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EVALUATION AND QUALITY ASSURANCE DEVELOPMENT FOR BENCHMARK FARMS DATABASE

Evaluation and Quality Assurance Development For Benchmark Farms Database

A report presented to the
St. Johns River Water Management District
Project SG357AA

by

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Executive Summary

The St. Johns River Water Management District (District) established the Benchmark Farms Project (BMF) in the late 1980s in order to provide quality assured data for use in planning, permitting, and modeling of water use for its largest agricultural crops. The Division of Water Supply Management at the District determined the need to review the and modify the current Benchmark Farms Database for statistical integrity and quality assurance checks. Original work published in SJRWMD Special Publication SJ88-SP8, established sample sizes to assure the precision of water use estimates and outlined methods to ensure data integrity. Changes have occurred in crop types and crop management in the tri-county area over the last fifteen years. These changes and the need to continually assess the cost-effectiveness of the BMF dictate this analysis. This analysis used data collected in the BMF on irrigation water withdrawals for (upland) ridge citrus, flatwoods citrus , potatoes and leatherleaf ferns over the last ten to fifteen years. Analysis was performed by faculty and staff of the Department of Statistics, Institute of Food and Agricultural Sciences at the University of Florida.

The project had three main tasks. In Task I, an assessment was made of the level of precision achieved by the current BMF sample set as compared to the targets described in SJ88-SP8. In general, looking across all crops, it was clear that sample sizes are just adequate to estimate average acre-inches per acre for the high irrigation water withdrawal period of the year but are inadequate for estimating water withdrawal during those times of the year or growing season where irrigation is not uniformly practiced or only periodically needed. This report concludes that there seems little need to expand sample sizes, but there is a need to maintain the current number unless lower precision targets are set.

In Task II, the report examines the extent to which the BMF data are consistent with what is expected for irrigation data from the specified crops (e.g. an examination of data integrity). In general this analysis found very significant site, year and month effects in the site-specific water withdrawal time series. Of the three, the most interesting were month effects. In many cases, the month effects reflected overall agronomic use of irrigation water by a crop over the year or in the case of potatoes over the growing season. The patterns observed were logical and tended to reflect what would be expected if growers were following best management practices. Year effects reflected the broader general climatic conditions, demonstrating greater water use in dryer years. Site effects were more difficult to explain, reflecting a combination of a number of uncontrollable and/or unmeasured factors. Surprisingly, attempts to explain these temporal effects with readily available climate data, such as rainfall and average or extreme temperatures were generally unsuccessful. This report concludes that with the exception of a couple of extreme observations, the data for each crop was observed to match expectations and have integrity.

In Task III, the report used the available BMF data to recommend quality assurance checks that can be implemented into the data collection/recording process to ensure

continued data integrity. Three approaches were used to identify suspect data, i) a simple test, ii) a step test and iii) and a model-based range test. The report provides a procedure for checking all new observations that is site, crop and month specific, and provides tables of values needed to implement the tests in the District data entry process. The model-based range test was recommended because it fully utilizes the available data and provides threshold values that work for any site, regardless of the length of time series data available for that site. Methods for developing quality assessment thresholds for new sites are also included.

This analysis focused primarily on climate driven variability.Although the District has been consistent in its commitment to the collection of quality BMF data, the agronomic and economic practices associated with this industry have been undergoing significant change, which is reflected in the general irrigation water use. Future efforts at understanding irrigation water usage might include agronomic and economic practices associated with the industry types. There is, furthermore, sufficient BMF data available to spatially analyze irrigation water usage. The mean amount of water withdrawn and the associated temporal variability was found to be clearly site-specific, some aspect of the variability in mean and temporal standard deviation should be due to spatial differences. It is known that soil type and composition varies significantly across the area, possibly influencing irrigation water usage. The spatial analysis effort would relate some physical aspect of the region to changes in the average irrigation water use.

The report and all SAS© code and dataset used in this report are provided in electronic form on CDROM.

Table of Contents

List of Tables

List of Figures

1 Description of Tasks

1.1 Background

Two previous studies performed by University of Florida, IFAS - Department of Statistics (University) are relevant to this project.

In Portier (1988), the sample survey design specifications for improvement of the Benchmark Farms Program (BMF) were developed. The overall objective of this report was to evaluate the problems of obtaining precise estimates of agricultural water consumption in the St. Johns River Water Management District (District). The proposed water use survey had three specific objectives, namely i) estimation of irrigation water use (in acre-inches) for major District crops, ii) estimation of water used for freeze protection and iii) estimation of total ground water and surface water consumed for agriculture in the District. At that time, 29 agricultural commodities were grown in the District, with citrus, potatoes and ferns considered the crops of most concern regarding irrigation water use. The key finding from the report was a specification of the sample sizes needed to achieve various levels of precision in water used for irrigation on specified crops. This was accomplished using variability estimates from the limited data available at the time on irrigation water use by crop and the overall number of wells permitted by the District for each crop. This report recommended that as many as 200 citrus, 75-100 fern and 55 potato wells would need to be monitored to achieve a 20% relative precision target. The report also outlined other changes that needed to be made to the District permitting database to allow easier analysis.

In Portier (1994), a statistical analysis was performed on the first two years of data from the objective measurements of irrigation water use for BMF. This analysis represented a first check on the validity of the variance assumptions made in the 1988 design report. Objective measurements from monthly irrigation water use for 18 months from 68 well sites for citrus and 14 months for 55 well sites for potatoes were available for this analysis. A mixed effects linear model, not unlike the models used in the analyses reported in this study, was used to examine the relationship between acre-inches pumped for irrigation and agronomic and environmental parameters. For citrus, all of the available environmental and agronomic parameters, including monthly rainfall, pump capacity, soil type and county of well were found to be ineffective in explaining variation in monthly irrigation water pumped. For potatoes, the age of the crop at the time of water withdrawal measurement, type of soil as well as month of the year explained about 50% of total variability. This dramatically reduced the spatial variability but left significant remaining temporal and residual variability. The report recommended the continuation of measurement for both crops with the addition of twice-monthly recording of water withdrawn during the growing season. In addition, the report recommended the collection of site-specific rainfall. Finally, the report suggested that a larger fraction of water use variability might be explained with information on site-specific agronomic and crop management characteristics. For example, at the time of analysis, information on citrus tree planted densities and tree age was unknown for about 20% of sites.

Many of the recommendations of the 1988 and 1994 analyses were enacted by the District and are reflected in the data used in this report. It should be noted that while the District has been constant in its commitment to the collection of quality Benchmark Farm Program data, the agricultural industry being measured has been changing. These agronomic and economic management changes have produced changes in general irrigation water use. These changes are also reflected in temporal patterns in the mean water withdrawn in a crop and the variances. This idea of a changing agricultural industry should be remembered as the results presented here are examined.

1.2 Study Objectives

The District has determined that there is a need to review the BMF data set and modify the current BMF Database for statistical integrity and quality assurance checks. The District established BMF in order to provide quality assured data for use in planning, permitting, and modeling of the largest agricultural crops. Original work published in SJRWMD Special Publication SJ88-SP8, established sample sizes to assure data integrity. Since that time the project has evolved to a level where current analyses of sample size needs to be re-established. This analysis will use the data collected to date to establish the sample size needed to assure BMF is collecting data at an acceptable level.

There have been various changes to crop types since 1988 in the tri-county area. These changes have caused a decrease in the yearly number of participants in the project. In addition, the recommended number of participants has not yet been established for other areas and crops in the District. The need to establish the same number of participants as that recommended in 1988 may be affected by this work. If the current sample sizes are determined to be adequate, the District would save money on equipment and on travel. In addition, staff time could be used for project expansion to other crops/areas of concern. If the previously recommended sample sizes are still considered valid, than the need to expand the project to assure adequate sample sizes will be verified.

Beyond determining adequate sample sizes, this project will analyze the data set. This review is necessary in order to assure that the data represents a valid sample of the population being captured by this project. It will validate the integrity of the data set as a whole, so that the District's level of confidence in the data is assured. Outside of the data issues, there are two other tasks to be performed by the University; these involve quality assurance. The first is to establish the interval needed for calibration of the equipment. At this time the project calibrates equipment to the three-year time interval established by the District to meet compliance recommendations. However, the need of data integrity for compliance versus research purposes may establish an interval of less than three years. As a further quality assurance measure, the University will work with the District to establish quality assurance procedures to check the data on a routine basis. These checks will flag suspect data for review by staff. These checks will be used by staff as a measure upon which to check the data in order to assure that the data is of the highest quality.

In order to complete this work on a timely basis, the District contracted with the University to provide the needed consulting services for this project. The contract agreement provided for the University to perform the statistical evaluation and QA checks. As part of this process, the University worked closely with the District to verify that the statistical work being performed met the District's needs.

The following tasks, which are described in the agreement between the District and the University, are covered in this report.

1.2.1 Task One: Sample Size

The data set supplied by the DISTRICT shall be analyzed by the UNIVERSITY to evaluate the adequacy of current sample sizes. Adequacy shall be determined in terms of how well the sample distribution of water consumption can be considered to reflect the water consumption of the population of producers. UNIVERSITY should consider the previous work as documented in Special Publication SJ88-SP8 "Statistical Sample Survey Design for Estimation of Agricultural Water Use" (Portier 1988) while performing this task. Recommendations in sample size changes from those indicated by SJ88-SP8 shall be documented in the final report.

1.2.2 Task Two: Data integrity

The current data set of agricultural water use as supplied by the DISTRICT shall be analyzed by the UNIVERSITY to investigate whether the data represents a valid sample of agricultural water use. This task shall investigate beyond the variability as analyzed in task one. It shall investigate the actual data set to assure that there are no apparent flaws in the data. It shall further compare the data within sites and between sites to determine the validity of the data. This task shall also determine a relationship between rainfall and irrigation and between minimum daily temperatures and freeze protection water use. Any other tests that the university feels are appropriate should be used.

1.2.3 Task Three: QA Checks

After evaluating the data in tasks one and two the UNIVERSITY shall determine appropriate quality assurance (QA) checks that can be used to flag suspect data. These checks shall be used by staff to indicate whether obvious trends in the data need to be investigated to determine whether data represent actual conditions. The statistical QA checks shall be such that they can be implemented in an access database, or if this is not feasible, then the UNIVERSITY shall develop a packaged format that DISTRICT staff can run without manipulation using the DISTRICTs statistical software. DISTRICT shall provide an access database consultant to work with the UNIVERSITY on this task or provide the necessary support for the DISTRICTs statistical software. Due to the use of Access as the data reservoir, priority shall be given to a system that utilizes the functionality of being incorporated into the current database. If this is not possible then the UNIVERSITY shall need to work with DISTRICT’s Project Manager to assure functionality of the use of the proposed methodology.

2 Methodology

This chapter is organized around the three substantive tasks of the contract. While the methodology for each task is described separately, the overall analysis in one task depended to some extent on the information learned from the results of the previous task.

2.1 Task One: Determine Sample Size

2.1.1 Data Files

The District submitted five (5) Excel® formatted datasets, defined below to support task-related analysis.

1. **Qryirrigpotatoes.xls:** Irrigation water consumption for potatoes production in the District with a column that identifies irrigation method.
2. **Qryirrigleatherleaf.xls:** Irrigation water consumption for leatherleaf fern production in the District with a column that identifies irrigation method.
3. **Qrotherfern.xls:** Irrigation water consumption for other ferns production in the District. The latter file has an additional column that identifies irrigation method.
4. **Qryirrigcitrus.xls:** Irrigation water consumption for ridge citrus production in the District with a column that identifies irrigation method.
5. **Qryirrigflatwoodcitrus.xls:** Irrigation water consumption for flatwoods citrus production in the District with a column that identifies irrigation method.

Each of the crop datasets was processed as described below.

1. Any observation for which the quality indicator was "Inaccurate" or the acre-inches was less than zero was dropped from the analysis.
2. The spreadsheet was sorted by year and month.
3. Data were input into the SAS ® system for subsequent analysis. The SAS procedures will be provided on CDROM as part of the final project materials.
4. Data were processed to compute relative standard error for each month, year and commodity using two approaches as described in the remainder of this section. Tables were computed in SAS, output to Excel, reformatted and input into this report. SAS was also used to produce time-series plots of relative standard error.

2.1.2 Relative Standard Error

This task addresses an assessment of the adequacy of the current sample size used to assess total water withdrawn for each of the crops across the whole District. With the available data there are two methods for estimating total water withdrawn. The first method estimates total consumption by multiplying the sample average of 'acre-inches per acre consumed' by the total crop acreage in the District. For this method, the uncertainty in the final total consumption estimate is tied to the uncertainty in estimating the average ‘acre-inches per acre consumed’. The second method assumes that the acre-inches per acre is a ratio composed of acre-inches consumed divided by acres. Both the denominator and numerator are random variables in this method because it is possible for both the acre-inches consumed and acreage to vary from site-to-site. The ‘acre-inches per acre consumed’ ratio estimate is constructed as the ratio of the average acre-inches consumed divided by the average acreage. This ratio is then multiplied by the total acreage as for the first method to estimate the total water consumed for that crop in the specific month and year. The uncertainty in the final estimate is a multiple of the uncertainty in the estimated ratio. The uncertainty in the estimated ratio is tied to the uncertainty (variability) in both the denominator and numerator means. An approximation for this variance is presented; it relies on the correlation between acres irrigated and acre-inches consumed.

The equations for both estimates and their estimated standard errors are given below.

2.1.2.1 Relative precision of the mean estimate of acre-inches per acre consumed.

Let

t = an index of data, t = 1 to M where M is the total number of months for which data on a crop is available (e.g. for ridge citrus M=146 months, 7-1991 to 8-2003).

$\overline{y}_t$ = average water withdrawn in month t as measured in acre-inches per acre (aci).

s_t = standard deviation of the water withdrawn in month t.

N_t = total number of wells used by this crop type in month t. It will typically be assumed that this number is fixed for the 12 years of the study but there is nothing in the analysis that requires this.

n_t = number of wells used by this crop type that are sampled in month t. This number does change from month-to-month.

A_t=Total acreage in the crop in month t. (assumed constant for all t).

$\hat{T}_t = A_t \overline{y}_t$ = estimated total water pumped for this crop type in month t.

$SE\left(\hat{T}_t\right) = A_t \sqrt{\frac{N_t - n_t}{N_t - 1}} \left(\frac{s_t}{\sqrt{n_t}}\right)$ = estimated standard error for the total water pumped for this crop type for month t. Note that this estimate takes into account the “finite correction factor” (the square root term) that adjusts the standard error downward if a fairly large fraction of the total population is sampled.

The precision of the estimate of total water used can be defined by a 95% confidence interval computed using the equation below (Cochran, 1963).

$$\hat{T}_t \pm t_{(n_t - 1, .975)} SE(\hat{T}_t) \qquad (2.1)$$

where $t_{(n-1,.975)}$ is the upper 97.5 percentile of a t distribution with n_t-1 degrees of freedom. The right-hand side of this equation can be used as a measure of the precision of the total water use estimator. This precision relative to the total can be expressed by dividing the right-hand term by the estimate.

$$t_{(n_t-1,0.975)} SE\left(\hat{T}_t\right) = \sqrt{\frac{N_t - n_t}{N_t - 1}} \left(\frac{t_{(n_t-1,0.975)}\left(s_t \big/ \sqrt{n_t} \right)}{\overline{y}_t} \right) \qquad (2.2)$$

Note that the total acreage (A_t) terms drops out of the equation. Also, the rightmost term in parenthesis is the relative precision of the same mean estimator unadjusted for the finite sampling fraction. If N_t is very large compared to n_t, the finite correction term is close to 1.0 and can be disregarded. In this study, the finite correction term is typically much smaller than 1.0 and hence cannot be disregarded.

To compute the relative precision using Equation (I-2) requires values for n_t, $\overline{y}_t$, and s_t. For each crop, these values are computed for each month and presented in tabular form. Using these values and a current estimate of N_t, the relative precision term is also computed and values presented in tabular form. Finally, a times-series plot of the relative precision term, multiplied by 100%, is presented.

The sample size study performed in 1988 (District Special Publication SJ 88 – SP 8) provided sample size estimates for relative precision values of 50%, 30%, 20%, 10% and 5%. Although not specifically stated in this report, the sample sizes recommended in 1988 tended to center around the 20% relative precision target. For this reason, a 20% relative precision reference line is included on the time-series plots. This line is provided for discussion purposes only and does not limit the user from choosing their own reference line, nor does it represent the stated precision targets of the District.

2.1.2.2 Relative precision of a ratio estimate of acre-inches per acre consumed.

Let

t = an index of data, t = 1 to M where M is the total number of months for which data on a crop is available (e.g. for ridge citrus M=146 months, 7- 1991 to 8-2003).
x_{it}= water withdrawn in month t as measured in acre-inches (ai).
a_{it}=acreage irrigated at site i in month t as measured in acres.
$\overline{x}_t$ =average water withdrawn in month t (in acre-inches) from the sample sites.
$\overline{a}_t$ =average acreage irrigated in month t (in acres) from the sample sites.
$A = \sum_{i=1}^{N} a_i$ = the total acreage of the crop within the District.

$\hat{r}_t = \frac{\overline{x}_t}{\overline{a}_t}$ = sample estimate of average ‘acre-inches per acre’ in month t.

s_{xt} = standard deviation of the water withdrawn (ai) in month t from sample sites.

s_{at} = standard deviation of the acreage irrigated (acres) in month t from sample sites.

N_t = total number of wells used by this crop type in month t. It will typically be assumed that this number is fixed for the 12 years of the study but there is nothing in the analysis that requires this.

n_t = number of wells used by this crop type that is sampled in month t. This number does change from month to month.

$\hat{T}_t = A_t \hat{r}_t$ = estimated total water pumped for this crop type in month t.

$\hat{V}_{x_t}^2 = \left(\frac{N_t - 1}{N_t}\right)\left(\frac{s_{x_t}^2}{\overline{x}_t^2}\right)$ = the estimated variance associated with the amount of water withdrawn in month t measured in acre-inches (ai).

$\hat{V}_{a_t}^2 = \left(\frac{N_t - 1}{N_t}\right)\left(\frac{s_{a_t}^2}{\overline{a}_t^2}\right)$ = the estimated variance associated with the acreage irrigated in month t measured in acres.

$\hat{\rho}_{xa} = \sum_{i=1}^{n} \frac{\left(x_{it} - \overline{x}_t\right)\left(a_{it} - \overline{a}_t\right)}{(n-1) s_{x_t} s_{y_t}}$ = the sample estimate of the correlation between the amount of water withdrawn and the acreage irrigated in month t.

Therefore the standard error associated with $\hat{r}_t$, the estimate of average acre-inches per acre in month t can be estimated using (Levy and Lemeshow, 1999);

$$SE\left(\hat{r}_t\right) = \left(\frac{\hat{r}_t}{\sqrt{n_t}}\right)\left(\hat{V}_{x_t}^2 + \hat{V}_{a_t}^2 - 2\hat{\rho}_{xa}\hat{V}_{x_t}\hat{V}_{a_t}\right)^{1/2}\sqrt{\left(\frac{N_t - n_t}{N_t - 1}\right)} \qquad (2.3)$$

This estimate of the true standard error of the ratio is adequate if the following condition is met.

$$\left(\frac{s_{a_t}}{\sqrt{n_t} \cdot \overline{a}_t}\right)\left(\sqrt{\frac{N_t - n_t}{N_t}}\right) \le 0.05 \qquad (2.4)$$

The estimate of total water consumed by the crop in the District in month t is given as:

$$\hat{T}_t = \hat{r}_t \cdot A_t . \qquad (2.5)$$

The associated standard error is

$$SE\left(\hat{T}_t\right) = \left(\frac{A_t \hat{r}_t}{\sqrt{n_t}}\right)\left(\hat{V}_{x_t}^2 + \hat{V}_{a_t}^2 - 2\hat{\rho}_{xa}\hat{V}_{x_t}\hat{V}_{a_t}\right)^{1/2}\sqrt{\left(\frac{N_t - n_t}{N_t - 1}\right)}. \qquad (2.6)$$

The relative precision is computed as before with

$$\frac{SE\left(\hat{T}_t\right)}{\hat{T}_t} = \left(\frac{1}{\sqrt{n_t}}\right)\left(\hat{V}_{x_t}^2 + \hat{V}_{a_t}^2 - 2\hat{\rho}_{xa}\hat{V}_{x_t}\hat{V}_{a_t}\right)^{1/2}\sqrt{\left(\frac{N_t - n_t}{N_t - 1}\right)} \qquad (2.7)$$

Note that the relative precision of this total water consumed estimate does not depend on the total acreage but does depend directly on the variability in acre-inches water consumed and the variability in acreage. If there is a high positive correlation between acre-inches water consumed and acres irrigated, this estimate has the potential to become small suggesting that this ratio estimate could be more precise than the estimate based on average acre-inches per acre. If there is little or negative correlation (ρ) this estimate will be less precise.

2.1.3 Sample size determination

If the observed relative precision is greater than the target relative precision, the sample size must be increased. To determine what the sample size should be requires knowledge of the population coefficient of variation (CV) and the following equations. For all crops and all sample dates, the sample CV is presented. Using an average CV value in the sample size equations below should produce an estimate of the new required sample size.

Given CV= population coefficient of variation, RP= target relative precision and assuming the need for a 100(1-α)% confidence in reaching the target precision, the estimated sample size is computed by solving the following equation.

$$n_0 = \left(\frac{t_{n_0-1,1-\alpha/2} CV}{RP}\right)^2 \qquad (2.8)$$

Note that the estimated sample size is found on both sides of the equation. This equation is solved by first guessing a value of n_0, using this value to compute the right-hand-side value and then checking whether it matches with the original n_0 value assuming you round the value up to the next integer. If not, reset the n0 value to the integer part of the previous value of the right-hand-side and recompute the right-hand-side equation. Continue in this fashion until both the left and right sides are approximately equal. Typically this takes only two or three iterations.

If the estimated sample size, n_0, is greater than 5% of the total population size, N, then a second step in the sample size estimation is used. This step reduces the needed sample size to account for the fact that you have a finite number of potential members of the sample. The new sample size is computed simply as:

$$n_1 = \left(\frac{n_0}{1 + \left({}^{n_0}\!/\!_N \right)} \right) \qquad (2.9)$$

These computations can easily be implemented in a spreadsheet program using the TINV() function found in most packages.

2.2 Task Two: Evaluate Data Integrity

2.2.1 Basic Approaches

There are two related issues in evaluating data integrity. The first issue is whether the sample sites can be considered representative for the crop. The second considers whether the values recorded in the database are normal and expected water use values for the crop and time of year in which the values were recorded.

Sample Representativeness: The issue of representativeness is partially answered by examining the statistical distribution of population acreages represented by wells and a comparison of this distribution to that of the sample wells. Histograms and box plots are provided for this analysis. Another aspect of representativeness could be addressed by examining the relationship between the spatial coverage of the sample wells to the population distribution of permitted wells for each crop. Neither of these aspects was examined because a full list of all permitted wells and their geographical locations were not provided for this project. It is recommended that the District staff perform these analyses.

Analysis of Normal and Expected Water Use: This analysis could be approached in two ways. One analysis approach is to obtain information from growers and Agricultural Extension crop specialist on what amounts of water (in acre-inches per acre) should or would normally be applied under various seasonal and climate scenarios. The expected amounts for each month for the period of record for this analysis were formulated and compared to observed use. This would be time consuming and difficult to perform but would assess whether water use for the crop matches best management practices. This analysis was not performed.

A statistical approach to the issue of data integrity involves modeling the relationships between factors that are known to affect water use, such as monthly total rainfall, average daily temperature, irrigation method (where applicable) and the response, acre-inches per acre. The statistical model allows one to estimate the average water use for each possible setting of the climate factors. In addition, the residuals are analyzed to determine whether the variability in the deviations from average water use follow a Gaussian (or normal) distribution and whether the variance of this distribution is constant over time. The expected annual and monthly values for each sample site are then estimated and the distribution of these averages examined to determine if they also follow a Gaussian distribution. In both cases, a Gaussian distribution indicates that the variation about the mean has characteristics that suggest that they are random. A different distribution would be an indication that there are factors other than those in the statistical model that are affecting water use.

A general linear mixed effect model is fit to the acre-inches per acre data to allow estimation of site, year and month effects. Next, monthly, or in the case of potato, biweekly, rainfall and average temperature measured by District staff were used as covariates to determine if period rainfall or temperature could explain a significant fraction of the residual variation. Finally, National Weather Service data archives were accessed for monthly (or biweekly) measures for the following parameters:

- DP01 – Number of days with ≥ 0.1 inch precipitation,
- DP05 – Number of days with ≥ 0.5 inch precipitation,
- DP10 – Number of days with ≥ 1.0 inch precipitation,
- EMNT – Extreme minimum temperature for the month,
- EMXP – Extreme maximum daily precipitation in the month,
- MMXT – Monthly maximum temperature for the month,
- MMNT – Monthly mean minimum temperature,
- MNTM – Monthly mean temperature,
- TPCP – Total monthly precipitation.

These parameters were obtained from a site typically considered central to the growing region. In the case of crops with large regions, such as ridge citrus or ferns, multiple sites were examined. In the case of flatwoods citrus and potatoes, the spatially limited location of the wells allowed information from one location to be used.

The above parameters are only the ones that make the initial cut for inclusion into the model. The full list of climate parameters that were considered is given below. Note that some parameters were eliminated because there was very little information available, others because that did not show up as significant when included in the overall mixed model. A principal components analysis was also attempted that included all the parameters below. Any parameter having a very small standardized coefficient for the first two principal components was also excluded from consideration. Finally, the first two principal components of the total climate parameter set were also examined as possible covariates in the mixed model analysis. The final fits for the principal components were poorer than the one and two parameter models presented in the findings.

- CLDD - Monthly cooling degree days - base 65 F. (1980 onward)
- DP01 - Number days with > 0.1 inch precipitation. (1954 onward)
- DP03 - Number days with > 3.0 millimeters precipitation. (Metric stations only)
- DP05 - Number days with > 0.5 inch precipitation. (1951 onward)
- DPOH - Number days with > 0.01 inch precipitation. (Only before 1954)
- DPOQ - Number days with > 0.25 inch precipitation. (Only before 1951)

- DP10 - Number days with > 1.0 inch precipitation.
- DP25 - Number days with > 25.0 millimeters precipitation. (Metric stations only.)
- DP50 - Number days with > 50.0 millimeters precipitation. (Metric stations only.)
- DPNP - Departure from normal monthly precipitation.
- DPNT - Departure from normal monthly temperature.
- DT00 - Number days with minimum temperature < 0 F.
- DT15 - Number days with maximum temperature < 15 C. (Metric stations only.)
- DT30 - Number days with maximum temperature > 30 C. (Metric stations only.)
- DT32 - Number days with minimum temperature < 32 F.
- DT90 - Number days with maximum temperature > 90 F.
- DX15 - Number days with maximum temperature < 15 C. (Metric stations only.)
- DX32 - Number days with maximum temperature < 32 F.
- EMXP - Extreme maximum daily precipitation in the month. (Contains the day of occurrence in the DAY field.)
- EMNT - Extreme minimum temperature for the month. (Contains the day of occurrence in the DAY field.)
- EMXT - Extreme maximum temperature for the month. (Contains the day of occurrence in the DAY field.)
- HTDD - Monthly heating degree days - base 65 degrees F. (July 1950 onward.)
- MMNT - Monthly mean minimum temperature.
- MMXT - Monthly mean maximum temperature.
- MNTM - Monthly mean temperature.
- TPCP - Total monthly precipitation.

2.2.2 Statistical Analysis Model

Generalized linear mixed effects models were used in all analyses of this task. The models have general form

$$y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ijk} \qquad (2.10)$$

Where
y_{ijk} = acre-inches for the i-th location, j-th year and k-th month.
μ = overall mean acre-inches,
α_i = effect due to the i-th location, and assumed to be normally distributed with mean zero and standard deviation σ_α,
βj = effect due to the j-th year, and assumed to be normally distributed with mean zero and standard deviation σ_β
γ_k = effect due to the k-th month, and assumed to be normally distributed with mean zero and standard deviation σ_γ.
ε_{ijk} = residual effect, assumed to be normally distributed with mean zero and standard deviation σ_ε.

Essentially this model assumes that there is an overall mean acre-inches value that is common to all sites, years and months. A particular site will have a long term mean irrigation level that deviates slightly from the overall mean. When one looks across all sites, these deviations look like observations from a random variable having a normal (Gaussian) distribution. This distribution has mean zero which is required if μ is to be the overall mean. This distribution has standard deviation $\sigma_\alpha > 0$ which indicates how spread out the site deviations are from this overall mean. Using this information the 95% coverage region is computed and used to define “normal and expected” overall long-term site average acre-inches pumped value. This would answer the question “What is a typical range of acre-inches pumped across all sites?”

The year and month effects are defined similarly to the site effect. For example, the standard deviation of year effect σ_β can be used to compute another 95% coverage interval that defines the “normal and typical range of average annual acre-inches pumped over and above the site-specific long-term mean”. Similarly the standard deviation of month effect σ_γ can be used to compute another 95% coverage interval that defines the “normal and typical range of average within-year (monthly) acre-inches pumped over and above the site-specific long-term mean and any year-to-year deviations.”

Plots of the site, year, month and residual effects from the general linear mixed model fit to the different crop data that are provided in the results section. These plots are useful in identifying systematic patterns in pumping (in particular with site, year and month) and in identifying site by year by month combinations that produced very large residuals. In addition, normal probability plots are used to assess whether the normality assumptions made above are acceptable.

Finally, because the data represent time series recorded for each well, an additional model that allowed the residual terms to be autocorrelated was examined. Significant autocorrelation suggests that the residual observed for one site, year, and month is correlated with the residual recorded for the previous month for that site. If significant autocorrelation exists and is not accounted for in the model, the variance components for site, year and month may underestimate the true variability and hence provide a false description of true (long-run) variability in the response. Adding an autocorrelation term (typically denoted as $0 \leq \rho \leq 1$) to the variance structure of the residuals adds to the complexity of variance component estimation and testing. In this analysis, state-of-the art estimation and testing techniques were used as implemented in the MIXED procedure in SAS (SAS Version 9.0, 2003, SAS Institute, Inc., Cary, NC.).

Once the model in Equation 1 was fit, it was systematically examined to determine if any of the climate data significantly improved on the model. If x_{ijk} represents rainfall or temperature at the i-th sample well, j-th year and k-th month, the new model is:

$$y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \theta x_{ijk} + \varepsilon_{ijk} \qquad (2.11)$$

where θ is the regression coefficient that measures the degree to which knowledge of x explains variability in the response y. Approximate F-tests are used to test whether θ is equal to zero. For the climate data obtained from the National Weather Service recording sites, each sample well was linked to its nearest climate site, hence the data from the climate site was replicated for each sample well with which it was associated. Note that the site-specific climate data is available for a subset of years and hence a reduced size dataset was used for these covariate analyses. When the national data were used, all sites and times were analyzed.

When climate information is available for only one site for a particular crop, the model is further reduced to:

$$y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \theta x_{jk} + \varepsilon_{ijk} \qquad (2.12)$$

where site-specific covariate information is not available (note that x only has the jk subscripts). In this case, the climate information can only help to explain variability in year and month means but will not be useful to describe site differences.

A manual version of stepwise regression was used to explore whether some combination of the national climate information could be useful in explaining residual variability. Approximate F-tests were used to determine which factors should be included or excluded in the model. The reported results are presented with a “generalized R^2 goodness of fit statistic” (Schabenberger, Pierce and Pierce 2001) that is interpreted as is typical for the R^2 term in multiple regression, that is, as the percent of total variability in the response y that is explained by the model.

2.3 Task Three: Quality Assurance (QA) Checks

In deciding on the methods to be used in evaluating incoming data from the wells, the degree of complexity of the test as well as the extent to which the testing incorporated the information learned in Task 2 were considered. From this, the following three methods are used in the quality assurance checks.

2.3.1 Simple Range Testing

A simple range test is an algorithm that determines if an observation lies within a predetermined range. The allowable ranges are based on the distribution of past data. If a datum is observed outside the allowable range, it is flagged with a failure flag.

A range test essentially examines the whole or some part of the dataset, generates an empirical distribution of these values and from this distribution, upper and lower thresholds defining the range are estimated. Typically the thresholds are set not at the minimum or maximum observed values but at some tail percentile. Measures that divide a group of ordered data into equal parts are collectively called quartiles. Use of the lower and upper 2.5 percentiles is recommended, i.e., the estimated 25/1000 quartile or the $Q_{0.025}$ and the 975/1000 quartile or $Q_{0.975}$, if one wishes a two sided interval. If one is only interested in the high irrigation events, the 95th percentile (the $Q_{0.95}$) or the 99th percentile (the $Q_{0.99}$) should be considered. These values are easily computed using the formulas that follow. Note that this method is non-parametric in that no assumption of a parametric distribution is used. In this case, the available data set the limits.

Assume $y_{[1]}, y_{[2]}, \ldots, y_{[n]}$ are the observed data (acre-inches) arranged from smallest to largest.
Let p be the desired quartile (with values like 0.025, or 0.95 or 0.975).

Define the ordinal of the desired quartile as n*p and divide this into an integer part, i, and a fractional part, f. For example, suppose n=91 and p=0.95, then n*p = 91*0.95 = 86.45 = (i=86) + (f=0.45). Then the value of the desired quartile is

$$q_p = \begin{cases} \dfrac{(y_{[i]} + y_{[i+1]})}{2} & \text{if } f > 0 \\ y_{[i+1]} & \text{if } f = 0 \end{cases} \tag{2.13}$$

Thus the quartile is estimated by an actual observed value (f = 0) or by the average of the two values on either side of the true value (f > 0). Instead of the simple average a weighted average as could be used follows:

$$q_p = \begin{cases} (1-f)y_{[i]} + (f)y_{[i+1]} & \text{if } f > 0 \\ y_{[i+1]} & \text{if } f = 0 \end{cases} \tag{2.14}$$

For moderate to large sample sizes there will be little difference between these two values. In the tables provided in this report, the formula for equation 1 is used since this is automatically computed in SAS. Computation of these numbers can also easily be performed in a spreadsheet application.

These values have been computed for three subgroups.

1. The dataset constructed for all sites over all recorded time. This results in one set of threshold range values. This also allows examination of the range computed from the largest possible set of data. Of course, site, month and year effects are all combined in the analysis and hence the range thresholds do not change by site, month or year. These are the most extreme values one would expect anywhere and anytime.
2. A dataset of the time series for each specific site. This results in one set of threshold range values for each site. This identifies the expected to be the most extreme events at a particular site anytime. If there is little data from the site it becomes difficult to produce the range values with any confidence.
3. A dataset of the data across sites for each specific time. In practical terms this would be a particular month or week depending on crop, combining in the dataset data from all available years. This produces a set of threshold range values for

each time, essentially producing a pair of threshold time series. These are the most extreme values one would expect at a specific time across all sites.

Clearly each dataset above produces slightly different range values that are used in slightly different ways. In a quality control setting, any new value arriving from a particular well would first be checked against the overall range thresholds, then against its site thresholds and also against it date threshold.

2.3.2 Step Test

A step test is a range test that is designed to determine if the change in value from one month to the next is greater than or less than expected. It is designed specifically for a time series and hence can only be applied to each crop by dataset.

To develop the range thresholds for a step test, first compute change in acre-inches between neighboring dates. Using the notation of the previous section, now let y_1, y_2, …, yn be the acre-inches measurements for time 1, 2, …n respectively, where time may be month or week. What to do about potato data where the time series breaks each year is discussed later. The step, denoted d_i, between time i-1 and i is computed as $d_i = y_i - y_{i-1}$. Note that the step may be positive or negative. For this analysis the absolute value of the step is computed. This allows exploration of the distribution of changes, regardless of whether it was an increase or decrease. Once the steps are computed, the step data is handled in the same manner that the actual acre-inches measurements were dealt with in the previous section. In this way quantiles for steps are computed. If the step from the previous month to the current month is greater than (or less than) the upper quantile, say $q_{0.975}$ (or the lower quantile, $q_{0.025}$) then the measurement for that month is flagged as a failure and further study on that value is merited.

The step test threshold values can be computed for 1) the total time series for each site, or 2) for each site by month. The latter values allow assessment of steps by month. Thus, for example, the distribution of steps from November to December may indicate that very large steps are quite common, whereas steps from December to January are less common.

The above ranges can also be computed on the absolute value of the step if it is only the magnitude of step that is of importance and not whether the step was an increase or a decrease. In this case, only one-sided tests are of interest and the $q_{0.95}$ or the $q_{0.99}$ of the absolute steps are used as the threshold values.

With potatoes, the time series is not continuous in the sense that measurements are only taken, and rightly so, during the production season. This means that the step values are only computed within each season. This will result in fewer step values in the distributions and hence more uncertainty associated with the quantiles.

2.3.3 Model-Based Range Test

The simple range and step tests are non-parametric in the sense that no distributional assumptions are required to obtain the threshold ranges. This can be an advantage but it also can be quite inefficient. For example, if there is only a little information on a particular site, the threshold values will be very poor estimates of what would be expected over a longer sampling time. In addition, all sites associated with the same crop should be experiencing similar climate and soils. This suggests pooling information across this common experience to obtain more precise threshold estimates.

To be able to pool information requires the use of a parametric model. In Task II a number of factors were identified and variability model fit to the crop datasets. In the model-based range test the fitted model is used to derive a test that has greater power to identify observations that should be flagged while avoiding other observations, that while large, are not unexpectedly so, for the particular site and month.

The models developed in Task II essentially decompose the time series data into site, year, month and residual effects. The site effects represent adjustments to the overall average acre-inches irrigation that can be attributed to a site. The month effect represents adjustment to the overall average acre-inches irrigation that can be attributed to a particular month. As in Task II let

$$y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ijk} \tag{2.15}$$

where

y_{ijk} = acre-inches for the i-th location, j-th year and k-th month.

μ = overall mean acre-inches,

α_i = effect due to the i-th location, and assumed to be normally distributed with mean zero and standard deviation σ_α,

βj = effect due to the j-th year, and assumed to be normally distributed with mean zero and standard deviation σ_β

γ_k = effect due to the k-th month, and assumed to be normally distributed with mean zero and standard deviation σ_γ.

ε_{ijk} = residual effect, assumed to be normally distributed with mean zero and standard deviation σ_γ.

Let

$\hat{\mu}$ = overall mean acre-inches (the BLUE = best linear unbiased estimator),

$\hat{\alpha}_i$ = estimated effect (the EBLUP = the estimated best linear unbiased predictor) associated with the i-th location

$\hat{\sigma}_\alpha$ = estimated standard deviation associated with site effects,

$\hat{\beta}_j$ = estimated effect (the EBLUP = the estimated best linear unbiased predictor) associated with the j-th year

$\hat{\sigma}_\beta$ = the estimated standard deviation associated with year effects.

$\hat{\gamma}_k$ = estimated effect (the EBLUP = the estimated best linear unbiased predictor) associated with the k-th month

$\hat{\sigma}_\gamma$ = the estimated standard deviation associated with month effects.

$\hat{\varepsilon}_{ijk}$ = estimated residuals

$\hat{\sigma}_\varepsilon$ = the estimated standard deviation associated with residual effects.

All of these estimates, with the exception of the estimated residuals are provided in tables in the chapter in this document beginning on page 133.

To assess the value of a newly recorded observation, say from site i in month k, one can use the information on the expected overall mean (the intercept term, $\hat{\mu}$), its site effect ($\hat{\alpha}_i$) and its month effect ($\hat{\gamma}_k$) to compute the mean for that measurement. The year effect is not known since all of the information needed to estimate that year effect has not yet been collected. On the other hand, estimates are available for the year and residual standard deviations ($\hat{\sigma}_\beta$ and $\hat{\sigma}_\varepsilon$ respectively). These estimates, and the assumption that deviation of the observed value from the expected value is normally distributed, are used to create a model-based range check.

Let $y_{i.k}$ be the newly observed value for well i in month k. Define the expected value for this observation as:

$$\hat{y}_{i.k} = \hat{\mu} + \hat{\alpha}_i + \hat{\gamma}_k \tag{2.16}$$

and compute the difference as

$$d_{i.k} = y_{i.k} - \hat{y}_{i.k} = y_{i.k} - \hat{\mu} + \hat{\alpha}_i + \hat{\gamma}_k \tag{2.17}$$

From the models developed in Task II, the $d_{i.k}$ should be normally distributed with mean equal to zero and standard deviation approximately equal to:

$$\sigma_d = \sqrt{\sigma_\beta^2 + \sigma_\varepsilon^2}\ . \tag{2.18}$$

Replacing the unknown standard deviations with expected values compute a 95% expected range for $d_{i.k}$ using

$$\left[-z_{0.975}\hat{\sigma}_d, +z_{0.975}\hat{\sigma}_d\right]. \tag{2.19}$$

The nice thing about this range is that it works regardless of site or month since site and month effects are removed and it is only the residuals that are being examined. Thus, in this check one is able to flag measurements that are not only large (or small), but that deviate much from the model expectations fit using the long-term time series.

Because significant autocorrelations were found in the residuals of the fitted models in Task II, the range thresholds in equation 5 are not theoretically exact. In fact, these ranges are probably slightly too large. Additional statistical research is needed to get these limits exact. The recommendation to use equation 5 is supported since the difference between the theoretical best limits and the ones recommended here are unlikely to be very large.

3 Results of Analysis

3.1 Task One: Sample Size Determination

3.1.1 Ridge Citrus

The ridge citrus dataset as originally supplied had 9820 observations. Removing the “Inaccurate” and “below zero” acre-inches irrigation observations resulted in 9421 observations for the analysis. A table of n_t, $\overline{y}_t$, and s_t estimates for each month for which data are available is presented in Table 1. A times-series plot of the total estimated water withdrawal and associated 95% confidence intervals is given in Figure 1.

A table of the estimated relative precision for each month, based on the assumption of a finite population size at each month of N_t=536 (the population count for permits in 2003) and using the average ‘acre-inches per acre’ method is presented in Table 2. A table of the estimated relative precision for each month, based on the same population size assumption but using the ratio method is presented in Table 3. Times-series plots of percent relative precision for ridge citrus based on Table 2 and Table 3 statistics are given in Figures 2 and 3.

On average about 1 acre inch per acre is applied for irrigation of ridge citrus with higher amounts possible most months in the year but with higher probability in the winter months. Table 2 and Figure 2 demonstrate that relative precision in most spring months is below 20%. The fall months typically have much higher variability and hence the relative precision for these months are much higher, closer to 30% and in some cases can get as high at 70%. The larger relative precision values in recent years seem to be more a factor of smaller average withdrawals than either increased variability or decreased sample size. This suggests that sample sizes for ridge citrus are adequate to estimate total water withdrawal in the spring but that much larger samples sizes would be needed to precisely estimate withdrawal in the other months of the year. At 200% CV, a sample of 260 wells would be needed, roughly half the 536 estimated for the total population.

Table 3 and Figure 3 suggest that the ratio method represents a much less precise method of estimating total water withdrawal. This is probably due to the lack of correlation between total acre-inches withdrawn and acreage. Essentially irrigation is based on acre-inches per acre and not on acreage, hence it makes sense to use the sample average acre-inches per acre in estimating the total water consumed.

Table 1 Basic Statistics on Acre-inches per Acre for sampled ridge citrus wells.

		Month											
Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991	Count							3	11	18	31	37	40
	Average							0.21	0.65	0.87	0.7	1.08	0.89
	Std Dev							0.19	0.49	0.6	0.63	0.82	0.57
	CV							91.06	75.48	69.34	89.6	76.05	63.5
1992	Count	40	42	42	43	42	42	49	55	56	54	60	63
	Average	1.96	0.19	0.57	1.04	1.46	0.34	1.24	0.25	0.52	0.98	0.35	0.36
	Std Dev	1.21	0.27	0.61	0.62	1.05	0.29	1.09	0.51	0.59	0.84	0.35	0.41
	CV	61.91	142.3	105.9	58.91	71.66	84.79	88.13	200.6	112.9	85.73	100.4	116.9
1993	Count	63	63	65	65	63	66	67	67	67	66	66	70
	Average	0.15	0.12	1.33	0.94	1.76	1.26	0.88	1.7	0.65	0.78	0.73	1.61
	Std Dev	0.25	0.16	1.26	0.69	1.32	0.99	0.86	1.14	0.61	0.62	0.66	1.41
	CV	165.9	132.1	94.69	73.93	74.72	78.65	96.97	66.74	94.13	79.58	90.28	87.47
1994	Count	71	71	71	70	71	70	71	72	70	72	72	71
	Average	0.26	0.14	0.97	1.79	1.7	0.31	0.44	0.09	0.19	0.2	0.3	0.14
	Std Dev	0.48	0.23	0.57	1.24	1.06	0.38	0.6	0.15	0.26	0.23	0.33	0.2
	CV	181.5	164.2	58.68	68.89	62.32	123.8	138.1	172.7	136.8	116.9	111.5	139.3
1995	Count	71	71	68	71	71	72	72	73	73	75	75	75
	Average	0.05	1.39	0.56	0.91	1.83	1	0.79	0.53	0.49	0.22	0.88	1.26
	Std Dev	0.12	1.17	0.47	0.7	1.23	0.85	0.88	0.6	0.8	0.34	1.4	1.09
	CV	233.6	84.69	83.41	76.66	67.15	84.99	112.1	113.7	163.1	156.2	158.7	86.95
1996	Count	76	75	76	76	75	73	74	75	76	76	76	76
	Average	1.71	2.82	0.28	0.81	1.55	0.7	1.25	0.9	0.72	0.91	1.11	0.69
	Std Dev	2.94	1.82	0.43	0.67	1.06	0.67	0.88	0.69	0.77	0.75	0.84	0.85
	CV	172.1	64.72	156.3	82.31	68.27	97.02	69.94	76.66	106.2	82.48	75.47	123.3
1997	Count	76	75	75	76	76	76	73	72	72	70	69	69
	Average	1.4	0.55	1.08	0.86	1.29	0.54	0.64	0.79	1.1	1.1	0.35	0.08
	Std Dev	1.18	0.54	0.72	0.78	0.91	0.61	0.58	0.76	0.73	0.85	0.39	0.16
	CV	84.56	98.37	66.9	91.47	70.34	112.7	91.12	96.58	66.91	77.46	110.6	198.2
1998	Count	71	70	69	70	68	68	67	68	69	68	68	68
	Average	0.07	0.02	0.22	1.56	2.26	3.01	1.06	0.68	0.34	1.26	1.03	1.48
	Std Dev	0.17	0.07	0.37	0.89	1.27	1.62	0.93	0.82	0.66	1.09	0.9	1.82
	CV	251.1	269	168.4	57.11	56.05	53.94	87.34	121.4	193.9	86.43	86.86	122.8
1999	Count	68	68	67	67	68	68	68	67	65	66	66	65
	Average	1.02	0.91	2.06	2.49	1.07	0.49	0.97	0.95	0.63	0.32	0.69	0.9
	Std Dev	0.69	0.77	2.26	1.26	0.84	0.48	0.73	1.07	0.63	0.65	0.77	0.88
	CV	67.44	84.27	109.9	50.46	78.39	97.16	75.98	112.6	100.8	200.3	112.3	97.37
2000	Count	65	65	65	65	67	67	66	67	67	67	66	67
	Average	1.36	0.92	1.99	1.47	2.76	1.81	0.45	0.72	0.49	1.37	1.69	2.16
	Std Dev	1.09	0.99	1.37	1.03	1.75	1.18	0.56	1.05	1.46	1.06	1.57	1.56
	CV	79.99	107.8	68.92	69.71	63.37	65.23	123.6	145	298.6	77.82	92.83	72.19
2001	Count	67	65	65	65	65	65	62	61	61	61	61	61
	Average	3.16	0.76	0.7	1.65	1.99	0.99	0.22	0.38	0.47	0.98	0.79	1.28
	Std Dev	2.22	0.59	0.52	1.06	1.02	0.69	0.38	0.42	1.11	1.02	0.83	0.94
	CV	70.05	77.5	74.65	63.88	51.28	69.96	170.6	111.5	235.5	104.5	104.1	73.32
2002	Count	60	60	62	62	62	61	60	60	60	58	59	59
	Average	1.82	0.72	1.6	1.97	2.52	0.53	0.14	0.24	0.11	0.63	0.47	0.17
	Std Dev	1.33	0.98	1.18	1.11	1.52	0.5	0.39	0.58	0.28	1.43	0.65	0.3
	CV	73.52	135.9	73.62	56.4	60.35	94.53	276.2	246.2	250.9	226.2	137.2	176.5

Table 1 Continued.

Year		Jan	Feb	Mar	Apr	May	Month Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	Count	61	63	63	61	63	64	63	62				
	Average	2.51	0.06	0.20	0.95	1.60	0.31	0.23	0.09				
	Std Dev	2.32	0.14	0.65	0.97	1.09	0.54	0.47	0.18				
	CV	92.57	219.9	324.3	102.7	68.24	174.6	204.8	194.6				

Table 2 Estimated relative precision of average acre-inches per acre as measured in SJRWMD database for ridge citrus based on the simple average estimate on a finite population of N=536 permitted wells.

Year	Jan	Feb	Mar	Apr	May	Month Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	0.19	0.43	0.32	0.18	0.22	0.26	0.25	0.53	0.29	0.23	0.25	0.28
1993	0.4	0.32	0.23	0.18	0.18	0.19	0.23	0.16	0.22	0.19	0.21	0.2
1994	0.41	0.37	0.13	0.16	0.14	0.28	0.31	0.39	0.31	0.26	0.25	0.32
1995	0.53	0.19	0.19	0.17	0.15	0.19	0.25	0.25	0.37	0.34	0.35	0.19
1996	0.38	0.14	0.34	0.18	0.15	0.22	0.16	0.17	0.23	0.18	0.17	0.27
1997	0.19	0.22	0.15	0.2	0.15	0.25	0.2	0.22	0.15	0.18	0.26	0.46
1998	0.57	0.62	0.39	0.13	0.13	0.13	0.21	0.28	0.45	0.2	0.2	0.29
1999	0.16	0.2	0.26	0.12	0.18	0.23	0.18	0.26	0.24	0.48	0.27	0.23
2000	0.19	0.26	0.16	0.17	0.15	0.15	0.29	0.34	0.7	0.18	0.22	0.17
2001	0.16	0.19	0.18	0.15	0.12	0.17	0.42	0.28	0.58	0.26	0.26	0.18
2002	0.18	0.34	0.18	0.14	0.15	0.23	0.69	0.62	0.63	0.58	0.35	0.45
2003	0.23	0.54	0.79	0.25	0.17	0.42	0.5	0.48				

Table 3 Estimated relative precision for average acre-inches per acre for ridge citrus based on the ratio method estimate using acre-inches and acres and assuming a finite population of N=536 permitted wells.

Year	Jan	Feb	Mar	Apr	May	Month Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	0.50	1.02	0.62	0.41	0.38	0.77	0.39	0.68	0.76	0.44	0.66	0.70
1993	0.75	0.68	0.59	0.49	0.5	0.45	0.42	0.24	0.57	0.54	0.56	0.41
1994	0.63	0.61	0.24	0.27	0.28	0.62	0.55	0.56	0.66	0.66	0.65	0.59
1995	0.57	0.54	0.69	0.41	0.38	0.44	0.58	0.59	0.58	0.64	0.52	0.44
1996	0.48	0.36	0.54	0.45	0.48	0.56	0.36	0.47	0.54	0.49	0.39	0.54
1997	0.52	0.50	0.46	0.52	0.46	0.56	0.54	0.58	0.46	0.52	0.65	0.62
1998	0.55	0.55	0.57	0.45	0.44	0.44	0.36	0.53	0.58	0.49	0.54	0.41
1999	0.53	0.55	0.41	0.42	0.50	0.52	0.49	0.51	0.50	0.68	0.67	0.53
2000	0.58	0.58	0.39	0.39	0.30	0.43	0.55	0.56	0.60	0.57	0.50	0.45
2001	0.51	0.61	0.64	0.49	0.39	0.48	0.62	0.59	0.61	0.62	0.69	0.49
2002	0.63	0.71	0.48	0.30	0.27	0.64	0.68	0.60	0.60	0.67	0.75	0.70
2003	0.56	0.65	0.58	0.57	0.53	0.59	0.62	0.63				

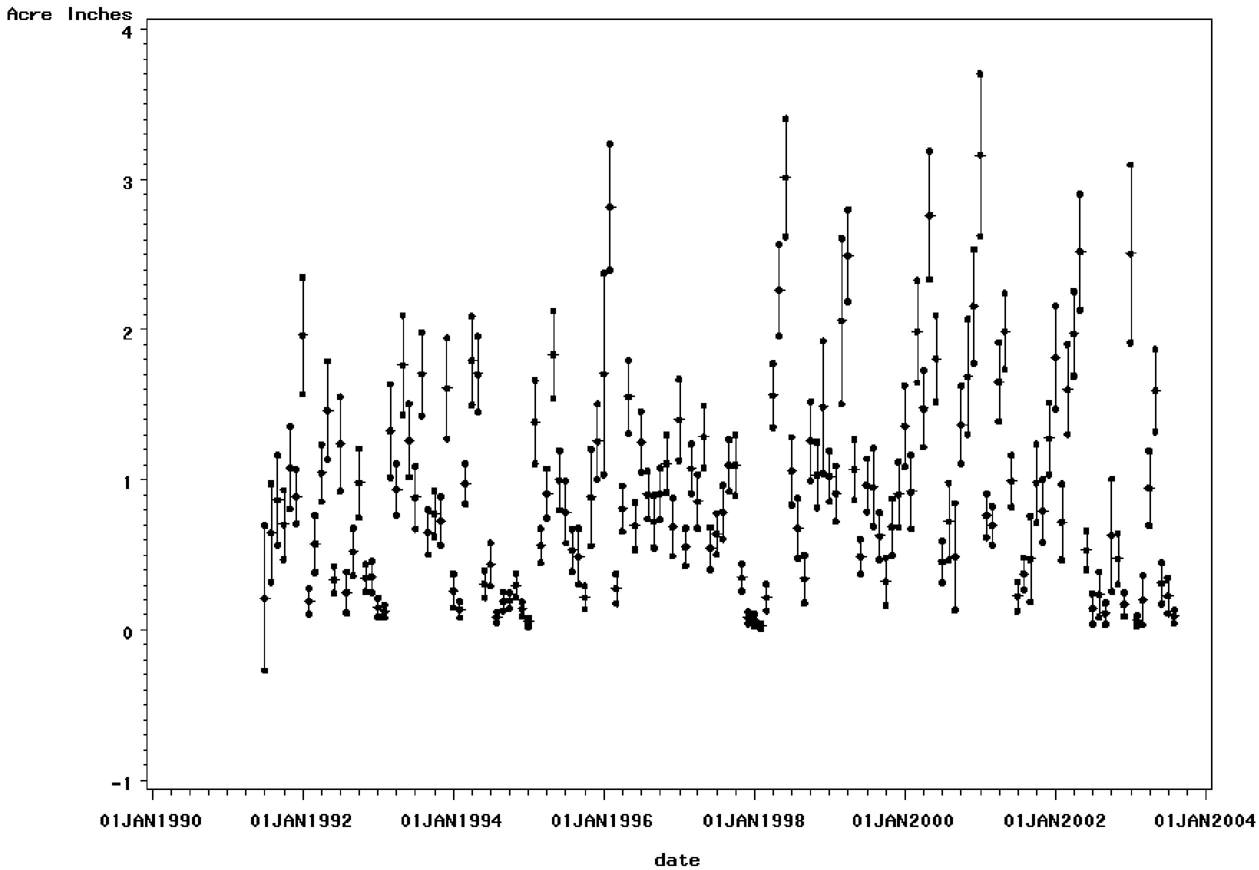

Figure 1 Time series plot of sample means with upper and lower 95% confidence bounds for sampled ridge citrus wells.

