Prepared for the Colorado Water Conservation Board and the Arkansas Groundwater Users Association

A Multimedia Program for Reporting Crop and Turf Water Use Estimates from the Colorado Agriculture Meteorological Network (CoAgMet)

53-7885-0 Project Report 123115

Section 1

1.1 Original Scope and Objectives for project LISA (Lawn Irrigation Self Audit)

This project request received funding on April 1, 2013 as part of a subcontract with the Arkansas Groundwater Users Association in the amount of $26,941.62, of which $5,388.12 were payable as indirect costs to CSU. The project was funded as a "nonstructural water project or activity" under the Colorado Water Conservation Board WSRA funding program, and approved by the Arkansas Basin Roundtable. A timeline for the LISA project can be seen in Table 1 of Appendix A.

The original objectives of the project were as follows:

1. Develop a Lawn Irrigation Self Auditing (LISA) tool that allows homeowners access to auditing kits, through local Extension offices, and a reliable online web-tool (model) to give homeowners a yearly lawn irrigation schedule.
2. Because the LISA program relies on a vast network of Extension agents for distribution and implementation, educate Extension agents throughout the state on how to implement the LISA program.

More specifically, the original tasks associated with these objectives are summarized below:

1. Capitalize on the CoAgMet network of weather stations to provide highly localized data to improve the accuracy of the web-based LISA model
2. Distribution of LISA kits to Extension Offices throughout the state
3. Development of coding and programming for the LISA web-tool
4. Deployment of LISA toolkits to CSU Extension offices
5. Monitoring and assessment of program

1.2 LISA Background

The LISA project was initiated in 2013 by a research team from Colorado State University. The team consisted of Dennis Reich, Dr. Perry Cabot, Troy Bauder, Nolan Doesken, and Reagan Waskom. Each team member had a Colorado State University (CSU) Extension appointment at the time and the idea for the LISA project was conceived by talking with Colorado homeowners and horticulture professionals. Each team members Extension appointment is distinguishable in that it allows us to leverage the network of in-situ county Extension agents that are embedded within the communities they serve. One of the primary benefits of LISA is that it can be used anywhere in Colorado and not-only capitalizes on a statewide network of Extension agents but also a statewide network of localized weather data sources.

Although lawn irrigation audits have existed for many years there have not, to our knowledge, been any attempts to provide a low/no cost self-auditing system for Colorado homeowners. The development of the LISA program is intended to give homeowners access to the material resources and knowledge necessary to more efficiently irrigate their lawns. Most Colorado homeowners or renters with yard maintenance responsibilities know water conservation is important, but some may not know how to apply water in the most effective manner. LISA is a means of not only improving lawn watering practices but filling water knowledge gaps.

We entered this project with the understanding that many people enjoy lawns, even in a semi-arid environment such as Colorado. It is generally understood that green lawns grow property values. With this in mind, we set out to create a product to encourage homeowners to improve irrigation efficiency of turf grass while understanding the need for a municipality's resiliency to demand hardening. Utilities providers often look to the "blue grass reservoir" in times of drought to address water gaps. Many new construction homes are being landscaped with drought in mind and there has been an increase in xeriscaped properties as a result. However, many of the established residential developments in Colorado have turf grass. Water managers realize water conservation measures are important aspects of future growth yet irrigation efficiency improvements to current turf grass lawns can also supplement water in times of need.

1.2 Applications to State of Colorado Objectives

The Colorado Water Conservation Board (CWCB), which considers "water conservation, and drought planning" as part of its mission, has identified significant water shortages or "gaps" developing and increasing across the state over the next 20 to 40 years (SWSI Phase II[1]). Over 50% of all domestic water use occurs outside and usually to water lawns. Hence it is no surprise that at least two of the Best Management Practices (BMPs)[2] the CWCB's Office of Water Conservation and Drought Planning recommends to domestic water users relate directly to irrigation:

