GERMAN MILLS CREEK GEOMORPHIC SYSTEMS MASTER PLAN MONITORING REPORT

APPENDIX E

Prepared for:
CITY OF TORONTO

Prepared by:
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Version 1.0
December 2024
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APPENDIX E
Monitoring Report

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SHORT TERM EROSION MONITORING REPORT

Prepared for the City of Toronto, January 2023

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1 INTRODUCTION

Matrix Solutions Inc. is pleased to submit this monitoring technical report outlining the results of the short-term, 2-year erosion monitoring program completed at three sites within the German Mills Creek Geomorphic Systems Master Plan (GSMP) study area (Figure 1). The GSMP study area focuses on a 2 km length of German Mills Creek along the northern boundary of Toronto, Ontario, and was identified in the 2003 *Wet Weather Flow Management Master Plan, Overview and Implementation Plan* (2003 WWFMP ; City of Toronto 2003) as a priority for stream restoration (Don River, Area 4, Reach 17).

Three erosion monitoring sites were selected within reaches GM-1, GM-2, and GM-3 at locations where geomorphic change was expected. At these locations, stream morphology was characterized once annually (in the fall) through a detailed channel survey of the longitudinal bed profile and monumented cross-sections. Repeat substrate characterization and flow measurements were also included as part of the monitoring. Ecological monitoring was also completed along transects within the monitoring sites and consisted of an aquatic habitat assessment following the provincial Ontario Stream Assessment Protocol (OSAP), benthic macroinvertebrate sampling, and water quality sampling.

2 GEOMORPHIC MONITORING

A detailed geomorphological assessment was completed as part of the establishment of the erosion monitoring sites for German Mills Creek. Detailed geomorphic data was collected within three erosion monitoring areas once annually:

- MON1: located downstream of Steeles Avenue, upstream of pedestrian bridge
- MON2: located between trail bridge and downstream pedestrian bridge
- MON3: located downstream of confluence

Monitoring site locations are presented in Figure 1.

Year 1 and Year 2 geomorphic monitoring were completed in September 2021 and 2022, respectively. Each year, the survey consisted of six cross-sections and a longitudinal profile in each of the three monitoring areas. To ensure the entire active channel was encompassed by the survey, cross-sections were extended several metres beyond the top of the bank. Within the study area, the top of bank often does not correspond to the bankfull channel, due to channel entrenchment and confinement at valley contacts. The bankfull channel can be defined as the channel geometry that results from the channel-forming discharge. The channel-forming discharge has come to be associated with the 1- or 2-year flow in natural or equilibrium watercourses. In natural unconfined systems bankfull indicators include the elevation at which the channel spills into the floodplain, which is also often marked by changes in vegetation and the degree of bank exposure, among other indicators. Within the study area, standard protocols and known field indicators such as vegetation and breaks in slope were used to identify the bankfull dimensions within the entrenched channel where possible.

Longitudinal surveys were completed through the monitoring sites during both monitoring years. This provides a measure of the local energy gradient and identifies fundamental elements of the channel bed morphology (i.e., riffle crests and maximum pool depths) and changes in morphology during the monitoring interval. Longitudinal survey points were taken at 2 to 3 m intervals and at inflection points on the channel bed.

Repeat photographs were taken in both monitoring years (eight photographs per monitoring site) to provide a visual comparison of channel conditions.

A modified Wolman pebble count was completed to characterize the channel bed substrate materials. This procedure involved the measurement of 300 individual clasts within each monitoring area. The pebble counts included clasts of 0.5 cm diameter and larger, which were collected at riffle cross-sections to characterize the erosion-resistant component of the bed substrate. Visual observations of finer materials were also completed to characterize local variation within the reach and the overall substrate composition of the reach as a whole. Additional probing of substrates was completed over sewer pipe crossings to target depths of at least 0.3 m where feasible.

2.1 Channel Geometry

2.1.1 Cross-sections

Bankfull channel dimensions are presented in Tables A, B, and C, and overlays of the Year 1 and Year 2 surveyed cross-sections are presented in Appendix B. Cross-sections are presented looking upstream. Although all cross-sections were surveyed along either a measuring tape or digital GPS line, some variation was encountered in the field. To correct for this and improve the accuracy of the comparison between monitoring years, the cross-section survey data were straightened during the desktop analysis using a standard spatial adjustment tool. In some cross-sections, the bankfull elevations identified in 2021 were revised based on indicators observed in 2022. This has resulted in some minor variation from the bankfull channel dimensions that were presented in the GSMP Phase 2 report (Matrix 2022).

The surveyed channel cross-sections extended beyond the channel banks to document changes in the bankfull and entrenched channel over time. Total cross-section length ranged from approximately 17 to 37 m in width. Bankfull widths ranged from 7.07 to 15.55 m among all surveyed cross-sections in 2021 and 2022. The average bankfull width was smallest in MON2 (<10 m), larger in MON1 (11 to 12 m) and widest in MON3 (12 to 13 m). The average bankfull depth among all sites ranged from 0.53 to 1.21 m among all surveyed cross-sections. The maximum bankfull depth among all sites was 2.09 m within the riprap-lined section below MON-1. Bankfull elevation was difficult to confidently discern in the most entrenched (MON-1; refer to Section 2.1.2) and modified (MON-2 near pedestrian bridge) sections. The average bankfull cross-sectional area among all sites was 13.34 m^2 in 2021 and 13.29 m^2 in 2022. Bank heights were generally between 1.0 and 3.5 m. The north bank of cross-section MON2-1 is confined by a valley contact and railway embankment with an elevation of approximately 5.0 m. At MON3-6 the channel flows along the toe of a valley wall contact, and the north bank height is 4.5 m. Bank erosion of up to 0.98 m (MON1-3), 0.6 m (MON2-1), and 2.3 m (MON3-1; note the high value is related to movement of a tree root ball) was recorded in MON1, MON2, and MON3, respectively.

Morphological adjustments observed between monitoring years:

- MON1: This is a meandering reach with erodible sandy banks, an entrenched channel (refer to Section 2.1.2) and is impacted by local hardening and an exposed manhole. The three most upstream sections (MON1-1, MON1-2, and MON1-3) underwent changes in the channel bed profile due to the mobility of the coarse mid-channel bar and point bar. These sections are located downstream of the scour pool at the armourstone wall and may be prone to episodic mobilization of bed materials because of the energy deflected off the armourstone wall. MON1-2 and MON1-3 appear to have experienced some recession of the inside (west) bank of the meander, which is out of phase with the planform. At MON1-3 the outer bank (east bank) slumped which shifted the thalweg away from that bank. The three most downstream sections (MON1-4, MON1-5, and MON1-6) underwent less change in cross-sectional profile; some deepening at the thalweg (MON1-4 and MON1-5) and bank recession or slumping (MON1-5 and MON1-6) was observed.

- MON2: This is a straightened reach with extensive erosion protection near the bridges at the upstream and downstream ends of the site. Five of the six cross-sections underwent some widening at the interpreted bankfull elevation. MON2-1 widened the most due to local movement of riprap near bankfull elevation, although the overall bank profile remained largely the same. Change in channel above bankfull was greatest at MON2-2, also likely due to shifting of riprap. The thalweg at MON2-2 deepened by 11 cm, while the margins of MON2-4 and MON2-5 filled in. Overall, the cross-sections within MON2 underwent less change overall than monitoring sites MON1 and MON3, which is expected as most of the sections are partially or entirely lined with riprap and the planform of the reach is straight.

- MON3: This reach has a meandering planform, erodible sandy bank and an over-widened channel. There is no obvious pattern in the changes in bankfull width; three sections narrowed slightly, two widened, and one remained the same. However, channel depth decreased in five of six cross-sections resulting in a corresponding decrease in channel cross-sectional area. MON3-1 underwent the most change in cross-sectional profile due to channel migration toward the south bank nearest the pedestrian path; as observed in the repeat photos (Appendix B2, Photograph 2), the south bank receded by 2.3 m (large value due to local change in location of tree root ball; not representative of south bank as a whole), and a new tree fell between 2021 and 2022; however, this channel migration occurred without a significant change in bankfull cross-sectional area. Bank migration was generally in phase with the planform, with erosion occurring on the outside of meanders (for instance, migration to the south bank at MON3-1, MON3-3, and MON3-5, and to the north bank at MON3-6).

MON3-2 also indicated some change near the margin of the floodplain, possibly due to erosion from overbank flows.

TABLE A Bankfull Cross-section Dimensions MON1

Cross-section Name	Year	MON1-1	MON1-2	MON1-3	MON1-4	MON1-5	MON1-6
Bankfull Width (m)	2021	13.36	12.16	12.55	11.72	10.52	9.44
	2022	13.00	12.85	13.35	11.34	10.25	9.40
	Change	-0.36(1)	0.69(2)	0.80(2)	-0.38(1)	-0.27(1)	-0.04(1)
Average Bankfull Depth (m)	2021	1.21	0.77	0.73	0.83	0.53	0.64
	2022	1.31	0.74	0.72	0.81	0.64	0.61
	Change	0.10(2)	-0.03(1)	-0.01(1)	-0.02(1)	0.11(2)	-0.03(1)
Maximum Bankfull Depth (m)	2021	1.52	1.41	1.39	1.39	0.89	0.89
	2022	1.57	1.43	1.32	1.45	0.97	0.84
	Change	0.05(2)	0.02(2)	-0.07(1)	0.06(2)	0.08(2)	-0.05(1)
Bankfull Width: Depth	2021	11.04	15.79	17.19	14.12	19.85	14.75
	2022	9.92	17.36	18.54	14.00	16.02	15.41
	Change	-1.12(1)	1.57(2)	1.35(2)	-0.12(1)	-3.83(1)	0.66(2)
Bankfull Cross-sectional Area (m^2)	2021	17.00	17.59	18.36	12.12	22.92	21.79
	2022	15.73	18.85	20.9	12.5	22.62	19.44
	Change	-1.27(1)	1.26(2)	2.54(2)	0.38(2)	-0.30(1)	-2.35(1)
Bank Height (m) (LB, RB)	-	2.0, 1.8	1.9, 1.9	1.7, 1.8	3.0, 3.0	2.3, 3.0	2.5, 2.0
Cross-section Morphology	-	Transitional	Pool	Pool	Riffle	Pool	Riffle

Notes:
(1) Decrease between monitoring years
(2) Increase between monitoring years
LB - left bank looking upstream
RB - right bank looking upstream

TABLE B Bankfull Cross-section Dimensions MON2

Cross-section Name	Year	MON2-1	MON2-2	MON2-3	MON2-4	MON2-5	MON2-6
Bankfull Width (m)	2021	8.48	7.07	11.51	10.13	10.71	9.84
	2022	9.50	7.30	11.24	10.46	10.89	9.88
	Change	1.02(2)	0.23(2)	-0.27(1)	0.33(2)	0.18(2)	0.04(2)
Average Bankfull Depth (m)	2021	1.13	0.98	0.63	0.79	0.61	0.79
	2022	1.11	1.05	0.57	0.64	0.57	0.79
	Change	-0.02(1)	0.07(2)	-0.06(1)	-0.15(1)	-0.04(1)	0.00
Maximum Bankfull Depth (m)	2021	2.09	1.35	0.94	0.8	0.86	1.07
	2022	2.09	1.46	0.93	0.96	0.83	1.12
	Change	0.00	0.11(2)	-0.01(1)	0.16	-0.03(1)	0.05(2)
Bankfull Width: Depth	2021	7.50	7.21	18.27	12.82	17.56	12.46
	2022	8.56	6.95	19.72	16.34	19.11	12.51
	Change	1.05(2)	-0.26(1)	1.45(2)	3.52(2)	1.55(2)	0.05(2)

Cross-section Name	Year	MON2-1	MON2-2	MON2-3	MON2-4	MON2-5	MON2-6
Bankfull Cross-sectional Area (m^2)	2021	15.30	8.91	7.93	8.88	13.41	11.20
	2022	16.44	9.6	7.98	8.65	13.42	11.59
	Change	1.14(2)	0.69(2)	0.05(2)	-0.23(1)	0.01(2)	0.39(2)
Bank Height (m) (LB, RB)	-	5.0, 3.0	2.0, 3.0	2.5, 2.5	1.5, 2.5	2.8, 2.0	2.5, 2.5
Cross-section Morphology	-	Pool	Transition	Riffle	Riffle	Pool	Riffle

Notes:
(1) Decrease between monitoring years
(2) Increase between monitoring years
LB - left bank looking upstream
RB - right bank looking upstream

TABLE C Bankfull Cross-section Dimensions MON3

Cross-section Name	Year	MON3-1	MON3-2	MON3-3	MON3-4	MON3-5	MON3-6
Bankfull Width (m)	2021	14.2	12.17	10.5	13.28	9.39	15.22
	2022	13.95	12.06	10.5	13.21	10.02	15.55
	Change	-0.25(1)	-0.11(1)	0.00	-0.07(1)	0.63(2)	0.33(2)
Average Bankfull Depth (m)	2021	0.94	0.77	0.69	0.71	0.71	0.77
	2022	0.72	0.74	0.65	0.68	0.75	0.70
	Change	-0.22(1)	-0.03(1)	-0.04(1)	-0.03(1)	0.04(2)	-0.07(1)
Maximum Bankfull Depth (m)	2021	1.45	1.17	1.14	0.97	1.16	1.16
	2022	1.44	1.15	1.12	0.96	1.32	1.07
	Change	-0.01(1)	-0.02(1)	-0.02(1)	-0.01(1)	0.16(2)	-0.09(1)
Bankfull Width: Depth	2021	15.11	15.81	15.22	18.70	13.23	19.77
	2022	19.38	16.30	16.15	19.43	13.36	22.21
	Change	4.27(2)	0.49(2)	0.94(2)	0.72(2)	0.13(2)	2.45(2)
Bankfull Cross-sectional Area (m^2)	2021	14.01	14.90	7.26	9.93	7.47	11.08
	2022	13.95	12.28	6.75	9.91	7.63	11.04
	Change	-0.06(1)	-2.62(1)	-0.51(1)	-0.02(1)	0.16(2)	-0.04(1)
Bank Height (m) (LB, RB)	-	1.5, 3.0	2.0, 1.5	2.0, 1.0	0.8, 2.0	1.0, 2.8	4.5, 1.5
Cross-section Morphology	-	Pool	Run	Pool	Riffle	Pool	Riffle

Notes:
(1) Decrease between monitoring years
(2) Increase between monitoring years
LB - left bank looking upstream
RB - right bank looking upstream

2.1.2 Entrenchment Ratios

Entrenchment ratios were calculated based on the cross-sectional dimensions measured in 2021 (Table D). This was done by dividing the flood-prone width (the width at two times the bankfull elevation) by the bankfull width. A channel with a wide, well-developed floodplain has a larger entrenchment ratio, while an incised, confined channel has an entrenchment ratio closer to 1. Based on the Rosgen (1994) classification of river channels, an entrenchment ratio of 1.0:1.4 indicates that the channel is "entrenched." Entrenchment ratios of 1.41:2.2 represent "moderate entrenchment." The cross-sections measured in MON1 and MON2 are generally classified as either “entrenched” or “moderately entrenched,” where the sections are long enough to confirm entrenchment ratios. Based on the revised channel dimensions (Section 2.1), the most severely entrenched cross-section among all sites is MON1-5, which has an entrenchment ratio of 1.06. MON3 has the best floodplain connection of the three monitoring sites with a mixture of moderately entrenched and not entrenched channel cross-sections.

TABLE D Entrenchment Ratios for Cross-sections in German Mills Creek

Monitoring Area	Cross-section	Bankfull Width (m)	Flood-proneWidth (m)	Entrenchment Ratio
MON1	MON1-1	13.36	>17.55	>1.31
	MON1-2	12.16	>16.48	>1.36
	MON1-3	12.55	16.65	1.33
	MON1-4	11.72	16.20	1.38
	MON1-5	10.52	11.10	1.06
	MON1-6	9.44	10.80	1.14
MON2	MON2-1	8.48	>18.96	>2.24
	MON2-2	7.07	11.00	1.56
	MON2-3	11.51	16.20	1.41
	MON2-4	10.13	12.50	1.23
	MON2-5	10.71	12.45	1.16
	MON2-6	9.84	13.50	1.37
MON3	MON3-1	14.20	>33.38	>2.35
	MON3-2	12.17	20.55	1.69
	MON3-3	10.50	30.80	2.93
	MON3-4	13.28	26.60	2.00
	MON3-5	9.39	28.45	3.03
	MON3-6	15.22	>17.00	>1.12

2.1.3 Longitudinal Bed Profiles

Overlays of the longitudinal profiles from Years 1 and 2 are presented in Figures A to C. Each monitoring site has riffle-pool bedform morphology, which is best developed in the more natural sites (MON1 and MON3) and less so in the more modified and armoured site (MON2). Riffle pool spacing is approximately 45 to 65 m, 35 to 50 m, and 12 to 45 m in MON1, MON2, and MON3, respectively. Riffle lengths are approximately 30 to 35 m in MON1, 15 to 22 m in MON-2, and 8 to 25 m in MON-3. Riffles were longest in MON1 and were most closely spaced in the upstream portion of MON3, becoming longer near the valley contact near the site’s downstream extent. Riffle-pool spacing is erratic in the more modified monitoring site (MON2).

