STORMWATER TREATMENT STUDY

North Side Stormwater Treatment Study
UEI Project No.: R07.50052 (507.052)

Detroit Lakes, Minnesota

May 2009

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Gary L. Nansen (signature)	Gary L. Nansen, P.E.
Signature	Typed or Printed Name
07 MAY 09	14529
Date	Lic. No.

Ulteig Engineers, Inc.
Bismarck Denver Detroit Lakes Fargo Minneapolis Sioux Falls

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1.0 Introduction

1.1 Background

The preparation of this stormwater study was requested by the City of Detroit Lakes as a requirement of the Pelican River Watershed District (PRWD) in order to reconstruct Curry Avenue within the northern portion of the City of Detroit Lakes. The reconstruction of Curry Avenue was completed in 2007. As this street segment lies within a developed region, stormwater treatment methods were limited to the use of the existing system. As a result, the PRWD granted the City of Detroit Lakes a permit for the reconstruction of this street with the stipulation that the City conduct an overall analysis of the existing treatment level within the area shown in Exhibit No. 1.

1.2 Intent of Study

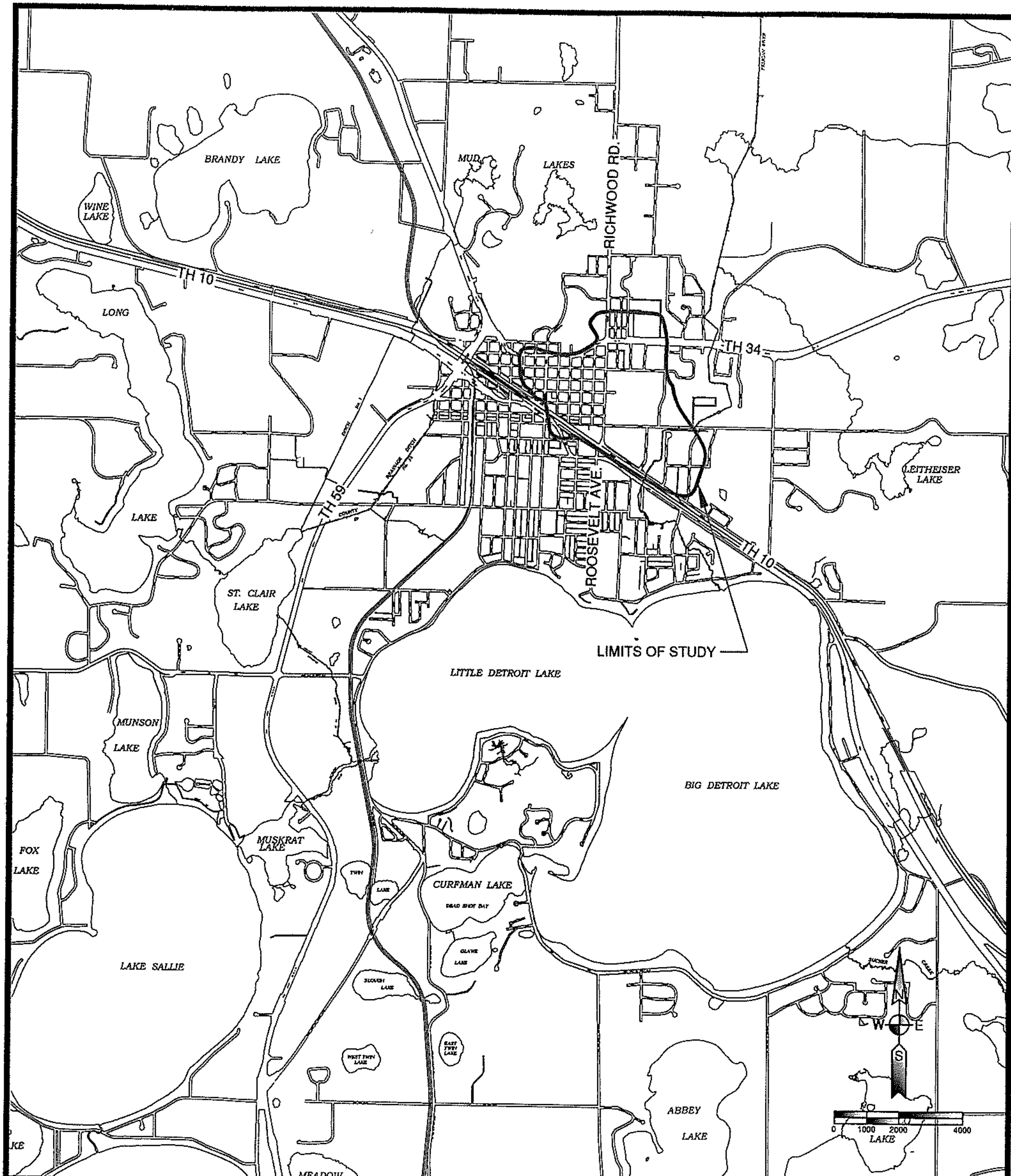
The primary intent of this study is to determine the current treatment level within the north side drainage area as well as to ascertain whether additional treatment measures are required. See correspondence from PRWD in Appendix No. 1.

The existing treatment levels will be compared to the levels of current requirements of regulatory agencies. If treatment levels are lower than current standards, recommendations for increasing treatment levels for the Curry Avenue project will be discussed, along with general opportunities for increasing the overall treatment levels of the entire drainage area.

2.0 Existing Conditions

2.1 Limits of Study

Hydraulically, the City of Detroit Lakes is generally split into two separate areas. The area focused on, within this study, includes the area north of the Burlington Northern Santa Fe (BNSF) railroad. The drainage or runoff



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North Side Stormwater Treatment Study

Detroit Lakes, Minnesota

Exhibit No. 1
City of Detroit Lakes
Limits of Study

Project Number: 507.052
Date: May, 2009

from this area is collected in a network of storm sewer piping and detained in a series of retention basins, which ultimately discharge to the Pelican River in the City's Industrial Park. The studied area is approximately 300 acres and is shown in Exhibit Nos. 1 and 2.