- Landscape Irrigation Management
- Educational Programs

Efficient lawn sprinklers, such as the automated pop-up systems are steadily becoming the new standard in urban Colorado. Unfortunately while wise water use is a concern for most Coloradans, proven techniques for improving water efficiency within the household are not always employed even when the correct equipment is installed. According to the Irrigation Association[3], irrigation audits are considered an essential part of any water conservation program and are proven tool for closing this knowledge gap between having the latest irrigation technology and using it to maximum efficiency. Audits translate existing water use into an intuitive visual tool that water users can easily understand[4], allowing the recipient to make improvements as they learn. Indeed, conservation strategies identified for Colorado include "water use audits for all customer classes.[5]"

One of the challenges with providing audits for larger populations (that continue to grow) is the time, labor and cost requirement. Most domestic irrigators are deterred from participating in an audit because of some combination of these concerns. An ideal scenario would be for domestic users to conduct the audit themselves at their convenience, if only to determine if a professional, certified auditor would be worth the expense. Such programs have been initiated in neighboring Western states, such as Arizona[6] where water scarcity is at an even greater level. This proposal is targeted at domestic water users. The incentive of lowering water bill cost and improving lawn health combined with a user friendly 30 minute self-audit format means improved efficiency and/or uniformity among domestic lawn sprinkler systems will be more achievable. Feedback generated from a program website will further help users identify inefficiencies with their system and recommend future actions.

[1] Statewide Water Supply Initiative Phase II http://cwcb.state.co.us/IWMD/SWSITechnicalResources/SWSIPhaseIIReport/
[2] http://cwcb.state.co.us/Conservation/Conservation/BestManagementPractices/
[3] The Irrigation Association: http://www.irrigation.org/certification/default.aspx?pg=draft_guidelines.htm&id=25
[4] Solomon / Kissinger. 2005. "Water Conservation Diagrams Illustrate the Benefits of Improved Irrigation." http://www.mprotator.com/resources/files/284.pdf
[5] http://cwcb.state.co.us/Conservation/Conservation/OWCDPSWSI/

[6] http://www.wateruseitwisely.com/region/arizona/100-ways-to-conserve/outdoor-tips/water-guides/lawn-guide.swf

Section 2

2.1 A Physical Lawn Audit

The first assumption of the LISA project is that homeowners are committed enough to improve their lawn irrigation efficiency that they will make the effort to checkout a kit of tools from the local Extension office. If they are not driven by water conservation, perhaps they could be driven by the possibility of lowering their water usage bill. Either way, the homeowner will likely need to make the effort to perform a laborious task on their own accord. The appeal of wise water use inherent with LISA versus other means has a number of multiplier effects: since there is a self-education element in conducting a LISA, participants will be well equipped to foster increased interest in wise water use and conservation techniques. This, combined with LISA's affordability and user-friendliness, gives the LISA project the potential to generate more water savings than traditional conservation programs. (As a side note, it has been discussed that an entrepreneurial youth could check out an auditing kit and use it to collect a small fee-for-service from neighbors, with a time limit of course.) We recommend performing a physical audit every 2-3 years to ensure ET data, as well as sprinkler performance evaluations, are current. We aim to help further the public understanding that, in spite of its potential as an efficient system, a lawn sprinkler can still waste water and add additional costs to the end user. LISA is available as a cheap, quick, and effective check for water waste with the possibility of improving efficiency at no cost to lawn health and saving money on household water expenditures.

Once the homeowner checks out an auditing kit, they will have a specified amount of time (likely 1-2 weeks) to perform an audit on their property. The audit consists of two main tasks: a catch can test and a determination of rooting depth. Each auditing kit will contain over 40 complete catch can devices (including stand rings) and a soil probe. The kit contains other tools (anemometer for determining wind speed, pressure gauges to check nozzle pressures, high visibility landscaping flags, etc.), but these "other tools" are not required for data collection purposes, they simply help make the auditing process easier.

A physical audit is best described below:

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Step 1 – Pre-audit inspection

Inspect irrigation system to ensure all irrigation components are functioning properly. Optimizing system performance before the audit takes place will ensure your audit creates the most efficient watering schedule. LISA **is not** designed to diagnose or treat problems with your irrigation system, but rather enhance system performance to water your lawn more efficiently. Please be sure to diagnose and correct any problems with your irrigation system prior to your irrigation audit.

