BIG SKY GOLF COURSE WATER QUALITY MONITORING PLAN

AND

SUMMARY OF LYSIMETER AND MONITOR WELL DATA: 1996

Prepared for:

Big Sky County Water & Sewer District #363

by

MSE-HKM, Inc.
P.O. Box 31318
Billings, MT 59107

March 1997
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MSE - HKM, Inc.
2727 Central Avenue
P. O. Box 31318
Billings, MT 59107-1318
(406) 656-6399
FAX (406) 656-6398

June 2, 1998
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Mr. Grant Burroughs
Big Sky County Water and Sewer District 363
P.O. Box 160670
Big Sky, MT 59716

RE: Testing Summary and Schedule

Dear Grant:

Following our conversation, I went back and reviewed the testing schedule that had previously been submitted to DEQ in the Big Sky Golf Course Water Quality Monitoring Plan...,in March of 1997. I have summarized the monitoring requirements below with proposed additions underlined and proposed deletions interlined. The testing schedule was also sent to the Department of Environmental Quality for their review and concurrence.

INFLUENT TO AERATION POND

- BOD_5 weekly sampled weekly ~~during land application season~~.
- TSS weekly sampled weekly ~~during land application season~~.
- Total Nitrogen sampled weekly ~~during land application season~~.
- pH, weekly ~~during land application season~~
- ~~Alkalinity sampled weekly during land application season.~~
- Total flow, daily ~~during the irrigation season~~

POND 1 FILTER INFLUENT (SAMPLED IN FILTER BUILDING PRIOR TO THE FILTERS).

- BOD_5 weekly during the irrigation season.
- TSS weekly during the irrigation season
- Total Phosphorus weekly during the irrigation season

} Weekly sample during 1st two years of operation then 1/month

FILTER EFFLUENT

- Turbidity, continuous monitoring
- pH weekly
- TSS weekly during filter operation
- Total Phosphorus, weekly during filter operation

} Weekly samples for 1st two years of operation then monthly.

- Total Nitrogen weekly during filter operation
- Chlorine residual daily during filter operation
- Fecal coliforms weekly during filter operation.

IRRIGATION WATER BEING DELIVERED TO THE GOLF COURSE (SAMPLED AT IRRIGATION PUMP SUCTION).

- ~~TSS ,sampled weekly during land application season~~
- Total Nitrogen sampled weekly during the land application season
- ~~Total Phosphorous sampled weekly during the land application season~~
- Fecal coliforms, sampled weekly during land application season
- Total flow, daily during land application season.

LYSIMETERS AND MONITORING WELLS

- Weigh lysimeters every two weeks
- Rain gauge volumes 3 times per week and after storms
- BOD5
- pH
- TSS
- TDS (Total Dissolved Solids)
- Fecal Coliforms
- ~~Alkalinity~~
- Total Nitrogen
- Total Phosphorous
- Chlorides

Every two weeks for rest of 1998 irrigation season, then monthly in following irrigation seasons.

Sincerely,

MSE-HKM, INC.

Ray Armstrong

Ray Armstrong, P.E.

cc: Todd Teegarden, DEQ
Ron Edwards, District Manager

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BIG SKY GOLF COURSE WATER QUALITY MONITORING PLAN AND SUMMARY OF LYSIMETER AND MONITOR WELL DATA: 1996

WATER QUALITY MONITORING PLAN

Background

The Big Sky Golf Course has historically been irrigated with effluent from the wastewater treatment facility. As part of the 1979 contractual agreement between Rural Improvement District No. 305 (RID) and Big Sky of Montana Incorporated (Big Sky), Big Sky agreed to furnish land to RID "for the application and disposal of wastewater by irrigation". The agreement outlines the District's responsibilities not to pollute the environment with their wastewater disposal. Part of the District's responsibilities include irrigation scheduling measures to prevent over-irrigation and a water quality monitoring program to "monitor the system's pollution control performance and guiding its operation".

In July of 1993, the State of Montana's Department of Environmental Quality (DEQ), formerly the Department of Health and Environmental Sciences (DHES), issued a Compliance Order that required the District to submit an Interim Work Plan and a Long-Term Compliance Work Plan. The Compliance Order placed a moratorium on new connections to the sewer system which resulted in stopping new construction activity. The moratorium was the result of deficiencies in the sewer and wastewater facilities and due to the fact that effluent was being applied on the golf course that did not meet DEQ standards.

MSE-HKM, Inc. (MSE-HKM) prepared an Interim Action Work Plan (IAWP) that outlined short-term solutions necessary to comply with DEQ's requirements. MSE-HKM also prepared a Long-Term Compliance Work Plan including further expansion and rehabilitation of the Big Sky wastewater facilities. The IAWP outlines corrective measures to eliminate lagoon leakage and provide filtration and chlorination for disinfection of wastewater for land application to the unrestricted golf course.

The 1993 Compliance Order issued to Big Sky by the Department of Environmental Quality stated that the District develop an "improved land application management and monitoring plan". Personnel from the DEQ, the District and MSE-HKM met early in 1997 to determine what would be necessary to fulfill the new requirements. Based on the expected treatment levels of the newly improved system (1996-97 construction including the new filtration unit), the parties agreed that the influent and effluent monitoring requirements would consist of the following components and monitoring frequency:

Sewage Influent to Aeration Pond

- Biological Oxygen Demand (BOD), sampled weekly during land application season
- Total Suspended Solids (TSS), sampled weekly during land application season
- Total Nitrogen (N) = Nitrate plus Nitrite as N + Total Kjeldahl Nitrogen + Ammonia as N, sampled weekly during land application season
- pH, sampled weekly during land application season
- Alkalinity, sampled weekly during land application season
- Total Flow, daily during land application season

Wastewater Effluent (Irrigation Water Being Delivered to Golf Course)

