APPENDIX I

Fluvial Geomorphology

MEMO

TO: Joe de Koning, P.Eng., County of Wellington

FROM: Peter Hayes, P.Geo., WSP and Emily Stephenson, B.Sc., P.Geo., WSP

SUBJECT: Wellington Road 109 Schedule C Municipal Class Environmental Assessment – Fluvial Geomorphology Assessment

DATE: June 28, 2023

Project No.: 17M-01271-02

As requested, this memo summarizes the fluvial geomorphology assessment for four Conestogo River crossings along Wellington Road 109, as a part of the Schedule C Municipal Class Environmental Assessment just outside of Arthur, Ontario. The crossing locations are shown on attached **Figure 1**.

The following summarizes the proposed and existing spans based on the General Arrangements:

- B109132 – proposed 22.3m vs 17.1m for the existing span;
- C109123 – proposed 18.3m vs 13.1m for the existing span;
- B109133 – proposed 17.3m vs 13.7m for the existing span; and
- B109134 – proposed 17.3m vs 12.2m for the existing span.

It is noted that the design for B109132 is being reviewed and the span may increase.

APPROACH

WSP's approach for the desktop fluvial geomorphology assessment was as follows:

- Obtaining historical aerials;
- Adding watercourse alignments on historical aerials;
- Completing a site visit (including a site walk along the watercourse, collecting site photographs, measuring watercourse widths and depths and completing the Rapid Geomorphic Assessment form)
- Reviewing relevant TRCA guidance documents;
- Assessing historical aerials, including a composite figure;
- Complete a 100-year erosion rate assessment and meander belt assessment; and
- Finally making recommendations for the bridge span based on the findings.

1.0 SITE SETTING

The site is located in a rural setting, surrounded primarily by agricultural farm fields and rural residences with some commercial businesses. The Village of Arthur is just located to the northwest of the site. Natural features of the site include the Conestogo River, tributaries, and wooded areas.

The site is situated within drumlinized till plains, specifically the Stratford Till Plain physiographic region (Chapman and Putnam, 1984). This physiographic region is characterized by undulating till plains with drumlins. Creeks and rivers have incised valleys into this plain. Larger rivers and creeks, such as the Conestogo River, have deeper incised valleys, and there are shallower valleys around smaller creeks. The surficial Tavistock Till presents a more subdued topography, noting that there is a thin deposit of glaciolacustrine sediments on top of the till. This region has a gentle but steady slope to the south, ultimately towards Lake Erie.

Quaternary geology at the site consists of Tavistock Till, a sandy silt. Quaternary geology is shown on attached **Figure 2**.

The topography at the site is slightly undulating with elevations ranging from approximately 450 metres above mean sea level (mASL) to 470 mASL, with higher elevations present north and south of Wellington Road 109. There is a broad valley around the Conestogo River as well as the surrounding tributaries. The study area generally slopes towards the Conestogo River and the other smaller tributaries to the east of the river.

The GRCA (2001) Technical Background Report for the Grand River Fisheries Management Plan describes part of the Conestogo River is an area with till plains, with relatively low infiltration, and rapid runoff, especially now that the land use is primarily agricultural, with tile drained fields. This indicates that the Conestogo River and smaller creeks may become sediment-laden due to runoff from fields, and higher runoff flows increase the potential for creek channel erosion and flooding.

2.0 HYDRAULIC ASSESSMENT

WSP completed hydraulic analysis, under a separate cover, for the 4 subject bridges under both existing and proposed conditions.

The proposed bridge configurations (as per the 2022 General Arrangement Drawings) has adequate capacity and would not cause any noticeable increase in water surface elevations or flow velocities.

Once it is confirmed that the 2022 General Arrangement drawings are final for the EA Study, WSP will prepare a draft Hydrology and Hydraulics Report and communicate with GRCA to get their initial approval on the hydraulic modelling and results.

3.0 FLUVIAL GEOMORPHOLOGY ASSESSMENT

3.1 HISTORICAL AERIAL IMAGERY

As a part of the desktop background review, WSP retrieved aerial imagery of the site from 1930 to 2018 (1930, 1954, 1969, 1976, 1980, 1990, 2000, 2010, 2018; **Appendix**

A). WSP approximated the channel for each available aerial and overlaid them onto one figure to highlight the historical stream channel variations of both watercourses (**Figures 3 and 4)**, watercourse alignments have various colours for individual historical aerial watercourse alignments such that each can be easily identified on the composite figure.

3.1.1 1930 AERIAL

The area was developed prior to the 1930's. Wellington Road 109 and the Village of Arthur to the northwest were constructed prior to the 1930's. The four bridge crossing are located in a rural setting with rural residential homes, agricultural fields, and natural areas.

3.1.2 1954, 1968, 1976, 1980, 1990, 2000, 2010 AND 2018 AERIALS

The area has remained relatively unchanged, the four bridge crossing are still located in a rural setting with rural residential homes, agricultural fields and natural areas.

3.1.3 SUMMARY

The watercourse channel through all four structures has remained relatively unchanged over this 88 year timeframe with the expectation of some minor fluctuations. It is noted the there is degree of error associated with the overlapped historical aerials.

3.2 FIELD VISIT

WSP completed a field visit at the site on November 1, 2021, site photos are provided in **Appendix B**. During the site visit WSP noted the composition of the watercourse bed at all four crossing to be fairly consistent with silt, sand, gravel, cobbles and boulders. WSP completed a pebble count at bridge 109123 (water levels at the other bridge locations were too high to safely complete a pebble count).

WSP observed gabion baskets bank protection at B109133 and B109134. No bank protection was observed at B109132 and C109123.

As per the general arrangements the gabion baskets will be removed and replaced at B109133 and B109134 during construction. Opportunity to restore the banks to more natural conditions (instead of replacement with gabion) will be reviewed at detail design. The erosion protection methods employed have been largely adequate to protect the abutments.

It is recommended that bank protection measures also be considered at B109132 and C109123. Also, some of the existing abutments (at all four crossings) to be removed with the works are located below the bankfull channel width and opportunity to restore the banks and bed to more natural conditions will be reviewed at detail design.

The pebble count is summarized in **Table 1** below.

Table 1: Pebble Count WR Crossing 109123

Parameter	Units (mm)	Bridge 109123
Silt/Clay		
Sand	<2	27
Gravel		

Parameter	Units (mm)	Bridge 109123
Fine	2-8	
Medium	9-16	1
Coarse	17-64	17
Cobble		
Small	65-90	12
Medium	91-128	11
Large	129-256	12
Boulder		
Small	256-512	14
Medium	513-1024	5
Large	>1024	1
Bedrock		
Woody Debris		

WSP collected watercourse measurements on November 1, 2021 and WSP's ecology team completed a site visit on August 19, 2020 and also collected watercourse measurements.

On November 1, 2021, the watercourse at B109132 was too deep to cross south (upstream) of Wellington Road 109. WSP crossed the watercourse north (downstream) of Wellington Road 109 and measured a wetted width of 5.96 m with a wetted depth of 0.48 m, approximately 5 m north of the bridge. WSP ecology measured bankfull widths of 12.2 m north (approximately 3 m downstream of the bridge) and 12.1 m south (approximately 30 upstream of the bridge) on August 19, 2020, with bankfull depths of 0.5 m and 0.3 m respectively. Additionally, WSP ecology measured a wetted width of 4 m at the 30 m south (upstream) location. Based on the ecology field visit the watercourse bankfull width average for B109132 was 12.2 m.

On November 1, 2021, the watercourse at C109123 was too deep to cross south (downstream) of Wellington Road 109. WSP crossed the watercourse north (upstream) of Wellington Road 109 and measured a wetted width of 11.88 m, 11.9 m and 7.78 m with a wetted depth of 0.19 m, 0.27m and 0.36m, approximately 2 m north, 15 m north and 25 m north of the bridge, respectively. WSP ecology measured bankfull widths of 10 m (approximately 10 m downstream or south of the bridge) and 12.5 m (approximately 30 m upstream or north of the bridge) on August 19, 2020 with bankfull depths of 0.4 m and 0.5 m respectively. Additionally, WSP ecology measured a wetted width of 3.75 m and 7.5 m, respectively. Based on the ecology field visit the watercourse bankfull width average for C109123 was 11.3 m.

On November 1, 2021, the watercourse at B109133 was too deep to cross south (upstream) and north (downstream) of Wellington Road 109. WSP ecology measured bankfull widths of 8.9 m (approximately 7 north or downstream of the bridge) and 5 m (approximately 35 upstream or south of the bridge) on August 19, 2020 with bankfull depths of 0.5 m and 0.6 m respectively. Additionally, WSP ecology measured a wetted width of 8.1 m and 4.5 m, respectively. Based on the ecology field visit the watercourse bankfull width average for B109133 was 7.0 m.

On November 1, 2021, WSP crossed the watercourse at B109134 to the north (upstream) and south (downstream) of Wellington Road 109. WSP measured wetted widths of 7.82 m and 8.34 m, respectively, with wetted depths of 0.48 m and 0.71 m, measurements were collected adjacent to the bridge. WSP ecology measured bankfull widths of 7 m (approximately 10 m north or upstream of the bridge) and 9 m (approximately 8 m south or downstream of the bridge) on August 19, 2020, with bankfull depths of 0.6 m and 0.5 m, respectively. Based on the ecology field visit the watercourse bankfull width average for B109134 was 8.0 m.

