Report on Performance of ET Based Irrigation Controller

Prepared for the Cities of:
Boulder,
Greeley, and
Longmont, Colorado

Analysis of Operation of WeatherTRAK™ Controller in Field Conditions During 2002

April 23, 2003

Submitted by: ***Aquacraft, Inc.*** *Water Engineering and Management*
2709 Pine Street
Boulder, CO 80302
(303) 786-9691
(303) 786-8337 (fax)
www.aquacraft.com

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EXECUTIVE SUMMARY

The WeatherTRAK™ ET based irrigation controller consists of an irrigation controller unit linked to a network of local weather stations via pager technology. During this study the ET_o data were downloaded by Aquacraft and then faxed to HydroPoint Data Systems in California. They then sent a signal to the individual controllers on a periodic basis and the controller adjusted the irrigation schedule, as appropriate, in order to insure the correct applications for the specific plant types in each zone of the system. In normal operations the data collection will be automated and future modifications will allow it to net out rainfall as well.

Between 2000 and 2002, the cities of Boulder, Longmont, and Greeley, Colorado conducted a three year field study of the performance of the WeatherTRAK system in actual field use. There were 10 sites in the original study group; over the course of the study some dropped out and others were added. The study had two main goals: To determine whether the controllers functioned reliably, and whether the ET_o control system could accurately match irrigation applications against ET_o. Incidentally, we were able to determine how the system could use its communications facilities to send rain interrupts, percent reductions in applications and deal with the drought restrictions imposed during 2002.

In 2002 the Colorado Front Range was in its third consecutive year of drought. With the 2002 year being the most extreme year of the drought to date, all the cities in the study were on voluntary or mandatory watering restrictions during most of the irrigation season. In cases where the city required reduction of irrigation to a specific application target, either as a depth or percent of ET_o, the WeatherTRAK was able to respond with no field adjustments. In the case where irrigation was limited to specific irrigation days it was necessary to reprogram the controller, but it was still able to water using ET_o data. Figure 1 shows the results for the 7 full season accounts during 2002. The first bar in this graph show the historical irrigation application for each customer, the second shows the application allowed by the WeatherTRAK™, and the third shows the ET_o. Of note is the fact that that five of the seven customers were historical under-irrigators. The WeatherTRAK™ was capable of watering less than ET_o and meeting the historical operations in most cases. In only one site (SVS) did it apply more than the ET_o, and we know at that site the occupants used the percent adjustment feature to provide a wetter environment, but even with their adjustments their application were still drastically lower than their historical pattern.

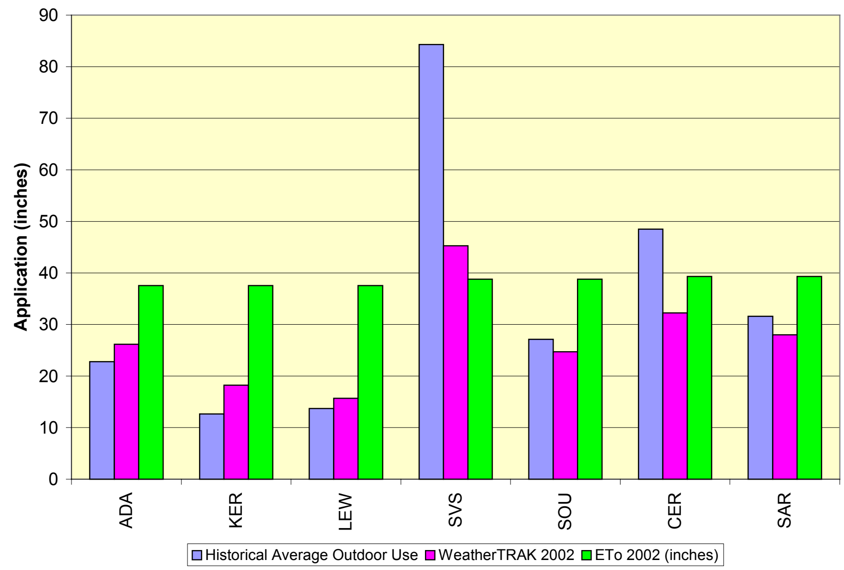


Figure 1: Summary of irrigation applications during 2002

Other important findings of the 2002 study were:

- As a group, in 2002, the nine active sites applied 66% of the ET_o. The seven sites that were in operation the entire irrigation season applied 27.2 inches of water to their landscapes or 71% of ET_o.
- As a group, the seven sites saved an average of 35,000 gal of water per site compared to their historical use.
- If only the four participants who saved significant amounts of water were included, their average annual savings were 64,000 gallons per site. This shows the greater savings potential if the program focuses on high users.
- The four participants that saved water with the WeatherTRAK™ system also saved an average of $190 per year in water charges. This was based on the weighted average water rates of $2.40 per kgal in effect in the three cities during 2002.
- Some of the volunteer participants in the study were historically under irrigating. Consequently, it was not possible for the system to save them water. But, the WeatherTRAK system matched their historical performance. Most importantly, the system delivered the appropriate ET_o information to the controllers with a high degree of reliability and with little or no user programming.
- The WeatherTRAK irrigation controller was able to respond to the different drought restrictions imposed by each individual city.

As was the case during 2001 the WeatherTRAK ET controller system operated with a high degree of reliability. The consultants made no routine visits to any of the sites to check them, so they were operating on their own. Only a single problem was reported that required a field visit. Also, the system for obtaining and transmitting the ET_o data to the units in the field worked well. The field units successfully converted the ET_o data into irrigation programs that matched applications to ET_o based requirements. Finally, the system showed that with some modifications it could meet the locally imposed drought restrictions. However, it worked best in systems that set application targets as a percentage of ET_o rather than requiring specific scheduling of irrigation. In these cases the systems were able to respond precisely to the requests with no field modifications.

INTRODUCTION

In the spring of 2000 the cities of Boulder, Longmont, and Greeley, Colorado began a small pilot study of the reliability and effectiveness of the WeatherTRAK ET signal controller. The purpose of this study was to document the performance of the system in actual field conditions at homes of volunteer customers. Due to delays in receiving the controllers, little data were collected during the 2000 irrigation season and the test was extended through the 2001 and 2002 seasons. A total of ten customers had a WeatherTRAK unit installed by the middle of June 2001, and water use data were collected throughout the 2001 irrigation season. For the 2002 irrigation season nine customers participated in the study. During the 2002 irrigation season one of the study participants moved and dropped out of the study and one business participant was added. Historical analysis of the 2002 irrigation year is based on a sample of seven participants where the WeatherTRAK irrigation controller was in operation the entire season. When possible the data from the nine participants was utilized. The purpose of this report is to provide the results of this study.

STUDY DESCRIPTION

Participants

In 2000 three Colorado cities: Boulder, Greeley and Longmont began the WeatherTRAK irrigation controller study. In 2002 seven of the nine participants were single family residential customers. The St. Vrain Valley School District administration building and Boulder Public Radio, KGNU, were the institutional customers in the study. The City of Boulder had three residential customers and an institutional customer in the study; Greeley had three residential customers and Longmont had one residential customer and an institutional customer. A map showing the three study cities is shown in Figure 2.

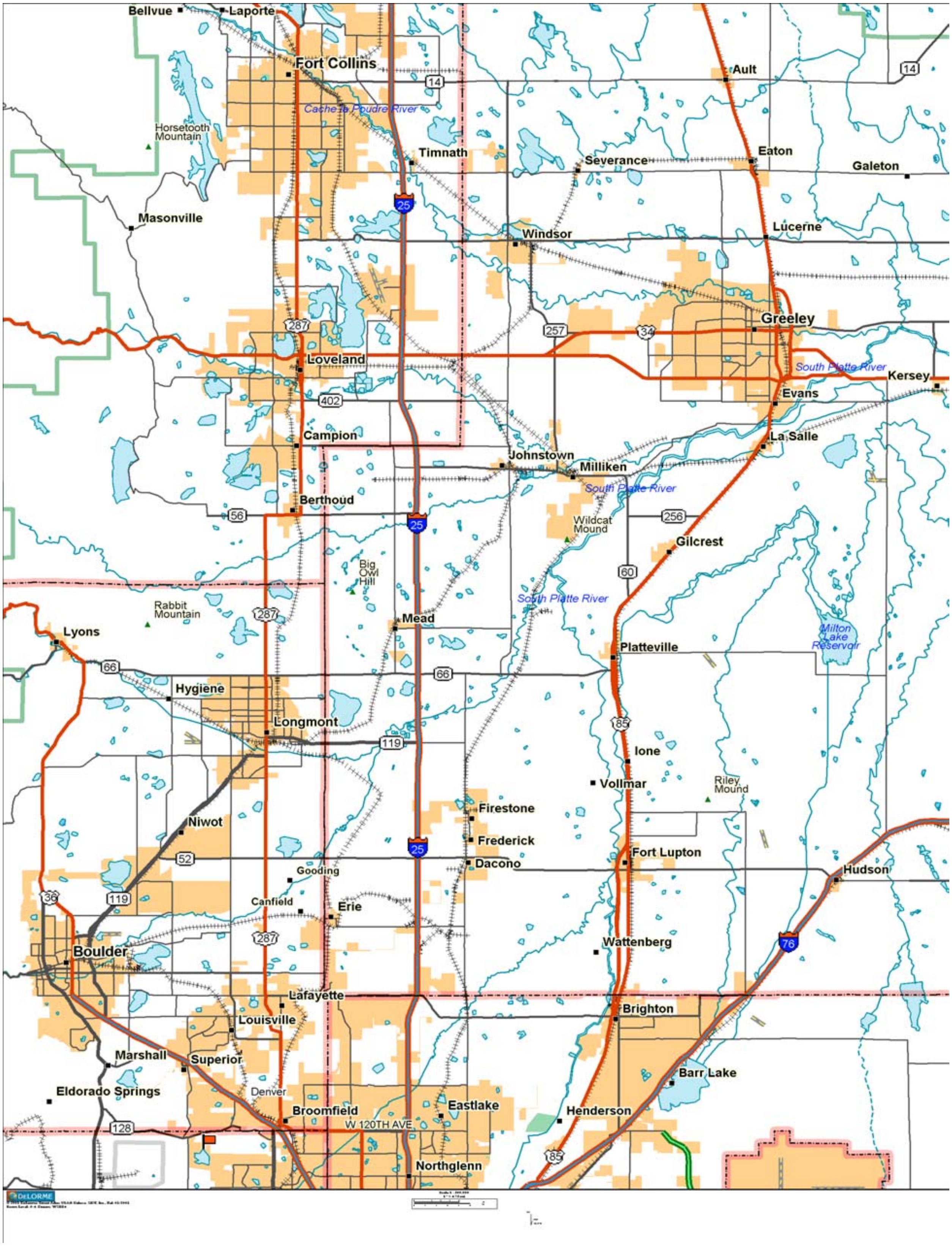


Figure 2: Location of study sites

Overview of WeatherTRAK™ System

The WeatherTRAK system consists of three elements: a network of weather stations that can be remotely down-loaded, a central data processor and communications hub, and the WeatherTRAK field controllers (ET_o signal controllers). These controllers are capable of receiving evapotranspiration (ET_o) data via satellite. The network utilizes pager-like technology to send a signal pulse that can be broadcast to any number of WeatherTRAK controllers. Each controller can be addressed in several ways. All controllers in the same utility, or linked to the same weather station, or zip code can be sent the same message. Specific messages can also be sent to individual controllers by their serial number. The information typically transmitted to the field units in this study was the ET_o for the past 7 days, which was used by the controller to develop an irrigation schedule for the current week. The WeatherTRAK controllers have crop coefficients built in to modify the ET_o for the predominant vegetation in each irrigation zone. In this way, the controllers are continuously replenishing the soil moisture depletion from the previous time period in current time. In addition, signals can be sent out to initiate a rain pause, to apply a percent increase or decrease in applications, or to update the date and time information on the controller.

