# Twin Lake Hydrologic Study

November 1993

Ramsey-Washington Metro Watershed District

# *TWIN LAKE*
# *HYDROLOGIC STUDY*

A Report of the
Ramsey-Washington Metro Watershed District

Prepared by
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CERTIFICATION

I Hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Dennis E. Palmer
Date: November 3, 1993 Reg. No. 9632

# EXECUTIVE SUMMARY

Twin Lake was studied to formulate management guidelines to reduce flood potential and protect water quality for the lake. The effect of possible flows from Vadnais Lake was also evaluated. Although water quality and water level data is scarce for Twin Lake, several conclusions resulted from this study.

Water quality in Twin Lake is above average for the Twin Cities area, and the lake should remain isolated to preserve its trophic status. Overflow from Vadnais Lake into Twin Lake is normally prevented by the Saint Paul Water Utility's management of water levels in Vadnais Lake. If this situation should change, the water quality of Twin Lake would likely suffer. Likewise, any outlet to the County Ditch 16 system should protect against backflow to Twin Lake.

A 1975 report suggested that 63 cfs flood flow may need to be directed from Vadnais Lake through Twin Lake; present I-694 culverts downstream of Twin Lake could not accommodate a flow greater than about 14 cfs. If an outflow of 63 cfs from Vadnais Lake is necessary, the flow should be diverted around Twin Lake. This would protect Twin Lake's water quality, and would also reduce the potential for flooding. A route for such flow is suggested, through wetlands west of Twin Lake, under Interstate 694, and into the County Ditch 16 system. Further study of this route is necessary.

Based on apparent low house floor elevations, a reasonable flood elevation for Twin Lake is 875 feet.

Assuming that outflow from Vadnais Lake does <u>not</u> flow through Twin Lake, Twin Lake should rarely, if ever, reach this flood stage. Historic levels for Twin Lake range from Elevation 866.6 to 869. Hydrologic modeling of the watershed estimates the flood level to be 875.1 feet after the critical runoff event (the 100-year, 30-day snowmelt), even assuming a maximum allowable beginning water level of 870.7 feet. Without any improvements, lake levels should be monitored and kept at or below Elevation 870.5. If a 36-inch culvert with a flap gate at Elevation 872.3 is installed upstream of I-694, the maximum allowable beginning water level could be as high as Elevation 873.9. The one-way flap gate would serve the purpose of protecting the water quality of Twin Lake from the freeway runoff.

The proposed culvert through the dike at I-694 should be planned, but actual construction could be deferred until Twin Lake rose to its action level of 870.5. At that time, pumping or culvert construction could be selected as a management technique.

# 1.0 INTRODUCTION

This report summarizes the findings of a hydrologic study of Twin Lake. The study sought to establish the maximum allowable normal-water level for the lake, to investigate flooding potential, and to identify strategies that would diminish the likelihood of flooding and degradation of Twin Lake's water quality.

The work described in this report was begun in April, 1993. The Ramsey-Washington Metro Watershed District (RWMWD) commissioned the study as a part of continuing evaluations of sub-watersheds within the District. Barr Engineering Co. (Barr) conducted the study and prepared this report.

# 2.0 BACKGROUND

## 2.1 Location

Twin Lake is located in Ramsey County, in the Saint Paul suburb of Little Canada (USGS White Bear Lake West, Minnesota Quadrangle; Range 22, Township 30, Sections 31 and 32). The lake is situated just north of the junction of Interstate Highways 694 and 35E, and just south of Vadnais Lake. (See location map, Figure 1.) At the water surface elevation of 869 feet MSL, as shown on the USGS Quadrangle, the lake has an area of approximately 37 acres.

## 2.2 Relationship to Larger Watersheds

Twin Lake and its direct watershed comprise part of the County Ditch 16 watershed, which is in turn part of the larger Phalen chain of lakes watershed. This Phalen chain of lakes watershed is located in the northern half of the RWMWD. Vadnais Lake and its watershed is not included in the RWMWD, even though it naturally overflows to Twin Lake, the subject of this report. Overflows are possible, but rare because the City of St. Paul water utility draws its water from Vadnais Lake, thus controlling water levels.

## 2.3 Past Analyses

Twin Lake has been included in several past hydrologic studies. In the Hydrologic Analysis of Lakes and Open Space in Ramsey County (1975, Barr), overflow drainage from the Vadnais Lake system is projected to flow into Twin Lake during severe rainstorms. This study described the outlet control elevation for Twin Lake as being 874 feet MSL, and the lowest home's elevation as being at 876 feet. At such time as the upstream watershed should be completely converted to urban-style land use, the 1975 study projected a need for Twin Lake to be able to discharge 63 cfs in order for it not to exceed a projected maximum allowable elevation of 875 feet. The report also recommended lowering the outflow control elevation to 871 feet.

The Phalen Chain of Lakes Surface Water Management Plan (1988, Barr) describes Twin Lake's position within the County Ditch 16 system. A detailed study of the lake's hydrology was not included, but the report states that the lake will overflow to County Ditch 16 during very large storms or snowmelt periods at an outflow rate of 63 cfs, based on the 1975 study.

Since the city of Vadnais Heights lies just to the north of Twin Lake, the lake is affected by water management plans for that municipality. The Surface Water Management Plan for the City of Vadnais Heights, developed by Short, Elliott & Hendrickson Engineering Company (SEH) in 1989 shows Twin Lake receiving overflow drainage from both the east and west portions of Vadnais Lake. Barr was not able to verify an existing connection between the Twin Lake watershed and west Vadnais Lake during this study. The SEH report asserts that a maximum of approximately 10 cfs will flow from Twin Lake during the 100-year high-water event (assuming a high normal level, discussed below).