WSP completed the Rapid Geomorphic Assessment (RGA) form at each crossing on November 1, 2021; B109133 and B109134 was found to be in regime; C109123 was found to be transitional and C109123 was found to be adjusting. The complete RGA forms are provided in **Appendix B**.

3.3 TRCA CROSSING GUIDELINES FOR VALLEY AND STREAM CORRIDORS

According to the TRCA, proponents should conduct a meander belt and erosion rate analyses to assess the risk associated with migration of the watercourse channel across the floodplain and the potential for future destructive contact between the channel and road infrastructure. **All to minimize the risk of channel contact with abutments, footings and fill slopes.**

The 100-year migration rates of the watercourse channel in the vicinity of the crossing are assumed to be equal to the migration rate of the stream bend immediately upstream of the crossing or the average rates of the four-stream bends measured in the analysis, whichever is greater.

In order to assess whether channel migration will affect the proposed structure the migration rate should then be applied to the existing plan form with the watercourse such that the future location of the channel within the anticipated structure lifespan has been accounted for.

In the plan form when extended and then translated according to the calculated erosion rate, falls outside the proposed crossing structure opening, the width of the opening should be increased to accommodate the anticipated future alignment to the watercourse. As noted above if the projected future plan form is narrower than the crossing structure opening a reduction in the opening size may be considered.

3.4.1 LATERAL AND DOWN-VALLEY EROSION RATES

As a part of this assessment measurements of the lateral and down valley 100-year erosion rates were completed based on the TRCA (2015) *Crossing Guidelines for Valley and Corridors (Appendix 2.A)*.

As per the TRCA (2015) erosion rates were measured for four meanders at each structure, approximately two meanders immediately upstream and downstream of the crossings. To complete the assessment meanders were identified on the composite historical aerial figures and meander wavelengths and meander amplitudes were marked-up for each of the assessed meanders are provided in **Appendix C**. Finally,

meander extension (lateral migration) and meander translation (down-valley migration) values were measured for each meander.

Based on the TRCA (2015) *"the 100-year migration rate of the watercourse channel in the vicinity of the crossing are assumed equal to the migration rate of the bend immediately upstream of the crossing, or the average rate of the four bends measured in the analysis, whichever is greater".*

The approximate 100-year upstream lateral migration and down-valley migration rates are as follow:

- B109132:
  - lateral migration: 20m to 28m;
  - down-valley migration: 16m to 112m;
  - **average: 41m**; and
  - upstream extension meander: 20,
- C109123:
  - lateral migration: 12m to 28m;
  - down-valley migration: 18m to 112m;
  - **average: 36m**; and
  - upstream extension meander: 12m
- B109133:
  - lateral migration: 11m to 27m;
  - down-valley migration: 5m to 47m;
  - **average: 23m**; and
  - upstream extension meander: 13m.
- B109134:
  - lateral migration: 6m to 22m;
  - down-valley migration: 10m to 45m; and
  - average: 18m; and
  - **upstream extension meander: 23m**.

The average is greater than the upstream extension meander for three of the four crossings and therefore the average is the erosion rate for B109132, C109123 and B109133 and the upstream meander is the erosion rate for B109134.

3.4.2 MEANDER BELT ASSESSMENT

As per Parish Geomorphic Ltd. (2001) *"Meander belt width is a term that quantifies the lateral extent of a river's occupation on the floodplain. The meander belt is measured for a reach between lines drawn tangentially to the outside bends of the laterally extreme meander bends in a reach."*

As a part of this investigation WSP completed a meander belt assessment in accordance with Parish Geomorphic (2004) Belt Width Delineation Procedures – Accurate Quantification I (when the hydrologic regime of the subject watercourse is not expected to be altered) for a simple meander pattern in a partially confined valley setting.

Valley Settings are defined as follows:

Unconfined – where there are no limits or controls on the spatial occupation of the floodplain by a watercourse

Partially confined – where the meander bends are adjacent to only one valley wall with the reach. The watercourse is restricted in migration and floodplain occupation along one side of the valley

Confined – where meander bends are adjacent to both valley walls within the reach; the watercourse may be restricted from occupying it potential meander belt by the valley walls

Incised – where the watercourse is actively incising into the floodplain or valley

To complete the meander belt assessment WSP outlined the meander belt and the meander axis on the composite historical aerial figures based on Parish Geomorphic (2004) are provided in **Appendix C**. The following are the assumptions and limitations associated with this method:

Assumptions

- The meander migration and evolution processes that occur within the reach will continue to occur into the future; and
- The meander belt, as defined in Parish Geomorphic (2004), encompasses the area in which all future meandering and migration tendencies of the watercourse are anticipated to occur.

Limitations

- Calculated meander migration rates are dependant on quality and time-span of historical air photo record;
- Precise direction and sequence of meander evolution and migration direction cannot be easily predicted;
- Meander belt does not take into account any consideration of geotechnical slope set-backs for valley walls (e.g. confined or partially confined setting);
- Accuracy of meander belt is dependent on the care taken to complete the work described in this document; and
- There is some subjectivity in the meander belt delineation procedure although when it is defined by a practitioner who has a general appreciation of planform processes the subjectivity decreases.

From the composite figure WSP estimated the average meander belt width of 36m, 32m, 32m, and 27m, for the four structures respectively. Next WSP used the Parish Geomorphic (2004) equation for when no change in hydrology is anticipated, and the meander belt is less than 50m.

For the meander belt less than 50m:

Final Belt Width = (average bankfull width + measured meander belt width) + (the average migration rate / number of years) + 100 year shift in belt axis

B109132 Final Belt Width = (12.2m + 36m) + (14m/88) + 0 = ***49 m***

C109123 Final Belt Width = (11.3m + 32m) + (10m/88) + 0 = ***44 m***

B109133 Final Belt Width = (7.0m + 32m) + (10m/88) + 0 = ***39 m***

B109134 Final Belt Width = (8.0m + 27m) + (8m/88) + 0 = ***35 m***

As per the TRCA (2015):

"Crossings should be located away from geomorphically active and unstable areas, and be designed to span the zone of potential future channel migration, as defined by the meander belt or the 100-year erosion limit, to reduce risks from channel migration over time."

It is however evident from review of the 88 year period of aerial photography that the channel has been trained to be directed to the crossings. Which would indicate that the existing crossing sizing is not an adverse constraint with respect to the natural channel meander migration and form.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the fluvial assessment the following conclusion and recommendations are presented:

1. Based on General Arrangements the proposed and existing spans are as follows:
   a. B109132 – proposed 22.3m vs 17.1m for the existing span;
   b. C109123 – proposed 18.3m vs 13.1m for the existing span;
   c. B109133 – proposed 17.3m vs 13.7m for the existing span; and
   d. B109134 – proposed 17.3m vs 12.2m for the existing span.
2. Based on the ecology field visit the watercourse bankfull width average for B109132 was 12.2 m; C109123 was 11.3 m, B109133 was 7.0 m and B109134 was 8.0 m.
3. Based on the rapid geomorphic assessment B109133 and B109134 were in regime; C109123 was transitional and C109123 was adjusting.
4. Based on the lateral and down-valley erosion rate assessment this watercourse was found to have a migration rate and 100-year toe erosion rate as follows:
   a. B109132: 41m;
   b. C109123: 36m;
   c. B109133: 23m; and
   d. B109134: 23m.
5. Based on the meander belt assessment this watercourse was determined to have a final belt width as follows:
   a. B109132: 49m;
   b. C109123: 44m;
   c. B109133: 39m; and
   d. B109134: 35m.
6. As per the general arrangements the gabion baskets will be removed and replaced at B109133 and B109134 during construction. Opportunity to restore the banks to more natural conditions (instead of replacement with gabion) will be reviewed at detail design.The erosion protection methods employed have been largely adequate to protect the abutments. It is recommended that bank protection measures be considered at B109132 and C109123 compared to the assessed meander belt and erosion rates. Also, some of the existing abutments (at all four crossings) to be removed with the works are located below the bankfull channel width and opportunity to restore the banks and bed to more natural conditions will be reviewed at detail design.
7. Overall based on the fluvial assessment the proposed spans should be acceptable provided appropriate bank erosion erosion protection is applied at all four crossing

given the proposed narrow spans compared to the meander belt widths and calculated erosion rates.

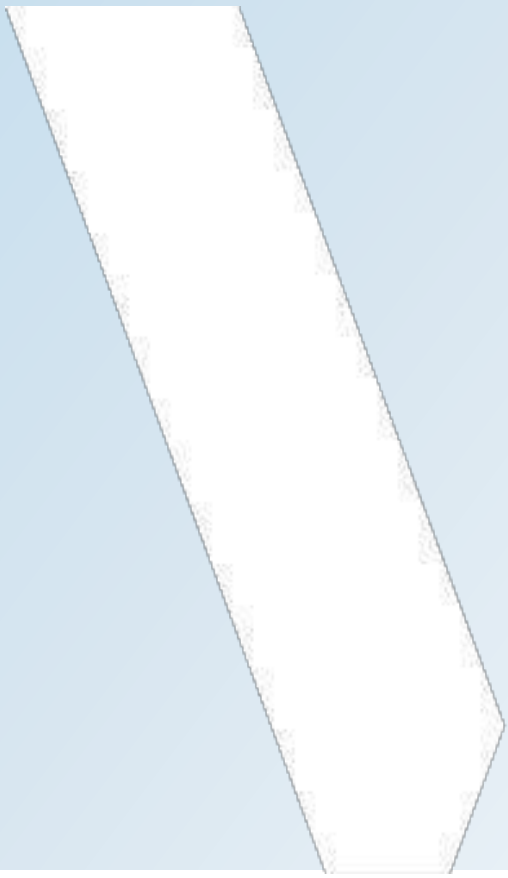
5.0 REFERENCES

- Chapman, L.J. and Putnam, D.F., 1984. The Physiography of Southern Ontario, Ontario Geological Survey Special Volume 2.
- GRCA (2001). Technical Background Report for the Grand River Fisheries Management Plan Draft Report Prepared for Fisheries and Oceans Canada.
- Parish Geomorphic, 2004. Belt Width Delineation Procedures prepared for the Toronto and Region Conservation Authority.
- Toronto and Region Conservation, 2015. Crossings Guideline for Valley and Stream Corridors.

