Delivering Education Programs Focused on Stakeholder Needs to Address Agricultural NPS in the Arroyo Colorado Watershed

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Texas Water Resources Institute
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Texas Water Resources Institute
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Delivering Education Programs Focused on Stakeholder Needs to Address Agricultural NPS in the Arroyo Colorado Watershed

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Texas A&M AgriLife Extension Service

Texas Water Resources Institute

United States Department of Agriculture, Natural Resources Conservation Service

Texas State Soil and Water Conservation Board, Harlingen Regional Office

Southmost Soil and Water Conservation District #319

Hidalgo Soil and Water Conservation District #350

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TEXAS WATER RESOURCES INSTITUTE TR-490

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The Texas Water Resources Institute is part of the Texas A&M AgriLife Extension Service, Texas A&M AgriLife Research, and the College of Agriculture and Life Sciences at Texas A&M University

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Executive Summary

The focus of Texas State Soil and Water Conservation Board (TSSWCB) Project 15-53, "*Delivering Education Programs Focused on Stakeholder Needs to Address Agricultural NPS in the Arroyo Colorado Watershed*," was to continue efforts to alleviate impairments in the Arroyo Colorado watershed through educational programs and direct mailings targeted at controlling agricultural nonpoint source pollution. The Texas Water Resources Institute (TWRI) and Texas A&M AgriLife Extension Service (Extension) conducted educational programs within the three county area of the Arroyo Colorado watershed that focused on best management practices (BMPs), particularly soil testing and nutrient management, and sources of financial and technical assistance. The continuation of these vital programs was made possible by funding from a State Nonpoint Source Program grant from the TSSWCB.

Through this project, initiated in 2014, Extension carried out priority programming that highlighted water quality issues in the Arroyo Colorado and provided guidance on how the agricultural community could aid in reducing pollutants. By working closely with the TSSWCB, U.S. Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS) and the local Soil and Water Conservation Districts, resources were utilized efficiently and programs were current and relevant. Through this project, the South Texas Irrigation Training Program Manual was updated along with several other educational materials and new fact sheets were developed for new, innovative BMPs (i.e. narrow border flood irrigation) and new incentive programs (i.e. RCPP).

Over the 1.5 years of this project, it reached 5,500 individuals through attendance at educational programs, direct mailings, or participation in the annual soil testing campaign. Approximately 110 individuals submitted over 130 soil samples, representing 7,517 acres in the three county area. Through this project, the effectiveness of the soil testing campaign and associated education programs became apparent as most producers in the Lower Rio Grande Valley were found to be applying the correct amount of nutrients to meet crop fertility needs.

Soil testing and agricultural education programs continue to be a vital part of accomplishing the goals outlined in the Arroyo Colorado Watershed Protection Plan. Considering that the majority of the land within the watershed is under some type of agricultural production, these efforts will play an important role in keeping the agriculture community engaged and reaching new producers.

Introduction

The Arroyo Colorado, an ancient channel of the Rio Grande River, is located in Cameron, Hidalgo, and Willacy counties in the Lower Rio Grande Valley of South Texas (Figure 1). It extends for about 90 miles, beginning near the City of Mission and running through southern Hidalgo County to the City of Harlingen in Cameron County before eventually discharging into the Lower Laguna Madre near the Cameron-Willacy county line. The Arroyo Colorado watershed is approximately 706 square miles of mostly coastal plain gently sloping eastward toward the Gulf of Mexico. Land uses, as classified by the Spatial Sciences Lab at Texas A&M University, primarily include agriculture (54%), range (18.5%), urban (12%), water bodies (6%), and sugarcane (4%) (Kannan, 2012). Vegetable and fruit crops are grown in portions of the watershed and some industry exists. The lower third of the stream is also used for shipping from the Gulf Intracoastal Waterway to the Port of Harlingen. The Arroyo Colorado not only serves as a natural habitat, fishery, and recreational waterway, but with its multiple land uses it also drains runoff and return flows from both urban wastewater discharges and agricultural irrigation as well as stormwater runoff and base flows from groundwater.

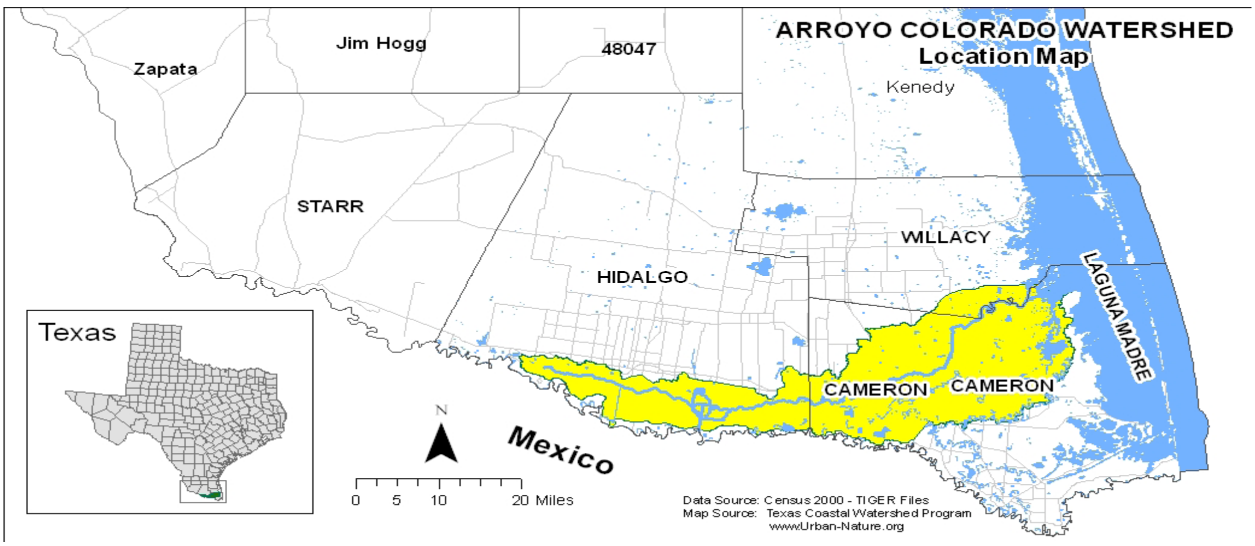

Figure 1. Highlighted in yellow is the Arroyo Colorado watershed.

Agriculture and municipalities are the two primary water users in the watershed and flow in the Arroyo Colorado is primarily sustained by agricultural irrigation return flows and wastewater discharges; thus, the Arroyo Colorado serves as a conveyer of this water as it leaves the system. The Arroyo Colorado serves as a primary drainage-way for 26 cities in the area, and is a major source of fresh water for the lower Laguna Madre, an economically and ecologically important resource to the region. The Laguna Atascosa National Wildlife Refuge and several county and city parks are located within the Arroyo Colorado watershed, making it an area for bird-watchers, nature-lovers, and outdoors enthusiasts. When wastewater discharges and agricultural return flows enter the Arroyo Colorado, they carry nutrients, sediment, and bacteria into the water body.

The tidal segment of the Arroyo Colorado was first listed as having low levels of dissolved oxygen in 1996 and elevated levels of bacteria in 2006 (Texas Commission on Environmental Quality, 2013), and the above tidal segment was listed for having elevated levels of bacteria in 1996. To address the Arroyo Colorado's bacteria and dissolved oxygen impairment as well as nutrient concerns, the Arroyo Colorado Watershed Partnership developed a watershed protection plan (WPP) for the Arroyo Colorado – Phase I. The WPP, which was released in 2007, included recommendations from five major workgroups: wastewater infrastructure; agricultural issues; habitat restoration; water quality monitoring; and education and outreach. The Arroyo Colorado Agricultural Issues Workgroup, made up of local, state, and federal stakeholders, recommended that education and outreach be one of the priorities for implementation.

Since then, several projects have been implemented, such as an integrated farm management program, pesticide education program, and a cost-share education program. Although the programs have been effective in raising awareness about water quality, the Arroyo Colorado Watershed Partnership has still not met its water quality goals nor its goal of acreage under a conservation plan. To address this, an education program is still needed to 1) continue raising awareness and 2) provide technical education so that people understand which practices they should consider adopting and why they need to do so.

Results from a recent survey support that outreach and education for agricultural producers is a critical component to achieving voluntary implementation of BMPs. Agricultural producers indicated that their main concern is the amount of irrigation water available for the upcoming year and specific conservation practices that reduce the amount of irrigation water used. Reducing the quantity of irrigation water applied is of particular importance in improving water quality, as Enciso (2012) found that excessive tailwater during irrigation events can contain high amounts of nutrients. Curbing tailwater flows into the Arroyo Colorado is just as important as nutrient management in reducing the nutrient loads applied to the land's surface that can contribute to local impairments. Second to water quantity, agricultural producers were generally interested in water quality, per the evaluation results. They are mostly interested in knowing what current water quality levels are and how that may impact their operations. In discussions with producers, they have expressed a desire to reuse irrigation water runoff, but are concerned about the water quality, especially related to salinity. Financial incentives were the third highest area that producers were interested in according to the results. Sources of available financial incentives and how to apply for them to help implement conservation practices ranked among the highest in the construct. Finally, in response to conservation practice educational needs, producers wanted more information on conservation practice effectiveness and how those practices can improve their operations. Addressing these educational needs is crucial to gaining widespread adoption of agricultural management practices.

In addition to determining educational needs, the evaluation also assessed barriers to adopting BMPs by agricultural producers in the Lower Rio Grande Valley. Economic barriers ranked highest among the reasons for non–adoption, specifically the initial cost of installation and low incentive levels. These barriers are evident in the Lower Rio Grande Valley as water is very inexpensive and the antiquated water delivery system is not conducive to some of the more efficient methods of irrigation. For example, drip irrigation is known to be more efficient, but because the water delivery system is designed to deliver large quantities at one time, in order to utilize drip irrigation one must have a reservoir on farm in order to deliver small quantities of water frequently. The high initial cost of installing drip irrigation combined with inexpensive water costs deters producers from switching to more efficient methods of irrigation. Another barrier noted by producers is the lack of opportunity to see demonstrations of conservation practices and their effectiveness. Many producers do not believe that conservation practices such as reduced tillage or planting cover crops will work in their area. Following closely behind economic barriers is the lack of information on incentive programs. The survey results indicate that there is a need for educational programs and demonstrations that will address the primary barriers to adopting practices.

Supporting these barriers in the literature, Nowak (1992) described two reasons for non-adoption; 1) being unable to adopt and 2) being unwilling to adopt. In the first reason, he describes that information is lacking or scarce and the availability and accessibility of supporting resources is limited, which are directly tied to education. In his second reason, he says that limitation is related to conflicting information and poor applicability and relevance of information, which are also related to education. Rogers (2003) also supports this by providing the needed components of innovations, which are: relative advantage, compatibility, complexity, observability, and trialability. Although educators are not able to meet the trialability component, they can provide the other four. However, recent education programs have not provided the relative advantage, compatibility, or complexity components to producers and as a result, the amount of interest in adopting management practices has not met the goals of the Arroyo Colorado Watershed Partnership. It is the goal of this project to deliver the most relevant information to agricultural producers and equip them with the technical information needed to adopt BMPs, especially through incentive programs.

This project continued the efforts from TSSWCB 10-11 but targeted the educational program (1) by providing the most up-to-date information on technical and financial assistance from federal, state and local agencies and (2) by developing educational material and delivering it by a direct mailing list to inform producers on most recent information on BMPs for better on-the-farm conservation management. By focusing on building educational efforts on these two topics, those barriers were addressed first-hand.

Project Coordination

Throughout the project, TWRI and project partners regularly communicated to ensure that project tasks and deliverables were completed consistent with the work plan and met measures outlined in the WPP. To facilitate this, the Extension Assistant served as the co-lead for the Arroyo Colorado Watershed Partnership Agricultural Issues Workgroup (Appendix 1) and participated in Arroyo Colorado Watershed Partnership and other workgroup meetings as needed. The Extension Assistant also routinely participated in meetings of the Soil and Water Conservation Districts and various other entities to communicate and coordinate agricultural NPS education activities. Further, the Extension Assistant ensured that the project website, www.arroyocolorado.org, was routinely updated.

Educational and Outreach Material

To support delivery of educational programs, TWRI worked to inventory, assess and revise educational materials related to the Arroyo, priority BMPs (Appendix 2), and cost-share programs to ensure they were updated and reflected the most current information available. TWRI developed educational factsheets on new techniques on how to irrigate citrus with Narrow Border Flood irrigation to help conserve irrigation water up to 30% (Appendix 3). Another factsheet (Appendix 3) and press release (Appendix 4) was developed by TWRI to inform producers about technical and financial assistance from the Regional Conservation Partnership program (RCPP), where funds are available for on-the-farm improvements.

The Extension Assistant collaborated with the AgriLife Extension Irrigation Engineers to update the Irrigation Training Program developed in 2008 to better meet the needs of the Lower Rio Grande Valley (Appendix 5). This manual will be a guide for producers on relevant methods of irrigation, their installation costs, water use efficiency, and economic analysis. Again, water quantity and practices to reduce water use ranked high in an evaluation of agricultural producers' educational needs. Updating this manual to include current information tailored to the Lower Rio Grande Valley covers educational needs that producers have voiced as highly important to them. In addition, revising the manual will support the delivery of irrigation training workshops in coming years, where it will be used as curriculum for experts to present on priority topics.