Step 2 – Weather conditions

Before performing a LISA, make sure your site is suitable for an audit. Follow these steps to ensure the audit is set up properly:

- Wind speed should not exceed 5 miles per hour or 2.3 meters per second (anemometer located in LISA kit)

- LISA should not be performed in the rain or snow (for obvious reasons)

Step 3 – Audit setup

Follow these easy steps to carry out a successful audit.

1. Using the soil core tool in the LISA kit, extract a soil core from your lawn (**1** & **2** below). Slide the soil core towards the top of the probe to expose the bottom of the core (**3**). Starting at the bottom of the soil core, break apart the soil until you identify roots (**4** & **5**). Measure the core, this is the rooting depth of your lawn.

2. Locate sprinkler heads (**1** below). Find sprinkler heads that are representative (in terms of distance apart) of the zone being audited and mark them with flags (**2**). Using the measuring tape in the audit kit, measure the distance between sprinkler heads (**3**). 50% of the measured distance between sprinkler heads will be the distance between catch can devices.

3. Starting in one corner, measure (or pace) out the distance from step 2. Place a ring at this point followed by a catch can device. Make sure the catch can devises are level! Measure and place catch can devices in a uniform grid pattern. Do not place a catch can device within 16 inches of a sprinkler head, simply move the catch can 18 inches away from the sprinkler head if this occurs. A minimum of 12 catch cans should be used for each zone audited.

4. Turn on Zone 1 (or the appropriate zone being audited) and leave running for a specified run time, usually between 5-10 minutes. Make sure to record the amount of time the sprinkler has been running. Also, you can use this time to make any notes about sprinkler performance such as "west corner sprinkler is watering the driveway" or "sprinkler head height too low on south west sprinkler".

5. After the runtime has expired turn off the system and record the volume of water in each catchcan. The catch cans have two units; **MAKE SURE YOU RECORD THE DEPTH IN INCHES (in)**.This is vital information for the final step, which involves the online irrigation scheduling tool.

6. Repeat steps 1-5 for subsequent irrigation zones.

Step 4 – Entering audit information into the web tool irrigation scheduler

Go to www.LISAudit.colostate.edu and follow the easy process of entering your auditing results. This free and simple web tool will allow you to irrigate your lawn more efficiently and reduce the harmful effects of over or under watering your lawn.

Follow up steps *(only if needed)*: If the distribution uniformity of your sprinkler setup is less than ideal (as determined from highly irregular catch can volumes), use the tools in the LISA kit to test sprinkler pressure. If you have pop-up nozzles, use the pressure gauge attached to test the pressure.

If you have rotor, impact, or rotator nozzles, use the pressure gauge below by placing the metal tip into the stream of water.

Comparing nozzle pressures from valves in the same zone will tell you where distribution uniformity issues may arise and which sprinkler heads may be contributing the most to the poor uniformity. If your lawn sprinkler system seems to be applying water in a highly irregular pattern, consult a professional landscape irrigation company to remedy the issue.

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2.2a Development of a Lawn Irrigation Self Audit Web-Tool

Arguably the most important product developed from the LISA project is the web-tool. The web-tool is best described as an "all-in-one" resource for answering lawn irrigation questions while providing a user-specific product. At the heart of the web-tool is a process based model that computes monthly growing season irrigation requirements using a set of user-provided information. The user enters information into LISA's Graphical User Interface and several equations compute irrigation requirements. LISA can be thought of as an irrigation scheduler specifically designed for homeowner scale lawns.

The web-tool was designed by CSU Extension personnel with the help of Abdo Designs, a website development company from Pueblo, CO. The web-tool was designed as a web-based application, or web app. Because of the increasing mobility of computing, the site was designed to function seamlessly on a mobile device as well. In keeping with CSU's branding model, the aesthetics of the site were created using CSU approved colors and logos. We also made sure to prominently feature the logo's of our partners and funding sources. Principally, these collaborators were the Arkansas Groundwater Users Association (AGUA), the Colorado Water Conservation Board (CWCB), The Southeast Colorado Water Conservancy District (SECWCD), and CSU. Abdo Designs was a critical partner in formatting the layout of the website to be very user friendly while creating a modern look that shows the web-tool is "up-to-date" with modern technologies. It was important for us to know that the user will not find this tool "archaic", which can often happen with an unrefined look to technology.