The Northern Colorado Water Conservancy District (NCWCD) operates a network of remote, solar powered, automated weather stations throughout its service area. The weather station network is currently composed of 16 stations, 10 in alfalfa fields and six on urban turf grass. The urban turf grass stations are located in large, well-irrigated areas. Stations are approximately 25 to 30 miles apart to provide the best practical coverage for the District's 1.5 million-acre service area. The three stations used for the study were turf grass sites and each was located in one of the participating cities (Boulder, Greeley, and Longmont).

Each station recorded air temperature, relative humidity, wind speed and solar radiation. The data were used daily to calculate standardized reference evapotranspiration (ET_o) using the 2000 standardized ASCE Penman-Monteith equation for turf grass. Stations automatically transmitted data via modem and cell phone twice daily to district headquarters. This ET_o information was downloaded by Aquacraft from the NCWCD's web pages and then faxed to the signal processing company, HydroPoint Data Systems[1]. HydroPoint Data Systems, located in Petaluma, California, designed and maintains the software, builds the controllers and operates the network used to operate the WeatherTRAK system. In normal operations the data acquisition is an automated process, and in the near future the system will include rainfall data from Nexrad stations, and net this out of the ET_o.

The Colorado Front Range region has numerous microclimates that can dramatically affect the calculation of ET_o from one city to another. To account for this, Aquacraft created a distinct ET_o zone for each city in the study and there was at least one weather station in each ET_o zone. All WeatherTRAK controllers were coded to receive signals for the appropriate ET_o zone. This allowed individual WeatherTRAK irrigation controllers to receive an ET_o signal that closely represented the specific local microclimate.

[1] Formerly known as Network Services, Inc.

The specific ET_o data used to adjust the ET_o signals for the WeatherTRAK irrigation controllers were faxed to Petaluma initially on a tri-weekly basis. Tri-weekly signals were sent from April 1 to Oct 31, 2002. The ET_o signals were transmitted three days a week, on Monday, Wednesday and Friday. If local weather conditions changed dramatically between these periods, a signal was sent, adjusting the ET_o or initializing the rain pause feature of the WeatherTRAK irrigation controller.

Irrigation Study Sites

Table 1 shows the locations and installation dates for all nine of the WeatherTRAK controllers that were active during the 2002 irrigation season. The KGNU site was installed at the end of 2001, but the landscaping there was not completed until the beginning of 2002.

Over the course of the 2002 irrigation season the water use at each the nine sites was tracked so that the application rate of the system as controlled by the WeatherTRAK units could be compared to the ET_o. This comparison is displayed in Figure 3, which shows applications as a percentage of ET_o.

Table 1: Irrigated area and landscape

Site #	City	Weather TRAK Install Date	# of Irrigation Zones	Approximate Areas		
				Total Landscape Area (sf)	Cool Season Grass (sf)	Shrubs, Trees Flowers and Garden (sf)
ADA	Boulder	6/5/01	5	4,500	3,825	675
KER	Boulder	9/12/00	6	8,230	4,527	3,704
LEW	Boulder	8/7/00	6	5,860	4,395	1,465
CER	Greeley	9/11/00	7	4,000	3,800	200
SAR	Greeley	9/18/00	10	13,000	9,750	3,250
SOU	Longmont	04/27/01	9	17,500	10,500	7,000
SVS	Longmont	05/11/01	7	6,665	5,665	1,000
AND	Greeley	4/27/01	7	11,000	6,050	4,950
KGNU	Boulder	10/01/01	10	6,990	0	6,990
Total				**77,745**	**48,512**	**29,233**

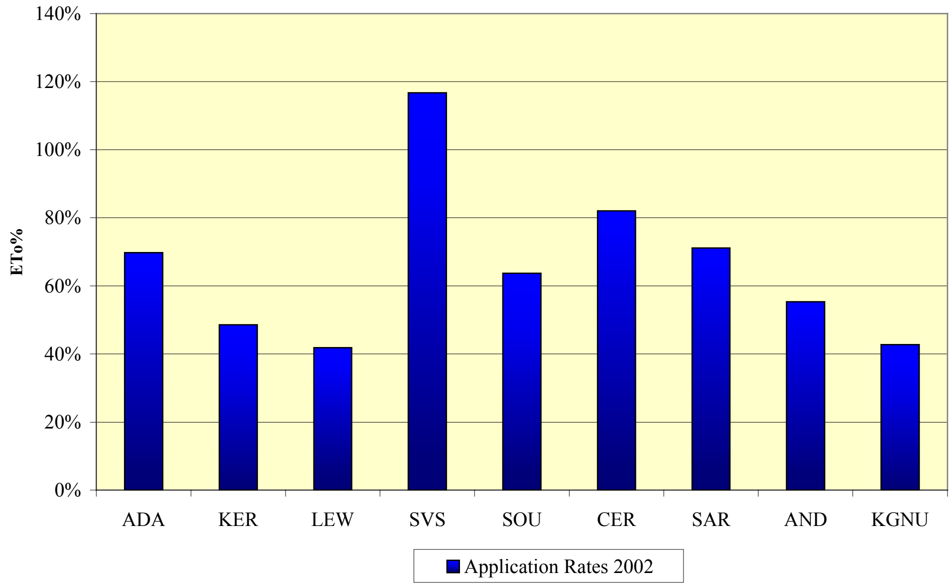


Figure 3: Application rate at nine WeatherTRAK sites as percent of ETo

Irrigated Area and Historical Water Use

The 9 study participants had an average irrigated area of 8,638 square feet (sf). The maximum irrigated area in the study was 17,500 sf and the minimum irrigated area was 4,000 sf. The total irrigated area for the nine study sites was 77,745 sf and of this irrigated area approximately 48,512 sf or 62% percent was cool season grass and 29,233 sf or 38% percent was shrubs, trees, flowers, low to moderate water use plants and gardens. Table 1 shows the information on the landscaped areas for each of the 9 sites.

The historical water use and application rate data for the sites are shown in Table 2. It is important to note that this table shows that many of the participants in this study were irrigating well below ET_o *before* the installation of the WeatherTRAK controller. In fact, while the average application rate was 99% of ET_o, three of the nine sites were applying significantly less than ET_o. The 95% confidence interval of the data was 20% so the true average could lie anywhere between 79% and 119% of ET_o. The wide range in historical applications is shown graphically in Figure 4 which is a histogram showing the number of sites falling into 10% bins ranging from 30% to 250% of ET_o.

Table 2: Historical irrigation application rates for study sites

Site	City	Irrigated Area (sf)	Historical Outdoor Use		
			kgal	Historical (inches)	Percent of ET_o
ADA	Boulder	4,500	64	22.8	64%
KER	Boulder	8,230	65	12.7	35%
LEW	Boulder	5,861	50	13.7	38%
SVS	Longmont	6,665	350	84.3	238%
SOU	Longmont	17,500	296	27.1	77%
CER	Greeley	4,000	121	48.5	145%
SAR	Greeley	13,000	256	31.6	95%
AND	Greeley	11,000	220	32.1	96%
KGNU	Boulder	6990	New Acct.		
Average (±95%Conf. Int.)					**99% ± 20%**

It is fairly typical for volunteers in water efficiency studies to be people who are already concerned about irrigation and efficient use of water. It is not surprising then that so many of these people were efficient irrigators to begin with. On the other hand, some of the persons who had higher application rates were requested to join the study, so in a sense they could be called conscripts, and their motivation may have been mainly to please the utility rather than a desire to take advantage of this technology.

The exact attitudes and motivations of the participants, while important, were not a critical element for this study. The primary goal was to determine whether or not the technology *works*. From this perspective, then, the real critical elements were:

- To observe how the WeatherTRAK units performed with the citys' different drought management water restrictions.
- To measure the actual application rate of the WeatherTRAK controller and to compare this to the ET_o requirement.

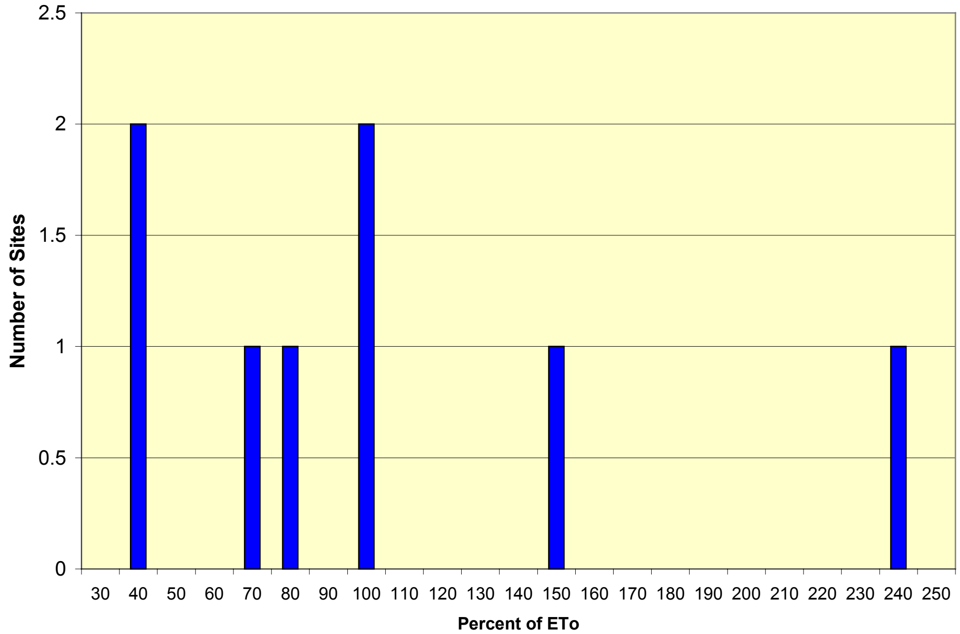


Figure 4: Historical irrigation applications of eight sites as percent of ET_o

RESULTS

Comparison of Irrigation Applications

Evapotranspiration (ET_o) gives a measurement of the amount of water (in inches) required to replace evaporation and transpiration for maximum plant growth. The reference ET_o is for 12 cm (4.7 inches) high, cool season turf grass. ET_o is calculated by measuring the energy from various sources that impact plant growth. These energy sources are solar radiation, wind, and air temperature as moderated by relative humidity. Standard instruments on weather stations measure these parameters, and the energy equation converts them into inches of evapotranspiration. ET_o includes rainfall only indirectly through its effect on relative humidity. It also does not include water requirements for flushing salts from the soil and irrigation system inefficiencies.

