Wetting Front

Water Management Research Unit Newsletter

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Irrigation Research Golden Anniversary. . .

by Terry Howell, Arland Schneider, and Ron Allen

Fifty years ago irrigation research was started at Bushland. *"A tentative program of irrigation research needs for the High Plains of Texas was formulated in a meeting of interested agencies at Amarillo, Texas on September 27, 1948. Agencies represented were as follows: Texas Agricultural Experiment Station, Texas A. & M. College Extension Service, Texas A. & M. College Agricultural Engineering Department, Texas State Board of Water Engineers, Bureau of Reclamation, Soil Conservation Service Operations Division, and Soil Conservation Service Research."*[1/] By October 1948, Norris P. Swanson, irrigation engineer, with the USDA Soil Conservation Service Research (one of the predecessor agencies that formed the Agricultural Research Service) was working in the Amarillo Conservation Experiment Station office. Research staff were housed in the Amarillo Post Office Building and were not moved onto the Experiment Station at Bushland, Texas, (now the Conservation and Production Research Laboratory at Bushland) until March 1, 1955. Research plans were organized in 1949, and research on both station plots and off-station fields was initiated during 1949. *"Irrigation land preparations and the installation of over 4,000 feet of underground concrete pipeline on the Amarillo station in 1950 incorporated more than 20 acres in intensive irrigation study plots."*[2/] These early projects involved cooperative research with the Lubbock sub-station of the Texas Agricultural Experiment Station (as it was called them), and the off-station field studies were conducted in cooperation with the USDA Soil Conservation Service Operations (formerly known as USDA-SCS and now as the USDA-NRCS, Natural Resources Conservation Service). The first Bushland irrigation research was organized in two projects:

Line Project No. R-3-1-1-#1, *Irrigation Requirements of Crops on the High Plains of Texas*, initiated on June 13, 1949 and

Line Project No. R-3-1-1-#3, *Methods of Water Application on the High Plains of Texas*, initiated on June 13, 1949.

USDA-SCS recognized the need for technical assistance to farmers using sprinkler irrigation, so in 1953 Norris Swanson met with SCS personnel from Area 13 to discuss methods and plans for field evaluations of sprinkler irrigation. Sprinker irrigation studies were started in 1954, but this work was conducted off-station on the South Plains of Texas near Brownfield, Texas. Norris Swanson conducted research at Bushland until he was transferred to Lincoln, Nebraska, on April 1, 1955. He was replaced by Marvin E. Jensen, agricultural engineer, who reported for duty on July 5, 1955. Marvin Jensen was formerly employed by the North Dakota Agricultural Experiment Station at Fargo.

Research Irrigation
50th 1948 to 1998
Agricultural Research Service
Bushland, Texas

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[1/] Progress Report of Irrigation Studies on the High Plains of Texas Calendar Years 1949 and 1950 (by Norris P. Swanson). Source USDA-ARS Bushland Archives.

[2/] Annual Report of Progress, Calendar Year 1952, Line Project No. R-3-1-1-#3 (by Norris P. Swanson). Source USDA-ARS Bushland Archives.

Interestingly, the irrigation program emphasis at Bushland remains mainly centered around the themes of these 1949 projects – irrigation water management through knowing the crop water requirements and improving irrigation application techniques. Although the Bushland irrigation programs were started on the right path by Norris Swanson and Marvin Jensen, the Bushland irrigation programs matured under the tutelage of Jack T. Musick, who moved to Amarillo in 1961 after prior assignments at Prosser, Washington; Garden City, Kansas; and Akron, Colorado. He was the Assistant to the Branch Chief, Dr. J.R. (Rex) Johnston, and located in Amarillo. In 1964, Jack Musick returned to full-time research on irrigation at Bushland. He directed the irrigation programs until December 1993 and retired in January 1995. He remains on a collaborator's appointment but has not actively worked since he underwent surgery in April 1997. He had a significant role in hiring almost all of our current staff, directing current projects on irrigation, and in advising and suggesting new research project directions both on irrigation and on dryland water management. He is probably the most knowledgeable person here about irrigation programs in this region, has published extensively on irrigation in the High Plains of Texas and the Ogallala situation, and conceived the term "limited irrigation."

The Water Management Research Unit was organized in 1968, and it is the "home" at the USDA-Agricultural Research Conservation and Production Research Laboratory at Bushland, Texas, for the irrigation programs. A groundwater recharge research program, not a part of the irrigation program, operated from 1957 until 1978. Wind energy research was started in 1976 at Bushland and led by Dr. R. Nolan Clark, agricultural engineer (now the Laboratory Director) and was a separate research unit from 1981 until 1985, when it was reassigned back into the Water Management Research Unit. In 1993, wind energy research was combined with the soil management (dryland) research and the animal research program to form the Energy, Soil, and Animal Waste Resources Research Unit.

The first well was drilled at Bushland in 1938, when the research station opened, and served both domestic and irrigation needs. Marvin Jensen supervised the drilling of the second irrigation well which was drilled on the south section in 1957, and this well is still in use today for irrigation. Underground pipe was installed on the south section in 1964. Storage reservoirs were constructed on the south section in 1967 and on the north section in 1971. Sprinkler irrigation research was started at Bushland in 1971 when Dr. Clark was hired and assigned one-half time to that project (his other assignment then was on animal waste management research). The first center pivot sprinkler (3 tower) was installed in 1977. Surge flow graded furrow research in Texas was pioneered by Dr. Arland Schneider (ARS-Bushland) and Jerry Walker (NRCS-Amarillo formerly the SCS) in 1982. Ron Allen and Jack Musick later conducted many surge management experiments. Four large weighing monolithic lysimeters (10 ft by 10 ft by 8 ft in depth) were designed, built, and installed from 1985 to 1987. A rain shelter with 48 smaller monolithic lysimeters (each 30 in. by 40 in. by 8 ft in depth) were built during the 1987-1989 period for controlled research on plant water deficits. Two 3-span lateral move sprinkler systems were added in 1992 and 1993 for irrigation methods and sprinkler irrigated cropping systems research. In 1993, subsurface drip irrigation (SDI) research was started. A smaller weighing monolithic lysimeter (5 ft by 5 ft by 8 ft in depth) was designed, built, and installed in 1993-1994 for measuring grass reference ET. The irrigation research facilities at Bushland are among the finest anywhere in the world for field irrigation research.

Scientific research personnel who have worked on the irrigation research projects at Bushland are listed below:

Norris Swanson, 1948-1955 *
Dr. Marvin Jensen, 1955-1958*
Willis Sletten, 1956-1966 *†
Dr. James Box, 1959-1961*
Jack Musick, 1964-1995 *
Dr. Arland Schneider, 1965-
Dr. Nolan Clark, 1971- . . . [wind energy since 1981]
Dr. Arbra Mathers, 1979-1985 *
Dr. Fred Vosper, 1982-1985 . . . . . [wind energy]
Ron Allen, 1966-74, 1984-1997 *¶
Dr. Terry Howell, 1983-
Dr. Fadi Kamand, 1986-1989 . . . . . [wind energy]
Dr. Steve Evett, 1989-
Dr. Judy Tolk, 1997-
Dr. Rick Todd, 1997-

* retired from ARS
¶ collaborator
† deceased

Many scientists at Bushland contributed significantly to the irrigation research program although not directly involved on the irrigation research project, like Dr. Victor Hauser, Dr.

