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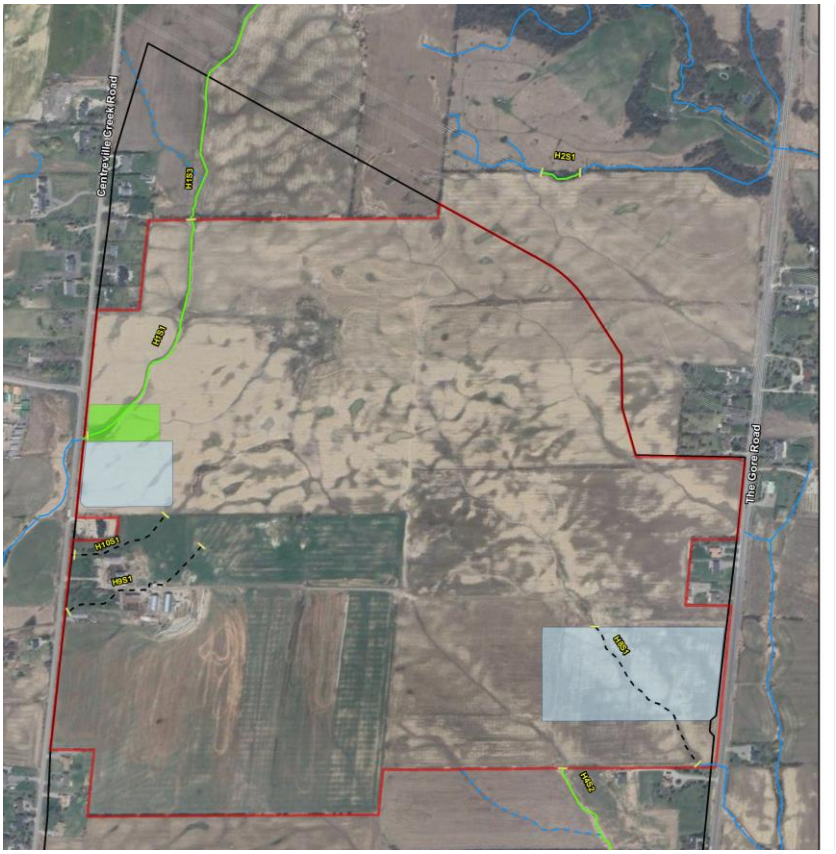
APPENDIX F

EROSION ASSESSMENT

Tributaries of West Humber River Erosion Mitigation and Erosion Hazard Assessment

Wildfield Village Development

Caledon, Ontario



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Submitted:
August 28, 2025

GEO Morphix Project No. 24105

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0.1	Draft circulation to client and project team	Karine Smith, MSc; Jan Franssen, PhD	P. Villard, PhD, P.Geo., CAN-CISEC, EP, CERP	January 24, 2025
1.0	Finalized report submitted to Client and project team	Karine Smith, MSc; Jan Franssen, PhD	P. Villard, PhD, P.Geo., CAN-CISEC, EP, CERP	January 29, 2025
2.0	Amended report – Second Submission	Karine Smith, MSc; Jan Franssen, PhD	P. Villard, PhD, P.Geo., CAN-CISEC, EP, CERP	August 27, 2025

Disclaimer

This report presents professional opinions and findings of a scientific and technical nature based on the knowledge and information available at the time of preparation. This document is prepared solely for the Client, and the data, interpretations, suggestions, recommendations, and opinions expressed in the report pertain only to the project being completed for the Client.

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1 Introduction

GEO Morphix Ltd. was retained by Global Properties Inc. to provide fluvial geomorphology services in support of the stormwater management (SWM) plan associated with the proposed development at Centreville Creek Road in Caledon, Ontario. The lands are within the Wildfield Village Secondary Plan Area situated in the West Humber River Subwatershed. Several tributaries to the West Humber River originate within or transect the western and eastern portions of the subject lands. The subject lands span approximately 358 ha, of which approximately a third drains to the western branch of the West Humber River, and approximately two-thirds drain to the eastern branch of the West Humber River. The confluence between the two branches is located approximately 2.8 km south of the proposed development block, with a combined drainage area of 4,527 ha.

The Wildfield Village Secondary Plan Area is bounded by The Gore Road to the east, Mayfield Road to the south, Centreville Creek Road to the west, and agricultural fields to the north. Highway 413 is proposed to border the northern extent of the Secondary Plan Area following development. As part of the first development phase, only the northern portion of the Secondary Plan Area, hereon referred to as the 'subject lands', will be developed.

The subject lands span approximately 138 ha, comprising approximately 35% of the Wildfield Village Secondary Plan Area. A map of the subject lands showing the development blocks proceeding in the first phase of development is provided in **Appendix A**, for reference. Current land use is predominantly agricultural, with several rural residential homes located along the bordering roads. Under existing conditions, several headwater drainage features and small tributaries originate within the eastern portion across the Secondary Plan Area and drain to the east branch of the West Humber River, which flows south parallel with the development boundaries. Three tributaries drain the western portion of the proposed development, one originating north of the subject lands and transecting the northwest corner, and the other two tributaries originating south of the subject lands. All three of the western tributaries join the western branch of the West Humber River, which flows southeast parallel with Centreville Creek Road.

The proposed development will include a combination of residential developments and urban core areas. The north portion of the subject lands will be serviced by two stormwater management (SWM) ponds; one of which will outlet to a tributary to the western branch of the West Humber River, and one which will outlet to a headwater drainage feature to the eastern branch of the West Humber River. Under post-development conditions, the western headwater drainage feature is proposed for relocation and enhancement to accommodate the proposed SWM strategy.

The primary objective of the current study is to provide a geomorphological assessment of the proposed stormwater management plan, and to ensure the stormwater management strategy is consistent with the requirements outlined in the Stormwater Management Guidelines (TRCA, 2012). The two main components include an erosion mitigation and an erosion hazard assessment in support of the proposed SWM plan. The following activities were completed as part of the erosion mitigation assessment:

- Review historical aerial photographs and LiDAR data to ascertain alterations in the receiving watercourses and surrounding land usage
- Conduct field reconnaissance (where permitted) using standard, industry-accepted tools such as the rapid geomorphic assessment (RGA) and rapid stream assessment technique (RSAT) to evaluate existing instream and riparian conditions (i.e., evidence of ongoing channel processes, active erosion/deposition, or potential channel instability) and note any erosion-sensitive areas
- Delineate erosion hazard and confirm the 100-year erosion limit, where necessary
- Calculate erosion threshold(s) for the identified field site(s) to define the magnitude of flow required to potentially entrain and transport bed and/or bank materials in the associated watercourse
- Review detailed geomorphic field assessment data to support the determination of an erosion threshold, or flow target, to help inform the SWM plan for the site
- Conduct erosion exceedance analysis using GEO Morphix developed models applied to data from continuous hydrological simulation models of pre- and post-development conditions

- Evaluate pre- to post-development changes in geomorphic metrics used to assess erosion potential in the receiving watercourse (e.g., time of exceedance, cumulative effective discharge, and cumulative excess work index)

The purpose of this study is to conduct an erosion exceedance analysis to ensure the proposed stormwater management plan adequately addresses erosion concerns along the receiving watercourses.

2 Background Review

2.1 Humber River Characterization Report – TRCA

A review of site plans and pertinent watershed reports published by TRCA was completed to inform and provide context regarding local hydrology and stream morphology. Watercourses, HDFs, and wetlands were assessed through the watershed characterization process. The watercourses were determined as perennial, intermittent, or unknown. The HDFs were assessed to be either intermittent (12%) or unknown (88%); however, overall management classifications were not determined.

A classification of erosion sensitivity within the Humber River Watershed was conducted in 2023 as part of the Humber River Watershed Characterization Report (TRCA, 2023). The receiving watercourses downstream from the proposed development were included within the characterization report. The erosion sensitivity classification was completed based on erosion thresholds, results from rapid geomorphic assessments, specific stream power ratios, and cross-sectional changes as measured using erosion pins (TRCA, 2023). It should be noted that the tributaries within the subject lands were omitted from this assessment due to their relatively minor drainage area.

2.2 Local Subwatershed Study, Phase 2 – Impact Study

The Wildfield Village LSWS was prepared by SCS Consulting Group Ltd. (SCS) and GEI Consultants Inc. (SCS and GEI, 2024). The LSWS included fluvial geomorphological characterization of drainage features within the subject lands to support future land use planning. The geomorphological work included stream reach delineation, rapid geomorphological field assessments, headwater drainage feature assessments, erosion threshold analysis, and proposed management strategies for natural heritage features and headwater drainage features.

Reaches within the subject lands were previously delineated at a high level as part of the Scoped Subwatershed Study prepared by Wood (2022) via a desktop review and windshield survey. However, the reach delineation was further refined specifically for headwater drainage features in the LSWS prepared by SCS and GEI for the subject lands. Reach delineation from the LSWS is graphically presented in **Appendix A**, for reference.

Several detailed assessments were completed by GEI (2024) for the purpose of an erosion threshold assessment including Reaches **WHT3(7)1-1, WHT2(1)1-1c, WHT2(1)1-1b, WHT2(1)1-1a, WHT2(1)2-1,** and **WHT2(1)1-1.** The erosion threshold results are summarized below in **Table 2** in **Section 3.0.**

Multiple headwater drainage features were identified through the subject lands including Reaches **H1S1**, **H1S3**, **H10S1**, **H9S1**, and **H8S1**. Reaches **H1S1**, **H1S3**, **H10S1**, and **H9S1** generally flow in a southerly direction and cross Centreville Creek Road along the western boundary of the subject lands. Reach **H8S1** generally flows in a west-to-east direction off-site before ultimately discharging to the West Humber River, east of The Gore Road. The reaches were identified as HDFs that pass through active agricultural fields. The extent of the reaches is provided in a map under **Appendix A**.

Reaches **H10S1**, **H9S1**, and **H8S1** were assigned an HDF management classification of *no management* under the LSWS. The HDF management classification of *no management* indicates that the HDFs may be removed from the landscape without any requirement to replicate existing feature form or function.

Reach **H1S1** and **H1S3** were recommended to have a final management classification of *mitigation*, which allows for the removal of the features if the feature's function is replicated through future stormwater management including approaches such as lot-level conveyance measures and/or LID

stormwater options. As such, all HDFs lengths in the subject lands are proposed for removal in the post-development scenario.

2.3 Physiography and Geology

Channel morphodynamics are largely governed by the flow regime, availability, and type of sediments (i.e., surficial geology) within the stream corridor. These factors are explored as they offer insight into existing conditions and potential changes that could be expected in the future as they relate to a proposed activity. Understanding local surficial geology is important for determining the stability of the channel banks and valley slope is dependent, at least in part, on the composition of soils and underlying parent materials (MNR, 2002).

The northern portion of the subject lands is located within the South Slope physiographic region, characterized by gently-sloping shallow shale, till plains and low-relief drumlins and moraines (Chapman and Putnam, 1984). The southern portion of the subject lands is situated within the Peel Plain physiographic region, characterized by gently rolling slopes consisting of clayey soils. Both physiographic regions gradually slope to the southeast towards Lake Ontario. The physiographic landforms present consist of bevelled till plains within the South Slope region, and drumlinized till plains within the Peel Plain region (Chapman and Putnam, 2007). Published mapping indicates that the local surficial deposits are composed of clay to silt-textured till along the northern portion of the subject lands, with the main tributaries to the West Humber River off-site flowing through modern alluvial deposits and glaciolacustrine deposits along the southern portion (OGS, 2010).

2.4 Stormwater Management Plan Details

Existing and future catchment areas and drainage plans provided by DSEL (2025) were reviewed to inform the erosion exceedance analysis. As detailed above, under existing conditions a portion of the subject lands drains west toward Centreville Creek Road and a portion of the subject lands drains east toward Gore Road. Reach **H1S1** drains the northwestern portion of the subject lands, approximately 19.01 ha. An additional 20.85 ha within the western subject lands is drained by drainage features located south of **H1S1**. Ultimately, the western headwater drainage features convey flow to the western branch of the West Humber River, which flows in a generally southeastern direction parallel to Centreville Creek Road before joining the main (eastern) branch of the West Humber River south of the subject lands. The eastern portion of the subject lands conveys approximately 98.41 ha of runoff to six separate eastern headwater drainage features. The eastern drainage features ultimately convey flow to the main (eastern) branch of the West Humber River.

Under proposed conditions, the northern portion of the proposed development will be serviced by two (2) SWM Ponds; one located along the eastern portion and one along the western portion. All SWM Ponds are proposed to discharge directly to the headwater drainage features draining the subject lands, with runoff from the development ultimately conveyed to the West Humber River. This includes one northwestern SWM Pond draining to Reach **WHT3(7)1-1** (Node A), and one eastern SWM Pond draining to **WHT2(1)1-1**b (Node F), ultimately discharging to the confluence with the East Branch of the West Humber River immediately downstream from Reach **WHT2(1)1-1** (Node H). The total drainage area to the eastern and western branches of the West Humber River will remain unchanged.

A review of drainage areas for the major branches of the West Humber River and the headwater drainage features draining the subject lands was completed using site plans and the Ontario Watershed Information Tool (OWIT). Drainage node locations are shown in **Appendix A**, and results are presented below in **Table 1**. Agency guidance suggests assessing the development impact on the receiving watercourse to a point downstream where the developed property occupies 10% of the total drainage area (CVC, 2012). This recommendation is based on the understanding that there is an attenuation of potential impacts in the downstream direction and that a drainage area equal to 10 times the development area of the site is considered sufficient to evaluate potential impacts on the receiving water course. Thus, erosion threshold and exceedance analyses were considered for reaches where the fraction of the drainage areas from the subject lands were more than 10%. Drainage ratios for the West Humber River indicate that impacts to erosion potential within the highly sensitive downstream reach GHU 14 are not expected, as the subject lands consist of less than 10% of the total drainage area. Thus, erosion

threshold and exceedance analyses were focused along the receiving headwater drainage features located within the subject lands, and on the branches of the West Humber River which drain the east and west portions of the proposed development.

Table 1. Drainage area ratios

Drainage nodes		Contributions from subject lands (ha)	Drainage area (total) (ha)	Fraction of total drainage (%)
Western Portion	**A**	39.86	367.7	10.8%
	B		496.5	8.02%
	C		550.7	7.2%
	D		1056.9	3.8%
Eastern Portion	**E**	21.3	53.9	39.5%
	F	55.68	105.4	52.8%
	G	88.13	180.4	48.9%
	H	98.41	2914.1	3.4%
	I		3024.0	3.3%
	J		3086.8	3.2%
Downstream confluence	**K**	138.27	4527.4	3.1%

2.5 Historical Assessment

A series of historical aerial photographs and publicly available LiDAR data were reviewed to determine the changes to the channels and surrounding land use and land cover that have occurred over the period of record. This information partly provides an understanding of the historical factors contributing to current channel morphodynamics. Various aerial photographs and satellite images from 1946 to 2024 were retrieved to complete the historical assessment and inform the erosion hazard delineation. Specifically, aerial photographs for the years 1946 (1:20,000), 1969 (1:25,000), 1976 (1:50,000), and 1980 (1:50,000) were retrieved from the National Air Photo Library; 1954 (~1:60,000) was retrieved from University of Toronto Map and Data Library (Hunting Survey Corporation Limited); 1999 (1:20,000) was retrieved from The Ministry of Natural Resources and Forestry; 1982 (1:30,000) was retrieved from Kenting Earth Sciences Limited, and 2004, 2016, 2017, and 2024 were retrieved from Google Earth Pro. All historical aerial photographs are provided in **Appendix B** for reference.

