Areas Prone to Flooding in Sawmill Brook Watershed

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Sawmill Brook and its tributaries drain rocky uplands, expansive wetlands and developed impervious areas, before discharging to Manchester Harbor through a narrow tide gate. Many areas of the town are subject to flooding during extreme storm events due to the combination of storm surge, hydraulic restrictions from culverts and the tide gate, stormwater runoff from impervious areas, the channelized stream system, and poor infiltration conditions. Impacts from climate change including increased precipitation and sea level rise will exacerbate flooding. This memorandum summarizes the current understanding of the areas within the Sawmill Brook Watershed that are prone to flooding from coastal and inland discharge events.

1) Surficial Features that Contribute to Flooding

a) Topography and Soils

The steep rocky topography, poorly draining soils, and impervious surfaces of Manchester-by-the-Sea are significant factors that contribute to rapid stormwater runoff conditions, accelerated peak stream channel flows, and ultimately property and roadway flooding. Section 4 of the Final Open Space and Recreation Plan (Manchester-by-the-Sea, 2014) provides a detailed description of the geology, soils, and topography. Glacial deposits of fine-grained marine clays and silts over sand and gravel, in addition to peat and muck are widespread in the flooded areas at elevations below 50 feet mean sea level. Shallow-to-bedrock soils account for most of the soils in Manchester. Nearly 40% of the Town is mapped as outcrop complex with up to 35% slopes, 12% is wetlands, and an additional 10% is covered with impervious surfaces from structures and roadways. Virtually all the undeveloped land in Manchester-by-the-Sea is characterized as having "severe" or "moderate to severe" limitations for use as building or road sites. All soils are rated as having "severe" limitations for construction of septic tank absorption fields. The ability of swamps and wetland areas to provide floodwater storage is limited by the normal high water table and presence of upstream flooding due to heavily developed areas.

b) Drainage System

A significant portion of the Sawmill Brook drainage system has been channelized over the past 100 years, predominantly in the lower reaches from Lincoln Street to the tide gate/dam. The channelized areas worsen flooding by accelerating flow and limiting natural stream bank storage during flood events. In some sections, the stone retaining walls along the channel are in poor condition placing properties including the Fire Station at risk from breach flooding.

There are approximately 40 culverts and stream crossings throughout the Sawmill Brook Watershed. Department of Public Works (DPW) and Highway crews report dozens of culverts that appear to be undersized, in poor condition, or impacted by beaver dams. Residents report stream channel and culverts are clogged with debris and trash contributing to the backup events during significant rain events.

2) Present Understanding of Areas Impacted by Flooding

a) FEMA Flood Insurance Rate Maps and Flood Control Districts

FEMA Flood Insurance Rate Maps (FIRMs) for Manchester-by-the-Sea represent the areas that are likely to be impacted by inland and coastal flooding. The map identifies the limit and extent of the 100-year and 500-year floodplain and wave hazards (VW Zone and Limit of Moderate Wave Actions (LIMWA)). The map includes the base flood elevation of still water (storm surge) flooding for coastal areas only. The FIRMs were revised in July 16, 2014. Since that time, the Town has hired Woods Hole Group to assess and challenge several transects including Manchester Harbor entrance.

The Town complies with participation in the National Flood Insurance Program (NFIP) by enforcing floodplain regulations, issuing floodplain development permits, and providing information to property owners and builders regarding floodplains and building requirements. The floodplain zoning for a Flood Zone Control District includes a particularly vulnerable section of Manchester-by-the-Sea within the Sawmill Brook watershed known as Bennett's Brook. Filling and impervious cover regulations in the Flood Control District are more stringent than required by the NFIP. A wider Floodplain District includes all special flood hazard areas designated by FEMA maps. Building in the floodplain must conform to Massachusetts State Building Code dealing with construction in floodplains and coastal high hazard areas.

b) Hurricane Surge Inundation Zones

Manchester Harbor currently experiences a 7 to 10 foot tidal range. Storm conditions bring higher tides, storm surge, and waves that increase coastal flooding and may exceed the mapped FIRM floodplain areas. Mapping developed by the National Hurricane Center SLOSH Storm model data indicates that storm surge could impact the entire downtown area and though unlikely, could extend over 1 mile upstream under worst case conditions. Storm surge impacts on Sawmill Brook are mitigated by the Central Street tide gate/dam; however the dam also restricts upstream drainage, hydraulically isolating floodwaters. This is particularly problematic during storms with combined high tide and prolonged rainfall.

c) Manchester-by-the-Sea Hazard Mitigation Plan

The Manchester-by-the-Sea Hazard Mitigation Plan (HMP) (MAPC, 2012) summarizes the flooding and winter storm hazard risks in the Sawmill Brook watershed based on FEMA flood zones.