## 2.4 Water Quality Considerations

Twin Lake currently demonstrates water quality conditions that are good for a metropolitan lake. This water quality owes largely to the regional topography and local geology which isolates the lake hydrologically from nearby water bodies and watersheds. It currently receives runoff only from its own watershed, which is small relative to the lake's volume. In addition, much of the lake's watershed remains in its natural state, so that degradation of the lake due to human activities has remained minimal. The lake's present loading rate of pollutants and fertilizers is relatively low.

## 3.0 PRESENT STUDY

### 3.1 Methods

Hydrologic modeling and several sources of data were combined in this hydrologic evaluation of Twin Lake. A topographic map based on 1991 aerial photographs of the lake area was commissioned in order to accurately assess the drainage patterns and surrounding development (see Figure 2). Field investigations and surveys were conducted to locate drainage structures within the lake's watershed, and determine flow elevations and structure sizes. Previous hydrologic studies of the area were reviewed, and Mn/DOT plans were examined to collect information on existing culverts. State and local agencies - including the City of Vadnais Heights; the City of Little Canada; the Minnesota Department of Natural Resources (MDNR); the Minnesota Pollution Control Agency (MPCA); the Ramsey County Public Works Department; the Saint Paul Water Utility (SPWU); and engineers at SEH - were contacted and interviewed to gather historical data on water levels, drainage patterns and drainage plans. Finally, hydrologic modeling was conducted and analyzed to evaluate likely changes in lake levels as a result of storm and snowmelt events.

### 3.2 Water Level Data

Historical water elevation records for Twin Lake are apparently unavailable; neither the MDNR nor the MPCA were able to supply such information. The scarcity of data makes the establishment of "normal" and high water levels difficult. On the United States Geological Survey quadrangle map of the area, the water level for Twin Lake is shown as 869 feet. However, the topographic map commissioned for this study shows the water surface at 866.6 feet, and a 7/13/93 Barr survey reported the water surface elevation as 868.2 feet. The 1989 SEH report reports the normal elevation for Twin Lake is 872.2 feet; this elevation, however, appears to be based on culvert invert elevation data rather than actual lake levels.

A wide range of projected high water elevations also exists. A 1982 MDNR study reported a projected 10-year high water elevation of 870.6 and a 100-year level of 871.5 for Twin Lake. The MDNR, however, was unable to identify the basis of these projections. The Little Canada building inspector reported a "high water mark" of Elevation 872 that is employed by the City of Little Canada in issuing building permits; he was similarly unable to identify the source of the information. A 100-year lake level of 873.2 feet was projected in the SEH report (1989) for the City of Vadnais Heights, but that may be high because of the high normal lake level which was assumed.

## 3.3 Regional Groundwater Elevations and Twin Lake

Regional groundwater maps show Twin Lake to be approximately at the level of the local water table. Curiously, the normal water elevation of Twin Lake remains approximately 12 feet below the water level of neighboring Vadnais Lake, just 500 feet away. The maintenance of this head difference between the lakes apparently owes to the low permeability of fine glacial drift underlying the higher Vadnais Lake.

## 3.4 Overflow from Vadnais Lake

To evaluate the likelihood of flooding at Twin Lake, the likely flow to the lake from neighboring Vadnais Lake must be estimated. Vadnais Lake is the last in the chain of lakes utilized by the Saint Paul Water Utility for conveyance and storage of water for the city's drinking water supply. The SPWU pumps water from Vadnais Lake daily, and controls flow into Vadnais Lake through regulation of pumping from the Mississippi River into the chain of lakes leading to Vadnais Lake. Because it is used as a reservoir for the city, the water levels in the lake are closely monitored and controlled. In addition, due to water quality considerations, SPWU officials are reluctant to allow water from Vadnais to flow into Twin Lake. The policy of the SPWU is to maintain the water level of the lake between 882.07 and 884.17 feet in order to maintain sufficient storage but prevent overflow to Twin Lake; the outlet from Vadnais to Twin Lake is at Elevation 884.6. Flow from Vadnais to Twin Lake is insignificant and occurs rarely, if ever, according to the SPWU.

## 3.5 The Twin Lake Watershed

The immediate watershed for Twin Lake is relatively small, consisting of approximately 240 acres. The watershed is bounded on the northeast by Vadnais Lake, on the northwest by the outer edge of a trailer park, and on the southwest by Interstate 694 (see Figure 3). A significant portion of the triangle of land lying south and east of the Burlington Northern Railroad line (just southeast of the lake), and north and west of Centerville Road currently drains to Twin Lake; this portion is also part of the lake's direct watershed.

Three sub-watersheds contributing to Twin Lake were identified through this study: the storm-sewered trailer park area north of Twin Lake Boulevard, the steeply sloped area surrounding the lake and consisting primarily of undisturbed land or single family homes, and the triangular basin southeast of the railroad tracks. Using the Barr surveys, the topographic map commissioned for this study, and

plans supplied by the Minnesota Department of Transportation, these sub-watersheds were measured and evaluated to enable storm event modeling.

In addition to the direct overland runoff that the lake receives, Twin Lake may receive stormwater flow from three culverts. To the northwest, a system of two culverts (a 36-inch diameter concrete pipe, followed by a 24-inch concrete pipe) carries water from the low park land associated with the trailer park. The triangular basin of land southwest of the railroad tracks drains to the lake via a 48-inch concrete pipe. Overflow from Vadnais Lake may also occur through an arched corrugated metal culvert under Twin Lake Boulevard. Culvert conditions, sizes, positions, and inlet and outlet invert elevations were identified. The drainage system is shown in plan view on FIgure 2, and in profile on Figure 4.