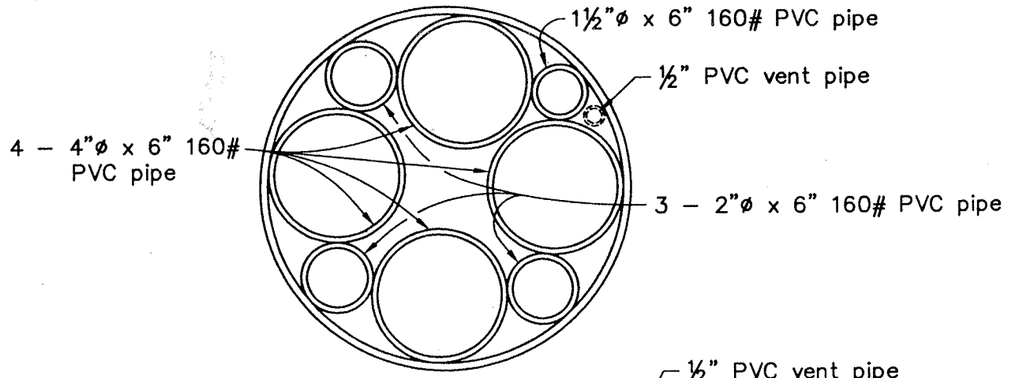
- Total Suspended Solids (TSS), sampled weekly during land application season
- Total Nitrogen (N) = Nitrate plus Nitrite as N + Total Kjeldahl Nitrogen + Ammonia as N, sampled weekly during land application season
- Total Phosphorous, sampled weekly during land application season
- Fecal Coliforms, sampled weekly during land application season
- Total Flow, daily during land application season

Introduction

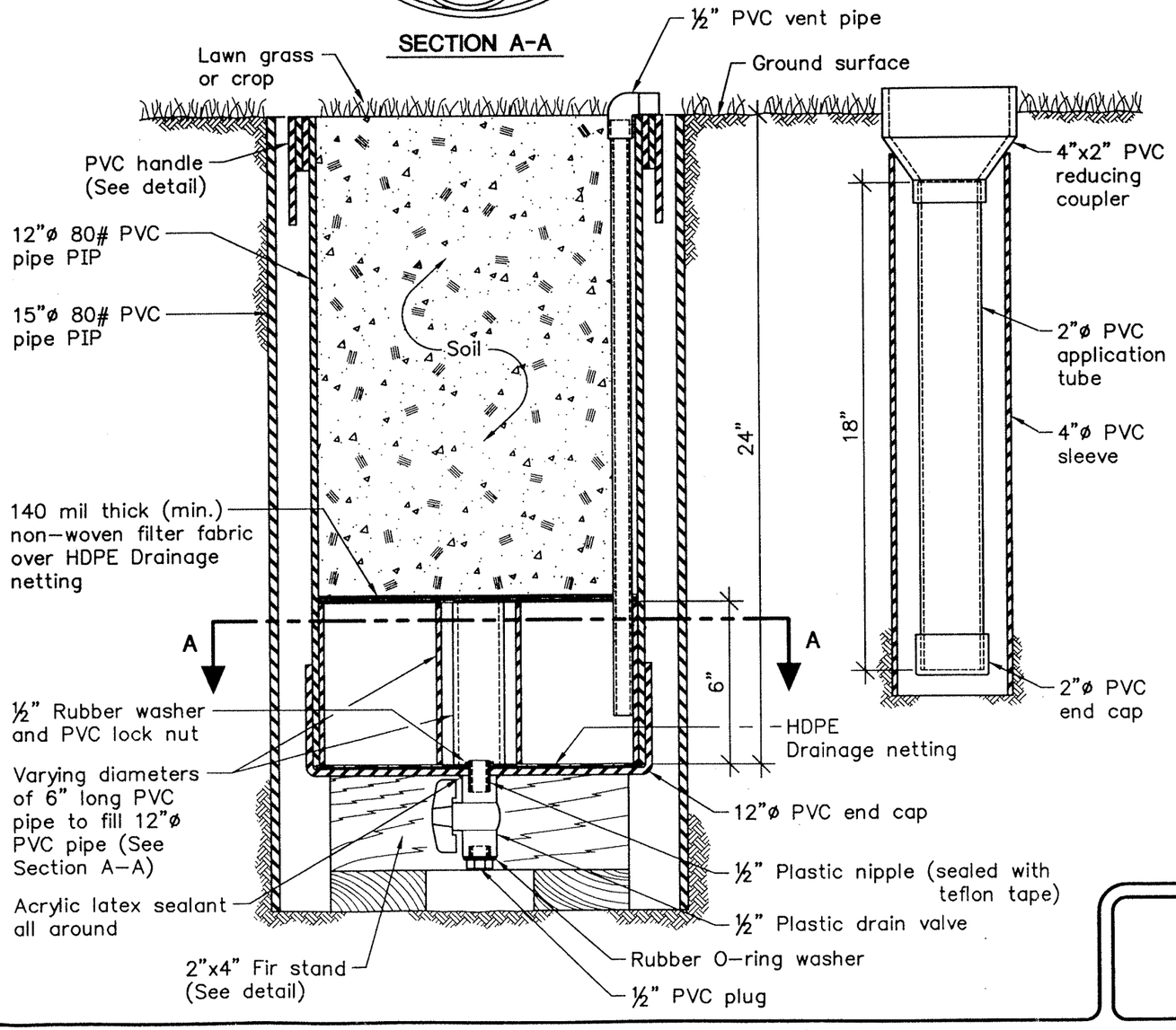
In February 1995, MSE-HKM prepared a scope of services for a golf course water quality monitoring plan for Big Sky Water & Sewer District #363 (Big Sky). The scope included the design, layout and implementation of a water quality monitoring plan. The monitoring plan included monitor wells and lysimeters, designed to assess the performance of the effluent land application system on the golf course.

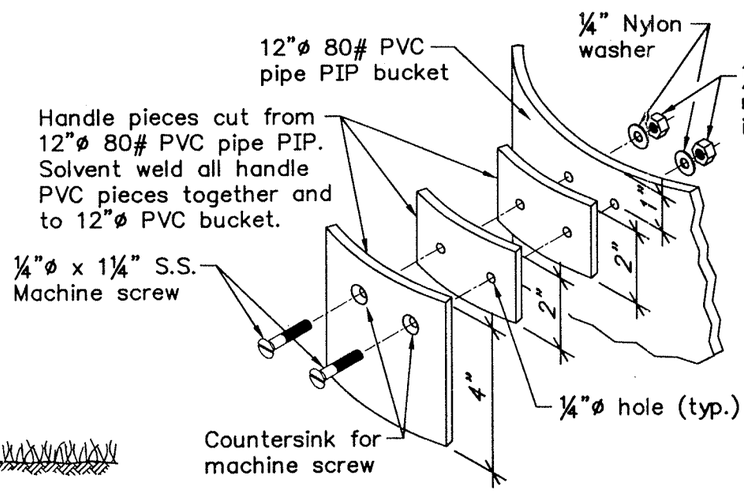
In the spring of 1995, six monitor wells and six lysimeters were installed. Figure 1 shows the details of a bucket lysimeter, similar to those installed at Big Sky. Photos 1 and 2 at the end of this report show the lysimeter installation. Photos 3 and 4 show completed lysimeters approximately 1 week after installation. Photos 5 and 6 show monitor well installation. Five permeameter tests were conducted throughout the golf course and at an adjacent site to document the saturated infiltration rates of the soils in the area. Photos 7 and 8 show two permeameter tests being conducted. Figure 2 shows the golf course layout and the location of the monitor wells, lysimeters, and permeameter tests.

