Potential Removal of the Coldstream Dam

St. Clair Region Conservation Authority

21-118

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1 INTRODUCTION

The St. Clair Region Conservation Authority (SCRCA) is evaluating possible removal of the Coldstream and Head Street dams. These dams are located on the East Sydenham River near Strathroy, Ontario.

Removal of the dams are anticipated to improve environmental conditions in the East Sydenham River, provide new recreational opportunities and eliminate long term costs for dam maintenance and replacement.

The Coldstream dam is located in Coldstream, Ontario. The dam is located approximately 12 km northeast of Strathroy. This dam is constructed of vertical sheet piling with large armour stone placed on the downstream side of the dam as well as additional armour stone on the upstream side of the dam. The sheet pile dam section is approximately 45 m long with an additional earthen berm portion which is also approximately 40 m long. The earthen berm section is located at the south end of the sheet pile dam portion.

The Coldstream dam is approximately 3.35 m (11’) high. The dam was built in approximately 1968. The dam was originally constructed to support recreational activity (swimming, boating, fishing, etc.). However, use of the head pond (reservoir) has declined over the years in part due to accumulated sediment depth and a decline in water quality.

This report summarizes various studies and analysis completed to support possible removal of the Coldstream dam in the future. A similar report has been prepared for the Head Street dam in Strathroy.

This report includes the following appendices relating to possible removal of the Coldstream dam:

Appendix A contains a dam condition report for the Coldstream dam as completed by True Engineering (June, 2022).

Appendix B provides a separate study completed by GEO Morphix consultants to estimate channel formation features through the head pond area of the dam if the dam was removed, including estimates of the sediment volumes that could be mobilized by dam removal.

Appendix C provides sediment quality data based on samples collected in April 2022 by SCRCA. Six samples were collected and analysed for heavy metals and nutrients and two separate samples were collected for particle size analysis.

2 DAM REMOVAL IN ONTARIO

Many dams in Ontario were constructed over a century ago during early days of industrial development. The dams were constructed to generate electricity for local, early hydro systems and to harness water power for grist mills, sawmills and wood manufacturing industries.

Many of the earliest dams were constructed of wood and in many cases these early dams were destroyed by flood events. In some cases, there dams were rebuilt using concrete often mixed with stone and wood in the core of the dam. Some of the early concrete dams are still intact but many have significantly deteriorated. The structural condition of these dams will continue to deteriorate with time and remain vulnerable to failure during major flood events.

In some case, these legacy, industrial dams remain owned by private interests. However, it is also common that ownership of legacy dams has transferred over the years to the local municipality or to the local conservation authority. The Ministry of Natural Resources and Forestry also owns a relatively large number of dams in Ontario.

Additional dams were built during the 1950's to the 1970's but rarely to harness river power for industrial purposes. Many of these more recent dams were built to provide recreational opportunities and many private dams constructed during this era were on smaller streams to provide small lake and pond features for rural residents. Larger dams were also constructed during this era for flood and ice control and in some cases to provide dilution water to better assimilate treated wastewater plant effluents from downstream communities during periods of low stream flow.

In some cases, the owners of these dams have pursued decommissioning (removal) of these dams to eliminate the liabilities of dam ownership and long-term operation and maintenance costs. The construction cost of new dams for strictly recreational or aesthetic purposes is typically very high compared to funds available from stretched public sector capital budgets, especially in an era where other municipal or provincial owned infrastructure is aging out and requires expensive replacement or upgrading.

In addition, major power dams were built over the decades to provide hydroelectricity. Many or most of these hydro dams are owned and operated by Ontario Power Generation (OPG). Dams can also serve navigation. The Trent Severn waterway is one very good example where dams (i.e. locks) allow watercraft and larger vessels to navigate river systems from one water body to another at different elevations.

While dams can provide important benefits to the residents of Ontario, dams can also impact river ecology by blocking the migration of fish, increase water temperatures during hot summer weather and interfere with normal and healthy sediment transport. In many cases the head ponds behind dams slowly fill with river sediment carried downstream from upstream sources.

The Ministry of Natural Resources (MNRF) is the lead agency for dam safety in Ontario. Large dams have the capacity to cause extreme damage to downstream communities if they fail especially during major flood events. The Lakes and Rivers Improvement Act (LRIA) in Ontario is the principal legislation in Ontario governing the design, operation, maintenance and decommissioning of dams.

The following sections describe the reasons for dam removal, the new recreational and environmental site opportunities that can be provided by dam removal, the challenges that face the owner of a dam who is considering dam removal and permitting requirements in Ontario for dam removal.

2.1 Reasons for Dam Removal

Like other infrastructure, dams age over time and have a finite life span. Some other forms of infrastructure, such as renewable energy installations, may include decommissioning plans that provide financial guarantees to ensure the removal (or replacement) of the infrastructure at the end of their life span.

Most dams and in particular older dams in Ontario likely have no long term decommissioning plan and even more unlikely to have financial securities in place to ensure the long term decommissioning of the dam.

Dam owners therefore at some point need to consider when and how an aging dam should be removed. Dam decommissioning (removal) should be considered in the following circumstances:

i) The dam is aged, structurally unsafe and unstable and considered to be at risk of failure.

ii) Catastrophic failure of the dam could result in damage or destruction of downstream infrastructure including housing and buildings and potentially result in the loss of life.

iii) The dam no longer serves its original, intended purpose.

iv) The dam is unsafe particularly if serious injury or death (i.e. drownings) have previously occurred at the dam.

v) The dam is undersized in terms of its ability to safely convey major flood events.

vi) The dam owner wants to eliminate the liability of dam ownership and eliminate the costs of dam operation and maintenance.

vii) The dam has environmental issues including impacts to fish passage, excessive heating of cold or cool water streams and interruption of normal sediment transport.

viii) Sediment accumulation results in reduced swimming and boating opportunities. Sediment accumulation also linked with declining water quality and algae growth in the head pond.

ix) Removal of the dam would eliminate the dam head pond and provide an opportunity to restore the original stream habitat.

x) The dam owner recognizes the dam has a finite life span and dam removal at the present time is likely less costly than dam removal in the future.

xi) The dam also incorporates a bridge component, and the bridge needs to be replaced due to structurally deficiencies, limited traffic capacity or high costs for repair and maintenance.

xii) The dam head pond is accumulating sediment from upstream sources and the dam owner recognizes that removal of dam now reduces the amount of sediment that needs to be dealt with in the future.

2.2 Recreational and Environmental Site Opportunities.

Dams owned by municipalities and conservation authorities are usually on lands with public access and established passive recreational activities. The dam property may feature developed and maintained picnic and camping areas, beach and swimming areas, parking areas and washrooms etc.

As well, the public lands surrounding dams and associated reservoirs may include natural areas bisected by walking trails. As such, public lands around dam locations may feature a mix of wild areas for management of fish and wildlife and areas more managed for park visitors and recreational use.

Most dams owned by municipalities and conservation authorities have been in place for many decades. Many of the dams are aged (50 years old or more) or very aged (80 years old of more). While these older dams have likely received maintenance over the years, likely the dam height and area of the reservoir (head pond) is largely unchanged since the early days of construction.

As such, removal of a dam, and the resulting loss of the head pond, will have a major impact on the appearance of the dam site. In our opinion, it is often difficult for the public to visualize what the property will look like once the dam is removed. Due to the marked change in the appearance of the site once a dam is removed and given this change in appearance may be difficult to visualize, members of the public may be uncomfortable with a dam removal proposal.

Long time users of the recreational opportunities provided by the head pond area may be reluctant to have the dam removed, especially if boating or swimming opportunities are lost as a result of dam removal. However, the majority of dam reservoirs slowly fill with sediment and silty or muck sediments can impair water quality and bottom conditions that negatively effect swimming enjoyment. Head ponds filling with sediment also impair boating on such head ponds.

It is therefore possible that over many years the use and enjoyment of using dam head ponds for swimming and boating has declined due to sediment accumulation and possibly worsening of water quality conditions. Conservation authority budgets are also likely limited in providing lifeguards etc. for swimming areas.

While some established recreational activities will be lost or reduced due to dam removal, other features can become available after dam removal is completed. These additional features can include the following:

i) Site aesthetics and view. Many old dams are not considered attractive. Concrete can be rough, unfinished and spalling and worst case the concrete components are broken, failing, unstable and potentially dangerous to persons around the actual dam. Metal components can be rusty and earthen berms may be eroded, stony and unsightly. Graffiti may be present on concrete surfaces.

Removal of the dam eliminates the normally unpleasant aesthetic view of an aging dam structure. Removal of the dam also frees up new landscape areas that were previously blocked from view. For instance, a dam normally obscures the downstream view of the river when viewed from above unless one is standing on the dam.

ii) New river use opportunities. Depending on the size of the river, removal of the dam can restore and enhance kayak and canoeing on moving river water as opposed to lake waters. Likely, water quality conditions will improve after dam removal which can enhance the kayaking or canoeing experience.

iii) More land area. The former head pond area can, over time, be converted to new green space. This additional land area can be used for a variety of purposes including an expanded trail system, open manicured area for passive sports and dog walking or expanded natural revegetation areas with or without supplemental planting of new shrubs and trees.

iv) Additional natural features. The former head pond area can be repurposed to provide enhanced wildlife habitat. Depending on location, sediment type and local preferences, the new land area can be converted to natural grasslands, new shrub and forest cover, isolated and/or seasonal wetlands and pond habitat. These habitat choices can be selected to promote pollinators, grassland bird and animal species, mixed forest bird and animal species and wetland fish and wildlife species.

v) New stream habitat. The new river habitat replacing the former impounded area may support new cold or cool water fishing opportunities for brook, brown or rainbow trout.

2.3 Dam Removal Challenges

Dam removal in Ontario can be challenging process when financing, environmental and permitting (regulatory) factors are considered. As well, dams can be very important to the history of the community so that dam removal can become a political issue at the local level.

The following challenges may be encountered when the dam owner contemplates removal of a dam:

i) A Class Environmental Assessment (Class EA) will likely be required for dams owned by municipalities or conservation authorities.

ii) Dam removal may be opposed by the local community resulting in the proposed dam removal becoming a political issue.

iii) Removal of the dam would result in the loss of still water recreational opportunities such as boating, swimming, fishing etc.

iv) The overall cost of dam removal (approvals and capital cost) may be much higher than initially estimated and beyond the financial capacity of the dam owner.

v) The dam may provide flood control benefits to the downstream water course and removal of the dam could increase flood risk to downstream areas.

vi) The dam may store large volumes of sediment within the head pond that has accumulated over many years. Dealing with such sediment on a proactive basis can be difficult and expensive.

vii) In addition to applying to MNRF for approval to remove the dam under LRIA, as well as completing an initial Class EA, additional permitting by other agencies will likely be required. Collectively, obtaining all permits and completing the Class EA can be a very long, complex and expensive process.

viii) In some cases, the dam has been identified by MNRF or Fisheries and Oceans Canada, or other groups, as a dam that should stay to prevent upstream migration of predatory or invasive aquatic species, especially if aquatic species at risk have been identified upstream of the dam.

ix) Conversely, if there are species at risk that inhabit the river downstream of the dam, there could be concerns that an increase in short term or long term sediment loadings from the dam removal could impact such downstream aquatic species.

2.4 Permitting Requirements for Dam Removal

As per previous sections, there are a large number of permitting and regulatory requirements that often need to occur before a dam is removed in Ontario. The following sections summarize permitting and planning requirements.

Class Environmental Assessment (Class EA). Currently, a Schedule B Class EA needs to be completed to decommission a dam in Ontario if the dam is owned by a municipality or conservation authority. If privately owned, the dam may have to complete a similar public consultation process before permits are issued by MNRF in particular.

A municipal Class EA is a public consultation process required under the *Environmental Assessment Act*. Consultation with various stakeholder groups is required including various provincial and federal ministries as well as consultation with Indigenous communities.

Lakes and Rivers Improvement Act. The LRIA approval process under MNRF requires the proponent to determine the need for the proposed dam removal. This normally involves completion of an Environmental Screening Table which reviews a wide range of natural environment, land use, social, cultural, economic and Indigenous community considerations for both positive and negative effects of dam removal. Documentation of successful consultation with Indigenous communities is normally required for MNRF to issue an approval under LRIA.

As well, while not specifically listed as a requirement for dam removal, MNRF typically requires the proponent identify the Hazard Potential Classification (HPC) of the dam which classifies the dam as being low, moderate, high or very high hazard. The hazard classification is based on incremental losses to life, property, the environment and cultural - built heritage features that could result from the uncontrolled release of the reservoir (head pond) due to dam failure.

Once the HPC is completed, the Inflow Design Flood (IDF) is estimated. The IDF is based on the return frequency of flood flows appropriate for the HPC. For instance, dams deemed to have a low hazard classification have a lower IDF (25 year to 100 return flood flow) compared to dams having a high hazard classification which would have a higher IDF (1000 year to Probable Maximum Flood (PMF) flow).

The LRIA application also identifies where the proposed project is a full dam removal or a partial dam removal. In the case of a partial dam removal, the proponent is required to complete a dam stability analysis to confirm that the remaining portion of the dam is structural stable under normal flow and flood flow conditions as well as considering ice and earthquake effects.

As part of the LRIA application, construction drawings are submitted that include the proposed, step wise methodology to be employed by the contractor to remove the dam.

Fisheries Act. The Fisheries Act is administered by Fisheries and Oceans Canada and was updated in 2019.

The updated Act restores the previous requirement to prohibit the harmful alteration, disruption or destruction of fish habitat (HADD) and to prevent the death of fish by means other than fishing. The updated Act also promotes restoration of degraded fish habitat and rebuilding of fish stocks.

For a dam removal project, the proponent would normally submit a Request for Review which acts an approval application under the Fisheries Act. The Request for Review includes submission of reports, drawings and other documents prepared by the proponent which identifies the features of the work plan intended to prevent HADD and to prevent the release of deleterious substances.

The Act also provides the means to allow the proponent to apply for an authorization under the Act. The authorization, if granted, would approve the harmful alteration, disruption or destruction of fish habitat in particular circumstances. In some cases, the proponent of a dam removal project may conclude that some impact to fish habitat is unavoidable and may consider applying for an authorization at the time of the Request for Review application.

On Site Excess Soil Management O.Reg. 406/19. This relatively new regulation under the Environmental Protection Act was passed in 2019 and came fully into effect on January 1, 2023. This regulation governs the sampling, transport and reuse or disposal of excess soil in Ontario where soil is proposed to be transported from one site to another.

At this time, it is understood this regulation applies to the handling of sediment in dam reservoirs (head ponds). If sediment is proposed to be collected and transported away from the dam site, the regulation outlines testing and analytical requirements for sediment samples.

Subject to considerations that include the volume of excess soil to be removed, the past use and location of the site of origin, and certain specified exemptions, filing a notice in the provincial Registry may be required prior to removal of excess soil from the project site. Filing a notice requires the preparation of certain documents, including an assessment of past uses, sampling and analysis plan, soil characterization report, and excess soil destination report.

The number of sediment samples requiring analysis is based on the proposed volume of sediment proposed for relocation. A historic site review of the dam site is used to guide the range of parameters to be tested for. The planning of the testing program and the collection of sediment samples for laboratory analysis is to be completed by a Qualified Person as defined by Ontario Regulation 153/04.

Depending on results of laboratory analysis, the sediment may be reused elsewhere. Registration of the re-use site(s) may be required. If a notice of project is filed on the Registry, then transportation of excess soil (including reservoir sediment) is to be described in an excess soil destination report developed by the Qualified Person and a tracking system for each load must be implemented.

Canadian Navigable Water Act. The Canadian Navigable Waters Act is administered by Transport Canada. An application to Transport Canada for an Approval under the Act may be required in those cases where the removal of the dam could impact navigation during the work or after the dam is removed.

Evidence of successful consultation with Indigenous communities is normally required as part of the application process.

Conservation Authorities Act (RSO 1990 as amended). An application for a permit to remove a dam would normally be required when the proponent proposes to remove a dam within an area covered by a Conservation Authority. The purpose of the application and subsequent permit approval (if granted with or without conditions) is to help ensure the preservation of life and property due to the risk of flooding, erosion and other natural hazards.

3 EAST SYDENHAM RIVER WATERSHED CHARACTERISTICS AND HYDROLOGY

Tables 1, 2 and **3** overleaf respectively provide general watershed characteristics, estimates of low river flows during the dry summer period and estimates of return flood flows. The following section provides a summary of watershed characteristics upstream of the Coldstream dam and low flows and flood flows at the dam location.

3.1 Watershed Characteristics

The East Sydenham River in Coldstream has an upstream drainage area of approximately 61.6 square kilometers. The watershed extends northeast from Coldstream to near Southgate and Ilderton. Overall, the watershed has a modest gradient of approximately 0.26 % on average in the Coldstream area (from MNRF OWIT). See **Table 1** for details.

The watershed is well described in previous reports. Parrish Geomorphic previously prepared the report entitled "Sydenham River - Fluvial Geomorphology Assessment (December, 2000)". This report covers the entire Sydenham River watershed but describes the East Sydenham River as follows:

- While much of the Sydenham watershed features primarily silt and clay soils, the East Sydenham River is influenced significantly by the Caradoc Sand Plain.
- In addition, the East Sydenham River crosses glaciofluvial and recent fluvial deposits consisting of silt, sand and gravel.
- River substrate is typically a mix of bedrock, clay, silt, sand or gravel. Combined with low channel gradient, "this mixture of substrate has created unique stream habitats".
- The overall watershed (including the East Sydenham) has relatively poor drainage due to low stream gradients and overall low relief. Such low relief has resulted historically in flooding.
- Land use is largely agricultural and minimal forest cover remains. The Parrish report indicates the original forest cover was cleared in the 1800's, though riparian forest cover remains or has re-established along the East Sydenham River.

The report also discussed sedimentation, erosion and changes in peak flows over time. Overall, the East Sydenham River drainage basin is prone to erosion. Relatively low gradients result in poor mobilization of fine sediments (silt, sand and clay) in the river channel. Accumulation of silt and sandy sediment in the Coldstream dam head pond is further discussed in this report.

3.2 Low Flow River Conditions

Daily flows from the Federal Stream flow gauge 02GG005 were analyzed for years 2002 to 2022 and prorated for the drainage area upstream of Coldstream. This gauge is located approximately 400 m downstream of the Head Street dam in Strathroy.

Table 2 provides estimated, average summer monthly flows at the Coldstream dam based on prorated data from the above Federal Stream flow gauge. Average, monthly summer flows (July, August and September) range from approximately 0.08 cubic meters per second (m^3/s) to 1.7 m^3/s. Overall, average monthly flows during the dry summer period are approximately 0.28 m^3/s.

Table 1

Watershed Characteristics of

East Sydenham River at Coldstream, Ontario

(From OWIT)

October 2022 21-118

Drainage Area	61.6 km^2
Length of Main Channel	20.8 km
Maximum Channel Elevation	296.96 m
Minimum Channel Elevation	242.61 m
Overall Channel Slope	± 0.26%
Local Channel Slope Near Dam Site (From MNR Make A Map)	± 0.43%

Table 2

Summary of Low Flow Information (m^3/s)

***Estimate of Average Monthly Flows – Sydenham River at Coldstream**

Environment Canada Gauge 02GG005

Year	July	August	September	Average
2002	0.126	0.081	0.082	0.096
2003	0.150	0.096	0.128	0.125
2004	0.257	0.223	0.155	0.212
2005	0.162	0.144	0.184	0.163
2006	0.639	0.364	0.270	0.425
2007	0.143	0.174	0.129	0.149
2008	0.201	0.190	0.297	0.230
2009	0.281	0.197	0.177	0.218
2010	0.236	0.139	0.125	0.167

Year	July	August	September	Average
2011	0.249	0.260	0.307	0.272
2012	0.177	0.156	0.153	0.162
2013	0.335	0.200	1.725	0.753
2014	0.323	0.179	0.743	0.415
2015	0.382	0.191	0.165	0.246
2016	0.203	0.536	0.196	0.312
2017	0.220	0.176	0.176	0.191
2018	0.375	0.436	0.239	0.350
2019	0.265	0.404	0.245	0.305
2020	0.183	0.379	0.262	0.274
2021	0.338	0.224	1.336	0.632

Year	July	August	September	Average
2022	0.159	0.174	0.153	0.162
Average	**0.257**	**0.234**	**0.345**	**0.279**

*Average monthly flows of the Sydenham River at Coldstream are estimated by prorating the average monthly flows of the downstream gauge (02GG005) by the difference in upstream drainage area (drainage area upstream of gauge is 2.8 times that of Coldstream)

Table 3

Summary of Return Flood Flows for East Sydenham River at Coldstream

Prorated from East Sydenham River at Strathroy

June 2023 21-118

*East Sydenham River at Coldstream	
Return Period	**Flood Flow**
Mean Annual Flow	0.7 m^3/s
2 year	19 m^3/s
5 year	24 m^3/s
10 year	29 m^3/s
20 year	33 m^3/s
50 year	39 m^3/s
100 year	45 m^3/s

*Flood flows of the East Sydenham River at Coldstream are estimated by prorating B.M. Ross and Associates’ flood flow estimates of the East Sydenham River at Strathroy by the difference in upstream drainage area (drainage area upstream of Strathroy is 2.8 times that of Coldstream)

3.3 Return Flood Flows

Table 3 summarizes return peak flood flows for the Coldstream dam. Flood flows range from 19 m^3/s for the 2-year flood flow to 45 m^3/s for the 100-year flood flow. These return flood flows are based on previously estimated flood flows for the East Sydenham River in Strathroy (as estimated by BM Ross Consultants). The Strathroy flood flows were then prorated based on the upstream drainage area for the Coldstream dam location.

4 DESCRIPTION OF COLDSTREAM DAM AND CURRENT HEAD POND CONDITIONS

The Coldstream dam was constructed in approximately 1968. The dam is located adjacent to Ilderton Road, a short distance downstream of Coldstream Road. The Coldstream Conservation Area is located along the northwest side of the dam and head pond.

As noted previously, the dam is approximately 3.35 m high (normal upstream water level compared to normal downstream water level). The dam consists of vertical steel sheet piles driven into the riverbed below, forming a continuous retaining wall. The piles are made of heavy gauge ARCH-Type individual metal sheets locked together at the joints during installation. Original drawings for the dam show the sheets are driven into the soil below for a similar depth as the height of the sheets above the downstream water level.

The downstream side of the sheet piling is protected by large armour stone (ranging in size from 16 inches to 24 inches in diameter) on a slope of approximately 3:1 horizontal to vertical. The armour stone provides protection to the soil material below the sheet pile wall from erosion. The sheet pile portion of the dam is approximately 45 m wide. The adjacent earthen berm portion of the dam (south of sheet pile dam portion) is approximately 40 m long.

Photo 1: Coldstream dam constructed of vertical sheet piling and downstream armour stone.

The Coldstream dam does not contain any spillways or stop logs. As such, there is no way to easily adjust water levels in the dam head pond.

Photo 2: Large sloping armour stone placement on downstream side of sheet pile dam. Sydenham River downstream of dam visible in background.

The dam is also equipped with a low flow bypass valve. The condition of the bypass valve is not known but is not believed to be operatable (personal communication with SCRCA).

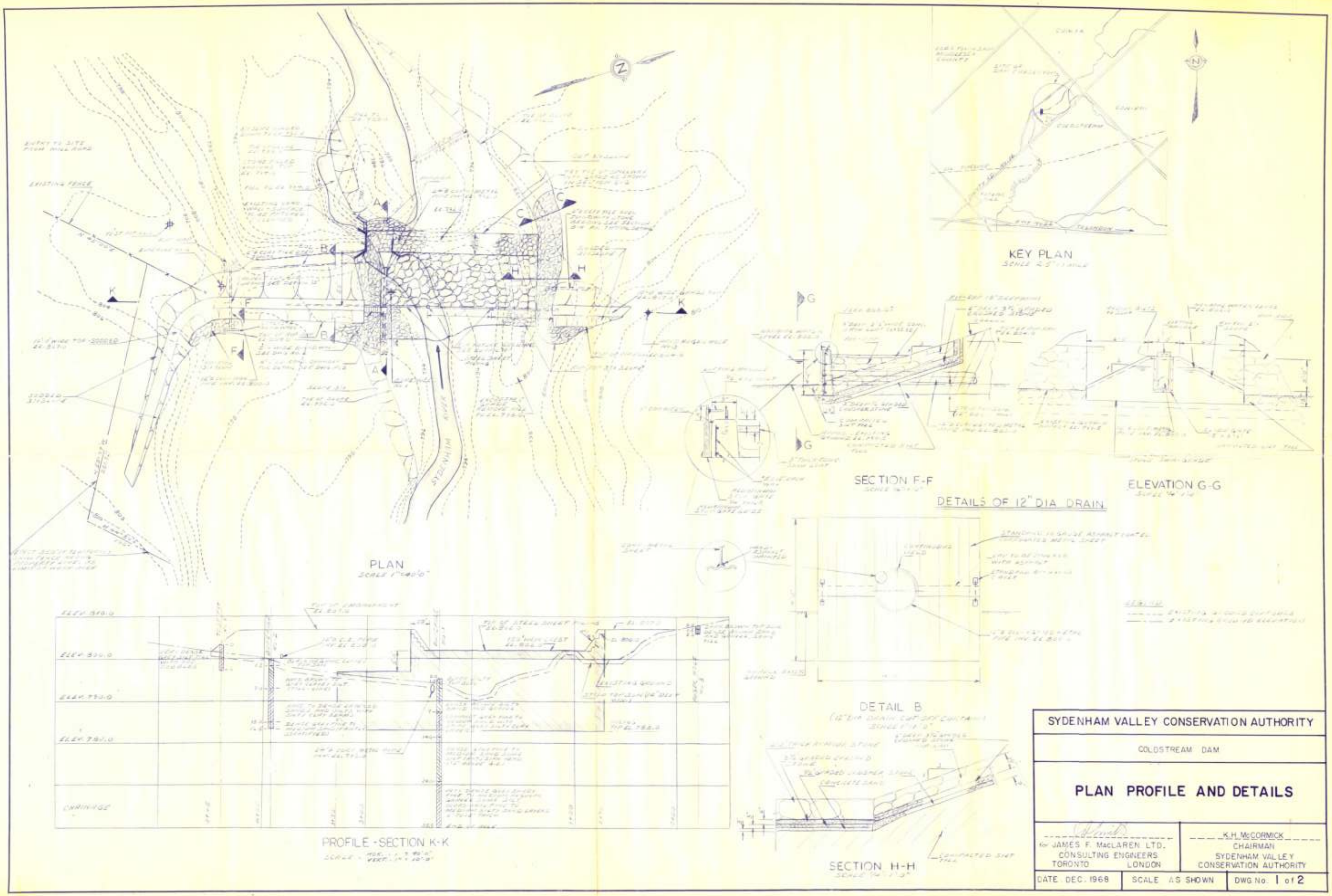
Original **dam design drawings (three)** are provided overleaf. Drawings available include plan views and cross section views of the dam. A dam site plan is also available that shows the original contours in the head pond area as well as the original stream location and gradient in the head pond area. The site plan drawings also indicate a significant amount of native fill was removed from the head pond area before the dam was constructed, likely to increase the depth of the head pond to promote recreational activities.

