Wetting Front

Water Management Research Unit Newsletter

Vol. 1, No. 1 — May 1997

USDA-ARS Conservation and Production Research Laboratory

P.O. Drawer 10 • Bushland, Texas 79012-0010 U.S.A.

(806) 356-5724 • FAX (806) 356-5750 • 2300 Experiment Station Road

Those Dalhart Lights . . .

Although the Marfa lights, those mysterious lights that brighten the southwest Texas skies during the spring and summer, are better known, they now are nearly rivaled by those that brighten the evening skies on the Texas High Plains. But unlike the mysterious Marfa lights, the origin of the Texas High Plains lights, dubbed the "Dalhart lights," are the running lights of the thousands of center pivots that turn this near desert into an agricultural paradise for producing wheat, corn, soybean, sorghum, and sugar beet. The Texas High Plains share the vast High Plains aquifer (or as it is better known, the Ogallala aquifer) with the New Mexico northern plains, the Oklahoma panhandle, the southwestern Kansas plains, and the southeastern Colorado plains. This northern Texas High Plains region, the northern 26 counties of the Texas panhandle, has as much in common with its northern neighbors as it does with its central and southern Texas High Plains sister regions, where cotton is a much more important crop. Anyone traveling at night, from Lubbock to Plainview or from Dumas to the state line near Texline, will be dazzled by the "Dalhart lights" that mysteriously blink from a thousand seemingly random spots.

by Terry Howell

> ***"The effects of overdraft are likely to be most severe in the southern Great Plains, where significant irrigated acreage may be removed from production within the next 20 years."***
>
> ***— Vaux et al. (1996)***

Texas High Plains Irrigation . . .

Irrigated agriculture remains vitally important in the U.S. and the world as we attempt to feed and clothe a rapidly expanding population with finite land and water resources. Nowhere in the U.S. is irrigation as threatened, as well as the economic base for rural communities that depend on the economic survival of irrigated agriculture, as it is in the Southern High Plains. This region encompasses parts of five states — the Texas and Oklahoma panhandles, the plains of eastern New Mexico and the plains of southeastern Colorado and southwestern Kansas. Vaux et al. (1996) stated, ***"The effects of overdraft are likely to be most severe in the southern Great Plains, where significant irrigated acreage may be removed from production within the next 20 years."*** The northern Texas High Plains, which is a 26-county area in the Texas Panhandle and only a fraction of the entire Southern High Plains, is a major economic segment accounting for $773 million in annual crop receipts, $1.793 billion in annual livestock and livestock products receipts alone from its 14 million acres of agricultural land (9 million ac in pasture and 5 million in crops) and its 2 million ac of irrigated cropland (Amosson and Ledbetter, 1996). Major irrigated crops in this region of Texas are wheat (49.5% of all Texas' production), corn (48.4% of all Texas' production), sorghum (19.4% of all Texas' production), and sugar beet (96.8% of all Texas' production). This region consistently has some of the highest county corn yields in the whole U.S. because it has excellent soils and a good environment and because practically all the corn grown in the region is fully irrigated. Peanut production is expanding in importance in the eastern portions of the northern Texas High Plains region and especially in the southern and eastern portions of the southern Texas High Plains and is an important crop in both New Mexico and Oklahoma. Cotton is a major irrigated and dryland crop in the southern Texas High Plains accounting for more than 60% of Texas' production with an estimated value of $3.5 billion in 1994. The Texas High Plains region, alone, would rank very high in agricultural production as a separate state in the U.S. or as another country in the world. For example, the Texas High Plains would rank as the 6th leading cotton producing country in the world if it was a separate country.

Irrigated agriculture is nearing a crossroads as we attempt to balance needs for water, needs for a safe

environment and for safe drinking water, and needs for a safe and dependable food supply. Gardner et al. (1996) captured many of these cultural dynamics associated with irrigation. They said, ***"... it [irrigation] is the basis for an economy and a way of life."*** Many problems face irrigation in the Southern High Plains and especially the Texas High Plains as detailed in these two recent studies (Gardner et al., 1996 and Vaux et al., 1996). However, irrigation has seemed to turn the corner in this region since the mid 1980s as evidenced by the gradual increase in Texas irrigated land in the High Plains (fig. 1). A rapid escalation of adaption of center pivot sprinklers using the latest

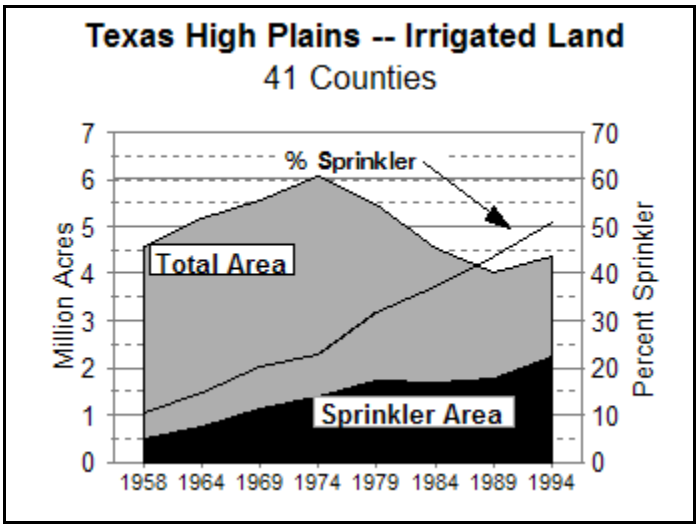

Figure 1. Historical trends in irrigated area on the Texas High Plains (41-county area) as summarized from the TWDB data by Jack Musick.