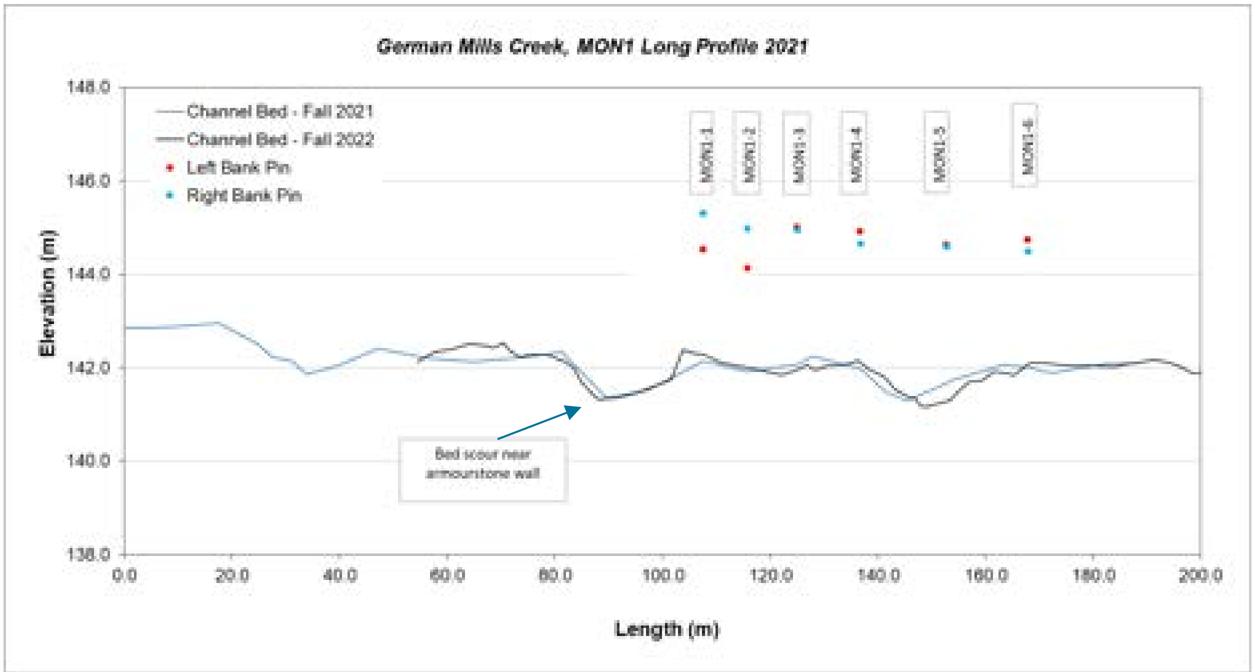

FIGURE A Overlay of Year 1 and Year 2 Longitudinal Profile for MON1

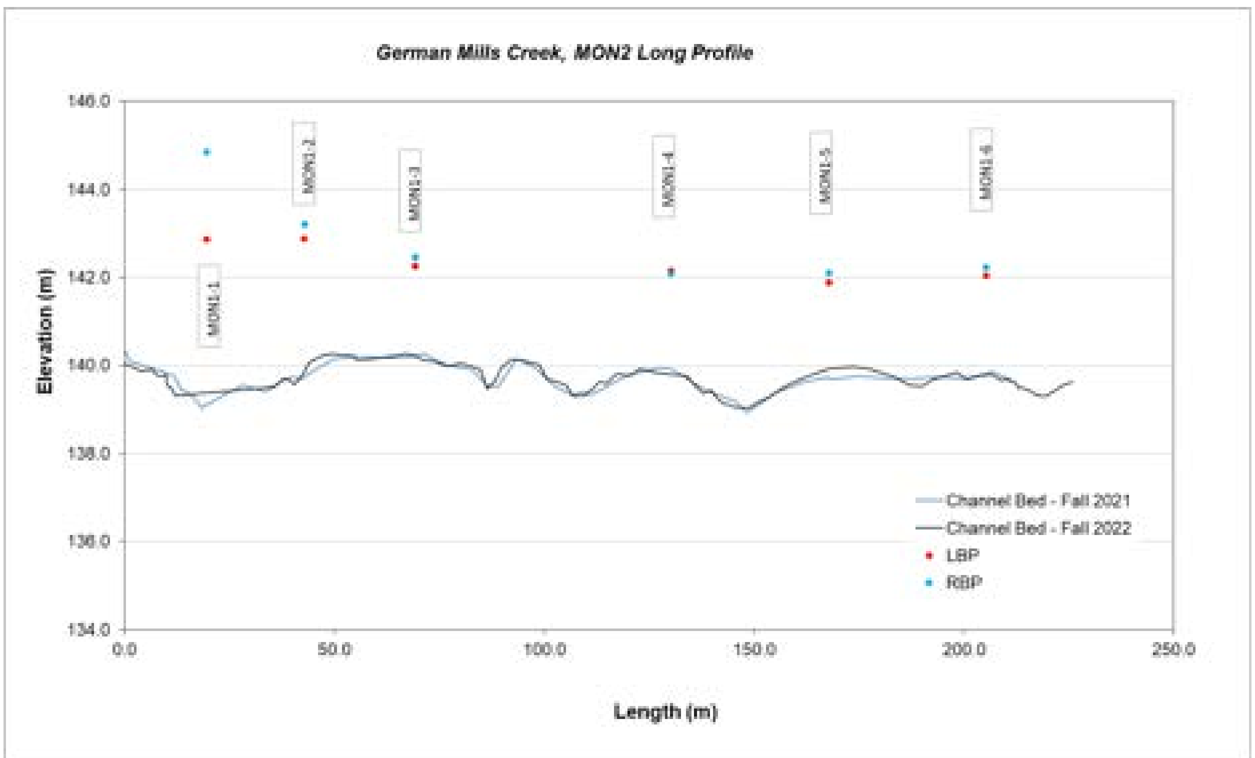

FIGURE B Overlay of Year 1 and Year 2 Longitudinal Profile for MON2

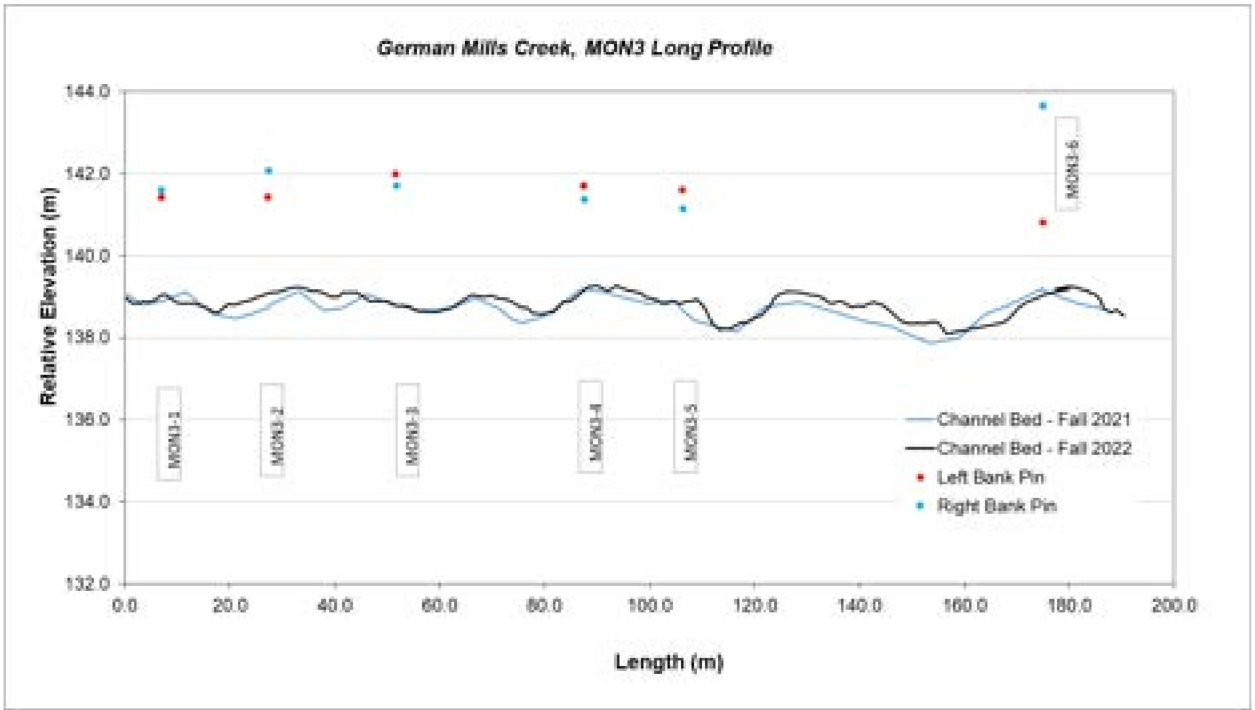

FIGURE C Overlay of Year 1 and Year 2 Longitudinal Profile for MON3

Riffle crest and pool locations were sampled from the longitudinal profiles and compared between years to describe the downstream migration distance observed during the monitoring period. Measurements were rounded to the nearest 10 cm to account for variations in surveyor judgement in the field.

- In MON1, riffle crests in the overlay variously extended upstream or moved downstream between 2022 and 2021. The average annual riffle migration distance was 0.6 m in a downstream direction. Riffle profiles changed slightly, with crest height increasing by 4 to 23 cm and other parts of the riffles decreasing in elevation, indicating that the sediment is mobile. The deepest part of the pool at the armourstone wall extended upstream by 1.5 m due to ongoing bed scour, and the deepest part of the pool located near cross-section MON1-5, downstream of the exposed manhole, migrated downstream by 3.9 m.

- In MON2, riffle crests generally did not migrate between the monitoring years. Two riffle crests increased in height by 2 and 22 cm, one decreased in height by 10 cm, and one remained static. The uneven riprap material lining parts of the bed could introduce local variation in the survey results of up to approximately 20 cm. so the slight variation in riffle elevation is not considered meaningful. The pool nearest the pedestrian crossing could not be surveyed due to excessive water depth so this pool cannot be compared between years. No downstream migration was observed within the other pools in MON2, and there was little to no infilling. The lack of bedform development is attributed to stabilization by riprap.

- MON3 had the most active longitudinal profile of the three monitoring sites. Although four of five riffle crests remained in place (one migrated downstream by 5.5 m), all five riffle toes extended downstream between 2.2 to 4.5 m. This partially filled in three of the four surveyed pools, with reductions in pool depth ranging from 14 to 25 cm. Riffle crest height also increased in several riffles. These adjustments in the MON3 longitudinal profile indicate net deposition of coarse material during the monitoring period within this reach.

2.2 Repeat Photographs

Table E summarizes the most notable changes observed in the repeat photographs between monitoring years. At monitoring sites MON-1 and MON-3, changes were observed in five of eight repeat photographs. Changes included movement of large woody debris, bank recession, changes in bar form and location, leaning and fallen trees and encroachment of vegetation. At MON-2, notable change occurred in only one photograph location.

TABLE E Changes Observed in Repeat Photographs

Site	Notable Changes Observed 2021-2022
MON1	Photograph 2: Additional large woody debris accumulated at armourstone wall Photograph 3: Bank top tree leans further toward channel Photograph 4: Additional large woody debris accumulated at armourstone wall (view from above) Photograph 5: Bar form downstream of armourstone wall changed during monitoring period
MON2	Photograph 7: Additional vegetation covers slumped material at toe of eroding bank below bridge
MON3	Photograph 1: Additional sedimentation at confluence with Bestview Tributary. Photograph 2: Between 2021 and 2022 a downed tree (located near MON3-1) was pushed downstream, and a new tree fell. The top of bank appears to have receded. Photograph 3: Minor slumping has occurred since 2021 on bank near trail (upstream of MON3-1) Photograph 6: Near MON3-5, vegetation filled in upper point bar while the lower bar remains unvegetated and covered in fresh deposits of fines Photograph 7: Top of high eroding bank at MON3-6 receded slightly. Bar material migrated downstream. Large woody debris has accumulated upstream at meander.

Note:
Photographs can be found in Appendix B.

2.3 Sediment Character

Pebble counts were completed in each of the three erosion monitoring areas (MON1, MON2, and MON3). In each monitoring area and in each monitoring year, 300 pebbles of 0.5 cm diameter and larger were counted at riffles to characterize the coarse component of the bed material. The coarse component of bed material is the most resistant to transport, particularly where it is imbricated at riffles; as such, a description of this component provides insight into the resistance of the bed to erosion. In addition, the proportions of finer materials (clay, silt, and sands) were visually estimated within the pebble count sampling area and were incorporated into the grain size distributions. Results are presented in Figures D to F and in Table F.

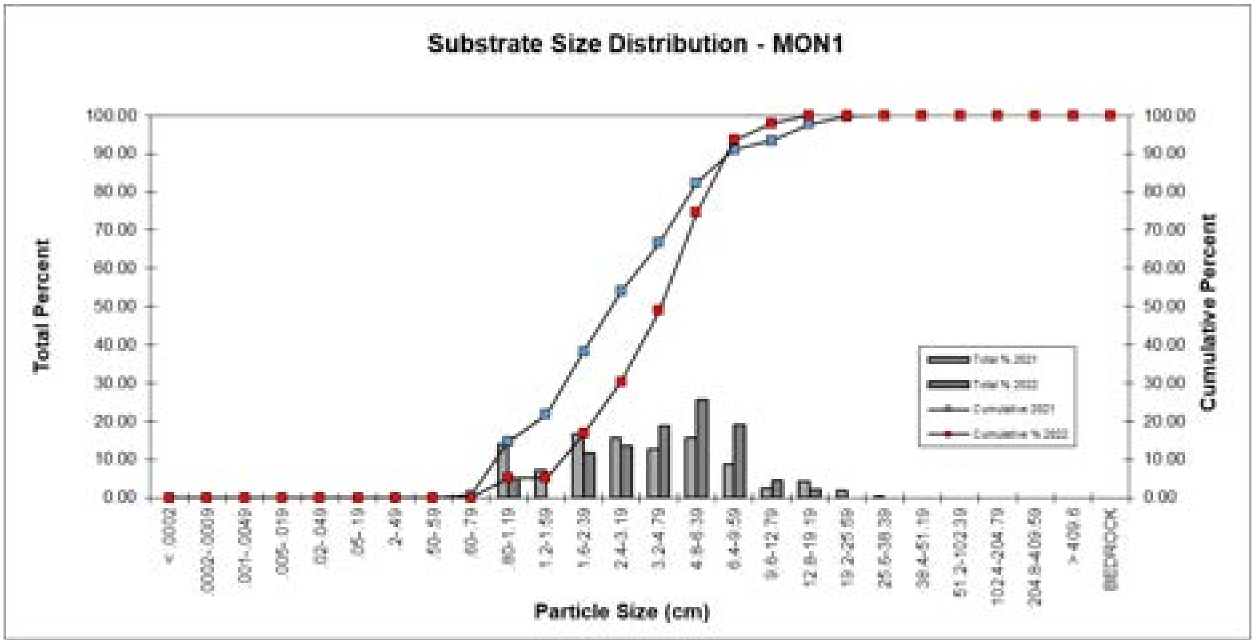

FIGURE D MON1 Grain Size Distributions, Year 1 and Year 2

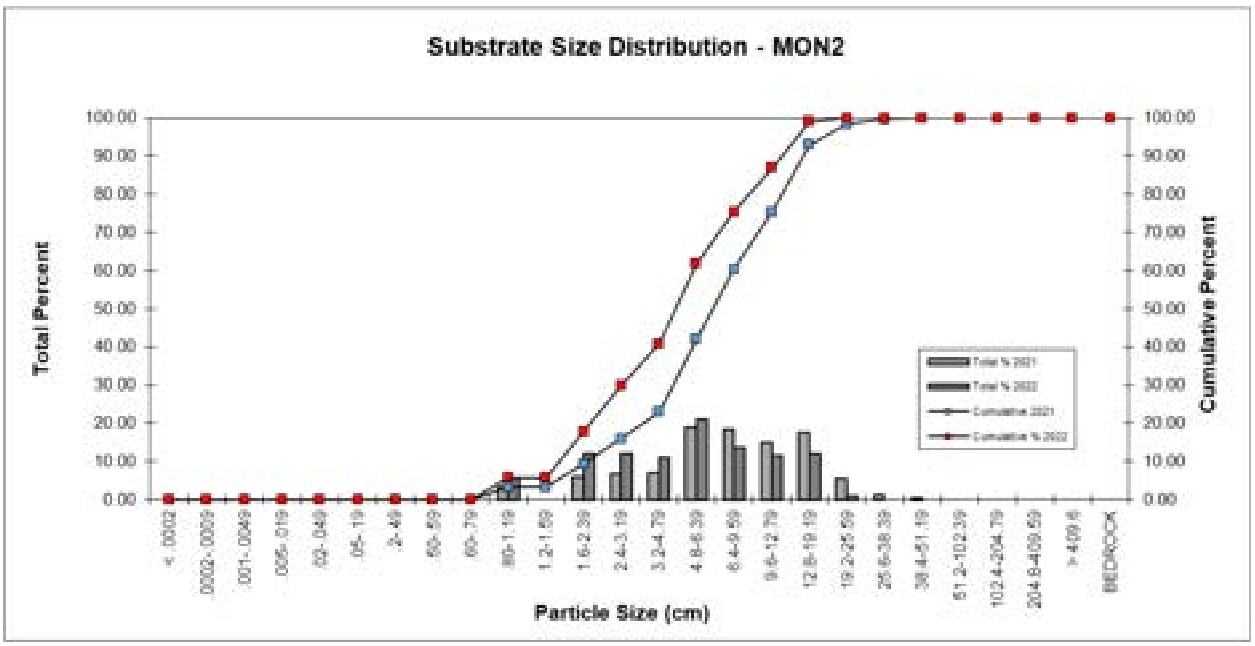

FIGURE E MON2 Grain Size Distributions, Year 1 and Year 2

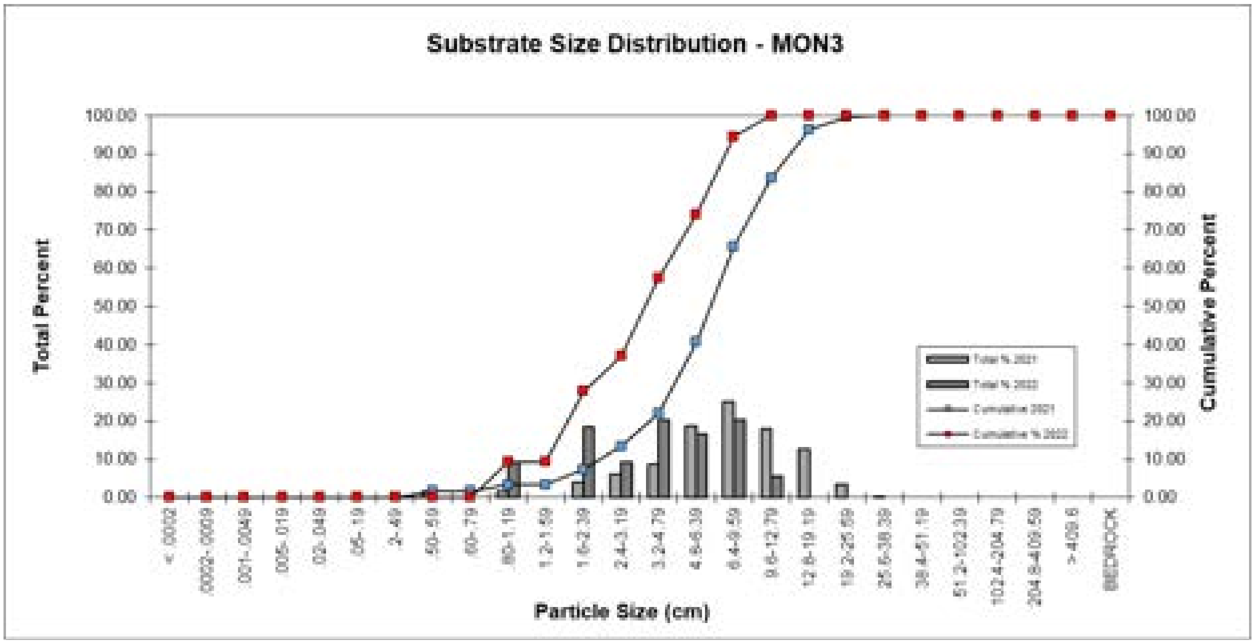

FIGURE F MON3 Grain Size Distributions, Year 1 and Year 2

TABLE F Pebble Count Summary, German Mills Creek Riffle Material

Site	Percentile	Diameter (cm) Year 1 - Fall 2021	Log_{10} of Year 1	Diameter (cm) Year 2 - Fall 2022	Log_{10} of Year 2	Log Difference
MON1	D10	1.06	0.03	1.93	0.29	-0.26
	D50	2.99	0.48	4.85	0.69	-0.21
	D90	9.20	0.96	8.99	0.95	0.01
MON2	D10	2.47	0.39	1.87	0.27	0.12
	D50	7.78	0.89	5.49	0.74	0.15
	D90	18.10	1.26	14.43	1.16	0.10
MON3	D10	2.74	0.44	1.62	0.21	0.23
	D50	7.58	0.88	4.21	0.62	0.26
	D90	15.99	1.20	8.89	0.95	0.25

Note: does not include visually-assessed fines.

A wide range of size classes were sampled in German Mills Creek, ranging from pebbles to large cobbles and small boulders. Much of the coarse material was provided by alluvial and till deposits, but in some areas was also provided by failed bank treatments (riprap, gabion baskets, imported rounded river stone and occasionally failed concrete and asphalt), particularly in the vicinity of armoured areas, outfalls, and crossings. To avoid artificially coarsening the bed distribution, failed bank protection material was not included in the pebble counts. Till (consolidated clay) was frequently exposed in the bed and banks due to ongoing incision through the reach.

The median grain size (D_{50}) measured in 2021 was 2.99, 7.78, and 7.58 cm at sites MON1, MON2, and MON3, respectively. These sizes are classified as coarse gravel at MON1 and as small cobble at MON2 and MON3. The median grain sizes measured in 2022 were within the same order of magnitude at each monitoring site (4.85 cm, 5.49 cm, and 4.21 cm at MON1, MON2, and MON3, respectively), which is considered to fall within the natural range of variability of most alluvial systems.

Banks are composed of sandy loam containing gravel, cobble overlying clay till which was exposed at the toe of some banks (Table G). The sand fraction of the bank material makes the banks prone to erosion.

TABLE G Bank Height and Materials

Monitoring Area	Bank Material
MON1	Sandy loam. Some sections include gravel strata, occasional small cobble, organic matter, and clay exposure near bottom of bank.
MON2	Sandy loam. Some sections include gravel strata, organic matter, and clay exposure near bottom of bank. Riprap and fill near train bridge.
MON3	Sandy loam. Some sections include gravel strata, organic matter, and clay exposure near bottom of bank.

2.4 Flow Measurements

Flow depth and velocity profiles were collected using an Acoustic Doppler Velocimeter flow meter to estimate stream discharge at the time of the topographic surveys. The results of the flow measurements are presented in Table H. Discharge rates were 0.19 to 0.26 m^3/s and 0.14 to 0.15 m^3/s (where data is available) during the 2021 and 2022 surveys, respectively. These discharge rates represent low flow conditions and are equivalent to approximately 1% to 3% of the estimated bankfull flow of 10 m^3/s.

TABLE H Flow Monitoring Results

Monitoring Area	Discharge (m^3/s)	
	2021	2022
MON1	0.2085	N/A
MON2	0.1926	0.1415
MON3	0.2611	0.1465

N/A - Data missing

Toronto and Region Conservation Authority's (TRCA's) monitoring stream gauge HY092 is located on German Mills Creek at Cummer Avenue. While historic flow information is available, flow data is not publicly available for the monitoring period. Should updated flow information from TRCA's monitoring stream gauge HY092 become available, this information may be included in an updated version of the current report.

