoir/River System Models, TWRI TR-282, April 2005.

Water Availability Modeling Process

Historical Hydrology

- Develop sequences of naturalized monthly flows for the period-of-analysis at selected gaging stations.
- Distribute flows from gaged to ungaged sites.

Specified Water Management and Use

- Simulate a specified scenario of water management and use during an assumed repetition of historical hydrology.
- Develop measures of water supply reliability, stream flow and reservoir storage frequency, and water availability.

Natural Hydrology

- Naturalized flows at gaged sites
- Flow distribution to ungaged sites
- Channel losses
- Net reservoir evaporation-precipitation rates

Water Resources Development, Allocation, Management and Use

- Water right priority systems
- Water supply diversion target options
- Return flow specifications
- Instream flow requirements
- Hydroelectric energy generation
- Reservoirs and their operation
- Multiple-reservoir/river system operations
- Multiple owner reservoirs
- Off-channel storage
- Conveyance facilities

Water Availability Indices

- Volume reliability
- Period reliability
- Frequency relationships for storage, regulated flows, and unappropriated flows

Daily Modeling System

- Naturalized flow disaggregation
- Demand target disaggregation
- Flow routing and forecasting
- Flood control reservoir operations
- Environmental pulse flows

Additional Modeling Features

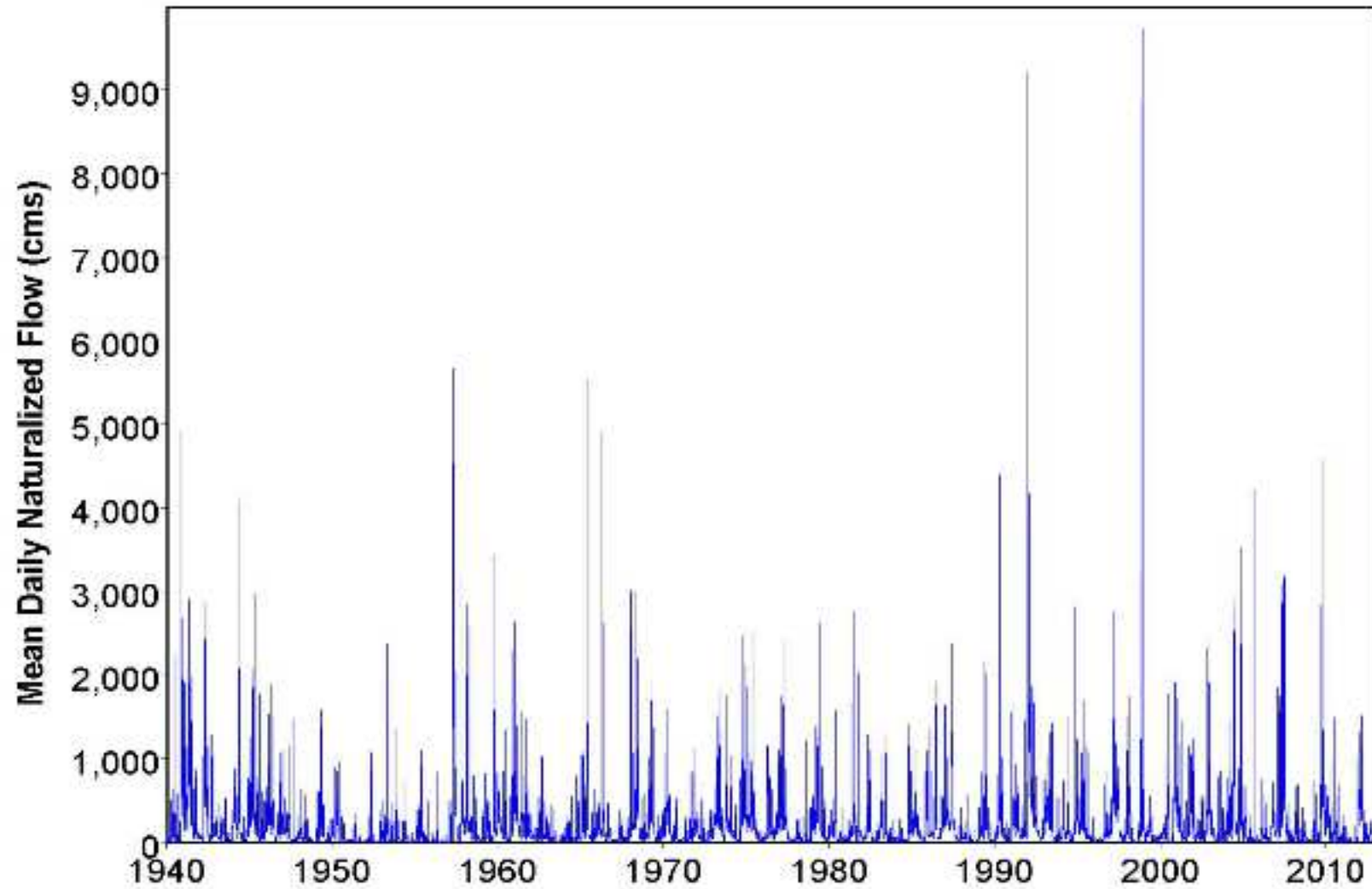
- Long-term planning versus short-term conditional reliability
- Iterative firm yield simulations
- Salinity simulation
- Hydrologic period-of-analysis updates
- Condensed datasets