water conserving technologies is evident. Much of this growth might be attributed to three factors — 1) stable short- and long-term energy prices; 2) stable short- and long-term capital costs (interest) along with many supportive investment instruments (in Texas, state supported low interest loans have been available for water conserving technology for several years); and 3) a desire to simplify and automate irrigation labor. Many additional factors have contributed to this trend besides just these three items including: the extension of irrigation well life by using electric submersible turbine pumps, enhanced dependability of center pivot systems, and the maintenance of irrigated area by using lower irrigation capacity (flow rate per unit area) now possible with newer and more efficient sprinkler application methods.

Irrigation trends in this region show gradual but steady growth since the mid 1980s, while dryland area is simply being maintained (fig. 2). The Conservation Reserve Program (CRP) likely has reduced both irrigated and dryland crop production in this region, but CRP has probably impacted dryland to a greater

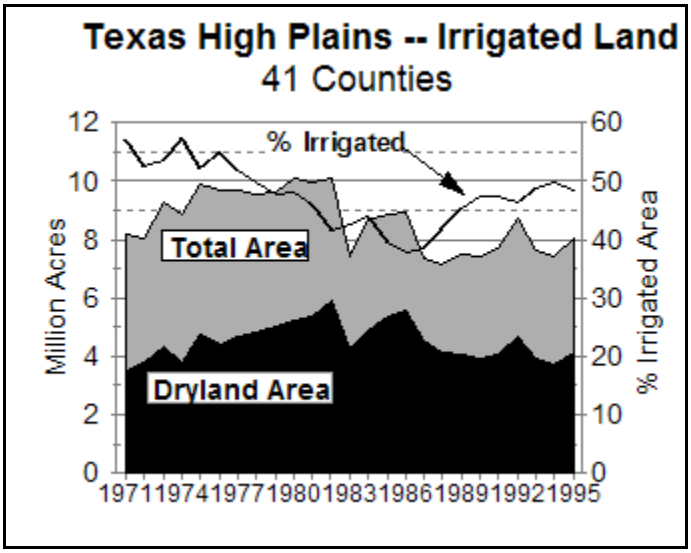

Figure 2. Historical trends in irrigated and dryland cropping on the Texas High Plains (41-county area) as summarized by Jack Musick using the USDA-NASS Texas Agric. Statistics Service data.

extent. Over a quarter million acres of irrigated lands have been documented by Texas Agricultural Statistics Service to have gone into the CRP. Some of these CRP contracts have already been "bought" and the land returned to irrigated agriculture. Vaux et al. (1996) concluded ***"... a smaller CRP probably would not have a significant effect on irrigation in the region [this region of the U.S.]."***

Although slightly less than ½ of the cropped area in the whole Texas High Plains region (41 counties) is irrigated (fig. 2), production from these irrigated lands greatly exceeds the dryland crop production. For the past 28 years (1968 to 1995), irrigated crop production, as a percentage of all production in the total Texas High Plains, has averaged 62% for winter wheat, 74% for sorghum, 87% for all feed grains (corn and sorghum; fig. 3), and 65% for cotton. Water use efficiency (yield per unit of water used) is often far greater under irrigation than dryland in this region, particularly for wheat (Musick et al., 1994). Although the region is dependent on both dryland and

Wetting Front is published semi-annually (May and November) and distributed by the USDA-ARS, Conservation and Production Research Laboratory, Water Management Research Unit, P.O. Drawer 10, Bushland, TX 79012-0010.

Editor: Dr. Terry A. Howell, P.E.
USDA-ARS
P.O. Drawer 10
Bushland, TX 79012-0010
e-mail: tahowell@ag.gov
Phone: (806) 356-5746
Fax: (806) 356-5750
Shipping: 2300 Experiment Station Road