Lysimeter monitoring data from 1995 provided inaccurate results due to the compound used in lysimeter installation for the side sealant. A letter in the MSE-HKM project file documents this in more detail. In June 1996, the lysimeters were replaced with new units without the side sealant compound that created the faulty results in 1995. Monitoring resumed in July 1996 and throughout the land application season. The last section of this report summarizes the monitoring data from the lysimeters and monitor wells for 1996. Included are the water quality monitoring measurements, as received by MSE-HKM, Inc. on February 26, 1997, for the six lysimeters and six monitor wells located throughout the golf course.

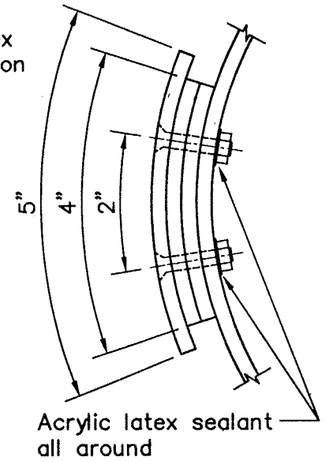


SECTION A-A



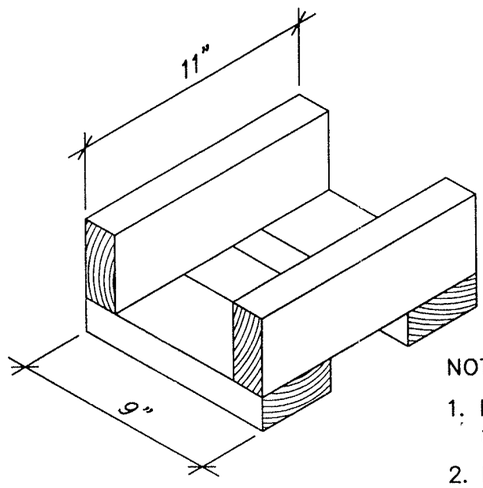


ISOMETRIC VIEW



TOP VIEW

HANDLE DETAIL



LYSIMETER STAND

NOTE :

1. Entire stand to be constructed from 2"x4" Fir lumber.
2. Fasten pieces together with #7x3" deck screws.

LYSIMTR.DWG

BIG SKY GOLF COURSE WATER QUALITY MONITORING PLAN

DETAIL OF BUCKET LYSIMETER

FIGURE #1

ENGINEERING

4M357.102 | MAR 1997

LEGEND

- BOUNDARY OF NEW IRRIGATION SYSTEM
- BOUNDARY OF EXISTING IRRIGATION SYSTEM
- DH-1 DRILL HOLE NUMBER FOR GROUNDWATER MONITORING
- L1 LYSIMETER NUMBER
- P3 PERMEAMETER TEST LOCATIONS

SOIL SERIES CLASSIFICATION

- 280B LIBERG
- 482C PHILIPSBURG
- 608B TURSON SERIES, FUBAR SERIES

LOT LINE BOUNDARIES ARE NOT TO SCALE
THEIR ONLY PURPOSE IS FOR SHOWING LOT OWNERSHIP

DISCLAIMER

THIS DRAWING DOES NOT REPRESENT A SURVEY.
NO LIABILITY IS ASSUMED AS TO THE ACCURACY OF THE DATA DELINEATED HEREIN.

FIG-2.DWG

BIG SKY GOLF COURSE WATER QUALITY MONITORING PLAN

GOLF COURSE IRRIGATION AREA AND MONITORING LOCATIONS

FIGURE 2

MSE-HKM ENGINEERING

4M357.102 | MARCH 1997

Monitoring Components

The six monitor wells and six lysimeters throughout the golf course land application area are shown in Figure 2. These are the major tools that will be used to determine the ground water quality impacts of effluent land application. Data in addition to the lysimeters and monitor wells are necessary to assess the performance of the land application system. For instance, flow data, effluent quality (nitrogen concentration, etc.) and the application of commercial fertilizers by golf course maintenance personnel can have a significant impact on drain water quality data collected from the lysimeters. If fertilizer is applied on a given day and the following day has a significant rainfall event, a flush of nitrogen may occur and appear in the water quality sampling data for a given lysimeter. This type of "influential" activity, outside the effluent land application system, is important to document throughout the irrigation season.

General flow data needs to be collected at the treatment facility to document the total volume of irrigation water being delivered to the golf course. A flow meter is located at the discharge side of the pumps delivering effluent to the golf course. This meter will continually keep records of the total volume delivered to the golf course irrigation system. Accumulated flow data and corresponding nitrogen concentrations of the effluent can be used to calculate the total nitrogen load being delivered to the golf course.

The six rain gages located at each lysimeter will document the depths of water being applied throughout various locations on the golf course. Along with flow meter records from the treatment building, an adequate record of irrigation distribution throughout the golf course can be maintained. A baseline rain gage was installed at a non-irrigated site to document the natural precipitation occurring on the golf course. The precipitation data collected from the baseline rain gage is assumed to represent natural precipitation throughout the Big Sky Meadow Village and golf course.

Monitoring data from eighteen additional sites in the Big Sky area have been collected by the District for several years. They include six monitor wells and 12 surface water sites. Data

collected at these sites includes: BOD, pH, TSS, TDS, fecal coliforms, alkalinity, nitrogen, phosphorous, and chlorides. Analysis of these data are not included in this report. The District has indicated that they will continue monitoring these sites in the future.

Monitoring Schedule

During the irrigation season, typically mid-May through September, measurements from the lysimeters should be taken at least every two weeks (ie. no longer that 14 days between any two measurements). The single volume drained from any one lysimeter should not exceed 5,700 ml. If this occurs, the lysimeters may be experiencing saturation and should be drained more frequently (once per week) to assure representative samples. An outline of the lysimeter data collection procedures is discussed further in the following section of this report.