Appendix A includes a dam condition report prepared by True Engineering (June, 2022). This report concludes the Coldstream dam appears to be in overall good condition.

Given that the dam was built in 1968, the dam is now about 55 years old. As above, engineering assessments have deemed the dam to be in good condition. As such, the total life expectancy of the dam could be estimated as 75 to 100 years. Therefore, the remaining life expectancy would be approximately 20 to 45 years.

However, while in good condition at present, the dam at some point will likely deteriorate and need to be removed.

BM-1
REFERENCE
SYDENHAM VALLEY CONSERVATION AUTHORITY
COLDSTREAM CONSERVATION AREA
SCALE
CONTOUR INTERVAL 2 FEET


KEY PLAN
PLAN
PROFILE - SECTION K-K
SECTION F-F
ELEVATION G-G
DETAILS OF 12" DIA DRAIN
DETAIL B
SECTION H-H
SYDENHAM RIVER
SYDENHAM VALLEY CONSERVATION AUTHORITY
COLDSTREAM DAM
PLAN PROFILE AND DETAILS
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CONSULTING ENGINEERS
TORONTO LONDON
K.H. McCORMICK
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SYDENHAM VALLEY
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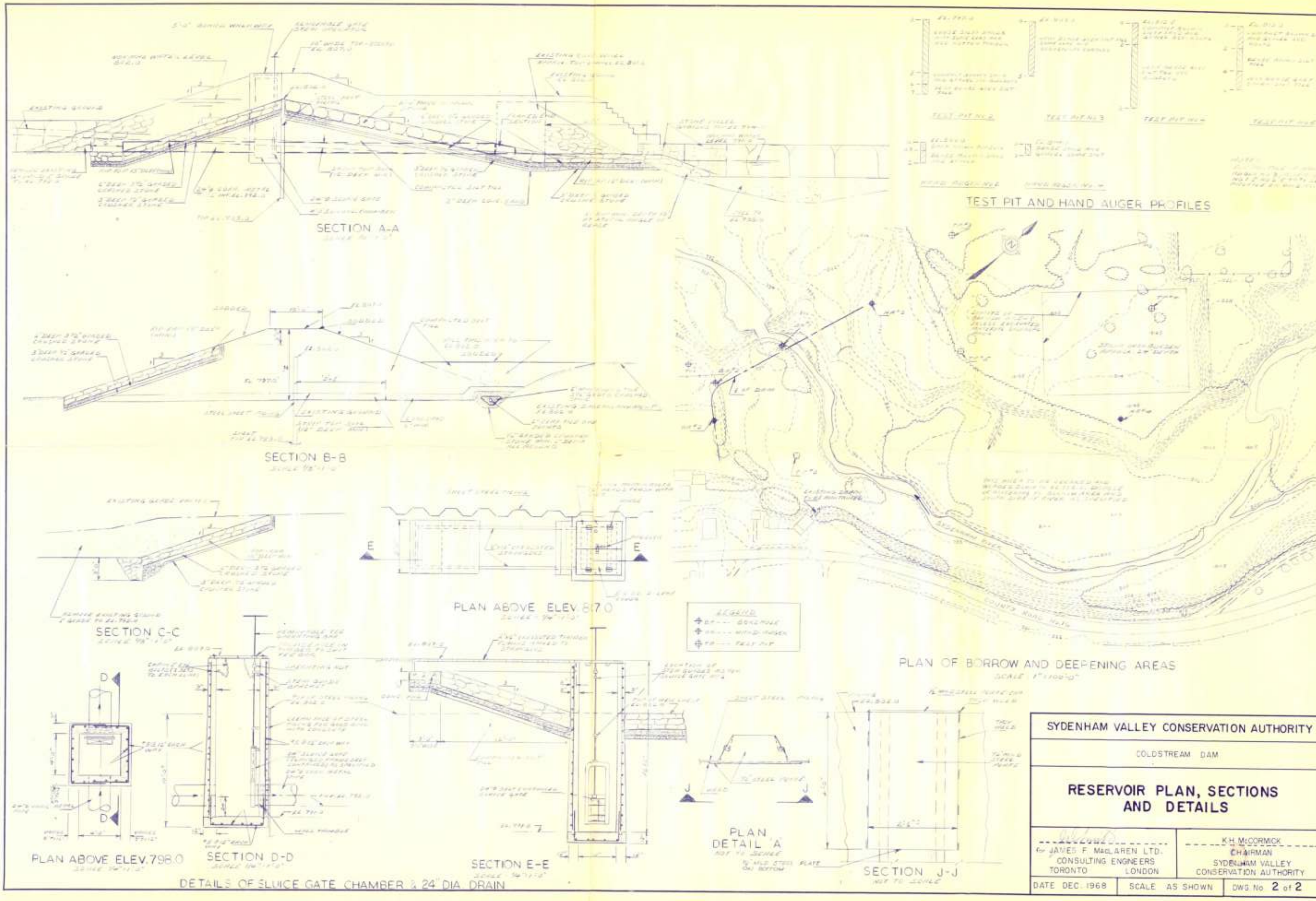

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While reasonable life expectancy remains for the Coldstream Dam, it is beyond the scope of this report to assess capacity of the dam for very large flood events in the future. Climate change may affect precipitation patterns and may increase the frequency and magnitude of major rain events that could result in flood flows exceeding the capacity of the dam.

The current area of the head pond is approximately 4.5 ha (11.2 acres). The overall depth of the head pond is relatively shallow with a maximum depth of approximately 1.37 m (4.5’) (water depth above accumulated sediment levels). Historically, much of the head pond would have been deeper, but the head pond has accumulated large volumes of sediment since being constructed. Accumulation of sediment is assumed to be ongoing and downstream areas of the head pond toward the Coldstream dam are assumed to still be filling with sediment (i.e. sediment depths will continue to get deeper over time near the dam).

The following sections describe in further detail sediment conditions in the head pond.

4.1 Head Pond Sediment Depth

Figures 1, 2 and **3** detail sediment conditions in the Coldstream dam head pond.

Figure 1 shows the depth of water to top of sediment and also depth of water to hard bottom for each point and also provides the calculated depth of sediment (depth of sediment is equal to total depth of water to hard bottom minus depth of water to top of sediment.).

As per **Figure 1**, depth of water over the sediment ranges from 0.76 m (30”) to 1.37 m (4.5’) with a typical depth of water over sediment being about 1.1 m depth. Overall, water depths increase only slightly in the downstream portion of the head pond (toward the Coldstream dam) indicating that the head pond in this area is still slowly filling with sediment. **Figure 1** also shows locations of cross sections.

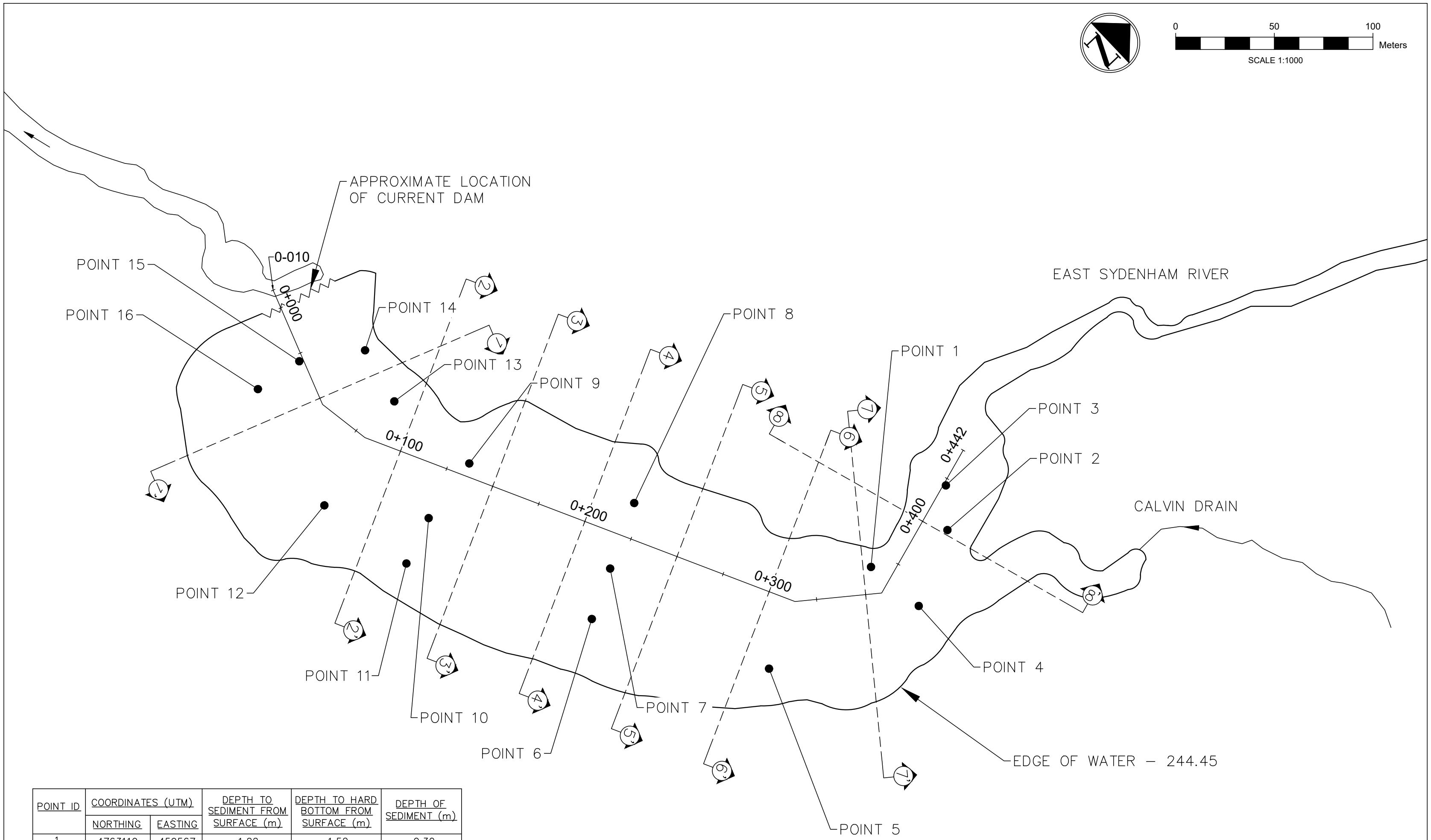
Figure 2 provides cross-sectional information of the sediment depth at various sections of the head pond. While water depth over the sediment layer increases slowly toward the Coldstream dam, the top of sediment is generally flat across the width of the head pond.

Figure 3 uses color to illustrate total sediment depth (depth of sediment from top of sediment to hard bottom). As per **Figure 3**, the depth of sediment around the edges of the head pond is typically less than 0.5 m but increases to over 2 m depth in certain portions of the head pond. However, sediment depths of 0.5 m to 1.5 m cover much of the head pond area.

4.2 Head Pond Sediment Volume

As per **Figure 1**, the total estimated volume of sediment in the head pond at this time is estimated to be over 22,500 cubic meters.

As discussed in later sections, this volume of sediment is significant. Sediment management is therefore a significant consideration if a decision was made to remove the Coldstream dam in the future.



POINT ID	COORDINATES (UTM)		DEPTH TO SEDIMENT FROM SURFACE (m)	DEPTH TO HARD BOTTOM FROM SURFACE (m)	DEPTH OF SEDIMENT (m)
	NORTHING	EASTING			
1	4763119	459567	1.22	1.52	0.30
2	4763160	459580	0.76	0.91	0.15
3	4763175	459563	0.76	1.22	0.46
4	4763123	459598	0.91	1.22	0.30
5	4763046	459569	0.91	1.52	0.61
6	4762998	459489	0.76	2.13	1.37
7	4763022	459477	1.22	1.98	0.76
8	4763054	459461	1.07	1.37	0.30
9	4763007	459389	0.91	2.29	1.37
10	4762973	459395	1.07	2.44	1.37
11	4762949	459404	1.07	1.83	0.76
12	4762939	459354	1.07	1.83	0.76
13	4763001	459340	1.07	2.13	1.07
14	4763008	459311	1.07	1.22	0.15
15	4762980	459292	1.37	3.05	1.68
16	4762955	459288	1.22	2.13	0.91

AREA OF RESERVOIR = ± 45,000 m^2

AREA OF SEDIMENT = ± 44,000 m^2

VOLUME OF SEDIMENT = ± 22,500 m^3

KEY PLAN

LEGEND

—244.00m—	SEDIMENT SURFACE CONTOURS (0.25m)
— — — — —	STATION CROSS SECTIONS
————	EDGE OF WATER (244.45m)

CAUTION: THE POSITION OF POLE LINES, CONDUITS, WATERMAINS, SEWERS, PROPERTY LINES AND OTHER UNDERGROUND AND OVERGROUND UTILITIES ARE STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES, PROPERTY LINES & STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES, PROPERTY LINES & STRUCTURES, AND SHOULD ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

DD/MM/YY	DESCRIPTION
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Seal not valid unless signed and dated

GSS ENGINEERING CONSULTANTS LTD
Unit 104D 1010 9th Avenue West, Owen Sound, ON, N4K 5R7
Telephone: (519) 372-4828

Title:

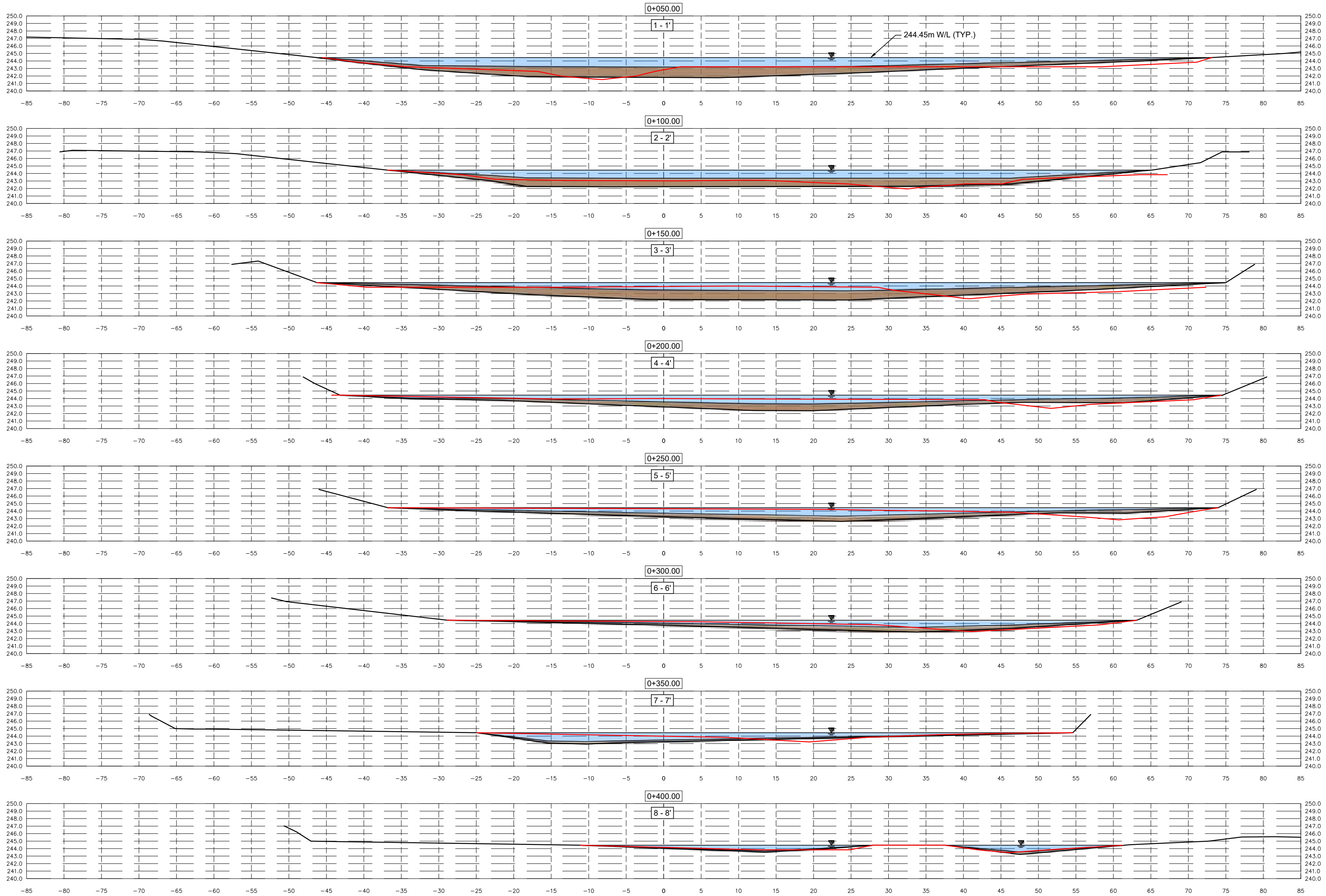
EXISTING SITE PLAN AND SEDIMENT ELEVATIONS COLDSTREAM RESERVOIR

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	SNM	Scale:	1:1000
Drawn:	SNM	Approved:	Design Engineer
Checked:	JTG		
Date:	MAR. 2022		

Drawing No. 21118C–FIGURE 1

COLDSTREAM RESERVOIR CROSS-SECTION VIEWS
VERT / HORZ 1:250 SCALE



NOTE: ALL CROSS-SECTIONS ARE LOOKING UPSTREAM AT THE COLDSTREAM RESERVOIR

KEY PLAN

LEGEND

- WATER SURFACE (244.45m)
- TOP OF SEDIMENT / SURFACE
- TOP OF HARD BOTTOM
- 1968 SURFACE (PRE DAM CONSTRUCTION)
- WATER
- SEDIMENT

CAUTION: THE POSITION OF POLE LINES, CONDUITS, WATERMAINS, SEWERS, PROPERTY LINES AND OTHER UNDERGROUND AND OVERGROUND UTILITIES ARE STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES, PROPERTY LINES & STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES, PROPERTY LINES & STRUCTURES, AND SHOULD ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

DD/MM/YY	DESCRIPTION
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ENGINEERING CONSULTANTS LTD
Unit 104D 1010 9th Avenue West, Owen Sound, ON, N4K 5R7
Telephone: (519) 372-4828

Title:

CROSS-SECTIONS
SEDIMENT LAYERS
COLDSTREAM RESERVOIR

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	SNM	Scale:	VERT/HORZ 1:250
Drawn:	SNM	Approved:	Design Engineer
Checked:	JTG		
Date:	MAR. 2022		

Drawing No. 21118C-FIGURE 2

G:\GSS Common\2021\21-118 Head Street and Coldstream Dam Decommissioning\Drawings\Coldstream\21118C.dwg Jul 06, 2023 - 11:42am

KEY PLAN

LEGEND

FLOW DIRECTION

EDGE OF WATER

CAUTION: THE POSITION OF POLE LINES, CONDUITS, WATERMAINS, SEWERS, PROPERTY LINES AND OTHER UNDERGROUND AND OVERGROUND UTILITIES ARE STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES, PROPERTY LINES & STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES, PROPERTY LINES & STRUCTURES, AND SHOULD ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

DD/MM/YY	DESCRIPTION

REVISION / ISSUE

Seal not valid unless signed and dated

GSS ENGINEERING CONSULTANTS LTD
Unit 104D 1010 9th Avenue West, Owen Sound, ON, N4K 5R7
Telephone: (519) 372–4828

Title:
SEDIMENT DEPTH ANALYSIS
PLAN VIEW
OF COLDSTREAM RESERVOUR
COLDSTREAM DAM

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	JTG	Scale:	1:1000
Drawn:	JTB	Approved:	Design Engineer
Checked:	JTG		
Date:	JULY 2022		

Drawing No. 21118C–FIGURE 3

4.3 Estimated Original River Channel Location and Form

The original dam and site plan drawings provided in this section show the original stream channel location. In general, the stream channel appears to have run along the southeast side of the pond near Ilderton Road.

If the dam was removed, there is some possibility that the new channel would form again in the original, historic channel with similar depth, cross-sectional shape and meander pattern as historically existed. However, the original excavation of fill from the head pond area, coupled with the large volume of sediment in the head pond, could result in a new channel location or the new channel having a different form (i.e. different channel depth, cross-sectional shape and meander pattern) than the original, historic channel.

To better estimate what channel form might develop in the head pond area if the Coldstream dam was removed, GEO Morphix fluvial geomorphologists were retained by GSS Engineering to evaluate a future stream formation in the head pond. The results of the GEO Morphix analysis are provided in **Appendix B.**

4.4 GEO Morphix Evaluation Summary

The GEO Morphix study (January 2023) in **Appendix B** provides the following conclusions and observations.

The study concludes that the new channel that forms in the head pond area (after dam removal) could form significant meander belts. The estimated meander belt width (MBW) that could form is quite significant and ranges from about 55 m to 80 m. Key conclusions are:

i) The above meander belt width approaches the widest part of the current head pond.

ii) The channel width and depth that could form over time through the sediment deposition area is estimated to have a width of 7.4 m and a depth of 0.74 m. However, this depth is from final water level to final channel bottom and does not include the height of riverbanks (i.e. remaining sediment) above the final water level at normal river flow rates.

iii) The volume of sediment that would be released from the head pond is estimated to be approximately 7,000 cubic meters if the sediment was allowed to be naturally released from the head pond. This estimate is 31% of the total estimated volume of sediment currently in the head pond (see Section 4.2).

iv) Overall, the GEO Morphix study concludes that removal of the sediment from the head pond in advance of dam removal is not likely practical.

4.5 Head Pond Sediment Contaminant Analysis

Appendix C provides results of contaminant analysis completed by ALS Laboratories of London, Ontario for sediment samples collected in the head pond during April, 2022. Samples were analyzed for metals and nutrients. Sediment samples were collected from six locations.

The **Technical Memorandum** provided at the end of this section provides greater detail of the sediment sampling, testing, and results. **Figure 4** (see the Tech. Memo) shows the location of the sampling locations. As per **Figure 4**, samples CS1 and CS4 were collected in the upper end of the head pond, samples CS2 and CS5 were collected in the middle part of the head pond, and samples CS3 and CS6 were collected in the downstream portion of the head pond. **Table 4** (of the Tech. Memo) provides all analytical results for all samples.

Results of analysis are summarized as follows:

i) There were no exceedances of metals for any samples other than for Manganese (samples CS4 and CS6) which had levels above the low effect level but below the severe effect level as published by MECP for sediment quality in Ontario (1993);

ii) All metal results were lower than sediment standards set by MECP for soil, ground water and sediment quality (2011);

iii) Phosphorus levels in sediment samples CS2, CS3 and CS6 were the only nutrient exceeding the above MECP levels or standards. Levels of phosphorus in these three samples exceeded the low effect level set by the 1993 MECP sediment quality standard for phosphorus (600 ug/g) but levels in these samples were well below the severe effect level for phosphorus (2,000 ug/g).

iv) Cyanide testing levels were set higher for sample CS2 due to high moisture content to a level above the 2011 MECP standard for sediment. As such, it cannot be confirmed if cyanide levels in CS2 were below the MECP standard. However, the other five sediment samples were also tested at the normal minimum detection level and results for all five samples were below the MECP cyanide quality standard.

Overall, sediment quality in the Coldstream dam head pond appears to be free of contaminants other than elevated levels of phosphorus in three of six samples and elevated levels of manganese in two of the six samples.

It should be noted that there are new regulations in Ontario that govern the movement of excess fill and earth material (*Excess Soil Regulation O. Reg. 406/19*). If there was serious consideration of excavating or dredging sediment from the dam head pond, then additional samples of sediment may have to be collected and analyzed for a wider range of parameters to meet the requirements of the above Regulation. Potentially, the same additional samples, and additional analysis of additional parameters, would be required if approvals were obtained to allow sediment in the head pond to naturally be carried downstream following dam removal.

4.6 Head Pond Sediment Characteristics

Appendix C also provides results of particle size analysis completed for two sediment samples collected in the head pond during April, 2022, being sediment samples CSPSA1 and CSPSA2.

Sample CSPSA1 was collected at the CS4 location and therefore represents sediment in the upstream portion of the head pond. Sample CSPSA2 was collected at the CS6 location and therefore represents sediment in the downstream portion of the head pond.

Based on particle size analysis, the upstream sample CSPSA1 consisted primarily of gravel (33%), medium sand (36%) and coarse sand (22%) with lesser amounts of fine sand and trace amounts of silt and clay.

The downstream sample CSPSA2 consisted of mainly fine sand and silt (45% and 23% respectively) with 37% medium sand.

In general, these results are consistent with soil and geologic conditions within the watershed upstream of the Coldstream dam, as discussed in earlier sections of this report.

4.7 Head Pond Sedimentation Accumulation Rate

Previously, a report entitled *Strathroy Reservoir Management Study* (2003) was prepared by Greck and Associates Limited (Greck) which described the Head Street dam and head pond in Strathroy. This report was wide ranging and discussed sediment accumulation, water quality issues, fish passage, effects on species at risk and invasive species, recreational uses, flood control and protection, erosion control and reservoir ecology. The study proposed measures to address and manage the reservoir impacts.

In Section 4.2 of the Study (Sediment Accumulation and Quality), Greck used historical water depths in the Head Street dam head pond to estimate the rate of sediment accumulation. Overall, Greck estimated that approximately 800 m^3/year of sediment were being deposited in the head pond. Review of the report in 2023 by GSS Engineering Consultants Ltd; combined with other data resulted in GSS Engineering concluding the rate of sediment accumulation could actually be higher at 1,300 m^3/year. GSS Engineering also noted the depth of water over the accumulated sediment in the Head Street head pond was 0.7 m.

The Coldstream dam is located on the same river (East Sydenham River) as is the Head Street dam. As such, sedimentation rates are believed to be at least comparable for the Coldstream dam as they are for the Head Street dam.

As noted, the current water depth over the accumulated sediment in the Head Street head pond is only 0.7 m, while the average depth of water over the sediment in the Coldstream head pond is 1.1 m (see Section 4.1 of this report).

Therefore, it would appear the Coldstream head pond is still accumulating sediment. The area of watershed upstream of Coldstream is approximately 61.6 square kilometers (see **Table 1**). The total watershed upstream of the Head Street dam is approximately 172.6 square kilometers which includes the watershed of the Coldstream dam.