During the primary irrigation season, from April through October, for the years 1998-2000, the average ET_o for Boulder, Longmont, and Greeley was 34.4 inches. In 2002 the average ET_o for Boulder, Longmont, and Greeley was 38.5 inches. As shown in Table 2, during the 1998-2000 irrigation seasons, the participants averaged 34.4 inches of irrigation application, while, as shown in Table 3, in 2002 the application rates for the 7 sites dropped to 27.2 inches, a reduction of 21%.

Results varied considerably from site to site as are shown in Figure 5, but it is evident that the 2002 application rates were closer to the ET_o values than were the historical application rates. In addition, it can be seen that those customers who historically over-irrigated tended to make adjustments to the WeatherTRAK that increased their application rate and those that were under-irrigators made the opposite changes. As shown in Table 3 the post WeatherTRAK applications were 71% of ETo with a margin of error of ± 23%.

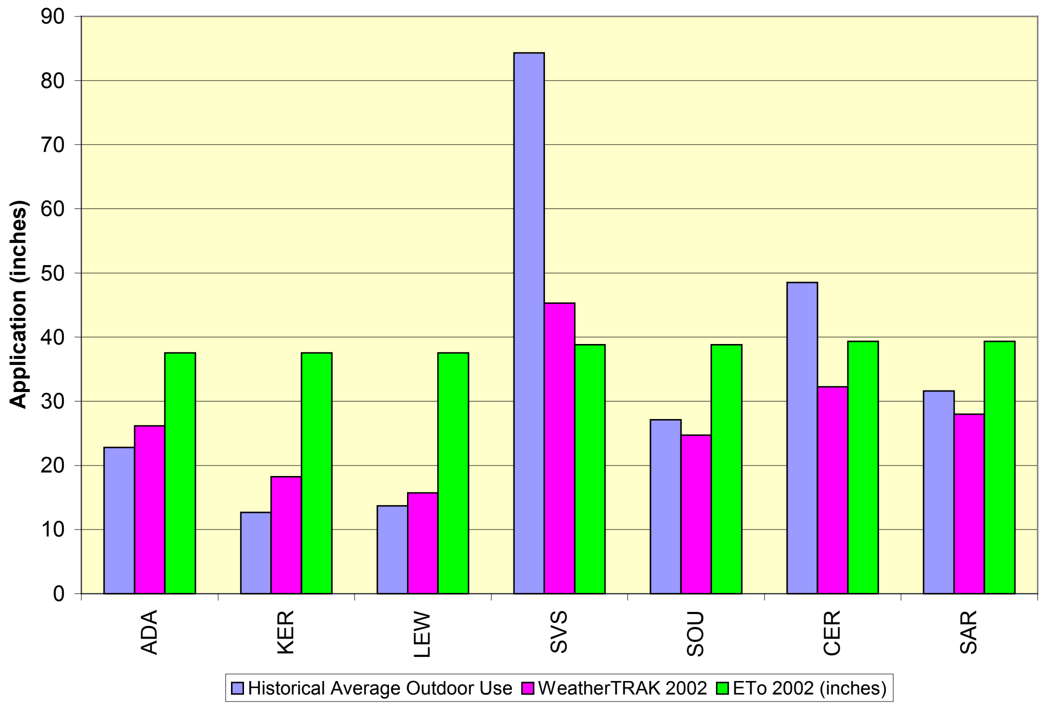


Figure 5: Irrigation application rates before and after WeatherTRAK installation

Table 3: 2002 Irrigation application with WeatherTRAK

Site	**Precipitation during Irrigation Season (in)**	**Irrigation Application with WeatherTRAK (in)**	**Irrigation Application as Percent of ET_o**
ADA	7.6	26.2	70%
KER	7.6	18.2	49%
LEW	7.6	15.7	42%
SVS	7.4	45.3	117%
SOU	7.4	24.7	64%
CER	5.3	32.3	82%
SAR	5.3	28.0	71%
Average (± 95% Confidence Interval)		**27.2 ± 9**	**71% ± 23%**

Cumulative Application Comparisons

Appendix A shows graphs for each of the nine participants that compare the cumulative irrigation applications of each site against the ET_o and historical applications for the 2002 irrigation season. Appendix B has eight graphs that track each participant's irrigation application rates versus the ET_o from the installation date until the completion of the study. The nine graphs in Appendix A show how well the system tracked ET_o during the irrigation season. In some cases the applications lie above or below the ET_o line, but in all cases they tend to mirror the shape of the ET_o line from the beginning to the end of the season. It can be noted that in most cases the drought restrictions curtailed irrigation usage to levels well below ET_o. The most likely explanation for consistently over or under irrigating by the WeatherTRAK™ controllers is that the precipitation rates programmed into the controller are not accurate. In cases where the precipitation rates are under estimated the systems will run too long and use more water than desired. The opposite effect occurs if the precipitation rates are overestimated. Then the system will not run long enough and too little water will be applied.

With two minor exceptions (sites CER and SVS), all of the irrigation application lines lie below the ET_o line and run parallel to it. The SVS site started out just below the line but was adjusted to a slightly higher position in order to maintain a more lush appearance desired by the staff. At the CER site irrigation began above ET_o and tailed off sharply in July, most likely due to stricter water restrictions that were imposed during the drought. The remainder of the sites showed applications that parallel and run at 40-85% of ET_o.

Percent of Potential Savings Captured

The applications with the WeatherTRAK decreased from 34.4 inches for the 1998 to 2000 period to an average of 27.2 inches in 2002 – a 21% reduction. A full turf landscape should be able to do well with an application of 30" after effective rainfall and plant coefficients are considered, and with mixed landscapes the overall applications should easily decrease to 25 inches. Using these guidelines, the WeatherTRAK system appears to have captured around 92% of the potential savings on the seven sites that were active during the entire 2002 irrigation season.

Water and Cash Savings

The WeatherTRAK system clearly was able to regulate irrigation in order to match ET_o. But how does the system perform in terms of simple water and money savings? Figure 6 shows the net savings for each of the seven sites. Savings for the group as a whole averaged 30 kgal for the year, including both increased and decreased uses. The data show that three of the sites used more water in 2002 than they did historically. The KER and LEW sites used more water in 2002, but this was compared to very sparse historical irrigation practices. The ADA site used slightly more water, but their historical use was right at ET_o as was their WeatherTRAK use, so their numbers are essentially a break-even situation.

If we look just at the sites where savings were achieved, and if we assume these sites could be targeted for participation in large-scale projects, then the potential savings appear more favorable. All of the sites with savings were in either Longmont or Greeley. Table 4 shows that for those customers that achieved water savings their average savings amounted to 64 kgal. At the water rates shown in Table 4 this resulted in savings of $190 per site, on average. At higher water rates these savings would be greater.

Table 4: Results from sites showing savings

Site	City	Water Rate ($/kgal)	Savings (kgal)	Savings ($)
SVS	Longmont	3.41	162	$668
SOU	Longmont	3.41	26	$ 89
CER	Greeley	1.73	40	$ 69
SAR	Greeley	1.73	29	$ 51
Average			**64**	**$190**

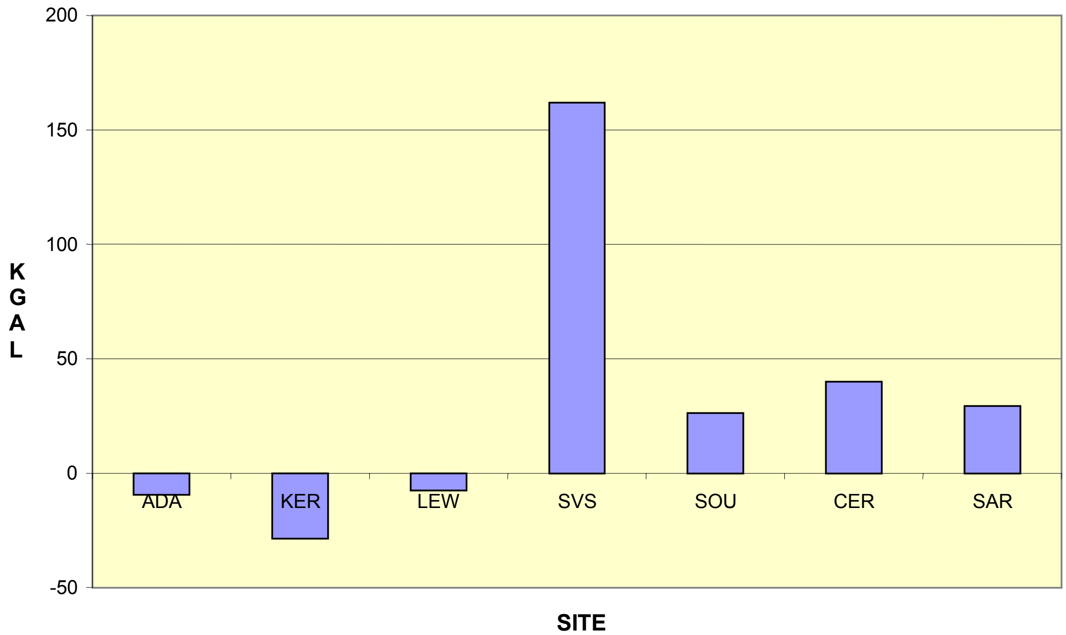


Figure 6: Net water savings for seven study sites

WeatherTRAK™ and Water Restrictions

An important finding of the study during 2002 was that the Weather TRAK controller was able to adapt to local drought restrictions with more or less effort, depending on the type of restrictions favored by the local utility staff. In Boulder, where strict irrigation schedules were required the WeatherTRAK units needed to be programmed for manual irrigation with ET_o. This meant that specific days were set up for watering, and run times were entered for each zone. In the cases of Longmont and Greeley, however, the schedules were much more flexible. These cities gave target applications in terms of inches of application or percent of ET_o. In these cases the WeatherTRAK units could meet the goals by simply sending the necessary ET_o signal.

Boulder's goal was to achieve a 25% reduction in outdoor water use during the summer of 2002. However, they didn't believe that most of their customers could translate a goal of this kind to a watering schedule, so they used a system where watering was limited to 15 minutes, twice a week, for each zone, as a short cut approach, and they applied this to all customers. In order to come as close as possible to meeting these requirements the WeatherTRAK controllers in Boulder were programmed to irrigate only on the days allowed, and their run times were set so that the actual applications would be no more than 50% of the actual ET_o. We reasoned that the average customer normally irrigates at around 80% of ET_o, and programming for a 50% application we would achieve an actual 25% reduction in water use for the customers.

The results in Boulder were very good. The four sites applied an average of 51% of ET_o with a maximum application of 70% and a minimum application of 42%. As a whole the Boulder group tracked ET_o very well and the participants' application rates were within the goals set by Boulder's mandatory watering restrictions.

