

FINAL ANNUAL PROGRESS REPORT

February 2014-2015

Springs to the Sea

Education & Outreach to Better Understand and Protect Linkages Between Natural Resources and Groundwater

To

The Trull Foundation

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From

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INTRODUCTION

Water and its linkages with all living systems are essential, yet there is a finite amount that must meet all our needs. In the state of Texas more water has been allocated for use than actually flows in its rivers and lakes. Our vital waters and natural resources are becoming polluted, groundwater is being withdrawn at unsustainable rates, and this will only get worse as Texas' population doubles in the next generation. Key habitats for aquatic, estuarine, and bay species are at risk from low freshwater flows. The State's waters and natural resources are utilized for energy, economic growth, livelihoods, and recreation. However, our management of these resources, including resiliency to changes in climate and sustainable resource use practices, depend on better understanding and implementation of sound policies to conserve and protect these same waters and natural resources. The conservation of water and preservation of living systems depends on increased knowledge of these systems and relationships.

To address challenges to water systems and natural resources, Texas State University founded the River Systems Institute in February 2002. Since then, the Institute's emphasis on educational and outreach programs has resulted in new and holistic approaches to the management of river, lake, groundwater, and coastal water systems. Through this work, it has become increasingly clear that **innovative approaches to education, outreach** to the general public, and **empowerment of stakeholders** through timely dissemination of information are all key strategies to improved conservation of water and natural resources. Without the involvement of community members and stakeholders at all levels, conservation efforts may falter just when most needed.

In August 2012, the River Systems Institute and Texas State University were endowed with a substantial gift from The Meadows Foundation. The Institute's name was changed to The Meadows Center for Water and the Environment, and in addition to carrying out the Institute's research and outreach activities, our goals were expanded to promote components of The Meadows Foundation's Strategic Plan for the Environment. Priorities include water resource aspects of environmental issues focused on sustainable energy, land and habitat conservation and environmental awareness.

The Meadows Center is committed to greater conservation of natural and water resources through innovative education, outreach efforts, and engaged stakeholder participation. Results from our diverse projects strongly support that improvements in education outreach are magnified through the creation, dissemination, and tracking of impacts through timely, relevant information to stakeholders. These informational materials are prepared and targeted so as to grow and increase knowledge in the general public. Such information, and the feedback that is collected, is critical for current and future decision making necessary for healthy watersheds and coastal zones.

Little understood, but fundamental to the linkages between freshwater, bays and estuaries, is the underlying groundwater. While the State-mandated instream flows studies examine the effects of river flows on habitats along stream reaches and bays, the impacts and interactions with groundwater are a very minor part of the studies, when considered at all. From headwaters to the coast, however, the rivers have major interactions with groundwater, receiving and losing flows to the subsurface as well as fresh water interacting with brackish water in the subsurface. Understanding groundwater interactions in proximity to bays and estuaries, as well as increasing knowledge of freshwater and coastal resource relationships, is a key aspect necessary to sustainably manage the entire water system.



This work is greatly needed to bolster understanding and support sound decision making for present and future groundwater and coastal water systems management and ensure their long-term sustainability. The program methodology and educational outreach efforts can be replicated for other river systems in Texas of importance to Gulf resources, as well as in other Gulf Coast states and will provide a potentially valuable tool for coastal resource management.

We are grateful to the Trull Foundation for supporting this innovative education program. In Year One (February 2012 through February 2013), in cooperation with Texas A&M university Press, The Meadows Center published a book about the Colorado River and Matagorda Bay. In addition, the Meadow's Center Staff attended numerous public events and forums to provide unbiased scientific information and education.

Year Two was focused on developing educational materials for students, teachers, and the general public for groundwater, linkages to coastal resources, water resource conservation and environmental protection. These materials will promote a better understanding of groundwater and its interactions near the coast in Texas. In addition, the results of this work will aid in equipping communities with information to improve understanding and decision-making with regard to local and regional water resource issues.

Year Three was focused on developing groundwater educational modules using a web-based and web-linked platform, publications and outreach materials on water for multiple audiences, and participation in conferences, meetings, and outreach activities which focus on the linkages between natural resources, coastal systems and groundwater.

