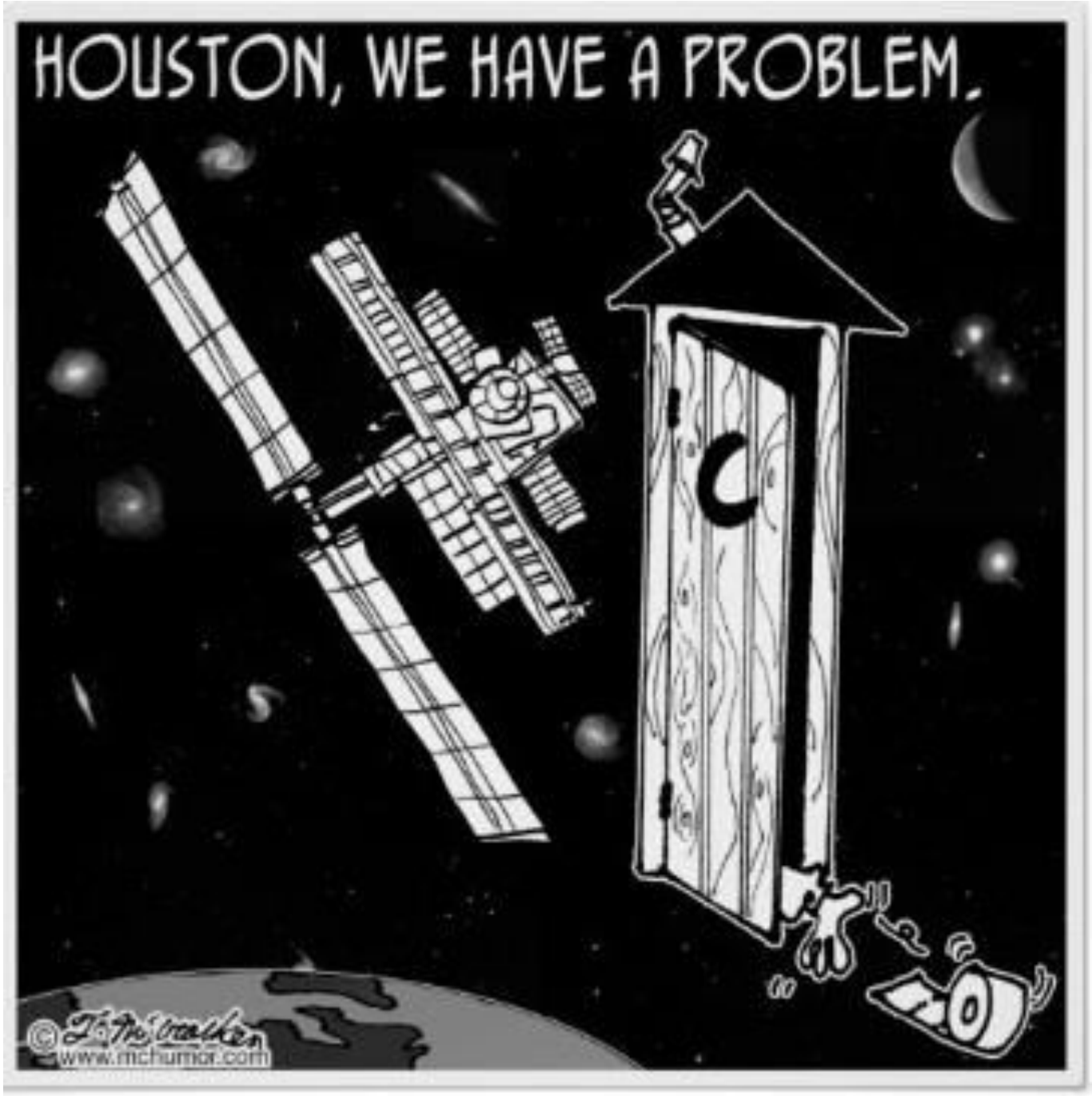
TRANSDISCIPLINARY BRIDGES TO WATERSHED SCIENCE AND HUMAN SYSTEMS IN TEXAS, USA

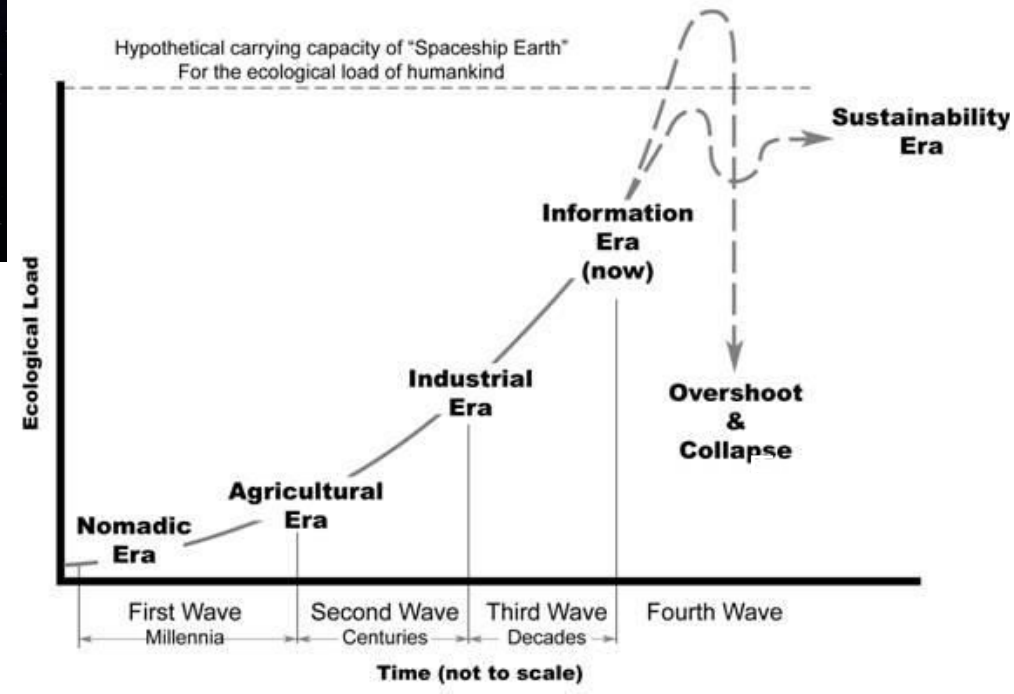
T.L. Arsuffi, T. Broad, E. Seldomridge, K. Rainwater, T. Mclendon – TTU LLANO RIVER FIELD STATION

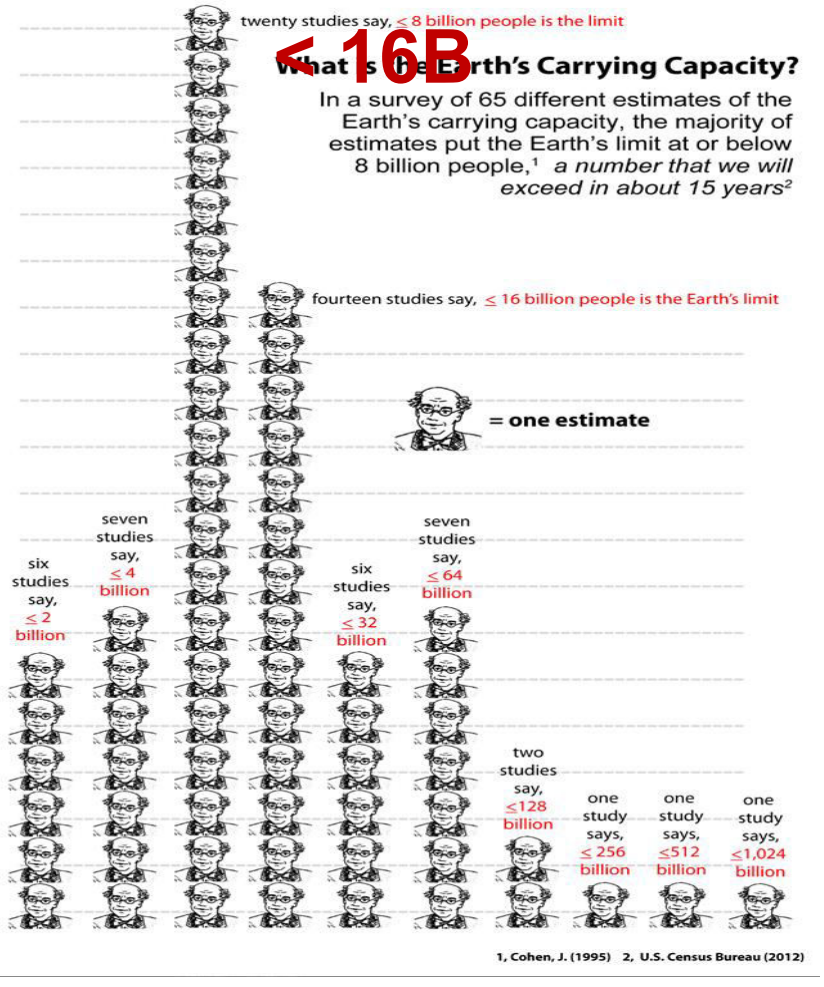
K. Wagner - TWRI, TX A&M University


HOUSTON, WE HAVE A PROBLEM.
©
www.mchumor.com

< 8B


WELCOME TO
EARTH
POP. 6,000 000 000 000 000


Hypothetical carrying capacity of "Spaceship Earth"
For the ecological load of humankind
Sustainability Era
Information Era (now)
Industrial Era
Agricultural Era
Nomadic Era
Overshoot & Collapse
Ecological Load
First Wave
Millennia
Second Wave
Centuries
Third Wave
Decades
Fourth Wave
Time (not to scale)

