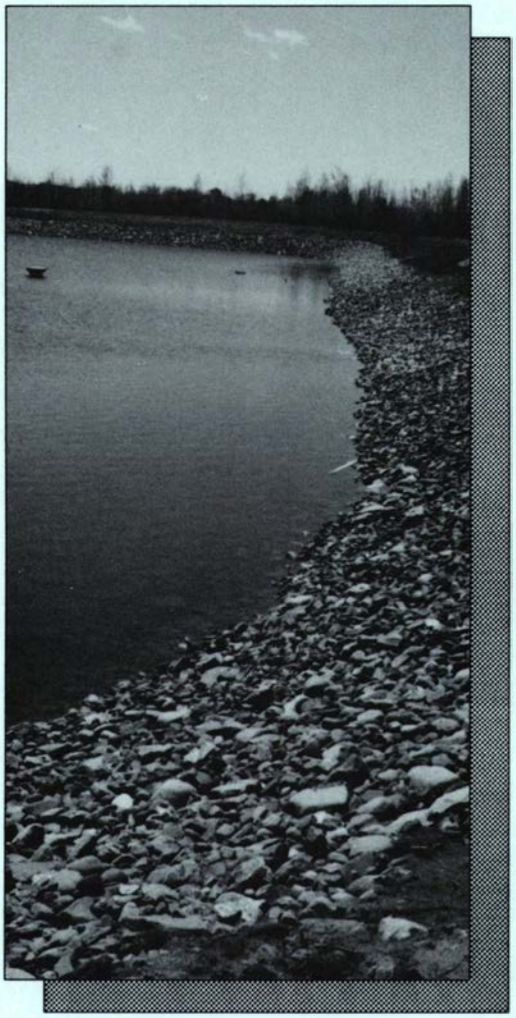
REPORT ON EVALUATION OF MINNESOTA WATER BALANCE TEST



Minnesota Pollution Control Agency
Consulting Engineers Council of Minnesota

REPORT ON EVALUATION OF

MINNESOTA WATER BALANCE TEST

April 1989

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Twin City Testing, Incorporated

The cover photo shows one of the Kettle River Sewage Stabilization Ponds. The photo was taken by a Water Balance Task Force member during the water balance test.

DISCLAIMER

ABSTRACT

All newly constructed wastewater treatment ponds and existing ponds undergoing upgrades in Minnesota are required to assess the seepage rate of the pond seal by the Minnesota Water Balance Test. A Water Balance Task Force consisting of representatives from the Consulting Engineers Council and the Minnesota Pollution Control Agency (MPCA) was formed in June 1987 to evaluate the test.

The purpose of the Task Force was to (1) provide guidance for evaluation and review of water balances, (2) generate improvements in materials and techniques for operation of the test, (3) evaluate the test in a statistical manner to determine its reliability, (4) consider the implications of combining a performance test with prescriptive specifications, and (5) study the impacts of freezing on the water balance.

To accomplish these goals, the Task Force reviewed data from six previous water balance tests, conducted two field water balances, sent questionnaires to other regulatory agencies in the United States and Canada, and sought legal counsel for assessing the contractual implications of combined specifications.

The Task Force concluded that the Minnesota Water Balance Test is an effective tool for evaluating seepage loss from ponds and that the methods used to analyze the data collected during the test have an accuracy to within +/- 1,000 gallons/acre/day.

Recommendations developed by the Task Force for modification and standardization of the test are presented in this report. The recommendations address both physical changes in testing procedures and modifications of the analytical evaluation of test data.

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1. INTRODUCTION

The Minnesota Water Balance test for determining seepage loss from ponds was developed to determine whether newly constructed or existing stabilization ponds were properly sealed. The test was seen as an inexpensive and effective method of assessing the integrity of the lining seal.

Over the last 30 years, design requirements for wastewater stabilization ponds have become progressively more restrictive. The changes in design criteria reflect the broadening of concerns related to stabilization ponds.

Initially, the prime concern defining design requirements was the need to maintain adequate water levels. An early theory held that, over time, the cells would seal themselves with the solids loading if the original seal was sufficient to maintain water.

Later the design standard called for the removal of porous topsoil and compaction of the subgrade to enhance sealing; a liner was required only in areas where porosity was "excessive." These requirements were meant to avoid nuisance conditions and weed growth in the bottom of the cells that provided prime conditions for mosquito breeding.

A heightened awareness of the potential for ground water contamination was the impetus for the next development in pond design. The 1975 Recommended Design Criteria for Stabilization Ponds by the Minnesota Pollution Control Agency (MPCA) included the best available technology to achieve a sealed pond with a seepage loss of less than of 500 gallons/acre/day. This seepage rate was interpreted by the MPCA as meeting its nondegradation standard.

The Agency contracted a study to determine the effectiveness of this standard in protecting the ground water in the vicinity of several existing stabilization ponds. The study was conducted by Eugene A. Hickok and Associates and showed that where ponds leaked approximately 3,000 gallons/acre/day some localized contamination of ground water resulted. The 500 gallon per acre per day seepage limit was determined to be acceptable and remains in effect to ensure that localized contamination does not occur.

In 1987, a Water Balance Task Force (WBTF) was formed to evaluate the accuracy of the Minnesota Water Balance test and to see if any changes could be made to improve the test without significantly increasing its cost. The WBTF consisted of staff from the MPCA and representatives of the Consulting Engineers Council (CEC). At their first meeting on June 16, 1987, Task Force members outlined the scope of work for the WBTF:

1. Provide guidance for MPCA staff reviewing new stabilization pond systems.

2. Develop a data sheet for uniform recording of information.

3. Study the issue of water balances extending into a freeze-up period, versus deferring the test until the spring thaw.

4. Generate improvements in testing techniques.

5. Review water balance data in a statistical manner to determine if reliability and confidence can be obtained from the number of readings currently specified.

6. Recommend contract specification requirements in regard to the water balance test.

7. Identify any substitute standard method tests that may be utilized.

8. Assess implications associated with using both prescriptive and performance style specifications in a contract.

9. Collect information from other states on how they protect ground water from pond seepage and how they determine pond seepage rates.

The Task Force met on a monthly basis. In order to address a range of issues, it conducted water balances at two new sewage stabilization ponds sites. One system was located in Cleveland, Minnesota; the tests there went from October 14, 1987, to November 13, 1987. The second test was conducted at Kettle River, Minnesota, from May 10, 1988, to June 24, 1988. The Kettle River test was interrupted on May 20 for construction repairs and restarted on May 23.

Participants in the Water Balance Task Force were:

Consulting Engineering Council members

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Tom Noyes, P.E. McCombs-Frank, Roos and Associates, Inc.
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The following chapters outline the work, conclusions and recommendations of the Water Balance Task Force.

2. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Water Balance Task Force reached the following conclusions:

1. The Minnesota Water Balance Test is adequate to determine if newly constructed ponds are properly sealed to achieve a seepage loss of less than 500 gallons/acre/day with a 95 percent confidence interval of plus or minus 1,000 gallon/acre/day if the test is run according to the criteria contained in this report. This barrel test is only acceptable for insuring an adequate seal if the installation of the pond seal is done with adequate inspection as outlined in the prescriptive specifications.

2. Although the task force did not study testing of seepage from existing ponds extensively, it concluded that, with some changes, this test can be applied to them. Test accuracy may not be as good with existing ponds because of the problems of dealing with incoming sewage, settling of barrels and uneven pond floors. Evaluation of the seepage from existing ponds may be done by the Minnesota Water Balance or other methods that can be demonstrated to Minnesota Pollution Control Agency staff as being acceptable.

Recommendations

The Water Balance Task Force recommended that the Minnesota Water Balance test should continue to be required for the evaluation of the performance of newly constructed sewage stabilization ponds (both aerated and nonaerated). The task force made recommendations for changes in the test and in the evaluation of the data.

The following recommendations for physical changes in the test are also included in the recommended criteria in Chapter 8:

1. The color of the barrels should be standardized to pure white.

2. The baffle that protects the barrel from splash-over of water from wave action should be standardized.

3. The barrels should be firmly attached to a concrete pad to minimize movement during the test.

4. A minimum of three evaporation-rainfall barrels should be placed in each pond.

5. To reduce errors in reading measurements, the ruler for measuring water level in the barrels should be in millimeters and securely attached to the inside of the barrels for the entire test.

6. All test barrels shall be made of steel with a capacity of 55 gallons. Barrels whether new or used, should have an inside diameter dimension of 22.5, inches plus or minus one inch, and a height a of 35 inches, plus or minus two inches. The barrels dimensions must not be reduced for the test.

7. The water depth and concrete pad in the ponds should be such that the water depth on the outside of the barrels is about two-thirds of the barrel height at the beginning of the test.

8. Because of the uncertainty of weather conditions, the bidding documents for conducting the test should cover costs for a test period of four weeks.

9. The test can be continued into the freeze up period if ice has not permanently formed in the barrels for the winter. In any case the test must be started so as to be concluded by November 20.

10. Evaporation pans are not recommended to be used to measure evaporation. If this is the only method available, a pan evaporation coefficient of 0.6 shall be used.

11. The number of perforated barrels should be increased to a minimum of three.

The following recommendations are for changes in the evaluation of the test and described more fully in Chapters 7 and 8:

1. The minimum number of readings allowable for any water balance test will be nine. The readings may be made up of combinations of barrel data from different barrels. However, for a barrel to be included in a combined analysis, that barrel must contribute at least five readings to the analysis.

2. The water balance test periods should be run concurrently for all newly constructed stabilization pond cells on a project. This is due to the seasonal fluctuations of the mean seepage rate. In dry, hot summers, infiltration rates of up to 2,000 gallons/acre/day and higher have been recorded. This is thought to be due to accelerated evaporation from the water in the barrel when compared to the pond evaporation. By checking pond against pond, localized conditions can be accounted for on a broad scale.

3. The water balance should be evaluated using the least squares analysis. The confidence interval band given by the least squares analysis is to be used in combination with the mean seepage rate. Passing the water balance test requires: that the sum of the estimated mean seepage rate plus the confidence interval not exceed 1500 gallons/acre/day, and the correlation coefficient for each of the two estimated slopes be greater than 0.8. Only one properly evaluated data set is needed to meet this criteria in order for a pond to pass the Minnesota Water Balance test.

4. Ice in the barrel or the pond makes it impossible to make accurate readings. When free of ice the barrel may again be read, and the time between readings recorded. In order for the time span during freezing conditions to be used, a reading before the ice occurred and after the ice melted must be recorded.

5. Although the contract for the test must cover a period of four weeks, actual evaluation of the test may only require a two-week period, depending upon variability of the readings collected.

6. Dike runoff should be considered in the data analysis if major storms occur during the test. The smaller the pond, the greater the effect and the more intense the storm, the greater the effect.

The task force also recommended that:

1. The MPCA staff develop and maintain a data file of future water balance tests. Additional refinement of the standardized test is foreseeable and a good data base will be required to support that effort.

2. To avoid biases in design or evaluation of the liner, a soils engineer must be retained by the pond owner, preferably hired through the consulting engineer, for both the predesign and construction testing. Soils testing during construction should not be the responsibility of the contractor. Further, selection of the engineer by the pond owner should be based on qualifications, rather than price or a combination of qualifications and price. Typically at the time a soils engineer is selected, there is not enough information available for reasonable pricing of the design investigation, so no valid price comparisons are possible. Selection of a firm with the best qualifications should result in the lowest overall cost for design and construction.

3. TASK FORCE STUDIES AT CLEVELAND AND KETTLE RIVER

The Water Balance Task Force (WBTF) set up and operated two water balance tests to collect information. The first test was conducted on the Cleveland wastewater stabilization ponds from October 20, 1987 to November 13, 1987. The Cleveland ponds were designed by Bolton and Menk, Incorporated. The three ponds are approximately six (6) acres each and are sealed with 18 inches of clay. Additional information of the Cleveland water balance study is contained in a report entitled "Report of Water Balance Study, Wastewater Stabilization Ponds, Cleveland, Minnesota" by Twin City Testing, dated December 9, 1987.

The second water balance test was conducted on the Kettle River wastewater stabilization ponds from May 10, 1988 to June 20, 1988. It was interrupted on May 20th for repairs to pipes and the subsequent lowering of the water levels in the cells. It was restarted on May 23, 1988. The Kettle River pond system was designed by John Baker Engineering, Incorporated. Additional information on the Kettle River water balance study is contained in a report entitled "Water Balance Study, Wastewater Treatment Pond Project, Kettle River, Minnesota" by Braun Engineering Testing, Incorporated dated August 3, 1988. The Kettle River ponds are sealed with 30 mil polyvinyl chloride liner. Each of the three cells are approximately two acres.

A special thanks is given to Braun Engineering Testing, Incorporated, Bolton and Menk, Incorporated and Twin City Testing Corporation for assisting the Agency staff by donating time and equipment to conduct these tests.

Cleveland

The following is a discussion of the tasks that were performed at the Cleveland wastewater stabilization ponds. Bolton and Menk, Inc. collected daily readings for the water balance test and MPCA staff was onsite several times per week to take independent readings. Comparisons between the readings taken by Bolton and Menk, Inc. and the MPCA were used to determine a level of accuracy for the readings. The water balance test was conducted as outlined in the MPCA 1985 Recommended Design Criteria for Stabilization Ponds and revisions published in the Construction Grants Memorandum dated March 1986. The results were used as the basis of control for the investigation.

Three metal barrels were placed in the corners of each pond (Figure 3.6). A fourth barrel was placed near the center of each pond. The center barrel was used to determine if proximity to the dikes affects the amount of evaporation.

One stock tank was placed in each pond near one of the three barrels used for control. Comparisons between the barrels and the stock tanks were used to determine if the size of the barrel's or stock tank's opening affects evaporation. It appeared that the size of the container used to measure evaporation and rainfall could affect the test. In ponds 1 and 2, the stock tanks indicated more seepage from the ponds than the barrel. Since the stock tanks in pond 3 showed the opposite effect, it is not possible to draw any conclusion. It should be noted that the confidence interval for the stock tank in pond 3 is more than 20 percent greater than that of any of the pond 3 barrels. This indicates that other outside variables may have had a greater impact on the results for pond 3. Based on this information, additional experiments could be conducted to evaluate how the size of the barrel opening affects evaporation.

Continuous measurements of the temperature of the water in the barrel, stock tank, and pond were recorded. This was done to find out if the surface temperatures of the water in the barrels, tanks or pond were significantly different, which could explain varying evaporation rates. Temperature readings were taken in the top inch of water. These tests, were taken from the stock tank, barrel, and pond all located in the northwest corner of pond 1 (Table 3.1). Although there were differences found in the temperatures measured in the pond, barrel and stock tank they do not appear to be significantly different. Figure 3.1 is a plot of the maximum and minimum daily temperatures recorded in the pond, barrel, and stock tank. Figures 3.2, 3.3, and 3.4 are plots of hourly temperature readings for four days (October 28 and 30 and November 10 and 11, 1987). These field observations showed that the barrels and stock tanks warmed up and cooled down slightly faster than the pond. This could have an effect on evaporation rates. On some mornings ice had formed in the barrel and stock tank but did not form on the pond. This indicates that the barrel and stock tank cooled faster than the pond or that wave action prevented the ponds from freezing.

It was concluded that during periods of freezing weather the barrel would typically freeze first (Figure 3.4). It was not determined whether this is due to energy storage by the pond, wind action on the pond or other factors. It is clear that the majority of energy is expended in melting the ice in the barrel or stock tank. It is assumed that the temperature of the water in the barrel remained close to freezing because the available energy was used melting the ice, much the same way ice is used to cool drinks. The pond, however, shows fluctuation in its surface temperature until the presence of ice on its surface. Therefore, this inaccurate modeling of the pond with barrels containing ice should be accounted for. As a side note, other tests have indicated that the type of material used to make the barrel may affect temperatures.

Evaporation out of the barrels and stock tanks were measured from the top rim with a hand-held scale. The pond level was measured on the outside of the barrels and in the control structures to find out what, if any, effect the wind has on the pond surface. Pond levels in cell #1 were also measured using a perforated barrel near the center of the cell.

The most useful benefit of this experiment came from observing the way the water balance was performed. It appeared that stricter quality control measures were needed. During these tests, the barrels rocked noticeably and settling of the barrels was possible, which could cause errors in reading water levels. Another possible source of error can be in the actual reading of water levels. A ruler was used to measure from the rim of the barrels down to the water surface. Errors can occur using this method. It is difficult to hold one end of the ruler at the water surface while reading the ruler at the rim of the barrel. To improve quality, the following changes are suggested:

-- Specifications should be more precise on how the test is to be conducted.

-- Barrels should be placed on solid surfaces such as splash pads to prevent settling. If this is not possible, the elevation of the barrel rims should be determined at the start of the test and checked again at the conclusion of the test. If the barrels settle, this could be taken into account when evaluating the results.

-- The scale used to measure the water levels should be permanently mounted. It is also easier to read a millimeter scale instead of reading 1/32nd of an inch.

Two evaporation pans were set up on the dikes to determine the correlation between the evaporation pans and the barrels. The data that was collected at Cleveland from the evaporation pans was inconsistent and determined not reliable, therefore no conclusions can be made.

One automatic recording and five manual rain gauges were installed at the pond site. Rain data were used to estimate the amount of runoff from the dikes and to determine if barrel location had an effect on how the barrel performed as a rain gauge. There was a total of 0.96 inches of rainfall during the study period. Wind directions and speed were also recorded.

The following are the seepage rates calculated from the data in the Cleveland water balance study.

	Statistical Method		End Point Method	
	Maximum Seepage Rate (upper limit of 95% confidence interval)		Average Seepage Rate	
	Using Barrels	Using Stock Tanks	Using Barrels	Using Stock Tanks
Pond	Gal/Acre/Day	Gal/Acre/Day	Gal/Acre/Day	Gal/Acre/Day
1	117	580	-355	94
2	410	556	-310	-255
3	752	743	323	-967

Negative numbers indicate the pond gained water
Positive numbers indicate the pond lost water

The statistical method consists of performing a linear regression to find the best fit line describing the data for each pond and barrel. The slopes of these lines are compared to determine a mean seepage rate and the 95% confidence interval is calculated assuming a t-distribution. The maximum seepage rate is obtained by adding the confidence interval to the mean seepage rate.

NOTE: The confidence interval equation used to determine these Cleveland intervals is different than that used in the proposed criteria. Chapter 3's values reflect a purely additive band width derived from the 95 percent level of the evaporation barrels added to the 95 percent band width of the pond barrels. The criteria formula takes into account that two worse case scenarios will not occur within the 95 percent band width. The new numbers are found in Table 6.3.

Kettle River

This section outlines the data and conclusions made from the water balance study performed at Kettle River, Minnesota in May and June of 1988. The Kettle River study was intended to gather information on various methods of conducting water balances. Starting the week of May 9, 1988, Braun Engineering Testing provided a staff person to check readings of the barrels every Monday and Thursday. The MPCA provided staff to take barrel readings, evaporation pan readings and check wind/run recorders and temperature recorders every Tuesday and Friday. The test ran until June 21, 1988. Water levels were altered on May 20 to allow for pond piping repairs and the test was restarted on May 23, 1988.

The test equipment supplied was as follows:

1. Six metal evaporation barrels.
2. Six plastic evaporation barrels.
3. Three stock tanks.
4. Three perforated metal control barrels.
5. Two evaporation pans.
6. Two rain gauges (manual reading)
7. One wind/run measuring recorder.

Approximate equipment locations are shown on Figure 3.7.
The analysis used in the study is as follows:

1. Use the unpaired t-Test to determine if the evaporation/rainfall rate, (i.e., the average daily change in water level) varies significantly between the metal barrels, plastic barrels and stock tanks.

    a. Check for significant differences between the two common evaporation barrels in each pond. If there are no significant differences within ponds then check for:

        (1) significant differences among all six metal barrels.
        (2) significant differences among all six plastic barrels.
        (3) significant differences among all three stock tanks.

    B. If the rates do not vary significantly over the whole pond system, then there is no need to analyze the vessels within each individual cell (i.e., if the rates among all six metal evaporation barrels do not vary significantly then all six may be used when calculating seepage rates for each cell).

        (1) Check for significant differences between the metal barrels and the plastic barrels for each pond (or for the system as a whole if the above note is applicable).

(2) Check for significant differences between the metal barrels and the stock tanks.

(3) Check for significant differences between the plastic barrels and the stock tanks.

2. Use the Paired t-Test to determine if the use of a hook gauge gives significantly different results from the metal ruler. Calculate the confidence interval for the mean of the average daily water level change for both methods.

3. Determine if the average daily evaporation/rainfall rate varies significantly between the two evaporation pans. Determine if the rate varies significantly between the evaporation pans and the plastic barrel on the dike. Determine if the rate varies significantly between the plastic barrel on the dike and those in the ponds.

4. Calculate the seepage rate for each pond using the metal barrels, plastic barrels, stock tanks and evaporation pans. Calculate the confidence interval for each.

5. Determine if the hourly temperatures of the pond, metal barrel, plastic barrel and stock tank vary significantly. If so, determine which vessel most closely approximates the pond temperature.

The Kettle River Stabilization Ponds passed the water balance and accepted for use. The Braun report indicated the end point method results as follows:

ALL UNITS IN GALLONS PER ACRE PER DAY

Pond	Dike Run Off	End Point Seepage	Adjusted Seepage
Braun's Readings			
Cell A	299	-447	-148
Cell B	405	-228	177
Cell C	405	420	825
MPCA's Readings			
Cell A	299	-324	-25
Cell B	482	-248	234
Cell C	482	-97	385

Braun's staff suspected that the first 10 days of their readings were inaccurate for cell C. Comparing the data from the MPCA and the remainder of the 18 day period of Braun's test, shows that a disproportionately large amount of seepage occurred in the first ten days, from Braun's data. This aids as a demonstration of the variability in tests due to operation methods since the same time period and same equipment resulted in two different findings.

The following are the results of the statistical analysis proposed.

NOTE: All test data were run using like time period windows. Since Braun and MPCA alternated readings, a data set that had only MPCA readings available was compared to the other sets using only MPCA dates of record. The least squares correlation uses day rates and the sample variance to estimate a best fit line. Slopes of the means of the different data sets can be compared for seepage loss rates.

A. Observations on the above calculated results

1. The Unpaired t-Test demonstrates there are no significant differences among all three cells for:

   a. metal barrels.
   b. plastic barrels.
   c. stock tanks.
   d. metal barrels and stock tanks.
   e. stock tanks and plastic barrels.
   f. evaporation pan one and evaporation pan two.
   g. the plastic barrel loss, on the dike, when compared with the evaporation pans.

2. The Paired t-Test demonstrates no significant differences between the readings collected using the hook gauge and the readings collected using the mm rule.

3. The least squares analysis for the water balance indicates:

   a. Cell A

      Metal barrels had a gain of 460 gallons/acre/day and a loss of 345 gallons/acre/day (this barrel had a dead bird removed from it during the test period). The plastic barrel had a gain of 1292 gallons/acre/day and the stock tank had a gain of 661 gallons/acre/day.

      The confidence interval for 95% was approximately +/- 730 gallons/acre/ day, +/- 710 gallons/acre/day, +/- 695 gallons/acre/day, respectively, for metal, plastic and stock tank readings.

b. Cell B

The metal barrel seepage average was 27 gallons/acre/day loss and 182 gallons/acre/day gain. The plastic barrel results were 1412 and 1542 gallons/acre/day gain. The stock tank in Cell B indicated a 603 gallon/acre/day gain.

The 95% confidence interval as approximately +/-650 gallons/acre/day, +/-645 gallons/acre/day and +/-603 gallons/acre/day for the metal, plastic and stock tank readings, respectively.

c. Cell C

The metal barrel seepage rates were 465 and 450 gallon/acre/day loss. The plastic barrel seepage rates were a 59 gallon/acre/day loss and a 914 gallon/acre/day gain. The stock tank had a 380 gallon/acre/day gain.

The 95% confidence interval is approximately +/-675 gallons/acre/day, +/- 630 gallons/acre/day and +/-670 gallons/acre/day for the metal, plastic and stock tank readings, respectively.

[Note: The confidence interval bands are calculated using the additive equation discussed in the Cleveland results. The confidence interval data on the metal barrels calculated by the criteria method are found in Table 7.1]

4. Temperature Measurements

Temperature measurements were taken during the survey of the top one inch of water in the pond, steel barrel, plastic barrel, and stock tank. Figure 3.5 is a plot of the 4-hour temperature readings in the steel barrel, plastic barrel, stock tank and the pond from June 1 through the June 15th. The surface water temperatures do not appear to be signficantly different in the four vessels. Compared to the variations that can occur due to wind, precipitation and scale of the test, effects of surface water temperatures may be slight.

5. The Evaporation Pan Data

The least square analysis was run on cell A using the two evaporation pans to check against the pond level. Evaporation pan coefficients of 0.6, 0.7 and 0.8 were used to correct the pan data for shallow reservoir results. Results using the first pan varied between a seepage rate of 1098 gallons/acre/day loss to a gain of 316 gallons/acre/day. The 95% confidence interval is +/- ~ 820. The second pan varied between a loss of 1033 gallons/acre/day to a gain of 402 gallons/acre/day. The 95% confidence interval is +/- ~ 800. The wider confidence interval for pans, as opposed to barrel tests, can be attributed to the fact that pan readings were taken only by MPCA staff (i.e., the sample size is one half of the other sets).

The level of accuracy for the test limit of 500 gallon/acre/day was not obtained. Also, the confidence interval did not significantly improve by use of one type of equipment instead of another. However, the seepage rates show large differences in the results of projected gallons/acre/day of each pond. This shows that the variance of the results may not show a detectable improvement in testing methods until the test is standardized.

The remaining question is which barrel more truly reflects the pond's actual seepage rate? Kettle River's data seems to indicate that the metal barrels came the closest. Deleting the data from the barrel with the dead bird, the metal barrels gave closer seepage rates to each other than the plastic barrels; and the metal barrels had lower gain rates. Gain rates above ground water tables may be attributed to evaporation of the barrel exceeding evaporation of the pond. Assuming the synthetic seal to be above the ground water table, the metal barrels depict pond evaporation better in this test.

Wind/run data was gathered during the test period. Exact time and duration of wind storm events was not defined. However, the levels of winds or average wind speeds may be determined for the months in question. Approximately six wind events occurred during the test period ranging from 15 to 30 miles per hour. The remainder of recordings showed that the month had equal parts of 0 to 5 mile per hour winds and 5 to 10 mile per hour winds.

Method Observations

Several MPCA staff members commented on their observations made during the test. These observations are presented below for information and future reference.

-- Plastic barrels required a large area (half the submerged volume of the barrel) to be filled with rock for stability. It is not known if this amount of rock mass has a significant effect on evaporation.

-- Plastic barrel sidewalls were extremely sensitive to deflection. The waves set up by wading to the barrel for a reading, created a problem with accurately reading the water level in the barrel.

-- High winds were not visually observed at Kettle River, however it is questioned if the plastic barrels (with rock in them) would be stable enough to withstand a wind storm.

-- One problem associated with both plastic and metal barrels was the difficulty in reading the ruler when the water level was down deep inside the barrel.

-- The sun's reflection from the water surface to the ruler increased the difficulty of water level readings. Attaching the ruler on the south side of the barrel should help.

-- Three different types of baffles were used during the test: the metal baffle welded to the top of the metal barrels, the pallets tied together around the barrel and a snow fence arrangement similar to pallet baffles. Both wood products sank after seven to ten days. If used in the future, flotation devices such as bleach bottles should be affixed to the baffles.

-- The hook gauge was easier to read.

-- To quantify possible settling, elevation of the perforated barrels should be taken at the beginning and end of the test.

-- Also due to settling, level measurements of the top rim of the barrel should be required before each reading.

°C - Cleveland - Stock Tank

Table 3.1

Time (hr.)	10/14	10/15	10/16	10/17	10/18	10/19	10/20	10/21	10/22	10/23
1		9.5	10.5	9.5	9.5	7.5	7.5	2.5	5	5
2		9.5	10.5	9.5	9.5	7.5	7.5	2	5	5
3		9.5	10.5	9	9	7	7	1	5	5
4		9.5	10.5	9	9	7	7	1.5	4.5	5
5		9.5	10.5	9	9	7	6.5	1.5	4.5	5.5
6		9.5	10	9	8.5	6.5	6.5	1.5	4	5.5
7		9.5	10	8.5	8.5	6.5	6	1.5	4	5.5
8		9.5	10	8.5	7.5	7	6	2	3.5	5.5
9		9.5	10	8.5	8.5	7.5	6	3	2	5.5
10		9.5	10.5	9	8.5	8.5	6	?	1.5	5.5
11		10	10.5	10	9	9	6	?	4.5	5
12		10.5	10.5	11	9.5	9.5	6	?	4.5	5
13		10.5	10.5	11.5	9.5	9.5	6	5	5.0	5
14	10	10.5	11	12	9.5	9	6	5	5.0	5
15	10.5	10.5	11	12	9.5	9	6	5.5	5.5	5
16	11	10.5	11	12	9.5	9	6	5.5	5.5	5
17	10.5	11	11	11.5	9.5	9	5.5	5.5	5.5	5
18	10	11	11	11	9.5	8.5	5.5	5.5	5.5	5.5
19	10	11	10.5	11	9	8.5	5	5.5	5.5	5.5
20	10	11	10.5	11	9	8.5	5	5.5	5.5	5
21	10	11	10	11	8.5	8	4.5	5.5	5.5	5
22	10	11	10	10.5	8.5	8	4.5	5.5	5	5
23	10	11.5	10	10	8	8	4	5	5	5
24	10	10.5	9.5	10	8	8	3.5	5	5	5

Time (hr.)	10/24	10/25	10/26	10/27	10/28	10/29	10/30	10/31	11/1	11/2
1	5	2	4.5	4	1.5	4	6	6.5	8.5	7.5
2	4.5	1	4.5	4	1	4	6	6	9.5	10
3	4.5	1	4.5	3.5	0.5	4	5.5	6	8.5	10.5
4	4	1	4.5	3.5	0	4	5.5	6	8.5	10.5
5	4.5	1	4	3	-0.5	4	5.5	6	8.5	10.5
6	4.5	1	4	3	-1	3.5	5	6	8	11
7	4	1	4	2	0.5	3.5	5	5.5	8	11
8	3.5	1	4.5	1.5	0.5	3	5.5	5.5	8	11
9	3.5	1	4.5	3.5	1.5	3.5	7.5	6	8	12
10	3	2	4.5	4	1.5	4	8	6.5	8.5	12.5
11	3.5	3	5	4.5	2	4.5	9	7.5	9	13
12	3.5	3.5	5.5	5	4	5	10	7.5	9	13.5
13	3.5	4	6	5.5	5	6	10.5	8	9	14
14	4	4.5	6	5.5	5.5	6.5	10.5	8.5	9.5	14.5
15	4	5	6.5	5.5	5.5	7	10	8.5	9.5	14
16	4.5	5	6.5	5.5	5	7	9.5	9	9.5	14
17	4.5	5	6.5	5	5	7.5	8.5	9	9.5	14
18	4	5.5	6.5	5	5	7	8	8.5	9.5	13
19	4	5	6	5	5	7	8	8.5	9.5	13.5
20	4.5	5	6	4.5	4.5	7	7.5	8.5	9.5	13.5
21	4	5	5.5	3	4.5	7	7.5	8.5	9.5	14
22	4	5	5.5	2	4	6.5	7	8.5	9.5	14
23	3.5	4.5	5	1.5	4	6.5	7	8.5	9.5	13
24	2.5	4.5	4.5	2	4	6.5	6.5	8.5	9.5	12.5

°C - Cleveland - Stock Tank

Table 3.1

Time (hr.)	11/3	11/4	11/5	11/6	11/7	11/8	11/9	11/10	11/11
	Date								
1	12.5	12	6	3	4	7.5	0	0.5	0
2	12.5	11.5	5.5	3	4	7.5	0	0.5	0
3	12.5	11.5	5	3	4	7.5	0.5	0.5	0.5
4	12.5	11	4.5	3	3.5	7	0.5	0	0
5	12.5	11	4	3	3.5	6.5	0.5	0	0
6	12.5	10.5	3	3	4	6	0.5	0	0
7	12.5	10.5	3.5	3.5	4.5	6	0.5	0.5	0.5
8	12.5	10.5	4.5	4.5	5	5.5	0.5	0.5	2.5
9	12.5	10.5	5	5	5.5	6	1.5	1.5	4
10	13	11	5.5	5.5	6	6	3.5	4	6
11	13	11	6	6.5	6.5	6.5	5	5.5	6
12	14	11	6.5	7	6.5	7	6	5	6.5
13	13.5	11	7	8	7	7	4.5	4.5	5
14	13.5	11	7	8	7	6.5	2	2	4.5
15	13	11	7	8	7.5	5.5	1	1	3.5
16	12.5	10	6	6.5	7.5	5	0	0.5	1.5
17	12.5	10	6	6	7.5	4	0.5	1	2
18	12.5	9.5	5.5	6	7	3	0	1	1.5
19	12.5	9	5	6	7	2.5	0	1	2.5
20	12.5	8.5	5	5.5	7	1.5	0	0.5	1
21	12	8	4.5	5	7	1	0	0	1
22	12	7.5	4	4.5	7	-0.5	0	0.5	1
23	12	7	4	4.5	7.5	0	0.5	0.5	0.5
24	12	6.5	3.5	4	7.5	0	0.5	0.5	1

°C - Cleveland - Stock Tank

Time (hr.)	11/12	11/13
	Date	
1	0.5	2.5
2	0.5	2
3	0.5	1.5
4	1	1.5
5	1	1
6	1.5	1.5
7	2	2
8	5	5
9	7	8
10	8.5	?
11	10	
12	10.5	
13	9	
14	8.5	
15	6.5	
16	5.5	
17	5	
18	4.5	
19	4	
20	3.5	
21	3	
22	3	
23	2.5	
24	2.5	

BARREL TEMPS. (°C) Table 3.1

Date Time	10/14/87	10/15/87	10/16/87	10/17/87	10/18/87
0100		9.5	10.0	9.0	9.25
0200		9.0	10.0	9.0	9.0
0300		9.0	10.0	9.0	8.75
0400		9.0	10.0	9.0	8.5
0500		9.0	9.5	8.5	8.5
0600		9.0	9.5	8.5	8.0
0700		9.0	9.5	8.5	8.0
0800		9.0	9.5	8.5	8.0
0900		9.0	9.5	8.5	8.0
1000		9.0	10.0	8.5	8.2
1100		9.5	10.0	9.0	8.4
1200		10.0	10.5	10.0	8.5
1300		10.0	10.5	10.5	9.0
1400	10.0	10.0	10.5	11.0	9.0
1500	10.0	10.0	10.5	11.0	9.0
1600	10.0	10.5	10.5	11.0	9.0
1700	10.0	10.5	10.5	11.0	9.0
1800	9.5	10.5	10.0	10.5	9.0
1900	9.5	10.5	10.0	10.5	8.75
2000	9.5	10.5	10.0	10.5	8.5
2100	9.5	10.5	10.0	10.0	8.25
2200	9.5	10.5	9.5	10.0	8.0
2300	9.5	10.5	9.5	9.75	8.0
2400	9.5	10.0	9.0	9.5	7.5

Date Time	10/19/87	10/20/87	10/21/87	10/22/87	10/23/87
0100	7.5	7.1	3.25	4.5	4.5
0200	7.0	7.0	2.5	4.0	4.25
0300	7.0	6.75	1.5	3.5	4.5
0400	6.5	6.5	1.0	3.5	4.4
0500	6.5	6.25	1.0	3.0	4.4
0600	6.3	6.0	0.9	2.5	4.0
0700	6.0	5.75	0.75	2.0	3.8
0800	6.00	5.5	1.0	1.5	3.8
0900	6.2	5.5	1.5	2.0	4.0
1000	7.0	5.5	2.5	3.0	4.0
1100	7.5	5.5		5.0	4.8
1200	8.0	5.5	2.5	5.0	5.0
1300	8.5	5.5	3.0	5.5	5.0
1400	8.5	5.5	5.0	5.5	5.0
1500	8.5	5.5	5.0	5.5	5.0
1600	8.5	5.4	5.0	5.2	5.0
1700	8.5	5.0	5.0	5.1	5.0
1800	8.3	5.0	5.0	5.0	4.6
1900	8.0	4.5	5.0	5.0	4.6
2000	8.0	4.0	5.0	5.0	4.6
2100	7.5	4.1	4.5	5.0	4.6
2200	7.5	4.0	4.5	4.8	4.5
2300	7.5	3.5	4.5	4.6	4.3
2400	7.4	3.0	4.5	4.6	4.0

Table 3.1

	10/24/87	10/25/87	10/26/87	10/27/87	10/28/87	10/29/87
0100	4.0	0.4	3.9	4.0	0.0	2.9
0200	3.9	0.1	3.8	3.7	0.2	2.5
0300	2.8	0.5	3.8	3.3	0.0	2.0
0400	4.0	0.5	3.4	3.0	0.0	2.0
0500	3.5	0.5	3.4	2.5	0.0	2.0
0600	3.0	0.5	3.4	2.6	0.0	2.8
0700	2.5	0.7	3.6	3.3	0.2	3.6
0800	2.4	1.0	4.0	3.5	1.0	4.0
0900	2.5	1.9	5.0	4.0	1.5	4.5
1000	2.5	3.0	4.7	4.0	2.6	5.5
1100	3.0	3.6	5.0	4.9	4.0	6.0
1200	3.1	4.0	5.1	4.9	4.5	6.9
1300	3.2	4.2	5.5	5.0	4.1	7.1
1400	3.2	4.5	6.0	5.0	4.1	6.0
1500	3.2	4.5	6.0	4.8	4.0	6.5
1600	3.2	4.5	6.0	4.5	3.9	6.5
1700	3.1	4.3	5.5	4.5	3.0	6.2
1800	3.0	4.5	5.4	3.8	2.8	6.1
1900	3.0	4.4	5.1	2.8	3.0	6.1
2000	2.6	4.3	5.0	2.0	3.0	6.0
2100	2.1	4.0	4.8	2.1	3.0	5.9
2200	1.4	3.9	4.8	2.0	2.9	5.5
2300	1.0	3.9	4.3	1.3	3.0	5.5
2400	0.9	3.9	4.0	1.0	2.9	5.4

	10/30/87	10/31/87	11/1/87	11/2/87	11/3/87	11/4/87
0100	5.1	5.5	7.6	10.6	12.0	10.5
0200	5.0	5.5	7.5	10.5	12.0	10.4
0300	5.0	5.2	7.5	10.6	12.0	10.0
0400	4.5	5.0	7.5	11.0	12.0	10.0
0500	4.5	5.0	7.5	11.5	12.0	10.0
0600	5.5	5.4	7.6	12.0	12.4	10.0
0700	6.1	6.0	7.7	12.4	12.5	10.0
0800	7.0	7.0	8.2	12.8	12.9	10.2
0900	8.0	7.5	8.5	13.5	13.0	10.5
1000	8.5	8.0	8.5	14.0	13.0	10.5
1100	9.0	8.5	9.0	13.5	12.2	10.3
1200	9.0	8.5	9.0	13.5	12.0	9.9
1300	9.0	8.2	9.0	13.5	12.0	9.1
1400	8.5	8.2	8.9	13.4	11.9	8.9
1500	7.6	8.0	8.9	13.0	11.8	8.4
1600	7.4	8.0	8.9	13.2	11.5	8.0
1700	7.0	7.8	8.8	13.2	11.5	7.5
1800	7.0	7.8	8.8	13.5	11.5	7.0
1900	6.75	7.9	8.9	13.0	11.5	6.4
2000	6.5	7.9	9.1	12.5	11.5	6.0
2100	6.4	7.9	9.4	12.4	11.4	5.0
2200	6.0	7.8	9.5	12.0	11.2	4.5
2300	5.9	7.6	9.8	12.0	11.0	4.0
2400	5.6	7.6	10.5	12.0	10.6	4.6

	11/5/87	11/6/87	11/7/87	11/8/87	11/9/87	11/10/87
0100		4.3	1.0	2.0	5.5	-2.4
0200		3.5	1.0	2.1	5.0	-2.2
0300		2.6	1.5	2.5	4.5	-2.0
0400		2.5	3.5	3.4	4.6	-1.0
0500		3.0	4.0	5.0	4.6	0.0
0600		4.0	4.6	5.8	5.0	1.0
0700		4.5	5.6	6.5	5.0	1.5
0800		4.8	6.2	7.0	5.2	1.9
0900		5.3	7.0	7.0	5.2	2.0
1000		5.5	7.2	7.4	5.0	1.2
1100		5.6	7.2	7.0	4.5	0.0
1200		5.5	7.0	7.0	3.3	-0.2
1300		5.0	5.6	7.2	3.0	-1.0
1400		5.0	5.2	7.0	2.2	-1.0
1500		4.9	5.0	7.0	1.5	-1.0
1600		3.4	4.5	7.0	0.5	-1.2
1700		3.0	4.2	7.0	-0.2	-1.2
1800		2.4	4.0	7.0	-2.0	-1.0
1900		2.5	4.0	7.0	-1.3	-0.8
2000		3.0	3.5	7.0	-1.2	-0.8
2100		2.0	3.0	7.0	-2.0	-1.0
2200		2.0	3.0	7.2	-2.0	-1.2
2300		1.5	2.5	7.2	-2.0	-1.2
2400		1.0	2.2	7.0	-2.1	-2.0

	11/11/87	11/12/87	11/13/87	11/14/87	11/15/87	11/16/87
0100	-2.0	-1.0	1.0	2.0		
0200	-1.2	0.0	2.1	4.0		
0300	-0.8	2.0	4.9	5.0		
0400	0.0	3.5	7.4			
0500	0.2	5.0	9.0			
0600	1.0	6.0	10.5			
0700	1.0	6.5	11.2			
0800	1.0	7.0	11.3			
0900	1.0	6.0	9.0			
1000	1.0	4.5	6.2			
1100	-0.5	2.0	5.6			
1200	-0.3	2.1	4.3			
1300	-0.2	2.0	4.3			
1400	0.2	2.1	4.0			
1500	0.0	1.2	3.0			
1600	-0.2	1.0	2.5			
1700	-0.3	1.0	2.8			
1800	-0.3	0.9	2.2			
1900	-0.4	1.0	2.2			
2000	-0.6	0.0	2.2			
2100	-1.0	0.0	1.0			
2200	-1.5	-0.5	1.4			
2300	-1.5	-0.1	0.5			
2400	-1.4	0.2	1.0			

TEMPERATURE RECORD OF
CLEVELAND'S PONDS

Table 3.1

Date	Time	Temp°C	Date	Time	Temp°C	Date	Time	Temp°C
10/14/87	1:00 AM		10/16/87	1:00 AM	10.3	10/18/87	1:00 AM	9.5
	2:00			2:00	10.2		2:00	9.4
	3:00			3:00	10.1		3:00	9.3
	4:00			4:00	10.1		4:00	9.0
	5:00			5:00	10.1		5:00	8.9
	6:00			6:00	10.0		6:00	8.8
	7:00			7:00	9.9		7:00	8.6
	8:00			8:00	9.9		8:00	8.5
	9:00			9:00	9.9		9:00	8.5
	10:00			10:00	10.0		10:00	8.7
	11:00			11:00	10.3		11:00	9.0
	Noon			Noon	10.5		Noon	9.6
10/14/87	1:00 PM		10/16/87	1:00 PM	10.6	10/18/87	1:00 PM	9.7
	2:00 PM	9.7		2:00	10.7		2:00	9.7
	3:00	9.9		3:00	10.7		3:00	9.7
	4:00	9.9		4:00	10.7		4:00	9.7
	5:00	10.0		5:00	10.7		5:00	9.5
	6:00	10.0		6:00	10.6		6:00	9.3
	7:00	9.9		7:00	10.6		7:00	9.1
	8:00	9.8		8:00	10.4		8:00	9.0
	9:00	9.8		9:00	10.1		9:00	8.8
	10:00	9.8		10:00	10.0		10:00	8.5
	11:00	9.6		11:00	9.9		11:00	8.2
	Midnight	9.6		Midnight	9.8		Midnight	8.0
10/15/87	1:00 AM	9.5	10/17/87	1:00 AM	9.5	10/19/87	1:00 AM	7.8
	2:00	9.5		2:00	9.3		2:00	7.5
	3:00	9.3		3:00	9.1		3:00	7.5
	4:00	9.1		4:00	9.0		4:00	7.1
	5:00	9.1		5:00	9.0		5:00	7.0
	6:00	9.2		6:00	8.8		6:00	6.9
	7:00	9.2		7:00	8.6		7:00	6.6
	8:00	9.2		8:00	8.5		8:00	6.6
	9:00	9.1		9:00	8.4		9:00	6.8
	10:00	9.0		10:00	8.7		10:00	7.5
	11:00	9.5		11:00	9.2		11:00	8.0
	Noon	9.9		Noon	10.1		Noon	8.7
10/15/87	1:00 PM	10.0	10/17/87	1:00 PM	10.5	10/19/87	1:00 PM	9.1
	2:00	10.0		2:00	11.3		2:00	9.2
	3:00	10.1		3:00	11.5		3:00	9.0
	4:00	10.3		4:00	11.3		4:00	8.9
	5:00	10.3		5:00	11.2		5:00	8.9
	6:00	10.5		6:00	11.1		6:00	8.7
	7:00	10.4		7:00	11.0		7:00	8.5
	8:00	10.4		8:00	10.5		8:00	8.3
	9:00	10.4		9:00	10.2		9:00	8.1
	10:00	10.4		10:00	10.1		10:00	8.0
	11:00	10.4		11:00	10.0		11:00	7.8
	Midnight	10.4		Midnight	9.8		Midnight	7.5

