

Executive Summary

Introduction

The Mud Creek Subwatershed (MCS) is located within the City of London (City), in an area that is predominantly urban development. The 759-hectare (ha) subwatershed is situated in the northwestern area of the City's boundaries and is a major tributary to the Thames River. Mud Creek functions as a key component to manage stormwater in the MCS's urban and natural areas, and provides valuable habitat for many aquatic and terrestrial species. As such, it is very important to the City and its residents that the creek function properly in its roles in stormwater conveyance, and in supporting areas of natural environment.

It has been documented as early as 1995, (Marshall Macklin Monaghan Limited [MMM], 1995), that stormwater runoff within the MCS contributes to frequent flooding along Oxford Street and Proudfoot Lane, as well as in the vicinity of Wonderland Road, Riverside Drive, and Hutton Place. Oxford Street is an arterial road, and has infrastructure warranting protection from flooding. Private property is also at risk of flooding and is of concern within areas of the MCS in close proximity to the creek. Mud Creek has been highly altered in the past with channel realignments to accommodate development over the last 100-years. These alterations include channel straightening to accommodate the construction of a sanitary sewer, enclosing the creek outlet to the Thames River, and realigning the creek along Oxford Street. Mud Creek has a history of substantial environmental degradation, including bank erosion and sediment deposition; many natural indicators of aquatic health, including benthic organisms, fish species, and water quality parameters, underline the poor aquatic and terrestrial health within the creek system. However, it also provides habitat for many species of wildlife (birds, amphibians, mammals) and contains several valuable terrestrial features, particularly large trees and animal refuge areas.

The City's Official Plan (OP) (2006) designates 54 ha within the subwatershed that are subject to future land use changes. As the area continues to develop, it is important to create a strategy to rehabilitate the creek, protect important natural environment areas from further degradation, and mitigate future flooding potential in the area to acceptable levels. This Schedule B Environmental Assessment (EA) of the MCS is being completed to develop an effective strategy that will allow the City to mitigate flooding impacts, improve the ecological health of the creek system, and move forward with further development in the MCS, aligning its urban development plans with its goals for flood management and environmental protection and enhancement.

Study Area

The entire MCS covers 759 ha in the northwestern area of the City's boundaries. Figure ES-1 outlines the MCS boundaries. The Mud Creek EA study area focuses on a portion of the MCS directly adjacent to the creek located on the eastern side of the subwatershed, as indicated on Figure ES-1. This area is affected directly by local stormwater runoff and may also be affected by proposed remedial work to the creek. Runoff from the western portion of the MCS tributary to the west drain, which discharges to the culvert at Wonderland Road, does not affect the upstream reaches of Mud Creek that are of concern in this EA. A future monitoring program will evaluate how the west drain flows affect the local flood elevations downstream on Mud Creek.

The Mud Creek EA study area is 358 ha. It consists of a mixture of urban development, areas of open space, and the following arterial roads:

- Wonderland Road
- Sarnia Drive, Oxford Street
- A portion of Riverside Drive

Main land use categories in the MCS include open space (11 percent), agricultural (2 percent), and urban (87 percent) (Delcan Corporation, 2014).

The Canadian National Rail (CNR) and the Canadian Pacific Rail (CPR) also own railway corridors that extend through a large portion of the Mud Creek EA study area. Existing infrastructure along Mud Creek includes a sanitary sewer that runs parallel to the channel from Oxford Street to Wonderland Road. Several manholes are found along this section of the sewer, adjacent to Mud Creek or within its floodplain. The 1,050-millimetre (mm)-diameter sanitary sewer was constructed in 1965 and is therefore not scheduled to be replaced for another 40 to 50 years. However, this sanitary sewer does not have a standard maintenance access road to allow for inspection and maintenance.

According to zoning and the City's OP [City, 2006], approximately 54 of the 759 ha within the MCS area are subject to future land use changes. Of those 54 ha, 51 are within the 358-ha Mud Creek EA study area.

Purpose and Objectives

The purpose of this Municipal Schedule B Class EA is to develop environmentally sound recommendations to remediate erosion and sedimentation, protect important natural heritage features, and mitigate flooding in the Mud Creek EA study area. These recommendations must reflect the current and future subwatershed land use through a review of potential development in the study area and anticipated changes to municipal infrastructure. The recommendations must also meet the expectations of the public, First Nations, and stakeholders through a collaborative consultation process.

Previous subwatershed studies have been completed in the MCS; however, the City requires this EA to be completed to amalgamate those previous studies, identify data gaps, and complete required field investigations and desktop studies, to develop a preferred remedial alternative that adequately address the environmental issues and flooding concerns. This preferred alternative should both remediate identified issues and mitigate against future impacts.

The objectives of the EA strategy are:

1. To mitigate the flooding impacts on developed and undeveloped public and private lands, and to reduce the frequency of flooding of the proposed Oxford Street Rapid Transit Corridor.
2. To rehabilitate sections of the Mud Creek corridor to a sustainable creek cross-section, which will improve the aquatic habitat in the short term and the terrestrial habitat in the long-term.
3. To protect natural heritage features and functions through retention where possible and where necessary, to provide appropriate mitigation/compensation so proposed or upgraded infrastructure satisfies Official Plan Policy 15.3.3.

