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Flood Risk Assessment Study

Final Report - DRAFT

January 2022

WHITEWATER
REGION

Prepared for: **The Township of Whitewater Region**
44 Main Street
Cobden, Ontario K0J 1K0

Executive Summary

Jp2g Consultants Inc. and the Township of Whitewater Region have partnered to complete a flood risk assessment for an area south-west of Westmeath Provincial Park along the Ottawa River. The purpose of this Flood Risk Assessment Study is to develop a mitigation plan, including seasonal and permanent measures, to address flooding concerns. The mitigation plan includes emergency procedures as well as intermediate, short-term, and long-term solutions to alleviate the effects of high water on existing infrastructure.

The area addressed in this study is located along the Ottawa River, south-west of the village of Westmeath, in the Township of Whitewater Region. The study area includes many properties situated within the floodway or flood fringe, as well as a Provincially Significant Wetland within Westmeath Provincial Park. This area is prone to seasonal flooding and represents a significant flood risk. In 2019, as the water level in the Westmeath basin increased to a very high level, many homes and cottages sustained damage.

The existing condition of the infrastructure within the study area was reviewed prior to determining flood mitigation options. Based on background reports and field investigations, it was determined that all the houses and cottages in the study area are located within the floodplain. Some homeowners have raised their homes above the floodplain elevation.

The at-risk infrastructure was evaluated in terms of future flood impacts and potential future climate change impacts. The considerations and constraints for the infrastructure include site conditions, usability, flooding depth, and barrier protection, as well as areas of concern, which are outlined in this report. Proposed mitigation solutions were developed based on capital cost, permeance, consideration for aesthetics, effectiveness of mitigation, and ease of implementation. Seasonal barrier methods and long-term barrier methods to mitigate the flood risk in the study area were evaluated.

Jp2g recommends that floodplain mapping for the study area along the Ottawa River take place as a next step, to accurately determine the floodplain elevation. Immediate flood mitigation options include monitoring river levels and sandbagging when necessary, and long-term mitigation options include floodproofing homes and cottages up to the flood line elevation or raising homes and cottages above the flood line if possible.

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1 Introduction

Jp2g Consultants Inc. partnered with the Township of Whitewater Region ('the Township') to complete a flood risk assessment for an area south-west of the Westmeath Provincial Park along the Ottawa River which includes a Provincially Significant Wetland and some grandfathered properties situated in the floodway or flood fringe. This area seasonally floods with the spring freshet and represents a significant and recurring flood risk. The Township has identified flooding in its Hazard Identification and Risk Assessment. The study will follow the PIEVC Engineering Protocol for Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate, which was developed by Engineers Canada to provide a step-by-step methodology for risk assessment of public infrastructure in response to climate change. The procedures set out in this protocol set the overall framework for carrying out this risk assessment study. This protocol was selected as a best practice, industry accepted methodology.

This study will be consistent with the natural hazard policies in the Ontario Provincial Policy Statement (2020). It will also address relevant natural hazard technical guidelines issued by the Ministry of Natural Resources and Forestry, specifically:

- Understanding Natural Hazards
- Technical Guide River & Stream Systems: Flooding Hazard Limit
- Technical Guide River & Stream Systems: Erosion Hazard Limit.

1.1 Background

The spring water levels of the Ottawa River around the study area pose a significant risk to nearby infrastructure. Portions of land become fully submerged, and buildings experience flooding at peak water levels. The general area was severely impacted by 2019 flooding. New high-water levels were observed in both 2017 and 2019 and may represent a trend toward more frequent flooding occurrences.

The study area requires significant sandbagging and pumping efforts each freshet. During the 2019 flood, more than 75,000 sandbags were deployed to the area. The high water and wave action damaged much of the infrastructure and numerous properties required renovation, raising, reconstruction, or demolition. Several property owners relied on the Disaster Recovery Assistance for Ontarians (DRAO) Program to address flood damage.

The current method to deal with flooding is to install seasonal sandbag coffer dams along the properties adjacent to the Ottawa River where water encroaches on permanent residences, cottages, and roadways.

Historically, flooding of the project area has been a threat mainly due to the flat, low-lying topography of the area relative to the adjacent Ottawa River. The history of overland flooding from this portion of the Ottawa River has been documented in shoreline studies and damage surveys including the Flood Damage Reduction Program (FDRP) prepared by Environment Canada, the Ontario Ministry of Natural Resources, and the former Township of Westmeath in the late 1980's, early 1990's. The FDRP Ottawa Risk Flood Maps project was composed of three phases, of which the project area comprises Phase 1, and indicates that the two-zone approach is applicable (i.e., identification of the floodway and flood fringe areas).

1.2 Purpose

The purpose of this project is to assess current and future flooding conditions and risks, to examine flood mitigation solutions and ultimately develop a mitigation plan to address the flooding concerns along the Ottawa River adjacent to Westmeath Provincial Park. This project intends to generate emergency procedures as well as short-term, intermediate, and long-term solutions to mitigate the effects of high water on existing infrastructure. It will prioritize areas for rehabilitation and identify projects for future construction.

This flood risk assessment study report summarizes the understanding of impacts from seasonal high-water levels on infrastructure, identifies specific at-risk infrastructure and identifies recommended projects, including seasonal and permanent measures. The study evaluates the two-zone flood management policy by documenting and assessing the condition of the existing flood control measures, documenting the condition of the existing infrastructure, quantifying the risk to the flood-prone areas under various scenarios, preparing a prioritized action plan to address and mitigate the risk of flooding, and identifying alternative solutions for flood protection measures in the general area.

This risk assessment is intended to assist property owners, as well as the Township, on ways to mitigate flood risk and response and help prioritize funding and potentially reduce claims under the Disaster Recovery Assistance for Ontarians Program (DRAO) and Municipal Disaster Recovery Assistance Program (MDRAP).

1.3 Site Location

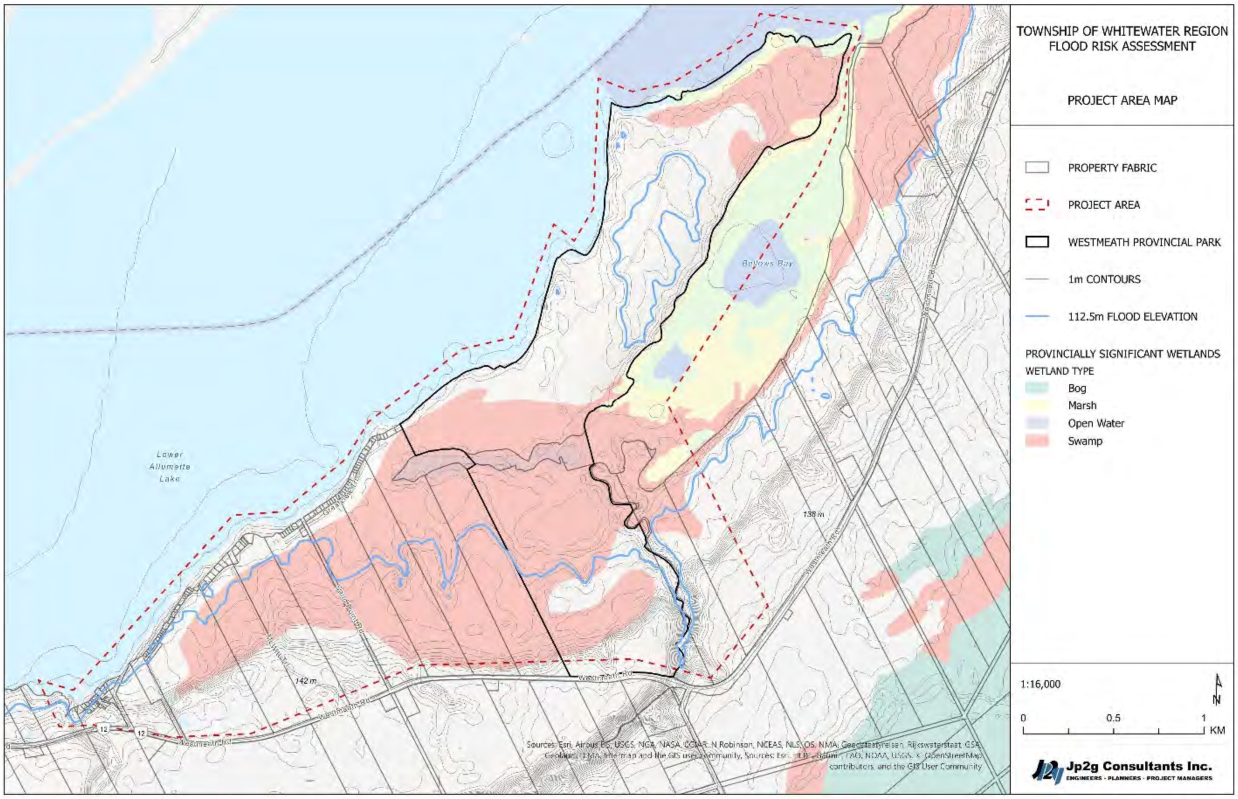
The study area for this project is south-west of Westmeath Provincial Park along the Ottawa River, which includes a Provincially Significant Wetland and some grandfathered properties situated in the floodway or flood fringe. The study area is illustrated in **Figure 1** below. It is bound by the Ottawa River to the north, Westmeath Provincial Park to the east, Westmeath Road (County Road 12) to the south, and Moore's Beach Road to the west.

The area comprises 105 properties, from the area west of Westmeath Provincial Park along the Ottawa River from Greatview Trail to Moore's Beach Road, including Sunset Trail, Edgewater Trail, McWitt Trail and Sand Point Road.

Figure 1: Study Area Location

As shown in **Figure 2** below, the majority of the study area is within the existing floodplain elevation of 112.50m. Additional discussion on the existing floodplain elevation is located in Section 3.0.

Figure 2: Floodplain Mapping in Study Area



1.4 Definitions

For the purpose of this report, the following definitions apply:

Drainage Basin (or watershed): Area of land that channels rainfall and snowmelt into a body of water or stream.

Floodplain: the spatial extent of the still-water elevation of the river that occurs infrequently.

Floodway: the inner portion of the flood plain, representing that area required for the safe passage of flood flow and/or that area where flood depths and/or velocities are considered to pose a threat to life and/or property damage.

Flood Fringe: the outer portion of the flood plain where the two-zone concept applies.

Freshet: Large increase of water discharged in a river during spring months due to snow melt and sometimes rainfall.

Reservoir: Area upstream of a dam where water is or can be stored for a long period of time (several weeks and sometimes months). A large reservoir can regulate (or alter) the flows in the downstream river section.

Runoff: The excess water, from precipitation or spring melt, which isn't retained in the ground and flows into the surrounding streams.

Run-of-river dam (facility): Type of hydroelectric facility where no or little water is stored. A dam is built to cause water to pond upstream, ensuring the river water is high enough to enter the pipes leading to the turbines. A run-of-river facility has little ability to regulate (or alter) the flows in the downstream river section.

Tributary: A stream or river which flows into a larger lake or river, for example the Petawawa and Gatineau rivers.

Two-Zone Concept: differentiates lands that are unsafe for development (floodway) because the depth and velocity of water, from lands that may be safely developed where proper flood proofing and other measures are undertaken (flood fringe).

Still–Water Elevation: the elevation of the river when there is no wave action.

Flooding: the presence of surface water that causes damage to infrastructure, buildings, or puts people at risk.

Active Flood Proofing: the methods used to protect infrastructure against damage from flooding that are implemented during the flooding event and are decommissioned between events. Coffer damming, disconnecting electrical power, and pumping basements are examples.

Passive Flood proofing: the methods used to protect infrastructure against damage from flooding that are implemented in advance of a flooding event and remain in place between events. Breakwaters, disconnecting storm drainage, raising electrical junctions are examples.

Wet Flood Proofing: locating all sensitive infrastructure above the flood elevation, and then allowing water to occupy the floodplain.

Dry Flood Proofing: creating a barrier between the flood waters and the sensitive infrastructure and preventing water from occupying a portion of the floodplain.

2 Background Information

2.1 Site Review

Jp2g conducted general onsite field investigations, with a focus on the areas of special concern including Greatview Trail, Edgewater Trail and Sunset Trail. During the field visit, the general site topography was reviewed, as well as the structures within the floodplain, existing flood mitigation features, and locations for proposed (temporary or permanent) flood proofing solutions.

Historically, flooding of the project area has been a threat mainly due to the flat, low-lying topography of the area relative to the adjacent Ottawa River.

It was evident that existing flood proofing measures were present on certain properties along Greatview Trail and Edgewater Trail. There were several structures that had been raised onto cinderblocks, had open foundations, or had raised their decks to be above the floodplain elevation.

The pictures taken on site are attached in Appendix A.

2.2 Interviews with Homeowners

A newsletter was sent to the property owners' which included the scope of the project, schedule, and a request for information to support the project. Information gathering occurred through 1-on-1 interviews, phone calls, and emails received from property owners. Information collected from the homeowners included a description of damages, specific locations of flooding, what flood mitigation measures were successful, 2019 flood limits and seasonal flood limits. Below is a summary of the information collected from homeowners:

127 Greatview Trail

- Residents raised their deck approximately 4ft after 2019 flood. The cottage was also raised 4.5ft.
- Every spring, approximately 2/3 of road is impassible even with sandbagging; water comes around onto road through Bellows Bay. Annually, there can be water on the road up to the third week of June. Although, in 2018, there was no water on the road.
- Wave action seemed to be the problem in 2019; waves were 2-3ft high which went over the sandbags in most places.
- Greatview Trail has lower topography than Edgewater Trail & Sunset Trail.

- Water can fluctuate annually, and throughout the summer; contamination can happen, and things float away downstream.
- These local homeowners are invested in the area, some have been here approximately 70 years.
- Residents are paying residential taxes for cottage properties.
- Bellows Bay is more of an issue; flood waters come around
- Only primary/permanent residents on Greatview Trail got funding for permits (3 or 4 only on Greatview).
- Seasonal flood causes no damage to cottages
- Could make water-resistant houses, raise cottages, etc.
- Residents would like to live in harmony, co-exist with OPG, Quebec Government; agencies are still able to make a lot of money.
- If the Township can be an ally for taxpayers, and take that to OPG, didn't get any little breaks from the Township after the flood.

49 Greatview Trail

- There are only hydrometers in Pembroke and Lac Coulonge, which is not indicative of what is happening here. Up until 1995, there was a hydrometer here (near Spotswoods Landing), but OPG removed it. One resident is working with Councillor Neil Nicholson and OPG to work on getting one back to give an accurate depiction of what is occurring in Westmeath.
- Dams: Rolphton to Pembroke = 8-hour delay; Temiskaming to Rolphton = 1.5 days; depending on flow rate, there is no warning system of dam changes, there should be an alert system in place for when dams are open to a high-water event;
- In 2019, a hydrometer upstream at the Temiskaming reservoir went faulty 6 hours before the dam was open under emergency high levels at a critical time;
- The level of the reservoir at Temiskaming went over 1 foot over the normal operating high-level limit due to incoming flood waters and high melt which resulted in the dam having to be open for 4 days straight;
- All dams in series had to open their gates or remove logs once Temiskaming was open;
- The Otto Holden Dam downstream opened quickly and flooded Mattawa;
- The water then hit the Rolphton dam which was kept 50% open and did not fill up like normal, until a few weeks later once the flood threat for Mattawa was reduced;
- Normally in Rolphton, it fills fairly nonstop until it reaches the high limit;
- Therefore, when the dam gates were open and the levels from Rolphton to Mattawa were very low and excess water was let out to Pembroke and downstream;
- Dam parameters may need to be adjusted, there is concern about low limit and high limit for dams and balancing of flood waters; Upstream of Rolphton dam was very low yet peak levels were reached in both Mattawa and Pembroke close to the same time frame; Lower 1ft and could save many cottages
- There are a series of reservoirs that can divert water to Pembroke which was done in 2017 freshet and was not publicly recorded, Diversion was done once the threat of flooding was lowered in the Pembroke area. The public should be informed of any diversion;
- The governing bodies have recently started releasing information and becoming more cooperative;
- Governing bodies/perhaps OPG diverted water up here in 2017, they said they know the water was going down here, and wanted to save houses downstream instead (Ottawa, etc.); Diversion – OPG and Quebec Hydro are making money, OPG makes more with more water diverted; these companies are making money at the local homeowners' expense, while they spend their time repairing.
- There are no full-time operators at most of the dams, just relying on instrumentation. Need to send in an outside crew to remove logs out of the dam during a high-water event. Need to upgrade dams to automated sluice gates for quicker response and will result in better balancing of peak levels
- No warning system of dam changes
- Can we relieve the problem? Maybe get permission from MNRF to dredge the river? MNRF says this would send the problem downstream. We should investigate remnants of rocks from logging operations, which blocks off the river downstream which could be backing up water to a certain extent.

119 Greatview Trail

- 2017 flood waters came up to the base of the cottage, in 2019 there was approximately 2ft of water in the cottage; & then Ottawa and Montreal started to flood, maybe dams closed to reduce the impacts downstream, and therefore water backed up in the Westmeath basin.
- There is a natural bottleneck with two small rivers downstream. The water sits here in a reservoir since it is backed up.

19 Edgewater Trail

- No support from Whitewater Region; as cottagers, they are second class
- In 2017, there was minor flooding in the garage
- In 2019, only the top 2 ft of the garage was above water; trailer & addition flooded, halfway up the front windows and through large kitchen window into the trailer; lots of damage occurred under the trailer
- A few weeks ago (from August 17, 2021), the water came up approximately 2 ½ ft, and in Arnprior it only went up 3 inches. How did this happen?
- Cottagers pay the same taxes as permanent residents but don't get the funding.
- Ideally would have brought another trailer in after the 2019 flood, but Whitewater Region didn't allow it. Allowed to renovate the addition, but in order to bring in another trailer they would have had to raise it on to gravel
- Only a few permanent residents on Edgewater Trail
- Flood hits fast, not much warning
- Property was shown on CTV news three nights in a row

25 Edgewater Trail

- Original structure built in 1959/1960
- Seasonal flood comes up to 1 ½ ft below rock wall (and stairs down to beach)
- Wave action adds 2 ½ ft
- In 2017, water came up over the rock wall, into the crawl space. Sandbags worked to protect some areas
- In 2019, twice as many sandbags were used, deck washed away, more damages
- Permit was issued to renovate
- Raised their cottage and the bunk house above the 100yr flood line. The front section of the bunk house is within the flood line but has been finished with marine grade materials.
- Spent approximately $300,000 on repairs and still working on it
- Water comes through provincial wetland
- Neighbour at 33 Edgewater Trail had water halfway up cottage in 2019
- Based on the Township of Whitewater Region By-law, the permit had to be opened within 12 months of the flood to support renovation. If not, the property could be considered abandoned, and the buildings forced to be torn down.

99 Greatview Trail

- Cottage was built in 1960, and therefore higher than the highest water mark of the previous flood of 1960, so it was one of only a few on the beach that escaped major damage in the 2019 flood. The water came up to a couple inches below the floorboards of the cottage, and half-collapsed the deck. The homeowners had to canoe and paddleboard down Sand Point Road and Greatview Trail to get to the cottage. It was far more than sandbags could handle. The sand of the beach has been eroding for decades from the bottom of the retaining wall and has probably dropped at least a couple feet in the last few decades, and the land at the top of the retaining wall is therefore sinking.

85 Greatview Trail

- Displaced in 2019 for three months, have recovered less than 50% of losses through insurance and DRAO
- Flooding was largely due to mismanagement of flow in the Ottawa River from the dams at the northern end as the water flowed through far too late and too rapidly during the spring freshet
- Blaming climate change and precipitation which likely accounted for 10% of the flooding was both frustrating and lacking any semblance of communication with the stakeholders

75 Greatview Trail

- Small existing retaining wall in front, seasonal water never reaches the top of it
- Every spring, the water comes up the road they drive in, by the middle of June it has cleared
- 2017 flood barely missed going into their cottage; sandbags were placed to keep piers intact
- In 2019:
    - There was 23” of water in one section in the cottage and 9” in another section for several weeks
    - The cottage was sitting in the middle of the river
    - Residents were in their cottage when the water started coming in - it was rising by the minute
    - There was 6-8 feet of water over the road and around the cottage
    - Residents had to row in a kilometre to reach their cottage
    - With the height of the water surrounding the cottage, no sandbagging effort would have been successful and there was no way to transport them in
    - There was no time as the water rose within minutes to a couple of hours
    - Residents were present as the water started to come up through the floor
    - They scrambled to raise as much furniture as they could onto tables etc.
- Cottage was built in 1963 and there were no regulations back then to prevent from building or building above recorded flood levels.

See attached emails in Appendix B.

2.3 Desktop Review

A detailed review of all available drawings, relevant as built drawings, site conditions, background reports and studies, letters and information on file has taken place. Below is a summary of the background studies that were reviewed as part of the Flood Risk Assessment Study.

2.3.1 Reports

An Independent Review of the 2019 Flood Events in Ontario, prepared by Douglas McNeil, P.Eng., October 31, 2019

During spring of 2019, heavy rains paired with melting snow and a sudden temperature increase led to devastating flooding across many areas throughout northern and southern Ontario. As a Special Advisor on Flooding, Douglas McNeil, P.Eng., was appointed by the government to provide expert advice to the Minister, and to make recommendations to the government on opportunities to improve the existing flood policy framework.

Doug McNeil explained that major storm events that contribute to significant flood events will happen again, but with climate change we can expect that they will be more frequent and/or more significant. He notes that historic investment in flood mitigation infrastructure, such as dams, dikes, flood channels and shoreline protection, has delivered structural solutions to reduce flood risk to existing and new developments in floodplains. He also says that the sheer amount of water on the landscape directly contributed to the flooding in 2019, due to the amount of snow and rainfall.

It was noted that Environment and Climate Change Canada characterized the 2018/2019 winter as very long and extremely cold, including higher than normal snowfall across northern, central, and eastern Ontario. The key drivers leading up to the flooding of spring 2019 included a colder than average winter, larger average snowpack, and higher than average snow water conditions. The spring temperatures were colder than usual, and there were many heavy rainfall events that contributed to the flooding.

It was explained that recent climate change reports have suggested that Canada’s climate is warming twice as fast as the global average. Changes in temperature can affect the timing and extent of snowpack development, soil freezing, snow and ice melt, and rainfall potential during colder seasons, as well as the timing, intensity, duration, amount, and phase of precipitation events.

It was also noted that OPG has a heightened level of control and storage on flows and levels on the Ottawa River when flows are considered normal outside of freshet periods. However, OPG generating stations do not have the ability to store enormous amounts of water and manipulate levels that would prevent extreme high water and flooding in conditions experienced in spring 2017 and 2019.

The significantly affected area in the vicinity of Westmeath is situated within the floodplain of the Ottawa River under the 1% flood (pursuant to mapping prepared under the Canada-Ontario Flood Damage Reduction Program during the 1980s and early 1990s). This area is also mapped to be in the floodway, where flood depths can exceed one metre and/or flow velocities above one metre per second can create significant hazards for development. Many of the dwellings along the Ottawa River in this area were once modest camps that were transitioned into seasonal cottages, and now many exist as permanent year-round residences.

Several recommendations were made throughout the report to address flooding in Ontario. It was recommended that the MNRF update floodplain mapping technical and implementation guidelines recognizing new technology and approaches for flood hazard and flood risk mapping. It was also recommended that the Province update its technical guides pertaining to floods and natural hazards. This includes undertaking a review of the flood event standards, with a view to providing for current science and climate change, as well as reviewing the floodplain areas (floodway, floodway fringe, shoreline setbacks). It was recommended that the Province continue to monitor the effectiveness and location of gauges to ensure that there is appropriate coverage and consider repositioning gauges if necessary. It was recommended that the Province review the funding formula for eligibility of municipalities under the Municipal Disaster Recovery Assistance program, and that the "build back better" pilot under the DRAO program move from a "pilot" to a full program. The program should be tied to legislated flood protection levels and floodproofing criteria. It was also recommended that the DRAO program be flexible enough to allow for removal of the structure from the floodplain (buyout) if this is the only technically and financially feasible option. It was also recommended that the International Joint Commission, the Ottawa River Regulation Planning Board, and Ontario Power Generation make their detailed information about their flood operations readily available on their respective websites.

2.3.2 Flooding in Study Area

According to the Ottawa River Regulation Planning Board, "there is no one agency responsible for the regulation of water, due to the multi-jurisdictional nature of the Ottawa River. A group of agencies, each responsible for their own operations, comprise the Ottawa River Regulating Committee and work together with the purpose of integrating the management of the flow from the thirteen principal reservoirs in the Ottawa River basin. During the spring, the goal of this management is to minimize the impacts of flooding as much as possible.

In the spring, water levels on the river increase naturally because the volume of water that flows into the river is increased by the natural runoff from snow melt and rainfall. The natural constrictions on the river and other features such as islands restrict the flow of water. Under natural flow conditions in a river the water level will increase as the flow increases.

In 2019, the Ottawa River basin was hit by heavy rainfall when the melting of a deep snowpack was already causing historic floods on the tributaries that feed into the Ottawa River. The water contained in the snowpack was approximately twice that of a normal year in early spring."

According to CTV News, the Disaster Recovery Assistance for Ontarians (DRAO) program could provide a maximum of $250,000 to permanent residents after the 2019 flood. The Disaster Recovery Assistance for Ontarians is designed to help people affected by natural disasters get back on their feet. DRAO provides financial assistance to individuals, small owner-operated businesses, farmers, and not-for-profit organizations. Homeowners (primary residence only) and residential tenants are eligible to apply (Government of Ontario).

Flooding along Ontario's rivers, lakes and streams can occur at any time of the year and there is concern that the likelihood of extreme weather and flooding will increase with a changing climate. Ontario's approach to managing flood risk is based on the core components of emergency management. The four pillars of emergency management related to flooding include mitigation and preparedness prior to the flood, and response and recovery after the flood. The mitigation phase includes keeping people and property out of flood-prone areas and taking steps like floodproofing and other approaches to reduce the impact of flooding. Successful implementation relies on partnerships between provincial ministries, municipalities, Indigenous communities, conservation authorities, stakeholder organizations and the federal government. Priority #1 in the flooding strategy is to enhance flood mapping. The Office of the Auditor General suggests that up-to-date flood maps would allow municipalities to better plan for future growth in areas of low flood risk and build infrastructure resiliency in high-risk flood areas. Priority #3 is to enhance flood preparedness, ensuring Ontarians have access to current and timely information in order to prepare for flood events. Climate change scenarios are indicating that Ontario may be exposed to more intense heavy rainfall events and corresponding flooding. Priority #5 is to invest in flood risk reduction. Having flood protection, mitigation works and activities that are well funded would be an intended outcome of this priority. The Flooding Strategy seeks to ensure Ontarians can access funding programs for flood protection and mitigation works and help municipalities and conservation authorities to invest in local flood risk reduction initiatives.[1]

2017 Spring Flood Summary

Unusually heavy rainfall, coinciding with melting snow that had already saturated the ground and swollen waterways, generated exceptional volumes of water in the Ottawa River basin in 2017. This generated record volumes and major peak water levels in the Ottawa River and its tributaries, exceeding those set in 1974 and 1976, causing major flooding in the southern section of the basin, from Chats Lake to Montreal.

Spring floods largely depend on weather conditions that can only be predicted a few days in advance, including precipitation, duration and trajectory of rain and the temperature. The snow cover is an additional risk factor, but in 2017, the snow accumulation levels were less than 2016, and therefore do not directly correlate with the flooding. In 2017, the precipitation totalled 257mm in April and May, which is a 174% increase from the normal values. According to the Environment and Climate Change Canada, major precipitation records were set in the month of April. The exceptionally heavy precipitation combined with the melting snow on the ground led to water volumes that were much above normal.

Flood reduction measures are undertaken annually in preparation for the spring runoff, which involves emptying the principal reservoirs during the winter period to provide storage for the spring melt. Integrated reservoir management maximizes the use of this storage and allows dam managers to coordinate operations between multiple reservoirs to minimize flood damage. In 2017, reservoirs were emptied by the end of March. In early May, at the height of the spring flooding, the storage capacity of the reservoirs was being used nearly at full capacity.[2]

2019 Spring Flood Summary

During the 2019 spring freshet, the regulation strategy consisted of reducing water flow from the principal reservoirs while southern tributary rivers such as the Petawawa, Dumoine, Coulonge, Mississippi, Petite Nation and Rouge rivers reached their peak and started to recede. Due to this strategy, it was estimated that peak water levels were reduced by 40cm. In 2019, the water contained in the snowpack was approximately twice that of a normal year, and due to cooler than normal temperatures, there was little reduction of the snowpack prior to the spring runoff. Flows in the Ottawa River vary from year to year because the weather conditions over the watershed such as precipitation and temperatures change from year to year. The principal reservoirs in the Ottawa River basin have a storage capacity of approximately 40% of the average spring runoff.[3]

2.3.3 Westmeath Provincial Park

The Westmeath Provincial Park Management Plan is an official policy for the management and development of Westmeath Provincial Park. Westmeath Provincial Park is one of the few undeveloped areas remaining along the Ottawa River in Ontario. The Park possesses a diversity of landforms including a sand dune system and a 1,980-metre sand beach. The area of the park is 610 hectares, 353 of which are dry land. Representative and significant life science features also exist on the property including a dry beach community, lowland and upland forest community and a wetland.

Sand carried by the river current was, and still is, continuously being deposited at this large bend in the river. The sand spit is slowly growing northeast into the Ottawa River, creating an enclosure for a large wetland known as Bellows Bay. The Westmeath Provincial Park Management Plan provides policies, which guide the careful development and management of the park. Westmeath Provincial Park is classified as a Natural Environment Park under the Provincial Park Classification System. This is the most appropriate classification given the need to balance the protection and recreational use of the site. One of the park objectives is to protect significant elements of the natural and cultural landscape of Westmeath Provincial Park.

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[1] Government of Ontario. (2020). https://www.ontario.ca/page/protecting-people-property-ontarios-flooding-strategy

[2] Ottawa River Regulation Planning Board. (2020). http://ottawariver.ca/wp-content/uploads/2020/03/FAQ_2019_ORRPBV.Oct24.pdf

[3] Ottawa River Regulation Planning Board. (2019). http://ottawariver.ca/wp-content/uploads/2019/02/2017-Spring-Flood-Summary.pdf

The Park contains three Nature Reserve Zones. They encompass the following areas of earth and life science significance: Sand Point, the cuspate foreland, and the southern end of Bellows Bay. Almost 50 percent of Westmeath Provincial Park's land base has been designated Nature Reserve Zones to protect its significant features. Bellows Bay Nature Reserve is 55 hectares in size and is characterized by open water with a border of wet meadow in the northern end and a complex marsh community in the southern end.

Natural water fluctuations will provide the best management of the vegetative, fish and wildlife communities in Bellows Bay.[4]

2.4 Topographic Survey

2.4.1 Site Plan Survey

A topographic survey was completed at 7 Greatview Trail, Westmeath, on November 18, 2020, by Adam Kazprzak Surveying Ltd. A site plan was issued on February 24th, 2021, by Jim Bell Architectural Design Inc.

A topographic survey was also completed at 16 Greatview Trail, Westmeath, on September 23rd, 2019, by Adam Kasprzak Surveying Ltd. A site plan was issued for building permit on October 1st, 2019, by P-Squared (P2) Concepts Inc.

The surveys are attached in Appendix C.

2.4.2 2019 Flood Level Survey

Jp2g conducted a spotted topographic survey on January 13, 2022. The survey was completed to establish the ground elevation at trees which were marked with nails. We were advised by two residents that the nails/marks on the trees are supposed to be 112.50m not the 2019 water level. They also both said that the highest water level in 2019 was approximately 16in (0.4m) lower than the nails. In general, the elevation of the nails surveyed in January 2022 is 112.39m and if the 16in (0.4m) is subtracted, the elevation of the flood was approximately 111.99m.

On May 12, 2019, Jp2g shot the highest water level on Sullivan Point Road at 111.92m. That's only a 70mm difference noting that the GPS will have a small error in the elevation. It is anticipated that the water level on Forest Park Road, Sullivan Point Road and Sand Point Road should all be about the same elevation. Therefore, we except that the 2019 flood level was somewhere around 111.92 and 111.99m.

2.5 Ottawa River Operating Ranges and Flood Frequency

Due to the lack of hydrometer in the Westmeath basin, there is no accurate water level elevation data for the study area. The Ottawa River water level at Pembroke has been recorded, as well as downstream of Westmeath at Lake Coulonge, but the basins in the Ottawa River are not linear. According to the Ottawa River Regulation Planning Board, the annual extreme water level in Pembroke in 2017 was 113.00m, and in 2019 was 113.71m. The regulatory flood elevation in the study area is 112.50m.

Table 1: Historical Flood Water Levels

	Flood Event		
Location	**2017 (m)**	**2019 (m)**	**Historic Peak (m)**
Mattawa	153.96	155.64	155.78
Pembroke	113.03	113.71	113.71
Lac Coulonge	108.52	109.10	109.10

[4] Government of Ontario. (2017). https://www.ontario.ca/page/westmeath-provincial-park-management-plan

The 1:100-year floodway elevation for the Pembroke section of the Ottawa River (Allumette Lake) has been established as 113.90m. The flood fringe elevation is 112.90m.

Figure 3 below shows the location of the Des Joachims Generating Station and the Chenaux Generating Station in reference to the study area.

Figure 3: Generating Station Locations on the Ottawa River

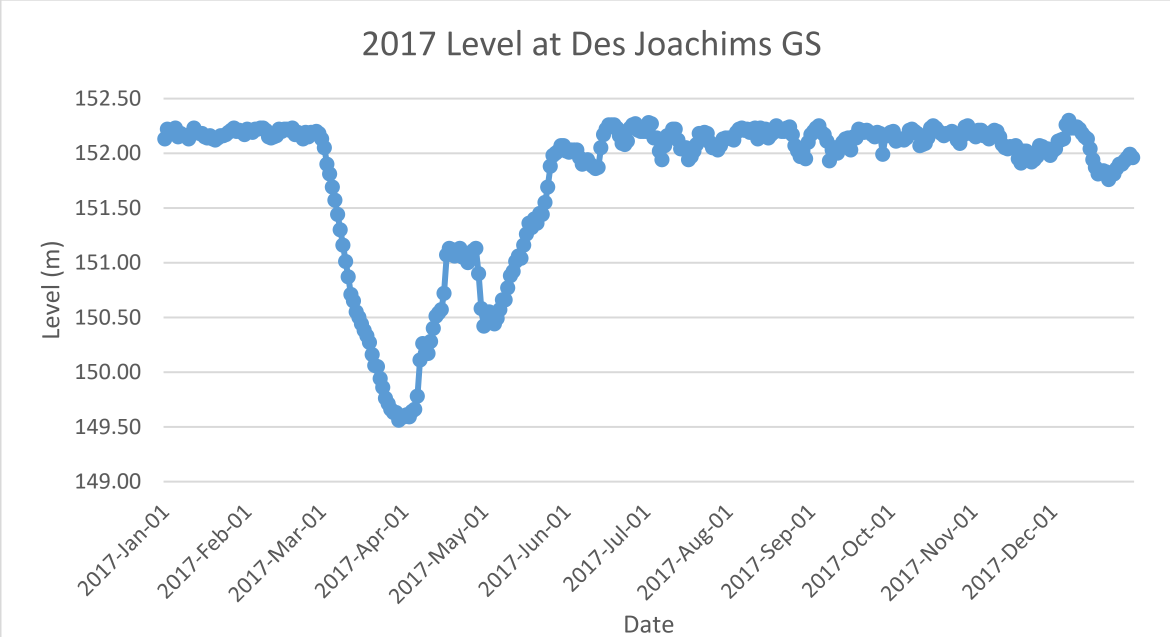
Figure 4 below is an image from the Ottawa River Regulation Planning Board, showing the Ottawa River Basin. The drainage area to the Ottawa River is approximately 146,300km^2, with the majority of the drainage area in Quebec. The subcatchments within this basin drain to the generating stations on the Ottawa River.

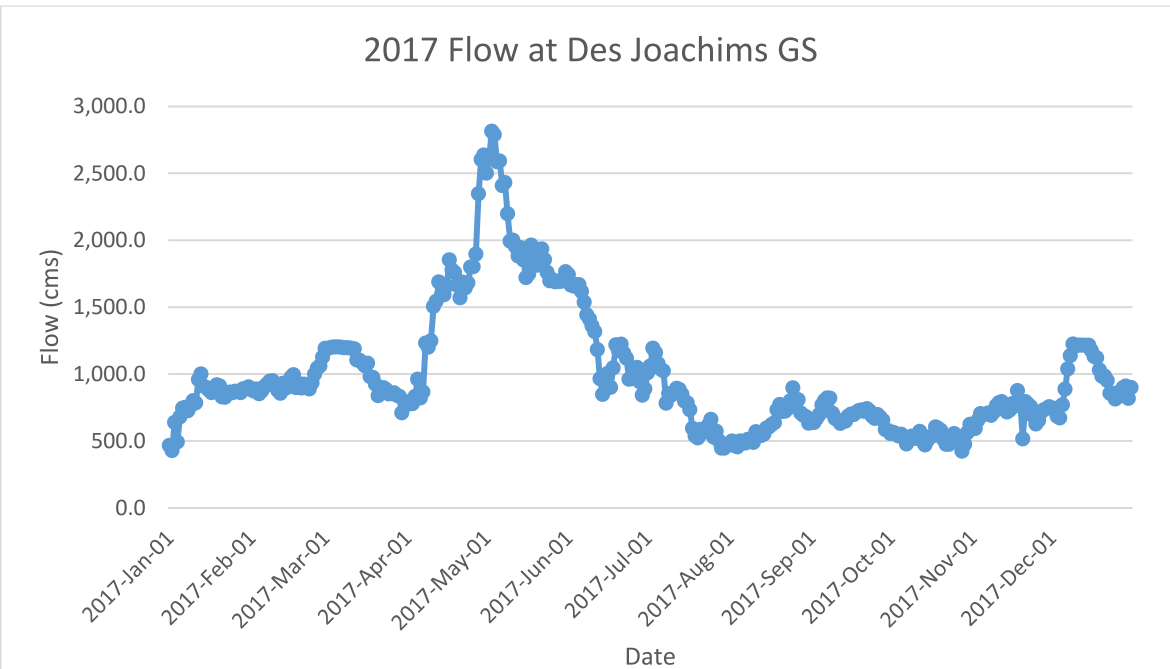
Figure 4: Ottawa River Basin (ORRPB)

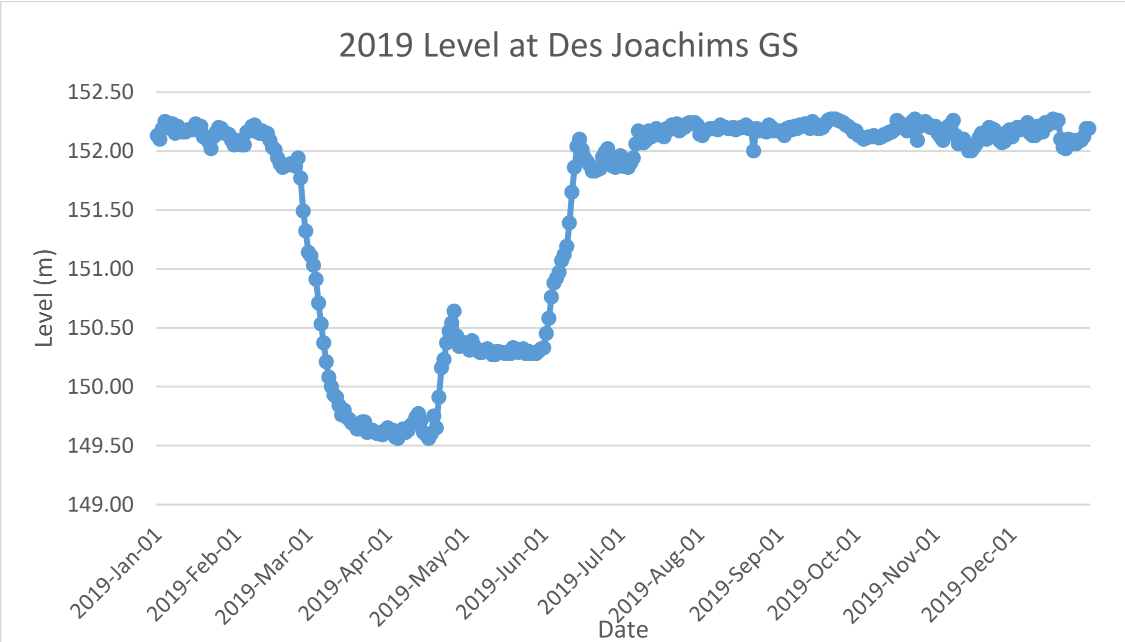
2.5.1 Historical River Levels

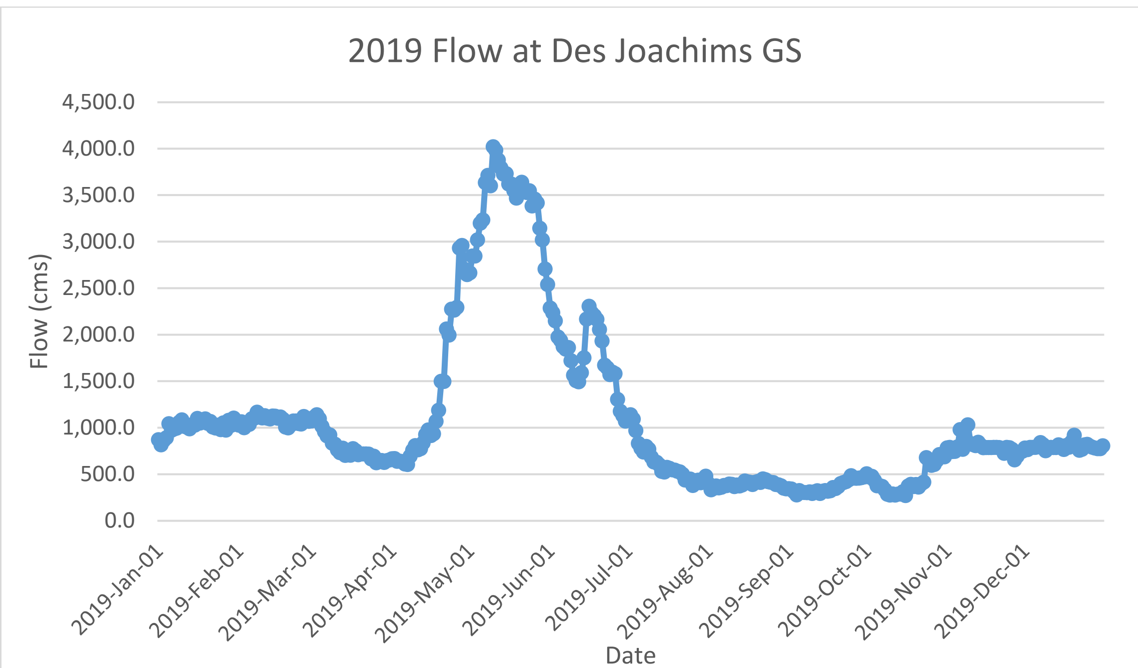
OPG has provided the operating water levels of the generating stations along the Ottawa River. The water levels are taken into consideration while evaluating the hydraulics of the river.

