Report for

Village of Prairie du Sac, Wisconsin

Southwest Side Flood Evaluation

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INTRODUCTION

Strand Associates, Inc. has conducted a planning level flood study for an area generally located on the southwest side the Village of Prairie du Sac, Wisconsin (Village) (refer to Figure 1). The need for the study stems from a unique flooding event that occurred during the week of March 11th, 2019 where a prolonged period of unseasonably high temperatures caused rapid snow melt while frozen ground conditions were still present. Additionally, approximately 0.6-inches of rainfall fell between March 13th and March 15th, which generated additional stormwater runoff. The graphic below taken from the Weather Underground website includes a plot of hourly temperatures and cumulative rainfall depths that occurred during the week of March 11th, 2019. As can be seen from this graphic, the high temperatures on March 12th, 13th, and 14th reached about 62, 53, and 70 degrees Fahrenheit (ºF), respectively and low temperatures on 13th, 14th and 15th hovered between 40 and 50 ºF. It was reported that approximately 8-inches of snow cover was present in the Village at the beginning of the week.

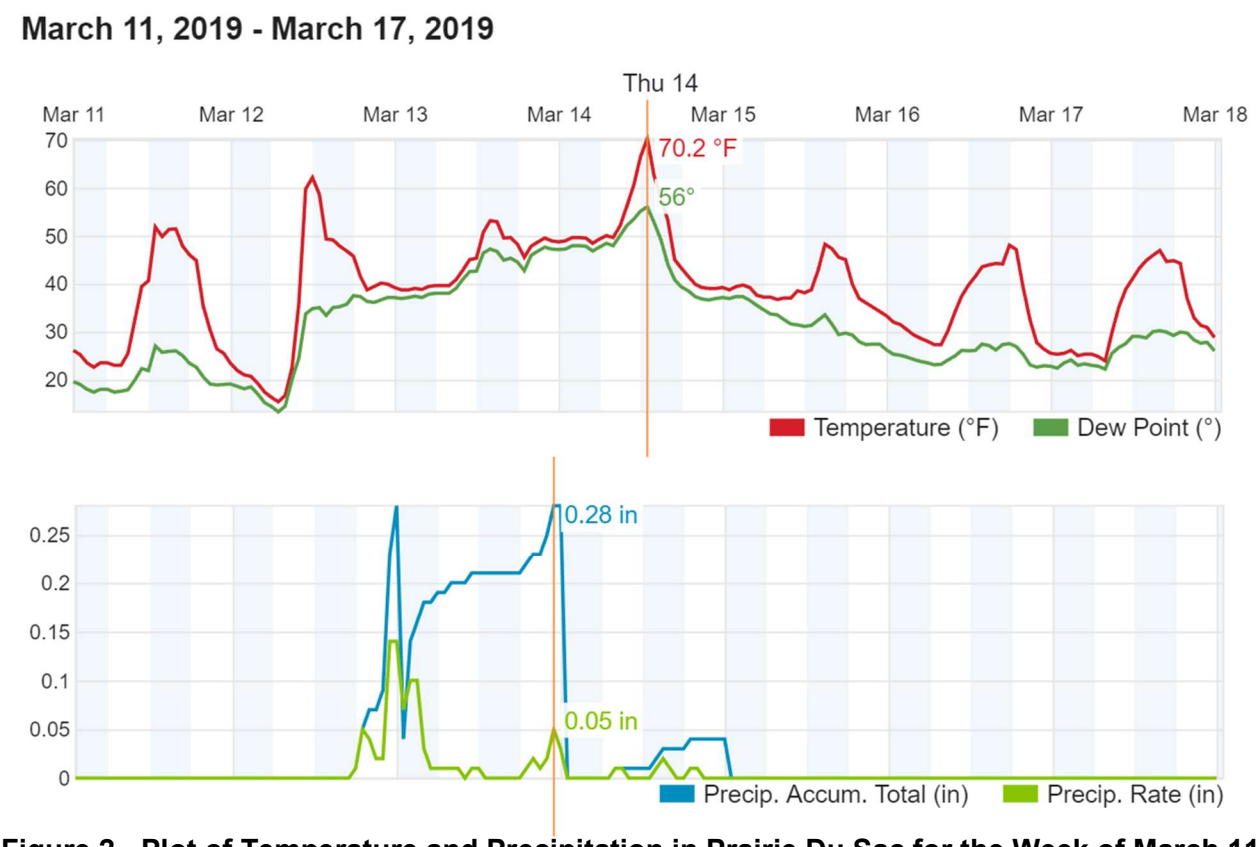


Figure 2 - Plot of Temperature and Precipitation in Prairie Du Sac for the Week of March 11, 2019 (source: Weather Underground)

This area of the Village is particularly susceptible to flooding under frozen ground conditions because no gravity outlet is available to allow positive drainage to occur from the tributary watershed. Drainage within the subject watershed is generally directed to two existing dry bottomed detention ponds. The

larger of the two ponds is located within Walter Doll Park and a smaller pond that is located within the Parkside subdivision near the intersection of Lueders Road and Parkside Drive. These two ponds are interconnected via a storm sewer system that based on its constructed slope, flows to the northeast from the Parkside Pond to the Walter Doll Pond. However, under certain conditions, including the March 2019 flood event, water surface levels in the Walter Doll Pond become higher than the water surface levels in the Parkside Pond, which then results in flow backing up into the Parkside Pond.

During non-frozen ground periods of the year, the subject stormwater drainage system has generally functioned quite effectively in the past, despite the fact that no positive gravity outlet from the overall watershed is available. This is primarily due to predominantly sandy soils in the watershed that are highly conducive to rapid stormwater infiltration. The focus of this flood study is to evaluate flooding conditions when frozen ground conditions are present and stormwater runoff from a combination of snow melt and rainfall must be managed.

TIMELINE OF MARCH 2019 FLOOD EVENT

- Monday, March 11th, 2019
  - No rainfall was recorded.
  - High temperature was 52 degrees.
  - Low temperature was 15 degrees.

