



Village of Winnetka
FLOOD RISK REDUCTION
ASSESSMENT
25-, 50-, and 100-year
Protection

Prepared for

The Village of Winnetka
510 Green Bay Road
Winnetka, IL 60093

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EXECUTIVE SUMMARY

This report presents a summary of alternatives and recommendations, completed by Christopher B. Burke Engineering, Ltd. (CBBEL) at the request of the Village of Winnetka, to increase the design level of protection for eight areas that significantly flood during heavy rains. The flooding ranges from street flooding to house flooding depending on the study area. CBBEL completed September 2009 and July 2011 stormwater reports which recommended projects to reduce flooding for the requested 10-year level of protection. At the request of the Village Board, this study goes beyond the previous studies to analyze the 25-, 50- and 100-year design storm events and recommend alternatives to reduce the risk of future flooding for the various design storm events.

Two of the previous study areas, Provident Avenue area and the Tree Street area (Oak, Cherry and Ash), were combined into one study area for this report. The seven study areas were modeled using hydrologic and hydraulic software and various scenarios and improvements were analyzed. A brief summary of each of the recommendations for the seven study areas is shown below with the engineer's estimate of probable cost.

North of Willow Road and Provident Avenue Study Area

The improvements for this area consists of new large storm sewers throughout the study area, stormwater storage designed in conjunction with the Park District's plans and significant additional storage on Cook County Forest Preserve District (CCFPD) property to obtain the 100-year level of protection. For the 25- and 50-year level of protection, the recommendations are similar to the 100-year design except smaller amounts of detention and smaller diameter storm sewers. The engineer's estimate of probable cost for the 25-, 50- and 100-year level of protection is \$13.0 million, \$14.8 million and \$17.5 million, respectively.

South of Willow Road Study Area

The improvements in this area include storage on CCFPD property southwest of Willow and Hibbard Roads, storm sewer conveyance from Skokie Ditch to the forest preserve and the relocation of the Mount Pleasant Road pump station. Underground storage is proposed on CCFPD property to provide the storage required for the 25-, 50- and 100-year design storms. The engineer's estimate of probable cost for the 25-, 50- and 100-year level of protection is \$9.7 million, \$12.6 million and \$17.8 million, respectively.

Underpass Study Area

The improvements for this area include a new storm sewer from the Winnetka Avenue underpass to the outlet at Elder Lane to Lake Michigan. The storm sewer improvements reduce flooding at the Winnetka Avenue underpass for the 25-, 50-, and 100-year design storms. The proposed storm sewer sizes decrease with each decreasing design storm. The engineer's estimate of probable cost for the 25-, 50- and 100-year level of protection is \$2.9 million, \$3.4 million and \$4.4 million, respectively.

Cherry Street Outlet Study Area

The improvements in this area consist of new storm sewers along Sheridan Road, Oak Cherry and Ash Streets, as well as a larger outlet to Lake Michigan at Cherry Street. The storm sewer improvements eliminate flooding in the study area for the 25-, 50-, and 100-year design storms. The proposed storm sewer sizes decrease with each

decreasing design storm. The engineer's estimate of probable cost for the 25-, 50- and 100-year level of protection is \$1.8 million, \$1.9 million and \$2.0 million, respectively.

Spruce Street Outlet Study Area

The two identified problem areas in the Spruce Street Outlet study area have been separated into two separate proposed improvement projects (Tower Road relief and Lloyd Park outlet) due to the proposed outlet configurations. The proposed projects can be constructed independently and are designed to eliminate flooding in the identified problem areas for each of the design events. The engineer's estimate of probable cost of the Tower Road Relief improvements is \$1.3 million for the 25-year and \$1.4 million to the 50- and 100-year levels of protection. The engineer's estimate of probable cost for the new outlet to Lake Michigan at Lloyd Park is \$0.5 million for the 25-, 50- and 100-year levels of protection.

Greenwood Avenue Study Area

The improvements for this area consist of new large storm sewers throughout the study area for the 25-, 50- and 100-year level of protection. For the 25- and 50-year level of protection, the recommendations are similar to the 100-year design except smaller diameter storm sewers. The engineer's estimate of probable cost for the 25-, 50- and 100-year level of protection is \$2.2 million, \$2.3 million and \$2.9 million, respectively.

Ravine Study Area

To prevent the low point of Sheridan Road from becoming impassable for the 25-, 50-, and 100-year design storm events, we have recommend regarding the area to prevent ponding from occurring during each event. The engineer's estimate of probable cost for the 25-, 50- and 100-year level of protection is \$0.5 million, respectively.

Lake Michigan Outlet – Benefits North and South of Willow Road, Cherry Street and the Underpass Study Areas

This is not an additional study area. This is a proposed improvement that benefits the North (including Provident Avenue) and South of Willow Road, Cherry Street Outlet and the Underpass Study areas for the 100-year design storm event. The benefits realized in each of the study areas included with this improvement are equal to the benefits realized for the recommendations in each itemized study area. This proposed improvement consists of a large storm sewer under Willow Road extending from Glendale Avenue to Lake Michigan with multiple storm sewers extending into each of the study areas to be benefitted from this improvement. A portion of the sewer is proposed to be tunneled. The engineer's estimate of probable cost is \$32.5 million for tunneling through clay.

INTRODUCTION

On the morning of July 23rd 2011, over six inches of rain was measured in three hours according to the precipitation gage located west of Hibbard Road south of Pine Street in the Village of Winnetka (Village). The precipitation gage is part of the Cook County Precipitation Gage Network used to measure precipitation throughout Cook County. The July 2011 storm event caused widespread flooding throughout the entire Village for the second time since the September 2008 storm event. The depth and duration (intensity) of the precipitation measured during the September 2008 and July 2011 storm events exceeded a 100-year storm event according to rainfall depths and durations published in Bulletin 70. Bulletin 70 is the widely accepted study used to design stormwater management infrastructure in Northeastern Illinois. The 100-year design storm event refers to a storm event that has a 1% chance of occurring in any given year. Therefore, it is possible to have multiple 100-year storm events within several years.

In 2009, Christopher B. Burke Engineering Ltd. (CBBEL) was retained by the Village to conduct a Flood Risk Reduction Assessment of the Western Winnetka Study Area for frequent storm events. The Western Winnetka Study Areas consists of the area south of Pine Street, west of Linden Street, east of Hibbard Road and north of Winnetka or Hill Road. The design criteria requested by the Village in the 2009 Assessment was based on frequent storm events including the 2-, 5-, and 10-year design events or storm events with a 50%, 20%, or 10% chance of occurring in any given year. The results of the 2009 Assessment indicated that the storm sewer infrastructure throughout the Western Study Area had less than 5-year capacity. The recommendations from the September 2009 report were designed to provide a 10-year level of protection for the Western Study Area. Following the 2009 Assessment, CBBEL was retained by the Village to conduct a Flood Risk Assessment of six additional flood prone areas of the Village not included in the Western Study Area for the 10-year design event. The results of the July 2011 Study indicated that the remaining portions of the Village had less than 5-year capacity with some areas less than 2-year capacity. Both the September 2009 and July 2011 reports recommended stormwater improvement projects for the various study areas based on the 10% chance storm (10-year design storm event).

Conventional stormwater infrastructure is designed such that storm sewers are sized to convey stormwater produced from a 10-year design storm to a detention facility where the water is released at a predetermined release rate. For larger storm events, the 10-year flow rate is conveyed in the storm sewer and excess flow is conveyed overland to the detention facility. Overland flow paths typically consist of swales and/or roadways. The far majority of the Village was developed prior to the implementation of conventional stormwater management and the Village does not have stormwater detention facilities. Most Village storm sewers are limited to a 20% chance storm (5-year design storm event).

Following the July 23rd 2011 storm event, CBBEL was retained by the Village to perform a flood risk reduction analysis for each area identified in the previous studies to provide 25-, 50-, and 100-year level of protection. The study areas analyzed are generally described below and shown in Figure 1. The description of each study area below does not limit this analysis to only the areas described. The descriptions are intended to identify general areas. An all-inclusive approach was used in this flood protection analysis for the entire storm sewer network in the Village.

- North of Willow Rd Study Area; Tree Streets and Provident Ave
 - Pine and Spruce between Hibbard and Glendale
 - Oak Cherry and Ash between Hibbard and Glendale
 - Willow, Rosewood to Birch
 - Ash, Rosewood to Birch, east and west of Provident
 - Provident between Oak and Elm
 - Walden and Blackthorn north of Pine
 - Locust at Starr and Westmoor

- South of Willow Rd Study Area
 - White Oak and Sunset
 - DeWindt and DeWindt at Sunset
 - Sunset and Locust
 - Birch and Alles

- Underpass Study Area
 - Winnetka Ave underpass at Green Bay and railroad tracks
 - Pedestrian underpass at Sunset and railroad tracks
 - Fuller between Sheridan and Winnetka Ave

- Cherry St Outlet Study Area
 - Oak, Cherry, and Ash between Poplar and Sheridan
 - Sheridan between Elm and Oak

- Spruce St Outlet Study Area
 - Sheridan between Maple and Pine
 - Tower at Foxdale

- Greenwood Ave Study Area
 - Grove, Greenwood and Vernon between Scott and Tower
 - Tower between Grove and Vernon
 - Edgewood between Vernon and Grove

- Ravine Study Area
 - Sheridan at Ravine

STUDY METHODOLOGY

The study methodology used in this analysis is consistent with the methodology used in the September 2009 and July 2011 studies. The purpose of the current study is to expand the previous studies to include the 25-, 50- and 100-year critical duration storm events and provide concept level alternatives and costs for a 25-, 50-, and 100-year level of protection. The following description of hydrologic and hydraulic model development has been included to provide clear understanding of what was used to determine the proposed alternatives.

Each study area has been delineated by drainage boundaries defined by 1-foot Cook County aerial topography and the existing storm sewer system draining the area to the final storm sewer outlet. The Village has six main storm sewer outlets (Figure 1). In general, areas east of Green Bay Road drain to Lake Michigan and areas west of Green Bay Road are pumped into the Skokie River. The storm sewer system draining each area is defined using the Village’s extensive storm sewer atlas. The Village storm sewer atlas includes storm sewer elevations, locations, sizes, lengths and connections as well as all recently constructed storm sewer improvement projects.