Owing to its low elevation, mild slope and large diameter, the culvert under the railroad tracks may also act as a flood outlet for Twin Lake when water levels become extremely high. Water would flow from the lake to the basin north of Interstate 694, and from there through the culvert under I-694 and into County Ditch 16.

It must be noted that there are two problems associated with this outlet for Twin Lake:

- The land surface in the basin southeast of the railroad tracks rises in front of the entrance to the culvert running below the westbound leg of Interstate 694, effectively creating a dike restricting flow to the pipe under the freeway. The invert elevation for the I-694 culvert is given by Mn/DOT as 872.3 feet. However, the terrain presently dictates that flow to this conveyance cannot occur until the water level in the basin exceeds the height of the low point in the "dike", at 876.9 feet.

- The culverts under the Interstate highway are of relatively small diameter and very little slope. The first of the two culverts is 30 inches in diameter; this connects to a 36-inch culvert that passes under the eastbound leg of the freeway. Mn/DOT maps show the slope of the culvert system to be only about 0.03 percent. At the lake's flood elevation of 875 feet, this system is incapable of transmitting more than 14 cfs, much less than the projected 63 cfs.

## 4.0 HYDROLOGIC MODELING AND RESULTS

### 4.1 Methodology

To assess the likelihood of flooding in Twin Lake, and to estimate the 100-year flood levels for the lake, the Barr Watershed Model was used. Watershed characteristics, including use, soil type, and slope were described. Culvert characteristics and capabilities were analyzed. Storage volumes - in the lake, in the basin southeast of the railroad tracks, and in the depression southeast of the trailer park - were computed and used as input for the model.

All modeling runs were made with the assumption that Twin Lake would not be receiving overflow runoff from the Vadnais Lake watershed. This assumption is critical, and is discussed further below.

A range of storms and runoff events were analyzed in order to determine which events would be critical in causing extreme water elevations in Twin Lake. Two snowmelt events - the 100-year 30-day event, and the 100-year 10-day event, were considered; the 100-year rainfall events of 1, 2, 3, 6, and 12 hours, and 1, 2 and 4 days were also evaluated.

Since the topographic map showed the existing low house low floor elevation at approximately 877 feet MSL, a maximum allowable flood elevation of approximately 875 feet was determined. With Elevation 875 feet as an upper limit, the model was run with the storm and snowmelt series described above to find a starting elevation for Twin Lake such that the lake level would not exceed Elevation 875 feet as a result of the critical 100-year runoff event.

### 4.2 Modeling

Assuming that all existing culverts and topography were unchanged, modeling shows the maximum allowable beginning lake level to be about 870.7 feet MSL (see Table 1). Throughout the modeling, rainfall events proved to cause less lake level fluctuation than the snowmelt events; the model predicted that spring snowmelt runoff would be of more concern than summer rainstorms.

TABLE 1

MODELING RESULTS

| Starting Lake Level (feet MSL) | Source of Starting Lake Level | Final Lake Level (feet MSL) |
|---|---|---|
| 870.7 | Computed (see text) | 875.1 |
| 869 | USGS Quad Sheet | 873.7 |
| 868.2 | Barr Survey (7/13/93) | 873.0 |
| 866.6 | MarkHurd Topo Map (based on 1991 photo) | 871.7 |

The outflow from Twin Lake during flood conditions could be increased by removing the earthen dike that currently restricts flow to the culvert under I-694. If this were done, and no additional work was done to enlarge the capacity of the I-694 culvert, modeling indicates that the lake could start at the existing invert Elevation 872.3 and still not exceed the limit of 875 feet. Under these conditions, the maximum predicted elevation as a result of the 100-year, 10-day snowmelt event is 874.0 feet. However, this method of increasing flood outflow carries the disadvantage of allowing a route for storm runoff from the I-694 system to find its way into Twin Lake.

This water quality concern could be addressed by leaving in place the dike that separates the I-694 stormwater flow from the Twin Lake system. Flood outflow could still be provided by piercing the existing dike with a culvert that connects the Twin Lake system to the I-694 drainage. A simple flap gate could be provided to prevent back flow from the freeway system to Twin Lake.

This culvert-and-gate system was evaluated using the hydrologic model. Assuming no upgrading of the conveyances beneath I-694, the system hydraulics were first evaluated. The analysis showed a maximum possible outflow of approximately 12 cfs with lake water levels at 875 feet. Modeling demonstrates that the above system would be capable of keeping lake water levels below 875 feet, even when the initial water level was set at 873.9 feet.

## 5.0 LAKE MANAGEMENT CONSIDERATIONS

### 5.1 Flood Level

The modeling results indicate that maintaining lake water levels below the designated flood stage of 875 feet should not be difficult. Without any changes to the existing structures, there should be little

cause for concern provided that early spring (pre-snowmelt) water levels have not exceeded 870.7 feet. And despite the scarcity of existing lake level data, it appears that the lake rarely, if ever, reaches 870.7 feet. As a management strategy, Elevation 870.5 has been established as a management "action" level for Twin Lake.

It should be noted, however, that this analysis assumes both the continued absence of inflow from Vadnais Lake, and a continuation of the existing hydrologic regime for the lake. If the projected 63 cfs inflow from Vadnais Lake were actually permitted into Twin Lake, storage capability would be exhausted in less than 3 days and the lake would rise above the 875-foot elevation limit.