- Tuesday, March 12th, 2019
  - Rainfall begins around 6:00 pm. Approximately 0.3-inches of rain fell through midnight.
  - High temperature was 62 degrees.
  - Low temperature was 40 degrees.

- Wednesday, March 13th, 2019
  - Rainfall continued to fall throughout the day. Approximately 0.28-inches fell through midnight.
  - High temperature was 53 degrees.
  - Low temperature was 46 degrees.
  - Parkside pond was reported to be filling up.

- Thursday, March 14th, 2019
  - Minimal rainfall fell during the day. Daily rainfall total was about 0.05 inches.
  - High temperature was 70 degrees.
  - Low temperature was 40 degrees.
  - In the morning, overland drainage started crossing Lueders Road from the west into Parkside Drive. Note that this is the first time that flow overtopping Lueders Road from the west has ever been observed or experienced.
  - Far west end of Broadway Street flooded at the intersection of Lueders Road. Storm inlets at this location were reported to be taking in flow. Note that this is the first time flow overtopping Broadway Street from the north has ever been observed or experienced.
  - At 9:00 am, fire truck started pumping at approximately 700 gallons per minute (gpm) from Walter Doll Pond. Pumped approximately 1,500 feet through a 5-inch diameter hose. Water elevation in Walter Doll Pond continued to rise.

  - In the morning, the Village ordered two 5,000 gpm pumps from an area farm pumping company. The first pump arrived by noon and pumping at Walter Doll Pond began at 1:00 pm. Flow was directed to the east down Grand Avenue via 10-inch flexible hose and discharged into the storm sewer system. Pumps initially cavitated, limiting the flow rates until the problem was resolved after a few hours.
  - A second pump arrived later in the afternoon and starting pumping at Parkside Drive pond with discharge being directed to Walter Doll Pond.
  - The two pumps pumped into the night.

- Friday, March 15th, 2019
  - Both pond elevations were lowered substantially by 2:00 am on Friday morning.
  - Both pumps were shut off mid-morning after 20 hours of pumping.
  - By noon, area roads were opened back up.

- Sunday, March 17th, 2019
  - Village witnessed that frost came out of Walter Doll Pond and remaining water in the pond quickly infiltrated.

WATERSHED DESCRIPTION

Below is a description of the tributary 441.5-acre study watershed (refer to Figure 1 for an overall watershed map). Note that some of the sub-basins in the study watershed do not directly drain to the Walter Doll and Parkside Ponds, but drainage instead can overflow into the ponds during extreme runoff events.

A. Parkside Pond Watershed

The area draining directly to the Parkside Pond (Sub-basin 8) is approximately 15.4-acres of mostly residential lands. Two small storm sewer systems provide drainage along portions of Parkside Drive and Lueders Road that is directed to the Parkside Pond. The pond itself resides on a 0.6-acre outlot and has approximately 1.4 acre-feet of storage volume before drainage begins inundating the adjacent residential lots to the south and east and spilling onto Parkside Drive to the north. The pond must fill approximately 3.5 feet to an elevation of 768 before discharging via a 14-inch by 23-inch elliptical (18-inch equivalent) diameter intake to the east. This storm sewer line extends to the east and north along Parkside Drive where it ultimately outlets into the Walter Doll Pond.

During heavy storm events, excess runoff enters the Parkside Pond from lands to the west of Lueders Road. Based on discussions with area residents and Village staff, the March 2019 flood event was the first time that flow overtopping Lueders Road into the Parkside area has ever been observed or experienced. As the pond continues to fill, it eventually becomes hydraulically connected to ponded water located upstream (north) of Sauk Prairie Road. Flood overtopping of Sauk Prairie Road at an approximate elevation of 770.5 essentially serves as the main surface overflow for the Parkside Pond and surrounding areas. Based on observations during the March 2019 flood event, it is believed that the Parkside Pond area and the area located upstream of Sauk Prairie Road flooded to an approximate elevation of 771.0 (refer to Figure 1). A flood elevation of 771.0 equates to just over one foot of flood depth within Lueders Road and Parkside Drive. The storage volume available within the Parkside Pond

and surrounding areas at a flood elevation of 771.0 is approximately 3.5 acre-feet. Note this doesn't include storage volume that is available within the ponded areas upstream of Sauk Prairie Road. It is estimated that this area has approximately 4.0 acre-feet of storage volume at a flood elevation of 771.0.

B. Walter Doll Pond Watershed

The area that directly drains to the Walter Doll Pond (Sub-basin 4) is approximately 167.1 acres, most of which is developed lands within the Village. These lands are generally drained by storm sewer systems that directly drain into Walter Doll Pond. There are two additional sub-basins (Sub-basin 4 and 5) generally located north of Sub-basin 4 that for most storm events, do not appear to contribute runoff to Walter Doll Pond. Sub-basin 5 consists of 7.6 acres of undeveloped lands and natural depressional storage, while Sub-basin 6 consists of 13.5-acres of developed lands that includes Bridges Elementary School. Stormwater facilities at this site were designed to fully store and contain runoff from a 100-year storm event.

The Walter Doll Pond itself resides on a 4.1-acre park site. The pond does not have a gravity outlet and must rely entirely on stormwater infiltration for pond drawdown during non-frozen ground conditions. Note that the pond had previously been equipped with a stormwater pump station that could drain the pond to help relieve flooding experienced during heavy rainfall events. However, this pump station had to be removed because the receiving storm sewer system at Grand Avenue and 9th Street did not have sufficient conveyance capacity at that time and flooding in the area resulted. Note that this was prior to the storm sewer improvements that have since been constructed along 9th Street and Ray Street which have significantly increased the available receiving storm sewer system capacity. The 8-inch diameter force main that was used is still in place and extends approximately 2,800 lineal feet to the east along Grand Avenue, where it discharges into an existing storm sewer located near the intersection of 9th Street. Further discussion regarding the potential for utilizing this existing force main for future pumping operations is provided later in this report.

