Project #08223

CRYSTAL LAKE FLOODING STUDY

PREPARED FOR:

City of Crystal Lake
100 W. Municipal Complex
Crystal Lake, Illinois 60039-0597

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26575 W. COMMERCE DRIVE, SUITE 601, VOLO, ILLINOIS 60073
OFFICE (847) 740-0888 FAX (847) 740-2888

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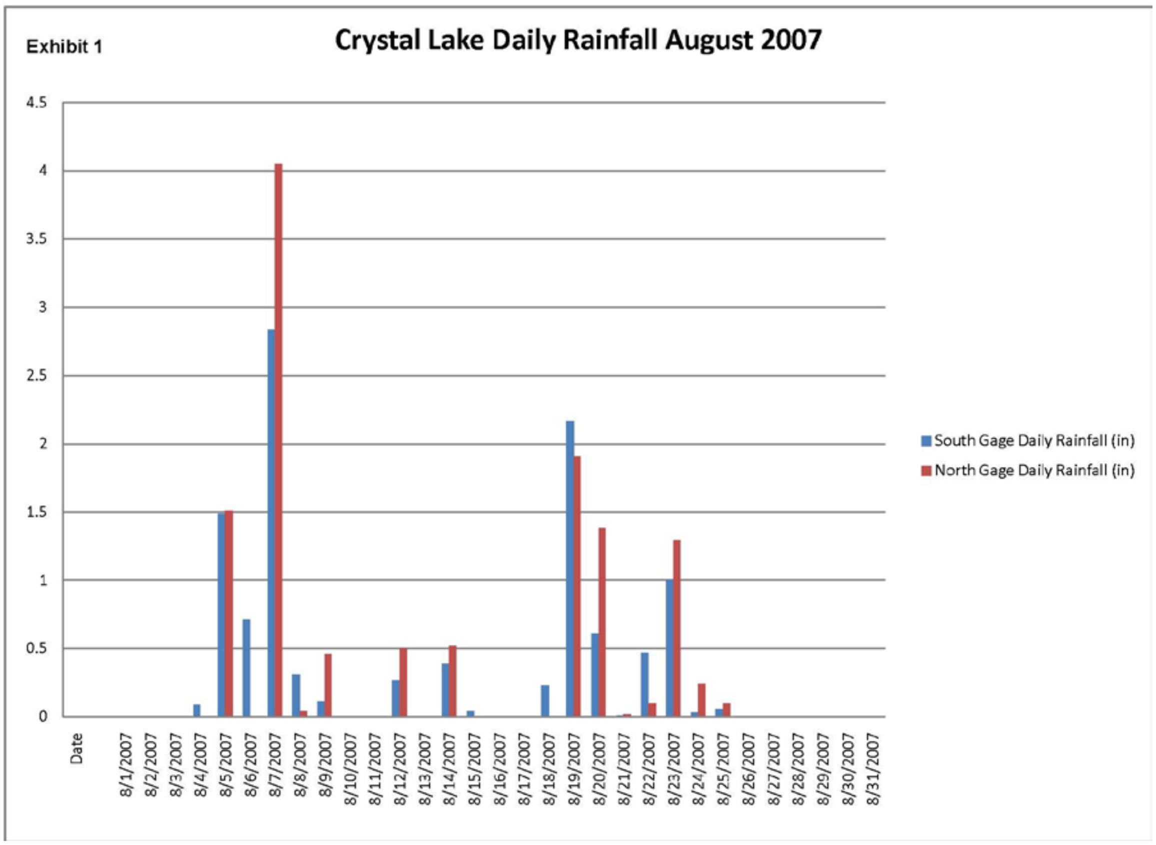
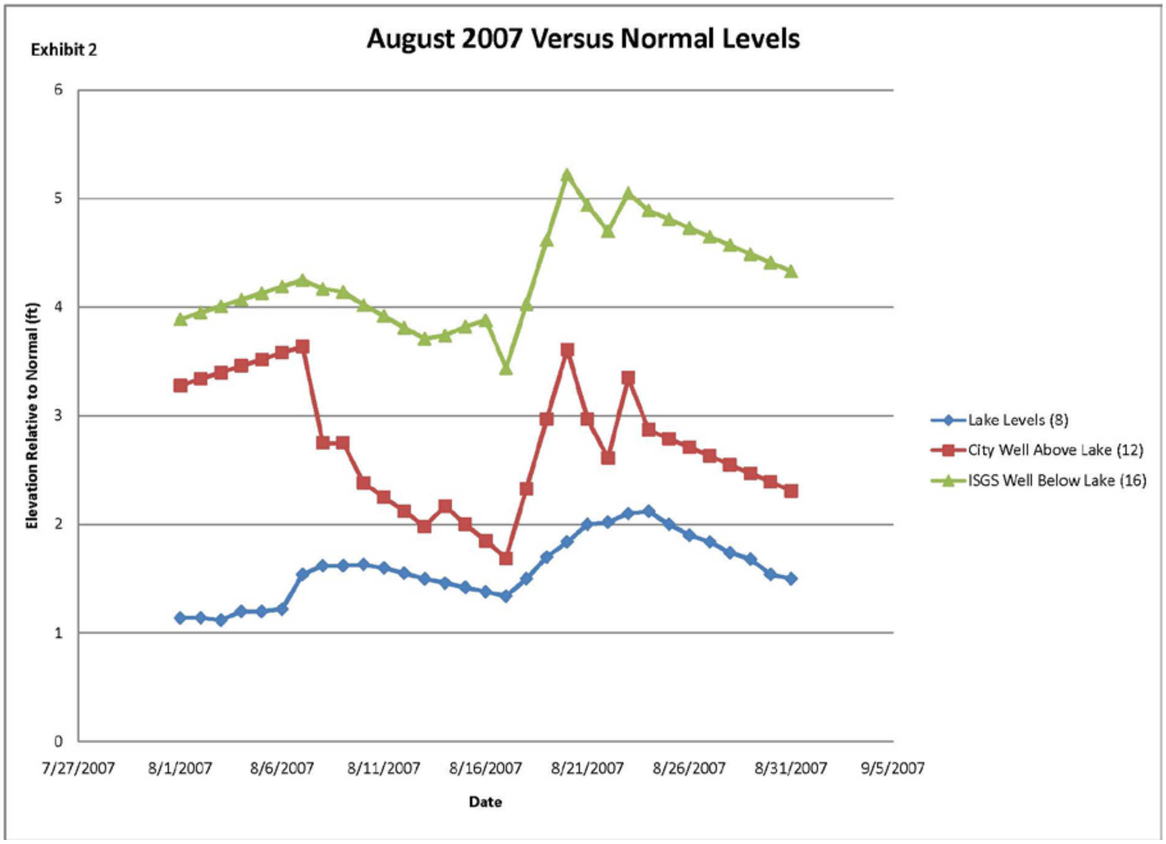
INTRODUCTION

In August of 2007, the area surrounding Crystal Lake received between 11 and 12 inches of rainfall as shown in Exhibit 1. Prior to this rainfall, Crystal Lake had been near or above its spillway elevation of 890.9 for the entire year.



The rainfall produced the highest lake level ever recorded and groundwater levels around the lake reached the ground surface in several locations. Storm sewers were at capacity, overland flow occurred and depressions filled with water that could not drain fast enough. Exhibit 2 shows how lake and groundwater levels exceeded normal circumstances.



At least 60 residents around the lake reported flooding complaints and many more experienced at least some type of flooding problem or inconvenience. North Shore Drive was closed as Cove Pond flowed over the road and traffic was rerouted down Woodland Drive by a temporary connection. The City pumped water from Cove Pond to the lake in an effort to lower water levels. Residents in the Oriole Trail vicinity and on the south side of the lake experienced sanitary sewer backups as well.

The City categorized flooding complaints in a report issued in April 2008. Four areas were identified as shown on Exhibit 3. Area 1 generally is associated with Cove Pond and North Shore Drive. This study further divides Area 1 into three subareas, A-C. Area 1A flows to Area 1B and is bounded by Virginia Street and Crystal Lake Avenue. Area 1B includes Cove Pond, North Shore Drive, the Woodland Wetland and Woodland Drive. Area 1C also flows to Area 1B and is generally the Area east of Virginia Street north and south of Crystal Lake Avenue. Area 2 is the North Shore from East End Avenue to Crystal Beach Avenue. Area 3 is the west end of the Lake from Floresta Vista to North Avenue. Area 4 is the south side of the Lake from Meridian Lane to Riverside Drive. The City did not include an analysis of Crystal Creek and downstream areas in this study. The location and nature of flooding complaints is presented in

Appendix A from the City report. The City also provided residents an opportunity to voice their flooding complaints at an Open House held December 9, 2008. The input received from over 50 residents was included with the earlier complaint database for this study.

The City asked Hey and Associates to diagnose the causes of flooding and to develop conceptual solutions with cost estimates that can address the flooding complaints. The data gathered above were used to classify flooding complaints in each area. The classifications used were as follows.