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Harold Eck, Dr. B.A. Stewart, Dr. Paul Unger, and several Texas Agricultural Experiment Station scientists at Bushland. Leon New (TAEX-Amarillo) conducted his M.S. degree research at Bushland in 1971. Thomas Marek (TAES-Amarillo) was first employed at Bushland on an ARS cooperative agreement and worked on sprinkler irrigation research with Dr. Clark. Dr. Jean Steiner (now the laboratory director for ARS at Watkinsville, GA) did her Ph.D. research in Kansas on a project supported by irrigation research funding from Bushland. Later she was employed at Bushland from 1983 until 1993 on the dryland soil management project. She was a key member of the ARS Bushland ET team and cooperated on many irrigation experiments. Two current water management scientists — Dr. Tolk and Dr. Todd – conducted their Ph.D. research at Bushland (but most of Dr. Todd's work was done at North Platte, Nebraska).

Dr. Terry A. Howell has served as Research Leader for the Water Management Research Unit since December 1993. Currently, the research unit has four permanent scientists (Dr. Terry Howell, agricultural engineer; Dr. Steve Evett, soil scientist; Dr. Arland Schneider, agricultural engineer; and Dr. Judy Tolk, plant physiologist), one post-doctoral research associate (Dr. Rick Todd, plant physiologist), two support scientists (Karen Copeland, soil scientist; and Don Dusek, agronomist), four technicians (Keith Brock, biological technician; Jim Cresap, biological technician; Brice Ruthardt, biological technician; and Rob Robertson, biological technician), one program assistant (Carole Perryman), and two part-time students (Gary Marek, biological aide; Kevin von Netzer, biological aide).

The 1998 Bushland field day on August 12 (see additional details on p. 10) will honor this milestone of service to agriculture, Texas, and to our country. The current staff appreciates our research legacy and the commitment to support irrigation research in the U.S. Southern High Plains and the Texas High Plains. The field day keynote speaker, Dr. Allen Dedrick, Associate Deputy Administrator, for ARS in Beltsville, Maryland, was hired by Norris Swanson in Nebraska. We are anticipating that Norris Swanson may attend the field day program. Although Dr. Jensen cannot attend the field day due to a prior commitment, he remains active in irrigation from Ft. Collins, Colorado, and he is one of the world's most renowned irrigation experts.

32ND ANNUAL TEXAS SWCS MEETING . . .

by Judy Tolk

Water in the 21st Century: Rights and Realities will be the theme of the 32nd annual state meeting of the Texas Council of Chapters, Soil and Water Conservation Society (SWCS), to be held in Amarillo June 17-19.

"We have opened the technical tour and session to non-society members, with separate registration fees, because we feel this is a timely topic and hope that many individuals would like to attend," said Steve Evett, president of the Golden Spread Chapter of SWCS which is sponsoring the event. SWCS members and non-members from Oklahoma and New Mexico have also been invited.

The day-long technical session on June 18 at the Radisson Inn begins at 8:30 a.m. and features ten speakers from throughout the state. Exhibits from state and local sponsors will also be on display.

The future of water use from the Edwards aquifer will be discussed by Gregory Ellis, general manager of the Edwards Aquifer in San Antonio, and water use from the Ogallala aquifer by Dr. Lloyd Urban, director of the Water Resources Center at Texas Tech University in Lubbock. John C. Williams, general manager of the Canadian River Municipal Water Authority in Sanford, will talk about future water use from Lake Meredith.

Potential new water supplies will be the topic of Comer Tuck, regional planning team leader, Texas Water Development Board, Austin. George Bomar, weather modification specialist with Texas Natural Resources Conservation Commission in Austin, will discuss weather modification projects throughout the state. Gale Henslee, environmental projects director at New Century Services in Amarillo, will discuss his company's utilization of Amarillo's waste water.

The future for irrigation will be examined by Dr. Ron Lacewell, assistant vice chancellor at Texas A&M University in College Station. The impact on the Texas economy of conversion to dryland farming will be evaluated by Dr. Steve Amosson, agricultural economist with the Texas Agricultural Extension Service in Amarillo. Marketing water rights will also be discussed. Five continuing education units (CEUs) for Certified Crop Advisors in soil and water management may be earned by attending the technical session.

The keynote address at noon on June 18 will be given by Dr. Wayne Jordan, director of the Texas Water Resources Center at Texas A&M University in College Station.

The technical tour on June 17 will focus on equipment and techniques for efficient use and management of precipitation and irrigation water resources for crop production and will be at the USDA Agricultural Research Service at Bushland, which is west of Amarillo. The tour participants will see the world-class evapotranspiration facilities, where very accurate measurements of water loss are made so that cropping systems and various production strategies can be evaluated. Other tour stops will show the latest technology in center pivot irrigation, including above- and within-canopy sprinklers and LEPA (low energy spray application), as well as subsurface and surface drip irrigation systems. Participants will see an 8-span center pivot using sprinkler management methods to reduce or control plant diseases and dryland water management systems. Two Certified Crop Advisor CEUs in soil and water management may be earned by attending the tour.

For more information, call Carole Perryman at (806) 356-5749, or send an e-mail message to her at cperryma@ag.gov. Registration for the technical tour is $5, and registration for the technical session is $35. Any registrations, which include lunch at the technical session, must be made by

June 12. Full details are available from the meeting Web site at http://www.cprl.ars.usda.gov/programs/swcs.htm.

THE NORTH PLAINS PET NETWORK . . .

by Terry Howell, Thomas Marek, Leon New, and Don Dusek

Irrigation uses a large volume of water and is the largest use of water in the Texas High Plains. This region is dependent on the Ogallala aquifer for the majority of its water supply, but this incredible water resource is declining. Despite the enormous changes in irrigated agriculture in this area in the past 20 years that have dramatically decreased the water applied per unit land area, some areas in the region are still experiencing water table decline rates exceeding two feet per year. At Bushland, most of our well hydrographs now show water table decline rates less than one foot per year, but well yields have declined appreciably as the aquifer saturated thickness has declined. Irrigation scheduling is one technology not widely used in the Texas High Plains that can further reduce irrigation applications and help sustain irrigation in this important region.