Assuming all sediment washing into Coldstream stays in the Coldstream head pond, the contributing watershed area to the Head Street dam, downstream of Coldstream, is 111 square kilometers. If the lower sedimentation rate for the Head Street dam of 800 is m^3/year is assumed, the sedimentation rate per square kilometer of watershed area is 7.2 m^3/year per square kilometer.

Based on the watershed area upstream of the Coldstream dam being 61.6 square kilometers, and a sediment inflow rate of 7.2 m^3/year per square kilometer, the total sediment inflow to the Coldstream dam is approximately 444 m^3/year.

The estimated area of the Coldstream dam head pond is 4.5 ha (45,0000 square meters) as per Section 4 of this report. Based on the above, estimated sediment inflow rate of 444 m^3/year, the head pond is filling at approximately 10 mm (1 cm) per year. As such, over the next 50 years, the remaining water depth, above the sediment, would reduce by approximately 0.5 m (20 inches) to a depth of approximately 0.6 m.

TECHNICAL MEMORANDUM

Coldstream Sediment Analysis

November 7, 2022 21-118

In April, 2022, sediment samples were collected by staff of SCRCA from the Coldstream headpond in the small settlement area of Coldstream. Six sediment samples were collected and analysed from the six locations shown approximately on Figure 4 overleaf.

The sediment samples were analysed for a wide variety of metals and nutrients by ALS Laboratories of London. A copy of the lab results from ALS dated May 11, 2022 are provided in this section. A total of 36 metals and nutrients were analyzed for. See also Table 4.

As per Table 4, manganese levels in sediment samples CS4 and CS6 were the only metal exceeding MECP levels or standards. Levels of manganese in these two samples exceeded the low effect level set by the 1993 MECP sediment quality standard for manganese (460 ug/g) but levels in these samples were well below the severe effect level for manganese (1,100 ug/g).

Phosphorus levels in sediment samples CS2, CS3 and CS6 were the only nutrient MECP levels or standards. Levels of phosphorus in these three samples exceeded the low effect level set by the 1993 MECP sediment quality standard for phosphorus (600 ug/g) but levels in these samples were well below the severe effect level for phosphorus (2,000 ug/g).

The detection limit of cyanide was increased from 0.050 ug/g to 0.123 ug/g for sample CS2, due to high sample moisture content. This is higher than the 2011 MECP sediment quality standard for cyanide (0.1 ug/g). Therefore, sample CS2 was not sufficiently measured for a safe level of cyanide. However, this sample contains less then 0.123 ug/g of cyanide and since all five other samples have less then 0.050 ug/g of cyanide, it is assumed that sample CS2 does not exceed the 2011 MECP standard.

Overall, sediment quality in the Coldstream dam head pond appears to be free of contaminants other than elevated levels Manganese in two of six samples and Phosphorus in three of six samples.

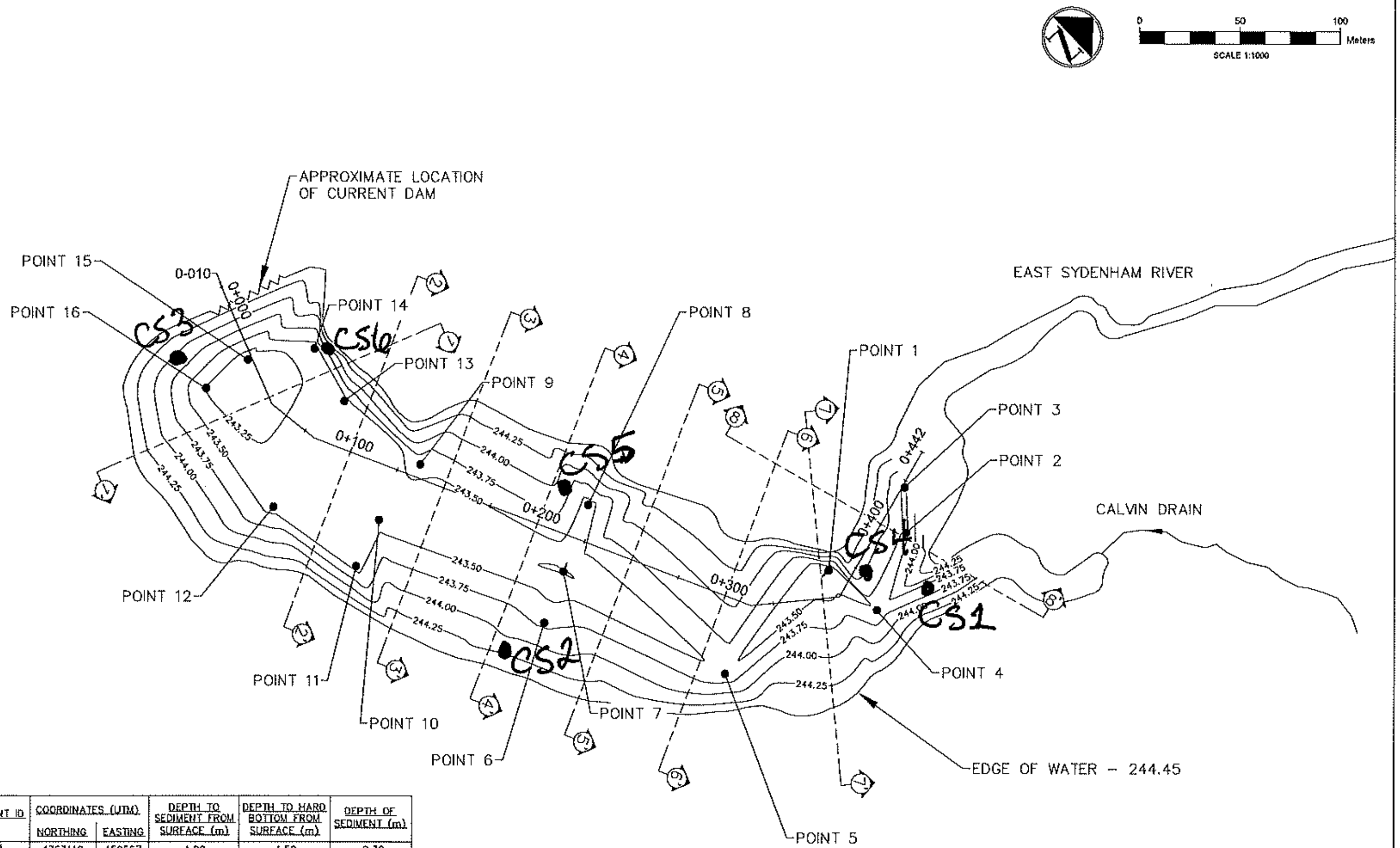
Sediment samples were also submitted for particle size analysis. Sample CSPSA1 was collected at the CS4 location. Sample CSPSA2 was collected at the CS6 location. As per the results, the upstream sample (CSPSA1) consisted of mostly gravel (33%), medium sand (36%) and coarse sand (22%) and the downstream sample (CSPSA2) contained more fine sand and silt (45% and 23% respectively) with 37% medium sand.

Prepared by

GSS ENGINEERING CONSULTANTS LTD.

Jacob Bartley

Jacob Bartley, E.I.T



POINT ID	COORDINATES (UTM)		DEPTH TO SEDIMENT FROM SURFACE (m)	DEPTH TO HARD BOTTOM FROM SURFACE (m)	DEPTH OF SEDIMENT (m)
	NORTHING	EASTING			
1	4763119	459567	1.22	1.52	0.30
2	4763160	459580	0.76	0.91	0.15
3	4763175	459563	0.76	1.22	0.46
4	4763123	459598	0.91	1.22	0.30
5	4763046	459569	0.91	1.52	0.61
6	4762998	459489	0.76	2.13	1.37
7	4763022	459477	1.22	1.98	0.76
8	4763054	459461	1.07	1.37	0.30
9	4763007	459389	0.91	2.29	1.37
10	4762973	459395	1.07	2.44	1.37
11	4762949	459404	1.07	1.83	0.76
12	4762939	459354	1.07	1.83	0.76
13	4763001	459340	1.07	2.13	1.07
14	4763008	459311	1.07	1.22	0.15
15	4762980	459292	1.37	3.05	1.68
16	4762955	459288	1.22	2.13	0.91

AREA OF RESERVOIR = ± 45,000 m^2
AREA OF SEDIMENT = ± 44,000 m^2
VOLUME OF SEDIMENT = ± 22,500 m^3

Figure 4
Sediment Sampling Locations in April, 2022

KEY PLAN

LEGEND

- 244.00m — SEDIMENT SURFACE CONTOURS (0.25m)
- STATION CROSS SECTIONS
- EDGE OF WATER (244.45m)

ENGINEERING

Title: EXISTING SITE PLAN AND SEDIMENT ELEVATIONS COLDSTREAM RESERVOIR

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	JTG	Scale:	1:1000
Drawn:	SNM	Approved:	Design Engineer
Checked:	JTG		
Date:	MAR. 2022		

Drawing No. 2111BC-03

GSS ENGINEERING CONSULTANTS LTD

TABLE 4
Summary of Sediment Quality Data for Metals and Other Inorganic Parameters
Potential Removal of the Coldstream Dam

November 4, 2022 | 21-118

Sample Identification		CS1	CS2	CS3	CS4	CS5	CS6	MECP (1993)		MECP (2011)
Date Collected		14-Apr-22	14-Apr-22	14-Apr-22	14-Apr-22	14-Apr-22	14-Apr-22	Sediment Quality [1]		Table 1 [2]
Lab Sample ID		L2699441-1	L2699441-2	L2699441-3	L2699441-4	L2699441-5	L2699441-6	LEL	SEL	Background
Parameter	Units									
Cyanide, Free	µg/g	<0.050	<0.123	<0.050	<0.050	<0.050	<0.050	-	-	0.1
Aluminum (Al)	µg/g	3260	8740	10900	8150	5290	12100	-	-	-
Antimony (Sb)	µg/g	<0.10	<0.10	<0.20	0.20	<0.20	<0.20	-	-	NV
Arsenic (As)	µg/g	1.89	2.37	3.02	4.50	2.81	3.22	6	33	6
Barium (Ba)	µg/g	17.1	56.4	75.1	41.3	33.2	78.3	-	-	NV
Beryllium (Be)	µg/g	0.16	0.36	0.42	0.31	0.24	0.47	-	-	NV
Bismuth (Bi)	µg/g	<0.20	<0.20	<0.40	<0.20	<0.40	<0.40	-	-	-
Boron (B)	µg/g	<5.0	7.8	10.0	7.2	<10	12.0	-	-	NV
Cadmium (Cd)	µg/g	0.089	0.255	0.280	0.166	0.140	0.304	0.6	10	0.6
Calcium (Ca)	µg/g	200000	114000	174000	143000	172000	183000	-	-	-
Chromium (Cr)	µg/g	9.68	14.50	18.30	14.8	11.4	19.5	26	110	26
Cobalt (Co)	µg/g	2.43	4.85	5.96	5.01	3.07	6.42	-	-	50
Copper (Cu)	µg/g	4.23	11.50	14.30	13.40	6.60	15.60	16	110	16
Iron (Fe)	µg/g	8330	12200	14600	14100	9120	15800	20000	40000	-
Lead (Pb)	µg/g	4.03	6.72	8.10	13.00	4.20	8.80	31	250	31
Lithium (Li)	µg/g	4.3	9.6	10.9	8.7	6.3	13.9	-	-	-
Magnesium (Mg)	µg/g	15200	14200	17700	20600	19200	18700	-	-	-
Manganese (Mn)	µg/g	266	338	418	**<u>492</u>**	313	**<u>495</u>**	460	1100	-
Mercury (Hg)	µg/g	0.0146	0.0248	0.0280	0.0331	0.0110	0.0320	0.2	2	0.2
Molybdenum (Mo)	µg/g	0.27	0.27	0.25	0.55	<0.20	0.29	-	-	NV
Nickel (Ni)	µg/g	6.09	11.60	14.40	11.80	7.8	15.70	16	75	16
Phosphorus (P)	µg/g	339	**<u>834</u>**	**<u>850</u>**	587	590	**<u>900</u>**	600	2000	-
Potassium (K)	µg/g	400	1,110	1,700	1,040	790	1,790	-	-	-
Selenium (Se)	µg/g	<0.20	0.70	0.76	0.28	<0.40	0.69	-	-	NV
Silver (Ag)	µg/g	<0.10	<0.10	<0.20	<0.10	<0.20	<0.20	-	-	0.5
Sodium (Na)	µg/g	159	287	230	206	190	230	-	-	NV
Strontium (Sr)	µg/g	121.0	87.3	139.0	101.0	131.0	149.0	-	-	-
Sulfur (S)	µg/g	<1000	1,200	<2000	<1000	<2000	<2000	-	-	-
Thallium (Tl)	µg/g	<0.050	0.074	0.10	0.062	<0.10	0.120	-	-	NV
Tin (Sn)	µg/g	<2.0	<2.0	<4.0	8.5	<4.0	<4.0	-	-	-
Titanium (Ti)	µg/g	120	130	207	211	208	232	-	-	-
Tungsten (W)	µg/g	<0.50	<0.50	<1.0	<0.50	<1.0	<1.0	-	-	-
Uranium (U)	µg/g	0.754	0.715	0.720	0.735	0.650	0.720	-	-	NV
Vanadium (V)	µg/g	13.40	17.60	23.1	22.2	15.6	25.4	-	-	NV
Zinc (Zn)	µg/g	21.2	47.2	57.0	41.3	30.4	66.1	120	820	120
Zirconium (Zr)	µg/g	<1.0	1.4	<2.0	<1.0	<2.0	<2.0	-	-	-

Notes:
1. Lowest Effect Level (LEL) and Severe Effect Level (SEL) from the 1993 MECP "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario".
2. Table 1 Background Site Condition Standards for Sediment from the 2011 MECP "Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act".
3. Results higher than corresonding guideline or standard are shown in **BOLD** and <u>underlined</u>.
4. "NV" indicates no value derived. "-" indicates no applicable standard or not analysed.

5 ECOLOGICAL IMPACTS AND BENEFITS OF THE COLDSTREAM DAM

The International Union for Conservation of Nature has designated the Sydenham River as one of thirteen freshwater Key Biodiversity Areas in Canada. This is due to the diversity of freshwater species supported by the Sydenham River. The Sydenham River is home to 34 mussel species and 80 fish species as well as many other semi-aquatic species such as turtles, snakes, amphibians, and dragonflies. Some of these species are designated as Species at Risk and are found nowhere else in Canada or remain in only a few locations globally.

As noted in the 2018 Sydenham River Recovery Strategy (Strategy) there are a number of threats to aquatic Species at Risk that inhabit the Sydenham River. Specifically, dams are identified in the Strategy as negatively impacting aquatic habitat by causing thermal warming, impacting normal sediment transport processes and sediment deposition, and posing a barrier to fish migration and mussel distribution. The identified impacts and benefits of the Coldstream dam are discussed in the following sections:

5.1 Sedimentation and Sediment Distribution

Sediment loading and turbidity are some of the major factors affecting aquatic species in the Sydenham River. Increases in sediment loads over time can be attributed to land use practices such as agricultural activity, lack of riparian areas and erosion.

Benefits of Dam Removal:

The Coldstream dam interrupts natural sediment transport which degrades aquatic habitat for Species at Risk downstream of the Coldstream dam. If the dam was removed, natural sediment transport would be restored which would benefit downstream populations of fish, mussels and turtles which rely on these sand and gravel substrates for various life stages.

Possible Negative Impacts of Dam Removal:

Although natural sediment transport and loading is a benefit to the aquatic habitats downstream, the dam currently decreases the rate of downstream siltation. Silt, unlike sand and gravel, can negatively impact species downstream by increasing turbidity and making it difficult for species to fulfill their life cycle requirement. Silt can also smother and suffocate sedentary species like mussels or fish eggs. With the amount of silt that has accumulated behind the Coldstream dam, additional study is recommended to determine silt transport rates and the affected downstream area if the decision is made to remove the dam and allow sediment to naturally migrate downstream.

5.2 Water Temperatures

Water temperature plays an important role in aquatic ecosystems and can directly impact the species composition of an area.

Water temperature loggers were placed upstream of the Coldstream dam head pond and downstream of the dam during the summers of 2016, 2017 and 2018.

During these summers, the water temperature significantly increased from upstream to downstream of the dam. The following **Table 5** summarizes the average upstream and downstream water temperatures for the years 2016, 2017 and 2018. The following averages are for temperatures at 4 pm each day when normally stream temperatures reach their daily maximum before cooling off to varying degrees overnight.

Table 5

Summer Water Temperatures Upstream and Downstream of the Coldstream Dam for 2016, 2017 and 2018

Year	Average Upstream Water Temperature at 4:00 pm.	Average Downstream Water Temperature at 4:00 pm.	Increase in Average Water Temperature due to Coldstream Dam at 4:00 p.m.
2016	20.96 C	22.91C	1.95 C
2017	19.24 C	22.31 C	3.07 C
2018	20.19 C	23.56 C	3.37 C
Average	**20.13 C**	**22.93 C**	**2.80 C**

As per **Table 5** above, the average increase in water temperature due to the dam head pond was 2.80 C. This is a significant increase in summer water temperatures that could limit cold and cool water fish species downstream of the dam. The warming effect of impoundments such as the Coldstream Dam are also anticipated to increase due to warmer summer air temperatures resulting from climate change.

5.3 Water Quality

Increase in summer water temperatures and excess nutrients can have a negative effect on the aquatic ecosystem, including change in species composition, increase in algal blooms and depleted oxygen levels.

The Coldstream dam is situated within the East Sydenham River Headwaters sub-watershed. The geology in this sub-watershed includes sand and gravel areas which contribute groundwater, which encourages cool/cold-water fish communities. As per Section 5.2, the Coldstream dam causes some warming of the Sydenham River during the summer months.

As such, the dam is likely causing warming of the river water downstream of the dam as well as warmer temperatures in the head pond. As sediment accumulates behind the dam the reservoir has become shallower, leading to quicker warming of water and likely contributes to algal blooms during the open water period. Excess nutrient loading from upstream sources, including agriculture, may also contribute to algae blooms.

The following photos (**Photo 3** and **Photo 4**) depict unusually heavy algae blooms in the Coldstream dam head pond in May, 2022.

Photo 3: Algal bloom in the Coldstream dam head pond in May 2022. View to the southwest to the dam area from the Coldstream Conservation Area on the northwest shore. (SCRCA photo.)

Photo 4: Algal bloom in the Coldstream dam head pond in May, 2022. View to the east toward Ilderton Road from the Coldstream Conservation Area on the northwest shore. (SCRCA photo.)

5.4 Fish Passage

The Sydenham River is home to eighty (80) fish species, ten (10) of which are listed as Species at Risk. Barriers and modifications to natural stream flows can impact fish movement through the ecosystem to fulfill life cycle requirements.

Benefits of Dam Removal:

The Coldstream dam limits the ability of fish to move freely through the East Sydenham River and access a wide variety of fish habitat types. Removal of the dam would restore fish passage upstream.

Possible Negative Impacts of Dam Removal:

Invasive species like Round Goby (Neogobius melanostomus) are currently unable to move upstream of the Coldstream dam. If Round Goby were to first move upstream past the Head Street dam in Strathroy, removal of the Coldstream dam would allow Round Goby access to much of the entire watershed. Records show the current distribution is just below the Head Street dam. Round Goby, like many other invasive species, is prolific at reproducing and will outcompete native fish like Darters for food and other habitat resources.

The presence of Round Goby has shifted the feeding ecology of benthic species in the Sydenham River, as well as species with direct diet overlap such as the Eastern Sand Darter (Firth et al, 2021). As native species decline and natural hosts of mussel larvae (glochidia) are removed, the glochidia must attach to the next best option, being Round Goby. This results in the glochidia being unable to mature into juveniles and therefore do not survive.

A study by Tremblay et al in 2016 states "*N. melanostomus are likely acting as a sink for glochidia, whereby they prevent glochidia from reaching their intended hosts. This has negative implications for unionid species that exhibit high rates of infection and poor/no metamorphosis on N. melanostomus".* Without the Coldstream dam in place, Round Goby and other invasive species could move more freely upstream through the East Sydenham River which could impact native species in this area.

5.5 Mussel Distribution

As previously mentioned, the Sydenham River is home to 34 freshwater mussel species in the family Uniondae and is identified as the most mussel diverse watershed in Canada. These organisms are long lived filter feeders that strain out oxygen, food, and nutrients and also remove pollutants and suspended particles. Mussels are also sedentary or slow-moving organisms that often rely on host fishes to carry their larva (glochidia) upstream. Mussels rely on clear water to attract a host fish using their lures and releasing their larva into the water column.

Benefits of Dam Removal:

The existing Coldstream dam may hinder mussel distribution as host species (fish) are unable to move freely upstream due to the barrier created by the dam. Removal of the dam would allow for further movement of the mussels as the larva (glochidia) would be carried further by the host fish.

As previously noted, the dam impedes the natural transport of sand and gravel through the river system. This may result in less suitable downstream habitat and degraded mussel beds.

Possible Negative Impacts of Dam Removal:

As previously noted, the dam holds back silt and sand sediment. If the silt was allowed to wash downstream, the silt may negatively affect mussel habitat and limit essential life cycle processes such as reproduction, respiration and feeding.

6 GENERAL ANALYSIS OF SEDIMENT REMOVAL FROM THE COLDSTREAM DAM HEAD POND.

The following section evaluates generally possible options to remove the Coldstream dam in terms of managing the large volume of sediment in the head pond. As per previous sections, there is significant sediment build up in the head pond consisting of fine sand as well as silt and clay.

Section 4.4 summarizes the major findings of the January, 2023 GEO Morphix review of potential effect on channel formation and possible sediment release following removal of the Coldstream dam.

As per Section 4.4, GEO Morphix estimates a significant volume of sediment would be released from the head pond if the dam was removed.

However, the GEO Morphix review did not estimate the rate of transport of the released sediment through the downstream river channel. As such, if removal of the dam was seriously considered, additional evaluation of sediment management options would be recommended.

Section 7 discusses options for sediment management that would accompany dam removal. Two of the options include removal of sediment from the head pond before the dam is removed.

These two options are i) dredging of the head pond sediment with the full water level present in the head pond or ii) excavation of sediment from the head pond “in the dry” after a temporary channel (or temporary pipeline) is first constructed around the head pond.

With the above two options, the amount of sediment released downstream would be significantly less than if the river flow was allowed to naturally carve a new channel through the head pond sediment once the dam was removed.

If the river was allowed to carry the sediment downstream then two additional options are available being i) the dam is removed in stages (i.e. over three years) and the sediment is allowed to be carried downstream over an extended time frame or ii) the dam is removed entirely at one time and the sediment is allowed to be carried downstream in a relatively short period (i.e. over one year).

As sediment is released from the reservoir a portion would be deposited along the riverbed and edges of the East Sydenham River. Finer sediment particles will likely travel further and faster downstream then heavier sediment particles. The heavier sediment particles are likely to deposit in deeper portions of the riverbed and on the inside of river bends, where water velocities are reduced. The pool below the dam and the river reach a short distance below the dam would likely receive heavy sediment loadings. Finer sediment particles would likely be transported many kilometres downstream during high flows in the East Sydenham River.

These particles will likely continue to move downstream over time and eventually deposit in the Head Street dam head pond in Strathroy unless the Head Street dam had already been removed.

If the dam removal option selected allows sediment to wash freely downstream, additional study is recommended to estimate sediment transport rates and the area(s) along the East Sydenham River that will be most affected by the sediment transport.

However, without additional study, the following general conclusions are provided at this time:

i) As per later sections of this report, it does not appear practical to dredge or excavate the sediment from the head pond before the dam is removed. A similar conclusion was reached by GEO Morphix in their January, 2023 evaluation of channel formation in the head pond sediment.

ii) Slow release of head pond sediment over say three years (by step wise removal of the dam over three years) would likely pose lesser risks to the downstream channel condition than if the dam was completely removed in one work season.

Based on the above, it is recommended that further modelling of sediment transport downstream of the dam site be carried out if a decision was made in principle to remove the dam without first removing significant volumes of sediment from the head pond.

7 METHODS OF DAM REMOVAL AND SEDIMENT MANAGEMENT STRATEGIES

This section discusses various options to remove the Coldstream dam if a decision was made to remove the dam in the future. As per previous sections, there is a significant amount of sediment in the dam head pond. Management of sediment is therefore a major consideration when alternatives for dam removal are evaluated.

7.1 Dam Removal Methodologies

Dams can be removed using several methods as follows:

i) Full removal of the dam during one summer work period.

ii) Gradual removal of the dam over two or more seasons where stop logs (if existing) are removed in the first year followed by full removal of the dam in the second year or full removal of the dam over a number of subsequent years.

iii) Partial removal of a dam whereby enough of a dam is removed to achieve environmental goals (i.e. restore fish passage and reduce summertime heating of stream water temperatures) but retain some of the dam to retain sediment storage capacity or to provide some other social or economic benefit that would accrue by retaining some level of ponding behind the remaining portion of the dam.

iv) Potentially leave dam in place and construct new stream bypass channel around the entire headpond.

With the above general options, there are the following sediment management options:

i) Option 1 - Prior to dam removal, remove the sediment from the head pond by use of a hydraulic dredge. This requires a floating dredge system that pumps a large volume of sediment mixed with water to a receiving basin that would allow the sediment fraction to settle and the clear “decant” water to return to the river

ii) Option 2 - As part of the dam removal process, construct a large bypass channel or pipeline around the head pond and dam and discharge the river flow below the dam site. Once the stream bypass is established, mechanically remove head pond sediment “in the dry” using large excavation equipment and dump trucks etc.

iii) Option 3 - Remove complete dam in one season, or remove the dam in stages over several years, and allow river flow to transport the sediment in the head pond downstream naturally.

iv) Option 4 – Leave sediment and dam in place if new stream bypass channel constructed around entire head pond.

Table 6 provides a summary of seven dam removal options including sediment management strategies for each option. This includes Option 6 which is construction of a new bypass channel around dam and head pond and Option 7 which is “do nothing” (leave dam in place as is).

For all options proposing dam removal (Options 1, 2, 3, 4 and 5), the dam removal component of the overall project is of moderate complexity as the dam height (3.35 m) is of moderate height and the volume of fill and rock armour stone beside the sheet pile dam is relatively large.

However, access to the south end of the sheet pile section of the dam is good for large equipment and access to the north end of the dam is also relatively good. These factors would allow the dam to be removed relatively easily, compared to the sediment management options for each option which would be more complex.

As per **Table 6**, removal of the dam would also have social and environmental advantages and disadvantages. While removal of the head pond would negate some recreational opportunities, swimming is currently very restricted in the head pond due to high bacteria levels and the occurrence of heavy algae growth in some years. Significant sediment accumulation in the head pond over the years has also reduced the recreational benefits of the dam.