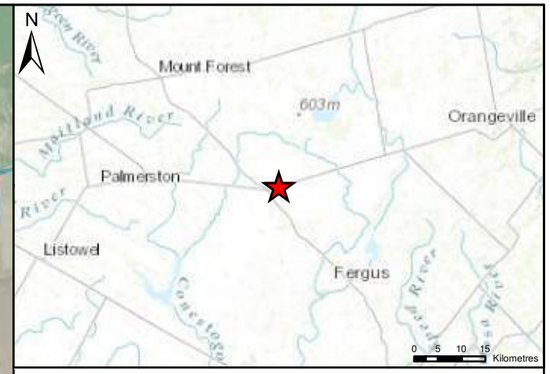
ATTACHMENTS:

Figure 1: Site Location
Figure 2: Surficial Geology and Topography
Figure 3: Composite Historical Watercourse B109132
Figure 4: Composite Historical Watercourse C109123
Figure 5: Composite Historical Watercourse B109133
Figure 6: Composite Historical Watercourse B109134
Appendix A: Individual Historical Aerials (1930, 1954, 1969, 1976, 1980, 1990, 2000, 2010, 2018)
Appendix B: Site Photographs and Rapid Geomorphic Assessment (RGA) Forms
Appendix C: Meander Belt Assessment and Erosion Rate Analysis

FIGURES



Prepared By: Tanya.Peterson



LEGEND:

- SITE LOCATION
- CULVERT CROSSINGS
- STUDY AREA
- WATERCOURSES

TITLE:

SITE LOCATION

PROJECT:

FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:

WELLINGTON COUNTY

	PROJECT NO.: 17M-01271-02	REVIEWED BY: PH
	DATE: NOVEMBER 2021	FIGURE: 1

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 1 Site Location.mxd

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LEGEND:

- CULVERT CROSSINGS
- STUDY AREA
- WATERCOURSES
- TOPOGRAPHIC CONTOURS

QUATERNARY GEOLOGY

- TAVISTOCK TILL

TITLE: **QUATERNARY GEOLOGY**

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: NOVEMBER 2021	FIGURE: **2**

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 2 Quaternary Geology.mxd

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LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE: **HISTORICAL WATERCOURSE PATHS CULVERT B 109132**

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

	PROJECT NO.: 17M-01271-02	REVIEWED BY: PH
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D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3 Historical Watercourse Composite.mxd

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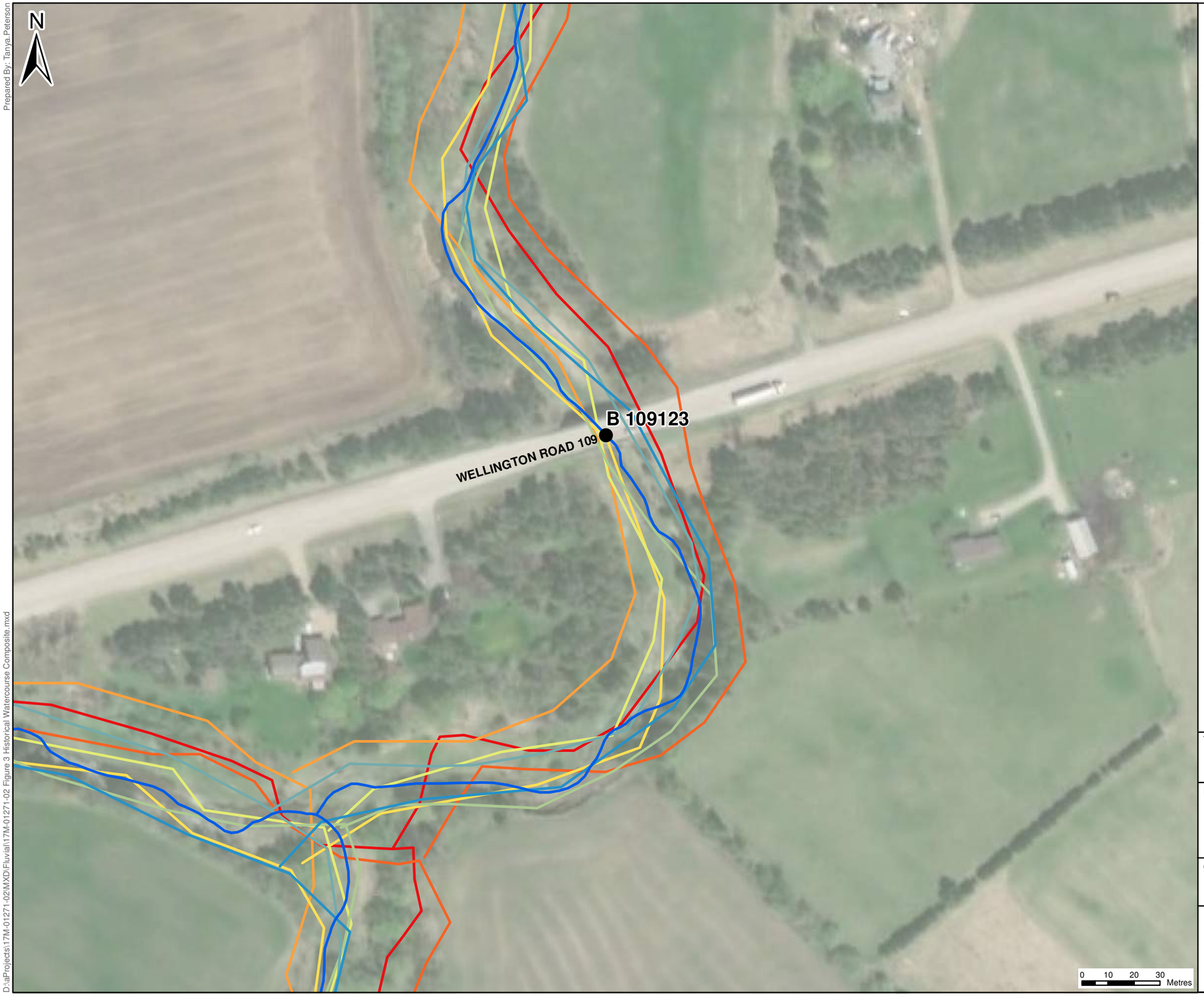

LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE: **HISTORICAL WATERCOURSE PATHS CULVERT B 109123**

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

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D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3 Historical Watercourse Composite.mxd

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LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE:
HISTORICAL WATERCOURSE PATHS
CULVERT B 109133

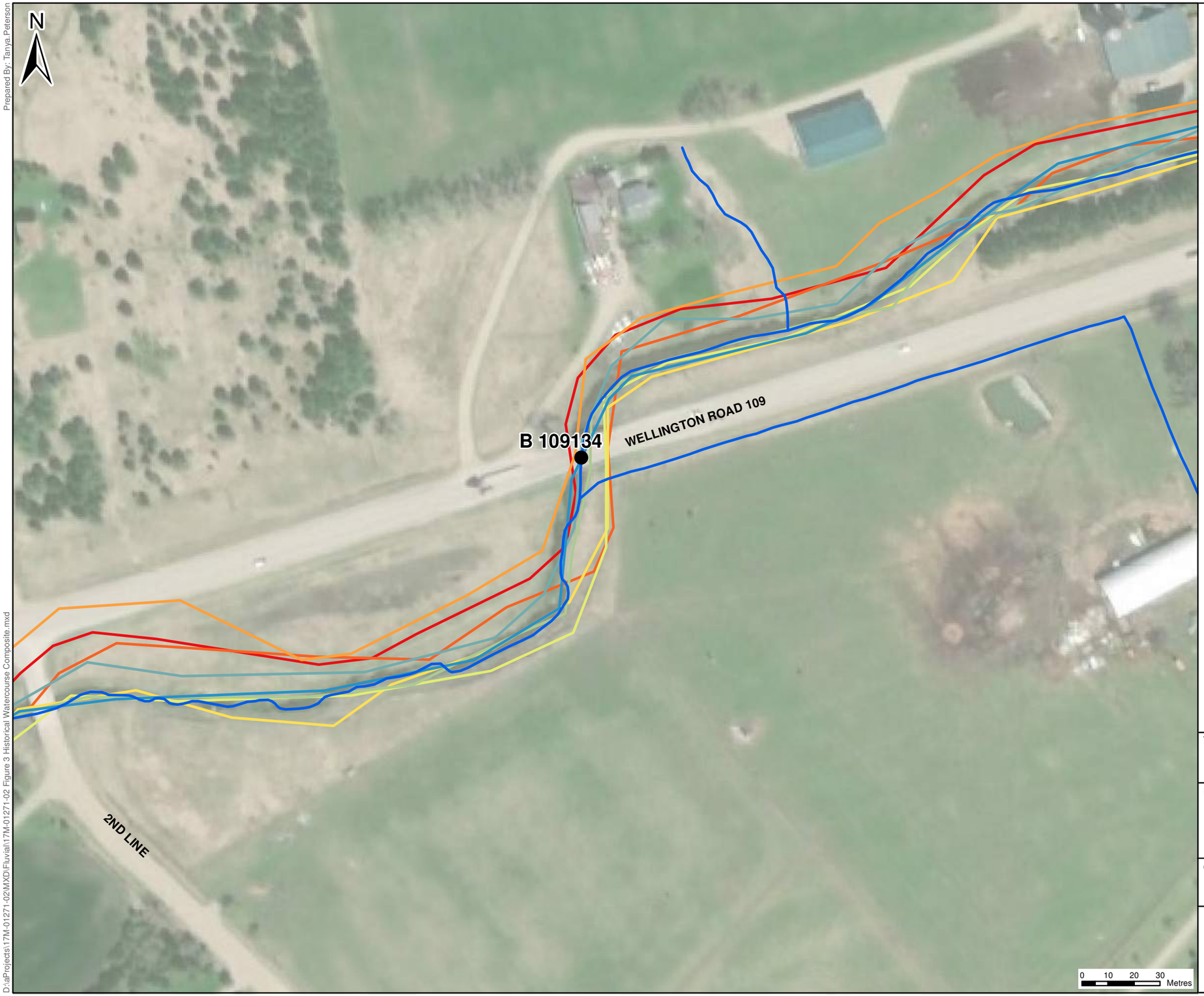
PROJECT:
FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:
WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: NOVEMBER 2021	FIGURE: **5**