In 1946, land use was predominantly agricultural and rural within and upstream of the subject lands. There were a few residential dwellings located adjacent to southeast features, and within the subject land, manicured grasses, and limited natural riparian vegetation. The channel planform of most headwater drainage features appeared to be previously straightened for agricultural purposes and the reaches were not clearly discernible from the aerial photograph due to poor aerial image quality; however, some vegetation presence was observed towards the reaches in the southern portion of the site.

In 1954, the subject lands and the surrounding area were actively cultivated. The minor drainage features within the subject lands were visible, draining agricultural fields southwest to the western branch of the West Humber River, and southeast to the northern branch of the West Humber River. The

riparian zone along both branches of the West Humber River appeared to be relatively narrow and fragmented, and the subject lands and surrounding areas appeared to have been cleared to facilitate agriculture.

Between 1954 and 1969, land use on the subject property remained predominantly agricultural with some fragmented forests present throughout the subject property and some rural residential areas that consisted of residential dwellings, manicured grasses, and some immature trees. The drainage features through the northern portion of the property flowed north-east to south-west, and north-west to south-east exhibiting a relatively straightened channel planform. Other drainage features visible at the southern portion of the site flowed north-east to south-west, and north-west to south-east with a channel planform of moderately straightened with limited sinuosity.

Between 1969 and 2024, little change to the channel planform or surrounding land use was observed when aerial imagery was compared. Surrounding lands remained actively cultivated, and residential dwellings in the area remained sparse. Woody vegetation along the riparian buffer was scarce, composed primarily of grasses. Within the subject lands towards the east and southeast, the features had a low sinuosity planform with few meanders. Continued residential development upstream and downstream of the subject lands was observed, especially closer to the main road; Mayfield Road (south), The Gore Road (east), and Centreville Creek Road (west); however, agriculture remained the primary land use.

In summary, between 1946 and 2024, there were no major changes in land use or land cover within and immediately surrounding the subject property. The channel planforms associated with all reaches were unchanged with more established riparian vegetation surrounding the features over time. The limited channel adjustments over time, as well as the increase in riparian vegetation surrounding some of the reaches, indicate that the features are generally stable.

A review of publicly available 2014 LiDAR data was also conducted using hillside imagery derived at 0.5 m resolution. The subject lands appear relatively flat near Mayfield Road, with some topographic relief occurring to the north close to Healey Road. The features located within the south-southeast to north-northwest portions of the site are moderately incised 1-3 m into the valley. The HDFs originating within the subject property appear to be poorly defined unconfined or partially confined drainage features, while the main branches of the West Humber River appear to be confined and well-defined. The feature running parallel to the eastern portion of the site and draining the eastern subject lands also appears to be confined, flowing through a relatively steep valley. An analysis of 2024 aerial imagery indicates little to no significant changes in channel planform, relative to the 2014 LiDAR-derived DEM, along the watercourses originating within the subject lands. **Appendix A** demonstrates the extent of the subject property and drainage features on-site.

3 Erosion Hazard Assessment

Most watercourses in Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. This assessment is, therefore useful for determining the potential erosion hazard to proposed activities adjacent to a given watercourse. Unconfined and confined valley systems are assessed differently when defining the meander belt width or erosion hazard for a creek system. Unconfined systems are those with poorly defined valleys or slopes well outside where the channel could realistically migrate. Unconfined systems are generally found within glaciated plains with flat or gently rolling topography. In contrast, confined systems are those where the watercourse is contained within a defined valley, where contact between the watercourse and a valley wall is possible. The erosion hazard for confined systems is based on a valley toe erosion allowance and a stable slope allowance.

Erosion hazard delineations are required for watercourses in which erosion is likely to occur and may present a risk to proposed infrastructure. Headwater drainage features are typically excluded from this analysis as they present little to no erosion risk to surrounding infrastructure. Post-development, the headwater drainage features present within the subject lands (**H10S1**, **H9S1** and **H8S1**) will be removed to accommodate the development and associated stormwater management ponds. Additionally, the northwestern tributary transecting the western portion of the subject lands (**H1S1**) will

be rerouted underground, with an outlet to the proposed relocated wetland. Thus, under the proposed conditions, no watercourse will be present within the subject lands. As such, an erosion hazard delineation is not required for the proposed development.

4 Erosion Threshold Assessment

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material (Garcia, 2008; Villard and Parish, 2003). As such, they are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans. Site access to the receiving reaches was limited within and outside of the subject lands, preventing field reconnaissance and detailed assessment along most receiving reaches. A detailed assessment was conducted by GEI (2024) along reach **WHT3(7)1-1** to inform erosion thresholds along the northwestern portion of the subject lands, while the erosion thresholds along the northeastern portion of the subject lands were informed by a combination of visual observations from roadways and LiDAR data (GEI, 2024). An erosion threshold for the northeastern feature, **WHT2(1)1-1c**, could not be determined from the LiDAR data as the morphology of the channel feature was too subtle to be accurately defined on the high-resolution LiDAR-derived digital elevation model. Thus, a critical discharge was determined for Reach **WHT2(1)1-1c** using a unitary approach based on the erosion threshold determined for the adjacent tributary, **WHT3(7)1-1**; further details provided below.

The erosion threshold is the theoretical point, typically expressed as a critical discharge, velocity or shear stress, at which entrainment of sediment is expected to occur based on the morphology of the channel and characteristics of the bed and bank materials. The lower of the bed and bank erosion thresholds is adopted, as it provides a more conservative and limiting estimate of erosion potential. Results from the LiDAR assessment and erosion threshold analysis conducted by GEI (2024) are summarized below in **Table 2.** Erosion threshold locations are shown in Figure 3, **Appendix A**, for reference.

Table 2. Channel parameters and erosion threshold results

Channel Parameter	WHT3(7) 1-1	WHT2(1) 1-1c[1]	WHT2(1) 1-1b[2]	WHT2(1) 1-1a[2]	WHT2(1) 2-1[2]	WHT2(1) 1-1[2]
Drainage area (ha)	108.84	26.97	33.36	5.88	48.53	182.3
Bankfull width (m)	4.0*	N/A	2.45	2.73	3.81	4.2
Bankfull depth (m)	0.34*	N/A	0.27	0.12	0.55	0.72
Gradient (%)	0.6*	1.11	0.94*	2.8*	3.5*	2.0*
Bed materials	Silt loam*	Silt loam	Firm loam*	Firm loam*	Firm loam*	Firm loam*
Manning's n	0.040*	0.040	0.040*	0.040*	0.040*	0.040*
Bankfull discharge (m^3/s)	0.528*	N/A	N/A	N/A	N/A	N/A
Bankfull velocity (m/s)	0.667*	N/A	N/A	N/A	N/A	N/A

Erosion Thresholds (GEI, 2024)						
Criteria (m/s)	0.61 (Julien, 1998)	N/A	0.76 (Julien, 1998)	0.76 (Julien, 1998)	0.76 (Julien, 1998)	0.76 (Julien, 1998)
Critical discharge (m^3/s)	0.363	0.089[1]	0.396	0.188	0.088	0.858
Unitary thresholds ($m^3/s/ha$)	0.0033	0.0033[1]	0.0118	0.0320	0.0018	0.0047

[1]Calculated based on the unitary threshold determined for **WHT3(7)1-1**
[2]Calculated using LiDAR data
*Channel parameters provided by GEI (2024)

Bed and bank materials within reach **WHT3(7)1-1** were composed of silt loam, as determined based on samples collected during the detailed geomorphological assessment (GEI, 2024). Using the criteria for silt loam developed by Julien (1998), a critical velocity of 0.61 m/s was determined for the reach, yielding a critical discharge estimate of 0.363 m^3/s.

WHT2(1)1-1c was classified as an agricultural drainage feature with poorly-defined bed and banks, preventing a LiDAR-derived erosion threshold (GEI, 2024). Based on surficial geology mapping, the feature flows through clay- to silt-textured till, indicating bed and bank materials are likely consistent with the silt loam identified in the field along **WHT3(7)1-1**. While the drainage area for Reach **WHT2(1)1-1c** is more consistent with the **WHT2(1)1-1b** catchment, substrate within the reach is likely less cohesive, suggesting increased sensitivity to erosion. Thus, to remain consistent, the unitary threshold of 0.0033 $m^3/s/ha$ derived from the field assessment of **WHT3(7)1-1** was used to calculate an erosion threshold of 0.089 m^3/s for **WHT2(1)1-1c**.

The remaining reaches along the eastern portion of the subject lands were not accessible for field assessments, and LiDAR data was used to calculate an erosion threshold (GEI, 2024). Gradients ranging from 0.94% to 3.5% were determined using slope analysis methods applied to the high-resolution LiDAR-derived digital elevation models. Based on surficial geology mapping and observations from a public roadway, bed and bank materials were determined to be more compact and cohesive fine sediment along the eastern tributaries (GEI, 2024). Therefore, the dominant material for the eastern reaches was determined as firm loam, with an associated critical velocity of 0.76 m/s. The critical velocity for firm loam resulted in erosion thresholds ranging from 0.088 m^3/s to 0.858 m^3/s along the eastern receiving reaches.

5 Pre- to Post-Development Erosion Exceedance Analysis

In support of the proposed Stormwater Management (SWM) plan, an erosion exceedance analysis was completed for the receiving watercourse (CVC, 2015; TRCA, 2012). The application of erosion threshold analysis for evaluating the effectiveness of stormwater management facilities in mitigating changes in downstream erosion potential is a concept developed with support by a co-author of the present report (Dr. Paul Villard) and detailed in guidelines prepared by Dr. Villard on behalf of the Credit Valley Conservation Authority and Toronto and Region Conservation Authority and in Villard and Parish (2003).

Our understanding is that runoff from the proposed development will be directed to one SWM Pond along the western portion, and one SWM Pond along the eastern portion. The SWM Pond servicing the western portion will discharge to **WHT3(7)1-1**, and the eastern SWM Pond will outlet to **WHT2(1)1-1b**, ultimately discharging to **WHT2(1)1-1**. To assess potential changes in downstream erosion processes, an erosion exceedance analysis was completed using the thresholds determined for **WHT3(7)1-1** for the western node, and the thresholds determined for **WHT2(1)1-1** for the eastern node.

Using the erosion threshold analysis results and hydrological simulation modelling provided by DSEL (2025) for pre- and post-development conditions, an erosion exceedance analysis was completed with our in-house Erosion Exceedance Model. The most relevant erosion exceedances indices calculated by the model are summarized below:

1) Cumulative time of exceedance
2) Number of exceedance events
3) Cumulative effective discharge
4) Cumulative effective work index (i.e. cumulative effective stream power)

These indices have been applied in numerous jurisdictions, such as Conservation Halton and Toronto and Region Conservation Authority and have been widely accepted by Ontario Conservation Authorities for assessing changes in post-development erosion potential along receiving watercourses. They provide an evaluation of the number, duration, and magnitude of exceedance events (CVC, 2015). We note that the most relevant indicator is the cumulative effective work index, which reflects the duration and magnitude of erosion exceedance events (TRCA, 2012).

Time of exceedance, number of exceedances, and cumulative effective discharge and work can be calculated from the discharge record and a critical discharge value for sediment entrainment (i.e., erosion threshold). The cumulative time of exceedance is simply the summed duration of time where discharge exceeds the established erosion threshold, and the number of exceedances is the count of erosion exceedance events throughout the discharge record. The cumulative effective work represents the average magnitude of discharge exceeding the erosion threshold during a given erosion event. In contrast, the cumulative effective discharge represents the total discharge that exceeds the erosion threshold throughout the entire modelled discharge record. Specific details about how each of these key erosion metrics are calculated is provided in the following subsection.

For more relevant indicators, namely the cumulative effective work index, variables related to channel hydraulic conditions are required. Our model applies the discharge to a characteristic cross-section. Using Manning's approach, the discharge at each time step in the continuous hydrological model is converted into a velocity, depth of flow, shear stress, and/or stream power. These parameters are calculated based on field measurements of slope, cross-section, and channel roughness. This provides analysis appropriate to the specific site conditions.

Continuous flow simulation data for the eastern and western SWM Ponds was provided by DSEL (2025) in 15-minute increments for a 20-year simulation period (i.e., 1987 to 2007). The hydrological simulation data for pre- and post-development conditions was analyzed to calculate the aforementioned erosion indices. The pre- and post-development hydrographs, overlain with the respective erosion threshold and bankfull discharge values, are provided in **Appendix C**, for reference.

5.1 Methods

To calculate erosion indices, both velocity and shear stress were calculated at each time step. Water depth and velocity were calculated for each discharge passing through a representative cross-section through an iterative process. The cross-section is divided into floodplain and bankfull sections. The cross-section is further broken into panels. Velocity, U, is calculated for each panel using the Manning's approach. This is a conservative approach as it allows dissipation of flood energy in the floodplain.

The total discharge, Q_T at each time step is based on the summation of the discharge of all panels, Q_i, such that:

$$Q_{T=} \sum Q_i \quad \text{[Eq. 1]}$$

Q_i is discharge through a panel (which is set at 10 percent of the cross-section). Q_i is defined as:

$$Q_i = U_i w_i d_i \quad \text{[Eq. 2]}$$

where, w_i and d_i are width and depth of each panel. The discharge for each panel was then summed to give a total discharge. This is more accurate than using average cross-sectional dimensions of a simple trapezoidal channel, as the bed is usually irregular, and a panel approach more accurately represents the true cross-sectional area.

For each event, the discharge is converted into a maximum depth and average velocity. The maximum depth is used to calculate a maximum bed shear stress, $\tau_{o_{\max}}$ based on:

$$\tau_{o_{\max}} = d_{\max}\rho g S_{\text{bed}} \quad \text{[Eq. 3]}$$

where, $d_{\max}$ is the maximum water depth, ρ is water density, g is acceleration due to gravity, and S_{bed} is the channel bed slope.

Cumulative total work, ω_{tot} is defined as:

$$\omega_{\text{tot}} = \sum \tau_{0_{\max}} . U_{\text{avg}} . \Delta t \quad \text{[Eq. 4]}$$

where, U_{avg} is average velocity (Q_{tot}/A_{tot}, where A_{tot} is wetted area), while cumulative effective work index (ω_{eff}) is defined by:

$$\omega_{\text{eff}} = \sum \tau - \tau_{cr} . U . \Delta t, \omega < 0 = 0 \quad \text{[Eq. 5]}$$

where, τ_{cr} is the critical shear stress.

Time of exceedance t_{ex} defined as:

$$t_{\text{ex}} = \sum \Delta t \quad \text{for } (Q_T > Q_{\text{threshold}}) \quad \text{[Eq. 6]}$$

where, $Q_{\text{threshold}}$ is the discharge at the erosion threshold.

The cumulative effective discharge volume (CEV) is defined as:

$$\text{CEV} = \sum Q \text{ (for } Q > Q_{threshold}) \quad \text{[Eq. 7]}$$

Similarly, the cumulative effective discharge (CED) is defined as:

$$\text{CED} = \text{CEV}/t_{ex} \quad \text{[Eq. 8]}$$

5.2 Results

Erosion exceedance modelling results indicate that the proposed stormwater management plan effectively mitigates the risk of increases in erosion potential within the receiving watercourses. The results indicate moderate reductions in erosion potential along Reaches **WHT3(7)1-1** (West) and **WHT2(1)1-1** (East). We note that the cumulative effective work index (ωeff; CEWI) is considered the most relevant index for erosion potential, reflecting the flow magnitude and exceedance duration of a given erosion event. Results over +/-5% are potentially significant enough to result in a measurable change in erosion potential within the receiving watercourse when the absolute change in the erosion metric is significant. The cumulative effective volume (CEV) indicator is of secondary relevance, representing the total discharge volume exceeding the established critical discharge throughout the modelling record. A representative selection of pre-development and post-development hydrographs is included in **Appendix C**. **Table 3** summarizes the results of the erosion exceedance model assessment based on the hydrological simulation data provided by DSEL (2025).

