Texas Water Tech Roadmap Forum

A Race Against Time

"There is no resource more important to the sustainable growth of Texas than water."

- Andrew Sansom
Texas Water Tech Roadmap Forum
February 25, 2015

Texas Water Technology

Roadmap Forum

Held
February 25, 2015

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The Meadows Center for Water and the Environment is a water research and education center at Texas State University.

STAR Park is the Science, Technology and Advanced Research Park at Texas State University.

Water Institute of Texas is at the University of Texas at San Antonio and was established to conduct research on the various factors related to water sustainability and their effect on the health and economic development of Texas and the Southern US.

AccelerateH2O is a Texas water technology accelerator.

RCN-CE3SAR is the National Science Foundation funded Research Coordination Network for Climate, Energy, Environment and Engagement in Semiarid Regions. RCN-CE3SAR is composed of the following institutions: Southwest Research Institute in San Antonio; Conrad Blucher Institute, Texas A&M University-Corpus Christi; Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi; Center for Research on Environmental Sustainability in Semi-Arid Coastal Areas, Texas A&M University-Kingsville; Sub-Tropical Research Center, University of Texas-Brownsville/University of Texas-Pan American; Meadows Center for Water and the Environment, Texas State University; Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville; Binational Center, Texas A&M International University; Texas Water Resources Institute, Texas A&M University-College Station; Texas Center for Climate Studies, Texas A&M University-College Station; Institute for Science, Technology & Public Policy, Texas A&M University-College Station; Center for Housing and Urban Development, Texas A&M University-College Station.

A Path Forward

In December 2014 the Wells Fargo Foundation granted funds to Texas State University to take a series of practical first steps to define the most pressing water-related technology deficiencies for which there may be applicable intellectual property (IP) or researched solutions. This would serve as an initial "target list" for IP mapping and subsequent application of available, but unused or underused research in a range of water technology areas.

Work evolved through a series of partnerships into an expanded effort to lay the groundwork for developing a novel water technology roadmap to help guide Texas toward global leadership in water technology and sustainable use. By invitation, key thought leaders in the water sector from throughout Texas were brought together to help lay that groundwork. This report summarizes that effort and recommends a path forward to help solve Texas' water problems and move new water technology from lab, to market, to application.

"Market forces will drive innovation of water technologies."

- Ed Archuleta
Texas Water Tech Roadmap Forum
February 25, 2015

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Summary

The Wells Fargo Foundation granted funds to Texas State University to define pressing water technology deficiencies for which there may be intellectual property or research solutions that can be implemented now. Furthering accomplishment of this goal and expanding its scope to lay the basis for a technology roadmap for Texas, numerous partners pooled resources to host the Texas Water Technology Roadmap Forum.

By invitation only, the Forum brought key thought leaders from Texas' water sectors together. Participants came from throughout Texas, representing business, industry, government, academia, investment, and research. A network of 12 Texas university and independent research institutes funded by the National Science Foundation, called RCN-CE3SAR, served as an unbiased independent facilitator of the forum.

A consensus emerged through discussion that Texas is rapidly approaching a water crisis reflecting issues of supply, use and quality which demands immediate effort to ensure sustainable and equitable access. Participants described critical problems in Texas' water sectors and expressed concern over consequences to Texans and the Texas economy if action is delayed. Participants focused on a pathway to help solve Texas' water problems and speed water technology from lab, to market, to application.

Participants described fragmentation in the water sectors and a dysfunctional system for water technology innovation. Lack of adequate investment, with investors misunderstanding the current market environment, including inadequate and inaccurate valuing of water as a commodity, was among top observations. The key challenge for bringing technology to market was described as reducing the length of time it takes to bring technology from lab to application. A high degree of regulation, not just over public safety concerns, but also across acquisition and supply chain management was felt to obstruct bringing innovative technology to market. Participants called for regulatory relief, industry standards, and accelerated research, development, demonstration, and deployment of new technology facilitated by technology-specific demonstrations. Participants also expressed need for enhanced public and consumer education about water scarcity, values of water, and water use and reliability, including providing insight on the age and condition of water infrastructure.

Participants called for enhancing access to data, and increasing data quality and quantity. They suggested a trusted clearing house or virtual network for connecting with data housed at Texas' water institutes. Universities were described as best able to support such a service. Need for continued development and implementation of water-smart technologies and education programs to reduce water use were emphasized. Water reuse should be expanded and supported. New markets for water residuals should be created, such as for saline and gray waters, and water processing byproducts.

Four Strategic Actions

Participants identified actions to take now to support water technology development:

- develop a cyberinfrastructure for information sharing,
- provide water technology demonstration and pilot project test beds,
- inventory water technology assets, and
- map water technologies.

There are other urgent actions needed in policy and market development that, while critically important, are outside of the technology envelope of the forum.

Failing to act now could have dire economic impacts to Texans through increased costs of water affecting the economy, loss of fresh water in some areas, affects on public health, civil unrest caused by disparities in access to and cost of water, adverse environmental impacts, and reduction of food production.

Participants felt that with action now Texans can have a sustainable supply of safe water for all uses, including to support future growth in population and the economy.

Overview

The main goal of the Forum was to create a pathway for solving Texas' water problems and move new water technology from lab, to market, to application.

The workshop was designed to bring together invited thought leaders of water-related companies, water associations, university and other Texas research institutes, and others interested in accelerating the growth of Texas' water conservation technologies and industries. A National Science Foundation-supported Texas research coordination network served as an independent unbiased facilitator and additional sponsor.

Participants focused on defining the most critical problems facing Texas water sustainability that may be solved through use of new technologies.

Specific solutions and barriers were discussed. Participants also considered roles of the various sectors working in water and opportunities for cooperation and networking.

Results from the workshop will refine technology targets, describe actions to reach those targets, and ultimately define the current scientific and technical capacity of the State's centers of research and technology demonstration.

Roadmapping

Roadmaps are much like strategic plans. At the outset, roadmaps require a clear vision of the goal and objectives obtained through stakeholder agreement.

A roadmap contains three basic categories of information and guidance to users.

A Compass - There is a means of guidance for what to do and what not to do, relating to the goals and objectives.

A Dashboard - There are ways to track progress and status, including metrics and milestones, in as many categories as needed to allow regular tracking of progress.

A GPS - There is a way to determine location relative to the goal at any point in time.

The roadmap displays a continuum of steps to take to achieve stated outcomes. It outlines links among tasks and priorities for actions to be taken immediately and in the future. Stakeholders help create a consensus around performance targets, pathways, assets, priorities, market needs, obstacles, and time frames for research, development, demonstration, and deployment of technology and subsequent commercialization pathways.

Roadmaps are often used as a means to help display and simplify understanding of complex systems. The process itself engages and aligns stakeholders in a common course of action.

Building a roadmap is a dynamic process. Over time, the roadmap must evolve and be adapted, accommodating the successes and failures of implementing roadmap-guided actions, with stakeholders remaining engaged.

The Forum & Charrettes

The Forum was an intensive workshop involving people working together under compressed deadlines. It was facilitated using a charrette process.

Charrettes provide for an interactive pace in which a diverse group of stakeholders, representing pluridisciplinary perspectives (i.e., multi-, inter-, cross-, and trans-disciplinary) are brought together. Participants follow a rigorous, facilitated vision-driven process to achieve specified outcome-oriented goals and objectives. Charrettes are especially suited to encourage discussions that go beyond conventional thinking, and that stretch the envelope of the status quo into the realm of new possibilities.

Participants were asked to organize their thoughts in advance of the forum by filling out an input sheet provided directly to all participants and also available on line (see Appendix III).

Upon arrival, participants received a welcome from the organizers and a briefing on the charrette process. After the briefing, participants were asked to attend any two of four breakout discussions.

Breakout group discussions during the Forum offered participants an opportunity to contribute to discussions and learn from others. Discussion is an essential element of the process, because it begins the vitally important process of developing a common understanding among stakeholders with different perspectives and knowledge levels regarding the various issues. In their subgroups, participants brought forward the most critical issues facing residential, commercial, agricultural, and utility-based water use and markets that could be addressed through technology. They focused on solutions and the roles of the private sector, government, academia, and research institutes to address critical problems through technology innovation and market-driven solutions.

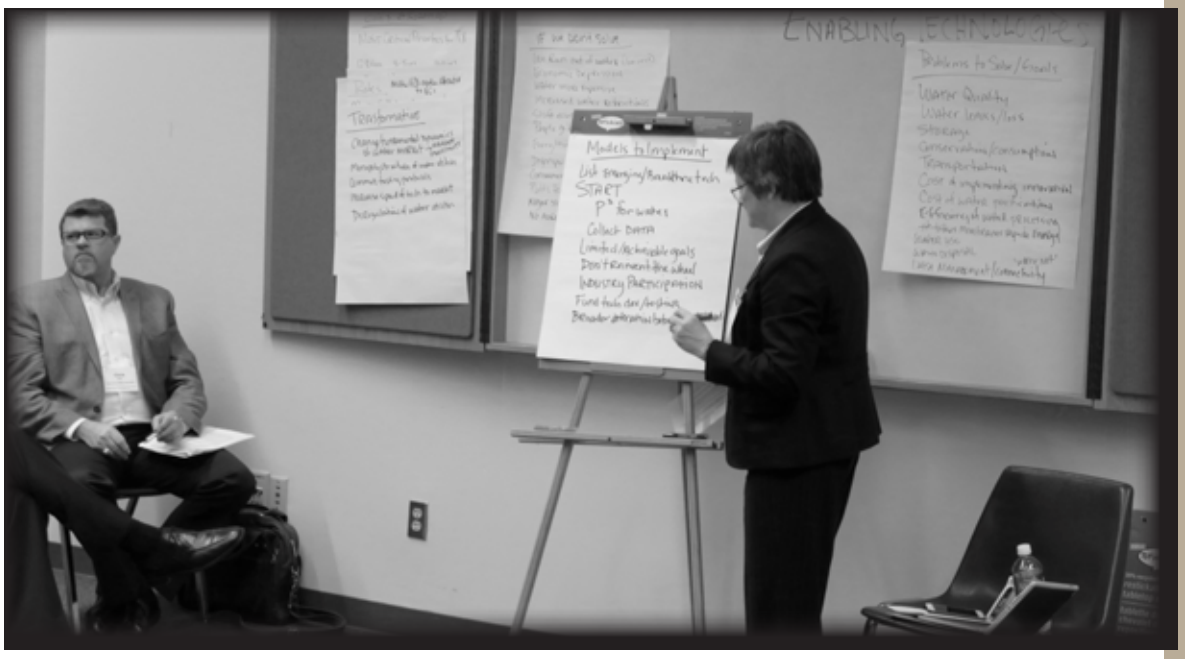
Moving from a generalized discussion to a more specific scientific and technical level, participants discussed priorities, near-term needs, and gaps from an end-user market perspective. The groups discussed scenarios for collaboration, coordination, and alignment of opportunities for activities, such as proof of concept and pilot projects, demonstration, and validation of emerging technologies.

After subgroup breakout discussions, a final plenary session provided participants an opportunity to immediately hear highlights of discussions from each breakout session. Breakout group facilitators from RCN-CE3SAR presented the summaries. A presentation by Forum facilitator Dr. Jorge Vanegas on the "Path Ahead" during the final plenary session offered participants an opportunity to contribute to possible next steps.

This Forum report provides participants a record of the process, results, conclusions, and next steps.

Forum Results & Conclusions

Forum participants worked in four subgroups chosen to roughly divide participants into groups of 20 individuals each. This is the general maximum number of participants in a charrette.



Breakout groups focused on four areas:

- **Water Sources**
- **Water transport**
- **Water uses**
- **Enabling technologies**

Each topic area was the subject of discussion by two groups of participants. The results and conclusions of discussions in each area are presented separately in following sections of this report.

The fifth section that follows is derived from subgroup discussions and covers consequences should Texans fail to take action on critical water problems, barriers to implementation, and benefits should the barriers be removed and critical problems solved. Numerous measures of success were also described.

A sixth section covers the last plenary session of the day, when the lead facilitator asked the entire group several questions about discussions during the day and ways to move forward.

A final section covers general overall conclusions from the forum.

Results - Water Sources

This breakout session focused participant attention on water technologies from a source point of view. The discussions included, but were not limited to conventional sources, gray water, brackish/salt water, contaminated/impaired sources, membrane technologies, materials for making water fit for purpose, energy conservation associated with production and processing water sources, and energy recovery or production from water sources.

Critical Problems

The most critical problems brought forward by the groups are listed with notes of explanation. These are not presented in any particular order.

Water rights. The basis for water rights is inadequate for today and Texas' future, including inappropriate allocations and inconsistency. There is also a general public misunderstanding about water rights and how such rights affect consumer access to water.

Saline water. There is a lack of proven technologies for dealing with and the beneficial use of saline water, including desalinization and disposal of brine and solid residuals.

Regulation. There are inconsistencies in relevant regulations and some regulations impose undue burdens on developing water resources.