Study Implementation

The Mud Creek EA included a review of previous environmental studies conducted on the creek system since 1995 and field surveys. This review took place to complete a combined Environmental Impact Study (EIS) and Subject Land Status Report (SLSR) that updated the natural heritage assessments completed through the previous studies.

The Environmental Impact Study was completed and the Subject Land Status Report was developed to support the evaluation of possible alternatives. Natural heritage features, including terrestrial, aquatic habitats, and wildlife and vegetation surveys defined the existing conditions in the Mud Creek EA study area. Natural heritage features include the Mud Creek Significant Corridor and several Significant Woodlands. The SLSR and EIS report found the following:

- All woodlands assessed are Significant Woodlands
- Woodlands did not meet the criteria for an Environmentally Sensitive Woodlands designation

- Mitigation and compensation plans are recommended to address impacts of alternative implementation
- Species at risk (SAR) found in the study area included snapping turtle, wood thrush, Little brown bats, and northern long-eared bats
- The woodlands south of the CNR railway meet the criteria for significance due the presence of Mud Creek, size of the patch, community successional stage, number of ecosites, and high landscape richness, as well as the presence of endangered bat species

The current EA also included an updated hydrological and hydraulic assessment of the flooding conditions on the creek, and a geomorphic analysis of the physical condition of the creek in terms of channel form, sedimentation, and bank stability. The hydrological and hydraulic analysis focused on Mud Creek's existing and potential future flood characteristics. The Upper Thames River Conservation Authority (UTRCA) original flood hazard delineation work supported the development of draft regulatory floodlines as part of this EA.

A Stage 1 Archaeological Assessment and Heritage Impact Assessment was also completed in 2015 to provide background information about the geography, history, previous archaeological field work, and current land conditions within the archaeological assessment area for this EA.

The City collaborated closely with the UTRCA and local stakeholders to complete the Mud Creek EA. A public consultation process was implemented to inform and solicit comment from the public, First Nations, and stakeholders. The consultation process consisted of notices, mailings to stakeholders, meetings with local stakeholders, and Public Information Centres held in the MCS.

The Mud Creek EA study included an assessment of the opportunities and constraints related to flood mitigation and creek remediation within the Mud Creek EA study area. The various planning objectives of the City, represented in the *Transportation Master Plan* and the *Parks and Recreation Master Plan*, were integrated with the EA objectives as opportunities to further their goals. The City's OP provides guidance on the protection and enhancement of natural areas in the Mud Creek study area. This guidance was integrated into the development of alternative management strategies that meet the objectives of the EA and leverage opportunities to meet the City's environmental objectives.

Alternatives Development

From a long list of feasible alternative management strategies, four individual alternatives were short-listed and evaluated against a set of EA criteria that determined their relative abilities to meet or exceed the study objectives:

- Alternative 1: do nothing
- Alternative 2: quantity control and stream stabilization upstream of the CNR culvert, and various naturalization, culvert cleaning, and enhancement elements
- Alternative 3: lowered and enlarged CNR culvert, upgraded Oxford Street and Proudfoot Lane culverts, channel deepening/widening, and various naturalization, culvert cleaning, and enhancement elements
- Alternative 4.2: lowered and enlarged CNR culvert, upgraded, enlarged and relocated Oxford Street culvert, upgraded and enlarged Proudfoot Lane culvert, realignment of Mud Creek from Oxford Street to Proudfoot Lane, channel deepening/widening, and various naturalization, culvert cleaning, and enhancement elements (Note: Alternative 4 evolved through the public consultation process following PIC No. 2, and therefore is referred to as Alternative 4.2).

Table ES-1 summarizes the management alternatives.

Preferred Alternative Selection

The four alternative management strategies were scored against a comprehensive set of EA criteria. These criteria were developed and categorized into five main categories: (1) Technical, (2) Environmental, (3) Social & Cultural, (4) Planning, and (5) Economic. The purpose of this evaluation was to eliminate alternatives that did not meet the EA objectives, and to identify a preferred alternative for further detailed analysis. This evaluation process identified Alternative 4.2 as the preferred alternative. Alternative 4.2 is shown on Figure ES-2.

Alternative 4.2 relies on upgrades to the CNR culvert, the Oxford Street Culvert and the Proudfoot Lane culvert, channel realignment, and channel deepening and widening to control flooding and channel naturalization, mitigation/compensation and environmental management plans to improve ecological conditions.

This alternative will, over the long term, provide for better hydraulic conditions in the creek corridor, including increased conveyance and less flooding. Figure ES-3 illustrates the existing and draft future flood lines. The hydraulic grade line in the creek, which is substantially lowered, will promote the transport of sediment loads and will result in a more stable stream environment. It will also provide for better riparian and aquatic habitats over the long term. This alternative requires the removal of a number of hectares of woodland to accommodate the new floodplain and a comprehensive mitigation/compensation plan to replace the woodland area in the long term.

Detailed hydrological, hydraulic, and geomorphic analyses were completed to confirm that Alternative 4.2 met the technical objectives of the EA. These technical analyses confirmed Alternative 4.2 will successfully mitigate flooding within the MCS to meet the EA objectives. Mitigation and compensation strategies, as well as Environmental Management Plans, have been recommended to address the impacts Alternative 4.2 may have on the natural heritage components within the Mud Creek EA study area.