Local Education Meetings

The main objective of this project was to educate agricultural producers in the Arroyo Colorado watershed about the impairments facing the Arroyo Colorado and what they can do to help improve water quality, as well as improve soil health, their overall operations, and water use efficiency. To do so, the Extension Assistant attended meetings and delivered education programs to raise awareness of agriculture NPS pollution in the watershed, educate producers on the use of BMPs, promote nutrient management and soil health, and encourage voluntary adoption of conservation plans, participation in the soil testing campaign, and involvement in the Regional Conservation Partnership Program. Educational materials were distributed at these meetings and education programs, as well as through direct mailings and social media.

Because of the wide array of potential impacts to water quality, various programs were attended, including the Pre-Plant Conference, Cotton and Grain Meetings, Soil and Water Conservation District meetings, and the Arroyo Colorado Steering Committee meeting, as well as the Kids, Kows and More event in Hidalgo and Willacy counties, and the Coastal Expo in Edinburg. At the latter two events, TWRI presented the Arroyo Colorado watershed model to approximately 4,400 kids and 225 educators to teach them about nonpoint source pollution within the watershed. Specifically, the audience learned about water quality and quantity, how dissolved oxygen in the Arroyo has become an issue that endangers the ecology of the river and leads to less recreational usage of the water system, how anyone can unknowingly contribute to water pollution, and how everyone can all help keep the water clean.

The Extension Assistant worked closely with county Extension Agents, NRCS, FSA, TSSWCB, Soil and Water Conservation Districts, Irrigation Districts and Drainage Districts to help promote their activities and educational programs as well as gave presentations and helped host/organize programs as requested. Communication on a regular basis ensured efforts were not duplicated and the most up-to-date information reached agricultural producers in the area. The Extension Assistant worked closely with NRCS to publicize their renewed emphasis on soil health, particularly by identifying producers already working with NRCS and enlisting them for programs and field tours to showcase their conservation practices and highlight their success.

As this is a continuation of an existing project, a producer mailing list already existed, but the Extension Assistant continued to develop the list as new contacts were made as well as use contacts within other agencies to distribute information to their own existing mailing lists. These mailing lists were used to inform producers about the availability of technical and financial assistance, upcoming educational programs (i.e. pesticide safety training and building water-conserving landscapes), field demonstrations, and trials.

Field days were conducted in coordination with this project. A kick off for the Soil Testing Campaign was held in conjunction with a Crops Fertility Workshop on October 16, 2014 to remind producers of the many benefits of soil testing and encourage them to participate in the Soil Testing Campaign. Additionally, this workshop provided a field tour of no till implements, cover crop planting, and other BMPs being implemented at a nearby property.

Through this project, 1,500 individuals were reached through educational efforts directly related to the goals of this project and another 4,000 individuals were reached at larger, indirectly related events such as environmental expos, conferences, and meetings.

Soil Testing Campaign

Improving and maintaining soil health plays a key role in reducing pollutant loads in the Arroyo Colorado. Since 2002, an annual soil testing campaign has been offered free of charge to agricultural producers in the Lower Rio Grande Valley to help them make educated decisions on nutrient application for their crops. The campaign was originally funded by USDA – Cooperative State Research, Education, and Extension Service and then by the Rio Grande Basin Initiative in Starr, Hidalgo, Willacy, and Cameron counties. Since 2008, the campaign has been funded by various grants awarded to TWRI by TSSWCB. As those projects focused on the Arroyo Colorado watershed, only Hidalgo, Cameron, and Willacy counties could participate in the campaign.

The soil testing campaign generally runs from October through February. Soil sample bags and forms were available at local County Extension Offices and the Texas A&M AgriLife Extension Service District 12 Office in Weslaco. Once soil samples were returned by landowners to those locations, they were shipped to the Texas A&M Soil, Water, and Forage Testing Laboratory in College Station. In addition to the soil analysis, the Extension Assistant and County Extension Agents were available to demonstrate how to properly collect a soil sample and in some cases to assist in collecting samples. The free soil analysis was mailed directly to the producer, where they could then consult with County Extension Agents or representatives from NRCS or TSSWCB for further interpretation of those results.

There are a number of benefits that resulted from the Soil Testing Campaign; not only did it help keep nutrients out of the Arroyo, but it provided agricultural producers an opportunity to save money on fertilizer costs by using residual nutrients already in the soil. As previously discussed, the kick off for the Campaign was held in conjunction with the Crops Fertility Workshop on October 16, 2014 to remind producers of the many benefits of soil testing and encourage them to participate in the Soil Testing Campaign. The 42 producers attending the Workshop were provided a very informative presentation by Dr. Mark McFarland, Associate Department Head of Soil and Crop Sciences at TX A&M University. Dr. McFarland's research over the past 15 years has proven that the many nutrients needed to produce a successful stand of crops are already present in the soil if we are willing to look for them. One big take away message was that nitrogen is a highly soluble nutrient that moves down into the soil profile. In order to determine the amount of the residual nitrogen in the soil, you need to take your soil sample deeper than previously recommended, between18-24 inches, to give producers a better understanding of the amount of Nitrogen they have to work with. It is recommended that two soil samples be collected, one from the top 6 inches for nutrients that do not move through the soil profile very easily and another deeper sample to capture the nutrients that do move within the soil profile (i.e. nitrogen).

In the 2015-2016 soil testing campaign, 110 producers submitted 130 soil samples, representing approximately 7,517 acres. Data showed that producers are benefiting from the availability of this campaign and through this project it became apparent that the program is having an impact as most producers in the Valley were already applying the correct amount of nutrients. This demonstrates that the soil testing campaign and associated educational programs have been effective in teaching producers about nutrient management and crop fertility needs.

The soil testing campaign was promoted in flyers posted at local farm and ranch stores. The Extension Assistant was available to assist with interpreting soil testing results if requested. The soil testing campaign was promoted each season (1) with a fact sheet and flyers posted at cotton gins, feed and seed stores and hardware stores, (2) by information sent via email to contact lists and (3) by word of mouth. The 2014 news release was printed in at least four media outlets, according to Google News Alerts (Appendix 6). In addition, soil testing was encouraged at nutrient management programs, cost share programs, and any other educational programs, where appropriate. The postcard (below) was sent to 2,515 agricultural producers in the watershed.

Annual Soil Testing Campaign for Agricultural Producers
in Hidalgo, Cameron and Willacy Counties

Free soil testing until February 28, 2015

The campaign provides free soil sample analysis to determine the amount of readily available nutrients in the soil. Using residual nutrients in the soil decreases the amount of fertilizer necessary for plant growth and the possibility of excess nutrients leaving fields in irrigation runoff, ultimately ending up in the Arroyo Colorado. Pick up and drop off sample forms and bags at any of the following locations:

Cameron County Office
1390 W Expressway 83
San Benito, TX 78586-7633
(956) 361-8236, cameron-tx@tamu.edu

Willacy County Office
170 N 3rd Street
Raymondville, TX 78580-1940
(956) 689-2412, willacy-tx@tamu.edu

Hidalgo County Office
410 N 13th Ave
Edinburg, TX 78541-3582
(956) 383-1026, hidalgo-tx@tamu.edu

District 12 Office
2401 East Highway 83
Weslaco, TX 78596-8344
(956) 968-5581, d12south@ag.tamu.edu

For more information, contact Ashley Gregory at 956-968-5581 or ahgregory@ag.tamu.edu

Texas A&M AgriLife Extension Service
Texas Water Resources Institute
South District 12
2401 East Bus. Highway 83
Weslaco, TX 78596

NON PROFIT ORG.
U.S. Postage
PAID
Bryan, TX
Permit No. 83

Return Service Requested

Additionally, flyers (see below) were posted at feed and seed stores, John Deere dealerships, chemical and fertilizer companies, county offices, handed out personally to producers, irrigation districts, drainage districts, NRCS offices, Harlingen regional office of the TSSWCB, FSA offices, and the Edinburg cattle Auction Barn.

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Free Soil Testing and Shipping

Free Soil Testing and Shipping by Texas AgriLife Extension Service

- Pick up forms and sample bags at your local county AgriLife Extension office or the AgriLife District 12 office located in Weslaco. Office addresses are listed below.
- Drop off filled sample bags and forms at the same county or district office for shipping.
- Producers in Cameron, Hidalgo and Willacy Counties can participate.

Cameron County Office
1390 W Expressway 83
San Benito, TX 78586-7633
(956) 361-8236, cameron-tx@tamu.edu

Hidalgo County Office
410 N 13th Ave
Edinburg, TX 78541-3582
(956) 383-1026, hidalgo-tx@tamu.edu

Willacy County Office
170 N 3rd Street
Raymondville, TX 78580-1940
(956) 689-2412, willacy-tx@tamu.edu

District 12 Office
2401 East Highway 83
Weslaco, TX 78596-8344
(956) 968-5581, d12south@ag.tamu.edu

Campaign funded by the Texas State Soil and Water Conservation Board and administered by the Texas Water Resources Institute for nonpoint source pollution reduction in agricultural fertilizer runoff into the Arroyo Colorado Watershed.

For more information, visit these websites:

- arroyocolorado.org
- twri.tamu.edu
- irnr.tamu.edu
- www.tsswcb.texas.gov

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Conclusions

Through this project, the South Texas Irrigation Training Program Manual was updated along with several other educational materials. New fact sheets were developed for new, innovative BMPs (i.e. narrow border flood irrigation) and new incentive programs (i.e. RCPP). Through this project, 5,500 individuals were reached through attendance at educational programs, direct mailings, or participation in the annual soil testing campaign. Through this project, the effectiveness of the soil testing campaign and associated education programs became apparent as most producers in the Lower Rio Grande Valley were found to be applying the correct amount of nutrients to meet crop fertility needs.

With financial and education needs continuing to be the top barriers to adopting BMPs, continued delivery of education programs focused on assisting stakeholder with addressing agricultural NPS in the Arroyo Colorado Watershed will remain an important endeavor in the watershed, even after water quality begins to improve. The majority of the land in the watershed is comprised of some form of agriculture, and because implementation of BMPs and conservation plans are voluntary, it will be necessary to keep promoting these practices along with technical and financial assistance. The soil testing campaign has been a huge success in the past and continues to be highly utilized by producers. Since it is known that nutrient and irrigation water management are two of the most impactful BMPs when it comes to reducing nutrient and sediment loading into the Arroyo Colorado, agricultural education programs, along with soil testing, will continue to be vital to improving water quality in the Arroyo.

References

Kannan, N. Texas Water Resources Institute, (2012). Swat modeling of the Arroyo Colorado watershed (Technical Report 426). Retrieved from website: http://twri.tamu.edu/reports/2012/tr426.pdf

Nowak, P. (1992). Why farmers adopt production technology Overcoming impediments to adoption of crop residue management techniques will be crucial to implementation of conservation compliance plans. Journal of Soil and Water Conservation, 47(1), 14-16.

Rogers, E. M. (2003). Diffusion of Innovations. New York, NY: Free Press.

Texas Commission on Environmental Quality. (2013, February 13). Draft 2012 Texas integrated report - Texas 303(d) list (category 5). Retrieved from http://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/12twqi/2012_303d.pdf

Appendices

1. Arroyo Colorado Watershed Partnership Ag Issues Workgroup Agendas and sign-in sheets
2. Inventory/review of priority BMPs
3. Fact Sheets (NBF and RCPP)
4. RCPP News Release
5. Irrigation Training Program Manual
6. Press release and marketing for the soil testing campaign

1. **Arroyo Colorado Watershed Partnership Ag Issues Workgroup Agendas**

Ag Issues Workgroup

Arroyo Colorado Watershed Partnership

Cameron County Extension Services
1390 W. Exp. 83
San Benito, TX
9:00AM – 11:00AM

MEETING AGENDA

- **Welcome and Introductions**
  Ronnie Ramirez, TSSWCB
- Update on **Arroyo Colorado Watershed Protection Plan.**
  Jaime Flores, TWRI
- **Soil Test Campaign**
  Victor Gutierrez, TWRI
- **Texas Commission on Environmental Quality ~ Water Issues in the Rio Grande**
  Harlingen TCEQ, Rio Grande Watermaster
- **Vegetation Management Plan (VPM) for Arroyo Colorado Flood Control.**
  Rodolfo Montero - IBWC
- **Texas Department of Agriculture**
  Nelda Barrera – Field Rep
- **Texas State Soil and Water Conservation Board – WQMP Programs**
  Harlingen Regional Office
- **Farm Service Agency**
  Cris Perez, County Executive Director
- **United States Department of Agriculture – NRCS**
- **Grant Updates**
  Jaime Flores, TWRI

Ag Workgroup Meeting

Cameron County Extension Meeting Room

1390 W. Expressway 83, San Benito, TX 78586

February 19th, 9:00 – 11:00 am

- Welcome and Introductions

- Update on Ag Activities
    - Educational Programs and Soil Testing Campaign – Ashley Gregory
    - 319 Water Quality Management Plans – Ronnie Ramirez
    - Sugar Cane Aphid

- Announcement of NRCS Regional Conservation Partnership Program Grant

- Ongoing Modeling Issues – Jaime Flores

- Update Planning Document for Phase II of the WPP
    - Accomplishments →New goals
        - Can we categorize active BMPs by subwatershed?
    - Need input from group on contents of ag section
    - Review which maps need to be updated and discuss new maps/images
        - Land use map

- Other Issues

- Set date for next meeting

2. Inventory/review of priority BMPs

Irrigated Pasture/Hay Land- 500 ac./co./yr (excluding Willacy County)

- 314- Brush Management in conjunction with Forage Planting (512), Nutrient Management (590), and/or Range Planting (550)
- 340- Cover Crops
- 382- Cross Fencing
- 430- Pipeline
- 464- Land Leveling
- 512- Forage Planting
- 528A- Prescribed Grazing
- 550- Range Planting
- 590- Nutrient Management
- 614- Watering Facility

Range Land/Wildlife – 250-300 ac./co./yr

- 314- Brush Management
- 382- Cross Fence
- 528A- Prescribed Grazing
- 550- Range Planting
- 614- Watering Facility
- 645- Wildlife Habitat Management
- 657- Wetlands Enhancements

Other/Complimentary BMPs:

- 315- Herbaceous Weed Control
- 320- Irrigation Canal or Lateral
- 332- Contour Buffer Strip
- 338- Prescribed Burning
- 342- Critical Area Planting
- 378- Pond
- 388- Irrigation Field Ditch
- 410- Grade Stabilization Structures
- 428- Irrigation Water Conveyance
- 436- Irrigation Reservoir

- 441-443- Irrigation System
- 447- Irrigation Tailwater Recovery
- 449- Irrigation Water Management
- 516- Livestock Pipeline
- 587- Structure for Water Control
- 606- Subsurface Drain
- 612- Tree/Shrub Establishment
- 642- Wildlife Water Facility
- 644- Wetland Wildlife Habitat Management
- 645- Upland Wildlife Management
- 646- Shallow Water Management for Wildlife
- 656- Constructed Wetland

3. Fact Sheets (NBF and RCPP)

Water Quality Best Management Practices Series

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Narrow Border Flood Irrigation

What is Narrow Border Flood Irrigation?

