Work Plan

SWES Scope of Work Overview

This (Smart Water-Energy Savings) SWES project seeks to maximize and quantify the life-cycle energy savings secured through behavior-based residential water conservation in the cities of Fresno, Modesto, Ontario, Riverside and Turlock. The Center for Water-Energy Efficiency (CWEE) at UC Davis has partnered with WaterSmart Software in this effort. CWEE has been a leading innovator in advancing a data-driven approach to characterizing and optimizing linked water-energy systems at both the infrastructure and residential scale. WaterSmart has developed a proven, information-driven technology to encourage water users to reduce household water consumption. The WaterSmart technology is comprised of customized Home Water Reports (delivered by either mail or email) and an interactive Customer Portal where residents can learn more about their water use and ways to save. A key aspect of their technology is driving behavior-change by comparing a consumer's water use to that of similar households (see Figure 1).

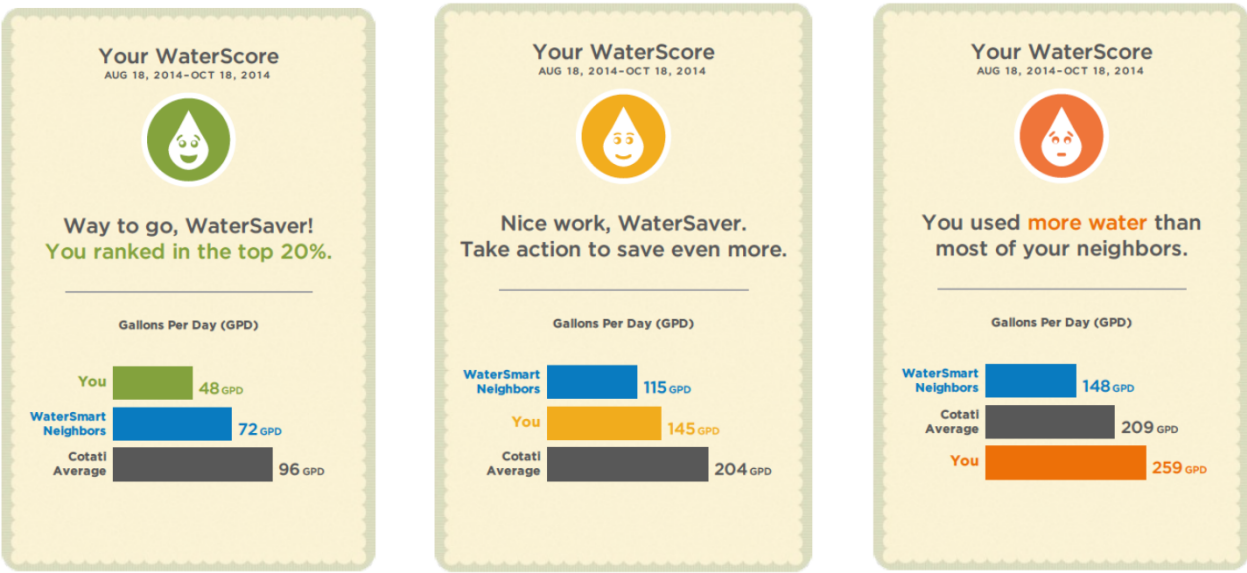


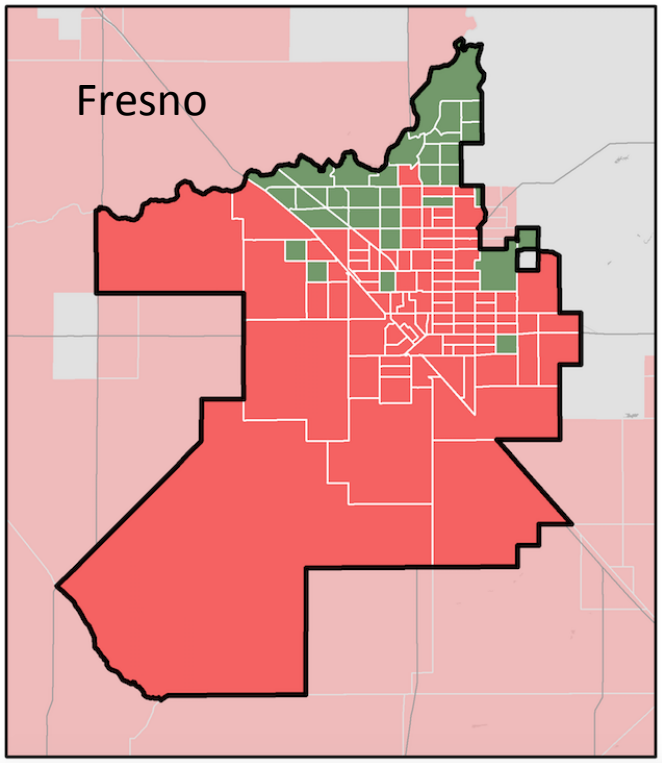
Figure 1. Examples of WaterSmart Home Water Report social comparison of water use

CWEE will work with WaterSmart to 1) research and develop conservation messages targeted at decreasing residential hot water use and energy related to water use (both methods of water-energy reductions will be referred to as "hot water conservation"), and 2) design and deploy the WaterSmart technology in a randomized control trial (RCT) in five California cities. By deploying an RCT of WaterSmart, CWEE will be able to measure and monitor the impact of the technology on reducing residential water use and water-related energy consumption in the home. In addition, CWEE will apply its established methodology for monitoring and measuring the infrastructure-related energy savings of water conservation as it applies to both water delivery and wastewater systems.

Since the proposed project is entirely based on information and communications, there are no CEQA obligations nor permit requirements in connection with the project. The Scope of work is identical for each of the five project sites–Fresno, Modesto, Ontario, Riverside and Turlock–but individualized work plan tasks are provided as follows.

Fresno Project Work Plan Tasks

Our first deployment site is the City of Fresno. Fresno has a population of 560,030 people and its proportion of disadvantaged communities (DAC) by area is 89%. There are 110,000 households eligible for the WaterSmart technology. Of these, the SWES project will cover the costs of deployment to 38,500 households (35% of eligible households). Provided WaterSmart generates the same household water savings that it has demonstrated in other communities (i.e. average of 5% reduction in water use) across all household end-uses, we expect to secure lifetime savings of 1,823 MG of water; 81,592 MWh of energy; and 15,767 metric tons of CO_2e of GHGs.



Map 1. City of Fresno territory divided in red DAC census tracts (CES score of >76% percentile or higher) and green non-DAC census tracts

We anticipate that the City of Fresno will match our investment in WaterSmart to extend coverage to 70% of total eligible households, though this match funding is not required for the success of the project nor to meet the estimated water, energy, and GHG savings as provided above. In fact, if the matching funding is approved by the Fresno City Council, then the anticipated savings provided above would *double* at no additional cost to DWR.

Task 1: Direct Project Administration and Reporting

This task includes management of the grant agreement in compliance with grant requirements, and communication and coordination with other project partners including the Grantor, the CA Department of Water Resources (DWR).

CWEE will be responsible for managing the grant agreement. CWEE will aim to hold quarterly meetings (by phone or in person) with WaterSmart and DWR to ensure that all parties are satisfied with project

progress in terms of both approach and execution. We will also submit invoices to DWR on a quarterly basis that provide a brief explanation of project outcomes over the reporting period. Finally, we will draft, share, review, and complete a final project report in advance of the project end date.

Activities for this task include:

- Project meetings and coordination between CWEE, WaterSmart, and DWR
- Progress Reports and Invoicing
- Draft and Final Project Report

Deliverables: project partner meetings, preparation of invoices, submission of project reports, submission of final report, and other management deliverables as required.

Task 2: Design WaterSmart Hot Water Messaging Content

This task involves adapting the WaterSmart technology to increase home water-energy savings through messages that specifically target hot water conservation.

CWEE will work with WaterSmart to research and develop new consumer behavior-based messaging that specifically targets hot water conservation (see Figure 2). Some options that will be considered, include: 1) informational messages informing the consumer of conservation actions that will save water, energy, and money (*e.g. If your family of 4 reduced your shower time by 3 minutes each, you could save 17,520 gallons, 171 therms and $180 annually*), and 2) messages incentivizing hot water conservation through rebates (*e.g. Hand washing dishes uses six times more water and twice the energy as running a full dishwasher. Rebates are available for purchasing a new efficient dishwasher*). Our hot water messaging content will be reviewed and updated at the beginning of each project year for inclusion in the following year's set of Home Water Reports.

Figure 2. Prototype customer messaging for residential hot water conservation.

Activities for this task include:

- Development of a library of hot water conservation messaging content including supporting water and energy calculations, research, and development of figures and photos
- Exploration of rebate messaging on hot water-related water devices (e.g. efficient showerheads) to potentially increase the participation in existing programs in the service territory
- Cooperation with WaterSmart to integrate hot water messaging into existing home water report design and web portal

Deliverables: development of new content for targeted hot water messaging, integration of these messages into a new package of WaterSmart Home Water Reports, and incorporation of the content into the WaterSmart software platform

Task 3: Randomized Deployment of WaterSmart Software

This task involves the design and deployment of a randomized control trial to test the impact of WaterSmart Software on household water and water-related energy use.