Des Joachims Generating Station – Upstream

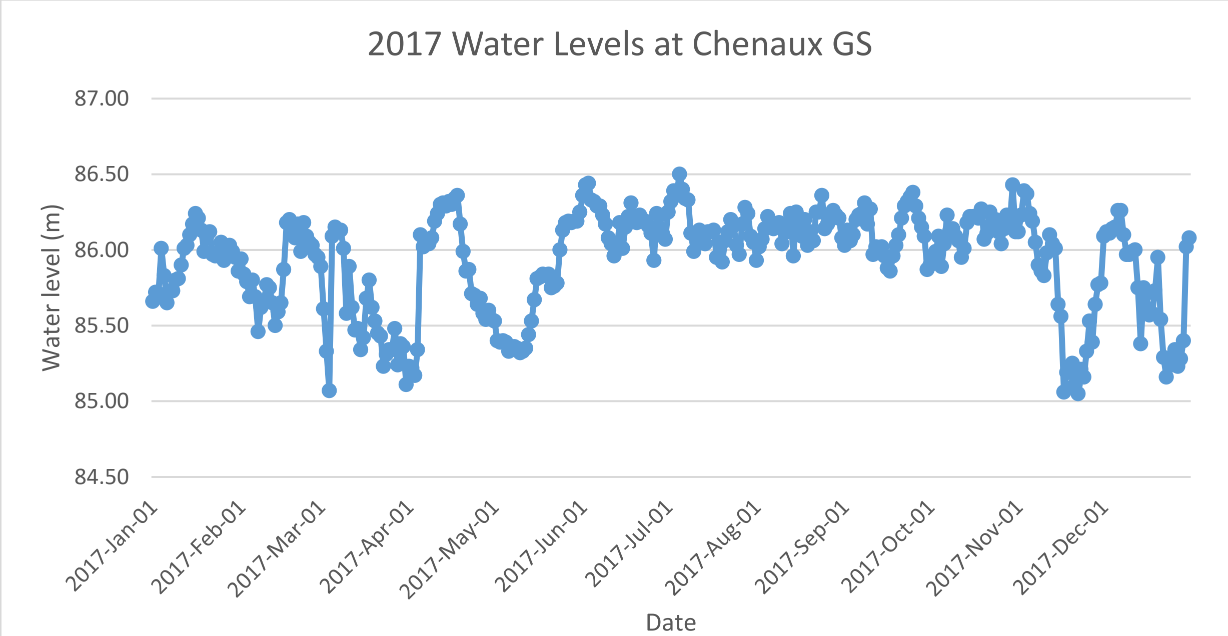


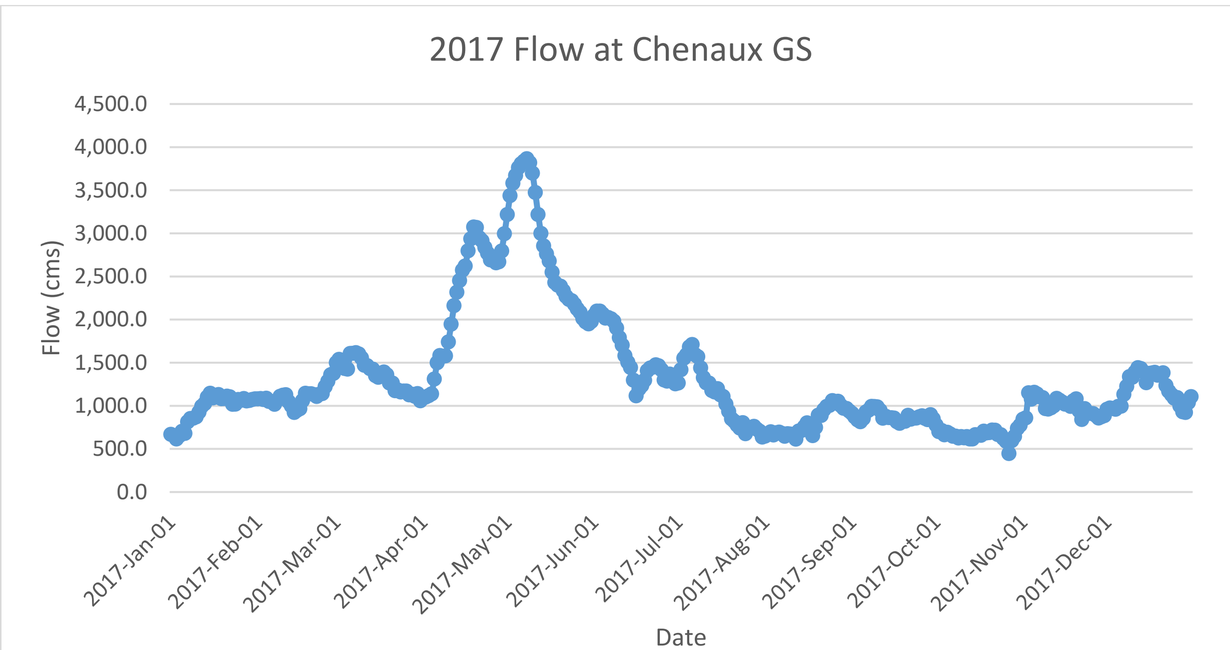


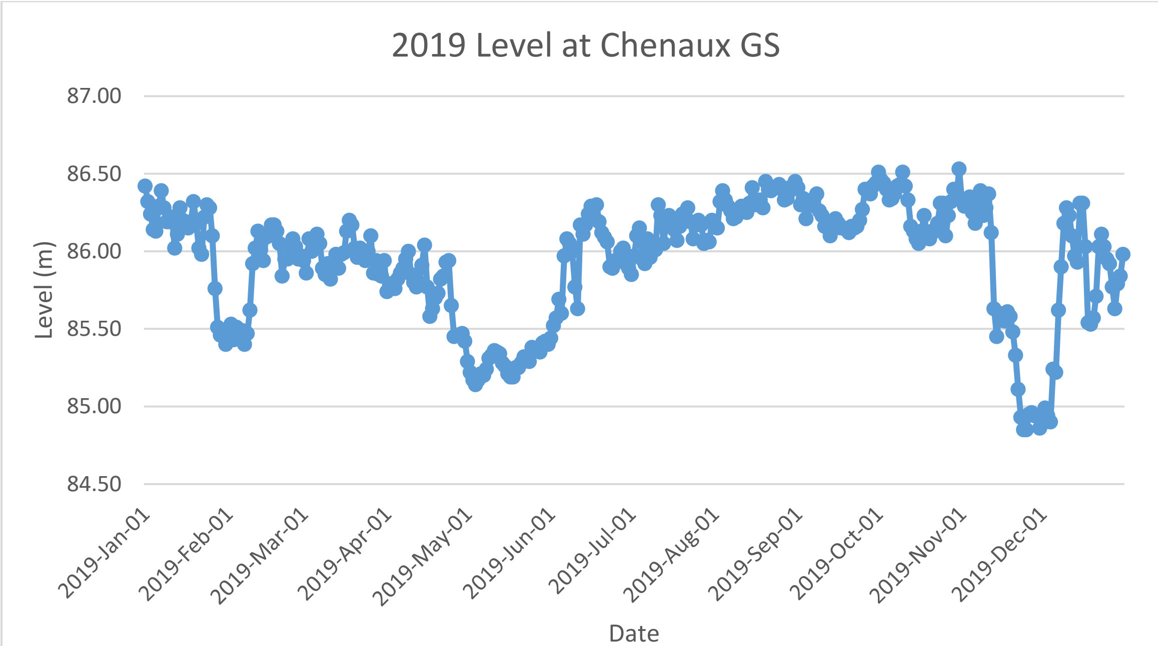

2019 Level at Des Joachims GS
152.50
152.00
151.50
151.00
150.50
150.00
149.50
149.00
Level (m)
2019-Jan-01
2019-Feb-01
2019-Mar-01
2019-Apr-01
2019-May-01
2019-Jun-01
2019-Jul-01
2019-Aug-01
2019-Sep-01
2019-Oct-01
2019-Nov-01
2019-Dec-01
Date

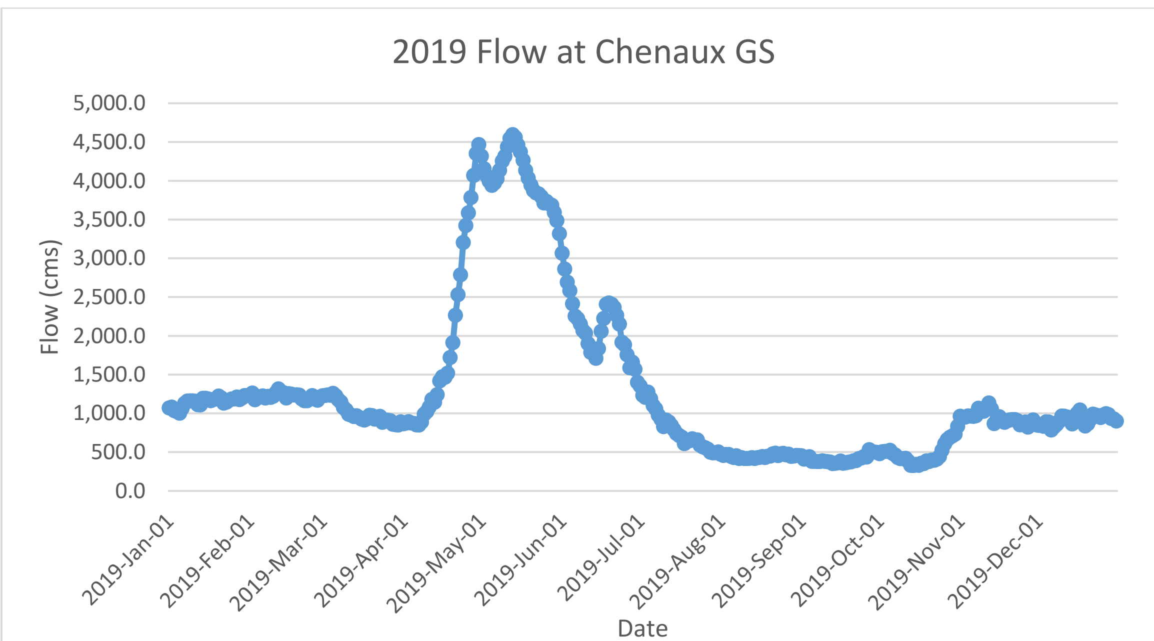

2019 Flow at Des Joachims GS
4,500.0
4,000.0
3,500.0
3,000.0
2,500.0
2,000.0
1,500.0
1,000.0
500.0
0.0
Flow (cms)
2019-Jan-01
2019-Feb-01
2019-Mar-01
2019-Apr-01
2019-May-01
2019-Jun-01
2019-Jul-01
2019-Aug-01
2019-Sep-01
2019-Oct-01
2019-Nov-01
2019-Dec-01
Date

Chenaux Generating Station – Downstream









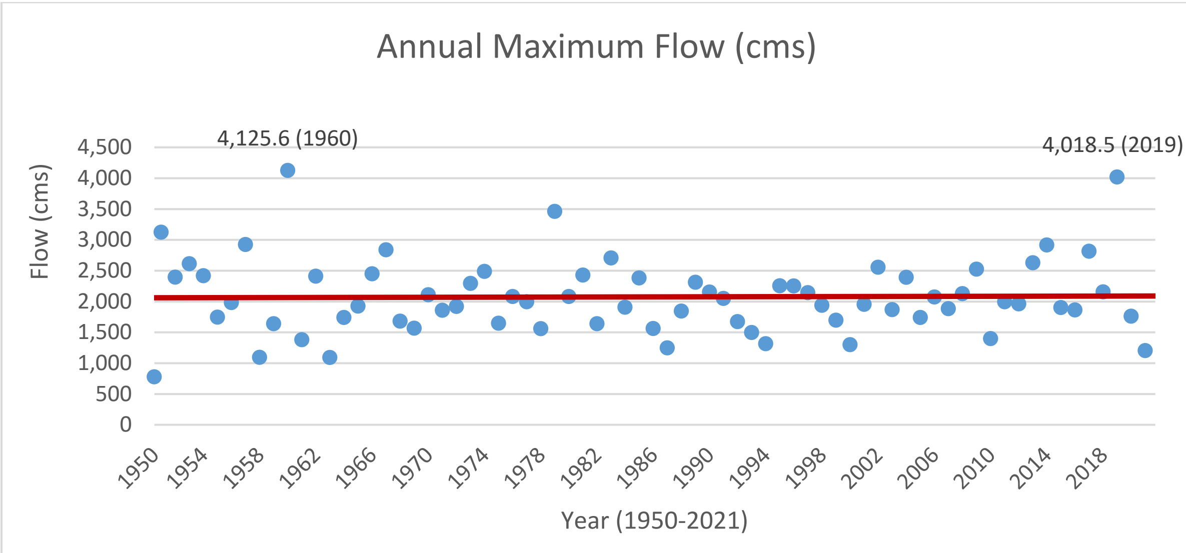
Throughout the spring freshet, the Ottawa River Regulating Committee posts news releases and announcement regarding upcoming forecasts and flooding. On April 4, 2019, the Bulletin from OPG read: The current strategy at Des Joachims is to pass inflow on a daily/weekly basis. The refill towards 151m will start when the flow increases. Balancing upstream versus downstream flooding may require adjustments to the current refill strategy.[5]

On May 9, 2019, the Ottawa River Regulation Committee released a statement that the water levels between Mattawa and Lac Deschenes are expected to increase and may reach a peak that exceed previous record levels. Therefore, the forecasted

[5] Ottawa River Regulation Planning Board. (2019). https://ottawariver.ca/des-joachims-gs/

water levels downstream at Mattawa and Pembroke could also exceed the historic high of 1960, and the levels could exceed the previous high of April 29, 2019, at Lac Coulonge.

The graph below shows the annual maximum flow released from the Des Joachims Generating Station, from 1950 to 2021.



Dam Management

The graphs below were presented by the Ottawa River Regulation Planning Board at the Westmeath Public Meeting. This meeting highlighted the Limits to the Regulation of the 2019 Spring Flood Overview. Figure 5 below shows the water level at Pembroke through 2017, in comparison with the annual maximum and minimum values, and the average water level of the Ottawa River.

Figure 5: Pembroke Water Level in 2017

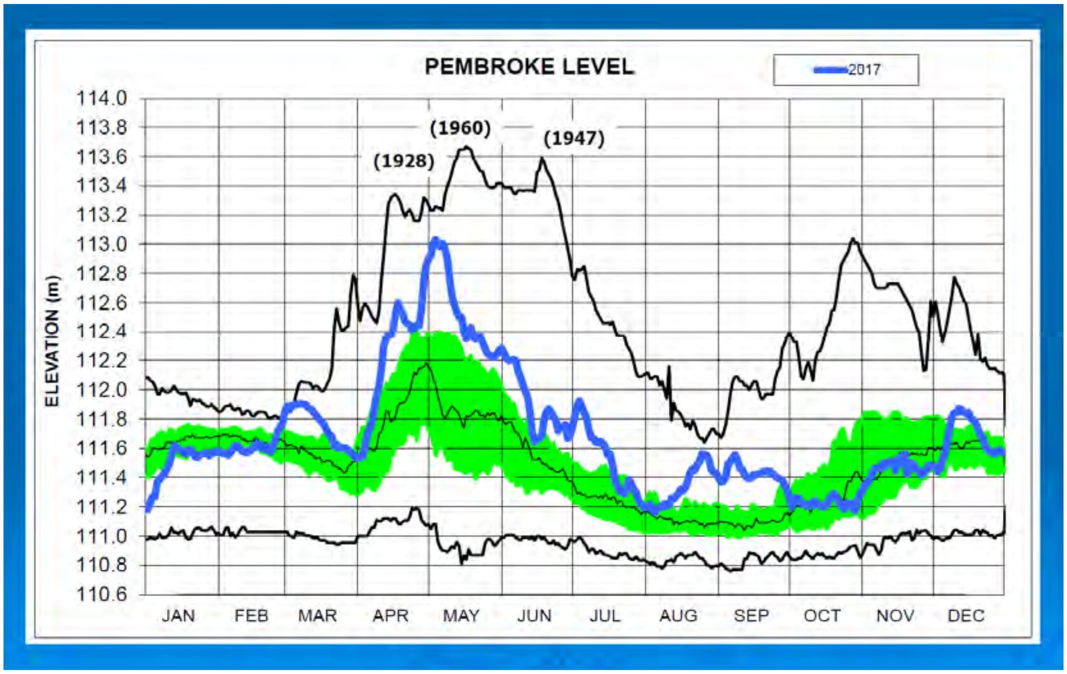


Figure 6 below shows the water level at Pembroke through 2017, in comparison with the annual maximum and minimum values, and the average water level of the Ottawa River, as well as the 2019 water levels up to June 23rd, which was the date of the meeting. This captured the spring flooding values and notes that the high water level in Pembroke in 2019 was 113.69m.

Figure 6: Pembroke Water Level in 2017 and 2019

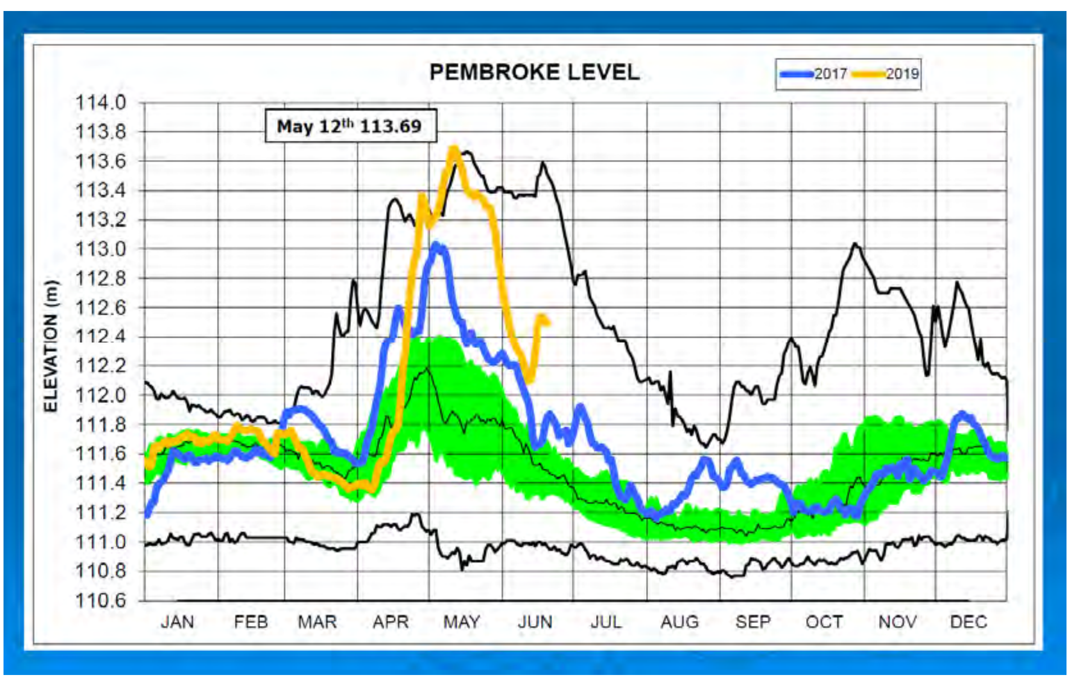
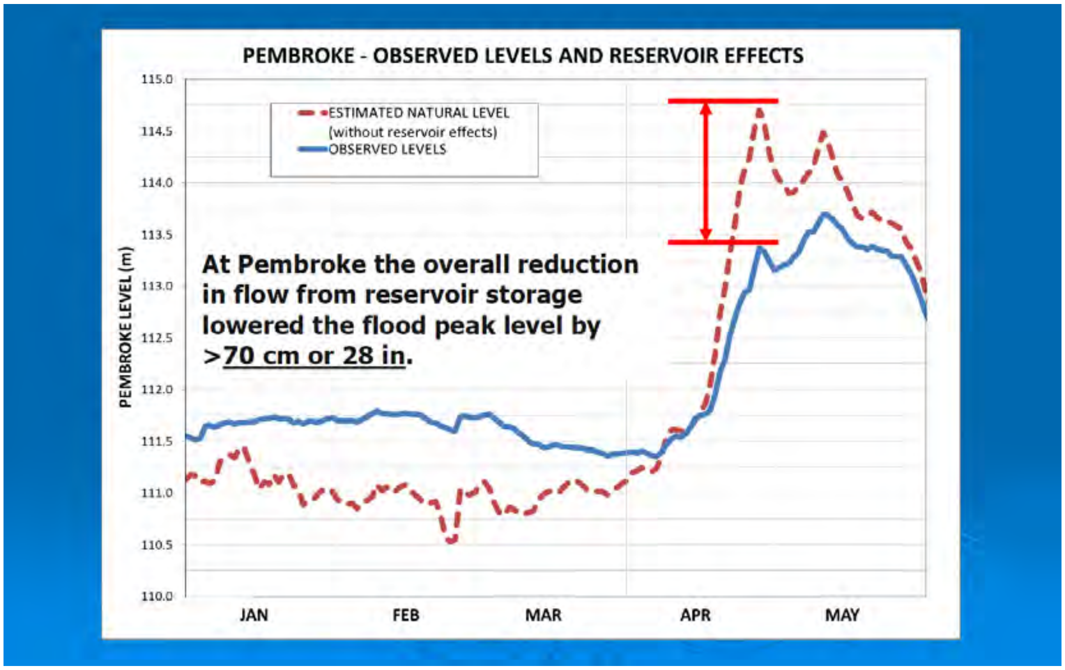


Figure 7 below shows the water level in Pembroke January through May in 2019. The estimated water level without reservoir effects is also shown, and peaks above the observed 2019 water level in April and May. Therefore, the overall reduction in flow from reservoir storage lowered the flood peak level by approximately 70cm. Without upstream reservoir effects, the water level at Pembroke could have increased to 114.75m.

Figure 7: Pembroke Water Level and Reservoir Effects



Figures 8 and 9 below show the water level in Lac Coulonge, which is downstream of Pembroke. The 2017 and 2019 levels are compared to the annual maximum and minimum, as well as the average water level at this location. In Figure 9, it is shown that the maximum water level of 2019 was 109.17m, which is now the historical maximum value.

Figure 8: Lac Coulonge Water Level in 2017

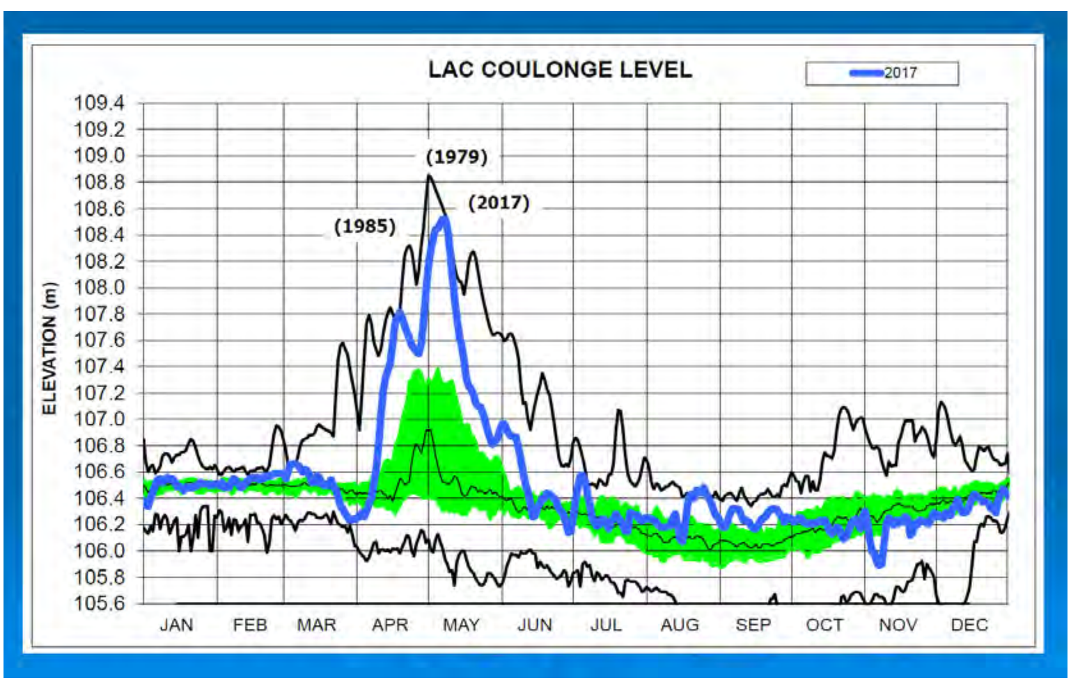


Figure 9: Lac Coulonge Water Level in 2017 and 2019

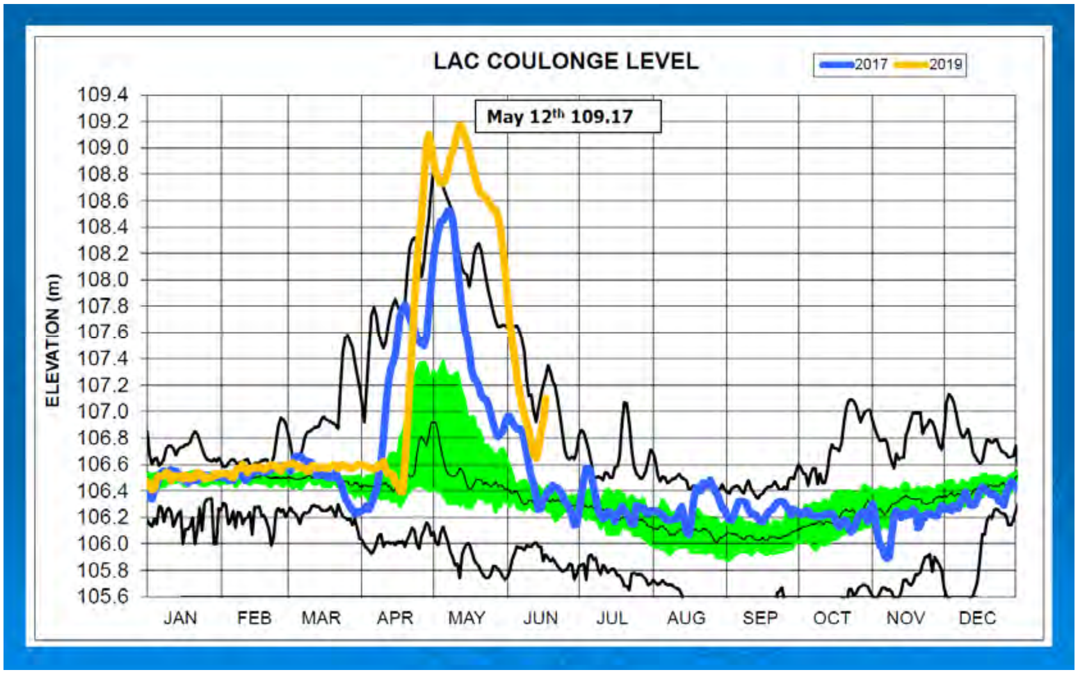
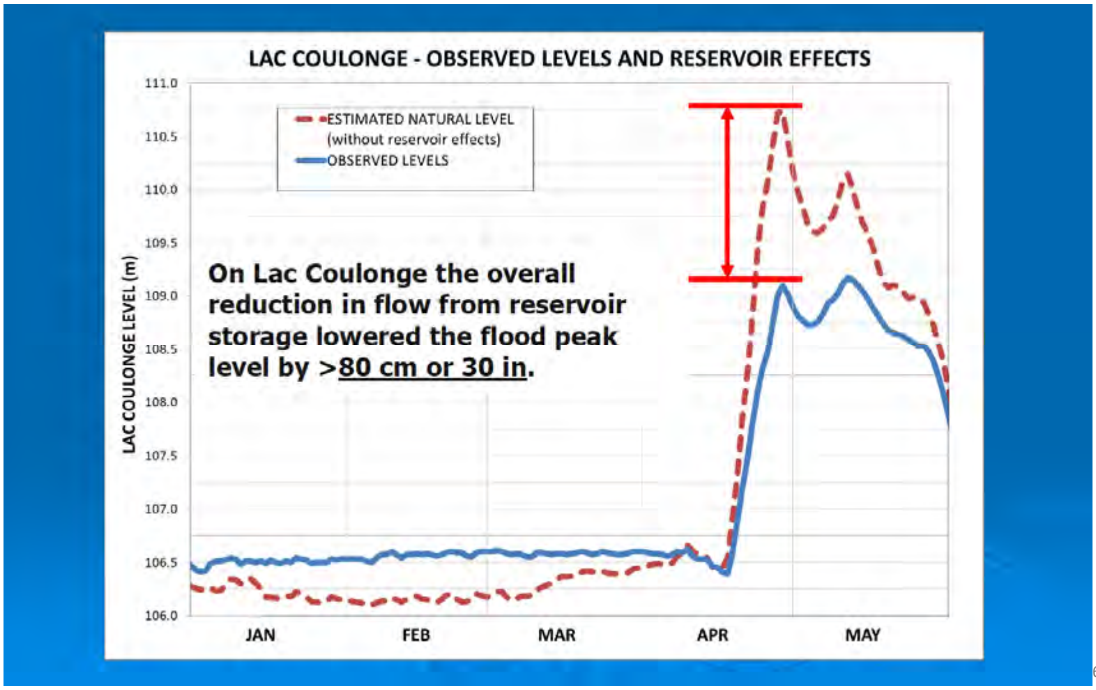


Figure 10 below shows the water level at Lac Coulonge January through May in 2019. The estimated water level without reservoir effects is also shown, and peaks above the observed 2019 water level in April and May. Therefore, the overall reduction in flow from reservoir storage lowered the flood peak level by approximately 80cm. Without upstream reservoir effects, the water level at Lac Coulonge could have peaked at approximately 110.75m.

Figure 10: Lac Coulonge Water Level and Reservoir Effects



[6]

[6] Ottawa River Regulation Planning Board. (2019). https://ottawariver.ca/wp-content/uploads/2020/04/2019-06-23-WestmeathPublicMeeting.pdf

3 Existing Flood Control Measures and Infrastructure

3.1 Existing Flood Control Measures

At the project site, there are minimal flood control measures present to protect infrastructure from regular seasonal water level rises. The most notable measures observed during the site review are retaining walls and elevated housing. In 2017, some residents used sandbags to protect their property, while they were not required for others. In 2019, sandbags were used extensively in an effort to protect most cottages. Attempts to protect houses and cottages were naturally made directly from the Ottawa side, however, the river flooding extended through Bellows Bay and onto the roads, surrounding the properties on Greatview Trail, Edgewater Trail, and Sunset Trail requiring sandbagging from all directions. Very few residents escaped 2019 without damage to their property and house/cottage.

3.2 Existing Infrastructure

After the damage to houses/cottages from the 2017 flood, some residents chose to lift their homes/cottages. In 2019, after the flood, many homes and cottages required extensive repair. Due to a lack of funding, some homeowners abandoned their properties. Others decided to renovate and lift their cottages to prevent further damage but had no funding to do so. Based on the DRAO, only permanent residents could receive up to $250,000 for repairs. Building permits were issued from the Township of Whitewater Region to nine properties on Greatview Trail, and four properties on Edgewater Trail. Due to the duration of the flooding in 2019, there was extensive damage to the existing infrastructure. There are several existing buildings that are abandoned and in disrepair.

When the water rises in the area, the roads become flooded, and access becomes a problem. Due to the topography of the study area, the water enters Bellows Bay and floods around the south side of the existing houses and cottages. The only municipally maintained road within the study area is Sand Point Road.

3.3 Existing Floodplain Mapping

Floodplain mapping for the Westmeath area on the Ottawa River was completed in 1985 and can be seen in Appendix E. Under the Canada/Ontario Flood Damage Reduction Program (FDRP), a Floodline Mapping Report for Pembroke Township Ottawa River/Alumette Lake was prepared by the Water Planning and Management Branch Inland Waters Directorate of Environment Canada in 1991. According to the Floodline Mapping Report for the Lower Allumette Lake, the wave uprush is not expected to be significant due to the shallow bay and prevailing wind direction. Due to the large flood estimate using the Wakeby distribution (112.47m), and the need to be consistent with the Westmeath floodlines, it was recommended that a regulatory flood level of 112.50m be adopted for Lower Allumette Lake. This level would include a freeboard allowance of 0.44 m above the recommended three parameter lognormal (3PLN) estimate for the 1-in-100 year flood.

It was concluded that the regulatory elevation for Lower Allumette Lake should be based on the 1-in-100 year flood elevation (3PLN) derived for the Thrasher's Island farm gauge plus 0.44 metres freeboard. Therefore the regulatory flood elevation recommended is 112.50m, for consistency with Westmeath Shoreline Flood Plain Mapping. The FDRP Floodline Mapping Report is included in Appendix D.

4 Design Considerations and Constraints

The anticipated maximum flooding (uprush and flood line) mapping was reviewed to determine the at-risk infrastructure. The flooding mitigation options to be provided for this at-risk infrastructure includes design considerations and constraints described in the following sections, with consideration for the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol.

The PIEVC Protocol was developed by Engineers Canada in partnership with Natural Resources Canada (NRCan). The Protocol is a structured, rigorous qualitative process to assess the risks and vulnerabilities of individual infrastructures to current and future extreme weather events and climatic changes. The PIEVC is used to assist engineers in factoring climate change impacts into plans for design, operation and maintenance of public infrastructure. The Protocol considers how the information might interact and result in the infrastructure being vulnerable or adaptive to climate change. The procedures set out in this protocol set the overall framework for carrying out a risk assessment within this study.

4.1 Site Conditions

Due to the variable nature of the river water elevation, the study area can be exposed to highly fluctuating water levels and wave heights. In extremely high water, waves can pass over the point of land, while in extremely low water, there is a significant separation from the infrastructure to the water. There is a provincial park within the study area containing a low-lying body of water.

4.2 Flooding Depth

The flood level in 2019 was approximately 111.99m. This resulted in flooding of the infrastructure within the study area. Most houses and cottages were affected by the flood, and the access roads were completely underwater.

The flooding depth and duration provides guidance for the level of risk for future projects and current flooding protection requirements. For example, infrequent flooding to a certain elevation may be damaging and risky to homeowners but also acceptable, but frequent flooding to a lower depth may be somewhat damaging and risky to homeowners and be unacceptable. Flooding depth constraints are separated into two categories: threshold flooding and severe flooding.

Threshold flooding: poses a risk to infrastructure, but precautions can be taken to prevent risk to human safety.

Severe flooding: In the absence of remedial measures (barriers, pumping), damage to infrastructure and risk to human safety is expected. In addition to depth, velocity of waves can influence risk to health and safety.

Flooding on the Ottawa River is expected to be of long duration.

4.3 Response Time

The Ottawa River Regulation Planning Board provides a forecast of the predicted flood levels on their website during the spring freshet, that are updated weekly. The website is located here https://ottawariver.ca/forecasts/. The upstream water levels are reported which can be related to Pembroke levels and those downstream at Lac Coulonge.

4.4 Areas of Concern

Through the site review and background review, Jp2g was able to determine areas of special concern that may benefit our proactive emergency response considerations. The entire study area is of concern due to the floodplain elevation, although certain areas have lower topography than others.

4.4.1 Emergency Access

It is expected that emergency vehicles should be able to access all buildings and that passenger vehicle parking areas should have both safe access for cars and pedestrians. Emergency access for cars should extend from the houses to a roadway out of the uprush zone.

4.4.2 Building Protection

Uprush should not be allowed to reach the buildings, and the river 'still-water' level is not to back up into the building. Connections should be plugged at the building, and drainage provided by sump pumps that discharge to the ground. Buildings that are constructed within the flood plain should be protected with barriers and pumps.

4.5 Data Gathering and Sufficiency

4.5.1 Climate Change

High-water levels observed in 2017 and 2019 may represent a trend toward more frequent flooding occurrences. Climate change is a concern due to the extreme weather changes and rising temperatures predicted. Climate change can cause severe storms, changes to water quality and water balance, changes to the spring melt timing, and an increased risk of flooding. It is our understanding that the Ontario government is taking steps to adapt to climate change and protect Ontarians from its negative impacts.

The MNRF has developed a Climate Adaptation Strategy[7], which has mandates managing water resources sustainably and operating and maintaining Crown owned dams and other public infrastructure. MNRF is exploring potential options to expand the climate change considerations in the technical guide – River & Stream Systems: Flooding Hazard Limit, which is used for managing flood susceptible lands. Undertaking new modelling and building on existing modelling studies to improve data on the predicted impacts of climate change is also included in their goals. Flood management in Ontario is a shared responsibility between the province, municipalities, and conservation authorities. Projected increases in extreme precipitation are expected to increase the potential for future urban flooding.[8]

There is a greater variability in highs and lows. A warming will produce a greater range and extremes and a difference in timing. Infrastructure built before 1980, when restrictions against building on floodplains were introduced, remains a challenge. Many of the houses would never be permitted under current policies. The process of mapping floodplain zones is based on anomaly events, called "100-year storms." Ontario's current floodplain zones were drawn in the wake of Hurricane Hazel, which hit Southern Ontario in 1954. It is likely that the result of climate change will be earlier and more significant snow melt. The federal government has plans to help those who live in areas most prone to flooding that may not have the means to move. They can create a low-cost insurance problem for people living in "high risk flooding" areas or develop a plan to help re-settle people who live in high-risk zones in another, flood-free location. Both approaches were proposed in Public Safety Minister Bill Blair's mandate letter when he took over the federal portfolio in November.[9]

4.5.2 Historical Flooding

Hurricane Hazel was one of the costliest flood events in Ontario's history and due to the large amount of precipitation that the storm brought, Ontario is using the event in flood mapping. Similarly, due to the compounding impact from heavy rain and snow melt during the spring season, high amounts of runoff were produced in 2019.[10] The intensity from precipitation events is expected to increase as a result of climate change. Flood standards for river systems have been developed within the *River and Stream Systems: Flooding Hazard Limit* published by the Ontario Ministry of Natural Resources. The flooding hazard limit is the greater of:

i) the flood resulting from a rainfall experienced during a major storm such as the Hurricane Hazel storm (1954) or the Timmins storm (1961), transposed over a specific watershed and combined with the local conditions, where evidence suggests that the storm event could have potentially occurred over watersheds in the general area;

ii) the 100-year flood; or

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[7] Ministry of Natural Resources. (2017). https://apps.mnr.gov.on.ca/public/files/er/mnrf-17-313-climate-change.pdf
[8] Environment and Climate Change Canada. (2019). https://conservationontario.ca/fileadmin/pdf/conservation_authorities_section/Flood_2_Dr_Xeubin_Zhang_OttawaFloods.pdf
[9] Capital Current. (2020). https://capitalcurrent.ca/climate-change-creating-unpredictable-future-of-extremes-for-people-living-in-ontario-floodplains/
[10] Braden, J. & Simonovic, S. (2020). https://www.eng.uwo.ca/research/iclr/fids/publications/products/107.pdf

iii) a flood which is greater than i) or ii) which was experienced on a particular watershed or portion thereof, for example as a result of ice jams and which has been approved as the standard for that specific area by the Minister of Natural Resources (MNRF, 2002).

