New Hamburg Flood Mitigation Study
Technical Memo No. 2:
Flood Mitigation Options

Prepared for:
Grand River Conservation Authority

Prepared by:
Matrix Solutions Inc.

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March 2020
Guelph, Ontario

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Table of Contents

List of Graphics

List of Tables

Figures

Appendices

1 Introduction

The Town of New Hamburg, population of 14,000, in the Township of Wilmot, Ontario, is located along the Nith River and is one of 27 municipal Flood Damage Centres in the Grand River watershed. The Town developed historically within the Nith River floodplain and is subject to regular routine nuisance flooding, in addition to significant flooding events in 1975, 2008, and most recently in February 2018 and January 2020. Significant flooding affects residential, commercial and municipal properties: 194 buildings are located within the Regulatory floodplain - 152 (78%) are residential buildings and 42 (22%) are industrial, commercial or institutional (ICI) buildings.

To investigate potential mitigation strategies, the Grand River Conservation Authority (GRCA) retained Matrix Solutions Inc. (Matrix) to support the New Hamburg Flood Mitigation (NHFM) Study. This study includes: an assessment of the average annual damages associated with flooding in the Town of New Hamburg; the development and evaluation of potential mitigation strategies; and support for Public Information Centres (PIC).

1.1 Current Project Status

Matrix documented under Technical Memorandum #1 (Matrix 2020) the methodology for estimating annual average flood damages and results of the flood damage estimates under existing conditions.

GRCA held three Public Information Centres (PICs) for the New Hamburg Flood Mitigation Study. GRCA held a first PIC on June 26, 2019 to introduce the study to the New Hamburg community. A second PIC was held on November 25, 2019 to present the draft findings of the existing conditions flood damage estimates, and to seek input on the evaluation criteria as well as the long list of mitigation options. To obtain additional insight into the flood conditions/damages specifically experienced by New Hamburg landowners, GRCA undertook a survey in November-December 2019 (GRCA 2020). The results of the PIC and survey informed the development of a short list of mitigation solutions presented herein and provided valuable input for refining flood damage estimates. These flood damage estimates form the basis for evaluating the mitigation options. A third PIC was held March 11, 2020 to present the results of the evaluation of mitigation options.

This Technical Memorandum #2 outlines the development and evaluation of potential mitigation strategies. All contents in this memorandum are tailored to the flood mitigation options scope of the NHFM study.

1.2 Objective

The objectives of the flood mitigation options component of the NHFM study are to:

- identify potential flood mitigation options to reduce flood damages in New Hamburg
- provide a high-level evaluation of potential mitigation options based on estimated flood damages and return-on-investment
- identify and prioritize potential mitigation projects warranting further study or eligible for future funding programs

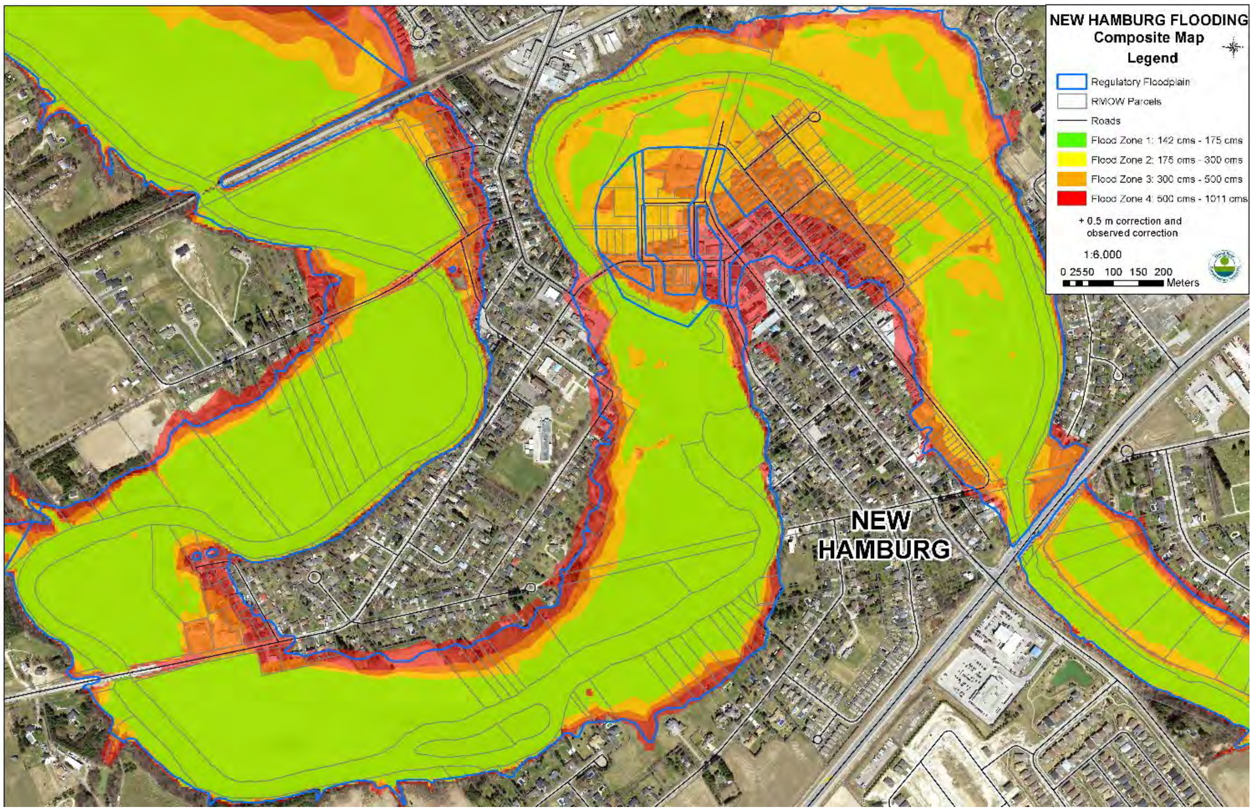
In consultation with the GRCA and Township of Wilmot, the approach to developing and evaluating flood mitigation options and updating flood damage estimates was tailored to these objectives. The approach is outlined in the Section 3.

1.3 Study Area

The study area for the flood damages assessment and flood mitigation options is shown on Figure 1. The study area includes structures within the updated (draft) 2020 Regional inundation boundary, south of the railway crossing.

The study area is illustrated with the breakdown of the Town's flood warning zones levels 1 to 4 (Graphic A). Level 1 reflects routine nuisance flooding under flows up to a about a 2-year return frequency (179 m^3/s), Level 2 up to near a 10-year return frequency(322 m^3/s), Level 3 up to a 100-year frequency (500 m^3/s), and Level 4 up the Regional Flood that is derived from Hurricane Hazel (1954, 1,011 m^3/s). The recent flooding in February 2018 and January 2020 were categorized as Level 3 floods with flows approaching a 50-year and 25-year return period, respectively.

Existing flood protection infrastructure consists of a low dike system and river channelization efforts completed in the 1970s that provides protection to less than the 5-year return interval (Figure 1). There is also an existing run-of-river dam downtown, upstream of the Hartman (Huron St) bridge (Figure 1).



Graphic A New Hamburg Floodplain and Flood Warning Zones (GRCA 2019a)

1.4 Types of Flooding

The focus of this study is riverine flooding and the associated risks. The difference between urban (also called pluvial) and riverine flooding can be subtle, especially for local landowners, but the contrast is important for appreciating the scope of this study, agency responsibility, and the impacts to regulated flood hazard limits. The following sections describe the differences and mechanism of flooding between urban and riverine flooding, as well as the mechanisms of flooding in New Hamburg.

Urban Flooding

Urban flooding includes “street flooding and basement flooding [which] occurs when there is more water than the local drainage system (sewers and streets) can handle, or when there is a lack of an overland flow route from a low-lying area. Urban storm infrastructure is the responsibility of municipalities” (TRCA 2019) and is not considered in regulated flood hazard areas. Flood mechanisms causing urban flooding include undersized inlets (i.e., catch basins, ditch inlets, etc.), undersized sewers, ill-defined overland flow paths, low-lying areas with no outlet, and combinations thereof.

Riverine Flooding

Riverine flooding occurs when water levels of rivers, streams, and creeks rise and overflow their banks, spilling onto adjacent areas. “Conservation Authorities are responsible for determining the hazard from riverine flooding” (TRCA 2019). Riverine flooding naturally occurs, but impacts can be made more severe by human influences such as urbanization, structures (i.e., bridges and culverts) built with insufficient hydraulic capacity, and development within floodplains reducing the conveyance capacity of channel systems.

Mechanisms of Flooding in New Hamburg

There are two distinct floodplain areas in New Hamburg, namely upstream and downstream of the New Hamburg Dam. In addition to the dam, there are five existing bridges crossing the Nith River through New Hamburg (Figure 1). Structures along rivers can impede ice flow during the winter and cause debris or ice jams. Ice jam flooding is less predictable than open-water flooding. These blockages can cause backwater flooding at flow rates well below what would be encountered in open water conditions. The release of a jam can also cause a sudden surge in flow downstream. Ice jams were a contributing factor to the February 2018 floods in New Hamburg, which had the third-highest flows since 1951. Ice jams have been observed behind the dam and around the Pedestrian and Highway 7/8 bridges.

1.5 Flood Prevention

In 2019, the Province of Ontario released *Ontario’s Special Advisor on Flooding Report to Government - An Independent Review of the 2019 Flood Events in Ontario*. The report provides an overview of the provincial flood program. It states:

> *Ontario’s current approach to managing risks associated with flooding is based on the five core components of emergency management: 1) Prevention; 2) Mitigation; 3) Preparedness; 4) Response; and 5) Recovery. Management is achieved through the use of a series of provincial acts, regulations, policies and technical guides that are implemented through partnerships with a number of provincial ministries, municipalities, First Nations and conservation authorities.*
>
> *The objectives with this approach are to save lives and money, protect property, public health and the environment, maintain economic stability, help assure the continuance of critical infrastructure, and reduce social disruption associated with emergencies.*

The prevention component of managing flood hazards in New Hamburg includes land use planning and implementation of the GRCA Regulation 150/06 which requires permission from the GRCA for development, alteration and some activities in the floodplain. In New Hamburg there are two types of floodplain policies that apply. These are One Zone Floodplain Policies and a Special Policy Area (SPA). The SPA provides greater flexibility than One Zone policies to ensure the economic and social viability of the downtown area of New Hamburg.

Although this study provides options related to mitigation of flood hazards to reduce damages due to flooding, any new infrastructure or new measures that may be implemented in the future are not intended to allow a significant increase in investments in development in the floodplain or open up new areas for development.

The updated floodplain maps that were developed through this study will be incorporated into municipal planning documents and will be used in the review of planning applications and GRCA Regulation maps and applications.

2 Background

This background section outlines the context for the development and evaluation of flood mitigation alternatives completed as part of the current study. This includes the review of historical flooding and previous flood mitigation alternatives considered by previous studies. It also outlines the current flood warning system.

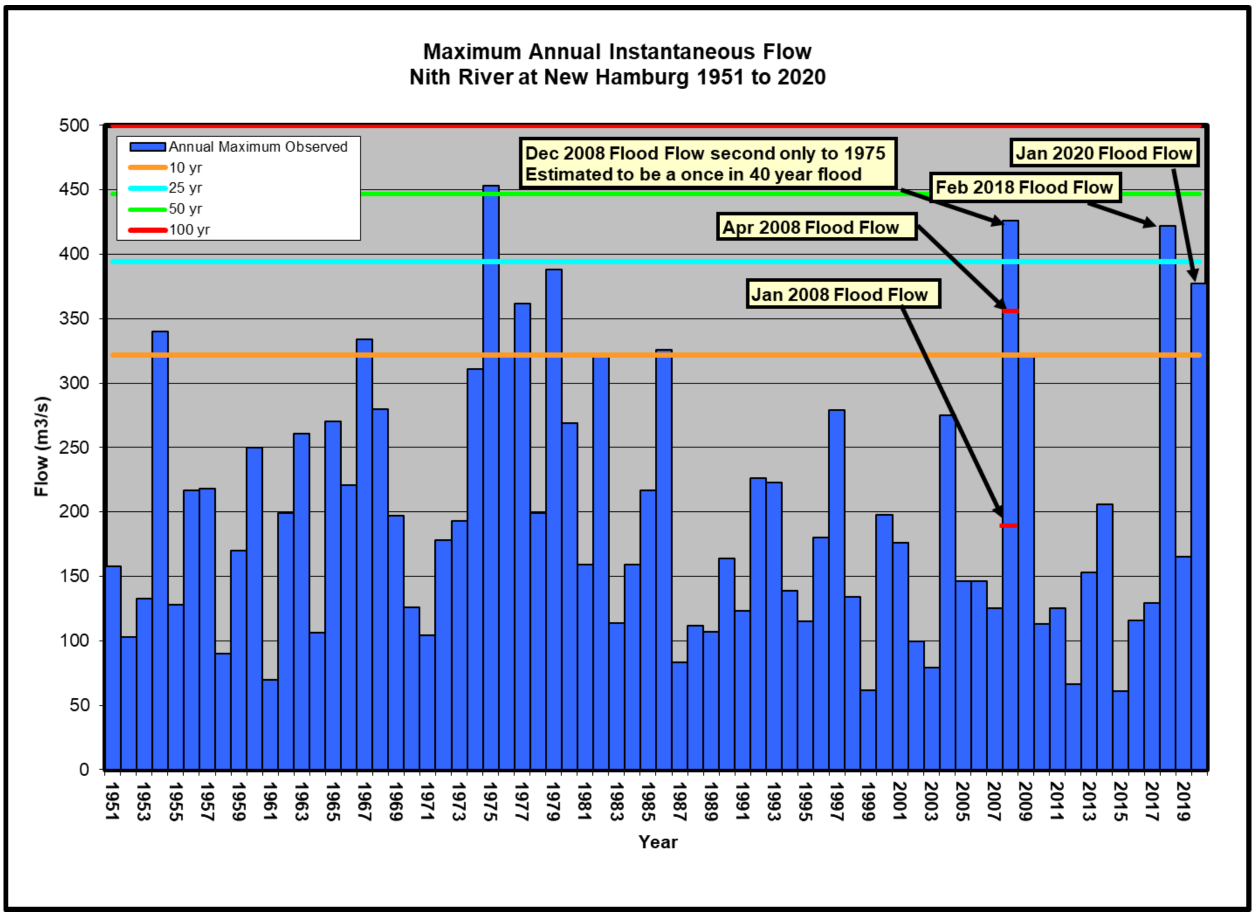
2.1 Historical Flood Mitigation

The Town of New Hamburg has a long history of flooding, with significant flooding events in 1948, 1954 (Hurricane Hazel), 1975, and more recently in April and December 2008, February 2018, and January 2020. Maximum instantaneous flows recorded at the Nith River at New Hamburg gauge are shown on Graphic B provided by GRCA for this study. The existing dike provides protection between the 2-year and 5-year flow rate of 179-265 m^3/s (Table A). The Nith River can also be impacted by ice and debris jams, which further reduces the conveyance capacity of the Nith River through New Hamburg, exacerbating flood conditions and impacts.

The frequency analysis and flood flow probabilities for this study (Table A) were provided by GRCA and are discussed in Technical Memorandum #1 (Matrix 2020).

Table A Flood Flow and Probability

Flow (m³/s)	Return Period (Year)	Probability
179	2	50%
265	5	20%
322	10	10%
350	15	6.7%
377	20	5%
394	25	4%
447	50	2%
500	100	1%
1,011 (Regional)	1,000 (estimated)	0.1%



Graphic B Maximum Instantaneous Flows Recorded on the Nith River at New Hamburg from 1951 to 2020 (provided by GRCA)

Early studies considered a proposed reservoir at Nithburg, channelization, and diking. Existing flood mitigation infrastructure and studies are summarized as follows:

- Nithburg Reservoir (studied 1950s-1980s)
- Channelization and dikes
    - Pre-1951 an existing dike was in place
    - 1951 Department of Planning & Development, Nith Valley Conservation Report Study (DPD 1951)
    - 1970 existing dike was built (Kilborn 1970 - which assumed Nithburg Reservoir would be built)
    - 1978 Preliminary Engineering Study (Kilborn 1978)
    - 1978-1982 Erosion Protection Works in place
    - 1982 Water Management Study of the Grand River basin (GRIC 1982)

The historical studies of flood mitigation alternatives are summarized in the following subsections.

2.1.1 Nithburg Reservoir

Previous studies completed by the GRCA (DPD 1951, GRCA 1979, GRIC 1982) have discussed the potential for upstream reservoirs as a method for mitigating downstream flooding.
The Nithburg Reservoir was proposed on the Nith River at the Town of Nithburg, approximately 40 km upstream of New Hamburg. However, due to the large uncontrolled area between the proposed site and New Hamburg (approximately 22,000 ha or 220 km^2), the structure was deemed unable to provide complete flood protection to the Town (DPD 1951).

The 1979 Environmental Assessment (EA) (GRCA 1979) performed a preliminary screening on 18 structural alternatives for flood control, water quality improvement and water supply requirements in the Grand River basin. The Nithburg Reservoir passed primary screening. During secondary screening, it was assessed on the basis of flood control (drainage area controlled, flood storage, reduction in peak damage cost), water supply (amount of water supplies, cost of water supplies), environmental impacts (impact on natural environment, impact on existing land use) and river quality (non-point source pollution abatement, point source abatement). The Nithburg Reservoir scored low for the flood control and the environmental impact criteria and was not carried on for future analysis.

2.1.2 Channelization and Diking

Nith Valley Conservation Report 1951

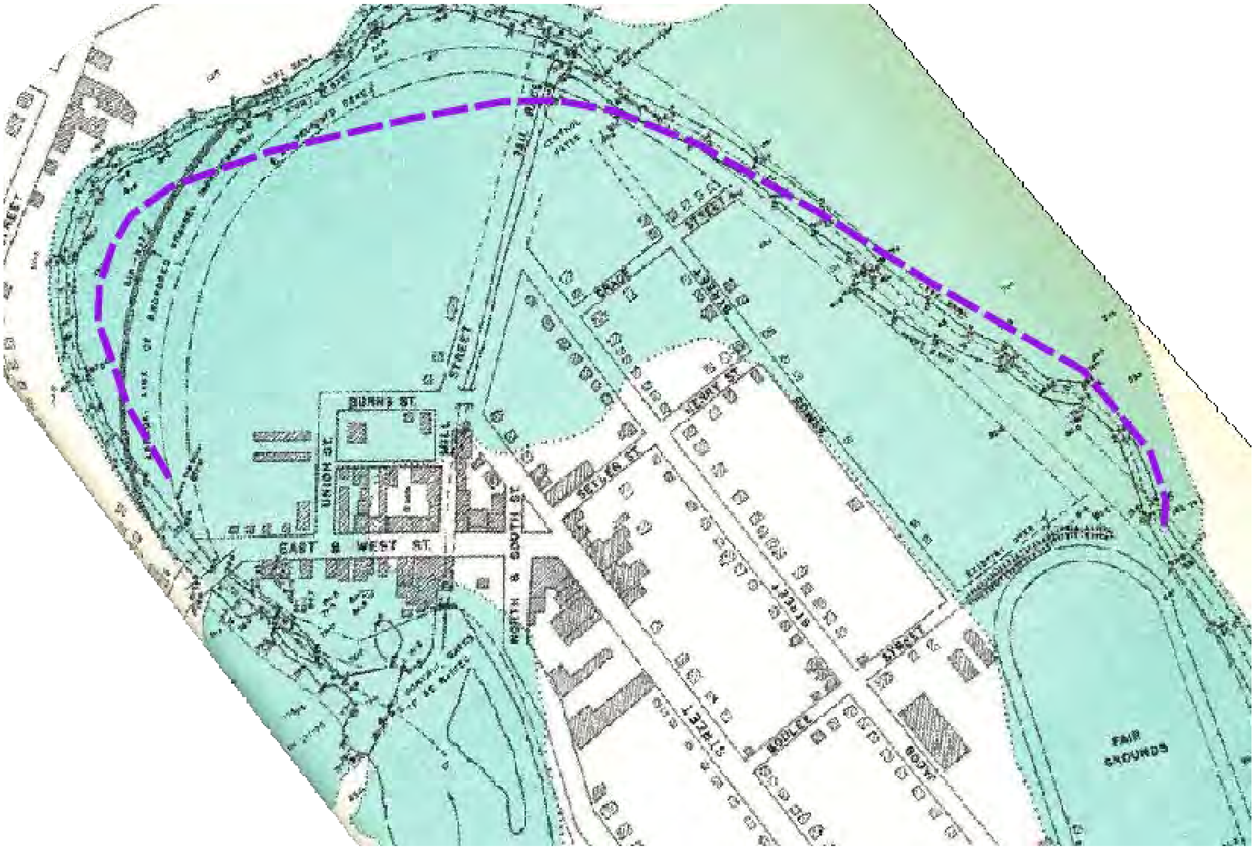
The 1951 Nith Valley Conservation report (DPD 1951) discusses flood mitigation options in the Nith Watershed. The report notes the need for immediate relief of flooding at New Hamburg, and the inadequacy of the proposed Nithburg Reservoir. New Hamburg channel improvements and diking are presented as alternative solutions.

Channel improvements include excavating 7,900 feet (2,400 m) in length with a channel bottom width of 100 feet (30 m) graded to uniform slope. This would be enough to contain flow of 4,740 ft^3/s (134 m^3/s) without flooding. The channel improvements would follow the course of the river, cutting off one bend just downstream of the Huron St (previously called East-West St) bridge. Rip-rap along the outer bank of the cut-off channel would need to be installed for erosion protection. Any further improvements are limited by the channel capacity immediately downstream of New Hamburg.

The diking proposed by DPD (1951) would raise the existing dike and provide protection up to 9,400 ft^3/s (266 m^3/s), the then-current capacity of the Huron St bridge. The dike alignment was proposed to begin approximately 140 m north of Church St and Wilmot St in New Hamburg, and extend to the existing dike at the fairgrounds, as shown in Graphic C. It was proposed that the dike would have a width of 8 feet (approximately 2.4 m) and would incorporate control gates at the (then-current) millrace.

The report recommended channel upgrades plus raising and extending the existing dikes to provide protection up to 9,400 ft^3/s (approximately 266 m^3/s, which is the current 5-year flow). Cost estimates at the time estimated river channel improvement at $49,500 and raising and extending dikes at $32,000, for a total of $81,500 all values in 1951 dollars, which is approximately equal to $777,400 in 2019 dollars.

The proposed dike and channel realignment from DPD (1951) were not constructed (Graphic C).



Graphic C **Preliminary Dike Alignment (DPD 1951) Shown with Current Dike Alignment (purple, dashed line)**

Preliminary Engineering Report Nith River at New Hamburg (Kilborn 1978)

Kilborn (1978) found that the existing earth dike was able to contain the 7-year flow.
To mitigate flooding at New Hamburg, dike improvements were proposed, and modelled in the HEC2 hydraulic modelling software. The study looked raising the top elevations of the existing earth dikes, extending the dike to the Highway 7 bridge, and improving the dikes in combination with raising the elevation of Jacob St in downtown. The review assessed options based on the effectiveness of mitigating flooding, property requirements, the effect on existing roadways and properties, constructions costs, maintenance and aesthetics. Two mitigations options were modelled and are presented and summarized in Table B below and shown in Graphic D below.

Table B Summary of Proposed Dike Options from Kilborn 1978

Option	Description
A	• Raise elevation of existing dike • Extend dike to the Hwy 7 bridge, on alignment adjacent to riverbank (Pink line in Graphic D)
B	• Raise elevation of existing dike • Extend dike to the Hwy 7 bridge, on alignment which follows extension of Boulee St. to high ground, then parallel to Jacob St (Green line in Graphic D)

The raising of Jacob Street was considered but deemed unviable due to access problems to houses on the lower portion of this street and the effects on storm drainage.

Option B was ultimately recommended, since it had a lower required dike height, lower channel velocities, smaller requirements for bank protection, and a subsequent lower cost.
The proposed alignment was found to contain the Regional storm with 1 - 1.5 ft of freeboard.

The hydraulic modelling included the reach from the dam to Highway 7. The report did not speak to any upstream impacts; however, the hydraulic modelling results table does list higher water surface elevations at the dam of 1 ft (30 cm) in the Regional under Option A and 0.11 ft (3 cm) in the Regional for Option B. For context, the Regional flow was 30,710 ft^3/s or 870 m^3/s in the 1978 study and is currently 1,011 m^3/s. The 100-year and 50-year water surface elevations at the dam under options A and B were lower than existing conditions.

Preliminary engineering construction cost estimates were provided based on three dike levels (Regional, 100-year and 50-year), as summarized in Table C. The construction costs considered the following (i.e., no engineering design or approval costs, and no land acquisition or easement costs):

- Site preparation
- Clearing and grubbing
- Restoration and cleanup
- Topsoil removal
- Supply and place earth fill for dikes
- Supply and install a 12-inch culvert, headwall and flap gate
- Supply and place topsoil, sod, riprap
- Contingency

Table C Construction Cost Estimates for Various Dike Control Levels from Kilborn 1978

	Regional Control	100-year control	50-year control
Option A	$747,800	$426,025	$292,575
Option B	$635,150	$337,475	$257,925

Note: All costs in 1978 dollars

Graphic D Proposed Dike Improvements from Kilborn 1978 Option A (pink line), Option B (green line), Current Dike Alignment (purple, dashed line)

2.1.3 Reservoir and Channelization/Diking Evaluation

A water management study of the Grand River basin (GRIC 1982) provides a comprehensive overview of water management in the watershed and includes an evaluation of a reservoir at Nithburg and channelization and diking in New Hamburg. This report states that channel improvements at New Hamburg would be less costly than the Nithburg Reservoir and would provide a greater reduction in the annual average flood damages. Channel improvements were estimated to eliminate $362,526 (1979 dollars) in damages, while the Nithburg Reservoir was expected to provide a reduction in damages of only $220,668 (1979 dollars) (GRIC 1982). These damages were based on the 1979 average annual damages (AAD) of $25,000 ($77,500 in 2016 dollars) applied over 50 years with a discount rate of 6% (per Appendix C to GRIC 1982).

The costs of channelization and diking, $760,000 (1979 dollars; roughly equivalent to $2.5M in 2019 dollars), were significantly less than the estimated $24M (1979 dollars; roughly equivalent to $79M in 2019 dollars) required for a reservoir at New Hamburg (GRIC 1982).

2.2 Flood Forecasting and Warning Systems

The GRCA's existing flood forecasting and warning system relies upon a combination of forecast information and real-time observed data to derive predicted flow conditions. In addition to monitoring forecast weather provided by international, national, and provincial sources, the GRCA operates a network of stream, rain and snow gauges, supported by human observations (e.g., River Watch), in and around the Nith River watershed, to create flow forecasts. Should potential flooding conditions be identified, the GRCA issues advisories, watches, and warning, in accordance with established provincial protocols, directly to emergency response agencies at the provincial and municipal level through an established and tested message "fan out" system.

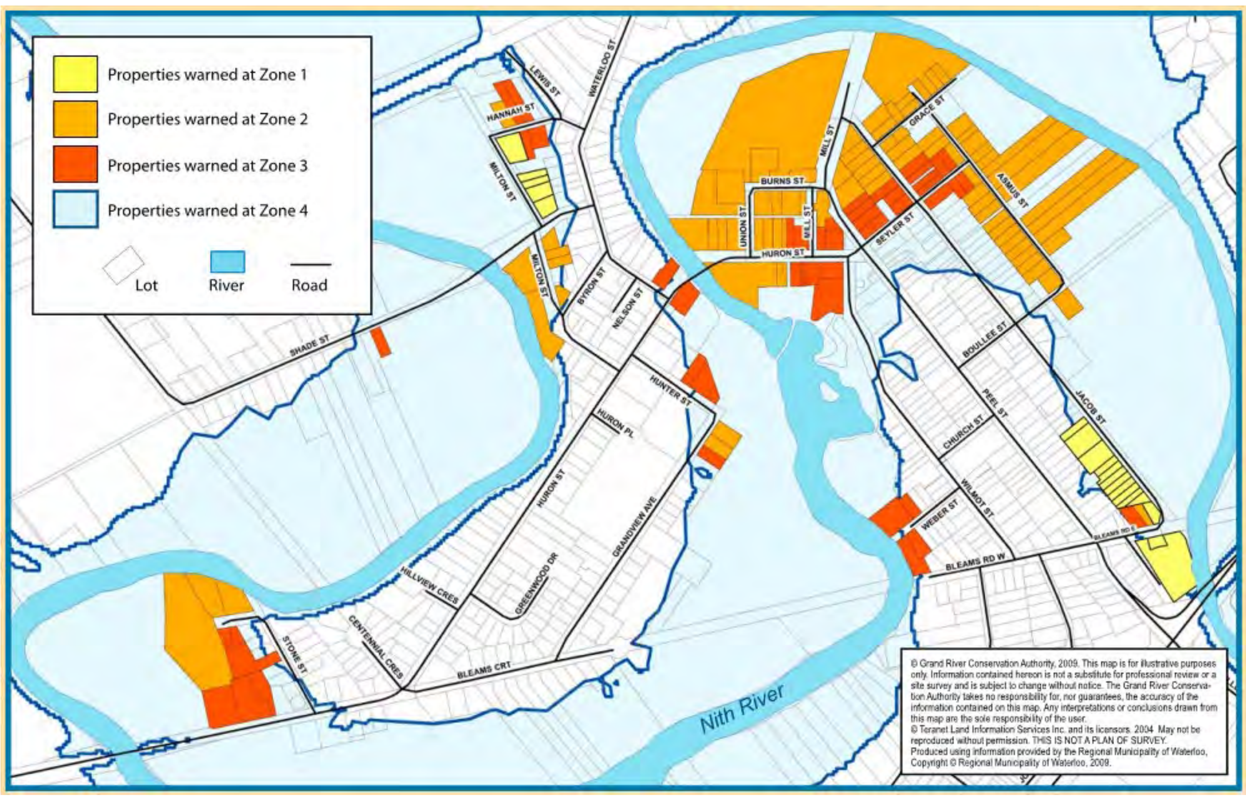
Numerous rain gauges, most notably those at Conestogo Dam, Nithburg, Wellesley Dam, Millbank, and Baden, monitor real-time precipitation conditions and are used as data inputs to flood forecasting models for the Nith Watershed. Snow surveys are completed during winter/spring periods, typically on a bi-weekly basis, in order to estimate the amount of potential runoff water that sits on the landscape in solid form. Stream gauges at Nithburg and Philipsburg provide in-river flow information and early warning (9 hours and 4 hours, respectively) for New Hamburg.

Flood warning zones are used within the Town to approximate limits of anticipated flood water inundation and identify properties at risk of flooding such that warnings can be disseminated efficiently and in a priority sequence. The four warning zones conform to known flow ranges as summarized in Table D.

Table D New Hamburg flood warning zones

Warning Zone	Nith River Flow Rate
1	142 - 175 m^3/s
2	175 - 300 m^3/s
3	300 - 500 m^3/s
4	>500 m^3/s

Properties that would be affected by flooding within a given zone have been identified, as shown in Graphic E, and these are individually notified by municipal responders upon issuance of an associated warning or watch from the GRCA as described further below (GRCA 2019b).



Graphic E New Hamburg Properties Affected at Flood Warning Zones (GRCA 2019b)

The GRCA has developed a “fan out” flood warning system to provide timely flood warning and information to concerned officials and to citizens where lives and property may be in danger. The GRCA is responsible for warning Municipal Flood Coordinators and Community Emergency Management Coordinators, police, provincial ministries and the media. In addition, the GRCA communicates flood messages through its website and social media channels. These methods of communication are considered supplementary and are not intended to serve as the primary warning system for watershed residents. The GRCA is not responsible for notifying individual citizens of the watershed. That responsibility lies with the municipality and the appointed Flood Coordinator. Each municipality is responsible for their own “fan out” system. The GRCA provides the following types of warning: watershed conditions statement (water safety when there are potential unsafe conditions for recreation or flood outlook as an early notice of the potential for flooding based on weather forecasts), flood watch (possible flooding) and flood warning (flood is imminent or occurring; road closures and/or evacuations may be required).

The effectiveness of the flood warning zone system is dependent on the ability to estimate and predict flows and levels through New Hamburg. Problems with monitoring equipment can result in either delayed warnings or false alarms. Uncertainty within key forecast model input data, such as weather forecasts, must be acknowledged and managed to the extent possible. As an example of how uncertainty can exist in a forecast, consider the April 2008 event, when greater flooding was observed than was predicted from estimated upstream flows.
This difference was subsequently attributed to problems with the rating curve at Philipsburg gauge, which is approximately 20 km upstream of New Hamburg and provides 4 hours of lead time. Additionally, it was found that the New Hamburg gauge level was measuring 0.33 m low (GRCA 2008). As a result of the events in April 2008, changes were made to the monitoring equipment at New Hamburg and to the Philipsburg rating curve. A buffer to the forecasted flows was added to be more conservative when assessing the flood warning zone.

The effectiveness of the flow-based warning system can also be compromised by ice and debris jams. These blockages can cause backwater flooding at flow rates well below what would be encountered in open water conditions. The release of a jam can also cause a sudden surge in flow downstream. Ice jams were a contributing factor to the February 2018 floods in New Hamburg, which had the third-highest flows since 1951.

3 Approach

The approach of identifying, developing, and evaluating potential flood mitigation strategies for the Town of New Hamburg included the following steps:

- review previously proposed flood mitigation options
- develop a long list of flood mitigation options
- establish screening criteria and evaluate long list of options:
    - screen out unviable mitigation options based on evaluation criteria
    - hydraulically screen variations and combinations of potentially viable mitigation options to inform short list of mitigation options

- select short list of conceptual mitigation options to evaluate based on the following criteria:
  - implementation costs
  - hydraulic impacts (i.e., flood reductions)
  - reductions to average annual flood damage estimates
  - return on investment (ROI)

3.1 Hydraulic Modelling Overview

The GRCA is concurrently updating the Regulatory floodplain mapping for Nith River at New Hamburg. The GRCA created a new HEC-RAS 1-D hydraulic model based on updated base mapping. GRCA has provided draft inundation mapping and the draft hydraulic model for use in this study. It is understood that peer review and public consultation of these products is ongoing. Matrix reviewed this model (version dated January 31, 2020) and views it as appropriate for use as the basis for evaluating conceptual flood mitigation alternatives.
If significant changes to water levels occurs as a result of finalizing the existing HEC-RAS model (e.g., > 10 cm during the Regional Flood), then it is recommended that the flood damage assessment be updated to reflect changes. Should alternatives move forward to a detailed design stage, a more rigorous hydraulic model may be required including a 2-D model for the downtown core.

Matrix modified the GRCA Nith River at New Hamburg hydraulic model to develop and evaluate flood mitigation options. These modifications included increasing the size of river cross-sections to reflect channelization works, re-aligning and modifying the height of the dike, and removing/modifying key structures represented in the model such as the New Hamburg Dam, the Hartman (Huron St) Bridge, the Pedestrian bridge, and the Highway 7/8 Bridge. Water levels at for all flood-prone structures (Figure 1), predicted by the hydraulic model for each mitigation option, were used in the flood damage calculations (Matrix 2020), to estimate average annual flood damages for each option. By completing this analysis, the reduction in annual average flood damages associated for each mitigation option was quantified.

3.2 Evaluation Criteria

Table E presents the criteria used to evaluate the long list of potential flood mitigation options. These criteria were developed with input from GRCA, the Township, as well as the public. Matrix applied a qualitative assessment based on these evaluation criteria (Appendix A), which formed the basis for advancing high-level mitigation options to a conceptual design (i.e., the short-listed options).

Table E Evaluation Criteria

1. Technical
1.1 Flood Risk Improvements
1.2 Ice Jam Resiliency
1.3 Climate Change Resiliency
1.4 Upstream Impacts
1.5 Technical feasibility/Constructability
2. Economic
2.1 Preliminary Return on Investment
2.2 Capital Costs (based on high-level evaluation)
2.3 Operation and Maintenance Costs
3. Environmental
3.1 Ecology and Aquatic Habitat
3.2 Geomorphology (e.g., erosion and sediment transport)
3.3 Heritage and Archaeology
4. Stakeholder
4.1 Public Acceptance
4.2 Property and Landowner Impacts
4.3 Safety
5. Policy
5.1 Regulatory Approvals
5.2 Land Use Planning and Floodplain Regulation
5.3 Environmental Assessment Requirements

3.3 Long List of Mitigation Options

Table F summarizes the long list of mitigation options that were considered in this study. These options were developed with input from GRCA and Wilmot Township and presented to the public for input at PIC No. 2 on November 25, 2019. Table F also summarizes the screening of the high-level solutions against the evaluation criteria and resulting options that were screened for further study; the full evaluation is provided in Appendix A.

Table F Long List of Mitigation Options Summary Evaluation

Long List Mitigation Options	Evaluation Summary (see Appendix A)	Evaluation Result
Channel Conveyance Improvements		
Channel Widening (i.e., widening the main channel)	• Preliminary hydraulic screening indicated minor water level improvements during Regional storm. • Moderate water level improvements for smaller flood flows and in combination with dike improvements and bridge improvements. • Requires engagement of GRCA, all levels of government, private property owners. • High aquatic habitat disturbance during construction; high long-term effects on ecology if regular dredging is required to maintain conveyance capacity.	Medium Preference (standalone option) Medium Preference (with other options) • Hydraulically screened in combination with bridge replacement and dike improvements. **Option Advanced for Further Study**
Dam Removal and Channel Naturalization (i.e., removing the dam and restoring the main channel to pre-dam conditions)	• Preliminary hydraulic screening indicated minimal opportunity to improve flood risks. • High environmental impacts and regulatory requirements anticipated for dam removal. • Low acceptance from public anticipated.	Low Preference **Option screened out**

Long List Mitigation Options	Evaluation Summary (see Appendix A)	Evaluation Result
Floodplain Improvement (i.e., modifying the dike alignment to increase the floodplain width)	• Preliminary hydraulic screening indicated minor water level improvements during large floods (i.e., >10 year - 322 m^3/s). • Moderate water level improvements during smaller floods (i.e., <10 year - 322 m^3/s). • Minimal ecology and aquatic habitat impacts expected (no instream construction). • Requires engagement of GRCA, all levels of government, private property owners.	Medium Preference (standalone option) High Preference (with other options) • Hydraulically screened in combination with dike improvements (i.e., floodplain improvements counter backwater impacts from flow containment). **Option Advanced for Further Study**
Bridge Replacement (i.e., evaluated by removing existing bridges)	• Preliminary hydraulic screening of backwater impacts of the Pedestrian and Highway 7/8 bridges were considered individually • Backwater impacts are mainly due to Hwy 7/8 bridge up to the 100-year flood (500 m^3/s), and mainly due to Pedestrian bridge at Regional Flood • Combined replacement of both Pedestrian and Highway 7/8 bridges indicated moderate water level improvements and was included in the short-list. • High capital costs • Minimal ecology and aquatic habitat impact long term.	Medium Preference (standalone option) Medium Preference (with other options) • Hydraulically screened in combination with other channel conveyance improvements. **Option Advanced for Further Study**

Long List Mitigation Options	Evaluation Summary (see Appendix A)	Evaluation Result
Flow Containment		
Dike Improvements (i.e., increased height for higher protection level)	• Dike improvements may be limited by upstream backwater impacts ('no go' if increased risk to upstream properties) • Requires engagement of GRCA, all levels of government, private property owners based on impacts to construction, property, heritage, and performance.	Medium Preference (standalone option) High Preference (with other options) • Hydraulically screened in combination with floodplain improvements (i.e., to counter backwater impacts). **Option Advanced for Further Study**
Floodwalls (i.e., where there is not enough space for earthen dike, a vertical treatment can be used)	• Moderate potential to mitigate small floods (e.g., 2- to 10- year - 179-322 m^3/s). • A floodwall solution may be limited by upstream backwater impacts ('no go' if increased risk to upstream properties). • Requires engagement of GRCA, all levels of government, private property owners based on impacts to construction, property, heritage, and performance. • A floodwall in combination with dike improvements could block flood flows from entering downtown.	Medium Preference (standalone option) High Preference (with other options) • Hydraulically screened in combination with floodplain improvements (i.e., floodplain improvements counter backwater impacts). **Option Advanced for Further Study**

Long List Mitigation Options	Evaluation Summary (see Appendix A)	Evaluation Result
Flow Diversion		
Bleams Road Conduit or Surface Flow (i.e., divert flows around downtown via Bleams Road)	• Minimal opportunity to improve flood risks due to spatial constraints. • Large impacts to property and existing Town infrastructure. • Low public acceptance anticipated.	Low Preference **Option screened out**
Highway 7/8 Diversion (i.e., divert flows around Highway 7/8 bridge via culverts etc.)	• Moderate capital costs, potentially moderate ROI. • Solution would need to consider cemetery just downstream of bridge. • Minimal ecology and aquatic habitat impacts expected. • Long-term monitoring and operation and maintenance required. • Advanced option as part of bridge replacement mitigation option. Details on the improved hydraulics as a function of bridge redesign or as diversion of flows can be assessed under future study.	Medium Preference (standalone option) Medium Preference (with other options) • Hydraulically screened in combination with channel conveyance improvements. **Option Advanced for Further Study** (as part of Bridge Replacement mitigation option scenario)
Storage		
Regional Flood Control (i.e., Nithburg Reservoir)	• Very high capital and operating costs, low ROI anticipated. • High environmental impacts anticipated. • Significant property/landowner impacts, lower acceptance from upstream stakeholders anticipated.	Low Preference **Option screened out**
Online Storage (i.e., lower the dam Invert to add online storage capacity)	• Minimal storage capacity available by lowering dam invert. Therefore, minimal opportunity to improve flood risks.	Low Preference **Option screened out**

Long List Mitigation Options	Evaluation Summary (see Appendix A)	Evaluation Result
Non-structural Solutions		
Improved Flood Resilience of Buildings (i.e., backflow prevention valves, basement waterproofing, sealed entrances, etc.)	• High to moderate ROI anticipated. The number/extent of properties implementing flood resilience measures can be selected to maximize ROI. • High public acceptance anticipated if program is developed to subsidize/rebate capital costs.	High Preference **Option Advanced for Further Study**
Land Acquisition (i.e., property buyouts)	• High ROI anticipated. The number of properties acquired can be a selected to maximum ROI. • Low stakeholder acceptance is anticipated due to 'ghost town' fears; but with some who support. • Economics of broader scale property buyouts could be considered in future study but was excluded from this study	Medium Preference **Option screened out**; could be assessed under future study
Improvements to the Flood Warning System	• Existing flood warning system is a watershed wide system, and review and improvements to the system are being pursued continuously. Therefore, the potential to achieve additional damage reductions may be marginal.	Low Preference **Option screened out**

3.4 Short List of Mitigation Options

Thirteen high-level mitigation options were screened against the evaluation criteria as summarized in the previous section: six were deemed to have a low preference and were screened out of the study, seven options were advanced for further study based on medium and high preference. Additional hydraulic screening was conducted for the medium preference options to assess their flood mitigation potential in combination with other options. This additional screening evaluated floodwall/dike improvements to have a high preference when combined with floodplain improvements as the latter reduces the backwater impacts caused by the former.

The high preference mitigation options (improved flood resilience of buildings, and floodwall/dike improvements in combination with floodplain improvements) along with two medium preference options (channel widening and bridge replacement) were carried forward and incorporated into the short list mitigation options. There are many potential combinations/variations for how these options could be implemented. As a means of narrowing down these variations, the short list mitigation options were established with a focus on providing flood protection against a range of design flows. This approach recognizes that providing mitigation against large floods (i.e., >100-year, 500 m^3/s) may be impractical and therefore evaluating options that provide protection against smaller floods (i.e., <50-year, 4 m^3/s) was viewed as key for the study objective of identifying potential projects that warrant further study. Even with implementation of some of these options, flooding would still have been experienced during recent events in 2020, 2018, 2008 (Graphic B). No mitigation options will remove all risk of flood damages - there will always be flood risk in the floodplain in New Hamburg.

The short-listed mitigation options are summarized as follows and Options 1-5 are illustrated in Figures 2 through 6:

Option 1 - Conveyance Improvements

- widened channel by 10 m over a 2 km reach between Hartman (Huron St) Bridge to Highway 7/8 Bridge (modified cross-sections 5406 to 3375 in the HEC-RAS model)

Option 2 - Dike and Floodplain Improvements for 100 Year Protection

- relocated existing dike to create additional floodplain area and set height to 0.5 m above the 100-year water level, 500 m^3/s (modified cross-sections 5333 to 4585 and 4218 to 3544 in the HEC-RAS model)

- raised existing dike to 0.5 m above the 100-year water level (modified cross-section 4585 to 4218 in the HEC-RAS model)
- extended flood containment upstream with floodwall, tied-in to Hartman (Huron St) Bridge (modified cross-section 5664 to 5406 in the HEC-RAS model)
- note that additional hydraulic mitigation was not able to reduce backwater impacts during the Regional storm upstream of the dam for this option (see Section 4.2)
- without considering backwater impacts, flooding would not have been experienced during recent events in 2020, 2018, 2008 with the implementation of this option (red line in Graphic B).

Option 3 - Dike, Floodplain and Conveyance Improvements for 25 Year Protection

- relocated existing dike to create additional floodplain area and set height to 0.15-0.20 m above the 25-year water level (modified cross-sections 5333 to 4585 and 4218 to 3544 in the HEC-RAS model)
- raised existing dike to 0.15-0.20 m above the 25-year water level, 394 m^3/s (modified cross-section 4585 to 4218 in the HEC-RAS model)
- extended flood containment upstream with floodwall, tied-in to Hartman Bridge (modified cross-section 5664 to 5406 in the HEC-RAS model)
- backwater impacts between the Dam and Highway 7/8 bridge were mitigated with conveyance improvements by widening the channel 10 m for 170 m between the Pedestrian bridge and Highway 7/8 bridge (modified cross-sections 3544 to 3375 in the HEC-RAS model)
- with the implementation of this option, flooding would still have been experienced during recent events in 2018, 2008 (blue line in Graphic B).

Option 4 - Dike Improvements for 10-Year Protection

- raised existing dike from a 2- to 5-year level to 0.15-0.20 m above 10-year water level (322 m^3/s) and extended upstream to Hartman (Huron St) Bridge, and downstream to Pedestrian bridge; dike alignment around the Fairgrounds similar to Option B from the Kilborn 1979 study (modified cross-section 5427 to 3544 in the HEC-RAS model)
- with the implementation of this option, flooding would still have been experienced during recent events in 2020, 2018, 2008 (orange line in Graphic B).

Option 5 - Pedestrian and Highway 7/8 Bridge Replacement

- removed Pedestrian and Highway 7/8 bridge from HEC-RAS model to estimate maximum impact those structures have on high water levels. It is assumed that structure replacements (i.e., at end of design life) would have negligible impact on modelled “no bridges” water levels due to presumed implementation of a design with increased conveyance capacity and improved hydraulics
- during bridge redesign, hydraulics can be assessed and optimized between bridge design capacity and flow diversion (e.g., culvert); this was not assessed further under this study.

Option 6 - Improved Flood Resilience of Buildings

- reduce flood damages by implementing a suite of residential lot-level measures including basement waterproofing, sealing basement entrances (doors and windows), and installing backflow prevention valves
- estimated potential flood damage reductions by assuming 80% reduction in basement damages for residences implementing the flood resilience measures within the 50-year inundation boundary until the first floor is flooded
- this assumes no additional or new flood resilience measures for residences outside the 50-year inundation boundary (i.e., same as existing conditions)
- no modifications to HEC-RAS model required to evaluate options
- flood damage calculations assume ICI buildings do not have basements; therefore, improved flood-resiliency measures are not applicable for ICI flood damage calculations

Option 7 - Vegetation Management along Existing Dike

- This option was explored by GRCA and findings have been incorporated in this report
- Vegetation between the river and existing dike is very dense which impedes flow conveyance and results in higher flood elevations
- Vegetation removal between the riverbank and the existing dike for a distance of 1,620 m was assessed by reducing the roughness coefficient between cross sections 5333 and 3714 in the HEC-RAS model
- Annual maintenance of vegetation removal would be required

4 Results

Each of the short-listed mitigation options were evaluated in terms of the following aspects:

- Implementation Costs
- Hydraulic Impacts
- Flood Damages
- ROI

The results from the short list mitigation option evaluation is summarized in the following sections.

4.1 Implementation Costs

High-level cost estimates have been prepared to provide capital costs for the mitigation options (Appendix B). Estimates for major items associated with construction of channel conveyance widening and retainment system (i.e., dike/floodwall) works including removals, clearing, earthworks, armouring, restoration and re-vegetation have been developed primarily as a function of length (options 1 to 5).

Additional construction costs associated with minor construction items (15%), access/staging (3%), erosion/sediment control (2%) and general items (i.e., mobilization/demobilization, costs of carrying bonding/insurance, site offices, etc., 2%) have been developed as a percentage of major construction items, and have been included in the total implementation costs.

Other project costs associated with study/design/approvals (15%), contingency (15%) and contextual allowances for impacts to adjacent utilities and urban/semi-urban environment have also been included for each alternative.

Notably, all estimates exclude costs associated with HST, cost sharing (if available), property acquisition or easements, phased/staged implementations and future operation/maintenance/monitoring.

Specific to each option, key considerations and cost estimates are summarized in the Table G.

Table G Cost Estimate Summary

Short List Mitigation Options	Implementation Costs	Cost Considerations
Option 1 - Conveyance Improvements	$26.2M	• Dewatering/water management of watercourse flows. • Infrastructure modifications (i.e., existing outfalls, local infrastructure, adjacent parking lots, etc.). • Naturalization features and compensation (i.e., low flow improvements, overbank area features, etc.). • Modifications to existing channel features (i.e., weirs, vanes, riffle/pools, etc.). • Tie-ins and connection of channel widening at upstream limits, existing Pedestrian bridge, existing Highway 7/8 bridge and downstream limits. • Perimeter barriers or fencing. • Modifications to existing dike, where impacted by channel widening. • Costs do not include ongoing operation and maintenance (i.e., dredging)
Option 2 - Dike and Floodplain Improvements for 100-Year Protection (500 m^3/s)	$27.7M	• Cut off wall/buoyancy treatments, toe drainage and local ditching/drainage and outlet features associated with new dike structure. • Vertical retainment treatments adjacent to existing urban areas (i.e., upstream and downstream of Hartman bridge). • Infrastructure modifications (i.e., existing outfalls, backwater valving/gates, local infrastructure, adjacent parking lots). • Tie-ins and connection of new dike at upstream limits, existing Hartman Bridge and downstream limits. • Perimeter barriers or fencing. • Removal of existing dike for floodplain creation or modifications where impacted by new dike. • Modify existing infrastructure, features and park programming within and adjacent to the created floodplain in the Fairgrounds area. • No costs have been included to account for upstream backwater impacts (e.g., property buyouts) which would be required in order for this option to be carried forward • Costs do not include operation and maintenance or land acquisition

Short List Mitigation Options	Implementation Costs	Cost Considerations
Option 3 - Dike, Floodplain and Conveyance Improvements for 25-Year Protection (394 m^3/s)	$25.9M	• Dewatering/water management of watercourse flows. • Naturalization features and compensation (i.e., low flow improvements, overbank area features etc.). • Modifications to existing channel features (i.e., weirs, vanes, riffle/pools etc.). • Tie-ins and connection of channel widening at upstream limits, existing Pedestrian bridge, existing Highway 7 bridge and downstream limits. • Cut off wall/buoyancy treatments, toe drainage and local ditching/drainage and outlet features associated with new dike structure. • Vertical retainment treatments adjacent to existing urban areas (i.e., upstream/downstream of Hartman bridge). • Infrastructure modifications (i.e., existing outfalls, backwater valving/gates, local infrastructure, adjacent parking lots). • Tie-ins and connection of dike at upstream limits, existing Hartman bridge and downstream limits. • Perimeter barriers or fencing. • Removal of existing dike for floodplain creation or modifications where impacted by new dike • Modify existing infrastructure, features and programming within and adjacent to the created floodplain in proximity to the Fairgrounds area. • Costs do not include operation and maintenance or land acquisition
Option 4 - Dike Improvements for 10-Year Protection (322 m^3/s)	$7.7M	• Cut off wall/buoyancy treatments, toe drainage and local ditching/drainage and outlet features associated with new dike structure. • Infrastructure modifications (i.e., existing outfalls, backwater valving/gates, local infrastructure, adjacent parking lots). • Tie-ins and connection of new dike at upstream limits, existing Hartman bridge and downstream limits. • Perimeter barriers or fencing. • Modifications of existing dike to increase height. • Costs do not include operation and maintenance or land acquisition

Short List Mitigation Options	Implementation Costs	Cost Considerations
Option 5 - Pedestrian and Highway 7/8 Bridge Replacement	\$18M - \$21M	• It is outside the scope of this study to determine bridge designs that would achieve the desired hydraulic improvements. As such, a simplified cost was carried forward to analyze the ROI under a 'best case' type of scenario for a replacement bridge installed before end-of-lifecycle. • The estimated implementation cost is based on the simplified assumption of \$8,000/m^2 deck area based on the existing bridge dimensions plus a 30% to 50% cost increase to achieve a more hydraulically efficient bridge (e.g., wider span, improved bridge piers). • Costs do not include operation and maintenance
Option 6 - Improved Flood Resilience of Buildings	\$1.6M	• The cost includes basement waterproofing, sealing basement openings (i.e., windows/doors), installing backflow preventers, and grading and exterior area modifications (\$25,000/ residence) • Costs were applied to all 63 residences within the 50-year inundation boundary
Option 7 - Vegetation Management along Existing Dike	\$0.2M	• Cost of clearing and grubbing for initial vegetation removal • Annual maintenance of vegetation removal would be required to maintain improved flow conveyance; however, annual maintenance costs may be lower once initial removal is completed • Costs do not include annual operation and maintenance

Notes: Option 7 results determined by GRCA. All costs are in 2019 dollars.

4.2 Hydraulic Impacts

The estimated flood depths for existing conditions and flood mitigation options 1 through 5 are shown on the Figure sets included in Appendix C for the 2-, 5-, 10-, 15-, 20-, 25-, 50-, 100-year, and Regional events using the water surface profiles modelled with HEC-RAS. These Figures show the updated Draft Regional inundation boundary (for existing conditions), the water surface elevation raster for each flood event and mitigation option, and the impacted buildings. The buildings are colour coded based on the depth of first floor flooding expected for each building. The flood depths for each building are used to inform the flood damage estimates. Appendix D includes water surface elevation profiles for existing conditions and short-listed mitigation options 1-5 for selected return period events and the Regional event. As Option 6 does not result in changes to flood depths, no figures are included in Appendices C or D. Option 7 does not result in significant (greater than 0.10 m) changes to flood depths; therefore, no figures are included in Appendices C or D.

Table H summarizes the hydraulic impacts for each mitigation option by comparing the average change in water level, modelled between the New Hamburg Dam and Highway 7/8 bridge, relative to existing conditions. It should be noted that this table presents the average water level change and is included to understand the relative change that can be expected. There may be locations within the reach that experience greater, or less, water level change. Furthermore, increases in water levels associated with a mitigation option should not be viewed as increasing flooding conditions. While certain mitigation options may increase riverine water levels, the assessed mitigation options are meant to contain these higher water levels within the floodplain, away from structures. Table H provides context on the degree to which the flood mitigation options change water levels and complement the figures provided in Appendix C and D.

As part of the preliminary hydraulic screening for Option 5 - Pedestrian and Highway 7/8 Bridge Replacement, the hydraulic impacts of replacing the Pedestrian and Highway 7/8 bridges were looked at individually and combined. The hydraulic impacts were determined to be mainly from the Highway 7/8 bridge up to the 100-year event and from the Pedestrian bridge (because it is overtopped) in the Regional event.

Table H Hydraulic Impact Summary - Average Change in Water Level New Hamburg Dam to Highway 7/8 Bridge Compared to Existing Conditions

Option*	Change in Water Level from Existing Conditions (m)								
	2 Year	5 Year	10 Year	15 Year	20 Year	25 Year	50 Year	100 Year	Regional
1	-0.34	-0.31	-0.31	-0.31	-0.32	-0.32	-0.34	-0.35	-0.48
2	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.05	0.09
3	-0.16	-0.17	-0.18	-0.18	-0.17	-0.17	-0.18	-0.20	-0.43
4	0.00	0.01	0.04	0.05	0.05	0.05	0.05	0.04	0.02
5	-0.15	-0.16	-0.17	-0.17	-0.16	-0.17	-0.19	-0.20	-0.26
6	0	0	0	0	0	0	0	0	0
7	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.03	-0.02

Notes:
*Mitigation Options include:
Option 1 - Conveyance Improvements
Option 2 - Dike and Floodplain Improvements for 100-Year Protection (500 m^3/s)
Option 3 - Dike, Floodplain and Conveyance Improvements for 25-Year Protection (394 m^3/s)
Option 4 - Dike Improvements for 10-Year Protection (322 m^3/s)
Option 5 - Pedestrian and Highway 7/8 Bridge Replacement
Option 6 - Improved Flood Resilience of Buildings does not result in changes to flood levels
Option 7 - Vegetation Management along Existing Dike; Option 7 results determined by GRCA

4.2.1 Backwater Impacts

Flood mitigation options 2, 3, and 4 raise the existing dike level to increase flood protection. A key design requirement for flood mitigation involving dikes is maintaining upstream water levels, or at a minimum, not increasing upstream flood risk. Table I summarizes the backwater impacts of each of the dike improvement options.

Table I **Hydraulic Backwater Summary during Regional Flood - Average Change in Water Level from New Hamburg Dam to Highway 7/8 Bridge Compared to Existing Conditions**

Option*	Backwater Impact during Regional Flood		Distance Upstream of New Hamburg Dam and with No/Minimal Backwater Impacts
	Along Dike/Floodwall (From New Hamburg Dam to Highway 7/8 Bridge)	Upstream of New Hamburg Dam and Reservoir (HEC-RAS Section 5863)	
2	0.09 m	0.38 m	3.6 km (≤5 cm backwater)
3	-0.43 m	0.05 m	1.9 km (≤3 cm backwater)
4	0.02 m	<0.01 m	0 km

Notes:
*Mitigation options with Regional backwater impacts include:
Option 2 - Dike and Floodplain Improvements for 100-Year Protection (500 m^3/s)
Option 3 - Dike, Floodplain and Conveyance Improvements for 25-Year Protection (394 m^3/s)
Option 4 - Dike Improvements for 10-Year Protection (322 m^3/s)

Backwater impacts for the dike improvement mitigation options are highlighted as follows:

- Option 2 realigns and raises the elevation of the dike and provides additional floodplain to provide protection to the 100-year water level (Figure 3). To counter the backwater impacts of the floodwall and raised dike, the dike alignment is shifted back from the river where practical to create floodplain (Figure 3). The net result is an increase in average water level, between the New Hamburg Dam and Highway 7/8 Bridge, of 1 cm during the 10-year return event to 9 cm during the Regional Flood (Table H). Upstream of the dam, the hydraulic modelling shows significant backwater impacts up to nearly 40 cm during the Regional Flood (Table I and Appendix D). This backwater impact is significant and would affect Regulatory floodplain and would not be acceptable without further mitigation measures.

- Option 3 realigns and raises the elevation of the dike, provides additional floodplain to provide protection to the 25-year water level (Figure 4). In addition, this option improves channel conveyance capacity by widening the channel along a 170 m reach upstream of the Highway 7/8 bridge. The net result is an average water level **decrease** between New Hamburg Dam and Highway 7/8 Bridge (Table H). Upstream of the dam, there are minor backwater impacts of about 5 cm during the Regional Flood (Table I) but no impacts to any structures (Appendix C and D).

- Option 4 raises the elevation of the existing dike along its current alignment and extends it to provide protection to the 10-year return event (Figure 5). The net result of this dike improvement is an average water level increase of 2 cm during the Regional Flood between the Dam and Highway 7/8 Bridge (Table H). Upstream of the dam, backwater impacts are negligible (Table I and Appendix D).

Evaluating hydraulic impacts in detail (e.g., using a 2-dimensional hydraulic model to evaluate conditions behind the existing/proposed dike in downtown New Hamburg) should be key in any future study that advances a dike improvement option. Based on the hydraulic impacts modelled in this study, dike improvements providing protection to the 100-year return event (option 2) are not acceptable without additional and extensive mitigation to reduce backwater impacts (e.g., property buyouts). Under the current hydraulic analysis, no combination of mitigation options (e.g., conveyance improvements, bridge removal) was sufficient to mitigate these upstream impacts. Alternatively, providing dike improvements for the smaller flood events evaluated in option 3 (25-year) and option 4 (10-year) are likely feasible where detailed modelling can confirm that minor backwater impacts do not increase upstream flood risks, and where required, these minor impacts are addressed with additional mitigation (e.g., channel conveyance improvements).

4.2.2 Flood Emergency Response Risk

Some short-listed mitigation options may have an impact on emergency response during flood events. For the purposes of this study, Table J identifies depth of flooding, flow velocity, and the product of depth and velocity as criteria for low, medium and high-risk areas for vehicular and pedestrian access. Low risk includes areas that are inundated but where vehicular and pedestrian access and egress may still be feasible. Medium risk areas do not permit vehicular access and egress due to water depths, but pedestrian access and egress (by a healthy adult) may be possible. High risk areas do not facilitate access of any kind. These flood risk criteria were used to develop high-level flood risk mapping using the output of the HEC-RAS model for the 25-year (394 m^3/s), 100-year (500 m^3/s) and Regional (1,011 m^3/s) events. The flood risk map sets are included in Appendix E and include the depth, velocity, depth x velocity, and flood risk for the 25-year, 100-year and Regional events for current conditions and the short-listed flood mitigation options 1 through 5. As Option 6 does not result in changes to flood depths, no Figures are included in Appendix E. Option 7 does not result in significant (greater than 0.10 m) changes to flood depths; therefore, no figures are included in Appendix E.

Table J Flood Emergency Response Risk Criteria

	Low	Medium	High*
Depth	≤0.3 m	>0.3 m and ≤0.8 m	>0.8 m
Velocity	≤1.7 m/s	≤1.7 m/s	>1.7 m/s
Depth × Velocity	≤0.4 m^2/s	≤0.4 m^2/s	>0.4 m^2/s

*Note: Exceedance of any one of the criteria results in high risk.

The intention of these maps is to provide a high-level comparison of how the potential mitigation options may improve emergency access during flood events. The results are based on output from the draft HEC-RAS model. The uncertainty level is higher with the velocity results, particularly behind the dike, due to the limitations of the 1-D hydraulic modelling.

Table K provides a qualitative comparison of the routes that meet the “high” risk criteria based on the maps in Appendix E and Table J above. The only mitigation options that substantively improve emergency access are options 2 and 3 with the new dike, until it is overtopped, and then emergency access is the same as under existing conditions. Option 6 (Improved Flood Resiliency of Buildings) and Option 7 (Vegetation Management along Existing Dike) would not impact emergency access routes (i.e., same as existing).

Table K Comparison of High-Risk Access Routes by Mitigation Option and Flood Event

Mitigation Option	25-Year (394 m^3/s)	100 Year (500 m^3/s)	Regional (1,011 m^3/s)
Existing Conditions	• South end of Jacob St • Asmus St • North end of Mill St • Milton St	• Same as 25-year plus • North end of Jacob St • Grace St • Union St	• Same as 100-year plus • Middle block of Jacob St • Huron St • Peel St • (i.e., all of downtown within Reg. inundation extent)
Option 1 Conveyance Improvements	• Same as existing (Existing dike is providing some protection on west side of downtown but once it is breached the area will be inundated and this is more a limitation of 1D modelling than actual risk level)	• Same as existing	• Similar to existing - middle block of Jacob St is reduced to low/medium risk
Option 2 Dike and Floodplain Improvements for 100 Year Protection	• access routes through downtown core are protected from flooding	• access routes through downtown core are protected from flooding	• Same as existing (dike is overtopped)
Option 3 Dike, Floodplain and Conveyance Improvements for 25 Year Protection	• access routes through downtown core are protected from flooding	• Same as existing (dike is overtopped)	• Similar to existing - middle block of Jacob St is reduced to low/medium risk
Option 4 Dike Improvements for 10 Year Protection	• Same as existing	• Same as existing	• Same as existing
Option 5 Pedestrian and Highway 7/8 Bridge Replacement	• Same as existing	• Same as existing	• Same as existing

Note: Routes listed are those that have limited access (i.e., they are not routes to be used during high-risk events).

4.3 Flood Damages

The estimated total flood damages were calculated as direct damage costs (i.e., content and structural damages), plus indirect damage costs. Indirect damage costs are calculated as a percentage of direct damage costs and include costs incurred due to:

- loss of sales/production/revenue and extra expenditure
- loss of transportation/ communication facilities/ public services, and
- flood clean up and flood fighting

Intangible damages, such as illness, stress, depression, insecurity, inconvenience, physical risk, community relations, and loss of environmental/historical assets, are not given a dollar value within the framework of the project; however, they are considered in the evaluation of mitigation options. The method for the flood damage calculations is documented in Technical Memo #1 (Matrix 2020).

The flood damages are used to calculate the average annual damages and when compared to the existing AAD, can be used to evaluate the ROI of the short-listed flood mitigation options.

The estimated total flood damages for existing conditions and mitigation options 1 through 5 are shown on the figure sets in Appendix F, for the 2-, 5-, 10-, 15-, 20-, 25-, 50-, 100-year, Regional events. Flood damage reductions for Option 6 were estimated using reduction factors (see Section 3.4) and did not require modifications of the HEC-RAS model; as a result, figures are not provided in Appendix F. Flood damage reductions for Option 7 were assessed by GRCA, and have not been included in the figure sets as it does not result in a significant (greater than 0.10 m) reduction in flood elevations. In this map series, the white buildings are those that were included in the study area but are not flooded under that event. Coloured buildings are represented by the total flood damages (direct + indirect damages) for each storm event. Grey buildings are not included in the study area.

