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A New Model for Industry–University Partnerships

A RESEARCH PARTNERSHIP BETWEEN THE CALIFORNIA WATER SERVICE CO. AND SAN JOSÉ STATE UNIVERSITY HAS DEVELOPED CRITICAL PROJECTS TO HELP ADDRESS GAPS IN THE KNOWLEDGE BASE WITHIN THE DRINKING WATER INDUSTRY AND RESEARCH COMMUNITIES.

California Water Service Co. (Cal Water), San José, Calif., has made a $450,000, five-year pledge to San José State University (SJSU) to support research that will help provide solutions to various challenges facing the water industry. This opportunity will allow industry professionals and university representatives to work together on real business issues within the water utility sector. Through this research partnership project, seven critical (top-tier) projects that are aligned with both corporate goals and key business and industry concerns will be carried out to help address knowledge-base gaps in the drinking water industry and research community over a 4.5-year period. It was mutually agreed that hands-on exchange and interaction, publication efforts, outreach, and the visibility of research outcomes should be emphasized. Also of utmost importance is that research outcomes be considered within both practical and applied contexts to ensure broad industry effects and transference. The spring 2015 issue of SJSU's *Engineering at San José State–Charles W. Davidson College of Engineering* magazine highlighted this project in detail (see the photograph on page 85). In this article, the decision-making process used to formulate the seven critical research projects is described.

BACKGROUND

Cal Water, through its subsidiaries, serves as both a regulated and nonregulated water utility and provides other services in California, Washington, New Mexico, and Hawaii. Key service elements include the production, purchase, storage, treatment, testing, distribution, and sale of water for domestic, industrial, public, and irrigation uses as well as for fire protection. Within California specifically, water service is provided to roughly 478,000 customers—about 1.7 million people—located in 83 statewide communities. The key infrastructure components that support this customer base consist of about 5,700 mi of water main, 134,400 line and control valves, 970 booster stations, 650 wells, seven surface water treatment plants, 420 water storage facilities, and 450 supervisory control and data acquisition transmitting units.

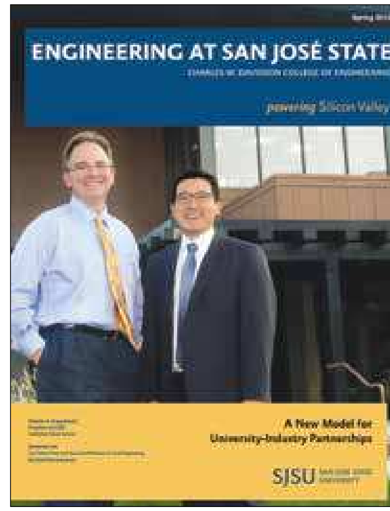
Given the broad range of technical, legal, financial, social, and environmental factors that accompany managing a utility of its size and complexity, Cal Water has embraced the underlying philosophy and tenets of effective utility management. This management framework was developed in 2008 by a consortium of water-related entities and focuses on 10 core management elements, all of which deeply affect Cal Water's corporate vision, structure, mandate, and daily operations. These elements are water resource adequacy, product quality, customer satisfaction, employee and leadership development, operational optimization, financial viability, infrastructure stability, operational resilience, community sustainability, and stakeholder understanding and support.

To explore as well as more effectively incorporate several effective utility management elements into Cal Water's culture and operations, the company embarked on developing and implementing an industry–university exchange program with SJSU in 2014. This program is designed to allow academic and industry representatives to work closely together on real business issues. Some of the principal outcomes that both entities envision (and will enjoy) from this exchange program include the following:

- An improved understanding of key physical processes that occur within Cal Water's infrastructure system that can lead to better life-cycle planning, analysis, design, and operational decision-making
- Improved business intelligence that springs from complete life-cycle considerations of data architecture, collection, warehousing, and postprocessing (analytics)
- Additional opportunities to rationally plan and optimize capital and operational projects and programs
- Additional opportunities to improve product quality
- Improved general rate case and other stakeholder and public processes as they pertain to project and program identification, evaluation, justification, and presentation

Cal Water believes that the new or additional considerations that result from this research will constitute "value-added" development to its overall corporate and business processes and, by extension, that these values and benefits can be passed on to a variety of stakeholders and constituents.

