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Skokie Headwaters

Feasibility Study

Dady Slough Area Drainage Improvements

Park City, Illinois

February 7, 2020
Project No. 210-218-

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Introduction:

The Skokie River headwaters begins in a wetland area approximately 200' north of Washington Street and extends into the Village of Gurnee and the cities of Waukegan, Park City and North Chicago. The Skokie River headwaters experiences overbank flooding which causes significant damages within the watershed.

Previous studies have been completed resulting in updated hydrology and hydraulics models (enhancements to the FIS) as well as a host of alternatives investigated (feasibility studies) as cited below. A stated in the CBBEL study, the watershed is urbanized and nearly fully built-out, with much of the development having occurred prior to modern stormwater management practices such as stormwater detention and floodplain management. A significant amount of background information on the watershed and discussions on various alternatives is available in these past studies and is not replicated in this report. Several of the recommended drainage improvements have already been implemented but significant flooding and damages still occur. In addition to the numerous structures subject to annual damages, local and state roads also are closed during flood events as frequent as the 10-yr event.

This report expands on the Skokie Headwaters Flood Storage Site B described in both the STS 2006 and CBBEL 2009 reports.

FIS:

The Skokie River headwaters is included on the NFIP maps along with supporting technical information in the FIS. This area was included on the original NFIP maps for the county (produced in 1981). Revised hydrologic and hydraulic analysis for the Skokie River were prepared by IDOT-DWR and incorporated into the 1997 FIS. There have been no updates to the hydrologic and hydraulic analysis incorporated into subsequent NFIP map updates since 1997. Associated FIS profile and table information is included.

Dady Slough

Storm Frequency (years)	Peak Flow (cfs) [1]	Peak Elevation
10	69	696.2
50	166	696.7
100	221	697.0

[1] Depressional outflow per Table 9 2600' upstream of roadway

Casimer Pulaski / Greenbelt Forest Preserve

Storm Frequency (years)	Peak Flow (cfs) [1]	Peak Elevation
10	105	696.2
50	250	696.7
100	323	697.0

[1] Depressional outflow per Table 9 50' downstream of roadway

Available Hydrology and Hydraulics data for the watershed:

In effort to identify flood reduction measures several feasibility studies have previously been completed since 1997 FIS. These studies produced updated H&H modeling as well as resulted in several constructed projects within the watershed to reduce flood heights.

- Skokie Headwaters and North Chicago Flood Damage Reduction Feasibility Study Report, STS, July 2006. This study was based on the following documents.
  - Effective FIS (HEC-1 and HEC-2)
  - 2002 2' contours (1' within Village of Gurnee)
  - Supplemental stream cross-section survey upstream Washington Street
  - LCDOT Washington Street improvement plans
  - Amhurst Business Park hydrology study (STS, 1990)

  The resultant HEC-1 is based on Bulletin 70 rainfall data (12-hr). It does not appear that there were significant revisions to the FIS HEC-2 model.

- Lake Bluff Flood Storage Site Feasibility Study Skokie River Watershed, CBBEL, September 2009. This study utilized above documents and models in addition to the following.
  - Updated hydraulic information from the City of Highland Park
  - Updated Survey Information from James Anderson Company

  The resultant HEC-1 is based on Lake County specific Bulletin 70 rainfall depths. The resultant HEC-2 model is the baseline condition for all subsequent modeling efforts.

- Gillette Property LOMR, CBBEL, 2016. This study developed a HEC-RAS model for a small portion of the watershed based on the above documents and models. There were no revisions to the hydrologic model from their 2009 work.

- Pulaski Drive Culvert Replacement Stormwater Report, Hey and Associates, June 2016. This study was based on the above documents and models. Hey created an alternative HEC-1 model (48-hr event), slightly revised the LOMR HEC-RAS model and created an XP-SWMM model for the Casimer Pulaski Drive (herein after referred to as Pulaski Drive) storage area.