Table 3. Erosion exceedance analysis results for receiving reaches WHT2(1)1-1 and WHT3(7)1-1

Scenario		CEV (m^3)	ωeff (N/m^2)	t_{ex} (hours)	Number of exceedances (#)
WHT2(1)1-1 (East Flow Node)	Existing	322,457	1,671	177	69
	Proposed	239,616	1,254	141	33
	Change (%)	**-25.69**	**-24.94**	**-20.31**	**-52.17**
WHT3(7)1-1 (West Flow Node)	Existing	170,313	479	207	75
	Proposed	134,356	379	149	40
	Change (%)	**-21.11**	**-20.83**	**-27.93**	**-46.67**

A post-development reduction in erosion potential along the lower eastern reach, **WHT2(1)1-1,** is expected, as demonstrated by a 26% and 25% decrease in CED and CEWI, respectively. The duration and number of exceedances are predicted to decrease by 20% and 52%, respectively. The decrease in all four erosion indices is associated with a post-development reduction in peak flow. However, the post-development average annual peak flow remains above the critical discharge, at 1.51 m^3/s. Thus, sediment-mobilizing events are still expected to occur under proposed conditions. Based on the post-development peak flow values, the moderate reduction in erosion potential is not expected to significantly impact channel morphology.

Moderate reductions in erosion potential are also expected along the western reach, **WHT3(7)1-1**, as demonstrated by a 21% decrease in CED and CEWI. A 28% reduction in duration of exceedance events and a 47% decrease in the number of exceedances is predicted, reflecting post-development reductions in peak flow. However, the average annual post-development peak flow of 0.73 m^3/s is above the defined erosion threshold for the reach, sufficient for maintaining sediment-mobilizing events. Thus, the reduction in erosion potential associated with the proposed development is not expected to significantly impact the western reach.

A sensitivity analysis was also conducted for Reach **WHT2(1)1-1**, to ensure erosion exceedance results remain within an acceptable range under lower critical discharges. This analysis was only completed for **WHT2(1)1-1,** as the threshold was LiDAR-derived and yielded a relatively large critical discharge and associated unitary value. Conversely, the threshold for reach **WHT3(7)1-1** was derived from a combination of field observations and desktop methods, allowing for an increased degree of confidence in the defined critical discharge. The sensitivity analysis was completed using critical discharges at 50% (0.429 m^3/s) and 25% (0.215 m^3/s) of the defined erosion threshold. Results are presented in **Table 4**.

Results from the sensitivity analysis are consistent with those using the defined erosion threshold for the eastern reach. Moderate reductions in CED and CEWI are predicted at 50% of the critical discharge, and minimal reductions are expected at 25% of the critical discharge. The sensitivity analysis demonstrates that the SWM Plan appropriately mitigates erosion concerns along Reach **WHT2(1)1-1** at a range of discharges below the defined threshold. Thus, the proposed stormwater management strategy addresses potential increases in erosion potential for the western and eastern receiving reaches.

Table 4. Sensitivity analysis for Reach WHT2(1)1-1.

Scenario		CED (m^3/s)	ωeff (N/m)	t_{ex} (hours)	Number of exceedances (#)
50% of critical discharge					
WHT2(1)1-1 (East Lower Flow Node)	Existing	846,396	5,685	603	158
	Proposed	672,231	4,557	549	111
	Change (%)	**-20.58**	**-19.83**	**-9.08**	**-29.75**
25% of critical discharge					
WHT2(1)1-1 (East Lower Flow Node)	Existing	1,538,690	13,018	1,333	263
	Proposed	1,390,845	12,019	1,634	223
	Change (%)	**-9.61**	**-7.67**	**22.58**	**-15.21**

Results from the sensitivity analysis are consistent with those using the defined erosion threshold for the eastern reach. Moderate reductions in CED and CEWI are predicted at 50% of the critical discharge, and minimal reductions are expected at 25% of the critical discharge. The sensitivity analysis demonstrates that the SWM Plan appropriately mitigates erosion concerns along Reach **WHT2(1)1-1** at a range of discharges below the defined threshold. Thus, the proposed stormwater management strategy addresses potential increases in erosion potential for the western and eastern receiving reaches.

6 Summary

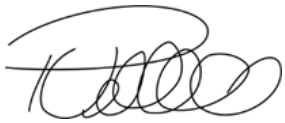
GEO Morphix Ltd. was retained by Global Properties Inc. to complete a fluvial geomorphological and erosion assessment of the tributaries to the West Humber River associated with the proposed Wildfield Villages development. The development block is located at Centreville Creek Road in Caledon, Ontario. The initial assessment phase is focused on the northern portion of the development block, spanning approximately 138 ha. The subject lands will be serviced by two stormwater management ponds, one discharging to the west feature, and one discharging to an eastern headwater drainage feature. Access to the receiving reaches within and outside of the property boundaries was limited, preventing field assessments. Therefore, a desktop assessment was completed, and LiDAR-derived erosion thresholds provided by GEI (2024) were used to inform the erosion assessment.

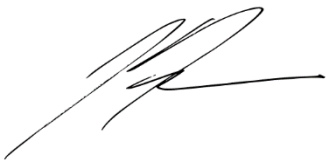
A LiDAR-derived erosion threshold was provided by GEI (2024) for reach **WHT2(1)1-1**, located along the lower east tributary and proposed to receive discharge from the eastern SWM Pond. A detailed assessment was completed by GEI (2024) along **WHT3(7)1-1**, allowing for a field-based erosion threshold for the western reach proposed to receive discharge from the west SWM Pond. The erosion thresholds defined for the receiving reaches were used to inform the subsequent erosion exceedance analysis. Erosion exceedance modelling was completed using continuous hydrological data spanning 20 years at 15-minute intervals from 1987-2007 provided by DSEL (2025) for all three reaches.

Results from the exceedance analysis demonstrated moderate reductions in erosion potential within **WHT3(7)1-1** and **WHT2(1)1-1**. However, post-development peak flows are predicted to be sufficient for sediment mobilization events within both reaches. A sensitivity analysis was also conducted at 50% and 25% of the critical discharge for the LiDAR-derived threshold at **WHT2(1)1-1.** This analysis was completed to increase confidence in exceedance results, as the reach was inaccessible in the field and exhibited a relatively large critical discharge. Results from the sensitivity analysis demonstrate that even under conservative erosion thresholds, post-development erosion potential is not increased within the receiving watercourse. Ultimately, the erosion assessment demonstrates that the stormwater management strategy adequately addresses erosion concerns along the western and eastern receiving reaches, and that the proposed development is not anticipated to negatively impact the tributaries to the West Humber River.

We trust this report meets your current requirements. Should you have any questions, please contact us.

Respectfully submitted,





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Director, Principal Geomorphologist

Jan Franssen, Ph.D.
Senior Watershed Scientist

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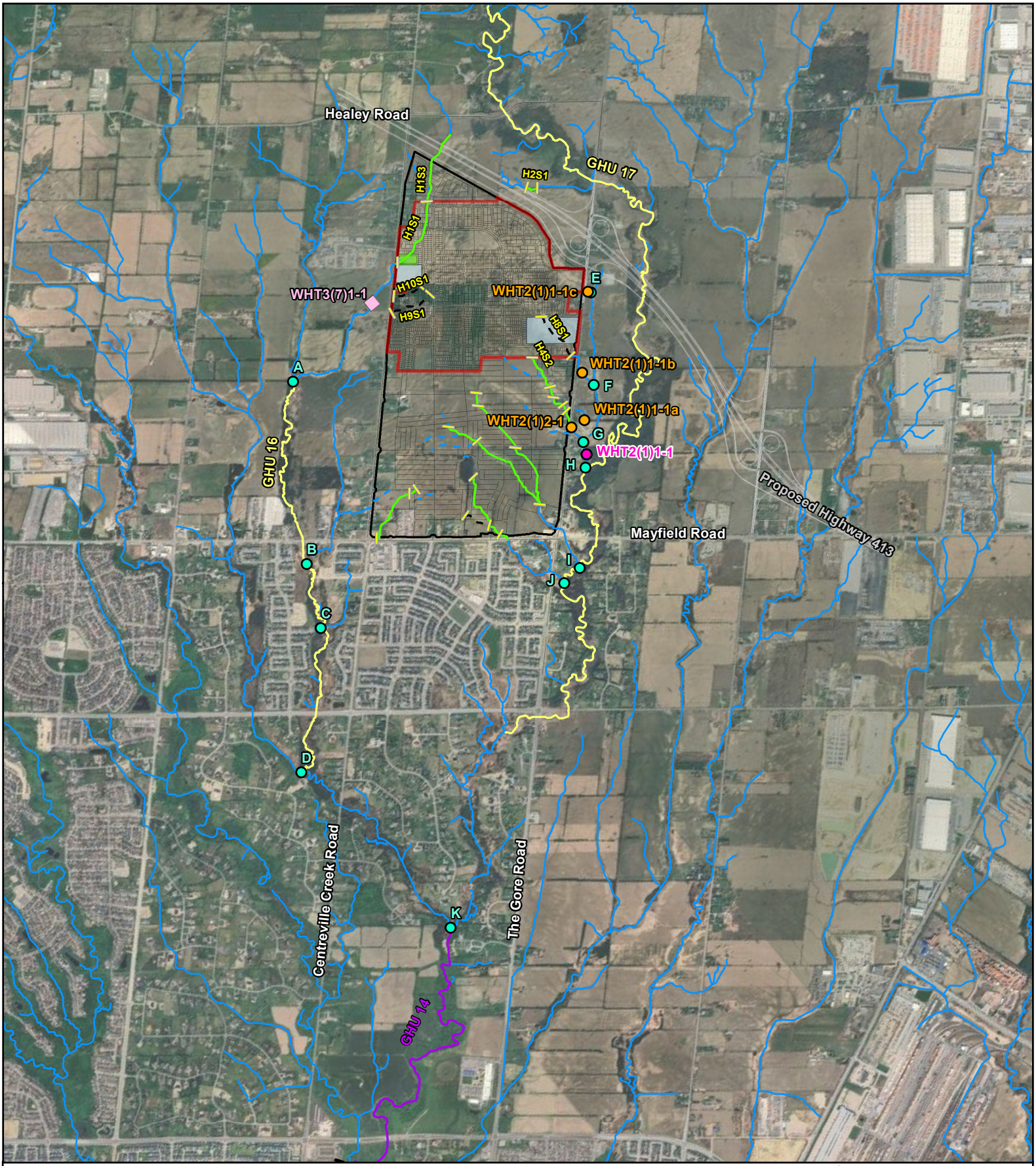
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Wood. 2022b. Scoped Subwatershed Study, Part B: Detailed Studies and Impact Assessment (Final Report). Prepared for the Regional Municipality of Peel.

Wood. 2022c. Scoped Subwatershed Study, Part C: Implementation Plan (Final Report). Prepared for the Regional Municipality of Peel.

Appendix A:
Study Area Mapping



Legend

- Reach Break and ID
- Watercourse
- Potential Drainage Feature
- Erosion Exceedance Modelling Node
- GEI LiDAR Threshold
- Drainage Area
- GEI Detailed Assessment and Threshold

HDF Management Recommendations

- Mitigation
- No Management Required

Erosion Sensitivity Classification (TRCA)

- High
- Moderate
- Phase 1 Boundary
- Future Highway
- Study Area
- Development Fabric
- Wetland Relocation and Compensation Area
- Proposed SWM Pond Location

Erosion Assessment
Proposed Conditions

West Humber River Tributaries

Caledon, Ontario

GEO MORPHIX™

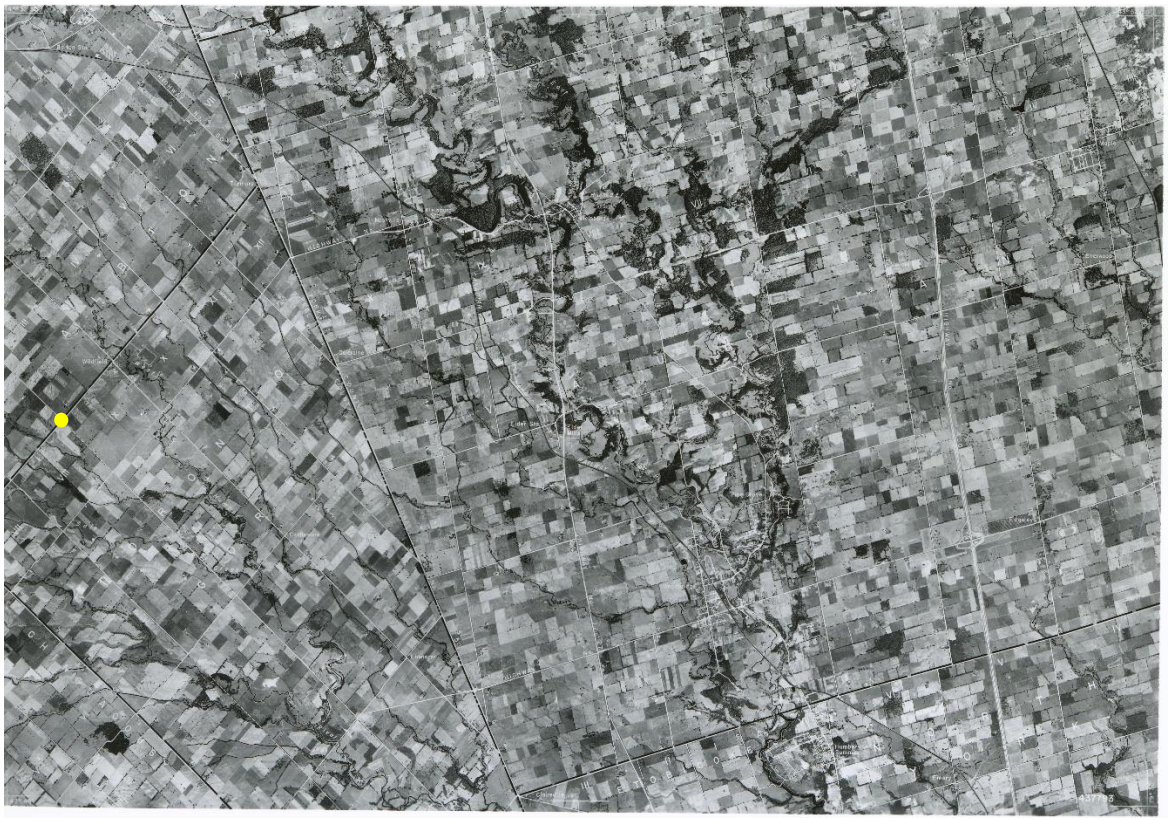
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Metres

Imagery: Google, 2024.
Watercourse, HDF, Potential, Detailed Assessment and Threshold, Lidar Thresholds, Drainage Area Nodes, GEI and GEO Morphix, 2024. Erosion Sensitivity Classification: GEO Morphix Ltd., 2024. Study Area, Proposed Highway 413, Proposed Dev. Fabric: DSEL, 2024.
Print Date: August 2025. PN24105. Drawn By: M.O., K.W.,K.Sm., G.U.