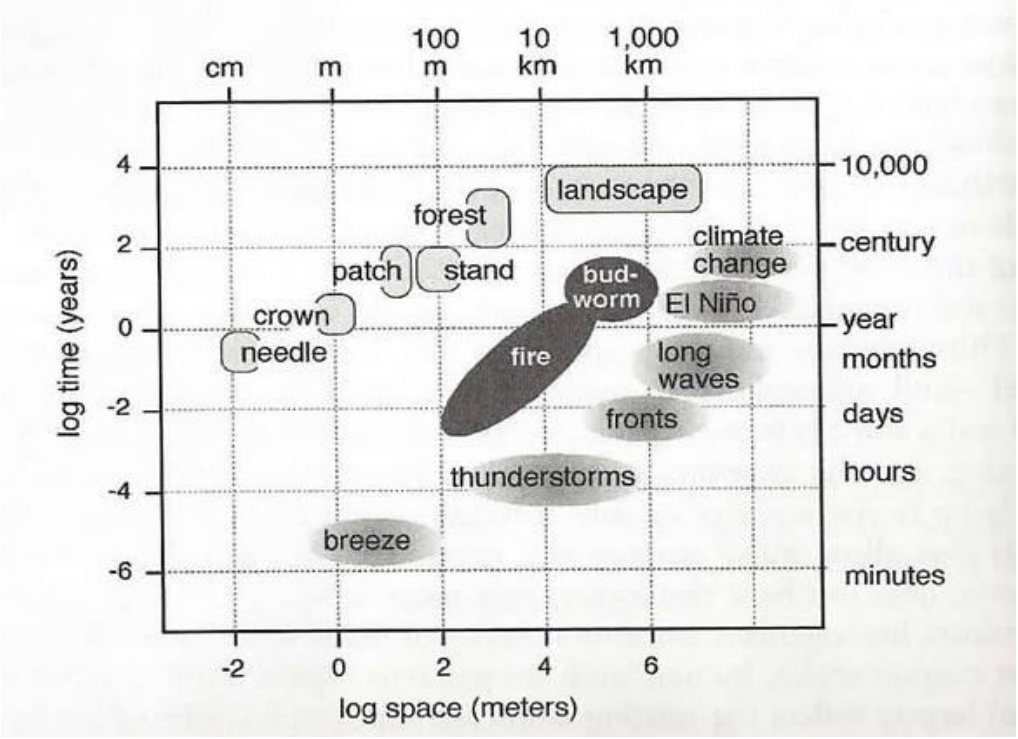

twenty studies say, ≤ 8 billion people is the limit
< 16B
What is the Earth's Carrying Capacity?
In a survey of 65 different estimates of the Earth's carrying capacity, the majority of estimates put the Earth's limit at or below 8 billion people,[1] a number that we will exceed in about 15 years[2]
fourteen studies say, ≤ 16 billion people is the Earth's limit
= one estimate
six studies say, ≤ 2 billion
seven studies say, ≤ 4 billion
six studies say, ≤ 32 billion
seven studies say, ≤ 64 billion
two studies say, ≤128 billion
one study says, ≤ 256 billion
one study says, ≤512 billion
one study says, ≤1,024 billion
1, Cohen, J. (1995) 2, U.S. Census Bureau (2012)

Challenges for the South Central Region

- Ecosystem restoration under increased climate variability.
- Fish and wildlife response to climate change?
- Invasive species and fires
- Protection of trust species
- Wildlife diseases
- Climate impacts on agriculture
- Renewable resources - water

Ecological scale

- **Refers to the spatial and temporal dimensions of an object, process or problem**



Vision and Change

“We can’t see where the barriers are by only talking to ourselves”

Morse, W. C., M. Nielsen-Pincus, J. Force, and J. Wulfhorst. 2007. Bridges and barriers to developing and conducting interdisciplinary graduate-student team research. *Ecology and Society* **12**(2): 8. [online] URL: http://www.ecologyandsociety.org/vol12/iss2/art8/

Insight

Bridges and Barriers to Developing and Conducting Interdiscipl Graduate-Student Team Research

Wayde Cameron Morse[1,2], *Max Nielsen-Pincus*[1], *Jo Ellen Force*[1], *and J. D. Wulfhorst*[1]

ABSTRACT. Understanding complex socio-environmental problems requires specialists disciplines to integrate research efforts. Programs such as the National Science Foundation Graduate Education and Research Traineeship facilitate integrated research efforts and ch academic institutions train future leaders and scientists. The University of Idaho and Agricultural Research and Higher Education Center in Costa Rica collaborate on a joint rese focusing on biodiversity conservation and sustainable production in fragmented landscapes. W a spectrum of integration ranging from disciplinary to transdisciplinary across seven aspects process. We then describe our experiences and lessons learned conducting interdisciplinary gr team research. Using our program as a case study, we examine the individual, disc programmatic bridges and barriers to conducting interdisciplinary research that emerged duri team research projects. We conclude with a set of recommendations for exploiting the overcoming the barriers to conducting interdisciplinary research, especially as part of gradu

Ecosystems (2001) 4: 716–722
DOI: 10.1007/s10021-001-0040-1

ECOSYSTEMS

Natural Resource Management: The Need for Interdisciplinary Collaboration

Katherine C. Ewel

USDA Forest Service, Pacific Southwest Research Station, 1151 Punchbowl Street, Room 323, Honolulu, Hawaii 96813, USA

Abstract

Human influence is now so pervasive that every ecosystem on Earth is being managed, whether intentionally or inadvertently. It is therefore imperative for scientists and managers to work together so that appropriate management regimes can be put in place wherever possible. However, it is not always clear what is appropriate, and the difficulties that often arise when scientists and managers work together can be even further compounded by the inclusion of lay stakeholders in the decision-making process. The expansion of interdisciplinary undergraduate and graduate programs would help both scientists and managers to deal more effectively with sociological issues and to understand how economic and demographic changes impact on natural resources. In addition, continuing education programs in these areas should be made available to established professionals to help them deal with new challenges. The concept of ecosystem services should be used to communicate the importance of various ecosystem components and processes to a broader audience. Consensus on a management regime can often be achieved through adaptive management. The process by which interdisciplinary collaboration can lead to new insights and research initiatives is exemplified by a resource management study on the island of Kosrae, Federated States of Micronesia. As a paradigm of natural resource management, microcosms like this small island community offer a unique opportunity for training and education.

Key words: interdisciplinary education; continuing education; ecosystem services; adaptive management; Micronesia.

"I understand they're going to connect them. The Provost ordered it."

As water resource problems increase in complexity, the present state of having uncoordinated and mission-driven water resources agendas within and between the agencies, within and between research components of universities, and within and between companies and industries in the private sector, will have to change to:

1) surmount future water problems and 2) address the many and complicated water supply and water demand solutions.

Two Case Study Examples

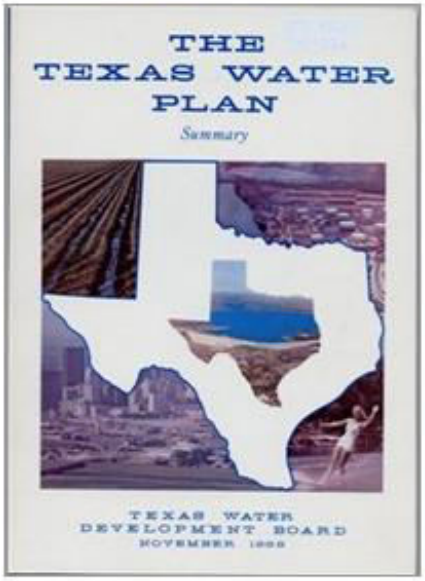
1. Senate Bill 3 Environmental Flows

   Nueces River/Corpus Christi Bay

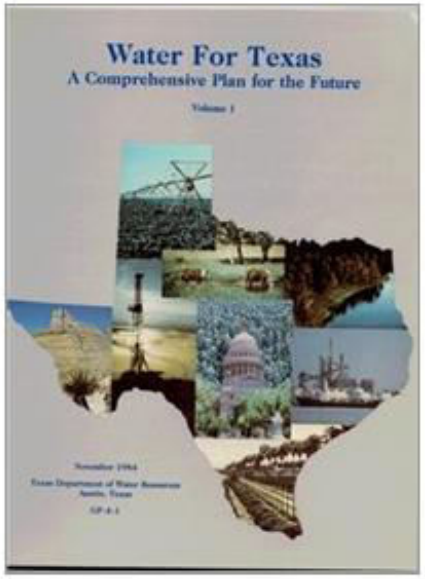
2. Upper Llano Watershed Protection Plan