CWEE will apply an RCT methodology for testing the effectiveness of WaterSmart to consistently deliver water and energy resource savings over the three-year project study. This approach involves randomly dividing the target population into treatment and control groups. More specifically, CWEE and WaterSmart will design, deploy, and analyze two different treatments and one control group in a randomized control trial:

1. Treatment #1: "Standard" Home Water Report (deployment of WaterSmart technology as it currently exists)
2. Treatment #2: "Hot Water" Home Water Reports (enhancing the standard WaterSmart report with additional, targeted hot water messaging)
3. Control Group (no treatment at all)

By randomly assigning all households in the study to either the control group or either of the two treatment groups, CWEE will be able to identify the impact of the traditional home water report on residential water and energy use, as well as the marginal value of additional hot-water messaging on customer resource conservation.

Activities for this task include:

- Collection of Fresno water and energy customer data to ensure randomization across diverse customer classes.
- Designing the randomized control trial (randomly assigning households into the two treatment groups and one control group)
- Deployment of the WaterSmart technology to randomized households

Deliverables: Data-driven randomization of Fresno households for WaterSmart treatments, deployment of the WaterSmart to selected households.

Task 4: Data platform for integrating Fresno water-energy data – infrastructure and residential systems

Task 4 involves establishing an integrating data platform for ongoing monitoring of water and energy flows through the network over the life of the project

A major challenge to designing and evaluating joint water-energy programs is efficiently organizing the data from water and energy systems at multiple scales, e.g the infrastructure and the residential scale. To streamline data management over the life of the SWES project, CWEE will build a data platform that will integrate both infrastructure and customer data from multiple sources as shown in Figure 3. While we will build this platform to specifically meet the objectives of the SWES project, once the data is aligned, our tool will allow the Fresno water agency to pursue additional operational objectives, such as water balance-based leak loss detection and pump efficiency monitoring. CWEE has developed an early version of this platform through existing research efforts, and we believe it will be especially useful to meet the SWES project objectives of analyzing the full life-cycle energy savings of behavior-based residential water conservation.

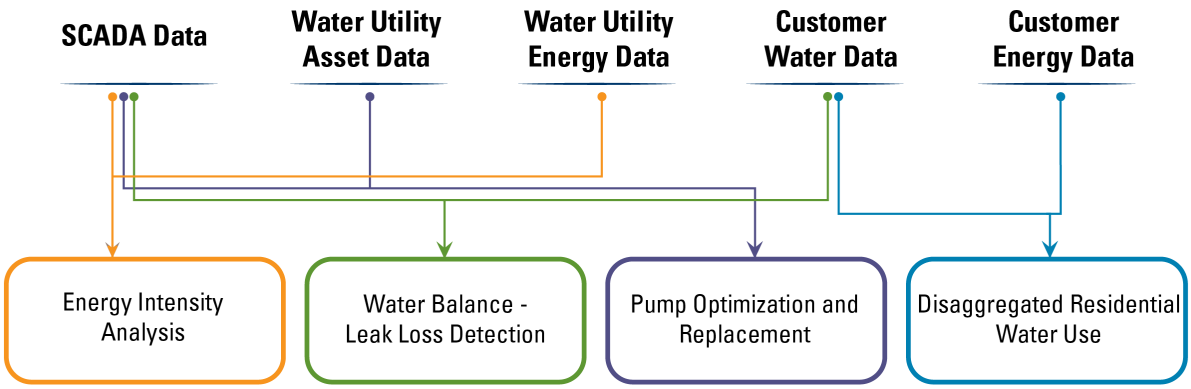


Figure 3. Integrated Data Platform for Water-Energy Analytics and Monitoring

Activities for this task include:

- Collection of relevant water, wastewater, and energy data from Fresno and PG&E
- Design and development of integrated data platform to manage all data for the SWES Project
- Elaboration of a protocol for regular data transfers between Fresno, PG&E and CWEE to enable "live" updating of database

Deliverables: advanced database of Fresno water and energy data that integrates data across multiple scales, data agreements that ensure streamlined delivery of data form project partners, "live" updating of database with available data over the life of the project

Task 5: Application for Estimating Energy Intensity of the Fresno Water and Wastewater Systems

The purpose of this task is to calculate energy intensity of the Fresno water and wastewater infrastructure systems to determine exactly how much system energy is saved when water is conserved.

CWEE will build an analytical tool onto the database platform described in Task 4 to estimate water infrastructure energy intensity at a highly granular spatial and temporal resolution (see Figure 4 for example results from a previous CWEE project with the Otay Water District). For Fresno, we will calculate energy intensity at a monthly resolution (and even hourly resolution if data is available) and at the geographic scale of the pressure zone. Energy intensity will be calculated for both the water and wastewater systems in Fresno. The web-based tool will be made available to all project partners and will be updated regularly based on regular data transfers from Fresno and PG&E as described in Task 4.

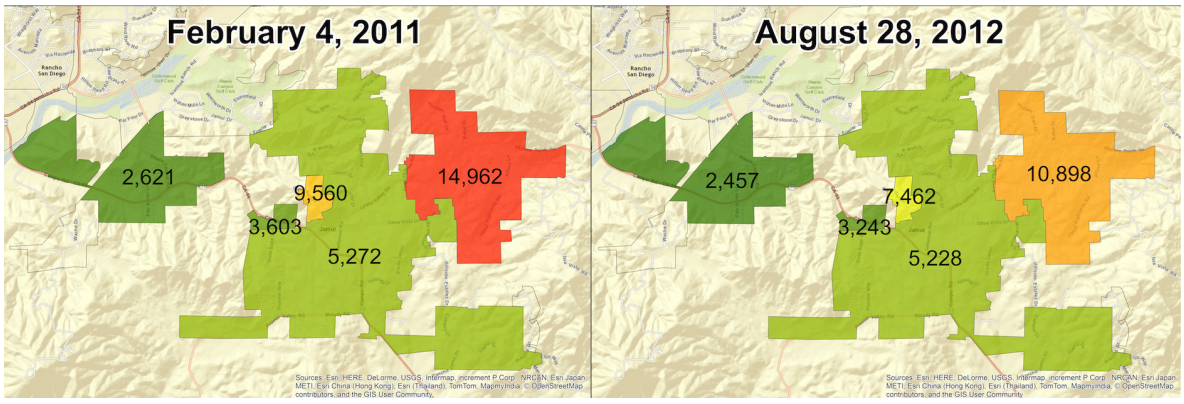


Figure 4. Time-specific mapping of pressure zone energy intensity values within the Otay Water District. Values are provided in kWh/MG.

Activities for this task include:

- Review and mapping of water distribution and wastewater collection service networks;
- Historical and ongoing high-resolution calculation of energy intensity for water treatment and delivery;
- Historical and ongoing high-resolution of energy intensity for wastewater collection/treatment.

Deliverables: seasonal and spatial energy intensity characterizations of water and wastewater systems; web-based tool to explore energy intensity results at multiple spatial and temporal scales.

Task 6: Monitoring and Verification of Water-Energy Reductions from WaterSmart Deployment

This task involves analyzing the effectiveness of the WaterSmart deployment in reducing household hot water use and reductions in energy associated with water use.

We will work with the water and energy utility providers in Fresno to establish a protocol for ongoing data transfers to regularly monitor (e.g. on a monthly or quarterly basis) the water, wastewater and energy flows through the service territory and at the customer meters. Based on the RCT design, CWEE will calculate the behavior-driven water, hot water, and water-energy savings for the two treatment groups relative to the control group. The analysis will include a retrospective analysis of water and energy use by residential customers in the study area before and after technology deployment, and between the treatment and control group households. Finally, based on the infrastructure energy intensity calculations produced in Task 5, we will estimate the impact of the verified household water savings on the associated water and wastewater energy consumption.

Activities for this task include:

- Collect and organize the water, electricity and gas data for the residences involved in the RCT.
- Evaluate the data to detect the signals of water, gas, and electricity reductions observed from the WaterSmart technology deployment, including:
    - Total water savings in the households in each of the two treatment groups relative to the control group;
    - Total energy savings (gas and electric) in the households in each of the two treatment groups relative to the control group;
    - And, total water infrastructure energy savings (water and wastewater systems) secured through verified reductions of residential water consumption.

Deliverables: detailed summary of findings (data and analysis)

Task 7: Proposal Monitoring Plan

This task involves preparation of the Proposal Monitoring Plan, to be approved by DWR.

CWEE will further develop the general plan for proposal monitoring (as described in Attachment 6 of the grant application and incorporating Tasks 5 and 6 above) and work with DWR to solidify the plan.

