

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 9.5
CONCEPTUAL SWMF
OUTLET STRUCTURE

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9.6 On-Site SWM Controls

On-site stormwater management controls are proposed for approximately 7.2 ha in the southwest quadrant of the KNUEA. The proposed land uses in this area (school, multi-unit residential) are compatible with on-site stormwater management. On-site SWM will need to include pre-to-post quantity control for allowable flows into Tributary 3 and an enhanced level of quality control (80% TSS removal) consistent with the SWM criteria listed in **Section 5.0**.

The required quantity control storage for areas with on-site SWM controls was estimated using the 'Route Reservoir' command in SWMHYMO. The results of this analysis indicate that these areas will only require storage for flows in excess of the 5-year post-development peak flow. Runoff from storms up to and including the 5-year event can be released uncontrolled.

The allowable release rates and storage requirements are summarized as follows:

- Overall release rate (7.2 ha area): 816 L/s (5-year peak flow)
- **Allowable per-hectare release rate: 112 L/s/ha**

- Total required storage (7.2 ha area): 1,650 m³
- Approximate on-site storage required: 227 m³/ha

The overall release rate of 816 L/s was taken from the storm sewer design sheets prepared as part of the Master Servicing Study. The on-site storage requirements are approximate and will need to be confirmed as part of each individual site plan.

9.7 External Drainage Areas

9.7.1 Tributary 4

Under existing conditions, Tributary 4 serves as the outlet for approximately 30 ha upstream of the southwest quadrant of the KNUEA, including a portion of the Marchbrook Circle subdivision. Under post-development conditions, runoff from the upstream area will be captured by the proposed storm sewers and routed through the KNUEA lands to Tributary 3 at March Road.

9.7.2 Headwater Channel 'F'

Under existing conditions, Headwater Channel 'F' serves as the outlet for Nadia Lane. Under post-development conditions, runoff from Nadia Lane will be collected by a DICB at the KNUEA property boundary and piped directly to Tributary 2.

9.8 Culverts

9.8.1 March Road

The proposed SWM facilities will control post-development peak flows to pre-development levels, and there will be no increase in flow through the existing culverts crossing March Road at Tributaries 2 and 3. The existing culverts have sufficient capacity to convey the 100-year peak flows while confining the 100-year floodplain within the limits of the proposed 40m stream corridors.

The existing culverts crossing March Road do not need to be replaced as part of the planned development of the KNUEA, but will require either replacement or modification to accommodate the future widening of March Road.

9.8.2 Abandoned CN Rail Corridor

The existing culverts crossing the CN rail corridor have been evaluated, and will provide sufficient capacity to convey the anticipated post-development flows. Additional details and supporting calculations for the CN rail culverts (anticipated post-development flows, available capacity) are provided in the *Kanata North Community Design Plan Master Servicing Study* – refer to **MSS Section 5.4.2** Major System Drainage Areas and **MSS Appendix B, Table B4**.

9.8.3 Proposed Culverts

The culverts for the proposed crossings of Tributaries 2 and 3 have been sized based on the required hydraulic capacity to convey the 100-year flows in the tributaries. The conceptual designs for the proposed crossings (Street ‘A’ and Street ‘C’) are based on 1800mm x 1200mm concrete box culverts, which have been included in the post-development HEC-RAS model of the Northwest Branch – refer to **Section 10.0**. At the detailed design stage, the culvert crossings will need to be designed to meet all applicable requirements and guidelines, including:

- Hydraulic capacity;
- Geomorphology;
- Fish Passage (DFO); and
- Species at Risk (MNR).

9.9 Watercourse Crossings (STM / SAN / WATER)

The recommended servicing strategy (outlined in the Master Servicing Study) includes storm, sanitary, and water crossings under Tributaries 2 and 3. The proposed trenches for these crossings will be in rock and will require a clay cap to prevent surface water in the tributaries from migrating into the underlying trenches. Details of the proposed crossings will be prepared at the detailed design stage.

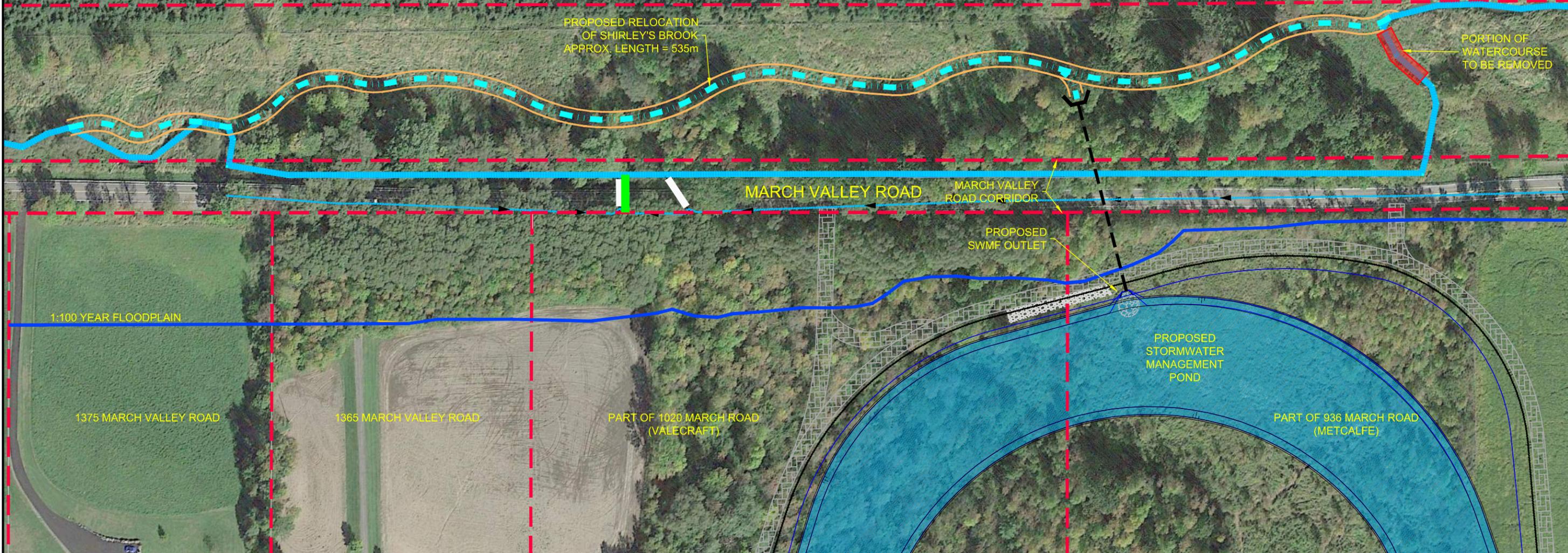
9.10 Shirley’s Brook Realignment

While the KNUEA boundary stops at the abandoned CN Rail line, storm drainage will be directed under the former rail corridor to Pond 3 which will outlet to the main branch of Shirley’s Brook. The reach of Shirley’s Brook adjacent to the proposed SWMF is located within the March Valley Road right-of-way. The roadway embankment along this reach is steep and prone to washout during periods of high flow and has been reinforced with gabion baskets and riprap. Further downstream, the watercourse resumes a more natural flow path outside of the right-of-way and flows northeast through the Department of National Defence (DND) lands towards Shirley’s Bay and the Ottawa River.

Post-development runoff from the KNUEA will be controlled to pre-development levels, but the volume of water entering Shirley’s Brook will increase. The reach of Shirley’s Brook within the March Valley Road right-of-way is at the downstream end of a large urban watershed and the additional flow contribution from the KNUEA will be relatively small.

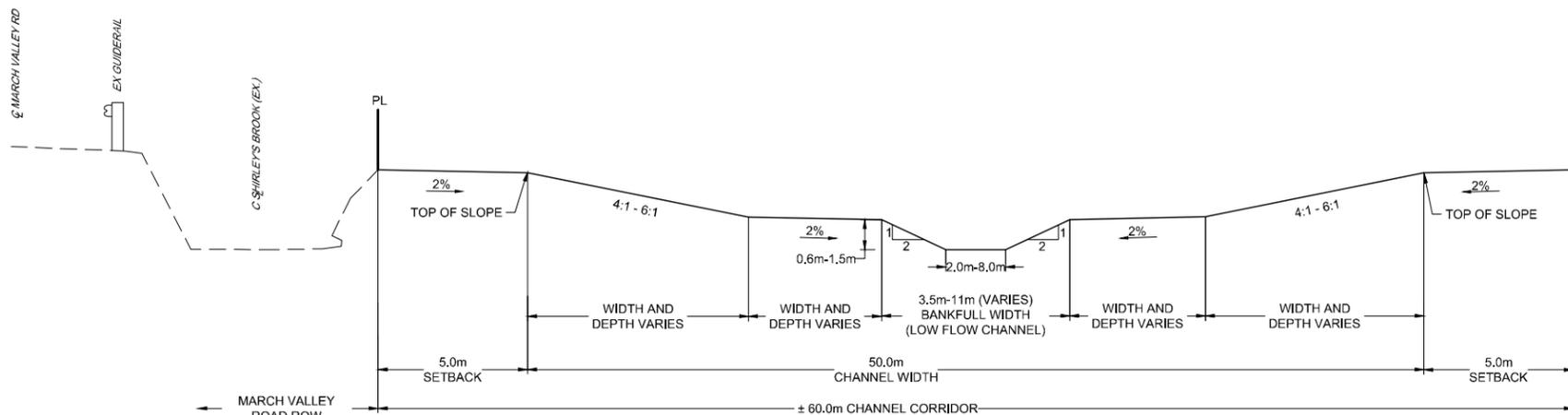
To address the issue of roadway washout, it is suggested that the reach of Shirley’s Brook within the right-of-way be re-located. Currently, Shirley’s Brook flows parallel to the March Valley Road right-of-way for approximately 450m. There is an opportunity to relocate this reach of the watercourse outside of the right-of-way using natural channel design techniques.

Details of the re-aligned channel (cross-sections, features, tree removal, etc.) will be prepared at the detailed design stage with input from a fluvial geomorphologist. The channel alignment will be designed to minimize the extent of tree removal, and to integrate (where feasible) any existing features (oxbow lakes, wetlands, large trees).



LEGEND

- SHIRLEY'S BROOK
100-YEAR FLOODPLAIN (~65.0m)
(EXISTING - TO BE CONFIRMED
FOLLOWING RE-ALIGNMENT OF
SHIRLEY'S BROOK)
- - - EXISTING WATERCOURSE
- - - PROPERTY LINE
- - - PROPOSED SHIRLEY'S BROOK
REALIGNMENT
- - - PORTION OF WATERCOURSE
TO BE REMOVED



SHIRLEY'S BROOK REALIGNED CREEK CORRIDOR TYPICAL SECTION
NTS



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FIGURE NO. 9.6
SHIRLEY'S BROOK
REALIGNMENT

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The proposed channel would be located on federal lands (DND gun range) managed by the National Capital Commission (NCC). The storm outlet for the KNUEA could discharge to the re-aligned watercourse in the location shown on **Figure 9.6**. This option could require a permit from MVCA (alterations to watercourses). Although federal lands are exempt from such permit requirements, applying for such a permit is considered a best management practice.

The channel relocation represents the best long-term solution, and has been approved in-principle by both the NCC and the DND – Refer to the letter located in **Volume 2, Appendix B**. The relocation also allows for the opportunity for future improvements to March Valley Road by relocating Shirley's Brook outside the right-of-way.

Section 10.0 Post-Development Floodplain Evaluation

10.1 Stream Corridors

The existing conditions HEC-RAS model for Shirley's Brook Northwest Branch Tributaries 2 and 3 has been modified to reflect proposed conditions, including culvert crossings and the proposed channel realignment for Tributary 2.

A steady-state hydraulic analysis was performed using the post-development flows listed in **Table 7.2**. The results of this analysis indicate the 100-year floodplain limits will be confined within the proposed 40m stream corridors, as shown on **Figure 10.1**. The post-development model results are provided in **Volume 2, Appendix H**.

10.2 SWM Facility Outlet Elevations

The proposed stormwater management facilities have been designed to have normal water levels (NWL) above the 2-year water level in the receiving watercourses at the proposed SWMF outlet locations, as shown in **Table 10.1**.