Generally, there would likely be an overall environmental benefit to removing the dam by restoring fish passage, restoring natural sediment transport and reducing summer water temperatures. Option 6 (new stream channel constructed around dam head pond) also achieves most of these benefits.

Sediment management would be a major challenge for most options, and as noted on **Table 6**, pre-consultation with regulatory agencies regarding options for sediment management is recommended.

Sediment management costs could be very large if sediment removal is to be completed using a hydraulic dredge or is excavated mechanically. Such large costs include the costs for construction of a very large settling pond (lagoon) for the dredging option or a temporary bypass channel or pipeline system for the option to remove sediment from the head pond “in the dry”.

Preliminary cost estimates for the seven different dam removal options (including the “do nothing” option) are provided in **Table 7.**

As per **Table 7**, costs to remove just the dam (not including sediment management costs) are estimated to be $500,000 to $1,600,000 depending on which option is considered. Option 5 (partial removal of the sheet pile dam) has the lowest estimated cost, with the highest cost being Option 3 where the dam is removed in steps over several years with water remaining in the head pond at declining levels as the dam is removed.

Much higher costs are assigned to active sediment management for Options 1 and 2. With these Options, sediment is removed by dredging or mechanical excavation before the dam is removed. Such active sediment management costs are estimated to cost at least $1,800,000 in addition to the actual dam removal costs. As discussed in the next sections, these active sediment management costs would likely have significant technical challenges and potentially high social impacts.

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TABLE 6
Sediment Management and Dam Removal Options
Potential Removal of the Coldstream Dam

Sediment Management and Dam Removal Options	Economic Considerations	Technical Obstacles	Social Impacts	Environmental Impacts	Regulatory Concerns
<u>Option 1:</u> **Dredging of sediment with water in head pond followed by complete dam removal.**	• Very expensive sediment management option as very large volume of sediment/ water mixture will be produced. • Dam removal will be relatively inexpensive.	• Onsite sediment dewatering required. Very large settling pond likely required. • Ultimate sediment disposal requirements could be difficult. • Equipment mobilization, operation and demobilization required.	• Large area required for sediment dewatering in current park area. Major impact to park users.	• Aquatic species (fish, turtles, etc.) in the head pond may be entrained in the dredged sediment. • Fish migration provided. • Thermal impacts to water temperature from head pond are eliminated.	• Regulations regarding sediment disposal on off-site lands are now quite stringent.
<u>Option 2:</u> **Temporary bypass of river around dam. Excavate sediment "in the dry" and complete dam removal.**	• Expensive sediment management option. • Temporary bypass pipe or channel around head pond will be expensive to construct. • Least expensive dam removal option.	• Construction of bypass pipe or new channel around the reservoir could be very difficult to design and locate. • Ultimate sediment disposal requirements could be difficult. • Excavating wet sediment with equipment within pond footprint likely difficult.	• Bypass pipe or channel could be a safety hazard until dam and sediments are removed. • Large area of deep, soft sediment could be a danger to pedestrians.	• As head pond level lowers, aquatic species may become trapped in the drying up reservoir. • Fish migration provided. • Thermal impacts to water temperature from head pond are eliminated.	• Regulations regarding sediment disposal on off-site lands are now quite stringent.
<u>Option 3:</u> **Remove dam in phases over ± 3 years. Allows slow release of sediment over 3 years.**	• More expensive dam removal option than Option 4. • No significant cost for sediment management.	• Maintaining structural integrity of dam is required over ± 3 year process. • The long timeline to remove dam may be difficult contractually.	• Current reservoir area could be a safety hazard for multiple years due to large areas of deep, soft sediment.	• Sediment is released downstream at a relatively high rate. • Sydenham River downstream of dam will become turbid following each step of dam removal due to entrained sediment. • Fish migration provided. • Thermal impacts to water temperature from head pond are eliminated.	• LIRA (MNRF) permitting may be complicated due to partial removal of dam in steps. • Regulators may not allow the periodic release of large volumes of sediment.
<u>Option 4:</u> **One time removal of complete dam. Allow one time release of sediment.**	• Relatively inexpensive dam removal option. • No significant cost for sediment management.	• Water velocity management required to allow head pond to drain slowly.	• Current reservoir area could be a safety hazard for one or two years due to large areas of deep, soft sediment.	• Very large amount of sediment will be transported downstream in a relatively short timeframe. • Sydenham River downstream of dam will become turbid due to entrained sediment. • Fish migration provided. • Thermal impacts to water temperature from head pond are eliminated.	• Regulators may not allow the sudden release of large volumes of sediment.
<u>Option 5:</u> **Partial dam removal. Construct "rocky ramp" step pool system to provide fish passage.**	• Least expensive dam removal option. • No significant cost for sediment management.	• Water velocity management required to allow head pond to drain slowly.	• Current reservoir area could be a safety hazard for one or two years due to large areas of deep, soft sediment.	• Fish migration provided. • Thermal impacts to water temperature from head pond are largely eliminated. • Sediment is partially released downstream at a relatively high rate. • Sydenham River downstream of dam will become turbid following partial dam removal due to entrained sediment.	• Regulators may not allow the sudden release of sediment.

Sediment Management and Dam Removal Options	Economic Considerations	Technical Obstacles	Social Impacts	Environmental Impacts	Regulatory Concerns
<u>Option 6:</u> **Construct permanent new, natural stream channel around dam headpond. Leave dam, head pond and sediment in place as is.**	• Cost to build permanent bypass stream channel quite high. • Avoids cost of dam removal and cost of removing sediment.	• Geotechnical investigations required to confirm remaining land between water in head pond and new channel will be structurally stable and hydraulically stable. • Bridges (pedestrian and/or vehicle bridges) to cross over new stream channel may be required to access north end of dam.	• This Option maintains a lake environment at the site and provides a new, natural stream channel area for viewing, nature enjoyment and passive recreational use. • As the dam deteriorates it will eventually become safety hazard.	• Fish migration provided. • Thermal impacts to water temperature from head pond are largely eliminated as flow through head pond is significantly reduced. • Sediment release from the head pond is avoided.	• This option requires a large volume of earth fill to be removed to construct new, natural stream channel. Need to follow Excess Fill regulations for disposal of fill elsewhere. • As the dam's structural integrity degrades over time, regulators may be concerned with public safety and dam failure.
<u>Option 7:</u> **Do nothing.**	• No immediate cost. • Potential for increased maintenance costs as the dam deteriorates.	• Dam may need to be structurally reinforced in the future.	• As the dam deteriorates it will eventually become safety hazard.	• The dam obstructs fish migration. • The dam deprives aquatic species (including SAR) downstream of dam of required sediment. • The head pond continues to warm up water temperatures during the summer.	• As the dam's structural integrity degrades over time, regulators may be concerned with public safety and dam failure.

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TABLE 7
Sediment Management and Dam Removal Options - Preliminary Cost Estimate
Potential Removal of the Coldstream Dam

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Sediment Management and Dam Removal Options	Capital Cost Estimate for Dam Removal	Capital Cost Estimate for Sediment Removal	Total Capital Cost Estimate	Comments
Option 1: **Dredging of sediment with water in head pond followed by complete dam removal.**	$1,100,000 to $1,300,000	>$2,000,000 Need to construct very large sediment/dewatering lagoon on north side of head pond.	>$3,100,000 to $3,300,000	Cost to design, approve and construct large sediment/dewatering pond difficult to estimate. Would also be final restoration costs of dewatering pond once sediment dries. Major impact on conservation authority site project.
Option 2: **Temporary bypass of river around dam. Excavate sediment "in the dry" and complete dam removal.**	$700,000 to $900,000	>$1,800,000 Cost to build large bypass channel or large bypass pipe around north side of head pond would be extremely high.	>$2,500,00 to $2,700,000	Technically difficult. The bypass channel/pipeline likely would need to be quite large to accommodate a reasonably large flow, i.e. ± 5 m^3/s. Deep excavation likely required through higher lands on northern side of pond. Removal of excavated sediment from "dry pad" likely difficult due to wet, soft soil conditions.
Option 3: **Remove dam in phases over ± 3 years. Allows slow release of sediment over 3 years.**	$1,600,000	Essentially zero cost for active sediment management as sediment would slowly wash downstream. Assume $300,000 for bioengineering stabilization of emerging stream banks.	$1,900,000	Second lowest overall cost. Agreement from all review agencies (DFO, MECP, MNRF and SCRCA) required in advance to allow downstream sediment release from head pond.
Option 4: **One time removal of complete dam. Allow one time release of sediment.**	$1,100,000 to $1,300,000	Essentially zero cost for active sediment management as sediment would wash downstream. Assume $300,000 for bioengineering stabilization of emerging stream banks.	$1,400,000 to $1,600,000	Lowest overall cost. Agreement from all review agencies (DFO, MECP, MNRF and SCRCA) required in advance to allow downstream sediment release from head pond.
Option 5: **Partial dam removal. Construct "rocky ramp" step pool system to provide fish passage.**	$500,000 for partial dam removal in one year.	Essentially zero cost for active sediment management as sediment would wash downstream. Assume $300,000 for bioengineering stabilization of emerging stream banks.	$800,000	Lowest overall cost. Provides fish passage and minimizes downstream sediment migration.
Option 6: **Construct permanent new, natural stream channel around dam headpond. Leave dam and sediment in place as is.**	New channel would be approximately 350 m long and designed for major flood flows of approximately 100 cubic meters per second. The cost of the new channel is estimated to be $1,800,000 to $2,100,000.	No cost. Sediment remains in place.	Cost for new permanent, stream channel estimated to be $1,800,000 to $2,100,000.	Cost similar to Options 3 and 4 but more than Option 5. Long term, dam removal and sediment management may still be required.
Option 7: **Do nothing.**	Theoretically zero cost. However, ultimately, dam will reach end of service life and will need to be repaired, rebuilt or removed.	No cost.	Theoretically zero.	Volume of sediment in head pond will continue to increase over time. With inflation and extra sediment, future costs for dam removal will increase compared to current costs.

Note: Capital costs do not include consultation, engineering or permitting costs.

A summary of the seven options is provided as follows:

7.1.1 Option 1 – Dredging of Sediment from the Head Pond Before the Dam Is Removed.

This option assumes a floating barge would be used to pump a large volume of water and sediment mixture from the head pond in advance of dam removal.

The additional volume of water mixed with the sediment could be very large. For instance, the total volume of sediment above the Coldstream dam is estimated to be 22,500 cubic meters. Even if only half of the sediment was removed by dredging (11,000 cubic meters) there could be easily twice that amount of water entrained with the true sediment (i.e. 2 cubic meters of water per cubic meter of sediment). If so, the total volume of water/sediment removed would be approximately 33,000 cubic meters. A large settling pond would be required to allow the sediment particles to settle out of the water. If there was enough settling time, the water exiting the pond should be clear enough to run back into the river downstream of the dam.

If the floating dredge system featured a 12 inch diameter discharge pipe, and the velocity of the pumped flow was 1.2 m/s (to maintain entrained sediment in suspension) the pump discharge rate would be 70 liters per second (approx. 250 cubic meters per hour.). For a ten hour workday, the total discharge would be 2,500 cubic meters. If one third of the total volume was sediment, then there would be approximately 850 cubic meters of sediment removed per day.

To remove the above 11,000 cubic meters of sediment, the process would require close to 13 days of pumping. This represents about two to three weeks of pumping and if this rate of productivity could be sustained, then a sediment removal target of 11,000 cubic meters could be achieved in one summer season.

However, the volume of a temporary sediment settling pond would be quite large. If a 2 m deep lagoon was assumed, and that sediment storage of only 1 m depth was assumed, then a settling pond (lagoon) with an area of at least 11,000 square meters would be required for a target volume of just half of the total sediment volume.

A pond of therefore approximately 1 ha would be required with total water depth of 2 m (in addition to say 0.6 m freeboard above the water surface) meaning that a large lagoon with a volume of 20,000 to 25,000 cubic meters would be required with a depth of 2.6 m. If the settling pond was rectangular in shape with the length 3 times the width, the overall dimensions would be about 65 m wide by 200 m long. Overall, a lagoon of this size would take up a considerable portion of the Conservation Authority property on the north side of the head pond. There would also be costs and analytical costs associated with transporting the fill generated by construction of the settling pond offsite.

The capital cost of a settling pond of this size would likely exceed $500,000 at a nominal construction cost of $20 per cubic meter. The outlet would also have to be designed to allow an outflow rate of 70 liters per second of settled, clear overflow water. The inlet design would have to feature energy dissipation to avoid eroding the inlet area. The overall site would likely have to be fenced off to prevent the public from entering the settling pond area. Once all costs are considered, the cost to construct the lagoon would likely exceed $1 M. In addition, the actual costs of the dredging equipment and manpower etc. would be in addition and is estimated to be between $500,000 to $1,000,000.

The actual dam removal cost would be relatively high ($1.1 M to $1.3 M) as the dam would be removed with the head pond full of water.

The other consideration is the quality (clarity) of water being discharged from the downstream end of the lagoon. Assuming the clear water surface volume of the lagoon is 11,000 cubic meters, and with an inflow rate of 70 l/s, the settling time in the pond would be approximately 2 days. Depending on settling rates associated with various particle sizes, 2 days of settling time may not be enough to ensure relatively clear water leaving the settling pond.

Assuming the lagoon was built and used over the course of one summer, decommissioning costs of the lagoon would need to be considered, including drying out the sediment which could be problematic depending on weather conditions and design details of the lagoon (i.e. bottom level of lagoon relative to final water level in the head pond area). Such decommissioning costs, including possible trucking away of the sediment after drying, could be very high. A general alternative would be regrading the lagoon and storing the sediment permanently on site.

As per **Table 7**, the preliminary capital cost of Option 1 (excluding engineering, planning and permitting costs) is estimated to be $3.1 M to $3.3 M. These costs assume the sediment stays on site.

In addition is the environmental concerns associated with a dredging system pumping a sediment/water slurry from the head pond. The head pond contains fish and other aquatic animals and, normally, Department of Fisheries and Oceans requirements dictate fine screening of bypass pumping system to avoid entrainment of even very small fish and other aquatic life in the pumping system. The large flow volume capacity, and heavy solids contents, of a pumped dredging system would suggest fine screening is impractical due to frequent plugging of a screening system.

7.1.2 Option 2 – Construct a Bypass Channel (or Pipeline) Around Dam Head Pond and Then Mechanically Remove Some or All of the Sediment “In the Dry”.

This option assumes that first a temporary bypass channel is built around the dam head pond. In the case of the Coldstream dam, it is assumed that this channel (or bypass pipeline) would be constructed around the north west side of the head pond on Conservation Authority lands.

The total length of channel or bypass pipeline would need to be approximately 350 m long. The channel or pipeline would start upstream of the head pond and require a coffer dam system to direct the water into the bypass system.

The capacity of the new bypass channel (or pipeline) would need to be substantial. General guidance provided by MNRF for other dam removal projects suggests the capacity of the temporary bypass channel should be adequate for a 2 year return summer flood flow. In the case of the Coldstream dam, the average summer flow is only 0.28 cubic meters per second. Conversely, the 2-year return flood flow (for all seasons) is much larger (19 cubic meters per second). Overall, a summer flood flow capacity of perhaps 2 to 5 cubic meters per second would be required to provide a balance between the risk of flow capacity exceedance of the channel (or pipeline) versus costs to build an even larger capacity bypass channel or pipeline.

If a channel was constructed for say 5 cubic meters per second, and assuming a slow flow velocity of 1.0 m/s, a channel 5 m wide by 1 m deep (plus freeboard) would be required. If freeboard height of 0.5 m was assumed, a rectangular channel with a cross section of 1.5 m deep by approximately 14 m wide at the top (giving 3:1 stable side slopes) would be required.

The nominal excavation volume of this channel would be approximately 14.25 cubic meters per meter of channel. However, the lands on the north west side of the pond rise rapidly from the water surface by 2 to 3 m, and total excavation to construct an open channel would likely be in the range of 30 to 40 cubic meters per meter. Total volume would be approximately 13,000 cubic meters for a channel length of 350 m. Based on $30 per cubic meter for excavation, the nominal cost would be $390,000 plus the added cost for removal of this soil, at least temporarily, from the site.

As a second option, a buried bypass pipeline could be installed. However, the pipeline(s) would also need to have a capacity of 5 cubic meters per second. Normally, a pipeline would consist of one (or two) large diameter pipes. Water velocity would have to be quite low (i.e. 0.6 m/s) to avoid excessive friction losses in the pipe to prevent the water level entering the pipeline from backing up and overflowing the upstream end of the pipeline during high stream flow events.

If a two pipe system was employed (2.5 cubic meters per second per pipeline), the diameter of each pipe would be approximately 1.8 m in diameter (6’ diameter) to convey the flow at low velocity.

Overall, a bypass pipe system would likely exceed material and installation costs of $2,500 per meter. The actual cost could be much more recognizing that essentially all of the pipeline would need to be built below the current water level in the head pond. Even if the pipeline was well set off from the north edge of the head pond, the groundwater level would likely be at the same level as the head pond surface level. This same groundwater level challenge would also apply to the bypass channel sub-option first described. Given a 350-meter-long pipeline, the cost for the pipeline alone would be approximately $875,000. Constructing the outlet with erosion protection, and a major coffer dam system at the inlet, would likely result in overall costs of approximately $1,300,000.

With this option, sediment would be excavated “in the dry” from the head pond. In reality, to excavate in the dry, there would need to be zero water flow entering the head pond through the upstream coffer dam. This is likely unrealistic as the working depth in the head pond would be below the water level upstream of the head pond. As well, there would be ground water seepage and surface runoff entering the pond. All combined, the sediment would be wet and loose and access into the pond area for excavation and hauling away of sediment (i.e. track excavators and dump trucks) could be very difficult without equipment sinking into the soft and wet material.

Disposal of the sediment would be assumedly off site. Assuming half of the sediment was removed from the site (11,000 cubic meters) then this sediment would be subject to new excess fill regulations that would require extensive testing of the sediment for contaminants and careful tracking of the disposal site for the material among other requirements of the relatively new *On-Site and Excess Soil Management Regulation (Ont. Reg 406/19).* Likely, costs for excavation, loading of trucks and off loading of the sediment at another location would likely be at least $40 per cubic meter and thus sediment disposal costs would likely exceed $500,000 with testing and other costs.

As per **Table 7**, the preliminary capital cost of Option 2 (excluding engineering, planning and permitting costs) is estimated to be $2.0 M to $2.2 M. It is also difficult to assess the practicality of removing wet sediment from the head pond and transporting to an acceptable disposal site.

7.1.3 Option 3– Remove Dam Over Several Years. Remove Approximately 1/3 of the Dam Each Year for Three Years. Allow Sediment to Be Washed Downstream Over Several Years As Dam Is Removed

As per Options 1 and 2, removal of sediment before the dam is removed may not be feasible or cost effective due to the large volume of sediment in the head pond and difficulty in constructing a large settling pond for dredging or a bypass pipeline or channel.

As such, with Option 3, it is assumed that government agency approvals would be received in advance that allows the sediment to naturally transport downstream from the head pond over time. Option 3 assumes the dam will be removed in stages over three years. This should spread the release of sediment over three years and therefore minimize concerns with sediment transport downstream of the dam.

With Option 3, it is assumed that say the top 1.2 m of the dam would be removed in year 1. In practise this could mean an initial series of notches is cut in the sheet piling wall to drop the water level in the head pond by 1.2 m over the course of say two weeks. Subsequently, the balance of the sheet pile above the new water level could be removed along with removal of the armour stone above the new level.

Given the average water depth now is approximately 1.1 m above the accumulated sediment, some sediment would be mobilized during the first year removal.

The next year, an additional 0.8 to 1.2 m of sheet pile height could be removed along with the armour stone above the new water level. This second lowering would increase substantially the volume of sediment released over time.

In the third year, the balance of the dam would be removed. More sediment would be released over time, and it could take several seasons for the new stream channel to fully develop. While a substantial volume of sediment would be washed downstream in the three years, there would likely still be a significant volume of sediment that would remain in the head pond that would likely revegetate with grass and shrubs naturally.

As noted, a stable channel through the sediment therefore may take several years to fully develop. As per the GEO Morphix report, channel meander may be significant and total volumes of sediment released from the head pond over time could be very large. However, removal of the dam over several years would result in a relatively gradual release of sediment over several years. This should minimize any negative impacts of sediment transport downstream of the dam.

In practise, it may be difficult to remove a dam slowly over several years. In most cases, an experienced construction company with heavy equipment is hired to remove the dam. Mobilization of equipment, preparation of the site for construction, providing equipment access etc. and other economic factors usually favours completion of a dam removal project in a relatively short, one season period with no major interruptions. As well, if grant funding is available, the terms of the grant funding may require the complete project be done in one season. As well, part removal of the dam each year over several years can lead to complications with obtaining permits from regulators. Part removal of the dam may require the proponent (the dam owner) to prove the partially removed dam remains safe to the public and structurally stable until the full dam is removed.

The main benefit of a slow dam removal process is, theoretically, that sediment management can be improved and major loss of stored sediment from the head pond to the downstream watercourse can be avoided.

As per **Table 7** the preliminary capital cost of Option 3 (excluding engineering, planning and permitting costs) is estimated to be $1,900,000. The cost for dam removal is higher as the complete dam is removed partially every year and the contractor (or contractors) have to remobilize etc. to the project site over a three year period.

7.1.4 Option 4 – Remove Entire Dam in One Year. Allow Sediment to Be Washed Downstream Over One Year After Dam Is Removed.

This option is the same as Option 3 except the dam is completely removed over one year.

With this case, the full water drop (3.35 m) will occur relatively quickly, and water levels would stay low and consistent for larger flood flows as well as smaller flows as the full width of the existing dam (45 m wide) would be available to convey large flood flows.

More sediment would migrate downstream in the first year though total sediment transported downstream would be essentially the same for Option 3 and Option 5 though sediment discharge would be more spread out over time than with Option 5.

As per **Table 7**, the preliminary capital cost of Option 4 (excluding engineering, planning and permitting costs) is estimated to be $1,400,000 to $1,600,000. Costs for this Option is relatively low as there is no significant active sediment management costs and the dam is fully removed in a single year construction contract.

7.1.5 Option 5 – Remove Portion of Dam in One Year. Provide Step Pool System Downstream of Remaining Dam to Provide Fish Passage Through Lowered Dam Crest. Allow Relatively Small Portion of Sediment to Be Washed Downstream.

This Option is part removal of the dam only. With this option, the top portion of the dam is removed and a smaller flow way through the central portion of the remaining sheet pile wall is also removed.

The intent is to allow a new channel to carve through the upper sediment layer but provide a grade control level, and central flow through location in the remaining dam, to control upstream channel formation and minimize downstream sediment migration.

Figure 5A provides a cross section view of the existing dam on top and a second view below showing one possible option for partial dam removal. As per the drawing, it proposed that the top 0.9 m of the dam be first removed which would drain a significant amount of water from the head pond but leave a water level that is still slightly above the top of sediment in the head pond.

The second step would be removal of additional sheet pile to provide a spillway through the remaining sheet pile wall. See **Figure 5B**. The spillway is 0.8 m deep by 8.8 m wide with additional end slopes at 3:1 slope. In addition, a 0.5 m deep by 2 m wide low flow channel would be cut through the sheet pile wall below the main spillway for a low flow channel.

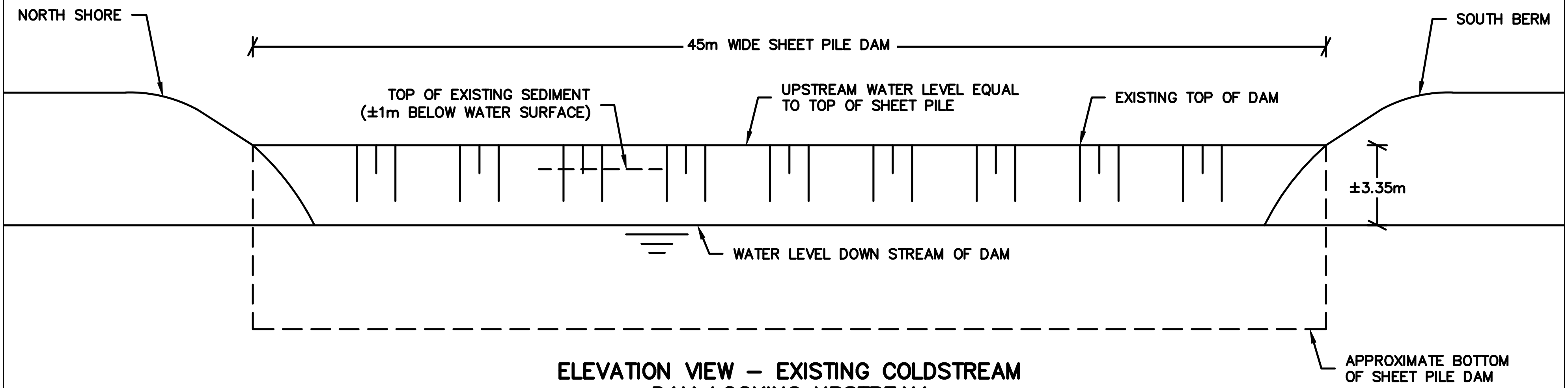
Based on the spillway geometry, the cross section area of sediment upstream of the flow way (including low flow channel) is approximately 6 square meters. If this area of new channel formed upstream for the entire length of the head pond (approximately 500 m), then approximately 3,000 cubic meters of sediment would move downstream. If 50% more sediment was lost due to channel meanders forming upstream, then total sediment lost would be approximately 4,500 cubic meters. This compares to an estimated volume of 22,500 cubic meters of sediment in the head pond.

The cross section of the spillway, as above, is approximately 6 square meters. The estimated 2 year return flood flow is 19 m^3/s. At a nominal velocity of 3 m/s, the spillway has a capacity of approximately the 2 year return flood flow. This flow will be sufficient to carve a stable channel through the sediment upstream but leave a significant flood plain area on each side of the channel. Under very large flows (i.e. 50 and 100 year flood flows), the water level would rise and flow over the entire top of the remaining dam.