- High groundwater either natural or due to failed drain tiles
- Inadequate storm sewer capacity (minor drainage system)
- Inadequate overland flow capacity (major drainage system)
- Overbank flooding including FEMA floodplain

High Groundwater

High groundwater within a few feet of the surface is often present throughout the Crystal Lake watershed both above and below the Lake. The slope of groundwater from north to south into the Lake is about 4 feet every 1000 feet (CLPD, 2006). If the groundwater table rises, the Lake level rises with it. If the groundwater table is low, the Lake falls with it. The higher the groundwater table, the less storage is available for rainfall that infiltrates into the ground. This volume of storage in the granular soils (porosity) around Crystal Lake is 15 to 25 percent of the total soil volume (ISWS, 1998).

High groundwater can be the result of several different causes. The first is that the groundwater is naturally high because that is where the water table naturally occurs relative to the geology of an area and the presence of water bodies. The second is that water can pond temporarily in depressions until it can infiltrate into groundwater or evaporate. The third is that drain tiles fail. The naturally high groundwater was lowered throughout the Crystal Lake watershed by the use of field tiles that were built to facilitate farming in the early 1900s. This artificially lowered water table condition was present when much of the area around the Lake was first developed. These tiles are now from 50 to 90 years old and some are failing or have been accidentally destroyed. As a result, groundwater may be returning to its naturally occurring levels.

Storm Sewer Capacity (Minor Drainage System)

Storm sewers are typically referred to as the minor drainage system. They are designed to safely drain away runoff from events that have a 10 to 20 percent chance of occurring in any year (10-year to 5-year event). When these systems are undersized, in need of repair, or when larger rainfall events occur that won't fit in the sewer, water ponds and will attempt to find other routes of flow.

Overland Flow Route Capacity (Major Drainage System)

Storm sewers are not designed to drain larger rainfall events. These larger events that cannot fit into the storm sewer system must be safely conveyed through developed areas in overland flow routes protected by easements. These routes are called the major drainage system and are intended for events that have a less than 10 percent chance of occurring in any year (greater than 10-year event). When a safe overland flow route does not exist, excess runoff causes flooding.

Crystal Lake's topography contains frequent depressions without natural overland flow routes. This creates flooding risks when rainfall exceeds storm sewer system capacity and when infiltration capacity is not available due to high groundwater. There are depressions in each of the four flooding complaint areas that flood.

Overbank Flooding

Overbank flooding refers to the condition where a stream or lake overflows its banks. The floodplain maps prepared by FEMA map overbank flooding risk. When a base flood elevation is determined under the Crystal Lake Stormwater Ordinance, it often documents the extent of overbank flooding.

In Crystal Lake, overbank flooding occurs at two major locations. The first is the Lake itself. It has a 100-year (one percent chance in any year) flooding elevation of 892.6. The second is Crystal Creek below the Lake. It also has a base flood elevation that ranges from 891.2 at Lake Avenue to 891.0 at Country Club according to FEMA (Appendix B)(FIRM, Map No. 17111C, Panels 326J, 327J, effective 11-16-06).

DRAINAGE BACKGROUND

The area surrounding Crystal Lake reflects the lake's hydrologic influence. It also reflects over 100 years of development and infrastructure much of which occurred over the last 60 years.

Drainage above the Lake is controlled first by the Lake itself. When its levels are high the groundwater table above the Lake is high as well. When the Lake is low groundwater levels above the Lake are lower.

Drainage reaches Crystal Lake by the following major routes (Exhibit 3).

- The Crystal Lake Drainage District (CLDD) tile system constructed in 1917 and the Crystal Lake Park District's Lippold Park Wetland Restoration (affects Area 2).
- The storm sewer discharge from Crystal Cove Pond (affects Area 1). Cove Pond receives flow from the tile system on the Hoyne property and the storm sewers that serve the area along Virginia Street (Area 1A).
- A loosely connected system of pipes and drywells that serve the Greenfield Road area (affects Area 2).
- Groundwater that infiltrates through the sand and gravel deposits that extend from Crystal Beach Avenue on the west to Virginia Street on the east and on the west end of the Lake (affects Areas 1, 2 and 3).
- There also is an important sub-drainage area, referred to in this report as the Woodland Wetland, that is bounded by North Shore Drive, Woodland Drive, and Virginia Street (Area 1B). This area receives storm sewer discharges from the area east of Virginia Street and does not have a well defined outlet. At one time, it was connected by a 48-inch pipe under North Shore Drive with Cove Pond but this was abandoned by the City around 1967. There also may be an ineffective storm sewer connection to the culvert that drains Cove Pond.

Drainage leaves Crystal Lake in three known ways (Exhibit 4).

- The first and most efficient outlet is flow over the weir and through the culvert under Lake Avenue. This flow then proceeds down Crystal Creek and into the myriad of pipes downstream described earlier.
- The second outlet is groundwater flow. Most of this flow exits the Lake in the vicinity of Crystal Creek. Flow also exits along the Lake's south side. However, this groundwater flow turns and moves parallel to the lake to the east where it joins groundwater flow at the east end of the Lake and then proceeds generally under Crystal Creek.
- Direct infiltration into existing storm and sanitary sewers. In particular, observations have shown that the 24-inch storm sewer along Riverside Drive between Lake Avenue and Country Club Road flows nearly full at all times if the Lake is above elevation 887. This indicates a large constant water source, i.e. the Lake.

Drainage south of the Lake (Area 4) is controlled by topography and limited storm sewer capacity. This area did not have any storm or sanitary sewers until the 1940s (IDPW, 1949). The first drainage system installed was a combined sanitary and storm sewer system (IDPW, 1949). This system was separated into independent storm and sanitary systems in the 1950s. Area 4 bounded by Broadway Street, Country Club Road, Meridian Lane and Crystal Creek is drained by part of this system which originates to the west in Lakewood. A storm sewer branch under Broadway Street drains into an old 24-inch tile line 5 feet under Crystal Creek that serves as a storm sewer. Another storm sewer drains Wedgewood Subdivision and the southern part of Area 4 directly to Crystal Creek but is about 5 feet higher than the Broadway Street storm sewer.

The 24-inch storm tile extends to a junction box above Lundahl School at Nash Road and the Creek. Crystal Creek itself passes through culverts at Country Club Road before entering a 30-inch culvert and proceeding underground to the same junction box as the 24-inch tile. Flow from the CLPD detention basin at Main Beach also enters this junction box in a 24-inch tile down Nash Road. Another 30-inch storm sewer also enters the box from McHenry Avenue. Flow leaves the box by three approximately 36-inch culverts and then enters the Creek at St. Andrews Lane.

AUGUST 2007 MONITORING AND FLOODING SEQUENCE

The flooding during August of 2007 was recorded by the CLPD as part of their Lake protection efforts. The CLPD has maintained the hydrologic monitoring program that was part of its Clean Lakes study with the IEPA. The components of the monitoring program that were active in August 2007 are shown on Exhibit 5.

The most relevant monitoring locations by area are listed below and identified by their map number.

Area 1 Wells (12) and (15) and Cove Pond flow to the Lake (13) and Lake outflow (8)

Area 2 Honeysuckle Drive storm sewer flow (3) and Well (15) and Lake outflow (8)

Area 3 Well (16) and Lake outflow (8)

Area 4 Wells (7), (16) and (17), Lake outflow (8) and Lakewood storm sewer flow (9)(10).

These data were combined with engineering data for the existing minor and major drainage system in each of the three areas from City design drawings and residents' flooding complaints to form the basis for the evaluation of causes of flooding.

At the end of July 2007, Crystal Lake had been at or above its weir elevation nearly the entire year. This was unusual since the Lake typically is below its weir elevation two-thirds of the time (CLPD, 2006). The large storage volume that is normally available in the Lake (as much as the runoff from a one-year event for its watershed) was already filled with water when the August rains began. As a result of the groundwater table above and below the Lake also was higher than normal. Storage that was normally available within the soil was already filled with water. Residents above the Lake had already been complaining of high groundwater problems.

The unusually high amounts of rainfall on August 5th through 9th caused the CLDD tile system and the storm sewers from the west side of Crystal Lake into Cove Pond to discharge at full capacity into the Lake. These inflows to the Lake exceeded outflows and water levels rose. Rising groundwater levels also meant rising Lake levels. The rising Lake levels reduced the already small capacity of the Cove Pond outlet and caused the pond to rise, flooding the storm sewers that lead into it.

When 5 inches of rainfall occurred between August 19th through the 23rd, there was nowhere for the water to go since groundwater infiltration was impossible because of already high water tables. Surface runoff entered storm sewers and flowed into Cove Pond. The inadequate capacity available through Cove Pond's outlet pipe was further restricted by high Lake levels. This caused water levels to rise in Cove Pond and flood over North Shore Drive. The depressions in Areas 1, 2 and 3 all filled with water. Because groundwater infiltration was shut off, overland flow filled the detention area at Lippold Park then flowed along its natural drainage path and into Area 2 making flooding problems worse.