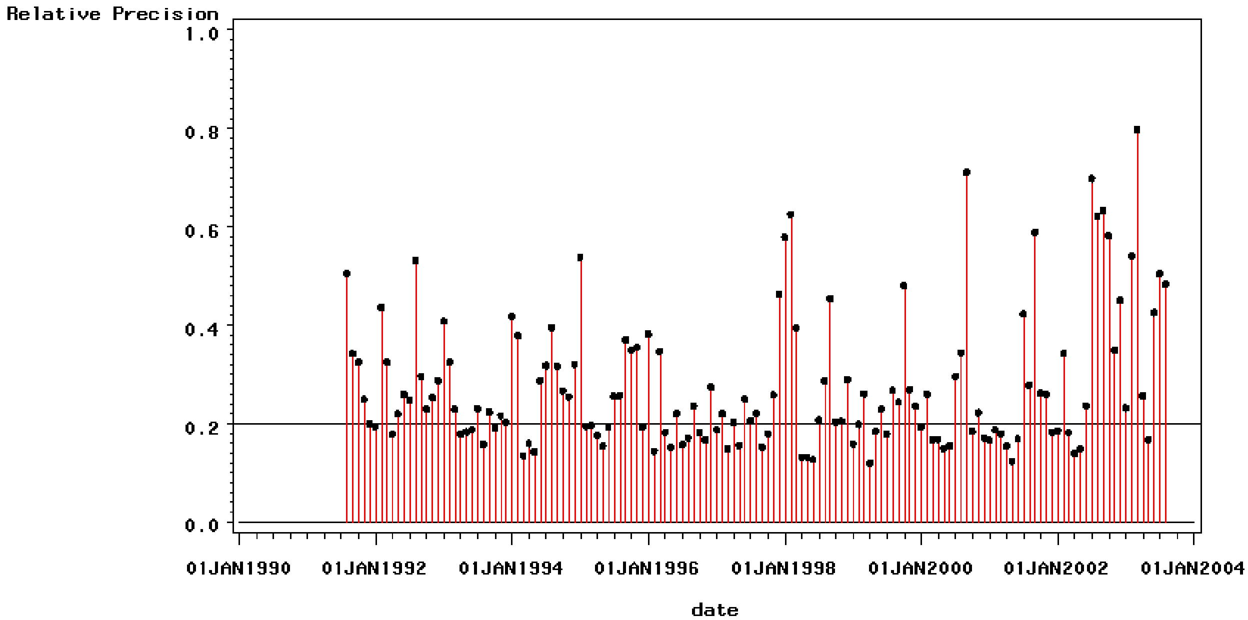

Figure 2 Relative precision of the average acre-inches per acre by date for ridge citrus wells using the simple average estimate and assuming the finite population size is 536 permitted wells.

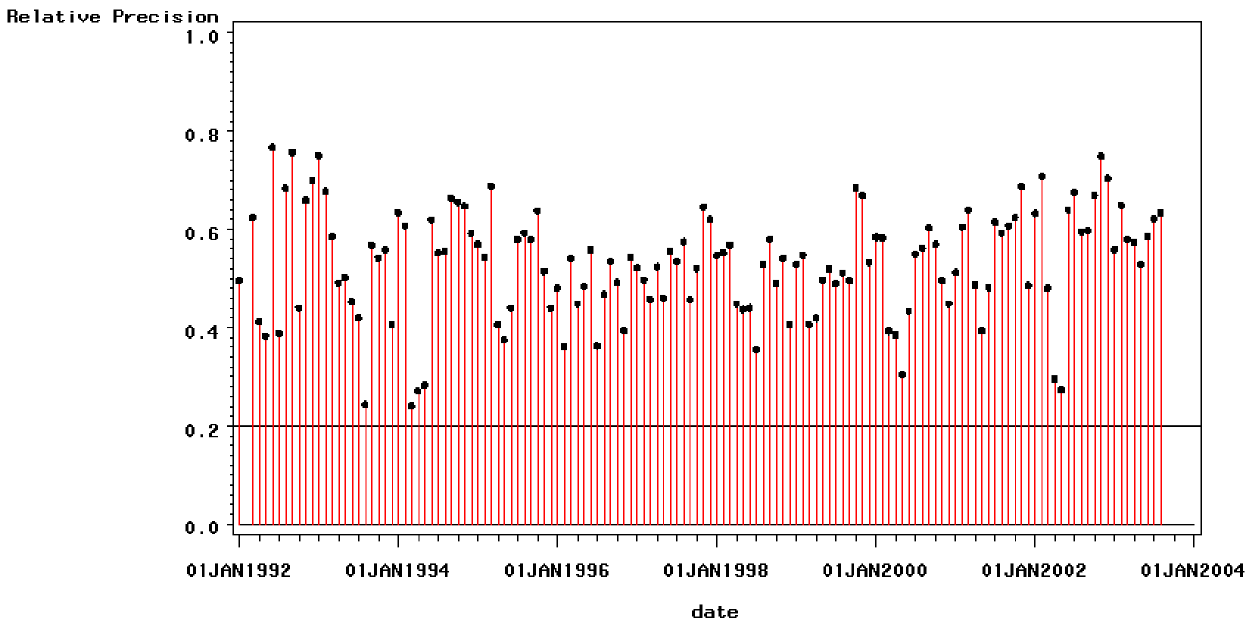

Figure 3 Relative precision of average acre-inches per acre by date for ridge citrus wells using the ratio method and assuming the finite population size is 536 permitted wells.

3.1.2 Flatwoods Citrus

The flatwoods citrus dataset as originally supplied had 1515 observations. Removing the "Inaccurate" and "below zero" acre-inches irrigation observations resulted in 1383 observations for the analysis. A table of n_t, $\bar{y}_t$, and s_t estimates for each month for which data are available is presented in Table 4. A times-series plot of the total estimated water withdrawal and associated 95% confidence intervals is given in Figure 4.

The breakdown between ridge citrus and flatwoods citrus was not performed in the original 1988 report. It was assumed that the total number of wells for flatwoods citrus was N_t=244 based on the 2003 well permits file submitted by the District. The estimated relative precision for total consumption based on the average acre-inches per acre for each month are presented in Table 5 and those for the ratio method are presented in Table 6. Times-series plot of percent relative precision for flatwoods citrus based on Table 5 and Table 6 are given in Figures 5 and 6.

From Figure 4 the variability in acre-inches per acre is shown to have been decreasing over time as has the associated uncertainty in the average. This is primarily due to the increased sample sizes for the last three years of data. Table 5 and Figure 5 suggest that current sample sizes are still not sufficient to estimate total water withdrawn to a relative precision of 20% for most months but that that level of precision is close for the spring months. Current sample sizes are more adequate for about 30% relative precision. The last measurement in July of 2003 suggests that current sample size for the flatwoods citrus monitoring program is n=67 wells (27% of total well population). With CV values being quite larger than 100% and closer to say 140% in recent months, simple size calculations as described in the results section suggests that an n of 67 should be adequate to meet a 33% relative precision targets in most months. To reach the 20% relative precision target in most months with high CV (say 140%) would require a sample size closer to 123 wells, about half the total wells. This sample size is clearly not realistic and is only required for those months where average acre-inches per acre water use is quite low. In these months, only a few wells show positive water withdrawal with the rest at zero, resulting in large coefficient of variability.

As was found with ridge citrus, the ratio method of estimation results in a much less precise estimate and cannot be recommended for evaluation of sample size adequacy in this case.

Table 4 Basic Statistics on sampled flatwoods citrus wells.

YEAR		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999	Count		1	5	5	5	6	6	5	5	5	10	10
	Average		2.17	2.58	2.97	0.33	0.05	0.70	0.48	0.10	0.02	0.32	0.26
	Std Dev			1.68	2.62	0.16	0.07	0.77	0.63	0.22	0.04	0.33	0.23
	CV			65	88	48	154	110	131	224	194	103	86
2000	Count	11	12	12	15	15	16	15	16	20	22	22	23
	Average	0.21	0.75	1.71	1.36	3.19	1.20	0.22	0.74	1.24	1.14	2.05	1.74
	Std Dev	0.27	0.65	1.40	0.96	1.94	0.62	0.39	0.66	1.00	0.97	1.36	0.97
	CV	128	86	82	71	61	52	175	88	81	85	67	56
2001	Count	23	22	22	22	22	23	23	23	23	23	23	23
	Average	0.97	1.32	1.74	1.47	0.83	0.15	0.09	0.11	0.04	0.16	0.07	0.44
	Std Dev	0.67	0.87	1.32	0.89	0.61	0.20	0.17	0.14	0.06	0.32	0.13	0.36
	CV	70	66	76	60	74	130	186	126	159	204	179	81
2002	Count	23	22	23	27	33	38	41	39	40	42	45	45
	Average	0.31	0.33	1.17	0.93	1.44	0.34	0.03	0.06	0.59	1.28	1.18	0.12
	Std Dev	0.32	0.27	0.99	0.78	0.98	0.45	0.12	0.10	0.54	1.13	0.89	0.14
	CV	105	80	85	84	68	131	388	179	92	89	75	124
2003	Count	47	48	47	54	54	57	57	67				
	Average	0.47	0.83	0.59	0.99	0.98	0.13	0.53	0.04				
	Std Dev	0.49	0.65	0.78	0.84	0.89	0.23	0.64	0.10				
	CV	106	78	133	85	91	186	121	257				

Month (spanning header over Jan–Dec)

Table 5 Estimated relative precision for average acre-inches per acre for flatwoods citrus using the simple average method and assuming a finite population of N=244 permitted wells.

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999			0.81	1.10	0.60	1.62	1.15	1.62	2.77	2.40	0.73	0.61
2000	0.86	0.55	0.52	0.39	0.34	0.27	0.96	0.47	0.37	0.37	0.29	0.24
2001	0.30	0.29	0.33	0.27	0.32	0.55	0.79	0.54	0.68	0.87	0.76	0.35
2002	0.45	0.35	0.36	0.33	0.24	0.42	1.20	0.57	0.29	0.27	0.22	0.36
2003	0.30	0.22	0.38	0.22	0.24	0.48	0.31	0.60				

Table 6 Estimated relative precision of average acre-inches per acre for flatwoods citrus using the ratio method and assuming a finite population of N=244 permitted wells.

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999			1.99	2.21	1.64	5.63	4.45	3.20	9.03	8.01	1.83	0.80
2000	3.38	0.95	0.72	0.60	1.52	0.56	2.21	1.45	0.80	0.95	0.49	0.41
2001	0.51	0.75	0.84	0.41	0.72	1.12	1.32	1.12	0.96	1.30	1.44	1.07
2002	1.44	1.52	1.14	0.93	0.36	0.53	0.71	0.63	0.52	0.54	0.37	0.62
2003	0.61	0.37	0.54	0.42	0.40	0.42	0.43	0.37				

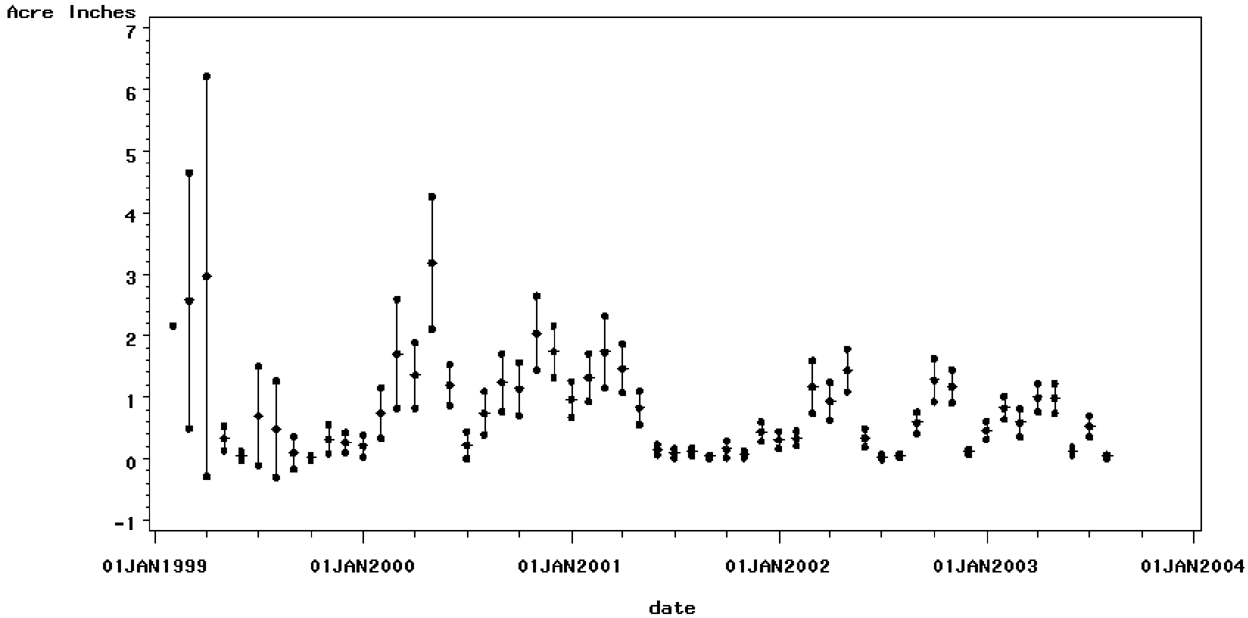

Figure 4 Time series plot of sample means with upper and lower 95% confidence bounds for flatwoods citrus.

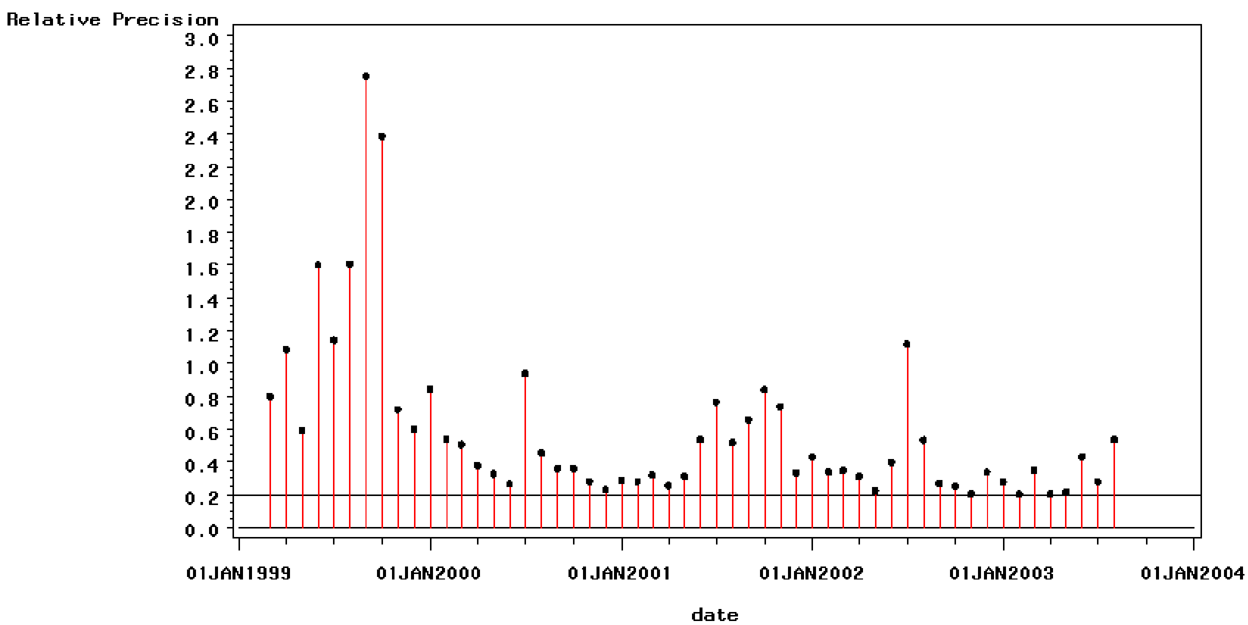

Figure 5 Relative precision of the simple average estimate by date for flatwoods citrus assuming the finite population size is 244.

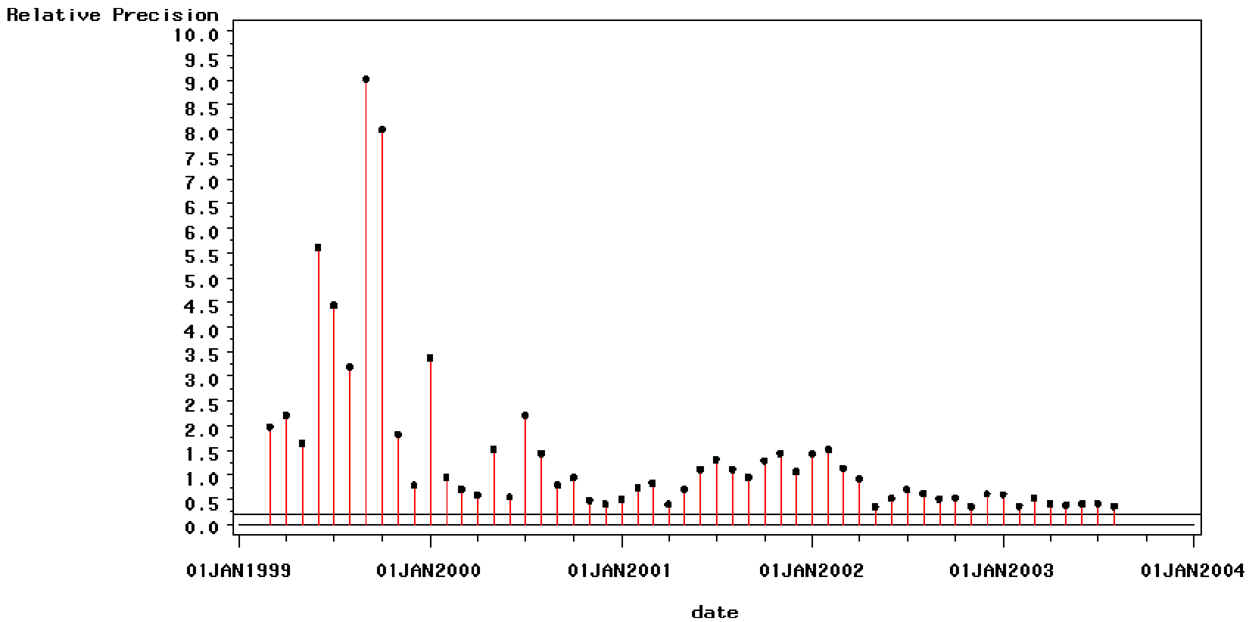

Figure 6 Relative precision of the ratio estimate by date for flatwoods citrus assuming the finite population size is 244.

3.1.3 Potatoes

The potato dataset as originally supplied had 5165 observations. Removing the "Inaccurate" and "below zero" acre-inches irrigation observations resulted in 5164 observations for the analysis. A table of n_t, $\bar{y}_t$, and s_t estimates for each month for which data are available is presented in Table 7. A times-series plot of the total estimated water withdrawal and associated confidence intervals is given in Figure 7.

Estimated relative precision for each sample date, based on the assumption that the finite population size of N_t=169 permitted wells, was computed using both the average acre-inches per acre statistics as well as the ration method. These values are also presented in Table 7 and plotted in Figures 8 and 9 respectively. The value of 169 was used in the initial computation of sample sizes in the 1988 report and no new population value was available from the permit file submitted by the District.

From Figure 8 it can be seen that the 20% relative precision estimate is typically met during the middle of the potato-growing season but is inadequate for the early and late sampling dates. At the beginning of the season, some wells are simply not used (having zero withdrawal) either because the crop was planted later than the first measurement dates or the grower simply felt no need to irrigate at that time. By the middle of the growing season, all wells are being used to some extent. Late in the season, some wells are not used because the crop has been harvested. The mixture of zero and non-zero withdrawals produces large standard errors that translate into large relative errors. The pattern is very consistent from year-to-year.

The sample size of 44 is adequate to handle CV values up to 66% for a total population size of 169. To handle a CV of 150%, not an atypical value for the end of the potato growing season, would require 66 wells, a 50% increase over the current monitoring well set.

The ratio method again does not work for the same reason it did not work for ridge citrus.

Table 7 Basic Statistics on sampled potato wells along with associated relative precision estimates using the simple average method as well as the ratio method.

Date	Number of Sites	Average Acre-inches per Acre	Standard Error	Coefficient of Variation	Relative Precision (Average Method)	Relative Precision (Ratio Method)
3/1/1990	21	1.40	2.45	174.6	0.746	1.31
4/2/1990	22	6.99	2.05	29.4	0.122	0.34
4/30/1990	22	3.91	1.77	45.2	0.188	0.88
5/31/1990	21	1.33	2.56	193.5	0.827	1.25
2/4/1991	38	0.01	0.08	616.4	1.789	0.39
3/1/1991	36	1.97	1.56	79.2	0.239	0.68
4/1/1991	37	2.81	1.83	65.1	0.192	0.31
5/2/1991	38	1.99	1.33	66.9	0.194	0.26
6/3/1991	38	0.79	1.43	180.4	0.000	0.63
2/1/1992	41	0.47	1.37	289.5	0.798	0.57
3/1/1992	41	0.39	1.18	299.6	0.826	0.56
4/1/1992	41	4.86	2.63	54.2	0.149	0.25
5/1/1992	41	6.85	2.27	33.2	0.091	0.17
6/1/1992	41	2.40	2.25	93.7	0.000	0.57
3/1/1993	40	0.22	0.62	282.3	0.791	0.54
3/31/1993	40	0.32	0.66	207.5	0.582	0.57
4/30/1993	40	7.89	2.35	29.8	0.083	0.14
6/1/1993	40	4.80	3.49	72.9	0.000	0.27
7/1/1993	1	6.51				
1/31/1994	39	0.00	0.00	624.5	1.781	0.35
3/1/1994	39	0.49	1.49	301.8	0.860	0.58
4/1/1994	38	5.43	2.46	45.3	0.132	0.22
4/8/1994	1	3.23				
5/2/1994	39	6.37	2.89	45.3	0.129	0.27
6/2/1994	38	1.70	2.61	153.1	0.000	0.70
1/31/1995	41	0.06	0.25	447.3	1.232	0.42
2/28/1995	41	2.11	2.31	109.5	0.302	0.53
4/1/1995	39	6.27	2.67	42.5	0.121	0.21
5/1/1995	41	4.29	2.40	55.9	0.154	0.43
6/1/1995	39	1.68	1.82	108.1	0.000	0.69
2/2/1996	37	0.19	0.72	387.9	1.147	0.57

Table 7 Continued.

Date	Number of Sites	Average Acre-inches per Acre	Standard Error	Coefficient of Variation	Relative Precision (Average Method)	Relative Precision (Ratio Method)
3/1/1996	38	3.67	2.17	59.0	0.171	0.50
4/1/1996	38	0.57	0.60	104.7	0.304	0.55
5/1/1996	38	5.46	2.14	39.2	0.114	0.42
6/3/1996	38	3.56	3.74	105.2	0.000	0.62
1/16/1997	46	0.10	0.47	474.4	1.206	0.39
2/3/1997	49	0.16	0.67	428.4	1.040	0.39
2/17/1997	48	0.24	0.67	283.0	0.697	0.47
3/3/1997	47	2.03	1.68	83.1	0.208	0.45
3/17/1997	47	3.31	1.45	43.9	0.110	0.34
4/1/1997	47	2.14	1.43	66.7	0.167	0.40
4/15/1997	47	3.59	1.65	46.0	0.115	0.37
5/1/1997	48	1.17	0.96	82.1	0.202	0.49
5/15/1997	48	0.39	0.98	250.7	0.618	0.46
6/4/1997	48	0.72	1.59	222.7	0.000	0.48
6/30/1997	49	0.00	0.00			
7/31/1997	1	0.00				
10/1/1997	2	0.42	0.60	141.4		
11/1/1997	2	3.94	0.53	13.4		
12/2/1997	2	0.68	0.96	141.4	0.000	19.05
1/15/1998	49	0.00	0.00	700.0	1.699	0.28
2/2/1998	49	0.00	0.00	700.0	1.699	0.24
2/16/1998	49	0.00	0.00	420.1	1.020	0.28
3/2/1998	49	0.00	0.00			
3/16/1998	49	0.30	0.68	228.6	0.555	0.47
4/1/1998	49	1.78	1.86	104.5	0.254	0.46
4/15/1998	49	3.86	1.87	48.4	0.117	0.35
4/30/1998	48	4.24	1.43	33.7	0.083	0.28
5/14/1998	49	2.31	2.00	86.4	0.210	0.46
6/1/1998	48	1.67	2.09	125.4	0.000	0.51
6/9/1998	1	0.00				
6/15/1998	8	3.05	2.08	68.3	0.000	1.90
7/1/1998	50	1.03	1.73	168.3	0.000	0.45
12/31/1998	52	0.00	0.00	721.1	1.675	0.18
1/14/1999	50	0.18	0.82	445.7	1.066	0.37
2/1/1999	50	0.01	0.05	646.2	1.546	0.31
2/15/1999	50	0.17	0.50	290.9	0.696	0.41
3/1/1999	49	1.71	2.06	120.5	0.292	0.47
3/15/1999	49	2.42	1.46	60.2	0.146	0.40
3/30/1999	50	4.08	1.92	47.1	0.113	0.31
4/15/1999	50	3.31	1.73	52.3	0.125	0.36
5/4/1999	50	3.00	2.40	80.1	0.192	0.39
5/17/1999	51	0.88	1.35	153.4	0.362	0.48
6/2/1999	51	0.80	1.52	189.3	0.000	0.45
6/15/1999	51	0.59	1.23	209.9	0.000	0.47

Table 7 Continued

Date	Number of Sites	Average Acre-inches per Acre	Standard Error	Coefficient of Variation	Relative Precision (Average Method)	Relative Precision (Ratio Method)
6/29/1999	50	0.21	1.04	502.5	0.000	0.37
1/18/2000	40	0.79	1.66	208.9	0.585	0.60
1/31/2000	42	0.27	0.57	209.5	0.567	0.55
2/15/2000	41	0.63	1.29	203.6	0.561	0.61
2/29/2000	41	2.59	1.81	69.9	0.193	0.52
3/14/2000	38	4.12	1.36	33.1	0.096	0.18
3/30/2000	38	3.19	1.25	39.0	0.113	0.21
4/13/2000	38	1.69	1.34	79.5	0.231	0.49
5/1/2000	39	3.01	2.57	85.3	0.243	0.60
5/15/2000	39	1.82	1.82	100.1	0.286	0.62
5/30/2000	39	1.00	1.94	193.4	0.551	0.69
6/14/2000	38	0.85	1.69	199.8	0.000	0.71
6/28/2000	40	0.44	1.11	250.2	0.000	0.58
1/2/2001	43	0.00	0.00			
1/16/2001	41	0.59	1.28	216.3	0.596	0.55
1/29/2001	39	1.52	2.43	160.0	0.456	0.64
2/14/2001	42	0.66	1.07	161.3	0.437	0.58
2/27/2001	41	2.52	1.86	73.9	0.204	0.50
3/14/2001	41	2.37	1.15	48.6	0.134	0.39
4/2/2001	42	1.05	0.89	84.7	0.230	0.45
4/16/2001	42	3.74	1.87	49.9	0.135	0.44
4/30/2001	42	2.72	1.62	59.6	0.161	0.50
5/14/2001	42	1.29	1.69	130.7	0.354	0.62
5/29/2001	42	0.70	1.26	180.2	0.488	0.58
6/14/2001	42	0.04	0.19	507.4	0.000	0.41
7/2/2001	43	0.01	0.04	628.4	0.000	0.35
1/15/2002	42	0.52	1.23	237.0	0.642	0.60
1/28/2002	42	0.00	0.01	551.7	1.495	0.33
2/14/2002	42	0.64	1.09	170.1	0.461	0.60
2/28/2002	42	1.81	1.94	107.3	0.291	0.56
3/14/2002	42	1.55	1.40	90.3	0.245	0.56
4/2/2002	42	5.18	2.19	42.2	0.114	0.19
4/16/2002	41	2.58	1.29	50.1	0.138	0.38
4/30/2002	42	3.13	2.45	78.3	0.212	0.57
5/14/2002	42	2.08	2.18	104.5	0.283	0.61
5/30/2002	42	0.18	0.36	201.9	0.547	0.58
6/12/2002	42	0.17	0.59	350.6	0.000	0.50
7/1/2002	42	0.00	0.00		0.000	0.22
1/14/2003	44	0.10	0.47	465.1	1.220	0.39
2/3/2003	44	0.49	1.38	280.4	0.735	0.52
2/13/2003	44	0.07	0.28	371.2	0.973	0.45
3/3/2003	44	0.00	0.00	263.4	0.691	0.36
3/13/2003	44	0.03	0.18	649.8	1.704	0.37
4/1/2003	43	0.75	0.99	131.7	0.351	0.53

Table 7 Continued

Date	Number of Sites	Average Acre-inches per Acre	Standard Error	Coefficient of Variation	Relative Precision (Average Method)	Relative Precision (Ratio Method)
4/14/2003	44	3.98	1.61	40.5	0.106	0.19
5/1/2003	44	3.71	1.75	47.3	0.124	0.38
5/15/2003	44	2.18	1.97	90.6	0.238	0.55
6/2/2003	44	0.42	0.62	147.9	0.000	0.57
6/15/2003	44	0.00	0.00	521.1	0.000	0.33
7/1/2003	44	0.00	0.00	463.6	0.000	0.28

Table 8 Relative precision based on a finite population total of 169 permitted wells for potato.

YEAR	Jan	Feb	Mar	Apr	May	Dec
1990		0.75	0.12	0.19	0.83	
1991	1.79	0.24	0.19	0.19	0.52	
1992	0.80	0.83	0.15	0.10	0.26	
1993		0.79	0.58	0.08	0.20	
1994	1.78	0.86	0.13	0.13	0.44	
1995	1.23	0.30	0.12	0.15	0.31	
1996	1.15	0.17	0.30	0.11	0.31	
1997	0.61	0.19	0.08	0.10	0.32	
1998	0.96	0.78	0.20	0.05	0.14	1.68
1999	0.78	0.23	0.08	0.08	0.21	
2000	0.38	0.18	0.06	0.15	0.23	
2001	0.31	0.18	0.11	0.09	0.23	
2002	0.54	0.21	0.12	0.11	0.25	
2003	0.52	0.77	0.31	0.06	0.19	

Table 9 Relative precision based on a finite population total of 100 permitted wells for potato.

YEAR	Jan	Feb	Mar	Apr	May	Dec
1990		0.71	0.12	0.18	0.79	
1991	1.60	0.22	0.17	0.17	0.47	
1992	0.71	0.74	0.13	0.09	0.23	
1993		0.70	0.52	0.07	0.18	
1994	1.59	0.77	0.12	0.12	0.40	
1995	1.09	0.27	0.11	0.14	0.28	
1996	1.03	0.15	0.27	0.10	0.27	
1997	0.23	0.06	0.03	0.03	0.10	
1998	0.21	0.17	0.04	0.01	0.03	1.40
1999	0.00	0.04	0.01	0.00		
2000	0.22	0.11	0.04	0.10	0.14	
2001	0.19	0.10	0.06	0.05	0.13	
2002	0.30	0.12	0.07	0.06	0.14	
2003	0.26	0.38	0.16	0.03	0.10	

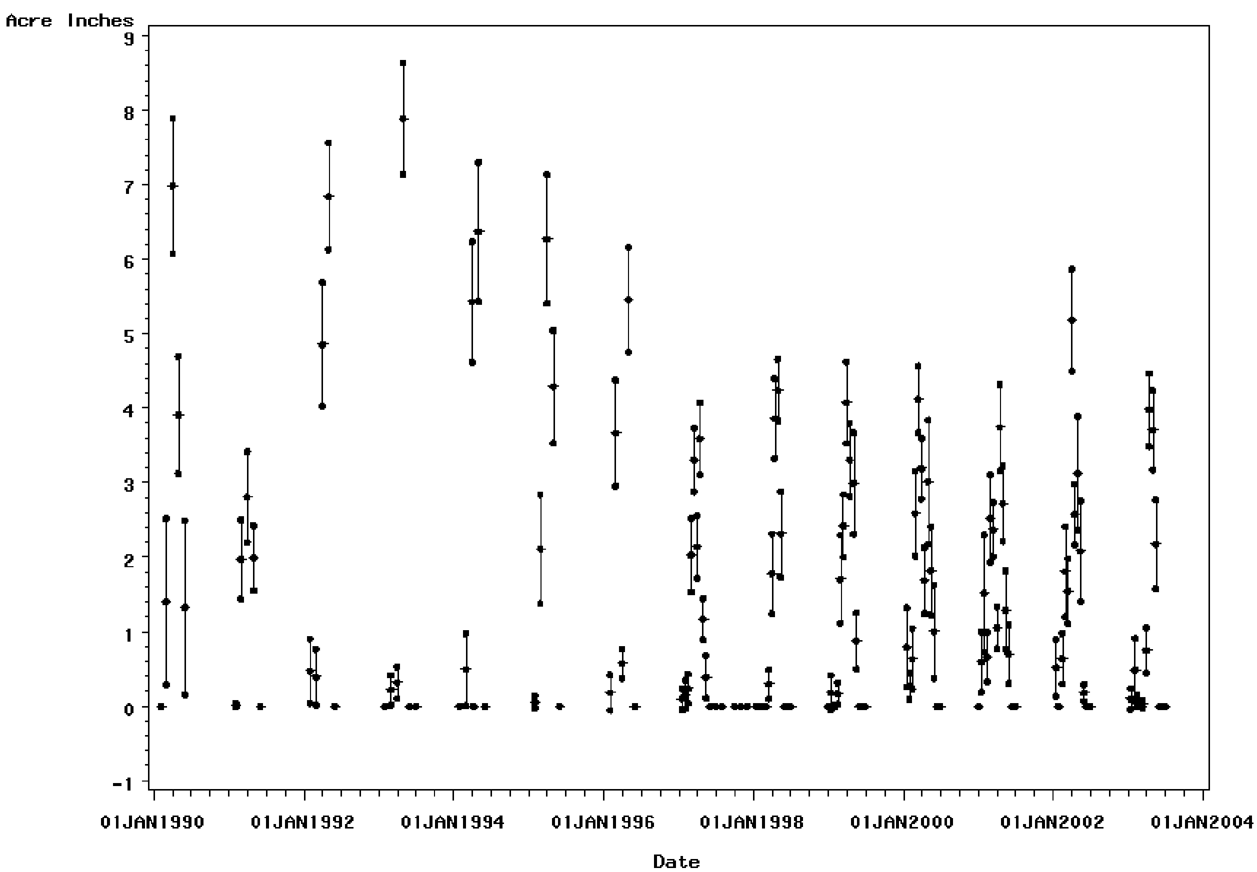

Figure 7 Time series plot of sample means and associated 95% confidence intervals for potato sample wells.

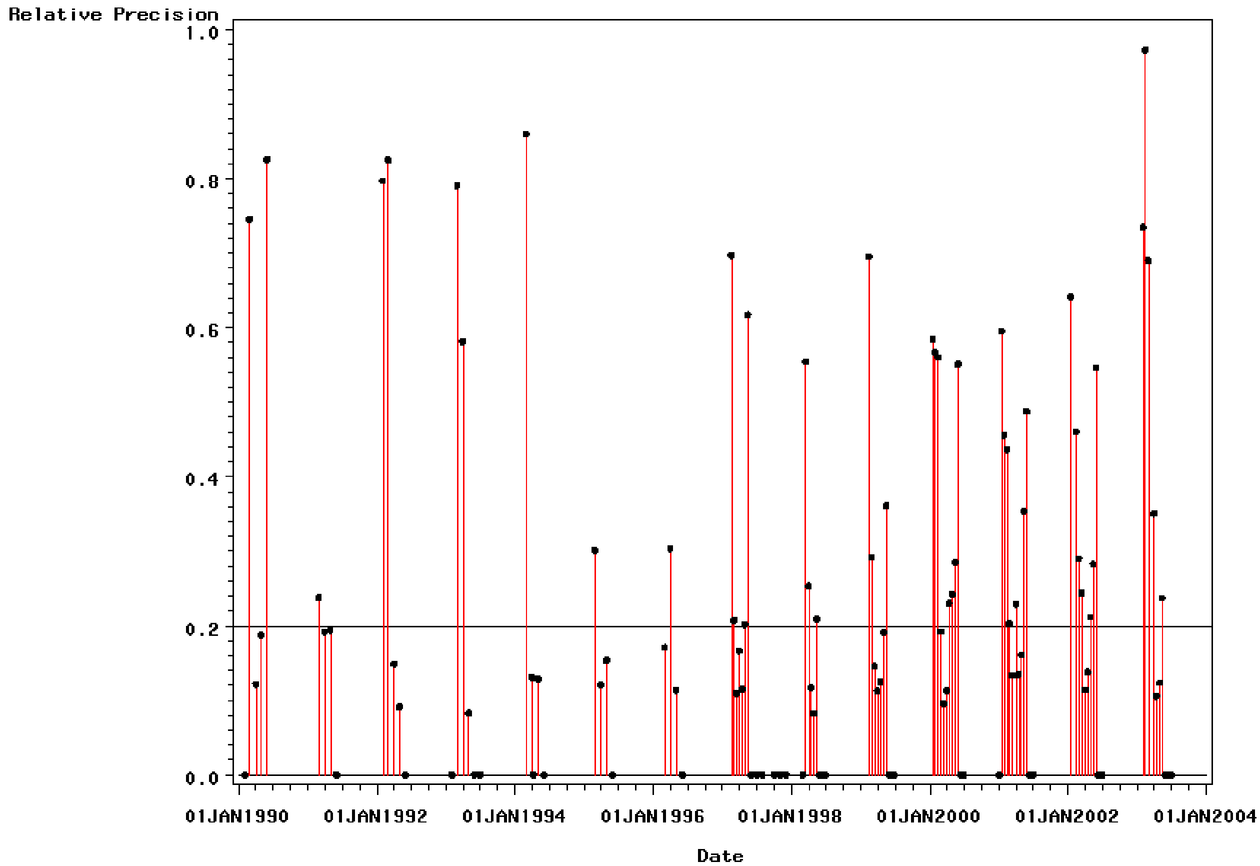

Figure 8 Relative precision of the simple average estimate by date for potato assuming the finite population size is 169.

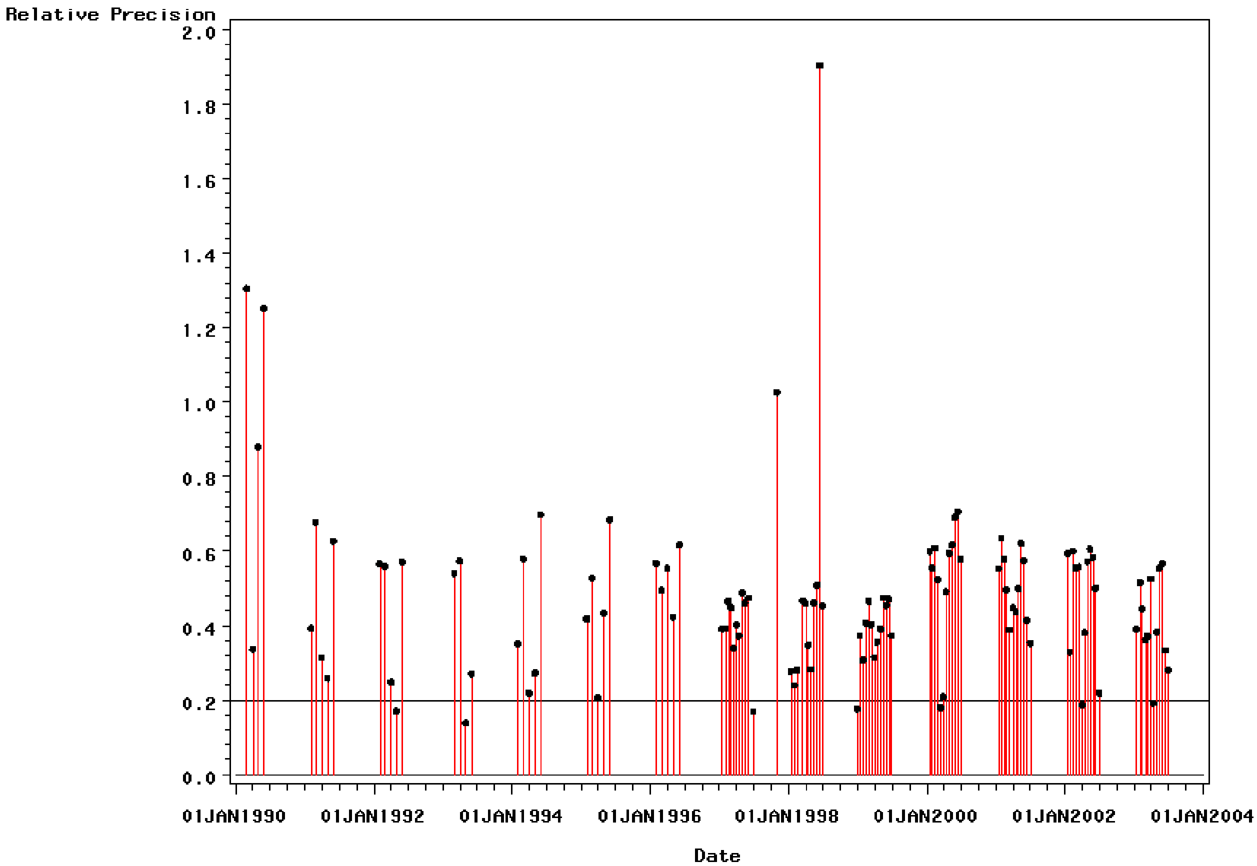

Figure 9 Relative precision of the ratio estimate by date for potato assuming the finite population size is 169

3.1.4 Leatherleaf Fern

The leatherleaf fern dataset as originally supplied had a total of 6286 observations from a total of 45 sites. Removing the "Inaccurate" and "below zero" acre-inches irrigation observations resulted in 5761 observations for the analysis. A table of n_t, $\overline{y}_t$, and s_t estimates for each month for which data are available is presented in Table 10. A times-series plot of the total estimated water withdrawal and associated confidence intervals is given in Figure 10.

A total population size of N_t=576 (total 10,851 acres) fern producers was used to compute the average and ratio relative precision estimates that are presented in Table 11 and Table 12 respectively and plotted in Figures 11 and 12.

From Figure 11 it can be seen that the 20% relative precision target is met for spring months but is inadequate for the rest of the year in most years. Thus a sample size of 35 wells for this crop is slightly inadequate. The necessary sample size will depend on the target relative precision (in this case 20%) and the sample coefficient of variation (ranging from 45% to 95%). Assuming an average CV of 55% results in a needed sample size of 38 wells and assuming an average CV of 65% results in a needed sample size of 51 wells.

Table 10 Basic statistics on sampled leatherleaf fern wells by year and month.

		Month											
Year	**Statistic**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1989	Count						3	7	12	20	25	24	24
	Average						2.3	2.9	2.7	2.1	2.6	3.3	25.0
	Std Dev						0.3	1.3	1.8	1.2	1.5	2.0	8.1
	CV						11.7	43.9	66.0	59.7	59.4	60.4	32.3
1990	Count	25	27	27	27	27	27	27	27	27	27	27	28
	Average	5.1	2.0	3.3	2.6	4.1	3.4	2.1	2.3	3.4	2.6	2.2	3.6
	Std Dev	2.9	1.1	1.7	1.6	1.9	1.7	1.2	1.2	1.4	1.5	1.1	1.7
	CV	56.4	53.2	52.4	62.3	46.7	50.5	54.4	50.9	40.4	58.9	48.6	47.0
1991	Count	27	27	27	27	28	30	31	31	31	33	33	33
	Average	3.0	7.9	3.5	2.0	2.1	1.7	1.4	2.3	2.8	2.6	4.4	3.6
	Std Dev	1.5	2.4	1.8	1.4	1.1	1.2	0.9	1.3	1.6	1.4	2.5	2.2
	CV	51.4	30.2	53.4	68.3	52.6	70.0	59.6	55.5	58.2	53.0	56.3	60.8
1992	Count	34	34	33	35	34	34	38	36	38	39	39	42
	Average	10.8	2.5	2.8	2.6	2.9	1.7	3.4	1.4	1.1	1.8	2.3	3.7
	Std Dev	6.6	1.3	1.5	1.6	1.9	1.0	1.8	0.9	0.7	0.9	1.6	2.0
	CV	61.4	53.5	52.4	60.3	63.5	61.1	51.7	65.4	62.6	50.4	67.0	55.1
1993	Count	44	43	43	43	43	42	43	43	43	43	42	42
	Average	2.4	3.2	4.6	2.8	2.5	2.1	1.8	2.7	1.4	1.9	1.9	7.4
	Std Dev	1.5	2.2	2.6	1.8	1.5	1.3	1.4	1.5	0.8	1.2	1.5	4.1
	CV	61.3	68.4	57.1	63.2	63.0	59.2	73.9	57.7	53.3	65.0	77.6	55.1
1994	Count	42	42	41	42	41	39	37	39	36	37	37	37
	Average	4.6	2.4	2.6	3.0	2.8	1.4	1.7	1.0	1.3	1.3	1.1	1.3
	Std Dev	2.5	1.5	1.4	1.9	1.8	1.0	0.9	0.6	0.8	0.9	0.7	1.0
	CV	54.0	63.5	54.3	63.0	65.2	69.4	53.2	57.2	60.6	64.5	62.0	72.6
1995	Count	39	38	38	39	40	36	37	37	36	34	37	36
	Average	5.9	8.2	2.2	2.1	2.4	1.9	1.6	1.8	1.2	1.1	3.0	13.5
	Std Dev	3.7	3.8	1.6	1.3	1.5	1.0	0.9	1.2	0.8	0.7	1.8	7.6
	CV	61.8	46.5	71.8	62.8	63.4	55.1	52.0	69.0	65.1	60.9	59.4	56.4
1996	Count	36	37	38	38	37	37	35	33	31	35	37	37
	Average	12.7	12.7	4.1	1.8	2.3	1.5	1.6	1.6	1.4	1.7	1.6	5.5
	Std Dev	6.6	7.8	2.6	1.1	1.3	1.1	1.1	1.0	0.7	0.9	1.1	2.5
	CV	52.0	61.0	64.2	62.4	54.2	68.8	66.5	61.6	50.7	54.4	66.2	45.2
1997	Count	37	37	37	37	34	34	35	37	37	35	34	34
	Average	10.5	2.0	1.6	1.6	2.1	1.0	1.6	1.3	1.5	1.4	1.3	3.4
	Std Dev	4.4	0.9	0.9	1.1	1.4	0.8	0.9	0.8	0.8	1.0	0.8	2.0
	CV	42.1	45.7	53.1	68.1	63.6	74.2	58.4	61.1	54.9	67.8	57.0	60.7
1998	Count	35	36	36	36	36	35	36	36	35	35	35	37
	Average	2.4	1.3	4.4	2.5	4.0	3.9	2.4	1.9	1.2	2.3	1.9	4.2
	Std Dev	1.7	0.9	2.5	1.5	2.1	2.1	1.4	1.7	0.7	1.2	1.0	2.7
	CV	70.7	70.3	55.6	61.2	53.6	52.8	60.0	93.2	64.7	51.1	50.7	62.8
1999	Count	37	38	36	36	36	36	35	35	35	35	36	35
	Average	8.8	3.6	4.4	3.9	2.3	1.7	2.2	2.2	1.9	1.9	2.0	6.0
	Std Dev	5.7	2.6	2.5	2.2	1.5	1.0	1.4	1.5	1.2	1.9	1.6	4.6
	CV	64.9	71.6	56.9	55.5	66.6	59.1	65.0	68.6	64.8	102.4	80.3	77.6

Table 10 Continued

Year	Statistic	Jan	Feb	Mar	Apr	May	Month Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Std Dev	6.4	3.0	1.8	1.5	2.0	2.1	1.1	1.2	1.0	1.1	4.2	13.1
	CV	64.0	55.5	57.7	57.7	56.1	66.2	68.3	65.5	68.5	60.8	68.2	59.4
2001	Count	33	34	33	34	34	32	32	31	30	30	30	30
	Average	16.4	2.4	2.9	2.8	2.7	1.6	1.2	1.5	1.3	1.6	1.4	3.9
	Std Dev	10.0	1.2	1.7	1.4	1.7	1.0	0.6	0.8	0.7	1.0	1.0	2.4
	CV	60.9	47.8	59.7	49.8	61.6	62.5	45.8	53.1	56.1	63.5	69.2	61.6
2002	Count	29	29	29	29	29	29	29	29	29	29	28	29
	Average	11.6	3.7	4.6	2.3	3.2	1.4	1.2	1.2	1.5	1.7	6.6	8.6
	Std Dev	5.8	1.8	2.3	1.1	2.0	0.9	0.6	0.6	0.9	1.0	3.5	5.6
	CV	49.6	48.3	50.6	47.7	61.9	59.9	54.8	46.4	59.0	61.9	53.9	64.7
2003	Count	29	30	29	29	29	31	30	32				
	Average	20.9	2.3	1.3	3.1	2.1	1.1	1.0	0.9				
	Std Dev	10.8	1.7	0.8	1.8	1.4	0.8	0.7	0.8				
	CV	51.6	73.5	60.9	56.0	65.8	75.9	75.1	95.1				

Table 11 Estimated relative precision on Acre-inches per Acre as measured for leatherleaf fern based on the simple average estimate assuming a finite population of N=576 permitted wells

YEAR	Jan	Feb	Mar	Apr	May	Month Jun	Jul	Aug	Sep	Oct	Nov
1989						0.29	0.40	0.42	0.28	0.24	0.25
1990	0.23	0.21	0.20	0.24	0.18	0.20	0.21	0.20	0.16	0.23	0.19
1991	0.20	0.12	0.21	0.26	0.20	0.26	0.21	0.20	0.21	0.18	0.19
1992	0.21	0.18	0.18	0.20	0.22	0.21	0.16	0.22	0.20	0.16	0.21
1993	0.18	0.20	0.17	0.19	0.19	0.18	0.22	0.17	0.16	0.19	0.23
1994	0.16	0.19	0.17	0.19	0.20	0.22	0.17	0.18	0.20	0.21	0.20
1995	0.19	0.15	0.23	0.20	0.20	0.18	0.17	0.22	0.21	0.21	0.19
1996	0.17	0.20	0.20	0.20	0.18	0.22	0.22	0.21	0.18	0.18	0.21
1997	0.14	0.15	0.17	0.22	0.22	0.25	0.20	0.20	0.18	0.23	0.19
1998	0.24	0.23	0.18	0.20	0.18	0.18	0.20	0.31	0.22	0.17	0.17
1999	0.21	0.23	0.19	0.18	0.22	0.19	0.22	0.23	0.22	0.34	0.26
2000	0.21	0.18	0.19	0.19	0.19	0.22	0.23	0.22	0.23	0.21	0.24
2001	0.21	0.16	0.21	0.17	0.21	0.22	0.16	0.19	0.20	0.23	0.25
2002	0.18	0.18	0.19	0.18	0.23	0.22	0.20	0.17	0.22	0.23	0.20
2003	0.19	0.27	0.23	0.21	0.24	0.27	0.27	0.33			

Table 12 Estimated relative precision for the average Acre-inches per Acre for leatherleaf fern based on the ratio method and assuming a finite population of N=576 permitted wells.

	Month											
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1989						0.87	2.16	1.64	1.18	0.70	0.78	0.43
1990	1.36	0.64	0.49	1.27	0.56	0.59	0.57	1.23	0.51	1.29	0.49	0.60
1991	0.61	0.36	0.64	0.60	0.60	0.73	0.55	0.87	0.61	0.47	0.53	0.55
1992	0.57	0.63	0.46	0.83	0.89	0.45	0.77	0.78	0.70	0.47	0.49	0.44
1993	0.58	0.74	0.54	0.55	0.44	0.47	0.50	0.45	0.57	0.49	0.49	0.55
1994	0.69	0.63	0.66	0.68	0.57	0.66	0.56	0.50	0.66	1.00	0.84	0.75
1995	0.52	0.79	0.96	0.73	0.84	0.77	0.47	0.51	0.49	0.78	0.82	0.51
1996	0.51	0.46	0.75	0.44	0.41	0.78	0.51	0.48	0.53	0.80	0.96	0.41
1997	0.36	0.51	0.50	0.78	0.59	0.83	0.67	0.82	0.75	0.77	1.15	0.66
1998	0.58	0.73	0.55	0.52	0.50	0.71	0.65	0.67	0.69	0.65	0.74	0.83
1999	0.89	0.79	0.87	0.82	0.48	0.82	0.87	1.03	1.22	1.24	1.17	1.26
2000	1.30	1.10	1.22	1.25	1.17	1.22	1.11	1.28	1.23	1.12	0.98	1.04
2001	1.06	0.88	0.92	0.89	0.89	0.35	0.41	0.51	0.72	0.76	0.79	0.81
2002	0.69	0.57	0.54	0.99	0.53	0.48	0.61	0.55	0.64	1.07	0.64	1.33
2003	1.22	1.03	0.81	0.59	1.02	1.09	1.11	1.17				

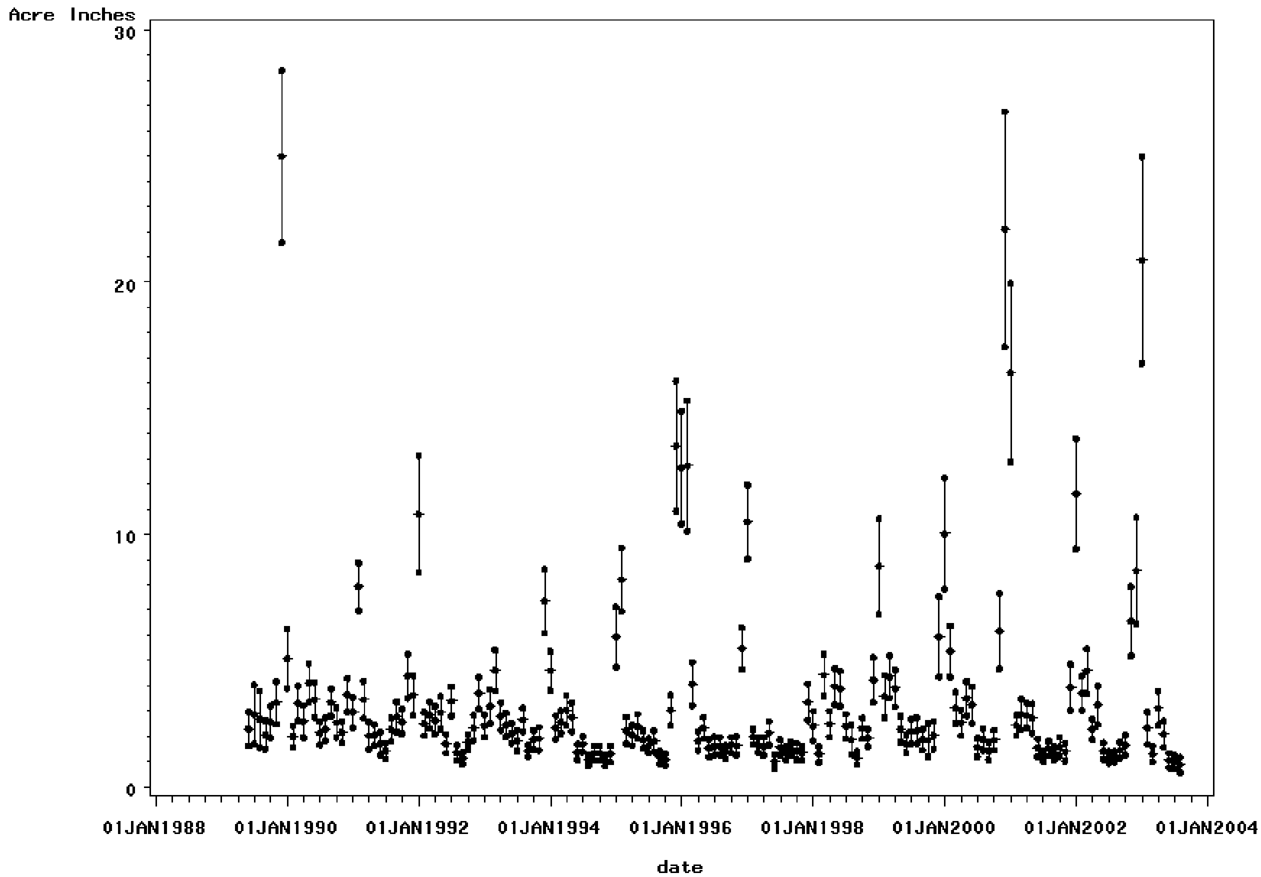

Figure 10 Time series plot of sample means and associated 95% confidence intervals for the leatherleaf fern sample wells.