Rain gage volumes should be collected three times each week, preferably Mondays, Wednesdays, and Fridays. Also, rain gages should be emptied and measured after each rainfall event that exceeds approximately 0.10 inches. Frequent collection of rain gage volumes minimizes the errors that occur by evaporation in the rain gage after an irrigation or precipitation event.

During the non-irrigation season, the lysimeter drain valves should remain open to allow any unfrozen moisture to exit the lysimeter. Leaving the lysimeter drain valves open prevents moisture in the lysimeter from freezing, which can cause cracks in the PVC and destroy the lysimeter. It is important, however, for the lysimeters to stay in place during winter months so that they remain in close equilibrium with the surrounding soil/water environment.

Rain gages should be removed, emptied and stored in a dry, protected location during winter months. This will prevent freezing of water in the PVC rain gage tube which may result in cracking.

Recommended Data Collection Procedures

Table 1 outlines the general data collection procedures for the lysimeters and rain gages on the golf course. Table 1 should be used as a guideline when taking measurements to make sure all data is collected for each lysimeter. A data collection template for each lysimeter and a conversion table which coverts volumes collected from the four-inch diameter rain gages from milliliters to inches of depth have been created by MSE-HKM and are being used by Big Sky personnel during data collection. These tables are on file at MSE-HKM and Big Sky.

TABLE 1
BIG SKY GOLF COURSE WATER QUALITY MONITORING PLAN
GENERAL DATA COLLECTION GUIDELINES

GENERAL:	1.	Record current date of measurement.
	2.	Record the total gallons from flowmeter at pump.
	3.	Measure precipitation* from baseline rain gage in ml and convert to inches using attached chart.
	Note:	*Measure baseline rain gage precipitation after every significant rainfall event (P≥25 ml or 0.10 inches).
FOR EACH LYSIMETER:	1.	Measure precipitation plus irrigation (P+I) from rain gage at lysimeters (convert ml to inches).
	2.	Measure lysimeter weight prior to draining (lbs).
	3.	Drain lysimeter and measure deep percolation (DP) (convert ml to inches).
	4.	Measure lysimeter weight after draining (lbs).
	5.	Check to assure lysimeter weight after draining is less than lysimeter weight prior to draining. Also check that the weight of drain water ≈ Δ in measured weights.
	6.	Close drain valve and replace end cap on drain valve.
	7.	Carefully replace lysimeter into PVC casing.

It is very important when replacing the lysimeters back into the PVC casings and onto the wooden stands to take extreme caution to protect the drain valves. If the drain valves are bumped on the wooden stand or the edge of the PVC casing, the leak-proof seal may be broken. This may result in leaking valves and inaccurate lysimeter drain volumes. The manhole tripod allows the lysimeters to be raised and lowered slowly. If done diligently, the structural integrity of the drain valves will be maintained. It is also important to make sure the drain valve is closed prior to replacing the lysimeter into the casing.

The District will enter data from the lysimeters and monitor wells into a computer spreadsheet. Field measurements and water quality sampling results will then be readily available on computer.

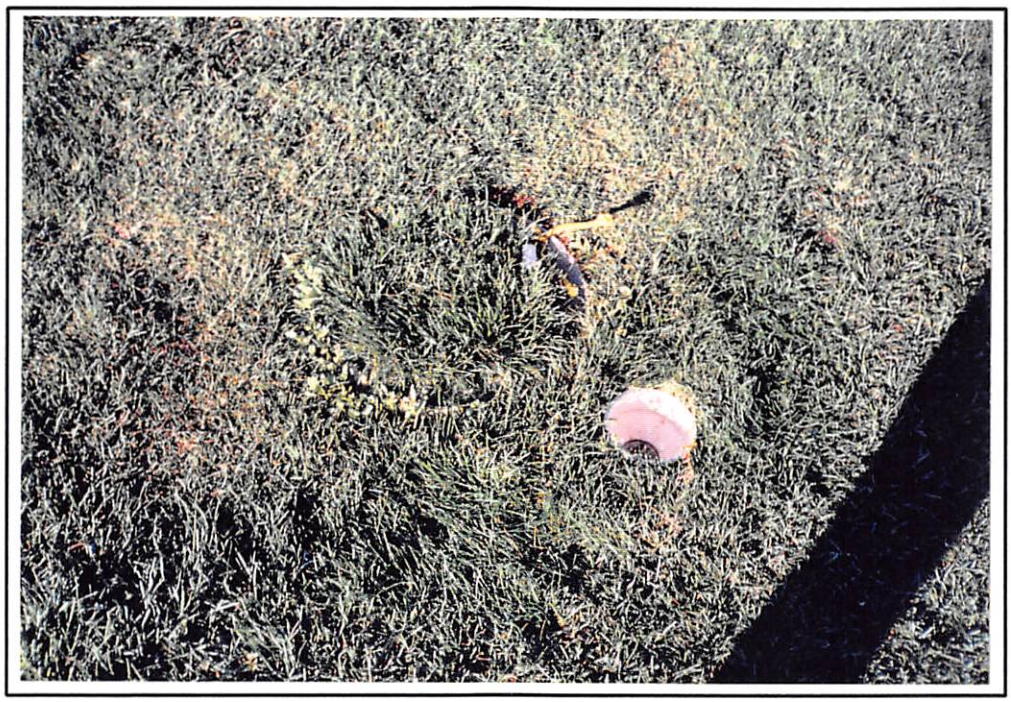
Summary

This report summarizes the general water quality monitoring plan for the Big Sky Golf Course. Prudent irrigation water management by the golf course personnel, which appears to be occurring, is vital to maintaining a quality land application project. It will be important to maintain active communication among golf course personnel and Big Sky Water and Sewer District #363 personnel. Fertilizer, pesticide and herbicide applications should be documented. Specifically, the timing and quantity of applications should be noted so that water quality sample outputs can be related to all of the system inputs.