In the absence of updated flow information from TRCA, real-time flow data collected at Water Survey of Canada's (WSC's) 02HC056 Don River East Branch near Thornhill monitoring gauge is presented in

Figure G. At the gauge the Don River East Branch has a drainage area of approximately 38 km^2, which is comparable to the drainage area of the German Mills study area of approximately 42 km^2 (MNRF 2023). Given the similarity in drainage area and the relative proximity of the sites, data from the Don River East Branch may be considered a rough approximation of flows within the German Mills Creek. At least six storm events occurred over the monitoring period (indicated on Figure 8 by the red box) that had discharge rates above half-bankfull flows, in the range of approximately 5.5 to 8.5 m^3/s, along with several smaller storm flows with peak discharge rates in the range of 4 m^3/s. As well, one storm event causing flows over bankfull (>10 m^3/s) occurred in August 2021, 1 month before the Year 1 monitoring data was collected. These peak flows caused the morphological changes observed during the monitoring period as described in Section 2.1.

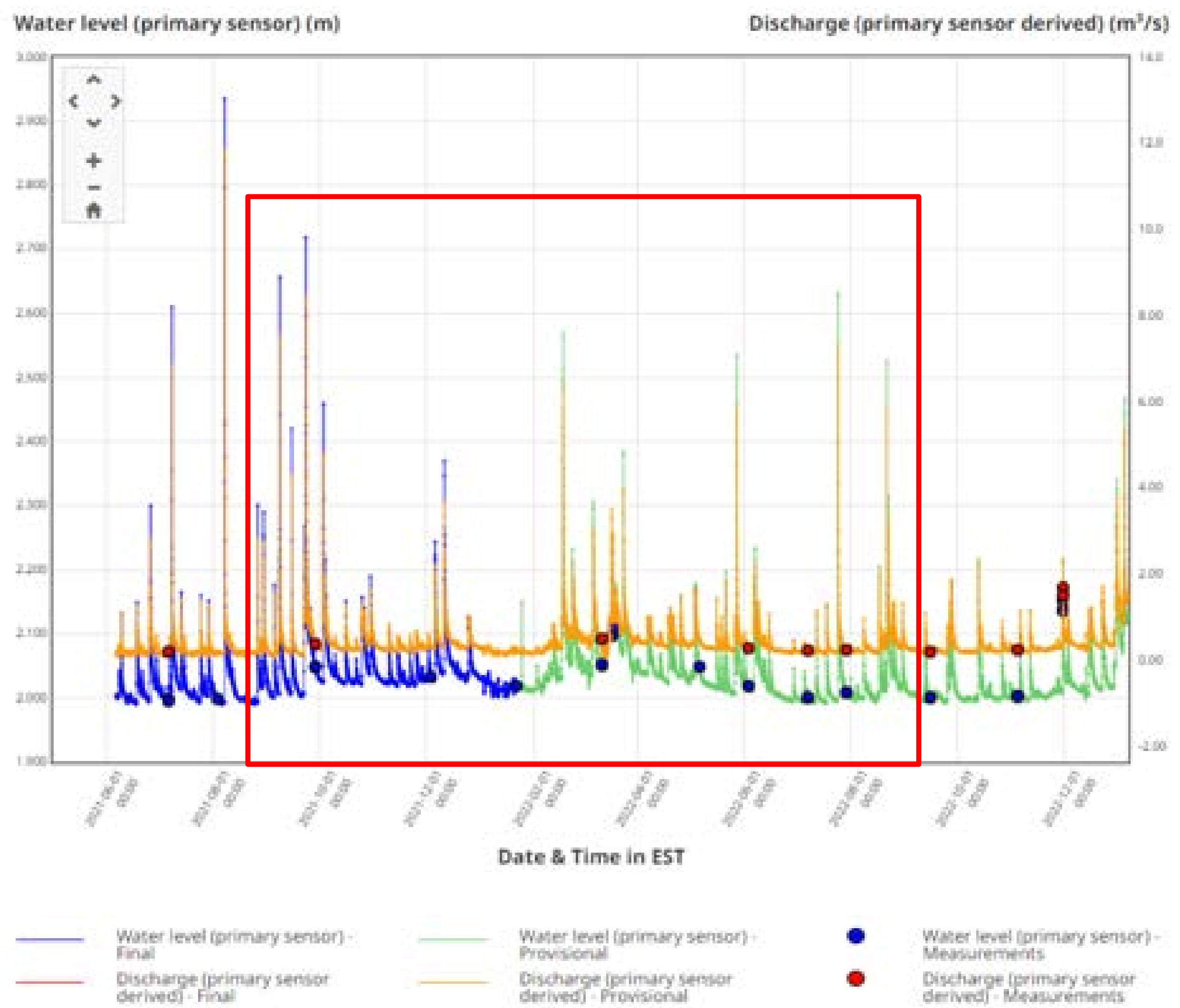

FIGURE G 2021-2022 Flow Rates, Don River East Branch near Thornhill (Government of Canada 2022)

2.5 Summary of Observations

Bank erosion was documented at 13 of 18 monitoring cross-sections. Individual banks eroded up to 0.98 m, 0.6 m, and 2.3 m in MON1, MON2 and MON3, respectively, during the 1-year monitoring interval. The largest bank erosion measurement occurred where the root ball of a fallen tree detached from the bank and is not representative of larger-scale bank erosion rates.

Geomorphic adjustments were observed during the monitoring period most notably within MON1 and MON3, where the creek is less modified and has less erosion protection as compared with MON2. Within these monitoring sites, the channel has a meandering planform and change over time included bank migration, bank slumping and bar movement, downstream riffle migration of up to 5.5 m, and downstream migration or partial infilling of pools. Noticeable changes occurred at five of six repeat photographs within both MON1 and MON3, and included bank erosion, tree fall, bar reworking, and movement of large woody debris. Morphological adjustments in MON1, where the channel is entrenched, were sometimes out of phase with the planform, and adjustments appear to response strongly to the local influence of infrastructure such as the armourstone wall. Adjustments in MON3, which is moderately to not entrenched, indicated deposition was occurring in pools and riffles.

The type of channel substrate was similar among sites and did not change in any of the three monitoring sites beyond the expected natural range of variability but the changes in the longitudinal profile indicated that bed materials are mobile where the channel bed is not protected (MON1 and MON3), with most riffles lengthening or migrating downstream as noted above.

The surveys were completed during summer and early fall low flow conditions, and the morphological adjustments captured in the data are a response to peak storm flows in the range of 4 to 8.5 m^3/s, which occurred between monitoring years.

3 ECOLOGICAL MONITORING

Ecological monitoring was completed over 2years to establish a baseline profile of the natural heritage character within the subject reach. Aquatic habitat condition was assessed through background review, application of the OSAP, water quality measurements, and benthic biomonitoring within the three monitoring locations utilized for the geomorphic field program:

Year 1 and Year 2 ecological monitoring were completed in August/September 2021 and September/October 2022, respectively. Monitoring for each year assessed aquatic habitat quality, benthos quality, and water quality at each monitoring site. Aquatic habitat quality was assessed through application of the OSAP (Stanfield 2017). Benthos quality was assessed through the Ontario Benthos Biomonitoring Network protocol and matrix analysis (Jones et al. Y. 2007). Water quality was monitored for multiple parameters during base flow and high-water conditions in both 2021 and 2022.

Though collection of sampling results for 2 years allows some limited potential for comparison, the intensity of precipitation and spring freshet indicates that conditions within the subject reach at German Mills are dynamic in nature, and it should be assumed that the monitoring duration is limited in scope to the extent that data from both years are considered together as a baseline for the subject reach.

3.1 Aquatic Habitat Monitoring

3.1.1 Monitoring Site 1

MON1 (Figure 2) is the most upstream monitoring site within the study area. The aquatic habitat monitoring portion of this station is 87 m long and incorporates a run, two pools, a confined riffle, and a backwatered area. A portion of the western bank adjacent to the existing multi-use trail has been protected with a tall armourstone retaining-wall feature, although this structure, and by extension the shear slope adjacent to the trail, is failing in areas. The armourstone is located on the outside meander bend of a deep pool that has collected a large amount of woody debris.

An exposed maintenance hole is located at the next meander bend opposite a prominent unvegetated gravel bar. Substantial amounts of deposited sediment here has also influenced the development of a large, backwatered area along the eastern side of the watercourse. A prominent grouping of boulders immediately downstream of the riffle transect appears to be redirecting flow toward the eastern side of the channel, further scouring the deep pool feature opposite the gravel bar.

At the time of the 2021 survey, the pool transect had the largest wetted width at 9.92 m, and the run had the smallest wetted width at 5.80 m. As expected, the pool had the greatest depth at 0.93 m, the riffle had the shallowest depth at 0.16 m, while the run had a mid-range depth of 0.24 m. The pool was noted to have a sand dominated substrate, the riffle was dominated by large gravel, and the run transect was dominated by small cobble and gravel.

The only aquatic vegetation noted throughout this station was algae attached to cobbles. The forested riparian corridor is thinner at this portion of the watercourse, due in part to a parking lot within 10 m of the watercourse along the eastern bank and houses within 30 m of the station. Generally, fish microhabitat within MON1 was limited to woody debris build-up in the pool, backwatered areas for fish refuge, and instream boulders, cobbles, and interstitial voids between armourstone.

3.1.2 Monitoring Site 2

MON2 (Figure 3) is located at a relatively straight channel section upstream of a pedestrian bridge crossing. The aquatic habitat monitoring portion of this station is 96 m long and incorporates a short riffle, an extended run, and a pool. The vegetation along the banks on the western half of this monitoring reach is shrubby meadow/thicket, whereas the eastern half of the reach was found to be dominated by mature deciduous trees. There is a grouping of large Willow (*Salix sp.*) trees surrounding the pool transect at the upstream extent of the monitoring site that completely shades this section of creek.

At the time of the 2021 survey, the run feature had the greatest wetted width at 10.14 m and the riffle and run were noted to have narrower wetted widths ranging between 6.0 and 7.5 m. As expected, the pool had the greatest depth at 0.79 m and the riffle was the shallowest, measuring at 0.24 m. The extended run was consistent in depth throughout the reach, averaging 0.36 m.

The riffle substrate was dominated by large cobble and gravel, whereas the run and pool were completely dominated by sand. A large boulder was located in the center of the creek immediately upstream of the pool transect. The entirety of the monitoring site banks showed evidence of advanced erosion, with the most eroded portions of the bank being observed at the pool transect along the eastern bank exposing large tree roots.

There was minor instream vegetation noted throughout the station, which included attached algae on the cobble within the riffle and rooted emergent vegetation along the bank toe at the pool transect. Notable fish habitat features within MON2 were exposed roots in highly-eroded bank areas, downed woody vegetation, which is anticipated to be transient in nature, and areas around large cobbles and boulders at the surface of the channel bed.

3.1.3 Monitoring Site 3

MON3 (Figure 4) is the most downstream of the three monitoring sites. The aquatic monitoring portion of this station is 108 m long and incorporates an extended run, a riffle, another small run, and a deep pool along the downstream meander bend. There are distinct gravel bars on the inside of each meander bend and substantial woody debris due to fallen woody vegetation adjacent to the pool and south of the run feature.

Substantial erosion was evident at each outer meander bend, with undercutting, mass failure, and fallen trees noted at the downstream and middle meander feature. At the time of the 2021 survey, the run feature had the smallest wetted width at 4.9 m and the riffle had the greatest wetted width at 8.62 m; it is anticipated the riffle width at this area has been influenced by the eroded southern bank at this location. The pool exceeded 1 m in depth and had no discernible flow, whereas the riffle had a maximum depth of 0.23 m and visible flow with a hydraulic head of 3 mm. The substrate in the pool and run were dominated by sand, while the substrate in the riffle was dominated by gravel and small cobble. This station did not have any aquatic vegetation, however there was a densely forested riparian zone adjacent to the creek and detritus from overhanging vegetation (leaves, twigs) were evident within calmer portions of the channel. Fish habitat within this reach was present in the form of large, downed woody snags, including trees with full canopy, as well as small voids resulting from larger cobbles at the bed surface within riffle and run areas. The majority of these downed woody snags were not present during surveys in 2021. Two of these snags still had leaves on the canopy, indicating that they had fallen recently. Their presence within this section of the channel is anticipated to be transitory.

3.2 Fish Community

No fish community data was collected for this project. However, existing fish community data exists for areas near the study area. The Schedule B German Mills Environmental Assessment (TRCA 2019) provides information on fish collected at monitoring station DN008WM, which is located in the same branch as the current study area, just upstream of Steeles Avenue. The Don River Watershed Plan (TRCA 2009) also provides fish community information within the German Mills Creek subwatershed. This information is based on collections from 2002-2005. Fish community data is summarized in Table I. None of the species collected at this station are listed as at risk either provincially or federally.

TABLE I Fish Community Data

Common Name	Scientific Name	German Mills Subwatershed Collected 2002 to 2005 (TRCA 2009)	Station DN008WM Collected July 31, 2021 (TRCA 2019)
Blacknose Dace	*Rhinichthys atratulus*	X	X
Bluntnose Minnow	*Pimephales notatus*	X	
Creek Chub	*Semotilus atromaculatus*	X	X
Common Shiner	*Luxilus cornutus*	X	X
Fathead Minnow	*Pimephales promelas*	X	X
Goldfish	*Carassius auratus*	X	
Johnny Darter	*Etheostoma nigrum*	X	X
Longnose Dace	*Rhinichthys cataractae*	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X
White Sucker	*Catostomus commersonii*	X	X

Based on the fish community data and the thermal regime results in the Don River Watershed Plan (TRCA 2009), German Mills Creek is classified warm/cool water system. All fish species observed are species are common and secure in Ontario. One invasive fish species was recorded: Goldfish. It was recorded in 2005 but not recorded at station DN008WM upstream of Steeles Avenue. However, Goldfish were visually observed downstream of MON1 and, as a result, would still be considered a record for the German Mills study area.

As discussed in the GSMP Phase 2 report (Matrix 2022) there are two locations along the watercourse within the study area that may act as potential fish barriers during baseflow conditions (Figures 5 to 19).

3.3 Water Quality

The discrete water quality sampling for dry-weather conditions were conducted on September 3, 2021 (Year 1) and on September 7, 2022 (Year 2). Wet-weather event conditions were assessed on September 8, 2021 (Year 1) and on September 26, 2022 (Year 2).The dry weather events were collected under conditions where there had been no precipitation within the previous couple of days. Wet-weather conditions were collected immediately following precipitation events (>5 mm of rainfall). On both dates the water samples were collected and total suspended solids (TSS) was tested for at ALS Canada Ltd. laboratory. The weather summary for both collections and the TSS results can be found in Table J.

TABLE J Total Suspended Solids Results

Sample Event	Date	Air Temperature (°C)	Precipitation within last 24 Hours (mm)	TSS (mg/L)(1)		
				MON1	MON2	MON3
Year 1: Dry Weather	September 3 2021	22	0	<3	<3	<3
Year 1: Wet Weather	September 8 2021	26	28.2	105	139	111
Year 2: Dry Weather	September 7 2022	20	0	<3	<3	7.0
Year 2: Wet Weather	September 26 2022	16	25.6	4.1	15.3	5.0

Notes:
(1) detection limit is 3 mg/L
TSS - total suspended solids
Source:
The Weather Network 2022

For all monitoring locations in Year 1, the TSS concentrations were below detection limits for the dry weather sampling event, which indicates that the watercourse was clear, with limited suspended sediment load during baseflow conditions. The wet weather event resulted in substantially increased TSS for all three monitoring sites. It is anticipated that increased discharge mobilized additional particles that were previously stable, while overland flow contributed additional sediment to the system therefore increasing the TSS in the watercourse.

Year 2 dry-weather results generally agreed with the Year 1 results, with MON1 and MON2 having TSS below detection limits, though MON3 was found to have measurable levels of TSS (7.0 mg/L). The Year 2 wet-weather results, however, were found to be drastically lower than the Year 1 wet-weather results. This may be due to a difference in intensity between events in 2021 and 2022. If the event from 2021 delivered a higher amount of precipitation in less time, it would increase the rate of overland runoff and potentially exacerbate exposed mineral bank areas within the channel to a greater degree than a more gradual precipitation event.

Additionally, in situ water quality parameters were collected during both the dry weather sampling (Table K) and following the wet weather event sampling (Table L). Though dissolved oxygen is not directly comparable between years due to the temperature-dependence of oxygen solubility, generally the concentration of dissolved oxygen (>6 mg/L in warmwater systems) indicates that minimal detrimental effects are anticipated for non-salmonid species within this system (CCME 1999, DataStream Initiative 2021).

Conductivity and pH were both noted to be markedly lower during wet-weather sampling than dry-weather sampling. This is likely due to the diluting and buffering effect of precipitation on ion concentration and $[H^+]$ within the water column. In all cases conductivity ranged from 319 to 1,415 $\mu S/m^3$.

The pH in all cases ranged from 7.03 to 8.36. No water quality guidelines for the protection of aquatic life are published in Canada, though the acceptable range for pH within fresh water is between 6.5 to 9 (CCME 2022).

TABLE K Dry Weather In Situ Water Quality Results

In situ Water Quality Parameter (Dry Weather)	MON1 (2021)	MON1 (2022)	MON2 (2021)	MON2 (2022)	MON3 (2021)	MON3 (2022)
Water Temperature (°C)	17.9	16.4	15.6	16.7	15.1	17.5
Dissolved Oxygen (mg/L)	12.70	7.18	10.64	9.64	9.73	9.92
Conductivity (µS/cm)	1,094	1,392	1033	1,397	1,020	1,415
pH	8.36	7.87	8.17	8.02	8.05	8.06

TABLE L Wet Weather In Situ Water Quality Results

In-situ Water Quality Parameter (Wet Weather)	MON1 (2021)	MON1 (2022)	MON2 (2021)	MON2 (2022)	MON3 (2021)	MON3 (2022)
Water Temperature (°C)	18.2	14.9	18.1	14.9	18.3	14.8
Dissolved Oxygen (mg/L)	9.50	9.06	9.28	8.79	9.42	8.83
Conductivity (µS/cm)	338	945	319	942	343	933
pH	7.09	7.65	7.03	7.84	7.22	7.71

3.4 Benthic Macroinvertebrates

A multi-metric suite of analyses were conducted on the benthic invertebrate data sets of samples collected from the three monitoring sites for both Year 1 and Year 2. These include analysis on abundance, species richness, and community structure (Appendix C).

Expected values have been developed for unimpaired gravel bottom creeks in southern Ontario. The results from German Mills sampling were compared where applicable to these expected values following the methodologies of Griffiths (1999). This method of comparison represents an industry standard, and these expected values can act as a baseline for comparison in the absence of habitat specific expected values. Similarly, it is established that larger respective values for Taxa Richness, percent Ephemeroptera, Plecoptera, and Trichoptera (EPT), number of EPT taxa, and the Shannon-Weiner Diversity Index imply a healthy biological community, whereas low values for these metrices can indicate reduced or impaired ecosystem health (Barbour et al. 1999, Jones et al. Y. 2007). Conversely, lower values for percent *Diptera*, percent *Chironomidae*, percent dominant and Hilsenhoff Biotic Index (HBI) values imply a healthier biological community. (Barbour et al. 1999, Jones et al. Y. 2007).

Table M presents a summary of the 2021 results of the calculated metrics used to analyze the benthic invertebrates collected at the three sample stations. The full list of benthic species captured is located in Appendix C.