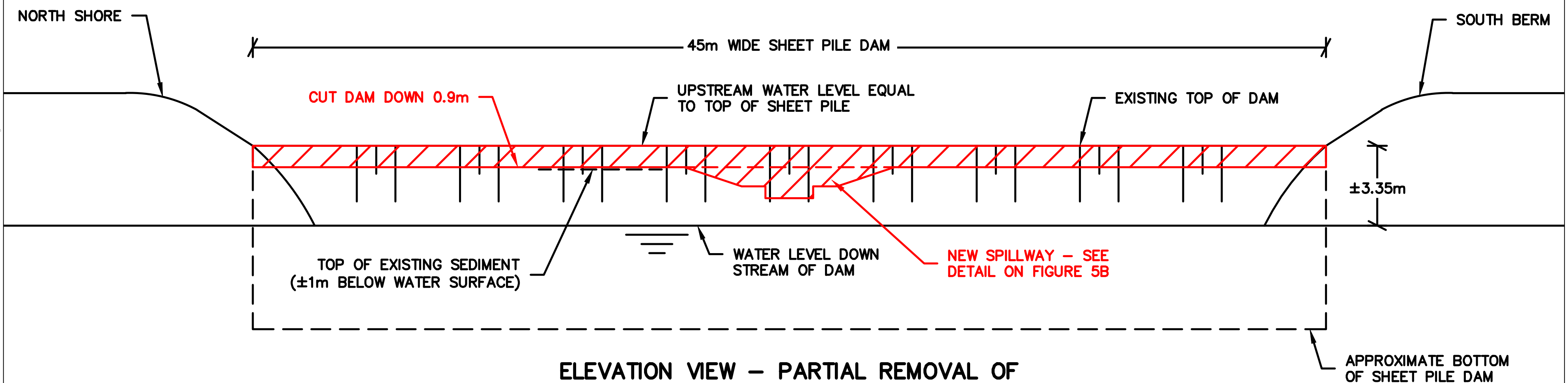
The cross section of the low flow portion of the spillway is 2 m wide by 0.5 m (1 square meter) which should convey 2 m^3/s at a nominal flow velocity of 2 m/s. This exceeds the average, annual stream flow of 0.7 m^3/s by approximately 3 times. As such, normally, all stream flow would pass through the low flow portion of the spill way.

Downstream of the low flow spill way, the large armour stone on site would be repurposed to form a series of 200 mm (8") high step pools to provide a rocky ramp style fishway from the river below up to the low flow spillway. The sheet pile dam now has armour stone for approximately 11 m downstream of the dam to the river below. This would allow for 5 step pools with a nominal length of 2 m each (and a drop of 8" from pool to pool) to be constructed over the 11 m. This should allow migration of fish up through the remaining dam for even weak swimming fish.

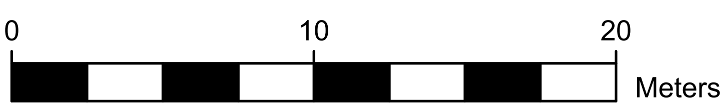
Figure 5C shows a similar step pool constructed on Armstrong Creek in Markdale, Ontario. The step pool system was part of a dam removal project on this stream. In this case, the dam on Armstrong Creek was an earthen berm dam and the intent was to remove most of the dam but leave the dam base intact to retain most of the pond sediment. The step pool allows the dam base to remain but also to restore fish passage up Armstrong Creek.



ELEVATION VIEW – EXISTING COLDSTREAM DAM LOOKING UPSTREAM



ELEVATION VIEW – PARTIAL REMOVAL OF COLDSTREAM DAM LOOKING UPSTREAM

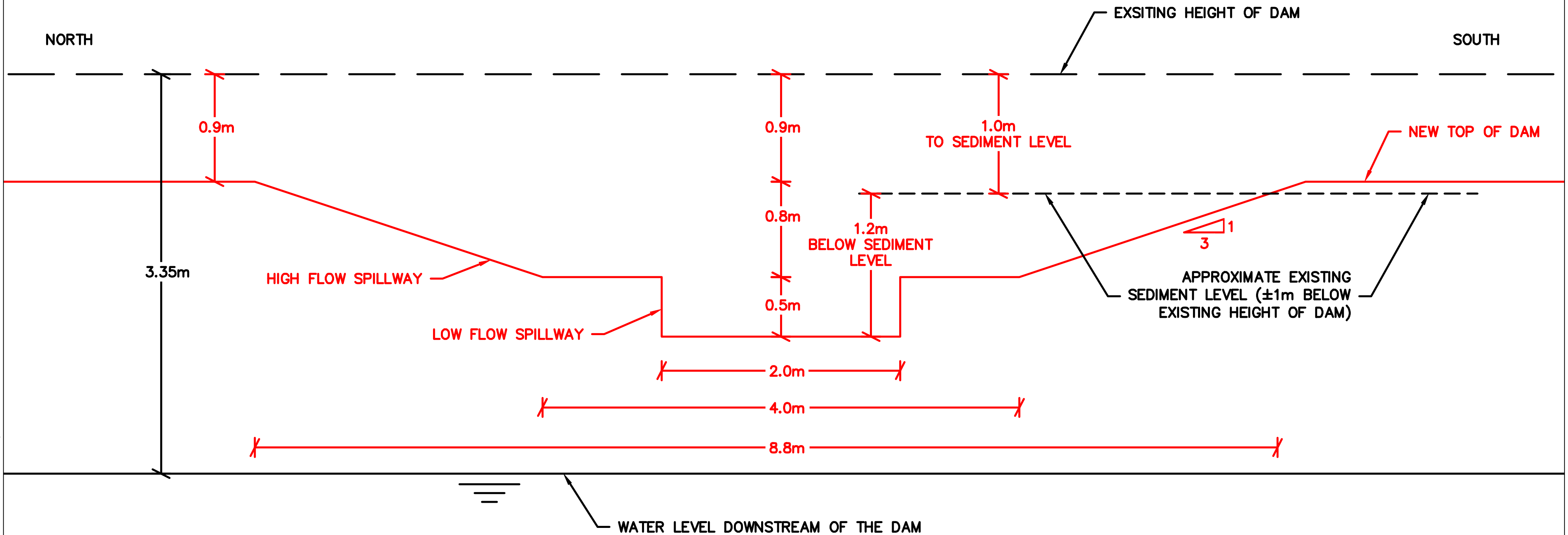


SCALE 1:250

PARTIAL REMOVAL OF THE COLDSTREAM DAM

GSS ENGINEERING CONSULTANTS LTD

Design:	JTG
Drawn:	JTB
APPROVED:	JTG
Date:	JULY 2023
Scale:	1:250
FILE No.	21-118
FIG. No.	5A



ELEVATION VIEW – DETAIL OF NEW SPILLWAY

0 2 4 Meters

SCALE 1:50

PARTIAL REMOVAL OF THE
COLDSTREAM DAM
NEW SPILLWAY DETAIL

ENGINEERING CONSULTANTS LTD

Design:	JTG
Drawn:	JTB
APPROVED:	JTG
Date:	JULY 2023
Scale:	1:50
FILE No.	21-118
FIG. No.	5B

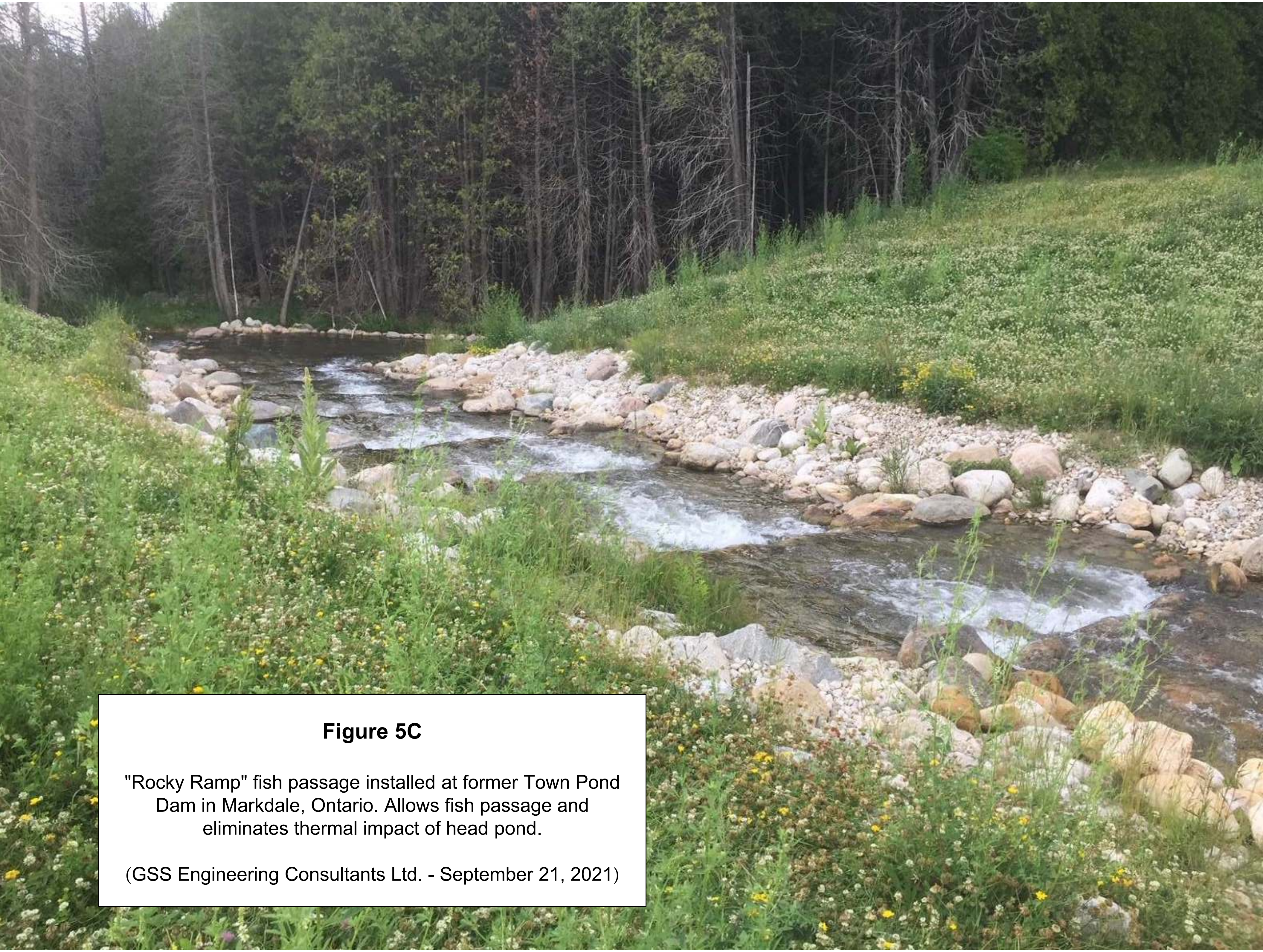


Figure 5C

"Rocky Ramp" fish passage installed at former Town Pond Dam in Markdale, Ontario. Allows fish passage and eliminates thermal impact of head pond.

(GSS Engineering Consultants Ltd. - September 21, 2021)

As per **Table 7**, the preliminary capital cost of Option 5 (excluding engineering, planning and permitting costs) is estimated to be $800,000. As per **Table 7**, the capital cost of the partial dam removal option is estimated to be $500,000 (relatively low cost) as much of the sheet pile steel remains in place. Also, approximately 60% of the armour stone could remain on site. The existing armour stone would also be used to construct the rocky ramp step pool system. The total cost estimate is $800,000 which includes $300,000 for bioengineering stabilization of emerging stream banks.

Part removal of the dam, in conjunction with the rocky ramp step pool system, provides significant cost savings, provides effective fish passage and minimizes downstream sediment transport.

7.1.6 Option 6 – Construct Permanent Bypass Channel Around Head Pond. Leave Dam and Head Pond Sediment As Is.

This Option builds in some part on Option 2 (temporary bypass channel around the head pond) but in this case the channel is permanent.

Figure 6A provides a plan view of the new natural stream channel running through the conservation area on the northwest side of the existing head pond. Overall, the new channel would be approximately 350 m long and would route the main branch of the Sydenham River around the head pond. However, the smaller unnamed tributary entering the top of the head pond from the northeast (labelled Unnamed Tributary A) would continue to flow into the head pond as per current conditions with this conceptual design. See end of this section for **Figure 6A** (and for **Figure 6B**).

However, the majority of sediment coming into the head pond would be eliminated as well as nutrients, etc. that contribute to periodic algae blooms in the head pond. This approach would also restore free fish passage up the Sydenham River and allow the majority of sediment in the river system to be transported downstream naturally. Leaving the dam and sediment in place avoids the upfront cost of full or partial dam removal and retains a local lake type water feature.

The new channel would be constructed to include fish habitat features and be hydraulically designed so it conveys summer low flows as well as safely conveying peak flood flows and by rights should be designed to safely convey the regional flood flow which is normally two times or more of the 100 year flood flow.

As per **Table 3,** the 100-year flood flow is estimated to be 45 cubic meters per second (m^3/s). Therefore, for preliminary design purposes, the regional flood flow is estimated as 100 m^3/s. Assuming a water depth under flood conditions of 1.5 m deep and a flow velocity of 3 m/s, the width of the new channel flood plain would have to be approximately 20 m wide given the side slopes of the new channel are included in the conveyance cross section.

This relatively flat, broad floodplain would normally be dry and would support natural vegetation. Within the flood plain, a smaller, low flow channel would be constructed to carry approximately the 2- year return flood flow (19 m^3/s – see **Table 3**) at bank full conditions. Assuming a 2.5 m/s velocity at bank full conditions, the low flow channel would be approximately 7.5 m wide by 1 m deep. This channel would be constructed of imported, natural large stone and gravel to replicate as close as possible a natural stream channel and include riffles and pools and meandering similar to existing conditions upstream and downstream of the dam location. For costing, 1,000 tonnes of 12” to 16” diameter natural stone and 2” to 3” diameter river stone is assumed.

Figure 6B provides cross section views though the head pond and new channel area at the 25% and 75% points down the new channel. As per **Figure 6B**, the elevation of land where the channel is built is approximately 3.5 m above the existing water level in the head pond at the upstream end of the head pond but is about 2.5 m above the head pond near the dam.

As the new channel has to be lower than the pond level at the upstream end, the upstream excavation depth is approximately 4.5 m deep. As the new channel progresses downstream, it needs to get progressively deeper until it is at the same level of the river downstream of the dam. As such, the depth of excavation of the channel at the downstream end is approximately 7.0 m below the existing ground level.

Given the depth of the channel excavation (4.5 m to 7.0 m deep) and the approximate 20 m width of the flood plain, (before side slopes are considered), the volume of fill requiring excavation and disposal elsewhere would be approximately 56,000 cubic meters. This is a very large volume compared to the amount of sediment (approximately 22,500 cubic metes) contained within the head pond.

The success of the project relies on the remaining native earth material between the pond and the new stream channel being structurally and hydraulically stable to prevent seepage of water though this material from the higher water level in the head pond into the new, lower stream channel. As well, the fill removed from the new channel would be subject to relatively new provincial Excess Fill regulations that require extensive contaminant testing of fill being transported offsite and a reporting schedule for the off site disposal location(s) of the fill. In addition, some bridge passage from the conservation authority lands to the northwest of the new channel to the berm area between the head pond and new channel may be required to access the north end of the existing dam for maintenance.

As per **Table 7**, the estimated cost of Option 6 is $1,800,000 to $2,100,000. This value includes excavation and then disposal of the excess fill elsewhere. The estimate cost also includes significant volumes of new natural stone to build a series of low level step pools as well as topsoiling, seeding and planting of native trees and shrubs along the side slopes of the new channel. While this option avoids any cost of dam removal, or removal of the sediment in the dam head pond, the dam may need to be removed at some point in the future. Future dam removal would require dealing with the sediment at that time.

There are also property constraints at the downstream end of the new channel where it would connect to the existing river below the dam. A private property extends into this area from the north and leaves little room to create the new channel and continue pedestrian pathways in this area.

Finally, it may be preferable to have some water overflow into the head pond from the Sydenham River during flood events to shed some of the flood flow out of the new natural channel. However, this would require detailed hydraulic analysis to determine if some shedding of peak flood flow is feasible.

7.1.7 Option 7 – Do Nothing. Leave Dam and Sediment As Is.

With this option, no action would be taken with the dam or sediment. Costs (economic and social) would be minimal. However, this option ignores the fact the dam likely has a finite service life and ultimately the dam could fail, become unsafe or the environmental effects of the dam could become significant.

Costs will also rise with time as more stringent environmental regulations might evolve with time. As well, the total sediment storage capacity of the dam does not appear to have occurred as yet. In other words, the reservoir still appears to be filling with sediment. As per this report, the dam was constructed approximately 55 years ago in 1968. It is therefore possible that the total sediment volume stored in the head pond in the future could be 50% to 100% more than currently exists in the head pond.

As such, costs for dam removal and sediment management will likely increase with time due to greater sediment volumes and additional regulatory requirements before inflationary effects are considered.

7.2 Summary of Options and Costs

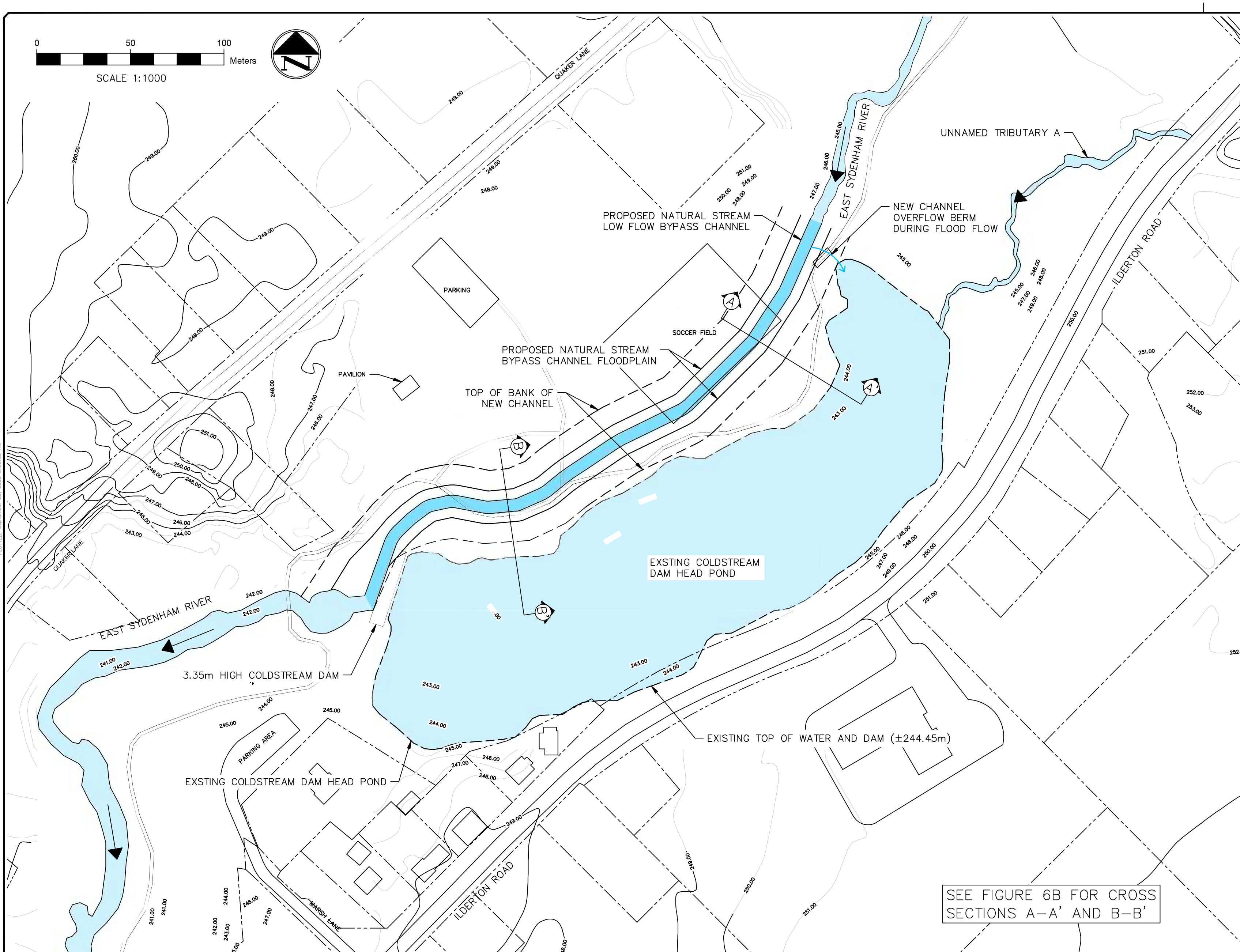
As per the above analysis, there appears to be very significant cost and technical challenges to complete Option 1 or Option 2. Both of these options would deal proactively with the sediments to prevent sediment in the head pond from being naturally transported downstream. However, the technical and environmental challenges, and the capital and engineering costs of Option 1 and 2, would appear beyond the reach of the project.

As such, the recommendation of this report is that Option 1 and Option 2 are not considered feasible at this time and that Option 3, 4, 5 and 6 be considered further for removal or modification of the Coldstream dam.

7.3 Potential Removal of Coldstream Dam Next-Steps

The flow chart overleaf provides a general outline of the next steps for the potential removal of the Coldstream dam. The flow chart includes numerous steps including selection of the preferred dam removal and sediment management method, consultation with review agencies, recommended additional studies, engineering of the dam removal drawings and specifications, tendering the project, removal of the dam, and finishing with the rehabilitation of the former head pond area.

Emphasize is placed on effective communication with review agencies. If the dam is to be removed, it is very important that all appropriate review agencies (MNRF, MECP, DFO, Indigenous groups) are consulted in advance to determine the preferred method to remove the dam and to manage the sediment. If passive sediment management is the preferred option, it is important that all review agencies are aware of the affects this will have on the East Sydenham River (increased turbidity and siltation downstream of the dam).



SEE FIGURE 6B FOR CROSS SECTIONS A–A' AND B–B'

KEY PLAN

LEGEND

- EDGE OF EXISTING HEAD POND
- PROPERTY LINE
- EXISTING TRAIL
- DAM HEAD POND AND EXISTING RIVER
- PROPOSED LOW FLOW CHANNEL OF PORTION OF NEW NATURAL STREAM CHANNEL
- 253.00 *CONTOURS (1.00m)

*ELEVATION CONTOURS IN THE RESERVOIR REPRESENT THE HARD BOTTOM.

CAUTION: THE POSITION OF POLE LINES, CONDUITS, WATERMAINS, SEWERS, PROPERTY LINES AND OTHER UNDERGROUND AND OVERGROUND UTILITIES ARE STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES, PROPERTY LINES & STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES, PROPERTY LINES & STRUCTURES, AND SHOULD ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

DD/MM/YY	DESCRIPTION
	REVISION / ISSUE

Seal not valid unless signed and dated

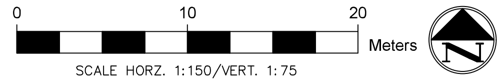
ENGINEERING CONSULTANTS LTD
Unit 104D 1010 9th Avenue West, Owen Sound, ON, N4K 5R7
Telephone: (519) 372-4828

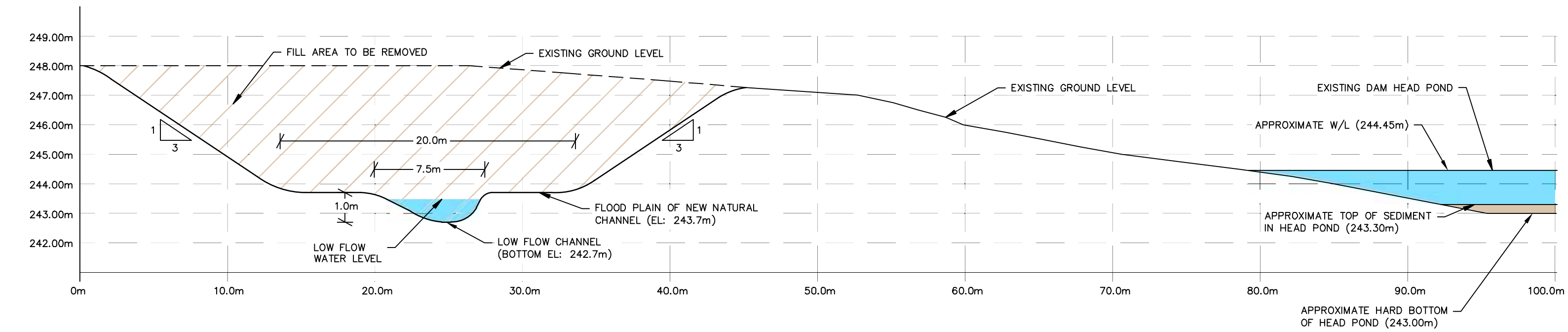
Title:
PROPOSED CHANNEL
AROUND HEAD POND
COLDSTREAM DAM

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	JTG	Scale:	1:1000
Drawn:	JTB	Approved:	Design Engineer
Checked:	JTG		
Date:	SEPT 2023		

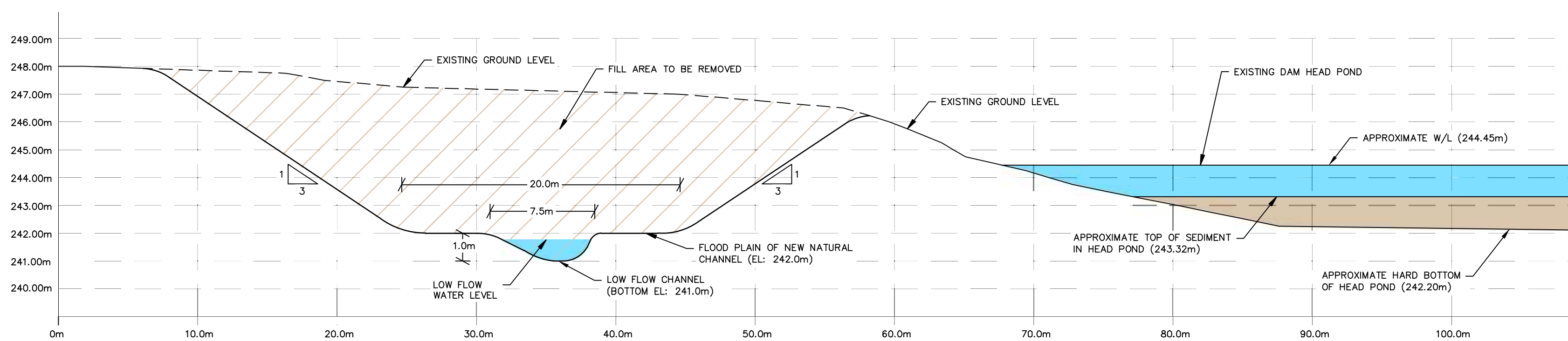
Drawing No. 21118C–FIGURE 6A





CROSS SECTION A–A' – UPSTREAM SECTION

SCALE HORZ. 1:150/VERT. 1:75



CROSS SECTION B–B' – DOWNSTREAM SECTION

SCALE HORZ. 1:150/VERT. 1:75

KEY PLAN

LEGEND

- DAM HEAD POND
- SEDIMENT
- EXISTING GROUND
- PROPOSED CHANNEL

*AREAS FOR POTENTIAL EROSION CONTROL ARE BASED ON THE ASSUMED FINAL CHANNEL PATH. THE ACTUAL AREAS REQUIRING EROSION CONTROL SHOULD BE SELECTED BASED ON THE ACTUAL FINAL CHANNEL PATH.