In 1992, a Texas Agricultural Experiment Station and Texas Agricultural Extension Service team at Lubbock (Seymour et al., 1994) developed the South Plains PET Network around the three weather stations at Lamesa (AgCares), Lubbock, and Halfway. They faxed daily PET (potential evapotranspiration) and heat unit information to subscribers and distributed it to mass media. They developed spreadsheet programs to use these data for irrigation scheduling, and extensively worked on education and training of growers to use this technology. In 1994, a Texas Agricultural Experiment Station, Texas Agricultural Extension Service, and USDA-Agricultural Research Service team at Amarillo/Bushland/Etter (Marek et al., 1996) developed a similar North Plains PET Network to serve the northern Texas Panhandle. Currently, the NP-PET operates 10 separate weather stations across the central and northern Texas Panhandle. Although these two networks are separate and distinctly different, they collaborate and use similar methods. The NP-PET network sends more than 325 faxes each night to a wide range of subscribers. Both networks maintain a Web site where the faxes and archived data can be located. The NP-PET Web site archives and makes available the hourly data and its daily statistics (maximums, minimums, totals, etc.). Another similar network was developed in 1995 by Dr. Guy Fipps at Texas A&M University that now has more than 12 station sites from the Lower Rio Grande Valley to the Coastal Bend and Edwards aquifer regions to north and central Texas. Other weather networks are in Texas and surrounding states. The Oklahoma Mesonet (Brock et al., 1995) may be the most extensive such example. Plans are being made for a Texas Mesonet for more complete electronic state-wide weather information coverage.

NP-PET NETWORK OPERATION

The NP-PET sites are shown in Fig. 1. The northern tier of stations are located at Dalhart, Etter, Morse, and at Perryton. The central tier of stations are located at Bushland, White Deer, and Wellington, and the southern tier of stations are located at Farwell, Dimmitt, and Earth. The NP-PET computers are at Bushland and call each station after midnight to acquire the weather data from the previous day. The computers process the data, computing PET, heat units (growing degree days or GDDs), and the crop water use for corn, cotton, wheat, sorghum, soybean, and peanut. These data are used to format a fax sheet for each weather station (and its associated crops; some stations only have certain crop data segments). Then, the computers send the fax sheets to each subscriber for that station before 7:00 a.m. The computers upload the fax files and the hourly processed weather data files to a central server for access on the world wide web.

Table 1 illustrates a daily fax sheet sent on April 25, 1998, for the Farwell, TX, NP-PET weather station. On this date, only data on wheat, corn, and peanut are reported, but cotton and soybean data will begin appearing on May 1 and May 15, respectively. The upper section gives a mini 3-day climate summary with the daily PET value, maximum and minimum air temperatures, minimum soil temperatures for the 2 and 6 inch depths, precipitation, and GDDs for various crops. The 10-day average minimum soil temperatures are also given as a crop planting guide. The middle sections give specific data for each crop (in season) that we report for that specific weather station site. Each crop's water use is bracketed for four planting dates that generally cover the expected range in planting dates. The accumulated GDDs from sowing until the current day are given for each sowing date along with a predicted crop development stage; and the current day's, past 3-days', past 7-days', and the accumulated season's water use (ET). For corn, sorghum, and peanut, water use and development are estimated for two types of typical long- and short-season cultivars (hybrids for corn and sorghum and varieties for peanut). For cotton, wheat, and soybean (mid group IV type) only one cultivar type is simulated. We only simulate "well-watered" and "normal" crops (no insect, diseases, or weed pest limitations) for "a high level" production practice. The bottom section contains a limited space for

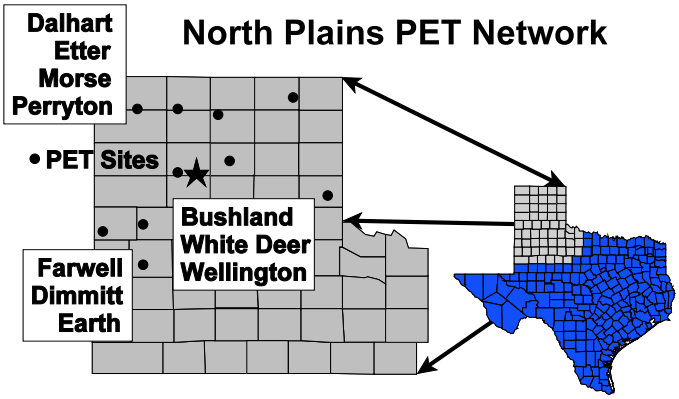

Figure 1. Map illustrating NP-PET network weather station sites.

remarks, messages, notices, and alerts. The notices on this fax sheet highlight our web site addresses and our "standard" winter disclaimer about the measured precipitation (our rain gauges are not capable of accurately recording snow and/or ice).

Many users need more detailed data for their particular applications, especially consultants and industries that may be using models. Therefore, all the NP-PET hourly data (as well as the fax sheets) are available on the Amarillo Agricultural Research and Extension Center web server at the address http://amarillo2.tamu.edu/nppet/petnet1.htm. These data and fax files are updated daily, but then they are compacted into 10-day "zip" files to save space and for faster downloading. Table 2 illustrates the hourly data file for April 24, 1998, for the Farwell, TX, NP-PET weather station site. All the NP-PET data are measured and recorded in the S.I. (System International) unit system for integrity and consistency. Conversion factors into common English units are widely available (or we can assist with any specific questions). The file header gives station data and standard astronomical data for that day. The data columns represent hourly means (or a total for precipitation) of the data and derived parameters. The bottom section contains daily sums (an integrated value for solar radiation), daily averages, and maximums and minimums and their time of occurrences for specific column variables. If you will look back at Table 1, you will notice a dramatic increase in PET from 0.27 to 0.37 in./day on April 23rd and April 24th. A PET value of 0.37 in./day is "fairly" large but not uncommon for West Texas. The air temperatures were only a little warmer on April 24th (see Table 1), and the amount of solar radiation (sunshine) was quite similar to the previous day. The main differences were the drier air (mean relative humidity of 31% on 4/24/98 and 42% on 4/23/98) and the much stronger winds (mean of 12.1 miles/hr on 4/24/98 and 7.1 miles/hr on 4/23/98). Our data and experiences (together with these NP-PET data) have illustrated that such occurrences are not uncommon in this region, but that they can greatly impact water management decisions in the spring. The ARS ET team at Bushland has measured and documented many extremely high ET rates for wheat, corn, alfalfa, and grass that are as large at Bushland as any place in the world. In fact, often these extreme events occur in spring and early summer in the Texas High Plains when wind speeds are strong, the air is drier, and the skies are relatively clear as contrasted to summer months when temperatures may be warmer, but when more clouds occur (afternoon and evening convective storms), winds are much calmer, and the air is more humid.