TABLE M Benthic Invertebrate Results

Benthic Invertebrate Metrics	Range of Expected Values [1]	2021 Results			2022 Results		
		MON1	MON2	MON3	MON1	MON2	MON3
Total Number of Organisms	>300 [2]	3,105	2,297	1,658	3,550	2,250	3,339
Taxa Richness	20-40	50	43	44	44	42	55
Percentage Insects (%)	-	74.27	75.01	68.82	87.13	89.24	77.09
Percentage Dominant (%)	-	17.39	13.32	14.23	26.70	17.78	15.27/15.24
Dominant Genus/Species	-	*Hydropsyche bronta*	*Cheumatopsyche*	*Caecidotea*	*Cheumatopsyche*	*Cheumatopsyche*	*Paratanytarsus/ Caecidotea*
Tolerant Groups							
Percentage Oligochaetes (%)	-	18.52	13.71	11.94	3.41	3.16	4.73
Percentage Diptera (%)	-	27.70	39.49	40.65	44.82	57.56	62.95
Percentage Chironomidae (%)	10-30	25.09	38.01	40.11	43.32	55.33	60.86
Sensitive Groups							
EPT Taxa Richness	>10 [3]	7	7	6	8	7	6
Percentage EPT (%)	-	40.61	32.65	25.7	41.35	30.93	13.66
Diversity and Biotic Indices							
Hilsenhoff Biotic Index	0.0-3.5 [4]	6.60	6.65	6.93	5.76	5.53	6.14
Hilsenhoff Biotic Index Water Quality	Excellent	Fairly Poor	Fairly Poor	Fairly Poor	Fair	Fair	Fair
Shannon-Wiener Index	3-5 [4]	3.05	3.07	3.03	2.75	2.95	2.96

Notes:
(1) Range of expected values for unimpaired gravel-bottom creeks in southern Ontario. Values taken from Griffiths (1999) unless otherwise noted
(2) Restricted by subsampling until 100 organisms are reached in each replicate (riffle, pool, riffle), or whole sample is enumerated
(3) >10 indicates a Non-impacted system (Mackie [2004])
(4) These values indicate the range considered “Unpolluted” or “Excellent” water quality, as per Hilsenhoff (1987)
EPT - Ephemeroptera, Plecoptera, and Trichoptera

3.4.1 Monitoring Site 1

The results of the metrics indicate that MON1 has fair to fairly poor water quality. Total abundances were high within the riffle and run subsamples but was well below the target of 100 organisms within the pool subsample (39 and 78 organisms for Year 1 and Year 2, respectively). This reach contained a large population of EPT species (>40%); however, the majority of species present here belong to one major family group (*Hydropsychidae*) which is moderately tolerant to pollution. The majority of the remaining benthic population (>46% in Year 1, >48% in Year 2) broadly consisted of pollution tolerant species (*Oligochaetes and Diptera*). MON1 had the best HBI score in Year 1, and second best HBI score in Year 2. It also contained the highest percent EPT of the three stations sampled for both Year 1 and Year 2. The HBI score corresponds to water quality ranging from fairly poor (6.60) to fair (5.76), while the number of EPT families present indicate moderately-impacted water quality.

3.4.2 Monitoring Site 2

The results of the metrics indicate that at MON2 has fair to fairly poor water quality. Similar to MON1, total abundances were high within the riffle and run subsamples but was well below the target of 100 organisms within the pool subsample in Year 1 (34 organisms). Though the pool still contained the fewest organisms in Year 2, it did exceed the target of 100 organisms (121). The reach was dominated by pollution tolerant groups (*Oligochaetes and Diptera)* which represented >53% of sampled organisms in Year 1 and >60% of sampled organisms in Year 2. Although the percentage of EPT was moderate within the samples (>32% in Year 1, >30% in Year 2), the majority of species surveyed belonged to one major family group (*Hydropsychidae*), which is moderately tolerant to pollution. Benthic results from MON2 resulted in a HBI score ranging from fairly poor (6.65) to fair (5.53) water quality according to this metric. Similar to MON1, The number of EPT families present at this station indicate moderately-impacted water quality.

3.4.3 Monitoring Site 3

The results of the metrics at MON3 indicate that this site has fair to fairly poor water quality. This station also failed to reach the target of 100 organisms within the pool subsample in Year 1 (36 organisms). In Year 2, the pool contained the second highest total of organisms (787). This reach contained a high population of pollution tolerant groups (Oligochaetes and Diptera) which represented >52% of the sampled organisms in Year 1 and >67% of sampled organisms in Year 2. The EPT within MON3 contained the lowest average and represented 25.7% of the sampled organisms from Year 1, and 15.3% of sampled organisms from Year 2. MON3 contained the highest HBI score of all three reaches for both Year 1 and Year 2 sampling results, which indicates water quality ranging from fairly poor (6.93) to fair (6.14). This reach also had the lowest number of EPT families (six in both Year 1 and Year 2) indicating moderately-impacted water quality.

3.5 Summary of Observations

Ecological monitoring was completed over 2 years within the larger geomorphic monitoring sites (MON1, MON2, MON3). An aquatic habitat assessment was conducted within each monitoring site to generally characterize the reach morphological features as they pertain to supporting aquatic life. Typically, all reaches exhibited similar bed substrate profiles, with riffles dominated by cobbles and large gravels, pools dominated by silt and sand, and runs varying in composition. All monitoring sites exhibited signs of erosion and/or bank dysfunction. MON1 microhabitat was limited to woody debris, backwatered channel areas, and voids from larger instream substrate and armour stone. MON2 habitat consisted of downed woody vegetation and voids from larger in-stream substrate. MON3 in-stream habitat was predominantly large, downed woody snags (whole trees) recently fallen from nearby bank erosion.

Fish communities within the subject reach were assessed from background review as being typical of warm/cool water systems. All fish species within the system are noted as being common and secure, with one invasive fish species (goldfish) noted as potentially present.

Water quality was assessed for both dry-weather and wet-weather conditions through laboratory analysis (TSS) and use of a handheld multi-meter (temperature, dissolved oxygen, conductivity, pH). TSS for dry-weather sampling was found to be very low (five out of six samples below detectable limits). Year 1 wet-weather sampling exhibited substantially higher TSS (105 to 139 mg/L) than Year 2 wet-weather sampling (4.1 to 15.3 mg/L). This discrepancy may be due to variable intensity of respective precipitation events, with a more intense and shorter event anticipated to create higher volumes of overland flow and greater energy within the system to pick up sediment. Water temperature was relatively close to ambient temperatures and generally above 14°C, confirming warm-water temperature regime. Dissolved oxygen and pH generally indicated acceptable conditions to support aquatic life.

Benthic results were relatively consistent between Year 1 and Year 2. The system exhibits a high proportion of benthic organisms with moderate or higher tolerance to low water quality. In general, the water quality, as assessed through benthic metrics, was determined to be fairly poor to fair.

4 CLOSING

The short-term monitoring program completed in 2021 and 2022 provides a snapshot of geomorphic and ecological conditions and how they changed over the course of one year. This year was characterized by flows in the range of 4 to 8.5 m^3/s, based on flow data from a nearby gauge with a comparable drainage area. Some of the results, for instance of water quality and flow measurements, reflect conditions at the time of survey, while other observations, such as change in channel dimensions, are the product of cumulative change over the monitoring period.

Bank erosion was documented at 13 of 18 monitoring cross-sections. Individual banks eroded up to 0.98 m, 0.6 m, and 2.3 m in MON1, MON2 and MON3, respectively, during the 1-year monitoring interval. Geomorphic adjustments were observed during the monitoring period most notably within MON1 and

MON3, where the creek is less modified and has less erosion protection as compared with MON2. Within these monitoring sites change over the 1-year monitoring interval included bank migration, bank slumping and bar movement, downstream riffle migration of up to 5.5 m, and downstream migration or partial infilling of pools. Noticeable changes occurred at five of six repeat photographs within both MON1 and MON3, and included bank erosion, tree fall, bar reworking, and movement of large woody debris. German Mills Creek is generally classified as either entrenched or moderately entrenched in MON1 and MON2 where entrenchment ratios could be confirmed, while MON3 includes both moderately entrenched and not entrenched channel cross-sections.

Fish communities within the subject reach were assessed from background review as being typical of warm/cool water systems. Water temperature was relatively close to ambient temperatures and generally above 14°C, confirming warm-water temperature regime. Dissolved oxygen and pH generally indicated acceptable conditions to support aquatic life. Benthic results were relatively consistent between Years 1 and 2. The system exhibits a high proportion of benthic organisms with moderate or higher tolerance to low water quality. In general, the water quality, as assessed through benthic metrics, was determined to be fairly poor to fair.

The erosion and channel adjustments documented demonstrate that the alluvial channel, in areas without extensive hardening, is dynamic in response to sub-bankfull flow events that may occur several times per year (e.g., more than half-dozen times). The entrenched channel conditions further accentuate the channel erosion and dynamics by limiting access to the floodplain, and thus strategically reconnecting the floodplain should be considered a component of the alternative solutions being considered to reduce long-term erosion risks to Toronto Water infrastructure.

Aquatic ecology monitoring confirms that German Mills is urban impacted aquatic system with respect water quality and benthics, which is expected to support a warm water fish community. While erosion mitigation measures would be unlikely to substantively address the water quality impacts from the urban catchment, natural channel design solutions can be considered to maintain and enhance the existing aquatic system while also protecting Toronto Water infrastructure without excessive hardening.

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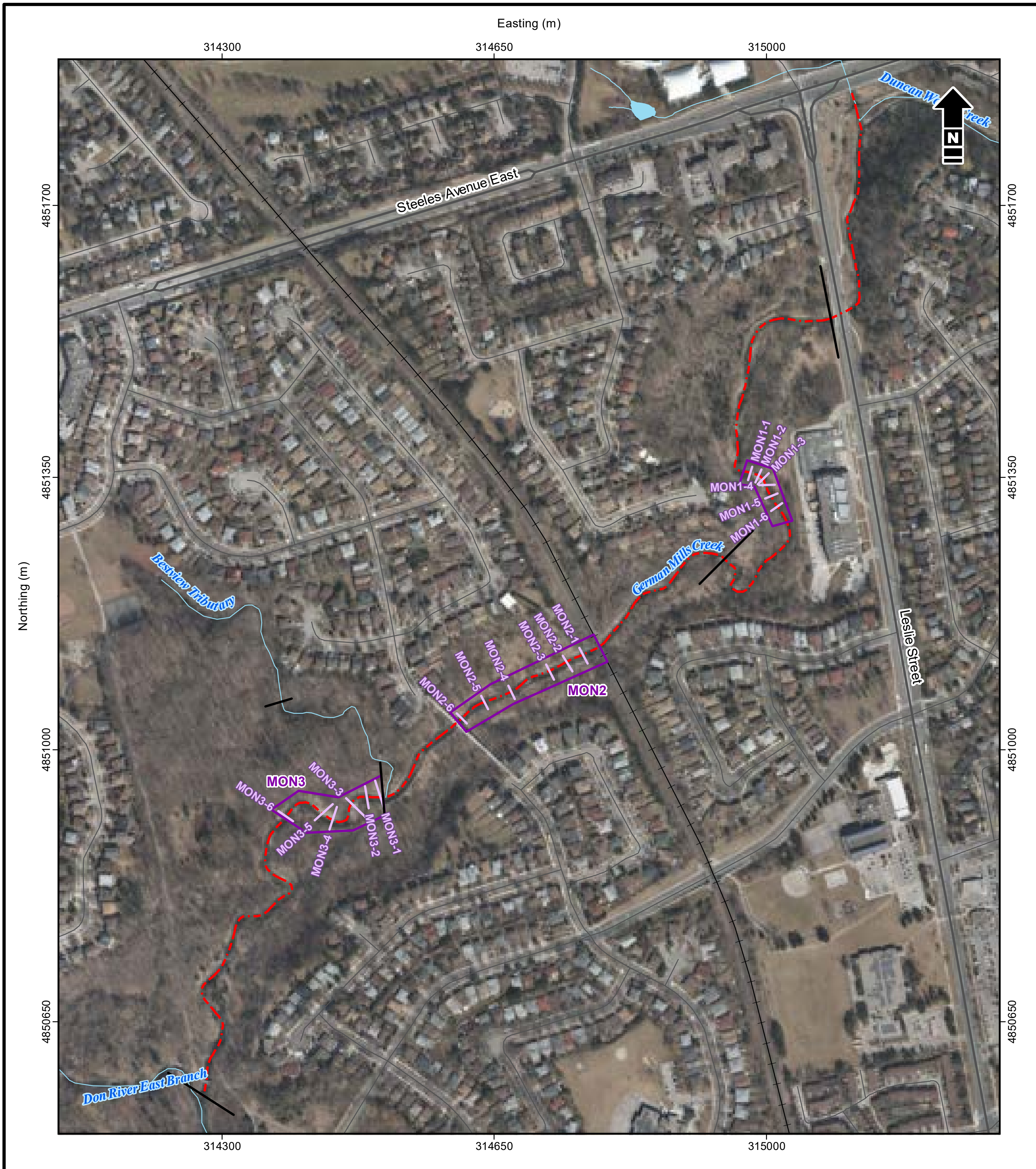

Disclaimer: Sewers have been clipped to the Focused Study Area.

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City of Toronto
German Mills Creek GSMP EA

Short-term Monitoring Sites

Date:	Project:	Submitter:	Reviewer:
January 2023	32227	A. Nicoll	R. Phillips

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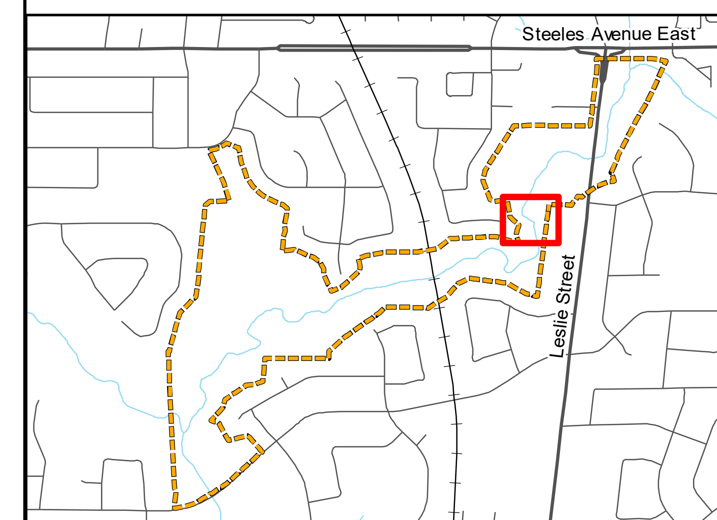
Figure 1

I:\CityofToronto\32227\FiguresAndTables\GMY2022\ReportMonitoring\Figure-1-Short_Term_Monitoring_Sites.mxd - Letter_P - 20-Jan-23, 02:51 PM - sylam - TID001

German Mills Creek GSMP Critical Area
OSAP Transect
Upstream/Downstream Extent
Water Quality Sample

Benthic Location

- Pool
- Riffle
- Run



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

Monitoring Site 1

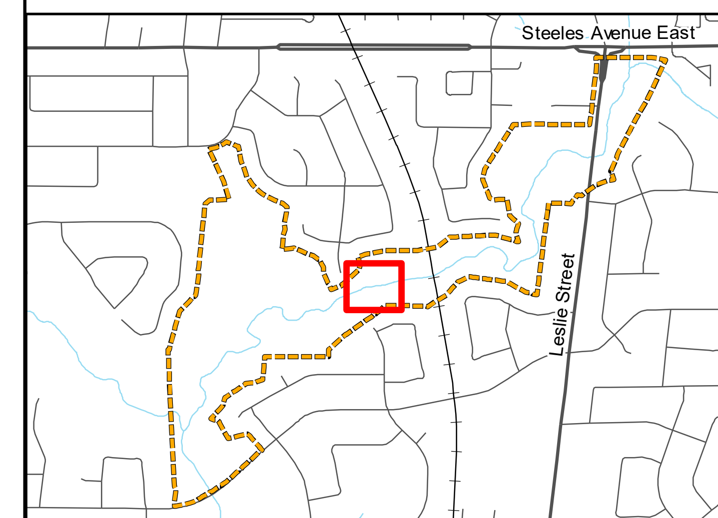
Date: January 2023	Project: 32227	Submitter: P. De Carvalho	Reviewer: R. Phillips

Figure 2

German Mills Creek GSMP Critical Area
OSAP Transect
Upstream/Downstream Extent
Water Quality Sample

Benthic Location

Pool
Riffle
Run



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

Monitoring Site 2

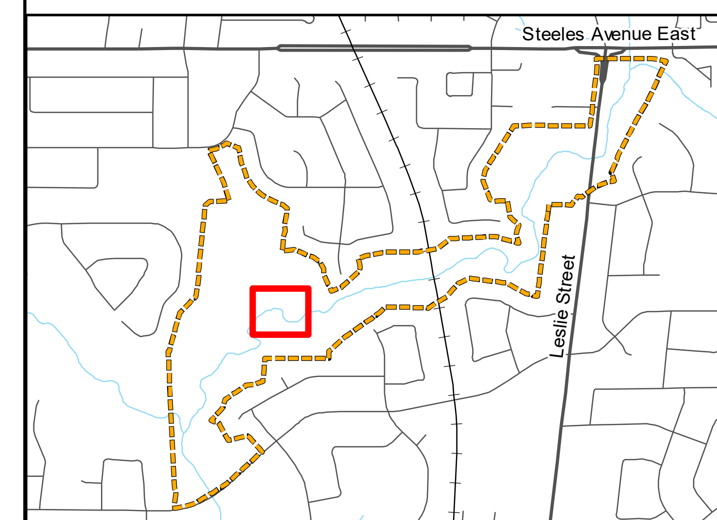
Date:	Project:	Submitter:	Reviewer:
January 2023	32227	P. De Carvalho	R. Phillips

Figure 3

German Mills Creek GSMP Critical Area
OSAP Transect
Upstream/Downstream Extent
Water Quality Sample

Benthic Location

Pool
Riffle
Run



1:500 metres

5 0 5 10

NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

Monitoring Site 3

Date: January 2023	Project: 32227	Submitter: P. De Carvalho	Reviewer: R. Phillips

Figure 4

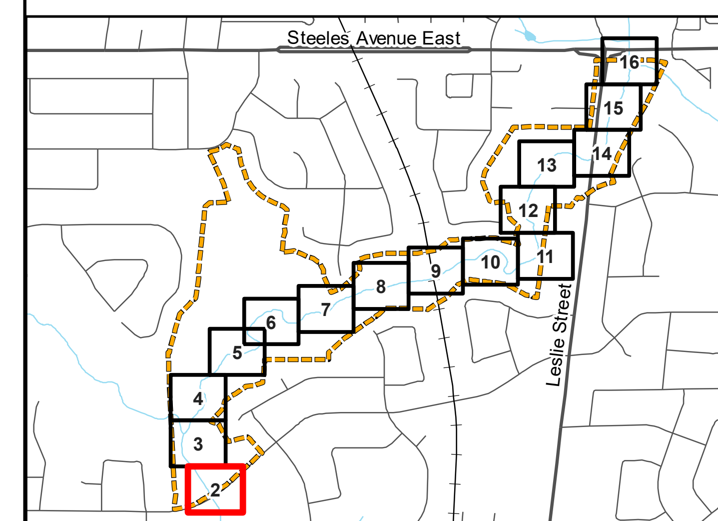
I:\CityofToronto\32227\FiguresAndTables\ECL\2022\Report\Figure-4-Monitoring_Site_3.mxd - Tabloid_L - 20-Jan-23, 02:55 PM - sylam - TID005

German Mills Creek GSMP Critical Area
Watercourse
Road
Field Note

Channel Units
Pool
Riffle
Run

Habitat Element
Bar
Woody Debris

Notes:
1. Pool with a wetted width of 10.1m and wetted depth of 79cm. Armour stone on left bank, right bank heavily vegetated. Sandy with consolidated substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date: January 2023	Project: 32227	Submitter: P. De Carvalho	Reviewer: R. Phillips

Figure 5a

German Mills Creek GSMP Critical Area
Watercourse
Field Note

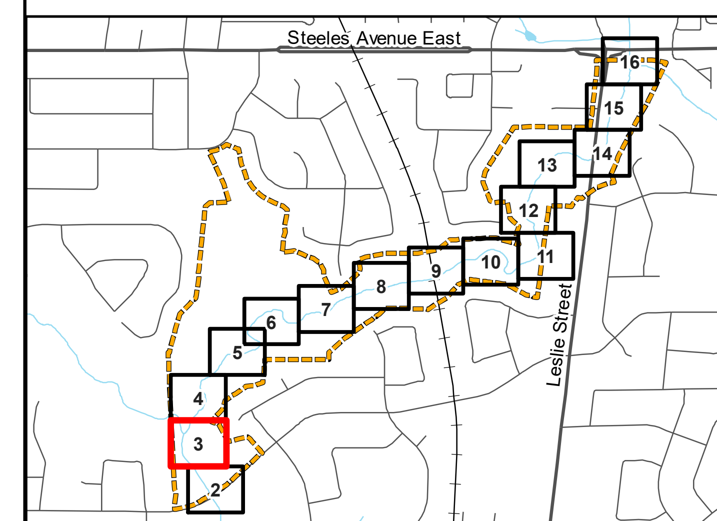
Channel Units

Pool
Riffle
Run

Habitat Element

Undercut Bank

Notes:
2. Riffle with a wetted depth of 18 cm. Left bank heavily vegetated with undercut, right bank heavily vegetated. Large cobble substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
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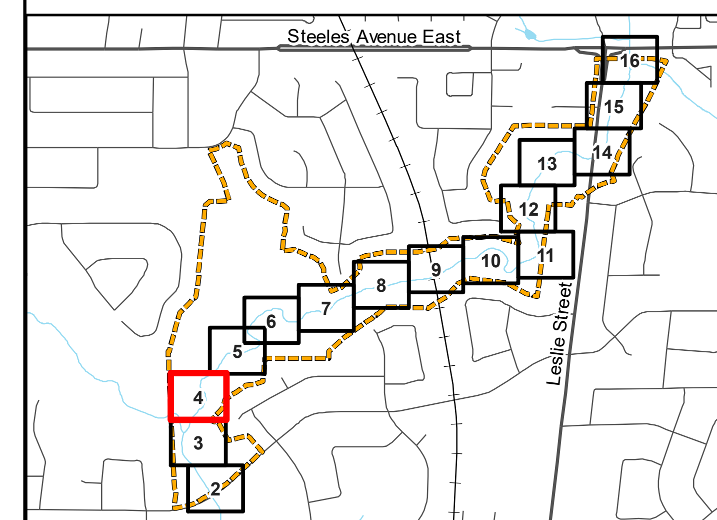
Figure
5b