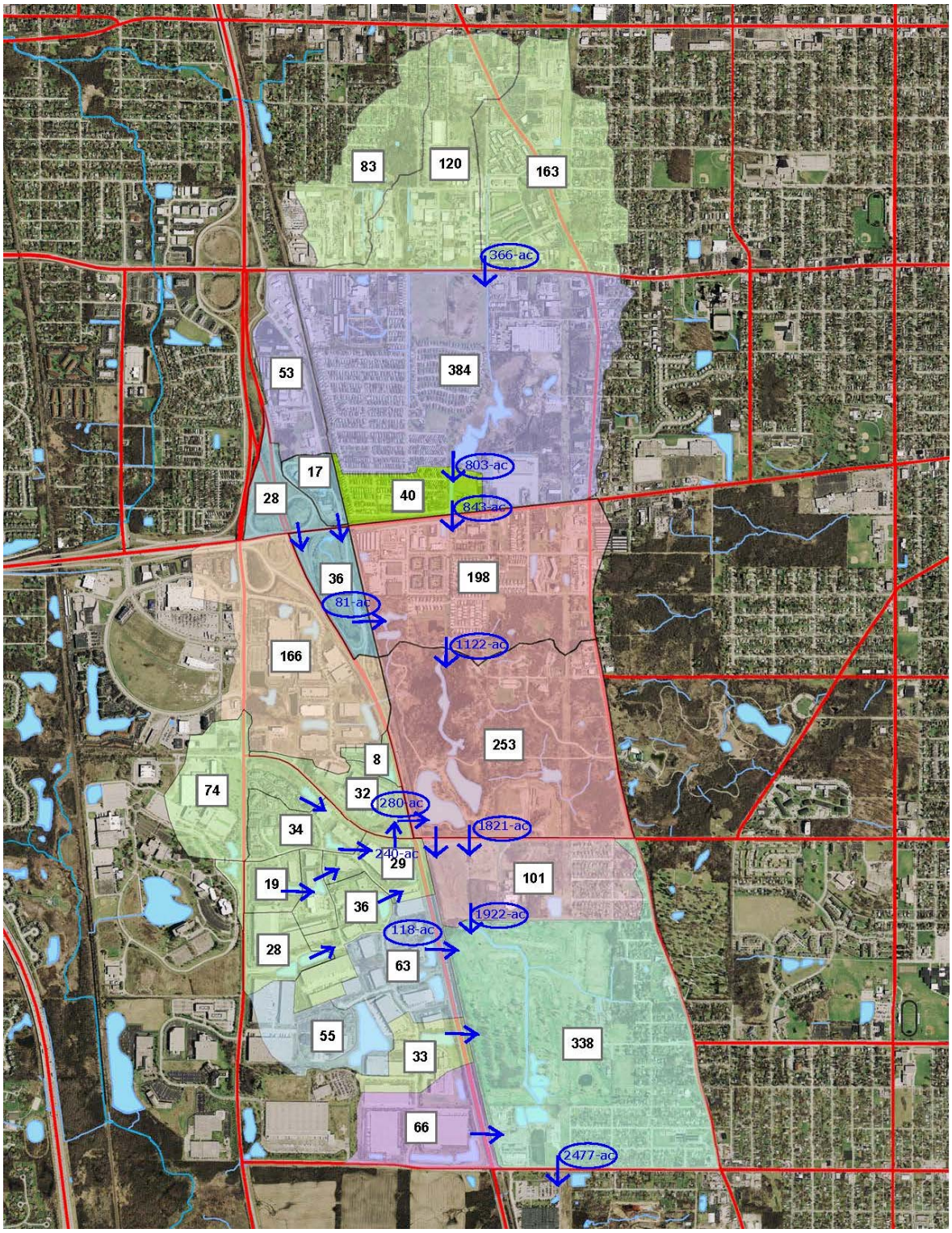
- IDOT Hydraulic Analysis of Box Culvert Across IL Route 120 (2015). Improvements on IL Route 120 are scheduled for 2020 and do not include any hydraulic modification to the box culvert.

Updated Hydrology & Hydraulics (Modified Existing Model):

The 2006 STS model revised the effective 1997 FIS model. During our cursory review of the hydrology models and associated discharges used in the hydraulic model, we noted deficiencies with the STS/FIS model; numerous hydrographs were added in locations that are not consistent with actual field conditions. The Hey HEC-1 model is significantly more simplistic and does not explicitly model the Amhurst Business Park.

