LAKE BEULAH WATER BALANCE STUDY

LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN

RSV PROJECT #04-566
June 30, 2006

Prepared for:
Lake Beulah Management District

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LAKE BEULAH WATER BALANCE STUDY
LAKE BEULAH, WISCONSIN

TABLE OF CONTENTS

TABLES

FIGURES

1.0 PURPOSE AND FOCUS

The Lake Beulah Management District ("LBMD") authorized this water balance study in as an initial step in the development of an overall lake management plan. Essential to the development of a lake management plan is an understanding of the rate of flow into and out of a lake. The purpose of the Lake Beulah water balance study is to quantify, to the extent practicable, the sources contributing water to Lake Beulah, and the sinks removing water from the lake.

The focus of this study is to evaluate flow specifically into and out of Lake Beulah. Lake Beulah is an 846-acre water body located in northeastern Walworth County, Wisconsin. Although it is not an exceptionally large lake in area, it is quite long, with a distance from the southwest tip to the northeast end of nearly 3 miles. However, as Figure 1 shows, the Lake Beulah watershed encompasses several smaller watersheds, including Booth Lake, Swan Lake and Army Lake. It also includes several broad wetland areas, all of which have diffuse flow into the lake, which cannot be measured utilizing conventional methods of stream flow measurement.

2.0 SCOPE

The scope of work for this study included significant field studies, combined with groundwater modeling. Figure 2 shows locations of five sets of well nests, consisting of paired driven points, one intersecting the water table and the adjacent point driven to approximately 7 to 8 feet below the water table. During non-winter months, water levels were measured in these wells by volunteers from the LBMD. This work has been on-going since the summer of 2004.

Figure 2 also shows the location of the single surface water outlet from Lake Beulah, located on County Trunk Highway J ("Highway J dam"). Periodic measurements of streamflow immediately downstream from the dam were collected over the past 3 years. This work was completed by RSV Engineering, Inc. ("RSV").

Finally, the LBMD contributed funding toward the completion of a three-dimensional groundwater flow model. This model was part of a Masters Thesis by Hilary Gittings, at the University of Wisconsin-Madison Department of Geology & Geophysics. The funding contributed by the LBMD was for the purpose of collecting additional calibration data on Lake Beulah, as well as refinement of the vertical structure of the model to more accurately simulate the vertical migration of groundwater in the unconsolidated deposits.

While the collection of field data is on-going, the measurements collected over the past 3 years have been tabulated and combined with groundwater flow estimates from the model to complete an initial water balance estimate. Over time, the estimate will be refined with additional data.

3.0 FIELD MEASUREMENTS

3.1 Groundwater Elevations

Hand-measured groundwater levels were collected from nine of the ten drive points. The tenth point was equipped with a data logger, which recorded groundwater levels on 5-minute intervals. Groundwater elevations are summarized in Table 1. Figures 3 through 7 show groundwater hydrographs for sites 1 through 5, respectively. Daily precipitation values are also plotted on these figures. As the figures show, the shallow groundwater is somewhat responsive to precipitation. In response to the heavy spring and summer precipitation in 2004, water levels in all five locations were at their highest levels over the course of the monitoring. In 2005, with significantly less precipitation, water levels were much lower.

Figures 8 through 12 show the vertical groundwater flow gradients for the five sites. On these graphs, a negative number indicates an upward flow gradient (groundwater discharge). Wells at sites 1, 2 and 3 produced a mixture of upward and downward gradients, with most being upward. Site 4, which is located at the north end of the lake, yielded almost all downward gradients, or gradients close to 0. At the opposite end of the lake, the wells at site 5 yielded nearly all upward gradients. These data suggest that Lake Beulah is a flow-through water body, with groundwater discharging into the lake at the south end, and surface water recharging the aquifer at the north. The lake between the north and south ends is a transitional area, with some temporal variability in vertical flow.

3.2 Stream Flow

Stream flows have been measured periodically at the Highway J dam for the past 2 years. Flows were measured by establishing a transect across the stream, with depths and flow velocities measured at ten evenly-spaced locations along the transect. The endpoints of the transect were marked, and the same transect was used for each flow measurement taken. Because of the episodic nature of the measurements, an accurate correlation of flows with precipitation is not possible; however, some measurements indicate that precipitation has a strong influence on surface water outflow from the lake. Table 2 summarizes the flow rates that have been measured, and tabulates those data in terms of cubic feet per second (“CFS”) and gallons per minute (“GPM”). Although an average flow is listed, the table does not include very low flow periods, including winter and dry periods, when there are some periods of no flow.

Figures 13 and 14 are plots of stream flow and precipitation for 2004 and 2005, respectively. At most times, there is a clear correlation between precipitation and a subsequent increase in flow. An exception occurs in the spring (late April/early May) of 2004, where a significant rainfall event did not produce a significant increase in flow. Another anomaly is in late May/early June of 2005, when the lag between precipitation and increased flow seems to be longer than at other times.

Also note that the 2004 data extend from April until late July. At that time, dry conditions resulted in a period of no flow over the dam, followed by winter, when no measurements were taken. In 2005, more frequent late summer rainfall resulted in the ability to monitor flow conditions into mid-November. Although these data result in an accurate average of flow in the warm weather months, the data set is not complete enough to evaluate an annual average flow.

4.0 GROUNDWATER FLOW MODELING

The groundwater flow model constructed and calibrated by Hilary Gittings uses the USGS finite difference model "MODFLOW." The model is processed by the software "Groundwater Vistas," (Environmental Simulations, Inc.). The approximate model area is shown on Figure 15. The model contains 130 rows, 130 columns and 36 layers. The row and column spacings are 519 feet; layers are of varying thicknesses, based on the stratigraphic conditions. MODFLOW allows the simulation of various hydrogeologic features, including streams and lakes. Lake Beulah was simulated using the River Module, which is a common approach for surface water bodies.

The model was calibrated to observed normal hydrogeologic conditions, and verified using drought data from the summer of 2004. Calibration details can be found in Ms. Gittings' master's thesis documentation.

Figure 16 shows the simulated interaction of groundwater with the lake. Consistent with the vertical gradient measurements (see Figures 8 through 12), the model simulates strong groundwater discharge to the lake at the south end, and a small area of groundwater being recharged by the lake at the north end.

Based on the model mass balance calculations, an estimate of overall groundwater discharge and recharge beneath Lake Beulah is as follows:

Total groundwater discharge to lake:	202,765 cubic feet per day
Total lake water recharge of the aquifer:	5,265 cubic feet per day

5.0 MASS BALANCE

5.1 Calculations

The measurements and simulations discussed in Sections 3 and 4 can be used to estimate the water balance for Lake Beulah. Components of the total source of water to the lake include:

- Groundwater discharge
- Precipitation
- Surface water inflow

Components of water loss from the lake include:

- Evaporation
- Discharge to the groundwater system
- Surface water outflow

Site studies have provided an estimation of surface water outflow over the Highway J dam. This is the only outflow identified in our work. Groundwater elevations collected during the past 2 years were useful in verifying that the model was functioning properly in terms of areas of groundwater discharge and recharge. Precipitation data were obtained from the U.S. Weather Service office in Waukesha.

Evaporation and surface water inflow measurements are beyond the scope of work for this project, due to their complexities. Although the USGS topographic map of the lake shows a clear inlet at Stringer's Bridge, several attempts to measure flow at that location were unsuccessful. This location, like several others (e.g., the wetland areas between Lake Beulah and Swan Lake and between Lake Beulah and Army Lake) have very diffuse surface flow conditions. Although the surface water contribution at these locations is likely significant, it could not be measured.

Estimations of evaporation have many variables, as well as several different methods of calculation. However, a lake management plan was completed at nearby Pewaukee Lake in 2003. This document estimated a total annual rate of evaporation from Pewaukee Lake of 6,520 acre-feet. With a lake size of 2,493 acres, this results in an evaporation rate of approximately 2.62 acre-feet per acre per year. (An "acre-foot" is the amount of water contained in an area of 1 acre, to a depth of 1 foot, or 43,560 cubic feet of water.)

By using this value, along with the measured and simulated values for the other parameters, the lake balance can be estimated. Because the total flow into the lake must equal the total flow out, the surface water inflow component is simply calculated as the difference between the inflow and outflow values utilizing the available data. The overall water balance is summarized in Table 3. Graphical representations of the components are shown on Figures 17 and 18 for inflow and outflow, respectively.

5.2 Qualifications

Some degree of uncertainty is inherent in this effort. While computer provide perhaps the best means of quantifying surface water/groundwater interaction, models should always be considered as works-in-progress, in need of some re-calibration as new data are obtained.

Perhaps the largest uncertainty with the water balance calculations lies in the surface water outflow calculations. For the summary in Table 3, the average measured value in Table 2 was used. However, the measurements in that table represent periodic measurements during a time of the year when flow over the dam is likely at above-average rates. As a result, the overall inflow/outflow values may be lower than summarized in Table 3; however, the ratios of various components should remain somewhat constant.

6.0 FOLLOW UP WORK

Subsequent work should include several tasks. RSV recommends continued monitoring of flow over the Highway J dam. However, due to the relatively high cost of manual measurements, and the periodic nature of these measurements, RSV recommends that a stilling well be installed in the stream, with a pressure transducer and data logger to monitor depth of water. During the course of our studies, we found a correlation between flow rates and water depths at the two deepest measuring points along the transect. RSV recommends that a Chapter 30 permit be obtained and the stilling well and data logger be installed at one of these measuring points. Periodic manual measurements should still be collected to verify and refine the correlation between flow and water depth. Doing this will provide a more accurate understanding of flow rates as they relate to precipitation events, and will also provide important information during low-flow periods.

Finally, this understanding of the components of the water balance for the lake, planning should be undertaken to develop a lake management strategy. For example, the various components of sources and sinks of water should be considered in relation to the database of lake quality information that lake volunteers have developed over the past several years to better evaluate causes of deteriorating quality. This work should also be used to identify sensitive areas, where extra effort should be taken to ensure the protection of both the quality and quantity of water in Lake Beulah.