## 5.2 Water Quality

Twin Lake's unusual hydrologic situation has allowed it to remain relatively free of pollutants and algal overabundance. Changes in the lake's watershed are likely to result in changes in the lake's water quality. Preservation of the current water quality conditions in Twin Lake will require management of possible sources of nutrients or contamination.

Twin Lake is currently segregated from the drainage system for the nearby Interstate highway. This segregation is desirable, since it prevents pollutants in the highway stormwater runoff - grease and oil, particulate matter, roadside debris, etc. - from reaching the lake. If possible, this segregation should be maintained.

According to personnel at the SPWU, Eurasian water milfoil has been found in Vadnais Lake. As a result, the current practice of the SPWU is to maintain lake levels below the outlet, thus preventing flow from Vadnais into Twin Lake. In addition to the exotic species problem, other consequences of receiving flow from Vadnais must be considered. Vadnais is positioned at the downstream end of a very large watershed, and therefore is subject to much larger loading rates of contaminants and fertilizers than is Twin Lake. If Twin Lake is to be isolated from nutrients from the larger watershed, the segregation between the lakes should be maintained.

New construction within the watershed can contribute an increased silt and sediment load to the lake. Establishing and maintaining effective erosion control measures during and after any periods of construction will be necessary. Construction will also bring an increase in the amount of impervious surfaces (such as roofs, roads, driveways) and stormwater conveyances. These will contribute increased amounts of organic material and increased stormwater runoff rich in nutrients expected to cause an increase in algal production. Landscape and stormwater system design measures to mitigate these effects

will be necessary. These measures might include a program of public education for the residents of the Twin Lake watershed. The program would include educational briefings and pamphlets alerting the residents to be mindful of what is allowed to enter the storm sewer systems and the lake, and would help discourage harmful lawn care practices.

## 6.0 MANAGEMENT ALTERNATIVES AND RELATIVE COSTS

Management alternatives for Twin Lake are dependent on whether Vadnais Lake is allowed to overflow to Twin Lake. Alternatives without and with overflow are discussed below.

- If it can be determined that Twin Lake will not be required to accommodate any flows from the neighboring Vadnais watershed, management considerations are simplified. The lake would still need to be managed to stay below flood levels, and the water quality of the lake would need to be preserved. Lake management would likely take one of two forms.

    1. The preferred method would require installing a culvert through the dike currently guarding the entrance to the culvert under I-694. The culvert would allow increased capacity for Twin Lake at lower elevations. To avoid adverse water quality impacts, the culvert should have a flap gate which allows flow only from Twin Lake and to the I-694 culverts. This alternative would provide additional capacity for outflow during large storm events, but would serve to maintain the lake's isolation from the interstate runoff. Hydraulic and hydrologic considerations for this alternative were discussed above; the arrangement would prevent flooding even if the water level before the rainfall or snowmelt event were right at the level of the outlet. This system is estimated to cost about $13,000 and would not require pumping to control water levels. Construction could be deferred until a need is demonstrated by the lake level rising to the maximum beginning (action) level of 870.5.

    2. If no culvert improvements are made, the lake must be monitored for dangerously high pre-snowmelt or mid-summer water levels. If in the early spring, the lake level were above 870.5 feet, and large accumulations of snow were present, pumping (presumably into Vadnais) could be done to lower the lake and eliminate the possibility of flooding. Similarly, if mid-summer levels exceeded 870.5 feet, pumping could be performed to avoid flooding from large rainfall events. No

capital costs are associated with this alternative, but emergency expenditures would be significant, perhaps as great as the culvert improvements, and unbudgeted. Lake water quality would be maintained through maintaining isolation from Vadnais Lake, through monitoring of construction activities, and through public education.

- If allowing a periodic outflow of 63 cfs from the Vadnais chain to the RWMWD becomes necessary at some time in the future, different management scenarios must be considered:

1. The preferred scenario would be to route the 63 cfs outflow from Vadnais Lake around Twin Lake, rather than through it. This would preserve Twin Lake's water quality. One possibility is to construct a conveyance system that would carry flows from the west arm of Vadnais Lake around the west side of Twin Lake to the County Ditch 16 system (see Figure 5). The existing outflow from Vadnais to Twin could then be abandoned. Preliminary estimates have not been prepared for such a conveyance; additional study of the route is required.

   Easements and permits would almost certainly be required for the construction of this bypass system. An examination of the National Wetlands Inventory map for the region indicates that wetlands permits for the work may also be necessary. As a result, a separate study to evaluate the feasibility and better estimate the costs would be necessary before proceeding with this alternative.

2. The Vadnais outflow could be routed through Twin Lake, and then through the Interstate highway storm sewer conveyances, as was outlined in the 1975 Ramsey County Open Space report. However, two complications exist:

   The existing culverts beneath I-694 are not capable of handling 63 cfs; the outflow system would have to be upgraded or severe flooding around Twin Lake would occur. This upgrading would involve considerable expense, since over 1,600 feet of additional culverts would need to be installed deep beneath the existing I-694 roadway. The expense of installing the required culverts is expected to be in the neighborhood of $400,000.

   Water quality in Twin Lake would undoubtedly suffer as a result of its being flushed with water bearing an elevated contaminant load and possible exotic plant species.

Financing of any required improvements has not been considered. Negotiations with local units of government and neighboring watershed organizations will be required.