4.5.3 Climate Change Assumptions/Projections

Recent climate change reports have suggested that Canada's climate is warming twice as fast as the global average. A recently published MNRF study documenting results for the period 1980 to 2010 has confirmed a significant decreasing trend in maximum snow water equivalent of 6.4% per decade, or approximately minus 9 millimeters, across Ontario, representing a reduction of 5 to 10% of the annual precipitation in affected watersheds. The most serious impacts of climate change are expected to be the changes in climate extremes. Although it cannot be concluded that climate change is causing the flooding that has been observed over the past number of years in Ontario, it is evident that water levels and flows are affected by a combination of temperature, precipitation and solar inputs that affect changes in precipitation and evaporation.[11]

Data from the Ontario Ministry of the Environment and Climate Change project an average annual temperature increase of 3.6°C in the 2050s versus the 1990s (when warming was already underway). By 2080, precipitation is expected to increase 11% from the 1990s, accelerating the trend toward extreme weather and associated flooding. "What were once considered hundred-year storms will happen more frequently and unpredictably" (Metzger, 2017).[12]

"The hydrological cycle is expected to intensify with global warming, which likely increases the intensity of extreme precipitation events and the risk of flooding. Results show an intensification of extreme precipitation and flood events over all climate regions. There is also an increase in the intensification of extreme precipitation and flood."[13] Included in these climate regions impacted by climate change is the study area. As noted, "Precipitation patterns have changed in Canada over the past century, and projections indicate that climate change will cause more frequent heavy precipitation events and floods (Lemmen & Lacroix, 2014). This is likely to have impacts on the Ottawa River Watershed, notably through flooding events and shifts in average temperatures."[14]

4.5.4 Climate Parameters

The climate parameters included in this assessment were selected because of their potential to impact infrastructure. This includes events that can damage infrastructure over time (flood events). Individual climate parameters are listed as follows:

- Precipitation
  - Annual (as snow and rain)
  - Monthly (as snow and rain)
  - Extreme daily
  - Extreme sub-daily
  - Consecutive daily with rain (wet spells)
- Temperature
  - Monthly maximums (extreme highs)
  - Monthly minimums (extreme lows)
- Wind
  - Monthly averages
  - High velocity (gusts)
- Ice
  - River ice build-up

[11] Government of Ontario. (2020). Climate Change – A Recent History (2019 Flood Events in Ontario)
[12] Metzger, P. (2017). https://www.tvo.org/article/what-climate-change-has-in-store-for-ontario
[13] Tabari, H. (2020). https://www.nature.com/articles/s41598-020-70816-2
[14] Environment and Climate Change Canada. (2020). https://publications.gc.ca/collections/collection_2019/eccc/En4-373-2019-eng.pdf

Climate parameters that combine to create hazards which may affect the infrastructure are:

- Spring rainfall + snowmelt (high stream flows)

4.5.5 Time Horizon

Many projected climate parameter values are averaged over 30-year periods. Based on the "Adapting to Climate Change Report", a typical 30-year time horizon to be selected for future projections would be the following.

Future: 2020s (2011-2040)

2050s (2041-2070)

2080s (2071-2100)

Within the study area, most of the Township and private infrastructure has been in service for several decades. Therefore, the assessed existing infrastructure are expected to have a remaining service life of between 10 to 50 years, in which more substantial maintenance would be required. This means that some assets must operate until at least 2070. Climate projections are typically available to 2100, so for this assessment, vulnerabilities were assessed using the full temporal range of available climate projections.

4.5.6 Infrastructure Components

The study area is located in a rural setting with predominantly seasonal residents. The at-risk infrastructure components are identified below:

1. Buildings (Houses and Cottages)

Aspects of buildings likely to be influenced by climate changes include the following:

- For most buildings in Canada, it is assumed that they will last at least 50 years;
- Accelerated physical weathering, due to changing atmospheric physical, chemical properties and biological – including wind-driven rain and abrasive materials, broad-spectrum solar and ultraviolet radiation; mould, mildew, rot and possible pest infestations;
- Impacts related to water levels – in flood plains;
- Need to apply revised building codes and standards, as well as design values relating to expected changes in frequency of certain weather events;
- Resiliency, strength and durability of materials – including concrete, stone, masonry and plaster – and how they are used; and
- Structural integrity of walls and roofs in the face of stronger winds, and more frequent and intense precipitation, leading to changing snow patterns and packs.

2. Roads

Aspects of roads likely to be influenced by climate changes include the following:

- Roadways, particularly low-lying ones, could become more vulnerable to flooding from added precipitation, more frequent and more intense rainstorms, or from overflowing streams and water bodies
- Road destabilization and/or erosion

3. Water Resources Infrastructure

Aspects of water resources likely to be influenced by climate changes include the following:

- Seasonal shifts in stream flows in snowmelt-fed rivers that could lead to increased winter flows and decreases in other seasons. This could impact water storage and electrical power generation and cause possible flooding. In the longer term, this also means depletion of water storage;
- Greater and more intense precipitation events and lengthened dry spells in given locations could increase both flooding and drought; and
- Droughts and decreased availability of water may reduce stream flows, and lower

reservoir levels.

4. Dams, Reservoirs and Hydropower

Dams help to reduce flooding, allow harnessing of energy and provide for reliable water sources for domestic, industrial and agricultural use. Issues arising in connection with dams include long-term supply and availability of water. Changes in precipitation patterns raise questions about erosion, dam failure, safety and contingency planning. Besides supporting electrical generation, dams along with diversions and dykes, can control or reduce flooding.

4.5.7 Risk Analysis of Infrastructure

In the table below, high vulnerability elements are depicted in red while moderate vulnerability elements are depicted in yellow. These scales of vulnerability are defined as follows.

Red		High Vulnerability
Yellow		Moderate Vulnerability

High Vulnerability – Based on professional judgement (engineering and operational), there is a high risk of reduced or limited performance and perhaps even failure of the element due to the indicated climatic factor. High vulnerabilities will require remedial action in the short-to-medium term. In many cases, the design can accommodate these changes in the operating environment. However, in other cases, vulnerabilities can occur that require review, prioritization and, for this level of vulnerability, are severe enough to require mitigation and/or adaptive strategies to compensate for the vulnerability. These actions may range from retrofitting or rehabilitating the component to changes in operations/maintenance procedures or to more detailed engineering analysis. A high vulnerability may also exist if there is insufficient information or too many unknowns to make a professional judgement.

Moderate Vulnerability – Based on professional judgement, there is a moderate risk of failure of the component from an interaction with the identified climatic factor. Moderate vulnerabilities will require remedial action in the medium-to-longer term and would involve specific actions that are likely lower in scope and cost compared to higher vulnerabilities.

Table 2: Climate Change Factors

Infrastructure Component	Precipitation as Rain	Precipitation as Snow	Flooding	Intense Rain	Wind	Ice/Ice Storm	Freeze Thaw	Exceedance of Water Depth
Buildings								
Houses/Cottages								
Doors								
Windows								
Power Supply								
Heating System								
Cooling System								
Communication								
Telephone								
Transportation								
Vehicle Access								
Roadway Infrastructure								
Sewage								
Septic Tanks								

Frequency of high intensity rainstorm events or quicker spring freshets combined with rainstorms is likely to increase due to climate change and therefore poses the largest risk. Due to the historical flooding events, and the depth of water in 2017 and 2019 storms, the infrastructure is at risk in the existing condition and will continue to be in the future, taking climate change effects into consideration. Due to the nature of the Ottawa River, and the complex system of generating stations/reservoirs, the effect of climate change on the water level at the study area is difficult to quantify. Climate change impacts may include more frequent and more intense storm events, which could cause local flooding, but conversely the reservoir may have sufficient storage available. The combination of precipitation as rain or intense rain and wind would also pose a risk of flooding to the study area. If the effects of climate change increased the flood depth, the existing houses, cottages, and roadways would see increased water depth and further damage in comparison to the 2019 event.

5 Floodplain Mapping

5.1 Hydrologic Computations

Using the MNRF River and Stream Systems: Flooding Hazard Limit Guideline, the flooding hazard limit is the greater of:

i) the flood resulting from a rainfall actually experienced during a major storm such as the Hurricane Hazel storm or the Timmins storm;

ii) the 100-year flood; or

iii) a flood which is greater than i) or ii), which was actually experienced on a particular watershed or portion thereof.

The study area is located within Zone 2, which results in a flood standard of 100-year flood level (item ii above). Where recorded and documented flood levels are found in the same watershed within Zone 2 which exceeded the computed 100-year flood levels, the use of the 100-year criterion should be reviewed. The historical event should be considered for the flood plain standard if the observed event is at least 0.1m higher than the 100-year event.

The purpose of the hydrologic analysis in this study was to estimate flows for the Ottawa River basin watershed for the use in the hydraulic analysis of the river. The study area is within Zone 2 of Ontario's 'Flood Hazard Criteria Zones' (MNR 2002). As such the regulatory flood risk area is based on the 1:100-year peak flow event. The HEC-RAS software was used to model runoff resulting from rainfall events.

Two-Zone Concept for Rivers and Streams:

The two-zone concept recognizes the fact that the flood plain can often be divided into two zones: the floodway, where the majority of the flow is conveyed, and flood fringes which exist on both sides of the floodway.

Where the two-zone concept is applied, the floodway is the inner portion of the flood plain, representing that area required for the safe passage of flood flow and/or that area where flood depth and/or flood velocities are considered to be such that they pose a potential threat to life and/or property damage.

Floodway for a river system means the portion of the flood plain where development and site alteration would cause a danger to public health and safety or property damage. Uses which by their nature must be located in within the floodway, such as flood and/or erosion control works, or where appropriate, minor additions or passive, non-structural uses which do not affect flood flows may be permitted. New development in the floodway is to be prohibited or restricted.

The extent of the floodway is to be determined based on local watershed conditions, such as critical flood depth and velocity, existing and proposed development, and the potential for upstream or downstream impacts. The Floodway was based on the 100-year flood, while the flood fringe was based on the Hazel or Timmins flood. The benefit of this approach was that the 100-year flood represents a sufficiently extreme event to identify a portion of the river that carries the majority of the flow, and it is relatively easy to identify the limits of the floodway.

According to the 1991 Flood Report, the Ottawa River at Allumette Lake has a long term mean discharge of approximately 1,050 m^3/s. It is also stated that there are several dams upstream and it is reported that their operation has minimal, if any, impact on the extreme flood flows. At the downstream of Allumette Lake, outflow is controlled by a series of rapids around Morrison, Beckett and Cotnam Islands. The rapids outlet into the Lower Allumette Lake which is approximately 3 metres lower than Allumette Lake under average flow conditions. Under the regulatory flow conditions the elevation difference is reduced to 1.67 metres. For the Lower Allumette Lake the wave uprush is not expected to be significant in the study area due to the shallow bay and prevailing wind direction. Due to the larger flood estimate using the Wakeby distribution (112.47m), and the need to be consistent with the Westmeath floodlines, a regulatory flood level of 112.5 metres should be adopted for Lower Allumette Lake. This flood level would include a freeboard allowance of 0.44m above the recommended three parameter lognormal estimate for the 1:100-year flood.

Typically, watercourse assessments are completed for the 1:2-, 1:5-, 1:10-, 1:25-, 1:50-, and 1:100-year design storms. However, the numerous dams along the Ottawa River complicate this analysis, since a 1:100-year storm coming through the study area when the dam reservoirs are empty may have a significantly less impact than a 1:5-year storm occurring during the peak spring freshet. Therefore, the purpose of a hydraulic model is to relate predicted water levels at the upstream and downstream dams and provide understanding what this means for water levels in the study area. To perform this analysis, Jp2g will use measured peak flow rates during the last five years provided by the upstream dam broken out as follows:

- 2017: 2814.4 m^3/s
- 2018: 2155.6 m^3/s

- 2019: 4018.5 m^3/s
- 2020: 1699.3 m^3/s
- 2021: 1203.3 m^3/s

5.2 Hydraulic Computations

Hydraulic modelling was performed using HEC-RAS software, developed by U.S. Army Corps of Engineers. HEC-RAS is an integrated hydraulic modelling system which is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. It is capable of modelling subcritical, supercritical, and mixed flow regimes along with the effects of bridges, culverts, dams, weirs, and other structures. Steady-state flow is based on the solution of the one-dimensional Energy equation, where energy head loss between two cross-sections comprises friction losses and contraction/expansion losses. Headwater, tailwater, and velocity can be determined using the steady flow analysis within the HEC-RAS software.

A simplified model of the existing channel of the Ottawa River has been assessed using the hydraulic design software. The core model input parameters include channel/floodplain topographic cross-sections, the design flow, the channel/floodplain surface roughness, and the boundary condition at the downstream and upstream sections of the model. In addition, channel expansion and contraction losses are provided to account for channel restrictions or openings. The channel geometry was developed from GIS.

5.2.1 Cross Sections

The cross-section was created using QGIS, with the RiverGIS plugin. This plugin is an open-source alternative to the HEC-RAS plugin for ArcGIS and creates RAS files (.sdf) for import into HEC-RAS. In order to effectively use the RiverGIS plugin/tool, the necessary parameters must be met. The necessary parameters included banks, river centerline, flowpath, and several other features. These were identified and populated based on existing as well as newly created data. This data, in conjunction with a raster dataset (Imagery-derived DRAPE 2014 DEM) was used to generate the river cross-sections.

In total, 39 cross-sections were used in the Ottawa River reach from west of Pembroke to east of Lapasse. The cross-sections were created to contain the expected floodplain and be perpendicular to the flow direction of the channel and overbanks.

Left and right overbanks were estimated using GIS software; this procedure captured the floodplain and most of the low flow channel. Detailed cross-sections, longitudinal profile and the model schematic can be seen in Appendix F.

5.2.2 Channel Roughness

The roughness of the main channel and the floodplains were determined using aerial photographs and field surveys according to the standard procedure (Chow, 1959). Based on field observation and aerial imagery the land use layer was augmented and representative Manning's 'n' values were assigned to each cross-section. The main channel was assigned an 'n' value of 0.035. The left and right overbank were assigned an 'n' value of 0.07.

5.3 Analysis and Results

Jp2g completed several iterations of the model analysis, varying the roughness and channel banks to suit the channel/bank flow conditions. However, when calibrating the model, it was noted that it produces results for the 2019 flood approximately 1.0-2.0m higher (elevations of 112.90 – 113.90m) than the surveyed water level elevation as described in Section 2.4.2. It is anticipated that this is a result of the following:

- Additional cross-sections: Based on a review of the watercourse profile and the water levels, there are significant bottlenecks at each of the rapids. Additional cross-sections through the rapids may establish a better flow channel, lowering the water level upstream.
- Effective Flow Areas, Levees, Storage: The high-level model does not consider ineffective flow areas or have levees/storage areas established. Defining these may better establish water levels throughout the watercourse.
- Manning's 'n' Roughness: Roughness is established using standard values for the watercourse and banks. Some sections, especially the rapids may benefit from a more appropriate roughness to better represent existing conditions.
- Bathymetry: Water levels may vary depending on the accuracy of the bathymetry. A review of the accuracy and additional cross-sections where better data is available may represent the water levels better.

- Left and Right Overbanks: The overbanks were produced assuming a channel during normal flow conditions. However, each section needs to be reviewed with the change in channel overbank as the floodwater rises.

It is anticipated that other factors may contribute to the unexpected water levels at the study area and should be further studied until the calibration is acceptable.

6 Flood Mitigation Options

6.1 Protection Options

Temporary flood barriers rely on either the mass of the barrier to resist hydrostatic pressure on the 'wet' side, or use the mass of the water itself, pressing on a membrane, to seal itself off. All barriers 'leak', with water flowing through gaps, splashing over, and coming up through the ground. Barriers are not intended to make a space 'dry', but rather to slow the rate of flow so that the water level can be managed with pumping. Barriers should be placed to a height of 0.30m above the expected still-water elevation.

6.1.1 Sandbag Barrier

Sandbags are the classic mass barrier. Although labour intensive, they are relatively cheap, easy to place, and can be constructed in place without special tools. Sandbag barriers can be made to adapt to most geometry or terrain, can be extended vertically and longitudinally without any special effort, and can be exposed to some overtopping without much risk of failure. Typically, the sandbags are placed higher than the expected uprush level, and barriers are constructed 3x as wide as they are high, with an additional row of bags placed to hold down the waterproof membrane, per **Figure 5**. Where the depth of flooding is relatively low, they can be built more simply, per **Figure 6**. In some cases, they can be difficult to remove and dispose of safely.

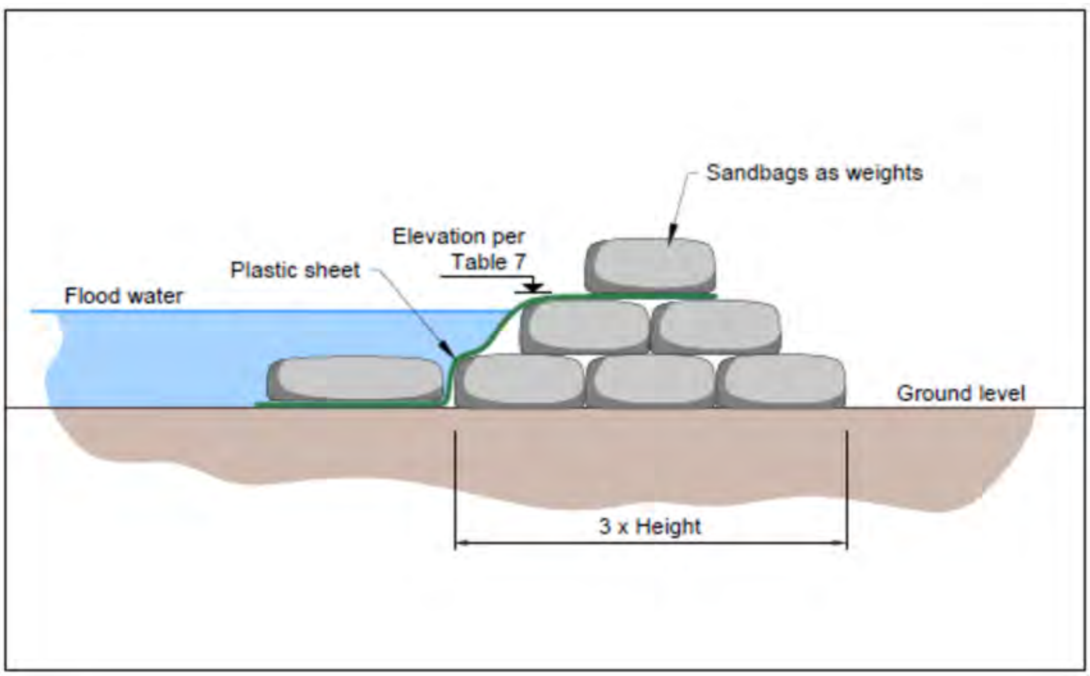

Figure 11: Tall Sandbag Wall

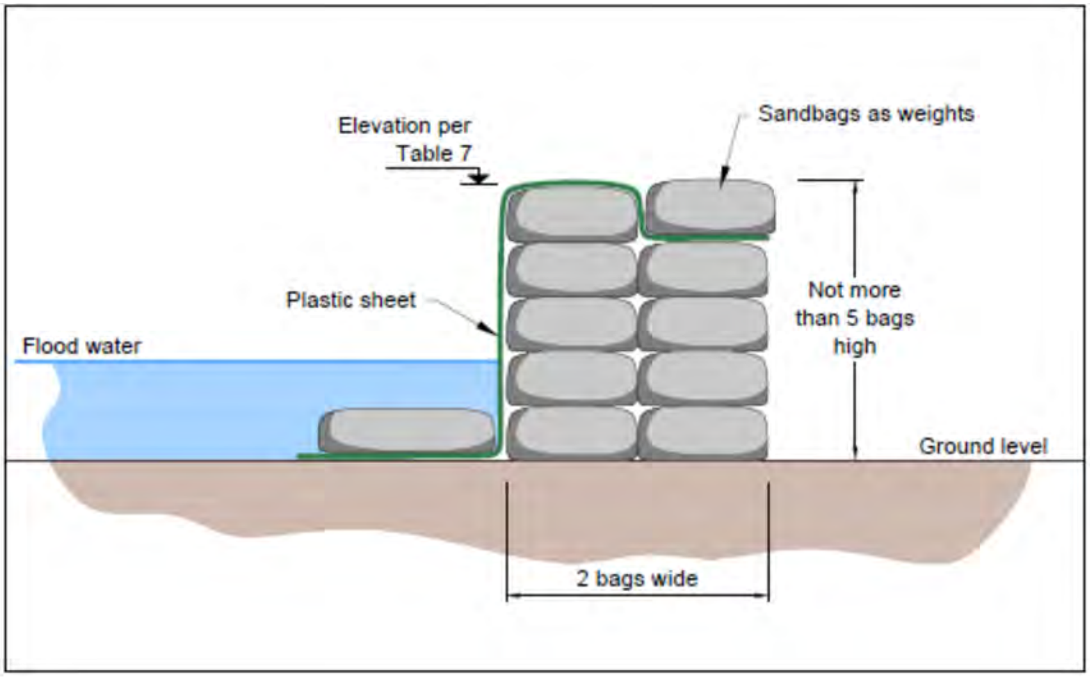

Figure 12: Short Sandbag Wall

6.1.2 Tubes, Tanks, & Bladder Barrier

Water can be used as an alternative to sand for providing the required mass in a mass barrier. Products that can be used in this way include tubes, tanks, and bladders.

- Tube systems can be laid out where the barrier is intended to be and filled in-place with water. When not in use, they are rolled up and stored. Drying them typically means hanging them from one end, requiring either short segments or tall ceilings. Some tube systems can be expended on, allowing greater heights to be protected during the event.
- Tanks are either solid or semi-solid structures that can be stacked or folded up when not in use.
- Bladders can be thought of as short tubes, or flexible tanks, with some of the advantages and disadvantages of each.

In all cases, the containers must be stored dry, and both the process of drying the containers and the means of storing them will typically govern the choice of equipment to use. The containers have a water level somewhat higher than the height of the flood water to ensure sufficient friction on the ground surface to prevent sliding. Overtopping is risky, as the hydrostatic pressure can then exceed the friction, and segments can be pushed around. The significant advantage over sandbagging is the ability to fill them and drain them out on site and thus transportation is made substantially simpler.

6.1.3 Membrane Barrier

Membrane systems are laid out on the land and rely on the water's weight to seal themselves to the ground. Membrane barriers require a significantly greater width than depth. They only work if the dry side has a significantly lower water level than the wet side. While some overtopping can be allowed, the factor of safety is entirely dependent on the tailwater elevation.

Membrane barriers have all the same advantages as water-mass barriers; they can be transported to site readily and set up quickly. An additional benefit is they can be set up without filling them with water – often the process of laying them out is all that is required to make them ready for use. This makes them much faster to set up and remove. Preparing them for storage can be somewhat simpler than water-mass barriers, as they are not enclosed, so cleaning them and drying them out is relatively simple.

6.1.4 Self-Rising Flood Barrier

Modular in nature and self-supporting with tension members rather than stanchions or vertical stops, this ideal for long continuous runs on seawalls or any waterfront path. The self-rising flood barrier provides permanent passive protection along lakes without blocking views or limiting community access to the water. The barriers remain hidden below ground or are cantilevered over the water until an actual flood event. Rising water lifts the buoyant panel in the same manner ensuring the flood gates deploy. When the water recedes, the self-draining and self-retracting passive barrier returns to its rest position. The system sits on a structural space frame within a formed in place concrete pan recessed in the walkway and mounts to a structural footing to support hydrostatic loads. Drains on the water side facilitate deployment and drainage as the water recedes. If needed, drainage can be routed through the system bottom. Self-rising flood barriers have the following benefits:

- Materials are specified for long-term exposure to outdoor, extreme conditions.
- The systems are low maintenance, highly durable, not prone to corrosion, and easy to clean and inspect.
- Maintenance can be handled by one- or two-man crews.
- Designed to withstand impact from floating debris with a factor of safety.

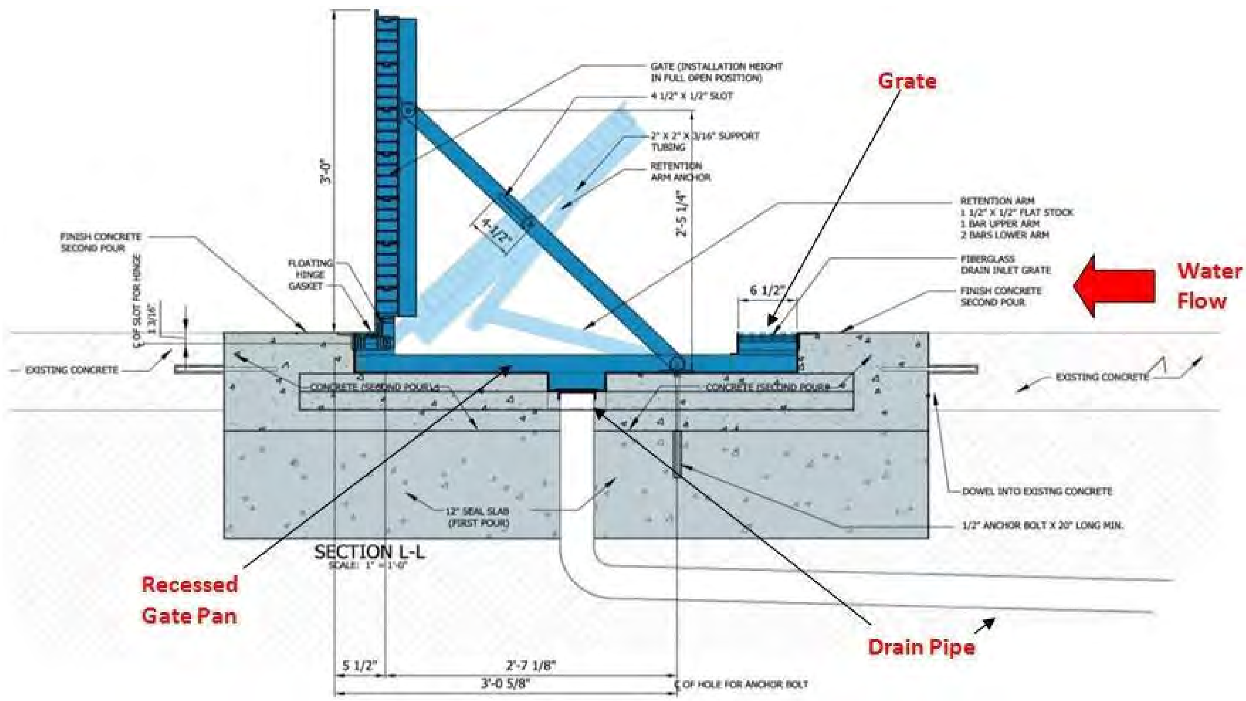

Figure 13: Self-Rising Flood Barrier

6.1.5 Stop Logs

Stop logs have been used for many years to contain water in channels. Stop logs are hydraulic engineering control elements that are used in floodgates to adjust the water level in a river. They are typically long rectangular timber beams or boards that are placed on top of each other and dropped into premade slots inside a weir, gate, or channel to reach the desired height[15]. The process of adding and removing stoplogs is done with hydraulic stop log lifter and hoists. Each log is lowered

[15] U.S. Department of the Interior Bureau of Reclamation. (2018). https://www.usbr.gov/tsc/techreferences/designstandards-datacollectionguides/finalds-pdfs/DS6-6.pdf

horizontally into a space between two grooved piers referred to as a stop log check. Stoplogs are typically used in structures where the removal, installation, and replacement of the logs is expected infrequently.

6.1.6 Vegetative Berms

A berm is a barrier placed at the edge of a slope or a wall built adjacent to a river to guard against potential flooding. A berm could be built to the flood plain elevation or a designated elevation to prevent damage from flooding. The berm can be planted with permanent vegetation (native grasses, legumes) to stabilize the soil.

Berms can often interfere with other stream processes such as floodplain function and habitats and can exacerbate flood-related erosion and stream instability.[16]

6.1.7 Floodproofing

Flood-proofing, or the design of buildings that can resist floods, is a means of reducing potential damage to structures built in flood plain areas. Existing buildings located in fringe flood zones, or in areas where protection works such as dykes may not be adequate, can be protected by design provisions. If flood control works are not economically feasible, the flood-proofing of new buildings may be an alternative way of flood protection.

Flood-proofing the lower levels of buildings by sealing them against water penetration requires that they be made strong enough to withstand cracking from the lateral and uplift pressure of the water. Accordingly, careful design of drainage systems, floor slabs, lower windows and all entrances is essential. This method can be used for existing structures if they are of adequate strength and built on soils of low permeability.

The method requires an adequate flood warning system and pre-planned evacuation measures, for there is greater risk of catastrophic damage if design flood level is exceeded. It is not suitable for floods of long duration or where high flood depths are possible.[17]

<u>Dry Flood-Proofing</u>

Dry floodproofing describes a range of strategies to seal the exterior of a building from flood waters and prevent or limit water from entering a building[18].

Temporary or active dry floodproofing measures are suited to flood hazards that have a longer warning time. Measures include:

- Guards (to fill gaps) that can be quickly installed when flooding is imminent
- Covers that can be fitted over ventilation bricks
- Watertight doors or floodwalls that can be closed or fitted right before a flood

Permanent or passive dry floodproofing measures do not require action at the time of the flood. Measures include:

- Elevating windows or doors and sealing cracks
- Sealing floors

<u>Wet Flood-Proofing</u>

Wet floodproofing refers to a range of strategies used to prevent or provide resistance to flood damage – while allowing water into the uninhabited portion of a building. Allowing floodwater to enter the enclosed areas of a home equalizes pressure, which can prevent structural damage[19].

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[16] http://www.catskillstreams.org/pdfs/instreamtablepdfs/Berming.pdf
[17] National Research Council Canada. (1978). https://nrc-publications.canada.ca/eng/view/object/?id=9343724e-9a71-4ebc-8b63-8faa0f20682e
[18] Floodwise. https://floodwise.ca/protect-your-home-business/floodproofing/dry-floodproofing/
[19] City of Edina. https://www.edinamn.gov/DocumentCenter/View/8416/Wet-Floodproofing-PDF#:~:text=Wet%20floodproofing%20refers%20to%20a,basement%2C%20crawlspace%2C%20garage

The "wet" method accepts that the interior of the building will be flooded. Flood damage is kept to a minimum by using special water-resistant construction materials in the lower levels of the building. Wet flood-proofing is frequently the only method of controlling or reducing flood damage to existing buildings in areas subject to flooding.

6.1.8 Raise Houses

The floodplain elevation in the study area is 112.50m. Raising the houses and cottages above the floodplain elevation would prevent further damage.

Buildings on Fill

New buildings are often constructed on fill raised above the design flood level. This method is used most extensively for flood-proofing new buildings in Canada. It does not require design modifications, and if the design flood water level is exceeded, the depth of water over the fill will be shallow and of short duration. It is not, however, a practical alternative for protecting existing buildings.

When fill is used, it should be designed and constructed to withstand flooding conditions for instance scour and erosion due to floods, quick rise and drawdown of flood water, and prolonged inundation.[20]

Buildings on Piers, Piles, Columns or Bearing Walls

Elevating structures above design flood level on some kind of support provides reliable protection against flood damage. This method uses land efficiently, does not raise the flood level, and has minimal adverse effects on flood flows. This alternative requires careful design to prevent damage of supports from floating debris and to allow sufficient space for it to pass underneath. It cannot be used for large existing buildings and may be difficult to apply even to small, light structures.

In this case, the lowest floor should be elevated to design flood elevation. Design flood elevation includes wave height relative to a datum determined based on the flood hazard map of the area. The foundation design of flood resistant structures should depend on the geotechnical characteristics of soil and strata beneath the foundation and on the soil foundation interaction.

6.1.9 Water Gauge

There are currently rain gauges along the Ottawa River upstream at Des Joachims and Pembroke. The Government of Canada has historical hydrometric data at these rain gauges. There was an existing hydrometer (02KC005) in the Westmeath basin at one point but was discontinued in 1995.[21] Re-instating a hydrometer in the Westmeath basin would provide a level of responsiveness.

According to the Government of Ontario, in Ontario's flooding strategy, priority #3 is to increase flood preparedness. The continuation of this agreement will allow us to support and continue to:

- provide information used by flood forecasting and warning professionals to support early warning for flood – allowing forecasters to make better informed decisions to keep Ontarians safe from floods
- monitor the effectiveness and location of stream gauges to ensure that there is appropriate coverage and where necessary repositioning gauges

Ontario is committed to its continued investment of over $4.7 million in the hydrometric (stream gauge) network to enable flood forecasting and flood warnings that help municipalities better prepare for flood events. Water levels upstream in Pembroke are measured daily and are available on the Ontario River Regulation Planning Board website.

[20] National Research Council. (1978). https://nrc-publications.canada.ca/eng/view/ft/?id=9343724e-9a71-4ebc-8b63-8faa0f20682e
[21] Government of Canada. (2019). https://wateroffice.ec.gc.ca/report/historical_e.html?stn=02KC005

6.1.10 Dam Management

At this point, dam management is not an option. Due to the multi-jurisdictional nature of the Ottawa River and the large drainage area, the generating stations are of large scale and any changes would result in effects upstream and downstream. It may be further looked in to in the future, but it is beyond the scope of this study.

6.1.11 Floodplain Management

The management and planning of floodplains is a reasonable alternative to ensure public safety and reduce the cost of damages. Land use regulations can be implemented based on the premise that the specified hazard area will continue to be flooded occasionally. Land acquisition in the floodplain is another method of controlling land use.[22]

6.2 Evaluation of Options

While barriers can be constructed to prevent stillwater levels and uprush from reaching sensitive infrastructure, it is also possible to make improvements to the infrastructure to minimize or eliminate the risks associated with high water.

Table 3: High Impact Projects Mitigation Assessment

Project	Effect	Rationale	Choice
Construct temporary barriers (sandbags) and pump water	Allows houses & cottages to be used during high river levels	Due to duration of flooding, the capacity to dewater flooded areas is mandatory	Install temporary barriers, rather than have residents evacuate
Aqua-Barrier water inflated dams	Allows houses & cottages to be used during high river levels	Due to duration of flooding, the capacity to dewater flooded areas is mandatory	Install temporary barriers, rather than have residents evacuate
Construct permanent barriers as landscaping elements (berm)	Eliminates inland flooding	Permanent works are considered more desirable than temporary works	Construct a berm with landscaping features
Stop-log system	Eliminates inland flooding	Semi-permanent; residents could add stop logs when waters are set to rise	Construct a stop log system along the shoreline throughout the study area
Raise road elevation to allow safe access for emergency vehicles	In an emergency, such as a flood event, this would ensure emergency vehicle access	Due to duration of flooding, there is a non-zero risk that the roadway would cease to be usable, potentially preventing access to houses	Raise roadway to provide safe access for emergency vehicles
Floodproofing up to flood line	Prevents damage to infrastructure while allowing flood waters to rise	Due to duration of flooding, flood waters can cause damage to structures	Floodproof up to flood line elevation to prevent damage
Raise houses and cottages	Allows houses and cottages to be higher than the floodplain elevation	Structures raised above the flood line will eliminate the risk of flooding up to the 100-year event	Raise houses and cottages above floodplain elevation of 112.50m (bottom floor elevation)

[22] Environment and Climate Change Canada. (2020). https://www.canada.ca/en/environment-climate-change/services/water-overview/quantity/reducing-flood-damage.html#non

Project	Effect	Rationale	Choice
Move houses and cottages/Buy-out/expropriate	Eliminates risk of flooding	Regardless of the water level the ongoing risk to the homeowners is removed	Move houses out of the floodplain
Install Water Gauge	Used as a flood warning system	Residents will be aware of water levels and can prepare for a flood and evacuate if necessary	Install water gauge in the Westmeath basin to give residents a flood warning system in future years
Dam management/water diversion (through Quebec) / Flow Regulation[23]	Minimizes flow through the Westmeath basin	Water diversion through Quebec could prevent flooding in the Westmeath basin	Out of the scope of this study; could be further looked into
Floodplain Management/Floodplain Mapping	Determines updated flood line elevation	Enables the Township to determine any changes to the development within the floodplain	Get updated floodplain mapping to determine 100-year flood level

6.3 Evaluation Criteria

Projects were developed based on a degree of a permanent solution, aesthetics, effectiveness of mitigation, and ease of implementation. Table 15 below provides a description of all the evaluation factors used in consideration of each of the mitigation solutions which were considered.

Table 4: Evaluation Criteria

CRITERIA	DESCRIPTION
Permeance	Assess if the option provides a permanent solution or requires periodic sandbagging
Challenges of Constructability	Assess the potential for impacts of the alternative related to the site features to include site size, geological constraints, manmade features and water related constraints
Impact to Permanent Operations	Assess if the option will provide a negative positive or neutral benefit to the permanent operations of the location
Aesthetics	Assess the potential impact to the visual appearance of the area
Capital Costs*	Assess the potential capital cost of the alternative considering engineering, design, and construction.
Effectiveness	Assess the overall benefit to how the solution is expected to work for the issue
Maintenance	Assess the general maintenance concerns for the option
Availability	Assess the availability of the material
Risk	Assess the risk of the option in regard to health and safety

* Limitations
In providing cost consideration, the Client understands that the Consultant has no control over the cost or availability of labour, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the Consultant's opinion costs are made on the basis of the Consultant's professional

[23] Environment and Climate Change Canada. (2020). https://www.canada.ca/en/environment-climate-change/services/water-overview/quantity/reducing-flood-damage.html

judgement, current knowledge and past experience. The Consultant makes no warranty, express or implied, that bids or negotiated cost of the Work will not vary from the Consultant's opinion of cost.

6.4 Mitigation Options Evaluation and Recommendations

6.4.1 Options Evaluation

The mitigation options were evaluated individually based on the considerations outlined in Section 6.3. They were evaluated based on a red, yellow, or green assessment, with the following descriptions:

Green		Clear potential to meet the criteria
Yellow		Potential to meet the criteria in part or in whole with impacts
Red		Significant challenges in meeting the criteria in part or in whole

In order to evaluate the options, green was given a score of 2 points, yellow a score of 1 point, and red a score of 0 points.

Table 5: Evaluation Criteria Matrix

Options	CRITERIA									Overall Score
	Permeance	Challenges of Constructability	Impact to Permanent Operations	Aesthetics	Capital Costs	Effectiveness	Maintenance	Availability	Risk	
Sandbag Barrier	Red	Green	Green	Green	Green	Red	Yellow	Green	Red	**11**
Tubes, Tanks & Bladder Barrier	Red	Yellow	Green	Green	Green	Red	Red	Green	Red	**9**
Membrane Barrier	Red	Yellow	Green	Green	Green	Red	Red	Green	Red	**9**
Self-Rising Flood Barrier	Red	Yellow	Green	Green	Yellow	Red	Red	Yellow	Yellow	**8**
Stop Logs	Yellow	Yellow	Green	Yellow	Red	Yellow	Yellow	Yellow	Yellow	**9**
Vegetative Berms	Green	Yellow	Red	Red	Red	Yellow	Green	Yellow	Yellow	**8**
Flood Proof Homes	Green	Red	Green	Green	Yellow	Green	Green	Green	Green	**15**
Raise Homes	Green	Red	Yellow	Yellow	Red	Green	Green	Green	Green	**12**
Water Gauge	Red	Yellow	Green	Green	Red	Yellow	Yellow	Green	Green	**11**

6.5 Action Plan

6.5.1 Immediate Solutions and Emergency Procedure

Immediate solutions encompass proactive measures to minimize flooding impacts based on existing conditions. At this point it is recommended to continue to monitor river levels and install temporary sandbag barriers when necessary to prevent seasonal flooding. Flood forecasting can be viewed on the Ottawa River Regulation Planning Board website.