Below the Lake, the 24-inch tile line was flowing full and had no capacity. This caused water to pond in Area 4 as the groundwater table rose to at or near the surface. Crystal Creek also had significant flow in it causing flooding downstream due to the inadequate pipe and culvert capacity where the stream is conveyed underground. The limited capacity in the County Club Road storm sewer was exceeded causing overland flow. The lack of a defined major drainage system caused this water to pond in Area 4.

FLOODING COMPLAINTS

The Crystal Lake Flooding Report (April, 2008) is reproduced in Appendix A. It lists all of the flooding complaints received by the City as a result of the August rainfall and also classifies them by type: yard flooding, street flooding, basement flooding, and sanitary backups.

The City also held an Open House on December 9, 2008 to invite residents to learn more about the August 2007 flooding and to receive new or additional flooding complaints from residents. Over 50 residents attended the Open House and shared their flooding concerns. The information they provided has been saved in the City's flooding complaint file.

The results of the original flooding complaint list and the comments received at the Open House are summarized on Exhibit 6 also by location and type. Exhibit 6 presents the following data in relation to the flooding complaints.

- FEMA floodplain based on current mapping
- Topography, particularly depressions that do not drain well

- Hydric soils indicating frequent inundation
- Wetlands also indicating the frequent presence of water
- Storm sewers
- Drain tiles

CLASSIFICATION OF FLOODING COMPLAINTS

Each of the four flooding complaint areas defined by the City was examined in this study and flooding was diagnosed and classified according to the classification system presented in the Introduction. The flooding analysis for each area follows.

Area 1 Flooding Complaints

Area 1 was subdivided into three subareas 1A, 1B and 1C to better focus on the specific flooding complaints. Area 1A includes the area around Sycamore Lane and Green Oaks Drive north of Crystal Lake Avenue and west of Virginia Street including the Hoyne, State Farm and DiMonte properties. Exhibit 1B includes the area around North Shore Drive south of Crystal Lake Avenue and west of Virginia Street. Cove Pond, the Woodland Wetland, North Shore Drive and Woodland Drive are included in this area. Area 1C includes the area around Pine Street and Oriole Trail east of Virginia Street. Table 1 documents flooding causes for each flood complaint in Area 1.

Table 1 Flooding Complaint Analysis and Classification – Area 1A-C

Name of Area	Address	Flooding Location	Flooding Cause			
			Minor Damage	Major Damage	High Groundwater	Overbank Flooding
Area 1A	131 N. Virginia Avenue	Yard	Depression		Drain Tile	
	59 Sycamore Lane	Yard			Drain Tile	
	668 Green Oaks Drive	Yard			Drain Tile	
	632 Green Oaks Drive	Yard			Drain Tile	
Area 1B	854 North Shore Drive	Basement/Crawl	Culvert			
	820 North Shore Drive	Basement/Crawl	Culvert			
	816 North Shore Drive	Yard	Culvert			
	811 North Shore Drive	Yard	Culvert			
	807 North Shore Drive	Yard	Culvert			
	803 North Shore Drive	Yard	Culvert			
	350 Fairview Park Avenue	Yard	Culvert			
	794 North Shore Drive	Yard	Culvert			
	785 North Shore Drive	Basement/Crawl	Culvert			
	780 North Shore Drive	Yard	Culvert			
	740 Woodland Drive	Road	Culvert			
	707 Woodland Drive	Yard				
	701 Woodland Drive	Basement/Crawl				
	700 Woodland Drive	Yard	Culvert			
	690 Woodland Drive	Yard	Culvert			
	591 Woodland Drive	Yard	Culvert			
	610 Woodland Drive	Yard	Culvert			
	606 Woodland Drive	Yard	Culvert			
Area 1C	132 N. Virginia Avenue	Yard				
	490 W. Crystal Lake Avenue	Sanitary	Storm Sewer			
	468 Crystal Lake Avenue	Basement/Crawl	Storm Sewer			
	505 W. Crystal Lake Avenue	Basement/Crawl	Depression/ Storm Sewer			
	489 W. Crystal Lake Avenue	Yard	Depression/ Storm Sewer			
	25 S. Virginia Avenue, Unit 202	Basement/Crawl	Depression/ Storm Sewer			
	494 Pine Street	Basement/Crawl	Depression/ Storm Sewer			
	15 Oriole Trail	Sanitary				
	25 Oriole Trail	Sanitary				

= Problem

Area 1A Exhibit 7 presents the data that were available for Area 1A. It shows both a plan (looking down) and profile (looking through) of the flooding areas, measured groundwater levels, field tiles and storm sewers. These are about 50 residences and businesses in Area 1A.

The minor drainage system for Area 1A consists of a 10-inch storm sewer under Green Oaks Drive and a 12-inch storm sewer under Sycamore Lane both of which drain to a 48-inch storm sewer that empties into Cove Pond. This 48-inch sewer used to connect with the sewer from the west under Crystal Lake Avenue then crosses under Virginia Street. When Cove Pond was built, this 48-inch sewer was split and re-directed into Cove Pond sooner as shown on Exhibit 9. Virginia Street drains through a 30-inch storm sewer and then into the 48-inch storm sewer before it enters Cove Pond. Hey and Associates partially mapped a field tile system in 2001 that exists in this area as well. The main tile line is a 10-inch tile that is about three feet underground and discharges to Cove Pond and acts as the minor drainage system for the Hoyne, DiMonte, and State Farm parcels.

Soils throughout this area are granular below the first few feet of topsoil and drain rapidly (>20 inches per hour) when capacity is available. Hydric soils are present in depressions indicating pockets of poor drainage. They also contain significant potential water storage in their void spaces.

The major drainage system for Area 1A consists of flow down Sycamore Lane and Green Oaks Drive across the walking trail and into Cove Pond. It also includes depressions and hydric soil areas particularly around the State Farm infiltration basin and is not well defined.

The groundwater table in Area 1A is controlled by soil properties, the water elevation in Cove Pond, storm sewers and the field tile system. During early August 2007, measured groundwater levels had already risen to near the surface. The large rainfall of August 2007 consumed the remaining soil storage, filled depressions and overwhelmed the limited storm sewer capacity available. The outlet capacity from Cove Pond was limited by sediment at the Lake and high Lake levels. This caused Pond levels to rise rapidly and overflow North Shore Drive. During the August 2007 flooding, groundwater levels were ponded as much as 6 inches above the ground west of Sycamore Lane. Based on these measured data the conclusion is that flooding in Area 1A resulted from the following causes.

- Inadequate culvert outlet capacity from Cove Pond
- High groundwater due to high Cove Pond elevations, inadequate tile capacity and large rainfall volume
- Inadequate major drainage system conveyance
- Inadequate minor drainage system for Hoyne, State Farm, and DiMonte properties

Area 1B Area 1B is shown on Exhibit 8 along with available flooding data. There are about 125 residences in Area 1B. The minor drainage system for Area 1B consists of the 58-inch by 36-inch outlet culvert from Cove Pond, a 15 and 18-inch storm sewer from Virginia Street into the Woodland Wetland and an unidentified possible outlet from the Woodland Wetland into the Cove Pond outlet culvert. The Woodland Wetland and Cove Pond were once one wetland. The Woodland Wetland was isolated from

Cove Pond by the construction of North Shore Drive and the abandonment of a former 48-inch connector pipe around 1967 by the City.

Soils through this area are mostly granular with some hydric soils in depressions and near the Lake. Infiltration capacity is limited because Area 1B is only a few feet above the spillway elevation for the Lake and therefore always has groundwater near the surface. All of Area 1B except for a narrow isthmus along Woodland Drive and west along North Shore Drive is within the 100-year floodplain of the Lake.

The major drainage system for this area consists of overland flow down streets and through lots to Cove Pond, the Woodland Wetland and the Lake. When Cove Pond's outlet capacity is exceeded, it fills and will overtop North Shore Drive at an elevation of about 892. The low point where overflow begins causes water to enter the Woodland Wetland where it is trapped until it overflows to City property adjacent to East Street and then to the Lake at elevation 893.17. The City improved this overland flow route to the Lake in August 2007 to reduce flooding.

During the August 2007 flooding, Cove Pond's outlet capacity was exceeded and its water surface elevation overtopped North Shore Drive. The outlet capacity from Cove Pond was reduced by high Lake levels and the fact that half of the culvert was below the level of the shoreline at the Lake and filled with soil. The lack of groundwater storage and continued rainfall caused Cove Pond to overflow North Shore Drive for several days, filling the Woodland Wetland and causing it to flow to the Lake along East Street. The water was 6 to 9 inches deep over North Shore Drive closing the road and effectively isolating the residents to the west. A temporary road was created to connect East End with Woodland Drive so residents could get in and out. The City has constructed a permanent emergency access in this location for any future incidents.

Based on the measured water surface elevations and the sequence of flooding events in Area 1B, the following diagnosis of flooding problems was reached (Table 1).