Narrow Border Flood (NBF) Irrigation is an alternative flood irrigation practice that saves water in citrus orchard groves. It is a simple on-farm management option that can be implemented immediately with minimal modifications to current cultural practices and accommodates the irrigation systems typically used throughout the Lower Rio Grande Valley of South Texas. Dr. Shad D. Nelson, Texas A&M University-Kingsville, has demonstrated that using NBF Irrigation saves up to 35% of water supplies. It also leads to higher net-cash farm income to citrus growers who implement and use this practice.

What are the benefits?

- Increased percentage of fruit going to fresh market rather than juice market, which leads to more net farm income to grower
- Less weed competition
- Keeps fertilizers within root zone when compared to conventional flood irrigation

What needs to be done to apply this practice?

- Raise a berm about 3 feet wide and I foot high between tree rows.
- Irrigate using polypipe or gated pipe to direct water between rows.

What does it take to apply this practice?

- Bed shaper or disks to form a raised bed placed behind a tractor
- A little extra time
- Extra fuel cost for the bed
- Good to knock the bed down prior to harvest or at time of hedging trees

Be a part of conserving this precious natural resource by adopting a BMP and lessen the impacts of agriculture on water quality.

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Narrow Border Flood Irrigation

Agriculture in the Arroyo Colorado

The Arroyo Colorado watershed is a 706 square mile watershed that runs from McAllen to the Lower Laguna Madre and is impaired for low dissolved oxygen, bacteria and legacy pollutants. In an effort to correct it, a watershed protection plan (WPP) was developed by stakeholders (released in 2007) and is being implemented throughout the watershed. If you have questions, you may also contact the Texas AgriLife Extension Service agent for your county.

Agricultural production comprises of almost half the land within the Arroyo Colorado watershed and of that 50 percent, approximately half needs to implement best management practices (BMPs) by the year 2015. Runoff from these agricultural lands, carry nutrients and sediments which cause the above impairments in the Arroyo Colorado and inhibit aquatic life.

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lower rio grande valley water improvement initiative

The Lower Rio Grande Valley is experiencing tremendous population growth. Between 2010 and 2060, the region's population is predicted to grow 142 percent. The 2012 Rio Grande Regional Water Plan estimates that an additional supply of 610,000 acre-feet of water a year will be needed by 2060 to support this growth.

This increased population is putting pressure on the region's limited water supplies and heightening the need for water conservation. At the same time, the Valley is experiencing degraded water quality, particularly due to excess nutrients, necessitating improved nutrient management and reductions in edge-of-field nutrient runoff.

These water resource issues in the Valley require innovative, integrated approaches to achieve needed improvements. ***The Lower Rio Grande Valley Water Improvement Initiative***, led by the Texas Water Resources Institute (TWRI), addresses these water quantity and quality issues. The initiative is part of the U.S. Department of Agriculture-Natural Resources Conservation Service (NRCS) Regional Conservation Partnership Program (RCPP).

A new 2014 Farm Bill program, RCPP is a voluntary conservation effort providing financial and technical assistance to agricultural producers and landowners to install and maintain conservation practices that address priority natural resource concerns.

Initiative Objectives

- Foster coordinated water conservation and water quality activities
- Improve the efficiency of irrigation water delivery
- Improve nutrient and irrigation water management
- Monitor progress and water resource benefits

More than 12 initiative partners are working on improving irrigation scheduling and application, increasing efficiency of irrigation water delivery and adapting innovative irrigation management and technologies for the Valley. These practices will decrease water use, improve productivity and reduce irrigation return flows, thus reducing nutrient and sediment loading to local waters. The Texas A&M AgriLife Extension Service is providing education programs on irrigation management, nutrient management and water resource issues. TWRI is working to ensure the initiative supports and is integrated into regional water quantity and water quality planning efforts and monitor the initiative's success by tracking practices implemented and their benefits at the field and watershed level.

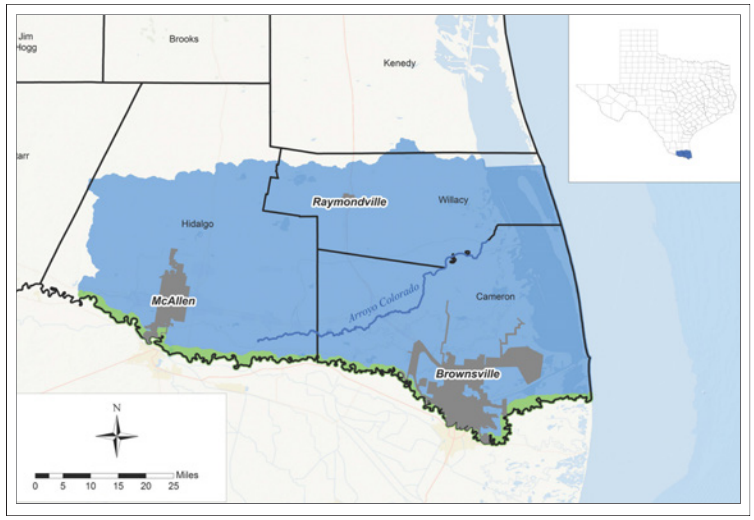
twri.tamu.edu

texas water resources institute

lower rio grande valley water improvement initiative

Through this initiative, NRCS is providing an additional $592,800 annually to agricultural producers in Cameron, Hidalgo and Willacy counties to implement best management practices, including:

- Land leveling
- Soil testing/nutrient management
- Irrigation pipelines and canals
- Irrigation systems – sprinklers, drip, etc.
- Narrow border flood irrigation
- Surge valves
- Irrigation reservoirs
- Filter strips
- Cover crops
- No till or reduced tillage practices
- Conversion of cropland to pasture
- Many others



Contacts

To participate, agricultural producers and landowners should contact their local NRCS field office:

Edinburg Service Center
2514 S Veterans Blvd
Edinburg, TX
956.383.3002 ext. 121

San Benito Service Center
2315 W Frontage Hwy 83
San Benito, TX
956.399.2522

Raymondville Service Center
255 FM 3168
Raymondville, TX
956.689.2542

For more information on the initiative, contact: Dr. Kevin Wagner, Associate Director, Texas Water Resources Institute, klwagner@ag.tamu.edu or 979.845.2649.

Collaborators

- Arroyo Colorado Watershed Partnership
- Black and Veatch
- Cameron County Irrigation District #2
- Harlingen Irrigation District
- Rio Grande Regional Water Authority
- Rio Grande Regional Water Planning Group
- Texas A&M AgriLife Research
- Texas A&M AgriLife Extension Service
- Texas Citrus Mutual
- Texas Commission on Environmental Quality
- Texas State Soil and Water Conservation Board
- Texas Vegetable Association
- Texas Water Development Board
- Texas Water Resources Institute
- USDA-Natural Resources Conservation Service

Texas Water Resources Institute
make every drop count

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8/2015

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4. RCPP News Release

TEXAS A&M AGRILIFE RESEARCH | EXTENSION

TEXAS A&M UNIVERSITY
AGRICULTURE & LIFE SCIENCES

TEXAS WATER RESOURCES INSTITUTE

March 3, 2016

Valley agricultural producers, landowners eligible for assistance to improve irrigation, nutrient management

Contact: Kevin Wagner, 979-845-2649, klwagner@ag.tamu.edu
Victor Gutierrez, 956-969-5615, victor.gutierrez@ag.tamu.edu

WESLACO--Agricultural producers and landowners in Willacy, Cameron and Hidalgo counties may be eligible for financial assistance to improve their irrigation systems and implement other conservation practices through a U.S. Department of Agriculture Natural Resources Conservation Service program.

The Lower Rio Grande Valley Water Improvement Initiative, a five-year, $3 million partnership effort led by the Texas Water Resources Institute, is funded through the Regional Conservation Partnership Program, or RCPP, authorized by the 2014 Farm Bill.

"Ag producers and landowners in the Valley can apply at any time for these funds, but to be eligible for this year's allocations, they are encouraged to apply by March 18," said Dr. Kevin Wagner, deputy director of the water institute. "They should contact their local Natural Resources Conservation Service or Soil and Water Conservation District offices to find out how to apply for RCPP funding, the best management practices they are eligible for and more information."

Wagner said additional funds will be available each of the next four years for Valley agricultural producers and landowners to install and maintain conservation practices that improve on-farm efficiency.

"The Lower Rio Grande Valley is experiencing significant population growth, which puts greater pressure on the limited water supplies and increases the need for improved irrigation efficiency," he said. "Along with the limited supplies, degraded water quality necessitates improved conservation as well. Although addressing water quantity is the primary concern, the importance of water quality and quantity are inseparable and intricately linked in the Valley."

According to Natural Resources Conservation Service, the initiative encompasses 1.59 million acres in Cameron, Hidalgo and Willacy counties and includes the lower Rio Grande, Arroyo Colorado and north Floodway.

Wagner said examples of conservation practices eligible for funding include land leveling; installation of drip, sprinkler, or microspray irrigation systems; soil testing; implementation of surge valves; use of narrow border flood irrigation on citrus, and other practices to conserve soil and water resources.

The Texas A&M AgriLife Extension Service is providing education programs on irrigation management, nutrient management and water resource issues as part of the initiative, Wagner said.

-more-

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RCPP
Add One

For more information on available RCPP funding, producers and landowners in the three counties should call the San Benito Service Center at 956-399-2522 and/or visit their nearest Natural Resources Conservation Service Field Office, located in Edinburg, San Benito or Raymondville.

For more information on the partnership and its activities, contact Wagner at 979-845-2649, klwagner@ag.tamu.edu, or Victor Gutierrez, the institute's Extension assistant in Weslaco, at 956-969-5615, victor.gutierrez@ag.tamu.edu.

The Texas Water Resources Institute is part of Texas A&M AgriLife Research, Texas A&M AgriLife Extension Service and the College of Agriculture and Life Sciences at Texas A&M University.
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5. Irrigation Training Program Manual

Texas Water Resources Institute
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Soil Water TSSWCB
Texas State Soil and Water Conservation Board

Texas A&M AgriLife Extension

SOUTH TEXAS IRRIGATION TRAINING PROGRAM MANUAL

Texas Water Resources Institute EM-121
Spring 2016 | twri.tamu.edu

SOUTH TEXAS IRRIGATION TRAINING PROGRAM MANUAL

Texas Water Resources Institute EM-121
Spring 2016 | twri.tamu.edu

Acknowledgments

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PREFACE

Goal

- Equip irrigation managers and technical support personnel with information and resources to support improved irrigation management and water conservation.

Objectives

1. Provide participants with core knowledge base, including irrigation fundamentals, irrigation technologies, and best management practices.
2. Compile currently available and new educational materials into a convenient resource package.
3. Develop a series of educational events to deliver the information to the target audiences to improve their knowledge base.

Chapter 1: Economic issues in irrigation

Economic issues in irrigation reflect complex and highly dynamic factors. Energy costs, commodity markets, weather patterns, and other issues are difficult to predict and impossible to control. Irrigation is as much a risk management tool as a (sometimes expensive) production input. Equipment selection, irrigation management, and other decisions need to be made with economics in mind.

Objectives

- Increase understanding of factors that affect economics of irrigation systems.
- Increase understanding of costs and associated benefits of commonly used irrigation systems.
- Increase understanding of methods for evaluating and comparing irrigation systems.

Key points

1. When considering investing in an irrigation system, several major factors should be noted: availability (reliability, quantity, and quality) of water; the system's application efficiency; the depth from which water must be pumped (pumping lift); operating pressure of the system; financing; savings in field operations; energy sources; energy prices; crop mix/rotations; economies of scale; fixed and variable costs; labor availability; management capabilities; commodity prices, and, of course, the site-specific layout and physical conditions.
2. Overlaying these factors are differences in the costs and water application efficiencies of the various irrigation systems.
3. Generally speaking, low pressure center pivot irrigation systems and microirrigation systems are more efficient than high pressure sprinkler systems or surface irrigation systems. Good management and maintenance are critical to realizing the benefits of any system.

Economics of irrigation systems

Investing in a new irrigation system can be expensive, and factors affecting the feasibility of systems are complex. In addition to initial capital and installation investment costs, water availability (reliability, quantity, quality); pumping lift and system pressure requirements; system efficiencies; labor and fuel cost; tax and interest rates; operation specific considerations (crop rotations, soil type, field topography, management capabilities, etc.) determine the relative economic feasibility and practical suitability of the options.