6.5.2 Short-Term, and Long-Term Solutions

The study area was reviewed, and the mitigation options were categorized into short-term and long-term solutions. Short-term solutions include maintenance activities which will ensure minimal impacts during a flooding event. Long-term solutions involve the proposed projects and provide the expected outcome of the projects.

6.5.2.1 Floodproofing

Floodproofing is defined as a combination of structural changes and/or adjustments incorporated into the construction or alteration of individual buildings, structures or properties subject to flooding. If applied effectively, floodproofing can play a significant role in comprehensive flood plain management. Floodproofing should be no lower than the 1:100-year flood level. Types of floodproofing can be active or passive, providing wet or dry protection. Regarding portable or mobile buildings and structures, when located in the flood fringe, they should be properly floodproofed to the flood standard in order to prevent floatation, collapse, and lateral movement.

6.5.2.2 Raise Buildings and Roadways

The floodplain elevation in the study area is 112.50m. Raising the houses and cottages above the floodplain elevation would prevent further damage. Elevating structures above design flood level on some kind of support provides reliable protection against flood damage. This method uses land efficiently, does not raise the flood level, and has minimal adverse effects on flood flows. This alternative requires careful design to prevent damage of supports from floating debris and to allow sufficient space for it to pass underneath. In this case, the lowest floor should be elevated to design flood elevation. Design flood elevation includes wave height relative to a datum determined based on the flood hazard map of the area. The foundation design of flood resistant structures should depend on the geotechnical characteristics of soil and strata beneath the foundation and on the soil foundation interaction.

7 Data Gaps and Future Investigations

Due to the multi-jurisdictional nature of the Ottawa River, the generating stations on the Ottawa River, and the large drainage area, it is difficult to quantify the flow at location of the study area.

It is recommended that a flood plain analysis take place to determine an accurate 1:100-year flood line elevation.

Due to the lack of data at the Westmeath basin, there is limited flow or water depth information, and it is difficult to understand due to the changes in the river profile as well as the effect of the generating stations. Installing a water gauge at the Westmeath basin would confirm the water level and flow, and therefore provide data for future flood forecasting and predictions.

8 Conclusion and Recommendations

The study area includes a Provincially Significant Wetland within Westmeath Provincial Park, and many grandfathered properties situated in the floodway or flood fringe. This area seasonally floods with the spring freshet and represents a significant and recurring flood risk. In 2019 because of flooding, the high water and wave action caused varying amounts of damage in the study area.

The current method to deal with flooding is to install seasonal sandbag coffer dams along the properties adjacent to the Ottawa River where water encroaches on permanent residences, cottages, and roadways. In 2017, sandbags were used as a flood mitigation strategy, which proved unsuccessful leaving some lower lying structures and accessory buildings flooded and requiring repair. Based on the information collected from homeowners, no mitigation measures were successful in the 2019 flood.

It is recommended that immediate flood mitigation options include monitoring river levels and sandbagging when necessary, and that long term mitigation options include floodproofing homes and cottages up to the flood line elevation or raising homes and cottages above the flood line if possible.

Should you require any further clarification, please contact the undersigned.

Sincerely,

Jp2g Consultants Inc.

ENGINEERS • PLANNERS • PROJECT MANAGERS

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Appendix A

<u>75 Greatview</u> – photos from Roger Chamberlain


ONDON

99 Greatview – photos from Sheila McCullough

25 Edgewater Trail – photos from Rob Byce

May 11, 2019
May 13, 2019
PIC•COLLAGE

Site Visit – July 7th, 2021 – Photos by Stephen Arends, Jp2g




187

NO
TRESPASSING
1631



Appendix B

From:	Kevin Abrams
To:	Andrea Bishop
Cc:	rtremblay@whitewaterregion.ca
Subject:	Whitewater Region Flood Risk Assessment
Date:	July 25, 2021 2:31:37 PM

Good afternoon Andrea and Robert
Thank you for the opportunity to provide information and opinion on our flooding history.
Our primary residence is at 85 Greatview Trail. We've owned the property for about five years. We also recently sold the property at 81 Greatview Trail in November of 2020. We purchased it in 2010. Prior to that we owned the cottage at 79. Needless to say we love this area.
In 2019 we were displaced for three months and have recovered less than 50% of our losses through insurance and DRAO.
As you may or may not know, the flooding was largely due to mismanagement of flow in the Ottawa River from the dams at the northern end as the water flowed through far too late and too rapidly during the spring freshet.
Blaming climate change and precipitation which likely accounted for 10% of the flooding was both frustrating and lacking any semblance of communication with the stakeholders.
It was a similar but less severe problem in 2017.
Our neighbor is Dan Poole who has property at 49 Greatview. He's our expert and I would defer to his recommendations on how to better manage the flow.
He's clearly on top of the situation.
Our township was extremely helpful especially Councillor Neil Nicholson. I hope they can lobby the Ottawa River board to lower the water levels before winter to ensure it has enough capacity to offset the spring thaw. We love it in Whitewater and it's been our home for 15 years.
The flood devastated us financially.
Our primary residence is 85 Greatview Trail. Our property is likely worth approximately $450,000 in the current market based on the sale of a smaller seasonal cottage at the end of our road for $325,000 two weeks ago.
We would be mortgage free were it not for the flood where we had to access equity to address losses.

Kevin Abrams

From: Sheila McCullough
To: Andrea Bishop
Subject: Whitewater Region Flood Risk Assessment
Date: August 10, 2021 11:36:10 PM
Attachments: 20190520_130107.jpg
20190520_130110.jpg
20190520_134651.jpg

Hello,

My mother received the newsletter regarding the Whitewater Region Flood Risk Assessment. She is the owner of 99 Greatview Trail, a cottage off of Sand Point Road along the Ottawa River, near the Westmeath Provincial Park. I'm writing for her as she is not very good with computers.

She inherited the cottage from her parents, who bought the lot in 1959 and built the cottage beginning in 1960. Because it was built in 1960, it was built higher than the highest water mark of the previous record flood of 1960, so it was one of only a few on our beach that I believe escaped major damage in the 2019 flood. The water came up to a couple inches below the floorboards of the cottage, washed away our paddleboat, and half-collapsed the deck. The pump room was flooded and the pump destroyed, and various things stored in the sheds were ruined by the water and had to be thrown out. The flood also washed up all sorts of debris that collected under the cottage and had to be dug out.

We went up to the cottage on May 20, 2019 to check out the damage, and had to canoe and paddleboard down Sand Point Road and Greatview Trail to get there. There were a number of cottages/houses almost fully submerged. There was absolutely nothing people on Greatview Trail could have done to mitigate the flood damage - it was far more than sandbags could handle.

When the water level went down, many cottage/house owners on our beach decided to raise their cottages or increase the height of their retaining walls, but we haven't done this because it would be costly, complicated, and possibly impracticable. The river floods most springs, and I can recall a few occasions when Greatview Trail was flooded and anyone who wanted to reach their cottages had to walk across everyone's lawns to get there, but of course it was never anywhere near as bad as 2019. The sand of the beach has been eroding for decades from the bottom of the retaining wall, and has probably dropped at least a couple feet in the last few decades, and the land at the top of the retaining wall is therefore sinking. Photos my mom has from the 1960s show the sand level was much higher back then.

I'm attaching a few photos I took of the flooding on May 20, 2019, slightly after the peak of the flood. The first picture is taken from a boat on Greatview Trail, and shows some of the flooded neighbours' properties. The second shows the flooding on the stairs at my cottage leading down to Greatview Trail, and the third shows the flooding facing the Ottawa River - the metal railing sticking out of the water is at the top of the stairs that lead down to the beach and is almost completely under water.

Appendix C

PROJECT:
TOPOGRAPHIC SKETCH

LOCATION:

PART OF

LOT 13,
CONCESSION NFA

TOWNSHIP OF WESTMEATH

MUNICIPALITY OF WHITEWATER

COUNTY OF RENFREW

SCALE 1 : 100

METRES 1 0 5 10

ADAM KASPRZAK SURVEYING LTD.

NOTES:

ELEVATION NOTE:

ELEVATIONS SHOWN ON THIS PLAN ARE GEODETIC AND REFERRED TO VERTICAL BENCHMARK 0011993U833 HAVING AN ELEVATION OF 123.087m CGVD28:78.

BENCH MARK NOTE:

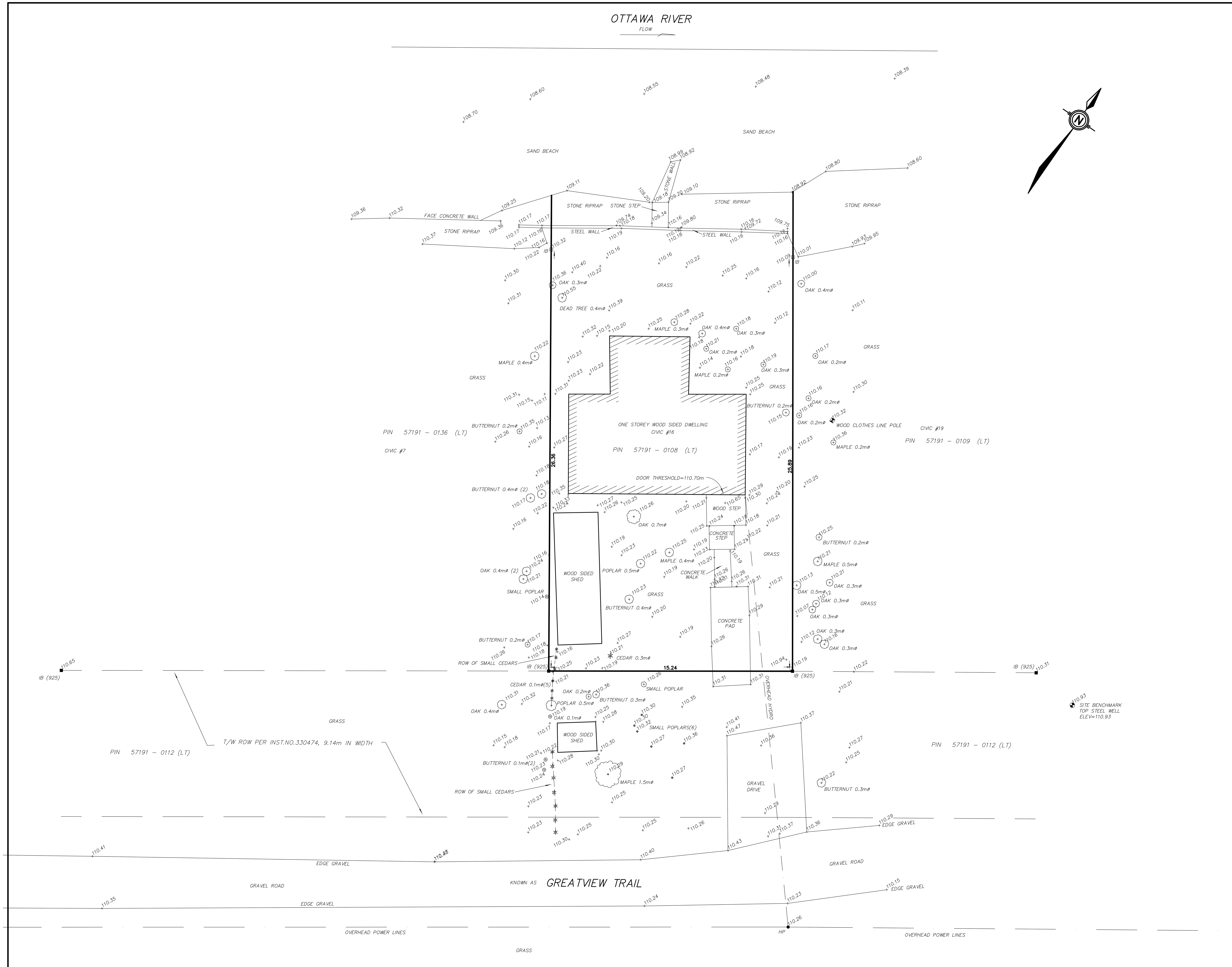
SITE BM–TOP OF STEEL WELL CASING ON PROPERTY CIVIC#19 GREATVIEW TRAILHAVING AN ELEVATION =110.93m CGVD28:78.

LEGEND

- ■ – IRON BAR FOUND
- SIB – STANDARD IRON BAR
- IB – IRON BAR
- [symbol] – MANHOLE
- [symbol] – LAMPPOLE
- ACU – AIR CONDITIONING UNIT
- WIT. – WITNESS
- [symbol] – HYDRO POLE (HP)
- [symbol] – CONIEROUS TREE
- [symbol] – DECIDUOUS TREE/SHRUB
- [symbol] – CONTROL POINT
- [symbol] – SITE BENCH MARK
- SS – STEEL SIGN
- SANMH – SANITARY MANHOLE
- STMH – STORM MANHOLE
- DECID – DECIDUOUS TREE

ADAM KASPRZAK SURVEYING LTD.
ONTARIO LAND SURVEYORS
432 PEMBROKE ST. W. P.O. BOX 492
PEMBROKE ONTARIO K8A 6X7
PHONE (613) 735-0764

SCALE: 1 : 100	REF: 20-5155
DATE : NOVEMBER 18,2020	



PROJECT:
TOPOGRAPHIC SKETCH

LOCATION:
PART OF
LOT 13,
CONCESSION NFA
TOWNSHIP OF WESTMEATH
MUNICIPALITY OF WHITEWATER
COUNTY OF RENFREW

SCALE 1 : 100
METRES 1 0 5 10

ADAM KASPRZAK SURVEYING LTD.

NOTES:

ELEVATION NOTE:

ELEVATIONS SHOWN ON THIS PLAN ARE GEODETIC AND REFERRED TO VERTICAL BENCHMARK 0011993U833 HAVING AN ELEVATION OF 123.087m CGVD28:78.

BENCH MARK NOTE:

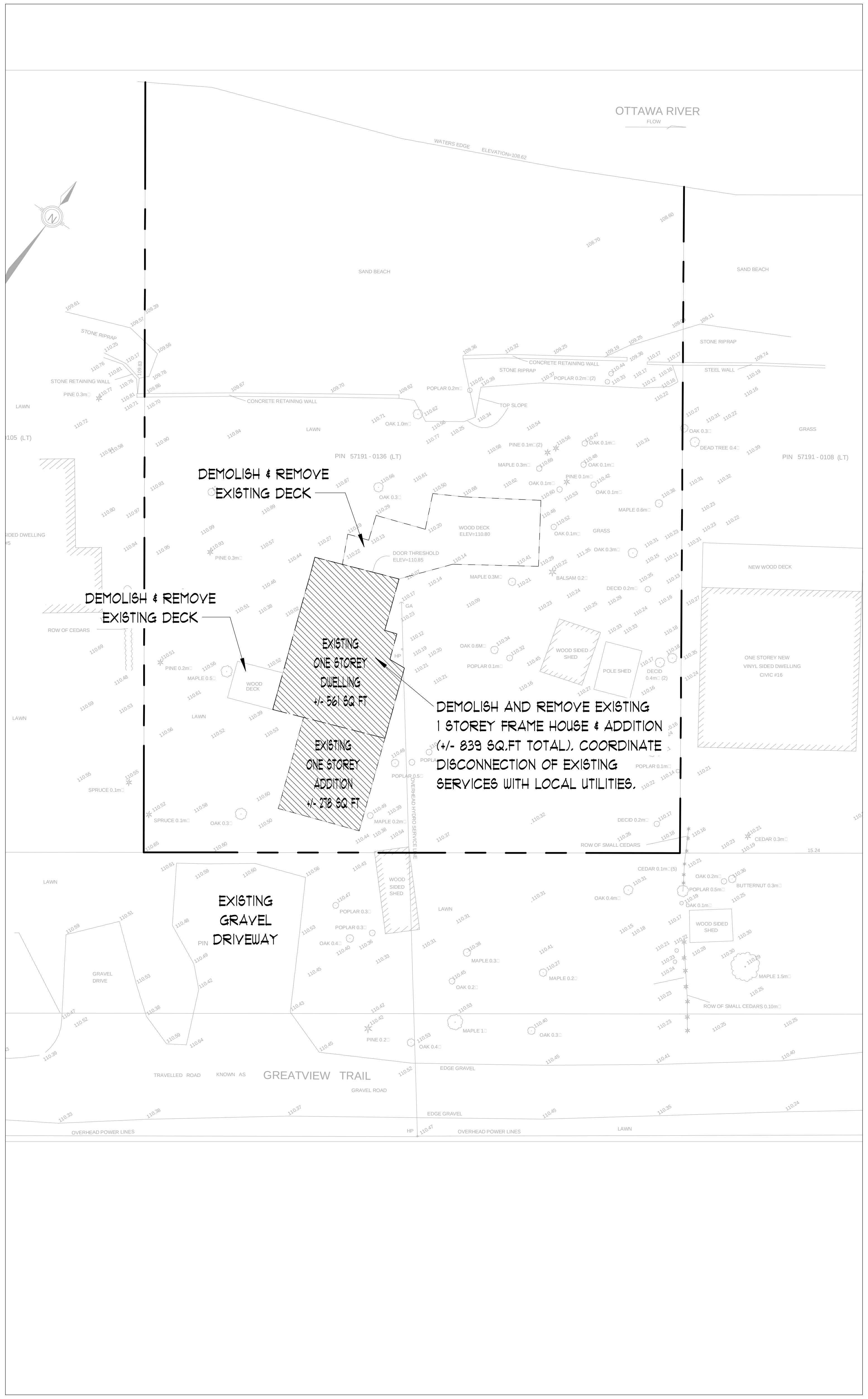
SITE BM–TOP OF STEEL WELL CASING ON ADJACENT PROPERTY HAVING AN ELEVATION =110.93m CGVD28:78.

LEGEND

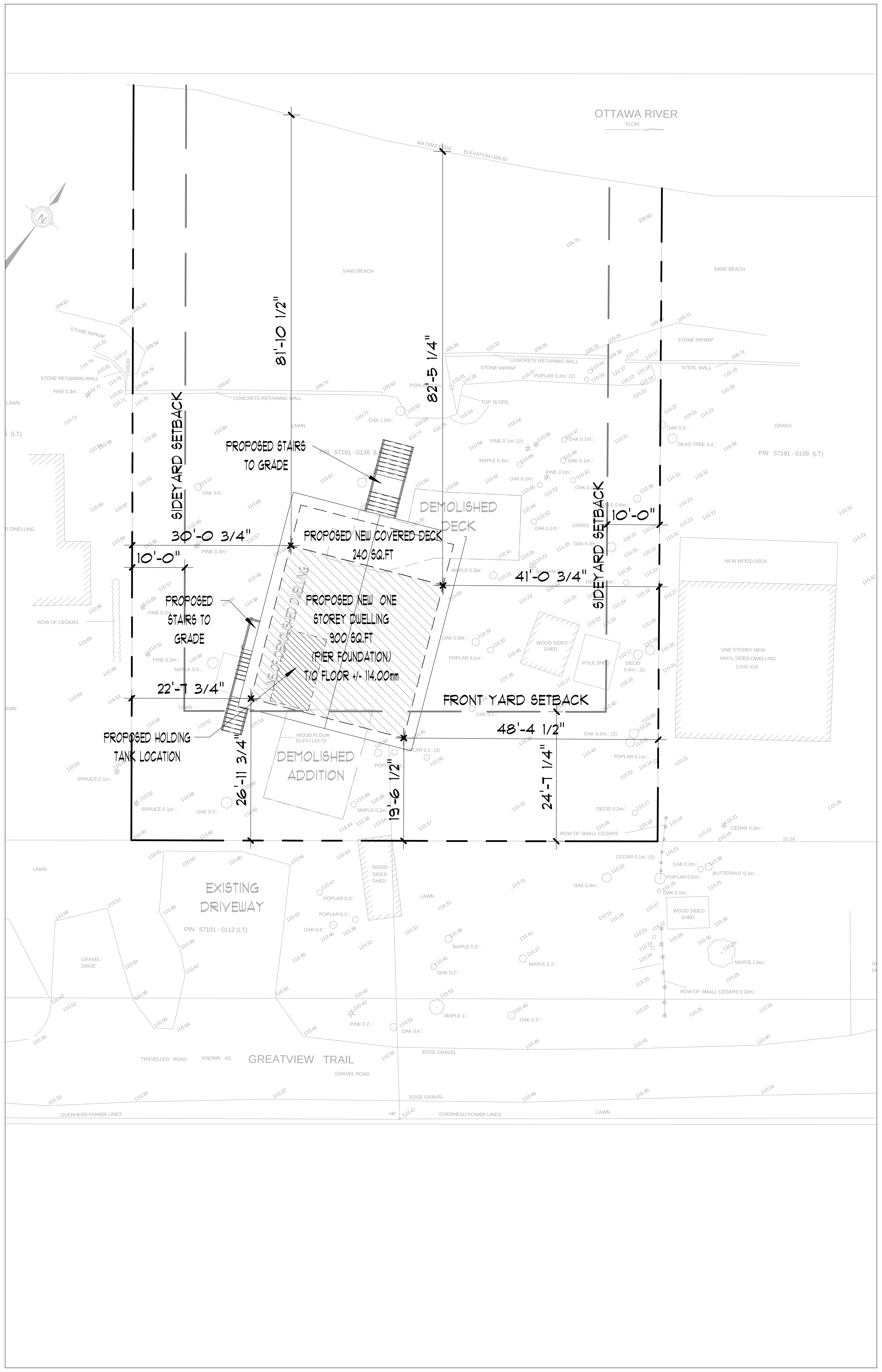
■	– IRON BAR FOUND
SIB	– STANDARD IRON BAR
IB	– IRON BAR
⦿	– MANHOLE
▣	– LAMPPOLE
ACU	– AIR CONDITIONING UNIT
WIT.	– WITNESS
●	– HYDRO POLE (HP)
✳	– CONIEROUS TREE
◌	– DECIDUOUS TREE/SHRUB
△	– CONTROL POINT
⊗	– SITE BENCH MARK
SS	– STEEL SIGN
SANMH	– SANITARY MANHOLE
STMH	– STORM MANHOLE
(925)	– T. J. KIEFFER O.L.S.

ADAM KASPRZAK SURVEYING LTD.
ONTARIO LAND SURVEYORS
432 PEMBROKE ST. W., P.O. BOX 492
PEMBROKE ONTARIO K8A 6X7
PHONE (613) 735-0764

SCALE: 1 : 100 METRIC	REF: 19–5126
DATE : SEPTEMBER 23,2019	



2
A.1
DEMO SITE PLAN
SCALE: 1" = 20'-0"



3
A.1
PROPOSED SITE PLAN
SCALE: 1" = 20'-0"

1
A.1
KEY PLAN
SCALE: 1" = 300'-0"

PRELIMINARY

NOTES:

REFER TO GENERAL NOTES FOR ALL TYPICAL CONSTRUCTION NOTES & DETAILS. WHEN DRAWINGS OR NOTES REFERENCE O.B.C. IN ALL CASES PLEASE REFER TO THE LATEST VERSION OF THE ONTARIO BUILDING CODE 2012.

LEGEND:

1	EXTERIOR DOOR & WINDOW TAG (SEE SCHEDULE ON A.0.c)
1	DOOR TAG (SEE SCHEDULE on A.0.c)
W1	EXTERIOR WALL TYPE (SEE A.0.a)
P1	INTERIOR PARTITION WALL TYPE (SEE A.0.a)
F1	FLOOR TYPE (SEE A.0.a)
R1	ROOF TYPE (SEE A.0.a)
P1	POST TYPE (SEE A.0.a)
L1	LINTEL TYPE (SEE A.0.a)

LEGEND:

F1	PAD FOOTING TYPE (SEE A.0.a)
WF1	WALL FOOTING TYPE (SEE A.0.a)
SCD	SMOKE/CARBON DETECTOR TO O.B.C. 9.10.19
1	CONSTRUCTION NOTE (SEE A.0.a)

JimBell
Architectural Design Inc.

Stittsville Office
26 Bert G. Argue Drive
Stittsville, Ontario,
K2S 1X9
p. 613-831-9688

Pembroke Office
Unit A 184 John Street,
Pembroke, Ontario,
K8A 1H7
p. 613-629-6988
e. info@jbell.ca

VERSION NO.

SEAL:

NOTES:

- ALL CONTRACTORS MUST COMPLY WITH ALL CODES & BYLAWS HAVING JURISDICTION
- IT IS THE RESPONSIBILITY OF THE APPROPRIATE CONTRACTOR TO CHECK & VERIFY ALL DIMENSIONS ON SITE & REPORT ALL ERRORS AND/OR OMISSIONS TO THE DESIGNER PRIOR TO COMMENCEMENT.
- DO NOT SCALE DRAWINGS.
- DRAWINGS MAY NOT BE USED FOR CONSTRUCTION UNTIL NOTED AS ISSUED FOR CONSTRUCTION.

REVISIONS

NO.	ITEM	DATE
1	SITE PLAN ISSUED	22/03/21

PROJECT
7 GREATVIEW TRAIL, WESTMEATH ON. K0J 2L0

CLIENT
MURRAY MCDONALD

DRAWING
SITE PLAN

SCALE	As indicated
DRAWN BY	AAC
DATE	24FEB21
CHKED BY	JB
APPRD BY	JB
PROJECT NO.	220-44

SHEET NO.
A.1

☐ Reviewed & approved   ☒ Reviewed & approved as noted

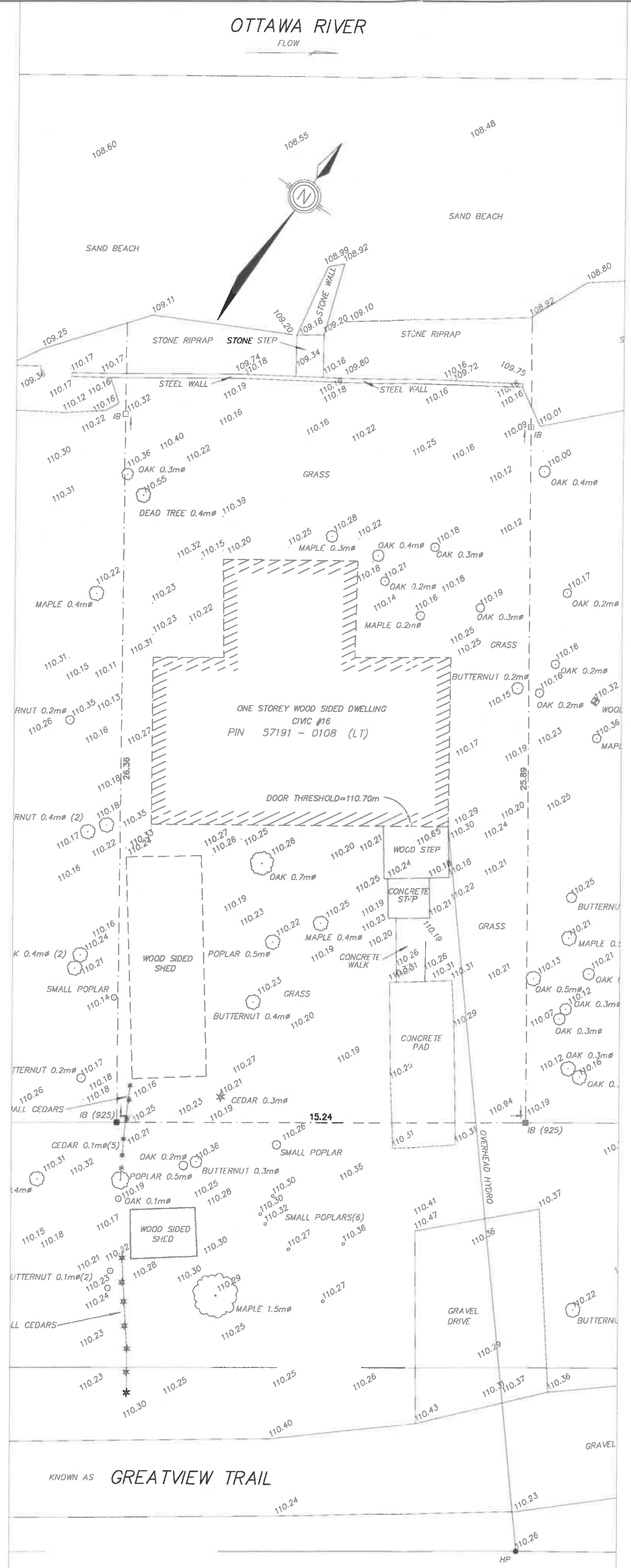
☐ Revise & resubmit   Zone: WU, By-law 98-13

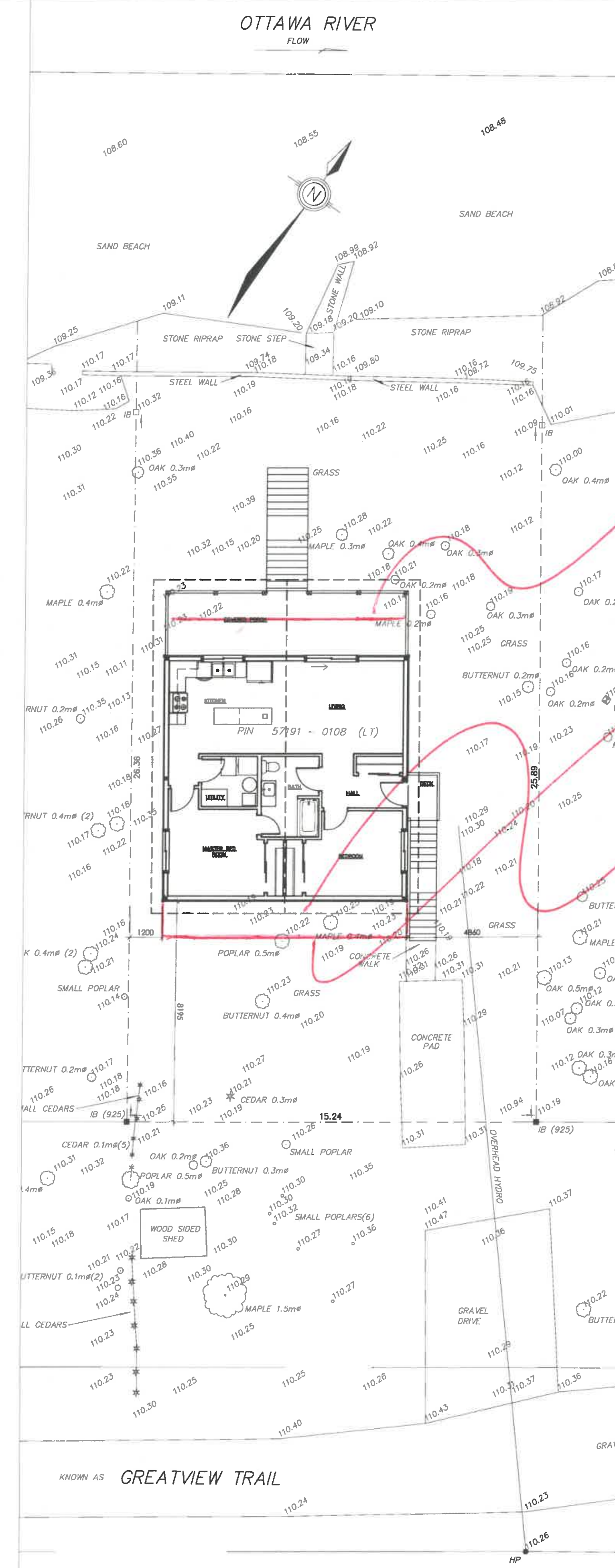
This review is for the sole purpose of ascertaining that the location the building and the type of dwelling/structure conforms with the Town's by-law in terms of zoning. Any modification to the location shall be reported to the Department of Development & Works for approval.

21. Oct. 2019

* New Dwelling must be raised above Regulatory Flood Elevation of 112.5m As shown on the Ottawa River Flood Risk Map, Phase I

* Elevation Certificate must be submitted for occupancy.





Edge of Covered Porch

Edge of Proposed Dwelling

Edge of Proposed location

Relocate Proposed Dwelling 1.5m back from proposed location

Tony Johnson Oct 18/19 on behalf of B. Duncan

ALL CONTRACTORS TO VERIFY ALL DIMENSIONS ON SITE AND TO REPORT ALL ERRORS AND/OR OMISSIONS TO THE ARCHITECT.

ALL CONTRACTORS MUST COMPLY WITH ALL CODES AND BYLAWS AND OTHER AUTHORITIES HAVING JURISDICTION OVER THE WORK.

DO NOT SCALE DRAWINGS.

LICENSED PROFESSIONAL ENGINEER
P.M. TREVISAN
100136551
PROVINCE OF ONTARIO

NO.	REVISION	DATE	BY
6			
5			
4			
3			
2	ISSUED FOR BUILDING PERMIT	01-10-19	S.B.
1	ISSUED FOR REVIEW	20-09-19	C.H.

ALL DIMENSIONS AND CONDITIONS TO BE VERIFIED ON SITE. FIGURED DIMENSIONS TAKE PRECEDENCE OVER SCALE.

CONSULTING ENGS.

STRUCTURAL

MECHANICAL

ELECTRICAL

P2 concepts
739 RIDGEWOOD AVE., UNIT 201
OTTAWA, ONTARIO K1V 6M8

NEW RESIDENCE

16 GREATVIEW TRAIL
PEMBROKE   ONTARIO

DATE: DATE:	05-09-2019	SCEAU: SEAL:	
ECHELLE: SCALE:	AS NOTED		
DESSINE: DRAWN:	S. BROWN		
VERIFIE: CHECKED:	P.R.		

DRAWING NAME   0352

SP-1

Appendix D

CANADA/ONTARIO FLOOD DAMAGE REDUCTION PROGRAM

FLOODLINE MAPPING REPORT

for

PEMBROKE TOWNSHIP

Ottawa River / Allumette Lake

prepared by

WATER PLANNING AND MANAGEMENT BRANCH
INLAND WATERS DIRECTORATE
ENVIRONMENT CANADA

September 1991

CANADA/ONTARIO FLOOD DAMAGE REDUCTION PROGRAM

FLOODLINE MAPPING REPORT

for

PEMBROKE TOWNSHIP

Ottawa River / Allumette Lake

prepared by

M. A. Shaw

WATER PLANNING AND MANAGEMENT BRANCH
INLAND WATERS DIRECTORATE
ENVIRONMENT CANADA

September 1991

ACKNOWLEDGEMENTS

The analyses carried out for this report were undertaken using data collected by Water Survey Canada (Pembroke Gauge) and Ontario Hydro (Thrasher's Farm Gauge). Assistance was provided by D. W. Brown, Environment Canada, who initiated this in-house study and provided comments and guidance for its completion. Comments on the draft report were also provided by W. McMullen of the Ontario Ministry of Natural Resources, Algonquin Region.

TABLE OF CONTENTS

List of Figures

SUMMARY

This report presents information on the procedures used to determine the flood risk areas along the Ottawa River shoreline within Pembroke Township.

Flood Frequency analyses were carried out on the water level data collected at the Town of Pembroke gauge (WSC #02KC013) on Allumette Lake, and the Thrasher's Farm gauge (Ontario Hydro # HEPC 32) located downstream of Morrison Island on Lower Allumette Lake.

The 1-in-100 year return period flood was used to compute the regulatory flood elevation for the study area.

On Allumette Lake **(Zone 1)**, a freeboard allowance of 0.16 M was added to the 1-in-100 year flood level at the Pembroke gauge for consistency with the mapping study undertaken upstream. A regulatory flood elevation of **113.89 M** was assumed for the entire mainland shoreline.

On the western portion of Allumette Lake **(Zone 2)**, a freeboard allowance of 0.50 M was added to the 1-in-100 year flood level at the Pembroke gauge. The larger freeboard is recommended in this area due to the increased exposure to severe winds and the associated wave action. A regulatory flood elevation of **114.23 M** was assumed for the northern shoreline of Cotnam island and the eastern shoreline Morrison Island.

For Lower Allumette Lake **(Zone 4)**, the regulatory elevation of **112.50 M** derived in the Westmeath Township Shoreline Flood Plain Study was confirmed as being a realistic estimate, and used for consistency.

The regulatory flood elevations for the area between Allumette Lake and Lower Allumette Lake **(Zone 3)** was determined by linear interpolation of the regulatory flood elevations between Zone 1 and Zone 3; or between Zone 2 and Zone 3.

The limits of the regulatory flood zones and the regulatory flood elevations as described above are shown on Figure 1 of this report.

As large scale maps are not available for areas outside of the City of Pembroke, the location of the flood line in those areas will have to be determined using field survey techniques.

The floodlines for the City of Pembroke shoreline will not be plotted by Environment Canada on the 1:2000 scale Ontario Base Mapping available.

The shoreline areas upstream (Petawawa Township) and downstream (Westmeath Township) of Pembroke Township are currently regulated by the respective Townships using a 2-zone floodway-flood fringe approach. **Development is allowed within an area 1 metre below the regulatory flood elevation but is subject to flood proofing requirements.** ***It appears at this time that the same policy will also be applied to shoreline development within Pembroke Township for all areas except Zone 3 (interconnecting channels).***
(See Figure 1 for location of Zones.)

1.0 Introduction

Due to the increased recreational activity on the Ottawa River and the significant growth of the Ottawa-Carleton Region, interest in development along the Ottawa River shoreline has increased substantially.

The Township of Pembroke requested that floodline mapping funded under the Canada-Ontario Flood Damage Reduction Program (FDRP) be undertaken along the Ottawa River shoreline within the Township boundaries. This mapping would ultimately help Township officials to prevent development in flood prone areas.

This project did not receive the FDRP funds to prepare the 1:2000 scale topographic mapping and carry out the necessary engineering studies due to program priorities and funding constraints. However, in order to provide information to help the Township in their development planning, Environment Canada agreed to undertake this study in-house.

Two floodline mapping studies were previously undertaken by consulting engineers for the Ottawa River shoreline upstream (at Petawawa Township) and downstream (at Westmeath Township). These areas are currently regulated by the respective Townships using a 2-zone floodway-flood fringe approach. **Development is allowed within an area 1 metre below the regulatory flood elevation but is subject to flood proofing requirements.**

This study will provide information on the Regulatory Flood Elevations for the shoreline along the Ottawa River between the areas covered by the two previous studies.

2.0 Study Area

The study area is located on the shoreline within Pembroke Township along the Ottawa River at Allumette Lake. At this location, the River drains an area of approximately 75,000 Km^2 and has a long term mean discharge of approximately 1050 M^3/s. Several dams are located upstream for hydroelectric generation and it is reported[1] that their operation have minimal, if any, impact on the extreme flood flows. The River is split into two main channels around Allumette Island and it is estimated[2] that the northern Culbute channel, located in the Province of Quebec, can carry up to 33% of the entire flow.

At the downstream of Allumette Lake outflow is controlled by a series of rapids around Morrison, Beckett and Cotnam Islands. The rapids outlet into the Lower Allumette Lake which is approximately 3 metres lower than Allumette Lake under average flow conditions. Under the regulatory flow conditions the elevation difference is reduced to 1.67 metres.

Allumette Lake is approximately 6.7 Km long with an average width of 1.8 Km. Lower Allumette Lake is very similar in size but crescent shaped. Only a short stretch of shoreline on Lower Allumette Lake lies within Pembroke Township, primarily on the western shoreline for the Islands and the bay area around Moffats Canal.

3.0 Topographic Mapping

Topographic mapping at 1:2000 scale was not prepared as part of this study due to funding constraints previously mentioned.

Existing OBM mapping at 1:2000 scale is available for the City of Pembroke and may be used to plot the Regulatory Flood Elevations recommended in this report.

4.0 Historical Flood Events

It is reported that flooding occurs virtually every spring in the study area. The highest flood elevations recorded to date are as follows :

May 16, 1960	- 113.70 metres GSC	Pembroke Gauge
May 16, 1960	- 111.73 metres GSC	Thrasher's Farm Gauge

5.0 Determination of Regulatory Flood Elevations

5.1 Data Analysis

A single station flood frequency analyses were carried out on the **maximum mean daily** water level data collected at the following gauges:

> Water Survey Canada No. **02KC013** - Ottawa R. at Pembroke
> (data contributed by Ontario Hydro)
> *Period of record 1913 to 1989 (75 samples - data missing for 1968, 1969)*
>
> Ontario Hydro Station No. **HEPC 32** - Ottawa R. at Thrasher's Farm
> *Period of record 1946 to 1983 (38 samples)*

The water level data used in the frequency analyses were referenced to a datum close to minimum water level elevations recorded at the respective gauge. For the Pembroke gauge datum was taken as 111 metres GSC, and for the Thrasher's Farm gauge the datum is 108 metres GSC.

Statistical tests were carried out on the data for Randomness, Trend, Homogeneity and Independence. All of the statistical analyses were carried out using the latest version of the computer program "Consolidated Flood Frequency Analysis Package (CFA)".