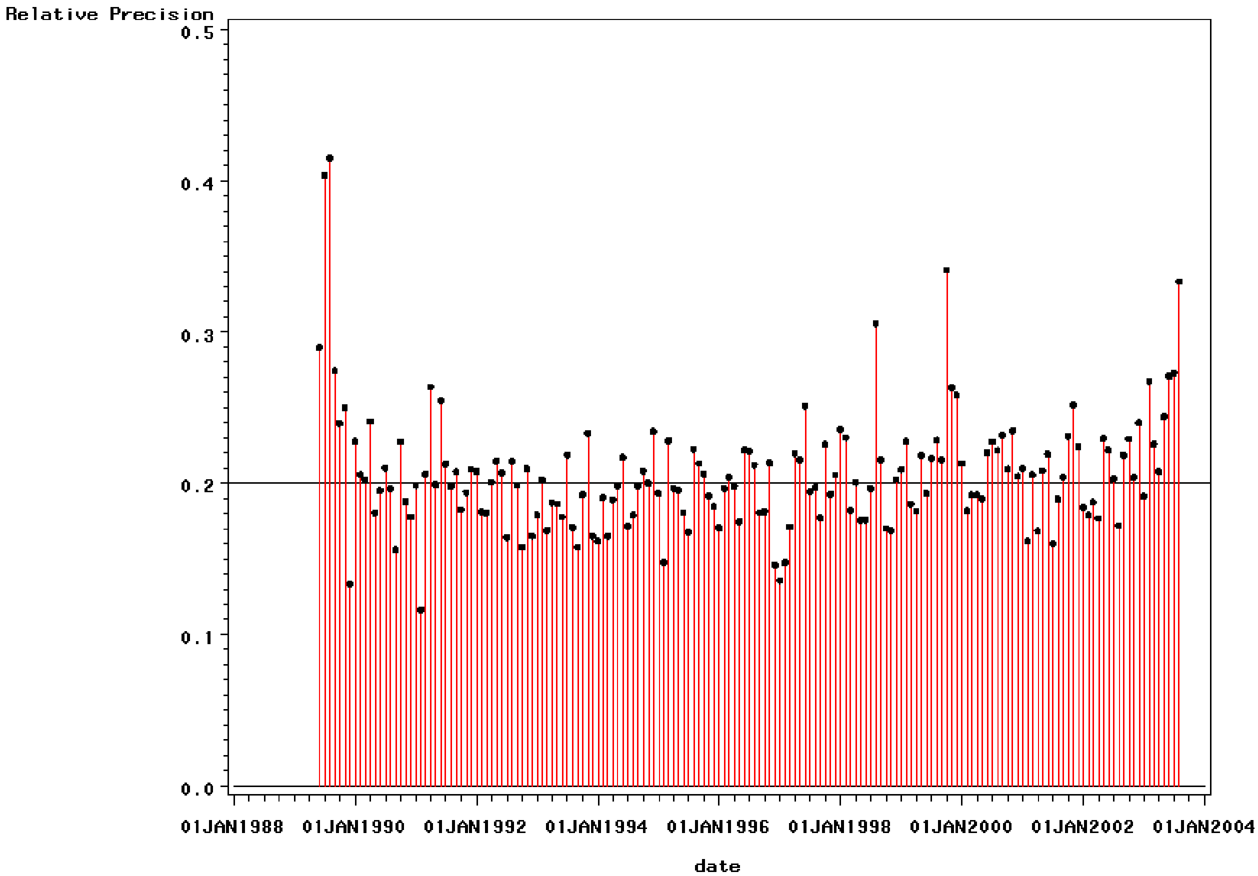

Figure 11 Relative precision of the simple average estimate by date for leatherleaf fern assuming the finite population size is 576

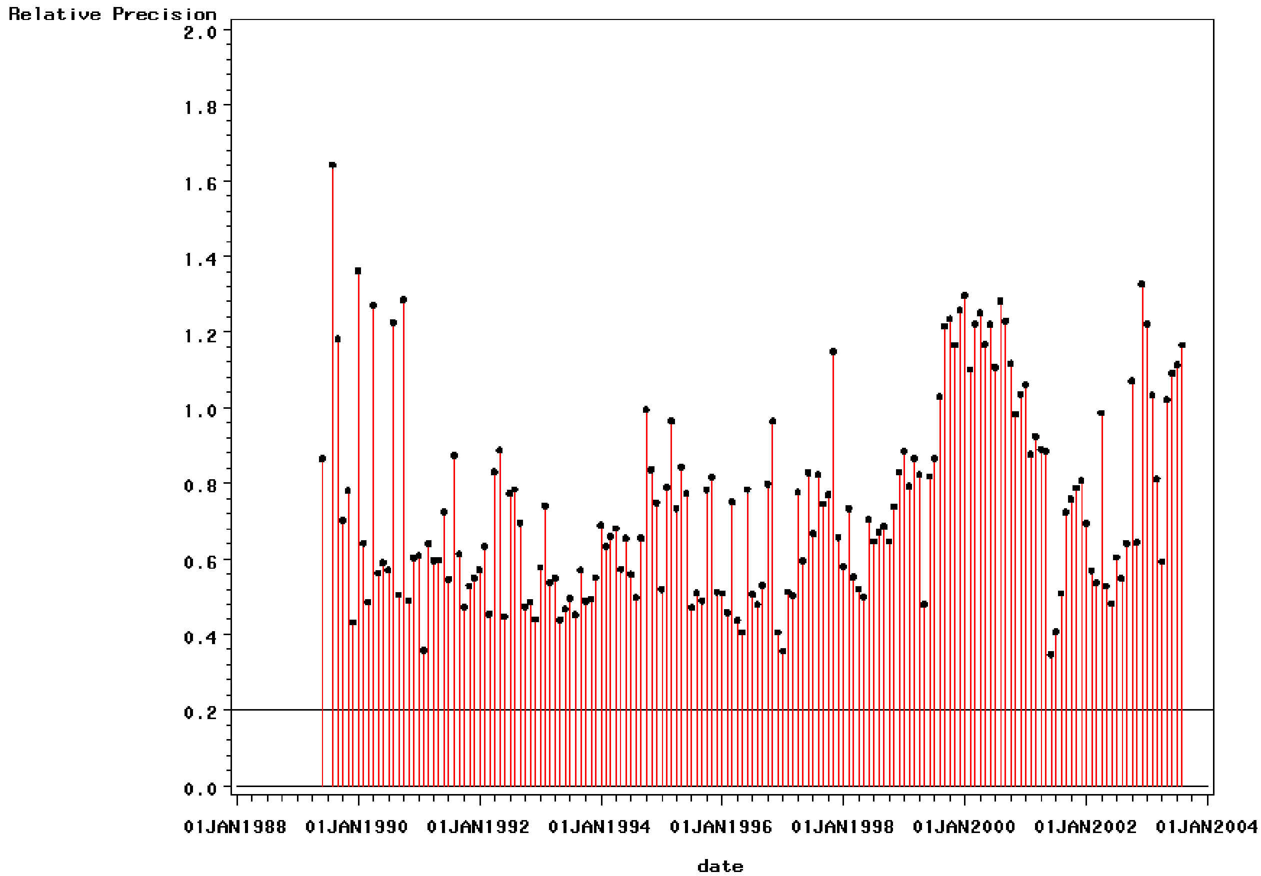

Figure 12 Relative precision of the ratio estimate by date for leatherleaf fern assuming the finite population size is 576.

3.2 Task Two: Evaluate Data Integrity

3.2.1 Ridge Citrus

3.2.1.1 Basic Model and Site-Specific Rainfall Regressions

A summary of the estimated variance components and associated rainfall regression coefficients are given in Table 13. The reduced dataset typically excludes some of the early years of data, hence it is expected that the year-to-year variability would be reduced when the full dataset is moved to the reduced dataset. Note that residual variability is typically five to six times larger than site variability and site and month variability are about the same magnitude.

The effect of adding site-specific rainfall is to reduce somewhat the year, month and residual variability, leaving site variability and the autoregressive coefficient mostly unchanged. An estimated autocorrelation term of 0.26 suggests that there is a roughly 26% carryover of residual effects from one month to the next and this amount is statistically significantly different from zero.

Table 13 Regression coefficients and variance component estimates for general linear mixed effects models fit to the ridge citrus irrigation well time series data.

	full **dataset**	***reduced*** **dataset**	
Model Component		**Without Covariate**	**With Rain Covariate**
Year (σ_β)	0.05‡	0.04‡	0.02
Month (σ_γ)	0.14‡	0.27‡	0.18‡
Site (σ_α)	0.16‡	0.17‡	0.17‡
Site (AR ρ)	0.25‡	0.30‡	0.26‡
Residual (σ_ε)	1.09‡	1.26‡	1.11‡
Intercept	0.94 (0.13)	1.05 (0.18)	1.58 (0.15)
Coefficient for rain	NI	NI	-0.13 (0.006)

Plots of model effects: Below are plots of the overall and individual model effects for the full dataset with parameter estimates given in column 2 of Table 13. Explanations of these graphs are given in the figure captions.

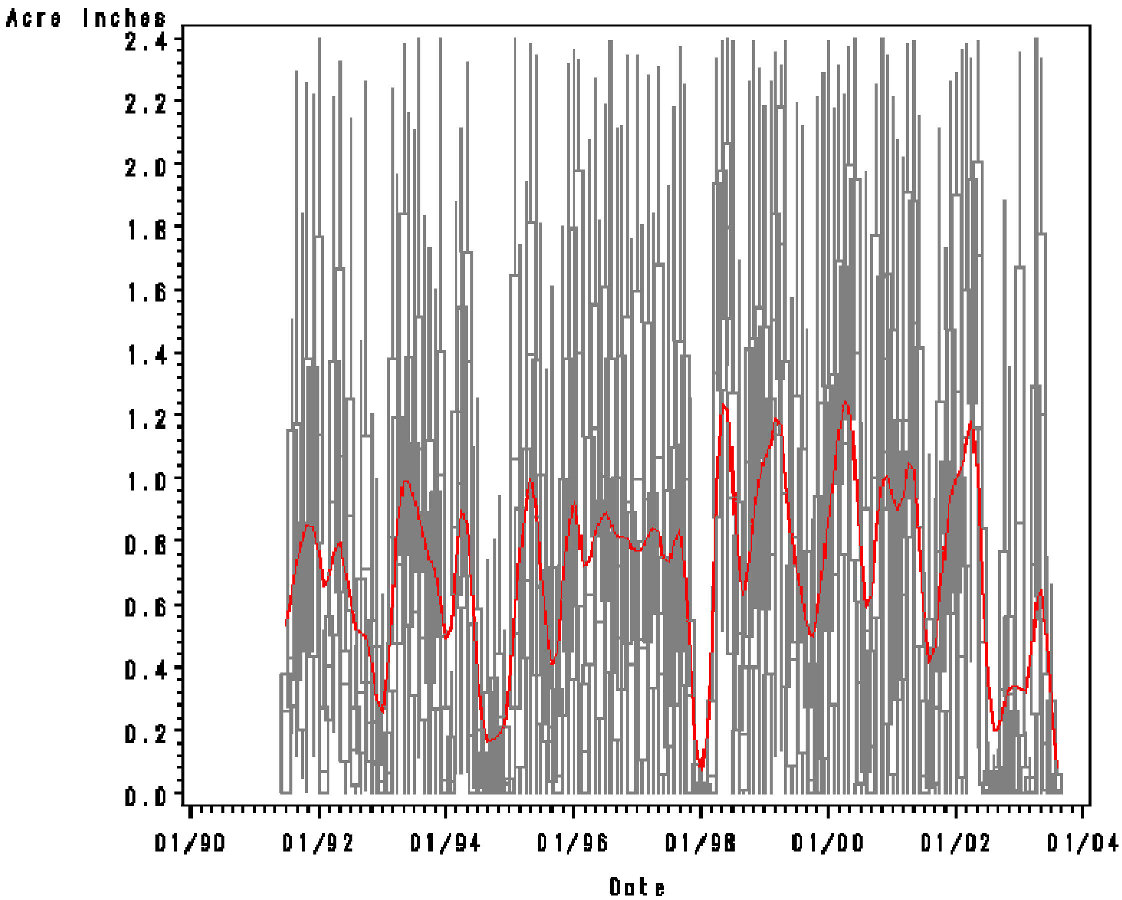

Figure 13 Monthly acre-inches distributions for ridge citrus for the entire monitoring period with the average monthly mean estimates connected by a smoothed curve. Monthly patterns are very evident with year differences more difficult to see. The objective of the analysis is to decompose the variability seen here into site, year, month and residual effects. The scale of the vertical axis is in acre-inches.

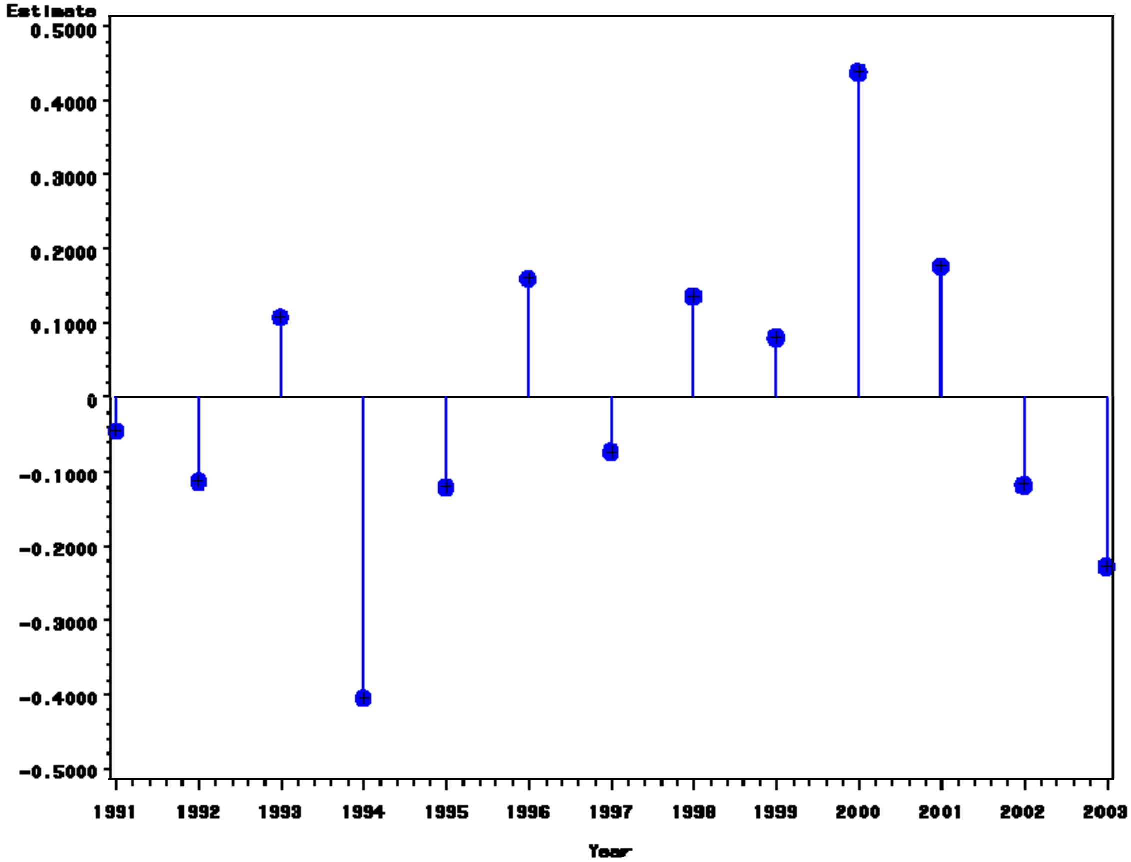

Figure 14 Estimated year effects (the β_j) for ridge citrus across the monitoring period. The estimated variance component (σ^2_β = 0.05 or σ_β = 0.224, see Table 13) suggests that 95% of these effects should fall between ±1.96(σ_β) = ±0.438. There does not seem to be any pattern to year effects hence one would not expect to be able to predict next year's effect by using this year's estimate. One would expect these effects to reflect years with a surplus of rainfall (negative effects) from years with a deficit of rainfall (positive years) since the whole goal of irrigation is to supplement natural rainfall. The scale of the vertical axis is in acre-inches.

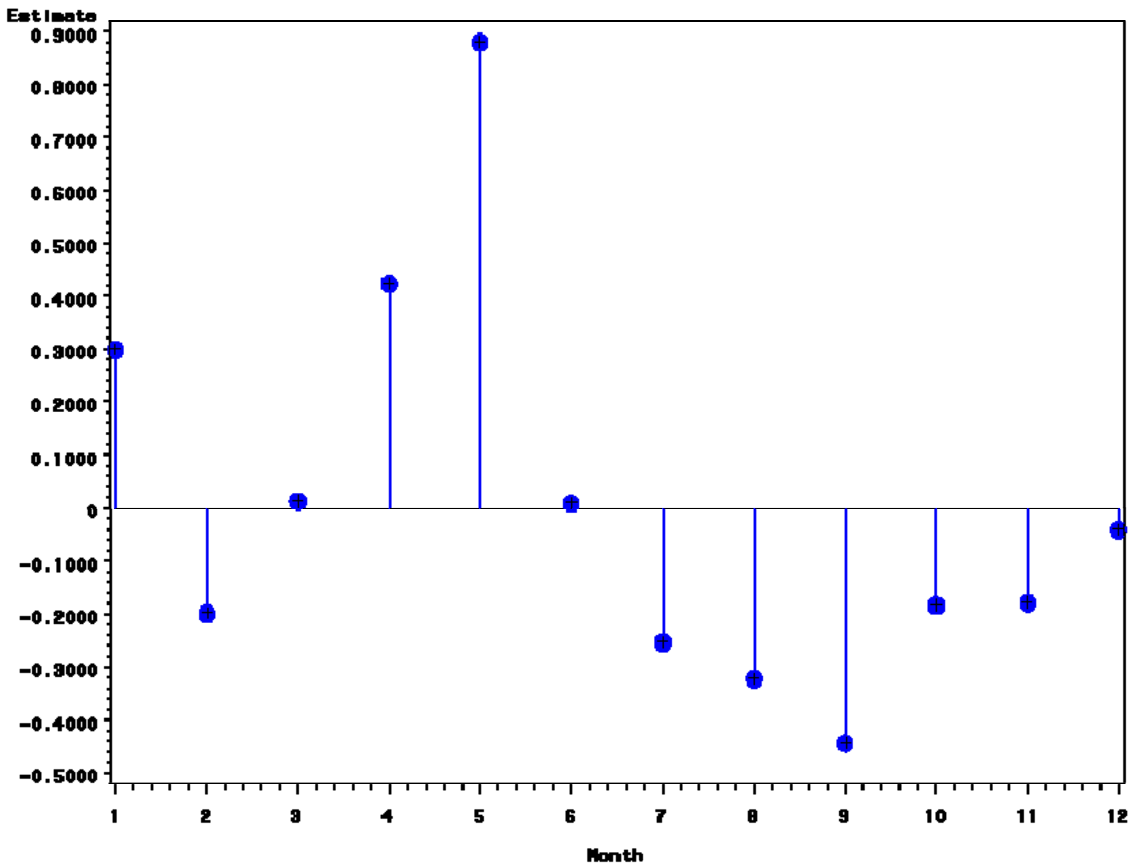

Figure 15 Estimated month effects (the γ_k) for ridge citrus across the monitoring period. The estimated variance component (σ^2_γ = 0.14 or σ_γ = 0.374, see Table 13) suggests that 95% of these effects should fall between ±1.96(σ_γ) = ±0.733. Note that month 5 (May) has an effect that is outside of this bound, suggesting that more irrigation than expected is seen in this month. Months with positive effects pump more water than the overall average, months with negative effects pump less water than the annual average. The differences in monthly effects should be explainable from ridge citrus agronomic practice and should mimic pest management practices. The scale of the vertical axis is in acre-inches.

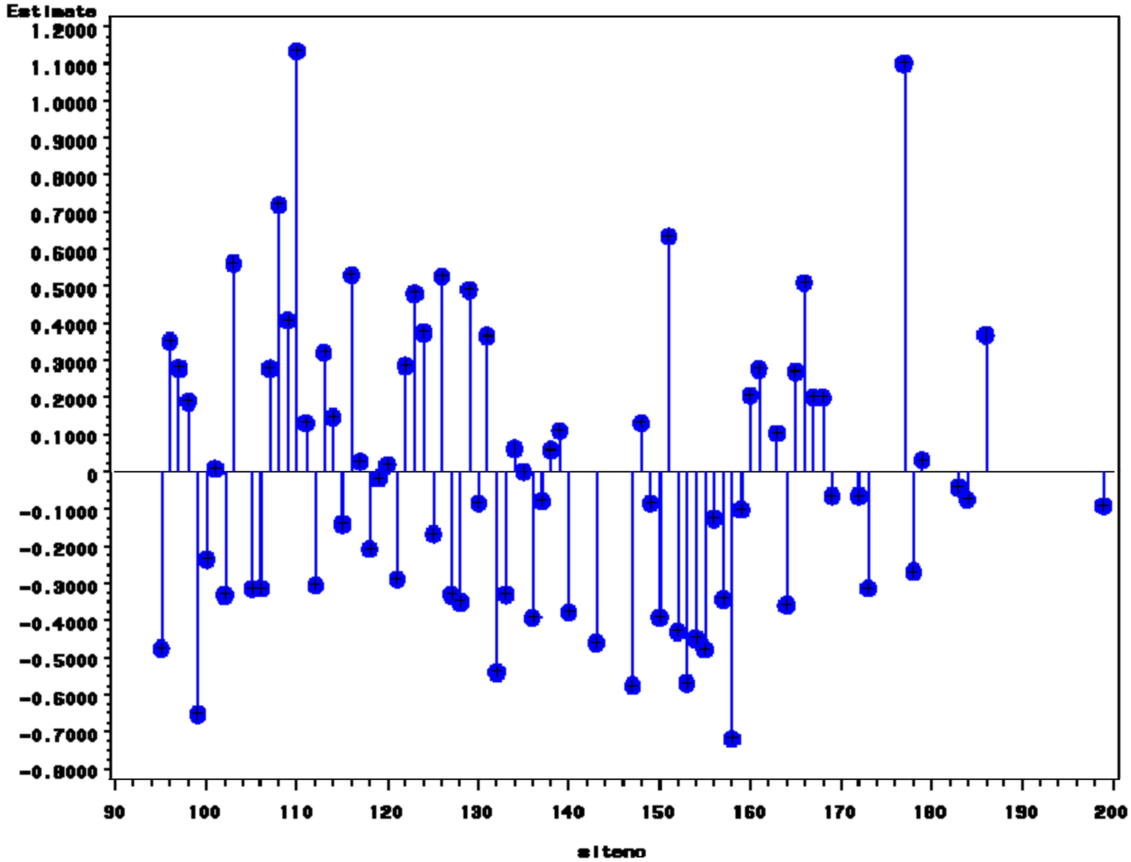

Figure 16 Estimated site effects (the α_i) for ridge citrus across the monitoring period. The estimated variance component (σ^2_α = 0.16 or σ_α = 0.40, see Table 13) suggests that 95% of these effects should fall between ±1.96(σ_α) = ±0.784. Note that two sites, 110 and 177, have expected effects that fall outside these bounds. In a perfectly managed world, each site would be managed as every other site and one would see very small site-to-site variability. Sites with positive effects use, on average, more than the overall average. Sites with negative effects will use, on average, less than the overall average. Differences among site effects should reflect differences in local soil and microclimate and their ability to provide ridge citrus the water needed to grow and produce fruit. The sites having extreme values would be expected to reside at the extremes of soil and microclimate for ridge citrus production. The units on the vertical axis are in acre-inches.

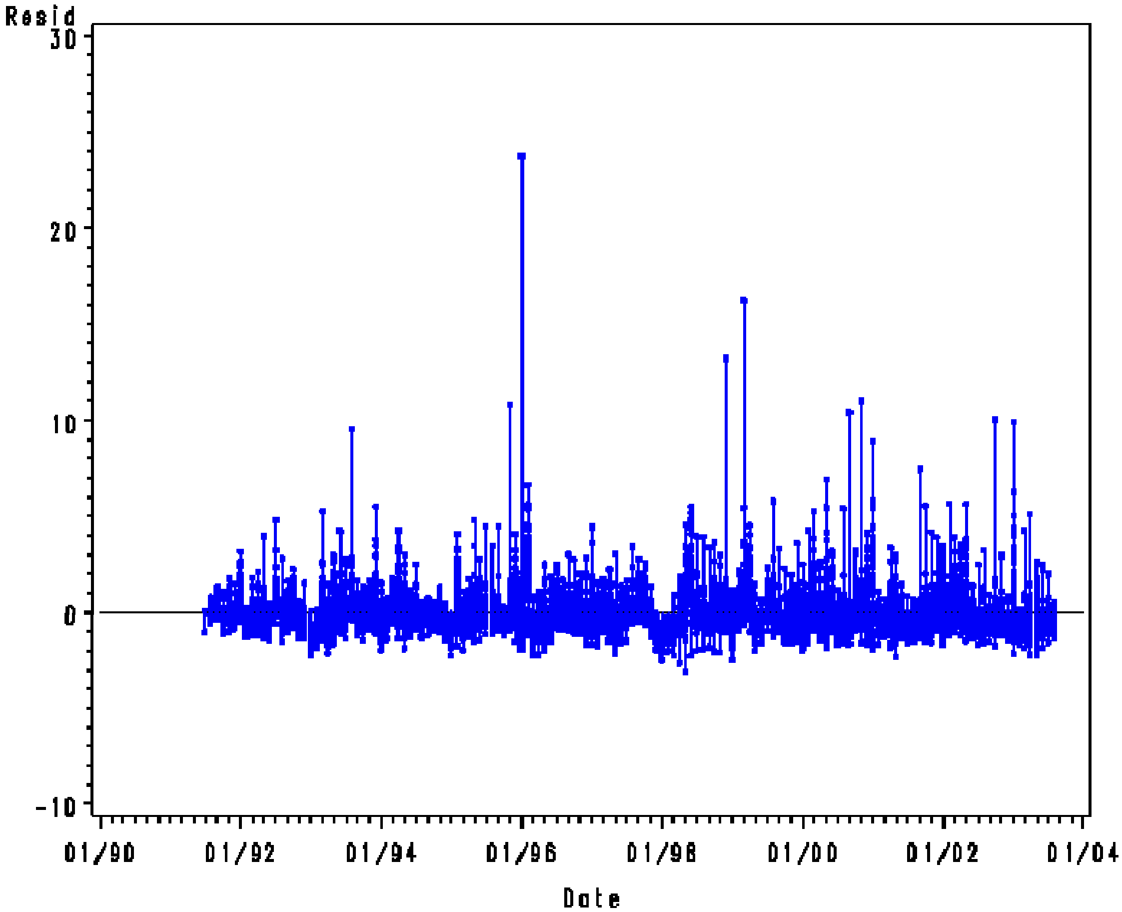

Figure 17 Estimated residual effects (the ε_{ijk}) (in acre-inches) for ridge citrus across the monitoring period. The estimated variance component (σ^2_ε = 1.09 or σ_ε = 1.044, see Table 13) suggests that 95% of these effects should fall between ±1.96(σ_ε) = ±2.046. This is not quite correct since this equation does not take into account the effect of the autocorrelation but does work as a rough rule of thumb. Note that there are a number of site/dates where the residual exceeds this value. At this point, the exceedences should reflect management decisions at specific sites on specific months and years. There are any number of reasons that a particular well might exceed the expected site/year/month mean as estimated by the model. Some agronomic situations, such as establishment of a newly planted grove, irrigation for freeze protection or as a result of extended drought, would be expected to produce these extreme events. Other less predictable causes would be event such as pipe leak, faulty valves or management lapses. For this reasons one should not automatically assume that all residuals greater than the 2.046 is indication of "poor" irrigation practice. More analysis of the extreme events would be necessary before this conclusion might be drawn.

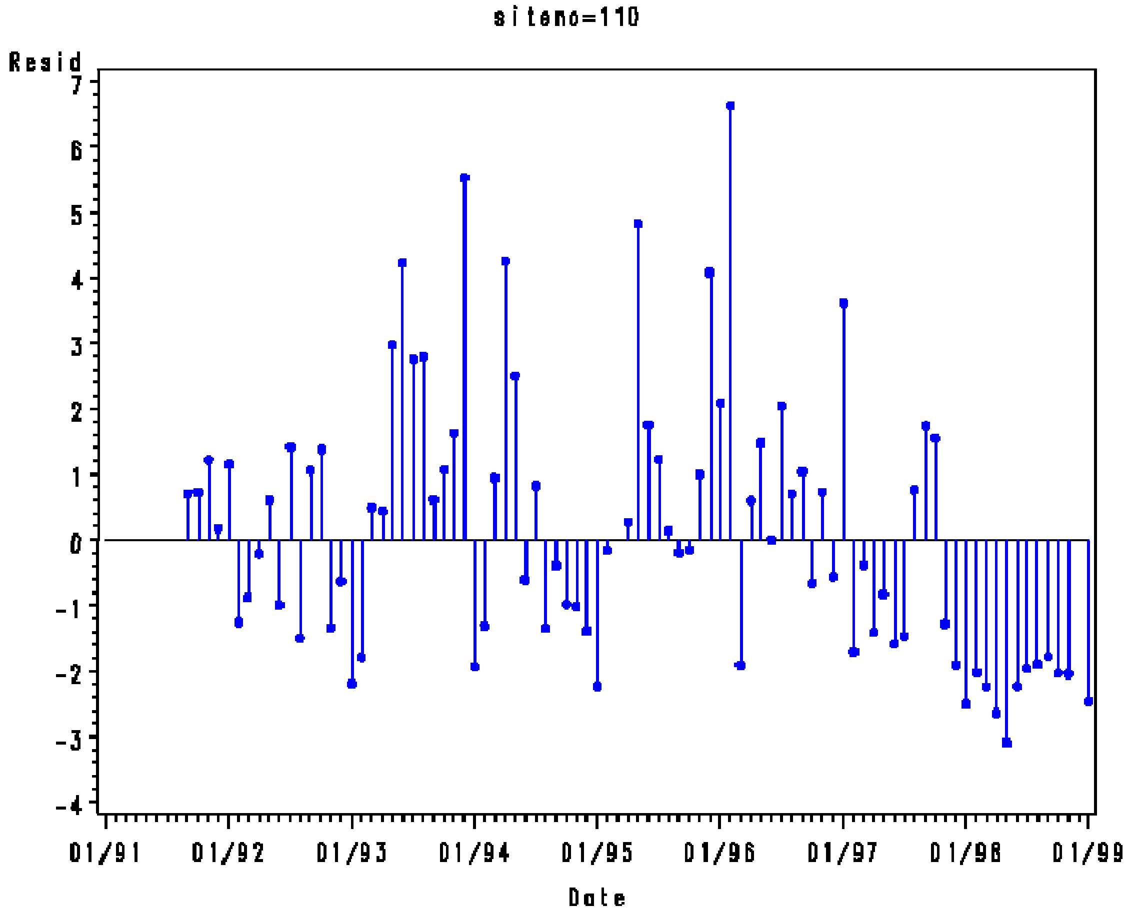

Figure 18 Plot of residuals (ε_{ijk}, i=110) (in acre-inches) for site 110 ridge citrus. This site is presented here because of its large site effect. Note that on top of the large site effect there are quite a few large positive and negative residuals. The pattern of the residuals does not look random, but the reason for this lack of randomness is not readily apparent.

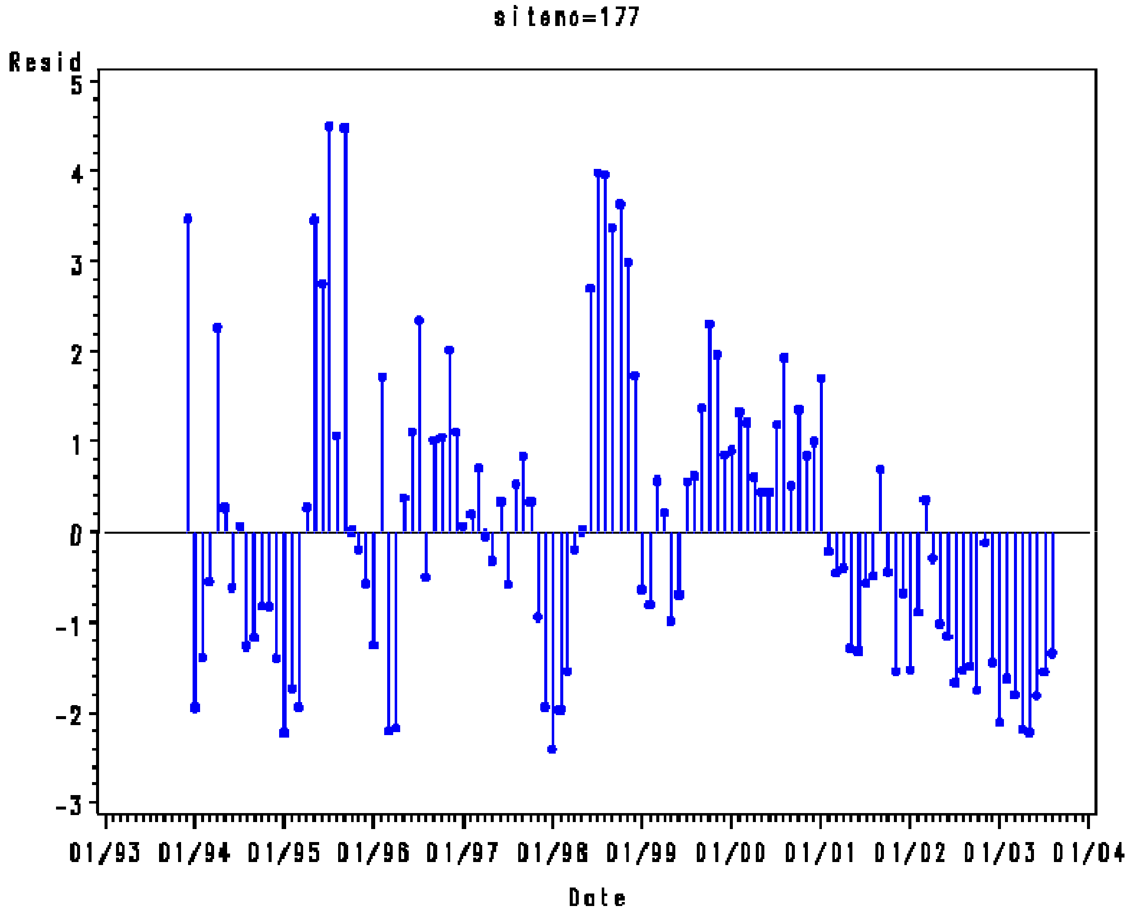

Figure 19 Plot of residuals (ε_{ijk}, i=177) (in acre-inches) for site 177 ridge citrus. This site is presented here because of its large site effect. Note that on top of the large site effect there are quite a few large positive and negative residuals. In contrast to site 110, this site demonstrates periods of positive residuals followed by periods of negative residuals, making the pattern look anything but random. This pattern suggests some form of management decisions as a driver for water pumped at this well.

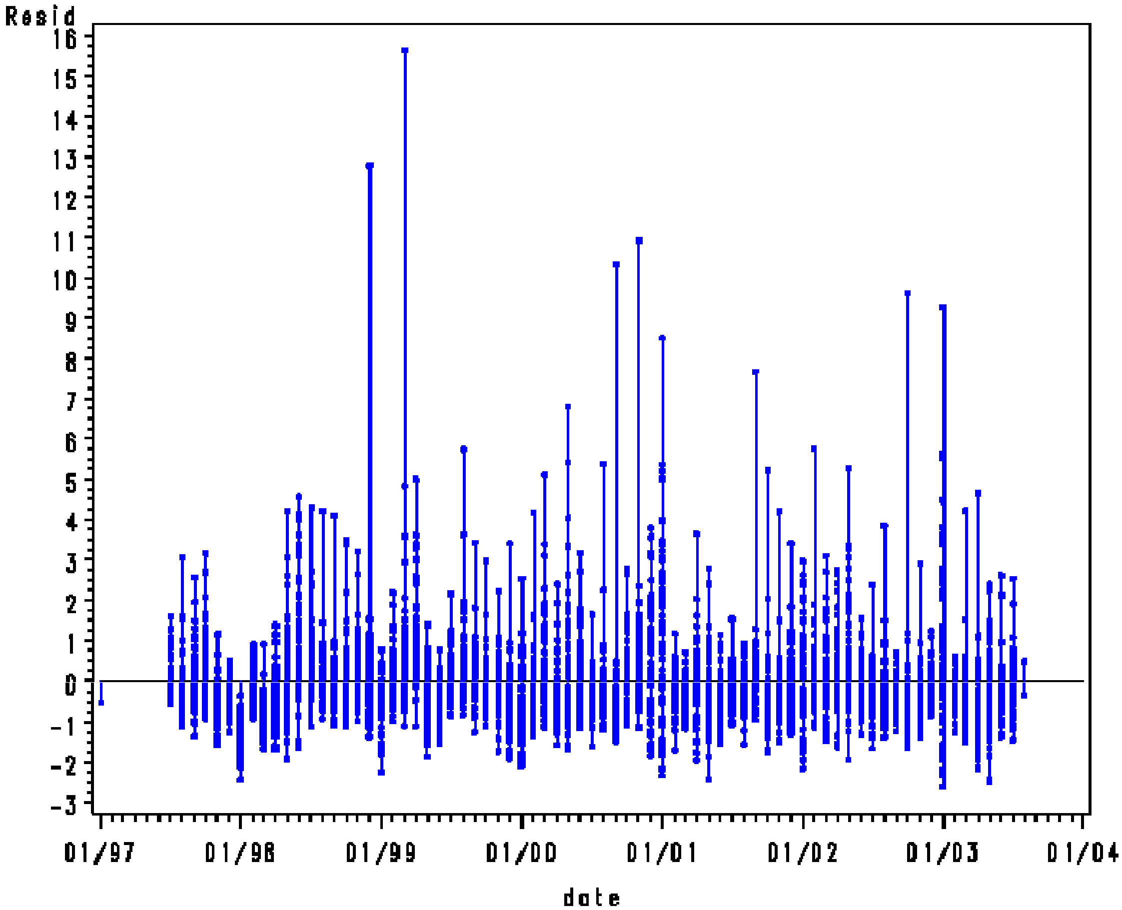

Figure 20 Estimated residual effects (the ε_{ijk}) (in acre-inches) for ridge citrus across the monitoring period but in which the effect of site-specific rainfall has been added to the model. The estimated variance component (σ^2_ε = 1.11 or σ_ε = 1.053, see Table 13) suggest that 95% of these effects should fall between ±1.96(σ_ε) = ±2.064. Note that adding rainfall to the model has reduced some of the extreme events but has not impacted others.

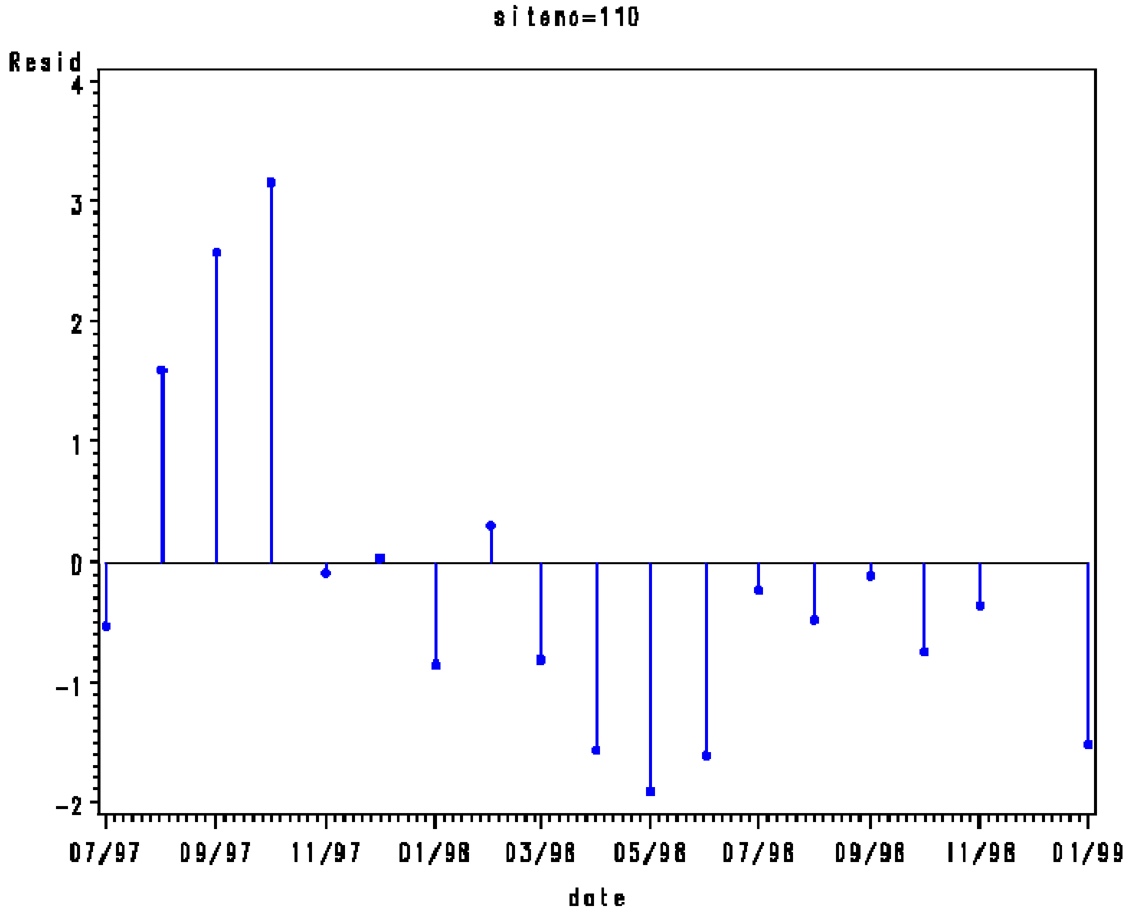

Figure 21 Plot of residuals for site 110 for ridge citrus over the reduced period for which site-specific rainfall is available. Note that in the full model roughly 80 months of data was usable but in this model only about 18 months are available. The predominate trend consists of positive residuals in the early months with negative residuals for the last 13 months.

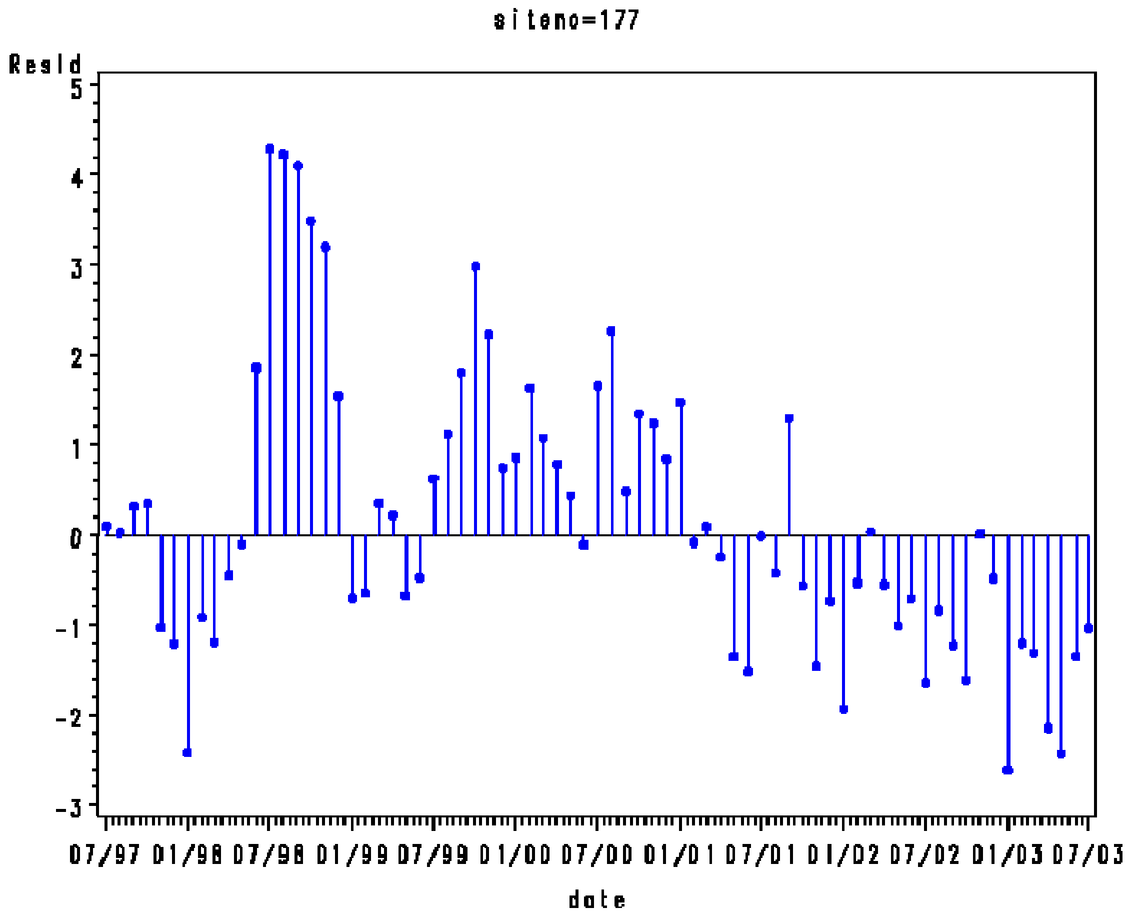

Figure 22 Plot of the residuals for site 177 over the reduced period for which rainfall is available for use in the model. The inclusion of rainfall has not reduced residuals to any appreciable extent nor has it impacted the trend.

3.2.1.2 Regressions with climate variables

The original ridge citrus dataset was augmented with climate data obtained from the Nation Weather Service public databases. One climate data collection site was chosen within each county having ridge citrus and each site in that county was assigned copies of that climate time series. The basic mixed effects general linear model used in the previous analyses (the one having site, year, month and residual random effects and assuming autocorrelation of residuals) was fit with one additional climate variable added. Results of these models are given in Table 14.

The scaled Pseudo-R^2 term measures the expected reduction in residual variance that results from adding the climate covariate to the model. The best one-variable model resulted in roughly a 32% decrease in residual variation. Table 14 shows that the effect of adding a covariate typically results in a reduction in either the Year or the Month variances. The Site, Residual and Autocorrelation variance components are not affected by any of the climate factors. The intercept term value changes with each model as does its interpretation. The best one-variable model, using extreme maximum daily precipitation (in hundreds of an inch denoted EMXP), shows a 0.001 reduction in expected acre-inches pumped for a .01 inch increase in maximum daily precipitation (0.1 acre inch decrease per inch of max daily precipitation). This translates to a increase of 0.039 acre-inches per centimeter of extreme rainfall. In the dataset, EMXP ranges from 0 to 621 hundreds (15.9 centimeters) with an average of 153.6 (3.94 centimeters). As a result of adding EMXP to the model, the variation among years was reduced by an order of magnitude.

Table 15 displays the results of the fit for the best two-covariate model. The best two-variable model resulted in an additional 10% reduction in residual variation. The two-variable model consisted of EMXP and monthly minimum temperatures (MMNT reported in tenths of a degree Fahrenheit). The combination of these two covariates resulted in a decrease in the Year and Site variability, with a corresponding increase in Month variability. The residual variability was reduced from 1.1 to .85. The regression coefficient for EMXP is approximately twice the one-variable model (0.002 ACI per hundredth or 0.52 ACI per centimeter with the MMNT coefficient 0.001 ACI per tenth ^oF (0.01 ACI per ^oF). EMXP and MMNT are very loosely correlated ($r=0.19$ $p<0.01$) hence there is little concern that using the two factors in the same model would result in collinearity issues.

Three-variable and more models showed less than 5% additional reduction on residual variation suggesting that the two variable model is probably the best.

Table 14 Random and fixed effects coefficients from the single climate covariate models for ridge citrus. Values in parentheses are standard errors of the estimates with associated significance probabilities in brackets.

Factor	Intercept	Regression Coefficient	Year	Month	Site	AR(1)	Residual	Scaled Pseudo-R^2
Effect Type	Fixed	Fixed	Random	Random	Random	Random	Random	
Base Model	.94 (.13) [<.01]	-	.048(.02) [.01]	.14(.06) [.01]	.16(.03) [<.01]	.25(.01) [<.01]	1.1(.017) [<.01]	
DP01	1.61 (.12) [<.01]	-.11(.004) [<.01]	.01(.01) [.02]	.13(.06) [<.01]	.17(.03) [<.01]	.25(.01) [<.01]	1.01(.02) [<.01]	0.373
DP05	1.28 (.12) [<.01]	-.12(.006) [<.01]	.03(.010) [<.01]	.11(.05) [<.01]	.18(.03) [<.01]	.24(.01) [<.01]	1.03(.02) [<.01]	0.353
DP10	1.14 (.12) [<.01]	-.13(.009) [<.01]	.03(.01) [<.01]	.12(.05) [<.01]	.18(.03) [<.01]	.25(.01) [<.01]	1.06(.02) [<.01]	0.342
EMNT	2.18 (.20) [<.01]	-.02(.003) [<.01]	.004(.02) [<.01]	.21(.1) [<.01]	.17(.03) [<.01]	.24(.01) [<.01]	1.10(.02) [<.01]	0.197
EMXP	1.14 (.12) [<.01]	-.001(.0001) [<.01]	.003(.01) [<.01]	.11(.05) [<.01]	.16(.03) [<.01]	.25(.01) [<.01]	0.97(.02) [<.01]	0.771
MMNT	3.48 (.30) [<.01]	-.004(.0004) [<.01]	.004(.02) [<.01]	.25(.11) [<.01]	.16(.03) [<.01]	.26(.01) [<.01]	1.03(.02) [<.01]	0.456
MMXT	-3.88 (.47) [<.01]	.006(.0005) [<.01]	.004(.02) [<.01]	.37(.16) [<.01]	.16(.03) [<.01]	.26(.01) [<.01]	1.02(.02) [<.01]	0.458
MNTM	1.20 (.38) [<.01]	-.0003(.0005) [<.01]	.005(.02) [<.01]	.16(.07) [<.01]	.16(.03 [<.01]	.27(.01) [<.01]	1.04(.02) [<.01]	0.448
TPCP	1.30 (.2) [<.01]	-.0008(4E-5) [<.01]	.03(.01) [<.01]	.11(.05) [<.01]	.18(.03) [<.01]	.24(.01) [<.01]	1.02(.02) [<.01]	0.357

Table 15 Random and fixed effects coefficients from the two climate covariate models for ridge citrus. Values in parentheses are standard errors of the estimates with associated significance probabilities in brackets

Factor	Random Effects	Factor	Fixed Effects
year	.023 (.011) [0.022]	**Intercept**	2.41 (0.46) [<.01]
month	.018 (.08) [0.012]	**EMXP**	-0.00021 (.0005) [<.01]
siteno	.14 (.03) [<.01]	**MMNT**	-0.0013 (.00012) [0.01]
AR(1)	.26 (.01) [<.01]		
Residual	.85 (.02) [<.01]		

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3.2.2 Flatwoods Citrus

3.2.2.1 Basic Model and Site-Specific Rainfall Regressions

A summary of the estimated variance components and associated rainfall regression coefficients are given in Table 16. The reduced dataset excludes 67 observations from the full dataset but this did not seem to affect the model parameter estimates. Note that residual variability is about four times site variability and site and month variability are about the same magnitude. Year to year variability is small and not significantly different from zero.

The effect of adding site-specific rainfall is to reduce somewhat the year, month and residual variability, leaving site variability and the autoregressive coefficient mostly unchanged. An estimated autocorrelation term of 0.30 suggests that there is a roughly 30% carryover of residual effects from one month to the next and this amount is significantly different from zero.

Table 16 Regression coefficients and variance component estimates for general linear mixed effects models fit to the flatwoods citrus irrigation well time series data.

	full **dataset**	***reduced*** **dataset**	
Model Component		**Without Covariate**	**With Rain Covariate**
Year (σ_β)	0.11	0.11	0.09
Month (σ_γ)	0.15‡	0.14‡	0.07‡
Site (σ_α)	0.11‡	0.14‡	0.15‡
Site (AR ρ)	0.31‡	0.32‡	0.30‡
Residual (σ_ε)	0.52‡	0.54‡	0.49‡
Intercept	0.83 (.20)	0.84 (0.19)	1.16 (0.17)
Coefficient for rain	NI	NI	-0.085 (0.008)

Flatwoods citrus demonstrates less overall variability in irrigation well withdrawal than does ridge citrus, with variance component estimates about the same for site effects and autocorrelation carry-over, greater annual variation but less monthly and residual variation.