Historically, the performance of the Walter Doll Pond has been very effective during non-frozen ground conditions due to very high infiltration rates. Measurements to determine actual infiltration rates have not been performed, but it is not unreasonable to assume that infiltration rates of at least 5-inches per hour can be realized, and possibly even higher. Based on the bottom footprint that is present in the pond, this equates to a discharge rate of about 13 cubic feet per second (CFS). As a frame of reference, an 18-inch diameter concrete pipe sloped at one percent flowing full has the capacity to convey about 11 CFS.

Based on review of available topographic mapping, as the pond reaches its storage capacity, it begins to inundate the intersection of Grand Avenue and 13th Street at an approximate elevation of 769.5. At this elevation, the storage depth and volume of the pond is approximately 6 feet and 14 acre-feet, respectively. As the pond continues to fill, there is no positive overland drainage route available that allows the pond to draw down. As evidenced during the March 2019 flood event, it is believed that the pond filled up to an approximate elevation of 771.5. This equates to about two-feet of flooding at the intersection of Grand Avenue and 13th Street. The approximate limits of this inundated area is shown on Figure 1. As can be seen on this exhibit extensive flooding is evident along 13th Street between Fairview Drive and Lincoln Avenue and along Grand Avenue between Parkside Drive and a point

located about 300 feet east of 13th Street. At elevation 771.5, the pond and the surrounding inundated streets can store approximately 18 acre-feet of runoff.

C. Lands West of Lueders Road and North of Broadway Street.

As stated previously, there are also primarily undeveloped agricultural lands generally located west of Lueders Road and north of Broadway Street that can contribute runoff to both the Parkside and Walter Doll Ponds during significant runoff events. Note that this occurred during the March 2019 event. A brief description of how these lands drain is as follows:

1. Sub-basin 2 - An approximate 52.3-acre watershed that is generally bounded by Prairie Street to the north, 13th Street to the east, and Broadway Street to the south drains to a low depressional area located immediately northeast of the intersection of Broadway Street and Lueders Road. During extreme runoff events, this depressional area can pond approximately three feet before overflowing onto the far west end of Broadway Street. Flow that does not enter the storm inlets at this location appears to overflow to the south into another small depression located within Sub-basin 3.

2. Sub-basin 3 - An approximate 9.2-acre watershed located immediately west of Lueders Road near the intersection of Meadowlark Lane drains to a small depressional area. This depressional area is not drained by storm sewer and must pond to a depth of about 1.5 feet before flowing overland the south into another small depression within Sub-basin 1.

3. Sub-basin 1 - An approximate 102.6-acre watershed originating within industrial developed lands located north of Prairie Street generally drains to the south through undeveloped agricultural lands located immediately east of the Westwynde subdivision. This drainage is ultimately directed to a small depression located immediately west of Lueders Road at its intersection with Locust Lane. This depression is drained by a 12-inch diameter endwall that is directed into a storm sewer system that runs to the east along Locust Lane and ultimately outlets into the Walter Doll Pond. Note that when the 12-inch diameter intake west of Lueders Road reaches capacity, flow is directed overland to the south into Sub-basin 7.

4. Sub-basin 7 - An approximate 43.8-acre primarily undeveloped watershed directs drainage to an existing 18-inch diameter intake storm sewer located immediately north of Sauk Prairie Road approximately 100 feet to the east of Shirley Street. Several adjacent residential lots that are located immediately north of Sauk Prairie Road reported significant flooding issues during the March 2019 runoff event. It is evident that the 18-inch diameter intake and the receiving storm sewer system that passes to the south through the Village of Sauk City does not have sufficient capacity. When the capacity of this storm sewer system is exceeded runoff inundates the surrounding neighborhood. Note that before overflowing Sauk Prairie Road to the south at an approximate elevation of 770.5, drainage appears to overflow at an elevation of about 770 to the east between two residences located on the west side of Lueders Road. This overflow drainage then passes to the east over Lueders Road and enters the Parkside Pond. As stated within the March 2019 flood event timeline, flow passing over Lueders Road from the west was

witnessed on the morning of March 14th. It was also reported that during the March 2019 flood event, Sauk Prairie Road was closed for a period of time due to water overflowing the road to the south.

EXISTING CONDITIONS MODELING RESULTS

A. Rapid Snow Melt Event with Frozen Ground Conditions

To best simulate this type of event, we chose to model the March 2019 flood event. It is a challenging exercise to estimate the amount of runoff that is generated via snow melt because there are a variety of factors involved. These factors include the depth of snow present during the event. In the case of the March 2019 event, it has been estimated that about 8-inches of snow was on the ground. The amount