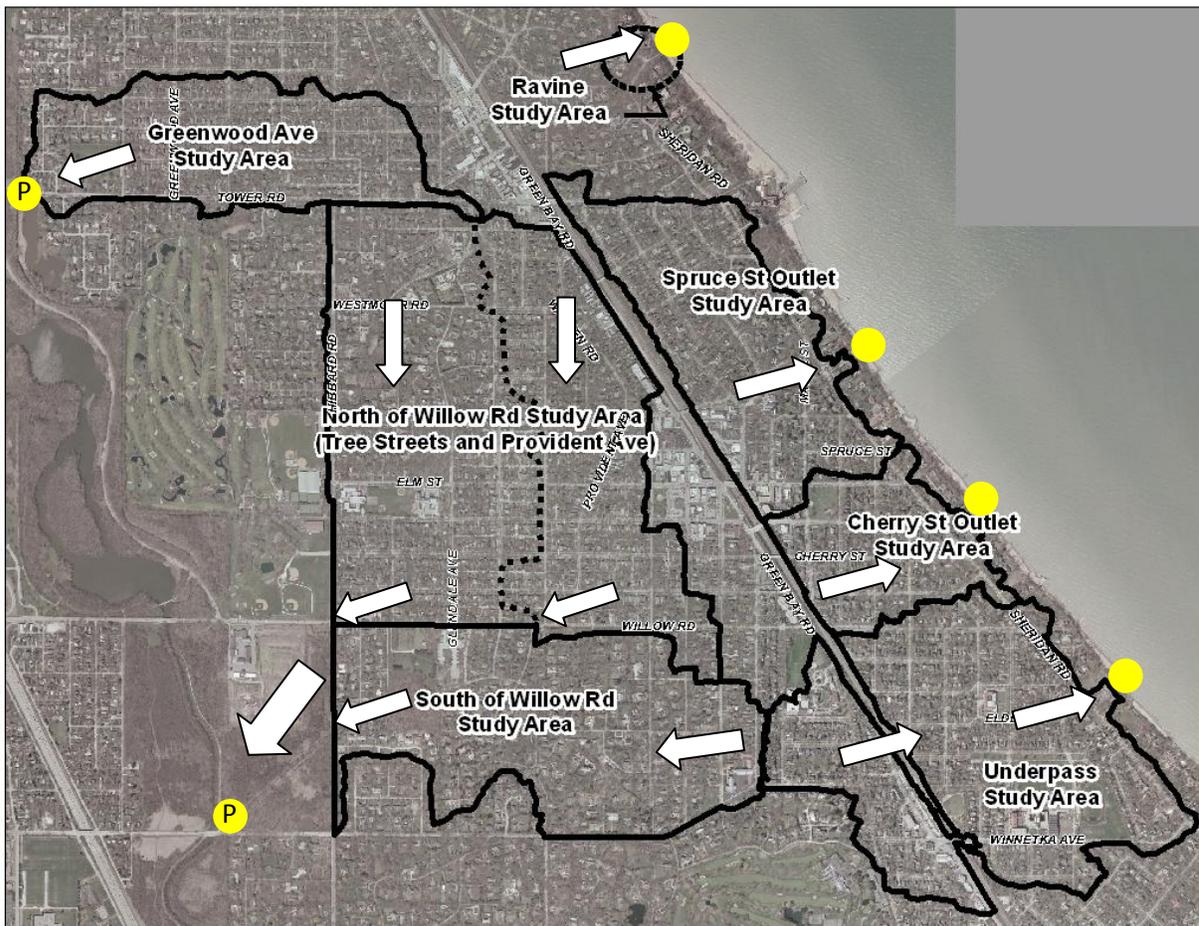


Figure 1. Study Areas and Outlets

Following the delineation of each study area by outlet, hydrologic and hydraulic information was collected and input into an XP-Software Stormwater and Wastewater Management Model (XP-SWMM) for each study area. The XP-SWMM software is a two phase dynamic modeling program that determines runoff (hydrologic phase) from a storm event and routes the runoff through a storm sewer network (hydraulic phase).

Each study area was further delineated into subbasins within the study areas where tributary areas were assigned based on topography and storm sewer location. Hydrologic parameters including area, Runoff Curve Number (RCN) and Time of Concentration (Tc) were calculated based on topography and current land use using aerial photography for each of the subbasins. The RCN value calculated for each subbasin is based on the ratio of impervious to pervious area in the subbasin. The hydrologic parameters were then entered into the hydrologic phase of the XP-SWMM for each study area.

The storm sewer network as shown Village's storm sewer atlas was entered into the hydraulic phase of the XP-SWMM for each study area. In addition to the storm sewer network data, overland flow paths and depressional storage areas were entered into the model using aerial topography. When the capacity of a storm sewer has been exceeded during a storm event, the runoff begins to flow overland along the street, through a backyard, or fills a depressional storage area. Overland flow paths and depressional storage areas were included in the hydraulic phase of the XP-SWMM analysis. CBBEL also field verified overland flow paths and depressional storage areas during storm events as these areas are generally associated with flood areas.

The critical duration was determined for each study area utilizing rainfall depths published in Bulletin 70. The critical duration refers to the intensity of a storm that produces maximum water surface elevations or flood depths. For example, the 100-year critical duration analysis included executing the XP-SWMM for the 1-, 2-, 3-, 6-, 12-, 18-, 24- and 48-hour storm events. The storm event producing the highest flood elevation is the critical duration storm event and all proposed improvements are then designed for the critical duration storm. The XP-SWMM was also executed for the September 2008 and July 2011 storm events to verify the accuracy of the modeling compared to observed surveyed low entry elevations obtained in the September 2009 study, and observations obtained by CBBEL staff and the Village during the storm events.

Flooding problems were then identified in each study area using the following information:

- Flood questionnaires submitted by residents
- A total of 857 flood questionnaires have been collected since July 2011
 - 302 during September 2009 study
 - 555 during July 2011 study
- Flood reports from Village staff about known flooding areas
- Accounts of historically known flooding areas from Village staff
- Numerous field observations and investigations during storm events conducted by Village and CBBEL staff
- Existing condition XP-SWMM modeling results

The existing condition storm sewer systems in each study area were evaluated for the 25-, 50-, and 100-year design events. The existing condition capacity and cause of flooding has been described in detail in the

September 2009 and July 2011 studies for each study area however an overall description of the existing condition capacity for each study area is given in the following sections of this report.

The cause of flooding for the 25-, 50-, and 100-year design events for each problem area within the study areas was identified and a proposed alternative to reduce flooding was determined. The flood reduction benefits from each proposed alternative was analyzed throughout the study area to determine benefits for more than one problem area. The proposed improvements analyzed in this study include increasing storm sewer sizes, adding relief storm sewers, increasing outfall sizes, incorporating storage, and increasing pump rates. Improvements were analyzed for each study area to determine the effect on peak water surface elevations through entire study areas.

This study is based on conceptual plans and limited information. Because of this, there are many unknowns including soil conditions, utility conflicts and right-of-limits that will affect the ultimate design and cost of the improvements. CBBEL has provided an engineer's estimate of probable cost for many alternatives based on the conceptual designs and limited information. The engineer's estimate of probable cost includes a 20% contingency. Permitting and design engineering for each project has also been included in the estimates and is a percentage depending on the total cost of the project.

The following sections of this report have been organized by study area where each section describes the existing and proposed condition study area in detail and provides the engineers estimate of probable cost for each alternative.

NORTH OF WILLOW ROAD STUDY AREA

The area north of Willow Road and Provident Avenue is shown in Figure 2. The North of Willow Road Study Area includes Pine, Spruce, Oak, Cherry and Ash Streets (Tree Streets) as well as the Provident Avenue Area. These areas have been combined since the areas drain to the same location. The Tree Streets outlet west to Hibbard Road and the Provident Avenue system outlets south to Willow Road. The Willow and Hibbard Road systems combine at the intersection of Willow and Hibbard Roads. The system continues south to the outlet channel on Cook County Forest Preserve District (CCFPD) property southwest of the intersection Hibbard and Willow Roads where it drains into the Skokie River. When the Skokie River rises above the ditch water surface elevation through the CCFPD, the flow from Winnetka must be pumped.

4.1 NORTH OF WILLOW ROAD EXISTING CONDITIONS

The Willow Road storm sewer begins as a 12-inch storm sewer just west of Linden Street and flows westward, ultimately draining to the outlet channel on the CCFPD through a 6-foot by 8-foot box culvert. Between Linden Street and Hibbard Road, the Willow Road system picks up several major drains in this study area, including sewers from Provident Avenue, Glendale Avenue and Hibbard Road. Drainage along Hibbard Road is comprised of four storm sewers that connect to the Willow Road system at the intersection of the two roads. Based on our existing conditions XP-SWMM hydraulic analysis, the Willow Road system has less than a 10-year capacity and the Hibbard Road system has less than a 2-year storm event capacity. The storm sewer along Willow Road between Glendale and Provident is the limiting factor causing flooding along Willow Road as well as east and west of Provident Avenue along Oak and Ash Streets.

Pine and Spruce Streets are drained by two storm sewers that vary between 12-inch and 24-inch diameter pipes running westward toward Hibbard road before connecting with the 36-inch by 46-inch arch pipe along Hibbard Road. The results of the existing conditions XP-SWMM analysis indicate that the systems along Pine and Spruce Streets have less than a 2-year storm event capacity.

Oak, Cherry, and Ash Streets all drain westward toward Hibbard Road with 12-inch storm sewers. The Oak and Cherry Street storm sewers combine with the 24-inch pipe that runs south along Hibbard Road. The 24-inch system as well as the 12-inch system along Ash Street are pumped to the 36-inch by 46-inch arch pipe that runs south along Hibbard, which limits the capacity of this system. This study area receives surcharging overland flow from the 24-inch storm sewer along Glendale Avenue when that system exceeds its capacity. There is several large depressional storage areas located along Oak Cherry and Ash Streets and in the backyards of residences with no positive gravity outlets. The lowest points in this study area are located east and west of Berkeley Avenue on Oak Cherry and Ash Streets. During large storm events, all of the depressional areas merge through overland flow paths and have the same flood elevation.