In the short term, the recommended alternative will require a significant number of large trees to be removed, to lower and widen portions of the channel, which will disturb the existing aquatic habitat. This will require a comprehensive mitigation/compensation strategy to accompany the implementation of the preferred alternative, as well as an Environmental Management Plan. The area disturbed during construction will be replanted with trees and native vegetation, and may require additional land area planted to compensate for the removal of the trees. Selecting vegetation for replanting presents the opportunity to remove invasive species within the construction area.

In the medium term, the disturbed areas along the creek channel will have younger vegetation that will be smaller and less established than those removed as a result of construction. In the long term, the replanted vegetation is expected to replace or improve on the current terrestrial habitat. The aquatic habitat will benefit from construction activities almost immediately following completion, and will continue to improve over the medium and long terms.

In the long term, these activities are expected to significantly improve the aquatic habitat within the MCS, and improve the long-term quality and viability of the terrestrial habitat.

Municipal Works

Alternative 4.2 consists of the following elements:

- **Realign Mud Creek:** Realigning Mud Creek from Oxford Street to Proudfoot Lane removes the right-angle turn at Oxford Street in the current flow path, restoring a more natural and hydraulically efficient creek alignment.

- **Relocate and Increase Capacity of the Oxford Street Crossing:** The realignment of Mud Creek between Oxford Street to Proudfoot Lane requires the relocation of the Oxford Street crossing. The new crossing at Oxford Street will also be enlarged to increase capacity and better accommodate creek flow volumes during storm events. It must be remembered that should the TMP components along Oxford Street within the study area implemented there will be a requirement to replace the culvert to also accommodate a wider transportation corridor.
- **Channel Deepening and Widening:** The Mud Creek Channel will be widened and deepened to lower the flooding elevation and to better accommodate creek flow volumes.
- **Increase Capacity of the Proudfoot Lane Crossing:** Sediment collected in the Proudfoot Lane crossing and adjacent creek reaches will be cleaned out, restoring the capacity of the creek system and crossing. The Proudfoot Lane culvert will be enlarged to increase capacity and better accommodate creek flow volumes during storm events. The realigned Mud Creek will cross Proudfoot Lane at the existing crossing location.
- **CNR Culvert Modifications:** The CNR culvert will be lowered and enlarged to better accommodate creek flow volumes.
- **Channel Naturalization:** channel morphology will be naturalized along Mud Creek, and will include cleaning, bank repair, and bank stabilization.
- **Vegetation Buffer Rehabilitation:** The channel riparian vegetation buffer will be rehabilitated, particularly where the creek is lowered and widened
- **Quality and Quantity Control:** Permanent Private Stormwater policies quality and quantity control will be implemented on future development lands to comply with City requirements for stormwater management.
- **Cleanout of Sewers and Culverts:** Sediment will be cleaned out of all other culverts and sewers within the subwatershed as required. This includes the existing Oxford Street culvert that would receive only local drainage.
- **Flood Management North of CPR Line:** The CPR culvert will be cleaned, and the major flow path from the CP railway will be maintained or improved.
- **Construction of an Enhanced Multipurpose Recreational Trail System:** The existing trail system in the Mud Creek corridor is currently limited to as short boardwalk and trail system, downstream of Proudfoot Lane. As part of this alternative, an enhanced multipurpose recreational trail system would be constructed between the CNR line and Oxford Street, using the easement for the sanitary sewer that transects the Mud Creek floodplain in that area of the creek corridor. This would provide for better and more appropriate public access to public lands.
- **Maintenance and Enhancement of Natural Areas:** This alternative will result in short-term and intermediate-term impacts to natural areas. Impacts are extensive over new floodplain construction areas. Construction practices that mitigate the short-term and intermediate-term impact to natural areas will be used where possible. Restoring construction-impacted lands will provide long-term enhancement of natural areas. A mitigation/compensation strategy will be necessary to assure: (1) the tree removals will not detract from the significance of the woodlot in the short term; (2) the project will support a healthier and more diverse aquatic habitat within the corridor in the short to long term; and (3) the project will result in a more sustainable significant woodlot and wildlife habitat in the intermediate to long term.

Developer-Led Works

The proposed developer-led works will include the following:

- Construction of a 60-metre wide and approximately 1 kilometer long natural corridor channel from north of Oxford Street to the CP Railway. These lands are owned by Edmar Land Ltd and ESAM Lands.

- Compensation measures include the following:
 - Wetland and terrestrial habitat re-creation for Species at Risk, and other wildlife;
 - Pools and riffles within the stream corridor to enhance the aquatic habitat;
 - A multi-use pathway and 5 metre buffer along the west side of the corridor; and,
 - Realignment of the sanitary trunk sewers to the road network to mitigate impacts from future sewer maintenance/replacement.
- Up to three stream crossings of the proposed Beaverbrook Avenue extension
- Onsite stormwater management controls (private permanent systems) for the remaining 54 hectare service area.

These proposed developer-led works are recommended at the cost of the developer.