TEMPERATURE RECORD OF CLEVELAND'S PONDS

Table 3.1

Date	Time	Temp°C	Date	Time	Temp°C	Date	Time	Temp°C
10/20/87	1:00 AM	7.4	10/22/87	1:00 AM	4.3	10/24/87	1:00 AM	4.7
	2:00	7.2		2:00	4.1		2:00	4.4
	3:00	7.1		3:00	4.0		3:00	4.3
	4:00	7.0		4:00	3.9		4:00	4.3
	5:00	6.6		5:00	3.8		5:00	4.1
	6:00	6.3		6:00	3.4		6:00	3.9
	7:00	6.0		7:00	3.3		7:00	3.8
	8:00	5.9		8:00	3.0		8:00	3.6
	9:00	5.8		9:00	3.1		9:00	3.6
	10:00	5.8		10:00	3.8		10:00	3.6
	11:00	5.8		11:00	4.3		11:00	3.6
	Noon	5.8		Noon	4.9		Noon	3.8
10/20/87	1:00 PM	5.8	10/22/87	1:00 PM	5.1	10/24/87	1:00 PM	3.9
	2:00	5.8		2:00	5.3		2:00	4.0
	3:00	5.9		3:00	5.3		3:00	4.0
	4:00	5.9		4:00	5.3		4:00	4.0
	5:00	5.6		5:00	5.3		5:00	4.0
	6:00	5.3		6:00	5.3		6:00	4.0
	7:00	5.2		7:00	5.2		7:00	3.9
	8:00	4.9		8:00	5.1		8:00	3.8
	9:00	4.8		9:00	5.1		9:00	3.8
	10:00	4.6		10:00	5.1		10:00	3.7
	11:00	4.4		11:00	5.0		11:00	3.2
	Midnight	4.3		Midnight	4.9		Midnight	3.2
10/21/87	1:00 AM	4.1	10/23/87	1:00 AM	4.9	10/25/87	1:00 AM	1.9
	2:00	3.9		2:00	4.8		2:00	0.5
	3:00	3.8		3:00	4.8		3:00	0.6
	4:00	3.3		4:00	4.7		4:00	1.9
	5:00	3.3		5:00	4.7		5:00	2.0
	6:00	3.1		6:00	4.7		6:00	1.9
	7:00	2.9		7:00	4.5		7:00	1.9
	8:00	3.3		8:00	4.5		8:00	1.9
	9:00	3.7		9:00	4.5		9:00	2.1
	10:00	4.5		10:00	4.5		10:00	2.7
	11:00	4.5		11:00	4.5		11:00	3.1
	Noon	4.5		Noon	4.8		Noon	3.5
10/21/87	1:00 PM	4.9	10/23/87	1:00 PM	5.0	10/25/87	1:00 PM	3.8
	2:00	5.5		2:00	5.0		2:00	4.1
	3:00	5.6		3:00	5.0		3:00	4.3
	4:00	5.7		4:00	5.0		4:00	4.4
	5:00	5.6		5:00	5.0		5:00	4.5
	6:00	5.4		6:00	5.0		6:00	4.5
	7:00	5.1		7:00	4.9		7:00	4.4
	8:00	5.0		8:00	4.9		8:00	4.3
	9:00	4.9		9:00	4.9		9:00	4.2
	10:00	4.8		10:00	4.9		10:00	4.1
	11:00	4.8		11:00	4.9		11:00	4.0
	Midnight	4.5		Midnight	4.8		Midnight	3.9

TEMPERATURE RECORD OF
CLEVELAND'S PONDS

Table 3.1

Date	Time	Temp°C	Date	Time	Temp°C	Date	Time	Temp°C
10/26/87	1:00 AM	3.9	10/28/87	1:00 AM	3.7	10/30/87	1:00 AM	5.4
	2:00	3.8		2:00	1.4		2:00	5.3
	3:00	3.7		3:00	1.0		3:00	5.1
	4:00	3.6		4:00	0.0		4:00	5.0
	5:00	3.5		5:00	0.0		5:00	5.0
	6:00	3.5		6:00	0.2		6:00	4.9
	7:00	3.6		7:00	0.2		7:00	4.9
	8:00	3.8		8:00	0.4		8:00	5.0
	9:00	3.8		9:00	1.6		9:00	5.5
	10:00	4.0		10:00	2.6		10:00	6.0
	11:00	4.5		11:00	3.0		11:00	6.5
	Noon	4.9		Noon	3.3		Noon	7.0
10/26/87	1:00 PM	5.0	10/28/87	1:00 PM	3.7	10/30/87	1:00 PM	7.8
	2:00	5.5		2:00	4.0		2:00	8.0
	3:00	5.9		3:00	4.2		3:00	8.0
	4:00	6.1		4:00	4.3		4:00	8.0
	5:00	6.1		5:00	4.4		5:00	7.9
	6:00	5.9		6:00	4.4		6:00	7.3
	7:00	5.6		7:00	4.3		7:00	7.1
	8:00	5.4		8:00	4.1		8:00	7.0
	9:00	5.3		9:00	3.9		9:00	7.0
	10:00	5.5		10:00	3.7		10:00	6.4
	11:00	4.9		11:00	3.7		11:00	6.7
	Midnight	4.8		Midnight	3.6		Midnight	6.5
10/27/87	1:00 AM	4.8	10/29/87	1:00 AM	3.7	10/31/87	1:00 AM	6.4
	2:00	4.4		2:00	3.6		2:00	6.0
	3:00	4.3		3:00	3.5		3:00	5.8
	4:00	5.1		4:00	3.3		4:00	5.7
	5:00	3.9		5:00	3.2		5:00	5.3
	6:00	3.6		6:00	3.0		6:00	5.0
	7:00	3.5		7:00	2.9		7:00	5.0
	8:00	3.4		8:00	2.9		8:00	5.3
	9:00	3.4		9:00	3.3		9:00	5.8
	10:00	3.7		10:00	3.7		10:00	6.4
	11:00	4.1		11:00	4.5		11:00	7.0
	Noon	4.4		Noon	5.0		Noon	7.2
10/27/87	1:00 PM	4.8	10/29/87	1:00 PM	5.7	10/31/87	1:00 PM	7.5
	2:00	5.0		2:00	6.2		2:00	7.6
	3:00	5.0		3:00	6.5		3:00	7.8
	4:00	4.9		4:00	6.7		4:00	7.8
	5:00	4.7		5:00	6.6		5:00	7.8
	6:00	4.5		6:00	6.2		6:00	7.8
	7:00	4.4		7:00	6.3		7:00	7.8
	8:00	4.2		8:00	6.2		8:00	7.8
	9:00	4.0		9:00	6.1		9:00	7.7
	10:00	3.8		10:00	6.0		10:00	7.7
	11:00	3.7		11:00	5.9		11:00	7.7
	Midnight	3.7		Midnight	5.9		Midnight	7.7

Table 3.1

TEMPERATURE RECORD OF CLEVELAND'S PONDS

Date	Time	Temp°C	Date	Time	Temp°C	Date	Time	Temp°C
11/1/87	1:00 AM	7.7	11/3/87	1:00 AM	11.7	11/5/87	1:00 AM	6.1
	2:00	7.7		2:00	11.6		2:00	6.0
	3:00	7.7		3:00	11.6		3:00	5.3
	4:00	7.7		4:00	11.6		4:00	5.1
	5:00	7.7		5:00	11.6		5:00	5.0
	6:00	7.7		6:00	11.5		6:00	4.9
	7:00	7.6		7:00	11.5		7:00	4.9
	8:00	7.6		8:00	11.7		8:00	5.0
	9:00	7.6		9:00	11.8		9:00	5.3
	10:00	7.8		10:00	11.9		10:00	5.9
	11:00	8.0		11:00	12.0		11:00	6.1
	Noon	8.1		Noon	12.1		Noon	6.6
11/1/87	1:00 PM	8.2	11/3/87	1:00 PM	12.2	11/5/87	1:00 PM	6.8
	2:00	8.4		2:00	12.1		2:00	6.9
	3:00	8.5		3:00	12.1		3:00	6.4
	4:00	8.5		4:00	12.1		4:00	6.2
	5:00	8.5		5:00	12.0		5:00	6.0
	6:00	8.5		6:00	12.0		6:00	6.0
	7:00	8.5		7:00	11.9		7:00	5.2
	8:00	8.5		8:00	11.8		8:00	4.9
	9:00	8.6		9:00	11.8		9:00	4.9
	10:00	8.6		10:00	11.7		10:00	4.9
	11:00	8.7		11:00	11.7		11:00	4.9
	Midnight	8.8		Midnight	11.7		Midnight	4.8
11/2/87	1:00 AM	8.9	11/4/87	1:00 AM	11.4	11/6/87	1:00 AM	4.1
	2:00	9.0		2:00	11.1		2:00	4.0
	3:00	9.4		3:00	11.0		3:00	4.0
	4:00	9.2		4:00	10.8		4:00	3.8
	5:00	9.3		5:00	10.6		5:00	3.3
	6:00	9.4		6:00	10.4		6:00	3.6
	7:00	9.4		7:00	10.4		7:00	3.8
	8:00	9.6		8:00	10.4		8:00	4.0
	9:00	10.1		9:00	10.7		9:00	4.9
	10:00	10.8		10:00	10.8		10:00	5.6
	11:00	10.7		11:00	11.0		11:00	6.1
	Noon	10.9		Noon	11.1		Noon	6.5
11/2/87	1:00 PM	11.3	11/4/87	1:00 PM	11.1	11/6/87	1:00 PM	7.0
	2:00	11.6		2:00	10.8		2:00	7.1
	3:00	11.7		3:00	10.4		3:00	6.7
	4:00	11.9		4:00	10.0		4:00	6.3
	5:00	12.2		5:00	9.4		5:00	6.0
	6:00	12.3		6:00	9.0		6:00	6.1
	7:00	12.6		7:00	8.8		7:00	5.9
	8:00	12.6		8:00	8.4		8:00	5.7
	9:00	12.2		9:00	7.8		9:00	5.6
	10:00	12.1		10:00	7.5		10:00	5.4
	11:00	12.0		11:00	7.0		11:00	5.3
	Midnight	11.9		Midnight	7.5		Midnight	5.1

TEMPERATURE RECORD OF
CLEVELAND'S PONDS

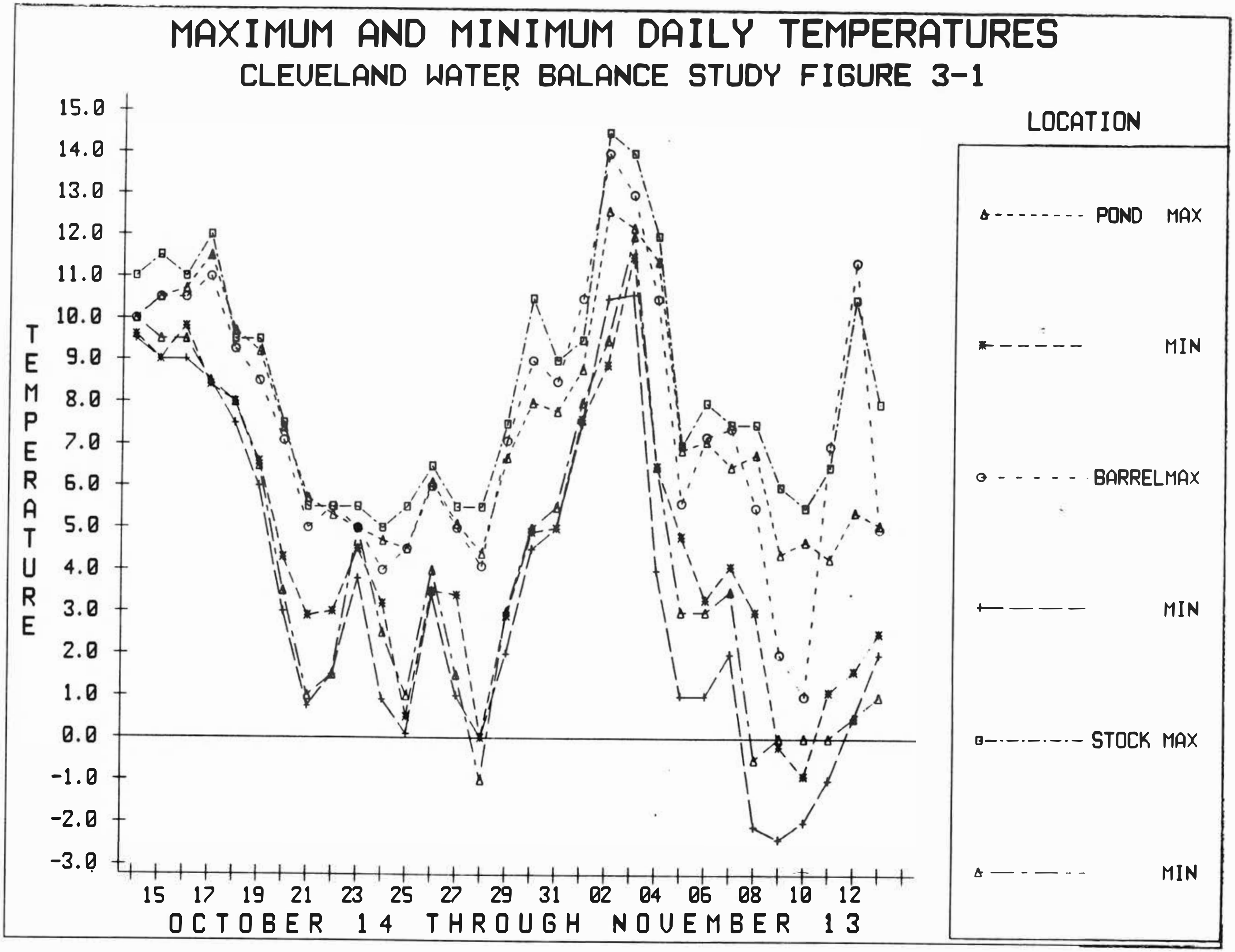
Table 3.1

Date	Time	Temp°C	Date	Time	Temp°C	Date	Time	Temp°C
11/7/87	1:00 AM	4.9	11/9/87	1:00 AM	3.4	11/11/87	1:00 AM	1.9
	2:00	4.7		2:00	0.1		2:00	1.7
	3:00	4.6		3:00	0.0		3:00	1.6
	4:00	4.4		4:00	0.0		4:00	1.4
	5:00	4.2		5:00	0.0		5:00	1.1
	6:00	4.1		6:00	0.0		6:00	1.2
	7:00	4.8		7:00	2.1		7:00	1.5
	8:00	4.5		8:00	3.4		8:00	2.0
	9:00	4.7		9:00	3.5		9:00	2.7
	10:00	5.1		10:00	3.9		10:00	3.3
	11:00	5.4		11:00	4.2		11:00	3.7
	Noon	5.7		Noon	4.2		Noon	4.0
11/7/87	1:00 PM	5.9	11/9/87	1:00 PM	4.4	11/11/87	1:00 PM	4.3
	2:00	5.9		2:00	4.0		2:00	3.9
	3:00	6.0		3:00	2.1		3:00	3.0
	4:00	6.0		4:00	1.7		4:00	3.2
	5:00	5.9		5:00	2.0		5:00	3.2
	6:00	6.0		6:00	0.5		6:00	3.2
	7:00	6.0		7:00	0.0		7:00	3.1
	8:00	6.1		8:00	0.0		8:00	3.0
	9:00	6.2		9:00	0.0		9:00	2.9
	10:00	6.4		10:00	0.0		10:00	2.8
	11:00	6.5		11:00	-0.2		11:00	2.7
	Midnight	6.5		Midnight	-0.2		Midnight	1.1
11/8/87	1:00 AM	6.5	11/10/87	1:00 AM	-0.2	11/12/87	1:00 AM	1.8
	2:00	6.3		2:00	-0.2		2:00	1.7
	3:00	6.2		3:00	-0.5		3:00	2.0
	4:00	6.0		4:00	-0.8		4:00	1.6
	5:00	5.8		5:00	-0.9		5:00	1.8
	6:00	5.6		6:00	-0.6		6:00	2.0
	7:00	5.6		7:00	-0.1		7:00	2.3
	8:00	5.5		8:00	0.0		8:00	3.2
	9:00	5.8		9:00	0.1		9:00	4.0
	10:00	6.1		10:00	1.0		10:00	4.9
	11:00	6.4		11:00	2.1		11:00	5.1
	Noon	6.7		Noon	2.8		Noon	5.2
11/8/87	1:00 PM	6.8	11/10/87	1:00 PM	4.7	11/12/87	1:00 PM	5.4
	2:00	6.5		2:00	4.1		2:00	5.3
	3:00	5.9		3:00	2.5		3:00	5.1
	4:00	5.4		4:00	3.3		4:00	5.0
	5:00	5.1		5:00	3.3		5:00	4.8
	6:00	4.9		6:00	3.0		6:00	4.7
	7:00	4.5		7:00	3.1		7:00	4.1
	8:00	4.1		8:00	2.9		8:00	4.0
	9:00	3.8		9:00	2.9		9:00	3.7
	10:00	3.5		10:00	2.8		10:00	3.9
	11:00	3.0		11:00	2.5		11:00	3.6
	Midnight	3.0		Midnight	2.1		Midnight	4.0

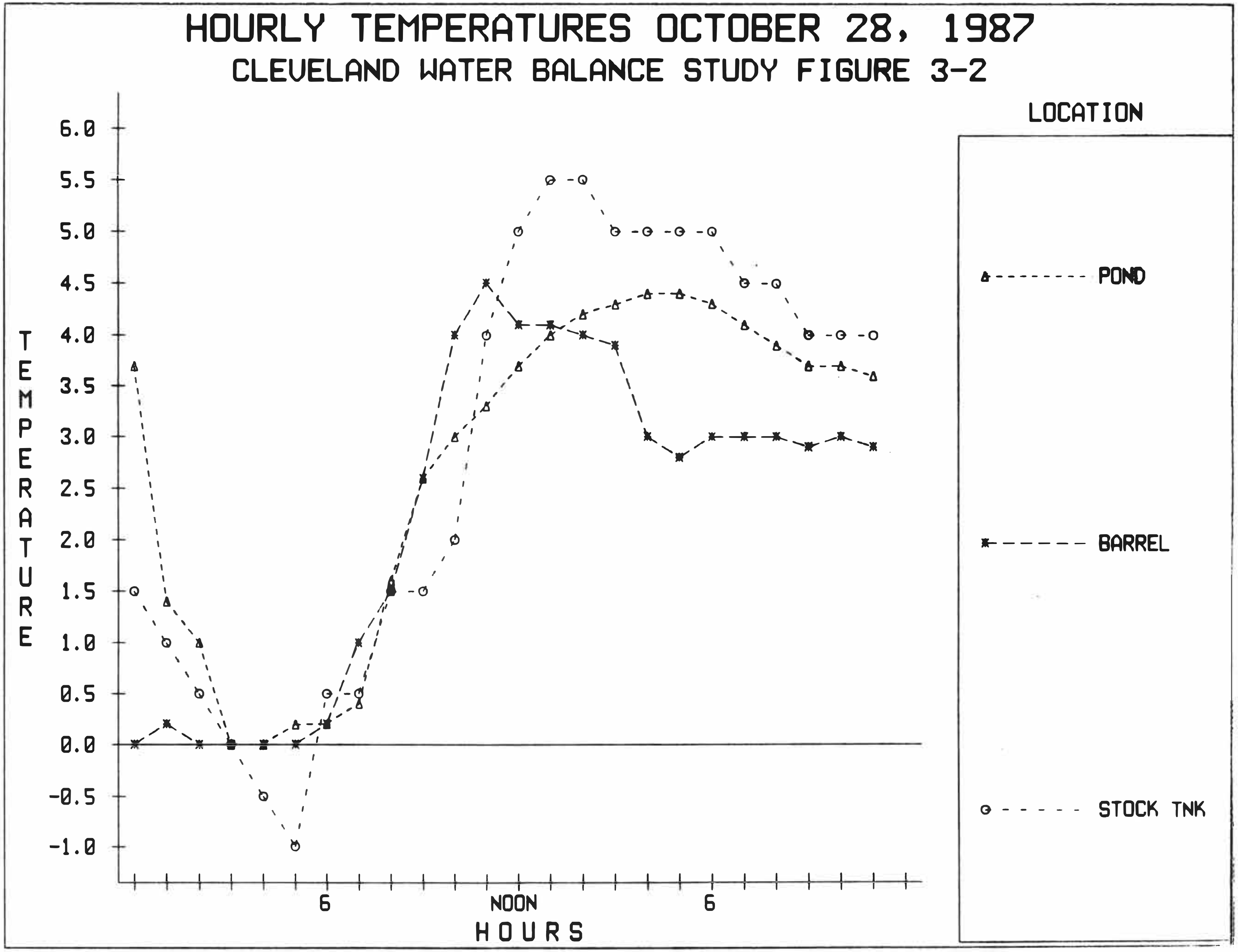
TEMPERATURE RECORD OF
CLEVELAND'S PONDS

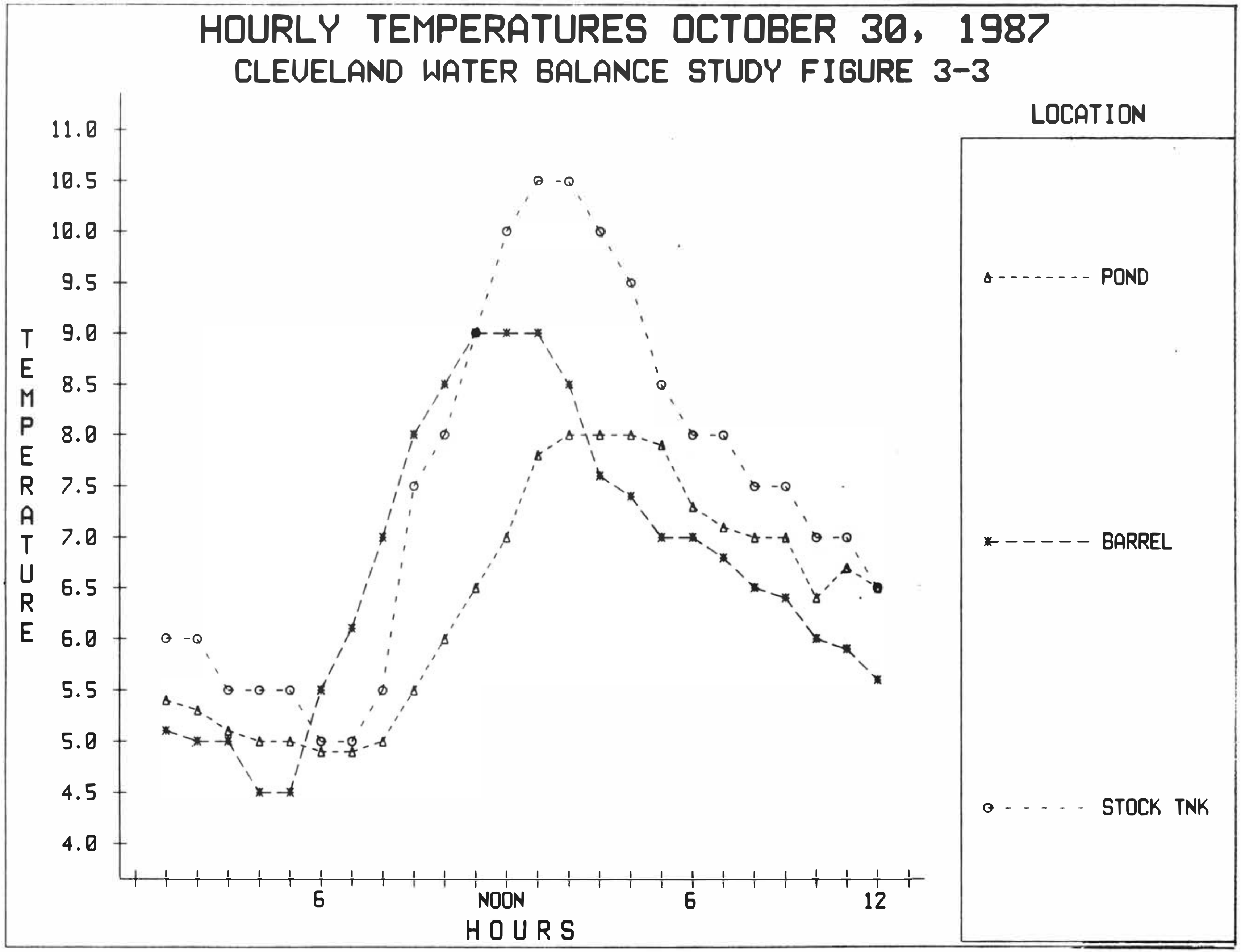
Table 3.1

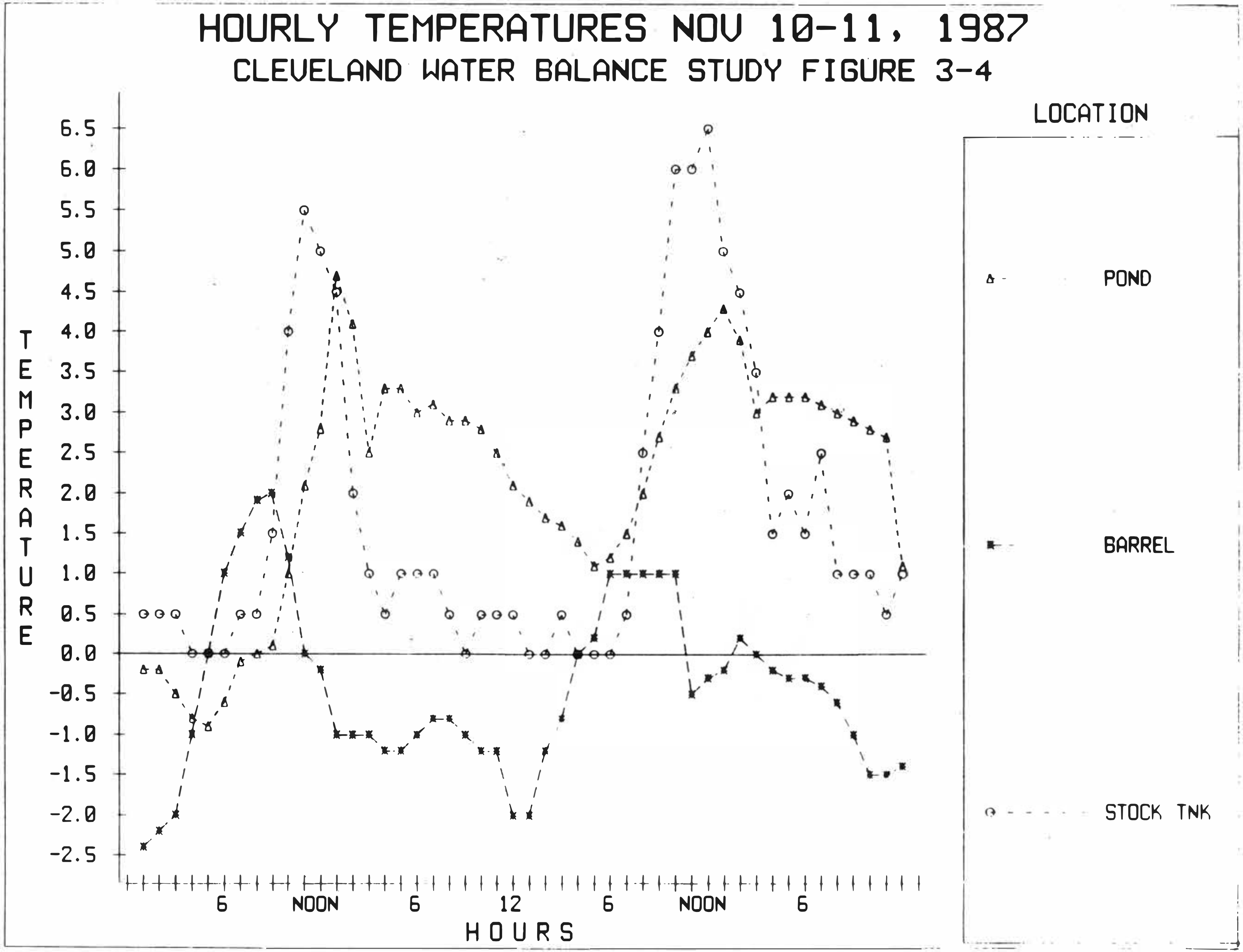
Date	Time	Temp°C	Date	Time	Temp°C	Date	Time	Temp°C
11/13/87	1:00 AM	3.7		1:00 AM			1:00 AM	
	2:00	3.8		2:00			2:00	
	3:00	2.5		3:00			3:00	
	4:00	3.0		4:00			4:00	
	5:00	3.8		5:00			5:00	
	6:00	3.7		6:00			6:00	
	7:00	4.4		7:00			7:00	
	8:00	5.1		8:00			8:00	
	9:00			9:00			9:00	
	10:00			10:00			10:00	
	11:00			11:00			11:00	
	Noon			Noon			Noon	

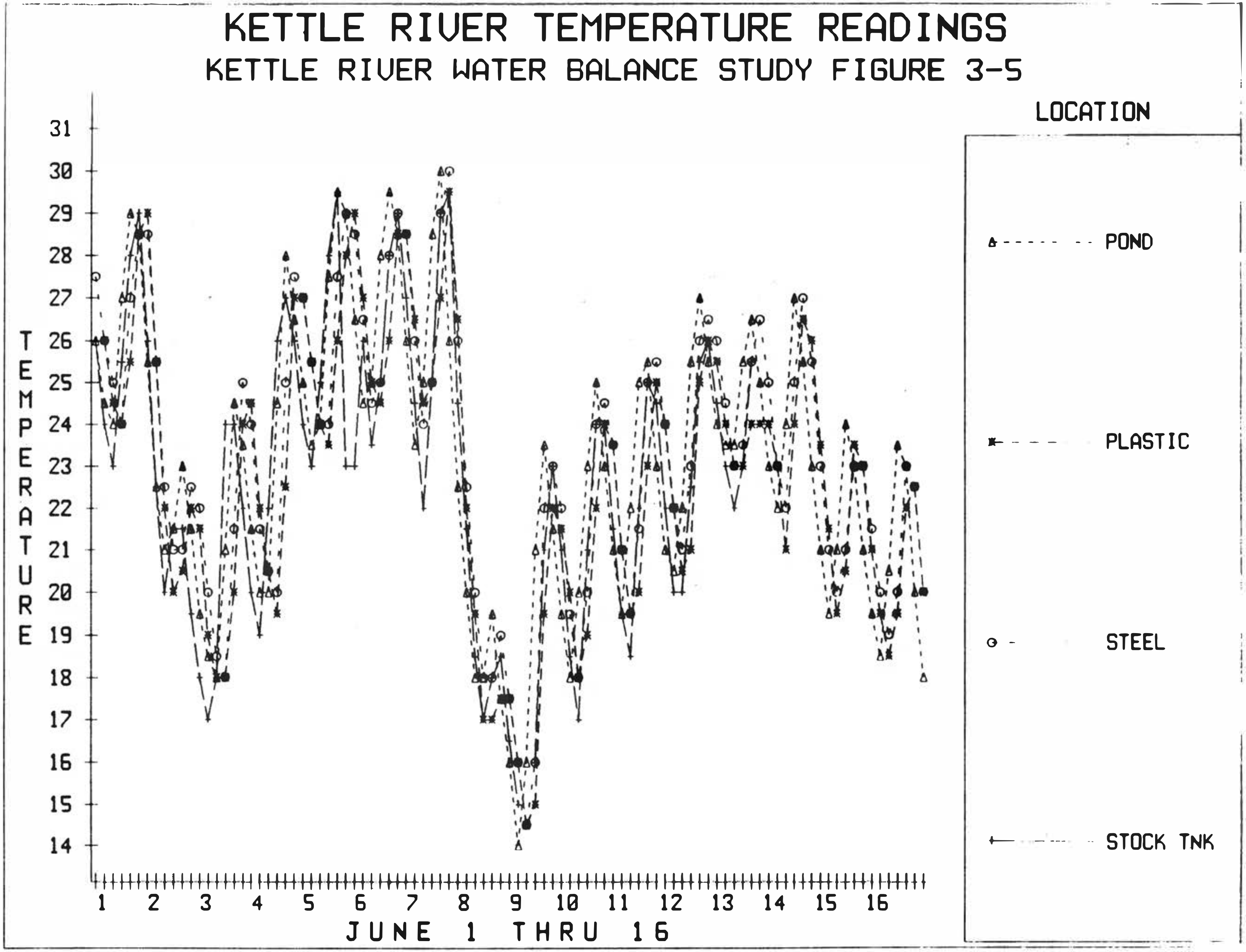


MAXIMUM AND MINIMUM DAILY TEMPERATURES
CLEVELAND WATER BALANCE STUDY FIGURE 3-1
TEMPERATURE
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
15 17 19 21 23 25 27 29 31 02 04 06 08 10 12
OCTOBER 14 THROUGH NOVEMBER 13
LOCATION
POND MAX
MIN
BARRELMAX
MIN
STOCK MAX
MIN


HOURLY TEMPERATURES OCTOBER 28, 1987
CLEVELAND WATER BALANCE STUDY FIGURE 3-2
TEMPERATURE
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
6
NOON
6
HOURS
LOCATION
POND
BARREL
STOCK TNK


HOURLY TEMPERATURES OCTOBER 30, 1987
CLEVELAND WATER BALANCE STUDY FIGURE 3-3
TEMPERATURE
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
6
NOON
6
12
HOURS
LOCATION
POND
BARREL
STOCK TNK


HOURLY TEMPERATURES NOV 10-11, 1987
CLEVELAND WATER BALANCE STUDY FIGURE 3-4
TEMPERATURE
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
6
NOON
6
12
6
NOON
6
HOURS
LOCATION
POND
BARREL
STOCK TNK


KETTLE RIVER TEMPERATURE READINGS
KETTLE RIVER WATER BALANCE STUDY FIGURE 3-5
TEMPERATURE
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
JUNE 1 THRU 16
LOCATION
POND
PLASTIC
STEEL
STOCK TNK

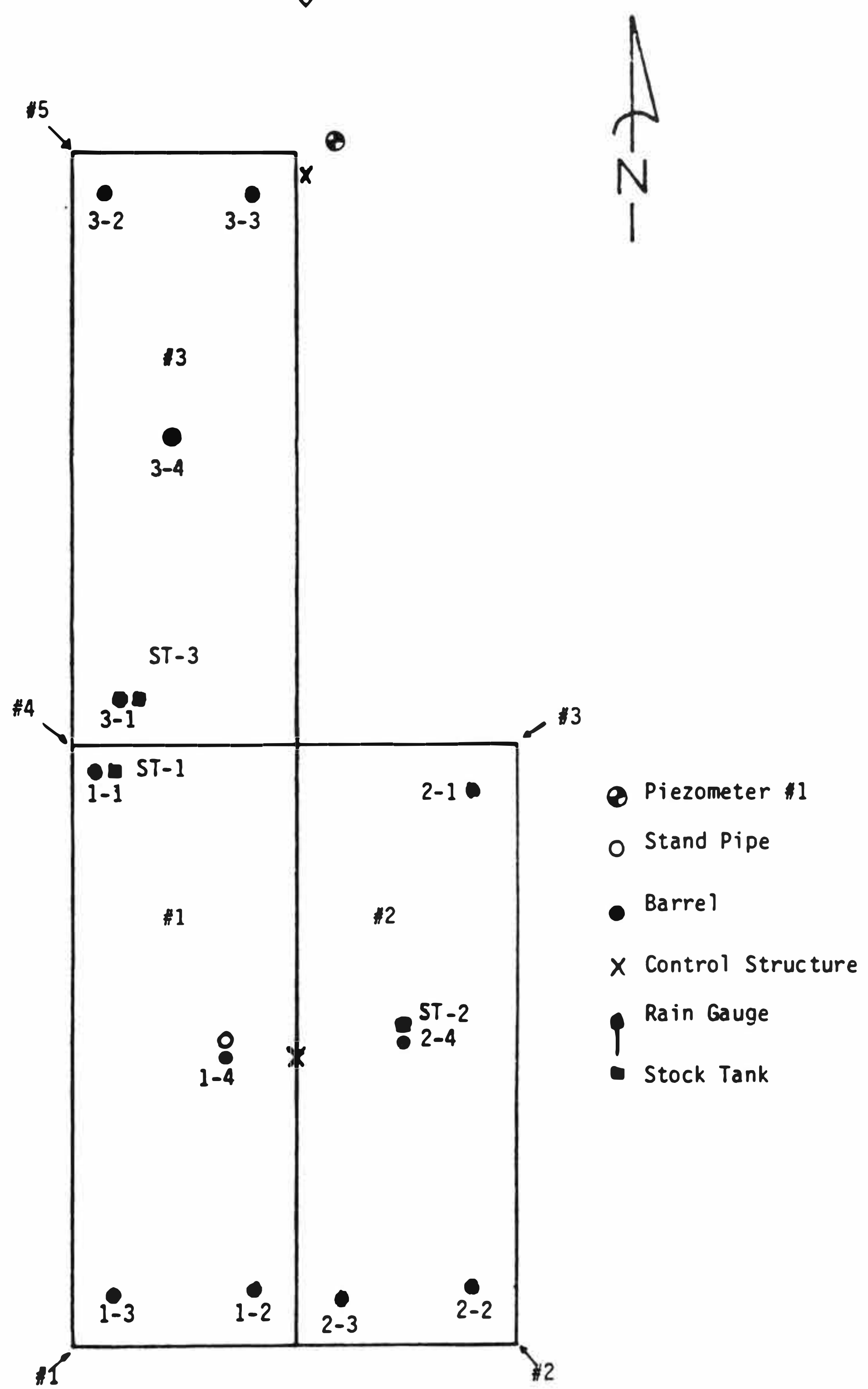
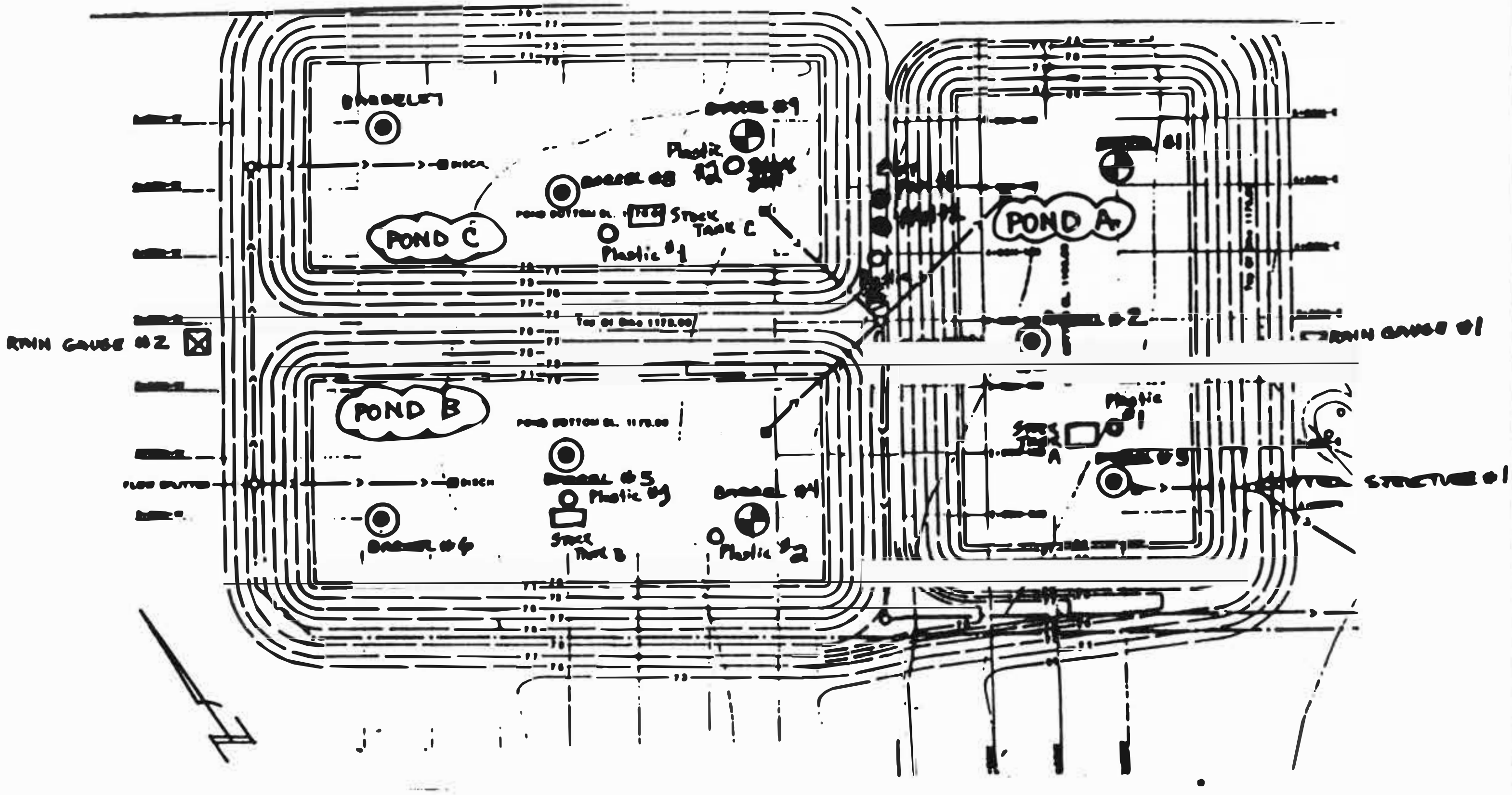


FIGURE 3.6

	JOB NO. 4900 87-641	SCALE: 1"=200'	DRAWN BY SG	CHECKED BY MS

FIGURE 3.7



NOTE: ABOVE BARREL LOCATIONS ARE APPROXIMATE.