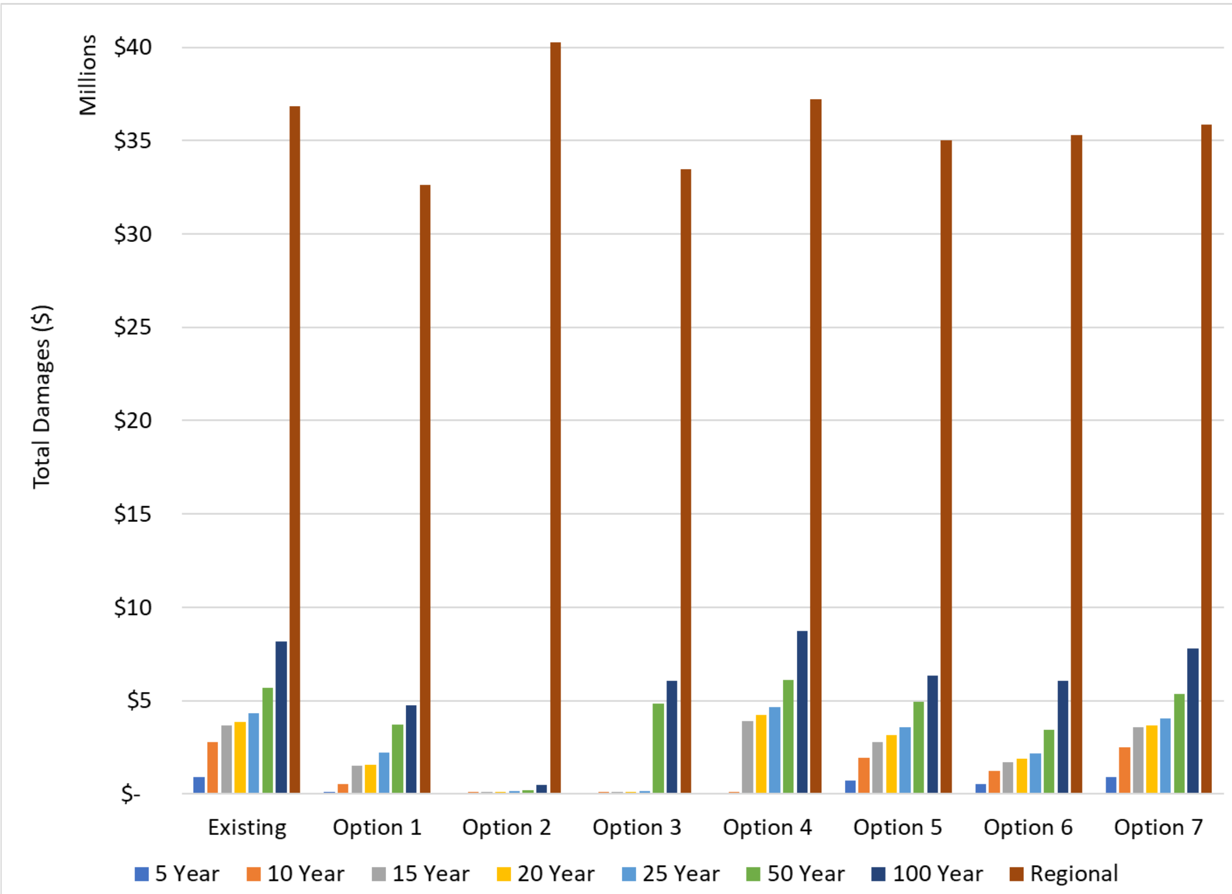
The total flood damages for existing conditions and each mitigation option are summarized in Graphic F for each flood event, and as a percent reduction in total damages from existing conditions in Graphic G. In Appendix F, the direct, indirect and total flood damages are listed for existing conditions and each mitigation options, broken down for residential buildings (Table F1), for ICI buildings (Table F2), and combined total (Table F3). The 2-year event was omitted as there are no damages. Based on these Graphics and Tables it can be seen that:

- **Option 1 Conveyance Improvements** - provides higher reductions in damages for smaller flood events (5- to 10-year), tapering to smaller reductions in damages in the Regional event
- **Option 2 Dike and Floodplain Improvements for 100-Year Protection (500 m^3/s)** - provides nearly complete reduction in damages in the 5- through 100-year events, and slightly higher Regional damages (from backwater creating higher flood depths once the dike is breached)
- **Option 3 Dike, Floodplain and Conveyance Improvements for 25-Year Protection (394 m^3/s)** - provides nearly complete reduction in damages in the 5- through 25-year events, and then smaller reductions in damages for events >25-year (from the added conveyance improvements)
- **Option 4 Dike Improvements for 10-Year Protection (322 m^3/s)** - provides nearly complete reduction in damages in the 5- through 10-year events, and then slightly higher damages for the events >10-year (from backwater creating higher flood depths once the dike is breached)
- **Option 5 Pedestrian and Highway 7/8 Bridge Replacement** - provides reductions in damages ranging from 10% to 30% for the 5- through 100-year events and by 5% for the Regional event
- **Option 6 Improved Flood Resilience of Buildings** - provides significant reductions in damages (30% to 70%) for the 5- through 100-year events and <5% in the Regional event
- **Option 7 Vegetation Management along Existing Dike** - reduces damages by 2-10% for the 5- through 100-year events, and by 2.5% for the Regional event

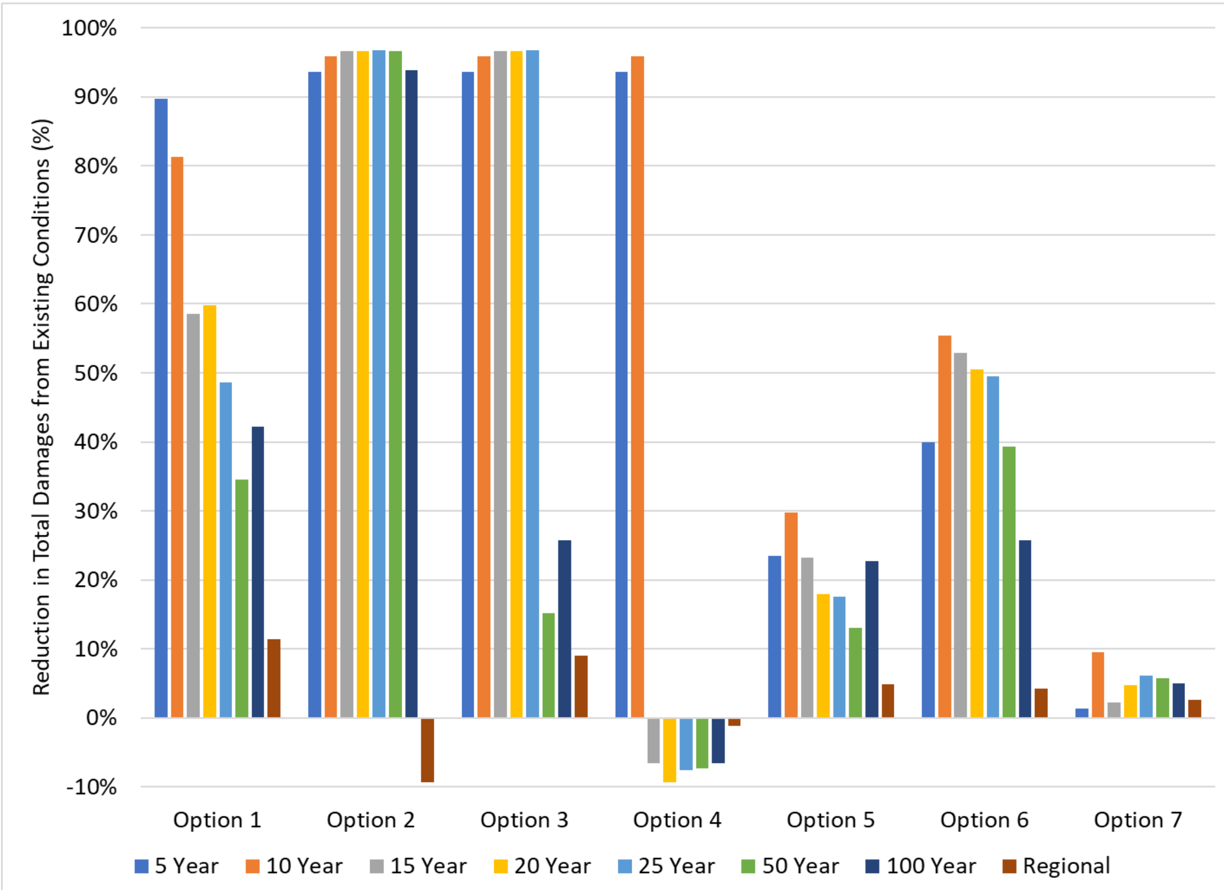
Table L summarizes the number of buildings affected by flooding for each mitigation option relative to existing conditions. This table provides context on the degree to which the flood mitigation options reduce flooding, based on basement flooding and first floor flooding.

Due to backwater impacts in mitigation Option 3, there are 11 buildings that are flooded in the Regional event that are outside of the Draft Regional inundation boundary and therefore, outside of the study area. The damages associated with these buildings were not included in the flood damage assessment as the associated building data was not included in the input data for the flood damage assessment tool. The impact of these is considered minimal for the overall AAD assessment and overall screening evaluation of the mitigation options. It should be noted that increasing the flood risk to these 11 structures would not be supported, and additional mitigation measures would be required in order to move forward with this mitigation option.

Option 7 Vegetation Management was assessed by GRCA; details in total damages have been provided in the tables found in Appendix F.



Graphic F Total Flood Damages for Existing Conditions and Mitigation Options



Graphic G Percent Reduction in Total Flood Damages from Existing Conditions

Table L Number of Flooded Buildings Summary Table

Flooding Description		No. of Building Flooded (No. Relative to Existing Conditions)								
		2 Year	5 Year	10 Year	15 Year	20 Year	25 Year	50 Year	100 Year	Reg.
Existing	Basement only	-	12	41	50	50	53	54	56	53
	First floor and basement	-	-	-	1	1	2	7	14	83
	First floor (no basement)	-	1	3	6	7	8	15	23	58
	Total Structures Flooding	**-**	**13**	**44**	**57**	**58**	**63**	**76**	**93**	**194**
Option 1	Basement only	-	3 (-9)	13 (-28)	24 (-26)	25 (-25)	33 (-20)	50 (-4)	58 (2)	55 (2)
	First floor and basement	-	-	-	(-1)	(-1)	(-2)	1 (-6)	2 (-12)	76 (-7)
	First floor (no basement)	-	(-1)	(-3)	1 (-5)	1 (-6)	3 (-5)	7 (-8)	10 (-13)	54 (-4)
	Total Structures Flooding	**-**	**3 (-10)**	**13 (-31)**	**25 (-32)**	**26 (-32)**	**36 (-27)**	**58 (-18)**	**70 (-23)**	**185 (-9)**
Option 2	Basement only	-	2 (-10)	3 (-38)	3 (-47)	3 (-47)	3 (-50)	4 (-50)	8 (-48)	52 (-1)
	First floor and basement	-	-	-	(-1)	(-1)	(-2)	(-7)	(-14)	87 (4)
	First floor (no basement)	-	(-1)	(-3)	(-6)	(-7)	1 (-7)	1 (-14)	2 (-21)	64 (6)
	Total Structures Flooding		**2 (-11)**	**3 (-41)**	**3 (-54)**	**3 (-55)**	**4 (-59)**	**5 (-71)**	**10 (-83)**	**203 (9)**
Option 3	Basement only	-	2 (-10)	3 (-38)	3 (-47)	3 (-47)	3 (-50)	57 (3)	58 (2)	55 (2)
	First floor and basement	-	-	-	(-1)	(-1)	(-2)	2 (-5)	5 (-9)	77 (-6)
	First floor (no basement)	-	(-1)	(-3)	(-6)	(-7)	1 (-7)	12 (-3)	17 (-6)	54 (-4)
	Total Structures Flooding	**-**	**2 (-11)**	**3 (-41)**	**3 (-54)**	**3 (-55)**	**4 (-59)**	**71 (-5)**	**80 (-13)**	**186 (-8)**
Option 4	Basement only	-	2 (-10)	3 (-38)	50 (0)	53 (3)	56 (3)	53 (-1)	55 (-1)	53 (0)
	First floor and basement	-	-	-	1 (0)	1 (0)	2 (0)	8 (1)	17 (3)	83 (0)
	First floor (no basement)	-	(-1)	(-3)	7 (1)	7 (0)	11 (3)	16 (1)	25 (2)	59 (1)
	Total Structures Flooding	**-**	**2 (-11)**	**3 (-41)**	**58 (1)**	**61 (3)**	**69 (6)**	**77 (1)**	**97 (4)**	**195 (1)**
Option 5	Basement only	-	7 (-5)	26 (-15)	36 (-14)	41 (-9)	45 (-8)	56 (2)	58 (2)	52 (-1)
	First floor and basement	-	-	-	(-1)	(-1)	(-2)	2 (-5)	5 (-9)	81 (-2)
	First floor (no basement)	-	1 (0)	2 (-1)	6 (0)	7 (0)	8 (0)	12 (-3)	17 (-6)	54 (-4)
	Total Structures Flooding		**8 (-5)**	**28 (-16)**	**42 (-15)**	**48 (-10)**	**53 (-10)**	**70 (-6)**	**80 (-13)**	**187 (-7)**

Flooding Description		No. of Building Flooded (No. Relative to Existing Conditions)								
		2 Year	5 Year	10 Year	15 Year	20 Year	25 Year	50 Year	100 Year	Reg.
Option 6	Basement only	-	12 (0)	41 (0)	50 (0)	50 (0)	53 (0)	54 (0)	56 (0)	53 (0)
	First floor and basement	-	-	-	1 (0)	1 (0)	2 (0)	7 (0)	14 (0)	83 (0)
	First floor (no basement)	-	1 (0)	3 (0)	6 (0)	7 (0)	8 (0)	15 (0)	23 (0)	58 (0)
	Total Structures Flooding	-	13 (0)	44 (0)	57 (0)	58 (0)	63 (0)	76 (0)	93 (0)	194 (0)
Option 7	**Total Structures Flooding**	-	13 (0)	42 (-2)	57 (0)	57 (-1)	62 (-1)	75 (-1)	91 (-2)	189 (-5)

Note: Option 7 - Vegetation Management along Existing Dike was assessed by GRCA and does not include the breakdown of basement only, first floor and basement, and first floor (no basement).

4.3.1 Average Annual Damages

The AAD is the cumulative potential damages occurring from various flood events over an extended period of time. The AAD is averaged over time and presented as a uniform annual amount. The AAD from flooding is computed by plotting the total damages vs probability distribution and then computing the area under the curve. The AAD for each mitigation option is summarized in Table M. To provide context for the AAD, the AAD was also calculated based on only direct damages and only indirect damages, as well as under two climate change scenarios - the 2050s and 2080s. The current climate science understands that storms are becoming more frequent with the changing climate, and therefore, have an increased probability of occurring. The details on how the AAD scenarios are calculated are documented in Technical Memo #1 (Matrix 2020).

Under future climate scenarios, the AAD is much higher than the existing storm event probabilities; for the 2050s, it is on average 115% higher and for the 2080s, it is on average 250% higher. There is a lot of uncertainty around climate change predictions. Preparedness and warning are important adaptive measures and the GRCA will continue to improve the flood forecasting system and tools and work with Township emergency managers to deliver warnings to affected residents.

Table M Average Annual Damages for Existing Conditions and Mitigation Options

Mitigation Option	Total (Direct + Indirect) Damages AAD	Direct Damages AAD	Indirect Damages AAD	Total AAD under 2050s Climate Change Scenario	Total AAD under 2080s Climate Change Scenario
Existing Conditions	$905,000	$739,700	$165,400	$1,587,400	$2,266,400
Option 1 - Conveyance Improvements	$392,900	$324,200	$68,800	$847,900	$1,380,200
Option 2 - Dike and Floodplain Improvements for 100 Year Protection	$215,200	$175,000	$40,200	$566,600	$1,067,700
Option 3 - Dike, Floodplain and Conveyance Improvements for 25 Year Protection	$307,200	$250,700	$56,500	$769,300	$1,283,900
Option 4 - Dike Improvements for 10 Year Protection	$584,900	$478,000	$106,900	$1,204,200	$1,956,000

Mitigation Option	Total (Direct + Indirect) Damages AAD	Direct Damages AAD	Indirect Damages AAD	Total AAD under 2050s Climate Change Scenario	Total AAD under 2080s Climate Change Scenario
Option 5 - Pedestrian and Highway 7/8 Bridge Replacement	$728,200	$590,100	$138,100	$1,322,200	$1,931,100
Option 6 - Improved Flood Resilience of Buildings	$562,469	$442,566	$119,903	$1,085,536	$1,658,407

Note: Option 7 - Vegetation Management along Existing Dike was assessed by GRCA and was not assessed under climate change scenarios.

4.4 Preliminary Return on Investment

The preliminary ROI was computed for each option using the implementation cost and AAD and is summarized in Table N. The values in Table N are based on the probabilities under existing climate conditions and return periods (not future climate scenarios).

When considering the ROI, it is important to understand that it is based on the AAD, which is a theoretical concept, and not a concrete or certain cost or cost reduction. It is not the same as computing the ROI for a new road or bridge for example, which has a finite cost and lifecycle. The investment in flood mitigation could pay off in only a few years if multiple large floods occur shortly after implementing the mitigation options, or it could be much longer if there are no large floods for many years.

The ROI presented is considered preliminary, for the purpose of evaluating potential mitigation options and it is recommended that more advanced economic assessment would be done as part of further studies.

Table N Return on Investment

Option	Implementation Cost	Benefit (AAD Reduction)*	Cost:Benefit Ratio	Preliminary Return on Investment
Option 1 - Conveyance Improvements	$26M	$0.51M	51:1	51 years
Option 2 - Dike and Floodplain Improvements for 100 Year Protection (500 m^3/s)	$28M	$0.69M	41:1	41 years
Option 3 - Dike, Floodplain and Conveyance Improvements for 25 Year Protection (394 m^3/s)	$26M	$0.60M	43:1	43 years
Option 4 - Dike Improvements for 10 Year Protection (322 m^3/s)	$7.7M	$0.32M	24:1	24 years
Option 5 - Pedestrian and Highway 7/8 Bridge Replacement	$18M - $21M	$0.17M	106-123:1	106 to 123 years
Option 6 - Improved Flood Resilience of Buildings	$1.6M	$0.56M	5:1	5 years
Option 7 - Vegetation Management along Existing Dike	$0.2M	$0.04M	5:1	5 years

Note: *Benefit is calculated as the reduction in average annual flood damages from existing conditions.

4.5 Summary

Table O summarizes the results of the short-listed mitigation options evaluation. The evaluation includes the cost:benefit analysis outlined in the previous sections, and qualitative evaluations of each option for climate change resiliency, debris and ice jam resiliency, emergency access (from Section 4.2.2), and stakeholder considerations, as well as notes for future study.

For the climate change resiliency evaluation, as storms are becoming more frequent with the changing climate and have an increased probability of occurring, then if the mitigation option can be designed to have added capacity or provide a higher level of protection to account for this, it was considered to have climate change resiliency.

For debris and ice jam resiliency, each mitigation option was evaluated if the proposed measures would improve, worsen, or not change the likelihood of debris/ice jams. Flood mitigation options that widen the channel or floodplain and add conveyance capacity were assumed to potentially improve debris/ice jamming; conversely, flood mitigation options that further confine or restrict flows, were assumed to potentially worsen debris/ice jamming. It was assumed that any new bridge replacement designs can be redesigned to improve conveyance and improve debris/ice jamming. There is considerable complexity in debris/ice jam flooding, and it is less predictable than open-water flooding. The debris/ice jam resiliency of potential flood mitigation measures should be looked at further in future studies.

As previously outlined and referring back to Graphic B, even with implementation of some of these mitigation options, flooding would still have been experienced during recent flood events:

- without considering the backwater impacts, flooding would not have been experienced during recent events in 2020, 2018, 2008 with the implementation of Option 2 (red line in Graphic B).
- with the implementation of Option 3, flooding would still have been experienced during recent events in 2018, 2008 (blue line in Graphic B).
- with the implementation of Option 4, flooding would still have been experienced during recent events in 2020, 2018, 2008 (orange line in Graphic B).

Table O Summary of Short-Listed Mitigation Options Evaluation

Mitigation Option	Implementation Cost	Benefit: AAD Reduction & Summary	Preliminary ROI or Cost:Benefit Ratio	Climate Change Resiliency	Debris/Ice Jam Resiliency	Emergency Access	Stakeholder Considerations	Notes on Future Study
Option 1 - Conveyance Improvements	$26M	$0.51M Higher reductions in damages for smaller flood events (5- to 10-year), tapering to smaller reductions in damages in the Regional event	51 years or 51:1	Expanding channel widening for climate change resiliency is constrained by hydraulic benefit, land and environmental impacts	Conveyance improvements may improve debris/ ice jam resiliency.	No change to emergency access (flooded roads)	Requires engagement of GRCA, all levels of government, private property owners.	This option has a lower preference compared to options 2, 3, and 4, due to a lower ROI, ongoing maintenance and environmental considerations. Conveyance improvements warrant future study when used in combination with dike improvements (e.g., Option 2). Under future study, costs should consider operation and maintenance requirements (e.g., frequency of dredging) and more advanced economic assessment.
Option 2 - Dike and Floodplain Improvements for 100-Year Protection (500 m^3/s)	$28M	$0.69M Nearly complete reduction in damages in the 5- through 100-year events, and slightly higher Regional damages	41 years or 41:1	Increasing flood protection level for climate change resiliency is constrained by backwater impacts	Floodplain improvements may improve debris/ ice jam resiliency.	Improvements to emergency access (flooded roads) until the dike is overtopped (Regional Flood event)	Requires engagement of GRCA, all levels of government, private property owners. Impacts to private property from raised dike, number of properties affected depend on dike alignment	The results of the dike improvement options warrant further study as medium-term mitigation options. It would be a key objective of a future study to balance dike improvements with the additional mitigation required (e.g., floodplain creation, channel widening) to offset backwater impacts. The results of this study indicate that protecting to the 100-year return period (500 m^3/s) may be impractical based on increased flood risks caused by backwater impacts; whereas protection to a 10-year flood (322 m^3/s) or 25-year flood (394 m^3/s) are likely feasible. Under future study, costs should include land acquisition and/or mitigate upstream backwater impacts, operation and maintenance requirements and more advanced economic assessment.
Option 3 - Dike, Floodplain and Conveyance Improvements for 25-Year Protection (394 m^3/s)	$26M	$0.60M Nearly complete reduction in damages in the 5- through 25-year events, then smaller reductions in damages for events >25-year	43 years or 43:1			Improvements to emergency access (flooded roads) until the dike is overtopped (>25-year flood event)		
Option 4 - Dike Improvements for 10 Year Protection (322 m^3/s)	$7.7M	$0.32M Nearly complete reduction in damages in the 5- through 10-year events, slightly higher damages for events >10-year	24 years or 24:1		Raising dike without realignment to create floodplain may worsen debris/ ice jamming.	Improvements to emergency access (flooded roads) until the dike is overtopped (>10-year flood event)		

Mitigation Option	Implementation Cost	Benefit: AAD Reduction & Summary	Preliminary ROI or Cost:Benefit Ratio	Climate Change Resiliency	Debris/Ice Jam Resiliency	Emergency Access	Stakeholder Considerations	Notes on Future Study
Option 5 - Pedestrian and Highway 7/8 Bridge Replacement	$18M - $21M (before end of lifecycle)	$0.17M Reduces damages by 10% to 30% for the 5- through 100-year events and by 5% for the Regional event	106 to 123 years or 106-123:1	New bridges can be designed for climate change resiliency (i.e., increased capacity).	New bridges can be designed for debris/ ice jam resiliency.	No change to emergency access (flooded roads)	Requires engagement of Ministry of Transportation, municipal government, and GRCA.	Return on investment exceeds typical bridge lifecycle. The cost-benefit of replacing the bridges is too high to warrant further consideration in the short-term to medium-term. When the existing bridges are replaced at the end lifecycle, the marginal cost of improving the hydraulic capacity of the bridge compared to the existing structures can be optimized for a given ROI period. More advanced hydraulic and economic assessments would be done as part of future studies.
Option 6 - Improved Flood Resilience of Buildings	$1.6M	$0.56M Reduces damages by 30% to 70% for the 5- through 100-year events and <5% in the Regional event	5 years or 5:1	Number of properties and proposed measures can be expanded for climate change resiliency	No change compared to existing conditions.	No change to emergency access (flooded roads)	Requires voluntary private property participation. Number and extent of properties can be optimized to maximize return on investment.	These measures are feasible to be implemented in the immediate/short-term.
Option 7 - Vegetation Management along Existing Dike	$0.2M	$0.04M Reduces damages by 2% to 10% for the 5- through 100-year events and 2.5% in the Regional event	5 years or 5:1	Limited climate change resiliency because vegetation management has smaller impact at higher flows	Limited potential to improve debris and ice jam resiliency	No change to emergency access (flooded roads)	Engagement of all landowners would be required.	These measures are feasible to be implemented in the immediate/short-term.

5 Conclusions, Recommendations and Next Steps

The objective of the NHFM study was to provide a high-level evaluation of potential flood mitigation options. This high-level study was needed to assess and update earlier studies with new information, assessment tools and modelling. This study was not intended as an Environmental Assessment (EA). The high-level study considered a range of options both in terms of level of protection and type of mitigation. An EA is required in order to determine a preferred solution, prior to proceeding with detailed design.

The results of the high-level evaluation completed in this study identified:

- Short-term, low-cost initiatives with a high ROI (5 years) for improving the flood resilience of buildings. These measures are feasible to be implemented in the immediate/short-term, pending landowner agreement and funding availability. Public awareness and education on these mitigation strategies should be a focus for local and regional government, GRCA, and other stakeholders, such as the insurance industry, which can also play a role in education. The residents of New Hamburg have already proven their resiliency and many residents are already implementing some of these measures. Consolidated efforts, with the assistance (both financially and logistically) by government, agencies, local organizations, landowners, or other stakeholders will provide the greatest impact, and greatest immediate reduction in flood damages. This initiative will provide protection to varying levels and flood events, depending on the measures that are implemented and to what elevation, for each individual property.

- A second short-term, low-cost initiative is vegetation management along existing dike. Cost and ROI considerations were for initial implementation, and ongoing (annual) maintenance of vegetation removal would be required. This initiative provides a modest reduction in flood elevations (less than 0.10 m) for all flood events (2-year through 100-year and Regional floods).

- Medium-to-long-term initiatives may be feasible to assist in reducing flood damages within the Town of New Hamburg by providing flood protection during more frequent flood events (e.g., up to the 25-year flood, 394 m^3/s). The high-level screening completed in this study found that these initiatives have a longer ROI (24-41 years) and would require further study, including an EA and detailed design. The next steps are to explore potential funding sources, including, but not limited to:

    - Funding arrangements among all levels of government and GRCA.
    - The Government of Canada launched the Disaster Mitigation and Adaptation Fund (DMAF), a national merit-based program that cost-shares implementation of large-scale infrastructure projects to help communities better manage the risks of disasters triggered by natural hazards (administered through Infrastructure Canada).
    - These next steps could be looked at in parallel with the implementation of the short-term mitigation measures.
- As a long-term initiative, the Highway 7/8 and Pedestrian bridges have a moderate impact on the hydraulics within New Hamburg. Under existing conditions, the hydraulic impacts were determined to be mainly from the Highway 7/8 bridge for the 5-year through 100-year events and from the Pedestrian bridge (it is overtopped) in the Regional event.
  The cost-benefit of replacing the bridges is too high to warrant further consideration in the short term. The ROI is longer than, or in line with, the lifecycle of the bridge. However, in line with the lifecycle of the bridge, further study on improved hydraulics should be considered in the design of the new bridges to reduce backwater impacts and ice and/or debris jams. Given the age of the existing bridge (built in the 1980s), this is anticipated to be in 30-40 years. These bridge improvements would reduce flood elevations during all flood events (2-year through 100-year and Regional floods).

In addition to the next steps recommended above, the following are technical considerations and recommendations for future studies:

- It is understood that the HEC-RAS model which forms the basis of the flood damage estimates is in draft and will go through peer review in the near future. Once the modelling is finalized, the results should be reviewed, and the flood damage assessment should be revised if necessary.
- 2D modelling is recommended to assess flow paths behind the dikes which may more accurately assess the backwater impacts of proposed mitigation options including conveyance and dike improvements.
- Provincial maintenance of vegetation in the right-of-way of Highway 7/8 within the floodplain of the Nith River could be another short-term, low-cost initiative that was not assessed under this study.

- The economics of broader scale property buyouts were excluded from this study and are recommended to be considered under future studies, particularly in combination with structural mitigation options.

- A more sophisticated analysis of ROI (e.g., discount values, property costs) in any future EAs.

6 Closure

Overall, the NHFM study achieved the objectives of identifying, evaluating and prioritizing at a high level, potential flood mitigation options to reduce flood damages in New Hamburg. The initiatives warranting further study should be explored with future funding programs.

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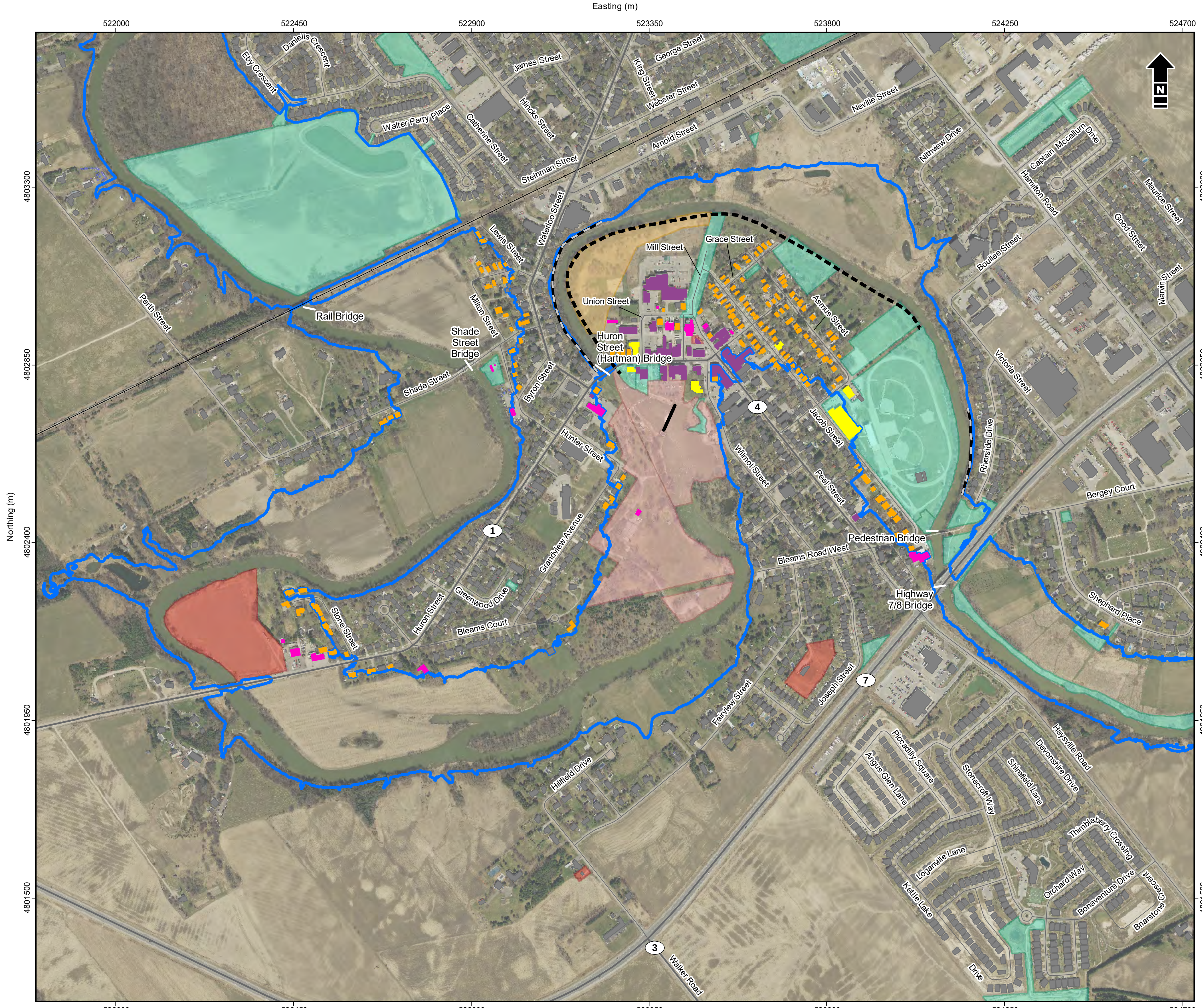

Draft Regional Inundation Boundary
GRCA Owned but Township Managed Lands
GRCA Owned and Managed Lands
Township of Wilmot Managed Lands
Region of Waterloo Managed Lands
Dam
Existing Dike
Existing Erosion Control Works
Railway
Highway
Road

Building Type

Commercial
Industrial
Institutional
Residential
Not in Study Area

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1:10,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Study Area

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

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Figure 1

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ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 – Conveyance Improvements

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

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Figure 2

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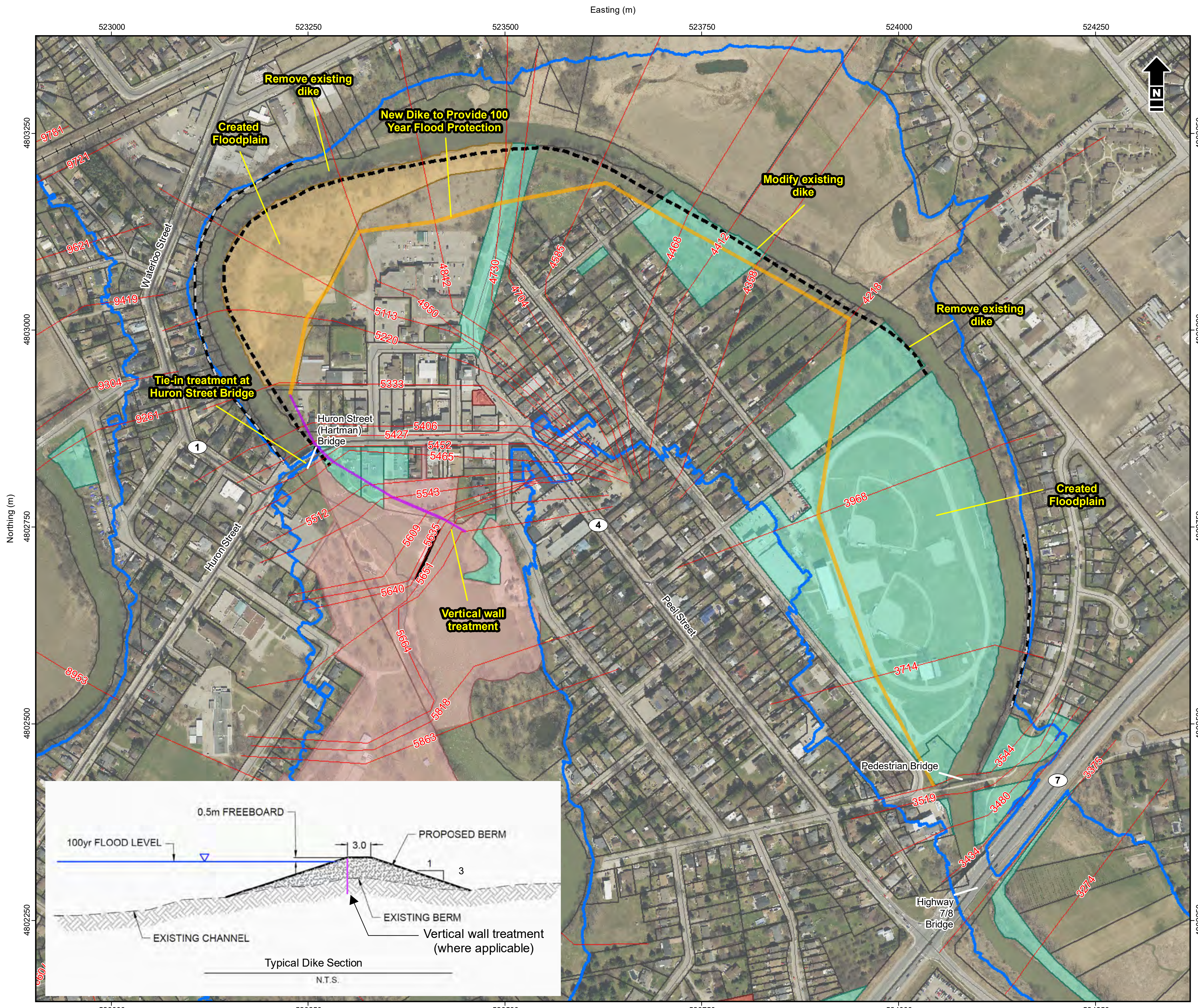

Draft Regional Inundation Boundary
GRCA Owned but Township Managed Lands
GRCA Owned and Managed Lands
Township of Wilmot Managed Lands
Region of Waterloo Managed Lands
Parcel Fabric
Proposed Top of Dike
Proposed Vertical Wall Treatment
Hydraulic Cross Section
Dam
Existing Dike
Existing Erosion Control Works
Railway
Highway
Road

1:5,000 metres
NAD 1983 UTM Zone 17N

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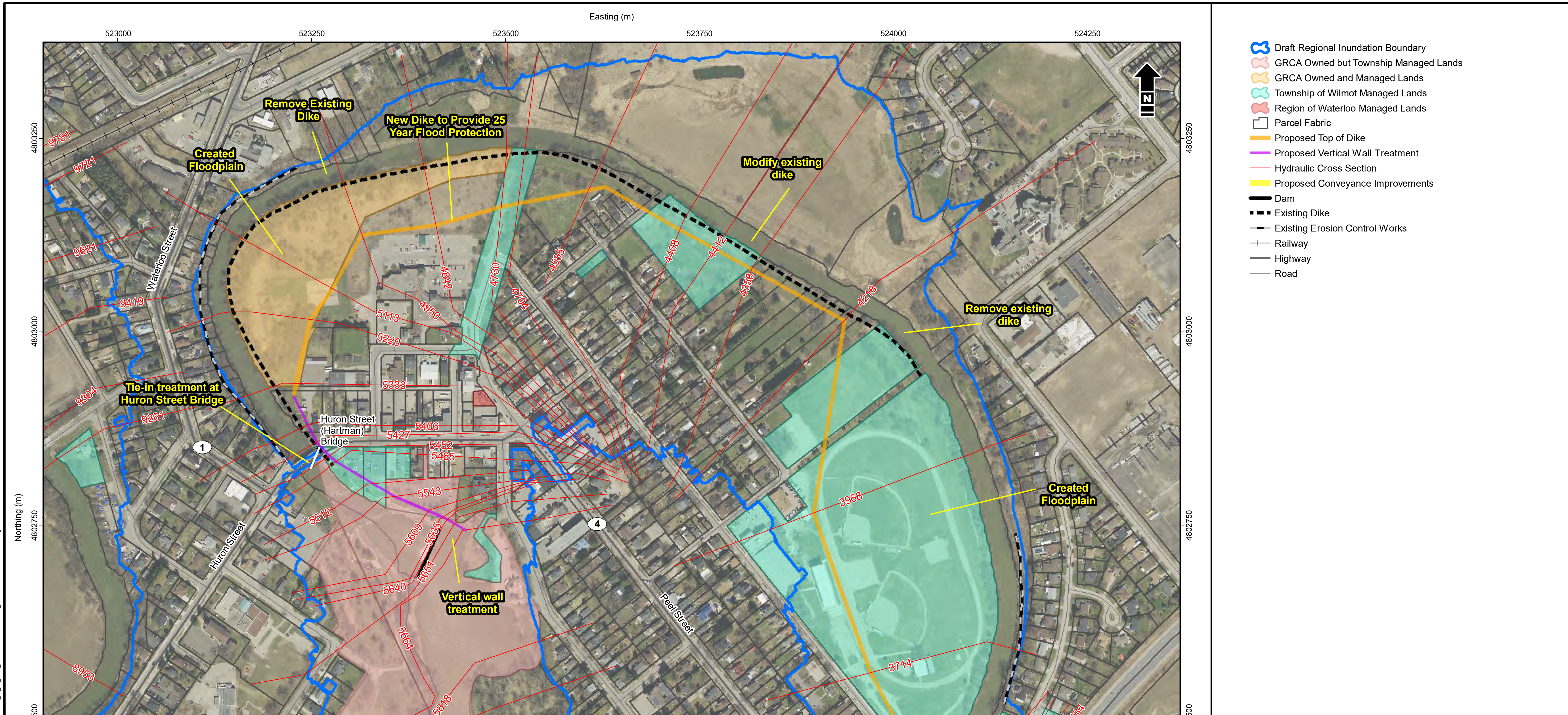
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 – Dike Improvements for 100-Year Protection (500 m³/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 3



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1:5,000 metres
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NAD 1983 UTM Zone 17N

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 – Dike and Conveyance Improvements for 25-Year Protection (394 m³/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

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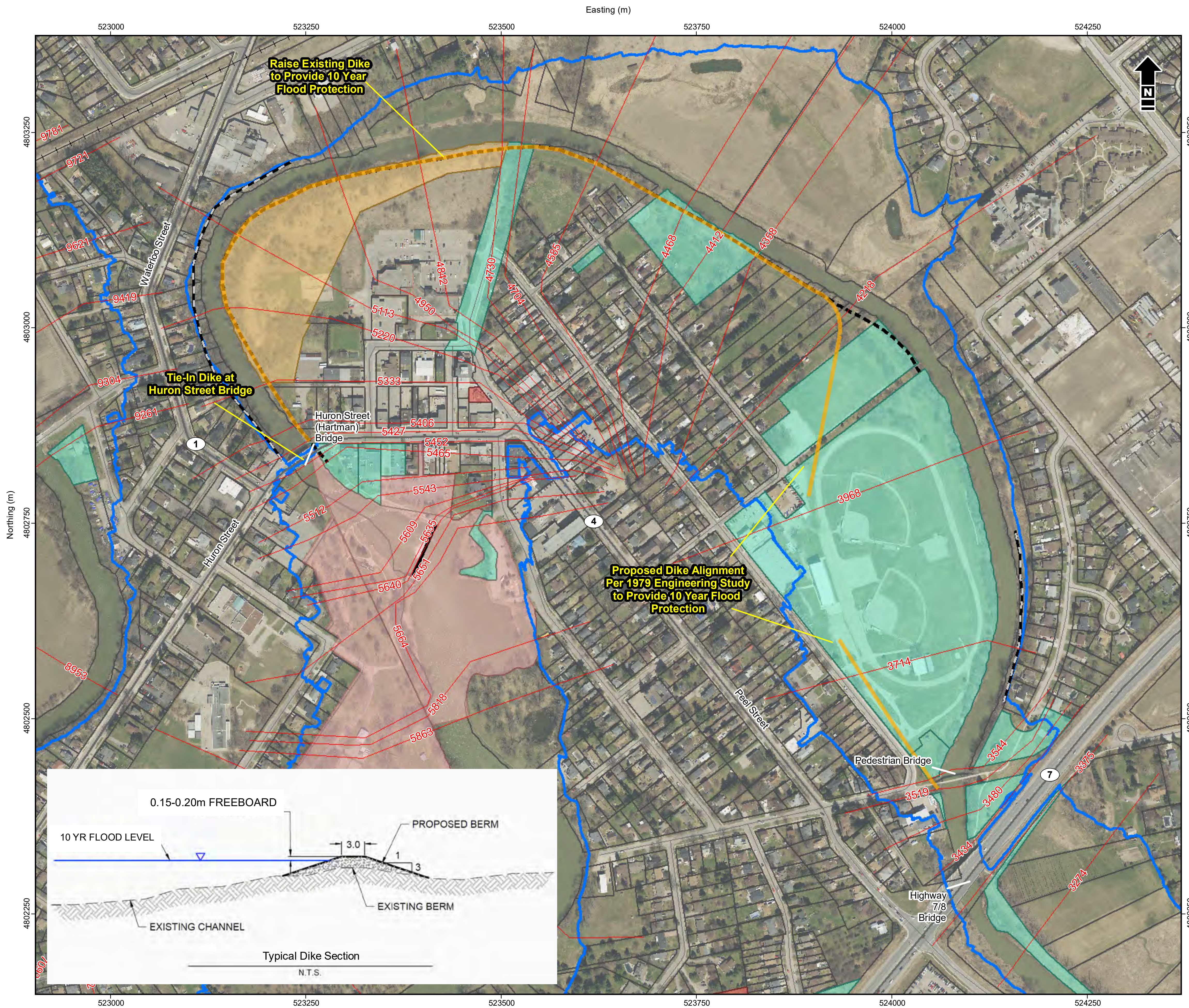
Figure 4



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Dam
Existing Dike
Existing Erosion Control Works
Railway
Highway
Road

1:5,000 metres
50 0 50 100
NAD 1983 UTM Zone 17N

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New Hamburg Flood Mitigation Study

Option 4 – Dike Improvements for 10-Year Protection (322 m³/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
5

I:\GrandRiverCA\29006\FiguresAndTables\HYD2020\ClientTM2\Figure-5-Option_4_Dike_Improvements_for_10_Year_Protection.mxd - Tabloid_L - 19-Mar-20, 10:42 AM - lmwright - TID005

- Draft Regional Inundation Boundary
- Dam
- Existing Dike
- Existing Erosion Control Works
- Railway
- Highway
- Road

County and Township data: Data provided by the Region of Waterloo and Township of Wilmot.

Reference: Contains information licensed under the Open Government Licence – Ontario. Imagery (2015) obtained by Grand River Conservation Authority and Matrix Solutions Inc. used under license.

1:5,000 metres
50 0 50 100
NAD 1983 UTM Zone 17N

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 – Pedestrian and Highway 7/8 Bridge Replacement

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 6

Appendix A
Evaluation of Long List of Mitigation Options

Long-List Mitigation Alternatives Screening Table

Criteria	Channel Conveyance Improvements				Flow Containment	
	Channel widening/lowering	Dam Removal and Upstream Channel Naturalization	Floodplain Improvement	Bridge Replacement	Dike Improvements	Floodwalls
Description of Hydraulic Screening Scenario	10 m widening on inside bend through downtown and downstream of Hwy 7/8 bridge.	Removed dam and replaced cross-sections upstream of dam with typical channel and floodplain dimensions.	Moved existing dike back from the top of the right bank to the edge of existing building.	Removed Hwy 7/8 and pedestrian bridge from HEC-RAS model to estimate backwater impacts.	Moved existing dike back from the top of the right bank to the edge of existing building and increased the height.	Blocked flow along the right bank upstream of the existing dike to evaluate the required floodwall height for various design flows.
1. Technical						
1.1 Flood Risk Improvements	Limited opportunity to lower channel due to relatively shallow channel gradients. Minor water level improvements during regional storm. Moderate water level improvements for smaller flood flows and in combination with dike improvements and bridge improvements.	Minimal improvements to water levels.	Minor water level improvements during large floods. Moderate water level improvements during smaller floods (e.g. 2 to 10 yr).	Moderate water level improvements for Hwy 7/8 and pedestrian bridge. Minimal water level improvements for other bridges including the Hartman Bridge.	Moderate potential for small floods (e.g. 2 to 10 yr). Dike improvements may be limited by upstream backwater impacts.	Moderate potential for small storms (e.g. 5 to 10 yr). Floodwall height is limited by upstream backwater impacts.
1.2 Ice Jam Resiliency (due to improvements upstream of dam)	Minimal with channel widening downstream of dam.	High with dam removal and upstream channel naturalization.	Minimal with floodplain creation downstream of dam.	High with increase of bridge spans at Hwy 7/8. No change for ice jam at dam.	Restricted flow area may worsen flood jamming.	Restricted flow area may worsen flood jamming.
1.3 Climate Change Resiliency	Limited opportunity to incorporate climate change resiliency into channel widening design.	Limited capacity within floodplain of naturalized channel upstream of dam.	Limited capacity within floodplain creation downstream of dam.	Bridge replacement can be designed for climate change resiliency.	Dike improvements can be designed for climate change resiliency.	Floodwall can be designed for climate change resiliency.
1.4 Upstream Impacts	Improvements to upstream water levels.	Small improvements to water levels upstream of dam.	No impacts to water levels upstream of dam.	No improvements to water levels upstream of dam.	Upstream backwater impacts of dike improvements need to be addressed or "no go" due to increased flood risks to upstream properties. 2D modelling recommended to assess upstream backwater impacts.	Backwater impacts of floodwall need to be addressed to not increase flood risks to upstream properties. If not addressed, this is a 'no-go'. 2D model required
1.5 Technical feasibility/Constructability	High. Access available. Construction in the river.	Moderate. Construction in the river.	High.	Moderate.	High. Infrastructure (e.g. pumping) required for drainage back to River. Likely only feasible in combination with other solutions to address backwater impacts.	High. Infrastructure (e.g. pumping) required for drainage from to River. Likely only feasible in combination with other solutions to address backwater impacts.
Technical Screening Result	High Preference	Low Preference	Medium Preference	High Preference	Medium Preference	Medium Preference
2. Economic						
2.1 Return on Investment (ROI)	Potentially moderate ROI, particularly in combination with other solutions.	Low ROI anticipated.	Low on its own; potentially moderate in combination with other options.	Potentially moderate ROI anticipated.	Potentially moderate ROI, particularly in combination with other solutions.	Potentially moderate ROI, particularly in combination with other solutions.
2.2 Capital Costs (based on high-level evaluation)	Moderate capital costs.	Moderate capital costs.	Moderate capital costs. Downstream of dam: capital costs required to move existing dike from top of bank to edge of floodplain. Upstream of dam: evaluate benefit of acquiring property to increase floodplain conveyance.	High capital costs.	Moderate capital costs.	Moderate capital costs.
2.3 Operation and Maintenance (O&M) Costs	Regular dredging may be required to maintain channel conveyance capacity due to deposition. However, the dam may reduce potential for deposition due to blocked sediment transport.	Post-construction monitoring required. No long-term O&M anticipated.	Low O&M costs anticipated. Vegetation management may be deemed beneficial, if incorporated in mitigation design (assessed by GRCA).	Same as existing.	Same as existing.	Same as existing.
Economic Screening Result	Medium Preference	Low Preference	High Preference	Medium Preference	Medium Preference	Medium Preference
3. Environmental						
3.1 Ecology and Aquatic Habitat	High aquatic habitat disturbance during construction High long-term effects on ecology if regular dredging is required.	High habitat disturbance during construction. Dam removal will improve fish passage and channel naturalization may provide opportunity to improve aquatic habitat.	Moderate ecologic and aquatic habitat impacts expected.	Minimal long-term ecologic and aquatic habitat impacts. Moderate disturbance during construction.	Minimal ecologic and aquatic habitat impacts expected.	Minimal ecologic and aquatic habitat impacts expected.
3.2 Geomorphology (e.g. erosion and sediment transport)	Widening will impact geomorphic channel processes: an over-widened channel will tend to deposit sediment. However, potential for deposition will be reduced due to the upstream dam blocking sediment transport.	High potential to improve geomorphic function of river. Initial sediment release with dam removal (or sediment clean out).	Moderate potential to improve geomorphic function by naturalizing flow conditions during flood events.	Same as existing, or potentially improved.	Potential erosion risks caused by confining flood flows with dike.	Potential erosion risks caused by confining flood flows with floodwall.
3.3 Heritage and Archaeology	Potential for archaeology impacts due to excavation near river.	High potential for archaeology impacts due to the importance of the historical significance of the dam	Low potential for archaeology impacts due to excavation near river.	Low potential for archaeology impacts due to excavation near river.	No or minimal impacts.	No or minimal impacts.
Environmental Screening Result	Low Preference	Medium Preference	Medium Preference	High Preference	High Preference	High Preference

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Long-List Mitigation Alternatives Screening Table

Criteria	Channel Conveyance Improvements				Flow Containment	
	Channel widening/lowering	Dam Removal and Upstream Channel Naturalization	Floodplain Improvement	Bridge Replacement	Dike Improvements	Floodwalls
4. Stakeholder						
4.1 Public Acceptance	High public acceptance anticipated based on relatively minimal impacts to property and heritage.	Public may not prefer this solution due to the historical significance of the dam.	Moderate public acceptance anticipated based on potential impacts to private property and heritage.	Public acceptance anticipated based on performance; however, some resistance anticipated due to construction disruptions on Highway 7/8.	Moderate public acceptance anticipated based on impacts to construction, property, and heritage, while achieving a high level of performance.	High public acceptance anticipated based on relatively minimal impacts to construction, property, and heritage, while achieving a high level of performance.
4.2 Property and Landowner Impacts	No or limited impacts to property and landowners.	Minimal impacts to existing property. Floodplain creation will make land available for parks and/or recreational use. Reclamation of existing inundated area.	Potential impacts to existing buildings downtown may (potentially) be avoided. Works may be focused on public land with some impacts to private landowners. Property acquisition upstream of dam may be part of flood mitigation solution. The frequency of flooding of fairgrounds is same as existing.	Same as existing.	Works may be focused on public land with some impacts to private landowners. Property acquisition may be required upstream of dam.	Minimal property impacts anticipated downstream of dam. A floodwall in combination with dike improvements could block flood flows from entering downtown. Property acquisition may be required upstream of dam.
4.3 Safety	Same as existing.	Improvement.	Improvement due to access restriction to floodplain.	Improvement due to improved conveyance.	Improvement due to access restriction of access to more of floodplain	Improvement due to restriction of access to more of floodplain
Stakeholder Screening Result	High Preference	Low Preference	Medium Preference	High Preference	Medium Preference	Medium Preference
5. Policy						
5.1 Regulatory Approvals	EA and regulatory submissions/approvals would need to address instream construction requirements.	EA and regulatory submissions/approvals would need to address significant instream construction requirements. Approval required under Lakes and Rivers Improvement Act	Mitigation measure can be constructed with no or minimal instream construction.	MTO approval required. Standard Class EA for bridge replacement anticipated.	EA and regulatory submissions/approvals would need to address upstream water level impacts caused by confining flow with dike improvements.	EA and regulatory submissions/approvals would need to address upstream water level impacts caused by confining flow with dike improvements.
5.2 Land Use Planning and Floodplain Regulation	May require review of regulatory floodplain.	May require review of regulatory floodplain.	May require review of regulatory floodplain.	May require review of regulatory floodplain.	May require review of regulatory floodplain.	May require review of regulatory floodplain.
5.3 EA Requirements	Schedule B	Schedule B	Schedule B	Schedule C	Schedule B	Schedule B
Policy Screening Result	Medium Preference	Low Preference	High Preference	Medium Preference	Medium Preference	Medium Preference
Overall Screening - Standalone Option	Medium Preference	Low Preference	Medium Preference	Medium Preference	Medium Preference	Medium Preference
Overall Screening - Combined with Other Solutions	Medium Preference	Low Preference	High Preference	Medium Preference	High Preference	High Preference
Screening Result	Advanced for Further Study	Option Screened Out	Advanced for Further Study	Advanced for Further Study	Advanced for Further Study	Advanced for Further Study

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Long-List Mitigation Alternatives Screening Table

Criteria	Flow Diversion		Storage		Non-structural Solutions		
	Bleams Road West Conduit or Surface Flow	Highway 7/8 Diversion	Regional Flood Control (e.g. Nithburg Reservoir)	Online Storage - Lower Dam Invert	Improved Flood-Resiliency of Buildings	Land Acquisition	Improvements to Flood Warning System
Description of Hydraulic Screening Scenario	Estimated diversion flow area required to convey flow above the channel capacity.	Removed Hwy 7/8 and pedestrian bridges from HEC-RAS model to estimate backwater impacts. Scenario assumes hydraulic conveyance improvements can be acheived by a flow diversion (e.g., culverts) around the bridge (as opposed to replacing the bridge itself)	Review of background feasibility study.	Lowered the invert of the dam in the draft GRCA HEC-RAS model.	No hydraulic screening for policy solution	No hydraulic screening for policy solution	No hydraulic screening for policy solution
1. Technical							
1.1 Flood Risk Improvements	Minimal flood risk improvements expected due to spatial constraints including existing utilities, infrastructure, and properties. Possible risk of isolating downtown and preventing access/ egress.	Moderate water level improvements by providing flow diversion at Highway 7/8 bridge.	Significant storage capacity required to achieve flood risk improvements.	Low. Minimal storage capacity upstream of dam achieved by lowering invert.	No flood improvement; however, improved flood-resilience will reduce damages caused by flooding. Uncertainty in number of 'opt-in' properties.	Potentially minor improvements to water levels due to improved floodplain conveyance; however, land acquisition and building removal would reduce damages caused by flooding.	No flood improvement; however, flood warning systems can reduce flood damages. Existing flood warning system is a watershed wide system, and review and improvements to the system are being pursued continuously. Therefore, the potential to achieve additional damage reductions may be marginal.
1.2 Ice Jam Resiliency (due to improvements upstream of dam)	No impacts anticipated.	May improve ice jamming by allowing flow conveyance when channel is blocked.	May improve due to controlled flow.	Moderate impact with lower dam invert due to decrease in water levels.	No impacts.	No impacts.	No impacts.
1.3 Climate Change Resiliency	Limited opportunity to incorporate climate change resiliency into flow diversion due to spatial constraints of urban area.	Diversion can be designed for climate change resiliency.	High opportunity for storage capacity to be designed for climate change resiliency; however, storage volumes required are significant.	Limited capacity to incorporate climate change resiliency into design.	Can be accounted for in ROI analysis.	Can be accounted for in ROI analysis.	Can be accounted for in ROI analysis.
1.4 Upstream Impacts	No change or improvements to upstream water levels.	Improvements to upstream water levels.	Improvements to upstream water levels.	Slight improvements to water levels upstream of dam.	No change to upstream water levels.	Potentially minor improvements to upstream water levels due to improved floodplain conveyance.	No change to upstream water levels.
1.5 Technical feasibility/Constructability	Very low due to spatial constraints.	Moderate. Mitigation could be used as an interim measure before bridge replacement.	Very low due to required storage volume.	High.	High.	Low due to private properties.	Moderate.
Technical Screening Result	Low Preference	High Preference	Low Preference	Low Preference	Medium Preference	Low Preference	Low Preference
2. Economic							
2.1 Return on Investment (ROI)	Low ROI anticipated.	Potentially moderate ROI anticipated.	Low ROI anticipated.	Low ROI anticipated.	High to moderate ROI anticipated. The number/extent of properties floodproofed can be selected to maximize ROI.	High ROI anticipated. The number of properties acquired can be a selected maximum ROI.	Low ROI anticipated.
2.2 Capital Costs (based on high-level evaluation)	High capital costs.	Moderate capital costs.	Very high capital costs.	Low capital costs.	Moderate capital costs.	Moderate to High capital costs.	Minimal additional investments in capital costs.
2.3 Operation and Maintenance (O&M) Costs	Long-term monitoring and O&M required (e.g. sediment removal). Maintenance after diversion spill occurs.	Long-term monitoring and O&M required	Long-term monitoring and O&M required. Standard dam/reservoir maintenance.	Same as existing.	Long-term monitoring and O&M required.	No monitoring and maintenance costs anticipated.	On-going additional investments in operation costs.
Economic Screening Result	Low Preference	Medium Preference	Low Preference	Low Preference	Medium Preference	High Preference	Low Preference
3. Environmental							
3.1 Ecology and Aquatic Habitat	Minimal ecologic and aquatic habitat impacts expected.	Minimal ecology and aquatic habitat impacts expected.	High aquatic habitat impacts due to construction activities. High long-term effects on ecology and would need to be considered in design.	Moderate habitat disturbance during construction.	No impacts.	No or minimal ecologic and aquatic habitat impacts expected.	No impacts.
3.2 Geomorphology (e.g. erosion and sediment transport)	Minimal impacts to erosion risks and sediment transport processes. Potential impacts at discharge outlet location.	Geomorphic impacts to be considered in design.	Significant geomorphic impacts to be considered in design.	Same as existing.	No impacts.	Same as existing.	No impacts.
3.3 Heritage and Archaeology	Potential for impact on heritage and archaeology.	No or minimal impacts.	Potential for impact on heritage and archaeology.	Same as existing.	No impacts.	No or minimal impacts.	No impacts.
Environmental Screening Result	Low Preference	High Preference	Low Preference	Medium Preference	High Preference	High Preference	High Preference

Long-List Mitigation Alternatives Screening Table

Criteria	Flow Diversion		Storage		Non-structural Solutions		
	Bleams Road West Conduit or Surface Flow	Highway 7/8 Diversion	Regional Flood Control (e.g. Nithburg Reservoir)	Online Storage - Lower Dam Invert	Improved Flood-Resiliency of Buildings	Land Acquisition	Improvements to Flood Warning System
4. Stakeholder							
4.1 Public Acceptance	Low public acceptance anticipated due to property and construction impacts.	High public acceptance anticipated based on relatively minimal impacts to construction, property, and heritage. Less construction disturbance compared to full bridge replacement.	Low acceptance from upstream stakeholders is anticipated due to significant storage land requirements.	Moderate public acceptance anticipated based on opportunity to preserve dam. Low acceptance anticipated based on performance.	High public acceptance anticipated if program to subsidize/ rebate capital costs.	Low stakeholder acceptance is anticipated due to 'ghost town' fears; but some may support.	Moderate public acceptance anticipated as public may prefer improvements to flood warning system to be implemented with other (structural) mitigation options.
4.2 Property and Landowner Impacts	Large property and landowner impacts.	Minor property and landowner impacts anticipated. Solution would need to consider cemetery just downstream of bridge.	High probability of property and landowner impacts. Substantive private land would have to be acquired / expropriated.	Minimal property and landowner impacts anticipated.	Moderate impact since solution can be implemented on an opt-in basis.	High property and landowner impacts.	No direct property or landowner impacts.
4.3 Safety	Higher risk to public safety.	Same as existing.	Safety considerations for dam/reservoir construction. Lower water levels in NH are improved safety for the town.	Same as existing.	Initiatives should consider public safety.	Improvement.	Improvement due to better flood warning
Stakeholder Screening Result	**Low Preference**	**Medium Preference**	**Low Preference**	**Medium Preference**	**High Preference**	**Low Preference**	**Medium Preference**
5. Policy							
5.1 Regulatory Approvals	Solutions can be constructed with no or minimal instream construction.	Standard Class EA for flow diversion at Highway 8 bridge. Solutions can be constructed with no or minimal instream construction.	Significant regulatory effort anticipated to implement mitigation options.	EA and regulatory submissions/approvals would need to address instream construction requirements.	Relatively minor regulatory effort anticipated to implement mitigation options.	Relatively minor regulatory effort anticipated to implement mitigation options. Legal effort required to acquire property.	Relatively minor regulatory effort anticipated to implement mitigation options.
5.2 Land Use Planning and Floodplain Regulation	May require review of regulatory floodplain.	May require review of regulatory floodplain.	May require review of regulatory floodplain.	May require review of regulatory floodplain.	No change.	No change.	No change.
5.3 EA Requirements	Schedule B	Schedule B (<$2.4M) or C (>$2.4M)	Schedule C	Schedule C	n/a	n/a	n/a
Policy Screening Result	**Low Preference**	**Medium Preference**	**Low Preference**	**Medium Preference**	**High Preference**	**Medium Preference**	**Medium Preference**
Overall Screening - Standalone Option	**Low Preference**	**Medium Preference**	**Low Preference**	**Low Preference**	**High Preference**	**Low Preference**	**Low Preference**
Overall Screening - Combined with Other Solutions	**Low Preference**	**Medium Preference**	**Low Preference**	**Low Preference**	**High Preference**	**Medium Preference**	**Low Preference**
Screening Result	**Option Screened Out**	**Advanced for Further Study**	**Option Screened Out**	**Option Screened Out**	**Advanced for Further Study**	**Option Screened Out (Consider under future study)**	**Option Screened Out**

Appendix B
Cost Estimates

Benchmark Cost Calculation Sheet

Project Name	New Hamburg Flood Mitigation Feasibility Study
Project Location	New Hamburg, GRCA
Project Number	29006
Option ID	Option 1
Description	2km Conveyance Improvements
Prepared By	Phil Campbell
Date	06-Feb-20

Option 1 Input Parameters

A	Total Channel Modification Length	2060	m
B	Total Existing Dike Modification Length	1220	m

Section 1	**MAJOR CONSTRUCTION ITEMS**	**Estimated Quantity**	**Unit**	**Estimated Unit Cost**	**Total**
Part A	**Channel Modifications**				
	Removals/Abandonments	2060	m	$ 100.00	$ 206,000
	Clearing and Grubbing	2060	m	$ 250.00	$ 515,000
	Dewatering/Water Management	2060	m	$ 300.00	$ 618,000
	Earthworks	123600	m^3	$ 30.00	$ 3,708,000
	Channel Armouring	43260	t	$ 100.00	$ 4,326,000
	Channel Feature Modifications/Extensions (weirs, vanes etc.)	21	EA	$ 25,000.00	$ 525,000
	Upstream Tie In Treatment	1	EA	$ 100,000.00	$ 100,000
	Downstream Tie-in Treatment	1	EA	$ 100,000.00	$ 100,000
	Soft Area Restoration	82400	m^2	$ 10.00	$ 824,000
	Tree Planting	500	EA	$ 500.00	$ 250,000
	Shrub Planting	16500	EA	$ 40.00	$ 660,000
	Naturalization Features/Compensation (i.e. low flow, overbank areas etc.)	2060	m	$ 250.00	$ 515,000
	Infrastructure Modifications (i.e. outfalls, local infrastructure, parking lots etc.)	5	EA	$ 75,000.00	$ 375,000
	Tie-in Treatment at Pedestrian Bridge	1	EA	$ 250,000.00	$ 250,000
	Tie-in Treatment at Highway 7 Bridge	1	EA	$ 250,000.00	$ 250,000
	Barriers and Fencing	2060	m	$ 250.00	$ 515,000
SUBTOTAL	**Channel Modifications**	....			**$ 13,737,000**
				per metre cost	*$ 6,668.45*
Part B	**Retainment System(s) (Dike/Floodwall)**				
	Existing Dike Modifications	1220	m	$ 1,500.00	$ 1,830,000
SUBTOTAL	**Retainment System(s) (Dike/Floodwall)**	....			**$ 1,830,000**
				per metre cost	*$ 1,500*
SUBTOTAL	**MAJOR CONSTRUCTION ITEMS**	....			**$ 15,567,000**

Section 2	**OTHER CONSTRUCTION ITEMS**	**Estimated Quantity**	**Factor**	**Total**
	Minor Items	$ 15,567,000	15%	$ 2,335,100
	Erosion/Sediment Control	$ 15,567,000	2%	$ 311,400
	Access and Staging	$ 15,567,000	3%	$ 467,100
	General Items	$ 15,567,000	2%	$ 311,400
SUBTOTAL	**OTHER CONSTRUCTION ITEMS**	....		**$ 3,425,000**

Section 3	**SOFT COSTS**	**Quantity**	**Factor**	**Total**
	Property Acquisition (Allowance)	???????	100%	???????
	Study/Design/Approvals	$ 18,992,000	15%	$ 2,848,800
	Contingency	$ 18,992,000	15%	$ 2,848,800
SUBTOTAL	**SOFT COSTS**	....		**$ 5,697,600**

Section 4	**CONTEXT ADJUSTMENTS FACTORS**	**Quantity**	**Factor**	**Total**
N	Greenfield Area			
N	Brownfield Area			
N	Urban Area			
Y	Semi-Urban Area	$ 18,992,000	8%	$ 1,519,400
N	Rural Area			
N	Utilities Present			
N	Railway Area			
N	Provincial Influence Area			
N	Cost Sharing Applicable			
SUBTOTAL	**CONTEXT ADJUSTMENTS FACTORS**	....		**$ 1,519,400**

Option 1	**GRAND TOTAL (excl HST)**	....		**$ 26,209,000**
			per metre cost	*$ 12,722.82*

Benchmark Cost Calculation Sheet

Matrix Solutions Inc. ENVIRONMENT & ENGINEERING

Project Name	New Hamburg Flood Mitigation Feasibility Study
Project Location	New Hamburg, GRCA
Project Number	29006
Option ID	Option 2
Description	Dike and Floodplain Improvements for 100 Year Protection
Prepared By	Phil Campbell
Date	06-Feb-20

Option 2 Input Parameters

A	Total Existing Dike Length to be Removed	860	m	
B	Total Existing Dike Modification Length	360	m	
B	Total New Retainment System(s) (Dike/Floodwall)	1160	m	New Dike
C		420	m	New Vertical

Section 1	**MAJOR CONSTRUCTION ITEMS**	**Estimated Quantity**	**Unit**	**Estimated Unit Cost**	**Total**
Part A	**Dike Removal and Floodplain Creation**				
	Removals/Abandonments	860	m	$ 100.00	$ 86,000
	Clearing and Grubbing	860	m	$ 250.00	$ 215,000
	Earthworks	19000	m^3	$ 30.00	$ 570,000
	Soft Area Restoration	25800	m^2	$ 10.00	$ 258,000
	Tree Planting	200	EA	$ 500.00	$ 100,000
	Shrub Planting	5200	EA	$ 40.00	$ 208,000
	Modify Existing Infrastructure/Features in/adjacent to Created Floodplain	1	EA	$ 750,000.00	$ 750,000
SUBTOTAL	**Dike Removal and Floodplain Creation**	....			**$ 2,187,000**
				per metre cost	*$ 2,543.02*
Part B	**Retainment System(s) (Dike/Floodwall)**				
	Existing Dike Modifications	360	m	$ 2,000.00	$ 720,000
	Removals/Abandonments	1580	m	$ 100.00	$ 158,000
	Clearing and Grubbing	580	m	$ 500.00	$ 290,000
	Earthworks	38000	m^3	$ 30.00	$ 1,140,000
	Reinforced Earth Surface Restoration	33200	m^2	$ 10.00	$ 332,000
	Armouring Surface Restoration	9960	m^2	$ 50.00	$ 498,000
	Toe Drainage and Ditching	1160	m	$ 750.00	$ 870,000
	Cut-off Wall/Buoyancy Treatment	2370	m	$ 250.00	$ 592,500
	Downstream Tie-in Treatment	1	EA	$ 50,000.00	$ 50,000
	Vertical Treatment	1837.5	m^2 (FACE)	$ 1,800.00	$ 3,307,500
	Upstream Tie In Treatment	1	EA	$ 100,000.00	$ 100,000
	Dewatering/Water Management	420	m	$ 300.00	$ 126,000
	Hartman Bridge Tie In Treatments	2	EA	$ 50,000.00	$ 100,000
	Soft Area Restoration	66400	m^2	$ 10.00	$ 664,000
	Tree Planting	400	EA	$ 500.00	$ 200,000
	Shrub Planting	13300	EA	$ 40.00	$ 532,000
	Outlets for Local Drainage and Backwater Prevention	5	EA	$ 100,000.00	$ 500,000
	Infrastructure Modifications (i.e. outfalls, local infrastructure, parking lots etc.)	15	EA	$ 200,000.00	$ 3,000,000
	Barriers and Fencing	1580	m	$ 250.00	$ 395,000
SUBTOTAL	**Retainment System(s) (Dike/Floodwall)**	....			**$ 13,575,000**
				per metre cost	*$ 8,931*
SUBTOTAL	**MAJOR CONSTRUCTION ITEMS**	....			**$ 15,762,000**