Table 10.1: Peak Flows and Water Levels at SWM Facility Outlets

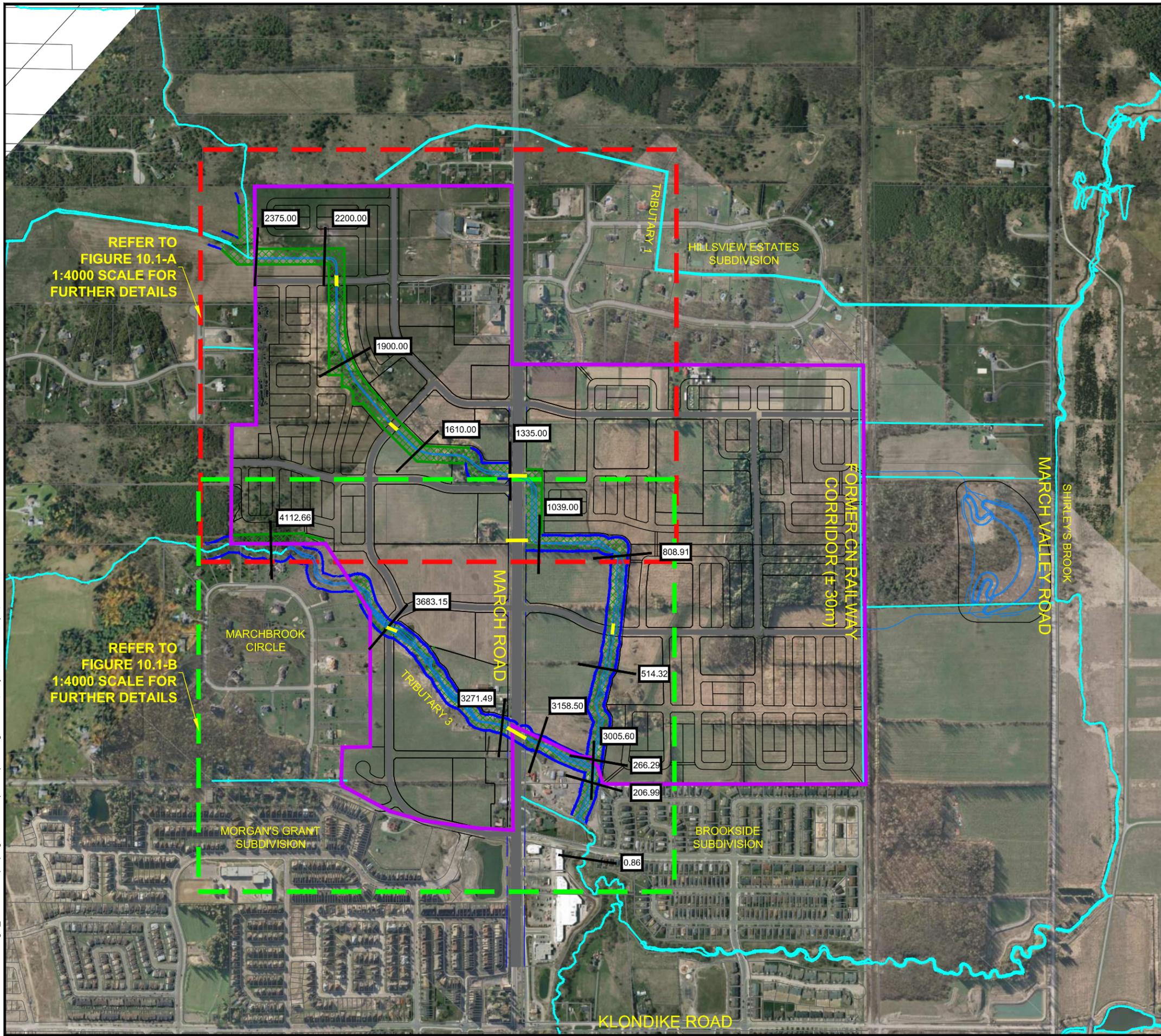
SWM Facility	Outlet Location	2-year Event			100-year Event		
		Peak Flow in Receiver (m ³ /s)	Water Level in Receiver (m)	NWL in SWMF (m)	Peak Flow in Receiver (m ³ /s)	Water Level in Receiver (m)	100yr WL in SWMF (m)
SWMF 1	Tributary 2 (Sta. 1+335)	0.25	79.20	79.50	1.07	79.52	81.65
SWMF 2	Tributary 3 (Sta. 3+271)	0.37	77.85	79.50	1.45	78.30	81.50
SWMF 3	Shirley's Brook Main Branch (Sta. 2+011.088)	5.71	64.61*	65.50	17.90	64.94	67.00

*Shirley's Brook and Watts Creek Phase 2 Stormwater Management Study (DRAFT) – Appendix D (AECOM, March 2013)

10.3 Shirley's Brook Main Branch

The stormwater management facilities have been designed to ensure no changes in post-development peak flows from the KNUEA into Shirley's Brook. Since peak flows will not be increased in Shirley's Brook downstream of KNUEA, water levels will not increase.

M:\2012\112117\CAD\Design_EMP\MEMO (CS)\Figure 10.1 Prop Floodplain.dwg, FIG-10.1, May 26, 2016 - 1:50pm, bthurber



LEGEND

- KNUEA
- DRAINAGE CHANNEL
- PROPOSED CULVERT (1.8m WIDE x 1.2m HIGH)
- PROPOSED TRIBUTARY REALIGNMENT
- RETAINED TRIBUTARY CORRIDOR
- 2375.00 HEC-RAS STATION

TRIBUTARY 2			
STATION	2-YEAR WL	5-YEAR WL	100-YEAR WL
2375.00	88.64	88.69	88.85
2200.00	87.61	87.67	87.83
1900.00	85.98	86.04	86.19
1610.00	82.24	82.33	82.55
1335.00	79.20	79.30	79.52
1039.00	78.70	78.76	78.93
808.91	77.89	77.90	77.96
514.32	76.59	76.66	76.80
266.29	74.76	74.83	75.02

TRIBUTARY 3			
STATION	2-YEAR WL	5-YEAR WL	100-YEAR WL
4112.66	89.35	89.38	89.46
3683.15	81.68	81.78	82.10
3271.49	77.81	77.97	78.31
3158.50	76.69	76.76	76.93
3005.60	74.51	74.59	74.78

NORTHWEST BRANCH (CONFLUENCE OF TRIBUTARIES 2 & 3)			
STATION	2-YEAR WL	5-YEAR WL	100-YEAR WL
206.99	74.39	74.43	74.55
0.86	71.88	71.95	72.13



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FIGURE NO. 10.1
PROPOSED
FLOODPLAIN LIMITS

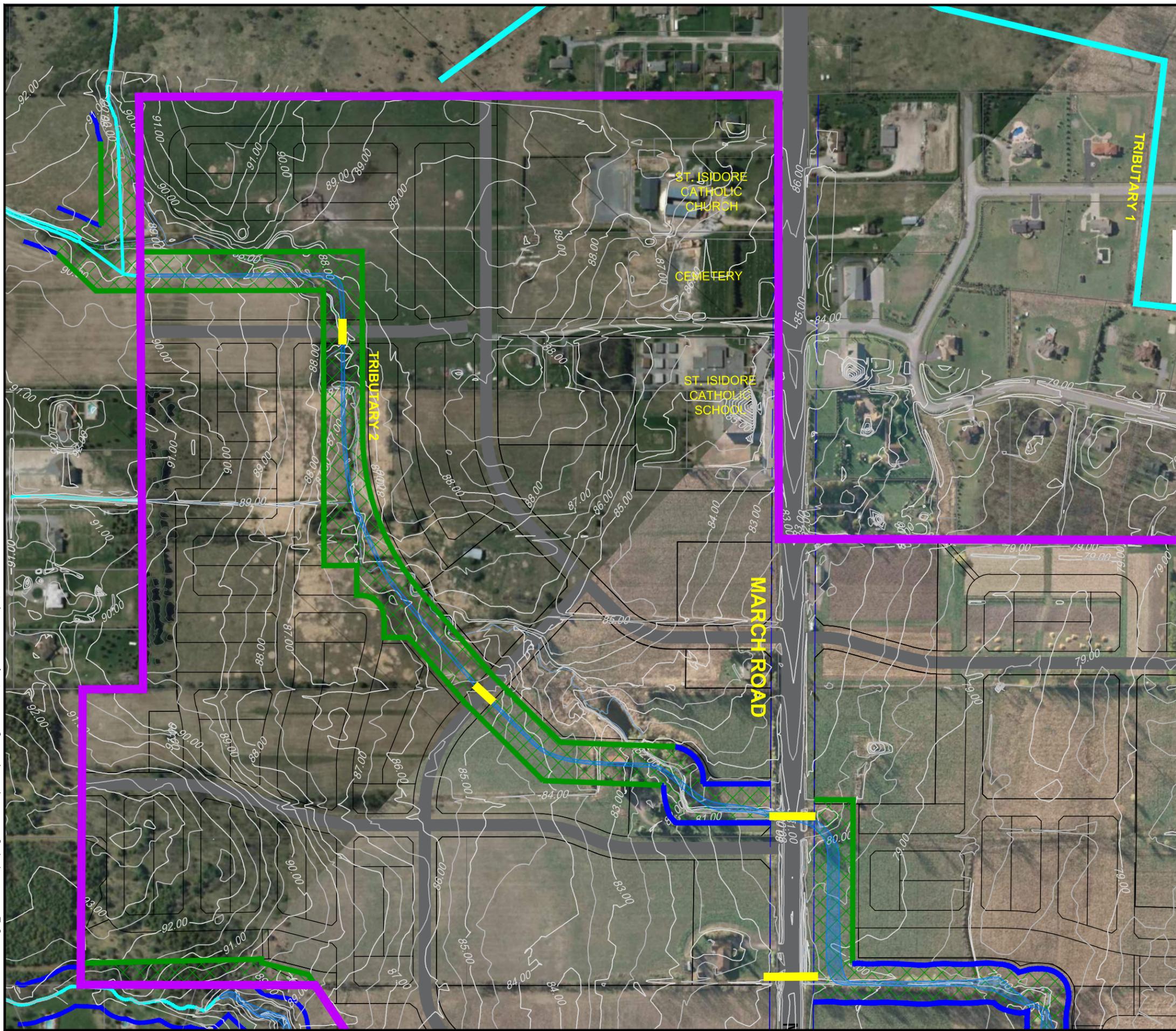


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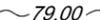


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M:\2012\112117\CAD\Design_EMP\MEMO (CS)\Figure 10.1 Prop Floodplain.dwg, FIG-10.1-A, May 26, 2016 - 1:50pm, bthurber



LEGEND

-  KNUEA
-  DRAINAGE CHANNEL
-  PROPOSED FLOODPLAIN
-  CREEK CORRIDOR
-  RETAINED TRIBUTARY CORRIDOR
-  PROPOSED CULVERT (1.8m WIDE x 1.2m HIGH)
-  ~ 79.00 ~ EXISTING GROUND SURFACE CONTOUR (m)

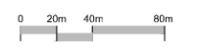


KANATA NORTH COMMUNITY DESIGN PLAN

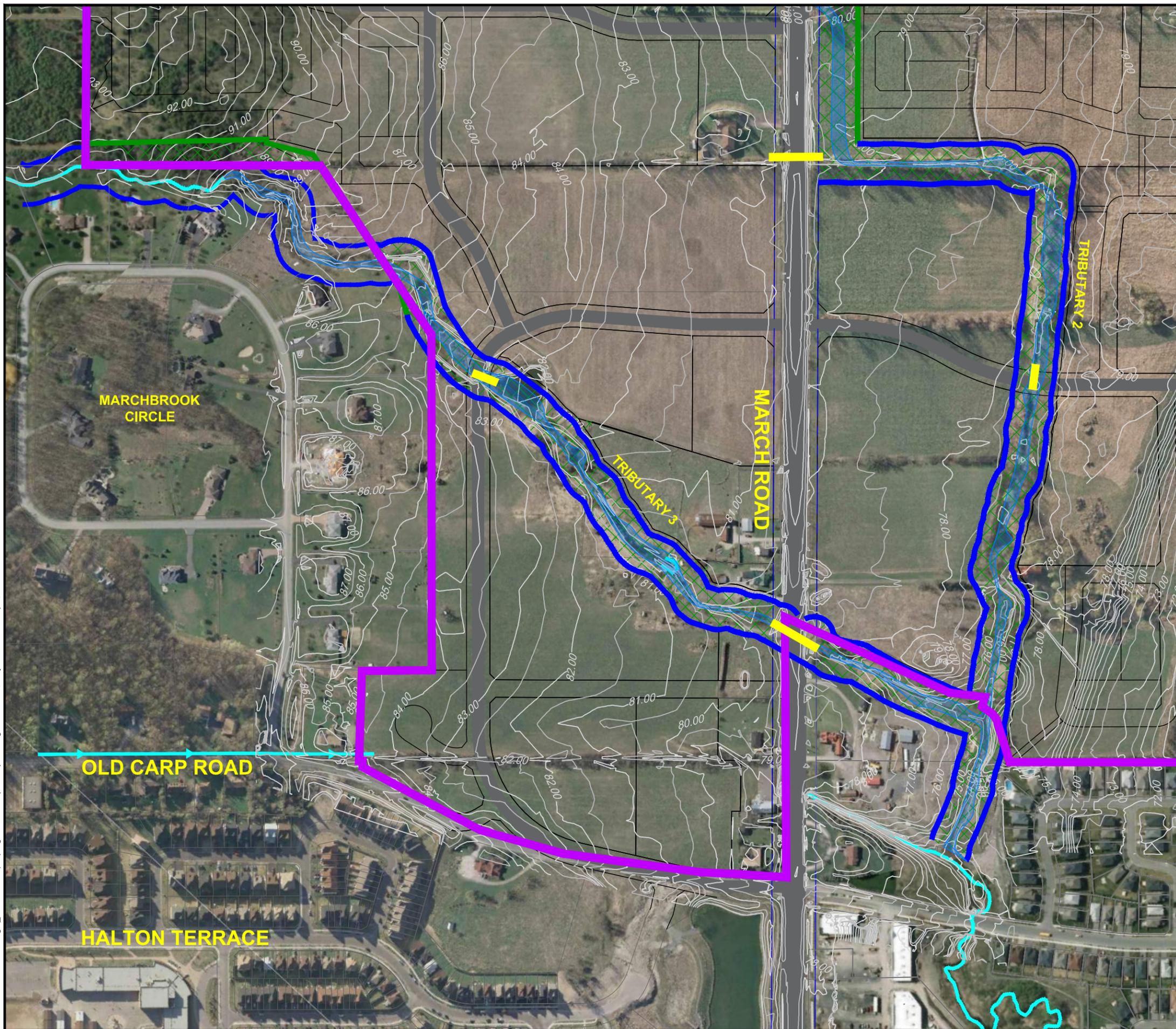
FIGURE NO. 10.1-A PROPOSED FLOODPLAIN EXTENTS



DATE MAY 2016 JOB 112117
SCALE 1:4,000



M:\2012\112117\CAD\Design_EMP\MEMO (CS)\Figure 10.1 Prop Floodplain.dwg, FIG-10.1-B, May 26, 2016 - 1:50pm, bthurber



LEGEND

-  KNUEA
-  DRAINAGE CHANNEL
-  PROPOSED FLOODPLAIN
-  CREEK CORRIDOR
-  RETAINED TRIBUTARY CORRIDOR
-  PROPOSED CULVERT (1.8m WIDE x 1.2m HIGH)
-  ~ 79.00 ~ EXISTING GROUND SURFACE CONTOUR (m)



KANATA NORTH COMMUNITY DESIGN PLAN

FIGURE NO. 10.1-B PROPOSED FLOODPLAIN EXTENTS



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SCALE 1:4,000



Section 11.0 Environmental Management Guidelines & Recommendations

The recommended environmental management strategy has been developed in conjunction with the proposed land use plan and is intended to provide a holistic approach for addressing and mitigating the environmental impacts associated with development of the KNUEA based on the natural environment opportunities and features that have identified as part of the EMP. Refer to the following drawings:

- **Figure 11.1** Preferred Demonstration Plan
- **Drawing 112117-EMP** Recommended Environmental Management Plan
(located in **Volume 2, Appendix I**)

The environmental guidelines and recommendations outlined below are intended to represent a holistic approach for addressing and mitigating the environmental impacts associated with development of the KNUEA. The size and location of recommended SWM facilities, stream corridors and other areas recommended for retention have been integrated into the land use plan along with the recommended solutions for servicing and transportation.