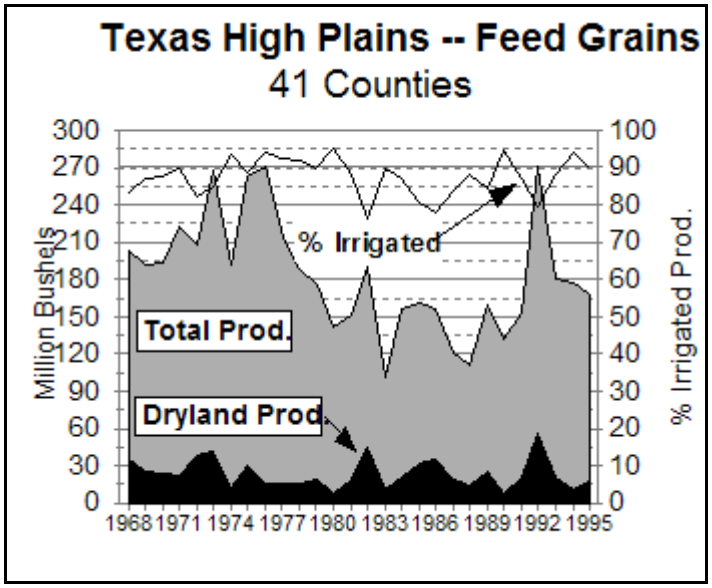

Figure 3. Historical trends in feed grains (sorghum and corn) production from irrigated and dryland cropping on the Texas High Plains (41-county area) as summarized by Jack Musick using USDA-NASS Texas Agric. Statistics Service data.

irrigated crops, irrigated agriculture has far greater economic significance in the rural economies for farm equipment sales, irrigation equipment sales, fertilizer sales, chemical sales, energy sales revenues, and tax revenues besides supplying the bulk of the grain that makes this region the ***Cattle Feeding Capital of the World*** (Amosson and Ledbetter, 1996). Irrigation has also been a contributing factor in maintaining the region's population base (Albrecht and Murdock, 1985). Yet the questions of how much irrigated land should be maintained and how much ground water can be removed are lingering questions that directly impact how the "sustainability" of irrigation can be defined. Neither of these questions can be answered, because they require a historical view from some future time. It is our responsibility to make sure we do not squander this water resource while preserving the future ability of this land resource to remain a viable non-irrigated (if that ever happens) production region again. Nevertheless, free-market forces dictate that irrigation is a viable option and is still economically feasible for this region for the near- and the long-term (Gardner et al., 1996 and Vaux et al., 1996). But irrigation must become even more efficient as demands for the scarce water resource increase from numerous competitors (municipalities, industry, recreation, etc.).

References:
Albrecht, D.E., and S.H. Murdock. 1985. The consequences of irrigation development in the Great Plains. Agric. Exp. Sta. Technical Report No. 85-1, Tex. Agric. Exp. Sta., College Station, TX.

Amosson, S., and K. Ledbetter. 1996. The impact of agribusiness in the High Plains trade area, Amarillo Chamber of Commerce Ag Council and Southwestern Public Service Company, Amarillo, TX. 9 p.

Gardner, W. (chair), K. Fredrick (vice-chair), H. Adelsman, J.S. Boyer, C. Congdon, D.F. Heermann, E. Kanemasu, R.D. Lacewell, L. MacDonnell, T.K. MacVicar, S.T. Pyle, L. Snow, C. Vandermoer, J. Watson, J.L. Wescoat, Jr., H.A. Wuertz, and C.H. Olsen (liaison WSTB) and C. Elfring and A.A. Hall (NRC staff). 1996. A new era for irrigation. Water Science Technology Board, National Research Council, National Academy Press, Washington, D.C. 203 p.

Musick, J.T., O.R. Jones, B.A. Stewart, and D.A. Dusek. 1994. Water—yield relationships for irrigated and dryland wheat in the U.S. Southern Plains. Agron. J. 86(6):980-986.

Vaux, H.J., Jr. (chair), R.M. Adams, H.W. Ayer, J.R. Hamiliton, R.E. Howitt, R. Lacewell, R. Supalla, and N. Whittlesey. 1996. Future of irrigated agriculture. Task Force Report No. 127, Council for Agricultural Science and Technology, Ames, IA. 76 p.

by Terry Howell and Jack Musick

Newsletter . . .

The *Wetting Front* is a newsletter designed to foster technology transfer from our research to industry and to agricultural producers in the Southern High Plains. We hope that it will improve communications with our stakeholders and partners as well. We plan to publish two issues each year — one in May and one in November. A post card is included that can be used to add individuals to our mailing list, to update your mailing information, or to remove your name from our mailing list. If you prefer, you can simply fax the information to (806) 356-5750 or send the information in an e-mail message to Mrs. Carole Perryman at <cperryma@ag.gov>. Feel free to call Mrs. Perryman at (806) 356-5749 to update your mailing information or to request removal or additions. Wetting Front can also be found on the WWW at http://www.net.usda.gov/cprl/wmru/wfront.htm. Any suggestions or comments are welcome too.

Awards and Recognitions . . .

Steve Evett, 1996 Soil & Water Division Outstanding Reviewer, American Society of Agricultural Engineers.

Arland Schneider, 1996 Engineer of the Year, Texas Section of ASAE.

Jerry Thomas, Don Dusek, Karen Copeland, Jim Cresap, Steve Evett, Terry Howell, and Arland Schneider, Certificates of Merit for 1995-96 performance, USDA-ARS.