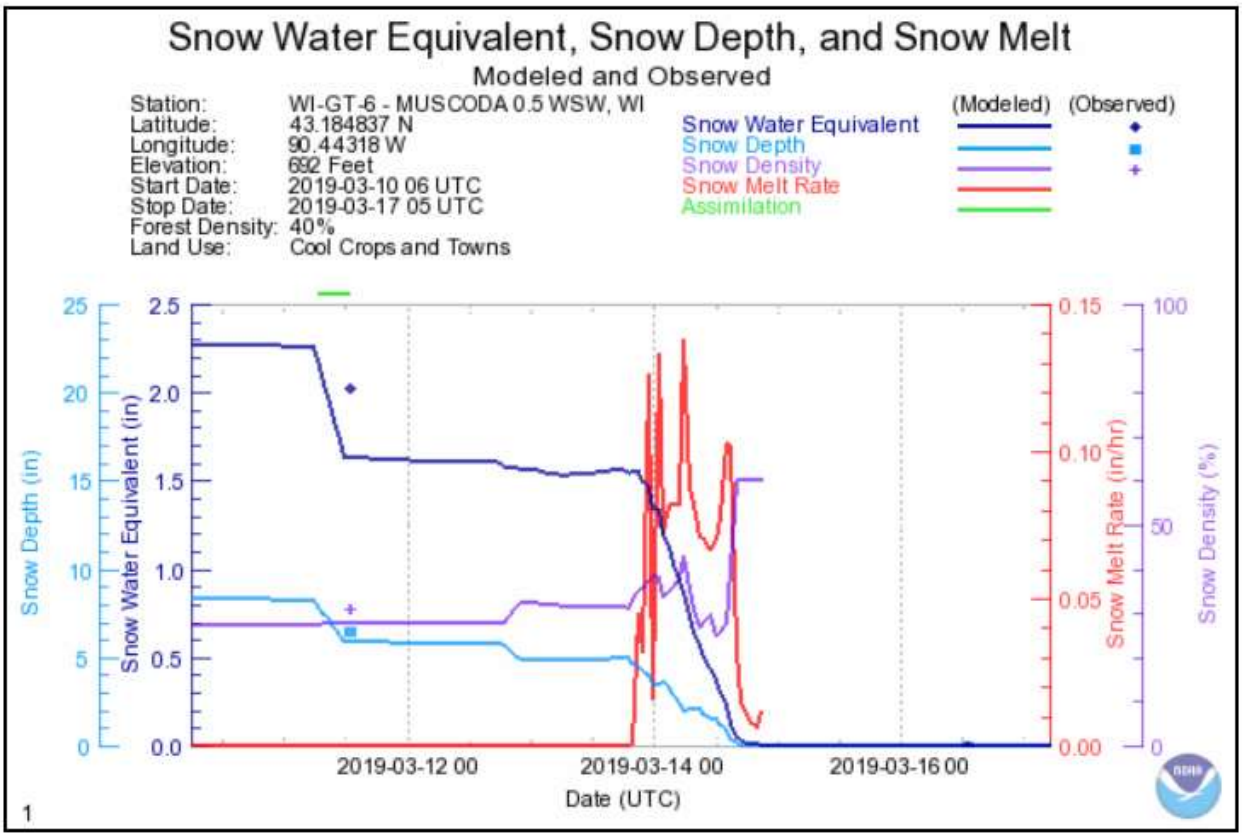


Figure 3 - Plot of Snow Depth, SWE, and Snow Melt in Muscoda for the Week of March 11, 2019 (source: NOAA)

of water that is present within the snowpack or what is called the snow water equivalent (SWE) is another important factor. The National Oceanic and Atmospheric Administration (NOAA) maintains an interactive snow information website that indicated that the SWE was 2.3-inches for the closest remote sensing location in Muscoda that also had 8-inches of snowpack (refer to Figure 3). Note that this data indicated that the snow depth was entirely melted by March 15th.

Other snow melt factors to consider include air temperature (both temperature ranges and durations), cloud cover/solar radiation, wind, how old the snowpack is (if it's older, it becomes more compacted

and is slower to melt), and presence of rainfall. For ease of this analysis, we assumed that for the March flood event, 2.3-inches of runoff was produced through snow melt (i.e. this assumes all 8-inches of snow melted) and the amount of rainfall that fell was 0.6-inches. Therefore, the total amount of runoff generated in our analysis is 2.9 inches. Plugging these values into the stormwater model yielded flood elevation results that are slightly higher than what was observed during the March 2019 flood event (refer to Table 1 below for modeled results). However, the model simulation did not include any of the pumping activity that occurred. This model run is more of a representation of the flood levels that would have occurred had no pumping occurred.

Location	Modeled Flood Elevation (feet)	Observed Flood Elevation (feet)	Storage Volume (acre-feet)	Discharge (CFS)
Walter Doll Pond	772.63	~771.50	41.98	0.0
Parkside Pond	771.35	~771.00	4.88	0.0
Depressional Area Upstream of Sauk Prairie Road	771.35	~771.0	5.89	47.5

Table 1 Modeled versus observed flood elevations of March 2019 flood event.

Based on review of the modeling results, approximately 80 percent of the runoff directed to the Walter Doll Pond was generated from Sub-basin 4 (the 167.1-acre watershed primarily located in the Village). The remaining 20 percent of the runoff directed to the Walter Doll Pond was generated from lands north of Broadway Street and west of Lueders Road. The model results indicated that the majority of the runoff that was directed to the Parkside Pond was generated from lands located north of Broadway Street and west of Lueders Road. It is evident that once the shallow depressions within Sub-basins 1,2, 3, and 7 become inundated, runoff is ultimately directed to the south towards Sauk Prairie Road. It is also evident that the existing 18-inch diameter storm sewer that drains the depression upstream of Sauk Prairie Road does not have sufficient capacity for a flood event that involves frozen ground conditions. This lack of pipe capacity caused flow to continue to back up on lands upstream (north) of Sauk Prairie Road until it overflowed between residences located on the west side of Lueders Road and ultimately across Lueders Road into the Parkside Pond. This caused the pond to fill up very quickly and likely created one large area of ponding that includes the area upstream of Sauk Prairie Road and the Parkside Pond area. As stated previously, it is fortunate that flow is eventually able to overflow Sauk Prairie Road at an elevation low enough that does not allow water to continue to back up to flood elevations that could be even more damaging.

B. Rapid Snow Melt Event with Non-frozen Ground Conditions

Taking the same 2.9-inches of precipitation with non-frozen ground conditions yields expected results of minimal flood elevations within both the Parkside and Walter Doll Ponds (refer to Table 2 below). While it is improbable that such an event would occur, the model results do reinforce how much of an impact frozen ground conditions have in the study watershed.

Location	Modeled Flood Elevation (feet)	Storage Volume (acre-feet)	Discharge (CFS)
Walter Doll Pond	767.72	8.99	0.0
Parkside Pond	766.00	0.00	0.0
Depressional Area Upstream of Sauk Prairie Road	769.05	0.04	3.86

Table 2 Modeled flood elevations of March 2019 flood event with non-frozen ground conditions.

C. 24-hour Duration Rainfall Events with Frozen Ground Conditions

The frozen ground conditions model was evaluated considering a range of 24-hour duration design rainfall events (2-, 5-, 10-, 25- and 100-year recurrence interval events). The rainfall amounts for these storm events are summarized in Table 3. Note that the March 2019 flood event closely matches a 2-year rainfall event on frozen ground (2.9 versus 2.83-inches, respectively).

As can be seen from the flood elevation data for these design storm events, significant flooding would occur at both the Walter Doll and Parkside Ponds if high intensity rainfall events or an equivalent combination of rainfall and snow melt events were to occur on frozen ground.