4.2 NORTH OF WILLOW ROAD PROPOSED CONDITIONS

Improvements for the North of Willow Road Study Area include upsizing storm sewers, stormwater storage provided in multiple locations and an additional outlet to the Skokie River. The proposed improvements vary in storage volume and storm sewer size depending on the design storm criteria. For each design level of protection, the storm sewer sizes and storage volume has been designed to significantly reduce flooding along the streets and eliminate all overland flooding in structures.

The low points along Oak, Cherry and Ash Streets are the lowest in the study area. The storage volume required for each design event was determined by providing a level of acceptable ponding on Oak, Cherry and Ash Streets. Ponding was not eliminated along these streets due to the large amount of storage required to provide a limited benefit. The storage required to eliminate ponding in these streets exceeds the space available to provide cost effective storage. The proposed level of street ponding has been limited to 0.8 feet at the deepest point with majority of the proposed ponding limited to 0.5 feet or less for each design storm (Exhibits 1A-1C).

The proposed alternatives include storage provided on Park District property as well as CCFPD property west of Hibbard Road. We understand that the Park District has plans for future improvements that will also require storage. Therefore, the storage configurations shown for the proposed alternatives for this study area have been coordinated with the Park District's concept plans. The proposed storage areas include the Park District's concept storage volume required and the Village's storage requirement for flood control. The proposed alternative for the 25-, 50- and 100-year flood protection is shown Exhibits 1A – 1C. The storage areas required for the Park District's future plans is shown on Exhibits 1A through 1C however the Park District's storage provided is not included in the cost estimates for the Village's flood control requirements.

The proposed alternatives are described below:

100-Year Protection (Exhibit 1A):

- 58.5 ac-ft open water storage area on CCFPD property

- 13.4 ac-ft underground storage vault on Park District property
- 5.6 ac-ft underground storage vault south of Elm Street at Berkeley Avenue
- 8 cfs pump station to dewater proposed storage basins
- 48-inch storm sewers from Berkeley Avenue to Hibbard Road along Oak, Cherry, and Ash Streets
- 48-inch storm sewer along Pine Street
- 60- and 66-inch relief sewers along Hibbard Road
- 24-inch relief along Walden Road east of Blackthorn Road
- 36-inch from Westmoor Road to Pine Street along Walden and Blackthorn Road
- 42-inch along Pine Street from Blackthorn to Glendale Avenue to underground storage area

The proposed 100-year improvements do not lower the flood elevations at the intersection of Willow Road and Provident Avenue (Exhibit 1A). Upsizing the storm sewer along Willow Road was tested and did not reduce flood elevations due to the downstream capacity of the Willow Road storm sewer. The proposed storm sewers would be constructed significantly lower than the existing systems to allow for the larger pipe sizes. Each of the storage basins on Park District property will be dewatered using a single pump. A range of pump capacities for the storage basins were tested and it was determined that the pump capacity does have an effect on the flood elevation within the study area. The Park Districts future improvements may require quick draw down times in the open water storage basins therefore the final required pump rate will be determined through coordination with the Park District. The total volume provided in storage areas for the 100-year improvement is 77.5 ac-ft. The cost estimates for this study area have been based on an 8 cfs pump.

50-Year Protection (Exhibit 1B):

- 31.2 ac-ft open water storage area on CCFPD property
- 13.4 ac-ft underground storage vault on Park District property
- 5.6 ac-ft underground storage vault south of Elm Street at Berkeley Avenue
- 8 cfs pump station to dewater proposed storage basins
- 36-inch storm sewers from Berkeley Avenue to Hibbard Road along Oak, Cherry, and Ash Streets
- 48-inch storm sewer along Pine Street
- 60-inch relief sewers along Hibbard Road
- 24-inch relief along Walden Road east of Blackthorn Road
- 36-inch from Westmoor Road to Pine Street along Walden and Blackthorn Road
- 36-inch along Pine Street from Blackthorn to Glendale Avenue to underground storage area

The 50-year alternative is similar to the 100-year alternative, with smaller pipe sizes in the storm sewer system. The required storage volume is slightly smaller than the 100-year alternative and requires the footprint and depth in the storage basin on CCFPD property to be reduced. The total volume provided in storage areas for the 50-year improvement is 50.2 ac-ft.

25-Year Protection (Exhibit 1C):

- 10.2 ac-ft open water storage area on CCFPD property
- 13.4 ac-ft underground storage vault on Park District property
- 5.6 ac-ft underground storage vault south of Elm Street at Berkeley Avenue
- 8 cfs pump station to dewater proposed storage basins
- 36-inch storm sewers from Berkeley Avenue to Hibbard Road along Oak, Cherry, and Ash Streets
- 42-inch storm sewer along Pine Street
- 54- and 60-inch relief sewers along Hibbard Road
- 24-inch relief along Walden Road east of Blackthorn Road
- 36-inch from Westmoor Road to Pine Street along Walden and Blackthorn Road
- 36-inch along Pine Street from Blackthorn to Glendale Avenue to underground storage area

The 25-year alternative is similar to the 100- and 50-year alternatives, with smaller pipe sizes in the storm sewer system. The required storage volume is significantly smaller than the 100-year alternative, which allows for the basin footprint to be reduced on CCFPD property. The total volume provided in storage areas for the 100-year improvement is 29.2 ac-ft.

A summary of the cost estimates to provide 25-, 50- and 100-year level of flood protection is provided in Table 1. The Park District’s storage requirement is not included in the cost estimates. The recommended improvement from the September 2009 study for the 10-year level of protection has also been included.

Level of Protection	Engineer’s Estimate of Probable Cost
10-year	\$6,842,000
25-year	\$12,994,000
50-year	\$14,806,000
100-year	\$17,470,000

Table 1. North of Willow Road Study Area Cost Summary

Permitting, approval or agreement requirements for the proposed improvements include:

- Land acquisition and approval from CCFPD
- Land acquisition/agreement with the Winnetka Park District
- Approval from the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) for storm sewer improvements
- Approval from Illinois Department of Transportation (IDOT) for work within the IDOT ROW associated with Hibbard and Willow Roads
- Approval from Winnetka Public School District 36 (D36)

SOUTH OF WILLOW ROAD STUDY AREA

The South of Willow Road and DeWindt Avenue Study Area are shown in Figure 3. These areas have been combined since the areas drain to the same location. The areas are controlled by two pump stations, the first controlling the majority of the south area at Mount Pleasant Road and the second at the intersection of DeWindt and Sunset Roads. The South of Willow Road Study area is pumped to the outlet channel on CCFPD property where it drains into the Skokie River. When the Skokie River rises above the water surface elevation in the outlet channel through the CCFPD, the flow from the south area must be pumped again.

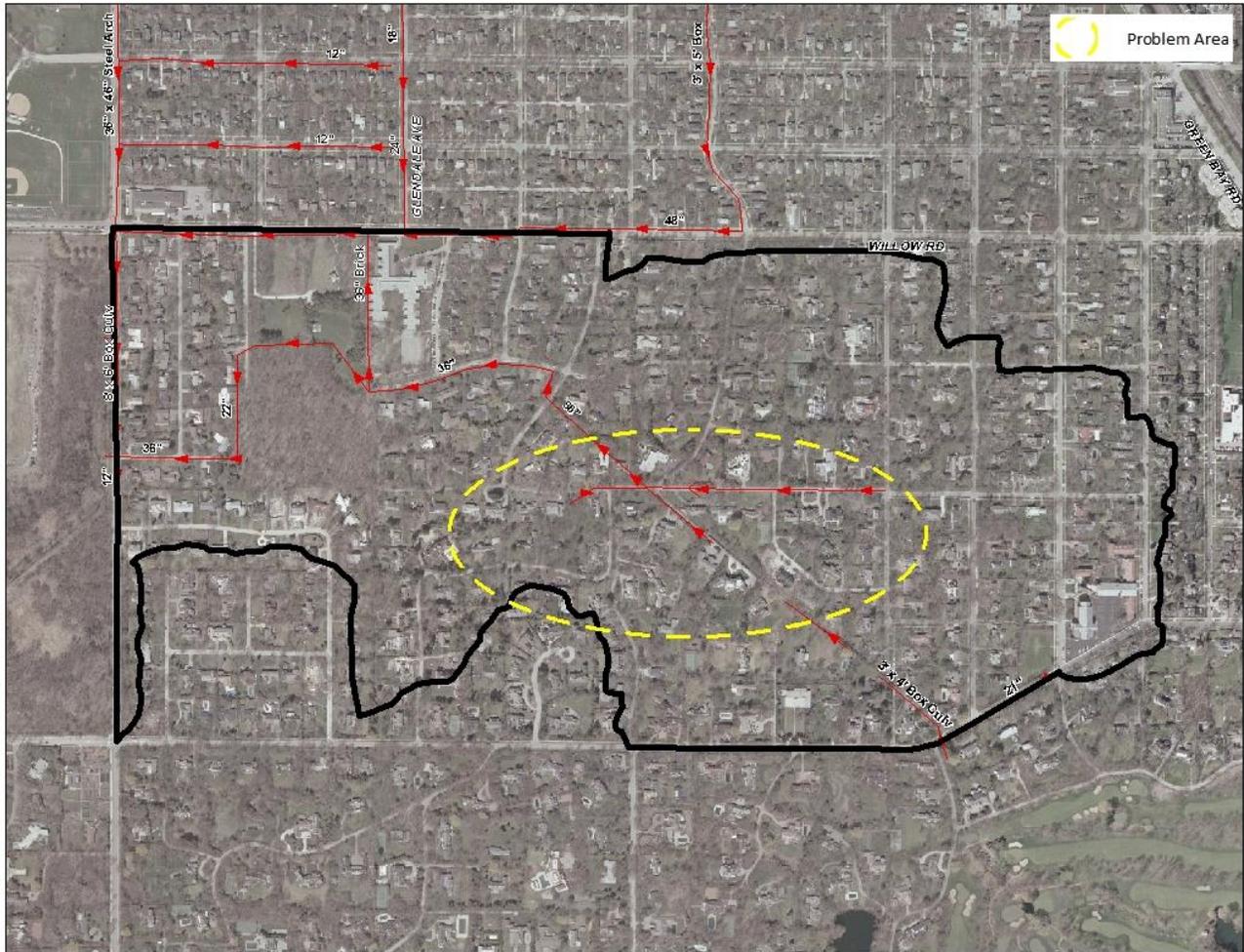


Figure 3. South of Willow Road Study Area

5.1 SOUTH OF WILLOW ROAD EXISTING CONDITIONS

Skokie Ditch (Ditch) flows northwesterly from south of the intersection of Alles Road and Birch Street through the center portion of the study area and drains approximately 178 acres of off-site tributary area from the Indian Hill Golf Course to the southeast. The Ditch alternates between open and closed sections. The

DeWindt Road and Sunset Road storm sewer systems combine with the Ditch at the intersection of White Oak Lane and Sunset Road before continuing northwest through a 36-inch RCP. At the end of Mount Pleasant Road, runoff is pumped to the CCFPD outlet channel west of Hibbard Road.