11.1 Tree Preservation

11.1.1 Woodlot S20

It is recommended that the stand of healthy, mature white cedars in the northwest corner of Woodlot S20 be retained as part of the proposed parkland within the KNUEA. The location of the white cedar stand is shown on **Drawing 112117-EMP**.

11.1.2 Woodlot S23

The 'northeast forest' of Woodlot S23 is the recommended location of the SWM facility for the KNUEA lands east of March Road. The functions of the northeast forest are reduced by the dominance of ash, poplar and invasive species of ground flora, as well as road noise from March Valley Road. The remaining areas of Woodlot S23, east of the former CN Rail corridor, will be conveyed to the City for conservation once the detailed design of the storm pond has been confirmed. The location of the proposed SWM facility and the areas of Woodlot S23 that will be retained are shown on **Drawing 112117-EMP**.

The proposed inlet channels to Pond 3 will be outside the limits of Woodlot S23. The required setbacks for the channel corridors will be established at the Plan of Subdivision stage as part of the Environmental Impact Statement (EIS) and Tree Conservation Reports (TCR).

11.1.3 Southwest Wooded Area

It is recommended that a portion of the southwest wooded area be retained as part of the stream corridor for Shirley's Brook Northwest Branch Tributary 3.

A portion of the wooded area (approximately 0.3 ha), located along the western border of the KNUEA is to be retained as a part of the Natural Heritage System (NHS) and will be retained as a part of the proposed development, and conveyed to the City for conservation.

The areas recommended for retention are shown on **Drawing 112117-EMP**.



Figure 11.1: Preferred Demonstration Plan

11.1.4 Individual Trees & Hedgerows

The grading design for urban subdivisions generally precludes the large-scale preservation of trees outside natural areas. Where feasible, the preservation of individual healthy trees and clusters of woody vegetation should be considered on case-by-case basis along edge conditions, in neighborhood parks and school sites. Perimeter hedgerows, as indicated on **Drawing 112117-EMP** are to be retained and/ or enhanced where possible. This will provide increased tree cover to act as a buffer between the existing and proposed subdivisions.

The identification of individual trees and/ or vegetation clusters suitable for retention is outside the scope of the EMP, and will need to be evaluated at the Plan of Subdivision stage based on proposed road layouts and grading/ servicing requirements.

11.2 Species at Risk

11.2.1 Blanding's Turtle

New habitat enhancement and compensation features will be created within the proposed stream corridors to compensate for the potential impacts on Blanding's Turtle habitat resulting from development of the KNUEA. To simplify the detailed design process, the number and type of habitat features recommended in each Quadrant to achieve an overall benefit are summarized in **Table 11.1**.

This approach will allow landowners in each quadrant to apply for an individual *Overall Benefit Permit* (OBP) and to implement the proposed habitat compensation without the requirement for one overall application from all landowners.

In order to maintain flexibility for the detailed design process, the position of the proposed compensation features have not been finalized. Conceptual cross-sections have been developed to illustrate how these features could be incorporated into the overall stream corridors (refer to **Section 11.4**).

Discussions with the City of Ottawa and the Ministry of Natural Resources and Forestry (MNRF) in regards to the mitigation and compensation of Blanding's Turtle habitat have been documented in an email located in **Volume 2, Appendix B**.

Table 11.1: Recommended Blanding's Turtle Habitat Compensation Features

Habitat Type	Habitat Feature	Number of Features				
		Northwest Quadrant	Northeast Quadrant	Southwest Quadrant	Southeast Quadrant	All Quadrants
Category 1 Habitat	Deep Pools (15m x 45m)	2	0	1	1	4
	Artificial Nesting Area (10m x 30m)	2	0	1	1	4
Category 2 Habitat	Shallow Pans / Pools (10m x 60m)	3	2	1	2	8
	Deep Channel Pockets (5m diameter)	5	2	3	4	14
Total Number of Features		12	4	6	8	30

Fencing, Road Crossings, and Vehicle Impact Mitigation

Following development, the risk of road related mortality will be better controlled and mitigated through the construction of a turtle exclusion fence for Blanding's Turtles that can be installed on both sides of the 40 m creek corridor, except where adjacent to park blocks. The proposed 6 m wide recreational pathway will be within this fencing, so that the fencing will enclose both the 6 m wide pathway and the 40 m creek corridor. The type of fencing used may vary based on location, and will be assessed at the detailed design stage.

11.2.2 Butternut Trees

As development plans in the KNUEA are brought forward, further assessments will be required for any butternut tree within a 25m radius of planned future development. Butternut trees to be retained, and compensation for trees to be removed will be addressed on a case-by-case basis as part of each individual Site Plan or Plan of Subdivision.

11.2.3 Barn Swallows

An authorization from the Ontario Ministry of Natural Resources and Forestry to remove the structures where the birds are nesting has been received (Confirmation # M-102-9977528356). The structures containing Barn Swallow nests were removed in the winter of 2015-2016, following the Ontario Endangered Species Act regulatory guidelines. Compensation habitat in the form of artificial Barn Swallow nesting structures will be built northwest of the KNUEA (McKinley Environmental, 2015).

11.3 Headwater Drainage Features

A number of headwater drainage channels in the vicinity of the KNUEA will be impacted by the proposed development.

- The headwater channels inside the KNUEA will be removed.
- The contributing drainage area to headwater channels east of the KNUEA between the rail corridor and March Valley Road will be reduced.
- The drainage channel adjacent to Woodlot S23 ('B' east) will be routed through the proposed SWM pond

Mitigation measures

To compensate for the impacts to, and loss of some of the headwater features within the KNUEA, the following general mitigation measures are proposed:

- Replace lost headwater functions within the protected and/ or enhanced creek corridors;
- Create new headwater features east of the abandoned CN Rail corridor;
- Flow from channel 'F' will be intercepted at the KNUEA property boundary and piped to Tributary 2;
- Flow from channel 'G' will be conveyed via pipe through the development, to Tributary 3;
- Re-grade ditch west of the former rail corridor to eliminate perched culverts and direct rearyard drainage to headwater channels east of the rail corridor.

Details of headwater compensation will occur during the detailed design stage, in consultation with the Conservation Authority, to comply with the appropriate permit process and regulations.

11.4 Stream Corridors

40m wide stream corridors will be retained for Tributaries 2 and 3 through the KNUEA. The stream corridors will serve a variety of ecological functions and will be a key component of the overall storm drainage strategy for the KNUEA.

11.4.1 Corridor Alignments

Tributary 2 will be realigned within the proposed 40 m corridor shown on **Drawing 112117-EMP**. The realigned sections of Tributary 2 should be designed using natural channel design techniques to ensure long-term stability and enhance the ecological function of the corridor. Areas where the realigned channel bed is situated directly on bedrock will require geotechnical evaluation and measures to prevent excessive diversion of baseflows into rock fractures.

The stream corridor for Tributary 3 will follow the existing channel alignment. The existing inline pond on Tributary 3 will be reduced in size to fit within the proposed 40m corridor.

11.4.2 Natural Channel Design

Natural channel design principles will be utilized to enhance the realigned sections of Tributary 2. In the realigned portions of the Tributary, the channel will be designed to create a moderately meandering stream.

- The low flow channel should have a bottom width between 1 and 4 m.
- The maximum bank angle within the wetted channel should be approximately 25 degrees (2:1) and the bank beyond the wetted channel should be approximately 10 to 15 degrees maximum (4:1 to 6:1) and should be nearly flat to 6 degrees (10% slope).
- Limited portions of the stream may have a steeper bank angle where final grades would require extensive excavation to create a shallow angle, but the majority of the watercourse will feature a shallow bank.
- The water depth profile will be similar to the existing channel, with bankfull depths ranging from 30 cm to 75 cm during periods of high water.
- Water depths will be less than 30 cm during low flow periods.

11.4.3 Planting

The proposed planting strategies will differ between areas where the existing channel alignment is retained and areas where the existing channel will be realigned. In both cases, shade tree planting should be selective, as the goal is not to create a fully shaded riparian corridor. During detailed design, landscaping and grading features, including potentially live plantings of shrubs/trees, will be identified to ensure that critical habitat areas are well separated from the adjacent recreational trail. This will also ensure that some portions of the watercourse corridor and key habitat features remain undisturbed by recreational usage.

Realigned channel sections should be seeded with a native wetland/riparian seed mix to encourage re-establishment of native vegetation and improve habitat quality compared to the riparian vegetation that currently exists, which has a high proportion of invasive species and few aquatic plants.

Natural seed dispersal from upstream areas and adjacent wetlands should lead to relatively rapid regeneration of aquatic vegetation once conditions are made suitable. Where possible, the realigned channel sections should be designed to take advantage of existing shade trees and surrounding woody vegetation in hedgerows.

Woody debris such as logs, root wads, or cut trees should be placed within wider sections of the channel (>2 m low flow bottom width). Woody debris, grubbed stumps, logs, flat rocks, rock piles and other cover materials should be interspersed along the banks of the realigned channel to create habitat within (or adjacent) to the main channel.

11.4.4 New Habitat Features & Enhancements

New habitat enhancement and compensation features will be created within the stream corridors of both Tributary 2 & 3, to compensate for the potential impacts to Blanding's Turtle and other wildlife habitat resulting from development of the KNUEA. **Figures 11.2 – 11.6** illustrate how the habitat features listed in **Table 11.1** and described in further detail below can be integrated into the proposed 40m stream corridors.

Deep Pools

Deep pools will function as potential hibernacula sites for Blanding's Turtles, while also providing general foraging habitat and refuge areas for other aquatic wildlife. Each deep pool should measure approximately 15 m x 45 m (675 m²) and may be designed either inline or offline.