Return Interval (years)	Rainfall Amount (inches)
2	2.83
5	3.49
10	4.11
25	5.09
100	6.88

Table 3 Rainfall Amounts (24-hour duration design storms)

	Walter Doll Pond			Parkside Pond			Upstream of Sauk Prairie Road		
Return Interval (years)	Flood Elev. (feet)	Storage Vol. (ac-ft)	Flow Out (CFS)	Flood Elev. (feet)	Storage Vol. (ac-ft)	Flow Out (CFS)	Flood Elev. (feet)	Storage Vol. (ac-ft)	Flow Out (CFS)
2	772.58	40.98	5.94	771.32	4.74	19.92	771.32	5.72	43.17
5	772.77	44.71	18.86	771.48	5.55	25.45	771.48	6.63	67.87
10	772.91	47.82	33.49	771.62	6.37	39.81	771.61	7.45	92.01
25	773.09	52.11	58.07	771.88	8.26	66.83	771.86	9.23	141.64
100	773.37	59.88	101.75	772.27	11.64	113.68	772.22	12.3	229.31

Table 4 Modeled design storms (24-hour duration) with frozen ground conditions.

One important factor to consider when evaluating design rainfall events on frozen ground is that the probability of receiving high intensity rainfall events during an early spring timeframe when the ground is typically still frozen (i.e. generally the month of March) is much lower. The Rainfall Frequency Atlas of the Midwest (Bulletin 71, Illinois State Water Survey) cites that for the state of Wisconsin, the seasonal contribution of top-ranked 1-day storms for spring is only five percent. The summer and fall seasons account for the remaining 95 percent. This data suggests that it is likely not practical to design for the highest intensity rainfall amounts on frozen ground, given that the probability of such an occurrence is fairly low. The question then becomes, “what is the appropriate frozen ground condition rainfall event to design for?”. The other question to consider is “what is the proper snow melt event to design for during frozen ground conditions and what is the probability that it will occur concurrently with an intense rainfall event?”. It’s probably reasonable to use the 2.9-inch event that occurred in March 2019 as a baseline, given that this appears to have been the most severe rainfall/snow melt event that has occurred in the Village that we have records for. However, this event only involved 0.6 of an inch of rainfall, which seems like it is possible to receive a more intense rainfall amount during the month of March. We checked historic rainfall data from a weather station in Prairie du Sac maintained by the National Weather Service from the year 1908 to present, and the highest 24-hour rainfall total in the month of March was 2.7 inches on March 31st, 1998. The rainfall data indicated that the next ten highest rainfall events ranged between 1.2 inches and 1.68 inches. Based on this data, it seems like a reasonable goal to design for a rainfall and snow melt event that would total the 5-year, 24-hour return interval rainfall amount of 3.49 inches. This would also adequately account for a snow melt amount that closely matched what was experienced in March 2019 (2.3 inches).

D. 24-hour Duration Rainfall Events without Frozen Ground Conditions

The non-frozen ground conditions model results, which are summarized below in Table 5, yield results that indicate minimal flooding conditions at the Parkside and Walter Doll Ponds for storm events up to and including a 25-year storm event. However, a 100-year storm event would result in flood elevations that are just below the flood elevations that were observed in the areas surrounding the ponds during the March 2019 flood event. The results of this analysis indicate that even smaller rainfall and snow melt events that occur with frozen ground conditions creates greater flood elevations than a 100-year storm event with non-frozen ground conditions.

	Walter Doll Pond			Parkside Pond			Upstream of Sauk Prairie Road		
Return Interval (years)	Flood Elev. (feet)	Storage Vol. (ac-ft)	Flow Out (CFS)	Flood Elev. (feet)	Storage Vol. (ac-ft)	Flow Out (CFS)	Flood Elev. (feet)	Storage Vol. (ac-ft)	Flow Out (CFS)
2	764.98	1.86	0.00	766.00	0.00	0.00	769.01	0.03	3.70
5	766.09	4.52	0.00	766.08	0.02	0.00	769.27	0.10	4.68
10	767.37	8.00	0.00	766.65	0.17	0.00	769.81	0.59	6.09
25	769.25	13.61	2.25	768.99	0.99	0.00	770.41	1.88	7.67
100	771.14	22.64	2.40	770.86	3.10	0.08	770.86	3.49	8.69

Table 5 Modeled design storms (24-hour duration) with non-frozen ground conditions.

POTENTIAL FLOOD MITIGATION ALTERNATIVES

Based on discussions with Village staff, several potential flood mitigation measures have been discussed to help relieve flood impacts that were experienced in the March 2019 flood event. Based on the existing conditions modeling results that we have completed, it is clear that the effectiveness of potential flood control measures will primarily need to address frozen ground conditions. Flood control measures were evaluated to manage a 5-year, 24-hour design storm under frozen ground conditions. Flood control measures that provide flood relief for the Walter Doll Pond area would seek to limit flood elevations to 770.5. This flood elevation would result in about one foot of ponding at the intersection of Grand Avenue and 13th Street. Flood mitigation alternatives to provide relief to the Parkside Pond area would seek to limit flood elevations to an elevation of 770.0, which would result in minimal flooding to adjacent residential lots and along Parkside Drive and Lueders Road.

A. Stormwater Lift Station at Walter Doll Pond

Based on stormwater modeling results, a lift station at Walter Doll Pond would need sufficient capacity to convey a design flow of 15,000 gpm (33.4 CFS). It is understood that a goal of implementing a permanent lift station would be to utilize the existing 8-inch diameter force main that is already in place between the pond and 9th Street along Grand Avenue. It is evident that the existing 8-inch force main is not nearly large enough to handle a 15,000 gpm design flow. Typically, a force main should limit pipe velocities to not exceed 10 feet per second (ft/s). At 10 ft/s, an 8-inch diameter force main could pump approximately 1,600 gpm. If the 15,000 gpm design goal is to be met, a force main size of 24 inches would be needed. Note that this option would not provide significant flood relief benefit for the Parkside Pond. For a 5-year storm event, the flood elevation at Parkside Pond would be lowered 0.16 feet from 771.48 to 771.33.