> The California Water Service Co.–San José State University partnership is designed to allow academic and industry representatives to work closely together on real business issues.

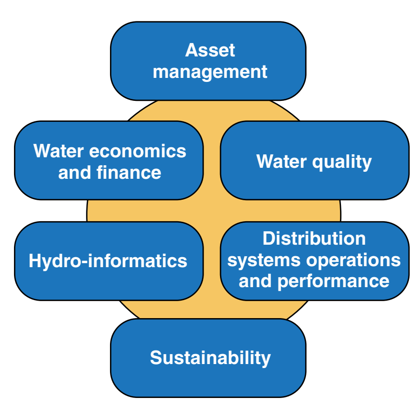


The spring 2015 cover of the *Engineering at San José State–Charles W. Davidson College of Engineering* magazine features the president and chief executive officer of the California Water Service Co. (Cal Water), Martin A. Kropelnicki, and this article's coauthor Juneseok Lee. Cal Water and San José State University are collaborating on a new model for university–industry partnerships.

DECISION-MAKING PROCESS

Between the beginning of August 2014 and mid-March 2015, 24 meetings were held between staff from Cal Water and faculty from SJSU. These meetings included three major team meetings and one progress update meeting with executive

FIGURE 1 Project focus areas



members. Following is a description of the significant objectives and outcomes for each major meeting.

Brainstorming session (Aug. 6, 2014). The principal objective of this meeting was to formulate a mature list of research focus areas, topics, and potential projects. The key participants were a diversified group of Cal Water engineering, water quality, and operations managers and supervisors and two representatives from SJSU. The principal outcome of this meeting was a comprehensive list of about 60 candidate research topics, areas, and individual projects (a broad agenda or umbrella) captured in the form of meeting minutes. These were then reviewed and organized in more detail from the perspective of conceptual, theoretical, and business-process similarities and linkages as well as from the perspective of overall categorical impact for both Cal Water, and the broader water utility sector. Both mind-mapping and spreadsheet tools were used to complete this consolidation and organizational step. This process resulted in candidate research projects and topics being categorized into the six focus areas in Figure 1. The supporting details behind this categorical formulation are provided in Table 1.

The definitions of the six selected focus areas shown in Figure 1 are outlined as follows:

- Asset management—maintain a desired level of service at the lowest life-cycle cost.

TABLE 1 Summary of categorical formulation

Category	No.	Topic	Cross-linkage[a]
A	1	Modeling/forecasting of pipeline failures in water distribution systems considering physical, chemical, and biological synergistic factors	A, E
A	2	Decision support system for water main replacement—prioritization program considering risk-assessment and investment strategies	A, E
A	3	Decision support system for water main replacement—AC pipe management	
A	4	Modeling/forecasting variations and trends/timing of water main failures using statistical/stochastic modeling	A, E
A	5	Optimal strategies for well rehabilitation: risk and cost–benefit assessment	A, E
A	6	Leak detection of water distribution systems (using hydraulic transient)	
A	7	Trade-off analysis of pipe material selection	
B	1	Multiobjective water distribution systems control of water quality, cost, energy, and reliability constraints	B, C, E
B	2	On-line real-time water distribution system monitoring to optimize water quality	B, E
B	3	Hydraulic transients–related water quality issues	B, C
B	4	Analysis of water quality/age within water distribution systems—tank mixing	
B	5	Analysis of water quality/age within water distribution systems—chlorine concentration decay	
B	6	Analysis of water quality/age within water distribution systems—reaction and transport of multiple species	
B	7	Analysis of water quality/age within water distribution systems—nitrification	
B	8	Optimization of water treatment processes—general	
B	9	Optimization of water treatment processes—GAC replacement	
B	10	Optimization of water treatment processes—nitrate	
B	11	Optimization of water treatment processes—arsenic	
B	12	Optimization of water treatment processes—hexavalent chromium	
B	13	Optimization of water treatment processes—multispecies	
B	14	Optimization of water quality sensor locations within water distribution systems	
B	15	Optimal flushing program considering water quality	
C	1	Multiobjective water distribution systems control of water quality, cost, energy, and reliability constraints	B, C, E
C	2	Water demand management and planning: spatial and temporal forecasting	C, E
C	3	Impact analysis of hydraulic transients in pipelines—breakage	
C	4	Impact analysis of hydraulic transients in pipelines—leakage	
C	5	Impact analysis of hydraulic transients in pipelines—water quality	
C	6	Impact analysis of hydraulic transients in pipelines—frequency and severity of surges	
C	7	Optimization of water source management—single-source type	
C	8	Optimization of water source management—multiple-source type	
C	9	Optimization of water source management—conjunctive use	
C	10	Repurposing of existing infrastructure for recycled water resources	