Cal Stone, Spot Award for outstanding contributions to the remodeling of the irrigation building in 1996, USDA-ARS.

Karen Copeland, Spot Award for outstanding temporary service as imprest fund cashier in 1996, USDA-ARS.

Internet News . . .

Our Web page [http://www.net.usda.gov/cprl/] has been updated. Several new features include the "News" page with information about upcoming events and seminars. Several 1997 spring seminars slide shows are published on the WWW and can be accessed from this page. Also, information about employment opportunities both at the CPRL and ARS can be accessed from the "News Page."

We would like to highlight the following WWW addresses that we think may interest our *Wetting Front* readers:

http://www.wmuinfo.colostate.edu/ ARS Water Management Research Unit, Ft. Collins, CO

http://kimberly.ars.usda.gov/ ARS Northwest Irrigation

and Soils Research Lab., Kimberly, ID
http://asset.arsusda.gov/wmrl/WMRL.html ARS Water Management Research Lab., Fresno, CA
http://www.uswcl.ars.ag.gov/uswcl.htm ARS U.S. Water Conservation Lab., Phoenix, AZ
http://www.csrl.ars.usda.gov/ ARS Cropping Systems Lab., Lubbock, TX
http://www.wtamu.edu/academic/anns/ag/dryland/index.html Dryland Agriculture Institute West Texas A&M University, Canyon, TX
http://achilleus.tamu.edu/ TAES Soil Physics Agricultural Research & Extension Center, Lubbock, TX
http://www.agen.tamu.edu/wqit/petnet/pet.html PET Web Site Texas A&M University, Agric. Engr. Dept. College Station, TX

SURF'S UP!!!!!

Grant News . . .

Steve Evett and Terry Howell were awarded $299,818 for

"Water Requirements of Maize Under Drip and Sprinkler Irrigation" by USDA-FAS and USAID in cooperation with Egypt for the ATUT (agricultural technology utilization and transfer project).

PENDING PROPOSALS:

Steve Evett with Charles Rush, Dan Upchurch, Giovanni Piccinni, Leon New, Mike Shannon, and Frank Dalton, $457,000 for "Optimization of Crop Water Use Efficiency in Pathogen Infested Soils " from USDA-CSREES for the NRI.

Terry Howell and Steve Evett with Leon New, Thomas Marek, B.A. Stewart, Brent Bean, and Jerry Michels, $600,000 for "Enhancing the Sustainability of Irrigation on the Texas High Plains, a REE Approach" to USDA-CSREES for the Fund for Rural America.

Coming Events and Upcoming Meetings and Presentations . . .

COMING EVENTS

1997 FIELD DAYS

May 22, 1997
Bushland Wheat Field Day
Call Pam Dillard at (806) 359-5401 for additional information.

July 24, 1997
North Plains Research Field Day at Etter
Call Pam Dillard at (806) 359-5401 for additional information.

MEETINGS & PRESENTATIONS

May 19-20, 1997
Joint Texas Panhandle-New Mexico Soil and Water Consecration Society meeting at Clovis, NM and a tour on Animal Waste Management. Contact Steve Evett at (806) 356-5775 or <srevett@ag.gov> for more information.

July 15-17, 1997
U.S. Committee on Irrigation and Drainage and ASCE Committee Evapotranspiration in Irrigation and Hydrology
Fargo, ND T.A. Howell

August 10-14, 1997
American Society of Agricultural Engineers
Annual International Meeting
Minneapolis, MN T.A. Howell, A.D. Schneider

September 15-19, 1997
International Society of Sugar Cane Technologists
Townsville, Queensland AUSTRALIA
"Water Use Efficiency" [invited keynote] T.A. Howell

October 26-31, 1997
American Society of Agronomy and Soil Science Society of America Annual Meeting
Anaheim, CA
"Evapotranspiration of Irrigated Fescue Grass Compared with Computed Reference ET" T.A. Howell, S.R. Evett
"Alfalfa Evapotranspiration Compared with Reference ET" S.R. Evett, T.A. Howell, J.A. Tolk, A.D. Schneider
"Corn Water Use and Yield Response to Growing Season Mulch and Soil Differences" J.A. Tolk, T.A. Howell, S.R. Evett

June 17-20, 1998
Soil and Water Conservation Society State Meeting
Amarillo, TX
Contact Steve Evett at (806) 356-5775 or <srevett@ag.gov> for additional information.

CRADA News . . .

Where's the Water? . . .