Section 2	**OTHER CONSTRUCTION ITEMS**	**Estimated Quantity**	**Factor**	**Total**
	Minor Items	$ 15,762,000	15%	$ 2,364,300
	Erosion/Sediment Control	$ 15,762,000	2%	$ 315,300
	Access and Staging	$ 15,762,000	3%	$ 472,900
	General Items	$ 15,762,000	2%	$ 315,300
SUBTOTAL	**OTHER CONSTRUCTION ITEMS**	....		**$ 3,467,800**

Section 3	**SOFT COSTS**	**Quantity**	**Factor**	**Total**
	Property Acquisition (Allowance)	???????	100%	???????
	Study/Design/Approvals	$ 19,229,800	15%	$ 2,884,470
	Contingency	$ 19,229,800	15%	$ 2,884,470
SUBTOTAL	**SOFT COSTS**	....		**$ 5,768,940**

Section 4	**CONTEXT ADJUSTMENTS FACTORS**	**Quantity**	**Factor**	**Total**
N	Greenfield Area			
N	Brownfield Area			
Y	Urban Area	$ 19,229,800	12%	$ 2,307,600
N	Semi-Urban Area			
N	Rural Area			
Y	Utilities Present	$ 19,229,800	2%	$ 384,596
N	Railway Area			
N	Provincial Influence Area			
N	Cost Sharing Applicable			
SUBTOTAL	**CONTEXT ADJUSTMENTS FACTORS**	....		**$ 2,692,196**

Option 2	**GRAND TOTAL (excl HST)**	....	**$ 27,690,936**
		per metre cost	*$ 17,525.91*

Benchmark Cost Calculation Sheet

Project Name	New Hamburg Flood Mitigation Feasibility Study
Project Location	New Hamburg, GRCA
Project Number	29006
Option ID	Option 3
Description	Dike, Floodplain and Conveyance for 25 Year Protection
Prepared By	Phil Campbell
Date	06-Feb-20

Option 3 Input Parameters

A	Total Channel Modification Length	170	m	
B	Total Existing Dike Length to be Removed	860	m	
C	Total Existing Dike Modification Length	360	m	
C	Total New Retainment System(s) (Dike/Floodwall)	1160	m	New Dike
		420	m	New Vertical

Section 1	MAJOR CONSTRUCTION ITEMS	Estimated Quantity	Unit	Estimated Unit Cost	Total
Part A	**Channel Modifications**				
	Removals/Abandonments	170	m	$ 100.00	$ 17,000
	Clearing and Grubbing	170	m	$ 250.00	$ 42,500
	Dewatering/Water Management	170	m	$ 300.00	$ 51,000
	Earthworks	10200	m^3	$ 30.00	$ 306,000
	Channel Armouring	3570	t	$ 100.00	$ 357,000
	Channel Feature Modifications/Extensions (weirs, vanes etc.)	2	EA	$ 25,000.00	$ 50,000
	Upstream Tie In Treatment	1	EA	$ 100,000.00	$ 100,000
	Downstream Tie-in Treatment	1	EA	$ 100,000.00	$ 100,000
	Soft Area Restoration	6800	m^2	$ 10.00	$ 68,000
	Tree Planting	100	EA	$ 500.00	$ 50,000
	Shrub Planting	1400	EA	$ 40.00	$ 56,000
	Tie-in Treatment at Pedestrian Bridge	1	EA	$ 250,000.00	$ 250,000
	Tie-in Treatment at Highway 7 Bridge	1	EA	$ 250,000.00	$ 250,000
	Naturalization Features/Compensation (i.e. low flow, overbank areas etc.)	170	m	$ 250.00	$ 42,500
	Infrastructure Modifications (i.e. outfalls, local infrastructure, parking lots etc.)	1	EA	$ 75,000.00	$ 75,000
	Barriers and Fencing	170	m	$ 250.00	$ 42,500
SUBTOTAL	**Channel Modifications**				**$ 1,857,500**
				per metre cost	$ 10,926.47
Part B	**Dike Removal and Floodplain Creation**				
	Removals/Abandonments	860	m	$ 100.00	$ 86,000
	Clearing and Grubbing	860	m	$ 250.00	$ 215,000
	Earthworks	19000	m^3	$ 30.00	$ 570,000
	Soft Area Restoration	25800	m^2	$ 10.00	$ 258,000
	Tree Planting	200	EA	$ 500.00	$ 100,000
	Shrub Planting	5200	EA	$ 40.00	$ 208,000
	Modify Existing Infrastructure/Features in/adjacent to Created Floodplain	3	EA	$ 250,000.00	$ 750,000
SUBTOTAL	**Dike Removal and Floodplain Creation**				**$ 2,187,000**
				per metre cost	*$ 2,543.02*
Part C	**Retainment System(s) (Dike/Floodwall)**				
	Existing Dike Modifications	360	m	$ 1,660.00	$ 597,600
	Removals/Abandonments	1580	m	$ 100.00	$ 158,000
	Clearing and Grubbing	580	m	$ 500.00	$ 290,000
	Earthworks	22000	m^3	$ 30.00	$ 660,000
	Reinforced Earth Surface Restoration	27400	m^2	$ 10.00	$ 274,000
	Armouring Surface Restoration	8220	m^2	$ 50.00	$ 411,000
	Toe Drainage and Ditching	1160	m	$ 750.00	$ 870,000
	Cut-off Wall/Buoyancy Treatment	2370	m	$ 250.00	$ 592,500
	Downstream Tie-in Treatment	1	EA	$ 50,000.00	$ 50,000
	Vertical Treatment	787.5	m^2 (FACE)	$ 1,800.00	$ 1,417,500
	Upstream Tie In Treatment	1	EA	$ 100,000.00	$ 100,000
	Dewatering/Water Management	420	m	$ 300.00	$ 126,000
	Hartman Bridge Tie In Treatments	2	EA	$ 50,000.00	$ 100,000
	Soft Area Restoration	54800	m^2	$ 10.00	$ 548,000
	Tree Planting	400	EA	$ 500.00	$ 200,000
	Shrub Planting	11000	EA	$ 40.00	$ 440,000
	Outlets for Local Drainage and Backwater Prevention	5	EA	$ 100,000.00	$ 500,000
	Infrastructure Modifications (i.e. outfalls, local infrastructure, parking lots etc.)	15	EA	$ 200,000.00	$ 3,000,000
	Barriers and Fencing	1580	m	$ 250.00	$ 395,000
SUBTOTAL	**Retainment System(s) (Dike/Floodwall)**				**$ 10,729,600**
				per metre cost	*$ 7,059*
SUBTOTAL	**MAJOR CONSTRUCTION ITEMS**				**$ 14,774,100**

Section 2	OTHER CONSTRUCTION ITEMS	Estimated Quantity	Factor	Total
	Minor Items	$ 14,774,100	15%	$ 2,216,200
	Erosion/Sediment Control	$ 14,774,100	2%	$ 295,500
	Access and Staging	$ 14,774,100	3%	$ 443,300
	General Items	$ 14,774,100	2%	$ 295,500
SUBTOTAL	**OTHER CONSTRUCTION ITEMS**			**$ 3,250,500**

Section 3	SOFT COSTS	Quantity	Factor	Total
	Property Acquisition (Allowance)	???????	100%	???????
	Study/Design/Approvals	$ 18,024,600	15%	$ 2,703,690
	Contingency	$ 18,024,600	15%	$ 2,703,690

SUBTOTAL	**SOFT COSTS**	....		**$**	**5,407,380**

Section 4	**CONTEXT ADJUSTMENTS FACTORS**	**Quantity**	**Factor**		**Total**
N	Greenfield Area				
N	Brownfield Area				
Y	Urban Area	$ 18,024,600	12%	$	2,163,000
N	Semi-Urban Area				
N	Rural Area				
Y	Utilities Present	$ 18,024,600	2%	$	360,492
N	Railway Area				
N	Provincial Influence Area				
N	Cost Sharing Applicable				
SUBTOTAL	**CONTEXT ADJUSTMENTS FACTORS**	....		**$**	**2,523,492**

Option 3	**GRAND TOTAL (excl HST)**	....		**$**	**25,955,472**
			per metre cost	*$*	*16,427.51*

Benchmark Cost Calculation Sheet

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Project Name New Hamburg Flood Mitigation Feasibility Study
Project Location New Hamburg, GRCA
Project Number 29006
Option ID Option 4
Description Dike Improvements for 10 Year Protection
Prepared By Phil Campbell
Date 06-Feb-20

Option 4 Input Parameters

A	Total Existing Dike Modification Length	1030	m	
A	Total New Retainment System(s) (Dike/Floodwall)	510	m	New Dike
		0	m	New Vertical

Section 1 MAJOR CONSTRUCTION ITEMS

		Estimated Quantity	Unit	Estimated Unit Cost	Total
Part A	**Retainment System(s) (Dike/Floodwall)**				
	Existing Dike Modifications	1030	m	$ 1,440.00	$ 1,483,200
	Removals/Abandonments	510	m	$ 100.00	$ 51,000
	Clearing and Grubbing	255	m	$ 500.00	$ 127,500
	Earthworks	6000	m^3	$ 30.00	$ 180,000
	Reinforced Earth Surface Restoration	6375	m^2	$ 10.00	$ 63,750
	Armouring Surface Restoration	1912.5	m^2	$ 50.00	$ 95,625
	Toe Drainage and Ditching	510	m	$ 750.00	$ 382,500
	Cut-off Wall/Buoyancy Treatment	765	m	$ 250.00	$ 191,250
	Downstream Tie-in Treatment	1	EA	$ 50,000.00	$ 50,000
	Vertical Treatment	0	m^2 (FACE)	$ 1,800.00	$ -
	Upstream Tie In Treatment	1	EA	$ 100,000.00	$ 100,000
	Dewatering/Water Management	0	m	$ 300.00	$ -
	Hartman Bridge Tie In Treatments	2	EA	$ 50,000.00	$ 100,000
	Soft Area Restoration	12750	m^2	$ 10.00	$ 127,500
	Tree Planting	200	EA	$ 500.00	$ 100,000
	Shrub Planting	2600	EA	$ 40.00	$ 104,000
	Outlets for Local Drainage and Backwater Prevention	3	EA	$ 100,000.00	$ 300,000
	Infrastructure Modifications (i.e. outfalls, local infrastructure, parking lots etc.)	5	EA	$ 200,000.00	$ 1,000,000
	Barriers and Fencing	510	m	$ 250.00	$ 127,500
SUBTOTAL	**Retainment System(s) (Dike/Floodwall)**	....			**$ 4,583,825**
				per metre cost	*$ 2,977*
SUBTOTAL	**MAJOR CONSTRUCTION ITEMS**	....			**$ 4,583,825**

Section 2 OTHER CONSTRUCTION ITEMS

		Estimated Quantity	Factor	Total
	Minor Items	$ 4,583,825	15%	$ 687,600
	Erosion/Sediment Control	$ 4,583,825	2%	$ 91,700
	Access and Staging	$ 4,583,825	3%	$ 137,600
	General Items	$ 4,583,825	2%	$ 91,700
SUBTOTAL	**OTHER CONSTRUCTION ITEMS**	....		**$ 1,008,600**

Section 3 SOFT COSTS

		Quantity	Factor	Total
	Property Acquisition (Allowance)	???????	100%	???????
	Study/Design/Approvals	$ 5,592,425	15%	$ 838,864
	Contingency	$ 5,592,425	15%	$ 838,864
SUBTOTAL	**SOFT COSTS**	....		**$ 1,677,728**

Section 4 CONTEXT ADJUSTMENTS FACTORS

		Quantity	Factor	Total
N	Greenfield Area			
N	Brownfield Area			
Y	Urban Area			
N	Semi-Urban Area	$ 5,592,425	8%	$ 447,400
N	Rural Area			
N	Utilities Present			
N	Railway Area			
N	Provincial Influence Area			
N	Cost Sharing Applicable			
SUBTOTAL	**CONTEXT ADJUSTMENTS FACTORS**	....		**$ 447,400**

Option 4	**GRAND TOTAL (excl HST)**	....		**$ 7,717,553**
			per metre cost	*$ 15,132.46*

Benchmark Cost Calculation Sheet

Matrix Solutions Inc. ENVIRONMENT & ENGINEERING

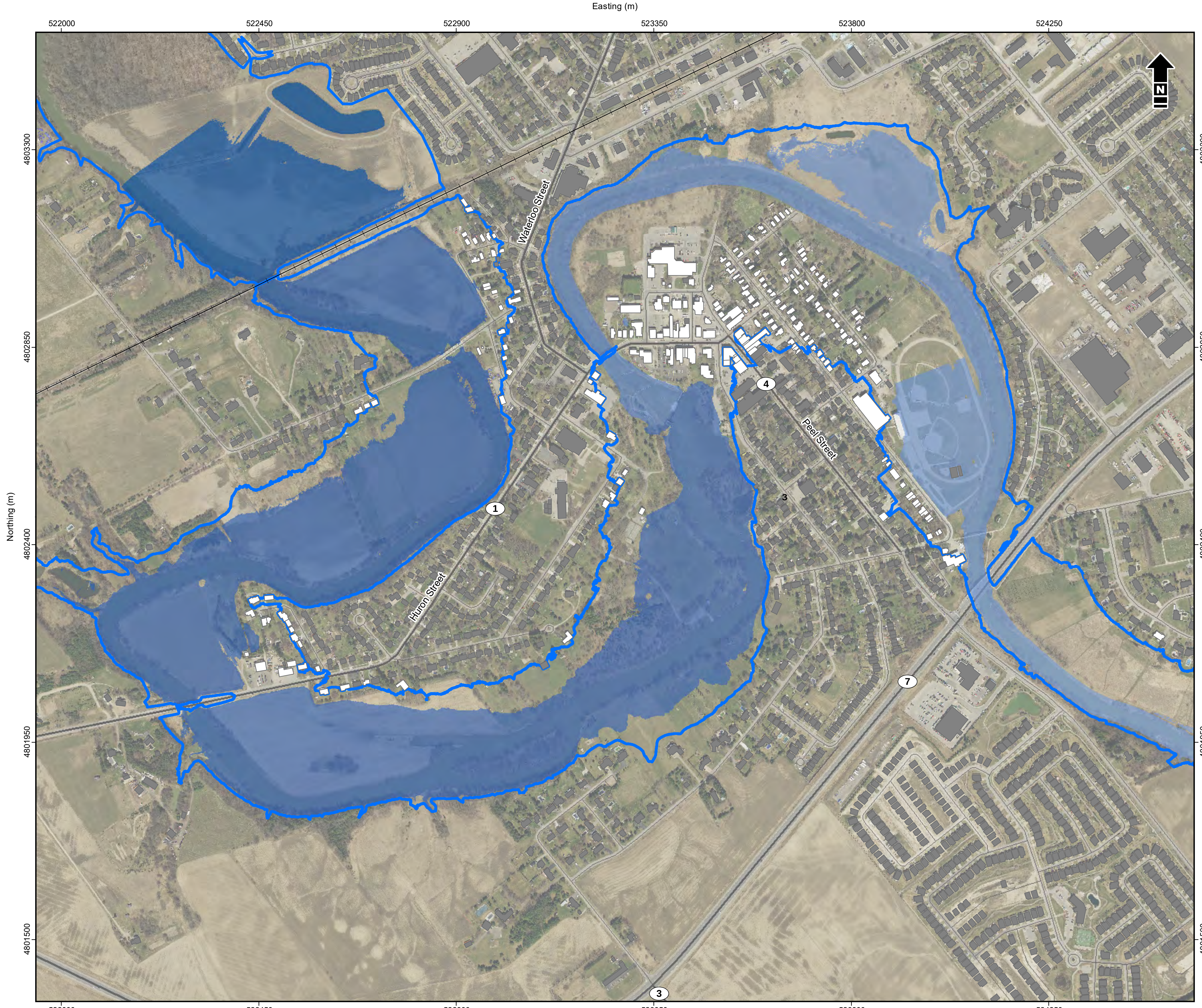
Project Name	New Hamburg Flood Mitigation Feasibility Study
Project Location	New Hamburg, GRCA
Project Number	29006
Option ID	Option 5
Description	Bridge Replacement
Prepared By	Andrew Doherty
Date	13-Feb-20

Option 5 Input Parameters

A	Deck of Existing Bridge Span: approx. 70 m Bridge Width: 25 m	1750	m^2
		0	m

Section 1	**MAJOR CONSTRUCTION ITEMS**	**Estimated Quantity**	**Unit**	**Estimated Unit Cost**	**Total**
	Existing Bridge	1750	m^2	$ 8,000.00	$ 14,000,000
	Hydraulic Improvements	30%	-	-	$ 4,200,000
Option 5	**GRAND TOTAL (excl HST)**	....			**$ 18,200,000**
				per metre cost	

Appendix C
Flood Depth Figure Set



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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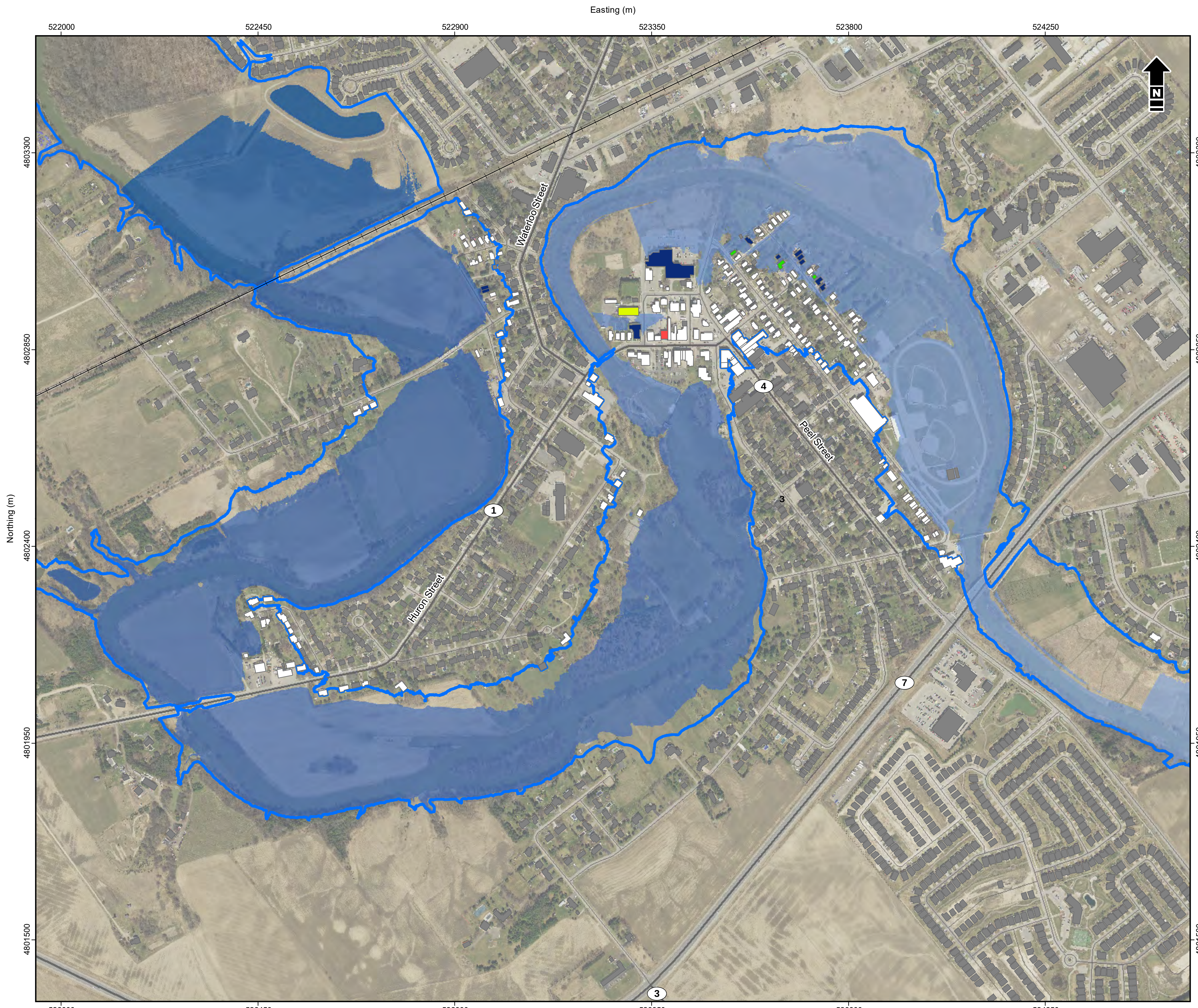
ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 7.1



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000
metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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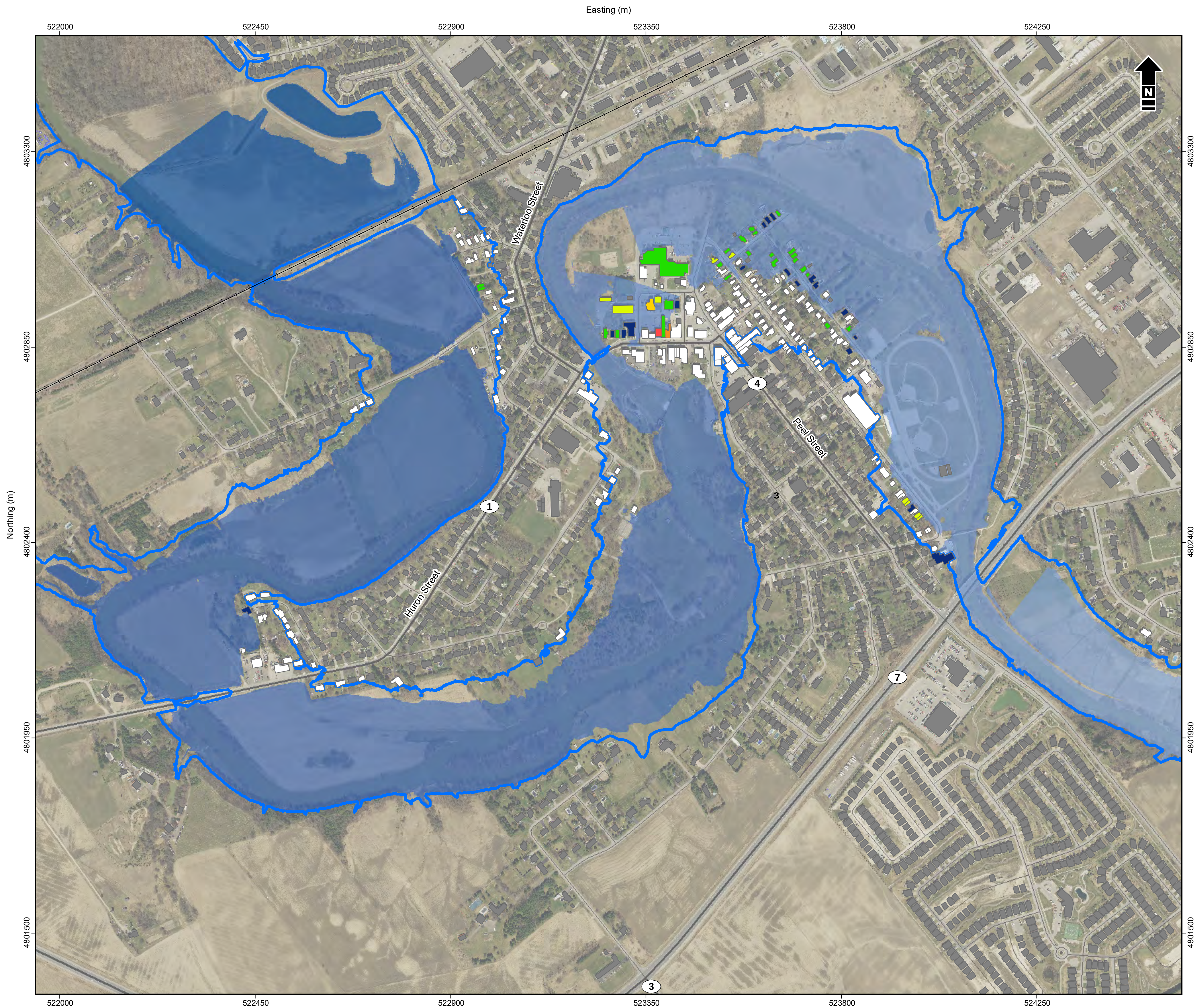
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - 5 Year (265 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 7.2



- Draft Regional Inundation Boundary
- Railway
- Highway
- Road
- Building - Not Flooded
- Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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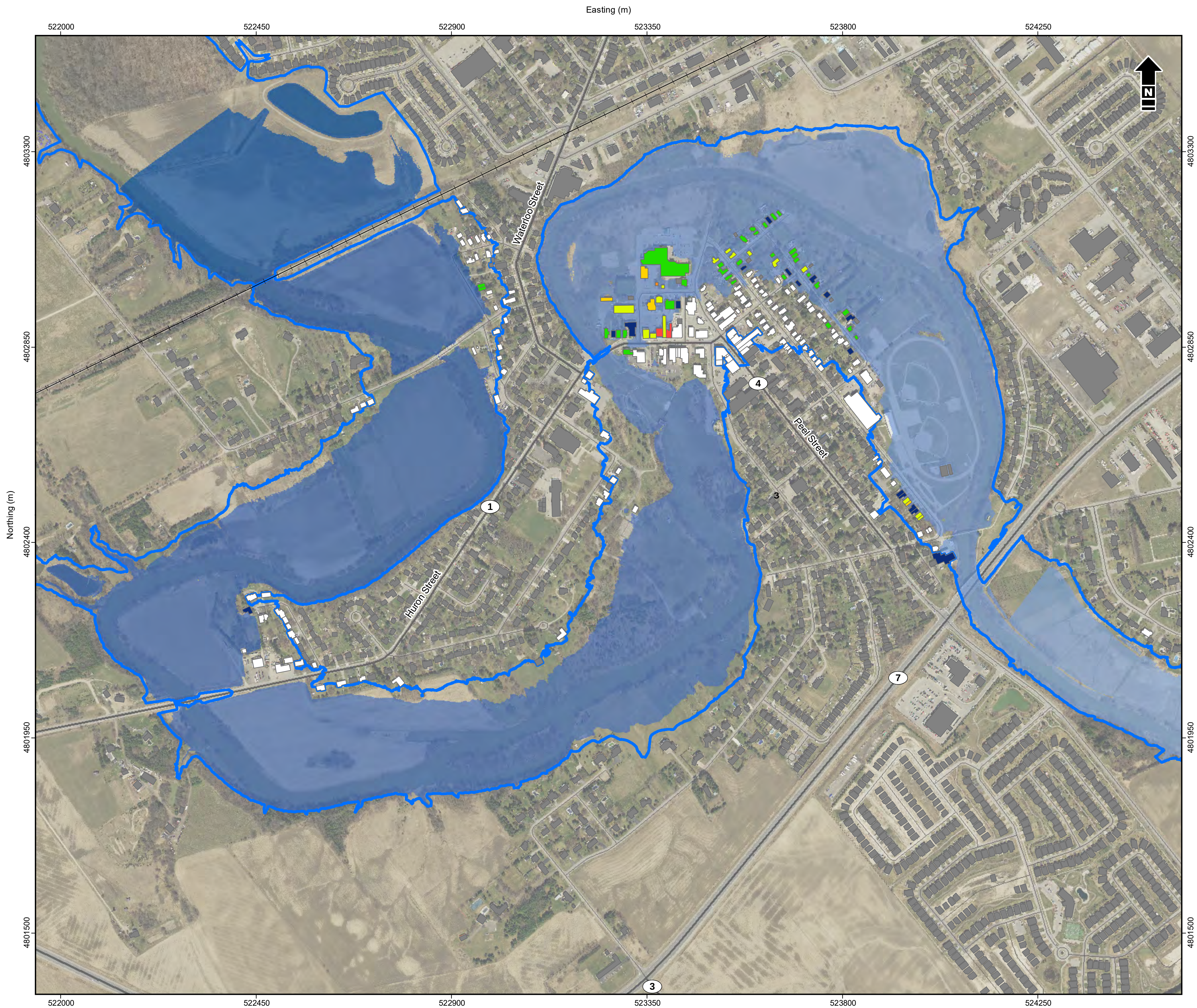
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 7.3



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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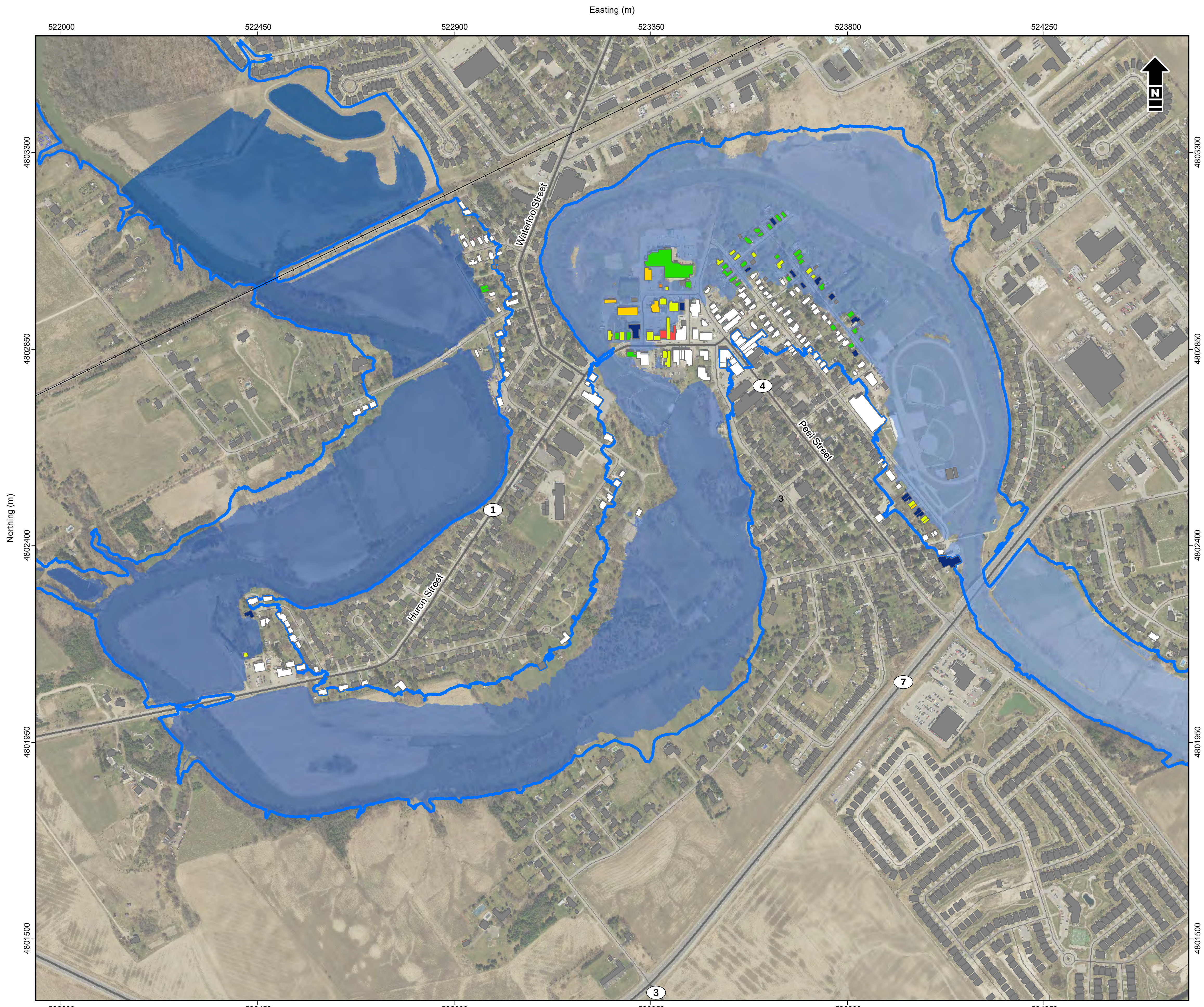
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - 15 Year (350 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 7.4



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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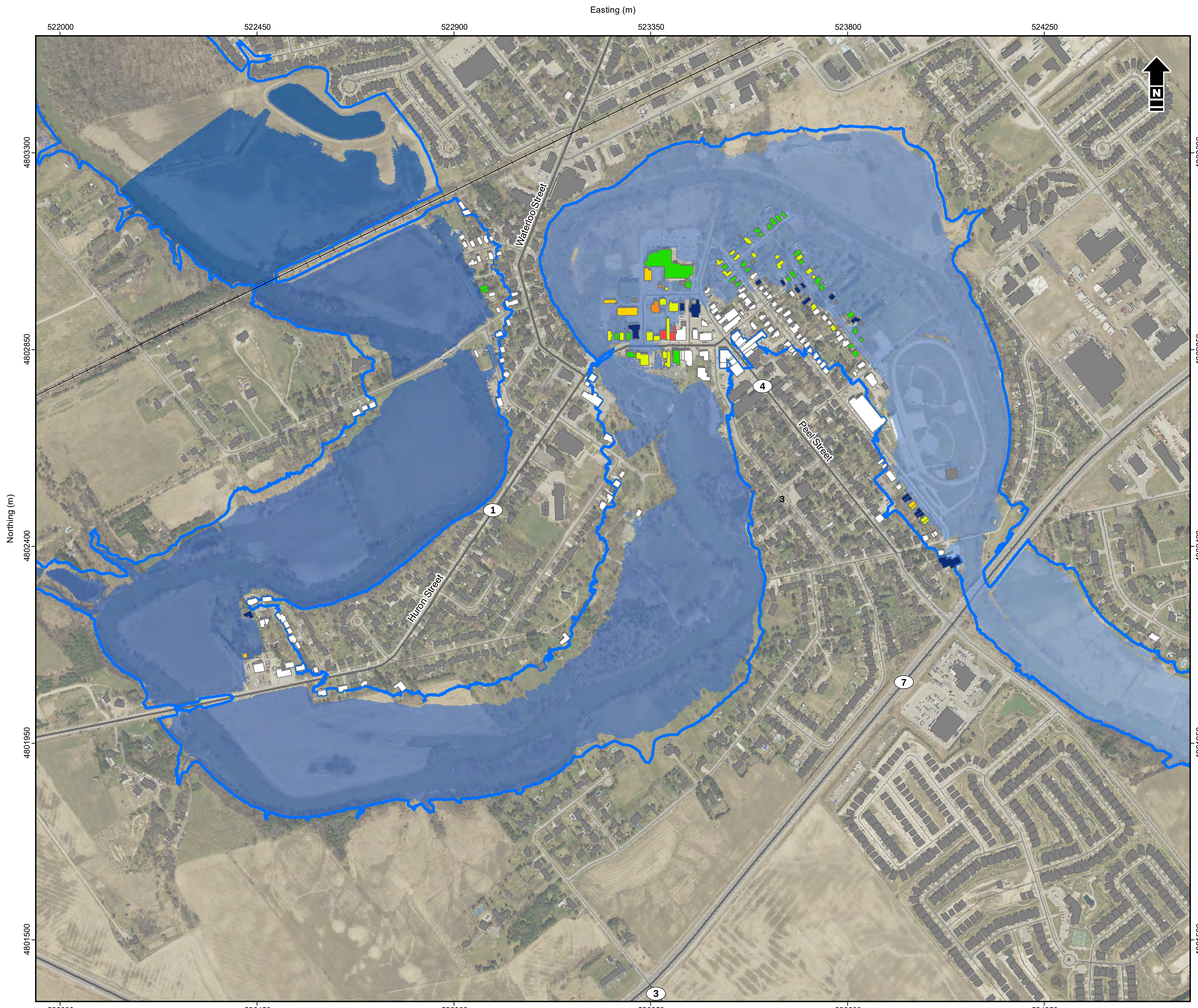
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 7.5

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-7-X-Existing_Conditions_Inundated_Buildings.mxd - Tabloid_L - 19-Mar-20, 10:51 AM - lmwright - TID005



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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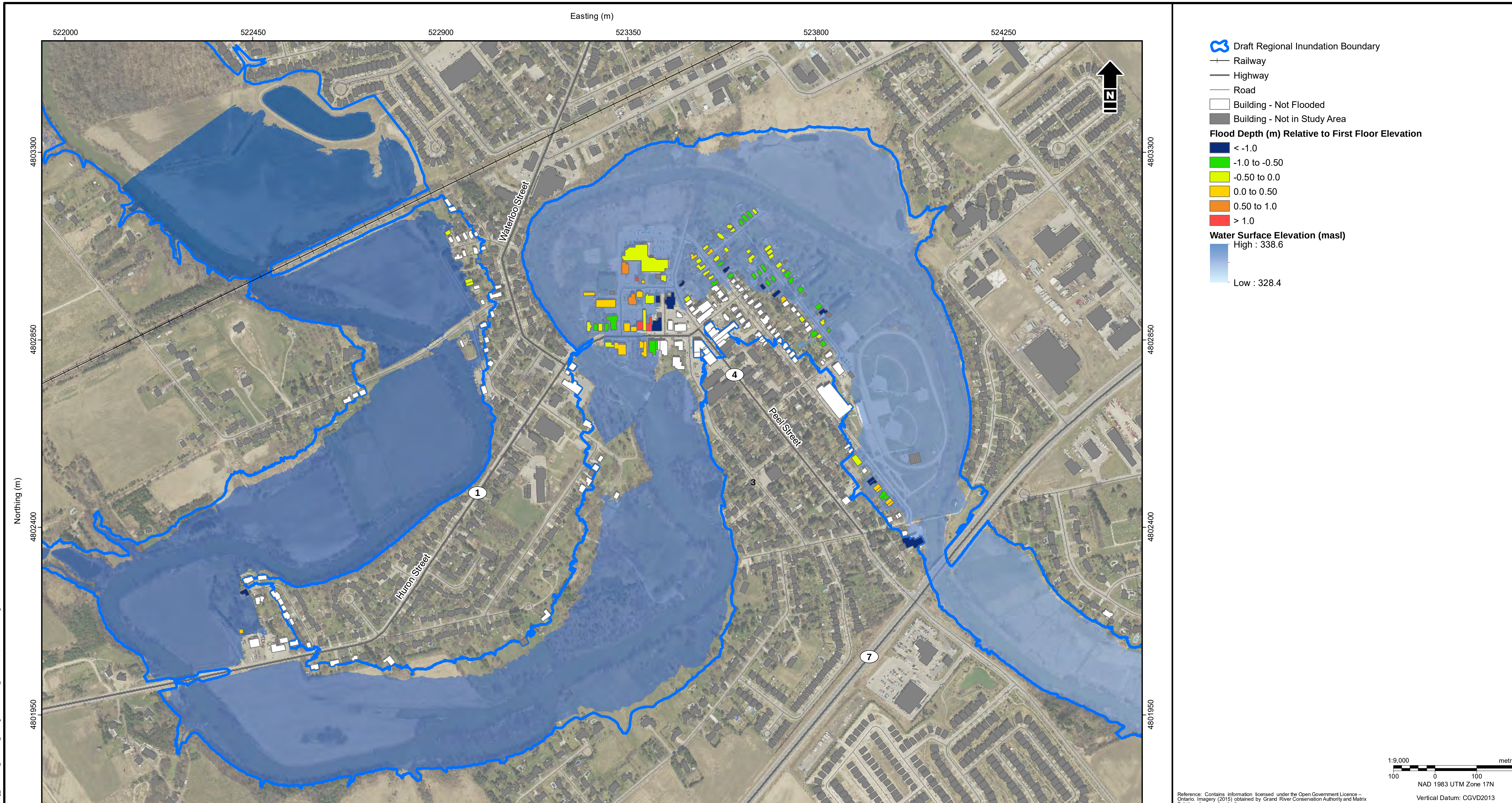
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 7.6



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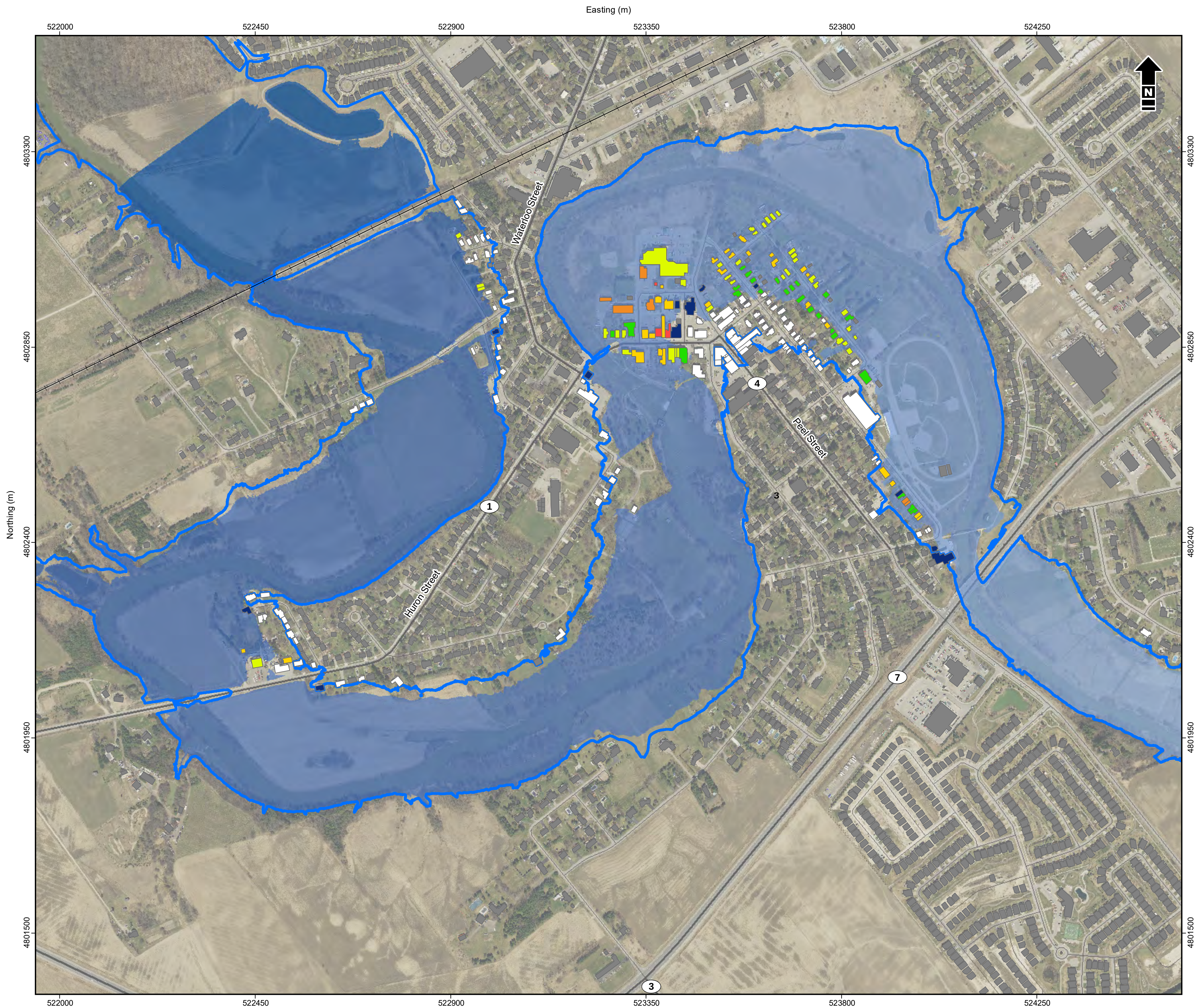
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - 50 Year (447 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 7.7



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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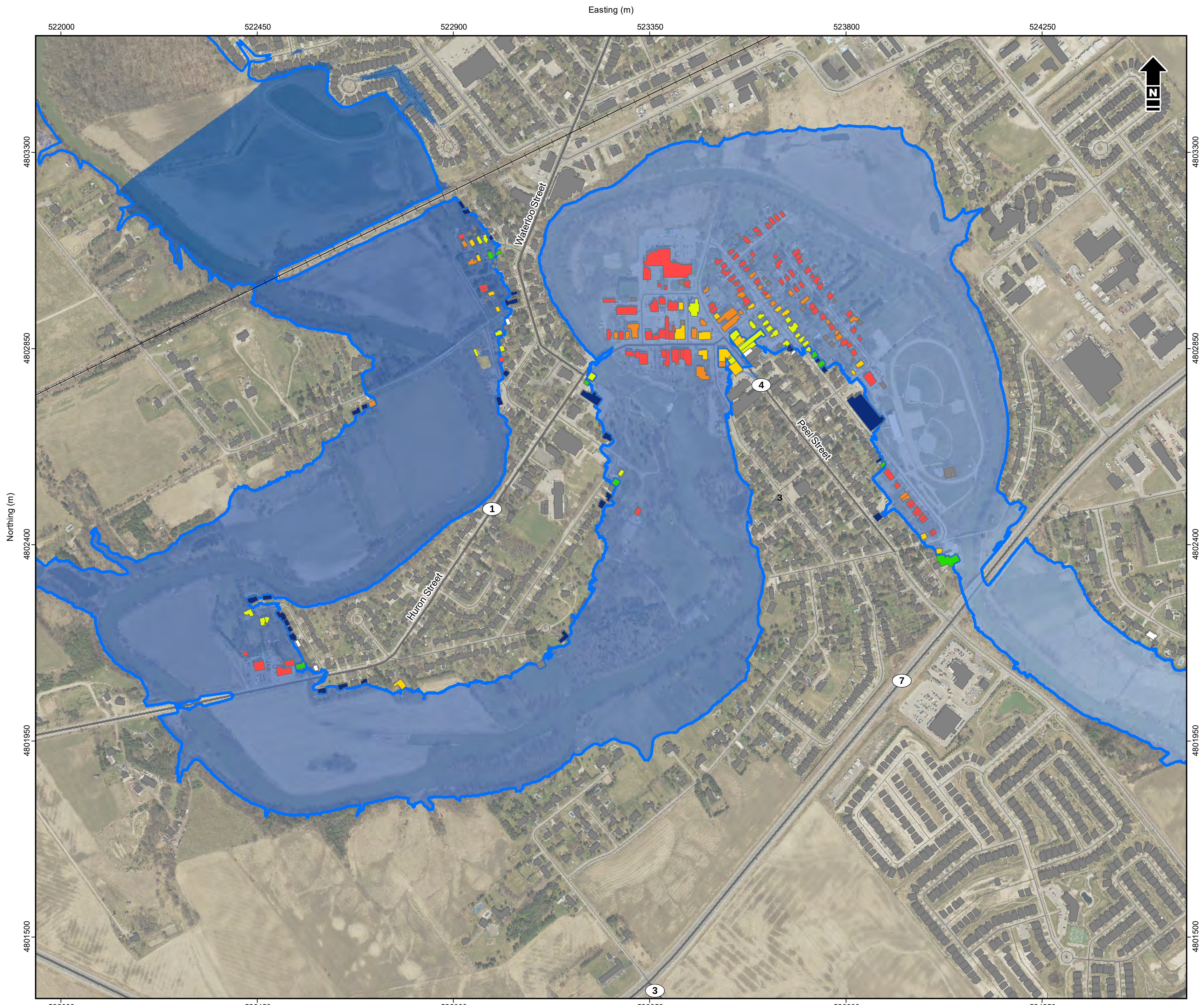
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 7.8



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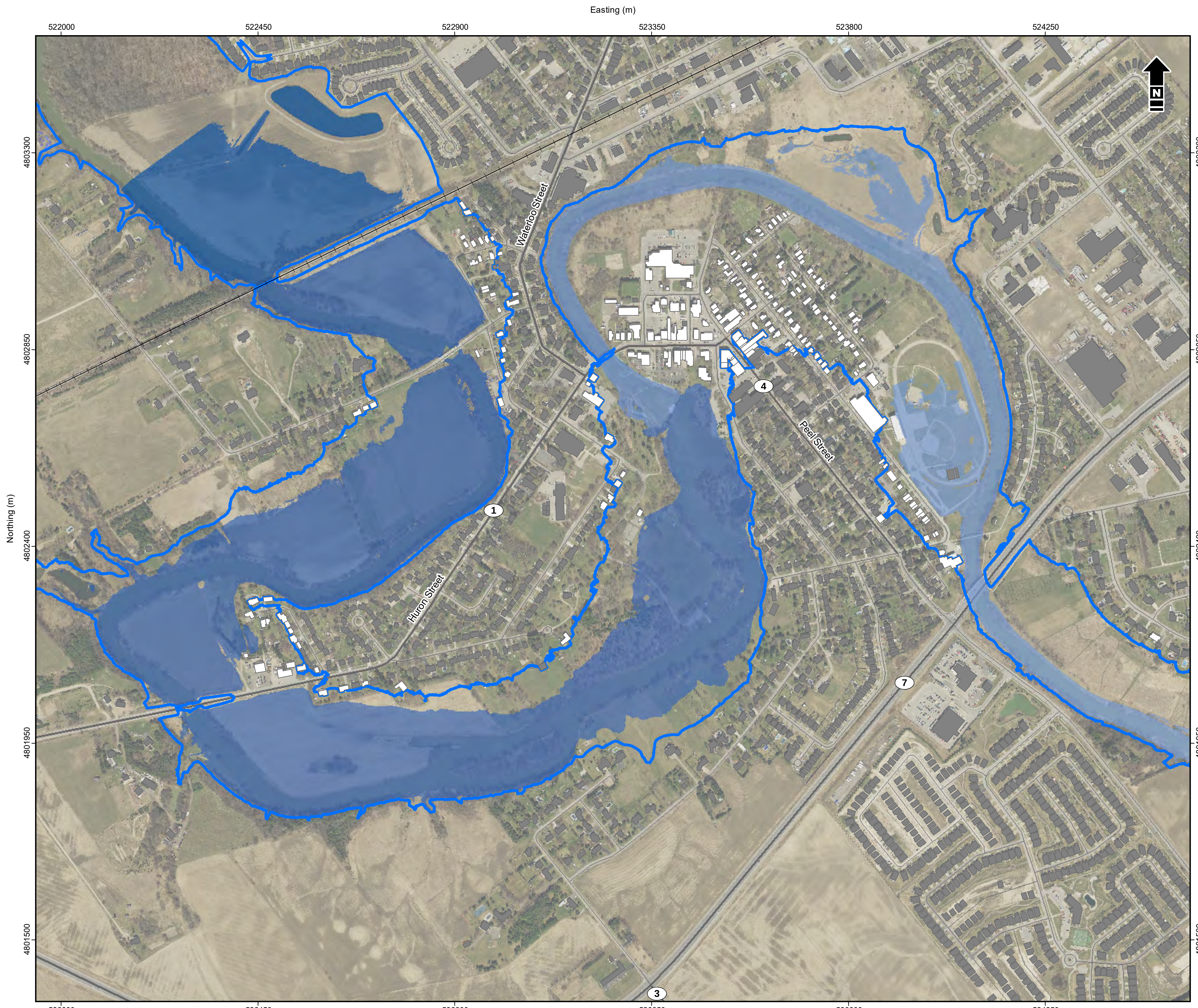
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Inundated Buildings - Regional (1,011 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 7.9



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - 2 Year (179 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

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Figure 8.1

Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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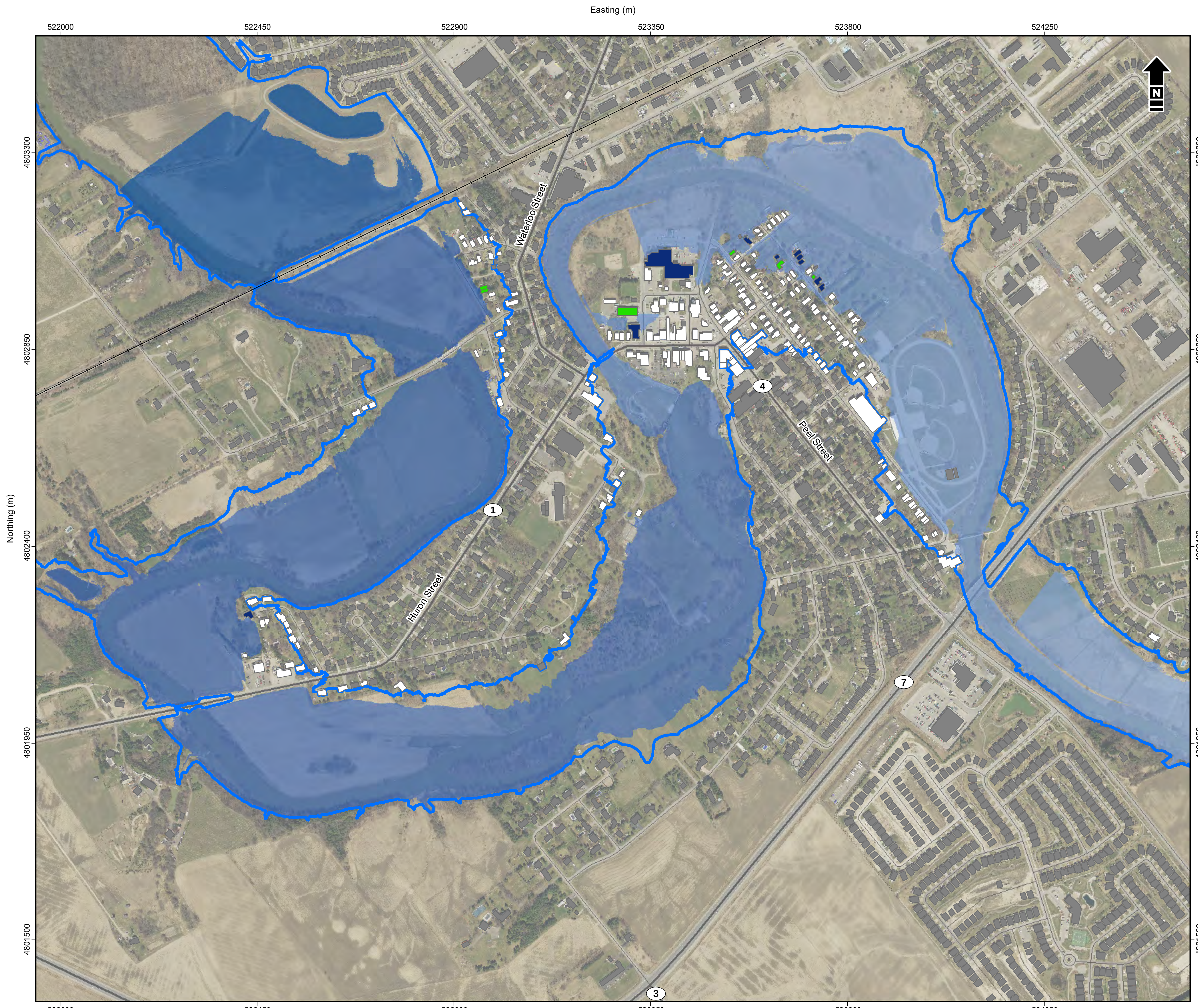
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - 5 Year (265 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 8.2



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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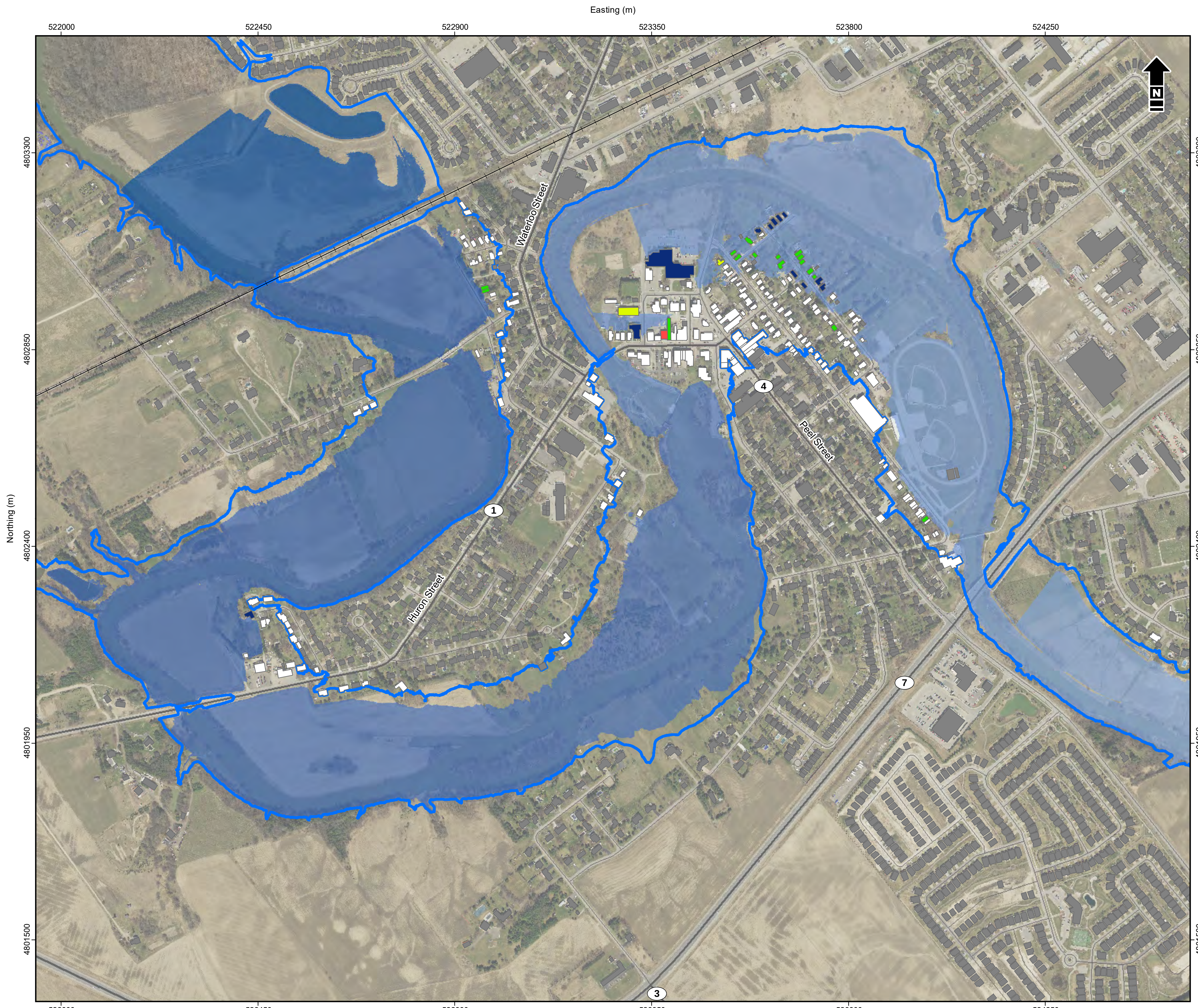
ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 8.3



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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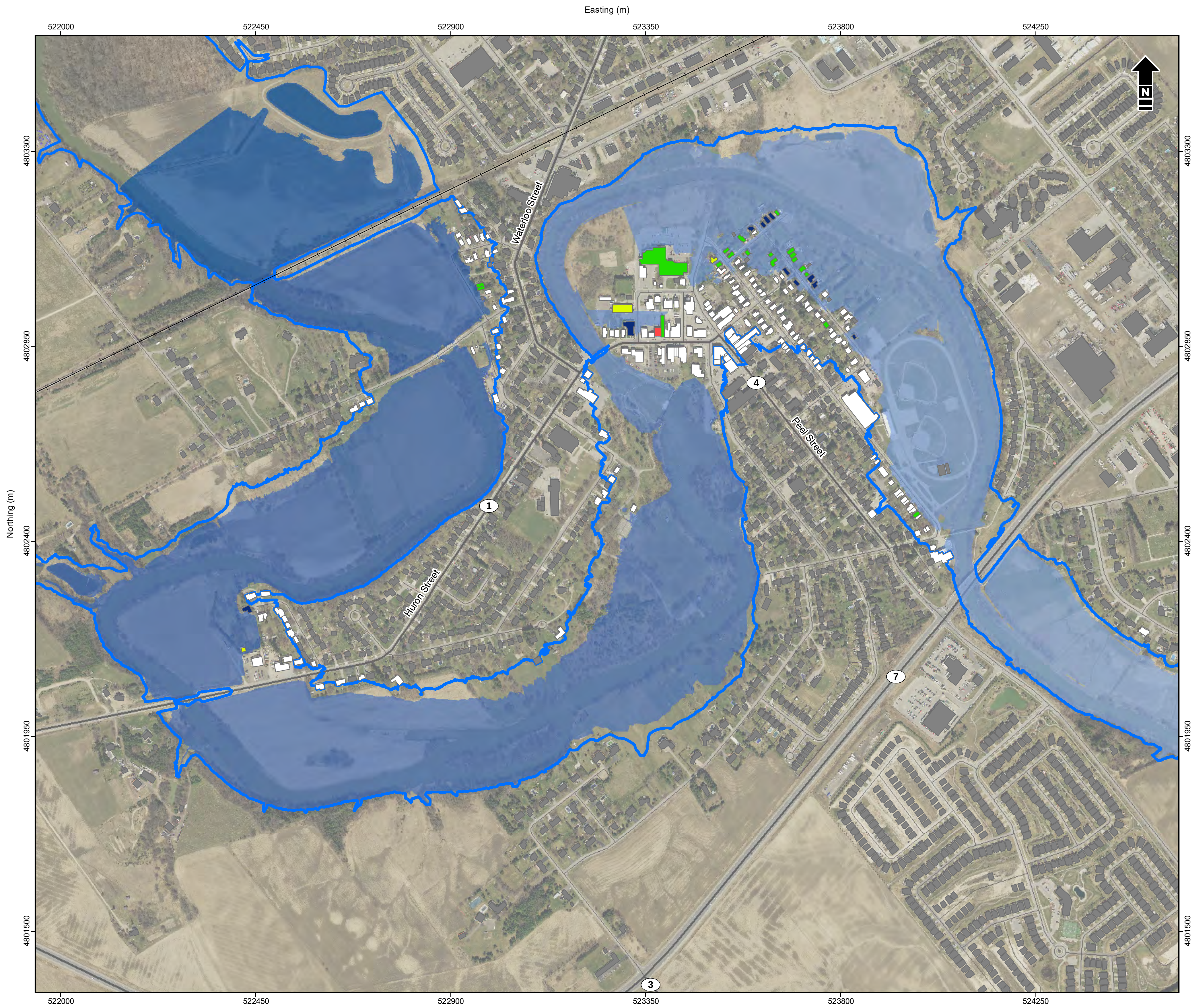
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - 15 Year (350 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 8.4



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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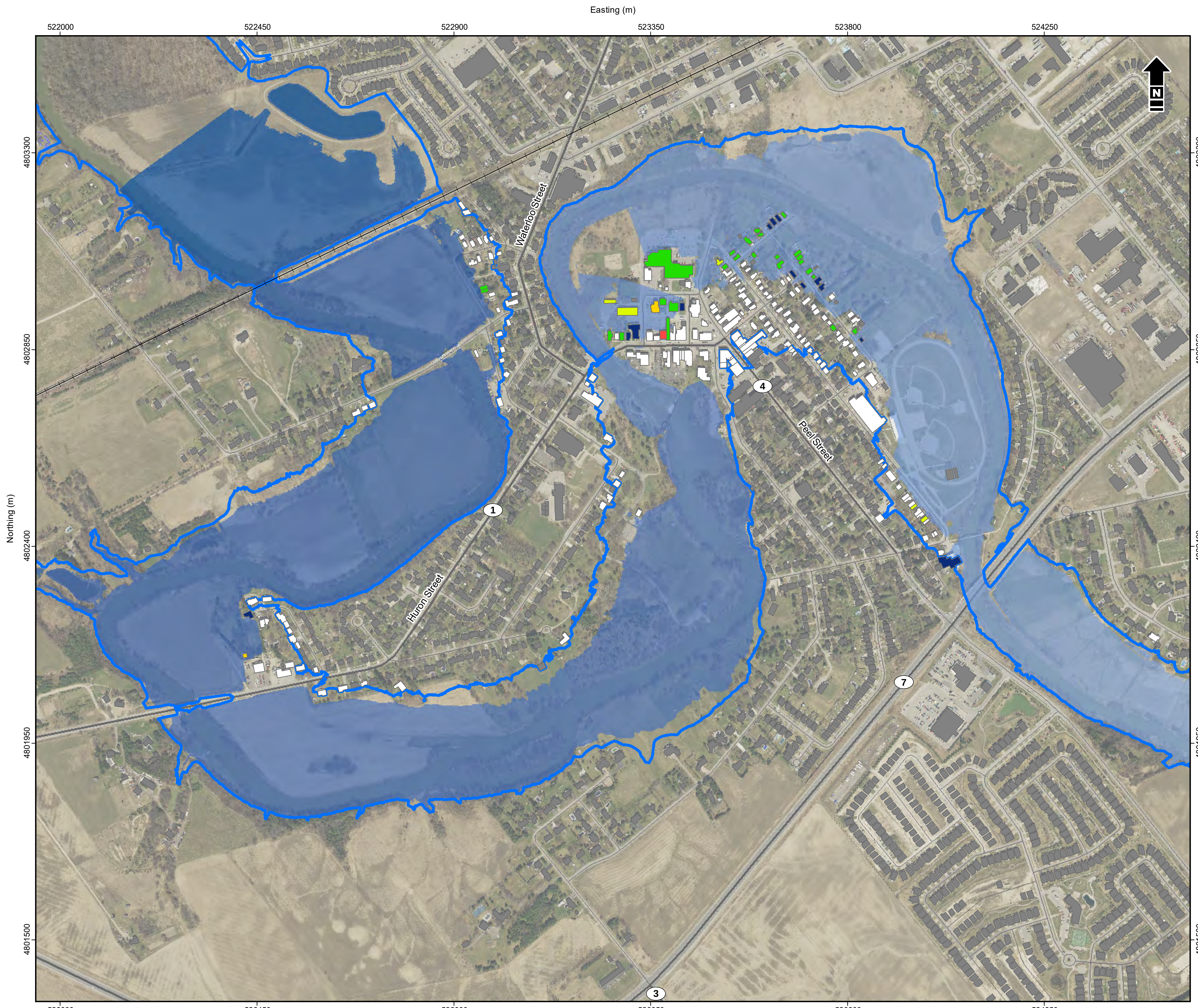
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - 20 Year (377 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 8.5



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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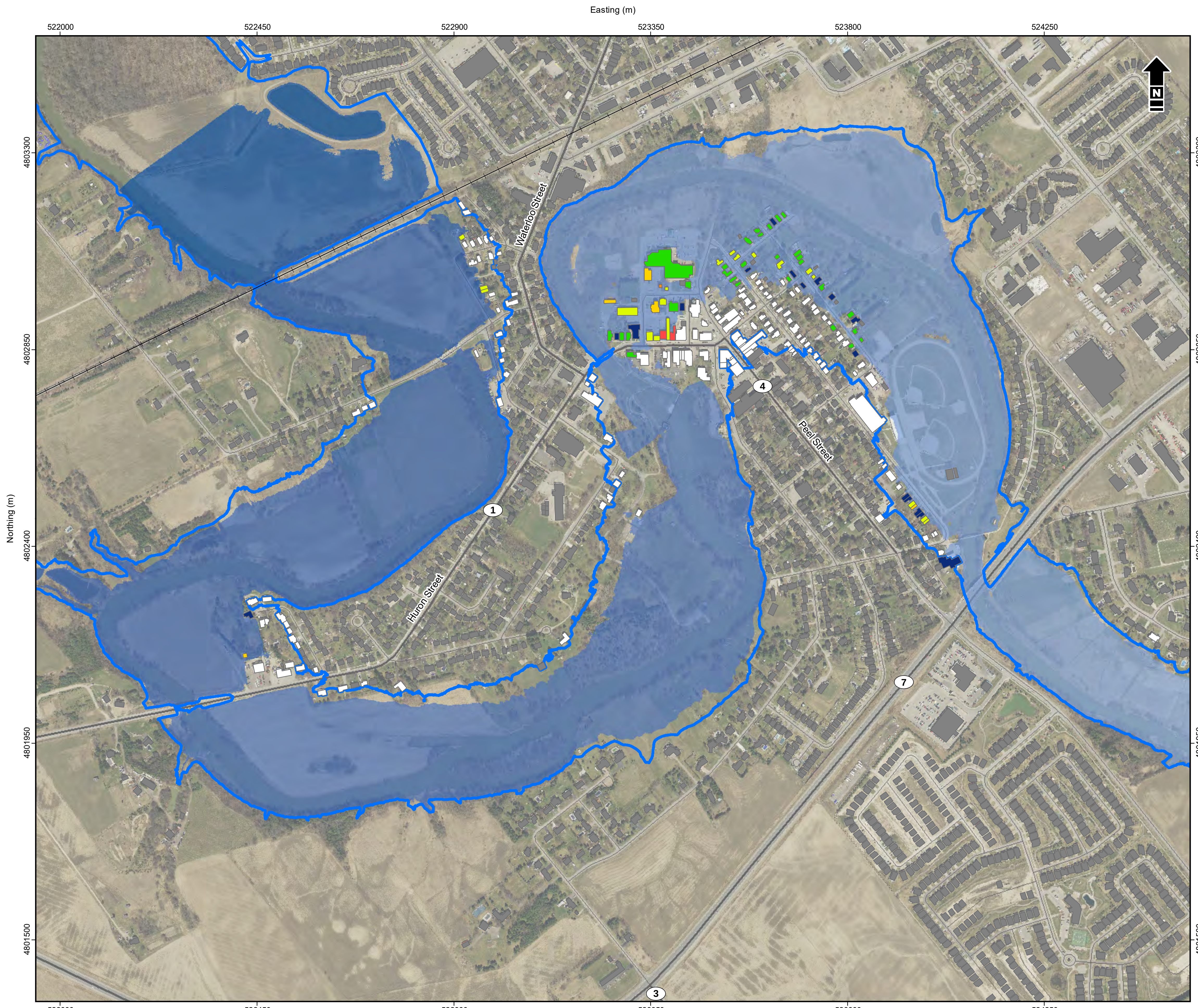
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 8.6