- Inadequate outlet capacity from Cove Pond
- Inadequate safe major drainage system conveyance from Cove Pond to the Lake
- Lack of both a minor and a major drainage outlet from the Woodland Wetland to the Lake
- High groundwater

Area 1C This area is shown on Exhibit 9 along with hydric soils, depressions, storm sewers and groundwater elevations. There are about 50 residences and businesses in Area 1C. The minor drainage system for Area 1C consists of a storm sewer system that collects runoff from Oriole Trail, Pine Street, and Crystal Lake Avenue and conveys it west under Virginia into the upper end of Cove Pond. The Crystal Lake Avenue storm sewer system actually collects water from about 250 acres and is bounded by Route 176 on the north, Lincoln Parkway on the east and Carpenter Street on the south (Exhibit 3).

The storm sewer system capacity is restricted by the limited hydraulic grade line from the 36-inch sewer on Crystal Lake Avenue through Cove Pond to the Lake. This section of the storm sewer system is very flat since it is barely above Lake level with low areas below 892.0. When Cove Pond is at the Lake spillway elevation of 890.9, the capacity in this sewer is only about 40 cfs before surcharging begins. This is probably equivalent to less than the 2-year event (50% chance in any year).

The soils in Area 1C are granular with about a 15 to 25 percent porosity ratio and rapid permeability. The groundwater elevations in the area are controlled by Cove Pond to the west. The apparent groundwater divide is located to the south near Dole Avenue where groundwater has been diverted directly toward Crystal Creek by the storm and sanitary sewers in this area.

The area around Pine Street and Oriole Trail and Crystal Lake Avenue lacks a safe major drainage system. When capacity is not available in the storm sewers, overland flow collects in the depressions, particularly north of Pine Street where many of the flooding complaints occurred as shown on Exhibit 9. If groundwater is high, there is no capacity to store runoff in soils. Also, the bottom of the Pine Street depression is below the invert of adjacent storm sewers and cannot drain to them currently. This depression filled with water during the August 2007 flooding because it could not infiltrate and capacity was not available in the storm sewers. One of the residents has provided stormwater pumping from this area for two decades to prevent flooding of houses. Without this pumping, flooding would have been much deeper and damages worse.

This area also reported sanitary sewer backups. This appears related to infiltration and inflow into the sanitary sewers.

Based on these measured data, the conclusion is that flooding in Area 1C resulted from the following causes.

- Inadequate outlet capacity from Cove Pond which causes ponding which in turn reduces the capacity of the Crystal Lake Avenue storm sewer
- High groundwater due to high Cove Pond elevations, unavailable storm sewer capacity and large rainfall volume
- Inadequate minor and major drainage system conveyance from the Oriole and Pine depression

Area 2 Flooding Complaints

Area 2 covers the north shore of the Lake from East End Avenue to Edgewood Drive and is shown on Exhibit 10. This area does not have a well organized minor drainage system. The only drainage system in this area is a collection of private field tiles and drywells that drain to the Lake at East End Avenue. The classification of flooding complaints for Area 2 is shown in Table 2. There are about 125 residences and businesses in Area 2.

Table 2 Flooding Complaint Analysis and Classification – Area 2

Name of Area	Address	Flooding Location	Flooding Cause			
			Minor Damage	Major Damage	High Groundwater	Overbank Flooding
Area 2	137 Mayfield Avenue	Yard			Drain Tile	
	100 Crystal Beach Avenue	Yard			Drain Tile	
	153 Crystal Beach Avenue	Yard			Drain Tile	
	87 Crystal Beach Avenue	Basement/Crawl	Depression		Drain Tile	
	88 Crystal Beach Avenue	Basement/Crawl	Depression		Drain Tile	
	1031 North Shore Drive	Yard			Drain Tile	
	144 N. Greenfield	Yard	Depression		Drain Tile	
	148 N. Greenfield	Yard	Depression		Drain Tile	
	152 N. Greenfield	Yard	Depression		Drain Tile	
	170 N. Greenfield	Yard	Depression		Drain Tile	
	121 N. Greenfield	Yard			Drain Tile	
	151 N. Greenfield	Yard	Depression		Drain Tile	
	164 E. End Avenue	Yard	Depression		Drain Tile	
	159 E. End Avenue	Yard	Depression		Drain Tile	
	947 North Shore Drive	Sanitary				

[shaded box] = Problem

The soils in this area are a combination of hydric within depressions (particularly around Greenfield Road) and granular elsewhere. The granular soils have a very high infiltration rate and this entire area overlies the major groundwater flow path to the Lake. Groundwater is very near the ground surface. When the Lake is below its spillway, the water table is 3 to 5 feet below the surface. When the lake is at or above the spillway, the water table is as little as 1 to 3 feet below the surface.

There is no organized major drainage system along the north shore area. In particular there is a large depression just north of North Shore Drive extending from Crystal Beach Avenue to East End Avenue. During the August 2007 flooding, this area filled with water as a result of high groundwater and runoff from Area 2 and the entire watershed to the north. Flooding in this area has been reported many times before.

Flooding in Area 2 during August 2007 resulted from the following factors.

- Lack of an adequate minor drainage system to convey routine flows
- High groundwater related to high Lake levels that restricted infiltration of the large amounts of runoff
- Lack of a major drainage route to reduce flood heights in the existing depression and to convey extreme runoff events safely through the area
- Large runoff volumes from the entire watershed to the north

Area 3 Flooding Complaints

Area 3 covers the west end of the Lake and is shown on Exhibit 11. Area 3 also does not have a storm sewer system or any organized minor drainage system except at its far west end along Briarwood Road. The classification of flooding complaints in Area 3 is shown on Table 3. There are about 50 residences in Area 3.

Table 3 Flooding Complaint Analysis and Classification – Area 3

Name of Area	Address	Flooding Location	Flooding Cause			
			Minor Damage	Major Damage	High Groundwater	Overbank Flooding
Area 3	57 Timber Hill	Sanitary				
	1381 Floresta	Basement/Crawl	Depression			
	1378 Gardena Lane	Yard	Depression			
	1364 Snowberry Lane	Yard				
	1344 Snowberry Lane	Yard	Depression			
	1324 Snowberry Lane	Yard	Depression			
	1370 North Avenue	Yard				
	1338 North Avenue	Yard				
	364 Corrine Avenue	Sanitary				

= Problem

The soils in Area 3 are granular and have a high infiltration rate. The groundwater table is slightly below the surface because Area 3 is near Lake level.

There are depressions near Floresta Lane, west of Edgewater Drive and between Gardina Lane and Snowberry Lane and several smaller depressions throughout Area 3. There is no defined safe major drainage system for larger runoff events. Portions of the eastern part of Area 3 are within the FEMA 100-year floodplain.

During the August 2007 flooding, water accumulated in the depressions and then flowed overland through yards in the Gardina Lane and Snowberry Lane areas. There was little infiltration given the high Lake levels and no organized drainage route to move water away from the area.

The causes of flooding during August 2007 for Area 3 were as follows.

- Lack of an adequate minor drainage system to convey routine flows
- High groundwater related to high Lake levels that restricted infiltration of the large amounts of runoff
- Lack of a major drainage route to reduce flood heights in the existing depressions and to convey extreme runoff events safely through the area

Area 4 Flooding Complaints

Area 4 is bounded by Broadway on the north, Country Club Road on the south, Meridian Lane on the west and Crystal Creek on the east and is shown on Exhibit 12. The classification of flooding complaints for Area 4 is shown in Table 4. There are about 80 residences in Area 4.

Table 4 Flooding Complaint Analysis and Classification – Area 4

Name of Area	Address	Flooding Location	Flooding Cause			
			Minor Damage	Major Damage	High Groundwater	Overbank Flooding
Area 4	901 Broadway Avenue	Basement/Crawl	Depression			
	471 Meridian	Basement/Crawl	Depression			
	481 Meridian	Basement/Crawl	Depression			
	491 Meridian	Sanitary				
	460 Melrose Lane, Gate 10	Sanitary				
	460 Cumberland Lane	Basement/Crawl	Depression			
	779 Broadway Avenue	Sanitary				
	440 Riverside Drive	Basement/Crawl	Depression			
	460 Riverside Drive	Basement/Crawl	Depression			
	500 Riverside Drive	Basement/Crawl	Depression			
	496 Edgebrook Drive	Basement/Crawl				
	615 Edgebrook Drive	Basement/Crawl				

= Problem

Area 4 is served by a 24-inch storm sewer down Broadway that connects to a 24-inch tile that flows about 5 feet under Crystal Creek. This tile is very old and starts near Lake Avenue and extends to the junction box above Lundahl School as shown on Exhibit 5 (IDPW, 1949; ISWS, 1957) and recently has had repairs undertaken by the Village of Lakewood to maintain its capacity. Another 21-inch storm sewer drains Area 4 along Country Club Road but this sewer is about 5 feet higher than the Broadway Street sewer and it flows directly into Crystal Creek. This same sewer was enlarged when it was constructed in 1968 to serve the Wedgewood property.

The City hired a consulting firm to evaluate the role of Wedgewood in flooding in Area 4 in 1999. Their conclusion was that Wedgewood was not an issue. The problem was the inadequate capacity available in the Country Club Road storm sewer (or any storm sewer given the flat topography) and the fact that the major drainage system directed water into the depressions in Area 4 especially along Meridian Lane and Melrose Lane. We concur with that analysis.