TABLE 1
LAKE BEULAH MANAGEMENT DISTRICT
LAKE WATER BALANCE STUDY

DATE	SITE	SITE 1		SITE 2		SITE 3		SITE 4		SITE 5	
	WELL	SHALLOW	DEEP	SHALLOW	DEEP	SHALLOW	DEEP	SHALLOW	DEEP	SHALLOW	DEEP
	ELEVATION	811.71	811.78	811.43	811.39	816.68	816.72	812.61	812.26	812.90	813.14
6/22/2004	DTW	1.47	1.91	1.04	0.93	7.23	7.25	1.84	3.11		2.02
	GWE	810.24	809.87	810.39	810.46	809.45	809.47	810.77	809.15	809.896	811.12
7/1/2004	DTW	1.71	1.77	1.12	1	7.3	5.5	2.91	5.13		1.72
	GWE	810	810.01	810.31	810.39	809.38	811.22	809.7	807.13	809.891	811.42
7/13/2004	DTW	0.9	1.65	1.01	1.02	7.34	7.35	6.5	6.68		2.53
	GWE	810.81	810.13	810.42	810.37	809.34	809.37	806.11	805.58	809.921	810.61
7/15/2004	DTW	1.73	1.67	1.11	1.09	7.47	6.65	1.83	2.42		2.51
	GWE	809.98	810.11	810.32	810.3	809.21	810.07	810.78	809.84	809.898	810.63
7/21/2004	DTW	1.8	1.71	1.25	1.15	7.42	7.45	1.97	5.15		2.62
	GWE	809.91	810.07	810.18	810.24	809.26	809.27	810.64	807.11	809.875	810.52
8/13/2004	DTW	1.78	1.8	1.32	1.1	7.55	7.5	1.77	1.35		2.66
	GWE	809.93	809.98	810.11	810.29	809.13	809.22	810.84	810.91	809.828	810.48
8/18/2004	DTW	1.82	1.84	1.32	1.29	5.52	6.54	2.8	4.25		2.7
	GWE	809.89	809.94	810.11	810.1	811.16	810.18	809.81	808.01	809.935	810.44
8/26/2004	DTW	1.82	1.92	1.4	1.34	7.65	7.61	1.38	2.27		2.74
	GWE	809.89	809.86	810.03	810.05	809.03	809.11	811.23	809.99	809.778	810.4
8/30/2004	DTW	1.17	1.86	1.37	1.25	7.55	7.56	7.26	6.94		2.65
	GWE	810.54	809.92	810.06	810.14	809.13	809.16	805.35	805.32	809.785	810.49
9/14/2004	DTW	1.89	1.43	1.46	1.39	7.65	7.68	1.8	5.3		2.8
	GWE	809.82	810.35	809.97	810	809.03	809.04	810.81	806.96	809.668	810.34
9/27/2004	DTW	2.05	1.75	1.57	1.51	7.66	7.65	7.7	6.88		2.88
	GWE	809.66	810.03	809.86	809.88	809.02	809.07	804.91	805.38	809.611	810.26
10/11/2004	DTW	1.94	2.13	1.57	1.5	7.72	7.76	7.95	7.52		2.88
	GWE	809.77	809.65	809.86	809.89	808.96	808.96	804.66	804.74		810.26
10/25/2004	DTW	2	2.24	1.5	1.44	7.68	7.7	7.46	7.88		2.84
	GWE	809.71	809.54	809.93	809.95	809	809.02	805.15	804.38		810.3
11/3/2004	DTW	2.03	2.2	1.5	1.35	7.65	7.67	7.83	7.42		2.85
	GWE	809.68	809.58	809.93	810.04	809.03	809.05	804.78	804.84		810.29
11/22/2004	DTW	2.03	2.24	1.5	1.43	7.68	7.7	7.9	7.49		2.88
	GWE	809.68	809.54	809.93	809.96	809	809.02	804.71	804.77		810.26
5/5/2005	DTW	2.06	2.13	1.41	1.35	7.62	7.65	6.91	7.23		2.75
	GWE	809.65	809.65	810.02	810.04	809.06	809.07	805.7	805.03		810.39

ELEVATION: Well top elevation (feet, MSL).
DTW: Depth from top of well to water (feet).
GWE: Groundwater elevation (feet, MSL).

TABLE 1
LAKE BEULAH MANAGEMENT DISTRICT
LAKE WATER BALANCE STUDY

5/10/2005	DTW	2.1	2.19	1.4	1.36	7.62	7.65	7.3	7.43		2.99
	GWE	809.61	809.59	810.03	810.03	809.06	809.07	805.31	804.83		810.15
6/12/2005	DTW	2.25	2.25	1.6	1.5	7.75	7.79	7.7	7.3		2.97
	GWE	809.46	809.53	809.83	809.89	808.93	808.93	804.91	804.96		810.17
7/27/2005	DTW	2.42	2.47	1.67	1.57	7.81	7.85	7.96	7.52		3.22
	GWE	809.29	809.31	809.76	809.82	808.87	808.87	804.65	804.74	809.837	809.92
8/2/2005	DTW	2.45	2.52	1.75	1.68	7.89	7.92	8.19	7.73		3.33
	GWE	809.26	809.26	809.68	809.71	808.79	808.8	804.42	804.53	809.724	809.81
8/5/2005	DTW	2.42	2.43	1.76	1.62	7.87	7.87	8.18	7.68		3.32
	GWE	809.29	809.35	809.67	809.77	808.81	808.85	804.43	804.58	809.698	809.82
8/31/2005	DTW	2.52	2.58	1.8	1.72	7.94	7.97	7.92			3.38
	GWE	809.19	809.2	809.63	809.67	808.74	808.75	804.69	812.26	809.757	809.76
9/2/2005	DTW	2.45	2.49	1.79	1.73	7.96	7.92		7.81		3.39
	GWE	809.26	809.29	809.64	809.66	808.72	808.8		804.45	809.72	809.75
9/6/2005	DTW	2.55	2.63	1.8	1.75	8	8				3.4
	GWE	809.16	809.15	809.63	809.64	808.68	808.72			809.681	809.74
9/30/2005	DTW	2.53	2.6	1.66	1.58	7.8	7.83	7.79			3.29
	GWE	809.18	809.18	809.77	809.81	808.88	808.89	804.82		809.847	809.85
10/9/2005	DTW	2.51	2.57	1.73	1.66	7.89	7.92	8.15			3.38
	GWE	809.2	809.21	809.7	809.73	808.79	808.8	804.46		809.757	809.76
10/14/2005	DTW	2.54	2.6	1.77	1.69	7.91	7.95	8.27	7.85		3.4
	GWE	809.17	809.18	809.66	809.7	808.77	808.77	804.34	804.41	809.732	809.74
10/20/2005	DTW	2.55	2.62	1.79	1.71	7.94	7.96	8.31	7.65		3.41
	GWE	809.16	809.16	809.64	809.68	808.74	808.76	804.3	804.61	809.716	809.73
11/4/2005	DTW	2.57	2.6	1.8	1.73	7.94	7.97				3.41
	GWE	809.14	809.18	809.63	809.66	808.74	808.75			809.712	809.73
11/10/2005	DTW	2.55	2.6	1.73	1.65	7.86	7.89		7.73		3.35
	GWE	809.16	809.18	809.7	809.74	808.82	808.83		804.53	809.767	809.79

ELEVATION: Well top elevation (feet, MSL).
DTW: Depth from top of well to water (feet).
GWE: Groundwater elevation (feet, MSL).

TABLE 2
LAKE BEULAH MANAGEMENT DISTRCT
LAKE BEULAH, WISCONSIN
LAKE OUTFALL FLOW RATES

DATE	FLOW	
	CFS	GPM
4/12/2004	6.40	2,871.4
4/19/2004	6.62	2,969.3
4/26/2004	9.75	4,374.5
5/3/2004	7.77	3,489.1
5/10/2004	15.00	6,730.7
5/17/2004	17.59	7,893.0
5/25/2004	37.87	16,997.9
6/2/2004	22.00	9,874.6
6/14/2004	18.71	8,395.9
7/13/2004	16.04	7,199.9
7/23/2004	7.93	3,559.9
6/3/05	6.96	3,123.3
6/6/05	8.53	3,826.2
6/7/05	8.14	3,652.0
6/8/05	7.49	3,362.8
6/9/05	6.43	2,887.6
6/10/05	5.64	2,530.0
6/14/05	8.25	3,700.9
6/17/05	3.65	1,638.3
6/21/05	3.01	1,350.2
6/24/05	2.08	931.3
7/8/05	2.08	935.2
7/12/05	1.94	869.8
7/15/05	3.67	1,645.9
7/18/05	2.19	982.4
7/22/05	7.87	3,531.7
7/27/05	9.45	4,241.5
7/29/05	6.88	3,089.7
8/2/05	5.92	2,657.0
8/4/05	3.54	1,588.9
8/5/05	2.60	1,166.7
8/9/05	2.04	914.8
8/18/05	3.02	1,357.2
8/30/05	3.70	1,660.6
9/2/05	2.49	1,116.6
9/7/05	1.46	655.7
9/12/05	2.11	948.3
9/20/05	3.85	1,729.7
10/3/05	16.78	7,530.9
10/10/05	2.85	1,280.4
10/17/05	3.57	1,602.7
10/24/05	2.86	1,283.1
11/1/05	4.69	2,105.8
11/7/05	22.08	9,910.0
11/18/05	9.75	4,374.9
MAX	37.87	16,997.9
MIN	1.46	655.7
AVERAGE	7.85	3,523.1

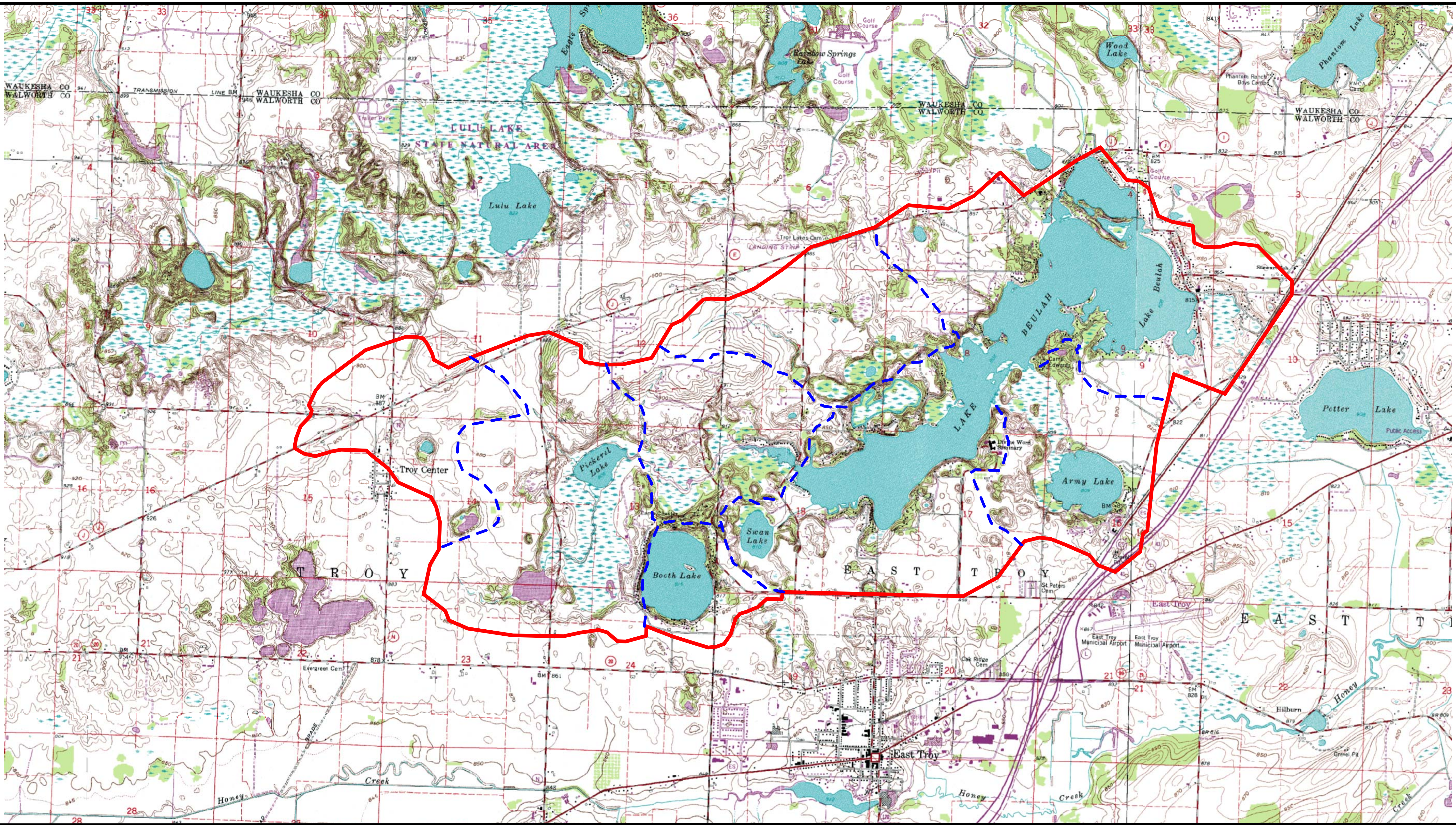
CFS: Cubic feet per second.
GPM: Gallons per minute.