Represents Anticipated Position of Evaporation Barrels

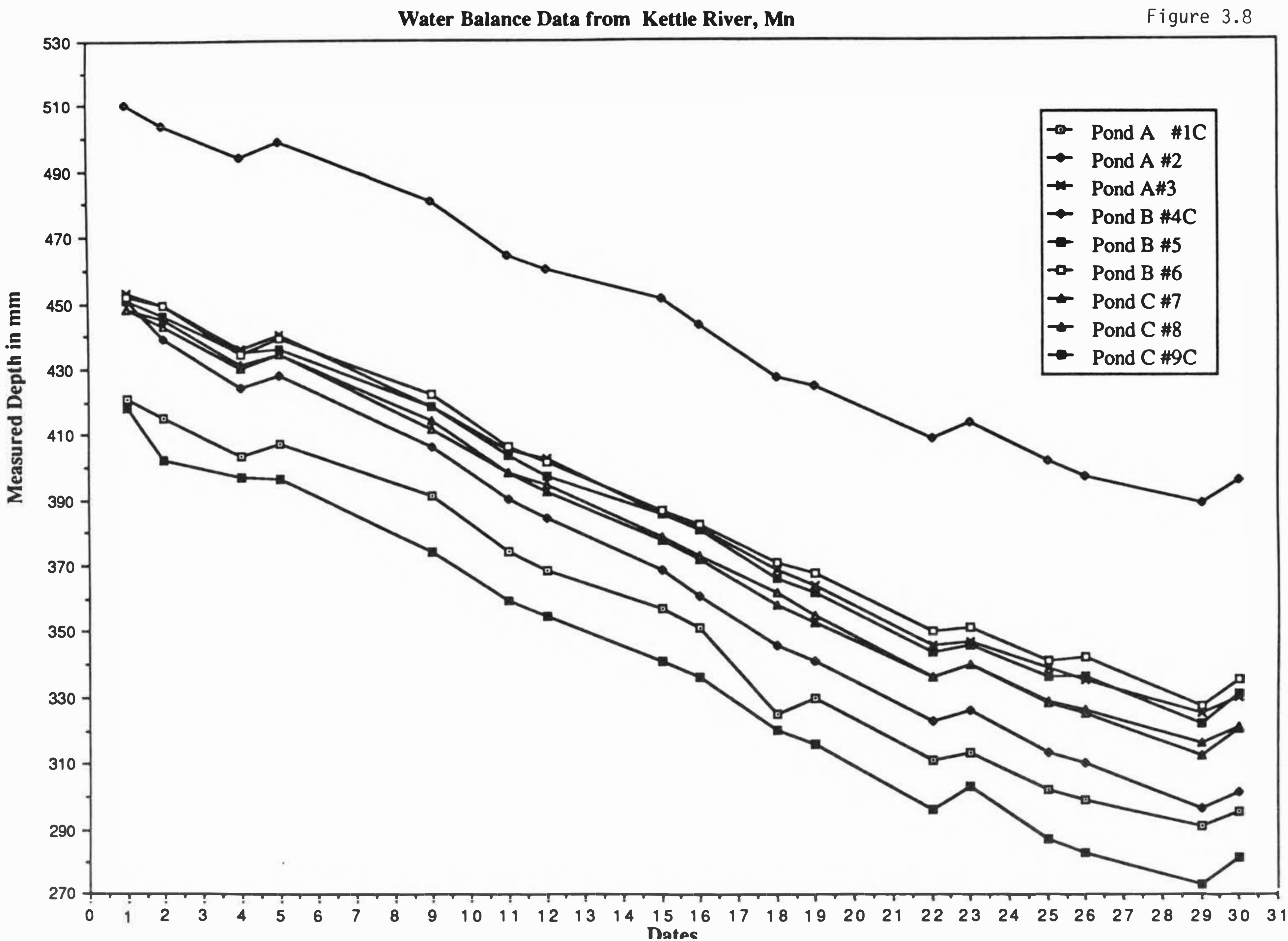
Represents Anticipated Position of Control Barrels

Represents Anticipated Location of Rain Gauges

BRAUN

N85-01 PROPOSED WATER BALANCE STUDY
Wastewater Stabilization Ponds
Kettle River, MN

Date:	10/12/87
Revised:	
Drawn:	TRB
Scale:	Layout Reduction


Water Balance Data from Kettle River, Mn
Measured Depth in mm
530
510
490
470
450
430
410
390
370
350
330
310
290
270
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Dates
Pond A #1C
Pond A #2
Pond A#3
Pond B #4C
Pond B #5
Pond B #6
Pond C #7
Pond C #8
Pond C #9C

KETTLE RIVER WATER BALANCE DATA RESULTS
FROM THE STUDENT T TEST CALCULATIONS

WATER BALANCE TASK FORCE DECEMBER 1988

Table 3.2

POND & PAN DATA	BARREL TYPE	T TEST NUMBER	n 1 n 2	DEGREE OF FREEDOM	SIGMA	t alpha/2 +/-	T	ASSUME NULL HYPOTH	NUMBER OF BARRELS
POND A EVAP PANS 1 & 2 0.6 RESV. COEF.	METAL	# 3	43 23	64	0	2.000	3.316	NO	4
	PLASTIC	# 3	22 23	43	0	2.021	1.033	YES	3
	STOCK	# 3	23 23	44	0	2.020	1.809	YES	3
POND B EVAP PANS 1 & 2 0.6 RESV. COEF.	METAL	# 3	43 23	64	0	2.000	3.905	NO	4
	PLASTIC	# 3	42 23	63	0	2.000	0.5932	YES	4
	STOCK	# 3	23 23	44	0	2.020	2.173	NO	3
POND C EVAP PANS 1 & 2 0.6 RESV. COEF.	METAL	# 3	46 23	67	0	1.999	3.570	NO	4
	PLASTIC	# 3	44 23	65	0	2.000	2.444	NO	4
	STOCK	# 3	23 23	44	0	2.020	1.961	YES	3
PLASTIC BARREL VERSUS PLASTIC DIKE BARREL	POND A	# 3	23 23	44	0	2.020	-0.6537	YES	2

KETTLE RIVER WATER BALANCE DATA RESULTS
FROM THE STUDENT T TEST CALCULATIONS

WATER BALANCE TASK FORCE DECEMBER 1988

Table 3.2

POND	BARREL TYPE	T TEST NUMBER	n 1 n 2	DEGREE OF FREEDOM	SIGMA	t alpha/2 +/-	T	ASSUME NULL HYPOTH	NUMBER OF BARRELS
A & C	METAL	# 4	46 46	90	0	1.990	0.141	YES	4
	PLASTIC	# 3	22 45	65	0	1.999	-0.497	YES	3
	STOCK	# 4	23 23	44	0	2.020	-0.076	YES	2
B & C	METAL	# 4	46 46	90	0	1.990	-0.328	YES	4
	PLASTIC	# 3	42 45	85	0	1.995	-0.209	YES	4
	STOCK	# 4	23 23	44	0	2.020	-0.315	YES	2
A,B & C	METAL PLASTIC	# 2	138 108	244	0	1.960	Z -2.459	NO	11
	METAL STOCK	# 2	138 69	205	0	1.960	Z -1.006	YES	9
	PLASTIC STOCK	# 2	69 108	175	0	1.960	Z -1.174	YES	8
EVAP PANS	0.6 COEF EVAP	# 4	11 12	21	0	2.080	-0.084	YES	2
1 & 2	0.7 COEF EVAP	# 4	11 12	21	0	2.080	-0.084	YES	2
	0.8 COEF EVAP	# 4	11 12	21	0	2.080	-0.084	YES	2

KETTLE RIVER WATER BALANCE DATA RESULTS
FROM THE STUDENT T TEST CALCULATIONS

WATER BALANCE TASK FORCE DECEMBER 1988

Table 3.2

POND	BARREL TYPE	T TEST NUMBER	n 1 n 2	DEGREE OF FREEDOM	SIGMA	t alpha/2 +/-	T	ASSUME NULL HYPOTH	NUMBER OF BARRELS
A	METAL	# 4	23 23	44	0	2.020	0.566	YES	2
	PLASTIC							YES	1
	STOCK							YES	1
B	METAL	# 4	23 23	44	0	2.020	0.080	YES	2
	PLASTIC	# 4	21 21	40	0	2.021	0.261	YES	2
	STOCK							YES	1
C	METAL	# 4	23 23	44	0	2.020	-0.019	YES	2
	PLASTIC	# 3	23 22	43	0	2.020	-1.168	YES	2
	STOCK							YES	1
A & B	METAL	# 4	43 43	84	0	1.970	0.461	YES	4
	PLASTIC	# 4	22 42	62	0	2.000	0.469	YES	3
	STOCK	# 4	23 23	44	0	2.020	-0.315	YES	2

4. SUMMARY OF RESPONSES TO QUESTIONNAIRE

A questionnaire for determination of what other regulatory agencies are doing to estimate seepage from wastewater treatment ponds, was sent to the 48 contiguous states, Alaska and the twelve provinces of Canada. After an initial response period, the task force members contacted all nonresponding agencies to make sure they had received the questionnaire and to ask whether the agency still wished to participate in the survey. Some questionnaires were filled out by the task force subgroup by phone. A total of 41 responses were received, including Minnesota.

Due to the nature of some of the questions and the fact that some states and provinces do not build ponds or do not participate to much degree in evaluating seepage rates, all the states do not have responses to all the questions. The summary generally counts a positive response. Other notes are made for each item in the questionnaire. Copies of the questionnaires received are available for review at the MPCA. The following are the questions asked, with a summary of the responses received.

#1 What is the current maximum allowable seepage rate for new stabilization ponds? Existing ponds?

The following was reported in gallons/acre/day or in inches equivalent to this:

gallons/acre/day	227	500	850	1000	1700	3400	4300	6800
no. of agencies	1	10	1	2	1	3	1	3

Five responded by specifying a permeability or hydraulic conductivity (K) of 1×10^{-7} cm/sec and do not specify a minimum liner thickness. One of these also specified a minimum liner thickness of 2 feet in conjunction with the K. Six responded by stating that they do not build ponds. The other seven responses ranged from none, to varies with ground water quality, and 20% of the inflow.

Responses about existing ponds were in three groups: The first group (twenty) could be characterized by the response of no maximum allowable seepage rate specified/case by case basis determination/or non-degradation requirements. A second group (fourteen) responded with the same requirements as new ponds. The third group (five) allowed seepage greater than new ponds - usually 1/4 to 1/16 of an inch which is approximately 1700 to 3400 gal. per acre per day.

#2 Is this rate based on state rules and regulations or agency policy?

	Rules and Regulations	Both	Agency Policy (design standards & guidelines)
No. of Agencies	9	1	23

#3 What testing methods do you allow and/or require to determine whether the seepage rate has been properly obtained? What party conducts these tests . . . engineers, contractor, soils testing firm, etc.?

The responses can be divided into the following categories: Of the Water Balance type (measuring infiltration over the whole area), we have Barrel or Evaporation pan and meteorological data collection. Eight responses indicated they would use or allow the barrel test and 14 would use the evaporation pan method. Two of these indicated they would use a floating pan.

For ASTM testing methods, there were 16 favorable responses. Other methods mentioned were in-situ permeameter, and ground water monitoring. Two responses indicated nothing specific was used. Two other responses indicated it was up to the engineer and stated in the specifications.

The second part of this question indicated that five agencies have the engineer assisted by the contractor, do the testing. Sixteen had the engineer in conjunction with an independent soil firm do the testing. One agency responded that the owner/contractor do the testing.

> #4 & #5 If water balances are used, how are rainfall and evaporation determined and used in determining the seepage rate? If the barrel method is used to measure evaporation/rainfall, what type of correction, if any, is used between the barrel and the pond to determine the seepage rate?

These two items are grouped together because of the nature of the responses. As indicated in #3, it seemed that the water balance was taken to mean the use of the barrel or collection of meteorological data. Ten responses indicated they would use some version of collection of precipitation and evaporation data using evaporation pans. Idaho sent very detailed requirements and a description of how to calculate results. Nine agencies would use or allow the use of the barrel method. Five agencies indicated direct correlation for either method.

> #6 What is your agency's role in quality control relating to the test and the testing techniques?

Generally, the response to this item indicates no role in quality control. A few responses indicated that they have some quality control by reviewing and approving the plans and specifications. Three responded that some observation of testing was done through construction inspection.

> #7 Do you allow or require engineers to use performance specifications, prescriptive specifications, or both for new stabilization ponds which must not exceed a specific seepage rate?

We felt the answers to this question were difficult to interpret. In general, the choice was not made between the words allow or require. Require was used in 11 responses. They were divided as follows: performance - 7, prescriptive (design) - 1, both - 3. When the word require was not stated, we interpreted this to mean allow. The results were performance - 11, prescriptive (design) - 5, and both - 13.

> #8 Approximately how many new pond systems are installed each year? Approximately what percentage of these fail to meet the proper seepage rate?

Under this question, some agencies included lagoons for livestock manure or stated "all categories," which would include industrial. Some separated grant from nongrant. We created some groups of ranges for these numbers of ponds constructed per year.

No. of Ponds	1-3	4-10	11-20	25	100-125
Agencies	9	10	9	2	2

Of these, the range given for failure rate was:

No. of Ponds Failing	0-10%	10-25%	30-50%	Unknown
Agencies	7	3	3	13

Other responses included were: any failures are corrected, 15-30% need extra effort, and all are synthetic.

#9 Approximately how many existing ponds are tested each year? Approximately what percentage of these fail to meet the proper seepage rate?

There was little response to this question. It would appear not much is done in the line of testing older ponds for seepage.

#10 Do you have strict guidelines for your agency's staff to use when reviewing seepage rate data to determine whether the proper rates have been obtained? Who reviews the seepage reports? Do these reviewers have flexibility to use their discretion, judgement or risk analysis in determining if the seepage rate was properly met?

Four agencies do and nineteen do not have strict guidelines for review of reports.

Fourteen indicated reviews done by the agency's project engineer or field staff/inspection department. Three stated that no one did reviews. Two had reviews done by consulting engineers. Two other stated it varies.

Seventeen indicated staff had discretion, while one replied they did not.

#11 What corrective measures must be taken if the seepage rate fails to meet the prescribed limits? Please list some examples of what has been done to correct a problem situation.

The following responses were given:

- additional seepage control/whatever is necessary to meet specifications
- N/A - little regulatory control
- engineers discretion
- negotiation
- no final payment
- no measures specifically required
- depends on the specific situation
- seams are corrected after failing

Examples of methods used to correct a problem were:

- dewater and reline
- bentonite slurry or drain and mix bentonite in soil
- drain, recompact and cover with asphalt
- cement/concrete
- additional soil or soil importation
- drainage interceptor trenches with pumping
- cutoff walls
- chemical sealant
- abandon lagoon
- synthetic collars around structures
- attempt by engineer to show that fractured bedrock in a steep sided lagoon was impermeable
- improved surface drainage
- purchase adjoining land

#12 Have any court cases resulted due to a pond not meeting the proper seepage rate? If so, what was the outcome of the case(s)?

No Court Case	Have Court Case	Settled Out of Court
23	5	6

Four of the 5 responding "yes," indicated pending decisions or still in court, while one stated the engineer had to disperse the costs.

The Task Force was interested in the legal aspects with regard to performance and/or descriptive (prescriptive) specifications. Interest in this aspect of pond construction by the MPCA stems from our requirements for using both descriptive and performance specifications. In other words, if both are used, how is this treated in court if a contractor meets one and not the other? We were able to contact five of the six agencies reporting cases, however, none of the cases pertained to descriptive and/or performance specifications. So, the states and provinces which stated they had a court case were contacted again.

In the case for which it was stated that the engineer had to disperse the costs, the ponds visibly leaked.

#13 Do you have specific guidelines on how the tests must be run, data collected, and results submitted? If you have any written rules, guidelines or criteria related to seepage rates, seepage test procedures, specific soil requirements for liner construction, etc. Please enclose copies of them when you return the survey.

No	Yes	Some
3	18	1

The following is a list of the states and provinces responding to the questionnaire.

Utah
Colorado
Virginia
Illinois
British Columbia
Alaska
Michigan
Manitoba
Rhode Island
Kentucky
Massachusetts
Saskatchewan
New Hampshire
Maine
Idaho
New York
Wisconsin
Missouri
Florida
Montana
Alabama
Georgia
Texas
Kansas
Oklahoma
Quebec
North Dakota
Alberta
Iowa
Wyoming
New Brunswick
Pennsylvania
North Carolina
Nebraska
West Virginia
Mississippi
Delaware
Connecticut
Newfoundland/ Labrador
Nevada

5. ASSESSMENT OF COMBINATION PERFORMANCE/PRESCRIPTIVE SPECIFICATIONS

Introduction

In the 1960's and early 1970's, stabilization pond design criteria required only that pond seal maintain a satisfactory water level in the pond. Since 1975, Minnesota stabilization pond design criteria has required that pond liners limit seepage to a maximum rate of 500 gallons per acre per day. This seepage rate was set in an attempt to minimize groundwater contamination. This current allowable maximum seepage rate is equivalent to one inch of seepage every 54 days.

Historically, stabilization pond designers have written combination performance/prescriptive specifications (i.e., simultaneous use of performance and prescriptive specifications). The performance specification required the completed stabilization ponds to meet the maximum allowable seepage rate, with the rate determined by the Minnesota Water Balance Test. The prescriptive specification, also known as a "design" or "detail" specification, specifically established minimum work procedures and tasks necessary to construct the stabilization pond seals. Unfortunately, when both performance and prescriptive requirements are cited, the potential for conflict is present.

The Water Balance Task Force completed a study of the implications of using combination performance/prescriptive specifications for stabilization pond liners. The major issues researched included:

- Evaluation of responsible parties involved in stabilization pond construction.
- Potential problems associated with simultaneous use of performance and prescriptive specifications.
- Legal implications of using combination specifications.
- Alternatives to simultaneous use of performance and prescriptive specifications.
- Identification of possible improvements to the current practice.

The following contains a discussion of each of these major issues.

Evaluation of Responsible Parties

In a typical stabilization pond situation, many parties share responsibility for a project's success or failure. Obviously, the Engineer that designs and the Contractor that builds a stabilization pond share primary project responsibility. However, the Engineer typically will rely upon a goetechnical subconsultant to provide specialized expertise - especially on clay sealed pond projects. The Contractor, likewise, may use subcontractors to construct portions of the work. Typically, an earthwork subcontractor may construct a clay liner or an experienced synthetic membrane liner installer may construct ponds sealed with man-made materials. In addition, the MPCA is indirectly involved in the design of stabilization ponds through creation of design guidelines and review of project plans and specifications. And, of course, the City, as the owner and permit holder, is always responsible for achieving a properly constructed project.

Potential Problems

Generally, there are only two types of stabilization pond performance tests - comprehensive tests, such as the Minnesota Water Balance Test, and spot tests, such as permeability tests for clay liners and seam tests for synthetic membrane liners. Unfortunately, both types of performance tests have good as well as bad points.

The most significant bad aspect of the water balance test is that a large number of factors may combine to yield a large standard deviation. The factors which contribute to the deviation include water level measurement errors, rainfall runoff assumption errors, and evaporation rate differences between the ponds and the barrels. The most significant good aspect of the water balance test is that the entire liner is tested.

Spot tests do not test the entire seal but the deviation range is much smaller at the spot tested. The margin for error is reduced as the the number of spot tests is increased, but some potential margin for error is inherent with all spot test methods. Spot test errors are typically due to the non-homogeneous nature of clay soil liners and the non-uniform seam quality typically found on synthetic membrane liners.

Therefore, both types of stabilization pond performance testing have a deviation range and for this reason, it is possible for projects to appear to exceed specified performance limit - even though the project is designed, specified, and constructed properly. Conversely, it is also possible for projects to appear to meet the specified performance limit - even though the pond system may be leaking. Due to the margin of error of pond performance tests, as described in the above scenarios, the potential for conflict between performance and prescriptive tests always exists.

Legal Implications

The primary concern of all responsible parties is whether corrective work is legally enforceable in the following situation. A Contractor may perform all prescriptive requirements perfectly, all interim testing may indicate acceptable work, all inspections may look good, and the Engineer's specification may not be faulty, but still the final water balance test may indicate that the ponds appear to exceed the maximum allowable pond seepage rate. The Contractor at this point would not have met the performance requirements of the specification, would be required to correct the problem, and would need to retest the pond to prove compliance with the performance specification. The source of the excessive seepage is unknown (and possibly may not be present), the cost of trying to locate, correct, and retest a failing pond may be very great.

Attorneys David Sand and Thomas Larson, of the law firm of Briggs and Morgan, addressed this specific question at the November 18, 1987 meeting of the CEC/MPCA Water Balance Task Force. They stated that in cases where both prescriptive and performance requirements were specified, the tendency of the legal system is to provide relief to a Contractor who had properly met all detailed requirements of the contract, but was unable to meet the performance requirement. Also, in cases of specification ambiguity, relief is generally provided to the Contractor, because he did not prepare the specifications. The remaining parties, the City, Engineer, Geotechnical Subconsultant, and MPCA, may then become directly responsible for correcting pond systems which appear to be leaking.

The legal implications, therefore, of simultaneously using performance and prescriptive specs, are undesirable. This is especially true for stabilization ponds, because the reliability of the various performance test methods unquestionable. Therefore, the simultaneous use of both performance and prescriptive specifications on stabilization pond projects could create a situation that is difficult to enforce. The question remains is there on acceptable alternative?

Alternatives

The most apparent alternatives to the simultaneous use of performance and prescriptive specifications is exclusive use of one or the other.

A performance specification without prescriptive requirements is not an acceptable alternative because we lack suitable performance tests and it provides the Contractor too many options and doesn't provide the Engineer/Owner/MPCA adequate control over the project. Contractors faced only with a performance specification may have the option to construct a liner from on-site soils, borrow materials, or synthetic membrane materials. The risk is too great that a contractor selected by the low bid system would build a project that didn't work, then go bankrupt and result in loss of time and money for the City, MPCA and EPA. As the construction progressed and/or as the construction was completed, performance tests would be conducted to determine whether the project met the specified performance criteria. Due to the margin of error of water balance testing methods, the performance testing may not accurately reflect the actual seepage rate of the pond system. For the above reasons, exclusive use of performance specifications would not be acceptable.

Contractors faced only with a prescriptive specification would be required to follow specified steps and/or procedures during construction of the project. Continuous inspection would be provided to ensure that each of the steps and procedures is performed properly. This type of specification would not require performance test criteria to be met.

The basic problem with this type of specification is an inability of the responsible parties to prove that the completed pond system does not negatively impact the underlying groundwater. State rules require non-degradation of ground water and the success of a project is determined to a large extent by verification of non-degradation. Exclusive use of prescriptive specifications is not an acceptable alternative because only a small percentage of the total project is spot tested.

Therefore, since exclusive use of either performance or prescriptive specifications does not appear to be a viable alternative, the responsible parties associated with pond projects must attempt to reduce the possible problems associated with simultaneous use of performance and prescriptive specifications.

Possible Improvements to Current Practice

Assuming that the current practice of specifying both performance and prescriptive requirements will continue, it is important that steps be taken to minimize the possibility of incorrectly assessing success or failure of stabilization pond projects. To reduce this possibility, it is imperative that the current pond seal performance criteria be evaluated and revised as necessary.

Currently, pond seal performance is evaluated by use of the Minnesota Water Balance Test. Therefore, an obvious first step toward accurately evaluating pond seal performance would be to increase the accuracy of all component factors involved in water balance tests. Methods for standardizing the test are contained in Chapter 8.

Some prescriptive specifications spot indicators of pond seepage rates include gradation tests, moisture content tests, field density tests, plasticity indices, Atterburg Limits, lab or field permeability tests, and visual inspection of clay liner installations. Synthetic membrane liners, spot indicators include physical property tests on the liner, lab or field seam tests, and visual inspections. The minimum spot indicators, as recommended by the MPCA, are contained in other publications concerning pond design. Improvements in these spot indicators can be made as deficiencies are identified.

In summary, many parties share responsibility for successful stabilization ponds, either directly or indirectly. It is possible for projects to appear to exceed the maximum allowable seepage rate, even though the project is designed, specified, and constructed properly. Conversely, it is also possible for projects to appear to meet the specified performance limit, even though the pond system may be leaking.

The legal implications of using combination performance/prescriptive specifications are undesirable, but no viable alternatives have been identified. Therefore, it is essential to improve the accuracy of the water balance tests, carefully analyze the reliability of the test, and develop spot testing methods to evaluate stabilization pond performance.

6. STATISTICAL ANALYSIS FOR SIX WATER BALANCES

Purpose

The purpose of this analysis is to estimate the relative effect of several factors on the outcome of the water balance test. Factors selected for the study include precipitation, temperature, wind speed, number of days in the test period and variation among barrels in the same pond and among ponds at the same location.

Historically seepage for the Minnesota Water Balance has been calculated as:

$$S = - WL + R$$

where:

WL is the change in the pond level minus the change in the barrel level over the test period, and

R is runoff into the ponds from the pond dikes due to rainfall calculated over the test period.

WL is the element of the equation which varies among barrels within the same pond and among ponds. There may be some variation in runoff among ponds due to differences in water and runoff areas, but since runoff is calculated only once for a pond, there is no variation in runoff among barrels within the same pond. Each day pond levels were corrected for runoff.

A statistical procedure called Analysis of Variance (ANOVA) was used to analyze the relative importance of each of several factors (independent variables) to explain variations in the dependent variable, WL.

The focus of the analysis was to explain the variation in calculated "WL's" as a function of variation among ponds, variation among barrels within each pond, cumulative precipitation, and cumulative days of the test.

Pond and barrel within pond are called class variables. Cumulative precipitation and cumulative days of the test are continuous; they are called covariates.

Questions to be addressed include 1) Was there a significant difference in WL among barrels and if so, how many barrels were needed to provide a statistically reliable estimate of WL, and 2) Was there a significant difference in WL depending on how many days were used and, if so, how many days were needed to provide a statistically reliable estimate of WL.

Data Used

Data from water balance studies at six locations were coded onto a standardized coding sheet and entered into the computer. These locations were Cleveland, Onamia, Carver City, Elko-New Market, Blackduck and Tower-Breitung. Data elements entered for each location were 1) dates on which any information was collected, 2) daily precipitation, if any, 3) daily wind speed, if available and 4) daily temperature. Data elements entered for each date, for each pond, were 1) pond number, 2) level of water in the pond expressed as inches and 32nds of an inch and 3) pond temperature. At Elko-New Market and Blackduck, there were two control structures and thus two sets of measurements for level of water in the ponds. Data elements entered for each date, for each barrel, were 1) barrel number and 2) level of water in the barrel expressed as inches and 32nds of an inch.

After the data was entered, a series of calculations was done. All water level measurements were changed from inches and 32nds of an inch to inches expressed as decimal values. Pond levels for each day were corrected for runoff into the ponds from the pond dikes. This correction took into account all estimated runoff up to that day. The runoff correction was a function of precipitation, dike area, pond area, and runoff coefficient. For each water level measurement, the change in water level since the most recent measurement and the change since the initial measurement were calculated. The number of days since the most recent measurement and since the initial measurement were also calculated, as was the cumulative precipitation to date. The variable WL was defined for the purpose of this analysis to be, for any given date, the most recent change in pond level minus the most recent change in barrel level. The variable CUMWL was cumulative WL, that is the change in the pond level minus the change in the barrel level over the period of the study. Since the runoff correction is incorporated in each day's pond level measurement, the variable CUMWL is equivalent to WL - R in terms of the above formula for calculating seepage.

A listing of this complete data set for Cleveland, with definitions of the data elements, is found in Appendix C. Data for the other locations is available from the MPCA.

Testing Analysis of Variance Assumptions

The data representing the dependent variable must be normally distributed if the Analysis of Variance procedure is to be used. The Statistical Analysis System (SAS) UNIVARIATE procedure was used to test for normal distribution of CUMWL values. For those locations where there were two control structures, there were two sets of CUMWL values; whereas for those locations with only one set of pond measurements, there was one set of CUMWL values. Neither the CUMWL values nor the log transformations of these values were normally distributed.

Since there were some negative CUMWL values for which log transformations could not be done, the next step was to adjust CUMWL by adding a constant to all values so that there were no negative values. Neither the adjusted values nor the log transformation of the adjusted values were normally distributed.

The next step was to separately test for normality of CUMWL values each location. This approach was slightly more successful, as described in the next section.

The original analysis plan also assumed that the number of barrels per pond, number of days per pond and the dates used for the test would be the same for all ponds at any given location. As can be seen in Table 6.1, this was not the case. Also, the data from Carver City, which had only one barrel per pond, will give no information about variation among barrels.

Analysis by Location

As indicated above, CUMWL values were tested for normality and separately for each location. These values were first adjusted to remove negative values and then the adjusted values and the log transformations of the adjusted values were tested for normality. Two tests for normality were done. Both the adjusted CUMWL and the log transformation of the adjusted CUMWL at Cleveland were normally distributed according to at least one of these tests. These values were not normally distributed at any other locations.

An analysis of variance was performed to explain the variation in adjusted CUMWL and log adjusted CUMWL as a function of several factors of interest. Results of this analysis are given in Table 6.2.

The Analysis of Variance procedure is used to explain the variation in adjusted WL as a function of the four independent variables 1) variation among ponds, 2) variation among barrels within each pond, 3) cumulative precipitation and 4) cumulative days of the test. The sum of squares total, in this case 43.6214, is a measurement of variation in adjusted WL. The sum of squares model, in this case 26.5120, is a measurement of variation in adjusted WL which can be explained by the model (that is, by the four independent variables). The proportion of variance in adjusted WL which is explained by the model is the R-square value, in this case 0.6078. In general, the larger the R-square value, the better the model fits. The F value on the top line Of table 6.2 how well the model, as a whole, accounts for variation in the dependent variable. The value under PR > F gives the significance level. In this case, the model variables as a group have a significant effect on adjusted WL at the p=0.0001 level. This is a very significant effect.

The portion of the table for ADJWL (below the first line) examines the effect of each of the independent variables or sources of variation. The values in the Type I SS (sum of squares) column add up to the model sum of squares. The PR > F gives the significance level for each effect. In this case, variation among ponds, among barrels and due to cumulative precipitation are all significant at the 0.01 level. That is, they are all very significant contributors to the variation in adjusted WL. The effect of cumulative days is not significant at the 0.05 level. This may be because days were included in which there was precipitation, but no barrel or pond level measurements. The adjusted WL used in this analysis does use the pond level which has been corrected for estimated runoff from the dikes.

The columns in Table 6.2, headed type III SS (sum of squares), F and PR > F (probability of an F-statistic greater than the given value, i.e., significance level) give analogous information "adjusted" for variation in cumulative days. The effects of variation among ponds and among barrels are still very significant. The effect of cumulative precipitation is no longer significant.

TABLE 6.1 WATER BALANCE TEST DATA

Location	Ponds	Barrels Per Pond	Total Precipitation	Total Days
Blackduck	1 2 values each	3	0.44	28
Carver City	3	1	Different months 1.02 5.51 0.45	32
Cleveland	3	3,4,4	0.96 (average of five gauges)	30 for 3 barrels 28 for 4th barrel
Elko-New Market	3 2 values each	3	2.63	31--ponds 1,2 28--pond 3
Onamia	3	3	Different months 6.82 2.87	34--pond 1 27--ponds 2,3
Tower-Breitung	1	6	2.32	32

TABLE 6.2 ANALYSIS OF VARIANCE RESULTS

CLEVELAND
ADJUSTED WL

DEPENDENT VARIABLE: ADJWL

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	12	26.51204973	2.20933748	42.35	0.0001	0.607776	2.4350
ERROR	328	17.10938336	0.05216275		ROOT MSE		ADJWL MEAN
CORRECTED TOTAL	340	43.62143309			0.22839167		9.37934327

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
PONDNO	2	3.49502216	33.50	0.0001	2	3.49502216	33.50	0.0001
BNO(PONDNO)	8	21.89877615	52.48	0.0001	8	21.89877615	52.48	0.0001
CUMPREC2	1	1.02415407	19.63	0.0001	1	0.04117922	0.79	0.3749
CUMDAY	1	0.09409734	1.80	0.1802	1	0.09409734	1.80	0.1802

LOG TRANSFORMATION OF ADJUSTED WL

DEPENDENT VARIABLE: LADWL

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	12	0.30363765	0.02530314	43.04	0.0001	0.611605	1.0835
ERROR	328	0.19282308	0.00058788		ROOT MSE		LADWL MEAN
CORRECTED TOTAL	340	0.49646073			0.02424614		2.23778227

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
PONDNO	2	0.03910216	33.26	0.0001	2	0.03910216	33.26	0.0001
BNO(PONDNO)	8	0.25298450	53.79	0.0001	8	0.25298450	53.79	0.0001
CUMPREC2	1	0.01057301	17.99	0.0001	1	0.00042131	0.72	0.3979
CUMDAY	1	0.00097797	1.66	0.1980	1	0.00097797	1.66	0.1980

This reflects the fact that once the number of cumulative days is known for a given location, the cumulative precipitation is also known-- it explains no additional variation.

The results of the analysis of variance using log transformation of the adjusted WL gives similar results. The R-square value is slightly larger, 0.6116, indicating that the model using the log transformation shows a slightly better fit.

Although the analysis of variance for Cleveland indicates that there is a significant difference among barrels within a pond, it still does not provide the information needed to determine how many barrels are needed for a reliable estimate. This is true since none of the other factors are held constant. The recommended number of barrels will be discussed later in the chapter.

Testing Regression Assumptions

The next step was to estimate the seepage rate and the precision of this estimate, using the least squares regression method. This method uses barrel level measurements and pond level measurements. Use of this regression method also assumes that the data used is normally distributed. Since the regression is done for each barrel and pond separately, the normality of barrel level measurements and of pond level measurements is done for each barrel and pond separately. At four of the six locations, Cleveland, Onamia, Blackduck, and Tower-Breitung, barrel level measurements are normally distributed and pond level measurements are normally distributed. At Carver City and Elko-New Market, there are mixed results. Since it appeared that usually the measurements were normally distributed, the decision was made to perform the regression analysis.

Estimation of Regression Lines

The least squares regression method (also called the slope method), for estimating mean seepage rate calculates 1) a least squares regression line for pond level (corrected for runoff) over time and a confidence interval for that line and 2) a least squares regression line for barrel level over time and a confidence interval for that line. The difference between the slopes of the two regression lines times a conversion factor gives the estimate of mean seepage rate. The confidence interval for the difference between the slopes times a conversion factor provides the estimate of confidence interval for the mean seepage rate. The details for these calculations are found in Appendix D.

The best fitting regression line for barrel level by day was calculated first using each barrel separately. Next, a t-Test was done to determine which barrels within the same pond had regression line slopes that were not significantly different. The regression lines for barrel level by day, were then calculated for the expanded combinations of barrels. Using these combinations of barrels, the seepage rate and the confidence interval of the seepage rate were calculated. The confidence interval is a measurement of how precisely the seepage rate can be calculated.

Table 6.3 gives the estimates of the seepage rate and the corresponding confidence intervals for each barrel in each pond. Results are also given across barrels, for those combinations of barrels which resulted in a reduction of the confidence interval. The smaller the confidence interval, the more precise the estimate.

As shown in Table 6.3, there were eleven ponds with more than one barrel per pond. Of these eleven ponds, three had two or more barrels which could be combined and which resulted in an improvement in the confidence interval. These were Onamia (pond 1), Blackduck (only one pond) and Tower-Breitung (only one pond). Even in these cases, the confidence interval for combined barrels was only about +/- 100 less than the smallest confidence interval for a single barrel in that pond.

Whenever a t-Test indicates that the slope of the regression lines for two different barrels are not significantly different, the information for the two barrels can be combined. The results from the single barrel and from the combined barrels should be compared and the results which show the smallest confidence interval, that is, the most precise estimate of seepage rate, should be used. Variation among barrels may be due to a number of factors including location, wind and measurement procedures. It does emphasize the importance of standardizing measurement procedures, as one way of controlling the variation.

Table 6.3 also shows the correlation coefficients for 1) barrel level with time and 2) pond level with time. This value is an indication of how well the least squares regression line reflects the data. A value of 1.0 reflects a perfect straight line relationship between level and time; a value of 0.0 reflects no relationship between level and time. As a rule of thumb, if the correlation coefficient is less than .80, the data should be further examined to determine possible reasons for the lack of relationship. When results from barrels in the same pond differ, the results from those barrels with the higher correlation coefficients should be used.

Using the guideline of an acceptable seepage limit of 500 and an acceptable confidence interval of +/- 1000, the upper limit of the confidence interval should not exceed 500 + 1000, or 1500. Using all of the information in Table 6.3, we can determine whether these ponds would pass or fail the water balance test as follows:

In Blackduck, the upper limit of the confidence interval for the seepage rate is never greater than +1500, and the correlation coefficients are high. The pond passes.

In Carver City's pond 1, the upper limit of the confidence interval is 754 + 1060, or 1814. The correlation coefficient is acceptable, so the data can be used. This pond would fail. The decision to fail the pond, using the method described in this report, agrees with the decision that was actually made for this pond.

In Carver City's pond 2, the test passes, but the correlation coefficient is a little lower than desirable. Unfortunately, there were measurements for only one barrel in this pond, so it was not possible to select barrels with higher

TABLE 6.3 ESTIMATES OF SEEPAGE RATES WITH CONFIDENCE INTERVALS OF THE ESTIMATES FOR SIX LOCATIONS

BLACKDUCK

Only pond measurement 2 was used, since there was no pond measurement 1 on some days when there was a barrel measurement

	Pond 1			Barrels 1 and 2 combined
	Barrel 1	Barrel 2	Barrel 3	
Seepage Rate	-590.92	-237.58	-1004.88	-414.25
Confidence Interval	+/-788.51	+/-717.98	+/-825.77	+/-640.54
Correlation of barrel level with time	.99	.99	.99	.99

Correlation of pond level with time .99

CARVER CITY

Only one barrel per pond

	Pond 1
Seepage Rate	754.43
Confidence Interval	+/-1059.95
Correlation of barrel level with time	.95

Correlation of pond level with time .95

	Pond 2
Seepage Rate	-109.09
Confidence Interval	+/-1172.04
Correlation of barrel level with time	.76

Correlation of pond level with time .75

	Pond 3
Seepage Rate	-788.71
Confidence Interval	+/-400.17
Correlation of barrel level with time	.97

Correlation of pond level with time .95

TABLE 6.3. continued

CLEVELAND

Pond 1

	Barrel 1	Barrel 2	Barrel 3	Barrel 4
Estimates Seepage Rate	-575	-364.3	-360.57	
Confidence Interval	+/-294.14	+/-379.52	+/-295.41	
Correlation of barrel level with time	.98	.93	.97	

Correlation of pond level with time .91

Pond 2

	Barrel 1	Barrel 2	Barrel 3	Barrel 4
Seepage Rate	- 67.68	-454.55	-583.79	33.21
Confidence Interval	+/-436.11	+/-409.33	+/-378.75	+/-384.12
Correlation of barrel level with time	.90	.95	.97	.93

Correlation of pond level with time .88

Pond 3

	Barrel 1	Barrel 2	Barrel 3	Barrel 4
Seepage Rate	85.81	416.50	308.08	- 63.16
Confidence Interval	+/-308.35	+/-346.56	+/-328.12	+/-301.20
Correlation of barrel level with time	.97	.90	.93	.98

Correlation of pond level with time .93

TABLE 6.3. continued

ELKO-NEW MARKET

Pond 1	Barrel 1 Pondlev1	Barrel 1 Pondlev2	Barrel 2 Pondlev1	Barrel 2 Pondlev2	Barrel 3 Pondlev1	Barrel 3 Pondlev2
Estimates Seepage Rate	-560.37	-133.89	1170.21	1596.69	- 64.93	361.52
Confidence Interval	+/-809.79	+/-844.96	+/-724.70	+/-763.81	+/-718.98	+/-758.38
Correlation of barrel level with time	.82		.43		.82	

Correlation of pond level with time Pondlev1 .78 Pondlev2 .82

Pond 2	Barrel 1 Pondlev1	Barrel 1 Pondlev2	Barrel 2 Pondlev1	Barrel 2 Pondlev2	Barrel 3 Pondlev1	Barrel 3 Pondlev2
Seepage Rate	3519.70	3923.72	2801.48	3205.50	-705.81	-301.78
Confidence Interval	+/-721.17	+/-767.74	+/-1023.25	+/-1056.59	+/-781.81	+/-824.96
Correlation of barrel level with time	.87		.56		.77	

Correlation of pond level with time Pondlev1 .62 Pondlev2 .69

Pond 3	Barrel 1 Pondlev1	Barrel 1 Pondlev2	Barrel 2 Pondlev1	Barrel 2 Pondlev2	Barrel 3 Pondlev1	Barrel 3 Pondlev2
Seepage Rate	1132.72	1452.92	2173.34	2493.54	-208.84	111.35
Confidence Interval	+/-413.59	+/-433.75	+/-580.90	+/-595.40	+/-349.44	+/-373.05
Correlation of barrel level with time	.92		.60		.98	

Correlation of pond level with time Pondlev1 .98 Pondlev2 .98

TABLE 6.3, continued

ONAMIA

Pond 1	Barrel 1	Barrel 2	Barrel 3	All 3 barrels combined
Estimates Seepage Rate	-424.08	359.89	-585.91	-176.96
Confidence Interval	+/-1875.04	+/-1189.29	+/-1190.26	+/-1068.54
Correlation of barrel level with time	.23	.61	.39	.37
Correlation of pond level with time			.57	

Pond 2			
Seepage Rate	287.03	10.37	623.62
Confidence Interval	+/-1097.29	+/-958.16	+/-1132.86
Correlation of barrel level with time	.33	.60	.07
Correlation of pond level with time			.56

Pond 3			
Seepage Rate	-709.16	-523.02	-570.58
Confidence Interval	+/-874.20	+/-971.59	+/-896.85
Correlation of barrel level with time	.78	.82	.81
Correlation of pond level with time			.55

TABLE 6.3. continued

TOWER-BREITUNG

Pond 1	Barrel 1	Barrel 2	Barrel 3	Barrel 4	Barrel 5	Barrel 6
Seepage Rate	-1742.89	-1779.83	-2119.41	-1324.06	-1490.11	-2040.76
Confidence Interval	+/-804.28	+/-816.14	+/-809.26	+/-860.08	+/-836.80	+/-818.45
Correlation of barrel level with time	.98	.98	.99	.97	.98	.98

All barrels combined

Seepage Rate	-1749.51
Confidence Interval	+/-726.40
Correlation of barrel level with time	.92

Correlation of pond level with time .96

correlation coefficients. At Carver City, each pond was tested during a different month. As shown in Table 6.1, there was a large amount of precipitation during the month that pond 2 was tested.

In Carver City's pond 3, the upper limit of the confidence interval and the correlation coefficient are both acceptable. The data can be used and the pond passes.

In Cleveland, for all three ponds, the correlation coefficients are acceptable, so the data can be used. The upper limit of the confidence interval never exceeds 1500, so all the ponds pass the test.

In Elko-New Market's pond 1, the correlation coefficient of barrel level with time is acceptable for barrels 1 and 3, but not for barrel 2. The results for barrel 2 should not be used. Using the results for barrels 1 and 3 would indicate that the pond passes.

In pond 2 at Elko-New Market, the correlation coefficient for barrel 1 is the best. The results using barrels 1 and 2 all indicate very high seepage rates, ranging from 2801 + 1023 = 3824 for barrel 2 and pond level measurement 1 to 3923 + 767 = 4690 for barrel 1 and pond level measurement 2. An examination of the data, however, revealed that this test was done during a very windy period and there were several days that there was splash-over into the barrel, and one day on which the barrel was reset. The adjustments for the reset were not incorporated into the data used to produce Table 6.3. The correlation of pond level with time is also lower than desirable. Graphing of barrel level over time and pond level over time should first be done to help determine what days, not affected by rainfall, can be used. When adjustments for the reset were made and a period with no rainfall was used, we get quite different results.

For instance, for pond 2 and barrel 2, the correlation of barrel level with time is .98, rather than .56. The correlation of pond level, measurement 2, with time is .95, rather than .69. Using the non-rainfall days and the data adjusted for reset, the estimate of the seepage rate is -1489.61 with a confidence interval of +/-592.22. The upper limit of the confidence interval is less than 1500; the test passes.

In pond 3 at Elko-New Market, barrels 1 and 3 show acceptable correlation coefficients. Using the results from barrel 1 would indicate that the test fails; using results from barrel 3 indicates that the test passes. Examining the data more closely again indicates that there were also splash-over days and rain-days. These days should be eliminated and the analysis redone, as it was for pond 2, to get more consistent results.

At Onamia, all correlations for ponds 1 and 2 were unacceptably low. For pond 3, the correlation of pond level with time is unacceptably low. There were several rainy days which should have been deleted before the analysis was done. In order to determine which days should be deleted, the values for barrel level and the values for pond level should first be graphed over time. This procedure is further discussed in the chapter on recommended method.

For example, if the values for barrel 1 in pond 1 are used only for days not affected by rainfall, the correlation coefficient for barrel level with time becomes .98, rather than .23. The correlation coefficient for pond level with time becomes .96, rather than .57. The estimate of the seepage rate is -1416.03 and the confidence interval is +/-1129.67.

At Tower-Breitung, the upper limit of the confidence interval for the seepage rate is never greater than +1500, and the correlation coefficients are high. The pond passes the test.

Table 6.4 examines the size of confidence interval in comparison to the number of observations during the test period and total precipitation for the month. It appears that, for these locations, there is no clear relationship between either number of observations or total precipitation and the confidence interval of the seepage rate. However, the analysis done on the Kettle River data directly examines the effect of using different numbers of days.

If the end-point method is used, it does not matter how many intermediate points there are. There is, however, value in having some intermediate points, to use as a check. If the least squares regression method is used, the analysis done on the Kettle River data examines the effect of using different numbers of days. The least squares regression method is recommended because it uses more information.