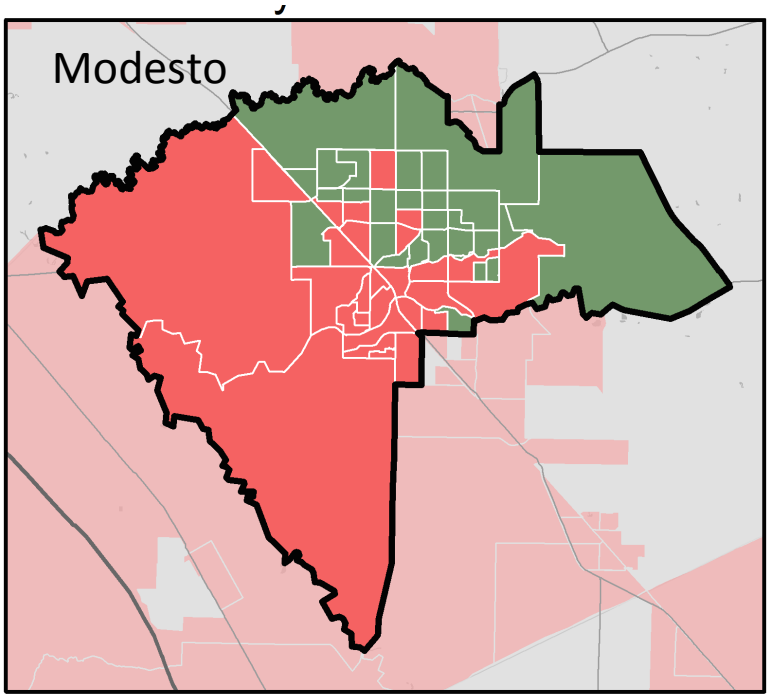
Activities for this task include:

- Develop a draft project monitoring plan
- Meet with DWR to discuss the draft plan
- Finalize and submit a project monitoring plan

Deliverables: submission of final project monitoring plan.

Modesto Project Work Plan Tasks

Our second deployment site is the City of Modesto. Modesto has a population of 288,963 people and its proportion of disadvantaged communities (DAC) by area is 63%. There are 35,000 households eligible for the WaterSmart technology. Of these, the SWES project will cover the costs of deployment to 12,250 households (35% of eligible households). Provided WaterSmart generates the same household water savings that it has demonstrated in other communities (i.e. average of 5% reduction in water use) across all household end-uses, we expect to secure lifetime savings of 492 MG of water; 22,022 MWh of energy; and 4,256 metric tons CO_2e of GHGs.



Map 1. City of Modesto territory divided in red DAC census tracts (CES score of >76% percentile or higher) and green non-DAC census tracts

We anticipate that the City of Modesto will match our investment in WaterSmart to extend coverage to 70% of total eligible households, though this match funding is not required for the success of the project nor to meet the estimated water, energy, and GHG savings as provided above. In fact, if the matching funding is approved by the Modesto City Council, then the anticipated savings provided above would *double* at no additional cost to DWR.

Task 1: Direct Project Administration and Reporting

This task includes management of the grant agreement in compliance with grant requirements, and communication and coordination with other project partners including the Grantor, the CA Department of Water Resources (DWR).

CWEE will be responsible for managing the grant agreement. CWEE will aim to hold quarterly meetings (by phone or in person) with WaterSmart and DWR to ensure that all parties are satisfied with project progress in terms of both approach and execution. We will also submit invoices to DWR on a quarterly basis that provide a brief explanation of project outcomes over the reporting period. Finally, we will draft, share, review, and complete a final project report in advance of the project end date.

Activities for this task include:

- Project meetings and coordination between CWEE, WaterSmart, and DWR
- Progress Reports and Invoicing
- Draft and Final Project Report

Deliverables: project partner meetings, preparation of invoices, submission of project reports, submission of final report, and other management deliverables as required.

Task 2: Design WaterSmart Hot Water Messaging Content

This task involves adapting the WaterSmart technology to increase home water-energy savings through messages that specifically target hot water conservation.

CWEE will work with WaterSmart to research and develop new consumer behavior-based messaging that specifically targets hot water conservation (see Figure 2). Some options that will be considered, include: 1) informational messages informing the consumer of conservation actions that will save water, energy, and money (*e.g. If your family of 4 reduced your shower time by 3 minutes each, you could save 17,520 gallons, 171 therms and $180 annually*), and 2) messages incentivizing hot water conservation through rebates (*e.g. Hand washing dishes uses six times more water and twice the energy as running a full dishwasher. Rebates are available for purchasing a new efficient dishwasher*). Our hot water messaging content will be reviewed and updated at the beginning of each project year for inclusion in the following year's set of Home Water Reports.

Figure 2. Prototype customer messaging for residential hot water conservation.

Activities for this task include:

- Development of a library of hot water conservation messaging content including supporting water and energy calculations, research, and development of figures and photos
- Exploration of rebate messaging on hot water-related water devices (e.g. efficient showerheads) to potentially increase the participation in existing programs in the service territory
- Cooperation with WaterSmart to integrate hot water messaging into existing home water report design and web portal

Deliverables: development of new content for targeted hot water messaging, integration of these messages into a new package of WaterSmart Home Water Reports, and incorporation of the content into the WaterSmart software platform

Task 3: Randomized Deployment of WaterSmart Software

This task involves the design and deployment of a randomized control trial to test the impact of WaterSmart Software on household water and water-related energy use.

CWEE will apply an RCT methodology for testing the effectiveness of WaterSmart to consistently deliver water and energy resource savings over the three-year project study. This approach involves randomly dividing the target population into treatment and control groups. More specifically, CWEE and

WaterSmart will design, deploy, and analyze two different treatments and one control group in a randomized control trial:

4. Treatment #1: "Standard" Home Water Report (deployment of WaterSmart technology as it currently exists)
5. Treatment #2: "Hot Water" Home Water Reports (enhancing the standard WaterSmart report with additional, targeted hot water messaging)
6. Control Group (no treatment at all)

By randomly assigning all households in the study to either the control group or either of the two treatment groups, CWEE will be able to identify the impact of the traditional home water report on residential water and energy use, as well as the marginal value of additional hot-water messaging on customer resource conservation.

Activities for this task include:

- Collection of Modesto water and energy customer data to ensure randomization across diverse customer classes.
- Designing the randomized control trial (randomly assigning households into the two treatment groups and one control group)
- Deployment of the WaterSmart technology to randomized households

Deliverables: Data-driven randomization of Modesto households for WaterSmart treatments, deployment of the WaterSmart to selected households.

Task 4: Data platform for integrating Modesto water-energy data – infrastructure and residential systems

Task 4 involves establishing an integrating data platform for ongoing monitoring of water and energy flows through the network over the life of the project

A major challenge to designing and evaluating joint water-energy programs is efficiently organizing the data from water and energy systems at multiple scales, e.g the infrastructure and the residential scale. To streamline data management over the life of the SWES project, CWEE will build a data platform that will integrate both infrastructure and customer data from multiple sources as shown in Figure 3. While we will build this platform to specifically meet the objectives of the SWES project, once the data is aligned, our tool will allow the Modesto water agency to pursue additional operational objectives, such as water balance-based leak loss detection and pump efficiency monitoring. CWEE has developed an early version of this platform through existing research efforts, and we believe it will be especially useful to meet the SWES project objectives of analyzing the full life-cycle energy savings of behavior-based residential water conservation.

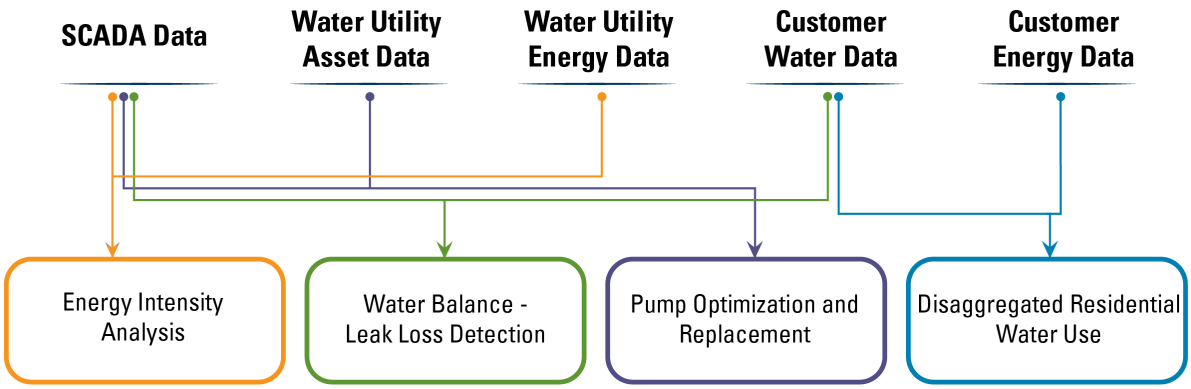


Figure 3. Integrated Data Platform for Water-Energy Analytics and Monitoring

Activities for this task include:

- Collection of relevant water, wastewater, and energy data from Modesto, the Modesto Irrigation District (MID), and PG&E
- Design and development of integrated data platform to manage all data for the SWES Project
- Elaboration of a protocol for regular data transfers between Modesto, MID, PG&E and CWEE to enable "live" updating of database

Deliverables: advanced database of Modesto water and energy data that integrates data across multiple scales, data agreements that ensure streamlined delivery of data form project partners, "live" updating of database with available data over the life of the project

Task 5: Application for Estimating Energy Intensity of the Modesto Water and Wastewater Systems

The purpose of this task is to calculate energy intensity of the Modesto water and wastewater infrastructure systems to determine exactly how much system energy is saved when water is conserved.