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3 Historical Watercourse Composite.mxd

Prepared By: Tanya.Peterson



LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE:
HISTORICAL WATERCOURSE PATHS
CULVERT B 109134

PROJECT:
FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:
WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: NOVEMBER 2021	FIGURE: 6

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3 Historical Watercourse Composite.mxd

APPENDIX

A

INDIVIDUAL HISTORICAL AERIALS (1930, 1954, 1969, 1976, 1980, 1990, 2000, 2010, 2018)

LEGEND:

- CULVERT CROSSINGS
- STUDY AREA

Historical Watercourse Path

- 1930

TITLE: **1930 HISTORICAL AERIAL**

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

PROJECT NO.:	REVIEWED BY:
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DATE: APRIL 2022	FIGURE: i

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LEGEND:

- CULVERT CROSSINGS
- STUDY AREA

Historical Watercourse Path

- 1954

TITLE:

1954 HISTORICAL AERIAL

PROJECT:

FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:

WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: APRIL 2022	FIGURE: ii

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure ii Historical Aerials.mxd

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N

B 109134

B 109133

B 109123

B 109132

LEGEND:

CULVERT CROSSINGS

STUDY AREA

Historical Watercourse Path

1969

TITLE:

1969 HISTORICAL AERIAL

PROJECT:

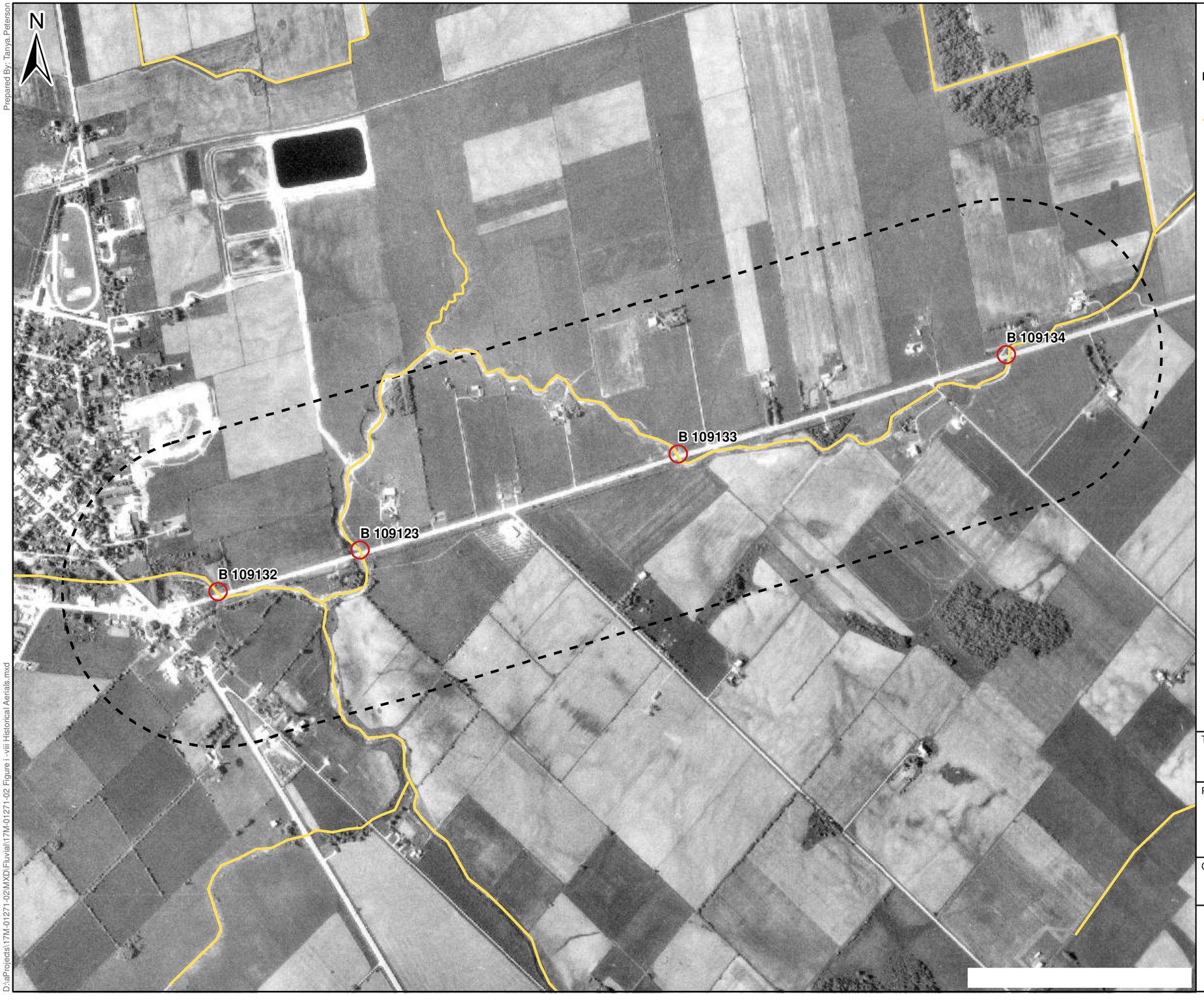
FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:

WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: APRIL 2022	FIGURE: iii

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure i - viii Historical Aerials.mxd



LEGEND:

- CULVERT CROSSINGS
- STUDY AREA

Historical Watercourse Path

- 1976

TITLE:

1976 HISTORICAL AERIAL

PROJECT:

FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

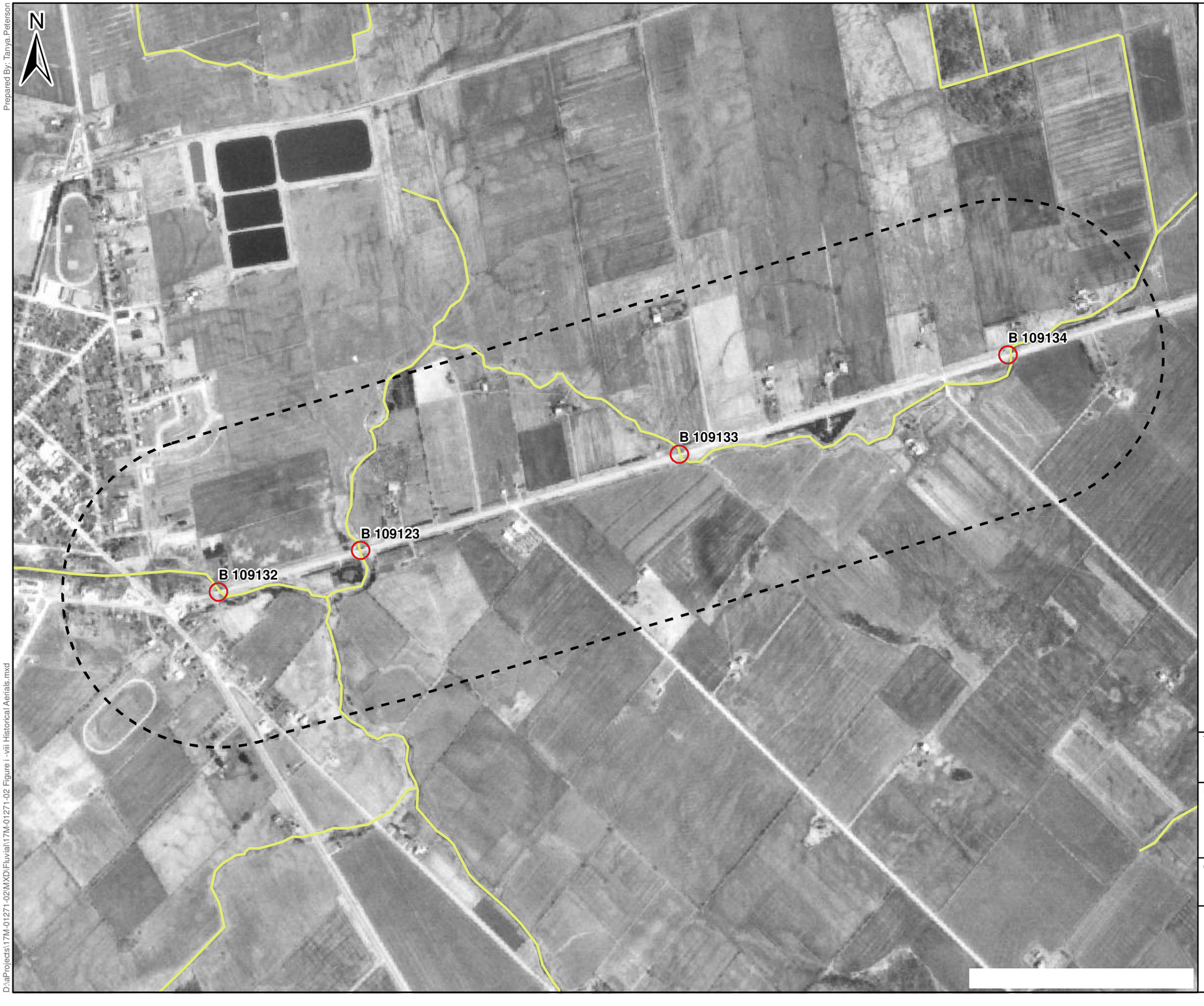
CLIENT:

WELLINGTON COUNTY

	PROJECT NO.: 17M-01271-02	REVIEWED BY: PH
	DATE: APRIL 2022	FIGURE: iv

Prepared By: Tanya.Peterson

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure i - viii Historical Aerials.mxd



LEGEND:

- CULVERT CROSSINGS
- STUDY AREA

Historical Watercourse Path

- 1980

TITLE:

1980 HISTORICAL AERIAL

PROJECT:

FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:

WELLINGTON COUNTY

PROJECT NO.:	REVIEWED BY:
17M-01271-02	PH
DATE: APRIL 2022	FIGURE: **V**

Prepared By: Tanya.Peterson

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure i -viii Historical Aerials.mxd

Prepared By: Tanya.Peterson

LEGEND:

- CULVERT CROSSINGS
- STUDY AREA

Historical Watercourse Path

- 1990

TITLE:

1990 HISTORICAL AERIAL

PROJECT:

FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:

WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: APRIL 2022	FIGURE: vi

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure vi Historical Aerials.mxd

Prepared By: Tanya.Peterson

N

B 109134

B 109133

B 109123

B 109132

LEGEND:

CULVERT CROSSINGS

STUDY AREA

Historical Watercourse Path

2000

TITLE:

2000 HISTORICAL AERIAL

PROJECT:

FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:

WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: APRIL 2022	FIGURE: **vii**

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure vii Historical Aerials.mxd

Prepared By: Tanya.Peterson

LEGEND:

- CULVERT CROSSINGS
- STUDY AREA

Historical Watercourse Path

- 2010

TITLE:

2010 HISTORICAL AERIAL

PROJECT:

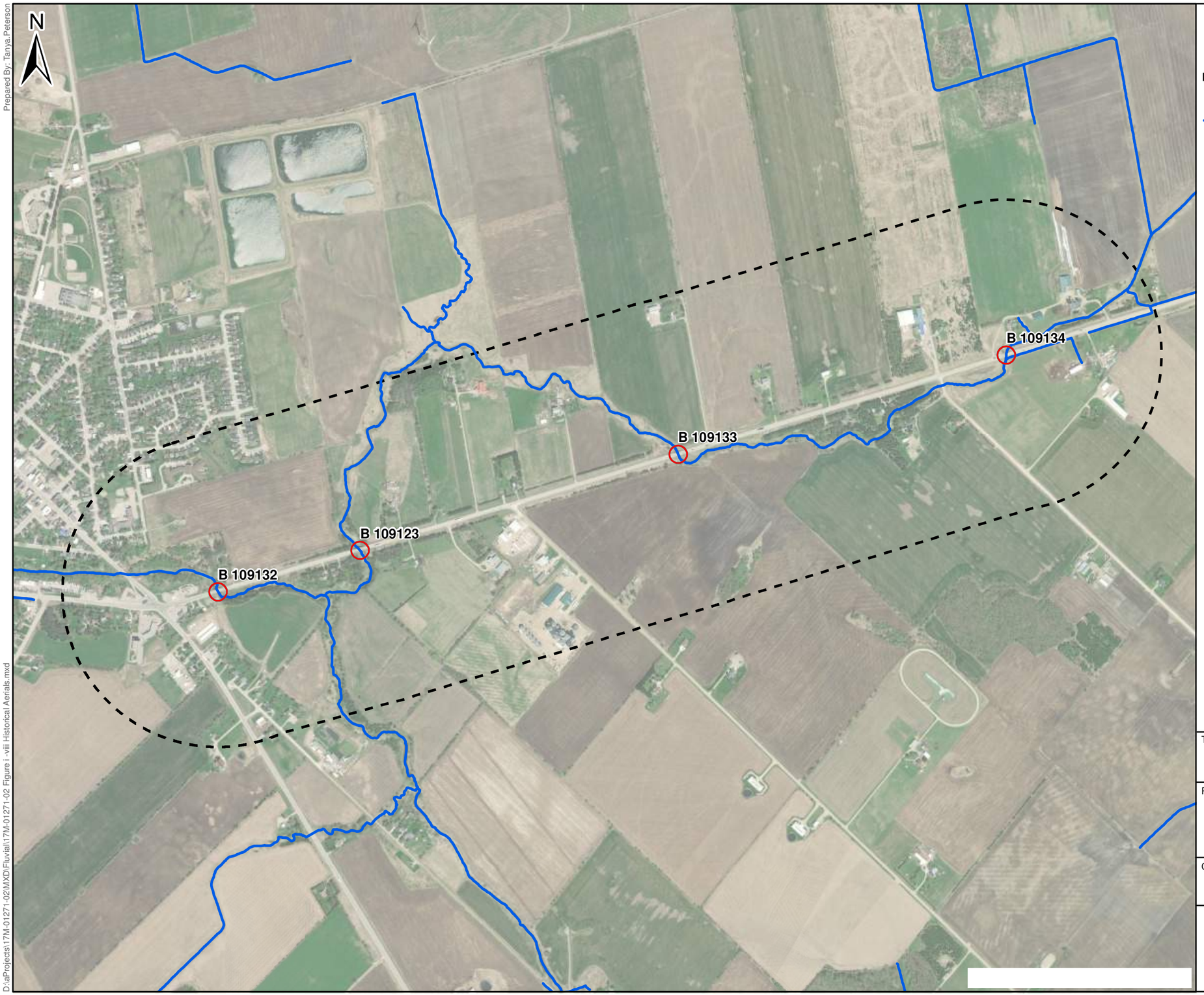
FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:

WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: APRIL 2022	FIGURE: **viii**

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure viii Historical Aerials.mxd



LEGEND:

- CULVERT CROSSINGS
- STUDY AREA

Historical Watercourse Path

- 2018

TITLE:

2018 HISTORICAL AERIAL

PROJECT:

FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT:

WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: APRIL 2022	FIGURE: ix

Prepared By: Tanya.Peterson

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure i - viii Historical Aerials.mxd

APPENDIX

B

SITE PHOTOGRAPHS AND RAPID GEOMORPHIC ASSESMENT (RGA) FORMS

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 15: B109132 looking south upstream

Photo 16: B109132 looking north downstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 17: B109132 looking north downstream

Photo 18: B109132 looking north downstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 19: B109132 looking south upstream

Photo 20: B109132 looking south upstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 9: B109123 looking south downstream

Photo 10: B109123 looking north upstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 11: B109123 looking north upstream

Photo 12: B109123 looking north upstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 13: B109123 looking south downstream

Photo 14: B109123 looking southwest at bank material

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 7: B109133 looking northeast downstream

Photo 8: B109133 looking north downstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 7: B109133 looking northeast downstream

Photo 8: B109133 looking southeast upstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 7: B109133 looking north downstream

Photo 8: B109133 looking south upstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 1: B109134 looking northeast at bridge

Photo 2: B109134 looking at bed sediment

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 3: B109134 looking north upstream

Photo 4: B109134 looking north upstream

Site Photographs – November 1, 2021
Wellington Road 109 Schedule C Municipal Class Environmental Assessment

Photo 5: B109134 looking south downstream

Photo 6: B109134 looking south downstream

Rapid Geomorphic Assessment (RGA)