A Texas-based evaluation of costs and associated benefits of six commonly used irrigation systems in Texas (conventional furrow, surge flow, mid-elevation spray application center pivot, low elevation spray application center pivot, low energy precision application center pivot, and subsurface drip irrigation) indicated that:

- Furrow irrigation requires less capital investment but has lower water application efficiency and is more labor intensive than the other irrigation systems.

- Adding surge flow valves increases water application efficiency enough to increase returns per acre. However, before purchasing surge equipment, growers should closely evaluate the ability to provide the required management of irrigation scheduling with surge flow systems.
- Compared to furrow irrigation, center pivots generally offer more than enough benefits in application efficiency and reduction in labor requirements to offset the additional costs.
- Advanced irrigation technologies are most advantageous to crops with high water needs, particularly in areas with deep pumping lifts. Producers using advanced systems will have not only lower pumping costs but also potential savings from chemigation and the need for fewer field operations.
- Compared to center pivot irrigation systems, subsurface drip irrigation (SDI) generally is significantly more expensive to install (on a per acre basis). SDI shows greater potential in situations less suited to center pivot irrigation (low water capacities, small or irregularly shaped fields, etc.).
- The less efficient the irrigation system, the more effect fuel price, pumping lift, and labor costs have on the cost of producing an irrigated crop.
- As more water is pumped, the fixed cost per acre-inch drops.

Chapter 2: Irrigation scheduling

Evapotranspiration

Objectives

- Increase understanding of fundamentals of evapotranspiration (ET).
- Increase familiarity with ET resources, including ET networks and internet-available data and online tools.
- Apply these concepts to optimizing water management in crop production.

Key points

1. Meteorological factors most often used to estimate ET are solar radiation (irradiance), air temperature, humidity, and wind speed.
2. ET can be limited by soil moisture availability.
3. Plant factors that affect ET include plant type, plant health, growth stage, plant population, and crop variety (affecting canopy and geometry). Successful application of ET models to irrigation scheduling requires appropriately relating the reference crop ET to the target crop ET through use of crop growth information and crop coefficients.
4. ET is most accurately measured through use of weighing lysimeters.
5. Alternate methods of estimating ET include water balance estimation techniques, including soil moisture monitoring, remote sensing, and eddy covariance and scintillometry methods.
6. All methods require understanding of the fundamentals and applications. ET-based crop water use estimates provided by ET networks (where available) require little or no investment in instrumentation and data collection on the part of the end-user.

What is evapotranspiration (ET)?

Evapotranspiration (ET) is a term that describes crop water demand by combining evaporation and transpiration. Evaporation is the process through which water is removed from moist soil and wet surfaces (such as dew on leaves). Transpiration is the process through which water is drawn up through the plant (roots extract water from the soil, and water is eventually removed through stomata on the leaves).

What is Reference ET?

Reference crop ET, also sometimes referred to as Potential Evapotranspiration (PET), is an estimate of the water requirement for a well-watered reference crop. This reference crop (an idealized cool season grass "short crop" or alfalfa "tall crop") is essentially a model crop used as a basis for the ET model. Reference ET is calculated by applying climate data (temperature, solar radiation, wind, humidity) in a model (equation). Reference ET is only an estimate of the water demand for this model crop, based upon weather station data at a given location.

How is crop evapotranspiration calculated?

Crop-specific ET is estimated by multiplying the Reference ET by a crop coefficient.

Crop ET = Reference ET x Crop Coefficient

The crop coefficient accounts for the crop's water use (at a given growth stage) compared with the reference crop. For instance, seedling corn does not use as much water as the idealized grass reference crop, but during silking, the corn can use more water than the grass reference crop. The crop coefficient is understood to follow a pattern (curve) of the general shape (Figure 1). Each crop (wheat, sorghum, cotton, etc.) will have its own crop coefficient curve. Important to note, the crop coefficient curve is SPECIFIC to the ET equation used. The preferred equation is the ASCE-EWRI Standardized Reference ET Equation* (Allen, et al., 2005), but some ET networks in Texas use other models.

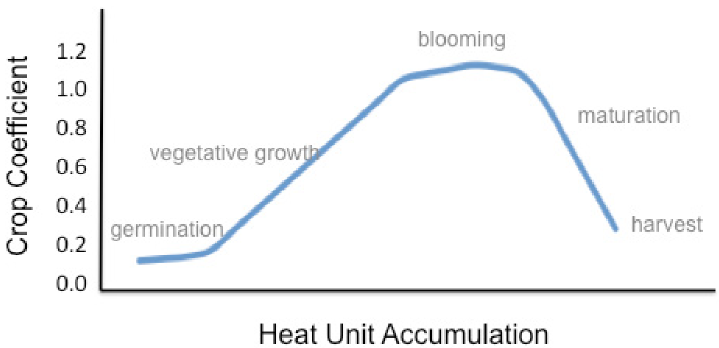


Figure 1. Generalized crop coefficient curve.

*Allen, Richard G., Ivan A. Walter, Ronald L. Elliott, Terry A. Howell, Daniel Itenfisu, Marvin E. Jensen, and Richard L. Snyder. 2005. ASCE Standardized Reference Evapotranspiration Equation. American Society of Civil Engineers, Baltimore, MD. 216 pp.

The reference crop ET model (equation) and the crop coefficient curves were developed from long-term research at various locations. Actual crop water demand can be affected by many factors, including available soil moisture, the crop's health, and likely by plant populations and crop variety traits. Models do not account for these factors. These additional factors are sometimes addressed through use of stress coefficients and other methods generally not reflected in simple ET network models. Hence, ET data provided by online networks are best used as guidelines for irrigation scheduling, and, where applicable, for integrated pest and crop management. The predicted growth stage and estimated water use should be verified with field observations. The actual crop water use may be less than the predicted value due to less than optimal field conditions.

How is estimated ET used to schedule irrigation?

A variety of irrigation scheduling methods, models, and tools are available. Many are essentially based upon a "checkbook" approach; water stored in the soil (in the crop's root zone) is withdrawn by evapotranspiration and deposited back into the soil through precipitation and irrigation. When soil moisture storage falls below a given threshold value (management allowable depletion), irrigation should be applied to restore the moisture. The threshold value may be determined by crop drought sensitivity, irrigation system capabilities, or other farm-level criteria.

Where can I find additional information on ET and related topics?

Reference Evapotranspiration (grass reference, ETo) and related agricultural weather data are available for some locations in South Texas on the Texas ET website: http://texaset.tamu.edu/. For locations without ET Network service, Reference ET (grass reference ET, ETo or alfalfa reference ET, ETr) can be calculated with local weather data and the Bushland Reference ET Calculator (smartphone app), available free of charge from iTunes. With reference ET and a reasonable crop coefficient, crop ET can be used with widely available ET-based irrigation scheduling tools, including KanSched, available at http://www.bae.ksu.edu/mobileirrigationlab/kansched-microsoft-excel.

Soil moisture management and monitoring

Objectives

- Increase understanding of soil physical properties that affect soil moisture storage and permeability.
- Increase familiarity with local soils and their characteristics as well as information resources addressing local soils.
- Apply these concepts to optimizing water management in crop production.

Key Points

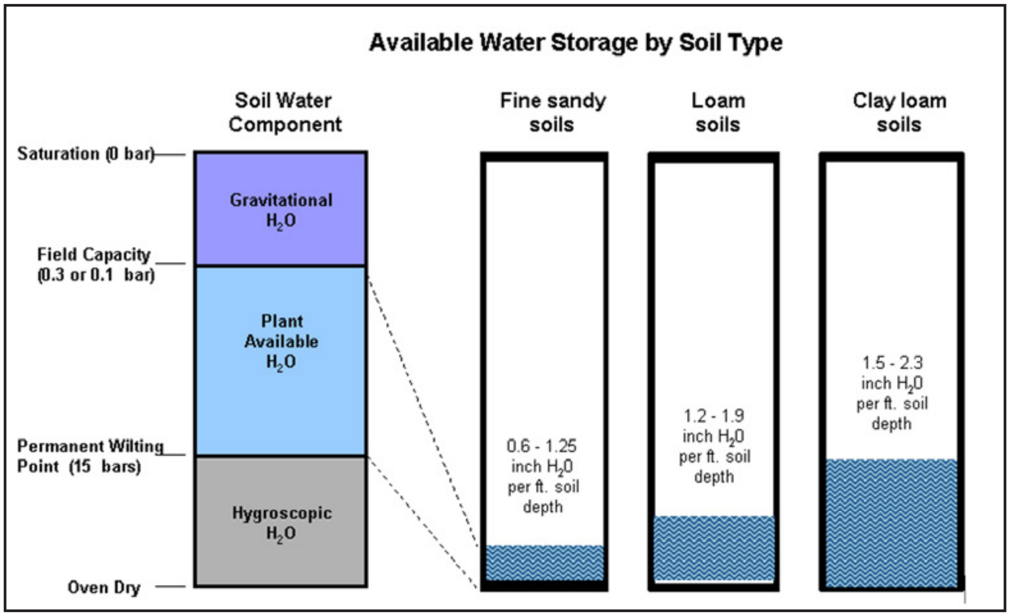
1. Soil permeability is affected by soil texture, structure, and moisture.
2. Plant available water in the root zone is water that can be stored in the soil between field capacity and permanent wilting point. Plant available water storage capacity is soil-specific.
3. Water in the soil is subjected to gravity, osmotic potential (suction), and matric (capillary) potential (suction).
4. There are several methods available for measuring or estimating soil moisture. These include gravimetric (oven dry), soil feel and appearance, resistance (WaterMark™ sensors), tensiometry, capacitance, time domain reflectometry, and other methods. Factors affecting the selection of a soil moisture monitoring method include costs, convenience, ease of use, required precision and accuracy, suitability for the soil texture, and personal preference of the operator.

Soil moisture storage capacity

Soil moisture characteristics: A soil's capacity for storing moisture is affected by its structure and organic matter content, but it is determined primarily by its texture.

Field capacity is the soil water content after soil has been thoroughly wetted when the drainage rate changes from rapid to slow. This point is reached when the *gravitational water* has drained. Field capacity is normally attained 2-3 days after irrigation and reached when the soil water tension is approximately 0.3 bars (30 kPa or 4.35 PSI) in clay or loam soils, or 0.1 bar in sandy soils.

Permanent wilting point is the soil moisture level at which plants cannot recover overnight from excessive drying during the day. This parameter may vary with plant species and soil type and is attained at a soil water tension of 10-20 bars. *Hygroscopic water* holds tightly onto the soil particles (below permanent wilting point) and cannot be extracted by plant roots.



Plant available water is retained in the soil between field capacity and the permanent wilting point. It is often expressed as a volumetric percentage or in inches of water per foot of soil depth. Approximate plant available water storage capacities for various soil textures are shown to the right.

If the goal is to apply water to moisten the root zone to some target level (75% field capacity, for instance, depending upon local factors), it is essential to know how much water the soil will hold at field capacity and how much water is already in the soil. Estimating soil moisture can be accomplished through direct methods (gravimetric soil moisture determination) or indirect methods. A variety of commercially available soil moisture monitoring instruments provide the means to estimate soil moisture relatively quickly and easily. Alternately, a soil's moisture condition can be assessed by observing its feel and appearance. A soil probe, auger, or spade may be used to extract a small soil sample within each foot of root zone depth. The sample is gently squeezed manually to determine whether the soil will form a ball or cast, and whether it leaves a film of water and/or soil in the hand. Pressing a portion of the sample between the thumb and forefinger allows one to observe whether the soil will form a ribbon. Results of the sample are compared with the following guidelines.

Table 1. How soil feels and looks at various soil moisture levels.

Soil moisture level	Fine sand, loamy fine sand	Sandy loam, fine sandy loam	Sandy clay loam, loam, silt loam	Clay loam, clay, silty clay loam
0%–25% available soil moisture	Appears dry. Will not retain shape when disturbed or squeezed in hand.	Appears dry. May make a cast when squeezed in hand but seldom holds together.	Appears dry. Aggregates crumble with applied pressure.	Appears dry. Soil aggregates separate easily, but clods are hard to crumble with applied pressure.
25%–50% available soil moisture	Slightly moist appearance. Soil may stick together in very weak cast or ball.	Slightly moist. Soil forms weak ball or cast under pressure. Slight staining on finger.	Slightly moist. Forms a weak ball with rough surface. No water staining on fingers.	Slightly moist. Forms weak ball when squeezed, but no water stains. Clods break with applied pressure.
50%–75% available soil moisture	Appears and feels moist. Darkened color. May form weak cast or ball. Leaves wet outline or slight smear on hand.	Appears and feels moist. Color is dark. Forms cast or ball with finger marks. Will leave a smear or stain and leaves wet outline on hand.	Appears and feels moist and pliable. Color is dark. Forms ball and ribbons when squeezed.	Appears moist. Forms smooth ball with defined finger marks. Ribbons when squeezed between thumb and forefinger.
75%–100% available soil moisture	Appears and feels wet. Color is dark. May form weak cast or ball. Leaves wet outline or smear on hand.	Appears and feels wet. Color is dark. Forms cast or ball. Will smear or stain and leaves wet outline on hand. Will make weak ribbon.	Appears and feels wet. Color is dark. Forms ball and ribbons when squeezed. Stains and smears. Leaves wet outline on hand.	Appears and feels wet. May feel sticky. Ribbons easily. Smears and leaves wet outline on hand. Forms good ball.

Root zone depth: Roots are generally developed early in the season and will grow in moist (not saturated or extremely dry) soil. Soil compaction, caliche layers, perched water tables, and other impeding conditions will limit the effective rooting depth. **Most crops will extract most (70%–85%) of their water requirement from the top 1 to 2 feet of soil, and almost all of their water from the top 3 feet of soil, if water is available**. Deep soil moisture is beneficial primarily when the shallow moisture is depleted to a water stress level. Commonly reported effective root zone depths by crop are listed in Table 2.