The City of Longmont 2002 drought response plan called for residents and businesses to voluntarily implement water conservation measures that would reduce water consumption by 10%. This 10% water use reduction was programmed into the WeatherTRAK irrigation controllers in the Longmont area using the percent reduction feature.

The two WeatherTRAK sites in Longmont had an average application rate of 90% of ET_o compared to historic application rates of 157%. Thus, in Longmont the WeatherTRAK controller was able reduce the irrigation application rates by more than the desired 10%.

In 2002 the City of Greeley had mandatory water restrictions that limited watering to two days a week an application of 1.5 inches of water per week for the months of June, July, and August. In September, 1.25 inches of application were allowed. Greeley, however, allowed the study participants an exemption from the watering day requirements on the condition that the application rate was still met. In order to meet these limits the WeatherTRAK irrigation controllers were programmed to the lower of the prescribed limits or the actual ET_o. During future droughts, if ETo signal controllers are in more general use, this would be a good approach to enforcing restrictions.

There were three WeatherTRAK sites in the City of Greeley. Two of the sites were in operation the entire irrigation season and one participant moved in July. For the period when the three sites were operational the average application rate was 70% of $ET_{o.}$ The average application rate for the two sites that were operational the entire irrigation season was 77% of $ET_{o.}$ In 2002 both sites were below their historical application rate and tracked ET_o better than in previous years. In addition they met the City of Greeley's 15% water reduction goal.

Each city in the study had different drought measures that limited outdoor water use. The WeatherTRAK irrigation controller was able to adapt to each of the drought measures and produce water savings. The results are displayed in Figure 7. For two of the citys' programs it was just a matter of modifying the signal to the units within the area. When the WeatherTRAK controller was in an area that had specified watering days it was necessary to manually adjust the controller using the manual user programmed ET_o function. For the study, the installer returned to the participant's homes and reprogrammed the controller. However, using the WeatherTRAK instruction manual, many of the participants could have reprogrammed the controller themselves.

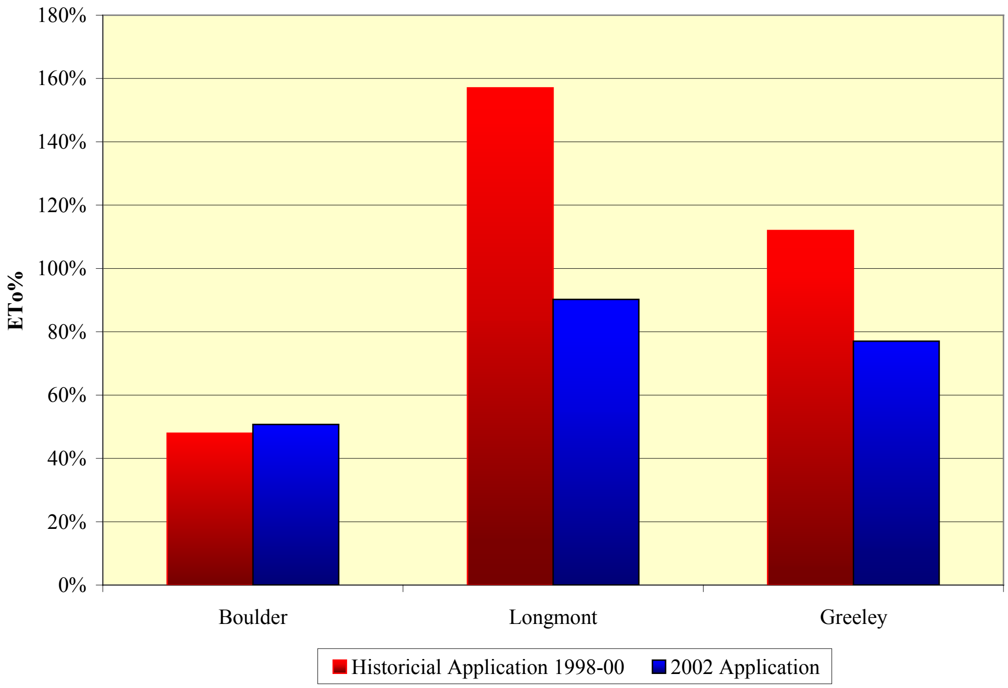


Figure 7: Historical usage versus drought restriction application rates 2002

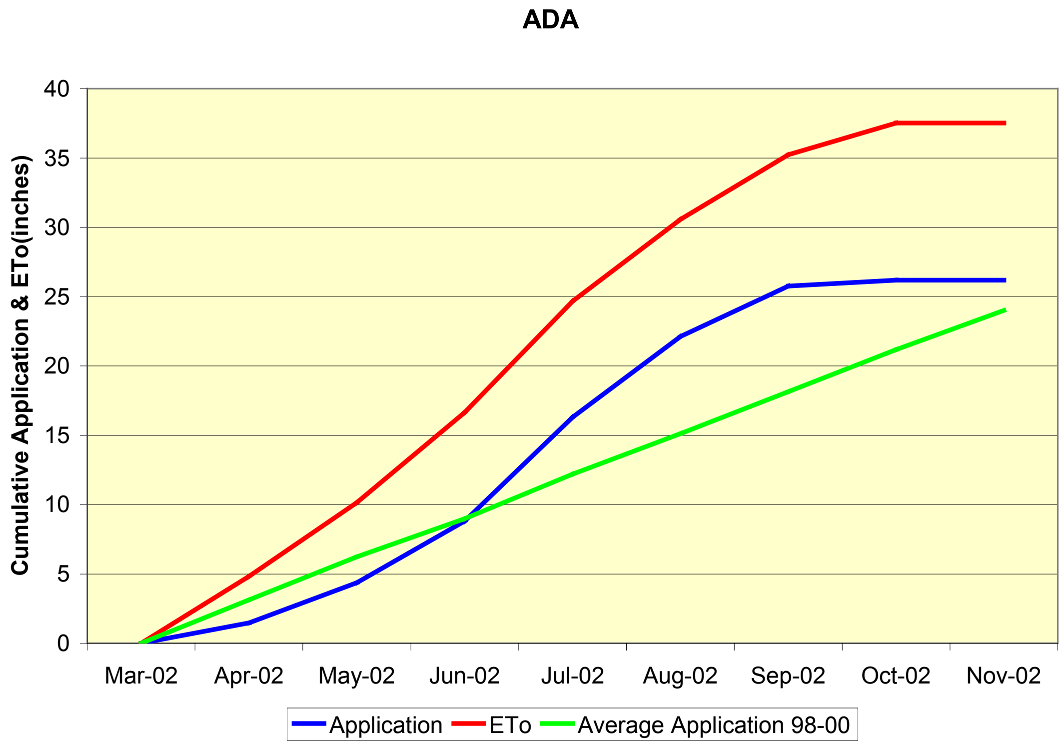
Problems

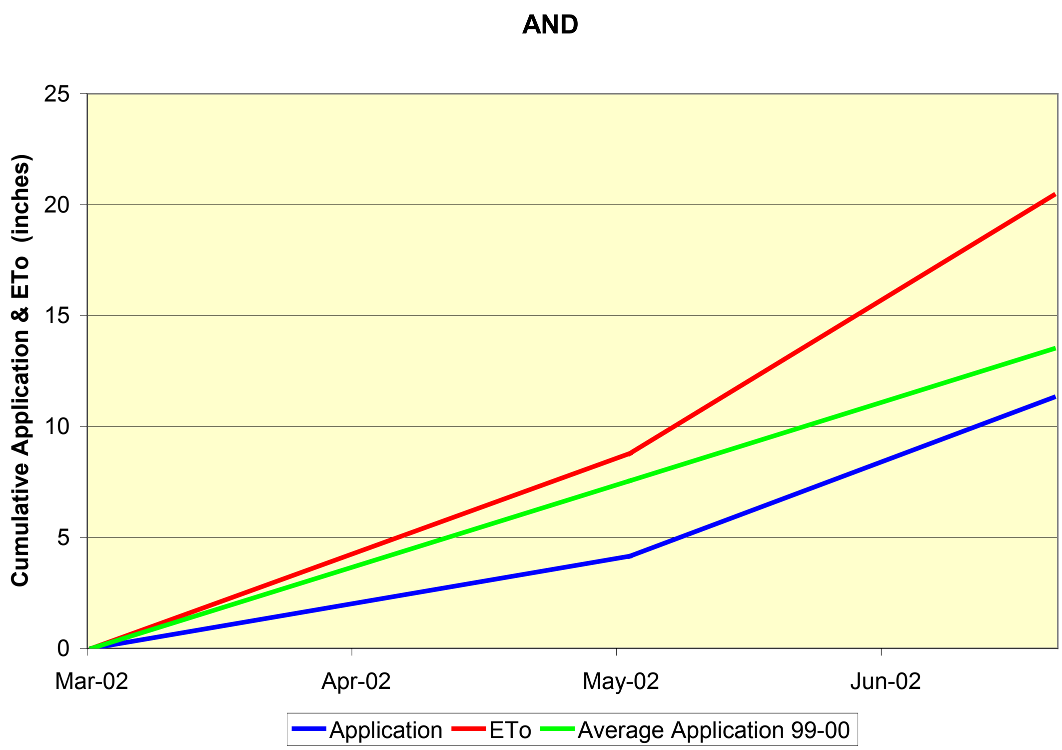
Only one user reported a problem with the WeatherTRAK controller during 2002. The problems were loss of signal and having a wrong ET_o value or date appear on the controller. This problem was successfully resolved by contacting HydroPoint Data Services and then having a representative of Aquacraft talk the participant through the process as a series of new signals were sent to the units. None of the controllers needed replacement for operational reasons in 2002.