Variability in supply and demand. There is spatial and temporal variability of water sources, resulting in fundamental disconnects between supply and demand, uncertainty in supply and demand, and supply shortages. Making this variability even harder to accommodate effectively is uncertainty in the available models (statistics, analytics, and numerical methods) for effectively predicting supply and demand.

Water quality/quantity. There are inadequate measurement and monitoring systems in place for the characterization of the quality and quantity of water. This deficiency includes inadequacies in characterizing the physical, chemical, radiological, microbiological, and other characteristics of various water sources. There is also a lack of adequate characterization of related end-user requirements for water.

Water valuation. Water is generally undervalued with respect to the benefits it provides, leading to disconnects between perceived value and cost to produce, process, and reuse/recycle from various primary and secondary sources.

Priority Solutions and Technologies

Top priorities for solving water problems identified by the groups are listed.

Improve education. There is a critical need for an educated water infrastructure workforce for current and future generations. This includes better educated and trained regulatory workers.

Education is not just needed for workers in water industries. The general public is inadequately educated to understand the connection between

water use, water sources, Texas' economies, and sustainable communities and industries. There is need for education of the public regarding water supply, demand, conservation, reuse, and other water matters, with a goal of increasing public understanding of the challenges of securing water and the need for new technological solutions.

Accelerate research, development and demonstration of new and improved technologies. Problem areas identified by the forum for accelerating application of technologies should become priority subject areas for research, development, and demonstration. This acceleration of technology applications should include an expedited and consistent process for evaluating, approving, and deploying existing and emerging technologies. There was discussion about applying a "systems-based approach" to development, evaluation, and deployment of economically viable technologies.

Priority areas include technologies that will enable beneficial use of saline waters, use of impaired water sources (e.g., chemical and radiological), and expansion of underutilized water sources (e.g., rainwater and saline groundwater). Coupled with discovery and application of new technologies for underutilized sources, there is a need to develop improved means to identify and characterize Texas' underutilized and unconventional water sources.

Success in this area will also involve enhancing the capacity of water providers and end users to match sources to demands, needs, and markets based on physical, chemical, radiological, microbiological, and other characteristics.

Develop and institute economically-based, valid valuation of water. There is need for a framework or an economic model for pricing water in a manner that reflects its true value (or value added). A sound economic model, supported by available statistics and analysis, will legitimize the water pricing structure and provide a sound basis for evaluating the cost-benefit of developing, demonstrating, and deploying innovative technologies to assure adequate water sources.

Water Sector Roles

There are many people spanning multiple sectors of the economy and society in general involved in addressing water matters in Texas. Private industry, government, consumers, academia, researchers, and the nonprofit sector all will have roles and influence on charting a roadmap for Texans. The two groups convened during the forum differed in their emphasis on the role of government versus private industry. One group felt government needed to take the lead on charting Texas' water future, with private industry and academia playing a supporting role. The other group felt it was the private sector that needed to lead, with academia providing technology support, and government establishing an appropriate statutory and regulatory framework for approval and implementation. Consequently, the results present a mix of direction on lead sector.

Key declarations regarding sector roles:

Research and development sector. Academia, private non-profit research and development institutes, and the National Academy of Sciences should serve as independent "honest brokers" to identify, conduct proof of concept tests, and oversee demonstrations of technologies needed to address critical problems.

Government sector. An appropriate State or Federal agency should establish a "clearinghouse" for information encompassing water supply, demand, quantity, and quality.

An appropriate State or Federal agency should establish a "technology clearinghouse" to house and distribute information on the availability and efficacy of technologies of potential value to water sector industries.

A government agency should establish a water pricing structure that incorporates the true value of water, on at least the state level.

Private Sector. Public-private partnerships are needed and should be stimulated by the private sector.

Private industry needs to fund appropriate research and development by academia and private non-profit research and development organizations, but such corporate funding should be incentivized through tax advantages or other financial offsets.

Multiple sectors. The private sector and government have roles that include funding partnerships and incentivizing research and development of innovative technologies having potential commercial value and relevancy to water industries and markets.

All parties have roles to play in educating and marketing to the public to facilitate changes in perceptions and, ultimately, behaviors regarding water use and technologies that enhance availability of water and decrease demand.

Results - Water Transport

This breakout session focused participant attention on discussing technologies for water transportation and delivery, including, but not limited to monitoring, decision tools, GIS tools, and physical water transport systems.

Critical Problems

The most critical problems brought forward by the groups are listed with notes of explanation. These are not presented in any particular order.

Infrastructure. The infrastructure for water transport is aging and failing, leading to increased water losses just as loss reduction is becoming more critical to maintaining current supply needs and keeping up with increasing demand. Water utilities face considerable and increasing liability just to maintain essential base level service. Inadequate funding and the complication of upgrading old infrastructure challenge solution. This issue extends to all areas of conveyance, such as pipes, pumps, storage, valves, lift stations, pressure regulators, etc.

Planning. There is a need for increased planning to address increasing demand, right of way conflicts, and sharing of water resources among competing users. Problems are amplified as water infrastructure crosses jurisdictional boundaries and responsibilities are shared among various governments and utility districts.

Regulation. There is a lack of common sense among regulators. Current regulations often cause unnecessary burdens and fail to allow for a common sense means to comply.

Pumping. There is a need to better manage and account for energy used in water transport.

Storage. Water loss due to evaporation is significant in Texas' large-scale storage reservoirs, canals, and natural waterways. (i.e., 22% loss mentioned)

Species. There are problems associated with invasive species' impact on water delivery and storage, the most prominent is impact of zebra mussels.

Water valuation. Water is generally undervalued with respect to the benefits it provides, leading to disconnects between perceived value and cost to develop and bring to market new technologies.

Priority Solutions and Technologies

In general, one of the two groups that met to discuss water transport felt there was considerable technology now available to address many of the challenges brought forward. They felt there was a lack of funding and capacity to implement that existing technology In other words, if there are no funds or capacity to implement existing technology, there is no market incentive to develop and bring on still newer technologies. Top priorities for solving water problems identified by the groups are listed.

Funding. While existing and emerging technology may provide ways to treat some of the symptoms of aging and failing infrastructure such as leakage, significant funding is needed to replace aging infrastructure through conventional manual construction methods and existing technologies. Continued support for and use of existing transport infrastructure will continue to be necessary regardless of technology advances, due to the high cost of alternatives and consequence of failing to maintain current base services. Lack of funding and realistic valuation of water hampers market-driven technology innovation in transport and delivery of water.

Reuse. Technologies to allow use of gray water and other lower quality water will help reduce demand and potentially extend delivery capacity.

Cooperation. There are several major areas where cooperation will create benefits. For example, cooperation during planning, especially where water conveyance systems cross jurisdictions. Some sharing of infrastructure could also provide efficiencies in cost and delivery. There is fragmentation within the industry, including infrastructure and jurisdictions. Cooperation should help reduce this and create mutually beneficial sharing and synergistic opportunities. Incentives will aid in promoting cooperation. Cooperative information sharing will be of benefit to all sectors and is another area of cooperation that could be reinforced by incentives, especially for sharing of proprietary information. Synthesis and sharing of information and group processes may lead to increased cooperation as well.

Regulatory relief. Regulators need to be better educated and better understand the reality of compliance within the context of day-to-day operations within the industry. Regulations should allow for testing of new technologies without undue burdens and provide for common sense relief from liability

and penalties. Without such relief, demonstration and implementation of many new technologies of benefit to improving water availability and use will be stymied.

Education. Many technologies already exist to address critical problems, but education is needed in several areas. To bring new technologies to market, education may be needed to identify them as valid solutions and to demonstrate they are reasonably priced so necessary public investments can be successfully made through regular utility financing mechanisms. Education can help focus public attention and investment to help solve problems and cover costs of aging water infrastructure in the face of increasing demand and decreasing supply. This will help lead to increased conservation and decreased demand.

Monitoring and assessment. There are new technologies requiring minimal disruption to improve monitoring and assessment of transport and delivery.

Incentives. Many technologies exist to address critical problems, but incentives are needed to make it financially possible and the regulatory environment must allow for testing and application safe from disincentives, such as unreasonable regulatory liability. An example is emerging technology for small-scale treatment plants for use in the oil and gas industry, for medical facilities, or for other specialized industrial application.

Energy. Improved ways to manage energy, reduce costs and increase energy efficiency of water transport are needed.

Value. Pricing of water needs to reflect true costs and allow for current and future public and private investment to maintain and upgrade transport and delivery infrastructure.

Water Sector Roles

There are many people working in multiple sectors of the economy and society in general who are involved in addressing water matters in Texas. Private industry, government, consumers, academia, researchers, and the nonprofit sector all will have roles and influence on Texas' water future. All sectors need to be actively involved. Here are the key declarations to emerge from discussions about water transportation and delivery.

Key declarations regarding sector roles:

Research and development sector. Academia and private non-profit research and development institutes should lead in conducting pilot projects and demonstrations, but should do so in cooperation with private industry.

Government sector. Regulatory agencies need to provide better training for regulatory staff and focus attention on use of common sense. The government sector needs to take a lead to better engage rate payers, in association with utilities to address misunderstanding about the value of and pricing of water.

Multiple sectors. All sectors need to be working together, especially through establishing unusual partnerships around solving specific problems or sharing resources.

Results - Water Uses

This breakout group focused on water technologies from a use point of view for agricultural, industrial, municipal, and other uses, including, but not limited to materials, sensors/devices, energy source, communications, software, behavior modification, analytical and decision tools, etc.

Critical Problems

The most critical problems brought forward by the groups are listed with notes of explanation. These are not presented in any particular order.

Infrastructure. The water industry is challenged by the cost and complexity of upgrading aging infrastructure. Continuing to manage supply and delivery in the old infrastructure will create continuing and increasing problems into the foreseeable future. Infrastructure deficiencies underlie distribution inefficiencies and water losses. Undervaluation of water and public/consumer lack of understanding of the cost of upgrades and consequences of not upgrading hamper support for adequate public investment.

Valuation. Water pricing models need to better address the commodity nature of water. Water is generally undervalued, creating conservation challenges and public misunderstanding about the true cost of public investment in upgrades and application of new technologies. There also are political pressures to keep water pricing low.

Information. There is a general lack of data collection, data management, data analysis, analytical tools, and comprehensive distribution of data (or access). The industry needs better water supply/use forecasting models and decision support systems to allow real-time response. There is also a lack of understanding by the public and consumers about water use and the role of technology. This lack of public understanding creates problems achieving conservation goals, obtaining public investment, and implementing new technologies.

Cooperation. There is fragmentation throughout the industry.

Capital. The current economic environment is not attracting investors in new water technology. Funding and financing are lacking for upgrades to existing infrastructure and new technologies. There is a general lack of risk taking in financing water technology.

Regulations. There is a lack of standards for testing and demonstration of new technologies. This causes delays moving technology through regulatory processes.

Priority Solutions and Technologies

Top priorities for solving problems identified by the groups are listed.

Technology validation and deployment. There is a need for independent third-party research and development test beds for conducting pilot projects and demonstrations required to validate technology. Participants suggested that standards for evaluating new water technologies be developed in cooperation with regulators to provide greater levels of certainty and accelerate moving technology to market and deployment.

Data. Participants stated there is a need for an "honest broker" of information. Basic data needs to be collected and shared within and across water sectors. This could potentially be done through networked information sharing or a clearing house openly available. Participants suggested the academic sector would best serve in this capacity. New analytical tools also need to be developed and shared for use in addressing analysis and real-time management of supply, use, distribution, conservation, environmental impacts, and other water sector needs.

Funding. There is need for access to private investment capital to bring new technologies to market and deployment. This may be accomplished through development/application of new business models, government incentives, and regulatory reform. Uncertainty and length of time to market caused by the current regulatory environment must be reduced to reduce risks for investors in early-stage water technology. More information is needed to better define the markets and risks.

There is great need for public investment to upgrade aging infrastructure. To promote greater public investment, consumers need to be provided better educational messages about the true value of water, costs of investment, and water security risks if infrastructure is not upgraded.

Regulatory relief. Regulators can help facilitate innovation and implementation of new technologies by enacting regulatory reforms that offer more certainty to entrepreneurs, provide standards for new technology approvals, and shorten the time frame for validation and approval of new technologies for use in Texas.

Infrastructure. Over short and long term planning horizons, water infrastructure must be upgraded to increase efficiencies to reduce cost and distribution losses. This can be accomplished by securing increased public investment in structural upgrades, application of smart technology (software and hardware) in system management, and use of technologies that provide for infrastructure repair and maintenance with minimal invasive construction.

Water use optimization. Challenges to water security that may result from fragmentation in the water industry should be addressed by greater focus on interoperability, balancing use among "competing" users (e.g., agricultural, municipal, industrial), increasing conservation and reuse, and matching quality with intended uses.

Water Sector Roles

There are many people spanning multiple sectors of the economy, and in society in general, involved in addressing water matters in Texas. For most purposes participants believed all sectors share responsibility and must work together to achieve progress in developing and bringing to market new technologies.