The results of the above mentioned tests are presented in Appendix A, and confirmed that the data were suitable for frequency analyses. Also the coefficients of skew and kurtosis computed for the data samples were within the acceptable limits.

The flood frequency plots, flood values and computed sample statistics are presented in the CFA flood frequency analyses output in Appendix A (referred to the appropriate datum elevation).

The results from the flood frequency analyses are summarized below.

Three-Parameter Lognormal Distribution

Return Period (Years)	Pembroke Gauge Flood Elevation (Metres GSC)	Thrasher's Farm Gauge Flood Elevation (Metres GSC)
2	112.61	109.77
5	112.96	110.44
10	113.17	110.86
20	113.35	111.24
50	113.58	111.71
100	113.73	112.06

Wakeby Distribution

Return Period (Years)	Pembroke Gauge Flood Elevation (Metres GSC)	Thrasher's Farm Gauge Flood Elevation (Metres GSC)
2	112.61	109.73
5	112.95	110.37
10	113.18	110.86
20	113.39	111.34
50	113.64	111.98
100	113.82	112.47

For consistency of these results with previous studies[1,2] it is recommended that the flood estimates derived using the Three-Parameter Lognormal (3PLN) Distribution be used for developing the regulatory flood elevations for the study area. The study for Petawawa utilized the Lognormal distribution. This distribution is not supported by the CFA package, however it probably gives very similar results to the 3PLN at the Pembroke gauge.

5.2 Regulatory Flood Elevations

The influence of wind generated wave action along the study shoreline was investigated. The previous study by Dillon[2] estimated the maximum wave uprush at approximately 0.5 metre for the Lower Allumette Lake based on the longest fetch and maximum 1 hour duration wind speed. The other study by A. J. Robinson[1] for the Petawawa Township area estimated that the wave uprush would be negligible for that shoreline due to the presence of islands, shallow onshore water depth and flat beach slopes.

The highest hourly wind speeds on record (1955-80) for the AES station at the Ottawa Rockcliffe Airport was 80 Km/hr. from the West South West (WSW), ie. **offshore** from the study area. The only severe wind speed recorded **onshore** was from the NNW at 58 Km/hr, which would have the most impact on the east side of Allumette Lake (downstream). Therefore, based on the wind data, the easterly shoreline areas of Allumette Lake would be subject to more severe wave action and require a larger wave uprush allowance.

The change in water level from the Pembroke gauge to MacGregor Bay due to hydraulic losses going upstream are negligible due to the large cross sectional flow area. Higher flood levels due to wave action are expected in areas having a westerly exposure combined with a long fetch and deeper water. The location susceptible to the most severe wave action lies along the shoreline of the Morrison, Beckett and Cotnam Islands.

Due to inadequate data on shoreline beach slopes and wave parameters, a detailed analysis was not undertaken to estimate wave uprush. Based observations in the foregoing discussion and a cursory review of the pertinent hydrographic and hydrometric data, it is justifiable to add a freeboard allowance to the computed 1-in-100 year flood levels computed.

In order to be consistent with the study done for Petawawa Township a freeboard allowance of 0.16 metres above the 1-in-100 year Pembroke flood elevation is recommended for the entire mainland shoreline of Allumette Lake. ***Therefore the regulatory flood elevation recommended for the south west mainland shoreline of Allumette Lake is 113.89 metres GSC.***

On the western portion of Allumette Lake, a larger freeboard allowance of 0.50 M is considered appropriate due to the increased exposure to severe winds and the associated wave action. ***A regulatory flood elevation of 114.23 M is recommended for the northern shoreline of Cotnam island and the eastern shoreline Morrison Island.***

For the Lower Allumette Lake the wave uprush is not expected to be significant in the study area due to the shallow bay and prevailing wind direction. However due to the larger flood estimate using the Wakeby distribution (112.47 M) and the need to be consistent with the Westmeath floodlines ***a regulatory flood level of 112.5 metres GSC should be adopted for Lower Allumette Lake***. This flood level would include a freeboard allowance of 0.44 M above the recommended three parameter lognormal estimate for the 1-in-100 Year flood.

Due to the limited budget for this study determination of flood levels in the transition zone between Allumette Lake and Lower Allumette Lake using hydraulic models and field data is not feasible. However due to the relatively small difference in elevation between the two lakes the accuracy of the accuracy of the final results are not expected to improve substantially over those derived using linear interpolation. ***Therefore, the regulatory elevation for the transition zone between Allumette Lake and Lower Allumette Lake was determined by linear interpolation between the regulatory flood elevations for the two lakes as described below and shown in Figure 1.***

The table provided on Figure 1 shows the interpolated regulatory flood elevations computed at 100 metre intervals, starting at the relevant downstream reference point. The reference points start at the outlets of each of the four channels identified below as Sections : A-A1, B-B1, B-B2, and C-C1. The dashed lines in the tables indicate that the ending points shown on the table are in excess of the transition zone channel length. The elevations shown at the starting and ending points are the regulatory flood elevations for Lower Allumette Lake and Allumette Lake respectively.

The procedure used to compute transition zone flood elevations is as follows :

The Transition Zone is subdivided into four areas for each of the Channels identified on Figure 1 by the notation A, A1; B, B1; B, B2; and C, C1.

The Transition Zone flood elevations are interpolated as follows :

$EL_{tz} = EL_{ds} + ELDIF_{us/ds} \times DIST_{rp} / DIST_{tot}$ .... (1)

For channel A-A1 :

$REGEL_{tz} = 112.5 + 1.39 \times DIST_{rp} / DIST_{tot}$ .... (2)

For all other channels :

$REGEL_{tz} = 112.5 + 1.73 \times DIST_{rp} / DIST_{tot}$ .... (3)

For Transition Channel Lengths see Figure 1, total channel lengths are as follows:

Channel A-A1 $DIST_{tot}$ = 1340 M { Moffats Canal }
Channel B-B1 $DIST_{tot}$ = 1450 M { Cotnam/Beckett Island channel }
Channel B-B2 $DIST_{tot}$ = 1050 M { Beckett/Morrison Island channel }
Channel C-C1 $DIST_{tot}$ = 1900 M { Main channel north of Morrison Island }

<u>Where</u> :

EL_{tz}	=	Flood Elevation for Transition Zone
$REGEL_{tz}$	=	Regulatory Flood Elevation for Transition Zone
EL_{ds}	=	Flood Elevation for Lower Allumete Lake
$ELDIF_{us/ds}$	=	Difference between corresponding Flood Elevations for Allumette Lake and Lower Allumette Lake
$DIST_{tot}$	=	Total distance measured along channel within transition zone.
$DIST_{rp}$	=	Distance from downstream reference point (A1, B1, etc.) to point of interest.

5.2.1 Procedure to Estimate Regulatory Flood Elevations in Transition Zone

Steps required to obtain Regulatory Flood Elevation for location within Transition Zone (*Zone 3* on Figure 1) :

1) Locate point of interest on Figure 1 and measure map distance from point of interest to reference point at downstream outlet for channel (rapids) {one of the dots identified A1, B1, B2, C on Figure 1}. Use the scale bar and map distance measured to estimate the distance in metres.

2) Refer to the Table on Figure 1 and select the elevation for the appropriate reference point, corresponding to the Distance ($DIST_{ds}$) which is closest to the measured distance from step (1). If the distance falls in the middle of two table values an average of the two corresponding elevation values should be used.

If more accurate results are desired or elevations for other return period floods are required, equations (1), (2), or (3) may be used to compute the flood elevation estimates. Note that equation (2) is only used for the regulatory flood elevation estimates.

In order to provide some consistency it is suggested that the following *freeboard* allowances be added to the three parameter lognormal estimates (see page 3) for the more frequent flood elevations computed at the two gauges (for flood elevations determined in Zones 2, 3 and 4) :

	Zone 1	**Zone 2 & 4**
2 Year	------	0.10 metre
5 Year	------	0.15 metre
10 Year	------	0.20 metre
20 Year	0.05 metre	0.25 metre
50 Year	0.10 metre	0.35 metre

The design flood elevations based on the above freeboard allowances are as follows :

	Allumette Lake		Lower Allumette Lake
	Zone 1	{Zone 2}	
Return Period (Years)	Flood Elevation (Metres GSC)		Flood Elevation (Metres GSC)
2	112.61	{112.71}	109.87
5	112.96	{113.11}	110.59
10	113.17	{113.37}	111.06
20	113.40	{113.60}	111.49
50	113.68	{113.93}	112.06
(Regulatory) 100	**113.89**	**{114.23}**	**112.50**

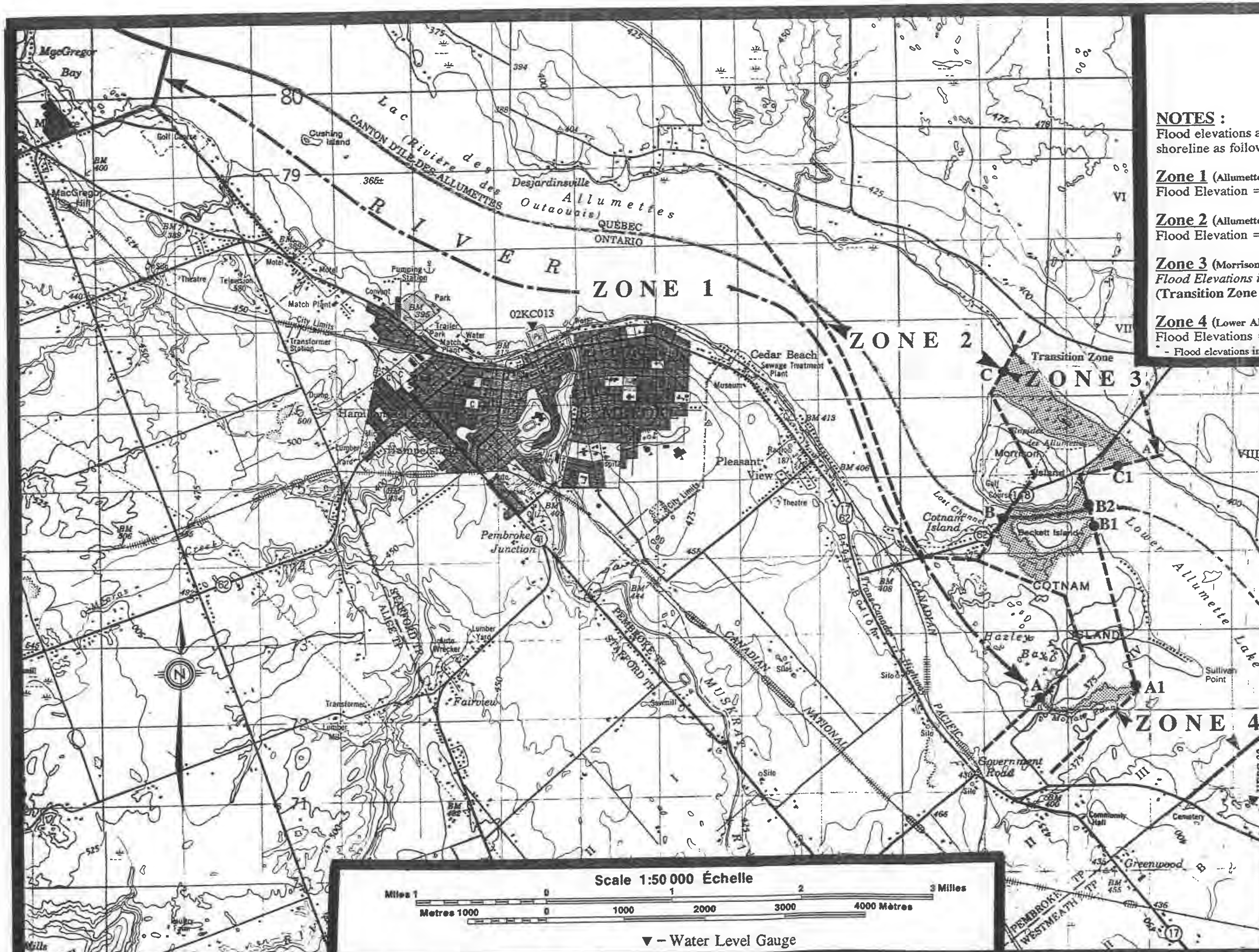


FIGURE 1

Regulatory Flood Elevations

Ottawa River/Allumette Lake

PEMBROKE TOWNSHIP

NOTES :

Flood elevations are given below for the three Zones shown along the Ottawa R. shoreline as follows :

Zone 1 (Allumette Lake)
Flood Elevation = **113.89 M** (GSC) *based on Pembroke Gauge data**.

Zone 2 (Allumette Lake - north & east shore of Cotnam and Morrison Islands)
Flood Elevation = **114.23 M** (GSC) *based on Pembroke Gauge data**.

Zone 3 (Morrison, Beckett and Cotnam Islands - Rapids)
*Flood Elevations interpolated using Pembroke and Thrasher's Farm Gauge data**
(Transition Zone between Zone 1 and 3 - See table below for flood elevations).

Zone 4 (Lower Allumette Lake)
Flood Elevations = **112.50 M** (GSC) *based on Thrasher's Farm Gauge data**.
* - Flood elevations include allowance for wave run-up.

Zone 3 (Transition Zone) **Flood Elevations**

$DIST_{rp}$ (M)	Regulatory Flood Elevation Upstream of Reference Point			
	A1	B1	B2	C1
0	112.50	112.50	112.50	112.50
100	112.60	112.62	112.66	112.59
200	112.71	112.74	112.83	112.68
300	112.81	112.86	112.99	112.77
400	113.91	112.98	113.16	112.86
500	113.02	113.10	113.32	112.96
600	113.12	113.22	113.49	113.05
700	113.23	113.34	113.65	113.14
800	113.33	113.45	113.82	113.23
900	113.43	113.57	113.98	113.32
1000	113.54	113.69	114.15	113.41
1100	113.64	113.81	114.23	113.50
1200	113.74	113.93	------	113.59
1300	113.84	114.05	------	113.68
1400	113.89	114.17	------	113.77
1500	------	114.23	------	113.86
1600	------	------	------	113.96
1800	------	------	------	114.14
2000	------	------	------	114.23

Zone 3 is subdivided into four areas for each of the Channels identified on this Map by the notation A, A1; B, B1; B, B2; C, C1.
The Transition Zone flood elevations are interpolated as follows:

$EL_{ds} + ELDIF_{us/ds} \times DIST_{rp} / DIST_{tct}$
$= 112.50 + 1.73 \times DIST_{rp} / DIST_{tct}$
$= 112.50 + 1.39 \times DIST_{rp} / DIST_{tct}$ (for A-A1 only)

For :
Section A-A1: $DIST_{tct}$ = 1340 M; Section B-B1: $DIST_{tct}$ = 1450 M
Section B-B2: $DIST_{tct}$ = 1050 M; Section C-C1: $DIST_{tct}$ = 1900 M

Where:
$DIST_{tct}$ = **total distance measured along channel within transition zone.**
$DIST_{rp}$ = distance from downstream reference point (A1, B1, etc.) to point of interest.

6.0 Conclusions and Recommendations

Based on the results of this analyses and previous studies the following are concluded :

- the water level data collected at the Pembroke and Thrasher's Farm Gauges is adequate for flood frequency analyses;

- the regulatory flood levels adopted for Pembroke Township should be consistent (*at township boundaries*) with regulatory flood levels previously derived and approved for Petawawa Township and Westmeath Township;

- a freeboard allowance should be incorporated with the computed flood frequency elevations to allow for wave action when determining a design flood level, and a larger freeboard should be adopted at the eastern end of Allumette Lake; and,

- the flood levels in the transition zone between Allumette Lake and Lower Allumette Lake should be determined by linear interpolation.

Based on the above conclusions, the following are recommended :

- The regulatory elevation for Allumette Lake should be based on the 1-in-100 Year flood elevation (3PLN) derived for the Pembroke gauge plus 0.16 metre freeboard allowance for the mainland shoreline (to provide consistency with the Petawawa Township flood elevations) and a freeboard allowance of 0.5 metres at the eastern end of the lake including Cotnam and Morrison Islands.

Therefore the regulatory flood elevation recommended for Allumette Lake is 113.89 metres and 114.23 metres GSC for the mainland shoreline, and Cotnam and Morrison Islands respectively (see Figure 1).

- The regulatory elevation for Lower Allumette Lake should be based on the 1-in-100 Year flood elevation (3PLN) derived for the Thrasher's Farm gauge plus 0.44 metres freeboard.

Therefore the regulatory flood elevation recommended for Lower Allumette Lake is 112.50 metres GSC. (For consistency with Westmeath Shoreline Flood Plain Mapping)

- The regulatory elevation for the transition zone between Allumette Lake and Lower Allumette Lake should be computed by linear interpolation between the regulatory flood elevations on the two lakes as described in Section 5.0. and Figure 1.

References

1. **A.J. Robinson & Associates Inc., Consulting Engineers;** Floodline Mapping of the Ottawa River in the Township of Petawawa, March 1983.

2. **DILLON, Consulting Engineers and Planners;** Westmeath Township - Ottawa River Shoreline Flood Plain Study, June 1985.

3. **Environment Canada, Water Resources Branch;** Consolidated Flood Frequency Analysis (CFA), 1990

4. **Fisheries and Oceans,** Small-Craft Chart 1980 - Ottawa River #1553, Sheet 1

5. **Atmospheric Environment Canada,** Canadian Climate Normals, Winds, 1982 - pgs.75, 76.

6. **Environment Canada, Inland Waters Directorate, Water Resources Branch;** Historical Water Levels Summary, Ontario - To 1987.

APPENDIX A

Single Station Flood Frequency Analyses for Water Level Flood Data at Pembroke Gauge and Thrasher's Farm Gauge

Flood Frequency Plots
Data Statistics and Flood Frequency Data
(*Selected Distribution - 3PLN*)

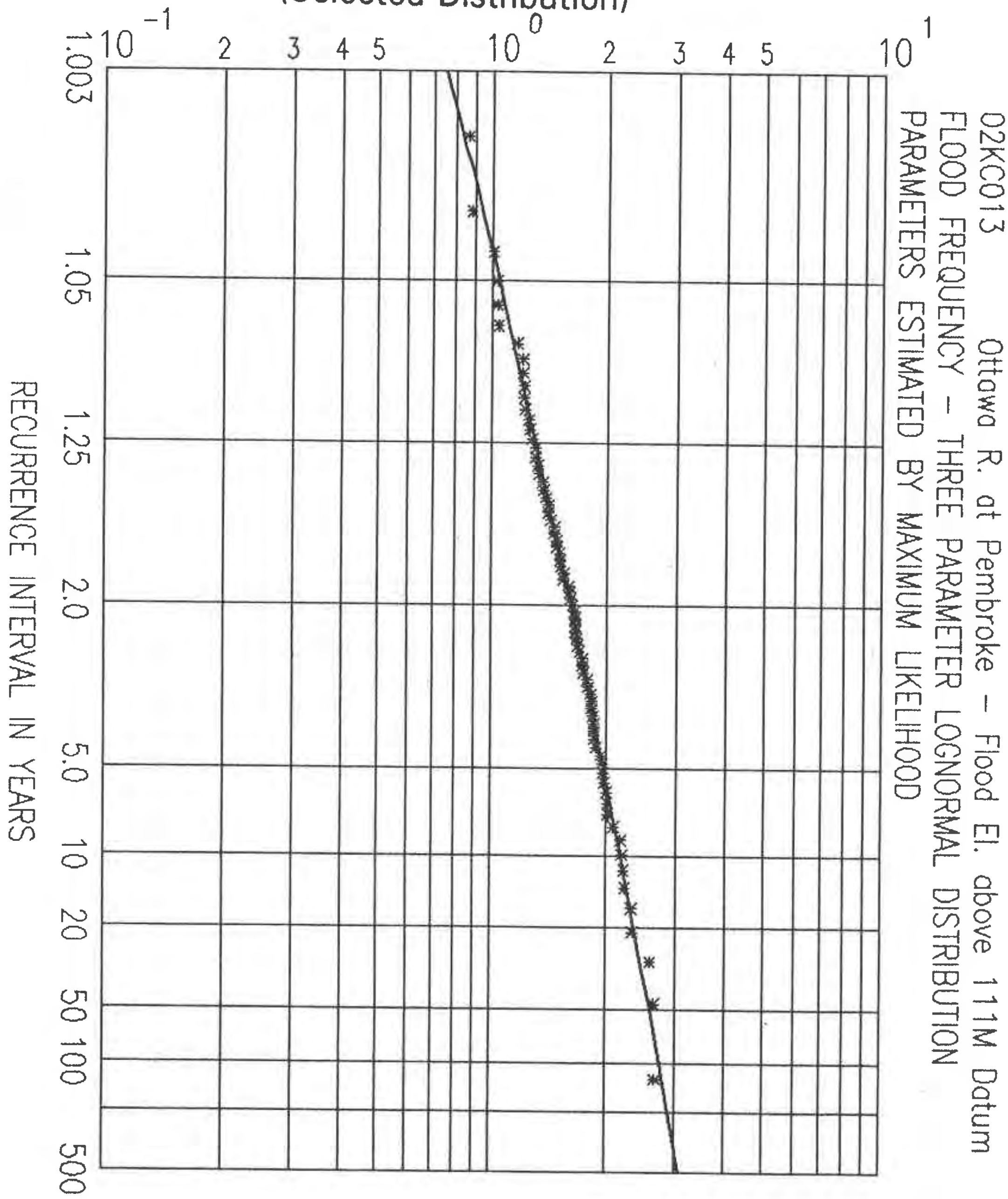
Flood Frequency Plots
Data Statistics and Flood Frequency Data
(*Wakeby Distribution*)

Water Level Data

Results of Statistical Tests on Data

FLOOD ELEVATION above DATUM 111 Metres GSC

(Selected Distribution)



FREQUENCY ANALYSIS - THREE-PARAMETER LOGNORMAL DISTRIBUTION
02KC013 Ottawa R. at Pembroke - Flood El. above 111M Datum

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.641	0.400	0.244	0.447	3.211
LN X SERIES	0.465	0.247	0.531	-0.216	3.046
LN(X-A) SERIES	0.820	0.173	0.211	-0.015	2.947

X(MIN)= 0.859 TOTAL SAMPLE SIZE= 75
X(MAX)= 2.669 NO. OF LOW OUTLIERS= 0
LOWER OUTLIER LIMIT OF X= 0.774 NO. OF ZERO FLOWS= 0

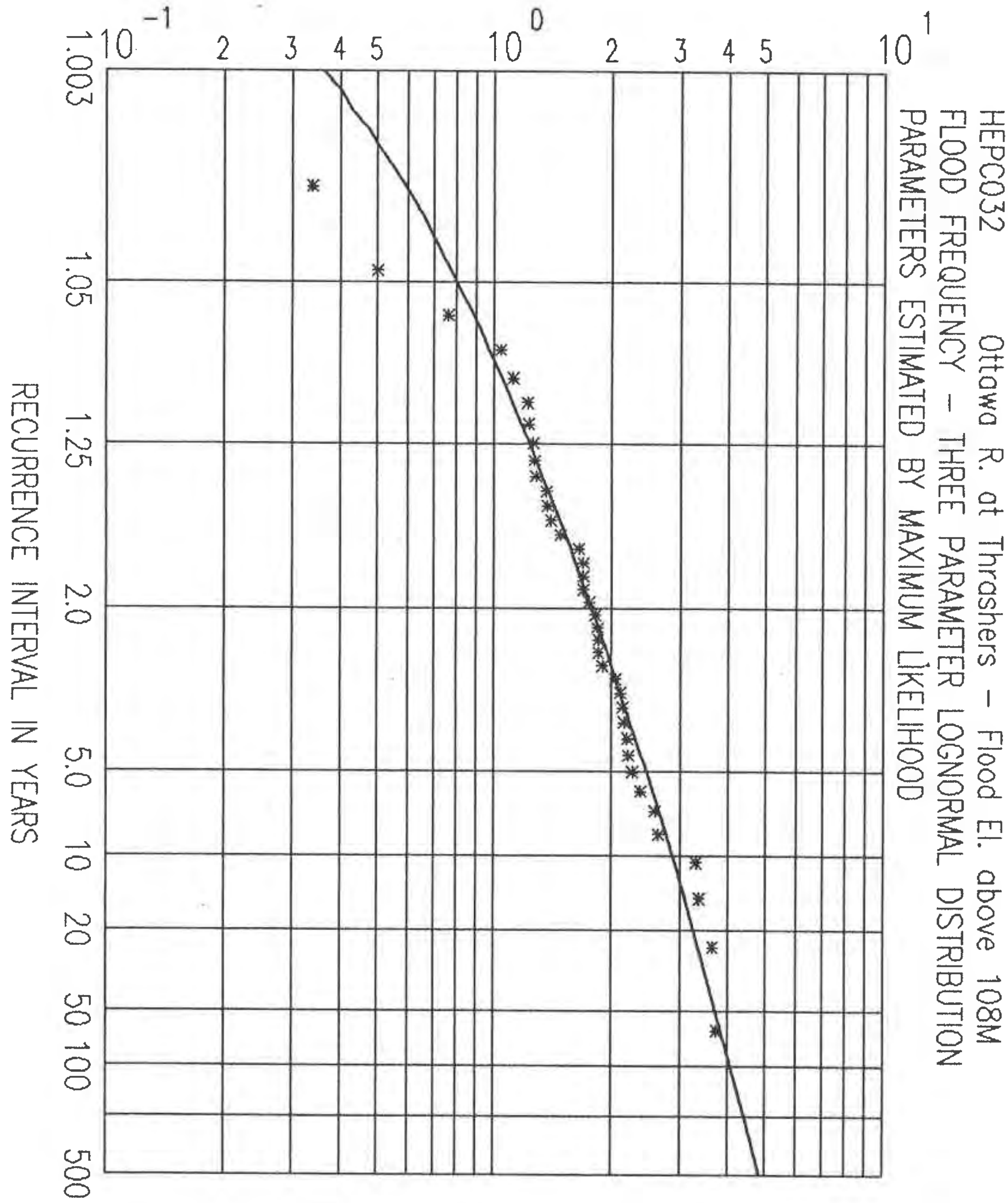
SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD

3LN PARAMETERS: A= -0.665 M= 0.820 S= 0.173

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	0.997	0.750
1.050	0.952	1.04
1.250	0.800	1.30
2.000	0.500	1.61
5.000	0.200	1.96
10.000	0.100	2.17
20.000	0.050	2.35
50.000	0.020	2.58
100.000	0.010	2.73
200.000	0.005	2.88
500.000	0.002	3.07

FLOOD ELEVATION above DATUM 108 Metres GSC
(Selected Distribution)



FREQUENCY ANALYSIS - THREE-PARAMETER LOGNORMAL DISTRIBUTION
HEPC032 Ottawa R. at Thrashers - Flood El. above 108M

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.844	0.779	0.423	0.663	3.888
LN X SERIES	0.512	0.487	0.951	-1.128	5.861

X(MIN)= 0.340
X(MAX)= 3.730
LOWER OUTLIER LIMIT OF X= 0.456

TOTAL SAMPLE SIZE= 38
NO. OF LOW OUTLIERS= 1
NO. OF ZERO FLOWS= 0

AFTER REMOVAL OF ZEROES AND/OR LOW OUTLIERS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.885	0.748	0.397	0.837	3.966
LN X SERIES	0.555	0.415	0.746	-0.556	4.612
LN(X-A) SERIES	1.017	0.256	0.251	0.060	3.637

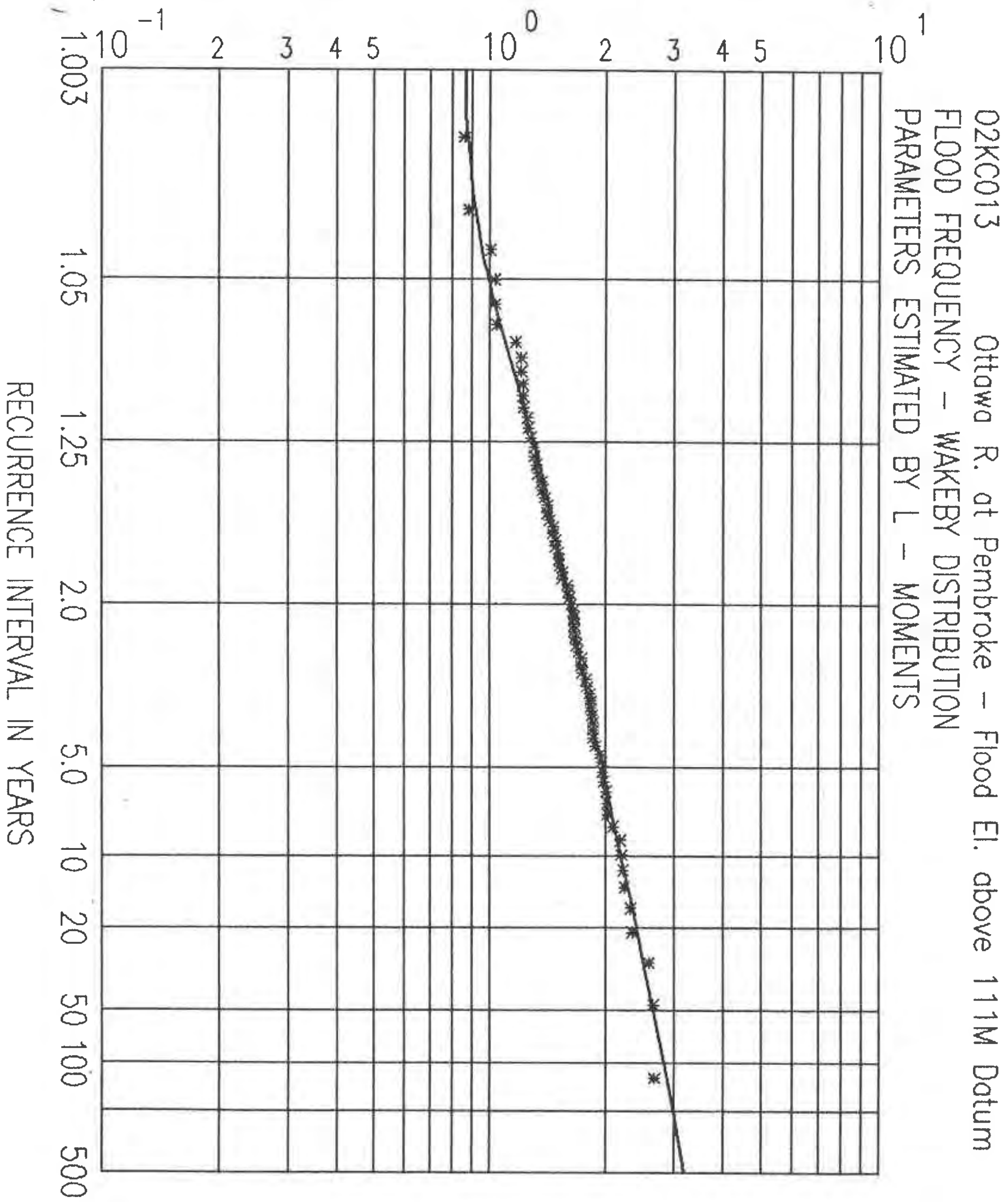
SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD

PARAMETERS OF THE 3LN WHICH DUPLICATES THE CONDITIONAL FUNCTION:
A= -0.971 M= 1.007 S= 0.261

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	0.997	0.360
1.050	0.952	0.800
1.250	0.800	1.23
2.000	0.500	1.77
5.000	0.200	2.44
10.000	0.100	2.86
20.000	0.050	3.24
50.000	0.020	3.71
100.000	0.010	4.06
200.000	0.005	4.40
500.000	0.002	4.84

FLOOD ELEVATION above DATUM 111 Metres GSC



FREQUENCY ANALYSIS - WAKEBY DISTRIBUTION

02KC013 Ottawa R. at Pembroke - Flood El. above 111M Datum

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.641	0.400	0.244	0.447	3.211
LN X SERIES	0.465	0.247	0.531	-0.216	3.046
L-MOM RATIO	1.641	0.226	0.138	0.080	0.131

X(MIN)= 0.859 TOTAL SAMPLE SIZE= 75

X(MAX)= 2.669 NO. OF LOW OUTLIERS= 0

LOWER OUTLIER LIMIT OF X= 0.774 NO. OF ZERO FLOWS= 0

THE FOLLOWING WAKEBY PARAMETERS WERE OBTAINED VIA L-MOMENTS

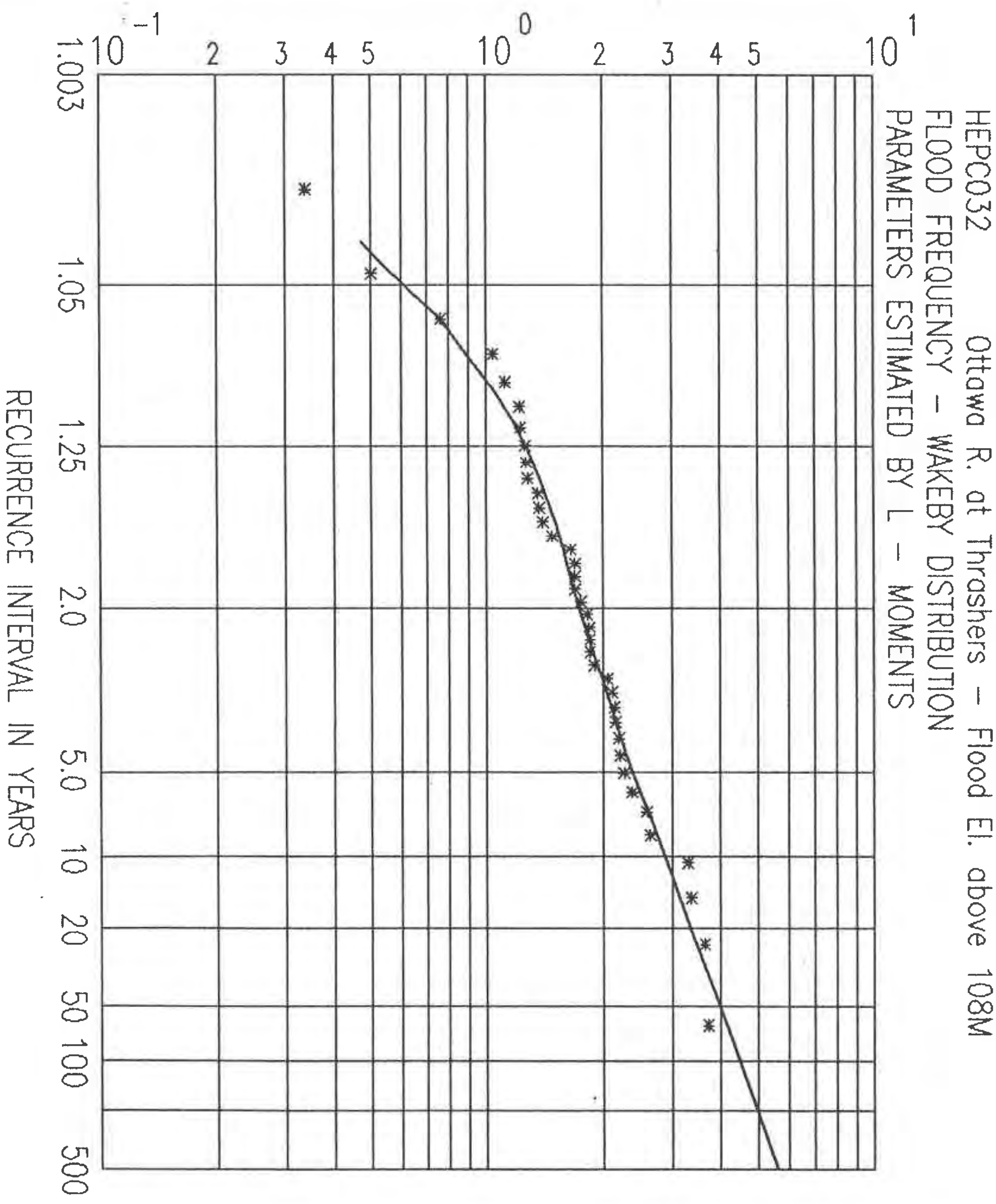
M= 0.846 A= 0.496 B= 5.79 C= -3.510 D=-0.118

DISTRIBUTION IS UPPER BOUNDED AT E= 0.4853E+01

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	0.997	0.860
1.050	0.952	0.990
1.250	0.800	1.30
2.000	0.500	1.61
5.000	0.200	1.95
10.000	0.100	2.18
20.000	0.050	2.39
50.000	0.020	2.64
100.000	0.010	2.82
200.000	0.005	2.98
500.000	0.002	3.17

FLOOD ELEVATION above DATUM 108 Metres GSC



FREQUENCY ANALYSIS - WAKEBY DISTRIBUTION
HEPC032 Ottawa R. at Thrashers - Flood El. above 108M

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.844	0.779	0.423	0.663	3.888
LN X SERIES	0.512	0.487	0.951	-1.128	5.861
L-MOM RATIO	1.844	0.431	0.234	0.126	0.200

X(MIN)= 0.340 TOTAL SAMPLE SIZE= 38
X(MAX)= 3.730 NO. OF LOW OUTLIERS= 1
LOWER OUTLIER LIMIT OF X= 0.456 NO. OF ZERO FLOWS= 0

AFTER REMOVAL OF ZEROES AND/OR LOW OUTLIERS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.885	0.748	0.397	0.837	3.966
LN X SERIES	0.555	0.415	0.746	-0.556	4.612
L-MOM RATIO	1.885	0.412	0.218	0.165	0.188

THE FOLLOWING WAKEBY PARAMETERS WERE OBTAINED VIA L-MOMENTS

M= 0.451 A= 0.820 B= 8.92 C= 309.067 D= 0.002

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	0.997	-
1.050	0.952	0.610
1.250	0.800	1.27
2.000	0.500	1.73
5.000	0.200	2.37
10.000	0.100	2.86
20.000	0.050	3.34
50.000	0.020	3.98
100.000	0.010	4.47
200.000	0.005	4.96
500.000	0.002	5.60

WSC STATION NO=02KC013
WSC STATION NAME=Ottawa R. at Pembroke - Flood El. above 111M Datum

MONTH (1)	YEAR (2)	DATA (3) (CMS)	ORDERED (4) (CMS)	RANK (5)	PROB. (6) (%)	RET. PERIOD (7) (YEARS)
5	1913	1.846	2.669	1	0.80	125.333
5	1914	1.221	2.650	2	2.13	47.000
5	1915	1.030	2.590	3	3.46	28.923
5	1916	2.010	2.343	4	4.79	20.889
5	1917	1.830	2.320	5	6.12	16.348
5	1918	1.310	2.236	6	7.45	13.429
5	1919	2.190	2.220	7	8.78	11.394
5	1920	1.250	2.190	8	10.11	9.895
5	1921	1.830	2.175	9	11.44	8.744
4	1922	2.220	2.090	10	12.77	7.833
5	1923	1.610	2.023	11	14.10	7.094
5	1924	1.460	2.010	12	15.43	6.483
6	1925	1.310	2.002	13	16.76	5.968
5	1926	1.670	1.974	14	18.09	5.529
6	1927	1.280	1.962	15	19.41	5.151
4	1928	2.650	1.950	16	20.74	4.821
5	1929	1.950	1.931	17	22.07	4.530
7	1930	1.730	1.880	18	23.40	4.273
4	1931	1.030	1.860	19	24.73	4.043
11	1932	1.730	1.852	20	26.06	3.837
5	1933	1.962	1.852	21	27.39	3.650
5	1934	2.090	1.846	22	28.72	3.481
5	1935	1.169	1.830	23	30.05	3.327
5	1936	2.175	1.830	24	31.38	3.186
5	1937	1.657	1.820	25	32.71	3.057
4	1938	1.974	1.788	26	34.04	2.937
5	1939	1.746	1.776	27	35.37	2.827
6	1940	1.852	1.746	28	36.70	2.725
4	1941	2.236	1.730	29	38.03	2.629
4	1942	1.630	1.730	30	39.36	2.541
5	1943	2.023	1.700	31	40.69	2.458
5	1944	1.413	1.682	32	42.02	2.380
6	1945	1.931	1.670	33	43.35	2.307
5	1946	1.413	1.663	34	44.68	2.238
6	1947	2.590	1.657	35	46.01	2.173
4	1948	1.322	1.657	36	47.34	2.112
5	1949	1.657	1.648	37	48.67	2.055
5	1950	1.483	1.630	38	50.00	2.000
4	1951	2.343	1.610	39	51.33	1.948
4	1952	1.590	1.599	40	52.66	1.899
3	1953	1.788	1.590	41	53.99	1.852
10	1954	1.547	1.547	42	55.32	1.808
4	1955	1.511	1.544	43	56.65	1.765
6	1956	1.435	1.520	44	57.98	1.725
7	1957	1.852	1.511	45	59.31	1.686
4	1958	0.859	1.508	46	60.64	1.649
5	1959	1.209	1.483	47	61.97	1.614
5	1960	2.669	1.483	48	63.30	1.580