Previous Texas Water Plans

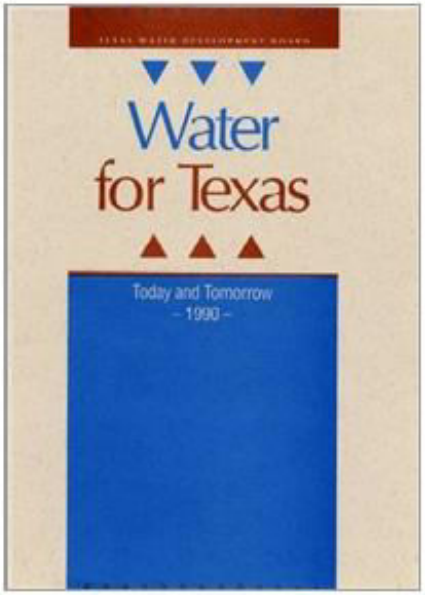
1968 State Water Plan



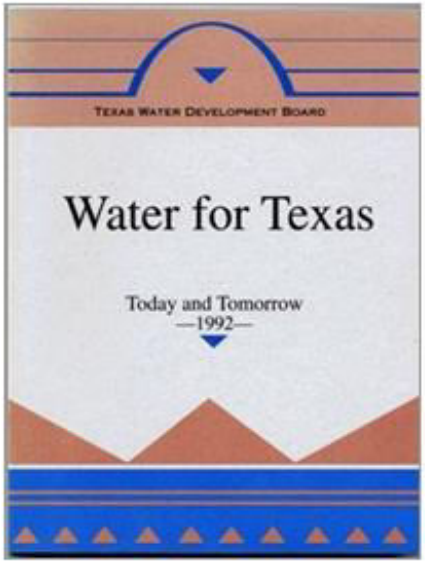
1984 State Water Plan



1990 State Water Plan



1992 State Water Plan



1997 State Water Plan

2002 State Water Plan

Water Planning

The Texas Water Development Board maintains a "Water Resource Planning and Information" link containing the State water plan, regional water planning, planning data, water use survey, and flood mitigation planning at

http://www.twdb.state.tx.us/wrpi/index.htm

Also the TCEQ and TWDB operate Drought Planning and Management sites at

TCEQ:
http://www.tceq.state.tx.us/nav/util_water/drought.html

TWDB:

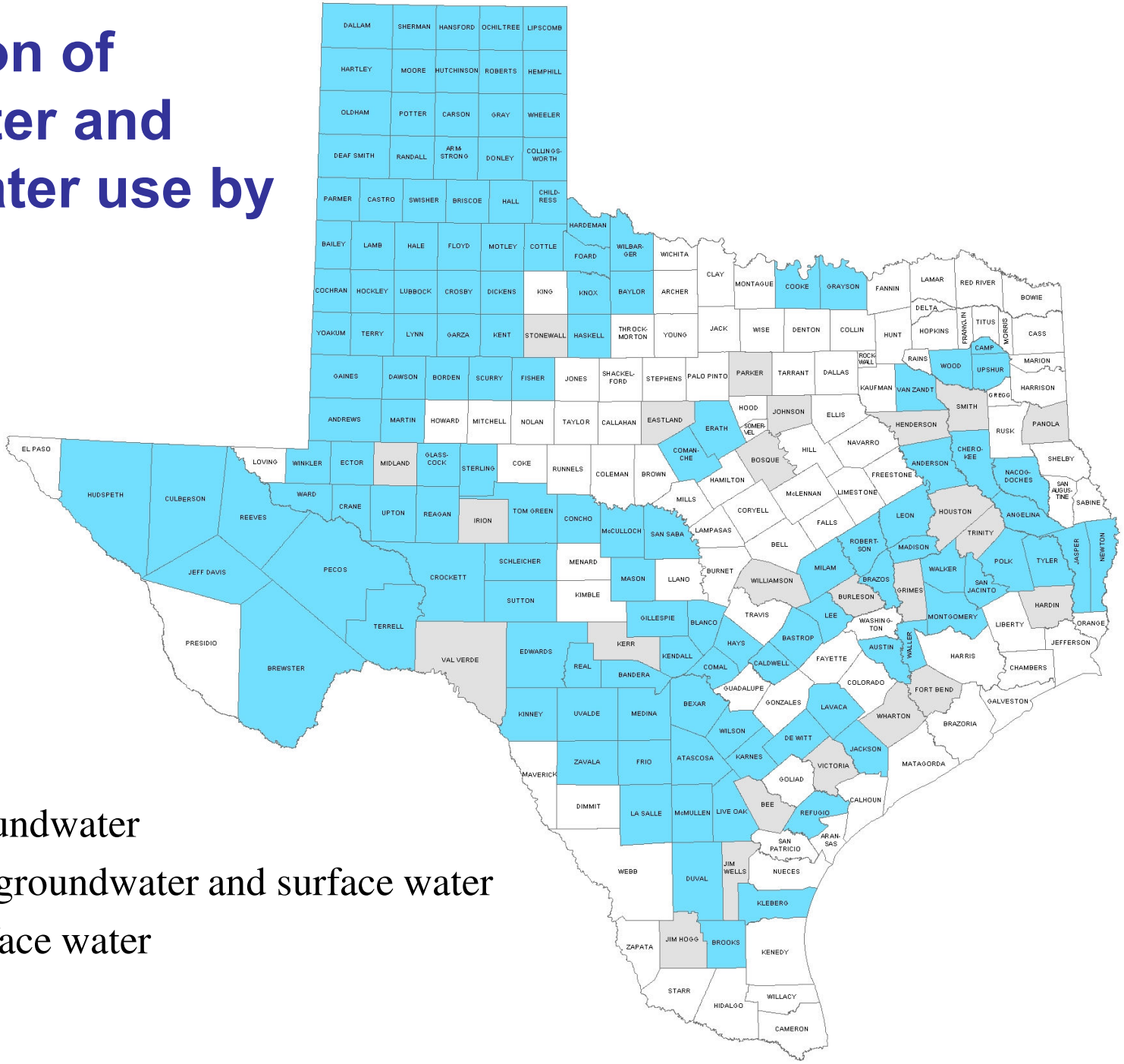
http://www.twdb.state.tx.us/DATA/DROUGHT/drought_toc.asp

Additionally the TCEQ maintains a site for emergency response to spills and storms at