**ELEVATION CONTOURS IN THE RESERVOIR REPRESENT THE HARD BOTTOM AND ASSUME THE ACCUMULATED SEDIMENT IS REMOVED.

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GSS ENGINEERING CONSULTANTS LTD
Unit 104D 1010 9th Avenue West, Owen Sound, ON, N4K 5R7
Telephone: (519) 372–4828

Title:

PROPOSED CHANNEL
AROUND HEAD POND
COLDSTREAM DAM

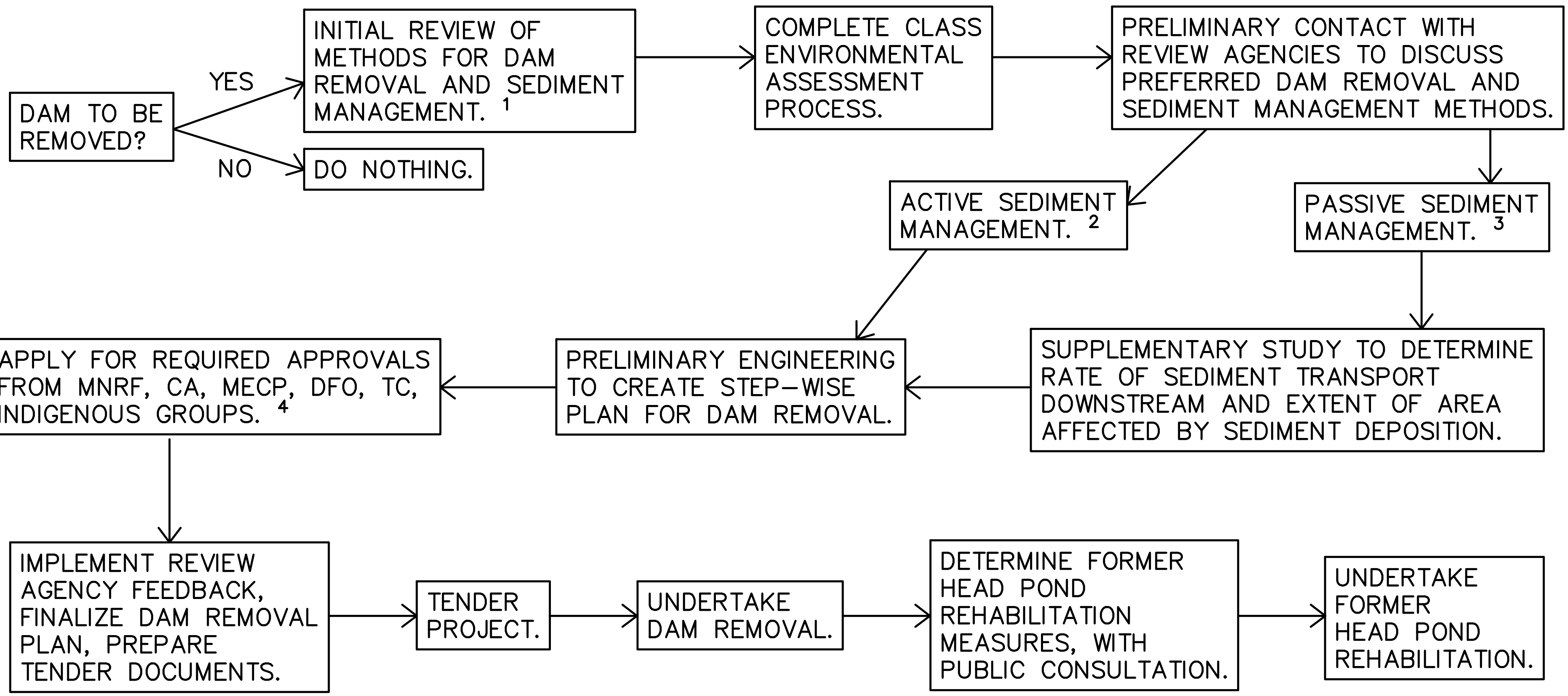
Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	JTG	Scale:	HORZ. 1:150/VERT. 1:75
Drawn:	JTB	Approved:	Design Engineer
Checked:	JTG		
Date:	SEPT 2023		

Drawing No. 21118C–FIGURE 6B

PLOTTED: September 25, 2023 9:31:22 AM
\\GSS_Common\GSS Common\GSS Common\2021\21-118 Head Street and Coldstream Dam Decommissioning\Drawings\Coldstream\21118C.dwg Sep 25, 2023 – 9:31am

POTENTIAL DECOMMISSIONING OF COLDSTREAM DAM
PROJECT FLOW CHART



1. PUBLIC CONSULTATION COULD BE CONSIDERED FOR DETERMINING THE PREFERRED METHOD FOR DAM REMOVAL AND SEDIMENT MANAGEMENT.

2. ACTIVE SEDIMENT MANAGEMENT INCLUDES DREDGING OR EXCAVATING ACCUMULATED SEDIMENT PRIOR TO DAM REMOVAL.

3. PASSIVE SEDIMENT MANAGEMENT CONSISTS OF ALLOWING THE SEDIMENT TO BE TRANSPORTED DOWN STREAM NATURALLY BY THE RIVER.

4. IF PASSIVE SEDIMENT MANAGEMENT IS SELECTED IT IS IMPERATIVE THAT ALL REVIEW AGENCIES ARE FULLY AWARE OF THE EFFECTS.

8 HEAD POND RESTORATION OPTIONS

The Coldstream Dam head pond has an area of approximately 4.5 ha. This large area thus represents an opportunity for a range of rehabilitation options if the dam is removed at some point.

As described in Section 2, removal of a dam can provide new habitat for a large variety of fish and wildlife species and new passive recreational opportunities.

In general, the former head pond area can be allowed to revegetate naturally over time with the new stream channel being allowed to form naturally. Or a variety of new, natural and manmade features could be developed. A list of possible features is as follows:

i) New wildlife habitat. The former head pond area can be restored in a number of ways for new grassland areas. The remaining sediment will contain a seedbank supporting growth of a variety of native plant species once seed germination occurs. Importation of topsoil may be required in some areas.

ii) Alternatively, the former head pond area can be supplemented with new native wildflower and grass lands seed mixes to provide tallgrass grassland and pollinator growth similar to what was originally common to the area. This may require importing some topsoil and/or clean fill material to shape the ground surface and enhance growing conditions.

Photo 5: Meadow seeded with pollinator plants.

Photo 6: Tall grass prairie in southwestern Ontario.

iii) In addition to grassland areas, part or all of the head pond area can be planted with native trees and shrubs to provide forest and edge habitat in addition to grass land habitat.

Photo 7: Tree planting project with popular trees over four year span.

iv) Shallow pool or pond features can be provided by excavating and shaping the remaining sediment. These water features (ponds) could be constructed deep enough to support fish year-round, and therefore provide public fishing opportunities. The water features can also be created as shallow wetland areas or shaped and located so they provide seasonal (ephemeral) wetland conditions.

Photo 8: Wetland pond system with adjacent pollinator areas as well as maintained grass areas.

v) Water features would not typically be directly connected to the new stream channel but could refill from local runoff, by intersecting the local groundwater table or by filling during high water (flood) conditions.

vi) It would be expected that pond or wetland areas would attract a wide variety of insects, birds and animals. Wildlife viewing platforms (or viewing towers) could be provided to support birdwatching etc.

vii) Trails and sitting areas within the head pond area to promote physical activity and located along the edges of wetlands and ponds to better view birds and other wildlife.

viii) The trail network could also feature adjoining parking areas, picnic areas, off leash dog parks or other recreational amenities including canoe and kayak access points.

ix) The final stream channel can be enhanced to provide erosion control and improved fish habitat conditions. Fish habitat can be enhanced with step pools, spawning gravels, vortex weirs and woody overhead cover. Stream fishing opportunities can also be provided.

The following sections outlines preliminary, recommended restoration options for the Coldstream head pond area once the dam is removed.

8.1 Overview of Head Pond Restoration Options.

In discussion with the SCRCA, a limited range of relatively low-cost restoration options (capital and maintenance costs) have been considered as part of this report.

Figures 7, 8, 9 and **10** overleaf are provided as conceptual restoration options for the dam head pond area if the dam was removed. These options feature a variety of passive recreational use opportunities, have minimal maintenance costs and provide a variety of natural wildlife habitats. The rehabilitation options are not included in the cost estimates for dam removal or sediment management discussed in Section 7 of this report.

All of the rehabilitation options show areas where erosion control along the new stream channel may be required. These areas include the shoreline at the dam site and along the south shoreline as this is the estimated path of the final river channel through the head pond area. If the final river path is different then that depicted on the restoration drawings, the areas requiring erosion control should be altered accordingly. The GEO Morphix study (January, 2023) in **Appendix B** describes potential erosion control methods.

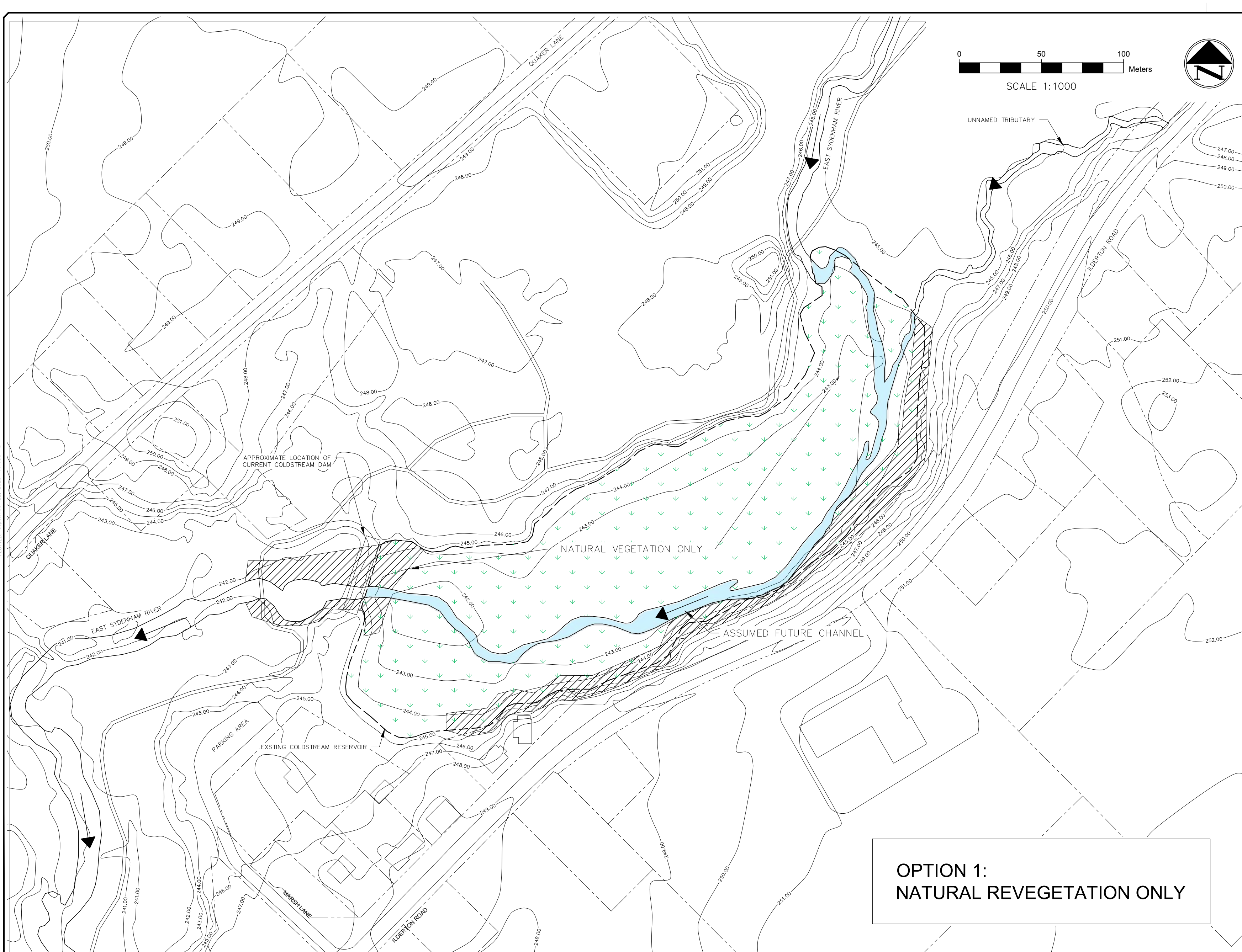
As noted in Section 7 of this report, it is likely unrealistic for a dam removal strategy to be implemented that proactively removes the accumulated sediment in the Coldstream dam reservoir. Therefore, it is assumed that if the dam is removed the accumulated sediment will be left to be naturally transported downstream over time. As the river meanders through the empty reservoir in search of its final channel path, much of the sediment may be transported and this will alter the topography of the former reservoir area. As such it is recommended that any major head pond rehabilitation efforts take place only after the river has found it's final path and the topography is relatively constant. This may take 5-10 years.

Alternatively, Section 7 describes Option 6 which includes a permanent, natural bypass channel around the dam and head pond. This option would avoid release of sediment from the head pond. The following rehabilitation options for the head pond area would not apply to Option 6 as the head pond would remain "as is" with Option 6.

Until the river has created a final path, the large plain of drying sediment and meandering river may be quite soft and dangerous for human use. Therefore, it is recommended that human use of the former head pond is discouraged until rehabilitation is fully completed.

8.1.1 Head Pond Restoration Option 1 – Natural Grassland and River Edge Wetlands.

This Option is the most basic and allows natural revegetation of the drained head pond area. The head pond sediment and underlying substrate likely contains an extensive, natural "seed bank" of natural grassland and wetland plants that would grow naturally once the head pond water was removed. The wetlands would develop along the stream edges and other areas having wet or moist soil conditions.



KEY PLAN

LEGEND

- EDGE OF EXISTING HEAD POND
- PROPERTY LINE
- EXISTING TRAIL
- ASSUMED FUTURE CHANNEL IN THE EXISTING HEAD POND
- PROPOSED NATURALLY RE-VEGETATED AREA
- PROPOSED PLANTED TREES AT HIGHER ELEVATIONS
- PROPOSED PLANTED WET TOLERANT SHRUBS AT LOWER ELEVATIONS
- PROPOSED TRAIL
- PROPOSED WATER FEATURE (POND/WETLAND)
- OVERFLOW CULVERT FROM WATER FEATURE TO RIVER
- *AREA FOR POTENTIAL EROSION CONTROL
- 253.00 **CONTOURS (1.00m)

*AREAS FOR POTENTIAL EROSION CONTROL ARE BASED ON THE ASSUMED FINAL CHANNEL PATH. THE ACTUAL AREAS REQUIRING EROSION CONTROL SHOULD BE SELECTED BASED ON THE ACTUAL FINAL CHANNEL PATH.

**ELEVATION CONTOURS IN THE RESERVOIR REPRESENT THE HARD BOTTOM AND ASSUME THE ACCUMULATED SEDIMENT IS REMOVED.

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DD/MM/YY	DESCRIPTION
	REVISION / ISSUE

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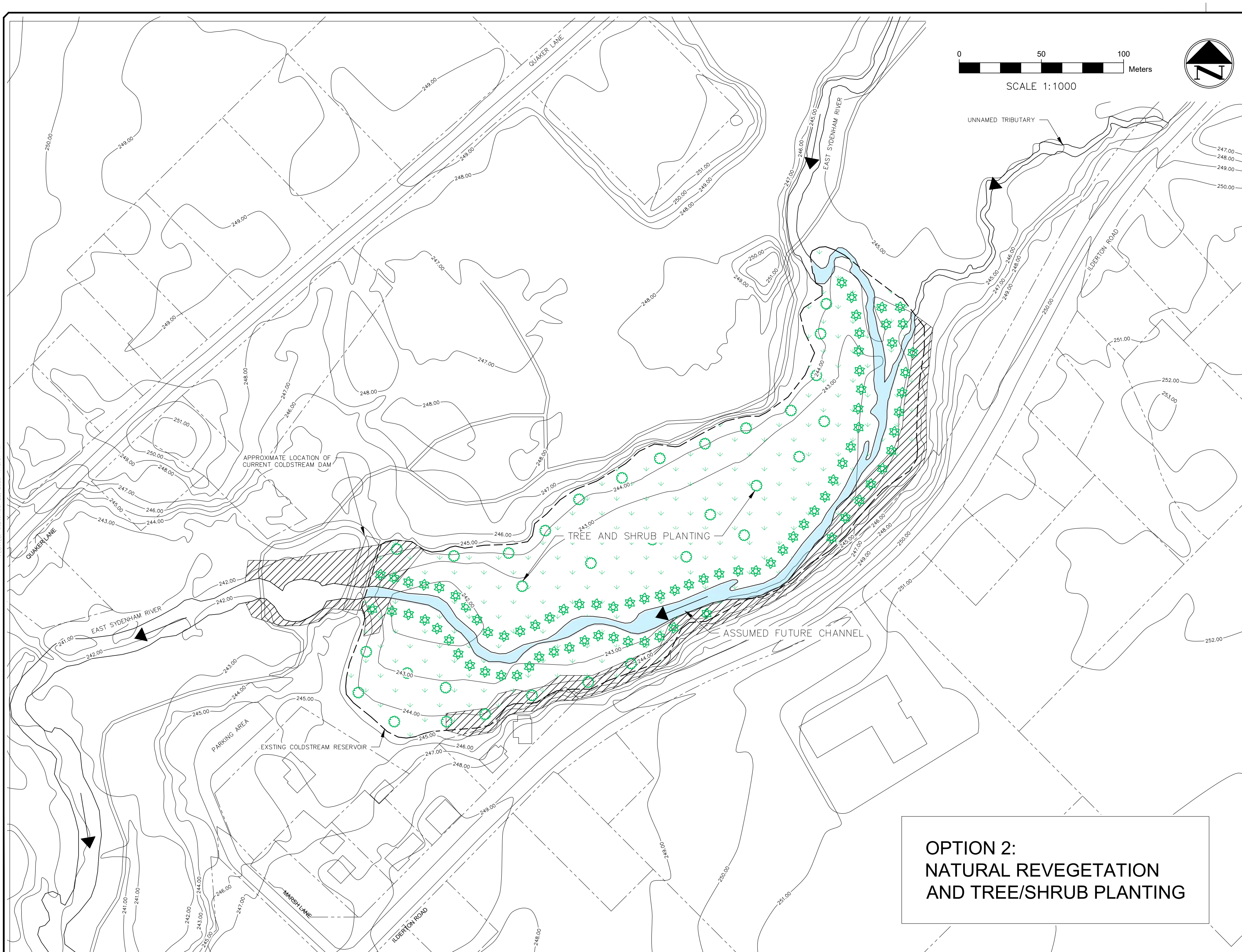
GSS ENGINEERING CONSULTANTS LTD
Unit 104D 1010 9th Avenue West, Owen Sound, ON, N4K 5R7
Telephone: (519) 372-4828

Title:
OPTION 1
HEAD POND RESTORATION
COLDSTREAM DAM

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	JTG	Scale:	1:1000
Drawn:	JTB	Approved:	Design Engineer
Checked:	JTG		
Date:	JUNE 2023		

Drawing No. 21118C-FIGURE 7



OPTION 2:
NATURAL REVEGETATION AND TREE/SHRUB PLANTING

KEY PLAN

LEGEND

- EDGE OF EXISTING HEAD POND
- PROPERTY LINE
- EXISTING TRAIL
- ASSUMED FUTURE CHANNEL IN THE EXISTING HEAD POND
- PROPOSED NATURALLY RE-VEGETATED AREA
- PROPOSED PLANTED TREES AT HIGHER ELEVATIONS
- PROPOSED PLANTED WET TOLERANT SHRUBS AT LOWER ELEVATIONS
- PROPOSED TRAIL
- PROPOSED WATER FEATURE (POND/WETLAND)
- OVERFLOW CULVERT FROM WATER FEATURE TO RIVER
- *AREA FOR POTENTIAL EROSION CONTROL
- 253.00 **CONTOURS (1.00m)

*AREAS FOR POTENTIAL EROSION CONTROL ARE BASED ON THE ASSUMED FINAL CHANNEL PATH. THE ACTUAL AREAS REQUIRING EROSION CONTROL SHOULD BE SELECTED BASED ON THE ACTUAL FINAL CHANNEL PATH.

**ELEVATION CONTOURS IN THE RESERVOIR REPRESENT THE HARD BOTTOM AND ASSUME THE ACCUMULATED SEDIMENT IS REMOVED.

CAUTION: THE POSITION OF POLE LINES, CONDUITS, WATERMAINS, SEWERS, PROPERTY LINES AND OTHER UNDERGROUND AND OVERGROUND UTILITIES ARE STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES, PROPERTY LINES & STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, THE CONTRACTOR SHALL INFORM HIMSELF OF THE EXACT LOCATION OF ALL SUCH UTILITIES, PROPERTY LINES, & STRUCTURES, AND SHOULD ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

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GSS ENGINEERING CONSULTANTS LTD

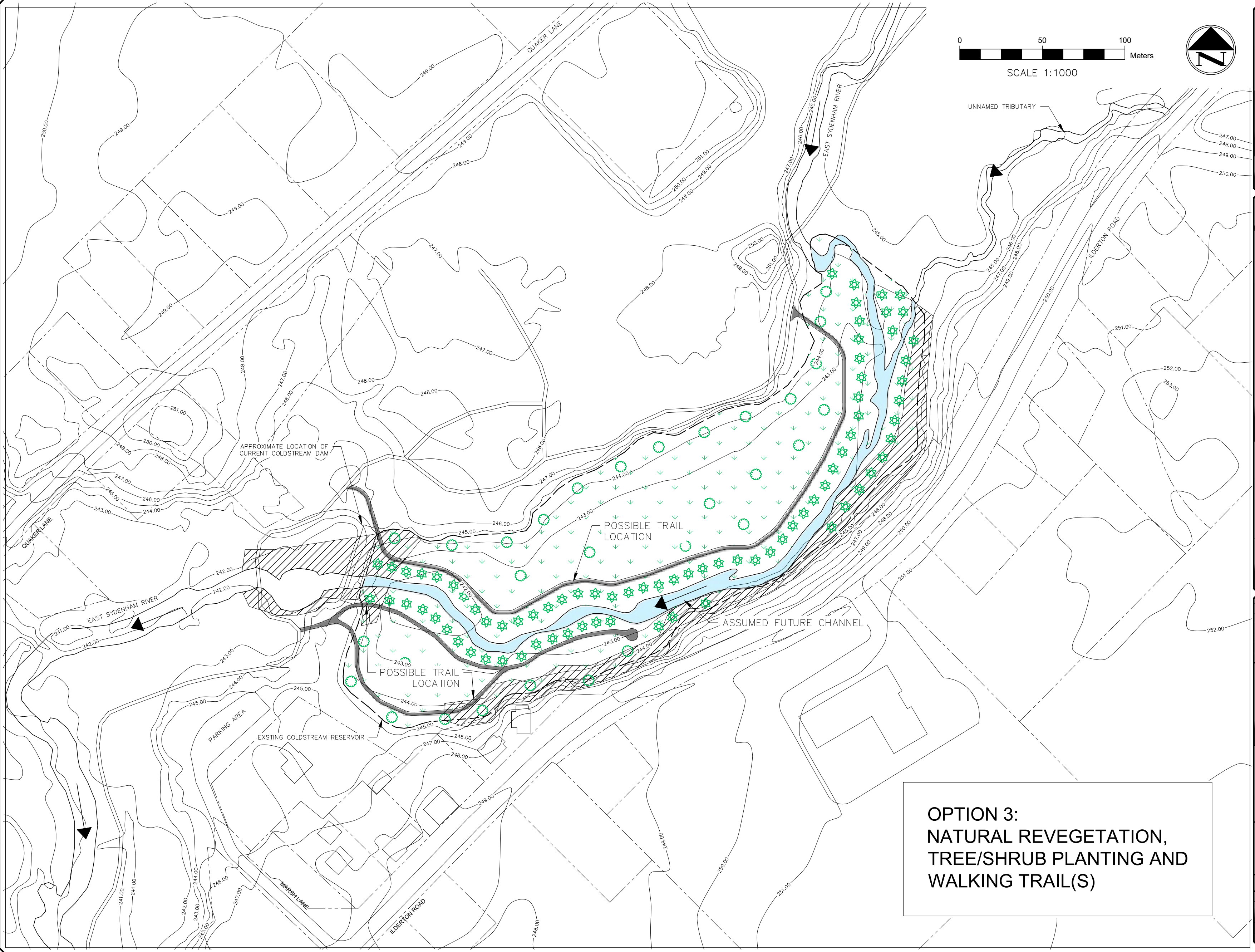
Unit 104D 1010 9th Avenue West, Owen Sound, ON, N4K 5R7
Telephone: (519) 372-4828

Title:
OPTION 2
HEAD POND RESTORATION
COLDSTREAM DAM

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	JTG	Scale:	1:1000
Drawn:	JTB	Approved:	Design Engineer
Checked:	JTG		
Date:	JUNE 2023		

Drawing No. 21118C-FIGURE 8



OPTION 3:
NATURAL REVEGETATION, TREE/SHRUB PLANTING AND WALKING TRAIL(S)

KEY PLAN

LEGEND

- EDGE OF EXISTING HEAD POND
- PROPERTY LINE
- EXISTING TRAIL
- ASSUMED FUTURE CHANNEL IN THE EXISTING HEAD POND
- PROPOSED NATURALLY RE-VEGETATED AREA
- PROPOSED PLANTED TREES AT HIGHER ELEVATIONS
- PROPOSED PLANTED WET TOLERANT SHRUBS AT LOWER ELEVATIONS
- PROPOSED TRAIL
- PROPOSED WATER FEATURE (POND/WETLAND)
- OVERFLOW CULVERT FROM WATER FEATURE TO RIVER
- *AREA FOR POTENTIAL EROSION CONTROL
- 253.00 **CONTOURS (1.00m)

*AREAS FOR POTENTIAL EROSION CONTROL ARE BASED ON THE ASSUMED FINAL CHANNEL PATH. THE ACTUAL AREAS REQUIRING EROSION CONTROL SHOULD BE SELECTED BASED ON THE ACTUAL FINAL CHANNEL PATH.