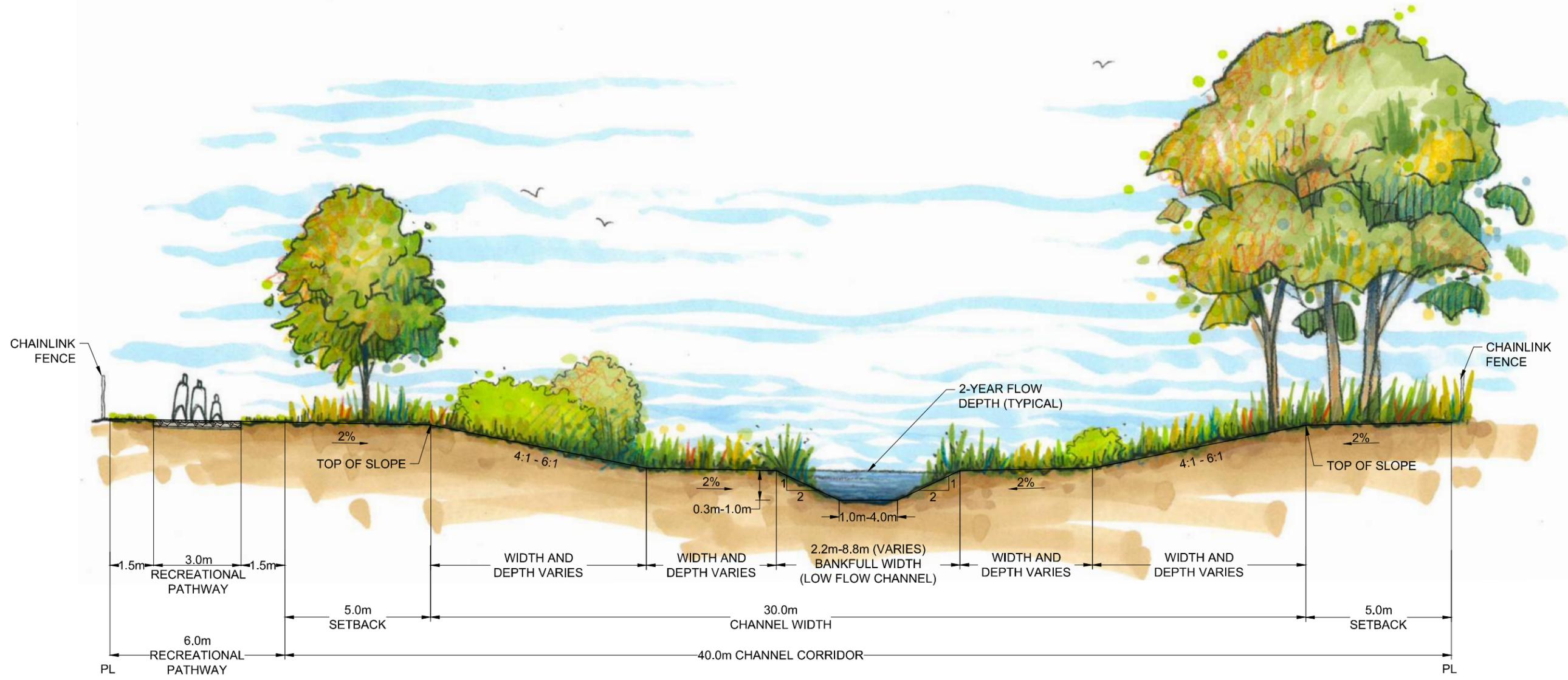
- Each pool should have maximum depth of approximately 2 m and an average depth of approximately 1 m.
- Approximately 2/3^{ds} of each pool area will be 1 m water depth or greater, and graded so that the remaining 1/3rd of the area transitions to an approximate average depth of 30 cm.
- Deep pools will include similar substrate and vegetation characteristics as the typical channel sections, including seeding with a native wetland restoration mix/riparian vegetation mix.

Artificial Nesting Areas

Artificial nesting areas will create nesting habitat for Blanding's Turtles. Each nesting area should measure approximately 10 x 30 m (300 m²) and should be built in locations that are likely to be dry throughout the nesting season (early June to late October).

- Nesting areas should be built near existing tree lines or near planting sites
- Nesting areas should be on level ground with full southern exposure. Where possible, selected sites will be graded to approximately level conditions.
- Nesting areas should be above the spring/summer flood plain.
- Nesting areas should consist of locations with well-drained soil, sand or gravel. If natural substrate conditions do not meet this requirement, imported fill should consist of fine washed sand with <5% clay and <25% gravel, spread to a depth of approximately 30 cm.
- Ground vegetation in the nesting areas should be sparse and should include native sedges, grasses, and a few low growing shrubs. Shrub cover should be less than 2-5% of the site.

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NOTES:

- REALIGNED CHANNEL SECTIONS ARE TO BE SEEDED WITH A NATIVE WETLAND/RIPARIAN SEED MIX.
- SHADE TREES ARE TO BE PLANTED IN SELECT AREAS ALONG THE CORRIDOR (TO BE DETERMINED DURING THE FINAL DETAILED DESIGN).
- WOODY DEBRIS (LOGS, ROOT WADS, CUT TREES) SHOULD BE PLACED IN WIDE SECTIONS OF THE CHANNEL (> 2m LOW FLOW BOTTOM WIDTH)
- COVER MATERIAL (STUMPS, LOGS, FLAT ROCKS, ROCK PILES, ETC.) SHOULD BE PLACED ALONG THE BANKS OF THE REALIGNED CHANNEL SECTIONS TO PROVIDE COVER AND BASKING AREAS FOR TURTLES AND OTHER WILDLIFE.



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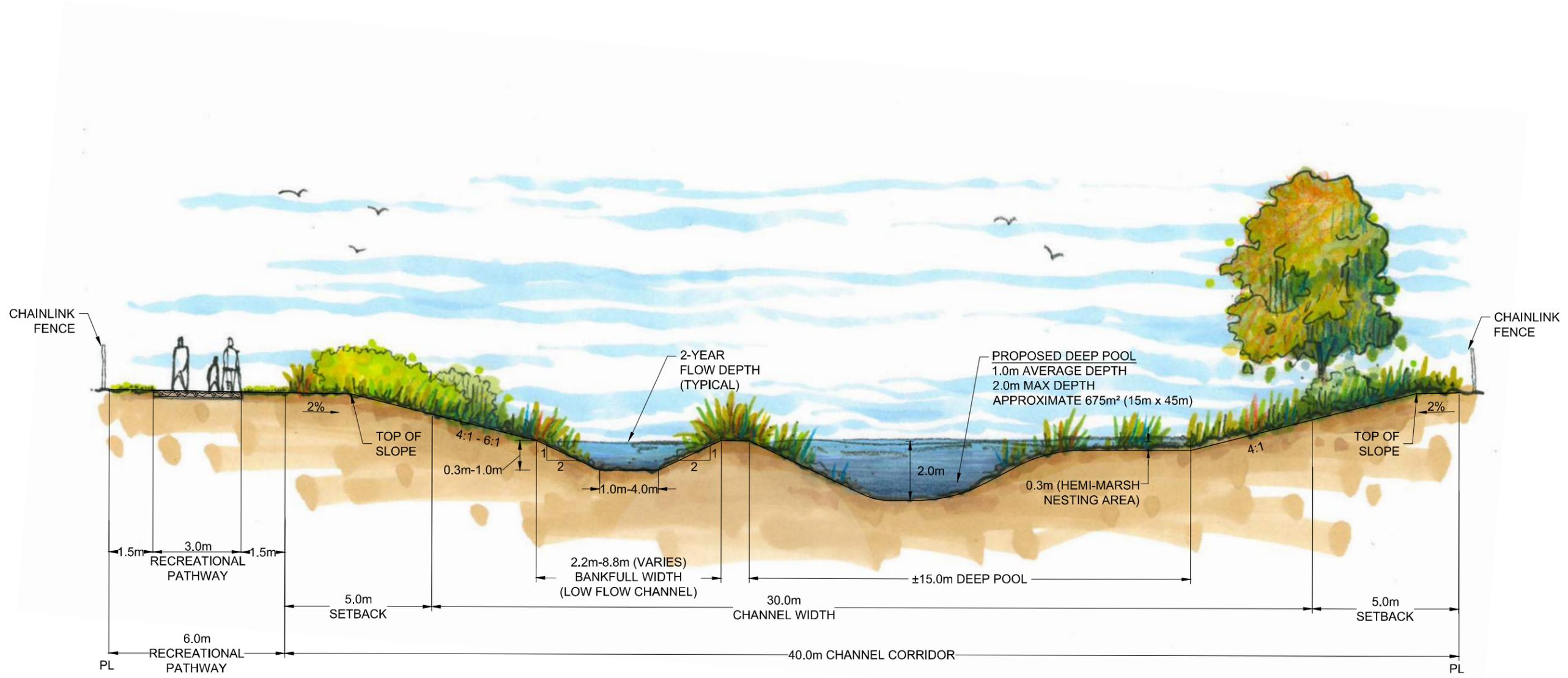
FIGURE NO. 11.2
TYPICAL DRAINAGE
CHANNEL SECTION

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SCALE 1:150



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NOTES:

NUMBER OF DEEP POOLS (15 X 45m):
 2 NORTHWEST QUADRANT
 0 NORTHEAST QUADRANT
 1 SOUTHEAST QUADRANT
 1 SOUTHWEST QUADRANT

- DEEP POOLS ARE INTENDED TO FUNCTION AS POTENTIAL HIBERNACULA SITES, WHILE ALSO PROVIDING GENERAL FORAGING HABITAT, AND CAN BE CREATED AS EITHER INLINE OR OFFLINE PONDS, DEPENDING ON FINAL DESIGN DETAILS.
- EACH POOL SHOULD HAVE A MAXIMUM DEPTH OF APPROXIMATELY 2m AND AN AVERAGE DEPTH OF APPROXIMATELY 1m.
- APPROXIMATELY 2/3RDS OF EACH POOL AREA WILL BE 1m WATER DEPTH OR GREATER, AND GRADED SO THAT THE REMAINING 1/3RD OF THE AREA TRANSITIONS TO AN APPROXIMATE AVERAGE DEPTH OF 30cm.
- DEEP POOLS WILL INCLUDE SIMILAR SUBSTRATE AND VEGETATION CHARACTERISTICS AS THEY TYPICAL CHANNEL SECTIONS, INCLUDING SEEDING WITH A NATIVE WETLAND RESTORATION MIX/RIPARIAN VEGETATION MIX.



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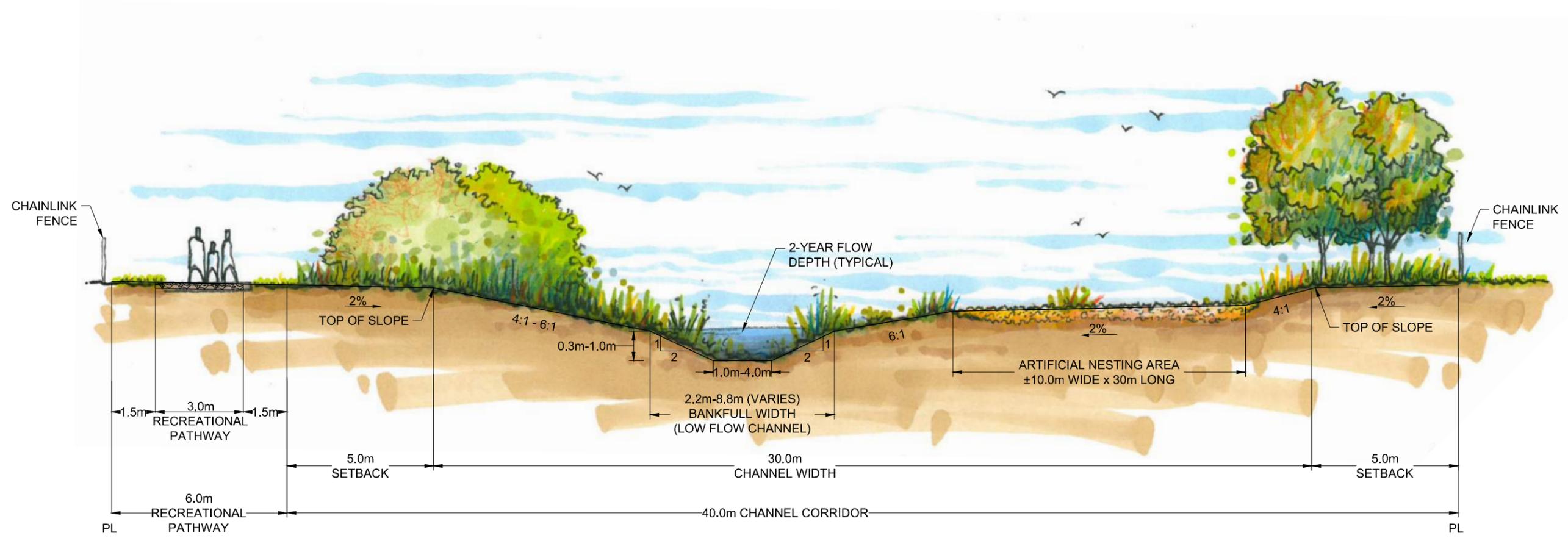
FIGURE NO. 11.3
 TYPICAL DEEP POOL
 DRAINAGE CHANNEL
 SECTION

DATE: MAY 2016
 JOB: 112117

SCALE: 1:150
 0 0.75m 1.5m 3.0m



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NOTES:

NUMBER OF TURTLE NESTING AREAS (10 X 30m):
 2 NORTHWEST QUADRANT
 0 NORTHEAST QUADRANT
 1 SOUTHEAST QUADRANT
 1 SOUTHWEST QUADRANT

- NESTING AREAS SHOULD BE BUILT IN LOCATIONS THAT ARE LIKELY TO BE DRY THROUGHOUT THE NESTING SEASON (EARLY JUNE TO LATE OCTOBER) AND CLOSE TO THE TRIBUTARIES.
- NESTING AREAS SHOULD BE BUILT NEAR EXISTING TREE LINES OR NEAR PLANTING SITES
- NESTING AREAS SHOULD BE ON LEVEL GROUND WITH FULL SOUTHERN EXPOSURE. WHERE POSSIBLE, SELECTED SITES WILL BE GRADED TO APPROXIMATELY LEVEL CONDITIONS.
- NESTING AREAS SHOULD BE ABOVE THE SPRING/SUMMER FLOOD PLAIN.
- NESTING AREAS SHOULD CONSIST OF LOCATIONS WITH WELL-DRAINED SOIL, SAND OR GRAVEL. IF NATURAL SUBSTRATE CONDITIONS DO NOT MEET THIS REQUIREMENT, IMPORTED FILL SHOULD CONSIST OF FINE WASHED SAND WITH <5% CLAY AND <25% GRAVEL, SPREAD TO A DEPTH OF APPROXIMATELY 30cm.
- GROUND VEGETATION IN THE NESTING AREAS SHOULD BE SPARSE AND SHOULD INCLUDE NATIVE SEDGES, GRASSES, AND A FEW LOW GROWING SHRUBS. SHRUB COVER SHOULD BE LESS THAN 2-5% OF THE SITE.