The HMP calls for the development of a comprehensive watershed drainage plan as a high priority mitigation measure, including design and construction to replace and properly size culverts. The HMP cites several contributing factors and concerns with flooding in the Sawmill Brook drainage system:

- Lack of upstream storage
- Undersized culverts at the intersection of Brook Street, Knight Circle, and School Street
- Narrow channel walls between Brook Street and Sawmill Brook, which accelerates flow
- Lack of a flood channel on North Street
- Undersized outlet at Sawmill Brook tide gate, which causes backups in the whole system
- The stone retaining wall from Brook Street to the dam outlet is constructed from granite blocks on the verge of collapse; if this structure were to fail several properties including the Fire Station would be at risk of breach flooding

- Flooding of School Street and Union Street are public safety risks, as they are major arteries in and out of Manchester.
- Flood locations include roadways and homes along Lincoln Street, School Street, Norwood Avenue, Putman Circle, Brook Street, Union Street and Knight Road.
- In 2006 the School Street Bridge was washed out.
- As of 2010 there were 19 repetitive loss structures in Manchester with a total of 43 losses. 70 claims for damages from flooding were paid, totaling over 1 million dollars.
- The HMP estimates of damages for properties within the current Flood Hazard Area are based on areas subject to flooding due to deficiencies in the drainage system. For these vulnerable areas, the building replacement value is $24 million, and damage costs range from $2-12 million.

The HMP identified the following measures, suggested by the Town, to mitigate the flooding:

- Enlarge School Street, Knight Circle, and Brook Street culvert, and/or make into raised bridge
- Overhaul the Inner Harbor drainage outlet
- Increase the size of the Route 127 culvert
- Increase the size of stone walled channels along School Street

The following specific areas and flooding issues are highlighted in the HMP:

Central Manchester-by-the-Sea drainage system

Sections of the system drain wetland areas, portions are highly developed and channeled, and numerous outfalls discharge directly to surface waters. Street crossings include a wide variety of structures, including a dam/ tide gate structure, historic stone culverts, concrete and metal culverts.

School Street (Sewer/Flooding)

This is a low lying area. Flood waters enter the sewer system, manhole covers pop and waste empties onto the street. Two sewer overflow events occurred in recent years. Stormwater infiltration and inflow (I/I) is an issue for the town sewer system. Drainage to Sawmill Brook and improving stormwater I/I may potentially mitigate problem. Other direct mitigation could include a sewer cutoff at School Street and Brook Street.

Sewer Treatment Plan (Flooding/Sewer)

Manchester-by-the Sea Wastewater Treatment Plant (WWTP) needs to be addressed. The WWTP is near parcels that sustain reoccurring flooding, and the WWTP may be susceptible to inflow and cause backups on streets and into homes. Immediate mitigation includes diverting stormwater away from the WWTP by improving the drainage system.

Old Essex Road (Flooding)

Several homes, a senior living facility and two sewer lift stations are at risk from flooding. Area floods when there is high water table, or when Millet Swamp backs up and overflows banks. Beaver activity exacerbates the flooding. Many homes are within the 100 year floodplain and several are in 10 year floodplain.

Blue Heron Lane (Flooding)

Residential flooding in Blue Heron Lane vicinity related to Millet Swamp, and undersized culvert. Also many homes built on fill with an inadequate above ground drainage system.

Bennett's Brook (Flooding)

Land area near Bennett's Brook from Walker Road to Highwood road floods frequently, resulting in partial to complete roadway closures. Damages to 50 homes, with several multiple insurance claims. Some homes must maintain multiple sump pumps. Causes are building on filled wetlands, undersized culverts. Area in need of comprehensive drainage study. Detention basins and dam built in 1996 at the east end of Walker Road to compensate for development of Brookwood Path were designed to meet 25-year storm event, have worked well except for base of Highwood Road continues to flood after storms that exceeded the 25-year event.

d) Millets and Sawmill Brook Evaluation

A hydrologic evaluation was completed in 2008 for Millets and Sawmill Brook with a focus on effects of the School Street, Lincoln Street and Norwood Avenue culverts on historic flooding (Metcalf & Eddy, 2008). The study examined the effect of enlarging the Blue Heron Lane culvert on upstream and downstream flooding and identified potential wetland impacts associated with the Blue Heron Culvert. Results indicate that enlarging the Blue Heron Culvert would reduce peak water elevation at Blue Heron Lane and in Millet Creek for 10 year storm, but flooding would still occur during 25 and 100 year storm from backwater due to downstream restrictions near Route 128, and from upstream restrictions at Millet Lane. Increasing the Blue Heron Culvert would increase peak flow and risk of flooding at Route 128 and have little impact on downstream flooding.