WRAP/WAM Users

- Texas Commission on Environmental Quality (TCEQ)
- Texas Water Development Board
- Texas Parks & Wildlife Department
- Texas Water Resources Institute at Texas A&M University
- Consulting engineering firms
- River authorities and other water management entities

River Basin	Area in Texas (km ²)	Outside Texas (km ²)	Water Rights	Lakes & Dams	Storage Capacity (10 ⁶ m ³)
Brazos River	115,000	6,660	1,634	670	5,758
Canadian River	32,900	90,700	56	47	1,192
Colorado River	108,000	5,100	1,922	511	5,878
Cypress Bayou	7,280	259	164	91	1,078
Guadalupe-SA	26,500	0	860	237	997
Lavaca River	5,980	0	71	22	290
Neches River	25,900	0	333	176	4,818
Nueces River	43,900	0	373	121	1,284
Red River	63,400	61,000	489	245	4,965
Sabine River	19,200	6,040	310	207	7,873
San Jacinto	14,500	0	148	114	787
Sulphur River	9,220	492	85	53	930
Trinity River	46,500	0	1,169	703	9,254
Rio Grande	125,000	347,000	2,584	113	16,149
8 Coastal Basins	41,528	0	315	125	255
Totals	569,808	517,251	10,513	3,435	61,508

Daily Naturalized Flows of Brazos River at Richmond



Authorized Use Scenario

- Annual water supply diversion targets from water right permits
- No return flows
- Reservoir storage capacities from water right permits
- No term permits

Current Use Scenario

- Largest diversion amount in any year of recent ten year period for each permit
- Best estimate return flows
- Reservoir storage capacities reflecting year 2000 sedimentation
- Term permits are included

Lessons from Implementation of Texas WAM System

- Model development was an institutional partnership effort.
- A modeling system is shared by a water management community.
- Regulatory and planning functions are integrally related.
- A modeling system was constructed rather than just a model.
- Model development is a process of continual expanding and improving.

Continuing Issues

- Instream flow requirements
- Return flows
- Ground/surface water interactions
- Climate change uncertainties
- Water quality considerations
- Storage priorities
- Defining optimal levels of reliability
- Water master operations
- Interstate and international rivers

Concluding Remarks

- The WRAP-WAM System is significantly contributing to water management in Texas.
- The range of modeling applications is expanding and new modeling capabilities continue to be added.
- Both institutional and hydrologic considerations are fundamental to water availability modeling.