German Mills Creek GSMP Critical Area
Watercourse
Field Note

Channel Units
Pool
Riffle
Run

Habitat Element
Backwater Area
Concrete Debris Build Up
RW Rootwad
Woody Debris

Notes:
3. Run with a wetted width of 7.6m and wetted depth of 25cm. Both banks heavily vegetated. Sandy gravel substrate.
4. Pool with a wetted depth of approximately 1m. Banks vegetated with embedded concrete chunks. Sand substrate with concrete chunks.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
January 2023	32227	P. De Carvalho	R. Phillips

Figure 5c

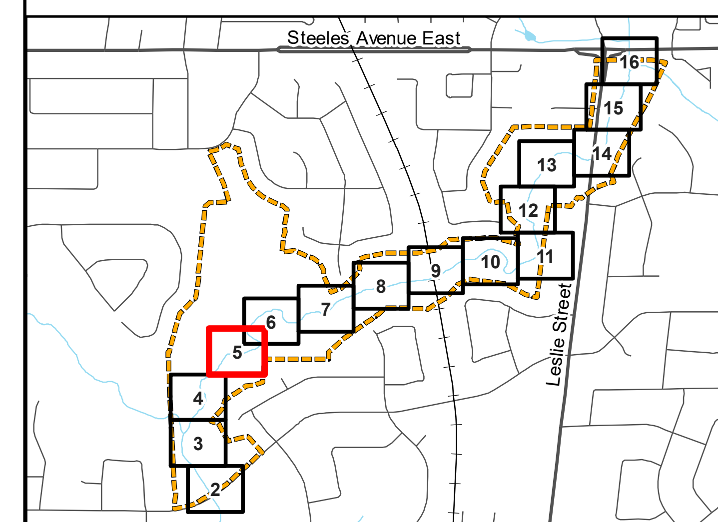
I:\CityofToronto\32227\FiguresAndTables\ECL\2022\Report\Figure-5a-to-5o-General_Aquatic_Habitat.mxd - Tabloid_L - 20-Jan-23, 03:08 PM - sylam - TID005

German Mills Creek GSMP Critical Area
Watercourse
Field Note

Channel Units
Pool
Riffle
Run

Habitat Element
Bar
Potential Fish Barrier
Undercut Bank
Woody Debris

Notes:
5. Potential fish barrier: A boulder weir with a drop of 65cm from top of water to upstream level.
6. Pool with an inlet with a wetted depth of approximately 1.2m. Banks eroded and vegetated. Substrate unconsolidated.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date: January 2023	Project: 32227	Submitter: P. De Carvalho	Reviewer: R. Phillips

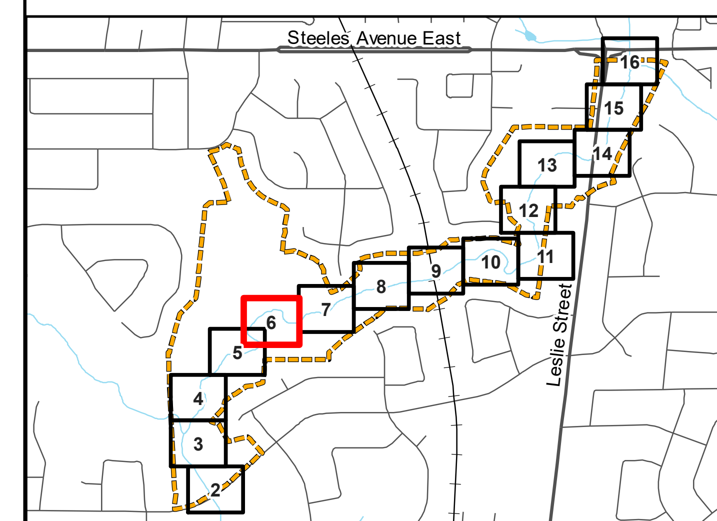
Figure 5d

German Mills Creek GSMP Critical Area
Watercourse
Field Note

Channel Units
Pool
Riffle
Run

Habitat Element
Bar
Undercut Bank
Woody Debris

Notes:
7. A riffle (left side) with a wetted depth of 13 cm, and a pool (right side) with a depth of 50 cm and a total wetted width of 8.6m. Banks eroded and vegetated. Substrate large gravel to the left and sand to the right side.
8. Run with a wetted depth of 22cm. Eroded left bank. Sandy gravel substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date: January 2023	Project: 32227	Submitter: P. De Carvalho	Reviewer: R. Phillips

Figure 5e

German Mills Creek GSMP Critical Area
Watercourse
Field Note

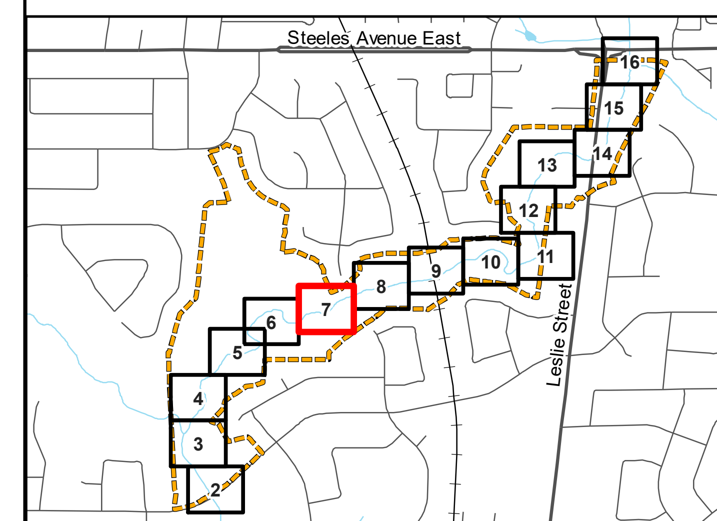
Channel Units

Pool
Riffle
Run

Habitat Element

Bar
Instream Vegetation
Woody Debris

Notes:
9. Riffle with a wetted width of 9.5 m and a wetted depth of 11cm. Banks vegetated. Small cobble and gravel substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
January 2023	32227	P. De Carvalho	R. Phillips

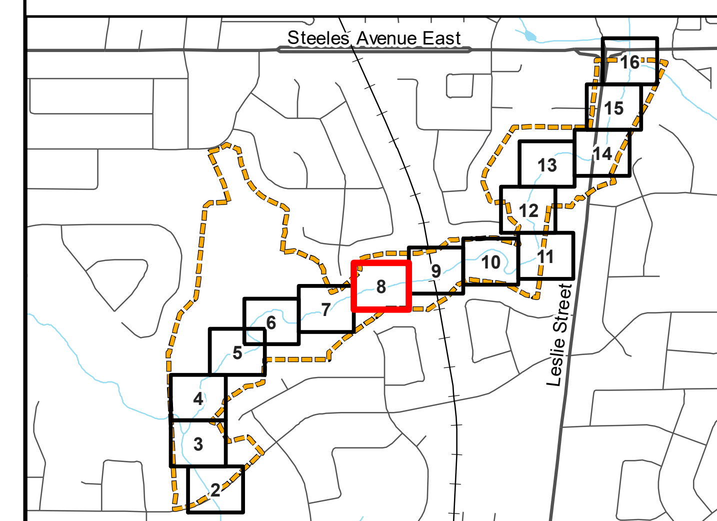
Figure
5f

German Mills Creek GSMP Critical Area
Watercourse
Field Note

Channel Units
Pool
Riffle
Run

Habitat Element
Instream Vegetation
Undercut Bank
Woody Debris

Notes:
10. Pool with a wetted depth of 95cm. Overhanging deciduous vegetation on banks. Sandy gravel substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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German Mills Creek GSMP

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Figure
5g

German Mills Creek GSMP Critical Area
Watercourse
Railway
Field Note

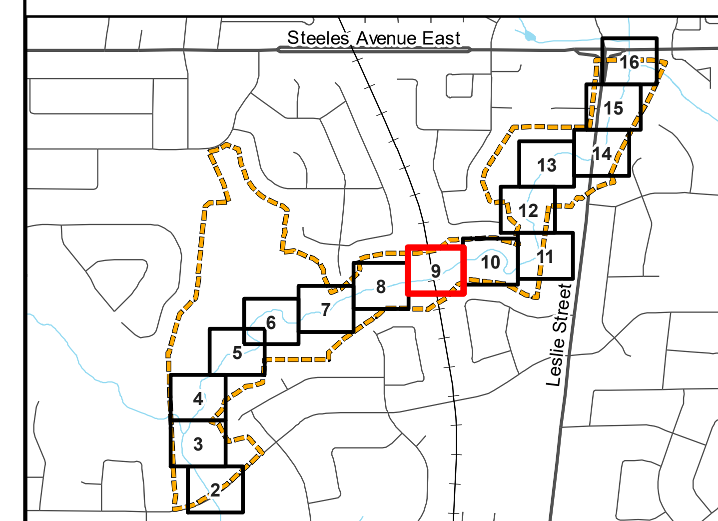
Channel Units

Pool
Riffle
Run

Habitat Element

Bar
Boulder/Boulder Cluster

Notes:
11. Riffle with a wetted width of 5.1m and a wetted depth of 15cm. Small cobble bar on the left bank. Small boulders and large cobble substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
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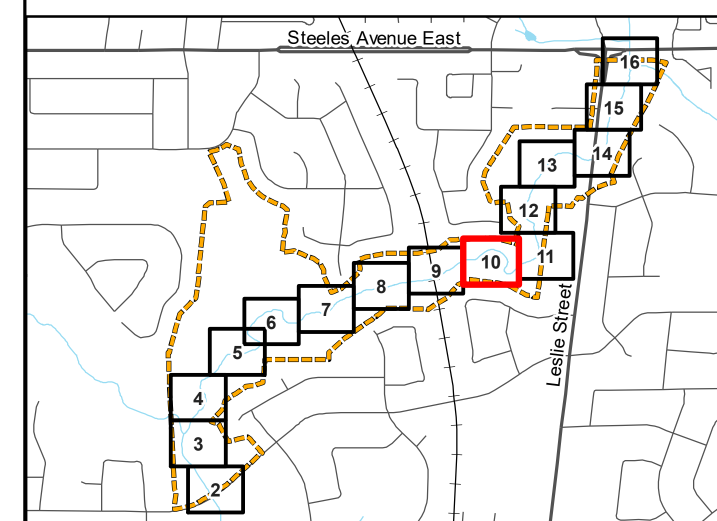
Figure
5h

German Mills Creek GSMP Critical Area
Watercourse
Field Note

Channel Units
- Pool
- Riffle
- Run

Habitat Element
- Bar
- Boulder/Boulder Cluster
- Exposed Tree Roots
- Woody Debris

Notes:
12. Pool with a wetted depth of over 1m. Banks eroded. Sandy substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date: January 2023	Project: 32227	Submitter: P. De Carvalho	Reviewer: R. Phillips

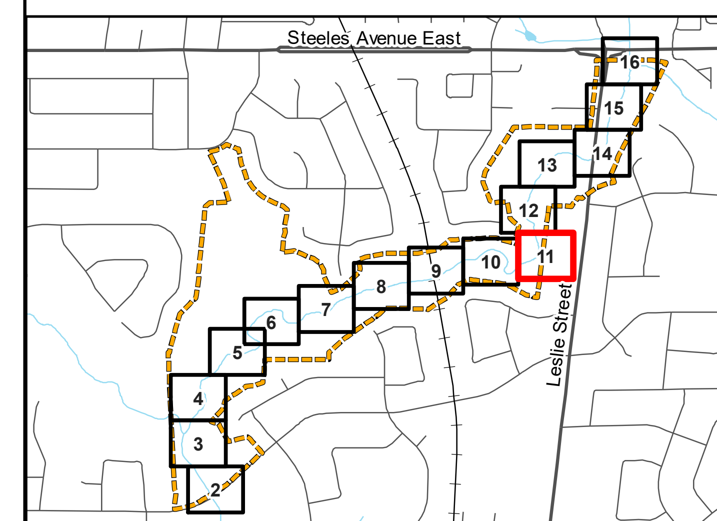
Figure 5i

German Mills Creek GSMP Critical Area
Watercourse
Field Note

Channel Units
Pool
Riffle
Run

Habitat Element
Bar
Boulder/Boulder Cluster
Exposed Tree Roots
Woody Debris

Notes:
13. Run with some pools concentrated along the banks with a wetted depth of 24-34 cm. Sandy gravel substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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Matrix Solutions Inc.
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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
January 2023	32227	P. De Carvalho	R. Phillips

Figure
5j

German Mills Creek GSMP Critical Area
Watercourse
Field Note

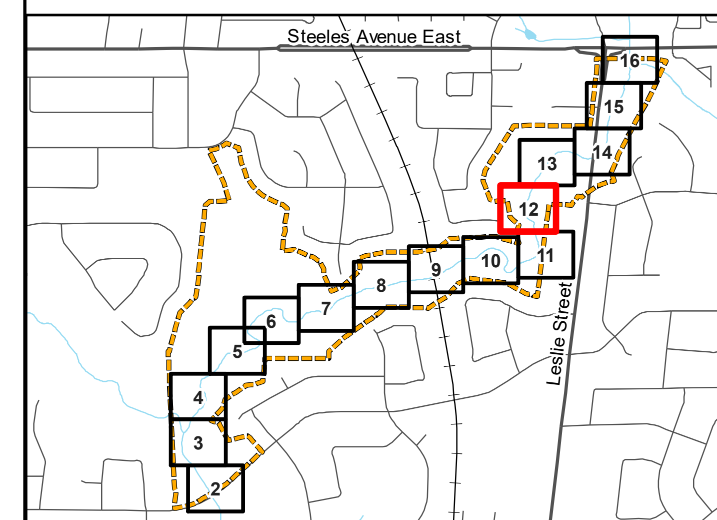
Channel Units

Pool
Riffle
Run

Habitat Element

Bar
Boulder/Boulder Cluster
Exposed Tree Roots
Woody Debris

Notes:
14. Pool with a wetted depth of over 2m. Left bank armourstone, right bank eroded. Sandy gravel substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
January 2023	32227	P. De Carvalho	R. Phillips

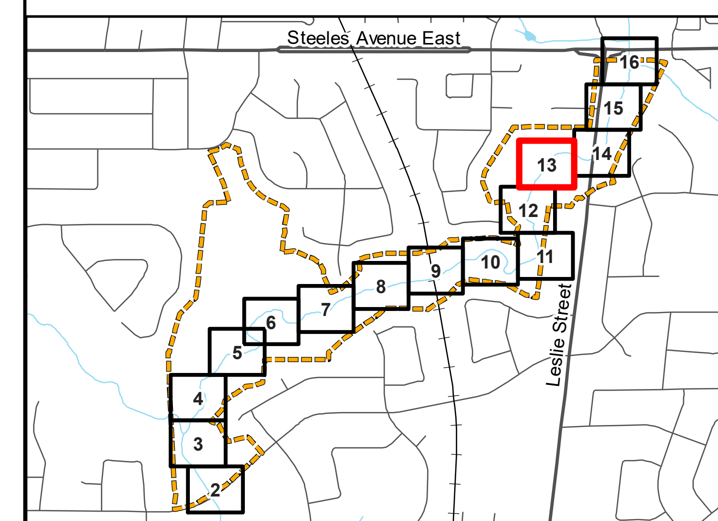
Figure
5k

German Mills Creek GSMP Critical Area
Watercourse
Field Note

Channel Units
Pool
Riffle
Run

Habitat Element
Backwater Area
Exposed Tree Roots
Undercut Bank
Woody Debris

Notes:
15. Riffle with a wetted depth of 32-12cm. Vegetated banks with island near the left bank. Gravel and cobble substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
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Figure
5l

I:\CityofToronto\32227\FiguresAndTables\ECL\2022\Report\Figure-5a-to-5o-General_Aquatic_Habitat.mxd - Tabloid_L - 20-Jan-23, 03:09 PM - sylam - TID005

German Mills Creek GSMP Critical Area
Watercourse
Highway
Field Note

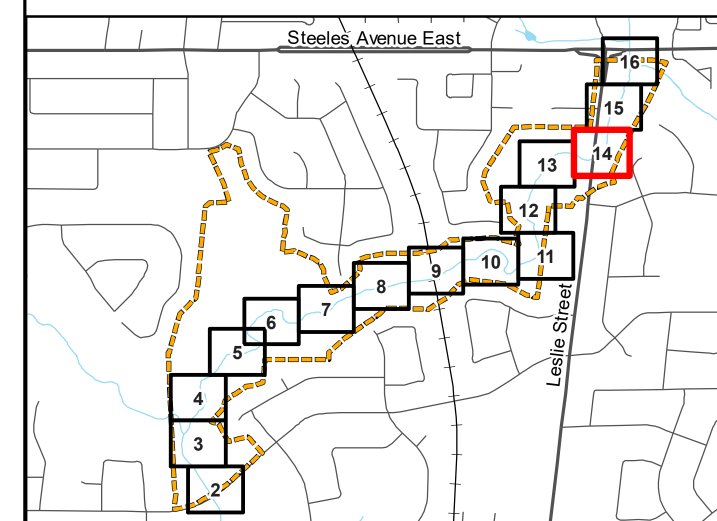
Channel Units

Pool
Riffle

Habitat Element

Backwater Area
Boulder/Boulder Cluster
Exposed Tree Roots
Historic Bridge Infrastructure

Notes:
16. Pool with a wetted width of 8.80m and wetted depth of 48 cm. Banks with overhanging vegetation and a pedestrian path on the left bank. Sandy gravel substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
January 2023	32227	P. De Carvalho	R. Phillips

Figure
5m

I:\CityofToronto\32227\FiguresAndTables\ECL\2022\Report\Figure-5a-to-5o-General_Aquatic_Habitat.mxd - Tabloid_L - 20-Jan-23, 03:09 PM - sylam - TID005

German Mills Creek GSMP Critical Area
Watercourse
Highway
Road
Field Note

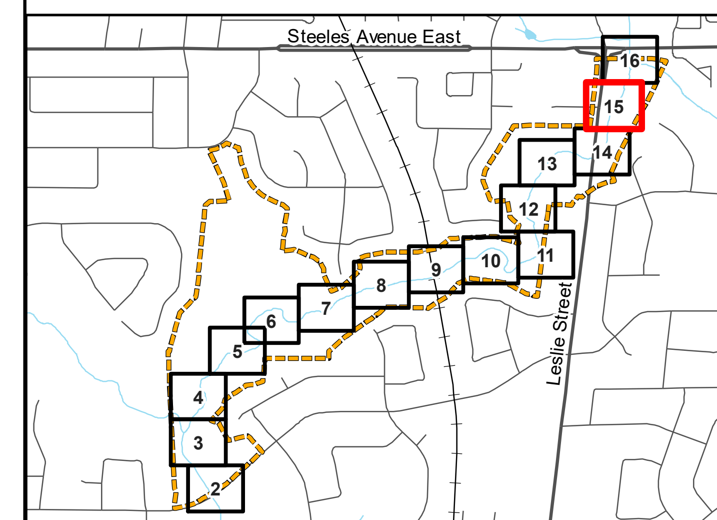
Channel Units

Pool
Riffle
Run

Habitat Element

Boulder/Boulder Cluster
Potential Fish Barrier
Woody Debris

Notes:
17. Riffle series with a wetted width of 5.30 m and a wetted depth of 16cm. Cobble and small boulder substrate.
18. Embedded armourstone forming riffles and creating a potential fish barrier with a drop of 50 cm.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

General Aquatic Habitat

Date:	Project:	Submitter:	Reviewer:
January 2023	32227	P. De Carvalho	R. Phillips

Figure
5n

German Mills Creek GSMP Critical Area
Watercourse
Highway
Road
Field Note

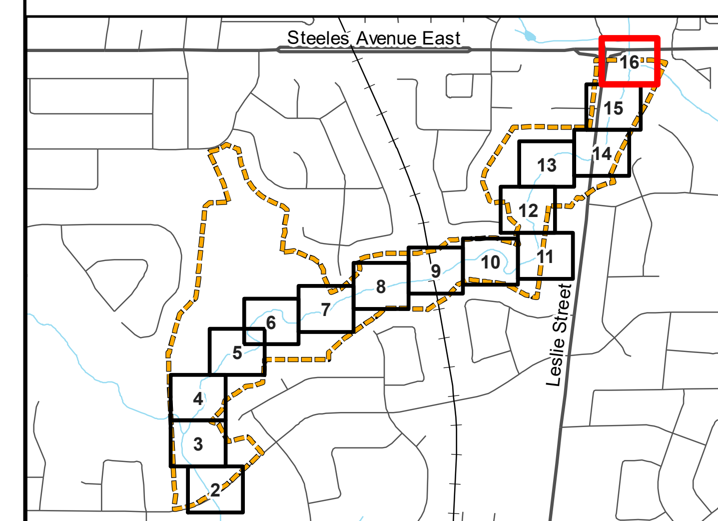
Channel Units

Pool
Riffle

Habitat Element

Boulder/Boulder Cluster

Notes:
19. Pool with a wetted width of 10.20 m and wetted depth of 1m. Both banks vegetated with tall grasses and shrubs. Sandy substrate.
20. Riffle with a wetted width of 2.3m and wetted depth of 19cm. Armourstone on right and left bank. Boulder and cobble substrate.