As a result BLECK delineated drainage areas based on the County's 2007 1' topography and field inspections. The STS hydrology model was revised with updated drainage area and routing information. This is an incredibly complicated watershed

with extensive (inconsistent) modeling done by various different consultants. Routing annotations were added to STS Exhibits 5-1 and 5-2.



Updates to the H&H were originally completed by BLECK on behalf of the LCSMC in 2018 and summarized below.

Drainage Area (Ac)	FIS/CBELL '09	HEY '16	BLECK '18
Belvidere	808.3	832	843
44.508	994.5	1018.2	1122
Casimer Pulaski	1772.1	1564.2	1821
43.548 (V)	1979.11	1861.76	1922

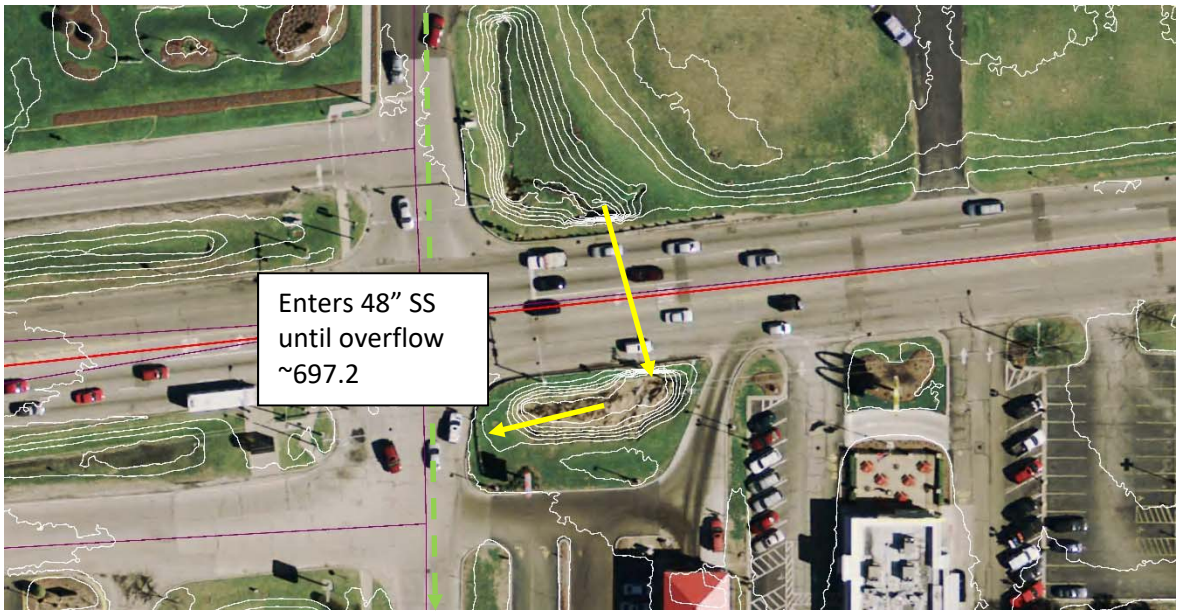
Discharge (cfs)	FIS/CBELL '09	HEY '16	BLECK '18
Inflow Dady Slough	477	383	475
Belvidere	227	205	151
44.508	234	236	354
Inflow Pulaski Drive	369	448	676
DS Pulaksi Drive	267/348		295
43.548 (V)	459/454	324	365

The Skokie River in the headwaters area upstream of Belvidere Road is comprised of open channels and ponds up to cross-section 45.030 located approximately 550 feet upstream of Belvidere Road. At that point stream flows are conveyed by two systems.

Flows initially discharge from the Dady Slough via the outlet structure shown above and follow the storm sewer shown in green dash. During larger events flow discharges to the south following the open channel shown in blue and crosses under Route 120.

- Historic information identified a 20" storm sewer traveling due south (out of Dady Slough) to Belvidere Road where the storm sewer increases to a 22-inch diameter pipe. However, survey data obtained by CBBEL and the City of Park City's storm sewer atlas, along with field reconnaissance, indicate the Dady Slough outlets through a FES into a 42" storm sewer that travels due south across Belvidere Road. This pipe size increases to a 48" within the Knight Street right-of-way and discharges into the Greenbelt Forest Preserve.