2.2b The Web-tool Empirical Model

Encoded within the LISA web-tool is an empirical lawn water use model. The model is accessed via the LISA web-tool at lisa-audit@colostate.edu and users enter information into the web-tool's Graphical User Interface. The model uses industry accepted parameters to answer specific questions that most greatly affect lawn water use (Appendix A, Figure 1). A description of the parameters are as follows:

1. **Irrigation application rates and distribution uniformities**
    a. This parameter is crucial for creating an accurate irrigation schedule
    b. How is the water distributed (i.e. rotor head, spray head)
2. **Physical characteristics of a homeowners lawn**
    a. **Slope**
        i. *Important for determining runoff probabilities*
    b. **Compaction**
        i. *Important for determining soil infiltration rates/capacity*
    c. **Vegetation Density**
        i. *Important for determining spatial scales*
    d. **Proximity to Trees**
        i. *Important for determining root water competition*
    e. **Micro-Climate Factor (including sun exposure and wind conditions)**
        i. *Important for determining the atmospheric demand for transpired water*
    f. **Species Factor**
        i. *Important for identifying general water use by plant species*
    g. **Rooting Depth**
        i. *Important for determining water holding capacity of root zone*
    h. **Soil Type**
        i. *Important for determining water holding capacity of root zone*

In addition to the parameters listed above, the LISA model capitalizes on a vast network of meteorological stations within the CoAgMet system to provide homeowners with a localized data source regarding plant water use (evapotranspiration, or hereafter referred to as ET). ET data is highly important and serves as a reference to help calibrate the model. The CoAgMet network was chosen for collaborative purposes, many of the team members for the LISA project are familiar with, and have worked on other projects, using the CoAgMet network. Additionally, the CoAgMet network has been designed to place agricultural weather stations in rural locations dependent on accurate weather measurements for the management of crops (Appendix A, Figure 2). Using the CoAgMet network allows the LISA project to fill a niche, providing access to lawn auditing technologies for homeowners in large cities *and* small towns.

Data from the nearest CoAgMet station is queried using an embedded script and stored in the cloud. The data gathered from CoAgMet and relayed to the LISA model represents a five year growing season (April – October) average for a reference ET crop, in our case Alfalfa. The data is given in terms of average inches of ET per day for a given month.

2.3 Outreach and Education

One of the key missions of the LISA project, and CSU Extension in general, is to provide outreach and education for the LISA tool and the benefits of efficient irrigation. From the beginning, the LISA team has reached out and provided education to Extension Agents regarding the project. We have made a significant

effort to educate Agents as their reach to homeowners is far greater than that of the individuals on the project team.

Fortunately, CSU has already created many resources for homeowners in regards to maintaining healthy lawns. CSU's horticulture department, along with Extension, have put forth several fact sheets and bulletins, including those aimed at improving lawn watering. However, the LISA project takes this outreach effort to new levels, and by creating a web-based application as part of the toolkit we are providing a means of plugging LISA into an already existing network of outreach materials. The LISA project also maintains an individual website, outside of our new website-based application (scheduling tool), that gives homeowners additional resources. It has been shown that linking websites in a way that conforms to circular logic creates stronger linkages between content. For example, having the same cross referenced links on all of our lawn health improvement materials will validate the interconnectedness of the many facets of lawn maintenance. LISA will have a presence on several outreach platforms and will be embedded in many links throughout CSU Extension webpages.

Timeline of Education and outreach for LISA:

November 2015: Presentation to Natural Resources Division of CSU Extension – Fort Collins, CO
November 2015 – April 2016: Form partnerships with Extension Agents interested in hosting a LISA kit
Chaffee County Lawn and Garden Show 2016: Presentation by local Extension agent

Presentations:
2016 Landscape conference in Pueblo, CO
Webinar for Extension Agents; March 2016

The lists represent an itemized description of presentations hosted by the principal project developers of LISA. These lists do not include any presentations given by Extension agents to their local constituencies.