The School Street culvert was identified as a significant restriction and responsible for backwater flooding during 10 year storm. The study noted that replacing the School Street culvert eliminates overtopping at School Street, but not flooding upstream. The channel upstream of School Street may be too small, creating a backwater limiting the capacity of culverts at Norwood Ave and Lincoln Street.

e) Department of Public Works Repairs and Concerns

Culverts are maintained by the DPW on an as needed basis. The following information was gathered from various reports on specific DPW responses to flooding.

- The Conservation Commission maintains beaver deceiver fencing around three culverts where Sawmill Brook exits from eastern portion of Cedar Swamp
- Stonewall repairs were completed in 2001 along Sawmill Brook near downtown School Street culvert with Five Star Restoration Grant
- Emergency repairs were done on the School Street culvert located near Route 128 after collapsing during a storm in 2012
- Three culverts were repaired on Loading Place Road (private) where flooding occurs from Cat Brook, but 2012 Open Space reports that one is still broken
- High groundwater flooding occurs at Sweeny Park playing fields

f) Local Reports of Areas Prone to Flooding

A meeting with Town staff and the Coastal Resilience Advisory Group (CRAG) was held in February 2015 to provide input to Tighe & Bond on local flooding conditions. The areas identified by the Town are summarized in Table 1 below as areas T-1 through T-9.

An online survey was conducted by the Manchester Conservation Administrator during the month of April 2015. The purpose of the survey was to get local input from residents regarding areas subject to flooding and to better understand local concerns and observations of weather and flooding patterns. The areas identified by the survey are summarized in Table 1 below as areas S-1 through S-6.

Additional information was gathered from residence at the Public Forum held on April 22, 2015. Maps stations were set up where residents could mark locations of concern and supplement the mapping locations with written observations. Tighe & Bond staff were available to discuss the local observations and get a deeper understanding of residents' concerns. The areas identified at the Public Forum are summarized in Table 1 below as areas F-1 through F-11.

The 26 identified areas are shown on Maps 1 and 2, including icons that capture the major flooding issues at each location. Locations where residents noted areas of flooding concern included Brook Street, School Street, Norwood Avenue, Knight Circle, Forest Lane, Old Essex Road and Friend Street. Impacts from flooding included basement and garage flooding, property damage as well as stream retaining wall collapse. Rising groundwater, extreme precipitation and extreme high tide events were listed as the greatest cause for flooding. Stream bank overflow and culvert backup were listed as the source of flooding. Clogged drainpipes and trash buildup in the brooks were also listed.

TABLE 1

Summary of local observations of areas prone to flooding

Map #	Location	Observations	Flooding Issues*
T-1	School Street north of 128	Culvert washed out in 2012. Replaced	(1) (2) (7)
T-2	Atwater Ave	Culvert rebuilt in 2005	(1) (2) (7)
T-3	Blue Heron Lane	Neighborhood flooding	(1) (2) (5) (7) (8)
T-4	Lincoln Street	Junction of Causeway and Sawmill Brooks, flooding and culvert damage	(1)(2)(5)(7)
T-5	Brook Street	Playing Fields flood often	(1)(2)(5)
T-6	School Street	Sawmill Brook north of School St culvert, wall was rebuilt and vegetation reestablished under 5-Star grant	(7)
T-7	School Street	Roadway and culvert collapsed in 2006 Mother's Day storm	(2)(5)(7)
T-8	Knights Circle	Neighborhood flooding	(2)(5)
T-9	Central Street	Parking lot near Town Hall floods	(2)(3)(4)
S-1	Brook Street	Flooded basement and garage during times of high tide AND heavy rain	(1) (2) (3)
S-2	School Street	Culvert backup	(2) (5) (7)
S-3	Norwood Ave	Basement Flooding and brook stone wall collapse	(1) (2) (5) (7)

