COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Last Updated: July 2017

Colorado Water Conservation Board

Water Plan Grant Application

Instructions

To receive funding for a Water Plan Grant, applicant must demonstrate how the project, activity, or process (collectively referred to as "project") funded by the CWCB will help meet the measurable objectives and critical actions in the Water Plan. Grant guidelines are available on the CWCB website.

If you have questions, please contact CWCB at (303) 866-3441 or email the following staff to assist you with applications in the following areas:

Supply and Demand Gap Projects	Gregory.Johnson@state.co.us
Water Storage Projects	Anna.Mauss@state.co.us
Conservation, Land Use Planning	Kevin.Reidy@state.co.us
Engagement & Innovation Activities	Ben.Wade@state.co.us
Agricultural Projects	Brent.Newman@state.co.us
Environmental & Recreation Projects	Linda.Bassi@state.co.us

Applicants interested in submitting an 'Intent to Apply' in the future are encouraged to check here ☐ and fill in all sections with the best information available at the time. Exhibits may be excluded.

This "Intent to Apply" will help CWCB prioritize Projects that are not ready for fully completed Water Plan Grant Application due to the initial timeframe and required deadlines.

FINAL SUBMISSION: Submit all application materials to *waterplan.grants@state.co.us* in the original file formats [Application (word); Statement of Work (word); Budget/Schedule (excel)]. Please do not combine documents.

Water Project Summary

Name of Applicant	Denver South Transportation Management Association (Denver South TMA)
Name of Water Project	InfraRed Plant Stress Monitoring Pilot

CWP Grant Request Amount	$ 19,350
Other Funding Sources _____	$
Other Funding Sources _____	$
Other Funding Sources _____	$
Applicant Funding Contribution	$ 19,350
Total Project Cost	$ 38,700

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Applicant & Grantee Information	
Name of Grantee(s)	Denver South TMA
Mailing Address	304 Inverness Way S #315, Englewood, CO 80112
FEIN	20-0833060
Organization Contact	Daniel Hutton
Position/Title	Managing Director
Email	daniel@denversouthedp.org
Phone	303.531.8376
Grant Management Contact	Bob Howey
Position/Title	Principal, Irrigation Analysis LLC (contractor and representing agent)
Email	bhowey@irrigationanalysis.com
Phone	303.726.1952
Name of Applicant (if different than grantee)	
Mailing Address	
Position/Title	
Email	
Phone	

Description of Grantee/Applicant
Provide a brief description of the grantee's organization (100 words or less).
The Denver South TMA, a 30-year-old, non-profit public-private partnership, serves as the South I-25 Corridor's connective tissue, encouraging thought leadership and multi-jurisdictional collaboration to build on the region's position as a leading economic engine for Colorado's economy. Its stakeholders include Arapahoe and Douglas Counties and the cities of Centennial, Denver, Greenwood Village and Lone Tree. The organization provides guidance on public policy and regional planning as well as match funding through its partnership with the Southeast Public Improvement Metropolitan District (SPIMD). It is also responsible for landscaping and landscape maintenance for the major interchange areas along the South I-25 Corridor.

Type of Eligible Entity (check one)	
	Public (Government): Municipalities, enterprises, counties, and State of Colorado agencies. Federal agencies are encouraged to work with local entities. Federal agencies are eligible, but only if they can make a compelling case for why a local partner cannot be the grant recipient.
	Public (Districts): Authorities, Title 32/special districts (conservancy, conservation, and irrigation districts), and water activity enterprises.
	Private Incorporated: Mutual ditch companies, homeowners associations, corporations.

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Type of Eligible Entity (check one)	
	Private Individuals, Partnerships, and Sole Proprietors: Private parties may be eligible for funding.
X	**Non-governmental organizations (NGO):** Organization that is not part of the government and is non-profit in nature.
	Covered Entity: As defined in Section 37-60-126 Colorado Revised Statutes.

Type of Water Project (check all that apply)	
	Study
X	Construction
	Identified Projects and Processes (IPP)
X	Other - Pilot

Category of Water Project (check all that apply and include relevant tasks)		
	Supply and Demand Gap - Multi-beneficial projects and those projects identified in basin implementation plans to address the water supply and demand gap. *Applicable Exhibit A Task(s):*	
	Water Storage - Projects that facilitate the development of additional storage, artificial aquifer recharge, and dredging existing reservoirs to restore the reservoirs' full decreed capacity. *Applicable Exhibit A Task(s):*	
	Conservation and Land Use Planning - Activities and projects that implement long-term strategies for conservation, land use, and drought planning. *Applicable Exhibit A Task(s):*	
X	Engagement & Innovation - Activities and projects that support water education, outreach, and innovation efforts. Please fill out the Supplemental Application on the website. *Applicable Exhibit A Task(s):*	
	Agricultural - Projects that provide technical assistance and improve agricultural efficiency. *Applicable Exhibit A Task(s):*	
	Environmental & Recreation - Projects that promote watershed health, environmental health, and recreation. *Applicable Exhibit A Task(s):*	
	Other	Explain:

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Location of Water Project	
Please provide the general county and coordinates of the proposed project below in **decimal degrees**. The Applicant shall also provide, in Exhibit C, a site map if applicable.	
County/Counties	Greenwood Village/Arapahoe
Latitude	39.59430555555556
Longitude	-104.88351111111115

Water Project Overview

Please provide a summary of the proposed water project (200 words or less). Include a description of the project and what the CWP Grant funding will be used for specifically (e.g., studies, permitting process, construction). Provide a description of the water supply source to be utilized or the water body affected by the project, where applicable. Include details such as acres under irrigation, types of crops irrigated, number of residential and commercial taps, length of ditch improvements, length of pipe installed, and area of habitat improvements, where applicable. If this project addresses multiple purposes or spans multiple basins, please explain.
The Applicant shall also provide, in Exhibit A, a detailed Statement of Work, Budget, Other Funding Sources/Amounts and Schedule.