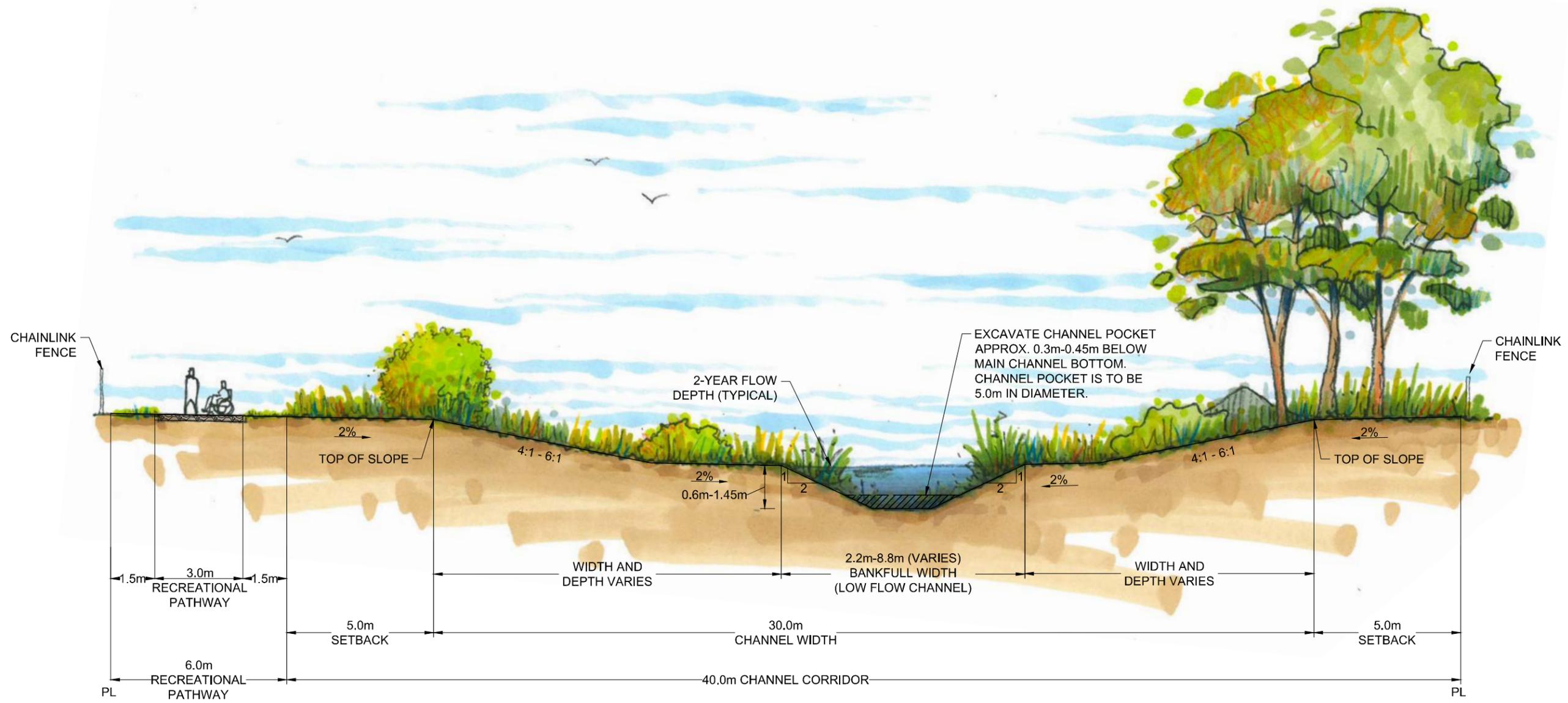
KANATA NORTH
 COMMUNITY DESIGN PLAN

FIGURE NO. 11.4
 TYPICAL ARTIFICIAL TURTLE
 NESTING AREA DRAINAGE
 CHANNEL SECTION

DATE: MAY 2016
 JOB: 112117
 SCALE: 1:150



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NOTES:

NUMBER OF DEEP CHANNEL POCKETS (5m DIAMETER):

- 5 NORTHWEST QUADRANT
- 2 NORTHEAST QUADRANT
- 3 SOUTHEAST QUADRANT
- 4 SOUTHWEST QUADRANT

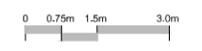
- SMALL DEEPER POCKETS (APPROXIMATELY 30 TO 45cm BELOW THE MAIN CHANNEL GRADE) WILL BE DUG SELECTIVELY ALONG THE LENGTH OF THE CHANNEL TO ENSURE THAT SOME DEEPER REFUGE POOLS ARE PRESENT WITHIN THE WATERCOURSE CORRIDOR.
- DEEP CHANNEL POCKETS WILL BE RELATIVELY SMALL (APPROXIMATELY 5m DIAMETER) AND SHOULD BE SEMI-RANDOMLY PLACED ALONG THE CHANNEL LENGTH.



KANATA NORTH
COMMUNITY DESIGN PLAN

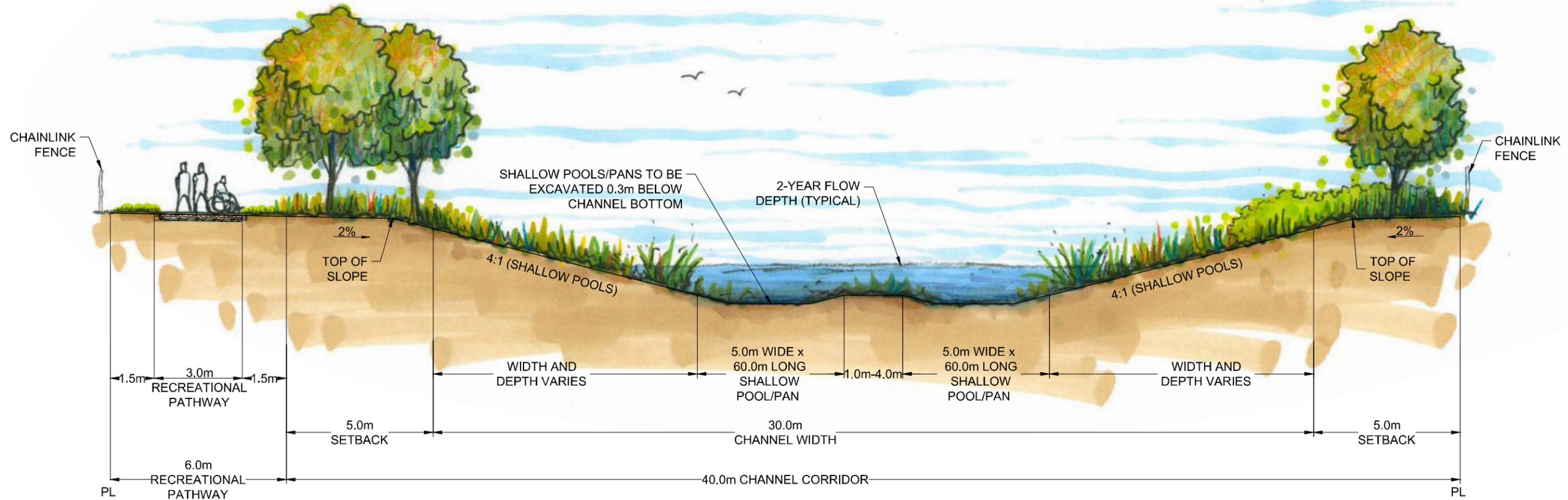
FIGURE NO. 11.5
TYPICAL DEEP CHANNEL
POCKET DRAINAGE
CHANNEL SECTION

DATE: MAY 2016
JOB: 112117
SCALE: 1:150



Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design\EMP\MEMO (CS)\Figures 11.2-11.6 Stream X-Sections.dwg, FIG-11.6, May 19, 2016 - 10:45am, kbanks



NOTES:

NUMBER OF SHALLOW PANS / POOLS (10m X 60m):

- 3 NORTHWEST QUADRANT
- 2 NORTHEAST QUADRANT
- 1 SOUTHEAST QUADRANT
- 2 SOUTHWEST QUADRANT

- SHALLOW PANS / SHALLOW POOLS WILL BE DUG AROUND THE CHANNEL IN ORDER TO EXPAND THE WETTED AREA, AND TO PROVIDE AREAS WHERE AQUATIC AND SEMI-AQUATIC VEGETATION CAN GROW.
- EACH SHALLOW PAN / SHALLOW POOL SHOULD MEASURE APPROXIMATELY 10m WIDE (5m ON EITHER SIDE OF THE CHANNEL) AND APPROXIMATELY 60m LONG (E.G. APPROXIMATELY 600m²).
- SHALLOW PANS / SHALLOW POOLS WILL BE DUG TO AN AVERAGE OF APPROXIMATELY 30cm BELOW THE CHANNEL GRADE SO THAT THEY MAINTAIN AN AVERAGE WATER DEPTH OF APPROXIMATELY 30cm.

KN **KANATA NORTH**
COMMUNITY DESIGN PLAN

FIGURE NO. 11.6
TYPICAL SHALLOW
POOL/PAN DRAINAGE
CHANNEL SECTION

DATE: MAY 2016 JOB: 112117

SCALE: 1:150



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Shallow Pans / Shallow Pools

Shallow pans/shallow pools excavated around the channel will expand the wetted area and provide areas where aquatic and semi-aquatic vegetation can grow to create habitat for amphibians, turtles and other aquatic wildlife. Each shallow pan / shallow pool should measure approximately 10 m wide (5 m on either side of the channel) and approximately 60 m long (600 m²).

- Shallow pans / shallow pools will be dug to an average of approximately 30 cm below the channel grade so that they maintain an average water depth of approximately 30 cm.

Deep Channel Pockets

Small deeper pockets (approximately 30 to 45 cm below the main channel grade) constructed along the length of the channel will create deeper refuge pools within the channel for turtles, fish and other aquatic wildlife.

- Deep channel pockets will be relatively small (approximately 5 m diameter) and should be semi-randomly placed along the channel length.

11.5 Culvert Crossings

Existing Culverts

All existing culverts to be retained following development of the KNUEA have been evaluated to ensure they will provide the required hydraulic capacity under post-development conditions:

- The existing culverts crossing March Road will need to be extended or replaced to accommodate the future widening of March Road.
- The existing culverts crossing the abandoned CN Rail corridor have sufficient capacity to convey the anticipated post-development flows.

Proposed Culverts

At the detailed design stage, the proposed culvert crossings of Tributaries 2 and 3 will need to be designed using a multi-disciplinary approach to ensure the crossings meet all applicable standards and regulations, including but not limited to the following categories:

- Flow / Hydraulics
- Fish Passage
- Turtle Passage
- Geomorphology

Refer to **Section 9.8** for preliminary culvert size information.

11.6 Water Balance

The site specific water budget for the KNUEA indicates that there will be an increase in runoff and a reduction in infiltration following development:

- No areas of significant groundwater recharge or discharge have been identified within the KNUEA
- No sensitive species have been identified that will be significantly impacted by the anticipated change to the water balance following development.

Based on the findings of the water budget, no specific targets for infiltration or baseflow have been identified, but the following design approaches are recommended:

- Infiltration best management practices and/or Low Impact Development design should be considered at the site plan / plan of subdivision stage in areas where geologic conditions and proposed land use are suitable – refer to **Section 11.7** for further guidance.
- SWM facilities should be designed to provide baseflow enhancement in the receiving watercourses.

11.7 Stormwater Management

The Environmental Management Plan has identified the recommended stormwater management strategy for the KNUEA, which consists of three (3) new end-of-pipe SWM facilities, and lot-level controls to service a portion of the southwest quadrant.

11.7.1 SWM Facilities

The recommended SWM facilities are shown on **Drawing 112117-EMP**. The recommended SWM strategy has been developed to provide flexibility in the location of the ponds, and to allow flexibility to any future changes to the Land Use Plan.

The objective of the EMP is to identify the recommended SWM strategy for the KNUEA in coordination with the Master Servicing Study. The conceptual designs included in the EMP are intended to demonstrate the feasibility of implementing the recommended SWM strategy. The required storage volumes, release rates, pond footprints, and operating levels of the proposed SWM facilities are to be re-evaluated at the detailed design stage. Changes to the pond configurations will be permissible, provided the ponds meet all applicable SWM criteria as outlined in **Section 5.0**.

11.7.2 On-Site SWM Controls

Lot-level stormwater management controls are recommended for approximately 8 hectares in the southwest quadrant of the KNUEA to provide water quality treatment and quantity control.

- On-site quantity control storage could be provided using a combination of surface and underground storage.
- On-site quality control could be provided using treatment units (Stormceptor, Vortech, etc.) or through the use of low-impact development design.

11.7.3 Stormwater Best Management Practices (BMPs)

The majority of the KNUEA will be residential development. By implementing stormwater BMPs as part of the storm drainage design for the KNUEA, the impacts of development on the hydrologic cycle can be considerably reduced. Recommended best management practices for residential areas include:

- Perforated pipes for rearyard catchbasin leads.
- Direct roof leaders to rearyard areas.
- Direct storm runoff from rearyard areas to stream corridors and/or headwater drainage channels.

11.7.4 Low Impact Development

The City of Ottawa has recently implemented several LID pilot projects to evaluate the performance and maintenance requirements of LID designs, with the expectation that LID designs will become more prevalent in the near future.

The MOECC have indicated their intention to update the Environmental Compliance Approval (ECA) process to incorporate low impact development practices. The MOECC have stated that it is critical to consider options and opportunities for the incorporation of LID practices during the watershed and subwatershed planning process, and early in the development planning process, and not left to the preparation of the detailed stormwater management plan submission.