CWEE will build an analytical tool onto the database platform described in Task 4 to estimate water infrastructure energy intensity at a highly granular spatial and temporal resolution (see Figure 4 for example results from a previous CWEE project with the Otay Water District). For Modesto, we will calculate energy intensity at a monthly resolution (and even hourly resolution if data is available) and at the geographic scale of the pressure zone. Energy intensity will be calculated for both the water and wastewater systems in Modesto. The web-based tool will be made available to all project partners and will be updated regularly based on regular data transfers from Modesto, MID and PG&E as described in Task 4.

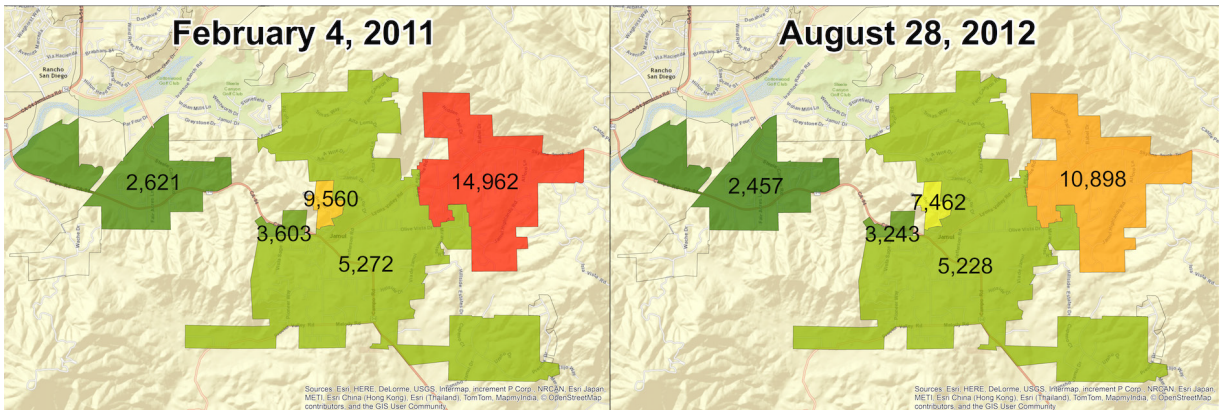


Figure 4. Time-specific mapping of pressure zone energy intensity values within the Otay Water District. Values are provided in kWh/MG.

Activities for this task include:

- Review and mapping of water distribution and wastewater collection service networks;
- Historical and ongoing high-resolution calculation of energy intensity for water treatment and delivery;
- Historical and ongoing high-resolution of energy intensity for wastewater collection/treatment.

Deliverables: seasonal and spatial energy intensity characterizations of water and wastewater systems; web-based tool to explore energy intensity results at multiple spatial and temporal scales.

Task 6: Monitoring and Verification of Water-Energy Reductions from WaterSmart Deployment

This task involves analyzing the effectiveness of the WaterSmart deployment in reducing household hot water use and reductions in energy associated with water use.

We will work with the water and energy utility providers in Modesto to establish a protocol for ongoing data transfers to regularly monitor (e.g. on a monthly or quarterly basis) the water, wastewater and energy flows through the service territory and at the customer meters. Based on the RCT design, CWEE will calculate the behavior-driven water, hot water, and water-energy savings for the two treatment groups relative to the control group. The analysis will include a retrospective analysis of water and energy use by residential customers in the study area before and after technology deployment, and between the treatment and control group households. Finally, based on the infrastructure energy intensity calculations produced in Task 5, we will estimate the impact of the verified household water savings on the associated water and wastewater energy consumption.

Activities for this task include:

- Collect and organize the water, electricity and gas data for the residences involved in the RCT.
- Evaluate the data to detect the signals of water, gas, and electricity reductions observed from the WaterSmart technology deployment, including:
    - Total water savings in the households in each of the two treatment groups relative to the control group;
    - Total energy savings (gas and electric) in the households in each of the two treatment groups relative to the control group;
    - And, total water infrastructure energy savings (water and wastewater systems) secured through verified reductions of residential water consumption.

Deliverables: detailed summary of findings (data and analysis)

Task 7: Proposal Monitoring Plan

This task involves preparation of the Proposal Monitoring Plan, to be approved by DWR.

CWEE will further develop the general plan for proposal monitoring (as described in Attachment 6 of the grant application and incorporating Tasks 5 and 6 above) and work with DWR to solidify the plan.

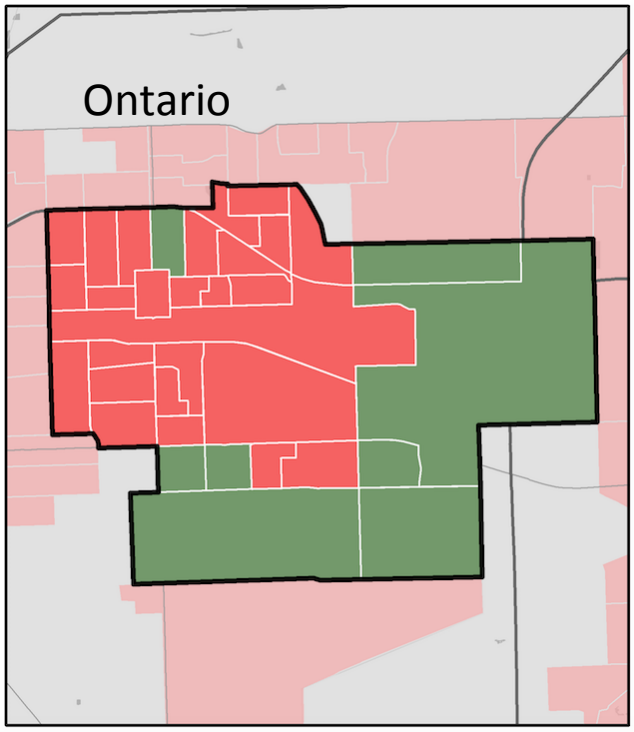
Activities for this task include:

- Develop a draft project monitoring plan
- Meet with DWR to discuss the draft plan
- Finalize and submit a project monitoring plan

Deliverables: submission of final project monitoring plan.

Ontario Project Work Plan Tasks

Our third deployment site is the City of Ontario. Ontario has a population of 167,275 people and its proportion of disadvantaged communities (DAC) by area is 47.8%. There are 29,000 households eligible for the WaterSmart technology. Of these, the SWES project will cover the costs of deployment to 10,150 households (35% of eligible households). Provided WaterSmart generates the same household water savings that it has demonstrated in other communities (i.e. average of 5% reduction in water use) across all household end-uses, we expect to secure lifetime savings of 350 MG of water; 17,127 MWh of energy; and 3,435 metric tons CO_2e of GHGs.



Map 1. City of Ontario territory divided in red DAC census tracts (CES score of >76% percentile or higher) and green non-DAC census tracts

We anticipate that the City of Ontario will match our investment in WaterSmart to extend coverage to 70% of total eligible households, though this match funding is not required for the success of the project nor to meet the estimated water, energy, and GHG savings as provided above. In fact, if the matching funding is approved by the Ontario City Council, then the anticipated savings provided above would *double* at no additional cost to DWR.

Task 1: Direct Project Administration and Reporting

This task includes management of the grant agreement in compliance with grant requirements, and communication and coordination with other project partners including the Grantor, the CA Department of Water Resources (DWR).

CWEE will be responsible for managing the grant agreement. CWEE will aim to hold quarterly meetings (by phone or in person) with WaterSmart and DWR to ensure that all parties are satisfied with project progress in terms of both approach and execution. We will also submit invoices to DWR on a quarterly basis that provide a brief explanation of project outcomes over the reporting period. Finally, we will draft, share, review, and complete a final project report in advance of the project end date.

Activities for this task include:

- Project meetings and coordination between CWEE, WaterSmart, and DWR
- Progress Reports and Invoicing
- Draft and Final Project Report

Deliverables: project partner meetings, preparation of invoices, submission of project reports, submission of final report, and other management deliverables as required.

Task 2: Design WaterSmart Hot Water Messaging Content

This task involves adapting the WaterSmart technology to increase home water-energy savings through messages that specifically target hot water conservation.

CWEE will work with WaterSmart to research and develop new consumer behavior-based messaging that specifically targets hot water conservation (see Figure 2). Some options that will be considered, include: 1) informational messages informing the consumer of conservation actions that will save water, energy, and money (*e.g. If your family of 4 reduced your shower time by 3 minutes each, you could save 17,520 gallons, 171 therms and $180 annually*), and 2) messages incentivizing hot water conservation through rebates (*e.g. Hand washing dishes uses six times more water and twice the energy as running a full dishwasher. Rebates are available for purchasing a new efficient dishwasher*). Our hot water messaging content will be reviewed and updated at the beginning of each project year for inclusion in the following year's set of Home Water Reports.

Figure 2. Prototype customer messaging for residential hot water conservation.

Activities for this task include:

- Development of a library of hot water conservation messaging content including supporting water and energy calculations, research, and development of figures and photos
- Exploration of rebate messaging on hot water-related water devices (e.g. efficient showerheads) to potentially increase the participation in existing programs in the service territory
- Cooperation with WaterSmart to integrate hot water messaging into existing home water report design and web portal

Deliverables: development of new content for targeted hot water messaging, integration of these messages into a new package of WaterSmart Home Water Reports, and incorporation of the content into the WaterSmart software platform

Task 3: Randomized Deployment of WaterSmart Software

This task involves the design and deployment of a randomized control trial to test the impact of WaterSmart Software on household water and water-related energy use.