Plots of model effects: Below are plots of the overall and individual model effects for the full dataset with parameter estimates given in column 2 of Table 16. Explanations of these graphs are given in the figure captions.

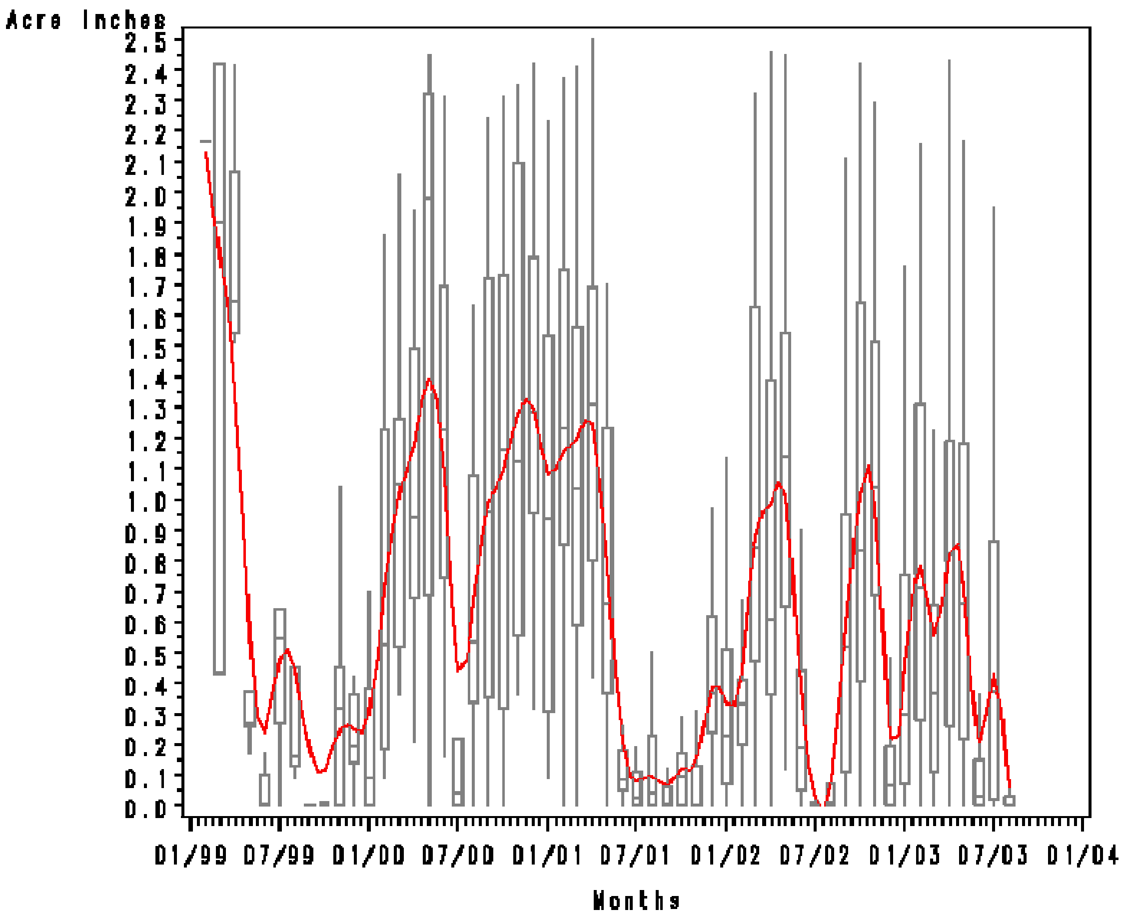

Figure 23 Monthly acre-inches distributions for flatwoods citrus for the entire monitoring period with the average monthly mean estimates connected by a smoothed curve. Monthly and annual patterns are very evident. The objective of the analysis is to decompose the variability seen here into site, year, month and residual effects. The scale of the vertical axis is in acre-inches.

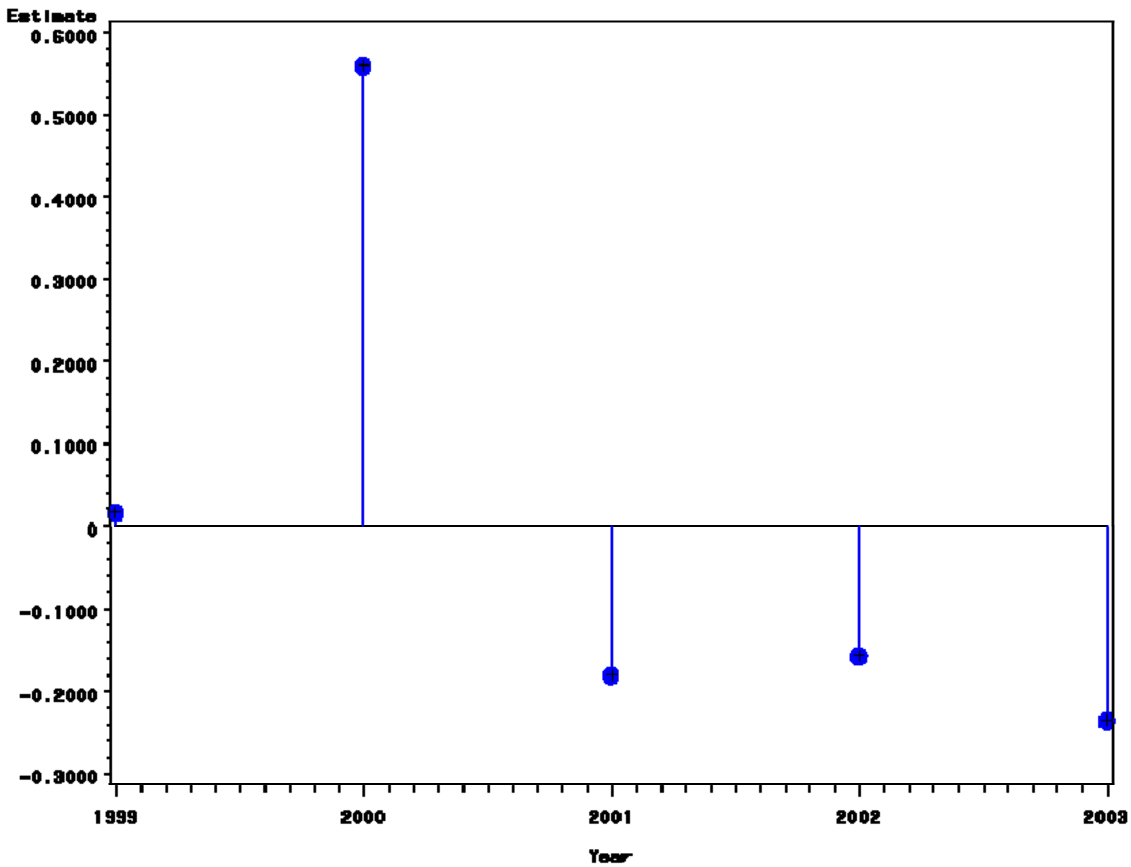

Figure 24 Estimated year effects (the β_j) for flatwoods citrus across the monitoring period. The estimated variance component ($\sigma^2_\beta = 0.11$ or $\sigma_\beta = 0.33$, see Table 16) suggest that 95% of these effects should fall between $\pm 1.96(\sigma_\beta) = \pm 0.65$. There does not seem to be any pattern to year effects hence one would not expect to be able to predict next year's effect by using this year's estimate. One would expect these effects to reflect years with a surplus of rainfall (negative effects) from years with a deficit of rainfall (positive years) since the whole goal of irrigation is to supplement natural rainfall. The scale of the vertical axis is in acre-inches.

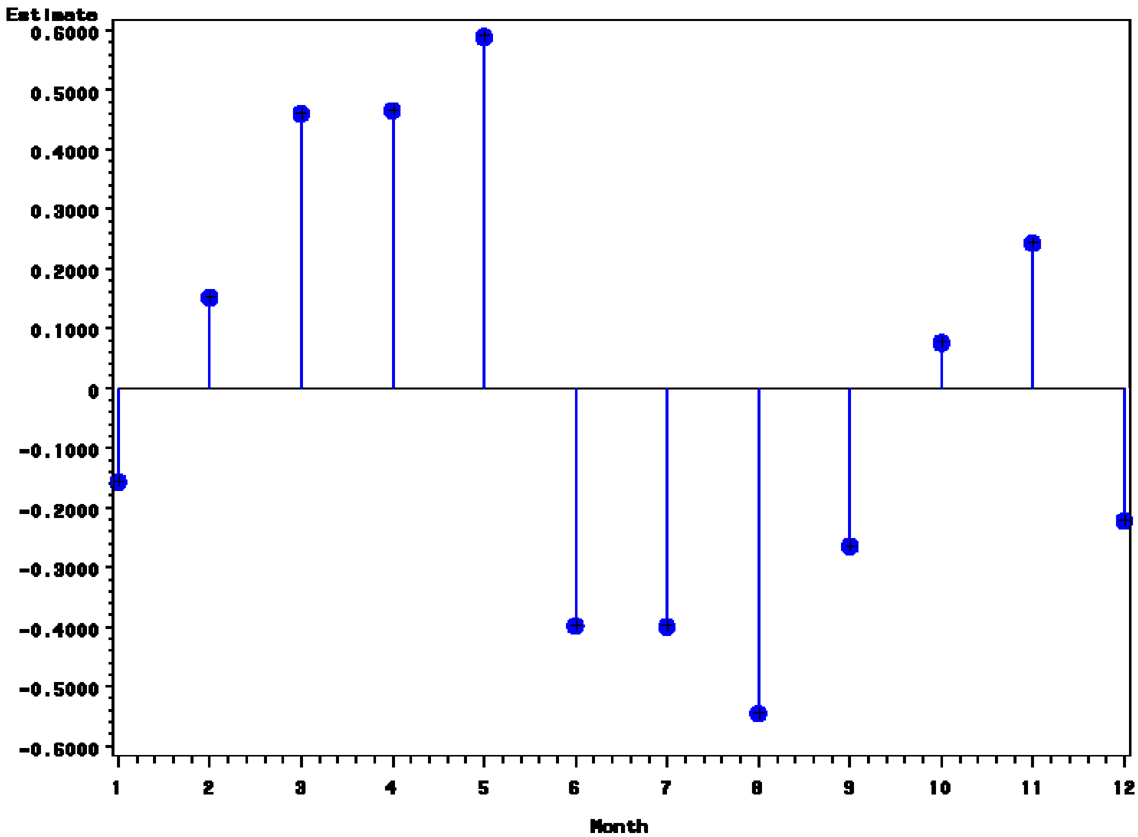

Figure 25 Estimated month effects (the γ_k) for flatwoods citrus across the monitoring period. The estimated variance component (σ^2_γ = 0.15 or σ_γ = 0.387, see Table 16) suggest that 95% of these effects should fall between ±1.96(σ_γ) = ±0.759. Note the dramatic shift in average monthly irrigation between May and June, primarily due to the onset of summer rains. The higher level of irrigation in the spring is probably a combination of reduced natural rainfall and needs for additional water during fruit setting. The scale of the vertical axis is in acre-inches.

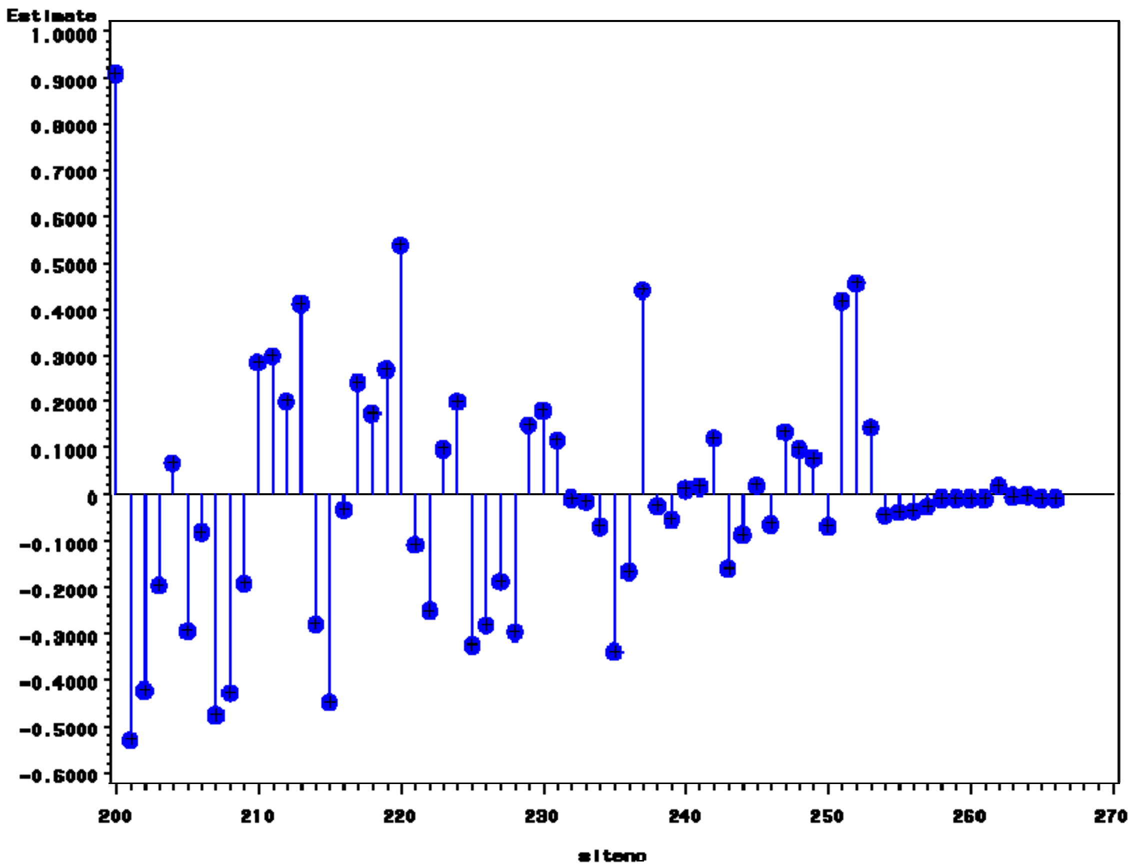

Figure 26 Estimated site effects (the α_i) for flatwoods citrus across the monitoring period. The estimated variance component (σ^2_α = 0.11 or σ_α = 0.33, see Table 16) suggest that 95% of these effects should fall between $\pm 1.96(\sigma_\alpha) = \pm 0.65$. Note that only site 200 has expected effect that falls outside these bounds. Also note that the limited effects for sites from number 247 to 266 are base on just one year's worth of data and in some cases on just a couple of month's of data. The group of sites (from number 218 to 247) in the middle has at most three years of data. The units on the vertical axis are in acre-inches.

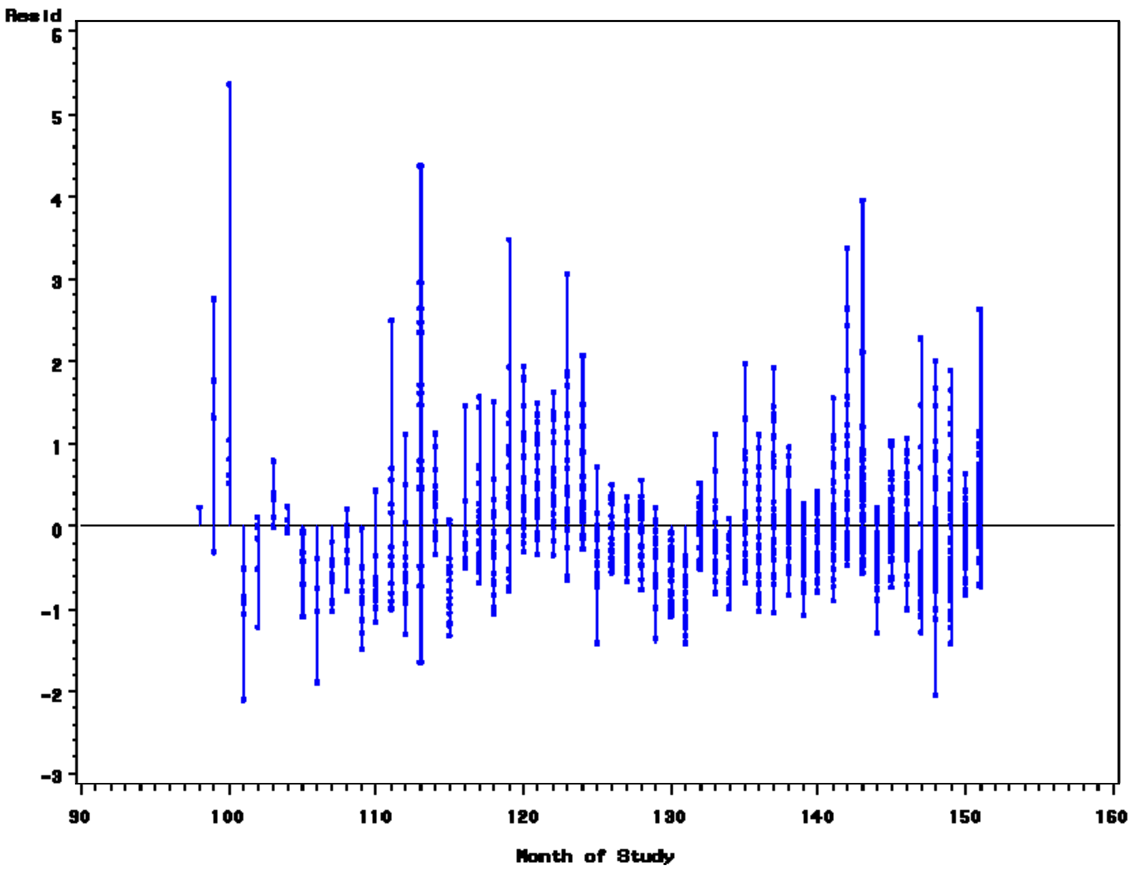

Figure 27 Estimated residual effects (the ε_{ijk}) (in acre-inches) for flatwoods citrus across the monitoring period. The estimated variance component (σ^2_ε = 0.52 or σ_ε = 0.72, see Table 16) suggest that 95% of these effects should fall between ±1.96(σ_ε) = ±1.41. This is not quite correct since this equation does not take into account the effect of the autocorrelation but does work as a rough rule of thumb. Note that there are a number of site/dates where the residual exceeds this value. At this point, the exceedences should reflect management decisions at specific sites on specific months and years. The inter-annual pattern in the residuals that is somewhat evident in this graph is captured in the autocorrelation parameter.

There are any number of reasons that a particular well might exceed the expected site/year/month mean as estimated by the model. Some agronomic situations, such as establishment of a newly planted grove, irrigation for freeze protection or as a result of extended drought, would be expected to produce these extreme events. Other less predictable causes would be event such as pipe leak, faulty valves or management lapses. For this reasons one should not automatically assume that all residuals greater than the 1.41 is indication of “poor” irrigation practice. More analysis of the extreme events would be necessary before this conclusion might be drawn.

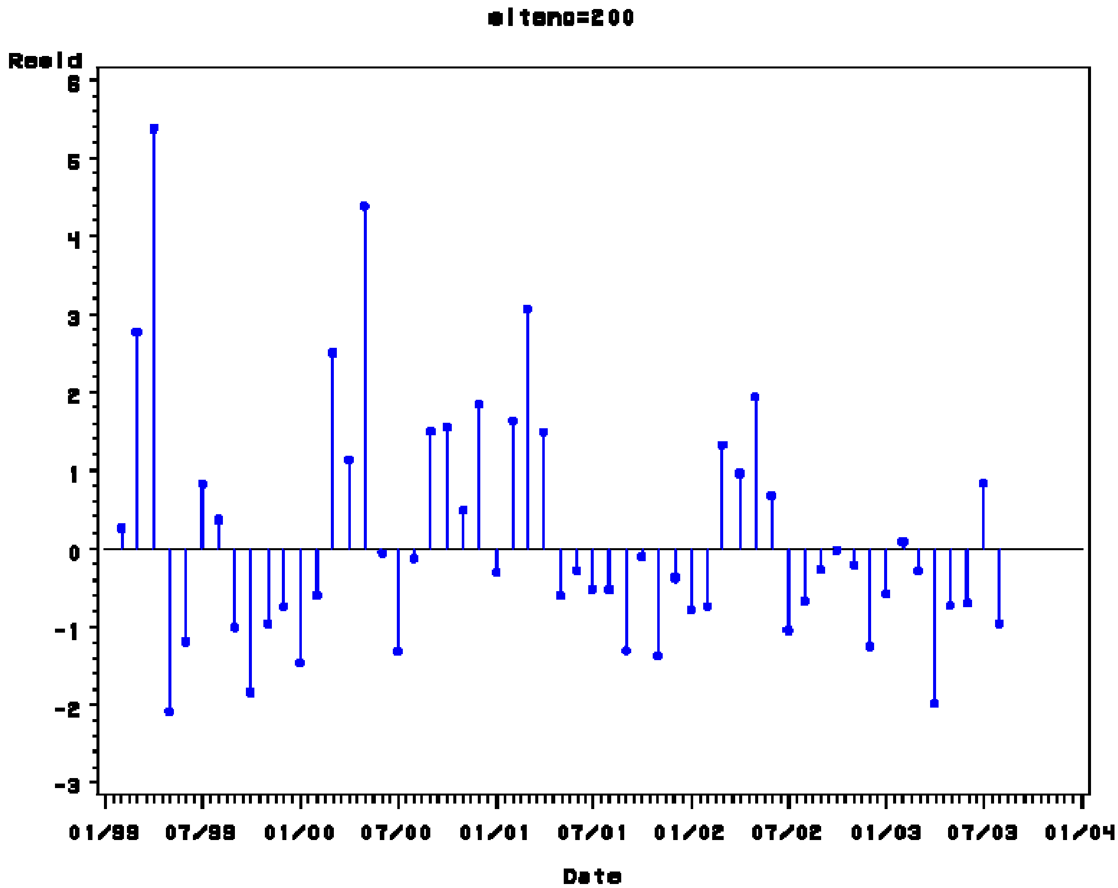

Figure 28 Plot of residuals (ε_{ijk}, i=200) (in acre-inches) for site 200. This site is presented here because of its large site effect. Note that on top of the large site effect there are quite a few large positive and negative residuals (greater than ±1.41**). The pattern of the residuals does not look random, but the reason for this lack of randomness is not readily apparent.**

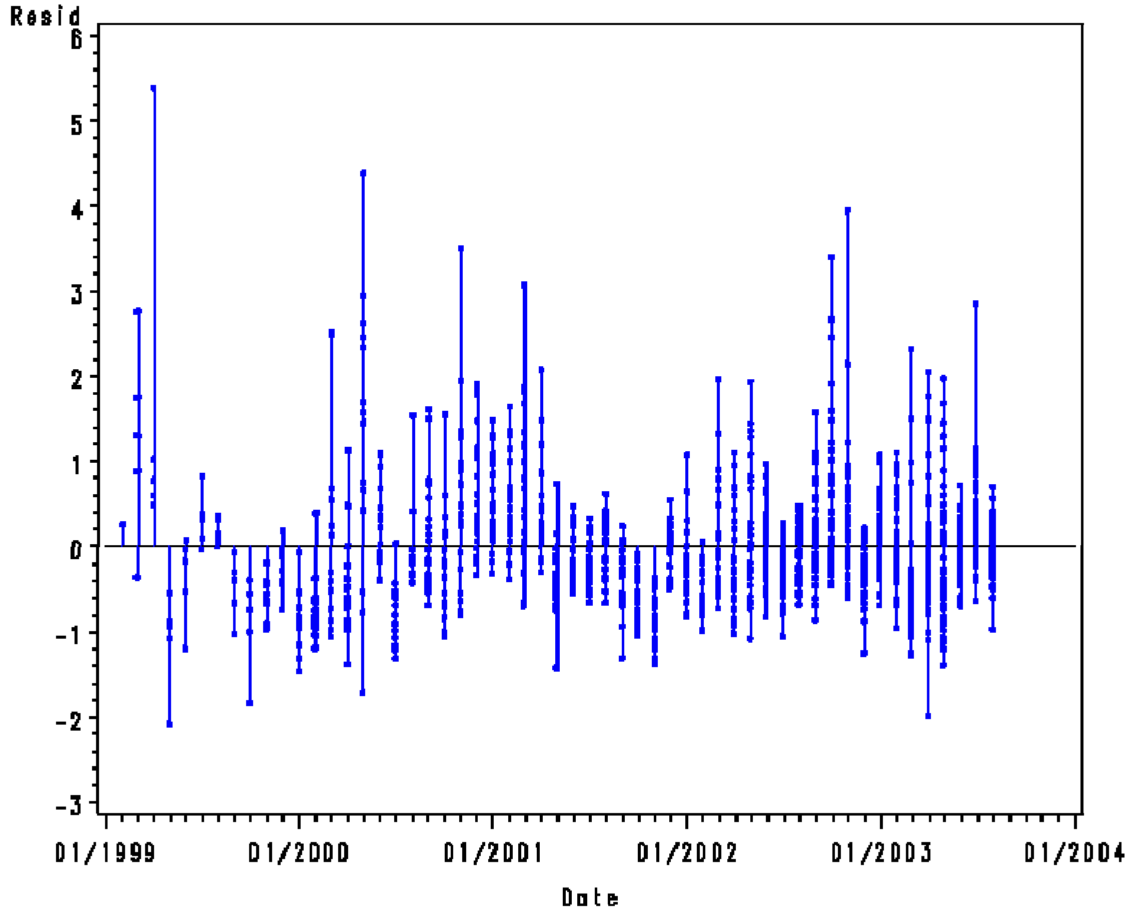

Figure 29 Estimated residual effects (the ε_{ijk}) (in acre-inches) for flatwoods citrus across the monitoring period but in which the effect of site-specific rainfall has been added to the model. The estimated variance component (σ^2_ε = 0.49 or σ_ε = 0.70, see Table 16) suggest that 95% of these effects should fall between ±1.96(σ_ε) = ±1.37. The residual variability noted here is not very different from that estimated without using rainfall as a covariate hence the impact of adding site-specific rainfall is not very strong in these data. Note that adding rainfall to the model has reduced some of the extreme events but has not impacted others. Also note that residuals above 1.37 do not seem to fall in a particular time period and are spread throughout the year.

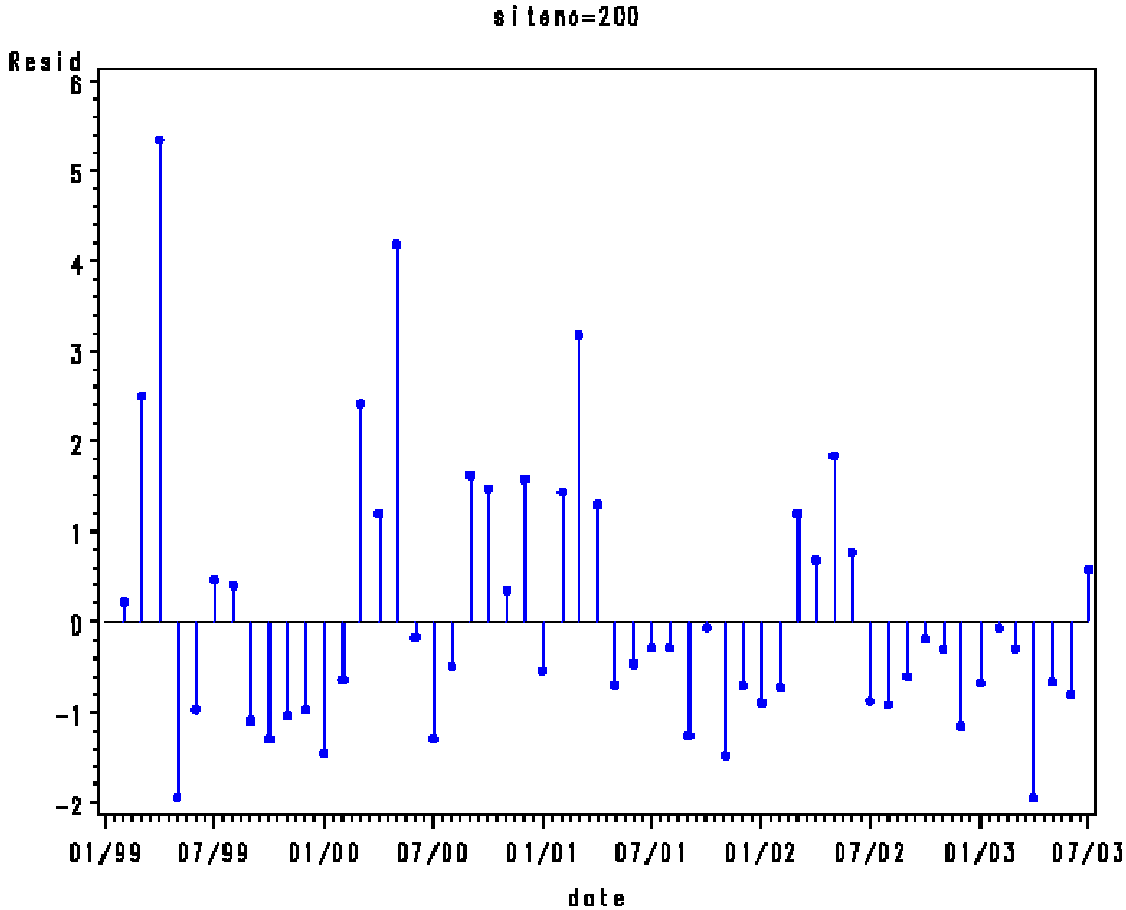

Figure 30 Plot of the residuals for site 200 over the reduced period for which site-specific rainfall is available. The trend in residuals does not seem to be very different after adjusting for rainfall effects. The reduction in extreme irrigation pumpage over time could be due to a number of factors. Physical factors, such as a change from furrow to micro-jet irrigation methodologies or simply changes in management philosophy could explain this pattern.

3.2.2.2 Regressions with climate variables

The original flatwoods citrus dataset was augmented with climate data obtained from the National Weather Service public databases. One climate data site was chosen within each county having the flatwoods citrus and each site in that county was assigned copies of that climate time series. The basic mixed effects general linear model used in the previous analyses (the one having site, year, month and residual random effects and assuming autocorrelation of residuals) was fit with one additional climate variable added. Results of these models are given in Table17.

The scaled Pseudo-R^2 term measures the expected reduction in residual variance that results from adding the climate covariate to the model. The best one-variable model (with EXMP) resulted in a very small 8% decrease in residual variation. From Table 17 you can see that the effect of adding a covariate is not strong, typically producing a small reduction in the residual and autocorrelation term but with a corresponding increase in the Year, Month and Site variances. The intercept term value changes with each model, typically increasing. The regression coefficients (Table 15) are quite small and negative. The best one-variable model, using extreme maximum daily precipitation (in hundreds of an inch denoted EMXP), shows a 0.005 reduction in expected acre-inches pumped for a .01 inch increase in maximum daily precipitation (0.5 acre inch per inch of maximum daily precipitation). This translates to a 0.195 increase in acre-inches per centimeter of extreme rainfall. In the dataset, EMXP ranges from 12 to 376 hundreds (10.44 centimeters) with an average of 141.4 (3.83 centimeters). As a result of adding EMXP to the model, the variation among years, months and sites was slightly increased.

Table 18 displays the results of the fit for the best two-covariate model. All of the two or more covariate models were actually worse fitting than the best one-covariate model above. While the one-covariate model using extreme maximum daily precipitation was considered the best among the covariate analyses, the improvement in fit from using this covariate is minimal and does not suggest that any of the covariates be used.

Table 17 Random and fixed effects coefficients from the single climate covariate models for flatwoods citrus. Values in parentheses are standard errors of the estimates with associated significance probabilities in brackets.

Factor	Intercept	Regression Coefficient	Year	Month	Site	AR(1)	Residual	Pseudo-R^2
no covariate	.83(.20) [<.01]		.11(.08) [.09]	.15(.07) [.01]	.11(.03) [<.01]	.31(.03) [<.01]	.52(.02) [<.01]	
DP01	1.22(.18) [<.01]	-.076(.008) [<.01]	.091(.067) [.09]	.095(.042) [.013]	.11(.028) [<.01]	.32(.028) [<.01]	.49(.022) [<.01]	0.031
DP05	1.11(.17) [<.01]	-.12(.012) [<.01]	.10(.075) [.09]	.067(.031) [0.02]	.11(.028) [<.01]	.31(.028) [<.01]	.49(.022) [<.01]	0.038
DP10	1.02(.19) [<.01]	-.18(.019) [<.01]	.12(.090) [.09]	.093(.04) [.01]	.11(.028) [<.01]	.31(.028) [<.01]	.49(.022) [<.01]	0.036
EMNT	1.80(.3) [<.01]	-0.02(.005) [<.01]	.09(.07) [.09]	.14(.06) [.01]	.11(.03) [<.01]	.30(.03) [<.01]	.51(.02) [<.01]	0.002
EMXP	1.67(.32) [.12]	-.005(.0007) [<.01]	.14(.21) [.25]	.18(.09) [.03]	.15(.04) [<.01]	.29(.05) [<.01]	.48(.03) [<.01]	0.642
MMNT	3.83(.88) [.14]	-.005(.001) [<.01]	.17(.25) [.25]	.25(.14) [.04]	.15(.04) [<.01]	.23(.05) [<.01]	.48(.03) [<.01]	0.631
MMXT	3.57(1.37) [.23]	-.0031(.002) [.05]	.20(.29) [.25]	.18(.09) [.02]	.15(.04) [<.01]	.23(.05) [<.01]	.49(.032) [<.01]	0.629
MNTM	3.93(1.09) [.17]	-.004(.001) [<.01]	.18(.69) [.25]	.21(.11) [.02]	.15(.04) [<.01]	.23(.046) [<.01]	.48(.032) [<.01]	0.630
TPCP	1.15(.18) [.003]	-.00076 (7.2E-5) [<.01]	.10(.07) [<.01]	.09(.04) [.01]	.12(.03) [<.01]	.3(.03) [<.01]	.48(.02) [<.01]	0.039

Table 18 Random and fixed effects coefficients from the two climate covariate models for flatwoods citrus. Values in parentheses are standard errors of the estimates with associated significance probabilities in brackets.

Factor	Random Effects	Factor	Fixed Effects
year	.095(.14) [.26]	**Intercept**	3.75(.9) [0.15]
month	.34(.22) [.06]	**EMXP**	-.004(.0007) [<.01]
siteno	.15(.05) [<.01]	**MMNT**	-.003(.001) [.02]
AR(1)	.29(.05) [<.01]		
Residual	.47(.03) [<.01]		

3.2.3 Potato

3.2.3.1 Basic Model and Site-Specific Rainfall Regressions

A summary of the estimated variance components and associated rainfall regression coefficients are given in Table 19. The reduced dataset typically excludes some of the early years of data (3716 and 2532 sample size respectively), hence it is expected that the year-to-year variability would be reduced when one moves from the full dataset to the reduced dataset. Note that residual variability is typically much larger than site, weeks since planting and year variability.

The effect of adding site-specific rainfall is to reduce somewhat the year, week since planting and residual variability but increasing site variability. An estimated autocorrelation term of 0.28 suggests that there is a roughly 28% carryover of residual effects from one month to the next and this amount is significantly different from zero.

Table 19 Regression coefficients and variance component estimates for general linear mixed effects models fit to the potato irrigation well time series data.

	full **dataset**	***reduced*** **dataset**	
Model Component		**Without Covariate**	**With Rain Covariate**
Year (σ_β)	0.52‡	0.03	0.02
Week Since Planting (σ_γ)	1.79‡	1.27‡	1.04‡
Site (σ_α)	0.32‡	0.21‡	0.24‡
Site (AR ρ)	0.23‡	0.32‡	0.28‡
Residual (σ_ε)	3.39‡	2.43‡	2.19‡
Intercept	1.88 (0.32)	1.34 (0.24)	1.83 (0.22)
Coefficient for rain	NI	NI	-0.22 (0.015)

Plots of model effects: Below are plots of the overall and individual model effects for the full dataset with parameter estimates given in column 2 of Table 19. Explanations of these graphs are given in the figure captions.

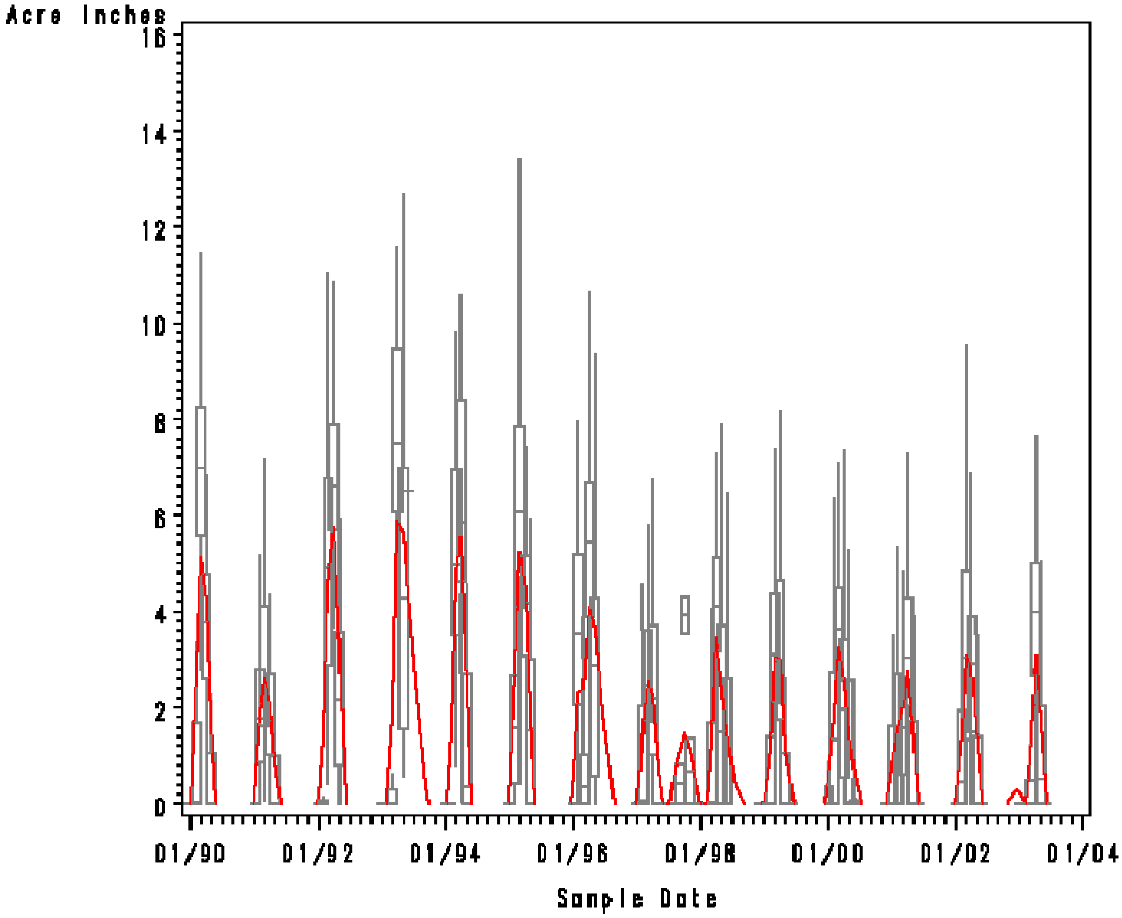

Figure 31 Monthly acre-inches distributions for potato for the entire monitoring period with the average monthly mean estimates connected by a smoothed curve. Annual cycles are very evident with year to year average effects also very clear. The model simply decomposes these cycles into site, year, weeks since planting and residual random effects with the added assumption that measurements of adjacent weeks within a site will be autocorrelated.

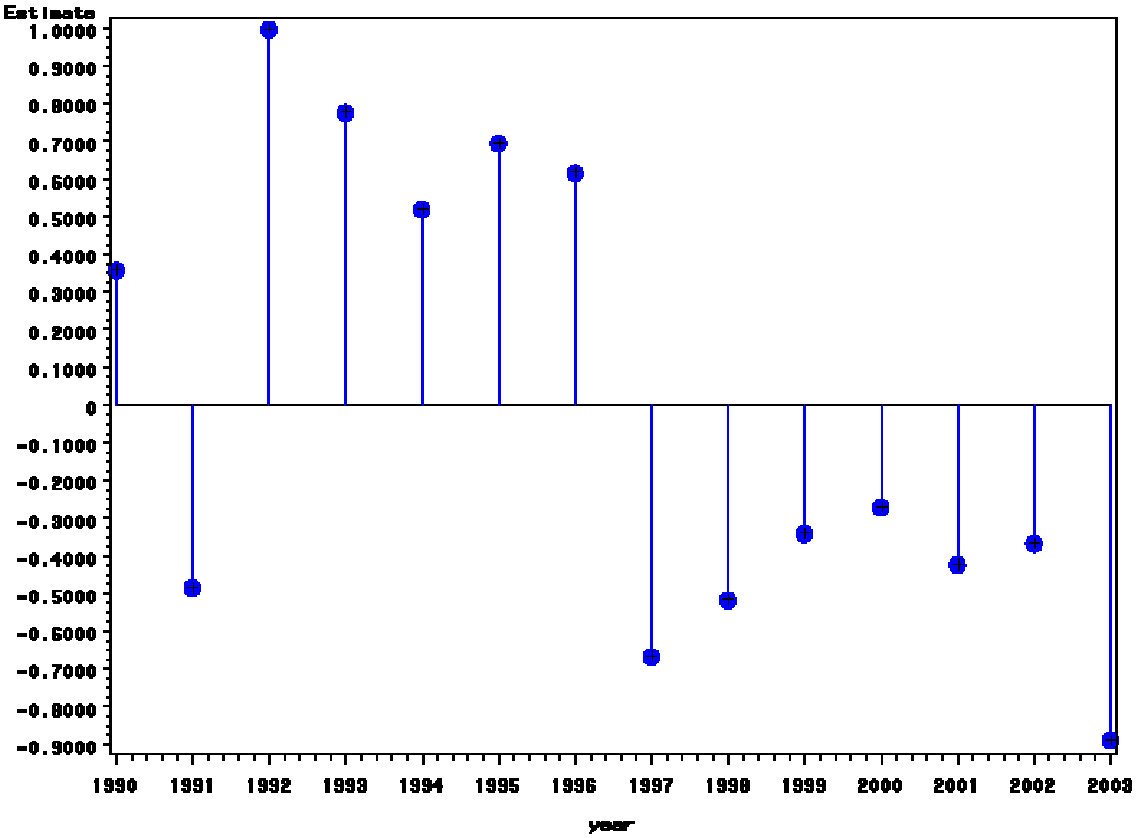

Figure 32 Estimated year effects (the β_j) for potato across the monitoring period. The estimated variance component (σ^2_β = 0..52 or σ_β = 0.72, see Table 19) suggest that 95% of these effects should fall between ±1.96(σ_β) = ±1.41. There is a clear pattern in annual effects with below average annual water pumpage in the last seven years preceeded by above average pumpage in six of the initial seven years. It would be interesting to determine what caused the major shift between the 1996 and 1997 crop season. The scale of the vertical axis is in acre-inches.

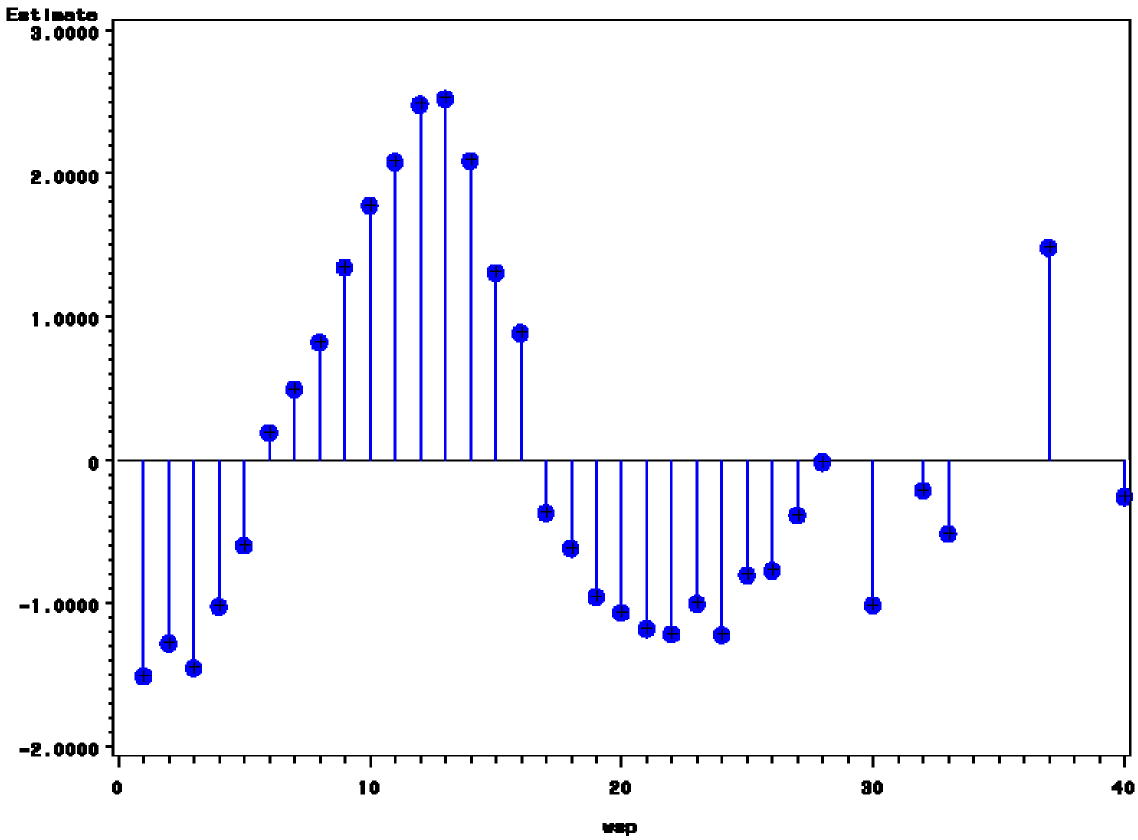

Figure 33 Estimated week-since-planting (WSP) effects (the γ_k) for potato across the monitoring period. The estimated variance component (σ^2_γ = 0.1.79 or σ_γ = 1.34, see Table 19) suggests that 95% of these effects should fall between ±1.96(σ_γ) = ±2.62. It is very clear that there is a fixed pattern of water use within the growing season. This factor represents a very large fraction of total variability in water use and suggests that most growers are following a similar water management plan that directly addresses the needs of the potato crop over time. The scale of the vertical axis is in acre-inches.

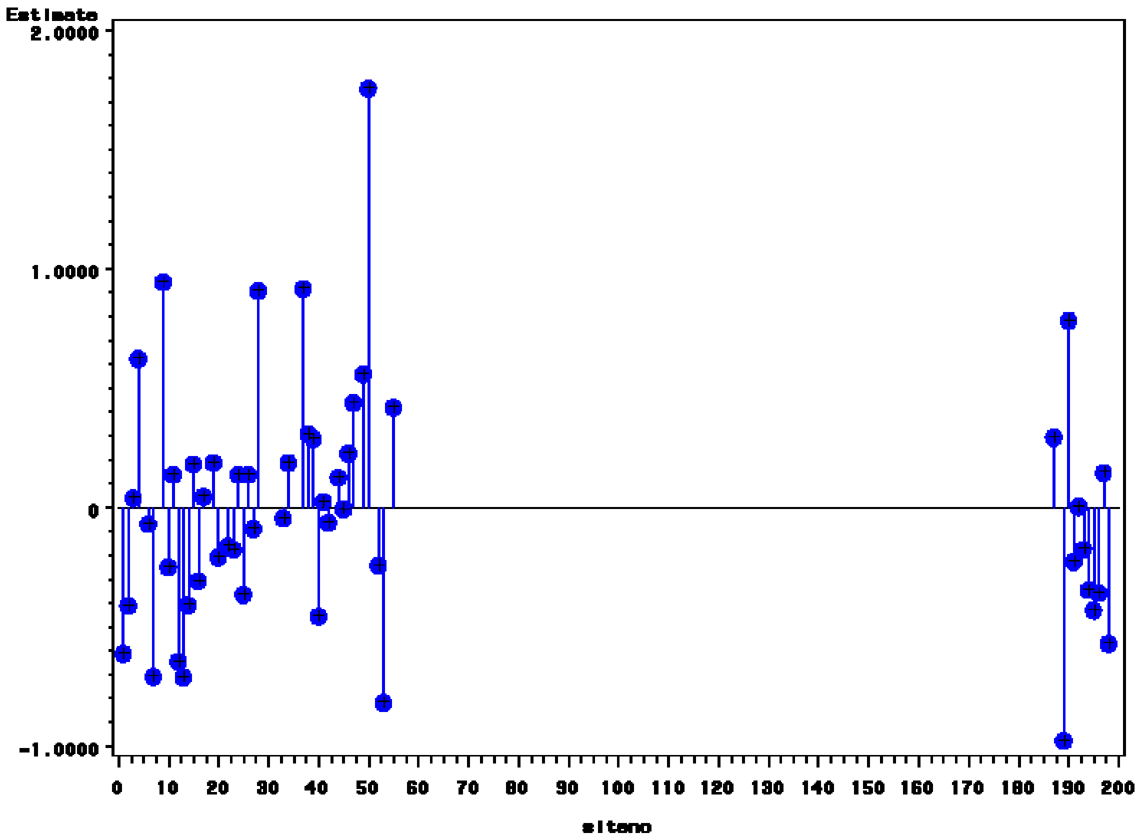

Figure 34 Estimated site effects (the α_i) for potato across the monitoring period. The estimated variance component (σ^2_α = 0.32 or σ_α = 0.57, see Table 19) suggests that 95% of these effects should fall between $\pm 1.96(\sigma_\alpha) = \pm 1.108$. Note that only site 50 has expected effect that falls outside these bounds. Sites with positive effects are expected to use, on average, more than the overall average. Sites with negative effects are expected to use, on average, less than the overall average. Since soils are very similar among the sites, the differences in the site effect should be primarily due to management. The units on the vertical axis are in acre-inches.

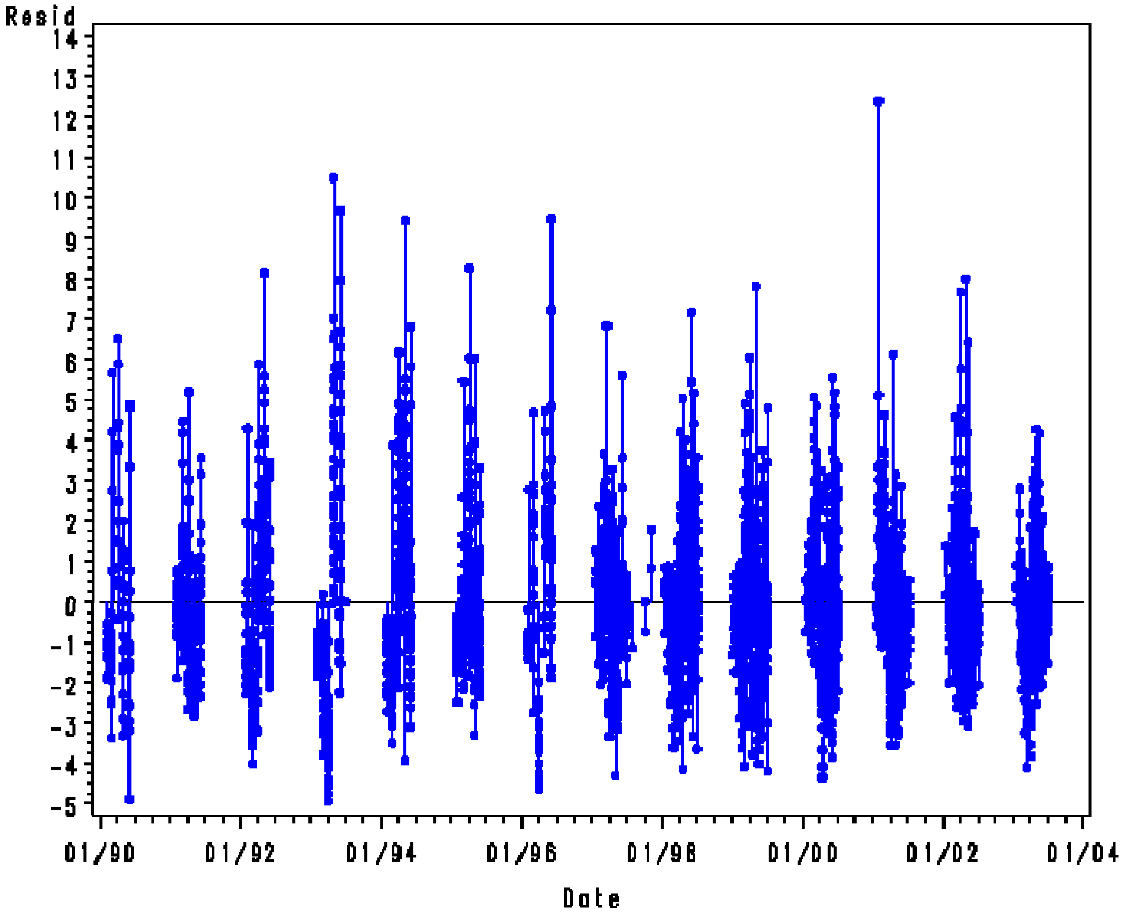

Figure 35 Estimated residual effects (the ε_{ijk}) (in acre-inches) for potato across the monitoring period. The estimated variance component (σ^2_ε = 3.39 or σ_ε = 1.84, see Table 19) suggests that 95% of these effects should fall between ±1.96(σ_ε) = ±3.61. This is not quite correct since this equation does not take into account the effect of the autocorrelation but does work as a rough rule of thumb. Note that exceedences above 3.61 occur for some sites in just about every year. The reason for this is not clear.