Table 1. Example fax sheet sent on April 25, 1998, for the Farwell, TX, NP-PET weather station.

```
              North Plains PET Network   Weather Station, Farwell,
TX

                        Temperatures (F)
           Date   PET  ---Air--  Soil Min. Prec.   Growing Degrees
Days (F)
                  in.  Max  Min  2in. 6in.  in.  Crn Srg Pnt Cot Soy
Bet Wht
        04/22/98  .18   72   35   49   53  0.00   11   0   9   0   0
16  22
        04/23/98  .27   85   41   51   55  0.00   17   0  15   0   0
23  28
        04/24/98  .37   89   43   55   58  0.00   18   0  17   0   0
26  29
        10-day avg min soil temp  48   53

        CORN       Short Season Var. Water Use     Long Season Var.
Water Use
        Seed  Acc  Growth   Day 3day 7day  Seas.  Growth   Day 3day
7day  Seas.
        Date  GDD  Stage    -----in/d-----  in.   Stage
-----in/d-----  in.
        04/01  238 Emerg    .13  .10  .07   1.5   Emerg    .13  .10
.07   1.5
        04/15   88 Seed     .09  .07  .05   0.5   Seed     .09  .07
.05   0.5

        PEANUTS    Short Season Var. Water Use     Full Season Var.
Water Use
        Seed  Acc  Growth   Day 3day 7day  Seas.  Growth   Day 3day
7day  Seas.
        Date  GDD  Stage    -----in/d----   in.   Stage
-----in/d----   in.
        04/15   68 Seeded   .03  .02  .01   0.1   Seeded   .03  .02
.01   0.1

        WHEAT                   Water Use
        Seed  Acc  Growth   Day 3day 7day  Seas.
        Date  GDD  Stage    -----in/d----   in.
        08/15 4628 2nd node .48  .35  .27  32.1
        09/10 3673 1st node .48  .35  .27  25.2
        10/01 2976 Stm Elg  .46  .34  .26  20.0
        10/15 2560 Stm Elg  .46  .34  .26  16.5


        NOTE-- Precipitation data reported from snow and/or ice will
               not be accurate.

           ARS-BUSHLAND WEB ADDRESS --
http://www.cprl.ars.usda.gov/
           *******************************************************
           NEW ADDRESS
           North Plains PET Home Page is on the web. Archived data
               as well as current data will be added soon.

               http://amarillo2.tamu.edu/nppet/petnet1.htm
           *******************************************************
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NP-PET METHODS

The NP-PET network uses GDD (growing degree days) as the thermal time parameter for computing crop coefficients (Kc) and for estimating crop development rates. GDDs are computed as

$$GDD = (Tmax + Tmin)/2 - Tbase$$

subject to these constraints:

if Tbase ≥ Tmax, then Tmax is set equal to Tbase
if Tmax ≥Tupper, then Tmax is set equal to Tupper
if Tbase ≥Tmin, then Tmin is set equal to Tbase
if Tmin ≥ Tupper, then Tmin is set equal to Tupper

where Tmax and Tmin are the daily maximum and minimum air temperatures, Tbase is the GDD base temperature, and Tupper is an upper cut-off threshold temperature. Table 3 summarizes the GDD crop constants used by the NP-PET programs. All computations are made in °C and converted °F scales for the fax sheets (see Table 1).

The NP-PET network computes PET for a cool-season grass type (about 4-5 in. tall) using standard procedures outlined by Allen et al. (1994) that are recommended world-wide. These equations are based on the grass reference ET

Table 2. Example hourly data file for Farwell, TX, NP-PET weather station for April 24, 1998.

Station:FARWELL, TX Long 103 deg 2 min Lat 34 deg 26 min
Date: 04/24/98 Year/DOY: 98114
Sunrise 610 Sunset 1931 Daylight time = 13 hours 21 minutes

Time CST	Rs W/m^2	Ts2 C	Ts6 C	Tair C	TDew C	RH %	VP kPa	VPD kPa	WSpd m/s	Wdir deg	SDd deg	PREC mm
100	-0.1	15.6	16.9	12.6	2.3	50	0.72	0.74	3.3	271	9	0.00
200	-0.0	15.1	16.5	15.3	0.4	36	0.63	1.11	5.1	264	9	0.00
300	-0.0	14.9	16.2	14.1	0.4	39	0.63	0.98	4.1	275	9	0.00
400	-0.1	14.4	15.9	11.5	1.4	50	0.67	0.69	2.7	281	7	0.00
500	-0.2	13.9	15.5	9.5	1.7	59	0.69	0.49	2.1	275	10	0.00
600	-0.1	13.3	15.2	8.5	1.9	64	0.70	0.41	2.1	295	31	0.00
700	39.2	12.8	14.9	7.5	1.6	67	0.69	0.35	1.7	319	29	0.00
800	235.5	12.9	14.6	13.3	2.8	49	0.75	0.80	2.0	306	15	0.00
900	451.0	14.2	14.5	19.5	2.1	31	0.71	1.56	4.6	303	11	0.00
1000	648.5	16.1	14.8	22.3	2.7	28	0.74	1.95	5.2	293	13	0.00
1100	809.9	18.5	15.4	24.9	2.6	24	0.74	2.40	5.6	297	13	0.00
1200	922.1	20.8	16.2	26.8	1.3	19	0.67	2.85	6.3	293	13	0.00
1300	976.0	22.9	17.1	28.2	0.5	17	0.64	3.18	6.7	283	14	0.00
1400	955.4	24.4	18.0	29.3	-0.4	15	0.59	3.49	8.4	278	13	0.00
1500	892.7	25.3	18.8	30.5	-1.9	12	0.53	3.83	9.7	266	14	0.00
1600	746.8	25.6	19.4	30.5	-1.8	12	0.54	3.83	10.7	268	13	0.00
1700	582.8	25.3	19.9	29.2	-1.4	14	0.56	3.51	10.8	270	12	0.00
1800	383.4	24.4	20.0	27.9	-1.7	14	0.54	3.21	8.7	272	11	0.00
1900	169.8	23.2	20.0	26.2	-4.0	13	0.46	2.95	8.3	265	10	0.00
2000	15.4	21.7	19.8	22.2	-3.1	18	0.49	2.20	5.4	258	10	0.00
2100	-0.2	20.1	19.5	20.3	-3.5	20	0.47	1.91	5.5	266	11	0.00
2200	-0.2	19.0	19.0	18.6	-2.5	24	0.51	1.63	4.8	263	11	0.00
2300	-0.2	18.1	18.7	14.0	-1.0	33	0.54	1.14	3.1	286	13	0.00
2400	-0.2	17.0	18.2	11.8	-1.0	41	0.57	0.81	2.6	281	7	0.00
Sum	28.2 MJ											0.00
Avg		18.7	17.3	19.8	-0.0	31	0.62	1.92	5.40	280	21	
Max	1007.6	25.7	20.1	31.7	4.9	73	0.87	4.15	16.20			
Time	1313	1534	1748	1516	1016	636	1016	1516	1455			
Min		12.6	14.4	-6.3	-6.6	10	0.37	0.27				
Time		701	808	617	1828	1450	1828	636				

Table 3. NP-PET network crop GDD base temperatures in °C and °F.

CROP	Tbase	Tupper
corn	C 10 / F 50	C 30 / F 86
sorghum	10 / 50	30 / 86
peanut	13 / 55	31.7 / 87.78
cotton	15.56 / 60	37.78 / 100
soybean	7.78 / 46	26.11 / 79
wheat	0 / 32	35 / 95

equations. A grass reference PET equation was chosen because it could, perhaps, be explained and visualized easier by our expected urban clientele. In fact, the Potter and Randall County Master Gardener Program now routinely uses the PET data to compute lawn grass water use for the Water Smart project in Amarillo/Canyon. The PET values for bluegrass, buffalo, and Bermuda grass are computed and published daily (May through November) in the Amarillo Globe News on page 2 with all the other weather news data.

Actual water use rates for the NP-PET crops are computed as

$$ET = Kc * PET$$