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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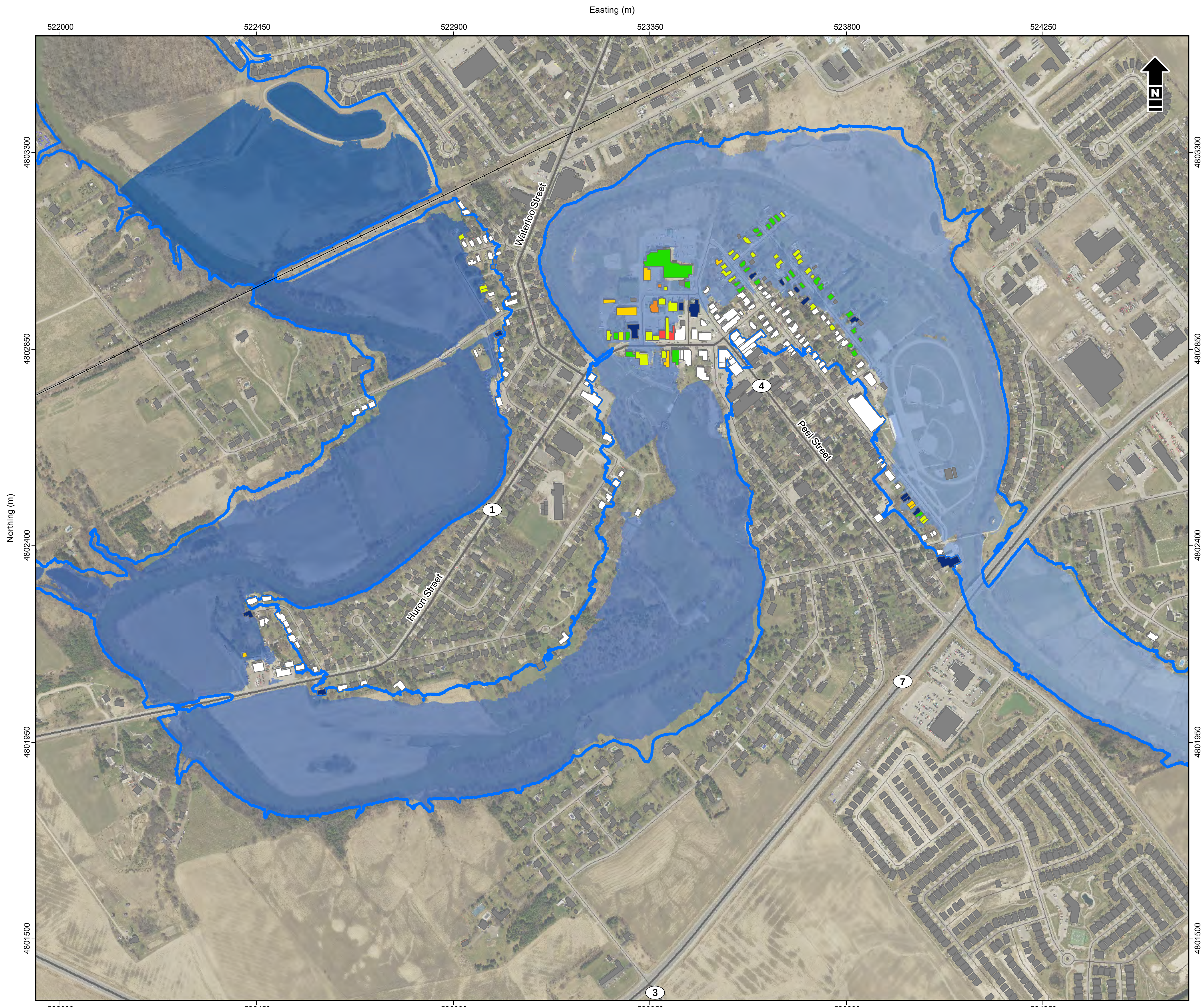
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - 50 Year (447 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 8.7



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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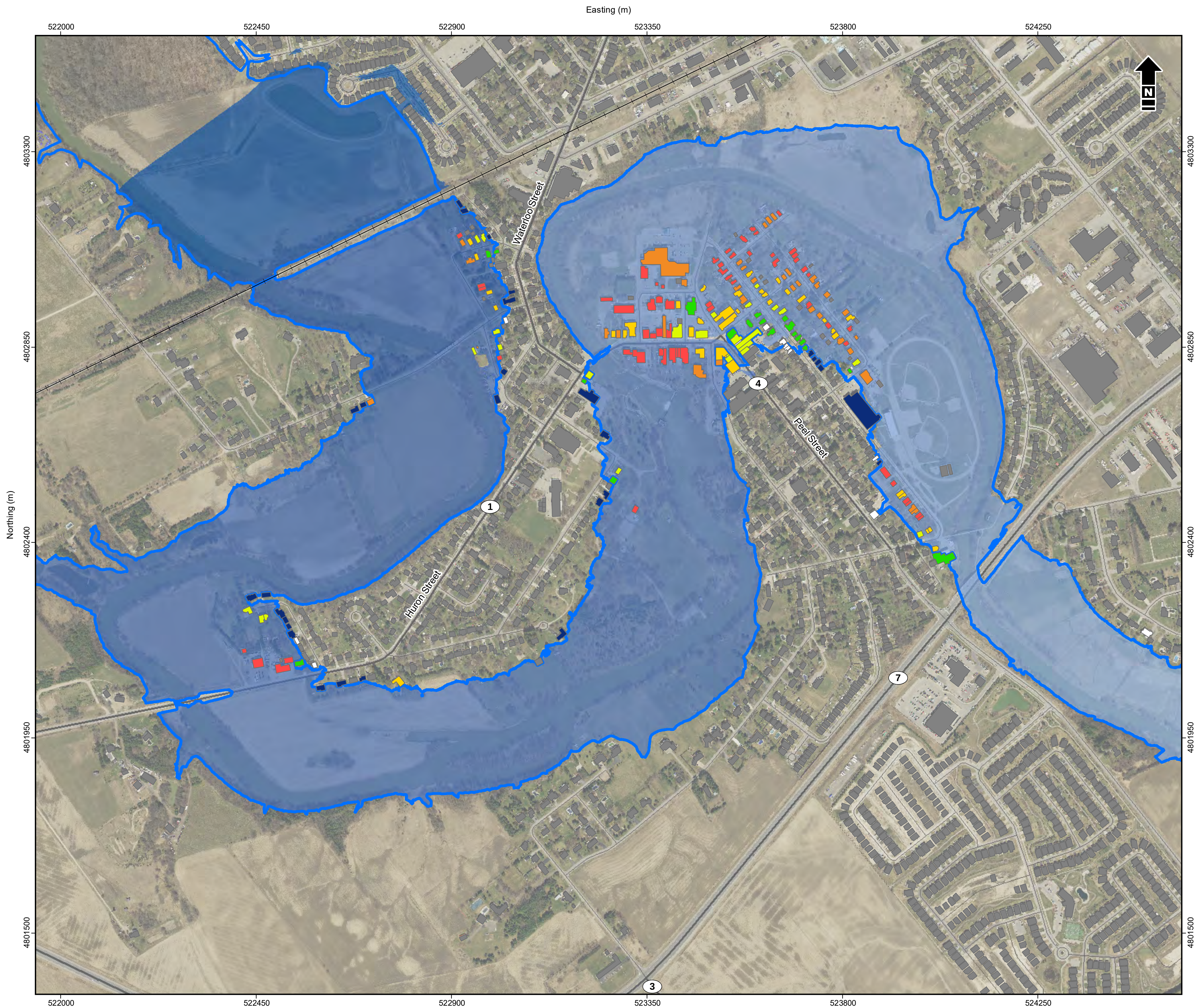
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - 100 Year (500 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 8.8



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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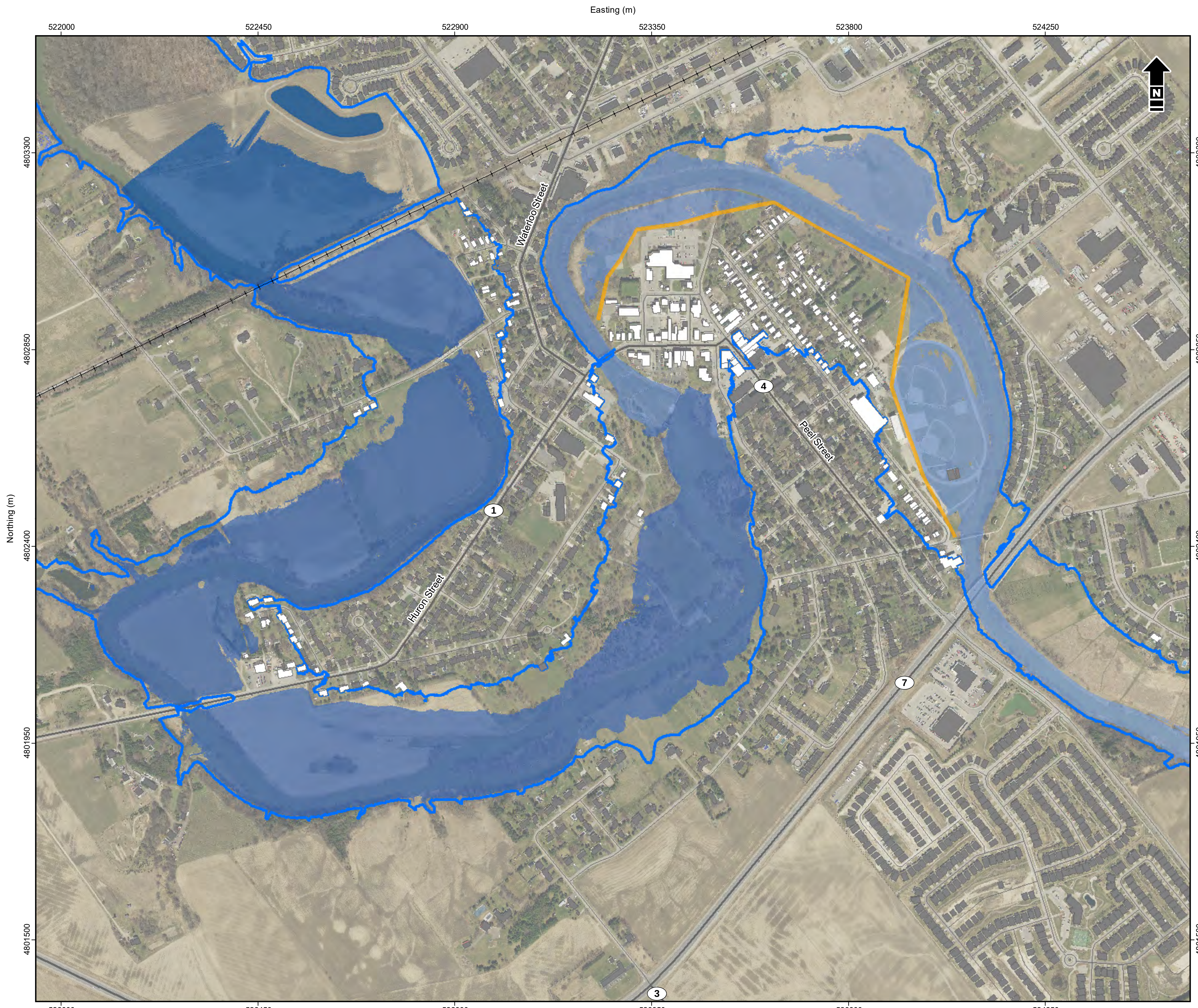
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Inundated Buildings - Regional (1,011 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 8.9



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 9.1

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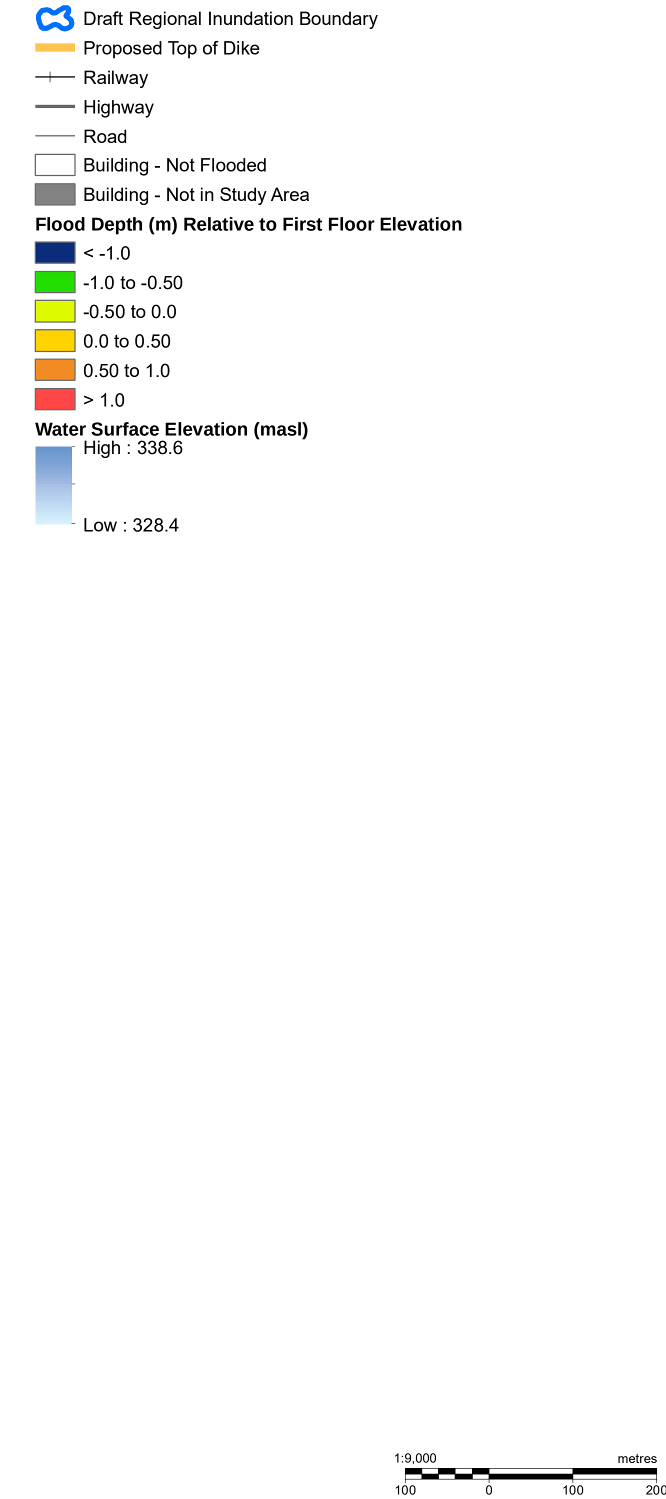

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - 5 Year (265 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 9.2

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-9-X-Option_2_Inundated_Buildings.mxd - Tabloid_L - 19-Mar-20, 10:59 AM - lmwright - TID005

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - 10 Year (322 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 9.3

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - 15 Year (350 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 9.4

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - 20 Year (377 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 9.5

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 9.6

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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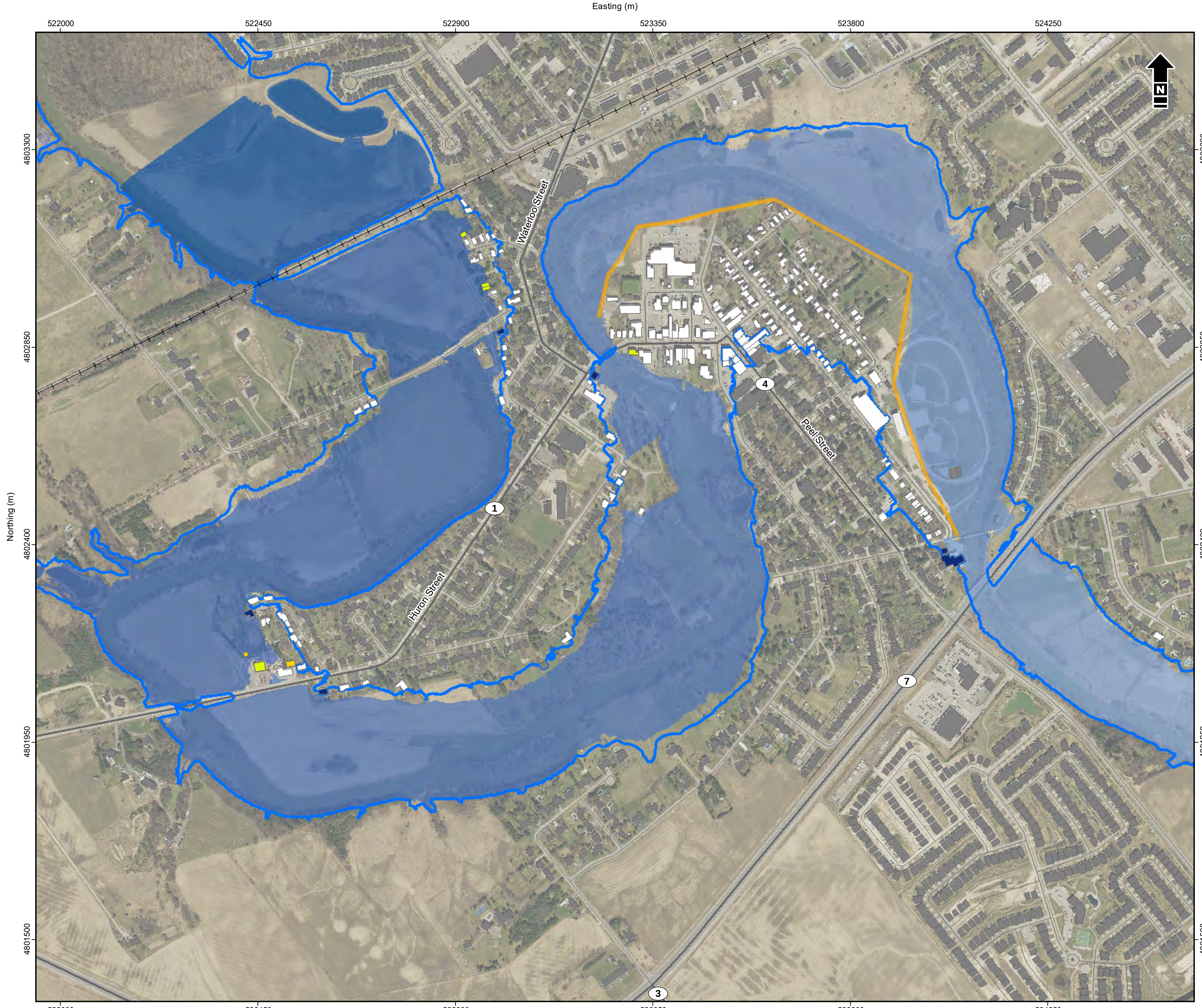
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - 50 Year (447 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 9.7



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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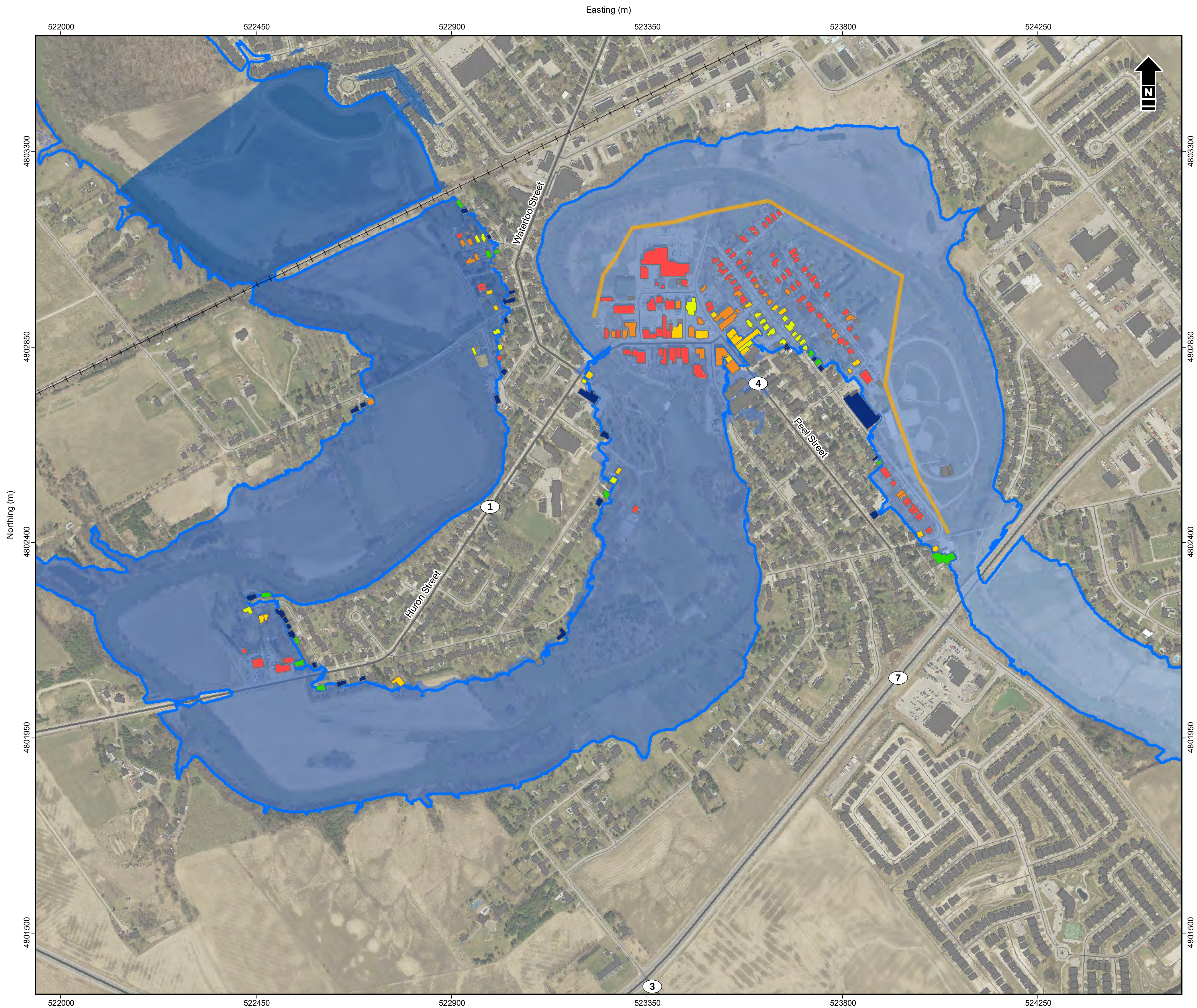
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 9.8



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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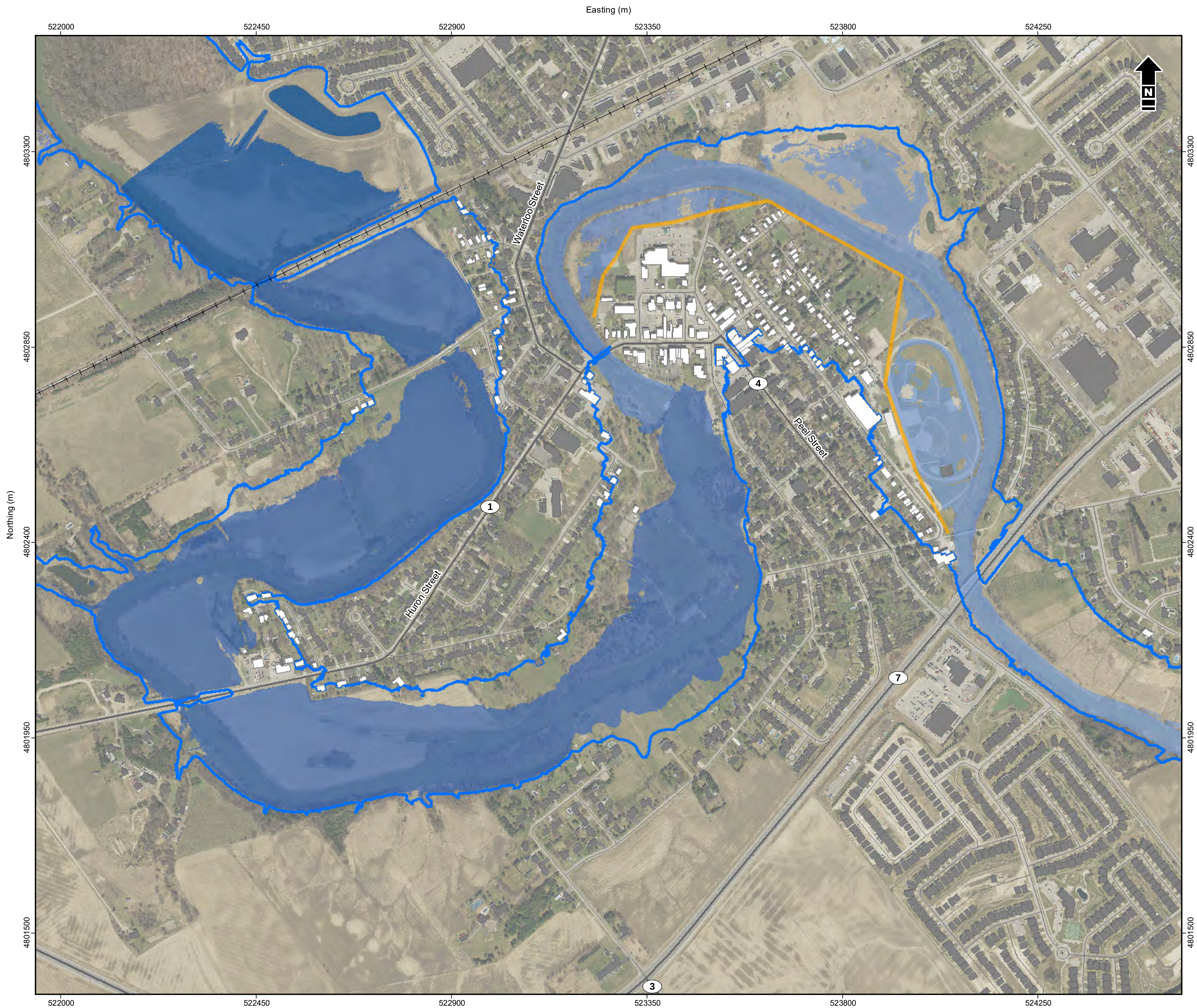
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Inundated Buildings - Regional (1,011 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 9.9



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

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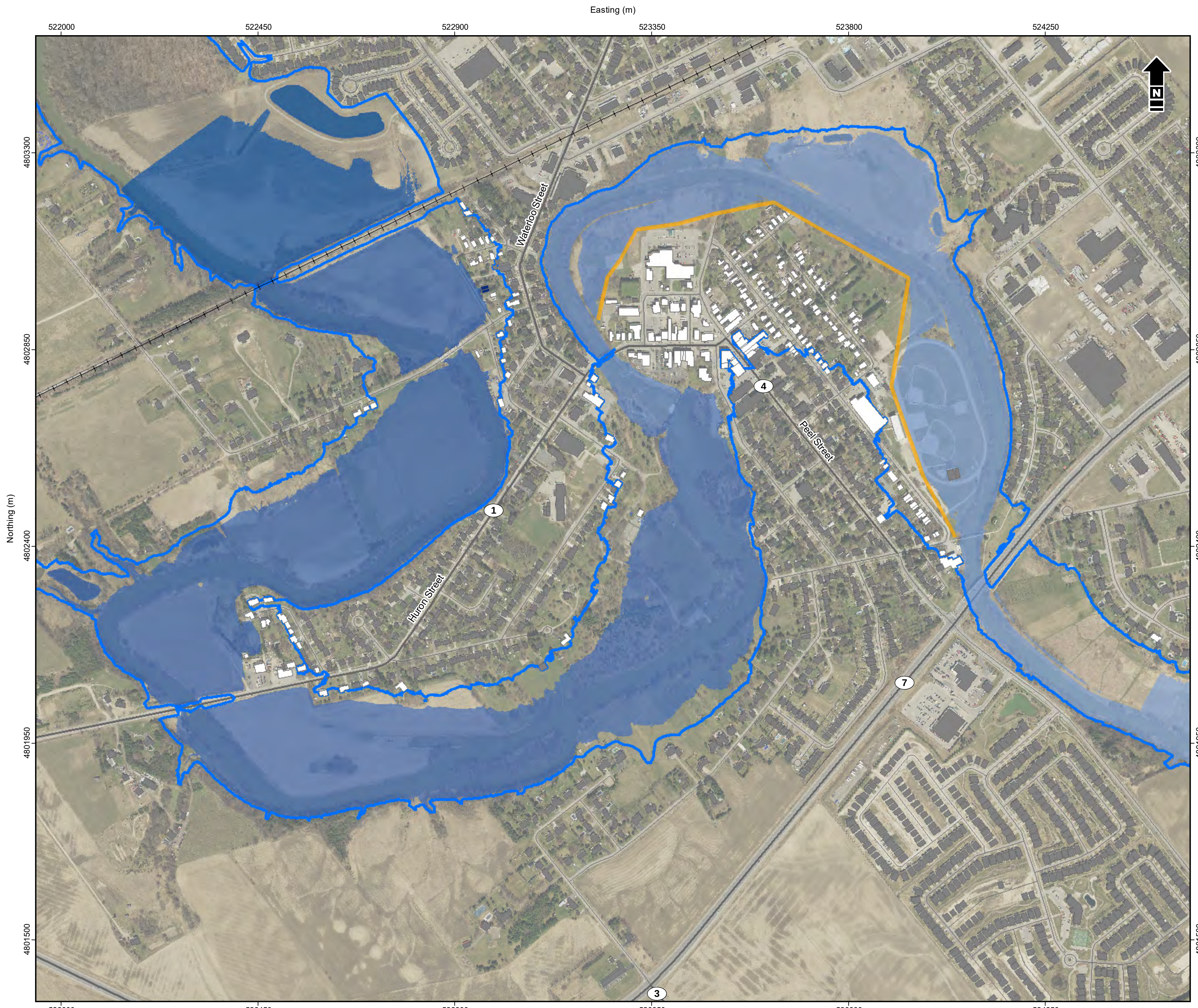
Figure 10.1



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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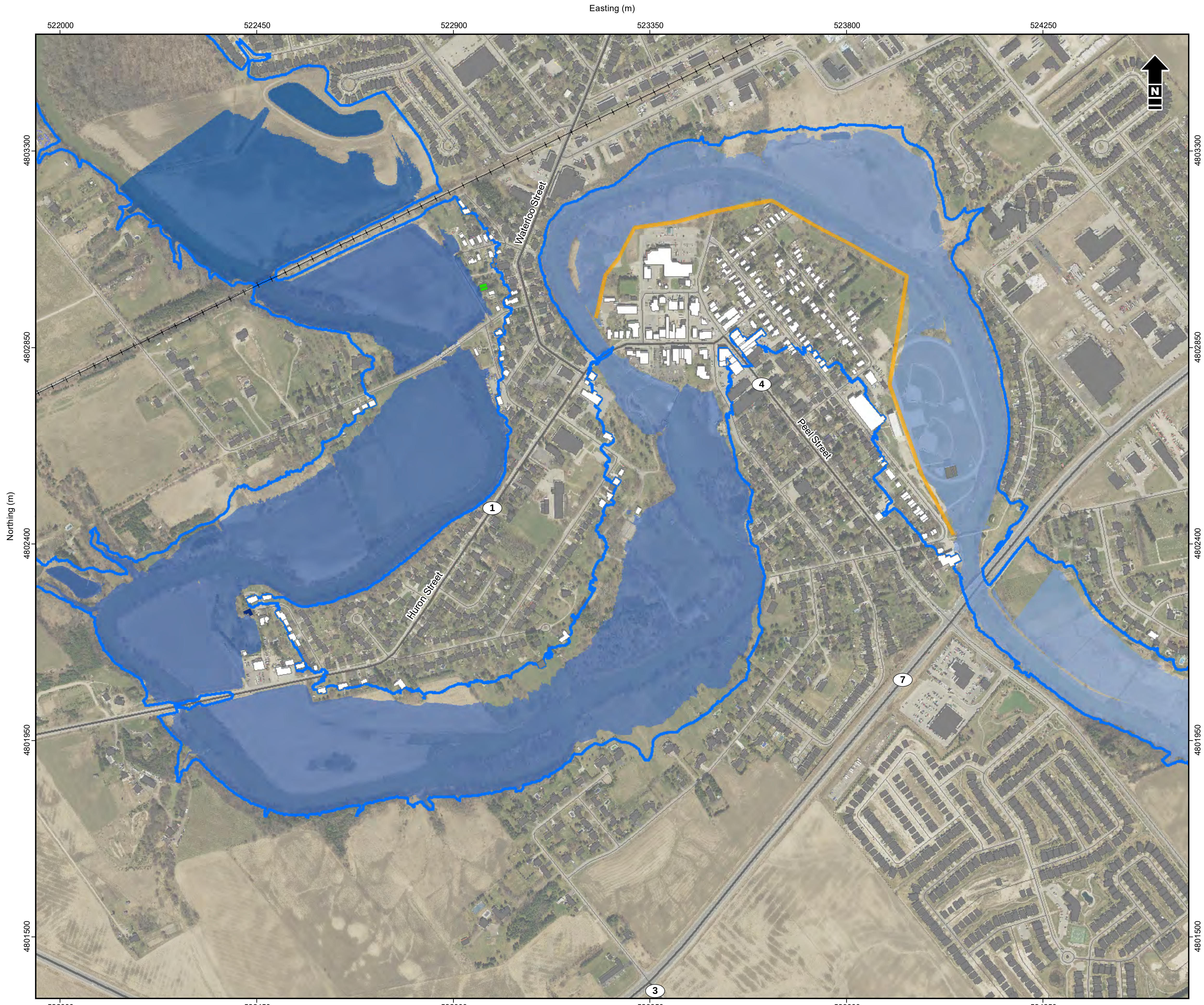
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - 5 Year (265 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
10.2



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
10.3

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
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Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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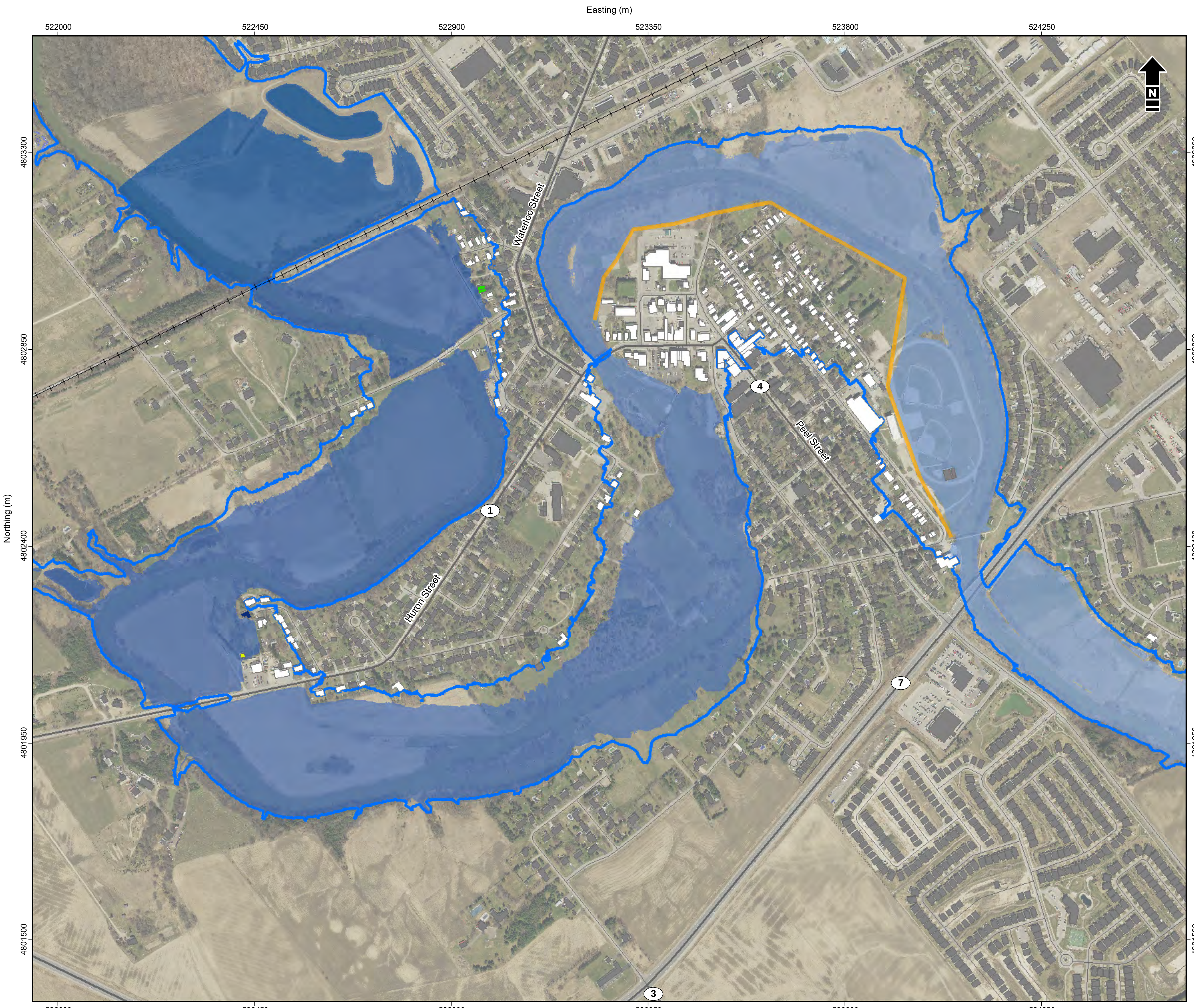
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - 15 Year (350 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 10.4



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

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-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
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Water Surface Elevation (masl)

High : 338.6

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1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 10.5

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Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
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Water Surface Elevation (masl)

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Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
10.6

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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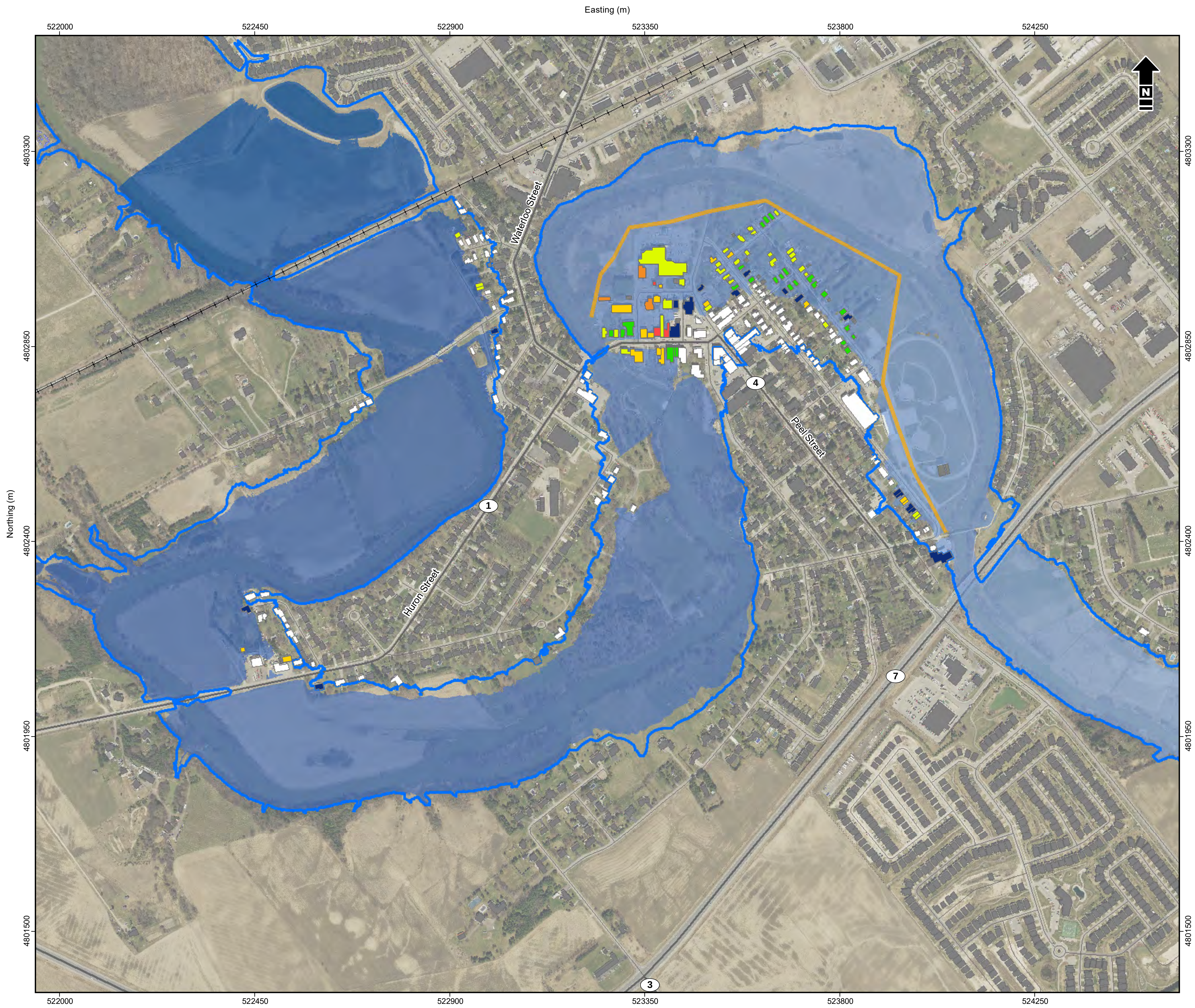
New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - 50 Year (447 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 10.7



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000
metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

Matrix Solutions Inc.
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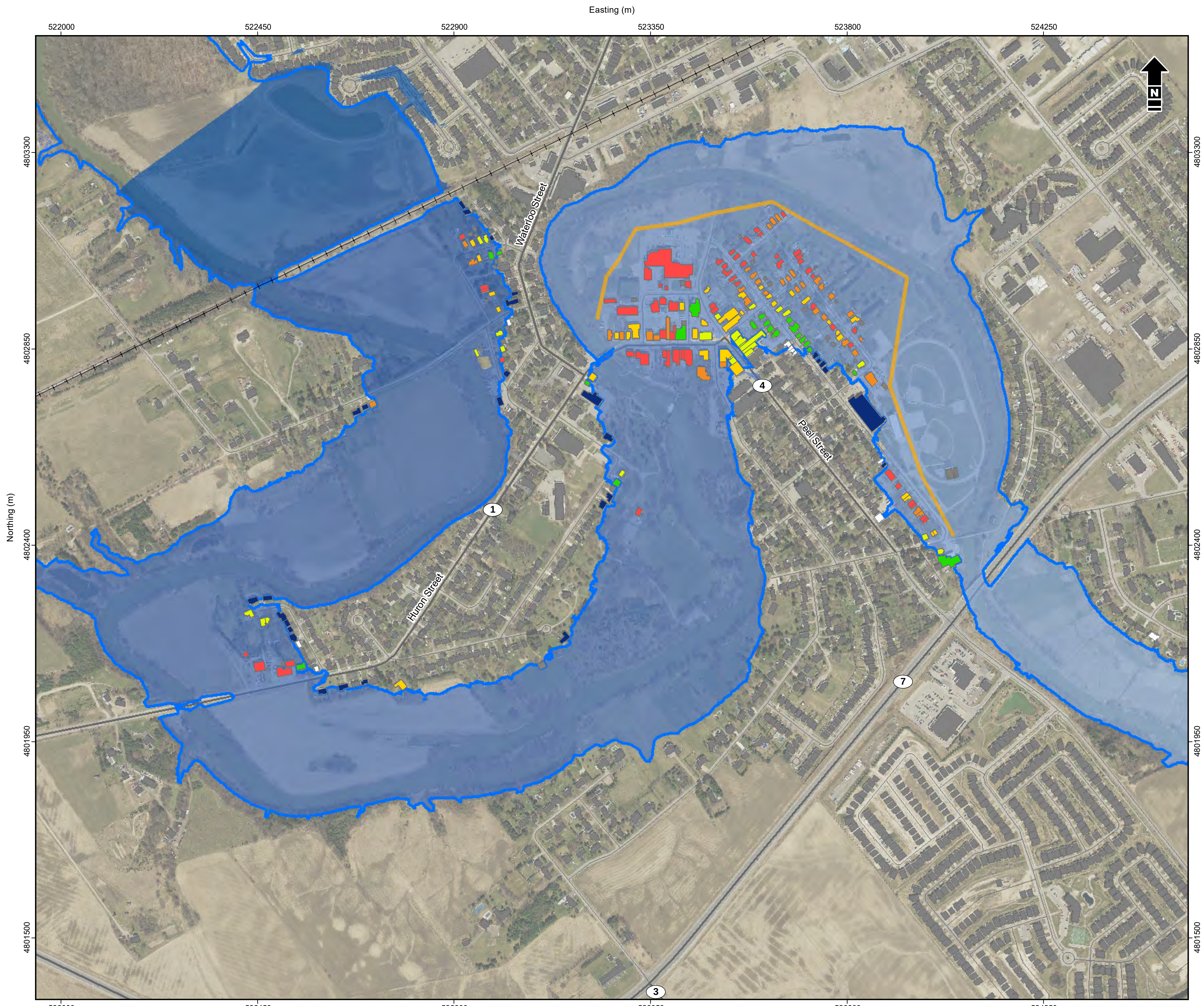
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
10.8



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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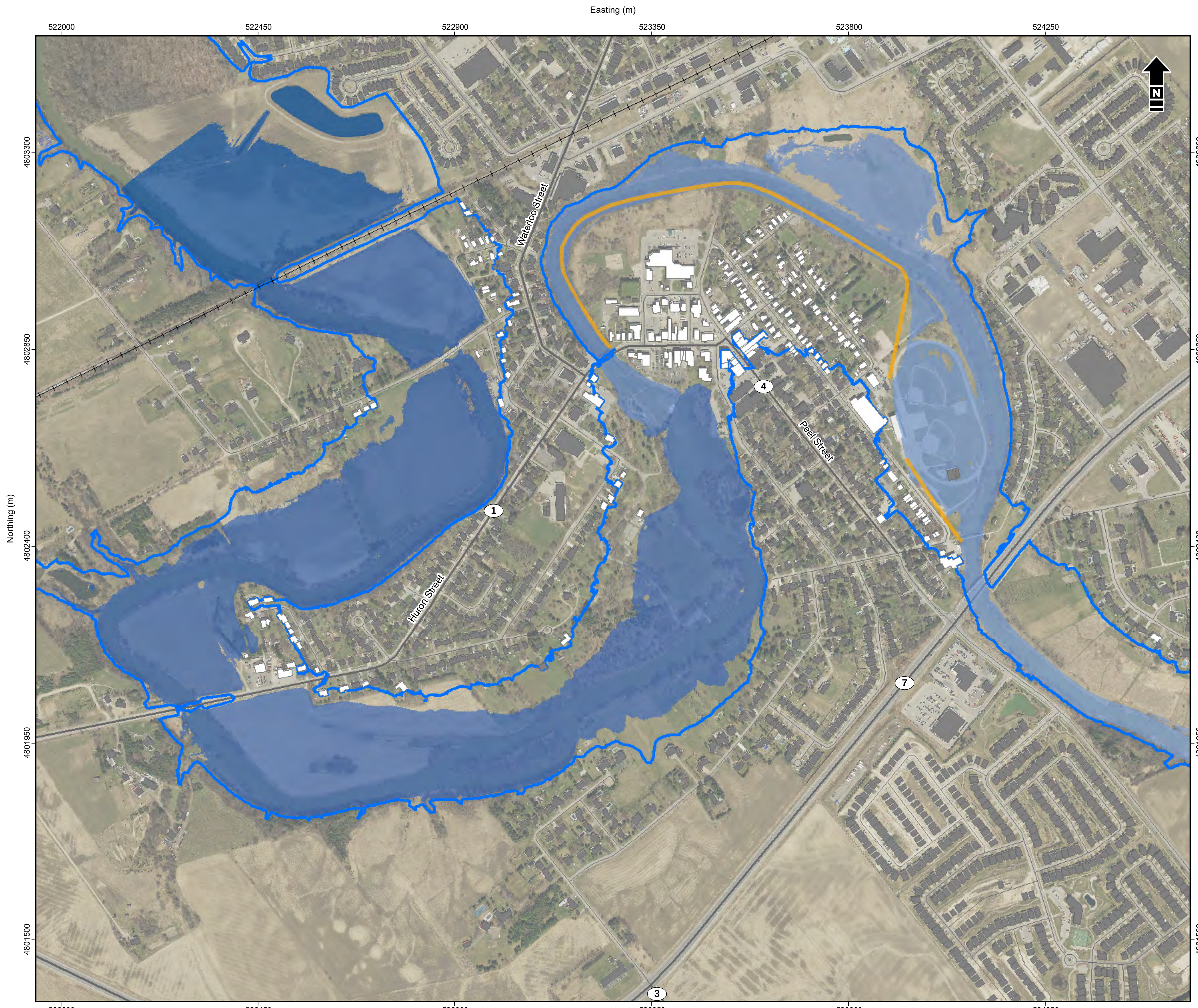
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Inundated Buildings - Regional (1,011 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 10.9



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Inundated Buildings - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 11.1

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000
metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Inundated Buildings - 5 Year (265 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
11.2

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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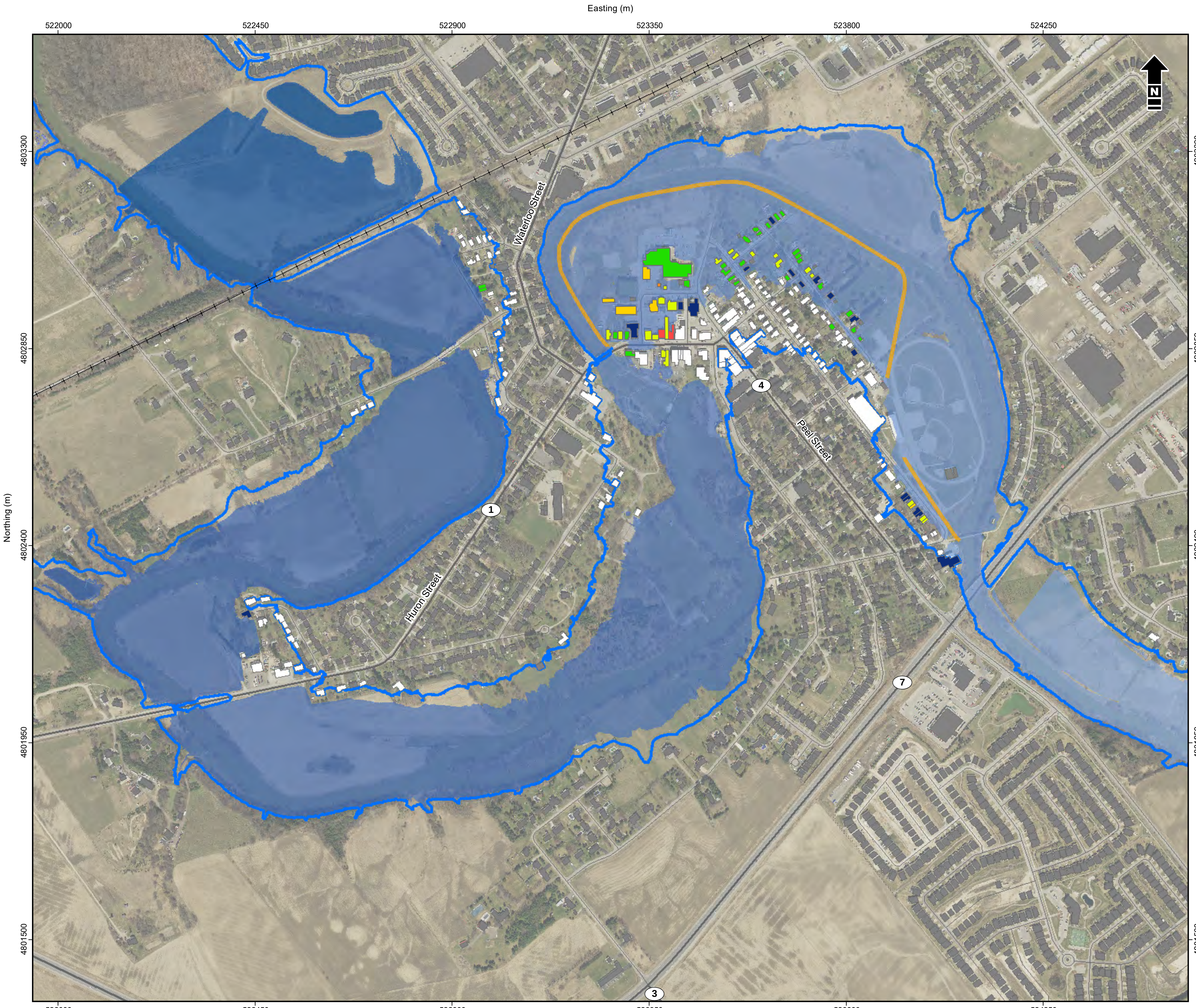
New Hamburg Flood Mitigation Study

Option 4 - Inundated Buildings - 10 Year (322 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 11.3



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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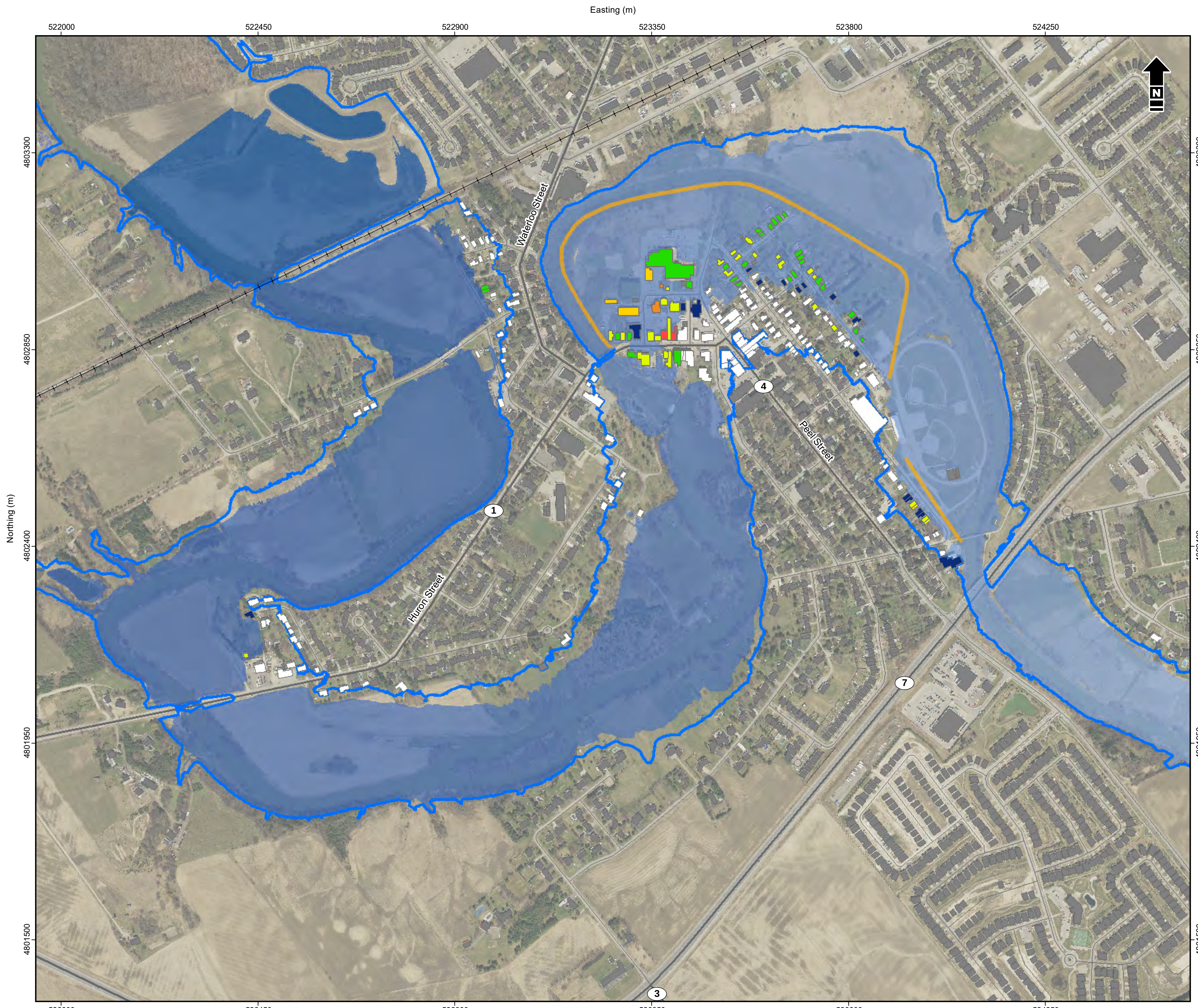
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Inundated Buildings - 15 Year (350 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 11.4

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-11-X-Option_4_Inundated_Buildings.mxd - Tabloid_L - 19-Mar-20, 11:13 AM - lmwright - TID005



- Draft Regional Inundation Boundary
- Proposed Top of Dike
- Railway
- Highway
- Road
- Building - Not Flooded
- Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000

metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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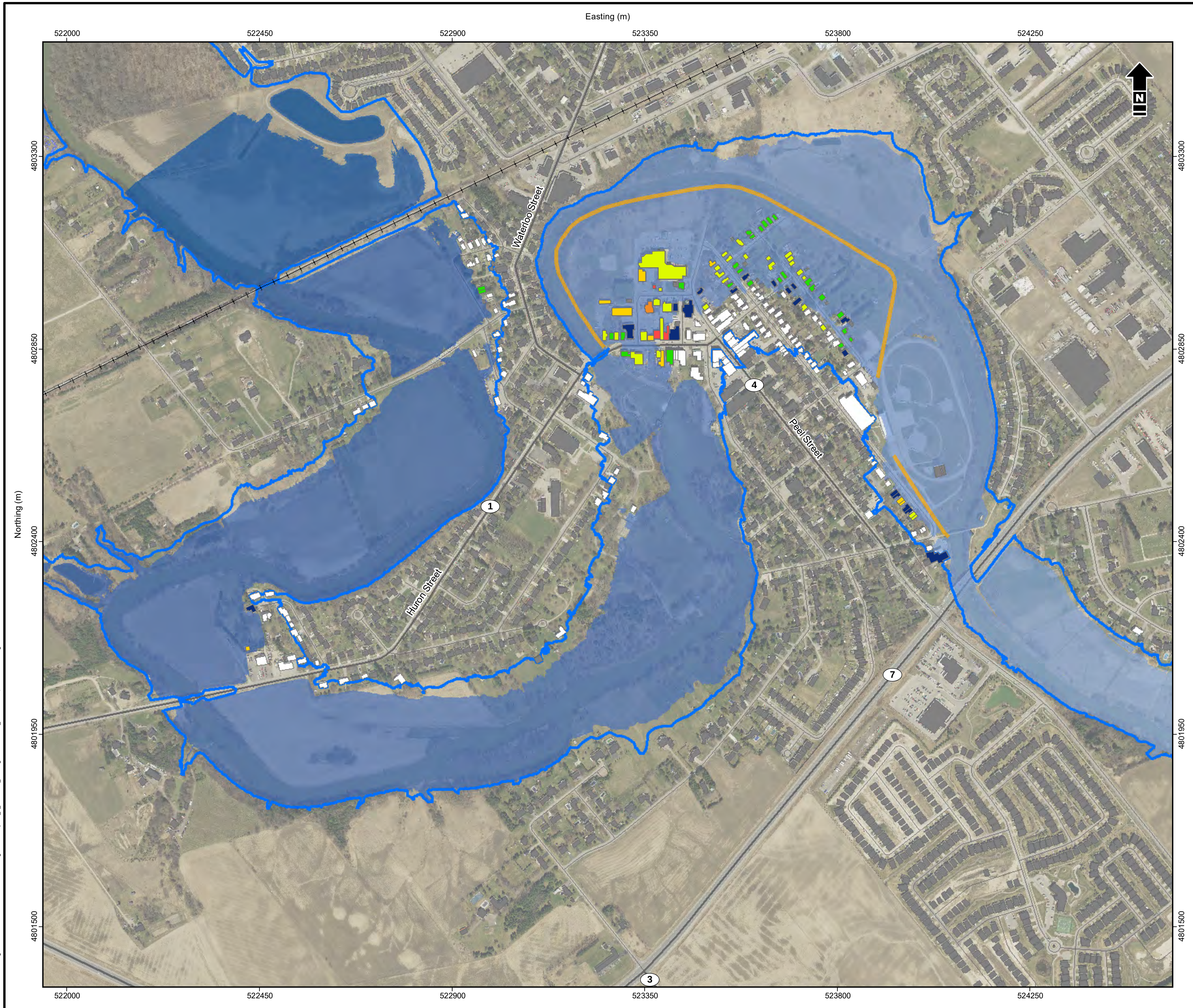
Option 4 - Inundated Buildings - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
11.5



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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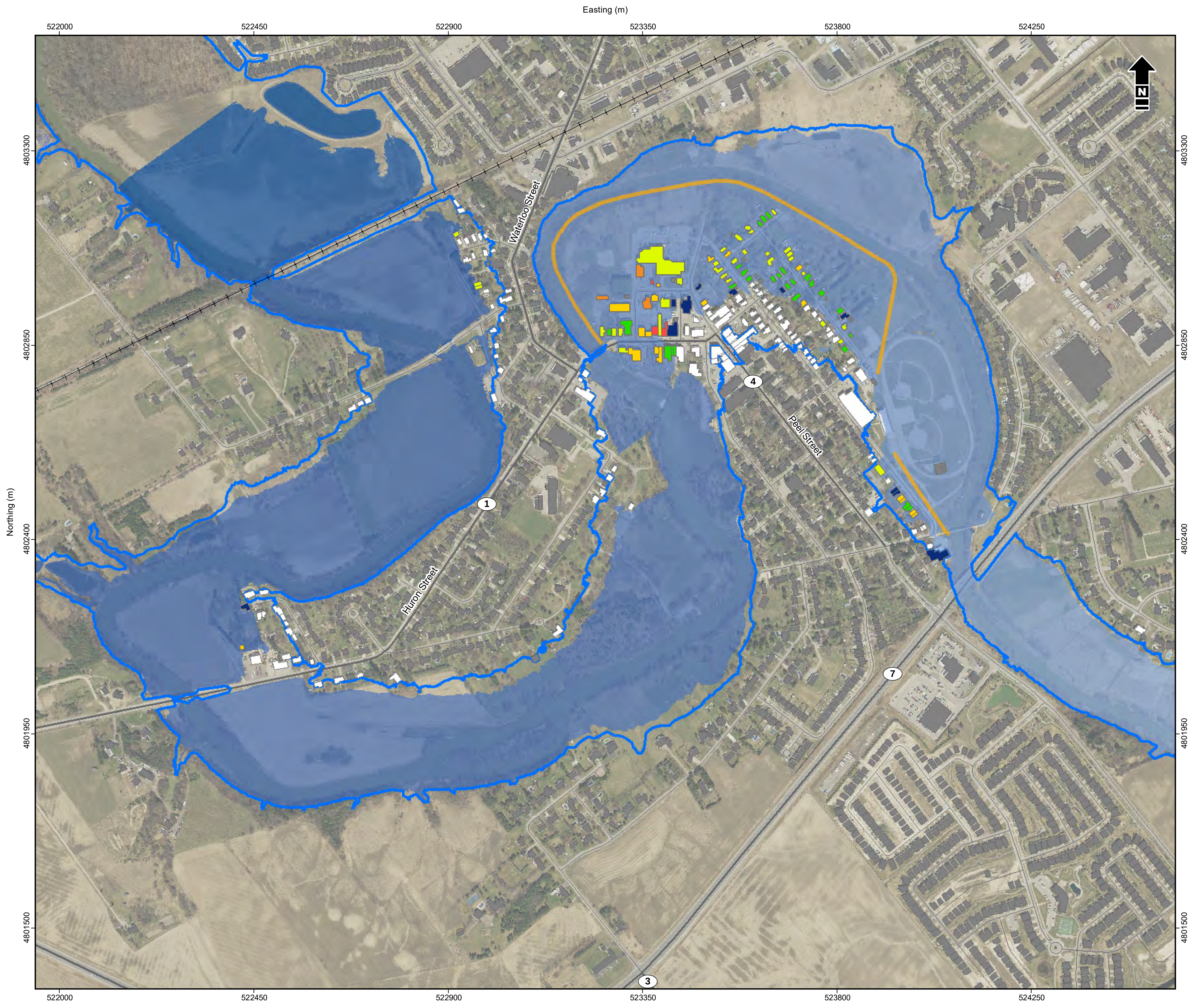
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Inundated Buildings - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 11.6



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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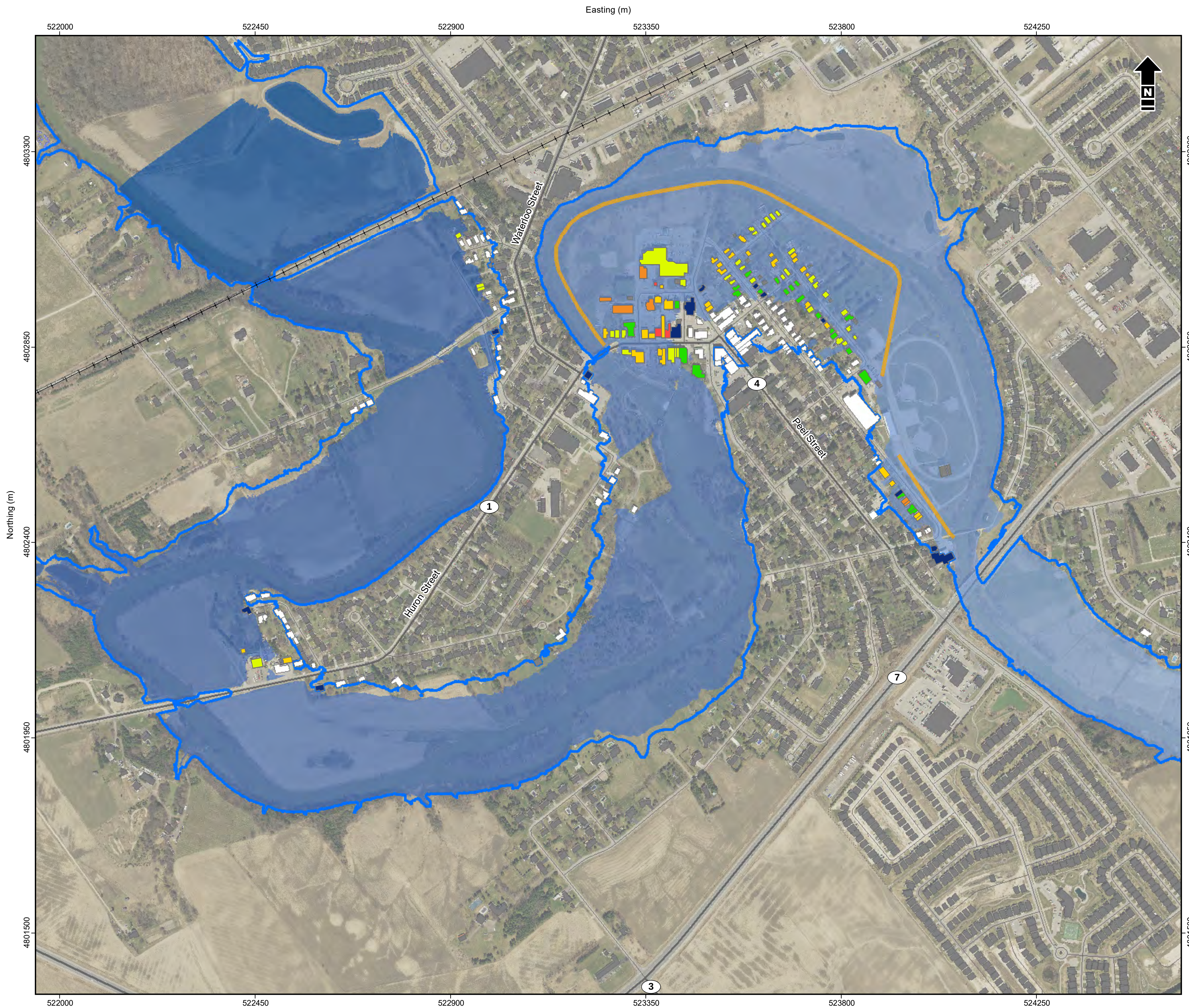
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Inundated Buildings - 50 Year (447 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 11.7