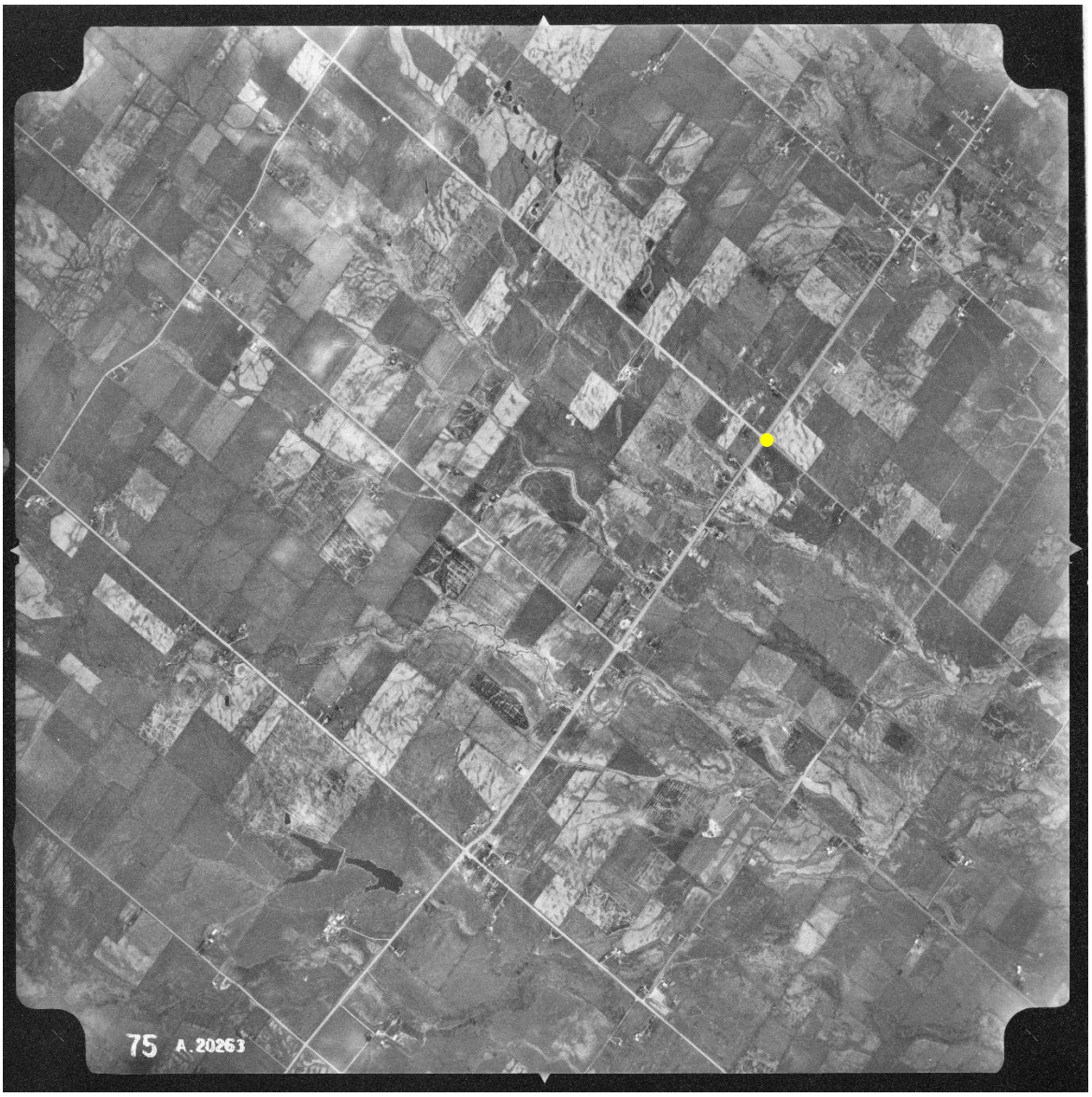
Appendix B:
Historical Aerial Imagery



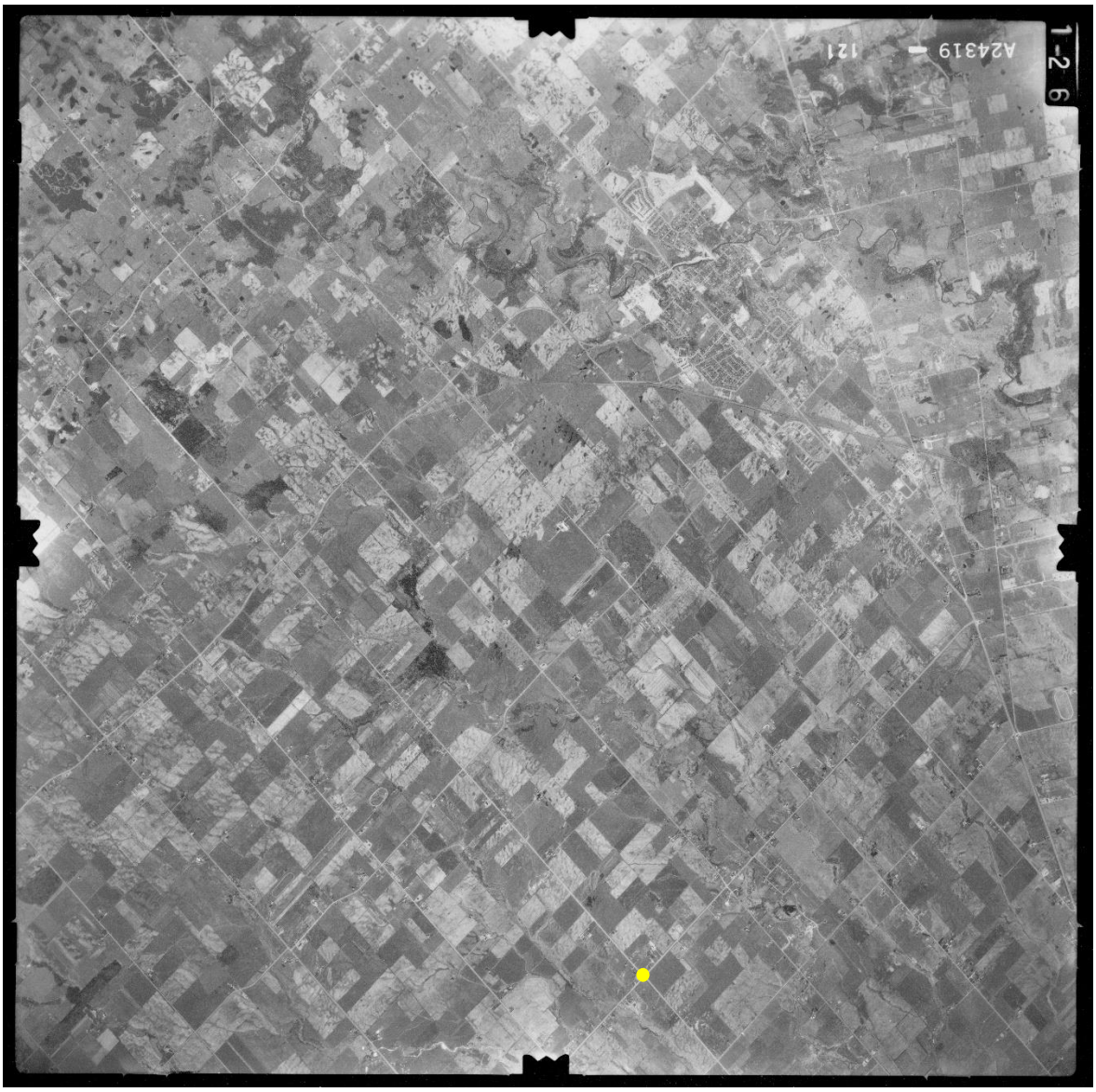
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Source: National Air Photo Library
Yellow Point: Intersection of The Centreville Creek Road and Mayfield Road



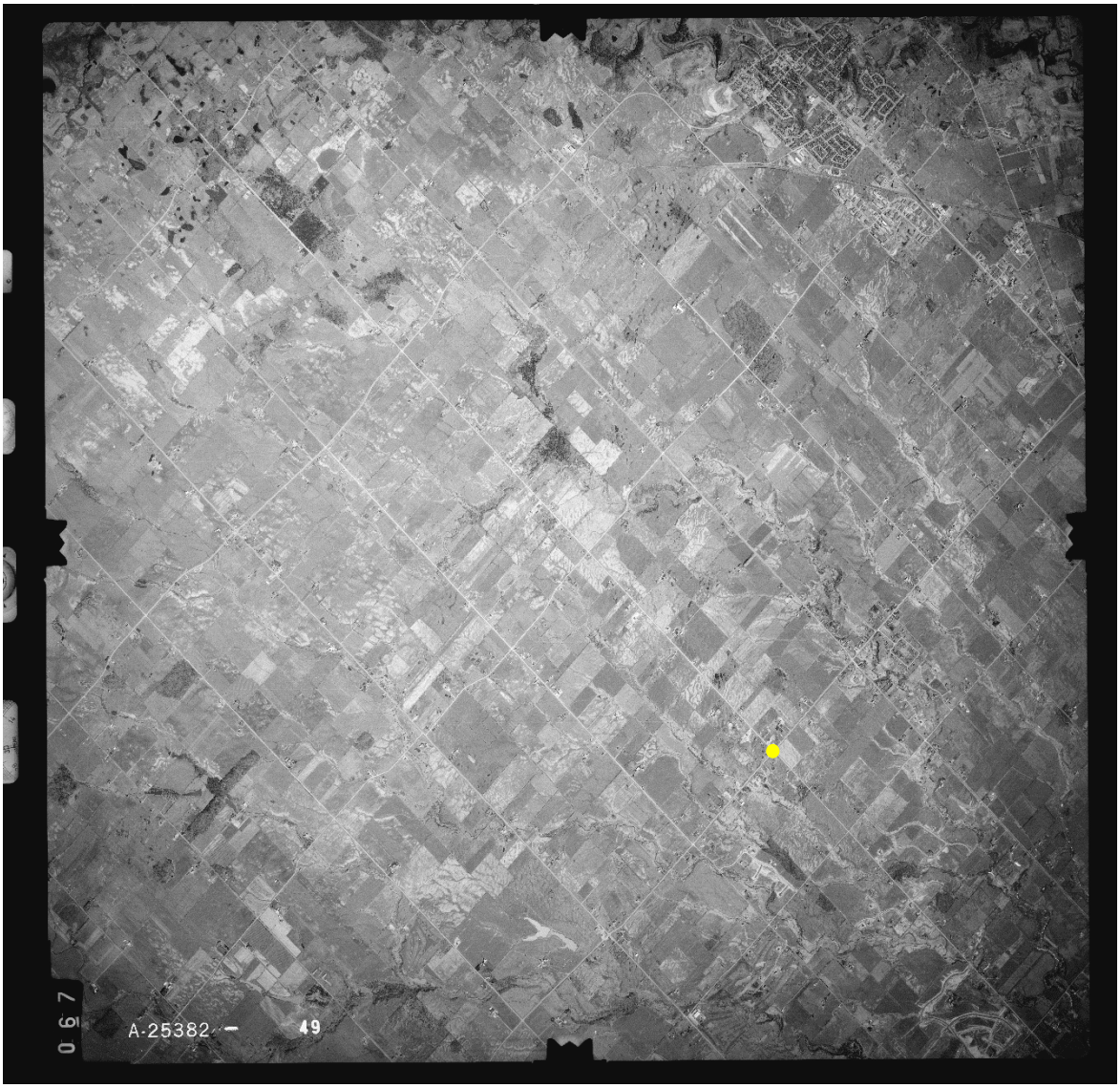
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Year: 1954
Scale: ~1:60,000
Source: University of Toronto
Yellow Point: Intersection of The Centreville Creek Road and Mayfield Road



Location: Caledon, ON
Year: 1969
Scale: 1:25,000
Source: National Air Photo Library
Yellow Point: Intersection of The Centreville Creek Road and Mayfield Road



Location: Caledon, ON
Year: 1976
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Source: National Air Photo Library
Yellow Point: Intersection of The Centreville Creek Road and Mayfield Road



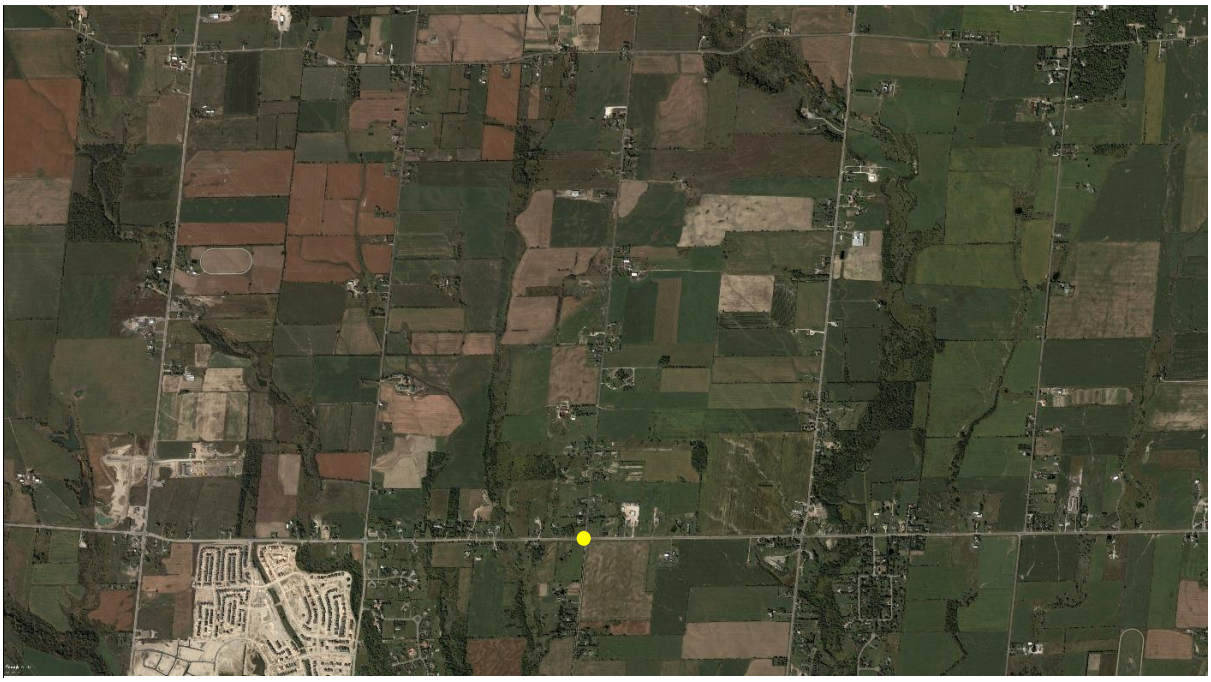
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Source: National Air Photo Library
Yellow Point: Intersection of The Centreville Creek Road and Mayfield Road



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Scale: 1:30,000
Source: Kenting Earth Sciences
Yellow Point: Intersection of The Centreville Creek Road and Mayfield Road