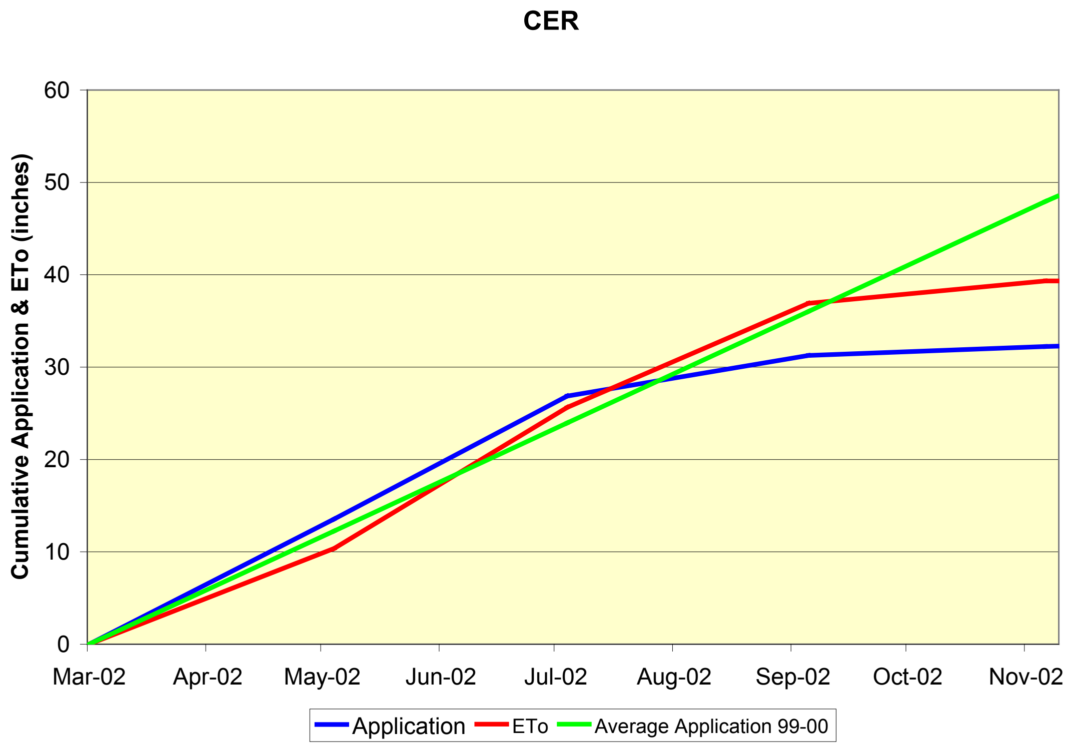
SUMMARY

The results of this study offer useful information about the performance of the WeatherTRAK system. Technically, the system appeared to perform quite well. Not only did the WeatherTRAK receive signals, it made good translation of these ET_o data into actual irrigation schedules. The WeatherTRAK irrigation controller adapted to each of the drought measures and produced water savings. From the standpoint of water savings, for the group as a whole, savings averaged 30 kgal per year. When accounts that saved no water were excluded, savings of 64 kgal per year were observed. Monetary savings on those sites, which reduced their water use, ranged from $51 to $668, and averaged $190 per site. Since these savings were based on relatively low water rates even greater savings could be expected as water rates increase.

Appendix A: Cumulative Applications vs. ET_o's 2002






CER
Cumulative Application & ETo (inches)
0
10
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30
40
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60
Mar-02
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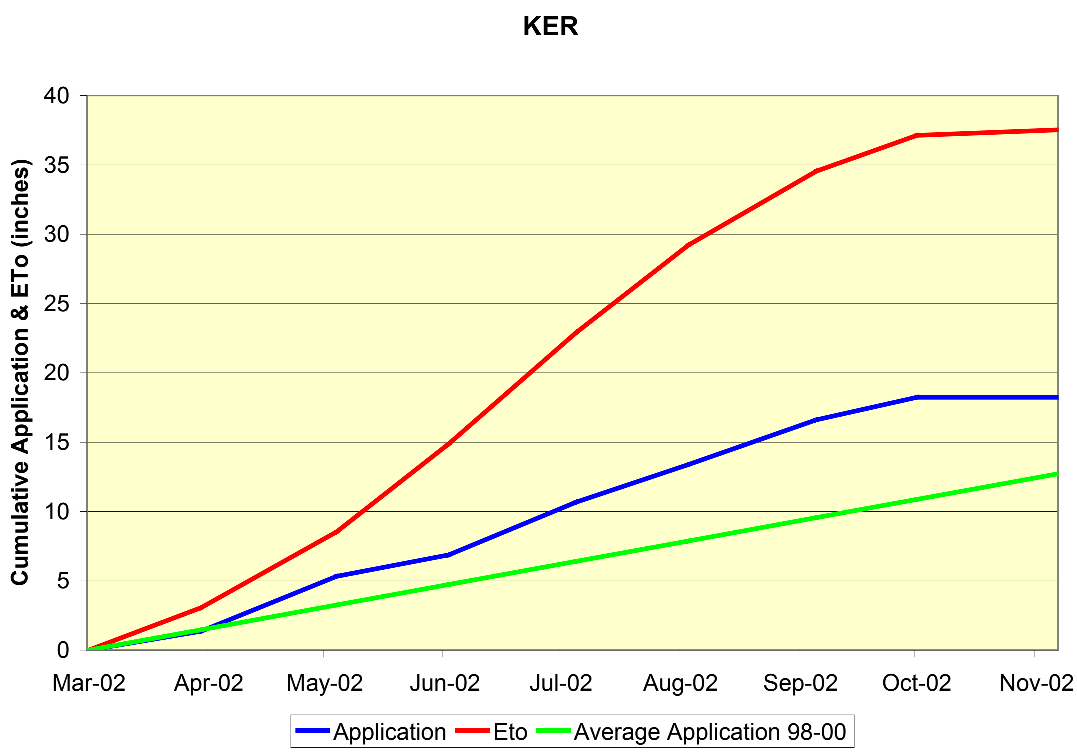
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Application
ETo
Average Application 99-00


KER
Cumulative Application & ETo (inches)
0
5
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15
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25
30
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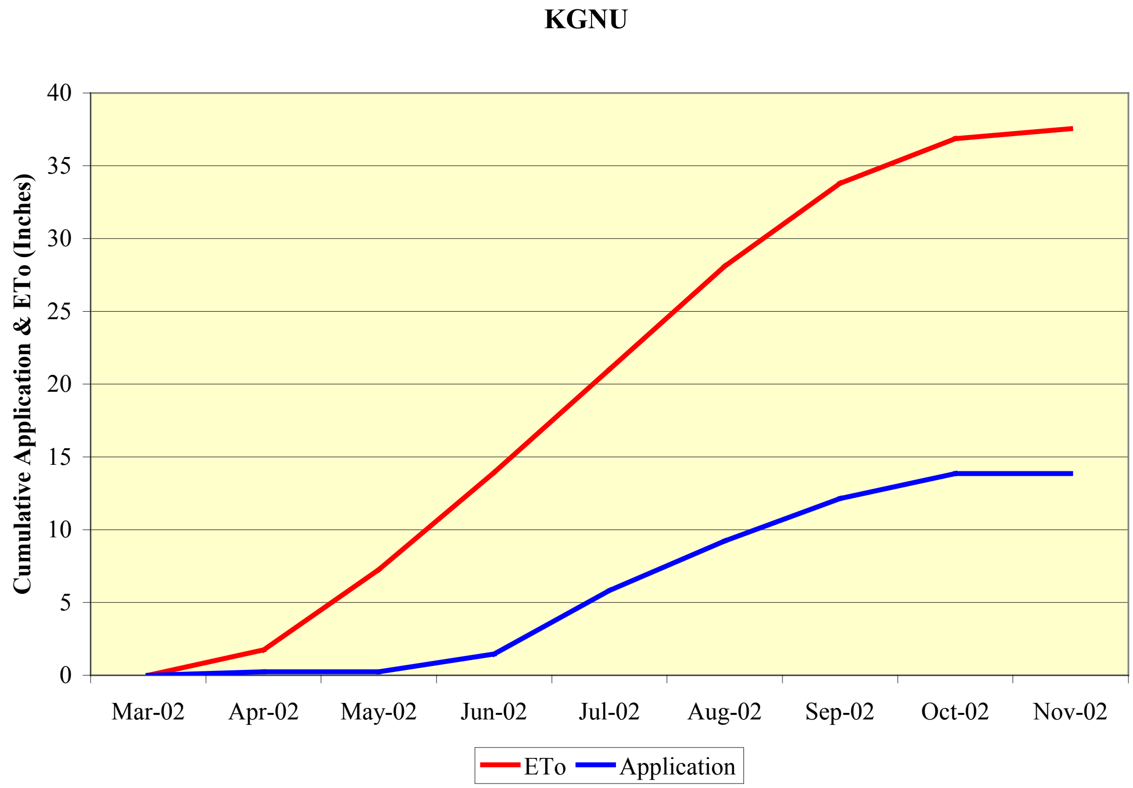
Sep-02
Oct-02
Nov-02
Application
Eto
Average Application 98-00