Implementation Costs

Based on the components of the Alternative 4.2 recommendations, a cost estimate was developed that includes construction of the works and land acquisition. The cost of any potential easements is not included in the estimate. Costs for restoration of the creek corridor have been included however the costs of the final compensation strategy and environmental management plans have also not been estimated, as additional design detail is required related to the overall compensation strategy for accurate costs to be forecast. Table ES-2 provides the cost analysis developed for Alternative 4.2.

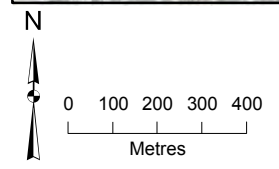
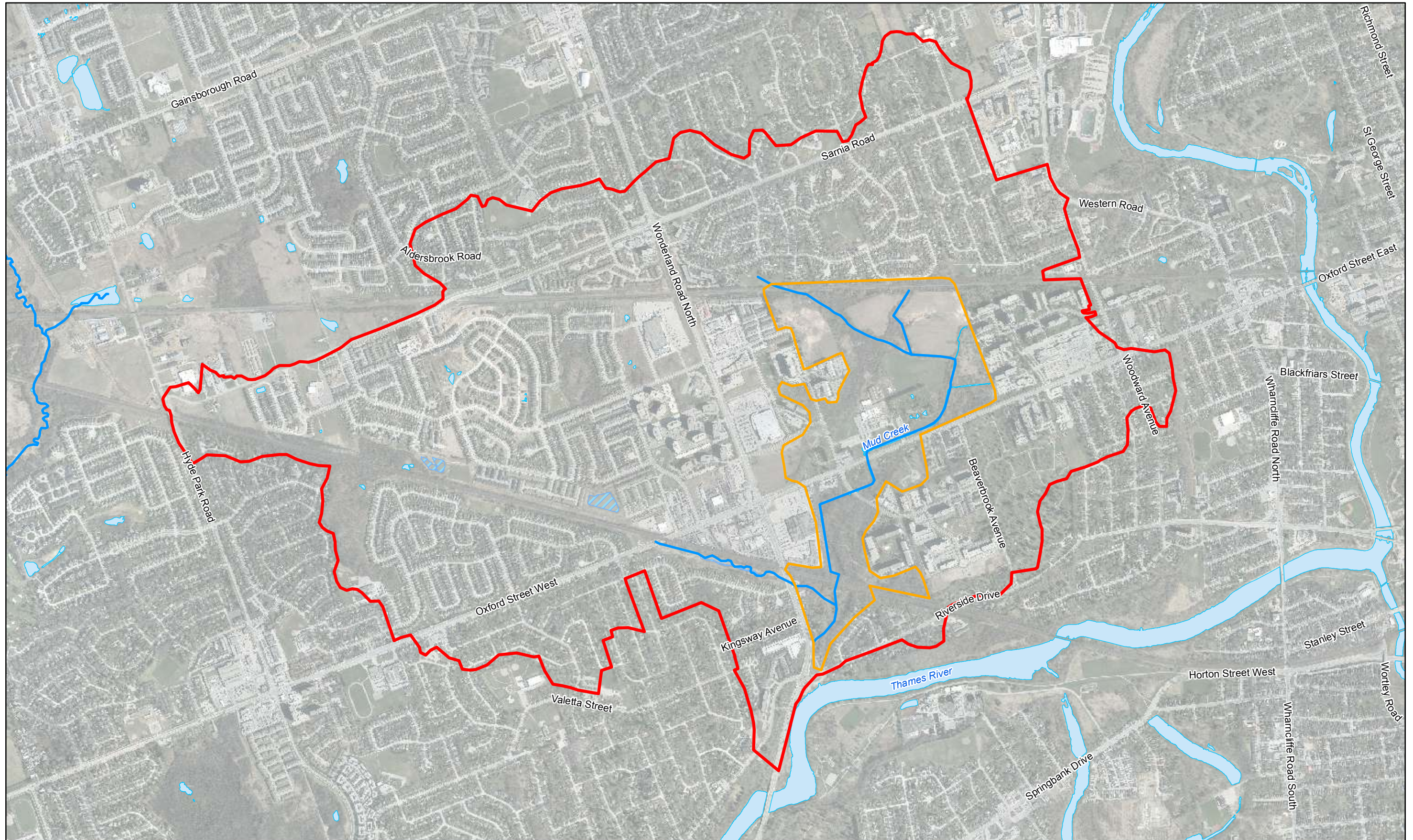
Implementation Schedule

The construction of individual phases will be impacted by seasonal restrictions. Fall through late winter is the preferred timeframe for the in-stream components due to low flows, generally easier ground conditions, and less environmental disruption. In particular, the construction of the CNR culvert should be avoided during the late winter and spring to reduce the risk of damage to the railway embankment in case of a major flood. The Oxford culvert and channel realignment downstream of Oxford Street to the confluence with the existing channel can be constructed offline; therefore, these are less susceptible to seasonal restrictions. Environmental restrictions for vegetation clearing (migratory bird nesting) and in-water work effectively limit the start of construction to mid-summer to allow an adequate length of construction before the start of in-water work restrictions the following season.