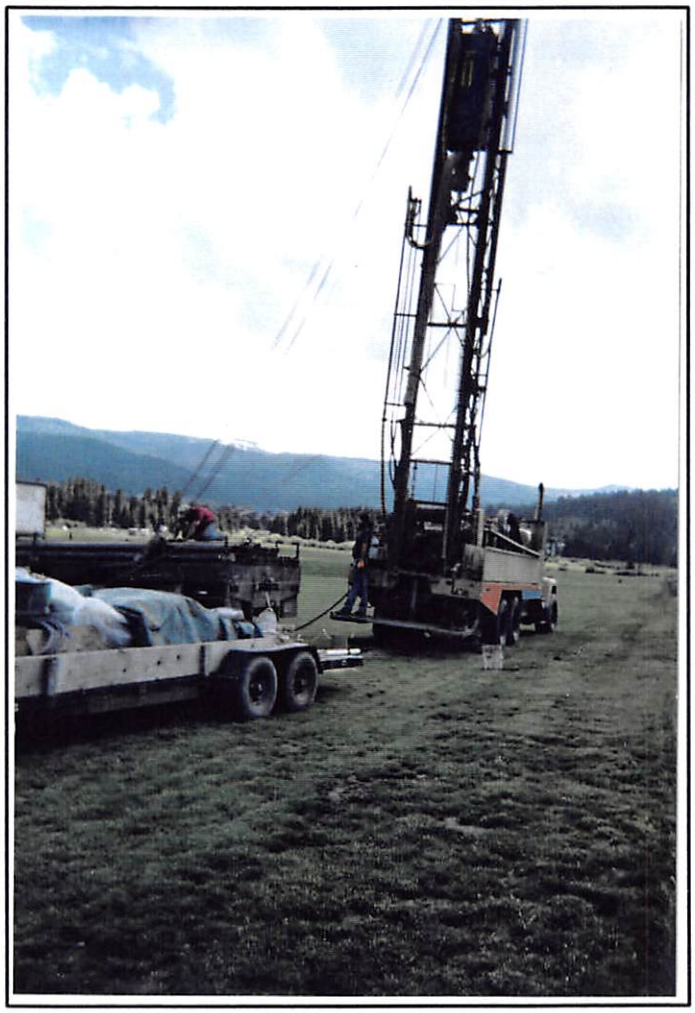
Careful management of fertilizer application is critical to minimize deep percolation of nutrients (mainly nitrogen) into the ground water. From a golf course water and nutrient management standpoint, the ultimate goal is to apply water and nutrients at a rate and quantity to provide optimum playing conditions for the golfers. From a water quality and environmental standpoint, the goal is to apply water and nutrients at as high a rate as possible without degrading surface or ground waters or presenting health hazards.

Photo 1: Lysimeter Installation 1995

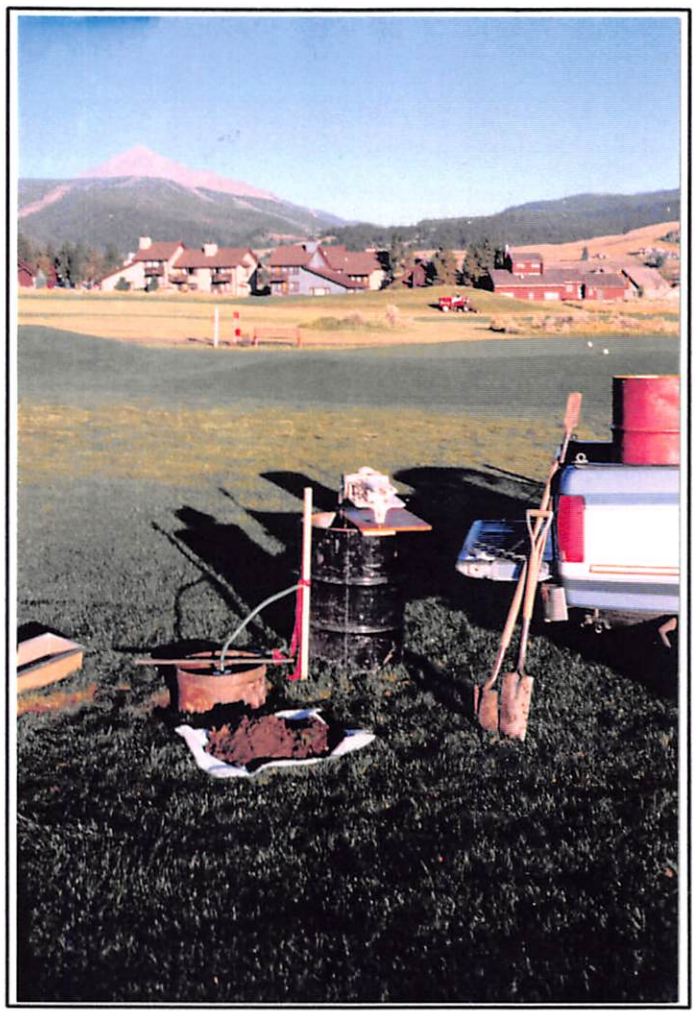
Photo 2: Installed Lysimeter 1995



Photos 3 and 4: Installed Lysimeter (approx. 1 week after installation)



Photos 5 and 6: Monitor Well Installation 1995



Photos 7 and 8: Permeameter Test 1995

SUMMARY OF LYSIMETER AND MONITOR WELL DATA: 1996

Introduction

The 1996 water quality monitoring program on the golf course began on July 11, 1996. Measurements were taken periodically throughout the irrigation season, which ended October 18. The data collected from the monitor wells and lysimeters were entered into a spreadsheet by Big Sky personnel and are presented at the end of this report. This report briefly summarizes the 1996 water quality monitoring data.

The lysimeters and monitor wells were installed in 1995 and the lysimeters were replaced with new units on June 7, 1996. Data collection began on July 11, 1996.

Monitor Wells

Six monitor wells are located throughout the golf course (refer to Figure 2 in the Water Quality Monitoring Plan). With the exception of DH-1, data from the monitor wells show very low levels of fecal coliforms and nitrate plus nitrite as nitrogen. The July 25 sampling shows a fecal coliform count of 14 per 100 ml. Fecal coliform counts in all of the other monitor wells on the July 25 sampling are 1 per 100 ml. Non-detectable levels of fecal coliform bacteria were found during all other sampling events. The higher level of fecal coliform bacteria found in DH-1 on the July 25 sampling may be caused from waterfowl, which at times concentrate in the small drainage pond located adjacent to DH-1. DH-1 is located in a low, enclosed area along the southern border of the golf course. No apparent surface drainage is provided for storm water runoff, which accumulates in the small drainage pond.