PROJECT DESCRIPTION – Springs to the Sea

To achieve the goal of improving knowledge about the vital linkages between coastal, groundwater, and surface water natural resources, this project supports education and conservation in three primary arenas: **1) Groundwater educational modules related to coastal resources, 2) Publications and outreach materials that translate scientific findings into meaningful information, and 3) Citizen and water resource expert interactions at public forums** that will leverage existing outreach as well as support better understanding, management, and conservation of groundwater and coastal systems.

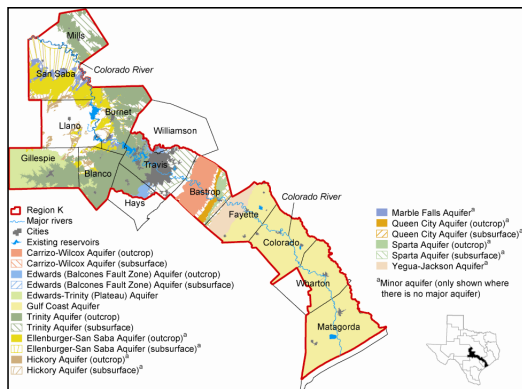
Groundwater tends to be an overlooked and underappreciated part of the natural water system and Texas' water supply. Recommended water management strategies indicate that Texas groundwater use may grow by 44% during the next 10 years (*Water for Texas: Summary of the 2011 Regional Water Plans*). The Region K figure below demonstrates the complexity of aquifer systems in the lower Colorado River basin. In just one watershed, eleven aquifers are present at and below the land surface and interact with the river to provide vast volumes of water storage. Each of these aquifers has unique characteristics. For example, near the Texas coast, the Gulf Coast aquifer contains interbedded layers of clays, silts, sands, and gravels that provide a multi-layer aquifer system. For the general public to make the connection about the importance of groundwater and its significance to the natural landscape, it is necessary to have understandable and memorable information about groundwater.

Further, projections in freshwater shortages to bays and estuaries have been a call to action for the past decade. While a great deal of attention has been focused on river flows, the changes in flow regimes including peak- and low-flow periods and how they interact with pumping-induced changes in aquifers and low natural replenishment of groundwater during droughts are also of concern. Less groundwater



flow to rivers means that less water, or under times of high water stresses such as extreme drought, no water will be available to bays and estuaries. The more that groundwater is pumped, particularly within the Gulf Coast aquifer system, the higher the probability is that salt waters will be induced through pumping to flow inland. These pumping-induced changes in flow direction and aquifer water quality are already occurring in some areas and may not be reversible. As well, reduced flow conditions increase pollutant and contaminant loads and salinity in the downstream bays and estuaries, further reducing the productivity and capacity of fish and other aquatic species' habitats. In turn, less fish and shrimping productivity has direct impacts on coastal communities. In short, the natural water system is one system, yet separate management regimes prevent an encompassing approach to addressing the causes and underlying problems with Texas' water supply, water quality, and reduced ecosystem functioning.

This project will provide such information through educational modules about basic groundwater in a variety of formats– text, graphics, video footage and maps – to better support different approaches to learning. Basic information on groundwater, including water paths through the subsurface, the soil and rock media through which movement occurs, information about rates, recharge, and discharge, will be supported by links to other educational and information sites that generally address groundwater movement. Specific information about aquifers in the coastal region and surface water-groundwater interactions will be prepared, as well as usable information and data concerning groundwater management on a regional and state basis. The educational modules will be designed for easy back-and-forth, hyperlinked mobility to engage a general audience. Other forms of media also will be utilized, including the publication of a hard cover book.



Map of Colorado River to the Gulf Coast,
Regional planning group boundaries (Region K Water Plan, 2010)

The Meadows Center works to leverage the impacts of existing partnerships in education, research, stakeholder, and outreach efforts. For this proposal, the tasks and deliverables will coordinate, when possible, with a similar Meadows Center educational program developed to increase the understanding of students and stakeholders about freshwater flows from the headwaters of Central Texas rivers to the coast. The Institute, in partnership with the Harte Research Institute, created Headwaters to Ocean (H2O) to create a technologically advanced program that demonstrates and educates participants about the interconnections between their actions and the sustainability of watersheds,

promotes public and student critical thinking, and determines the watersheds' economic resource values in order to stimulate environmental conservation behaviors.

While H2O targets river systems, this Project proposes to use H2O as a platform for similar educational work to demonstrate the linkages between groundwater, river flows, and interactions of freshwater and brackish salt waters in the subsurface along the central coast of Texas. Specifically, the proposal will



address groundwater in the Gulf Coast aquifer system within the Region K, or Lower Colorado State Regional Water Planning Group.