2.2 Existing Land Use

The existing land use, within the area studied, ranges from single family residential housing to industrial use. An aerial photo is shown in Exhibit No. 2.

2.3 Existing Storm Sewer System

The age of the existing storm sewer ranges from 60 plus years old to a few years old. The general drainage direction is from north to south. The pipes' main purpose is to convey surface runoff to a point of discharge. The retention basins are designed to minimize flooding and provide time for pollutants to settle out. Within the area studied, retention basins are the only source of stormwater treatment. The retention basins within this network are all connected with the only outlet at Basin F (Industrial Park softball diamonds). See Exhibit No. 3.

3.0 Current Stormwater Treatment Regulations

3.1 Pelican River Watershed District (PRWD) Requirements

The PRWD regulates the stormwater management system requirements for any new construction or reconstruction projects within their jurisdiction. Their main requirements for stormwater management are summarized below:

- Post-developed runoff discharge rates cannot exceed the pre-developed rates for the 5 year, 25 year, and 100 year rain events.
- On site retention must be provided for stormwater volumes greater than the volume of runoff created from a 5 year rain event or

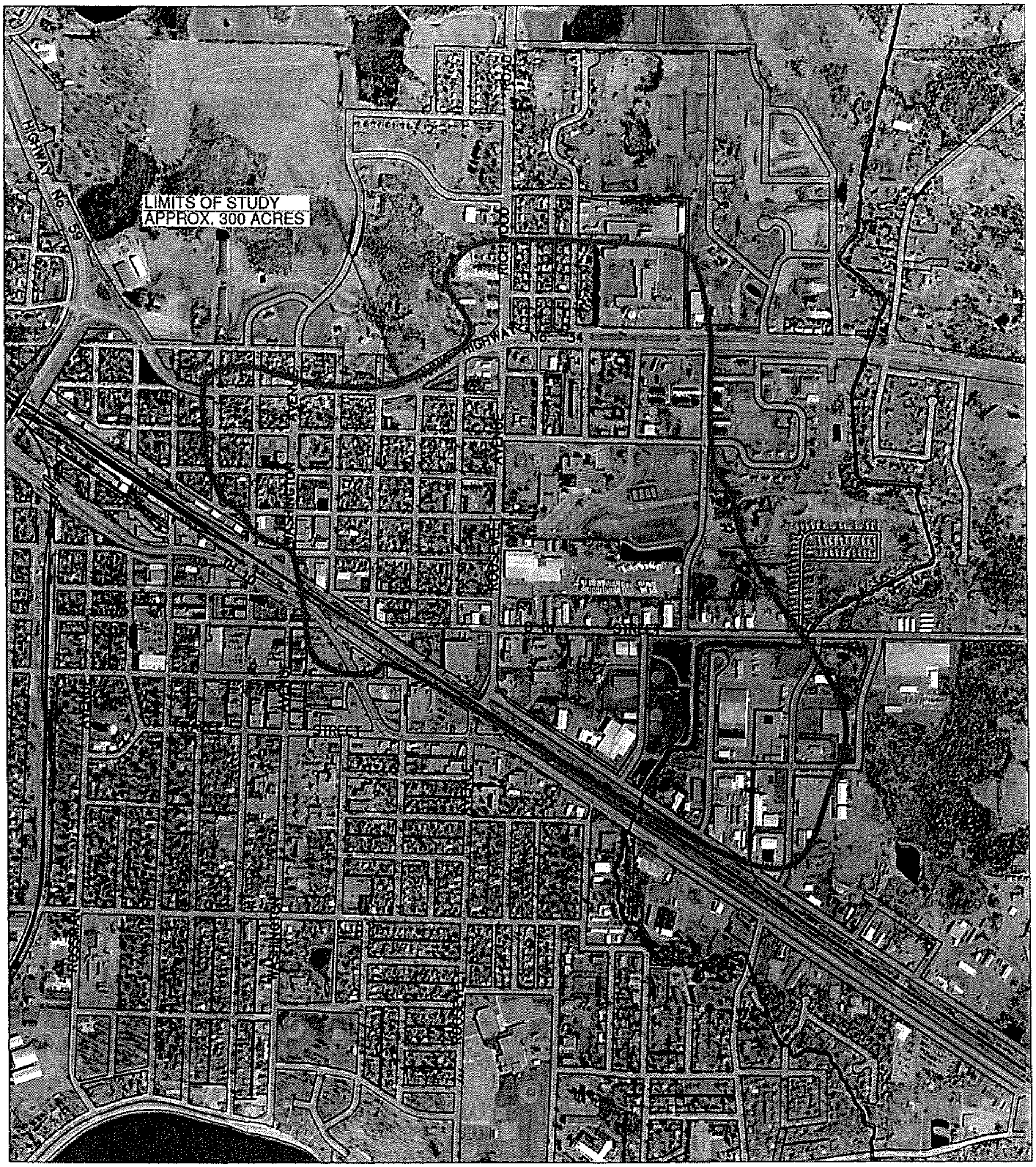

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Exhibit No. 2
Aerial Photo

Project Number: 507.052
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Exhibit No. 3
Existing Storm Sewer & Stormwater Basins

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alternately verify that 90 percent of total suspended solids removal and 50 percent phosphorous removal is achieved, using Walker's PondNet model, prior to offsite discharge.

A copy of the PRWD's current permit application along with their Permit Information Packet is included in Appendix No. 2.

3.2 NPDES General Stormwater Permit for Construction Activity

The NPDES (National Pollutant Discharge Elimination System) General Stormwater Permit for Construction Activity is a permit that is required for construction projects that disturb more than 1 acre of ground. This is a national permit issued, in the State of Minnesota, by the Minnesota Pollution Control Agency (MPCA). This permit requires that if new impervious surface is added in excess of 1 acre:

- For every acre within the drainage area, 1,800 cubic feet (cf) of dead storage must be provided.
- That stormwater from one-half (½) inch of rain over the new impervious surface is retained and not discharged at a rate of 5.66 cubic-feet per second (cfs) per surface acre of the basin. This standard is set to target a treatment level of 80 to 90 percent total suspended solids removal, which corresponds to a 40 to 50 percent total phosphorus removal.

A copy of the NPDES permit is attached in Appendix No. 3.