An automatic, real-time system for soil water content measurement has been brought to market via a Cooperative Research and Development Agreement (CRADA) with Dynamax, Inc. of Houston, Texas (800-727-3570). The system works by measuring the speed of an electronic signal passing through stainless steel probes inserted in the soil - the slower the speed, the larger the water content. Products developed at Bushland and now manufactured and sold by Dynamax include the probes and a multiplexer (electronic switch) that allows up to 256 probes to be connected to one system. Software, also developed at Bushland, controls the system through an IBM PC compatible computer. Almost any such computer may be used, from sub-notebook size to desktop. An electronic instrument called a cable tester measures the signal speed by time domain reflectometry (TDR) - a sort of underground radar. An 81-page TDR system manual describes how to set up systems ranging from simple one-probe-at-a-time manual readings to automatic systems containing up to 17 multiplexers and 256 probes. The manual contains a software instruction section, hardware setup instructions, a tutorial on TDR theory and methods, cabling instructions, and even advice on setting up solar powered systems for remote, unattended data acquisition. Most users of the system are scientists and engineers doing environmental and agricultural research and monitoring and infrastructure monitoring. However, a recent paper by Lascano et al. (1996) describes the use of the system in an automatic drip irrigation system for cotton.

Research on the TDR system began at Bushland in 1990 after Steve Evett visited ARS scientist John Baker at Minneapolis, MN, to learn first hand about TDR research there. Recognizing the need for a robust probe with the cable and rod connections encased in plastic, Evett experimented with several probe designs before settling on the one now sold by Dynamax. Next, it became evident that multiplexers on the market had only a few channels and were quite expensive. Evett designed a 16-channel multiplexer that could be controlled from the parallel port of a personal computer. Software development proceeded concurrently with hardware design and testing. The current version of the software is called TACQ (**T**DR **ACQ**uisition) and offers a flexible, graphical interface allowing the user to set up and customize a water content measurement system to meet various demands of data timing and density. The program may even be run from a batch file so that another program may make use of the water content values just measured (as in Lascano's irrigation system). The software automatically converts the electronic signals to water content values, but allows the user to fine-tune the conversion process for best performance or even to re-convert the signals at a later date. In September 1995, the system had developed to the point that a CRADA was signed with Dynamax for commercialization. New this year is the ability to gather the data needed for calculation of the soil's bulk electrical conductivity — a key indicator of soil salinity level.

Evett and his colleagues have used the system for several scientific studies. A field method for measurement of soil thermal conductivity employs TDR probes inserted horizontally into the side of a soil pit at several depths within the first foot of soil. Thermocouples are inserted at the same depths to measure soil temperature every half hour. The water content data allow the soil's thermal capacity to be calculated for every depth. A Fourier series analysis of the diurnal temperature waves for every adjacent pair of depths allows the soil thermal diffusivity of the intervening layer to be calculated. This value is then converted to the thermal conductivity corresponding to the mean water content between the two depths. Regression analysis of the data yields the relationship of thermal conductivity vs. water content for the soil (Evett, 1994). Water content measurements by TDR can be made quite close to the surface; and this ability has proven useful for correction of soil heat flux values measured at a 5-cm depth to heat flux values at the soil surface. Water contents measured at 2- and 4-cm depths were used to compute the soil's thermal capacity every half hour, and these data were used with soil temperatures measured at the same depths to correct heat flux by the combination method (Howell et al., 1993). The multiplexer is the subject of a paper submitted by Evett (1997) to the journal *Computers and Electronics in Agriculture*. For several multiplexers, it was shown that water content values and bulk electrical conductivity measurements were unaffected by which channel of the multiplexer or which multiplexer was used. Power consumption was also measured. Precise measurement of evapotranspiration (ET) by soil water balance is the subject of a paper by Evett et al. (1993). In this study, accurate measurements by TDR of soil water in the first foot of soil were combined with accurate deeper soil water content measurements made by neutron scattering to yield precise measurements of winter wheat ET that proved to be accurate when compared with weighing lysimeter data. Soil water measurements by TDR have also proven useful in several modeling studies conducted at Bushland for validation of model-calculated water contents (e.g. Tunick et al., 1994).

References:

Evett, S.R., T.A. Howell, J.L. Steiner, and J.L. Cresap. 1993. Evapotranspiration by soil water balance using TDR and neutron scattering. pp. 914-921 *In* R.G. Allen and C.M.U. Neale (eds.) Management of Irrigation and Drainage Systems, Integrated Perspectives. Am. Soc. Civil Engr., New York, NY. Proceedings of the National Conference on Irrigation and Drainage Engineering, Park City, UT, July 21-23, 1993.

Evett, S.R. 1994. TDR-Temperature arrays for analysis of field soil thermal properties. pp. 320-327 *In* Proceedings of the Symposium on Time Domain Reflectometry in Environmental, Infrastructure and Mining Applications, Sept. 7-9, 1994. Northwestern University, Evanston, Illinois.

Evett, S.R. 1997. Coaxial multiplexer for time domain reflectometry measurement of soil water content and bulk electrical conductivity. Submitted to *Computers and Electronics in Agriculture*.

Howell, T.A., J.L. Steiner, S.R. Evett, A.D. Schneider, K.S. Copeland, D.A. Dusek, and A. Tunick. 1993. Radiation balance and soil water

evaporation of bare Pullman clay loam soil. pp. 922-929 *In* R.G. Allen and C.M.U. Neale (eds.) Management of Irrigation and Drainage Systems, Integrated Perspectives. Am. Soc. Civil Engr., New York, NY. Proceedings of the National Conference on Irrigation and Drainage Engineering, Park City, UT, July 21-23.