Dominant Process (AI, DI, WI, PI): AI

Date: Nov. 1, 2021 Reach: B109134

Project: WR 109 Crew: ES, AL

Form / Process	#	Geomorphic Indicator: Description	Present? No	Present? Yes	Factor Value
Evidence of Aggradation (AI)	1	Lobate Bar	X		
	2	Coarse materials in riffles embedded	X		**Sum of Indicies**
	3	Siltation in pools		X	# of No's:
	4	Medial bars	X		# of Yes's: 2
	5	Accretion on point bars	X		Total #: 7
	6	Poor longitudinal sorting of bed materials		X	# of Yes's / Total # 0.3
	7	Deposition in the overbank zone	Y		
		Buried structures	X		
		Buried soils	X		
		Eroding banks at shallows	X		
		Contracting bridge space	X		
		Deep fine sediment over coarse gravels in banks	X		
		Many unvegetated point bars	X		
		Large silt/clay banks	X		
Evidence of Degradation (DI) (#6-Incision)	1	Exposed bridge footing(s)	X		
	2	Exposed sanitary / storm sewer / pipeline / etc.	X		
	3	Elevated storm sewer outfall(s)	X		**Sum of Indicies**
	4	Undermined gabion baskets / concrete aprons / etc	X		# of No's:
	5	Scour pools d/s of culverts / storm sewer outlets	X		# of Yes's: 1
	6	Cut face on bar forms	X		Total #: 10
	7	Head cutting due to knick point migration	X		# of Yes's / Total # 0.1
	8	Terrace cut through older bar material	X		
	9	Suspended armour layer visible in bank	X		
	10	Channel worn into undisturbed overburden/ bedrock		X	
		Terraces		X	
		Old channels	X		
		Old slope failures	X		
		Perched boulder berms	X		
		Exposed tree roots (both banks)	X		
		Narrow/deep channel		X	
		Bank failures, both banks	X		
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		**Sum of Indicies**
	4	Basal scour on inside meander bends	X		# of No's:
	5	Basal scour on both sides of channel through riffle	X		# of Yes's: 0
	6	Gabion baskets / concrete walls / etc. out flanked	X		Total #: 10
	7	Length of basal scour >50% through subject reach	X		# of Yes's / Total # 0
	8	Exposed length of previously buried pipe/ cable/ etc	X		
	9	Fracture lines along top of bank	X		
	10	Exposed building foundation	X		
		Bank Failure (both banks)	X		
		Evolvement of new planform at lower elevation	X		
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	X		
	2	Single thread channel to multiple channel	X		**Sum of Indicies**
	3	Evolution of pool-riffle form to low bed relief form	X		# of No's:
	4	Cut-off channel(s)	X		# of Yes's: 1
	5	Formation of island(s)	X		Total #: 7
	6	Thalweg alignment out of phase meander form		X	# of Yes's / Total # 0.1
	7	Bar forms poorly formed / reworked / removed	X		
		A significant number of bank erosion areas	X		
Evidence of Stability / Evidence of Narrowing (last one)		Vegetated bars and banks		X	
		Compacted weed covered beds	X		
		Bank erosion rare		X	
		Old structures in position		X	
		Sedimentation on both channel margins	X		

STABILITY INDEX (SI) = (AI+DI+WI+PI)/4 **STABILITY INDEX:** 0.132142857

SI < 0.20 = In regime, 0.21-0.40 = Transitional, >0.41 = Adjusting **CONDITION:** In Regime

Rapid Geomorphic Assessment (RGA)

Dominant Process (AI, DI, WI, PI): DI

Date: Nov. 1, 2021 Reach: B109133

Project: WR 109 Crew: ES, AL

Form / Process	#	Geomorphic Indicator Description	Present? No	Present? Yes	Factor Value
Evidence of Aggradation (AI)	1	Lobate Bar	X		
	2	Coarse materials in riffles embedded	X		**Sum of Indicies**
	3	Siltation in pools	X		# of No's:
	4	Medial bars	X		# of Yes's: 0
	5	Accretion on point bars	X		Total #: 7
	6	Poor longitudinal sorting of bed materials	X		# of Yes's / Total # 0
	7	Deposition in the overbank zone	X		
		Buried structures		X	
		Buried soils		X	
		Eroding banks at shallows	X		
		Contracting bridge space	X		
		Deep fine sediment over coarse gravels in banks	X		
		Many unvegetated point bars	X		
		Large silt/clay banks		X	
Evidence of Degradation (DI) (#6-Incision)	1	Exposed bridge footing(s)	X		
	2	Exposed sanitary / storm sewer / pipeline / etc.		X	
	3	Elevated storm sewer outfall(s)		X	**Sum of Indicies**
	4	Undermined gabion baskets / concrete aprons / etc	X		# of No's:
	5	Scour pools d/s of culverts / storm sewer outlets	X		# of Yes's: 3
	6	Cut face on bar forms	X		Total #: 10
	7	Head cutting due to knick point migration	X		# of Yes's / Total # 0.3
	8	Terrace cut through older bar material	X		
	9	Suspended armour layer visible in bank	X		
	10	Channel worn into undisturbed overburden/ bedrock		X	
		Terraces	X		
		Old channels	X		
		Old slope failures	X		
		Perched boulder berms	X		
		Exposed tree roots (both banks)	X		
		Narrow/deep channel		X	
		Bank failures, both banks	X		
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		**Sum of Indicies**
	4	Basal scour on inside meander bends	X		# of No's:
	5	Basal scour on both sides of channel through riffle	X		# of Yes's: 1
	6	Gabion baskets / concrete walls / etc. out flanked	X		Total #: 10
	7	Length of basal scour >50% through subject reach	X		# of Yes's / Total # 0.1
	8	Exposed length of previously buried pipe/ cable/ etc		X	
	9	Fracture lines along top of bank	X		
	10	Exposed building foundation	X		
		Bank Failure (both banks)	X		
		Evolvement of new planform at lower elevation	X		
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	X		
	2	Single thread channel to multiple channel	X		**Sum of Indicies**
	3	Evolution of pool-riffle form to low bed relief form	X		# of No's:
	4	Cut-off channel(s)	X		# of Yes's: 0
	5	Formation of island(s)	X		Total #: 7
	6	Thalweg alignment out of phase meander form	X		# of Yes's / Total # 0
	7	Bar forms poorly formed / reworked / removed	X		
		A significant number of bank erosion areas	X		
Evidence of Stability / Evidence of Narrowing (last one)		Vegetated bars and banks		X	
		Compacted weed covered beds	X		
		Bank erosion rare		X	
		Old structures in position		X	
		Sedimentation on both channel margins	X		

STABILITY INDEX (SI) = (AI+DI+WI+PI)/4 **STABILITY INDEX:** 0.1

SI < 0.20 = In regime, 0.21-0.40 = Transitional, >0.41 = Adjusting **CONDITION:** In Regime

Rapid Geomorphic Assessment (RGA)

Dominant Process (AI, DI, WI, PI): AI

Date: Nov. 1, 2021 Reach: B109123

Project: WR 109 Crew: ES, AL

Form / Process	#	Geomorphic Indicator Description	Present? No	Present? Yes	Factor Value	
Evidence of Aggradation (AI)	1	Lobate Bar		X		
	2	Coarse materials in riffles embedded		X	**Sum of Indicies**	
	3	Siltation in pools		X	# of No's:	
	4	Medial bars		X	# of Yes's:	4
	5	Accretion on point bars	X		Total #:	7
	6	Poor longitudinal sorting of bed materials	X		# of Yes's / Total #	0.6
	7	Deposition in the overbank zone	X			
		Buried structures	X			
		Buried soils		X		
		Eroding banks at shallows		X		
		Contracting bridge space	X			
		Deep fine sediment over coarse gravels in banks	X			
		Many unvegetated point bars	X			
		Large silt/clay banks	X			
Evidence of Degradation (DI) (#6-Incision)	1	Exposed bridge footing(s)	X			
	2	Exposed sanitary / storm sewer / pipeline / etc.	X			
	3	Elevated storm sewer outfall(s)	X		**Sum of Indicies**	
	4	Undermined gabion baskets / concrete aprons / etc	X		# of No's:	
	5	Scour pools d/s of culverts / storm sewer outlets	X		# of Yes's:	1
	6	Cut face on bar forms	X		Total #:	10
	7	Head cutting due to knick point migration	X		# of Yes's / Total #	0.1
	8	Terrace cut through older bar material	X			
	9	Suspended armour layer visible in bank	X			
	10	Channel worn into undisturbed overburden/ bedrock		X		
		Terraces	X			
		Old channels	X			
		Old slope failures		X		
		Perched boulder berms	X			
		Exposed tree roots (both banks)	X			
		Narrow/deep channel	X			
		Bank failures, both banks	X			
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X			
	2	Occurrence of large organic debris	X			
	3	Exposed tree roots	X		**Sum of Indicies**	
	4	Basal scour on inside meander bends	X		# of No's:	
	5	Basal scour on both sides of channel through riffle	X		# of Yes's:	0
	6	Gabion baskets / concrete walls / etc. out flanked	X		Total #:	10
	7	Length of basal scour >50% through subject reach	X		# of Yes's / Total #	0
	8	Exposed length of previously buried pipe/ cable/ etc	X			
	9	Fracture lines along top of bank	X			
	10	Exposed building foundation	X			
		Bank Failure (both banks)	X			
		Evolvement of new planform at lower elevation	X			
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	X			
	2	Single thread channel to multiple channel		X	**Sum of Indicies**	
	3	Evolution of pool-riffle form to low bed relief form	X		# of No's:	
	4	Cut-off channel(s)	X		# of Yes's:	3
	5	Formation of island(s)		X	Total #:	7
	6	Thalweg alignment out of phase meander form		X	# of Yes's / Total #	0.4
	7	Bar forms poorly formed / reworked / removed	X			
		A significant number of bank erosion areas	X			
Evidence of Stability / Evidence of Narrowing (last one)		Vegetated bars and banks	X			
		Compacted weed covered beds	X			
		Bank erosion rare		X		
		Old structures in position		X		
		Sedimentation on both channel margins	X			

STABILITY INDEX (SI) = (AI+DI+WI+PI)/4 **STABILITY INDEX:** 0.275

SI < 0.20 = In regime, 0.21-0.40 = Transitional, >0.41 = Adjusting **CONDITION:** Transitional