where ET is the estimated actual crop water use rate (in./day), Kc is the mean crop coefficient, and PET is the daily reference ET (in./day). The NP-PET network uses mean Kc values because our water use estimates are more "regionally generic" and not specifically for any one farm or field. Crop consultants and farm advisors can use the PET data or the actual weather data (see Table 2) in more detailed crop growth or ET models that can provide a better representation of exact farm and even individual field conditions. The NP-PET Kc values are developed from research at Bushland by the ARS ET team. The mean Kc values used in our programs better represent sprinkler (center pivot) irrigation practices with frequent irrigations (3-4 day intervals) than graded furrow (less frequent irrigations), but that should not create a significant difference. The crop development models relate crop growth stages to accumulated GDDs and the Kc values are related to the crop growth stages too by the accumulated GDDs. The NP-PET simple crop development models, Kc values, and PET methods are all being updated as new and improved data and procedures are developed.

USING THE NP-PET INFORMATION

To be able to use this information, considerable training and/or continuing education is needed. TAEX, TAMU, and WTAMU all extensively use the PET data in training and education. Local data on field rainfall and irrigation are needed at a minimum. Some critical data include the field system capacity (flow rate per unit

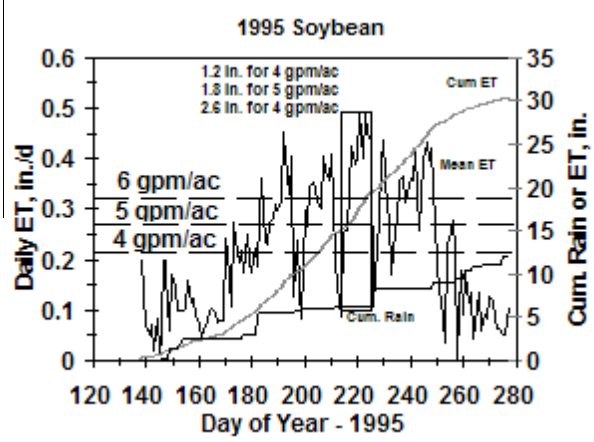

Figure 2. Example illustration for the 1995 soybean daily ET and accumulated rain and ET for the season at Bushland. The dashed horizontal lines are irrigation capacity (gpm/ac) on the ET scale of in./day .

area) and/or the gross flow rate and an estimate of "application efficiency." Crop data on sowing date and hybrid types are needed as well. It is probably better to match your actual crop development status (in your field) with the fax sheet crop growth stage rather than relying solely on your sowing date.

Figure 2 gives an example for a 1995 soybean crop. Only three significant rain events occurred for the whole season from planting through August although many smaller and less significant rains occurred. The difference between the rain and ET come from 1) previously stored soil water or 2) irrigations. Irrigations should be applied when the ET rates are lower to keep the soil water in the root zone replenished and so a "relatively full" soil profile can be available when the crop growth reaches the critical periods like flowering and pod development for soybean. Focus on the 3 weeks in August within the box. If 6 gpm/ac irrigation capacity was available, a deficit of 1.2 in. would develop during this period. And if the irrigation capacity was reduced to 5 or 4 gpm/ac, then the deficit would increase to 1.8 in. and 2.6 in., respectively, during this one period. These deficits would have to be drawn from soil water or the crop would suffer water deficits and reduced yields. This simple example illustrates the critical importance that maintaining an irrigation capacity that can meet the majority of the ET demand so some flexibility in irrigation management can be achieved. If a marginal irrigation capacity is used, then a producer is always trying to catch up and needing timely rains to "hopefully" achieve an acceptable yield. By knowing the crop ET needs, growers are in a much better position to make those critical strategic irrigation decisions and determine their acceptable levels of risk.

NP-PET TEAM

No one individual or agency is solely responsible for the NP-PET network, but it takes a collaborative effort and support (financial and physical) from many agencies and people. Grants from the Corn Producers Board, Texas Wheat Producers Board, High Plains Underground Water Conservation District No. 1, North Plains Ground Water Conservation District No. 2, Panhandle Ground Water Conservation District No. 3, Collingsworth County Underground Water Conservation District, and from other agencies (USDA-NRCS) and individual producer groups were instrumental in providing the resources to enable the Texas Agricultural Experiment Station, Texas Agricultural Extension Service, and USDA-Agricultural Research team at Amarillo/Bushland/Etter to develop and operate the NP-PET network. The multi-agency personnel involved with the NP-PET network are the following:

Texas Agricultural Experiment Station
- Thomas Marek
- Dr. Gerald Michels, Jr.

Texas Agricultural Extension Service
- Leon New
- Dr. Brent Bean

USDA-Agricultural Research Service
- Dr. Terry Howell
- Dr. Steve Evett
- Don Dusek

At Bushland, all the Water Management Research Unit personnel are involved with developing the ET data upon which the NP-PET network is based. Dr. Arland Schneider, Dr. Judy Tolk, Karen Copeland, Jim Cresap, Keith Brock, and Brice Ruthardt contribute directly to the ET research, facilities, ET data collection, and data processing.

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EXPLORING THE ANATOMY OF ET . . .

by Rick Todd

Far from being an alien concept, the Penman-Monteith (PM) combination equation is an elegant and useful approach which models crop water use by combining an aerodynamic description of water loss with the energy balance of a crop (Allen et al., 1989). It uses air temperature and humidity, wind speed, heat movement into the soil, and solar or net radiation to estimate evapotranspiration (ET). In addition to these, the resistances of the canopy and atmosphere to water vapor flux are important inputs to the PM equation.

The PM equation was adopted by the Food and Agriculture Organization (FAO, 1991) of the United Nations as the recommended method to calculate the reference ET of a hypothetical reference crop, which is then used with appropriate crop coefficients to estimate crop water use. Since its recommendation, many aspects of the revised FAO-PM approach have been investigated by researchers around the world.

The windy, semi-arid, advective environment of the southern High Plains of North America gives us an opportunity to test the PM equation under more extreme conditions. And, using the extensive data sets associated with the weighing lysimeters installed at the Conservation and Production Research Laboratory near Bushland, TX, we can take a detailed

look at key elements of the combination equation approach. Some of the questions we asked include:

- What is the behavior of the canopy resistances of alfalfa and grass? Can we distinguish between canopy stomatal resistance, which primarily reflects the integrated stomatal behavior of the crop canopy, and canopy surface resistance, which is also influenced by aerodynamic processes within the canopy and energy exchanges at the soil surface?

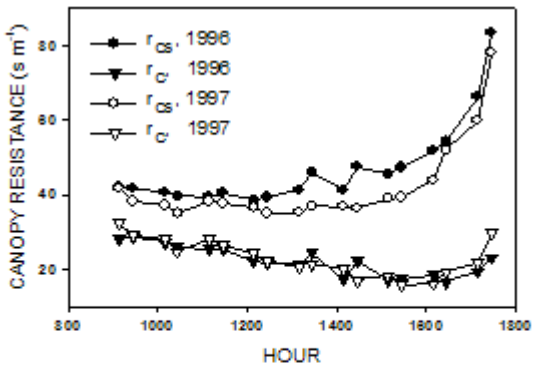

Figure 1. Mean hourly canopy stomatal resistance (r_{cs}) and canopy surface resistance (r_c) of alfalfa at Bushland, TX, 1996 and 1997.

- How coupled are our crops to the atmosphere, and how does that affect the sensitivity of ET to canopy resistance? How robust is the decoupling coefficient (McNaughton and Jarvis, 1983), and can decoupling theory, as an interpretation of the PM equation, accurately model ET?
- How accurate are other approaches to estimate ET, such as two-layer energy balance-combination models (Shuttleworth and Wallace, 1985), or mechanistic models (ENWATBAL, Evett and Lascano, 1993)?

Here are some preliminary answers.

We used a two-layer energy balance-combination model (Shuttleworth and Wallace, 1985) to calculate a canopy stomatal resistance (r_{cs}) and compared it with the canopy surface resistance (r_c) calculated from the revised FAO-PM equation (Fig. 1), using appropriate parameters for alfalfa (Allen et al., 1989). Days were selected when the alfalfa canopy was fully developed. Mean canopy height was 0.5 m both years. Leaf area index (LAI) averaged 4.0 m^2 m^{-2} in 1996 and 4.4 m^2 m^{-2} in 1997. Mean r_{cs} was 47 and 42 s m^{-1} in 1996 and 1997, respectively, and r_c averaged 23 s m^{-1} both years. In contrast, the recommended r_c of fully developed alfalfa used as a reference crop is about 45 s m^{-1}. Though not measured, part of the difference was because of evaporation from the soil surface. The PM equation integrates soil water evaporation together with canopy transpiration, but the two-layer model indicated that soil water evaporation was 13 to 18% of daytime alfalfa ET. The method of calculating the PM aerodynamic resistance also may have contributed to the discrepancy between r_{cs} and r_c.

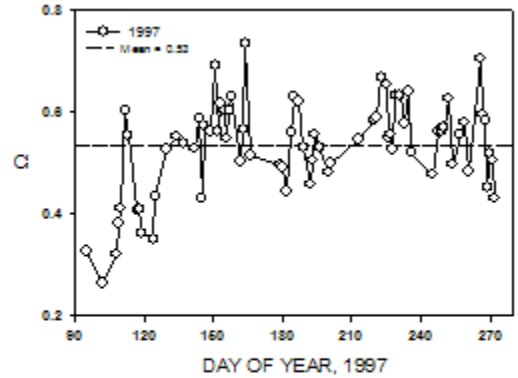

Figure 2. Mean daytime decoupling coefficient, Ω, for alfalfa at Bushland, TX, in 1997.

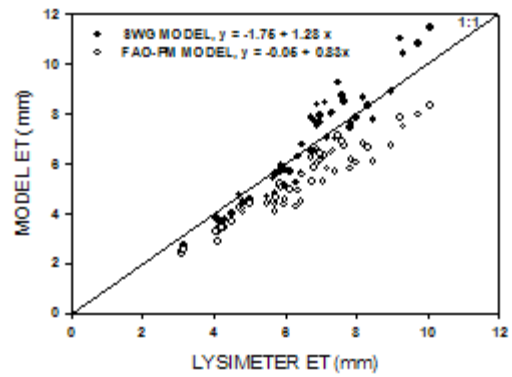

Figure 3. Mean daytime alfalfa ET measured by weighing lysimeter and estimated by the two-layer Shuttleworth-Wallace-Gurney model (SWG) or the FAO Penman-Monteith model (FAO-PM). Observations are days with a fully developed alfalfa canopy in 1996 and 1997.

The seasonal course of the decoupling coefficient, Ω, is illustrated in Fig. 2. Mean Ω was 0.58 in 1996 and 0.53 in 1997 (LAI>1). Values of Ω estimated with data from the Mediterranean region ranged from about 0.75 to 0.95 (Steduto et al., 1996). Lower Ω values mean that crops at Bushland are more coupled to the atmosphere, and that ET is more sensitive to canopy resistance and the saturation deficit of the atmosphere.

The FAO-PM equation consistently underestimated full canopy alfalfa ET (Fig. 3). Its underestimation was about the magnitude of the estimated evaporation from the soil surface. The two-layer model did slightly better, though it tended to overestimate alfalfa ET at higher rates. There was evidence of a positive response of r_{cs} to saturation deficit, especially in 1996. Inclusion of this effect in the canopy stomatal resistance submodel of the two-layer model may

improve estimation at the higher ET rates associated with high saturation deficits.

These preliminary findings point to several interesting areas of investigation as we look closely at the inner workings and varieties of the combination equation. We will extend our analysis to clipped grass, explore the implications of the decoupling coefficient and the effect of a higher reference height which is more independent of the crop, and investigate factors which influence canopy stomatal resistance, such as saturation deficit.

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TEXAS REGIONAL WATER PLANNING . . .

by Terry Howell

Senate Bill 1 (SB 1), the comprehensive water bill passed during the last state legislative session, required the Texas Water Development Board (TWDB) to designate regional water planning areas and initial coordinating bodies for each planning group. TWDB has designated 16 regional water planning areas and planning rules. Two areas, region A and region O, encompass the 42 counties of the Texas High Plains and specifically the Ogallala aquifer region. SB 1 and the TWDB rules give wide latitude to the regional water planning groups to develop a regional water plan for their areas. Then the TWDB will weave the regional plans into a new State Water Plan.

Each region's planning group is charged with developing a regional plan that identifies both short- and long-term water supply needs and recommending water management strategies to address these needs. The Texas drought of 1996 raised public awareness about the state's water problems and resulted in the SB 1 legislation. These plans will specifically prepare for drought conditions to ensure that sufficient water will be available at a reasonable cost to safeguard public health, safety, and welfare; to further economic development; and to protect irrigation and the natural resources within the region. Assigned deadlines for the regional plans are September 1, 2000, with the comprehensive State Water Plan to be due one year later. After 2001 and the approved plan has been developed, TWDB can only provide financial assistance to projects that meet needs consistent with the approved regional plan or the approved State Water Plan. Also after 2001, only water right permits for municipal purposes consistent with the approved plans can be issued by the Texas Natural Resource Conservation Commission.

The Region A planning group adopted the name "Panhandle Water Planning Group" (PWPG), and this region

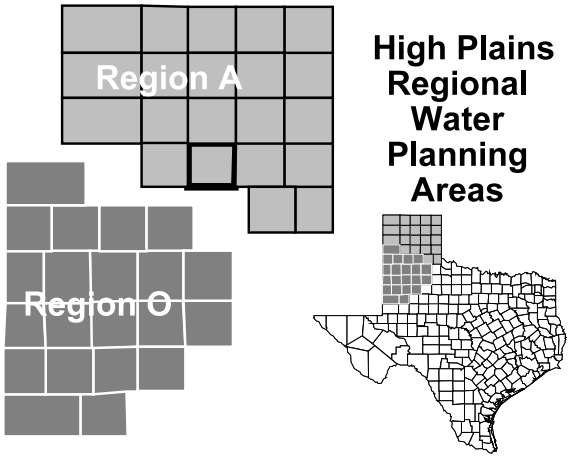

Figure 1. Map illustrating the Texas High Plains regional water planning regions.