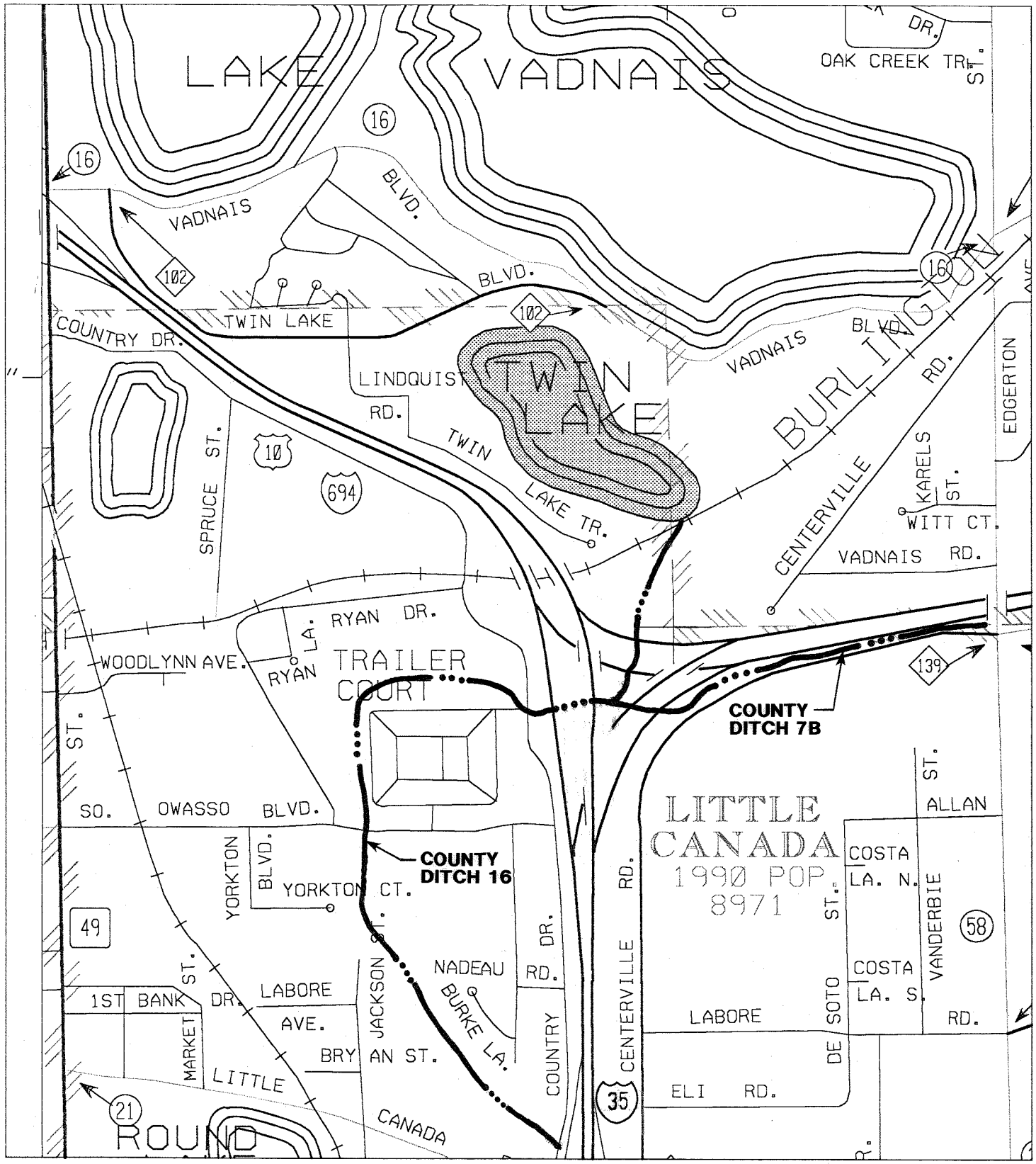
## 7.0 SUMMARY AND RECOMMENDATIONS

It is currently the policy of the SPWU to maintain Vadnais Lake levels below the outlet elevation, thus preventing outflow to Twin Lake. Assuming the future continuous operation of the water utility, and a continuance of present practices, it would appear that Twin Lake will not be called upon to accommodate overflow from Vadnais Lake.

A culvert should be constructed through the existing dike upstream of I-694. The culvert should be at the same elevation as the I-694 culverts (about 872.3) and should have a flap gate to prevent back flow of I-694 runoff to Twin Lake. Construction of the culvert could be delayed until the need is demonstrated by lake levels at or above the action levels. Development reviews must preserve an outlet route between the lake and the proposed culvert at the I-694 dike.

Provided that flow from Vadnais Lake does not occur, Twin Lake should be managed to allow 100-year frequency rainfall and snowmelt events without experiencing lake levels above 875 feet MSL. The RWMWD should install and monitor a lake elevation gage on Twin Lake. If pre-snowmelt or summer water levels exceed 870.5 feet, pumping to Vadnais Lake or County Ditch 16 should be considered to preserve storage capacity for accommodating storm runoff below Elevation 875 until the culvert can be installed.

If the projected 63 cfs outflow from the Vadnais chain of lakes needs to be accommodated, consideration should be given to routing this flow around Twin Lake to preserve the quality of Twin Lake. This diversion may also be less costly than the I-694 culvert upgrades that would be required to route the flow through Twin Lake. If overflow to Twin Lake were permitted, the increased outflow capacity of the lake would be expected to sacrifice the water quality advantages that Twin Lake currently enjoys. The RWMWD should evaluate and select an alternative overflow route so that future development reviews can consider implications with the selected route, should its use ever be required.