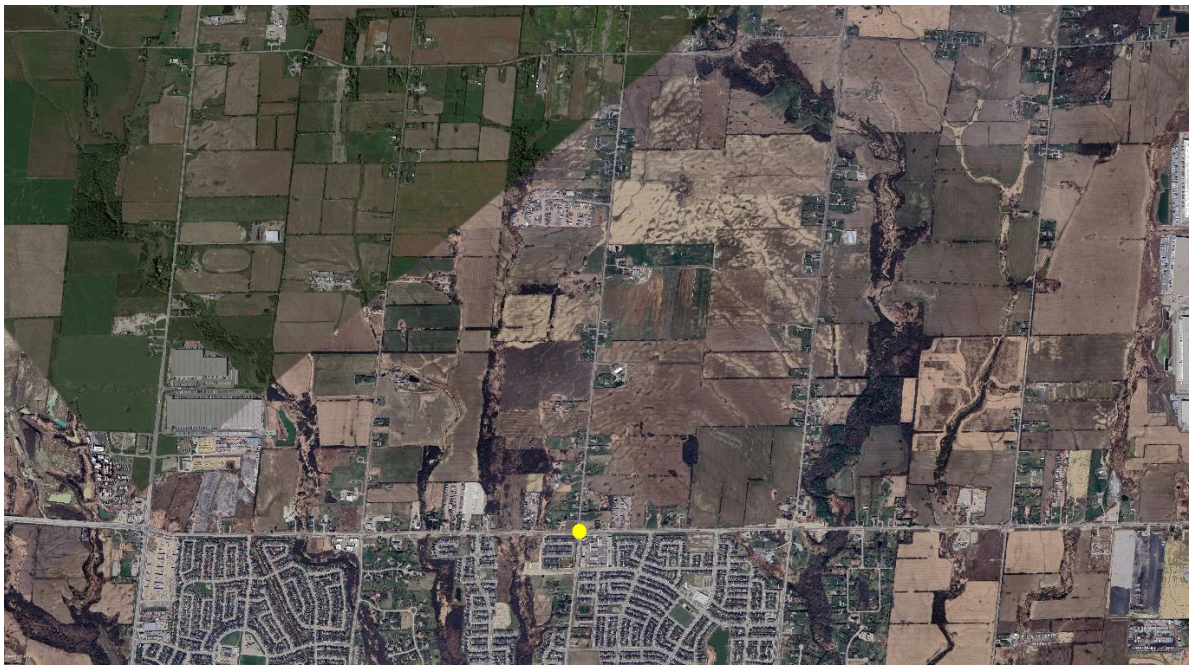
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Source: Ministry of Natural Resources
Yellow Point: Intersection of The Centreville Creek Road and Mayfield Road



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Year: 2004
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Source: Google Earth Pro
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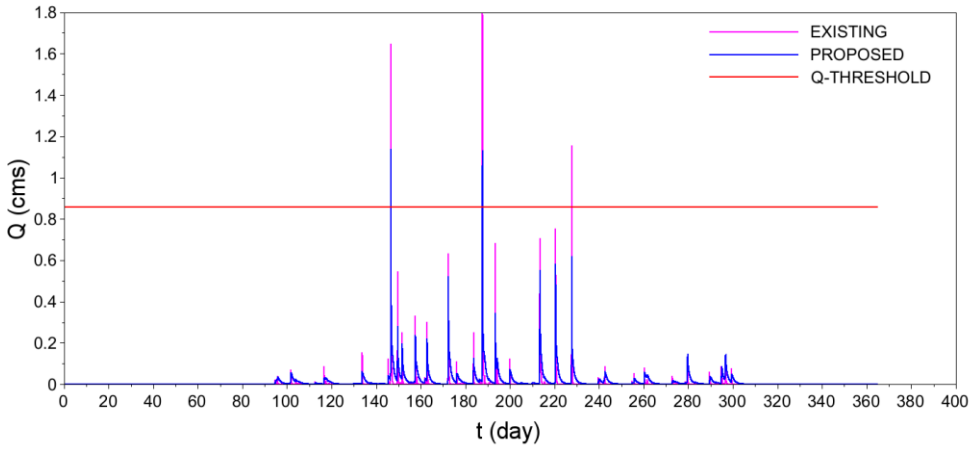
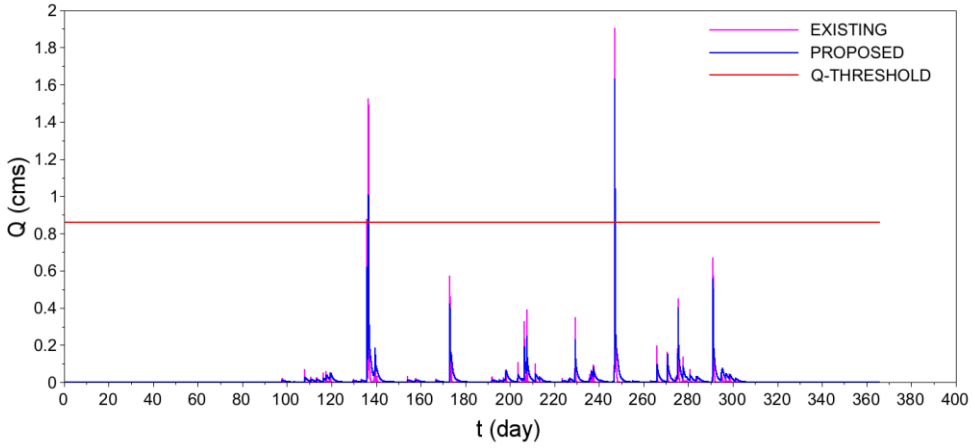


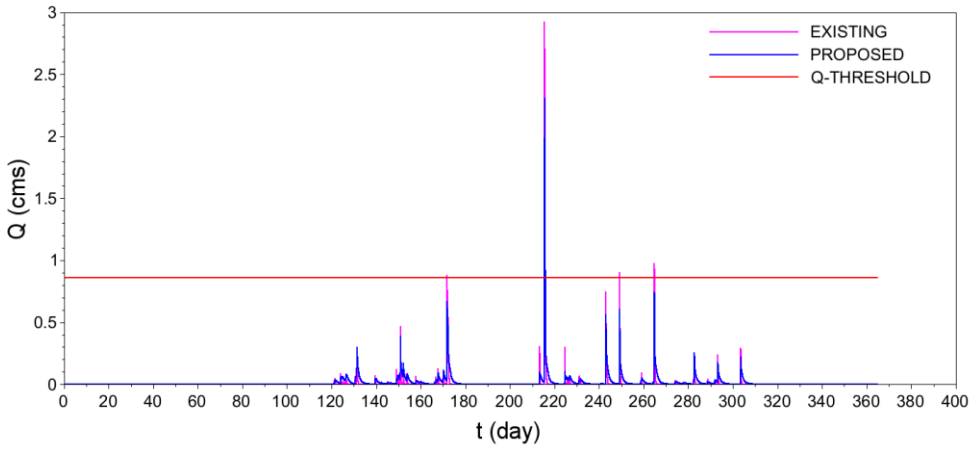
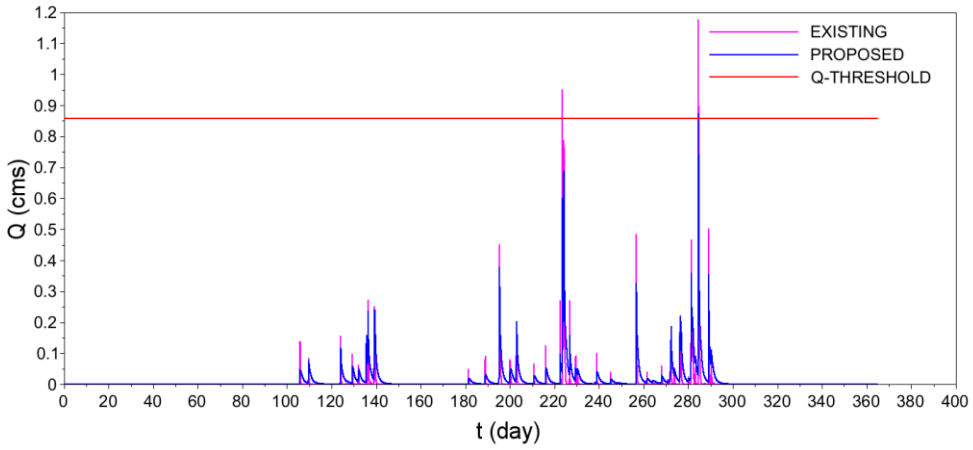
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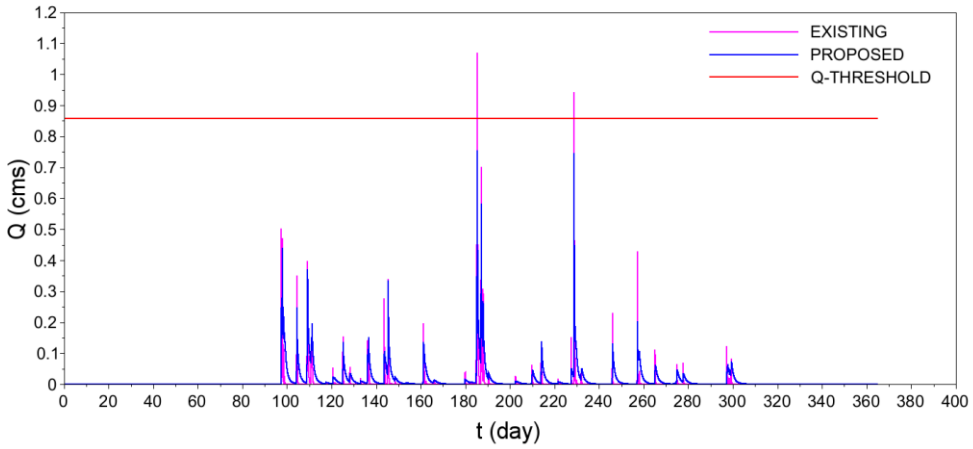
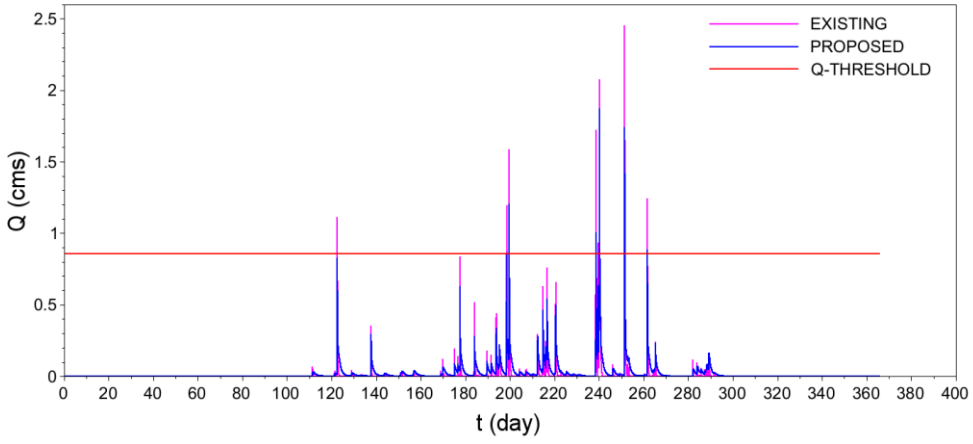


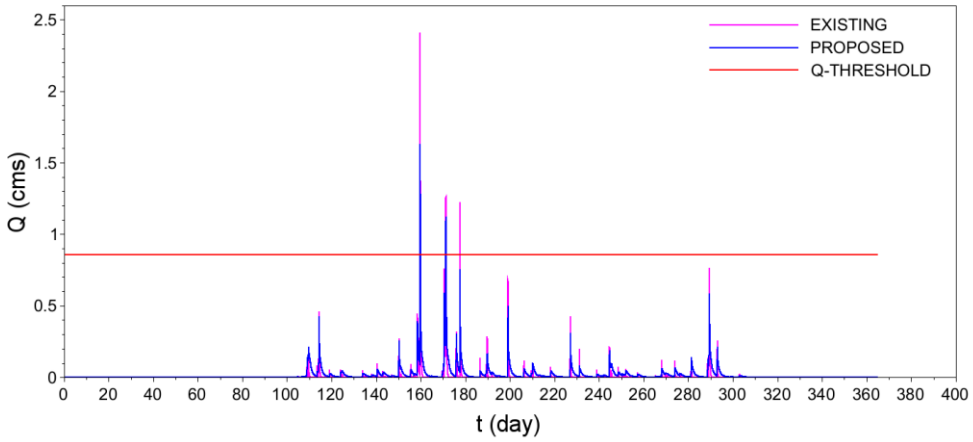
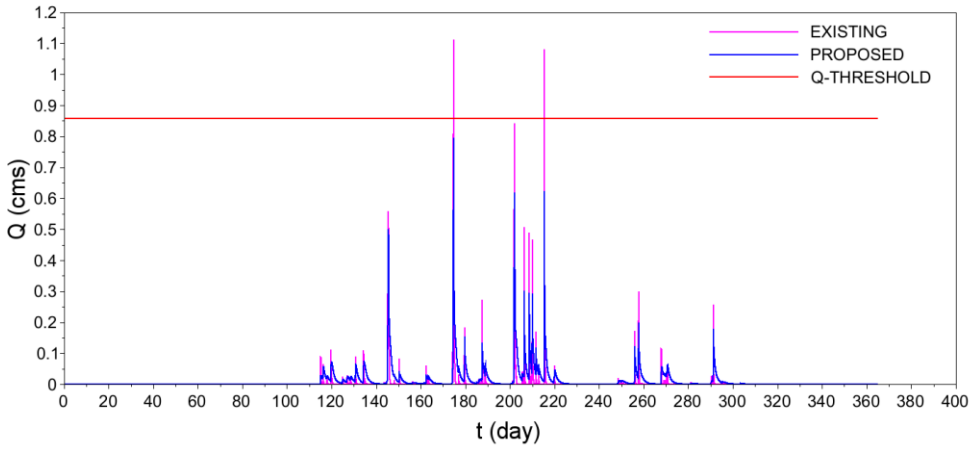
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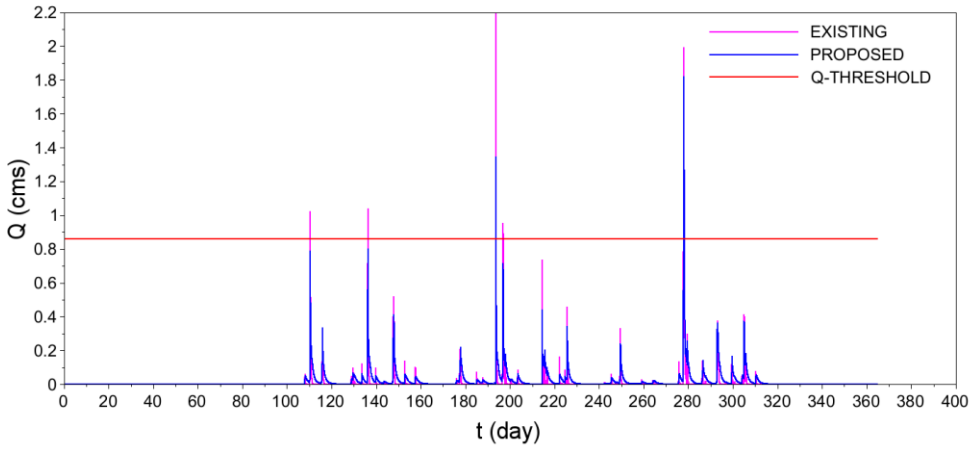
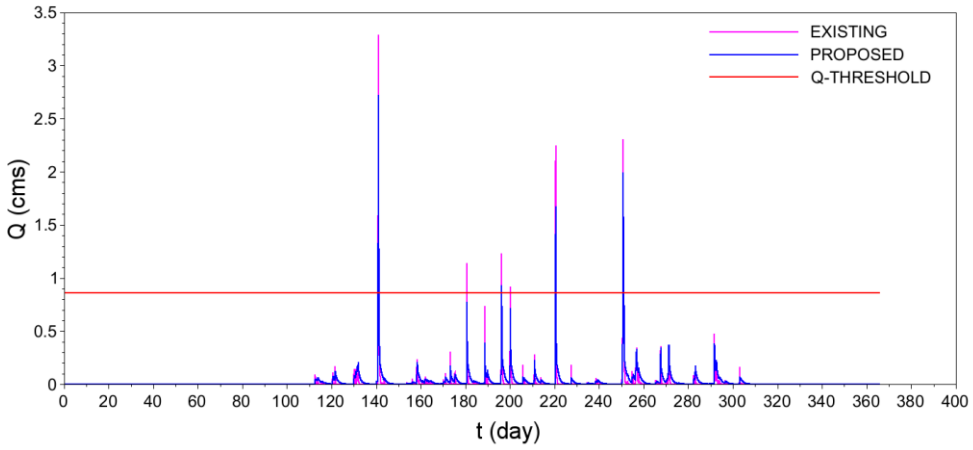
Appendix C:
Erosion Exceedance Hydrographs