Rapid Geomorphic Assessment (RGA)

Dominant Process (AI, DI, WI, PI): AI

Date: Nov. 1, 2021 Reach: B109132

Project: WR 109 Crew: ES, AL

Form / Process	#	Geomorphic Indicator Description	Present? No	Present? Yes	Factor Value
Evidence of Aggradation (AI)	1	Lobate Bar	X**	X	
	2	Coarse materials in riffles embedded		X	**Sum of Indicies**
	3	Siltation in pools		X	# of No's:
	4	Medial bars		X	# of Yes's: 5
	5	Accretion on point bars	X		Total #: 7
	6	Poor longitudinal sorting of bed materials		X	# of Yes's / Total # 0.7
	7	Deposition in the overbank zone	X		
		Buried structures		X	
		Buried soils		X	
		Eroding banks at shallows	X		
		Contracting bridge space	X		
		Deep fine sediment over coarse gravels in banks	X		
		Many unvegetated point bars	X		
		Large silt/clay banks	X		
Evidence of Degradation (DI) (#6-Incision)	1	Exposed bridge footing(s)	X		
	2	Exposed sanitary / storm sewer / pipeline / etc.		X	
	3	Elevated storm sewer outfall(s)	X		**Sum of Indicies**
	4	Undermined gabion baskets / concrete aprons / etc	X		# of No's:
	5	Scour pools d/s of culverts / storm sewer outlets	X		# of Yes's: 2
	6	Cut face on bar forms	X		Total #: 10
	7	Head cutting due to knick point migration	X		# of Yes's / Total # 0.2
	8	Terrace cut through older bar material	X		
	9	Suspended armour layer visible in bank	X		
	10	Channel worn into undisturbed overburden/ bedrock		X	
		Terraces	X		
		Old channels	X		
		Old slope failures	X		
		Perched boulder berms	X		
		Exposed tree roots (both banks)		X	
		Narrow/deep channel	X		
		Bank failures, both banks	X		
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		X	
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots		X	**Sum of Indicies**
	4	Basal scour on inside meander bends	X		# of No's:
	5	Basal scour on both sides of channel through riffle	X		# of Yes's: 3
	6	Gabion baskets / concrete walls / etc. out flanked	X		Total #: 10
	7	Length of basal scour >50% through subject reach	X		# of Yes's / Total # 0.3
	8	Exposed length of previously buried pipe/ cable/ etc		X	
	9	Fracture lines along top of bank	X		
	10	Exposed building foundation	X		
		Bank Failure (both banks)	X		
		Evolvement of new planform at lower elevation	X		
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	X		
	2	Single thread channel to multiple channel	X		**Sum of Indicies**
	3	Evolution of pool-riffle form to low bed relief form		X	# of No's:
	4	Cut-off channel(s)	X		# of Yes's: 3
	5	Formation of island(s)		X	Total #: 7
	6	Thalweg alignment out of phase meander form		X	# of Yes's / Total # 0.4
	7	Bar forms poorly formed / reworked / removed	X		
		A significant number of bank erosion areas	X		
Evidence of Stability / Evidence of Narrowing (last one)		Vegetated bars and banks		X	
		Compacted weed covered beds	X		
		Bank erosion rare		X	
		Old structures in position		X	
		Sedimentation on both channel margins	X		

STABILITY INDEX (SI) = (AI+DI+WI+PI)/4 **STABILITY INDEX:** 0.410714286

SI < 0.20 = In regime, 0.21-0.40 = Transitional, >0.41 = Adjusting **CONDITION:** Adjusting

APPENDIX

C MEANDER BELT ASSESSMENT AND EROSION RATE ANLYSIS

Prepared By: NureddinN

N

0 200 400 600 Metres

LEGEND:

GENERAL STUDY AREA

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE:

HISTORICAL WATERCOURSE PATHS

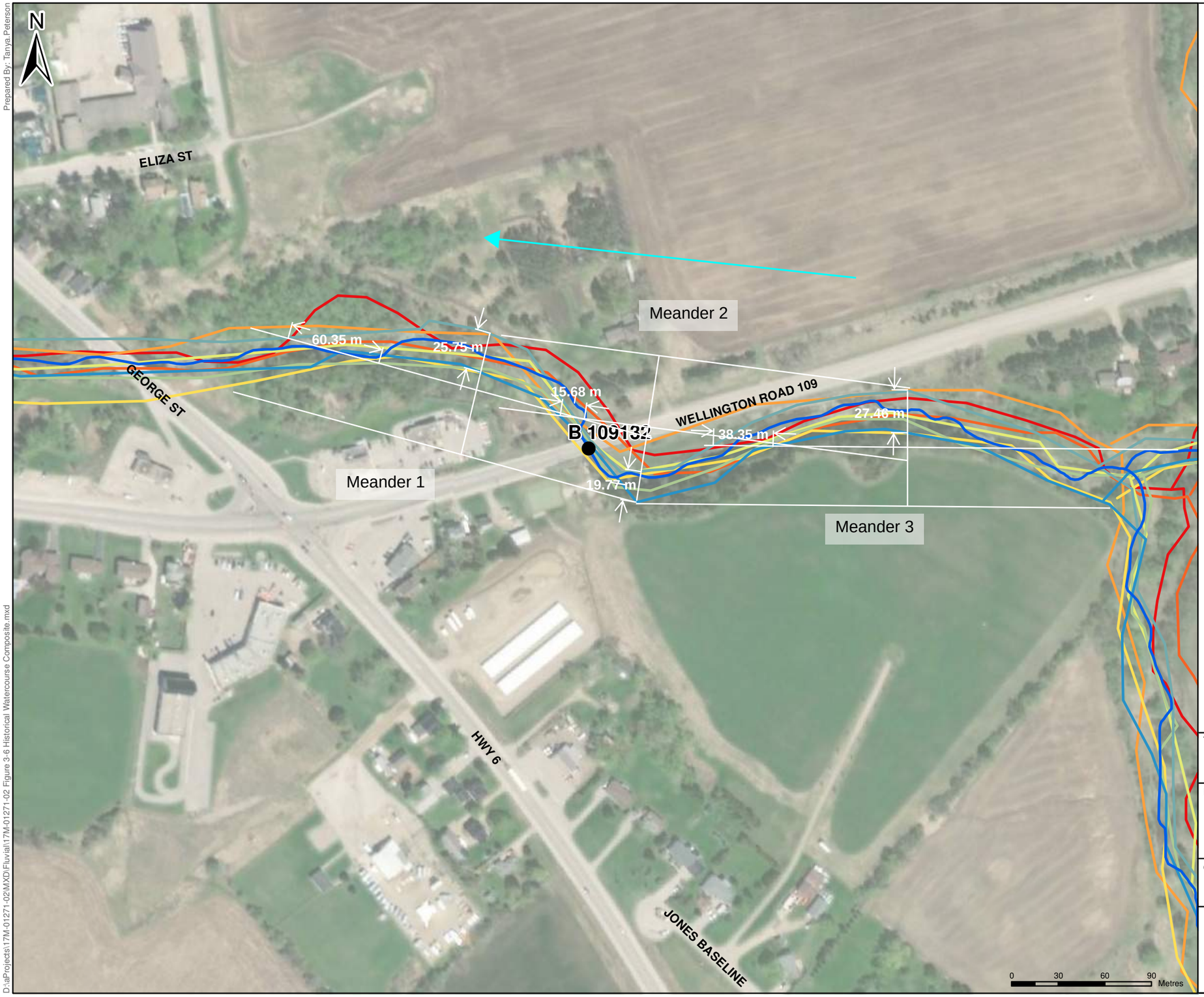
PROJECT: HYDROGEOLOGICAL INVESTIGATION
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: NOVEMBER 2020	FIGURE: D-1

J:\1442 Projects by Job Number\2017\17M-01271-02\MXD\Figure 13 Historical Watercourse Composite.mxd

Prepared By: Tanya.Peterson



LEGEND:

- CULVERT CROSSINGS

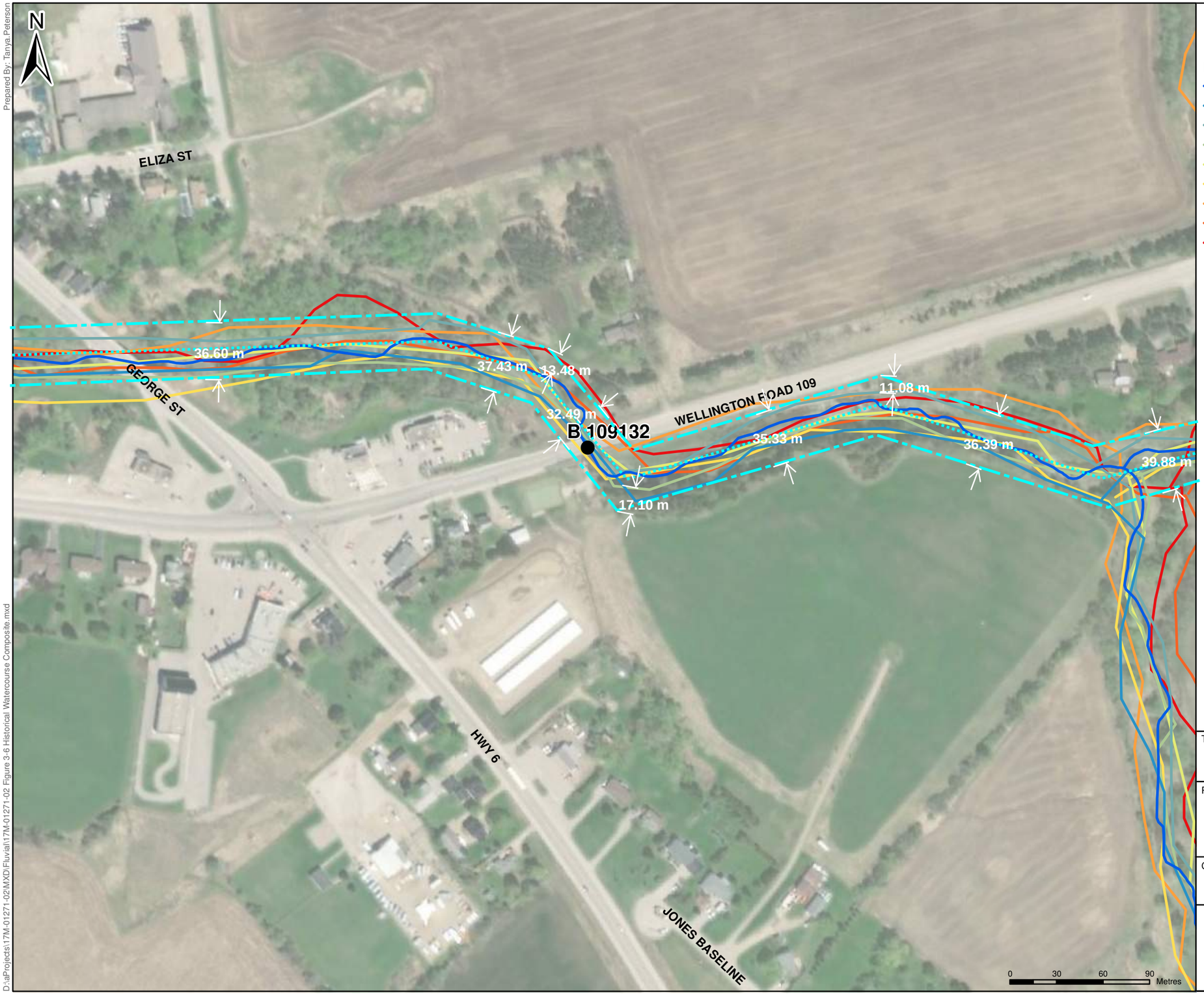
HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE:	Culvert B109132 - Lateral and Down-Valley Erosion Rates
PROJECT:	FLUVIAL ASSESSMENT WELLINGTON ROAD 109 BETWEEN HIGHWAY 6 AND SIDEROAD 7 ARTHUR, ONTARIO
CLIENT:	WELLINGTON COUNTY

wsp	PROJECT NO.: 17M-01271-02	REVIEWED BY: PH
	DATE: NOVEMBER 2021	FIGURE: D-2

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3-6 Historical Watercourse Composite.mxd



LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE: Culvert B109132 - Meander Belt Assessment

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

	PROJECT NO.: 17M-01271-02	REVIEWED BY: PH
	DATE: NOVEMBER 2021	FIGURE: D-3

Prepared By: Tanya.Peterson

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3-6 Historical Watercourse Composite.mxd

Meander 2

Prepared By: Tanya.Peterson

N

Meander 6

11.94 m

32.28 m

B 109123

Meander 5

WELLINGTON ROAD 109

Meander 4

20.45 m

111.77 m

17.83 m

27.96 m

LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE: Culvert B109123 - Lateral and Down-Valley Erosion Rates

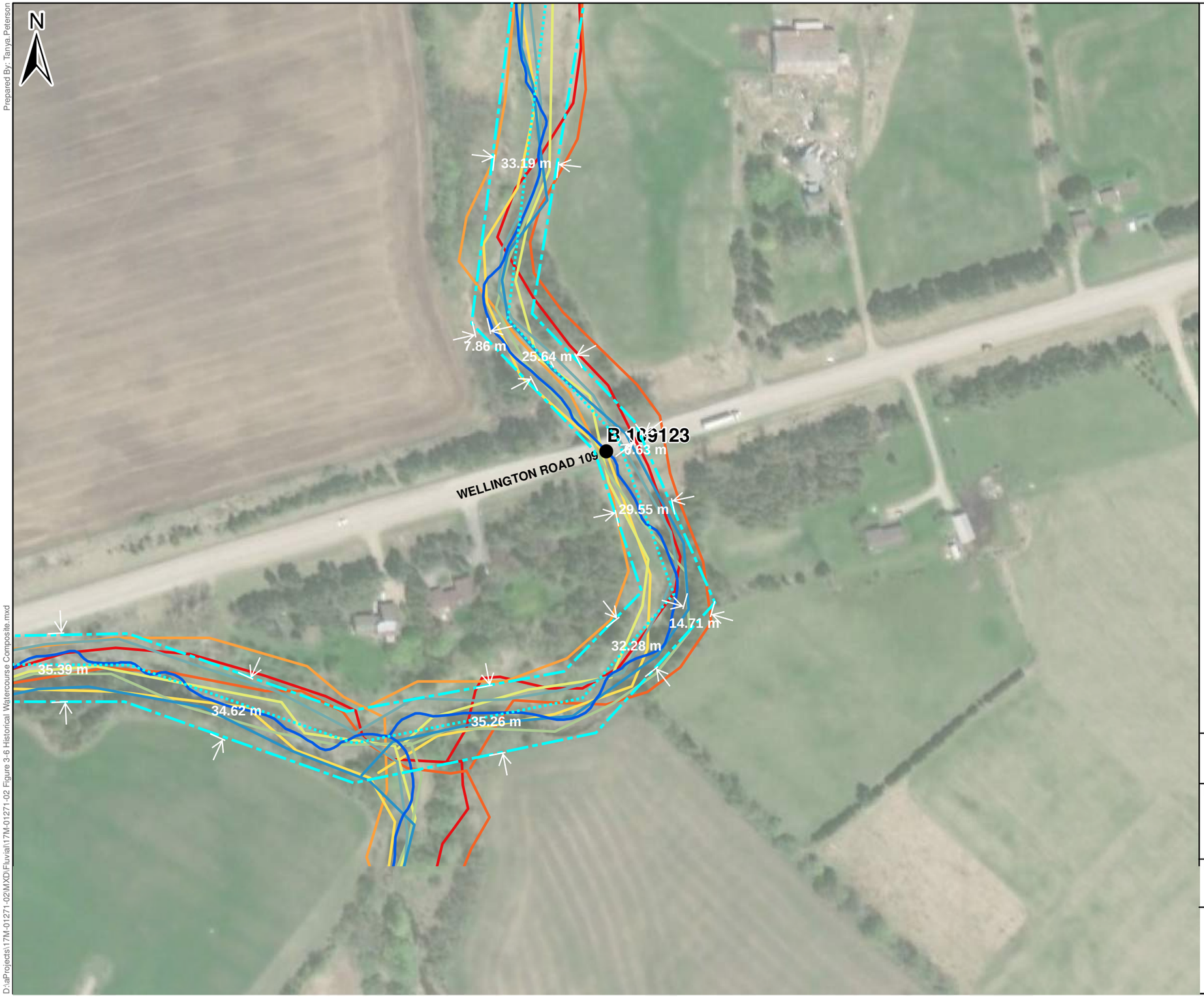
PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: NOVEMBER 2021	FIGURE: D-4

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3-6 Historical Watercourse Composite.mxd

Meander 2



LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE: Culvert B109123 - Meander Belt Assessment

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: NOVEMBER 2021	FIGURE: D-5

Prepared By: Tanya.Peterson

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3-6 Historical Watercourse Composite.mxd

LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE: Culvert B109133 - Lateral and Down-Valley Erosion Rates

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: NOVEMBER 2021	FIGURE: D-6

Prepared By: Tanya.Peterson

D:\aProjects\17M-01271-02\MXD\Fluvial\17M-01271-02 Figure 3-6 Historical Watercourse Composite.mxd

LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE: Culvert B109133 - Meander Belt Assessment

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

wsp	PROJECT NO.: 17M-01271-02	REVIEWED BY: PH
	DATE: NOVEMBER 2021	FIGURE: D-7

Prepared By: Tanya.Peterson

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LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE:	Culvert B109134 - Lateral and Down-Valley Erosion Rates
PROJECT:	FLUVIAL ASSESSMENT WELLINGTON ROAD 109 BETWEEN HIGHWAY 6 AND SIDEROAD 7 ARTHUR, ONTARIO
CLIENT:	WELLINGTON COUNTY

wsp	PROJECT NO.: 17M-01271-02	REVIEWED BY: PH
	DATE: NOVEMBER 2021	FIGURE: D-8

Prepared By: Tanya.Peterson

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LEGEND:

- CULVERT CROSSINGS

HISTORICAL WATERCOURSE PATH

- 2018
- 2010
- 2000
- 1990
- 1980
- 1976
- 1969
- 1954
- 1930

TITLE: Culvert B109134 - Meander Belt Assessment

PROJECT: FLUVIAL ASSESSMENT
WELLINGTON ROAD 109 BETWEEN
HIGHWAY 6 AND SIDEROAD 7
ARTHUR, ONTARIO

CLIENT: WELLINGTON COUNTY

	PROJECT NO.:	REVIEWED BY:
wsp	17M-01271-02	PH
	DATE: NOVEMBER 2021	FIGURE: D-9

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