CWEE will apply an RCT methodology for testing the effectiveness of WaterSmart to consistently deliver water and energy resource savings over the three-year project study. This approach involves randomly dividing the target population into treatment and control groups. More specifically, CWEE and

WaterSmart will design, deploy, and analyze two different treatments and one control group in a randomized control trial:

7. Treatment #1: "Standard" Home Water Report (deployment of WaterSmart technology as it currently exists)
8. Treatment #2: "Hot Water" Home Water Reports (enhancing the standard WaterSmart report with additional, targeted hot water messaging)
9. Control Group (no treatment at all)

By randomly assigning all households in the study to either the control group or either of the two treatment groups, CWEE will be able to identify the impact of the traditional home water report on residential water and energy use, as well as the marginal value of additional hot-water messaging on customer resource conservation.

Activities for this task include:

- Collection of Ontario water and energy customer data to ensure randomization across diverse customer classes.
- Designing the randomized control trial (randomly assigning households into the two treatment groups and one control group)
- Deployment of the WaterSmart technology to randomized households

Deliverables: Data-driven randomization of Ontario households for WaterSmart treatments, deployment of the WaterSmart to selected households.

Task 4: Data platform for integrating Ontario water-energy data – infrastructure and residential systems

Task 4 involves establishing an integrating data platform for ongoing monitoring of water and energy flows through the network over the life of the project

A major challenge to designing and evaluating joint water-energy programs is efficiently organizing the data from water and energy systems at multiple scales, e.g the infrastructure and the residential scale. To streamline data management over the life of the SWES project, CWEE will build a data platform that will integrate both infrastructure and customer data from multiple sources as shown in Figure 3. While we will build this platform to specifically meet the objectives of the SWES project, once the data is aligned, our tool will allow the Ontario water agency to pursue additional operational objectives, such as water balance-based leak loss detection and pump efficiency monitoring. CWEE has developed an early version of this platform through existing research efforts, and we believe it will be especially useful to meet the SWES project objectives of analyzing the full life-cycle energy savings of behavior-based residential water conservation.

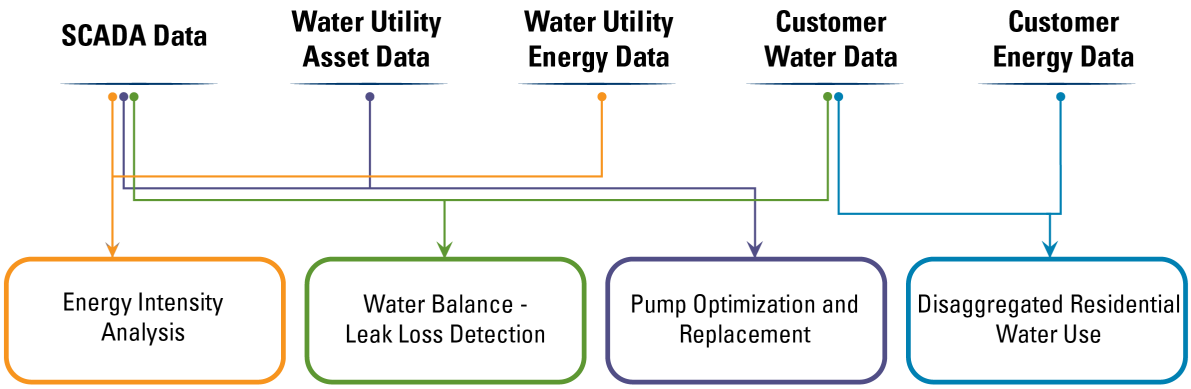


Figure 3. Integrated Data Platform for Water-Energy Analytics and Monitoring

Activities for this task include:

- Collection of relevant water, wastewater, and energy data from Ontario, Southern California Edison (SCE) and the Southern CA Gas Company (SCG)
- Design and development of integrated data platform to manage all data for the SWES Project
- Elaboration of a protocol for regular data transfers between Ontario, SCE, SCG and CWEE to enable "live" updating of database

Deliverables: advanced database of Ontario water and energy data that integrates data across multiple scales, data agreements that ensure streamlined delivery of data form project partners, "live" updating of database with available data over the life of the project

Task 5: Application for Estimating Energy Intensity of the Ontario Water and Wastewater Systems

The purpose of this task is to calculate energy intensity of the Ontario water and wastewater infrastructure systems to determine exactly how much system energy is saved when water is conserved.

CWEE will build an analytical tool onto the database platform described in Task 4 to estimate water infrastructure energy intensity at a highly granular spatial and temporal resolution (see Figure 4 for example results from a previous CWEE project with the Otay Water District). For Ontario, we will calculate energy intensity at a monthly resolution (and even hourly resolution if data is available) and at the geographic scale of the pressure zone. Energy intensity will be calculated for both the water and wastewater systems in Ontario. The web-based tool will be made available to all project partners and will be updated regularly based on regular data transfers from Ontario, SCE and SCG as described in Task 4.

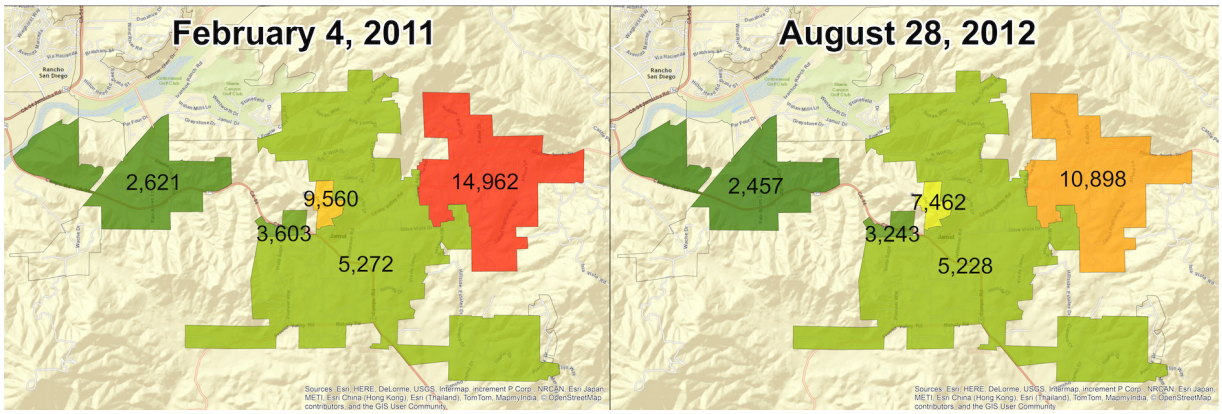


Figure 4. Time-specific mapping of pressure zone energy intensity values within the Otay Water District. Values are provided in kWh/MG.

Activities for this task include:

- Review and mapping of water distribution and wastewater collection service networks;
- Historical and ongoing high-resolution calculation of energy intensity for water treatment and delivery;
- Historical and ongoing high-resolution of energy intensity for wastewater collection/treatment.

Deliverables: seasonal and spatial energy intensity characterizations of water and wastewater systems; web-based tool to explore energy intensity results at multiple spatial and temporal scales.

Task 6: Monitoring and Verification of Water-Energy Reductions from WaterSmart Deployment

This task involves analyzing the effectiveness of the WaterSmart deployment in reducing household hot water use and reductions in energy associated with water use.

We will work with the water and energy utility providers in Ontario to establish a protocol for ongoing data transfers to regularly monitor (e.g. on a monthly or quarterly basis) the water, wastewater and energy flows through the service territory and at the customer meters. Based on the RCT design, CWEE will calculate the behavior-driven water, hot water, and water-energy savings for the two treatment groups relative to the control group. The analysis will include a retrospective analysis of water and energy use by residential customers in the study area before and after technology deployment, and between the treatment and control group households. Finally, based on the infrastructure energy intensity calculations produced in Task 5, we will estimate the impact of the verified household water savings on the associated water and wastewater energy consumption.

Activities for this task include:

- Collect and organize the water, electricity and gas data for the residences involved in the RCT.
- Evaluate the data to detect the signals of water, gas, and electricity reductions observed from the WaterSmart technology deployment, including:
    - Total water savings in the households in each of the two treatment groups relative to the control group;
    - Total energy savings (gas and electric) in the households in each of the two treatment groups relative to the control group;
    - And, total water infrastructure energy savings (water and wastewater systems) secured through verified reductions of residential water consumption.

Deliverables: detailed summary of findings (data and analysis)

Task 7: Proposal Monitoring Plan

This task involves preparation of the Proposal Monitoring Plan, to be approved by DWR.

CWEE will further develop the general plan for proposal monitoring (as described in Attachment 6 of the grant application and incorporating Tasks 5 and 6 above) and work with DWR to solidify the plan.