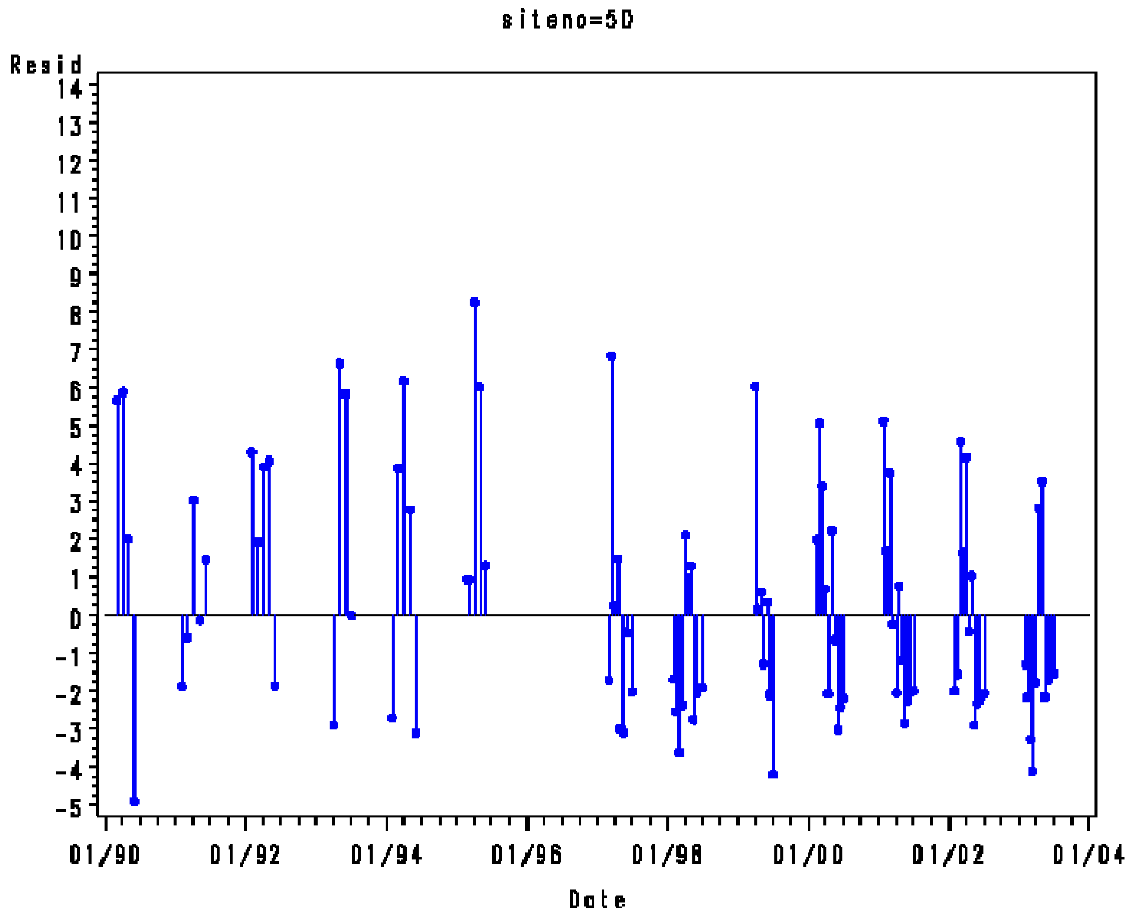

Figure 36 Plot of residuals (ε_{ijk}, i=50) (in acre-inches) for site 50. This site is presented here because of its large site effect. Note that values of irrigation use above 3.61 acre-inches are observed in every year. This clearly suggests that the high usage for this site is a result of a management decision.

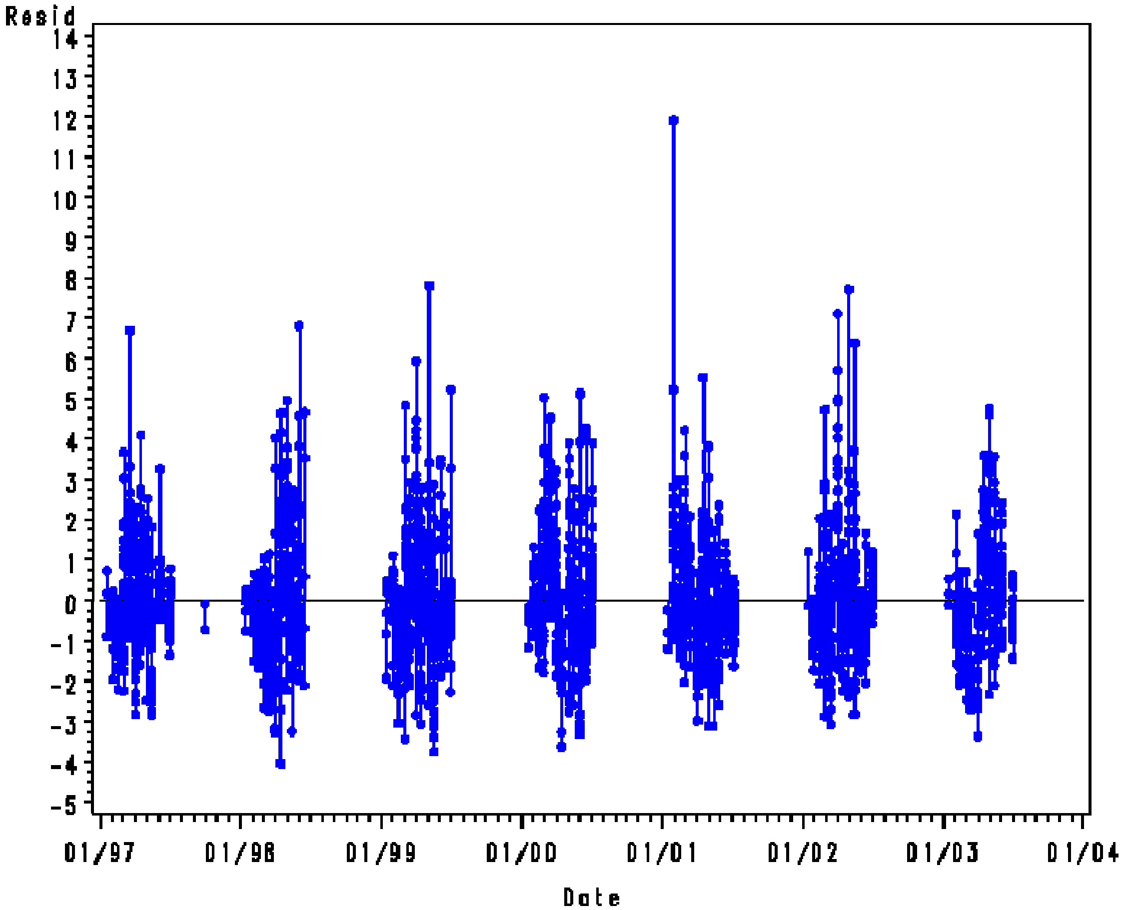

Figure 37 Estimated residual effects (the ε_{ijk}) (in acre-inches) for potato across the monitoring period but in which the effect of site-specific rainfall has been added to the model. The estimated variance component (σ^2_ε = 2.19 or σ_ε = 1.48, see Table 19) suggests that 95% of these effects should fall between ±1.96(σ_ε) = ±2.90. Note that adding rainfall to the model has reduced some of the extreme events but has not impacted others. Note also that there does not seem to be any pattern left to the residuals and that in each year the residuals seem to be normally distributed. Examination of specific sites does not suggest within or between growing season effects.

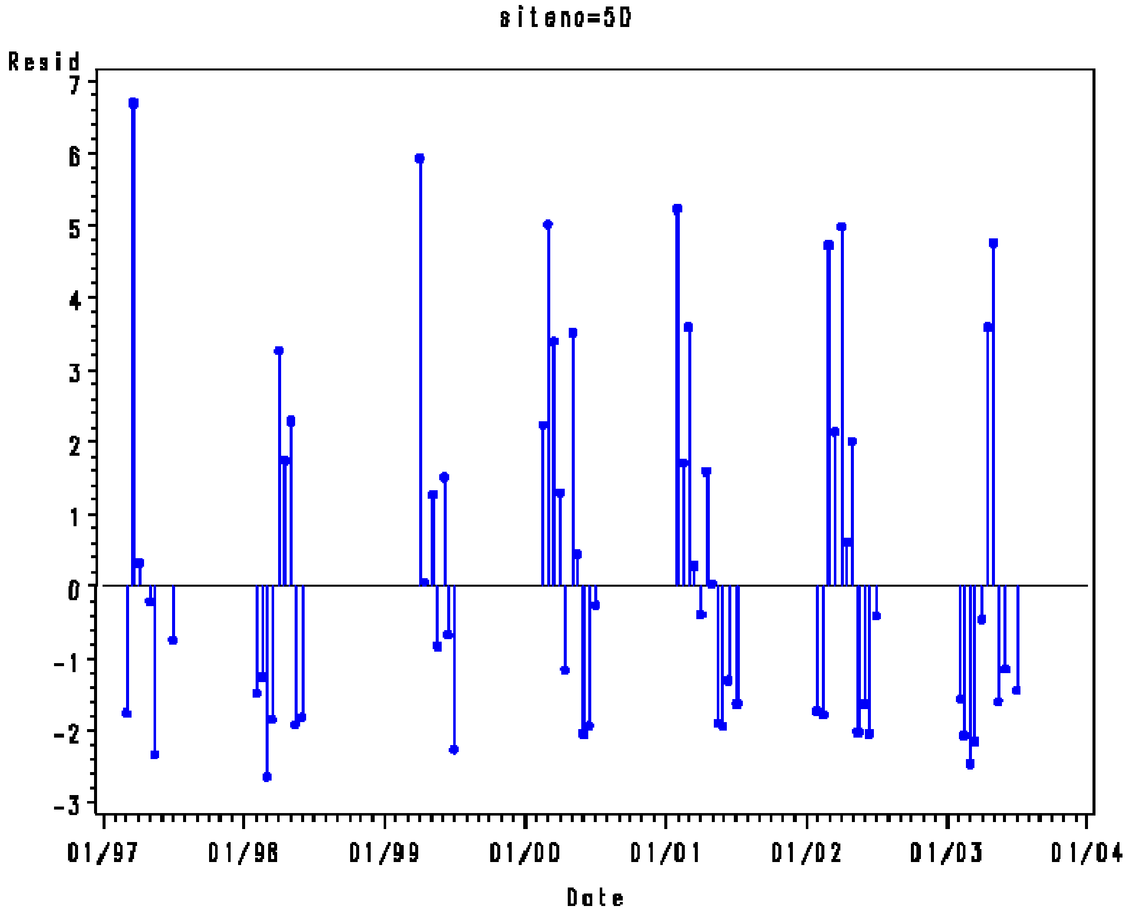

Figure 38 Plot of the model residuals of site no 50 over the monitoring period with rain as a covariate in the model. It is clear that the large site effect for this well is due to large bi-weekly irrigations, but that these irrigations do not always occur in at a particular time in the growing season.

3.2.3.2 Regressions with climate variables

The original potato dataset is broken up into bi-weekly readings. The National Weather Service public climate databases are organized into daily and monthly summaries. Adding the National Weather Service data to the potato dataset was attempted but found quite difficult to do. First, the geographically restricted area of the potato-growing region in north Florida means that data from only one area, Hastings, would be applicable. This means that all stations would share the same temperature and rainfall parameter values; hence these data could not be used to discriminate amongst the within-season patterns across sites. Because it was shown that the site-specific rainfall did not greatly reduce residual variation, no further work on adding climate data to the potato analysis was attempted.

3.2.4 Leatherleaf Fern.

3.2.4.1 Basic Model and Site-Specific Rainfall Regression:

A summary of the estimated variance components and associated rainfall regression coefficients are given in Table 20. The reduced dataset typically excludes half of the data (5583 and 2276 sample size respectively), hence it is expected that the year-to-year variability would be reduced when one moves from the full dataset to the reduced dataset. While this clearly happens, note also that month, site and residual variability grows as does the autocorrelation parameter estimate.

The effect of adding site-specific rainfall is minimal although the regression coefficient is statistically significant. This would be expected with the large sample sizes used in this analysis.

Table 20. Regression coefficients and variance component estimates for general linear mixed effects models fit to the leatherleaf fern irrigation well time series data.

	full **dataset**	***reduced*** **dataset**	
Model Component		**Without Covariate**	**With Rain Covariate**
Year (σ_β)	2.73‡	1.40	1.32
Month (σ_γ)	5.89‡	8.99‡	7.91‡
Site (σ_α)	1.06‡	1.40‡	1.47‡
Site (AR ρ)	0.30‡	0.39‡	0.37‡
Residual (σ_ε)	12.49‡	14.89‡	14.16‡
Intercept	3.81 (0.84)	3.81 (1.00)	4.85 (0.96)
Coefficient for rain	NI	NI	-0.25 (0.028)

3.2.4.2 Plots of model effects

Below are plots of the overall and individual model effects for the full dataset with parameter estimates given in column 2 of Table 20. Explanations of these graphs are given in the figure captions.

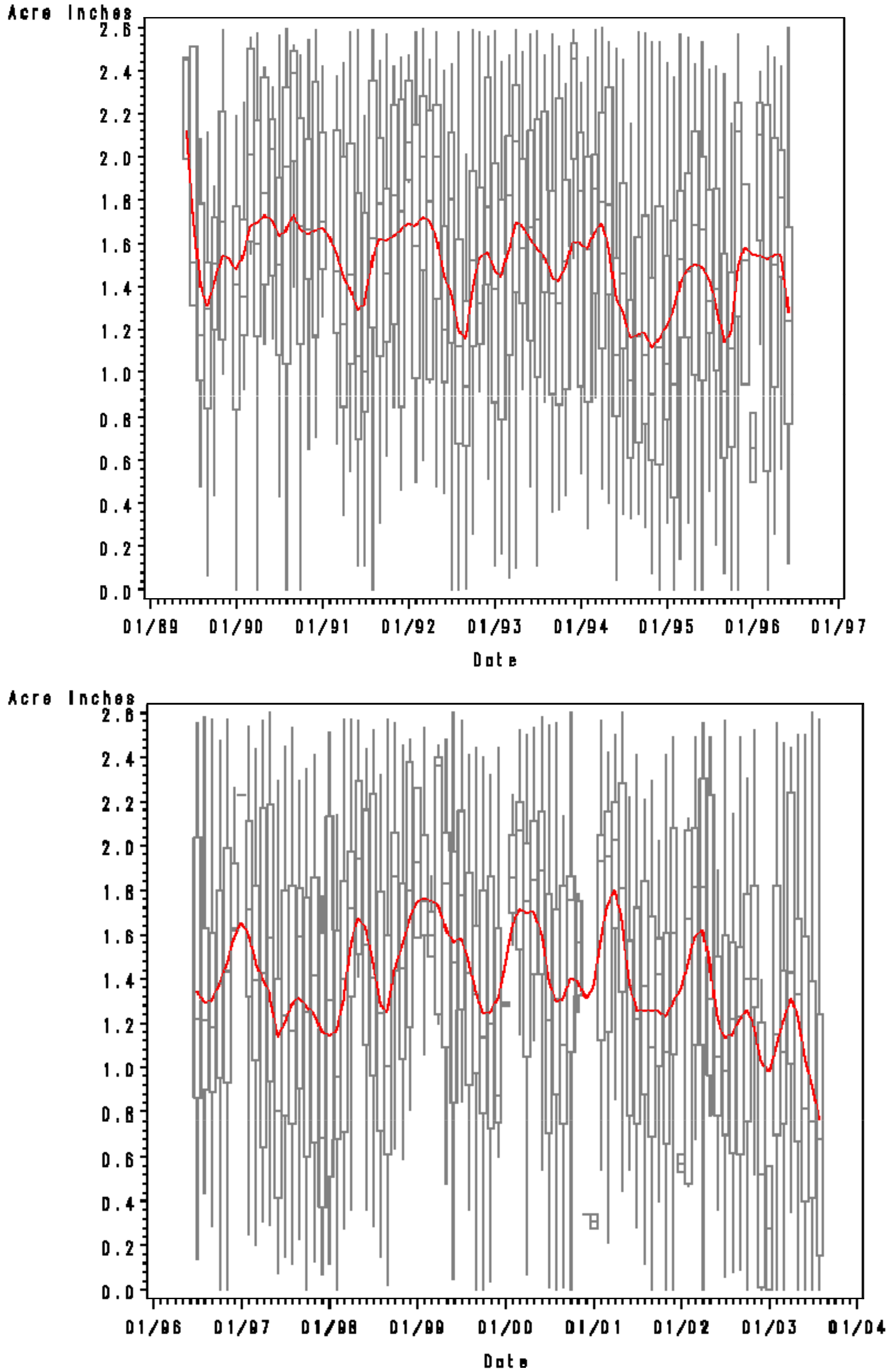

Figure 39 Monthly acre-inches distributions for leatherleaf fern for the entire monitoring period with the average monthly mean estimates connected by a smoothed curve. The time series pattern demonstrates very regular cyclical patterns with small year-to-year variation. Note that acre inch amounts are very evenly spread on either side of the mean trend. The objective of the analysis is to decompose the variability seen here into site, year, month and residual effects. The scale of the vertical axis is in acre-inches.

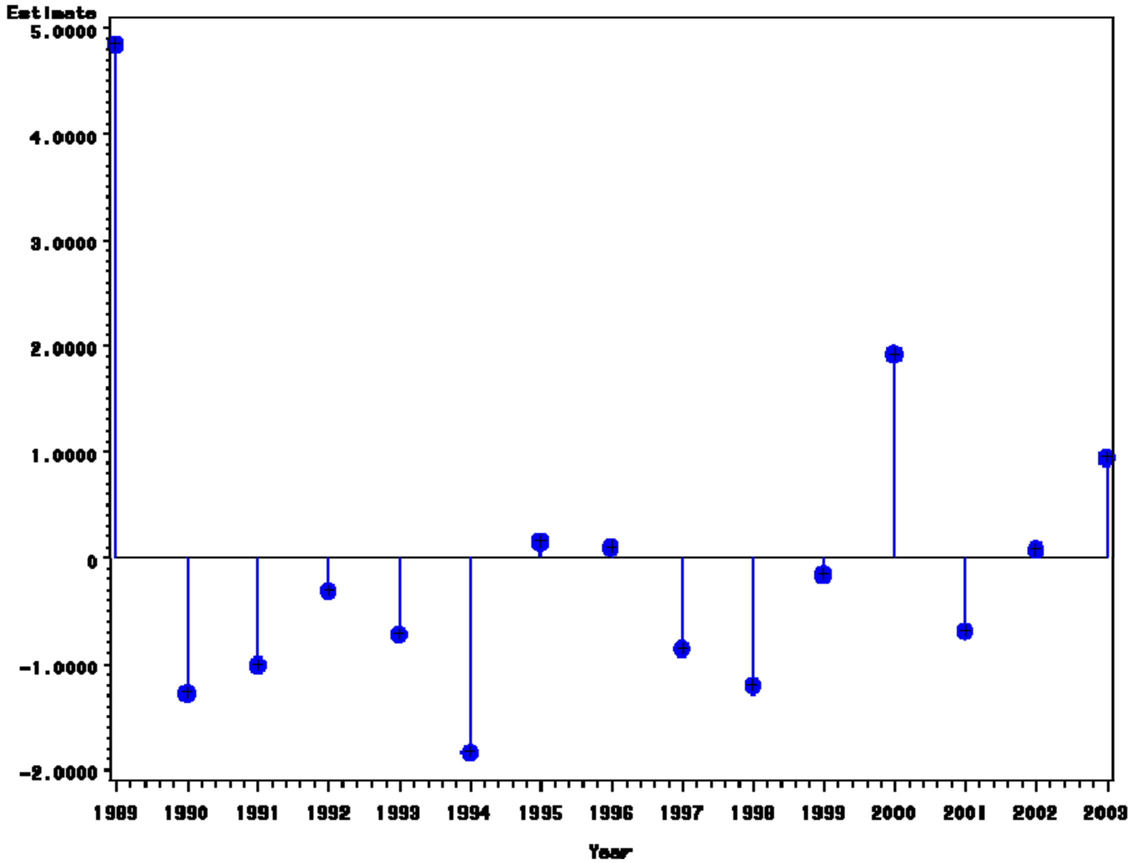

Figure 40 Estimated year effects (the β_j) for leatherleaf fern across the monitoring period. The estimated variance component (σ^2_β = 2.73 or σ_β = 1.65, see Table 20) suggest that 95% of these effects should fall between $\pm 1.96(\sigma_\beta) = \pm 3.23$. The effect for 1989 seems like an outlier and the fact that values from 1990 to 1994 are all negative should be examined more closely. Since 1995 the year effects look much more random. The scale of the vertical axis is in acre-inches.

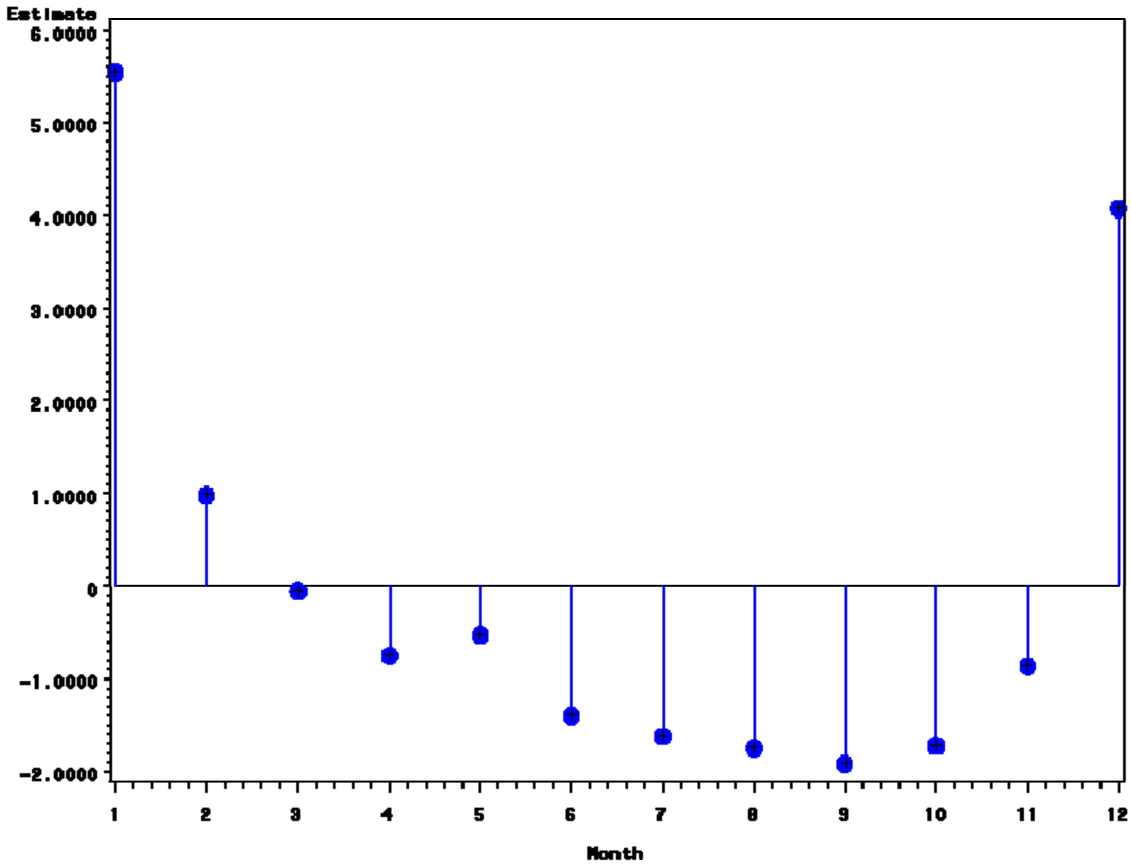

Figure 41 Estimated month effects (the γ_k) for leatherleaf fern across the monitoring period. The estimated variance component (σ^2_γ = 5.89 or σ_γ = 2.43, see Table 20) suggest that 95% of these effects should fall between ±1.96(σ_γ) = ±4.76. There is clearly a pattern to annual water pumped for irrigation. The large peaks in December and January could be due to a combination of irrigation for cold protection and dry conditions typical of these months. The scale of the vertical axis is in acre-inches.

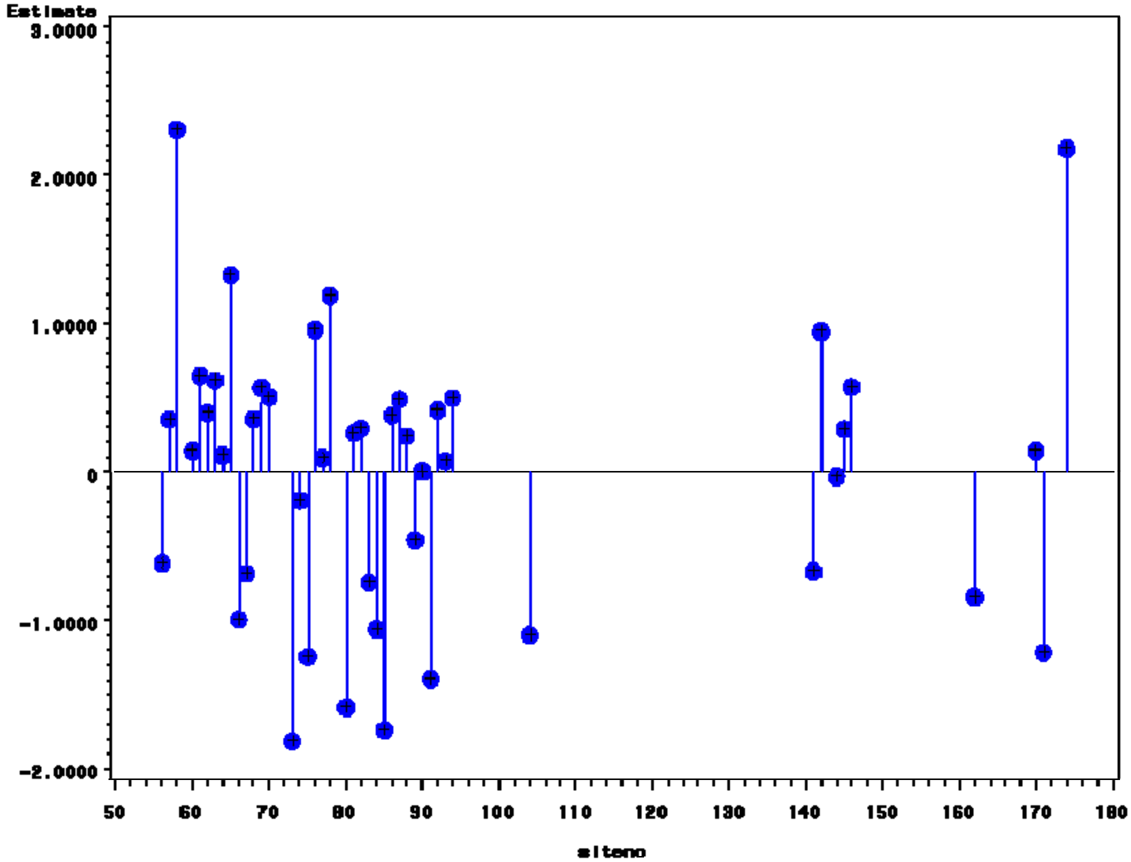

Figure 42 Estimated site effects (the α_i) for leatherleaf fern across the monitoring period. The estimated variance component (σ^2_α = 1.06 or σ_α = 1.03, see Table 20) suggests that 95% of these effects should fall between ±1.96(σ_α) = ±2.02. **Note that only sites 58 and 174 have expected effects that falls outside these bounds, but only by a small amount. In general the pattern looks random. The units on the vertical axis are in acre-inches.**

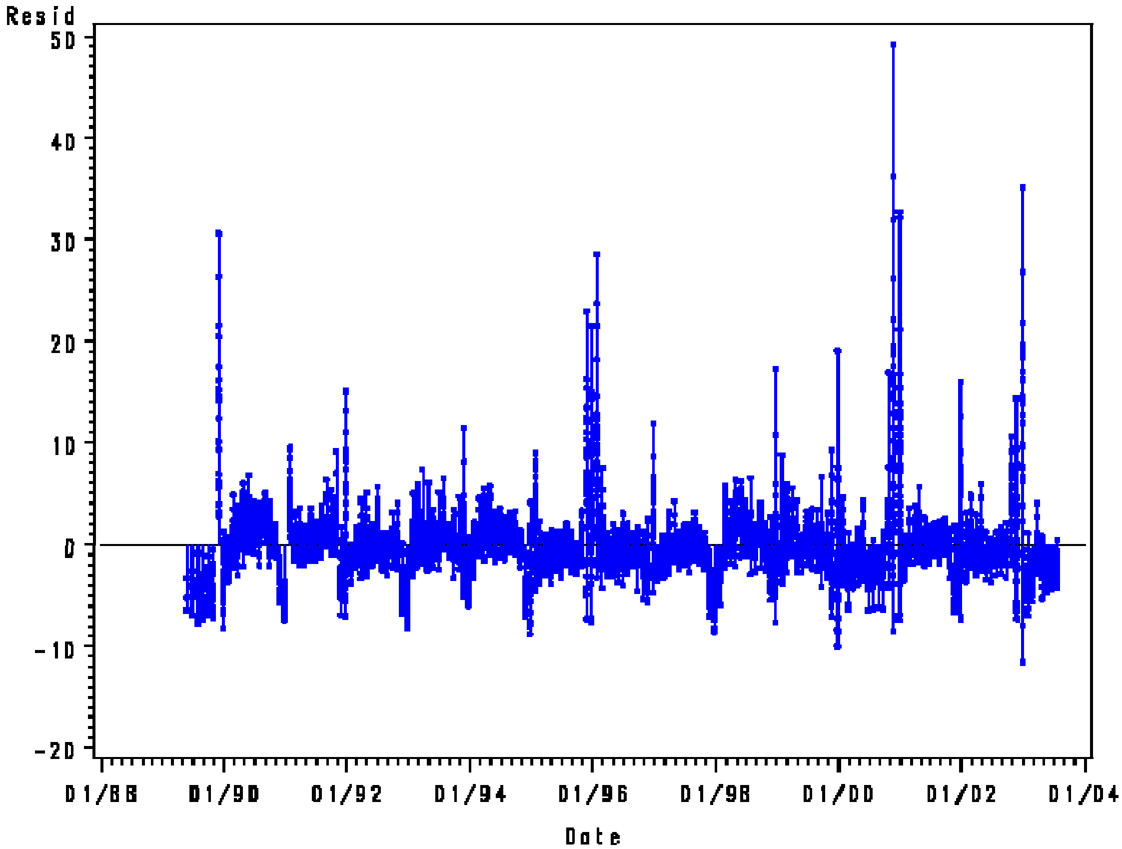

Figure 43 Estimated residual effects (the ε_{ijk}) (in acre-inches) for leatherleaf fern across the monitoring period. The estimated variance component (σ^2_ε = 12.49 or σ_ε = 3.53, see Table 20) suggest that 95% of these effects should fall between ±1.96(σ_ε) = ±6.92. Large deviations from the expected distribution are observed for months 144 (12/00), 145 (1/01) and 169 (12/03). Other large water pumping events are observed for month 121 (1/99), 133 (1/00), 157 (1/02), and 168 (12/02). All of these data should be associated with extreme temperature events. Some of the within-year pattern in residuals is still visible in these residuals suggesting that the month effect does not totally capture the annual pattern. Some of the inter-annual pattern evident in this graph is captured in the autocorrelation parameter.

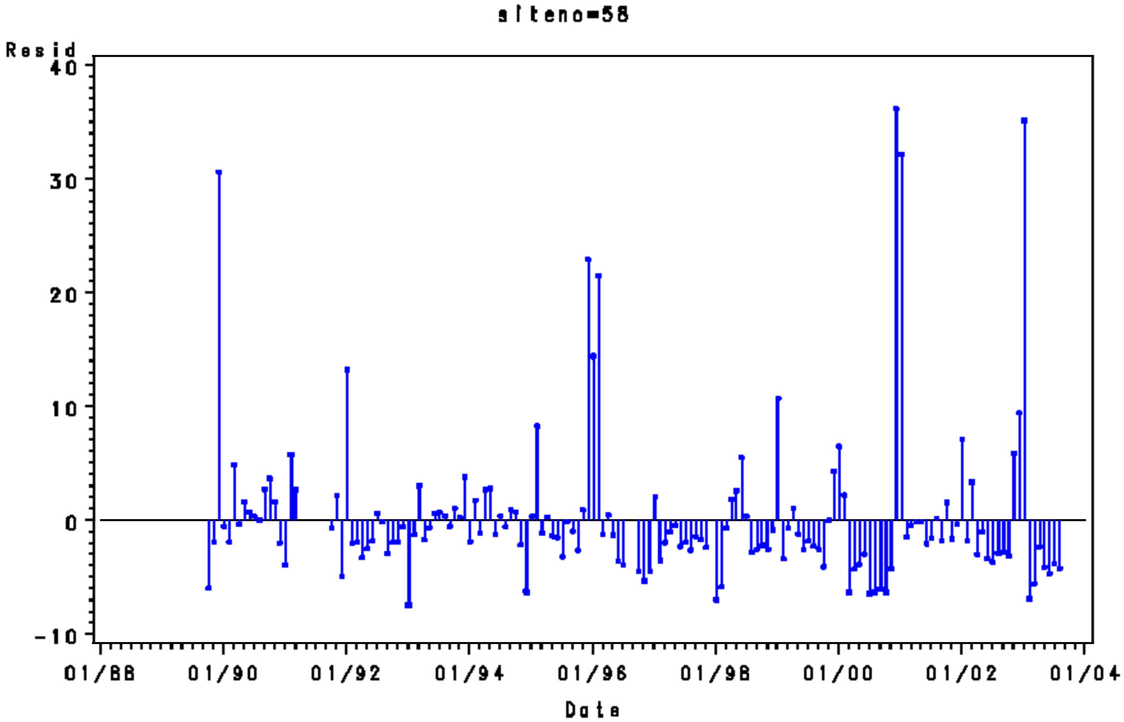

Figure 44 Plot of residuals (ε_{ijk} i=58) (in acre-inches) for site 58 for leatherleaf fern. This site is presented here because of its large site effect. Note that there are clearly extreme withdrawal months, all of them observed in the November to January time frame suggesting that these are related to cold protection irrigation that is over an above the average year and month patterns.

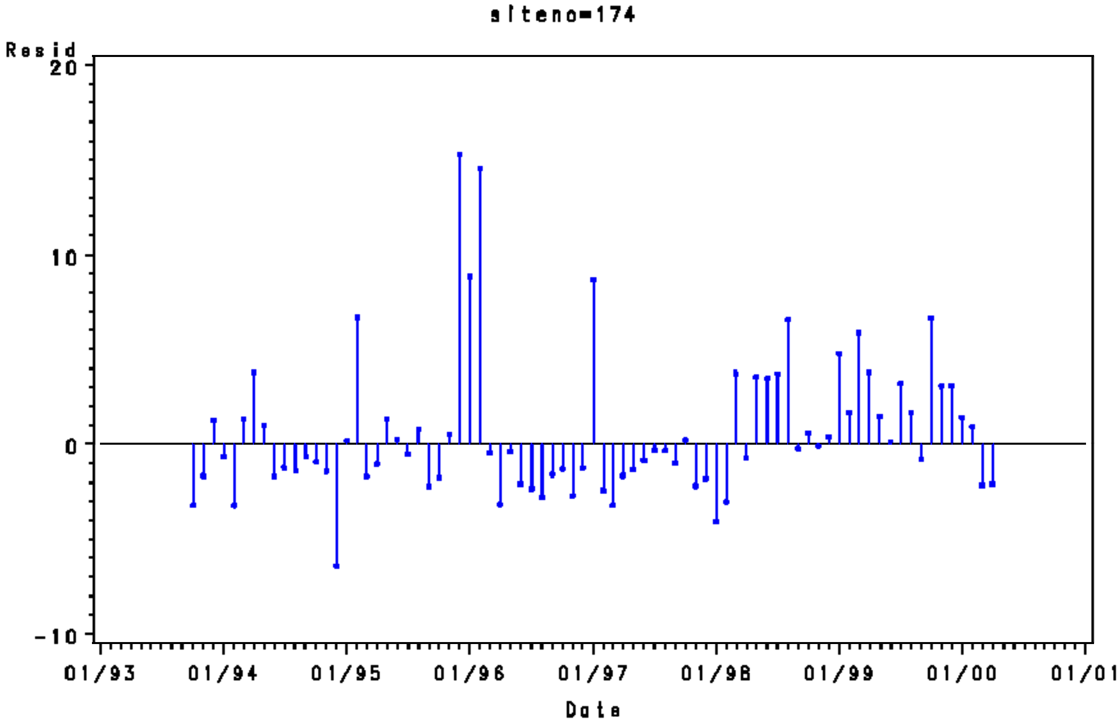

Figure 45 Plot of residuals (ε_{ijk} i=174) (in acre-inches) for site 174 of leatherleaf fern. This site is also presented because of its large site effect. While some of the extreme events can clearly be related to the winter months, the reason for the large water withdrawals for the period from 2/98 to 1/00 is not readily apparent. A change in irrigation method or a change in management could be the cause.

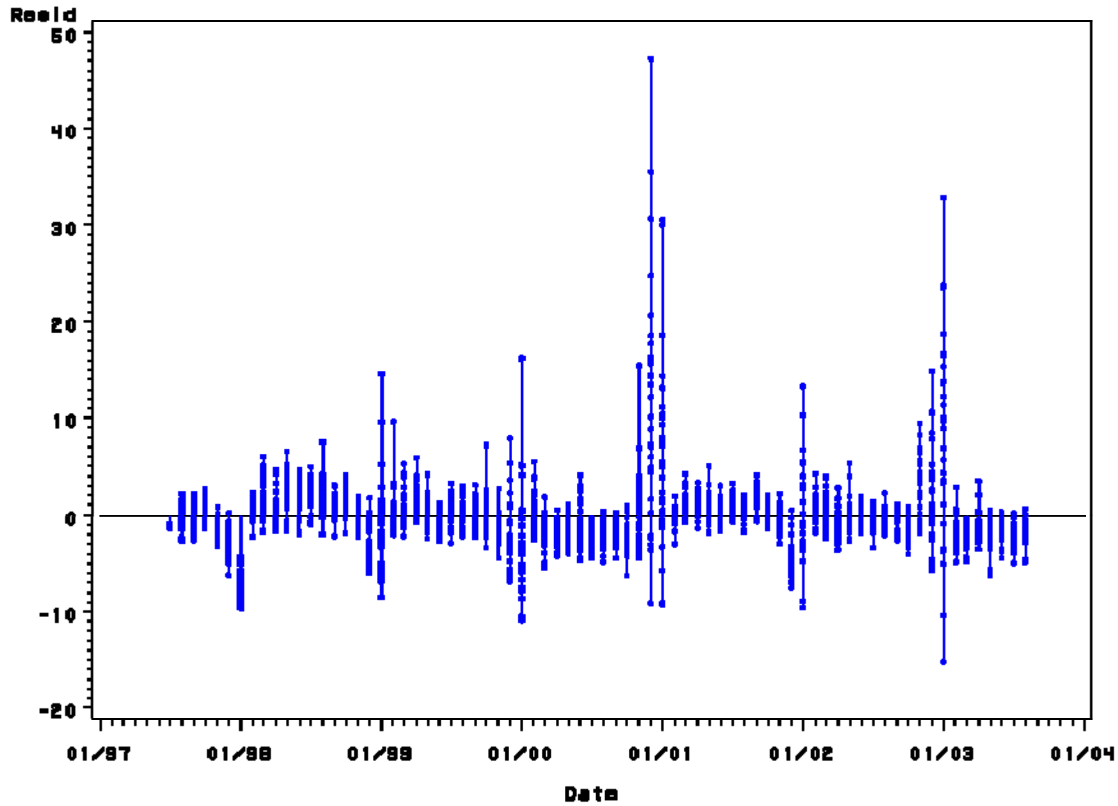

Figure 46 Estimated residual effects (the ε_{ijk}) (in acre-inches) for leatherleaf fern across the monitoring period but in which the effect of site-specific rainfall has been added to the model. The estimated variance component (σ^2_ε =14.16 or σ_ε = 3.76, see Table 20) suggest that 95% of these effects should fall between ±1.96(σ_ε) = ±7.38. The residual variability noted here is slightly larger than that estimated without using rainfall as a covariate and the mid-winter peaks have not been eliminated.

Plots of the residuals for site 58 and 174, not shown, are not much different than those shown in Figures F-5 and F-6. Little change would be expected because the peaks seem to be clearly and logically associated with temperature events and not rain-related events.

3.2.4.3 Regressions with climate variables

The original leatherleaf fern dataset was augmented with climate data obtained from the National Weather Service public databases. One climate data site was chosen within each county having the leatherleaf fern and each site in that county was assigned copies of that climate time series. The basic mixed effects general linear model used in the previous analyses (the one having site, year, month and residual random effects and assuming autocorrelation of residuals) was fit with one additional climate variable added. Results of these models are given in Table 21.

The scaled Pseudo-R^2 term measures the expected reduction in residual variance that results from adding the climate covariate to the model. The best one-variable model (with

EXMP) resulted in a 42% decrease in residual variation and resultant R^2 of 0.86. From Table 21 you can see that the effect of adding a covariate is strong, typically producing a good sized reduction in the residual and year effects. The regression coefficients are quite small and negative. The best one-variable model, using extreme maximum daily precipitation (in hundredths of an inch denoted EMXP), shows a 0.0021 reduction in expected acre-inches pumped for a 0.01inch increase in maximum daily precipitation (0.54 acre inch per inch of maximum daily precipitation). This translates to a 0.21 increase in acre-inches per centimeter of extreme rainfall. In the dataset, EMXP ranges from 0 to510 hundreds (13.08 centimeters) with an average of 151.6 (3.89 centimeters). As a result of adding EMXP to the model, the variation among years, months and sites was slightly increased.

Table 22 displays the results of the fit for the best two-covariate model. All of the two or more covariate models were actually worse fitting than the best one-covariate model above. While the one-covariate model using extreme maximum daily precipitation was considered the best among the covariate analyses, the improvement in fit from using this covariate is minimal and does not suggest that any of the covariates be used.

Table 21 Random and fixed effects coefficients from the single climate covariate models for leatherleaf fern. Values in parentheses are standard errors of the estimates with associated significance probabilities in brackets.

Factor	Intercept	Regression Coefficient	Year	Month	Site	AR(1)	Residual	Pseudo-R^2
no covariate	3.81(.84) [<.01]	-	2.73(1.08) [<.01]	5.86(2.51) [<.01]	1.07(.28) [<.01]	.3(.01) [<.01]	12.5(0.27) [<.01]	
DP01	4.57(.74) [<.0001]	-.16(.018) [<.01}	.84(.37) [<.01]	5.18(2.23) [.01]	1.37(.38) [<.01]	.35(.016) [<.01]	11.58(.29) [<.01]	0.57
DP05	3.98(.77) [<.01]	-.16(.026) [<.01]	.89(.40) [.01]	5.7(2.45) [.01]	1.35(.38) [<.01]	.35(.016) [<.01]	11.71(.29) [<.01]	0.56
DP10	3.86(.78) [<.01]	-.25(.034) [<.01]	.89(2.225) [.01]	5.95(2.55) [<.01]	1.35(.38) [<.01]	.36(.016) [<.01]	11.73(.30) [<.01]	0.57
EMNT	15.0(.091) [<.01]	-.24(.01) [<.01]	.71(.31) [.01]	5.36(2.38) [.01]	1.40(0.38) [<.01]	.33(.02 [<.01]	10.68(.26) [<.01]	0.57
EMXP	3.73(.72) [<.01]	-.00209(.0006) [<.01]	.68(.37) [.03]	4.90(2.3) [.01]	1.19(.35) [<.01]	.31(.02) [<.01]	10.22(.29) [<.01]	0.86
MMNT	29.95(1.37) [<.01]	-.043(.002) [<.01]	.57(.27) [.02]	7.34(3.25) [.01]	1.41(.39) [<.01]	.27(.02) [<.01]	10.36(.26) [<.01]	0.69
MMXT	29.92(2.03) [<.01]	-.032(.002) [<.01]	1.20(.55) [.01]	2.22(.98) [.01]	1.29(.38) [<.01]	.34(.02) [<.01]	11.94(.31) [<.01]	0.68
MNTM	36.43(1.77) [<.01]	-.046(.002) [<.01]	.81(.37) [.01]	5.98(2.70) [.01]	1.35(.38) [<.01]	.31(.017) [<.01]	10.96(.28) [<.01]	0.69
TPCP	4.15(.76) [<.01]	-.0014(.0002 [<.01]	.88(.39) [.01]	5.59(2.40) [.01]	1.35(.38) [<.01]	.35(.016) [<.01]	11.64(.29) [<.01]	0.57

Table 22 Random and fixed effects coefficients from the two climate covariate models for leatherleaf fern. Values in parentheses are standard errors of the estimates with associated significance probabilities in brackets.

Factor	Random Effects	Factor	Fixed Effects
year	.39(.22) [.04]	**Intercept**	27.36(1.36) [<0.01]
month	5.93(2.67) [<.01]	**EMXP**	-.002(.0006) [<.01]
siteno	1.20(.34) [<.01]	**MMNT**	-.038(.002) [<.01]
AR(1)	.22(.02) [<.01]		
Residual	8.44(.22) [<.01]		

3.3 Task Three: Quality Assurance (QA) Checks

3.3.1 Ridge Citrus

3.3.1.1 The Range Test: Over All Sites, Months and Years

Table 23 Quantiles for ridge citrus wells over all sites, months and years in acre-inches

.

Quantile	Estimate
Max	25.31
Q99	5.26
Q97.5	4.03
Q95	3.14
Q90	2.42
Q75	1.41
Q50 Median	0.62
Q25	0.13
Q10	0.00
Q5	0.00
Q2.5	0.00
Q1	0.00
Min	0.00

From Table 23 a value greater than 5.26 would be expected in only one out of 100 new measurements. Using 5.26 as the upper threshold would result in forced re-checking about 1% of the time. Similarly, if one used 4.03 as the upper threshold, re-checking would be expected about 2.5% of the time. Note that checks for the lower range are not particularly useful here since somewhere between 10 and 25% of observations are zero.

3.3.1.2 Range Test: By Site over all Months and Years

Table 24 Quantiles for ridge citrus wells by site over all months and years in acre-inches.

siteno	Max	Min	Q1	Q2.5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97.5	Q99
95	2.92	0.00	0.00	0.00	0.00	0.00	0.02	0.24	0.44	0.64	1.33	1.66	2.92
96	6.96	0.00	0.00	0.00	0.00	0.04	0.47	1.13	1.83	2.62	3.56	4.86	5.27
97	11.64	0.00	0.00	0.00	0.00	0.00	0.16	0.81	1.65	2.76	4.13	5.54	8.42
98	4.65	0.00	0.00	0.00	0.00	0.02	0.35	1.12	1.76	2.43	2.79	3.04	3.95
99	1.68	0.00	0.00	0.00	0.00	0.00	0.01	0.16	0.36	0.63	0.78	1.08	1.12
100	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.26	1.17	2.18	2.35	3.06	3.90
101	6.50	0.00	0.00	0.00	0.00	0.00	0.01	0.53	1.55	2.37	3.15	3.89	6.46
102	4.55	0.00	0.00	0.00	0.00	0.00	0.01	0.32	0.96	1.60	1.84	2.12	2.80
103	7.06	0.00	0.00	0.00	0.00	0.00	0.02	1.23	2.29	4.24	5.26	6.00	6.26
105	5.97	0.00	0.00	0.00	0.00	0.00	0.01	0.25	0.60	1.81	2.90	3.64	4.67
106	3.44	0.00	0.00	0.00	0.00	0.00	0.05	0.43	0.92	1.55	2.17	2.89	2.95
107	10.60	0.00	0.00	0.00	0.00	0.01	0.21	0.83	1.69	2.76	3.97	4.92	5.71
108	7.81	0.00	0.00	0.00	0.00	0.00	0.36	1.33	2.45	4.86	5.24	6.19	7.05
109	6.38	0.00	0.00	0.00	0.00	0.00	0.25	1.06	2.22	3.22	3.98	5.25	5.60
110	8.67	0.00	0.00	0.00	0.00	0.00	0.29	2.07	3.17	5.06	6.36	7.66	8.67
111	5.51	0.00	0.00	0.00	0.00	0.00	0.20	0.68	1.52	3.01	3.55	4.78	5.36
112	4.05	0.00	0.00	0.00	0.00	0.00	0.04	0.41	0.93	1.46	1.69	2.62	3.44
113	6.38	0.00	0.00	0.01	0.03	0.17	0.61	1.11	1.81	2.63	3.07	3.30	4.56
114	25.31	0.00	0.00	0.00	0.00	0.00	0.13	0.61	1.42	2.51	3.01	4.09	6.68
115	2.75	0.00	0.00	0.00	0.00	0.00	0.01	0.14	0.64	2.22	2.75	2.75	2.75
116	8.27	0.00	0.00	0.00	0.00	0.06	0.61	1.37	2.06	3.15	4.08	4.76	7.90
117	3.92	0.00	0.00	0.00	0.06	0.17	0.40	0.77	1.43	2.07	2.73	2.90	3.89
118	3.68	0.00	0.00	0.00	0.00	0.00	0.03	0.61	1.19	1.67	2.20	2.51	3.29
119	6.29	0.00	0.00	0.00	0.00	0.00	0.06	0.48	1.38	2.40	3.39	4.79	5.61
120	6.71	0.00	0.00	0.00	0.00	0.03	0.28	0.73	1.24	2.44	2.86	4.60	5.01
121	2.78	0.00	0.00	0.01	0.01	0.05	0.24	0.57	0.89	1.32	1.57	2.29	2.31
122	7.51	0.00	0.00	0.00	0.00	0.01	0.39	0.99	1.91	2.74	3.13	4.19	4.29
123	7.80	0.00	0.00	0.00	0.01	0.08	0.55	1.23	2.08	2.84	3.40	4.70	5.32
124	17.65	0.00	0.00	0.00	0.00	0.00	0.29	1.01	1.83	3.15	3.83	4.84	5.04
125	2.83	0.00	0.00	0.00	0.02	0.05	0.33	0.70	1.16	1.53	1.87	2.07	2.25
126	4.91	0.00	0.00	0.00	0.00	0.03	0.46	1.37	2.46	2.90	3.37	4.22	4.74
127	3.63	0.00	0.00	0.00	0.00	0.00	0.01	0.32	1.04	1.65	2.14	2.30	3.47
128	1.56	0.00	0.00	0.00	0.00	0.00	0.13	0.36	0.80	1.24	1.37	1.52	1.56
129	7.35	0.00	0.00	0.00	0.01	0.10	0.49	1.41	2.05	3.09	3.59	5.34	5.96
130	4.41	0.00	0.00	0.00	0.00	0.00	0.01	0.65	1.21	2.57	2.91	3.32	3.75
131	5.65	0.00	0.01	0.02	0.05	0.18	0.42	1.12	1.94	2.64	2.94	4.18	5.52
132	2.73	0.00	0.00	0.00	0.00	0.00	0.03	0.21	0.59	0.91	1.12	1.71	2.35
133	2.71	0.00	0.00	0.00	0.00	0.00	0.08	0.51	0.95	1.70	2.10	2.33	2.71
134	5.54	0.00	0.00	0.00	0.00	0.02	0.32	0.60	1.57	2.69	3.07	3.56	3.94
135	4.62	0.00	0.00	0.00	0.00	0.01	0.20	0.66	1.39	2.42	3.11	3.59	4.03
136	1.87	0.00	0.00	0.00	0.00	0.00	0.09	0.38	0.57	1.02	1.49	1.57	1.87
137	6.22	0.00	0.00	0.00	0.00	0.00	0.12	0.71	1.34	1.99	2.38	3.39	3.57

Table 24 Continued.

siteno	Max	Min	Q1	Q2.5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97.5	Q99
138	10.34	0.00	0.00	0.00	0.00	0.00	0.02	0.53	1.55	2.95	3.56	4.53	5.86
139	5.25	0.00	0.00	0.00	0.00	0.01	0.32	0.70	1.54	2.58	3.73	4.24	5.02
140	4.17	0.00	0.00	0.00	0.00	0.00	0.07	0.41	0.67	0.94	1.50	1.72	4.17
143	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.46	1.65	2.29	2.71	3.96
147	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.58	0.94	1.37	1.41	1.60
148	6.63	0.00	0.00	0.00	0.00	0.04	0.34	0.82	1.54	2.25	3.00	4.12	5.78
149	4.91	0.00	0.00	0.00	0.00	0.00	0.12	0.56	1.20	2.26	3.13	3.44	4.03
150	3.53	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.94	1.55	1.90	2.12	2.50
151	6.56	0.00	0.00	0.00	0.01	0.24	0.62	1.38	2.26	3.13	3.94	4.70	6.02
152	5.02	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.69	1.22	1.47	1.85	2.89
153	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.33	0.65	0.83	1.77	2.33
154	1.94	0.00	0.00	0.00	0.00	0.00	0.01	0.32	0.80	1.37	1.58	1.75	1.79
155	3.08	0.00	0.00	0.00	0.00	0.00	0.03	0.27	0.70	1.14	1.42	1.60	1.84
156	12.09	0.00	0.00	0.00	0.00	0.00	0.09	0.44	0.90	2.00	3.21	4.07	5.94
157	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.76	0.97	1.04	1.04	1.04
158	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.16	0.42	0.70
159	10.61	0.00	0.00	0.00	0.00	0.00	0.25	0.62	1.11	1.88	2.24	3.51	6.21
160	7.06	0.00	0.00	0.00	0.00	0.00	0.28	0.88	1.75	2.63	3.62	4.04	4.81
161	7.49	0.00	0.00	0.00	0.00	0.00	0.53	1.06	1.62	2.46	3.39	4.43	5.68
163	4.45	0.00	0.00	0.00	0.00	0.00	0.00	0.45	1.72	2.72	3.41	3.82	4.45
164	6.17	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.64	1.49	2.32	4.23	6.17
165	5.46	0.00	0.00	0.00	0.00	0.00	0.02	0.83	2.03	3.33	3.96	4.79	5.40
166	14.77	0.00	0.00	0.00	0.00	0.00	0.01	0.88	2.53	3.71	4.59	6.05	6.99
167	4.65	0.00	0.00	0.00	0.00	0.01	0.16	0.88	1.88	2.54	3.02	3.89	4.65
168	3.69	0.00	0.00	0.00	0.00	0.09	0.50	1.01	1.81	2.38	2.78	3.29	3.49
169	3.08	0.00	0.01	0.02	0.07	0.16	0.41	0.83	1.22	1.69	2.01	2.37	2.61
172	4.03	0.00	0.00	0.00	0.00	0.00	0.22	0.68	1.52	2.03	2.31	2.66	3.01
173	3.06	0.00	0.00	0.00	0.00	0.00	0.15	0.44	0.99	1.43	1.59	1.65	2.73
177	6.27	0.00	0.00	0.00	0.00	0.02	0.65	2.07	3.32	4.32	5.63	5.96	6.17
178	2.74	0.00	0.00	0.00	0.00	0.01	0.24	0.59	1.01	1.38	1.67	2.23	2.40
179	11.49	0.00	0.00	0.00	0.00	0.00	0.26	0.82	1.28	2.13	2.82	3.31	4.36
183	4.44	0.00	0.00	0.00	0.00	0.00	0.26	0.80	1.42	2.02	2.54	2.59	3.00
184	4.02	0.00	0.00	0.00	0.00	0.00	0.29	0.66	1.33	2.26	2.61	3.32	3.87
186	11.33	0.00	0.00	0.00	0.00	0.00	0.03	1.11	2.00	3.34	3.80	4.87	11.33
199	5.26	0.00	0.00	0.00	0.00	0.09	0.34	0.77	1.19	1.67	2.05	4.32	5.26

Note for example that in Table 24 the Q97.5 values range from a low of 1.04 to high of 7.66. By this method, well measurements at some sites would be flagged at values that would not be flagged at other sites. In addition, some sites have only 15 measurements whereas most other sites have over 100 measurements. With over 100 measurements, the estimate of the Q97.5 for example has acceptable properties (i.e. low associated uncertainty). With less than 100 measurements, the estimates of the upper tail quantiles are very uncertain. Finally, one needs to realize that these numbers are averaged over months that are known from the Task II analysis to be quite different.