Table 2. Root zone depths reported for various crops.*

Crop	Approximate Effective Rooting Depth (feet)
Alfalfa	3.3–6.6+
Corn	2.6–5.6
Cotton	2.6–5.6
Peanut	1.6–3.3
Sorghum	3.3–6.6

**These values represent the majority of feeder roots.*

Permeability is the soil's ability to take in water through infiltration. Soil with low permeability cannot take in water as fast as soil with high permeability; the permeability, therefore, affects the risk for runoff loss of applied water. Permeability is affected by soil texture, structure, and surface condition. Generally speaking, fine textured soils (clays, clay loams) have lower permeability than coarse soils (sand). Surface sealing, compaction, and poor structure (particularly at or near the surface) limit permeability.

Using soil moisture information to improve irrigation efficiency

Deep percolation losses are often overlooked, but they can be significant. Water applied in excess of the soil's water storage capacity can drain below the crop's effective root zone. In some cases, periodic deep leaching is desirable to remove accumulated salts from the root zone. However, generally deep percolation losses can have a significant negative impact on overall water use efficiency — even under otherwise efficient irrigation practices such as low energy precision application (LEPA) and SDI. Furrow irrigation poses increased deep percolation losses at upper and lower ends of excessively long runs. Surge irrigation can improve irrigation distribution uniformity, reducing deep percolation losses in furrow irrigation. Coarse soils are particularly vulnerable to deep percolation losses due to their low water-holding capacity. Other soils may exhibit preferential flow along cracks and in other channels formed under various soil structural and wetting pattern scenarios.

Runoff occurs when rainfall or the irrigation rate exceed the soil's permeability. Sloping fields with low permeability soils are at greatest risk for runoff losses. Vegetative cover, surface conditioning (including furrow dikes), and grade management (land leveling, contouring, terracing, etc.) can reduce runoff losses. Irrigation equipment selection (nozzle packages) and management can also help to minimize runoff losses.

Soil moisture monitoring

Methods used to measure soil water are classified as *direct* and *indirect*. The direct method refers to the gravimetric method in which a soil sample is collected, weighed, oven-dried and weighed again to determine the sample's water content on a mass percent basis. The gravimetric method is the standard against which the indirect methods are calibrated. Some commonly used indirect methods include electrical resistance, tensiometry, capacitance, time domain reflectometry (TDR) and time domain transmissivity (TDT).

Electrical resistance methods include gypsum blocks or granular matrix sensors (more durable and more expensive than gypsum blocks) that are used to measure electrical resistance in a porous medium. Electrical resistance increases as soil moisture decreases. Sensors are placed in the soil root zone (and remain in place), and a meter is connected to lead wires extending above the ground surface for each reading. For most on-farm applications, small portable handheld meters are used; automated readings and controls may be achieved through use of dataloggers.

Tensiometers measure the tension of water in the soil (soil suction). A tensiometer consists of a sealed water-filled tube equipped with a vacuum gauge on the upper end and a porous ceramic tip on the lower end. As the soil dries, soil water tension (suction) increases; in response to this increased suction, water is moved from the tensiometer through the porous ceramic tip, creating a vacuum in the sealed tensiometer tube. Water can also move from the soil into the tensiometer during or following irrigation. Most tensiometers have a vacuum gauge graduated from 0 to 100 (centibars, cb, or kilopascals, kPa). A reading of 0 indicates a saturated soil. As the soil dries, the reading on the gauge increases. The useful limit of the tensiometer is about 80 cb. Above this tension, air enters through the ceramic cup and causes the instrument to fail. Therefore, these instruments are most useful in sandy soils and with drought-sensitive crops, because they have narrower soil moisture ranges than other sensor types.

Capacitance sensors, time domain reflectometry (TDR), time domain transmissivity (TDT), and related technologies have become more popular in recent years. Sensors must be carefully installed in the root zone, and they are left in place during the entire monitoring period (crop season, for instance). They are typically connected to a datalogger for monitoring over time, and data are often accessible remotely. Advanced "packaging" of the data has improved adoption of these technologies. Initial costs of the sensors plus subscription fees in some cases make these sensors more expensive than simpler sensors, necessitating balance between cost(s) and numbers of sensors, and increasing the importance of the careful placement (installation and siting) of sensors.

All soil water monitoring methods have advantages and limitations. They vary in cost, accuracy, ease of use, and applicability to local conditions (soils, moisture ranges, etc.) Most require calibration for accurate moisture measurement. Practice and experience under given field conditions increases proficiency of use and interpreting information.

Chapter 3: Irrigation technologies and best management practices

Surface irrigation

Objectives

- Increase understanding of irrigation efficiency, losses, and distribution uniformity associated with surface irrigation.
- Increase understanding and application of best management practices to improve efficiency and uniformity of surface irrigation.

Key points

1. Surface irrigation uses gravity flow to spread water over a field. With flood irrigation, the entire land area to be irrigated is covered with water. Furrow irrigation uses small channels or ditches between planted rows to convey water across a field.
2. Using pipe systems to convey and distribute water increases on-farm irrigation efficiency, provides better irrigation control, and reduces labor costs.
3. The correct amount of water to apply at each irrigation event depends on the amount of soil water used by the plants between irrigations (soil water depletion), the water-holding capacity of the soil, and the depth of the crop root zone. Applying the right amount of water to an irrigation set does not guarantee efficient irrigation. Water also must be uniformly applied from one end of the irrigation run (field) to the other.
4. Best management practices to consider include precision land leveling, gated pipe, surge flow irrigation, irrigation scheduling, recirculating irrigation runoff (tailwater reuse), and alternate furrow application.

Surface irrigation uses gravity flow to distribute water over a field. Surface systems are the least expensive to install but have relatively high labor requirements for operation compared to other irrigation methods. Skilled irrigators also are needed to achieve good efficiencies. Even if properly designed, surface systems tend to have lower water application efficiencies than more advanced irrigation technologies.

Surface methods

With **flood irrigation,** the entire land area to be irrigated is covered with water. There may be no method of controlling water flow other than the topography of the land.

Furrow irrigation uses small channels or ditches between planted rows to convey water across a field. As water travels down the furrow, infiltrated water moves into the soil both laterally and vertically to saturate the soil profile.

With **level basin** irrigation, water is applied over a short period to a level area enclosed by dikes or borders. The basin's floor may be flat, ridged, or shaped into beds. Basin irrigation is most effective on uniform soils precisely leveled when large stream sizes relative to basin area are available (high flow turnouts).

Selection and applications

Application rates

The correct amount of water to apply at each irrigation event depends on the amount of soil water used by the plants between irrigations (soil water depletion), the water-holding capacity of the soil, and the depth of the crop root zone. Applying the right amount of water to an irrigation set does not guarantee efficient irrigation. Water also must be uniformly applied from one end of the irrigation run (field) to the other. Crop yields can be reduced by over-irrigation and/or under-irrigation, which is more likely to occur in fields with poor irrigation application uniformity.

In general, to avoid completely refilling the root zone in sandy textured soils, gross application amounts should not exceed 1.5 to 2 inches. On medium to fine textured soils, they should not exceed 2.5 to 3 inches.

Set time-stream size

Appropriate stream size should account for field slope, intake rate, and length of run. Runoff and the uniformity of water infiltrated along the furrow are related to the cutoff ratio. This is the ratio of the time required for water to advance to the end of the furrow to the total set time used for the irrigation. A cutoff ratio of 0.5 is desired. For example, for a 12-hour set time, the advance time should be about 6 hours. The easiest way to change the advance time is by altering the furrow stream size, i.e. by changing the size of the irrigation set. This change will affect the cutoff ratio and hence the uniformity of water application.

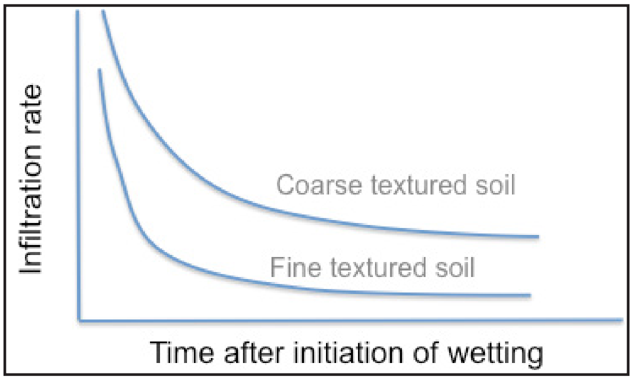
The best combination of furrow stream size and set time moves water to the end of the furrow within the requirements of the cutoff ratio, is less than the maximum erosive stream size, and results in gross applications that are not excessive.

Length of run

Excessively long irrigation runs result in water loss through deep percolation at the head of the furrow by the time the lower end is adequately irrigated. The length of irrigation runs should not exceed 600 feet on sandy soils and about 1300 feet on clay soils. However, on some low intake rate soils, the length of run may be as long as 2600 feet, provided the water can be distributed uniformly between the upper and lower end of the field. The time required for advance increases dramatically with furrow length.

Intake rates

The rate at which water infiltrates into the soil varies with slope, soil texture, spacing of furrows, and soil compaction. The rate at which the soil will absorb water also varies with time and soil moisture. At first, water will penetrate rapidly into the soil, but with time, it will decrease to a rate that stays relatively consistent for the remainder of the irrigation. (See figure to the right.) This fairly consistent rate is called basic intake rate. If the basic intake rate is 0.5 inches per hour or less, the length of run can be 1300 feet long. Higher intake rates require shorter water runs.



Generalized infiltration rate decrease with soil wetting. The infiltration curve is soil-specific.

Distribution and delivery systems

Using pipe systems (rather than earthen ditches) to convey and distribute water to fields offers several advantages:

- Increased on-farm irrigation efficiency due to reduced losses through deep percolation from earthen conveyance ditches.
- Better irrigation control and labor savings.

Surface method best management practices

Precision land leveling improves water application efficiency and uniformity. Leveling land generally is cost effective through increased yields and reduced water losses.

Gated pipe can result in a 35% to 60% reduction in water and labor costs. Gated pipe provides a more equal distribution of water into each furrow and eliminates seepage and evaporative losses that occur in unlined irrigation ditches. Gated pipe is available as the traditional aluminum pipe, the less expensive low-head PVC pipe, and the inexpensive "lay-flat" plastic tubing (also called "poly-pipe").

Surge flow irrigation is a variation of continuous-flow furrow irrigation. Water is usually applied in cycles of 1 to 3 hours of alternating on-off periods. Surge works by taking advantage of the natural surface sealing properties of many soils. Surge often results in increased irrigation efficiencies and gives the grower the ability to apply smaller amounts of water at more frequent intervals. Automatic surge valves reduce labor requirements.

Irrigation scheduling by use of evapotranspiration estimates (based upon weather data), soil moisture monitoring, or plant monitoring methods improves water use efficiency by aiding the manager to provide the right amount of water at the right times to reduce losses and improve crop response to water.

Recirculating irrigation runoff water (also called "tailwater reuse") effectively decreases the amount of water that needs to be pumped or delivered to the field.

Alternate furrow application effectively reduces the wetted surface area from which evaporation can occur.

Center pivot irrigation

Objectives

- Increase understanding of irrigation efficiency, losses, and distribution uniformity associated with center pivot irrigation.
- Increase understanding and application of best management practices to improve efficiency and uniformity of center pivot irrigation.

Key points

1. Low pressure center pivot and linear sprinkler irrigation systems are more water efficient and energy efficient than high pressure systems.
2. Low pressure systems, which include LEPA, Low Elevation Spray Application (LESA), Mid-Elevation Spray Application (MESA), and Low Pressure In-Canopy (LPIC), are well suited to automation and offer the potential to apply relatively precise irrigation amounts (from light, frequent irrigations to heavy, less frequent applications) as needed by the crop or for other field activities (such as chemigation applications).
3. Sprinkler nozzle packages should be inspected periodically and updated as needed.
4. Management and maintenance are key to good results with any pressurized sprinkler system.

Center pivot irrigation systems are used widely, especially in the Texas High Plains where most of the systems are low pressure systems, including LEPA, LESA, MESA, and LPIC.

LEPA

This type applies to the management system as well as to the actual hardware. LEPA irrigation applies water directly to the soil surface primarily through drag hoses or through "bubbler" type applicators. Notably LEPA involves more than just the hardware through which water is applied. It involves farming in a circular pattern (for center pivot irrigation systems) or straight rows (for linear irrigation systems). It also includes use of furrow dikes and/or residue management to hold water in place until it can infiltrate into the soil.

LEPA irrigation generally is applied to alternate furrows, reducing overall wetted surface area, and hence reducing evaporation losses immediately following an irrigation application. Because a relatively large amount of water is applied to a relatively small surface area, there is risk of runoff losses from LEPA, especially on clay soils and/or sloping ground. While furrow dikes and circular planting patterns help reduce the runoff risk, LEPA is not universally applicable; some slopes are just too steep for effective application of LEPA irrigation.

LESA and MESA

These similar irrigation application systems embody the LEPA technology but do not meet one or more of the criteria to be called LEPA. Low pressure spray systems — LESA, MESA, and LPIC — offer more flexibility in row orientation, and may be easier for some growers to manage, especially on clay soils or sloping fields. Objectives with these systems include applying water at low elevation (generally 1-2 feet from the soil surface for LESA; often 5-10 feet for MESA) to reduce evaporation losses from water droplets (especially important in windy conditions); applying water at a rate not exceeding the soil's infiltration capacity (preventing runoff); and selecting a nozzle package that provides uniform distribution and appropriate droplet size and wetting pattern.