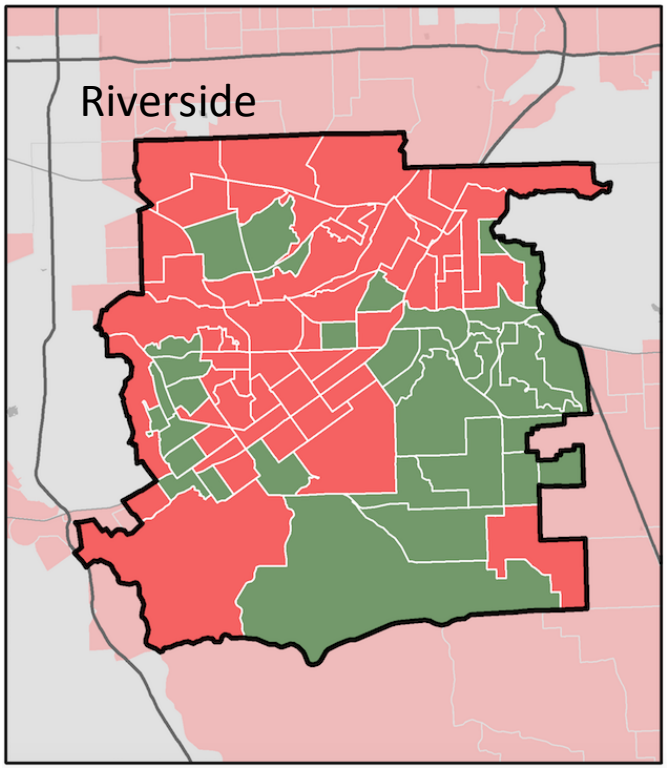
Activities for this task include:

- Develop a draft project monitoring plan
- Meet with DWR to discuss the draft plan
- Finalize and submit a project monitoring plan

Deliverables: submission of final project monitoring plan.

Riverside Project Work Plan Tasks

Our forth deployment site is the City of Riverside. Riverside has a population of 426,025 people and its proportion of disadvantaged communities (DAC) by area is 57.7%. There are 56,000 households eligible for the WaterSmart technology. Of these, the SWES project will cover the costs of deployment to 19,600 households (35% of eligible households). Provided WaterSmart generates the same household water savings that it has demonstrated in other communities (i.e. average of 5% reduction in water use) across all household end-uses, we expect to secure lifetime savings of 645 MG of water; 30,811 MWh of energy; and 6,077 metric tons CO_2e of GHGs.



Map 1. City of Riverside territory divided in red DAC census tracts (CES score of >76% percentile or higher) and green non-DAC census tracts

We anticipate that the City of Riverside will match our investment in WaterSmart to extend coverage to 70% of total eligible households, though this match funding is not required for the success of the project nor to meet the estimated water, energy, and GHG savings as provided above. In fact, if the matching funding is approved by the Riverside City Council, then the anticipated savings provided above would *double* at no additional cost to DWR.

Task 1: Direct Project Administration and Reporting

This task includes management of the grant agreement in compliance with grant requirements, and communication and coordination with other project partners including the Grantor, the CA Department of Water Resources (DWR).

CWEE will be responsible for managing the grant agreement. CWEE will aim to hold quarterly meetings (by phone or in person) with WaterSmart and DWR to ensure that all parties are satisfied with project progress in terms of both approach and execution. We will also submit invoices to DWR on a quarterly

basis that provide a brief explanation of project outcomes over the reporting period. Finally, we will draft, share, review, and complete a final project report in advance of the project end date.

Activities for this task include:

- Project meetings and coordination between CWEE, WaterSmart, and DWR
- Progress Reports and Invoicing
- Draft and Final Project Report

Deliverables: project partner meetings, preparation of invoices, submission of project reports, submission of final report, and other management deliverables as required.

Task 2: Design WaterSmart Hot Water Messaging Content

This task involves adapting the WaterSmart technology to increase home water-energy savings through messages that specifically target hot water conservation.

CWEE will work with WaterSmart to research and develop new consumer behavior-based messaging that specifically targets hot water conservation (see Figure 2). Some options that will be considered, include: 1) informational messages informing the consumer of conservation actions that will save water, energy, and money (*e.g. If your family of 4 reduced your shower time by 3 minutes each, you could save 17,520 gallons, 171 therms and $180 annually*), and 2) messages incentivizing hot water conservation through rebates (*e.g. Hand washing dishes uses six times more water and twice the energy as running a full dishwasher. Rebates are available for purchasing a new efficient dishwasher*). Our hot water messaging content will be reviewed and updated at the beginning of each project year for inclusion in the following year's set of Home Water Reports.

Figure 2. Prototype customer messaging for residential hot water conservation.

Activities for this task include:

- Development of a library of hot water conservation messaging content including supporting water and energy calculations, research, and development of figures and photos
- Exploration of rebate messaging on hot water-related water devices (e.g. efficient showerheads) to potentially increase the participation in existing programs in the service territory
- Cooperation with WaterSmart to integrate hot water messaging into existing home water report design and web portal

Deliverables: development of new content for targeted hot water messaging, integration of these messages into a new package of WaterSmart Home Water Reports, and incorporation of the content into the WaterSmart software platform

Task 3: Randomized Deployment of WaterSmart Software

This task involves the design and deployment of a randomized control trial to test the impact of WaterSmart Software on household water and water-related energy use.

CWEE will apply an RCT methodology for testing the effectiveness of WaterSmart to consistently deliver water and energy resource savings over the three-year project study. This approach involves randomly dividing the target population into treatment and control groups. More specifically, CWEE and WaterSmart will design, deploy, and analyze two different treatments and one control group in a randomized control trial:

10. Treatment #1: "Standard" Home Water Report (deployment of WaterSmart technology as it currently exists)
11. Treatment #2: "Hot Water" Home Water Reports (enhancing the standard WaterSmart report with additional, targeted hot water messaging)
12. Control Group (no treatment at all)

By randomly assigning all households in the study to either the control group or either of the two treatment groups, CWEE will be able to identify the impact of the traditional home water report on residential water and energy use, as well as the marginal value of additional hot-water messaging on customer resource conservation.

Activities for this task include:

- Collection of Riverside water and energy customer data to ensure randomization across diverse customer classes.
- Designing the randomized control trial (randomly assigning households into the two treatment groups and one control group)
- Deployment of the WaterSmart technology to randomized households

Deliverables: Data-driven randomization of Riverside households for WaterSmart treatments, deployment of the WaterSmart to selected households.

Task 4: Data platform for integrating Riverside water-energy data – infrastructure and residential systems

Task 4 involves establishing an integrating data platform for ongoing monitoring of water and energy flows through the network over the life of the project

A major challenge to designing and evaluating joint water-energy programs is efficiently organizing the data from water and energy systems at multiple scales, e.g the infrastructure and the residential scale. To streamline data management over the life of the SWES project, CWEE will build a data platform that will integrate both infrastructure and customer data from multiple sources as shown in Figure 3. While we will build this platform to specifically meet the objectives of the SWES project, once the data is aligned, our tool will allow the Riverside water agency to pursue additional operational objectives, such as water balance-based leak loss detection and pump efficiency monitoring. CWEE has developed an early version of this platform through existing research efforts, and we believe it will be especially useful to meet the SWES project objectives of analyzing the full life-cycle energy savings of behavior-based residential water conservation.

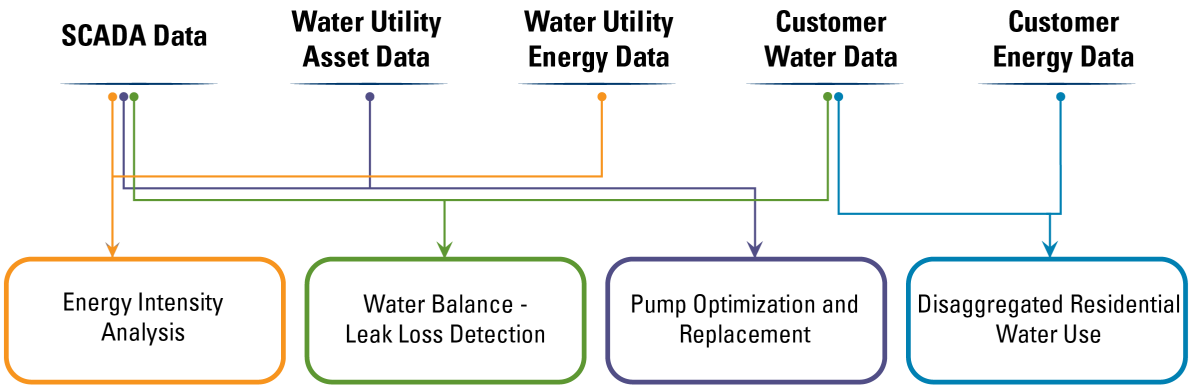


Figure 3. Integrated Data Platform for Water-Energy Analytics and Monitoring

Activities for this task include:

- Collection of relevant water, wastewater, and energy data from Riverside, Southern California Edison (SCE), and the Southern CA Gas Company (SCG)
- Design and development of integrated data platform to manage all data for the SWES Project
- Elaboration of a protocol for regular data transfers between Riverside, SCE, SCG, and CWEE to enable "live" updating of database

Deliverables: advanced database of Riverside water and energy data that integrates data across multiple scales, data agreements that ensure streamlined delivery of data form project partners, "live" updating of database with available data over the life of the project

Task 5: Application for Estimating Energy Intensity of the Riverside Water and Wastewater Systems

The purpose of this task is to calculate energy intensity of the Riverside water and wastewater infrastructure systems to determine exactly how much system energy is saved when water is conserved.