3.3.1.3 Range Test: By Month over all Sites and Years

Table 25 Quantiles for ridge citrus wells by month averaged over sites and years in acre-inches.

Month	N	max	min	Q1	Q2_5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97_5	Q99
1	770	25.31	0.00	0.00	0.00	0.00	0.00	0.01	0.76	1.91	3.31	4.37	5.26	7.35
2	768	8.67	0.00	0.00	0.00	0.00	0.00	0.00	0.30	1.07	2.08	3.20	4.24	5.46
3	768	17.65	0.00	0.00	0.00	0.00	0.00	0.15	0.68	1.42	2.36	2.97	3.60	5.17
4	771	6.38	0.00	0.00	0.00	0.01	0.28	0.57	1.16	2.02	2.76	3.39	4.05	5.13
5	771	9.55	0.00	0.00	0.00	0.15	0.47	0.97	1.65	2.48	3.37	4.12	5.06	6.26
6	772	6.96	0.00	0.00	0.00	0.00	0.00	0.21	0.60	1.37	2.36	3.32	4.24	5.61
7	776	6.17	0.00	0.00	0.00	0.00	0.00	0.08	0.50	1.03	1.66	2.19	2.94	3.66
8	791	10.34	0.00	0.00	0.00	0.00	0.00	0.03	0.36	0.88	1.63	2.31	2.79	3.83
9	736	11.64	0.00	0.00	0.00	0.00	0.00	0.02	0.34	0.74	1.36	1.83	2.29	3.05
10	746	10.61	0.00	0.00	0.00	0.00	0.00	0.13	0.56	1.18	1.86	2.43	3.17	3.89
11	758	12.09	0.00	0.00	0.00	0.00	0.00	0.20	0.54	1.12	1.82	2.34	2.91	3.61
12	765	14.77	0.00	0.00	0.00	0.00	0.00	0.09	0.58	1.38	2.42	3.16	4.03	5.03

The upper tail quantiles in Table 25 are seem to change significantly from month to month, being highest in the winter and spring and lowest during the rainy summer period.

3.3.1.4 Step Test: By Site over all Months and Years

Table 26 Quantiles for absolute value step test of ridge citrus wells over all sites and dates.

Quantile	Estimate
Max	25.31
Q99	4.79
Q97.5	3.64
Q95	2.90
Q90	2.13
Q75	1.21
Q50 Median	0.57
Q25	0.21
Q10	0.04
Q5	0.01
Q2.5	0.00
Q1	0.00
Min	0.00

The upper tail values for the steps are not that different from what was recorded for actual well measurements in Table 23. This tables suggests that jumps of over 4.79 should occur only once in 100 measurements and jumps of over 3.64 in 25 out of 1000 measurements.

3.3.1.5 Step Test: By Site and Month over all Years

Table 27 Q95 estimates for absolute step values for ridge citrus wells by site and month.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
95	1.39	1.33	1.10	2.92	0.86	0.45	0.38	0.18	0.17	0.33	0.28	0.74
96	1.43	4.14	2.29	3.14	4.16	6.94	2.23	2.49	1.34	1.84	1.86	3.13
97	1.10	2.82	4.46	2.76	2.73	4.51	1.37	1.86	10.17	4.70	2.40	2.17
98	2.85	3.80	2.11	1.67	1.40	2.33	0.99	2.85	1.28	1.82	1.92	3.01
99	0.78	1.12	0.57	0.75	0.92	1.61	0.59	0.51	0.38	0.76	1.03	0.67
100	5.40	2.99	2.25	2.18	2.25	2.66	2.08	1.56	1.48	1.70	2.42	1.75
101	3.15	3.36	1.81	1.93	5.50	3.75	2.04	6.49	3.88	3.53	2.32	1.91
102	3.51	2.55	2.01	1.22	1.32	2.04	1.65	1.52	0.77	1.57	1.05	1.60
103	4.03	4.02	6.29	3.20	4.14	4.24	4.35	1.70	1.26	3.22	3.07	2.22
105	1.30	1.67	2.61	3.97	5.38	3.83	2.76	3.64	1.06	1.03	0.76	1.33
106	1.09	1.15	1.70	1.97	2.95	3.44	2.38	1.51	2.89	1.41	1.86	2.17
107	8.21	4.23	3.34	1.44	3.84	2.45	2.49	1.03	1.44	3.26	2.61	4.54
108	5.03	6.19	6.70	3.42	5.02	3.52	2.45	2.49	1.65	1.94	2.71	3.61
109	3.78	2.77	5.17	4.10	2.83	5.35	2.11	2.16	1.31	2.52	1.53	3.44
110	5.90	8.57	2.28	3.71	3.45	5.44	3.74	4.65	3.31	3.37	3.18	7.41
111	4.01	4.57	4.76	2.21	3.82	2.82	1.49	1.25	1.40	2.51	3.02	3.11
112	3.06	3.29	1.28	1.03	1.47	2.26	0.87	0.78	0.48	1.21	1.29	1.43
113	4.40	6.38	3.04	1.69	1.78	2.37	1.74	2.50	1.49	1.12	1.09	3.06
114	25.31	6.66	2.03	2.10	2.18	4.07	1.30	1.32	1.49	1.25	2.72	4.09
115		1.86	0.01	0.50	2.24	2.69	0.58	0.50	0.13	0.04	0.47	2.22
116	2.58	4.87	3.52	1.99	6.48	2.38	1.26	2.95	1.01	2.31	1.82	3.21
117	1.97	2.17	1.99	2.77	2.03	2.85	1.97	1.97	1.00	1.38	1.49	1.39
118	3.04	2.18	1.35	3.08	2.50	3.26	1.94	1.46	0.99	1.52	1.34	2.16
119	3.03	6.29	1.83	3.39	3.18	5.57	1.17	1.73	1.07	1.46	0.93	4.79
120	1.39	2.59	6.71	2.40	4.55	4.24	1.34	2.37	1.18	1.68	1.62	2.03
121	1.63	1.71	1.04	0.88	1.66	2.09	0.49	1.11	0.66	0.90	0.46	1.44
122	3.43	7.14	2.49	2.04	1.72	2.28	1.34	2.26	1.44	1.08	1.57	3.86
123	3.57	6.48	2.74	2.61	2.42	2.44	2.18	2.76	1.32	1.54	2.47	3.23
124	3.56	3.44	17.54	1.64	3.26	4.16	2.10	1.72	1.38	1.87	1.64	3.17
125	1.61	2.03	2.03	1.23	1.22	1.41	1.00	1.46	0.43	1.14	0.57	1.77
126	3.46	3.00	2.59	1.93	1.79	2.71	0.94	3.83	2.12	2.16	2.55	4.42
127	2.34	3.63	2.13	1.07	2.38	3.43	1.10	0.90	1.19	1.19	1.59	2.30
128	0.53	1.24	0.80	0.77	1.11	1.37	0.66	1.07	0.54	1.11	0.80	1.34
129	4.28	3.83	3.79	2.86	3.52	4.39	2.00	2.99	1.40	3.38	1.96	4.06
130	0.80	1.01	2.94	2.14	3.46	4.41	1.37	2.31	1.27	2.89	0.89	2.26
131	3.65	5.52	2.78	1.60	1.62	1.75	1.56	2.33	1.62	1.44	2.03	2.58
132	1.06	2.31	2.30	0.75	1.08	0.44	1.69	0.63	0.42	0.70	0.92	0.87
133	2.19	1.65	1.40	0.98	2.21	2.10	0.32	0.81	0.68	0.86	0.74	1.25
134	3.59	2.34	1.81	1.28	3.04	2.88	1.19	1.10	0.59	1.20	2.01	3.92
135	3.58	3.21	2.08	1.99	2.10	2.37	0.90	1.80	0.48	1.16	1.34	4.02
136	1.02	1.17	0.51	0.96	1.20	1.65	1.21	1.41	0.82	1.42	1.05	1.03
137	0.93	1.41	3.39	1.77	1.70	5.71	1.40	1.80	2.15	2.08	1.66	1.80

Table 27 Continued.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
138	5.86	2.17	3.51	2.29	2.40	4.12	2.29	10.34	1.27	0.92	2.31	1.60
139	5.25	4.11	1.49	4.07	2.45	4.03	2.34	2.62	1.44	1.80	1.72	3.83
140	1.00	0.97	0.64	1.28	1.93	4.17	0.94	0.69	0.61	0.45	0.57	0.90
143	0.96	1.35	1.65	2.50	3.96	1.92	0.61	2.71	0.07	0.58	0.88	2.29
147	1.39	1.75	1.04	1.37	1.37	1.30	0.74	1.05	0.63	1.35	0.74	1.38
148	2.07	2.14	1.70	2.98	4.20	4.87	1.51	3.29	2.54	6.23	1.68	2.23
149	4.37	3.48	1.87	2.33	2.70	3.56	1.21	1.30	0.57	1.77	1.81	2.13
150	3.51	0.99	1.62	1.98	1.78	1.90	1.22	0.96	0.31	1.07	1.73	2.50
151	3.71	4.59	1.72	1.02	1.54	3.48	6.02	1.61	0.90	1.76	1.91	3.51
152	3.17	5.02	0.68	1.01	1.45	1.36	0.60	1.24	0.22	0.57	0.41	2.80
153	0.09	0.19	0.76	0.80	1.01	0.55	0.83	0.48	0.40	1.77	2.33	0.46
154	0.82	1.94	1.42	1.55	1.37	1.45	0.74	0.84	1.58	1.21	1.20	1.13
155	1.60	1.45	1.42	1.06	1.14	2.49	0.79	0.64	0.93	0.77	1.15	0.75
156	0.86	1.42	2.75	3.64	5.31	3.62	2.55	1.97	0.63	4.18	10.74	1.41
157		0.00	0.00	0.36	0.61	0.21	0.67	0.56	0.65	0.40	0.63	1.04
158	0.00	0.00	0.16	0.42	0.11	0.01	0.07	0.70	0.00	0.07	0.02	0.12
159	1.35	6.08	1.48	3.14	1.75	1.55	0.59	0.92	0.65	10.39	10.50	3.32
160	5.61	3.94	2.46	3.14	3.82	3.47	1.56	2.48	2.03	1.90	2.15	2.53
161	6.20	5.34	3.28	2.34	3.26	2.53	1.54	2.03	1.54	2.05	1.48	2.25
163	0.52	0.61	2.03	4.45	3.82	3.06	2.44	3.10	1.72	1.51	1.60	1.23
164	1.14	1.27	0.98	2.19	6.17	5.61	3.20	2.32	0.70	1.64	0.84	4.21
165	0.56	1.73	3.36	4.05	3.46	3.46	3.12	2.12	3.90	4.55	5.40	3.40
166	1.68	3.31	3.97	4.07	2.95	5.29	1.80	6.99	2.45	2.56	1.52	14.76
167	1.77	2.39	1.73	2.03	4.65	2.50	1.61	2.46	1.76	3.78	3.76	1.27
168	1.49	2.41	2.64	1.41	1.63	2.29	3.31	2.92	1.27	2.11	1.41	0.76
169	0.87	1.66	1.23	1.12	1.06	2.04	0.94	1.55	0.84	1.28	1.02	1.40
172	2.51	2.48	2.33	1.71	2.05	2.27	0.87	1.10	1.30	1.28	0.96	2.61
173	2.00	2.47	2.02	1.01	1.03	1.56	0.59	0.61	0.91	1.37	1.02	1.33
177	3.52	3.72	2.67	4.29	3.49	3.64	4.76	3.64	5.93	3.51	4.13	5.37
178	1.61	1.89	1.09	0.83	0.84	1.21	0.59	0.63	0.65	0.92	0.64	2.40
179	2.35	4.32	2.04	2.82	3.30	2.03	0.63	1.24	1.12	1.08	11.40	1.58
183	2.45	1.85	1.53	1.60	1.94	1.49	0.92	1.05	0.92	1.52	1.85	1.38
184	2.20	2.60	2.16	3.31	1.68	0.71	1.07	0.92	0.63	1.16	1.78	1.11
186	10.01	6.46	3.19	3.05	7.16	1.94	2.16	1.17	0.68	2.00	2.76	4.08
199	4.34	3.55	1.10	1.36	0.52	1.55	0.33	0.88	0.51	0.81	0.83	1.47

Table 28 Q97.5 estimates for ridge citrus by site and month.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
95	1.39	1.33	1.10	2.92	0.86	0.45	0.38	0.18	0.17	0.33	0.28	0.74
96	1.43	4.14	2.29	3.14	4.16	6.94	2.23	2.49	1.34	1.84	1.86	3.13
97	1.10	2.82	4.46	2.76	2.73	4.51	1.37	1.86	10.17	4.70	2.40	2.17
98	2.85	3.80	2.11	1.67	1.40	2.33	0.99	2.85	1.28	1.82	1.92	3.01
99	0.78	1.12	0.57	0.75	0.92	1.61	0.59	0.51	0.38	0.76	1.03	0.67
100	5.40	2.99	2.25	2.18	2.25	2.66	2.08	1.56	1.48	1.70	2.42	1.75
101	3.15	3.36	1.81	1.93	5.50	3.75	2.04	6.49	3.88	3.53	2.32	1.91
102	3.51	2.55	2.01	1.22	1.32	2.04	1.65	1.52	0.77	1.57	1.05	1.60
103	4.03	4.02	6.29	3.20	4.14	4.24	4.35	1.70	1.26	3.22	3.07	2.22
105	1.30	1.67	2.61	3.97	5.38	3.83	2.76	3.64	1.06	1.03	0.76	1.33
106	1.09	1.15	1.70	1.97	2.95	3.44	2.38	1.51	2.89	1.41	1.86	2.17
107	8.21	4.23	3.34	1.44	3.84	2.45	2.49	1.03	1.44	3.26	2.61	4.54
108	5.03	6.19	6.70	3.42	5.02	3.52	2.45	2.49	1.65	1.94	2.71	3.61
109	3.78	2.77	5.17	4.10	2.83	5.35	2.11	2.16	1.31	2.52	1.53	3.44
110	5.90	8.57	2.28	3.71	3.45	5.44	3.74	4.65	3.31	3.37	3.18	7.41
111	4.01	4.57	4.76	2.21	3.82	2.82	1.49	1.25	1.40	2.51	3.02	3.11
112	3.06	3.29	1.28	1.03	1.47	2.26	0.87	0.78	0.48	1.21	1.29	1.43
113	4.40	6.38	3.04	1.69	1.78	2.37	1.74	2.50	1.49	1.12	1.09	3.06
114	25.31	6.66	2.03	2.10	2.18	4.07	1.30	1.32	1.49	1.25	2.72	4.09
115		1.86	0.01	0.50	2.24	2.69	0.58	0.50	0.13	0.04	0.47	2.22
116	2.58	4.87	3.52	1.99	6.48	2.38	1.26	2.95	1.01	2.31	1.82	3.21
117	1.97	2.17	1.99	2.77	2.03	2.85	1.97	1.97	1.00	1.38	1.49	1.39
118	3.04	2.18	1.35	3.08	2.50	3.26	1.94	1.46	0.99	1.52	1.34	2.16
119	3.03	6.29	1.83	3.39	3.18	5.57	1.17	1.73	1.07	1.46	0.93	4.79
120	1.39	2.59	6.71	2.40	4.55	4.24	1.34	2.37	1.18	1.68	1.62	2.03
121	1.63	1.71	1.04	0.88	1.66	2.09	0.49	1.11	0.66	0.90	0.46	1.44
122	3.43	7.14	2.49	2.04	1.72	2.28	1.34	2.26	1.44	1.08	1.57	3.86
123	3.57	6.48	2.74	2.61	2.42	2.44	2.18	2.76	1.32	1.54	2.47	3.23
124	3.56	3.44	17.54	1.64	3.26	4.16	2.10	1.72	1.38	1.87	1.64	3.17
125	1.61	2.03	2.03	1.23	1.22	1.41	1.00	1.46	0.43	1.14	0.57	1.77
126	3.46	3.00	2.59	1.93	1.79	2.71	0.94	3.83	2.12	2.16	2.55	4.42
127	2.34	3.63	2.13	1.07	2.38	3.43	1.10	0.90	1.19	1.19	1.59	2.30
128	0.53	1.24	0.80	0.77	1.11	1.37	0.66	1.07	0.54	1.11	0.80	1.34
129	4.28	3.83	3.79	2.86	3.52	4.39	2.00	2.99	1.40	3.38	1.96	4.06
130	0.80	1.01	2.94	2.14	3.46	4.41	1.37	2.31	1.27	2.89	0.89	2.26
131	3.65	5.52	2.78	1.60	1.62	1.75	1.56	2.33	1.62	1.44	2.03	2.58
132	1.06	2.31	2.30	0.75	1.08	0.44	1.69	0.63	0.42	0.70	0.92	0.87
133	2.19	1.65	1.40	0.98	2.21	2.10	0.32	0.81	0.68	0.86	0.74	1.25
134	3.59	2.34	1.81	1.28	3.04	2.88	1.19	1.10	0.59	1.20	2.01	3.92
135	3.58	3.21	2.08	1.99	2.10	2.37	0.90	1.80	0.48	1.16	1.34	4.02
136	1.02	1.17	0.51	0.96	1.20	1.65	1.21	1.41	0.82	1.42	1.05	1.03
137	0.93	1.41	3.39	1.77	1.70	5.71	1.40	1.80	2.15	2.08	1.66	1.80

Table 28 Continued.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
138	5.86	2.17	3.51	2.29	2.40	4.12	2.29	10.34	1.27	0.92	2.31	1.60
139	5.25	4.11	1.49	4.07	2.45	4.03	2.34	2.62	1.44	1.80	1.72	3.83
140	1.00	0.97	0.64	1.28	1.93	4.17	0.94	0.69	0.61	0.45	0.57	0.90
143	0.96	1.35	1.65	2.50	3.96	1.92	0.61	2.71	0.07	0.58	0.88	2.29
147	1.39	1.75	1.04	1.37	1.37	1.30	0.74	1.05	0.63	1.35	0.74	1.38
148	2.07	2.14	1.70	2.98	4.20	4.87	1.51	3.29	2.54	6.23	1.68	2.23
149	4.37	3.48	1.87	2.33	2.70	3.56	1.21	1.30	0.57	1.77	1.81	2.13
150	3.51	0.99	1.62	1.98	1.78	1.90	1.22	0.96	0.31	1.07	1.73	2.50
151	3.71	4.59	1.72	1.02	1.54	3.48	6.02	1.61	0.90	1.76	1.91	3.51
152	3.17	5.02	0.68	1.01	1.45	1.36	0.60	1.24	0.22	0.57	0.41	2.80
153	0.09	0.19	0.76	0.80	1.01	0.55	0.83	0.48	0.40	1.77	2.33	0.46
154	0.82	1.94	1.42	1.55	1.37	1.45	0.74	0.84	1.58	1.21	1.20	1.13
155	1.60	1.45	1.42	1.06	1.14	2.49	0.79	0.64	0.93	0.77	1.15	0.75
156	0.86	1.42	2.75	3.64	5.31	3.62	2.55	1.97	0.63	4.18	10.74	1.41
157		0.00	0.00	0.36	0.61	0.21	0.67	0.56	0.65	0.40	0.63	1.04
158	0.00	0.00	0.16	0.42	0.11	0.01	0.07	0.70	0.00	0.07	0.02	0.12
159	1.35	6.08	1.48	3.14	1.75	1.55	0.59	0.92	0.65	10.39	10.50	3.32
160	5.61	3.94	2.46	3.14	3.82	3.47	1.56	2.48	2.03	1.90	2.15	2.53
161	6.20	5.34	3.28	2.34	3.26	2.53	1.54	2.03	1.54	2.05	1.48	2.25
163	0.52	0.61	2.03	4.45	3.82	3.06	2.44	3.10	1.72	1.51	1.60	1.23
164	1.14	1.27	0.98	2.19	6.17	5.61	3.20	2.32	0.70	1.64	0.84	4.21
165	0.56	1.73	3.36	4.05	3.46	3.46	3.12	2.12	3.90	4.55	5.40	3.40
166	1.68	3.31	3.97	4.07	2.95	5.29	1.80	6.99	2.45	2.56	1.52	14.76
167	1.77	2.39	1.73	2.03	4.65	2.50	1.61	2.46	1.76	3.78	3.76	1.27
168	1.49	2.41	2.64	1.41	1.63	2.29	3.31	2.92	1.27	2.11	1.41	0.76
169	0.87	1.66	1.23	1.12	1.06	2.04	0.94	1.55	0.84	1.28	1.02	1.40
172	2.51	2.48	2.33	1.71	2.05	2.27	0.87	1.10	1.30	1.28	0.96	2.61
173	2.00	2.47	2.02	1.01	1.03	1.56	0.59	0.61	0.91	1.37	1.02	1.33
177	3.52	3.72	2.67	4.29	3.49	3.64	4.76	3.64	5.93	3.51	4.13	5.37
178	1.61	1.89	1.09	0.83	0.84	1.21	0.59	0.63	0.65	0.92	0.64	2.40
179	2.35	4.32	2.04	2.82	3.30	2.03	0.63	1.24	1.12	1.08	11.40	1.58
183	2.45	1.85	1.53	1.60	1.94	1.49	0.92	1.05	0.92	1.52	1.85	1.38
184	2.20	2.60	2.16	3.31	1.68	0.71	1.07	0.92	0.63	1.16	1.78	1.11
186	10.01	6.46	3.19	3.05	7.16	1.94	2.16	1.17	0.68	2.00	2.76	4.08
199	4.34	3.55	1.10	1.36	0.52	1.55	0.33	0.88	0.51	0.81	0.83	1.47

A quick review of this table shows that there is great variability in these estimates from site to site and within each month. While these estimates are site and month specific, their utility for quality control is undermined by this large variability. Some sites record huge jumps (sites 114 and 186) whereas a large number of sites have Q97.5 absolute step values that are 0.01 or less (see highlighted cells). Using these values as the quality threshold would results in all non-zero absolute step values being flagged for these sites in the specified months.

3.3.1.6 Model-Based Range Test: Over all Sites, Months and Years

The expected means for each ridge citrus well and month are computed by adding the estimated intercept term from Table 13 in Section 3.2 to the appropriate ridge citrus site estimated effect from Table 56 and the estimated month effect from Table 53 in the appendix of this task report. These estimated effects are given in Table 60 in the appendix. These mean values are subtracted from the observed data and the overall range test computed on these residuals. The quantile statistics are given in Table 29.

Table 29 Estimated quantiles of model based residuals for ridge citrus wells.

Quantile	Residual	Absolute Residual
Max	23.92	23.92
Q99	3.75	3.75
Q97.5	2.63	2.64
Q95	1.76	1.87
Q90	1.10	1.37
Q75	0.36	0.89
Q50 Median	-0.16	0.50
Q25	-0.57	0.23
Q10	-0.96	0.09
Q5	-1.20	0.05
Q2.5	-1.37	0.02
Q1	-1.65	0.01
Min	-2.96	0.0001

To use these values in a quality control setting, one would subtract from the observed measurement the sum of the estimated intercept value (0.942 acre-inches) plus the month effect for the month of the observations plus the effect of the observation site. If the resulting value were greater than 3.75 (Q99) in absolute value for example, the measurement would be flagged for further assessment. This value is less than the 5.26 value suggested in Table 23 for an unadjusted measurement and less than the step value of 4.79 in Table 26.

3.3.2 Flatwoods Citrus

3.3.2.1 Range Test: Over All Sites, Months and Years

Table 30 Quantiles for flatwoods citrus wells over all sites, months and years in acre-inches.

Quantile	Estimate
Max	7.61
Q99	3.97
Q97.5	3.36
Q95	2.62
Q90	1.92
Q75	1.10
Q50 Median	0.36
Q25	0.13
Q10	0.03
Q5	0.00
Q2.5	0.00
Q1	0.00
Min	0.00

From Table 30 one would expect to see a value greater than 3.97 in only one out of 100 new measurements. Using 3.97 as the upper threshold would result in forced re-checking about 1% of the time. Similarly, if 3.36 were used as the upper threshold, re-checking would be expected about 2.5% of the time. Note that checks for the lower range are not particularly useful here since somewhere between 10 and 25% of observations are zero.

3.3.2.2 Range Test: By Site over all Months and Years

Table 31 Quantiles for flatwoods citrus wells by site over all months and years in acre-inches.

SiteNo	n	max	min	Q1	Q2_5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97_5	Q99
200	55	7.61	0.00	0.00	0.00	0.00	0.14	0.60	1.56	3.03	4.11	5.27	7.28	7.61
201	54	1.57	0.00	0.00	0.00	0.00	0.01	0.07	0.20	0.35	0.46	0.59	0.69	1.57
202	48	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.46	1.01	1.14	1.15	2.32
203	54	2.45	0.00	0.00	0.00	0.00	0.00	0.07	0.37	1.00	1.44	1.90	2.42	2.45
204	54	3.75	0.00	0.00	0.00	0.00	0.00	0.12	0.64	1.64	1.94	2.42	3.13	3.75
205	54	2.12	0.00	0.00	0.00	0.00	0.00	0.06	0.36	0.80	1.09	1.51	1.90	2.12
206	46	4.52	0.00	0.00	0.00	0.00	0.01	0.07	0.53	1.20	1.92	2.28	2.71	4.52
207	46	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.52	0.90	1.13	1.21	1.47
208	46	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.47	1.10	1.67	1.84	1.98
209	45	3.37	0.00	0.00	0.00	0.00	0.01	0.05	0.29	0.96	1.75	2.80	3.22	3.37
210	44	4.61	0.01	0.01	0.01	0.02	0.03	0.27	1.08	2.13	2.43	2.69	2.77	4.61
211	42	3.88	0.00	0.00	0.00	0.00	0.00	0.07	1.21	2.05	2.86	2.97	3.74	3.88
212	39	5.12	0.00	0.00	0.00	0.00	0.00	0.01	0.66	1.80	2.55	3.00	5.12	5.12
213	41	4.86	0.00	0.00	0.01	0.01	0.01	0.26	1.30	1.90	2.96	3.35	3.51	4.86
214	13	2.80	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.56	1.53	2.80	2.80	2.80
215	37	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.25	0.57	0.61	0.89	0.89
216	37	2.52	0.00	0.00	0.00	0.00	0.00	0.16	0.47	1.03	1.48	2.36	2.52	2.52
217	36	2.98	0.00	0.00	0.00	0.00	0.00	0.12	0.80	1.75	2.35	2.89	2.98	2.98
218	36	3.14	0.00	0.00	0.00	0.00	0.00	0.05	0.59	1.58	2.42	2.63	3.14	3.14
219	36	3.49	0.00	0.00	0.00	0.00	0.00	0.22	1.03	1.65	2.17	3.19	3.49	3.49
220	36	5.69	0.00	0.00	0.00	0.00	0.00	0.28	1.00	2.17	3.52	3.97	5.69	5.69
221	29	1.65	0.00	0.00	0.00	0.00	0.00	0.07	0.31	0.80	1.43	1.52	1.65	1.65
222	35	1.07	0.00	0.00	0.00	0.00	0.00	0.04	0.28	0.78	0.92	1.04	1.07	1.07
223	18	2.45	0.00	0.00	0.00	0.00	0.00	0.00	0.63	1.26	2.03	2.45	2.45	2.45
224	17	2.83	0.00	0.00	0.00	0.00	0.00	0.00	0.90	1.29	2.46	2.83	2.83	2.83
225	17	0.44	0.00	0.00	0.00	0.00	0.00	0.02	0.09	0.19	0.36	0.44	0.44	0.44
226	13	0.42	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.18	0.24	0.42	0.42	0.42
227	17	1.09	0.00	0.00	0.00	0.00	0.02	0.03	0.22	0.47	0.87	1.09	1.09	1.09
228	11	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.26	0.28	0.30	0.30	0.30
229	16	2.29	0.02	0.02	0.02	0.02	0.19	0.28	0.83	1.08	1.79	2.29	2.29	2.29
230	15	1.79	0.00	0.00	0.00	0.00	0.00	0.39	0.98	1.31	1.58	1.79	1.79	1.79
231	16	1.83	0.00	0.00	0.00	0.00	0.00	0.22	0.91	1.19	1.52	1.83	1.83	1.83
232	16	1.40	0.00	0.00	0.00	0.00	0.00	0.12	0.53	0.83	1.28	1.40	1.40	1.40
233	2	1.30	0.13	0.13	0.13	0.13	0.13	0.13	0.71	1.30	1.30	1.30	1.30	1.30
234	16	4.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	1.91	4.80	4.80	4.80
235	15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
236	15	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.79	1.48	1.48	1.48
237	14	4.60	0.00	0.00	0.00	0.00	0.00	0.01	0.13	3.51	3.82	4.60	4.60	4.60
238	15	1.48	0.00	0.00	0.00	0.00	0.00	0.06	0.47	0.69	1.09	1.48	1.48	1.48
239	15	1.00	0.00	0.00	0.00	0.00	0.00	0.15	0.43	0.74	0.90	1.00	1.00	1.00
240	14	1.54	0.01	0.01	0.01	0.01	0.10	0.13	0.51	0.82	1.39	1.54	1.54	1.54

Table 31 Quantiles for flatwoods citrus wells by site over all months and years in acre-inches (continued).

SiteNo	n	max	min	Q1	Q2_5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97_5	Q99
241	14	1.52	0.00	0.00	0.00	0.00	0.00	0.13	0.58	0.95	1.25	1.52	1.52	1.52
242	14	2.11	0.00	0.00	0.00	0.00	0.00	0.22	0.59	1.22	1.81	2.11	2.11	2.11
243	10	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.64	0.78	0.82	0.82	0.82
244	10	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.82	1.22	1.28	1.28	1.28
245	8	1.91	0.00	0.00	0.00	0.00	0.00	0.00	0.09	1.38	1.91	1.91	1.91	1.91
246	8	1.28	0.03	0.03	0.03	0.03	0.03	0.11	0.23	0.95	1.28	1.28	1.28	1.28
247	9	3.01	0.00	0.00	0.00	0.00	0.00	0.00	0.40	1.20	3.01	3.01	3.01	3.01
248	5	1.57	0.00	0.00	0.00	0.00	0.00	0.22	1.02	1.25	1.57	1.57	1.57	1.57
249	5	1.34	0.00	0.00	0.00	0.00	0.00	0.40	0.93	1.15	1.34	1.34	1.34	1.34
250	5	1.26	0.00	0.00	0.00	0.00	0.00	0.19	0.26	0.30	1.26	1.26	1.26	1.26
251	5	3.47	0.00	0.00	0.00	0.00	0.00	0.00	2.10	2.58	3.47	3.47	3.47	3.47
252	5	3.62	0.03	0.03	0.03	0.03	0.03	0.05	1.38	3.29	3.62	3.62	3.62	3.62
253	5	2.79	0.00	0.00	0.00	0.00	0.00	0.01	0.82	1.17	2.79	2.79	2.79	2.79
254	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255	3	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.09	0.09	0.09
256	3	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12
257	2	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
258	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
260	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
261	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262	1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
263	1	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
264	1	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
265	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
266	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note for example that the Q97.5 values range from a low of 0.03 to high of 5.69. By this method, well measurements at some sites would be flagged at values that would not be flagged at other sites. In addition, some sites have only 1 measurement where as most other sites have over 50 measurements. With over 100 measurements, the estimate of the Q97.5 for example has acceptable properties (i.e. low associated uncertainty). With less than 100 measurements, the estimates of the upper tail quantiles are very uncertain. The implication of which is that for flatwoods citrus not enough observations per site to attain an acceptable level of uncertainty are available. Finally, realize that these numbers are averaged over months that are known from the Task II analysis to be quite different.

Table 32 Quantiles for flatwoods citrus wells by month averaged over sites and years in acre-inches.

Month	N	max	min	Q1	Q2_5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97_5	Q99
1	101.00	2.23	0.00	0.00	0.00	0.00	0.00	0.09	0.31	0.77	1.31	1.80	1.94	1.97
2	102.00	3.36	0.00	0.00	0.00	0.00	0.07	0.28	0.64	1.34	1.86	2.16	2.37	2.52
3	106.00	5.27	0.00	0.00	0.00	0.00	0.03	0.33	0.78	1.90	2.86	3.51	4.99	5.10
4	120.00	7.61	0.00	0.00	0.00	0.00	0.23	0.49	1.08	1.68	2.45	3.15	3.65	3.90
5	126.00	7.28	0.00	0.00	0.00	0.00	0.18	0.43	1.03	1.70	2.96	3.75	4.61	5.12
6	137.00	2.31	0.00	0.00	0.00	0.00	0.00	0.01	0.11	0.36	1.13	1.43	1.85	2.09
7	139.00	3.47	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.47	1.07	1.28	1.54	2.19
8	147.00	2.36	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	0.39	0.70	1.55	1.63
9	86.00	3.54	0.00	0.00	0.00	0.00	0.00	0.01	0.28	0.92	1.54	2.11	2.24	3.54
10	89.00	4.60	0.00	0.00	0.00	0.00	0.00	0.12	0.52	1.58	2.31	3.22	3.94	4.60
11	97.00	5.69	0.00	0.00	0.00	0.00	0.00	0.15	0.77	1.54	2.67	3.19	3.88	5.69
12	98.00	3.92	0.00	0.00	0.00	0.00	0.00	0.06	0.25	0.76	1.84	2.80	2.89	3.92

The upper tail quantiles do change significantly from month to month, being highest in the winter and spring and lowest during the rainy summer period.

3.3.2.3 Step Test: By Site over all Months and Years

Table 33 Quantiles for absolute value step test of flatwoods citrus wells over all sites and dates.

Quantile	Estimate
Max	7.01
Q99	3.74
Q97.5	3.01
Q95	2.35
Q90	1.76
Q75	1.08
Q50 Median	0.47
Q25	0.14
Q10	0.01
Q5	0.00
Q2.5	0.00
Q1	0.00
Min	0.00

As with ridge citrus, the upper tail values for the steps are not that different from what was recorded for actual well measurements in Table 30. This tables suggests that jumps of over 4.79 should occur only once in 100 measurements and jumps of over 3.64 in 25 out of 1000 measurements.

3.3.2.4 Step Test: By Site and Month over all Years

Table 34 Q95 estimates for absolute step values for flatwoods citrus wells by site and month.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
200	0.45	2.36	3.24	5.93	7.01	1.68	1.81	1.13	3.54	3.94	2.59	3.12
201	0.09	0.47	0.35	1.37	0.34	0.32	0.23	0.12	0.22	0.34	0.35	0.16
202	0.30	1.01	1.04	0.72	1.97	0.88	0.02	0.06	0.35	0.70	1.15	0.99
203	0.73	0.52	1.82	1.39	2.28	1.27	0.64	0.32	0.54	0.91	1.68	0.92
204	0.77	1.08	2.36	1.78	3.16	1.86	0.62	0.59	1.06	1.67	2.00	1.46
205	0.24	0.60	1.44	1.21	1.86	1.23	0.45	0.38	0.60	1.00	1.09	0.84
206	0.56	1.80	1.66	1.07	4.03	1.27	0.05	0.60	0.86	1.56	2.27	1.78
207	1.12	0.41	0.52	0.57	0.98	0.50	0.19	0.35	0.24	0.01	0.53	1.12
208	0.82	0.60	0.38	0.47	1.98	1.47	0.61	0.40	0.22	0.15	0.58	1.81
209	1.15	1.48	0.77	1.45	3.01	1.68	0.18	0.42	0.38	3.21	3.22	1.35
210	0.80	1.66	0.54	1.42	3.08	1.64	1.52	1.51	2.19	1.90	2.40	1.45
211	1.01	1.93	1.31	1.37	2.04	1.45	0.27	1.00	1.50	2.90	3.88	1.04
212	1.61	2.30	3.00	2.54	4.94	2.31	0.75	0.93	2.06	1.79	2.73	1.76
213	1.40	2.35	3.09	1.48	3.51	1.86	1.40	0.89	1.76	1.64	3.02	2.12
214	1.35	0.43	0.61	0.21	0.00	0.56	0.01	0.00	.	.	.	2.80
215	0.11	0.51	0.57	0.24	0.40	0.09	0.09	0.09	0.04	0.16	0.38	0.74
216	0.16	1.01	0.61	0.58	0.25	0.83	1.16	2.20	1.24	2.18	2.32	0.88
217	1.67	1.54	1.60	1.58	0.51	1.60	0.80	0.57	2.98	2.31	2.35	2.16
218	0.94	1.43	1.60	2.02	2.22	1.45	0.69	0.66	1.26	2.42	2.19	2.60
219	1.41	0.94	1.20	1.02	1.81	2.01	1.47	1.53	1.72	3.49	2.90	1.08
220	1.47	1.01	2.22	3.07	0.41	2.36	1.03	1.07	2.24	3.74	5.38	1.34
221	0.02	0.93	0.51	1.12	0.35	0.61	0.02	0.28	0.88	1.36	1.52	1.08
222	0.67	0.85	0.65	0.93	0.47	0.47	0.86	0.82	0.15	0.61	0.83	0.68
223	.	0.23	1.58	1.39	2.36	0.09	0.65	0.65	0.44	0.65	0.40	1.66
224	.	1.56	1.30	2.11	1.81	1.02	1.15	1.15	0.90	1.07	0.68	0.95
225	.	0.08	0.01	0.27	0.08	0.17	0.14	0.11	0.06	0.04	0.27	0.44
226	.	0.06	0.04	0.13	0.06	0.14	0.10	0.10	.	0.19	0.23	0.41
227	.	0.11	0.03	0.29	0.65	0.36	0.37	0.35	0.34	0.50	0.02	0.82
228	.	0.07	0.23	0.04	0.08	0.18	0.01	0.01	.	0.16	0.12	0.28
229	.	0.11	0.63	1.35	0.48	0.72	0.90	0.76	0.35	0.29	1.29	2.07
230	.	0.48	0.81	0.25	0.77	1.04	1.13	1.13	0.92	0.08	0.26	0.40
231	.	0.75	0.99	0.14	0.13	0.52	1.24	1.24	1.52	1.09	0.78	0.98
232	.	0.88	0.74	0.20	0.82	0.40	0.54	0.47	1.20	0.54	0.33	0.87
233	.	.	.	.	.	1.17	.	.	.	.	.	.
234	.	0.00	0.00	0.00	0.12	0.00	0.00	0.00	1.39	0.52	2.89	4.80
235	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
236	.	0.36	0.18	1.30	1.05	0.24	0.00	0.00	0.00	0.79	0.13	0.66
237	.	1.73	3.58	0.26	2.90	0.64	0.02	0.00	0.01	4.60	1.09	3.48
238	.	0.44	0.18	0.32	0.12	0.93	0.40	0.40	0.48	0.96	0.79	0.63

Table 34 Continued.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
239	.	0.33	0.12	0.31	0.04	0.75	0.40	0.40	0.53	0.47	0.17	0.68
240	.	0.87	0.69	0.31	0.19	0.69	0.49	0.40	1.43	1.05	0.27	0.59
241	.	0.64	0.55	0.47	0.22	0.82	0.51	0.42	1.52	0.98	0.26	0.64
242	.	1.43	0.59	0.08	0.12	1.03	0.57	0.57	1.89	1.51	0.41	0.76
243	.	0.64	0.64	0.82	0.18	0.64	0.73	0.73	.	.	0.56	0.56
244	.	0.00	0.82	1.17	1.17	0.00	0.42	0.42	.	.	1.28	1.28
245	.	0.14	1.28	1.88	1.76	0.15	0.00	0.00	.	.	.	.
246	.	.	0.06	0.10	0.03	0.19	1.25	0.58	.	.	0.49	.
247	.	0.80	0.98	0.99	1.82	3.01	0.16	0.16	.	.	.	0.00
248	.	.	.	.	0.32	1.35	0.80	1.02	.	.	.	.
249	.	.	.	.	0.19	0.94	0.53	0.93	.	.	.	.
250	.	.	.	.	0.04	0.30	1.26	1.07	.	.	.	.
251	.	.	.	.	0.48	2.10	3.47	3.47	.	.	.	.
252	.	.	.	.	0.33	2.24	1.35	0.02	.	.	.	.
253	.	.	.	.	1.62	1.97	0.82	0.01	.	.	.	.
254	.	.	.	.	.	.	0.00	0.00	.	.	.	.
255	.	.	.	.	.	.	0.09	0.09	.	.	.	.
256	.	.	.	.	.	.	0.12	0.12	.	.	.	.
257	.	.	.	.	.	.	.	0.01	.	.	.	.
258	.	.	.	.	.	.	.	.	.	.	.	.
259	.	.	.	.	.	.	.	.	.	.	.	.
260	.	.	.	.	.	.	.	.	.	.	.	.
261	.	.	.	.	.	.	.	.	.	.	.	.
262	.	.	.	.	.	.	.	.	.	.	.	.
263	.	.	.	.	.	.	.	.	.	.	.	.
264	.	.	.	.	.	.	.	.	.	.	.	.
265	.	.	.	.	.	.	.	.	.	.	.	.
266	.	.	.	.	.	.	.	.	.	.	.	.

Table 35 Q97.5 estimates for flatwoods citrus by site and month.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
200	0.45	2.36	3.24	5.93	7.01	1.68	1.81	1.13	3.54	3.94	2.59	3.12
201	0.09	0.47	0.35	1.37	0.34	0.32	0.23	0.12	0.22	0.34	0.35	0.16
202	0.30	1.01	1.04	0.72	1.97	0.88	0.02	0.06	0.35	0.70	1.15	0.99
203	0.73	0.52	1.82	1.39	2.28	1.27	0.64	0.32	0.54	0.91	1.68	0.92
204	0.77	1.08	2.36	1.78	3.16	1.86	0.62	0.59	1.06	1.67	2.00	1.46
205	0.24	0.60	1.44	1.21	1.86	1.23	0.45	0.38	0.60	1.00	1.09	0.84
206	0.56	1.80	1.66	1.07	4.03	1.27	0.05	0.60	0.86	1.56	2.27	1.78
207	1.12	0.41	0.52	0.57	0.98	0.50	0.19	0.35	0.24	0.01	0.53	1.12
208	0.82	0.60	0.38	0.47	1.98	1.47	0.61	0.40	0.22	0.15	0.58	1.81
209	1.15	1.48	0.77	1.45	3.01	1.68	0.18	0.42	0.38	3.21	3.22	1.35
210	0.80	1.66	0.54	1.42	3.08	1.64	1.52	1.51	2.19	1.90	2.40	1.45
211	1.01	1.93	1.31	1.37	2.04	1.45	0.27	1.00	1.50	2.90	3.88	1.04
212	1.61	2.30	3.00	2.54	4.94	2.31	0.75	0.93	2.06	1.79	2.73	1.76
213	1.40	2.35	3.09	1.48	3.51	1.86	1.40	0.89	1.76	1.64	3.02	2.12
214	1.35	0.43	0.61	0.21	0.00	0.56	0.01	0.00	.	.	.	2.80
215	0.11	0.51	0.57	0.24	0.40	0.09	0.09	0.09	0.04	0.16	0.38	0.74
216	0.16	1.01	0.61	0.58	0.25	0.83	1.16	2.20	1.24	2.18	2.32	0.88
217	1.67	1.54	1.60	1.58	0.51	1.60	0.80	0.57	2.98	2.31	2.35	2.16
218	0.94	1.43	1.60	2.02	2.22	1.45	0.69	0.66	1.26	2.42	2.19	2.60
219	1.41	0.94	1.20	1.02	1.81	2.01	1.47	1.53	1.72	3.49	2.90	1.08
220	1.47	1.01	2.22	3.07	0.41	2.36	1.03	1.07	2.24	3.74	5.38	1.34
221	0.02	0.93	0.51	1.12	0.35	0.61	0.02	0.28	0.88	1.36	1.52	1.08
222	0.67	0.85	0.65	0.93	0.47	0.47	0.86	0.82	0.15	0.61	0.83	0.68
223	.	0.23	1.58	1.39	2.36	0.09	0.65	0.65	0.44	0.65	0.40	1.66
224	.	1.56	1.30	2.11	1.81	1.02	1.15	1.15	0.90	1.07	0.68	0.95
225	.	0.08	0.01	0.27	0.08	0.17	0.14	0.11	0.06	0.04	0.27	0.44
226	.	0.06	0.04	0.13	0.06	0.14	0.10	0.10	.	0.19	0.23	0.41
227	.	0.11	0.03	0.29	0.65	0.36	0.37	0.35	0.34	0.50	0.02	0.82
228	.	0.07	0.23	0.04	0.08	0.18	0.01	0.01	.	0.16	0.12	0.28
229	.	0.11	0.63	1.35	0.48	0.72	0.90	0.76	0.35	0.29	1.29	2.07
230	.	0.48	0.81	0.25	0.77	1.04	1.13	1.13	0.92	0.08	0.26	0.40
231	.	0.75	0.99	0.14	0.13	0.52	1.24	1.24	1.52	1.09	0.78	0.98
232	.	0.88	0.74	0.20	0.82	0.40	0.54	0.47	1.20	0.54	0.33	0.87
233	.	.	.	.	.	1.17	.	.	.	.	.	.
234	.	0.00	0.00	0.00	0.12	0.00	0.00	0.00	1.39	0.52	2.89	4.80
235	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
236	.	0.36	0.18	1.30	1.05	0.24	0.00	0.00	0.00	0.79	0.13	0.66
237	.	1.73	3.58	0.26	2.90	0.64	0.02	0.00	0.01	4.60	1.09	3.48
238	.	0.44	0.18	0.32	0.12	0.93	0.40	0.40	0.48	0.96	0.79	0.63
239	.	0.33	0.12	0.31	0.04	0.75	0.40	0.40	0.53	0.47	0.17	0.68
240	.	0.87	0.69	0.31	0.19	0.69	0.49	0.40	1.43	1.05	0.27	0.59
241	.	0.64	0.55	0.47	0.22	0.82	0.51	0.42	1.52	0.98	0.26	0.64
242	.	1.43	0.59	0.08	0.12	1.03	0.57	0.57	1.89	1.51	0.41	0.76

Table 35 Continued.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
243	.	0.64	0.64	0.82	0.18	0.64	0.73	0.73	.	.	0.56	0.56
244	.	0.00	0.82	1.17	1.17	0.00	0.42	0.42	.	.	1.28	1.28
245	.	0.14	1.28	1.88	1.76	0.15	0.00	0.00	.	.	.	.
246	.	.	0.06	0.10	0.03	0.19	1.25	0.58	.	.	0.49	.
247	.	0.80	0.98	0.99	1.82	3.01	0.16	0.16	.	.	.	0.00
248	.	.	.	.	0.32	1.35	0.80	1.02	.	.	.	.
249	.	.	.	.	0.19	0.94	0.53	0.93	.	.	.	.
250	.	.	.	.	0.04	0.30	1.26	1.07	.	.	.	.
251	.	.	.	.	0.48	2.10	3.47	3.47	.	.	.	.
252	.	.	.	.	0.33	2.24	1.35	0.02	.	.	.	.
253	.	.	.	.	1.62	1.97	0.82	0.01	.	.	.	.
254	.	.	.	.	.	.	0.00	0.00	.	.	.	.
255	.	.	.	.	.	.	0.09	0.09	.	.	.	.
256	.	.	.	.	.	.	0.12	0.12	.	.	.	.
257	.	.	.	.	.	.	.	0.01	.	.	.	.
258	.	.	.	.	.	.	.	.	.	.	.	.
259	.	.	.	.	.	.	.	.	.	.	.	.
260	.	.	.	.	.	.	.	.	.	.	.	.
261	.	.	.	.	.	.	.	.	.	.	.	.
262	.	.	.	.	.	.	.	.	.	.	.	.
263	.	.	.	.	.	.	.	.	.	.	.	.
264	.	.	.	.	.	.	.	.	.	.	.	.
265	.	.	.	.	.	.	.	.	.	.	.	.
266	.	.	.	.	.	.	.	.	.	.	.	.

A quick review of this table shows that there is less variability in these estimates from site to site and within each month than in ridge citrus. However, the effect of a low number of observations per site is noted by the large number of missing Q95 estimates in this table. While these estimates are site and month specific, their utility for quality control is undermined by the need for an adequate sample size.

3.3.2.5 Model-Based Range Test: Over all Sites, Months and Years

The expected means for each flatwoods citrus well and month are estimated by adding the estimated intercept term from Table 16 in Task II to the appropriate ridge citrus site estimated effect from Table 57 and the estimated month effect from Table 53 in the appendix of this task report. These estimated effects are given in Table 61 in the appendix. These mean values are subtracted from the observed data and the overall range test computed on these residuals. The quantile statistics are given in Table 36.

Table 36 Estimated quantiles of model based residuals for flatwoods citrus wells

.

Quantile	Residual	Absolute Residual
Max	5.40	5.40
Q99	2.52	2.52
Q97.5	1.82	1.90
Q95	1.30	1.43
Q90	0.85	1.09
Q75	0.17	0.74
Q50 Median	-0.20	0.43
Q25	-0.52	0.19
Q10	-0.83	0.08
Q5	-0.99	0.04
Q2.5	-1.17	0.02
Q1	-1.34	0.01
Min	-2.21	0.00

To use these values in a quality control setting, one would subtract from the observed measurement the sum of the estimated intercept value (0.83 acre-inches) plus the month effect for the month of the observations plus the effect of the observation site. If the resulting value were greater than 2.52 (Q99) in absolute value for example, the measurement would be flagged for further assessment. This value is less than the 3.97 value suggested in Table 30 for an unadjusted measurement and less than the step value of 3.74 in Table 33.

3.3.3 Potatoes

As noted before, potatoes present a special case in that the temporal element is represented as time (weeks) that has elapsed since planting. The ensuing tables were, therefore, computed over that time period versus the month intervals used in all other crops.

3.3.3.1 Range Test: Over All Sites, weeks since planting and Years

Table 37 Quantiles for potato wells over all sites, weeks since planting and years in acre-inches.

Quantile	Estimate
Max	15.29
Q99	9.79
Q97.5	8.05
Q95	6.77
Q90	5.28
Q75	3.33
Q50 Median	0.84
Q25	0.00
Q10	0.00
Q5	0.00
Q2.5	0.00
Q1	0.00
Min	0.00

From Table 37 a value greater than 9.79 would be expected in only one out of 100 new measurements. Using 9.79 as the upper threshold would result in forced re-checking about 1% of the time. Similarly, if 8.05 were used as the upper threshold, re-checking would be expected about 2.5% of the time. Note that checks for the lower range are not particularly useful here since somewhere between 25 and 50% of observations are zero.

3.3.3.2 Range Test: By site over all weeks since planting and years

Table 38 Quantiles for potato wells by site over all weeks since planting and years in acre-inches.

SiteNo	n	max	min	Q1	Q2.5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97.5	Q99
1	81	5.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.46	3.51	4.20	4.39	5.06
2	57	6.48	0.00	0.00	0.00	0.00	0.00	0.00	1.04	3.01	4.47	5.87	6.02	6.48
3	69	10.21	0.00	0.00	0.00	0.00	0.00	0.00	0.82	4.13	5.45	7.85	9.34	10.21
4	100	11.21	0.00	0.00	0.00	0.00	0.00	0.00	2.00	4.29	6.07	7.72	9.51	10.74
6	110	6.96	0.00	0.00	0.00	0.00	0.00	0.00	0.71	3.52	4.68	5.52	6.46	6.54
7	107	6.35	0.00	0.00	0.00	0.00	0.00	0.00	0.32	1.75	3.09	4.66	5.54	5.72
9	76	14.88	0.00	0.00	0.00	0.00	0.00	0.00	2.42	5.38	8.17	10.07	12.45	14.88
10	111	8.30	0.00	0.00	0.00	0.00	0.00	0.00	0.51	2.84	4.01	5.92	6.98	7.41
11	94	9.67	0.00	0.00	0.00	0.00	0.00	0.00	0.74	3.84	6.12	7.30	9.22	9.67
12	101	5.72	0.00	0.00	0.00	0.00	0.00	0.00	0.06	2.13	3.32	3.94	5.10	5.51
13	65	7.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.73	3.59	4.00	6.01	7.78
14	82	8.42	0.00	0.00	0.00	0.00	0.00	0.00	0.01	2.80	4.85	5.98	6.96	8.42
15	63	10.75	0.00	0.00	0.00	0.00	0.00	0.00	0.92	4.38	5.88	9.28	10.59	10.75
16	83	6.84	0.00	0.00	0.00	0.00	0.00	0.00	0.01	2.71	4.72	6.05	6.81	6.84
17	15	15.29	0.00	0.00	0.00	0.00	0.00	0.00	0.76	2.44	11.95	15.29	15.29	15.29
19	97	8.73	0.00	0.00	0.00	0.00	0.00	0.00	1.22	4.47	6.29	7.41	7.45	8.73
20	52	8.82	0.00	0.00	0.00	0.00	0.00	0.00	0.94	3.99	5.02	6.90	7.30	8.82

Table 38 Continued, quantiles for potato wells by site over all months and years in acre-inches.