Average nitrogen concentration levels in DH-1 are consistently higher than those found in the other monitor wells (5.49 mg/l for DH-1 versus 0.39 mg/l for DH's 2-6). This may also be due to the waterfowl waste accumulating in the drainage pond and deep percolating into the groundwater. Future monitoring of DH-1 should provide an indication of the potential sources of

increased nitrogen and fecal coliform bacteria. Average chloride concentrations are also higher in DH-1 than in the other monitor wells (27 mg/l for DH-1 versus 2.7 mg/l for DH's 2-6).

The pH levels in the monitor wells range from 7.1 to 8.4, showing generally neutral levels. Total suspended solids (TSS) in the groundwater are generally higher in the early summer months and lower later in the fall. Subsequent years of data should show better trends with regards to TSS levels. Total dissolved solids (TDS) are generally higher in DH-1, DH-2, DH-3 and DH-5. DH-4 and DH-6 are located closer to the West Gallatin River flowing through the golf course than are the other monitor wells. A higher level of groundwater mixing and dilution may be taking place closer to the stream, resulting in lower levels of TDS in DH's 4 and 6.

Lysimeters

Six lysimeters are located throughout the golf course (refer to Figure 2 in the Water Quality Monitoring Plan). The abbreviated lysimeter monitoring data from 1996 shows positive results for the land application and disposal system. There was very little deep percolation through the lysimeters, indicating that the land application of effluent closely matched the agronomic water uptake potential of the turf grass.

Lysimeters 1 and 4 had significant drain water quantities on July 11, the first data collection event of 1996. This occurred approximately one month after the lysimeters had been replaced by MSE-HKM. Lysimeters 1 and 4 had collected an average of 4.55 inches of irrigation and about 0.5 inches of precipitation since the new lysimeters had been installed. The 4.55 inch average irrigation depth in Lysimeters 1 and 4 is approximately 1.5 inches more than measured at Lysimeters 2, 3, 5 or 6. Lysimeters 2, 3, 5, and 6 had no deep percolation during this initial monitoring period. The timing and depth of irrigation and rainfall most likely had a role in the deep percolation that occurred in Lysimeters 1 and 4. Also, the fact that the lysimeters were not drained in the month's time between installation and the first monitoring event may have resulted in a nearly saturated lysimeter.

From a golf course water and nutrient management standpoint, the ultimate goal is to apply water and nutrients at a rate and quantity to provide optimum playing conditions for the golfers. From a water quality and environmental standpoint, the goal is to apply water and nutrients at as high a rate as possible without degrading surface or ground waters or presenting health hazards. Data from Lysimeters 2, 3, 5, and 6 show that the Big Sky golf course land application system is achieving the latter goal. Lysimeters 2, 3, 5 and 6 had no occurrences of deep percolation in 1996. This indicates that irrigation water is being applied at approximately the same rate as the agronomic uptake of the golf course turf grass, fulfilling the crop water and nutrient requirements without deep percolating below the root zone.

In general, it appears that nitrogen is being applied at a rate which closely matches the agronomic uptake rate of the golf course turf. One exception to this is data from Lysimeter 1. Not only is the initial deep percolation event in Lysimeter 1 high in nitrogen concentration, the subsequent two events (Aug 22 and Oct 3) also have high nitrogen concentrations (32 and 20.1 mg/l, respectively). These concentrations are significantly higher than the concentrations of effluent being applied to the golf course. Hence, an additional, high-concentration source of nitrogen must be occurring at the location of Lysimeter 1. One explanation may be the addition of supplemental fertilizer by golf course personnel.

Summary

Data from 1996 shows that throughout most of the golf course, water is being applied at a rate approximately equal to the water uptake rate of the turf grass. Drain water was collected in only two of the six lysimeters throughout the season. An average of 10.20 inches of irrigation was applied over the golf course from June 7 to October 18. Approximately 1.32 inches of precipitation occurred during the same period. MSE-HKM predicted the average year consumptive use for turf grass at Big Sky to be about 16 inches and a net irrigation requirement of about 11 inches.

Nitrogen concentrations in the drain samples from Lysimeter 1 are higher than the wastewater effluent being applied. An additional, outside source of nitrogen, such as commercial fertilizer, may be the cause of these high concentrations. The nitrogen concentrations in the drain water collected from Lysimeter 4 are lower than the average wastewater effluent nitrogen concentrations (5.19 mg/l versus about 15 mg/l). Although the nitrogen concentrations in the drain water are somewhat higher than expected, the total volume of drain water and the occurrences of drain water are low.

Lysimeters 1 and 4 received approximately 33% more irrigation water than Lysimeters 2, 3, 5, and 6 during the first monitoring period, resulting in deep percolation in those two lysimeters. Deep percolation water in Lysimeter 1 showed high levels of total nitrogen (41.6 mg/l) during the initial monitoring period and relatively high levels of total nitrogen in the other two events when deep percolation occurred in Lysimeter 1 (32 mg/l and 20.1 mg/l). The high concentrations of nitrogen found in Lysimeter 1 drain water are possibly caused by supplemental fertilizer applied by the golf course personnel.

Documentation of supplemental applications of commercial fertilizers should be made and communication among the golf course personnel and Big Sky Water and Sewer District #363 personnel concerning any fertilizer applications or other activity which might alter water quality data is essential. In addition, any unusual activity or observation that is made during monitoring and data collection should be documented. What might appear as erroneous or unexplainable data may be made clear if documentation of all other outside influences to the system is made.

In all, it appears that in 1996 the golf course land application system was operated with a level of management that will minimize environmental impacts to the ground water. Water quality monitoring data in future year(s) will continue to allow improved management and operation of the land application system. The newly installed irrigation system throughout the golf course should also provide more uniform irrigation depths to all areas of the golf course, minimizing over-watering or under-watering that may be occurring due to irrigation system deficiencies.