Low pressure systems offer cost savings, compared with high pressure systems, due to reduced energy requirements. They also facilitate increased irrigation application efficiency due to decreased evaporation losses during application. Considering high energy costs and, in many areas, limited water capacities, high irrigation efficiency can help lower overall pumping costs and improve crop yield/quality return relative to water and energy inputs.

Other considerations

In sloping fields, pressure regulators may be warranted to improve irrigation distribution uniformity in the field. This reduces occurrence of "wet spots" and "dry spots" in the field. Good uniform distribution is also essential to effective chemigation/fertigation.

In many semi-arid areas, pre-season irrigation or excess early season irrigation is used to provide moisture from crop establishment and to fill soil moisture storage capacity to augment often deficit irrigation during peak crop water use periods. Pre-season irrigation water losses through evaporation and deep percolation can be quite high. Hence, it is important for growers to understand how much water their soil root zone will hold, taking into account effective root zone depth and soil moisture storage capacity per foot of soil. Applying more water than the soil can hold can result in deep percolation losses or runoff; starting irrigation too early increases opportunity for evaporation losses. These risks need to be balanced with irrigation system capacity issues.

LEPA vs. LESA

Properly managed, LEPA is potentially more water-efficient than LESA. Both systems, when properly managed, can be very efficient. LEPA allows for alternate furrow irrigation — there are alternate dry "traffic" furrows that are more accessible for timely field applications. By limiting field operation traffic to the dry furrows, the infiltration capacity of soil in the "wet" irrigated furrows is maintained. LEPA allows for irrigation without foliar wetting. For some crops, this can reduce foliar disease risk. If water quality (salinity) is an issue, LEPA can reduce salt damage to foliage.

In very coarse soils, there sometimes may be insufficient lateral soil water movement from alternate furrow LEPA applications. This is mainly a concern for seed germination, shallow-rooted crops, and peanuts that require a moist zone near the soil surface for pegging and pod development. Spray irrigation (LESA and MESA) wet the soil surface more uniformly than LEPA. It is possible to apply LESA for crop germination/establishment, then convert to LEPA to take advantage of the higher irrigation application efficiency in season, and finally convert back to spray applications for chemigation or for uniform wetting of the shallow root zone as needed. Hardware is readily commercially available to accommodate these applications.

Recommendations for realizing the benefits of advanced irrigation technology

New irrigation systems

- Start with a good design.
- Work with a qualified designer (Certified Irrigation Designer or licensed Professional Engineer).
- Design for realistic well capacities.
- Consider whether the water delivery is likely to decrease during the season.
- Compare "apples to apples" on designs; a cheaper package may not be better.
- Things to look for in a design include adequate pressure/vacuum relief; flexibility to accommodate crop rotations and well capacity fluctuations as needed; ease of maintenance; and appropriately sized underground pipelines (consider friction losses, especially in longer pipeline runs).
- Consider whether pressure regulators are needed; they are more likely to be justified in sloping fields. Install the system correctly, and follow design specifications.

Older systems

- Periodically evaluate the irrigation system to determine if it is performing according to design specifications. Consider wear and maintenance requirements on electrical, mechanical, and hydraulic components; replace worn parts, and upgrade or replace them as needed. Applicators (nozzles, splash pads, etc.), pressure regulators, and other components wear out over time, and severe conditions (poor water quality, for instance) can accelerate wear.
- Consider whether the sprinkler should be re-nozzled. Has there been a significant drop in well capacity? Has the nozzle package departed from the original design over time? Broken or lost nozzles may be "temporarily"

replaced with the wrong size nozzle. Over time, these quick fixes can lead to poor distribution uniformity. Are pressure regulators or nozzles functioning properly? Replace them as needed.

- Calibrate the pivot system and conduct a distribution uniformity test periodically to ensure the correct application rates are applied and applications are uniform over the field. These are especially important for chemigation applications. Pressure gauges and flow meters can simplify pivot evaluation and trouble-shooting.

Irrigation management

Crop water requirements are crop-specific, and they vary with weather and growth stage. Water management is especially important for critical periods in crop development. Apply knowledge of the root zone to optimize irrigation management; account for the crop's effective rooting depth, the soil moisture storage capacity, and field-specific conditions (shallow soils, caliche layers, etc.). In irrigation scheduling, consider using soil moisture monitoring, evapotranspiration information, and/or plant indicators to fine-tune water applications to meet crop needs.

Microirrigation

Objectives

- Increase understanding of irrigation efficiency, losses, and distribution uniformity associated with microirrigation.
- Increase understanding and application of best management practices to improve efficiency and uniformity of microirrigation.

Key points

1. Microirrigation offers potential for high water, energy, and fertilizer efficiency and uniform distribution. These can result in a good crop response (yield and/or quality) to irrigation and agronomic inputs.
2. Microirrigation, like other advanced irrigation technologies, yields best results when properly designed, installed, maintained, and managed.
3. Microirrigation is well suited to automation. While it can offer labor savings, these savings can be offset by increased management requirement.
4. Water quality is especially important in microirrigation applications. Biological, chemical, and physical clogging of emitters generally can be prevented through appropriate filtration and use of chemical additives as needed.
5. Flow meters and pressure gauges are essential for monitoring system performance and in trouble-shooting.
6. Some potential problems encountered with microirrigation include rodent and insect damage to tape and components; clogging of emitters and components; and problems with germination and crop establishment.

Microirrigation, including microspray, surface drip, and subsurface drip irrigation methods, can deliver water precisely and efficiently. Microirrigation is commonly used for irrigation of high value horticultural crops, orchards, and vineyards. SDI is gaining popularity in production of agronomic "row" crops, especially in areas with limited well capacities and where small or irregularly shaped fields give SDI a competitive advantage over other irrigation technologies and methods.

Key components

Microirrigation systems typically work at relatively low pressures. A **pump** should be correctly sized to deliver required flow and pressure, taking into account system operating pressure, lift(s), friction and dynamic pressure losses, and required flushing volumes/velocities.

Filters are key to protecting the irrigation system from plugging by suspended solids in the water.

Depending on the type of filtration system, a **pressure-sustaining valve** may be needed to facilitate flushing of the filters.

Pressure gauges should be used at the inlet and outlet points of the filters to show pressure differential for initiating flushing of the filters.

A **backflow preventer** prevents backflow of fertilizers, chemicals, or particulates into the water supply and are installed between the water supply or pump and the chemical injection line.

A **regulation valve** helps to maintain proper operating pressure in the irrigation lines.

A **chemical injector** precisely injects chlorine, acid, fertilizers, and other agrichemicals into the irrigation stream.

A **flow meter** measures the volume of water moving through the system, either as a flow rate or as an accumulated total volume basis.

A chemigation line check valve is installed between the injector and the water source. It prevents backflow of water into the chemical supply tank in case of injector failure. This valve is often an integral part of an injector unit and can handle both backpressure and backsiphonage.

Zone valves are opened or closed to control the flow to appropriate zones. They may be manual or automatically controlled using an electronic control system.

Pressure regulators are typically located on the manifold to help regulate operating pressure for emitters.

Air and vacuum relief valves prevent soil or particulate material from being sucked back into emitters when the irrigation system is turned off or when driplines are drained.

Main line and sub-main lines supply water from the system head to the **manifolds,** which subsequently distribute the water to the **driplines.** The dripline is the polyethylene tubing that includes built-in **emitters.** Emitter spacing and rate are selected to match crop demands and soil water-holding capacity.

Flush lines at the system's tail end allow sediments and contaminants to be flushed from dripline laterals at a centralized location; equalize pressure in the dripline laterals; and allow positive pressure on both sides of a dripline break to prevent soil ingestion into the dripline.

Connectors are needed to attach the dripline to the manifold or sub-main.

Electronic **controllers** allow for automation of irrigation applications to irrigate selected zones based upon set times or volumes.

Maintenance considerations

A properly designed and maintained microirrigation system may last more than 20 years. A maintenance program includes cleaning the filters, flushing the lines, and injecting disinfectants and/or acids as needed according to water quality.

Suspended solids, magnesium and calcium precipitation, manganese-iron oxides and sulfides, algae, bacteria, and plant roots can plug emitters. Every system should contain a flow meter and pressure gauges. Daily monitoring of these gauges will indicate whether the system is working properly. A low pressure reading on a pressure gauge can indicate leaks in the system. Gradual increasing pressure with reduced flow can indicate clogging of emitters and/or laterals.

Maintaining filters

Filters remove suspended solids (sediments) from the water. There are three main types of filters: cyclonic filters (centrifugal separators or hydrocyclones); screen and disk filters; and media filters. It is common practice to install a combination of filters to deal with various particulate sizes effectively. Filtration requirements depend upon the water source and quality, and upon the emitter size.

Flushing lines and manifolds

Very fine particles pass through the filters and can eventually clog laterals and emitters. As long as the water velocity is high and the water is turbulent, these particles remain suspended. If the water velocity slows or the water becomes less turbulent, these particles may settle out. This commonly occurs at the distant ends of the lateral lines. If they are not flushed, the emitters will plug and the line eventually will be filled with sediment from the downstream end to the upstream end. Systems must be designed so that mainlines, sub-mains, manifolds, and laterals can all be flushed. Mainlines, sub-mains, and manifolds are flushed with a valve installed at the end of each. Lateral lines can be flushed manually or automatically. It is important to flush the lines at least every 2 weeks during the growing season, or as needed based upon local conditions (water quality and system layout).

Injecting chlorine

At a low concentration (1 to 5 ppm), chlorine kills bacteria and oxidizes iron. At a high concentration (100 to 1000 ppm), it oxidizes organic matter and effectively removes it from the system.

Injecting acid

Acids are injected into irrigation water to prevent or treat plugging caused by precipitation of calcium carbonate (lime), magnesium, and some other salts. Water with a pH of 7.5 or higher and a bicarbonate level of more than 100 ppm is likely to have problems with lime precipitation, depending on the hardness of the water. Maintaining a low pH (6.5 or less) can generally prevent chemical precipitation and subsequent plugging of emitters; alternately periodic shock acid injection (temporarily lowering the pH below 4) can prevent build-up of precipitates.

An excellent resource for maintenance and troubleshooting of microirrigation systems is the University of California Agriculture and Natural Resources Maintenance of Microirrigation website: http://micromaintain.ucanr.edu/.

Advantages and limitations of microirrigation

Advantages of microirrigation (properly designed, installed, maintained, and managed)

1. High efficiency and uniformity of water application.
2. Precise application of fertigation and chemigation. (Note: caution must be exercised to prevent precipitation of agrichemicals that may react with constituents in water. Read and comply with all chemical labels.)
3. Reduced labor requirement compared to other irrigation technologies.
4. Relatively high water use efficiency (water conservation and/or crop yield/quality response to water).
5. Applicability to operations with large or small water capacities and over a range of field sizes and topographic and soil conditions. Microirrigation is readily "scalable" to the field and water supply.
6. Reduced problems with annual weeds.
7. Suitability to automation.

Limitations of microirrigation (depending upon local conditions)

1. High initial cost.
2. Maintenance and operation require higher level of skilled management than other irrigation systems.
3. Potential problems with emitter clogging, root intrusion, and rodent and insect damage.
4. Potential problems with germination of a crop.
5. Limited root zone.
6. Limited options for deep tillage and deep injection of chemicals that may be needed for pest and disease management.

Chapter 4: Water quality issues in irrigation

Salinity management

Objectives

- Increase familiarity with terminology and interpretation of water quality analysis and soil salinity analysis reports.
- Increase understanding of how salts affect soils and plants.
- Apply these concepts to management of lightly to moderately saline water in crop production.

Key points

1. Salts occur naturally in water. The concentrations and specific ion species depend upon the water source. Some groundwater sources can have naturally high levels of some salts.
2. Some salts can affect soil properties or can interfere with the availability of essential plant nutrients.
3. Salt accumulation in the root zone can hurt soil productivity.
4. Some salts in high concentrations can be toxic to plants.
5. Plants' susceptibility to salt injury may vary with growth stage.
6. Leaching of salts is often recommended for removing excess accumulations from the root zone. This requires sufficient water; it may be facilitated with soil additives, depending upon the specific salt species.
7. Irrigation methods that limit leaf wetting may reduce risk of foliar salt injury.

One of the most common water quality concerns for irrigated agriculture is salinity. Recommendations for effective management of irrigation water salinity depend upon local soil properties, climate, and water quality; options of crops and rotations; and irrigation and farm management capabilities.

What is salinity?

All major irrigation water sources contain dissolved salts. These salts include a variety of natural occurring dissolved minerals, which can vary with location, time, and water source. Many of these mineral salts are micronutrients, having beneficial effects. However, excessive total salt concentration or excessive levels of some potentially toxic elements can have detrimental effects on plant health and/or soil conditions.

The term "salinity" is used to describe the concentration of (ionic) salt species, generally including calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}), carbonate(CO_3^{2-}), sulfate (SO_4^{2-}), and others. Salinity is expressed in terms of electrical conductivity (EC), in units of millimhos per centimeter (mmhos/cm), micromhos per centimeter (µmhos/cm), or deciSiemens per meter (dS/m). The electrical conductivity of a water sample is proportional to the concentration of the dissolved ions in the sample; hence, EC is a simple indicator of total salt concentration.

Another term frequently used in describing water quality is total dissolved solids (TDS), which is a measure of the mass concentration of dissolved constituents in water. TDS generally is reported in units of milligrams per liter (mg/l) or parts per million (ppm). Specific salts reported in a laboratory analysis report often are expressed in terms of mg/l or ppm; these represent mass concentration of each component in the water sample. Another term used to express mass concentration is normality; units of normality are milligram equivalents per liter (meq/l). The most common units used in expressing salinity are summarized in Table 3.