The soils in Area 4 range from hydric in the north to very low infiltration rate soils in the south. Groundwater in the area is very near the surface due to the hydrogeology of the south side of Crystal Lake. Groundwater leaves the Lake along its south side. This groundwater then flows east toward Crystal Creek under Area 4 (ISWS, 1957; ISGS, 2005). Groundwater is typically only 2 to 4 feet below the ground surface but during periods of high rainfall may approach the surface.

The major drainage system within Area 4 is not well organized and defined. There are a number of small depressions that collect water and eventually overland flow moves from west to east through the middle of Area 4 to Crystal Creek. Most of these depressions have bottoms at 890.0 and spill at 892.0. Crystal Creek's bottom where this route enters the creek is at about 888.0.

The eastern portion of Area 4 is within the 100-year FEMA floodplain and also contains floodway along Crystal Creek. As described earlier, Crystal Creek conveyance above St. Andrews Lane is limited by culverts that convey the stream underground and result in a large floodplain area when the capacity of these culverts is exceeded.

The Village of Lakewood's analysis of the August 2007 flooding concluded that flooding resulted from high groundwater and inadequate minor and major drainage systems. We concur with that analysis and found the same problems for Area 4. The 24-inch sewer and tile that flows under Crystal Creek only has about 5 to 6 cfs of capacity. This capacity was obviously inadequate during the August 2007 flooding. Lakewood attempted to augment this limited capacity by pumping stormwater from the tile downstream but even with this assistance it took weeks to drain the area. The storm sewer along Country Club Road also has limited capacity and was designed to convey only about 3.3 cfs. The major drainage system along Country Club Road and Broadway routes flow into Area 4. Once in Area 4, it ponds and either infiltrates, evaporates or flows overland to the Creek through the middle of the Area.

The causes of flooding in Area 4 are as follows.

- Inadequate minor drainage system capacity for Crystal Creek including the entire system to at least St. Andrews Lane.
- Inadequate minor drainage capacity for both Broadway Street and Country Club Road.
- Inadequate major drainage system capacity including the entire length of Crystal Creek to at least St. Andrews Lane.
- Inadequate major drainage capacity and routing along Broadway Street, Country Club Road and through Area 4.
- High groundwater resulting from high Lake levels, inadequate minor and major drainage system capacity and unusually large rainfall volumes.

ALTERNATIVE SOLUTIONS

Tables 5-9 present a list of alternative solutions by flooding area. The alternatives include traditional urban public works drainage measures such as storm sewers and pumping stations but also include non-traditional approaches such as field tiles for groundwater management. The specific types of solutions considered include the following.

- New or larger storm sewers or smooth walled perforated pipe
- Improved overland flow conveyance
- New or repaired field tiles to lower groundwater levels
- Stormwater pumping stations

Each potential solution identified in Tables 5-9 was evaluated first using the following criteria.

- Flooding problem addressed
- Complaints addressed
- Residences affected
- Potential offsite impacts resulting from implementation
- Cost

Appendix C presents conceptual cost estimates for each alternative.

Area 1

Table 5 presents a summary of the benefits and costs of alternative flooding solutions for Area 1.

Table 5 Alternative Comparison – Area 1

	Problems Addressed							
Area 1A	High Groundwater	Minor Drainage Deficiency	Major Drainage Deficiency	Floodplain/ Floodway Reduction	Lots Served	Cost	Ecological Effects	Other Impacts
1. New field tile system through Hoyne					10	$52,000		
2. Repair existing field tile through Hoyne property					4	$52,000		
3. New storm sewer through Hoyne property					10	$152,000		
4. New overland drainage swale through Hoyne property					10	$71,000		
5. New relief storm sewer to Crystal Creek watershed					4	NA	Lake Diversion	Increased Flooding
Area 1B								
6. New culverts under Northshore Drive					20	$94,000		
6A. New Open Channel From Northshore to Lake					20	$90,000	Added Habitat	
6B. New culverts from Northshore to Lake					20	$198,000		
7. Re-route Northshore Drive					20	$551,000	Added Habitat	Better Traffic Control
6 or 7. Culvert from Woodland Wetland to Lake					20	$32,000		
8. Add fill to selected lots	Not Effective							
9. Add storage at Cove Pond					20	$5,499,000	Trees and Wetland Lost	
Area 1C								
10. Pine relief storm sewer at 891 invert to existing sewers					10	$132,000		
11. Stormwater pumping station at 891.0 from Pine to Lake					10	$109,000		

Area 1A

Each of these alternatives is illustrated on Exhibit 13.

1. New field tile system through Hoyne property.

This alternative would add more drain tile capacity with or without repairing the existing system to better drain Area 1A. Additional drainage capacity would be available to restore the infiltration function of the State Farm basin and to facilitate future development along Virginia Street. The drain tile system would be modeled after the CLDD system which lowers the water table above the Lake. This will allow future development to meet the groundwater separation and infiltration requirements of the Crystal Lake Watershed Stormwater Design Manual and earn the Watershed Ordinance exception. This system would be designed to have 10-year capacity.

2. Repair existing field tile system through Hoyne property.

This alternative would restore the existing field tile system through the Hoyne property to lower groundwater levels in Area 1A. The existing system has some function but it appears to have deteriorated significantly. Repairing the tile would benefit flooding in the area by lowering groundwater levels to reduce sump pump operation. Lowering groundwater would increase storage capacity for rainfall within the permeable soils of the area to also reduce flooding. More rapid drainage of the area also would reduce the duration of flooding. Repairs would provide 2 to 5-year capacity.

3. New storm sewer through Hoyne property.

Alternative 3 would be a new storm sewer system with 10-year capacity instead of a new field tile system through the Hoyne property. This storm sewer would connect to the existing 48-inch storm sewer discharge to Cove Pond and would not technically create a new storm sewer discharge to the Lake. However, it conflicts with the Watershed Ordinance and the Crystal Lake Watershed Management Plan by potentially allowing new development to discharge directly to storm sewers.

4. Improved overland flow route through Hoyne to Lake.

Alternatives 1, 2 and 3 also would include grading a new overland flow swale to act as a major drainage system for events greater than 10-year recurrence to the Lake through the Hoyne property to create positive drainage to prevent surface flooding. It also could drain the depression north of the State Farm property.

5. New relief storm sewer out of the Crystal Lake watershed and into the Crystal Creek watershed.

This alternative would construct a relief storm sewer with 10-year capacity (or possibly a stormwater pumping station) to direct water away from Crystal Lake only during flooding periods. The proximity of the groundwater divide is such that a relief sewer could be constructed to the southeast. However, this transfers the Area 1 flooding issues to the flooding that occurs in the CLPD detention basin which is where all of the storm sewers below Dole Avenue converge. It may be possible to implement this alternative if the North Area Trunk Sewer project is implemented which also would address the CLPD detention issue.

Area 1B

Alternatives that would lower the flood level of Crystal Lake and Cove Pond also would benefit all of Area 1. Lowering the Lake and Cove Pond high water levels would lower the groundwater table. This would preserve existing storm sewer capacity and existing storage within the granular soils within Area 1A. Alternatives to manage Lake and Cove Pond flooding elevations are discussed below.

Alternative drainage improvements for Area 1B are shown on Exhibit 14.

6. New culverts under North Shore Drive and out of the Woodland Wetland.

This alternative would add culvert capacity under North Shore Drive to lower the risk of overtopping. North Shore Drive now overtops once every two to three years on average. This is due to the limited storage and undersized culvert capacity in Cove Pond relative to the large contributing watershed. Adding two 7-foot by 2-foot culverts would reduce the frequency of North Shore Drive overtopping to once in every 25 years on average. This alternative would require additional conveyance capacity from North Shore Drive to the Lake to be effective as described below.

Flooding in the Woodland Wetland and adjacent properties is exacerbated by overflows from Cove Pond across North Shore Drive. Once water enters the wetland, it stays until it infiltrates or evaporates – processes that can take weeks. Adding a culvert out of the wetland to the Lake (joining with either 6A or 6B) would eliminate this problem by allowing the Woodland Wetland to rise and fall with the Lake. The culvert would need to be 7-foot by 2-foot to convey incoming discharges.

6A. New open channel from North Shore Drive to the Lake.

Instead of culverts this alternative would enlarge the open channel to the Lake below North Shore Drive. This could have ecological benefits by restoring the connection between the Lake and Cove Pond for fish. The channel would be approximately three feet deep and 25 feet wide.

6B. New culverts from North Shore Drive to the Lake.

This alternative would add new culverts from North Shore Drive to the Lake to provide additional capacity to complement the new culverts under North Shore Drive.

7. Re-route North Shore Drive.

North Shore Drive could be re-routed through Cove Pond to connect with Crystal Lake Avenue and facilitate the use of the traffic signal at Virginia Street. North Shore Drive from Cove Pond to Virginia Street would be removed to allow Cove Pond and the Woodland Wetland to be re-joined. A new outlet from the combined Cove Pond and Woodland Wetland to the Lake would still be needed along with culverts under the re-aligned North Shore Drive to drain the area north of the road. This option has traffic control, flooding and ecological benefits.