Because of the variation in seepage rates within a pond, as shown in Table 6.3, it is recommended that each pond have at least three barrels. Whenever the estimated seepage rates for any two barrels in the same pond are significantly different from each other, possible reasons for this difference should be investigated.

TABLE 6.4 RANGES OF ESTIMATED SEEPAGE RATES, PRECISION OF ESTIMATES, DAYS OF OBSERVATIONS AND PRECIPITATION BY LOCATION

Location	Range of Estimated Seepage Rates	Range of Precision of Estimated Seepage Rates	Days of Observations	Precipitation
Blackduck	-1004 to -238	+/-718 to +/-826	9	0.44
Carver City				
Pond 1	+754	+/-1060	17	1.02
Pond 2	-109	+/-1172	14	5.51
Pond 3	-789	+/-400	25	0.45
Cleveland	-584 to +417	+/-294 to +/-436	20-21	0.96
Elko-New Market				
Ponds 1-2	-706 to +3924	+/-719 to +/-1056	32	2.63
Pond 3	-209 to +2494	+/-349 to +/-595	29	
Onamia				
Pond 1	-586 to +360	+/-1189 to +/-1875	31-32	6.82
Ponds 2-3	-709 to +624	+/-874 to +/-1132	14	2.87
Tower-Breitung	-1324 to -2119	+/-804 to +/-860	14	2.32

7. Suggested Method for Water Balance Analysis

Presently the water balance is the only method of testing the overall success of entire pond liner placement. However, some indication is available prior to the water balance test on the performance of the intended seal. Therefore, this chapter is developed to propose a uniform guidance for the review engineer to use in applying the appropriate emphasis on the water balance test given a projects compliance with the prescriptive portion of the specifications.

The reviewer of liner test data should be cognizant that spot testing is instrumental for predesign and construction of liners. For example on clay liners there are five purposes for conducting soil tests prior to design and again during actual construction:

- To find adequate quantities of suitable soils for the clay liner;
- To determine the depth of the groundwater in relation to the proposed cells;
- To evaluate the soils so that a suitable liner thickness can be determined so that placement specifications can be written;
- To evaluate the soils actually used, comparing them to the soils on which the design is based;
- To evaluate the contractor's placement to see if the liner conforms with the plans and specifications.

There are a number of factors which must be included in the soil testing program for it to be a satisfactory predictor of successful placement of a clay liner.

First, prior to the design, there must be an extensive investigation to evaluate the soil types and variability. This limits the risk of unexpected conditions at the time of construction;

Second, there must be full-time inspections during construction by a person who is qualified to identify soils and evaluate contractor operations. This person must be able to recognize the small changes in soil gradations which is important in obtaining suitable permeabilities. This person must also understand the process of soil compaction and be able to conduct the tests necessary to evaluate the processes.

Third, as a check on the original design and the contractor's performance, permeability tests should be conducted on samples taken from the compacted liners.

To avoid biases of evaluation of the liner the soils engineer must be retained independently of the contractor. This soils engineer, hired by the owner, preferably through the the consultant, should also be retained for both the predesign and construction testing.

A limited study of recently constructed ponds shows that when the above procedures are followed the soils tests can then predict whether the water balance will pass or fail. Failures occur when one or more of the items in the recommended approach are not followed.

The MPCA uses the water balance as a final verification of liner performance. When good prescriptive specifications are not written or the contractor chooses not to follow them, and the City/Engineer choose not to enforce them, one must consider a number of factors. Some of these factors on soil liners are: nonhomogeneous soils, multiple borrow sites, varying moisture contents and varying numbers of compaction passes. However, on large scale projects many of these factors make spot check testing susceptible to false indications of passing, on liners that should have failed. This also may occur on synthetic liners. The factors for synthetic liners are the risk of damage to the material from placing, seaming and covering equipment and operations. A final comprehensive test is necessary to ensure the integrity of the placed liner.

Since a comprehensive test is necessary, does the historic Minnesota Water Balance test suffice? Considering the history of the seepage limit development as outlined in the introduction to this report, reviewing the 1985 MPCA "Recommended Design Criteria for Stabilization Ponds" Appendix C and after observing the results from the two test water balances the Water Balance Task Force concludes that:

A. The historic Minnesota Water Balance method is not capable of accurately testing for 500 gallons/acre/day on a pass/fail basis. The confidence interval on a test for 95 percent assurance is approximately +/- 1000 gallons/acre/day.

B. Many factors limit the accuracy of the water balance test results. These factors include but are not limited to: precipitation, solar radiation, wind speed, freezing temperatures, magnitudes of scale, relative humidity, the current non-standardized testing methods and runoff coefficients.

Therefore, the Task Force recommends that the end point method currently specified in the MPCA Stabilization Pond Design Criteria (Appendix C) be replaced with the least squares analysis of slopes. The least squares method offers an estimate of the mean seepage rate plus the advantage of a confidence interval to indicate the precision of the estimate. A step by step procedure is given in Appendix B. The MPCA has this procedure on the VAX computer. The Task Force further recommends the Agency make staff time available to run this program with data points selected by the consulting engineer. The program would be available at the end of the 30 day test period. If weekly updates are done by the consultant it is recommend the firm place the formulas into an acceptable program which the MPCA staff would verify upon submittal of the test results.

Multiple barrel readings may be compared with the unpaired t-Test, to check for significant differences in the data. If not significant, the data may then be combined for the least squares analysis. (The t-Test procedure is outlined in Appendix B). This method is used, when possible, to decrease the band width given by the confidence interval. The confidence interval is impacted by changes in the number of readings, number of evaporation barrels, and number of pond rulers. Also elimination of rainfall periods and widely varying points can decrease the confidence interval significantly.

The examples given in Table 7.1 are from the Kettle River water balance at varying points of time. All twelve of the tests were run using the VAX-2020 program. The Kettle River data when graphed, indicates a good test. The slope of all evaporation lines are closely fit to one another (Figure 7.1). Therefore, this test was used to selectively remove reading dates (from the end of the data string) to demonstrate the effects on the confidence interval. The Kettle River test data was taken four times per week with two metal barrels per pond (i.e., the number of readings per month is twice the required amount). The data collected had nine readings without rainfall, the minimum statistically allowable. This compares to a month without rain if two readings per week were taken. It is interesting that combining certain barrels may "increase" the band width of the confidence interval for the group. Of the six metal barrels in Kettle River, at least two have variances large enough to provide an increase in the confidence interval band width. Hence, the duplication of barrels in a cell will not ensure tight confidence intervals. Review of the mean seepage rates and confidence intervals numbers is to be on an individual and combined data basis. Figure 7.2 shows how selection of different barrel sets impacts the confidence interval's results for the same testing time period in Kettle River. (It must be pointed out that statistical limitations of the least squares analysis require nine points, minimum, to be statistically reliable. Also, if a barrel contributes data to the analysis in a group set, it must contribute a minimum of five data points for the regression line.)

Table 7.1 data suggests that time could be saved if the data is analyzed weekly. MPCA staff should not be expected to run the calculations on the VAX weekly, but the consultant could duplicate the program by using the Appendix B flow chart. A minimum of two weeks is required for any test period to allow for graphical trends to become apparent. A clay seal, for instance, may be in the process of saturating itself during the initial portion of the test and show a trend toward a higher seepage rate. This effect would give better results in the latter portion of the test.

SECTION ONE

Table 7.1

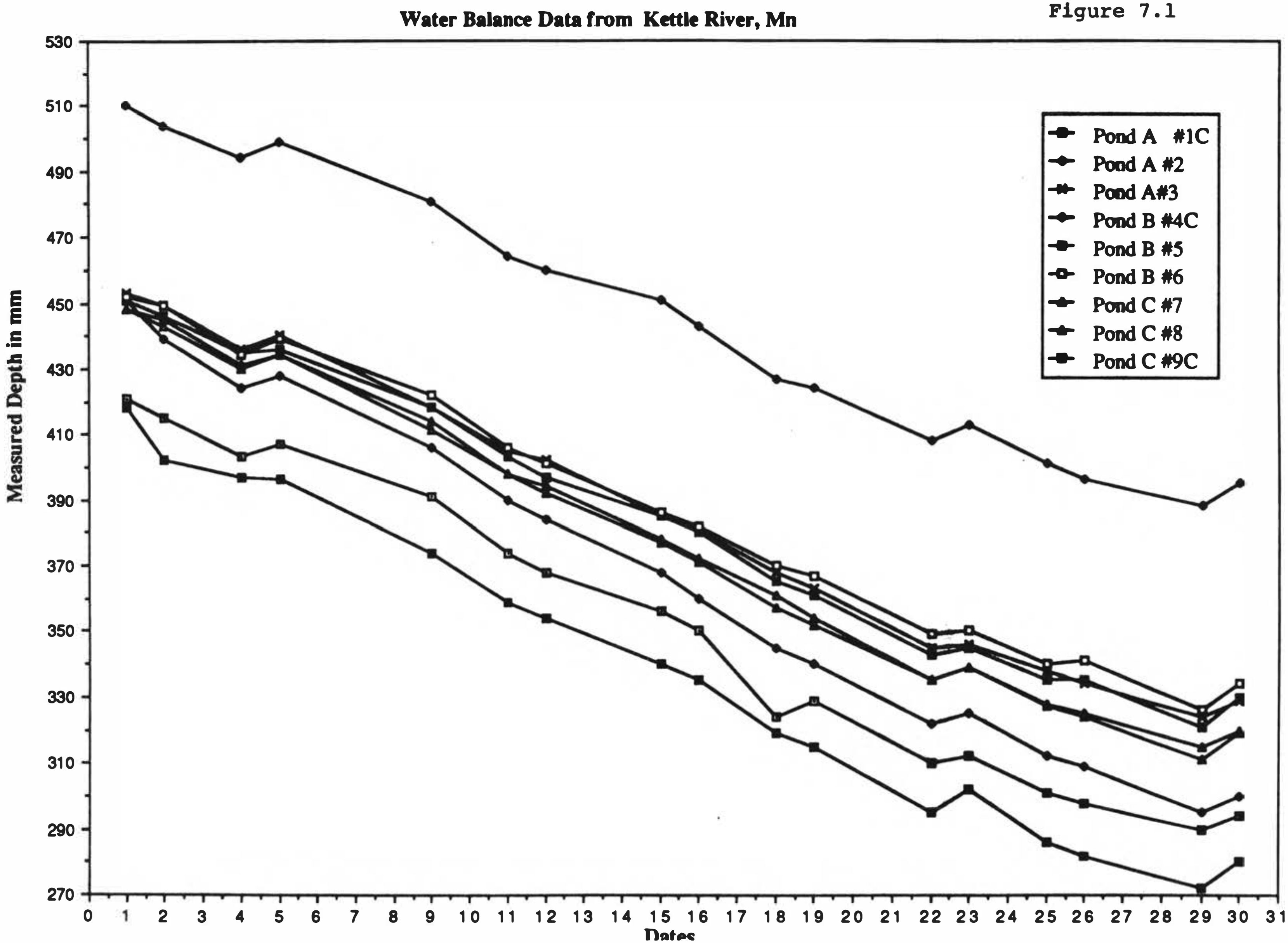
NUMBER OF BARRELS			6	3	2	4	3	2	1	1
CONF INTERVAL	READING	9	589	550	589	664	745	610	661	839
		8	605	565	618					
		6	693	681	744					
		5	796	771	837					
		4	1288	1295						
		3	1378	755						
MEAN SEEPAGE	READING	9	-707	-535	-451	-669	-726	-373	-406	-339
		8	-649	-491	-421					
		6	417	-304	-217					
		5	57	134	259					
		4	-33	393						
		3	-2096	-1421						
COMBINED RATE	READING	9	-118	15	138	-5	19	237	255	500
		8	-44	74	197	0	0	0	0	0
		6	1110	377	527	0	0	0	0	0
		5	853	905	1096	0	0	0	0	0
		4	1255	1688		0	0	0	0	0
		3	-718	-666		0	0	0	0	0

B C D E F G H I J K L

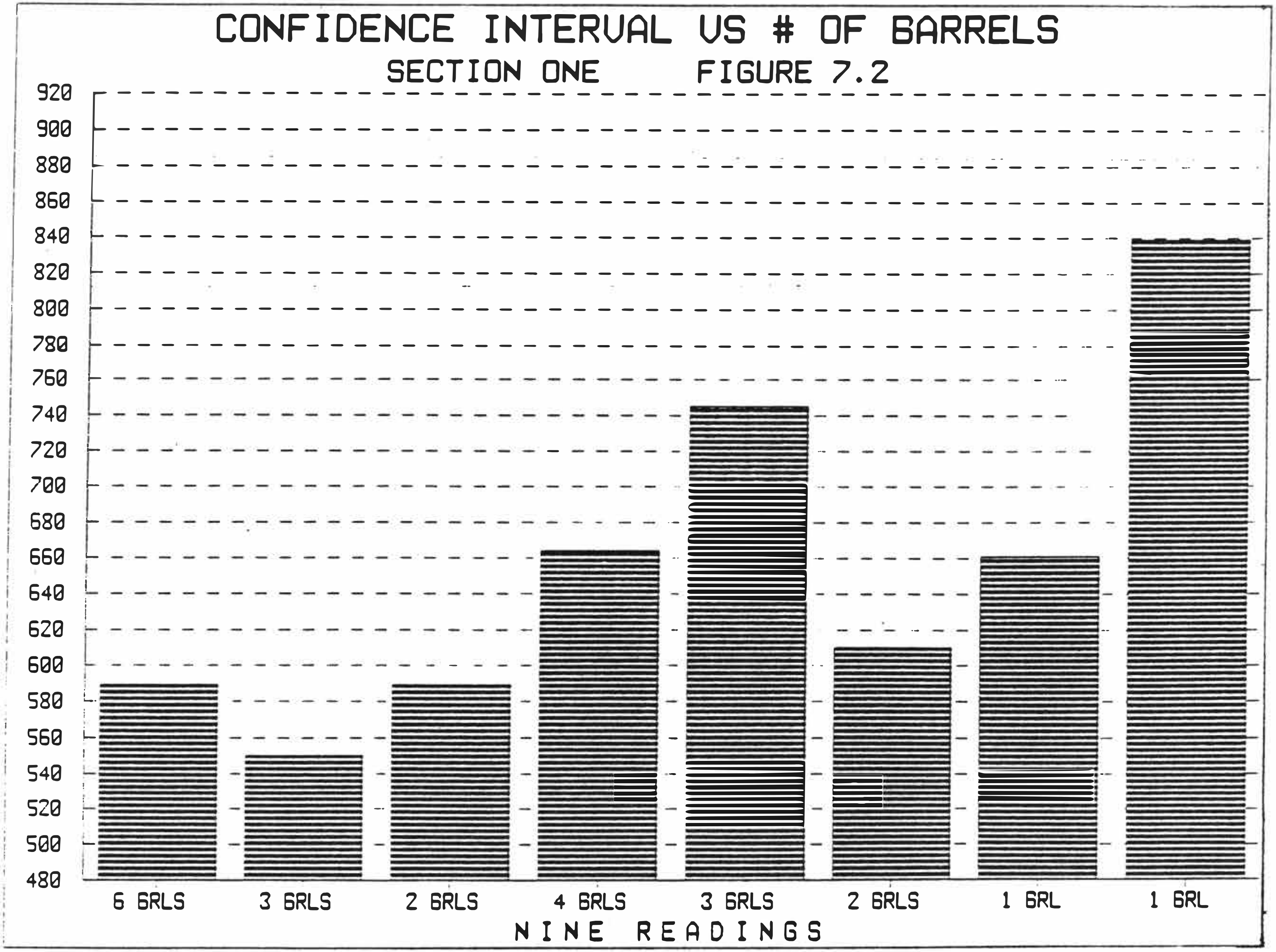
SECTION TWO

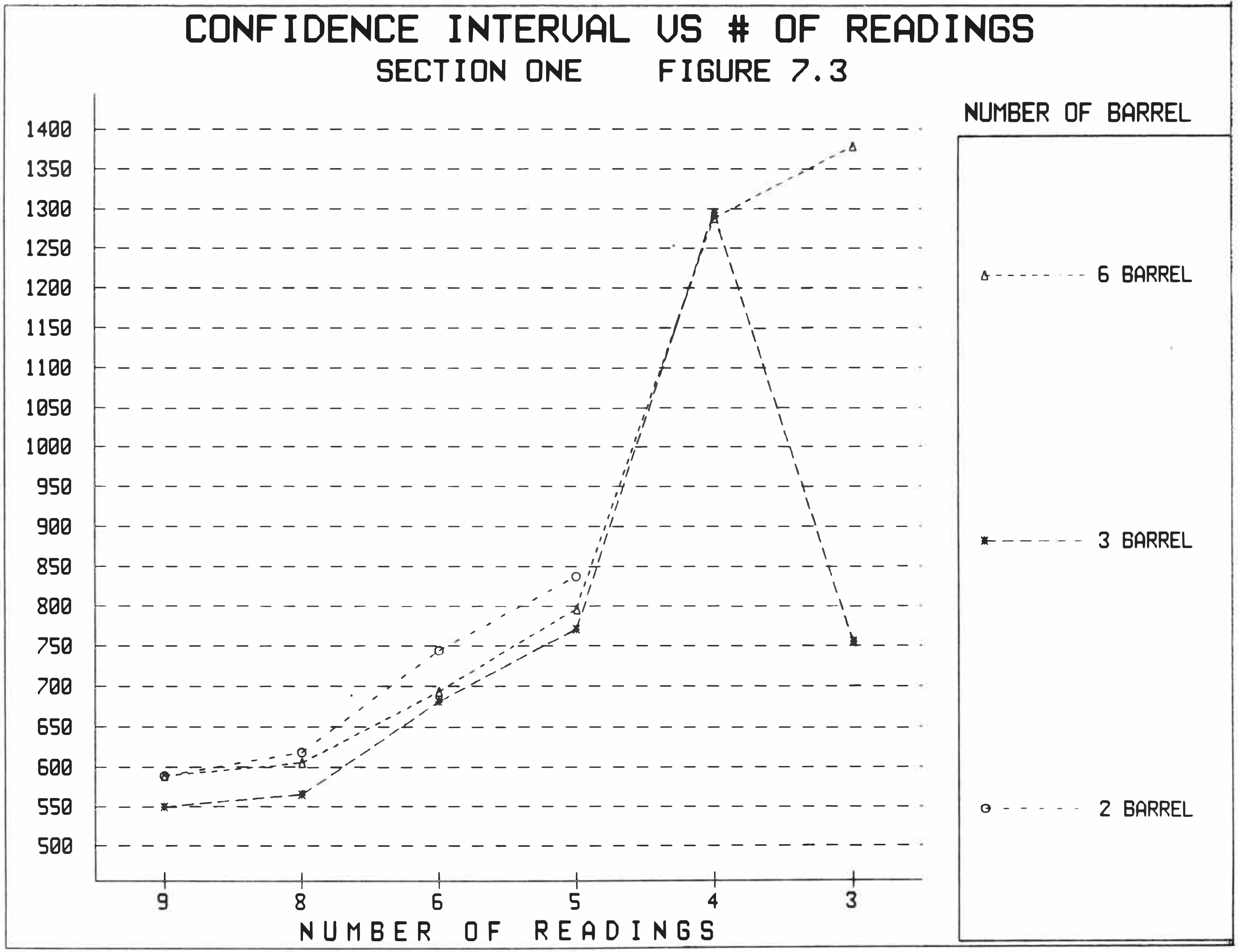
NUMBER OF BARRELS			6	3	2	4	3	2	1	1
CONF INTERVAL	READING	9	482	568	616	658	855	666	1053	1023
		8	553	813	765					
		6	886	1030	1334					
		5	1054	1217	1565					
		4	2180	2730						
		3	815	813						
MEAN SEEPAGE	READING	9	-707	-534	-451	-669	-726	-373	-494	-339
		8	-741	-460	-513					
		6	-658	-545	-458					
		5	-1011	-933	-809					
		4	-1307	-880						
		3	-1134	-460						
COMBINED RATE	READING	9	-225	34	165	-11	129	293	559	684
		8	-188	353	252	0	0	0	0	0
		6	228	485	876	0	0	0	0	0
		5	43	284	756	0	0	0	0	0
		4	873	1850		0	0	0	0	0
		3	-319	353		0	0	0	0	0

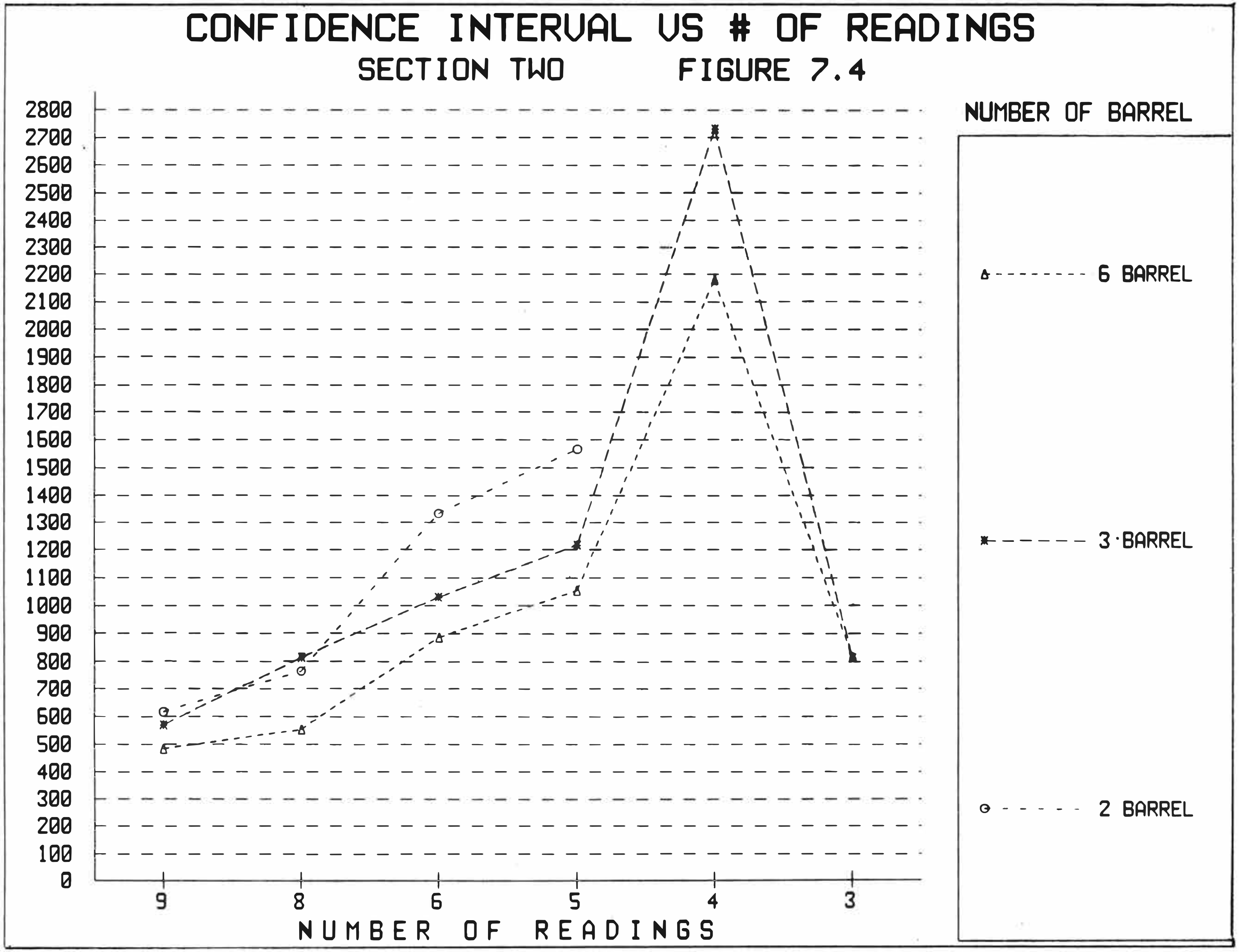
Figure 7.1



Water Balance Data from Kettle River, Mn
Measured Depth in mm
530
510
490
470
450
430
410
390
370
350
330
310
290
270
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Dates
Pond A #1C
Pond A #2
Pond A#3
Pond B #4C
Pond B #5
Pond B #6
Pond C #7
Pond C #8
Pond C #9C


CONFIDENCE INTERVAL VS # OF BARRELS
SECTION ONE FIGURE 7.2
920
900
880
860
840
820
800
780
760
740
720
700
680
660
640
620
600
580
560
540
520
500
480
6 BRLS
3 BRLS
2 BRLS
4 BRLS
3 BRLS
2 BRLS
1 BRL
1 BRL
NINE READINGS


CONFIDENCE INTERVAL VS # OF READINGS
SECTION ONE FIGURE 7.3
1400
1350
1300
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
9
8
6
5
4
3
NUMBER OF READINGS
NUMBER OF BARREL
6 BARREL
3 BARREL
2 BARREL



CONFIDENCE INTERVAL VS # OF READINGS
SECTION TWO FIGURE 7.4
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
9
8
6
5
4
3
NUMBER OF READINGS
NUMBER OF BARREL
6 BARREL
3 BARREL
2 BARREL

Trends toward inaccurate seepage rate estimates may also be weather related (Figures 7.5 and 7.6) these graphs show fluctuations of mean seepage rates in Kettle River (a synthetic pond liner) from one week to the next. During dry, hot periods, evaporation of the barrel may exceed the evaporation of the pond by as much as three times the current test limit. Therefore, a pond indicating a passing water balance mean seepage rate of -100 gallons per acre per day (infiltration of 100 gallons per acre per day) may actually be a failed pond. If other ponds in the state, with similar climatic conditions, indicate an infiltration rate of 1800 gallons/acre/day is more reflective of a good seal, then this pond may actually be leaking 1700 gallons per acre per day. Therefore, the Water Balance Task Force recommends that all three cell's water balance tests, on new construction, be run at the same time to give comparative pond seepage rates. If one cell is significantly different than the remaining two, more investigation may be required on that particular cell. It must be stressed that the pond's evaporation rate and the barrel's evaporation rate must be evaluated by some means other than the 500 gallon/acre/day mean seepage rate during dry, hot periods. Should simultaneous operation of the water balance on all three cells not be possible, options for evaluating this condition are: contacting the MPCA to check on other ponds operating the water balance in the area, operating the water balance at a later time if the dry conditions are thought to be over soon or accurately documenting detailed weather information. Three other factors of significance are localized wind speed, relative humidity and vapor pressure. These factors can greatly impact test results during mid-summer.

The MPCA should assign one review engineer from each of the three Community Assistance Units to track current water balances in their units. The three could exchange information and develop refinements of the test numbers for passing levels, weather related floating mean seepage rates and testing techniques if conditions and weather cycle records are kept.

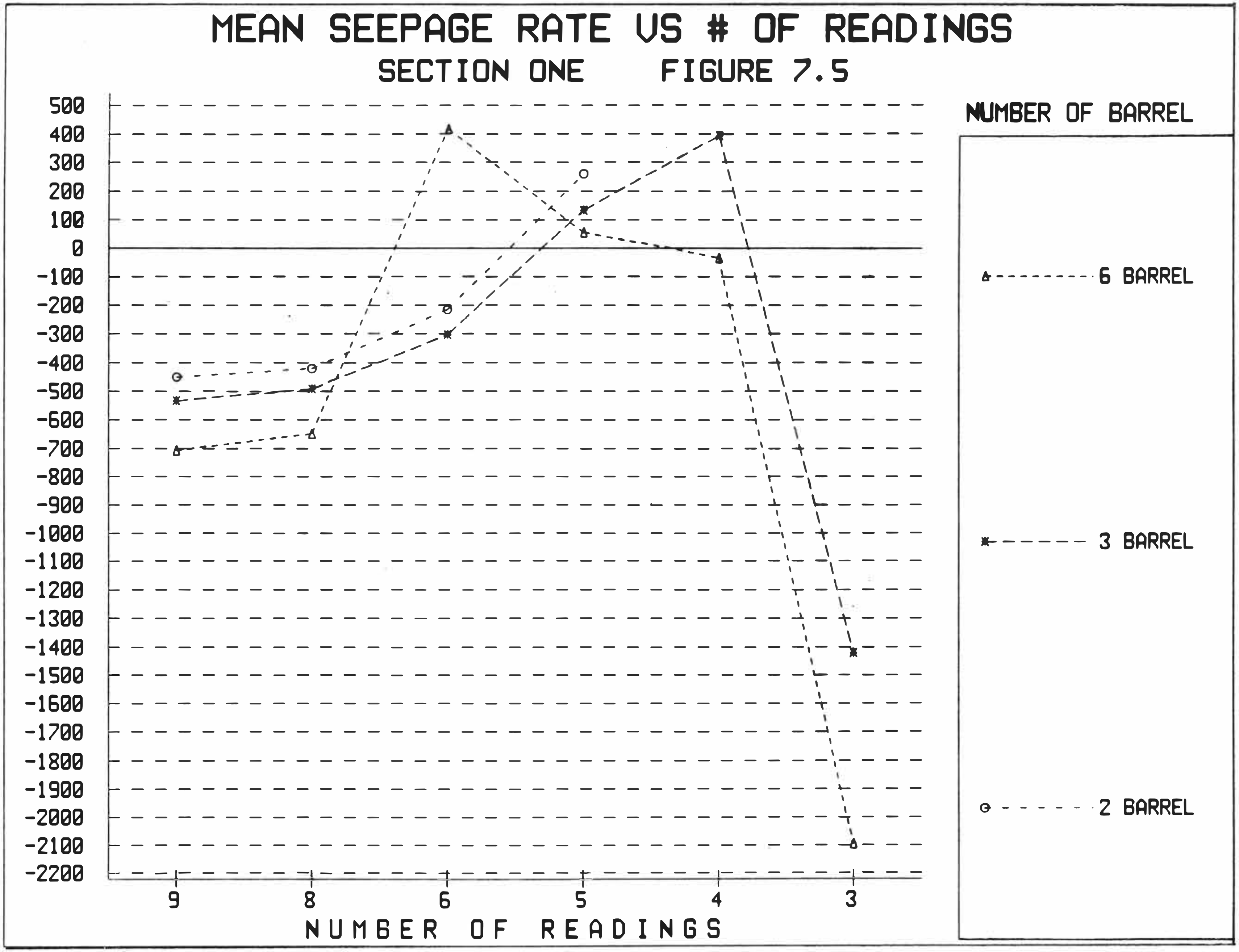
The Water Balance Task Force (WBTF) recommends the engineer follow this list of procedures when evaluating the water balance results for a given project:

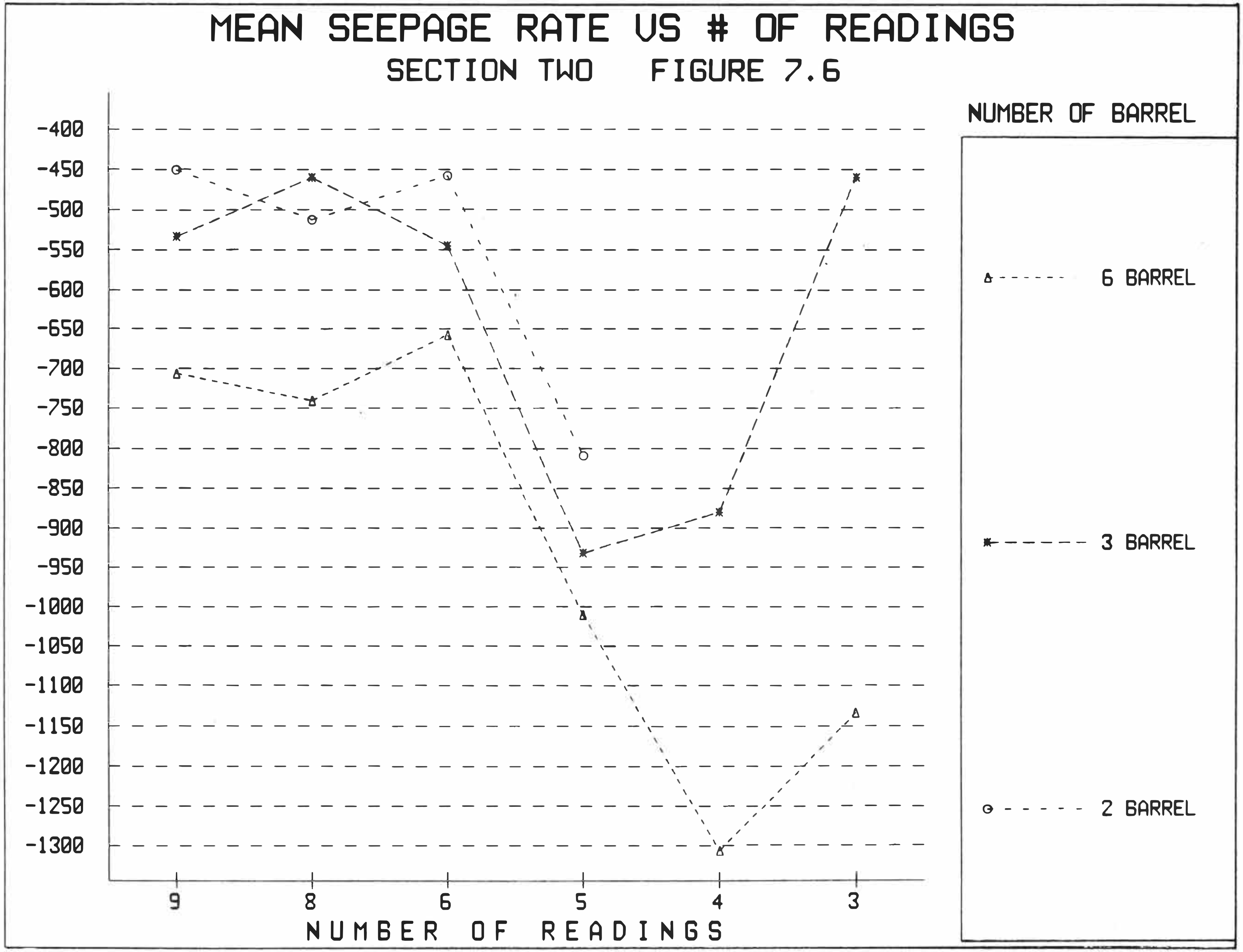
Guidance for Water Balance Analysis

1. The engineer graphs the barrel data (date versus depth of reading). The graph will provide a visual check for change in seepage rates and problem barrels. A change in the seepage rate is an indicator of a wider band in the confidence interval. A varying rate of seepage will increase the least square's confidence interval substainally. This is due to the linear assumption of the least square regression. By forcing a curve or two lines to be estimated by a single line equation the variation of each point from an estimated straight line increases, therefore, the confidence interval expands.

2. Run the unpaired t-Test to ensure no significant difference exists between barrels. This will allow multiple barrels to be combined (if beneficial) when comparing the confidence intervals.

3. Run the least squares analysis on the individual barrels and/or the combined set to use as an indicator of success of the test.


MEAN SEEPAGE RATE VS # OF READINGS
SECTION ONE FIGURE 7.5
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
-1400
-1500
-1600
-1700
-1800
-1900
-2000
-2100
-2200
9
8
6
5
4
3
NUMBER OF READINGS
NUMBER OF BARREL
6 BARREL
3 BARREL
2 BARREL


MEAN SEEPAGE RATE VS # OF READINGS
SECTION TWO FIGURE 7.6
-400
-450
-500
-550
-600
-650
-700
-750
-800
-850
-900
-950
-1000
-1050
-1100
-1150
-1200
-1250
-1300
9
8
6
5
4
3
NUMBER OF READINGS
NUMBER OF BARREL
6 BARREL
3 BARREL
2 BARREL

4. Compare the total combined numbers from the mean seepage rate and confidence interval to 1500 gallons/acre/day.

5. Check the correlation coefficient. It will range from zero to one. One indicates perfect correlation, zero indicates no correlation. A high correlation is required, approximately 0.8 or better.

6. Compare results for all cells run during the same time period. If all three cell tests were performed at the same time, the mean seepage rates should be comparable. If one cell out of three indicate an infiltration rate of 100 gallons/acre/day while the other two cells indicate an infiltration rate of 1500 gallons/acre/day, prescriptive specification compliance should be reviewed and questioned.

If the water balance results appear questionable, the following provides direction in detecting areas of concern with the performance test or in documenting areas of non-compliance with prescriptive specifications:

A. Was the water balance conducted over an acceptable duration and, if so, were there any days during which freezing of pond or barrel water may have occurred. Were there any rainfall events, or other reasons why the test may be non-representative?

B. Were the prescriptive tests performed satisfactorily and were there a sufficient number conducted? For soil seals this will mean moisture contents, densities and permeabilities. For synthetic liners this will involve all non-destructive and destructive testing done on site and in the laboratory. Were the tests conducted with equipment that had not been properly calibrated. For synthetic liners, review the factory certification of the liner, the manufacturer's warranty, and the certification letters from the manufacturer and contractor (plus the city for MPCA engineers) stating acceptance of the subgrade, cover material and compliance with the specifications.

C. The records of the full time liner inspector (soils or manufacturer) should be reviewed for working and weather conditions that may have hindered or jeopardized the process.

D. Was the liner (or a portion of it) exposed through a winter and, if so, was it protected? This is particularly important for clay seals. Synthetic liners will require a letter from the manufacturer stating that exposure to a winter season without wastewater will not cause any of the warranty to be null and void or impact the performance of the seal.

E. What is the quality of the clay material that make up the liner? The percent of clay in the seal should be assessed from the soils testing firm's reports. Comparisons should be made with the design-projected soils and those actually used in the field. Delineation of borrow sites not specified in the planning stage and compaction techniques used by the contractor should also be evaluated.

F. Is the groundwater affecting the water balance? MPCA criteria call for a four foot separation between the pond bottom elevation and high groundwater. Is there possible infiltration into the ponds due to high groundwater? Is the hydraulic gradient enhancing the sealing capabilities? This is a site specific evaluation that may require planning for piezometers.

The limits indicated in this chapter reflect current evaluation of several test sites (Chapter 6). The data demonstrates the capability of the analysis to estimate mean seepage rates within 1000 gallons/acre/day confidence intervals.

Then the MPCA staff will forward the program results to the consultant and city for their evaluation and recommendations. A turnaround time for a evaluation and response will be agreed to and, if necessary, a justification process will determine if the test will be retaken or the original decision on criteria level relaxed.

Selection of Minimum Number of Readings Required

Note: This analysis was done in two sections. Section 1 used current confidence intervals as calculated per current criteria. Section 2 adds the 95 percent confidence interval of the barrel to the 95 percent confidence interval of the pond (i.e., a worse-case scenario with both band widths occurring simultaneously). This method was the original method considered for the least squares analysis and work was completed in Section 2 of Table 7.1 prior to switching confidence interval formulas now recommended. The work is left in this chapter as it still reflects general trends in the confidence interval analysis, just at a magnified scale.

Analysis for development of the minimum number of points to be used in the least squares analysis begins with the Kettle River Data. Using the dates and data from May 23 through June 7, 1988, gives the task force nine (9) readings without rainfall. This is equivalent to the standard test length for previous water balances. A minimum of nine points is necessary to achieve statistical confidence for normal distributions. Therefore, all data sets were combined always keeping at least nine points in the population. Barrel sets, with nine readings, were calculated. The data set was then reduced to eight readings by removing the data point of the last date. The new data set was then recalculated. This process was done for seven readings, six readings, five readings, four readings and three readings per barrel. The attached Table 7.1 gives a breakdown of the number of readings, barrels, confidence interval and mean seepage results.

NOTE: Section 1 of Table 7.1 assumes the confidence interval formula that is applied in the guidelines, using a nine point data set for the pond over all test runs. Section 2 of Table 7.1 assumes a worse-case confidence interval formula where the extreme end occurrences of the linear slope projections compound to provide the wider confidence interval band projection. Section 2 data, also, uses duplicated pond level readings to provide the minimum number of pond measurements over the same period of barrel measurements. In other words, if three readings are used in three evaporation barrels, the first three pond level readings are all used three times to maintain the minimum number requirement (nine). This duplication may have shortened the confidence interval band for the pond level slope projection, which reduces the overall confidence interval band width. However, if Section 1 data is graphed with Section 1 comparisons and Section 2 data is graphed with only Section 2 data, general trends in the least squares analysis can be detected.

From Figures 7.3 and 7.4, it can be shown that a fluctuation exists with the reduction of readings per barrel. The confidence interval expands when the number of readings is reduced unless lines estimated with three points were evaluated. If three points are used, a sharp increase in the level of confidence often occurs. This may be due to the line being determined by two points and the error estimated by the third point's variance from that line. This false confidence could be eliminated by requiring each barrel to have a minimum of four points. However, as is also shown by these graphs four points will not provide an adequate confidence interval required when seepage rates are approximately 500 gallons/acre/day. Therefore, a minimum of five readings per barrel is necessary.

The mean seepage rate fluctuates from approximately -400 to -1150 gallons/acre/day (Figures 7.5 and 7.6). This is important when water balances are conducted under varying weather conditions. Again, if it is assumed that actual seepage is zero gallons per acre per day, then a shorter data base in Kettle River shows an accelerated evaporation by the barrels. This could be caused by less relative humidity, more wind, more solar radiation or any combination of the above during the first week of the test. Weather is not controllable, however, it re-enforces the proposed requirement that all three pond cell water balance tests be run at the same time and for a minimum of two weeks, all to aid in indicating the reliability of the estimated seepage rate.

Example Applications

Example Number One: A synthetically lined newly-constructed pond is tested for seepage in late fall. Information submitted by the consultant documents manufacturer inspection hours by date and hour. This compares to the contractor documentation for date and hour of work done on seaming. The manufacturer was present 95% of the application time. All seaming field tests pass, however, one 250 foot seam was redone due to cold temperatures during the initial sealing. The manufacturer's tests pass. The certification and warranty are present and complete. Ground water is not present in the soil until a depth of 28 feet.

The water balance data had readings on days: 1, 3, 5, 9, 12, 15, 17, 19 and 21 and evaporation barrels showed ice on days 12, 19 and 21. Total pond ice occurred by the 21st day. The test dates used were 1, 3, 5, 9, 15 and 17 and the unpaired student t-Test allows all three barrels to be combined. The test period has the required minimum of 9 readings and a two week period. The mean seepage rate indicated by the combined readings was 650 gallons/acre/day with a confidence interval of +/- 800 gallons/acre/day. Statistically, the correlation is 0.93.

Therefore, example number one's actual pond test indicates 650 gallons/acre/day plus 800 gallons/acre/day or 1450 gallons/acre/day.

This test passes.

Example Number Two: A clay seal in good soil with no ground water present six feet below pond bottom is tested. Field testing indicates all permeablities pass, however, 15 percent of the moisture density tests do not meet specifications the first round of testing. The soil inspector was on site every third day for soil testing and was able to correct the failed moisture density areas. Seal was not over wintered. However, the consultant is submitting results after two weeks of testing with five readings per barrel. Data from one barrel is deleted due to a low correlation coefficient (0.4). The estimated mean seepage rate for the two barrels combined is 450 gallons/acre/day with a confidence interval of +/- 1200 gallons/acre/day and a correlation of 0.90.

This procedure requires a mean seepage rate and confidence interval of 1500 gallons/acre/day. After two weeks the result is 1650 gallons/acre/day with two barrels, so the test must continue. There is concern over the moisture content of the soil during placement.

As testing continues, the seepage rate is raised to 500 gallons/acre/day with one barrel and twelve readings. The confidence interval is +/- 800 gallons/acre/day. The other good barrel indicates 550 gallons/acre/day with +/- 911 gallons/acre/day as the confidence interval band. Therefore, the totals for the two barrels are 1300 gallons/acre/day and 1461 gallons/acre/day.

This test passes.

Example Number Three: A synthetically lined cell with full time inspection from the manufacturer's representative is tested. The prescriptive testing all passes. The warranty and certification of the liner are submitted. The in house manufacturer's testing looks adequate and the cells are not over wintered or in areas with high groundwater. The water balance was run 32 days and had storm cycles at least once a week. The test operator recorded readings one day after each storm event, when possible. Each barrel has 14 readings and the following break down:

Barrel	Mean Seepage	Confidence Interval	Correlation	Data Adjusted Mean Seepage	Adjusted Confidence Interval	Adjusted Correlation
A	1410 gpad	+/- 1400 gpad	0.80	540 gpad	+/- 670 gpad	0.95
B	1450 gpad	+/- 1550 gpad	0.77	600 gpad	+/- 850 gpad	0.91
C	1800 gpad	+/- 1450 gpad	0.55			
A & B	1490 gpad	+/- 1575 gpad	0.75	680 gpad	+/- 920 gpad	0.85

Data from barrel C is deleted since the correlation coefficient was not representative of linear regression with normal distribution.