encompasses the upper 21 counties in the Texas Panhandle (Fig. 1). It is chaired by C.E. Williams, manager of the Panhandle Ground Water Conservation District. Dr. R. Nolan Clark, USDA-ARS at Bushland, is a member of the PWPG representing the environmental stake holders. Other officers of the PWPG are Judge Vernon Cook (Roberts County) as vice-chair, Dan Coffey (City of Amarillo) as secretary, John C. Williams (Canadian River Municipal Water Authority) and Dr. Nolan Clark (ARS-Bushland) representing members at large. Feel free to contact **Dr. Clark at (806) 356-5734 or rnclark@ag.gov (e-mail)** for more information regarding PWPG activities.

The Region O planning group met on March 24th and adopted the name "Llano Estacado Regional Water Planning Group" (LERWPG), and this region encompasses 21 counties of the Texas Southern High Plains (Fig. 1). The LERWPG is chaired by A. Wayne Wyatt, manager of the High Plains

Underground Water Conservation District No. 1. Other officers are Lee Arrington (South Plains Water District) as vice-chair and Ches Carthel (City of Plainview) as secretary. The LERWPG will meet at least quarterly on the third Thursday in April, July, October, and January, but more frequent meetings may be necessary between now and August 1 to complete the scope of work. Contact the **High Plains Water District office (806) 762-0181 or hpwd@worldnet.att.net (e-mail)** for additional information about the LERWPG activities.

TWDB maintains a web site at http://www.twdb.state.tx.us/www/twdb/sb1_hp.html with copies of the rules, maps of regional water planning areas, and initial coordinating body membership lists. They can be reached at TWDB at P.O. Box 13231, Austin, TX 78711-3231 or by contacting Diane Burr at (512) 475-2057 or dburr@twdb.state.tx.us (e-mail).

SB 1 empowers each region to develop plans specifically for that region based upon that region's needs. Each region is independent and not bound by any state-wide constraints or preconceived objectives. But the TWDB is strictly overseeing (but not directing or leading) and making sure each water planning group abides by its rules. It is imperative that everyone get involved in this planning effort which is a unique opportunity to impact public policy from a grass-roots level.

Newsletter . . .

The *Wetting Front* newsletter is designed to foster technology transfer from our research to industry and to agricultural producers in the Southern High Plains and to improve communications with our stakeholders and partners. For actions or corrections to our mailing list, contact Mrs. Carole Perryman by fax [(806) 356-5750], e-mail (cperryma@ag.gov), phone [(806) 356-5749], or mail [USDA-ARS, P.O. Drawer 10, Bushland, TX 79012]. The *Wetting Front* can also be found on the WWW at http://www.cprl.ars.usda.gov/wmru/wfront.htm. Any suggestions or comments are welcome too.

Awards and Recognitions . . .

Terry Howell received an *Outstanding Performance Award* and **Steve Evett** and **Arland Schneider** received *Superior Performance Awards* for FY-97. **Keith Brock** received an *Extra Effort Award* for his early completion of 1997 research yield data processing.

Terry Howell was notified of his selection to receive the **American Society of Civil Engineers Royce J. Tipton Award for 1998** that will be presented at the ASCE Water Resources Engineering Conference August 3-7, 1998 in Memphis, TN.

Internet News . . .

The Southern Plains Area Office web site is now on-line at http://www.spa.ars.usda.gov/

The NP-PET web site was moved an upgraded at http://amarillo2.tamu.edu/nppet/petnet1.htm

TAMU Agricultural Engineering web sites of interest:
http://irrigation.tamu.edu/ TAEX-School of Irrigation
http://texaset.tamu.edu/ Texas ET Network
http://agen.tamu.edu/ Agricultural Engineering *(Updated)*

Alberta Agriculture (excellent irrigation resources) at http://www.agric.gov.ab.ca/

Grant News . . .

Work is progressing nicely on the ATUT project with Egypt. Dr. Evett is installing equipment (if they find it in time; *where is Indiana Jones when you need him?*) during his trip to Egypt from April 24th to May 8th. Dr. Rick Todd is working on the ATUT project (funded by USDA-FAS through USAID).

Upcoming Events, Meetings, and Presentations . . .

UPCOMING EVENTS

1998 FIELD DAYS

★ May 21 – Wheat Field Day at Etter
Theme: Will precision agriculture work for me?

★ August 12 – Bushland Crops Field Day
Theme: 50 Years of Irrigation Research for the Texas High Plains
8:30 a.m. Registration and Exhibits Open
10:00 a.m. Field Tours
(irrigation, dryland, crop breeding, precision ag., etc.)
12:10 p.m. Lunch (catered)
1:00 p.m. Keynote Address
History and Contributions to Irrigation from Bushland
Dr. Allen Dedrick, Assoc. Deputy Adm., USDA-ARS
1:30 p.m. Precision Irrigation
Dr. Dale Heermann, ARS Ft. Collins, CO
1:50 p.m. SDI
Dr. Freddie Lamm, KSU Colby, KS

★ Check the CPRL Web page for updates and more information on the field days at
http://www.cprl.ars.usda.gov/news.htm.

UPCOMING MEETINGS & PRESENTATIONS

★ **May 26-29, 1998**
ARS Irrigation & Drainage Workshop, *A New Research Agenda: Irrigation and Drainage in Harmony with the Environment*, Ft. Collins, CO.

★ **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.

★ **July 12-16, 1998**
American Society of Agricultural Engineers Meeting Orlando, FL.
Latent Heat Flux of Alfalfa Measured by Weighing Lysimeters and Bowen Ratio Energy Balance . . . . . R.W. Todd, S.R. Evett, & T.A. Howell
Evapotranspiration of Irrigated Alfalfa in a Semi-Arid Environment . . . . . S.R. Evett, T.A. Howell, R.W. Todd,

. . . . . A.D. Schneider, & J.A. Tolk
Evapotranspiration of Irrigated Fescue Grass in a Semi-Arid Environment
. . . . . T.A. Howell, S.R. Evett, A.D. Schneider, & J.A. Tolk

★ **Aug. 3-7, 1998**

ASCE International Water Resources Engineering Conference & Groundwater Management Symposium Memphis, TN.

★ **Oct. 18-22, 1998**

ASA/SSA/CSA Meetings, Baltimore, MD.

Soil Type Effects on Crop Soil Water Extraction and Water Use Efficiency of Corn in the U.S. Southern High Plains . . . . . T.A. Howell & J.A. Tolk
Canopy Surface Stomatal Resistance of Alfalfa in a Semi-Arid Environment
. . . . . R.W. Todd, S.R. Evett, T.A. Howell, & J.A. Tolk
Comparative Field Calibration of Capacitance Sensors and Neutron Scattering Gauges
. . . . . S.R. Evett, R.L. Baumhardt, & R.J. Lascano

★ **Nov. 1-3, 1998**

Irrigation Assoc. Expo, San Diego, CA.

RECENT PRESENTATIONS

Using the PET Network to Improve Irrigation Water Management on March 11, 1998 to the Great Plains Symposium