The coastal area in this region includes Matagorda Bay and its surrounding estuaries. As the third largest in Texas, this estuarine system provides critical habitat for oyster, crab, shrimp, over 300 species of birds including songbirds, shorebirds and waterfowl and a host of economically important fish. In addition to Blue crab and at least two shrimp species, Striped Bass, Atlantic croaker, Black and Red drum, Flounder, Jack, Gulf menhaden, Sea trout, Blacktip shark, Snapper and others are important sources of revenue for commercial fisheries, recreational fishing and related tourism.

Much of the region's economy is tied to riverine, coastal and estuary activities, including fishing, seafood processing, agriculture (primarily rice farming along the lower reaches of the Colorado near the delta) and tourism. Port Lavaca is one of the nation's leading shrimp processors and nearby Palacios is also home to one of the largest blue crab and shrimp processing industries, both worth tens of millions of dollars annually. Recreational fishing and tourism are of great importance to the local economy and Matagorda Bay and surrounding areas have the nation's highest count of migrating birds, drawing thousands of tourists each year.

The Matagorda Bay area, as with the Colorado River Basin is facing rapid population growth and is much of the basin is expected to double in population as early as 2030. This will dramatically increase water demands, which coupled with current drought conditions further stress surface and groundwater resources, limiting freshwater inflows to the bay.

Groundwater systems along the Colorado River down to Matagorda Bay will be the centerpiece of this proposal and its creation of educational modules about groundwater influences, discharges and recharges with the Colorado River, and interactions between the Gulf Coast aquifers and saltwater influences in the subsurface. The overarching goal will be better-informed stakeholders of the region that are prepared to engage in water decision making of their future, including groundwater and coastal water resources.

Links can also be established and strengthened through the proposed efforts in groundwater and coastal waters education and outreach. Existing programs such as The Gulf of Mexico Foundation's Intercoastal Waterways and Wetland Expeditions and The Science and Spanish Network offer students and the community educational opportunities related to coastal and natural environments. The Foundation's programs include habitat exploration and highlight natural and anthropogenic threats to the Gulf Coast region. Multicultural extracurricular outreach projects foster relationships between English-speaking and Spanish-speaking students to address Gulf Coast environmental concerns. The inclusion of groundwater curricula and information developed under this proposal would increase the foundation's ability to educate students and community members about the relationships between groundwater and coastal resources, environments, issues and management needs.

To better support the long-term impacts of the proposed effort, publications that translate scientific findings to everyday terms and daily living examples are needed with respect to the significance of groundwater to Texas' coastal systems. To provide an excellent example of the strong linkages between people, their resources, and the absolute necessity of understanding the natural resources' fundamental groundwater support, the proposed efforts will include publications, outreach materials that can be used by citizen groups and non-profit organizations, and simplified flyers and brochures that are downloadable.



Finally, educational outreach and stakeholder discussions and networking through conferences can be quite powerful. Through meetings and Citizen's Forums, this proposal will take advantage of conferences supported by Meadows Center. The program will develop and present materials, introduce relevant and timely topics, and continue support of citizen's networking to continue conservation actions.

Potential Impact

- Stakeholders, teachers, students, and the general public from anywhere in Texas or beyond would have distance learning capabilities through river, coastal, and groundwater systems learning modules on a web-based platform.
- Environmental professionals and managers would have access to continuing education to understand implications of groundwater research findings and improve conservation efforts.
- Publications developed to translate research findings and critical groundwater resources needs would further improve community and stakeholder knowledge and awareness.
- Support and development of the citizen networking and conservation actions will be continued through The Meadows Center and their partners' conferences, workshops, and forums over a 3-year period.

Outcomes

The Meadows Center has been successful in building partnerships that have resulted in a lengthy list of outcomes in research, policy, and educational activities on Texas' water. This proposal seeks to continue that successful model, expanding access of educational and outreach materials to students, citizens and water resource stakeholders. The proposed targeted activities will increase community and stakeholder awareness of critical and often poorly understood water resources issues spanning Texas' rivers, aquifers, estuaries and coastlines. Further, project resources will provide the coastal community with resources to facilitate improved capacity for conservation related outcomes.