The criteria require that the test meet 1500 gallons/acre/day when combining both the mean seepage rate and confidence intervals. The test information passes on both good barrels when calculated independently, but not when combined.

This test passes.

8. WATER BALANCE STUDY

Introduction

These Water Balance Criteria apply to all newly constructed ponds. They also apply to existing ponds that are required to perform a water balance. These criteria are written in normal type for newly constructed stabilization ponds and capitalized type for modifications to accommodate aerated or existing cells. The only method that is acceptable for a new pond is a water balance by the barrel method which is discussed in this criteria.

Recommended Criteria

All parties involved in the project (grantee, engineer, inspector, contractor, testing labs, etc.) must be aware of the procedures, constraints and expectations related to the prefill and the water balance. The details of these items should be spelled out in the various contracts listed below:

1. Plans and specifications. (Contract between grantee and contractor).

2. Engineer's contract with the grantee.

3. Independent testing laboratory's contract with the grantee or consultant.

4. Independent soil laboratory's contract with the grantee or consultant.

The requirements for the water balance itself should be put into the contract of the party conducting the water balance (engineer or independent testing laboratory). The requirements for soils testing should be included in the independent soil laboratory's contract. Also, at the preconstruction conference the grantee should make sure that all parties, including the synthetic liner manufacturer when a synthetic liner is being used, are made aware of these items. All of the requirements that follow should be included in the plans and specifications.

Requirements For Prefill

A. For Clay Seals

   1. The grantee must submit a letter to the review engineer indicating that they have accepted the work necessary to conduct a prefill and water balance and are requesting MPCA to conduct a prefill inspection.

   2. Included with the above letter, if not previously submitted to the MPCA, must be the following:

      a. A copy of soil test results (density, permeability, etc. on both the pond bottom and pond dikes).

b. A sign-off or certification from the onsite independent soils inspector stating the clay seal was installed per plans and specifications and the correct materials were used for the clay seal construction.

c. The results of a survey of the pond bottom indicating that the level is within the proper tolerances.

B. For Synthetic Liners

1. The grantee must submit a letter indicating that they have accepted the work necessary to conduct the prefill and complete the water balance and are requesting MPCA to conduct a prefill inspection.

2. Included with the above letter, if not previously submitted to the MPCA, must be the following:

   a. The contractor and liner manufacturer certification that the liner was installed per the plans and specifications.

   b. The contractor and liner manufacturers' certification that the cover material was placed per the plans and specifications.

   c. The liner manufacturer's certification that the installation was in conformance with all warranty provisions and that no provisions of the warranty have been voided.

   d. A copy of all liner test results for seam strength, strength of liner material, mil thickness, etc.

   e. A copy of the liner warranty.

   f. A copy of the soil test results (density, etc., on both subbase and dikes).

   g. The written results of the pond bottom survey indicating the level is within the proper tolerances.

If all of the above information is in order during the site inspection, verbal approval by the MPCA may be given to prefill the pond. If items are pending at the time of the prefill inspection, these items must be resolved before any approval to prefill can be issued. The MPCA will send a prefill approval letter to the grantee when all items are resolved. The prefill approval is only an approval to put enough water (clear or chlorinated treated sewage) into the pond to conduct the water balance. No additional water or sewage (raw or treated) may be added to the cells until the water balance is approved (unless more clear water is required as part of the test) and the city is notified of the approval in writing.

At the MPCA prefill inspection, the ponds will be inspected for (at a minimum) the following:

1. Adequate erosion protection (i.e., proper grass growth, proper riprap material and placement).

2. Proper seal placement (for clay).

3. Proper completion of any other items necessary to approve the prefill or to conduct the water balance (piping placement, gates, controls).

Requirements For Water Balance

The following items relating to the water balance must be described in the specifications and in the contract of the firm conducting the water balance test.

A. Who will conduct the water balance (consultant, independent test laboratory or owner).

B. Where the prefill water will come from (river, lake, city water, treated effluent, etc.). If necessary has DNR permit been obtained?

C. The depth of water will water balance be run (2 feet of water should be used for non-aerated ponds. NORMAL OPERATING DEPTH SHOULD BE USED FOR AERATED PONDS).

D. Where the barrels will be located and how many will be used per pond (three pond barrel pads placed during construction in compliance with the Diagram 8.1).

E. Where the pond water elevation will be measured (minimum of three perforated barrels per pond. A PERMANENTLY MOUNTED SCALE, TO READ IN MILLIMETERS, IN THE CONTROL STRUCTURE OR IN SEPARATE PERFORATED BARREL(S)).

F. Where and how the rainfall will be measured (at pond site, type of recorder, etc.).

G. How often the barrels will be measured (twice a week, after rainfall events, if multiple barrels are used the minimum readings per barrel will be 5, etc.).

H. How often the pond water levels will be measured (twice a week, after rainfall events, minimum of 5 measurements per barrel if multiple barrel sets are used, IF ONLY ONE SCALE IS READ FOR CONTROL MEASUREMENTS THEN NINE READINGS MUST BE TAKEN FROM THAT ONE SCALE, etc.).

I. How often the rainfall will be measured (twice a week, when it rains, etc.).

J. Requirements for fixed measuring devices to be placed in all barrels AND CONTROL STRUCTURES. Describe measuring system to be used.

K. Water level measurements in barrels and control structures will be measured to the nearest millimeter (perforated barrel readings averaged over a time span of at least a minute).

L. Location of the ground water table. (i.e., Is it near liner elevation or will it be during the course of water balance? How was ground water elevation determined? Who is responsible for further ground water elevation readings?)

The grantee is responsible for submitting the water balance results to the MPCA. The transmittal letter should indicate if the consultant calculated the least squares analysis, shortened the length of the test, operated the test with ice occurring in any of the barrels or combined two non-rainfall event periods. Measurements, observations and a diagram of the actual pond layout designating the barrels numbers and placement shall also be submitted. For the least squares analysis the transmittal letter should identify which sets of barrels indicate passing and the respective correlation numbers of the least squares test.

In order to statistically evaluate whether the 500 gpad mean seepage rate plus or minus the 1000 gpad confidence interval has been met, all raw data collected (barrel levels, pond levels, rainfall and runoff measurements, etc.) must be evaluated independently and combined. All calculations and assumptions used to evaluate the raw data should be included in the submittal. If the 500 gpad +/- 1000 gpad requirements have not been met, a recommendation should accompany the water balance analysis detailing one of the following:

A. That the water balance(s) will be redone.

B. Identify the problem or possible source of the problem.

C. The corrective actions that will be taken to resolve the problem.

D. Justification as to why a higher seepage rate is acceptable. Improper or poor monitoring procedures which are not in accordance with Agency guidelines will not be accepted as justification for not meeting the 500 gpad mean seepage rate +/- 1000 gpad confidence interval limit.

The following items are the general requirements for conducting a water balance:

A. Recordable Data

1. Study Period

Data should be obtained at least twice weekly for a period of four consecutive weeks during a period of time when no permanent freezing can occur. To prevent the possible problem of freeze up, the water balance should be started so that it will be completed no later than November 20th. The city should inform the contractor of this restriction and coordinate the construction schedule accordingly. Water balance results may not be recorded if ice cover occurs in the barrel. After the ice melts, it is possible to resume water balances readings. Water balances which do not have nine (9) total readings from the data set without freezing will be returned. The nine readings must be made up of individual barrel results containing a minimum of five (5) readings per barrel (i.e., if ten readings are taken per barrel and two barrels are used to contribute data, then each barrel data set may be adjusted to give the optimum five (5) points. The five (5) adjusted readings must be input as continuous graphical points over an identical period for the graphically continuous pond readings). Although the data does not have to be continuous the method for combining data sets outlined at the end of Appendix B under data preparation must be followed. Also, the minimum time span of the data must cover a two week period for verification of the linear regression assumption.

2. Cell Sizing

Determine the square footage of cells. Calculate this area at the height of the water level used during the water balance study.

3. Inflow to System

No inflow to the pond, except as allowed in Section A.7., will be allowed until the test has been completed and approved. Any inflow of water to the pond occurring during the test period will invalidate the entire water balance test, and subsequently must be redone.

4. Total Rainfall

Rainfall measurement must be taken from a reliable rain gauge installed at the pond site. The minimum required rain gauge will have a four inch diameter outer cylinder with an inner receiver. The gradation shall be 0.01 inches. Capacity of the overflow cylinder and inner receiver shall be 11 inches. It is advised that rainfall measurements and test readings be taken after each rainfall event to provide as many dry daily recordings as possible. One day should be allowed prior to recording the pond level after a storm event due to slow percolation of dike runoff into the pond.

5. Discharger/Transfer From Pond Cells

In order to provide the highest degree of accuracy for the water balance test, no discharges should be made from the cells during the test period. All gates valves, etc., should be verified to be water tight (no leaks) before beginning the test. If any discharges do occur during the test period, it may be necessary to conduct the water balance again.

6. Pond Water and Depth Measurements

The water level of each cell should be recorded to the nearest millimeter. The measurements should be made from a fixed measuring device within the perforated barrels located by each evaporation barrel (MANHOLE CONTROL STRUCTURES MAY BE USED FOR AERATED CELLS). The measuring device for both the barrels (AND THE CONTROL STRUCTURE) should be situated such that the zero end of the scale of the measuring device is down in the barrel or STRUCTURE and the high end of the scale is up. If this is not done, the signs in the following calculations will not work out properly. The measurement devices shall be a metric ruler in one millimeter gradations. Measurements should be taken twice per week at a minimum. The measurement recording should be an average of two readings taken over at least one minute to check for fluctuation of the pond.

7. Barrel Method (Rainfall and Evaporation)

A large (approximately 55 gallon) barrel measuring 35 inches high plus or minus two (2) inches and having a diameter of 22.5 inches across plus or minus one (1) inch shall be used to determine rainfall and evaporation in a pond cell. The barrel will be free of defects and must be leak proof. Also, the barrels will be coated with a minimum 3-4 mil of DFT, white high solids epoxy paint (no oil or grease film). At least three barrels must be strategically located within each pond cell with a surrounding baffle on each to avoid possible splash-over. The baffle shall be 20 gauge metal welded to the top of the barrel at a 45 degree angle as shown in Diagram 8.2. The welds shall not perforate the barrel exterior and shall be two inches in length spaced eight inches center to center. The spacing is to allow the rainfall on the baffle to pass down the exterior of the barrel without upsetting the true rainfall occurrence in the barrel itself. Barrels shall be placed as shown in Diagrams 8.1 and 8.2. The top of the barrel (not the baffle) should extend at least twelve inches and no more than fifteen inches above the water in pond at the start of the test. If the pond water level falls more than six inches during the period of the test, consideration shall be given to stopping the test, filling the pond back to the initial point, and restarting the test. Weather projections, length of time remaining in the test and time constraints are factors to be considered when refilling is an issue. The purpose of refilling is to provide as stable a hydraulic head on the liner as possible while maintaining a limited factor of variation due to the barrel's metal exposure and its impact on evaporation. If the barrel water level differs greater than six inches from the pond water level, the reading will be recorded then water in the barrel shall be brought back to the pond water level and recorded again for adjustment. A measuring device shall be fixed to the inside of the barrel to facilitate accurate water depth measurement to the nearest millimeter. The measuring device shall preferably be a metal metric ruler in one millimeter gradations. The device and method of fixing it to the barrel should not impair the rainfall into or evaporation from the barrel.

The barrel must be on a four inch concrete pad (NOT REQUIRED FOR AERATION PONDS OR EXISTING CELLS) for firm footing with the bottom of the barrel shimmed for level. The top of the barrel should remain level throughout the test.

If possible, every newly constructed cell should run the water balance at the same time. Factors such as precipitation or wind combined with low relative humidity can alter test results significantly. Operating the tests during the same period will provide a check for the localized conditions at each cell. Also, results may be improved by contacting the MPCA to find other ponds operating the water balance in the area or if time is available avoiding operation of the test during dry hot periods and extremely moist months.

8. Seepage Calculation for the Barrel Method

The test results must provide three items: (1) the mean seepage rate in gallons/acre/day, (2) the confidence interval for the mean seepage rate also in gallons/acre/day and (3) the correlation coefficients for the least squares analysis (factors from zero to one with zero being n correlation and one being perfect correlation to a linear relationship). A passing test will have high correlation approximately 0.8 or better with a combined mean seepage rate and confidence interval of 1500 gals/acre/day. The net seepage rate(s) are calculated for each cell over the cell bottom and dike areas by using the following equations:

$$S = -(B_p - B_b) * 27225$$

where

S = Net seepage rate from a cell should be calculated to inches of water elevation and converted to gallons per acre per day. A positive number equals the amount of seepage the pond experiences whereas a negative number would indicate a negative seepage rate which is a net gain of water in the pond(s). "S" should be calculated separately for each cell.

B_p = The slope of the pond data figured from the least squares analysis.

B_b = The slope of the evaporation barrel data figured from the least squares analysis.

27225 = A multiplier to obtain units of gallons / acre / day. X inches divided by 12 inches in one foot times 43560 feet squared in one acre times 7.5 gallons per foot cubed.

The slopes of the readings are estimated as follows:

$$Sxx = n \sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i \right)^2 \qquad Syy = n \sum_{i=1}^{n} Y_i^2 - \left(\sum_{i=1}^{n} Y_i \right)^2$$

$$Sxy = n \sum_{i=1}^{n} X_i * Y_i - \sum_{i=1}^{n} X_i \left(\sum_{i=1}^{n} Y_i \right)$$

Sxx, Syy, Sxy are tools used to prepare the data to estimate slopes by the least squares analysis.

X = The day the event was recorded. Beginning from one and continuing chronologically.

Y = The evaporation barrel reading in inches. Or the pond level reading in inches adjusted for dike run off.

n = The number of data points used in the analysis.

B the Slope is then estimated by

$$B = \frac{Sxy}{Sxx}$$

The standard error of the estimate (Se) can be calculated by:

$$Se^2 = \frac{Sxx * Syy - (Sxy)^2}{n * (n-2) * Sxx}$$

The confidence interval of this line then may be estimated by:

$$\text{Beta} = B \pm t_{\alpha/2} * Se * \text{SQRT}\left(\frac{n}{Sxx}\right) * 27225$$

The $t_{\alpha/2}$ factor is a coefficient based on the degrees of freedom and the student t-Test. The degrees of freedom for this equation is n-2. The confidence interval for the two slopes combined may be calculated by:

$$\text{Beta} = S \pm t_{\alpha/2} * \text{SQRT}\left(Se_b^2 \frac{n_b}{Sxx_b} + Se_p^2 \frac{n_p}{Sxx_p} \right) * 27225$$

S = the difference in slopes as calculated above times the 27225 multiplier.

n_b = the number of data points used for the evaporation barrels.

n_p = the number of data points used for the pond level barrels.

The $t_{\alpha/2}$ factor is a coefficient based on the degrees of freedom and the student t-Test. The degrees of freedom for this equation is

$n_b + n_p - 2$.

The correlation coefficient rho is estimated by:

$$r = \frac{Sxy}{\text{SQRT}(Sxx * Syy)}$$

This coefficient is applied to each data set for an indicator of that data sets correlation with a linear regression (i.e. two correlation coefficients one for the pond data and one for the evaporation data).

Adjustment for Dike Runoff

To adjust for rainfall runoff, pond barrel measurements are reduced as follows:

$$Y_{di} = Y_i - \sum_{i=1}^{n} R_i$$

Y_i = Pond level reading.

n = number of days during the test period.

R = Runoff into the ponds from the pond dikes due to rainfall at the pond site must be calculated during the study period. Rainfall of any magnitude during the study period, must be identified and its impact must be included in the calculations when determining the seepage rate. Rainfall on the side slopes of the dikes may cause a significant rise in the pond water level during the water balance. The net gain is calculated by figuring the square footage of dike slope and dike road surface which contribute to runoff and multiplying this area by the rainfall measurement and a coefficient for the amount of rain that is not: (1) bound by rock or soil, or (2) evaporated back into the atmosphere. This figure is then divided by the square footage of water surface in the pond at the high water mark.

Applications During Ice Over

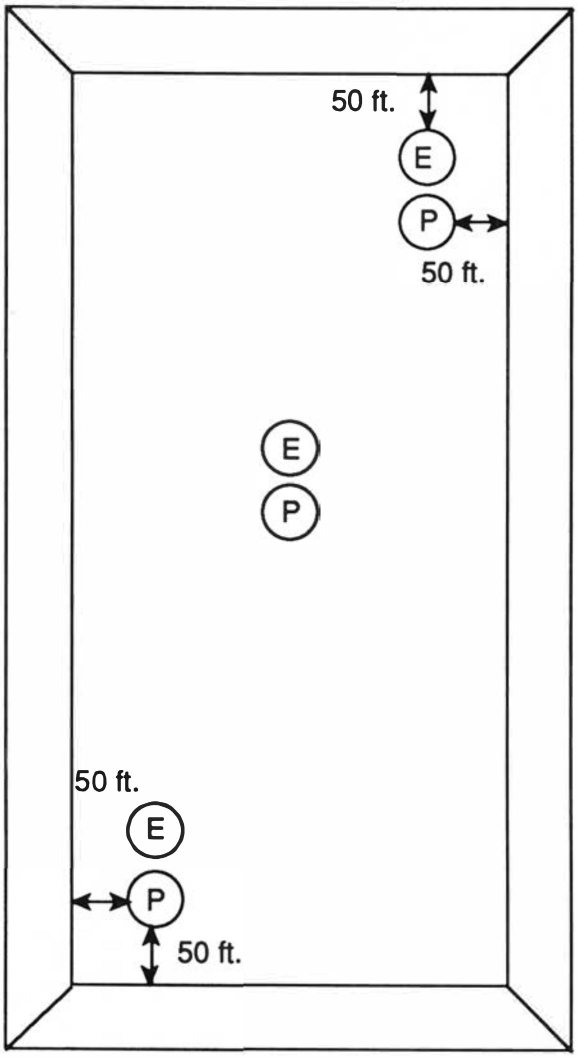
To use periods of ice formation on the water in the barrels a reading before and after the presence of ice is required. No permanent ice formation is allowable as readings may not be taken from the barrel when ice is present. The length of days the ice is present may be recorded and used due to the conservative error this would introduce. However, the total test minimum number of nine (9) readings must be obtained. As well as any one barrel's minimum readings totaling five (5).

Please refer to Appendix D for example calculation.

Questions on prefills or water balances should be directed to Jim Klang at (612) 296-8280.

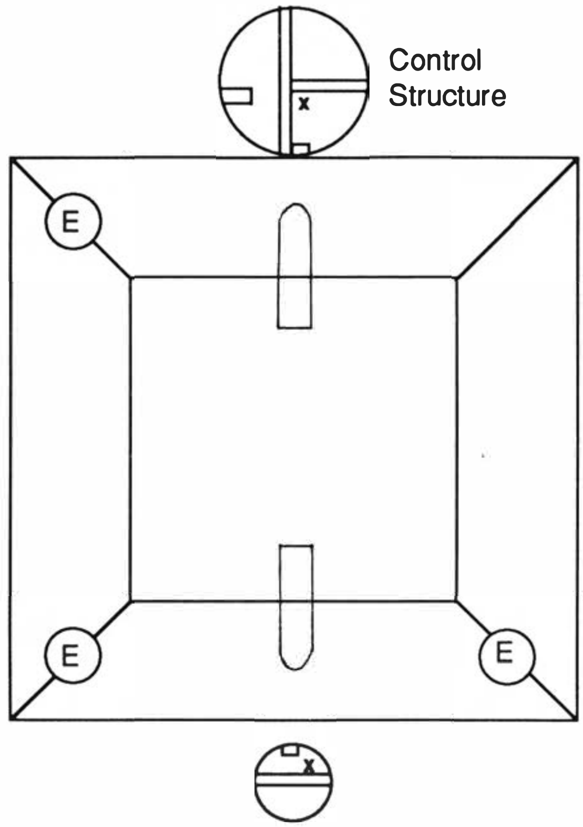
Diagram 8.1

Stabilization Pond



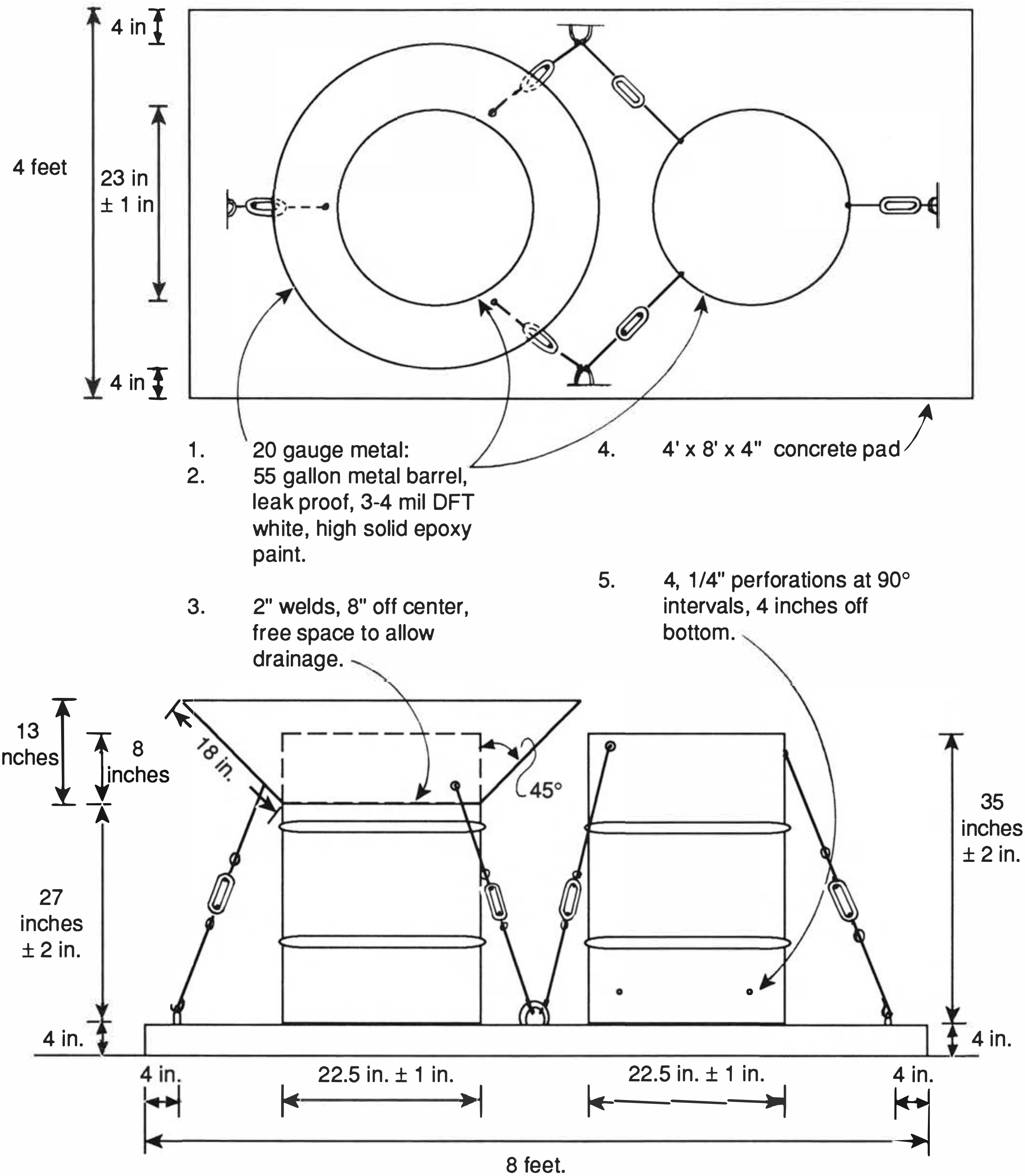
E = Evaporation Barrel
P = Perforated Barrel

Aeration Pond



Pond level measurements recorded from control structure at the locations marked with an X. Evaporation barrels at pond water level in corners. Perforated barrels may be used if desired.

Diagram 8.2



4 in
4 feet
23 in
± 1 in
4 in
1. 20 gauge metal:
2. 55 gallon metal barrel, leak proof, 3-4 mil DFT white, high solid epoxy paint.
3. 2" welds, 8" off center, free space to allow drainage.
4. 4' x 8' x 4" concrete pad
5. 4, 1/4" perforations at 90° intervals, 4 inches off bottom.
13 inches
8 inches
18 in.
45°
27 inches ± 2 in.
35 inches ± 2 in.
4 in.
4 in.
4 in.
22.5 in. ± 1 in.
22.5 in. ± 1 in.
4 in.
8 feet.

Water Balance Task Force - Statistical Analysis Data Entry Form

Wind Codes: A = Calm (0 - 5 MPH)
B = Breezy (6 - 15 MPH)
C = Windy (16 - 25 MPH)
D = Very Windy (> 25 MPH)

				BARREL MEASUREMENTS			POND MEASUREMENTS				
LOCATION	DATE YYMMDD	PRECIP (0.01")	WIND CODE	#	LEVEL — IN MILLIMETERS	TEMP	#	LEVEL - CONTROL IN MILLIMETERS	LEVEL - PERF BARREL MILLIMETERS	TEMP C	COMMENTS

9. EVALUATION OF ALTERNATIVE TEST METHODS

In our evaluation of the water balance test, we looked at alternatives to the water balance test and at variations of the specific methods of conducting the water balance test. Liners have been evaluated by most states. Thus, a number of different methods have been looked at and are being used. This basic information was obtained through our survey of states. We also looked briefly at information and methods suggested by researchers and evaluated various procedures for conducting the water balance test to try to find a balance between accuracy and cost.

Clay Liners

From the available test methods, we picked two alternatives for further evaluation -- sealed double-ring infiltrometer and reliance on pre-design and construction testing of soils.

Sealed Double Ring infiltrometer: The sealed double-ring infiltrometer is basically a field test of the permeability of the liner. The rings have an approximate diameter of 5 feet to evaluate a larger area than the 3-inch thin walled tube samples that are currently being used. The rings are sealed to prevent evaporation and eliminate that cause of test inaccuracy. The sealed double-ring infiltrometer is generally at the stage of practical research and development. It has not been used on many projects in the United States to evaluate permeabilities. However, it does hold considerable promise for accuracy of the measurements of the permeability at the ring test site.

In spite of the potential for accuracy, it was concluded that the costs and time required for the test and the number of tests which would be required to evaluate a liner make this test method undesirable.

Reliance on Soil Tests: The predictability of the successful completion of a clay liner based on evaluation of the pre-design and construction testing of the soils was evaluated for six pond sites. Of the six sites, two had liners which had to be reconstructed. Both of these ponds had pre-design and construction soils tests which indicated potential problems or marginal construction. The four suitable sites also had soils tests which predicted success.

However, the Water Balance Task Force felt that the use of these soils tests as the only criteria would not be acceptable to the Agency because of failures of liners in the past when lesser forms of soil testing were required.

Synthetic Liners

Electrical Resistivity: Only one alternative procedure was discussed: the use of electrical resistivity to identify areas of leaks. This testing technique is relatively new, particularly to the State of Minnesota. However, it appears to have considerable potential for evaluating synthetic liners. It appears that additional experience is needed before electronic resistivity can be used to replace water balance testing. Electrical resistivity has been used, with some limited success, to pinpoint leaks in one small pond in Minnesota. Additional experience will likely be gained in evaluating ponds that appear to be leaking.

VARIATIONS OF WATER BALANCE METHOD

Evaporation Pan Location: A primary source of inaccuracy in the water balance test is measuring evaporation from the pond surfaces. Evaporation is currently measured by using three barrels in each pond. We studied the use of evaporation pans on the dikes of the pond because this is easier to measure accurately.

However, it is well recognized that the evaporation of a pan placed on land is significantly different than the evaporation of a large body of water. Thus, a correction factor must be applied. These correction factors, to date, are quite approximate since there is no good way to accurately determine the relationship. Unfortunately, the variation in the factor is so great that it destroys the necessary accuracy for the water balance test. Therefore, this approach does not have much promise.

Hook Gauges: In one of the trials that the committee conducted, hook gauges were used to measure the level of the water in the barrels. These hook gauges were used in lieu of the millimeter rulers. It was determined that there was no statistically significant difference between the readings taken by hook gauge and those taken with a ruler graduated in millimeters. Thus, the additional cost and time of using a hook gauge does not appear warranted. It is possible that if other variables in the water balance test could be minimized, the difference would be statistically significant and use of hook gauges could be justified.

Types of "Barrels": During the two test projects different kinds of evaporation barrels were evaluated. These included the typical steel barrels, plastic barrels, and stock tanks. The steel barrels were generally 50-gallon barrels. In the second test these barrels were modified with a splash guard that extends above the typical lip of the barrel. The plastic barrels were chosen to evaluate the effects of different material. They were similar in size to the steel barrels. Stock tanks were used to evaluate the effect of a different size and shape of barrel. There were approximately 30 inches wide and 60 inches long.

In the raw data it appeared that there were differences between these types of barrels. However, statistically there was no significant difference between the steel barrels and the stock tanks but there was a statistically significant difference between the steel barrels and the plastic barrels. The plastic barrels recorded higher evaporation rates. The steel barrels are thought to be most representative of the true condition.

Protecting Barrels From Wave Action: Three different methods were tested to protect the barrels from splashing and wave action. The two methods which utilized floating wood, snow fence and pallets, did not work well since they became water-logged and sank before the end of the test period. Barrels with steel splash guards extending upward from the lip of the barrel in a cone shape did the best job of protecting from water splashing into the barrels.

Rain, Wind, and Temperature Measurements: Since weather is a significant factor in the accuracy of the testing, a number of methods were evaluated to measure weather conditions at the site during the test period. These included continuously recording gauges for rain, wind, and temperature measurements and non-recording gauges which had to be checked at the time that other survey measurements were taken.

The continuously recording gauges did provide additional information on weather conditions which was helpful in analyzing the amount of rainfall at the site. However, the question of runoff and runoff coefficients is still a bigger contributor to error in the final calculations than the difference in accuracy between the self-recording and non-recording gauges. Thus, the cost for continuously recording gauges does not appear warranted.

APPENDIX A

DATA ELEMENTS ON THE WATER BALANCE STATISTICAL ANALYSIS DATASET--SIX CITIES

Listed below are definitions for each of the data elements in the dataset used for the statistical analysis of six water balances. The data used for the Cleveland water balance is printed out, as an example. Data for the other water balances are available from the MPCA.

The definitions are given in the same order as the elements are listed on the attached Cleveland data listing.

OBS-observation number, there is one observation for each barrel within each pond for each date on which there are any barrel measurements made at that location

THE FOLLOWING ELEMENTS ARE TAKEN FROM THE DATA FORM FOR MEASUREMENTS

LOCATION-city where water balance is done

DATE-date of measurement

PRECIP-daily precipitation

WIND-wind speed (MPH)

TEMPC-air temperature (Centigrade)

PONDNO-code for pond number

PONDIN-level in the pond, whole inches, first control structure

POND32-level in the pond, fractional portion in 32nds of an inch, first control structure

PONDLIN-level in the pond, whole inches, second control structure

PONDL32-level in the pond, fractional portion in 32nds of an inch, second control structure

PONDTC-pond temperature (Centigrade)

BNO-code for barrel number

BLEVIN-level in the barrel, whole inches

BLEV32-level in the barrel, fractional portion in 32nds of an inch

THE FOLLOWING ELEMENTS ARE TAKEN FROM THE DATA FORM FOR POND DESCRIPTIONS

WAREA-water area of pond

RAREA-dike area

COEFF-runoff coefficient

DEPTH-prefill depth in feet

TYPE-liner type

THE FOLLOWING ELEMENTS ARE CALCULATED ELEMENTS

RUNCORR-daily runoff correction

BNOPNO-id code for barrel by pond, e.g. 11=1st barrel in 1st pond

MNPREC-mean daily precipitation (inches) over the study period

MNTEMPC-mean daily temperature (Centigrade) over the study period

MNWINDS-mean daily wind speed (MPH) over the study period

CUMPREC-total precipitation over the study period

BARLEVR-level in the barrel, converted to decimal values, for days on which barrel measurement was done

PONDLEV1-level in the pond, converted to decimal values, first control structure

PONDLEV2-level in the pond, converted to decimal values, second control structure

PNDLEV-PONDLEV1 if it exists, otherwise PONDLEV2, for days on which pond level measurement was done

BARLEV-most recent BARLEVR

CUMRUN-cumulative runoff correction

BARLAG-barrel level for the previous measurement

BARCH-change in barrel level since the previous measurement, BARCH=BARLEV-BARLAG

PONDLEV-most recent PNDLEV

PONDLAG-PONDLEV (pond level) for the previous measurement

PONDCH-change in pond level since the previous measurement, PONDCH=PONDLEV-PONDLAG

DATELAG-date value for the previous measurement, expressed in number of days between January 1, 1960 and that date

DAYDIF-number of days since the previous measurement

CUMDAY-cumulative days, number of days since the first measurement in the study period

WL-change in the pond level minus change in the barrel level, for that date, WL=PONDCH-BARCH

CUMBARCH-cumulative barrel change, change in the barrel level since the first measurement in the study period

CUMPONDC-cumulative pond change, change in the pond level since the first measurement in the study period

CUMPREC2-cumulative precipitation, total precipitation since the first measurement in the study period, for days with barrel level measurements

CUMWL-cumulative WL, total change in the barrel level minus change in the pond level since the first measurement in the study period

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
1	cleveland	871014	0.00	11	9.7	1	.	.	11	31	9.8	1	16	7	262138	4550	0.96
2	cleveland	871015	0.37	6	9.7	1	.	.	.	.	9.8	1	.	.	262138	4550	0.96
3	cleveland	871016	0.00	9	9.9	1	.	.	12	9	10.2	1	16	9	262138	4550	0.96
4	cleveland	871017	0.00	10	9.6	1	.	.	.	.	9.9	1	.	.	262138	4550	0.96
5	cleveland	871018	0.00	9	8.5	1	.	.	.	.	9.0	1	.	.	262138	4550	0.96
6	cleveland	871019	0.02	7	7.4	1	.	.	.	.	7.9	1	.	.	262138	4550	0.96
7	cleveland	871020	0.00	11	5.0	1	.	.	12	8	5.8	1	16	0	262138	4550	0.96
8	cleveland	871021	0.00	9	2.9	1	.	.	12	4	4.3	1	15	22	262138	4550	0.96
9	cleveland	871022	0.00	10	3.5	1	.	.	12	4	4.1	1	15	24	262138	4550	0.96
10	cleveland	871023	0.00	6	4.4	1	.	.	12	0	4.7	1	16	2	262138	4550	0.96
11	cleveland	871024	0.02	9	2.5	1	.	.	.	.	3.9	1	.	.	262138	4550	0.96
12	cleveland	871025	0.00	12	2.8	1	.	.	.	.	2.5	1	.	.	262138	4550	0.96
13	cleveland	871026	0.00	19	4.7	1	.	.	11	27	4.8	1	15	24	262138	4550	0.96
14	cleveland	871027	0.00	13	3.0	1	.	.	11	22	4.2	1	15	13	262138	4550	0.96
15	cleveland	871028	0.00	5	2.2	1	.	.	11	21	2.2	1	15	13	262138	4550	0.96
16	cleveland	871029	0.00	12	4.6	1	.	.	11	18	4.8	1	15	10	262138	4550	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
1	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	16.2188	.	11.9688	11.9688	16.2188	0.0000000
2	2	SOIL	0.00616530	11	0.0309677	5.62333	9.03226	0.96	.	.	.	11.9688	16.2188	0.0061653
3	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	16.2813	.	12.2813	12.2813	16.2813	0.0061653
4	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	16.2813	0.0061653
5	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	16.2813	0.0061653
6	2	SOIL	0.00033326	11	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	16.2813	0.0064986
7	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	16.0000	.	12.2500	12.2500	16.0000	0.0064986
8	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	15.6875	.	12.1250	12.1250	15.6875	0.0064986
9	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	15.7500	.	12.1250	12.1250	15.7500	0.0064986
10	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	16.0625	.	12.0000	12.0000	16.0625	0.0064986
11	2	SOIL	0.00033326	11	0.0309677	5.62333	9.03226	0.96	.	.	.	12.0000	16.0625	0.0068318
12	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	.	.	.	12.0000	16.0625	0.0068318
13	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	15.7500	.	11.8438	11.8438	15.7500	0.0068318
14	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	15.4063	.	11.6875	11.6875	15.4063	0.0068318
15	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	15.4063	.	11.6563	11.6563	15.4063	0.0068318
16	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	15.3125	.	11.5625	11.5625	15.3125	0.0068318

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
1	.	.	11.9688	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000
2	16.2188	0.00000	11.9626	11.9688	-0.00617	10148	1	1	-0.0062	0.0000	-0.0062	0.37	-0.00617
3	16.2188	0.06250	12.2751	11.9626	0.31250	10149	1	2	0.2500	0.0625	0.3063	0.37	0.24383
4	16.2813	0.00000	12.2751	12.2751	0.00000	10150	1	3	0.0000	0.0625	0.3063	0.37	0.24383
5	16.2813	0.00000	12.2751	12.2751	0.00000	10151	1	4	0.0000	0.0625	0.3063	0.37	0.24383
6	16.2813	0.00000	12.2748	12.2751	-0.00033	10152	1	5	-0.0003	0.0625	0.3060	0.39	0.24350
7	16.2813	-0.28125	12.2435	12.2748	-0.03125	10153	1	6	0.2500	-0.2188	0.2748	0.39	0.49350
8	16.0000	-0.31250	12.1185	12.2435	-0.12500	10154	1	7	0.1875	-0.5313	0.1498	0.39	0.68100
9	15.6875	0.06250	12.1185	12.1185	0.00000	10155	1	8	-0.0625	-0.4688	0.1498	0.39	0.61850
10	15.7500	0.31250	11.9935	12.1185	-0.12500	10156	1	9	-0.4375	-0.1563	0.0248	0.39	0.18100
11	16.0625	0.00000	11.9932	11.9935	-0.00033	10157	1	10	-0.0003	-0.1563	0.0244	0.41	0.18067
12	16.0625	0.00000	11.9932	11.9932	0.00000	10158	1	11	0.0000	-0.1563	0.0244	0.41	0.18067
13	16.0625	-0.31250	11.8369	11.9932	-0.15625	10159	1	12	0.1563	-0.4688	-0.1318	0.41	0.33692
14	15.7500	-0.34375	11.6807	11.8369	-0.15625	10160	1	13	0.1875	-0.8125	-0.2881	0.41	0.52442
15	15.4063	0.00000	11.6494	11.6807	-0.03125	10161	1	14	-0.0313	-0.8125	-0.3193	0.41	0.49317
16	15.4063	-0.09375	11.5557	11.6494	-0.09375	10162	1	15	0.0000	-0.9063	-0.4131	0.41	0.49317

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
17	cleveland	871030	0.00	6	7.0	1	.	.	11	17	6.4	1	15	10	262138	4550	0.96
18	cleveland	871031	0.00	8	6.7	1	.	.	.	.	6.4	1	.	.	262138	4550	0.96
19	cleveland	871101	0.00	8	9.0	1	.	.	.	.	8.2	1	.	.	262138	4550	0.96
20	cleveland	871102	0.00	7	12.2	1	.	.	11	15	10.7	1	15	10	262138	4550	0.96
21	cleveland	871103	0.28	10	11.8	1	.	.	11	18	11.8	1	15	7	262138	4550	0.96
22	cleveland	871104	0.01	15	8.4	1	.	.	11	15	9.8	1	15	3	262138	4550	0.96
23	cleveland	871105	0.00	13	.	1	.	.	11	19	5.8	1	14	27	262138	4550	0.96
24	cleveland	871106	0.00	9	3.3	1	.	.	11	5	5.1	1	14	24	262138	4550	0.96
25	cleveland	871107	0.00	7	4.1	1	.	.	.	.	5.3	1	.	.	262138	4550	0.96
26	cleveland	871108	0.00	8	6.2	1	.	.	.	.	5.4	1	.	.	262138	4550	0.96
27	cleveland	871109	0.26	7	1.7	1	.	.	11	3	1.6	1	14	23	262138	4550	0.96
28	cleveland	871110	0.00	4	0.6	1	.	.	11	3	1.6	1	14	20	262138	4550	0.96
29	cleveland	871111	0.00	4	0.5	1	.	.	11	20	2.6	1	14	18	262138	4550	0.96
30	cleveland	871112	0.00	9	2.2	1	.	.	10	31	3.7	1	14	17	262138	4550	0.96
31	cleveland	871113	0.00	7	4.6	1	.	.	11	0	3.6	1	14	15	262138	4550	0.96
32	cleveland	871014	0.00	11	9.7	2	18	23	.	.	9.8	1	17	26	259091	4809	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
17	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	15.3125	.	11.5313	11.5313	15.3125	0.0068318
18	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	.	.	.	11.5313	15.3125	0.0068318
19	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	.	.	.	11.5313	15.3125	0.0068318
20	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	15.3125	.	11.4688	11.4688	15.3125	0.0068318
21	2	SOIL	0.00466563	11	0.0309677	5.62333	9.03226	0.96	15.2188	.	11.5625	11.5625	15.2188	0.0114975
22	2	SOIL	0.00016663	11	0.0309677	5.62333	9.03226	0.96	15.0938	.	11.4688	11.4688	15.0938	0.0116641
23	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	14.8438	.	11.5938	11.5938	14.8438	0.0116641
24	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	14.7500	.	11.1563	11.1563	14.7500	0.0116641
25	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	.	.	.	11.1563	14.7500	0.0116641
26	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	.	.	.	11.1563	14.7500	0.0116641
27	2	SOIL	0.00433237	11	0.0309677	5.62333	9.03226	0.96	14.7188	.	11.0938	11.0938	14.7188	0.0159965
28	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	14.6250	.	11.0938	11.0938	14.6250	0.0159965
29	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	14.5625	.	11.6250	11.6250	14.5625	0.0159965
30	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	14.5313	.	10.9688	10.9688	14.5313	0.0159965
31	2	SOIL	0.00000000	11	0.0309677	5.62333	9.03226	0.96	14.4688	.	11.0000	11.0000	14.4688	0.0159965
32	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.8125	18.7188	.	18.7188	17.8125	0.0000000