1:500 metres
5 0 5 10
NAD27 MTM zone 10

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City of Toronto
German Mills Creek GSMP

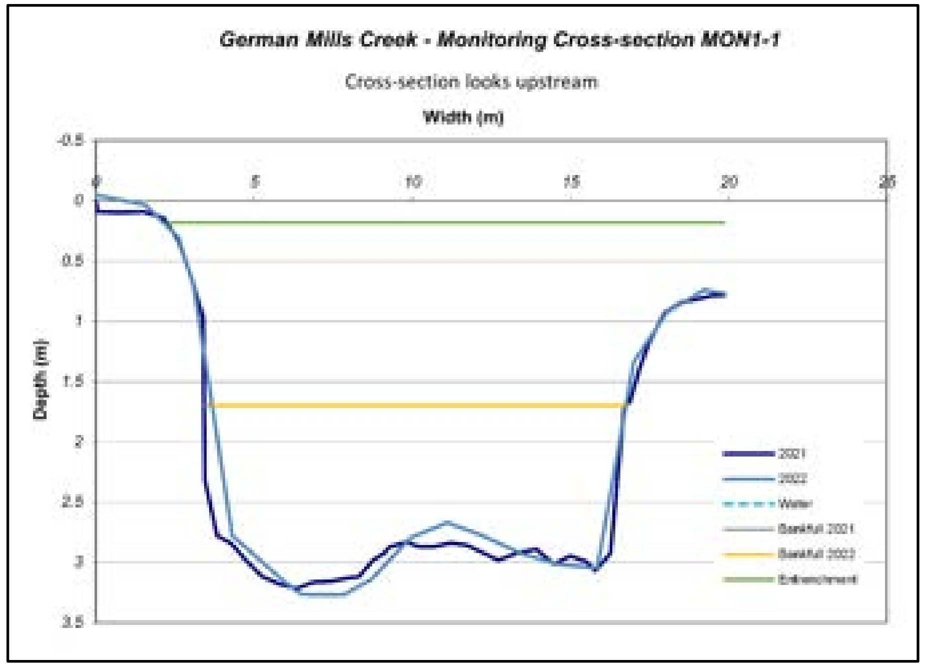
General Aquatic Habitat

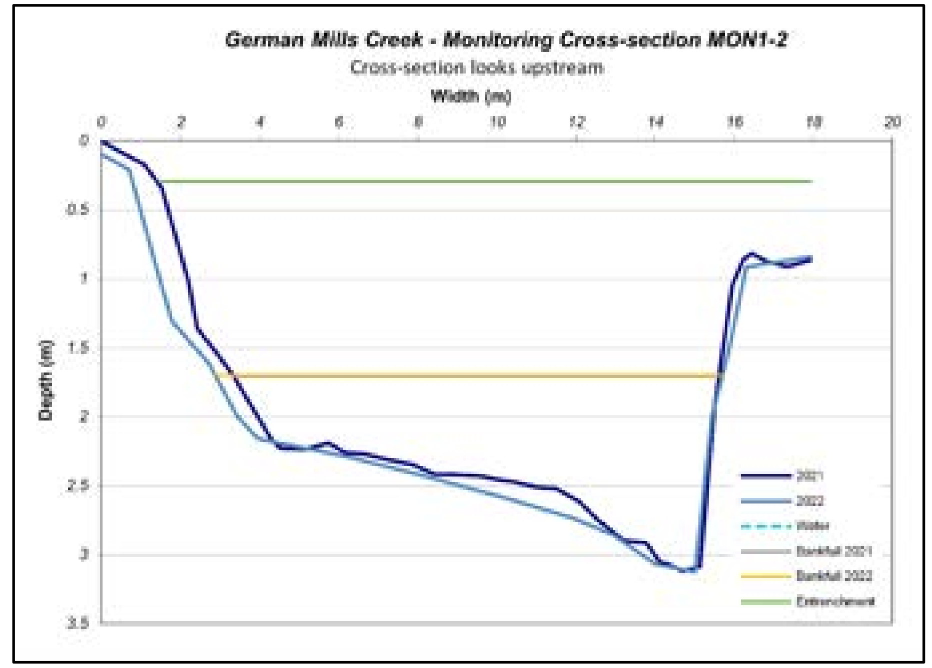
Date:	Project:	Submitter:	Reviewer:
January 2023	32227	P. De Carvalho	R. Phillips

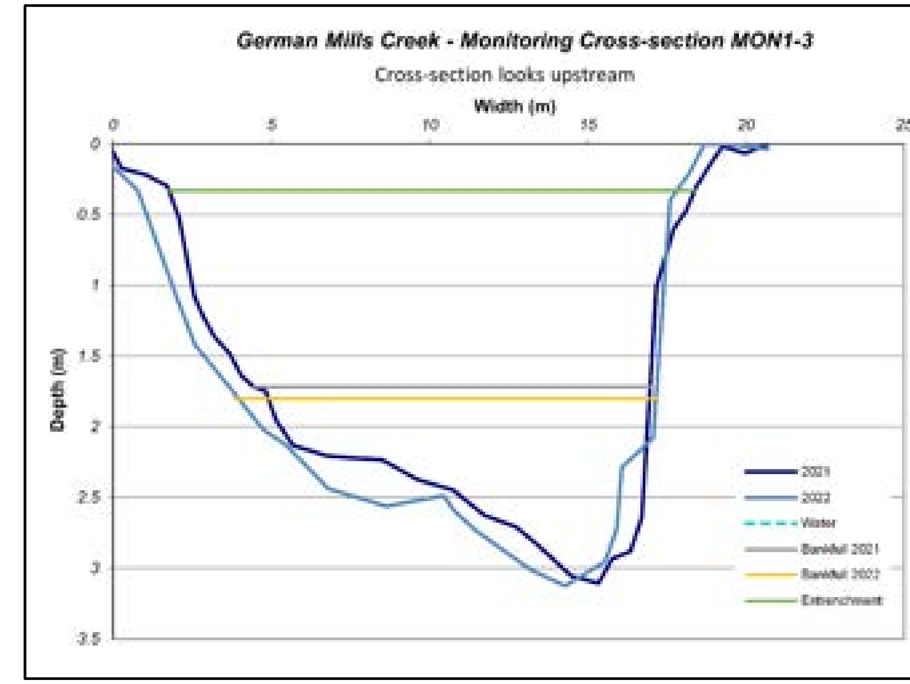
Figure 5o

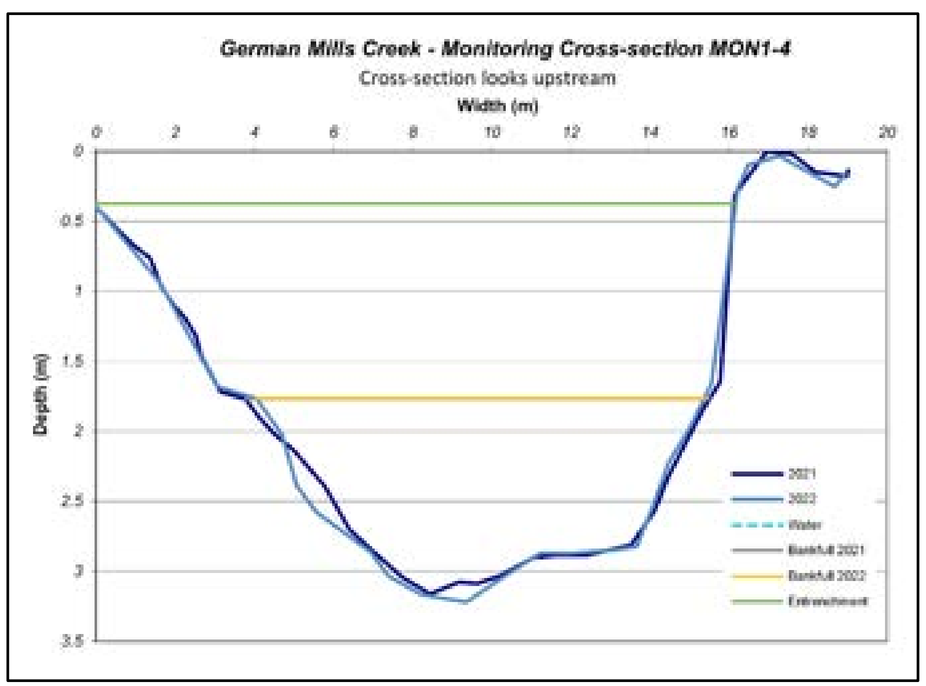
I:\CityofToronto\32227\FiguresAndTables\ECL\2022\Report\Figure-5a-to-5o-General_Aquatic_Habitat.mxd - Tabloid_L - 20-Jan-23, 03:10 PM - sylam - TID005

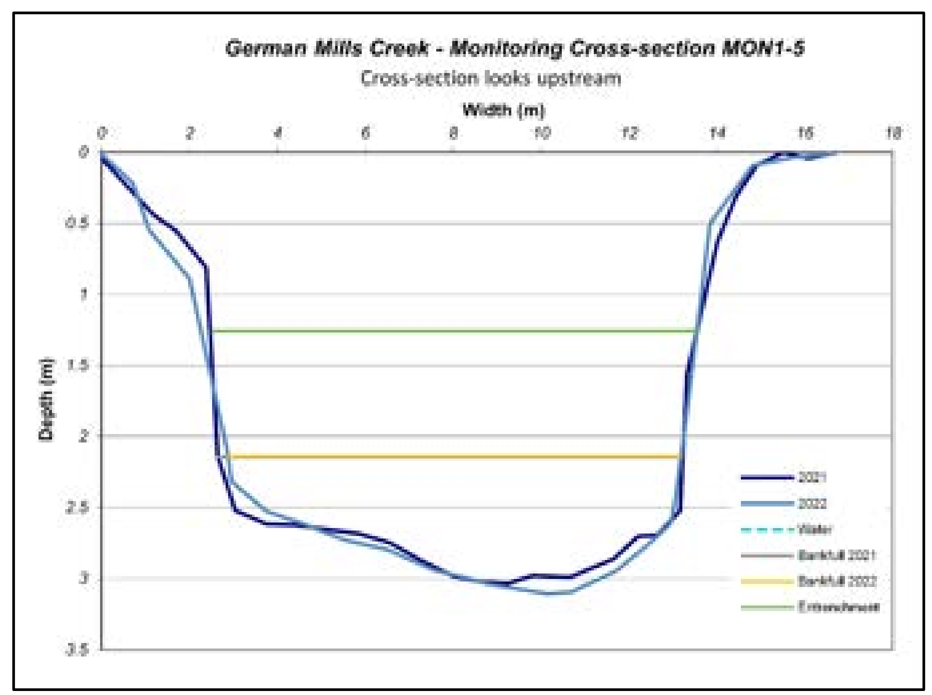
APPENDIX A
Channel Cross-sections

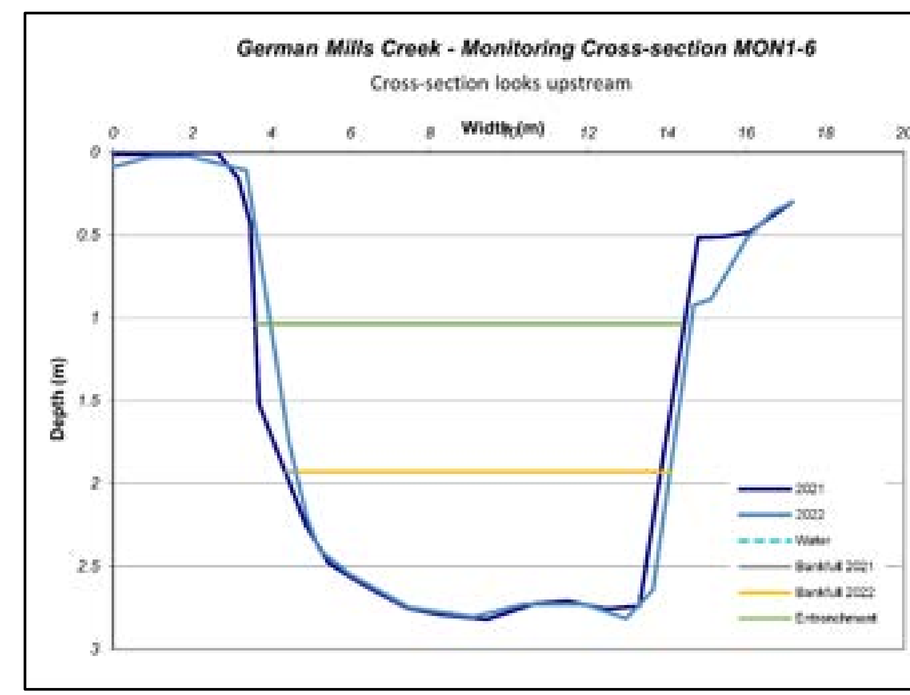

German Mills Creek - Monitoring Cross-section MON1-1
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

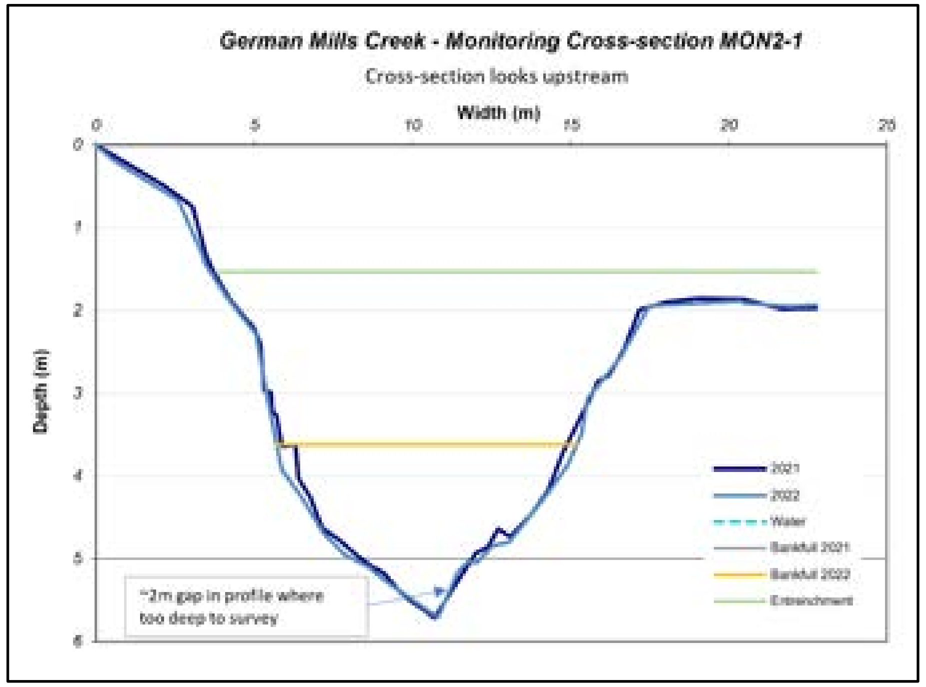

German Mills Creek - Monitoring Cross-section MON1-2
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

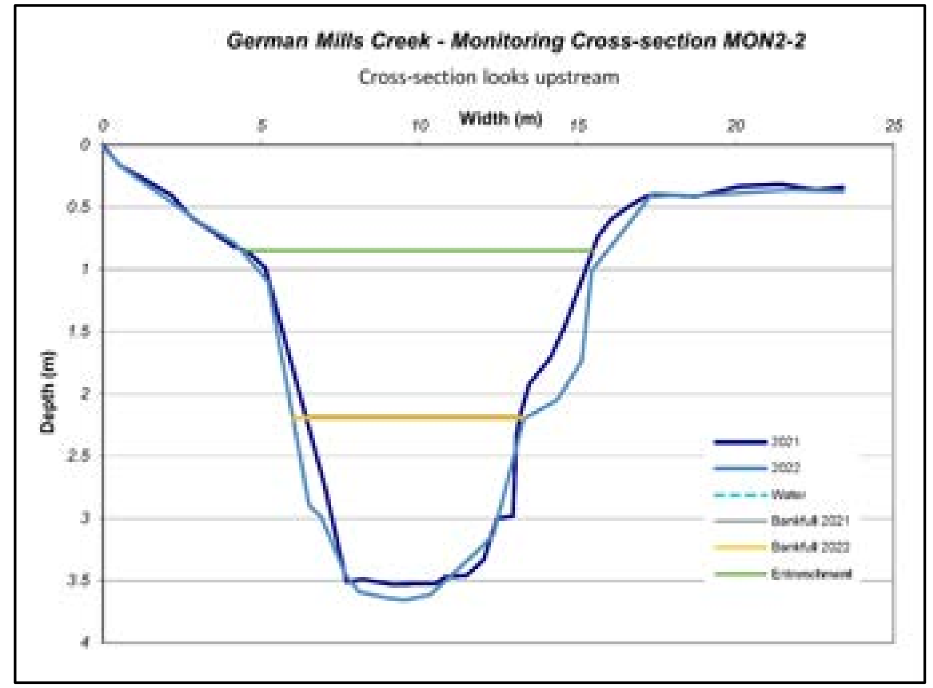

German Mills Creek - Monitoring Cross-section MON1-3
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

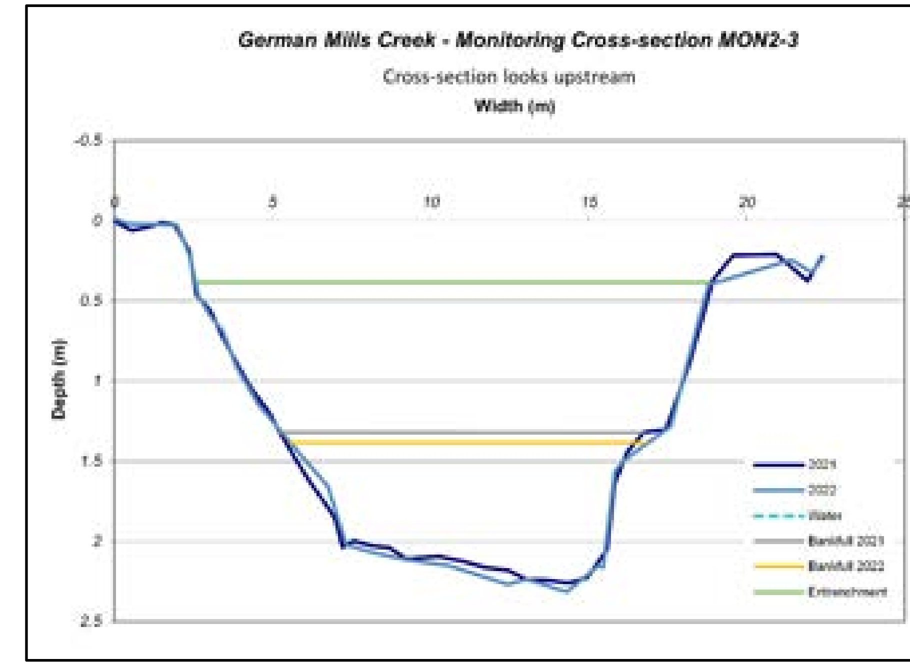

German Mills Creek - Monitoring Cross-section MON1-4
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