KGNU
Cumulative Application & ETo (Inches)
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ETo
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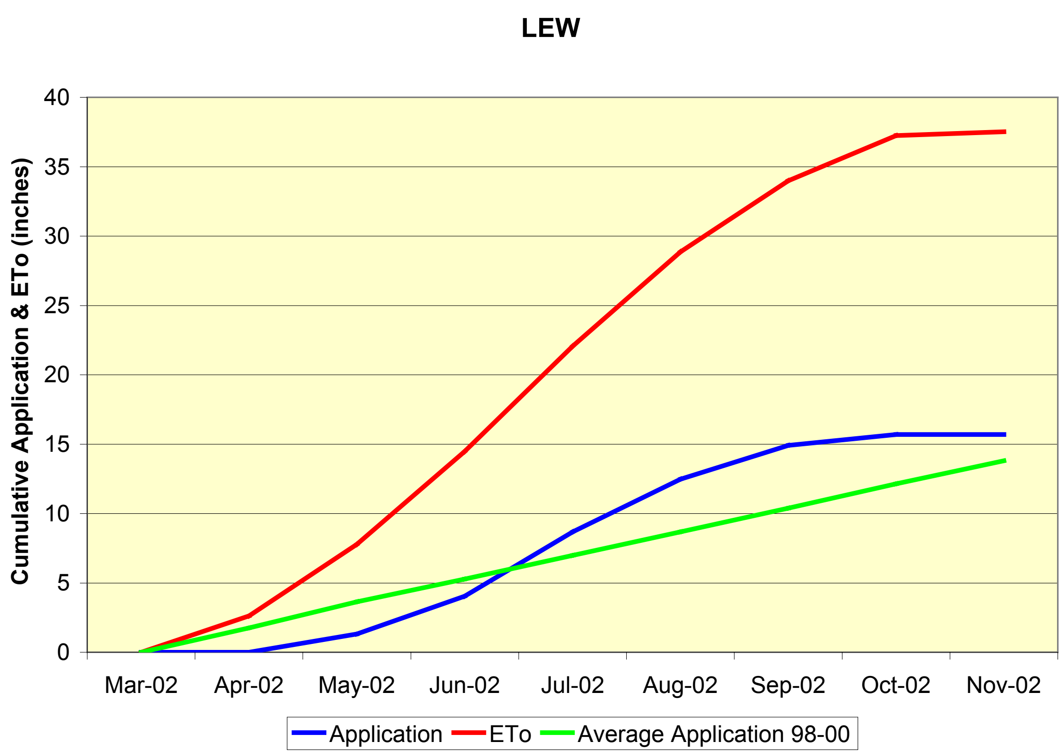
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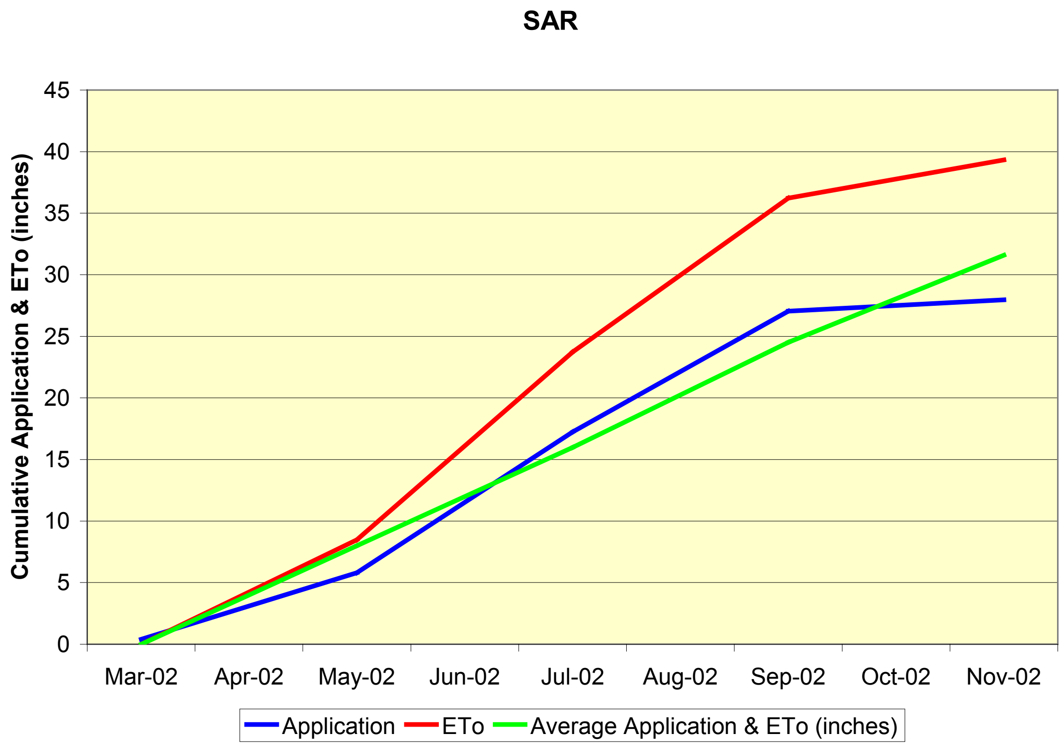
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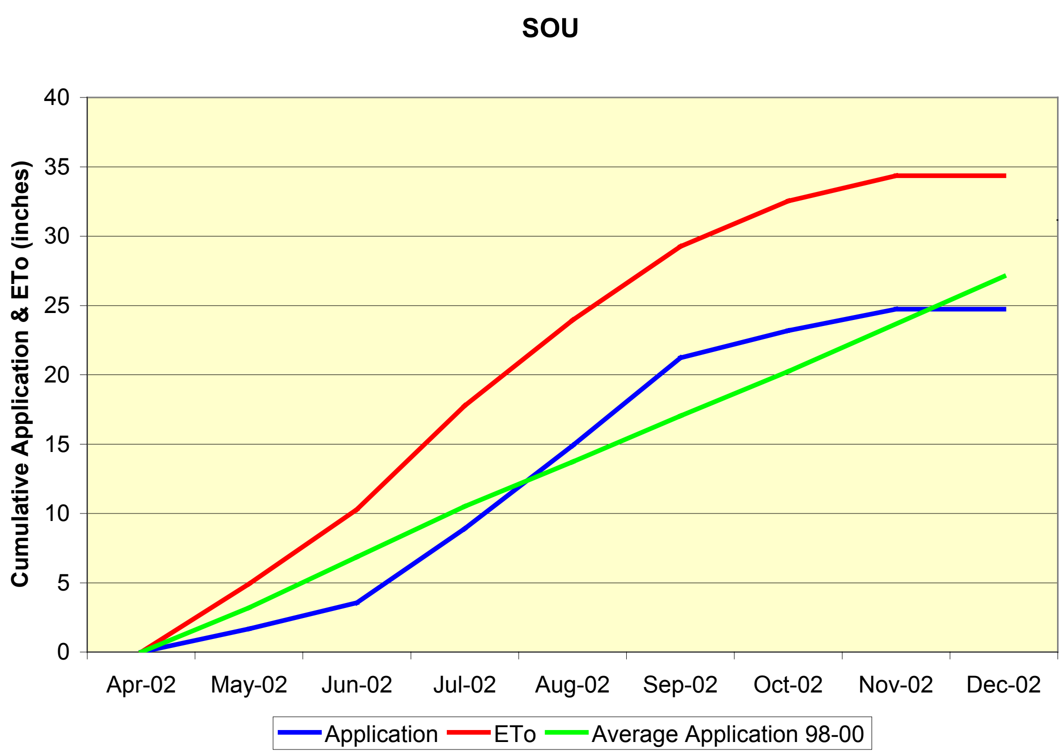
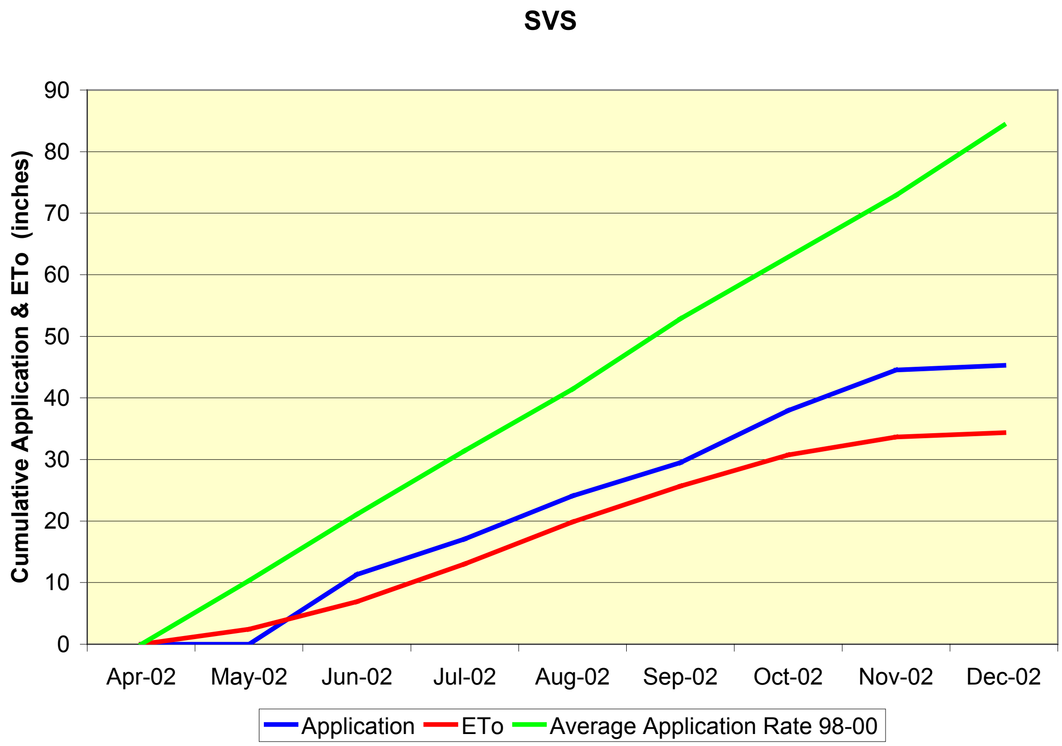
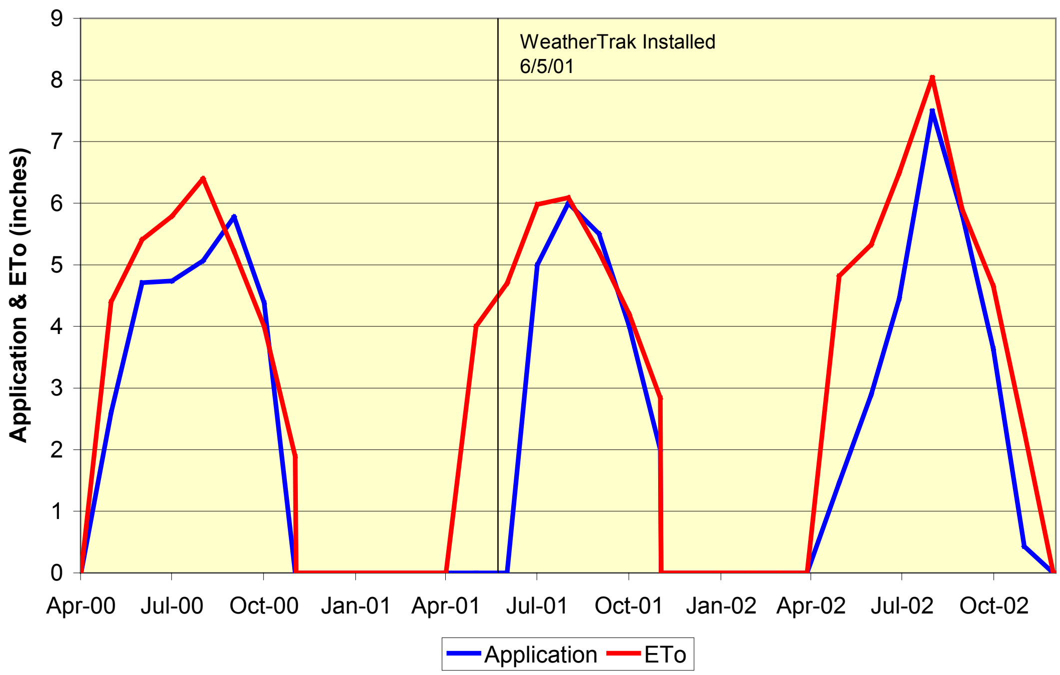
Aug-02
Sep-02
Oct-02
Nov-02
Application
ETo
Average Application & ETo (inches)


SOU
Cumulative Application & ETo (inches)
40
35
30
25
20
15
10
5
0
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Application
ETo
Average Application 98-00

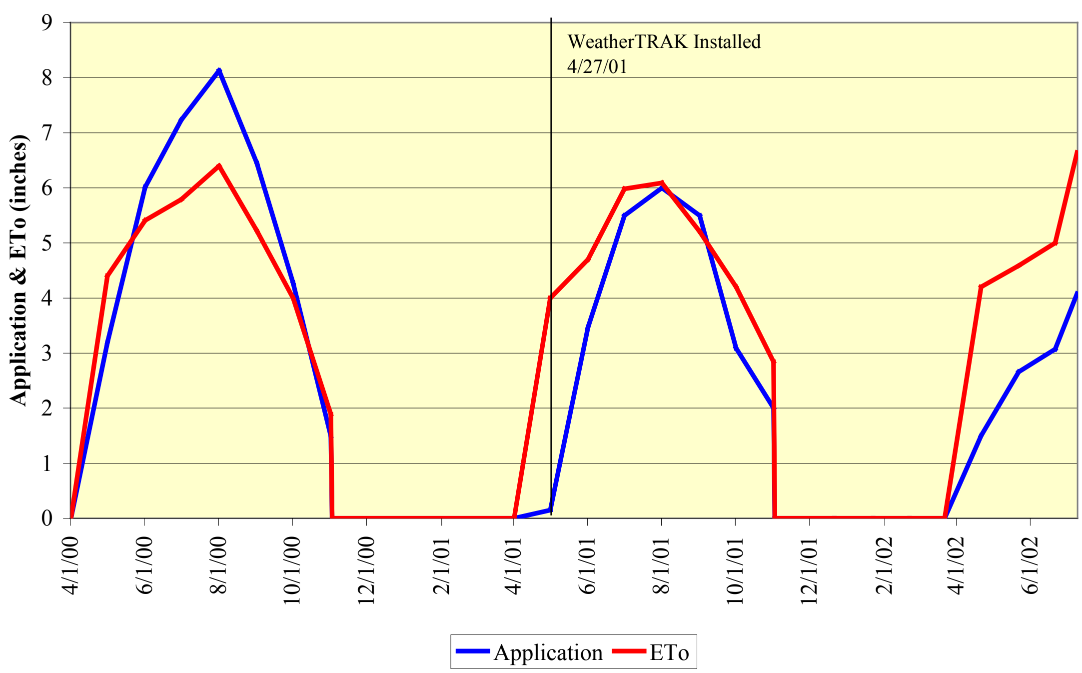

SVS
Cumulative Application & ETo (inches)
0
10
20
30
40
50
60
70
80
90
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Application
ETo
Average Application Rate 98-00