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-11-X-Option_4_Inundated_Buildings.mxd - Tabloid_L - 19-Mar-20, 11:13 AM - lmwright - TID005



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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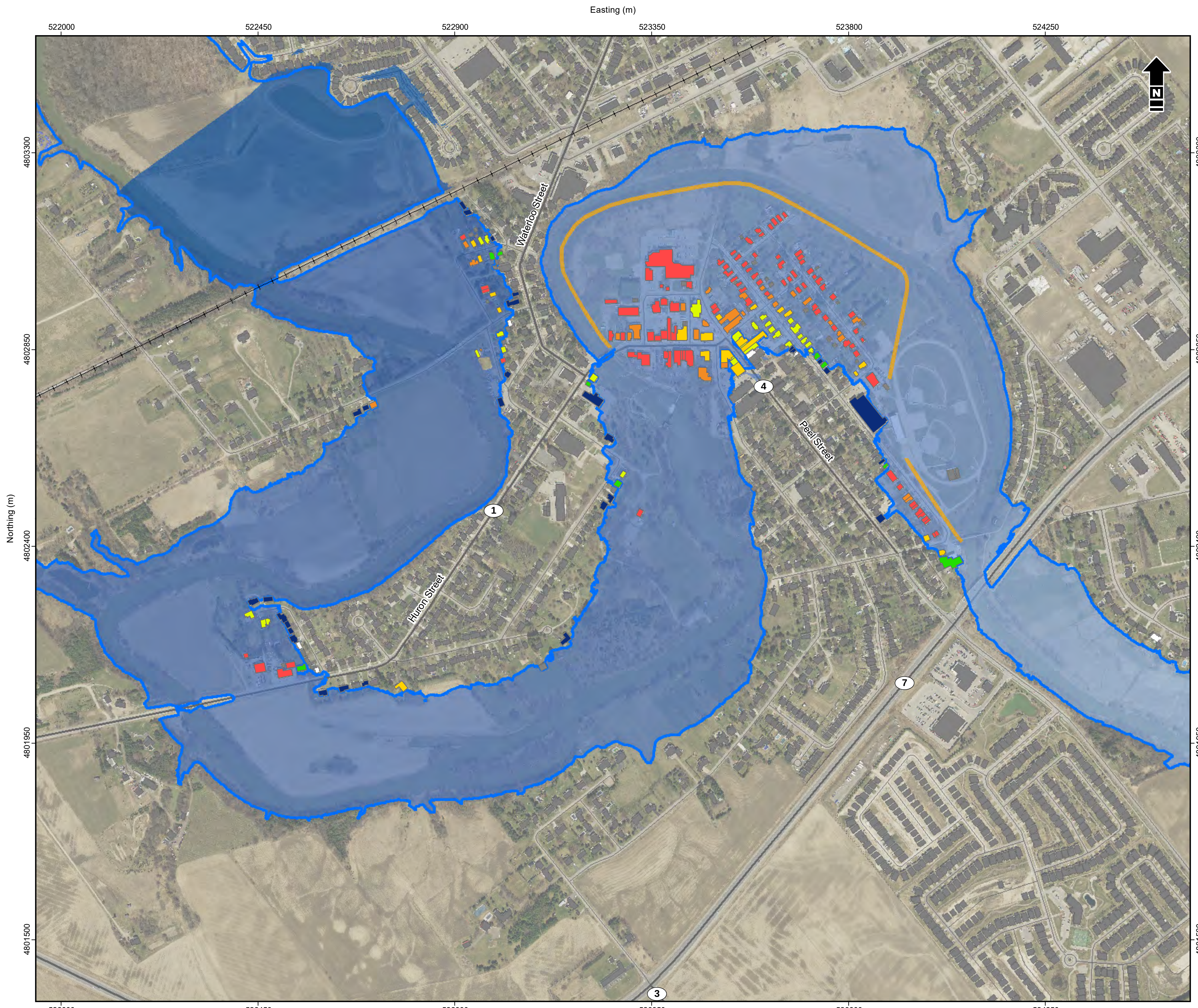
New Hamburg Flood Mitigation Study

Option 4 - Inundated Buildings - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 11.8



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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New Hamburg Flood Mitigation Study

Option 4 - Inundated Buildings - Regional (1,011 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 11.9

Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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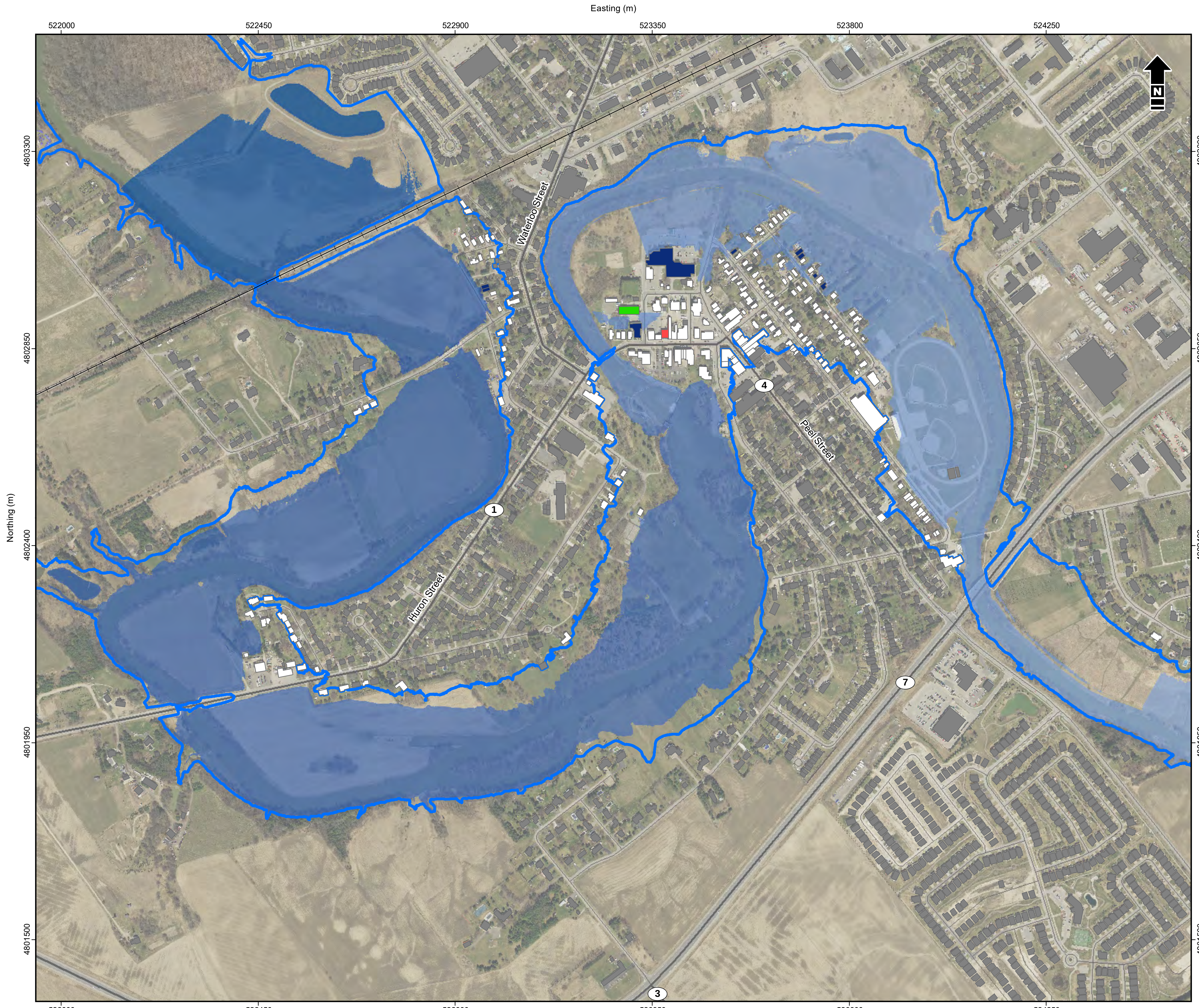
New Hamburg Flood Mitigation Study

Option 5 - Inundated Buildings - 2 Year (179 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 12.1



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

< -1.0
-1.0 to -0.50
-0.50 to 0.0
0.0 to 0.50
0.50 to 1.0
> 1.0

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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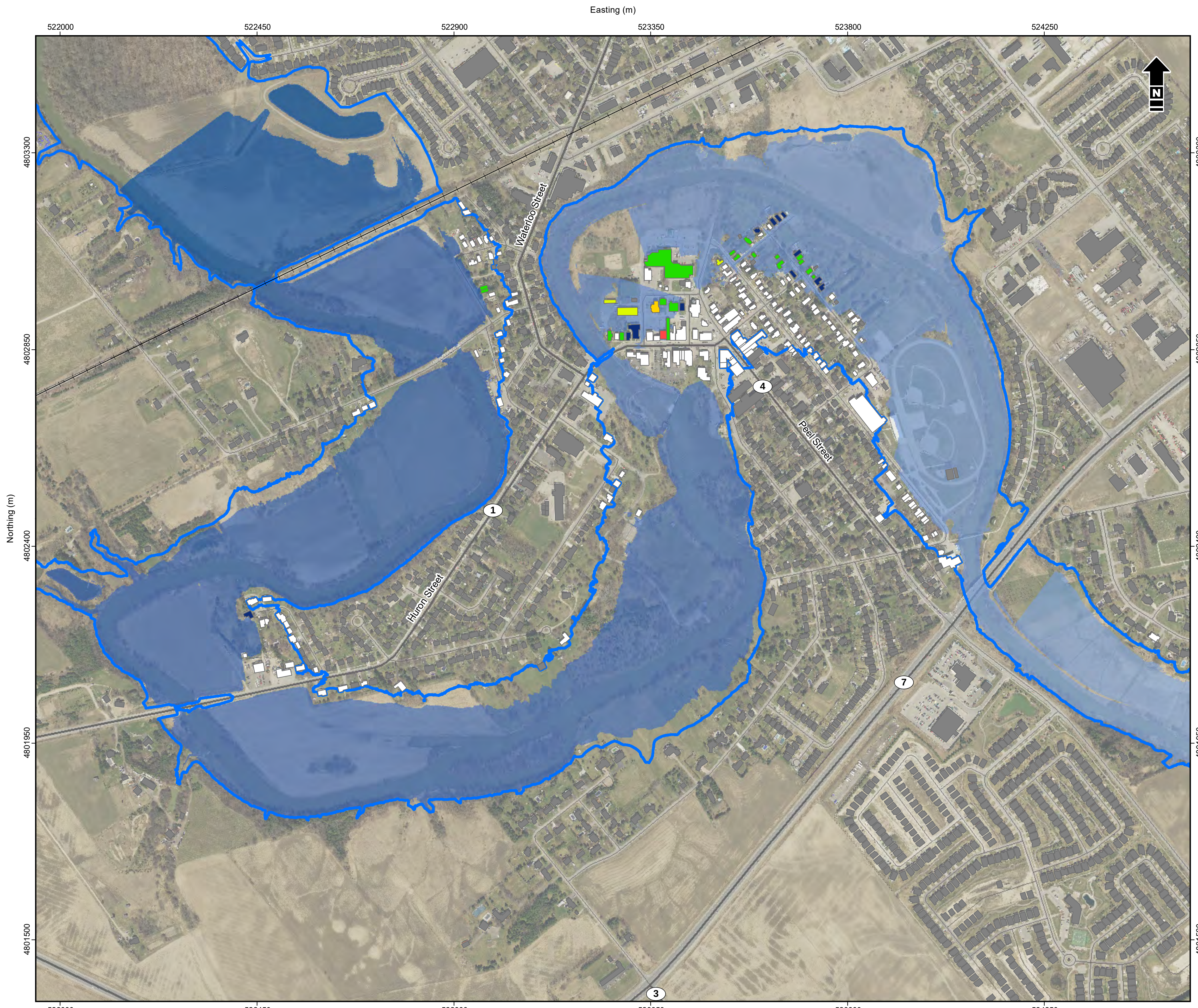
New Hamburg Flood Mitigation Study

Option 5 - Inundated Buildings - 5 Year (265 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 12.2



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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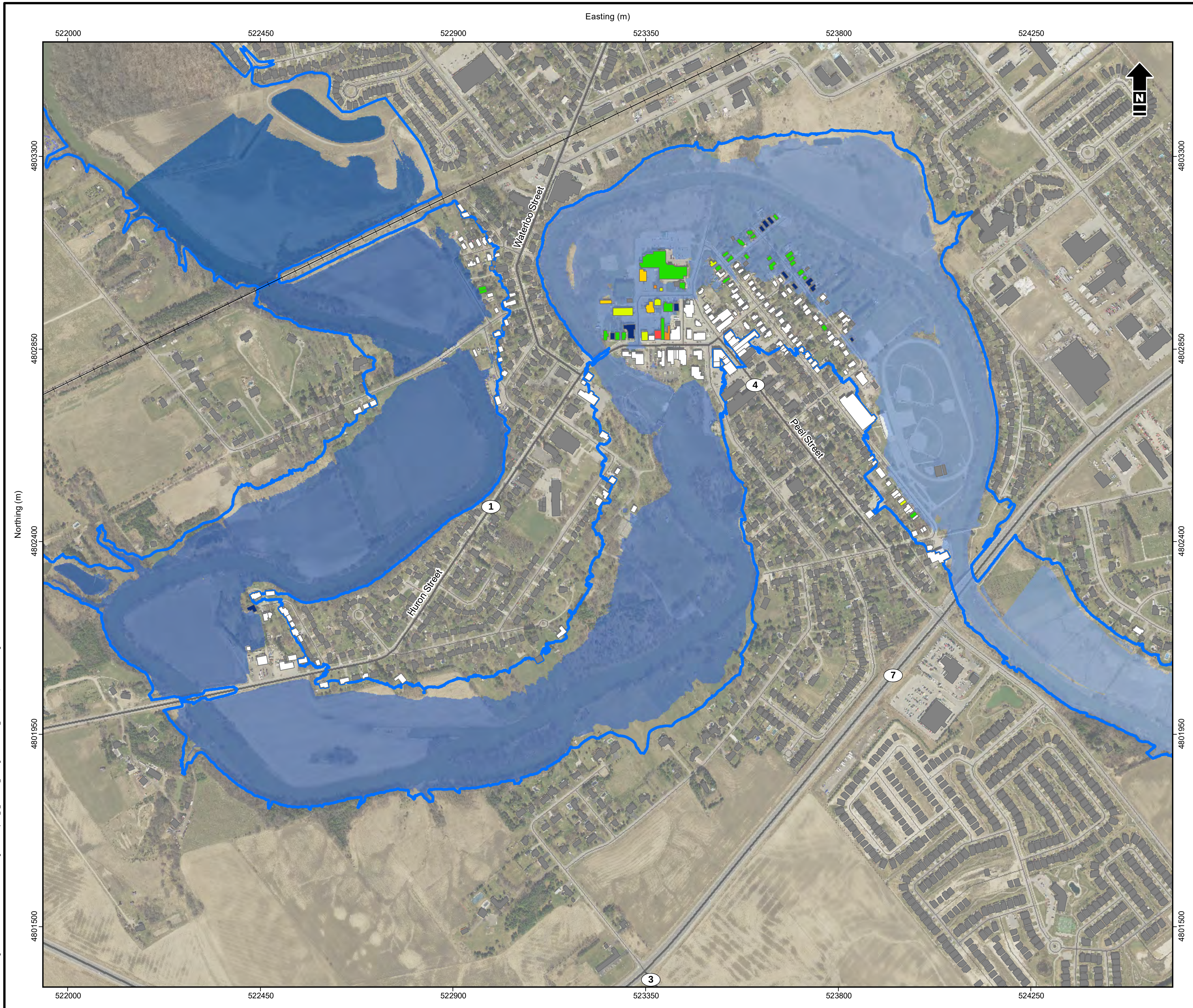
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 - Inundated Buildings - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 12.3



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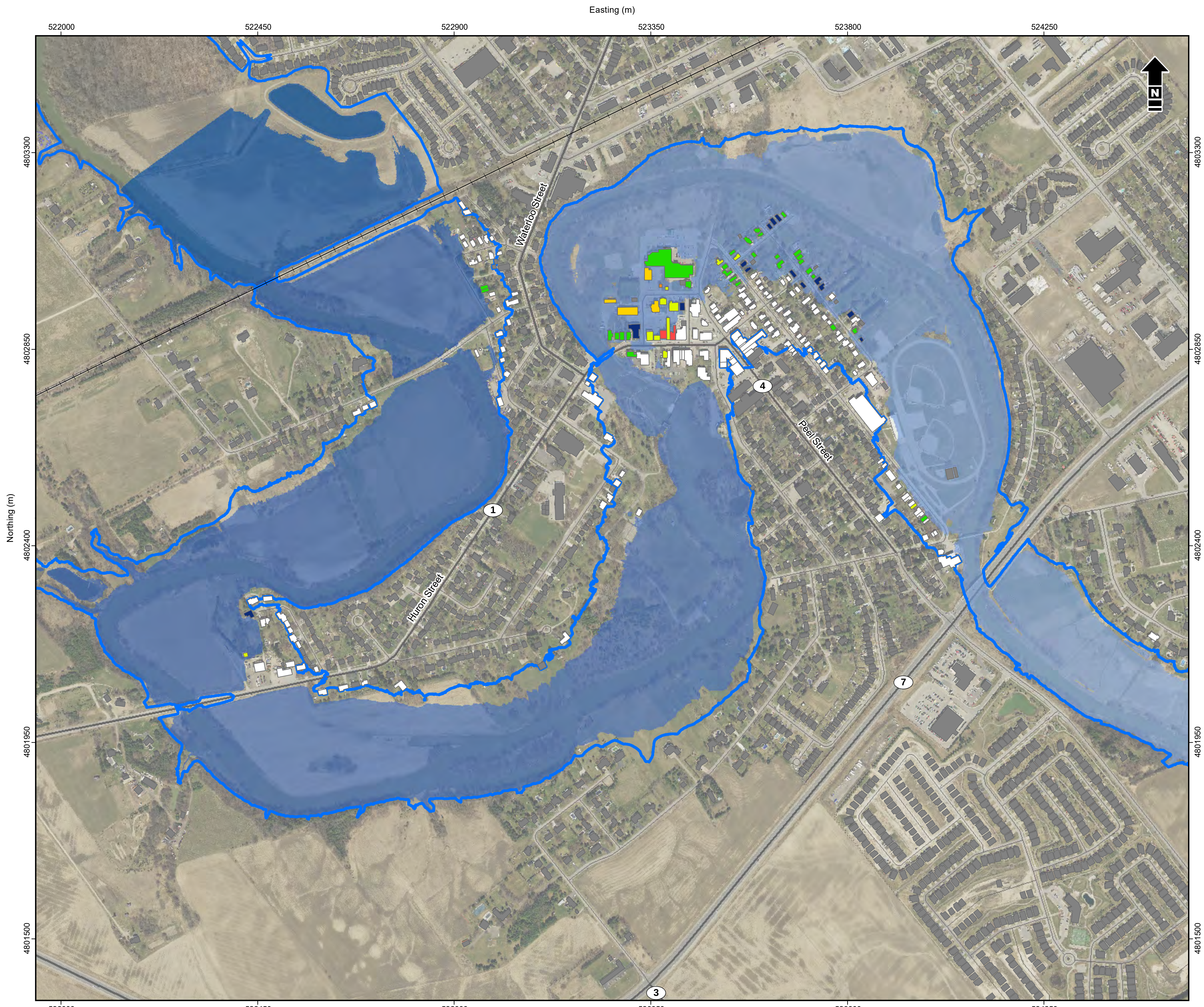
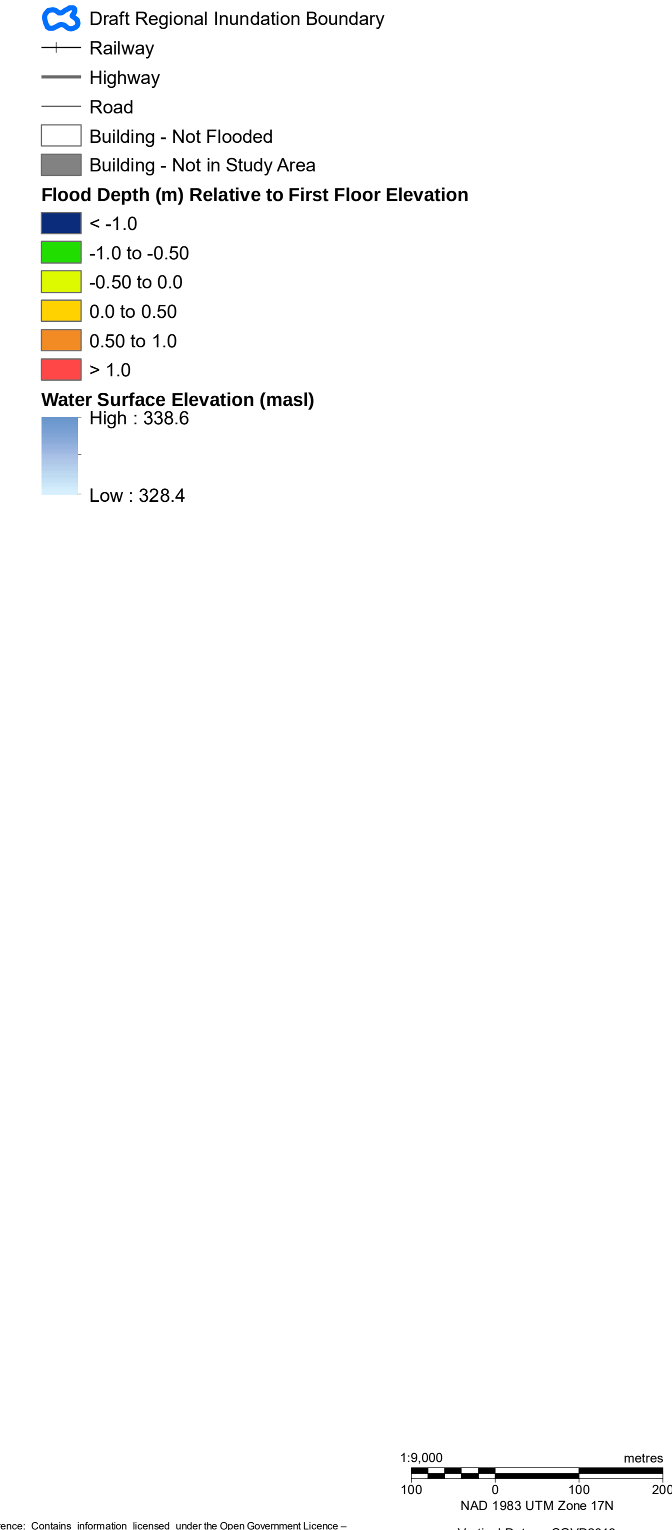
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 - Inundated Buildings - 15 Year (350 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 12.4





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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 - Inundated Buildings - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
12.5

Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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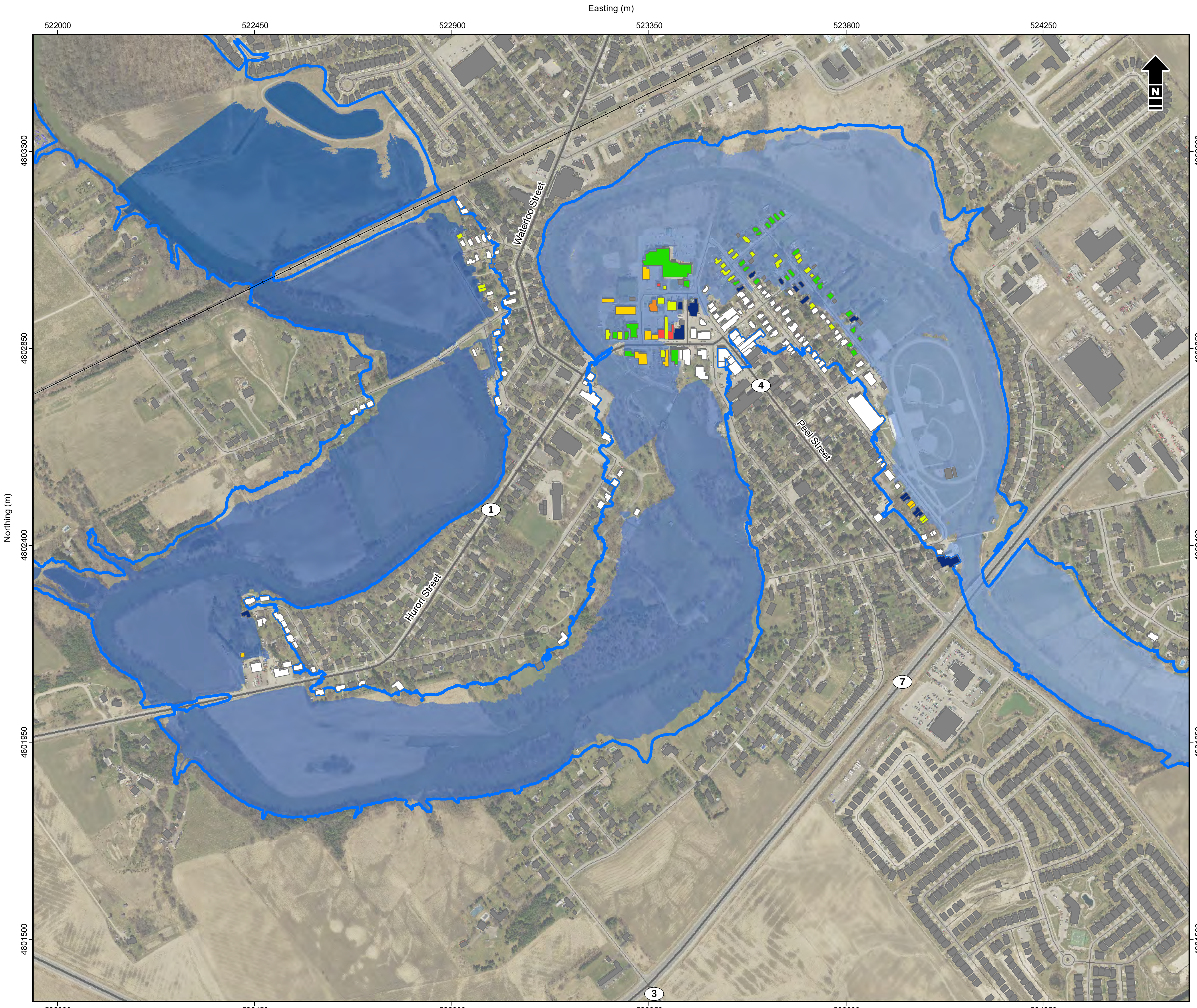
New Hamburg Flood Mitigation Study

Option 5 - Inundated Buildings - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
12.6

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-12-X-Option_5_Inundated_Buildings.mxd - Tabloid_L - 19-Mar-20, 11:17 AM - lmwright - TID005



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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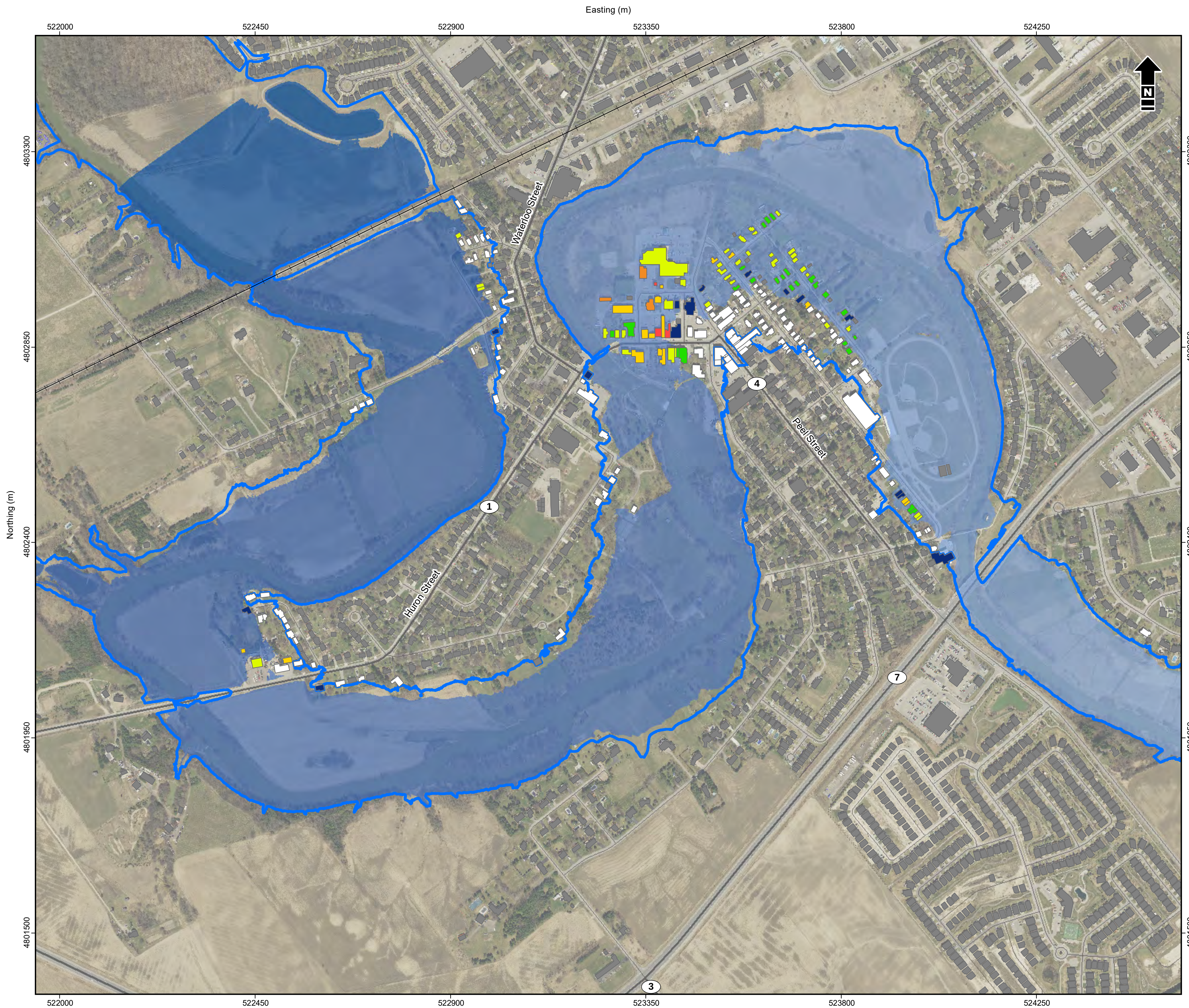
New Hamburg Flood Mitigation Study

Option 5 - Inundated Buildings - 50 Year (447 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 12.7



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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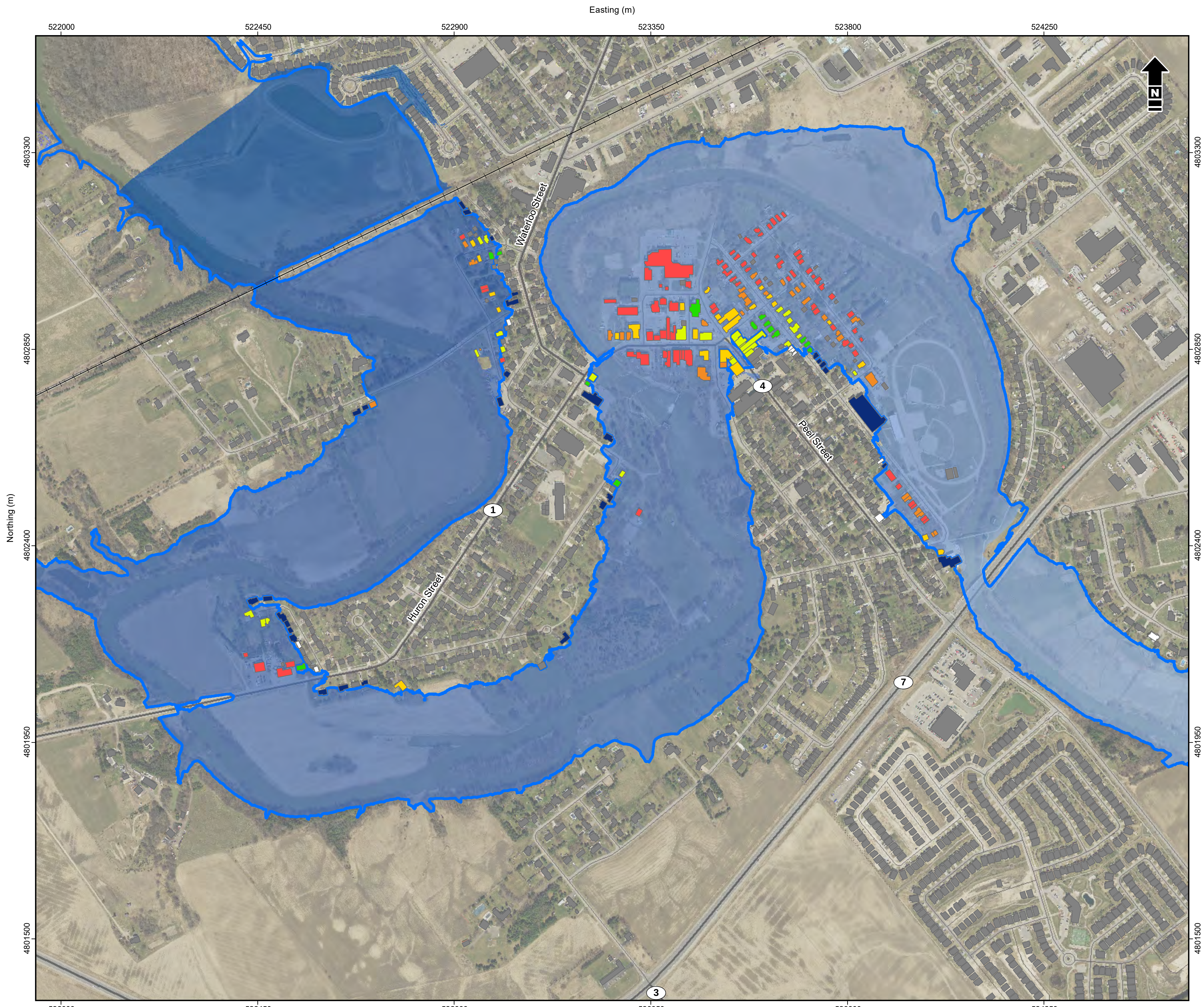
Option 5 - Inundated Buildings - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 12.8



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Flood Depth (m) Relative to First Floor Elevation

- < -1.0
- -1.0 to -0.50
- -0.50 to 0.0
- 0.0 to 0.50
- 0.50 to 1.0
- > 1.0

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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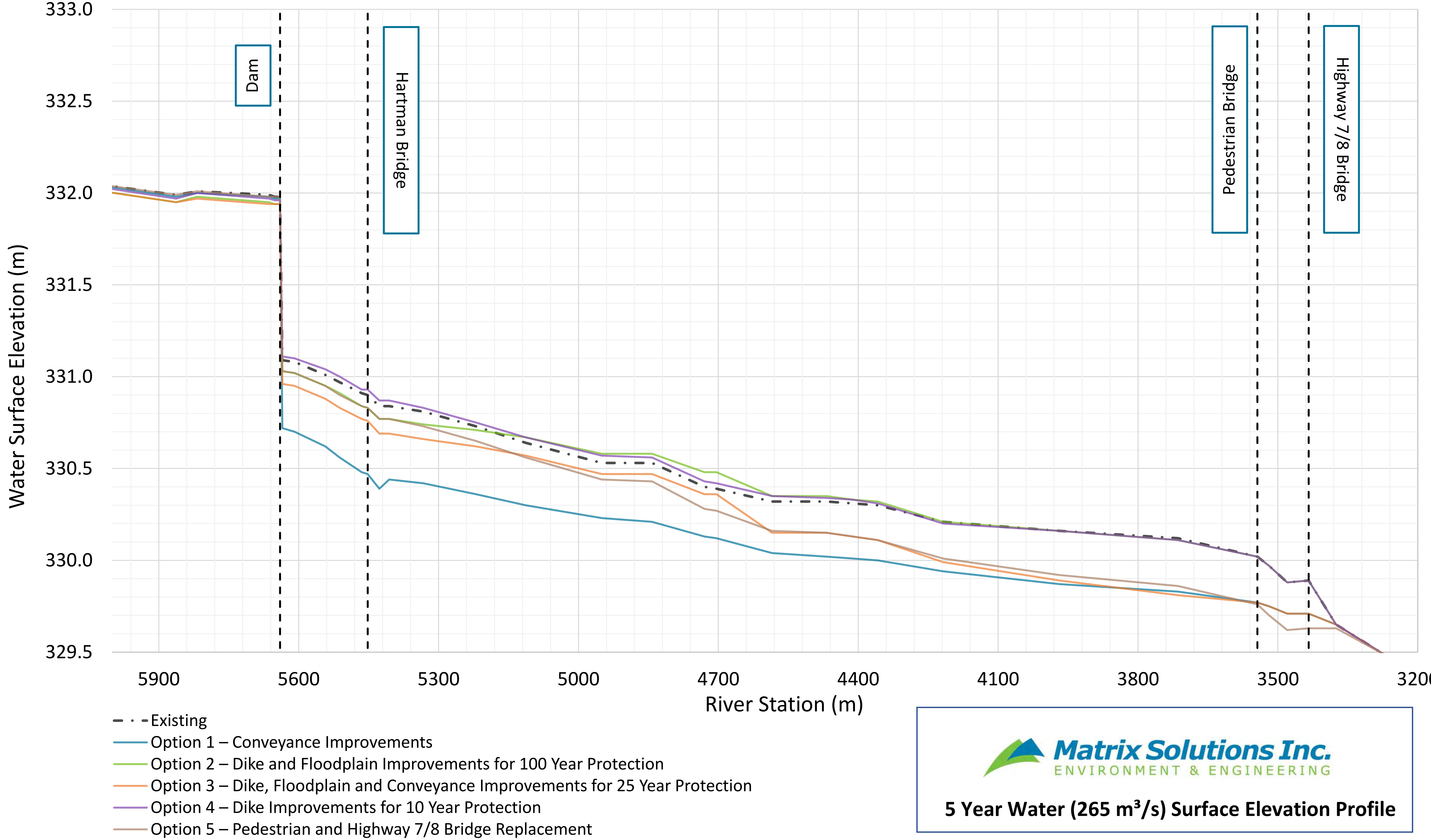
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 - Inundated Buildings - Regional (1,011 m^3/s)

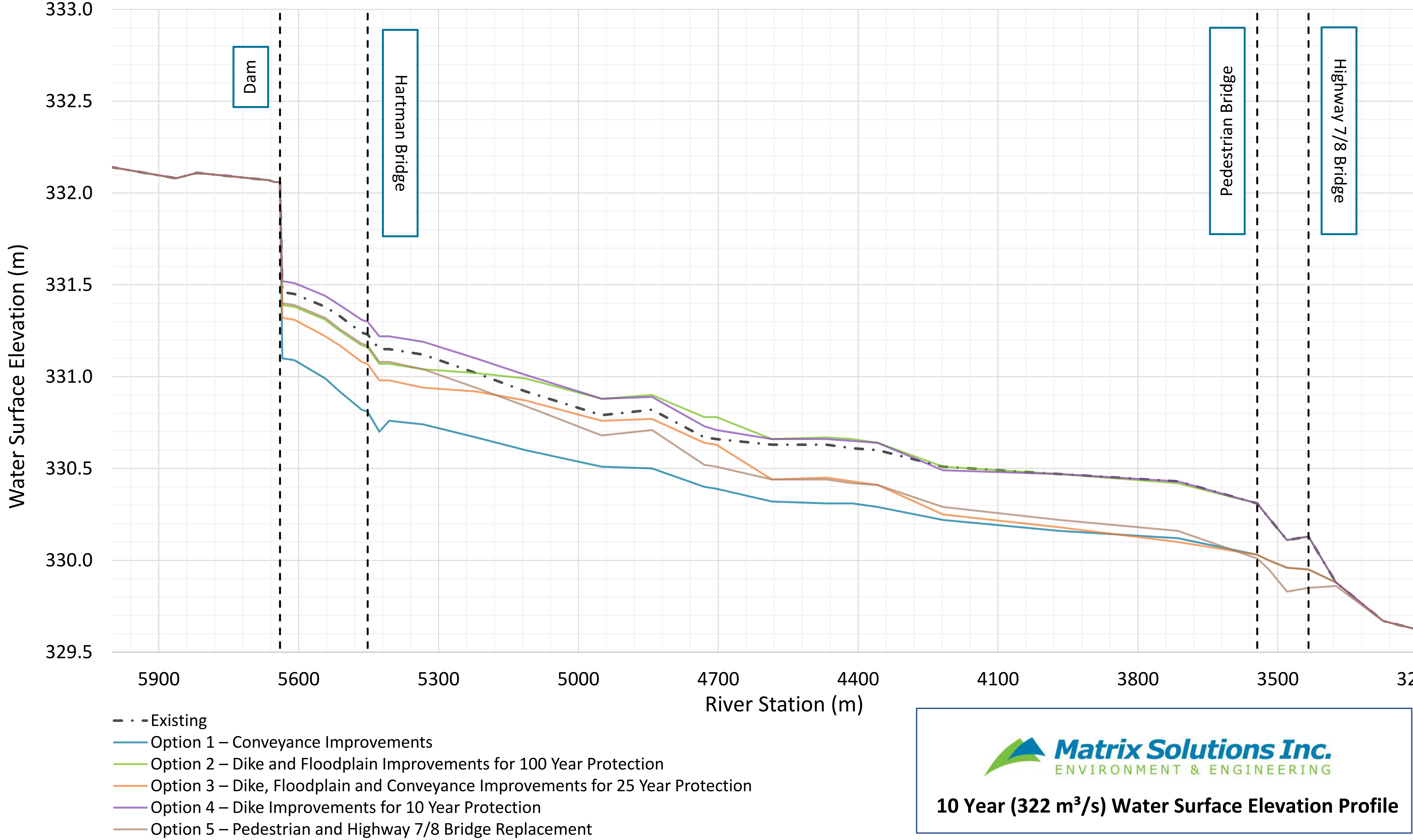
Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 12.9

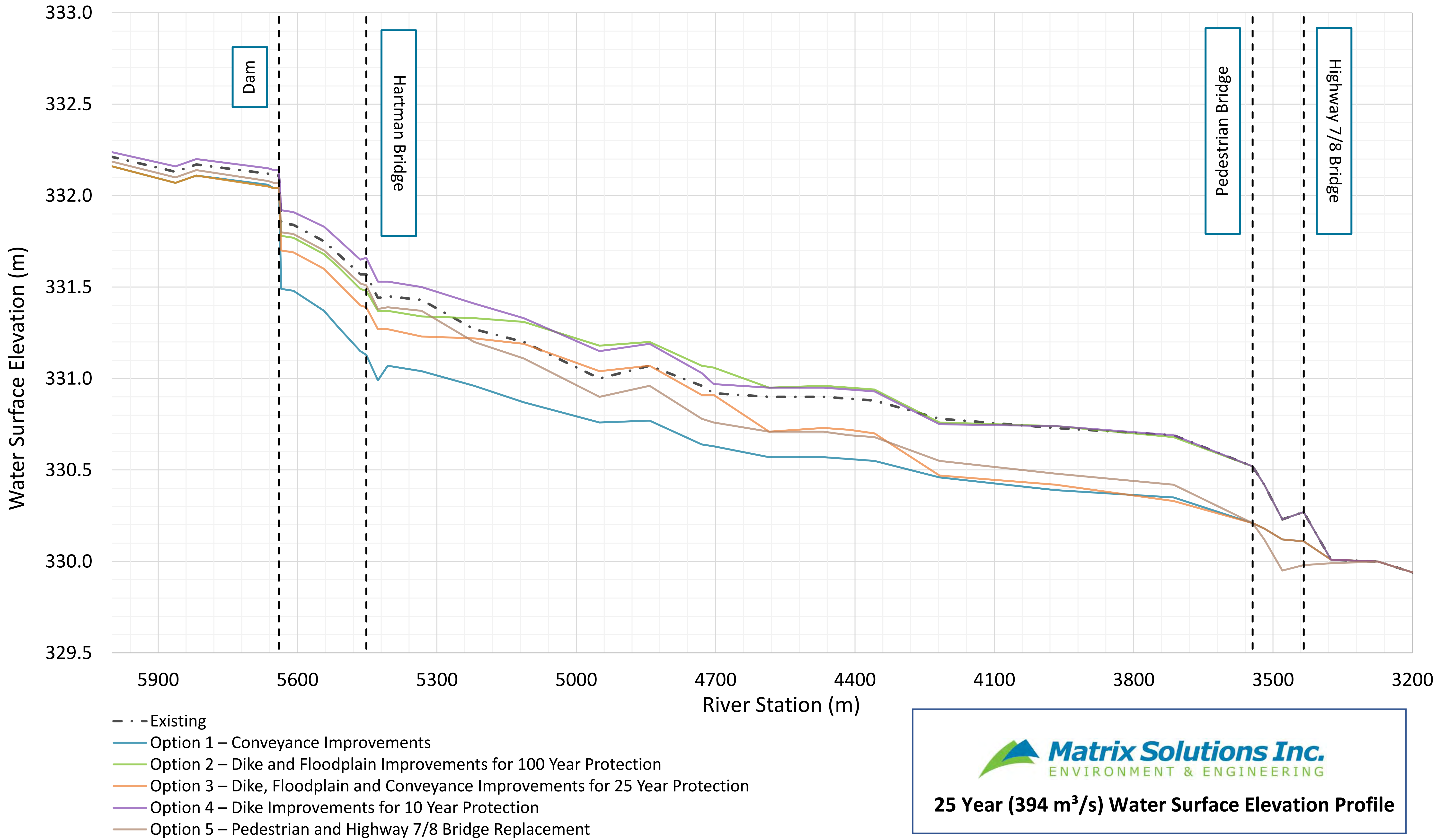
Appendix D
Flood Water Surfaces Profiles Figure Set



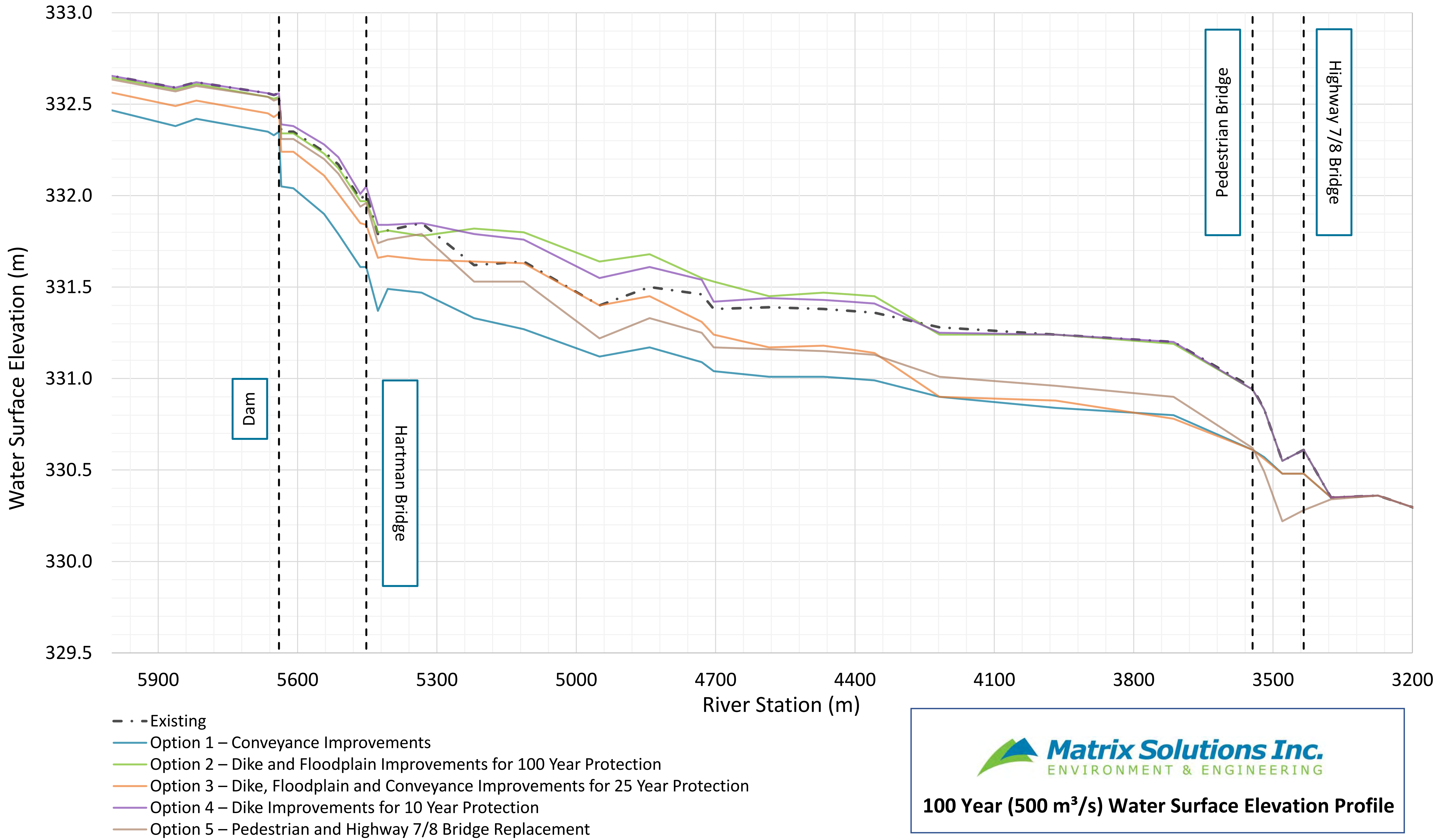
5 Year Water (265 m³/s) Surface Elevation Profile



10 Year (322 m³/s) Water Surface Elevation Profile



25 Year (394 m^3/s) Water Surface Elevation Profile



Water Surface Elevation (m)
333.0
332.5
332.0
331.5
331.0
330.5
330.0
329.5
5900
5600
5300
5000
4700
4400
4100
3800
3500
3200
River Station (m)
Dam
Hartman Bridge
Pedestrian Bridge
Highway 7/8 Bridge
Existing
Option 1 – Conveyance Improvements
Option 2 – Dike and Floodplain Improvements for 100 Year Protection
Option 3 – Dike, Floodplain and Conveyance Improvements for 25 Year Protection
Option 4 – Dike Improvements for 10 Year Protection
Option 5 – Pedestrian and Highway 7/8 Bridge Replacement
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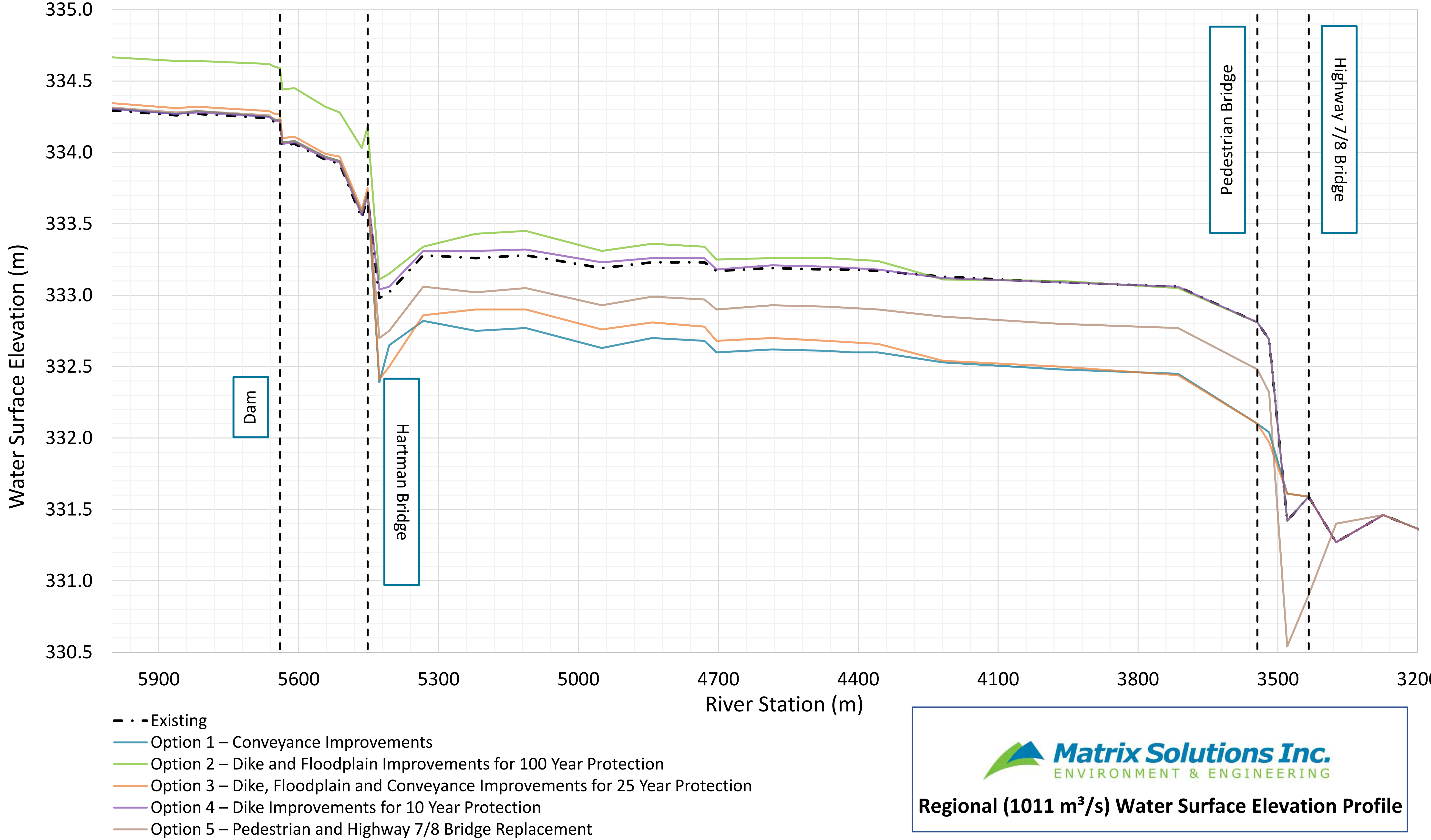
100 Year (500 m³/s) Water Surface Elevation Profile



Regional (1011 m³/s) Water Surface Elevation Profile

Appendix E
Flood Risk Figure Set

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

0 250 500 m

N

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Existing - 25-Year Event (394m³/s)
Depth

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Ziyang Zhang

Figure 13.1a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.1_Existing 25yr.qgs|Existing 25yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

N

0 250 500 m

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Existing - 25-Year Event (394m³/s)
Velocity

Ziyang Zhang

Figure 13.1b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.1_Existing 25yr.qgs|Existing 25yr|pg2|2020-03-29

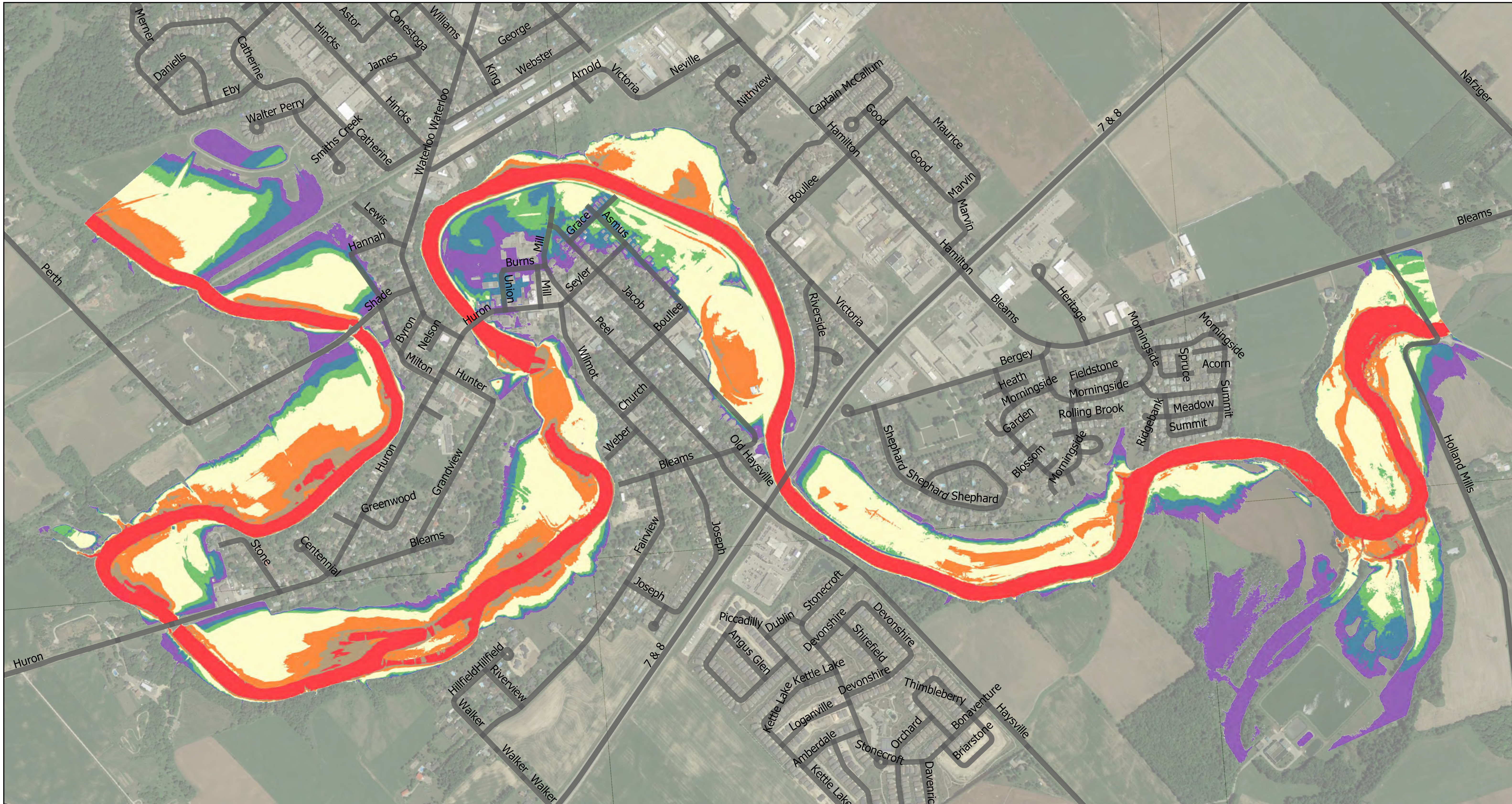

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

Matrix Solutions Inc.
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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Existing - 25-Year Event (394m³/s)
Depth x Velocity

Ziyang Zhang

Figure 13.1c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.1_Existing 25yr.qgs|Existing 25yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results

Risk
- Low
- Medium
- High

N

0 250 500 m

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Existing - 25-Year Event (394m³/s)
Risk

Ziyang Zhang

Figure 13.1d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.1_Existing 25yr.qgs|Existing 25yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

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Existing - 100-Year Event (500m³/s)
Depth

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Ziyang Zhang

Figure 13.2a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.2_Existing 100yr.qgs|Existing 100yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

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0 250 500 m

N

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Existing - 100-Year Event (500m³/s)
Velocity

Ziyang Zhang

Figure 13.2b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.2_Existing 100yr.qgs|Existing 100yr|pg2|2020-03-29

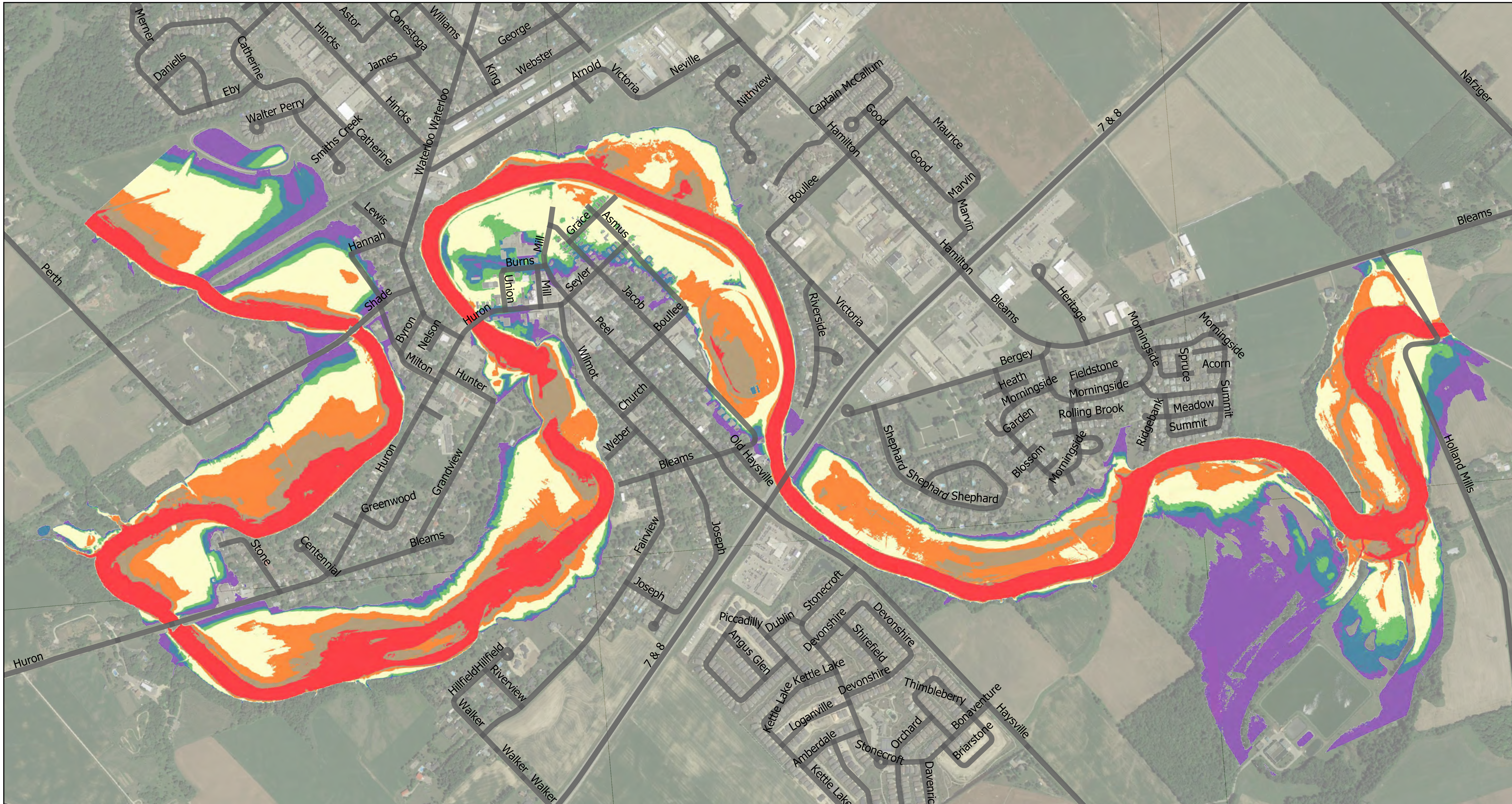

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m^2/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Existing - 100-Year Event ($500m^3/s$)
Depth x Velocity

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Figure 13.2c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.2_Existing 100yr.qgs|Existing 100yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

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Existing - 100-Year Event (500m³/s)
Risk

Ziyang Zhang

Figure 13.2d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.2_Existing 100yr.qgs|Existing 100yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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New Hamburg Flood Mitigation Study

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Existing - Regional Event (1011m³/s)
Depth

Ziyang Zhang

Figure 13.3a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.3_Existing Reg.qgs|Existing Reg|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

N

0 250 500 m

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New Hamburg Flood Mitigation Study

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Existing - Regional Event (1011m³/s)
Velocity

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Figure 13.3b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.3_Existing Reg.qgs|Existing Reg|pg2|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m^2/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

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Project #: 29006

Existing - Regional Event ($1011 m^3/s$)
Depth x Velocity

Ziyang Zhang

Figure 13.3c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_13.3_Existing Reg.qgs|Existing Reg|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

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N

0 250 500 m

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Project #: 29006

Existing - Regional Event (1011m³/s)
Risk

Ziyang Zhang

Figure 13.3d

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

0 250 500 m

N

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - 25-Year Event (394m^3/s)
Depth

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Figure 14.1a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.1_Option 1 25yr.qgs|Option 1 25yr|pg1|2020-03-29

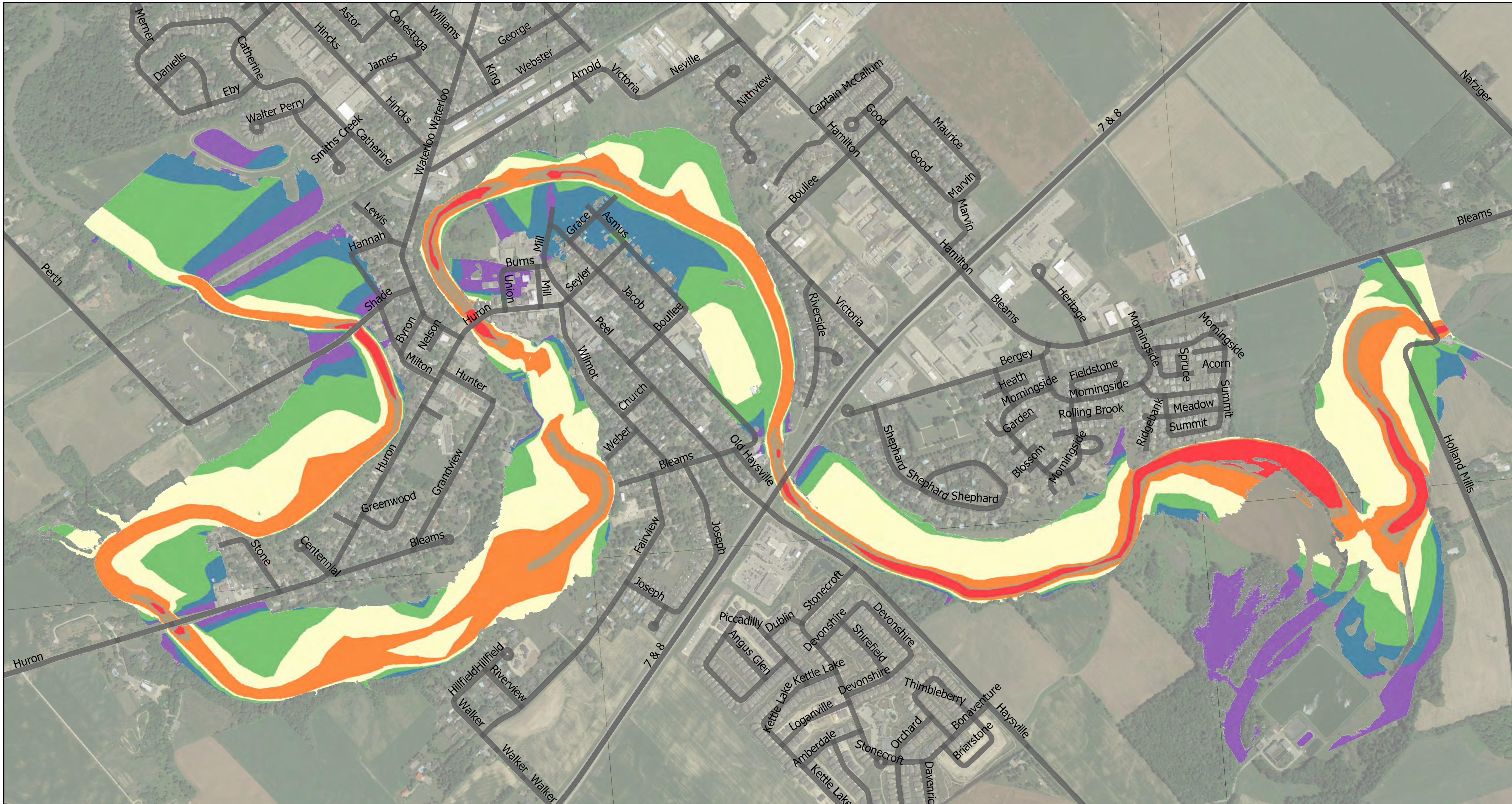

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

N

0 250 500 m

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - 25-Year Event (394m³/s)
Velocity