SiteNo	n	max	min	Q1	Q2.5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97.5	Q99
22	18	6.92	0.00	0.00	0.00	0.00	0.00	0.00	3.03	4.26	5.16	6.92	6.92	6.92
23	25	6.01	0.00	0.00	0.00	0.00	0.00	0.00	1.24	3.10	4.31	4.32	6.01	6.01
24	68	7.68	0.00	0.00	0.00	0.00	0.00	0.00	1.91	3.87	4.95	6.37	7.66	7.68
25	54	7.60	0.00	0.00	0.00	0.00	0.00	0.00	1.31	2.71	3.96	5.63	6.24	7.60
26	68	10.21	0.00	0.00	0.00	0.00	0.00	0.00	1.82	3.76	5.60	7.34	9.17	10.21
27	96	7.56	0.00	0.00	0.00	0.00	0.00	0.00	1.17	3.29	4.79	5.53	6.14	7.56
28	41	11.58	0.00	0.00	0.00	0.00	0.00	0.00	2.70	7.13	10.63	11.02	11.45	11.58
33	93	8.38	0.00	0.00	0.00	0.00	0.00	0.00	1.10	3.13	4.47	5.41	5.71	8.38
34	63	12.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	7.29	9.56	11.80	12.03
37	63	12.66	0.00	0.00	0.00	0.00	0.00	0.00	1.69	6.09	7.20	10.83	12.01	12.66
38	101	8.43	0.00	0.00	0.00	0.00	0.00	0.00	1.82	4.16	5.25	6.92	7.66	8.38
39	68	9.37	0.00	0.00	0.00	0.00	0.00	0.00	0.95	4.16	6.86	7.37	9.35	9.37
40	68	6.51	0.00	0.00	0.00	0.00	0.00	0.00	0.63	2.82	4.18	5.15	5.85	6.51
41	74	10.95	0.00	0.00	0.00	0.00	0.00	0.00	1.44	3.56	5.67	6.60	8.64	10.95
42	73	8.26	0.00	0.00	0.00	0.00	0.00	0.00	1.88	3.19	4.58	5.52	6.89	8.26
44	92	9.64	0.00	0.00	0.00	0.00	0.00	0.00	1.80	3.73	5.55	6.91	8.10	9.64
45	61	9.36	0.00	0.00	0.00	0.00	0.00	0.00	1.39	3.87	6.66	7.84	9.15	9.36
46	100	7.08	0.00	0.00	0.00	0.00	0.00	0.00	1.24	4.41	5.67	6.75	7.02	7.08
47	85	11.10	0.00	0.00	0.00	0.00	0.00	0.00	1.86	4.10	6.35	7.95	9.12	11.10
49	26	9.46	0.00	0.00	0.00	0.00	0.00	0.00	4.09	7.69	8.84	8.87	9.46	9.46
50	95	13.41	0.00	0.00	0.00	0.00	0.00	0.00	3.67	7.15	8.79	10.79	12.42	13.41
52	86	9.05	0.00	0.00	0.00	0.00	0.00	0.00	0.16	3.26	4.83	5.54	6.36	9.05
53	67	6.84	0.00	0.00	0.00	0.00	0.00	0.00	0.81	1.83	2.78	4.12	5.34	6.84
55	72	12.99	0.00	0.00	0.00	0.00	0.00	0.00	1.80	4.36	5.12	6.42	10.98	12.99
187	130	7.87	0.00	0.00	0.00	0.00	0.00	0.00	1.16	3.17	4.98	5.87	6.13	6.73
189	14	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.74	1.64	1.64
190	14	6.83	0.00	0.00	0.00	0.00	0.00	0.03	3.25	5.46	6.23	6.83	6.83	6.83
191	10	6.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.14	3.96	5.36	5.55	6.07
192	10	5.56	0.00	0.00	0.00	0.00	0.00	0.00	1.47	2.92	4.36	4.90	5.24	5.56
193	8	6.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	2.89	4.10	4.31	6.05	6.05
194	8	5.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.34	4.28	4.49	4.98	5.35
195	9	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.48	2.18	2.62	3.30	3.46	3.57
196	5	5.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.14	3.29	3.91	4.07	5.30
197	5	6.07	0.00	0.00	0.00	0.00	0.00	0.00	1.47	3.20	4.93	5.29	5.53	6.07
198	5	3.65	0.00	0.00	0.00	0.00	0.00	0.00	0.42	1.57	2.44	2.90	3.16	3.39

The Q97.5 values range from a low of 1.64 to high of 12.45. By this method, well measurements at some sites would be flagged at values that would not be flagged at other sites. In addition, some sites have only 5 measurements whereas most other sites have over 100 measurements. With over 100 measurements, the estimate of the Q97.5, for example, has acceptable properties (i.e. low associated uncertainty). With over 100 measurements, the estimate of the Q97.5 for example has acceptable properties (i.e. low associated uncertainty). With less than 100 measurements, the estimates of the upper tail quantiles are very uncertain. Finally, realize that these numbers are averaged over weeks after planting that are known from the Task II analysis to be quite different.

3.3.3.3 Range Test: By weeks since planting over all sites and years

Table 39 Quantiles for potato wells by weeks since planting (WSP) averaged over sites and years in acre-inches.

WSP	n	max	min	Q1	Q2.5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97.5	Q99
1	131	7.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	3.41	4.30
2	175	12.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.48	2.81	4.16	7.06
3	183	8.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.45	2.15	4.13	7.89
4	170	8.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34	2.49	3.26	4.25	7.41
5	189	10.47	0.00	0.00	0.00	0.00	0.00	0.00	0.57	2.20	3.46	4.36	4.85	5.97
6	166	8.04	0.00	0.00	0.00	0.00	0.00	0.00	1.69	2.97	4.85	5.52	6.59	7.19
7	188	10.38	0.00	0.00	0.00	0.00	0.00	0.04	1.91	3.83	5.21	7.08	7.89	8.53
8	160	13.41	0.00	0.00	0.00	0.00	0.00	0.36	2.55	3.80	5.12	6.47	7.06	7.95
9	175	11.61	0.00	0.00	0.00	0.00	0.00	1.10	2.86	4.45	6.07	7.56	8.69	11.02
10	152	11.45	0.00	0.00	0.00	0.00	0.03	1.66	3.28	4.82	6.78	8.73	10.33	11.14
11	188	14.88	0.00	0.00	0.00	0.34	1.01	2.16	3.42	5.24	7.16	8.47	9.28	12.42
12	158	12.84	0.00	0.00	0.01	0.55	1.04	2.37	4.08	5.44	7.34	9.34	10.63	12.03
13	192	11.58	0.00	0.00	0.00	0.02	0.84	2.35	4.02	5.75	7.11	8.38	9.71	11.36
14	163	15.29	0.00	0.00	0.00	0.00	0.63	1.92	3.49	5.19	6.89	8.84	10.79	11.80
15	177	11.10	0.00	0.00	0.00	0.00	0.00	0.66	2.50	4.10	6.05	7.26	8.27	10.46
16	166	12.45	0.00	0.00	0.00	0.00	0.00	0.00	2.22	4.31	5.98	7.82	10.07	11.95
17	159	9.46	0.00	0.00	0.00	0.00	0.00	0.00	0.19	2.00	3.80	5.03	7.87	9.36
18	164	12.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	3.21	4.70	5.53	6.91
19	147	7.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	2.99	4.12	6.51	7.62
20	128	10.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.44	3.63	5.24	6.60
21	115	5.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	2.41	2.87	4.74
22	93	6.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	2.17	3.04	6.52
23	55	6.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69	3.38	6.06	6.46
24	64	5.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16	2.60	3.65	5.52
25	30	6.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.45	5.06	6.16	6.16
26	16	4.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	3.54	4.07	4.07	4.07
27	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
28	3	2.84	0.00	0.00	0.00	0.00	0.00	0.00	1.68	2.84	2.84	2.84	2.84	2.84
30	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	1	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
33	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	2	4.31	3.56	3.56	3.56	3.56	3.56	3.56	3.94	4.31	4.31	4.31	4.31	4.31
40	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The upper tail quantiles do change significantly over the planting period; the largest Q97.5 values are obtained over 10 to 17 weeks after planting, the lower Q97.5 values are obtained in the weeks preceding and following this bracket. This is consistent with the results from task II.

3.3.3.4 Step Test: By Site over all weeks since planting and years

Table 40 Quantiles for absolute value step test of potato wells over all sites and dates.

Quantile	Estimate
Max	13.58
Q99	8.67
Q97.5	7.01
Q95	5.65
Q90	4.45
Q75	2.71
Q50 Median	1.08
Q25	0.00
Q10	0.00
Q5	0.00
Q2.5	0.00
Q1	0.00
Min	0.00

The upper tail values for the steps are not that different from what was recorded for actual well measurements in Table 37. This tables suggests that jumps of over 8.67 should occur only once in 100 measurements and jumps of over 7.01 in 25 out of 1000 measurements.

3.3.3.5 Step Test: By site and weeks since planting over all years

Table 41 Q95 estimates for absolute step values for potato wells by site and the first 12 weeks after planting.

SiteNo	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00	0.00	0.77	0.77	1.45	2.62	2.07	2.91	3.99	3.37	2.96	1.32
2		0.36	0.82	1.79	3.38	0.60	2.78	1.29	2.61	3.11	3.29	3.82
3	0.00	0.00	4.47	0.00	0.82	1.63	7.14	6.35	5.40	7.85	6.64	5.43
4	0.00	3.28	1.21	0.00	2.65		4.28	4.87	2.82	6.08	5.63	5.74
6	0.00	0.36	0.00	0.92	2.84	4.24	4.67	3.81	2.93	3.25	4.82	2.94
7	0.00	5.20	0.68	1.49	2.65	0.85	1.39	2.88	0.95	5.74	3.41	5.22
9	0.28	4.16	3.53	1.21	3.49	5.20	7.87	6.01	4.86	5.80	12.43	5.14
10	0.00	0.66	1.66	0.00	4.33	1.91	3.06	2.62	7.38	2.31	2.84	3.98
11	4.30	0.00	3.59	5.14	3.93	5.16	7.08	2.78	9.52	4.13	2.13	5.55
12	0.00	1.78	0.06		0.51	0.51	2.91	2.56	2.77	3.63	4.09	1.54
13	0.00	0.00	0.00	0.47	0.00		0.07	2.57	2.27		2.09	6.06
14		0.00	1.53	1.53	3.86	6.59	1.86	4.85	4.01	3.44	6.49	6.18
15	0.00	1.87	1.87	0.00	3.02	1.11	4.52	3.81	2.41	3.03	4.52	10.51
16		2.46	0.00	3.26	2.71	4.33	5.21	3.66	2.86	6.77	6.82	6.84
17			0.00	0.00		0.00	0.00	2.14		2.14	1.82	0.11

Table 41 continued Q95 estimates for absolute step values for potato wells by site and the first 12 weeks after planting.

SiteNo	1	2	3	4	5	6	7	8	9	10	11	12
19		0.00	1.23	1.77	1.66	5.72	3.37	5.78	7.41	3.48	4.45	3.42
20	0.00	0.00	0.00	0.00	0.00	0.00	4.51	3.47	0.13	2.08	4.38	6.15
22	0.00	0.00			2.20	0.74	2.97		0.00	4.98	2.01	
23		0.00	0.00	2.14		1.04	0.64	0.73		0.07	4.58	
24		0.01	1.24	2.48	2.52	3.98	2.67	7.15	0.89	2.92	3.78	3.24
25	0.00	0.00	0.00	1.35	0.94	1.74	1.47	2.82	3.64	3.60	4.43	0.35
26	0.00	4.68	0.07	1.80	1.84	3.89	3.74	2.76	3.21	5.61	6.67	2.16
27	0.00	1.20	1.20	1.32	4.72	0.00	4.16	0.13	4.66	4.05	2.78	2.29
28	0.00	0.00	4.13	0.00	2.10	1.41	8.48	7.35	11.0	7.08	2.73	3.50
33	2.13	0.35	0.66	2.16	0.57	2.90	2.35	3.29	4.94	4.52	2.31	4.36
34	0.00	0.00	0.00	0.00	1.04	2.63	7.37	4.27	4.43	9.56	10.80	11.69
37	3.41	3.41		0.52	0.52	5.35	6.59	4.20	5.40	9.14	5.98	8.04
38	0.00	1.82	0.00	0.00	3.58	1.94	5.04	3.85	2.95	7.66	8.43	1.64
39	0.00	0.00	1.45	4.98	2.44	4.72	6.37	6.12		9.37	4.68	7.34
40		1.45	2.20	2.20	2.83	2.64	3.57	3.19	0.07	3.34	5.53	4.10
41	0.00	4.00	2.15	1.01	3.95	1.82	1.37	0.19	3.69	5.51	8.63	1.48
42	0.00	0.00	2.56	1.85	2.79	4.35	2.68	2.64	5.52	2.86	3.90	2.99
44	0.00	0.00	0.00	2.66	4.68	3.29	3.91	0.90	7.13	6.90	3.80	5.53
45	0.00	0.00	0.00	2.26	2.78	2.78	3.84	2.69	5.98		5.92	3.71
46	3.53	3.53	0.00	5.29	4.36	5.52	6.73	4.06	1.39	6.34	3.32	1.04
47	0.00	0.00	0.05	2.05	1.86	3.19	3.61	6.10	7.94	2.28	4.24	5.30
49	0.00				4.94				5.43	7.21		
50	7.43	7.06	8.22	4.54	10.5	4.20	4.82	13.4	5.88	7.96	10.33	9.77
52	0.00	0.77	1.51	2.12	4.41	3.49	4.16	4.71	3.88	3.26	5.86	1.78
53	0.00	0.00	1.45	0.81	1.26	0.25	3.18	3.71	2.74	0.68	3.14	3.16
55		10.83	10.44	2.53	1.59	5.78	5.56	2.62	2.34	2.65	4.90	6.87
187		1.78	2.81	2.62	1.34	5.09	5.68	2.52	4.27	0.32	2.74	5.20
189		0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	1.64		0.01
190		0.03	0.03	2.78	2.78	5.46	1.83	0.70	3.18	0.53		4.18
191	0.00	0.55	0.00	2.14	2.20	1.44	1.14	0.32	6.01		3.27	2.65
192	0.00	0.00	0.70	0.04	2.07	3.79	2.69	3.46	2.41	2.42	2.52	2.28
193		0.00	0.00	1.43	2.61	2.09	3.50	4.07	2.89	3.33		1.88
194		1.48	0.00	0.48	0.00	2.34	2.77	2.84	4.37	2.74	3.40	1.30
195	0.00	0.06	0.06	1.68	1.30	1.74	1.09	0.95	1.94	2.93	1.28	1.47
196		0.00	0.00	0.00	0.57	0.57	2.70	0.59	3.27		1.48	4.08
197	0.00	0.00	1.61	2.83	4.42	1.52	2.44	3.59	3.70	1.07	1.76	1.08
198	2.23	2.42	1.01	1.15	1.51	1.94	1.49	2.42		2.39	1.87	1.93

Table 42 Q95 estimates for absolute step values for potato wells by site and the 12 to 24 weeks after planting.

SiteNo	13	14	15	16	17	18	19	20	21	22	23	24
1	3.49	1.44	2.61	4.20	0.17	0.00	0.00	0.00	0.00	0.00		0.00
2	4.11	3.02	3.36	3.52	1.04	2.66	0.87	0.00				
3	6.15	1.02	0.98	5.02	1.74	3.21	1.91		0.00	0.00		
4	6.09	2.20	3.74	5.34	7.21	1.78		6.43	2.66	3.68	6.06	6.06
6	6.12	5.03	5.01	3.61	4.60	3.81	4.69	0.40	1.07	0.54	3.38	5.52
7	0.92	2.43	3.61	2.31	2.94	0.95	0.08	0.00	0.00		0.06	0.00
9	2.78	3.04	4.59	6.89	5.63	2.39	0.58	0.00	0.00	0.00		0.00
10	3.99	3.63	3.07	3.48	0.00	2.70	0.74	0.00	0.00	3.04	0.00	3.65
11	6.21	5.35	9.67	4.39	3.72	1.84	1.54	1.58	1.93	1.93	0.00	0.00
12	2.72	2.39	4.88	4.12	1.60	1.37	0.75	0.86	0.00	0.00	0.00	0.00
13	2.66	2.44	0.94	1.46	3.59	0.73	0.00	0.00	0.00	0.00	0.00	
14	4.34	3.98	1.76	5.45	5.95	3.49	0.00	0.07	0.05	0.66	0.66	0.25
15	1.38	7.16	10.46	8.21	0.40	5.84		0.00	1.50		1.50	0.00
16	6.25	3.15	5.24		3.27	3.27	1.14	0.90	0.28	0.12	0.00	0.00
17		13.58		12.85			11.19	4.48	5.24			
19	7.90	3.76	6.29	4.72	4.45	1.81	1.81	1.31	0.00	0.00	0.00	
20		3.76	0.39	3.03		0.00	0.00	0.00	0.00			
22	2.66	1.17	2.07			1.40						
23	1.02		3.98		0.18		0.52	0.00				
24	5.47	3.45	3.38	3.12	4.25	1.52	3.10		4.74		1.69	
25	4.89	0.81	5.34	3.32	3.64	3.15	1.68	1.27	0.00	1.57		1.16
26	5.44	4.00	3.17	10.21	3.76	3.88	0.00	2.51	0.00	0.00		
27	2.43	1.45	5.60	2.67	2.45	3.08	0.84	0.86		0.00	0.00	0.00
28	4.45	8.83	7.01	5.05	5.00	7.87	2.70	2.70				
33	2.23	4.68	4.44	3.10	2.70	0.81	3.33	3.63	0.00	1.10	0.00	1.40
34	0.71	6.71	10.13	9.03	7.77	1.26	1.69	0.00		0.00	0.00	
37	5.27	3.56	1.45	7.20	4.38	12.66	0.11		0.17	6.52	0.06	6.46
38	3.62	2.42	7.01	4.85	4.11	4.70	7.62	6.51	2.87	0.00	0.00	0.00
39	5.46	7.37	8.27	4.16	1.07	3.15	4.49	4.49	2.44		2.21	
40	5.15	1.69	2.74	2.32	3.80	3.80	3.03		5.18		0.25	
41	4.14	7.14	5.12	3.00	1.32	0.00	2.99	10.95				
42	5.40	1.19	0.86	2.78	0.59	4.10	1.46	1.46	0.00		3.19	
44	3.73	7.35	4.56	4.16	2.28	5.47	0.00	0.00	0.00	0.68	0.00	
45	5.99	1.76	6.74	0.22	9.36	4.34	2.00			0.00		0.00
46	3.09	4.15	4.40	1.95	3.20	0.00	6.81	0.00	2.40	0.01	0.00	0.00
47	5.63	4.49	7.60	6.92	6.74	5.72	0.00	0.00	0.00	0.00	0.00	
49	5.23	3.73				4.05	1.47					
50	4.38	5.42	3.31	7.82	5.27	2.17	3.67	0.00	0.00	0.00		0.00
52	4.83	6.36	4.88	2.40	8.73	3.20	2.80	0.00	0.00	1.20		0.00
53	6.66	0.03	1.71	1.00	2.20	2.56		0.32	0.32			
55	2.87	6.67	5.45	0.96	4.44		0.61	0.00	0.37		0.37	0.03
187	5.77	1.44	2.18	3.63	1.04	2.65	7.87	3.46	0.00	2.88	0.00	3.24
189		0.74		0.57		0.01	0.01		0.01	0.01	0.02	
190	0.60	1.41		0.15	3.44			2.33	3.56			

Table 42 Continued, Q95 estimates for absolute step values for potato wells by site and the 12 to 24 weeks after planting.

SiteNo	13	14	15	16	17	18	19	20	21	22	23	24
191	4.08	0.29	5.23	3.95	1.60	0.00	0.00	0.00		0.00		0.00
192	1.37	4.53	1.03	1.47	0.00	4.76	4.76	5.20		5.20	2.14	
193	2.56	3.41	0.33	3.68		0.00	0.00	0.00	0.00	0.01	0.01	
194	5.27		4.84	0.00	0.00		0.00	0.00	0.00		0.00	0.00
195	1.59	1.22	3.30	2.65	2.47	2.35	0.00	0.00	0.43	0.43	0.00	
196	3.25	1.35	1.13	1.79	0.01	0.01	0.00	1.88	2.51	2.51		2.60
197	2.83	2.46	1.34	3.20	0.00	0.01	1.19	1.19	0.00	0.00		
198	2.15	1.57	1.47	2.78	1.10	0.37	0.72	0.60	0.00		0.01	0.01

Table 43 Q97.5 estimates for absolute step values for potato wells by site and the 12 weeks after planting.

SiteNo	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00	0.00	0.77	0.77	1.45	2.62	2.07	2.91	3.99	3.37	2.96	1.32
2		0.36	0.82	1.79	3.38	0.60	2.78	1.29	2.61	3.11	3.29	3.82
3	0.00	0.00	4.47	0.00	0.82	1.63	7.14	6.35	5.40	7.85	6.64	5.43
4	0.00	3.28	1.21	0.00	2.65		4.28	4.87	2.82	6.08	5.63	5.74
6	0.00	0.36	0.00	0.92	2.84	4.24	4.67	3.81	2.93	3.25	4.82	2.94
7	0.00	5.20	0.68	1.49	2.65	0.85	1.39	2.88	0.95	5.74	3.41	5.22
9	0.28	4.16	3.53	1.21	3.49	5.20	7.87	6.01	4.86	5.80	12.43	5.14
10	0.00	0.66	1.66	0.00	4.33	1.91	3.06	2.62	7.38	2.31	2.84	3.98
11	4.30	0.00	3.59	5.14	3.93	5.16	7.08	2.78	9.52	4.13	2.13	5.55
12	0.00	1.78	0.06		0.51	0.51	2.91	2.56	2.77	3.63	4.09	1.54
13	0.00	0.00	0.00	0.47	0.00		0.07	2.57	2.27		2.09	6.06
14		0.00	1.53	1.53	3.86	6.59	1.86	4.85	4.01	3.44	6.49	6.18
15	0.00	1.87	1.87	0.00	3.02	1.11	4.52	3.81	2.41	3.03	4.52	10.51
16		2.46	0.00	3.26	2.71	4.33	5.21	3.66	2.86	6.77	6.82	6.84
17			0.00	0.00		0.00	0.00	2.14		2.14	1.82	0.11
19		0.00	1.23	1.77	1.66	5.72	3.37	5.78	7.41	3.48	4.45	3.42
20	0.00	0.00	0.00	0.00	0.00	0.00	4.51	3.47	0.13	2.08	4.38	6.15
22	0.00	0.00			2.20	0.74	2.97		0.00	4.98	2.01	
23		0.00	0.00	2.14		1.04	0.64	0.73		0.07	4.58	
24		0.01	1.24	2.48	2.52	3.98	2.67	7.15	0.89	2.92	3.78	3.24
25	0.00	0.00	0.00	1.35	0.94	1.74	1.47	2.82	3.64	3.60	4.43	0.35
26	0.00	4.68	0.07	1.80	1.84	3.89	3.74	2.76	3.21	5.61	6.67	2.16
27	0.00	1.20	1.20	1.32	4.72	0.00	4.16	0.13	4.66	4.05	2.78	2.29
28	0.00	0.00	4.13	0.00	2.10	1.41	8.48	7.35	11.02	7.08	2.73	3.50
33	2.13	0.35	0.66	2.16	0.57	2.90	2.35	3.29	4.94	4.52	2.31	4.36
34	0.00	0.00	0.00	0.00	1.04	2.63	7.37	4.27	4.43	9.56	10.80	11.69
37	3.41	3.41		0.52	0.52	5.35	6.59	4.20	5.40	9.14	5.98	8.04
38	0.00	1.82	0.00	0.00	3.58	1.94	5.04	3.85	2.95	7.66	8.43	1.64
39	0.00	0.00	1.45	4.98	2.44	4.72	6.37	6.12		9.37	4.68	7.34
40		1.45	2.20	2.20	2.83	2.64	3.57	3.19	0.07	3.34	5.53	4.10
41	0.00	4.00	2.15	1.01	3.95	1.82	1.37	0.19	3.69	5.51	8.63	1.48
42	0.00	0.00	2.56	1.85	2.79	4.35	2.68	2.64	5.52	2.86	3.90	2.99
44	0.00	0.00	0.00	2.66	4.68	3.29	3.91	0.90	7.13	6.90	3.80	5.53

Table 43 continued, Q97.5 estimates for absolute step values for potato wells by site and the 12 weeks after planting.

SiteNo	1	2	3	4	5	6	7	8	9	10	11	12
45	0.00	0.00	0.00	2.26	2.78	2.78	3.84	2.69	5.98		5.92	3.71
46	3.53	3.53	0.00	5.29	4.36	5.52	6.73	4.06	1.39	6.34	3.32	1.04
47	0.00	0.00	0.05	2.05	1.86	3.19	3.61	6.10	7.94	2.28	4.24	5.30
49	0.00				4.94				5.43	7.21		
50	7.43	7.06	8.22	4.54	10.47	4.20	4.82	13.41	5.88	7.96	10.33	9.77
52	0.00	0.77	1.51	2.12	4.41	3.49	4.16	4.71	3.88	3.26	5.86	1.78
53	0.00	0.00	1.45	0.81	1.26	0.25	3.18	3.71	2.74	0.68	3.14	3.16
55		10.83	10.44	2.53	1.59	5.78	5.56	2.62	2.34	2.65	4.90	6.87
187		1.78	2.81	2.62	1.34	5.09	5.68	2.52	4.27	0.32	2.74	5.20
189		0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	1.64		0.01
190		0.03	0.03	2.78	2.78	5.46	1.83	0.70	3.18	0.53		4.18
191	0.00	0.55	0.00	2.14	2.20	1.44	1.14	0.32	6.01		3.27	2.65
192	0.00	0.00	0.70	0.04	2.07	3.79	2.69	3.46	2.41	2.42	2.52	2.28
193		0.00	0.00	1.43	2.61	2.09	3.50	4.07	2.89	3.33		1.88
194		1.48	0.00	0.48	0.00	2.34	2.77	2.84	4.37	2.74	3.40	1.30
195	0.00	0.06	0.06	1.68	1.30	1.74	1.09	0.95	1.94	2.93	1.28	1.47
196		0.00	0.00	0.00	0.57	0.57	2.70	0.59	3.27		1.48	4.08
197	0.00	0.00	1.61	2.83	4.42	1.52	2.44	3.59	3.70	1.07	1.76	1.08
198	2.23	2.42	1.01	1.15	1.51	1.94	1.49	2.42		2.39	1.87	1.93

Table 44 Q97.5 estimates for absolute step values for potato wells by site and the 12-24 weeks after planting.

SiteNo	13	14	15	16	17	18	19	20	21	22	23	24
1	3.49	1.44	2.61	4.20	0.17	0.00	0.00	0.00	0.00	0.00		0.00
2	4.11	3.02	3.36	3.52	1.04	2.66	0.87	0.00				
3	6.15	1.02	0.98	5.02	1.74	3.21	1.91		0.00	0.00		
4	6.09	2.20	3.74	5.34	7.21	1.78		6.43	2.66	3.68	6.06	6.06
6	6.12	5.03	5.01	3.61	4.60	3.81	4.69	0.40	1.07	0.54	3.38	5.52
7	0.92	2.43	3.61	2.31	2.94	0.95	0.08	0.00	0.00		0.06	0.00
9	2.78	3.04	4.59	6.89	5.63	2.39	0.58	0.00	0.00	0.00		0.00
10	3.99	3.63	3.07	3.48	0.00	2.70	0.74	0.00	0.00	3.04	0.00	3.65
11	6.21	5.35	9.67	4.39	3.72	1.84	1.54	1.58	1.93	1.93	0.00	0.00
12	2.72	2.39	4.88	4.12	1.60	1.37	0.75	0.86	0.00	0.00	0.00	0.00
13	2.66	2.44	0.94	1.46	3.59	0.73	0.00	0.00	0.00	0.00	0.00	
14	4.34	3.98	1.76	5.45	5.95	3.49	0.00	0.07	0.05	0.66	0.66	0.25
15	1.38	7.16	10.46	8.21	0.40	5.84		0.00	1.50		1.50	0.00
16	6.25	3.15	5.24		3.27	3.27	1.14	0.90	0.28	0.12	0.00	0.00
17		13.58		12.85			11.19	4.48	5.24			
19	7.90	3.76	6.29	4.72	4.45	1.81	1.81	1.31	0.00	0.00	0.00	
20		3.76	0.39	3.03		0.00	0.00	0.00	0.00			
22	2.66	1.17	2.07			1.40						
23	1.02		3.98		0.18		0.52	0.00				
24	5.47	3.45	3.38	3.12	4.25	1.52	3.10		4.74		1.69	

Table 44 Continued Q97.5 estimates for absolute step values for potato wells by site and the 12-24 weeks after planting.

SiteNo	13	14	15	16	17	18	19	20	21	22	23	24
25	4.89	0.81	5.34	3.32	3.64	3.15	1.68	1.27	0.00	1.57		1.16
26	5.44	4.00	3.17	10.21	3.76	3.88	0.00	2.51	0.00	0.00		
27	2.43	1.45	5.60	2.67	2.45	3.08	0.84	0.86		0.00	0.00	0.00
28	4.45	8.83	7.01	5.05	5.00	7.87	2.70	2.70				
33	2.23	4.68	4.44	3.10	2.70	0.81	3.33	3.63	0.00	1.10	0.00	1.40
34	0.71	6.71	10.13	9.03	7.77	1.26	1.69	0.00		0.00	0.00	
37	5.27	3.56	1.45	7.20	4.38	12.66	0.11		0.17	6.52	0.06	6.46
38	3.62	2.42	7.01	4.85	4.11	4.70	7.62	6.51	2.87	0.00	0.00	0.00
39	5.46	7.37	8.27	4.16	1.07	3.15	4.49	4.49	2.44		2.21	
40	5.15	1.69	2.74	2.32	3.80	3.80	3.03		5.18		0.25	
41	4.14	7.14	5.12	3.00	1.32	0.00	2.99	10.95				
42	5.40	1.19	0.86	2.78	0.59	4.10	1.46	1.46	0.00		3.19	
44	3.73	7.35	4.56	4.16	2.28	5.47	0.00	0.00	0.00	0.68	0.00	
45	5.99	1.76	6.74	0.22	9.36	4.34	2.00			0.00		0.00
46	3.09	4.15	4.40	1.95	3.20	0.00	6.81	0.00	2.40	0.01	0.00	0.00
47	5.63	4.49	7.60	6.92	6.74	5.72	0.00	0.00	0.00	0.00	0.00	
49	5.23	3.73				4.05	1.47					
50	4.38	5.42	3.31	7.82	5.27	2.17	3.67	0.00	0.00	0.00		0.00
52	4.83	6.36	4.88	2.40	8.73	3.20	2.80	0.00	0.00	1.20		0.00
53	6.66	0.03	1.71	1.00	2.20	2.56		0.32	0.32			
55	2.87	6.67	5.45	0.96	4.44		0.61	0.00	0.37		0.37	0.03
187	5.77	1.44	2.18	3.63	1.04	2.65	7.87	3.46	0.00	2.88	0.00	3.24
189		0.74		0.57		0.01	0.01		0.01	0.01	0.02	
190	0.60	1.41		0.15	3.44			2.33	3.56			
191	4.08	0.29	5.23	3.95	1.60	0.00	0.00	0.00		0.00		0.00
192	1.37	4.53	1.03	1.47	0.00	4.76	4.76	5.20		5.20	2.14	
193	2.56	3.41	0.33	3.68		0.00	0.00	0.00	0.00	0.01	0.01	
194	5.27		4.84	0.00	0.00		0.00	0.00	0.00		0.00	0.00
195	1.59	1.22	3.30	2.65	2.47	2.35	0.00	0.00	0.43	0.43	0.00	
196	3.25	1.35	1.13	1.79	0.01	0.01	0.00	1.88	2.51	2.51		2.60
197	2.83	2.46	1.34	3.20	0.00	0.01	1.19	1.19	0.00	0.00		
198	2.15	1.57	1.47	2.78	1.10	0.37	0.72	0.60	0.00		0.01	0.01

The Q95 and Q97.5 tables differ from those produced for the other crops in that they cover weeks since planting (WSP), versus months. Only the first 24 week period was chosen as representative of the total crop period. A quick review of these tables show that there is considerable variability in these estimates from site to site and within each WSP. Using these values as the quality threshold would results in all non-zero absolute step values being flagged for these sites in the specified months.

3.3.3.6 Model-Based Range Test: Over all sites, weeks since planting and years

The expected means for each of the potato wells and WSP are computed by adding the estimated intercept term from Table 19 in Task II to the appropriate potato site estimated effect from Table 58 and the estimated month effect from Table 53 in the appendix of this task report. These estimated effects are given in Table 62 in the appendix. These mean values are subtracted from the observed data and the overall range test computed on these residuals. The quantile statistics are given in Table 45.

Table 45 Estimated quantiles of model-based residuals for potato wells.

Quantile	Residual	Absolute Residual
Max	11.93	11.93
Q99	6.07	6.07
Q97.5	4.51	4.58
Q95	3.37	3.78
Q90	2.17	3.00
Q75	0.55	2.02
Q50 Median	-0.50	1.08
Q25	-1.30	0.52
Q10	-2.34	0.20
Q5	-2.83	0.10
Q2.5	-3.25	0.05
Q1	-3.81	0.02
Min	-5.10	0.00

To use these values in a quality control setting, one would subtract from the observed measurement the sum of the estimated intercept value (1.88 acre-inches) plus the month effect for the month of the observations plus the effect of the observation site. If the resulting value were greater than 6.07 (Q99) in absolute value for example, the measurement would be flagged for further assessment. This value is less than the value of 8.67 suggested in Table 37 for an unadjusted measurement and less than the 9.79 step value in Table 40.

3.3.4 Leatherleaf Fern

3.3.4.1 Range Test: Over All Sites, Months and Years

Table 46 Quantiles for leatherleaf fern wells over all sites, months and years in acre-inches.

Quantile	Estimate
Max	60.21
Q99	24.44
Q97.5	16.15
Q95	11.33
Q90	7.32
Q75	3.90
Q50 Median	2.19
Q25	1.26
Q10	0.71
Q5	0.45
Q2.5	0.27
Q1	0.02
Min	0.00

From Table 46 one would expect to see a value greater than 24.44 in only one out of 100 new measurements. Using 24.44 as the upper threshold would result in forced re-checking about 1% of the time. Similarly, if 16.15 were used as the upper threshold, re-checking about 2.5% of the time would be expected. Note that checks for the lower range are somewhat more useful as less than 1% are zeros.

3.3.4.2 Range Test: By Site over all Months and Years

Table 47 Quantiles for leatherleaf wells by site over all months and years in acre-inches.

SiteNo	n	max	min	Q1	Q2_5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97_5	Q99
56	18	5.68	0.11	0.11	0.11	0.11	0.47	0.73	1.47	1.90	2.49	5.68	5.68	5.68
57	56	24.44	0.00	0.00	0.44	0.45	1.40	1.92	2.53	4.40	7.40	10.57	20.00	24.44
58	158	48.24	0.00	0.00	0.00	0.14	1.01	1.95	3.89	6.28	12.91	24.53	43.13	47.77
60	23	30.35	0.00	0.00	0.00	0.07	0.11	1.05	3.25	4.05	6.89	8.06	30.35	30.35
61	170	39.67	0.42	0.91	1.23	1.61	1.70	2.11	2.94	4.28	7.72	13.17	18.68	26.90
62	171	22.57	0.00	0.68	0.81	1.06	1.48	2.03	3.13	4.65	6.98	10.93	16.29	20.86
63	167	29.92	0.51	0.53	0.85	1.07	1.29	1.91	3.13	5.30	7.99	10.13	14.76	27.97
64	138	28.59	0.53	0.67	0.86	0.92	1.10	1.58	2.35	3.43	7.69	14.36	16.58	21.25
65	51	29.27	0.48	0.48	0.80	0.99	1.26	2.49	3.95	7.87	9.94	12.38	14.45	29.27
66	148	25.94	0.00	0.00	0.00	0.34	0.54	1.07	1.82	2.88	4.48	5.44	8.20	9.12
67	164	24.43	0.35	0.44	0.48	0.61	0.75	1.02	1.80	2.96	6.26	8.58	12.12	19.39
68	60	27.35	0.56	0.56	0.94	0.99	1.08	1.92	3.00	5.27	6.04	7.62	8.76	27.35
69	164	32.50	0.07	0.53	0.73	0.92	1.28	1.94	3.20	5.17	7.95	11.73	12.72	27.83
70	167	24.77	0.00	0.00	0.68	0.87	1.37	2.04	3.06	4.59	7.57	12.12	15.85	24.66
73	158	8.37	0.02	0.04	0.05	0.29	0.52	0.68	1.10	1.56	2.26	3.76	4.71	7.91
74	149	21.07	0.00	0.00	0.31	0.48	0.64	1.34	2.42	4.08	6.75	9.10	14.72	18.72
75	168	16.10	0.07	0.07	0.12	0.15	0.31	0.52	1.10	2.53	5.24	8.78	12.58	15.40
76	168	36.86	0.00	0.06	0.31	0.36	0.74	1.25	2.00	5.09	13.23	18.20	23.04	35.19
77	162	27.38	0.00	0.01	0.20	0.36	0.55	1.18	2.27	4.36	8.10	14.12	17.65	26.40
78	93	60.21	0.00	0.00	0.00	0.01	0.96	1.87	2.85	5.41	11.40	22.97	30.06	60.21
80	171	14.11	0.00	0.07	0.28	0.42	0.55	0.88	1.41	2.39	3.62	4.19	4.88	7.05
81	166	33.43	0.08	0.13	0.18	0.29	0.95	1.81	2.72	4.22	7.13	12.74	17.75	25.13
82	168	27.65	0.56	0.82	0.91	1.02	1.24	1.46	2.12	4.19	9.03	14.24	17.44	23.16
83	166	24.74	0.01	0.08	0.32	0.73	0.87	1.37	2.00	3.15	5.42	7.36	8.24	22.03
84	95	23.31	0.12	0.12	0.14	0.17	0.31	0.88	1.33	1.95	3.16	8.25	16.08	23.31
85	158	16.36	0.00	0.05	0.26	0.33	0.42	0.64	0.96	1.55	2.49	4.48	7.02	15.24
86	124	32.41	0.00	0.17	0.37	0.54	0.87	1.61	2.96	4.84	8.37	12.94	14.35	24.44
87	119	20.53	0.12	0.20	0.37	0.50	1.00	1.71	2.89	5.01	8.18	11.80	18.24	18.77
88	152	26.71	0.00	0.00	0.13	0.39	0.98	1.54	2.41	3.89	8.54	14.02	16.32	22.99
89	39	11.52	0.00	0.00	0.00	0.00	0.00	0.77	2.09	4.12	5.99	6.49	11.52	11.52
90	111	18.07	0.04	0.08	0.36	0.72	0.88	1.43	2.64	4.04	5.67	8.94	14.54	14.60
91	140	15.10	0.07	0.28	0.29	0.38	0.52	0.66	0.98	1.92	4.75	7.23	9.65	13.99
92	146	37.42	0.39	0.46	0.60	0.65	0.91	1.53	2.27	3.97	8.43	13.61	16.93	25.95
93	141	29.54	0.39	0.48	0.53	0.64	1.02	1.41	2.03	3.37	8.74	13.15	15.43	28.73
94	144	29.86	0.00	0.22	0.65	0.84	0.99	1.49	2.39	4.57	10.71	14.14	18.24	20.52
104	146	24.35	0.16	0.17	0.26	0.34	0.57	0.84	1.53	2.45	3.90	6.60	7.84	21.23
141	137	22.35	0.40	0.40	0.72	0.80	0.85	1.35	1.84	2.57	6.10	8.50	11.04	16.55
142	131	42.70	0.00	0.00	0.01	0.36	0.81	1.34	2.21	4.76	9.61	15.48	26.38	42.34
144	77	13.42	0.11	0.11	0.14	0.30	0.77	1.77	2.53	3.68	7.15	9.11	13.24	13.42
145	130	37.37	0.00	0.00	0.46	0.59	1.24	1.72	2.56	4.73	8.26	11.54	13.49	18.79
146	61	31.47	0.16	0.16	0.18	0.32	0.46	0.88	1.75	3.82	10.17	19.17	24.82	31.47
162	8	2.46	0.06	0.06	0.06	0.06	0.06	0.15	0.83	1.55	2.46	2.46	2.46	2.46
170	120	33.65	0.00	0.00	0.32	0.44	0.79	1.28	2.32	3.84	7.48	11.73	23.18	30.07
171	101	16.90	0.02	0.11	0.19	0.27	0.58	0.84	1.15	1.99	4.45	7.03	8.45	9.44
174	79	25.54	0.37	0.37	1.00	1.31	1.81	2.66	4.61	8.49	13.03	19.37	21.63	25.54

Note for example that the Q97.5 values range from a low of 2.46 to high of 43.13. By this method, well measurements at some sites would be flagged at values that would not be flagged at other sites. In addition, some sites have only 8 measurements whereas most other sites have over 100 measurements. With over 100 measurements, the estimate of the Q97.5 for example has acceptable properties (i.e. low associated uncertainty). With less than 100 measurements, the estimates of the upper tail quantiles are very uncertain. Finally, realize that these numbers are averaged over months, which are known from the Task II analysis to be quite different.

3.3.4.3 Range Test: By Month over all Sites and Years

Table 48 Quantiles for leatherleaf fern wells by month averaged over sites and years in acre-inches.

Month	N	Max	min	Q1	Q2_5	Q5	Q10	Q25	Q50	Q75	Q90	Q95	Q97_5	Q99
1	466	47.77	0.00	0.27	0.50	0.77	1.46	3.07	7.40	12.81	18.99	24.35	29.73	37.37
2	471	33.65	0.00	0.25	0.38	0.61	0.89	1.67	3.02	5.42	9.49	12.94	15.85	21.63
3	466	12.28	0.00	0.11	0.32	0.67	1.03	1.73	2.92	4.65	6.37	7.73	8.58	9.62
4	470	11.09	0.00	0.10	0.35	0.52	0.93	1.47	2.39	3.36	4.69	5.90	6.92	7.69
5	465	9.92	0.00	0.27	0.45	0.67	1.03	1.62	2.46	3.72	5.20	6.61	7.35	8.63
6	465	8.98	0.00	0.01	0.15	0.36	0.53	0.98	1.65	2.70	4.04	4.81	6.15	7.97
7	473	8.12	0.00	0.01	0.14	0.37	0.61	0.98	1.68	2.44	3.44	4.11	5.24	6.91
8	477	9.60	0.00	0.00	0.08	0.22	0.51	0.94	1.53	2.45	3.52	4.07	4.95	5.50
9	450	7.59	0.00	0.02	0.23	0.34	0.52	0.88	1.46	2.19	3.12	3.66	4.74	5.62
10	458	10.77	0.00	0.00	0.08	0.32	0.58	1.06	1.69	2.51	3.53	4.08	4.75	5.67
11	459	22.97	0.00	0.06	0.34	0.54	0.73	1.22	1.93	3.37	6.46	8.06	9.26	12.38
12	463	60.21	0.00	0.02	0.37	0.70	1.10	2.46	5.06	9.38	18.78	25.95	30.06	39.67

The upper tail quantiles do change significantly from month to month, being highest in the winter and spring and lowest during the rainy summer period. This crop shows the highest range in values over the months.

3.3.4.4 Step Test: By Site over all Months and Years

Table 49 Quantiles for absolute value step test of leatherleaf fern wells over all sites and dates.

Quantile	Estimate
Max	48.28
Q99	22.55
Q97.5	15.13
Q95	10.20
Q90	6.03
Q75	2.77
Q50 Median	1.22
Q25	0.49
Q10	0.19
Q5	0.09
Q2.5	0.04
Q1	0.02
Min	0.00

The upper tail values for the steps are not that different from what was recorded for actual well measurements in Table 46. This tables suggests that jumps of over 22.55 should occur only once in 100 measurements and jumps of over 15.13 in 25 out of 1000 measurements.

3.3.4.5 Step Test: By Site and Month over all Years

Table 50 Q95 estimates for absolute step values for leatherleaf wells by site and month.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
56		3.98	3.67	1.35	1.82	1.57	1.79	1.17	1.76	1.54	0.60	0.44
57	22.22	4.83	6.39	3.55	3.54	4.12	2.50	0.98	1.59	1.80	3.34	18.10
58	28.94	43.84	8.47	3.29	3.11	7.40	2.61	3.83	4.64	5.28	8.20	39.02
60	3.40	1.84	2.31	1.34	5.84	7.46	2.80	3.14	5.61	4.11	2.80	28.23
61	14.54	21.67	5.07	5.06	3.34	2.80	2.56	3.32	2.48	3.26	3.35	37.85
62	11.97	20.85	5.49	4.07	3.70	6.84	3.92	2.85	3.62	1.83	6.16	18.23
63	13.51	20.15	5.37	4.38	5.49	4.95	6.19	4.10	5.48	5.38	3.74	28.67
64	11.98	19.93	5.59	1.84	2.28	3.04	2.03	2.24	3.65	3.93	6.28	23.37
65	11.57	8.22	4.27	9.05	8.16	7.78	6.24	7.42	8.43	2.16	9.84	26.68
66	8.17	7.89	3.66	2.38	2.98	3.66	3.37	2.87	4.40	3.31	4.18	25.94
67	11.10	18.00	3.47	1.92	1.63	2.68	1.67	2.56	1.92	1.36	6.08	19.69
68	6.43	5.15	2.43	2.83	2.96	3.59	4.37	3.13	7.03	4.04	6.67	26.11
69	15.55	24.65	4.22	4.49	4.98	6.60	3.78	4.10	2.06	2.68	7.05	26.63
70	13.69	22.15	4.58	2.48	2.43	3.44	2.39	2.80	3.18	1.76	5.42	19.47
73	3.94	7.51	1.14	1.25	0.86	1.70	1.32	1.90	2.37	2.45	1.65	4.46
74	9.77	16.11	5.79	4.87	6.01	4.03	5.47	1.44	2.38	3.06	4.03	15.23
75	9.08	10.69	5.55	1.64	2.35	2.53	1.59	1.12	0.77	1.78	5.50	14.99
76	14.85	28.43	9.23	4.01	1.53	1.80	2.96	3.19	1.35	2.21	14.54	28.90
77	13.45	15.38	5.66	4.38	5.78	5.11	2.59	3.12	1.85	3.82	8.56	24.47
78	21.53	9.53	5.40	5.45	9.36	5.40	2.69	2.86	2.90	3.26	22.24	48.28
80	5.94	5.09	2.76	2.34	4.25	5.77	2.03	3.20	2.93	3.16	2.03	12.84
81	14.28	21.97	6.30	2.39	4.75	1.62	4.70	2.96	2.72	2.10	5.77	28.10
82	12.82	11.84	5.30	3.18	3.58	3.08	1.73	1.76	0.80	1.77	9.35	22.17
83	7.45	7.76	5.84	2.55	6.25	4.20	2.10	2.73	2.67	2.64	2.06	22.94
84	18.35	14.74	2.98	0.96	2.89	2.01	3.35	1.55	1.48	1.28	1.13	16.37
85	12.28	14.32	2.71	1.72	1.81	1.45	1.06	1.73	1.46	2.04	2.20	6.06
86	16.83	28.72	8.89	2.14	3.90	3.48	2.38	4.02	1.13	2.97	6.43	13.14
87	11.54	16.90	6.17	3.20	6.82	6.46	3.60	4.27	2.08	4.47	5.79	19.40
88	11.92	23.96	6.19	2.31	3.92	2.33	2.62	3.74	1.80	2.44	9.28	19.34
89	10.75	2.79	5.36	6.49	2.55	3.09	0.95	5.38	3.10	3.89	1.77	2.55
90	14.17	11.73	4.02	1.89	2.78	3.45	2.89	2.35	4.80	3.66	8.86	12.31
91	7.71	13.79	2.25	5.19	2.01	1.73	1.13	0.62	1.69	1.14	4.13	12.02
92	20.80	35.03	5.69	1.67	1.40	3.68	2.92	1.86	1.01	1.81	6.93	17.92
93	15.29	25.57	4.60	2.14	1.26	1.94	1.44	1.88	2.82	1.35	7.67	25.28
94	19.15	25.97	4.78	1.92	3.33	2.92	2.05	2.86	2.60	2.97	9.43	17.70
104	17.75	19.64	4.50	2.79	2.08	2.67	1.85	2.86	1.43	3.21	4.62	6.69
141	14.36	20.29	2.27	5.71	6.50	1.41	1.05	1.00	1.42	1.32	5.95	13.58
142	22.55	27.56	10.44	5.91	6.87	3.89	4.06	2.39	2.71	3.25	8.83	36.78
144	11.51	8.68	7.37	2.29	1.98	2.33	2.63	3.89	2.68	1.58	1.11	3.36

Table 50 Continued, Q95 estimates for absolute step values for leatherleaf fern wells by site and month.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
145	18.58	33.28	4.20	2.71	3.25	2.34	1.81	2.56	3.69	1.57	9.21	11.30
146	20.38	15.75	5.35	3.25	1.78	0.79	2.27	1.60	0.89	1.24	6.56	24.36
162		0.03	1.50	0.04					0.10	0.23	0.79	1.24
170	14.12	32.61	4.69	3.68	5.86	3.59	2.13	1.40	1.21	1.33	8.98	24.01
171	7.80	9.01	0.69	2.07	3.94	1.46	1.45	2.00	0.89	1.27	3.53	14.79
174	13.09	17.95	6.58	5.54	4.55	5.72	3.70	6.53	4.15	7.12	7.99	23.73

Table 51 Q97.5 estimates for absolute step values for leatherleaf fern wells by site and month.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
56		3.98	3.67	1.35	1.82	1.57	1.79	1.17	1.76	1.54	0.60	0.44
57	22.22	4.83	6.39	3.55	3.54	4.12	2.50	0.98	1.59	1.80	3.34	18.10
58	28.94	43.84	8.47	3.29	3.11	7.40	2.61	3.83	4.64	5.28	8.20	39.02
60	3.40	1.84	2.31	1.34	5.84	7.46	2.80	3.14	5.61	4.11	2.80	28.23
61	14.54	21.67	5.07	5.06	3.34	2.80	2.56	3.32	2.48	3.26	3.35	37.85
62	11.97	20.85	5.49	4.07	3.70	6.84	3.92	2.85	3.62	1.83	6.16	18.23
63	13.51	20.15	5.37	4.38	5.49	4.95	6.19	4.10	5.48	5.38	3.74	28.67
64	11.98	19.93	5.59	1.84	2.28	3.04	2.03	2.24	3.65	3.93	6.28	23.37
65	11.57	8.22	4.27	9.05	8.16	7.78	6.24	7.42	8.43	2.16	9.84	26.68
66	8.17	7.89	3.66	2.38	2.98	3.66	3.37	2.87	4.40	3.31	4.18	25.94
67	11.10	18.00	3.47	1.92	1.63	2.68	1.67	2.56	1.92	1.36	6.08	19.69
68	6.43	5.15	2.43	2.83	2.96	3.59	4.37	3.13	7.03	4.04	6.67	26.11
69	15.55	24.65	4.22	4.49	4.98	6.60	3.78	4.10	2.06	2.68	7.05	26.63
70	13.69	22.15	4.58	2.48	2.43	3.44	2.39	2.80	3.18	1.76	5.42	19.47
73	3.94	7.51	1.14	1.25	0.86	1.70	1.32	1.90	2.37	2.45	1.65	4.46
74	9.77	16.11	5.79	4.87	6.01	4.03	5.47	1.44	2.38	3.06	4.03	15.23
75	9.08	10.69	5.55	1.64	2.35	2.53	1.59	1.12	0.77	1.78	5.50	14.99
76	14.85	28.43	9.23	4.01	1.53	1.80	2.96	3.19	1.35	2.21	14.54	28.90
77	13.45	15.38	5.66	4.38	5.78	5.11	2.59	3.12	1.85	3.82	8.56	24.47
78	21.53	9.53	5.40	5.45	9.36	5.40	2.69	2.86	2.90	3.26	22.24	48.28
80	5.94	5.09	2.76	2.34	4.25	5.77	2.03	3.20	2.93	3.16	2.03	12.84
81	14.28	21.97	6.30	2.39	4.75	1.62	4.70	2.96	2.72	2.10	5.77	28.10
82	12.82	11.84	5.30	3.18	3.58	3.08	1.73	1.76	0.80	1.77	9.35	22.17
83	7.45	7.76	5.84	2.55	6.25	4.20	2.10	2.73	2.67	2.64	2.06	22.94
84	18.35	14.74	2.98	0.96	2.89	2.01	3.35	1.55	1.48	1.28	1.13	16.37
85	12.28	14.32	2.71	1.72	1.81	1.45	1.06	1.73	1.46	2.04	2.20	6.06
86	16.83	28.72	8.89	2.14	3.90	3.48	2.38	4.02	1.13	2.97	6.43	13.14
87	11.54	16.90	6.17	3.20	6.82	6.46	3.60	4.27	2.08	4.47	5.79	19.40
88	11.92	23.96	6.19	2.31	3.92	2.33	2.62	3.74	1.80	2.44	9.28	19.34
89	10.75	2.79	5.36	6.49	2.55	3.09	0.95	5.38	3.10	3.89	1.77	2.55
90	14.17	11.73	4.02	1.89	2.78	3.45	2.89	2.35	4.80	3.66	8.86	12.31
91	7.71	13.79	2.25	5.19	2.01	1.73	1.13	0.62	1.69	1.14	4.13	12.02
92	20.80	35.03	5.69	1.67	1.40	3.68	2.92	1.86	1.01	1.81	6.93	17.92
93	15.29	25.57	4.60	2.14	1.26	1.94	1.44	1.88	2.82	1.35	7.67	25.28
94	19.15	25.97	4.78	1.92	3.33	2.92	2.05	2.86	2.60	2.97	9.43	17.70
104	17.75	19.64	4.50	2.79	2.08	2.67	1.85	2.86	1.43	3.21	4.62	6.69

Table 51 Continued Q97.5 estimates for absolute step values for leatherleaf wells by site and month.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
141	14.36	20.29	2.27	5.71	6.50	1.41	1.05	1.00	1.42	1.32	5.95	13.58
142	22.55	27.56	10.44	5.91	6.87	3.89	4.06	2.39	2.71	3.25	8.83	36.78
144	11.51	8.68	7.37	2.29	1.98	2.33	2.63	3.89	2.68	1.58	1.11	3.36
145	18.58	33.28	4.20	2.71	3.25	2.34	1.81	2.56	3.69	1.57	9.21	11.30
146	20.38	15.75	5.35	3.25	1.78	0.79	2.27	1.60	0.89	1.24	6.56	24.36
162		0.03	1.50	0.04					0.10	0.23	0.79	1.24
170	14.12	32.61	4.69	3.68	5.86	3.59	2.13	1.40	1.21	1.33	8.98	24.01
171	7.80	9.01	0.69	2.07	3.94	1.46	1.45	2.00	0.89	1.27	3.53	14.79
174	13.09	17.95	6.58	5.54	4.55	5.72	3.70	6.53	4.15	7.12	7.99	23.73

A quick review of this table shows that there is considerable variability in these estimates from site to site and within each month. While these estimates are site and month specific, their utility for quality control is undermined by this large variability. Some sites record huge jumps (sites 58 and 78) whereas a large number of sites have Q97.5 absolute step values that are 1.0 or less (see highlighted cells). Using these values as the quality threshold would results in all non-zero absolute step values being flagged for these sites in the specified months.

3.3.4.6 Model-Based Range Test: Over all Sites, Months and Years

Compute the expected means for each of the leatherleaf well and month by adding the estimated intercept term from Table 20 in Task II to the appropriate leatherleaf site estimated effect from Table 59 and the estimated month effect from Table 53 in the appendix of this task report. These estimated effects are given in Table 63 in the appendix. These mean values are subtracted from the observed data and the overall range test computed on these residuals. The quantile statistics are given in Table 52.

Table 52 Estimated quantiles of model based residuals for leatherleaf fern wells.