4.0 Methods of Analysis

An analysis was conducted by 2 computer software models. These software models are independent of each other. The first, XPSWMM, is capable of predicting runoff from sample rainfall events, determine flow within pipes, and calculate pond routing and storm sewer discharges. The second model used was Walker's PondNet model. This program is capable of predicting phosphorus removals when stormwater is routed through retention basins.

5.0 Terminology and Acronyms

5.1 Terminology

Following are definitions that apply specifically to this report:

Treatment: the term treatment will be used to refer to the removal of pollutants from runoff prior to discharge. Pollutants studied will be limited to phosphorus and sediment. Removals will typically be referenced as a percentage.

Retention Basin: a basin or pond that does not fully drain following a rain event, thus referred to as a "wet" basin. These types of basins provide holding times sufficient to provide stormwater treatment.

Rainfall Event: generally, the term rainfall event will be noted in terms of a specified year; example: 5 year rainfall event. This statement indicates a 24 hour storm that would have a return period of every 5 years. In the Detroit Lakes area, that rainfall depth is approximately 3.2 inches. The 24 hour time period simply indicates that the rainfall occurs within 1 event or 1 storm.

Drainage Area: for purposes of this report, drainage area indicates an area that drains to a common collection point, typically, a catch basin or an inlet.

Time of Concentration: a term used in the design of storm sewer systems, which indicates the time it takes for the furthest particle of rain to reach a desired point. Within this study, the time of concentration was typically calculated from the furthest point within the drainage area to the nearest catch basin or stormwater inlet.

Storage: also referred to as dead storage or permanent storage; storage is a term used to describe the volume of stormwater runoff that is held in a retention basin permanently. This is the volume of the basin below the outlet structure. Typically, denoted in cubic feet (cf) or acre-feet (ac-ft).

Water Quality Volume: indicates the volume of a retention basin above the outlet structure and the highest elevation of the basin. Typically, denoted in cf or ac-ft.

Runoff: is any excess rain that does not infiltrate into the ground. The term runoff and stormwater will be used interchangeably throughout the study.

5.2 Acronyms

NPDES: National Pollutant Discharge Elimination System

MPCA: Minnesota Pollution Control Agency

PRWD: Pelican River Watershed District

BNSF: Burlington Northern Santa Fe

MnDOT: Minnesota Department of Transportation

XPSWMM: a computer software modeling program used to simulate runoff and hydraulics

SCS: U.S. Department of Agriculture - Soil Conservation Service

CN: SCS curve number

TH: Trunk Highway

6.0 Data Collection

Information was compiled from various sources to build the 2 models. These sources are summarized below:

6.1 TH 10 Reconstruction

The Minnesota Department of Transportation (MnDOT) is currently reconstructing and realigning Trunk Highway (TH) 10 through the City of Detroit Lakes. This extensive reconstruction project incorporates many new stormwater treatment facilities and the project has been permitted through the Pelican River Watershed District (PRWD). For that reason, the area treated under this project will not be included within this study, as it is already meeting the standards set by the PRWD. This area is depicted in Exhibit No. 4.

6.2 Detroit Lakes Stormwater Drainage Plan

Larson-Peterson & Associates, Inc. of Detroit Lakes prepared a Stormwater Drainage Plan for the City of Detroit Lakes in June of 2001. This plan discussed the existing drainage areas of the City, the existing stormwater system, the existing retention facilities, and stormwater discharge points.

6.3 Archived Construction Plans

Archived construction plans were referenced for the building of the XPSWMM model. Information gathered from these plans includes:

- The location, type, and size of the existing storm sewer pipes, manholes, and catch basins.
- The location and size of existing stormwater retention basins.
- The approximate topography of existing terrain.
- Invert and rim elevations

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North Side Stormwater Treatment Study

Detroit Lakes, Minnesota

Exhibit No. 4
TH 10 Drainage Area

Project Number: 507.052
Date: May, 2009

6.4 Aerial Mapping

Aerial imagery was used to determine the existing land use and corresponding areas of impervious surface and green space.

6.5 Survey Data

A formal survey was not conducted for preparation of this study or corresponding models. Available survey information from projects within the recent past was referenced to coordinate between datum variances.

6.6 Visual Inspections

The area was driven and walked to visually verify much of the above information.

7.0 Existing Treatment Facilities

Within the area studied, the existing treatment is provided through 6 retention basins. The locations of the basins are shown in Exhibit No. 3. Included in the 6 basins are 2 private basins, at the north edge of the area studied, that discharge to the City's system, therefore, they were also modeled as part of the system.

7.1 Basins A and B (Private Basins)

Private retention basins A and B were modeled within the scope of this report as they discharge to the City's storm sewer system. These basins are relatively small and are designed to accommodate runoff from a private condominium association on the north side of the City. Basins A and B are shown in Exhibit Nos. 5 and 6, respectively.

7.2 Basin C (TH 34 Basin)

The TH 34 Basin (Basin C) was constructed in 1989. The approximate footprint of the basin is 180 feet by 320 feet. This basin was designed as a