BUDGET REPORT

"Springs to the Sea" Program Component	Amount		
	Feb 2012- Feb 2013 COMPLETED	Feb 2013- Feb 2014 COMPLETED	Feb 2013- Feb 2014 COMPLETED
Groundwater Education Modules and Linkages in Groundwater and Coastal Resources Program		\$2,250	\$2,250
Publications, Technology Transfer, and Educational Materials for Stakeholder and Citizen Groups	\$4,500	\$2,250	\$2,250
Educational Workshops and Outreach Activities	\$500	\$500	\$500
ANNUAL AMOUNT	\$5,000	\$5,000	\$5,000

YEAR ONE DELIVERABLES



YEAR TWO DELIVERABLES

Year Two was focused on developing educational materials for students, teachers, and the general public for groundwater, linkages to coastal resources, water resource conservation and environmental protection. These materials will promote a better understanding of groundwater and its interactions near the coast in Texas. In addition, the results of this work will aid in equipping communities with information to improve understanding and decision-making with regard to local and regional water resource issues. In Year Three, The Meadows Center will continue to expand these components.

A majority of the deliverables in Year Two were accomplished by Meadows Center staff working under the Texas Stream Team (TST) program. Texas Stream Team is a statewide network of citizen scientists and partner organizations that is run by The Meadows Center and is committed to environmental stewardship through citizen science and education and outreach.

Clean Rivers Program Meetings

Texas Stream Team conducted three presentations at Texas Clean Rivers Program (CRP) Steering Committee Meetings during 2013. The purpose of these presentations was to keep CRP Partners abreast of citizen scientist water quality monitoring and watershed education activities in their area, to offer TST services to both the regulatory agencies and the stakeholders in attendance, to identify new opportunities, and to share available data with partners and stakeholders.

Watershed Protection Planning/TMDL Stakeholder Meetings

Texas Stream Team attended and presented at Watershed Protection Plan and TMDL Stakeholder Meetings in 2013. The purpose of the initial presentation at these meetings was to offer TST services to the stakeholder group. Subsequent presentations focused on collaborative planning for activities such as education and outreach events, creating citizen scientists water quality monitoring groups, and sharing available data to the stakeholders. These meetings also helped TST identify activities in which they may be of assistance. Texas Stream Team's attendance at stakeholder meetings strengthened the relations between TST, partner agencies conducting the TMDLs and WPPs, TCEQ, the Texas State Soil and Water Conservation Board (TSSWCB), and the Texas Agri-Life Extension.

YEAR THREE DELIVERABLES

Meetings – Sharing water resources information in the Community
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March 21, 2013 – Guadalupe Blanco River Authority Clean Rivers Program Steering Committee Meeting
April 22, 2013 – Houston – Galveston Area Council Clean Rivers Program Steering Committee Meeting
April 30, 2013 – Trinity River Authority Clean Rivers Program Steering Committee Meeting
February 7, 2013 – Plum Creek Partnership WPP Stakeholder Meeting
February 11, 2013 – Improving Austin Streams TMDL Stakeholder Meeting
February 20, 2013 – San Marcos Watershed Initiative WPP Stakeholder Meeting
February 21, 2013 – Llano River WPP Stakeholder Meeting
May 2, 2013 – Plum Creek Partnership WPP Stakeholder Meeting
May 8, 2013 – San Marcos Watershed Initiative WPP Stakeholder Meeting

Education and Outreach **Events**

Texas Stream Team increases public awareness of watersheds, non-point source pollution, water quality, and groundwater surface water interactions by participating in educational events across the state. These events include festivals, science fairs, and environmental programs.

Outreach & Education Events – Water quality, environmental flows, groundwater protection
March 13, 2013 – Spring Lake Girl Scouts Field Trip, San Marcos, TX – 10 individuals
April 20, 2013 – Earth Day Dallas, Dallas, TX
May 21, 2013 – Lady Bird Johnson Earth Day Festival, Austin, TX – 60 individuals
May 23, 2013 – Bowie Elementary Science Fair, San Marcos, TX – 125 individuals
May 31, 2013 – Kerrville Folk Festival Canoe Tour, Kerrville, TX – 20 individuals
June 3, 2013 – Aquarena Springs Water Quality Demonstration, San Marcos, TX – 24 individuals
June 7, 2013 – Kerrville Folk Festival Canoe Tour, Kerrville, TX – 15 individuals
June 12, 2013 – Aquarena Springs Water Quality Demonstration, San Marcos, TX 22 individuals
June 20, 2013 – McKinney Falls S.P. Junior Ranger Camp, - Austin, TX – 20 individuals
June 28, 2013 – McKinney Falls S.P. Junior Ranger Camp, - Austin, TX – 12 individuals