The proposed project aims to pilot an infrared thermal imaging system in a suburban roadway landscape environment (please see Exhibit C for example: *Hawk-Eye System Described*). While these types of systems have been used in agricultural settings, Denver South TMA seeks to test this model at the southeast landscaping quadrant of the Arapahoe Rd & I25 Interchange, which is slated for reconstruction completion in July 2018.

This will be a first-of-its-kind application using visual and thermal imaging to measure plant stress, analyze data patterns and assist in decision making to ensure maximum water use efficiency. Denver South TMA is the only regional organization of its kind responsible for landscaping and landscape maintenance along CDOT controlled right-of-way (ROW). If successful, this pilot could impact water use efficiency in similar settings, such as other public ROW throughout Colorado's roadway system, suburban office parks and other environments that require irrigation to support mixed vegetation.

Denver Water is the water provider at this location and all irrigation originates from one commercial tap. The area includes approximately one acre for irrigation and types of crops include native seed, sod, shrubs and assorted deciduous and evergreen trees. The location(s) of the camera may also be changed.

Measurable Results	
To catalog measurable results achieved with the CWP Grant funds, please provide any of the following values as applicable:	
	New Storage Created (acre-feet)
	New Annual Water Supplies Developed or Conserved (acre-feet), Consumptive or Nonconsumptive
	Existing Storage Preserved or Enhanced (acre-feet)
	Length of Stream Restored or Protected (linear feet)

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Measurable Results		
	Efficiency Savings (indicate acre-feet/year OR dollars/year)	
	Area of Restored or Preserved Habitat (acres)	
	Quantity of Water Shared through Alternative Transfer Mechanisms	
	Number of Coloradans Impacted by Incorporating Water-Saving Actions into Land Use Planning	
	Number of Coloradans Impacted by Engagement Activity	
X	Other	Explain: Full evaluation of broader impacts to be conducted throughout the course of the pilot.

Water Project Justification
Provide a description of how this water project supports the goals of Colorado's Water Plan, the most recent Statewide Water Supply Initiative, and the applicable Roundtable Basin Implementation Plan and Education Action Plan. The Applicant is required to reference specific needs, goals, themes, or Identified Projects and Processes (IPPs), including citations (e.g. document, chapters, sections, or page numbers). The proposed water project shall be evaluated based upon how well the proposal conforms to Colorado's Water Plan Framework for State of Colorado Support for a Water Project (CWP, Section 9.4, pp. 9-43 to 9-44;)
Relating to the Colorado Water Plan: This Grant request addresses the CWP values of an efficient and effective water infrastructure (at the end user level in this case) and the critical goal to increase Municipal Conservation and Efficiency. This Grant request encompasses an integrated and comprehensive approach for improved irrigation efficiency and reduced water use with measurable and expected water savings. This Project advances the Education, Outreach, and Innovation objectives by deploying Innovative technology to better manage and hopefully reduce water usage. The Grant will also provide education and outreach in sharing of the results and findings with water providers, CDOT, the Colorado landscape industry, and others. Relating to supporting the Metro Roundtable (MRT) Priorities: This CWCB Innovation Grant Project grant request falls within the Municipal and Industrial - Conservation and Reuse as well as the Education and Outreach priorities within keeping with Plan Element #2 of the SP-BIP to maintain leadership in Conservation and Reuse and to implement additional measures to reduce water consumption rates. This project should serve to refine and normalize projected water conservation savings through both passive and active savings. There will be a final report with the documentation of the pilot project results and findings provided to the primary parties as well as any other interested parties on request. There is also an intention to provide education and outreach to water providers, the greater Colorado landscape industry through the Associated Landscape Contractors of Colorado (ALCC), CDOT as well as other possible interested venues and avenues.

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Related Studies

Please provide a list of any related studies, including if the water project is complementary to or assists in the implementation of other CWCB programs.

Primary source of interest (comprehensive review of the current state of research):

Ishimwe, R., Abutaleb K., and Ahmed, F. (2014) Applications of Thermal Imaging in Agriculture – A Review. *Advances in Remote Sensing*, 3, 128-140.

Secondary sources of interest:

Alves, I. and Pereira, L. (2000) Non-Water-Stressed Baselines for Irrigation Scheduling with Infrared Thermometers: A New Approach. *Irrigation Science*, 19, 101-106.

Hellebrand, H., Beuche, H. and Linke, M. (2002) Thermal Imaging: A Promising High-Tec Method in Agriculture and Horticulture. In: Blahovec, J. and Kutilek, M., Eds., *Physical Methods in Agriculture*: *Approach to Precision and Quality*, Kluwer Academic/Plenum Publishers, New York, 411-427.

Leinonen, I. and Jones, H.G. (2004) Combining Thermal and Visible Imagery for Estimating Canopy Temperature and Identifying Plant Stress. *Journal of Experimental Botany Volume*, 55, 1423-1431.

Martin, E. (2009) Methods of Determining When to Irrigate. Cooperative Extension. College of Agriculture and Life Sciences, The University of Arizona, Tucson.

Prakash, A. (2000) Thermal Remote Sensing: Concepts, Issues and Applications. *International Archives of Photogrammetry and Remote Sensing*, 33, 239-243.

Previous CWCB Grants, Loans or Other Funding

List all previous or current CWCB grants (including WSRF) awarded to both the Applicant and Grantee. Include: 1) Applicant name; 2) Water activity name; 3) Approving RT(s); 4) CWCB board meeting date; 5) Contract number or purchase order; 6) Percentage of other CWCB funding for your overall project.