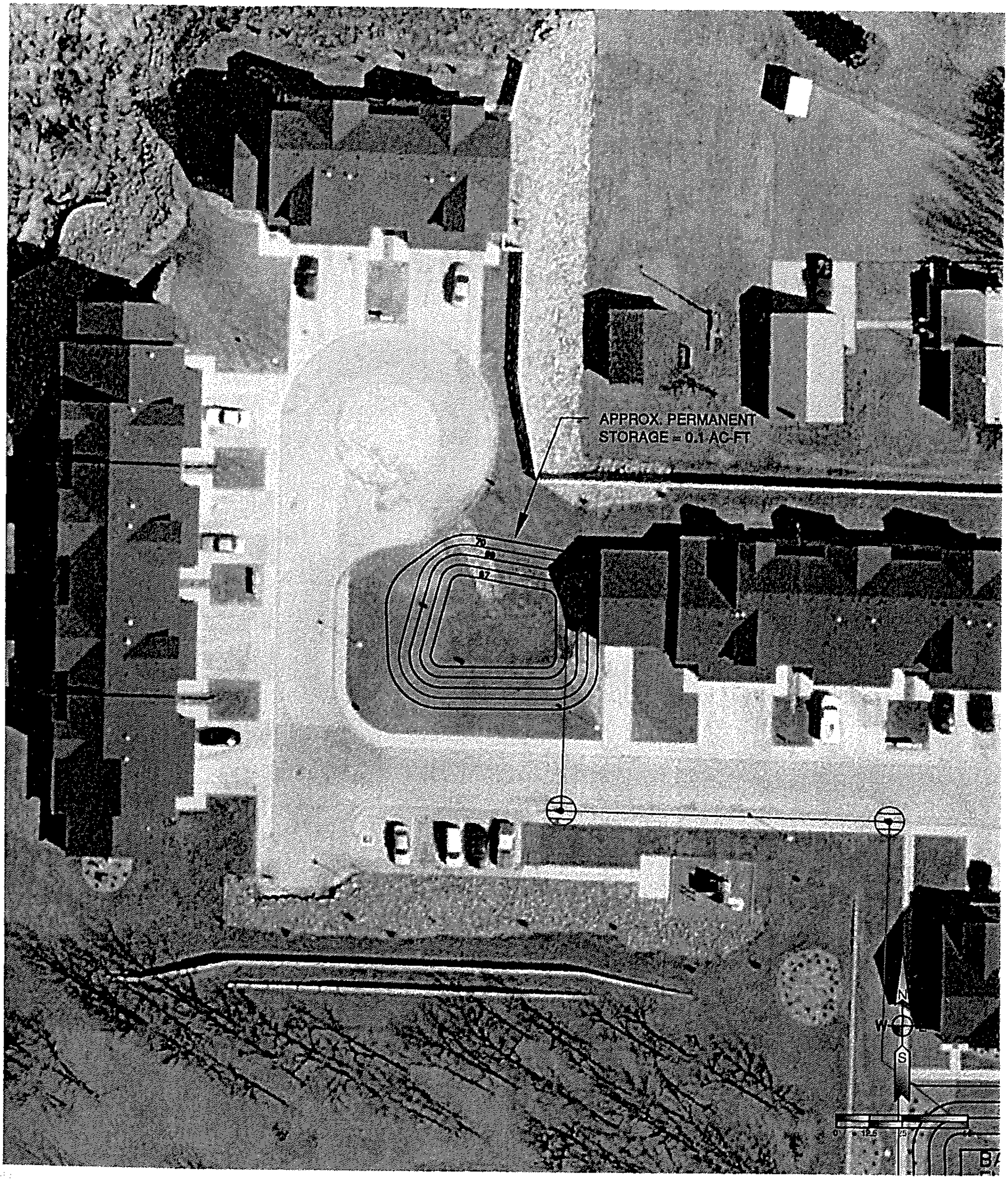

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Exhibit No. 5
Basin A
(Private Basin)

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Exhibit No. 6
Basin B
(Private Basin)

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detention basin and therefore, does not provide sufficient retention time to allow for any pollutant removal. Basin C is shown in Exhibit No. 7.

7.3 Basin D (Roosevelt Avenue Basin)

The Roosevelt Avenue Basin (Basin D) was also constructed in 1989. The approximate footprint of this basin is 150 feet by 200 feet. This basin was also designed as a detention basin and therefore, does not provide sufficient retention time to allow for any pollutant removal. Basin D is shown in Exhibit No. 8.

7.4 Basin E (Middle School Basin)

The Middle School Basin (Basin E) was constructed in 1999. The approximate footprint of the basin is 160 feet by 580 feet. The basin was designed as a retention basin and does allow for permanent water retention. Basin E is shown in Exhibit No. 9.

7.5 Basin F (Industrial Park Softball Basin)

The Industrial Park softball basin (Basin F) was also constructed in 1999. The approximate footprint of this basin is 280 feet by 360 feet. This basin was also designed as a retention basin. This basin is the end of the storm sewer/retention basin chain and is the only point of discharge to the Pelican River. Basin F is shown in Exhibit No. 10.