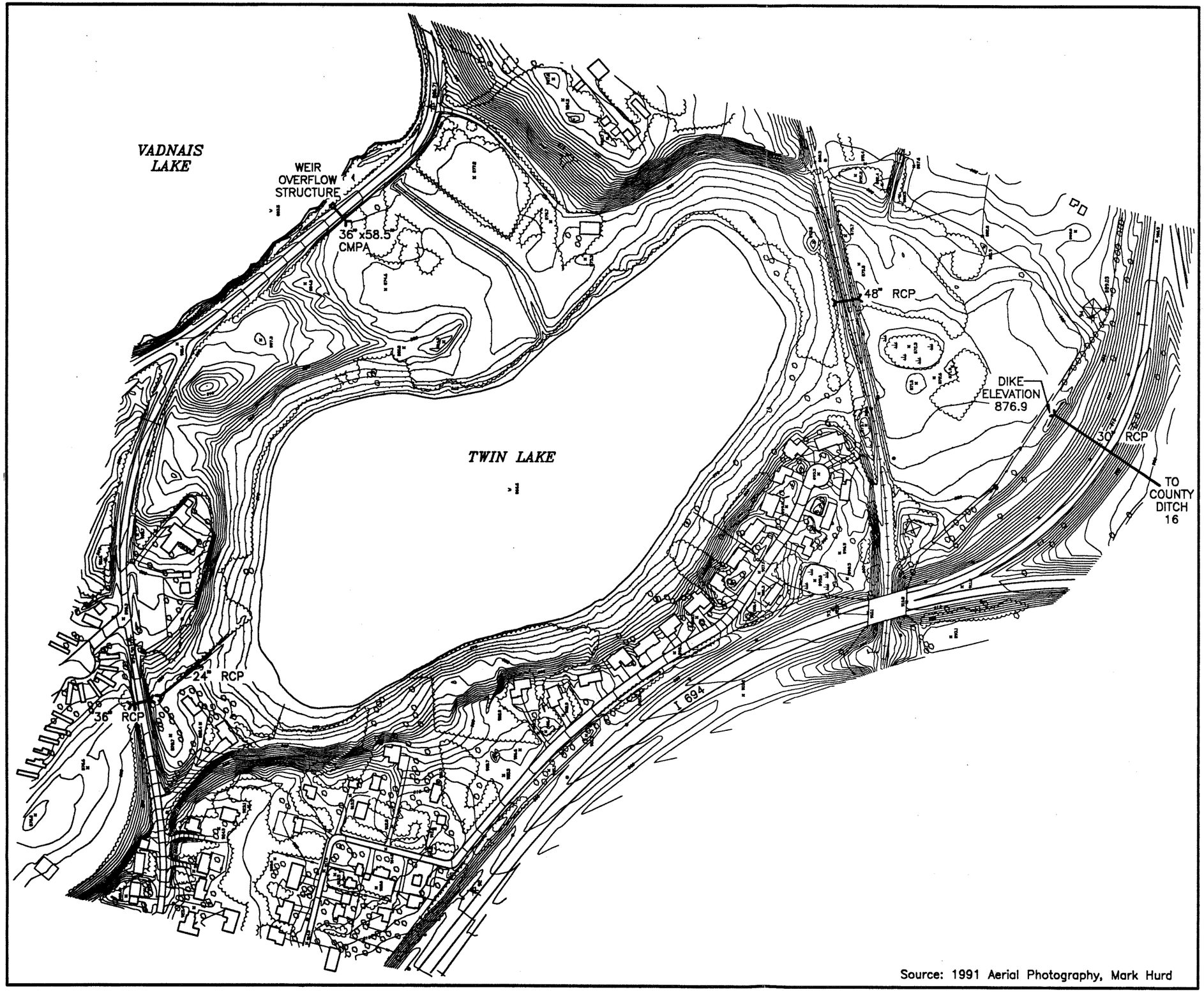

N

0 1000 2000

Scale in Feet

Figure 1

LOCATION MAP






0 300
SCALE IN FEET