- Water quality—maintain the physical, chemical, and biological characteristics of drinking water at all times and locations to protect public health.
- Distribution system operation and performance—provide adequate pressure and drinking water quality under varying loading conditions at all times and locations.
- Sustainability—create the conditions that will fulfill the social, economic, environmental, and technical requirements of present and future generations.
- Hydro-informatics—apply information and information systems to ensure equitable and efficient use of water resources.
- Water economics and finance—develop methodologies to properly value the full cost of water service, establish and maintain fair and equitable customer rates and rates of return, and protect affordability.

Progress update meeting (Oct. 20, 2014). The objective of this meeting was to discuss progress to date with executive members and obtain high-level feedback. The authors made notable progress in collecting, organizing, and framing potential research projects; the next step was to begin weighing and prioritizing the focus areas identified using surveys completed by Cal Water employees. After a thorough discussion, however, it was agreed that the list should be

TABLE 1 Summary of categorical formulation *(continued)*

Category	No.	Topic	Cross-linkage[a]
C	11	Effective procedures for hydraulic calibration	
D	1	Climate-change impacts assessment for the drinking water infrastructure considering vulnerability, resiliency, and sustainability index	D, E
D	2	Optimization of energy cost—TOU: water–energy nexus	
D	3	Optimization of energy cost—TOU: pump scheduling	
D	4	Energy loss and costs of leaky pipes	D, F
D	5	Water conservation: active and passive conservation	
D	6	Water reuse—dual systems	
D	7	Optimization of carbon footprint within water distribution systems	
D	8	Sustainable and effective utility management framework considering climate change issues	
E	1	Decision support system for water mains replacement prioritization program considering risk assessment and investment strategies	A, E
E	2	Modeling/forecasting of pipelines failures in water distribution systems considering physical/chemical/biological synergistic factors	A, E
E	3	Modeling/forecasting variations and trends/timing of water mains failures using statistical/stochastic modeling	A, E
E	4	Optimal strategies for well rehabilitation: risk and cost–benefit assessment	A, E
E	5	Multiobjective water distribution systems control of cost/water quality/and reliability	B, C, E
E	6	On-line real-time water distribution system monitoring to optimize water quality	B, E
E	7	Water demand management and planning: spatial and temporal forecasting	C, E
E	8	Climate-change impacts assessment for the drinking water infrastructure considering vulnerability, resiliency, and sustainability index	D, E
E	9	Sustainable database infrastructure of water distribution systems real-time modeling and decision-making	
E	10	Optimal installation and analysis of AMR/AMI data	
E	11	Development of smart water systems	
E	12	Link GIS, hydraulic, and hydrologic analysis modeling capacities—water distribution and groundwater modeling	
F	1	Optimization of cost/energy considering TOU	D, F
F	2	Energy loss and costs of leaky pipes	D, F
F	3	Optimization of general rate case considering the true cost and value of water/water productions/ratemaking	
F	4	Analysis of nonrevenue water	
F	5	Analysis of price elasticity for each district	
F	6	Willingness to pay for improved level of service	

[a]As applicable, denotes a cross-linkage among the six focus categories

A—asset management, AC—asbestos cement, AMI—advanced metering infrastructure, AMR—automatic meter reading, B—water quality, C—distribution system operation and performance, D—sustainability/corporate responsibility/effective utility management, E—hydro-informatics, F—water economics and finance, GAC—granular activated carbon, GIS—geographic information system, TOU—time of use reviewed and narrowed by a small group of high-level engineering, operations, water quality, and financial executives (rather than conducting a time-intensive survey) to facilitate more effective administration and in-depth discussion of the issues.