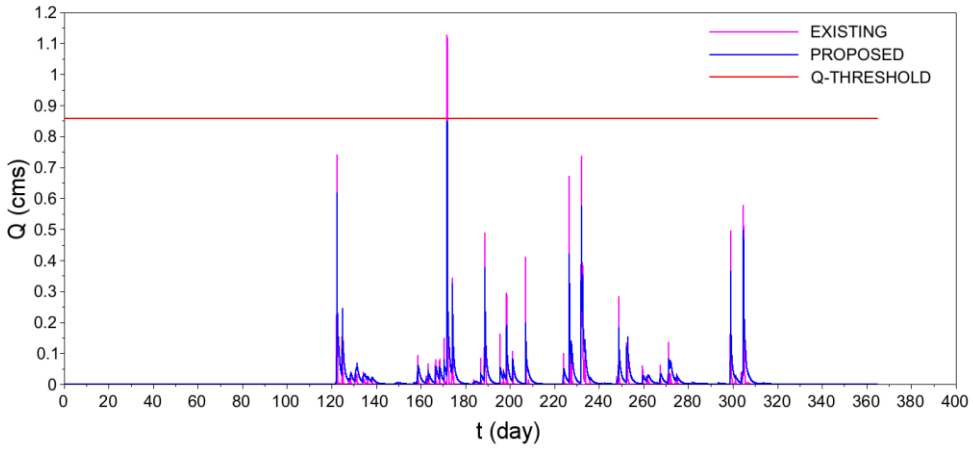
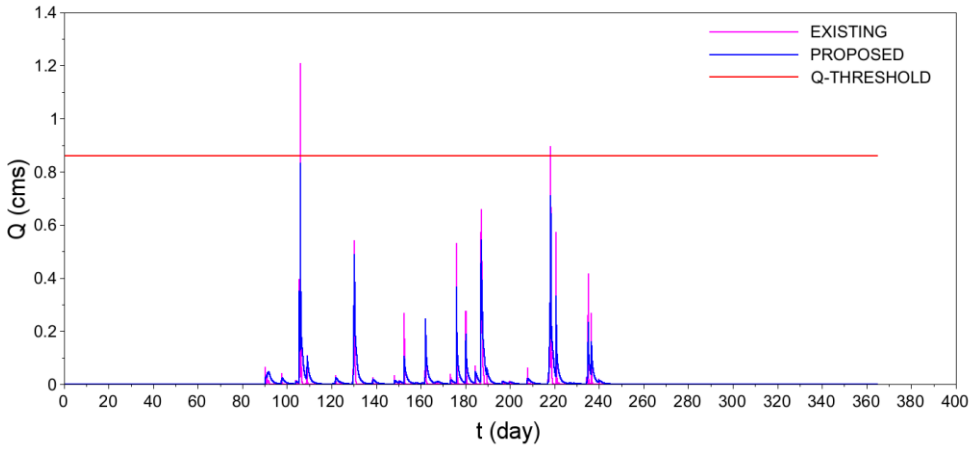
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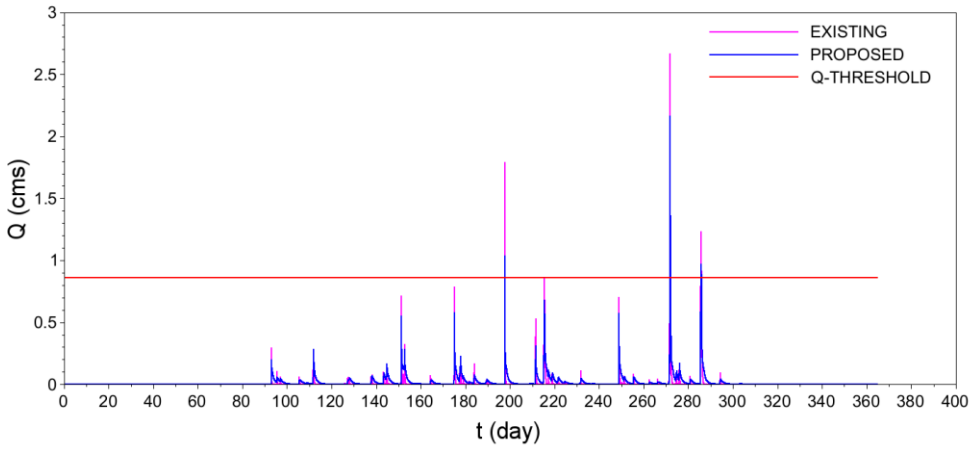
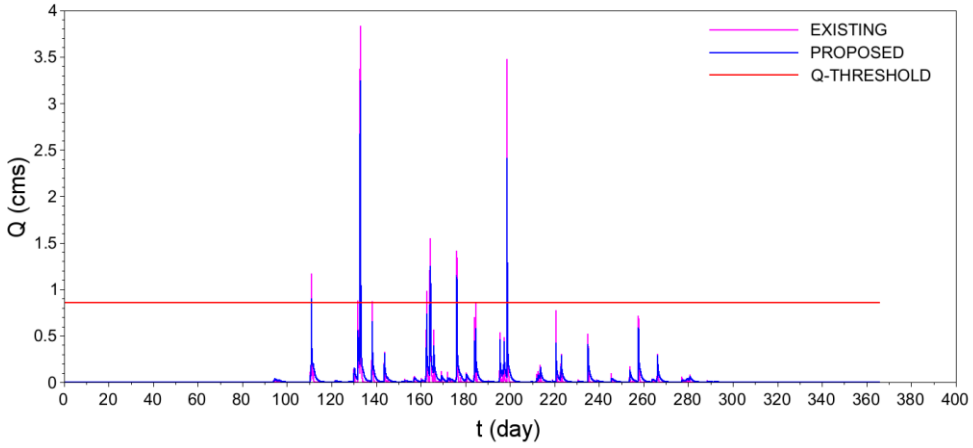
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Reach WHT2(1) 1-1 1990	