Quantile	Residual	Absolute Residual
Max	51.14	51.14
Q99	15.01	15.01
Q97.5	8.11	8.54
Q95	4.46	6.84
Q90	2.34	4.73
Q75	0.54	2.41
Q50 Median	-0.57	1.24
Q25	-1.68	0.56
Q10	-3.22	0.22
Q5	-4.86	0.10
Q2.5	-6.39	0.05
Q1	-7.36	0.02
Min	-10.54	0.00

To use these values in a quality control setting, one would subtract from the observed measurement the sum of the estimated intercept value (3.81 acre-inches) plus the month effect for the month of the observations plus the effect of the observation site. If the resulting value were greater than 15.01 (Q99) in absolute value for example, the measurement would be flagged for further assessment. This value is less than the value of 24.44 suggested in Table 46 for an unadjusted measurement and less than the 22.55 step value in Table 49.

4 Discussion and Recommendations

4.1 Task One: Sample Size Determination

In all computations in this report, the use of acre-inches per acre (simply referred to as acre-inches) as the response variable of interest results in the effective elimination of acreage as a factor in the analysis. The District monitoring program objective is to estimate the average acre-inches withdrawn to a specified precision. Used together with total acreage, an estimate of total water withdrawn within a precision target is possible. This study suggests that for the critical growing months for most crops of interest, the sample sizes used are adequate for estimating total water withdrawn to within ±20% of the true value with 95% confidence. For some crops this is only just achieved in the latest data (for example flatwoods citrus, Figure 5). Achieving greater precision than this would require, in most cases, monitoring many more permitted wells for each crop. The case for a higher level of precision has not been made.

Sample sizes are just adequate to estimate average acre-inches for the high water withdrawal periods of the year but are inadequate for estimating water withdrawal during those times of the year or growing season where irrigation is not uniformly practiced or is only periodically needed. Higher uncertainty is observed typically in months or weeks where little irrigation is used or used only sporadically across the crop growing area. There seems little need to expand sample sizes at this time for the four crops analyzed but at the same time, any reductions in sample size will result in precision levels falling below the 20% relative precision level. It is recommended that in the future the argument for addition of sites not be based on a need for additional precision but reflect some other characteristic, such as the need for more uniform geographical coverage or the need to increase representation in specific subpopulations, e.g. more small farms or more farms with smaller acreage.

Finally, to estimate the final precision of the water use means requires knowledge of the total number of wells for each crop. These total counts were provided by the District using information in its permit database. The values provided are assumed to be the true value but clearly the possibility exists that these are only estimates of the true exact number of wells per crop in the District. Fortunately, the analysis results are not particularly sensitive to the total number in that values for total number of wells could change by ±15% and the conclusions would not change dramatically. If these values are grossly in error, the computations would be as well.

The SAS code for performing these analyses is available on CDROM from the author and is provided to the District with this document.

4.2 Task Two: Data Integrity

The general linear models analysis for all crops identified very recognizable site, year and months (or week since planting) effects. Beyond this, each crop produced its own set of conclusions and recommendations.

In general this analysis found very significant site, year and month effects. Of the three, the most interesting were month effects. In many cases, the month effects reflected overall agronomic use of irrigation water by a crop over the year or in the case of potatoes over the growing season. The patterns observed were logical and tended to reflect what would be expected if growers were following best management practices. Year effects reflected the broader general climatic conditions, demonstrating greater water use in dryer years. Site effects were more difficult to explain, reflecting a combination of a number of uncontrollable and/or unmeasured factors. Primary among these are factors such as soil and local climate differences or management philosophies. Since the type of irrigation system used has become more standard within a crop in the last decade, this factor is not expected to affect site differences very much. The temporal variability in the residuals does not seem to be explainable by climatic factors, such as rainfall, and average or extreme temperatures. In a number of crops, a reduction in residual variability over time was found, but this could be due more to standardization of irrigation methods than to anything else. It was not clear when examining sites with large residuals what were the causes of these effects, except in the case of leatherleaf fern where the large residuals tended to occur in specific winter months in some years. This year by month interaction effect was not directly accounted for in the analysis model but is visible in an examination of the residuals.

The lack of strong correlations between irrigation and climatic factors was somewhat surprising. One reason climate does not factor in could be that its effects are captured by year and month effects that are taken out of the analysis before climate factors are regressed in. Another reason could be that the climate data is not site-specific enough to capture enough of site variability to be an effective predictor. Finally, it could be that while irrigation management may respond to short-term climatic events (freeze events or high rainfall events) because the irrigation amounts represent an integration of activities over a month of time, the correlation with available measured climatic factors is lost. Whatever the reason, it does not seem productive at this point to expend many resources getting better site-specific climatic data unless the eventual goal is the development of predictive models.

What was not explored in this report were ways of predicting year effects for future years or site effects for new locations. Development of a year effect predictor model would most likely need to quantify links to broader global climate events that accommodate such large-scale trends as El Niño or La Niña cycles. In addition, year effect models need to explore how recommendations on irrigation to growers by experts will impact annual effects. Site effect models should explore issues of soil type, micro-climate characterization and management characteristics. Other factors, such as irrigation type, are becoming much less important as growers move toward a common approach to irrigation.

4.2.1 General Conclusions and Recommendations

Reexamine the cost-benefit ratio for site-specific rainfall data with the goal of reducing or eliminating this aspect of the Benchmark Farm program. The low fraction of variability in irrigation water withdrawal that could be attributed to rainfall for all crops lowers the utility of collecting site-specific rainfall data. The District should utilize the information already collected at National Weather Service climate stations on monthly minimum temperature and extreme monthly precipitation.

Models to predict site-specific effects should be developed using site-specific information on soil type, micro-climate and/or manager characteristics. Previous studies have examined some aspects of these site characteristics but the detailed association models have not been developed. Of the three factors listed, management is the hardest to quantify but may have the greatest impact on site effects.

Models to predict year effects should be developed. As a starting point correlations with outputs from readily available global climate models should be explored.

4.2.2 Ridge Citrus Specific Conclusions and Recommendations

The data observed for ridge citrus followed expected patterns and seemed to be consistent with expectations. A couple of observations were clearly outliers. The impact of these outliers on subsequent analysis was minimal and hence they were not removed.

Some of the variability in water use identified to year, month and site effects could be "explained" by associations with climate variables, such as extreme monthly precipitation and monthly minimum temperatures. But site-specific rainfall data does not explain a very large fraction of the residual variation in the model once site, year and month factors are accounted for. In addition, extreme residuals could not be explained by climate factors alone. It is hypothesized that unobserved factors, such as temporal changes in management or unpredictable equipment changes may explain some of these extreme residuals.

4.2.3 Flatwoods Citrus Specific Conclusions and Recommendations

The conclusions and recommendations for flatwoods citrus are identical to that of ridge citrus in general.

Improving predictability in irrigation water use over what was accomplished in this analysis will be more difficult and more expensive than with ridge citrus, because the data on flatwoods citrus are perhaps less variable than that of ridge citrus.

4.2.4 Potato Specific Conclusions and Recommendations

The potato data were determined to display patterns consistent with generally accepted agronomic patterns for potato and hence, were deemed to have data integrity.

The analysis of the potato data suggest that site-specific rainfall when added to the analysis model was significant and could reduce year, week since planting and residual variability. At the same time, adding rainfall resulted in increased site variability. This may be simply a side effect of the statistical model used but at the least, efforts to relate site variability to spatial patterns should be attempted.

Because knowledge of site-specific rainfall does provides some improvement in model fit, its utility is higher than for ridge citrus and flatwoods citrus. Still, a cost and benefits analysis should be preformed to justify the continued cost of collecting these data.

Finally, efforts should be made to understand the causes of the very clear within season pattern in water pumped for potatoes. This pattern suggests that growers are following similar irrigation patterns. It would be interesting to examine the extent that the estimated patterns correspond to current best management practices (BMP) recommendations.

4.2.5 Leatherleaf Fern Specific Conclusions and Recommendations

The conclusions and recommendations for leatherleaf fern data are the same as those for ridge citrus and flatwoods citrus. While extreme positive residuals in the leatherleaf fern analysis seemed to occur at periods of high cold damage potential, site-specific climate data were not adequate to confirm. A more detailed analysis focused on low temperature events might be very productive.

4.3 Task Three: Quality Assurance (QA) Checks

Three approaches were used to identify suspect data, i) a simple test, ii) a step test and iii) and a model-based range test. The range test is based on existing data and problems were observed with the method in a number of cases, particularly in the situation where the method was used with site-specific data as the ranges, being based on past data alone, were particularly sensitive to sample size. The range test was applied to three types of datasets. Initially the range test was applied to a dataset constructed from all sites over all recorded time producing range thresholds applicable to all sites over all times. Next the range test was applied to the time series for each specific site producing a unique set of threshold range values for each site. Finally ranges were computed for each specific time from datasets constructed of the combined sites by year data.

In a quality control setting, any new value arriving from a particular well would first be checked against the overall range thresholds, then against the date threshold, and finally against the site thresholds. Values exceeding the thresholds would be flagged for further examination. The site-specific thresholds are sensitive to sample size; with less than 100 measurements the estimates of these thresholds are very uncertain. This is an inconvenience of using the range test in that large data sets (n> 100) are needed for each site. While all crops have sufficient data to estimate these range thresholds, it is recommended that potato be limited to the cropping period to the first 24 weeks. The sample size limitation suggests that the range test not be used as the primary tool for quality checking of new measurements on a site-by-site basis.

The step test is similar to the range test in that it generates range thresholds but generates these for changes over time. The threshold estimates computed as step ranges were consistently lower than those calculated as simple ranges. This is not surprising as step ranges are somewhat more efficient than simple range tests primarily because it integrates out long-term changes in overall mean over time. The step test threshold values were computed for 1) the total time series for each site, and 2) for each site by month. As with the simple range tests, the estimates of the thresholds require more that 100 computed steps, so a minimum of 101 dates for each time step at each site is needed. In a quality control setting, a new value is subtracted from the same observation from a previous month (or week) and the absolute difference is checked against the overall threshold and the site-specific threshold. As a result of using the absolute difference, this test is inherently one sided and only the upper q0.95 or the q0.99 of the absolute steps would be used as the threshold values.

The simple range and step tests are non-parametric and as such are relatively inefficient in the use of information that is available. A new site will inherently not be able to provide the amount of historical water use data that is needed to compute site-specific thresholds. The alternative is to use data from longer established sites with similar climatological and soil conditions to establish the action thresholds. In the model-based range test a fitted model (from Task II) is used to estimate the threshold values. The overall threshold estimates were found to be lower for the model-based range test than for those obtained for the simple and step range tests. This test is particularly of interest as it works regardless of site or month since site and month effects are accounted for first, and it is only the residuals that are being tested.

In a quality control setting, a new value is flagged if the residual produced when the overall mean, site and time effects are subtracted deviates too much from zero. The threshold values takes into account annual as well as residual variation. The significant degree of autocorrelation found when fitting the model means that the threshold estimates produced in the report are slightly larger than theory suggests they should be.

It is recommended that the model-based range thresholds be used, primarily because they make more efficient use of existing data and are site and time dependent. If a 95% confidence threshold value is chosen, the observed measurement has subtracted from it its crop-specific intercept, month and site effect as given in the appropriate tables in the appendix and the resulting residual compared to the critical value given in Table 26 (ridge citrus), Table 36 (flatwoods citrus), and Table 52 for leatherleaf fern. For potatoes one needs to know how many weeks since planting in order to calculate the residual and compare it to the critical value from Table 45.

5 Areas of Possible Future Analysis

5.1 Examination of Spatial Pattern

No attempt was made to examine the spatial distribution of measurements for each crop in this report. The focus of this report was on temporal variability. While the mean amount of water withdrawn and the associated temporal variance is clearly site-specific, some aspect of the variability in mean and in temporal standard deviation should be due to location differences. It is known that there are major and minor soil composition differences across the sites that could be factors in this spatial pattern. There is sufficient data available from BMF for a spatial analysis.

One specific analysis that would be a natural extension of this report would be to examine how the residuals left over after fitting the mixed effects general linear model relate to spatial location. In effect, the linear model removes gross site and temporal pattern, with the result that there should be little of the residual variation that could be described by spatial pattern. If there is spatial pattern in the residuals this would suggest that some spatially related factor(s) is missing in our understanding of the processes driving irrigation water use.

At a higher level of resolution, it would be interesting to examine how the site effects extracted in the linear model are related to geographic location. In essence, one can think of splitting the variability in site effects into one fraction that might be explained by spatial patterns, in soil type, access to groundwater, etc, and a site effect residual. The site effect residual could then be considered that part of site effect that is due to factors such as management. The spatial fraction would be related to some physical aspect of the region that changes average irrigation water use.

5.2 Examination of Changes in Annual Pattern

The linear models analyses extracted year and month (or weeks since planting for potatoes) effects from the site-specific water use time series data. The time series plots of the year effects seem to display slightly greater variability in the early years of BMF. In other year effects plots there seemed to be large shifts of effects from positive to negative values (see Figure 32 for example). These observations raise the question as to whether these are continuing trends. This has large importance in the effective use of the fitted models for quality control as well as our ability to predict future annual effects. The analysis proposed here may be less of a statistical analysis and more of a research project to document what may have occurred in the past that would effect these changes. This report has mentioned the possibility of management or economic drivers for these annual effects and further recommends that this might be a good place to start.

5.3 Examination of Inter-Annual Pattern

The linear models analysis extracted month effects for citrus and leather fern and weeks since planting effects for potatoes. It was hypothesized that these effect levels should reflect or be closely related to recommended best water management practices for these crops. It would seem very useful to determine this directly by discussing the inter-annual pattern plots with specialists in the Cooperative Extension Service or with private crop management advisors working in the District. This analysis would either confirm that indeed growers are paying heed to expert advise and BMP recommendations or suggest that further education is needed. Either way, the analysis performed here is the best evidence of exactly what the sites are doing.

In an early phase of the development of the linear model, site by month (or week) interactions were examined and found to be generally not significant. Still, it might be enlightening to fit a separate mixed effects linear model for each site and estimate that site's specific inter-annual pattern. While time consuming and somewhat constrained by limited data for each site, this would allow examination of the evidence for consistent or inconsistent patterns across sites in a way that is less constrained than that of the interaction models actually examined. It may be that in general there is little evidence of a global site by inter-annual pattern interaction, but that there may be specific sites that demonstrate patterns that are very different from the general trend.

6 Appendices. Supporting Documentation

6.1 Tables of Model Estimates

Table 53 Estimated month effects by crop, excluding potato. Value is in acre-inches.

Crop	Month											
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
Ridge Citrus	0.30	-0.20	0.02	0.42	0.88	0.01	-0.25	-0.32	-0.44	-0.18	-0.18	-0.04
Flatwoods Citrus	-0.16	0.15	0.46	0.47	0.59	-0.40	-0.40	-0.55	-0.26	0.08	0.24	-0.22
Leatherleaf Fern	5.54	0.98	-0.05	-0.75	-0.53	-1.40	-1.62	-1.75	-1.92	-1.73	-0.86	4.07

Table 54 Estimated week-since-planting effects for potatoes. Values are in acre-inches.

WSP	Estimate	WSP	Estimate	WSP	Estimate	WSP	Estimate
1	-1.51	11	2.08	21	-1.18	32	-0.21
2	-1.28	12	2.48	22	-1.22	33	-0.51
3	-1.45	13	2.52	23	-1.00	37	1.48
4	-1.02	14	2.09	24	-1.22	40	-0.26
5	-0.60	15	1.31	25	-0.80		
6	0.19	16	0.89	26	-0.77		
7	0.49	17	-0.37	27	-0.39		
8	0.82	18	-0.62	28	-0.02		
9	1.34	19	-0.95	30	-1.01		
10	1.78	20	-1.07				

Table 55 Estimated year effects by crop for potatoes. Values are in acre-inches.

	Ridge Citrus	Flatwoods citrus	Potato	Leatherleaf Fern
1989				4.84
1990			0.36	-1.27
1991	-0.04		-0.48	-1.01
1992	-0.11		1.00	-0.30
1993	0.11		0.78	-0.72
1994	-0.40		0.52	-1.84
1995	-0.12		0.69	0.15
1996	0.16		0.62	0.10
1997	-0.07		-0.67	-0.85
1998	0.14		-0.52	-1.20
1999	0.08	0.02	-0.34	-0.15
2000	0.44	0.56	-0.27	1.92
2001	0.18	-0.18	-0.42	-0.68
2002	-0.12	-0.16	-0.37	0.08
2003	-0.23	-0.24	-0.89	0.94

Table 56 Estimated site effects for ridge citrus. Values are in acre-inches.

Siteno.	Effect	Siteno.	Effect	Siteno.	Effect	Siteno.	Effect
95	-0.48	116	0.53	136	-0.39	161	0.28
96	0.35	117	0.03	137	-0.08	163	0.10
97	0.28	118	-0.21	138	0.06	164	-0.36
98	0.19	119	-0.02	139	0.11	165	0.27
99	-0.65	120	0.02	140	-0.38	166	0.51
100	-0.23	121	-0.29	143	-0.46	167	0.20
101	0.01	122	0.29	147	-0.58	168	0.20
102	-0.33	123	0.48	148	0.13	169	-0.06
103	0.56	124	0.38	149	-0.08	172	-0.06
105	-0.31	125	-0.17	150	-0.39	173	-0.31
106	-0.31	126	0.53	151	0.64	177	1.10
107	0.28	127	-0.33	152	-0.43	178	-0.27
108	0.72	128	-0.35	153	-0.57	179	0.03
109	0.41	129	0.49	154	-0.45	183	-0.04
110	1.13	130	-0.08	155	-0.48	184	-0.07
111	0.13	131	0.37	156	-0.12	186	0.37
112	-0.31	132	-0.54	157	-0.34	199	-0.09
113	0.32	133	-0.33	158	-0.72		
114	0.15	134	0.06	159	-0.10		
115	-0.14	135	0.00	160	0.21		

Table 57 Estimated site effects for flatwoods citrus. Values are in acre-inches.

Siteno.	Effect	Siteno.	Effect	Siteno.	Effect	Siteno.	Effect
200	0.91	220	0.54	240	0.01	260	-0.01
201	-0.53	221	-0.11	241	0.02	261	-0.01
202	-0.42	222	-0.25	242	0.12	262	0.02
203	-0.20	223	0.10	243	-0.16	263	0.00
204	0.07	224	0.20	244	-0.09	264	0.00
205	-0.29	225	-0.33	245	0.02	265	-0.01
206	-0.08	226	-0.28	246	-0.06	266	-0.01
207	-0.48	227	-0.19	247	0.13		
208	-0.43	228	-0.30	248	0.10		
209	-0.19	229	0.15	249	0.08		
210	0.28	230	0.18	250	-0.07		
211	0.30	231	0.12	251	0.42		
212	0.20	232	-0.01	252	0.46		
213	0.41	233	-0.01	253	0.14		
214	-0.28	234	-0.07	254	-0.04		
215	-0.45	235	-0.34	255	-0.04		
216	-0.03	236	-0.17	256	-0.04		
217	0.24	237	0.44	257	-0.03		
218	0.17	238	-0.02	258	-0.01		
219	0.27	239	-0.05	259	-0.01		

Table 58 Estimated site effects for potato. Values are in acre-inches.

Siteno.	Effect	Siteno.	Effect	Siteno.	Effect
1	-0.61	25	-0.36	55	0.42
2	-0.41	26	0.14	187	0.29
3	0.04	27	-0.09	189	-0.98
4	0.62	28	0.91	190	0.78
6	-0.07	33	-0.04	191	-0.23
7	-0.71	34	0.19	192	0.00
9	0.94	37	0.92	193	-0.17
10	-0.25	38	0.31	194	-0.35
11	0.14	39	0.29	195	-0.43
12	-0.64	40	-0.46	196	-0.36
13	-0.71	41	0.02	197	0.15
14	-0.41	42	-0.06	198	-0.57
15	0.18	44	0.12		
16	-0.31	45	-0.01		
17	0.04	46	0.23		
19	0.19	47	0.44		
20	-0.21	49	0.56		
22	-0.16	50	1.76		
23	-0.17	52	-0.24		
24	0.14	53	-0.82		

Table 59 Estimated site effects for leatherleaf fern. Values are in acre-inches.

Siteno.	Effect	Siteno.	Effect	Siteno.	Effect
56	-0.61	80	-1.59	146	0.57
57	0.35	81	0.26	162	-0.84
58	2.31	82	0.29	170	0.14
60	0.14	83	-0.74	171	-1.21
61	0.65	84	-1.06	174	2.18
62	0.40	85	-1.74		
63	0.62	86	0.38		
64	0.11	87	0.49		
65	1.33	88	0.24		
66	-0.99	89	-0.46		
67	-0.68	90	0.00		
68	0.36	91	-1.39		
69	0.57	92	0.41		
70	0.50	93	0.07		
73	-1.81	94	0.50		
74	-0.19	104	-1.10		
75	-1.24	141	-0.67		
76	0.96	142	0.95		
77	0.09	144	-0.03		
78	1.19	145	0.29		

Table 60 Expected average withdrawal from ridge citrus wells by month. Values in acre-inches.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
95	0.77	0.27	0.48	0.89	1.35	0.48	0.21	0.14	0.02	0.28	0.29	0.43
96	1.59	1.10	1.31	1.72	2.18	1.30	1.04	0.97	0.85	1.11	1.12	1.25
97	1.52	1.02	1.23	1.65	2.10	1.23	0.97	0.90	0.78	1.04	1.04	1.18
98	1.43	0.93	1.14	1.56	2.01	1.14	0.88	0.81	0.69	0.95	0.95	1.09
99	0.59	0.09	0.30	0.71	1.17	0.30	0.04	-0.03	-0.15	0.11	0.11	0.25
100	1.01	0.51	0.72	1.13	1.59	0.72	0.45	0.39	0.26	0.53	0.53	0.67
101	1.25	0.75	0.96	1.37	1.83	0.96	0.70	0.63	0.51	0.77	0.77	0.91
102	0.91	0.41	0.62	1.03	1.49	0.62	0.36	0.29	0.17	0.43	0.43	0.57
103	1.80	1.31	1.52	1.93	2.38	1.51	1.25	1.18	1.06	1.32	1.33	1.46
105	0.93	0.43	0.64	1.05	1.51	0.64	0.37	0.31	0.18	0.44	0.45	0.59
106	0.93	0.43	0.64	1.05	1.51	0.64	0.38	0.31	0.18	0.45	0.45	0.59
107	1.52	1.02	1.23	1.64	2.10	1.23	0.97	0.90	0.78	1.04	1.04	1.18
108	1.96	1.46	1.68	2.09	2.54	1.67	1.41	1.34	1.22	1.48	1.48	1.62
109	1.65	1.15	1.36	1.77	2.23	1.36	1.10	1.03	0.91	1.17	1.17	1.31
110	2.38	1.88	2.09	2.50	2.96	2.09	1.82	1.75	1.63	1.89	1.90	2.04
111	1.37	0.88	1.09	1.50	1.95	1.08	0.82	0.75	0.63	0.89	0.90	1.03
112	0.94	0.44	0.65	1.06	1.52	0.65	0.38	0.31	0.19	0.45	0.46	0.60
113	1.56	1.07	1.28	1.69	2.14	1.27	1.01	0.94	0.82	1.08	1.09	1.22
114	1.39	0.89	1.10	1.51	1.97	1.10	0.84	0.77	0.65	0.91	0.91	1.05
115	1.10	0.60	0.82	1.23	1.68	0.81	0.55	0.48	0.36	0.62	0.62	0.76
116	1.77	1.27	1.49	1.90	2.35	1.48	1.22	1.15	1.03	1.29	1.29	1.43
117	1.27	0.77	0.98	1.39	1.85	0.98	0.72	0.65	0.53	0.79	0.79	0.93
118	1.03	0.54	0.75	1.16	1.62	0.74	0.48	0.41	0.29	0.55	0.56	0.69
119	1.22	0.73	0.94	1.35	1.81	0.93	0.67	0.60	0.48	0.74	0.75	0.88
120	1.26	0.76	0.97	1.39	1.84	0.97	0.71	0.64	0.52	0.78	0.78	0.92
121	0.95	0.46	0.67	1.08	1.53	0.66	0.40	0.33	0.21	0.47	0.48	0.61
122	1.53	1.03	1.24	1.65	2.11	1.24	0.98	0.91	0.78	1.05	1.05	1.19
123	1.72	1.22	1.44	1.85	2.30	1.43	1.17	1.10	0.98	1.24	1.24	1.38
124	1.62	1.12	1.33	1.74	2.20	1.33	1.06	1.00	0.87	1.14	1.14	1.28
125	1.08	0.58	0.79	1.20	1.66	0.79	0.52	0.45	0.33	0.59	0.60	0.74
126	1.77	1.27	1.48	1.89	2.35	1.48	1.22	1.15	1.03	1.29	1.29	1.43
127	0.91	0.41	0.63	1.04	1.49	0.62	0.36	0.29	0.17	0.43	0.43	0.57
128	0.89	0.39	0.61	1.02	1.47	0.60	0.34	0.27	0.15	0.41	0.41	0.55
129	1.73	1.23	1.45	1.86	2.31	1.44	1.18	1.11	0.99	1.25	1.25	1.39
130	1.16	0.66	0.87	1.28	1.74	0.87	0.61	0.54	0.42	0.68	0.68	0.82
131	1.61	1.11	1.32	1.73	2.19	1.32	1.06	0.99	0.86	1.13	1.13	1.27
132	0.70	0.20	0.42	0.83	1.28	0.41	0.15	0.08	-0.04	0.22	0.22	0.36
133	0.91	0.41	0.63	1.04	1.49	0.62	0.36	0.29	0.17	0.43	0.43	0.57
134	1.30	0.81	1.02	1.43	1.88	1.01	0.75	0.68	0.56	0.82	0.83	0.96
135	1.24	0.74	0.96	1.37	1.82	0.95	0.69	0.62	0.50	0.76	0.76	0.90
136	0.85	0.35	0.56	0.97	1.43	0.56	0.30	0.23	0.11	0.37	0.37	0.51
137	1.16	0.67	0.88	1.29	1.75	0.87	0.61	0.54	0.42	0.68	0.69	0.82

Table 60 Continued.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
138	1.30	0.80	1.01	1.42	1.88	1.01	0.75	0.68	0.56	0.82	0.82	0.96
139	1.35	0.85	1.07	1.48	1.93	1.06	0.80	0.73	0.61	0.87	0.87	1.01
140	0.86	0.37	0.58	0.99	1.45	0.57	0.31	0.24	0.12	0.38	0.39	0.52
143	0.78	0.28	0.50	0.91	1.36	0.49	0.23	0.16	0.04	0.30	0.30	0.44
147	0.67	0.17	0.38	0.79	1.25	0.38	0.11	0.04	-0.08	0.18	0.19	0.33
148	1.37	0.88	1.09	1.50	1.95	1.08	0.82	0.75	0.63	0.89	0.90	1.03
149	1.16	0.66	0.87	1.28	1.74	0.87	0.61	0.54	0.42	0.68	0.68	0.82
150	0.85	0.35	0.56	0.97	1.43	0.56	0.30	0.23	0.11	0.37	0.37	0.51
151	1.88	1.38	1.59	2.00	2.46	1.59	1.32	1.26	1.13	1.39	1.40	1.54
152	0.81	0.31	0.52	0.94	1.39	0.52	0.26	0.19	0.07	0.33	0.33	0.47
153	0.67	0.18	0.39	0.80	1.25	0.38	0.12	0.05	-0.07	0.19	0.20	0.33
154	0.79	0.29	0.51	0.92	1.37	0.50	0.24	0.17	0.05	0.31	0.31	0.45
155	0.76	0.27	0.48	0.89	1.35	0.47	0.21	0.14	0.02	0.28	0.29	0.42
156	1.12	0.62	0.83	1.24	1.70	0.83	0.56	0.50	0.37	0.63	0.64	0.78
157	0.90	0.40	0.61	1.02	1.48	0.61	0.35	0.28	0.16	0.42	0.42	0.56
158	0.52	0.02	0.24	0.65	1.10	0.23	-0.03	-0.10	-0.22	0.04	0.04	0.18
159	1.14	0.64	0.85	1.26	1.72	0.85	0.59	0.52	0.40	0.66	0.66	0.80
160	1.45	0.95	1.16	1.57	2.03	1.16	0.89	0.83	0.70	0.96	0.97	1.11
161	1.52	1.02	1.23	1.64	2.10	1.23	0.97	0.90	0.78	1.04	1.04	1.18
163	1.35	0.85	1.06	1.47	1.93	1.05	0.79	0.72	0.60	0.86	0.87	1.01
164	0.88	0.39	0.60	1.01	1.46	0.59	0.33	0.26	0.14	0.40	0.41	0.54
165	1.51	1.01	1.22	1.64	2.09	1.22	0.96	0.89	0.77	1.03	1.03	1.17
166	1.75	1.25	1.46	1.88	2.33	1.46	1.20	1.13	1.01	1.27	1.27	1.41
167	1.44	0.95	1.16	1.57	2.02	1.15	0.89	0.82	0.70	0.96	0.97	1.10
168	1.44	0.94	1.15	1.57	2.02	1.15	0.89	0.82	0.70	0.96	0.96	1.10
169	1.18	0.68	0.89	1.30	1.76	0.89	0.63	0.56	0.44	0.70	0.70	0.84
172	1.18	0.68	0.89	1.30	1.76	0.89	0.63	0.56	0.44	0.70	0.70	0.84
173	0.93	0.43	0.64	1.05	1.51	0.64	0.38	0.31	0.19	0.45	0.45	0.59
177	2.34	1.85	2.06	2.47	2.92	2.05	1.79	1.72	1.60	1.86	1.87	2.00
178	0.97	0.48	0.69	1.10	1.55	0.68	0.42	0.35	0.23	0.49	0.50	0.63
179	1.27	0.78	0.99	1.40	1.85	0.98	0.72	0.65	0.53	0.79	0.80	0.93
183	1.20	0.70	0.91	1.32	1.78	0.91	0.65	0.58	0.46	0.72	0.72	0.86
184	1.17	0.67	0.88	1.29	1.75	0.88	0.62	0.55	0.43	0.69	0.69	0.83
186	1.61	1.11	1.32	1.73	2.19	1.32	1.06	0.99	0.87	1.13	1.13	1.27
199	1.15	0.65	0.86	1.28	1.73	0.86	0.60	0.53	0.41	0.67	0.67	0.81

Table 61 Expected average withdrawal from flatwoods citrus wells by month. Values in acre-inches.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
200	1.59	1.89	2.20	2.21	2.33	1.34	1.34	1.20	1.48	1.82	1.99	1.52
201	0.15	0.46	0.77	0.77	0.89	-0.09	-0.09	-0.24	0.04	0.38	0.55	0.08
202	0.26	0.56	0.87	0.88	1.00	0.01	0.01	-0.13	0.15	0.49	0.66	0.19
203	0.48	0.79	1.10	1.10	1.23	0.24	0.24	0.09	0.37	0.71	0.88	0.42
204	0.75	1.05	1.36	1.37	1.49	0.50	0.50	0.36	0.64	0.98	1.14	0.68
205	0.38	0.69	1.00	1.01	1.13	0.14	0.14	-0.01	0.27	0.62	0.78	0.32
206	0.60	0.90	1.21	1.22	1.34	0.35	0.35	0.21	0.49	0.83	1.00	0.53
207	0.20	0.51	0.82	0.83	0.95	-0.04	-0.04	-0.19	0.09	0.44	0.60	0.14
208	0.25	0.56	0.87	0.87	1.00	0.01	0.01	-0.14	0.14	0.48	0.65	0.19
209	0.49	0.79	1.10	1.11	1.23	0.24	0.24	0.10	0.38	0.72	0.89	0.42
210	0.96	1.27	1.58	1.58	1.71	0.72	0.72	0.57	0.85	1.19	1.36	0.90
211	0.98	1.28	1.59	1.60	1.72	0.73	0.73	0.59	0.87	1.21	1.38	0.91
212	0.88	1.19	1.49	1.50	1.62	0.64	0.63	0.49	0.77	1.11	1.28	0.81
213	1.09	1.40	1.71	1.71	1.83	0.85	0.85	0.70	0.98	1.32	1.49	1.02
214	0.40	0.71	1.02	1.02	1.14	0.16	0.16	0.01				0.33
215	0.23	0.54	0.85	0.85	0.98	-0.01	-0.01	-0.16	0.12	0.46	0.63	0.16
216	0.65	0.95	1.26	1.27	1.39	0.40	0.40	0.26	0.54	0.88	1.05	0.58
217	0.92	1.23	1.54	1.54	1.66	0.68	0.68	0.53	0.81	1.15	1.32	0.85
218	0.85	1.16	1.47	1.47	1.60	0.61	0.61	0.46	0.74	1.08	1.25	0.79
219	0.95	1.26	1.56	1.57	1.69	0.71	0.70	0.56	0.84	1.18	1.35	0.88
220	1.22	1.52	1.83	1.84	1.96	0.97	0.97	0.83	1.11	1.45	1.62	1.15
221	0.57	0.88	1.19	1.19	1.32	0.33	0.33	0.18	0.46	0.80	0.97	0.50
222	0.43	0.74	1.04	1.05	1.17	0.19	0.18	0.04	0.32	0.66	0.83	0.36
223	0.78	1.08	1.39	1.40	1.52	0.53	0.53	0.39	0.67	1.01	1.17	0.71
224	0.88	1.19	1.49	1.50	1.62	0.64	0.63	0.49	0.77	1.11	1.28	0.81
225	0.35	0.66	0.97	0.97	1.10	0.11	0.11	-0.04	0.24	0.59	0.75	0.29
226	0.40	0.70	1.01	1.02	1.14	0.15	0.15	0.01		0.63	0.80	0.33
227	0.49	0.80	1.11	1.11	1.24	0.25	0.25	0.10	0.38	0.72	0.89	0.43
228	0.38	0.69	1.00	1.00	1.13	0.14	0.14	-0.01		0.61	0.78	0.32
229	0.83	1.14	1.44	1.45	1.57	0.59	0.58	0.44	0.72	1.06	1.23	0.76
230	0.86	1.17	1.48	1.48	1.60	0.62	0.62	0.47	0.75	1.09	1.26	0.79
231	0.79	1.10	1.41	1.42	1.54	0.55	0.55	0.40	0.68	1.03	1.19	0.73
232	0.67	0.98	1.28	1.29	1.41	0.43	0.43	0.28	0.56	0.90	1.07	0.60
233					1.41	0.42						
234	0.61	0.92	1.23	1.23	1.35	0.37	0.37	0.22	0.50	0.84	1.01	0.54
235	0.34	0.65	0.96	0.96	1.08	0.10	0.10	-0.05	0.23	0.57	0.74	0.27
236	0.51	0.82	1.13	1.13	1.26	0.27	0.27	0.12	0.40	0.74	0.91	0.45
237	1.12	1.43	1.73	1.74	1.86	0.88	0.87	0.73	1.01	1.35	1.52	1.05
238	0.65	0.96	1.27	1.28	1.40	0.41	0.41	0.26	0.55	0.89	1.05	0.59
239	0.62	0.93	1.24	1.25	1.37	0.38	0.38	0.23	0.52	0.86	1.02	0.56
240	0.69	1.00	1.31	1.31	1.43	0.45	0.45	0.30	0.58	0.92	1.09	0.62
241	0.69	1.00	1.31	1.32	1.44	0.45	0.45	0.30	0.59	0.93	1.09	0.63
242	0.80	1.11	1.41	1.42	1.54	0.56	0.56	0.41	0.69	1.03	1.20	0.73
243	0.52	0.83	1.14	1.14	1.26	0.28	0.28	0.13			0.92	0.45
244	0.59	0.90	1.21	1.21	1.34	0.35	0.35	0.20			0.99	0.53

Table 61 Continued.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
245	0.70	1.00	1.31	1.32	1.44	0.45	0.45	0.31				
246		0.92	1.23	1.24	1.36	0.37	0.37	0.22			1.01	
247	0.81	1.12	1.43	1.43	1.56	0.57	0.57	0.42				0.75
248				1.40	1.52	0.53	0.53	0.39				
249				1.38	1.50	0.51	0.51	0.37				
250				1.23	1.36	0.37	0.37	0.22				
251				1.72	1.84	0.85	0.85	0.71				
252				1.76	1.88	0.89	0.89	0.74				
253				1.44	1.57	0.58	0.58	0.43				
254						0.39	0.39	0.24				
255						0.40	0.40	0.25				
256						0.40	0.40	0.25				
257							0.41	0.26				
258								0.28				
259								0.28				
260								0.28				
261								0.28				
262								0.31				
263								0.28				
264								0.29				
265								0.28				
266								0.28				

Table 62 Expected average withdrawal from potato wells by WSP. Values in acre-inches.

SiteNo	1	2	3	4	5	6	7	8	9	10	11	12
1	-0.26	-0.05	-0.11	0.35	0.77	1.46	1.80	2.08	2.59	2.94	3.28	3.68
2	-0.06	0.16	0.09	0.56	0.97	1.67	2.01	2.29	2.80	3.14	3.49	3.89
3	0.46	0.67	0.61	1.07	1.49	2.18	2.52	2.80	3.31	3.66	4.00	4.40
4	1.06	1.27	1.21	1.67	2.09		3.12	3.40	3.91	4.26	4.60	5.00
6	0.32	0.53	0.47	0.94	1.35	2.05	2.39	2.67	3.18	3.52	3.87	4.27
7	-0.34	-0.13	-0.19	0.28	0.69	1.39	1.72	2.01	2.52	2.86	3.20	3.60
9	1.42	1.63	1.57	2.04	2.45	3.15	3.49	3.77	4.28	4.62	4.96	5.36
10	0.14	0.35	0.29	0.76	1.17	1.86	2.20	2.48	2.99	3.34	3.68	4.08
11	0.54	0.75	0.69	1.15	1.57	2.26	2.60	2.88	3.39	3.74	4.08	4.48
12	-0.29	-0.08	-0.14		0.74	1.44	1.78	2.06	2.57	2.91	3.25	3.65
13	-0.40	-0.19	-0.25	0.22	0.63		1.66	1.95	2.45		3.14	3.54
14	-0.05	0.16	0.10	0.57	0.98	1.68	2.02	2.30	2.81	3.15	3.49	3.89
15	0.58	0.79	0.73	1.19	1.61	2.30	2.64	2.92	3.43	3.78	4.12	4.52
16		0.30	0.24	0.71	1.12	1.82	2.15	2.44	2.94	3.29	3.63	4.03
17		0.73	0.67	1.14		2.25	2.58	2.87		3.72	4.06	4.46
19		0.81	0.75	1.22	1.63	2.33	2.66	2.95	3.46	3.80	4.14	4.54
20	0.16	0.37	0.31	0.77	1.19	1.88	2.22	2.50	3.01	3.36	3.70	4.10
22	0.20	0.41			1.23	1.93	2.26		3.06	3.40	3.74	
23		0.41	0.35	0.81		1.92	2.26	2.54		3.40	3.74	
24	0.55	0.76	0.70	1.17	1.58	2.28	2.61	2.90	3.41	3.75	4.09	4.49
25	-0.01	0.20	0.14	0.61	1.02	1.72	2.05	2.34	2.85	3.19	3.53	3.93
26	0.55	0.76	0.69	1.16	1.57	2.27	2.61	2.89	3.40	3.74	4.09	4.49
27	0.31	0.52	0.46	0.93	1.34	2.04	2.37	2.66	3.17	3.51	3.85	4.25
28	1.43	1.64	1.57	2.04	2.46	3.15	3.49	3.77	4.28	4.63	4.97	5.37
33	0.36	0.57	0.51	0.98	1.39	2.09	2.42	2.71	3.22	3.56	3.90	4.30
34	0.61	0.82	0.76	1.23	1.64	2.34	2.67	2.96	3.46	3.81	4.15	4.55
37	1.39	1.60		2.01	2.42	3.12	3.46	3.74	4.25	4.59	4.93	5.33
38	0.73	0.94	0.88	1.35	1.76	2.46	2.79	3.08	3.59	3.93	4.27	4.67
39	0.71	0.92	0.86	1.33	1.74	2.43	2.77	3.06		3.91	4.25	4.65
40	-0.10	0.11	0.05	0.52	0.93	1.63	1.96	2.25	2.76	3.10	3.44	3.84
41	0.44	0.65	0.59	1.06	1.47	2.17	2.51	2.79	3.30	3.64	3.98	4.38
42	0.34	0.56	0.49	0.96	1.37	2.07	2.41	2.69	3.20	3.54	3.89	4.29
44	0.54	0.75	0.69	1.16	1.57	2.27	2.60	2.89	3.40	3.74	4.08	4.48
45	0.39	0.60	0.54	1.01	1.42	2.11	2.45	2.74	3.24		3.93	4.33
46	0.65	0.86	0.80	1.26	1.68	2.37	2.71	2.99	3.50	3.85	4.19	4.59
47	0.87	1.08	1.02	1.49	1.90	2.60	2.93	3.22	3.73	4.07	4.41	4.81
49	1.07				2.10				3.92	4.27		
50	2.25	2.46	2.40	2.87	3.28	3.97	4.31	4.60	5.10	5.45	5.79	6.19
52	0.15	0.36	0.30	0.77	1.18	1.87	2.21	2.50	3.00	3.35	3.69	4.09
53	-0.48	-0.27	-0.33	0.14	0.55	1.24	1.58	1.86	2.37	2.72	3.06	3.46
55	0.85	1.06	1.00	1.47	1.88	2.58	2.91	3.20	3.71	4.05	4.39	4.79
187		0.92	0.86	1.33	1.74	2.44	2.77	3.06	3.57	3.91	4.25	4.65
189	-0.73	-0.52	-0.59	-0.12	0.29	0.99	1.33	1.61	2.12	2.46		3.21
190	1.33	1.54	1.48	1.95	2.36	3.06	3.39	3.68	4.19	4.53		5.27
191	0.17	0.38	0.32	0.79	1.20	1.90	2.23	2.52	3.03		3.71	4.11

Table 62 Continued.

SiteNo	1	2	3	4	5	6	7	8	9	10	11	12
192	0.41	0.62	0.56	1.03	1.44	2.13	2.47	2.75	3.26	3.61	3.95	4.35
193	0.20	0.41	0.35	0.81	1.23	1.92	2.26	2.54	3.05	3.40		4.14
194	0.03	0.24	0.17	0.64	1.05	1.75	2.09	2.37	2.88	3.23	3.57	3.97
195	-0.08	0.13	0.07	0.54	0.95	1.65	1.98	2.27	2.78	3.12	3.46	3.86
196	0.00	0.21	0.15	0.62	1.03	1.73	2.07	2.35	2.86		3.55	3.94
197	0.57	0.78	0.72	1.19	1.60	2.30	2.63	2.92	3.43	3.77	4.11	4.51
198	-0.20	0.01	-0.05	0.42	0.83	1.53	1.87	2.15		3.00	3.34	3.74

Table 63 Expected average withdrawal from potato wells by WSP (13-24). Values in acre-inches.

SiteNo	13	14	15	16	17	18	19	20	21	22	23	24
1	3.61	3.21	2.37	2.05	0.80	0.50	0.23	0.17	0.08	0.02		0.11
2	3.82	3.42	2.58	2.26	1.01	0.71	0.44	0.38				
3	4.33	3.93	3.09	2.77	1.52	1.22	0.95		0.80	0.74		
4	4.93	4.53	3.69	3.37	2.12	1.82		1.49	1.40	1.34	1.73	1.43
6	4.20	3.80	2.96	2.64	1.39	1.09	0.82	0.76	0.67	0.61	0.99	0.70
7	3.53	3.13	2.30	1.97	0.73	0.43	0.15	0.10	0.00		0.33	0.04
9	5.30	4.90	4.06	3.74	2.49	2.19	1.91	1.86	1.77	1.71		1.80
10	4.01	3.61	2.78	2.45	1.20	0.90	0.63	0.57	0.48	0.43	0.81	0.51
11	4.41	4.01	3.17	2.85	1.60	1.30	1.03	0.97	0.88	0.83	1.21	0.91
12	3.59	3.19	2.35	2.03	0.78	0.48	0.20	0.15	0.06	0.00	0.38	0.09
13	3.47	3.07	2.24	1.91	0.66	0.36	0.09	0.03	-0.06	-0.11	0.27	
14	3.83	3.43	2.59	2.27	1.02	0.72	0.44	0.39	0.30	0.24	0.62	0.33
15	4.45	4.05	3.21	2.89	1.64	1.34		1.01	0.92		1.25	0.95
16	3.96	3.56	2.73		1.15	0.86	0.58	0.52	0.43	0.38	0.76	0.47
17		3.99		2.83			1.01	0.95	0.86			
19	4.48	4.07	3.24	2.91	1.67	1.37	1.09	1.04	0.94	0.89	1.27	
20		3.63	2.79	2.47		0.92	0.65	0.59	0.50			
22	4.07	3.67	2.84			0.97						
23	4.07		2.83		1.26		0.69	0.63				
24	4.43	4.02	3.19	2.86	1.62	1.32	1.04		0.89		1.22	
25	3.87	3.46	2.63	2.30	1.06	0.76	0.48	0.43	0.33	0.28		0.37
26	4.42	4.02	3.18	2.86	1.61	1.31	1.04	0.98	0.89	0.83		
27	4.18	3.78	2.95	2.62	1.38	1.08	0.80	0.74		0.60	0.98	0.69
28	5.30	4.90	4.06	3.74	2.49	2.19	1.92	1.86				
33	4.23	3.83	3.00	2.67	1.43	1.13	0.85	0.79	0.70	0.65	1.03	0.74
34	4.48	4.08	3.25	2.92	1.67	1.38	1.10	1.04		0.90	1.28	
37	5.27	4.87	4.03	3.71	2.46	2.16	1.88		1.74	1.68	2.06	1.77
38	4.60	4.20	3.37	3.04	1.80	1.50	1.22	1.16	1.07	1.02	1.40	1.11
39	4.58	4.18	3.35	3.02	1.77	1.47	1.20	1.14	1.05		1.38	
40	3.78	3.38	2.54	2.22	0.97	0.67	0.39		0.25		0.57	
41	4.32	3.92	3.08	2.76	1.51	1.21	0.93	0.88				
42	4.22	3.82	2.98	2.66	1.41	1.11	0.84	0.78	0.69		1.02	
44	4.42	4.01	3.18	2.86	1.61	1.31	1.03	0.98	0.89	0.83	1.21	
45	4.26	3.86	3.03	2.70	1.45	1.15	0.88			0.68		0.77

Table 63 Continued.

SiteNo	13	14	15	16	17	18	19	20	21	22	23	24
46	4.52	4.12	3.28	2.96	1.71	1.41	1.14	1.08	0.99	0.93	1.32	1.02
47	4.75	4.34	3.51	3.18	1.94	1.64	1.36	1.31	1.21	1.16	1.54	
49	4.94	4.54				1.83	1.56					
50	6.12	5.72	4.89	4.56	3.31	3.01	2.74	2.68	2.59	2.54		2.63
52	4.02	3.62	2.79	2.46	1.21	0.91	0.64	0.58	0.49	0.44		0.53
53	3.39	2.99	2.16	1.83	0.58	0.28		-0.05	-0.14			
55	4.73	4.32	3.49	3.16	1.92		1.34	1.29	1.19		1.52	1.23
187	4.59	4.18	3.35	3.02	1.78	1.48	1.20	1.15	1.05	1.00	1.38	1.09
189		2.74		1.58		0.03	-0.24		-0.39	-0.45	-0.06	
190	5.21	4.80		3.65	2.40			1.77	1.68			
191	4.05	3.64	2.81	2.49	1.24	0.94	0.66	0.61		0.46		0.55
192	4.28	3.88	3.05	2.72	1.47	1.17	0.90	0.84		0.70	1.08	
193	4.07	3.67	2.83	2.51		0.96	0.69	0.63	0.54	0.48	0.87	
194	3.90		2.66	2.34	1.09		0.52	0.46	0.37		0.70	0.40
195	3.79	3.39	2.56	2.23	0.99	0.69	0.41	0.35	0.26	0.21	0.59	
196	3.88	3.48	2.64	2.32	1.07	0.77	0.50	0.44	0.35	0.29		0.38
197	4.44	4.04	3.21	2.88	1.64	1.34	1.06	1.00	0.91	0.86		
198	3.68	3.28	2.44	2.12	0.87	0.57	0.30	0.24	0.15		0.47	0.18

Table 64 Expected average withdrawal from leatherleaf fern wells by month. Values in acre-inches.

SiteNo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
56	8.74	4.18	3.14	2.45	2.67	1.80	1.58	1.45	1.28	1.47	2.33	7.27
57	9.71	5.15	4.11	3.42	3.64	2.76	2.55	2.42	2.25	2.44	3.30	8.24
58	11.66	7.10	6.06	5.37	5.59	4.72	4.50	4.37	4.20	4.39	5.25	10.19
60	9.49	4.93	3.90	3.20	3.42	2.55	2.33	2.20	2.03	2.22	3.09	8.02
61	10.00	5.44	4.40	3.71	3.93	3.06	2.84	2.71	2.54	2.73	3.59	8.53
62	9.75	5.19	4.15	3.46	3.68	2.81	2.59	2.46	2.29	2.48	3.34	8.28
63	9.97	5.41	4.38	3.68	3.90	3.03	2.81	2.68	2.51	2.70	3.57	8.50
64	9.46	4.90	3.87	3.17	3.40	2.52	2.30	2.17	2.00	2.20	3.06	8.00
65	10.68	6.12	5.08	4.39	4.61	3.74	3.52	3.39	3.22	3.41	4.27	9.21
66	8.36	3.80	2.77	2.07	2.29	1.42	1.20	1.07	0.90	1.09	1.96	6.89
67	8.67	4.11	3.08	2.38	2.61	1.73	1.51	1.38	1.21	1.41	2.27	7.20
68	9.71	5.15	4.11	3.42	3.64	2.77	2.55	2.42	2.25	2.44	3.30	8.24
69	9.92	5.36	4.33	3.63	3.85	2.98	2.76	2.63	2.46	2.65	3.52	8.45
70	9.86	5.30	4.26	3.57	3.79	2.91	2.69	2.57	2.40	2.59	3.45	8.39
73	7.54	2.98	1.94	1.25	1.47	0.60	0.38	0.25	0.08	0.27	1.13	6.07
74	9.17	4.61	3.57	2.88	3.10	2.22	2.00	1.88	1.71	1.90	2.76	7.70
75	8.11	3.55	2.51	1.82	2.04	1.17	0.95	0.82	0.65	0.84	1.70	6.64
76	10.31	5.75	4.72	4.02	4.24	3.37	3.15	3.02	2.85	3.04	3.91	8.84
77	9.45	4.89	3.85	3.16	3.38	2.50	2.28	2.16	1.99	2.18	3.04	7.98
78	10.54	5.98	4.95	4.25	4.47	3.60	3.38	3.25	3.08	3.27	4.14	9.07
80	7.77	3.20	2.17	1.48	1.70	0.82	0.60	0.48	0.31	0.50	1.36	6.30
81	9.61	5.05	4.02	3.32	3.55	2.67	2.45	2.32	2.16	2.35	3.21	8.15
82	9.65	5.08	4.05	3.36	3.58	2.70	2.48	2.36	2.19	2.38	3.24	8.18
83	8.61	4.05	3.02	2.32	2.54	1.67	1.45	1.32	1.15	1.34	2.21	7.14
84	8.30	3.73	2.70	2.01	2.23	1.35	1.13	1.01	0.84	1.03	1.89	6.83
85	7.62	3.05	2.02	1.33	1.55	0.67	0.45	0.33	0.16	0.35	1.21	6.15
86	9.73	5.17	4.14	3.44	3.67	2.79	2.57	2.44	2.28	2.47	3.33	8.27
87	9.84	5.28	4.24	3.55	3.77	2.90	2.68	2.55	2.38	2.57	3.43	8.37
88	9.59	5.03	4.00	3.30	3.53	2.65	2.43	2.30	2.13	2.33	3.19	8.12
89	8.90	4.34	3.30	2.61	2.83	1.95	1.74	1.61	1.44	1.63	2.49	7.43
90	9.36	4.80	3.76	3.07	3.29	2.41	2.20	2.07	1.90	2.09	2.95	7.89
91	7.96	3.40	2.36	1.67	1.89	1.02	0.80	0.67	0.50	0.69	1.55	6.49
92	9.77	5.21	4.17	3.48	3.70	2.82	2.61	2.48	2.31	2.50	3.36	8.30
93	9.43	4.86	3.83	3.14	3.36	2.48	2.26	2.14	1.97	2.16	3.02	7.96
94	9.85	5.29	4.25	3.56	3.78	2.91	2.69	2.56	2.39	2.58	3.44	8.38
104	8.26	3.69	2.66	1.97	2.19	1.31	1.09	0.97	0.80	0.99	1.85	6.79
141	8.69	4.12	3.09	2.40	2.62	1.74	1.52	1.40	1.23	1.42	2.28	7.22
142	10.30	5.74	4.70	4.01	4.23	3.36	3.14	3.01	2.84	3.03	3.89	8.83
144	9.32	4.76	3.73	3.03	3.25	2.38	2.16	2.03	1.86	2.05	2.92	7.85
145	9.64	5.08	4.05	3.35	3.57	2.70	2.48	2.35	2.18	2.37	3.24	8.17
146	9.93	5.36	4.33	3.64	3.86	2.98	2.76	2.64	2.47	2.66	3.52	8.46
162	8.51	3.95	2.92	2.22					1.05	1.25	2.11	7.05
170	9.49	4.93	3.90	3.21	3.43	2.55	2.33	2.20	2.04	2.23	3.09	8.03
171	8.14	3.58	2.54	1.85	2.07	1.20	0.98	0.85	0.68	0.87	1.73	6.67
174	11.53	6.97	5.94	5.24	5.47	4.59	4.37	4.24	4.07	4.27	5.13	10.07

6.2 Climate data other than supplied by the District.

Metadata described in file NOOAdocumentation.doc (format MSWORD 2002)
Monthly climate data obtained from the National Weather Service for the following stations (ascii format, comma delimited):

- Palatka in Putman County ()
- Clermont in Lake County (Lake_Clermont.txt)
- Ocala in Marion County (Ocala_Marion.txt)
- Hastings in St Johns County (Hastings_StJohns.txt)
- Orlando in Orange County (Orlando_Orange.txt)
- Titusville in Brevard County (Titusville_Brevard.txt)
- Deland in Volusia County (Volusia County_Deland.txt)
- Vero Beach in Indian River County (Verobeach_Indianrive.txt)
- Palm Coast in Flagler County (Palmcoast_Flagler.txt)
- Winter Haven in Polk County (Winter Haven.txt)

Daily Climate data was obtained from the National Weather Service for the Hastings station in St Johns County.

7 References

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2. Levy, P. S. and S. Lemeshow, 1999, Sampling of Populations Methods and Applications, Third Edition, Chapter 7 Ratio Estimation, John Wiley and Sons, Inc., NY.

3. Portier, K. M., 1988, Statistical Sample Survey Design for Estimation of Agricultural Water Use, Special Publications SJ 88 – Sp 8, St. Johns River Water Management District, Palatka, FL.

4. Portier, K. M., 1994, Statistical Analysis of Agricultural Water Consumption Data, Unpublished Technical Report, Department of Statistics, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

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