N/A

Taxpayer Bill of Rights

The Taxpayer Bill of Rights (TABOR) may limit the amount of grant money an entity can receive. Please describe any relevant TABOR issues that may affect your application.

N/A

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Submittal Checklist	
X	I acknowledge the Grantee will be able to contract with CWCB using the Standard Contract.
Exhibit A	
X	Statement of Work(1)
X	Budget & Schedule(1)
X	Letters of Matching and/or Pending 3rd Party Commitments(1)
Exhibit C	
X	Map (if applicable)(1)
	Photos/Drawings/Reports
X	Letters of Support (Support letter from Basin Roundtable encouraged)
X	Certificate of Insurance (General, Auto, & Workers' Comp.) (2)
X	Certificate of Good Standing with Colorado Secretary of State(2)
X	W-9(2)
	Independent Contractor Form(2) (If applicant is individual, not company/organization)
Engagement & Innovation Grant Applicants ONLY	
X	Engagement & Innovation Supplemental Application(1)

(1) Required with application.
(2) Required for contracting. While optional at the time of this application, submission can expedite contracting upon CWCB Board approval.

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Colorado Water Conservation Board

Water Plan Grant - Exhibit A

Statement Of Work	
Date:	**2/16/2018**
Name of Grantee:	**Denver South TMA**
Name of Water Project:	**InfraRed Plant Stress Monitoring Pilot**
Funding Source:	**CWCB – CWP Innovation Grant**

Water Project Overview:

The proposed project aims to pilot an infrared thermal imaging system in a suburban roadway landscape environment (please see Exhibit C for example: *Hawk-Eye System Described*). While these types of systems have been used in agricultural settings, Denver South TMA seeks to test this model at the southeast landscaping quadrant of the Arapahoe Rd & I25 Interchange, which is slated for reconstruction completion in July 2018.

This will be a first-of-its-kind application using visual and thermal imaging to measure plant stress, analyze data patterns and assist in decision making to ensure maximum water use efficiency. Denver South TMA is the only regional organization of its kind responsible for landscaping and landscape maintenance along CDOT controlled right-of-way (ROW). If successful, this pilot could impact water use efficiency in similar settings, such as other public ROW throughout Colorado's roadway system, suburban office parks and other environments that require irrigation to support mixed vegetation.

Denver Water is the water provider at this location and all irrigation originates from one commercial tap. The area includes approximately one acre for irrigation and types of crops include native seed, sod, shrubs and assorted deciduous and evergreen trees. The location(s) of the camera may also be changed.

Project Objectives:

The overall goal of this project is to pilot a novel, high-tech solution to demonstrate water use efficiency in landscaped environments such as public ROW settings. In demonstrating success at a small scale, this project would support Colorado's water innovation ecosystem by creating a replicable, saleable model that could possibly be deployed where appropriate along CDOT's 23,000 total lane miles of highway throughout the state in addition to other public and private landscapes. We hope to manage irrigation and water usage at or below the typical water usage and volume for the test area.

This pilot will allow us to remotely collect, warehouse and analyze visual and thermal imaging data. Systems such as the provided "Hawk-Eye" example will allow the organization to interface with controllers over cellular (or Wi-Fi) networks, enabling real-time data capturing through the cloud and allowing access from virtually anywhere. Data points will include real-time temperature readings, heat stress indicators, evapotranspiration rates, general weather indicators and agricultural stresses.

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Tasks
Task 1 – Complete set up and monitoring of infrared system
Description of Task:
1.1) Installation of infrared system with 320 x 240 thermal camera with pan/tilt 1.2) Installation of 25 foot pole and run power 1.3) Commissioning including: camera set up and training 1.4) Managing subscription to communications 1.5) Monitoring of camera and plant material condition 1.6) Reporting of water use
Method/Procedure: Once securing the CWCB Water Plan Innovation Grant, Denver South TMA will install, deploy and manage the infrared camera and thermal imaging system to pilot advanced detection of plant stress in an urban landscape setting. Systems such as the provided “Hawk-Eye” example will allow our organization to interface with controllers over WiFi and cellular networks, enabling real-time data capturing through the cloud and allowing access from virtually anywhere. Data points will include real-time temperature readings, heat stress indicators, evapotranspiration rates, general weather indicators and agricultural stresses. One initial hypothesis of the pilot is that targeting the smaller footprints of plants - the actual “users” of the water - should lead to use efficiency. Deploying this technology in one-two locations will allow us to validate the function/use of infrared systems in typical urban/suburban landscape settings. We will track monthly and seasonal usage data including weather adjustments. As the Arapahoe Rd & I-25 interchange landscaping reconstruction project will be complete In June-July 2018, Denver South TMA will spend the first six months of the project (July – December 2018) to collect and analyze baseline data, pairing traditional, manually collected data points with newly gathered infrared information. In 2019, Denver South TMA plans to collect monthly water use data and compare it to the actual monthly ET values with and without precipitation adjustment in for months when the camera is and then is not being used to manage and adjust the system. The quantitative and qualitative data from when the camera is and is not being used will be logged and compared for the final report. It may be desirable to extend the pilot for a second full season in 2020, but this is not included at this time.
Deliverable:

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Tasks

The results of this pilot, such as monthly and seasonal water usage data, will be shared with CWCB, other direct Grant Project supporters including: the Metro Basin Roundtable, Denver Water, South Metro Water Supply Authority, Colorado Department of Transportation (CDOT), Associated Landscape Contractors of Colorado (ALCC), South Platte Basin Roundtable and the Colorado Smart Cities Collaborative. Results and findings will include project updates and a final report. Denver South TMA will also provide presentations to these stakeholders/supporters as well as other potential interested groups or parties within the State of Colorado on request. In the sharing of this project information and data, this Innovation Grant Project will provide a valuable understanding of this infrared technology as a means to remotely managing the water use of urban landscapes and provide benefit for outdoor irrigation users of all sizes as well as to Colorado water providers and the water conservation community.