CWEE will build an analytical tool onto the database platform described in Task 4 to estimate water infrastructure energy intensity at a highly granular spatial and temporal resolution (see Figure 4 for example results from a previous CWEE project with the Otay Water District). For Riverside, we will calculate energy intensity at a monthly resolution (and even hourly resolution if data is available) and at the geographic scale of the pressure zone. Energy intensity will be calculated for both the water and wastewater systems in Riverside. The web-based tool will be made available to all project partners and will be updated regularly based on regular data transfers from Riverside, SCE and SCG as described in Task 4.

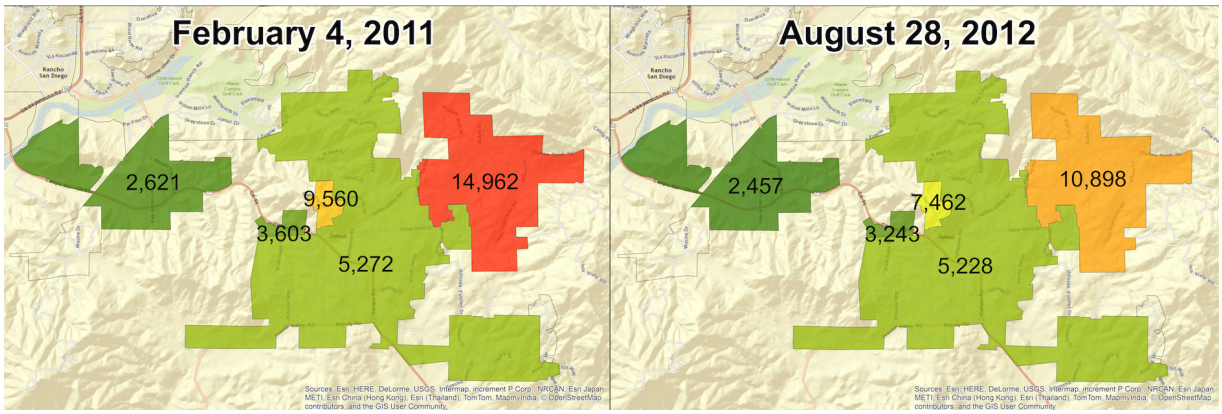


Figure 4. Time-specific mapping of pressure zone energy intensity values within the Otay Water District. Values are provided in kWh/MG.

Activities for this task include:

- Review and mapping of water distribution and wastewater collection service networks;
- Historical and ongoing high-resolution calculation of energy intensity for water treatment and delivery;
- Historical and ongoing high-resolution of energy intensity for wastewater collection/treatment.

Deliverables: seasonal and spatial energy intensity characterizations of water and wastewater systems; web-based tool to explore energy intensity results at multiple spatial and temporal scales.

Task 6: Monitoring and Verification of Water-Energy Reductions from WaterSmart Deployment

This task involves analyzing the effectiveness of the WaterSmart deployment in reducing household hot water use and reductions in energy associated with water use.

We will work with the water and energy utility providers in Riverside to establish a protocol for ongoing data transfers to regularly monitor (e.g. on a monthly or quarterly basis) the water, wastewater and energy flows through the service territory and at the customer meters. Based on the RCT design, CWEE will calculate the behavior-driven water, hot water, and water-energy savings for the two treatment groups relative to the control group. The analysis will include a retrospective analysis of water and energy use by residential customers in the study area before and after technology deployment, and between the treatment and control group households. Finally, based on the infrastructure energy intensity calculations produced in Task 5, we will estimate the impact of the verified household water savings on the associated water and wastewater energy consumption.

Activities for this task include:

- Collect and organize the water, electricity and gas data for the residences involved in the RCT.
- Evaluate the data to detect the signals of water, gas, and electricity reductions observed from the WaterSmart technology deployment, including:
    - Total water savings in the households in each of the two treatment groups relative to the control group;
    - Total energy savings (gas and electric) in the households in each of the two treatment groups relative to the control group;
    - And, total water infrastructure energy savings (water and wastewater systems) secured through verified reductions of residential water consumption.

Deliverables: detailed summary of findings (data and analysis)

Task 7: Proposal Monitoring Plan

This task involves preparation of the Proposal Monitoring Plan, to be approved by DWR.

CWEE will further develop the general plan for proposal monitoring (as described in Attachment 6 of the grant application and incorporating Tasks 5 and 6 above) and work with DWR to solidify the plan.

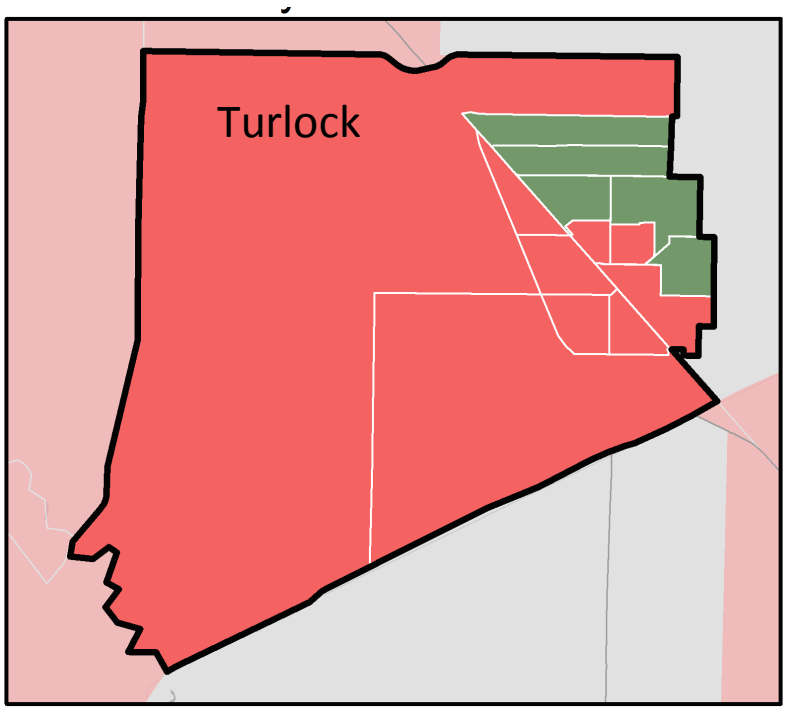
Activities for this task include:

- Develop a draft project monitoring plan
- Meet with DWR to discuss the draft plan
- Finalize and submit a project monitoring plan

Deliverables: submission of final project monitoring plan.

Turlock Project Work Plan Tasks

Our fifth deployment site is the City of Turlock. Turlock has a population of 74,365 people and its proportion of disadvantaged communities (DAC) by area is 92%. There are 17,382 households eligible for the WaterSmart technology. Of these, the SWES project will cover the costs of deployment to 6,084 households (37.5% of eligible households). Provided WaterSmart generates the same household water savings that it has demonstrated in other communities (i.e. average of 5% reduction in water use) across all household end-uses, we expect to secure lifetime savings of 244 MG of water; 10,937 MWh of energy; and 2,113 metric tons CO_2e of GHGs.



Map 1. City of Turlock territory divided in red DAC census tracts (CES score of >76% percentile or higher) and green non-DAC census tracts

We anticipate that the City of Turlock will match our investment in WaterSmart to extend coverage to 70% of total eligible households, though this match funding is not required for the success of the project nor to meet the estimated water, energy, and GHG savings as provided above. In fact, if the matching funding is approved by the Turlock City Council, then the anticipated savings provided above would *double* at no additional cost to DWR.

Task 1: Direct Project Administration and Reporting

This task includes management of the grant agreement in compliance with grant requirements, and communication and coordination with other project partners including the Grantor, the CA Department of Water Resources (DWR).

CWEE will be responsible for managing the grant agreement. CWEE will aim to hold quarterly meetings (by phone or in person) with WaterSmart and DWR to ensure that all parties are satisfied with project progress in terms of both approach and execution. We will also submit invoices to DWR on a quarterly basis that provide a brief explanation of project outcomes over the reporting period. Finally, we will draft, share, review, and complete a final project report in advance of the project end date.

Activities for this task include:

- Project meetings and coordination between CWEE, WaterSmart, and DWR
- Progress Reports and Invoicing
- Draft and Final Project Report

Deliverables: project partner meetings, preparation of invoices, submission of project reports, submission of final report, and other management deliverables as required.

Task 2: Design WaterSmart Hot Water Messaging Content

This task involves adapting the WaterSmart technology to increase home water-energy savings through messages that specifically target hot water conservation.

CWEE will work with WaterSmart to research and develop new consumer behavior-based messaging that specifically targets hot water conservation (see Figure 2). Some options that will be considered, include: 1) informational messages informing the consumer of conservation actions that will save water, energy, and money (*e.g. If your family of 4 reduced your shower time by 3 minutes each, you could save 17,520 gallons, 171 therms and $180 annually*), and 2) messages incentivizing hot water conservation through rebates (*e.g. Hand washing dishes uses six times more water and twice the energy as running a full dishwasher. Rebates are available for purchasing a new efficient dishwasher*). Our hot water messaging content will be reviewed and updated at the beginning of each project year for inclusion in the following year's set of Home Water Reports.

Figure 2. Prototype customer messaging for residential hot water conservation.