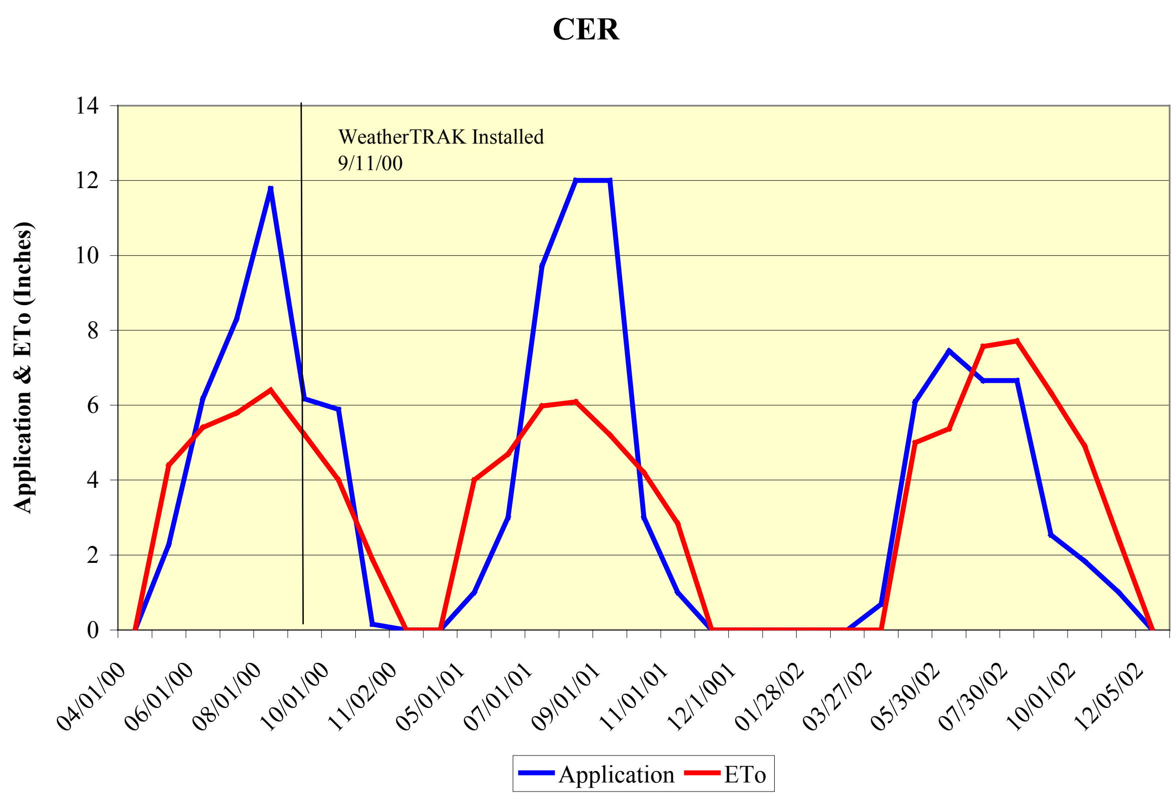
Appendix B: 3 Years Tracking Application versus ET_o