We also expect that Denver South TMA will develop at least one article for regional circulation and also possibly presentations. ALCC has already indicated and requested that they want to publish the information to their membership via the Colorado Green Magazine, the on-line Colorado Green Now, and via Social Media. ALCC is a very strategically important organization to have interested in and backing this work as they are influential in the landscape community. ALCC's membership represents the biggest, best companies and a majority of the landscapers in the State.

Budget and Schedule

This Statement of Work shall be accompanied by a combined Budget and Schedule that reflects the Tasks identified in the Statement of Work and shall be submitted to CWCB in excel format.

Reporting Requirements

Progress Reports: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of issuance of a purchase order, or the execution of a contract. The progress report shall describe the status of the tasks identified in the statement of work, including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Report: At completion of the project, the applicant shall provide the CWCB a Final Report on the applicant's letterhead that:

- Summarizes the project and how the project was completed.
- Describes any obstacles encountered, and how these obstacles were overcome.
- Confirms that all matching commitments have been fulfilled.
- Includes photographs, summaries of meetings and engineering reports/designs.

The CWCB will pay out the last 10% of the budget when the Final Report is completed to the satisfaction of CWCB staff. Once the Final Report has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.

Last Updated: Jan 16, 2018

Payment

Payment will be made based on actual expenditures and must include invoices for all work completed. The request for payment must include a description of the work accomplished by task, an estimate of the percent completion for individual tasks and the entire Project in relation to the percentage of budget spent, identification of any major issues, and proposed or implemented corrective actions.

Project costs not covered by those or other grants, and are therefore the responsibility of the grantee, will be eligible for CWCB funds at the following percentages of project costs:

	Percent of Project Costs		
Type of Activity	Recommended Grant Funding Request	Max Grant Funding Request (All CWCB Sources)	Minimum Funding Match (Non-CWCB Sources)
Engineering & Construction	20%	50%	50%
Feasibility Study	50%	50%	50%
Reducing Agricultural Dry Up	50%	80%	20%
Conservation/Efficiency Methods	50%	80%	20%
Educational Efforts	50%	80%	20%
Environmental Conservation	50%	80%	20%
Watershed Improvements	50%	80%	20%
Stream Improvements	50%	80%	20%
Land Use Planning	20%	50%	50%
Recreational Projects	20%	80%	20%

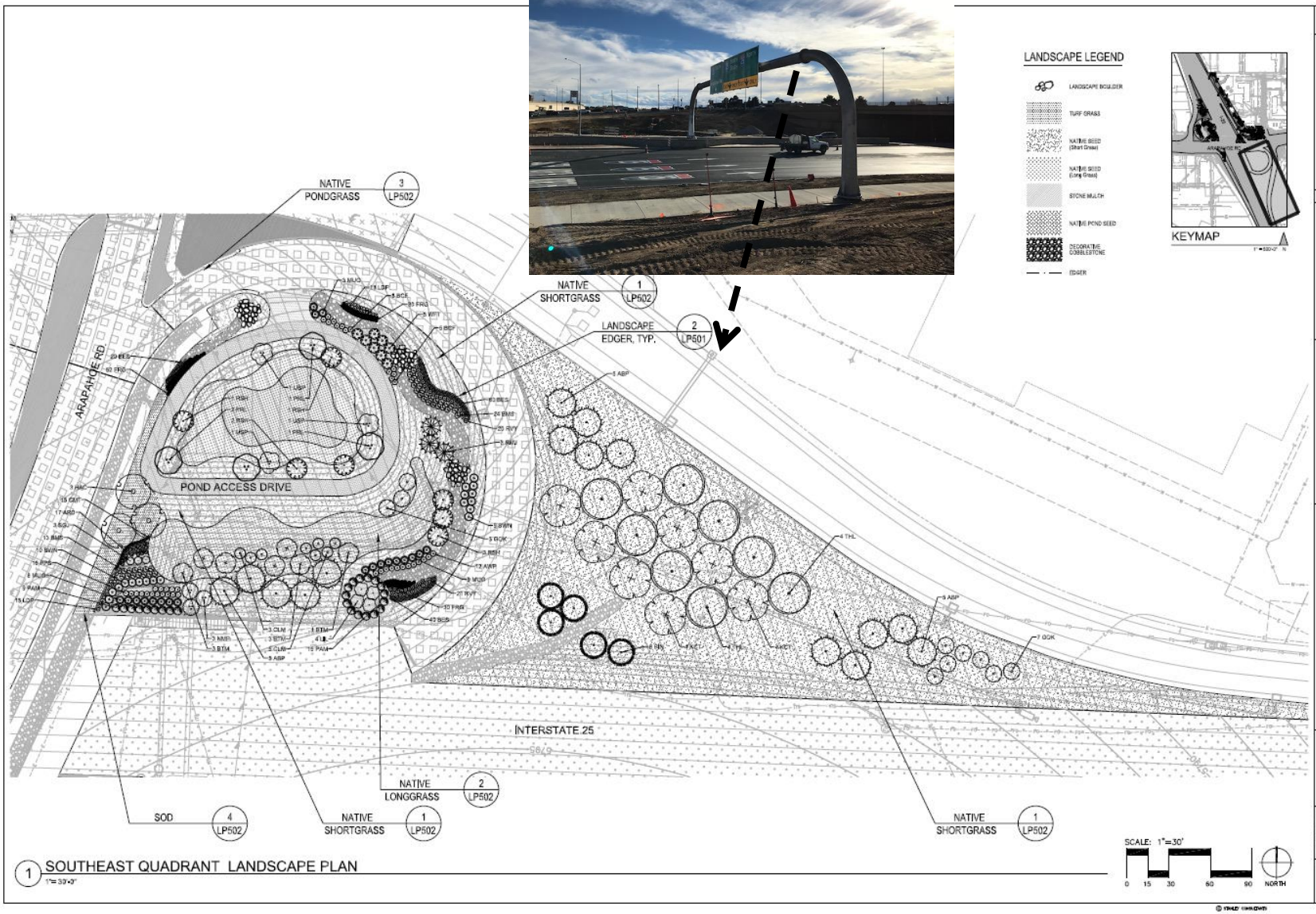
Costs incurred prior to the effective date of this contract are not reimbursable. The last 10% of the entire grant will be paid out when the final deliverable has been received. All products, data and information developed as a result of this contract must be provided to CWCB in hard copy and electronic format as part of the project documentation.