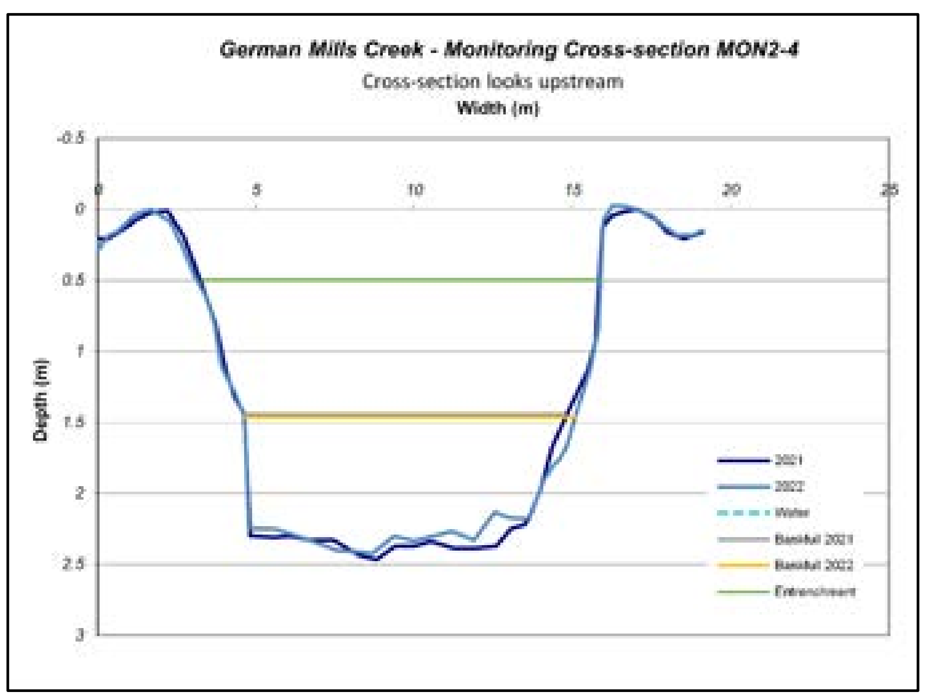

German Mills Creek - Monitoring Cross-section MON1-5
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

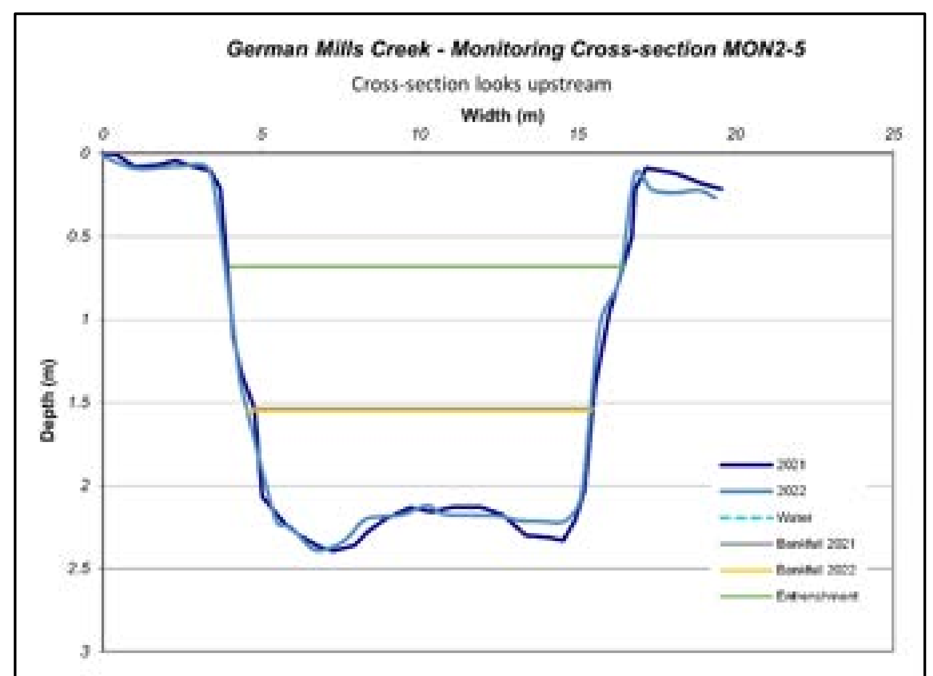

German Mills Creek - Monitoring Cross-section MON1-6
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

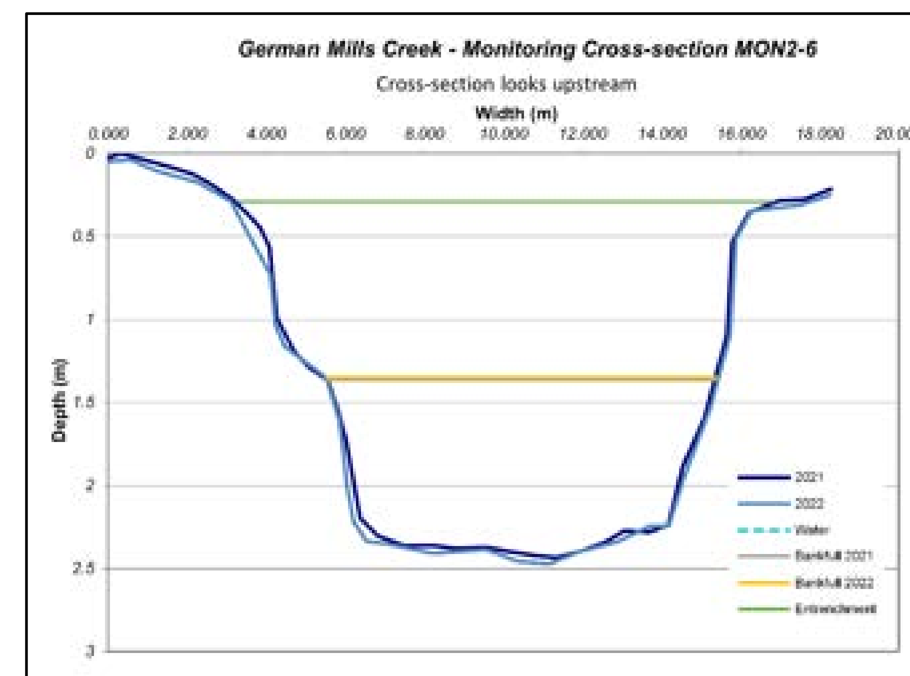

German Mills Creek - Monitoring Cross-section MON2-1
Cross-section looks upstream
Width (m)
Depth (m)
*2m gap in profile where too deep to survey
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

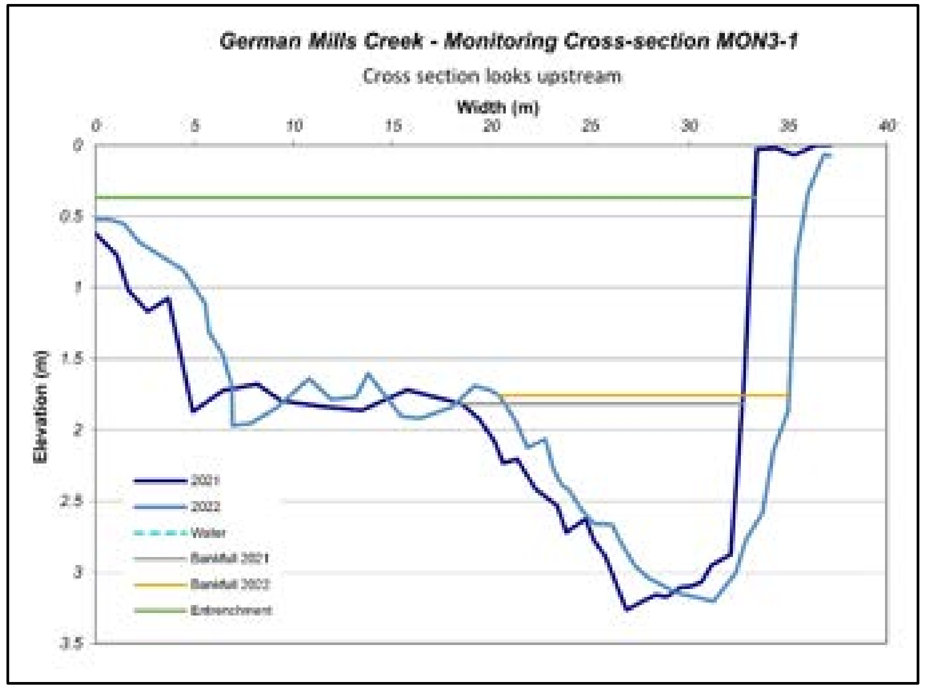

German Mills Creek - Monitoring Cross-section MON2-2
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

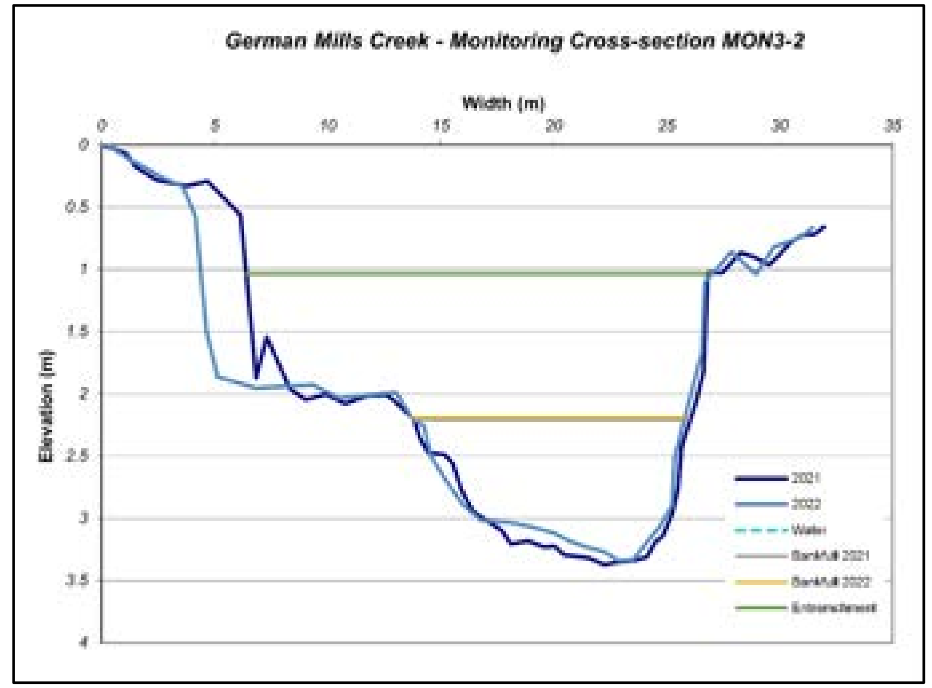

German Mills Creek - Monitoring Cross-section MON2-3
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

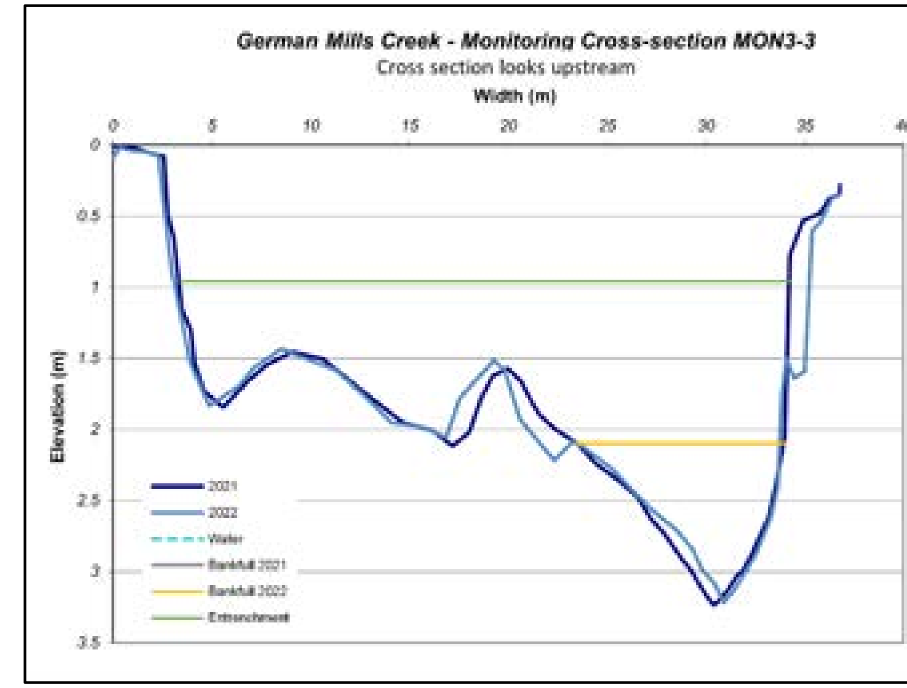

German Mills Creek - Monitoring Cross-section MON2-4
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

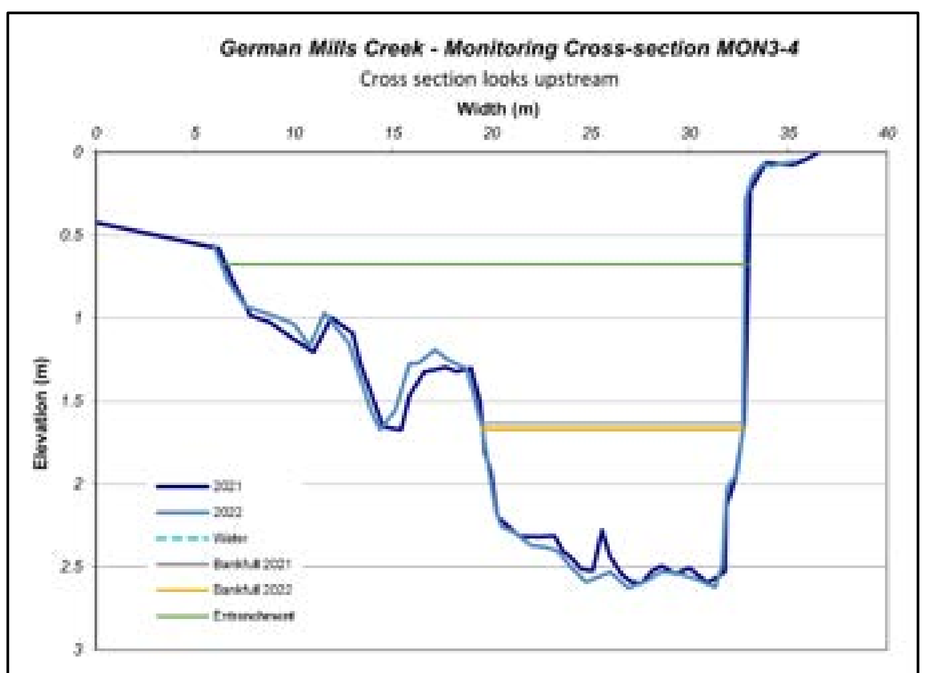

German Mills Creek - Monitoring Cross-section MON2-5
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

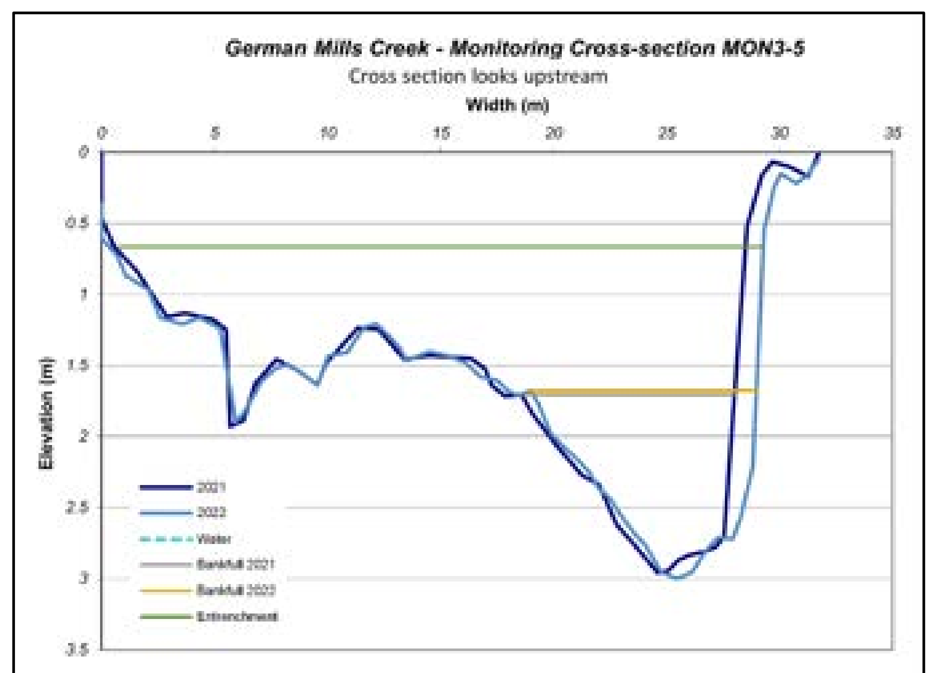

German Mills Creek - Monitoring Cross-section MON2-6
Cross-section looks upstream
Width (m)
Depth (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

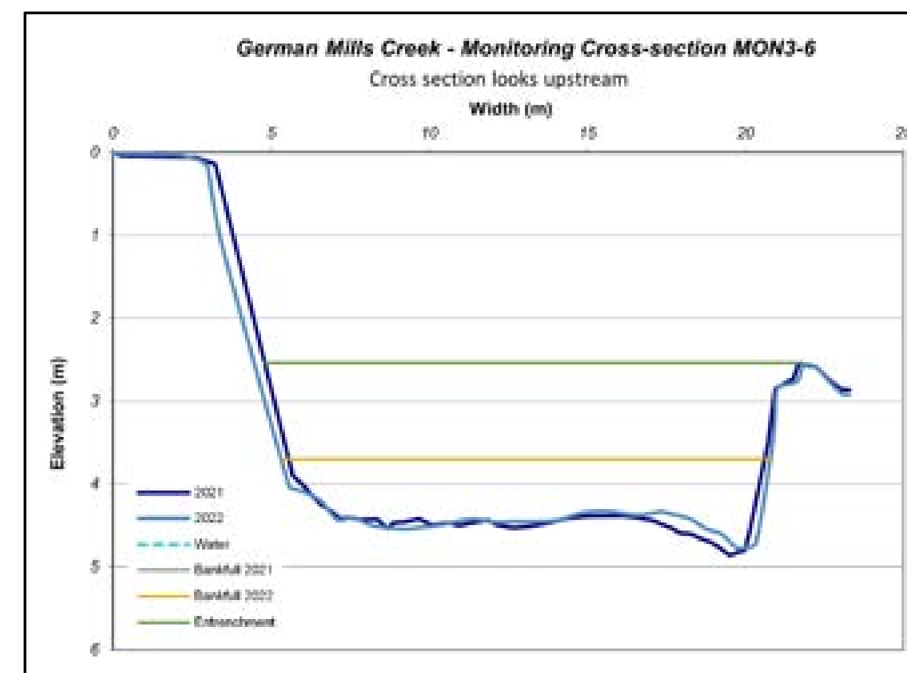

German Mills Creek - Monitoring Cross-section MON3-1
Cross section looks upstream
Width (m)
Elevation (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment


German Mills Creek - Monitoring Cross-section MON3-2
Width (m)
Elevation (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment


German Mills Creek - Monitoring Cross-section MON3-3
Cross section looks upstream
Width (m)
Elevation (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment


German Mills Creek - Monitoring Cross-section MON3-4
Cross section looks upstream
Width (m)
Elevation (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment


German Mills Creek - Monitoring Cross-section MON3-5
Cross section looks upstream
Width (m)
Elevation (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment


German Mills Creek - Monitoring Cross-section MON3-6
Cross section looks upstream
Width (m)
Elevation (m)
2021
2022
Water
Bankfull 2021
Bankfull 2022
Entrenchment

APPENDIX B
Repeat Photographs

Matrix Supplied
July 19, 2021

Photo 1 – YEAR 1 - German Mills Creek upstream of armourstone wall, looking upstream.

Matrix Supplied
August 15, 2022

Photo 1 – YEAR 2 - German Mills Creek upstream of armourstone wall, looking upstream.

Matrix Supplied
July 19, 2021

Photo 2 – YEAR 1 - View of armourstone wall.

Matrix Supplied
August 15, 2022

Photo 2 – YEAR 2 - View of armourstone wall. Additional debris has accumulated.

Matrix Supplied
July 19, 2021

Photo 3 – YEAR 1 - South creek bank at downstream limit of armourstone wall.