Activities for this task include:

- Development of a library of hot water conservation messaging content including supporting water and energy calculations, research, and development of figures and photos
- Exploration of rebate messaging on hot water-related water devices (e.g. efficient showerheads) to potentially increase the participation in existing programs in the service territory
- Cooperation with WaterSmart to integrate hot water messaging into existing home water report design and web portal

Deliverables: development of new content for targeted hot water messaging, integration of these messages into a new package of WaterSmart Home Water Reports, and incorporation of the content into the WaterSmart software platform

Task 3: Randomized Deployment of WaterSmart Software

This task involves the design and deployment of a randomized control trial to test the impact of WaterSmart Software on household water and water-related energy use.

CWEE will apply an RCT methodology for testing the effectiveness of WaterSmart to consistently deliver water and energy resource savings over the three-year project study. This approach involves randomly dividing the target population into treatment and control groups. More specifically, CWEE and

WaterSmart will design, deploy, and analyze two different treatments and one control group in a randomized control trial:

13. Treatment #1: "Standard" Home Water Report (deployment of WaterSmart technology as it currently exists)
14. Treatment #2: "Hot Water" Home Water Reports (enhancing the standard WaterSmart report with additional, targeted hot water messaging)
15. Control Group (no treatment at all)

By randomly assigning all households in the study to either the control group or either of the two treatment groups, CWEE will be able to identify the impact of the traditional home water report on residential water and energy use, as well as the marginal value of additional hot-water messaging on customer resource conservation.

Activities for this task include:

- Collection of Turlock water and energy customer data to ensure randomization across diverse customer classes.
- Designing the randomized control trial (randomly assigning households into the two treatment groups and one control group)
- Deployment of the WaterSmart technology to randomized households

Deliverables: Data-driven randomization of Turlock households for WaterSmart treatments, deployment of the WaterSmart to selected households.

Task 4: Data platform for integrating Turlock water-energy data – infrastructure and residential systems

Task 4 involves establishing an integrating data platform for ongoing monitoring of water and energy flows through the network over the life of the project

A major challenge to designing and evaluating joint water-energy programs is efficiently organizing the data from water and energy systems at multiple scales, e.g the infrastructure and the residential scale. To streamline data management over the life of the SWES project, CWEE will build a data platform that will integrate both infrastructure and customer data from multiple sources as shown in Figure 3. While we will build this platform to specifically meet the objectives of the SWES project, once the data is aligned, our tool will allow the Turlock water agency to pursue additional operational objectives, such as water balance-based leak loss detection and pump efficiency monitoring. CWEE has developed an early version of this platform through existing research efforts, and we believe it will be especially useful to meet the SWES project objectives of analyzing the full life-cycle energy savings of behavior-based residential water conservation.

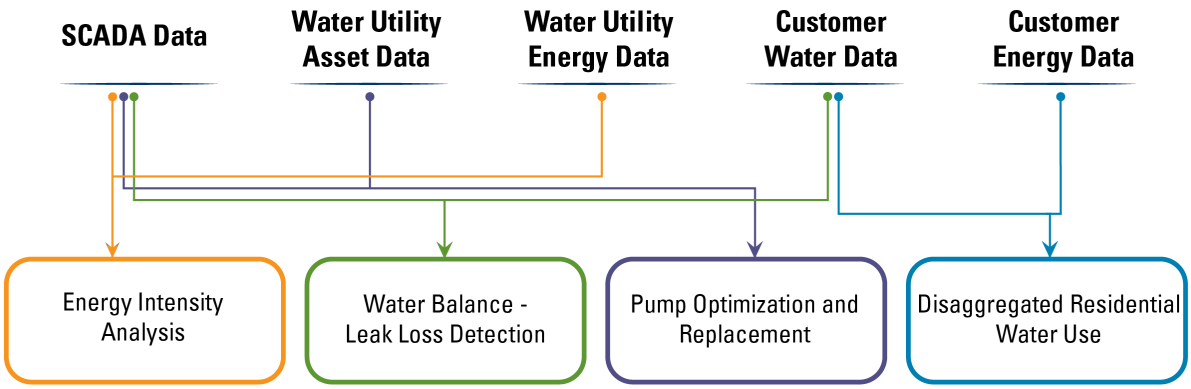


Figure 3. Integrated Data Platform for Water-Energy Analytics and Monitoring

Activities for this task include:

- Collection of relevant water, wastewater, and energy data from Turlock, the Turlock Irrigation District (TID) and PG&E.
- Design and development of integrated data platform to manage all data for the SWES Project
- Elaboration of a protocol for regular data transfers between Turlock, TID, PG&E and CWEE to enable "live" updating of database

Deliverables: advanced database of Turlock water and energy data that integrates data across multiple scales, data agreements that ensure streamlined delivery of data form project partners, "live" updating of database with available data over the life of the project

Task 5: Application for Estimating Energy Intensity of the Turlock Water and Wastewater Systems

The purpose of this task is to calculate energy intensity of the Turlock water and wastewater infrastructure systems to determine exactly how much system energy is saved when water is conserved.

CWEE will build an analytical tool onto the database platform described in Task 4 to estimate water infrastructure energy intensity at a highly granular spatial and temporal resolution (see Figure 4 for example results from a previous CWEE project with the Otay Water District). For Turlock, we will calculate energy intensity at a monthly resolution (and even hourly resolution if data is available) and at the geographic scale of the pressure zone. Energy intensity will be calculated for both the water and wastewater systems in Turlock. The web-based tool will be made available to all project partners and will be updated regularly based on regular data transfers from Turlock, TID and PG&E as described in Task 4.

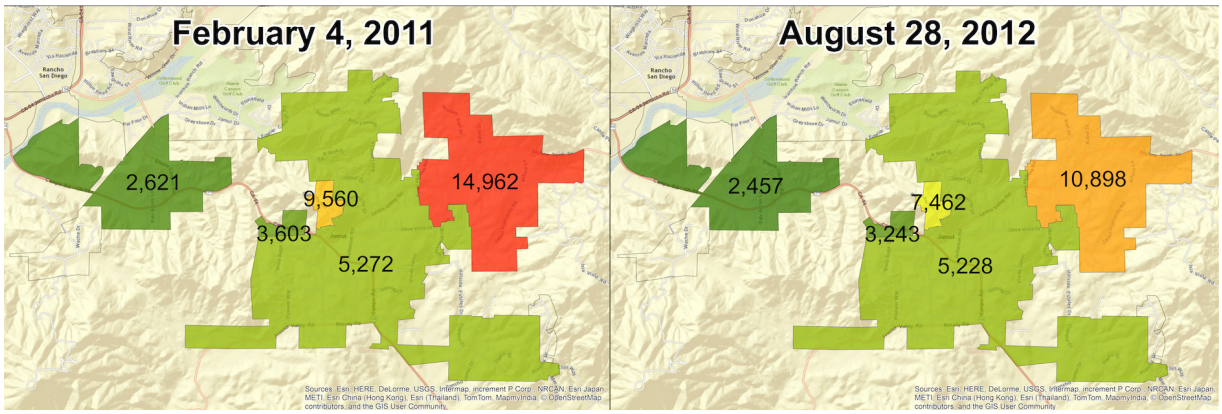


Figure 4. Time-specific mapping of pressure zone energy intensity values within the Otay Water District. Values are provided in kWh/MG.

Activities for this task include:

- Review and mapping of water distribution and wastewater collection service networks;
- Historical and ongoing high-resolution calculation of energy intensity for water treatment and delivery;
- Historical and ongoing high-resolution of energy intensity for wastewater collection/treatment.

Deliverables: seasonal and spatial energy intensity characterizations of water and wastewater systems; web-based tool to explore energy intensity results at multiple spatial and temporal scales.

Task 6: Monitoring and Verification of Water-Energy Reductions from WaterSmart Deployment

This task involves analyzing the effectiveness of the WaterSmart deployment in reducing household hot water use and reductions in energy associated with water use.

We will work with the water and energy utility providers in Turlock to establish a protocol for ongoing data transfers to regularly monitor (e.g. on a monthly or quarterly basis) the water, wastewater and energy flows through the service territory and at the customer meters. Based on the RCT design, CWEE will calculate the behavior-driven water, hot water, and water-energy savings for the two treatment groups relative to the control group. The analysis will include a retrospective analysis of water and energy use by residential customers in the study area before and after technology deployment, and between the treatment and control group households. Finally, based on the infrastructure energy intensity calculations produced in Task 5, we will estimate the impact of the verified household water savings on the associated water and wastewater energy consumption.

Activities for this task include:

- Collect and organize the water, electricity and gas data for the residences involved in the RCT.
- Evaluate the data to detect the signals of water, gas, and electricity reductions observed from the WaterSmart technology deployment, including:
    - Total water savings in the households in each of the two treatment groups relative to the control group;
    - Total energy savings (gas and electric) in the households in each of the two treatment groups relative to the control group;
    - And, total water infrastructure energy savings (water and wastewater systems) secured through verified reductions of residential water consumption.

Deliverables: detailed summary of findings (data and analysis)

Task 7: Proposal Monitoring Plan

This task involves preparation of the Proposal Monitoring Plan, to be approved by DWR.

CWEE will further develop the general plan for proposal monitoring (as described in Attachment 6 of the grant application and incorporating Tasks 5 and 6 above) and work with DWR to solidify the plan.

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Deliverables: submission of final project monitoring plan.