Based on the findings of the geotechnical and hydrogeological investigations and feedback from the City, there are areas within the KNUEA where LID designs should be considered. While the majority of the surficial soils within the KNUEA are underlain by clay and/or bedrock, this does not necessarily preclude the use of LIDs. For areas with tight, slow draining soils, it is recommended that any LID infrastructure be designed with overflows or subdrains to provide an engineered outlet for excess water.

East of March Road

The alluvial sand deposits east of March Road represent the most suitable areas for LID within the KNUEA. The alluvial soils are relatively shallow and underlain by clay and/or bedrock, and do not provide any significant contribution to groundwater recharge. However, these soils can provide storage and attenuation of runoff, and contribute to baseflow in Shirley's Brook.

West of March Road

The soils west of March Road generally consist of tight clays with relatively shallow depths to bedrock. While tighter soils do not preclude the use of LID measures, the presence of bedrock close to the surface will. The suitability of LID measures shall be considered in this area subject to such constraints.

11.8 Shirley's Brook Realignment

To mitigate any adverse impacts development of the KNUEA may have on erosion and washout of the roadway embankment along March Valley Road, it is recommended that the reach of Shirley's Brook within the right-of-way should be redesigned and relocated onto the adjacent federal lands (DND gun range) managed by NCC. This option would require a permit from MVCA (alterations to watercourses).

The recommended channel relocation represents the best long-term solution, and has been approved in principle by the NCC and the DND. The relocation also opens up the opportunity for future improvements to March Valley Road by relocating Shirley's Brook outside the right-of-way.

11.9 Hydrogeology

11.9.1 Existing Wells

Regulation 903 of the *Ontario Water Resources Act* requires that all well owners maintain wells in a state that does not allow the entry of foreign matter or surface water into the well. Unused and unmaintained wells are to be properly abandoned. Improperly abandoned wells can be direct connections between the ground surface and the aquifers. All unmaintained and unused water wells and abandoned septic systems within the study area require proper decommissioning.

Abandonment of Decommissioned Wells

Existing wells within the limits of the proposed development should be decommissioned by licensed water well contractors as per Ontario Regulation 903 (Wells) under the *Ontario Water Resources Act*. Without proper decommissioning, wells may act as downward conduits for the migration of contaminants. Additionally, the potential for artesian conditions (elevation of piezometric surface above upper confining layer elevation) has been identified at the subject site, and well decommissioning by a licensed contractor will ensure any artesian conditions are properly addressed, if encountered.

Due to the complexities involved in some cases of well abandonment, each case should be considered as an individual problem and the design, construction of the well and the hydrogeology must be considered and studied before final selection of materials, methods and procedures can be realized.

Protection of Existing Wells

At the time of detailed engineering design, specific hydrogeological studies may be required to address any specific engineering challenges associated with selected designs. However, as a due diligence measure, prior to the earlier of subdivision registration or the commencement of site excavation works, it is recommended that a baseline monitoring program be completed at selected existing water wells in the vicinity of the subject site. The baseline monitoring program should be completed at all wells within 500 m of the subject site, and may be expanded on an as-required basis:

- The area to be covered by the monitoring program is shown on **Figure 3.6**.
- Details of the monitoring program are provided in the *Hydrogeological Existing Conditions Report* (Paterson, May 18, 2016) – refer to **Volume 3, Appendix N**.

The installation of these sentry wells will be considered mandatory to the development, although their locations may be altered as necessary to provide optimal coverage. It is recommended that baseline water level monitoring data be obtained at these wells for a period of at least one (1) event prior to site development. It is recommended that sentry wells be installed in pairs, at depths of 6-8 m and 10-15 m, in order to observe potential effects at the proposed maximum depth of services as well as at the depth at which the shallowest surrounding wells are completed.

In the event of impacts to surrounding wells by on-site construction activities, an alternative source of water will immediately be provided to the impacted properties by the proponents of the project. In the event of short-term impacts, tanked or bottled water may be provided, and in the event of long-term impacts which are confirmed to be a result of construction activities at the subject site, consideration will be given to deepening the pumps in affected wells where significant available drawdown is present, or potentially drilling a new well.

11.9.2 Existing Private Sewage Systems

It is recommended that existing private sewage systems within the subject site be properly decommissioned by a qualified contractor prior to the redevelopment of the subject site. Based on our field observations, the locations of existing sewage systems to be decommissioned are shown on Drawing PH2223-4, appended to this report. Any additional private sewage systems encountered will also be properly decommissioned.

11.9.3 Existing Tile Drains

The presence of tile drains was not confirmed on the subject site, although a potential tile drain outlet was observed in the vicinity of the Shirley's Brook tributary to the west of March Road, near BH4/BH4A.

Given that the subject site is to be developed with a high-density urban development, the site will no longer require subdrainage. It is recommended that tile drains be removed and/or capped on an as-encountered basis.

11.9.4 Sources of Contamination

No concerns were identified with respect to actual or potential sources of contamination at the time of the completion of this study.

Prior to and during site development, it is recommended that construction best practices with respect to fuels and chemical handling, spill prevention, and erosion and sediment control be followed, to minimize the potential for the introduction of contaminants to the soil, surface water, or groundwater at the subject site.

11.9.5 Blasting

In general, bedrock removal by means of blasting within the shallow bedrock at a site has limited potential to impact the water quantity and quality in neighbouring water wells, which are generally completed at depths significantly below underground service trenches. Best management practices for blasting are to be followed at all times.

As a general guideline, peak particle velocities (measured at the property boundary) should not exceed 25 mm per second at frequencies above 40 hertz during the blasting program to reduce the risk of damage or impacts to surrounding wells or structures. The blasting operations should be planned and conducted under the supervision of a licensed professional engineer who is also an experienced blasting consultant.

11.9.6 Groundwater Control in Excavations

For any water taking of greater than 50,000 L/day, a Permit To Take Water (PTTW) or registration of the water taking activity on the Environmental Activity and Sector Registry (EASR) is required from the MOECC. In general, EASR registration is required for construction dewatering where less than 400,000 L per day are to be pumped under normal conditions. Additional takings require PTTW registration. Passive diversion of a water course, active diversion of a water course with discharge control measures in place, or wetlands rehabilitation are exempted from PTTW or EASR registration.

The requirements for a PTTW or EASR will be determined during the detail design phase. The information contained in the hydrogeological existing conditions report may be used as supporting documentation for a PTTW or EASR application for future development within the KNUEA. Depending on the nature of the proposed water taking, additional hydrogeological investigation may be required.

Construction best practices should be employed when dewatering excavations at the subject site, including erosion and sedimentation control measures and discharge quality control.

11.10 Compensation by Quadrant

Each quadrant within the KNUEA lands will have a combination of environmental compensation and mitigation as outlined in the above sections relating to species at risk, headwater drainage features, and stream corridors. The following breaks down the proposed strategies on a quadrant-by-quadrant basis. **Drawing 112117-EMP** also provides a representation of the proposed strategies.

Northwest Quadrant

- Realigned 40m corridor + 6m pathway for Shirley's Brook Tributary 2.
- Channel 'F' (Nadia Lane) should be intercepted at the KNUEA property boundary and piped to Tributary 2.
- A portion of the southwest wooded area should be maintained as a part of the stream corridor for Shirley's Brook Tributary 3.
- A 0.30 ha portion of the southwest wooded area will be maintained as a part of the Natural Heritage system, and conveyed to the City for conservation.
- Blanding's turtle compensation with deep pools, artificial nesting areas, shallow pans/pools, and deep channel pockets.
- Headwater features compensation within protected and/ or enhanced creek corridor

Southwest Quadrant

- 40m corridor + 6m pathway for Shirley's Brook Tributary 3.
- Channel 'G' (Marchbrook Circle) should be intercepted at the KNUEA property boundary and piped to Tributary 3.
- Blanding's turtle compensation with deep pools, artificial nesting areas, shallow pans/pools, and deep channel pockets.
- Headwater features compensation within the protected and/ or enhanced creek corridor

Northeast Quadrant

- Realigned 40m corridor + 6m pathway for Shirley's Brook Tributary 2.
- Healthy and mature white cedars in the northeast corner of Woodlot S20 should be retained as a part of the proposed parkland.
- Blanding's turtle compensation with shallow pans/ pools, and deep channel pockets.
- Rear-yard flows from properties along eastern boundary should be directed to culverts crossing the abandoned CN rail corridor to maintain flows in channels 'C' and 'D'
- Re-grade ditch west of the former rail corridor to eliminate perched culverts and direct rearyard drainage to headwater channels east of the rail corridor
- Replace headwater functions in protected stream corridors or other areas.

Southeast Quadrant

- 40m corridor + 6m pathway for Shirley's Brook Tributary 2.
- Blanding's turtle compensation with deep pools, artificial nesting areas, shallow pans/pools, and deep channel pockets.
- Rear-yard flows from properties along eastern boundary should be directed to culverts crossing the abandoned CN rail corridor to maintain flows in existing headwater channels.
- Re-grade ditch west of the former rail corridor to eliminate perched culverts and direct rearyard drainage to headwater channels east of the rail corridor
- Replace headwater functions in protected stream corridors or other areas.

Section 12.0 Cost Estimates for SWM Facilities

Preliminary cost estimates have been prepared for each of the recommended SWM facilities based on the conceptual design drawings provided in **Section 10.0**.

Table 12.1: Pond 1 Cost Estimates

		Kanata North Urban Expansion Area Community Design Plan Preliminary Stormwater Facility Cost POND 1 - Junic/ Multivesco SWMF			
ITEM NO.	ITEM	EST. QTY	UNIT	UNIT PRICE	TOTAL AMOUNT
SECTION A - STORMWATER FACILITY (32,000m³)					
1	Earthworks				
	i) Earth Excavation (incl Topsoil Stripping)	45,000	m ³	\$10.00	\$450,000.00
	ii) Rock Excavation	34,000	m ³	\$40.00	\$1,360,000.00
	iii) Clay Liner (0.6m Thick)	12,000	m ²	\$9.00	\$108,000.00
2	Inlet				
	i) Flow Splitter	1	ea.	\$30,000.00	\$30,000.00
	ii) 1950mm dia. Storm Sewer	12.0	m	\$2,200.00	\$26,000.00
	iii) 2100mm dia. Storm Sewer	33.0	m	\$2,400.00	\$79,000.00
	iv) Manholes	1	ea.	\$30,000.00	\$30,000.00
	v) Concrete Headwall	2	ea.	\$20,000.00	\$40,000.00
3	Outlet				
	i) Structure (incl control & minor piping)	1	ea.	\$5,000.00	\$5,000.00
	ii) 600mm dia. Storm Sewer	59	m	\$350.00	\$21,000.00
	iii) Manholes	2	ea.	\$30,000.00	\$60,000.00
	iv) Concrete Headwall	1	ea.	\$20,000.00	\$20,000.00
	v) Overflow spillway	1	ea.	\$3,000.00	\$3,000.00
4	Rock Check Dam	2	ea.	\$3,000.00	\$6,000.00
5	Hydro Seeding	11,000	m ²	\$4.00	\$44,000.00
6	Landscaping Allowance	1	LS	\$95,000.00	\$95,000.00
7	Access Road/ Pathway Connection	650	m	\$205.00	\$133,000.00
TOTAL SECTION A - STORMWATER FACILITY					\$2,510,000.00
				Construction Total	\$2,510,000.00
				60% Capital Cost Allowance	\$1,506,000.00
				Urban Land (ac)	6.2
				Total	\$4,016,000.00

Table 12.2: Pond 2 Cost Estimates

		Kanata North Urban Expansion Area Community Design Plan Preliminary Stormwater Facility Cost POND 2 - Brigil SWMF			
ITEM NO.	ITEM	EST. QTY	UNIT	UNIT PRICE	TOTAL AMOUNT
SECTION A - STORMWATER FACILITY (10,000m³)					
1	Earthworks				
	i) Earth Excavation (incl Topsoil Stripping)	10,500	m ³	\$10.00	\$105,000.00
	ii) Rock Excavation	2,000	m ³	\$40.00	\$80,000.00
	iii) Clay Liner (0.6m Thick)	2,700	m ²	\$9.00	\$24,000.00
2	Inlet				
	i) 1800mm dia. Storm Sewer	82.0	m	\$2,000.00	\$164,000.00
	ii) Manholes	2	ea.	\$30,000.00	\$60,000.00
	iii) Concrete Headwall	1	ea.	\$20,000.00	\$20,000.00
3	Outlet				
	i) Structure (incl control & minor piping)	1	ea.	\$40,000.00	\$40,000.00
	ii) 375mm dia. Storm Sewer	95	m	\$200.00	\$19,000.00
	iii) Manholes	1	ea.	\$20,000.00	\$20,000.00
	iv) Concrete Headwall	1	ea.	\$15,000.00	\$15,000.00
	v) Overflow spillway	1	ea.	\$3,000.00	\$3,000.00
4	Rock Check Dam	2.0	ea.	\$3,000.00	\$6,000.00
5	Hydro Seeding	9,000	m ²	\$4.00	\$36,000.00
6	Landscaping Allowance	1.0	LS	\$63,000.00	\$63,000.00
7	Access Road/ Pathway Connection	500	m	\$205.00	\$103,000.00
TOTAL SECTION A - STORMWATER FACILITY					\$758,000.00