Performance Measures

Performance measures for this contract shall include the following:
(a) Performance standards and evaluation: Grantee will produce detailed deliverables for each task as specified. Grantee shall maintain receipts for all project expenses and documentation of the minimum in-kind contributions (if applicable) per the budget in Exhibit B. Per Water Plan Grant Guidelines, the CWCB will pay out the last 10% of the budget when the Final Report is completed to the satisfaction of CWCB staff. Once the Final Report has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.
(b) Accountability: Per Water Plan Grant Guidelines full documentation of project progress must be submitted with each invoice for reimbursement. Grantee must confirm that all grant conditions have been complied with on each invoice. In addition, per Water Plan Grant Guidelines, Progress Reports must be submitted at least once every 6 months. A Final Report must be submitted and approved before final project payment.
(c) Monitoring Requirements: Grantee is responsible for ongoing monitoring of project progress per Exhibit A. Progress shall be detailed in each invoice and in each Progress Report, as detailed above. Additional inspections or field consultations will be arranged as may be necessary.
(d) Noncompliance Resolution: Payment will be withheld if grantee is not current on all grant conditions. Flagrant disregard for grant conditions will result in a stop work order and cancellation of the Grant Agreement.

I-25 and E Arapahoe Centennial CO

SE Landscape



1 SOUTHEAST QUADRANT LANDSCAPE PLAN
1"= 30'-0"

Stanley Consultants INC.
Colorado Springs 80922
Colorado Springs, Suite 300
Denver, Colorado 80202
p 303.799.6606 f 303.799.8107
www.stanleyconsultants.com