TABLE 3
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
WATER BALANCE SUMMARY

COMPONENT	ACRE-FT/YEAR	
	INFLOW	OUTFLOW
Evaporation[1]		2208
Precipitation[2]	2295	
Surface flow	3941	5683
Groundwater	1699	44
Totals	7935	7935

[1]Evaporation: 2.61 acre/ft/acre/year x 846 acres

[2]Precipitation: (32.55/12 ft/year) x 846 acres



BASE MAP: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLES, MUKWONAGO AND EAST TROY, WISCONSIN, 1992.

WATERSHED DELINEATION: EARTH TECH, 1999.

SCALE IN FEET

0 1500 3000 4500 6000

LAKE BEULAH WATERSHED

SUBBASIN BOUNDARY

WISCONSIN

QUADRANGLE LOCATION

NORTH

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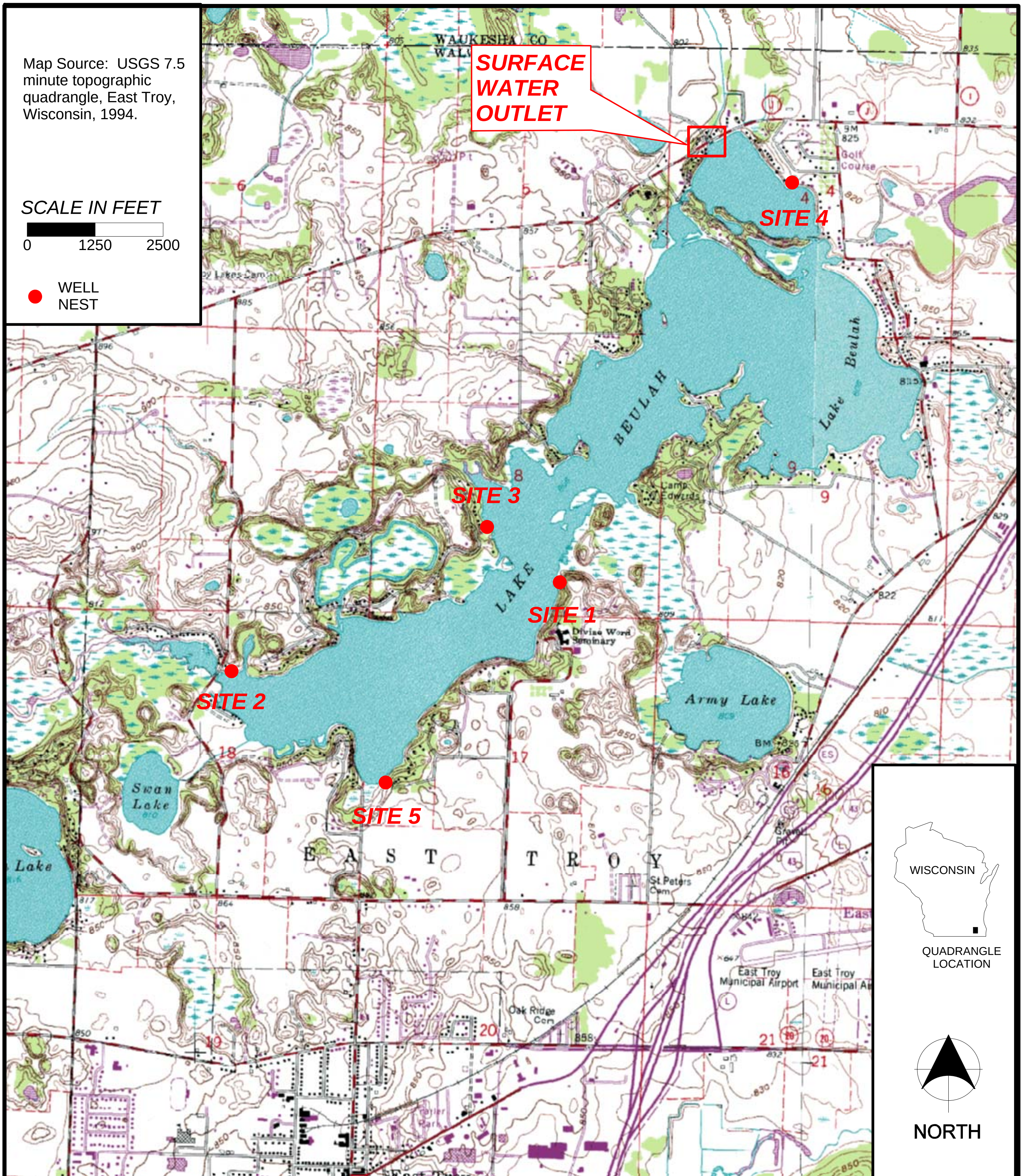
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
LAKE BEULAH WATERSHED

FIGURE 1

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	22 JUN 06	WATERSHED MAP



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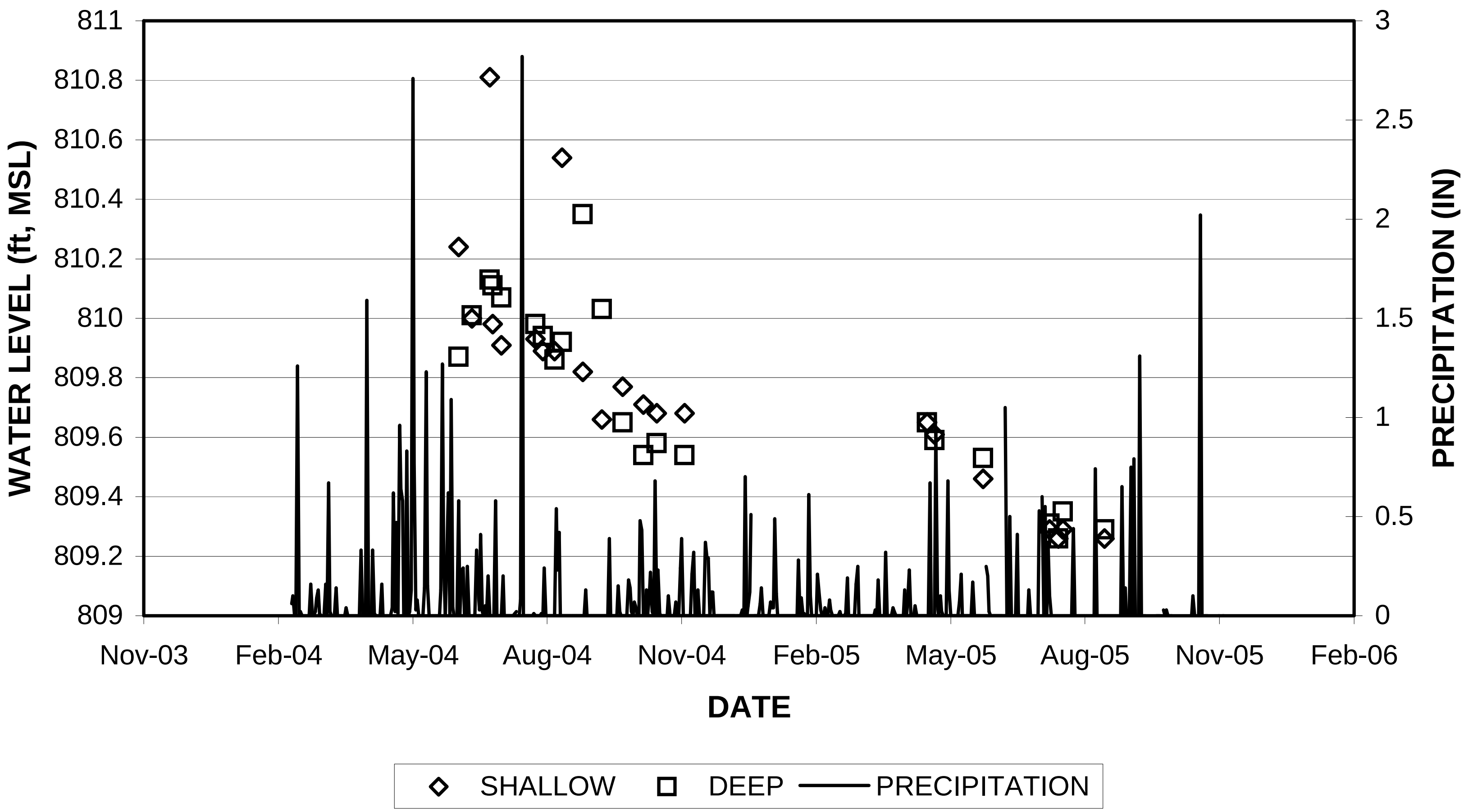
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
GROUNDWATER MONITORING LOCATIONS