Key declarations regarding sector roles:

Research and development sector. Academia and research institutes should serve as independent third-party sources for research and development test beds, and for technology evaluation and validation. There is also a role in this sector to house and support accelerators for commercialization and technology development.

This sector should develop/serve as an independent clearinghouse or virtual repository and distribution center for all Texas water sector information, data, best practices, analytical tools, and technology transfer.

Education of the workforce and development/distribution of public educational materials were described by participants as responsibilities of the academic sector.

Government sector. Government is responsible for safety and regulating the industry, but regulators need to reduce burdensome restrictions on approval of new technologies and speed up the regulatory review processes.

Government should increase funding for research and development and offer incentives for developing new water technologies. Such public investment in water would reduce risks inherent in bringing new technologies to market and difficulties in gaining investment.

The government can also play a larger role in creating a supportive policy framework that facilitates innovation and provides support for bringing technology into the marketplace.

Private sector. The private sector has a large role in investment in new technologies, but can enhance investment opportunities by also playing a role in policy input, support for new creative business models, and regulatory reform. Another role is to support scale-up and validation demonstrations in coordination with the research and development sector.

Utilities. New pricing models should be developed by utilities to better reflect true costs of water and future investments in infrastructure. The public and customers need to be engaged in supporting public investment in water through education about true costs and investments needed for water security.

Utilities can play a role in research and development funding, and technology demonstrations in coordination with the research and development sector. There is also a role in data collection and feeding data into a distribution outlet to share across water sectors.

Multiple sectors. All parties have roles to play in support for funding, encouraging investment, and bringing new water technologies to market and into use. All have shared responsibility to take on the inherent risks of bringing new technology to market. All have a responsibility to contribute data and information, to be shared within and across all water sectors.

Results - Enabling Technologies

This breakout session focused on a discussion of water technologies from the point of view of enabling technologies, including, but not limited to materials, sensors, devices, energy sources, system management, communications, analytical and decision tools, and user behavior modification.

Critical Problems

The most critical problems brought forward by the groups are listed with notes of explanation. These are not presented in any particular order.

Regulations. Some rules and regulations impose undue burdens, impede, and delay bringing new technology to market and into use. This makes the cycle time to develop, demonstrate, and adopt new technologies too long.

Delay. There is a need to decrease the time it takes to bring technology to the market and into use. Participants mentioned unwarranted regulations, delays caused by regulatory processes, need to speed up new technology validation, and reluctance to accept best practices from other states/elsewhere.

Validation. There is a lack of standards for testing and validating technologies, which makes it difficult for water utilities to make decisions to implement technologies. Third-party sources are needed for testing, pilot studies, demonstration, and other means of technology validation. Best practices and validation of technology from elsewhere may be discounted when seeking to apply new technologies in Texas. Problems are exacerbated because of a lack of information sharing.

Valuation. Water is generally undervalued and taken for granted in the minds of consumers. This has created a lack of perspective regarding the need for and cost of innovation. It hampers public investment and risk-taking in development and application of water technologies.

Costs. There are high costs associated with water treatment, purification, disposal, storage, loss, transport, reuse, and security. This, coupled with the relative low value of water makes it difficult to justify capital investments due to extended return on investment.

Capital. Participants described a lack of access to adequate capital and inadequate incentives for innovation and risk-taking in application of new technologies. Water industries were described as risk adverse, with consumers and sometimes water utility principals poorly educated about the advantages of use of new technologies. There is poor understanding of the need to share risks of innovation.

Cooperation. There is need for better cooperation among all water sectors. Lack of cooperation/coordination has resulted in a lack of consistent, uniform, and comprehensive water data. Data are unavailable or nonexistent in some areas of technology development, and a there is a lack of sharing data across the industry.

Education. There is a lack of understanding by the public and consumers about water use and the role of technology. Even water utility board members may have a poor understanding of new technologies.

Priority Solutions and Technologies

Top priorities for solving water problems identified by the groups are listed.

Improve education. There is a critical need for enhanced public and consumer education about water scarcity and consequences to water use and reliability. The public should be better educated about the interdependence of the various water sectors and what the water sector means to the economy and way of life in Texas. Water smart education programs linked to real-time consumer use of water may be an effective way to educate the public and increase water conservation. Public education should also cover value of water and the potential cost-benefits of new technologies. In addition to helping improve implementation of conservation measures, such education should enhance understanding of the benefits of public investment in development and application of new water technologies. Water utility board members may also need similar education on cost-benefits of water technologies and investment benefits.

Accelerate the cycle of research, development, demonstration, and deployment bringing new technology to market and use. Numerous priority solutions were described by participants. Most prominent were accelerating independent third-party testing, pilot projects, and demonstrations needed to validate technology. Among means to accelerate such activities, participants suggested developing sets of industry specific standards, accepting best practices from elsewhere, and reducing regulatory burdens and delays. Faster adoption of new technologies in large scale will enhance access to capital and increase investment. Time for regulatory review may be reduced by fewer people making decisions, creating efficiencies, and reducing costs.

Enhance quality and quantity of data, and access. Through a cooperative institute, clearing house, or virtual network (e.g., "Internet" for water) provide for access to and connectivity with existing data housed at the various water institutes, agencies, and entities in the Texas water sector. In addition, we need to increase the amount of data collected, especially at the water utility level. Available data should include research results, available technologies and IP, pilot study, and demonstration results. To facilitate use of information, data should be provided in a consistently structured and comprehensive format. Extending use of data still further, big data analytics should be employed, with focus on real-time operations, demand modeling, and availability.

Access to capital. Potential investment in new water technologies is hindered by various factors (described elsewhere) that inhibit bringing water technology to market quickly. This leads to uncertainty and added risks in the market and to investors. Actions to develop industry standards and accelerate research, development, demonstration, and deployment of new technology will help gain access to capital and increase investment.

Water use optimization. Continued development and implementation of water smart technologies and education programs will help reduce water consumption and use. Increased water reuse, such as use of gray water and rainwater harvesting should be expanded and supported through bringing new technologies to market. In addition new markets for water residuals should be created, such as beneficial uses of saline waters and brine, gray water, and byproducts from water processing.

Enabling Technologies Priority List

- Technologies that will extend the life of aging infrastructure
- "Big data" analytics, e.g., real-time operations dashboard, demand pattern prediction and management
- Advanced membrane technologies
- More energy efficient and less expensive desalination technologies
- 'Smart' water and conservation technologies, residential and commercial
- Engineered wetlands
- Brine concentrators
- Storage technologies
- Water cooling technology
- Technology to increase water shelf life
- New technology to address water loss
- Improved modeling GIS
- Commercial scale harvesting rain
- LIDAR technology for water
- Sensing technologies
- Stormwater management technologies
- Water conservation technology for agriculture
- Holistically 'smart' homes and businesses. Components within that use water communicate with each other
- Smart meters that ID problems
- Statewide water grid
- "Health monitoring" of water systems
- Technology implementation at small utilities
- In-situ nanotechnologies for leakage

Transformative Technologies List (Game Changers)

- Cost effective desalination
- Global access to available water, i.e., being able to move water from one place to another, anywhere it is needed
- Demand analysis to effectively predict needs and make informed decisions
- Technology validation in a timely and reliable way; common test protocols
- Eliminate monopoly structure of water utilities, including deregulation of water utilities
- Speed up technology to market
- Major change to current culture of investment; change fundamental dynamics of water markets

Water Sector Roles

There are many people spanning multiple sectors of the economy and in society involved in addressing water matters in Texas. For most purposes participants believed all sectors share responsibility and must work together to achieve progress in developing and bringing to market new technologies.

Key declarations regarding sector roles:

Research and development sector. Academia and research institutes should serve as independent third-party sources for technology evaluation and validation.

Government sector. Greater political leadership and will is needed to address water issues. Government needs to reduce burdensome restrictions on development of new technologies and speed up regulatory processes. One way to speed regulatory review is to reduce the number of decision makers required for approvals.
Government should also increase initiatives and incentives for new water technologies, helping reduce risks inherent in bringing new technologies to market and difficulties in gaining investment.

Multiple sectors. All parties have roles to play in bringing water technologies to market and use. All must work to remove silos and increase collaboration and cooperation. Every sector of the industry must help educate and inform the public about water scarcity and the need for advanced technology. All have shared responsibility to take on the inherent risks of bringing new technology to market; risk is not just for investors to assume. In furtherance of reducing risks, all share a role in accelerating the technology implementation cycle by helping reduce impediments to bringing new technologies to market.
Innovators within all sectors drive innovation, but for innovation to be viable in the marketplace it must be allowed to proceed at a more rapid pace.

Results - Predictions & Barriers

Many participants described consequences should Texans fail to take action on critical water problems and implement new technologies. They described barriers to implementation, and they envisioned improvements should the barriers be removed and critical problems solved. Numerous measures of success were also described. Such measures, or metrics, would form the basis for benchmarking progress in a roadmap, constituting items that might be found on a roadmap's "dashboard."

Consequences of Failure to Act

Economy. Leading the list of likely consequences were predictions of dire economic impacts to Texans. These included an increased cost of water, increased cost of water-dependent goods and services, slowing of economic growth in areas with declining availability of water, movement of people out of Texas, reductions in the agriculture economy, and a shift of economic growth to outside of Texas. They also envisioned an overall negative impact on the US economy as a whole due to the current importance of Texas to the national economy.

Public Health. Reduced access to water, impaired waters, and costly water may result in public health impacts as people come into greater contact with contaminated water or are cut off from access to clean water. Poor quality water or low water flows may reduce or eliminate water-related recreational activities in some areas due to health concerns.

Social—Society. Increased costs and reduced access to water could result in civil unrest. In particular, there could be a disproportionally higher impact on people in lower economic brackets. There will be an overall reduction in quality of life for many Texans. At a minimum, there will be increased water use restrictions in many areas of Texas and a likelihood of increased litigation over water access and use.

Environment. Reduced fresh water flows in Texas rivers and streams will result in decreased water quality, reduced biodiversity, loss of production of seafood, and increased environmental problems. Besides the impact on the environment, such conditions will result in increased regulatory compliance issues and potential litigation.

Food security. Reduced water supply will result in reduced food production.

Complete loss of access to water. Some areas may be subject to serious water supply crisis, in particular for lower priority water uses. Groundwater usage in some locations could result in temporary or long-term loss of access to groundwater.

Barriers to Solving Critical Problems

Participants listed a number of barriers. The following appeared to be the most significant. All are constraints on bringing technology to market and into use in Texas. None are limitations on advancements in technology itself.

Regulations. The regulatory framework in Texas creates undue burdens and slows progress in addressing water problems, including application of new technology. There is a lack of common standards for technology development and validation.

Investment -- Investors are risk-averse, leading to inadequate funding, principally due to the length of time it takes to get new technologies to market in the water industry. Infrastructure costs are high relative to cost recovery time frames, making many ventures relatively unattractive to private investors.

Leadership. There is a lack of political leadership/will to overcome the status quo. Leaders are pressured to keep water prices low, maintain a water rights system that may work counter to the Texas public's overall best interest, and accept weak groundwater protection in the face of serious long-term consequences. In general, the water industry has a history of being risk averse. Regulators are slow to adapt.

Reluctance of leaders to take aggressive action plagues the entire water sector. There are no leaders fully trusted to develop and manage cross-cutting, industry-wide approaches to solving water problems and supporting technology innovation. The result is no holistic approach, no significant regulatory relief, no cohesive plan, and no statewide plan accepted by all.

Education. Consumers, the public, and principals of water industry boards and commissions lack an understanding of the costs and benefits of new water technologies in solving Texas' water problems. Consumers, and the public in general, undervalue water. There may be widespread consumer distrust of new technology. The public does not yet understand the full economic and quality-of-life consequences of a failure to address Texas' water problems and the potential benefits of new technologies. This results in a failure of the public to insist on adequate investment and action by political leaders to address basic underlying constraints on innovation and to insist on corrective action.

Collaboration. There is a lack of cooperation and information sharing within and among water sectors. Industry sectors are fragmented. There are many Municipal Utility Districts, water delivery is disjointed, and there is a lack of interoperability. This reduces water security and challenges cooperation.

Benefits of Solving Texas' Water Problems and Implementing New Technologies

Water security. Texas will have a sustainable supply of safe water for all uses, including to support future growth in population and the economy.

Economy. Texas water supplies and delivery systems will support reasonable economic growth, maintaining or increasing Texas' business competitiveness and importance to the national economy.

Public Health. All Texans will continue to have access to an adequate supply of safe water. Texas' public waters will have adequate flows of water that meet clean water standards.

Social-Society. Texas will maintain or enhance quality of life for residents. Through "smart-use" education and technology-driven conservation measures, water will be better allocated among users reducing per capita consumption. Residents in all economic brackets will have access to adequate amounts of safe water

at true market-driven pricing. Education will enhance public understanding of the value/price of water and help drive public investment in water infrastructure, new technologies, and support for removal of barriers to water security.

Environment. Texas' public waters will have adequate flows of water that meet clean water standards, sustain diverse aquatic communities, and maintain production of seafood.