http://www.tceq.state.tx.us/response/

Texas Water Plan

Comparison of groundwater and surface water use by county



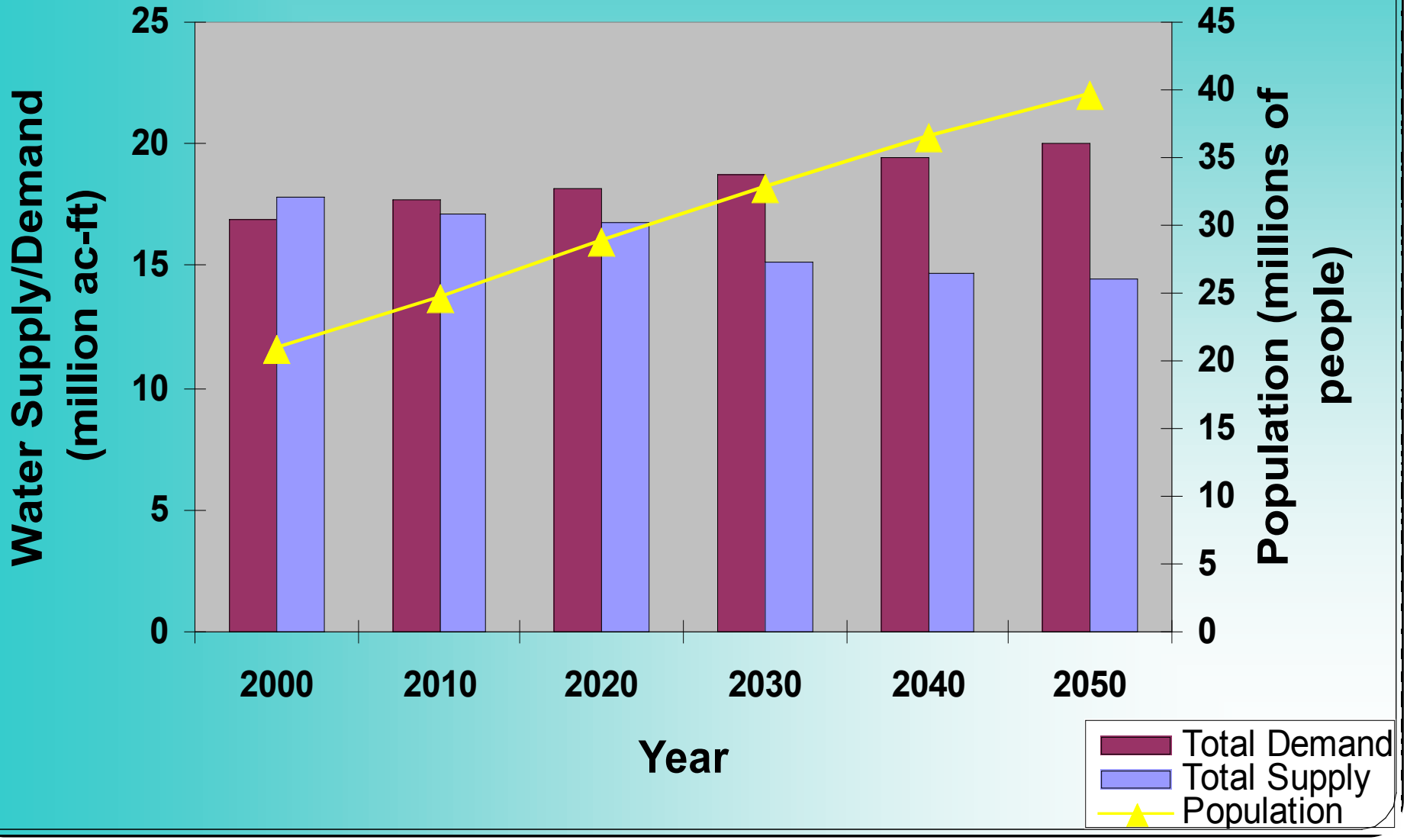
> 55% groundwater

45 to 55% groundwater and surface water

> 55% surface water

Projected Water Supply/Demand and Population for Texas

Note: water demand exceeds water supply beginning 2010



Texas Water Plan table of contents

Good resource for water data, maps and photos

http://www.twdb.state.tx.us/wrpi/swp/swp.htm

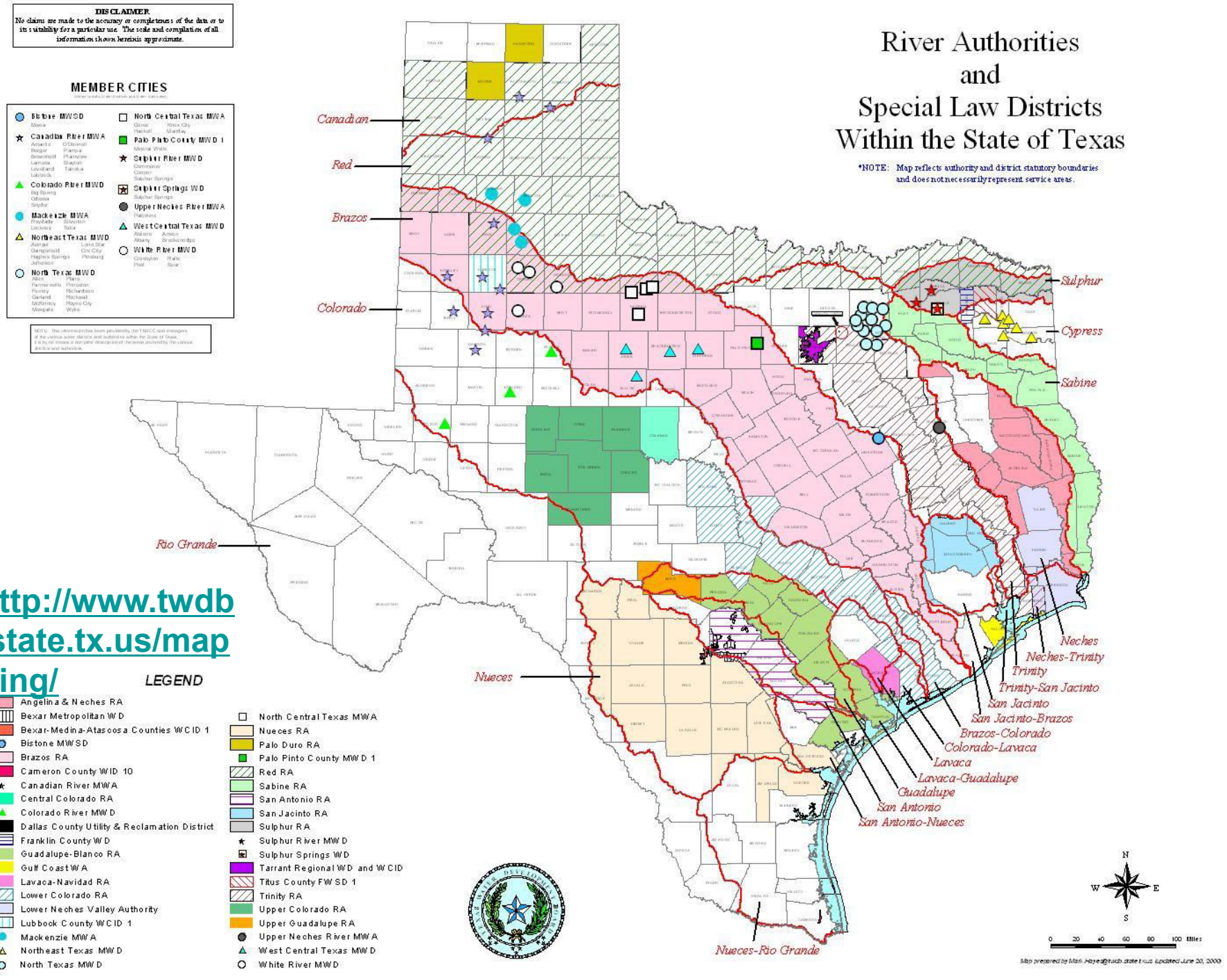
River Authorities

River Authorities (cont)

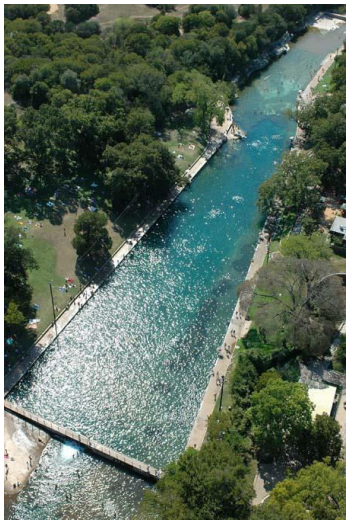
TITLE 5. SPECIAL LAW DISTRICTS of the Texas Water Code contains CHAPTER 152. RIVER AUTHORITIES ENGAGED IN DISTRIBUTION AND SALE OF ELECTRIC ENERGY

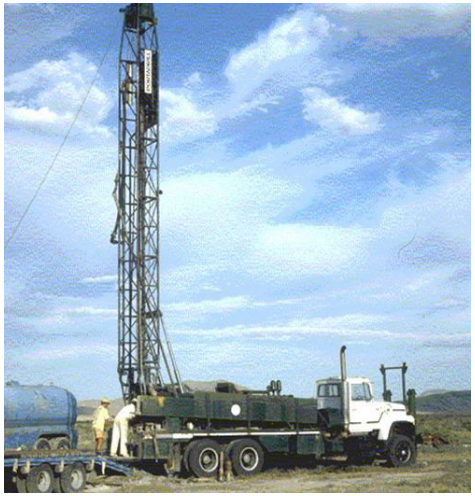
- River Authorities are created by the Texas Legislature
- In 1929 The Legislature created the first river authority (Brazos River Authority).

Fourteen Texas river authorities help protect and monitor more than 70 percent of the state's surface water. River authorities receive most of their revenue from services sold to customers, usually water or electricity. They also may receive federal, state or private grants, which are often designated for specific purposes such as planning, wastewater treatment or conservation. Some authorities also draw revenue from parks and recreation facilities. Authorities can levy taxes, but usually do not, and can issue revenue bonds — with voter approval — or obtain loans from the Texas Water Development Board.