There are three main areas of concern within the study area. The first is in the vicinity of DeWindt Road, which is drained by a private storm sewer system and pump station. The second is the areas adjacent to either side of Skokie Ditch and the intersection of Sunset and White Oak Roads, and the third is near Sunset Road and Birch Street. All three are low-lying areas with depressional storage that are drained by storm sewer systems. However, during heavy storms all three areas become merged through overland flow and have the same flood elevation. When this occurs, the extent of flooding in the area is controlled by the Mount Pleasant Road pump station and ultimately the Winnetka Avenue pump station on CCFPD property.

5.2 SOUTH OF WILLOW ROAD PROPOSED CONDITIONS

Several proposed improvements were evaluated to achieve 25-, 50-, and 100-year levels of protection within the study area. Several low entry elevations of structures in the study area were surveyed during the September 2009 study. The lowest of these structures has a low entry elevation of 622.4 ft. Therefore, the proposed improvements were designed to keep flood elevations within the three main flooding areas below elevation 622.4'.

The recommendation from the September 2009 study proposed a relief sewer on Hill Road, which was designed to achieve a 10-year level of protection. The purpose of the relief sewer was to intercept a large off-site runoff from south of Hill Road and route it directly to the Winnetka Avenue pump station, bypassing the study area. As part of this study, the bypass sewer concept was expanded to the 25-, 50-, and 100-year storm analysis. However, during this analysis it was determined that the Winnetka Avenue pump station capacity was a limiting factor. This was true for both the existing pump station (89 cfs capacity) as well as the proposed increased capacity (134 cfs). To determine if the bypass sewer works for storms greater than the 10-year event, a concept storage basin for the offsite drainage area (Indian Hill tributary area) was entered to the XP-SWMM analysis. The basin was sized for zero-release rate so that the offsite runoff would contribute insignificantly to the downstream sewer system. Even for this hypothetical scenario, the downstream flooding within the study areas was not eliminated. This is due to the limited capacity of the existing sewer system and pump station to handle the runoff from the South of Willow Road study area. Therefore, the Hill Road relief sewer was eliminated as an alternative for providing greater than a 10-year level of protection.

The recommended alternative for this analysis includes a new larger storm sewer system to convey drainage from Skokie Ditch into a new storage basin located on CCFPD property between Hibbard Road and the Village property adjacent to the landfill. The alignment of the proposed storm sewer is shown on Exhibits 2A-2C. The storage basin is required to keep the flood elevation within the forest preserve area west of Hibbard Road low enough so that there is a head differential between the upstream flooding areas. The proposed sewer system is large enough to convey the necessary flow rate with the small head differential between the outfall at the forest preserve area and the target flood elevation (622.4 feet) within the flooding areas. A proposed storage area was also analyzed at Crow Island Park.

The proposed improvements for the South of Willow Road Study Area were analyzed both with and without other proposed improvements within the upstream watershed (North of Willow Road Study Area). To be conservative, we have assumed that these improvements will not be in place. If there are upstream improvements, the sizing of the elements in the recommended alternative may be affected, however the overall concepts will be unchanged. If final design for the proposed projects were to proceed, we would recommend expanding the low-entry elevation survey to be sure that no homes are lower than 622.4 feet. Lowering the target protection elevation by just a few tenths of a foot could significantly increase the required scope of improvements.

The proposed storm sewers and storage basin have been sized to provide the desired level of protection. The proposed alternatives are described below:

100-Year Protection (Exhibit 2A):

- 84-inch sewer from Skokie Ditch to new storage basin west of Hibbard Road
- Proposed sewer to cross below the ditch on CCFPD property and into proposed vault
- Replace culvert connection between open ditches on Skokie Ditch and re-grade Skokie Ditch
- Sunset Road storm sewer between Skokie Ditch and Birch Street to be enlarged
- 65 ac-ft underground storage vault west of Hibbard Road adjacent to existing landfill
- 20 cfs pump station to dewater proposed storage vault

The proposed storm sewer would be constructed significantly lower than the existing system to allow for the larger pipe sizes, as well as to cross under the ditch on CCFPD property. A range of pump capacities for the storage basin were tested and it was determined that the pump capacity does have an effect on the flood elevation within the study area. To be consistent with the potential relocation of the existing pump at Mount Pleasant Road for the alternatives in this area, a 20 cfs pump rate was used in the analysis. The proposed storage basin can be constructed within the area west of Hibbard Road adjacent to the existing landfill. The ± 5 -acre available footprint can accommodate the required volume in an excavated basin approximately 13 feet deep. Due to the close proximity of the proposed storage basin to the existing landfill, the proposed storage basin will require an impermeable lining if an open water storage basin is constructed. To be conservative for cost estimate purposes, a sealed underground storage vault has been included in the cost estimates for the alternatives.

50-Year Protection (Exhibit 2B):

- Include the 100-year improvements with the following exceptions:
- 72-inch sewer from Skokie Ditch to new storage basin west of Hibbard Road
- 40 ac-ft underground storage vault west of Hibbard Road adjacent to existing landfill

The 50-year alternative is similar to the 100-year alternative, with smaller pipe sizes in the storm sewer system. The required storage volume is significantly smaller than the 100-year alternative, which allows for the vault footprint to be reduced to ± 3.5 acres. An open water basin is also an option within the footprint shown however is not included in the cost estimate for this alternative.

25-Year Protection (Exhibit 2C):

- Include 25-year improvements with the following exceptions:
- 60-inch sewer from Skokie Ditch to new storage basin west of Hibbard Road
- 15 ac-ft underground storage vault west of Hibbard Road adjacent to existing landfill

The 25-year alternative is similar to the 50-year alternative, with smaller pipe sizes and a smaller storage vault, which reduces the storage footprint on CFFPD property. An open water basin is also an option within the footprint shown on Exhibit 2C however is not included in the cost estimate for this alternative.

The required storage volumes for the 25-, 50- and 100-year levels of protection can be provided at Crow Island Park. Storage can be provided using either an open water basin or an underground storage vault. The construction of an open water storage basin at the park would require the entire parcel eliminating the existing stand of trees in the south portion of the park. Underground storage could be provided in the north portion of the park, requiring a smaller footprint. The Crow Island location was not used to provide storage due to the primarily residential location and destructive nature of the construction of either option. A summary of the cost estimates to provide 25-, 50- and 100-year level of flood protection by providing storage on CFFPD property is provided in Table 2. The recommended improvement from the September 2009 study for 10-year level of protection has also been included.

Level of Protection	Engineer’s Estimate of Probable Cost
10-year	\$3,100,000
25-year	\$9,683,000
50-year	\$12,580,000
100-year (underground detention)	\$17,765,000
100-year (open water detention)	\$9,611,000

Table 2. South of Willow Road Study Area Cost Summary

Permitting, approval or agreement requirements for the proposed improvements include:

- Land acquisition and approval from Cook County Forest Preserve District
 - No land acquisition is required for the 25-year alternative, only approval for the overflow structure
- Approval from MWRDGC for storm sewer improvements

UNDERPASS STUDY AREA

The Underpass Study Area is shown in Figure 4. The Underpass Study Area is bounded by Forest Street on the west, Ash Street to the north, MacLean Avenue to south, and Lake Michigan to the east. The Underpass Study Area drains into Lake Michigan via a restrictive, parallel 2-foot x 3-foot box culvert and 27-inch reinforced concrete pipe (RCP) storm sewer that drain into a single storm sewer down the bluffs and to the shore under a pier. The outlet is located east of the intersection of Elder Lane and Sheridan Road. The steep bluff creates a large storm sewer capacity down the slope. Therefore, the system is limited by the parallel 2-foot x 3-foot box culvert and 27-inch RCP at the top of the bluff.



Figure 4. Underpass Study Area

6.1 UNDERPASS EXISTING CONDITIONS

The tributary drainage area is divided by the Union Pacific - North (UP-N) Railroad and the West Basin drains under the UP-N Railroad in two locations. The northern connection point is a 24-inch storm sewer pipe located north of the intersection of Green Bay Road and Sunset Road. The southern connection point is an 18-inch storm sewer pipe located at the Winnetka Avenue underpass. As the two systems continue east, the 24-inch increases to a 48-inch and the 18-inch increases to a 36-inch before the two systems combine at Essex Road and Elder Lane. This main sewer junction restricts flow from the two systems as it continues east to Lake Michigan.

The two problem areas identified are the pedestrian walkway under the UP-N Railroad located at the intersection of Sunset Road and Green Bay Road and the Winnetka Avenue underpass of the UP-N railroad. Both underpasses flood for the 2-, 5-, and 10-year critical duration storm events.