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
17	15.3125	0.00000	11.5244	11.5557	-0.03125	10163	1	16	-0.0313	-0.9063	-0.4443	0.41	0.46192
18	15.3125	0.00000	11.5244	11.5244	0.00000	10164	1	17	0.0000	-0.9063	-0.4443	0.41	0.46192
19	15.3125	0.00000	11.5244	11.5244	0.00000	10165	1	18	0.0000	-0.9063	-0.4443	0.41	0.46192
20	15.3125	0.00000	11.4619	11.5244	-0.06250	10166	1	19	-0.0625	-0.9063	-0.5068	0.41	0.39942
21	15.3125	-0.09375	11.5510	11.4619	0.08908	10167	1	20	0.1828	-1.0000	-0.4177	0.69	0.58225
22	15.2188	-0.12500	11.4571	11.5510	-0.09392	10168	1	21	0.0311	-1.1250	-0.5117	0.70	0.61334
23	15.0938	-0.25000	11.5821	11.4571	0.12500	10169	1	22	0.3750	-1.3750	-0.3867	0.70	0.98834
24	14.8438	-0.09375	11.1446	11.5821	-0.43750	10170	1	23	-0.3438	-1.4688	-0.8242	0.70	0.64459
25	14.7500	0.00000	11.1446	11.1446	0.00000	10171	1	24	0.0000	-1.4688	-0.8242	0.70	0.64459
26	14.7500	0.00000	11.1446	11.1446	0.00000	10172	1	25	0.0000	-1.4688	-0.8242	0.70	0.64459
27	14.7500	-0.03125	11.0778	11.1446	-0.06683	10173	1	26	-0.0356	-1.5000	-0.8910	0.96	0.60900
28	14.7188	-0.09375	11.0778	11.0778	0.00000	10174	1	27	0.0938	-1.5938	-0.8910	0.96	0.70275
29	14.6250	-0.06250	11.6090	11.0778	0.53125	10175	1	28	0.5938	-1.6563	-0.3597	0.96	1.29650
30	14.5625	-0.03125	10.9528	11.6090	-0.65625	10176	1	29	-0.6250	-1.6875	-1.0160	0.96	0.67150
31	14.5313	-0.06250	10.9840	10.9528	0.03125	10177	1	30	0.0938	-1.7500	-0.9847	0.96	0.76525
32	.	.	18.7188	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
33	cleveland	871015	0.37	6	9.7	2	.	.	.	.	9.8	1	.	.	259091	4809	0.96
34	cleveland	871016	0.00	9	9.9	2	19	11	.	.	10.2	1	18	4	259091	4809	0.96
35	cleveland	871017	0.00	10	9.6	2	.	.	.	.	9.9	1	.	.	259091	4809	0.96
36	cleveland	871018	0.00	9	8.5	2	.	.	.	.	9.0	1	.	.	259091	4809	0.96
37	cleveland	871019	0.02	7	7.4	2	.	.	.	.	7.9	1	.	.	259091	4809	0.96
38	cleveland	871020	0.00	11	5.0	2	19	12	.	.	5.8	1	17	28	259091	4809	0.96
39	cleveland	871021	0.00	9	2.9	2	18	27	.	.	4.3	1	18	13	259091	4809	0.96
40	cleveland	871022	0.00	10	3.5	2	19	2	.	.	4.1	1	18	0	259091	4809	0.96
41	cleveland	871023	0.00	6	4.4	2	18	28	.	.	4.7	1	18	4	259091	4809	0.96
42	cleveland	871024	0.02	9	2.5	2	.	.	.	.	3.9	1	.	.	259091	4809	0.96
43	cleveland	871025	0.00	12	2.8	2	.	.	.	.	2.5	1	.	.	259091	4809	0.96
44	cleveland	871026	0.00	19	4.7	2	18	30	.	.	4.8	1	17	15	259091	4809	0.96
45	cleveland	871027	0.00	13	3.0	2	18	24	.	.	4.2	1	17	4	259091	4809	0.96
46	cleveland	871028	0.00	5	2.2	2	18	14	.	.	2.2	1	17	22	259091	4809	0.96
47	cleveland	871029	0.00	12	4.6	2	18	10	.	.	4.8	1	17	15	259091	4809	0.96
48	cleveland	871030	0.00	6	7.0	2	18	13	.	.	6.4	1	17	12	259091	4809	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
33	2	SOIL	0.00659288	12	0.0309677	5.62333	9.03226	0.96	.	.	.	18.7188	17.8125	0.0065929
34	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	18.1250	19.3438	.	19.3438	18.1250	0.0065929
35	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	18.1250	0.0065929
36	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	18.1250	0.0065929
37	2	SOIL	0.00035637	12	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	18.1250	0.0069493
38	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.8750	19.3750	.	19.3750	17.8750	0.0069493
39	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	18.4063	18.8438	.	18.8438	18.4063	0.0069493
40	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	18.0000	19.0625	.	19.0625	18.0000	0.0069493
41	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	18.1250	18.8750	.	18.8750	18.1250	0.0069493
42	2	SOIL	0.00035637	12	0.0309677	5.62333	9.03226	0.96	.	.	.	18.8750	18.1250	0.0073056
43	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	.	.	.	18.8750	18.1250	0.0073056
44	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.4688	18.9375	.	18.9375	17.4688	0.0073056
45	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.1250	18.7500	.	18.7500	17.1250	0.0073056
46	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.6875	18.4375	.	18.4375	17.6875	0.0073056
47	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.4688	18.3125	.	18.3125	17.4688	0.0073056
48	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.3750	18.4063	.	18.4063	17.3750	0.0073056

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
33	17.8125	0.00000	18.7122	18.7188	-0.00659	10148	1	1	-0.0066	0.0000	-0.00659	0.37	-0.00659
34	17.8125	0.31250	19.3372	18.7122	0.62500	10149	1	2	0.3125	0.3125	0.61841	0.37	0.30591
35	18.1250	0.00000	19.3372	19.3372	0.00000	10150	1	3	0.0000	0.3125	0.61841	0.37	0.30591
36	18.1250	0.00000	19.3372	19.3372	0.00000	10151	1	4	0.0000	0.3125	0.61841	0.37	0.30591
37	18.1250	0.00000	19.3368	19.3372	-0.00036	10152	1	5	-0.0004	0.3125	0.61805	0.39	0.30555
38	18.1250	-0.25000	19.3681	19.3368	0.03125	10153	1	6	0.2813	0.0625	0.64930	0.39	0.58680
39	17.8750	0.53125	18.8368	19.3681	-0.53125	10154	1	7	-1.0625	0.5938	0.11805	0.39	-0.47570
40	18.4063	-0.40625	19.0556	18.8368	0.21875	10155	1	8	0.6250	0.1875	0.33680	0.39	0.14930
41	18.0000	0.12500	18.8681	19.0556	-0.18750	10156	1	9	-0.3125	0.3125	0.14930	0.39	-0.16320
42	18.1250	0.00000	18.8677	18.8681	-0.00036	10157	1	10	-0.0004	0.3125	0.14894	0.41	-0.16356
43	18.1250	0.00000	18.8677	18.8677	0.00000	10158	1	11	0.0000	0.3125	0.14894	0.41	-0.16356
44	18.1250	-0.65625	18.9302	18.8677	0.06250	10159	1	12	0.7188	-0.3438	0.21144	0.41	0.55519
45	17.4688	-0.34375	18.7427	18.9302	-0.18750	10160	1	13	0.1563	-0.6875	0.02394	0.41	0.71144
46	17.1250	0.56250	18.4302	18.7427	-0.31250	10161	1	14	-0.8750	-0.1250	-0.28856	0.41	-0.16356
47	17.6875	-0.21875	18.3052	18.4302	-0.12500	10162	1	15	0.0938	-0.3438	-0.41356	0.41	-0.06981
48	17.4688	-0.09375	18.3989	18.3052	0.09375	10163	1	16	0.1875	-0.4375	-0.31981	0.41	0.11769

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
49	cleveland	871031	0.00	8	6.7	2	.	.	.	.	6.4	1	.	.	259091	4809	0.96
50	cleveland	871101	0.00	8	9.0	2	.	.	.	.	8.2	1	.	.	259091	4809	0.96
51	cleveland	871102	0.00	7	12.2	2	18	14	.	.	10.7	1	17	7	259091	4809	0.96
52	cleveland	871103	0.28	10	11.8	2	18	18	.	.	11.8	1	17	14	259091	4809	0.96
53	cleveland	871104	0.01	15	8.4	2	18	8	.	.	9.8	1	17	5	259091	4809	0.96
54	cleveland	871105	0.00	13	.	2	18	20	.	.	5.8	1	17	1	259091	4809	0.96
55	cleveland	871106	0.00	9	3.3	2	18	5	.	.	5.1	1	16	31	259091	4809	0.96
56	cleveland	871107	0.00	7	4.1	2	.	.	.	.	5.3	1	.	.	259091	4809	0.96
57	cleveland	871108	0.00	8	6.2	2	.	.	.	.	5.4	1	.	.	259091	4809	0.96
58	cleveland	871109	0.26	7	1.7	2	17	27	.	.	1.6	1	16	26	259091	4809	0.96
59	cleveland	871110	0.00	4	0.6	2	17	28	.	.	1.6	1	16	29	259091	4809	0.96
60	cleveland	871111	0.00	4	0.5	2	18	3	.	.	2.6	1	16	31	259091	4809	0.96
61	cleveland	871112	0.00	9	2.2	2	17	25	.	.	3.7	1	16	25	259091	4809	0.96
62	cleveland	871113	0.00	7	4.6	2	17	29	.	.	3.6	1	16	26	259091	4809	0.96
63	cleveland	871014	0.00	11	9.7	3	16	18	.	.	9.8	1	14	15	260547	4993	0.96
64	cleveland	871015	0.37	6	9.7	3	.	.	.	.	9.8	1	.	.	260547	4993	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
49	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	.	.	.	18.4063	17.3750	0.0073056
50	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	.	.	.	18.4063	17.3750	0.0073056
51	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.2188	18.4375	.	18.4375	17.2188	0.0073056
52	2	SOIL	0.00498921	12	0.0309677	5.62333	9.03226	0.96	17.4375	18.5625	.	18.5625	17.4375	0.0122948
53	2	SOIL	0.00017819	12	0.0309677	5.62333	9.03226	0.96	17.1563	18.2500	.	18.2500	17.1563	0.0124730
54	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	17.0313	18.6250	.	18.6250	17.0313	0.0124730
55	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	16.9688	18.1563	.	18.1563	16.9688	0.0124730
56	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	.	.	.	18.1563	16.9688	0.0124730
57	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	.	.	.	18.1563	16.9688	0.0124730
58	2	SOIL	0.00463284	12	0.0309677	5.62333	9.03226	0.96	16.8125	17.8438	.	17.8438	16.8125	0.0171059
59	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	16.9063	17.8750	.	17.8750	16.9063	0.0171059
60	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	16.9688	18.0938	.	18.0938	16.9688	0.0171059
61	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	16.7813	17.7813	.	17.7813	16.7813	0.0171059
62	2	SOIL	0.00000000	12	0.0309677	5.62333	9.03226	0.96	16.8125	17.9063	.	17.9063	16.8125	0.0171059
63	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	14.4688	16.5625	.	16.5625	14.4688	0.0000000
64	2	SOIL	0.00680689	13	0.0309677	5.62333	9.03226	0.96	.	.	.	16.5625	14.4688	0.0068069

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
49	17.3750	0.00000	18.3989	18.3989	0.00000	10164	1	17	0.00000	-0.4375	-0.3198	0.41	0.11769
50	17.3750	0.00000	18.3989	18.3989	0.00000	10165	1	18	0.00000	-0.4375	-0.3198	0.41	0.11769
51	17.3750	-0.15625	18.4302	18.3989	0.03125	10166	1	19	0.18750	-0.5938	-0.2886	0.41	0.30519
52	17.2188	0.21875	18.5502	18.4302	0.12001	10167	1	20	-0.09874	-0.3750	-0.1685	0.69	0.20646
53	17.4375	-0.28125	18.2375	18.5502	-0.31268	10168	1	21	-0.03143	-0.6563	-0.4812	0.70	0.17503
54	17.1563	-0.12500	18.6125	18.2375	0.37500	10169	1	22	0.50000	-0.7813	-0.1062	0.70	0.67503
55	17.0313	-0.06250	18.1438	18.6125	-0.46875	10170	1	23	-0.40625	-0.8438	-0.5750	0.70	0.26878
56	16.9688	0.00000	18.1438	18.1438	0.00000	10171	1	24	0.00000	-0.8438	-0.5750	0.70	0.26878
57	16.9688	0.00000	18.1438	18.1438	0.00000	10172	1	25	0.00000	-0.8438	-0.5750	0.70	0.26878
58	16.9688	-0.15625	17.8266	18.1438	-0.31713	10173	1	26	-0.16088	-1.0000	-0.8921	0.96	0.10789
59	16.8125	0.09375	17.8579	17.8266	0.03125	10174	1	27	-0.06250	-0.9063	-0.8609	0.96	0.04539
60	16.9063	0.06250	18.0766	17.8579	0.21875	10175	1	28	0.15625	-0.8438	-0.6421	0.96	0.20164
61	16.9688	-0.18750	17.7641	18.0766	-0.31250	10176	1	29	-0.12500	-1.0313	-0.9546	0.96	0.07664
62	16.7813	0.03125	17.8891	17.7641	0.12500	10177	1	30	0.09375	-1.0000	-0.8296	0.96	0.17039
63	.	.	16.5625	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000
64	14.4688	0.00000	16.5557	16.5625	-0.00681	10148	1	1	-0.00681	0.0000	-0.0068	0.37	-0.00681

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
65	cleveland	871016	0.00	9	9.9	3	17	4	.	.	10.2	1	14	26	260547	4993	0.96
66	cleveland	871017	0.00	10	9.6	3	.	.	.	.	9.9	1	.	.	260547	4993	0.96
67	cleveland	871018	0.00	9	8.5	3	.	.	.	.	9.0	1	.	.	260547	4993	0.96
68	cleveland	871019	0.02	7	7.4	3	.	.	.	.	7.9	1	.	.	260547	4993	0.96
69	cleveland	871020	0.00	11	5.0	3	16	28	.	.	5.8	1	14	21	260547	4993	0.96
70	cleveland	871021	0.00	9	2.9	3	16	18	.	.	4.3	1	14	15	260547	4993	0.96
71	cleveland	871022	0.00	10	3.5	3	16	15	.	.	4.1	1	14	15	260547	4993	0.96
72	cleveland	871023	0.00	6	4.4	3	16	14	.	.	4.7	1	14	8	260547	4993	0.96
73	cleveland	871024	0.02	9	2.5	3	.	.	.	.	3.9	1	.	.	260547	4993	0.96
74	cleveland	871025	0.00	12	2.8	3	.	.	.	.	2.5	1	.	.	260547	4993	0.96
75	cleveland	871026	0.00	19	4.7	3	16	10	.	.	4.8	1	14	9	260547	4993	0.96
76	cleveland	871027	0.00	13	3.0	3	16	10	.	.	4.2	1	13	31	260547	4993	0.96
77	cleveland	871028	0.00	5	2.2	3	16	4	.	.	2.2	1	14	4	260547	4993	0.96
78	cleveland	871029	0.00	12	4.6	3	16	6	.	.	4.8	1	13	31	260547	4993	0.96
79	cleveland	871030	0.00	6	7.0	3	15	27	.	.	6.4	1	13	30	260547	4993	0.96
80	cleveland	871031	0.00	8	6.7	3	.	.	.	.	6.4	1	.	.	260547	4993	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
65	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	14.8125	17.1250	.	17.1250	14.8125	0.0068069
66	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	14.8125	0.0068069
67	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	14.8125	0.0068069
68	2	SOIL	0.00036794	13	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	14.8125	0.0071748
69	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	14.6563	16.8750	.	16.8750	14.6563	0.0071748
70	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	14.4688	16.5625	.	16.5625	14.4688	0.0071748
71	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	14.4688	16.4688	.	16.4688	14.4688	0.0071748
72	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	14.2500	16.4375	.	16.4375	14.2500	0.0071748
73	2	SOIL	0.00036794	13	0.0309677	5.62333	9.03226	0.96	.	.	.	16.4375	14.2500	0.0075428
74	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	.	.	.	16.4375	14.2500	0.0075428
75	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	14.2813	16.3125	.	16.3125	14.2813	0.0075428
76	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.9688	16.3125	.	16.3125	13.9688	0.0075428
77	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	14.1250	16.1250	.	16.1250	14.1250	0.0075428
78	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.9688	16.1875	.	16.1875	13.9688	0.0075428
79	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.9375	15.8438	.	15.8438	13.9375	0.0075428
80	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8438	13.9375	0.0075428

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
65	14.4688	0.34375	17.1182	16.5557	0.56250	10149	1	2	0.21875	0.3438	0.5557	0.37	0.21194
66	14.8125	0.00000	17.1182	17.1182	0.00000	10150	1	3	0.00000	0.3438	0.5557	0.37	0.21194
67	14.8125	0.00000	17.1182	17.1182	0.00000	10151	1	4	0.00000	0.3438	0.5557	0.37	0.21194
68	14.8125	0.00000	17.1178	17.1182	-0.00037	10152	1	5	-0.00037	0.3438	0.5553	0.39	0.21158
69	14.8125	-0.15625	16.8678	17.1178	-0.25000	10153	1	6	-0.09375	0.1875	0.3053	0.39	0.11783
70	14.6563	-0.18750	16.5553	16.8678	-0.31250	10154	1	7	-0.12500	0.0000	-0.0072	0.39	-0.00717
71	14.4688	0.00000	16.4616	16.5553	-0.09375	10155	1	8	-0.09375	0.0000	-0.1009	0.39	-0.10092
72	14.4688	-0.21875	16.4303	16.4616	-0.03125	10156	1	9	0.18750	-0.2188	-0.1322	0.39	0.08658
73	14.2500	0.00000	16.4300	16.4303	-0.00037	10157	1	10	-0.00037	-0.2188	-0.1325	0.41	0.08621
74	14.2500	0.00000	16.4300	16.4300	0.00000	10158	1	11	0.00000	-0.2188	-0.1325	0.41	0.08621
75	14.2500	0.03125	16.3050	16.4300	-0.12500	10159	1	12	-0.15625	-0.1875	-0.2575	0.41	-0.07004
76	14.2813	-0.31250	16.3050	16.3050	0.00000	10160	1	13	0.31250	-0.5000	-0.2575	0.41	0.24246
77	13.9688	0.15625	16.1175	16.3050	-0.18750	10161	1	14	-0.34375	-0.3438	-0.4450	0.41	-0.10129
78	14.1250	-0.15625	16.1800	16.1175	0.06250	10162	1	15	0.21875	-0.5000	-0.3825	0.41	0.11746
79	13.9688	-0.03125	15.8362	16.1800	-0.34375	10163	1	16	-0.31250	-0.5313	-0.7263	0.41	-0.19504
80	13.9375	0.00000	15.8362	15.8362	0.00000	10164	1	17	0.00000	-0.5313	-0.7263	0.41	-0.19504

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
81	cleveland	871101	0.00	8	9.0	3	.	.	.	.	8.2	1	.	.	260547	4993	0.96
82	cleveland	871102	0.00	7	12.2	3	15	31	.	.	10.7	1	13	29	260547	4993	0.96
83	cleveland	871103	0.28	10	11.8	3	15	28	.	.	11.8	1	13	31	260547	4993	0.96
84	cleveland	871104	0.01	15	8.4	3	15	23	.	.	9.8	1	13	28	260547	4993	0.96
85	cleveland	871105	0.00	13	.	3	15	22	.	.	5.8	1	13	19	260547	4993	0.96
86	cleveland	871106	0.00	9	3.3	3	15	26	.	.	5.1	1	13	16	260547	4993	0.96
87	cleveland	871107	0.00	7	4.1	3	.	.	.	.	5.3	1	.	.	260547	4993	0.96
88	cleveland	871108	0.00	8	6.2	3	.	.	.	.	5.4	1	.	.	260547	4993	0.96
89	cleveland	871109	0.26	7	1.7	3	15	27	.	.	1.6	1	13	13	260547	4993	0.96
90	cleveland	871110	0.00	4	0.6	3	15	23	.	.	1.6	1	13	13	260547	4993	0.96
91	cleveland	871111	0.00	4	0.5	3	15	14	.	.	2.6	1	13	12	260547	4993	0.96
92	cleveland	871112	0.00	9	2.2	3	15	0	.	.	3.7	1	13	10	260547	4993	0.96
93	cleveland	871113	0.00	7	4.6	3	15	13	.	.	3.6	1	13	8	260547	4993	0.96
94	cleveland	871014	0.00	11	9.7	1	.	.	11	31	9.8	2	15	25	262138	4550	0.96
95	cleveland	871015	0.37	6	9.7	1	.	.	.	.	9.8	2	.	.	262138	4550	0.96
96	cleveland	871016	0.00	9	9.9	1	.	.	12	9	10.2	2	16	5	262138	4550	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
81	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8438	13.9375	0.0075428
82	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.9063	15.9688	.	15.9688	13.9063	0.0075428
83	2	SOIL	0.00515116	13	0.0309677	5.62333	9.03226	0.96	13.9688	15.8750	.	15.8750	13.9688	0.0126939
84	2	SOIL	0.00018397	13	0.0309677	5.62333	9.03226	0.96	13.8750	15.7188	.	15.7188	13.8750	0.0128779
85	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.5938	15.6875	.	15.6875	13.5938	0.0128779
86	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.5000	15.8125	.	15.8125	13.5000	0.0128779
87	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8125	13.5000	0.0128779
88	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8125	13.5000	0.0128779
89	2	SOIL	0.00478322	13	0.0309677	5.62333	9.03226	0.96	13.4063	15.8438	.	15.8438	13.4063	0.0176611
90	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.4063	15.7188	.	15.7188	13.4063	0.0176611
91	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.3750	15.4375	.	15.4375	13.3750	0.0176611
92	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.3125	15.0000	.	15.0000	13.3125	0.0176611
93	2	SOIL	0.00000000	13	0.0309677	5.62333	9.03226	0.96	13.2500	15.4063	.	15.4063	13.2500	0.0176611
94	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.7813	.	11.9688	11.9688	15.7813	0.0000000
95	2	SOIL	0.00616530	21	0.0309677	5.62333	9.03226	0.96	.	.	.	11.9688	15.7813	0.0061653
96	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	16.1563	.	12.2813	12.2813	16.1563	0.0061653

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
81	13.9375	0.00000	15.8362	15.8362	0.00000	10165	1	18	0.00000	-0.5313	-0.7263	0.41	-0.19504
82	13.9375	-0.03125	15.9612	15.8362	0.12500	10166	1	19	0.15625	-0.5625	-0.6013	0.41	-0.03879
83	13.9063	0.06250	15.8623	15.9612	-0.09890	10167	1	20	-0.16140	-0.5000	-0.7002	0.69	-0.20019
84	13.9688	-0.09375	15.7059	15.8623	-0.15643	10168	1	21	-0.06268	-0.5938	-0.8566	0.70	-0.26288
85	13.8750	-0.28125	15.6746	15.7059	-0.03125	10169	1	22	0.25000	-0.8750	-0.8879	0.70	-0.01288
86	13.5938	-0.09375	15.7996	15.6746	0.12500	10170	1	23	0.21875	-0.9688	-0.7629	0.70	0.20587
87	13.5000	0.00000	15.7996	15.7996	0.00000	10171	1	24	0.00000	-0.9688	-0.7629	0.70	0.20587
88	13.5000	0.00000	15.7996	15.7996	0.00000	10172	1	25	0.00000	-0.9688	-0.7629	0.70	0.20587
89	13.5000	-0.09375	15.8261	15.7996	0.02647	10173	1	26	0.12022	-1.0625	-0.7364	0.96	0.32609
90	13.4063	0.00000	15.7011	15.8261	-0.12500	10174	1	27	-0.12500	-1.0625	-0.8614	0.96	0.20109
91	13.4063	-0.03125	15.4198	15.7011	-0.28125	10175	1	28	-0.25000	-1.0938	-1.1427	0.96	-0.04891
92	13.3750	-0.06250	14.9823	15.4198	-0.43750	10176	1	29	-0.37500	-1.1563	-1.5802	0.96	-0.42391
93	13.3125	-0.06250	15.3886	14.9823	0.40625	10177	1	30	0.46875	-1.2188	-1.1739	0.96	0.04484
94	.	.	11.9688	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000
95	15.7813	0.00000	11.9626	11.9688	-0.00617	10148	1	1	-0.00617	0.0000	-0.0062	0.37	-0.00617
96	15.7813	0.37500	12.2751	11.9626	0.31250	10149	1	2	-0.06250	0.3750	0.3063	0.37	-0.06867

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
97	cleveland	871017	0.00	10	9.6	1	.	.	.	.	9.9	2	.	.	262138	4550	0.96
98	cleveland	871018	0.00	9	8.5	1	.	.	.	.	9.0	2	.	.	262138	4550	0.96
99	cleveland	871019	0.02	7	7.4	1	.	.	.	.	7.9	2	.	.	262138	4550	0.96
100	cleveland	871020	0.00	11	5.0	1	.	.	12	8	5.8	2	16	1	262138	4550	0.96
101	cleveland	871021	0.00	9	2.9	1	.	.	12	4	4.3	2	15	19	262138	4550	0.96
102	cleveland	871022	0.00	10	3.5	1	.	.	12	4	4.1	2	15	22	262138	4550	0.96
103	cleveland	871023	0.00	6	4.4	1	.	.	12	0	4.7	2	15	2	262138	4550	0.96
104	cleveland	871024	0.02	9	2.5	1	.	.	.	.	3.9	2	.	.	262138	4550	0.96
105	cleveland	871025	0.00	12	2.8	1	.	.	.	.	2.5	2	.	.	262138	4550	0.96
106	cleveland	871026	0.00	19	4.7	1	.	.	11	27	4.8	2	15	16	262138	4550	0.96
107	cleveland	871027	0.00	13	3.0	1	.	.	11	22	4.2	2	15	9	262138	4550	0.96
108	cleveland	871028	0.00	5	2.2	1	.	.	11	21	2.2	2	15	11	262138	4550	0.96
109	cleveland	871029	0.00	12	4.6	1	.	.	11	18	4.8	2	.	.	262138	4550	0.96
110	cleveland	871030	0.00	6	7.0	1	.	.	11	17	6.4	2	15	11	262138	4550	0.96
111	cleveland	871031	0.00	8	6.7	1	.	.	.	.	6.4	2	.	.	262138	4550	0.96
112	cleveland	871101	0.00	8	9.0	1	.	.	.	.	8.2	2	.	.	262138	4550	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
97	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	16.1563	0.0061653
98	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	16.1563	0.0061653
99	2	SOIL	0.00033326	21	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	16.1563	0.0064986
100	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	16.0313	.	12.2500	12.2500	16.0313	0.0064986
101	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.5938	.	12.1250	12.1250	15.5938	0.0064986
102	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.6875	.	12.1250	12.1250	15.6875	0.0064986
103	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.0625	.	12.0000	12.0000	15.0625	0.0064986
104	2	SOIL	0.00033326	21	0.0309677	5.62333	9.03226	0.96	.	.	.	12.0000	15.0625	0.0068318
105	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	.	.	.	12.0000	15.0625	0.0068318
106	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.5000	.	11.8438	11.8438	15.5000	0.0068318
107	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.2813	.	11.6875	11.6875	15.2813	0.0068318
108	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.3438	.	11.6563	11.6563	15.3438	0.0068318
109	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	.	.	11.5625	11.5625	15.3438	0.0068318
110	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.3438	.	11.5313	11.5313	15.3438	0.0068318
111	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	.	.	.	11.5313	15.3438	0.0068318
112	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	.	.	.	11.5313	15.3438	0.0068318

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
97	16.1563	0.00000	12.2751	12.2751	0.00000	10150	1	3	0.00000	0.3750	0.3063	0.37	-0.068665
98	16.1563	0.00000	12.2751	12.2751	0.00000	10151	1	4	0.00000	0.3750	0.3063	0.37	-0.068665
99	16.1563	0.00000	12.2748	12.2751	-0.00033	10152	1	5	-0.00033	0.3750	0.3060	0.39	-0.068999
100	16.1563	-0.12500	12.2435	12.2748	-0.03125	10153	1	6	0.09375	0.2500	0.2748	0.39	0.024751
101	16.0313	-0.43750	12.1185	12.2435	-0.12500	10154	1	7	0.31250	-0.1875	0.1498	0.39	0.337251
102	15.5938	0.09375	12.1185	12.1185	0.00000	10155	1	8	-0.09375	-0.0938	0.1498	0.39	0.243501
103	15.6875	-0.62500	11.9935	12.1185	-0.12500	10156	1	9	0.50000	-0.7188	0.0248	0.39	0.743501
104	15.0625	0.00000	11.9932	11.9935	-0.00033	10157	1	10	-0.00033	-0.7188	0.0244	0.41	0.743168
105	15.0625	0.00000	11.9932	11.9932	0.00000	10158	1	11	0.00000	-0.7188	0.0244	0.41	0.743168
106	15.0625	0.43750	11.8369	11.9932	-0.15625	10159	1	12	-0.59375	-0.2813	-0.1318	0.41	0.149418
107	15.5000	-0.21875	11.6807	11.8369	-0.15625	10160	1	13	0.06250	-0.5000	-0.2881	0.41	0.211918
108	15.2813	0.06250	11.6494	11.6807	-0.03125	10161	1	14	-0.09375	-0.4375	-0.3193	0.41	0.118168
109	15.3438	0.00000	11.5557	11.6494	-0.09375	10162	1	15	-0.09375	-0.4375	-0.4131	0.41	0.024418
110	15.3438	0.00000	11.5244	11.5557	-0.03125	10163	1	16	-0.03125	-0.4375	-0.4443	0.41	-0.006832
111	15.3438	0.00000	11.5244	11.5244	0.00000	10164	1	17	0.00000	-0.4375	-0.4443	0.41	-0.006832
112	15.3438	0.00000	11.5244	11.5244	0.00000	10165	1	18	0.00000	-0.4375	-0.4443	0.41	-0.006832

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
113	cleveland	871102	0.00	7	12.2	1	.	.	11	15	10.7	2	15	10	262138	4550	0.96
114	cleveland	871103	0.28	10	11.8	1	.	.	11	18	11.8	2	15	11	262138	4550	0.96
115	cleveland	871104	0.01	15	8.4	1	.	.	11	15	9.8	2	15	3	262138	4550	0.96
116	cleveland	871105	0.00	13	.	1	.	.	11	19	5.8	2	14	27	262138	4550	0.96
117	cleveland	871106	0.00	9	3.3	1	.	.	11	5	5.1	2	14	22	262138	4550	0.96
118	cleveland	871107	0.00	7	4.1	1	.	.	.	.	5.3	2	.	.	262138	4550	0.96
119	cleveland	871108	0.00	8	6.2	1	.	.	.	.	5.4	2	.	.	262138	4550	0.96
120	cleveland	871109	0.26	7	1.7	1	.	.	11	3	1.6	2	14	17	262138	4550	0.96
121	cleveland	871110	0.00	4	0.6	1	.	.	11	3	1.6	2	14	17	262138	4550	0.96
122	cleveland	871111	0.00	4	0.5	1	.	.	11	20	2.6	2	14	14	262138	4550	0.96
123	cleveland	871112	0.00	9	2.2	1	.	.	10	31	3.7	2	14	12	262138	4550	0.96
124	cleveland	871113	0.00	7	4.6	1	.	.	11	0	3.6	2	14	13	262138	4550	0.96
125	cleveland	871014	0.00	11	9.7	2	18	23	.	.	9.8	2	16	13	259091	4809	0.96
126	cleveland	871015	0.37	6	9.7	2	.	.	.	.	9.8	2	.	.	259091	4809	0.96
127	cleveland	871016	0.00	9	9.9	2	19	11	.	.	10.2	2	16	27	259091	4809	0.96
128	cleveland	871017	0.00	10	9.6	2	.	.	.	.	9.9	2	.	.	259091	4809	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
113	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	15.3125	.	11.4688	11.4688	15.3125	0.0068318
114	2	SOIL	0.00466563	21	0.0309677	5.62333	9.03226	0.96	15.3438	.	11.5625	11.5625	15.3438	0.0114975
115	2	SOIL	0.00016663	21	0.0309677	5.62333	9.03226	0.96	15.0938	.	11.4688	11.4688	15.0938	0.0116641
116	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	14.8438	.	11.5938	11.5938	14.8438	0.0116641
117	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	14.6875	.	11.1563	11.1563	14.6875	0.0116641
118	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	.	.	.	11.1563	14.6875	0.0116641
119	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	.	.	.	11.1563	14.6875	0.0116641
120	2	SOIL	0.00433237	21	0.0309677	5.62333	9.03226	0.96	14.5313	.	11.0938	11.0938	14.5313	0.0159965
121	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	14.5313	.	11.0938	11.0938	14.5313	0.0159965
122	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	14.4375	.	11.6250	11.6250	14.4375	0.0159965
123	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	14.3750	.	10.9688	10.9688	14.3750	0.0159965
124	2	SOIL	0.00000000	21	0.0309677	5.62333	9.03226	0.96	14.4063	.	11.0000	11.0000	14.4063	0.0159965
125	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	16.4063	18.7188	.	18.7188	16.4063	0.0000000
126	2	SOIL	0.00659288	22	0.0309677	5.62333	9.03226	0.96	.	.	.	18.7188	16.4063	0.0065929
127	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	16.8438	19.3438	.	19.3438	16.8438	0.0065929
128	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	16.8438	0.0065929

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
113	15.3438	-0.03125	11.4619	11.5244	-0.06250	10166	1	19	-0.03125	-0.4688	-0.5068	0.41	-0.038082
114	15.3125	0.03125	11.5510	11.4619	0.08908	10167	1	20	0.05783	-0.4375	-0.4177	0.69	0.019753
115	15.3438	-0.25000	11.4571	11.5510	-0.09392	10168	1	21	0.15608	-0.6875	-0.5117	0.70	0.175836
116	15.0938	-0.25000	11.5821	11.4571	0.12500	10169	1	22	0.37500	-0.9375	-0.3867	0.70	0.550836
117	14.8438	-0.15625	11.1446	11.5821	-0.43750	10170	1	23	-0.28125	-1.0938	-0.8242	0.70	0.269586
118	14.6875	0.00000	11.1446	11.1446	0.00000	10171	1	24	0.00000	-1.0938	-0.8242	0.70	0.269586
119	14.6875	0.00000	11.1446	11.1446	0.00000	10172	1	25	0.00000	-1.0938	-0.8242	0.70	0.269586
120	14.6875	-0.15625	11.0778	11.1446	-0.06683	10173	1	26	0.08942	-1.2500	-0.8910	0.96	0.359004
121	14.5313	0.00000	11.0778	11.0778	0.00000	10174	1	27	0.00000	-1.2500	-0.8910	0.96	0.359004
122	14.5313	-0.09375	11.6090	11.0778	0.53125	10175	1	28	0.62500	-1.3438	-0.3597	0.96	0.984004
123	14.4375	-0.06250	10.9528	11.6090	-0.65625	10176	1	29	-0.59375	-1.4063	-1.0160	0.96	0.390254
124	14.3750	0.03125	10.9840	10.9528	0.03125	10177	1	30	0.00000	-1.3750	-0.9847	0.96	0.390254
125	.	.	18.7188	.	.	.	.	0	.	0.0000	0.0000	0.00	0.000000
126	16.4063	0.00000	18.7122	18.7188	-0.00659	10148	1	1	-0.00659	0.0000	-0.0066	0.37	-0.006593
127	16.4063	0.43750	19.3372	18.7122	0.62500	10149	1	2	0.18750	0.4375	0.6184	0.37	0.180907
128	16.8438	0.00000	19.3372	19.3372	0.00000	10150	1	3	0.00000	0.4375	0.6184	0.37	0.180907

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
129	cleveland	871018	0.00	9	8.5	2	.	.	.	.	9.0	2	.	.	259091	4809	0.96
130	cleveland	871019	0.02	7	7.4	2	.	.	.	.	7.9	2	.	.	259091	4809	0.96
131	cleveland	871020	0.00	11	5.0	2	19	12	.	.	5.8	2	16	20	259091	4809	0.96
132	cleveland	871021	0.00	9	2.9	2	18	27	.	.	4.3	2	16	18	259091	4809	0.96
133	cleveland	871022	0.00	10	3.5	2	19	2	.	.	4.1	2	16	11	259091	4809	0.96
134	cleveland	871023	0.00	6	4.4	2	18	28	.	.	4.7	2	16	10	259091	4809	0.96
135	cleveland	871024	0.02	9	2.5	2	.	.	.	.	3.9	2	.	.	259091	4809	0.96
136	cleveland	871025	0.00	12	2.8	2	.	.	.	.	2.5	2	.	.	259091	4809	0.96
137	cleveland	871026	0.00	19	4.7	2	18	30	.	.	4.8	2	15	27	259091	4809	0.96
138	cleveland	871027	0.00	13	3.0	2	18	24	.	.	4.2	2	15	22	259091	4809	0.96
139	cleveland	871028	0.00	5	2.2	2	18	14	.	.	2.2	2	15	26	259091	4809	0.96
140	cleveland	871029	0.00	12	4.6	2	18	10	.	.	4.8	2	15	11	259091	4809	0.96
141	cleveland	871030	0.00	6	7.0	2	18	13	.	.	6.4	2	15	19	259091	4809	0.96
142	cleveland	871031	0.00	8	6.7	2	.	.	.	.	6.4	2	.	.	259091	4809	0.96
143	cleveland	871101	0.00	8	9.0	2	.	.	.	.	8.2	2	.	.	259091	4809	0.96
144	cleveland	871102	0.00	7	12.2	2	18	14	.	.	10.7	2	15	19	259091	4809	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
129	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	16.8438	0.0065929
130	2	SOIL	0.00035637	22	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	16.8438	0.0069493
131	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	16.6250	19.3750	.	19.3750	16.6250	0.0069493
132	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	16.5625	18.8438	.	18.8438	16.5625	0.0069493
133	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	16.3438	19.0625	.	19.0625	16.3438	0.0069493
134	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	16.3125	18.8750	.	18.8750	16.3125	0.0069493
135	2	SOIL	0.00035637	22	0.0309677	5.62333	9.03226	0.96	.	.	.	18.8750	16.3125	0.0073056
136	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	.	.	.	18.8750	16.3125	0.0073056
137	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.8438	18.9375	.	18.9375	15.8438	0.0073056
138	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.6875	18.7500	.	18.7500	15.6875	0.0073056
139	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.8125	18.4375	.	18.4375	15.8125	0.0073056
140	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.3438	18.3125	.	18.3125	15.3438	0.0073056
141	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.5938	18.4063	.	18.4063	15.5938	0.0073056
142	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	.	.	.	18.4063	15.5938	0.0073056
143	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	.	.	.	18.4063	15.5938	0.0073056
144	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.5938	18.4375	.	18.4375	15.5938	0.0073056

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
129	16.8438	0.00000	19.3372	19.3372	0.00000	10151	1	4	0.00000	0.4375	0.61841	0.37	0.18091
130	16.8438	0.00000	19.3368	19.3372	-0.00036	10152	1	5	-0.00036	0.4375	0.61805	0.39	0.18055
131	16.8438	-0.21875	19.3681	19.3368	0.03125	10153	1	6	0.25000	0.2188	0.64930	0.39	0.43055
132	16.6250	-0.06250	18.8368	19.3681	-0.53125	10154	1	7	-0.46875	0.1563	0.11805	0.39	-0.03820
133	16.5625	-0.21875	19.0556	18.8368	0.21875	10155	1	8	0.43750	-0.0625	0.33680	0.39	0.39930
134	16.3438	-0.03125	18.8681	19.0556	-0.18750	10156	1	9	-0.15625	-0.0938	0.14930	0.39	0.24305
135	16.3125	0.00000	18.8677	18.8681	-0.00036	10157	1	10	-0.00036	-0.0938	0.14894	0.41	0.24269
136	16.3125	0.00000	18.8677	18.8677	0.00000	10158	1	11	0.00000	-0.0938	0.14894	0.41	0.24269
137	16.3125	-0.46875	18.9302	18.8677	0.06250	10159	1	12	0.53125	-0.5625	0.21144	0.41	0.77394
138	15.8438	-0.15625	18.7427	18.9302	-0.18750	10160	1	13	-0.03125	-0.7188	0.02394	0.41	0.74269
139	15.6875	0.12500	18.4302	18.7427	-0.31250	10161	1	14	-0.43750	-0.5938	-0.28856	0.41	0.30519
140	15.8125	-0.46875	18.3052	18.4302	-0.12500	10162	1	15	0.34375	-1.0625	-0.41356	0.41	0.64894
141	15.3438	0.25000	18.3989	18.3052	0.09375	10163	1	16	-0.15625	-0.8125	-0.31981	0.41	0.49269
142	15.5938	0.00000	18.3989	18.3989	0.00000	10164	1	17	0.00000	-0.8125	-0.31981	0.41	0.49269
143	15.5938	0.00000	18.3989	18.3989	0.00000	10165	1	18	0.00000	-0.8125	-0.31981	0.41	0.49269
144	15.5938	0.00000	18.4302	18.3989	0.03125	10166	1	19	0.03125	-0.8125	-0.28856	0.41	0.52394

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
145	cleveland	871103	0.28	10	11.8	2	18	18	.	.	11.8	2	15	21	259091	4809	0.96
146	cleveland	871104	0.01	15	8.4	2	18	8	.	.	9.8	2	15	13	259091	4809	0.96
147	cleveland	871105	0.00	13	.	2	18	20	.	.	5.8	2	15	10	259091	4809	0.96
148	cleveland	871106	0.00	9	3.3	2	18	5	.	.	5.1	2	15	5	259091	4809	0.96
149	cleveland	871107	0.00	7	4.1	2	.	.	.	.	5.3	2	.	.	259091	4809	0.96
150	cleveland	871108	0.00	8	6.2	2	.	.	.	.	5.4	2	.	.	259091	4809	0.96
151	cleveland	871109	0.26	7	1.7	2	17	27	.	.	1.6	2	15	0	259091	4809	0.96
152	cleveland	871110	0.00	4	0.6	2	17	28	.	.	1.6	2	15	1	259091	4809	0.96
153	cleveland	871111	0.00	4	0.5	2	18	3	.	.	2.6	2	15	1	259091	4809	0.96
154	cleveland	871112	0.00	9	2.2	2	17	25	.	.	3.7	2	14	31	259091	4809	0.96
155	cleveland	871113	0.00	7	4.6	2	17	29	.	.	3.6	2	15	1	259091	4809	0.96
156	cleveland	871014	0.00	11	9.7	3	16	18	.	.	9.8	2	16	12	260547	4993	0.96
157	cleveland	871015	0.37	6	9.7	3	.	.	.	.	9.8	2	.	.	260547	4993	0.96
158	cleveland	871016	0.00	9	9.9	3	17	4	.	.	10.2	2	16	20	260547	4993	0.96
159	cleveland	871017	0.00	10	9.6	3	.	.	.	.	9.9	2	.	.	260547	4993	0.96
160	cleveland	871018	0.00	9	8.5	3	.	.	.	.	9.0	2	.	.	260547	4993	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
145	2	SOIL	0.00498921	22	0.0309677	5.62333	9.03226	0.96	15.6563	18.5625	.	18.5625	15.6563	0.0122948
146	2	SOIL	0.00017819	22	0.0309677	5.62333	9.03226	0.96	15.4063	18.2500	.	18.2500	15.4063	0.0124730
147	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.3125	18.6250	.	18.6250	15.3125	0.0124730
148	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.1563	18.1563	.	18.1563	15.1563	0.0124730
149	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	.	.	.	18.1563	15.1563	0.0124730
150	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	.	.	.	18.1563	15.1563	0.0124730
151	2	SOIL	0.00463284	22	0.0309677	5.62333	9.03226	0.96	15.0000	17.8438	.	17.8438	15.0000	0.0171059
152	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.0313	17.8750	.	17.8750	15.0313	0.0171059
153	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.0313	18.0938	.	18.0938	15.0313	0.0171059
154	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	14.9688	17.7813	.	17.7813	14.9688	0.0171059
155	2	SOIL	0.00000000	22	0.0309677	5.62333	9.03226	0.96	15.0313	17.9063	.	17.9063	15.0313	0.0171059
156	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	16.3750	16.5625	.	16.5625	16.3750	0.0000000
157	2	SOIL	0.00680689	23	0.0309677	5.62333	9.03226	0.96	.	.	.	16.5625	16.3750	0.0068069
158	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	16.6250	17.1250	.	17.1250	16.6250	0.0068069
159	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	16.6250	0.0068069
160	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	16.6250	0.0068069

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
145	15.5938	0.06250	18.5502	18.4302	0.12001	10167	1	20	0.05751	-0.7500	-0.1685	0.69	0.58146
146	15.6563	-0.25000	18.2375	18.5502	-0.31268	10168	1	21	-0.06268	-1.0000	-0.4812	0.70	0.51878
147	15.4063	-0.09375	18.6125	18.2375	0.37500	10169	1	22	0.46875	-1.0938	-0.1062	0.70	0.98753
148	15.3125	-0.15625	18.1438	18.6125	-0.46875	10170	1	23	-0.31250	-1.2500	-0.5750	0.70	0.67503
149	15.1563	0.00000	18.1438	18.1438	0.00000	10171	1	24	0.00000	-1.2500	-0.5750	0.70	0.67503
150	15.1563	0.00000	18.1438	18.1438	0.00000	10172	1	25	0.00000	-1.2500	-0.5750	0.70	0.67503
151	15.1563	-0.15625	17.8266	18.1438	-0.31713	10173	1	26	-0.16088	-1.4063	-0.8921	0.96	0.51414
152	15.0000	0.03125	17.8579	17.8266	0.03125	10174	1	27	0.00000	-1.3750	-0.8609	0.96	0.51414
153	15.0313	0.00000	18.0766	17.8579	0.21875	10175	1	28	0.21875	-1.3750	-0.6421	0.96	0.73289
154	15.0313	-0.06250	17.7641	18.0766	-0.31250	10176	1	29	-0.25000	-1.4375	-0.9546	0.96	0.48289
155	14.9688	0.06250	17.8891	17.7641	0.12500	10177	1	30	0.06250	-1.3750	-0.8296	0.96	0.54539
156	.	.	16.5625	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000
157	16.3750	0.00000	16.5557	16.5625	-0.00681	10148	1	1	-0.00681	0.0000	-0.0068	0.37	-0.00681
158	16.3750	0.25000	17.1182	16.5557	0.56250	10149	1	2	0.31250	0.2500	0.5557	0.37	0.30569
159	16.6250	0.00000	17.1182	17.1182	0.00000	10150	1	3	0.00000	0.2500	0.5557	0.37	0.30569
160	16.6250	0.00000	17.1182	17.1182	0.00000	10151	1	4	0.00000	0.2500	0.5557	0.37	0.30569