DISCLAIMER
No claims are made to the accuracy or completeness of the data or to its suitability for a particular use. The scale and compilation of all information shown hereinis approximate.
MEMBER CITIES
Bistone MWSD
Canadian River MWA
Colorado River MWD
Mackenzie MWA
Northeast Texas MWD
North Texas MWD
North Central Texas MWA
Palo Pinto County MWD 1
Sulphur River MWD
Sulphur Springs WD
Upper Neches River MWA
West Central Texas MWD
White River MWD
River Authorities
and
Special Law Districts
Within the State of Texas
*NOTE: Map reflects authority and district statutory boundaries and does not necessarily represent service areas.
Canadian
Red
Brazos
Colorado
Rio Grande
Nueces
Nueces-Rio Grande
Sulphur
Cypress
Sabine
Neches
Neches-Trinity
Trinity
Trinity-San Jacinto
San Jacinto
San Jacinto-Brazos
Brazos-Colorado
Colorado-Lavaca
Lavaca
Lavaca-Guadalupe
Guadalupe
San Antonio
San Antonio-Nueces
http://www.twdb.state.tx.us/mapping/
LEGEND
Angelina & Neches RA
Bexar Metropolitan WD
Bexar-Medina-Atascosa Counties WCID 1
Bistone MWSD
Brazos RA
Cameron County WID 10
Canadian River MWA
Central Colorado RA
Colorado River MWD
Dallas County Utility & Reclamation District
Franklin County WD
Guadalupe-Blanco RA
Gulf Coast WA
Lavaca-Navidad RA
Lower Colorado RA
Lower Neches Valley Authority
Lubbock County WCID 1
Mackenzie MWA
Northeast Texas MWD
North Texas MWD
North Central Texas MWA
Nueces RA
Palo Duro RA
Palo Pinto County MWD 1
Red RA
Sabine RA
San Antonio RA
San Jacinto RA
Sulphur RA
Sulphur River MWD
Sulphur Springs WD
Tarrant Regional WD and WCID
Titus County FWSD 1
Trinity RA
Upper Colorado RA
Upper Guadalupe RA
Upper Neches River MWA
West Central Texas MWD
White River MWD
N
W
E
S
0 20 40 60 80 100 Miles
Map prepared by Mark.Hayes@twdb.state.tx.us Updated June 20, 2000

Groundwater Districts





Groundwater Districts (cont)

Legislature can give special powers to districts to address specific water problems

The Texas State Legislature in 1949 authorized the creation of Groundwater Conservation Districts to perform certain prescribed duties, functions, and hold specific powers as set forth in Article 7880-3c, Texas Civil Statutes, changed to Chapter 52 of the Texas Water Code, currently Chapter 36 of the Texas Water Code.

Texas Alliance of Groundwater Districts
http://www.texasgroundwater.org/

Creation of Groundwater Conservation Districts

Action of the Legislature

- Petition by Property Owners
- Initiation by the TWDB priority groundwater management areas
- Adding territory to an Existing District

Based on the philosophy of

- local management of groundwater resources
- through groundwater conservation districts

GROUNDWATER CONSERVATION DISTRICTS*, (Confirmed and Pending Confirmation)

Confirmed Groundwater Conservation Districts

1. Anderson County UWCD
2. Bandera County River Authority & Ground Water District
3. Barton Springs/Edwards Aquifer CD
4. Bee GCD
5. Blanco-Pedernales GCD
6. Bluebonnet GCD
7. Brazoria County GCD
8. Brazos Valley GCD
9. Brewster County GCD
10. Central Texas GCD
11. Clear Fork GCD
12. Clearwater UWCD
13. Coastal Bend GCD
14. Coastal Plains GCD
15. Coke County UWCD
16. Colorado County GCD
17. Corpus Christi ASRCD
18. Cow Creek GCD
19. Crockett County GCD
20. Culberson County GCD
21. Edwards Aquifer Authority
22. Evergreen UWCD
23. Fayette County GCD
24. Fox Crossing Water District
25. Garza County UWCD
26. Gateway GCD
27. Glasscock GCD
28. Goliad County GCD
29. Gonzales County UWCD
30. Guadalupe County GCD
31. Hays Trinity GCD
32. Headwaters GCD
33. Hemphill County UWCD
34. Hickory UWCD No.1
35. High Plains UWCD No.1
36. Hill Country UWCD
37. Hudspeth County UWCD No.1
38. Irion County WCD
39. Jeff Davis County UWCD
40. Kenedy County GCD
41. Kimble County GCD
42. Kinney County GCD
43. Lipan-Kickapoo WCD
44. Live Oak UWCD
45. Llano Estacado UWCD
46. Lone Star GCD
47. Lone Wolf GCD
48. Lost Pines GCD
49. Lower Trinity GCD
50. McMullen GCD
51. Medina County GCD
52. Menard County UWD
53. Mesa UWCD
54. Mesquite GCD
55. Mid-East Texas GCD
56. Middle Pecos GCD
57. Middle Trinity GCD
58. Neches & Trinity Valleys GCD
59. North Plains GCD
60. Northern Trinity GCD
61. Panhandle GCD
62. Panola County GCD
63. Pecan Valley GCD
64. Permian Basin UWCD
65. Pineywoods GCD
66. Plateau UWC and Supply District
67. Plum Creek CD
68. Post Oak Savannah GCD
69. Presidio County UWCD
70. Real-Edwards C and R District
71. Red Sands GCD
72. Refugio GCD
73. Rolling Plains GCD
74. Rusk County GCD
75. Salt Fork UWCD
76. San Patricio County GCD
77. Sandy Land UWCD
78. Santa Rita UWCD
79. Saratoga UWCD
80. South Plains UWCD
81. Southeast Texas GCD
82. Starr County GCD
83. Sterling County UWCD
84. Sutton County UWCD
85. Texana GCD
86. Trinity Glen Rose GCD
87. Upper Trinity GCD
88. Uvalde County UWCD
89. Victoria County GCD
90. Wes-Tex GCD
91. Wintergarden GCD

http://www.twdb.state.tx.us/mapping/

Pending Groundwater Conservation Districts

- *92. Duval County GCD + &*
- *93. Laveca County GCD + #*
- *94. McLennan County GCD + #*
- *95. Tablerock GCD + #*

+ Pending Election Results
& Created by the 79th Legislature
 # Created by the 80th Legislature

Subsidence Districts

- Harris-Galveston Subsidence District
- Fort Bend Subsidence District

NOTE: These subsidence districts are not Groundwater Conservation Districts as defined under Chapter 36 of the Texas Water Code, but have the ability to regulate groundwater production to prevent land subsidence. (Refer to Senate Bill 1937 from the 70th Legislative Session)

DISCLAIMER

This map was generated by the Texas Water Development Board. No claims are made to the accuracy or completeness of the information shown herein nor to its suitability for a particular use. The scale and location of all mapped data are approximate. Boundaries for groundwater conservation districts are approximate and may not accurately depict legal descriptions.

0 25 50 75 100 Miles

Map updated by Mark Hayes, GISP
TWDB - GIS Mapping Coordinator
January 2009

** Districts that have, in whole or part, authority as assigned by Chapter 36 of the Texas Water Code. Please refer questions pertaining to individual districts to the district themselves.*

Special Districts created to protect groundwater

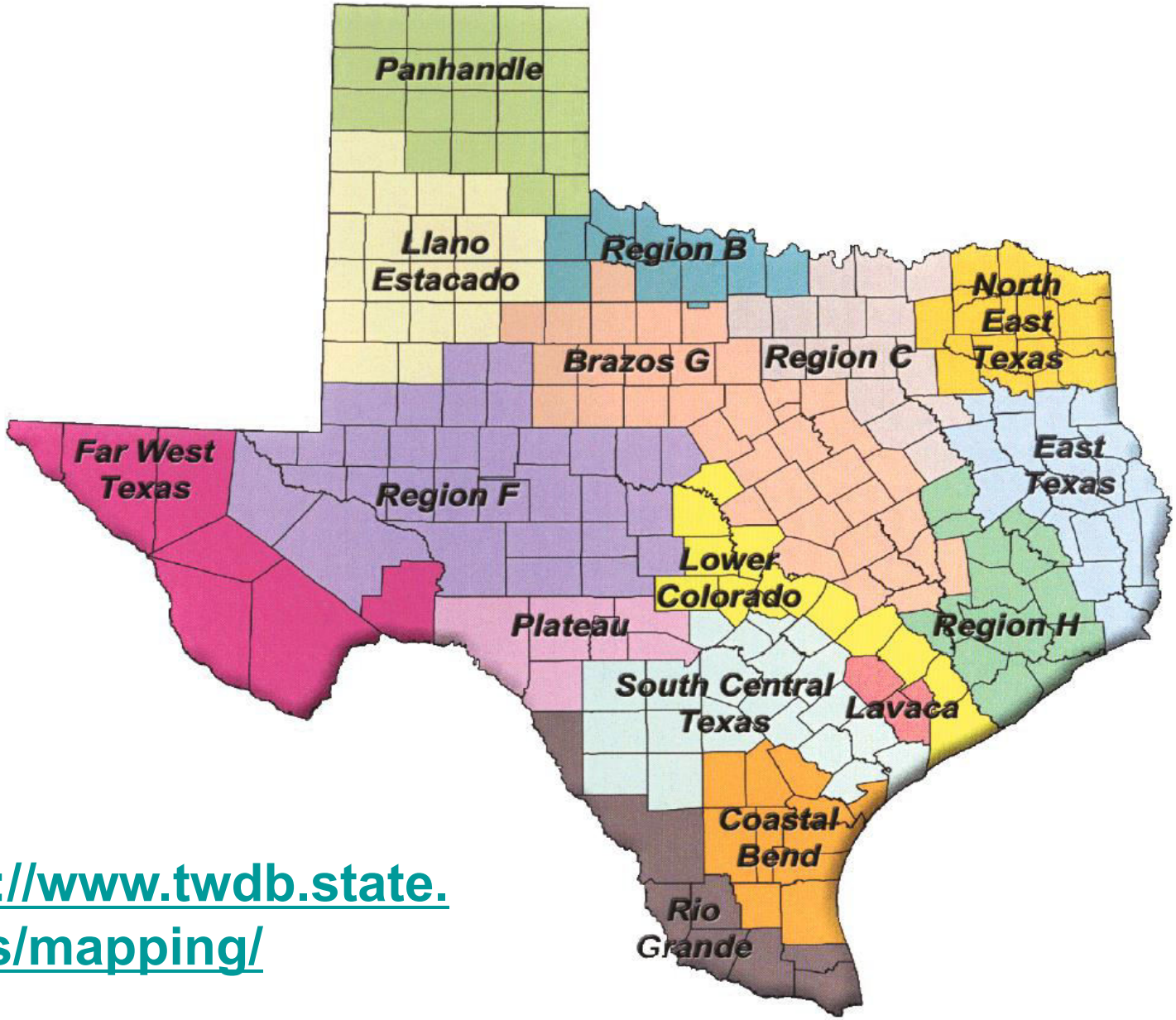
- Harris-Galveston Subsidence District (1975)
- Ft. Bend Subsidence District (1989)
- Edwards Aquifer Authority (1993)