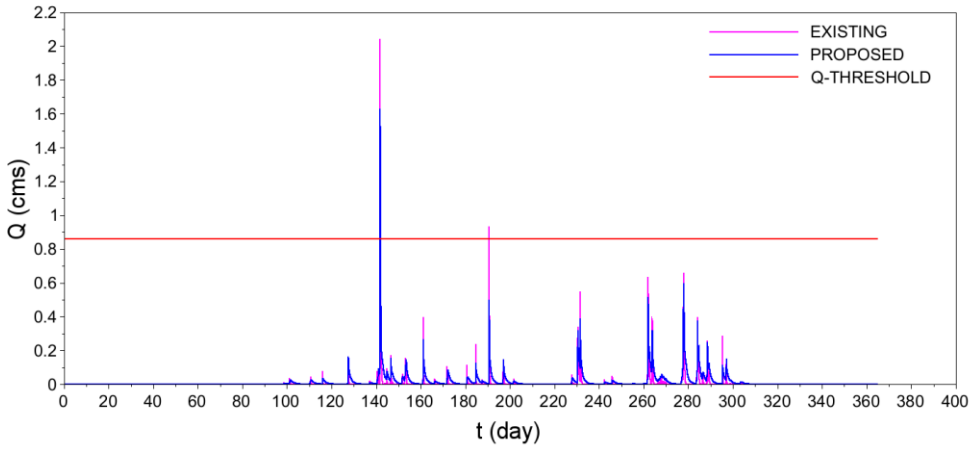
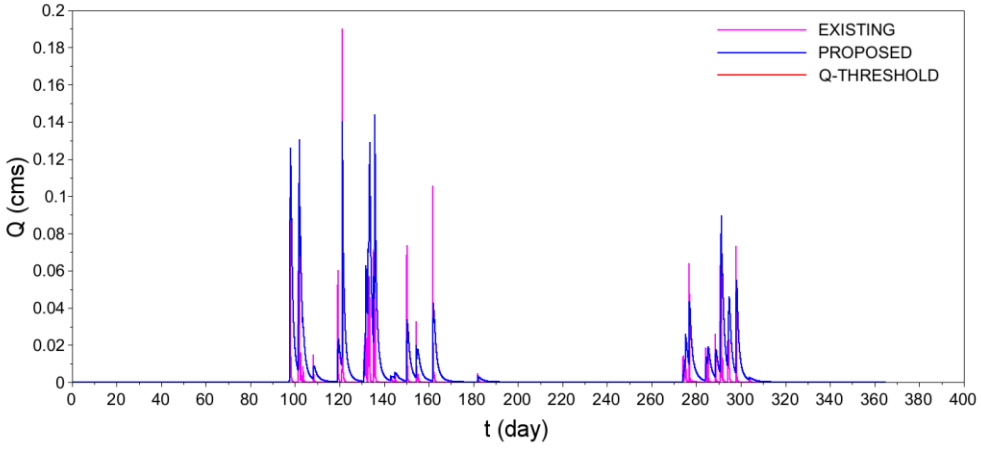
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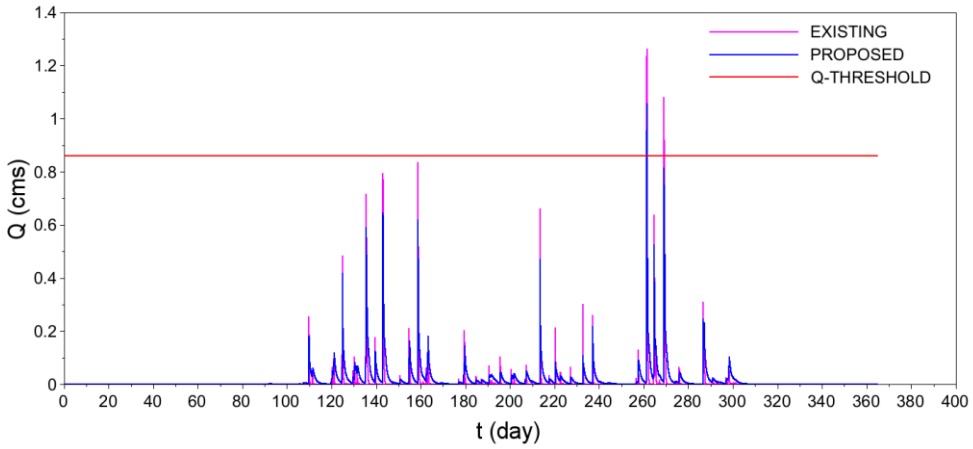
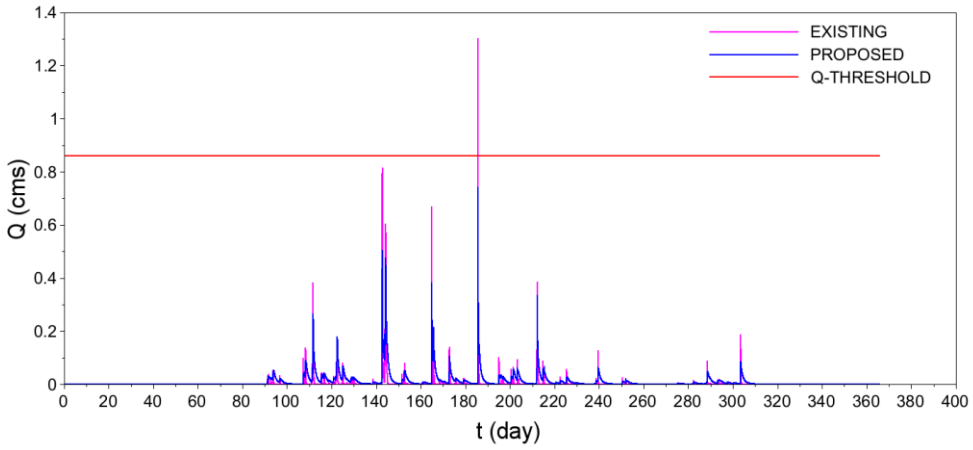
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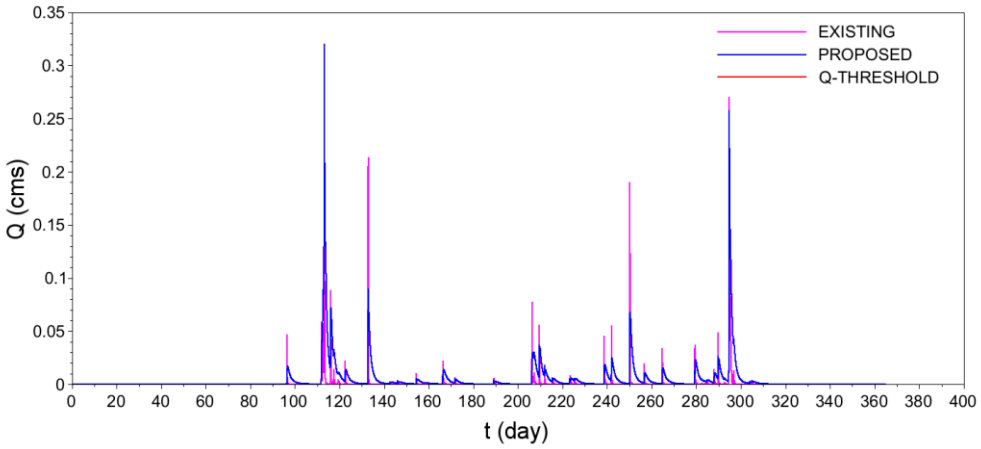
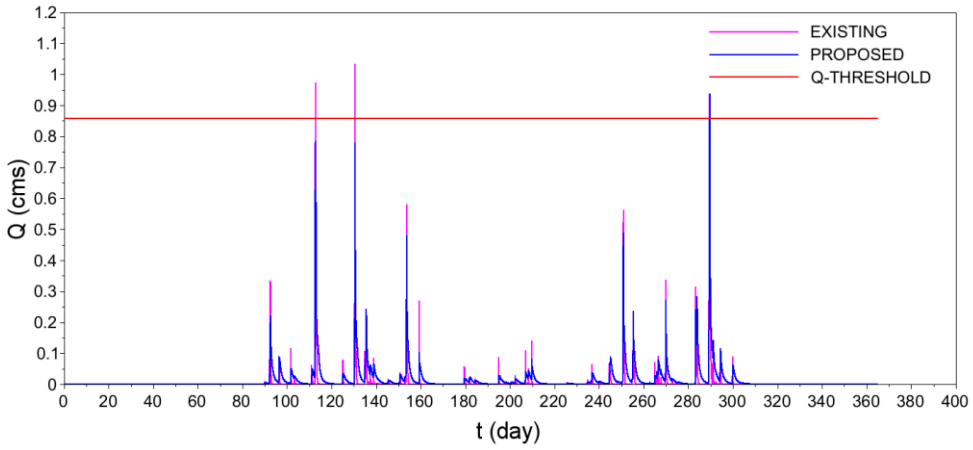
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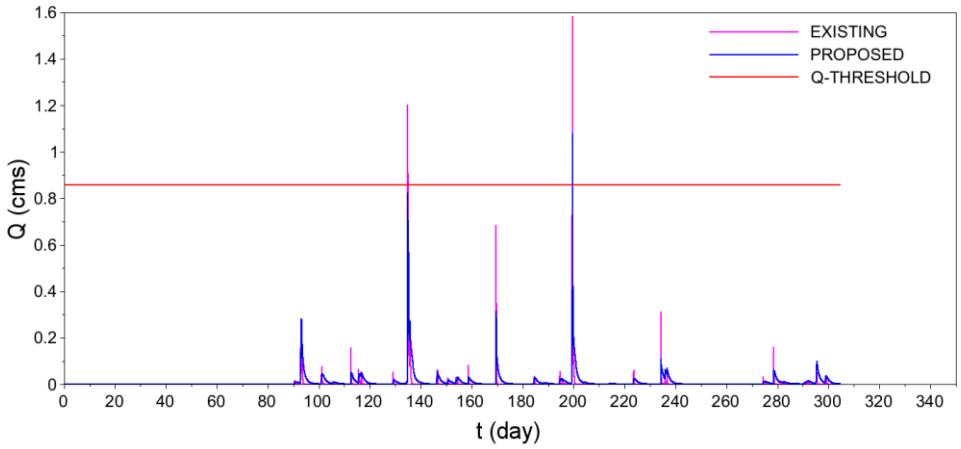
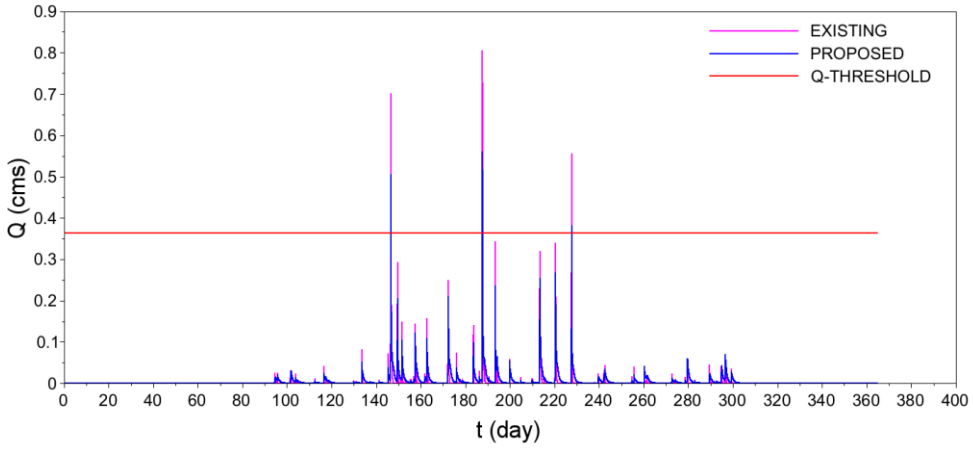
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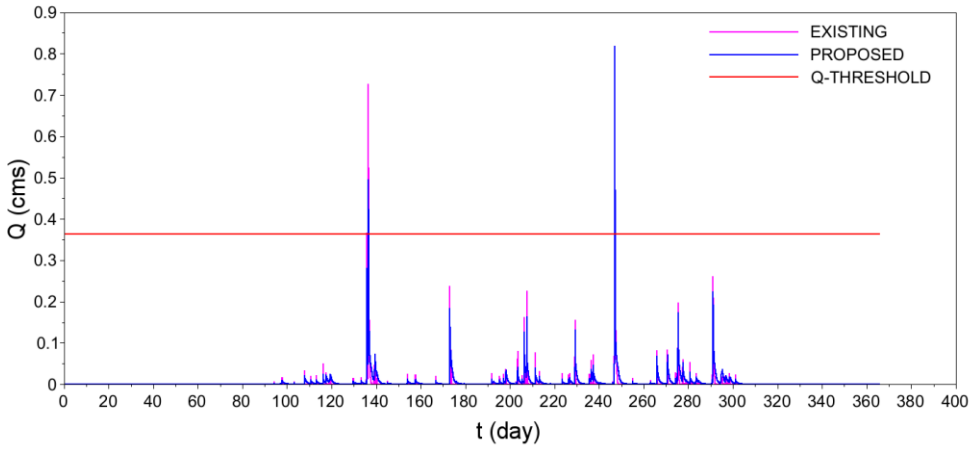
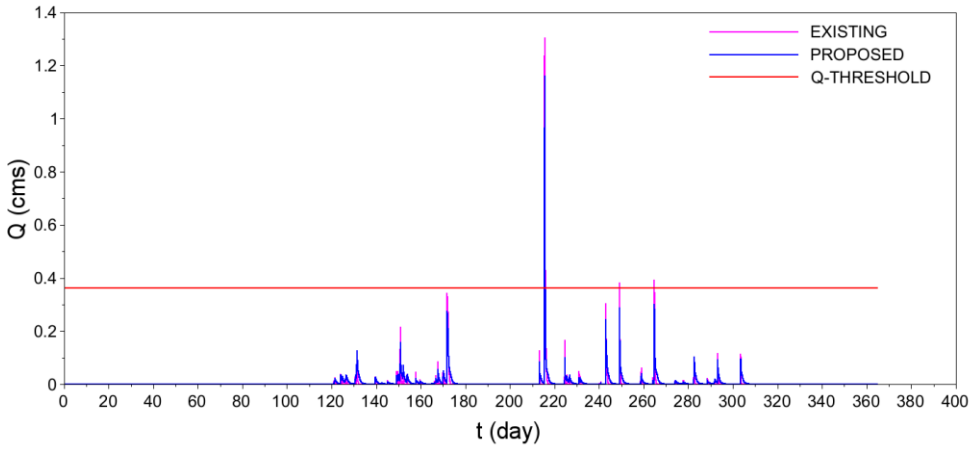
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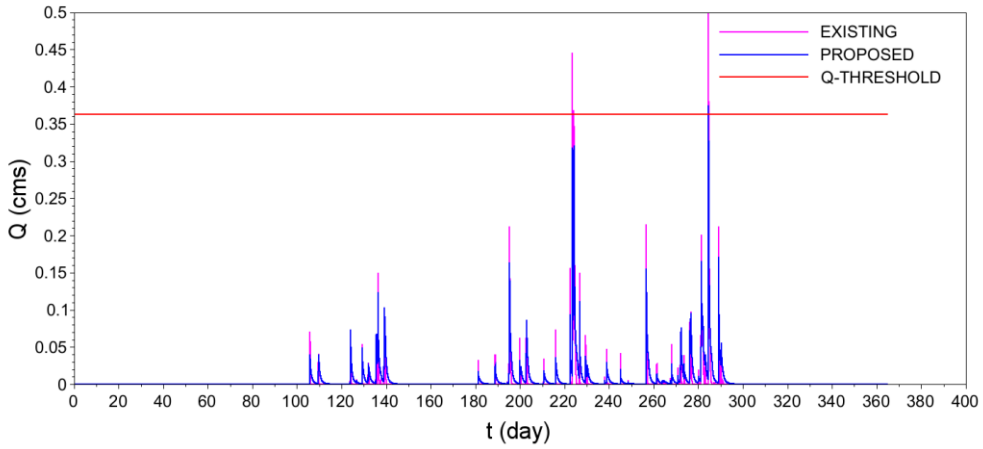
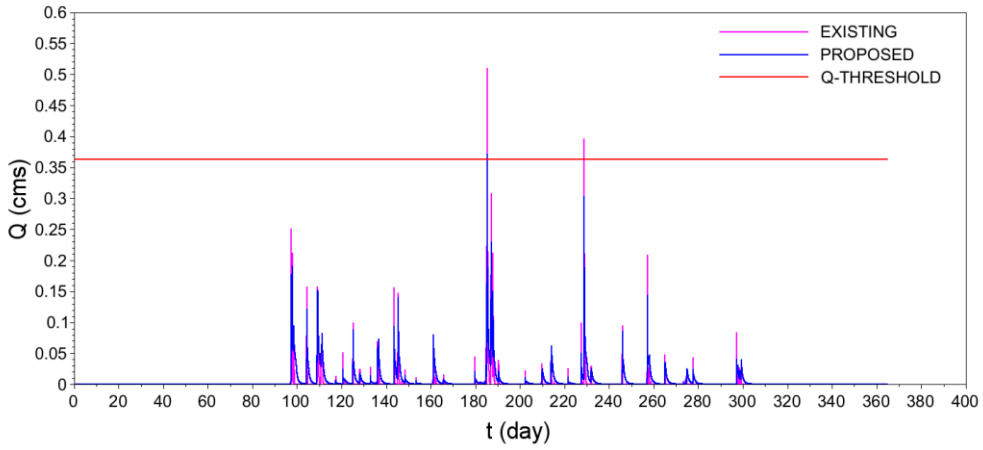
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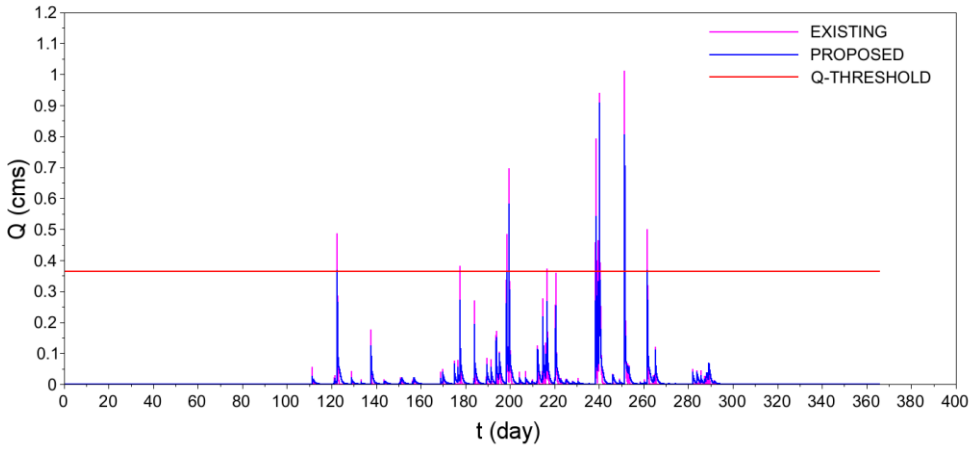
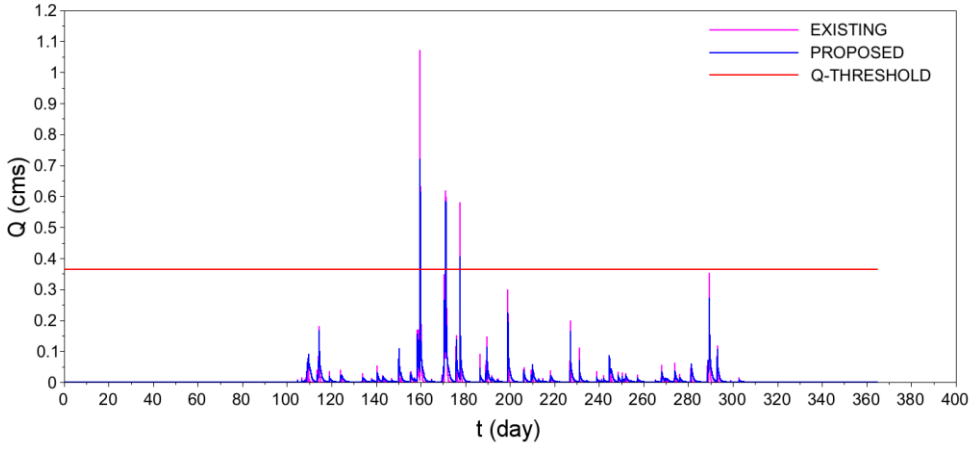
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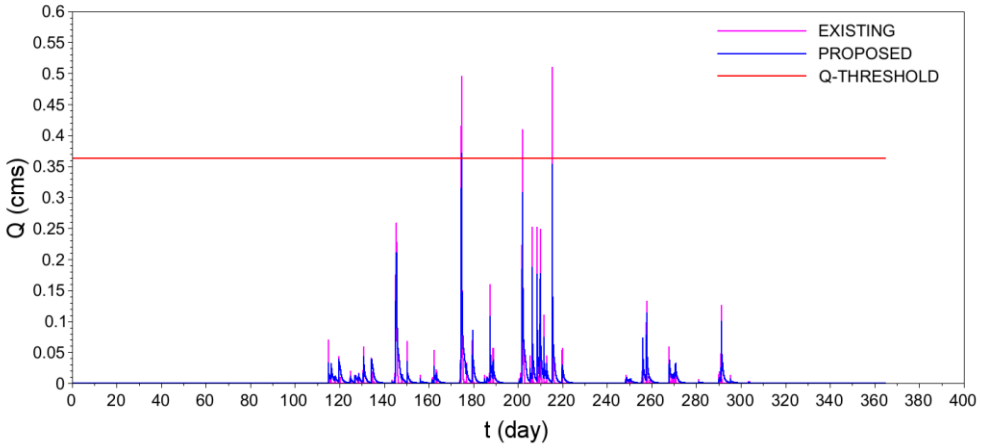