Based the foregoing, a phased approach proceeding from the lower to upper reaches is recommended, as follows:

- Phase 1 – CNR culvert and stream work from CNR culvert to Wonderland Road
- Phase 2 – Upstream of CNR culvert to Proudfoot culvert (including Proudfoot culvert)
- Phase 3 – Stream realignment from Proudfoot culvert to Oxford culvert (including Oxford culvert)
- Phase 4 – Developer works (work by others to proceed following the completion of downstream improvements)

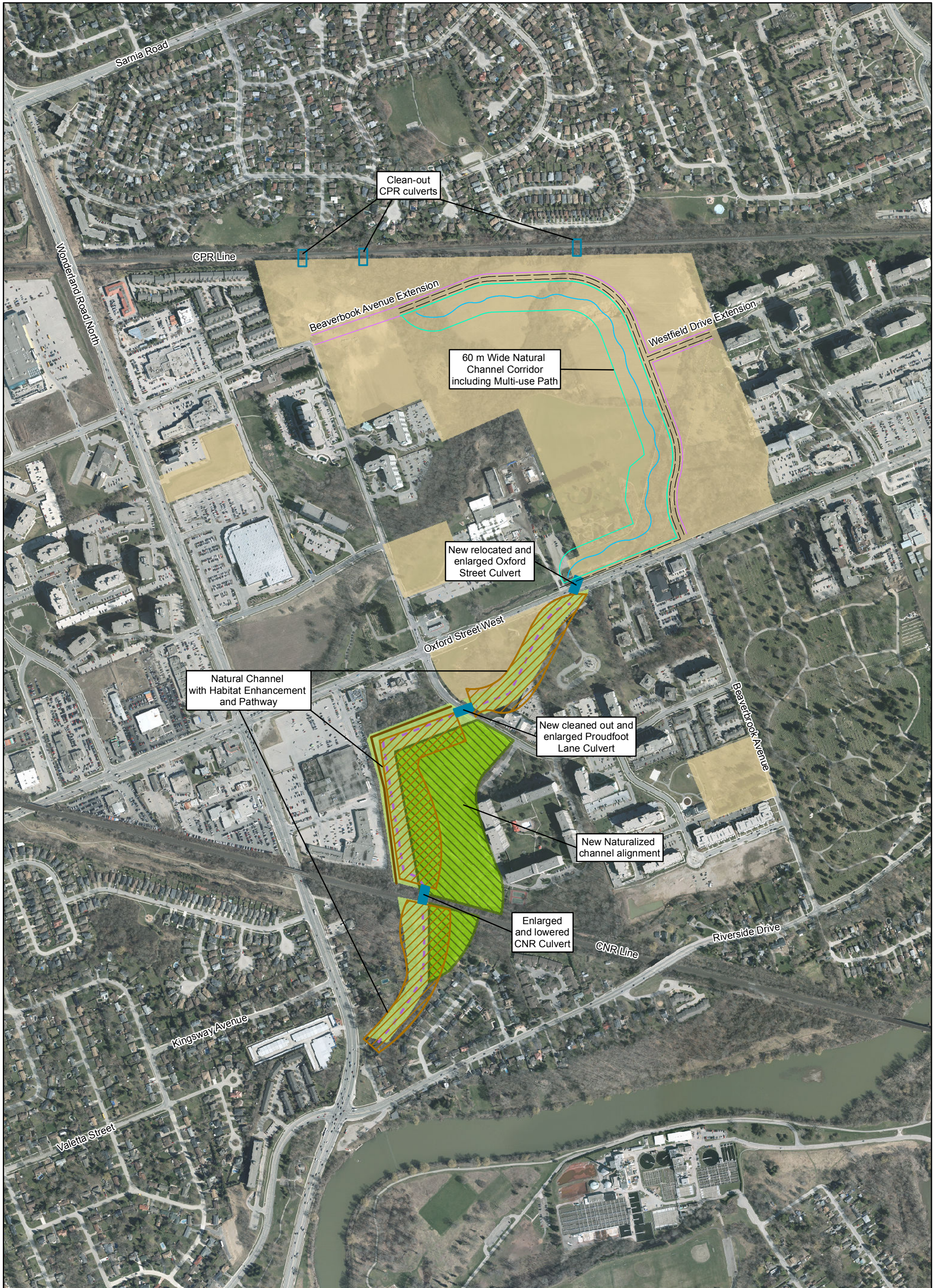
The progression of phases 1 through 4 is illustrated in Figure ES-3.



- Mud Creek
- River / Pond
- ▨ Stormwater Mangement Pond
- Mud Creek Subwatershed Boundary
- Environmental Assessment Study Area

Note:
1. Image Source: City of London, 2013.