Figure 2
TWIN LAKE DRAINAGE SYSTEM

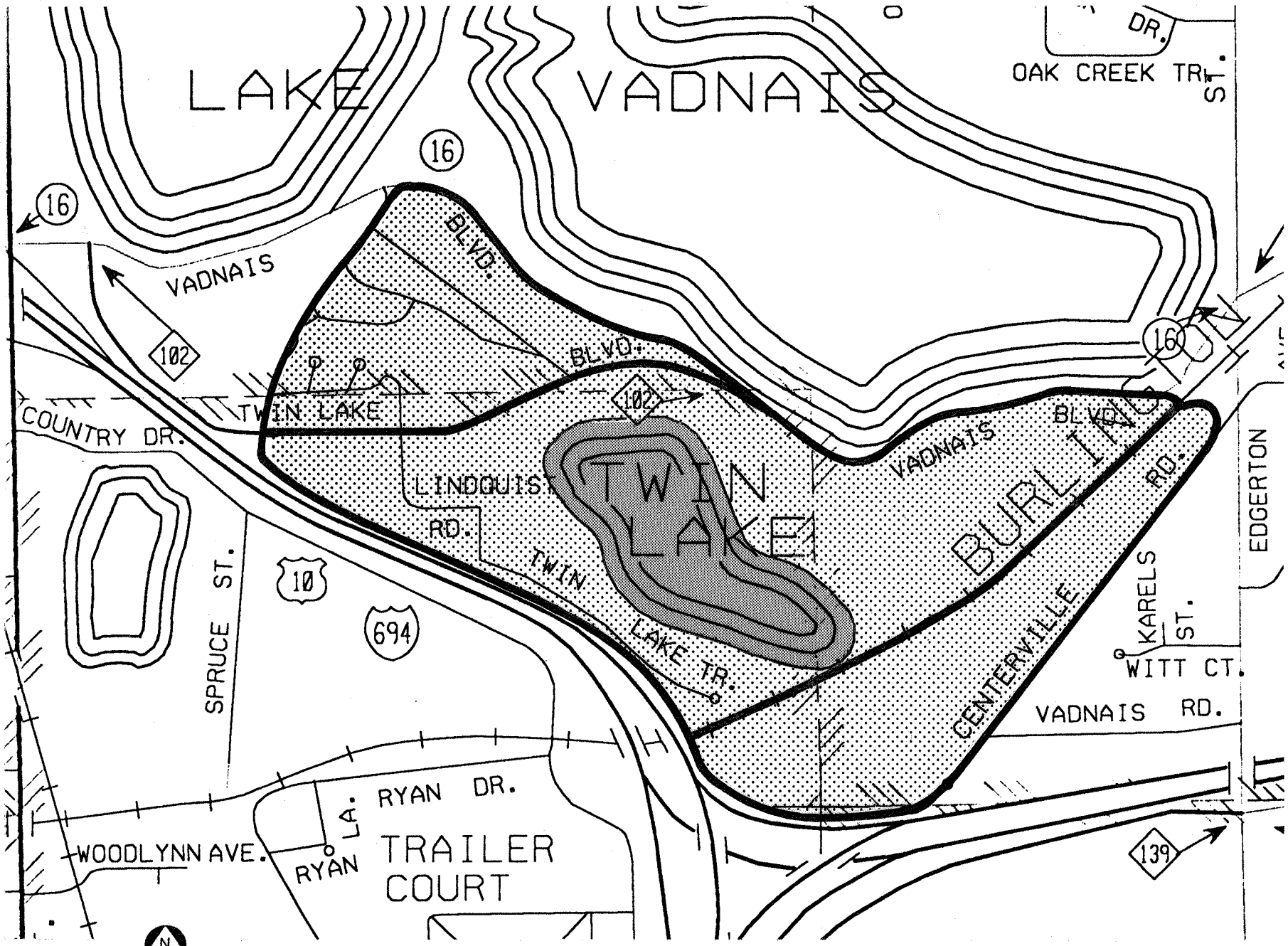
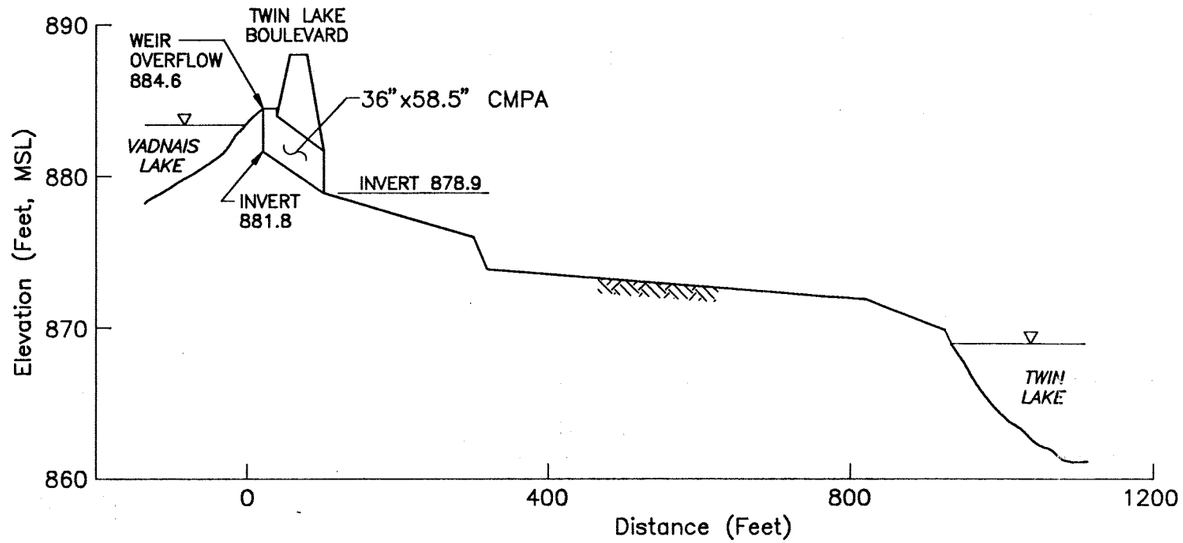