Table 3. Units commonly used to express salinity.*

Mass Concentration (Total Dissolved Solids): mg/l = milligrams per liter ppm = parts per million ppm ≅ mg/l
<u>Electrical Conductivity (increases with increasing TDS):</u> conductivity = 1/resistance (mhos = 1/ohm) mmhos/cm = millimhos per centimeter μmhos/cm = micromhos per centimeter dS/m = deciSiemens per meter 1 dS/M = 1 mmhos/cm = 1000 μmho/cm
<u>Salinity Conversions:</u> 0.35 X (EC mmhos/cm) = osmotic pressure in bars 651 X (EC mmhos/cm) = TDS in mg/l* 10 X (EC mmhos/cm) = Normality in meq/l 0.065 X (EC mmhos/cm) = percent salt by weight * Also has been related as: TDS (mg/l) = EC (dS/m) X 640 for EC < 5 dS/m TDS (mg/l) = EC (dS/m) X 800 for EC > 5 dS/m
<u>Normality</u> meq/l = milligram equivalents per liter (*aka* milliequivalents per liter) meq/l = mg/l ÷ equivalent weight equivalent weight = atomic weight ÷ electrical charge Example: To convert 227 ppm calcium concentration to meq/l: ppm = mg/l; therefore 227 ppm = 227 mg/l Calcium atomic weight = 40.078 g/mol valence: +2 (charge = 2) equivalent weight = 40.078 / 2 = 20.04 meq/l = 227 / 20.04 = 11.33 Therefore 227 mg/l = 11.33 meq/l for calcium.
** Compiled from various sources*

Why is salinity a problem?

High salinity in water (or soil solution) causes a high osmotic potential. In simple terms, the salts in solution and in the soil “compete” with the crop for available water. Some salts can have a toxic effect on the plant or can “burn” plant roots and/or foliage. Excessive levels of some minerals may interfere with relative availability and plant uptake of other micronutrients. Soil pH, cation exchange capacity (CEC), and other properties also influence these interactions.

High concentration of sodium in soil can lead to the dispersion of soil aggregates, thereby damaging soil structure and interfering with soil permeability. Hence, special consideration of the sodium level or “*sodicity”* in soils is warranted.

How do you know if you have a salinity problem?

Water and soil sampling and subsequent analysis are key to determining whether salinity will present a problem for a particular field situation. If wastewater or manure are applied to a field regularly or if the irrigation water source varies in quality, soil salinity should be monitored regularly for accumulation of salts.

Water quality and soil chemical analyses are necessary to determine which salts are present and their concentrations. Standard laboratory analyses include total salinity reported as EC or as TDS. Salinity indicates the potential risk of damage to plants. General crop tolerances to salinity of irrigation water and soil are listed in Table 4. These values should be considered only as guidelines, since crop management and site specific conditions can affect salinity tolerance.

Table 4. Tolerance* of selected crops to salinity in irrigation water and soil.

Crop	Threshold EC in irrigation water in mmhos/cm or dS/m		Threshold EC in soil (saturated soil extract) in mmhos/cm or dS/m	
	0% yield reduction	50% yield reduction	0% yield reduction	50% yield reduction
Alfalfa	1.3	5.9	2.0	8.8
Barley	5.0	12.0	8.0	18.0
Bermudagrass	4.6	9.8	6.9	14.7
Corn	1.1	3.9	1.7	5.9
Cotton	5.1	12.0	7.7	17.0
Sorghum	2.7	7.2	6.8	11.0
Soybean	3.3	5.0	5.0	7.5
Wheat	4.0	8.7	6.0	13.0
* After Rhoades, et. al. (1992); Fipps (2003) and various sources				

Additional information, including concentrations of specific salt components, indicates the relative risk of sodicity and toxicity. High sodium can present a risk of toxicity to plants. It can also indicate a risk of soil aggregate dispersion, which can result in breakdown of soil structure, reducing the soil's permeability. Relative risk of soil damage due to sodicity is indicated by the sodium adsorption ratio (SAR), which relates the relative concentration of sodium $[Na^+]$ compared to the combined concentrations of calcium $[Ca^+]$ and magnesium $[Mg^+]$. SAR is calculated by the following equation:

$$SAR = \frac{[Na^+]}{(([Ca^+] + [Mg^+]) / 2)^{1/2}}$$

Managing irrigation to mitigate salinity

Minimize application of salts

An obvious, simple, option to minimize effects of salinity is to minimize irrigation applications and the subsequent accumulation of salts in the field. This can be accomplished through converting to a rain-fed (dryland) production system; maximizing effectiveness of precipitation to reduce the irrigation required; adopting highly efficient irrigation and tillage practices to reduce irrigation applications required; and/or using a higher quality irrigation water source (if available). Since some salts are added through fertilizers or as components (or contaminants) of other soil additives, soil fertility testing is warranted to refine nutrient management programs.

Crop selection

Some crops and varieties are more tolerant of salinity than others. For instance, barley, cotton, rye, and Bermudagrass are classified as salt tolerant (a relative term). Wheat, oats, sorghum, and soybean are classified as moderately salt tolerant. Corn, alfalfa, many clovers, and most vegetables are moderately sensitive to salt. Some relatively salt tolerant crops (such as barley and sugarbeet) are more salt sensitive at emergence and early growth stages than in their later growth stages. Currently, crop breeding programs are addressing salt tolerance for several crops, including small grains and forages.

Some field crops are particularly susceptible to particular salts or specific elements or to foliar injury if saline water is applied through sprinkler irrigation methods. Elements of particular concern include sodium (Na), chlorine (Cl), and boron (B).

Irrigation leaching

The classical "textbook" solution to salinity management in the field is through leaching (washing) accumulated salts below the root zone. This is often accomplished by occasional excessive irrigation applications to dissolve, dilute, and move the salts. The amount of excess irrigation application required (often referred to as the "leaching fraction") depends upon the concentrations of salts within the soil and in the water applied to accomplish the leaching. A commonly used equation to estimate leaching fraction requirement (expressed as a percent of irrigation requirement) is:

$$\text{Leaching fraction} = \frac{\text{electrical conductivity of irrigation water}}{\text{permissible electrical conductivity in the soil}} \quad \text{X } 100\%$$

Where irrigation water quantity is limited, sufficient water for leaching may not be available. The combined problem of limited water volume and poor water quality can be particularly difficult to manage.

Soil additives and field drainage can be used to facilitate the leaching process. Site specific issues, including soil and water chemistry, soil characteristics, and field layout, should be considered in determining the best approach to accomplish effective leaching. For instance, gypsum, sulfur, sulfuric acid, and other sulfur-containing compounds, as well as calcium and calcium salts, may be used to increase the availability of calcium in soil solution to "displace" sodium adsorbed to soil particles, facilitating the sodium leaching for remediation of sodic soils. In soils with insufficient internal drainage for salt leaching and removal, mechanical drainage (subsurface drain tiles, ditches, etc.) may be necessary.

Irrigation method selection

Where foliar damage by salts in irrigation water is a concern, irrigation methods that do not wet plant leaves can be very beneficial. Furrow irrigation, LEPA irrigation, surface drip irrigation, and SDI methods can be very effective in applying irrigation without leaf wetting.

Wetting patterns by different irrigation methods affect patterns of salt accumulation in the seedbed and in the root zone. Evaporation and root uptake of water also affect the salt accumulation patterns. Often the pattern can be detected by a visible white residue along the side of a furrow, in the bottom of a dry furrow, or on the top of a row. Additional salt accumulations may be located at or near the outer/lower perimeter (outer wetting front) of the irrigated zone in the soil profile.

Seedbed and field management strategies

In some operations, seed placement can be adapted to avoid planting directly into areas with the highest salt accumulation. Row spacing and water movement within the soil can affect the amount of water available for seedlings as well as the amount of water required and available for the dilution of salts.

Irrigation scheduling

Light, frequent irrigation applications can result in a small wetted zone and limited capacity for dilution or leaching of salts. When salt deposits accumulate near the soil surface (due to small irrigation amounts combined with evaporation from the soil surface), crop germination problems and seedling damage are more likely. In arid and semi-arid conditions, a smaller wetted zone generally results in a smaller effective root zone; hence, the crop is more vulnerable to salt damage and drought stress injury.

Although excessive deep percolation losses of irrigation are discouraged for their obvious reduction in irrigation efficiency and their potential to contribute to groundwater contamination, occasional large irrigation applications may be required for leaching of salts. Managing irrigation schedules (amounts and timing) to support an extensive root zone helps to keep salt accumulations dispersed and away from plant roots, provides for better root uptake of nutrients, and offers improved protection from short-term drought conditions.

Advantages of organic matter

Organic matter offers chemical and physical benefits to mitigate the effects of salts. Organic matter can contribute to a higher CEC and therefore lower the exchangeable sodium percentage and help mitigate negative effects of sodium. By improving and preserving soil structure and permeability, organic matter helps to support the ready movement of water through the soil and maintain higher water-holding capacity of the soil. Where feasible, organic mulches also can reduce evaporation from the soil surface, thereby increasing water use efficiency (and possibly lowering irrigation demand). Because some organic mulch materials can contain appreciable salts, sampling and analysis for salt content of these products are recommended.

Special considerations: SDI maintenance

Some salts, including calcium and magnesium carbonates that contribute to water hardness, merit special consideration for SDI systems. These salts can precipitate out of solution and contribute to significant clogging of drip emitters and other components (such as filters). Water quality analysis, including acid titration, is necessary to determine appropriate SDI maintenance requirements. Common maintenance practices include periodic acid injection (shock treatment to prevent and/or dissolve precipitates) and continuous acid injection (acid pH maintained to prevent chemical precipitation).

References

Fipps, G. 2003. Irrigation Water Quality Standards and Salinity Management. Fact Sheet B-1667. Texas Cooperative Extension. The Texas A&M University System, College Station, TX.

Rhoades, J.D., A. Kandiah, and A.M. Mashali. 1992. The Use of Saline Waters for Crop Production. FAO Irrigation and Drainage Paper 48. Food and Agriculture Organization of the United Nations, Rome, 1992.

Protecting water resources from contamination

Objectives

- Increase awareness of the potential for contamination of groundwater and surface water resources as a result of irrigated agriculture.
- Increase familiarity with terminology, processes, and pathways associated with common agricultural sources of water resource contamination.
- Increase understanding and application of best management practices to reduce risk of groundwater or surface water contamination.

Key points

1. Water losses due to surface runoff or deep percolation can transport sediments, salts, and/or agricultural chemicals to groundwater or surface water.
2. Efficient irrigation and management to optimize rainwater can reduce runoff and deep percolation (leaching) losses.
3. Physical, chemical, and other properties of the soil and potential contaminants affect the relative risk of water contamination.
4. Safe and appropriate storage, handling, and application of agricultural chemicals and wastes are key to reducing risk of contamination.

Best management practices to prevent pesticide contamination of water resources

Groundwater and surface water resources are active components of a dynamically interrelated hydrologic system. In Texas, there are increasing demands on limited water resources, thus it is especially critical that they be protected from contamination.

Pesticide properties that affect risk of contamination

- **Solubility** determines how readily a chemical dissolves in water.
- **Adsorptivity** determines how strongly a chemical is adsorbed to soil particles.
- **Volatility** determines how quickly a chemical will evaporate in air.
- **Degradation** describes how quickly a chemical breaks down due to biological and environmental factors.

Local conditions that affect risk of contamination

- **Soil texture** affects how quickly water moves through soil, how much water can be stored in the soil, and relative particle surface area for chemical adsorption. Coarse (sandy) soils pose higher risk of groundwater contamination than finer textured soils (loam and clay soils).
- **Organic matter** in soil reduces water pollution risk, because it increases chemical adsorption potential and supports higher populations of microorganisms for biodegradation of pesticides.
- **Topography, soil structure, soil surface condition, and soil moisture** affect water movement into and through the soil, influencing relative risks of leaching contaminants to groundwater or runoff of contaminated water to surface water.
- **Distance** from groundwater and surface water resources, depth to groundwater, and the proximity of abandoned or poorly constructed water wells affect risk of contamination.

Pesticides in the environment

After application, pesticides may be evaporated (volatilized), adsorbed onto soil particles, broken down by sunlight (UV degradation), broken down by microorganisms (biodegradation), taken up in or attached to plants, or dissolved in water.

Pesticides dissolved in water may be transported to groundwater through leaching or to surface water through runoff. Pesticides adsorbed to soil particles also may move to surface water through erosion and sedimentation.

Pesticides in water may also undergo evaporation, UV degradation, or biodegradation. They may become diluted or dispersed in the water. They may even move within the groundwater or surface water.

Best management practices

Integrated pest management (IPM)

- Optimize pest management strategies, chemical selection, and application timing for efficient and effective control.
- Consider crop rotations, tillage practices, planting and harvest dates, and other strategies as applicable to achieve good crop results while minimizing the need for pesticide applications.

Pesticide storage, handling, and disposal

- Read and follow the pesticide label.
- Store, handle, mix, apply, and dispose of chemicals according to label instructions — not near water wells or water drainage areas.
- Purchase and mix only the amount of chemical that is required to minimize need for disposal.
- Contain and clean spills quickly to minimize risk of water contamination.
- Consider installing a concrete pad, detention storage, or berms to contain chemicals, spills, and rinsates in the mixing and tank filling area.
- Avoid spraying, mixing, and rinsing tanks near a wellhead; use a longer hose or use a water spigot away from the wellhead, if possible.