FIGURE 2

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	02-368	09 JUN 06	GW MON



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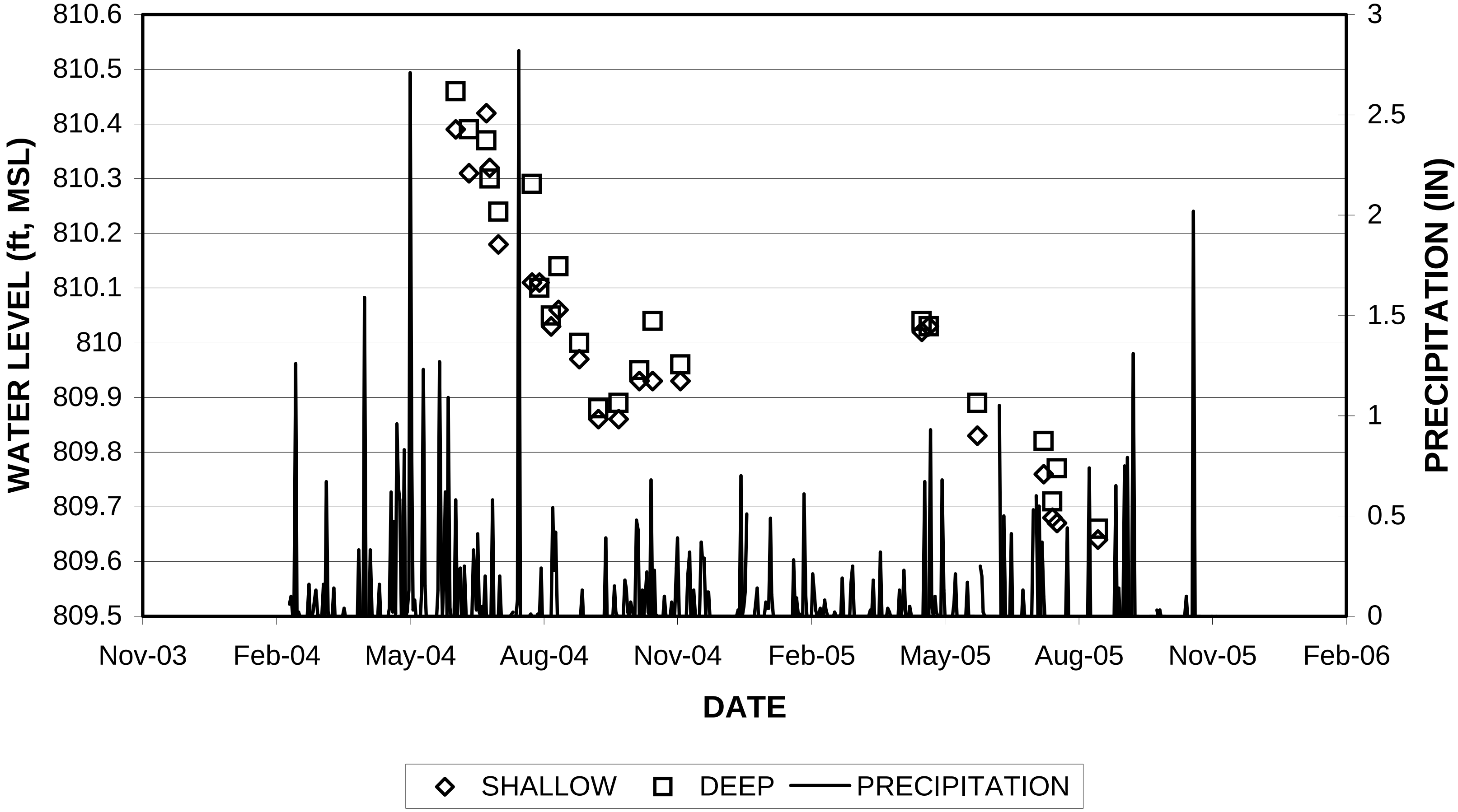
LAKE BEULAH MANAGEMENT DISTRICT LAKE BEULAH, WISCONSIN WATER LEVELS & PRECIPITATION SITE 1			FIGURE 3
DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	30 JUN 06	SITE 1 PPT



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LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
WATER LEVELS & PRECIPITATION
SITE 2

FIGURE 4

DRAWN BY	PROJ. No.	DATE	FILE NAME
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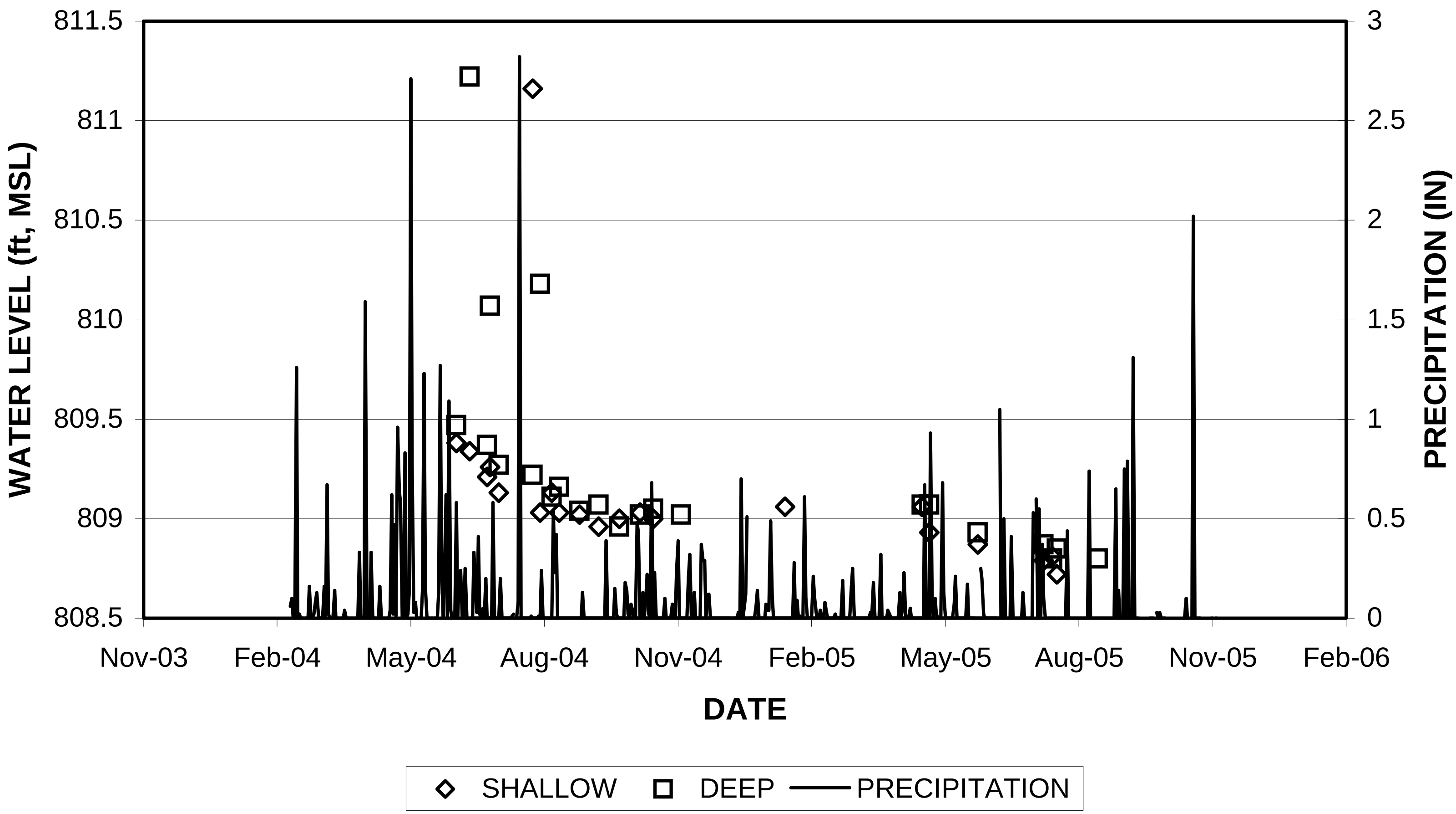

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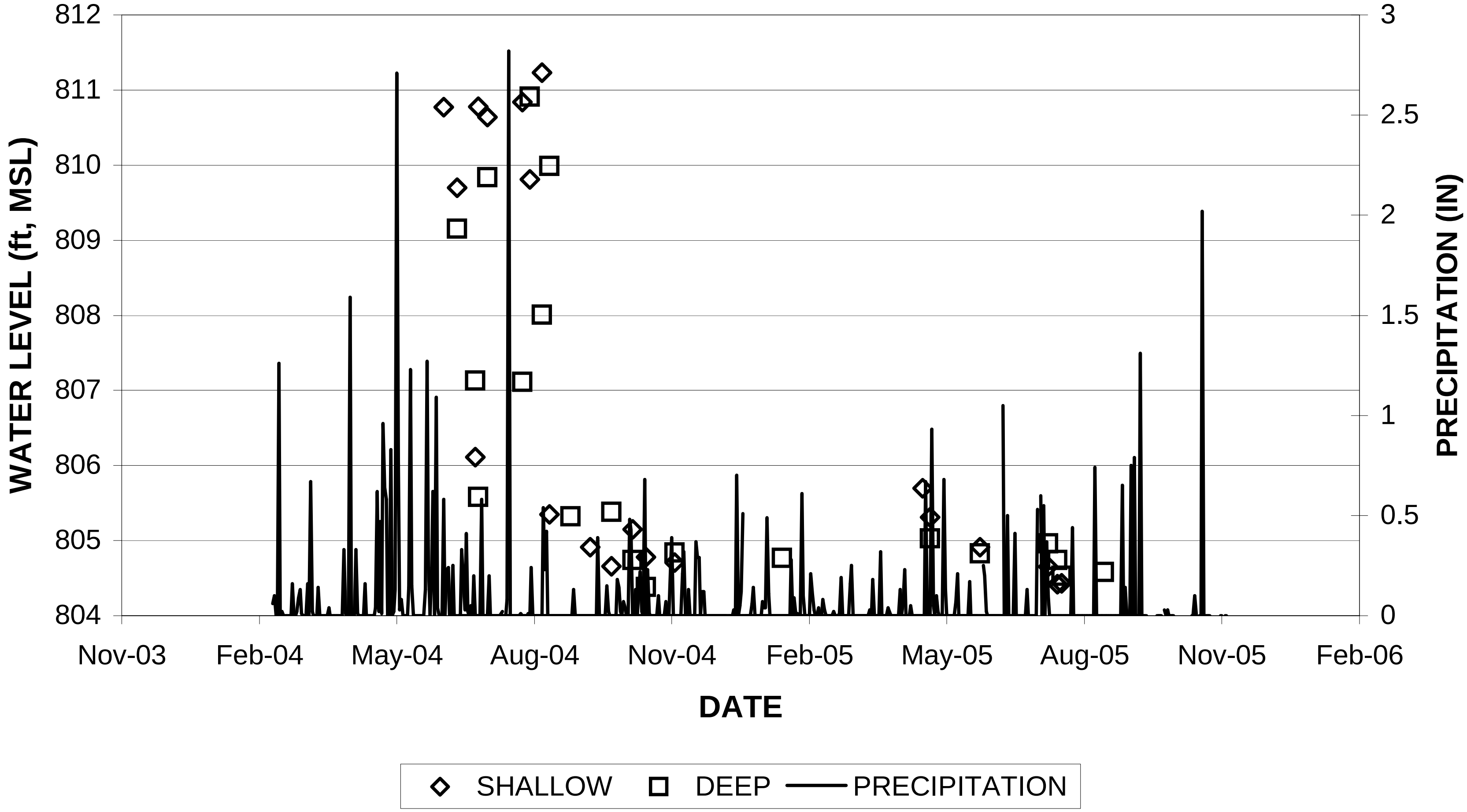
LAKE BEULAH MANAGEMENT DISTRICT LAKE BEULAH, WISCONSIN WATER LEVELS & PRECIPITATION SITE 3			FIGURE 5
DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	SITE 3 PPT