Figure ES-1
Mud Creek Subwatershed and Environment Assessment Study Area
Mud Creek Subwatershed Environmental Assessment
City of London
London, Ontario



Clean-out
CPR culverts

CPR Line

Beaverbrook Avenue Extension

Westfield Drive Extension

60 m Wide Natural
Channel Corridor
including Multi-use Path

New relocated and
enlarged Oxford
Street Culvert

Oxford Street West

Natural Channel
with Habitat Enhancement
and Pathway

New cleaned out and
enlarged Proudfoot
Lane Culvert

New Naturalized
channel alignment

Enlarged and lowered
CNR Culvert

CNR Line

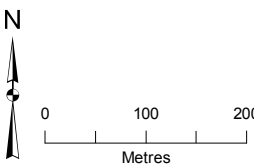
Riverside Drive

Beaverbrook Avenue

Kingsway Avenue

Valetta Street

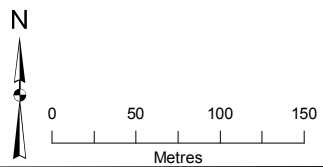
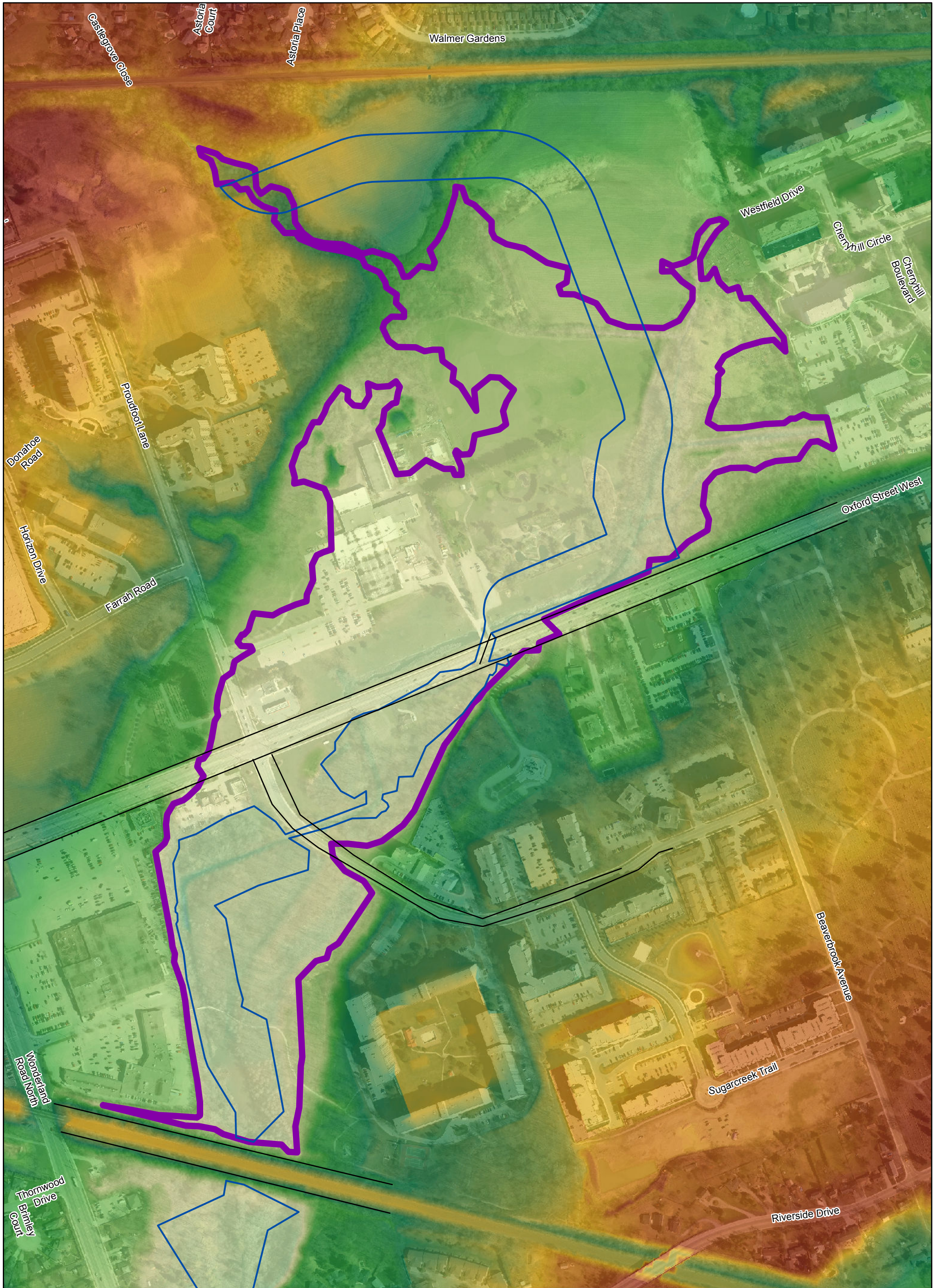
- Proposed Roads (Work by Others)
- Proposed Roads ROW (Work by Others)
- Proposed Realignment of Mud Creek (Work by Others)
- Width of Stream Corridor (Work by Others)
- Channel Deepening/ Widening/ Protection
- Potential Multiuse Pathway
- Culvert Cleanout/ Upgrade
- Relocated Culvert Upgrade
- Approximate Grading Limits
- Natural Area
- Riparian Corridor
- Development Lands (Onsite stormwater control)



Note:
1. Image Source: City of London, 2013.