6.2 UNDERPASS PROPOSED CONDITIONS

Three proposed alternatives were analyzed for the 100-, 50-, and 25-year storm events in the Underpass Study Area. The proposed improvements included increased conveyance as well as underground storage designed to reduce flooding at the Winnetka Avenue underpass and the pedestrian walkway underpass. Each alternative reduces flood depths or ponding at the Winnetka Avenue underpass to 0.9 feet or less. This flood depth was used as the design criteria for the acceptable depth of water in the underpass during the design storm event. The proposed storm sewer sizes and underground storage volumes for each alternative are based on the design storm event and decrease in size and volume with decreasing design storms.

The proposed alternatives are described below:

Alternative 1: Winnetka Avenue and Essex Road Improvements with Elder Lane Outlet Replacement

100-Year Protection (Exhibit 3A):

- 84-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 96-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure

50-Year Protection (Exhibit 3B):

- 66-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 84-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure

25-Year Protection (Exhibit 3C):

- 54-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 66-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure

Due to the steep slope of the bluffs, we have assumed the existing storm sewer along the bluff has sufficient capacity for the increased flow and will remain along the bluff and under the pier. The Alternative 1 improvements have an insignificant reduction in flood elevations at the pedestrian walkway.

Alternative 2: Underground Storage at Railroad Parking Lot with Winnetka Avenue and Essex Road Improvements, and Elder Lane Outlet Replacement

100-Year Protection (Exhibit 4A):

- 66-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 90-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure
- 6 ac-ft underground storage vault at railroad parking lot

50-Year Protection (Exhibit 4B):

- 54-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 72-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure
- 4.5 ac-ft underground storage vault at railroad parking lot

25-Year Protection (Exhibit 4C):

- 42-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 66-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure
- 3 ac-ft underground storage vault at railroad parking lot

The Alternative 2 improvements reduce peak 100-, 50-, and 25-year ponding elevations at the Winnetka Avenue underpass to 0.7-, 0.5-, and 0.6-feet. Alternative 2 also reduces the ponding elevation to 0.0 feet at the pedestrian walkway for each design storms.

Alternative 3: Underground Storage at New Trier High School Athletic Field with Winnetka Avenue and Essex Road Improvements, and Elder Lane Outlet Replacement

100-Year Protection (Exhibit 5A):

- 72-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 90-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure
- 5 ac-ft underground storage vault at athletic field of New Trier High School

50-Year Protection (Exhibit 5B):

- 60-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 78-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure
- 4 ac-ft underground storage vault at athletic field of New Trier High School

25-Year Protection (Exhibit 5C):

- 48-inch sewer from the Winnetka Avenue underpass along Winnetka Avenue and Essex Road to Elder Lane
- Large capacity inlet grate at Winnetka Avenue underpass
- 66-inch outlet from the intersection of Elder Lane and Essex Road to the top of the bluff at the Lake Michigan
- Water quality structure
- 3 ac-ft underground storage vault at athletic field of New Trier High School

The proposed underground storage vault along with the proposed storm sewers will reduce flood levels in the Winnetka Avenue underpass. The proposed Alternative 3 improvements reduce the 100-, 50-, and 25-year ponding elevations at the Winnetka Avenue underpass to 0.9-, 0.4-, and 0.0 feet. The proposed improvements have insignificant flood elevation reduction at the pedestrian walkway.

A summary of the cost estimates to provide 25-, 50- and 100-year level of flood protection is provided in Table 3. The recommended improvement from the July 2011 study for 10-year level of protection has also been included.

Alternative	Engineer's Estimate of Probable Cost			
	100-year	50-year	25-year	10-year
*Alternative 1	\$4,448,000	\$3,387,000	\$2,888,000	\$2,434,000
Alternative 2	\$6,562,000	\$5,429,000	\$4,467,000	--
*Alternative 3	\$5,919,000	\$5,142,00	\$4,220,000	--

*Alternative does not decrease flood depth at pedestrian underpass

Table 3. Underpass Study Area Cost Summary

Permitting, approval or agreement requirements for the proposed improvements include:

- Land acquisition and approval from New Trier High School, Alternative 3 only
- Approval from MWRDGC for storm sewer improvements and new outlet to Lake Michigan
- Approval from Illinois Department of Environmental Protection Agency (IEPA)
 - Must meet Lake Michigan Water Quality Standards

CHERRY STREET OUTLET STUDY AREA

The Cherry Outlet Study Area is bounded by the UP-N Railroad on the west, Elm Street on the north, Willow Road on the south and Lake Michigan on the east (Figure 5). Based on Cook County 1-foot aerial topography and Village storm sewer atlas, there is approximately 93 acres tributary to the restrictive 26-inch x 39-inch outlet draining into Lake Michigan at Cherry Street.



Figure 5. Cherry Street Outlet Study Area

7.1 CHERRY STREET OUTLET EXISTING CONDITIONS

A low spot identified by the Village is located on Sheridan Road between Elm Street and Ash Street and is drained by a 24-inch diameter storm sewer. Stormwater accumulates on Sheridan Road and at Elm, Oak, Cherry and Ash Street when the storm sewer capacity is exceeded in these locations. According to the existing conditions XP-SWMM analysis, the storm sewer system on Sheridan Road has between a 2-year and 5-year storm event capacity. Stormwater drainage is limited by the 24-inch storm sewer on Sheridan Road and the restrictive storm sewer outlet to Lake Michigan.

7.2 CHERRY STREET OUTLET PROPOSED CONDITIONS

Improvements for the Cherry Street Outlet Study Area include upsizing storm sewers. The proposed improvements vary in storm sewer size depending on the design storm criteria. For each design level of protection, the storm sewer sizes have been designed to eliminate all overland flooding in the problem areas.

The proposed alternatives are described below:

100-Year Protection (Exhibit 6A):

- New 60-inch outlet from Sheridan Road to Lake Michigan
- 60-inch sewer along Sheridan Road from Oak Street to Cherry Street
- 48-inch sewer along Oak Street from Poplar Street to Sheridan Road
- 54-inch sewer along Cherry Street from Poplar Street to Sheridan Road
- 36-inch sewer along Poplar Street from Ash Street to Cherry Street
- 27-inch sewer Ash Street to Cherry Street.
- Water quality structure
- Energy dissipater

50-Year Protection (Exhibit 6B):

- 54-inch from Sheridan Road to Lake Michigan.
- 48-inch sewer along Sheridan Road from Oak Street to Cherry Street.
- 42-inch sewer along Oak Street from Poplar Street to Sheridan Road.
- 48-inch sewer along Cherry Street from Poplar Street to Sheridan Road.
- 36-inch sewer along Poplar Street from Ash Street to Cherry Street.
- 24-inch sewer beginning on Ash Street continuing through neighborhood to Cherry Street.
- Water quality structure
- Energy dissipater

25-Year Protection (Exhibit 6C):

- 48-inch from Sheridan Road to Lake Michigan.
- 42-inch sewer along Sheridan Road from Oak Street to Cherry Street.
- 36-inch sewer along Oak Street from Poplar Street to Sheridan Road.
- 42-inch sewer along Cherry Street from Poplar Street to Sheridan Road.
- 30-inch sewer along Poplar Street from Ash Street to Cherry Street.
- 18-inch sewer beginning on Ash Street continuing through neighborhood to Cherry Street.
- Water quality structure
- Energy dissipater

A summary of the cost estimates to provide 25-, 50- and 100-year level of flood protection is provided in Table 4. The recommended improvement from the July 2011 study for 10-year level of protection has also been included.

Level of Protection	Engineer's Estimate of Probable Cost
10-year	\$692,000
25-year	\$1,807,000
50-year	\$1,852,000
100-year	\$1,959,000

Table 4. Cherry Street Outlet Study Area Cost Summary

Permitting, approval or agreement requirements for the proposed improvements include:

- Approval from MWRDGC for storm sewer improvements and new outlet to Lake Michigan
- Approval from IDOT for work within the ROW associated with Sheridan Road
- Approval from IEPA
 - Must meet Lake Michigan Water Quality Standards

NEW OUTLET TO LAKE MICHIGAN

CBEL analyzed an alternative that includes a new main storm sewer running under Willow Road and outlets to Lake Michigan. This alternative is designed for the 100-year design storm and will benefit the North of Willow Road, South of Willow Road, Underpass and Cherry Street Outlet Study areas. The proposed alternative combines sewer improvements proposed in each study area into one main outlet to Lake Michigan and eliminates the need for storage on either Park District property or CCFPD property. The proposed alternative provides 100-year level of protection and eliminates flooding at the problems areas in each study area included. There are several significant permitting obstacles associated with this alternative. The proposed alternative is described below:

100-Year Protection for North and South of Willow, Cherry Outlet and Underpass (Exhibit 10):

- 96-inch sewer along Willow Road from Glendale Avenue to Lake Michigan
- Tunnel 96-inch sewer from Birch Street to Poplar Street
- 84-inch sewer along Hibbard Road from Pine to Oak Streets, and from Oak Street to Willow Road along Glendale Avenue
- 5-foot by 8-foot box culvert along Oak Street from Hibbard Road to Glendale Avenue
- 66-inch sewer along Birch Street from Skokie Ditch to Sunset Road
- 72-inch sewer along Birch Street from Sunset Road to Willow Road
- 60-inch sewer along Provident Avenue from Pine Street to Willow Road

- Alternative 1, 100-year improvements for Underpass Study Area and 100-year improvements for the Cherry Street Outlet Areas
- Existing outlets in Underpass and Cherry Street remain unless larger laterals are used along Sheridan Road to connect to the main outlet
- Provident Avenue 100-year Improvements north of Pine Street to Westmoor Road

The analysis was also performed utilizing smaller sewers combined with storage provided on Park District property west of Hibbard Road. The minimum storage volume required to provide 100-year level of protection in this scenario was 24 ac-ft. The concept plan storage volume required by the Park District is approximately 25 ac-ft. A portion of the volume required for the Village’s flood control could be incorporated in to the Park District’s plans however it is likely that CCFPD property would likely be required to provide the remaining required storage. We have provided cost estimates for the large pipe scenario without storage based on tunneling through clay material or rock in Table 5. Because we do not know the subsurface conditions 15 feet plus below the ground, we believe it was prudent to show both cases.