Below is a list of press releases scheduled:

LISA Press Releases
Extension Small Acreage Newsletter
Pueblo Chieftain
Canon City Daily Record
Fort Collins Coloradoan
Grand Junction Sentinel
Longmont Times Call
Boulder Daily Camera

2.3 Evaluation of Program Effectiveness

Evaluating the effectiveness of LISA will consist of a compilation of user demographics and lawn information combined with feedback received from users. Total water savings will be estimated from lawn and audit information. We will ask each Extension office hosting a LISA kit to keep detailed records of checkout frequency, user demographics, and length of rental. Additionally, we will work with our website developer of the web-based applications (irrigation scheduler) to record website visits and compile statistics about user data.

Appendix A

Table 1: Timeline of entire LISA project

Task	LISA Project Timeline												
	2015							2016					Ongoing
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
Literature review of industry standards													
Develop irrigation scheduling model													
Website development													
Produce education and outreach resources													
Obtain and distribute LISA kits to Extension Agents													
Solicit feedback from external reviewers													
Provide education to Agents													
Monitor use and effectiveness of LISA													

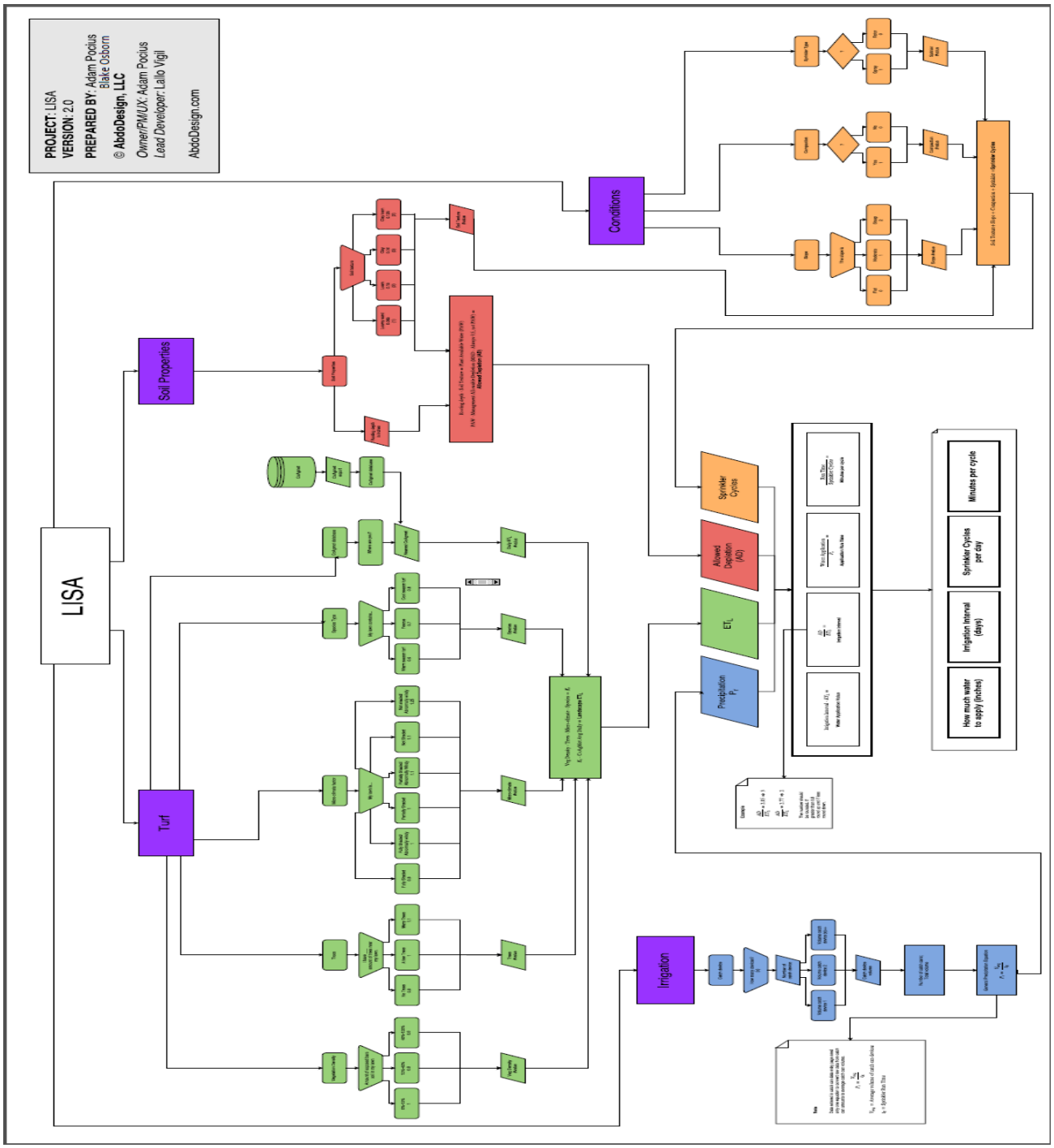
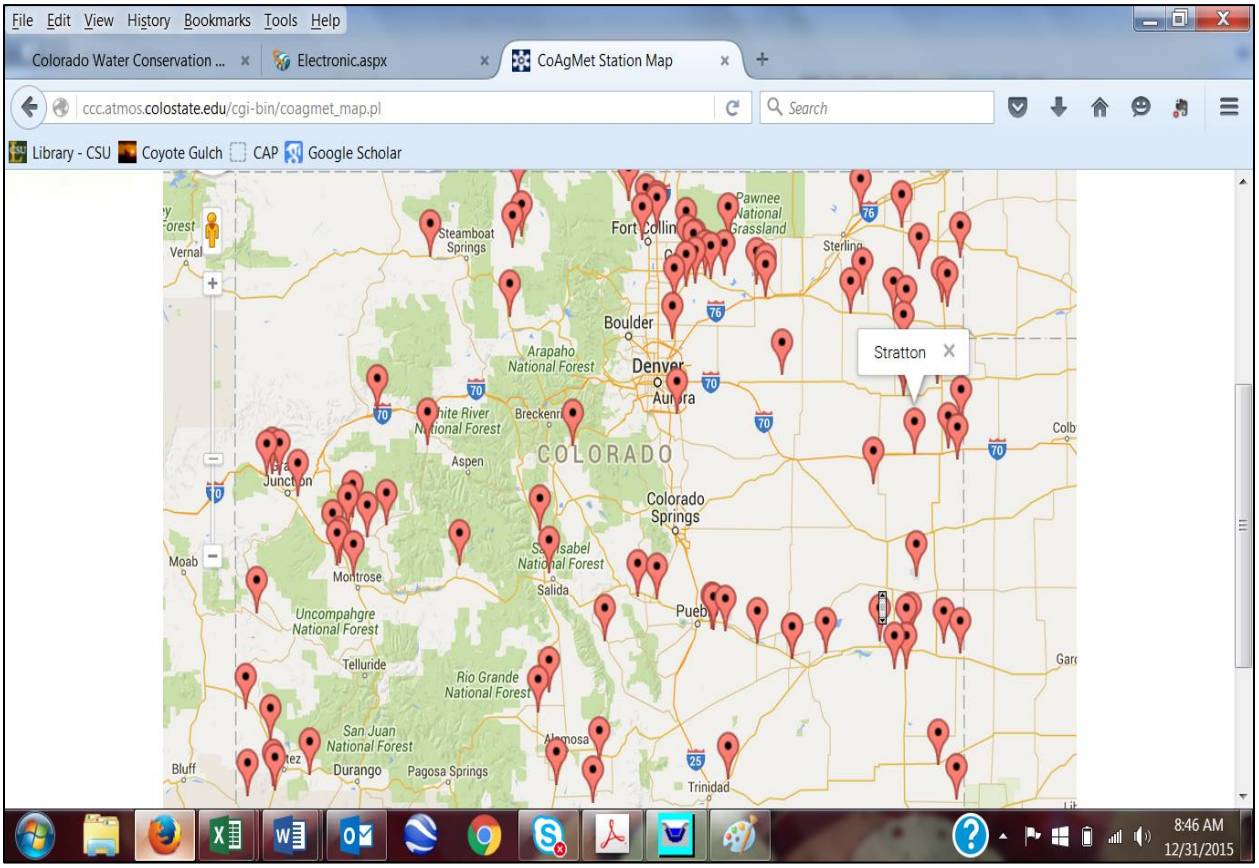