**ELEVATION CONTOURS IN THE RESERVOIR REPRESENT THE HARD BOTTOM AND ASSUME THE ACCUMULATED SEDIMENT IS REMOVED.

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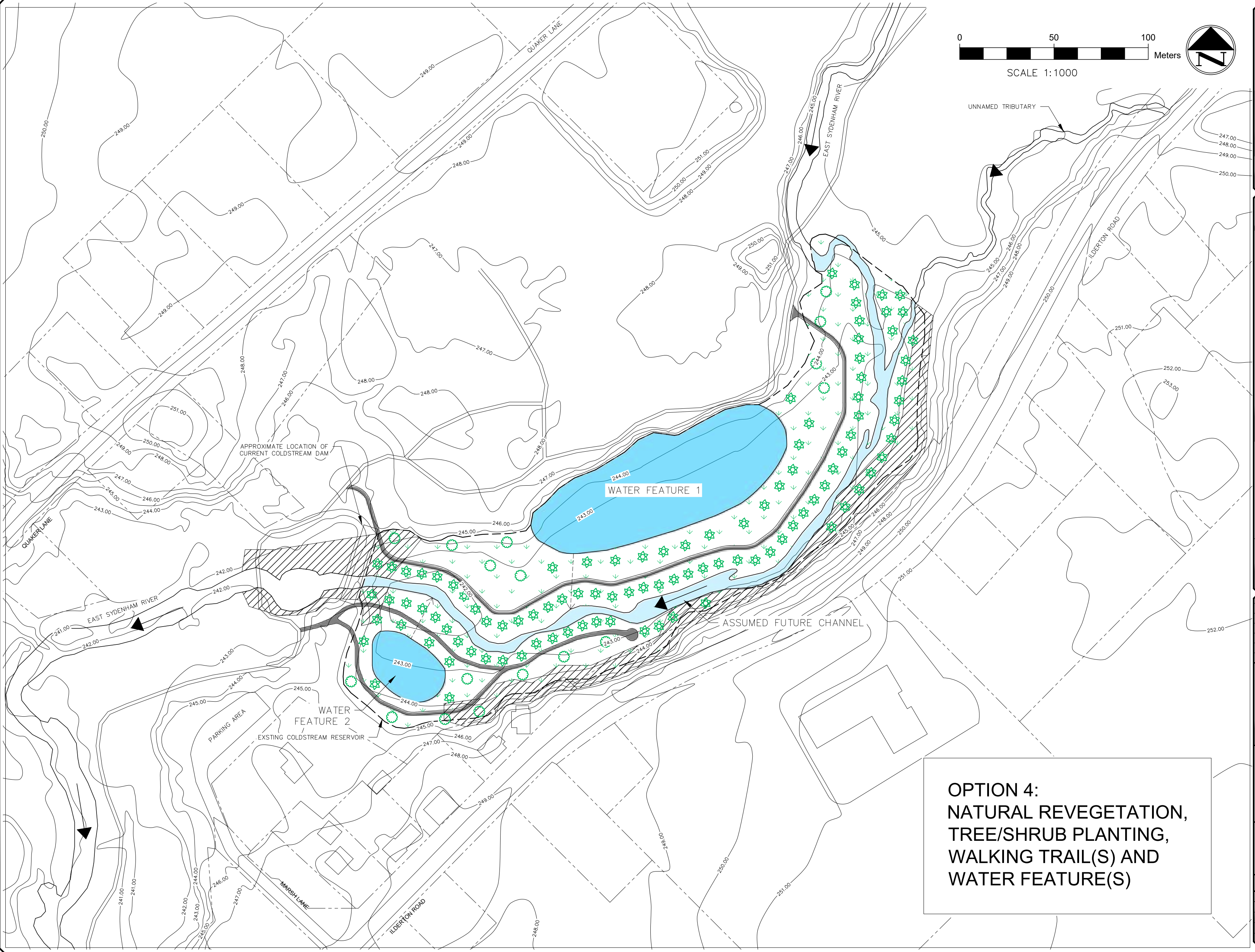
Telephone: (519) 372-4828

Title:
OPTION 3
HEAD POND RESTORATION
COLDSTREAM DAM

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	JTG	Scale:	1:1000
Drawn:	JTB	Approved:	Design Engineer
Checked:	JTG		
Date:	JUNE 2023		

Drawing No. 21118C-FIGURE 9



OPTION 4:
NATURAL REVEGETATION,
TREE/SHRUB PLANTING,
WALKING TRAIL(S) AND
WATER FEATURE(S)

KEY PLAN

LEGEND

- EDGE OF EXISTING HEAD POND
- PROPERTY LINE
- EXISTING TRAIL
- ASSUMED FUTURE CHANNEL IN THE EXISTING HEAD POND
- PROPOSED NATURALLY RE-VEGETATED AREA
- PROPOSED PLANTED TREES AT HIGHER ELEVATIONS
- PROPOSED PLANTED WET TOLERANT SHRUBS AT LOWER ELEVATIONS
- PROPOSED TRAIL
- PROPOSED WATER FEATURE (POND/WETLAND)
- OVERFLOW CULVERT FROM WATER FEATURE TO RIVER
- *AREA FOR POTENTIAL EROSION CONTROL
- 253.00 **CONTOURS (1.00m)

*AREAS FOR POTENTIAL EROSION CONTROL ARE BASED ON THE ASSUMED FINAL CHANNEL PATH. THE ACTUAL AREAS REQUIRING EROSION CONTROL SHOULD BE SELECTED BASED ON THE ACTUAL FINAL CHANNEL PATH.

**ELEVATION CONTOURS IN THE RESERVOIR REPRESENT THE HARD BOTTOM AND ASSUME THE ACCUMULATED SEDIMENT IS REMOVED.

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GSS ENGINEERING CONSULTANTS LTD

Unit 104D 1010 9th Avenue West, Owen Sound, ON, N4K 5R7
Telephone: (519) 372-4828

Title:
OPTION 4
HEAD POND RESTORATION
COLDSTREAM DAM

Client: ST. CLAIR REGION CONSERVATION AUTHORITY

Design:	JTG	Scale:	1:1000
Drawn:	JTB	Approved:	Design Engineer
Checked:	JTG		
Date:	JUNE 2023		

Drawing No. 21118C–FIGURE 10

In addition to the natural seed bank, this Option could include supplemental seeding with an initial “cover crop” to stabilize exposed soils as quickly as possible. The cover crop could also be combined with additional seeding with native, tallgrass prairie plants and wetland plant species.

This option would take several years to fully develop but would likely feature extensive plant growth in the second summer after the dam and head pond were removed. Such a grassland/wetland plant environment would provide good quality habitat within several years for a wide variety of bird, mammal and amphibian species as well as a wide variety of insect and pollinator species.

This Option does not include any trails or other features to specifically provide outdoor recreational opportunities, but the overall area would remain available for passive public use.

8.1.2 Head Pond Restoration Option 2 – Trees, Shrubs, Natural Grasslands and River Edge Wetlands.

Option 2 is the same as Option 1 but includes planting of native trees and shrubs in addition to establishing an extensive area of native plant and wetland plant growth. A more diverse range of wildlife habitats would be created over time that could expand the diversity of bird, animal and insect species.

8.1.3 Head Pond Restoration Option 3 – Modest Pedestrian Trail System Included with Trees, Shrubs, Natural Grasslands and River Edge Wetlands.

Option 3 includes all features included in Options 1 and 2 but introduces a walking trail component.

The walking trail component would be modest in scope and be designed to encourage passive, non-motorized use of the area with recreational use confined primarily to the walking trail corridors. To minimize maintenance requirements, additional amenities such as picnic shelters, additional parking areas, washrooms etc. are not proposed with Option 3.

Most of the area would continue to provide diverse, good quality wildlife habitat.

8.1.4 Head Pond Restoration Option 4 – Pond and Wetland Features as Well as Modest Pedestrian Trail System with Trees, Shrubs, Natural Grasslands and River Edge Wetlands.

This Option would include all the features of Options 1, 2 and 3 but would introduce several wetland or pond features separate from the actual stream channel. It would be anticipated that these water features would be shallow, excavated areas where the water levels are similar or the same as the water level in the adjacent stream channel.

Portions of the wetland or pond features would be located close to the trail edges to provide more wildlife viewing opportunities. The wetland and pond features would provide additional habitat features for a wide variety of shorebird and waterfowl species as well as other bird, mammal, amphibian and reptile species including turtles.

9 NATURAL (ECOLOGICAL) IMPACTS AND BENEFITS OF DAM REMOVAL

Overall, the Sydenham River supports a wide diversity of fish and mussel species. At least 82 species of fish and 24 species of mussels have been identified. Many of these fish and mussel species are rare elsewhere. Six species of fish and eleven species of mussels occurring in the watershed have been classified as being endangered, threatened or of special concern.

Numerous publications have described the rich diversity of fish and mussel species in the watershed including the many species considered at risk.

9.1 Impacts of Existing Coldstream Dam on SAR Species

One of these publications is *Action Plan for the Sydenham River in Canada: An Ecosystem Approach* as published by the Fisheries and Oceans Canada in 2018.

This report describes the North and East Sydenham River drainage basins in some detail including gradient, geology and land use. The report notes that much of the original forest and wetland habitat areas within the watershed have been lost. This report describes the East Sydenham River, which includes the Coldstream dam, as follows:

"*The East Sydenham River has a relatively diverse substrate and associated habitat with well defined riffles and pools, which create exceptional habitat for native freshwater mussels (including seven species listed under SARA as Endangered*)."

The report also describes, in general, threats to aquatic species at risk. These risks include negative land use practises, thermal impacts due to loss of stream side riparian zones and the thermal impacts of dams, suspended solids from drainage and overland runoff, nutrient enrichment from point and nonpoint sources, toxic contaminants associated with herbicides and pesticides and impacts of exotic aquatic species.

Dams are described in the report as impacting aquatic habitat by causing thermal warming and impacting normal sediment transport processes. While not noted specifically, dams are also barriers to fish migration. All three of these impacts would be associated with the Coldstream dam as per the following:

- The dam acts as an upstream migration barrier for almost all fish species.
- The temperature of the river increases due to the dam head pond in the summer.
- The dam stores a large volume of silt and sand sediments and impacts the natural transport of sediment in the river.

The report notes "Loadings of suspended solids as causing turbidity and siltation is presumed to be the primary limiting factor for most aquatic species at risk in the Sydenham River watershed." Therefore, removal of the dam could be cause for increased sediment loadings on the river downstream of the Coldstream dam.

9.2 Potential Benefits of Dam Removal on SAR Species

The DFO report also notes dams as being a general cause of two different Specific Threats being sedimentation upstream and erosion downstream. Both of these Specific Threats are considered High in terms of Level of Concern.

Removal of the Coldstream dam (or construction of the permanent, natural bypass channel) should benefit aquatic habitat downstream of the dam by restoring the natural supply of sediment to fish and mussel species downstream of the dam. As well, removal of the dam would reduce the thermal impact of the dam head pond and provide resilience to increased stream warming over time associated with climate change. As well, removal of the dam would eliminate a barrier to fish migration.

9.3 Potential Negative Ecological Impacts of Dam Removal

As per previous sections, removal of the dam may cause significant discharge of sediment stored in the dam head pond in a relatively short span of time depending on the option selected to remove the dam. Such sediment loading on the river downstream of the dam could be cause of negative impacts on fish and mussel habitat if the increased sediment loadings were excessive. The release of this sediment can negatively affect mussel species by limiting essential life cycle processes such as reproduction, respiration and feeding.

If it is decided that the dam is to be removed and sediment is to be managed passively, additional study is recommended to determine the rate of sediment transport and the affected downstream area.

Removal of the dam may also allow exotic fish species (including round goby) to gain access to the river upstream of the dam.

9.4 Impacts/Benefits of Dam Removal on Reptile, Amphibian and Bird Species Composition

Previous sections of the report describe habitat types that would be created in the dam head pond area if the dam was removed. While the diversity of habitat types varies with the selected head pond restoration option, the existing head pond area would convert, for all options, to a natural grassland habitat with wetland fringes along the edge of the river.

If trees and shrubs were also planted in the restored area, along with the creation of new ponds and/or wetlands, overall habitat diversity would increase and would support a wide range of plant and animal species including good habitat for birds, insects, mammals etc. as well as reptiles and amphibians.

10 SUMMARY AND DISCUSSION

This report examines options, impacts and costs to potentially remove the Coldstream dam. This report is summarized as follows:

10.1 Estimated Costs for Dam Removal and Head Pond Rehabilitation Options

The capital costs of dam removal vary significantly and depend largely on whether the sediment is removed from the dam head pond or if the sediment is allowed to naturally wash downstream.

Overall, removal of the sediment from the head pond appears to be very costly, difficult from a technical perspective, will likely have significant social impacts and is also risky in terms of whether sediment removal can be done successfully. The GEO Morphix report included in **Appendix B** concludes generally that sediment removal from the head pond is likely impractical.

Capital cost estimates range from $2,500,000 to $3,300,000 for Options 1 and 2 where sediment is removed from the head pond prior to dam removal. These cost estimates are very preliminary, however, and could increase significantly based on further detailed investigation. Costs could also be significantly impacted by new provincial regulations governing excess soil and fill management especially if the sediment was disposed off of site.

Conversely, the cost of dam removal, if the sediment was allowed to wash downstream (over one or multiple years), would be significantly less and estimated to range in cost from $800,000 to $1,900,000.

The cost of Option 6 (create a new permanent bypass channel) is estimated to be $1,800,000 to $2,100,000.

10.2 Summary of Ecological Impacts/Benefits of Dam Removal

Overall, removal of the dam (or construction of a permanent, natural bypass channel) should have a net benefit to river ecology. Dam removal should improve aquatic habitat for aquatic species at risk by restoring natural sediment transport and supply downstream of the dam, by reducing the thermal impact to the river caused by the dam head pond and by restoring full fish passage.

The dam removal options that include allowing the sediment to naturally wash down the river, if considered, should be carefully discussed in advance with regulatory authorities including the Department of Fisheries and Oceans, and the provincial MNRF and MECP.

It is likely critical that all of these agencies, and perhaps others, come to agreement early in the planning process as to the preferred means to deal with the large volume of sediment stored in the dam head pond.

It is recommended that further sediment transport assessment be completed if a preliminary decision was made to remove the dam and the preferred option was to allow the stored sediment in the head pond to wash naturally down the river.

Prepared by:

Jeff Graham, P. Eng., President, GSS Engineering Consultants Ltd.	Jacob Bartley, EIT GSS Engineering Consultants Ltd.

APPENDIX A

June, 2022 Dam Inspection Report
by True Engineering

DRAFT

Inspection Report of Water Control Structures

Submitted to St. Clair Region Conservation Authority

June 17, 2022
Project No. 2461-021

TRUE

ENGINEERING ■ PLANNING ■ URBAN DESIGN ■ LAND SURVEYING

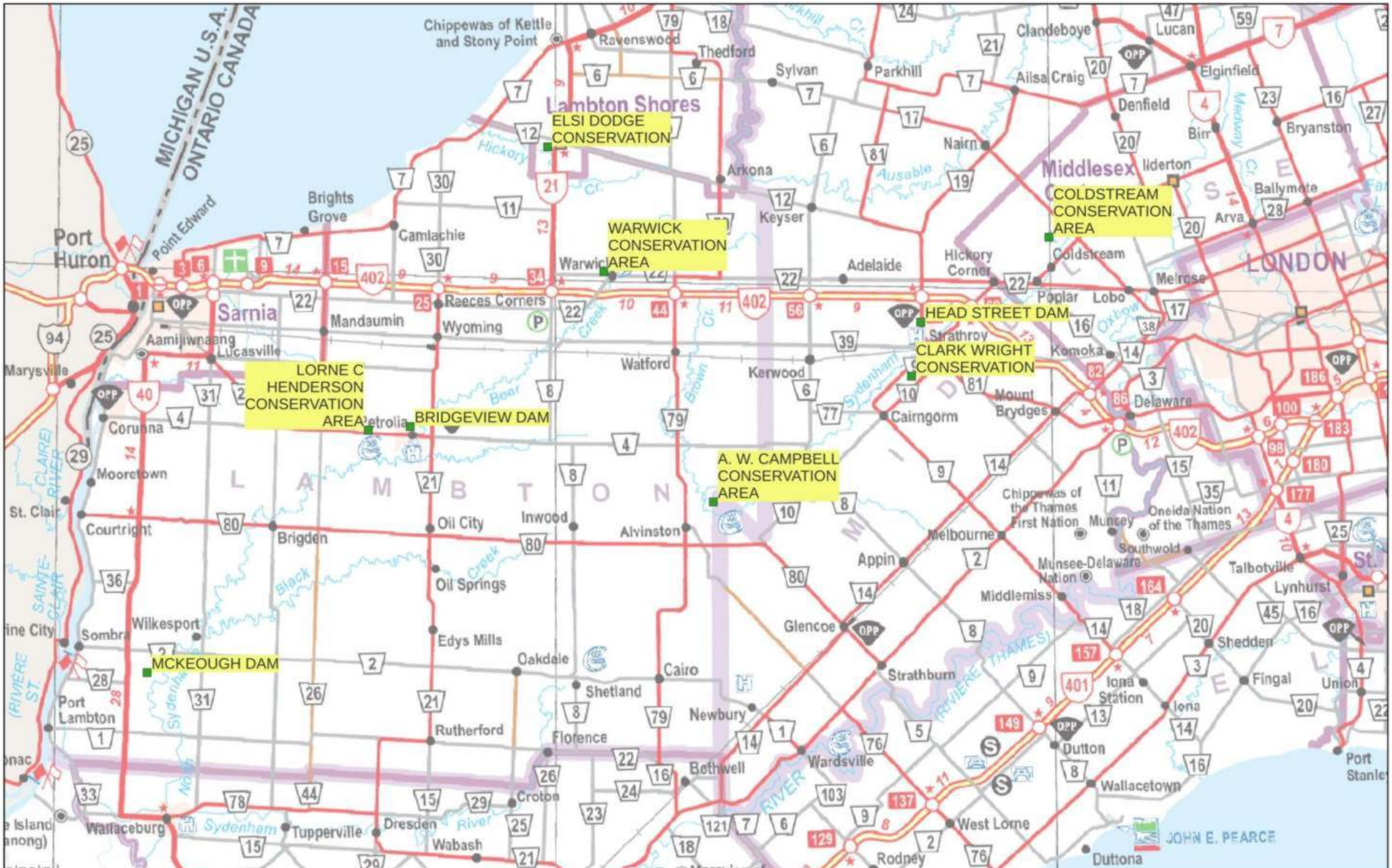
1.0 Introduction

St. Clair Region Conservation Authority (SCRCA) owns and operates water control structures at nine sites within its administrative area. The nine sites are listed below (also shown in Figure 1). Majority of the water control structures were constructed between 1960's and 1980's for the purposes of providing impoundments for recreational use. The McKeough Dam and Floodway is the only major water control structure that was constructed specifically for the purposes of flood control. The listing of water control structures that are subject to inspections in this work are:

1. Coldstream Conservation Area, Coldstream, ON
   a) Coldstream Dam
2. Head Street, Strathroy, ON
   a) Head Street Dam
3. Clark Wright Conservation Area, Strathroy, ON
   a) Clark Wright Dam
4. W. Darcy McKeogh Dam and Floodway, Sombra, ON
   a) Darcy McKeough Dam (embankment and control structure)
   b) Floodway channel (6 km)
   c) Drop structure (adjacent to St. Clair River)
5. A.W. Campbell Conservation Area, Alvinston, ON
   a) Morrough Lake Dam
   b) Campbell House Dam
6. Bridgeview Park (Petrolia)
   a) Bridgeview Dam
7. Lorne C. Henderson Conservation Area, Petrolia, ON
   a) Weir 1
   b) Weir 2
   c) Weir 3
   d) Pond Dam
8. Warwick Conservation Area, Warwick, ON
   a) Warwick Dam
9. Esli Dodge Conservation Area, Forest, ON
   a) Esli Dodge Dam

This report presents the summary findings of routine inspections carried out by TRUE Consulting staff at the above water control structures. Inspections in this work are limited to general site recognizance of civil works looking at overland drainage, erosion, shoreline protection, grading, general conditions of water control structures, embankments, seepage, etc. Structural inspections were not included in the present scope of work.

Inspections were carried out by a qualified hydrotechnical engineer with a license to practice engineering in the Province of Ontario.



LOCATION PLAN

INSPECTIONS OF SCRCA WATER CONTROL STRUCTURES

DRAWN BY: PP	
SCALE: 1:450,000	
FIG. NO: 1	REV.: 0

PROJECT NO. 2461-021

DATE: MAR 2022

1.1 Note on Site Visits/Inspections

Due to project reporting timelines some of the initial site visits and inspections were completed during late winter of 2022. Weather constraints (snow and ice cover, frozen lakes/rivers, ice at the shoreline) prevented a complete inspection at all features at the sites. In some instances snow and ice cover occupied an area that required inspecting, and thus prevented completion of all aspects of the inspections. Winter site visits were carried out in late February 2022 at Coldstream Dam, Head Street Dam, and Clark Wright Dam, from which only partial inspections could be completed. Snow and ice covered portions of the structures which hindered the inspection work. For example, snow and ice covered much of the shoreline and spillways in some locations, thus preventing the inspector from observing actual site conditions (such as erosion of shoreline, slope stability and characteristics of the embankments, etc).

Collection of aerial photographs by a drone-copter pilot at the McKeough Dam and Floodway were carried out in December of 2021.

Follow up site visits were completed at the end of May of 2022 to complete the remaining detailed visual inspections for the sites question. Observations made from follow up inspections have been appended to the original photographic log and are presented as Appendices to this document.

1.2 Scope of Work

A site visit by our staff are to be carried out on each of the nine sites included in this project. The intent of the inspections is to complete a condition survey of existing structures at each site and obtain an accurate visual record of conditions as it existed at the time of the inspections. The inspections are to include a check of gate valve/stop log operations for sites that have them (if available/possible), along with the conditions observed at upstream and downstream embankments and shoreline, spillways, river bed, control structures, etc. The inspections focus on identifying major deficiencies at the site of each water control structure.

Each component of each structure is to be photographed, tagged with a brief description, and assembled into a detailed photo log. The photo log is intended to be used as a template for future inspections, and could be used for the evaluation (or progression) of the rate of deterioration at each structure. The summary of inspections thus document all major material defects, and performance that will ultimately require future maintenance and/or repairs.

In accordance with provincial regulations, dam owners are responsible for the safe operation and maintenance of their dams. Part of the safe operation of the dams includes the responsibility to implement appropriate public safety measures to address potential exposure to hazards created at each site. Many of the sites in this project are located at Conservation Areas where public has access to the grounds.

A limited scope public safety assessment is to be completed. A prioritized list of recommendations in implementing public safety measures (such as installation of fences, signage, etc) is to be developed.

Structural inspections are not included in the scope of work for this project.

A preliminary review of the existing operating rules of the McKeough Dam has been included in this work. This review includes identification of elevation thresholds upon which overbank flooding starts at Wallaceburg, with the production of inundation extents from several water levels. Pluvial flooding (which occurs as ponding from heavy rainfall and/or snowfall) is not included, as all focus is to be on riverine flooding that could be controlled by the McKeough Dam. A review of available time series data (water levels, flows, and wind speed/directions) has also been included to identify if the said data could be used to support future updates to the existing operating rules.

1.3 Nomenclature

This report adopts the naming convention that assumes the observer stands in the middle of the river and looks downstream. For example, references are made to left and right embankments, wingwalls, banks, shoreline, or other structures or dam components, which relate to what a person sees by standing in the middle of the river and looking downstream. Such a convention adopts flow direction as a basis upon which structures/components are referenced in the report.

1.4 Repair Priority Levels

Identification of deficiencies and recommendations for future repairs/studies in this report are provided according to the following list of priorities:

- Priority S (safety related, requires immediate attention),
- Priority 1 (will require action within 1 to 2 years),
- Priority 2 (will require action within 2 to 5 years),
- Priority 3 (will require action within 5 to 10 years),

Recommendations for corrective action at each site/structure shall be provided according to the above priority level. Priority S (safety related) is one that requires immediate attention, as there is immediate risk to staff and/or public. Other priority levels are assigned to components according to their level of deterioration and/or overall function.

1.5 Background Review

Previous inspections of SCRCA water control structures include the following:

- 1995 general inspections of all SCRCA water control structures by Paragon Engineering Limited,
- 1997 inspections of the McKeough Floodway by Stanley Consulting Group (general and structural inspections of the Floodway only),
- 2005 general inspections of all SCRCA water control structures by Stantec, and
- 2011 general of all SCRCA water control structures by Stantec, and structural inspected by VDP Engineering Ltd.

SCRCA has provided to TRUE Consulting the 2011 Inspection Report of its water control structures (Stantec, 2011) for use in this project. The 2011 Inspection Report documents general conditions at the nine sites listed above, along with results of a limited scope structural inspection. A description was provided for each site, following with observations of conditions that existed at the time of the inspections. A set of recommendations for maintenance and repairs is provided for each dam site.

The photographic log portion of the 2011 Inspection Report was not provided to TRUE Consulting. Therefore, comparison between 2011 and 2022 conditions could only be made on the basis of photographs included in the main body of the 2011 Inspection Report.

Majority of the issues noted in the 2011 Inspection Report are related to vegetation management (trees and brush growing through the structures, and/or debris accumulation at the spillways). Conditions of vertical inlet drop structures (also refereed to as morning glory spillways) were noted in the 2011 inspections, as were areas where bank or slope erosion were identified. Significant damage to the Weir 2 structure at the Lorne C. Henderson Conservation Area was noted, with seepage and erosion at the upstream and downstream embankments were identified. Shallow surface slumping was identified on several section of the side slopes of the McKeough Floodway, and recommended to be monitored.

Major maintenance works implemented since the 2011 inspection have been included at the site of the McKeough Floodway only. The maintenance implemented included culvert replacement of drains that outlet into the floodway channel, repairs along the side slopes of the Floodway, and some overland drainage works.

Maintenance works at other sites were limited to brush and vegetation removal, and clearing debris at spillways and intake structures.

Existing drawings of the water control structures subject to inspections were not available for review. All comments offered in this report are based on visual evidence present during the inspection, and professional judgment of the report's author.

2.0 Description of Water Control Structures

This section provides a brief description of the water control structures that are subject of the inspections.

2.1 Coldstream Conservation Area

Coldstream Dam is located on the upper reaches of the Sydenham River within the hamlet of Coldstream and in the Municipality of Middlesex Centre. The dam consists of a 40 m +/- long steel sheet pile wall installed across the main channel, with riprap placed adjacent to the sheet piling on its downstream side. The entire sheet pile and riprap structure forms the main spillway at the Coldstream Dam. The dam structure is responsible for creating a headpond that is approximately 400 m long and 100 m wide.

The sheet piling at the dam site is keyed into the right bank. For this reason, the Coldstream Dam does not have a traditional right embankment.