WSC STATION NO=HEPC032
WSC STATION NAME=Ottawa R. at Thrashers - Flood El. above 108M

MONTH (1)	YEAR (2)	DATA (3) (M)	ORDERED (4) (M)	RANK (5)	PROB. (6) (%)	RET. PERIOD (7) (YEARS)
6	1946	2.150	3.730	1	1.57	63.667
6	1947	3.650	3.650	2	4.19	23.875
4	1948	1.370	3.360	3	6.81	14.692
4	1949	2.140	3.300	4	9.42	10.611
5	1950	1.650	2.630	5	12.04	8.304
4	1951	3.360	2.580	6	14.66	6.821
4	1952	1.850	2.370	7	17.28	5.788
3	1953	2.260	2.260	8	19.90	5.026
4	1954	1.690	2.210	9	22.51	4.442
4	1955	1.690	2.190	10	25.13	3.979
6	1956	1.280	2.150	11	27.75	3.604
7	1957	2.110	2.140	12	30.37	3.293
4	1958	0.500	2.110	13	32.98	3.032
5	1959	1.120	2.050	14	35.60	2.809
5	1960	3.730	1.900	15	38.22	2.616
5	1961	0.760	1.850	16	40.84	2.449
5	1962	1.820	1.850	17	43.46	2.301
4	1963	0.340	1.840	18	46.07	2.170
5	1964	1.040	1.820	19	48.69	2.054
10	1965	1.400	1.750	20	51.31	1.949
12	1966	1.360	1.690	21	53.93	1.854
5	1967	2.630	1.690	22	56.54	1.769
5	1968	1.260	1.690	23	59.16	1.690
5	1969	1.220	1.650	24	61.78	1.619
6	1970	1.690	1.480	25	64.40	1.553
5	1971	1.840	1.400	26	67.02	1.492
5	1972	2.210	1.370	27	69.63	1.436
5	1973	2.050	1.360	28	72.25	1.384
5	1974	2.580	1.280	29	74.87	1.336
5	1975	1.480	1.270	30	77.49	1.291
4	1976	1.850	1.260	31	80.10	1.248
4	1977	1.750	1.230	32	82.72	1.209
5	1978	1.270	1.220	33	85.34	1.172
5	1979	3.300	1.120	34	87.96	1.137
4	1980	1.900	1.040	35	90.58	1.104
4	1981	2.190	0.760	36	93.19	1.073
5	1982	1.230	0.500	37	95.81	1.044
5	1983	2.370	0.340*	38	98.43	1.016

```
        --- SPEARMAN TEST FOR INDEPENDENCE ---

HEPC032           Ottawa R. at Thrashers - Flood El. above 108M
ANNUAL MAXIMUM DAILY FLOW SERIES  1946 TO 1983  DRAINAGE AREA =  65400.00


SPEARMAN RANK ORDER SERIAL CORRELATION COEFF =-0.107   D.F.= 35
                   CORRESPONDS TO STUDENTS T =-0.634
                CRITICAL T VALUE AT 5% LEVEL = 1.691    NOT SIGNIFICANT
                    -    -    -    -  1%   -  = 2.440    NOT SIGNIFICANT


Interpretation: The null hypothesis is that the correlation is zero.


At the 5% level of significance, the correlation is not significantly
different from zero.  That is, the data do not display significant
serial dependence.



        --- SPEARMAN TEST FOR TREND ---

HEPC032           Ottawa R. at Thrashers - Flood El. above 108M
ANNUAL MAXIMUM DAILY FLOW SERIES  1946 TO 1983  DRAINAGE AREA =  65400.00


SPEARMAN RANK ORDER CORRELATION COEFF = 0.008   D.F.= 36
            CORRESPONDS TO STUDENTS T = 0.051
         CRITICAL T VALUE AT 5% LEVEL = 2.029    NOT SIGNIFICANT
             -    -    -    -  1%   -  = 2.722    NOT SIGNIFICANT


Interpretation: The null hypothesis is that the serial(lag-one) correlation
                is zero.


At the 5% level of significance, the correlation is not significantly
different from zero. That is, the data do not display significant
trend.



   --- MANN-WHITNEY SPLIT SAMPLE TEST FOR HOMOGENEITY ---

HEPC032           Ottawa R. at Thrashers - Flood El. above 108M
ANNUAL MAXIMUM FLOW SERIES  1946 TO 1983   DRAINAGE AREA=  65400.00

SPLIT BY TIME SPAN, SUBSAMPLE 1 SAMPLE SIZE=  7
                    SUBSAMPLE 2 SAMPLE SIZE= 31

(NOTE: Z IS THE STANDARD NORMAL VARIATE.)
                        For this test, Z = -1.544
CRITICAL Z VALUE AT 5% SIGNIFICANT LEVEL = -1.645    NOT SIGNIFICANT
   -     -    -    -  1%     -         -  = -2.326    NOT SIGNIFICANT

Interpretation: The null hypothesis is that there is no
                location difference between the two samples.

At the 5% level of significance, there is no significant
location difference between the two samples. That is, they
appear to be from the same population.



        --- RUN TEST FOR GENERAL RANDOMNESS ---

HEPC032           Ottawa R. at Thrashers - Flood El. above 108M
ANNUAL MAXIMUM DAILY FLOW SERIES  1946 TO 1983  DRAINAGE AREA =  65400.00

THE NUMBER OF RUNS ABOVE AND BELOW THE MEDIAN (RUNAB) = 21
      THE NUMBER OF OBSERVATIONS ABOVE THE MEDIAN(N1) = 19
      THE NUMBER OF OBSERVATIONS BELOW THE MEDIAN(N2) = 19
Range at 5% level of significance: 14. to 26.    NOT SIGNIFICANT

Interpretation: The null hypothesis is that the data are random.

At the 5% level of significance, the null hypothesis cannot be
rejected. That is, the sample is significantly random.
```

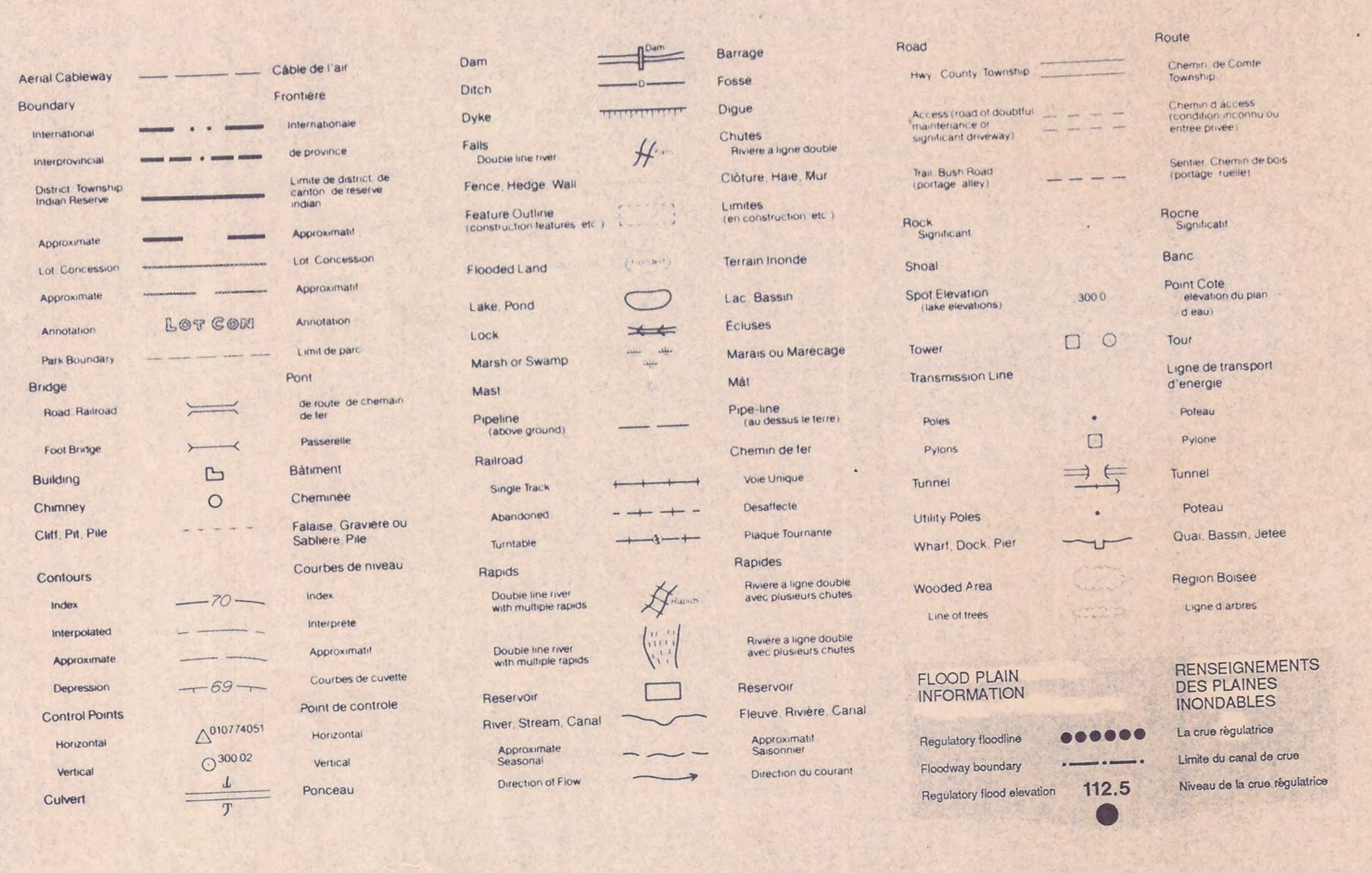
Appendix E

02 18 3510 50730

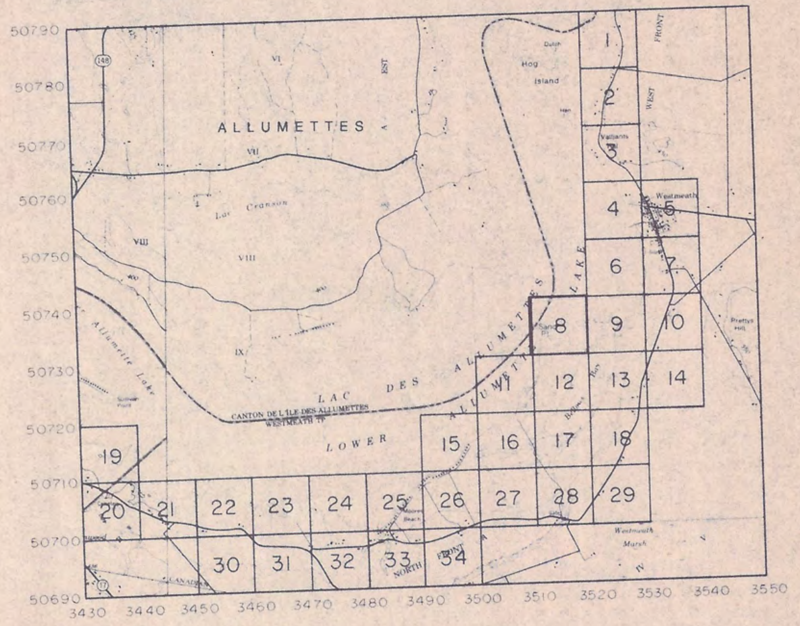
CORPORATION OF
The Township of Westmeath
Westmeath, Ontario
K0J 2L0

FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE



SHEET INDEX PHASE I / TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

Vertical datum: Mean sea level

Horizontal datum: North American (1927)

Map projection: U.T.M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

This map is prepared for use in conjunction with the flood plain mapping report dated June 1985 prepared by M.M. Dillon, Consulting Engineers and Planners for the Corporation of the Township of Westmeath.

COMPILATION NOTE

Production techniques used in the preparation of this map are designed for Class "A" standards.

This map was prepared under the auspices of the Canada-Ontario Flood Damage Reduction Agreement signed MARCH 31, 1978.

RENSEIGNEMENTS GENERAUX

Niveau de reference: Niveau moyen de la mer

Systeme geodesique: Nord Americain unifié (1927)

Projection: Transverse de Mercator

Meridien central 75°

Quadrillage de: 100 metres

Photographies aeriennes. Novembre - 3 - 1984

La présente carte a été dressée dans le but de faciliter la consultation du rapport cartographique de la plaine inondable publié en juin 1985 et réalisé par M.M. Dillon, firme d'ingénieurs-conseils et d'urbanistes, pour la corporation du canton de Westmeath.

PHOTOGRAMMETRIE

Les normes de production de cette carte se conforment aux standards de premiere classe.

Cette carte a ete preparee dans le cadre de l'accord Canada-Ontario de la reduction des dommages dus inondations conclu le 31 MARS, 1978

DILLON
Consulting Engineers & Planners

REGISTERED PROFESSIONAL ENGINEER F. I. LORANT PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C. B. DOHERTY PROVINCE OF ONTARIO

RAYMOND C. FOURNIER CANADA LANDS SURVEYOR

Ontario

Sheet 02 18 3510 50730

Ministry of Natural Resources
Ministère des richesses naturelles

Scale 1:2 000

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

Environment Canada — Inland Waters Directorate
Environnement Canada — Direction Générales des Eaux Intérieures

SHEET NUMBER 8 of 34

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont. K2E 7M3

1:2 000

02 18 3520 50730

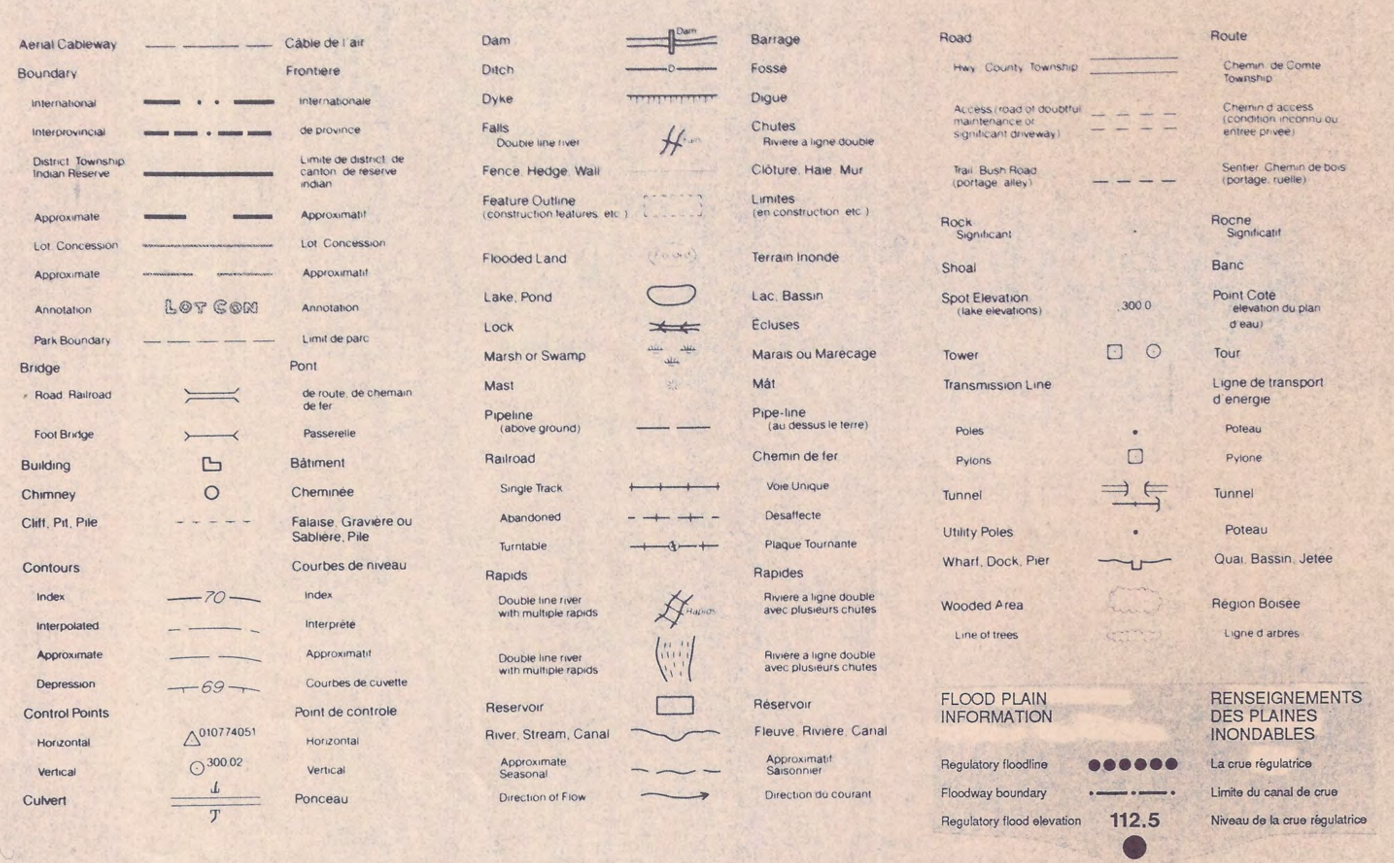
CORPORATION OF

The Township of Westmeath

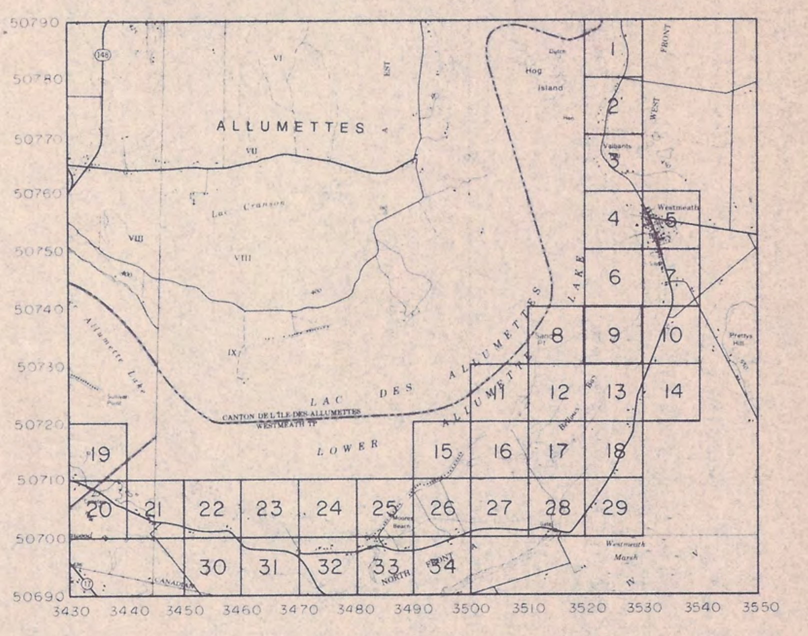
Westmeath, Ontario
K0J 2L0

FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE



SHEET INDEX PHASE I — TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

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Horizontal datum: North American (1927)

Map projection: U.T.M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

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COMPILATION NOTE

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RENSEIGNEMENTS GENERAUX

Niveau de reference: Niveau moyen de la mer

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Projection: Transverse de Mercator

Meridien central 75°

Quadrillage de: 100 metres

Photographies aeriennes: Novembre - 3 - 1984

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PHOTOGRAMMETRIE

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Ontario

Sheet 02 18 3520 50730

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate
Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS
NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE
SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

DILLON
Consulting Engineers & Planners

REGISTERED PROFESSIONAL ENGINEER — F. I. LORANT — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — C. B. DOHERTY — PROVINCE OF ONTARIO

RAYMOND G. FOURNIER — CANADA LANDS SURVEYOR

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont. K2E 7M3

SHEET NUMBER 9 of 34

CORPORATION OF

The Township of Westmeath

Westmeath, Ontario
K0J 2L0

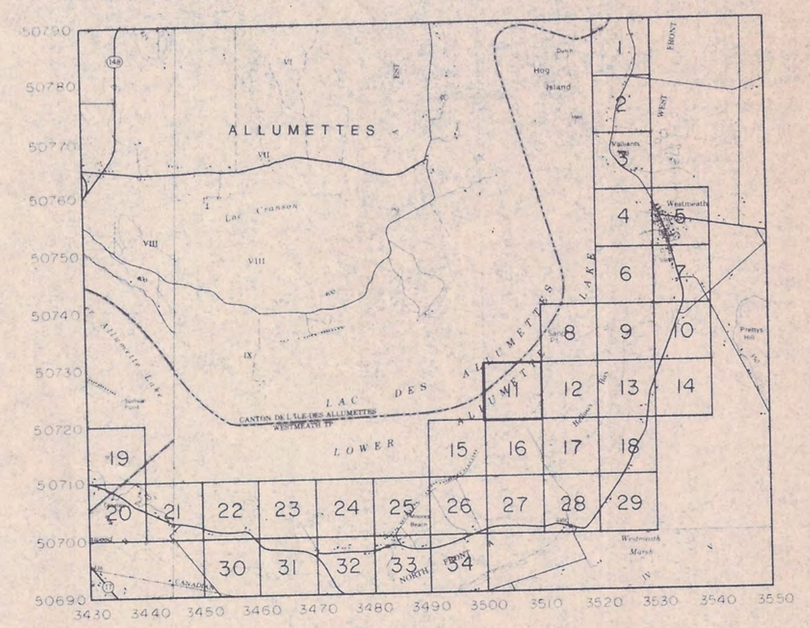
FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

02 18 3500 50720

1:2 000

LEGEND LÉGENDE

SHEET INDEX PHASE I
TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

Vertical datum: Mean sea level

Horizontal datum: North American (1927)

Map projection: U.T.M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

This map is prepared for use in conjunction with the flood plain mapping report dated June 1985 prepared by M.M. Dillon, Consulting Engineers and Planners for the Corporation of the Township of Westmeath.

COMPILATION NOTE

Production techniques used in the preparation of this map are designed for Class "A" standards.

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RENSEIGNEMENTS GENERAUX

Niveau de reference: Niveau moyen de la mer

Systeme geodesique: Nord Americain unifié (1927)

Projection: Transverse de Mercator

Meridien central 75°

Quadrillage de: 100 metres

Photographies aeriennes: Novembre - 3 - 1984

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PHOTOGRAMMETRIE

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Ontario

Sheet 02 18 3500 50720

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate
Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS
NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE
SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

SHEET NUMBER 11 of 34

DILLON
Consulting Engineers & Planners

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont., K2E 7M3

REGISTERED PROFESSIONAL ENGINEER — F.I. LORANT — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — C.B. DOHERTY — PROVINCE OF ONTARIO

RAYMOND G. FOURNIER — CANADA LANDS SURVEYOR

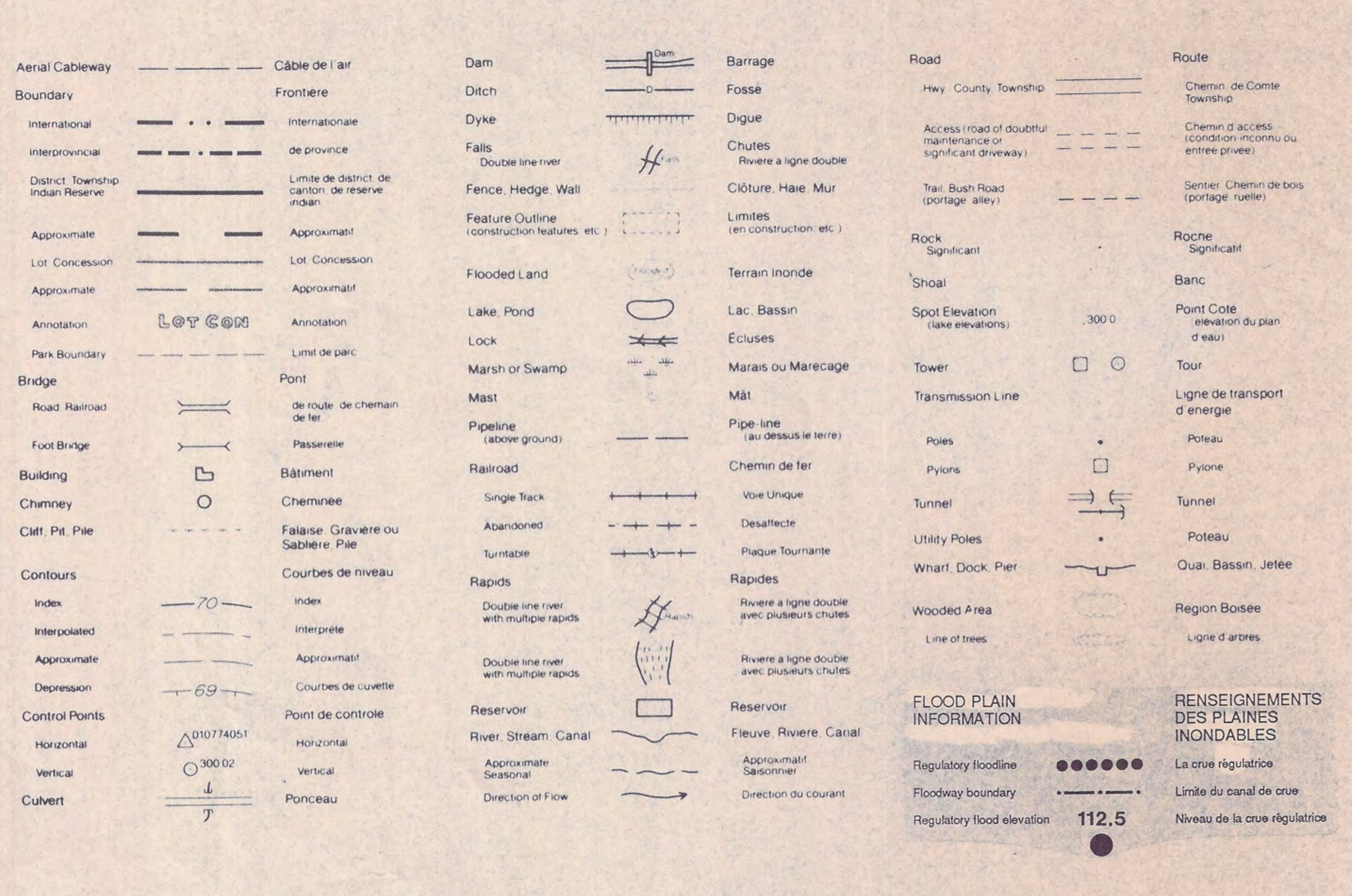
CORPORATION OF

The Township of Westmeath

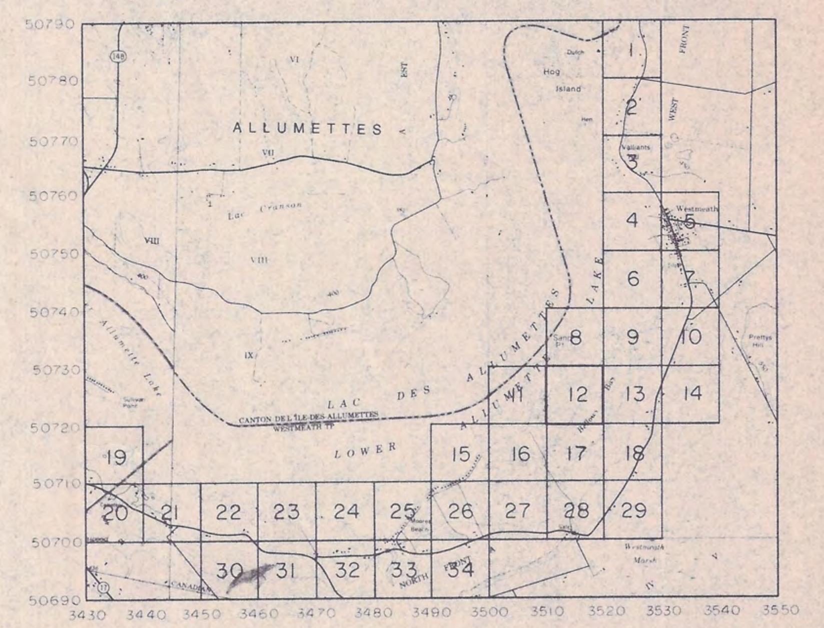
Westmeath, Ontario
K0J 2L0

FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE



SHEET INDEX PHASE I
TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

Vertical datum: Mean sea level

Horizontal datum: North American (1927)

Map projection: U.T.M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

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COMPILATION NOTE

Production techniques used in the preparation of this map are designed for Class "A" standards.

This map was prepared under the auspices of the Canada-Ontario Flood Damage Reduction Agreement signed MARCH 31, 1978.

RENSEIGNEMENTS GENERAUX

Niveau de reference: Niveau moyen de la mer

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Projection: Transverse de Mercator

Meridien central 75°

Quadrillage de: 100 metres

Photographies aeriennes. Novembre - 3 - 1984

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PHOTOGRAMMETRIE

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Cette carte a ete preparee dans le cadre de l'accord Canada-Ontario de la reduction des dommages dus inondations conclu le 31 MARS, 1978

Ontario

Sheet 02 18 3510 50720

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate
Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS
NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE
SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

DILLON
Consulting Engineers & Planners

REGISTERED PROFESSIONAL ENGINEER F. I. LORANT PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C. B. DOHERTY PROVINCE OF ONTARIO

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont., K2E 7M3

RAYMOND C. FOURNIER CANADA LANDS SURVEYOR

1:2 000

02 18 3520 50720

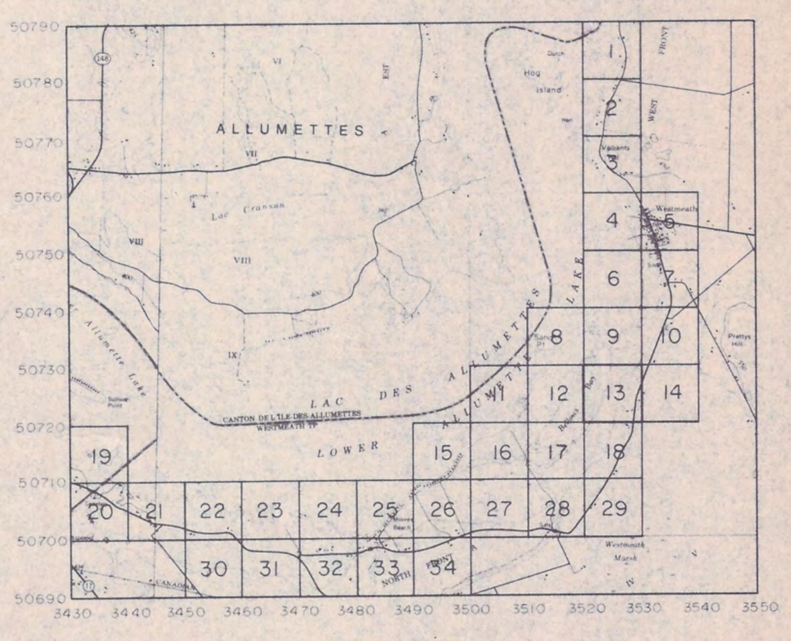
CORPORATION OF
The Township of Westmeath
Westmeath, Ontario
K0J 2L0

FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE

SHEET INDEX PHASE I

TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

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Map projection: U.T.M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

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RENSEIGNEMENTS GENERAUX

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Ontario

Sheet 02 18 3520 50720

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate

Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS
NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE
SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

DILLON
Consulting Engineers & Planners

REGISTERED PROFESSIONAL ENGINEER — F. I. LORANT — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — C. B. DOHERTY — PROVINCE OF ONTARIO

RAYMOND G. POUENIER — CANADA LANDS SURVEYOR

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont. K2E 7M3

SHEET NUMBER 13 of 34

1:2 000

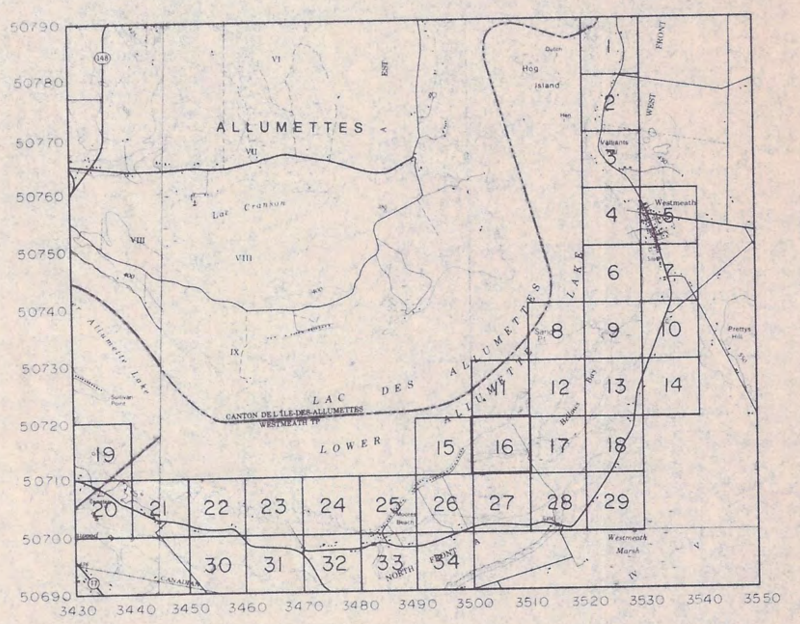
02 18 3500 50710

CORPORATION OF
The Township of Westmeath
Westmeath, Ontario
K0J 2L0

FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE

SHEET INDEX PHASE I
TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

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Map projection: U.T.M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

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RENSEIGNEMENTS GENERAUX

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Projection: Transverse de Mercator

Meridien central 75°

Quadrillage de: 100 metres

Photographies aeriennes: Novembre - 3 - 1984

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Ontario

Sheet 02 18 3500 50710

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate
Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

DILLON Consulting Engineers & Planners

REGISTERED PROFESSIONAL ENGINEER F. I. LORANT PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C. B. DOHERTY PROVINCE OF ONTARIO

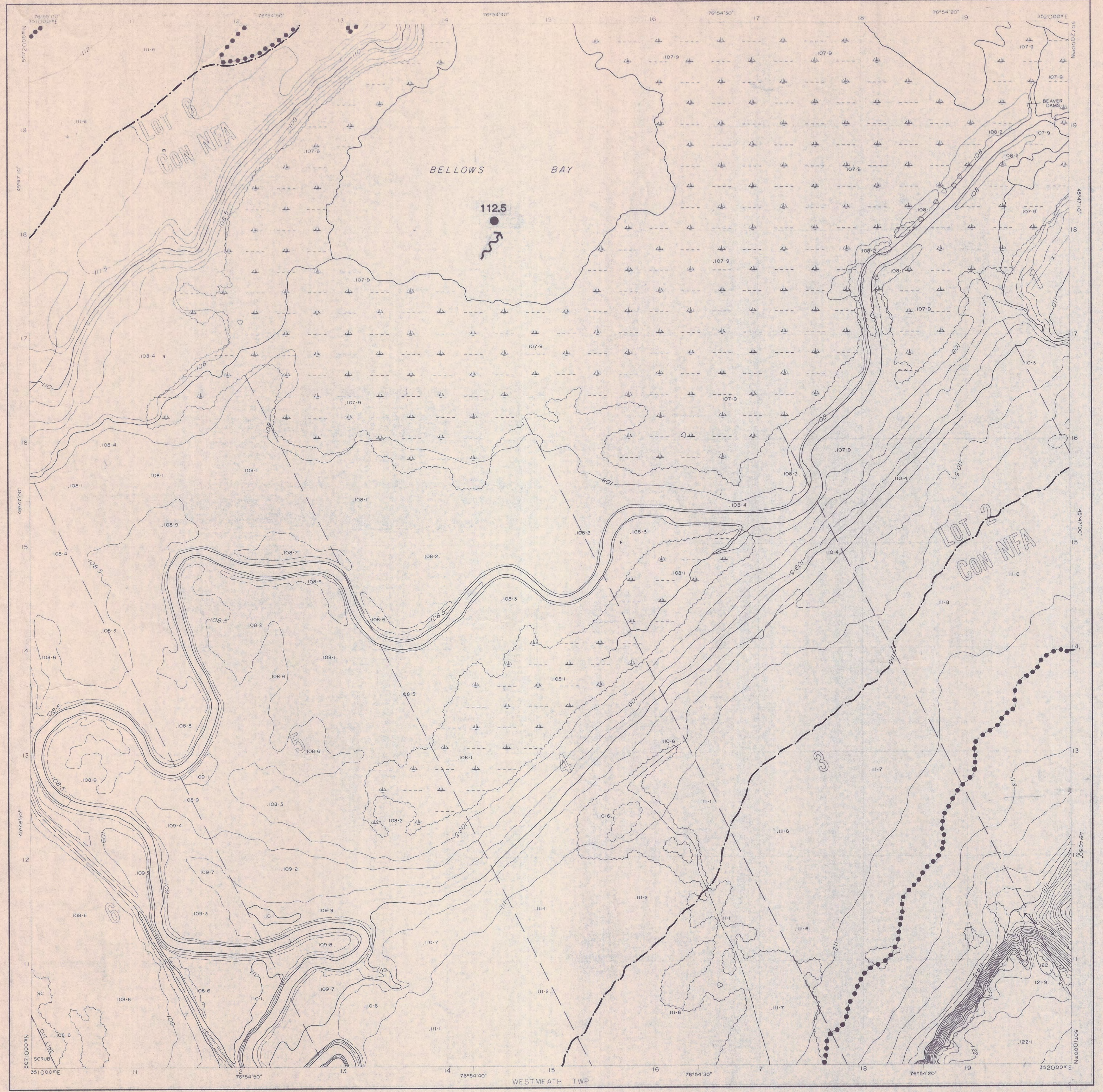
RAYMOND C. FOURNIER CANADA LANDS SURVEYOR

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont., K2E 7M3

SHEET NUMBER 16 of 34

1:2 000

02 18 3510 50710



CORPORATION OF

The Township of Westmeath

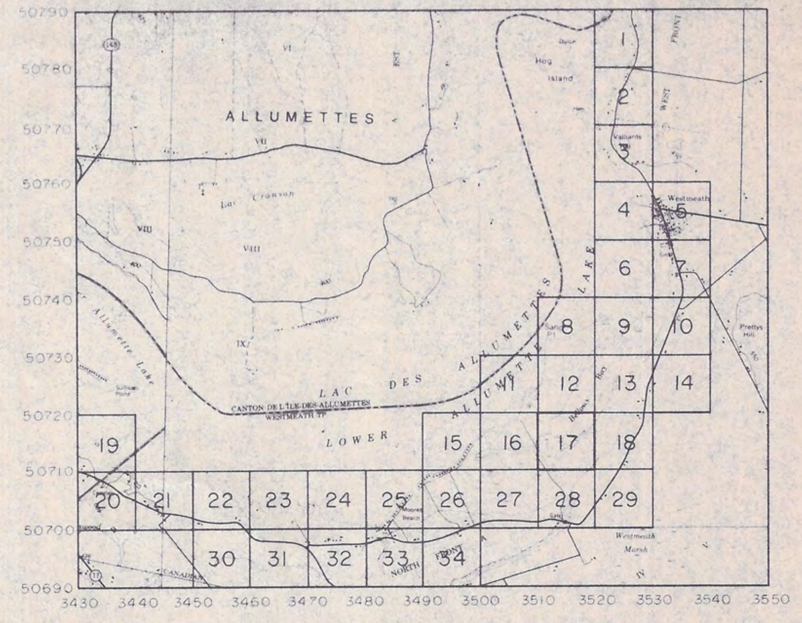
Westmeath, Ontario
K0J 2L0

FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE

SHEET INDEX PHASE I

TABLEAU D'ASSEMBLAGE PHASE I



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Map projection: U. T. M.