Figure ES-2
Alternative 4
Mud Creek Subwatershed Environmental Assessment
City of London, London, Ontario

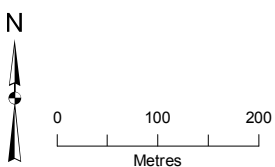
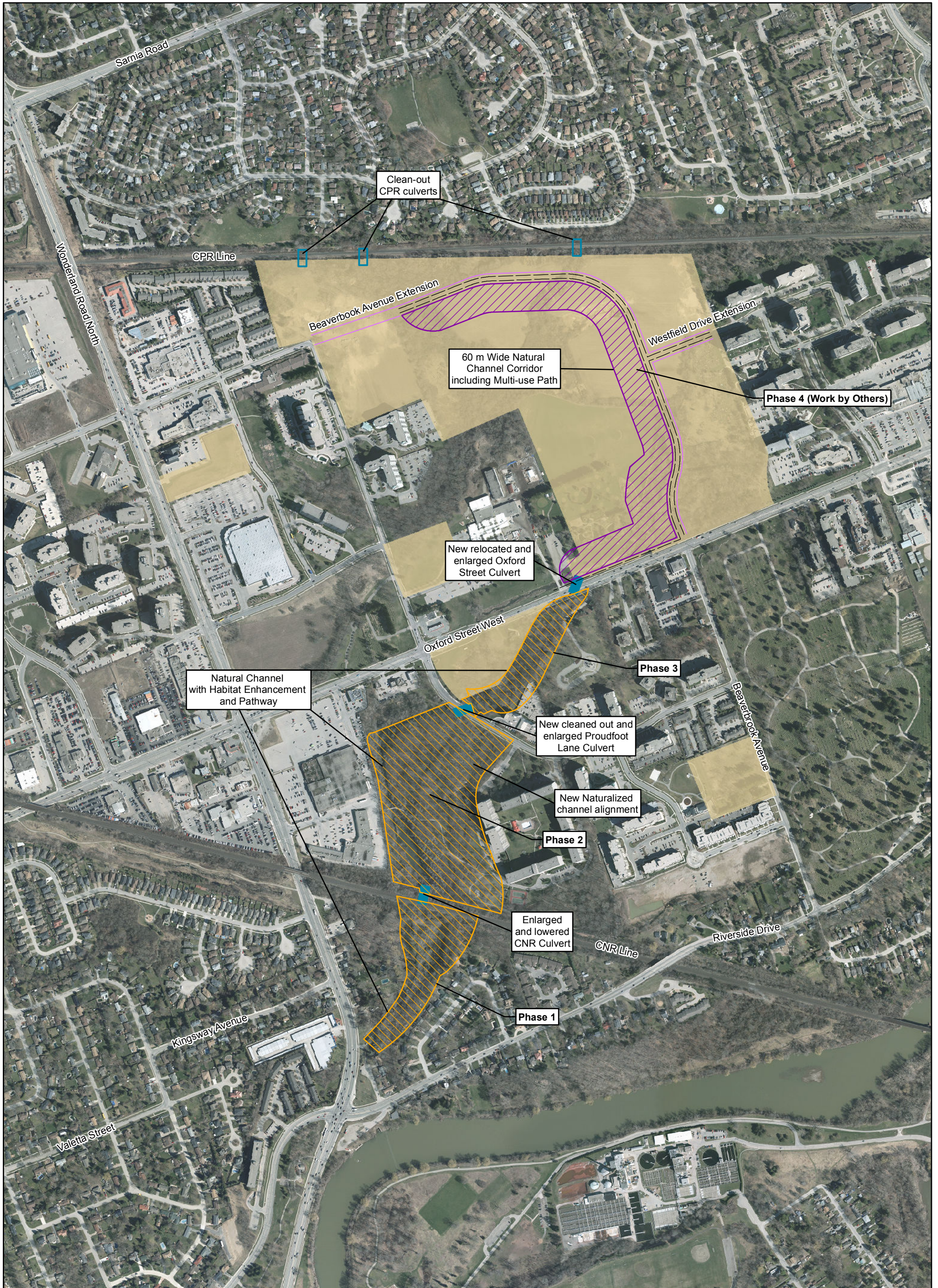
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- Existing 250yr Flood Line
- Draft Future Conditions Flood Line - A4.2

Note:
1. The Alternative 4.2 Draft Future Conditions floodline is pending approval and works completed

Figure ES-3
Draft Floodplain
Mud Creek Subwatershed Environmental Assessment
City of London, London, Ontario



- Proposed Roads (Work by Others)
- Proposed Roads ROW (Work by Others)
- Culvert Cleanout/ Upgrade
- Relocated Culvert Upgrade
- Development Lands (Onsite stormwater control)
- Work by Others
- Municipal Led Works

Figure ES-4
 Construction Phase
 Mud Creek Subwatershed Environmental Assessment
 City of London, London, Ontario

Note:
 1. Image Source: City of London, 2013.

