Science and Technology Innovation for California’s Water Future

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Background: i2i water

- 2010 legislative request to assess California's 'innovation ecosystem'
- Round tables with academic, industry & research leaders across state seeking their input on challenges
- Conclusions: State needs to bolster its international competitiveness by enlisting California's S&T community in finding solutions to two of the State's major challenges, education and water
- Development of Water Innovation Road Map
  - engaging broad segment of S&T community
  - finding innovative solutions to water issues facing California in coming decades
1. **Project Goals:**
   a. **Make specific recommendations** -
      • technologies having most promise over next 5-10 years
      • institutional & process changes needed to incorporate identified innovations
   b. **Identify appropriate technology planning, pilot projects & investments**
      • by Federal, Tribal, State, regional and local governments & agencies, NGOs, & private applied research and innovation initiatives
      • required to achieve the needs identified
   c. **Provide technology opportunities input to the DWR 2013 Update of the State Water Plan**
Overview: Results of Online Survey and Follow-up Focus Groups
1. Data Acquisition: Onsite Monitoring

Suggested technology priorities:

- Expanded collection of critical data
- Improved quality and consistency of data collection standards across agencies
- Improved data sharing and collection of data currently unavailable due to lack of regulation or user cooperation
- More widespread development and use of robust, cost effective sensors
### Survey Overview: Data Acquisition Technologies (In-Situ/Ground-Based Sensors)

| Currently possible, likely significant impact | • Office of environmental data quality - to establish consistent standards  
• Unified web portal for existing data  
• Small visual/hyperspectral sensors installed near water to measure water turbidity and chlorophyll content |
| Currently possible, likely limited impact | • Development of isotopic tracers to assess groundwater age, transport, and contaminants |
| Promising, likely significant impact | • Instruments to easily assess in situ nitrates and other constituents in groundwater |
| Promising, likely limited impact | • Phosphorous sensors  
• Noble gas sensors (to track groundwater recharge)  
• DNA analysis for monitoring invasive aquatic species |
2. Data Acquisition: Remote Sensors

Suggested technology priorities:

- Increased investment in the development and deployment of remote sensors

- Preparing California to exploit information derived from existing and future earth observing missions

- Convening individuals from National Laboratories in California together with experts from academia, government and the private sector to chart the course for necessary water related research that can best be performed by the National Laboratories (DOD, DOE, NASA)
### Survey Overview: Data Acquisition Technologies (Remote Sensing)

<table>
<thead>
<tr>
<th>Currently possible, likely significant impact</th>
<th>• New algorithms to take advantage of data from existing satellite platforms</th>
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<tr>
<td>Currently possible, likely limited impact</td>
<td>• Airborne drones to provide targeted data to complement satellite data on snowpack</td>
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<td>• Microgravity monitoring of water storage changes</td>
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<td>• Expanded network of inexpensive, local remote sensors</td>
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<tr>
<td>Promising, likely significant impact</td>
<td>• Partnerships between NASA, state and private sectors</td>
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<td>• Integrated modeling framework that combines data from remote and onsite sensors</td>
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<td>• SWOT mission</td>
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<td>Promising, likely limited impact</td>
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3. Data Management

Suggested technology priorities:

• Better systems for sharing data across agencies
• Better management/applications of data already being collected
• Developing consistent standards for data collection and dissemination
• Making more real-time data available, especially where regulation and enforcement are now lacking (e.g., measuring and reporting groundwater discharge, recharge and aquifer water quality)
• Investment in models capable of integrating data from remote and onsite sensor systems
• Improved modeling and decision making software
• New standards for verifying models against actual in situ data
# Survey Overview: Data Management (Access To and Use of Data and Modeling)

| Currently possible, likely widespread impact | Web-based information exchange systems using distributed data models allowing different entities to maintain and share data  
| | Better access to real-time data by the public |
| Currently possible, likely limited impact | Wider use of simulation programs such as CalSim 2, CalLite and Plexos (Power Benefits Model) |
| Promising, likely widespread impact | High performance computing resources for management and understanding of large scale, coupled environmental water and regional climate systems  
| | Advanced metering infrastructure and data communication tools to communicate real time water usage |
| Promising, likely limited impact | |
4. Water Treatment (membrane based)

Suggested technology priorities:

• Adaptable control systems (smart control systems), capable of automatically achieving predetermined operation goals in the face of variable water quality

• Further development of more robust general-purpose membranes, with an emphasis on lower cost and lower energy use

• Further development of energy recovery technology

• Significantly broadened deployment of desalination technologies, including the streamlining of the regulatory process and the incorporation of experience in other venues than California
## Survey Overview: Water Treatment Technologies (Membrane Filtration Based)

| Currently possible, likely significant impact | • More significant use of sensors to assess groundwater quality  
• Use of data from other states and countries to assess impacts of the use of membrane technologies |
| Currently possible, likely limited impact | • Increased use of renewable energy in membrane treatment |
| Promising, likely significant impact | • Development of more robust filters, possibly using hybrid desalination processes such as forward osmosis / reverse osmosis, forward osmosis/nanofiltration, etc.  
• Development of "smart control systems" to automatically adapt membrane filtration systems to changing water quality and demand  
• Collection of groundwater quality data from oil companies and other private operators |
| Promising, likely limited impact | • Real-time public display of sensor data on key contaminants to increase public confidence |
5. Water treatment (chemical/biological)