Construction Total	\$758,000.00
60% Capital Cost Allowance	\$454,800.00
Urban Land (ac)	4.2
Total	\$1,212,800.00

Table 12.3: Pond 2A Cost Estimates

		Kanata North Urban Expansion Area Community Design Plan Preliminary Stormwater Facility Cost POND 2A - Brigil SWMF (Alternative Location)			
ITEM NO.	ITEM	EST. QTY	UNIT	UNIT PRICE	TOTAL AMOUNT
SECTION A - STORMWATER FACILITY (10,000m³)					
1	Earthworks				
	i) Earth Excavation (incl Topsoil Stripping)	14,000	m ³	\$10.00	\$140,000.00
	ii) Rock Excavation	2,000	m ³	\$40.00	\$80,000.00
	iii) Clay Liner (0.6m Thick)	3,000	m ²	\$9.00	\$27,000.00
2	Inlet				
	i) 1800mm dia. Storm Sewer	42.0	m	\$2,000.00	\$84,000.00
	ii) Manholes	1	ea.	\$30,000.00	\$30,000.00
	iii) Concrete Headwall	1	ea.	\$20,000.00	\$20,000.00
3	Outlet				
	i) Structure (incl control & minor piping)	1	ea.	\$40,000.00	\$40,000.00
	ii) 375mm dia. Storm Sewer	213	m	\$200.00	\$43,000.00
	iii) Manholes	2	ea.	\$20,000.00	\$40,000.00
	iv) Concrete Headwall	1	ea.	\$15,000.00	\$15,000.00
	v) Overflow spillway	1	ea.	\$3,000.00	\$3,000.00
4	Rock Check Dam	2.0	ea.	\$3,000.00	\$6,000.00
5	Hydro Seeding	9,000	m ²	\$4.00	\$36,000.00
6	Landscaping Allowance	1.0	LS	\$63,000.00	\$63,000.00
7	Access Road/ Pathway Connection	500	m	\$205.00	\$103,000.00
TOTAL SECTION A - STORMWATER FACILITY					\$730,000.00
				Construction Total	\$730,000.00
				60% Capital Cost Allowance	\$438,000.00
				Urban Land (ac)	3.5
				Total	\$1,168,000.00

Table 12.4: Pond 3 Cost Estimates

ITEM NO.	ITEM	EST. QTY	UNIT	UNIT PRICE	TOTAL AMOUNT
SECTION C - STORMWATER FACILITY SHARED COSTS (62,000m³)					
1	Earthworks				
	i) Earth Excavation (incl Topsoil Stripping)	75,800	m ³	\$10.00	\$758,000.00
	ii) Rock Excavation	500	m ³	\$40.00	\$20,000.00
	iii) Clay Liner (0.6m Thick)	1000	m ²	\$9.00	\$9,000.00
2	Clearing and Grubbing	6	ha	\$10,000.00	\$60,000.00
3	Inlet				
	i) Manholes	1	ea.	\$30,000.00	\$30,000.00
	ii) Rail Line Crossing - 1950mm Conc Pipe	75	m	\$2,200.00	\$165,000.00
	iii) Rail Line Crossing - 2250mm Conc Pipe	63	m	\$2,600.00	\$164,000.00
	iv) Concrete Headwall	2	ea.	\$20,000.00	\$40,000.00
	v) Ditching (incl Earth Excavation)	500	m	\$700.00	\$350,000.00
	vi) 1800mm Conc Pipe	177.0	m	\$2,000.00	\$354,000.00
	vii) 2440mm Conc Pipe	30.0	m	\$3,000.00	\$90,000.00
	ix) Flow Splitter manhole	2	ea.	\$30,000.00	\$60,000.00
5	Outlet				
	i) Structure	1	ea.	\$50,000.00	\$50,000.00
	ii) 975mm Conc Pipe	76.0	m	\$900.00	\$68,000.00
	iii) Concrete Headwall	2	ea.	\$20,000.00	\$40,000.00
	iv) Ditching (incl Earth Excavation)	15	m	\$100.00	\$2,000.00
	v) Overflow Spillway	1	ea.	\$3,000.00	\$3,000.00
	vi) Road Reinstatement (March Valley Road)	40	m ²	\$100.00	\$4,000.00
6	Rock Check Dam	2	ea.	\$3,000.00	\$6,000.00
7	Hydro Seeding	53,000	m ²	\$4.00	\$212,000.00
8	Landscaping Allowance	1	LS	\$225,000.00	\$225,000.00
9	Access Road/ Pathway Connection	1,600	m	\$205.00	\$328,000.00
TOTAL SECTION C - STORMWATER FACILITY					\$3,038,000.00

Construction Total	\$3,038,000.00
60% Capital Cost Allowance	\$1,822,800.00
Valecraft Rural Land (ac)	14.5
Metcalfe Rural Land (ac)	14.7
Total	\$4,860,800.00

12.1 Shirley’s Brook Main Branch Re-Alignment

Preliminary cost estimates have been prepared for the proposed realignment of Shirley’s Brook outlined in **Section 10.0**. Realignment of the watercourse will benefit multiple landowners, and could be completed by way of drainage area development charges, or through cost-sharing between landowners and other parties, at the responsibility of the NCC. To date, the City of Ottawa and the NCC have made no commitment to cost-sharing for this work.

Table 12.5: Shirley’s Brook Main Branch Realignment Cost Estimate

		Kanata North Preliminary Stormwater Outlet Cost Option 3			
ITEM NO.	ITEM	EST. QTY	UNIT	UNIT PRICE	TOTAL AMOUNT
SECTION A - STORMWATER OUTLET					
1	Traffic Control	1	LS	\$10,000.00	\$10,000.00
2	Erosion and Sediment Control				
	i) Temporary Check Dams	7	ea.	\$500.00	\$3,500.00
	ii) Silt Fence	1	LS	\$12,000.00	\$12,000.00
3	Excavate New Natural Channel for Shirley’s Brook				
	i) Excavate, erosion blanket, live staking	560	m	\$650.00	\$364,000.00
4	Tree Removal	1	LS	\$5,000.00	\$5,000.00
TOTAL SECTION A - STORMWATER OUTLET					\$394,500.00
Construction Total					\$394,500.00
60% Capital Cost Allowance					\$236,700.00
Total					\$631,200.00

Section 13.0 Project Listing

The Environmental Management Plan component of the KNCDP, in conjunction with the Master Servicing Plan and the Transportation Master Plan, satisfies the requirements of Phase 1 and 2, and where required Phases 3 and 4, of the Integrated EA & Planning Act Process.

13.1 EA Projects

The following projects fall under the *Environmental Assessment Act*:

- Stormwater Management Pond #1 and associated storm sewers and access pathways (Schedule B)
- Stormwater Management Pond #2 and associated storm sewers and access pathways (Schedule B)
- Stormwater Management Pond #3 and associated storm sewers and access pathways (Schedule B)
- Realignment of Shirley's Brook Tributary 2 (Schedule B)
- Enhancement of Tributaries 2 & 3 with provisions for Blanding's Turtle habitat, and recreational pathways (Schedule B)
- Realignment of a portion of Shirley's Brook Main Branch at March Valley Road (Schedule B)
- Re-direction and piping through development area of Headwater Channel 'F' from KNUEA property boundary to Tributary 2 (Schedule B)
- Re-direction and piping through development area of Headwater Channel 'G' from KNUEA property boundary to Tributary 3 (Schedule B)

Review agencies and the public will have an opportunity to review the Class EA documentation being prepared for the KNCDP, and have the ability to appeal to the OMB. The assessment and review process is being harmonized with the *Planning Act* as the development application process is occurring simultaneously. Notification of the conditions of planning approvals and the Class EA documents will be advertised through a **Notice of Completion** and there will be an opportunity to appeal to the Ontario Municipal Board (OMB). If a project has been appealed to the OMB, the requirements of the integrated approach have not been met until the OMB renders a decision allowing the project to proceed. As outlined in section 2.8.1 of this Class EA, a Part II Order (PIIO) request may also be made to the Minister of the Environment or delegate.

However, the purpose of the integration provisions is to coordinate requirements under the *Planning Act* with this Class EA. When reviewing a PIIO request, the Minister of the Environment or delegate will consider the purpose and intent of the integration provisions.

Under the *Planning Act*, appeals to the OMB may be made to any of the Official Plan and zoning by-law amendments or to the approval of subdivisions. The deadlines for the appeals to each application are found in the *Planning Act*. For Draft Plans of Subdivision and Zoning By-law amendments, appeals are to be filed within 20 days after written notice of decisions are provided. In addition, the OMB may dismiss an appeal if the person does not submit either written or oral submissions before the approval authority has granted approval. Once approved, however, the Class EA documents and the preferred municipal infrastructure projects will not be subject to additional EA approval requirements with the submission of subsequent site plans or plans of subdivisions. Once the application is approved under the *Planning Act*, the requirements of the Class EA are met and projects identified in the Class Environmental Assessments for the

KNCDP are approved and can proceed to construction and no additional notification under the EA Act is necessary. This allows the integration of both planning processes while ensuring the intent and requirements of both Acts are met.

The implementation, over time, of the KNCDP and the required supporting infrastructure will take place as *Conditions of Approval*. The approvals will be conducted under the *Planning Act*, and other acts as listed in **Section 14**.

13.2 Other Approval Requirements

The Kanata North Community Design Plan CDP satisfies the EA requirements under the *Planning Act*. Additional approvals will be required for implementation of the proposed development plan including, but not limited to, the following:

13.2.1 Ministry of Environment (MOECC)

All sanitary sewers, stormwater drainage and stormwater facilities are regulated under the Ontario Water Resources Act and will require an Environmental Certificate of Approval from the Ministry of the Environment and Climate Change.

13.2.2 Department of Fisheries and Oceans (DFO)

Proposed works that may constitute a harmful alteration, disruption or destruction (HADD) of fish habitat and will require authorization from DFO under the Fisheries Act may include but are not limited to:

- The realignment of Tributary 2 of Shirley's Brook;
- The removal of the existing weir structures along Tributary 3 of Shirley's Brook;
- The installation of culvert crossings on Tributaries 2 and 3, and at March Road;
- The realignment of Shirley's Brook Main Branch at March Valley Road.

13.2.3 Conservation Authority (CA)

Proposed enhancements to watercourses are regulated under Section 28 of the Conservation Authorities Act. Development, Interference with Wetlands, and Alterations to Shorelines and Watercourses will require approval from the Mississippi Valley Conservation Authority (MVCA)

13.2.4 Ministry of Tourism, Culture and Sport (MTCS)

Archaeological Clearance for Stage 1 Archaeological Assessment and Stage 2 must be provided by the MTCS.

13.2.5 Ministry of Natural Resources and Forestry (MNRF)

The Endangered Species Act (S.O. 2007, c.6) is administered by the MNRF. Registration of activity and/or a permit is required for disruption of Species at Risk. An Overall Benefit Permit may also be required to ensure mitigation in some instances.

13.2.6 National Capital Commission (NCC)

An approval under the NCC's Federal Land Use, Design, and Transaction Approval Process (FLUDTA) is required when there is a defined project taking place on federal lands. The realignment of Shirley's Brook Main Branch at March Valley Road will likely trigger a FLUDTA. Approval in principal is provided in a letter from the NCC located in **Volume 2, Appendix B**.

Section 14.0 Implementation and Phasing

This section of the EMP describes the processes and mechanisms that will guide the implementation of the Kanata North Community Design Plan in fulfilment of the policies of the Official Plan and the CDP. The principal mechanisms include:

- An implementing Official Plan Amendment;
- Guidance on the interpretation of the CDP;
- Process to amend the CDP and Environmental Assessments;
- Preparation of a financial implementation plan, involving cost sharing agreements;
- Schedule for staging of key infrastructure to service the lands;
- Development monitoring.

As development proceeds within the Kanata North Urban Expansion Area, the implementation mechanisms will guide the timely advancement of municipal infrastructure and community amenities and facilities. Implementation strategies will include the use of front-ending agreements that will allow the developer(s) to advance the construction of certain facilities in accordance with agreed-upon principles. The City will be a party to the front-ending agreements.

Policy 5 of Section 5.3 of the Official Plan permits the use of private agreements among landowners to cost-share major infrastructure projects, associated studies and plans. These agreements may include development of community facilities such as parks. The agreements are initiated by landowners within a defined area and provide for the equitable sharing of costs among the benefiting parties, to complement in some instances or replace the provisions of a Development Charges By-law. These agreements are implemented through the Official Plan Amendment as site specific policies in Section 5.3 of the Official Plan and enforced through conditions of development approval. Section 5.3 of the Official Plan also states, that where such agreements are in place, the City shall require evidence of participation and payment, pursuant to the agreement(s), as a condition of draft approval for plans of subdivision and plans of condominium, and as a condition of approval of severance applications and site plans.

A cost sharing agreement will be developed for the KNUEA to establish principles for cost sharing of core services and other shared infrastructure prior to development approval.

A master parkland agreement will also be negotiated for the KNUEA to establish a compensation mechanism to equitably share parkland dedication and construction costs, and to ensure that parkland is developed in accordance with the CDP.

14.1 Official Plan Amendment

The Kanata North Community Design Plan and the Environmental Management Plan will be approved by Council. An Amendment to the City of Ottawa Official Plan will be required as it relates to the following matters:

- **Schedule A Rural Policy Plan** - remove the Urban Expansion Study Area from the Rural Policy Plan.