Level of Protection	Engineer’s Estimate of Probable Cost
100-year (tunnel through clay/soft material)	\$32,499,000
100-year (tunnel through rock)	\$56,866,000

Table 5. Lake Michigan Outlet Cost Summary

Permitting, approval or agreement requirements for the proposed improvements include:

- Approval from MWRDGC for storm sewer improvements and new outlet to Lake Michigan
 - The proposed improvements will be diverting tributary areas from Skokie River to Lake Michigan which is not generally favorable to permitting agencies
- Approval from IEPA
 - Must meet Lake Michigan Water Quality Standards
- Approval from the United States Army Corps of Engineers (USACOE)
- Approval from IDOT for work within the ROW associated with Willow and Sheridan Roads
- Approval from Illinois Department Natural Resources (IDNR)
- Approval from UP-N Railroad for tunneling under railroad tracks

SPRUCE STREET OUTLET STUDY AREA

The 176 acre Spruce Street Outlet Study Area is bounded by the UP-N Railroad to the west, Lake Michigan to the east, Oak Street to the south, and Tower Road to the north (Figure 6).



Figure 6. Spruce Street Study Area

9.1 SPRUCE STREET OUTLET EXISTING CONDITIONS

The northwest corner of the watershed, near the intersection of Tower Road and Foxdale Avenue, is drained by a 12-inch storm sewer that increases in size heading east along Tower Road to a 24-inch storm sewer near Sheridan Road. The system extends southeast along Sheridan Road, and increases to a 28-inch by 42-inch rectangular brick storm sewer near the intersection of Sheridan Road and Humboldt Avenue. The 28-inch by 42-inch storm sewer is drained by a 30-inch pipe down the steep bluffs to Lake Michigan.

Two problem areas were identified, the first at the intersection of Maple Street and Sheridan Road and the second along the north side of Tower Road at Tower Manor Drive. Overland flooding was reported by numerous residents along the north side of Tower Road near Foxdale Avenue at Tower Manor Drive and along the adjacent unnamed horseshoe driveway. The storm sewer draining the Sheridan Road and Maple Street intersection has between a 2-year and 5-year capacity. The Tower Road storm sewer has less than a 2-year capacity. Water backs up from the Tower Road storm sewer through the 8" CMP that drains Tower Manor

Drive in addition to the stormwater flowing north along Foxdale Avenue into the homes along Tower Road. Stormwater in excess of the Tower Road storm sewer capacity also flows overland toward the homes on the unnamed horseshoe driveway.

9.2 SPRUCE STREET OUTLET PROPOSED CONDITIONS

CBBEL analyzed improvements for the Spruce Street Outlet Study Area to provide 25-, 50-, and 100-year levels of protection. The two identified problem areas have been separated into two separate proposed improvement projects (Tower Relief and Lloyd Park Outlet) due to the proposed outlet configurations. The proposed projects can be constructed independently and are designed to eliminate flooding in the identified problem areas for each of the design events. The proposed improvements are described below:

100-Year Level of Protection (Exhibit 7A) – Tower Relief

- 30-inch relief sewer from the low point at Tower Road and Foxdale Avenue to the existing ravine storm sewer at Hubbard Place
- Upsize existing 36-inch sewer at the upstream end of the ravine to 48-inch sewer
 - Proposed 48-inch sewer will overflow at junction with existing 36-inch sewer at bottom of ravine through an overflow structure
 - The bottom of the ravine is 20-30 lower than the surrounding structures
- 12- and 15-inch outlet sewers to the new 30-inch relief sewer from the identified problem areas north of Tower Road at Foxdale Avenue
- Connect the existing 12-inch sewer to the relief sewer
- Install high capacity inlet grates on the Foxdale Avenue sewer

100-Year Level of Protection (Exhibit 7A) – Lloyd Park Outlet

- Create a new outlet to Lake Michigan at Lloyd Park
- New outlet configuration is a shallow 48-inch sewer connected to a steeper 24-inch sewer down the bluff to Lake Michigan.
- Water quality structure
- Energy dissipater (similar to the existing Spruce Street outlet)
- Plug the existing 28-inch x 42-inch sewer line heading south from the new Lake Michigan outlet at Lloyd Park
- Raise Maple Street approximately 6- to 12-inches and install a Tide-flex check valve on the storm sewer connection at Pine Street

Creating a new outlet to Lake Michigan at Lloyd Park separates the existing storm sewer systems into two and reduces the total tributary area to the Maple Street problem area. This also creates significantly more capacity within the Sheridan Road storm sewer for downstream runoff. Slightly raising Maple Street will direct surcharged stormwater runoff to the east down Pine Street and installing a Tide-flex check valve will prevent the Pine Street storm sewer from backing up onto Maple Street.

50-Year Level of Protection (Exhibit 7B) – Tower Relief

- 100-year improvements with the following exception:
- Install 12-inch outlet sewers to the 30-inch relief sewer from the identified problem areas north of Tower Road at Foxdale Avenue.

50-Year Level of Protection (Exhibit 7B) – Lloyd Park Outlet

- 100-year improvements

25-Year Level of Protection (Exhibit 7C) – Tower Relief

- 50-year improvements with the following exceptions:
- 24-inch relief sewer from the low point at Tower Road and Foxdale Avenue to the existing ravine storm sewer at Hubbard Place.
 - Do not upsize sewer at upstream end of ravine

25-Year Level of Protection (Exhibit 7C) – Lloyd Park Outlet

- 50-year improvements with the following exceptions:
- Outlet configuration is a shallow 36-inch sewer connected to a steeper 24-inch sewer down the bluff to Lake Michigan.

A summary of the cost estimates to provide 25-, 50- and 100-year level of flood protection is provided in Table 6 for each problem area. The recommended improvement from the July 2011 study for 10-year level of protection has also been included.

Level of Protection	Engineer’s Estimate of Probable Cost Tower Relief	Engineer’s Estimate of Probable Cost Lloyd Park Outlet
10-year	--	\$368,000
25-year	\$1,299,000	\$465,000
50-year	\$1,390,000	\$476,000
100-year	\$1,394,000	\$476,000

Table 6. Spruce Street Outlet Study Area – Tower Relief / Lloyd Park Outlet Cost Summary

Permitting, approval or agreement requirements for the proposed improvements include:

- Approval from MWRDGC for storm sewer improvements and new outlet to Lake Michigan
- Approval from IDOT for work within the ROW associated with Sheridan Road
- Approval from IEPA for new outlet to Lake Michigan
- Must meet Lake Michigan Water Quality Standards

GREENWOOD AVENUE STUDY AREA

The 166 acre Greenwood Avenue Study Area is bounded by the Skokie River to the west, Vine Street to the east, Tower Road to the south, and Drexel Avenue to the north (Figure 7).

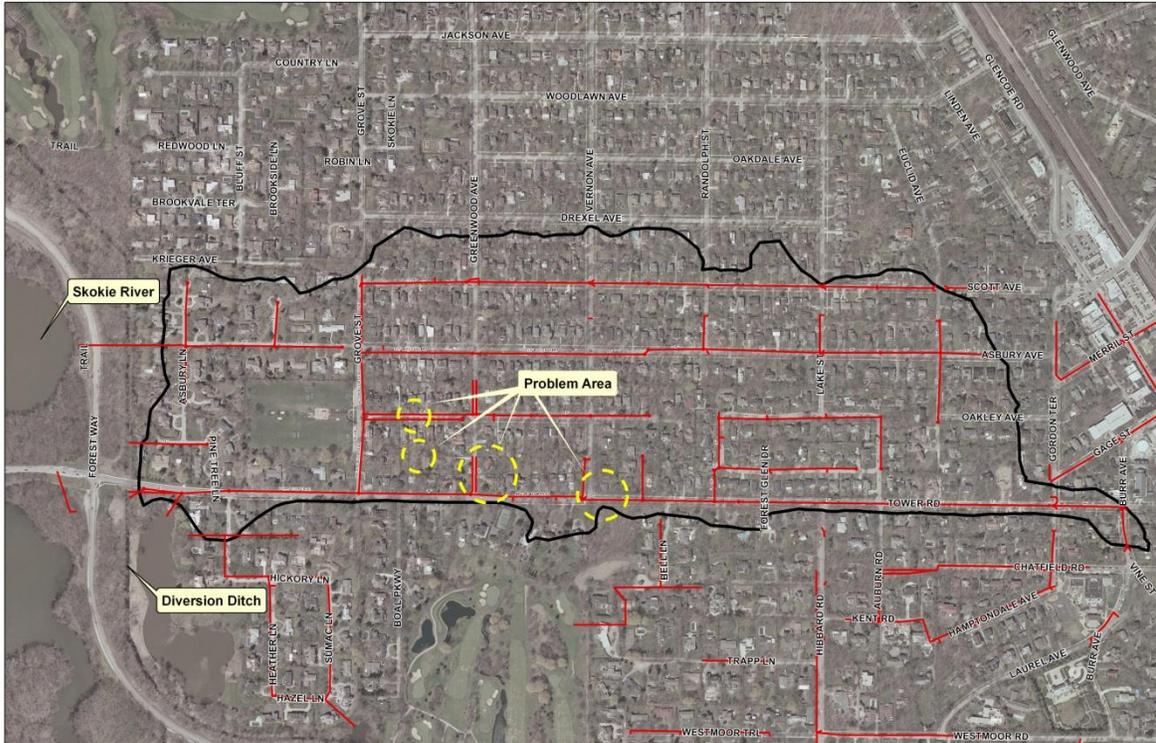


Figure 7. Greenwood Avenue Study Area

10.1 GREENWOOD AVENUE EXISTING CONDITIONS

Based on the Cook County 1-foot aerial topography, there are low spots in rear yards on Greenwood Avenue between Tower Road and Edgewood Lane. Stormwater surcharge from the storm sewers on Greenwood Avenue flows overland into the east problem area. In addition, surcharged storm sewers on Tower Avenue and Edgewood Lane overflow towards the east problem area for the 25-year return interval storm event. The problem areas do not have a gravity outlet, and the east area is pumped by the homeowner at 905 Greenwood Avenue. Residents adjacent to both problem areas have reported overland flooding into their homes.