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
161	cleveland	871019	0.02	7	7.4	3	.	.	.	.	7.9	2	.	.	260547	4993	0.96
162	cleveland	871020	0.00	11	5.0	3	16	28	.	.	5.8	2	16	19	260547	4993	0.96
163	cleveland	871021	0.00	9	2.9	3	16	18	.	.	4.3	2	16	14	260547	4993	0.96
164	cleveland	871022	0.00	10	3.5	3	16	15	.	.	4.1	2	16	3	260547	4993	0.96
165	cleveland	871023	0.00	6	4.4	3	16	14	.	.	4.7	2	15	30	260547	4993	0.96
166	cleveland	871024	0.02	9	2.5	3	.	.	.	.	3.9	2	.	.	260547	4993	0.96
167	cleveland	871025	0.00	12	2.8	3	.	.	.	.	2.5	2	.	.	260547	4993	0.96
168	cleveland	871026	0.00	19	4.7	3	16	10	.	.	4.8	2	16	1	260547	4993	0.96
169	cleveland	871027	0.00	13	3.0	3	16	10	.	.	4.2	2	15	19	260547	4993	0.96
170	cleveland	871028	0.00	5	2.2	3	16	4	.	.	2.2	2	15	31	260547	4993	0.96
171	cleveland	871029	0.00	12	4.6	3	16	6	.	.	4.8	2	15	26	260547	4993	0.96
172	cleveland	871030	0.00	6	7.0	3	15	27	.	.	6.4	2	15	28	260547	4993	0.96
173	cleveland	871031	0.00	8	6.7	3	.	.	.	.	6.4	2	.	.	260547	4993	0.96
174	cleveland	871101	0.00	8	9.0	3	.	.	.	.	8.2	2	.	.	260547	4993	0.96
175	cleveland	871102	0.00	7	12.2	3	15	31	.	.	10.7	2	15	22	260547	4993	0.96
176	cleveland	871103	0.28	10	11.8	3	15	28	.	.	11.8	2	15	27	260547	4993	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
161	2	SOIL	0.00036794	23	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	16.6250	0.0071748
162	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	16.5938	16.8750	.	16.8750	16.5938	0.0071748
163	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	16.4375	16.5625	.	16.5625	16.4375	0.0071748
164	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	16.0938	16.4688	.	16.4688	16.0938	0.0071748
165	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.9375	16.4375	.	16.4375	15.9375	0.0071748
166	2	SOIL	0.00036794	23	0.0309677	5.62333	9.03226	0.96	.	.	.	16.4375	15.9375	0.0075428
167	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	.	.	.	16.4375	15.9375	0.0075428
168	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	16.0313	16.3125	.	16.3125	16.0313	0.0075428
169	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.5938	16.3125	.	16.3125	15.5938	0.0075428
170	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.9688	16.1250	.	16.1250	15.9688	0.0075428
171	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.8125	16.1875	.	16.1875	15.8125	0.0075428
172	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.8750	15.8438	.	15.8438	15.8750	0.0075428
173	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8438	15.8750	0.0075428
174	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8438	15.8750	0.0075428
175	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.6875	15.9688	.	15.9688	15.6875	0.0075428
176	2	SOIL	0.00515116	23	0.0309677	5.62333	9.03226	0.96	15.8438	15.8750	.	15.8750	15.8438	0.0126939

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
161	16.6250	0.00000	17.1178	17.1182	-0.00037	10152	1	5	-0.00037	0.2500	0.5553	0.39	0.30533
162	16.6250	-0.03125	16.8678	17.1178	-0.25000	10153	1	6	-0.21875	0.2188	0.3053	0.39	0.08658
163	16.5938	-0.15625	16.5553	16.8678	-0.31250	10154	1	7	-0.15625	0.0625	-0.0072	0.39	-0.06967
164	16.4375	-0.34375	16.4616	16.5553	-0.09375	10155	1	8	0.25000	-0.2813	-0.1009	0.39	0.18033
165	16.0938	-0.15625	16.4303	16.4616	-0.03125	10156	1	9	0.12500	-0.4375	-0.1322	0.39	0.30533
166	15.9375	0.00000	16.4300	16.4303	-0.00037	10157	1	10	-0.00037	-0.4375	-0.1325	0.41	0.30496
167	15.9375	0.00000	16.4300	16.4300	0.00000	10158	1	11	0.00000	-0.4375	-0.1325	0.41	0.30496
168	15.9375	0.09375	16.3050	16.4300	-0.12500	10159	1	12	-0.21875	-0.3438	-0.2575	0.41	0.08621
169	16.0313	-0.43750	16.3050	16.3050	0.00000	10160	1	13	0.43750	-0.7813	-0.2575	0.41	0.52371
170	15.5938	0.37500	16.1175	16.3050	-0.18750	10161	1	14	-0.56250	-0.4063	-0.4450	0.41	-0.03879
171	15.9688	-0.15625	16.1800	16.1175	0.06250	10162	1	15	0.21875	-0.5625	-0.3825	0.41	0.17996
172	15.8125	0.06250	15.8362	16.1800	-0.34375	10163	1	16	-0.40625	-0.5000	-0.7263	0.41	-0.22629
173	15.8750	0.00000	15.8362	15.8362	0.00000	10164	1	17	0.00000	-0.5000	-0.7263	0.41	-0.22629
174	15.8750	0.00000	15.8362	15.8362	0.00000	10165	1	18	0.00000	-0.5000	-0.7263	0.41	-0.22629
175	15.8750	-0.18750	15.9612	15.8362	0.12500	10166	1	19	0.31250	-0.6875	-0.6013	0.41	0.08621
176	15.6875	0.15625	15.8623	15.9612	-0.09890	10167	1	20	-0.25515	-0.5313	-0.7002	0.69	-0.16894

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
177	cleveland	871104	0.01	15	8.4	3	15	23	.	.	9.8	2	15	29	260547	4993	0.96
178	cleveland	871105	0.00	13	.	3	15	22	.	.	5.8	2	15	22	260547	4993	0.96
179	cleveland	871106	0.00	9	3.3	3	15	26	.	.	5.1	2	15	21	260547	4993	0.96
180	cleveland	871107	0.00	7	4.1	3	.	.	.	.	5.3	2	.	.	260547	4993	0.96
181	cleveland	871108	0.00	8	6.2	3	.	.	.	.	5.4	2	.	.	260547	4993	0.96
182	cleveland	871109	0.26	7	1.7	3	15	27	.	.	1.6	2	15	18	260547	4993	0.96
183	cleveland	871110	0.00	4	0.6	3	15	23	.	.	1.6	2	15	17	260547	4993	0.96
184	cleveland	871111	0.00	4	0.5	3	15	14	.	.	2.6	2	15	14	260547	4993	0.96
185	cleveland	871112	0.00	9	2.2	3	15	0	.	.	3.7	2	15	7	260547	4993	0.96
186	cleveland	871113	0.00	7	4.6	3	15	13	.	.	3.6	2	15	15	260547	4993	0.96
187	cleveland	871014	0.00	11	9.7	1	.	.	11	31	9.8	3	12	24	262138	4550	0.96
188	cleveland	871015	0.37	6	9.7	1	.	.	.	.	9.8	3	.	.	262138	4550	0.96
189	cleveland	871016	0.00	9	9.9	1	.	.	12	9	10.2	3	13	2	262138	4550	0.96
190	cleveland	871017	0.00	10	9.6	1	.	.	.	.	9.9	3	.	.	262138	4550	0.96
191	cleveland	871018	0.00	9	8.5	1	.	.	.	.	9.0	3	.	.	262138	4550	0.96
192	cleveland	871019	0.02	7	7.4	1	.	.	.	.	7.9	3	.	.	262138	4550	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
177	2	SOIL	0.00018397	23	0.0309677	5.62333	9.03226	0.96	15.9063	15.7188	.	15.7188	15.9063	0.0128779
178	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.6875	15.6875	.	15.6875	15.6875	0.0128779
179	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.6563	15.8125	.	15.8125	15.6563	0.0128779
180	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8125	15.6563	0.0128779
181	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8125	15.6563	0.0128779
182	2	SOIL	0.00478322	23	0.0309677	5.62333	9.03226	0.96	15.5625	15.8438	.	15.8438	15.5625	0.0176611
183	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.5313	15.7188	.	15.7188	15.5313	0.0176611
184	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.4375	15.4375	.	15.4375	15.4375	0.0176611
185	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.2188	15.0000	.	15.0000	15.2188	0.0176611
186	2	SOIL	0.00000000	23	0.0309677	5.62333	9.03226	0.96	15.4688	15.4063	.	15.4063	15.4688	0.0176611
187	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.7500	.	11.9688	11.9688	12.7500	0.0000000
188	2	SOIL	0.00616530	31	0.0309677	5.62333	9.03226	0.96	.	.	.	11.9688	12.7500	0.0061653
189	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	13.0625	.	12.2813	12.2813	13.0625	0.0061653
190	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	13.0625	0.0061653
191	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	13.0625	0.0061653
192	2	SOIL	0.00033326	31	0.0309677	5.62333	9.03226	0.96	.	.	.	12.2813	13.0625	0.0064986

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
177	15.8438	0.06250	15.7059	15.8623	-0.15643	10168	1	21	-0.21893	-0.4688	-0.8566	0.70	-0.38788
178	15.9063	-0.21875	15.6746	15.7059	-0.03125	10169	1	22	0.18750	-0.6875	-0.8879	0.70	-0.20038
179	15.6875	-0.03125	15.7996	15.6746	0.12500	10170	1	23	0.15625	-0.7188	-0.7629	0.70	-0.04413
180	15.6563	0.00000	15.7996	15.7996	0.00000	10171	1	24	0.00000	-0.7188	-0.7629	0.70	-0.04413
181	15.6563	0.00000	15.7996	15.7996	0.00000	10172	1	25	0.00000	-0.7188	-0.7629	0.70	-0.04413
182	15.6563	-0.09375	15.8261	15.7996	0.02647	10173	1	26	0.12022	-0.8125	-0.7364	0.96	0.07609
183	15.5625	-0.03125	15.7011	15.8261	-0.12500	10174	1	27	-0.09375	-0.8438	-0.8614	0.96	-0.01766
184	15.5313	-0.09375	15.4198	15.7011	-0.28125	10175	1	28	-0.18750	-0.9375	-1.1427	0.96	-0.20516
185	15.4375	-0.21875	14.9823	15.4198	-0.43750	10176	1	29	-0.21875	-1.1563	-1.5802	0.96	-0.42391
186	15.2188	0.25000	15.3886	14.9823	0.40625	10177	1	30	0.15625	-0.9063	-1.1739	0.96	-0.26766
187	.	.	11.9688	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000
188	12.7500	0.00000	11.9626	11.9688	-0.00617	10148	1	1	-0.00617	0.0000	-0.0062	0.37	-0.00617
189	12.7500	0.31250	12.2751	11.9626	0.31250	10149	1	2	0.00000	0.3125	0.3063	0.37	-0.00617
190	13.0625	0.00000	12.2751	12.2751	0.00000	10150	1	3	0.00000	0.3125	0.3063	0.37	-0.00617
191	13.0625	0.00000	12.2751	12.2751	0.00000	10151	1	4	0.00000	0.3125	0.3063	0.37	-0.00617
192	13.0625	0.00000	12.2748	12.2751	-0.00033	10152	1	5	-0.00033	0.3125	0.3060	0.39	-0.00650

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
193	cleveland	871020	0.00	11	5.0	1	.	.	12	8	5.8	3	12	28	262138	4550	0.96
194	cleveland	871021	0.00	9	2.9	1	.	.	12	4	4.3	3	12	27	262138	4550	0.96
195	cleveland	871022	0.00	10	3.5	1	.	.	12	4	4.1	3	12	18	262138	4550	0.96
196	cleveland	871023	0.00	6	4.4	1	.	.	12	0	4.7	3	12	20	262138	4550	0.96
197	cleveland	871024	0.02	9	2.5	1	.	.	.	.	3.9	3	.	.	262138	4550	0.96
198	cleveland	871025	0.00	12	2.8	1	.	.	.	.	2.5	3	.	.	262138	4550	0.96
199	cleveland	871026	0.00	19	4.7	1	.	.	11	27	4.8	3	12	13	262138	4550	0.96
200	cleveland	871027	0.00	13	3.0	1	.	.	11	22	4.2	3	12	7	262138	4550	0.96
201	cleveland	871028	0.00	5	2.2	1	.	.	11	21	2.2	3	12	6	262138	4550	0.96
202	cleveland	871029	0.00	12	4.6	1	.	.	11	18	4.8	3	12	3	262138	4550	0.96
203	cleveland	871030	0.00	6	7.0	1	.	.	11	17	6.4	3	12	1	262138	4550	0.96
204	cleveland	871031	0.00	8	6.7	1	.	.	.	.	6.4	3	.	.	262138	4550	0.96
205	cleveland	871101	0.00	8	9.0	1	.	.	.	.	8.2	3	.	.	262138	4550	0.96
206	cleveland	871102	0.00	7	12.2	1	.	.	11	15	10.7	3	12	2	262138	4550	0.96
207	cleveland	871103	0.28	10	11.8	1	.	.	11	18	11.8	3	12	5	262138	4550	0.96
208	cleveland	871104	0.01	15	8.4	1	.	.	11	15	9.8	3	11	30	262138	4550	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
193	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.8750	.	12.2500	12.2500	12.8750	0.0064986
194	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.8438	.	12.1250	12.1250	12.8438	0.0064986
195	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.5625	.	12.1250	12.1250	12.5625	0.0064986
196	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.6250	.	12.0000	12.0000	12.6250	0.0064986
197	2	SOIL	0.00033326	31	0.0309677	5.62333	9.03226	0.96	.	.	.	12.0000	12.6250	0.0068318
198	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	.	.	.	12.0000	12.6250	0.0068318
199	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.4063	.	11.8438	11.8438	12.4063	0.0068318
200	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.2188	.	11.6875	11.6875	12.2188	0.0068318
201	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.1875	.	11.6563	11.6563	12.1875	0.0068318
202	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.0938	.	11.5625	11.5625	12.0938	0.0068318
203	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.0313	.	11.5313	11.5313	12.0313	0.0068318
204	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	.	.	.	11.5313	12.0313	0.0068318
205	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	.	.	.	11.5313	12.0313	0.0068318
206	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	12.0625	.	11.4688	11.4688	12.0625	0.0068318
207	2	SOIL	0.00466563	31	0.0309677	5.62333	9.03226	0.96	12.1563	.	11.5625	11.5625	12.1563	0.0114975
208	2	SOIL	0.00016663	31	0.0309677	5.62333	9.03226	0.96	11.9375	.	11.4688	11.4688	11.9375	0.0116641

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
193	13.0625	-0.18750	12.2435	12.2748	-0.03125	10153	1	6	0.15625	0.1250	0.2748	0.39	0.14975
194	12.8750	-0.03125	12.1185	12.2435	-0.12500	10154	1	7	-0.09375	0.0938	0.1498	0.39	0.05600
195	12.8438	-0.28125	12.1185	12.1185	0.00000	10155	1	8	0.28125	-0.1875	0.1498	0.39	0.33725
196	12.5625	0.06250	11.9935	12.1185	-0.12500	10156	1	9	-0.18750	-0.1250	0.0248	0.39	0.14975
197	12.6250	0.00000	11.9932	11.9935	-0.00033	10157	1	10	-0.00033	-0.1250	0.0244	0.41	0.14942
198	12.6250	0.00000	11.9932	11.9932	0.00000	10158	1	11	0.00000	-0.1250	0.0244	0.41	0.14942
199	12.6250	-0.21875	11.8369	11.9932	-0.15625	10159	1	12	0.06250	-0.3438	-0.1318	0.41	0.21192
200	12.4063	-0.18750	11.6807	11.8369	-0.15625	10160	1	13	0.03125	-0.5313	-0.2881	0.41	0.24317
201	12.2188	-0.03125	11.6494	11.6807	-0.03125	10161	1	14	0.00000	-0.5625	-0.3193	0.41	0.24317
202	12.1875	-0.09375	11.5557	11.6494	-0.09375	10162	1	15	0.00000	-0.6563	-0.4131	0.41	0.24317
203	12.0938	-0.06250	11.5244	11.5557	-0.03125	10163	1	16	0.03125	-0.7188	-0.4443	0.41	0.27442
204	12.0313	0.00000	11.5244	11.5244	0.00000	10164	1	17	0.00000	-0.7188	-0.4443	0.41	0.27442
205	12.0313	0.00000	11.5244	11.5244	0.00000	10165	1	18	0.00000	-0.7188	-0.4443	0.41	0.27442
206	12.0313	0.03125	11.4619	11.5244	-0.06250	10166	1	19	-0.09375	-0.6875	-0.5068	0.41	0.18067
207	12.0625	0.09375	11.5510	11.4619	0.08908	10167	1	20	-0.00467	-0.5938	-0.4177	0.69	0.17600
208	12.1563	-0.21875	11.4571	11.5510	-0.09392	10168	1	21	0.12483	-0.8125	-0.5117	0.70	0.30084

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
209	cleveland	871105	0.00	13	.	1	.	.	11	19	5.8	3	11	27	262138	4550	0.96
210	cleveland	871106	0.00	9	3.3	1	.	.	11	5	5.1	3	11	21	262138	4550	0.96
211	cleveland	871107	0.00	7	4.1	1	.	.	.	.	5.3	3	.	.	262138	4550	0.96
212	cleveland	871108	0.00	8	6.2	1	.	.	.	.	5.4	3	.	.	262138	4550	0.96
213	cleveland	871109	0.26	7	1.7	1	.	.	11	3	1.6	3	11	20	262138	4550	0.96
214	cleveland	871110	0.00	4	0.6	1	.	.	11	3	1.6	3	11	19	262138	4550	0.96
215	cleveland	871111	0.00	4	0.5	1	.	.	11	20	2.6	3	11	14	262138	4550	0.96
216	cleveland	871112	0.00	9	2.2	1	.	.	10	31	3.7	3	11	14	262138	4550	0.96
217	cleveland	871113	0.00	7	4.6	1	.	.	11	0	3.6	3	11	15	262138	4550	0.96
218	cleveland	871014	0.00	11	9.7	2	18	23	.	.	9.8	3	15	11	259091	4809	0.96
219	cleveland	871015	0.37	6	9.7	2	.	.	.	.	9.8	3	.	.	259091	4809	0.96
220	cleveland	871016	0.00	9	9.9	2	19	11	.	.	10.2	3	15	23	259091	4809	0.96
221	cleveland	871017	0.00	10	9.6	2	.	.	.	.	9.9	3	.	.	259091	4809	0.96
222	cleveland	871018	0.00	9	8.5	2	.	.	.	.	9.0	3	.	.	259091	4809	0.96
223	cleveland	871019	0.02	7	7.4	2	.	.	.	.	7.9	3	.	.	259091	4809	0.96
224	cleveland	871020	0.00	11	5.0	2	19	12	.	.	5.8	3	15	17	259091	4809	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
209	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	11.8438	.	11.5938	11.5938	11.8438	0.0116641
210	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	11.6563	.	11.1563	11.1563	11.6563	0.0116641
211	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	.	.	.	11.1563	11.6563	0.0116641
212	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	.	.	.	11.1563	11.6563	0.0116641
213	2	SOIL	0.00433237	31	0.0309677	5.62333	9.03226	0.96	11.6250	.	11.0938	11.0938	11.6250	0.0159965
214	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	11.5938	.	11.0938	11.0938	11.5938	0.0159965
215	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	11.4375	.	11.6250	11.6250	11.4375	0.0159965
216	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	11.4375	.	10.9688	10.9688	11.4375	0.0159965
217	2	SOIL	0.00000000	31	0.0309677	5.62333	9.03226	0.96	11.4688	.	11.0000	11.0000	11.4688	0.0159965
218	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	15.3438	18.7188	.	18.7188	15.3438	0.0000000
219	2	SOIL	0.00659288	32	0.0309677	5.62333	9.03226	0.96	.	.	.	18.7188	15.3438	0.0065929
220	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	15.7188	19.3438	.	19.3438	15.7188	0.0065929
221	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	15.7188	0.0065929
222	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	15.7188	0.0065929
223	2	SOIL	0.00035637	32	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	15.7188	0.0069493
224	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	15.5313	19.3750	.	19.3750	15.5313	0.0069493

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
209	11.9375	-0.09375	11.5821	11.4571	0.12500	10169	1	22	0.21875	-0.9063	-0.3867	0.70	0.51959
210	11.8438	-0.18750	11.1446	11.5821	-0.43750	10170	1	23	-0.25000	-1.0938	-0.8242	0.70	0.26959
211	11.6563	0.00000	11.1446	11.1446	0.00000	10171	1	24	0.00000	-1.0938	-0.8242	0.70	0.26959
212	11.6563	0.00000	11.1446	11.1446	0.00000	10172	1	25	0.00000	-1.0938	-0.8242	0.70	0.26959
213	11.6563	-0.03125	11.0778	11.1446	-0.06683	10173	1	26	-0.03558	-1.1250	-0.8910	0.96	0.23400
214	11.6250	-0.03125	11.0778	11.0778	0.00000	10174	1	27	0.03125	-1.1563	-0.8910	0.96	0.26525
215	11.5938	-0.15625	11.6090	11.0778	0.53125	10175	1	28	0.68750	-1.3125	-0.3597	0.96	0.95275
216	11.4375	0.00000	10.9528	11.6090	-0.65625	10176	1	29	-0.65625	-1.3125	-1.0160	0.96	0.29650
217	11.4375	0.03125	10.9840	10.9528	0.03125	10177	1	30	0.00000	-1.2813	-0.9847	0.96	0.29650
218	.	.	18.7188	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000
219	15.3438	0.00000	18.7122	18.7188	-0.00659	10148	1	1	-0.00659	0.0000	-0.0066	0.37	-0.00659
220	15.3438	0.37500	19.3372	18.7122	0.62500	10149	1	2	0.25000	0.3750	0.6184	0.37	0.24341
221	15.7188	0.00000	19.3372	19.3372	0.00000	10150	1	3	0.00000	0.3750	0.6184	0.37	0.24341
222	15.7188	0.00000	19.3372	19.3372	0.00000	10151	1	4	0.00000	0.3750	0.6184	0.37	0.24341
223	15.7188	0.00000	19.3368	19.3372	-0.00036	10152	1	5	-0.00036	0.3750	0.6181	0.39	0.24305
224	15.7188	-0.18750	19.3681	19.3368	0.03125	10153	1	6	0.21875	0.1875	0.6493	0.39	0.46180

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
225	cleveland	871021	0.00	9	2.9	2	18	27	.	.	4.3	3	15	10	259091	4809	0.96
226	cleveland	871022	0.00	10	3.5	2	19	2	.	.	4.1	3	14	31	259091	4809	0.96
227	cleveland	871023	0.00	6	4.4	2	18	28	.	.	4.7	3	14	28	259091	4809	0.96
228	cleveland	871024	0.02	9	2.5	2	.	.	.	.	3.9	3	.	.	259091	4809	0.96
229	cleveland	871025	0.00	12	2.8	2	.	.	.	.	2.5	3	.	.	259091	4809	0.96
230	cleveland	871026	0.00	19	4.7	2	18	30	.	.	4.8	3	14	23	259091	4809	0.96
231	cleveland	871027	0.00	13	3.0	2	18	24	.	.	4.2	3	14	16	259091	4809	0.96
232	cleveland	871028	0.00	5	2.2	2	18	14	.	.	2.2	3	14	16	259091	4809	0.96
233	cleveland	871029	0.00	12	4.6	2	18	10	.	.	4.8	3	14	14	259091	4809	0.96
234	cleveland	871030	0.00	6	7.0	2	18	13	.	.	6.4	3	14	14	259091	4809	0.96
235	cleveland	871031	0.00	8	6.7	2	.	.	.	.	6.4	3	.	.	259091	4809	0.96
236	cleveland	871101	0.00	8	9.0	2	.	.	.	.	8.2	3	.	.	259091	4809	0.96
237	cleveland	871102	0.00	7	12.2	2	18	14	.	.	10.7	3	14	11	259091	4809	0.96
238	cleveland	871103	0.28	10	11.8	2	18	18	.	.	11.8	3	14	13	259091	4809	0.96
239	cleveland	871104	0.01	15	8.4	2	18	8	.	.	9.8	3	14	6	259091	4809	0.96
240	cleveland	871105	0.00	13	.	2	18	20	.	.	5.8	3	13	31	259091	4809	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
225	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	15.3125	18.8438	.	18.8438	15.3125	0.0069493
226	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	14.9688	19.0625	.	19.0625	14.9688	0.0069493
227	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	14.8750	18.8750	.	18.8750	14.8750	0.0069493
228	2	SOIL	0.00035637	32	0.0309677	5.62333	9.03226	0.96	.	.	.	18.8750	14.8750	0.0073056
229	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	.	.	.	18.8750	14.8750	0.0073056
230	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	14.7188	18.9375	.	18.9375	14.7188	0.0073056
231	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	14.5000	18.7500	.	18.7500	14.5000	0.0073056
232	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	14.5000	18.4375	.	18.4375	14.5000	0.0073056
233	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	14.4375	18.3125	.	18.3125	14.4375	0.0073056
234	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	14.4375	18.4063	.	18.4063	14.4375	0.0073056
235	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	.	.	.	18.4063	14.4375	0.0073056
236	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	.	.	.	18.4063	14.4375	0.0073056
237	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	14.3438	18.4375	.	18.4375	14.3438	0.0073056
238	2	SOIL	0.00498921	32	0.0309677	5.62333	9.03226	0.96	14.4063	18.5625	.	18.5625	14.4063	0.0122948
239	2	SOIL	0.00017819	32	0.0309677	5.62333	9.03226	0.96	14.1875	18.2500	.	18.2500	14.1875	0.0124730
240	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	13.9688	18.6250	.	18.6250	13.9688	0.0124730

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
225	15.5313	-0.21875	18.8368	19.3681	-0.53125	10154	1	7	-0.31250	-0.0313	0.1181	0.39	0.14930
226	15.3125	-0.34375	19.0556	18.8368	0.21875	10155	1	8	0.56250	-0.3750	0.3368	0.39	0.71180
227	14.9688	-0.09375	18.8681	19.0556	-0.18750	10156	1	9	-0.09375	-0.4688	0.1493	0.39	0.61805
228	14.8750	0.00000	18.8677	18.8681	-0.00036	10157	1	10	-0.00036	-0.4688	0.1489	0.41	0.61769
229	14.8750	0.00000	18.8677	18.8677	0.00000	10158	1	11	0.00000	-0.4688	0.1489	0.41	0.61769
230	14.8750	-0.15625	18.9302	18.8677	0.06250	10159	1	12	0.21875	-0.6250	0.2114	0.41	0.83644
231	14.7188	-0.21875	18.7427	18.9302	-0.18750	10160	1	13	0.03125	-0.8438	0.0239	0.41	0.86769
232	14.5000	0.00000	18.4302	18.7427	-0.31250	10161	1	14	-0.31250	-0.8438	-0.2886	0.41	0.55519
233	14.5000	-0.06250	18.3052	18.4302	-0.12500	10162	1	15	-0.06250	-0.9063	-0.4136	0.41	0.49269
234	14.4375	0.00000	18.3989	18.3052	0.09375	10163	1	16	0.09375	-0.9063	-0.3198	0.41	0.58644
235	14.4375	0.00000	18.3989	18.3989	0.00000	10164	1	17	0.00000	-0.9063	-0.3198	0.41	0.58644
236	14.4375	0.00000	18.3989	18.3989	0.00000	10165	1	18	0.00000	-0.9063	-0.3198	0.41	0.58644
237	14.4375	-0.09375	18.4302	18.3989	0.03125	10166	1	19	0.12500	-1.0000	-0.2886	0.41	0.71144
238	14.3438	0.06250	18.5502	18.4302	0.12001	10167	1	20	0.05751	-0.9375	-0.1685	0.69	0.76896
239	14.4063	-0.21875	18.2375	18.5502	-0.31268	10168	1	21	-0.09393	-1.1563	-0.4812	0.70	0.67503
240	14.1875	-0.21875	18.6125	18.2375	0.37500	10169	1	22	0.59375	-1.3750	-0.1062	0.70	1.26878

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
241	cleveland	871106	0.00	9	3.3	2	18	5	.	.	5.1	3	13	28	259091	4809	0.96
242	cleveland	871107	0.00	7	4.1	2	.	.	.	.	5.3	3	.	.	259091	4809	0.96
243	cleveland	871108	0.00	8	6.2	2	.	.	.	.	5.4	3	.	.	259091	4809	0.96
244	cleveland	871109	0.26	7	1.7	2	17	27	.	.	1.6	3	13	26	259091	4809	0.96
245	cleveland	871110	0.00	4	0.6	2	17	28	.	.	1.6	3	13	26	259091	4809	0.96
246	cleveland	871111	0.00	4	0.5	2	18	3	.	.	2.6	3	13	24	259091	4809	0.96
247	cleveland	871112	0.00	9	2.2	2	17	25	.	.	3.7	3	13	21	259091	4809	0.96
248	cleveland	871113	0.00	7	4.6	2	17	29	.	.	3.6	3	13	21	259091	4809	0.96
249	cleveland	871014	0.00	11	9.7	3	16	18	.	.	9.8	3	16	30	260547	4993	0.96
250	cleveland	871015	0.37	6	9.7	3	.	.	.	.	9.8	3	.	.	260547	4993	0.96
251	cleveland	871016	0.00	9	9.9	3	17	4	.	.	10.2	3	17	13	260547	4993	0.96
252	cleveland	871017	0.00	10	9.6	3	.	.	.	.	9.9	3	.	.	260547	4993	0.96
253	cleveland	871018	0.00	9	8.5	3	.	.	.	.	9.0	3	.	.	260547	4993	0.96
254	cleveland	871019	0.02	7	7.4	3	.	.	.	.	7.9	3	.	.	260547	4993	0.96
255	cleveland	871020	0.00	11	5.0	3	16	28	.	.	5.8	3	17	11	260547	4993	0.96
256	cleveland	871021	0.00	9	2.9	3	16	18	.	.	4.3	3	16	22	260547	4993	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
241	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	13.8750	18.1563	.	18.1563	13.8750	0.0124730
242	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	.	.	.	18.1563	13.8750	0.0124730
243	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	.	.	.	18.1563	13.8750	0.0124730
244	2	SOIL	0.00463284	32	0.0309677	5.62333	9.03226	0.96	13.8125	17.8438	.	17.8438	13.8125	0.0171059
245	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	13.8125	17.8750	.	17.8750	13.8125	0.0171059
246	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	13.7500	18.0938	.	18.0938	13.7500	0.0171059
247	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	13.6563	17.7813	.	17.7813	13.6563	0.0171059
248	2	SOIL	0.00000000	32	0.0309677	5.62333	9.03226	0.96	13.6563	17.9063	.	17.9063	13.6563	0.0171059
249	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.9375	16.5625	.	16.5625	16.9375	0.0000000
250	2	SOIL	0.00680689	33	0.0309677	5.62333	9.03226	0.96	.	.	.	16.5625	16.9375	0.0068069
251	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	17.4063	17.1250	.	17.1250	17.4063	0.0068069
252	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	17.4063	0.0068069
253	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	17.4063	0.0068069
254	2	SOIL	0.00036794	33	0.0309677	5.62333	9.03226	0.96	.	.	.	17.1250	17.4063	0.0071748
255	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	17.3438	16.8750	.	16.8750	17.3438	0.0071748
256	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.6875	16.5625	.	16.5625	16.6875	0.0071748

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
241	13.9688	-0.09375	18.1438	18.6125	-0.46875	10170	1	23	-0.37500	-1.4688	-0.5750	0.70	0.89378
242	13.8750	0.00000	18.1438	18.1438	0.00000	10171	1	24	0.00000	-1.4688	-0.5750	0.70	0.89378
243	13.8750	0.00000	18.1438	18.1438	0.00000	10172	1	25	0.00000	-1.4688	-0.5750	0.70	0.89378
244	13.8750	-0.06250	17.8266	18.1438	-0.31713	10173	1	26	-0.25463	-1.5313	-0.8921	0.96	0.63914
245	13.8125	0.00000	17.8579	17.8266	0.03125	10174	1	27	0.03125	-1.5313	-0.8609	0.96	0.67039
246	13.8125	-0.06250	18.0766	17.8579	0.21875	10175	1	28	0.28125	-1.5938	-0.6421	0.96	0.95164
247	13.7500	-0.09375	17.7641	18.0766	-0.31250	10176	1	29	-0.21875	-1.6875	-0.9546	0.96	0.73289
248	13.6563	0.00000	17.8891	17.7641	0.12500	10177	1	30	0.12500	-1.6875	-0.8296	0.96	0.85789
249	.	.	16.5625	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000
250	16.9375	0.00000	16.5557	16.5625	-0.00681	10148	1	1	-0.00681	0.0000	-0.0068	0.37	-0.00681
251	16.9375	0.46875	17.1182	16.5557	0.56250	10149	1	2	0.09375	0.4688	0.5557	0.37	0.08694
252	17.4063	0.00000	17.1182	17.1182	0.00000	10150	1	3	0.00000	0.4688	0.5557	0.37	0.08694
253	17.4063	0.00000	17.1182	17.1182	0.00000	10151	1	4	0.00000	0.4688	0.5557	0.37	0.08694
254	17.4063	0.00000	17.1178	17.1182	-0.00037	10152	1	5	-0.00037	0.4688	0.5553	0.39	0.08658
255	17.4063	-0.06250	16.8678	17.1178	-0.25000	10153	1	6	-0.18750	0.4063	0.3053	0.39	-0.10092
256	17.3438	-0.65625	16.5553	16.8678	-0.31250	10154	1	7	0.34375	-0.2500	-0.0072	0.39	0.24283

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
257	cleveland	871022	0.00	10	3.5	3	16	15	.	.	4.1	3	16	31	260547	4993	0.96
258	cleveland	871023	0.00	6	4.4	3	16	14	.	.	4.7	3	16	26	260547	4993	0.96
259	cleveland	871024	0.02	9	2.5	3	.	.	.	.	3.9	3	.	.	260547	4993	0.96
260	cleveland	871025	0.00	12	2.8	3	.	.	.	.	2.5	3	.	.	260547	4993	0.96
261	cleveland	871026	0.00	19	4.7	3	16	10	.	.	4.8	3	16	24	260547	4993	0.96
262	cleveland	871027	0.00	13	3.0	3	16	10	.	.	4.2	3	16	22	260547	4993	0.96
263	cleveland	871028	0.00	5	2.2	3	16	4	.	.	2.2	3	16	23	260547	4993	0.96
264	cleveland	871029	0.00	12	4.6	3	16	6	.	.	4.8	3	16	22	260547	4993	0.96
265	cleveland	871030	0.00	6	7.0	3	15	27	.	.	6.4	3	16	18	260547	4993	0.96
266	cleveland	871031	0.00	8	6.7	3	.	.	.	.	6.4	3	.	.	260547	4993	0.96
267	cleveland	871101	0.00	8	9.0	3	.	.	.	.	8.2	3	.	.	260547	4993	0.96
268	cleveland	871102	0.00	7	12.2	3	15	31	.	.	10.7	3	16	16	260547	4993	0.96
269	cleveland	871103	0.28	10	11.8	3	15	28	.	.	11.8	3	16	19	260547	4993	0.96
270	cleveland	871104	0.01	15	8.4	3	15	23	.	.	9.8	3	16	15	260547	4993	0.96
271	cleveland	871105	0.00	13	.	3	15	22	.	.	5.8	3	16	9	260547	4993	0.96
272	cleveland	871106	0.00	9	3.3	3	15	26	.	.	5.1	3	16	7	260547	4993	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
257	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.9688	16.4688	.	16.4688	16.9688	0.0071748
258	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.8125	16.4375	.	16.4375	16.8125	0.0071748
259	2	SOIL	0.00036794	33	0.0309677	5.62333	9.03226	0.96	.	.	.	16.4375	16.8125	0.0075428
260	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	.	.	.	16.4375	16.8125	0.0075428
261	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.7500	16.3125	.	16.3125	16.7500	0.0075428
262	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.6875	16.3125	.	16.3125	16.6875	0.0075428
263	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.7188	16.1250	.	16.1250	16.7188	0.0075428
264	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.6875	16.1875	.	16.1875	16.6875	0.0075428
265	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.5625	15.8438	.	15.8438	16.5625	0.0075428
266	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8438	16.5625	0.0075428
267	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8438	16.5625	0.0075428
268	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.5000	15.9688	.	15.9688	16.5000	0.0075428
269	2	SOIL	0.00515116	33	0.0309677	5.62333	9.03226	0.96	16.5938	15.8750	.	15.8750	16.5938	0.0126939
270	2	SOIL	0.00018397	33	0.0309677	5.62333	9.03226	0.96	16.4688	15.7188	.	15.7188	16.4688	0.0128779
271	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.2813	15.6875	.	15.6875	16.2813	0.0128779
272	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.2188	15.8125	.	15.8125	16.2188	0.0128779

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
257	16.6875	0.28125	16.4616	16.5553	-0.09375	10155	1	8	-0.37500	0.03125	-0.1009	0.39	-0.13217
258	16.9688	-0.15625	16.4303	16.4616	-0.03125	10156	1	9	0.12500	-0.12500	-0.1322	0.39	-0.00717
259	16.8125	0.00000	16.4300	16.4303	-0.00037	10157	1	10	-0.00037	-0.12500	-0.1325	0.41	-0.00754
260	16.8125	0.00000	16.4300	16.4300	0.00000	10158	1	11	0.00000	-0.12500	-0.1325	0.41	-0.00754
261	16.8125	-0.06250	16.3050	16.4300	-0.12500	10159	1	12	-0.06250	-0.18750	-0.2575	0.41	-0.07004
262	16.7500	-0.06250	16.3050	16.3050	0.00000	10160	1	13	0.06250	-0.25000	-0.2575	0.41	-0.00754
263	16.6875	0.03125	16.1175	16.3050	-0.18750	10161	1	14	-0.21875	-0.21875	-0.4450	0.41	-0.22629
264	16.7188	-0.03125	16.1800	16.1175	0.06250	10162	1	15	0.09375	-0.25000	-0.3825	0.41	-0.13254
265	16.6875	-0.12500	15.8362	16.1800	-0.34375	10163	1	16	-0.21875	-0.37500	-0.7263	0.41	-0.35129
266	16.5625	0.00000	15.8362	15.8362	0.00000	10164	1	17	0.00000	-0.37500	-0.7263	0.41	-0.35129
267	16.5625	0.00000	15.8362	15.8362	0.00000	10165	1	18	0.00000	-0.37500	-0.7263	0.41	-0.35129
268	16.5625	-0.06250	15.9612	15.8362	0.12500	10166	1	19	0.18750	-0.43750	-0.6013	0.41	-0.16379
269	16.5000	0.09375	15.8623	15.9612	-0.09890	10167	1	20	-0.19265	-0.34375	-0.7002	0.69	-0.35644
270	16.5938	-0.12500	15.7059	15.8623	-0.15643	10168	1	21	-0.03143	-0.46875	-0.8566	0.70	-0.38788
271	16.4688	-0.18750	15.6746	15.7059	-0.03125	10169	1	22	0.15625	-0.65625	-0.8879	0.70	-0.23163
272	16.2813	-0.06250	15.7996	15.6746	0.12500	10170	1	23	0.18750	-0.71875	-0.7629	0.70	-0.04413

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA	COEFF
273	cleveland	871107	0.00	7	4.1	3	.	.	.	.	5.3	3	.	.	260547	4993	0.96
274	cleveland	871108	0.00	8	6.2	3	.	.	.	.	5.4	3	.	.	260547	4993	0.96
275	cleveland	871109	0.26	7	1.7	3	15	27	.	.	1.6	3	16	2	260547	4993	0.96
276	cleveland	871110	0.00	4	0.6	3	15	23	.	.	1.6	3	16	4	260547	4993	0.96
277	cleveland	871111	0.00	4	0.5	3	15	14	.	.	2.6	3	16	0	260547	4993	0.96
278	cleveland	871112	0.00	9	2.2	3	15	0	.	.	3.7	3	16	2	260547	4993	0.96
279	cleveland	871113	0.00	7	4.6	3	15	13	.	.	3.6	3	16	0	260547	4993	0.96
280	cleveland	871014	0.00	11	9.7	2	18	23	.	.	9.8	4	.	.	259091	4809	0.96
281	cleveland	871015	0.37	6	9.7	2	.	.	.	.	9.8	4	.	.	259091	4809	0.96
282	cleveland	871016	0.00	9	9.9	2	19	11	.	.	10.2	4	14	25	259091	4809	0.96
283	cleveland	871017	0.00	10	9.6	2	.	.	.	.	9.9	4	.	.	259091	4809	0.96
284	cleveland	871018	0.00	9	8.5	2	.	.	.	.	9.0	4	.	.	259091	4809	0.96
285	cleveland	871019	0.02	7	7.4	2	.	.	.	.	7.9	4	.	.	259091	4809	0.96
286	cleveland	871020	0.00	11	5.0	2	19	12	.	.	5.8	4	14	16	259091	4809	0.96
287	cleveland	871021	0.00	9	2.9	2	18	27	.	.	4.3	4	14	16	259091	4809	0.96
288	cleveland	871022	0.00	10	3.5	2	19	2	.	.	4.1	4	14	15	259091	4809	0.96

OBS	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
273	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8125	16.2188	0.0128779
274	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	.	.	.	15.8125	16.2188	0.0128779
275	2	SOIL	0.00478322	33	0.0309677	5.62333	9.03226	0.96	16.0625	15.8438	.	15.8438	16.0625	0.0176611
276	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.1250	15.7188	.	15.7188	16.1250	0.0176611
277	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.0000	15.4375	.	15.4375	16.0000	0.0176611
278	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.0625	15.0000	.	15.0000	16.0625	0.0176611
279	2	SOIL	0.00000000	33	0.0309677	5.62333	9.03226	0.96	16.0000	15.4063	.	15.4063	16.0000	0.0176611
280	2	SOIL	0.00000000	42	0.0309677	5.62333	9.03226	0.96	.	18.7188	.	18.7188	13.6563	0.0000000
281	2	SOIL	0.00659288	42	0.0309677	5.62333	9.03226	0.96	.	.	.	18.7188	13.6563	0.0065929
282	2	SOIL	0.00000000	42	0.0309677	5.62333	9.03226	0.96	14.7813	19.3438	.	19.3438	14.7813	0.0065929
283	2	SOIL	0.00000000	42	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	14.7813	0.0065929
284	2	SOIL	0.00000000	42	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	14.7813	0.0065929
285	2	SOIL	0.00035637	42	0.0309677	5.62333	9.03226	0.96	.	.	.	19.3438	14.7813	0.0069493
286	2	SOIL	0.00000000	42	0.0309677	5.62333	9.03226	0.96	14.5000	19.3750	.	19.3750	14.5000	0.0069493
287	2	SOIL	0.00000000	42	0.0309677	5.62333	9.03226	0.96	14.5000	18.8438	.	18.8438	14.5000	0.0069493
288	2	SOIL	0.00000000	42	0.0309677	5.62333	9.03226	0.96	14.4688	19.0625	.	19.0625	14.4688	0.0069493