Ziyang Zhang

Figure 14.1b

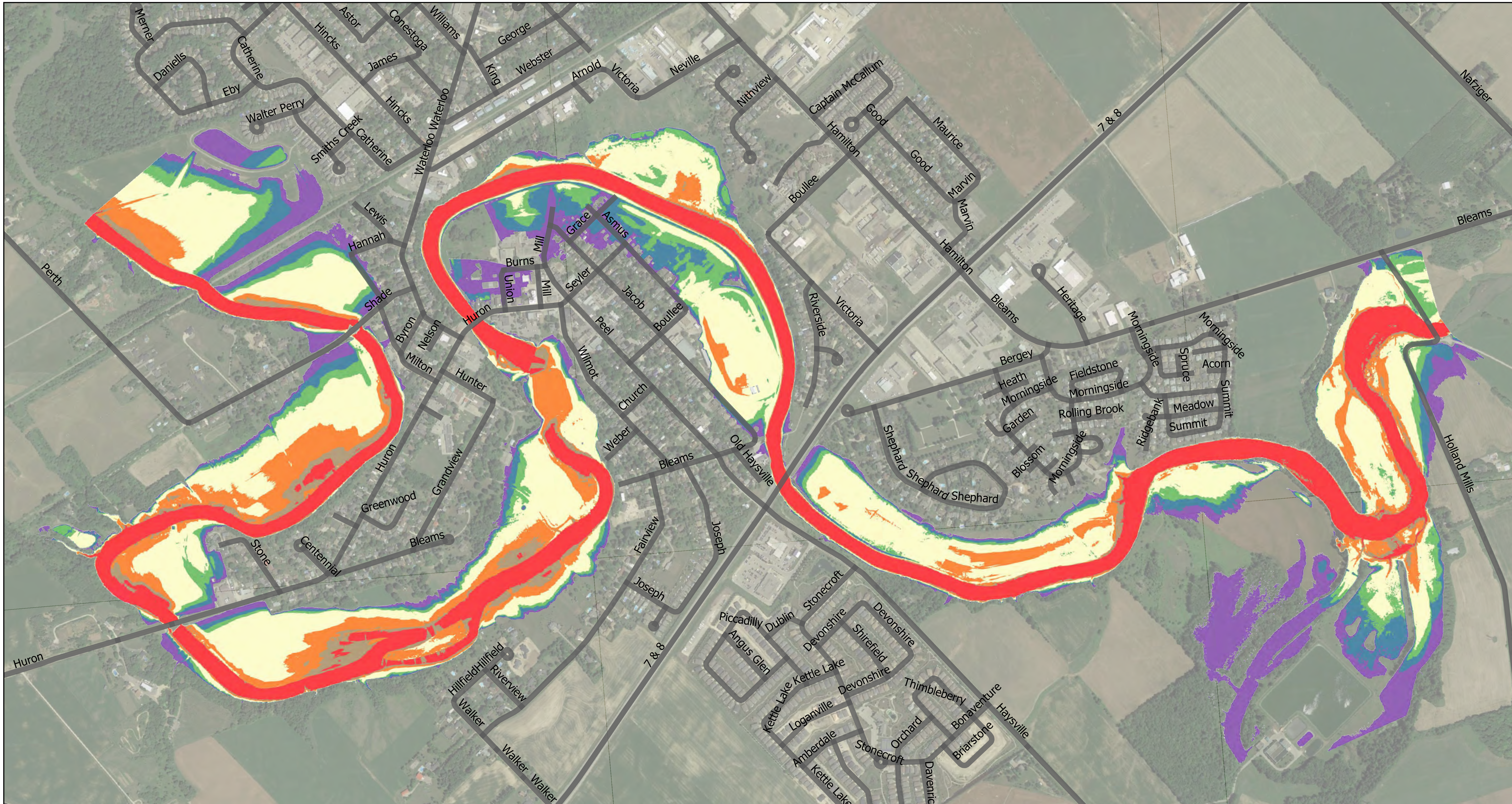

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Depth x Velocity (m^2/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - 25-Year Event (394m^3/s)
Depth x Velocity

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Ziyang Zhang

Figure 14.1c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.1_Option 1 25yr.qgs|Option 1 25yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - 25-Year Event (394m³/s)
Risk

Ziyang Zhang

Figure 14.1d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.1_Option 1 25yr.qgs|Option 1 25yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

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Mitigation Option 1 - 100-Year Event (500m³/s)
Depth

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Figure 14.2a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.2_Option 1 100yr.qgs|Option 1 100yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

0 250 500 m

N

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - 100-Year Event (500m³/s)
Velocity

Ziyang Zhang

Figure 14.2b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.2_Option 1 100yr.qgs|Option 1 100yr|pg2|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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0 250 500 m

N

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - 100-Year Event (500m³/s)
Depth x Velocity

Ziyang Zhang

Figure 14.2c

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - 100-Year Event (500m³/s)
Risk

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Ziyang Zhang

Figure 14.2d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.2_Option 1 100yr.qgs|Option 1 100yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - Regional Event (1011m³/s)
Depth

Ziyang Zhang

Figure 14.3a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.3_Option 1 Reg.qgs|Option 1 Reg|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - Regional Event (1011m³/s)
Velocity

Ziyang Zhang

Figure 14.3b

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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Mitigation Option 1 - Regional Event (1011m³/s)
Depth x Velocity

Ziyang Zhang

Figure 14.3c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.3_Option 1 Reg.qgs|Option 1 Reg|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 1 - Regional Event (1011m³/s)
Risk

Ziyang Zhang

Figure 14.3d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_14.3_Option 1 Reg.qgs|Option 1 Reg|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 2 - 25-Year Event (394m³/s)
Depth

Ziyang Zhang

Figure 15.1a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.1_Option 2 25yr.qgs|Option 2 25yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 2 - 25-Year Event (394m³/s)
Velocity

Ziyang Zhang

Figure 15.1b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.1_Option 2 25yr.qgs|Option 2 25yr|pg2|2020-03-29

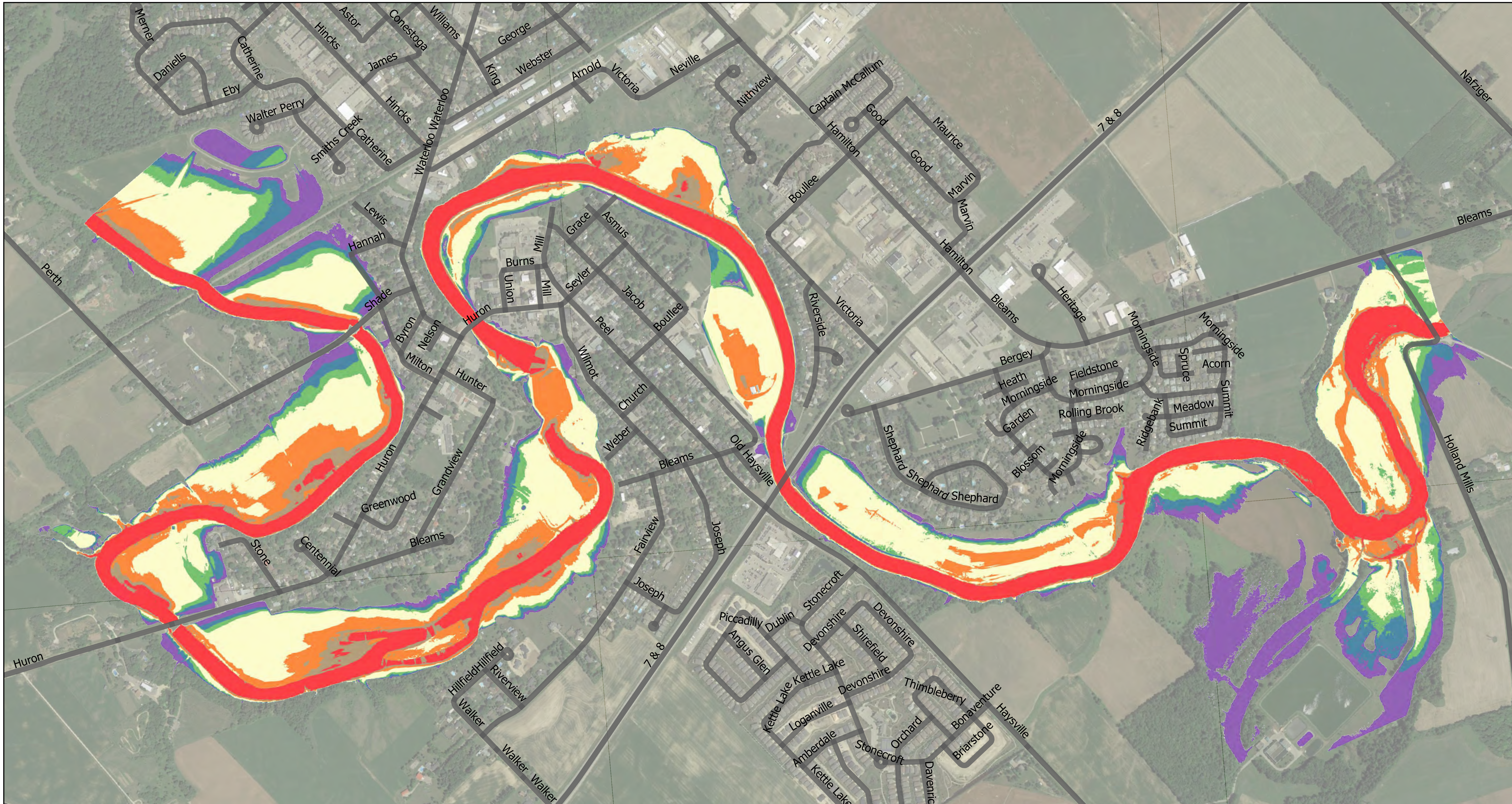

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

Matrix Solutions Inc.
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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 2 - 25-Year Event (394m³/s)
Depth x Velocity

Ziyang Zhang

Figure 15.1c

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

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Project #: 29006

Mitigation Option 2 - 25-Year Event (394m³/s)
Risk

Ziyang Zhang

Figure 15.1d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.1_Option 2 25yr.qgs|Option 2 25yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 2 - 100-Year Event (500m³/s)
Depth

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Ziyang Zhang

Figure 15.2a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.2_Option 2 100yr.qgs|Option 2 100yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 2 - 100-Year Event (500m³/s)
Velocity

Ziyang Zhang

Figure 15.2b

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results

Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

0 250 500 m

N

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 2 - 100-Year Event (500m³/s)
Depth x Velocity

Ziyang Zhang

Figure 15.2c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.2_Option 2 100yr.qgs|Option 2 100yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  - Maximum Depth: 0.3 m
  - Maximum Velocity: 1.7 m/s
  - Maximum Depth-Velocity product: 0.4 m²/s
- Medium Risk: Pedestrian Access/Egress Only
  - Maximum Depth: 0.8 m
  - Maximum Velocity: 1.7 m/s
  - Maximum Depth-Velocity product: 0.4 m²/s
- High Risk: No Access/Egress
  - An area is considered high risk if any of the criteria is exceeded.
  - Depth > 0.8 m
  - Velocity > 1.7 m/s
  - Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 2 - 100-Year Event (500m³/s)
Risk

Ziyang Zhang

Figure 15.2d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.2_Option 2 100yr.qgs|Option 2 100yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

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Mitigation Option 2 - Regional Event (1011m³/s)
Depth

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Figure 15.3a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.3_Option 2 Reg.qgs|Option 2 Reg|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

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N

0 250 500 m

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Mitigation Option 2 - Regional Event (1011m³/s) Velocity

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Figure 15.3b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.3_Option 2 Reg.qgs|Option 2 Reg|pg2|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m^2/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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Mitigation Option 2 - Regional Event (1011m^3/s)
Depth x Velocity

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Figure 15.3c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_15.3_Option 2 Reg.qgs|Option 2 Reg|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

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Mitigation Option 2 - Regional Event (1011m³/s)
Risk

Ziyang Zhang

Figure 15.3d

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results

Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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Project #: 29006

Mitigation Option 3 - 25-Year Event (394m³/s)
Depth

Ziyang Zhang

Figure 16.1a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.1_Option 3 25yr.qgs|Option 3 25yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

N

0 250 500 m

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Mitigation Option 3 - 25-Year Event (394m³/s)
Velocity

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Figure 16.1b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.1_Option 3 25yr.qgs|Option 3 25yr|pg2|2020-03-29

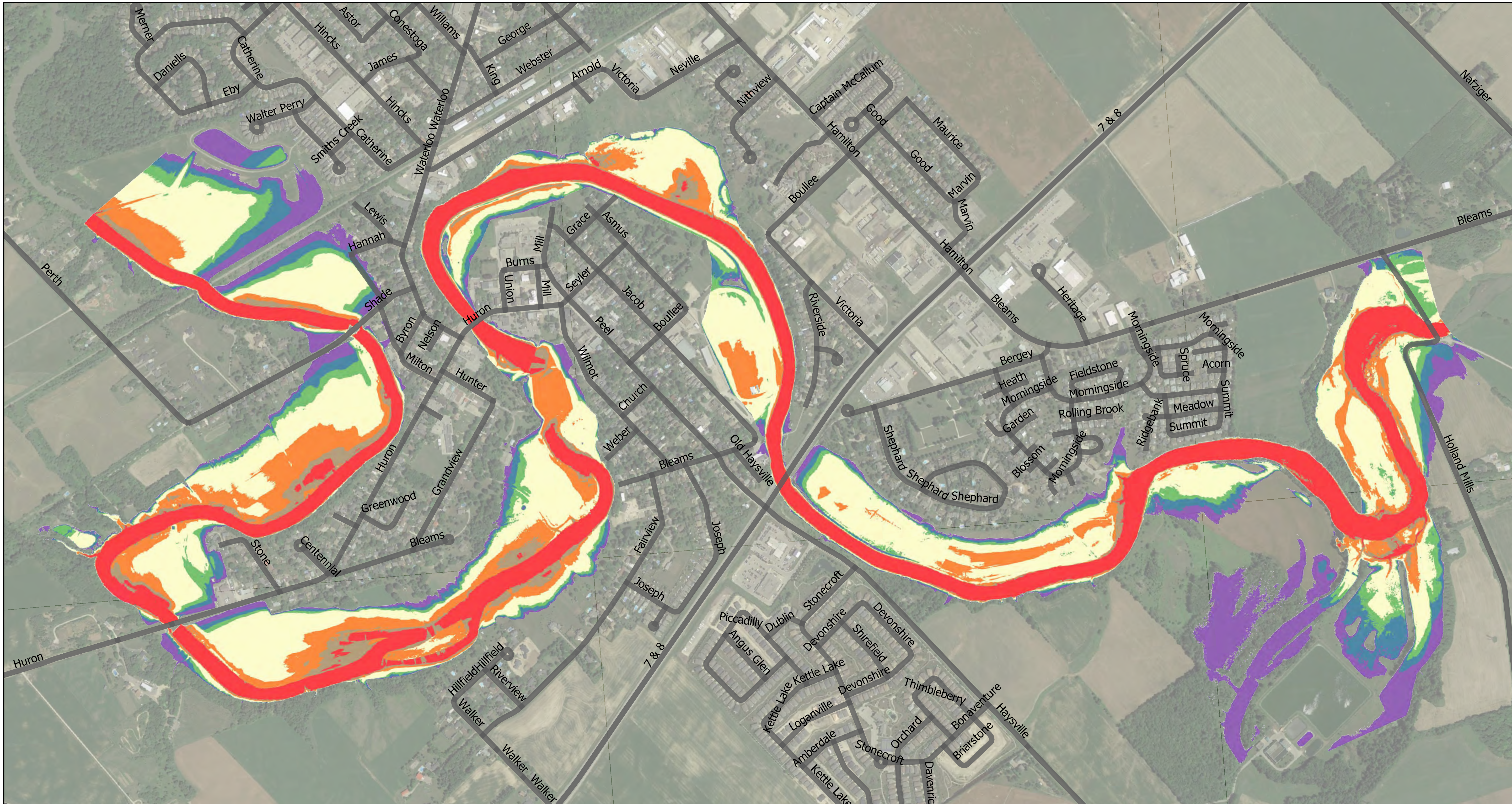

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

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Project #: 29006

Mitigation Option 3 - 25-Year Event (394m³/s)
Depth x Velocity

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Figure 16.1c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.1_Option 3 25yr.qgs|Option 3 25yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 3 - 25-Year Event (394m³/s)
Risk

Ziyang Zhang

Figure 16.1d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.1_Option 3 25yr.qgs|Option 3 25yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 3 - 100-Year Event (500m³/s)
Depth

Ziyang Zhang

Figure 16.2a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.2_Option 3 100yr.qgs|Option 3 100yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

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Mitigation Option 3 - 100-Year Event (500m³/s)
Velocity

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Figure 16.2b

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Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results

Maximum Depth x Velocity (m^2/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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Mitigation Option 3 - 100-Year Event (500m³/s)
Depth x Velocity

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Figure 16.2c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.2_Option 3 100yr.qgs|Option 3 100yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 3 - 100-Year Event (500m³/s)
Risk

Ziyang Zhang

Figure 16.2d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.2_Option 3 100yr.qgs|Option 3 100yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 3 - Regional Event (1011m³/s)
Depth

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Ziyang Zhang

Figure 16.3a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.3_Option 3 Reg.qgs|Option 3 Reg|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

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N

0 250 500 m

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Project #: 29006

Mitigation Option 3 - Regional Event (1011m³/s)
Velocity

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Ziyang Zhang

Figure 16.3b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.3_Option 3 Reg.qgs|Option 3 Reg|pg2|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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0 250 500 m

N

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Mitigation Option 3 - Regional Event (1011m³/s)
Depth x Velocity

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Figure 16.3c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.3_Option 3 Reg.qgs|Option 3 Reg|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
Low
Medium
High

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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Mitigation Option 3 - Regional Event (1011m³/s)
Risk

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Ziyang Zhang

Figure 16.3d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_16.3_Option 3 Reg.qgs|Option 3 Reg|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

0 250 500 m

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Mitigation Option 4 - 25-Year Event (394m³/s)
Depth

Ziyang Zhang

Figure 17.1a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.1_Option 4 25yr.qgs|Option 4 25yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

0 250 500 m

N

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Mitigation Option 4 - 25-Year Event (394m³/s)
Velocity

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Figure 17.1b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.1_Option 4 25yr.qgs|Option 4 25yr|pg2|2020-03-29

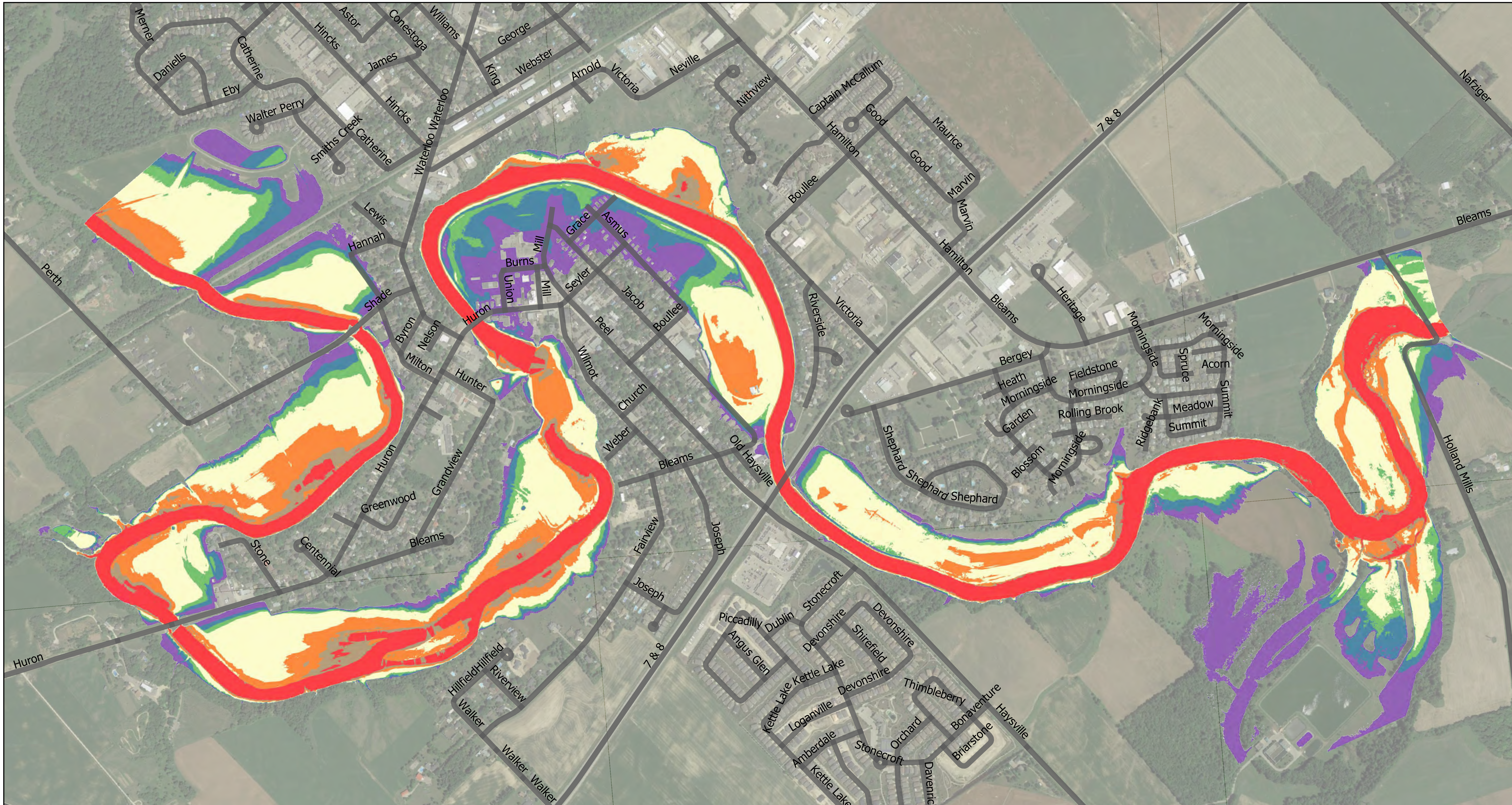

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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Mitigation Option 4 - 25-Year Event (394m³/s)
Depth x Velocity

Ziyang Zhang

Figure 17.1c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.1_Option 4 25yr.qgs|Option 4 25yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

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N

0 250 500 m

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Project #: 29006

Mitigation Option 4 - 25-Year Event (394m³/s)
Risk

Ziyang Zhang

Figure 17.1d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.1_Option 4 25yr.qgs|Option 4 25yr|pg4|2020-03-29

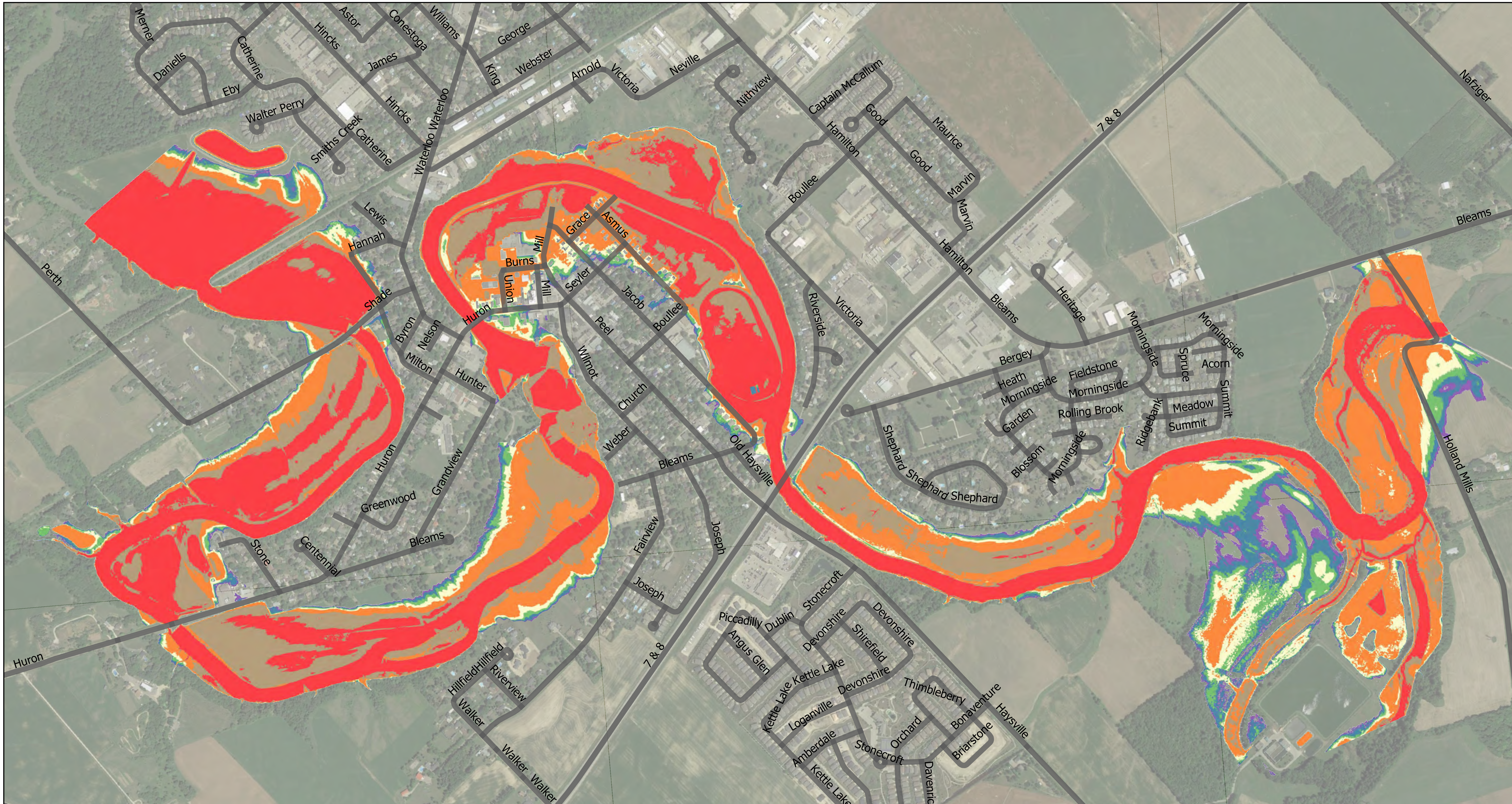

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

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Mitigation Option 4 - 100-Year Event (500m³/s)
Depth

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Figure 17.2a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.2_Option 4 100yr.qgs|Option 4 100yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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Mitigation Option 4 - 100-Year Event (500m³/s)
Velocity

Ziyang Zhang

Figure 17.2b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.2_Option 4 100yr.qgs|Option 4 100yr|pg2|2020-03-29

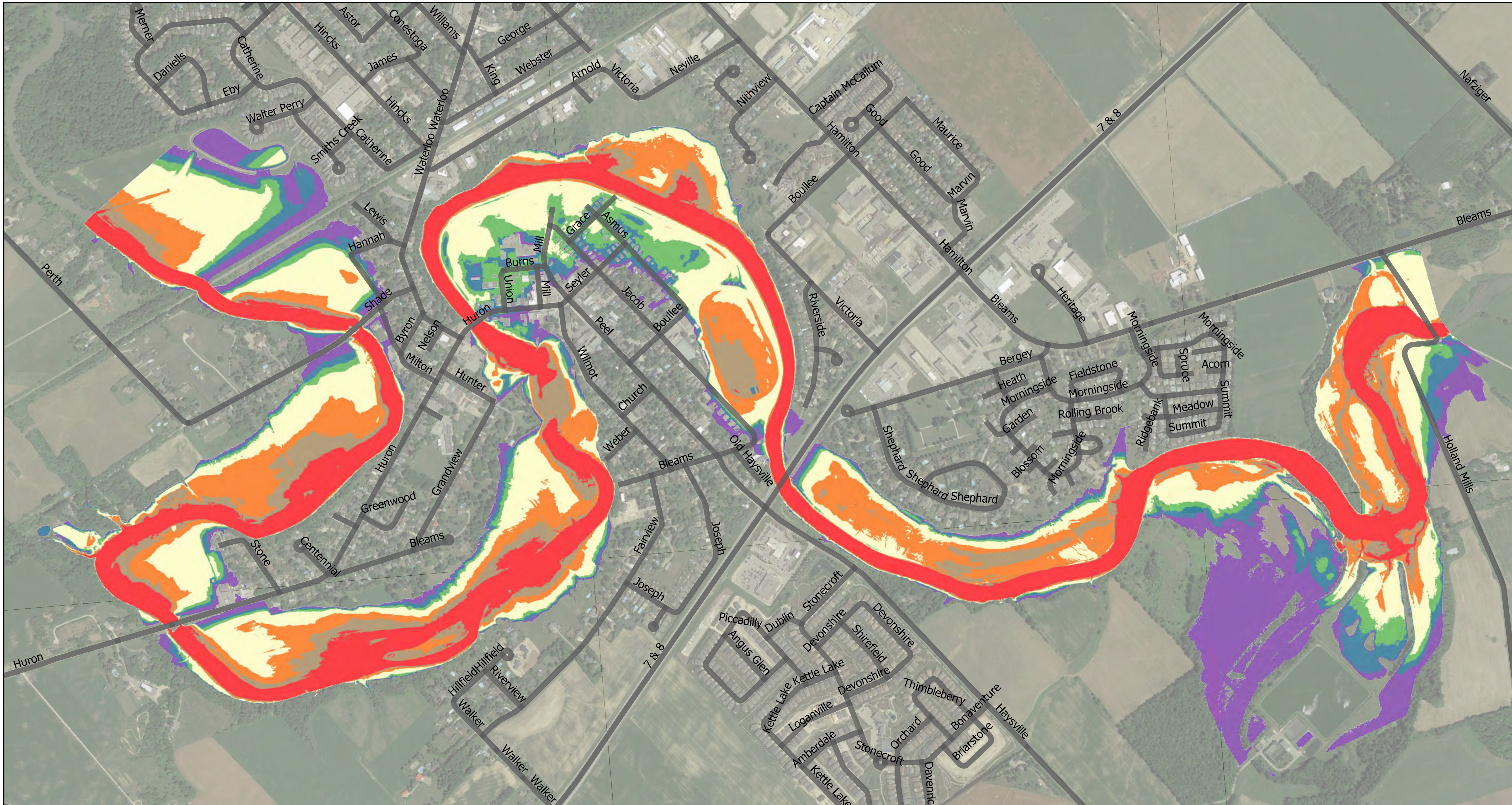

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m^2/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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Project #: 29006

Mitigation Option 4 - 100-Year Event (500m^3/s)
Depth x Velocity

Ziyang Zhang

Figure 17.2c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.2_Option 4 100yr.qgs|Option 4 100yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
Low
Medium
High

N

0 250 500 m

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Mitigation Option 4 - 100-Year Event (500m³/s)
Risk

Ziyang Zhang

Figure 17.2d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.2_Option 4 100yr.qgs|Option 4 100yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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Mitigation Option 4 - Regional Event (1011m³/s)
Depth

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Figure 17.3a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.3_Option 4 Reg.qgs|Option 4 Reg|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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Mitigation Option 4 - Regional Event (1011m³/s)
Velocity

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Figure 17.3b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.3_Option 4 Reg.qgs|Option 4 Reg|pg2|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

HECRAS Results
Maximum Depth x Velocity (m^2/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

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Project #: 29006

Mitigation Option 4 - Regional Event (1011m^3/s)
Depth x Velocity

Ziyang Zhang

Figure 17.3c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_17.3_Option 4 Reg.qgs|Option 4 Reg|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

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Mitigation Option 4 - Regional Event (1011m³/s)
Risk

Ziyang Zhang

Figure 17.3d

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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N

0 250 500 m

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Project #: 29006

Mitigation Option 5 - 25-Year Event (394m³/s)
Depth

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Figure 18.1a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.1_Option 5 25yr.qgs|Option 5 25yr|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

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0 250 500 m

N

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 5 - 25-Year Event (394m³/s)
Velocity

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Figure 18.1b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.1_Option 5 25yr.qgs|Option 5 25yr|pg2|2020-03-29

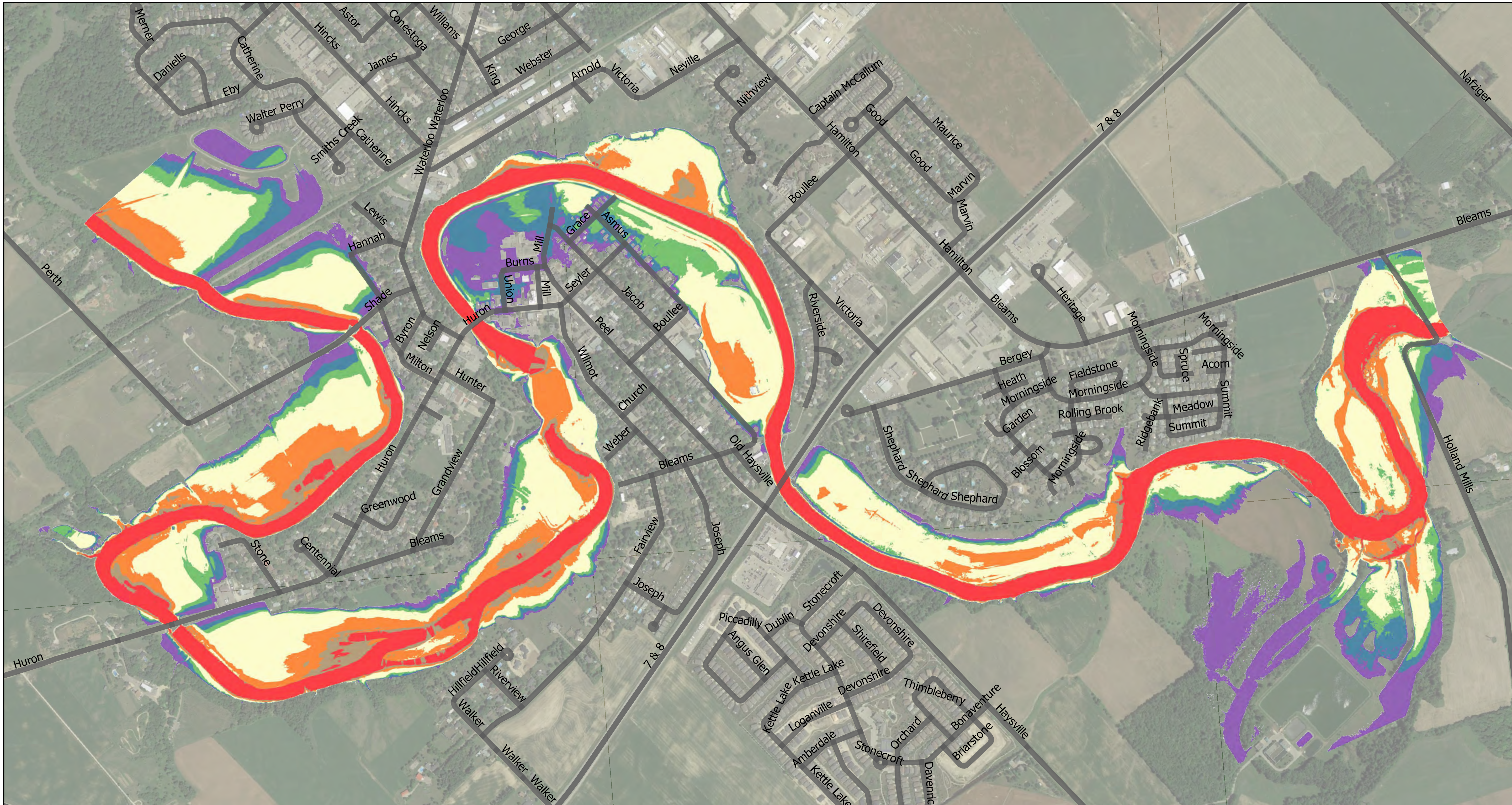

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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Mitigation Option 5 - 25-Year Event (394m³/s)
Depth x Velocity

Ziyang Zhang

Figure 18.1c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.1_Option 5 25yr.qgs|Option 5 25yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

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N

0 250 500 m

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 5 - 25-Year Event (394m³/s)
Risk

Ziyang Zhang

Figure 18.1d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.1_Option 5 25yr.qgs|Option 5 25yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

- <= 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 0.80
- 0.80 - 1.50
- 1.50 - 2.00
- > 2.00

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New Hamburg Flood Mitigation Study

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Mitigation Option 5 - 100-Year Event (500m³/s)
Depth

Ziyang Zhang

Figure 18.2a

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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New Hamburg Flood Mitigation Study

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Mitigation Option 5 - 100-Year Event (500m³/s)
Velocity

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Figure 18.2b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.2_Option 5 100yr.qgs|Option 5 100yr|pg2|2020-03-29

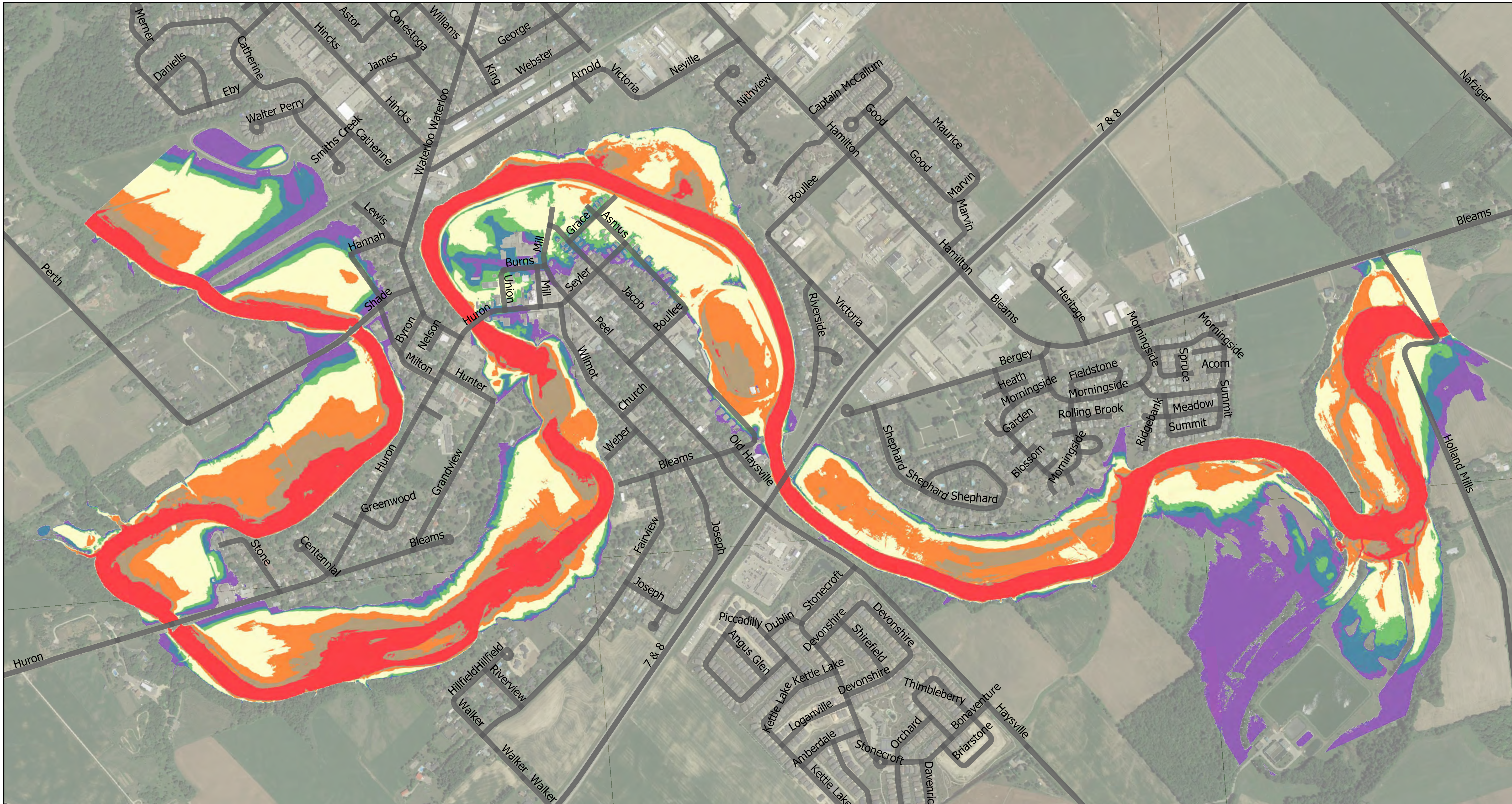

Figure Date: March 29 2020
Run Date: March 11, 2020

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HECRAS Results
Maximum Depth x Velocity (m^2/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

N

0 250 500 m

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New Hamburg Flood Mitigation Study

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Mitigation Option 5 - 100-Year Event (500m^3/s)
Depth x Velocity

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Ziyang Zhang

Figure 18.2c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.2_Option 5 100yr.qgs|Option 5 100yr|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s

- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

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New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 5 - 100-Year Event (500m³/s)
Risk

Ziyang Zhang

Figure 18.2d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.2_Option 5 100yr.qgs|Option 5 100yr|pg4|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth (m)

Maximum Depth (m)
<= 0.10
0.10 - 0.30
0.30 - 0.50
0.50 - 0.80
0.80 - 1.50
1.50 - 2.00
> 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

N

0 250 500 m

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Project #: 29006

Mitigation Option 5 - Regional Event (1011m³/s)
Depth

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

Ziyang Zhang

Figure 18.3a

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.3_Option 5 Reg.qgs|Option 5 Reg|pg1|2020-03-29

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.70
- 1.70 - 2.00
- > 2.00

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

0 250 500 m

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 5 - Regional Event (1011m³/s)
Velocity

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Ziyang Zhang

Figure 18.3b

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.3_Option 5 Reg.qgs|Option 5 Reg|pg2|2020-03-29

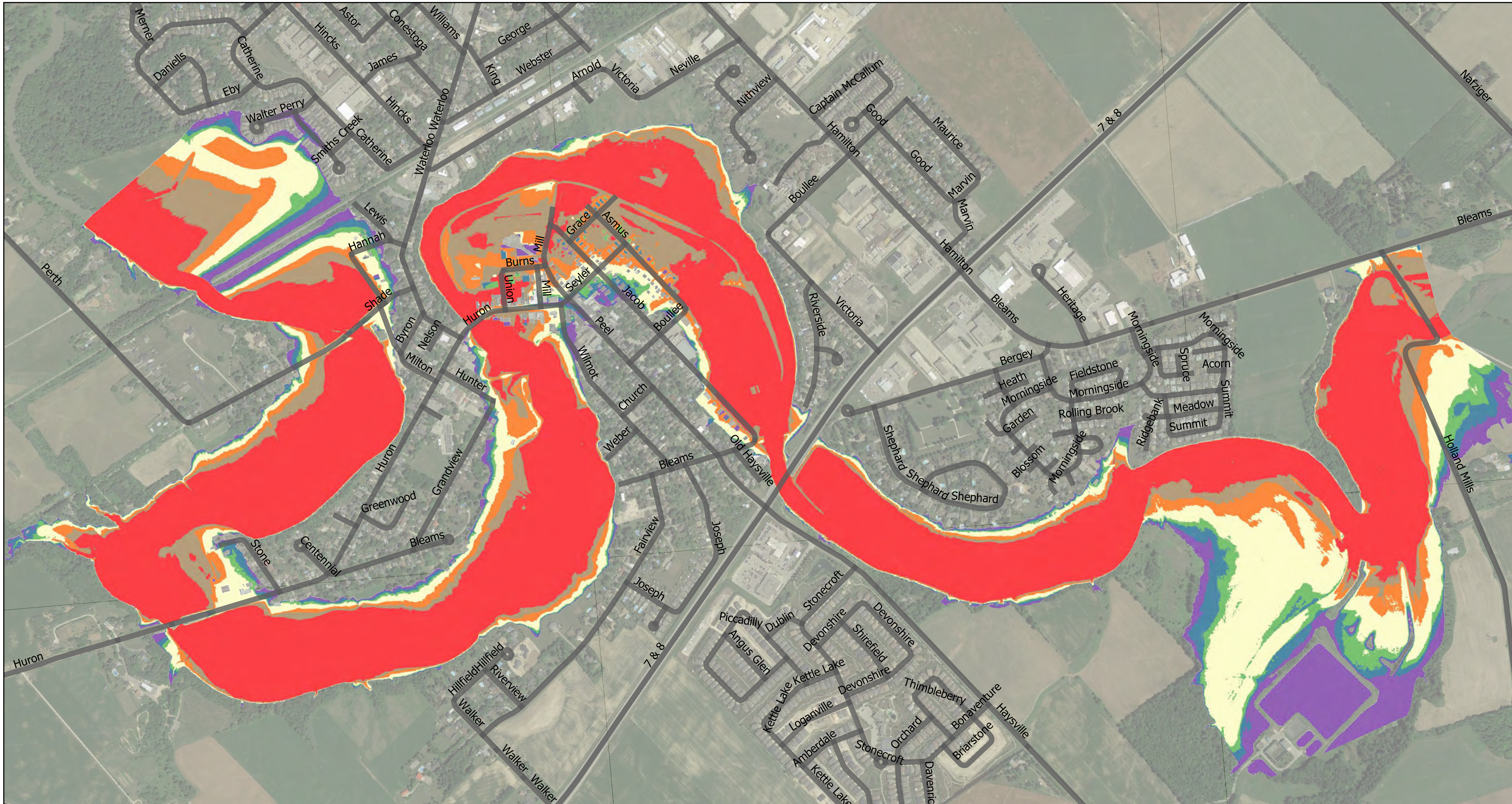

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Maximum Depth x Velocity (m²/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 5 - Regional Event (1011m³/s)
Depth x Velocity

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Ziyang Zhang

Figure 18.3c

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.3_Option 5 Reg.qgs|Option 5 Reg|pg3|2020-03-29

Flood risk characterization considers depth, velocity, and depth-velocity product with the following criteria:

- Low Risk: Vehicular and Pedestrian Access/Egress
  Maximum Depth: 0.3 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s
- Medium Risk: Pedestrian Access/Egress Only
  Maximum Depth: 0.8 m
  Maximum Velocity: 1.7 m/s
  Maximum Depth-Velocity product: 0.4 m²/s
- High Risk: No Access/Egress
  An area is considered high risk if any of the criteria is exceeded.
  Depth > 0.8 m
  Velocity > 1.7 m/s
  Depth-Velocity product > 0.4 m²/s

Figure Date: March 29 2020
Run Date: March 11, 2020

HECRAS Results
Risk
- Low
- Medium
- High

N

0 250 500 m

This drawing must be used in conjuction with the attached memorandum, New Hamburg Flood Mitigation Study - Technical Memo No. 2: Flood Mitigation Options (February 2020) and is subject to the same limitations and conditions stated in the memorandum.

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Project #: 29006

Mitigation Option 5 - Regional Event (1011m³/s)
Risk

Ziyang Zhang

Figure 18.3d

C:\Users\zzhang\Desktop\my HEC-RAS Model 1\my New Hamburg\Risk Maps 20200311\28875 Flood Risk Mapping_18.3_Option 5 Reg.qgs|Option 5 Reg|pg4|2020-03-29

Appendix F
Flood Damages Tables and Figure Set

Table F1 Residential Flood Damage Estimates Summary Table

Scenario	Category of Damage	5 Year	10 Year	15 Year	20 Year	25 Year	50 Year	100 Year	Regional
Existing Conditions	# of Buildings	12	41	51	51	55	63	77	152
	Direct Damages	$ 400,100	$ 1,660,500	$ 2,146,600	$ 2,168,700	$ 2,428,400	$ 2,981,600	$ 4,532,700	$ 17,664,000
	Indirect Damages	$ 60,000	$ 249,100	$ 322,000	$ 325,300	$ 364,300	$ 447,200	$ 679,900	$ 2,649,600
	Total Damages	**$ 460,200**	**$ 1,909,600**	**$ 2,468,500**	**$ 2,494,000**	**$ 2,792,700**	**$ 3,428,800**	**$ 5,212,600**	**$ 20,313,600**
Option 1	# of Buildings	3	13	24	25	33	51	61	146
	Direct Damages	$ 82,800	$ 447,800	$ 903,900	$ 928,600	$ 1,366,300	$ 2,168,700	$ 2,655,800	$ 15,527,800
	Indirect Damages	$ 12,400	$ 67,200	$ 135,600	$ 139,300	$ 204,900	$ 325,300	$ 398,400	$ 2,329,200
	Total Damages	**$ 95,200**	**$ 515,000**	**$ 1,039,500**	**$ 1,067,800**	**$ 1,571,200**	**$ 2,494,000**	**$ 3,054,200**	**$ 17,857,000**
Option 2	# of Buildings	2	3	3	3	3	4	9	155
	Direct Damages	$ 51,600	$ 99,400	$ 107,400	$ 114,900	$ 116,500	$ 137,400	$ 387,200	$ 18,288,200
	Indirect Damages	$ 7,700	$ 14,900	$ 16,100	$ 17,200	$ 17,500	$ 20,600	$ 58,100	$ 2,743,200
	Total Damages	**$ 59,300**	**$ 114,300**	**$ 123,500**	**$ 132,100**	**$ 134,000**	**$ 158,000**	**$ 445,200**	**$ 21,031,500**
Option 3	# of Buildings	2	3	3	3	3	60	66	147
	Direct Damages	$ 51,500	$ 99,300	$ 107,300	$ 114,900	$ 116,500	$ 2,609,800	$ 3,136,100	$ 15,874,600
	Indirect Damages	$ 7,700	$ 14,900	$ 16,100	$ 17,200	$ 17,500	$ 391,500	$ 470,400	$ 2,381,200
	Total Damages	**$ 59,300**	**$ 114,200**	**$ 123,400**	**$ 132,100**	**$ 134,000**	**$ 3,001,200**	**$ 3,606,500**	**$ 18,255,800**
Option 4	# of Buildings	2	3	51	54	59	63	80	152
	Direct Damages	$ 51,600	$ 99,400	$ 2,162,300	$ 2,309,900	$ 2,562,500	$ 3,166,100	$ 4,789,500	$ 17,694,300
	Indirect Damages	$ 7,700	$ 14,900	$ 324,300	$ 346,500	$ 384,400	$ 474,900	$ 718,400	$ 2,654,100
	Total Damages	**$ 59,300**	**$ 114,300**	**$ 2,486,600**	**$ 2,656,400**	**$ 2,946,900**	**$ 3,641,000**	**$ 5,507,900**	**$ 20,348,400**
Option 5	# of Buildings	7	26	36	41	45	58	66	148
	Direct Damages	$ 222,200	$ 1,120,800	$ 1,498,000	$ 1,711,700	$ 1,890,900	$ 2,543,000	$ 3,146,100	$ 16,637,600
	Indirect Damages	$ 33,300	$ 168,100	$ 224,700	$ 256,800	$ 283,600	$ 381,400	$ 471,900	$ 2,495,600
	Total Damages	**$ 255,500**	**$ 1,289,000**	**$ 1,722,700**	**$ 1,968,400**	**$ 2,174,500**	**$ 2,924,400**	**$ 3,618,000**	**$ 19,133,300**
Option 6	# of Buildings	12	41	51	51	55	63	77	152
	Direct Damages	$ 80,000	$ 332,100	$ 467,200	$ 471,800	$ 565,900	$1,031,400	$2,699,600	$ 17,550,700
	Indirect Damages	$ 12,000	$ 49,800	$ 70,100	$ 70,800	$ 84,900	$ 154,700	$ 404,900	$ 2,632,600
	Total Damages	**$ 92,000**	**$ 381,900**	**$ 537,300**	**$ 542,600**	**$ 650,800**	**$1,186,100**	**$3,104,600**	**$ 20,183,300**
Option 7	# of Buildings	12	40	51	51	54	63	77	149
	Direct Damages	$400,081	$1,605,590	$2,139,567	$2,160,604	$2,337,218	$2,976,727	$4,469,483	$17,470,682
	Indirect Damages	$60,012	$240,839	$320,935	$324,091	$350,583	$446,509	$670,422	$2,620,602
	Total Damages	**$460,093**	**$1,846,429**	**$2,460,503**	**$2,484,695**	**$2,687,801**	**$3,423,236**	**$5,139,905**	**$20,091,285**

No damages in the 2-year flood event; GRCA provided results for Option 7.

Table F2 Industrial-Commercial-Institutional Flood Damage Estimates Summary Table

Scenario	Category of Damage	5 Year	10 Year	15 Year	20 Year	25 Year	50 Year	100 Year	Regional
Existing Conditions	# of Buildings	1	3	6	7	8	13	16	42
	Direct Damages	$ 342,500	$ 629,000	$ 869,600	$ 1,007,400	$ 1,129,300	$ 1,666,500	$ 2,185,100	$ 12,074,100
	Indirect Damages	$ 119,900	$ 220,200	$ 310,700	$ 361,400	$ 407,000	$ 600,700	$ 789,500	$ 4,437,000
	Total Damages	**$ 462,400**	**$ 849,200**	**$ 1,180,300**	**$ 1,368,800**	**$ 1,536,300**	**$ 2,267,200**	**$ 2,974,600**	**$ 16,511,100**
Option 1	# of Buildings			1	1	3	7	9	39
	Direct Damages			$ 349,700	$ 357,500	$ 484,500	$ 908,900	$ 1,230,000	$ 10,788,400
	Indirect Damages			$ 122,400	$ 125,100	$ 169,800	$ 327,000	$ 446,700	$ 3,979,500
	Total Damages			**$ 472,100**	**$ 482,600**	**$ 654,300**	**$ 1,235,900**	**$ 1,676,600**	**$ 14,767,900**
Option 2	# of Buildings					1	1	1	48
	Direct Damages					$ 2,500	$ 25,600	$ 40,400	$ 14,058,100
	Indirect Damages					$ 1,100	$ 11,500	$ 18,200	$ 5,147,800
	Total Damages					**$ 3,600**	**$ 37,100**	**$ 58,600**	**$ 19,205,900**
Option 3	# of Buildings					1	11	14	39
	Direct Damages					$ 2,500	$ 1,341,800	$ 1,816,000	$ 11,123,000
	Indirect Damages					$ 1,100	$ 485,600	$ 656,800	$ 4,100,900
	Total Damages					**$ 3,600**	**$ 1,827,400**	**$ 2,472,800**	**$ 15,223,900**
Option 4	# of Buildings			7	7	10	14	17	43
	Direct Damages			$ 1,029,800	$ 1,152,800	$ 1,255,700	$ 1,817,000	$ 2,356,700	$ 12,351,500
	Indirect Damages			$ 369,800	$ 415,600	$ 453,100	$ 655,500	$ 857,300	$ 4,535,000
	Total Damages			**$ 1,399,700**	**$ 1,568,400**	**$ 1,708,800**	**$ 2,472,600**	**$ 3,213,900**	**$ 16,886,500**
Option 5	# of Buildings	1	2	6	7	8	12	14	39
	Direct Damages	$ 333,700	$ 481,000	$ 796,000	$ 883,800	$ 1,024,700	$ 1,490,200	$ 1,991,300	$ 11,611,100
	Indirect Damages	$ 116,800	$ 168,300	$ 283,000	$ 316,200	$ 368,000	$ 537,900	$ 717,100	$ 4,272,200
	Total Damages	**$ 450,600**	**$ 649,300**	**$ 1,079,000**	**$ 1,200,000**	**$ 1,392,700**	**$ 2,028,100**	**$ 2,708,500**	**$ 15,883,300**
Option 6	# of Buildings	1	3	6	7	8	13	16	42
	Direct Damages	$ 342,500	$ 629,000	$ 869,600	$ 1,007,400	$ 1,129,300	$ 1,666,500	$ 2,185,100	$ 12,074,100
	Indirect Damages	$ 119,900	$ 220,200	$ 310,700	$ 361,400	$ 407,000	$ 600,700	$ 789,500	$ 4,437,000
	Total Damages	**$ 462,400**	**$ 849,200**	**$ 1,180,300**	**$ 1,368,800**	**$ 1,536,300**	**$ 2,267,200**	**$ 2,974,600**	**$ 16,511,100**
Option 7	# of Buildings	1	2	6	6	8	12	14	40
	Direct Damages	$333,493	$481,932	$817,494	$878,881	$1,014,027	$1,428,431	$1,939,281	$11,537,033
	Indirect Damages	$116,723	$168,676	$290,551	$313,986	$363,855	$516,172	$699,757	$4,246,004
	Total Damages	**$450,216**	**$650,609**	**$1,108,045**	**$1,192,867**	**$1,377,882**	**$1,944,602**	**$2,639,038**	**$15,783,038**

No damages in the 2-year flood event; GRCA provided results for Option 7.

Table F3 Total Flood Damage Estimates Summary Table

Scenario	Category of Damage	5 Year	10 Year	15 Year	20 Year	25 Year	50 Year	100 Year	Regional
Existing Conditions	# of Buildings	13	44	57	58	63	76	93	194
	Direct Damages	$ 742,700	$ 2,289,600	$ 3,016,200	$ 3,176,100	$ 3,557,800	$ 4,648,000	$ 6,717,800	$ 29,738,200
	Indirect Damages	$ 179,900	$ 469,200	$ 632,700	$ 686,700	$ 771,300	$ 1,047,900	$ 1,469,400	$ 7,086,600
	Total Damages	**$ 922,600**	**$ 2,758,800**	**$ 3,648,800**	**$ 3,862,800**	**$ 4,329,000**	**$ 5,696,000**	**$ 8,187,200**	**$ 36,824,800**
Option 1	# of Buildings	3	13	25	26	36	58	70	185
	Direct Damages	$ 82,800	$ 447,800	$ 1,253,600	$ 1,286,000	$ 1,850,700	$ 3,077,600	$ 3,885,800	$ 26,316,200
	Indirect Damages	$ 12,400	$ 67,200	$ 258,000	$ 264,400	$ 374,800	$ 652,300	$ 845,100	$ 6,308,700
	Total Damages	**$ 95,200**	**$ 515,000**	**$ 1,511,600**	**$ 1,550,400**	**$ 2,225,500**	**$ 3,729,900**	**$ 4,730,800**	**$ 32,624,900**
Option 2	# of Buildings	2	3	3	3	4	5	10	203
	Direct Damages	$ 51,600	$ 99,400	$ 107,400	$ 114,900	$ 119,000	$ 163,000	$ 427,600	$ 32,346,300
	Indirect Damages	$ 7,700	$ 14,900	$ 16,100	$ 17,200	$ 18,600	$ 32,100	$ 76,300	$ 7,891,100
	Total Damages	**$ 59,300**	**$ 114,300**	**$ 123,500**	**$ 132,100**	**$ 137,600**	**$ 195,100**	**$ 503,800**	**$ 40,237,400**
Option 3	# of Buildings	2	3	3	3	4	71	80	186
	Direct Damages	$ 51,500	$ 99,300	$ 107,300	$ 114,900	$ 119,000	$ 3,951,500	$ 4,952,100	$ 26,997,600
	Indirect Damages	$ 7,700	$ 14,900	$ 16,100	$ 17,200	$ 18,600	$ 877,100	$ 1,127,200	$ 6,482,100
	Total Damages	**$ 59,300**	**$ 114,200**	**$ 123,400**	**$ 132,100**	**$ 137,600**	**$ 4,828,600**	**$ 6,079,300**	**$ 33,479,700**
Option 4	# of Buildings	2	3	58	61	69	77	97	195
	Direct Damages	$ 51,600	$ 99,400	$ 3,192,100	$ 3,462,800	$ 3,818,200	$ 4,983,100	$ 7,146,200	$ 30,045,800
	Indirect Damages	$ 7,700	$ 14,900	$ 694,200	$ 762,100	$ 837,400	$ 1,130,400	$ 1,575,700	$ 7,189,100
	Total Damages	**$ 59,300**	**$ 114,300**	**$ 3,886,300**	**$ 4,224,900**	**$ 4,655,700**	**$ 6,113,500**	**$ 8,721,800**	**$ 37,234,900**
Option 5	# of Buildings	8	28	42	48	53	70	80	187
	Direct Damages	$ 555,900	$ 1,601,800	$ 2,294,100	$ 2,595,500	$ 2,915,600	$ 4,033,200	$ 5,137,400	$ 28,248,700
	Indirect Damages	$ 150,100	$ 336,500	$ 507,700	$ 572,900	$ 651,600	$ 919,400	$ 1,189,000	$ 6,767,800
	Total Damages	**$ 706,000**	**$ 1,938,300**	**$ 2,801,700**	**$ 3,168,400**	**$ 3,567,300**	**$ 4,952,500**	**$ 6,326,400**	**$ 35,016,600**
Option 6	# of Buildings	13	44	57	58	63	76	93	192
	Direct Damages	$ 422,600	$ 961,100	$1,336,800	$1,479,200	$1,695,300	$2,697,800	$4,884,700	$ 29,624,900
	Indirect Damages	$ 131,900	$ 270,000	$ 380,800	$ 432,200	$ 491,900	$ 755,400	$1,194,500	$ 7,069,600
	Total Damages	**$ 554,500**	**$1,231,100**	**$1,717,600**	**$1,911,400**	**$2,187,200**	**$3,453,200**	**$6,079,200**	**$ 36,694,400**
Option 7	# of Buildings	13	42	57	57	62	75	91	189
	Direct Damages	$733,574	$2,087,522	$2,957,062	$3,039,485	$3,351,245	$4,405,158	$6,408,763	$29,007,716
	Indirect Damages	$176,735	$409,515	$611,486	$638,077	$714,437	$962,681	$1,370,180	$6,866,607
	Total Damages	**$910,309**	**$2,497,037**	**$3,568,548**	**$3,677,562**	**$4,065,683**	**$5,367,839**	**$7,778,943**	**$35,874,322**

No damages in the 2-year flood event; GRCA provided results for Option 7.

Easting (m)

Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Reference: Contains information licensed under the Open Government Licence – Ontario. Imagery (2015) obtained by Grand River Conservation Authority and Matrix Solutions Inc. used under license.