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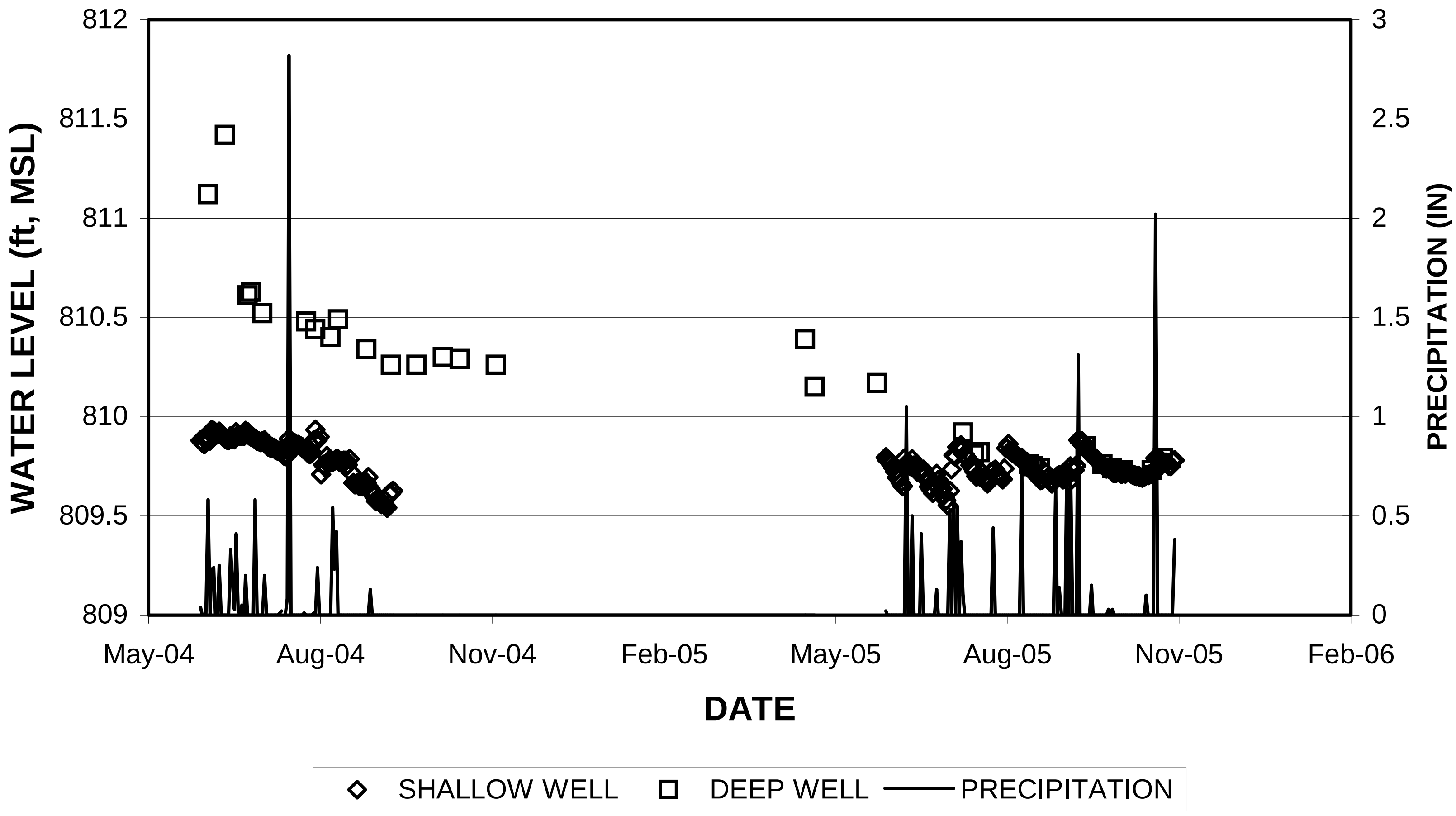
LAKE BEULAH MANAGEMENT DISTRICT LAKE BEULAH, WISCONSIN WATER LEVELS & PRECIPITATION SITE 4			FIGURE 6
DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	SITE 4 PPT



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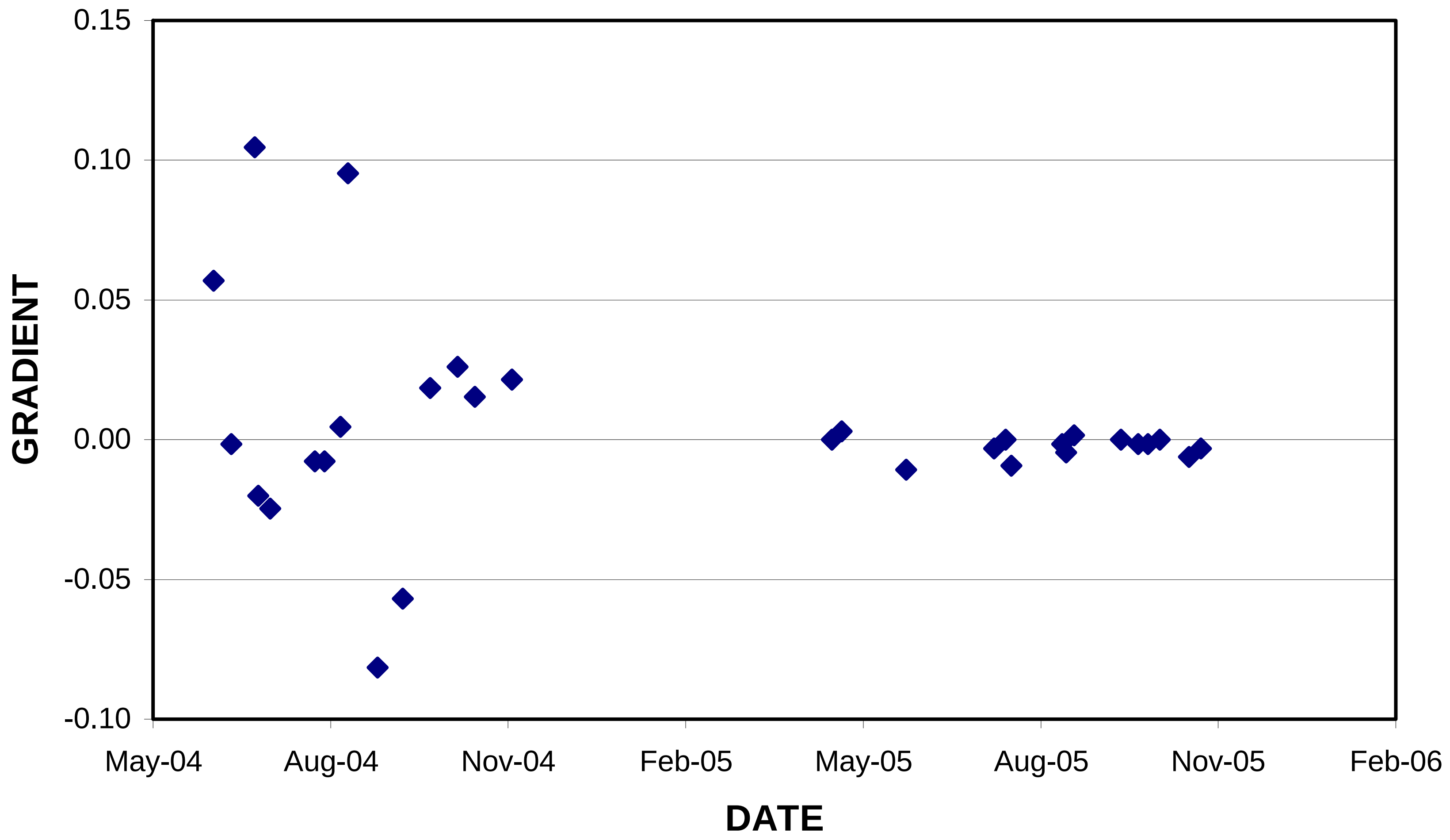
LAKE BEULAH MANAGEMENT DISTRICT LAKE BEULAH, WISCONSIN WATER LEVELS & PRECIPITATION SITE 4			FIGURE 7
DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	SITE 4 PPT



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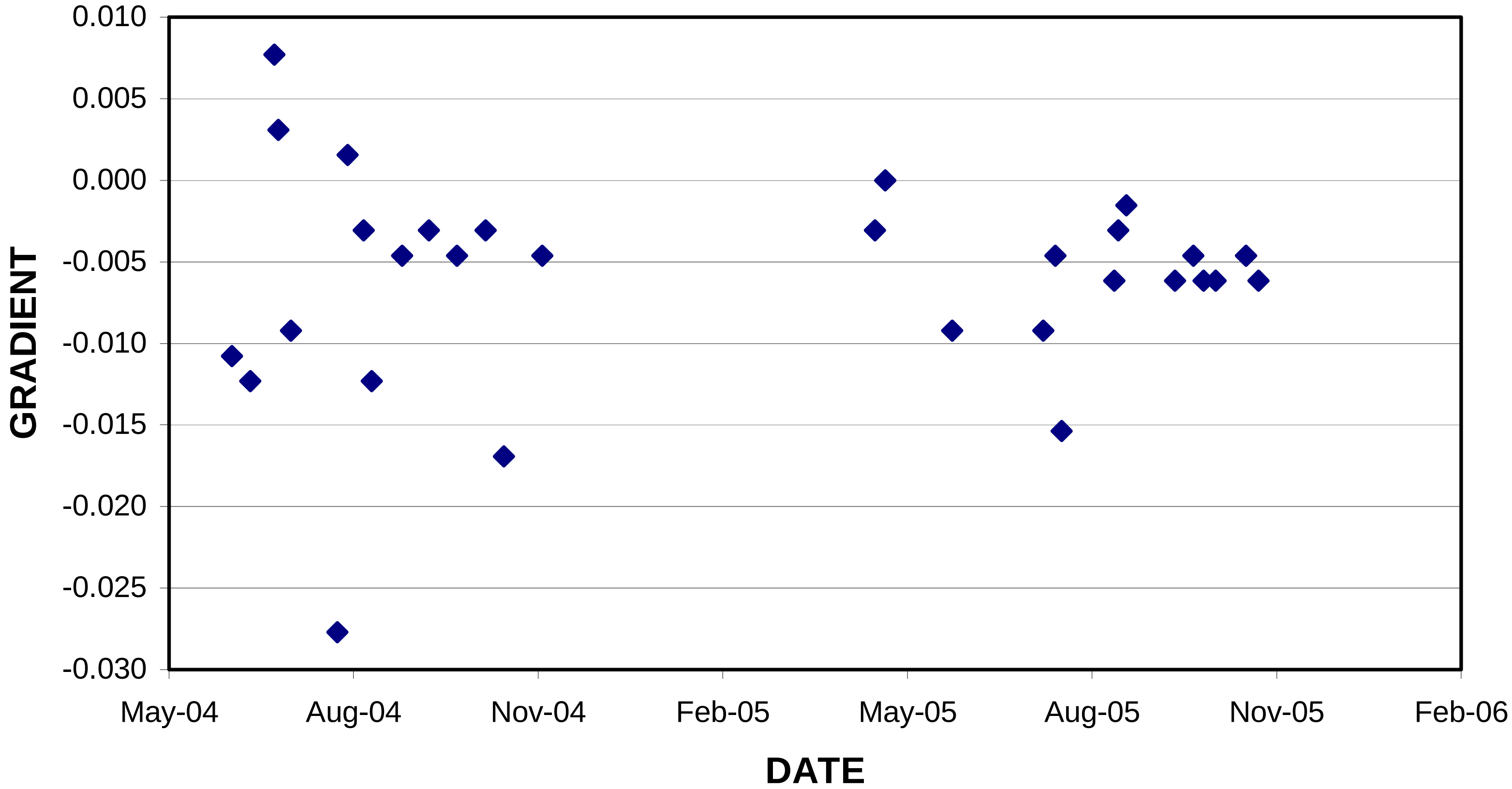
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
VERTICAL GROUNDWATER GRADIENTS
SITE 1