Lascano, R.J., R.L. Baumhardt, S.K. Hicks, S.R. Evett, and J.L. Heilman. 1996. Daily measurement and calculation of crop water use. pp. 225-230 *In* C.R. Camp, E.J. Sadler, and R.E. Yoder (eds.) Proceedings of the International Conference on Evapotranspiration and Irrigation Scheduling. Nov. 3-6, 1996, San Antonio, Texas, U.S.A. 1166 pp.

Tunick, A., H. Rachele, F.V. Hansen, T.A. Howell, J.L. Steiner, S.R. Evett, and A.D. Schneider. 1994. REBAL '92 - A cooperative radiation and energy balance field study for imagery and E.M. propagation. Bull. Amer. Meteo. Soc. 75(3):421-430.

by Steve Evett

Technology Transfer News . . .

9/24/96; Texas A&M University High & Rolling Plains Water Management Meeting at WTAMU, Canyon (T.A. Howell, R.N. Clark).
9/30/96; Chinese delegation from Huanan Province briefing (T.A. Howell).
11/7/96; Visitors from Israel, South Africa, Italy, and Kimberly, ID (S.R. Evett, A.D. Schneider, and T.A. Howell).
11/19/96; Bonham Middle School career-day (S.R. Evett).
12/3/96; ARS display at Amarillo Farm Show (S.R. Evett).
1/17/97; Joint ARS/TAES/TAEX/TVMDL/WTAMU seminar on ARS Research Program (R.N. Clark).
1/23/97; Quay Co. NM Agric. Meeting (A.D. Schneider).
2/21/97; Joint ARS/TAES/TAEX/TVMDL/WTAMU seminar on NP-PET (T.A. Howell).
2/27/97; Presentation on Sprinkler Irrigation Efficiency, New Mexico Section of ASAE, Portales, NM (A.D. Schneider).
3/3/97; Presentation on ET to WTAMU Water Management Continuing Education Class (T.A. Howell).
3/24/97; Interview with American Vegetable Growers magazine (S.R. Evett).
4/4/97; Texas A&M University System Leadership in Higher Education briefing on water management (T.A. Howell).
4/18/97; Joint ARS/TAES/TAEX/TVMDL/WTAMU seminar on Short-Season Corn/Sorghum Research (T.A. Howell).

Publications . . .

Normally, this list will be for the past 6 months. Since this is our first issue, we included all the publications since 1995.

1995. Allen, R. R., and Musick, J. T. Furrow irrigation intake with multiple traffic and increased axle mass. ASAE Paper No. 95-2418, Chicago, IL. June 21, 1995.

1995. Allen, R. R., Musick, J. T., and Schneider, A. D. Residual deep plowing effects on irrigation intake for Pullman clay loam. Soil Sci. Soc. Am. J. 59:1424-1429.

1995. Evett, S. R., Warrick, A. W., and Matthias, A. D. Wall material and capping effects on microlysimeter performance. Soil Sci. Soc. Am. J. 59:329-336.

1995. Evett, S. R., Peters, F. H., Jones, O. R., and Unger, P. W. Dryland soil hydraulic properties affected by tillage and crop rotation. Agron. Abstr. p. 197.

1995. Evett, S. R., Howell, T. A., and Schneider, A. D. Energy and water balances for surface and subsurface drip irrigated corn. pp. 135-140. In F. R. Lamm (ed.) Microirrigation for a Changing World: Conserving Resources/Preserving the Environment. Proc. Fifth International Microirrigation Congress. Am. Soc. Agric. Engr., St. Joseph, MI.

1995. Evett, S. R., and Steiner, J. L. Precision of neutron scattering and capacitance type moisture gauges based on field calibration. Soil Sci. Soc. Am. J. 59:961-968.

1995. Evett, S. R., Howell, T. A., Schneider, A. D., and Tolk, J. A. Crop coefficient based evapotranspiration estimates compared with mechanistic model results. pp. 1585-1589. In W. H. Espey, Jr. and P. G. Comps (eds.) Vol. 2, Water Resources Engineering. Am. Soc. Civil. Engr., New York, NY.

1995. Howell, T. A., Moustafa, A.T.A., Abou-Zeid, W., Schneider, A. D., and Evett, S. R. Water conservation with improved irrigation methods and management. Final Report, USDA-ARS, Conservation and Production Research Laboratory Report No. CPRL-95-10, Bushland, TX.

1995. Howell, T. A., Yazar, A., Schneider, A. D., Dusek, D. A., and Copeland, K. S. Yield and water use efficiency of corn in response to LEPA irrigation. Trans. ASAE 38(6):1737-1747.

1995. Howell, T. A., Steiner, J. L., Schneider, A. D., and Evett, S R. Evapotranspiration of irrigated winter wheat — Southern High Plains. Trans. ASAE 38(3):745-759.