Recent Water Planning

- 1996 Texas drought
  - Governor Bush asks "how much water do we have? How much are we using? How much do we need?" -- Ooops. No good answers!
- 1997 Senate **Bill 1** passed by Legislature
  - **Regionalizes water planning** in Texas and establishes **surface water availability modeling**
- 2001 Senate **Bill 2** passed by Legislature
  - Establishes groundwater availability modeling and initiates **instream flow assessment**

Note: Instream flow represents the flow rate to sustain a healthy habitat, biology, and geomorphology in the stream

Location of the 16 Regional Water Planning groups



http://www.twdb.state.tx.us/mapping/

11 Interests represented on each Planning Group

- Member of the Public at Large
- Counties
- Municipalities
- Industries
- Agricultural Interests
- Environmental Interests
- Small Business
- Electric Generating Utilities
- River Authorities
- Water Districts
- Water Utilities

Purpose of SB 3 Article 1

Establish Environmental Flow Recommendations

11.0235(d-6):

The legislature finds that recommendations for state action to protect instream flows and freshwater inflows should be developed through a consensus-based, regional approach involving balanced representation of stakeholders and that such a process should be encouraged throughout the state.

TEXAS PARKS & WILDLIFE

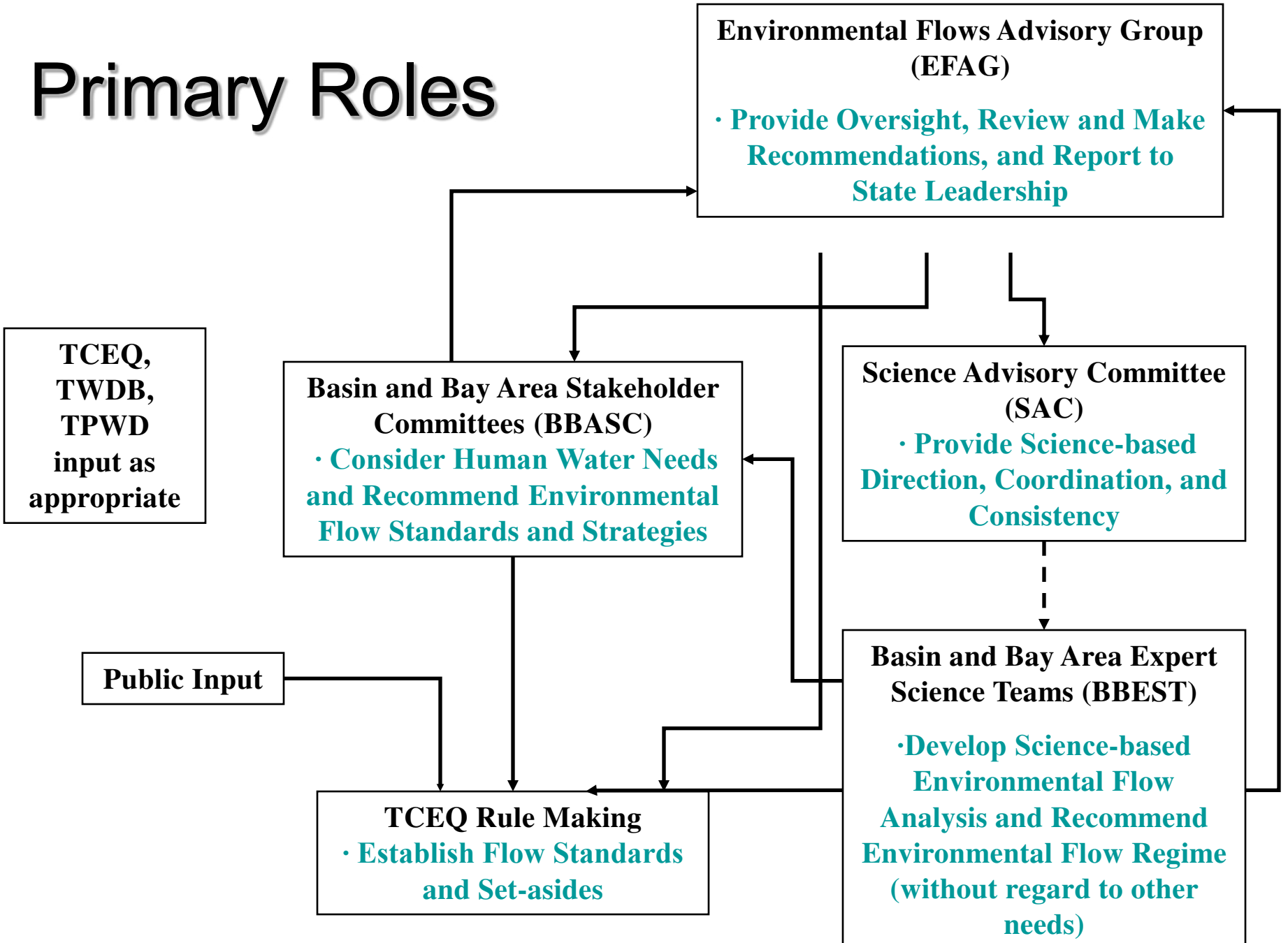
Purpose Continued

Environmental Flow Regime:

11.002(16):

A schedule of flow quantities that reflects seasonal and yearly fluctuations that typically would vary geographically, by specific location in a watershed, and that are shown to be **adequate to support a sound ecological environment** and to maintain the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies.

Primary Roles



Set-Asides and Alternatives

11.1471(a)(2)
Establish an amount of unappropriated water, if available, to be set aside to satisfy the environmental flow standards to the maximum extent reasonable when considering human water needs

11.0235(d-3)(2)
In those basins in which the unappropriated water **that will be set aside for instream flow and freshwater inflow protection** is not sufficient **to fully satisfy the environmental flow standards established by the commission,** a variety of market approaches**, both public and private, for filling the gap** must be explored **and pursued.**

TCEQ, TWDB, and TPWD Agency Roles

All resource agencies provide technical assistance as appropriate

TCEQ

- Overall coordination and facilitation

www.tceq.state.tx.us/permitting/water_supply/water_rights/eflows/group.html

TWDB

- Budget and contracting

Duties of Basin and Bay Area Stakeholders Committees

- Appoint the Expert Science Team for their river and bay system
- Review the flow regime recommendation of the Expert Science Team
- Provide comments and recommendations regarding flow regime to the TCEQ (TCEQ will consider comments and develop flow standard by May 1, 2011)

Overall Duties and Responsibilities

- **Primary Charge** to the Texas Environmental Flows Basin and Bay Expert Science Team (BBEST) is found in SB3, Section 11.02362 (m)
  - "Each basin and bay expert science team shall develop environmental flow analyses and a recommended environmental flow regime for the river basin and bay system for which the team is established through a collaborative process designed to achieve a consensus."

Overall Duties and Responsibilities, Continued

- In developing the analyses and recommendations, the science team must consider all reasonably available science, without regard to the need for the water for other uses, and the science team's recommendations must be based solely on the best science available.

Resources Available to the BBESTs

- The Science Advisory Committee (SAC) is developing guidance for:
  - Hydrology
  - Geomorphology
  - Biology
  - Water Quality
- Staff from TCEQ, TPWD, and TWDB are available to provide technical assistance to each BBEST.