Selection of research focus areas (Oct. 30, 2014). The goal of this meeting was to choose the final group of about seven research focus areas that Cal Water and SJSU would pursue in terms of action and implementation. The previously noted research umbrella (a list with draft topic and project descriptions) was distributed to the key participants, which included five Cal Water engineering and water quality managers and supervisors.

Team members were asked to review the list before the meeting under the auspices of their professional knowledge and experience, provide commentary aimed at creating additional focus and clarity for the purpose of comparative assessment,

TABLE 2 Top eight research category and topic areas

Group and Item Number	Category and Topic Area
A1	Modeling and forecasting of pipeline failures in water distribution systems considering physical, chemical, and biological factors—a synergistic framework and approach
A2	Development of a decision support system for water main replacement—enterprise prioritization program considering risk-control and investment strategies
B1	Multiobjective water distribution systems optimization—delivery cost and water quality control under regulatory performance and reliability constraints
B15	Optimal flushing program considering water quality
C3–6	Impact analysis of hydraulic transients in pipelines—breakages, leakages, water quality, and frequency and severity.
E4	Optimal strategies for well rehabilitation: risk and cost–benefit assessment
E6	On-line real-time water distribution system monitoring to optimize water quality
F3	Optimization of general rate case processes, enterprise-level framework for the consideration of cost and value of service, water supply and quality management, project selection and management, and ratemaking

A—asset management, B—water quality, C—distribution system operation and performance, E—hydro-informatics, F—water economics and finance

TABLE 3 Final project list

Recommended Projects	Expected Timeline	Envisioned Deliverables
1. Enterprise-level decision support system for water main replacement and prioritization program considering risk assessment and investment—Asset management with a GIS database using physical and chemical conditions; quantitative and qualitative standard-setting or policymaking project	30 months	Three journal articles will be published from this research
2. Multi-objective water distribution systems control of water quality, cost, energy, and reliability constraints—Multi-objective decision model framework; objective and constraints; development of distribution systems performance KPIs; decision-making metrics	24 months	Two to three journal articles will be published from this research
3. Optimal flushing program considering water quality—Development of enterprise-level flushing framework and standards	36 months	Three journal articles will be published from this research
4. Impact analysis of hydraulic transients to pipelines—breakage, failures, water quality, frequency and severity—Select hydraulic transients in susceptible/vulnerable cities (for different source water types and demographics)	24 months	Two to three journal articles will be published from this research
5. Optimal strategies for well rehabilitation: risk and cost-benefit assessment—Development of enterprise-level well's asset management standards/framework; deepen/improve WELMAT; combine GIS, CMMS, production records; business intelligence	36 months	Three journal articles will be published from this research
6. On-line real-time water distribution system monitoring to optimize water quality—Early contaminant warning system; optimal sensor placement problem; need to select a model city for implementation that are already well equipped with sensors and integration with SCADA systems	30 months	Two to three journal articles will be published from this research
7. Optimization of general rate case considering the true cost and value of water/water productions/ratemaking—Develop an integer programming tool to assist in go/no-go GRC decision-making	36 months	Two to three journal articles will be published from this research

CMMS—computerized maintenance management system, GIS—geographic information system, GRC—general rate case, KPIs—key performance indicators, SCADA—supervisory control and data acquisition, WELMAT—California Water Service Co.'s internal asset management database on supply wells and then come to the meeting prepared to argue for (and defend) their top five projects. They were also asked to use their specific knowledge of Cal Water subjects and issues as well as their knowledge of more broadly placed industry concerns as the working framework and perspective for their final judgment. During the meeting, final ratings and assessment guidelines were provided and discussed. The outcome of this meeting was a reduced list of research topic and categorical areas selected by the work group (Table 2 compared with Table 1).