- **Schedule B Urban Policy Plan** - include the Urban Expansion Study Area into the Urban Policy Plan and designate the majority of the lands as General Urban Area, designate the creek corridors as Urban Natural Feature
 - **Schedule L3 Natural Heritage System Overlay (West)** – amend the Natural Heritage System overlay to remove S20 and a portion of S12 and include the creek corridors
 - A site specific exception to **Section 3.11** for the KNUEA, to amend the policies of section 3.11.4 e. i) from:
 - i. At least 45% single detached but not more than 55% single detached, at least 10% apartment dwellings and the remainder multiple dwellings, other than apartments.
 - ii. In Urban Expansion Study Area designations, overall residential development will meet a minimum average density target of 34 units per net hectare.
- to
- i. A target of at least 30% single detached but not more than 55% single detached, at least 10% apartment dwellings and the remainder multiple dwellings, other than apartments.
 - ii. Overall residential development will meet a minimum average density target of 36 units per net hectare.
- **Section 5.3** ‘Other Implementation Policies’ – will be amended by adding a policy requiring the landowners within the KNUEA to enter into private agreements to:
 - Share the costs of the major infrastructure projects and required associated studies and plans and to distribute the costs fairly among the benefiting landowners; and,
 - Provide compensation between landowners respecting the dedication and development of municipal parkland.

14.2 EMP Interpretation and Amendments

The EMP has been prepared through an extensive process involving technical input and public consultation. Development should proceed in a manner that is consistent with the policies, plans, and recommendations contained in the document in order to ensure that the policies of Section 3.11 the Official Plan and the CDP are implemented.

It is not possible to anticipate every circumstance or issue that may arise over the course of the development of the lands. Accordingly, there must be a mechanism to permit landowners to make amendments as deemed necessary.

14.2.1 Minor Changes

Minor changes to the Demonstration Plan and Land Use Plan, such as minor adjustments to local street network and the location of pathway blocks, the size and location of multi-unit residential blocks, the size and shape of parkland, the location and area of school blocks, and the size, location and shape of stormwater management ponds, that result from applications for development can be made through the City of Ottawa development approvals process, provided they are consistent with the general intent of the CDP.

14.2.2 Major Changes

Major changes to the Land Use Plan or changes requiring amendment to schedules of the Official Plan, such as a major shift in the network of collector roads, reduction in the minimum amount of overall parkland, a significant change to the width or location of the creek corridors, or a change in the number of stormwater management ponds, will be subject to approval by Planning Committee and external agencies as required.

Major changes should be supported by a Planning Rationale prepared in conformity with the City's Planning Rationale Terms of Reference, and any technical documents to provide justification for the proposed change and to assist the City and the public in the review of the proposal. The Rationale should include a plan showing the context of the surrounding area, including information concerning other development applications that are approved or about to be approved.

14.3 Environmental Assessment Amendment Process

As noted previously, development should proceed in a manner that is consistent with the Master Plans. As with the Community Design Plan, it is not possible to anticipate every circumstance or issue that may arise over the course of the development of the lands and it may not be feasible to implement the projects as described in the environmental assessment reports. A major change to the project would require an addendum outlining the implications of the change and made available for public review. Not all changes however would be considered as major. Below is summary of a well-defined process that permits landowners to make modification as necessary as the detailed planning and designs proceed following approval of the environmental assessments.

14.3.1 Minor Changes

Minor changes are those that do not appreciably change the expected environmental impacts or proposed mitigation associated with the project. These are modifications that typically arise as projects are refined through the planning and design process, such as , a design change within the cross section of a roadway, landscaping around storm ponds, and natural habitat compensation as part of another approval process, would be considered minor.

Changes in alignment or facility footprints that do not affect more than three participating landowners should have the consensus of those land owners and would also be considered as minor. All affected landowners and appropriate stakeholders will be provided details of proposed minor changes. Minor changes will be dealt with at the time of detailed design through the City's development review process.

14.3.2 Major Changes

Major changes are those that substantially change the environmental net impacts with the project or occur as a result of a change in the environmental setting for the project. An example of a major change would be a proposed change in the number stormwater management facilities, or a change to a project that affects (increases) the identified project EA schedule.

If the proposed modification is major, the recommendations and conclusions in the EA would require updating. An addendum to the EA would be required to document the change, identify the associated impacts and mitigation measures and allow related concerns to be addressed and reviewed by the appropriate stakeholders. Notice of the addendum will be posted and the addendum made available for public review. Only those changes identified in the addendum are open for review.

14.4 Development Charge Projects

The Development Charges Act, 1997 (DCA) gives the authority to the City of Ottawa to pass a new Development Charges (DC) By-law every five years. Development charges are one-time fees levied by municipalities on new residential and non-residential properties to help pay for a portion of the growth-related capital infrastructure requirements. The adoption of this study will signify Council's intention to ensure that any increase in the need for service attributable to growth, based on the requirements outlined in the legislation, will be included in a future Development Charge Background Study.

The following is a list of the DC eligible growth related projects in Kanata North that should be covered in accordance with Schedule B of the Development Charges Background Study:

- March Road widening to four lanes;
- March Road intersections;
- Oversizing of sanitary sewers above 375 mm;
- Upgrade to the Briar Ridge Pump Station;
- Upgrade to off-site 400mm watermains;
- Land acquisition for park and ride and fire station.

14.5 Cost Sharing/Financial Plan

A Financial Plan is a requirement of Section 3.11 of the Official Plan. The following cost sharing agreements constitute the financial plan for the CDP. A separate Financial Implementation Plan has also been prepared.

14.5.1 Core Services Agreement

Core Services means any work, service or facility described below, but only to the extent required by an Approval Authority to be constructed in order for development to proceed within the KNUEA. Anticipated core services that fall under the scope of the EMP may include but are not limited to:

- Realignment of Shirley's Brook Main Branch through DND Property;
- Off-site compensation for Blanding's turtles including a crossing of March Valley Road.

All landowners will be required to become a party to the Core Services Agreement, and to contribute their proportionate share in the cost of these core services, before development is approved by the City.

14.5.2 Other Shared Works

As development proceeds, the cost to construct other infrastructure that is not a Core Service but is shared by at least two landowners will be negotiated by the benefiting landowners. Examples include planned stormwater management facilities, oversized and over-depth infrastructure and roadways where they cross property lines or run along property lines.

The Land Use Plan also includes four full movement signalized intersections on March Road. Construction of these intersections will proceed with the initial phases of the development. The construction costs will be shared by all benefiting landowners.

14.6 Greenspace

The Greenspace system is comprised of a variety of elements, including parkland, natural heritage features, such as the creek corridors and woodlot, and stormwater management facilities. The components of the greenspace system will ultimately be in public ownership. The City will pursue acquisition of such lands through:

- Parkland and/or open space dedication through the development approvals process;
- Conveyance of completed stormwater management facilities; and,
- Conveyances of other open spaces through the development approvals process.

Neighbourhood Parks are to be built concurrently with the development of the lands that the parks are intended to serve. The Community Park will be required at the time 50% of the anticipated building permits are issued based on an estimate of 3000 dwelling units.

Through the development approvals process, the identified components of the natural heritage system including the creek corridors referred to as Tributary 2 and Tributary 3, and the Southwest Wooded Area will be conveyed to the City as per Policy 5) b of Section 3.11 in the Official Plan.

Woodlot S23 located east of the CN rail corridor and outside the designated KNUEA will be conveyed by the landowners to the City of Ottawa following the detailed design and approval of the stormwater management facility referred to as Pond 3.

14.6.1 Creek Corridor Enhancements

Portions of the creek corridors will be modified as a result of required habitat enhancements for Blanding's Turtle and fish, and to compensate for loss of headwaters. The majority of these enhancements will be the responsibility of individual landowners in accordance with the recommendations of the EMP. Where necessary, compensation agreements will be made between individual landowners to coordinate enhancement measures crossing property lines or where specific headwater features can only be compensated for by providing enhancements on a different property within the KNUEA.

14.7 Infrastructure Staging

As demonstrated in the Master Servicing Study, Transportation Master Plan and the Environmental Master Plan, development can generally proceed from any location within the Study Area. Development is expected to begin close to March Road and spread out to the east and west. It is anticipated that development will occur incrementally through Plans of Subdivision with associated infrastructure and services being installed.

Where properties of non-participating landowners are located within a development phase, such properties shall not be required to develop with the balance of the lands in that phase. Through the review of draft plans of subdivision, consideration may be given to accommodate the potential integration of these individual properties.

Topography does play a role in the staging of sanitary servicing, as the KNUEA is geographically defined by the north-south ridge east of March Road. Generally, lands above the ridge will be serviced by the March Road Trunk Sewer while lands below (east of) the ridge will be serviced by the Briar Ridge Pump Station. Alternative options that result in a more efficient sanitary servicing scenario may be considered through the development review process. This may include some exchange of drainage areas above and below the ridge.

14.7.1 Core Services Staging

Details of the staging of the core services are set out in **Table 14.1**:

Table 14.1: Core Services Staging

INFRASTRUCTURE REQUIREMENT	DEVELOPMENT STAGE
Sanitary Servicing	
Extension of March Road Trunk Sewer and upgrade to Shirley's Brook Drive sanitary sewer to 600mm	Required prior to any development serviced from March Road
Briar Ridge Pump Station Upgrade	Servicing capacity is available up to 10 L/s of flow calculated from new development. Upgrade will be required for additional flow
Extension of sanitary sewer along the rail corridor, and upgrade to sanitary sewer in Brookside Subdivision to 450mm	Servicing capacity is available up to 46 L/s of flow calculated from new development. Upgrade will be required for additional flow
Water Servicing	
Water services extended from off-site	Required prior to any development serviced from March Road
Stormwater Management	
Stormwater management facilities	Required concurrent with lands tributary to the facility
Shirley's Brook realignment and outlet for Pond 3	Required concurrent with the lands tributary to the facility

INFRASTRUCTURE REQUIREMENT	DEVELOPMENT STAGE
Transportation	
Signalization of intersections on March Road	Required concurrent with initiation of adjacent development
March Road upgrade to four lanes through the CDP limits	To be determined through future City Transportation Master Plan updates and subject to Front Ending Agreement between City and landowners.
Park and Ride	To be determined through future City Transportation Master Plan updates
Kanata North Transitway BRT extension	To be determined through future City Transportation Master Plan updates

Section 15.0 Reliance Clause

This report has been prepared by Novatech, on behalf of the Kanata North Landowner's Group and in support of the Kanata North Community Design Plan. It is hereby acknowledged that Metcalfe Realty Company Limited, J. G. Rivard Limited and 8409706 Canada Inc. (Valecraft Homes), 3223701 Canada Inc. and 7089121 Canada Inc. (Junic/Multivesco) can rely upon and utilize this report for the purpose of obtaining approval of the community design plan and for their own use to seek development approval.

It is further acknowledged that future confirmed participating landowners within the Kanata North Landowner's Group can rely upon and utilize this report for the purpose of obtaining approval of the community design plan and for their own use to seek development approval.

Section 16.0 References

The following reports were used as reference material to provide background information used in the development of the Environmental Management Plan.

1. Kanata North Urban Expansion Area Community Design Plan Environmental Management Plan Existing Conditions Report, Storm Drainage, Hydrology, Floodplain Mapping (Novatech, February, 2016)
2. Existing Conditions Natural Environment Features Kanata North Urban Expansion Area (Muncaster Environmental Planning Inc., January 2016)
3. Consolidated Preliminary Geotechnical Investigation Kanata North Urban Expansion Area Community Design Plan (Patterson Group, October 7, 2013)
4. Hydrogeological Existing Conditions Report Kanata North Urban Expansion Area (Patterson Group, May 18, 2016)
5. Kanata North Urban Expansion Area Fluvial Geomorphic Assessment (Parish Aquatic Services, February 2016)
6. Kanata North Urban Expansion Area Headwater Drainage Features Geomorphic Assessment (Parish Aquatic Services, February, 2016)
7. Kanata North Headwaters Report (Bowfin Environmental Consulting & Muncaster Environmental Planning Inc., September 2015)
8. Sensitive Groundwater Assessment: Discharge and Recharge Area Evaluation Woodlot S20 (Patterson Group, October 24, 2014)
9. South March Highlands Blanding's Turtle Conservation Needs Assessment (Dillon Consulting Limited for City of Ottawa, January 31, 2013)
10. Kanata North Community Design Plan Blanding's Turtle Compensation Plan (DST Consulting Engineers, June 2015)
11. Kanata North Community Design Plan Blanding's Turtle Habitat Compensation Plan – Offsite Compensation Concept (Memo – DST Consulting Engineers, November 12, 2015)
12. Sewer Design Guidelines, W. R. Newell, P.Eng., City of Ottawa (Second Edition, October 2012)
13. Stormwater Management Facility Design Guidelines & Standards, City of Ottawa Environmental Services Department, Surface Water Management Services Branch, Stormwater & Municipal Drainage Unit (Draft, October 2012)
14. Stormwater Management Planning and Design Manual, Ministry of the Environment and Climate Change (March 2003)
15. Municipal Class Environmental Assessment, Municipal Engineers Association (Revised, December 2015)
16. Greater Shirley's Brook / Constance Creek Environmental Management Study (Aquafor Beech, 2006)
17. Shirley's Brook and Watts Creek Subwatershed Study (Dillon, 1999)
18. Shirley's Brook & Watts Creek Phase 2 Stormwater Management Study (AECOM, 2013)

NOVATECH

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