Village Staff and CBBEL have also identified low spots on Tower Road at Vernon Avenue and on Edgewood Lane between Grove Street and Greenwood Avenue. In both cases, surcharged storm sewers lead to runoff collecting on the pavement for the 25-year return interval storm event. Residents in these areas have reported severe street flooding during intense rain events.

The Greenwood Avenue storm sewers connect to a trunk storm sewer heading west on Tower Road to an outlet at the Skokie River Diversion Ditch (Diversion Ditch). The Edgewood Lane and Vernon Avenue storm sewer systems also ultimately tie into the Tower Road trunk line. A storage basin located on the south side of Tower Road adjacent to the Diversion Ditch (Storage Basin) provides relief for stormwater runoff during larger events. There is also a pump station on the Tower Road storm sewer line that pumps into the Diversion Ditch and provides approximately 45 cfs of additional conveyance capacity.

Based on the existing conditions XP-SWMM modeling results, limited storm sewer capacity leads to surcharged storm sewer conditions and ultimately flooding of the depressional storage areas and houses on Greenwood Avenue. Additionally, accessible flood storage volume within the watershed is limited. The three problem areas identified were:

- Houses and backyards adjacent to Greenwood Avenue
- Tower Road flooding east of Vernon Avenue
- Edgewood Lane flooding between Grove Street and Greenwood Avenue.

Observations from the existing conditions XP-SWMM analysis are provided below:

- The storm sewer systems on Greenwood Avenue and Tower Road provide between a 5-year and 10-year storm event capacity.
- Tailwater from the Diversion Ditch limits downstream storm sewer conveyance capacity during larger storm events.
- The branch storm sewer line from Tower Road to the Storage Basin steps down from a 48" diameter pipe to a 36" diameter pipe. This restriction limits the ability of stormwater to access the Storage Basin and contributes to higher peak water surface elevations upstream. *Existing conditions XP-SWMM model results show that less than half of the volume within the Storage Basin is accessed for the critical duration 100-year design storm event.*
- Discussions with the Village have indicated that the 36-inch sewer crosses underneath the Village's Commonwealth Edison electric interconnect, and that the stormwater basin is located on CCFPD property.
- Existing conditions XP-SWMM model results show that surcharged storm sewers on Edgewood Lane and Tower Road overflow towards the low point on Greenwood Avenue for the 25-year return interval storm event, greatly increasing peak flood elevations in the Greenwood Avenue backyards. In addition, runoff being conveyed west on Edgewood Lane flows south on Greenwood Avenue further contributing to street, rear yard and house flooding.
- Existing conditions XP-SWMM model results show that the low points on Edgewood Lane and Vernon Avenue begin ponding water on the pavement for the 25-year return interval storm event.

10.2 GREENWOOD AVENUE PROPOSED CONDITIONS

CBBEL analyzed three improvement alternatives to provide an increased level of protection for the 25-, 50-, and 100-year design storm events for the Greenwood Avenue Study Area. Improvements included additional pumping, flood storage, and new storm sewers to reduce flooding in the identified problem areas to less than 0.3 feet for each of the design events. Alternative #1 uses un-accessed flood storage volume within the existing storage basin on CCFPD property to mitigate increased downstream flowrates as a result of increased sewer sizes. The existing storage basin on CCFPD property drains to the Diversion Ditch through a flap gate and is hydraulically independent of the Diversion Ditch. Alternative #2 uses underground storage at Corwin Park and Alternative #3 is a combination of storage and an increased pumping rate. The sewer sizes and storage volumes decrease with each decreasing design storm event. The proposed improvements are described below:

Alternative #1 – Increase Pipe Sizes in the Area

100-Year Level of Protection (Exhibit 8A)

- 30-inch sewer from the problem area behind the homes on Tower Road and Grove Street to the Tower Road sewer
- 24-inch sewer from the problem area behind the homes on Tower Road and Greenwood Avenue to the Greenwood Avenue sewer
- The 30- and 24-inch sewers would be located on private property
- 30-inch sewer on Greenwood Avenue
- 30-inch sewer along Edgewood Lane between Greenwood Avenue and Grove Street
- 54-inch sewer along Grove Street between Edgewood Lane and Tower Road
- 36-inch sewer along Tower Road east of Vernon Avenue
- 83-inch by 53-inch elliptical sewer along Tower Road between Greenwood Avenue and Grove Street
- 83-inch by 53-inch elliptical sewer on Tower Road from Grove Street to the existing storage basin
- 60-inch outlet into the existing storage basin

50-Year Level of Protection (Exhibit 8B)

- Include the 100-year improvement with the following exceptions:
- 30-inch sewer along Tower Road east of Vernon Avenue
- 60-inch sewer along Tower Road between Greenwood Avenue and Grove Street
- 76-inch by 48-inch elliptical sewer on Tower Road from Grove Street to the existing storage basin

25-Year Level of Protection (Exhibit 8C)

- Include the 50-year improvements with the following exceptions:
- 21-inch sewer from the problem areas behind the homes on Tower Road, Greenwood Avenue and Grove Street to the Tower Road and Greenwood Avenue sewers.
- The additional 21-inch sewers would be located on private property
- 24-inch sewer line on Edgewood Lane between Greenwood Avenue and Grove street
- 48-inch sewer along Grove Street between Edgewood Lane and Tower Road
- 48-inch sewer along Tower Road between Greenwood Avenue and Grove Street
- 48-inch sewer on Tower Road from Grove Street to the existing storage basin

Alternative #2 – Provide Underground Storage at Corwin Park

100-Year Level of Protection (Exhibit 9A)

- 24-inch sewers from the problem areas behind the homes on Tower Road and Grove Street to the Grove Street sewer and from the problem area behind the homes on Tower Road and Greenwood Avenue to the Greenwood Avenue sewer.
- 24-inch sewers would be located on private property
- 36-inch sewer on Greenwood Avenue to Edgewood Lane.
- 36-inch sewer on Edgewood Lane between Greenwood Avenue and Grove street
- 8.9 acre-ft underground flood storage vault at Corwin Park
- 42-inch sewer on Tower Road east of Greenwood Avenue
- 48-inch sewer along Tower Road between Greenwood Avenue and Grove Street

50-Year Level of Protection (Exhibit 9B)

- Include the 100-year improvements with the following exceptions:
- 30-inch sewer on Greenwood Avenue to Edgewood Lane
- 36-inch sewer on Edgewood Lane between Greenwood Avenue and Grove street
- 6.4 acre-ft underground flood storage vault at Corwin Park
- 36-inch sewer along Tower Road east of Vernon Avenue
- 48-inch sewer along Tower Road between Greenwood Avenue and Grove Street

25-Year Level of Protection (Exhibit 9C)

- Include the 50-year improvements with the following exceptions:
- 30-inch sewer on Edgewood Lane between Greenwood Avenue and Grove street
- 4.7 acre-ft underground flood storage vault at Corwin Park.
- 30-inch sewer along Tower Road east of Vernon Avenue

Alternative #3 – Increase Pump Capacity, Additional Sewers and Storage at Corwin Park

Alternative #3 evaluated doubling the existing pump capacity on Tower Road from approximately 44.5 cfs to 89 cfs. For the 100-year storm event, providing additional conveyance at the pump station reduces the required storage volume at Corwin Park from approximately 8.9 acre-ft to 3.5 acre-ft. However, to convey additional runoff to the new pump station, much larger storm sewer lines are necessary upstream. Specifically, XP-SWMM modeling shows that a 5-foot by 10-foot RCBC (or equivalent) is necessary on Tower Road between Grove Street and the pump station. Discussions with the Village have indicated that utility conflicts in the available corridor may not accommodate a large pipe in this area. It is likely that the size storm sewer needed for effective pump station improvements is not feasible and a cost estimate was not determined for this alternative.

A summary of the cost estimates to provide 25-, 50- and 100-year level of flood protection is provided in Table 7. The recommended improvement from the July 2011 study for 10-year level of protection has also been included in the summary table.

Alternative	Engineer’s Estimate of Probable Cost			
	100-year	50-year	25-year	10-year
Alternative 1	\$2,881,000	\$2,264,000	\$2,178,000	\$67,000
Alternative 2	\$5,330,000	\$4,157,000	\$2,997,000	

Table 7. Greenwood Avenue Study Area Cost Summary

Permitting, approval or agreement requirements for the proposed improvements include:

- Approval from MWRDGC for storm sewer improvements
- Approval from CCFPD for Alternative 1

RAVINE STUDY AREA

The Ravine Study Area addresses the flood problem at the low point of Sheridan Road, located in the northern portion of the Village (Figure 8). Sheridan Road traverses through a ravine with a large tributary area that includes portions of the Village of Glencoe. The 307 acre watershed is bounded by Vernon Avenue to the west, Lake Michigan to the east, Tower Road to the south, and South Avenue to the north. Approximately 70 percent of the 307 acre watershed is located in the Village of Glencoe.



Figure 8. Ravine Study Area

11.1 RAVINE STUDY AREA EXISTING CONDITIONS

Based on the storm sewer atlas, two 36-inch storm sewers capture runoff and convey stormwater down the north and south forks of the ravine. When the 36-inch sewers reach capacity, excess stormwater flows overland along Sheridan Road to the low point on Sheridan Road. The north and south 36-inch storm sewers join at the low point of Sheridan Road and outlet east to Lake Michigan through a 5-foot by 4-foot box culvert. Ponding water makes Sheridan Road impassible during larger storm events.

11.2 RAVINE STUDY AREA PROPOSED CONDITIONS

The Ravine Study Area was analyzed for the 100-, 50-, and 25-year storm events. The peak 100-, 50-, and 25-year year flow rates from the tributary area to the Ravine Study Area are 311-, 286-, and 243 cfs respectively. The existing 5-foot by 4-foot box culvert from the low point on Sheridan Road outletting to Lake Michigan has a capacity of 227 cfs in its current configuration which is slightly less than a 25-year capacity. The low point on Sheridan Road ponds approximately one foot before overflowing east towards Lake Michigan. From the July 2011 study, CBBEL recommended a high capacity grate, 4-feet wide by 10-feet long to pass the 10-year flow rate at the low point along Sheridan Road (Exhibit 11A). Following the same calculations, four of these grates will be required to pass 227 cfs and fill the existing 5-foot by 4-foot box culvert to provide slightly less than 25-year protection for the Sheridan Road low point. To provide 100-year level of protection and pass a larger flow rate (311 cfs), a new pipe outlet to Lake Michigan will be required. A new outlet to Lake Michigan is not cost effective for this problem area compared to the alternative of regarding the area to pass all flow rates in excess of the existing storm sewer overland without ponding. Re-grading the area would provide 100-year level of protection for the area.