I-25 & ARAPAHOE INTERCHANGE
LANDSCAPE PLANS

SOUTH DENVER TMA
304 INVERNESS DRIVE SOUTH, SITE 315
ENGLEWOOD, CO 80112

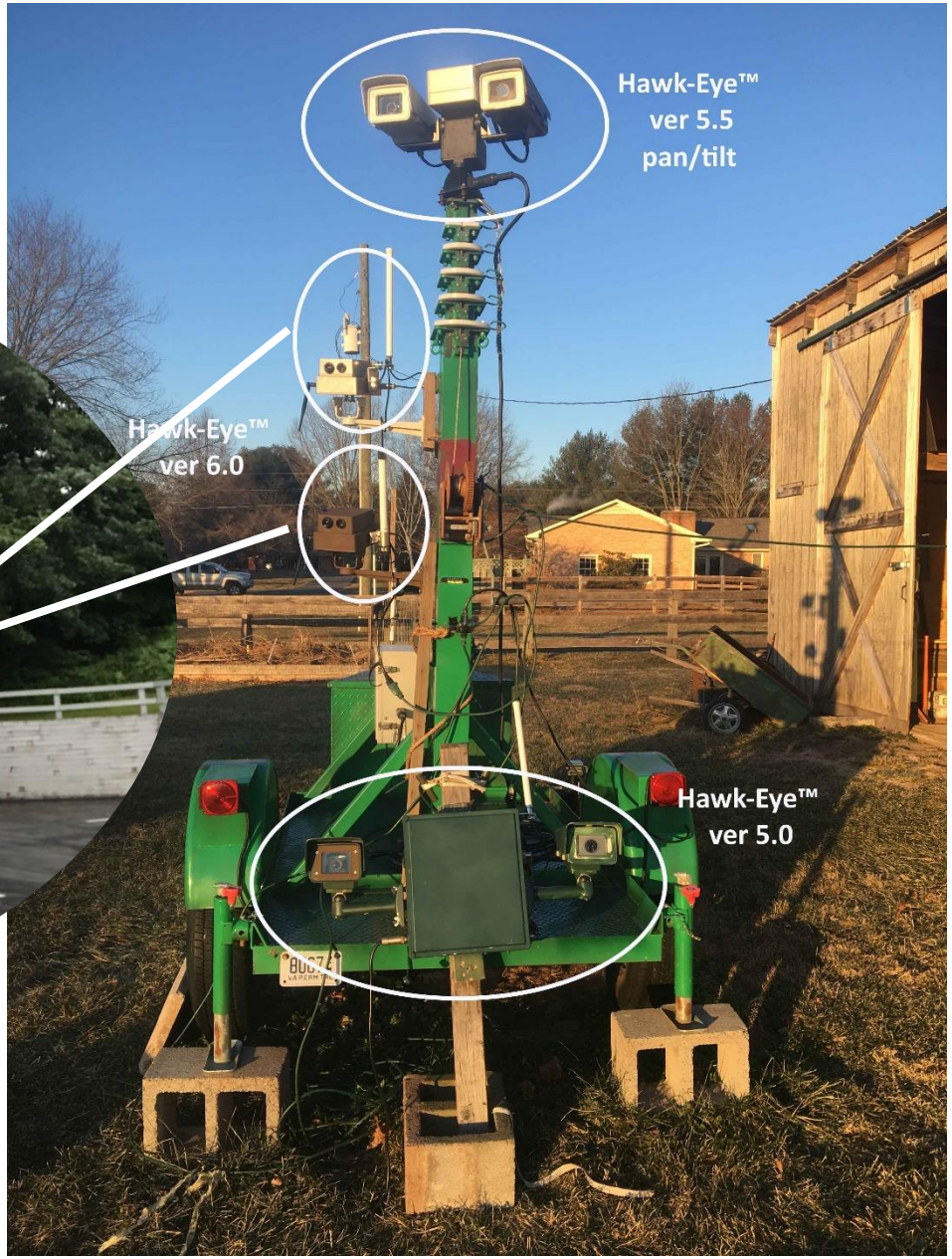
LANDSCAPE PLAN

DESIGNED: JCP
DRAWN: JCP
CHECKED: JPR
APPROVED:
APPROVED:
DATE: 19 OCT 2017
PROJ NO: 27844

LP401

Example Thermal Lens

for I-25 & E Arapahoe



COLORADO
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Colorado Water Conservation Board

Water Plan Grant - Exhibit B
Detailed Budget and Schedule

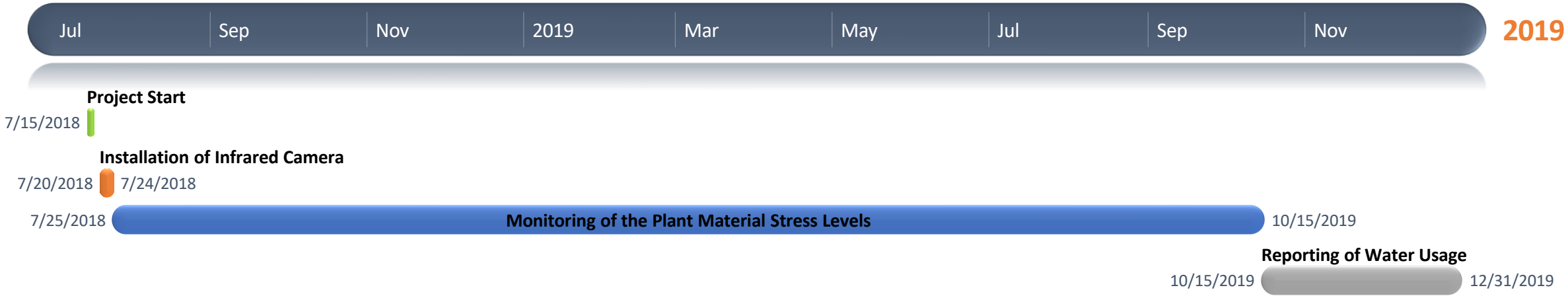
Date: February 1, 2018

Name of Applicant: Denver South TMA

Name of Water Project: InfraRed Plant Stress Monitoring Pilot

Task No.	Task Description	Hours/Qty	Rate/Cost	Grant Funding Request	Match Funding	Total
1.1	Infrared system with 320 x 240 thermal camera with pan/tilt	1	$16,530.00	$ 8,265.00	$ 8,265.00	$16,530
1.2	Install 25 foot Pole and Run Power	1	$4,850.00	$ 2,425.00	$ 2,425.00	$4,850
1.3	installation of camera including set up and training	1	$4,450.00	$ 2,225.00	$ 2,225.00	$4,450
1.4	Subscription to communications	18	$110.00	$ 990.00	$ 990.00	$1,980
1.5	Monitoring of camera and plant material condition	85	$90.00	$ 3,825.00	$ 3,825.00	$7,650
1.6	Reporting of water use	36	$90.00	$ 1,620.00	$ 1,620.00	$3,240
			Total	$19,350	$19,350	$38,700

2018 CWP Grant
Denver South Transportation Management Association
InfraRed Plant Stress Monitoring Pilot



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

ENGAGEMENT & INNOVATION GRANT FUND SUPPLEMENTAL APPLICATION

Introduction & Purpose

Colorado's Water Plan calls for an outreach, education, public engagement, and innovation grant fund in Chapter 9.5.

The overall goal of the Engagement & Innovation Grant Fund is to enhance Colorado's water communication, outreach, education, and public engagement efforts; advance Colorado's water supply planning process; and support a statewide water innovation ecosystem.

The grant fund aims to engage the public to promote well-informed community discourse regarding balanced water solutions statewide. The grant fund aims to support water innovation in Colorado. The grant fund prioritizes measuring and evaluating the success of programs, projects, and initiatives. The grant fund prioritizes efforts designed using research, data, and best practices. The grant fund prioritizes a commitment to collaboration and community engagement. The grant fund will support local and statewide efforts.

The grant fund is divided into two tracks: engagement and innovation. The Engagement Track supports education, outreach, communication, and public participation efforts related to water. The Innovation Track supports efforts that advance the water innovation ecosystem in Colorado.

Application Questions

*The grant fund request is referred to as "project" in this application.

Overview (answer for both tracks)
In a few sentences, what is the overall goal of this project? How does it achieve the stated purpose of this grant fund (above)?
The overall goal of this project is to pilot a novel, high-tech solution to demonstrate water use efficiency in landscaped environments such as public ROW settings. In demonstrating success at a small scale, this project would support Colorado's water innovation ecosystem by creating a replicable, saleable model that could be deployed along CDOT's 23,000 total lane miles of highway throughout the state in addition to other public ROW.
Who is/are the target audience(s)? How will you reach them? How will you involve the community?
The target audience includes CDOT, statewide city and county public works and maintenance staff, metropolitan districts, contract landscape maintenance firms and other organizations responsible for similar types of landscaped areas and landscape maintenance contracts. We would reach them through our direct contacts at the state and local government levels, through our participation in organizations such as the Colorado Municipal League and the Denver Metro Chamber of Commerce and through our social media and monthly newsletter channels. In addition, Denver South TMA is one of the founders of the Colorado Smart Cities Alliance, which the organization direct access to public, private and non-profit organizations across Colorado. *Please see "Innovation Track" below for more information regarding our involvement with the Colorado Smart Cities Alliance*.
Describe how the project is collaborative or engages a diverse group of stakeholders. Who are the partners in the project? Do you have other funding partners or sources?