Figure 3
WATERSHED DIVIDES



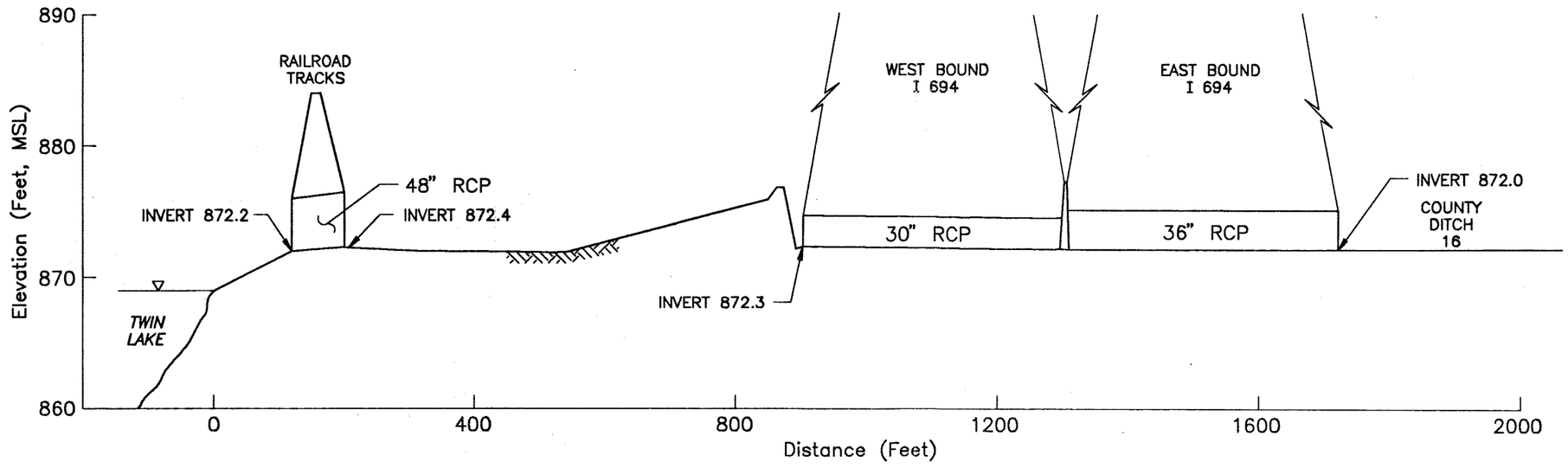




Figure 4

TWIN LAKE DRAINAGE
SYSTEM PROFILES

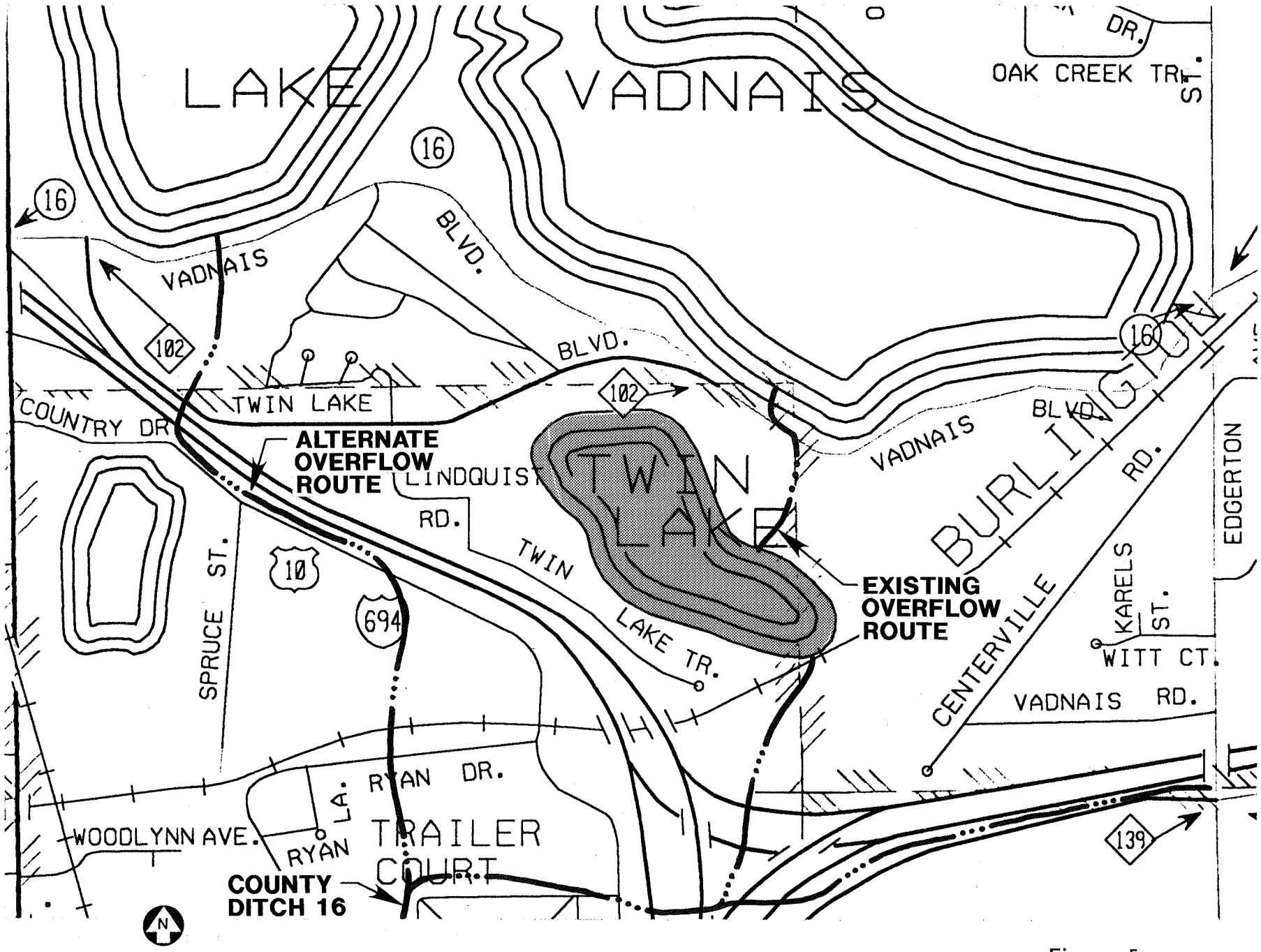



Figure 5

ALTERNATE VADNAIS OVERFLOW