Vertical Datum: CGVD2013

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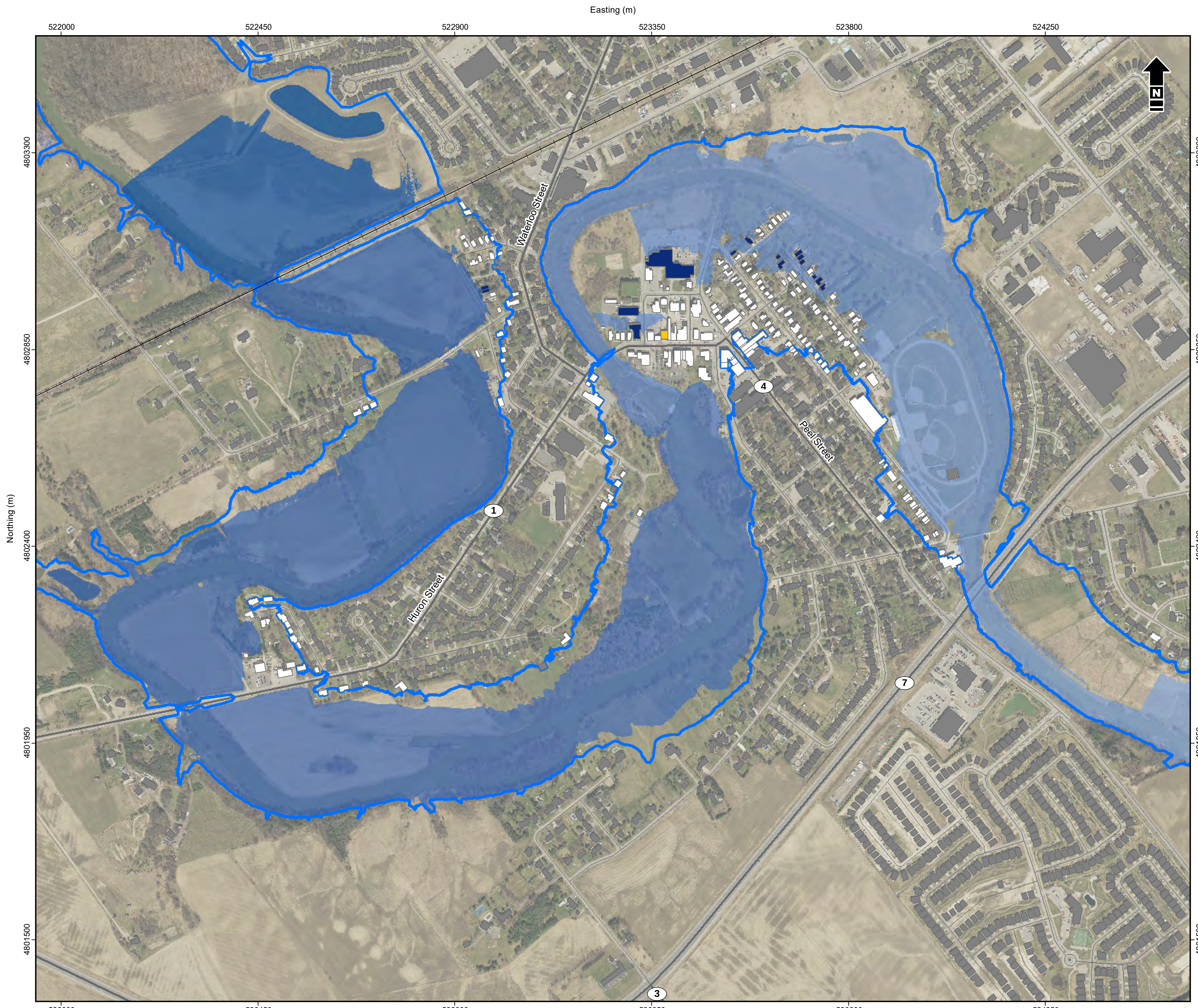
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 19.1



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

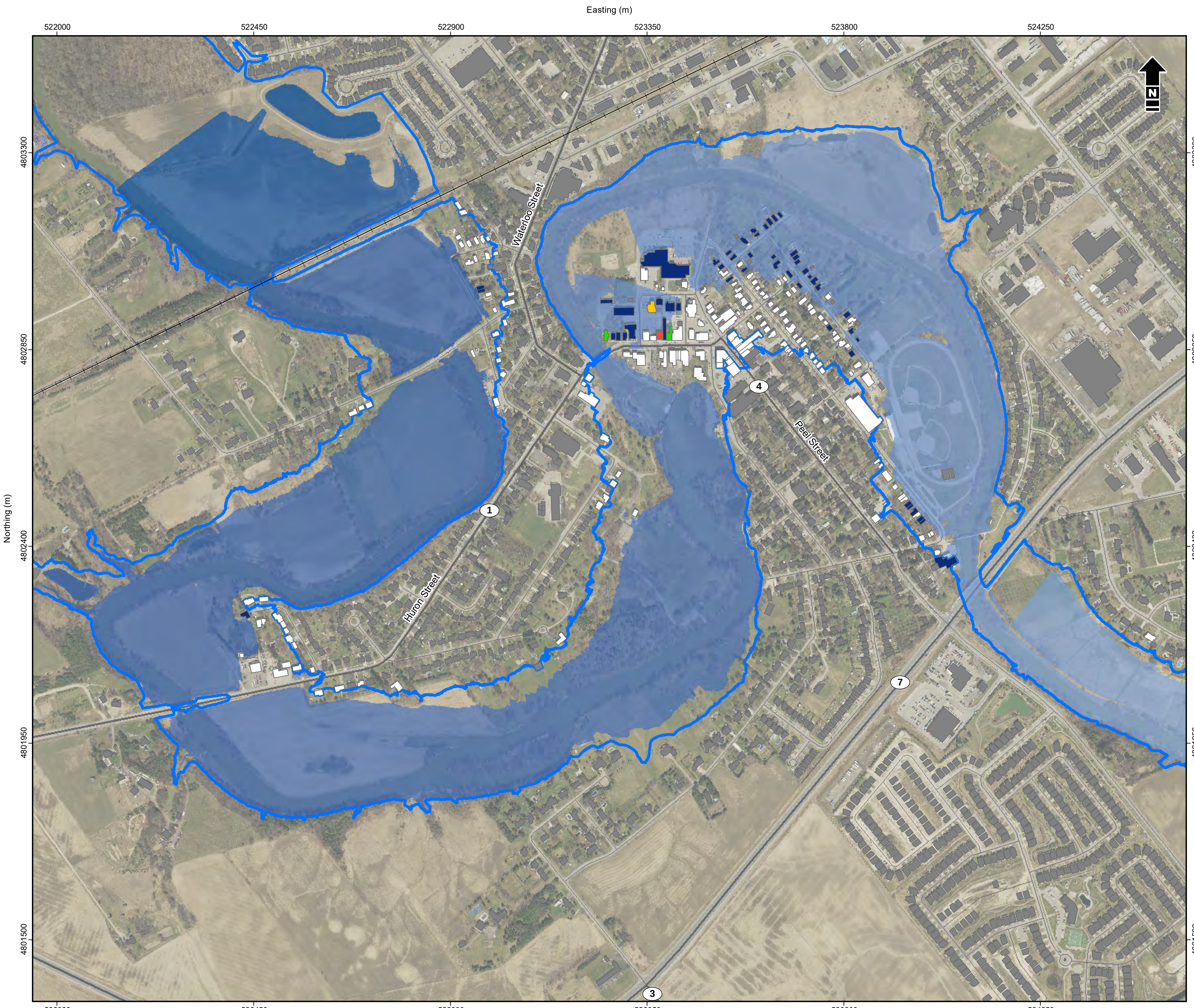
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - 5 Year (265 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 19.2



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 19.3

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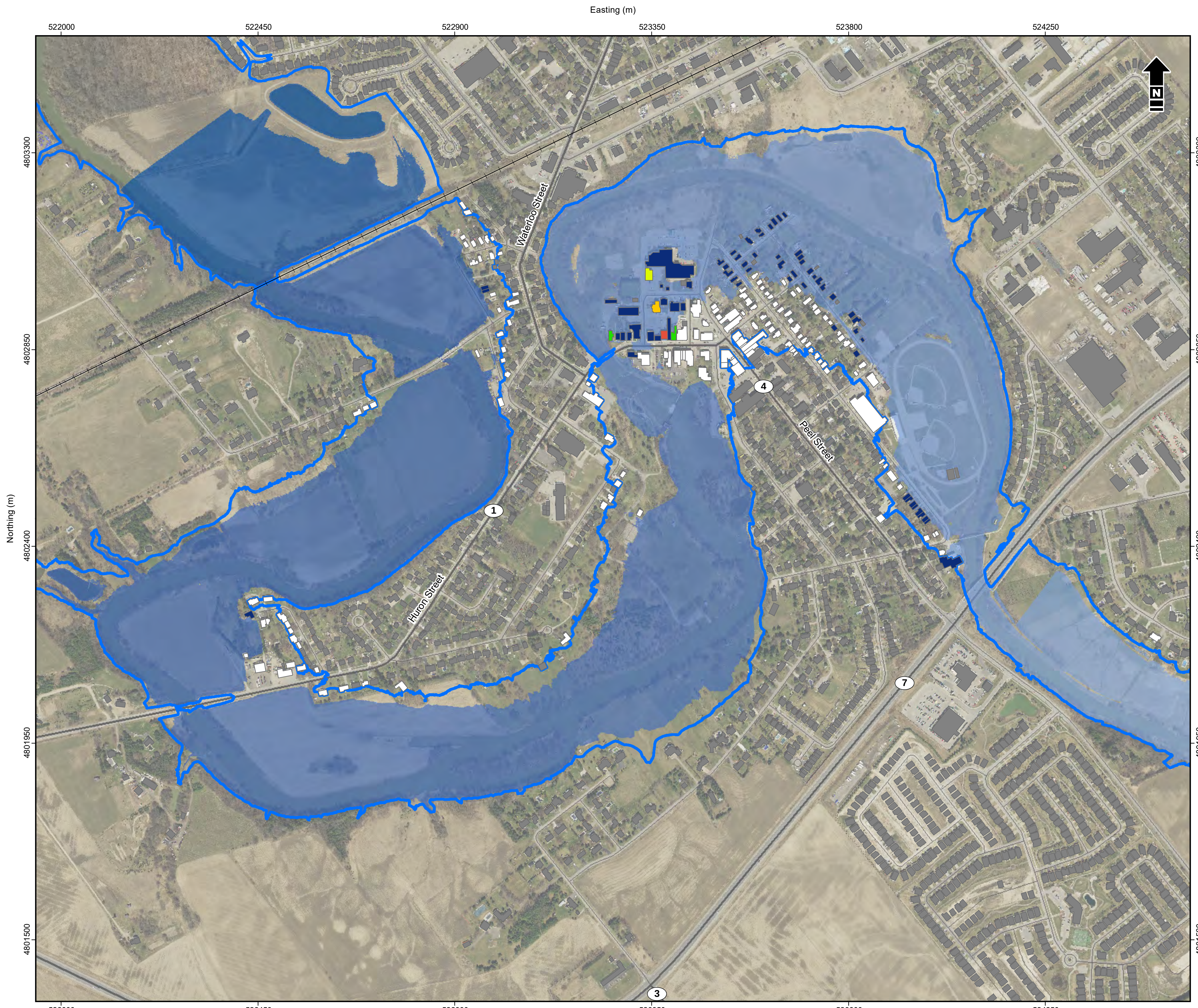

Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000
metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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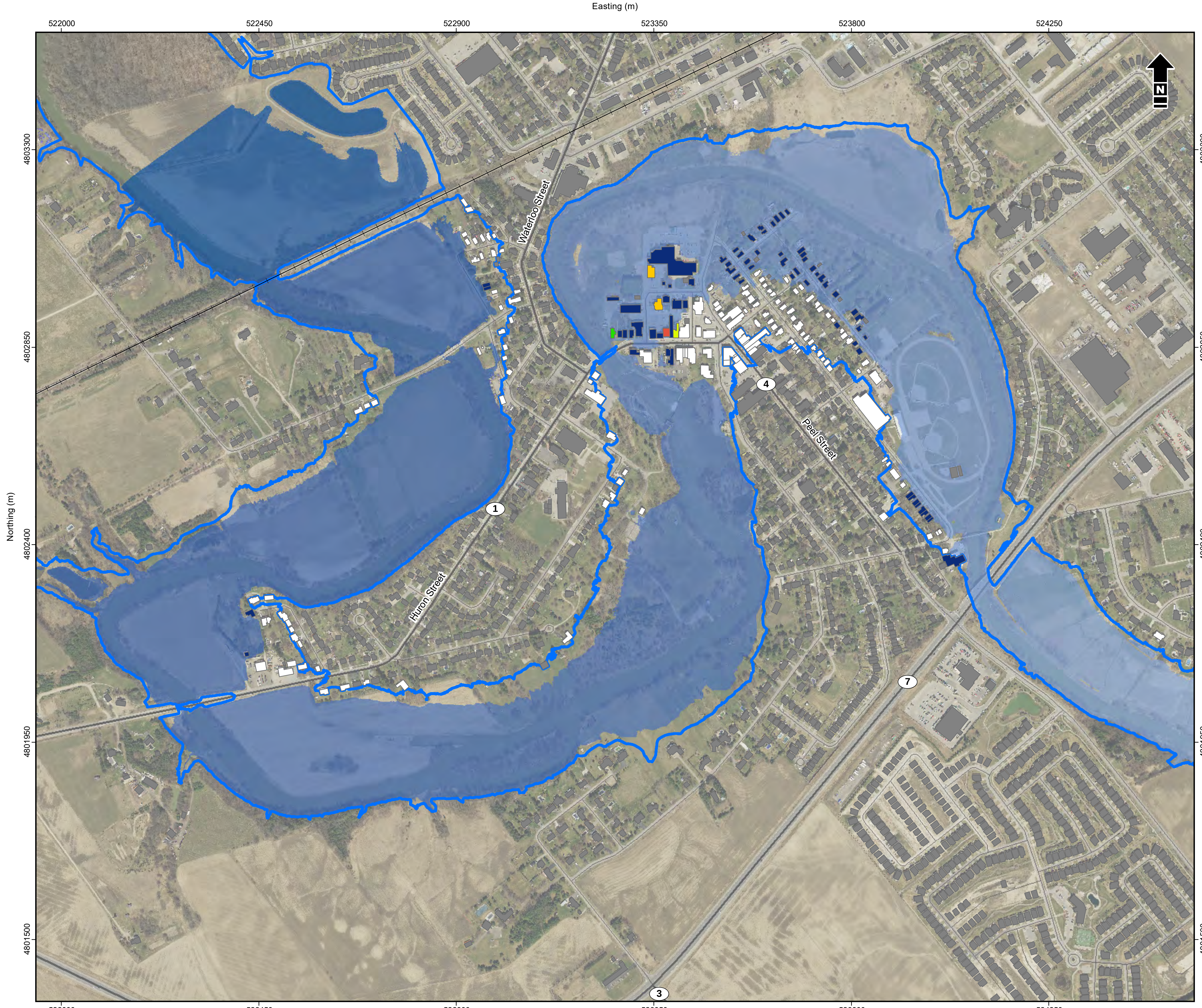
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - 15 Year (350 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
19.4



- Draft Regional Inundation Boundary
- Railway
- Highway
- Road
- Building - Not Flooded
- Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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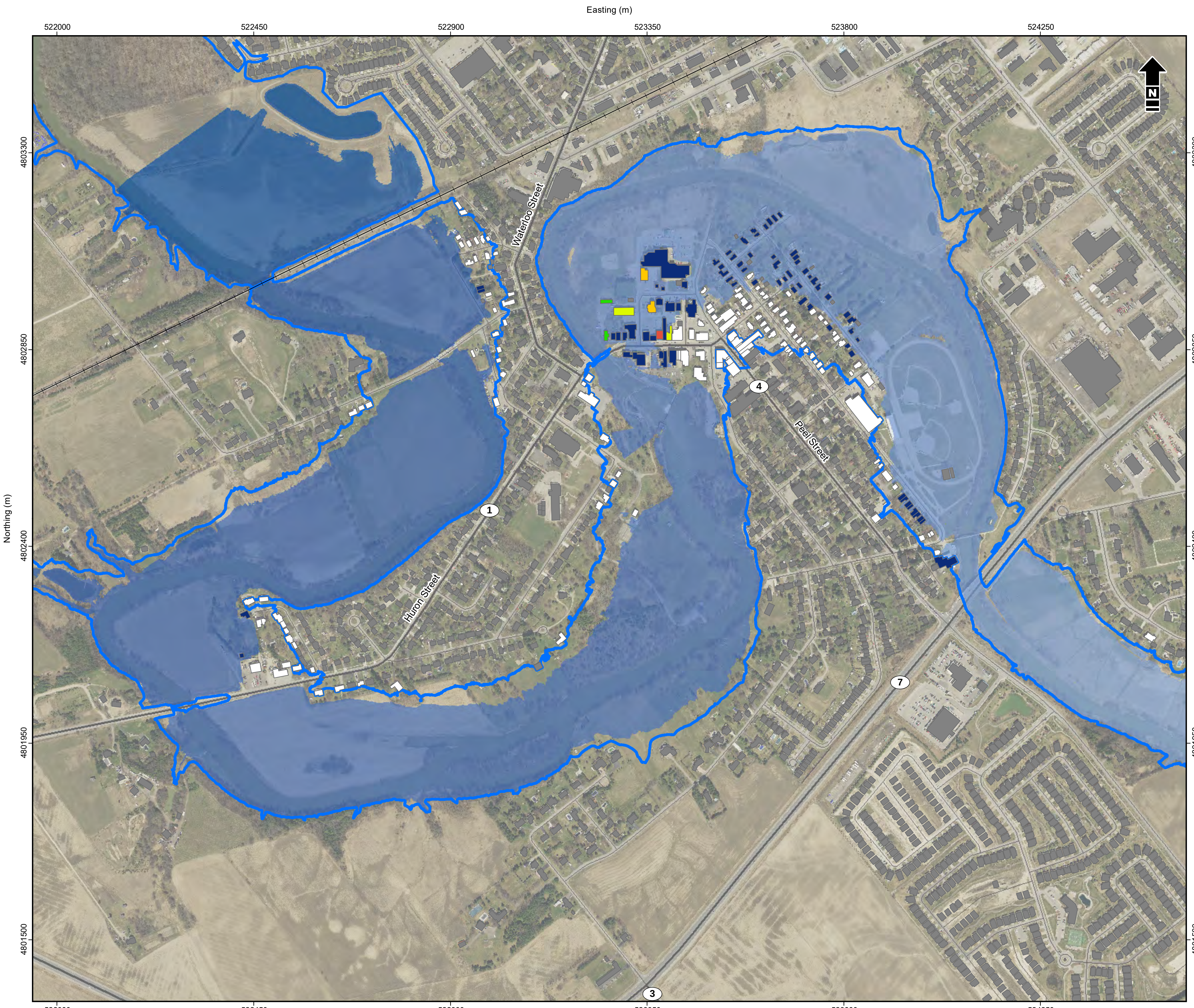
ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 19.5



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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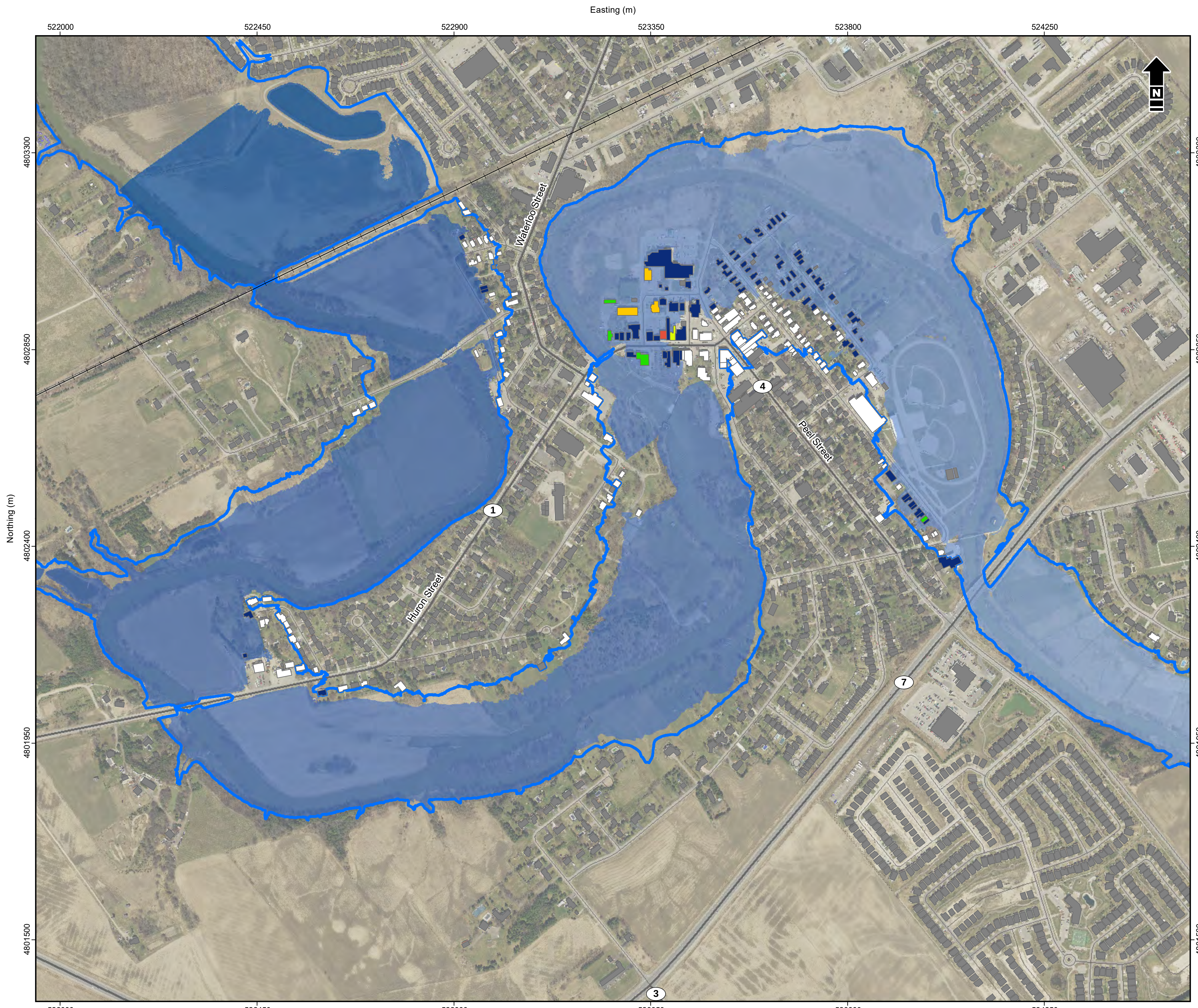
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 19.6



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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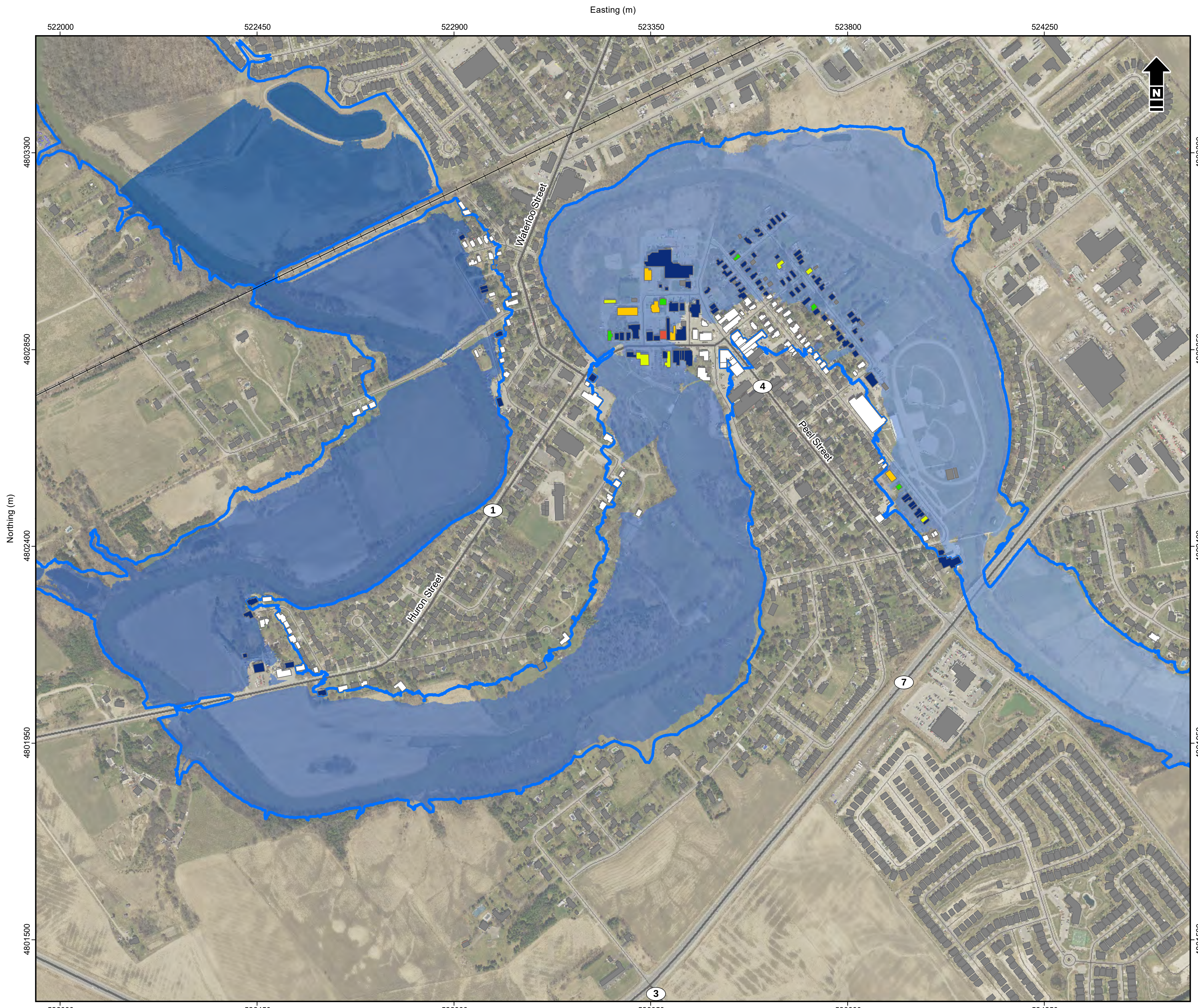
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - 50 Year (447 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 19.7



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

Matrix Solutions Inc.
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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - 100 Year (500 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 19.8

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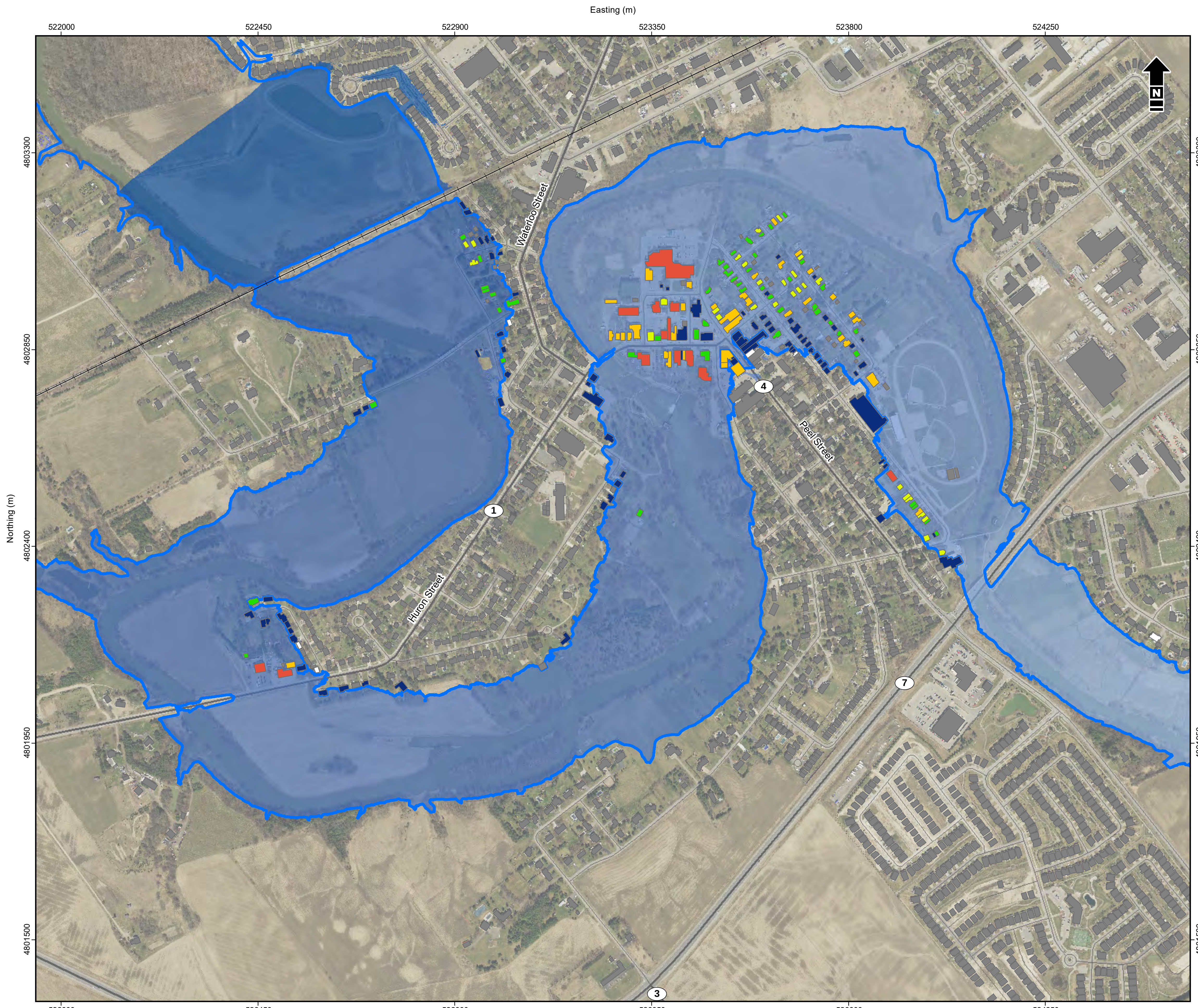

Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Existing - Flood Damages - Regional (1,011 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 19.9

Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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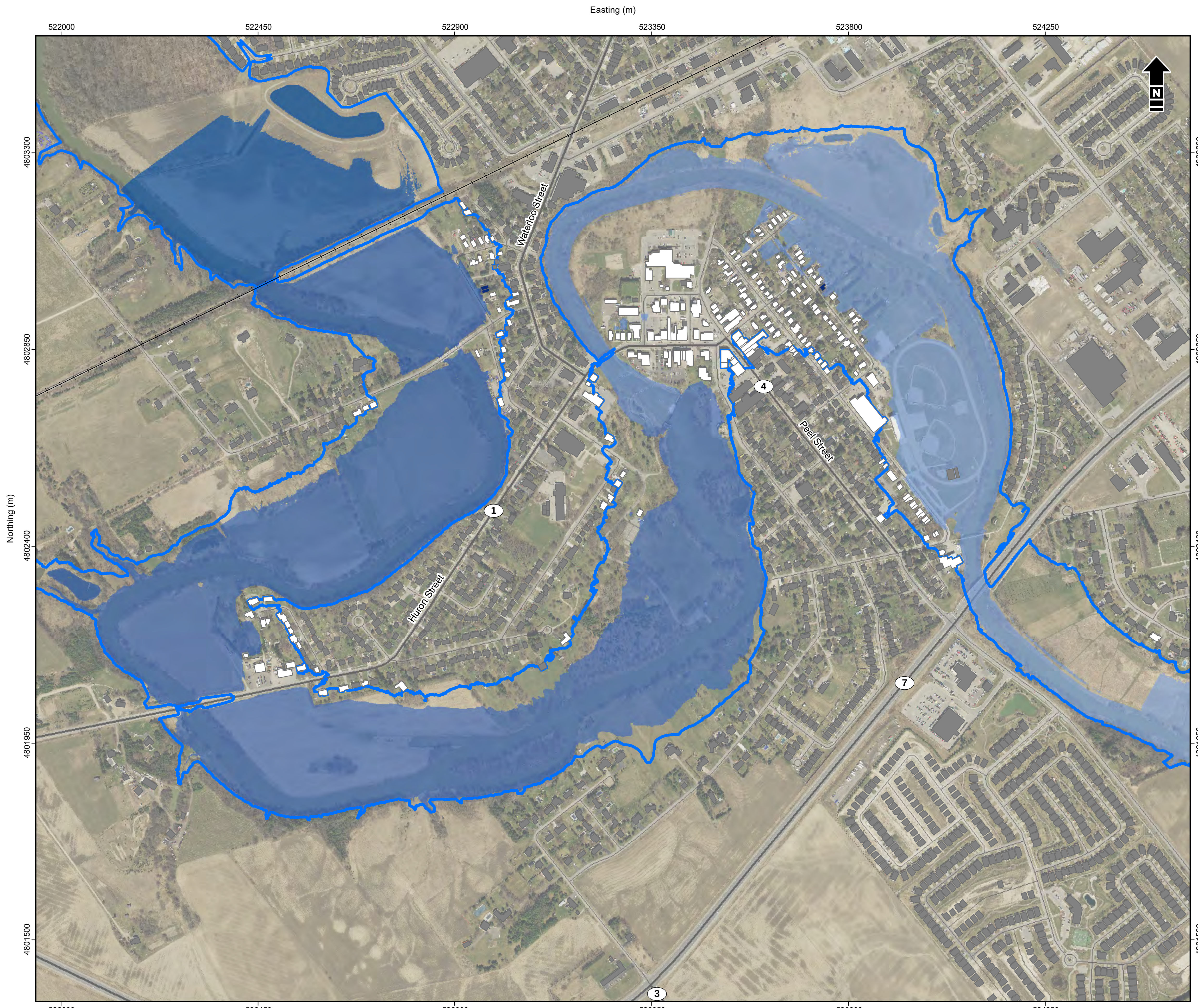
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 20.1



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - 5 Year (265 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 20.2

Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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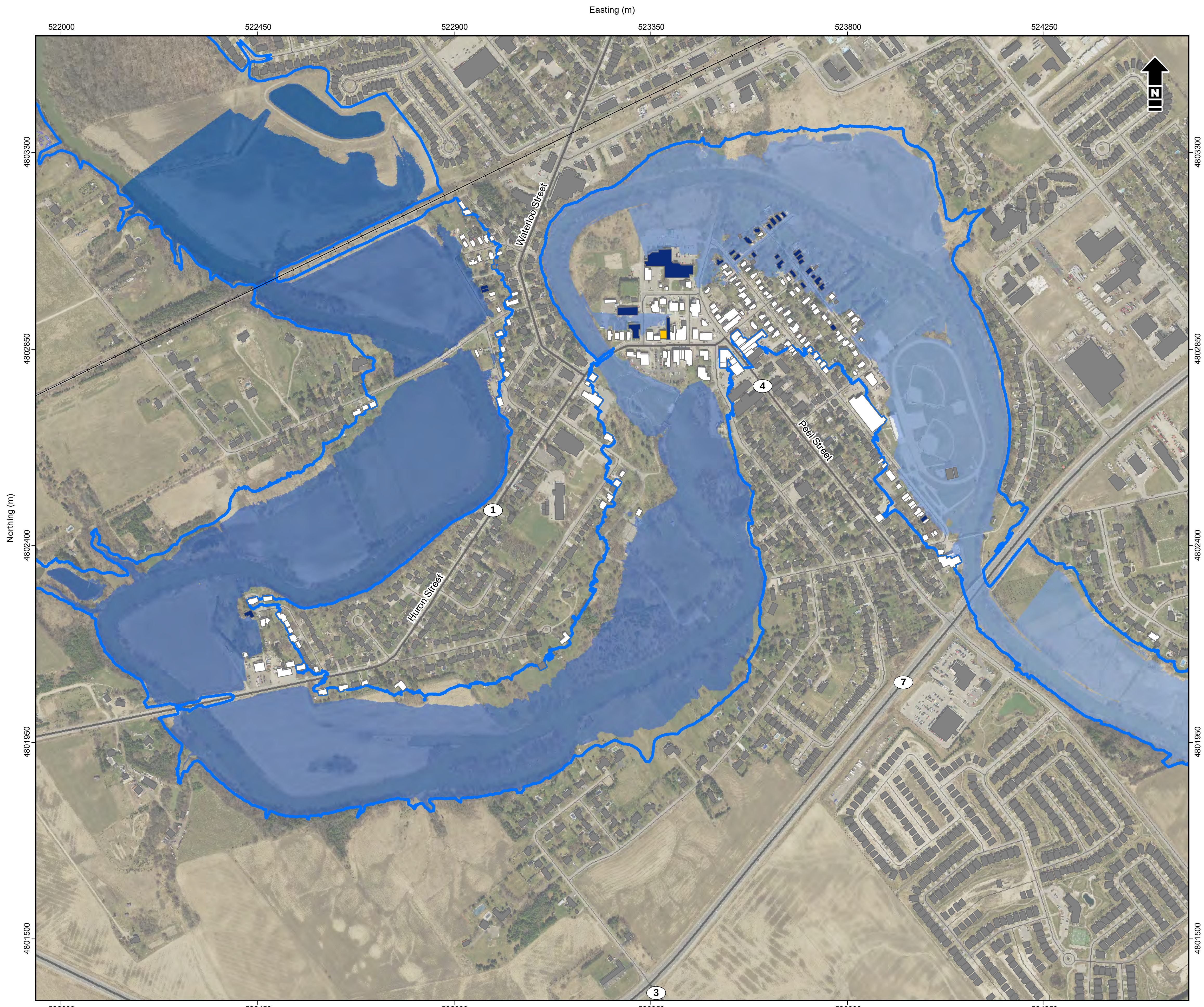
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - 10 Year (322 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 20.3



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - 15 Year (350 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

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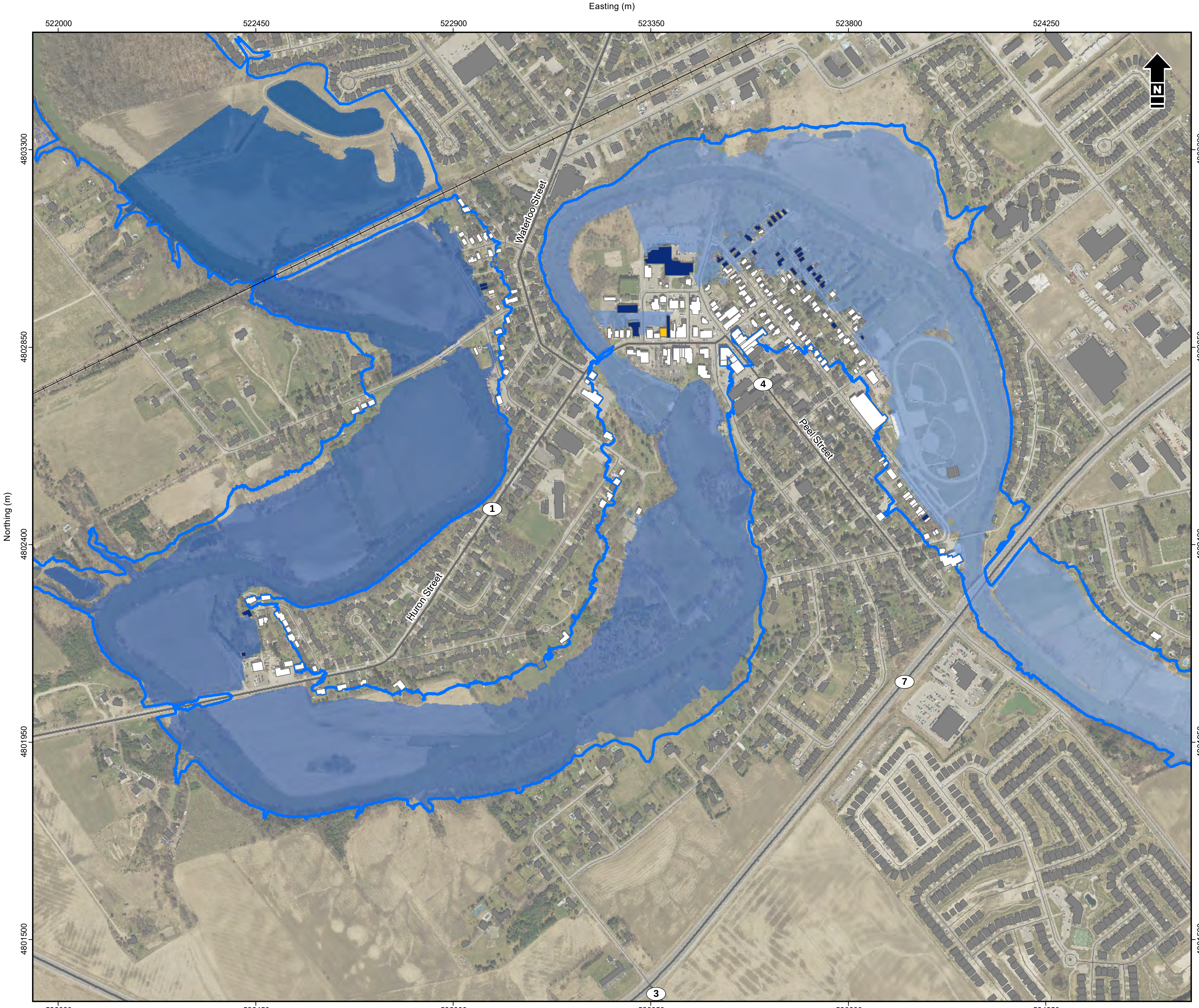
Figure 20.4



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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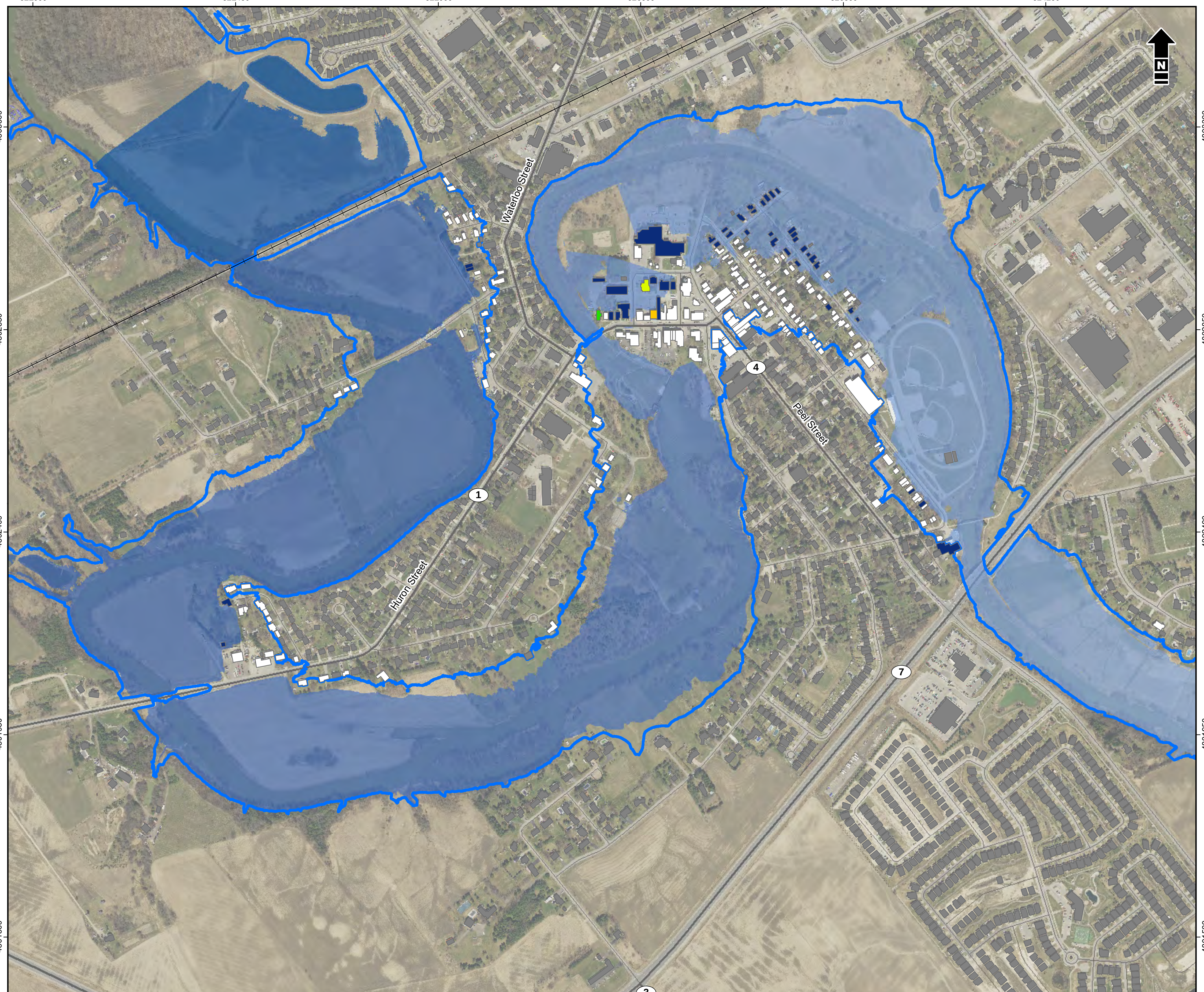
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 20.5



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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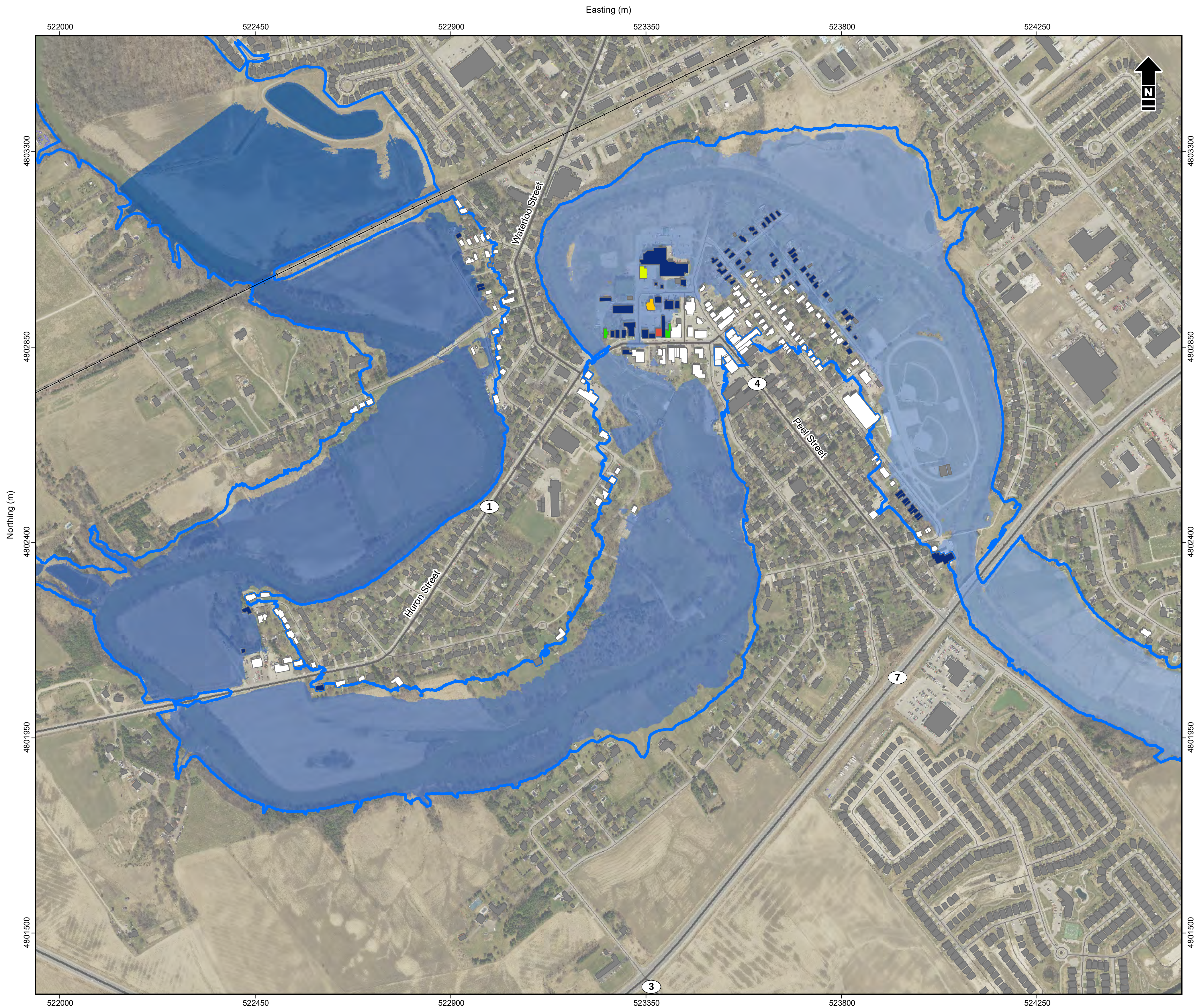
ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 20.6



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - 50 Year (447 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

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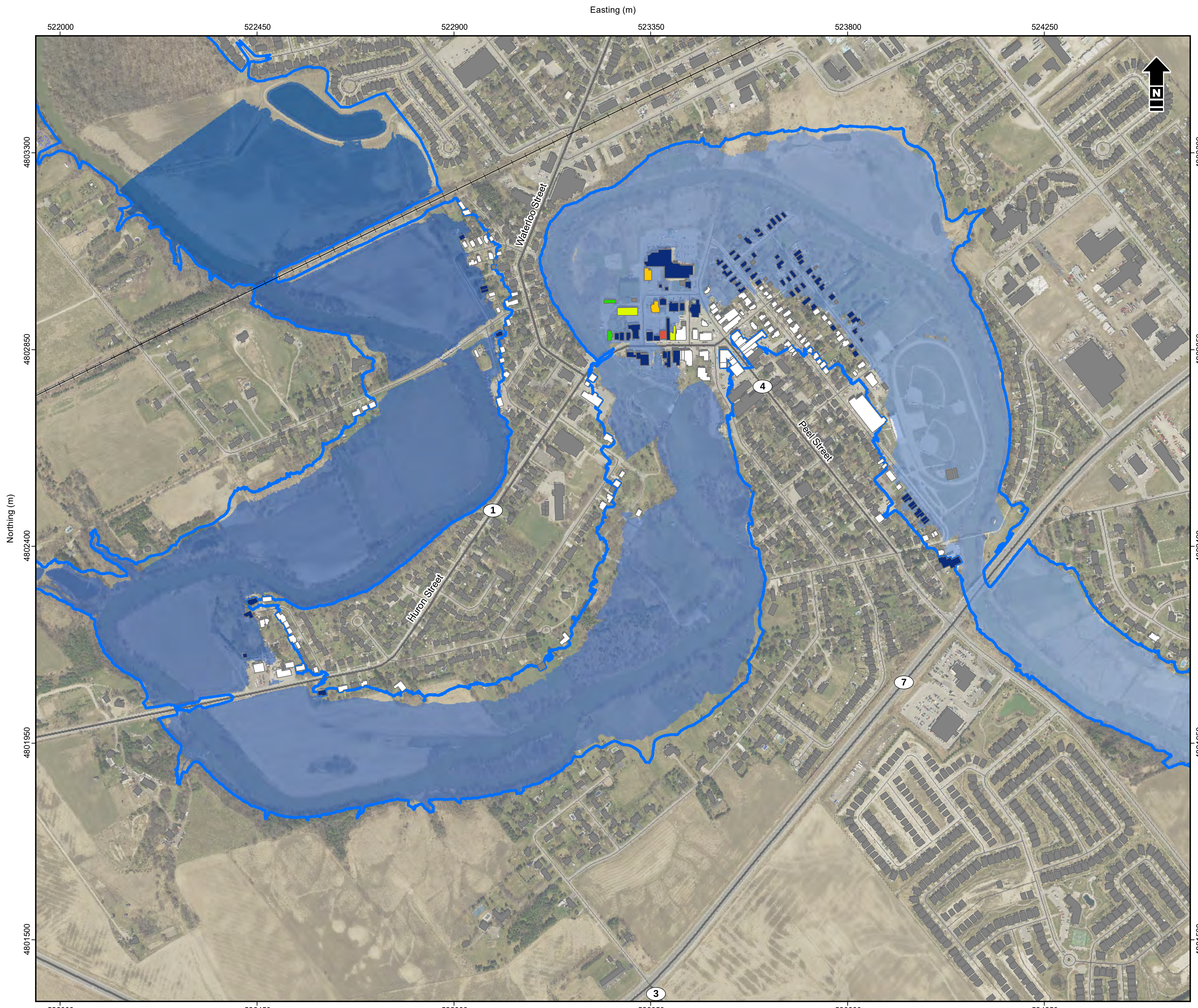
Figure 20.7



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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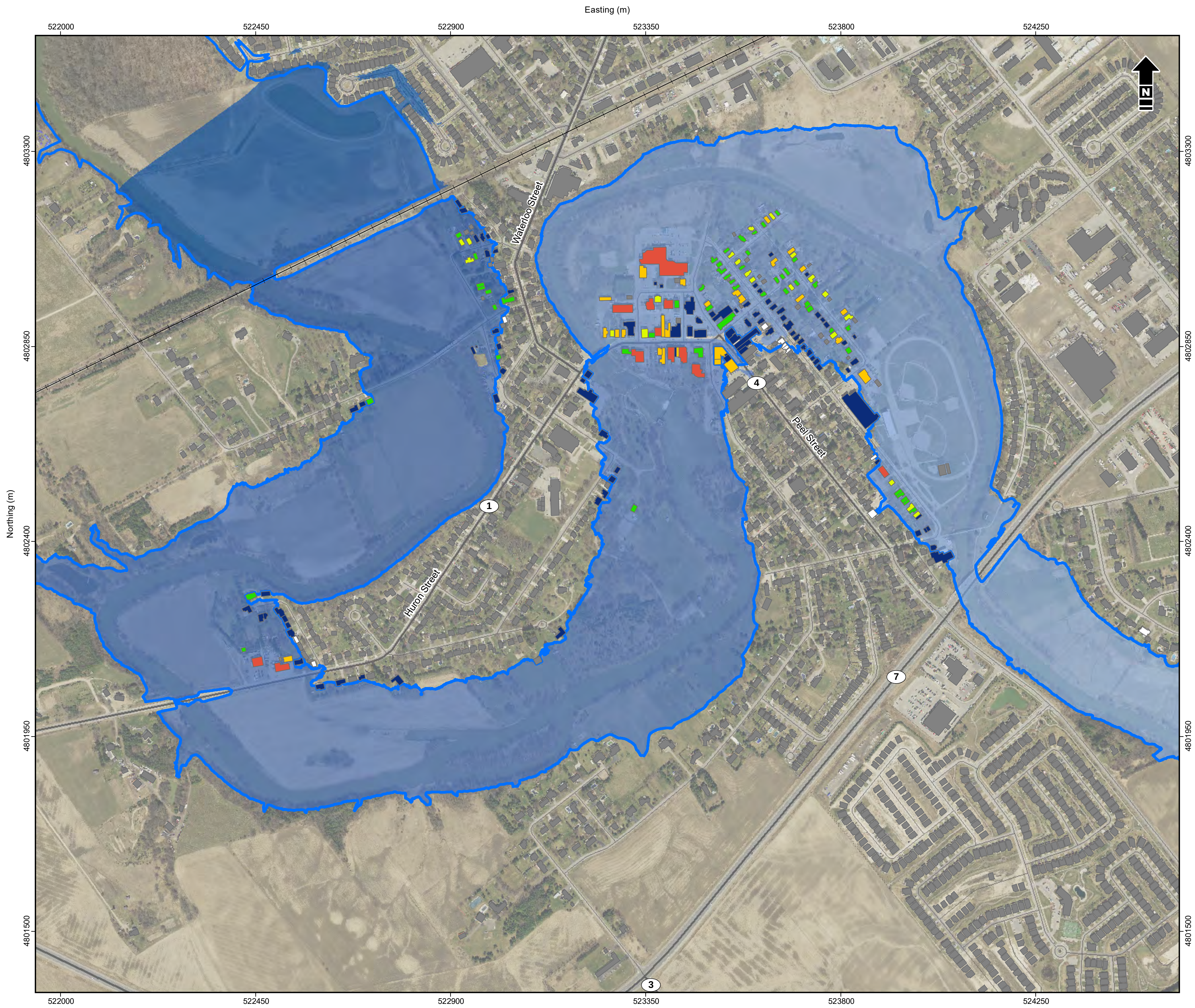
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 20.8



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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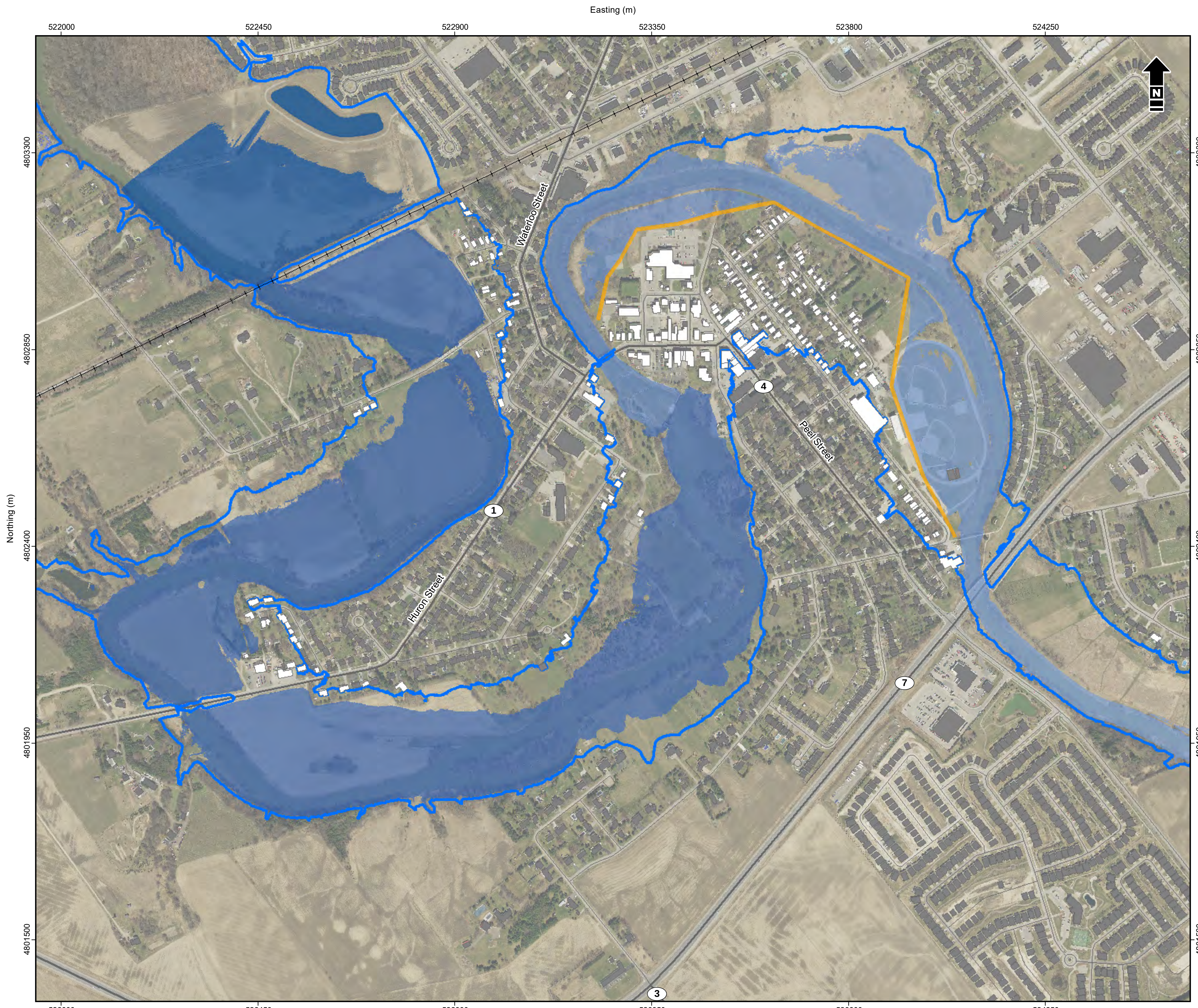
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 1 - Flood Damages - Regional (1,011 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 20.9



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 21.1

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N
Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - 5 Year (265 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
21.2

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

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New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
21.3

Easting (m)

Northing (m)

- Draft Regional Inundation Boundary
- Proposed Top of Dike
- Railway
- Highway
- Road
- Building - Not Flooded
- Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - 15 Year (350 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

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Figure 21.4

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
21.5

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-21-X-Option_2_Flood_Damages.mxd - Tabloid_L - 19-Mar-20, 11:30 AM - lmwright - TID005

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 21.6

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - 50 Year (447 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 21.7

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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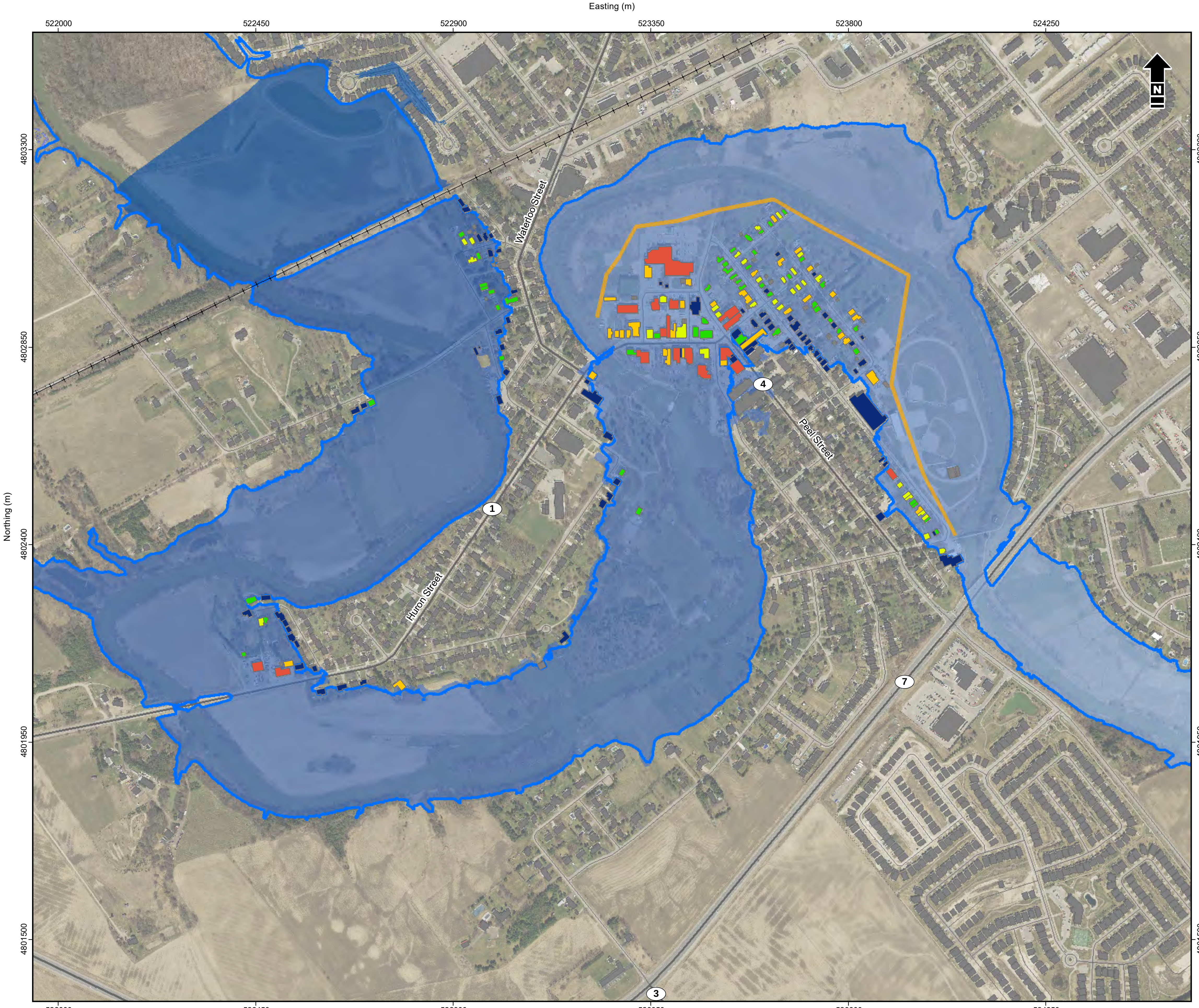
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 21.8



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 2 - Flood Damages - Regional (1,011 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 21.9

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-21-X-Option_2_Flood_Damages.mxd - Tabloid_L - 19-Mar-20, 11:30 AM - lmwright - TID005

Easting (m)

- Draft Regional Inundation Boundary
- Proposed Top of Dike
- Railway
- Highway
- Road
- Building - Not Flooded
- Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 22.1

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-22-X-Option_3_Flood_Damages.mxd - Tabloid_L - 19-Mar-20, 11:31 AM - lmwright - TID005

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - 5 Year (265 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 22.2

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 22.3

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - 15 Year (350 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 22.4

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-22-X-Option_3_Flood_Damages.mxd - Tabloid_L - 19-Mar-20, 11:32 AM - lmwright - TID005

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 22.5

I:\GrandRiverCA\29006\FiguresAndTables\HYD\2020\Client\TM2\Figure-22-X-Option_3_Flood_Damages.mxd - Tabloid_L - 19-Mar-20, 11:32 AM - lmwright - TID005

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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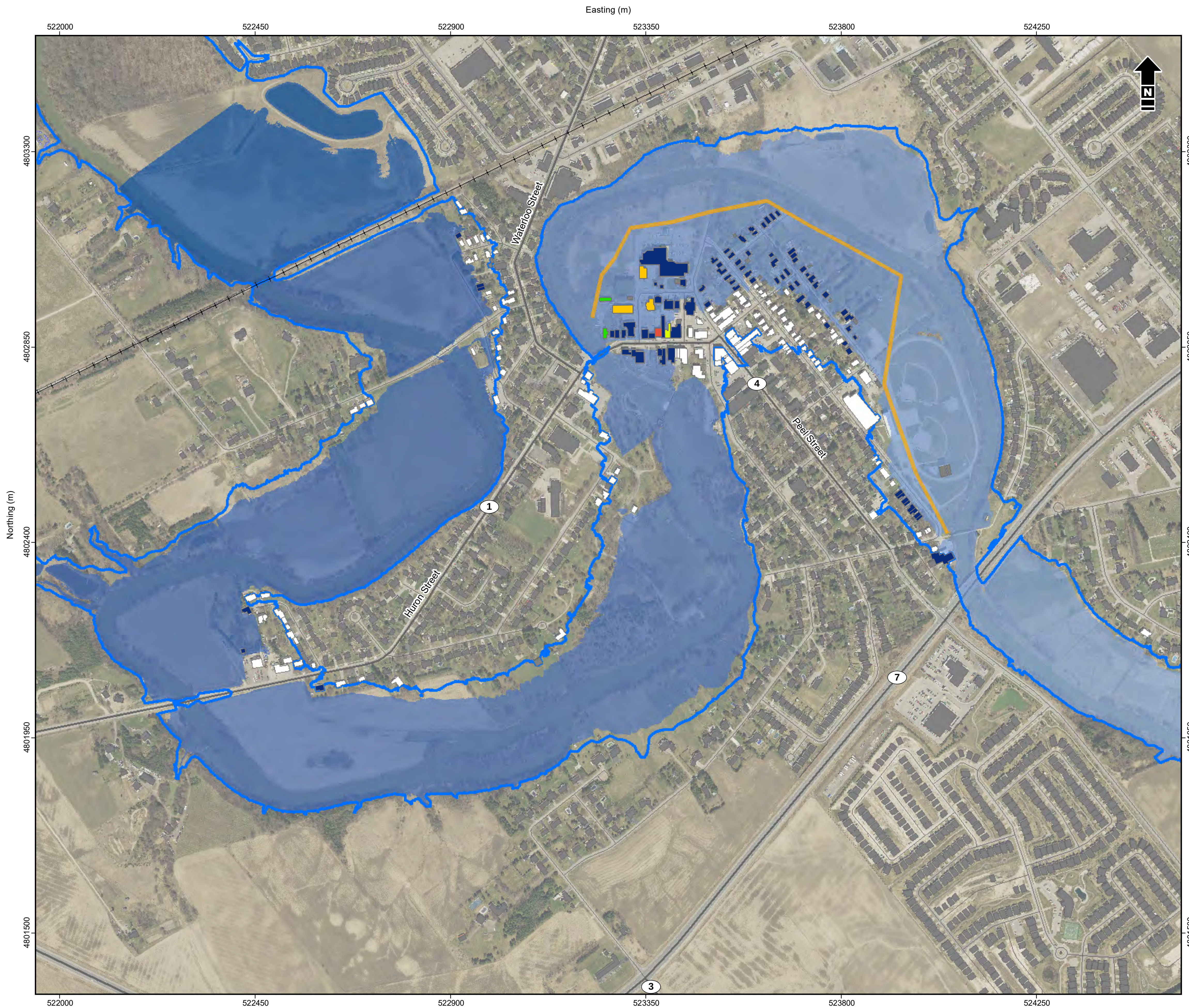
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 22.6



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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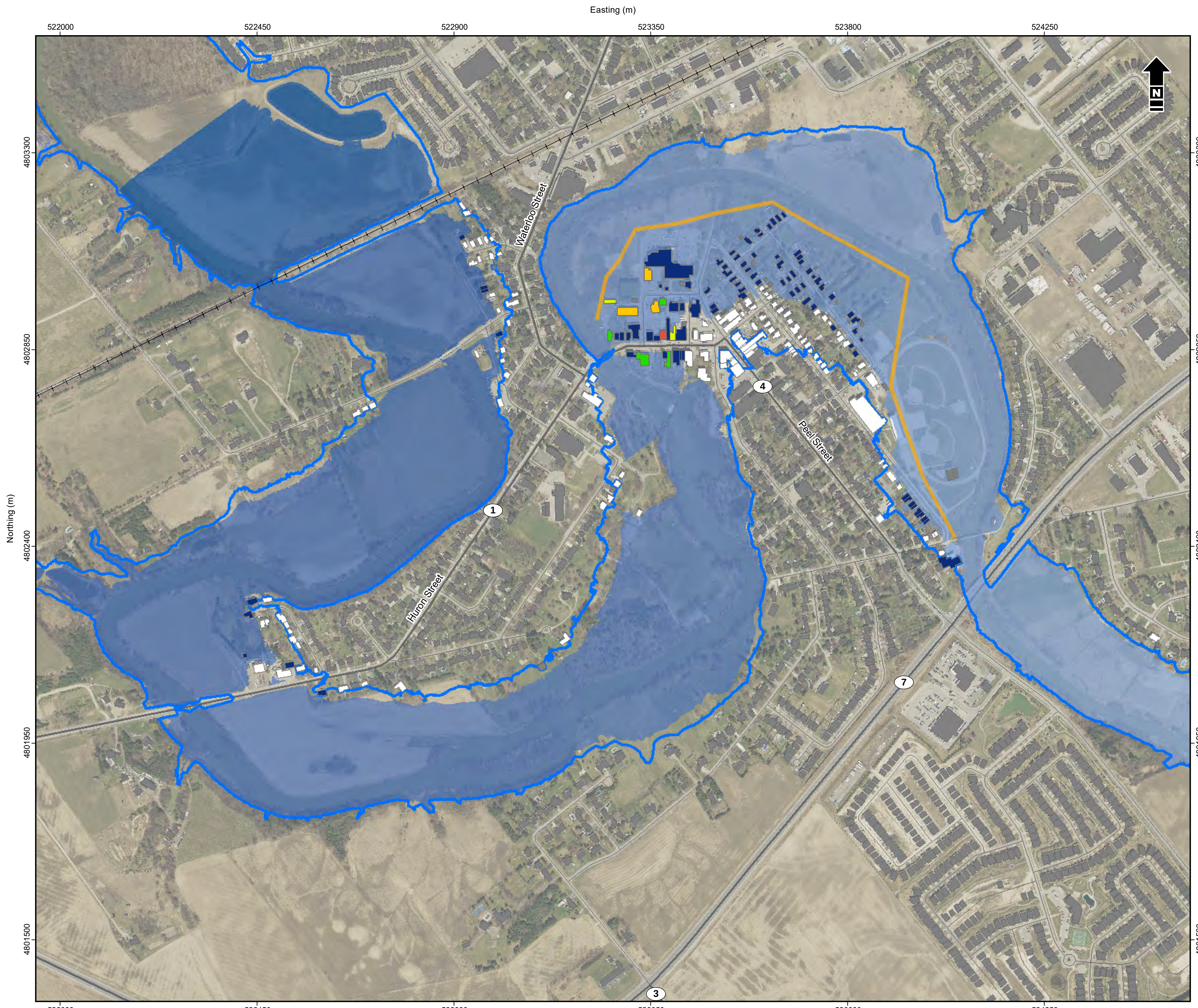
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - 50 Year (447 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 22.7