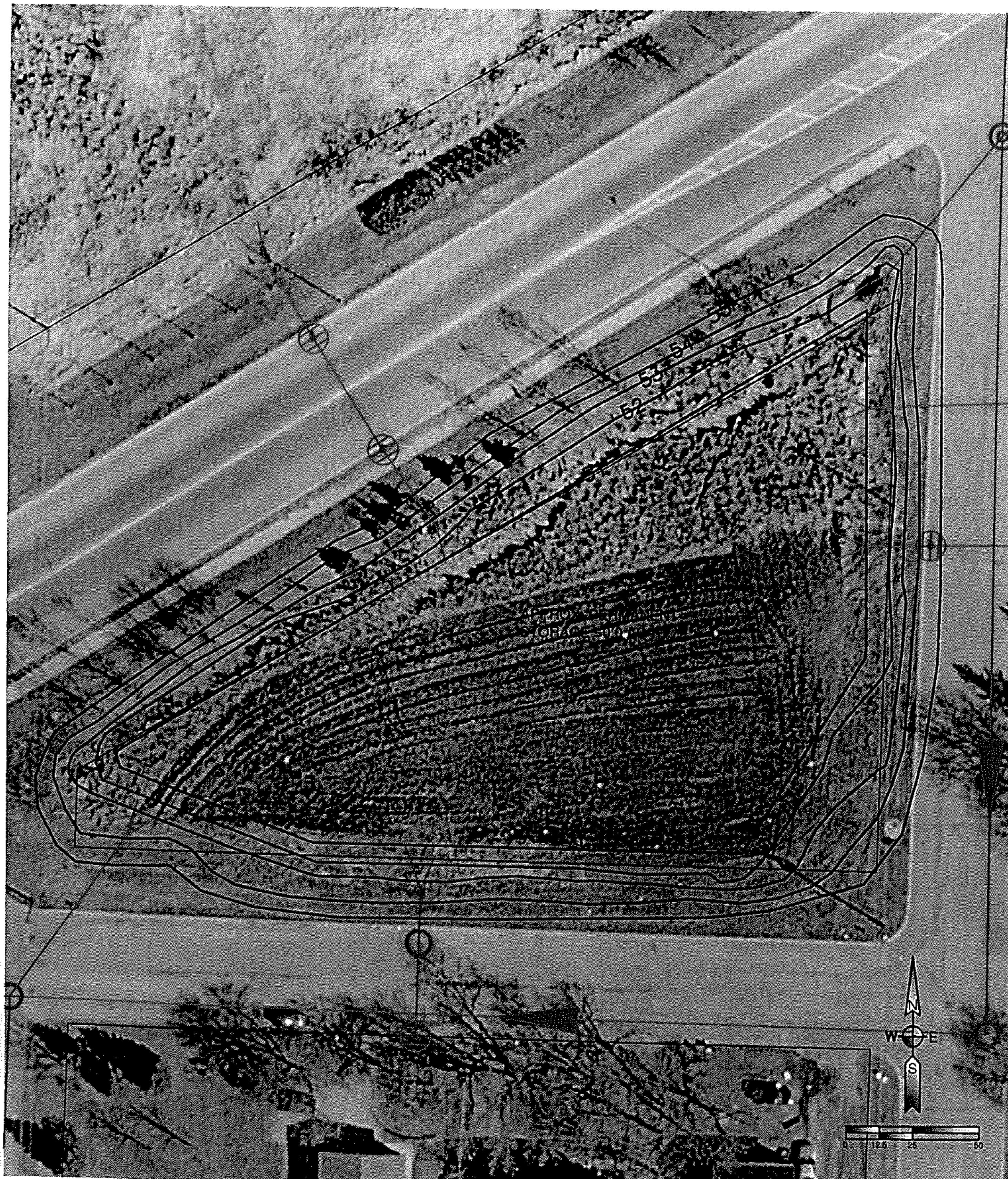

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Exhibit No. 7
Basin C
(Trunk Highway No. 34)

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Exhibit No. 8
Basin D
(Roosevelt Avenue)

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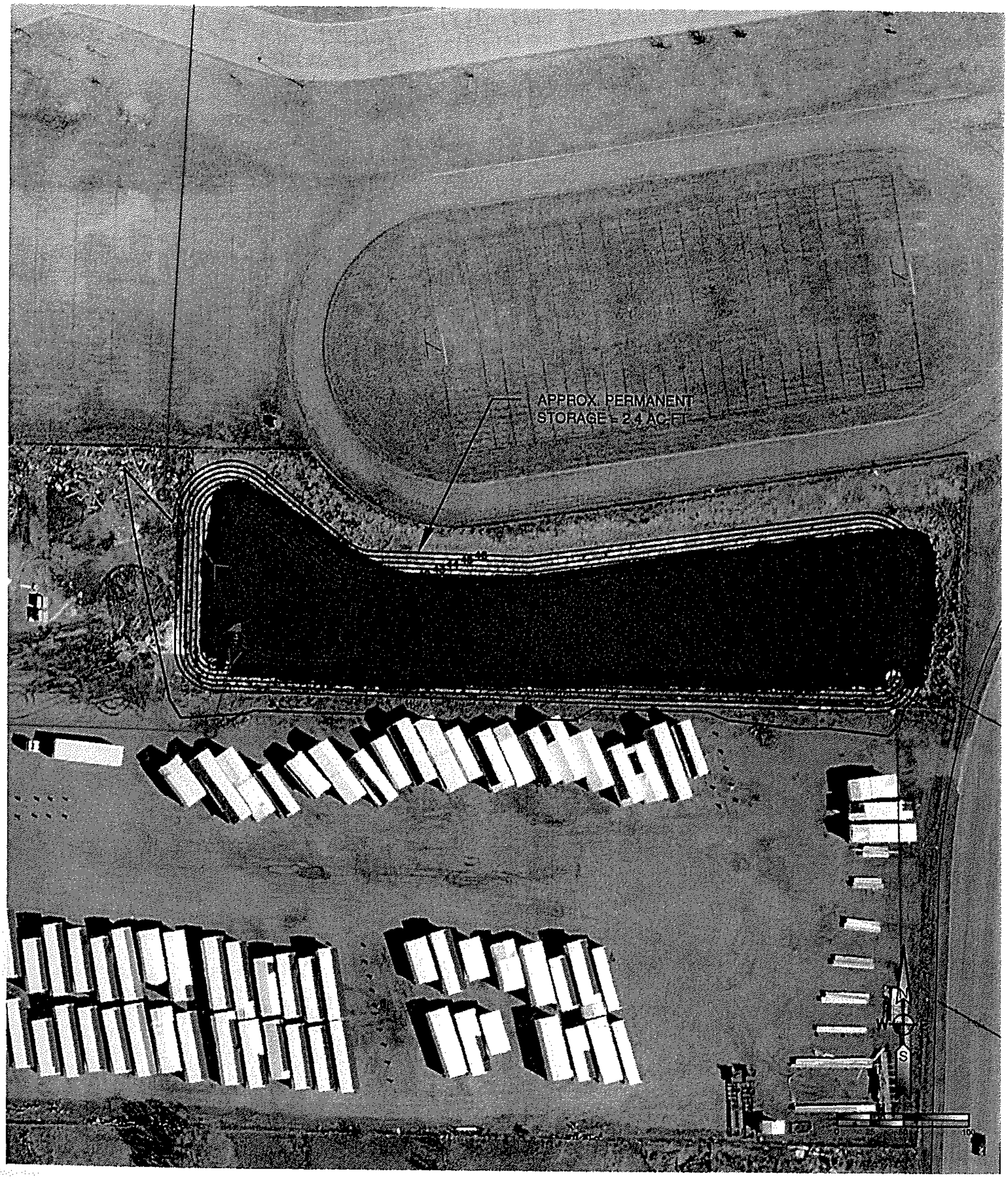

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Exhibit No. 9
Basin E
(Middle School)