FIGURE 8

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	SITE 1 GRAD



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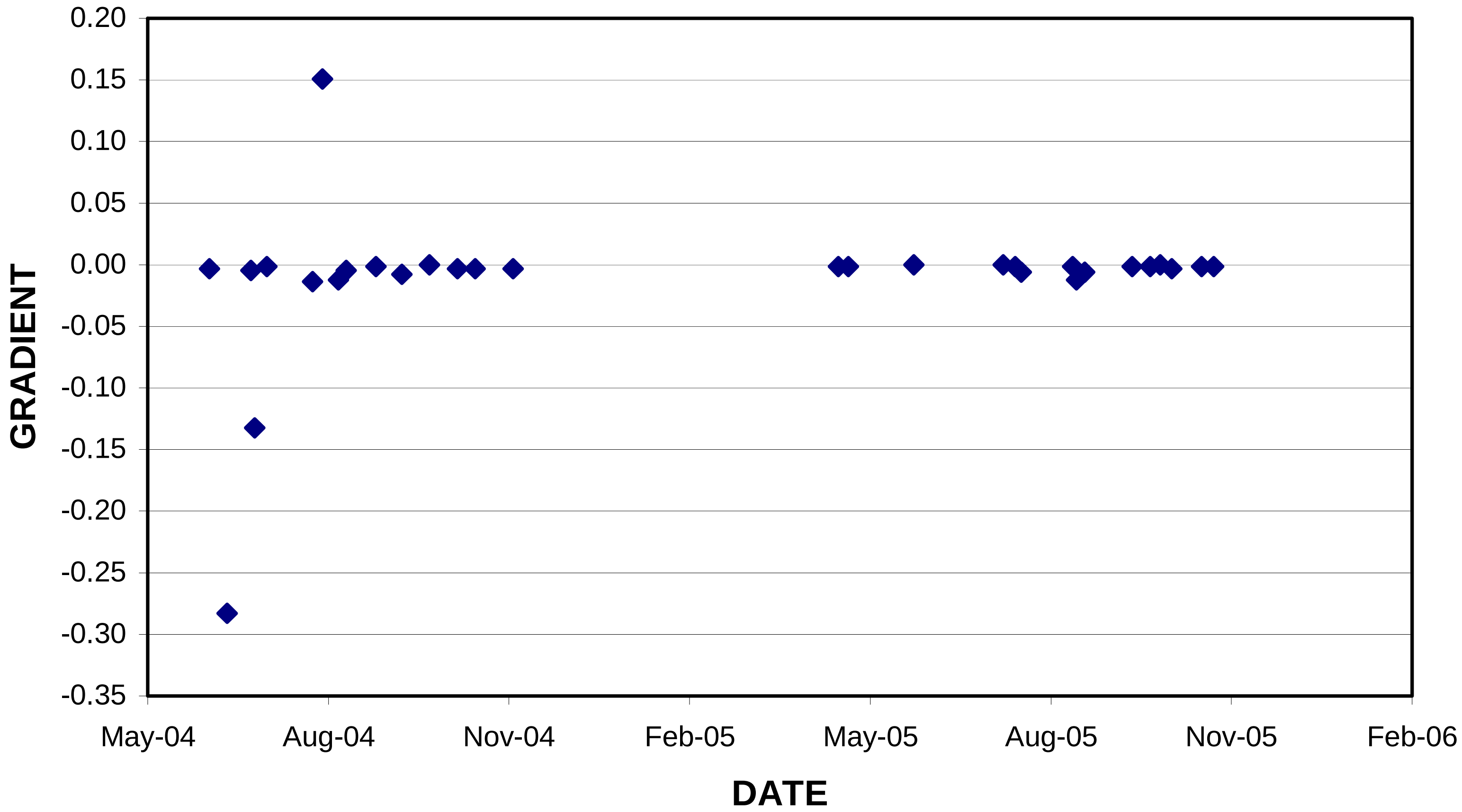
LAKE BEULAH, WISCONSIN
VERTICAL GROUNDWATER GRADIENTS
SITE 2

FIGURE 9

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	SITE 2 GRAD



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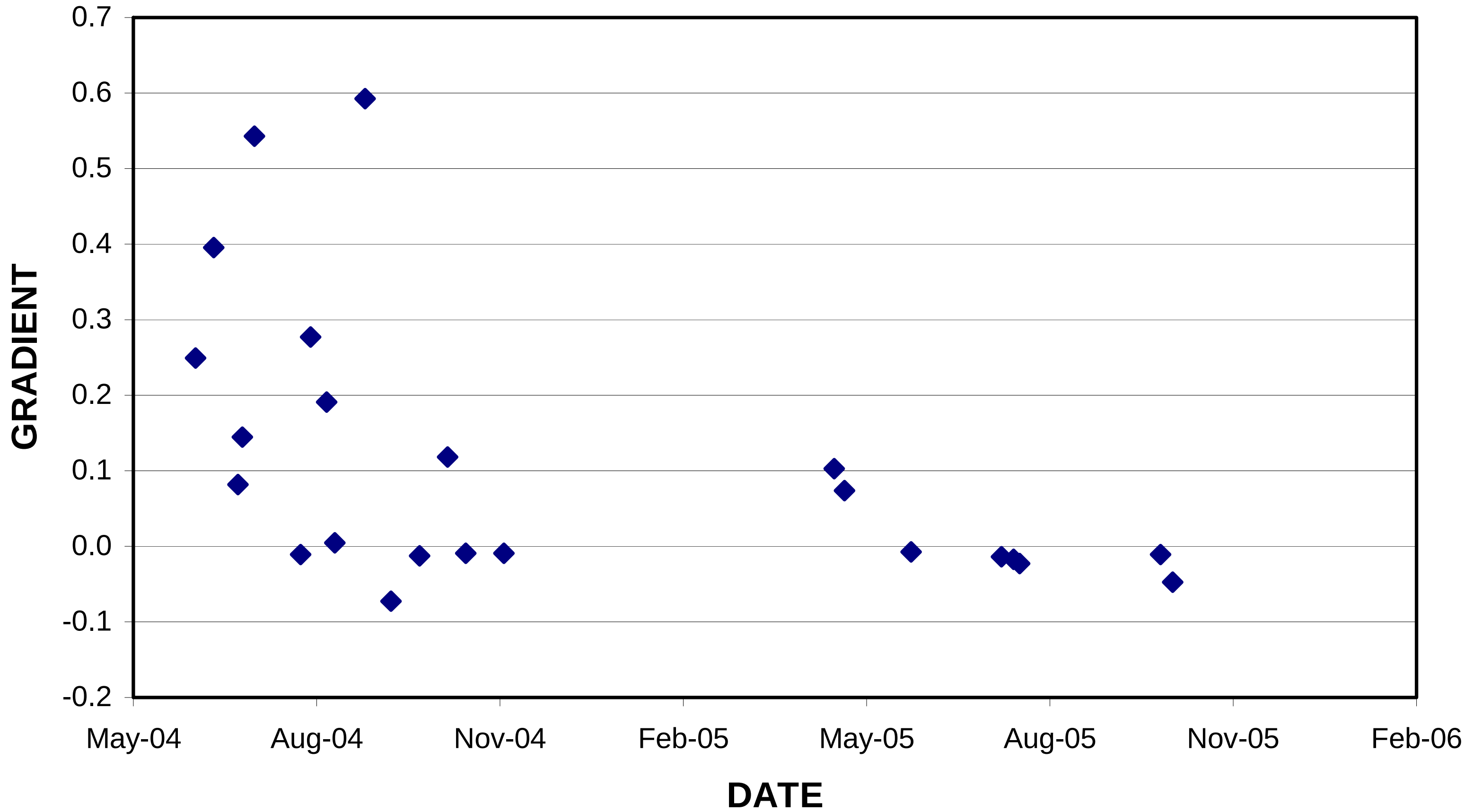
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
VERTICAL GROUNDWATER GRADIENTS
SITE 3

FIGURE 10

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	SITE 3 GRAD



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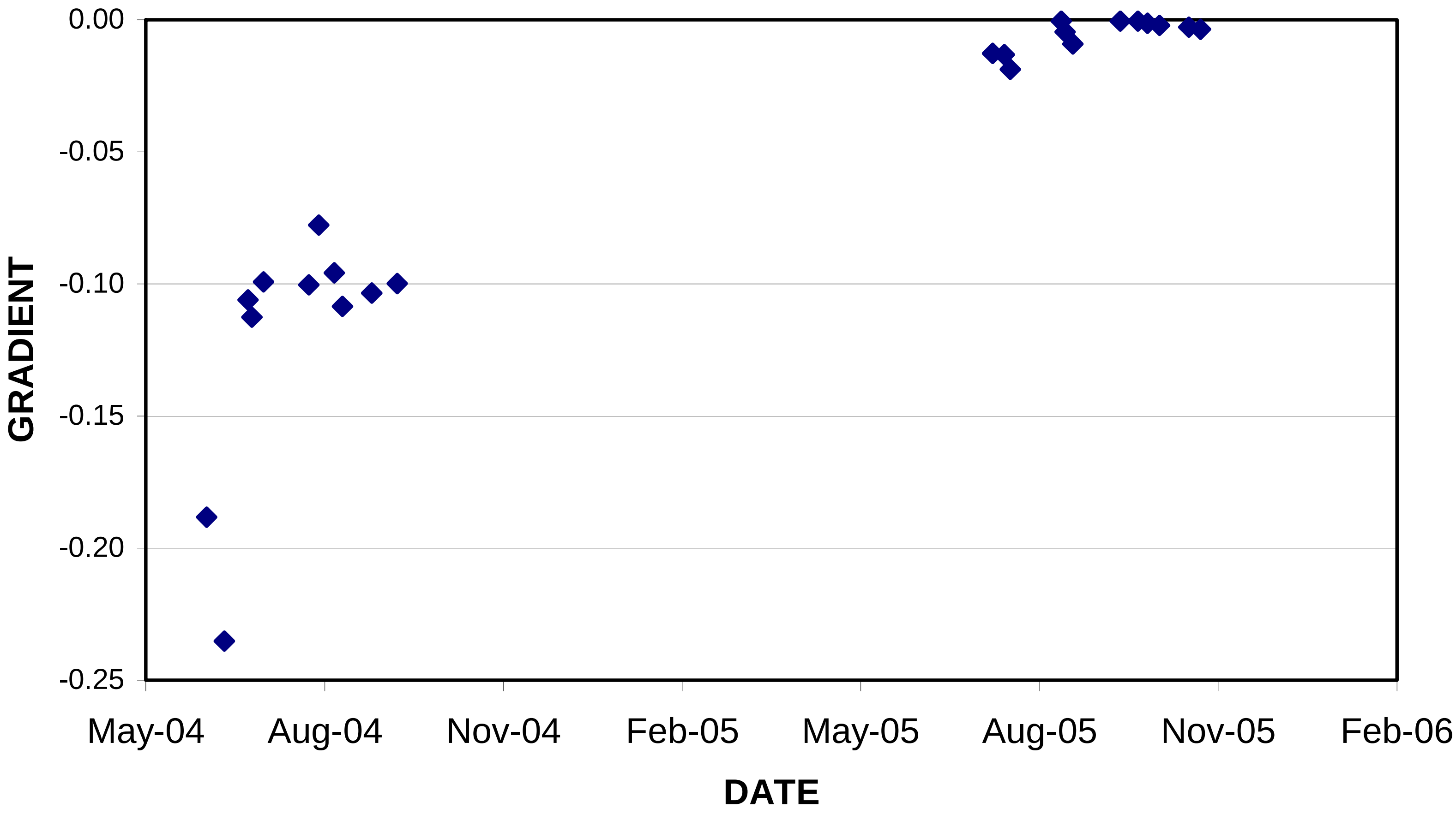
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
VERTICAL GROUNDWATER GRADIENTS
SITE 4