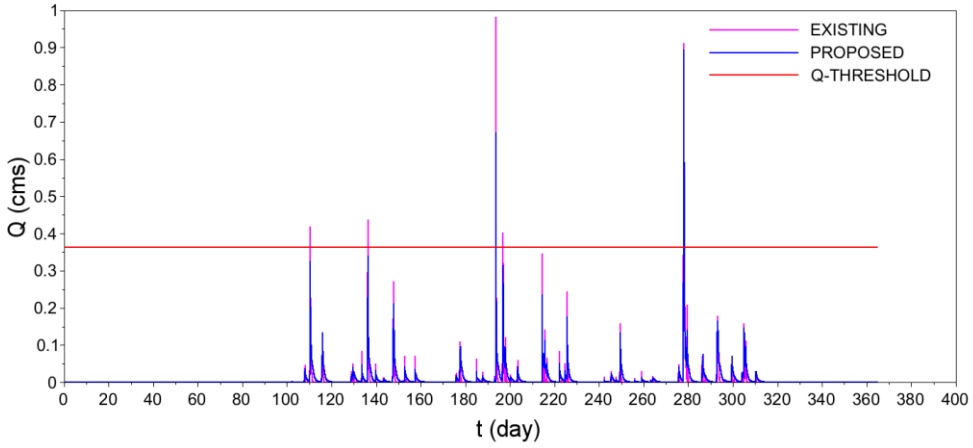
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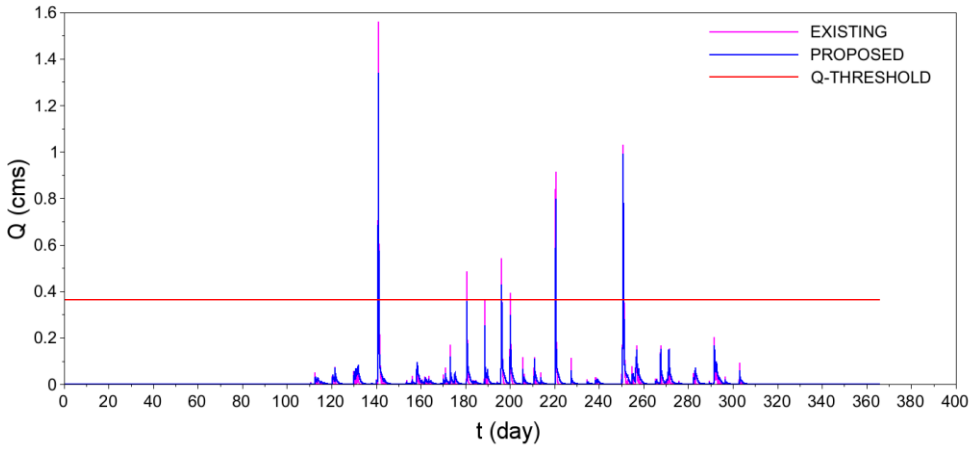
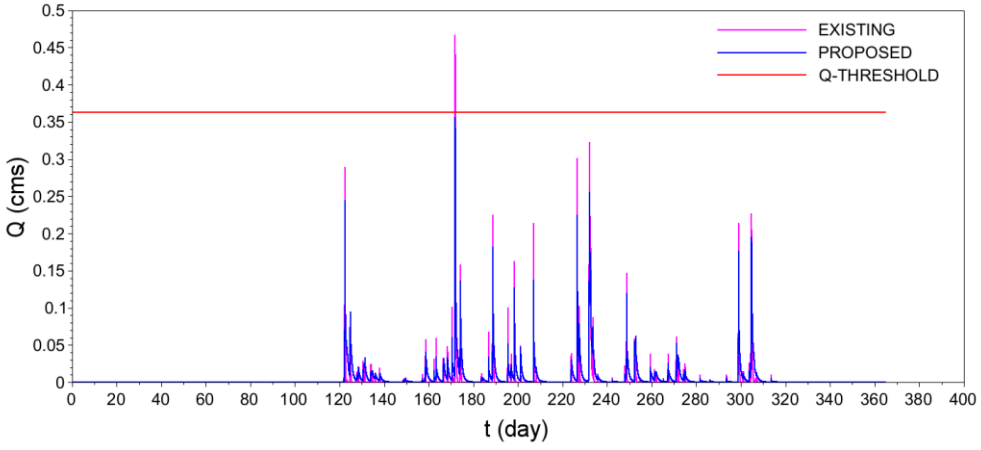
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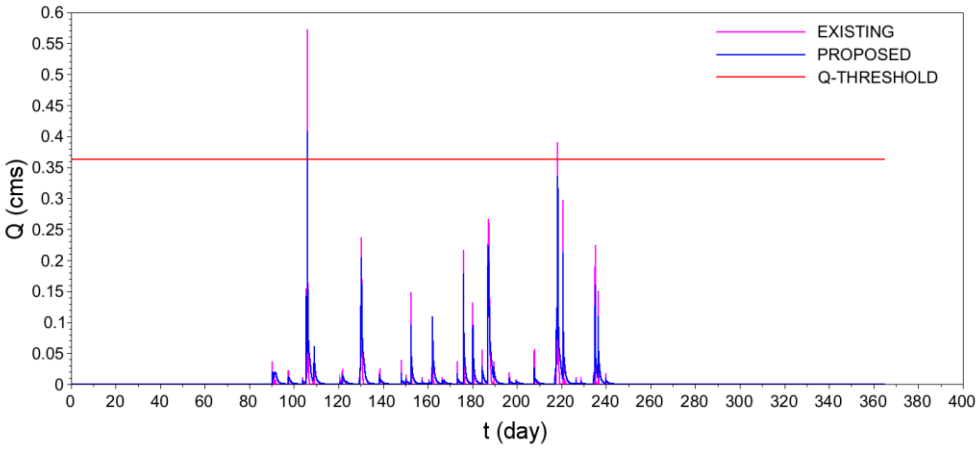
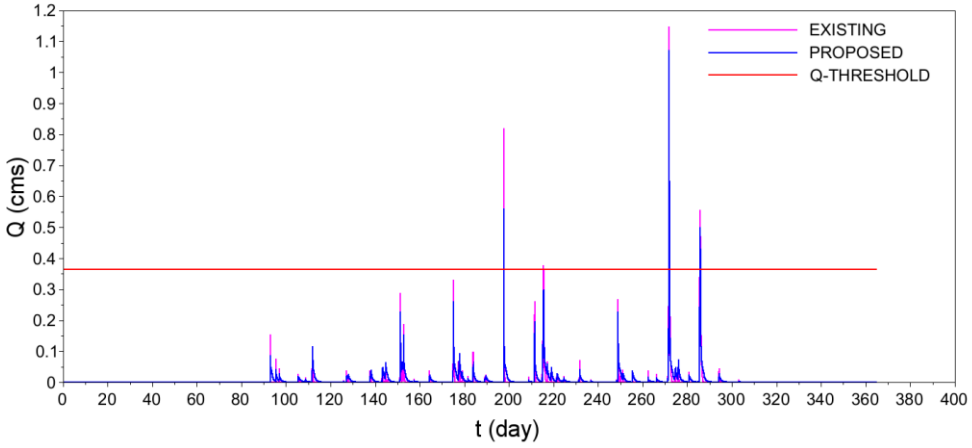
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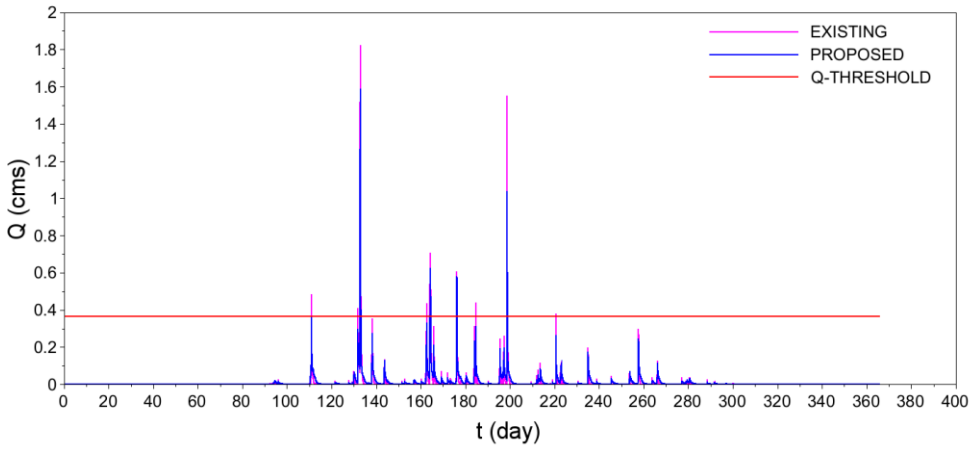
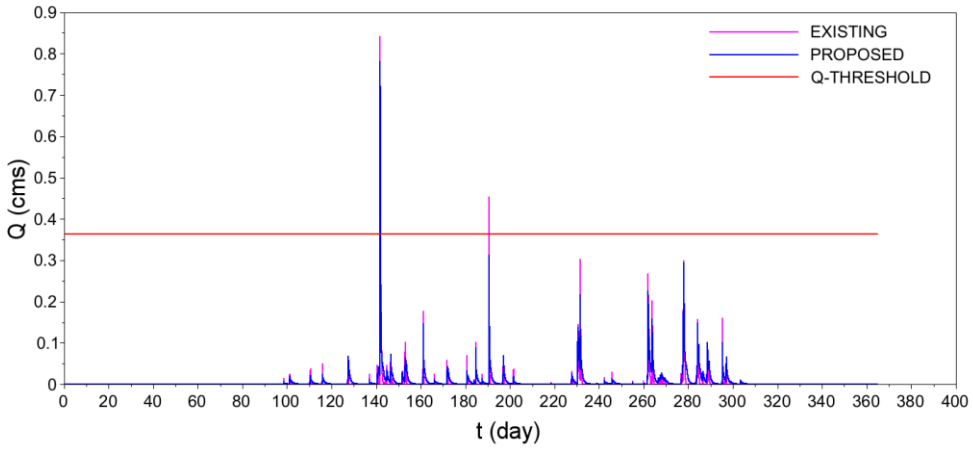
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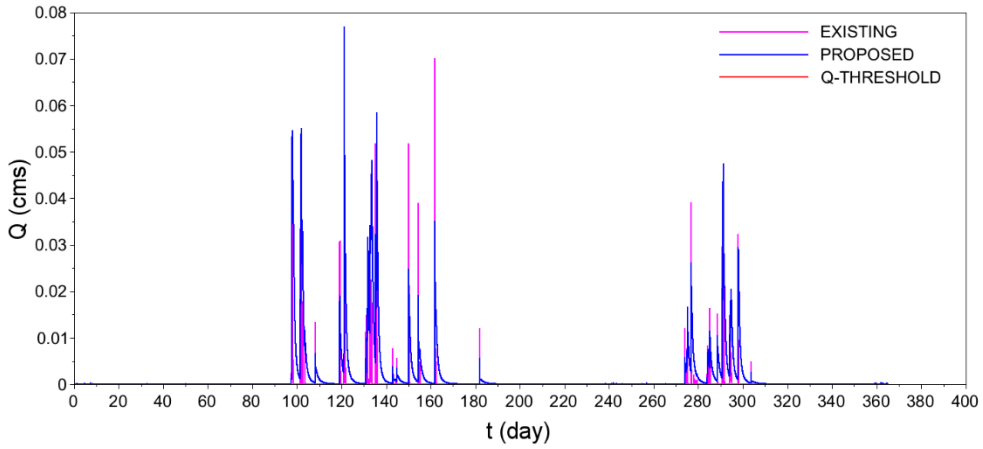
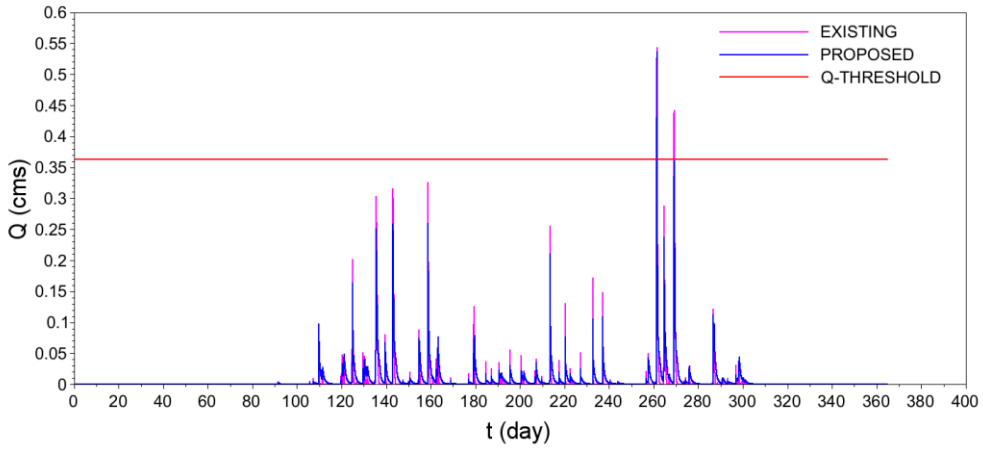
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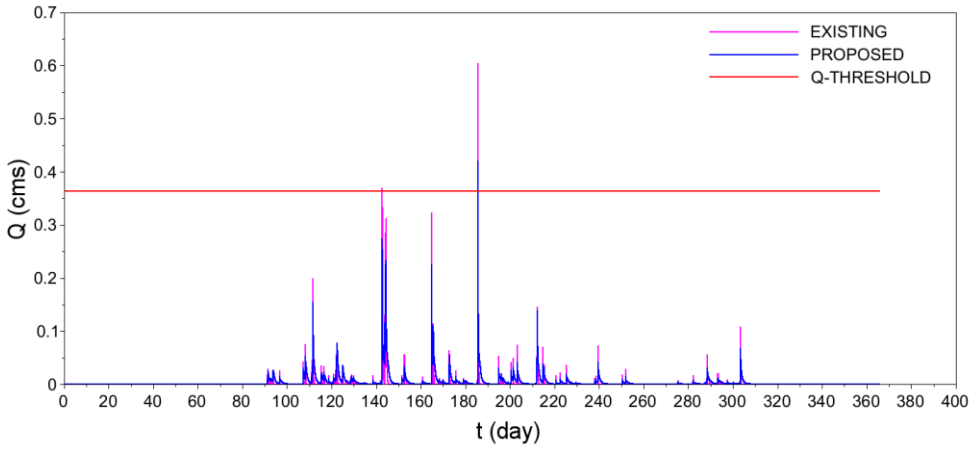
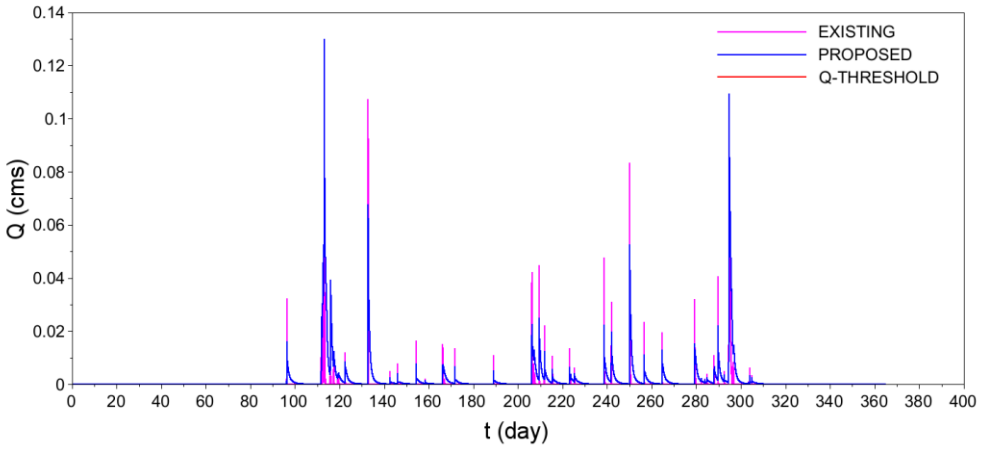
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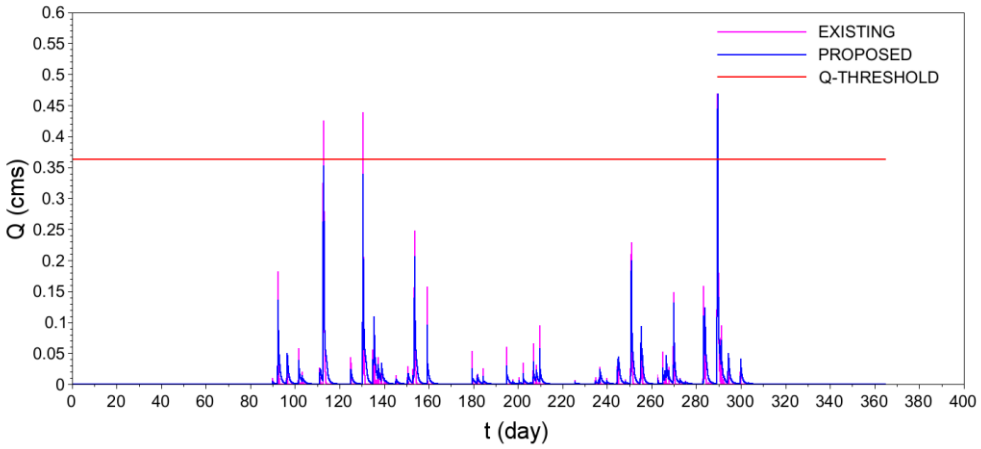
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Reach WHT3(7) 1-1 2002	
Reach WHT3(7) 1-1 2003	

Reach WHT3(7) 1-1 2004	
Reach WHT3(7) 1-1 2005	

Reach WHT3(7) 1-1 2006	
Reach WHT3(7) 1-1 2007	