1996 MONITORING DATA

GOLF COURSE MONITORING: Summer, 1996
Monitoring Wells

Drill Hole 1	FECAL COLIFORMS (col/100 ml)	TOTAL SUSPENDED SOLIDS	BOD5	ORTHOPHOSPHATE AS PHOSPHORUS	TOTAL PHOSPHORUS	NITRATE + NITRITE AS NITROGEN	pH	AMMONIA AS NITROGEN	TOTAL KJELDAHL NITROGEN	CHLORIDE	TOTAL DISSOLVED SOLIDS
11-Jul-96	ND	59	15	ND	0.07	6.70	7.5	ND	ND	23.0	1000
25-Jul-96	14	2000	2	ND	0.27	4.30	7.7	0.08	2.10	25.0	1400
22-Aug-96	ND	84	1	ND	0.09	3.70	7.5	ND	0.50	21.0	530
5-Sep-96	ND	ND	ND	ND	0.29	5.90	7.5	ND	0.93	25.0	570
20-Sep-96		7	1		0.06	4.40	7.7	ND	0.83	45.0	340
3-Oct-96	ND	240	1	ND	0.18	6.20	7.6	0.60	ND	27.0	450
18-Oct-96	ND	4100	1	ND	12.00	7.20	7.7	0.07	1.40	23.0	580

Drill Hole 2	FECAL COLIFORMS (col/100 ml)	TOTAL SUSPENDED SOLIDS	BOD5	ORTHOPHOSPHATE AS PHOSPHORUS	TOTAL PHOSPHORUS	NITRATE + NITRITE AS NITROGEN	pH	AMMONIA AS NITROGEN	TOTAL KJELDAHL NITROGEN	CHLORIDE	TOTAL DISSOLVED SOLIDS
11-Jul-96	ND	3700	12	ND	1.70	0.53	7.8	ND	5.90	ND	1400
25-Jul-96	1	4500	2	ND	0.31	0.50	8.2	ND	4.50	ND	1600
22-Aug-96	ND	8	1	ND	ND	0.86	7.6	0.18	6.30	ND	240
5-Sep-96	ND	560	2	ND	0.85	0.22	7.5	0.11	ND	ND	300
20-Sep-96		160	1		0.13	0.25	7.8	ND	1.20	ND	200
3-Oct-96	ND	1300	1	ND	0.99	0.57	7.9	0.40	ND	5.1	180
18-Oct-96	ND	33	2	ND	0.08	0.43	8.1	0.06	1.40	5.6	290

Drill Hole 3	FECAL COLIFORMS (col/100 ml)	TOTAL SUSPENDED SOLIDS	BOD5	ORTHOPHOSPHATE AS PHOSPHORUS	TOTAL PHOSPHORUS	NITRATE + NITRITE AS NITROGEN	pH	AMMONIA AS NITROGEN	TOTAL KJELDAHL NITROGEN	CHLORIDE	TOTAL DISSOLVED SOLIDS
11-Jul-96	ND	810	11	0.09	12.00	0.16	8.0	ND	ND	ND	1100
25-Jul-96	NO WATER IN MONITORING WELL										
22-Aug-96											
5-Sep-96											
20-Sep-96											
3-Oct-96											
18-Oct-96											

Drill Hole 4	FECAL COLIFORMS (col/100 ml)	TOTAL SUSPENDED SOLIDS	BOD5	ORTHOPHOSPHATE AS PHOSPHORUS	TOTAL PHOSPHORUS	NITRATE + NITRITE AS NITROGEN	pH	AMMONIA AS NITROGEN	TOTAL KJELDAHL NITROGEN	CHLORIDE	TOTAL DISSOLVED SOLIDS
11-Jul-96	ND	28	6	ND	ND	0.69	7.5	ND	ND	ND	490
25-Jul-96	1	38	2	ND	ND	0.48	7.9	ND	ND	ND	500
22-Aug-96	ND	ND	1	ND	ND	0.08	7.3	0.10	ND	ND	220
5-Sep-96	ND	ND	ND	ND	ND	ND	7.3	ND	ND	ND	160
20-Sep-96		57	2		ND	0.08	8.1	ND	ND	ND	70
3-Oct-96	ND	18	3	ND	ND	0.16	8.2	0.40	ND	3.3	98
18-Oct-96	ND	7	2	ND	ND	ND	7.7	0.05	ND	3.0	190

Drill Hole 5	FECAL COLIFORMS (col/100 ml)	TOTAL SUSPENDED SOLIDS	BOD5	ORTHOPHOSPHATE AS PHOSPHORUS	TOTAL PHOSPHORUS	NITRATE + NITRITE AS NITROGEN	pH	AMMONIA AS NITROGEN	TOTAL KJELDAHL NITROGEN	CHLORIDE	TOTAL DISSOLVED SOLIDS
11-Jul-96	ND	6400	5	ND	23.00	ND	7.7	ND	14.00	ND	1600
25-Jul-96	1	5900	2	ND	0.48	ND	7.9	ND	2.60	3.4	1500
22-Aug-96	ND	ND	3	ND	ND	ND	7.3	0.16	ND	6.8	310
5-Sep-96	ND	1500	1	ND	ND	ND	7.4	0.09	ND	ND	280
20-Sep-96		55	2		ND	ND	8.0	ND	2.60	2.2	150
3-Oct-96	ND	490	ND	ND	ND	0.14	7.9	0.29	4.30	5.2	240
18-Oct-96	ND	730	2	ND	0.62	ND	8.4	ND	5.80	6.0	310

Drill Hole 6	FECAL COLIFORMS (col/100 ml)	TOTAL SUSPENDED SOLIDS	BOD5	ORTHOPHOSPHATE AS PHOSPHORUS	TOTAL PHOSPHORUS	NITRATE + NITRITE AS NITROGEN	pH	AMMONIA AS NITROGEN	TOTAL KJELDAHL NITROGEN	CHLORIDE	TOTAL DISSOLVED SOLIDS
11-Jul-96	ND	26	5	ND	0.32	0.62	7.5	ND	ND	8.0	580
25-Jul-96	1	22	3	ND	ND	1.20	7.6	ND	0.52	7.7	670
22-Aug-96	ND	420	2	ND	0.30	ND	7.4	0.07	ND	3.4	310
5-Sep-96	ND	4	1	ND	ND	0.27	7.1	0.14	ND	ND	290
20-Sep-96		33	2		ND	1.20	8.0	ND	ND	4.7	160
3-Oct-96	ND	10	ND	ND	ND	1.40	7.8	0.23	ND	7.4	250
18-Oct-96	ND	ND	1	ND	ND	1.40	8.2	ND	0.24	7.7	330