Overview (answer for both tracks)
The Denver South TMA is a collaborative and interjurisdictional group by design. Our direct stakeholders include Arapahoe and Douglas Counties and the cities of Centennial, Denver, Greenwood Village and Lone Tree. We also support the transportation and mobility goals of regional small, medium and large-sized businesses and work directly with developers and property managers on important land-use and ROW decisions. We collaborate with CDOT, DRCOG and RTD and numerous other metropolitan districts throughout the corridor, including our direct partner SPIMD. While we consider all these entities partners in the Arapahoe Rd & I25 interchange reconstruction, we do not anticipate requesting additional funds from outside of our organization to implement this project.
Describe how you plan to measure and evaluate the success and impact of the project?
This pilot will allow us to remotely collect, warehouse and analyze visual and thermal imaging data. Systems such as the provided "Hawk-Eye" example will allow the organization to interface with controllers over Wi-Fi and cellular networks, enabling real-time data capturing through the cloud and allowing access from virtually anywhere. Data points will include real-time temperature readings, heat stress indicators, evapotranspiration rates, general weather indicators and agricultural stresses. To further expand on the key performance measures of the project, the pilot will allow us to begin collecting new and targeted data points. Whereas in-ground moisture content systems collect data related to the soil, the proposed project enables data collection related to the plants themselves. One initial hypothesis of the pilot is that targeting the smaller footprints of plants - the actual "users" of the water - should lead to use efficiency, As the Arapahoe Rd & I-25 interchange landscaping reconstruction project will be complete In June-July 2018, Denver South TMA will spend the first six months of the project (July – December 2018) to collect and analyze baseline data, pairing traditional, manually collected data points with newly gathered infrared information. In 2019, Denver South TMA plans to collect monthly water use data and compare it to the actual monthly ET values with and without precipitation adjustment in for months when the camera is and then is not being used to manage and adjust the system. The quantitative and qualitative data from when the camera is and is not being used will be logged and compared for the final report. We hope to develop comparative data demonstrating water savings from the actively managed camera, but we will report the findings regardless. It may be desirable to extend the Pilot for a second full season in 2020, but this is not included at this time.
What research, evidence, and data support your project?
Please see "Related Studies" in primary application.

Overview (answer for both tracks)
Describe potential short- and long-term challenges with this project.
There are several potential challenges with this project which further support the need for this type of experiment. As a small-scale pilot there are inherent hurdles – foreseen and unforeseen – that must be addressed through investigation prior to wide-scale adoption. The identification of these challenges could be one of the most valuable outcomes of the project, as this process may influence future decision making and potential wide-scale adoption. One specific challenge is that infrared monitoring is typically used in monocrop agricultural settings. The proposed project entails varied vegetation (native grass, sod, shrubs, etc.) and material types (rock, stone, concrete, steel, etc.). Effectively distinguishing between these types could be challenging during initial project design, but if executed to plan this process should provide insightful data and information. Another challenge is that available infrared monitoring systems do not interface directly with irrigation controllers currently on the market. While WIFI and cellular communications allow the project management team real-time data access, the controllers will still require manual adjustment. We hope to work with the selected equipment vendor to enable direct systems integration for future automation. If the pilot is successful, identifying process and technological challenges could help influence greater market adoption down the line.

Please fill out the applicable questions for either the Engagement Track or Innovation Track, unless your project contains elements in both tracks. If a question does not relate to your project, just leave it blank. Please answer each question that relates to your project. Please reference the relevant documents and use chapters and page numbers (Colorado's Water Plan, Basin Implementation Plan, PEPO Education Action Plan, etc.).

Innovation Track
Describe how the project enhances water innovation efforts and supports a water innovation ecosystem in Colorado.
The Denver South TMA views the field of innovation as a fluid and flexible extension of the sciences, consisting not only of quantitative experimentation but also qualitative analysis, storytelling and public relations. We believe that the concept of this pilot lends a compelling story from the outset, as applying high-tech and data rich solutions to the natural environment is a terrific analog for the futures of two of Colorado's largest industry clusters – advanced technology and outdoor recreation. From the ski resorts and parks of the High Country, to the increasing water demands of a booming Front Range metropolitan population, to the agricultural needs of the Eastern Plains, quality-of-life in Colorado is only as good as its water supply. Denver South TMA and its direct stakeholders - which include power players in the tech sector such as Arrow Electronics, Cable Labs, Charter Communications and Comcast – share the same understanding, as quality-of-life (QOL) is among the top indicators as to why these companies have chosen to locate in our region. As water efficiency efforts continue to grow in importance, our ability to involve the tech sector at the ground floor helps to advance statewide civic innovation and catalyze growing markets for resource efficiency solutions.