- Flood flows exceeding the capacity of the storm sewer (after a flood depth of at least 691.75 is achieved) are conveyed in an overland grass channel. When this channel reaches Belvidere Road, the flow is conveyed under the road in a 5.5 foot x 10 foot box culvert. Discharge from the box culvert is conveyed into a small depressional area with an outlet into the existing 48" storm sewer. Flows exceeding the capacity of the storm sewer continue to pond until approximately 697.2 when flow can overtop and discharge south along Knight Street, continuing into the Greenbelt Forest Preserve.



Route 120 & Knight

Neither HEY's nor CBBEL's HEC-RAS hydraulic models, for the Pulaski drive and the LOMR, include Pulaski Drive culverts. As determined by both previous engineers the unique storage and numerous culverts make the modeling of this roadway extremely challenging. Hey describes a multiple step approach using a combination of XP-SWMM, HEC-1 and HEC-RAS to evaluate discharge and water surface elevations as a result of the LCDOT improvements.

Initially we used an extension of the Hey procedure, utilizing their XP-SWMM to develop a rating curve of the Pulaski depression. However, several concerns were identified with respect to resultant rating curves. It was observed that when significant changes to the inflow and outflow conditions were made to the model (modifications to the Pulaski Storage area restrictor or changes to the inflow hydrograph) there was limited effect on the resultant HWL. HEC-RAS cross-sections 152 and 151.8 were removed from the model as these locations are no longer appropriate after the Pulaski roadway improvements[1].

[1] The use of 152 and 151.8 by Hey was later determined to be a primary reason that changes to the watershed resulted in insignificant changes to the resultant HWL.

After review of the various models and approaches (and discussions with both previous engineers) it was determined the use of unsteady state HEC-RAS or a 1D/2D XP-SWMM would be the most accurate way to model the watershed. However, this level of effort is significantly more extensive than necessary to evaluate potential flood reduction benefits from improvements near the Dady Slough. As a result Bleck used a similar iterative methodology as Hey (utilizing HEC-1, HEC-RAS, HY8 and manually computed rating curves). A detailed discussion of the methodology is included along with supporting modeling in Appendix 1.

Modified Existing Dady R3

Storm Frequency (years)	Peak Flow (cfs)	Peak Elevation
1	53	691.99
2	57	692.66
5	62	693.65
10	67	694.62
25	73	695.85
50	76	696.49
100	80	697.25

Modified Existing Casimer Pulaski (R6a)

Storm Frequency (years)	Peak Flow (cfs)	Peak Elevation
1	87	691.03
2	94	691.64
5	112	692.28
10	132	692.70
25	159	693.29
50	181	693.80
100	208	694.32

The modeling demonstrates that flooding is dictated by the tailwater conditions. A review of the FIS profile visually depicts this as there are large level pool areas near Martin Luther King Jr. and Casimer Pulaski Drives, and Belvidere Road (similar areas are located further downstream as well). Numerous roadways and structures are inundated. The modified existing model demonstrates that the drainage improvements made at Casimer Pulaski and Dady Slough in 2016 were insufficient to improve reduce 100-yr floodheights inundating roadways and structures in the headwaters, although benefits were achieved during more frequent events.

Alternatives Investigated:

The feasibility of the following options were evaluated.

1. Preferred Alternative
2. Remove the restrictors installed at Casimer Pulaski Drive (installed as part of the 2016 project.
3. No Change
4. Further improvement of the Dady Slough outlet
5. Increase the storage capacity of the Dady Slough.

1. Preferred Alternative: Increase Hydraulic Capacity between IL Route 120 and Greenbelt Forest Preserve

This alternative evaluated capacity upgrades between IL Route 120 and the Greenbelt Forest Preserve along with upgrades to improve conveyance into the existing system (42"-48"). The cross-culvert under IL Route 120 is not a limiting hydraulic feature. This alternative includes the following:

- Improve Dady Slough outlet - lower NWL to 689.
- Channel grading between Slough outlet and IL Route 120 (improve slope and cross-sectional capacity).
- Upgrade crossings at the radio station and Dady Slough outlet.
- Installation of a 6x4 box culvert from the downstream side of Belvidere (including associated inlet structure, along Knight Avenue and discharging into the Greenbelt Forest Preserve.
- Removal of the restrictor plate at Casimer Pulaski.