Figure 1: Hierarchical schematic of LISA equations. This hierarchical model takes important parameters, such as watering method and landscape features, and creates numerical solutions that can be used to program an automated sprinkler system.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Colorado Water Conservation ...
Electronic.aspx
CoAgMet Station Map
ccc.atmos.colostate.edu/cgi-bin/coagmet_map.pl
Search
Library - CSU
Coyote Gulch
CAP
Google Scholar
Steamboat Springs
Fort Collins
Pawnee National Grassland
Sterling
Boulder
Arapaho National Forest
Denver
Aurora
Stratton
Aspen
COLORADO
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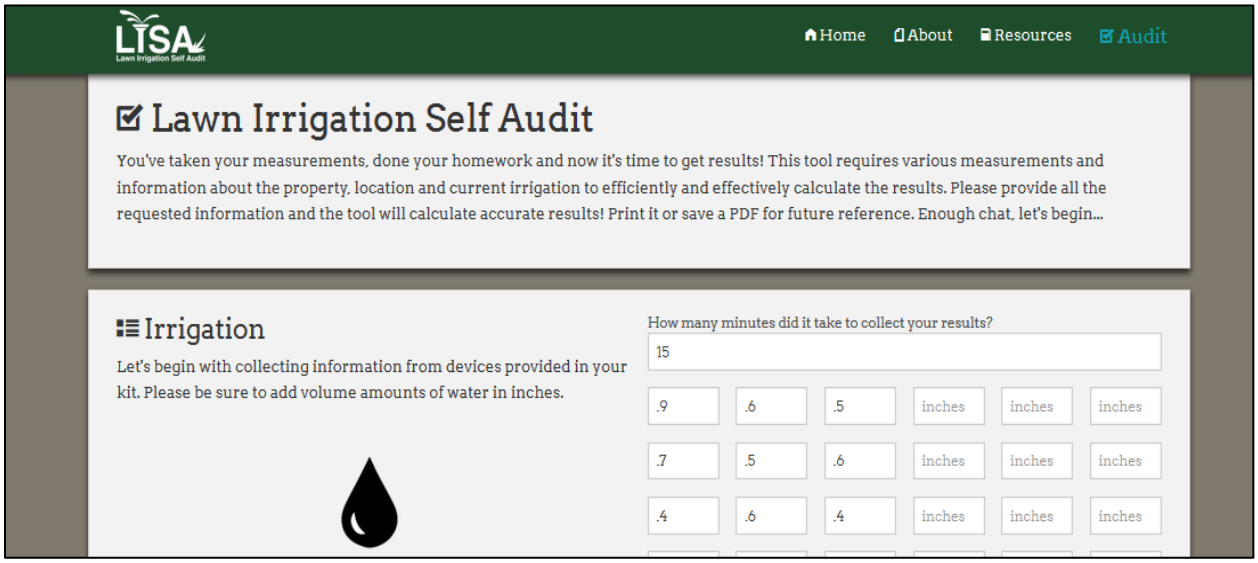

Figure 2: Example image from the LISA website. The clean design and interactive nature of the website gives users a modern experience. Instead of an antiquated, one dimensional look we chose to make the website feel more "layered", giving the perception of depth.

Lawn Irrigation Self Audit (LISA)

A Smarter Way to Irrigate Your Lawn **2016**

How can LISA help you?

LISA has been designed by a statewide team of CSU Horticulture, Atmospheric Science, and Water Resource experts with the goals of:

- Maximizing wise use of urban water
- Improving lawn health
- Less time and money invested in lawn maintenance

"Looking forward to having this resource in our county."

- Excited User

Where can I check out a LISA kit?

LISA is a small kit of tools available from your local Extension office. If Colorado is to accommodate another 3 million people over the next 25 years – most of them in towns and cities – the demand for urban water conservation and the cost to water a lawn can only increase. A diagnostic kit like LISA allows for a quick and effective assessment of lawn irrigation and the means to optimize it. The optimal operation of a lawn sprinkler system eliminates unnecessary watering that leads to time consuming weed problems and inflated water bills.

"LISA will provide us with an educational tool, not only for homeowners, but for kids as well."

- Environmental Educator

LISA Advantages

- Decrease runoff to storm drains
- Improve lawn health
- Eliminate unnecessary excess watering
- Possibly save money
- Improve understanding of lawn irrigation