Food security. Agriculture and seafood production will be maintained.

Measures (Metrics) for Bench Marking Progress in Meeting Goals

- Amount and percent of water reuse by area/Texas
- Instream water quality data from standard survey stations
- Amount of rainwater harvested by area/Texas
- Amount of private capital invested
- Economic output per unit of water
- Percent/watersheds compliance with water quality standards by area/Texas
- Number of people reached and changes in attitude with education
- Perception, as measured by standardized survey, of sectors of the public that Texas has having ample water for people and industry
- Chapter in state water plan on technology
- Percent change in consumer conservation rates by area/Texas
- Per capita use of water by area/Texas
- Utility conservation metrics by area/Texas
- Industrial conservation metrics by area/Texas
- Agriculture conservation metrics by area/Texas
- Customer satisfaction rates by utility
- Water supply availability statistics

Closing Plenary Session

Participants reconvened in plenary session following completion of breakout group discussions. First they heard summaries of results of the breakout group discussions (these results were covered in this report in preceding pages). Next they heard Forum facilitator Dr. Jorge Vanegas focus for a moment strictly on information flow, as he described several overarching information-oriented themes that cut across breakout sessions. Immediately before closing Dr. Vanegas asked several questions of the entire group in anticipation of future courses of action.

Information Flow

Several overarching themes in the area of information flow were discussed during breakout sessions that cut across all topic areas and support a consensus in need for taking specific actions.

The breadth of multidisciplinary stakeholders associated with water technologies is wide, representing numerous and different disciplines, institutions, and even nations. These range from governmental institutions and agencies (local, state, and federal), through private sector organizations (including corporations, businesses, and non-governmental organizations) and academic institutions (research, education, and service), to communities. Currently, there are no formal and explicit mechanisms to easily identify them, bring them together, and keep them together, to achieve common goals of interest and benefit to all in the water sectors.

One potential response to this void is the creation of a better means to collaborate, communicate, share information, and otherwise network for mutual benefit. One term commonly used to describe a mechanism to do this is "collaboratory." In our case this could be called a Texas Water Technology Collaboratory.

There is a significant amount of data, of information, of knowledge, of experience, of best practices, and of lessons learned regarding water technologies. But currently, there are no working formal and trusted mechanisms to easily identify, collect, generate, document, organize, archive, and maintain this accumulation of knowledge and experience, providing access to any stakeholder who can benefit.

One potential response to this void is the creation of a virtual network, or cyberinfrastructure for information sharing. This could be called Water Technology Cyberinfrastructure.

Trusted access to a complete continuum of water technology data emerged as a very specific thrust in breakout discussions that merits special attention in numerous areas, including but not limited to the following: (1) data, communications, sharing, applications, best practices, and use of data for planning, execution, and evidence-based decision-making; (2) definition of data types and attributes, and the multiple processes and mechanisms for data collection, and; (3) processes and mechanisms for data analysis, visualization, modeling, and simulation in support of specific desired outcomes.

Better access and sharing of information will facilitate formal and explicit action

within water sectors to reduce the time-to-market and accelerate the research, development, demonstration, deployment, dissemination, and evaluation of water technologies, products, processes, services, and business models, together with enablers (such as access to financing), obstacle removers, and barrier breakers (such as eliminating obsolete laws and regulations, and bureaucratic mazes).

Moving Forward

Four strategic actions to move forward in the immediate aftermath of the forum were presented at the closing plenary. These actions must be considered preliminary and not comprehensive, because the results of discussion during breakout had yet to be fully assembled.

Nonetheless, each action received general consensus support from the participants. Achieving such general objectives and many others will be critical to solving water problems and moving new water technology from laboratory, to market, to application.

Cyberinfrastructure; collaboratory. There is a need to plan, develop, establish, make available, and maintain a formal and trusted virtual network, cyberinfrastructure, collaboratory, or other means to collaborate, share information, and network. Oversight needs to be provided by an objective, neutral, respected, and reliable entity that represents and protects the interests of all stakeholders, including governmental institutions and agencies, private sector organizations, academic institutions, and communities.

Water technology demonstration and pilot project test beds. There is a need to finance, plan, develop, and execute water technology demonstration and pilot projects. These projects will provide a solid foundation for long-term initiatives, programs, projects, activities, and events associated with water technology in the State of Texas.

Water technology asset inventory. There is a need to plan, develop, execute, and maintain a formal, explicit, cohesive, and integrated water technology asset inventory. This information source – inventory -- would identify and document the talent, abilities, skills, and proficiencies embedded within all stakeholders in the development of water technology in Texas.

Mapping of water technologies. There is a need to plan, develop, establish, publish, and maintain a formal, explicit, cohesive, and integrated graphic representation of water technologies in Texas. The elements of this representation, or technology map, should capture and reflect both processes and products, and also, regulatory, engineering, economic, and other perspectives.

Conclusions

Participants in each breakout session, regardless of topic, described almost identical critical problems and priority solutions. There was a similar consensus among participants on consequences of failure to act, barriers to action, and benefits if action was taken.

While the Texas water sectors may be fragmented, there seems to be no lack of general agreement on what is most important to fix and what needs to be done to fix it. New technology will have a role in Texas' water future, but many of the most critical constraints on bringing new technology into play have little to do with questions of technology, science, engineering, or planning. What participants at the forum described needs to be focused on regulatory and financial constraints getting technology to market, dealing with inadequate public investment due to undervaluation of water, coordination and information sharing, validation/demo of technologies, and upgrading an aging infrastructure.

A Dysfunctional System for Innovation

The water arena lacks a functional system supporting innovation. The following characteristics contribute to the situation.

Investors do not well understand and are uncomfortable with the current market environment, including inadequate and inaccurate valuing of water as a commodity, which they see as offering greater risk than many wish to take on. This has created a significant lack of funding to support innovation. Some of the risk is caused by the length of time it takes to bring a new technology to market. This is in part due to the high degree of regulation, not just over public safety concerns with applying new technology, but also across acquisition and supply chain management. There is a lack of well-defined product cycles or pathways to market for innovators to understand and follow. There is also a lack of a market-driven pricing structure providing for anticipation of adequate rates of return to support deployment of efficient technologies (across the board from resource development to data analysis).

Combine all the above with the conservative nature of those needed to implement technology solutions. Then add-in the general feeling that there is considerable fragmentation in the industry, and it's no wonder many believe the environment for investment in water technology in Texas is dysfunctional.

The following lists a compilation of the most uniformly accepted solutions or actions presented by participants:

Access to capital. Potential investment in new water technologies is hindered by various factors that inhibit bringing water technology to market quickly. This leads to uncertainty and added risks in the market and to investors. Actions to develop industry standards and accelerate research, development, demonstration, and deployment of new technology will help gain access to capital and increase investment.

Regulatory relief. Regulators need to be better educated and better understand the reality of compliance in the context of day-to-day operations within the industry. Regulations should allow for testing of new technologies without undue burdens and provide for common sense relief from liability and penalties. Without such relief, demonstration and implementation of many new technologies of benefit to improving water availability and use will be stymied.

Improve education. There is a critical need for enhanced public and consumer education about water scarcity, values of water, and consequences of water use and reliability, including information about the age and condition of current water infrastructure. The public should be better educated about the interdependence of the various water sectors and what the water sector means to the economy and way of life in Texas. Water smart education programs linked to real-time consumer use of water may be an effective way to educate the public and increase water conservation. Public education should also cover value of water and the potential cost-benefits of new technologies. In addition to helping improve implementation of conservation measures, such education should enhance understanding of the benefits of public investment in development and application of new water technologies.

Accelerate the cycle of research, development, demonstration, and deployment bringing new technology to market and use. Numerous priority solutions were described by participants. Most prominent were accelerating independent third-party testing, pilot projects, and demonstrations needed to validate technology. Among means to accelerate such activities, participants suggested developing sets of industry-specific standards, accepting best practices from elsewhere, and reducing regulatory burdens and delays. Faster adoption of new technologies in large scale will enhance access to capital and increase investment. Time for regulatory review may be reduced by fewer people making decisions, creating efficiencies, and reducing costs.

Enhance access to data, and the quality and quantity of data collected. Through a trusted cooperative institute, clearing house, or virtual network (e.g., "Internet" for water) provide for access to and connectivity with existing data housed at the various water institutes, agencies, and entities in the Texas water sector. Universities were described as perhaps best able to support such a service. In addition, there is a need to increase the amount of data collected, especially at the water utility level. Available data should include research results, available technologies and IP, and pilot study and demonstration results. To facilitate use of information, data should be provided in a consistently structured and comprehensive format. Extending use of data still further, big data analytics should be employed, with focus on real-time operations, demand modeling, and availability.

Optimize water use. Continued development and implementation of water smart technologies and education programs will help reduce water consumption and use. Increased water reuse, such as use of gray water and rainwater harvesting should be expanded and supported through bringing new technologies to market. In addition, new markets for water residuals should be created, such as beneficial uses of saline waters and brine, gray water, and byproducts from water processing.

A Race Against Time

A consensus emerged that Texas is rapidly approaching a water crisis reflecting issues of supply, use and quality which demands immediate initiation of efforts to insure sustainable and equitable access.

Participants felt that action now can avert worsening of Texas' water crisis.

If we act now, Texans can have a sustainable supply of safe water for all uses, including to support future growth in population and the economy.

Next Steps

Four strategic actions to support technology development emerged from the forum.

These were development of the following:

- **a cyberinfrastructure or collaboratory for information,**
- **water technology demonstration and pilot project test beds,**
- **a water technology asset inventory, and**
- **mapping of water technologies.**

There were other urgent actions needed in policy and market development that, while critically important, were outside the technology envelope that was the subject of the forum. These included water sector fragmentation, under-valuation of water, water rights, and constraints on investment, such as regulatory process delay.

Many participants agreed to work together to take specific actions. Actions, activities and opportunities for collaboration will be listed, tracked and results reported on the forum website at http://texaswatertech.org/

Consequences of Failure to Act

While participants listed a number of barriers to solving critical problems, the consequences of failing to act now are onerous. Participants said the most damaging constraints on bringing technology to market and into use in Texas were the regulatory framework in Texas that creates undue burdens and a lack of investment, political leadership, education, and collaboration.

Participants predicted dire economic impacts to Texans if no action is taken. These included increasing costs of water affecting the entire economy, a complete loss of fresh water in some areas, affects on public health, civil unrest caused by disparities in access to and cost of water, adverse environmental impacts, and reduction of food production.

Appendices

Appendix I — Forum Participants

Texas Water Technology Roadmap Forum

Participants

James Abbey	Texas A&M University System
Robert Adair	Convergent
Michael Albach	Laguna Water
Troy Allen	TWCA Technology Council
Faisal Amin	Berkeley Research Group
Alan Amor	NASA
Ron Anderson	Lower Colorado River Authority
Ed Archuleta	AccelerateH2O
Jorge Arroyo	
Michael Baran	Isle Utility Technologies
Joe Barrera	University of Texas at Arlington
Jude Benavides	University of Texas at Brownsville
Tony Bennett	USEPA Office of Res. and Dev.
Frank Blaha	Water Research Foundation
Michael Bloom	R.G. Miller Engineers
Chris Boyd	Texas Rural Water Association
Todd Burrer	Association of Water Board Directors
Ken Burris	Enmore
Michael Callahan	NASA
Bill Callegari	
Lucy Camacho	Texas A&M University-Kingsville
Jim Campbell	WaterSmart Software
Adele CardenasMalott	EPA Region 6
Randall Charbeneau	The University of Texas System
James Chew	Nalco
Bella Chu	Texas A&M University-College Station
Luis Cifuentes	Texas A&M University-Corpus Christi
Keith Cole	Water Lens
Adam Conner	San Antonio Water System
Russ Conser	AccelerateH2O
Jim Dublin	Texas Research & Technology Fnd.
Mark Ellison	IDE-Americas
Michael Ewert	NASA
Ali Fares	Prairie View A&M University
Calvin Finch	Texas A&M University
Steven Frayser	STAR Park
David Freed	8 Rivers Capital
Ravi George	Water Environment Research Fnd.
Ronald Green	Southwest Research Institute
Karen Guz	San Antonio Water System
Tom Halbouty	
Bill Hargrove	University of Texas El Paso
Mark Holtzapple	Texas A&M University-College Station
Marta Hudecova	Global Water Intelligence
Bruce Hunter	University of North Texas
Robert Johnson	McManus & Johnson Consulting Engineers
Thomas Kasun	Alcoa
Carey King	University of Texas
Sandeep Kumar	Tech Ranch Austin
Weir Labatt	
Mike Lewis	Southwest Research Institute
Qilin Li	Rice University
Cindy Loeffler	Texas Parks and Wildlife
Erika Mancha	Texas Water Development Board
Carlos Marin	
David Marrs	Valero Energy Corp
Thomas Michalewicz	Bureau of Reclamation
Sean Mitchem	Southwest Research Institute
Ken Mix	Texas State University
Connie Mixon	MYCELX
Julie Nahrgang	Water Environment Assoc. of Texas
John Orr	Exelon Corporation
Roberto Osegueda	University of Texas at El Paso
George Ozuna	US Geological Survey
Tom Papagiannakis	University of Texas at San Antonio
Wesley Patrick	Southwest Research Institute
Jim Polonis	Sutton County Underground Water Con. Dist.
Qin Qian	Lamar University
Steve Raabe	San Antonio River Authority
Chara Ragland	Harte Research Institute, Corpus Christi
Fernando Rico	El Paso Water Utility
Rudy Rosen	Meadows Center for Water and Environment
Andrew Sansom	Meadows Center for Water and Environment
Bridget Scanlon	Bureau of Economic Geology
Richard Seline	AccelerateH2O
Saqib Shirazi	San Antonio Water System
Karen Smith	Texas Comm. Environmental Quality
Eva Steinle-Darling	Carollo Engineers
Aamir Sundrani	
Rebecca Taylor	Shell
Thomas Tunstall	University of Texas at San Antonio
Jessica van der Vooren	Exelon Corporation
Jorge Vanegas	Texas A&M University-College Station
Jim Wall	Texas A&M University-College Station
Cindy Wall	Texas A&M Engineering Experiment Station
Gary Walter	Southwest Research Institute
Kent Wartwick	Layne
TRENT WEBER	MYCELX
Hong Xu	RCN-CE3SAR
Katherine Zodrow	Rice University