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Grid spacing 100 metres

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Quadrillage de: 100 metres

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Ontario

Sheet 02 18 3510 50710

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate
Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

Metres 100 0 100 200 Metres

Feet 100 0 100 200 300 400 500 600 700 800 900 1000 Feet

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

DILLON
Consulting Engineers & Planners

REGISTERED PROFESSIONAL ENGINEER F. I. LORANT PROVINCE OF ONTARIO

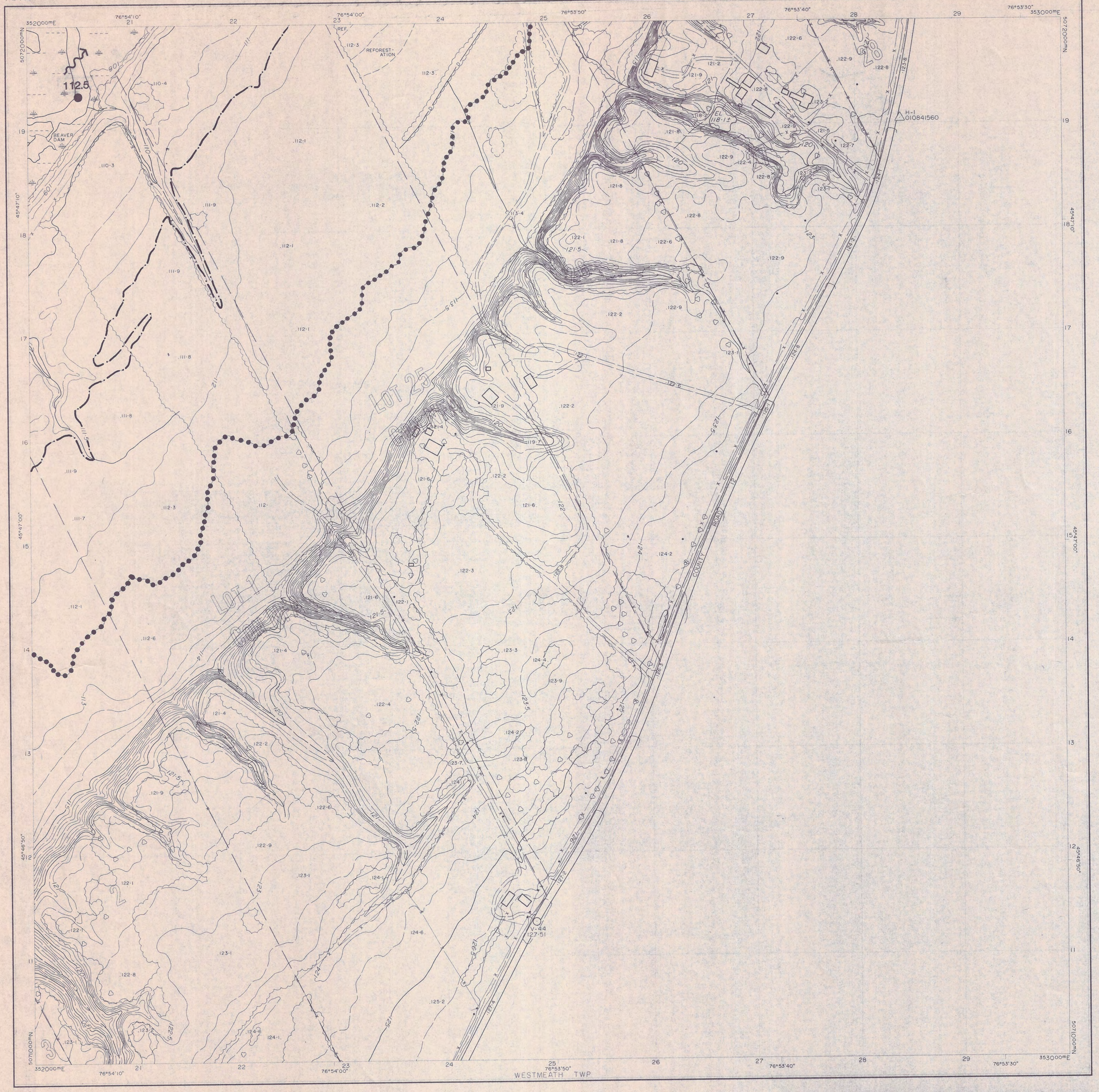
REGISTERED PROFESSIONAL ENGINEER C. B. DOHERTY PROVINCE OF ONTARIO

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont., K2E 7M3

RAYMOND C. FOURNIER CANADA LANDS SURVEYOR

1 2 000

02 18 3520 50710



CORPORATION OF
The Township of Westmeath
Westmeath, Ontario
K0J 2L0

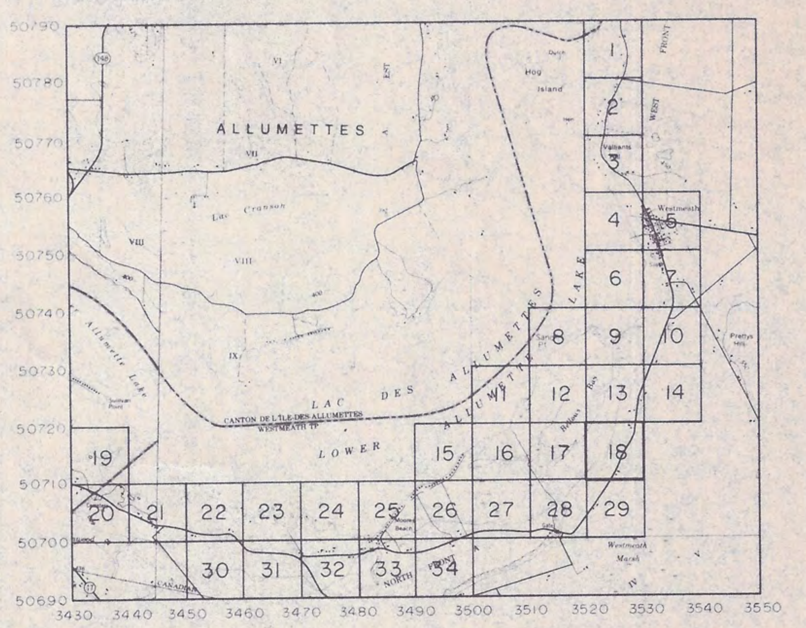
FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE

Legend	Légende
Aerial Cableway	Câble de l'air
Boundary	Frontière
International	Internationale
Interprovincial	de province
District, Township, Indian Reserve	Limite de district, de canton, de reserve indian
Approximate	Approximatif
Lot, Concession	Lot, Concession
Approximate	Approximatif
Annotation (LOT CON)	Annotation
Park Boundary	Limit de parc
Bridge	Pont
Road, Railroad	de route, de chemain de fer
Foot Bridge	Passerelle
Building	Bâtiment
Chimney	Cheminée
Cliff, Pit, Pile	Falaise, Gravière ou Sablière, Pile
Contours	Courbes de niveau
Index (70)	Index
Interpolated	Interprète
Approximate	Approximatif
Depression (69)	Courbes de cuvette
Control Points	Point de controle
Horizontal (010774051)	Horizontal
Vertical (300.02)	Vertical
Culvert	Ponceau
Dam	Barrage
Ditch	Fossé
Dyke	Digue
Falls, Double line river	Chutes, Riviere a ligne double
Fence, Hedge, Wall	Clôture, Haie, Mur
Feature Outline (construction features, etc.)	Limites (en construction, etc.)
Flooded Land	Terrain inonde
Lake, Pond	Lac, Bassin
Lock	Écluses
Marsh or Swamp	Marais ou Marécage
Mast	Mât
Pipeline (above ground)	Pipe-line (au dessus le terre)
Railroad	Chemin de fer
Single Track	Voie Unique
Abandoned	Desaffecte
Turntable	Plaque Tournante
Rapids	Rapides
Double line river with multiple rapids	Riviere a ligne double avec plusieurs chutes
Double line river with multiple rapids	Riviere a ligne double avec plusieurs chutes
Reservoir	Reservoir
River, Stream, Canal	Fleuve, Riviere, Canal
Approximate Seasonal	Approximatif Saisonnier
Direction of Flow	Direction du courant
Road	Route
Hwy, County, Township	Chemin, de Comte Township
Access (road of doubtful maintenance or significant driveway)	Chemin d'access (condition inconnu ou entree privee)
Trail, Bush Road (portage, alley)	Sentier, Chemin de bois (portage, ruelle)
Rock, Significant	Rocne, Significatif
Shoal	Banc
Spot Elevation (lake elevations) (300.0)	Point Cote (elevation du plan d'eau)
Tower	Tour
Transmission Line	Ligne de transport d'energie
Poles	Poteau
Pylons	Pylone
Tunnel	Tunnel
Utility Poles	Poteau
Wharf, Dock, Pier	Quai, Bassin, Jetee
Wooded Area	Region Boisée
Line of trees	Ligne d'arbres

FLOOD PLAIN INFORMATION	RENSEIGNEMENTS DES PLAINES INONDABLES
Regulatory floodline	La crue régulatrice
Floodway boundary	Limite du canal de crue
Regulatory flood elevation (112.5)	Niveau de la crue régulatrice

SHEET INDEX PHASE I — TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

Vertical datum: Mean sea level

Horizontal datum: North American (1927)

Map projection: U. T. M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

This map is prepared for use in conjunction with the flood plain mapping report dated June 1985 prepared by M.M. Dillon, Consulting Engineers and Planners for the Corporation of the Township of Westmeath.

COMPILATION NOTE

Production techniques used in the preparation of this map are designed for Class "A" standards.

This map was prepared under the auspices of the Canada-Ontario Flood Damage Reduction Agreement signed MARCH 31, 1978.

RENSEIGNEMENTS GENERAUX

Niveau de reference: Niveau moyen de la mer

Systeme geodesique: Nord Americain unifié (1927)

Projection: Transverse de Mercator

Meridien central 75°

Quadrillage de: 100 metres

Photographies aeriennes: Novembre - 3 - 1984

La présente carte a été dressée dans le but de faciliter la consultation du rapport cartographique de la plaine inondable publié en juin 1985 et réalisé par M. M. Dillon, firme d'ingénieurs-conseils et d'urbanistes, pour la corporation du canton de Westmeath.

PHOTOGRAMMETRIE

Les normes de production de cette carte se conforment aux standards de premiere classe.

Cette carte a ete preparee dans le cadre de l'accord Canada-Ontario de la reduction des dommages dus inondations conclu le 31 MARS, 1978

Ontario

Sheet 02 18 3520 50710

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate
Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

Metres 100 0 100 200 Metres
Feet 100 0 100 200 300 400 500 600 700 800 900 1000 Feet

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

DILLON
Consulting Engineers & Planners

REGISTERED PROFESSIONAL ENGINEER F. I. LORANT PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C. B. DOHERTY PROVINCE OF ONTARIO

RAYMOND C. FOURNIER CANADA LANDS SURVEYOR

McElhanney
McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont., K2E 7M3

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02 18 3490 50700

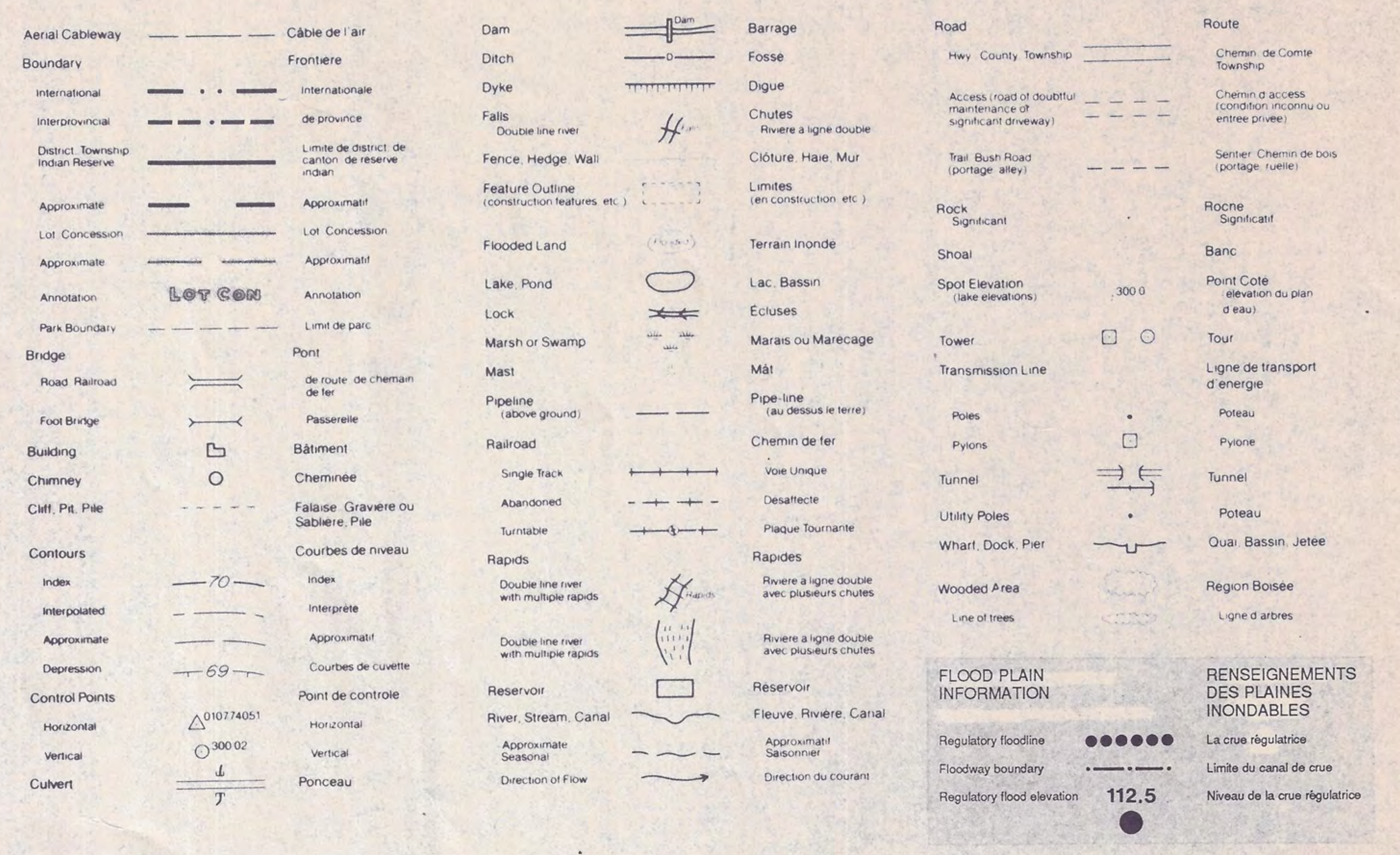
CORPORATION OF

The Township of Westmeath

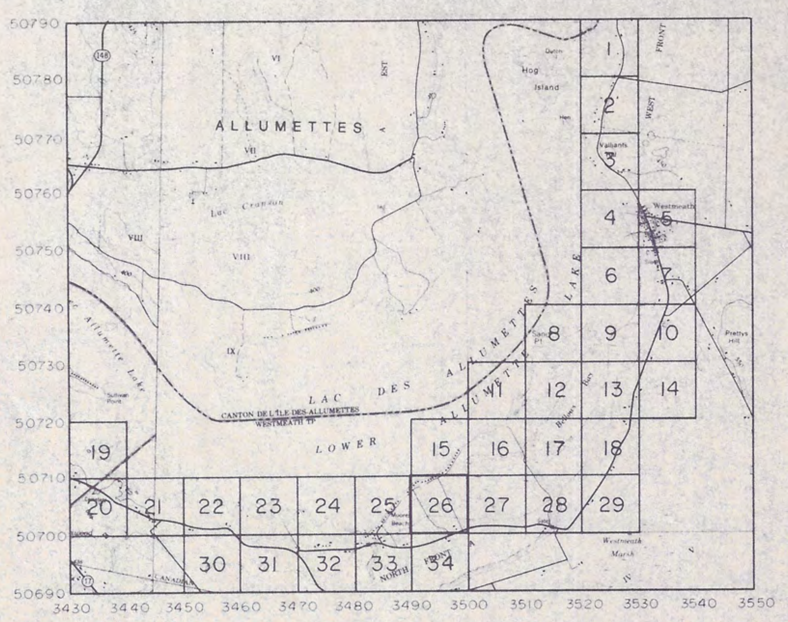
Westmeath, Ontario
K0J 2L0

FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE



SHEET INDEX PHASE I TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

Vertical datum: Mean sea level

Horizontal datum: North American (1927)

Map projection: U.T.M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

This map is prepared for use in conjunction with the flood plain mapping report dated June 1985 prepared by M.M. Dillon, Consulting Engineers and Planners for the Corporation of the Township of Westmeath.

COMPILATION NOTE

Production techniques used in the preparation of this map are designed for Class "A" standards.

This map was prepared under the auspices of the Canada-Ontario Flood Damage Reduction Agreement signed MARCH 31, 1978.

RENSEIGNEMENTS GENERAUX

Niveau de reference: Niveau moyen de la mer

Systeme geodesique: Nord Americain unifié (1927)

Projection: Transverse de Mercator

Meridien central 75°

Quadrillage de: 100 metres

Photographies aeriennes: Novembre - 3 - 1984

La présente carte a été dressée dans le but de faciliter la consultation du rapport cartographique de la plaine inondable publié en juin 1985 et réalisé par M.M. Dillon, firme d'ingénieurs-conseils et d'urbanistes, pour la corporation du canton de Westmeath.

PHOTOGRAMMETRIE

Les normes de production de cette carte se conforment aux standards de premiere classe.

Cette carte a ete preparee dans le cadre de l'accord Canada-Ontario de la reduction des dommages dus inondations conclu le 31 MARS, 1978

Ontario Sheet 02 18 3490 50700

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate

Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS
NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE
SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

DILLON Consulting Engineers & Planners

REGISTERED PROFESSIONAL ENGINEER F.I. LORANT PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER C.B. DOHERTY PROVINCE OF ONTARIO

RAYMOND C. FOURNIER CANADA LANDS SURVEYOR

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont. K2E 7M3

1:2 000

02 18 3500 50700

CORPORATION OF

The Township of Westmeath

Westmeath, Ontario
K0J 2L0

FLOOD RISK MAP
OTTAWA RIVER
CARTE DE RISQUE D'INONDATION
RIVIÈRE DES OUTAOUAIS

LEGEND LÉGENDE

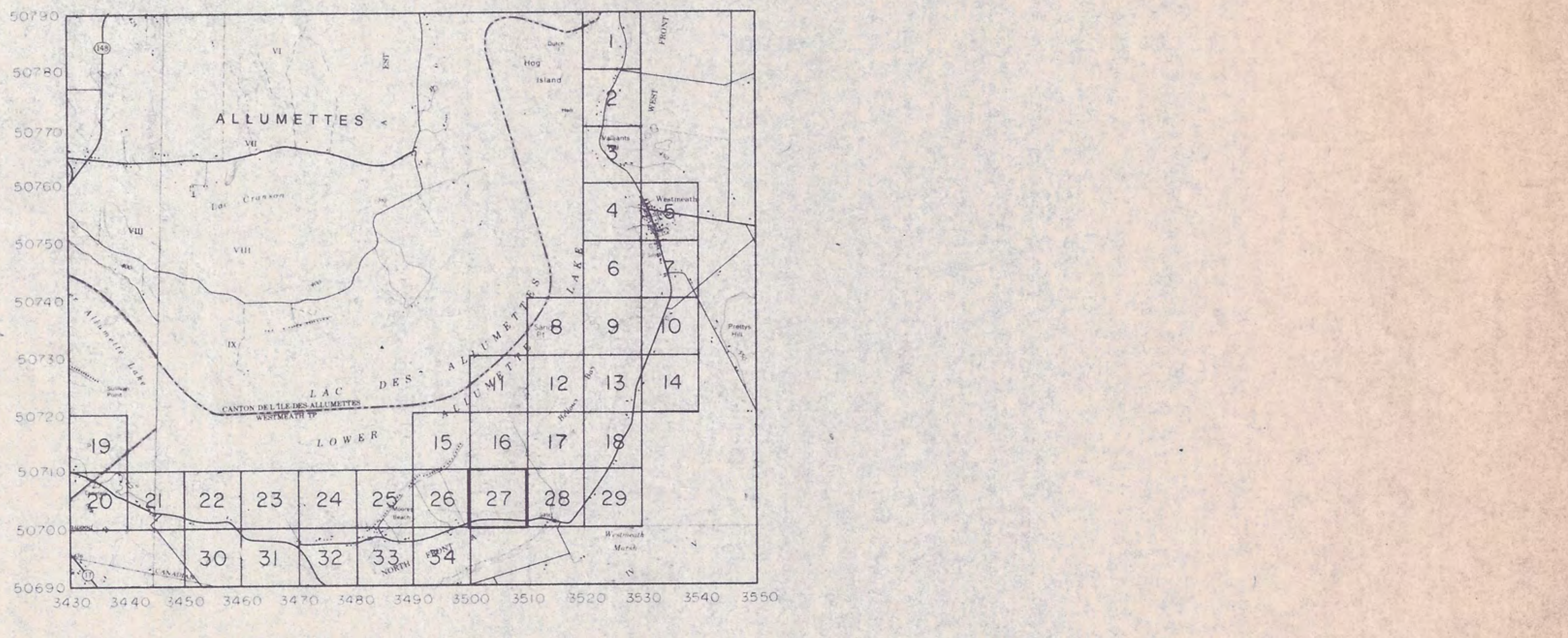
Legend	Légende
Aerial Cableway	Câble de l'air
Boundary	Frontière
International	Internationale
Interprovincial	de province
District, Township, Indian Reserve	Limite de district, de canton, de reserve indian
Approximate	Approximatif
Lot, Concession	Lot, Concession
Approximate	Approximatif
Annotation (LOT CON)	Annotation
Park Boundary	Limit de parc
Bridge	Pont
Road, Railroad	de route, de chemain de fer
Foot Bridge	Passerelle
Building	Bâtiment
Chimney	Cheminee
Cliff, Pit, Pile	Falaise, Gravière ou Sablière, Pile
Contours	Courbes de niveau
Index (70)	Index
Interpolated	Interprète
Approximate	Approximatif
Depression (69)	Courbes de cuvette
Control Points	Point de controle
Horizontal (010774051)	Horizontal
Vertical (300.02)	Vertical
Culvert	Ponceau

Legend	Légende
Dam	Barrage
Ditch	Fosse
Dyke	Digue
Falls: Double line river	Chutes: Riviere a ligne double
Fence, Hedge, Wall	Clôture, Haie, Mur
Feature Outline (construction features, etc.)	Limites (en construction, etc.)
Flooded Land	Terrain Inonde
Lake, Pond	Lac, Bassin
Lock	Écluses
Marsh or Swamp	Marais ou Marecage
Mast	Mât
Pipeline (above ground)	Pipe-line (au dessus le terre)
Railroad	Chemin de fer
Single Track	Voie Unique
Abandoned	Desaffecte
Turntable	Plaque Tournante
Rapids	Rapides
Double line river with multiple rapids	Riviere a ligne double avec plusieurs chutes
Double line river with multiple rapids	Riviere a ligne double avec plusieurs chutes
Reservoir	Reservoir
River, Stream, Canal	Fleuve, Rivière, Canal
Approximate, Seasonal	Approximatif, Saisonnier
Direction of Flow	Direction du courant

Legend	Légende
Road	Route
Hwy, County, Township	Chemin de Comte, Township
Access (road of doubtful maintenance or significant driveway)	Chemin d'access (condition inconnu ou entree privee)
Trail, Bush Road (portage, alley)	Sentier, Chemin de bois (portage, ruelle)
Rock: Significant	Rocne: Significatif
Shoal	Banc
Spot Elevation (lake elevations) (300.0)	Point Cote: elevation du plan d'eau)
Tower	Tour
Transmission Line	Ligne de transport d'energie
Poles	Poteau
Pylons	Pylone
Tunnel	Tunnel
Utility Poles	Poteau
Wharf, Dock, Pier	Quai, Bassin, Jetee
Wooded Area	Region Boisee
Line of trees	Ligne d'arbres

FLOOD PLAIN INFORMATION	RENSEIGNEMENTS DES PLAINES INONDABLES
Regulatory floodline	La crue régulatrice
Floodway boundary	Limite du canal de crue
Regulatory flood elevation (112.5)	Niveau de la crue régulatrice

SHEET INDEX PHASE I / TABLEAU D'ASSEMBLAGE PHASE I



GENERAL INFORMATION

Vertical datum: Mean sea level

Horizontal datum: North American (1927)

Map projection: U.T.M.

Central Meridian 75°

Grid spacing 100 metres

Aerial Photography: November - 3 - 1984

This map is prepared for use in conjunction with the flood plain mapping report dated June 1985 prepared by M.M. Dillon, Consulting Engineers and Planners for the Corporation of the Township of Westmeath.

COMPILATION NOTE

Production techniques used in the preparation of this map are designed for Class "A" standards.

This map was prepared under the auspices of the Canada-Ontario Flood Damage Reduction Agreement signed MARCH 31, 1978.

RENSEIGNEMENTS GENERAUX

Niveau de reference: Niveau moyen de la mer

Systeme geodesique: Nord Americain unifié (1927)

Projection: Transverse de Mercator

Meridien central 75°

Quadrillage de: 100 metres

Photographies aeriennes: Novembre - 3 - 1984

La présente carte a été dressée dans le but de faciliter la consultation du rapport cartographique de la plaine inondable publié en juin 1985 et réalisé par M.M. Dillon, firme d'ingénieurs-conseils et d'urbanistes, pour la corporation du canton de Westmeath.

PHOTOGRAMMETRIE

Les normes de production de cette carte se conforment aux standards de premiere classe.

Cette carte a ete preparee dans le cadre de l'accord Canada-Ontario de la reduction des dommages dus inondations conclu le 31 MARS, 1978.

Ontario

Sheet 02 18 3500 50700

Ministry of Natural Resources
Ministère des richesses naturelles

Environment Canada — Inland Waters Directorate
Environnement Canada — Direction Générales des Eaux Intérieures

Scale 1:2 000

Metres 100 0 100 200 Metres
Feet 100 0 100 200 300 400 500 600 700 800 900 1000 Feet

CONTOUR INTERVAL 1 METRE WITH 0.5 METRE INTERPOLATIONS NORTH AMERICAN DATUM 1927

EQUIDISTANCE DES COURBES DE NIVEAU 1 METRE AVEC INTERPOLATIONS DE 0.5 METRE SYSTEME DE REFERENCE GEODESIQUE NORD-AMERICAIN 1927

Date	Amendment / Revision
May 1989	Floodway boundary added re: 1988 policy.

DATE: June, 1985

SHEET NUMBER 27 of 34

DILLON
Consulting Engineers & Planners

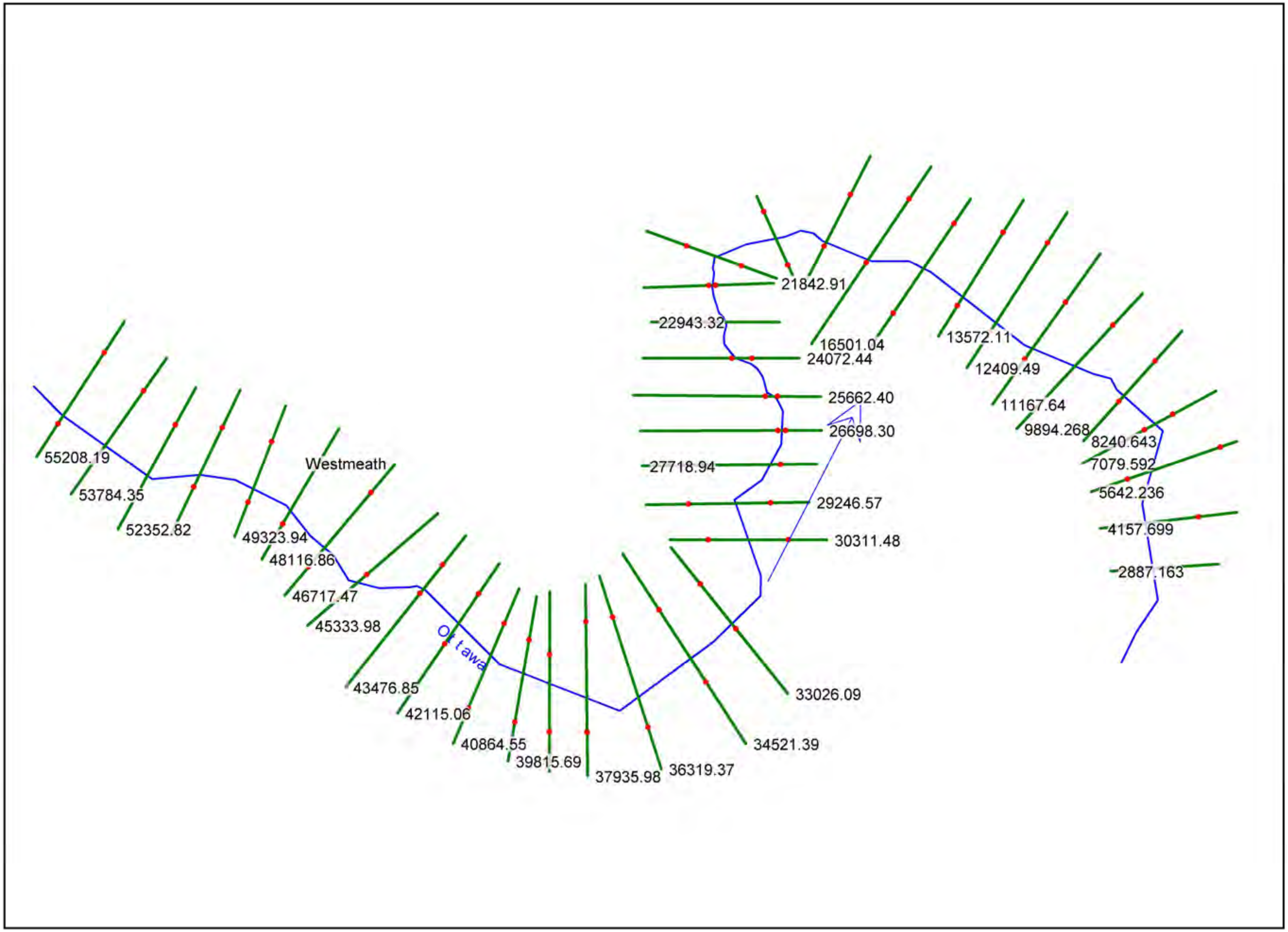
REGISTERED PROFESSIONAL ENGINEER — F. I. LORANT — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — C. B. DOHERTY — PROVINCE OF ONTARIO