Matrix Supplied
August 15, 2022

Photo 3 – YEAR 2 - South creek bank at downstream limit of armourstone wall. Bank top tree leans further toward channel.

Matrix Supplied
July 19, 2021

Photo 4 – YEAR 1 – View of creek looking upstream from top of armourstone wall.

Matrix Supplied
August 15, 2022

Photo 4 – YEAR 2 – View of creek looking upstream from top of armourstone wall.

Matrix Supplied
July 19, 2021

Photo 5 – YEAR 1 – View looking upstream near MON1-1.

Matrix Supplied
August 15, 2022

Photo 5 – YEAR 2 – View looking upstream near MON1-1. Bar form has changed. Water levels were lower during Year 2 than Year 1 survey.

Matrix Supplied
July 19, 2021

Photo 6 – YEAR 1 – Exposed manhole on north creek bank.

Matrix Supplied
August 15, 2022

Photo 6 – YEAR 2 – Exposed manhole on north creek bank.

Matrix Supplied
July 19, 2021

Photo 7 – YEAR 1 – View of pool with exposed manhole and riffle in background, looking upstream.

Matrix Supplied
August 15, 2022

Photo 7 – YEAR 2 - View of pool with exposed manhole and riffle in background, looking upstream.

Matrix Supplied
July 19, 2021

Photo 8 – YEAR 1 – View looking downstream near MON1-6.

Matrix Supplied
August 15, 2022

Photo 8 – YEAR 2 – View looking downstream near MON1-6.

Matrix Supplied
Sept 9, 2021

Photo 1 – YEAR 1 - Riffle below train bridge looking downstream.

Matrix Supplied
August 15, 2022

Photo 1 – YEAR 2 - Riffle below train bridge looking downstream.

Matrix Supplied
Sept 9, 2021

Photo 2 – YEAR 1 - MON2-1 area, view upstream toward train bridge.

Matrix Supplied
August 15, 2022

Photo 2 – YEAR 2 - MON2-1 area, view upstream toward train bridge.

Matrix Supplied
Sept 9, 2021

Photo 3 – YEAR 1 - View downstream from point bar on right bank just downstream of MON2-3

Matrix Supplied
August 15, 2022

Photo 3 – YEAR 2 - View downstream from point bar on right bank just downstream of MON2-3

Matrix Supplied
Sept 9, 2021

Photo 4 – YEAR 1 - View upstream from point bar on right bank just downstream of MON2-3

Matrix Supplied
August 15, 2022

Photo 4 – YEAR 2 - View upstream from point bar on right bank just downstream of MON2-3

Matrix Supplied
Sept 9, 2021

Photo 5 – YEAR 1 – Riffle looking downstream

Matrix Supplied
August 15, 2022

Photo 5 – YEAR 2 - Riffle looking downstream; water levels were lower

Matrix Supplied
Sept 9, 2021

Photo 6 – YEAR 1 – Riffle looking upstream

Matrix Supplied
August 15, 2022

Photo 6 – YEAR 2 - Riffle looking upstream; water levels were lower

Matrix Supplied
Sept 9, 2021

Photo 7 – YEAR 1 – South bank below pedestrian bridge

Matrix Supplied
August 15, 2022

Photo 7 – YEAR 2 - South bank below pedestrian bridge. Additional vegetation covers the slumped material at toe.

Matrix Supplied
Sept 9, 2021

Photo 8 – YEAR 1 – View downstream below pedestrian bridge

Matrix Supplied
August 15, 2022

Photo 8 – YEAR 2 – Bank conditions similar to previous year.

Matrix Supplied
July 27, 2021

1. Bestview Tributary confluence with German Mills Creek

Matrix Supplied
August 25, 2022

1. Bestview Tributary confluence with German Mills Creek. Additional sedimentation at confluence.

Matrix Supplied
July 27, 2021

2. View downstream from north bank toward MON3-1

Matrix Supplied
August 25, 2022

2. View downstream from north bank toward MON3-1. A different tree has fallen (leaves were still green on August 15, 2022) since the 2021 photograph, and the earlier tree has been pushed downstream. The top of bank appears to have receded.

Matrix Supplied
September 17, 2021

3. View upstream from south bank point bar at MON3-1

Matrix Supplied
August 25, 2022

3. View upstream from south bank point bar at MON3-1. Minor slumping has occurred since 2021.

Matrix Supplied
September 17, 2021

4. View downstream from south bank point bar at MON3-3

Matrix Supplied
September 15, 2022

4. View downstream from south bank point bar at MON3-3. Bar appears to be similar.

Matrix/Client Supplied
September 17, 2021

5. View downstream toward MON3-4 from south bank

Matrix/Client Supplied
September 15, 2022

5. View downstream toward MON3-4 from south bank

Matrix/Client Supplied
September 17, 2021

6. View downstream at MON3-5 from south bank

Matrix/Client Supplied
September 15, 2022

6. View downstream at MON3-5 from south bank. Vegetation has filled in on upper part of bank while the lower part of the bar remains unvegetated and covered in fresh deposits of fines.

Matrix/Client Supplied
September 17, 2021

7. View upstream toward MON3-6 from south bank. Eroding bank at valley contact visible at MON3-6.

Matrix/Client Supplied
September 15, 2022

7. View upstream toward MON3-6 from south bank. Top of bank has receded slightly. Bar material has migrated downstream. Large woody debris has accumulated upstream of exposed bank at a meander.

Matrix/Client Supplied
September 17, 2021

8. View of north bank at MON2-6 (eroding bank / valley contact)

Matrix/Client Supplied
September 15, 2022

8. View of north bank at MON2-6. Bank has receded slightly near top of bank.

APPENDIX C
Benthic Metric Data

TABLE C1 Benthic Macroinvertibrates Collected from German Mills Creek, 2021 (densities expressed per sampled area)

	Station 1			Station 2			Station 3		
	101	102	103	201	202	203	301	302	303
	pool	riffle	run	riffle	run	pool	pool	riffle	run
Roundworm									
P. Nemata	-	72	24	120	3	1	2	64	1
Flatworms									
P. Platyhelminthes									
Cl. Turbellaria									
F. Dugesiidae									
Dugesia	-	16	2	-	-	-	-	-	-
Annelids									
P. Annelida									
Worms									
Cl. Oligochaeta									
F. Enchytraeidae	-	30	20	-	-	-	-	4	-
F. Naididae									
S.F. Naidinae									
Dero digitata	-	-	-	11	4	-	-	-	-
Nais	-	15	-	-	-	-	-	23	4
S.F. Pristininae									
Pristina jenkinae	-	15	38	22	-	-	-	-	-
S.F. Tubificinae									
Limnodrilus hoffmeisteri	-	-	-	-	-	1	-	-	-
Limnodrilus udekemianus	2	-	-	11	-	-	-	-	-
Tubifex tubifex	-	15	-	-	-	-	-	-	-
immatures with hair chaetae	4	44	139	11	39	2	7	78	2
immatures without hair chaetae	12	178	63	162	44	4	5	55	20
Leeches									
Cl. Hirudinea									
F. Erpobdellidae									
Erpobdella	-	-	-	8	-	-	-	-	-
Mooreobdella microstoma	-	10	-	-	-	-	-	-	-
immature	-	**8**	-	-	-	-	-	16	1
F. Glossiphoniidae									
Helobdella stagnalis	-	-	-	-	1	-	-	-	3
Arthropods									
P. Arthropoda									
Mites									
Cl. Arachnida									
Subcl. Acari	-	-	2	-	-	-	-	-	-
O. Trombidiformes									
F. Hygrobatidae									
Hygrobates	-	-	-	-	-	-	-	4	-
Water Scuds									
O. Amphipoda									
F. Crangonyctidae									
Crangonyx	-	-	4	-	-	-	-	4	-
Aquatic Sow Bugs									
O. Isopoda									
F. Asellidae									
Caecidotea	3	64	18	104	1	11	1	212	23
Insects									
Cl. Insecta									
Beetles									
O. Coleoptera									
F. Elmidae									
Dubiraphia larvae	-	8	-	-	-	-	-	-	-
Optioservus larvae	-	8	-	-	-	-	-	-	-
Stenelmis crenata	-	24	-	8	-	-	-	8	-
Stenelmis larvae	1	**128**	8	**56**	-	-	-	**32**	1
Mayflies									
O. Ephemeroptera									
F. Baetidae									
Baetis flavistriga	-	16	2	16	-	-	-	4	-
O. Megaloptera									
Alderflies									
F. Sialidae									
Sialis	-	8	-	-	-	-	-	-	-
O. Odonata									
Damselflies									
F. Coenagrionidae									
Nehalennia	-	-	-	-	1	-	-	-	-
immature	-	-	4	-	-	1	-	4	-
Dragonflies									
F. Aeshnidae									
Boyeria	-	-	-	1	-	-	-	-	-
Caddisflies									

	Station 1			Station 2			Station 3		
	101	102	103	201	202	203	301	302	303
	pool	riffle	run	riffle	run	pool	pool	riffle	run
O. Trichoptera									
F. Hydropsychidae									
Cheumatopsyche	1	392	40	304	2	-	-	140	1
Hydropsyche betteni	-	80	2	136	-	1	-	24	-
Hydropsyche bronta	-	496	44	192	2	1	-	204	5
Hydropsyche slossonae	-	128	4	40	-	-	-	40	-
Hydropsyche sparna	-	40	-	32	-	-	-	-	-
Hydropsyche immature	-	**200**	**12**	**96**	-	**1**	-	**84**	-
pupae	-	**32**	-	-	-	-	-	-	-
immature	-	-	-	**16**	-	-	-	-	-
F. Hydroptilidae									
Hydroptila	-	16	-	24	-	-	-	8	-
pupae	-	**16**	-	-	-	-	-	**4**	-
True Flies									
O. Diptera									
Biting-Midge									
F. Ceratopogonidae									
Atrichopogon	-	-	-	-	-	-	-	4	-
Midges									
F. Chironomidae									
chironomid pupae	**3**	**120**	**8**	**64**	**1**	-	-	**24**	**4**
S.F. Chironominae									
Chironomus	2	-	2	-	2	3	4	4	6
Cryptochironomus	-	8	4	-	2	-	1	-	-
Dicrotendipes	-	-	4	8	1	-	-	16	6
Micropsectra	-	8	-	-	-	-	-	24	-
Microtendipes	-	16	-	-	-	-	-	-	-
Paratanytarsus	1	48	14	120	13	3	1	68	6
Phaenopsectra	5	8	4	-	3	3	9	4	-
Polypedilum flavum	-	16	6	40	-	1	-	24	-
Polypedilum scalaenum	-	-	2	-	6	1	-	4	2
Rheotanytarsus	-	-	-	-	-	-	-	44	2
Stictochironomus	2	8	12	-	14	-	3	4	7
Tanytarsus	1	16	12	56	3	2	-	24	4
S.F. Diamesinae									
Pagastia	-	-	-	-	-	-	-	4	-
S.F. Orthocladiinae									
Brillia	-	-	-	8	1	-	-	-	-
Corynoneura	-	-	-	8	-	-	-	-	-
Cricotopus	2	72	2	144	-	-	1	100	-
Cricotopus bicinctus	-	184	20	80	1	-	-	96	4
Cricotopus trifascia	-	32	-	64	1	-	-	-	-
Cricotopus/Orthocladius	-	104	16	128	4	-	-	108	-
Eukiefferiella devonica group	-	8	2	16	-	-	-	8	-
Eukiefferiella	-	-	-	16	-	-	-	4	-
Parakiefferiella	-	24	-	-	-	-	-	16	-
Parametriocnemus	-	80	4	112	-	-	-	20	-
Thienemanniella	-	-	-	-	-	-	-	4	-
indeterminate	-	-	-	-	-	-	-	4	-
S.F. Tanypodinae									
Ablabesmyia	-	-	-	-	-	-	1	-	-
Macropelopia	-	-	-	-	1	-	-	-	-
Natarsia	-	8	-	-	-	-	-	-	-
Thienemannimyia complex	-	8	14	8	-	-	-	28	-
F. Dolichopodidae	-	-	-	-	-	-	-	-	1
F. Empididae									
Hemerodromia	-	48	6	32	-	-	-	4	-
F. Simuliidae	-	8	-	-	-	-	-	-	-
F. Tipulidae									
Antocha	-	16	2	-	-	-	-	-	-
Tipula	-	1	-	2	-	-	-	-	-
Molluscs									
P. Mollusca									
Snails									
Cl. Gastropoda									
F. Physidae									
Physella	2	-	6	8	2	-	1	-	-
Clams									
Cl. Bivalvia									
F. Sphaeriidae									
Pisidium	1	-	-	-	-	-	-	4	-
TOTAL NUMBER OF ORGANISMS	42	####	566	####	152	36	36	####	103
TOTAL NUMBER OF TAXA (1)	14	42	34	34	23	14	12	41	19

Notes:

(1) Bold entries excluded from taxa count

TABLE C2 Benthic Macroinvertibrates Collected from German Mills Creek, 2022 (densities expressed per sampled area)

	Station 1			Station 2			Station 3		
	101	102	103	201	202	203	301	302	303
	pool	riffle	run	riffle	run	pool	pool	riffle	run
Roundworm									
P. Nemata	12	168	1	1	-	96	6	40	4
Flatworms									
P. Platyhelminthes									
Cl. Turbellaria									
F. Dugesiidae									
Dugesia	-	-	-	1	8	8	-	8	-
Annelids									
P. Annelida									
Worms									
Cl. Oligochaeta									
F. Enchytraeidae	16	54	2	-	-	31	2	64	-
F. Naididae									
S.F. Naidinae									
Nais									
S.F. Pristininae									
Pristina jenkinae	-	-	-	-	-	15	-	-	-
S.F. Tubificinae									
Limnodrilus hoffmeisteri	-	14	-	8	-	-	-	28	7
Limnodrilus udekemianus	-	14	7	-	17	-	-	-	-
Tubifex tubifex	-	14	-	-	-	-	29	-	-
immatures with hair chaetae	768	41	26	3	171	30	115	111	52
immatures without hair chaetae	384	177	117	46	188	244	606	417	97
Leeches									
Cl. Hirudinea									
F. Erpobdellidae									
immature	9	10	-	-	-	-	-	16	1
F. Glossiphoniidae									
Helobdella stagnalis	4	-	-	-	-	-	6	-	-
Arthropods									
P. Arthropoda									
Mites									
Cl. Arachnida									
Subcl. Acari	-	-	-	-	-	-	-	8	-
O. Trombidiformes									
F. Sperchontidae									
Sperchon	-	8	-	-	-	8	-	-	-
Water Scuds									
O. Amphipoda									
F. Crangonyctidae									
Crangonyx	4	-	-	-	-	-	4	8	-
Aquatic Sow Bugs									
O. Isopoda									
F. Asellidae									
Caecidotea	73	64	1	1	16	32	122	328	60
Crayfish									
O. Decapoda									
F. Cambaridae									
Cambarus	-	-	-	-	-	-	-	-	1
Insects									
Cl. Insecta									
Beetles									
O. Coleoptera									
F. Elmidae									
Dubiraphia larvae	-	-	-	-	-	-	2	-	-
Stenelmis crenata	8	16	-	-	-	8	-	8	-
Stenelmis larvae	**16**	**64**	-	-	-	**80**	-	**56**	4
F. Haliplidae									
Haliplus	-	-	-	-	-	-	2	-	-
F. Psephenidae									
Ectopria	-	-	-	-	-	8	2	-	-
Mayflies									
O. Ephemeroptera									
F. Baetidae									
Baetis flavistriga	-	16	-	-	-	32	-	24	-
Baetis	-	**64**	-	-	-	-	-	-	-
O. Megaloptera									
Fishflies & Dobsonflies									
F. Corydalidae									
Nigronia	-	-	-	-	-	-	-	-	4
Alderflies									
F. Sialidae									
Sialis	-	8	-	-	-	-	-	-	-
O. Odonata									

	Station 1			Station 2			Station 3		
	101	102	103	201	202	203	301	302	303
	pool	riffle	run	riffle	run	pool	pool	riffle	run
Damselflies									
F. Calopterygidae									
Calopteryx maculata	2	-	-	1	-	-	-	-	-
Calopteryx immature	-	-	-	**1**	-	-	-	16	-
F. Coenagrionidae									
immature	-	-	-	-	-	-	-	8	-
Bugs									
O. Hemiptera									
F. Gerridae									
immature	-	-	-	2	-	-	-	-	-
F. Veliidae									
immature	-	-	2	-	-	-	-	-	-
Caddisflies									
O. Trichoptera									
F. Hydropsychidae									
Cheumatopsyche	132	816	-	-	8	392	2	144	-
Hydropsyche betteni	-	40	-	-	-	48	-	40	-
Hydropsyche bronta	52	264	-	-	-	128	-	168	4
Hydropsyche slossonae	8	56	-	-	-	64	2	56	-
Hydropsyche sparna	-	16	-	-	-	16	-	16	-
Hydropsyche immature	**132**	**528**	-	1	-	**336**	-	**400**	**4**
immature	**16**	**88**	-	-	-	**80**	-	**80**	-
F. Hydroptilidae									
Hydroptila	4	-	-	-	-	8	-	-	-
pupae	-	-	-	1	-	-	-	-	-
True Flies									
O. Diptera									
Biting-Midge									
F. Ceratopogonidae									
Atrichopogon	-	-	-	-	-	-	2	-	-
Midges									
F. Chironomidae									
chironomid pupae	**72**	**48**	**3**	**2**	**24**	**48**	**16**	**96**	**12**
S.F. Chironominae									
Chironomus	20	-	14	38	64	-	152	16	108
Cryptochironomus	24	8	-	1	8	-	12	32	8
Dicrotendipes	4	-	-	-	-	-	8	-	-
Microtendipes	-	8	-	-	-	40	-	16	-
Paratanytarsus	144	88	-	3	24	56	113	344	52
Paratendipes	-	-	-	-	-	-	12	-	-
Phaenopsectra	4	-	1	9	8	-	-	-	12
Polypedilum flavum	16	8	1	-	-	8	-	24	-
Polypedilum scalaenum	48	-	29	33	144	-	58	40	20
Stenochironomus	-	-	-	-	-	-	-	8	-
Stictochironomus	56	16	14	8	8	-	43	8	36
Tanytarsus	20	64	5	13	24	32	58	48	68
S.F. Diamesinae									
Pagastia	-	-	-	-	-	16	-	8	-
S.F. Orthocladiinae									
Corynoneura	4	-	-	1	8	-	-	8	-
Cricotopus	64	456	1	1	8	176	63	112	12
Cricotopus bicinctus	20	-	-	-	-	96	12	40	4
Cricotopus (Isocladius)	-	-	-	-	-	-	8	-	-
Cricotopus trifascia	20	-	-	-	-	8	-	-	-
Cricotopus/Orthocladius	68	80	-	1	-	48	27	160	8
Eukiefferiella devonica group	4	40	-	-	-	64	-	8	-
Nanocladius	-	-	-	-	-	-	8	-	-
Parakiefferiella	28	48	1	-	16	64	20	64	28
Parametriocnemus	24	8	-	-	-	144	-	72	-
Tvetenia	-	-	-	-	-	48	-	-	-
S.F. Prodiamesinae									
Prodiamesa	-	-	-	-	-	-	2	-	-
S.F. Tanypodinae									
Labrudinia	-	-	-	-	-	-	4	-	-
Natarsia	4	-	-	-	-	-	-	-	4
Nilotanypus	-	-	-	-	-	8	-	8	-
Procladius	-	-	-	-	-	-	-	8	-
Thienemannimyia complex	28	48	-	1	-	16	4	32	12
F. Empididae									
Hemerodromia	16	16	-	-	-	40	2	48	-
F. Ephydridae	-	-	-	-	-	-	2	-	-
F. Muscidae	1	-	-	-	-	-	-	-	-
F. Tipulidae									
Antocha	4	16	-	-	-	8	-	16	-
Tipula	-	-	-	-	-	2	-	-	-
immature	-	-	-	-	-	-	2	-	-

	Station 1			Station 2			Station 3		
	101	102	103	201	202	203	301	302	303
	pool	riffle	run	riffle	run	pool	pool	riffle	run
Molluscs									
P. Mollusca									
Snails									
Cl. Gastropoda									
F. Physidae									
Physella	-	-	-	-	-	-	-	8	-
Clams									
Cl. Bivalvia									
F. Sphaeriidae									
Pisidium Cyclocalyx	-	-	1	-	-	-	-	-	4
TOTAL NUMBER OF ORGANISMS	####	####	226	177	744	####	####	####	626
TOTAL NUMBER OF TAXA (1)	14	42	34	34	23	14	35	41	19

Notes:

(1) Bold entries excluded from taxa count