8. Add fill to selected lots.

This alternative would facilitate the filling of individual lots to eliminate backyard flooding. Compensatory storage would be created at Cove Pond by the City to offset expected fills and property owners would be allowed to fill their lots to eliminate flooding. The City also would define wetland boundaries to prevent wetland fills. This alternative would not eliminate soggy backyards because during high lake levels the water table would be just below the surface.

9. Add storage at Cove Pond

This alternative would add storage at Cove Pond by cutting away existing upland and wetland to the northwest of Cove Pond to add live storage. It has been suggested by residents that North Shore Drive also could be raised to increase storage and prevent overtopping. Raising North Shore Drive is not feasible because it would cause water to pond to the east across Virginia Street in Area 1C because of its existing storm sewer connection to Cove Pond and the Lake.

A total of about 60 acre-feet of storage (about 2.5 inches over the contributing watershed) between 890.0 and 892.0 could be created by excavating the wooded HQAR wetland to the west of Cove Pond. A total of about 130 acre-feet of excavation would be needed to obtain this 60 acre-feet of storage to remove soils between 890 and 898. Unfortunately, this extra volume provides no flood storage benefit because storage above elevation 892.0 is not effective as discussed in the Classification section. Adding this amount of storage would prevent overtopping of North Shore Drive for about the 25-year event with the existing culvert outlet to the Lake from Cove Pond. The relatively inefficient excavation to produce this storage will be very expensive. The permitting to impact nearly 30 acres of high quality wetland, even though it will be replaced in-kind will be very difficult if not impossible.

Area 1C

Drainage improvement alternatives for Area 1C are shown on Exhibit 15.

Area 1C would benefit by any improvements that would lower Crystal Lake and Cove Pond flood elevations. This would reduce the level of water in the existing storm sewer system and retain more capacity for stormwater to leave Area 1C. Alternatives 6, 6A, 6B and 7 all would benefit Area 1 generally as would improvements to the outlet from Crystal Lake discussed later.

10. Relief storm sewer to Pine Street storm sewer.

Much of the flooding in Area 1C occurs in the depression north of Pine Street. As explained earlier, this area contains a depression that is below any of the inverts of the surrounding storm sewers. As a result it not only does not drain except by infiltration and evaporation, it also is the point at which any storm sewer surcharge collects and overland flow collects.

If capacity in the Crystal Lake Avenue storm sewer can be improved for frequent events by improvements to the Cove Pond outlet capacity, it would be possible to drain this depression to one of the adjacent storm sewers by gravity. A drain tile or perforated plastic sewer with an invert at about 891.0 could be constructed to the Crystal Lake Avenue sewer to provide drainage capacity to drain Area 1C. This would reduce the extent and duration of flooding for events less than 10-year recurrence. This alternative would not have provided much benefit during August 2007 however. The peak elevation of Cove Pond was 892.7 which exceeded the bottom of the Pine Street depression. Whenever the Crystal Lake Avenue sewer surcharges it would lead water directly to this depression as well.

11. Stormwater pumping station near the Pine Street depression.

Alternative 11 would add a stormwater pumping station to Alternative 10. This would provide additional drainage system capacity to Area 1C when the Lake and Cove Pond levels are high. The pump would discharge toward the Lake through adjacent storm sewers. One of the property owners that had a flooding complaint has suggested that they would be willing to discuss adding a pump station on what is currently their property. Since there is no storage available, the pump will have to be adequately sized to prevent flooding. A 1000 gpm pump would be able to drain 1 inch of runoff in 24 hours (about the one-year, 24-hour event) from 50 acres of contributing watershed. Capacity for the 5 to 10-year event could be provided.

12. Acquisition of properties to build a detention area to manage larger events

The City may wish to consider acquisition of properties. This would remove the most severely affected properties to reduce flooding damages. As indicated earlier at least one property owner may be willing to discuss this option.

13. Additional repairs to control infiltration and inflow (I/I).

This is not strictly within the purview of this study but has been included because it appears such work is necessary. Residents complained of sanitary sewer backups and this reflects problems with stormwater entering sanitary sewers or lift stations and causing their capacity to be exceeded. The City is currently undertaking studies to address these I/I issues.

Finally, when the Northwest Trunk Sewer project is designed and constructed, opportunities may be present to increase minor drainage system capacity to the south directly to Crystal Creek. This requires that the minor and major drainage systems downstream be improved to receive this diversion of flow. It would only be necessary to divert flow from the Lake when water levels exceed about 891.0 or about the elevation of the Lake's spillway. The amount of water diverted would be minimal and only in emergencies.

Area 2

Exhibit 16 and Table 6 present drainage improvement alternatives for Area 2.

Table 6 – Alternative Comparison – Area 2

	Problems Addressed							
Area 2	High Groundwater	Minor Drainage Deficiency	Major Drainage Deficiency	Floodplain/Floodway Reduction	Lots Served	Cost	Ecological Effects	Other Impacts
1. Replace existing Area 2 drainage					20	$263,000		Must Eliminate Septics
2. New field tile across south property line of Lippold					20	$105,000		
3. Repair CLDD Lateral 1 and 1A (East Line)					20	$114,000		
4. New overland flow route from CLPD detention					20	$63,000		

1. Replace and expand the existing drainage network along Greenfield Road and East End Avenue.

The flooding problems in Area 2 are located mostly between East End Avenue and Crystal Beach Avenue particularly along Greenfield Road. The existing drainage system in this area does not provide adequate minor and major drainage as evidenced by flooding during August 2007. It is maintained by the residents since it is privately owned. This alternative would replace the system above North Shore Drive with a new perforated field tile system that would lower groundwater levels and would provide minor system drainage to the Lake for events up to the 5 or 10-year recurrence. The existing connection to the Lake below North Shore Drive at East End Avenue would be repaired as needed. The system would extend from East End Avenue and Crystal Beach Avenue.

A condition for construction of this system would be that all property owners connect to City water and sewer. Existing septic systems would pollute the Lake if septic effluent were transported to the Lake with groundwater by the expanded system.

2. Build a new field tile across the south property line of Lippold Park above Area 2.

This alternative would lower groundwater above the flooding complaint area by intercepting it in a new 12-inch field tile and routing it down Greenfield Road where it would be discharged through the existing tile outlet to the Lake. Lowering the groundwater table above Area 2 would reduce flooding by increasing available storage in the granular soils under Area 2 and by increasing infiltration of rainfall. No new storm sewer discharge would be added to the Lake.

3. Repair the existing CLDD Laterals 1 and 1A.

The function of Laterals 1 and 1A of the CLDD field tile system that drains Lippold Park and the area northwest of the intersection of Routes 14 and 176 has been in question for 20 years. Recent flooding in Lippold in May 2008 suggests that it may not be draining at all. Restoring this tile to its former function will help to lower the groundwater table above Area 2.

4. Divert the discharge from the CLPD detention facility above Greenfield Road to the west to the Lippold wetland restoration.

This alternative would divert runoff from its natural drainage path out of Lippold Park through Area 2 to reduce the volume of surface runoff reaching the North Shore Drive. Both routine discharges and overflows would be routed by means of a new swale to the west. The existing detention basin should be adequate to prevent any increased flooding in the Lippold Wetland. Flow would leave the Lippold wetland restoration through the Honeysuckle Drive storm sewer.

Area 3

Drainage improvement alternatives for Area 3 are shown in Exhibit 17 and in Table 7. These solutions address nuisance, chronic flooding and would not be adequate to address the August 2007 flood event. The depressions across this area combined with its proximity to Lake levels makes protection from more extreme flood events impossible without rebuilding the entire minor and major drainage system to drain Area 3 to the Kishwaukee.

Table 7 Alternative Comparison – Area 3

	Problems Addressed							
Area 3	High Groundwater	Minor Drainage Deficiency	Major Drainage Deficiency	Floodplain/ Floodway Reduction	Lots Served	Cost	Ecological Effects	Other Impacts
1. Construct new field tile at 891 from Floresta to Kishwaukee					2	$123,000	Lake Diversion	
2. Construct new storm sewer from Snowberry to pumping station					6	$191,000		
3. Gravity discharge to Lake from Snowberry					6	$186,000		

1. Construct a new field tile from the Floresta Lane depression to the Briarwood Road storm sewer outlet.

This alternative would build a new 12-inch field tile from the existing depression near Floresta Lane to the Briarwood Road storm sewer outlet near Ballard Road. There is barely enough grade and cover to accomplish this along the route shown on Exhibit 17. The existing storm sewer along Briarwood Road is too high to receive flow from the eastern portion of Area 3. The use of a tile instead of a storm sewer will facilitate lowering of the groundwater table in the Floresta Lane depression to just above the Lake spillway or 890.9. However, continued flooding of this area during extreme events that exceed the capacity of the system when the Lake is above the spillway will continue.

This alternative would divert high flows that could not infiltrate away from the Lake to the Kishwaukee. It is expected that this would only occur once every year on average so the impact to the Lake would be minimal. However, it would set a precedent. The impact on downstream flooding would be minimal since the tile could only convey less than 1 cfs. The level of protection would be less than the 2-year event.