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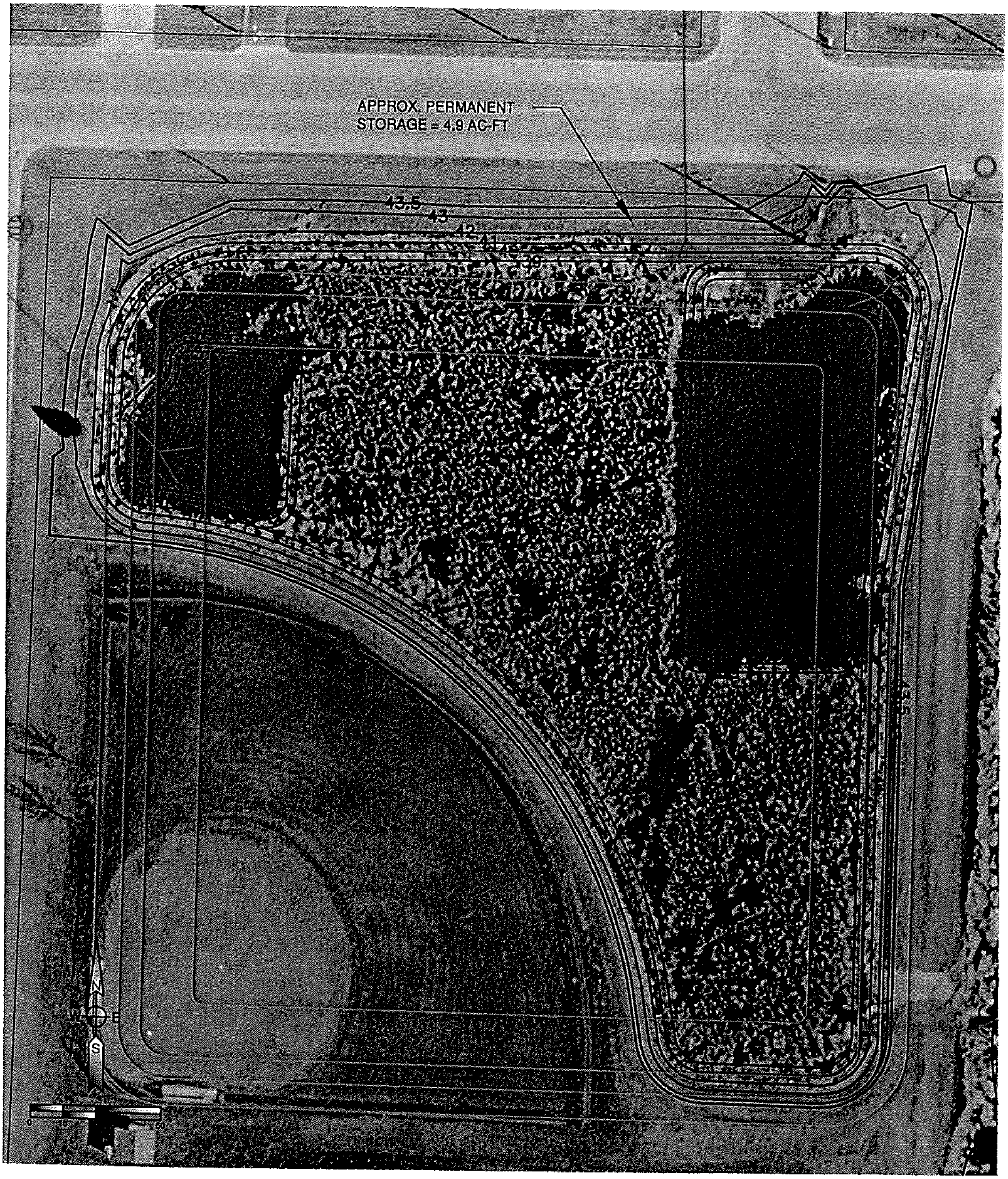

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Exhibit No. 10
Basin F
(Industrial Park Softball Field)

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8.0 Assumptions

As with any modeling, there are various assumptions that are made to develop and build the models. The following are the assumptions that were used for this analysis:

8.1 Consolidation of Inlets

The City is broken into drainage areas more so by intersection than by each individual inlet or catch basin. This method of dividing up the drainage areas was used as it simplifies the data and has minimal impact on the modeling results.

8.2 Time of Concentration

The time of concentration was calculated using the SCS lag method. The equations of this method are below:

$$t_c = \frac{L^{0.8}(S+1)^{0.7}}{1140Y^{0.5}} \text{ (time of concentration)}$$

L = longest length within drainage area

Y = average slope of drainage area

$$S = \frac{CurveNumber}{1000} - 10 \text{ (potential maximum retention)}$$

The Curve Numbers (CN) are used to quantify the terrain type. They range from 0 to 100, with the larger the value or the closer to 100, the more impervious the surface. The CN's were determined using Table 8.7.3 of the 2005 Edition of Water Resources Engineering by Mays and are summarized in the table below:

Terrain Type	CN
Lawns	61
1/4 Acre Residential	75
Impervious	98

Time of concentration calculations are summarized in Appendix No. 4.

8.3 Rational Method Runoff Coefficients

Rational Method Runoff Coefficients were used in the Walker's PondNet model to quantify the terrain type. Rational method runoff coefficients range from 0 to 1, with the larger the value or the closer to 1, the more impervious the surface. The runoff coefficients were determined from Table 3.7 in the MnDOT Drainage Manual. The values used are summarized in table below:

Terrain Type	Runoff Coefficients
Lawns	0.10
1/4 Acre Residential	0.40
Impervious	0.95

The runoff coefficients for each individual drainage area are summarized in Appendix No. 5.

9.0 Analysis and Results

9.1 XPSWMM

9.1.1 Drainage Area Delineations

The first step in creating the XPSWMM model was to divide the studied area into drainage areas. These drainage areas are shown in Exhibit No. 11.