The authors then suggested a list of specific research projects that fall within the selected topic areas. This step initially resulted in 25 individual projects at the brainstorming level. However, given the project timeline and other feasibility considerations, the number of specific projects under consideration was eventually consolidated to 13 for final discussion, ranking, and selection. In this case, the final list was framed around more specifically defined projects as opposed to the original broad focus, topic, and categorical areas.

Selection of final research projects (Mar. 13, 2015). The goal of this meeting was to choose up to seven detailed research projects (of the 13 proposed) that Cal Water and SJSU would pursue in terms of action and implementation. Before the meeting, a recommended project list was distributed that included developmental information that covered the projects' backgrounds as well as the overall domains. These documents were used for informational and feedback purposes as well as for providing a clear vision of how the projects could be conceptually framed. Key participants attending the meeting included six Cal Water engineering and water quality managers and supervisors.

As before, team members were asked to review the list before the meeting under the auspices of their professional knowledge and experience and come to the meeting prepared to argue for (and defend) their top five projects. During the meeting, final ratings and assessment guidelines were provided and discussed. Table 3 lists the seven projects selected by the group, along with their expected timelines and envisioned deliverables.

In Figure 2, the decision process timeline for project selection is shown. The selection of the final list of projects was recognized as a notable milestone, signifying the transition into the next phase of the work, including data collection and fine-tuning of the projects.

Ongoing process and outlook. The project implementation was then prioritized in terms of importance, urgency, and data availability. The projected timeline of the actual implementation over the next 4.5 years is shown in Figure 3. The working time span (green), the deadline for each project (red), and the proprosed journal publication efforts (blue) are indicated for each project. It is expected that more than 15 journal articles will be published over the project period.

During the second quarter of 2015, project 1 was being initiated by performing a series of thorough literature surveys, defining the data requirements, and selecting the most promising solution approaches.

Unique research collaborations will allow industry professionals and university representatives to work together on actual business issues within the water utility sector.

CONCLUSIONS

In this article, a new model for industry–university partnerships as well as a decision-making process for research projects is described. This unique research collaboration will allow industry professionals and university representatives to work together on actual business issues within the water utility sector. The seven selected critical projects that are aligned with corporate goals and key business and industry concerns will help address gaps in the knowledge base that exists