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
273	16.2188	0.00000	15.7996	15.7996	0.00000	10171	1	24	0.00000	-0.71875	-0.7629	0.70	-0.04413
274	16.2188	0.00000	15.7996	15.7996	0.00000	10172	1	25	0.00000	-0.71875	-0.7629	0.70	-0.04413
275	16.2188	-0.15625	15.8261	15.7996	0.02647	10173	1	26	0.18272	-0.87500	-0.7364	0.96	0.13859
276	16.0625	0.06250	15.7011	15.8261	-0.12500	10174	1	27	-0.18750	-0.81250	-0.8614	0.96	-0.04891
277	16.1250	-0.12500	15.4198	15.7011	-0.28125	10175	1	28	-0.15625	-0.93750	-1.1427	0.96	-0.20516
278	16.0000	0.06250	14.9823	15.4198	-0.43750	10176	1	29	-0.50000	-0.87500	-1.5802	0.96	-0.70516
279	16.0625	-0.06250	15.3886	14.9823	0.40625	10177	1	30	0.46875	-0.93750	-1.1739	0.96	-0.23641
280	.	.	18.7188	.	.	.	.	0	.	0.00000	0.0000	0.00	0.00000
281	13.6563	0.00000	18.7122	18.7188	-0.00659	10148	1	1	-0.00659	0.00000	-0.0066	0.37	-0.00659
282	13.6563	1.12500	19.3372	18.7122	0.62500	10149	1	2	-0.50000	1.12500	0.6184	0.37	-0.50659
283	14.7813	0.00000	19.3372	19.3372	0.00000	10150	1	3	0.00000	1.12500	0.6184	0.37	-0.50659
284	14.7813	0.00000	19.3372	19.3372	0.00000	10151	1	4	0.00000	1.12500	0.6184	0.37	-0.50659
285	14.7813	0.00000	19.3368	19.3372	-0.00036	10152	1	5	-0.00036	1.12500	0.6181	0.39	-0.50695
286	14.7813	-0.28125	19.3681	19.3368	0.03125	10153	1	6	0.31250	0.84375	0.6493	0.39	-0.19445
287	14.5000	0.00000	18.8368	19.3681	-0.53125	10154	1	7	-0.53125	0.84375	0.1181	0.39	-0.72570
288	14.5000	-0.03125	19.0556	18.8368	0.21875	10155	1	8	0.25000	0.81250	0.3368	0.39	-0.47570

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA
289	cleveland	871023	0.00	6	4.4	2	18	28	.	.	4.7	4	14	12	259091	4809
290	cleveland	871024	0.02	9	2.5	2	.	.	.	.	3.9	4	.	.	259091	4809
291	cleveland	871025	0.00	12	2.8	2	.	.	.	.	2.5	4	.	.	259091	4809
292	cleveland	871026	0.00	19	4.7	2	18	30	.	.	4.8	4	13	26	259091	4809
293	cleveland	871027	0.00	13	3.0	2	18	24	.	.	4.2	4	14	10	259091	4809
294	cleveland	871028	0.00	5	2.2	2	18	14	.	.	2.2	4	13	24	259091	4809
295	cleveland	871029	0.00	12	4.6	2	18	10	.	.	4.8	4	13	20	259091	4809
296	cleveland	871030	0.00	6	7.0	2	18	13	.	.	6.4	4	13	22	259091	4809
297	cleveland	871031	0.00	8	6.7	2	.	.	.	.	6.4	4	.	.	259091	4809
298	cleveland	871101	0.00	8	9.0	2	.	.	.	.	8.2	4	.	.	259091	4809
299	cleveland	871102	0.00	7	12.2	2	18	14	.	.	10.7	4	13	22	259091	4809
300	cleveland	871103	0.28	10	11.8	2	18	18	.	.	11.8	4	13	25	259091	4809
301	cleveland	871104	0.01	15	8.4	2	18	8	.	.	9.8	4	13	20	259091	4809
302	cleveland	871105	0.00	13	.	2	18	20	.	.	5.8	4	13	16	259091	4809
303	cleveland	871106	0.00	9	3.3	2	18	5	.	.	5.1	4	13	14	259091	4809
304	cleveland	871107	0.00	7	4.1	2	.	.	.	.	5.3	4	.	.	259091	4809

OBS	COEFF	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV
289	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	14.3750	18.875	.	18.8750	14.3750
290	0.96	2	SOIL	0.0003564	42	0.0309677	5.62333	9.0323	0.96	.	.	.	18.8750	14.3750
291	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	.	.	.	18.8750	14.3750
292	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	13.8125	18.938	.	18.9375	13.8125
293	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	14.3125	18.750	.	18.7500	14.3125
294	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	13.7500	18.438	.	18.4375	13.7500
295	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	13.6250	18.313	.	18.3125	13.6250
296	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	13.6875	18.406	.	18.4063	13.6875
297	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	.	.	.	18.4063	13.6875
298	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	.	.	.	18.4063	13.6875
299	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	13.6875	18.438	.	18.4375	13.6875
300	0.96	2	SOIL	0.0049892	42	0.0309677	5.62333	9.0323	0.96	13.7813	18.563	.	18.5625	13.7813
301	0.96	2	SOIL	0.0001782	42	0.0309677	5.62333	9.0323	0.96	13.6250	18.250	.	18.2500	13.6250
302	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	13.5000	18.625	.	18.6250	13.5000
303	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	13.4375	18.156	.	18.1563	13.4375
304	0.96	2	SOIL	0.0000000	42	0.0309677	5.62333	9.0323	0.96	.	.	.	18.1563	13.4375

OBS	CUMRUN	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
289	0.0069493	14.4688	-0.09375	18.8681	19.0556	-0.18750	10156	1	9	-0.09375	0.7188	0.1493	0.39	-0.56945
290	0.0073056	14.3750	0.00000	18.8677	18.8681	-0.00036	10157	1	10	-0.00036	0.7188	0.1489	0.41	-0.56981
291	0.0073056	14.3750	0.00000	18.8677	18.8677	0.00000	10158	1	11	0.00000	0.7188	0.1489	0.41	-0.56981
292	0.0073056	14.3750	-0.56250	18.9302	18.8677	0.06250	10159	1	12	0.62500	0.1563	0.2114	0.41	0.05519
293	0.0073056	13.8125	0.50000	18.7427	18.9302	-0.18750	10160	1	13	-0.68750	0.6563	0.0239	0.41	-0.63231
294	0.0073056	14.3125	-0.56250	18.4302	18.7427	-0.31250	10161	1	14	0.25000	0.0938	-0.2886	0.41	-0.38231
295	0.0073056	13.7500	-0.12500	18.3052	18.4302	-0.12500	10162	1	15	0.00000	-0.0313	-0.4136	0.41	-0.38231
296	0.0073056	13.6250	0.06250	18.3989	18.3052	0.09375	10163	1	16	0.03125	0.0313	-0.3198	0.41	-0.35106
297	0.0073056	13.6875	0.00000	18.3989	18.3989	0.00000	10164	1	17	0.00000	0.0313	-0.3198	0.41	-0.35106
298	0.0073056	13.6875	0.00000	18.3989	18.3989	0.00000	10165	1	18	0.00000	0.0313	-0.3198	0.41	-0.35106
299	0.0073056	13.6875	0.00000	18.4302	18.3989	0.03125	10166	1	19	0.03125	0.0313	-0.2886	0.41	-0.31981
300	0.0122948	13.6875	0.09375	18.5502	18.4302	0.12001	10167	1	20	0.02626	0.1250	-0.1685	0.69	-0.29354
301	0.0124730	13.7813	-0.15625	18.2375	18.5502	-0.31268	10168	1	21	-0.15643	-0.0313	-0.4812	0.70	-0.44997
302	0.0124730	13.6250	-0.12500	18.6125	18.2375	0.37500	10169	1	22	0.50000	-0.1563	-0.1062	0.70	0.05003
303	0.0124730	13.5000	-0.06250	18.1438	18.6125	-0.46875	10170	1	23	-0.40625	-0.2188	-0.5750	0.70	-0.35622
304	0.0124730	13.4375	0.00000	18.1438	18.1438	0.00000	10171	1	24	0.00000	-0.2188	-0.5750	0.70	-0.35622

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA
305	cleveland	871108	0.00	8	6.2	2	.	.	.	.	5.4	4	.	.	259091	4809
306	cleveland	871109	0.26	7	1.7	2	17	27	.	.	1.6	4	13	9	259091	4809
307	cleveland	871110	0.00	4	0.6	2	17	28	.	.	1.6	4	13	13	259091	4809
308	cleveland	871111	0.00	4	0.5	2	18	3	.	.	2.6	4	13	10	259091	4809
309	cleveland	871112	0.00	9	2.2	2	17	25	.	.	3.7	4	13	12	259091	4809
310	cleveland	871113	0.00	7	4.6	2	17	29	.	.	3.6	4	13	13	259091	4809
311	cleveland	871014	0.00	11	9.7	3	16	18	.	.	9.8	4	.	.	260547	4993
312	cleveland	871015	0.37	6	9.7	3	.	.	.	.	9.8	4	.	.	260547	4993
313	cleveland	871016	0.00	9	9.9	3	17	4	.	.	10.2	4	16	8	260547	4993
314	cleveland	871017	0.00	10	9.6	3	.	.	.	.	9.9	4	.	.	260547	4993
315	cleveland	871018	0.00	9	8.5	3	.	.	.	.	9.0	4	.	.	260547	4993
316	cleveland	871019	0.02	7	7.4	3	.	.	.	.	7.9	4	.	.	260547	4993
317	cleveland	871020	0.00	11	5.0	3	16	28	.	.	5.8	4	16	0	260547	4993
318	cleveland	871021	0.00	9	2.9	3	16	18	.	.	4.3	4	15	27	260547	4993
319	cleveland	871022	0.00	10	3.5	3	16	15	.	.	4.1	4	15	23	260547	4993
320	cleveland	871023	0.00	6	4.4	3	16	14	.	.	4.7	4	15	14	260547	4993

OBS	COEFF	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
305	0.96	2	SOIL	0.000000	42	0.0309677	5.62333	9.0323	0.96	.	.	.	18.1563	13.4375	0.012473
306	0.96	2	SOIL	0.004633	42	0.0309677	5.62333	9.0323	0.96	13.2813	17.844	.	17.8438	13.2813	0.017106
307	0.96	2	SOIL	0.000000	42	0.0309677	5.62333	9.0323	0.96	13.4063	17.875	.	17.8750	13.4063	0.017106
308	0.96	2	SOIL	0.000000	42	0.0309677	5.62333	9.0323	0.96	13.3125	18.094	.	18.0938	13.3125	0.017106
309	0.96	2	SOIL	0.000000	42	0.0309677	5.62333	9.0323	0.96	13.3750	17.781	.	17.7813	13.3750	0.017106
310	0.96	2	SOIL	0.000000	42	0.0309677	5.62333	9.0323	0.96	13.4063	17.906	.	17.9063	13.4063	0.017106
311	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	.	16.563	.	16.5625	16.0000	0.000000
312	0.96	2	SOIL	0.006807	43	0.0309677	5.62333	9.0323	0.96	.	.	.	16.5625	16.0000	0.006807
313	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	16.2500	17.125	.	17.1250	16.2500	0.006807
314	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	.	.	.	17.1250	16.2500	0.006807
315	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	.	.	.	17.1250	16.2500	0.006807
316	0.96	2	SOIL	0.000368	43	0.0309677	5.62333	9.0323	0.96	.	.	.	17.1250	16.2500	0.007175
317	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	16.0000	16.875	.	16.8750	16.0000	0.007175
318	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.8438	16.563	.	16.5625	15.8438	0.007175
319	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.7188	16.469	.	16.4688	15.7188	0.007175
320	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.4375	16.438	.	16.4375	15.4375	0.007175

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
305	13.4375	0.00000	18.1438	18.1438	0.00000	10172	1	25	0.00000	-0.2188	-0.5750	0.70	-0.35622
306	13.4375	-0.15625	17.8266	18.1438	-0.31713	10173	1	26	-0.16088	-0.3750	-0.8921	0.96	-0.51711
307	13.2813	0.12500	17.8579	17.8266	0.03125	10174	1	27	-0.09375	-0.2500	-0.8609	0.96	-0.61086
308	13.4063	-0.09375	18.0766	17.8579	0.21875	10175	1	28	0.31250	-0.3438	-0.6421	0.96	-0.29836
309	13.3125	0.06250	17.7641	18.0766	-0.31250	10176	1	29	-0.37500	-0.2813	-0.9546	0.96	-0.67336
310	13.3750	0.03125	17.8891	17.7641	0.12500	10177	1	30	0.09375	-0.2500	-0.6296	0.96	-0.57961
311	.	.	16.5625	.	.	.	.	0	.	0.0000	0.0000	0.00	0.00000
312	16.0000	0.00000	16.5557	16.5625	-0.00681	10148	1	1	-0.00681	0.0000	-0.0068	0.37	-0.00681
313	16.0000	0.25000	17.1182	16.5557	0.56250	10149	1	2	0.31250	0.2500	0.5557	0.37	0.30569
314	16.2500	0.00000	17.1182	17.1182	0.00000	10150	1	3	0.00000	0.2500	0.5557	0.37	0.30569
315	16.2500	0.00000	17.1182	17.1182	0.00000	10151	1	4	0.00000	0.2500	0.5557	0.37	0.30569
316	16.2500	0.00000	17.1178	17.1182	-0.00037	10152	1	5	-0.00037	0.2500	0.5553	0.39	0.30533
317	16.2500	-0.25000	16.8678	17.1178	-0.25000	10153	1	6	0.00000	0.0000	0.3053	0.39	0.30533
318	16.0000	-0.15625	16.5553	16.8678	-0.31250	10154	1	7	-0.15625	-0.1563	-0.0072	0.39	0.14908
319	15.8438	-0.12500	16.4616	16.5553	-0.09375	10155	1	8	0.03125	-0.2813	-0.1009	0.39	0.18033
320	15.7188	-0.28125	16.4303	16.4616	-0.03125	10156	1	9	0.25000	-0.5625	-0.1322	0.39	0.43033

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA
321	cleveland	871024	0.02	9	2.5	3	.	.	.	.	3.9	4	.	.	260547	4993
322	cleveland	871025	0.00	12	2.8	3	.	.	.	.	2.5	4	.	.	260547	4993
323	cleveland	871026	0.00	19	4.7	3	16	10	.	.	4.8	4	15	15	260547	4993
324	cleveland	871027	0.00	13	3.0	3	16	10	.	.	4.2	4	15	8	260547	4993
325	cleveland	871028	0.00	5	2.2	3	16	4	.	.	2.2	4	15	11	260547	4993
326	cleveland	871029	0.00	12	4.6	3	16	6	.	.	4.8	4	15	4	260547	4993
327	cleveland	871030	0.00	6	7.0	3	15	27	.	.	6.4	4	15	6	260547	4993
328	cleveland	871031	0.00	8	6.7	3	.	.	.	.	6.4	4	.	.	260547	4993
329	cleveland	871101	0.00	8	9.0	3	.	.	.	.	8.2	4	.	.	260547	4993
330	cleveland	871102	0.00	7	12.2	3	15	31	.	.	10.7	4	15	4	260547	4993
331	cleveland	871103	0.28	10	11.8	3	15	28	.	.	11.8	4	15	5	260547	4993
332	cleveland	871104	0.01	15	8.4	3	15	23	.	.	9.8	4	15	1	260547	4993
333	cleveland	871105	0.00	13	.	3	15	22	.	.	5.8	4	14	28	260547	4993
334	cleveland	871106	0.00	9	3.3	3	15	26	.	.	5.1	4	14	23	260547	4993
335	cleveland	871107	0.00	7	4.1	3	.	.	.	.	5.3	4	.	.	260547	4993
336	cleveland	871108	0.00	8	6.2	3	.	.	.	.	5.4	4	.	.	260547	4993

OBS	COEFF	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
321	0.96	2	SOIL	0.000368	43	0.0309677	5.62333	9.0323	0.96	.	.	.	16.4375	15.438	0.007543
322	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	.	.	.	16.4375	15.438	0.007543
323	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.469	16.313	.	16.3125	15.469	0.007543
324	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.250	16.313	.	16.3125	15.250	0.007543
325	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.344	16.125	.	16.1250	15.344	0.007543
326	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.125	16.188	.	16.1875	15.125	0.007543
327	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.188	15.844	.	15.8438	15.188	0.007543
328	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	.	.	.	15.8438	15.188	0.007543
329	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	.	.	.	15.8438	15.188	0.007543
330	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	15.125	15.969	.	15.9688	15.125	0.007543
331	0.96	2	SOIL	0.005151	43	0.0309677	5.62333	9.0323	0.96	15.156	15.875	.	15.8750	15.156	0.012694
332	0.96	2	SOIL	0.000184	43	0.0309677	5.62333	9.0323	0.96	15.031	15.719	.	15.7188	15.031	0.012878
333	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	14.875	15.688	.	15.6875	14.875	0.012878
334	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	14.719	15.813	.	15.8125	14.719	0.012878
335	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	.	.	.	15.8125	14.719	0.012878
336	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	.	.	.	15.8125	14.719	0.012878

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
321	15.438	0.00000	16.4300	16.4303	-0.00037	10157	1	10	-0.00037	-0.5625	-0.1325	0.41	0.429957
322	15.438	0.00000	16.4300	16.4300	0.00000	10158	1	11	0.00000	-0.5625	-0.1325	0.41	0.429957
323	15.438	0.03125	16.3050	16.4300	-0.12500	10159	1	12	-0.15625	-0.5313	-0.2575	0.41	0.273707
324	15.469	-0.21875	16.3050	16.3050	0.00000	10160	1	13	0.21875	-0.7500	-0.2575	0.41	0.492457
325	15.250	0.09375	16.1175	16.3050	-0.18750	10161	1	14	-0.28125	-0.6563	-0.4450	0.41	0.211207
326	15.344	-0.21875	16.1800	16.1175	0.06250	10162	1	15	0.28125	-0.8750	-0.3825	0.41	0.492457
327	15.125	0.06250	15.8362	16.1800	-0.34375	10163	1	16	-0.40625	-0.8125	-0.7263	0.41	0.086207
328	15.188	0.00000	15.8362	15.8362	0.00000	10164	1	17	0.00000	-0.8125	-0.7263	0.41	0.086207
329	15.188	0.00000	15.8362	15.8362	0.00000	10165	1	18	0.00000	-0.8125	-0.7263	0.41	0.086207
330	15.188	-0.06250	15.9612	15.8362	0.12500	10166	1	19	0.18750	-0.8750	-0.6013	0.41	0.273707
331	15.125	0.03125	15.8623	15.9612	-0.09890	10167	1	20	-0.13015	-0.8438	-0.7002	0.69	0.143556
332	15.156	-0.12500	15.7059	15.8623	-0.15643	10168	1	21	-0.03143	-0.9688	-0.8566	0.70	0.112122
333	15.031	-0.15625	15.6746	15.7059	-0.03125	10169	1	22	0.12500	-1.1250	-0.8879	0.70	0.237122
334	14.875	-0.15625	15.7996	15.6746	0.12500	10170	1	23	0.28125	-1.2813	-0.7629	0.70	0.518372
335	14.719	0.00000	15.7996	15.7996	0.00000	10171	1	24	0.00000	-1.2813	-0.7629	0.70	0.518372
336	14.719	0.00000	15.7996	15.7996	0.00000	10172	1	25	0.00000	-1.2813	-0.7629	0.70	0.518372

OBS	LOCATION	DATE	PRECIP	WIND	TEMPC	PONDNO	PONDIN	POND32	PONDLIN	PONDL32	PONDTC	BNO	BLEVIN	BLEV32	WAREA	RAREA
337	cleveland	871109	0.26	7	1.7	3	15	27	.	.	1.6	4	14	22	260547	4993
338	cleveland	871110	0.00	4	0.6	3	15	23	.	.	1.6	4	14	20	260547	4993
339	cleveland	871111	0.00	4	0.5	3	15	14	.	.	2.6	4	14	15	260547	4993
340	cleveland	871112	0.00	9	2.2	3	15	0	.	.	3.7	4	14	15	260547	4993
341	cleveland	871113	0.00	7	4.6	3	15	13	.	.	3.6	4	14	14	260547	4993

OBS	COEFF	DEPTH	TYPE	RUNCORR	BNOPNO	MNPREC	MNTEMPC	MNWINDS	CUMPREC	BARLEVR	PONDLEV1	PONDLEV2	PNDLEV	BARLEV	CUMRUN
337	0.96	2	SOIL	0.004783	43	0.0309677	5.62333	9.0323	0.96	14.688	15.844	.	15.8438	14.688	0.017661
338	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	14.625	15.719	.	15.7188	14.625	0.017661
339	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	14.469	15.438	.	15.4375	14.469	0.017661
340	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	14.469	15.000	.	15.0000	14.469	0.017661
341	0.96	2	SOIL	0.000000	43	0.0309677	5.62333	9.0323	0.96	14.438	15.406	.	15.4063	14.438	0.017661

OBS	BARLAG	BARCH	PONDLEV	PONDLAG	PONDCH	DATELAG	DAYDIF	CUMDAY	WL	CUMBARCH	CUMPONDC	CUMPREC2	CUMWL
337	14.719	-0.03125	15.8261	15.7996	0.02647	10173	1	26	0.05772	-1.3125	-0.7364	0.96	0.576089
338	14.688	-0.06250	15.7011	15.8261	-0.12500	10174	1	27	-0.06250	-1.3750	-0.8614	0.96	0.513589
339	14.625	-0.15625	15.4198	15.7011	-0.28125	10175	1	28	-0.12500	-1.5313	-1.1427	0.96	0.388589
340	14.469	0.00000	14.9823	15.4198	-0.43750	10176	1	29	-0.43750	-1.5313	-1.5802	0.96	-0.048911
341	14.469	-0.03125	15.3886	14.9823	0.40625	10177	1	30	0.43750	-1.5625	-1.1739	0.96	0.388589

APPENDIX B

This Appendix is for step by step guidance through the math used in evaluating water balance data from one or more barrels. The overall water balance process is laid out in the Chapter entitled Guidance for Review of Water Balances.

Application of the Graphical Plot of Data

The graph of the measured depths versus the date for each barrel is an important indicator of potential problems. Items to look for are:

1. Plotted points should produce lines as close to straight as possible. This limits the changes in rates of gain and is an indicator of a correct assumption for linear regression. It is important to remember the band width of the confidence interval is derived from the variation of the points around the estimated straight line.

2. Curves produced from barrel line plots should be as similar to each other as possible. The items of interest would be either an obscure barrel result (i.e., one barrel may be thrown out if results are anomalous), or nonconclusive information (i.e., if no barrel curve pattern is prevalent over another, this indicates the test is suspect).

The test information is impacted uniquely by the particular barrel which is selected as an indicator of seepage. Therefore, all barrels are to be run independently through the analysis and then similar sets may be selected and combined in an attempt to increase the number of sample points. This may remove any statistical limiting factor. However, the data in Kettle River demonstrated that the individual barrel variances were large enough in at least two instances to be a negative factor when combined with the other data. In other words, the confidence interval expanded, in spite of the fact that when these sets were added, the increased degrees of freedom allowed the statistical t_{α}(a multiplier) to decrease.

Application of the Unpaired t-Test

Prior to adding barrel data sets together the Unpaired t-Test must be performed to check for significant differences. The math is as taken from the book "Probability and Statistics for Engineers" by Irwin Miller and John E. Freund published by Prentice-Hall. The steps are as follows:

Definitions:

N1 = number of data points in data set 1

N2 = number of data points in data set 2

Degrees of Freedom = N1 plus N2 minus 2

δ = the acceptable variation level at which point the deviation becomes significant. For the water balance work may equal zero.

X1 = the mean of data set 1

X2 = the mean of data set 2

S1 = standard deviation of data set 1

S2 = standard deviation of data set 1

t_{α} = a statistically computed coefficient dependent on the predetermined confidence level and sample size. For the water balance work 95 percent confidence is required. Table B.1 is a t table to be used for this math analysis.

$t_{\alpha/2}$ = the t coefficent divided by two for a two tailed test. The water balance which should limit infiltration as well as seepage is a two tailed test.

V1 = variance of data set 1

V2 = variance of data set 2

Case I. Assumptions:

1. The sample size of the sets small (degrees of freedom less than 30)

2. The actual variance is unknown.

3. We are trying to prove the null hypothesis. The difference between the data sets does not exceed the variance level of the data sets plus the constant.

Then:

EQUATION A

$$\text{Test } t = \frac{(X1-X2) - \delta}{SQRT(\ (N1-1)S1**2 + (N2-1)S2**2\ )} * SQRT\ \frac{N1 * N2 * (N1 + N2 - 2)}{N1 + N2}$$

Assume the null hypothesis if $-t_{\alpha/2} < t < t_{\alpha/2}$

Case II. Assumptions:

1. The sample size of sets infinite (degrees of freedom greater than 30)

2. The sample set variance is representative of actual variance.

3. We are trying to prove the null hypothesis. The difference between the data sets does not exceed the variance level of the data sets plus the constant.

Then:

EQUATION B

$$\text{Test } z = \frac{(X1 - X2) - \delta}{\text{SQRT}\left(\frac{V1^{**}2}{N1} + \frac{V2^{**}2}{N2}\right)}$$

z = the Unpaired t-Test of a large population sample.

The large population sample gives a $t_{\alpha/2}$ coefficent of 1.960 for the boundaries. Therefore assume the null hypothesis if:

$$-1.960 < z < 1.960$$

The Case II equation may be utilized after several barrel data sets have been combined and one wishes to add more data points. The test assumes the data set variance is representative, therefore, no data set should be small.

If one set is small then the F test must be performed. As follows:

$$F = \frac{S1^{**}2}{S2^{**}2}$$

F is always greater than or equal to one as the larger standard deviation is always used in the numerator.

If F is greater than the regional boundary as determined by the Table B.2 using n-1 degrees of freedom for both numerator and denominator, then a significant variation in sets applies and equation C should be used. If is not greater than the regional boundary, then equation D should be applied.

Equation C

$$\text{Test } t = \frac{(X1 - X2) - \delta}{\text{SQRT}\left(\frac{S1^{**}2}{N1 - 1} + \frac{S2^{**}2}{N2 - 1}\right)}$$

The boundary conditions for this application are determined the same as for the Unpaired t-Test for small sample sets above. Degree of Freedom is approximately (N1 + N2 - 2)

Equation D

$$\text{Test } t = \frac{(X1 - X2) - \delta}{SQRT\left(SP{**}2 \left(\frac{1}{N1 - 1} + \frac{1}{N2 - 1} \right) \right)}$$

WHERE SP MEANS THE STANDARD DEVIATION OF THE POOLED SET AND IS APPROXIMATED BY:

$$SP = \frac{(N1 - 1) * S1 + (N2 - 1) * S2}{(N1 + N2 - 2)}$$

The boundary conditions for this application are determined the same as for the Unpaired t-Test for small sample sets above. The Degree of Freedom is approximately (N1 + N2 - 2)

Application of the Least Squares Analysis

The least squares analysis provides the mean seepage rate calculated by a least squares regression analysis and a confidence interval. The confidence interval gives the width of a band that a predetermined percentage of the data points will fall into. For the purpose of evaluation of water balance results 95 percent is the accepted norm for the confidence interval. Therefore, the water balance result is proposed to be given by a mean seepage rate in (gallons/acre/day) +/- the confidence interval of 95 percent (also in gallons/acre/day).

The analysis is put mathematically into a program on the MPCA contracted computer spread sheet program entitled 20/20. The Table B.3 is a copy of one spread sheet output of the analysis. The math involved will be given in equation form now and spreadsheet multiplication form will be used in as Table B.4. From the book entitled "Probability and Statistics for Engineers" by Irwin Miller and John E. Freund, the following expressions are developed:

1. $Sxx = n\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2$

2. $Syy = n\sum_{i=1}^{n} Y_i^2 - \left(\sum_{i=1}^{n} Y_i\right)^2$

3. $$Sxy = n \sum_{i=1}^{n} X_i * Y_i - \sum_{i=1}^{n} X_i \left(\sum_{i=1}^{n} Y_i \right)$$

Equation of the line:

4. $$a = \bar{Y} - b * \bar{X}$$

Slope:

5. $$b = \frac{Sxy}{Sxx}$$

The standard error estimate (Se) can be calculated by:

6. $$Se^2 = \frac{Sxx * Syy - (Sxy)^2}{n * (n - 2) * Sxx}$$

The confidence interval limits for Beta (the band width of 95% confidence) can be estimated by:

7. $$Beta = b +/- (t_{\alpha/2}) * Se * SQRT \frac{n}{Sxx}$$

The t_α table, used in conjunction with results from the Unpaired t-Test, gives the value of t_α used for the coefficient in the interval equation. The degrees of freedom are estimated by using n-2 and the 95 percent level.

The correlation coefficient rho can be estimated by:

8. $$r = \frac{Sxy}{SQRT (Sxx * Syy)}$$

The correlation is a ratio from zero to one. This is used as an indicator for the relationship between the x and y coordinates of the points on the estimated line. A value of zero indicates no correlation and one indicating a perfect correlation.

The above formulas can be converted into gallons per acre per day units by a multiplier of 27225.

$$27225 \text{ gals/acre/day} = \frac{(ft)}{12 \text{ (inches)}} * \frac{43560\ (ft^2)}{(acre)} * \frac{7.5 \text{ (gals)}}{(ft^3)}$$

The mean seepage rate becomes the slope of the pond control barrel data from Equation 5. minus the slope of the evaporation barrel data from Equation 5. multiplied by the quantity 27225. A sign change must take place to convert the the notation to the water balance. In historic notation, negative means infiltration gain and positive means seepage loss.

The confidence interval (both plus and minus bands) may be estimated statistically by the quantity of the slope of the barrel minus the slope of the pond times 27225 plus or minus the quantity of $t_{\alpha/2}$ multiplied by the square root of the following parameters: (1) the standard error estimate of the barrel slope squared, (2) the number of points in the barrel population set, (3) the quantity one over Sxx of the barrel, all plus the quantity of (4) the standard error estimate of the pond squared, (5) the number of points in the pond population set, (6) one over Sxx of the pond.

OR

$$(B_b - B_p)(27225) +/- t_{\alpha/2} * SQRT\left(Se_b^2 \frac{n_b}{Sxx_b} + Se_p^2 \frac{n_p}{Sxx_p} \right) * 27225$$

Therefore, when programmed, the engineer must only look at the mean seepage data, the confidence interval and the correlation coefficient to use as indicators of the test result.

<u>Data Preparation</u>

It is important to use the appropriate data parameters with each stage of the equations presented. To aid with common questions that have arisen with this work, the following will provide discussion for applications:

1. The t table is based on degrees of freedom for the data set currently being compared. This data set changes as one proceeds through the worksheet.

   In column F, row 71 of the spread sheet, the $t_{\alpha/2}$ value for only the control barrel population set minus two is entered in this cell.

   In column K, row 71 of the spread sheet, the $t_{\alpha/2}$ value is for only the pond barrel population set; minus two is entered in this cell.

Because the data is being expanded the value for the degrees of freedom used in the $t_{\alpha/2}$ value in column M in row 71 uses the pond barrel population set plus the control barrel population set minus 2.

2. All data being combined by use of the Unpaired t-Test should use equivalent initial reading points. Control barrels need not compare with evaporation barrels. However, evaporation barrels should align with evaporation barrels and control barrels with control barrels. The reference datum should be documented in the calculations (with the adjustment coefficient).

3. It is possible to add data selectively to the least squares analysis. To take a week of readings from the first half of the month and add it to a week of readings from the last half the month use the following steps: Readings were taken on the days; 1, 3, 5, 7, 11, 15, 17, 18, 20, 22, 24. Days 3 through 7 and 17 through 24 are the data without rain. The engineer may wish to combine just these points.

   A. Document the day transition for the second set of data keeping the elapsed time in the transformation equivalent (i.e., day 18 becomes day 8 and day 20 becomes day 10....).

   B. Document the evaporation measurement adjustment that accounts for the evaporation that occurred from that barrel during the interim period of measurements not being used (i.e. day 17 of the data is the beginning of the second subset of data to be used, so it becomes equivalent to the last reading of the first subset. That is, day 7's reading was 17.5 and day 17's reading was 14.0, so the second set of data, beginning on day 17 and going through day 24, all must have 3.5 added to their respective measurements).

   C. Graph the first week of data with the second set of data added as points on the end of the line.

   D. Check the points on the line and ensure at least 5 points per line exist and at least 9 points per analysis exist. The statistical assumption for linear regression will produce false levels of confidence if too few data points are used. The minimum level of data is felt to be around 9 for this application. However, the 9 points must be made up of no fewer than 5 points in a string. That is to say two barrels of 5 readings each may be combined into a least squares analysis but 3 barrels of 4 readings each may not.

Table 4

Values of t_α*

ν	$\alpha = 0.10$	$\alpha = 0.05$	$\alpha = 0.025$	$\alpha = 0.01$	$\alpha = 0.005$	ν
1	3.078	6.314	12.706	31.821	63.657	1
2	1.886	2.920	4.303	6.965	9.925	2
3	1.638	2.353	3.182	4.541	5.841	3
4	1.533	2.132	2.776	3.474	4.604	4
5	1.476	2.015	2.571	3.365	4.032	5
6	1.440	1.943	2.447	3.143	3.707	6
7	1.415	1.895	2.365	2.998	3.499	7
8	1.397	1.860	2.306	2.896	3.355	8
9	1.383	1.833	2.262	2.821	3.250	9
10	1.372	1.812	2.228	2.764	3.169	10
11	1.363	1.796	2.201	2.718	3.106	11
12	1.356	1.782	2.179	2.681	3.055	12
13	1.350	1.771	2.160	2.650	3.012	13
14	1.345	1.761	2.145	2.624	2.977	14
15	1.341	1.753	2.131	2.602	2.947	15
16	1.337	1.746	2.120	2.583	2.921	16
17	1.333	1.740	2.110	2.567	2.898	17
18	1.330	1.734	2.101	2.552	2.878	18
19	1.328	1.729	2.093	2.539	2.861	19
20	1.325	1.725	2.086	2.528	2.845	20
21	1.323	1.721	2.080	2.518	2.831	21
22	1.321	1.717	2.074	2.508	2.819	22
23	1.319	1.714	2.069	2.500	2.807	23
24	1.318	1.711	2.064	2.492	2.797	24
25	1.316	1.708	2.060	2.485	2.787	25
26	1.315	1.706	2.056	2.479	2.779	26
27	1.314	1.703	2.052	2.473	2.771	27
28	1.313	1.701	2.048	2.467	2.763	28
29	1.311	1.699	2.045	2.462	2.756	29
inf	1.282	1.645	1.960	2.326	2.576	inf.

*This table is abridged from Table IV of R. A. Fisher, *Statistical Methods for Research Workers*, published by Oliver and Boyd, Ltd., Edinburgh, by permission of the author and publishers.

Table 6 (a)

VALUES OF $F_{.05}$*

ν_2 = Degrees of freedom for denominator	ν_1 = Degrees of freedom for numerator																		
		2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	161	200	216	225	230	234	237	239	241	242	244	246	248	249	250	251	252	253	254
2	18.50	19.00	19.20	19.20	19.30	19.30	19.40	19.40	19.40	19.40	19.40	19.40	19.40	19.50	19.50	19.50	19.50	19.50	19.50
3	10.10	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.37
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.38	2.38	2.30	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	3.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.93
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

*This table is reproduced from M. Merrington and C. M. Thompson, "Tables of percentage points of the inverted beta (F) distribution," *Biometrika*, Vol. 33 (1943), by permission of the Biometrika trustees.

Table B.3

A	B	C	D	E	F	G	H	I	J	K	L	M	
DOUBLE BARRLE TEST			POND #1 LEVEL (INCHES)	ADJ DUE TO RUNOFF	ADJ POND LEVEL					BARREL #1 LEVEL			
	DAY # (X)	XSQD			(Y)	(YSQD)	(X*Y)	DAY # (X1)	XSQRD	(Y1)	(Y1SQD)	(X*Y1)	
	1	1.00	20.08	0.00	20.08	403.16	20.08	1	1.00	17.76	315.42	17.76	
	2	4.00	19.84	0.00	19.84	393.73	39.69	2	4.00	17.56	308.35	35.12	
	4	16.00	19.45	0.00	19.45	378.26	77.80	4	16.00	17.13	293.44	68.52	
	5	25.00	19.65	0.00	19.65	385.95	98.23	5	25.00	17.17	294.81	85.85	
	9	81.00	18.94	0.00	18.94	358.61	170.43	9	81.00	16.46	270.93	148.14	
	11	121.00	18.27	0.00	18.27	333.71	200.94	11	121.00	15.87	251.86	174.57	
	12	144.00	18.11	0.00	18.11	327.98	217.32	12	144.00	15.63	244.30	187.56	
	15	225.00	17.76	0.00	17.76	315.27	266.34	15	225.00	15.16	229.83	227.40	
	16	256.00	17.44	0.00	17.44	304.19	279.06	16	256.00	14.96	223.80	239.36	
								1	1.00	17.76	315.42	17.76	dead bird skewed
								2	4.00	17.61	310.11	35.22	test day 16
								4	16.00	17.10	292.41	68.40	
								5	25.00	17.25	297.56	86.25	
								9	81.00	16.39	268.63	147.51	
								11	121.00	15.87	251.86	174.57	
								12	144.00	15.76	248.38	189.12	
								15	225.00	15.09	227.71	226.35	
								16	256.00	14.92	222.61	238.72	

Table B.3

A	B	C		F	G	H	I	J	K	L	M		
							1	1.00	17.76	315.42	17.76		51
							2	4.00	17.56	308.35	35.12		
							4	16.00	17.05	290.70	68.20		
							5	25.00	17.21	296.18	86.05		
							9	81.00	16.30	265.69	146.70		55
							11	121.00	15.79	249.32	173.69		56
							12	144.00	15.63	244.30	187.56		
							15	225.00	15.00	225.00	225.00		
							16	256.00	14.76	217.86	236.16		
	(X)	XSQD		(Y)	(YSQD)	(X*Y)	(X1)	X1SQRD	(Y1)	(Y1SQD)	(X1*Y1)		60
n	9			9			27		27				
SUM	75	873.00		169.528	3200.85	1369.88	225.00	2619.00	442.51	7280.24	3544.42		
Sxx	2232						20088						64
Syy				68.0513					751.36				
Sxy				-385.63					-3865.41				
SeSQD				0.02262					0.0112059				
SLOPE			-0.1728	-0.1728					-0.192424				
CORRELATION			-0.9895	-0.9895					-0.994954				
CONFIDENCE INTERVAL (95%)				0.01971					0.0080103				70
t-alpha				2.064					2.064		1.96		
MEAN SEEPAGE RATE											-534.99		
SEEPAGE RATE RANGE (95% CONFIDENCE)										-1085.03	TO	15.0574	
Y-INTERCEPT				20.2762					17.984283				

EXAMPLE OF STATISTICAL SEEPAGE CALCULATION USING DATA FROM
KETTLE RIVER CELL A WITH POND LEVELS CORRECTED FOR RAINFALL RUNOFF

Table B.4

The following indexed system refers to the columnm and row sequenced spreadsheet used by the MPCA for the least squares analysis of the water balance data.

1. DEVELOP NOTATION FOR LEAST SQUARES ANALYSIS ON CONTROL BARRELS

COLUMN B	ROWS	6...59	Daily Measurements Read X	[from start of test]
	ROW	62	Counter of Days	[count(B6..B59)]
	ROW	63	Sum of Days	[sum (B6..B59)]
	ROW	64	Sxx	[B62 * C63 - (B63**2)]
COLUMN C	ROWS	6...59	Days Squared	[i.e. C6 = B6**2]
	ROW	63	Sum of Days Squared	[sum (C6..C59)]
COLUMN D	ROWS	6...59	Pond control readings in inches and at a referenced datum.	
COLUMN E	ROWS	6...59	Dike Runoff Correction in inches.	
COLUMN F	ROWS	6...59	Adjusted pond level	[F6 - E6]
	ROW	62	Counter of data points	[count(F6..F59)]
	ROW	63	Sum of data points in F	[sum(F6..F59)]
	ROW	65	Syy	[(F62*G63)-(F63**2)]
	ROW	66	Sxy	[(F62*H63)-(B63*F63)]
	ROW	67	Se^2	[(B64*F65-(F66**2))/(F62*(F62-2)*B64)]
	ROW	68	Slope = Sxy/Sxx	[F66 / B64]
	ROW	69	Correlation Coef.	[(F66 / SQRT(F62/F65)]
	ROW	70	Confidence Interval [F71 * SQRT (F67) * SQRT(F62 / B64)]	
	ROW	71	t-alpha for control barrel set from t table with degrees of freedom = F62 - 2	
COLUMN G	ROWS	6...59	Pond level squared Y	[i.e. G6 = F6**2]
	ROW	63	Sum of Y squared	[sum(G6..G59)]

2. NOW DEVELOP THE SAME NOTATION FOR THE EVAPORATION BARRELS

COLUMN I	ROWS	6...59	Daily Measurements Read X	[start at day 1]
	ROW	62	Counter of data in I	[count(6..59)]
	ROW	63	Sum of data in I	[sum(6..59)]
	ROW	64	Sxx	[(I62*J63)-(I63**2)]
COLUMN J	ROWS	6...59	X Squared	[i.e. J6=J6**2]
	ROW	63	Sum of Data in J	[sum(6..59)]
COLUMN K	ROWS	6...59	Barrel readings set to a reference datum on day 1	
	ROW	62	Counter of data in K	[count(6..59)]
	ROW	63	Sum of Data in K	[sum(6..59)]
	ROW	65	Syy	[K62*L63 - K63**2]
	ROW	66	Sxy	[(K62*M63)-(I63*K58)]
	ROW	67	Se^2	[(I64*K65-(K66**2))/(K62*(K62-2)*I64)]
	ROW	68	Slope	[(K66 / I64)]
	ROW	69	Correlation Coef.	[(K66) / SQRT(I64/K65)]
	ROW	70	Confidence interval [K71 * SQRT(K67) * SQRT(K62/I64)]	

```
          ROW   71         t-alpha coefficient from t table for degrees
                           of freedom equal to K62-2

Column L  ROWS  6.  59      Y Squared                     [ i.e.  L6 = K6**2 ]
          ROW   63          Sum of data in L              [ sum (L6..L59)    ]

COLUMN M  ROWS  6...59      DAYS TIMES BARRELS      X*Y [ i.e. M6=I6*K6      ]
          ROW   63          SUM OF DATA IN M            [ sum(M6..M59)       ]
          ROW   70          t alpha coefficient for both slopes compared
                            with a degree of freedom equal to K62 + F62 - 2.
```

3. DEVELOP SEEPAGE RATE IN UNITS OF GALLONS PER ACRE PER DAY

```
COLUMN L  ROW   74          LOWER SEEPAGE RATE RANGE
          [ M73 + (M71*SQRT((F67*F62/B64) + (K67*K62/I64))* 27225 )  ]

COLUMN M  ROW   73          MEAN SEEPAGE  RATE RANGE  [ -(F68 - K68) * 27225  ]

COLUMN N  ROW   74          UPPER SEEPAGE RATE RANGE
          [ M73 - (M71*SQRT((F67*F62/B64) + (K67*K62/I64)) * 27225 )  ]
```

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March 15, 1989

WRITER'S DIRECT DIAL NUMBER:

330-9866

Mr. James Klang
Municipal Waste Water
Treatment Section
Division of Water Quality
Minnesota Pollution Control
Agency
520 Lafayette Road
St. Paul, MN 55155

Re: Water Balance Task Force Report

Dear Mr. Klang:

I appreciate the opportunity to review the draft report of the water balance task force. I skimmed through most of the report, but read in detail Chapter 5 "Assessment of Combination Performance/Prescriptive Specifications". Below are my comments on Chapter 5.

I assume we are dealing with wastewater treatment projects which are funded through the EPA construction grant program. As such, the EPA grant regulations at Title 40 C.F.R. part 33 will apply. The regulations make it pretty clear that you should use performance, rather than design or prescriptive specifications when possible. As you may recall from the presentation given by me and Dave Sand of our law firm on November 17, 1987, the range of specifications includes on one end performance specifications and on the other detailed or prescriptive specifications. There are countless variations and combinations within the range of specifications.

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I believe the EPA regulations and protest decisions interpreting and enforcing those regulations allow for the use of a performance specification which gives enough detail or description of salient characteristics to meet the EPA goal of maximizing open and free competition.

Such a specification should be enforceable as a performance specification as long as it is clearly labeled as a performance specification, and the performance requirements are clearly spelled out. The specification writer must be very careful to not cross the line by providing so much design detail that the specification becomes a prescriptive specification.

The enforceability of a performance specification is bolstered by the use of a performance and payment bond to be provided by the general contractor for the benefit of the public owner. This bond is required by Minnesota statutes § 574.26. A public owner has the authority to require that subcontractors project also provide performance and payment bonds. The bond requirement should give the public owner some degree of performance and financial protection.

It is not clear to me if the task force is focusing on problems of design, construction, methods and materials or the water balance test itself. Each of these subjects should be addressed individually to the greatest extent possible. The draft report suffers somewhat from lack of focus. I believe the report would be more useful if there was a follow-on study which addressed in greater detail each of the subjects I have identified.

I offer these comments as an informed, but clearly a non-expert, person in matters of the water balance test. The task force's efforts are commendable and deserving of thanks within the engineering community, construction industry and the Minnesota Pollution Control Agency.

Sincerely,

Thomas A. Larson

TAL:dh/1.32
cc: David Sand
Ellie Lucas