Appendix II — Forum Organizers

Forum Chairs

Andrew Sansom – Meadows Center for Water and the Environment, Texas State University

Ed Archuleta – AccelerateH2O

Luis Cifuentes – RCN-CE3SAR and Texas A&M University - Corpus Christi

Forum Host

Athanassios T. Papagiannakis – The Water Institute of Texas, University of Texas at San Antonio

Organizing Committee

Co-Chairs

Rudolph Rosen – Meadows Center for Water and the Environment, Texas State University

Richard Seline – AccelerateH2O

Members

Stephen Frayser – STAR Park, Texas State University

Wesley Patrick – Southwest Research Institute, San Antonio

Cindy Wall – Texas A&M Engineering Experiment Station, College Station

Mona Behl – Sea Grant, Texas A&M University - College Station

Chara Ragland – Harte Research Institute for Gulf of Mexico Studies, Texas A&M University - Corpus Christi

Jude Benavides – University of Texas at Brownsville

Workshop Facilitator

Jorge Vanegas – Dean, College of Architecture, Texas A&M University-College Station and Professor, Texas A&M Engineering Experiment Station

Report Editor and Website Developer

Rudolph Rosen – Meadows Center for Water and the Environment, Texas State University

Appendix III — Agenda

The Forum Agenda & Charrette Activities

UTSA Downtown – Southwest Room, Durango Bldg.
8:00 a.m. – 4:00 p.m. • February 25, 2015

Registration and Breakfast
8: 00 a.m. – 8:45 a.m.

Session 1: "Establishing the Point of Departure for the Forum & Charrette Process"
9:00 a.m. – 9:30 a.m.
Welcome and Introduction to Forum objectives and logistics

- Welcome by sponsors
- Description, Examples and Historical Impact of Technology Roadmaps
- Presentation of the charrette process, scope, and "*Rules of Engagement*"
- Facilitated plenary discussion on, and formal documentation of, *roles*, *drivers*, and *expectations* of the forum participants
  [Input Sheet No. 1]

Move to Breakout Rooms; 9:30 a.m. – 9:45 a.m.
Assembly Rooms, Buena Vista Building

– **Session 2: *"Breakout Group Discussions Round 1"***
9:45 a.m. – 11:15 a.m.
Facilitated Breakout Group Discussions. Participants select their first choice of discussion topics.
[Input Sheet No. 2]

- Breakout Group No. 1: **Sources of Water**
  This breakout group will focus on a discussion of water technologies from a source point of view, including, but not limited to: gray water, brackish/salt water, membrane technologies and materials, energy conservation, energy production...
- Breakout Group No. 2: **Transportation/Delivery of Water**
  This breakout group will focus on a discussion of water technologies from a transportation and delivery point of view, including, but not limited to: monitoring, decision tools, GIS tools, systems...
- Breakout Group No. 3: **Use of Water (Agriculture, Industrial, or Other)**
  This breakout group will focus on a discussion of water technologies from a use point of view, including, but not limited to: resource management, sensors and tools, GIS tools, remote sensing...
- Breakout Group No. 4: **Enabling Technologies**
  This breakout group will focus on a discussion of water technologies from a use point of view, including, but not limited to: materials, sensors/devices, energy source and management, communications, analytical and decision tools, behavior modification...
  – *[Note: Depending on the number of forum participants and their interest in specific topics, additional breakout groups may be formed, as needed]*

***Coffee Break & Networking**; 11:15 a.m. – 11:30 a.m.*

- **Session 3: *"Breakout Group Discussions Round 2"***
  11:30 a.m. – 1:00 p.m.
  Facilitated Breakout Group Discussions. Participants select their second choice of discussion topics.
  [Input Sheet No. 3]
  - Breakout Group No. 1: **Sources of Water**
    This breakout group will focus on a discussion of water technologies from a source point of view...
  - Breakout Group No. 2: **Transportation/Delivery of Water**
    This breakout group will focus on a discussion of water technologies from a transportation and delivery points of view...
  - Breakout Group No. 3: **Use of Water (Agriculture, Industrial, or Other)**
    This breakout group will focus on a discussion of water technologies from a use point of view...
  - Breakout Group No. 4: **Enabling Technologies**
    This breakout group will focus on a discussion of water technologies from a use point of view...
    - *[Note: Depending on the number of forum participants and their interest in specific topics, additional brealout groups may be formed, as needed.*

***Box Lunch Break & Networking**; 1:00 p.m. – 1:30 p.m.*

***Return from Breakout Rooms**; 1:30 p.m. – 1:45 p.m.*

- **Session 4A: *"Plenary Presentations on Breakout Group Discussions Round 1"***
  1:45 p.m. – 2:30 p.m.
  Each Breakout Group will present the highlights of their discussions in Round 1 to all participants in the forum [7 minutes + 3 minutes Q&A each, strictly timed; length will be adjusted if there are more than four breakout groups]
- **Session 4B: *"Plenary Presentations on Breakout Group Discussions Round 2"***
  2:30 p.m. – 3:15 p.m.
  Each Breakout Group will present the highlights of their discussions in Round 2 to all participants in the forum [7 minutes + 3 minutes Q&A each, strictly timed; length will be adjusted if there are more than four breakout groups]

***Coffee Break & Networking**; 3:15 p.m. – 3:30 p.m. (*

- **Session 5: *"The Path Ahead"***
  3:30 p.m. – 4:00 p.m.
  Facilitated plenary discussion on, and formal documentation of, a preliminary consensus among forum participants on the content of the presentations done in Session 4A and 4B.
  [Input Sheet No. 4]

***Adjourn for the Day** at 4:00 p.m.*
[Input Sheet No. 5]

Appendix IV — Input Sheets

Texas Water Technology Roadmap Forum

Input Sheets

Please take time before the Forum to answer the following questions and complete the input sheets

The following input sheets are for you to organize your thoughts prior to the forum. Each set of sheets corresponds to a charrette session listed on the agenda. Completing these input sheets ahead of time will allow you to participate most fully in the charrette. This input provides the basis of our discussions during the charrette and the successful completion of each session.

At the end of the forum we will collect the sheets to ensure your ideas are incorporated into the final forum product.

Please bring completed sheets with you to the Forum

Name

Organization

CHARRETTE INPUT SHEET NO. 1:
Documenting Hats, Drivers, Expectations, and Initial Baselines

What "Hats" are you wearing today?
Please list all the different "***hats***" that you are wearing today for this forum. In other words, what ***roles*** will you play, what ***perspectives*** will you have, and/or what ***points of view*** will you represent, toward the topics that will be addressed at this forum?

What "Drivers" brought you here today?
Please list all the different "***drivers***" that brought you here today for this forum. In other words, what ***prompted*** or ***motivated*** you to attend this forum?

What "Expectations" do you have for this forum?
Please list all the different ***expectations*** you have for this forum. In other words, what specific ***outcomes*** or ***results*** do you want to accomplish that will make you satisfied or happy that you participated?

I Like, Like…

Please take a moment to tell us what do you ***like*** most about the potential development of a ***Texas Water Technologies Roadmap***. What do you like about it from your individual personal point of view? What do you like about it from your professional point of view? What do you like about it from the point of view of the organization you represent?

"Genie Wishes" (Aspirations)

If you had a *"**Genie in a Bottle**,"* what ***wishes at broad or specific levels would you make***, if you could, to ensure the full development of a ***Texas Water Technologies Roadmap***? What would you wish from your individual personal point of view? What would you wish from your professional point of view? What would you wish from the point of view of the organization you represent?

"Magic Wand" (Changes)

If you had *"**Harry Potter's Magic Wand**,"* what ***changes at broad or specific levels would you make***, if you could, to ensure the full development of a ***Texas Water Technologies Roadmap***? What would you change from your professional point of view? What would you wish from the point of view of the organization you represent?

CHARRETTE INPUT SHEET NO. 2:
Input Sheet for Breakout Group Discussions Round 1

Breakout Group Discussion Topic (Please check one)

- ◯ Sources of Water
- ◯ Use of Water (Agriculture, Industrial, and Other)
- ◯ Transportation/Delivery of Water
- ◯ Enabling Technologies

EXISTING TECHNOLOGIES

Please list as many ideas, suggestions, and recommendations as you can for the types of ***existing technologies*** related to this Breakout Group Discussion Topic that should be included within the development of a potential ***Texas Water Technologies Roadmap*** (***TWTR***).

EMERGING TECHNOLOGIES

Please list as many ideas, suggestions, and recommendations as you can for the types of ***emerging technologies*** related to this Breakout Group Discussion Topic that should be included within the development of a potential ***TWTR***.

BREAKTHROUGH, REVOLUTIONARY, AND DISRUPTIVE TECHNOLOGIES

Please list as many ideas, suggestions, and recommendations as you can for the types of ***breakthrough, revolutionary, and disruptive technologies*** related to this Breakout Group Discussion Topic that should be included within the development of a potential ***TWTR***.

QUESTIONS that a possible Texas Water Technologies Roadmap (TWTR) might ANSWER

Please list as many ideas, suggestions, and recommendations as you can for the types of ***questions*** that you would like to see addressed by the roadmap.

PROBLEMS that a possible TWTR might attempt to SOLVE

Please list as many ideas, suggestions, and recommendations as you can for the types of ***problems*** that you would like to see addressed by the roadmap.

NEEDS that a possible TWTR might attempt to SATISFY

Please list as many ideas, suggestions, and recommendations as you can for the types of ***needs*** that you would like to see addressed by the roadmap.

OPPORTUNITIES that a possible TWTR might attempt to REALIZE?
Please list as many ideas, suggestions, and recommendations as you can for the types of ***opportunities*** that you would like to see addressed by the roadmap.

ASPIRATIONS that a possible TWTR might attempt to FULFILL?
Please list as many ideas, suggestions, and recommendations as you can for the types of ***aspirations*** that you would like to see addressed by the roadmap.

OTHER ISSUES
Please list as many ideas, suggestions, and recommendations as you can for any ***other issues*** that you would like to see addressed by the roadmap.

CHARRETTE INPUT SHEET NO. 3:
Input Sheet for Breakout Group Discussions Round 2

Breakout Group Discussion Topic (Please check one)

- ◯ Sources of Water
- ◯ Use of Water (Agriculture, Industrial, and Other)
- ◯ Transportation/Delivery of Water
- ◯ Enabling Technologies

EXISTING TECHNOLOGIES

Please list as many ideas, suggestions, and recommendations as you can for the types of ***existing technologies*** related to this Breakout Group Discussion Topic that should be included within the development of a potential ***Texas Water Technologies Roadmap*** (***TWTR***).

EMERGING TECHNOLOGIES

Please list as many ideas, suggestions, and recommendations as you can for the types of ***emerging technologies*** related to this Breakout Group Discussion Topic that should be included within the development of a potential ***TWTR***.

BREAKTHROUGH, REVOLUTIONARY, AND DISRUPTIVE TECHNOLOGIES

Please list as many ideas, suggestions, and recommendations as you can for the types of ***breakthrough, revolutionary, and disruptive technologies*** related to this Breakout Group Discussion Topic that should be included within the development of a potential ***TWTR***.

QUESTIONS that a possible Texas Water Technologies Roadmap (TWTR) might ANSWER

Please list as many ideas, suggestions, and recommendations as you can for the types of ***questions*** that you would like to see addressed by the roadmap.

PROBLEMS that a possible TWTR might attempt to SOLVE

Please list as many ideas, suggestions, and recommendations as you can for the types of ***problems*** that you would like to see addressed by the roadmap.

NEEDS that a possible TWTR might attempt to SATISFY

Please list as many ideas, suggestions, and recommendations as you can for the types of ***needs*** that you would like to see addressed by the roadmap.