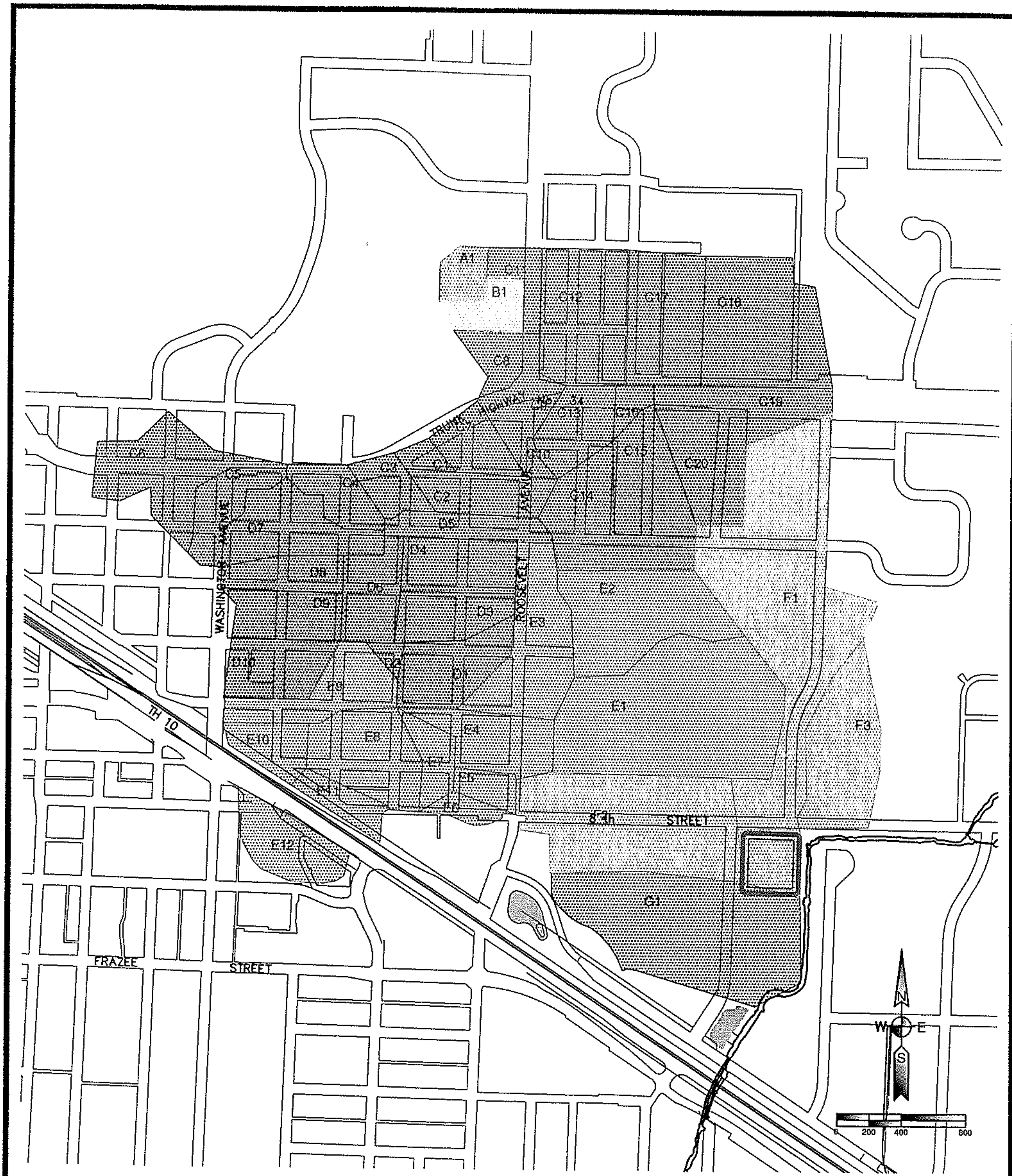

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Exhibit No. 11
Drainage Areas

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9.1.2 Modeled Rainfall Events

For this model, the SCS hydrology method was used with a Type II rainfall distribution. The model was run with a 0.5 inch, 1.0 inch, 2.5 inch, 3.2 inch (5 year), and 5.4 inch (100 year) rainfall events.

9.1.3 Five (5) Year Runoff

The runoff created from a 5 year rainfall is typically the required on site storage to obtain a PRWD permit. For the area studied, the 5 year rain event produced an estimated 40.7 ac-ft runoff. The cumulative permanent storage of the existing stormwater basins is 7.6 ac-ft.

9.1.4 Storm Sewer System Hydraulics

According to the modeling results, the system behaves well hydraulically during small rainfall events; however, it becomes over capacitated, at about the 1 to 2 year rain events.

9.1.5 Basin Performance

Private Basins (Basins A and B)

These basins appear, from a hydraulic viewpoint, to perform well during typical rain events. The models predict flooding conditions during the 100 year rain event.

Basin C (TH 34 Basin)

This basin performs well hydraulically for all storms modeled. There were no flooding conditions observed.

Basin D (Roosevelt Avenue Basin)

This basin performs well hydraulically for all storms modeled. There were no flooding conditions observed.

Basin E (Middle School Basin)

The capacity of this basin is sufficient for all storm events that were modeled. Minor flooding conditions were momentarily observed during the modeling of the 100 year storm event.

Basin F (Industrial Park Softball Basin)

This basin appears to experience moderate flooding for all rain events greater than the 1 to 2 year events. The flooding appears to primarily impact the surrounding softball fields.

Discharge to Pelican River

The only point of discharge to the Pelican River from the studied area is from the outlet at Basin F. The discharge to Pelican River varies with each storm event. The table below is a summary of the rates and volumes discharged to the Pelican River:

Rain Event (in)	Maximum Discharge Rate (cfs)	Volume Discharged (ac-ft)
0.5	9.9	1.5
1	28.5	6.6
2.5	30.6*	24.4
3.2	30.6*	28.3
5.4	30.6*	36.8

* Flooding conditions were observed in the model.

9.2 Walker's PondNet Model

Walker's PondNet model is capable of predicting the pollution removal of the runoff routed through retention basins. Using this model, the estimated phosphorus removal of the total storm sewer network was 29.9 percent. The modeling printout is attached in Appendix No. 5.

9.2.1 Private Basins (Basins A and B)

These 2 basins, working in series, provide phosphorus removal of nearly 42 percent. The mean depth of these basins is not sufficient to produce higher removals.

9.2.2 Basin C (TH 34 Basin)

This basin does not provide any measurable treatment levels, as it only provides detention and not retention for treatment purposes.