FIGURE 2 Decision process timeline for project selection

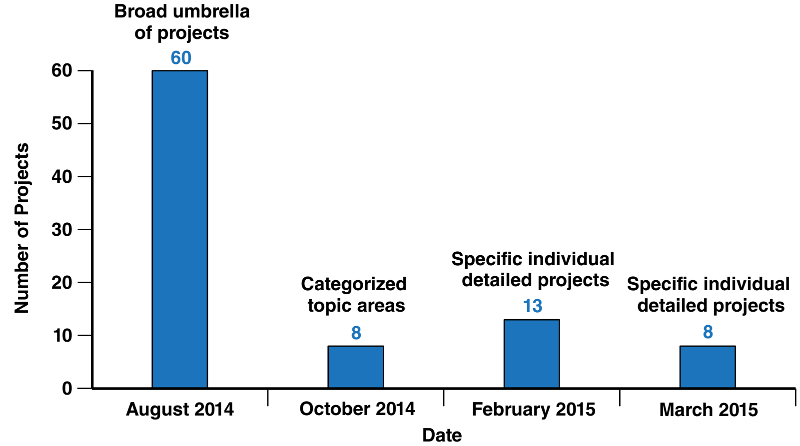
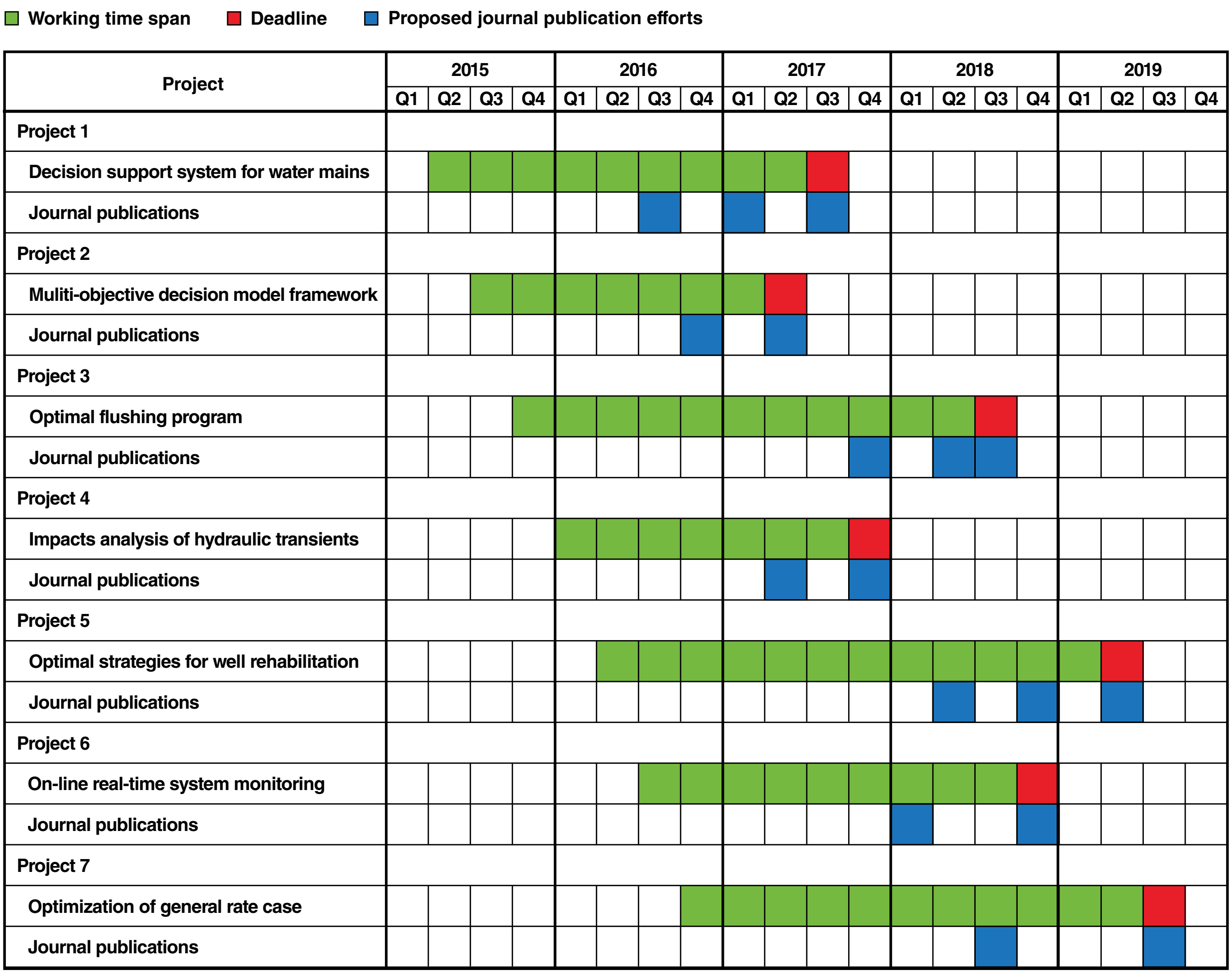


FIGURE 3 Proposed timeline of project implementation



within the drinking water industry and research communities.

Considering that all participating decision-makers were asked to use their professional experience and their comprehensive knowledge of the water industry, the authors believe that this unique research partnership will bring a new perspective on water infrastructure challenges and solutions while simultaneously providing a business-process foundation and framework that can have broad industry impact and transference.

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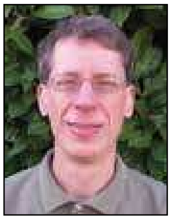

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