OPPORTUNITIES that a possible TWTR might attempt to REALIZE?

Please list as many ideas, suggestions, and recommendations as you can for the types of ***opportunities*** that you would like to see addressed by the roadmap.

ASPIRATIONS that a possible TWTR might attempt to FULFILL?

Please list as many ideas, suggestions, and recommendations as you can for the types of ***aspirations*** that you would like to see addressed by the roadmap.

OTHER ISSUES

Please list as many ideas, suggestions, and recommendations as you can for any ***other issues*** that you would like to see addressed by the roadmap.

CHARRETTE INPUT SHEET NO. 4:
Developing a Plan of Action

A. Elevator Pitch

Based on the discussions today, how could/would you describe succinctly the ***value/benefit*** of developing a ***TWTR***, and what could/would be its ***strategic importance*** for the State of Texas?

B. Strategic Goal (i.e., *What to do*…)

Please establish a set of ***general strategic goals***, which will enable the development of a potential ***TWTR***. Each goal established should define the tactical objectives and a preliminary operational plan of action:

Brief description of a **strategic goal**

C. Associated Tactical Objectives and Preliminary Operational Plans of Action (i.e., *How to do it and with what…*)

For each general strategic goal defined in B, above, please list the principal *specific tactical objectives* required to achieve it. Each tactical objective established should define the following elements:

Brief description of a **tactical objective**

What needs to be done to achieve the objective (i.e., specific *tasks*)?

Why (i.e., *justification* of these tasks)?

How (i.e., *procedures/methods* to be followed)?

Who (i.e., *responsibility* for execution of the tasks)?

With What (i.e., *resources* required to complete the tasks)?

When (i.e., target *date for completion* of the tasks)?

Where (i.e., *location* for the execution of the tasks)?

Metrics (i.e., how will *progress* be measured)?

Assumptions and Expectations

Please list any *assumptions*, and any *expectations* associated with the strategic goal and this tactical objective.

Assumptions:

Expectations:

Wants, Needs, Do's, and Don'ts

Please list any *wants* and *needs*, and any *do's* and *don'ts* associated with the strategic goal and this tactical objective.

Wants:

Needs:

Do's:

Don'ts:

[Note: Repeat steps B & C, as needed, for additional strategic goals and tactical objectives.]

D. Commitments

To ensure achieving the plan of action for the development of a potential ***TWTR***, define the commitments that need to be made.

Personal Commitments

Please list at least one specific *individual commitment* to the development of a potential ***TWTR***, which you are willing to make from a personal point of view.

Institutional Commitment

Please list at least one specific *institutional commitment* to the development of a potential ***TWTR***, which you are willing to make from an institutional point of view (i.e., the organization you represent).

Commitment from Others

Please list at least one *specific commitment* to the development of a potential ***TWTR***, which you would like to see from other individuals or organizations. Please name the individual or the organization, if any, that you would like to see make the commitment.

CHARRETTE INPUT SHEET NO. 5:
Reflections on, and Assessment of, the Forum

"Bugs"
Please list anything presented and/or discussed at this forum that may still *bothers and/or annoys you*.

"Rants"
Please list anything presented and/or discussed at this forum that *you hate* (i.e., *really do not like at all*).

"Raves"
Please list anything presented and/or discussed at this forum that *you love* (i.e., *really like a lot*).

"HUH...?'s"

Please list any *muddy points* (i.e., anything that may not be clear) and/or specific questions that might have been generated by the topics presented and discussed at this forum for which you would like to find an answer.

"AHA...!'s"

Please list any specific *insights*, *revelations*, or *lessons learned* that might have been generated by the topics presented and discussed at this forum, which you will take away with you.

Grade

On a scale of 1 to 10, with 1 being the worst and 10 being the best, what grade would you give to this forum?

Worst ***Best***

1 2 3 4 5 6 7 8 9 10

Perfection

If the grade you gave is not 10, what could/should/might/must be done to make it a 10?

Appendix V — Pre-Forum Background

Texas Water Technology Roadmap Forum

A Water Technology Roadmap Forum Facilitated through an Interdisciplinary and Multi-Stakeholder "Charrette"

Organized by:

The Meadows Center for Water and the Environment &
STAR Park at Texas State University

AccelerateH2O – Texas Water Technology Accelerator

The Water Institute of Texas

and

The National Science Foundation Research Coordination Network on Climate, Energy, Environment and Engagement in Semiarid Regions

Underwriting Sponsor

The Wells Fargo Foundation

Co-Sponsors

The Meadows Foundation
The Texas Research and Technology Foundation

Location and Date:

The University of Texas at San Antonio (UTSA) – Downtown Campus
Durango Building, Southwest Room
501 West Cesar Chavez Blvd., San Antonio, TX 78207
Parking: Lot D3

Coffee - registration - networking: 8:00 AM to 8:45 AM
Forum: 9:00 AM to 4:00 PM

February 25, 2015

Overview of the Roadmap Forum

Sponsors

This one day forum – to be conducted through a facilitated charrette - is underwritten by the Wells Fargo Foundation, and co-sponsored by the Meadows Foundation, and the Texas Research and Technology Foundation. The Forum is convened by The Meadows Center for Water and Environment and STAR Park at Texas State University, AccelerateH2O – the Texas Water Technology Accelerator, the Water Institute of Texas, and the National Science Foundation funded Research Coordination Network of Texas universities and institutes on climate, energy, environment and engagement in semiarid regions (RCN-CE3SAR).

Goals and Objectives

The main goal of the Forum is to prioritize and frame key milestones for a bold plan to initiate a "*Texas Water Technology Roadmap*" and a subsequent strategy on a "*Pathway to Commercialization,*" which will help guide Texas toward global leadership in water technology. To achieve these goals, the Forum brings together, by invitation only, individuals from diverse technical and business backgrounds in water. These individuals are interested in accelerating growth of Texas' water technologies, industries, and sustainable water use. They represent Texas' leading water, industry, and economic development associations; residential, industrial, and agricultural organizations; university research centers and other Texas research institutes; and non-profit centers of excellence. An explicit intent of this forum is to complement, supplement, strengthen, enhance, and extend the work, efforts, and accomplishments of these key stakeholders, and to offer a collaborative model and mutually beneficial solutions. Three objectives guide the Forum:

- To generate the first-ever Texas Water Technology Roadmap that will position the State to become a global water technology hub.
- To define a specific process to more effectively link research, expertise, facilities and programs, addressing our current challenges and long-term competitiveness.
- To form "innovation teams" within a virtual "collaboratory" that crosses disciplines, campuses, networks, and resources to implement recommendations and support vital roadmap activities.

Rationale

Why does Texas need a roadmap? While many efforts to address Texas' water matters have been undertaken, largely missing from the dialogue has been the creation of statewide and regional technology roadmaps. This "map" can be viewed as a tool to match goals with specific technology solutions, often including tactics, activities, and investments supporting current and future competitiveness and technology development. Texans have used such roadmaps in the past to attain global leadership in energy and agriculture, in transistors and microprocessors, and in life sciences and semiconductors. In short, a technology roadmap will show Texans the many connections and specific routes to sustainable water use, innovation, accelerated commercialization, and economic competitiveness.

Framework

The Forum builds upon recent work by AccelerateH2O, which, in cooperation with others, has worked to identify critical technical needs for water technology in Texas, finding significant opportunities for innovation and commercialization, in areas such as desalination, reuse, conservation, and 'smart-water' technologies (sensors, monitors, data analytics). The Forum will (1) further focus/refine technology needs and targets, (2) define the current scientific and technical capacity of the State's centers of research (i.e., academia, industry, non-profit) to address these needs, (3) provide a point of departure for the process of building a water technology roadmap for Texas, and (4) emphasize market-based and innovation-driven outcomes.

The topic of "water" has many dimensions, as is displayed in Figure 1. Therefore the overall topic is framed within a broad context that reflects the world we live in today and is influenced by "Volatility, Uncertainty, Complexity, and Ambiguity" (VUCA).

Water challenge dimensions, such as - economics, politics, social factors, protecting the environment, technologies, laws, policies and regulations, are all interconnected, interrelated, and interdependent. Add multiple stakeholders with multidisciplinary backgrounds, add multi-institutional and even multinational audiences, and water soon becomes a very complex topic.

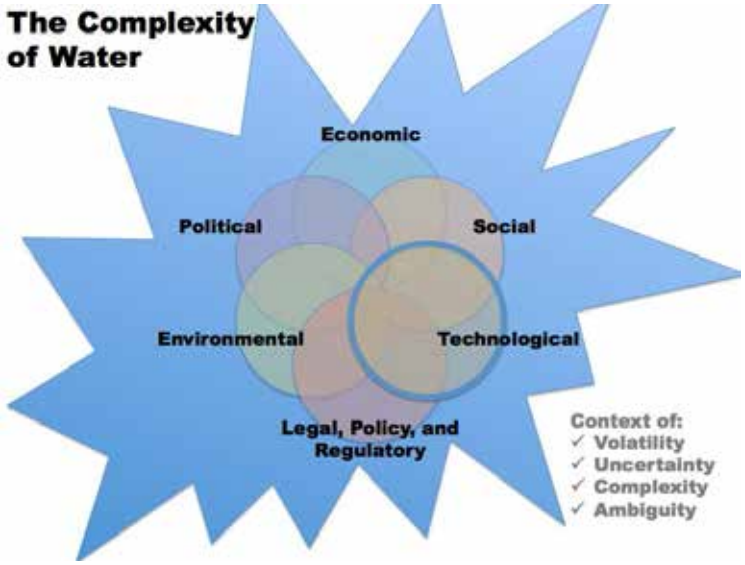


Figure 1. The General Context for the Charrette

Addressing this context and all of these dimensions is completely outside the scope of the Forum and facilitated charrette. Consequently, the focus of the Forum is on one area: **the technology dimension of water**, as shown in Figure 2.

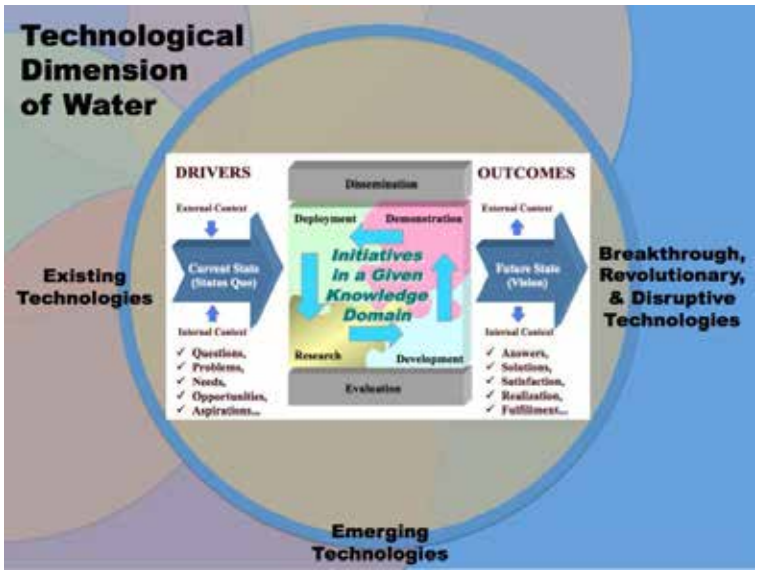


Figure 2. The Framework for the Charrette

A goal of the Forum - and instruction to facilitators - is to structure the discussions among participants around the identification, organization, and documentation of data, information, knowledge (as expressed in best practices), experience (as expressed in lessons learned), and wisdom across a broad continuum. Discussion will focus on the following:

(1) An initial set of existing technologies that define the status quo, together with a baseline of questions that have not been answered, problems that have not been solved, needs that have not been satisfied, opportunities that have not been realized, and aspirations that have not been fulfilled.

(2) A set of next-generation emerging technologies resulting from research that leads to development, development that leads to demonstration, demonstration that leads to deployment, and deployment that leads back to research, while continuously conducting dissemination and constant evaluation.

(3) A final set of breakthrough, revolutionary, and disruptive technologies that define a vision of the future state of outcomes composed of answers to the questions, solutions to the problems, satisfaction of the needs, realization of the opportunities, and fulfillment of the aspirations.

Process

The Forum will be facilitated using a **charrette** process. This will be an intensive workshop involving people working together under compressed deadlines. Charrettes are commonly used in urban planning and architecture. They provide for an interactive pace in which a diverse group of stakeholders, representing pluridisciplinary perspectives (i.e., multi-, inter-, cross-, and trans-disciplinary) on a given topic, come together and follow a rigorous, facilitated vision-driven process to achieve established outcome-oriented goals and objectives.

Charrettes are especially suited to encouraging discussions that go beyond conventional thinking, and that stretch the envelope of the status quo into the realm of new possibilities. They also are an effective means to initiate collaboration among a diverse group of parties with common interests. The charrette process combines techniques often referred to as brainstorming. The charrette provides for divergent, lateral, provocative, and convergent thinking. Charrettes allow ideas to flow in an open way, each new thought building upon the suggestions of all participants, while capturing key ideas of the discussion, and creating lists, issue maps, and diagrams. These all help charrette participants to visualize alternatives and to discuss and evaluate best choices.