A summary of the cost estimates to provide 25-, 50- and 100-year level of flood protection is provided in Table 8. The recommended improvement from the July 2011 study for 10-year level of protection has also been included.

Alternative	Engineer's Estimate of Probable Cost			
	100-year	50-year	25-year	10-year
Alternative 1	--	--	--	\$146,000
Alternative 2	\$475,000	\$475,000	\$475,000	\$475,000

Table 8. Ravine Study Area Cost Summary

- Approval from IDOT for work within the ROW associated with Sheridan Road

CONCLUSIONS AND RECOMMENDATIONS

The proposed improvements presented in this report have been designed to provide 25-, 50-, and 100-year level of protection for areas within the watershed that experience flooding problems identified by Village staff, the existing conditions XP-SWMM analysis, flood questionnaire data and numerous field investigations by CBBEL staff during storm events. For some study areas, the implementation of a single improvement will reduce the risk of flooding, while in other study areas multiple drainage improvements will be required. In general, flood reduction benefits and costs increase as proposed alternatives add drainage improvements and increase in magnitude depending on the level of protection provided. The level of protection for a design storm event refers to the water surface elevation produced during a particular design storm that exceeds a low entry elevation of a structure or causes flooding. The proposed improvements in each study area have been designed to decrease flood elevations below all known low entry elevations. The proposed water surface elevations, resulting from a proposed improvement is shown on the exhibits for each study area. Each study area benefitted from the proposed improvements is shown on Exhibit 12.

The proposed 100-year improvements will eliminate overland flooding throughout the study areas; however homeowners currently carrying flood insurance will need to continue carrying flood insurance even if the proposed 100-year improvements are constructed. The proposed improvements, while eliminating overland flooding from local storm events, do not preclude the Skokie River from overtopping and flooding large areas. Hence, the regulatory Federal Management Agency (FEMA) Flood Insurance Rate Map for the Village will not be changed.

The proposed improvements in three of the study areas include replacing the restrictive outlet to Lake Michigan with a larger outlet sewer. Improvements that increase stormwater flow to Lake Michigan will be required to address potential water quality issues by adding a Best Management Practice (BMP) component such as a manufactured water quality structure. BMP components are manufactured to reduce pollutants from the “first flush” of a storm event, typically the 1 to 2-year flow rate, and bypass excess flow during larger storm events. Pollutants removed by manufactured water quality structures typically include hydrocarbons, total suspended solids, total nitrogen and total phosphorus.

Recommendations for each of the study areas are discussed below and summarized in the following sections. An economic benefit-cost analysis was not part of the scope, and was not completed for this study. The proposed improvements projects or areas of concern have not been ranked.

12.1 RECOMMENDATIONS

12.1.1 North of Willow Road and Provident Avenue Study Area

The proposed improvements in this study area include flood storage on Park District and CCFPD properties combined with storm sewer improvements to convey stormwater to the storage areas (Exhibits 1A – 1C) and a new pump station. Utilizing the Park District’s concept plan for future development, flood storage has been provided throughout the areas west of Hibbard Road. Each storage area is hydraulically connected and outlets to a proposed pump station west of the Park District Property to the East Skokie Diversion Ditch. The required

storage on CCFPD property decreases with decreasing level of protection. The proposed improvements will require approvals from the CCFPD, Park District, New Trier High School, and D36. The engineer's estimate of probable cost for each level of protection is shown in Table 9.

12.1.2 South of Willow Road Study Area

The South of Willow Study area improvements include storage on CCFPD property southwest of Willow and Hibbard Roads, storm sewer conveyance from Skokie Ditch to the forest preserve and the relocation of the Mount Pleasant Road pump station. Underground storage is proposed on CCFPD property to provide the storage required for the 25-, 50- and 100-year design storms (Exhibits 2A – 2C). The engineer's estimate of probable cost for each level of protection is shown in Table 9. A cost estimate has also been provided for the 100-year level of protection utilizing an above ground detention basin. The proposed above ground detention basin would be approximately 12 feet deep and provide the required storage shown for the 100-year design storm in the footprint shown on Exhibit 2A. The proposed improvements will require approvals from the CCFPD.

12.1.3 Underpass Study Area

Although flooding at the underpass locations is common for frequent storm events, flooding at the underpass does not result in property damage. Three alternatives (Exhibits 3A-3C, 4A-4C, and 5A-5C) were analyzed including underground storage at the railroad parking lot and New Trier athletic fields combined with storm sewer improvements and an increased outlet to Lake Michigan at Elder Lane. Alternative 2 eliminates flooding at both the Winnetka Avenue and pedestrian underpass problem areas. It was determined that keeping Winnetka Avenue passable during major storm events for emergency vehicles was a priority over the pedestrian walkway. Therefore, Alternative 1 is recommended to remove flooding at Winnetka Avenue for the design storm events. The engineer's estimate of probable cost for each level of protection is shown in Table 9.

12.1.4 Cherry Street Outlet Study Area

The improvements in this area consist of new storm sewers along Sheridan Road, Oak Cherry and Ash Streets, as well as a larger outlet to Lake Michigan at Cherry Street (Exhibits 6A-6C). The storm sewer improvements eliminate flooding in the study area for the 25-, 50-, and 100-year design storms. The proposed storm sewer sizes decrease with each decreasing design storm. The engineer's estimate of probable cost for each level of protection is shown in Table 9.

12.1.5 Spruce Street Outlet Study Area

The two identified problem areas in the Spruce Street Outlet study area have been separated into two separate proposed improvement projects (Tower Road relief and Lloyd Park outlet) due to the proposed outlet configurations. The proposed projects can be constructed independently and are designed to eliminate flooding in the identified problem areas for each of the design events. The engineer's estimate of probable cost for each level of protection is shown in Table 9.

12.1.6 Greenwood Avenue Study Area

Three alternatives were analyzed for this study area, the first included storm sewer modifications only, the second included underground storage at Corwin Park with sewer modifications and the third included storage, sewers and pump modifications to the pump station on Tower Road. Storage at Corwin Park with smaller storm sewer modifications is not cost effective due to the underground storage component. Therefore the recommendation for this study area is the storm sewer modification. The engineer's estimate of probable cost for each level of protection is shown in Table 9.

12.1.7 Ravine Study Area

To prevent the low point of Sheridan Road from becoming impassable for the 25-, 50-, and 100-year design storm events, we have recommend regarding the area to prevent ponding from occurring during each event. The engineer's estimate of probable cost for each level of protection is shown in Table 9.

Engineer's Estimate of Probable Cost (Millions)				
Study Area	10-year	25-year	50-year	100-year
North of Willow Road and Provident Avenue	\$6.8	\$13.0	\$14.8	\$17.5
South of Willow Road (underground storage)	\$3.6	\$9.7	\$12.6	\$17.8
South of Willow Road (above ground storage)	--	--	--	\$9.6
Underpass - Alt 1 (new outlet)	\$2.4	\$2.9	\$3.4	\$4.4
Underpass - Alt 2 (new outlet storage at parking lot)	--	\$4.5	\$5.4	\$6.6
Underpass - Alt 3 (new outlet storage at high school)	--	\$4.2	\$5.1	\$5.9
Cherry St	\$0.7	\$1.8	\$1.9	\$2.0
Spruce St - Lloyd Park Outlet	\$0.4	\$0.5	\$0.5	\$0.5
Spruce St - Tower Relief Sewer	--	\$1.3	\$1.4	\$1.4
Greenwood Ave - Alt 1 (sewers only)	\$0.07	\$2.2	\$2.3	\$2.9
Greenwood Ave - Alt 2 (storage at Corwin Park)		\$3.0	\$4.2	\$5.3
Ravine - Alt 1 (grates)	\$0.1	--	--	--
Ravine - Alt 2 (re-grading)	\$0.5	\$0.5	\$0.5	\$0.5
TOTAL	\$14.1	\$31.9	\$37.4	\$47.0

Bold values indicate the value included in the total.

Table 9. Engineer's Estimate of Probable Cost Summary by Study Area

CBBEL analyzed an alternative that includes a new main storm sewer running under Willow Road and outlets to Lake Michigan for 100-year design storm. The proposed alternative combines sewer improvements from the North and South of Willow Road, Underpass and Cherry Street Outlet study areas into one main outlet draining to Lake Michigan. This proposed improvement consists of a large storm sewer under Willow Road extending from Glendale Avenue to Lake Michigan with multiple storm sewers extending into each of the study areas to be benefitted from this improvement. The proposed improvements eliminate the need for storage on either Park District property or CCFPD property. The benefits realized in each of the study areas included with this improvement are equal to or greater than the benefits realized for the recommendations in each itemized study area. There are several significant permitting obstacles associated with this alternative including the diversion of tributary area and a portion of the sewer is proposed to be tunneled. The engineer’s estimate of probable cost to provide 100-year protection using this improvement is shown in Table 10.

Engineer’s Estimate of Probable Cost (Millions)		
Study Area		100-year
North of Willow Road South of Willow Road Underpass Cherry St	Outlet to Lake Michigan (tunnel through clay)	\$32.5
	Outlet to Lake Michigan (tunnel through rock)	\$56.9
Spruce St - Lloyd Park Outlet		\$0.5
Spruce St - Tower Relief Sewer		\$1.4
Greenwood Ave - Alt 1 (sewers only)		\$2.9
Ravine - Alt 2 (re-grading)		\$0.5
TOTAL		\$37.8

Table 10. Engineer’s Estimate of Probable Cost - Outlet to Lake Michigan Summary

***Appendix 1
Cost Estimates***