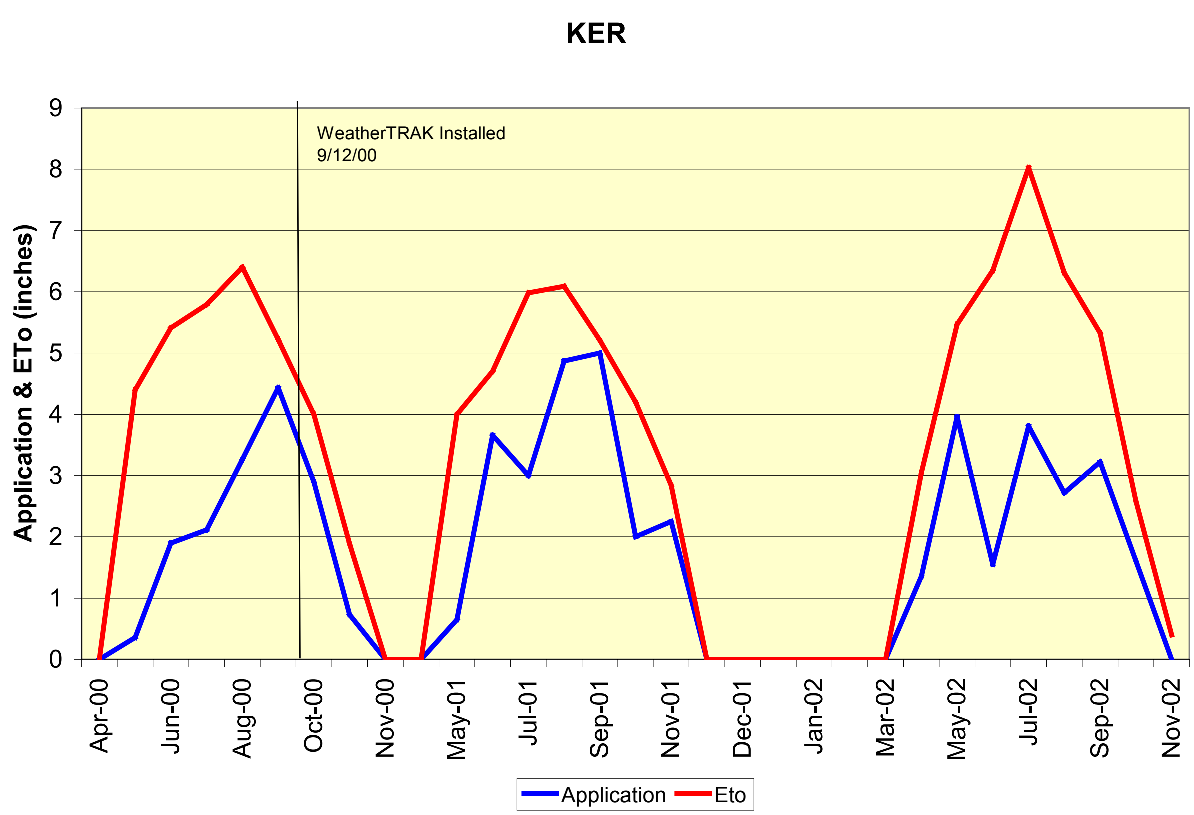
ADA

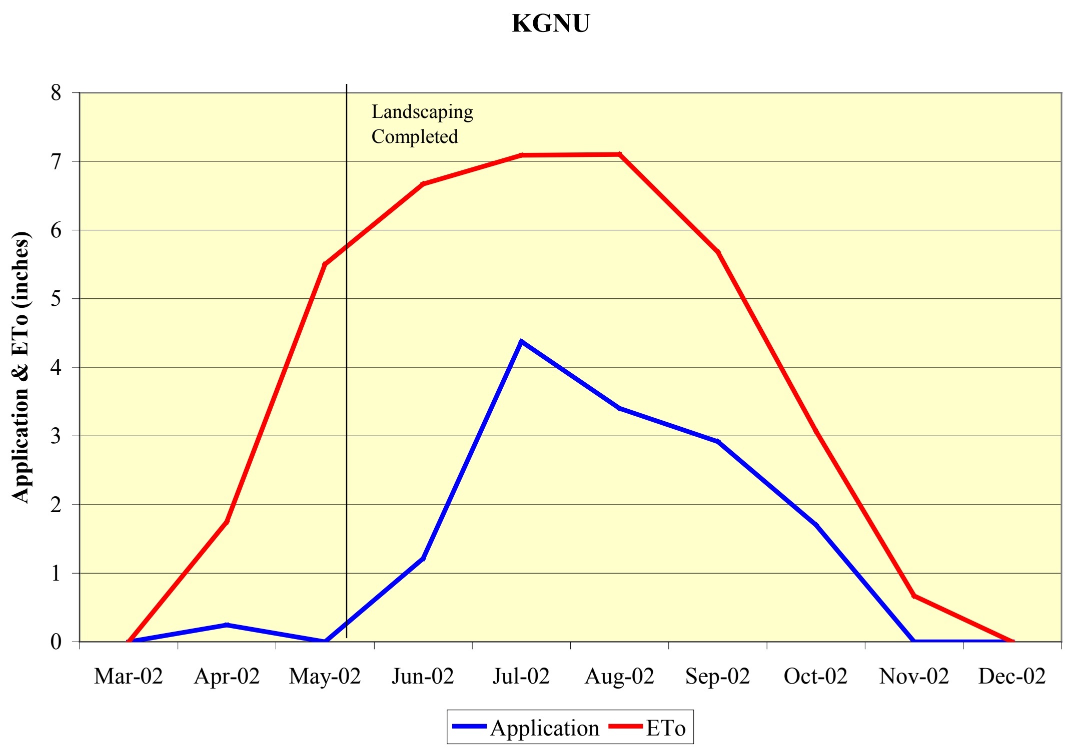


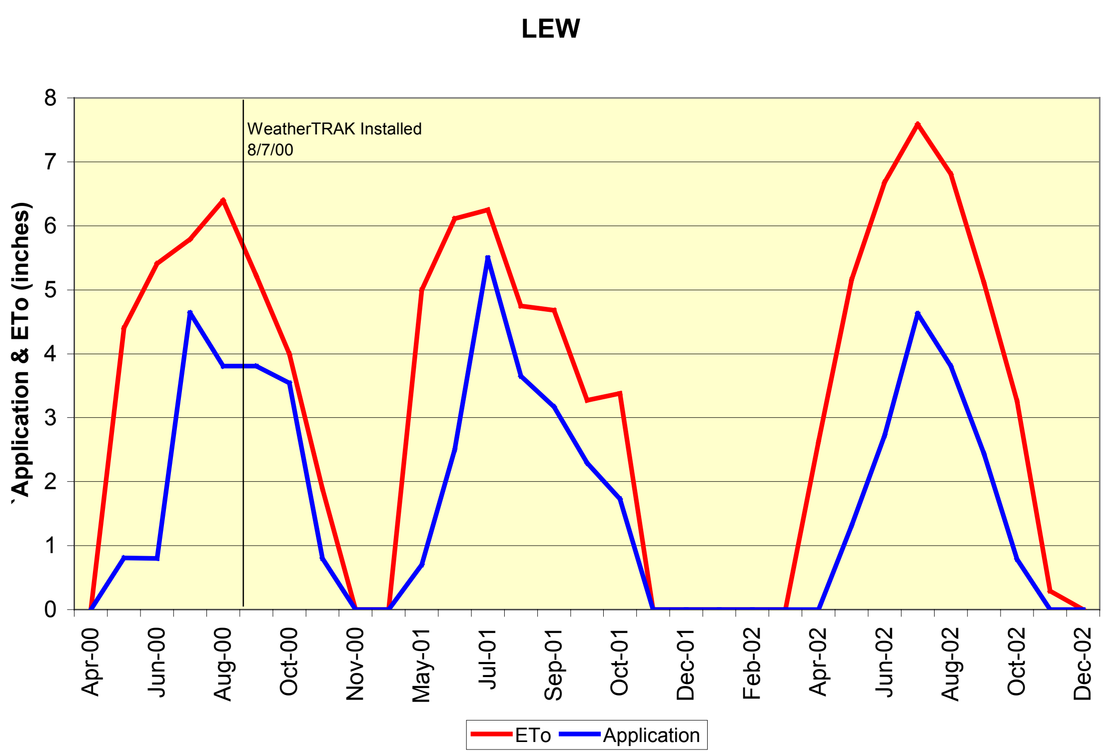
AND



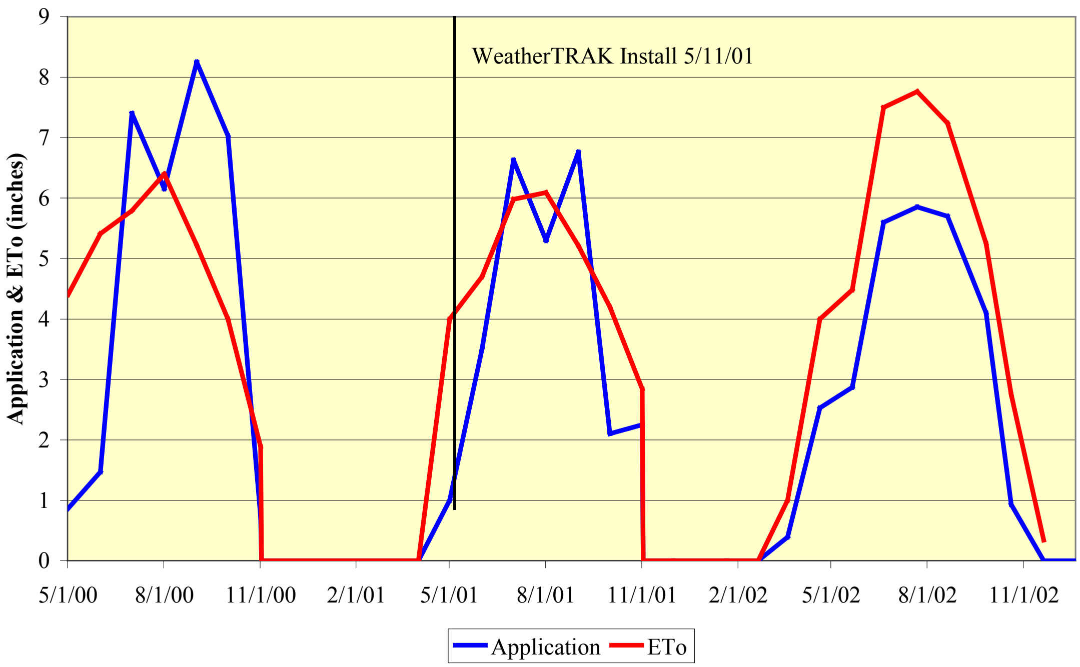

CER
WeatherTRAK Installed
9/11/00
Application & ETo (Inches)
14
12
10
8
6
4
2
0
04/01/00
06/01/00
08/01/00
10/01/00
11/02/00
05/01/01
07/01/01
09/01/01
11/01/01
12/1/001
01/28/02
03/27/02
05/30/02
07/30/02
10/01/02
12/05/02
Application
ETo


KER
WeatherTRAK Installed
9/12/00
Application & ETo (inches)
9
8
7
6
5
4
3
2
1
0
Apr-00
Jun-00
Aug-00
Oct-00
Nov-00
May-01
Jul-01
Sep-01
Nov-01
Dec-01
Jan-02
Mar-02
May-02
Jul-02
Sep-02
Nov-02
Application
Eto

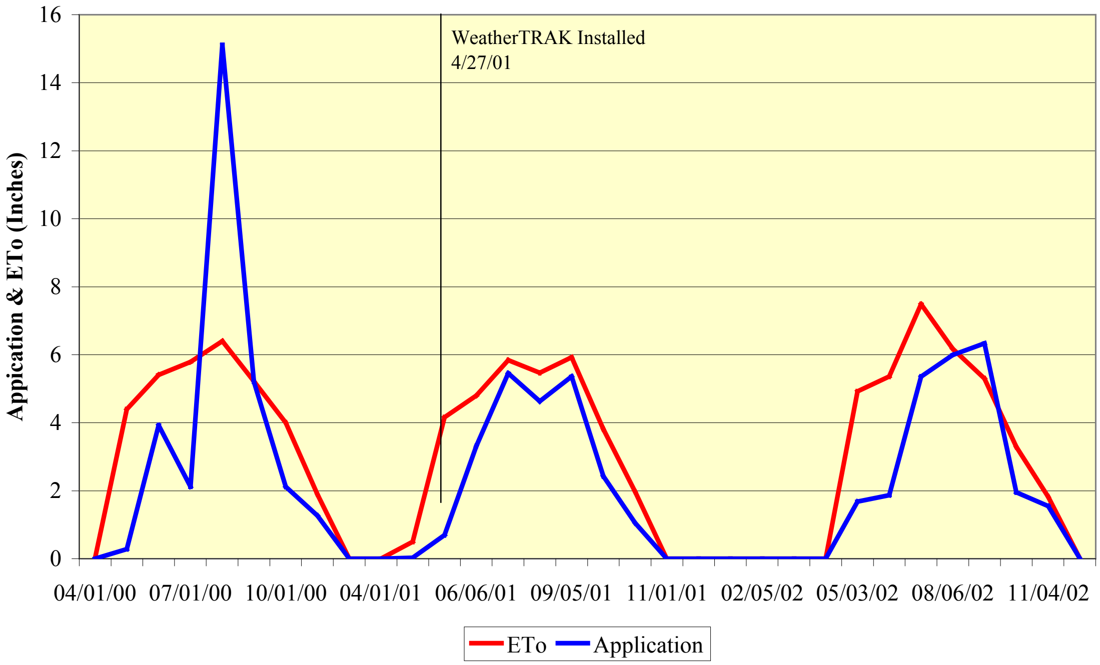

KGNU
Application & ETo (inches)
Landscaping
Completed
0
1
2
3
4
5
6
7
8
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Application
ETo

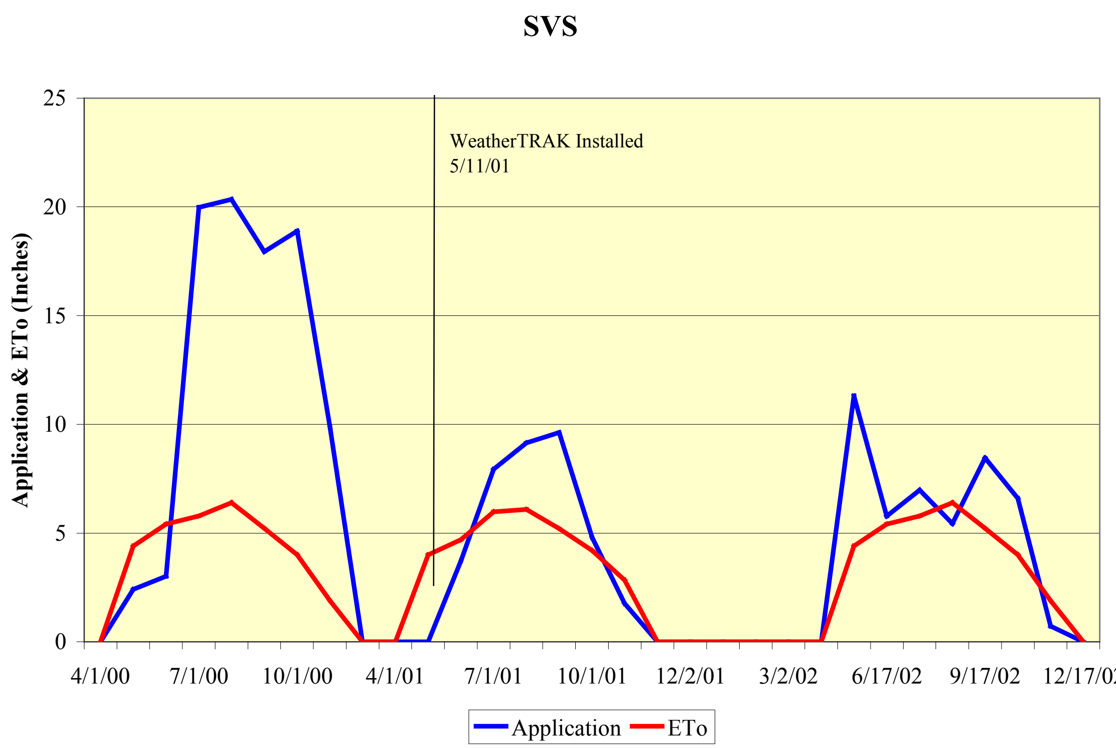

LEW
`Application & ETo (inches)
WeatherTRAK Installed
8/7/00
0
1
2
3
4
5
6
7
8
Apr-00
Jun-00
Aug-00
Oct-00
Nov-00
May-01
Jul-01
Sep-01
Oct-01
Dec-01
Feb-02
Apr-02
Jun-02
Aug-02
Oct-02
Dec-02
ETo
Application

SAR


WeatherTRAK Install 5/11/01
Application & ETo (inches)
0
1
2
3
4
5
6
7
8
9
5/1/00
8/1/00
11/1/00
2/1/01
5/1/01
8/1/01
11/1/01
2/1/02
5/1/02
8/1/02
11/1/02
Application
ETo

SOU


WeatherTRAK Installed
4/27/01
Appication & ETo (Inches)
0
2
4
6
8
10
12
14
16
04/01/00
07/01/00
10/01/00
04/01/01
06/06/01
09/05/01
11/01/01
02/05/02
05/03/02
08/06/02
11/04/02
ETo
Application


SVS
WeatherTRAK Installed
5/11/01
Application & ETo (Inches)
25
20
15
10
5
0
4/1/00
7/1/00
10/1/00
4/1/01
7/1/01
10/1/01
12/2/01
3/2/02
6/17/02
9/17/02
Application
ETo