1995. Howell, T. A., Schneider, A. D., Dusek, D. A., Marek, T. H., and Steiner, J. L. Calibration and scale performance of Bushland weighing lysimeters. Trans. ASAE 38(4):1019-1024.

1995. Howell, T. A., Schneider, A. D., and Stewart, B. A. Subsurface and surface microirrigation of corn — Southern High Plains. pp. 375-381. In F. R. Lamm (ed.) Microirrigation for a Changing World: Conserving Resources/Preserving the Environment. Proc. Fifth International Microirrigation Congress. Am. Soc. Agric. Engr., St. Joseph, MI.

1995. Howell, T. A., Johnson, K., and Dusek, D. A. Use of the SCS-Scheduler program — Southern High Plains. pp. 109-113, 264-266. In L. Ahuja, J. Leppert, K. Rojas, and E. Seely (eds.) Proc. Workshop on Computer Application in Water Management. Great Plains Agricultural Council and Water Resources Research Institute, Colorado State Univ., Fort Collins, CO.

1995. Howell, T. A., Tolk, J. A., Schneider, A. D., and Evett, S. R. Water use and water use efficiency of two different maturity corn hybrids. Agron. Abstr. p. 21.

1995. Howell, T. A., Jones, O. R., Reddell, D. L., Ngang, F., and Schneider, A. D. Influence of irrigation method, tillage, and crop residues on infiltration and interrill erosion on a Pullman soil. pp. 133-136. In Vol. III: Practices, Systems & Adoption. Conference Proc. of the Clean Water — Clean Environment — 21st Century. Am. Soc. Agric. Engr., St. Joseph, MI.

1995. Lamm, F., Schneider, A. D., Yitayew, M., and Schoneman, R. A. Issues for SDI system installations. Proc. Irrig. Assoc. Annual Meeting, Phoenix, AZ, Nov. 1995.

1995. Langdale, G. W., Allen, R. R., and Hill, P. R. The evolution and purpose of tillage systems: Range of systems and extent of use. In Farming for a Better Environment. SWCS White Paper, p. 3.

1995. Lascano, R. J., Baumhardt, R. L., Hicks, S. K., Evett, S. R., Heilman, J. L., and Van Bavel, C.H.M. Real time measurement of cotton water use with an integrated system. Agron. Abstr. p. 15.

1995. Musick, J. T. General guidelines for deficit irrigation management. 1995 Central Plains Irrigation Short Course, Garden City, KS, Feb. 7-8, 1995. (Handout)

1995. Schneider, A. D., and Howell, T. A. Grain sorghum response to sprinkler application methods and system capacity. Trans. ASAE 38(6):1693-1697.

1995. Schneider, A. D., and Howell, T. A. LEPA and spray irrigation in the Southern High Plains. pp. 1718-1722. In W. H. Espey, Jr. and P. G. Combs (eds.) Vol. 2, Water Resources Engineering. Am. Soc. Civil. Engr., New York, NY.

1995. Thompson, A. L., Martin, D. L., Norman, J. M., and Howell, T. A. Irrigation scheduling effects on water loss partitioning from sprinkler irrigation. ASAE Paper No. 95-2417.

1995. Tolk, J. A., Howell, T. A., Steiner, J. L., and Krieg, D. R. Aerodynamic characteristics of corn as determined by energy balance techniques. Agron. J. 87:464-473.

1995. Tolk, J. A., Howell, T. A., Evett, S. R., and Schneider, A. D. Evapotranspiration, growth, and yield of a short season corn variety. Agron. Abstr. p. 18.

1995. Tolk, J. A., Howell, T. A., Steiner, J. L., Krieg, D. R., and Schneider, A. D. Role of transpiration suppression by evaporation of intercepted water in improving irrigation efficiency. Irrig. Sci. 16:89-95.

1996. Allen, R. R., and J. T. Musick. Permanent ridge-till sorghum with furrow irrigation. ASAE Paper No. 96-2101, Phoenix, AZ. July 14-18, 1996.

1996. Dusek, D. A., and T. A. Howell. Effects of instrument shelters on air temperature and humidity measurements. pp. 491-496. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Evett, S. R., Howell, T. A., Schneider, A. D., Upchurch, D. R., and Wanjura, D. F. Canopy temperature based automatic irrigation control. pp. 207-213. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Howell, T. A. Irrigation scheduling research and its impact on water use. pp. 21-33. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Howell, T. A., Evett, S. R., Tolk, J. A., Schneider, A. D., and Steiner, J. L. Evapotranspiration of corn - Southern High Plains. pp. 158-166. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Lascano, R. J., Baumhardt, R. L., Hicks, S. K., Evett, S. R., and Heilman, J. L. Daily measurement and calculation of crop water use. pp. 225-230. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Marek, T., Howell, T., New, L., Bean, B., Dusek, D., and Michels, G. J. Texas north plains PET network. pp. 710-715. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Ritchie, J. T., Howell, T. A., Meyer, W. S., and Wright, J. L. Sources of biased errors in evaluating evapotranspiration equations. pp. 147-157. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Schneider, A. D., Ayars, J. E., and Phene, C. J. Combining monolithic and repacked soil tanks for lysimeters from high water table sites. Appl. Eng. Agric. 12(6):649-654.