One disadvantage of placing a permanent lift station is that it would afford the Village less flexibility versus acquiring portable pumps. Portable pumps could be used at other locations within the Village where there are pumping needs. The total estimated opinion of probable cost for a permanent lift station, including installation of the 24-inch diameter force main is approximately $2,500,000.

B. Underground Infiltration Chambers at Walter Doll Pond

Installation of precast concrete underground stormwater storage chambers would allow additional flood storage volume to be placed under the existing pond. Because the storage chambers would be installed below the frost line, stormwater infiltration would be enabled even under a frozen ground condition. Based on stormwater modeling results, underground chambers would need to have approximately 19.6 acre-feet of storage capacity on a footprint of 2.3 acres. This assumes the storage chambers would be 10 feet in height and have 85 percent effective storage capacity (this accounts for the walls of the storage chambers). The infiltration discharge amount assuming a 5 inch per hour infiltration rate would be 5,200 gpm (11.6 CFS). The total estimated opinion of probable construction cost for a 19.6 acre-foot underground storage chamber would be $5,900,000.

C. Detention Basin West of Lueders Road

Placement of an open detention basin west of Lueders Road can have a positive impact on both the Walter Doll Pond and the Parkside Pond area depending where the pond is located. In order for a pond to have a positive effect on the Walter Doll Pond, the detention pond would need to be located within the depression within Sub-basin 1 that is immediately west of Lueders Road near the intersection of Locust Lane. Recall this depression currently drains into a 12-inch diameter storm sewer intake that ultimately drains to the east along Locust Lane into Walter Doll Pond. The goal in placing detention storage at this location would be to temporarily block off this 12-inch diameter intake, but place sufficient storage so as not to increase the amount of runoff that this directed to the south. One possibility to consider would be to simply block off the 12-inch storm sewer intake and not place any additional storage. Pursuing an option like this is not recommended because it can aggravate flooding to the south, including the Parkside Pond area. Based on an initial evaluation, a detention pond would need to be implemented that provides approximately 10 acre-feet of storage and occupies a footprint of approximately 2.5 acres. The estimated opinion of probable construction cost, including land acquisition is $750,000. Note that this measure alone would only have an incremental flood relief benefit to the Walter Doll Pond. The estimated reduction in the frozen ground 5-year storm event would be minimal at 0.11 feet from 772.77 to 772.66. Stormwater detention at this location would need to be paired with some other type of flood control measure, most likely in the form of pumping from Walter Doll Pond and/or expansion of detention storage within Walter Doll Pond.

In order to provide flood relief to the Parkside Pond area, stormwater detention would likely need to be placed immediately north of the township subdivision located north of Sauk Prairie Road. Note that sufficient detention would need to be implemented at this location to prevent runoff from overflowing to the east across Lueders Road into the Parkside Pond area. Based on initial estimates, this would require a significant detention basin (approximately 36 acre-feet of storage on a 9-acre footprint). This detention basin would provide significant flood relief benefit for township properties located immediately north of Sauk Prairie Road, and areas further downstream (south) in the Village of Sauk City. Given the benefits that would be realized by other jurisdictional entities, there may be opportunities for cost sharing to implement regional detention at this location. The estimated opinion of probable construction cost, including land acquisition is approximately $2,700,000. Another more economical approach to relieving flooding in the Parkside Pond area is to simply regrade the residential lots located along the west side of Lueders Road in such a way as to prevent drainage from overflowing to the east across Lueders Road and into the Parkside Pond area. While this option would likely be much more economical, there are logistic challenges associated with this option. Most of the grading would need to be performed on already developed residential lots, so getting proper approvals and easements could be difficult. Also, by restricting flow from overflowing to the east as it does today across Lueders Road, may increase runoff amounts and flooding issues to areas to the south that already experience flooding issues. Placement of sufficient storage to the west of Lueders Road could be performed to offset the lost storage in the Parkside Pond area, which is estimated to be approximately 5 acre-feet of storage. The opinion of probable construction cost, including land acquisition for the regrading improvements and placement of 5 acre-feet of storage volume would be approximately $600,000. Clearly, this is a more economical approach than implementing the large-scale 36 acre-foot detention basin. But it should be noted that the regrading and smaller 5 acre-foot detention basin would not have associated cost sharing opportunities. This is because this project would only address Village flooding in the Parkside Pond area and not address downstream issues in the township and Village of Sauk City.

D. Implementation of Trailer Mounted Portable Stormwater Pump(s)

The effectiveness of implementing stormwater pumping improvements to the Walter Doll Pond was discussed to some extent in section A in the form of a permanent lift station. Implementation of portable stormwater pumping improvements having the same needed capacity of the permanent pump station would have similar flood relief impact and benefits. However, as stated in Section A, having portable stormwater pumps available definitely affords the Village more flexibility for usage in other applications and locations, which is a significant benefit. We have gotten pricing of trailer-mounted portable pumps from Godwin (Flygt) pumps for a range of pump models with varying capacities. The range of capacities for an 8-inch to an 18-inch pump are 3,240 gpm and 9,770 gpm, respectively. The range in costs for an 8-inch and 18-inch pump are approximately $82,000 and $275,000, respectively. Note that the option to quick connect to the existing 8-inch force main is only available for an 8-inch pump. The larger pump models would need to discharge to larger diameter portable hose that can be laid on the ground (similar to what was done in March 2019).

E. Modification of Existing Force Main Intake at Walter Doll Pond

As has been stated previously in this report, modification of the existing 8-inch diameter force main intake at Walter Doll Pond would enable a quick connection to a portable pump. This is a desirable solution given that it leverages the benefit of the 1,400 lineal feet of existing 8-inch force main between Walter Doll Pond and 9th Street along Grand Avenue. However, this existing force main does have certain limitations in terms of the maximum pumping capacity that can be realized. As stated in section A, the 8-inch force main could pump a maximum flow of 1,600 gpm assuming a 10 ft/s velocity. If the existing 8-inch force main is to be used and there is a desire to have a sufficient pumping rate to convey a 5-year storm event during frozen ground conditions, additional pumping likely via a portable pump and discharge piping laid on the ground would still be needed. In order to use the existing 8-inch diameter force main, it is also recommended that the condition of the existing pipe be assessed through televising and/or pressure testing the pipes. The cost to enable a quick connect to the existing 8-inch force main and to perform a condition assessment of the 1,400 lineal feet of force main is approximately $25,000.