The Dean of the College of Architecture at Texas A&M University, Dr. Jorge Vanegas, will lead the charrette. Dr. Vanegas is well-known for his facilitation skills and is providing support to the Forum through, RCN-CE3SAR, where he is a member of the Steering Committee.

To begin, participants will examine the most critical issues facing residential, commercial, agricultural, and utility-based water interests. Participants will focus on aspects of these issues that can be addressed through technology innovation and market-driven solutions.

Moving from a generalized discussion to a more specific level of the scientific and technical, participants will prioritize urgent and near-term needs and gaps from an end-user, market perspective.

Based on this framing of issues, participants will work in smaller cross-function groups of the research and IP development communities, and demand side of technology (such as suppliers, industry, and utility representatives). These groups will define scenarios for collaboration, coordination, and alignment of immediate opportunities (proof of concept, pilot projects, demonstration and validation).

A final full-group session will create an initial list of ‘targets of opportunity’ for which participants will be asked to continue their discussion, engagement, and partnership in a post-forum process.

Post-Forum Activities

Following the Forum, information collected during the course of the day will be used to begin drafting the roadmap.

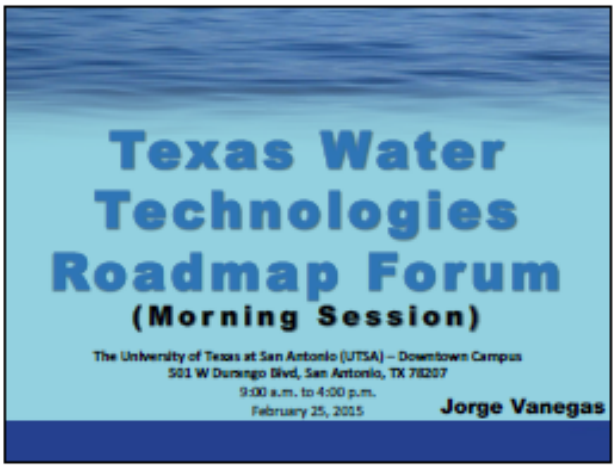
The facilitator, members of the Forum planning committee, and any volunteers from among the participants will assist in developing the initial draft roadmap document of findings and recommendations. A final report and associated briefing on Forum results will be disseminated among all participants, and will contain:

- An initial **plan of action** for completing an initial version of the water technology roadmap for Texas, based on the results of the Forum and subsequent discussions;
- A collective **consensus** of (1) baseline information; (2) vision and anticipated desired outcomes; (3) possible pathways on how to move between the baseline and desired outcomes; (4) indicators, metrics, benchmarks, and assessment mechanisms, and; (5) potential challenges.
- An **inventory of assets**, which identifies existing talent, infrastructure (data, information, knowledge, experience, resources, tools, etc.), and capacity that can be leveraged collaboratively and immediately to further develop the water technology roadmap.

May 1, 2015 is the target date to have a completed version of the Texas Water Technology Roadmap, though it need be understood that this will be an ongoing and iterative process, where updates and new priorities will emerge over time.

Appendix VI-Forum Presentation Graphics

Forum facilitator Dr. Jorge Vanegas presented information and introduced forum hosts, speakers and session facilitators. This appendix displays presentation graphics used by Dr. Vanegas.


Texas Water Technologies Roadmap Forum
(Morning Session)
The University of Texas at San Antonio (UTSA) – Downtown Campus
501 W Durango Blvd, San Antonio, TX 78207
9:00 a.m. to 4:00 p.m.
February 25, 2015
Jorge Vanegas


Organized by:
The Meadows Center for Water and the Environment &
STAR Park at Texas State University
AccelerateH2O – Texas Water Technology Accelerator
The Water Institute of Texas
and
The National Science Foundation (NSF) Funded Research Coordination Network (RCN) on Climate, Energy, Environment and Engagement in Semiarid Regions (CE3SAR)
Underwriting Sponsor:
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The Texas Research and Technology Foundation
RCN CE3SAR
Location:
The University of Texas at San Antonio (UTSA) – Downtown Campus
Texas Water Tech Roadmap Forum


Organized by:
Underwriting Sponsor
Co-Sponsors
Location
Texas Water Tech Roadmap Forum


A Short Welcome by our Sponsors
Texas Water Tech Roadmap Forum


Tom Papagiannakis
Ed Archuleta
Luis Cifuentes
Andrew Sansom


A Short Description, Examples and Historical Impact of Technology Roadmaps
Texas Water Tech Roadmap Forum

A short presentation by Andrew Sansom

Charrette Process, Scope, and Rules of Engagement

Jorge Vanegas

Texas Water Tech Roadmap Forum

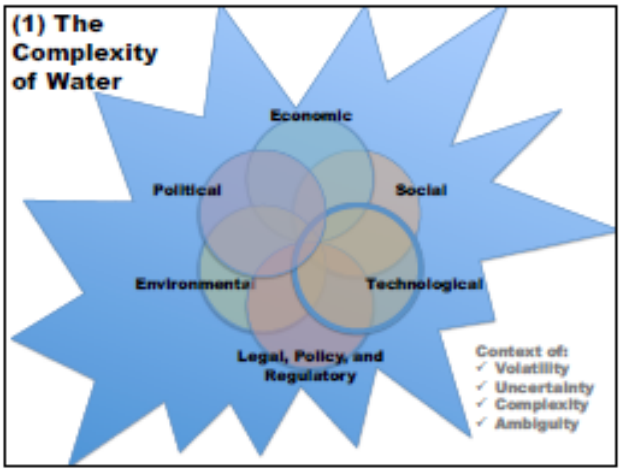
Process

Texas Water Tech Roadmap Forum

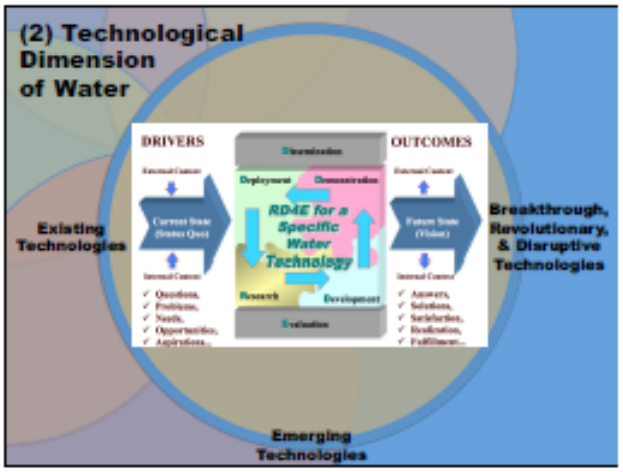
The process for this forum begins with two points of departure...

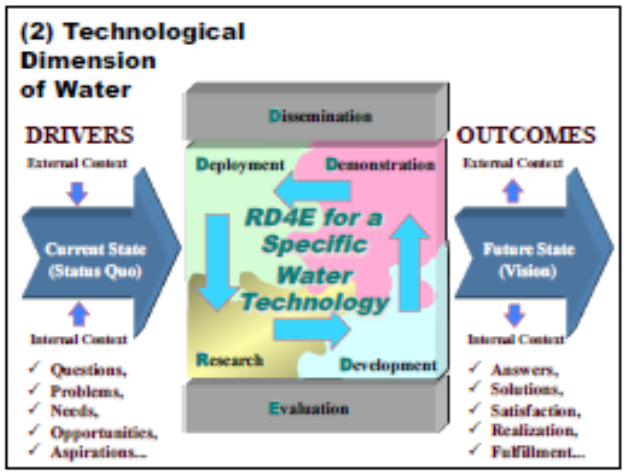
Texas Water Tech Roadmap Forum

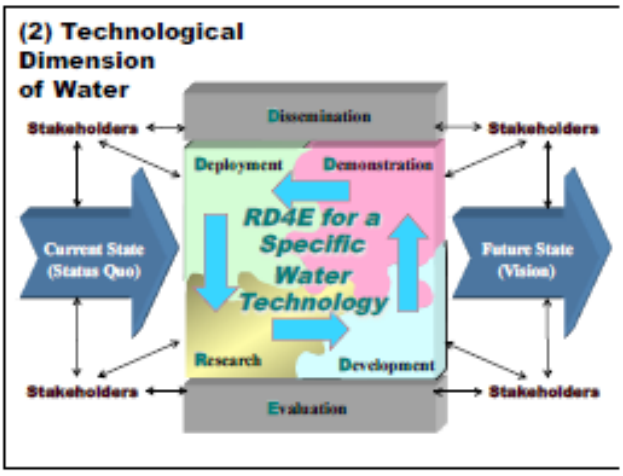
(1) The Complexity of Water

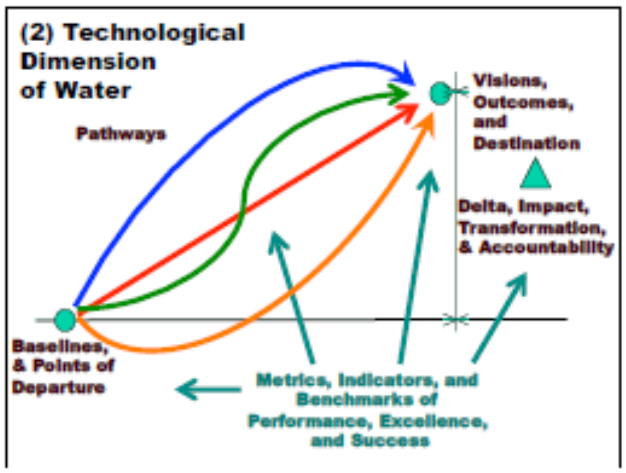


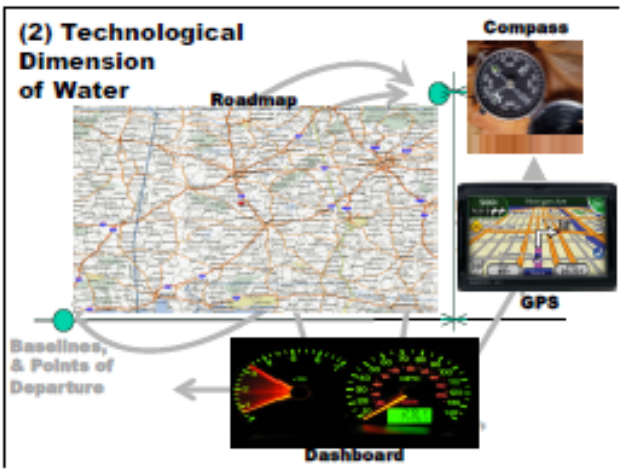
(2) Technological Dimension of Water

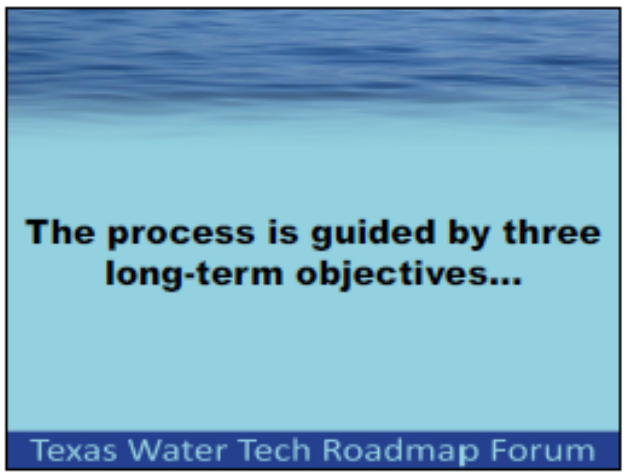












Long-term Forum Objectives

- To **generate the first-ever Texas Water Technology Roadmap** that will position the State to become a global water technology hub
- To **define a specific process to more effectively link research, expertise, facilities and programs**, addressing our current challenges and long-term competitiveness
- To **form "innovation teams" within a virtual "collaboratory"** that crosses disciplines, campuses, networks, and resources to implement recommendations and support vital roadmap activities.

In setting a foundation to achieve these long-term goals, the Forum will focus on four overarching types of water technologies...

Texas Water Tech Roadmap Forum

Water Technologies Focus Areas

- Breakout Group No. 1: **Sources of Water**
  *(Facilitated by **Wesley Patrick**)*
  This breakout group will focus on a discussion of water technologies from a source point of view, including, but not limited to: gray water, brackish/salt water, membrane technologies and materials, energy conservation, energy production...
- Breakout Group No. 2: **Transportation/Delivery of Water**
  *(Facilitated by **Chara Ragland**)*
  This breakout group will focus on a discussion of water technologies from a transportation and delivery point of view, including, but not limited to: monitoring, decision tools, GIS tools, systems...