FIGURE 11

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	SITE 4 GRAD



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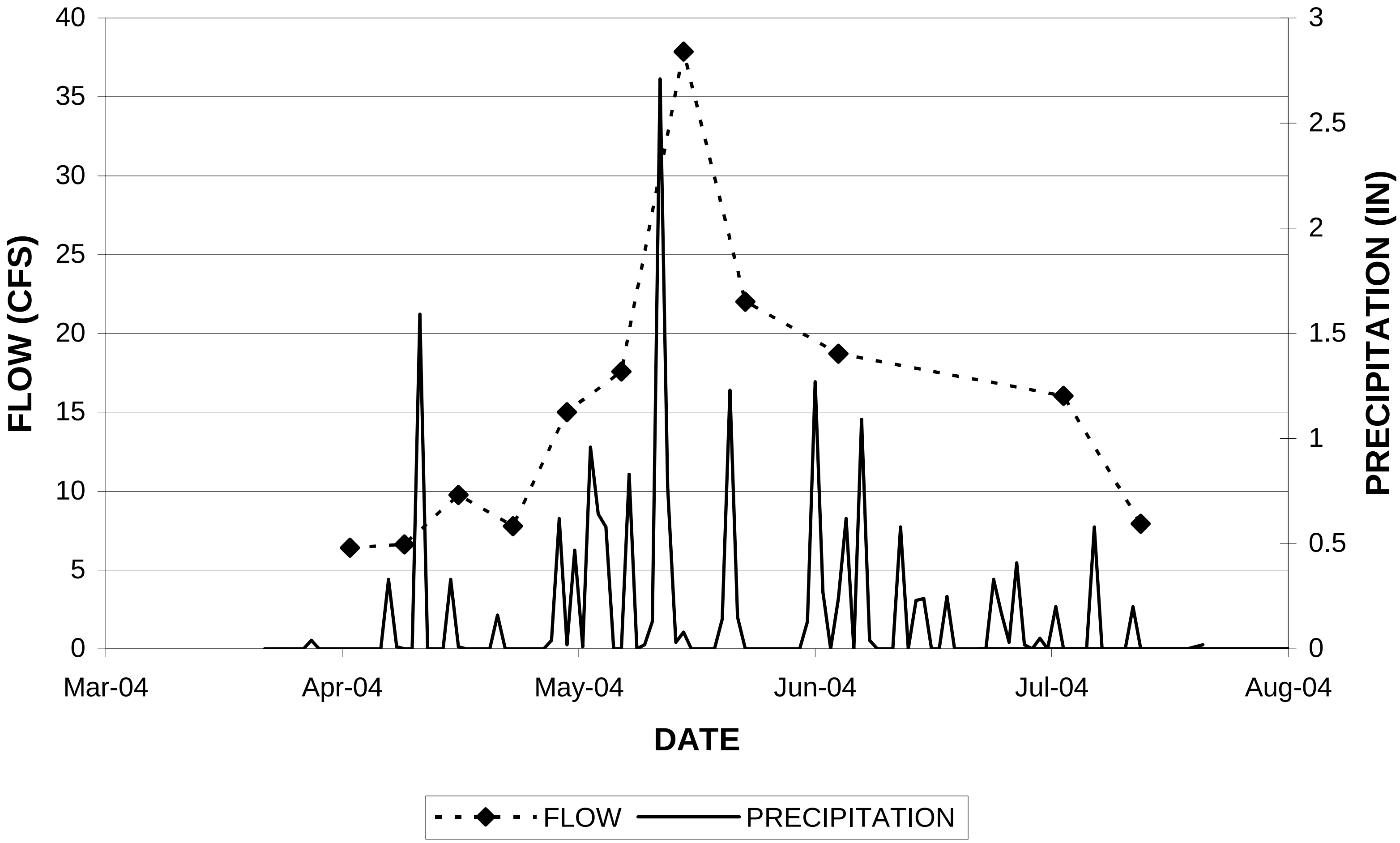
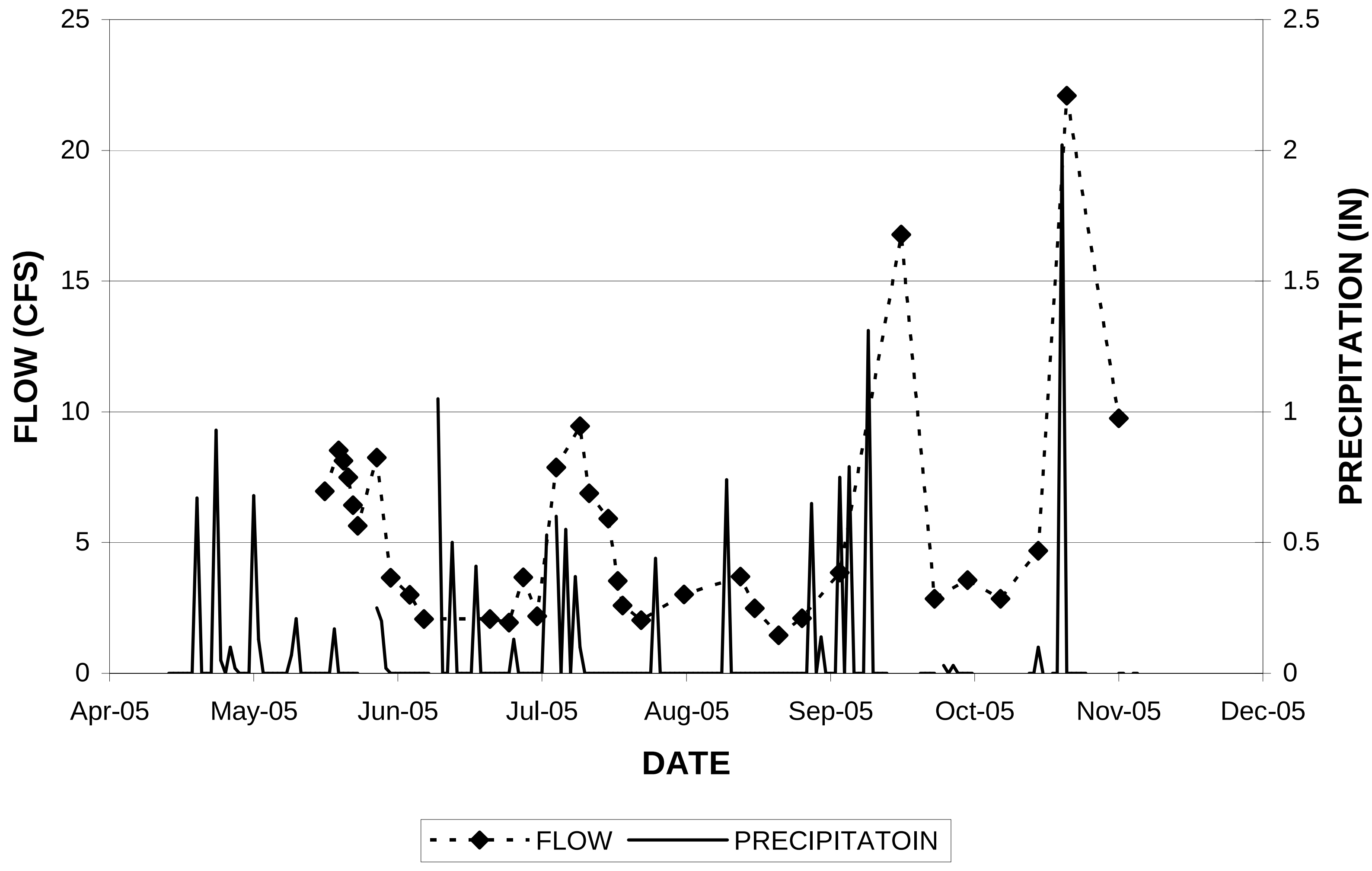
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
VERTICAL GROUNDWATER GRADIENTS
SITE 5

FIGURE 12

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	SITE 5 GRAD



RSV ENGINEERING, INC. Engineers • Land Surveyors • Environmental Scientists 112 S. MAIN STREET JEFFERSON, WISCONSIN 53549 (920)674-3411	LAKE BEULAH MANAGEMENT DISTRICT LAKE BEULAH, WISCONSIN OUTFLOW vs. PRECIPITATION 2004		FIGURE 13
DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	S FLOW 04



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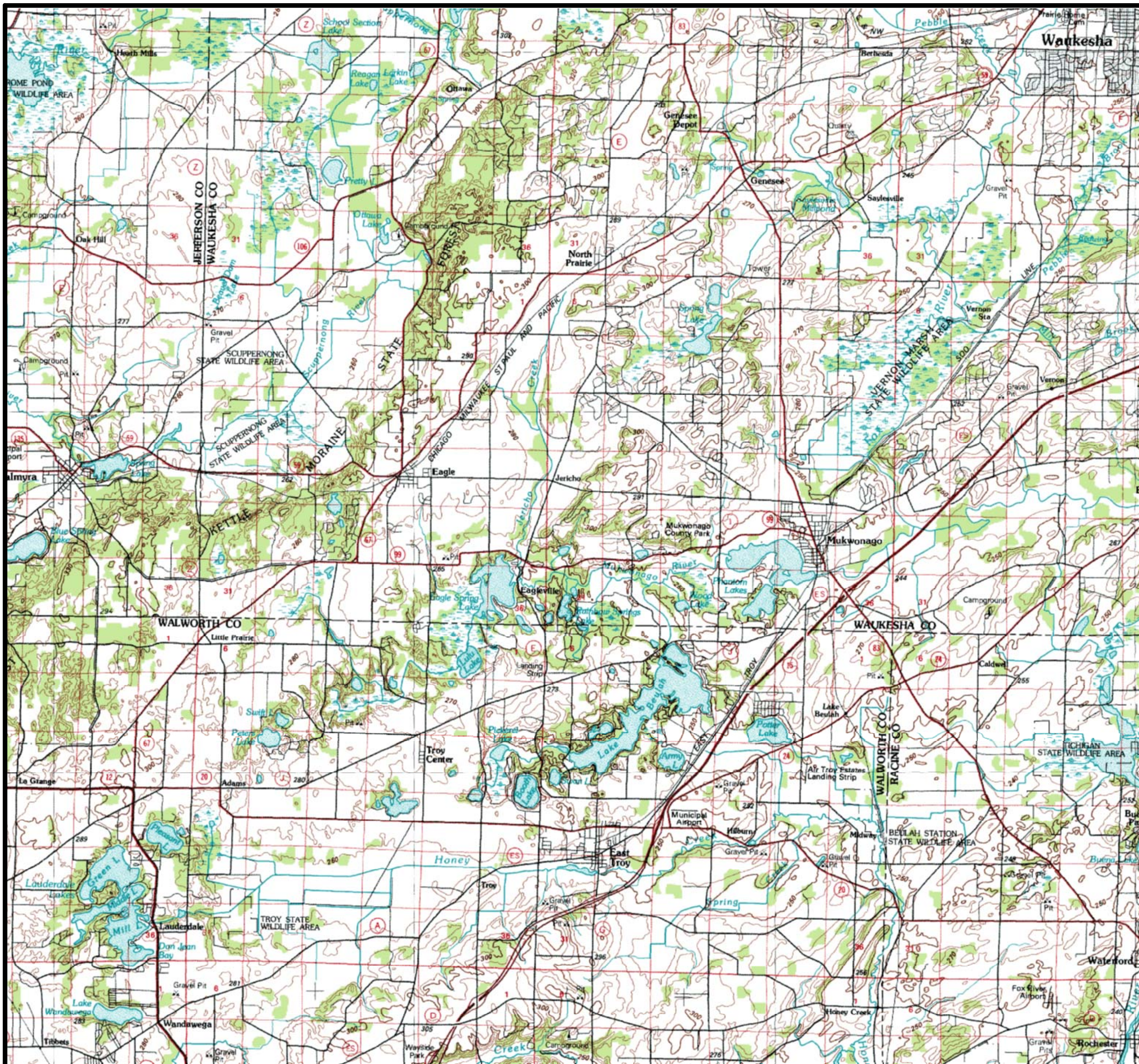
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
OUTFLOW vs. PRECIPITATION
2005