GOLF COURSE MONITORING: Summer, 1996
Lysimeters

LYSIMETER #1

Sample Date	Monitoring Period (days)	Precipitation + Irrigation (ml)	Precipitation (ml)	Irrigation (ml)	Irrigation (inches)	Lysimeter Weight (lbs) Before Draining	Lysimeter Weight (lbs) After Draining	Drain Water Weight (lbs)	Nitrate + Nitrite as N	TKN	Ammonia as N	Total N (mg/L)
11-Jul-96		1170.0	100.0	1070.0	4.11	146.0	142.0	4.0	38	3.5	0.1	41.6
25-Jul-96	14	510.0	25.0	485.0	1.86	142.0	142.0	0.0				
22-Aug-96	28	380.0	10.0	370.0	1.42	144.0	142.0	2.0	32			32
5-Sep-96	14	380.0	5.0	375.0	1.44	144.0	144.0	0.0	On August 22 there was only enough water in the Lysimeter for one sample paramater to be run			
20-Sep-96	15	275.0	200.0	75.0	0.29	136.0	136.0	0.0				
3-Oct-96	13	15.0	5.0	10.0	0.04	144.0	144.0	0.0	16	3.9	0.2	20.1
18-Oct-96	15	0.0	0.0	0.0	0.00	134.0	134.0	0.0				

LYSIMETER #2

Sample Date	Monitoring Period (days)	Precipitation + Irrigation (ml)	Precipitation (ml)	Irrigation (ml)	Irrigation (inches)	Lysimeter Weight (lbs) Before Draining	Lysimeter Weight (lbs) After Draining	Drain Water Weight (lbs)	Nitrate + Nitrite as N	TKN	Ammonia as N	Total N (mg/L)
11-Jul-96		1010.0	100.0	910.0	3.49	122.0	122.0	0.0				
25-Jul-96	14	370.0	25.0	345.0	1.32	122.0	122.0	0.0				
22-Aug-96	28	880.0	10.0	870.0	3.34	122.0	122.0	0.0				
5-Sep-96	14	690.0	5.0	685.0	2.63	122.0	122.0	0.0				
20-Sep-96	15	500.0	200.0	300.0	1.15	115.0	115.0	0.0				
3-Oct-96	13	20.0	5.0	15.0	0.06	122.0	122.0	0.0				
18-Oct-96	15	0.0	0.0	0.0	0.00	120.0	120.0	0.0				

LYSIMETER #3

Sample Date	Monitoring Period (days)	Precipitation + Irrigation (ml)	Precipitation (ml)	Irrigation (ml)	Irrigation (inches)	Lysimeter Weight (lbs) Before Draining	Lysimeter Weight (lbs) After Draining	Drain Water Weight (lbs)	Nitrate + Nitrite as N	TKN	Ammonia	Total N (mg/L)
11-Jul-96		1060.0	100.0	960.0	3.68	120.0	120.0	0.0				
25-Jul-96	14	610.0	25.0	585.0	2.24	122.0	122.0	0.0				
22-Aug-96	28	719.0	10.0	709.0	2.72	118.0	118.0	0.0				
5-Sep-96	14	75.0	5.0	70.0	0.27	114.0	114.0	0.0				
20-Sep-96	15	400.0	200.0	200.0	0.77	106.0	106.0	0.0				
3-Oct-96	13	0.0	5.0	-5.0	-0.02	113.0	113.0	0.0				
18-Oct-96	15	0.0	0.0	0.0	0.00	118.0	118.0	0.0				

LYSIMETER #4

Sample Date	Monitoring Period (days)	Precipitation + Irrigation (ml)	Precipitation (ml)	Irrigation (ml)	Irrigation (inches)	Lysimeter Weight (lbs) Before Draining	Lysimeter Weight (lbs) After Draining	Drain Water Weight (lbs)	Nitrate + Nitrite as N	TKN	Ammonia	Total N (mg/L)
11-Jul-96		1400.0	100.0	1300.0	4.99	176.0	153.0	23.0	1.6	0.5	0.09	2.19
25-Jul-96	14	390.0	25.0	365.0	1.40	152.0	146.0	6.0	ND	1.4	ND	1.4
22-Aug-96	28	737.0	10.0	727.0	2.79	150.0	150.0	0.0	13			13
5-Sep-96	14	550.0	5.0	545.0	2.09	154.0	148.0	6.0	4.1	ND	0.05	4.15
20-Sep-96	15	350.0	200.0	150.0	0.58	148.0	148.0	0.0				
3-Oct-96	13	0.0	5.0	-5.0	-0.02	140.0	140.0	0.0				
18-Oct-96	15	0.0	0.0	0.0	0.00	137.0	137.0	0.0				

LYSIMETER #5

Sample Date	Monitoring Period (days)	Precipitation + Irrigation (ml)	Precipitation (ml)	Irrigation (ml)	Irrigation (inches)	Lysimeter Weight (lbs) Before Draining	Lysimeter Weight (lbs) After Draining	Drain Water Weight (lbs)	Nitrate + Nitrite as N	TKN	Ammonia	Total N (mg/L)
11-Jul-96		800.0	100.0	700.0	2.69	133.0	133.0	0.0				
25-Jul-96	14	365.0	25.0	340.0	1.30	132.0	132.0	0.0				
22-Aug-96	28	590.0	10.0	580.0	2.23	130.0	130.0	0.0				
5-Sep-96	14	400.0	5.0	395.0	1.52	132.0	132.0	0.0				
20-Sep-96	15	420.0	200.0	220.0	0.84	136.0	136.0	0.0				
3-Oct-96	13	0.0	5.0	-5.0	-0.02	133.0	133.0	0.0				
18-Oct-96	15	425.0	0.0	425.0	1.63	132.0	132.0	0.0				

LYSIMETER #6

Sample Date	Monitoring Period (days)	Precipitation + Irrigation (ml)	Precipitation (ml)	Irrigation (ml)	Irrigation (inches)	Lysimeter Weight (lbs) Before Draining	Lysimeter Weight (lbs) After Draining	Drain Water Weight (lbs)	Nitrate + Nitrite as N	TKN	Ammonia	Total N (mg/L)
11-Jul-96		730.0	100.0	630.0	2.42	120.0	120.0	0.0				
25-Jul-96	14	405.0	25.0	380.0	1.46	118.0	118.0	0.0				
22-Aug-96	28	620.0	10.0	610.0	2.34	111.0	111.0	0.0				
5-Sep-96	14	250.0	5.0	245.0	0.94	112.0	112.0	0.0				
20-Sep-96	15	500.0	200.0	300.0	1.15	142.0	142.0	0.0				
3-Oct-96	13	0.0	5.0	-5.0	-0.02	112.0	112.0	0.0				
18-Oct-96	15	0.0	0.0	0.0	0.00	108.0	108.0	0.0				