Water Technologies Focus Areas

- Breakout Group No. 3: **Use of Water (Agriculture, Industrial, or Other)**
  *(Facilitated by **Stephen Frayser**)*
  This breakout group will focus on a discussion of water technologies from a use point of view, including, but not limited to: resource management, sensors and tools, GIS tools, remote sensing...
- Breakout Group No. 4: **Enabling Technologies**
  *(Facilitated by **Cindy Wall**)*
  This breakout group will focus on a discussion of water technologies from a use point of view, including, but not limited to: materials, sensors/devices, energy source and management, communications, analytical and decision tools, behavior modification...

To address these types of water technologies, the Breakout Groups will focus the discussions on a set of guiding questions...

Texas Water Tech Roadmap Forum

Guiding Discussion Questions

- What are the **problems we are seeking to solve** through the development-to-deployment of water technology? What are the **goals for a water technology road map**?
- Can we reach **consensus on the most critical priorities for Texas** the next 12-24 months, the next 3-5 years, the next decade related to using technology, innovation to solve water challenges?
- **What will happen** if we solve these problems? If we do not?

Guiding Discussion Questions

- What is the **role of state government** (agencies, programs, etc.), what is the **role of the academic institutions**, what is the **role of the water entities**, what is the **role of industry, innovators, entrepreneurs** – all in solving these problems?
- Are there more **transformative, large-scale issues** that supersede these problems? i.e., Are there any **big issues** that, if addressed, would solve or at least make it easier to solve these problems?

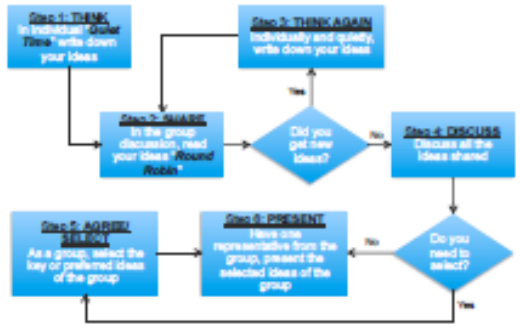
Guiding Discussion Questions

- What is the **strategic vision, the framework, and the model(s)** for applying technology to solve these problems? Simply – what is the **best approach to implementing a technology road map**?
- What are the **barriers, limitations, perceptions** that prevent us solving these problems? What are the **biggest hurdles** to solving these problems?
- How do we **measure success**, what **metrics** do we want or need to assign, is there a **timeframe**?
- What **necessary resources** are required to accomplish the road map goals? What exist, does not exist?

"Rules of Engagement"

Texas Water Tech Roadmap Forum

TSD(AS)P Process



And within this process...

Agenda

Texas Water Tech Roadmap Forum

Agenda

Session 1: "Establishing the Point of Departure for the Forum & Charrette Process"
9:00 a.m. – 9:30 a.m. (30 minutes)
Welcome and Introduction to Forum objectives and logistics

- Welcome by sponsors
- Description, Examples and Historical Impact of Technology Roadmaps
- Presentation of the charrette process, scope, and "*Rules of Engagement*"
- Facilitated plenary discussion on, and formal documentation of, *rules*, *drivers*, and *expectations* of the forum participants *[Input Sheet No. 1]*

Move to Breakout Rooms; 9:30 a.m. – 9:45 a.m. (15 minutes)
Assembly Rooms, Buena Vista Building

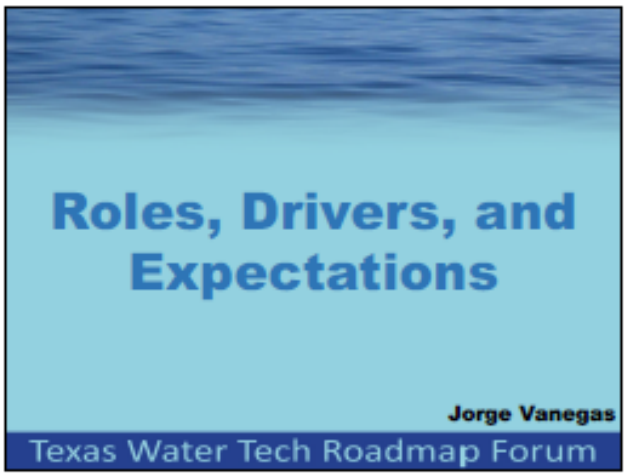
Texas Water Tech Roadmap Forum


Agenda
- Session 2: "Breakout Group Discussions Round 1"
9:45 a.m. – 11:15 a.m. (90 minutes)
Facilitated Breakout Group Discussions. Participants select their first choice of discussion topics. [Input Sheet No. 2]
o Breakout Group No. 1: Sources of Water
o Room: _____
o Breakout Group No. 2: Transportation/Delivery of Water
o Room: _____
o Breakout Group No. 3: Use of Water (Agriculture, Industrial, or Other)
o Room: _____
o Breakout Group No. 4: Enabling Technologies
o Room: _____
Coffee Break & Networking: 11:15 a.m. – 11:30 a.m. (15 minutes)
Texas Water Tech Roadmap Forum


Agenda
- Session 3: "Breakout Group Discussions Round 2"
11:30 a.m. – 1:00 p.m. (90 minutes)
Facilitated Breakout Group Discussions. Participants select their first choice of discussion topics. [Input Sheet No. 3]
o Breakout Group No. 1: Sources of Water
o Room: _____
o Breakout Group No. 2: Transportation/Delivery of Water
o Room: _____
o Breakout Group No. 3: Use of Water (Agriculture, Industrial, or Other)
o Room: _____
o Breakout Group No. 4: Enabling Technologies
o Room: _____
Box Lunch Break & Networking: 1:00 p.m. – 1:30 p.m. (30 minutes)
Return from Breakout Rooms: 1:30 p.m. – 1:45 p.m. (15 minutes)
Texas Water Tech Roadmap Forum


Agenda
- Session 4A: "Plenary Presentations on Breakout Group Discussions Round 1"
1:45 p.m. – 2:30 p.m. (45 minutes)
Each Breakout Group will present the highlights of their discussions in Round 1 to all participants in the forum [7 minutes + 3 minutes Q&A each, strictly timed; length will be adjusted if there are more than four breakout groups]
- Session 4B: "Plenary Presentations on Breakout Group Discussions Round 2"
2:30 p.m. – 3:15 p.m. (45 minutes)
Each Breakout Group will present the highlights of their discussions in Round 2 to all participants in the forum [7 minutes + 3 minutes Q&A each, strictly timed; length will be adjusted if there are more than four breakout groups]
Coffee Break & Networking: 3:15 p.m. – 3:30 p.m. (15 minutes)
Texas Water Tech Roadmap Forum

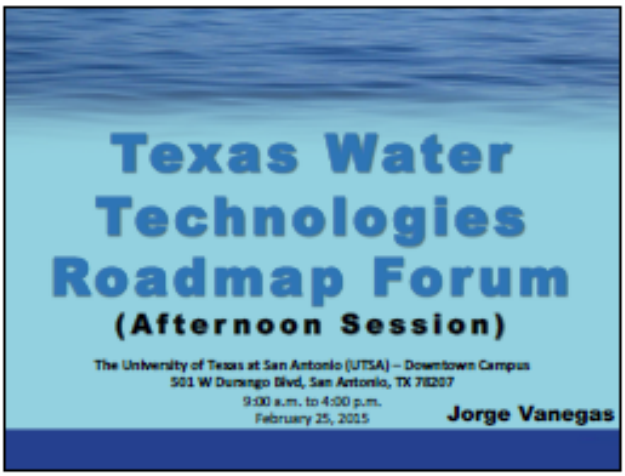

Agenda
- Session 5: "The Path Ahead"
3:30 p.m. – 4:00 p.m. (30 minutes)
Facilitated plenary discussion on, and formal documentation of, a preliminary consensus among forum participants on the content of the presentations done in Session 4A and 4B. [Input Sheet No. 4]
Adjourn for the Day at 4:00 p.m.
[Input Sheet No. 5]
Thank you.
Texas Water Tech Roadmap Forum


Roles, Drivers, and Expectations
Jorge Vanegas
Texas Water Tech Roadmap Forum


Roles
Texas Water Tech Roadmap Forum

You can expect five specific takeaways…

- Your completed **input sheets** prepared before, during, and/or after the Forum, which will be shared with all
- What you contribute to the discussions in the **breakout groups**, and what you listen/learn from others
- What you listen/learn from the plenary **summaries of breakout discussions**
- What you contribute to the **final plenary discussion on the "Path Ahead"**, and what you listen/learn from others
- The **post-forum report**, which will be shared with all



Focus Areas Presentations

Breakout Group No. 1:

Sources of Water

*(Facilitated by **Wesley Patrick**)*

[7 minutes + 3 minutes Q&A each

Focus Areas Presentations

Breakout Group No. 2:

Transportation/Delivery of Water

*(Facilitated by **Chara Ragland**)*

Focus Areas Presentations

Breakout Group No. 3:

Use of Water
(Agriculture, Industrial, or Other)

*(Facilitated by **Stephen Frayser**)*

Focus Areas Presentations

Breakout Group No. 4:

Enabling Technologies

*(Facilitated by **Cindy Wall**)*

Focus Areas Presentations

Breakout Group No. 1:

Sources of Water

*(Facilitated by **Wesley Patrick**)*

Focus Areas Presentations

Breakout Group No. 2:

Transportation/Delivery of Water

*(Facilitated by **Chara Ragland**)*

Focus Areas Presentations

Breakout Group No. 3:

Use of Water
(Agriculture, Industrial, or Other)

*(Facilitated by **Stephen Frayser**)*

Focus Areas Presentations

Breakout Group No. 4:

Enabling Technologies

*(Facilitated by **Cindy Wall**)*

Short Stretch Break

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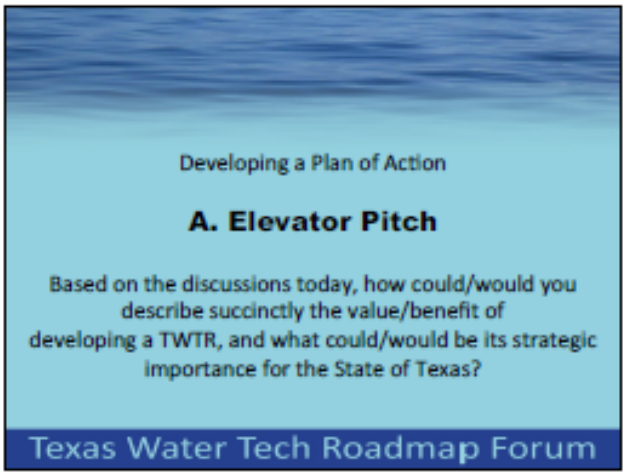
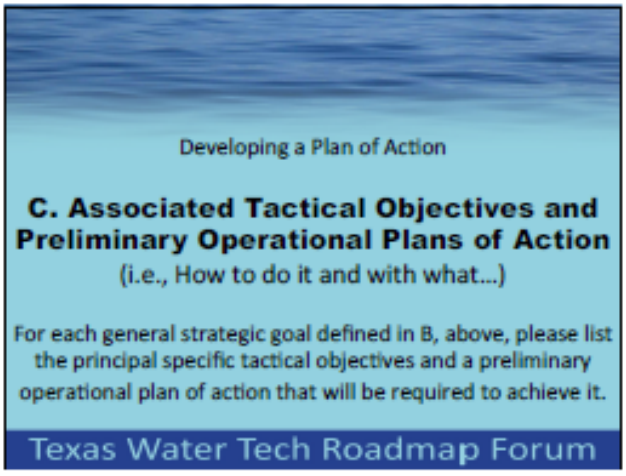
The Path Ahead...

Texas Water Tech Roadmap Forum


Developing a Plan of Action
A. Elevator Pitch
Based on the discussions today, how could/would you describe succinctly the value/benefit of developing a TWTR, and what could/would be its strategic importance for the State of Texas?
Texas Water Tech Roadmap Forum


Developing a Plan of Action
B. Strategic Goal
(i.e., What to do...)
Please establish a set of general strategic goals, which will enable the development of a potential TWTR.
Texas Water Tech Roadmap Forum


Developing a Plan of Action
C. Associated Tactical Objectives and Preliminary Operational Plans of Action
(i.e., How to do it and with what...)
For each general strategic goal defined in B, above, please list the principal specific tactical objectives and a preliminary operational plan of action that will be required to achieve it.
Texas Water Tech Roadmap Forum


Developing a Plan of Action
D. Commitments
To ensure achieving the plan of action for the development of a potential TWTR, define the commitments that need to be made.
Texas Water Tech Roadmap Forum

Appendix VII — Forum Website

The forum was supported through a specially designed website that provided background, registration links, pre-forum materials, access to electronic input sheets, example roadmaps, facility information, and maps to the site of the forum. This website will continue to provide follow-up information for participants and other interested parties. This site can be accessed at http://texaswatertech.org

The website that was available to participants can be viewed on YouTube here: http://youtu.be/eF7aloLw5FI

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Copies may be obtained at the Meadows Center for Water and the Environment, Texas State University, 601 University Dr, San Marcos, TX 78666. http://libguides.tamusa.edu/ld.php?-content_id=28446601