2. New storm sewer system from the Snowberry Lane depression to a pumping station discharging to the Lake.

Under this alternative, a new storm sewer system with 5-year capacity would be constructed along Snowberry Lane and Gardina Lane to the east to a stormwater pumping station that would discharge to the Lake. The pump would be set to discharge when the wet well reached an elevation of 892.0 so that only high flows would be pumped back to the Lake. This alternative is an inter-basin transfer of flow and would need careful evaluation for potential downstream impacts. A 500 gpm pumping station or larger would be needed to keep flooding below 892.0.

3. New gravity discharge to the Lake from the Snowberry Lane depression.

This alternative would be similar to Alternative 2 but would only function when the Lake was at or below its spillway. An overland flow outlet from the Snowberry Lane depression would be graded at an invert of 890.0 to Edgewood Drive with 5-year capacity. A culvert would be added under Edgewood Drive and another swale graded to the Lake. This would drain the Snowberry Lane depression whenever the Lake levels allow which is most of the time. However, it also would allow high Lake levels to reach this area directly.

Area 4

Exhibit 18 and Table 8 present alternatives to reduce flooding in Area 4.

Table 8 Alternative Comparison – Area 4

	Problems Addressed							
Area 4	High Groundwater	Minor Drainage Deficiency	Major Drainage Deficiency	Floodplain/ Floodway Reduction	Lots Served	Cost	Ecological Effects	Other Impacts
1. Prevent lake flow from reaching 24-inch sewer					11	Unknown	Stablizes Lake Level	Benefits Lakewood
2. Add storm sewers from Meridian and Melrose	Not Effective							
3. Repair,replace and expand existing storm sewers in Area 4					11	$1,137,000		Increases Downstream Flooding

1. Prevent Lake water from entering the existing 24-inch tile storm sewer.

Currently, Lake water is entering the 24-inch sewer under Crystal Creek above elevation 887.0. This leakage consumes the limited capacity available in this sewer when it is needed to convey stormwater runoff. Finding and eliminating this connection would preserve this capacity for minor drainage system conveyance for Area 4 and Lakewood to the west. It also would help greatly to stabilize Lake levels.

2. Add lateral storm sewers to the Country Club Road storm sewer at Meridian Lane and Melrose Lane to better drain Area 4.

This alternative would have benefit for events smaller than August 2007 when capacity is available in the Country Club Road storm sewer. This sewer was designed to convey only 3.3 cfs. It empties into Crystal Creek at an elevation of 886.2. The low point in the depression between Meridian Lane and Melrose Lane is 890.0. This provides very little room to install a sewer or field tile. Even if such a line is installed its effectiveness will be limited by the capacity of the existing storm sewer and Crystal Creek. During the August 2007 flooding this capacity would have been unavailable and would have provided no benefit. In fact, the 100-year floodplain elevation at this point is 891.2 and building this sewer would bring this depression into the FEMA floodplain.

3. Repair, replace, and expand the existing storm sewer system within Area 4.

This alternative is not currently feasible because there is no place for the storm sewer to discharge without improvements to the conveyance capacity in Crystal Creek including Lake Outlet and Crystal Creek. The existing storm sewer along Broadway Street discharges five feet under Crystal Creek into a 24-inch tile that may be 75 years old. Lakewood already has invested in repairing this sewer. The Lakewood drainage study also notes the very limited capacity available in this sewer and Crystal Creek. The problem with this alternative is that there still is no more than about 6 cfs of capacity in this line.

There is relatively little hydraulic grade change to allow sewers to be expanded and discharge to the creek. The creek elevation is 888.0 at the north to 886.0 to the south through Area 4. The low points of the depressions in Area 4 are at or below 890.0.

As stated in the analysis section, when the limited capacity of the Country Club Road storm sewer is exceeded, overland flow enters the depressional area along Melrose Lane. It does appear possible to regrade the area along the north side of Country Club Road to route flows to the east rather than into the depression. A 6-foot by 2-foot box culvert could be constructed on the north side of Country Club Road from Melrose Lane to the Creek to convey re-routed flows for events up to the 25-year recurrence. The west invert would be at 888.0 and it would enter the Creek at 886.0. This sewer would replace the existing Country Club Road storm sewer.

This alternative presents permitting challenges that were noted in the Lakewood Drainage study. However, the current FIS model already assumed free discharge from this area to arrive at the discharge rates used to calculate the 10, 50 and 100-year floodplain. This alternative does not increase those FIS discharges and so would not increase 10, 50 or 100-year floodplain elevations downstream.

However, it would increase flooding for lesser events in practice, since more runoff would be conveyed more frequently. The underground conveyance capacity of Crystal Creek is less than 25 cfs before roads are overtopped and overland flow begins based on the FEMA Flood Insurance Study recently completed. Flooding of the golf course parking area is a concern.

To provide channel capacity for Area 4 and Lakewood for the 100-year event, it would need to be about 200 to 300 cfs. Before effective drainage improvements can be made for Area 4, the existing inadequate capacity in Crystal Creek downstream should be addressed. A reduction in the floodplain and floodway of the Creek also could be accomplished at the same time removing about 50 homes from the FEMA floodplain and alleviating downstream flooding in Lake Outlet and Crystal Creek.

Additional Alterations – Lake Outlet and Crystal Creek

Although study of Crystal Creek was not included in the scope of this project, several alternatives needed to be presented.

Potential drainage improvements for the Lake outlet and Crystal Creek are shown on Exhibit 19 and Table 9.

Table 9 Alternative Comparison – Lake Outlet and Crystal Creek

	Problems Addressed							
Lake Outlet and Crystal Creek	High Groundwater	Minor Drainage Deficiency	Major Drainage Deficiency	Floodplain/ Floodway Reduction	Lots Served	Cost	Ecological Effects	Other Impacts
1. Increase lake outlet capacity to stabilize high levels					All	$113,000	Stablizes Lake Level	
2. Improve conveyance under Country Club					All	Unknown		Reduces Upstream Flooding
					50 Floodplain Lots			Increases Downstream Flooding
3. Analyze floodplain and culverts below Lake to					All	$35,000		Reduces Upstream Flooding
increase capacity and to reduce floodplain					50 Floodplain Lots			
4. Dredge Lake and lower normal water by one to two feet					150 Floodplain Lots	$1,000,000	Further Study Needed	Further Study Needed

Table 9 makes it apparent that improvements that could benefit all areas and Area 4 in particular are dependent on improvements to Crystal Creek and the Lake outlet or its high water levels.

As previously discussed, and shown on Exhibit 5, drainage below Crystal Lake is an amalgam of different pipes and overland flow. This is documented on the FEMA floodplain profile for the Creek along with significant obstructions to flow (Appendix B). A description of the minor and major conveyance out of the Lake and down Crystal Creek to St. Andrews Lane is important to understand why this is a critical problem. Flow out of the Lake first goes over a 21-foot wide weir and then into a 3.0-foot by 2.5-foot box culvert under Lake Street. For flow below about 14 cfs, the weir controls discharge and the Lake rises in response to its obstruction. For flows greater than 14 cfs, the box culvert controls flow and the Lake rises to force more water through it. During August 2007, the Lake rose to at least one foot above the spillway. The estimated peak discharge out of the Lake was about 25 cfs. If the weir had controlled the rise in the Lake for this discharge the Lake would have risen only 0.4 feet. This would have benefited all of the upstream areas by lowering groundwater elevations and increasing storm sewer capacity. This leads to the first alternative that could be considered in the future.

1. Increase the culvert capacity under Lake Street to reduce the height frequent floods on the Lake.

Discharges from the Lake need to be maintained at 50 cfs for the 100-year event to match FIS results unless a new study is undertaken by the City. However, this could be passed under Lake Street with a new culvert that would limit the rise in Lake level to a few inches instead of a foot or more as happened in August 2007.

Once flow leaves the Lake it passes down Crystal Creek until it reaches Country Club Road. The culverts there represent the first obstruction to flow and can pass less than 25 cfs before overtopping. This obstruction results in a significant overbank floodplain and floodway that affects about 50 homes.

2. Improve conveyance under Country Club Road to reduce existing floodplain and floodway.

This requires a careful balancing with downstream conveyance since there is a significant flood storage site at the Crystal Lake Country Club property immediately downstream. The effect of opening up the restriction at Country Club needs to be balanced against increasing conveyance downstream not making flooding worse for the Club and if possible making it better as well.

After reaching the Country Club, flow goes underground into a 30-inch storm sewer south of Edgebrook Drive. The 30-inch sewer has limited capacity of less than 25 cfs so larger events overflow it again causing an expanded floodplain above this point where flooding complaints have been registered.