Pesticide application

- Read and **follow label directions**.
- Calibrate, clean, and maintain all application equipment properly.
- Follow all label instructions regarding registered crops and rates, methods and timing of pesticide application.
- Observe all restrictions on location, soil types, depths to water table, and other limitations as noted on the label.

Additional best management practices

- **Manage irrigation** to minimize potential for runoff or deep percolation (leaching) losses.
- Consider using **conservation tillage**, setback areas, vegetative filter strips, contour farming, and other practices as appropriate to reduce runoff losses from irrigation or rainfall.
- **Practice wellhead protection.**
- Prevent back-siphoning; use adequate backflow protection devices in mixing chemicals and filling tanks. Use backflow protection (chemigation check) valves in chemigation operations. Properly close abandoned water wells.
- **Plan ahead to minimize risk.**
- Identify water wells, surface drainage, and other potential pathways for contamination. Avoid using, storing, or mixing pesticides near these areas.
- **Identify potential sources of contamination,** including chemical storage and mixing areas. Secure these areas to minimize risk of accidental spills.
- Prepare an **Emergency Response Plan.**

Appendix: Recommended information resources

Irrigation best management practices and comprehensive resources

Wagner, K. 2012. Status and Trends of Irrigated Agriculture in Texas. EM-115. Special Report of the Texas Water Resources Institute. Texas A&M AgriLife, Texas A&M University System. College Station, TX. 6 p. http://twri.tamu.edu/docs/education/2012/em115.pdf

Water Resources for Agriculture. Texas A&M AgriLife Water Education Network. http://water.tamu.edu/water-resources-agriculture/

Best Management Practices for Agricultural Water Users. 2014. Texas Water Development Board. Austin, TX. http://www.twdb.texas.gov/conservation/BMPs/Ag/doc/AgMiniGuide.pdf

USDA-NRCS. 1997. Irrigation Guide. National Engineering Handbook. United States Department of Agriculture Natural Resources Conservation Service. http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17837.wba

Irrigation at K-State Research and Extension. 2016. Kansas State University Research and Extension. http://www.ksre.k-state.edu/irrigate/

Economics of irrigation systems

Amosson, S.H., L. Almas, T. Marek, N. Kenny, B. Guerrero, J.R. Girase, et al., 2011. Economics of irrigation systems. B-6113. AgriLife Extension, Texas A&M University System. College Station, TX. 14 p. http://amarillo.tamu.edu/files/2011/10/Irrigation-Bulletin-FINAL-B6113.pdf

Irrigation scheduling: evapotranspiration

Allen, R.G., I.A. Walter, R.L. Elliott, T.A. Howell, D. Itenfisu, M.E. Jensen, and R.L. Snyder. 2005. ASCE Standardized Reference Evapotranspiration Equation. American Society of Civil Engineers, Baltimore, MD. 216 p.

Texas A&M AgriLife South Texas Weather Network. Texas A&M AgriLife Research. http://southtexasweather.tamu.edu/

Texas ET Network. Texas A&M AgriLife Extension Service. http://texaset.tamu.edu/

Irrigation scheduling: soil moisture monitoring

Enciso, J., D. Porter, and X. Peries. 2007. Irrigation Monitoring with Soil Water Sensors. Extension Fact Sheets B-6194 and B-6194S (Spanish). Texas A&M AgriLife Extension Service. College Station, TX. 12 p. http://cotton.tamu.edu/Irrigation/SoilWaterSensors.pdf

Evett, S. 2016. Soil Water Sensors for Agriculture - Theory and Issues. USDA Southern Regional Extension Forestry Webinar. http://www.conservationwebinars.net/webinars/soil-water-sensors-for-agriculture-theory-and-issues

Surface irrigation

Walker, W.R. 1989. Guidelines for designing and evaluating surface irrigation systems. Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/t0231e/t0231e04.htm

Fipps, G. 2016. Surge Flow Irrigation. Fact Sheet BN-013. Texas A&M AgriLife Extension Service. College Station, TX. http://www.agrilifebookstore.org/Surge-Flow-Irrigation-p/bn-013.htm

Microirrigation

Schwankl, L., F. Lamm, and D. Porter. 2016. Maintenance of Microirrigation Systems Website. Division of Agriculture and Natural Resources, University of California. http://micromaintain.ucanr.edu/

SDI in the Great Plains. 2016. Subsurface Drip Irrigation Resource. Kansas State University Research and Extension. http://www.ksre.k-state.edu/sdi/

Center pivot irrigation

Kranz, W.L. R.G. Evans, F.R. Lamm, S.A. O'Shaughnessy, R.T. Peters. 2012. A review of mechanical move sprinkler irrigation control and automation technologies. Appl. Engr. Agric. 28(3): 389-397. https://www.ksre.k-state.edu/irrigate/reports/KranzMM12.pdf

New, L. and G. Fipps. 2010. Center Pivot Irrigation. B-6096. Texas A&M AgriLife Extension Service. College Station, TX. http://www.agrilifebookstore.org/Center-Pivot-Irrigation-p/b-6096.htm

Center Pivot Online Training Course. Texas A&M University Department of Biological and Agricultural Engineering and Texas A&M AgriLife Extension Service. College Station, TX. http://itc.tamu.edu/online_center_pivot.php

Salinity management and water quality protection

Ayers, R.S. and D.W. Wescot. 1994. Water Quality for Agriculture. Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/003/t0234e/T0234E02.htm

Grattan, S.R. 2002. Irrigation Water Salinity and Crop Production. University of California – Davis. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_010748.pdf

ASABE. 2015. Safety Devices for Chemigation. ASAE Standard EP409.1. American Society of Agricultural and Biological Engineers. www.ASABE.org

Texas Water Resources Institute
make every drop count

TSSWCB
Texas State Soil and Water Conservation Board

Texas A&M AgriLife Extension

Texas Water Resources Institute EM-121

twri.tamu.edu

6. Press release for Soil Testing Campaign

Lower Rio Grande Valley soil testing campaign runs through February

today.agrilife.org/2014/10/07/valley-soil-testing-campaign/

View all articles by Rod Santa Ana → October 7, 2014

WESLACO — The Texas A&M AgriLife Extension Service in the Lower Rio Grande Valley is offering its annual soil testing campaign through February, according to AgriLife Extension personnel.

A campaign kickoff event has been scheduled for Oct. 16.

“We’re encouraging all commercial agricultural producers in Hidalgo, Cameron and Willacy counties to take part in this free soil testing campaign to help the environment and their bottom lines,” said Ashley Gregory, AgriLife Extension assistant in Weslaco. “This will be the 14th year in a row we’re offering this service and it’s been hugely successful.”

The Lower Rio Grande Valley Soil Testing Campaign runs through February. A kickoff event will be held Oct. 16. (AgriLife Communications photo by Rod Santa Ana)

The campaign began Oct. 1 and runs through Feb. 28, she said.

“The soil testing campaign first began here in 2001 and has been funded by various sources,” Gregory said. “Since 2008 the campaign has been paid by the Arroyo Colorado Watershed Partnership, made possible by funding from a Clean Water Act grant provided by the Texas State Soil and Water Conservation Board, the U.S. Environmental Protection Agency and administered through the Texas Water Resource Institute.”

The annual soil testing campaign has been instrumental in reducing excess nutrients from entering the Arroyo Colorado, and “it’s a service we hope to continue providing,” she said.

Agricultural producers can pick up soil sample bags and forms from AgriLife Extension offices in Willacy and Hidalgo counties and the Texas A&M AgriLife Research and Extension Center in Weslaco, 2415 E. U.S. Highway 83 in Weslaco, according to Brad Cowan, AgriLife Extension agent for agricultural and natural resources in Hidalgo County.

Producers in Cameron County are asked to pick up sample bags and forms at the U.S. Department of Agriculture’s Farm Service Agency office at 2315 W. Expressway 83 in San Benito.

“The samples can then be dropped off at the Willacy and Hidalgo county AgriLife Extension offices for shipping to the laboratory at Texas A&M University in College Station, all at no cost to producers,” he said. “Results will be mailed directly to producers.”

Cameron County producers can return their samples to the Farm Service Agency office in San Benito.

The 2014-2015 Soil Testing Campaign Kickoff will be held from 8:30 a.m.-noon Oct. 16 at the AgriLife center in Weslaco, Gregory said.

Topics will include an update on the Arroyo Colorado and past soil testing campaigns and sources of financial and

Topics will include an update on the Arroyo Colorado and past soil testing campaigns and sources of financial and technical assistance. One Texas Department of Agriculture continuing education unit in laws and regulations will be available, she said.

"Dr. Mark McFarland, Texas A&M soil and crop sciences associate department head in College Station, will be joining us to discuss nutrient management, and Bruce Henderson, a U.S. Department of Agriculture Natural Resource Conservation Service agronomist, will discuss a few of their programs, including Environmental Quality Incentives Program and the benefits of cover crops."

For more information about the Arroyo Colorado watershed, visit arroyocolorado.org. For more information about the soil testing program, contact the AgriLife Extension county office in Hidalgo, Cameron or Willacy counties.

October 20, 2014

Hello Arroyo Partners:

The Arroyo Colorado Conservancy hosted the Second Annual "SAVE THE ARROYO" Fiesta on October 9, at the Dargel Boats Showroom in Donna, TX. The Fiesta was a huge success with approximately 125 people attending the event. People began showing up at 6 o'clock sharp and filled the showroom by 6:30. The Fiesta started with Dr. Jude Benavides, Arroyo Colorado Steering Committee Chairman, thanking our sponsors and supporters and giving a presentation on the role that the Arroyo Colorado Watershed Partnership plays in the community and how we can help other organizations achieve their project goals. We continued by giving out several door prizes generously donated by "Flipside Fishing" and "Hook Line and Sinker" and conducting a "Bucket Auction" and "Silent Auction". During the auctions, we had an excellent homemade BB-Q dinner consisting of Brisket, fajitas, sausage, rice and beans. Everyone was having a great time as we announced the winners of the auction items and you could literally feel the anticipation and excitement building as the time came to draw the winner of the boat. In the end, the lucky winner was Mary and Julian Bentancourt of La Feria, TX. Julian only purchased one ticket the day before the Fiesta. When he bought the ticket, he stopped and said, "I am going to let my wife fill out the ticket stub because I never win anything and she is lucky, she always wins". Well Julian was right and now they are the proud owners of a brand new 186 Dargel Skout! They had Dargel install a "Power Pole", Shallow water anchor, and picked up the boat Monday morning. They were so excited. Mr. Bentancourt had just retired 4 months ago after working for 35 years for the same company. Congratulations to the Bentancourts! I hope you enjoy the boat for years to come and enjoy your retirement.

I want to remind everyone that the Watershed Partnership will be holding two of their Work Group meetings in October.

The Arroyo Colorado Habitat Workgroup meeting will be held on October 23, from 2-4 pm at the Estero Llano Grande World Birding Center located at 3301 S. FM 1015.

The Arroyo Colorado Watershed Partnership will be hosting an Arroyo Colorado Steering Committee meeting on October 23, from 5-7 pm. Food and refreshments will be served from 4:30-5:00 pm. The meeting will be held at The Estero Llano Grande World Birding Center located at 3301 S. FM 1015.

For the 14th consecutive year, Texas A&M AgriLife Extension is offering free Soil Tests for agricultural producers in Cameron, Hidalgo and Willacy Counties. The Soil Testing Campaign has had various sources of funding over the years, but the Arroyo Colorado Watershed Partnership has been proudly funding the campaign since 2008 through grants provided by the Texas State Soil and Water Conservation Board. The Soil Testing Campaign began on October 1st, 2014 and will run through the end of February, 2015.

There are a number of benefits that result from the Soil Testing Campaign; not only does it help keep nutrients out of the Arroyo, but it provides agricultural producers an opportunity to save money on fertilizer costs by using residual nutrients already in the soil. This year we kicked off the Campaign with a Crops Fertility Workshop on October 16th to remind producers of the many benefits of soil testing and encourage them to participate in the Soil Testing Campaign. The Workshop was attended by 42 producers and there was a very informative presentation by Dr. Mark McFarland, Associate Department Head of Soil and Crop Sciences at TX A&M University. Dr. McFarland's research over the past 15 years has proven that the many nutrients needed to produce a successful stand of crops are already present in the soil if we are willing to look for them. One big take away message was that Nitrogen is a highly soluble nutrient that moves down into the soil profile. In order to determine the amount of the residual nitrogen in the soil, you need to take your soil sample deeper than previously recommended, between18-24 inches, to give producers a better understanding of the amount of Nitrogen they have to work with. It's recommended to take two soil samples; one from the top 6 inches for nutrients that don't move through the soil profile very much and another deeper sample to capture the nutrients that do move within the soil profile, like nitrogen.

The Soil Testing Campaign offers free soil analysis to agricultural producers in Cameron, Hidalgo and Willacy Counties. Soil sample bags and forms can be picked up and dropped off at the following locations:

Cameron County FSA Office
2315 W Expressway 83
San Benito, TX 78586-7633
cameron-tx@tamu.edu

Hidalgo County Office
410 N 13th Ave
Edinburg, TX 78541-3582
(956) 383-1026, hidalgo-tx@tamu.edu

Willacy County Office
170 N 3rd Street
Raymondville, TX 78580-1940
(956) 689-2412, willacy-tx@tamu.edu

District 12 Office
2401 East Highway 83
Weslaco, TX 78596-8344
(956) 968-5581, d12south@ag.tamu.edu

Test results will be mailed directly to the producer and County Extension Agents are available to help further interpret test results if needed. We encourage producers to take advantage of this free service that has the potential to save them money and improve the water quality of the Arroyo Colorado. For more information or questions please contact Ashley Gregory at (956) 968-5581 or at ahgregory@ag.tamu.edu.

Looking ahead,

Jaime Flores