September 11, 2013 – Spring Lake Water Quality presentation – San Marcos, TX – 121 individuals
November 12, 2013 – Spring Lake Water Quality Presentation – San Marcos, TX 40 individuals
November 19, 2013 – Blue Hole Water Quality Presentation – Wimberley, TX – 110 individuals

Groundwater Education Modules

Texas Stream created online education modules on water resource management in the State of Texas. Two of these online modules are on groundwater management, law, and policy. Each module contained required reading material, a powerpoint presentation and a multiple choice quiz. The modules were designed for a college level geography course in resource management.

Aquatic Sciences Education Curriculum

Texas Stream Team compiled a curriculum of aquatic sciences educational activities. These activities are designed for K – 12 classrooms and are aligned with the Texas Essential Knowledge and Skills (TEKS) criteria. The curriculum covers six subjects related to aquatic sciences: water characteristics, the water cycle, groundwater, watersheds and aquifers, water quality monitoring, aquatic life, and pollution. The groundwater, watersheds and aquifers subject has five activities for classrooms to conduct to learn about how groundwater and surface water interact.

Intracoastal Waterways Wetland Expedition June 16 – June 21

Texas Stream Team collaborated with the Gulf of Mexico Foundation on the Intracoastal Waterways Wetland Expedition (IWWE). Twenty-four teachers boarded the M/V *Fling* for a five day cruise out of Freeport, TX. The *Fling* crossed the Gulf of Mexico, over to western Louisiana, and worked its way back to Freeport along the Intracoastal Waterway. During the cruise, the teachers learned about the flora and fauna of the wetlands and estuaries they were visiting along the way. Texas Stream Team was on board to give lessons on water quality and to educate teachers on how the wetland's water was impacted by the land use in the watershed. Water quality was tested by the teachers every day to see the changes as the ship moved from freshwater estuaries into more saline estuaries. A presentation on NPS pollution was given by TST on the ship, and the teachers also learned how to use the Enviroscope Watershed Model in their classrooms.

An article about the IWWE was published in Texas Stream Teams quarterly newsletter *Headwaters*.



Teachers on the Intracoastal Waterways Wetland Expedition collect plants, seine for fish, and conduct water quality in the wetlands.

Citizen Scientists Water Quality Monitoring

Texas Stream Team coordinates with partner organizations to support a citizen science water quality monitoring project. Volunteers are trained to collect water quality data which is submitted to Texas Stream Team. The data undergo quality assurance and are then posted onto Texas Stream Team's Dataviewer for the public to see. Texas Stream Team partners with the Houston Galveston Area Council to support groups of citizen scientists in the region. One group is the Galveston Bay Foundation. Ten citizen scientists with the Galveston Bay Foundation conducted monthly water quality monitoring in Galveston Bay. The data they collected contributed to Texas Stream Team's 23 year dataset on water quality in Texas, and also provided local residents with information on the quality of their coastal waters.

Data Reports

Once water quality data has been collected on a water body for at least two years, Texas Stream Team compiles data from all of the sites in the watershed and publishes a data report. The data report identifies long-term trends in water quality, and a site by site analysis that offers a comparison of different sites in the area. The data reports are posted on Texas Stream Team's website and are available as a public resource. In 2013, Texas Stream Team published a data report on the water quality of several sites in the estuarine area of the San Bernard River.



YEAR THREE DELIVERABLES

Year Three will have three specific deliverables that will be the basis for reporting and evaluation:

1. Groundwater educational modules using a web-based and web-linked platform. The groundwater the subsurface; the relevance of the local geology on aquifers; what aquifer systems exist beneath each educational area; how aquifers interact with coastal water resources through mixing zones; impacts of increased pumping on the overall river-to-coast and groundwater systems.
2. Publications and outreach materials on water resources in formats appropriate for the general public, environmental and conservation professionals, students, and stakeholders. The publications will focus on Texas rivers, groundwater and coastal resources, and will be prepared to reach a wide audience throughout the Texas coastal region and the state.
3. Organize and participate in multiple conferences, meetings, outreach activities and citizen's forums on the linkages between natural resources, coastal systems and groundwater.