A 30-inch storm sewer from the CLPD detention facility north of the Lake Avenue drains west of Nash Road and runs parallel to this pipe. While flow is proceeding overland down the Creek to this point, flow also is proceeding underground down the 24-inch tile that Lakewood owns. This is the tile that partially drains Area 4 and Lakewood south of the Lake. These three pipes join together in box structure upstream of St. Andrews Lane. Three culverts lead out of this box structure and then under St. Andrews Lane to Crystal Creek where it again becomes an open stream. The FIS study shows that during the 10-year event all of these pipes are overwhelmed and flow proceeds overland west of and along Nash Road until it reaches St. Andrews Lane. This brings the area bounded by Nash Road, Brook Drive and McHenry Avenue into the floodplain according the FIS mapping.

3. Re-study the floodplain and conveyance below the Lake along Crystal Creek and implement changes to reduce the floodplain by removing restrictions to flow if possible.

Removing the existing culverts while increasing the conveyance of Crystal Creek in an ecologically sensitive manner could increase the ability to drain Area 4 and Lakewood. These improvements also would remove as many as 50 homes from the floodplain. The potential for this to occur requires a restudy of the floodplain and conveyance below the Lake to see if it is feasible without increasing damage downstream.

OPTIONS

The twenty-five potential solutions were evaluated using the following criteria:

- Severity of flooding problem addressed
- Residences and businesses affected and complaints addressed
- Potential offsite impacts resulting from implementation
- Cost

The specific types of solutions considered to address the above causes of flooding included the following:

- New or larger storm sewers or smooth walled perforated pipe
- Improved overland flow conveyance
- New or repaired field tiles to lower groundwater levels
- Stormwater pumping stations
- Additional flood storage

One significant alternative that was considered but not selected was lowering the spillway of the Lake from its current elevation of 890.9. Normal water levels on the Lake are below the spillway based on many years of observation (CLPD, 2006 Clean Lakes Phase I Diagnostic Report). Lowering the spillway to the normal Lake elevation should not adversely affect low Lake water levels; however, it could lower flood elevations by making additional storage available during wet weather patterns. It also would help to lower groundwater levels around the Lake and would increase the culvert capacity under North Shore Drive. If this alternative was combined with increased culvert capacity under Lake Avenue it also could reduce the 100-year floodplain on the Lake by a foot and remove as many as 150 residences from the FEMA floodplain. This option requires significant additional analysis combined with Alternative 5 below.

SELECTED OPTIONS

After considering the probable benefits and costs of the 25 alternatives, the following projects were selected as options for the City to consider. Each provides varying degrees of relief from flooding in the study areas. Table 1 summarizes costs for each option.

1. Area 1, New culverts under North Shore Drive and out of the Woodland Wetland with an expanded open channel from North Shore Drive to the Lake.

High water levels on Cove Pond make flooding worse in all parts of Area 1 in addition to the overtopping of North Shore Drive and flooding of the Woodland Wetland. Larger culverts under North Shore Drive can reduce the frequency of this occurrence from once every two or three years to once in 25 years or less on average. Adding an outlet culvert from the Woodland Wetland to the new outlet channel will reduce the high water levels along Woodland Drive as well. These areas will still be in the floodplain and will still experience high water levels when the Lake is high as happens now. However, flooding from Cove Pond and the Woodland Wetland will be reduced.

This option has significant advantages from an ecological standpoint since it would add habitat to the Lake by connecting Cove Pond to the Lake. Water quality benefits would not be compromised since the area of wetland treatment would be increased by the addition of the outlet channel.

Over 250 residences and 40 flooding complaint sites will benefit from this option. In addition the costs associated with traffic delays, re-routing, and safety will be reduced significantly. Total conceptual construction cost is estimated at $94,000 for the larger culverts under North Shore Drive and $90,000 for the expanded open channel. The Woodland Wetland culvert is estimated to add another $32,000. Total construction cost is estimated to be $216,000.

1A. Area 1, Re-route North Shore Drive

This would be a highly desirable choice as an option to 1 above. However, it has possible time delays and higher costs than the previous option but provides the same benefits. It also provides the added benefits of providing a signalized intersection for North Shore Drive with Virginia Street and the ecological and water quality benefits of combining Cove Pond with the Woodland Wetland. If funding and timing were equal, it would be superior to the previous option. Total conceptual construction cost is estimated at $551,000.

2. Area 4, Further analyze the flooding south of the Lake and along Crystal Creek.

All of the options available to improve flooding in Area 4 are complicated by the lack of available drainage capacity in Crystal Creek or under it. This option is not a construction project but rather additional analysis and conceptual design. Improvements to Crystal Creek's drainage capacity would facilitate improvements to the drainage in Area 4. It may be possible to remove over 50 residences from the FEMA 100-year floodplain and stabilize Lake levels as well. Over 500 residences including 80 flooding complaint sites and over 100 floodplain or floodway properties will benefit from this option. Total cost is estimated at $35,000.

3. Area 2, Replace the existing drainage network along Greenfield Road and East End Avenue.

This option provides a minor drainage system for Area 2. It is proposed to also act as a field tile to lower normal groundwater within Area 2. It will not create a new storm sewer to the Lake since it will use the existing tile outlet. The total conceptual construction cost is estimated at $263,000. It does not appear feasible at this time to provide a major overflow route from Area 2 based on existing infrastructure. However, the additional options discussed below would help to address this issue.

The efficiency of this alternative can be enhance by the addition of two other projects,

- **Build a new field tile across the south property line of Lippold Park above Area 2 and**
- **Divert the discharge from the CLPD detention facility above Greenfield Road to the west to the Lippold wetland restoration.**

Adding a drain tile to lower groundwater immediately above Area 2 will help to facilitate infiltration in this area. Groundwater collected would be sent to the Lake through the existing tile outlet below Greenfield Road. The estimated construction cost is $104,000.

Diverting water from its natural drainage pathway through Area 2 and re-routing it to the Lippold Wetland prevents any surface flow from the entire Crystal Lake watershed to the north from entering Area 2 and causing increased flooding. There is sufficient capacity to receive this detained flow in the Lippold Wetland without increasing flood risk. All runoff would discharge down the Honeysuckle Drive storm sewer to the Lake. The estimated construction cost is $63,000.

Approximately 125 residences and 20 flooding complaint sites will benefit from these three options. Depending on Lake levels the level of flood protection would be about the 10-year event. Total conceptual construction cost is estimated at $430,000 for all three options.

4. Area 1, Replace field tile system adjacent to Sycamore Lane and Green Oaks Drive.

This option would replace the existing field tile system through the Hoyne property and would include an improved overland flow route to the Lake. In combination, these two options would provide a minor and major overland flow route for this area. The field tile would act to lower the normal groundwater. This would benefit residents on Sycamore Lane by reducing sump pump usage and standing water issues. The field tile also would improve the function of the State Farm infiltration basin by lowering groundwater to 4 feet below its bottom. The installation of the tile would also allow new infiltration basins to be built to meet the Crystal Lake Stormwater Management Watershed Design Manual within the area. Approximately 50 residences and 10 flooding complaint sites will benefit from this alternative. Total conceptual cost is estimated at $104,000. The level of flood protection would be about the 100-year event depending on Lake levels.

5. Area 1, Pine Street and Oriole Trail relief storm sewer.

This option would provide positive drainage from the Pine Street depression through a storm sewer when the Lake is below its spillway and Cove Pond is below elevation 890.0. The efficiency of this option is improved by new culverts under North Shore Drive. This is because more capacity under North Shore Drive will lower Cove Pond water levels and reduce groundwater levels. Total construction cost is estimated at $132,000. Approximately 50 residences and 10 flooding complaint sites will benefit. Level of flood protection would be about the 10-year event depending on Lake levels.

If new culverts under North Shore Drive are not constructed, a stormwater pumping station near the Pine Street depression could be implemented. This option relies on pumping instead of gravity discharge of stormwater. It appears that land could be available to site a pumping station. The pump would function even when Cove Pond is above elevation 890.0. Pumping would provide additional drainage capacity even when the Lake and Cove Pond are high. The pump would add another $30,000 in construction cost for a total cost of $162,000.

6. Area 3, New gravity discharge (or pumping station) from the Snowberry Lane depression.

This option would be effective when the Lake is at or below its spillway. When the Lake is higher, as it was during August 2007, this option will not help without adding a pumping station. In essence this option provides some relief from chronic drainage issues by providing a minor and major drainage system to the Lake out of the Snowberry Lane depression. Approximately 50 residences and 6 flooding complaint sites will benefit from this option. The level of flood protection would be about the 5-year event. Total conceptual cost is estimated at $185,000.

Another option for relief could be obtained by adding a pumping station discharging to the Lake. This would also provide minor drainage capacity (about the 10-year event) for the depression even when the Lake is high. Although this option essentially pumps water in a circle, it would still provide relief because the depression can be pumped down faster than it can refill. Total conceptual construction cost would be $191,000.

7. Area 3, New drain tile from Floresta Lane to the Kishwaukee River

This option would build a new tile drain from the depression on Floresta Lane to the Kishwaukee River. The inlet to the tile would be set at the same elevation as the Lake spillway to minimize diversions to the Kishwaukee. This option would benefit about 10 residences and 2 flooding complaint sites. It would provide about a 10-year level of protection. Total conceptual construction cost is estimated at $123,000.

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