RAYMOND C. FOURNIER — CANADA LANDS SURVEYOR

McElhanney Mapping Services
107 Colonnade Road, Nepean, (Ottawa), Ont. K2E 7M3

Appendix F



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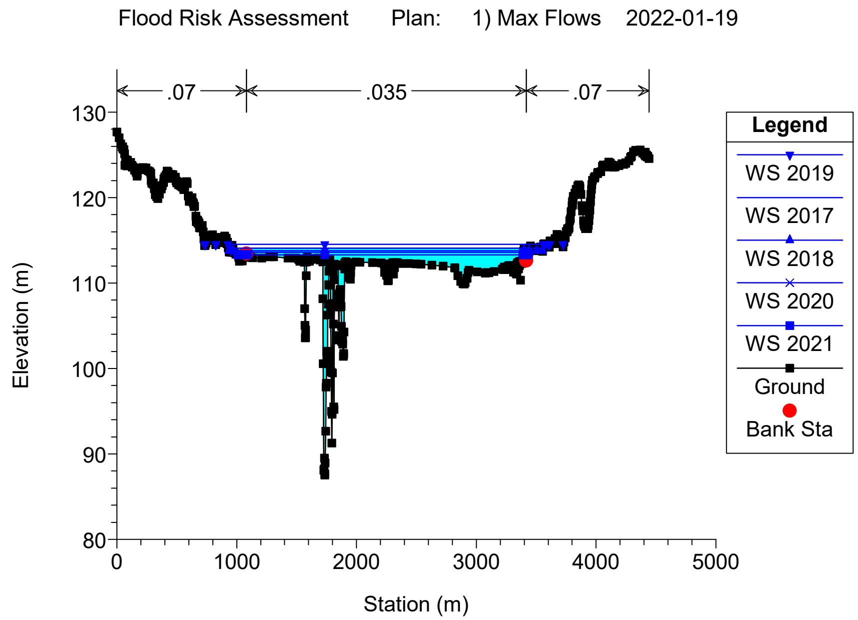
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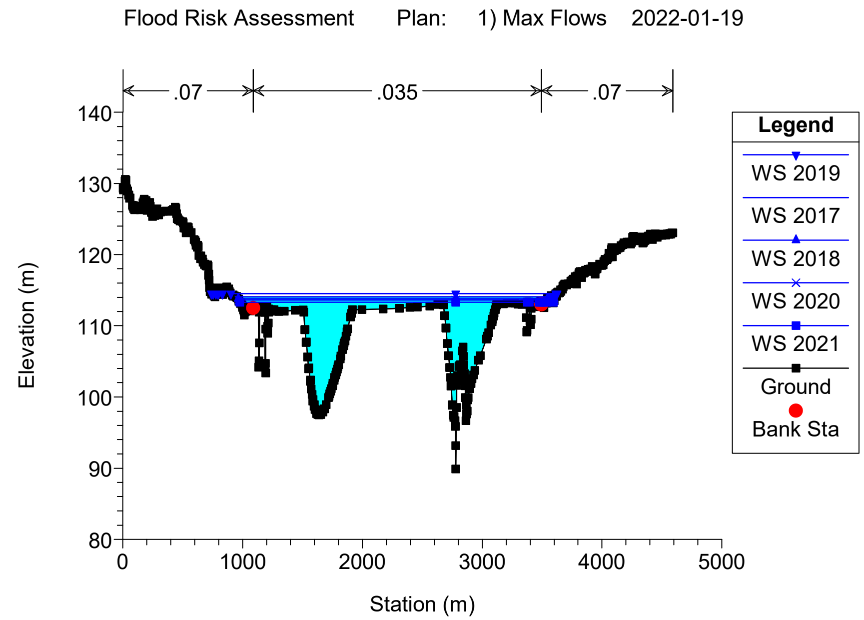
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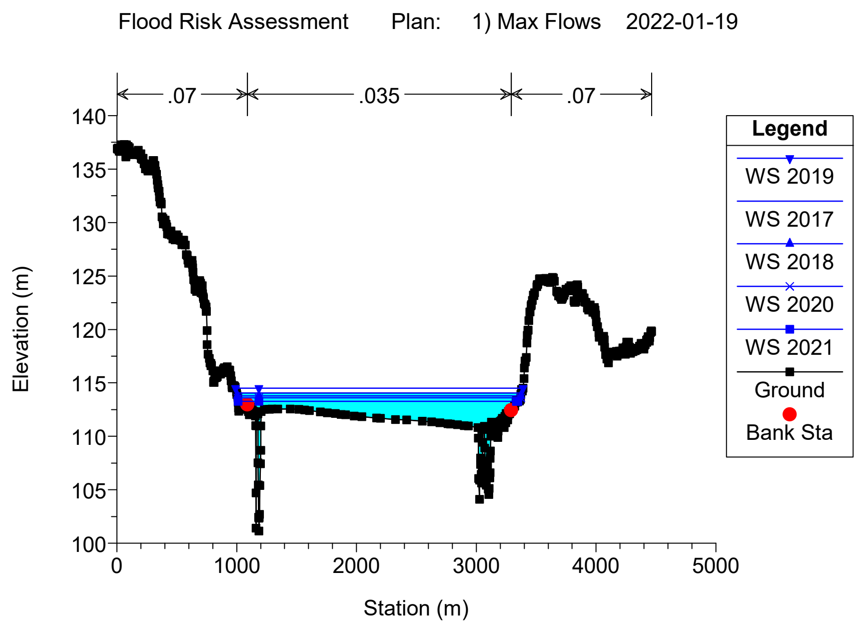
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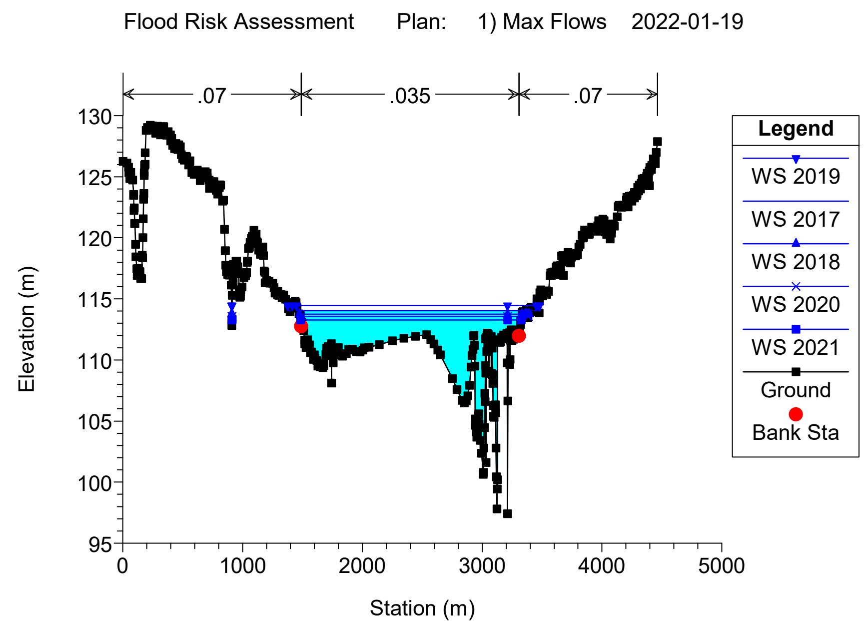
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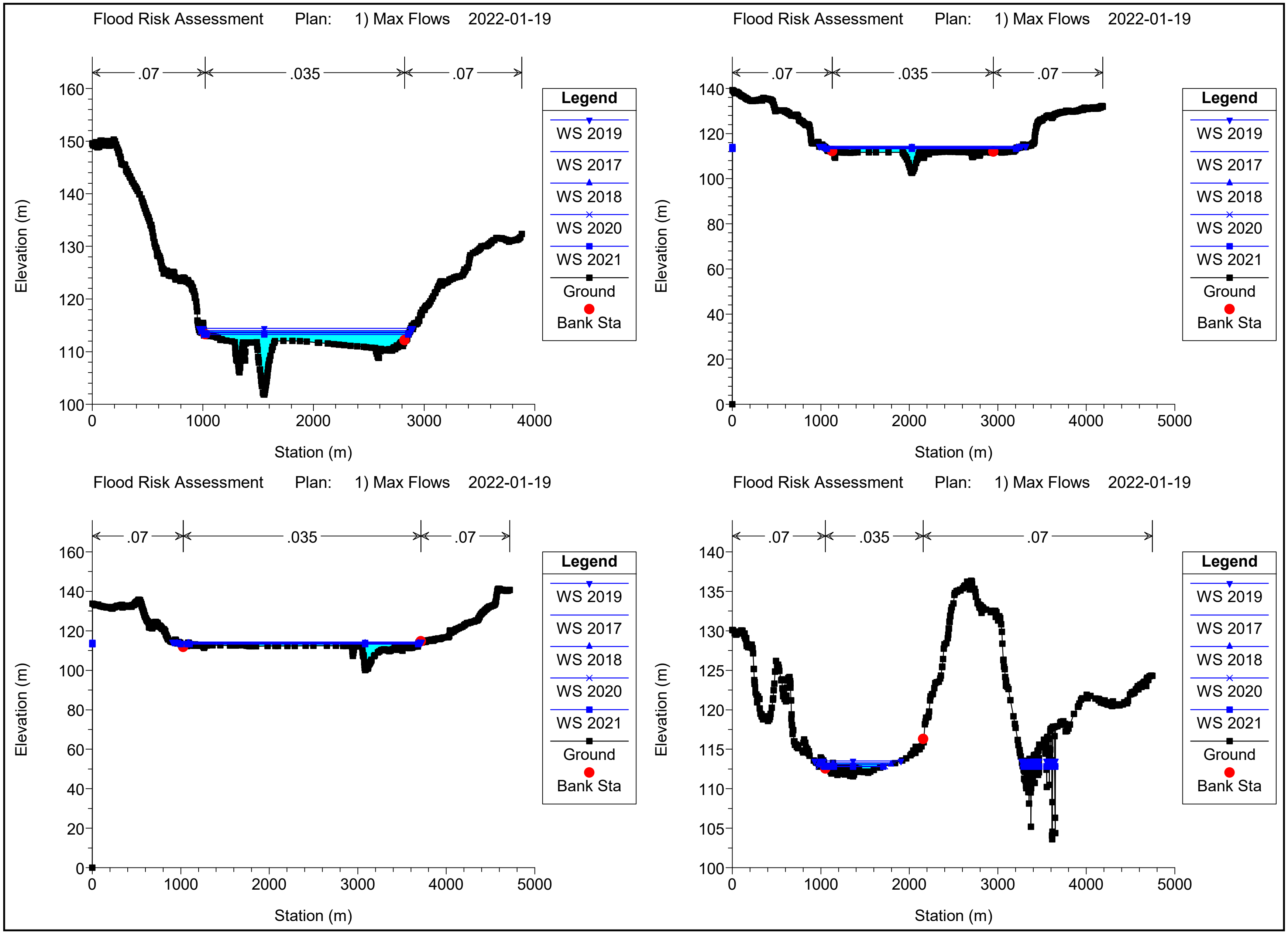
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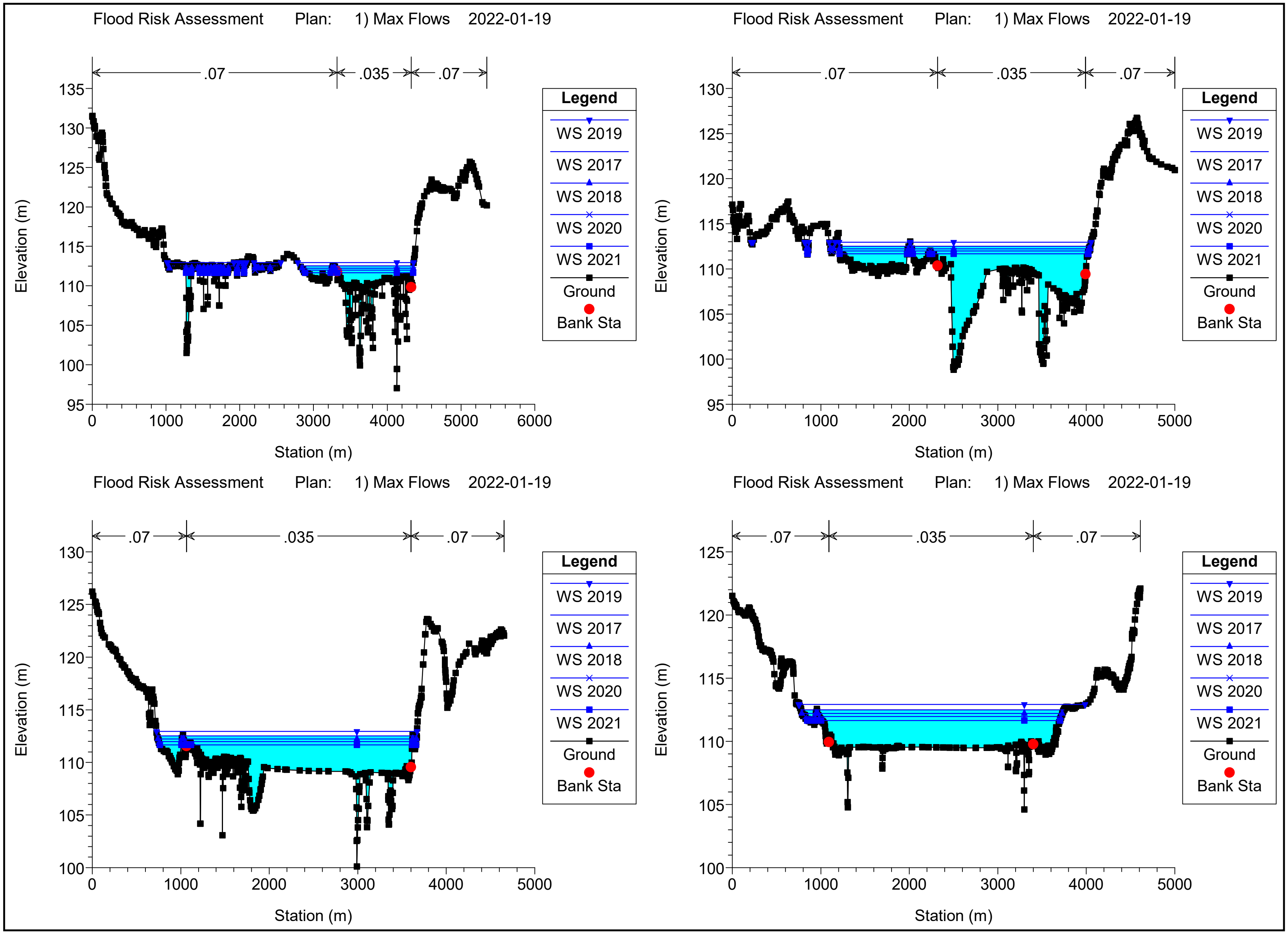
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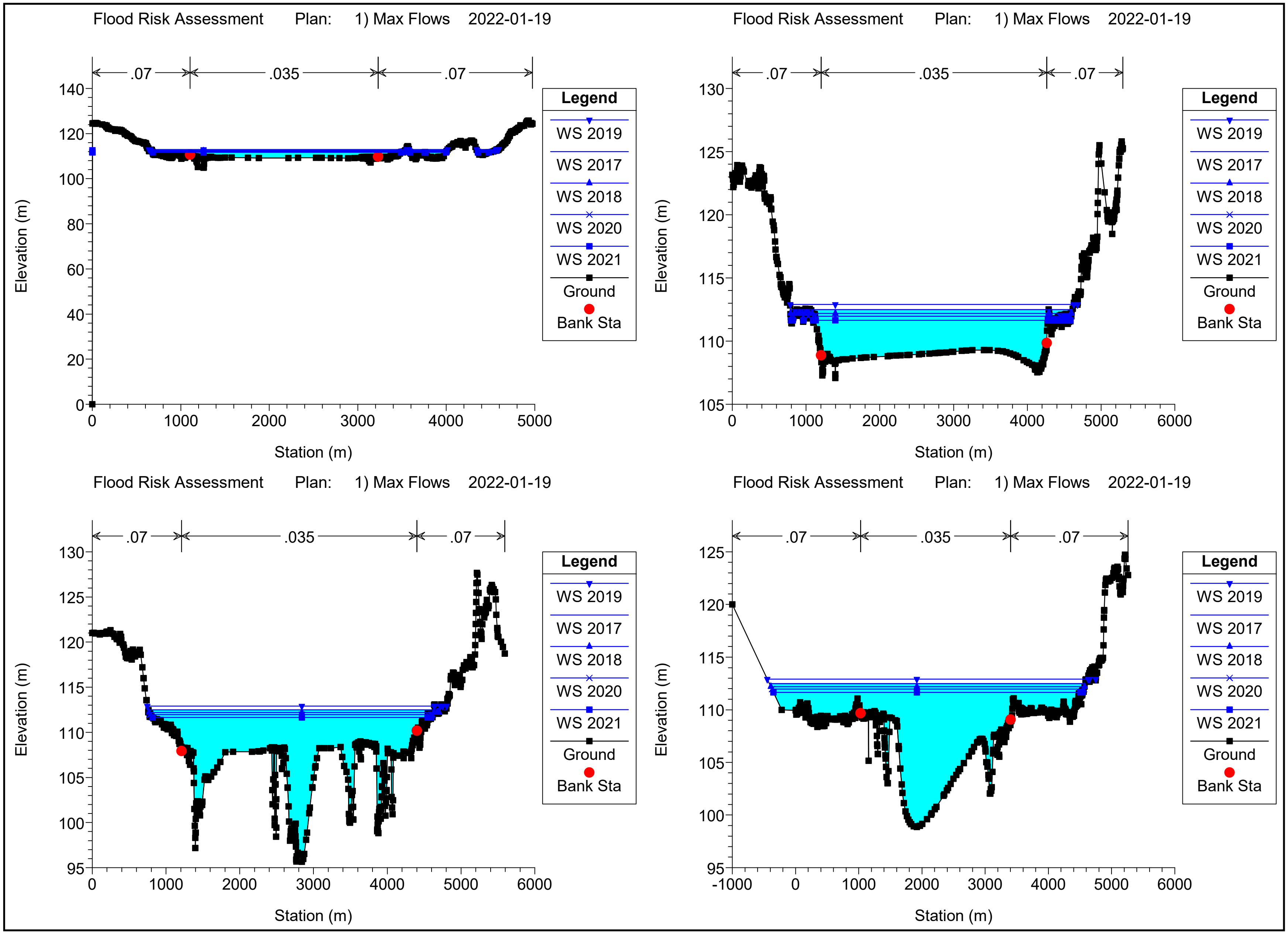
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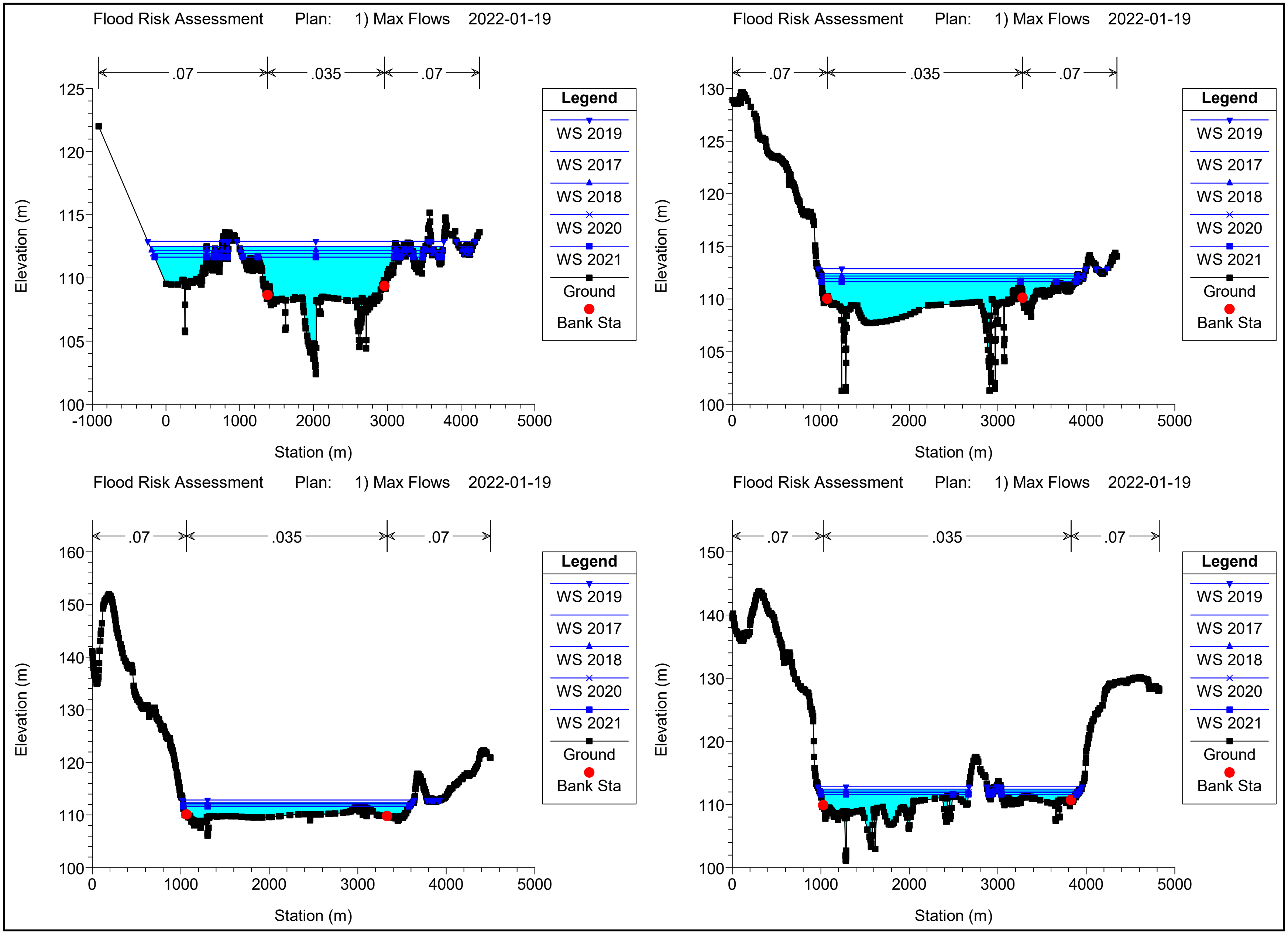
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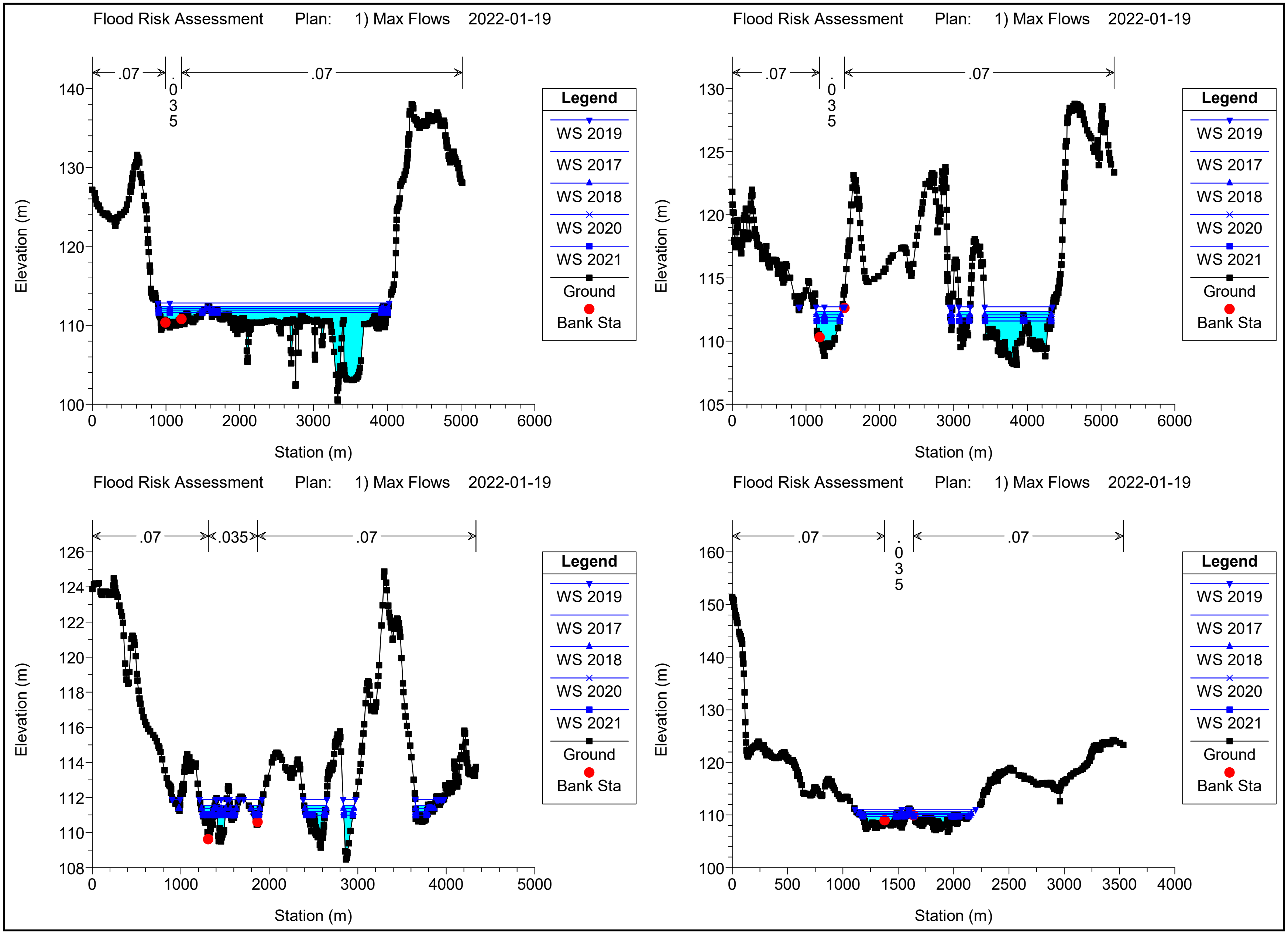
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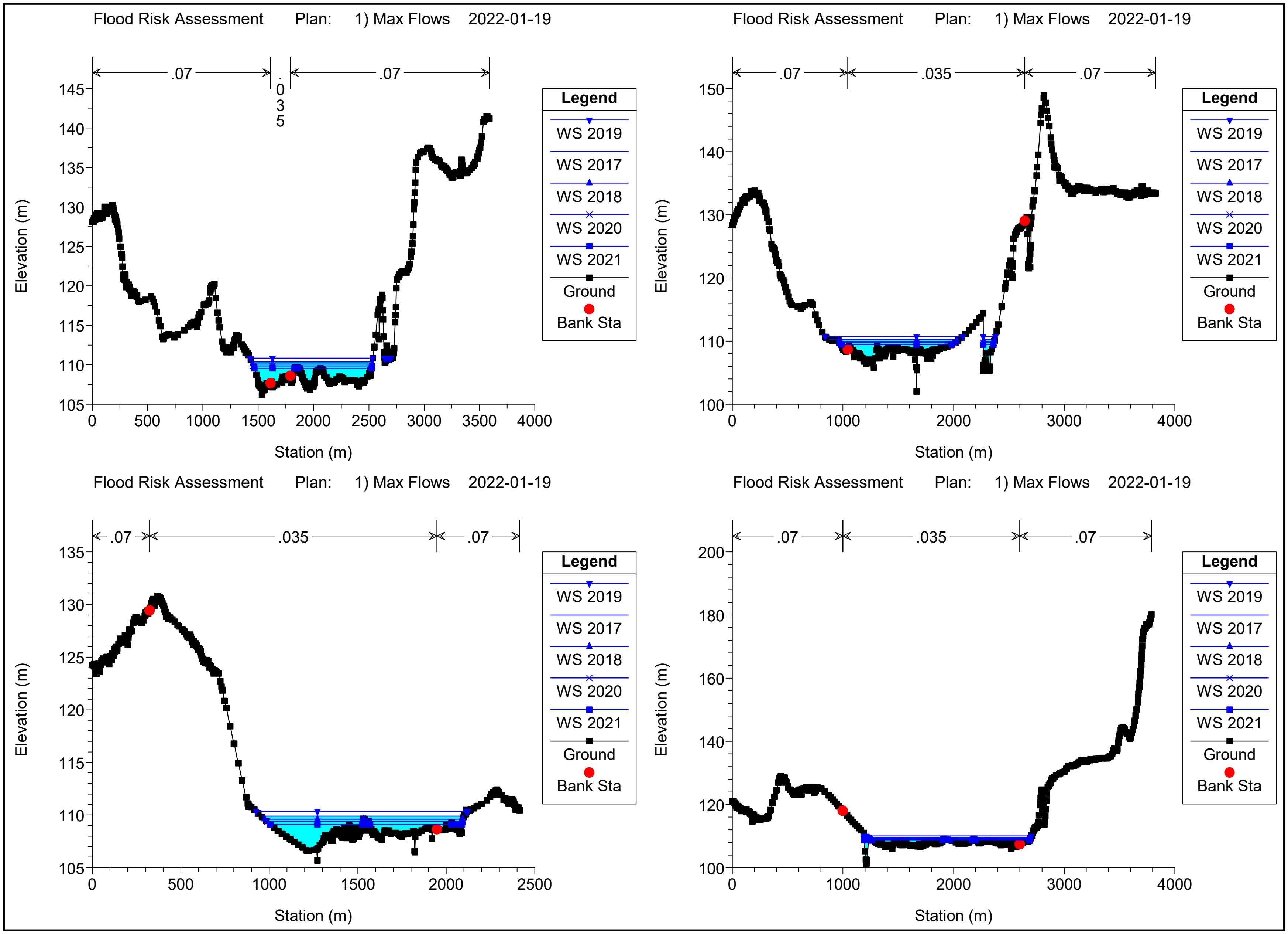

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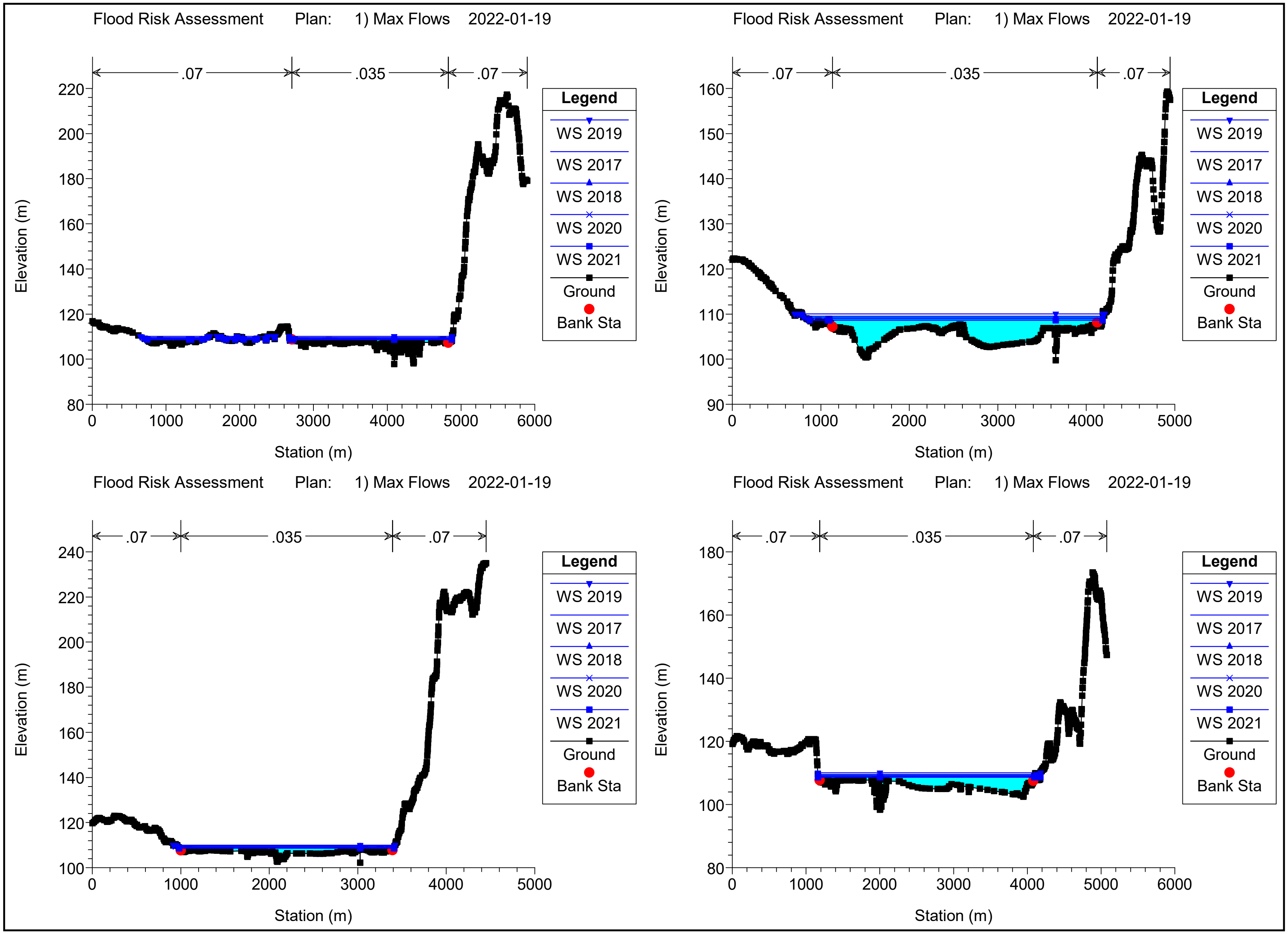
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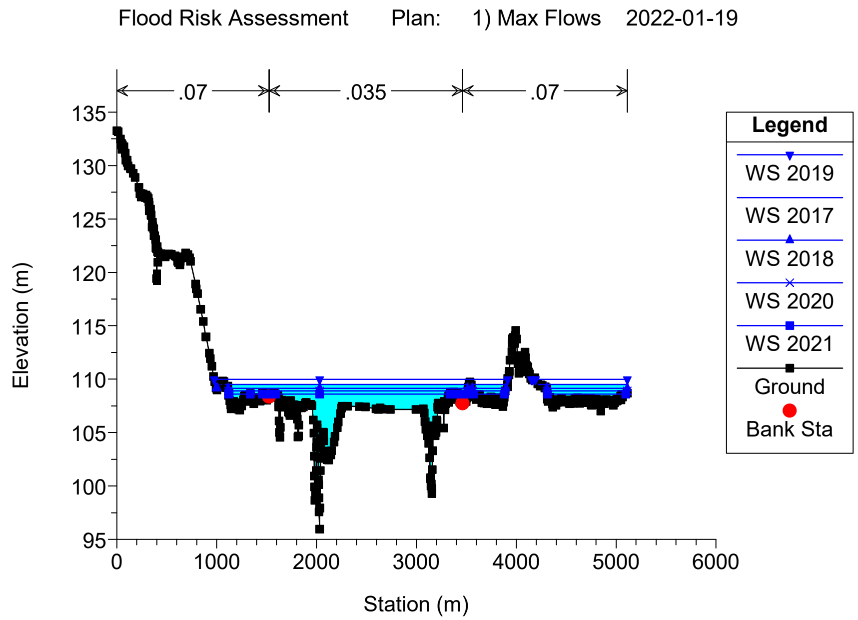
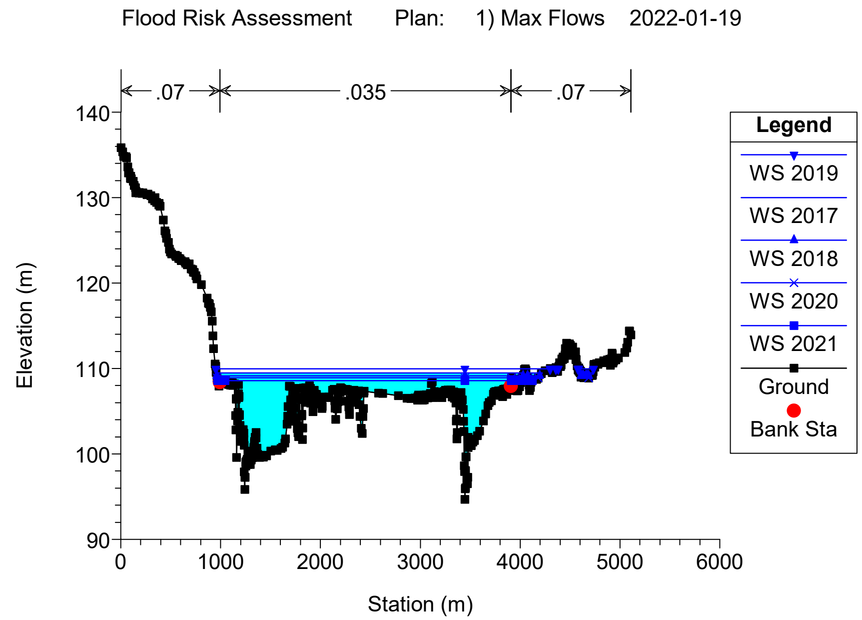

Flood Risk Assessment Plan: 1) Max Flows 2022-01-19
.07
.035
.07
Elevation (m)
135
130
125
120
115
110
105
100
95
0
1000
2000
3000
4000
5000
6000
Station (m)
Legend
WS 2019
WS 2017
WS 2018
WS 2020
WS 2021
Ground
Bank Sta


Flood Risk Assessment Plan: 1) Max Flows 2022-01-19
.07
.035
.07
Elevation (m)
140
130
120
110
100
90
0
1000
2000
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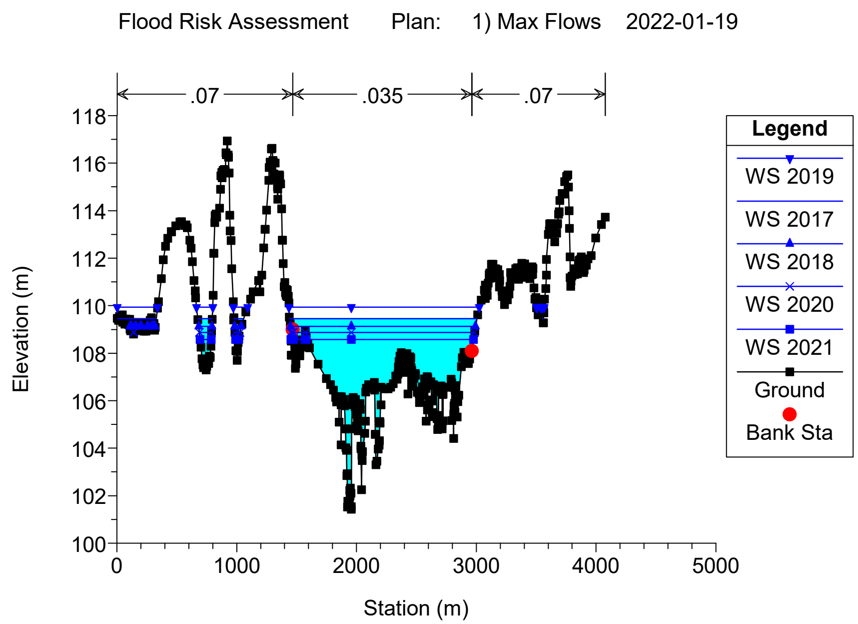
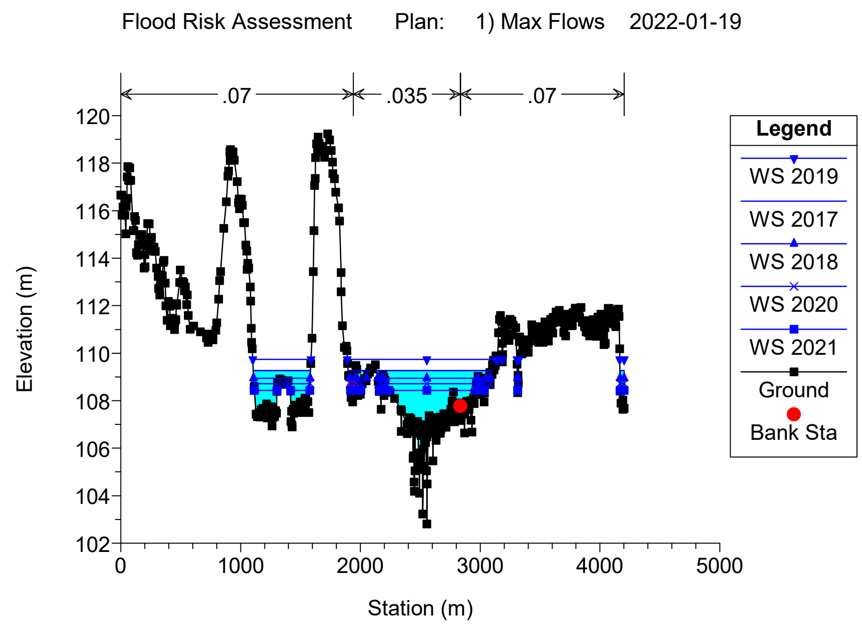
4000
5000
6000
Station (m)
Legend
WS 2019
WS 2017
WS 2018
WS 2020
WS 2021
Ground
Bank Sta


Flood Risk Assessment Plan: 1) Max Flows 2022-01-19
.07
.035
.07
Elevation (m)
118
116
114
112
110
108
106
104
102
100
0
1000
2000
3000
4000
5000
Station (m)
Legend
WS 2019
WS 2017
WS 2018
WS 2020
WS 2021
Ground
Bank Sta


Flood Risk Assessment Plan: 1) Max Flows 2022-01-19
.07
.035
.07
Elevation (m)
120
118
116
114
112
110
108
106
104
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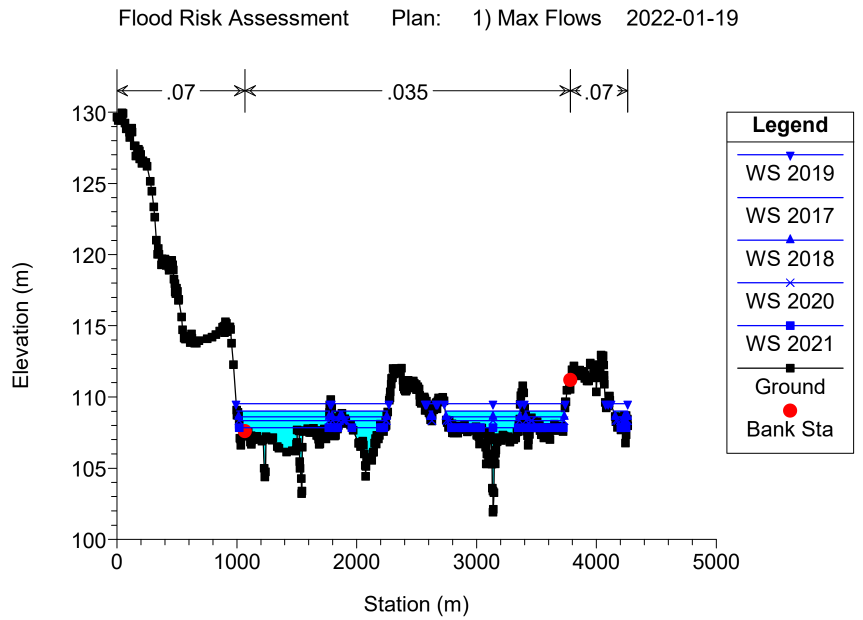
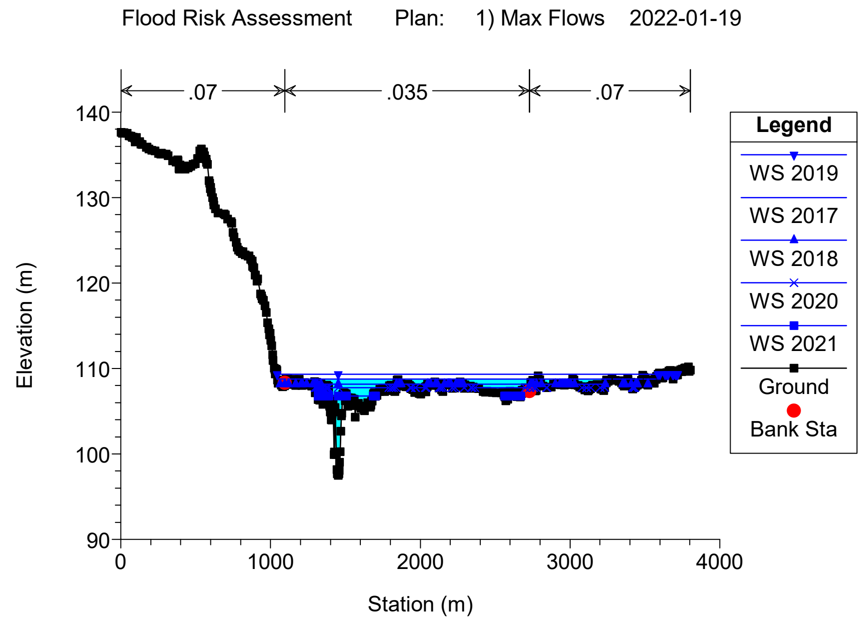
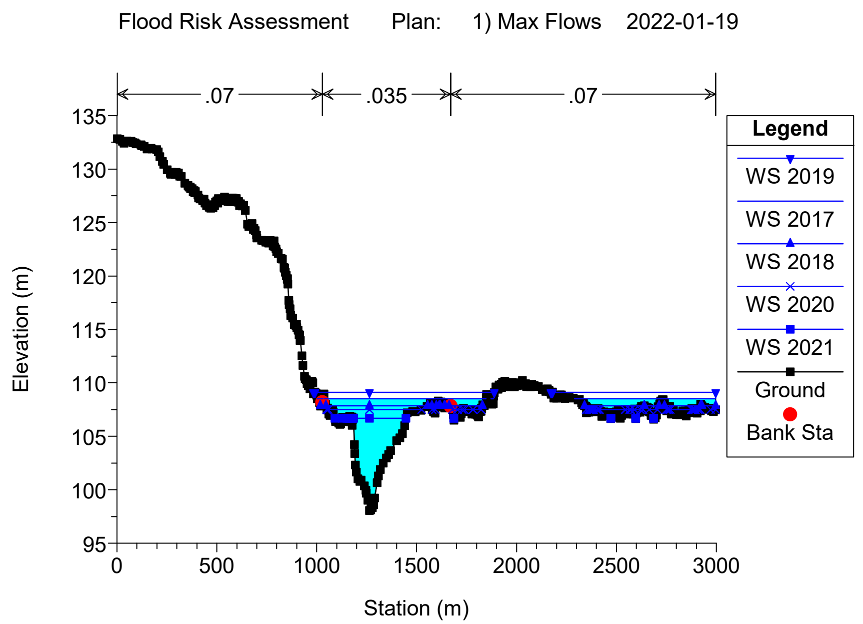
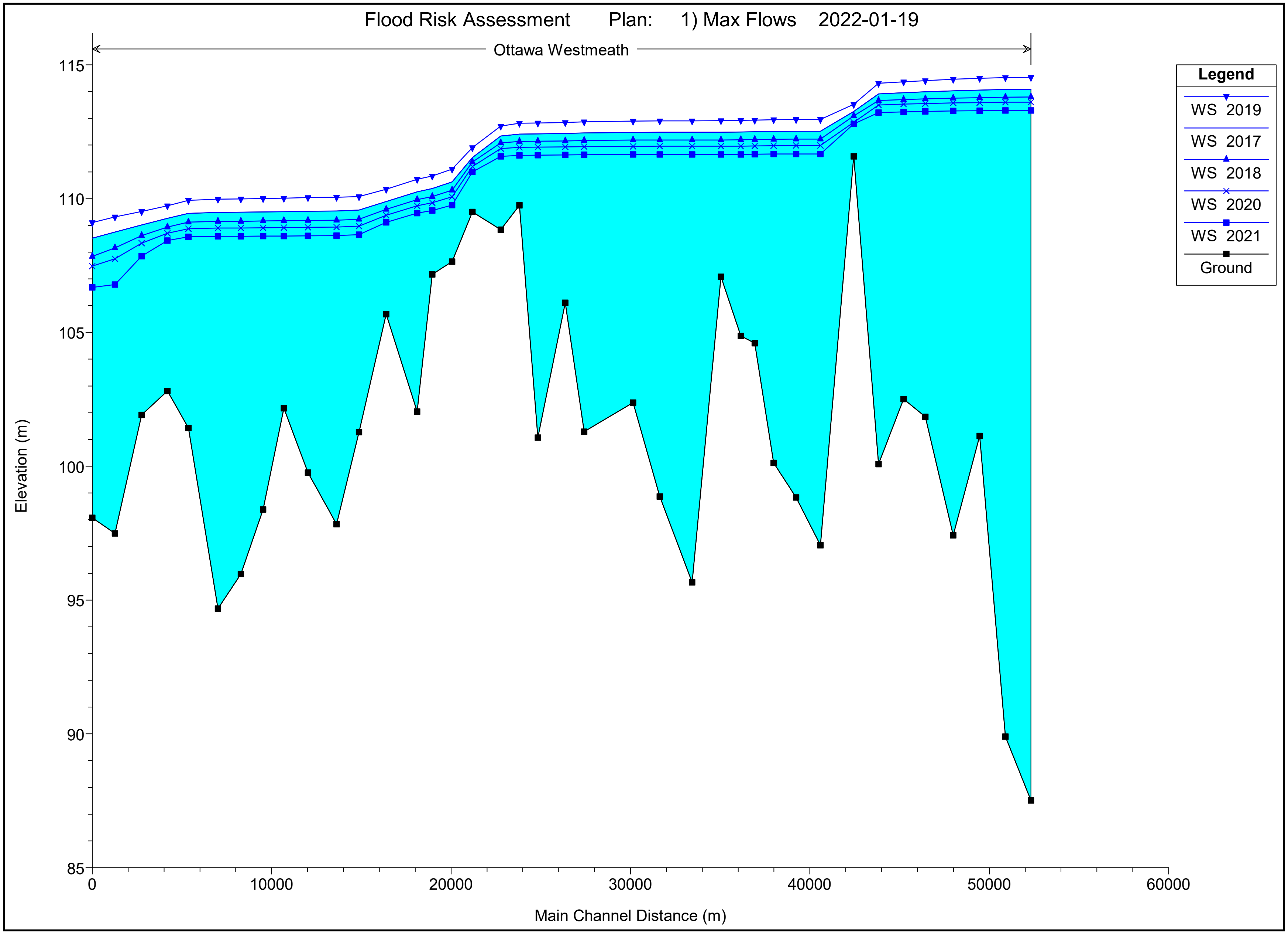
5000
Station (m)
Legend
WS 2019
WS 2017
WS 2018
WS 2020
WS 2021
Ground
Bank Sta


Flood Risk Assessment Plan: 1) Max Flows 2022-01-19
.07
.035
.07
Elevation (m)
Station (m)
Legend
WS 2019
WS 2017
WS 2018
WS 2020
WS 2021
Ground
Bank Sta


Flood Risk Assessment Plan: 1) Max Flows 2022-01-19
.07
.035
.07
Elevation (m)
Station (m)
Legend
WS 2019
WS 2017
WS 2018
WS 2020
WS 2021
Ground
Bank Sta


Flood Risk Assessment Plan: 1) Max Flows 2022-01-19
.07
.035
.07
Elevation (m)
Station (m)
Legend
WS 2019
WS 2017
WS 2018
WS 2020
WS 2021
Ground
Bank Sta



Flood Risk Assessment Plan: 1) Max Flows 2022-01-19
Ottawa Westmeath
Legend
WS 2019
WS 2017
WS 2018
WS 2020
WS 2021
Ground
Elevation (m)
115
110
105
100
95
90
85
0
10000
20000
30000
40000
50000
60000
Main Channel Distance (m)