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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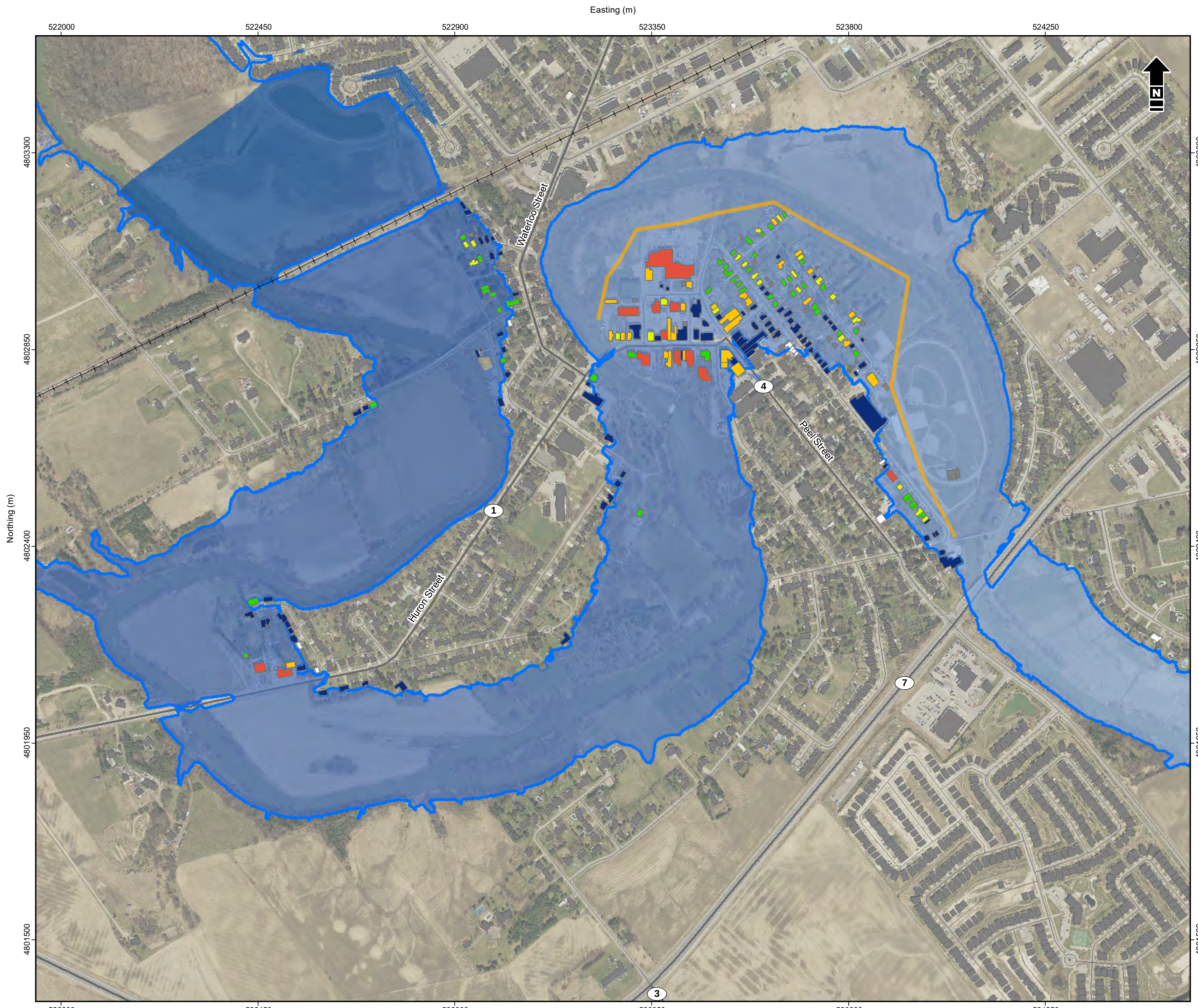
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 22.8



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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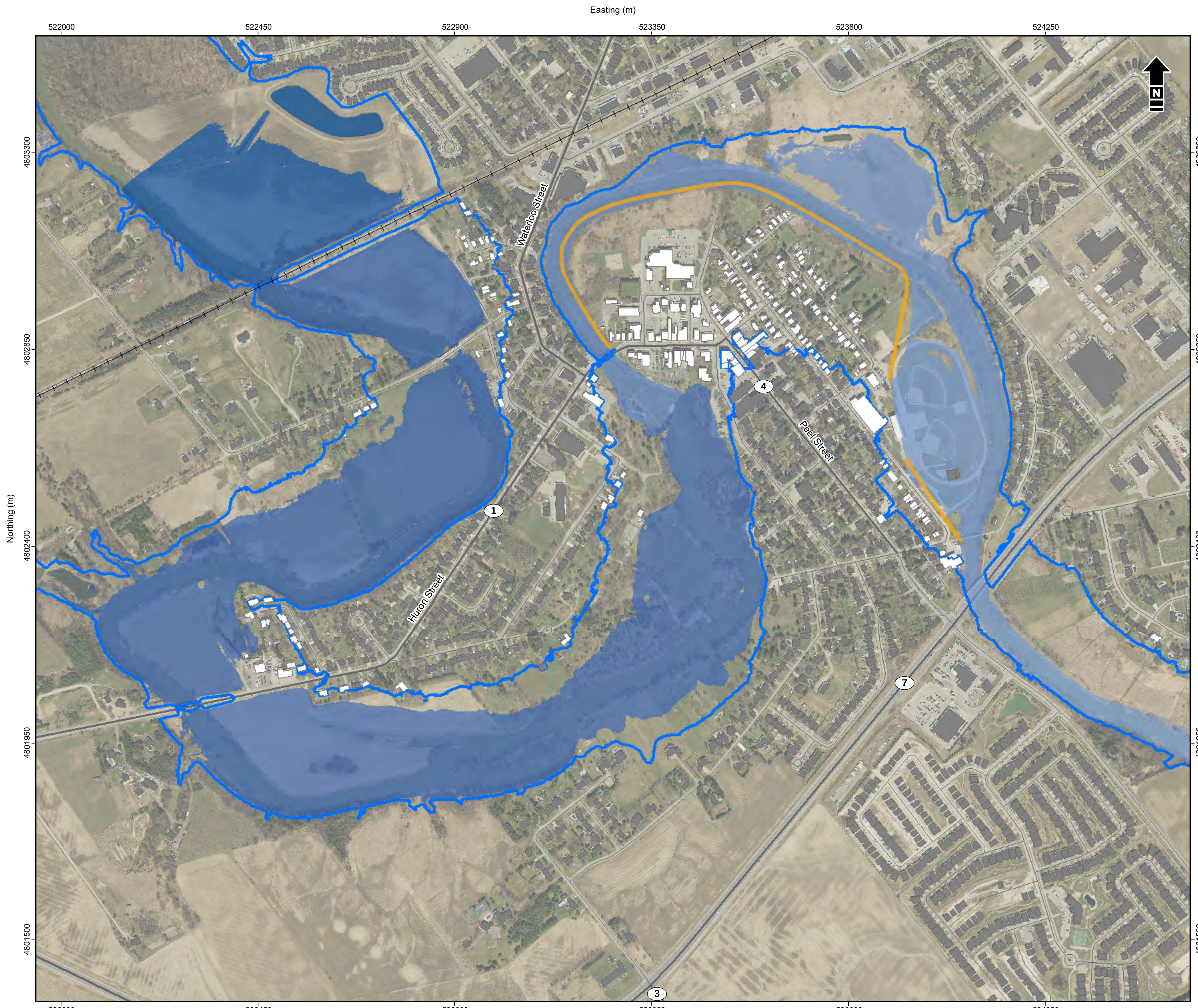
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 3 - Flood Damages - Regional (1,011 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
22.9



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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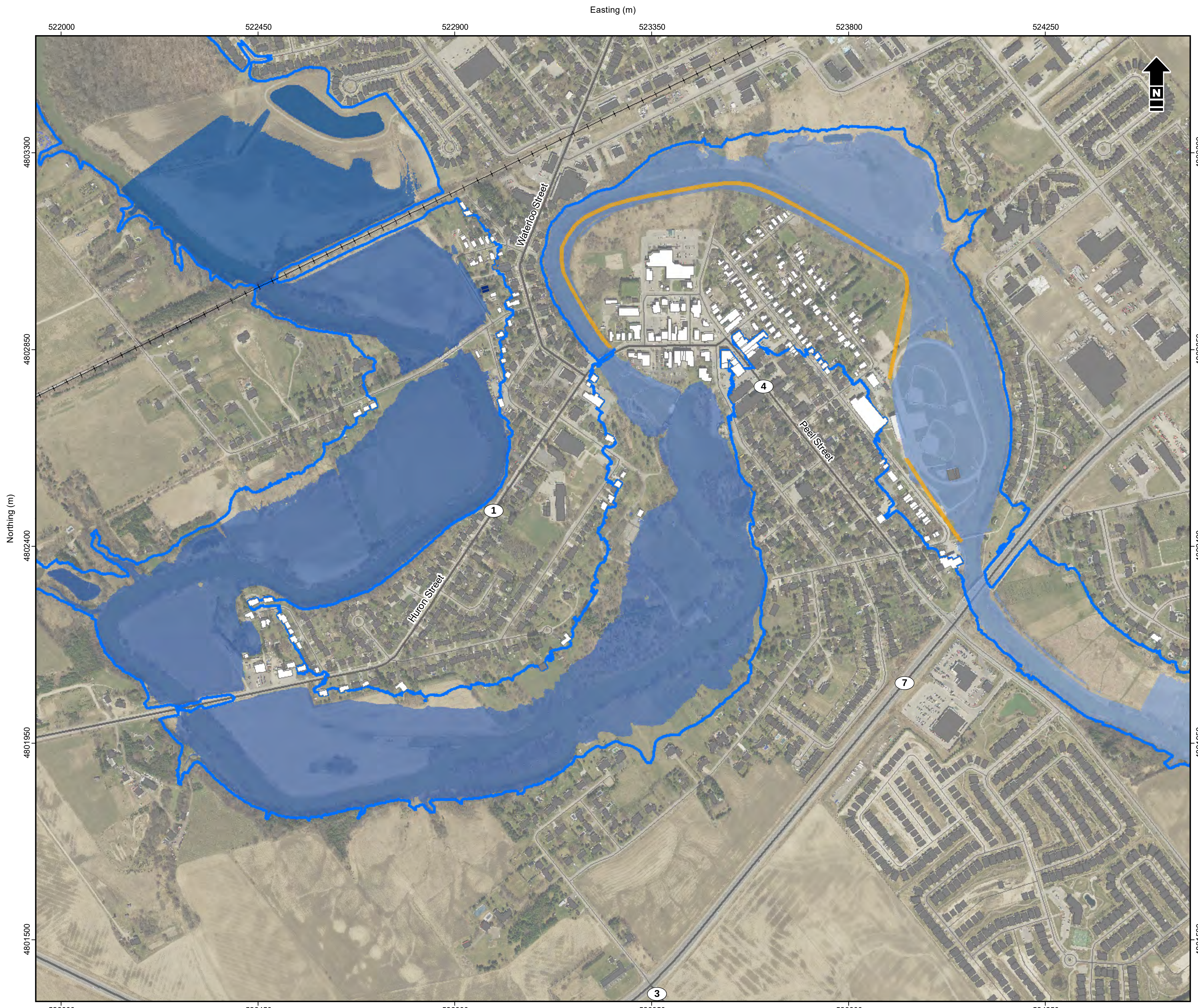
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - 2 Year (179 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 23.1



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - 5 Year (265 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 23.2

Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres

100 0 100 200

NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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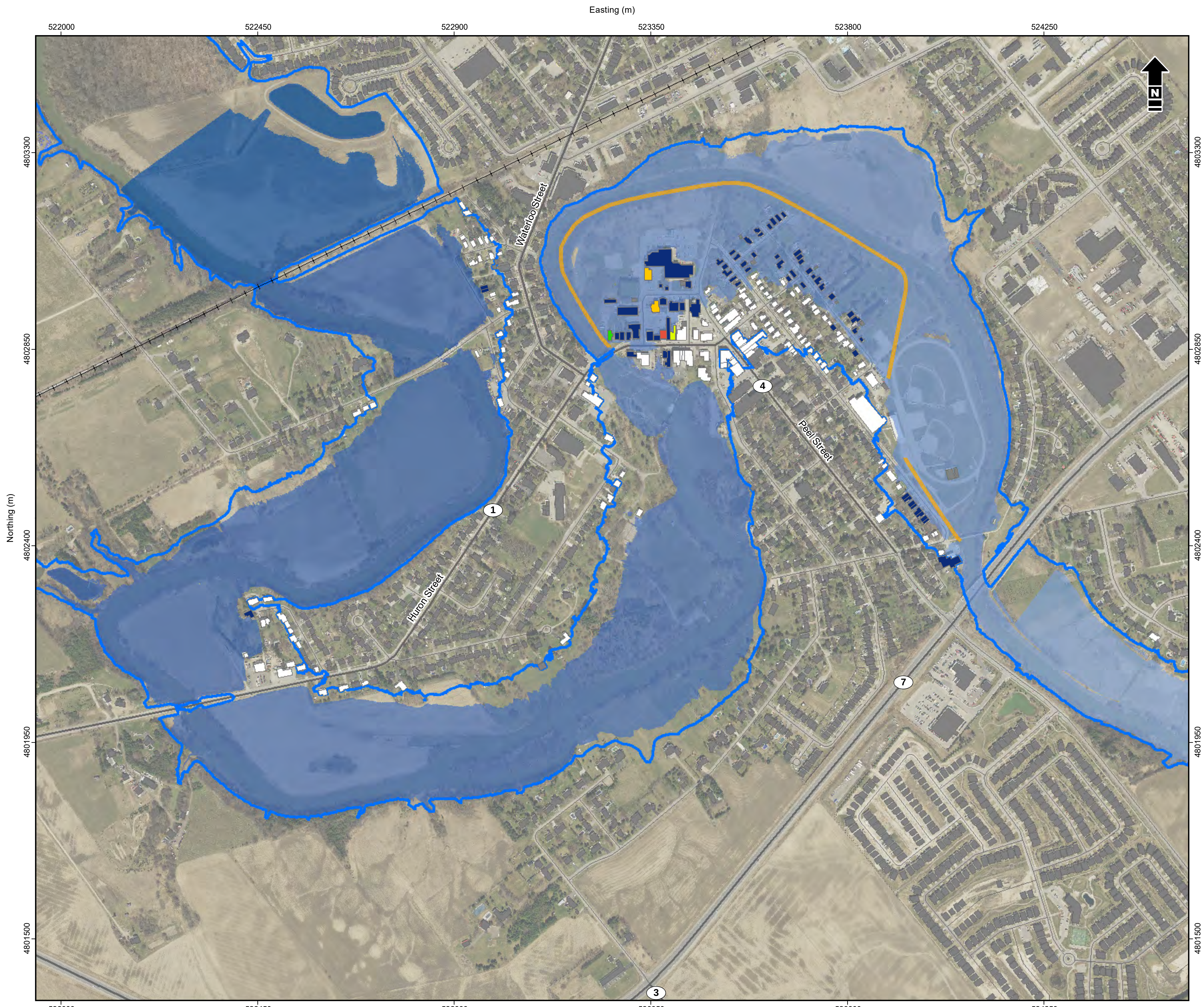
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure
23.3



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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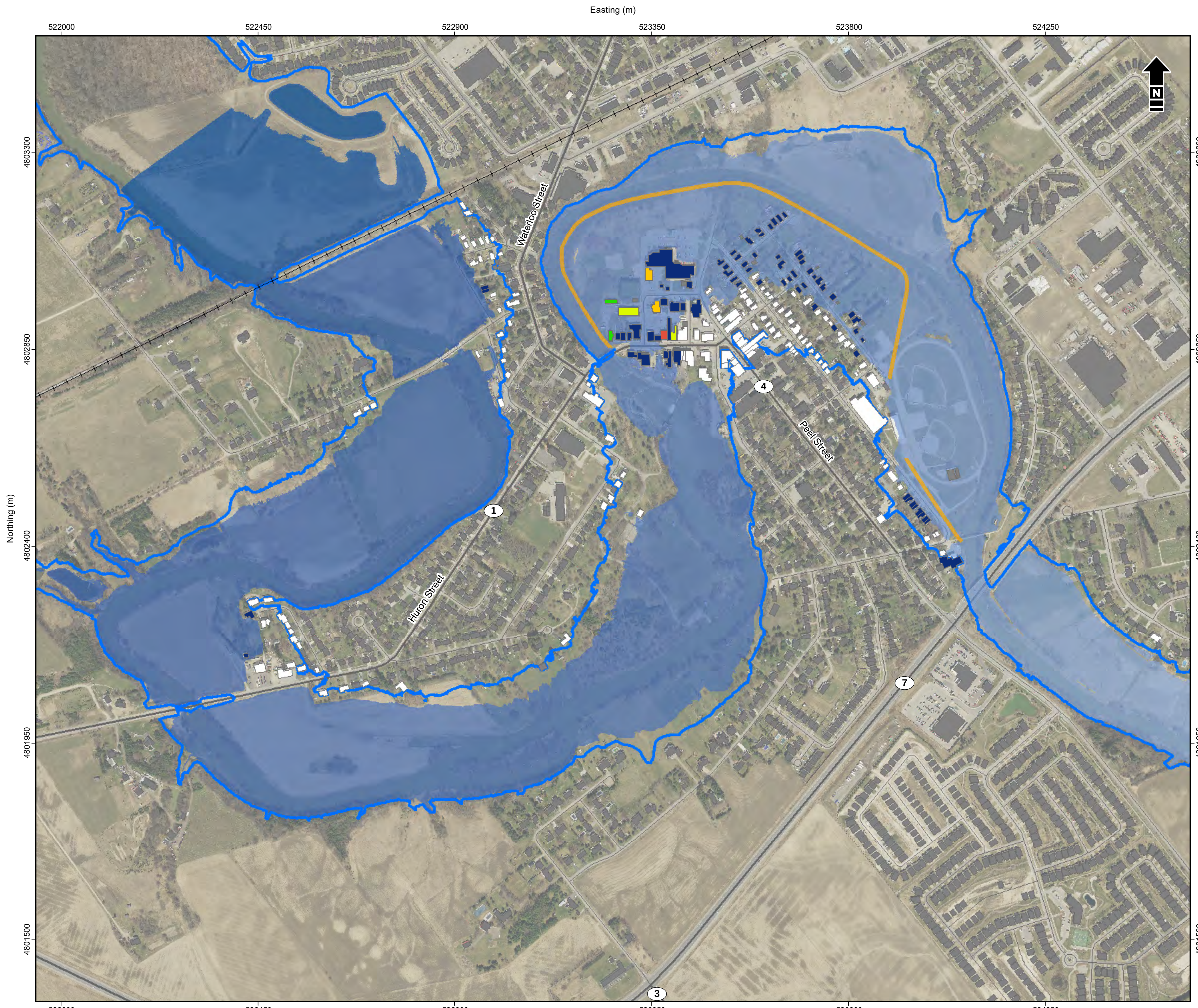
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - 15 Year (350 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 23.4



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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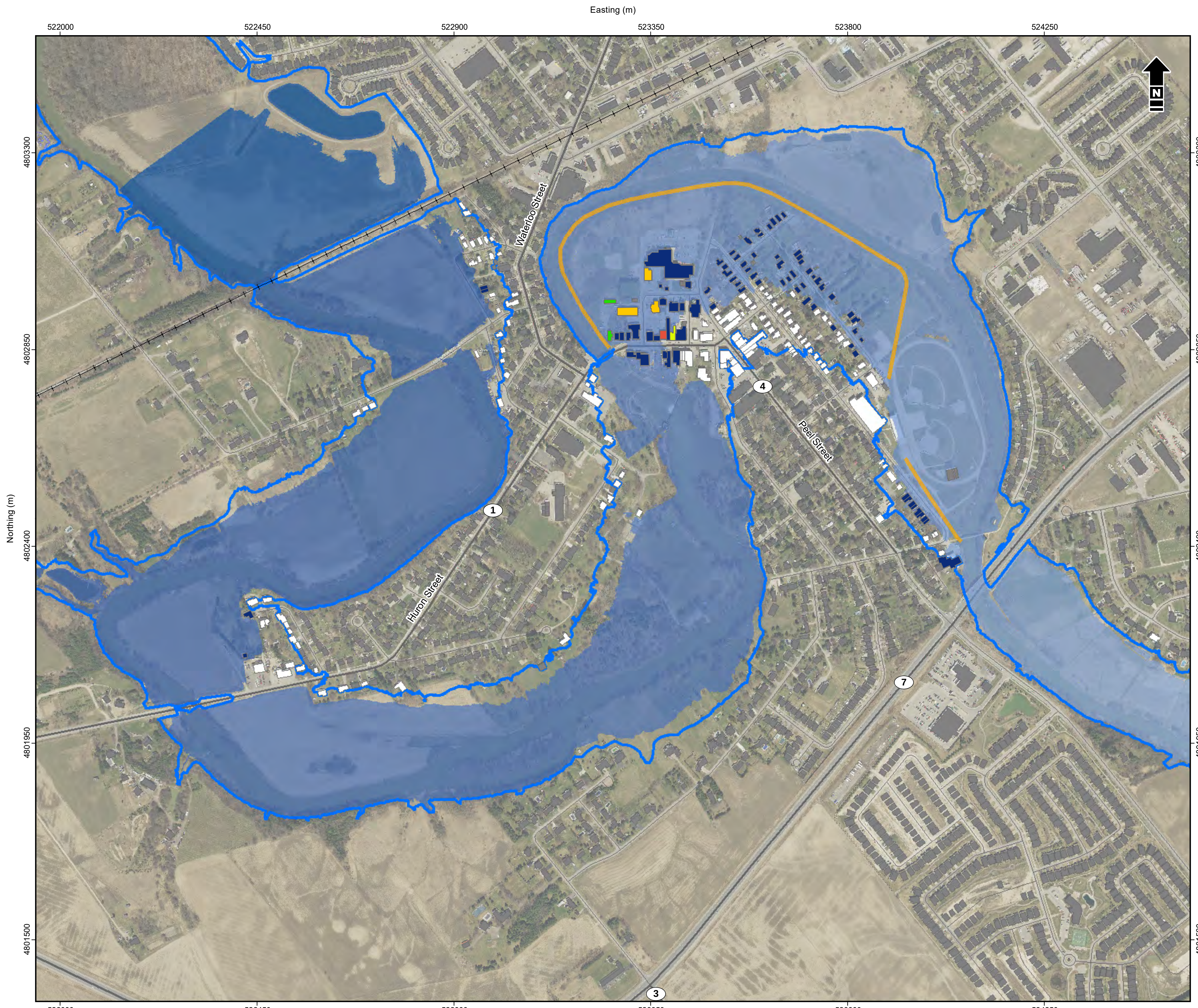
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 23.5



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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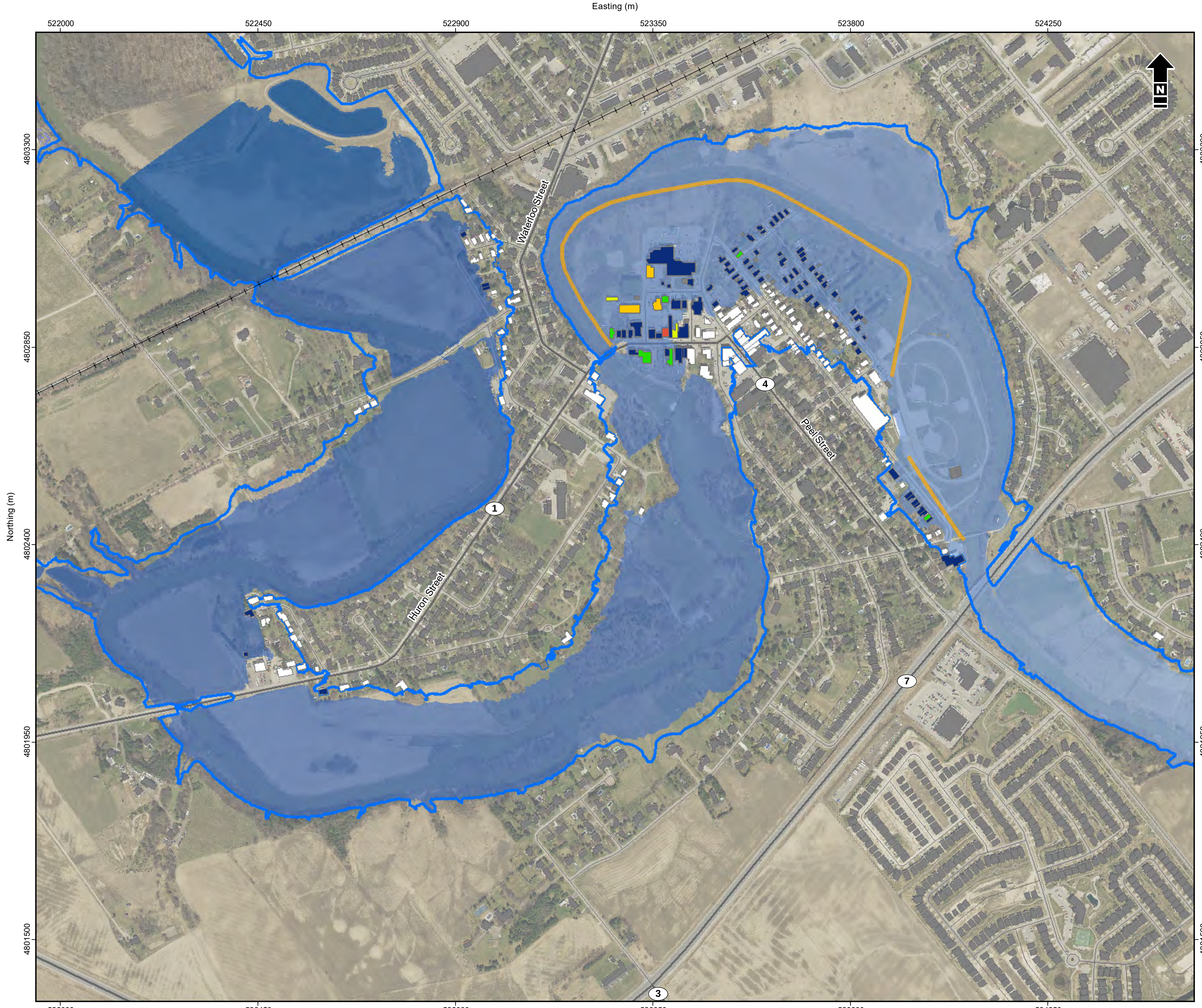
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 23.6



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

Matrix Solutions Inc.
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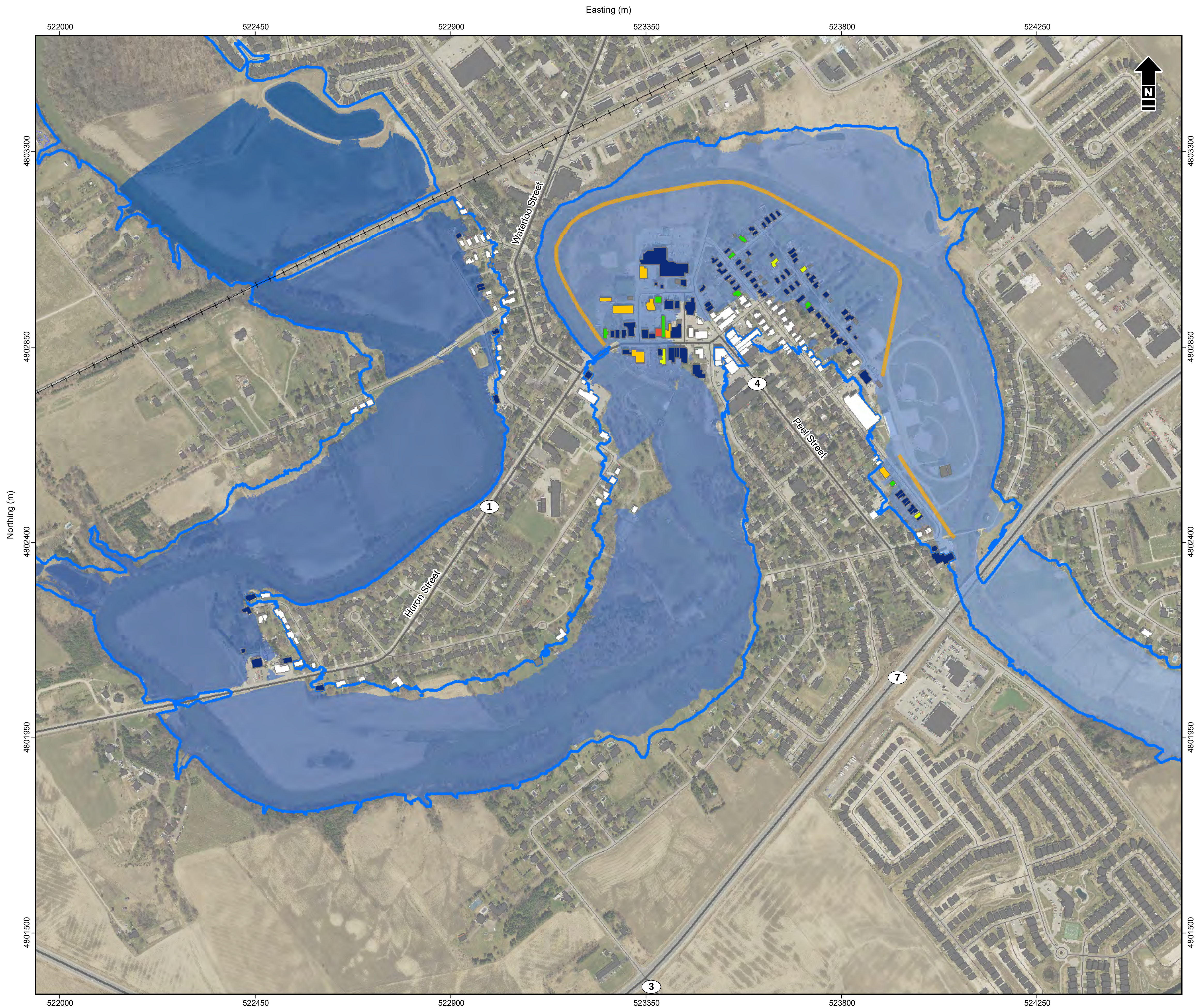
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - 50 Year (447 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 23.7



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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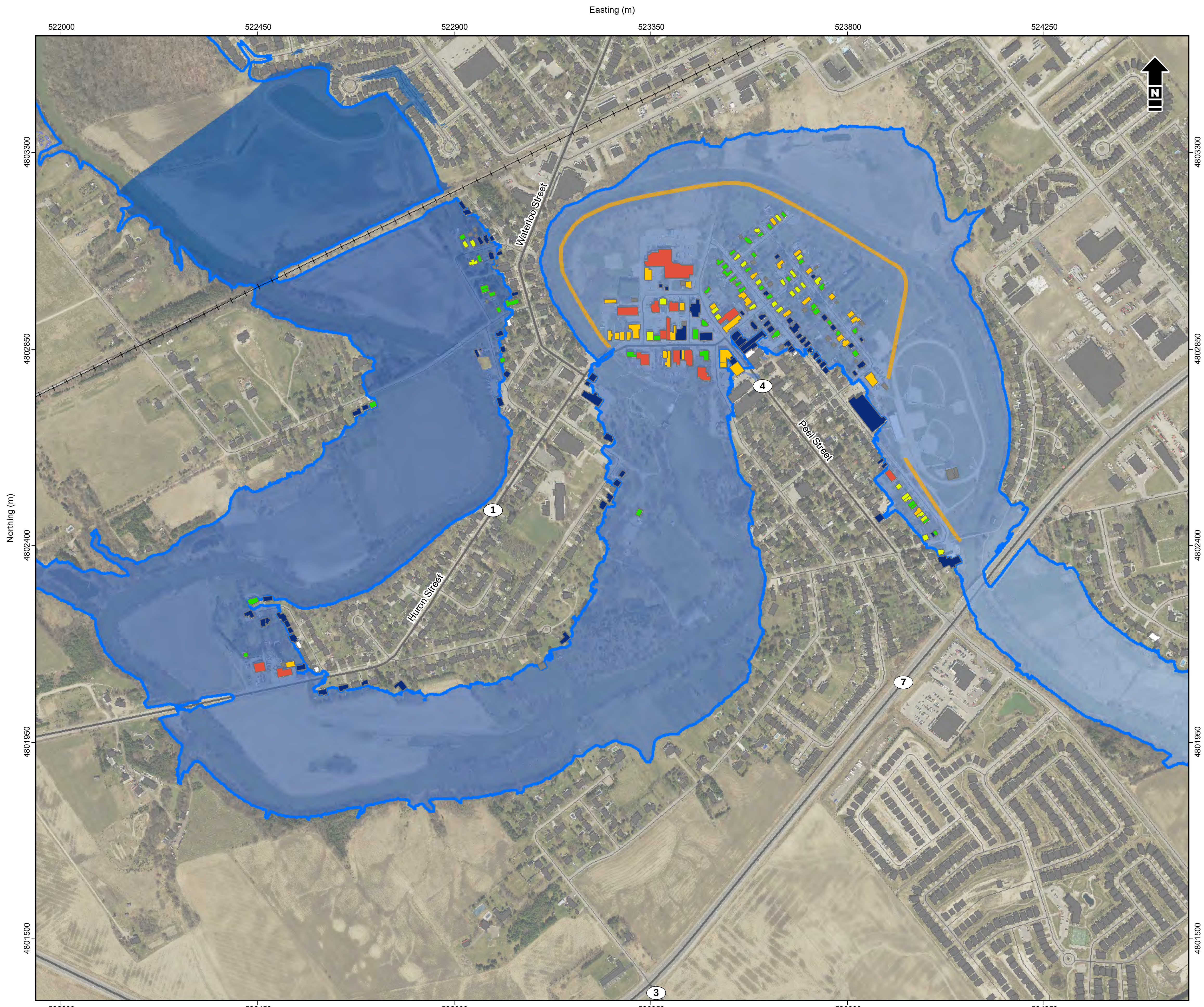
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - 100 Year (500 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 23.8



Draft Regional Inundation Boundary
Proposed Top of Dike
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total Damage ($) - See Note

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

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Vertical Datum: CGVD2013

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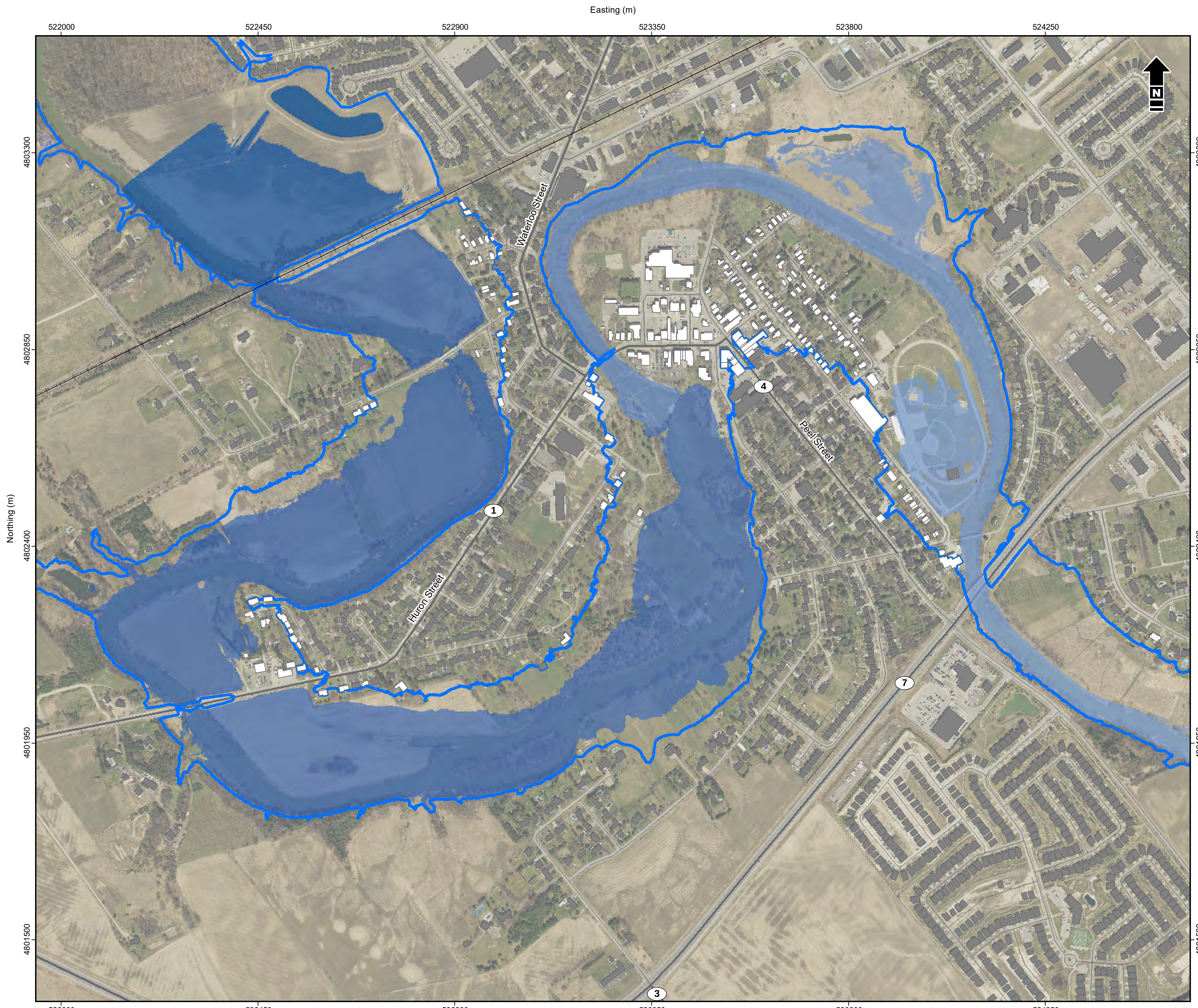
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 4 - Flood Damages - Regional (1,011 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 23.9



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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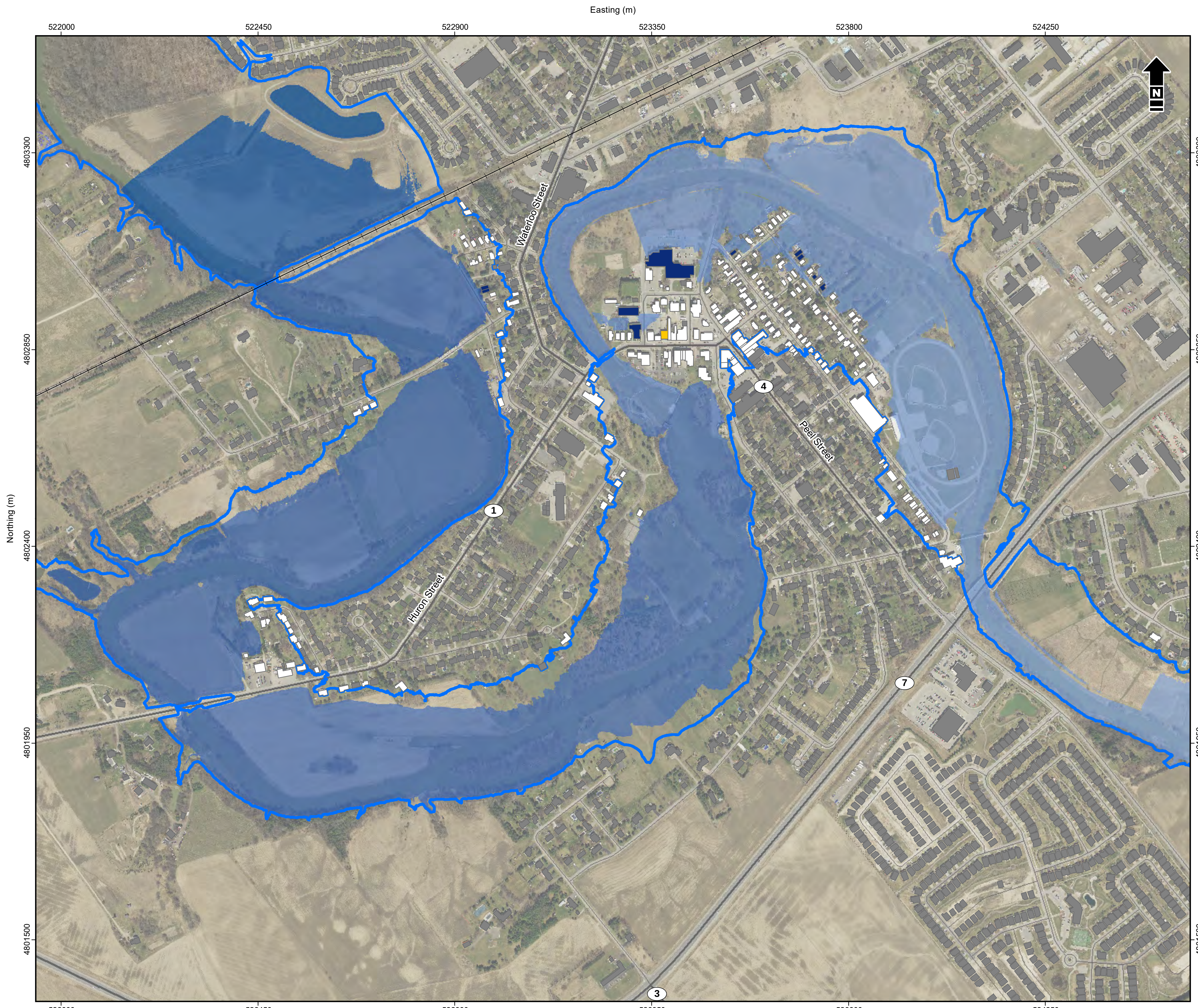
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 - Flood Damages - 2 Year (179 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 24.1



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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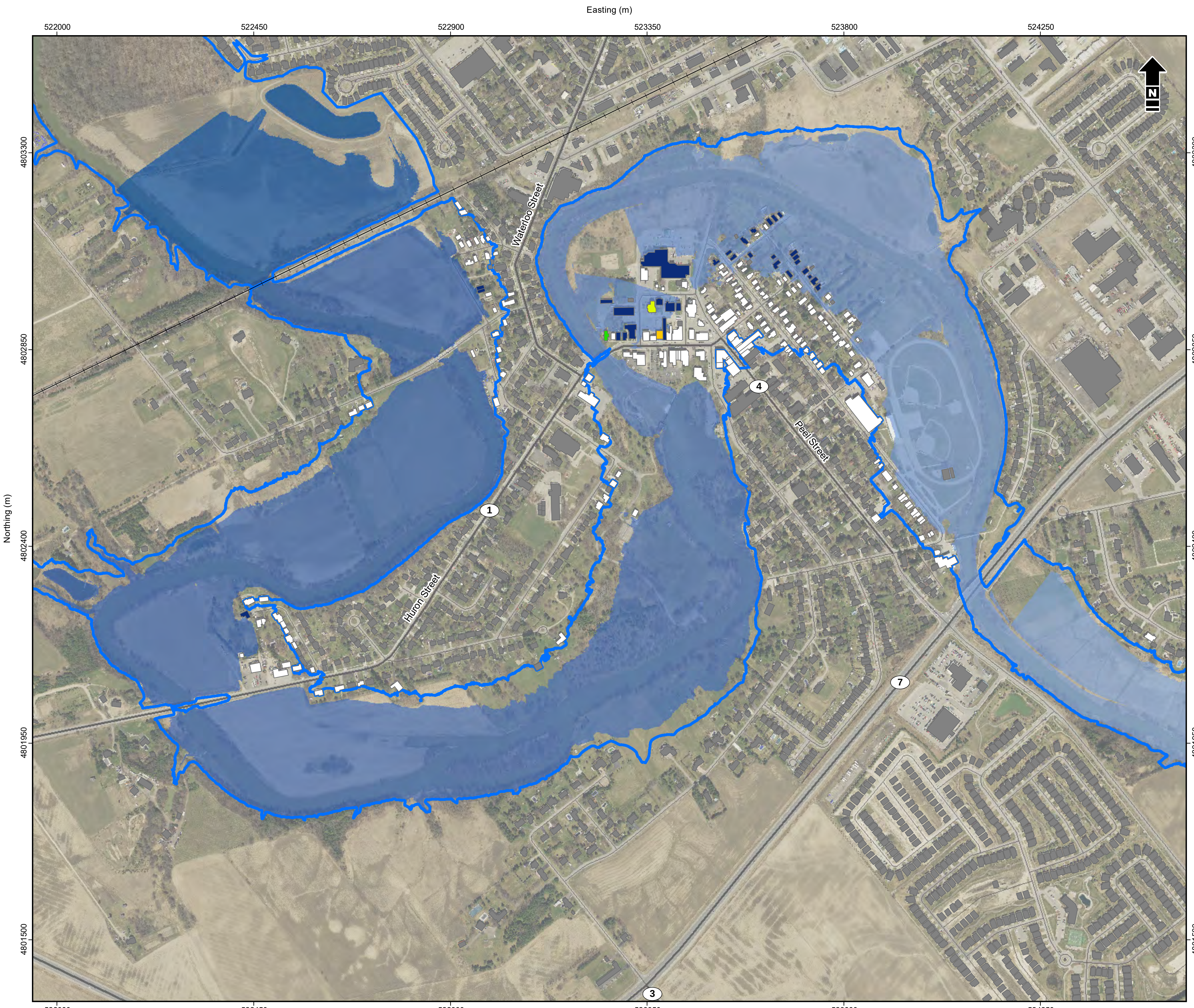
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 - Flood Damages - 5 Year (265 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 24.2



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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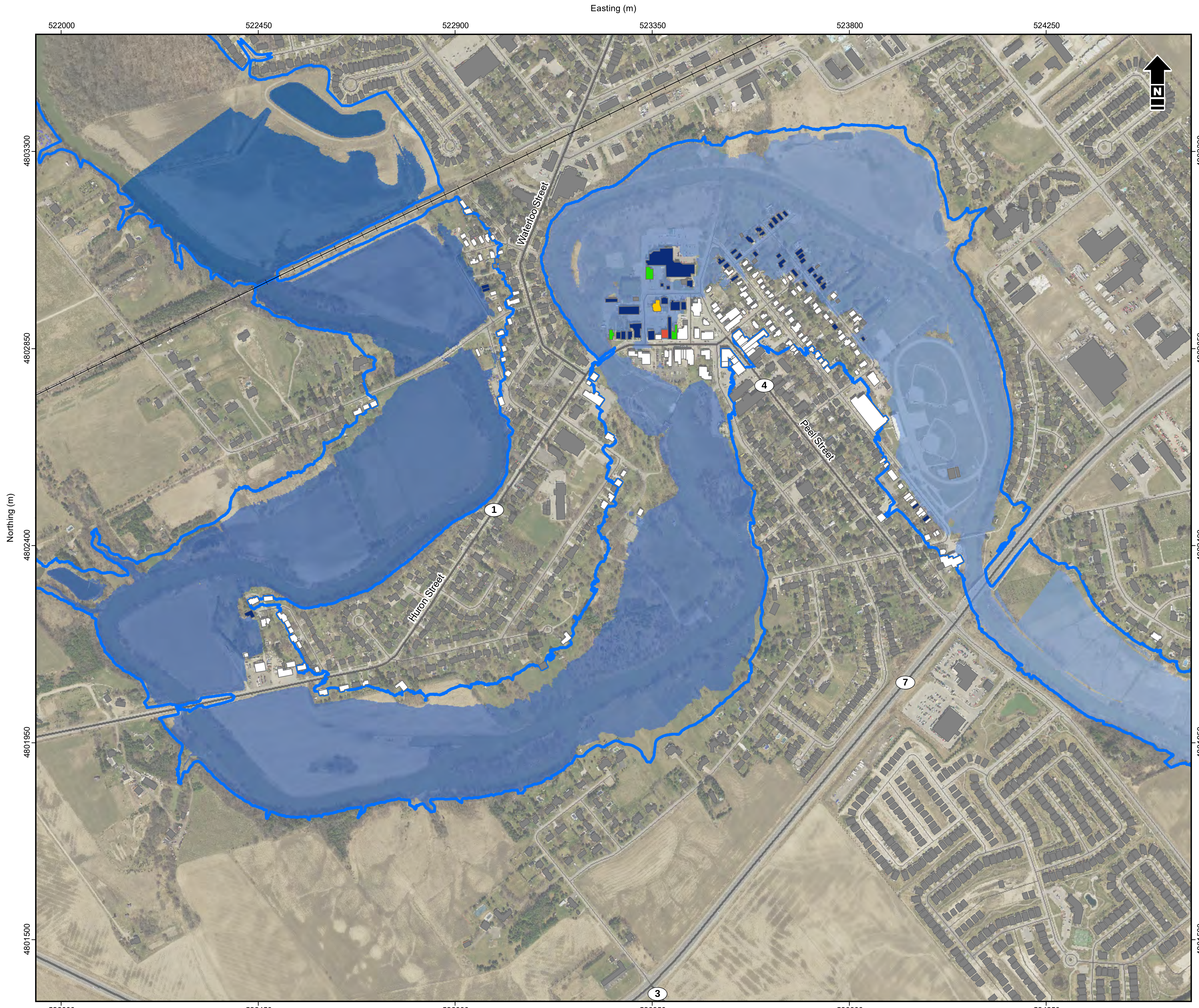
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 - Flood Damages - 10 Year (322 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 24.3



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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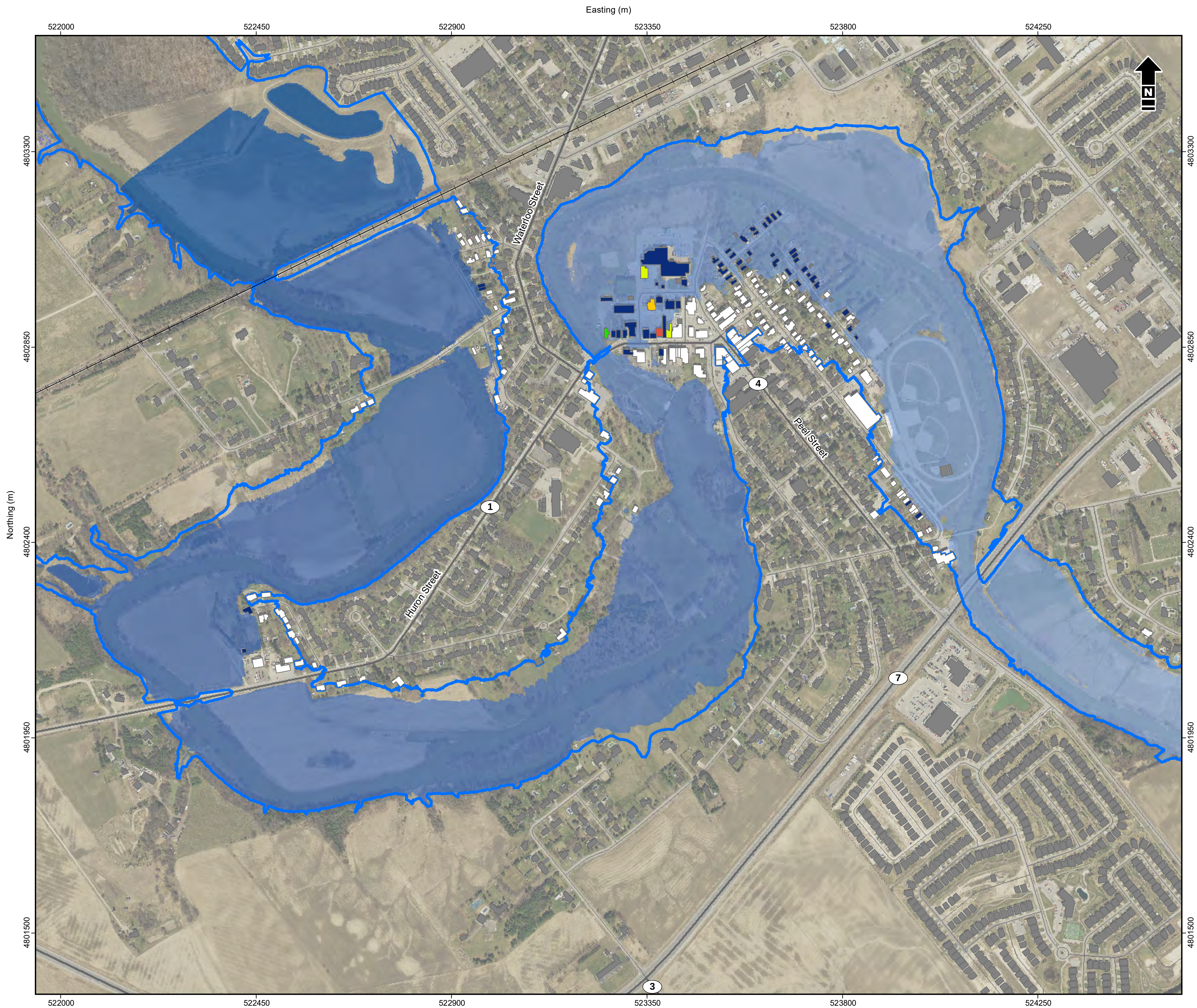
New Hamburg Flood Mitigation Study

Option 5 - Flood Damages - 15 Year (350 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 24.4



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage

0.0 - 100,000
100,000 - 150,000
150,000 - 200,000
200,000 - 500,000
500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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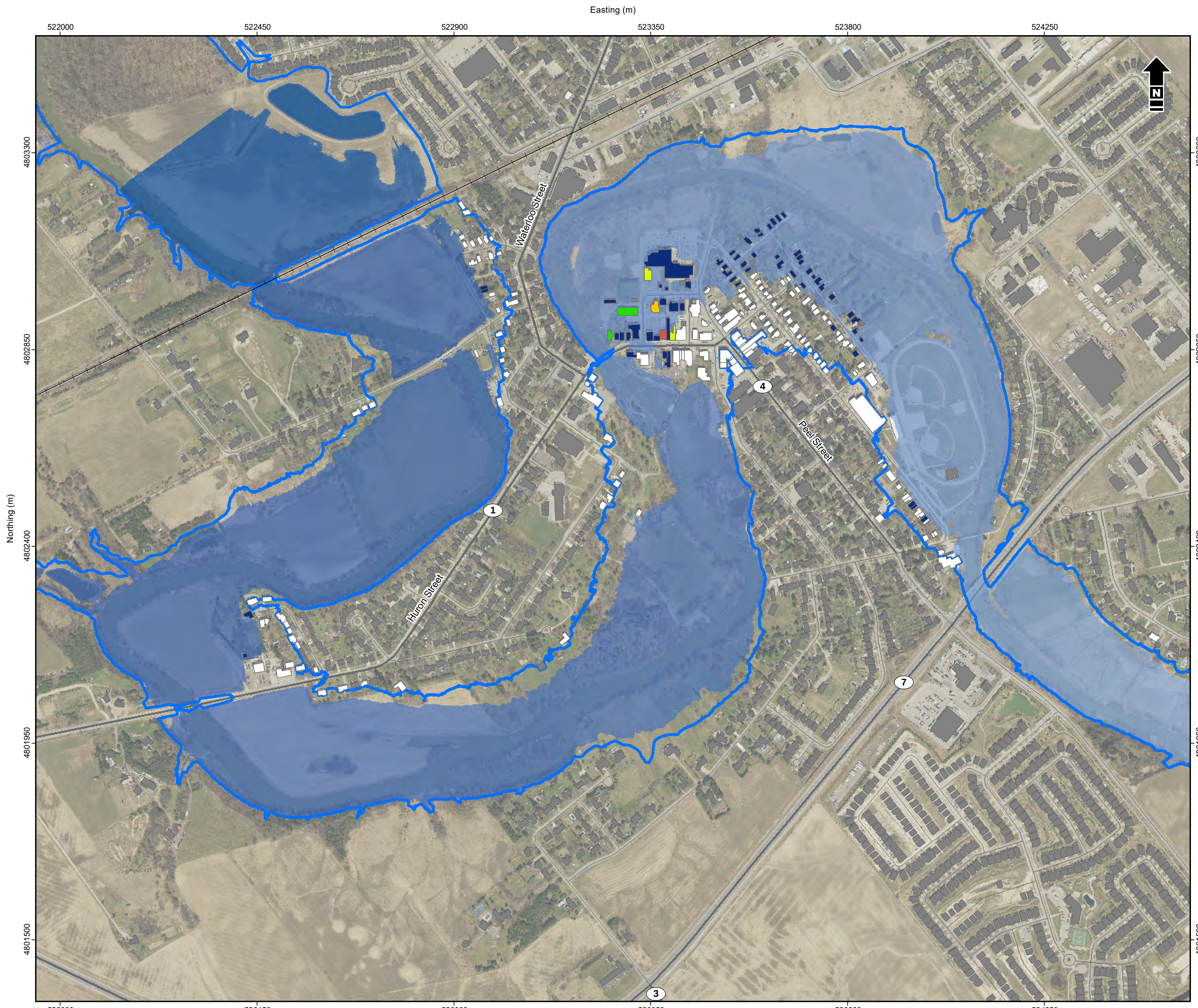
Option 5 - Flood Damages - 20 Year (377 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 24.5



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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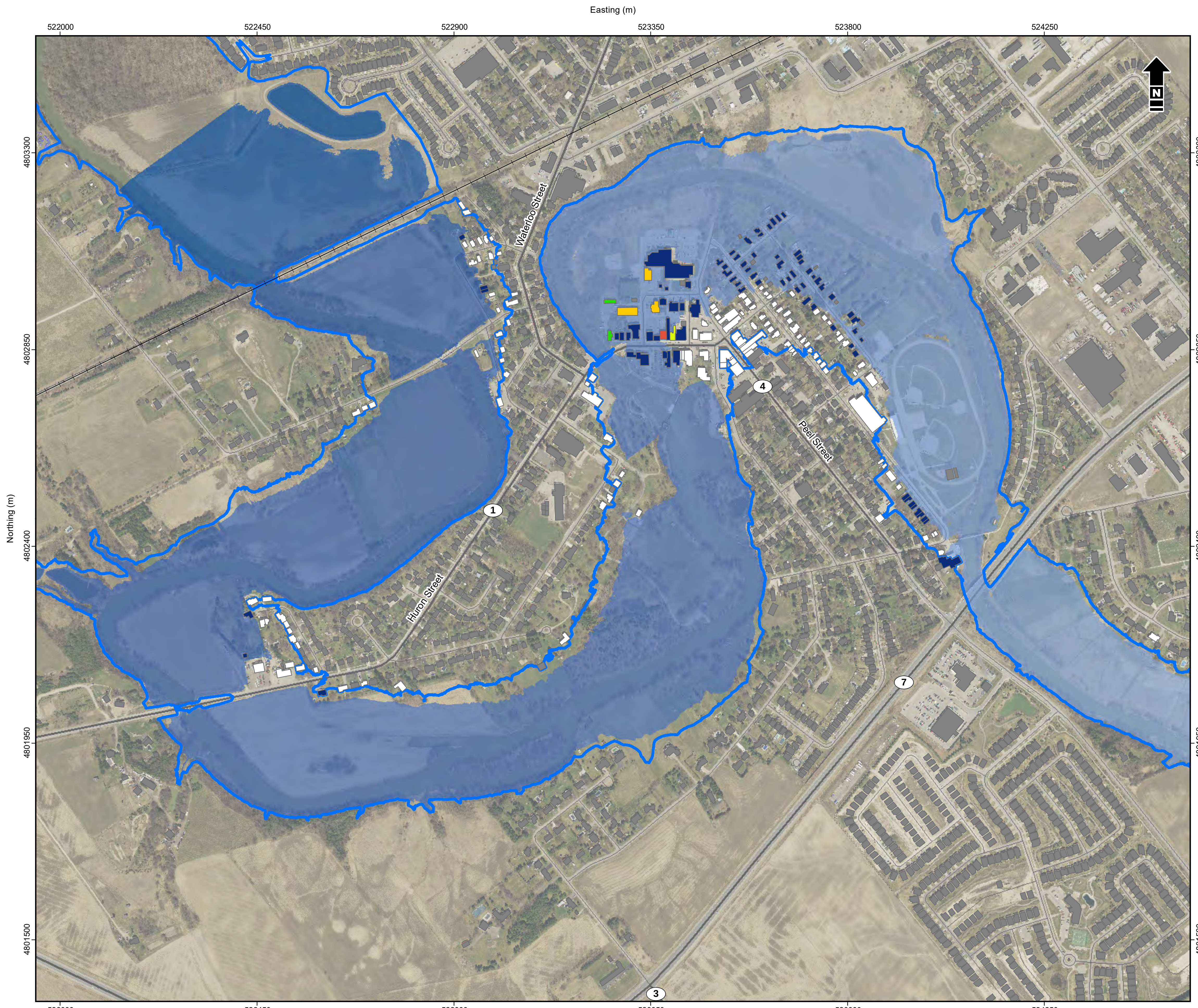
Option 5 - Flood Damages - 25 Year (394 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 24.6



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage

- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)

High : 338.6

Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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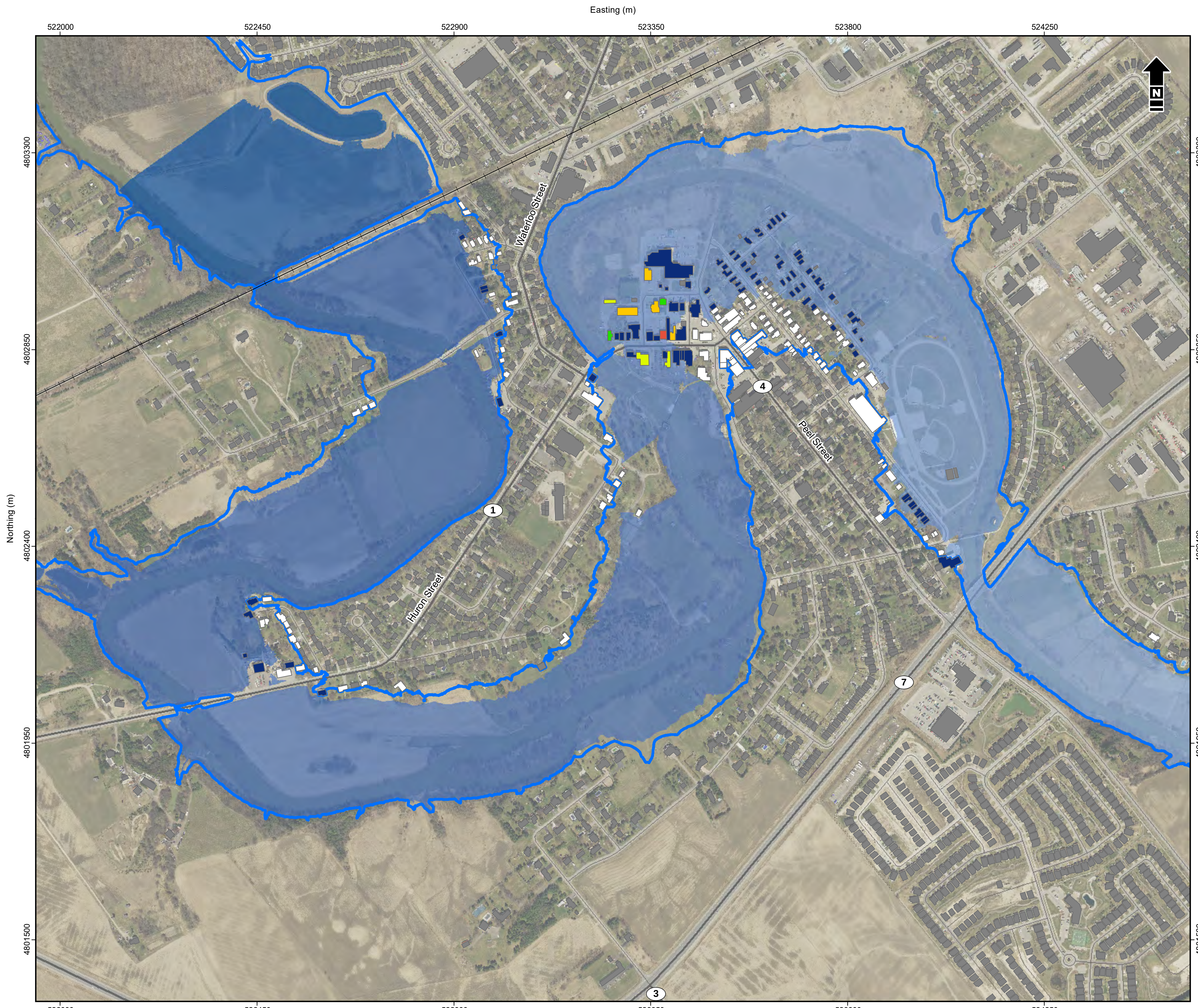
Grand River Conservation Authority
New Hamburg Flood Mitigation Study

Option 5 - Flood Damages - 50 Year (447 m^3/s)

Date: March 2020	Project: 29006	Submitter: S. Blue	Reviewer: K. Hofbauer

Figure 24.7



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage
- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)
High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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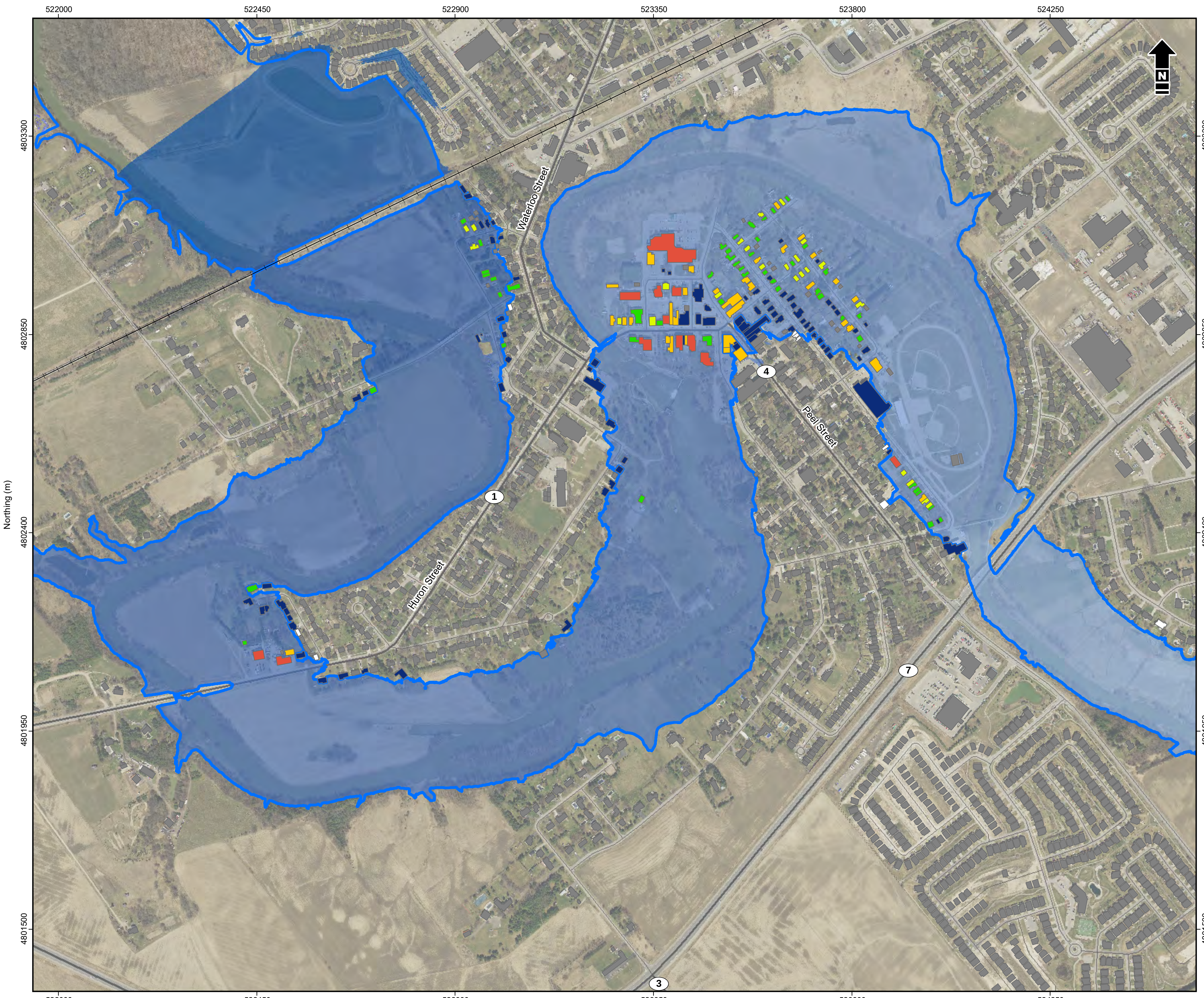
Option 5 - Flood Damages - 100 Year (500 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 24.8

Easting (m)



Draft Regional Inundation Boundary
Railway
Highway
Road
Building - Not Flooded
Building - Not in Study Area

Total_damage
- 0.0 - 100,000
- 100,000 - 150,000
- 150,000 - 200,000
- 200,000 - 500,000
- 500,000 +

Water Surface Elevation (masl)
High : 338.6
Low : 328.4

Note: Total damage estimate includes direct and indirect damages, and do not include damages to public infrastructure (roads, bridges, etc.)

1:9,000 metres
100 0 100 200
NAD 1983 UTM Zone 17N

Vertical Datum: CGVD2013

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Option 5 - Flood Damages - Regional (1,011 m^3/s)

Date:	Project:	Submitter:	Reviewer:
March 2020	29006	S. Blue	K. Hofbauer

Figure 24.9