Environmental Flow Regime Recommendations

- Submit to
  - Basin and Bay Stakeholders Committee
  - Environmental Flows Advisory Group
  - Texas Commission on Environmental Quality
- By
  - Date specific to each river/bay

Nueces River and Corpus Christi and Baffin Bays
Basin and Bay Expert Science Team (Nueces BBEST)

Environmental Flows Recommendations Report

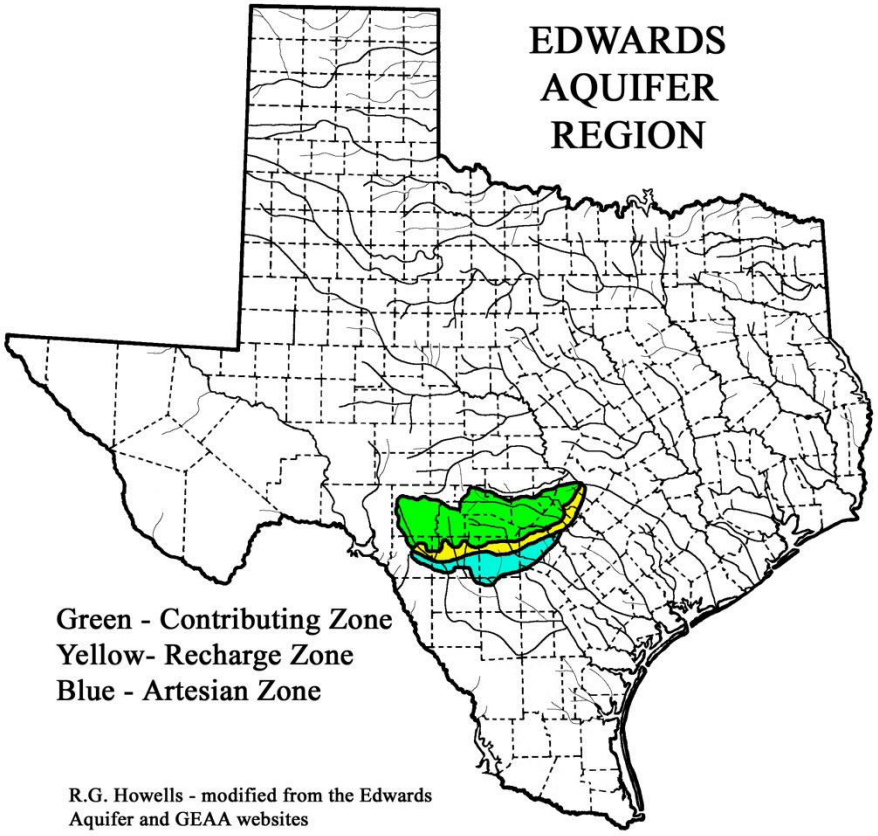
Nueces BBEST Recommendations Report

1) Preamble – Sound Ecological Environment
2) Overview of Watersheds & Bays
3) Instream Flow Analyses
4) Freshwater Inflow Analyses
5) Integration of Instream Flow & Estuary Inflow Regimes
6) Environmental Flow Regime Recommendations
7) Adaptive Management
8) References

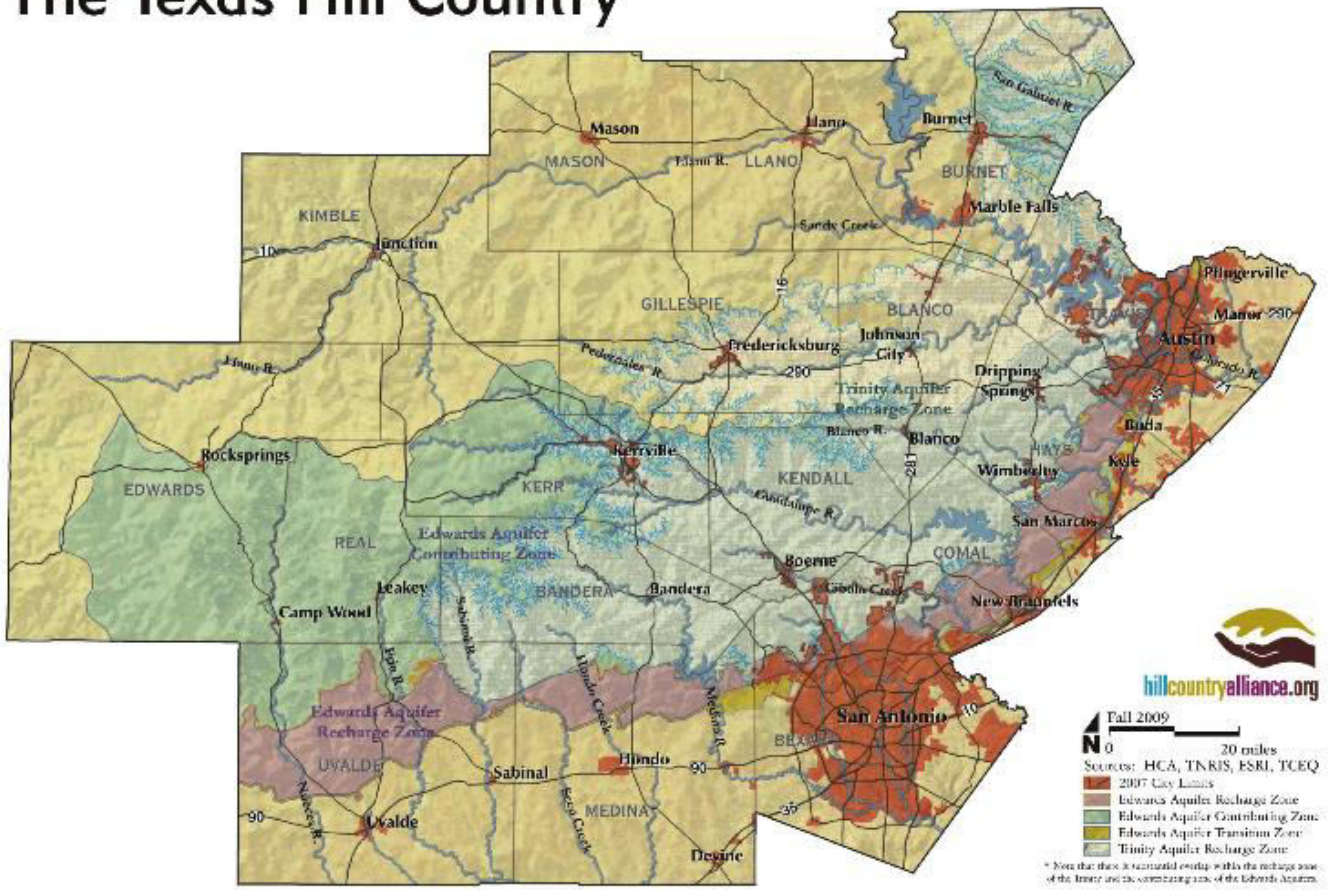
Adaptive Management

- Establish a periodic review (at least once every 10 yrs) of environmental flow recommendations, standards, and strategies
- Prescribe specific monitoring, studies, and activities
- Establish a schedule for continuing the validation or refinement of environmental flow recommendations, standards, and the strategies to achieve those standards