1996. Schneider, A. D., Howell, T. A., Moustafa, A.T.A., Evett, S. R., and Abou-Zeid, W. A weighing lysimeter for developing countries. pp. 289-294. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Schomberg, H. H., Steiner, J. L., Evett, S. R., and Moulin, A. P. Climatic influence on residue decomposition prediction in the wind erosion prediction system. Theor. Appl. Climatol. 54:5-16.

1996. Thompson, A. L., Martin, D. L., Norman, J. M., and Howell, T. A. Scheduling effects on evapotranspiration with overhead and below canopy application. pp. 182-188. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1996. Tolk, J. A., Howell, T. A., Steiner, J. L., and Krieg, D. R. Corn canopy resistance determined from whole plant transpiration. pp. 347-351. In C. R. Camp, E. J. Sadler, and R. E. Yoder (eds.) Proc. International Conference. Evapotranspiration and Irrigation Scheduling, San Antonio, TX.

1997. Allen, R. R., and Musick, J. T. Furrow irrigation infiltration with multiple traffic and increased axle mass. Appl. Engr. Agric. 13(1):49-53.

1997. Schneider, A. D., and Howell, T. A. Methods, amounts, and timing of sprinkler irrigation for winter wheat. Trans. ASAE 40(1)137-142.

1997. Thompson, A. L., Martin, D. L., Norman, J. M., Tolk, J. A., Howell, T. A., Gilley, J. R., and Schneider, A. D. Testing of a water loss distribution model for moving sprinkler systems. Trans. ASAE 40(1):81-88.

1997. Howell, T.A., J.L. Steiner, A.D. Schneider, S.R. Evett, and Tolk, J.A. Seasonal and maximum daily evapotranspiration of irrigated winter wheat, sorghum, and corn — Southern High Plains. Trans. ASAE 40(3): (in press).

1997. Howell, T. A., Schneider, A. D., and Evett, S. R. Subsurface and surface microirrigation of corn — Southern High Plains. Trans. ASAE 40(3): (in press).

1997. Schneider, A.D., and Howell, T.A. LEPA and spray irrigation both efficient for fully-irrigated grain crops. Irrig. Business and Technology (in press).

1997. Howell, T.A. Footprints of a profession (an editorial). Resource 4(5): (in press).

Personnel News . . .

Cal Stone resigned in December 1996, to accept a position with the Harrington Medical Center in Amarillo.

Ron Allen retired in January after 40 years of Federal service. Ron is a collaborator and finishing some writing.

Steve Evett accepted the laboratory Radiation Safety Officer assignment in January. He is responsible for all laboratory radiation equipment and personnel safety training, mainly for the neutron soil moisture gauges.

Kevin VonNetzer has re-enlisted for another tour of duty for the 1997 summer. Kevin is an Environmental Science graduate student at WTAMU.

Jerry Thomas was assigned to the Energy, Soil, and Animal Waste Research Unit to work with Dr. Clark on animal waste research.

Jim Cresap was assigned to our unit to continue working on the evapotranspiration team and on other irrigation and plant-water studies.

We are recruiting for a ***Plant Physiologist*** to conduct research on improving water use efficiency under water limiting conditions, particularly under limited irrigation.

Gary Marek is welcomed back for the 1997 summer. Gary will be a junior (at the close of this spring semester) at West Texas A&M University.

Terry Howell was appointed to serve on the ARS RPES (Research Position Evaluation System) and attended training in Dallas, TX, on Feb. 18-19, 1997.

Water Management Research Unit

http://www.net.usda.gov/cprl/

RESEARCH STAFF

Dr. Terry A. Howell, P.E.
Research Leader (Agric. Engr.)
(806) 356-5746
tahowell@ag.gov

Donald A. Dusek
Agronomist
(806) 356-5747

Ronald R. Allen
Collaborator (Agric. Engr.)
(806) 356-5725
rrallen@ag.gov

Dr. Steven R. Evett
Soil Scientist
(806) 356-5775
srevett@ag.gov

Dr. R. Nolan Clark
Laboratory Director (Agric. Engr.)
(806) 356-5734
rnclark@ag.gov

Jack T. Musick
Collaborator (Agric. Engr.)
(806) 356-5728

Karen S. Copeland
Soil Scientist
(806) 356-5735
kacopeland@ag.gov

Dr. Arland D. Schneider, P.E.
Agricultural Engineer
(806) 356-5732
aschneid@ag.gov

USDA United States Department of Agriculture

ARS Agricultural Research Service

USDA-ARS
P.O. Drawer 10
Bushland, TX 79012-0010

POSTMASTER: Send address changes to *Wetting Front*, USDA-ARS, P.O. Drawer 10 Bushland, TX 79012-0010.

U.S. Postage