FIGURE 14

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	S FLOW 05



MILES

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NORTH

RSV ENGINEERING, INC.	LAKE BEULAH MANAGEMENT DISTRICT LAKE BEULAH, WISCONSIN APPROXIMATE AREA OF MODEL COVERAGE		FIGURE 15

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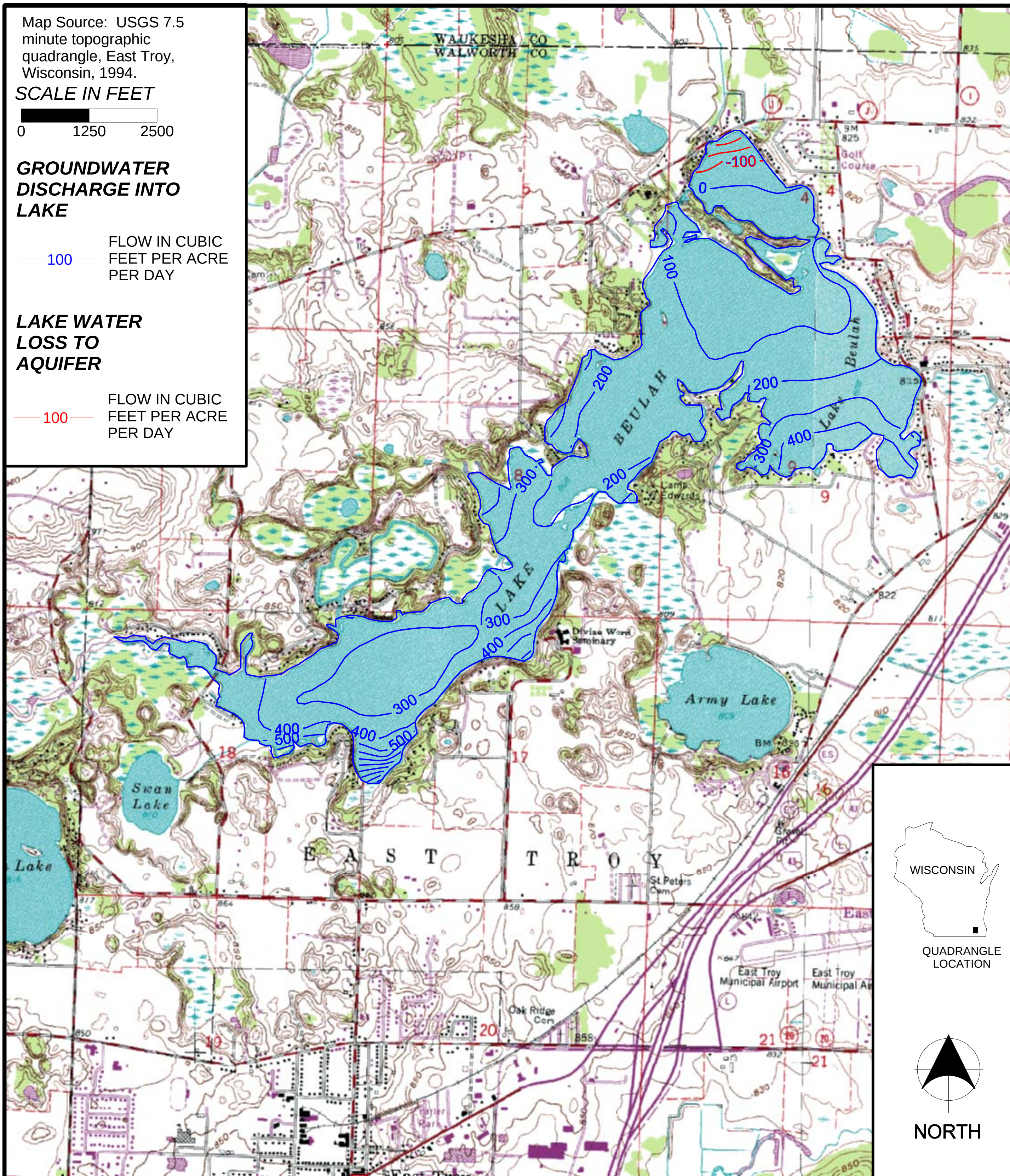
DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	02-368	09 JUN 06	MODEL AREA



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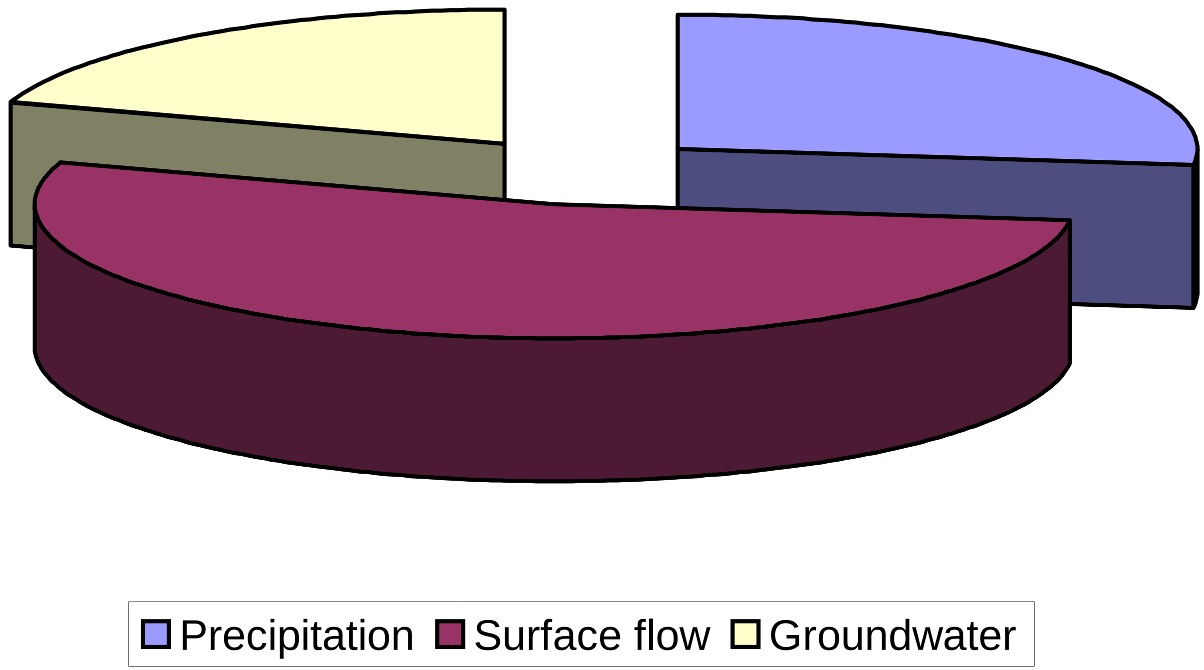
LAKE BEULAH MANAGEMENT DISTRICT LAKE BEULAH, WISCONSIN GROUNDWATER INTERACTION WITH LAKE			FIGURE 16
DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	02-368	09 JUN 06	BASE MAP



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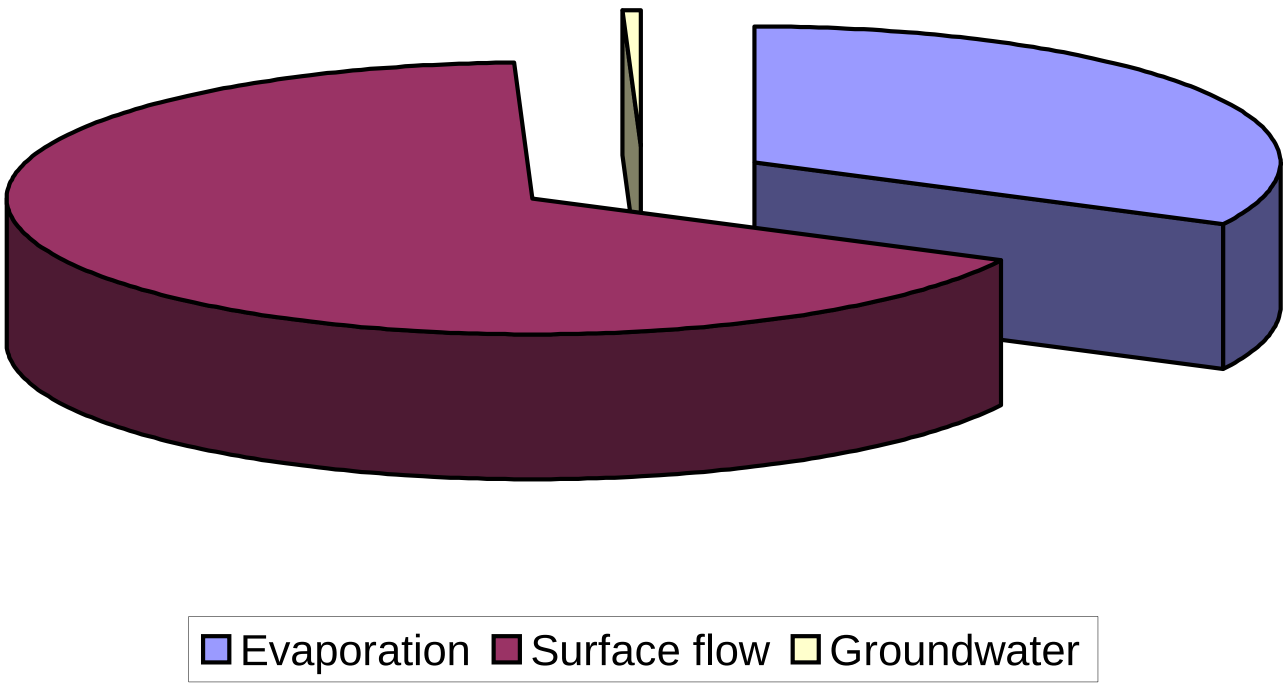
LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
WATER GAIN

FIGURE 17

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	WATER GAIN



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LAKE BEULAH MANAGEMENT DISTRICT
LAKE BEULAH, WISCONSIN
WATER LOSS

FIGURE 18

DRAWN BY	PROJ. No.	DATE	FILE NAME
RN	04-566	15 JUN 06	WATER LOSS