Map #	Location	Observations	Flooding Issues*
S-4	Knight Circle	Lowest portion of yard floods frequently, adjacent to brook. Flooding from rainstorm when neighbors drains sump pump into only catch basin on the road.	(1) (2) (5) (6)
S-5	Forest Lane	Backup of Cat Brook along the Rt 128 edge of property, backup related to trash accumulation at a culvert.	(2) (5) (9) debris
S-6	Old Essex Rd/ Pleasant Street/ Pine Street	Runoff from DPW yard flows toward residence on Old Essex.	(2) (6) (9) sheet flow
F-1	Old Essex Rd/ Pleasant St/ Blue Heron Lane	From south side of Pleasant St (foot of Powder House Hill), across Old Essex Rd, following behind the residence on Old Essex Rd all the way up to Blue Heron Lane and beyond floods during heavy rains. Ditch dug by the WLA in the 30's collects water but needs clearing.	(2)(5)(9) Debris
F-2	Knight's Circle & Friend Street	Flooding from Sawmill Brook- consistent when there is a rain event of the Brook is high. Sometimes the entire area behind Knight's Circle and 16 Friend St (and neighboring lots) is flooded.	(2) (5)
F-3	Vine & Lincoln St	After storms, street drain at the corner doesn't drain- big puddle.	(2) (6)
F-4	Sawmill Brook	Who, when and how often is cleanup done on Sawmill Brook. Debris has built up and had not been addressed in several years.	(9) debris
F-5	6 Friend Street	Very little flooding in the backyard, rarely the Brook goes over the barrier, it's racing to the sea usually. I've lived on Friend Street since 1963 and can't remember a real threat to 6 or 8 Friend Street	(5)
F-6	4 Friend Street	I live at 4 Friend St. My property does not abut the Brook, but our neighbors at 6 Friend St own a lot between us and the Brook and in very rainy weather their lot floods when it overtops the granite curbing.	(2) (5)
F-7	20 Forest Lane	Rear of property parallels Route 128 with Cat Brook which flows along our boundary with Route 128. We are on the hill above the brook with a wetland around us which controls water flow well. Our issue is with solid debris that collects at a culvert at the rear of the property to a degree where Cat Brook flow is partially impeded causing a wetland ponding effect.	(9)debris (8)
F-8		Numerous trees and debris in the Brook accumulated over the last 50+ years and never been cleaned. In hard rain it impedes water flow.	(9) debris
F-9	44 Norwood Ave	At 44 Norwood Ave the culvert & property on the Brook side is lined with granite versus the soft low banks elsewhere. During Mother Day Storm 44 Norwood Ave reported flooding from across the street and down the driveway.	(2) (5)
F-10	7 Knight Rd	House at the end of Millet Brook, with 3 storm drains draining into Millet Brook. No basement (built on slab) and have been flooded out 3 times since 1996.	(1) (2) (5) (7) (8)
F-11	14 Ancient County Way	Basement floods when excess snow melt and 1-2 inches of rain even with sump pumping. High water table.	(1) (2)

***Key for Flooding Issues**

(1) Rising groundwater (subsurface water) levels in the springtime
(2) Extreme rain events (heavy rain or long duration storms)
(3) High Tide
(4) Storm Surge
(5) Stream bank overflow
(6) Catch basin overflow
(7) Culvert back-up
(8) Swamp/Wetland overflow
(9) Other

g) Climatic Data and Design Storms

A review of 30 years of daily rainfall data from Boston Logan Airport (1985 to 2015) is summarized in Table 2 showing the top ten 24-hour precipitation and multi-day events (2-7 days of consecutive rainfall). This data is compared with currently published design storms (Hershfield, 1961) and extreme storm values for Essex County (Wilks, 1993) in Table 3.

TABLE 2

Observed precipitation extreme events at Logan Airport

Highest Days (24-hr)		**Highest Multi-Day**	
Date	Precip (inches)	Dates	Precip (inches)
10/20/1996	6.11	5/9/06-5/16/06	10.45
6/13/1998	5.69	6/13/98-6/17/98	8.54
9/10/1999	4.71	10/20/96-10/21/96	7.89
4/01/2004	4.29	6/7/13-6/14/13	7.69
12/12/1999	4.21	3/31/87-4/06/87	7.06
6/6/2000	4.00	10/8/05-10/15/05	6.44
5/13/2006	3.84	3/31/04-4/02/04	6.03
5/14/2006	3.77	5/2/98-5/4/98	5.97
8/01/1985	3.58	9/13/87-9/20/87	5.73
3/14/2010	3.40	12/11/92-12/13/92	5.73

TABLE 3

Design storms and extreme precipitation for Essex County

Return Period	**Design Storms TP-40**	**Extreme Precipitation Events RR 93-5**
10-year 24-hour	4.5 inches	4.8 inches
25-year 24-hour	5.4 inches	6.1 inches
50-year 24-hour	5.9 inches	6.7 inches
100 year 24-hour	6.5 inches	7.34 inches

3) Next Steps

Information discussed in this technical memorandum will be used to support the field efforts for culvert inspections and locations for providing additional flood storage. The observations will also be useful in refining the hydrologic model.

References

Metcalf & Eddy. (2008). *Hydrologic Study: Millets Brook and Sawmill Brook Watersheds.*

Hershfield, D. (1961). *Rainfall Frequency Atlas of the United States. Technical Paper 40.* Washington, D.C.: U.S. Department of Commerce.

Manchester-by-the-Sea. (2014). *Final Open Space and Recreation Plan.*

MAPC. (2012). *Town of Manchester-by-the-Sea Hazard Mitigation Plan.*

Wilks, W. a. (1993). *Atlas of Precipitation Extremes for the Northeastern United States and Southeastern Canada, Northeast Regional Climate Center Research Series, Publication No RR-93-5.* Ithaca, NY: Cornell University.

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