Innovation Track
Describe how the project engages/leverages Colorado's innovation community to help solve our state's water challenges.
As co-founders of the Colorado Smart Cities Alliance (see coloradosmart.city for more information), Denver South TMA and its sister organization the Denver South Economic Development Partnership (Denver South EDP), lead a network of 14 cities, the University of Colorado Denver, the Colorado Technology Association, the National Renewable Energy Lab (NREL) and the National Center for Atmospheric Research (NCAR), among others. The Alliance collaborates to benefit the citizens and businesses of Colorado by enhancing QOL through citizen-centered design, public policy and the deployment of 21st century technology and infrastructure. Our organization is perfectly positioned to champion projects that focus on resource efficiency, conservation and resiliency throughout Colorado, and for a majority of the Alliance's member communities water conservation is a top priority. Through this affiliation we have already established a formal and systematic process for sharing best practices and lessons learned as our network of partners continues to grow.
Describe how the project helps advance or develop a solution to a water need identified through TAP-IN and other water innovation challenges. What is the problem/need/challenge?
The challenge we are hoping to overcome with this pilot is to remove the guess work out of providing plants, in this case landscape plants, with sufficient but not excessive amounts of irrigation water. Additionally, we hope to water these plants when needed via remote management of the irrigation system with actual plant water need-based information. Being able to do this would increase the health and aesthetics of the landscape plantings and likely reduce overall water use by avoiding the typical over application of water which is commonly 30-50% higher than necessary. If it would be appropriate and beneficial we are open to discussing or presenting this need/opportunity and our findings at TAP-IN.
Describe how this project impacts current or emerging trends; technologies; clusters, sectors, or groups in water innovation.
Although this project has the potential to impact a broad range of emerging trends in technology, the greatest impacts we hope to see involve water conservation and operational efficiency. In its 2016 white paper titled *Water Tight 2.0: The Top Trends in the Global Water Sector*, Deloitte asserts that the needs for conservation and operational efficiency in water provision will continue to outpace the efficiency demands of nearly every other sector. Fresh water will continue to grow scarcer as populations continue to rise. As access to water is both a basic human right and (in most cases) provided through regulated utilities, supply-side conservation and the operational efficiency of distribution systems will be paramount as water cannot follow the same inflationary rates and price increases as those of other commodities. Throughout 2016 and 2017, the Denver South TMA piloted a remote cellular-based irrigation controller for the landscaped areas at the Orchard Rd & I-25 interchange, an environment very similar in form and function to the one proposed for this project. These types of controllers are becoming more commonplace in residential and commercial settings, which is a great leap for operational efficiency in terms of remote system access and ongoing analytics. There is also a well-established market for remotely accessible in-ground moisture content and weather-related data systems. Between these current market solutions, usable data can be collected, analyzed and used

Innovation Track
for better decision making to issue commands to controllers, all without having to physically monitor in the field. While these readily available systems are already positively impacting operational efficiency, the addition of visual and thermal imaging data stands to significantly enhance efficiency efforts through savings in water use, time, costs and mobilization.

February 9, 2018

Colorado Water Conservation Board
- Water Plan Grant: Innovation
1313 Sherman St. Room # 708
Denver, CO 80203

RE: MRT's Support of the CWCB Water Plan - Innovation Grant for Denver South Transportation Management

Dear CWCB:

The Metro Roundtable (MRT) has reviewed and was presented with an overview of the current CWCB Water Plan – Innovation Grant request for the Denver South Transportation Management Association. The use of Infrared Cameras to provide early and advance detection of plant stress/water need is intriguing and it will be interesting to see how this technology which has been used in agricultural settings to manage and reduce water use can work in a more urban landscape setting. We/the MRT are very interested in the hoped for outcome and the example that it can be to other water users in the metro area and across the State.

The MRT endorses and supports this Grant Request as it supports our Priorities with respect to encouraging and supporting water conservation and communication: education/outreach. These also are in keeping with the South Platte Basin Implementation Plan - Elements #2 and #9. We hope that CWCB will also support this Project with the requested Grant funding.

Please contact me/us if you have any questions.

Sincerely,

/s/ *Barbara Biggs*

Barbara J. Biggs
Chair, Metro Roundtable

DENVER WATER | 100 YEARS 1918 — 2018

February, 27th 2018

Attn: Ben Wade
Colorado Water Conservation Board
1313 Sherman St, Denver, CO 80203

Dear Water Plan Grants Committee:

Denver Water is aware of and supports Denver South Transportation Management Association's request for funding for the InfraRed Plant Stress Monitoring Pilot. We believe their request is important because information gained through the pilot could lead to better irrigation technology and practices for water-use efficiency in commercial, public areas and other large irrigated areas. The funds provided by Colorado Water Conservation Board will assist in the project costs and reporting needed to move the science forward.

I have read about similar innovations in agricultural where infrared imagery shows the ability to schedule irrigation when the plants need it most. The ability to schedule and right-size irrigation to varying plant types would stretch water resources further and could assist utilities with more operational flexibility during peak summer use.

Please give this proposal your full attention and if I can answer anything further, please let me know. I may be reached at 303-628-6301 or jeff.tejral@denverwater.org

Sincerely,

Jeff Tejral
Manager of Water Efficiency
Denver Water

ASSOCIATED LANDSCAPE CONTRACTORS OF COLORADO
BETTER BY NATURE

1660 S. Albion St., #831, Denver, CO 80222 303 757-5611 fax 303 757-5636 www.alcc.com

January 30, 2018

TO: Grant Review Board

RE: Colorado Water Plan Grant for Innovation
The Denver South Transportation Management Association

I am writing to provide ALCC's support for the grant proposal from the Grant for Innovation. As an organization, we support many efforts to promote water conservation research, especially via new technologies that can lead to more efficient use of Colorado's most precious natural resource.

The proposed study to apply InfraRed Camera technology to provide real-time data on plant stress should be a worthwhile study. Within the landscape industry, we are becoming aware of this new technology and are interested to learn of its potential applications within Colorado.

As an industry organization, we would be very interested to learn the outcomes of this research and how the results might lead to more means of water conservation.

Thank you for giving this project your utmost consideration.

Sincerely,

John McMahon
Executive Director