9.2.3 Basin D (Roosevelt Avenue Basin)

This basin does not provide any measurable treatment levels, as it only provides detention and not retention for treatment purposes.

9.2.4 Basin E (Middle School Basin)

The mean depth of this retention basin is 1.6 feet. This depth provides an estimated 17.7 percent phosphorus removal. At this point in the system, the cumulative percent of phosphorus removal is 18.2 percent.

9.2.5 Basin F (Industrial Park Softball Basin)

The mean depth of this retention basin is 1.5 feet. This depth provides an estimated 17.7 percent phosphorus removal. The total network phosphorus removal discharge from this retention basin is estimated at 29.9 percent.

9.3 Result Comparison to Current Regulations

As indicated above, there are 2 primary agencies within the Detroit Lakes area that regulate stormwater management and they are the MPCA (NPDES) and PRWD. Below is a comparison of the existing system to these agency's current standards:

9.3.1 NPDES General Stormwater Permit for Construction Activity

The NPDES permit only requires stormwater treatment in instances where 1 new acre or greater of impervious surface is created. However, if this was a newly developed area and the permit did apply, the required permanent storage volume would be 12.2 ac-ft, which is greater than the existing storage of the system of 7.6 ac-ft.

9.3.2 PRWD Permit

The PRWD rate control requirements do not apply to this study as the pre-developed and post-developed rates would be identical, as the area studied is entirely developed.

When comparing the runoff volume of the 5 year rain event to the existing storage of the system's retention basin, the current system has a storage capacity of 7.6 ac-ft and the 5 year rain event produces 40.7 ac-ft of runoff. Therefore, the storage capacity of the existing basins does not meet the current volume requirement standards of the PRWD.

As an alternative to the volume standards, the PRWD requires 50 percent phosphorus removal for all new permits. Currently, the storm sewer system is providing 29.9 percent phosphorus removal.

10.0 Opportunities for Treatment Level Improvements

10.1 Increase Capacity of Existing Retention Basins

Increasing the capacity of the existing basins would be the most economical approach to improving stormwater treatment. Basins C, D, E, and F all have the potential for expansion, not necessarily the footprint, but the depth of these basins could be increased, which would increase the level of pollutant removals. Basins C and D, especially, would see treatment levels increase as these are detention basins and do not provide any measurable treatment at this time.

Based on a preliminary review of increasing depth of these basins, a phosphorus treatment efficiency of greater than fifty (50) percent is likely achievable. Below is a summary of the preliminary review:

- Basin C: remove wetland and vegetation and excavate basin to a mean depth of five (5) feet.
- Basin D: remove wetland and vegetation and excavate basin to a mean depth of four (4) feet.
- Basin E: excavate basin to a mean depth of 3.5 feet.
- Basin F: Remove wetland vegetation and excavate basin to a mean depth of three (3) feet.

10.2 Possible Locations of Future Basins

The area studied is developed therefore, areas for future basins are limited. Perhaps the most feasible location for additional basins is at the location of the Basin F (Industrial Park softball basin). There are 2 softball fields at this location, if these softball fields are not utilized or the games could be relocated to other area fields, these fields could be converted to permanent retention basins.

10.3 Bioretention Basin Discussion

Bioretention basins, or more commonly referred to as rain gardens, are a relatively new method in stormwater management and treatment. Rain gardens are typically well vegetated depressions and can be constructed along the street within the right-of-way of redevelopment areas. This type of treatment can be aesthetically pleasing, when constructed properly and frequently maintained.

The general concept of the rain garden is to capture the initial stormwater runoff, which is referred to as the first flush, as it is the portion of the runoff that contains the highest percentage of pollutants. The captured runoff then infiltrates through a soil filter media and is utilized by the vegetation.

Many communities are implementing this type of treatment in redevelopment areas, as it is an effective method of stormwater treatment and can add significant appeal to the neighborhoods. Typically, cities that are implementing these systems are developing ordinances that require adjacent property owners to conduct all regular maintenance activities. Regular maintenance includes, but is not limited to, pruning overgrown vegetation, watering during dry times, and weeding. The city typically provides the necessary plantings and annually refreshes the mulch liners.

11.0 Summary

The preparation of this stormwater study was requested by the City of Detroit Lakes as a stipulation of the PRWD for the reconstruction of an existing local street on the north side of the City of Detroit Lakes in 2007. During the preparation of this study, 2 computer aided models were developed to assist in analyzing the existing hydraulics of the area and in predicting the existing treatment levels. The following is a brief summary of the results:

- The overall hydraulics of the storm sewer system behaves well for storm events in the 1 to 2 year range; however, the system lags during heavier events and flooding conditions do occur.

- The overall stormwater retention volume of the north side system is less than anticipated if it were a newly developed area. Current storage volume is 7.6 ac-ft and to comply with NPDES requirements, storage volume should be 12.2 ac-ft. Based on the PRWD volume requirements, the required storage volume would be 40.7 ac-ft.

- The estimated phosphorus removal for the entire basin network is 29.9 percent. Current regulations are set at a minimum standard of 50 percent or greater.

Significant infrastructure improvements would be required to increase the hydraulic capacity of the storm sewer system.

The treatment level of the area, as a whole, is less than current regulations and if development or reconstruction should occur within this area, the City would be required to provide additional treatment.

12.0 Conclusion

This study has determined that the current stormwater treatment level within the north side of the City of Detroit Lakes does not meet current regulations; therefore, the City may be required to provide additional treatment to comply with the PRWD regulations for the reconstruction of Curry Avenue in 2007. Additional treatment could be obtained by excavating one or more of the City's existing stormwater basins to greater depths.

The City has the opportunity to expand treatment levels beyond those levels that are required for the treatment of Curry Avenue to accommodate future development or reconstruction projects. If the City chooses to accommodate future projects, this could be done as one project, or as a staged project that could be completed over the course of years. Either way, this should only be completed with the written understanding from the PRWD that any improvements to treatment levels meet or exceed current and future PRWD's needs and that they would allow the City of Detroit Lakes to proceed with projects without the need to provide any additional treatment.

Respectfully submitted,

ULTEIG ENGINEERS, INC.
Consulting Municipal Engineers
Detroit Lakes, Minnesota