Suggested technology priorities:

- Development and deployment of technologies focused on wastewater cleanup for recycling
- Technology development to support the increased use of distributed water and wastewater treatment systems
- Narrowing the gap between what's feasible in the lab and what's approved for use in the field
- Deployment of engineered, constructed wetlands technology
### Survey Overview: Water Treatment: Physical, Biological and Chemical (non-membrane based technologies)

| Currently possible, likely significant impact | • Constructed wetlands, optimized for specific treatment outcomes  
                                              | • More reliable basic sensors |
| Currently possible, likely limited impact     | • Scanning techniques developed by oceanographic researchers such as fluorescent scans |
| Promising, likely significant impact          | • Distributed, low-energy treatment options applied at local level  
                                              | • Application of nanotechnology to enhance and bolster membrane treatments |
| Promising, likely limited impact              | • Improved biological filtration, e.g. targeted removal of selenium in agricultural runoff |
6. Watershed Management

Suggested technology priorities:

- Ability to combine and utilize applicable models more effectively in recognition of climate change impacts on watersheds

- Improved data collection for surface water and groundwater basin descriptive parameters, including water runoff and storage as a function of time throughout the basin

- Expanded use of flood plains and other sites having good recharge potential for groundwater recharge
## Survey Overview: Watershed Management (Including Groundwater Recharge)

| Currently possible, likely significant impact | • Restoration and expansion of forest and streamgaging stations  
| | • Better linking of NOAA data with data on the ground |
| Currently possible, likely limited impact | • Advance running of specific scenarios involving complex models using high-performance computing platforms |
| Promising, likely significant impact | • More complex and integrated models combining data from wider range of sources  
| | • Greater use of flood plains for groundwater recharge (possibly integrated with more storage to feed flood plains)  
| | • Better outreach to stakeholders using technology |
| Promising, likely limited impact | • Partnerships with private sector companies for local, real-time monitoring networks |
7. Agricultural Water Use Efficiency

Suggested technology priorities:

• Widespread adoption of water measurement and soil moisture sensing technologies;
• Selecting and installing high efficiency water distribution systems, providing necessary maintenance, and utilizing proper irrigation scheduling methods
• Adoption of one or more technologies for water management, including remote sensing, weather based, and/or crop/soil based technologies
• Development of cost-effective information management and controller technology for managing drip and micro-sprinkler line pressures throughout fields with diverse soil types
• Using agricultural water and land whenever possible to provide environmental benefits (e.g. flooded rice ground to provide seasonal wetlands for migratory birds and reproduction habitat for fish)
• Identification of multiple use opportunities for water supplies (e.g. water exchanges between agricultural and urban users)
• Improving water use efficiency with the adoption of pressurized irrigation systems
• Fully understanding third-party impacts before implementing any large-scale changes in agricultural practices
## Survey Overview: Agricultural Water Use Efficiency

| Currently possible, likely significant impact | • Improve on-farm water measurement and soil water sensing, that will lead to improved irrigation scheduling and management.  
• Growers need an active program to evaluate and upgrade their current irrigation systems that do not meet current distribution Uniformity standards |
| Currently possible, likely limited impact | • Identify opportunities to improve crop water use efficiencies |
| Promising, likely significant impact | • Remote sensing of crop cover and crop coefficient; combining satellite data with daily weather data, soils, and irrigation to help refine crop water balance |
| Promising, likely limited impact | • Crop switching to lower water demand. |
8. Urban Water Use Efficiency

Suggested technology priorities:

- Enhanced metering infrastructure
- Greater deployment of lower water use technologies
- Greater reuse and more reliance on partially treated water for non-potable purposes
- Enhanced leak detection and repair programs
- Greater use of incentive based pricing to encourage more water conservation
- Greater use of low water intensity landscaping, possibly reinforced with stricter codes/regulation
## Survey Overview: Urban Water Use Efficiency

| Currently possible, likely significant impact | - Improved metering infrastructure, e.g. wireless smart meters  
- More widespread use of lower water use technologies, such as low-flow toilets |
|-----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Currently possible, likely limited impact     | - Financial incentives for greater water conservation  
- Expanded use of "gray" water |
| Promising, likely significant impact          | - Improved high-resolution flood models parameterized with LIDAR and data offer greater understanding of urban flood risks and have the ability to improve urban planning and emergency management  
- Better leak detection, more aggressive repair programs |
| Promising, likely limited impact              | - |
Suggested technology priorities:

- Greater use of smart grid technologies, especially to increase use of renewable energy sources
- Minimizing unnecessary energy dissipation at point of use
- Implementation of energy harvesting technology where feasible
- Increased use of technologies to improve energy efficiency for water treatment and transport processes
### Survey Overview: Water-Energy Nexus

| Currently possible, likely significant impact | • Smart grid technologies for water and energy conservation and management. In particular greater utilization of automatic meter reading and advanced meter infrastructures, in concert with power providers |
| Currently possible, likely limited impact | • Use of renewable energy for water treatment and transport processes |
| Promising, likely significant impact | • Integrated models for management and understanding of large-scale, coupled water and regional climate systems and energy supply |
| Promising, likely limited impact | • Developing anaerobic processes to facilitate energy recovery from wastewater |