. . . . . T.A. Howell

Technology Transfer News . . .

Customer/Clientele Needs:

High Plains Irrigation Conference, Amarillo, on Jan. 7, 1998.

CREET (Cooperative Research, Education, and Extension Triangle) Interpretation Event, Amarillo Research and Extension Center, April 16, 1998.

Media Contacts:

none to report

Visitors:

Tom Spofford (USDA-NRCS, Portland, OR), Jerry Walker (USDA-NRCS, Temple, TX), and Dale Heermann (USDA-ARS, Ft. Collins, CO) on Dec. 3-5, 1997.
3 visitors from Mongolia on Feb. 4, 1998.
Dr. Freddie Lamm (KSU-Colby) and Dr. Todd Trooien (KSU-Garden City) on March 9, 1998.
Dr. Carlos Cerri (San Paulo, Brazil) on March 26, 1998.
30+ visitors from Leadership Amarillo on March 26, 1998.
Dr. Dick Amerman, USDA-ARS-NPS, on April 6, 1998.
Dr. Ron Korcak, USDA-ARS-SPA, on April 14, 1998.
5 visitors from China on April 20-21, 1998.

Seminars/Producer/Clientele Meeting Presentations:

Dr. Arland Schneider presented *Irrigation Pump Design* to the Yoakum County Conservation Seminar, Plains, TX, Dec. 16. 1997.

Dr. Arland Schneider presented *Drip Irrigation of Row Crops* to the South Texas Irrigation Conference in Hondo, TX, on Jan. 13, 1998.

Dr. Terry A. Howell presented the seminar *Texas High Plains Irrigation and the State's Virtual Irrigation Education Program* to the Agricultural Engineering Department at Texas A&M University, College Station, TX, on April 1, 1998.

Popular Magazine Articles:

Probing Plants' Water Needs, Agricultural Research, Jan. 1998, Vol. 46 (1):7.

Group Seeks Recognition for Graham, Hoeme, Southwest Farm Press, Jan. 15, 1998, p. 4 (commentary).

New Terms Come to Sprinkler Irrigation, Southwest Farm Press, Feb, 6, 1998, p. 16.

Three Crops Compared in Irrigation Tests, Southwest Farm Press, Feb. 6, 1998, p. 20, 28.

CRADA/Inter-Agency Collaboration:

Dr. Steve Evett is seeking a CRADA partner for developing a concept for a non-contact, non-wire irrigation controller-sensor concept. **Call Dr. Evett at (806) 356-5775 or send an e-mail to srevett@ag.gov**.

Other Technology Transfer Activities:

Dr. Arland Schneider participated in the Rotary International Mentor Program for High School Seniors on March 26, 1998.

Recent Publications *(since Nov. 1997)* . . .

1997. Allen, R. R., and Musick, J. T. Permanent ridge-till sorghum with furrow irrigation. Appl. Engr. Agric. 13(6):731-736.

1997. Burt, C. M., Clemmens, A. J., Strelkoff, T. S., Solomon, K. H., Bliesner, R. D., Hardy, L. A., Howell, T. A., and Eisenhauer, D. E. Irrigation performance measures: Efficiency and uniformity. J. Irrig. Drain. Engr. 123(6):423-442.

1997. Tolk, J. A., Howell, T. A., Steiner, J. L., and Evett, S. R. Grain sorghum growth, water use, and yield in contrasting soils. Agric. Water Mgmt. 35:29-42.

1998. Evett, S. R. Coaxial multiplexer for time domain reflectometry measurement of soil water content and bulk electrical conductivity. Trans. ASAE 41(2) (accepted; in press).

1998. Howell, T. A., Tolk, J. A., Schneider, A. D., and Evett, S. R. Water use, yield, and water use efficiency of two different maturity corn hybrids. Agron. J. 90:3-9.

1998. Tolk, J. A., Howell T. A., and Evett, S. R. Evapotranspiration and yield of corn grown in three High Plains soils. Agron. J. (accepted; in press).

1998. Howell, T.A. Using the PET network to improve irrigation water management. *In* Proceedings of the Great Plains Symposium 1998: the Ogallala Aquifer Determining the Value of Water, the Great Plains Foundation, Overland Park, KS (accepted; in press).

1998. Schneider, A. D., Howell, T. A., Moustafa, A. T. A., Evett, S. R., and Abou-Zied, W. A simplified weighing lysimeter for monolithic or reconstructed soils. Appl. Engr. Agric. 14(3) (accepted; in press).

Blamestorming: sitting around discussing why a project failed and who was responsible.

Personnel News . . .

Lorie Boudra resigned from ARS on Nov. 21, 1997, and is now with Asgrow Seed Co. in Plainview, TX.

Authur B. (Rob) Robertson III was hired as a Biological Technician (soils) and will be starting on May 11th. Rob worked here previously for Dr. Steiner on residue decomposition research.

Jack Musick will not be able to complete his current "collaborator" appointment due to continuing health problems. His address is 5502 Floyd in Amarillo, TX 79106 [home phone is (806) 352-7549].

Keith Brock and **Brice Ruthardt** were promoted. **Congratulations for your outstanding work!**

Don Dusek attended Windows 95 and network training in Amarillo on Jan. 29-30, 1998.

Jim Cresap, **Keith Brock**, and **Brice Ruthardt** attended Campbell Scientific software and programming training on data loggers in Amarillo on Feb. 17-20, 1998, that was provided by CSI and jointly sponsored by the Conservation and Production Research Laboratory and the Texas A&M University Amarillo Research and Extension Center.

The Water Management Research Unit depends heavily on our summer employees. In 1998, we are looking forward to the return of **Kyle Schniederjan** (who is graduating from Randall High School and had a terrific season playing football for the Randall Raiders) and ***Sara Ledbetter*** (who attended Amarillo College and worked for Dr. Clark during the school year). ***Gary Marek*** (attending WTAMU) returns to full-time summer work, but Gary worked during the school year (part-time) too. ***Kevin von Netzer*** (who is also attending WTAMU) will be leaving us for an environmental internship for Phillips Petroleum in Borger this summer. Kevin also worked part-time during the school year. **Good luck, Kevin, and welcome back to Kyle and Sara!**

Terry Howell was nominated to run for election for the American Society of Agronomy A-3 Chair. He was also appointed to chair an ASA/CSSA/SSSA Feasibility Committee to consider an update to Agronomy Monograph No. 30 *Irrigation of Agricultural Crops*.

NEW VOCABULARY TERMS FOR THE 1990s

Percussive Maintenance: the fine art of whacking the dickens out of an electronic device to get it to work again.

Seagull Manager: one who flies in, makes a lot of noise, craps on everything, and then leaves.
... source *Washington Post*

Water Management Research Unit

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

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