F. Expansion of Walter Doll Pond and/or Parkside Pond

The ability to expand both the Walter Doll Pond and Parkside Pond is somewhat limited, given that the footprint of public lands where the ponds reside has generally already been maximized. If either pond is to be expanded to provide additional storage volume, the only means to do so is by deepening the bottom of the existing ponds. The Walter Doll Pond does have a large enough footprint to allow creation of some additional storage volume. However, the bottom of the existing pond is currently actively used for athletic activities, and deepening of the pond may restrict the ability to continue do so in the future. By deepening the pond five feet at a maximum 4:1 side slope, approximately 7.0 acre-feet of additional detention volume can be realized. However, because the pond will still not be able to drain during frozen ground conditions, the effectiveness of such an improvement is somewhat limited. Based on modeling results, creation of 7 acre-feet of additional storage would lower the 5-year frozen ground flood elevation approximately 0.13 feet from 772.77 to 772.64. Given the relatively small and constrained bottom footprint of the Parkside Pond, further deepening of the pond to create additional detention storage is not feasible.

G. Construction of Check Valve Along Gravity Storm Sewer Connecting Ponds

It was reported during the pumping activities of the March 2019 flood event that despite pumping from the Parkside Pond to the Walter Doll Pond, water was backflowing from Walter Doll to Parkside via the connecting gravity storm sewer. This happened because the water surface elevation in the Walter Doll Pond was higher than the water surface of the Parkside Pond. The modeling results do indicate that generally speaking, the Walter Doll Pond flood levels are generally higher than the Parkside Pond levels. Note that the ponding upstream of Sauk Prairie Road somewhat controls the level and duration of flooding within the Parkside Pond area. Because this area of ponding actually has a gravity outlet (18-inch storm sewer at Sauk Prairie Road), the duration at which it stays flooded is significantly less than Walter Doll Pond, which has no gravity outlet. Installation of a Tideflex inline check mate type valve in a new manhole is recommended. The opinion of probable construction cost for this improvement is $30,000.

SUMMARY OF RECOMMENDATIONS

Based on the results of the various drainage improvement alternatives that were evaluated, it is evident that providing additional detention storage volume, whether involving expansion of the Parkside and Walter Doll Ponds, or providing additional detention volume west of Lueders Road is quite costly and provides very little flood relief benefit. The options that were evaluated that appear to provide the most flood relief benefit involve alternatives that seek to pump floodwaters to the east into receiving storm sewer along Grand Avenue that ultimately drain to the Wisconsin River. The following flood mitigation improvements are recommended for the Village to consider.

- Purchase two (2) trailer mounted 8-inch portable pumps (Godwin Dri-Prime CD225M pump or equal). Estimated cost = $164,000.
- Conduct condition assessment tasks of existing 1,400 lineal feet of 8-inch diameter force main along Grand Avenue between the intake at Walter Doll Pond and the outlet into a storm manhole located at 9th Street. Explore performing both televising and air pressure testing of the force main to determine condition and suitability of use of the existing force main. Estimated cost = $5,000.
- Conduct intake improvements to the existing 8-inch force main that will enable a quick connection with one of the newly purchased portable 8-inch pumps. Estimated cost = $20,000.
- Purchase approximately 2,800 lineal feet of 10-inch diameter flexible hose that will be laid along Grand Avenue between Walter Doll Pond and 9th Street. Note that having the 10-inch diameter discharge pipe will enable a pumping capacity of approximately 2,600 gpm. The two (2) portable pumps can be used in tandem (one connected to the 8-inch existing force main and one connected to the newly acquired 10-inch hose) and will achieve a maximum pumping rate of approximately 4,200 gpm. Estimated cost = $84,000.
- An alternative to purchasing two (2) trailer mounted 8-inch portable pumps would be to purchase one trailer mounted 8-inch portable pump and one stationary 8-inch pump to be placed at the Walter Doll Pond. This option presumes that the outcome of the condition assessment of the existing 8-inch force main indicates that it can be utilized. The estimated cost of this alternative would very similar to the cost of the dual portable pump option.
- Install an inline check valve within the storm sewer system connecting Parkside Pond and Walter Doll Pond. Given that the storm sewer system where the valve would be installed is elliptical pipe (14-inch by 23-inch), a short segment of this pipe would be removed and replaced with 18-inch

diameter round storm sewer pipe that will enable installation of the inline check valve. Estimated cost = $30,000.

Total engineer's opinion of cost for these improvements is approximately $303,000. These flood mitigation improvements would enable pumping of approximately 4,200 gpm (9.0 CFS) from Walter Doll Pond. By lowering the water surface level of Walter Doll Pond below the flood elevation of Parkside Pond, gravity discharge from Parkside Pond via the connecting storm sewer system would be activated. It is estimated that the capacity of these flood mitigation improvements would handle a frozen ground flood event that would produce approximately 1.8-inches of runoff in a 24-hour period.