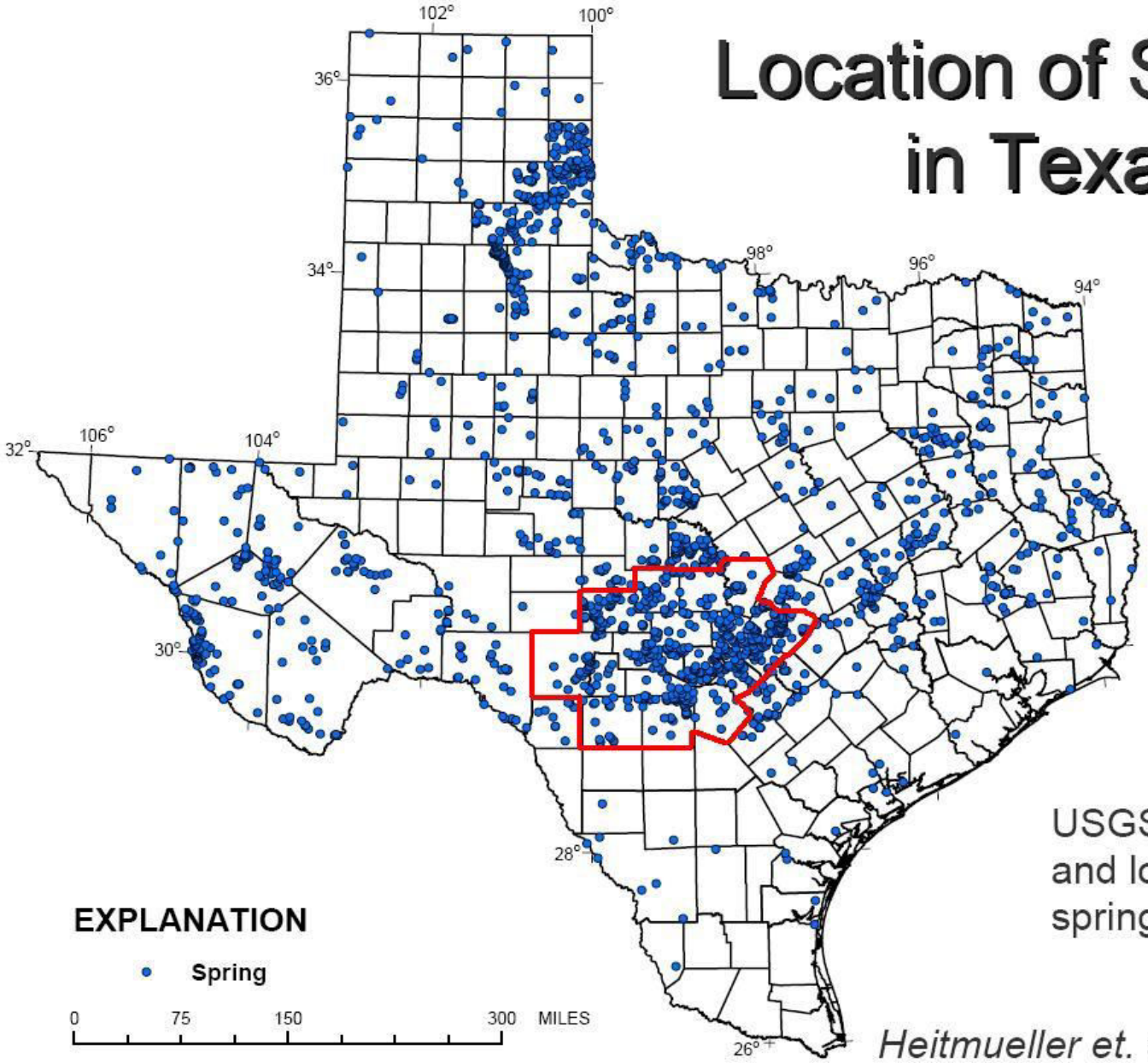
EDWARDS AQUIFER REGION



The Texas Hill Country



Location of Springs in Texas



USGS verified existence and location of 1,891 springs in Texas

Heitmueller et. al (2003)

Hill Country/Upper Llano Natural Resource Issues

- Water Management
- Water Resources
- Natural Threats
- Floods
- Droughts
- Water Resource Impairments due to Development
- Groundwater Quantity
- Groundwater Quality
- Surface Water Quality
- Invasive Species
- Wildlife Management
- Range Management

Upper Llano River Watershed Healthy & Notable

- 1) Hill Country - last great ecosystems,
- 2) 10 Waters to Watch,
- 3) Ecologically Significant Stream, TPWD
- 4) Important, here & downstream

EPA's Healthy Watersheds Initiative

A Wise Investment for Our Nation's Future

The Healthy Watersheds Initiative encourages states, local governments, watershed organizations and others to take a strategic, systems approach to conserve healthy watersheds with a goal to protect high quality waters and prevent future water quality impairments.

Benefits of Healthy Watersheds

- *Clean, Healthy Water*
- *Fish and Wildlife Habitat*
- *Flood Minimization*
- *Climate Adaptation*
  - *Carbon Sequestration (reduced green house gases)*
  - *Resistant and Resilient Ecosystems (habitat complexity and corridors)*
- *Recreation Opportunities*
- *Drinking Water Protection*
- *Billions in Cost Savings*

Despite billions of dollars spent in the last three decades to address impairments to water resources, aquatic ecosystems are still in decline. A recent EPA survey of the nation's wadeable streams found 42 percent in poor biological condition and 25 percent in fair condition. Nearly 40 percent of North America's freshwater fish, 700 species in total, are imperiled. We face a serious conservation crisis.

The solution demands a more integrated approach that looks broadly to maintain water quality and ecological integrity on a geographic – or watershed basis. Thanks to today's highly advanced assessment, planning and data anaylsis tools, we now can achieve the vision for holistic water resource management embraced by EPA and others in the early 1990's. Under the new ***Healthy Watersheds Initiative***, EPA is proposing:

- ***A Strategic Framework*** that outlines a systems-based approach to integrated watershed assessment, protection and conservation programs.
- ***A New Policy Direction*** that focuses on maintaining healthy waters and meeting Clean Water Act (CWA) goals of fishable and swimmable.
- ***A Collaborative Approach*** that integrates CWA programs and other aquatic resource programs across agencies and the private sector.
- ***Technical Assistance and Funding*** to states and watershed organizations to support healthy watershed assessment and conservation.

EPA Healthy Watersheds Approach

- Maintenance of aquatic ecological integrity by protecting our highest quality watersheds or those intact components of watersheds
- A **systems approach** that includes landscape condition (eco green infrastructure), water chemistry, biotic condition, and critical watershed functional attributes (hydroecology, geomorphology, & natural disturbance patterns)
- Identification of Healthy Watersheds state-wide
- Implementation of state-wide strategic protection priorities that leverage programs and resources across state agencies
- Inform priorities for ecological restoration

Benefits of Healthy Watersheds Approach

- Reduces costs to communities by minimizing vulnerability to floods, fires, and other natural disasters
- Reduces or eliminates costs of water treatment for drinking water by protecting aquifer recharge zones and surface water
- Ecosystems store carbon which can help offset carbon emissions
- Minimizes ecological impacts of future land use
- Facilitates ecological restoration downstream
- Helps target and prioritize ecological restoration opportunities
- Reduces vulnerability to invasive species
- Sustains future generations

Major Tasks

- Identify watershed/water resource issues
- Gather data/information & identify gaps
- Set Goals and Objectives
- Identify BMPs that could be implemented to address issues
- Identify Outreach and Education that is needed
- Develop an Implementation Plan & Schedule

Empowering stakeholders

- Landowners benefit because they are part of the process and their desires are incorporated into the WPP
- Partnerships
  - South Llano Watershed Alliance, TTU, and TWRI
- Voluntary community stakeholder meetings

Roles of Stakeholder Group and Work Groups

- Responsible for coming up with recommended implementation strategies to include in the Watershed Protection Plan

- Stakeholder Group/Steering Committee – Focus on developing management measures for entire Plan

- Work Groups – focus on work group specific issues
  - Ex. Natural Resources group focuses on solutions to agriculture, habitat, and wildlife related *E. coli* loading
- Work with LRFS, TWRI to draft ideas into Plan

Working Group Membership

- Invasive species
  - Fred Gregg
  - Andrew Murr/Billy Braswell)
  - Brady Richardson/Daryl Stanley
- Riparian protection and management
  - Melissa Parker/Gary Garrett
  - Znobia Wootan
  - Art Mudge
- Water quality and conservation
  - Marty Graham
  - Jerry Kirby
  - Marvin Ivy/Raymond McDonald
- Water supply enhancement
  - Marty Graham
  - Tom Vandivier
  - Souli Shanklin
  - Brady Richardson/Daryl Stanley
  - Ward Whitworth
- Upland management
  - Dandy Kothmann
  - Souli Shanklin
  - Sam Silvers/Marvin Ensor

Example Workgroup: Aquatic Invasives

1. Identify concern
   - Invasive, non-native elephant ear located within Upper Llano watershed
2. Identify region(s) of concern
   - Elephant ear has been documented along South and North Llano rivers
     - Found mostly on the SLR above 1st crossing to CR150
     - Patches found along NLR near Roosevelt
3. Methods of management
   - Manual removal; herbicide (glyphosate); mechanical cutting; combination
4. Informed decision making
   - Through experiences and previous studies: hand-painting herbicide with multiple treatments best
5. Implementation
   - Technical and financial assistance through TPWD
   - Education and outreach through SLWA
6. Make set of recommendations to Coordination Committee

Current Market System:
How we value ecosystem services

- Healthy watersheds provide ecosystem services at little to no cost
- Systems are under valued, their role not understood
- Services provided by intact watersheds are costly to replicate (if possible)
- Conservation of healthy watersheds can not only serve as a wise investment, but can also provide a variety of monetary and non-monetary benefits

Benefits of Protecting Healthy Watersheds

Reduced Flood Risk (and other natural disasters)

Increased Property Values

Lower Restoration/regulatory compliance costs

Lower drinking water treatment costs

Decreased health care costs

Decreased stormwater flows, treatment and infrastructure costs

Tourism and Recreation spending

Decreased infrastructure maintenance and costs

Timber/Farm products (working landscapes)

Nutrient Cycling

Carbon Storage

Increased biodiversity (genetic variability)

Wildlife movement corridors

Water storage

Micro-climate regulation

NY Times, p. A17.

July 10, 2009

Survey Shows Gap Between Scientists and the Public

"Scientists must find new ways to engage with the public. One cannot just exhort 'we all agree you should agree with us.' It's a much more interactive process that's involved. It's time consuming and can be tedious. But it's very important."

"I understand they're going to connect them. The Provost ordered it."

Bridging the Gap

Sustainable Environment

Sustainable Society