Associated stage-storage-discharge computation were completed and both the HEC-1 and HEC-RAS models were updated following the same methodology as discussed above for the development of the Modified Existing Model. The proposed BFE is consistent with the BFE established by HEY as part of the Casimer Pulaski improvements and lower than the published FIS elevation of 696.2.

Proposed Dady R3

Storm Frequency (years)	Peak Flow (cfs)	Peak Elevation
1	53	691.62
2	107	691.92
5	136	692.19
10	149	692.82
25	173	693.88
50	194	694.90
100	213	695.79

Proposed Casimer Pulaski (R6a)

Storm Frequency (years)	Peak Flow (cfs)	Peak Elevation
1	94	691.05
2	111	691.83
5	135	692.58
10	161	693.26

25	204	694.16
50	243	694.83
100	285	695.48

2. Removal of Restrictors at Casimer Pulaski:

The removal of the restrictors was determined to have limited effect on the profile. The 60" culvert was found to be the hydraulic control at elevations above ~686.5.

3. No Change:

Under the No Change scenario the significant hydraulic capacity upgrades at Casimer Pulaski, the channel downstream of Casimer Pulaski, further downstream improvement, and at the Dady Slough outlet have resulted in less than 0.5' decrease in the BFE at Dady Slough from the FIS. A significant number of residential structures, businesses and roadways remained inundated and cause repetitive flood damages in the region.

4. Further Improve the Dady Slough Outlet:

The upgrade of the outlet and conduits upstream of Belvidere were found to have limited effect on the profile. The 48" culvert, downstream of Belvidere, was found to be the hydraulic control until overtopping along Knight Avenue can occur beginning at approximately 697.2.

5. Increase Storage Capacity of Dady Slough:
Excavation of the basin with 5:1 slopes down from 30-acre surface area. Install an 18" outlet at 686, secondary overflow at 692 and maintaining the existing storm sewer system (30"-42"-48"). This option added more than 150-AcFt of storage and lowered the NWL over 4'. The resultant BFE only dropped 0.2' (~696.3). Various combinations of storage, NWL, outlet modifications were evaluated and the resultant BFE consistently was ~696.3. It became evident that the downstream hydraulic capacity resulting from tailwater at Greenbelt Forest Preserve/Casimer Pulaski coupled with the restrictive hydraulic control along Knight Avenue (697.2 surface overflow and 48" culvert) prevented further reduction on the BFE. In addition to the significant excavation cost associated with this alternative, stabilization of at least 30-ac and miles of shoreline would be required and resulted in only a minimal flood reduction benefit.

Conclusion:

The Modified Existing Profile takes into account recent drainage improvements made in the watershed. The drainage improvements made at Casimer Pulaski allow for the conveyance increase associated with the preferred alternative. As demonstrated by the various analysis to date, flood reduction cannot be achieved for this watershed without both conveyance and storage components. The tailwater effects begin miles downstream and limit flood reduction potential. Increasing storage alone is insufficient to achieve sufficient flood reduction to significant reduce roadway closures. The Preferred Alternative achieves the maximum flood reduction currently achievable. Additional flood reductions can only be achieved as a result of increased downstream conveyance and/or the creation additional storage.

Dady Slough

Storm Frequency (years)	FIS	Modified Existing	Proposed
10	696.2	694.62	692.82
50	696.7	696.49	694.90
100	697.0	697.25	695.79

Greenbelt Forest Preserve

Storm Frequency (years)	FIS	Modified Existing	Proposed
10	694.9	692.70	693.26
50	695.6	693.80	694.83
100	696.2	694.32 (695.51)[1]	695.48

[1] Proposed conditions BFE associated with the LCDOT project as presented by HEY and associates (report cited above).

The implementation of this improvement also reduces closures of Washington Street, Belvidere, numerous local roads and significantly reduces flood depths and frequency of inundation in the headwaters. The project also allows for the future expansion of flood reduction measures including additional excavation of Dady Slough, increase of conveyance at Washington Street and Casimer Pulaski which will provide in an even greater regional benefit.

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