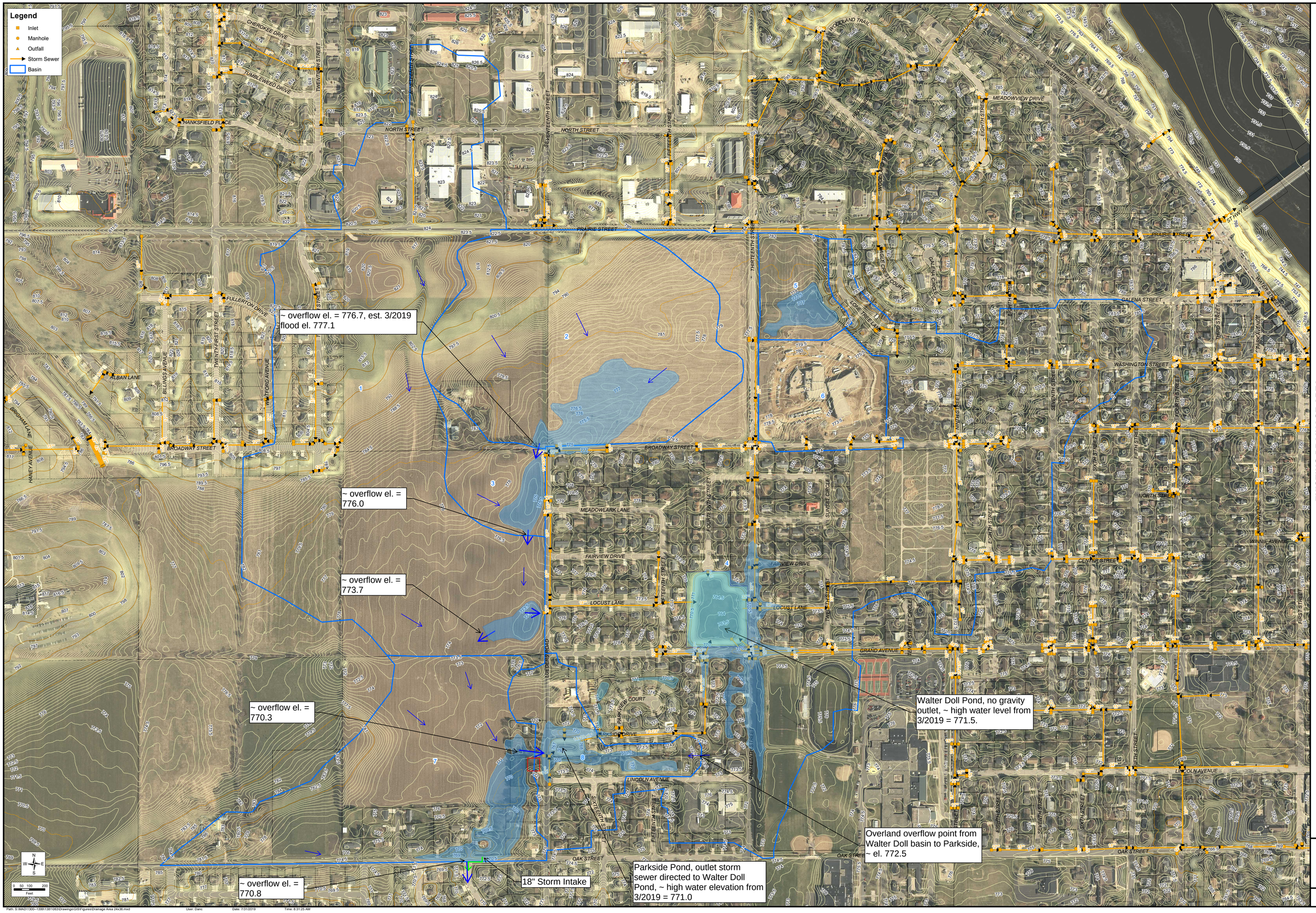
If the Village experiences a frozen ground flood event that produces greater than 1.8-inches of runoff within a 24-hour period (similar to the March 2019 flood event), it is recommended that the pumping capacity that is achieved via the newly purchased portable pumps be augmented by hiring a farm pumping company that can provide the needed pumping capacity to provide the desired level of flood protection. It is suggested that a retainer contractual arrangement with a pumping company be investigated that ensures availability of rapid response "on-call" pumping services in case of a flood event that is beyond the Village's ability to address with newly purchased portable pumps.

LIST OF POTENTIAL STANDARD OPERATING PROCEDURES

We have developed a list of standard operating procedures (SOPs) when frozen ground conditions exist and a high potential for flooding is possible either from rapid snow melt, rainfall events, or a combination thereof. For flood prevention to be effective, written procedures that includes standard checklists that can be reviewed prior to the threat of a flood event can effectively reduce potential flood impacts and damages and ensure higher levels of operating reliability.

1. Monitor the local weather forecast when frozen ground conditions and when a higher snowpack depths exist in the Village. Check the forecast for unusually warm temperatures both in terms of daily high temperatures, and "high" low temperatures. While it is more difficult to forecast rainfall events including the exact rainfall amounts and intensities, forecasting temperatures and therefore the potential for rapid snow melt is fairly predictable.
2. If the local weather forecast indicates the potential for rapid snow melt and/or rainfall events that will result in runoff amounts greater than one inch in a 24-hour period, complete the following activities:
   a. If the Village chooses to purchase portable pumps, mobilize the pumps and accessories to Walter Doll Pond to prepare for pumping activities. Monitor and document pond water levels to determine when it is appropriate to begin pumping operations.
   b. If flood conditions are forecasted or anticipated that will create conditions that are beyond the Village's capability to manage, contact a business that is able to quickly mobilize additional portable pumps for pumping operations. Ensure they are available and "on-call" for the dates they likely will be needed for service.
   c. Inspect the intake of the existing 18-inch storm sewer apron end wall that drains the ponding area upstream of Sauk Prairie Road. Confirm that this intake opening is not blocked with debris (snow, ice, etc.) and can freely drain. If any blockages are present, they should be removed immediately. The ability of this intake to positively drain significantly affects the potential for flooding in the Parkside Pond area.

d. Inspect the storm sewer intake pipe from the Parkside Pond and ensure it is not blocked and can freely drain. Remove any blockages, accordingly.
e. Send out e-mail blast notifications to residents to provide advanced notification of the high potential for flood conditions.
f. Make a sandbag filling station available to residents at the Public Works Garage or other designated location.
g. Prepare traffic control measures to detour traffic around flooded areas.
h. Contact police/fire/emergency responders to make sure all entities are fully informed of flooding conditions.
i. Install frost depth probe in Walter Doll Pond to monitor frost depths.



EXISTING DRAINAGE AREA

SOUTHWEST FLOOD ANALYSIS
VILLAGE OF PRAIRIE DU SAC
SAUK COUNTY, WISCONSIN

STRAND ASSOCIATES®

FIGURE 1
1381.063

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