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Table ES-1. Alternative Solutions

Alternative ID	Alternative Description	Unique Alternative Elements								Common Alternative Elements						
		CNR Culvert	Lining of CN Culvert	Lower Reach Channel	Lower Reach Channel	Quantity Control	Proudfoot Culvert	Oxford Culvert	New Oxford and Proudfoot Culverts	Channels	Riparian	PPS Quality	PPS Quantity	Sewers and Culverts	U/S Flooding	Natural Areas
		Lowered and enlarged CNR culvert to increase the conveyance capacity and stream gradient	Structural lining to increase lifespan of culvert	Channel stabilization and protection downstream of CNR culvert to reduce bank instability	Channel stabilization and protection downstream of CNR culvert to convey peak flow rate	Online quantity control storage upstream of existing CNR culvert	Clean Proudfoot Ln. culvert	Clean/upgrade existing Oxford St. culvert and private crossings upstream	New Oxford culvert 200 m east; Enlarged culvert at Proudfoot Lane	Naturalization of channel morphology including cleaning; Bank repair and stabilization upstream of CNR culvert	Rehabilitation of riparian vegetation buffer	PPS for quality control on future development lands	PPS for quantity control on future development lands	Sewer/culvert cleanout for select reaches	Flood management north of CP railway; Clean 450 cm dia. pipes under railway; maintain/improve major flowpath via berms as necessary	Maintain/enhance natural areas (woodlands)
1	Do Nothing															
2	No flood mitigation improvements to CNR culvert; Quantity control and stream stabilization upstream of CNR culvert; Common elements		✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓
3	Lowered and enlarged CNR culvert; No proposed upstream quality end-of-pipe facilities; Proudfoot Ln. crossing cleaned out; Oxford St. crossing upgraded in current location; Channel deepening/widening; Common elements	✓			✓		✓	✓		✓	✓	✓	✓	✓	✓	✓
4	Lowered and enlarged CNR culvert; No proposed upstream quality end-of-pipe facilities; Proudfoot Ln. crossing cleaned out with an option of enlarging the culvert; Oxford St. crossing relocated east with an option of enlarging the culvert; Realignment of Mud Creek from Oxford St. to Proudfoot Ln.; Channel deepening/widening; Common elements	✓			✓				✓	✓	✓	✓	✓	✓	✓	✓

Table ES-2. Cost Analysis Details for Alternative 4.2

Item No.	Description	Unit	Qty	Unit Price	Amount
General					
	Land acquisition (provisional)	LS	1	\$500,000.00	\$500,000
	Easements	LS			NOT INCLUDED
	Erosion and sediment control, bypass pumping	LS	1	\$400,000.00	\$400,000
	Fish/aquatic organisms stranding/rescue program	LS	1	\$25,000.00	\$25,000
					\$925,000
Removals and Local Culvert Cleanouts and Stream Works					
	Existing Oxford culvert cleanout	LS	1	\$25,000.00	\$25,000
	Oxford culvert removal, road reinstatement	LS	1	\$100,000.00	\$100,000
	Proudfoot culvert cleanout	LS	1	\$25,000.00	\$25,000
	Proudfoot culvert removal	LS	1	\$10,000.00	\$10,000
					\$160,000
Storm Sewers					
	Oxford culvert (new, relocated) 12m W x 3m H	m	42	\$42,000.00	\$1,764,000
	Oxford culvert utilities relocation/support	ea	1	\$50,000.00	\$50,000
	Oxford culvert road reinstatement (new location)	ea	1	\$50,000.00	\$50,000
					\$1,864,000
	Proudfoot culvert (new) 12m W x 3m H	m	28	\$42,000.00	\$1,176,000
	Proudfoot culvert utilities relocation/support	m	1	\$50,000.00	\$50,000
	Proudfoot culvert and road reinstatement	m	1	\$50,000.00	\$50,000
					\$1,276,000
	CN culvert - 3000 mm dia RCP, tunneled	m	90	\$15,000.00	\$1,350,000
	CN culvert headwalls	ea	2	\$100,000.00	\$200,000
	CN entry/exit pits, including access road	ea	2	\$250,000.00	\$500,000
	Grout existing CN culvert	m ³	220	\$250.00	\$55,000
	CN culvert Settlement monitoring	ea	1	\$30,000.00	\$30,000
	CN Flagman	ea	1	\$15,000.00	\$15,000
					\$2,150,000
					\$5,290,000
Earthworks and Landscaping					
	Clearing and grubbing (total includes 4.5 ha woodlots)	m ²	60,000	\$2.50	\$150,000
	Stockpile Topsoil	m ³	9,000	\$7.50	\$67,500
	Topsoil from stockpiles	m ³	9,000	\$15.00	\$135,000
	Earth excavation and offsite disposal	m ³	100,000	\$15.00	\$1,500,000
					\$1,852,500
	Live stakes	ea	6,400	\$5.00	\$32,000
	Shrubs/seedlings	ea	10,000	\$20.00	\$200,000
	Trees	ea	640	\$350.00	\$448,000
	Seeding	m ²	20,000	\$3.00	\$60,000
					\$740,000
	Erosion Control Blanket	m ²	9,600	\$3.00	\$28,800
	In-water works (riverstone, riffles, debris, etc)	ea	1	\$100,000.00	\$100,000
					\$128,800
					\$2,721,300
Totals					
				Construction	\$9,096,300
			15%	Engineering	\$1,364,445
				Subtotal	\$10,460,745
			20%	Contingency	\$2,092,149
				Subtotal	\$12,552,894
			13%	HST	\$1,631,876
				TOTAL	\$14,184,770

Notes:

Cost of easements not included.

Costs of developer-led works are not included.