The steel sheet piling is likewise keyed into the existing left bank, into an area with significant amount of fill that originally placed adjacent to the left bank. This area is referred as the left embankment. The crest of the left embankment is in the order of 20 m +/- wide.

Existing erosion protection is evident on the right downstream bank only.

There is a low flow valve control structure on the left upstream embankment, but is not operational.

Approximately 75 m downstream of Coldstream Dam is an existing pedestrian footbridge, which is used by the area residents to access the recreational trail system within the Coldstream Conservation Area.

Conditions observed at the Coldstream Dam are presented in the next section of the report, and are accompanied by a detailed photographic log in Appendix A.

2.2 Head Street Dam (Strathroy)

Head Street Dam is located on the Sydenham River in Strathroy, Ontario, about 60 m downstream of the Head Street bridge. The dam consists of approximately a 45 m long sheet piling installed across the main channel of the river, with riprap placed on a wedge adjacent to the sheet piling on its downstream side. The sheet piling is keyed into the banks on both sides. As a result of the keying in of the piling, there are no embankments at the dam site. Downstream shoreline on both left and right banks are protected with existing riprap erosion protection.

The dam includes an existing reinforced concrete control structure, with a concrete bridge accessible from the left bank. The control structure has one bay of removable stop logs that can control the water levels in the upstream headpond. Downstream of the control structure are reinforced concrete wingwalls with a small concrete channel that extends through the riprap spillway.

3.0 Inspection Findings and Recommendations

Observations from site inspections completed are documented in the text below, along with a detailed photographic log for each site. Attached appendices present photographic logs that document in detail observed conditions at the time of the inspections. The photographic logs provided are intended to be used as a baseline reference for future inspection and monitoring efforts to be carried out by SCRCA staff.

Site visits and inspections at Coldstream, Head Street and Clark Wright Dams were carried out in late February of 2022 when portions of the structures were covered with snow/ice. Follow-up site visits and inspections were completed in late May of 2022 at these sites.

Observations and inspections at the McKeough Dam and Floodway are made based on drone-copter aerial imagery collected in early December of 2021 and the site visit from May of 2022.

3.1 Coldstream Conservation Area

3.1.1 Observations

Refer to Appendix A – Coldstream Dam for a detailed photographic log and inspector's notes.

There are no signage warning users of the Conservation Area of the hazards associated at the dam site. An existing trail traverses the top of the left downstream bank that poses fall risk to some.

The left upstream embankment appears in good condition. The shoreline is noted as heavily vegetated at the waterline. Settlement of embankment crest, cracks or other signs of instability were not observed. The left upstream shoreline of the reservoir is likewise vegetated, with mature trees and/or brush growing close to the waterline. Some amount of shoreline protection visible at the left upstream embankment, and only at the waterline. Heavy vegetation cover exists along the left upstream bank.

The right upstream shoreline at Coldstream Dam is the reservoir bank is also heavily vegetated with trees/brush. There is some existing riprap on the right upstream bank but not to sufficient quantity to offer shoreline protection. Shoreline erosion was not observed at this location.

The main control structure at the dam site includes a 40 m +/- long steel sheet pile wall that spans the reservoir and main channel. On the downstream face of the sheet piling a wedge of riprap has been placed which forms the dam's main spillway. The spillway riprap adjacent on the right bank has previously washed out, and has an approximately 0.9 m lower crest than the remaining portion of the spillway. Similar conditions were noted in the 2011 Inspection Report, leading conclusion that the downstream riprap spillway erosion has occurred in the past, and is likely still ongoing. As a result of the noted erosion larger portion of the flow over the dam is concentrated through the narrow section near the right bank, which can lead to more future erosion of the downstream riprap spillway. Given the ongoing spillway erosion, monitoring for bed scour in the river channel downstream of the riprap spillway is recommended for the future.

Two large trees were observed to be growing through the side slopes of the downstream riprap spillway. Trees growing through the riprap spillway can eventually destabilize the riprap/sheet pile dam structure, and place the entire dam at risk. Note that in this type of construction, the sheet piling relies on the its downstream wedge of riprap to resist the forcing from upstream loading (water levels during floods, ice, silt, etc). Near the right bank brush vegetation was observed growing through the downstream spillway riprap as well.

Some amount of debris accumulation has been observed on the reservoir side of the sheet piling. It is anticipated that more debris accumulation typically occurs after the spring freshet.

The remaining downstream spillway riprap is in generally good condition. The individual stones are free of major deterioration or cracks. No major erosion of the downstream spillway riprap was observed.

There exists a control shaft structure near the left bank at the dam site, running parallel to the sheet piling. A timber walkway connects the control shaft structure to the left bank and shoreline. The top of control shaft structure has no accessible components (no hatches, or valves), leading to a conclusion that the low flow valve (typically used to lower the headpond in case of maintenance) is not functional. Outlet of the control shaft structure on the downstream side was not able to be identified.

The right downstream bank at the Coldstream Dam site is protected with large riprap stone, with the protection wrapping along the existing trail leading to the pedestrian bridge. There is significant amount of brush, shrub and even mature trees growing through the riprap bank. Some of the trees are leading towards the toe of slope, and are an indicative sign of bank instability. The individual riprap stones in this location are in good condition, however. Such growth through the riprap structure is not appropriate, and will increase its rate of deterioration, ultimately leading to higher maintenance costs.

The left downstream bank is located at the interface between the embankment slope and the riprap spillway. The area is heavily vegetated with brush. The shoreline at the left downstream bank is showing signs of bank instability, with trees growing sideways through the embankment slope (which will eventually collapse, and further destabilize the slope). Along the left downstream slope a mass concrete abutment of the former mill house is visible, and has a vertical face in excess of 2 m. As public has access to this area, the old abutment presents a vertical fall hazard, and thus requires installation of a handrail according to Ontario Building Code standards (MNR, 2011). The 2011 Inspection Report has also flagged this vertical fall hazard, and recommended installation of a handrail.

The trail that leads to the pedestrian bridge crossing downstream of the dam has shifted from erosion, with the bridge approach wooden sheeting heaving upwards. This poses a hazard to the pedestrians using the Coldstream Conservation Area. Further, the right shoreline in the vicinity of the right bridge abutment has significantly eroded. The shoreline downstream of the right abutment is presently showing signs of recent erosion and undermining via exposed tree roots. The erosion at this location has extended around the entire right footing, to the point that the entire footing is simply resting vertically on top of the eroded bank. There is no passive support to the footing from the surrounding soil, as all of it has eroded. Future erosion will continue, causing the shoreline around the abutment to further erode, and thus leading to a possible collapse of the pedestrian bridge. Erosion at this site is flagged as a public safety concern, and thus requires immediate corrective action.

3.1.2 Recommendations

Recommendations for follow-up action at the Coldstream Dam are as follows:

Priority S (safety related, require immediate attention)

- Install shoreline erosion protection works around the right abutment of the pedestrian bridge downstream of the dam.

Priority 1 (1 to 2 years)

- Install safety signs in the Conservation Area (on both sides of the river) indicating dangers associated to public access in close proximity of a dam.
- Remove brush and tree vegetation from: i) the left embankment (upstream and downstream), ii) the right downstream shoreline, and iii) the riprap spillway.
- Remove debris that accumulates on the upstream side of the reservoir along the sheet piling.

Priority 2 (2 to 5 years)

- Install hand railing at all location of vertical fall hazards that meet MNR (2011) standards (at the old mill house abutment, and at the valve control structure).
- Restore riprap slope protection along the left downstream bank, and re-grade bank as appropriate.
- Replace washed out rock from the downstream riprap spillway to match the crest of the sheet piling. Re-grade transition riprap spillway to match existing conditions.
- Conduct a topographic survey (or otherwise) probe the channel downstream of the riprap spillway for indications of possible channel bed scour.

Priority 3 (5 to 10 years)

- Restore functionality of the valve control structure to allow de-watering of the headpond during low flow conditions for maintenance operations.
- Complete routine inspections of the water control structure, establish a detailed photographic log, and compare deterioration against 2022 inspections.

3.2 Head Street Dam (Strathroy)

3.2.1 Observations

Refer to Appendix B – Head Street Dam for a detailed photographic log and inspector's notes.

5.0 General Recommendations

The following offers a set of general recommendations to assist SCRCA in operating and maintaining its water control structures.

1. Several safety related issues have been flagged by the inspections, including: i) erosion of the soil adjacent to the right abutment of the pedestrian bridge at Coldstream Dam, ii) access platform at Morrough Lake Dam that is loose, iii) deteriorated structural steel at Warwick Dam bridge, and iv) unsafe path over the emergency spillway at Esli Dodge Dam. These safety related issues should be addressed immediately.

2. There are no public safety related signage at any of the sites inspected. As public has access to ground at and around the water control structures, signs should be posted warning users of hazards around deep and/or fast moving waters.

3. Many of the sites inspected are between 40 and 60 years old, and are approaching the limit to their useful service life. As many of the structures have vertical inlet drop structures that are damaged, leaning, and otherwise deteriorating. Capital planning needs to take place on developing a priority schedule to repair and/or restore the structures to appropriate engineering standards.

4. Heavy brush vegetation is present along the engineering structures at majority of the water control structures owned by SCRCA. Allowing vegetation to establish increases the rate of deterioration of the structures, and will thus lessen their remaining useful life.

5. Similar to above, inspection at several sites have noted that mature trees are growing through the engineering structures, and should be removed.

6. At most sites heavy grass/brush/trees prevented detailed visual inspections as some features were not visible. After heavy vegetation and trees are removed, follow up inspections should be completed.

7. Two methodologies for updating the operating rules of the McKeough Dam are offered (one based on numerical model simulation and one based on revising elevation thresholds). Each have their own advantages and disadvantages, and it will ultimately be up to SCRCA to decide which approach to adopt in the future.

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APPENDIX B

GEO Morphix Report for Stream Channel Analysis in Head Pond

(January, 2023)

GEO Morphix Ltd.

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January 12, 2023

GSS Engineering Consultants Ltd.
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Attention: Jacob Bartley
B.Eng., E.I.T

Re: Geomorphological Technical Review, Removal of Coldstream Road Dam and Head Street Dam
East Sydenham River
Strathroy, Ontario
GEO Morphix Project No. PN22087

The Coldstream Road Dam and Head Street Dam located along the East Sydenham River in Coldstream and in the Town of Strathroy, Ontario, respectively, are proposed for possible removal. The St. Clair Region Conservation Authority (SCRCA) has requested that a geomorphological study be completed to evaluate the potential extent and alignments of the channel planform that will form following the dam removals within the upstream ponded area. An understanding of the extent of the future hazard posed by the watercourse and potential release of accumulated sediments is also required prior to deactivating the dams.

GEO Morphix Ltd. (GEO Morphix) was retained by the project engineer GSS Engineering Consultants Ltd. (GSS) to provide geomorphological input and guidance in support of the possible dam removals. To address these requirements, the following activities were completed:

- Review of East Sydenham River topographic surveys and sediment depth data to identify preferred channel pathways in the event of a dam removal
- Identify bankfull geometries and associated planimetric properties for the theoretical channel that will form within the ponded areas upstream of the dams
- Define a meander belt width for the theoretical channels
- Provide mapping of the expected planform and erosion hazard lines
- Outline in-channel bioengineering approaches to mitigate lateral and vertical erosion (e.g., channel widening and downcutting)
- Estimate quantities of potential sediment release based on geometric relationships

We provide this memo which summarizes the above-noted activities and provides geomorphological recommendations with respect to implementation.

Background Information

The Coldstream Road Dam is situated east of Strathroy along an upper reach of the East Sydenham River. The Coldstream Dam is bounded by Ilderton Road and residential dwellings to the south, Coldstream Road to the east, and Coldstream Conservation Area to the North. Based on our review of available watershed studies, the Coldstream Road Dam was built sometime between 1969 and 1972.

The Head Street Dam is situated within the Town of Strathroy. The Head Street Dam is bounded by Front Street and residential dwellings to the south, Head Street to the west, and Strathroy

Conservation Area to the north. Based on our review of available watershed studies, the Head Street Dam was built around 1973.

Sediment depth findings and topographical surveys were provided by GSS (drawings dated 2022).

Both dams form a significant barrier to fish, reducing the opportunity for upstream migration. They also produce languid flow conditions, due to backwatering effects, which in turn promotes poor water quality conditions (e.g., increased water temperature, sedimentation, and possibly algal growth).

Bankfull Channel Analyses

Removal of the dams will lower upstream water levels, thereby concentrating flow along the thalweg (e.g., deepest part of the channel/reservoir in cross sectional view). Along this path, a channel will develop naturally as the reservoir drains. The potential form of the channel is discussed below.

Channel Geometry

The geometries of the theoretical channel were informed based on a desktop assessment of a surrogate channel reach characterized by a predominantly unaltered or natural form. Bankfull channel width was measured remotely upstream and downstream from the dams using recent orthoimagery. Bankfull depth was estimated by applying known stream geometric relationships (Rosgen, 1994). With consideration to the existing channel conditions and increased potential for downcutting following dam removal (e.g., due to the relatively fine/erodible sediment composition in the reservoirs), a width to depth ratio of 10 was selected. For large rivers, width to depth ratios can be significantly higher (e.g., >12), but given the channel would be newly activated, we assumed relatively augmented rates of channel downcutting, which lowers the overall ratio.

At the Coldstream Street Dam location, the channel bankfull width and corresponding estimated depth were 7.4 m and 0.74 m. At the Head Street Dam location, the channel bankfull width and corresponding estimated depth were 16.1 and 1.61 m.

Channel Alignment

The alignment the theoretical channel will adopt was assessed through two approaches. The first examined the existing channel topography including existing sediment deposits, as surveyed by GSS. The low point or thalweg in each surveyed transect of the channel was mapped to delineate the theoretical channel central tendency (i.e., dominant or trending channel flowpath).

The second approach assumes the erosion/removal of the sediment deposits, as they consist of relatively loose and erodible materials, to identify the potential historical alignment of the channel. With this caveat applied, the thalweg is again extracted from the available surveys and mapped to form the theoretical historical channel central tendency.

Meander Belt Assessment

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width assessment estimates the lateral extent that a meandering channel could occupy and may potentially occupy in the future. The assessment is therefore useful for informing the potential hazard to proposed activities in the vicinity of the above-noted theoretical channels as well as the need for supporting erosion mitigation measures.

When defining the meander belt width for a creek system, the Ministry of Natural Resources and Forestry (MNRF, 2002) treats unconfined and confined systems differently. Unconfined systems are those with poorly defined valleys or slopes well-outside where the channel could realistically migrate. Confined systems are those where the watercourse is contained within a defined valley, where valley wall contact is possible.

Both the Coldstream Road Dam and Head Street Dam are likely unconfined systems. As such, the meander belt width is likely beyond the maximum extent of potential meander migration and areas of potential future valley wall contact. Where infrastructure is also present, these locations may need future infrastructure/erosion protection.

In unconfined systems, the limit of the erosion hazard and migration potential can be delineated based on empirical meander belt width models. For this study, we have selected and applied three desktop-based models to compute a range of meander belt widths. These models are scientifically defensible and have been verified in past studies as suitable for use in Southern Ontario. At this time, no method is preferred as each provides a range of potential migration extents based on different properties (i.e. watershed scale, flow, slope and bankfull geometry). The models are summarized below and their results provided are in **Table 1**.

TRCA (2004) Empirical Model

$$B_w = -14.827 + 8.319\ln(\rho g Q S * DA) \quad \textbf{[Eq. 1]}$$

where B_w is the meander belt width, ρ is the density of water, g is acceleration due to gravity, Q is the 2-year return period event discharge, S is the channel gradient, and DA is the drainage area.

For this study, the 2-year return period event discharges and drainage areas were estimated using a modified version of the Ontario Flow Assessment Tool which generates watersheds based on publicly available regional topography (e.g., LiDAR), and calculates watershed characteristics using empirical relations.

Modified Williams (1986) Empirical Approach

$$B_w = 4.3{W_b}^{1.12} + W_b \quad \textbf{[Eq. 2]}$$

Ward et al. (2002) Empirical Approach

$$B_w = 6{W_b}^{1.12} \quad \textbf{[Eq. 3]}$$

where B_w is the meander belt width, and W_b is the bankfull width, as estimated from aerial orthoimagery along an unaltered section of reach (see *Bankfull Channel* section above).

Table 1. Modelled Meander Belt Widths

Reach	Recommended Meander Belt Width (m)		
	TRCA (2004)	Modified Williams – Width (1986) *	Ward Width *
Coldstream Road	73	57	78
Head Street	82	136	187

**Includes a 20% Factor of Safety*

The meander belt widths in **Table 1** are applied equidistant along the channel central tendency (see Section *Bankfull Channel Analyses* for details related to central tendency estimation). Typically, the belt widths are based on a review of the existing meander pattern. However, in this case, the historical meandering planform could not be identified due to the presence of the dam and reservoir.

For the purpose of this analysis, two approximate central tendencies were delineated to project the calculated meander belt widths. The two central tendencies were delineated using different contour datasets provided by GSS; the current thalweg central tendency was delineated using the sediment surface contour dataset, and the historical thalweg central tendency was delineated using the hard bottom contour dataset. An overview of the meander belt widths associated with the theoretical channel at both locations is provided in **Appendix A**. From a review of topography, the assumed edge of reservoir is correlated with a defined break in slope, or the presumed "top of bank". This term is used loosely as the extent of the head is associated with the break in slope. As displayed in **Appendix A**, solid meander belt width lines indicate where the erosion hazard falls within the top of bank, whereas dotted meander belt width lines indicated where the erosion hazard extends beyond the top of bank. Note that the entire area delineated by the meander belt does not reflect an active erosion hazard. The delineated extents identify the potential migration limits the channel may attain in the future. In areas of concern, erosion mitigation treatments (e.g., bank bioengineering) may be installed to combat channel adjustment.

Potential Sediment Release

Dam structures create backwatering conditions, which slows upstream in-channel flow velocity, and promotes sediment settling/deposition. Therefore, a primary concern associated with dam removals is the corresponding abrupt release of these sediments downstream. Common related short-term impacts include increased water turbidity, sediment accumulation at downstream locations, as well as water quality impacts resulting from the sudden release of water (e.g., water temperature change).

Sediment release is a product of the available sediment as well as the method and phasing of the dam removal. One approach to estimate the amount of sediment mobilized is to calculate sediment entrainment as a function of the theoretical channel geometry (see *Bankfull Channel* section for details), plus contingency to account for potential activation of sediments beyond the bankfull channel limits. Assuming the release is limited to the channel size can result in a significant underestimate of the release, as most of the collected material within the reservoir extents will be fine and thus highly susceptible to entrainment in the post-condition. A more practical approach is to assume a worst-case scenario which better accounts for the volume of loose materials that extend beyond the theoretical bankfull channel limits and would represent a maximum probable release.

To gauge the release, a number of assumptions were made regarding channel geometry and the extent of active sediment. First, the channel width of the newly formed bankfull channel would be similar to channel widths found beyond the impact of the dam. Second, the channel depth could be approximated from the bankfull width applying industry known natural channel width-to-depth ratios (Rosgen, 1994). In this case, we assumed a width-to-depth ratio of 10 (see *Bankfull Channel* section for details), which resulted in a channel depth of 0.74 m and 1.61 m for the Coldstream Road Dam and Head Street Dam, respectively. The assumed depths fall within the depth of available sediments.

Additionally, we have assumed that the active erosion area is limited to three times the theoretical bankfull channel width, or 22 m for the Coldstream Road Dam channel and 48 m for the Head Street Dam channel. This was considered to be a reasonable estimate, if the work were combined with appropriate phasing of the dewatering and dam removal.

Finally, the erosion area was assumed to extend the entire length of the thalweg (central tendency), which measured 433 m at the Coldstream Road Dam location and 619 m at the Head Street dam location.

Table 2. Potential Sediment Release Estimates

Parameters	Coldstream Road	Head Street
Active Bankfull Width (*3) (m)	22	48
Average Bankfull Channel Depth (Bankfull Width/10) (m)	0.74	1.61
Thalweg Length (m)	433	619
Estimated Volume of Sediment (m^3)	7,049	47,836

Importantly, the release could be larger than what is indicated in **Table 2** if appropriate phasing and sediment management is not applied. With respect to phasing, removal of the dam structures should be timed to avoid high in-channel flow conditions and to promote soil stabilization through revegetation during favourable growing periods. Non-vegetated surfaces may also be mechanically stabilized with erosion control blankets for temporary protection as vegetation establishes. Dam structure removal and reservoir drawdown should occur in a gradual, staged manner to reduce erosivity of the associated flow release and to permit enhanced vegetation establishment during the interim period between drawdown events. Abrupt removal (e.g., over daily or weekly intervals) will subject relatively exposed, sensitive sediments to more turbulent flow conditions. Therefore, large reservoir drawdown is typically recommended to occur over the course of 1 or more years.

Strategic use and placement of erosion and sediment controls, such as silt fencing and cofferdams, can also help mitigate erosive forces and sediment transfer by forming temporary barriers and promoting backwatering/depositional conditions. In addition, a qualified environmental monitor or geomorphologist should conduct regular inspections to rapidly address potential erosion issues as they arise. Finally, longer-term erosion mitigation strategies, such as bioengineering, may be implemented for enhanced bed and bank protection (see below Section for details).

Selective removal of built-up sediments in the reservoir in advance of the dam removal can also help reduce the extent of release. However, this is not considered a practical or cost-effective approach due to the scale of the reservoirs and degree of existing sediment accumulation.

Channel Restoration Recommendations

The newly formed channels will be allowed to evolve over time, thereby forming naturally occurring habitat. However, the newly formed channel will be relatively susceptible to erosion as it will take years for vegetation to establish deep rooting systems to help hold the bank materials intact. As such, more robust erosion mitigation treatments may be required along the channel bed or bank in problematic areas and/or to address erosion concerns. There are multiple design alternatives depending on the degree of stability required. Several examples are described below.

Channel Bank Bioengineering

A vegetative rock buttress treatment is a popular and relatively robust bank treatment option for large river systems. It may be configured with hydraulically-sized stone, to offer the requisite stability to withstand severe flow conditions, and may be revegetated with a high density of live plantings to enhance terrestrial cover and provide shading benefits to the watercourse.

The vegetated rock buttress consists of multiple rows of large subrounded to subangular boulders with live plantings installed in the gaps that occur between adjacent stones. As the plantings establish, feature stability is further enhanced through root generation. The stones are hydraulically-sized to withstand entrainment during a range of flood events. Larger stones sourced from the mix are to be positioned along the toe of the treatment, where in-channel shear is greatest. Relatively smaller stones may be used to construct the upper rows of treatment.

Alternatively, relatively "soft", more heavily vegetated bioengineering solutions are also available where the erosion risk is relatively reduced. Soft treatments generally consist of stone-based toe protection, overlaid with vegetated treatments such as fascines, soil lifts, and/or simple live staking. These treatments rely on vegetation establishment and live woody elements to hold the bank intact. Successful, relatively easy-to-implement examples include brush mattressing, vegetated layering, and root wad bank protection. The treatments are further supported with biodegradable erosion control blanket to provide short-term erosion control while the plantings establish. Although slightly less robust than the vegetated rock buttress, soft treatments provide optimal benefit to aquatic wildlife through provision of a combination of stone and woody features.

Example photographs of constructed channel bioengineering techniques are included in **Figure 1**.

Channel Bed Grade Control

Removal of the dams will result in a gradual lowering of the channel bed as the channel adjusts to re-establish a stable invert at the dam location. Channel bed grade controls may be installed at strategic locations to provide stability while maintaining seamless flow connectivity between the upstream naturalized channel and downstream receiving channel.

Channel bed grade controls consist of stone-based weirs which extend laterally across the channel. Weir stones are hydraulically-sized (oversized) for long-term stability. Upstream of each weir, the degradational tendency of the bed in an alluvial stream is mitigated, although this effect decreases progressively farther upstream. To construct a weir, stones should be arranged with an arc shape with the apex of the arc pointing in the upstream direction. This not only helps to increase the stability of the weir by strengthening the contact between stones due the flow direction but also to locally concentrate flows towards the centre of the channel and promote pool development and maintenance. Weir spacing should be such that the backwater of a weir extends to the next upstream weir or existing stable riffle, under low flow conditions. In addition to combating channel degradation, the weirs provide a degree of morphological variability to the channel bed. This benefits aquatic wildlife through provision of spatially diverse flows, enhanced flow aeration, and refuge opportunity within the relatively languid pools that form between weirs.

Example photographs of constructed channel bed grade controls and bank bioengineering techniques are included in **Figure 1**. **Figure 1A** displays a weir grade control supported by brush mattressing along the channel banks. The toe of the brush mattress treatment is reinforced with stone, for stability, while the upper banks gradually revegetate. In **Figure 1B**, the left bank is reinforced with a vegetative rock buttress to combat lateral migration. In addition, the bed is reinforced with hydraulically-sized stone weirs to combat downcutting while maintaining flow connectivity (and fish passage) through the restored reach. This represents a more robust design alternative applicable in areas where the erosion potential is high.

Figure 1: A) Typical vortex rock weir B) Typical vegetated rock buttress

Implementation of a combination of the channel bed and bank treatments is likely appropriate at the dam removal locations to manage erosion in proximity to important assets or infrastructure.

Summary

GEO Morphix has reviewed the available data to estimate the channel configuration, meander belt, and potential release of sediment associated with the removal of both the Coldstream Road Dam and Head Street Dam in Strathroy, Ontario.

Empirical modelling was applied to delineate the meander belt widths at each location. The recommended meander belt width for the Coldstream Dam, ranged from 57 m to 78 m. The corresponding estimated sediment load was 7,049 m^3. The recommended meander belt width for the Head Street Dam ranged from 82 m to 187 m, with a potential sediment load of approximately 47,836 m^3.

We recommend that the water levels of both dams be lowered systematically through strategic dewatering and sediment stabilization. Sediment releases could be substantially larger if dewatering and stabilization is not undertaken during dam removal. These estimates assume no downcutting below the approximated bankfull depth, which could result in a much larger volumes of sediment being released.

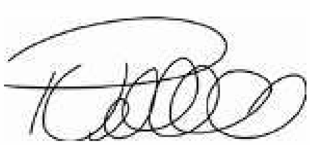
Bank bioengineering is recommended to mitigate future lateral migration, and in areas where the channel meanders near infrastructure. In addition, channel bed controls may be installed at the dam locations to provide vertical channel stability, as required. Although, implementation of the noted mitigation treatment is not an immediate concern and may be coordinated following identification of problematic areas during post-removal monitoring.

It is important to note that short-term transfer of sediments from the reservoirs is expected as the previously trapped sediments are uncovered and mobilized. Removal of the dam will also impact long-term sediment transfer, although transport rates are expected to align with natural pre-dam conditions.

Finally, the sediment surveys provide volumetric estimates, but were not detailed enough to identify the historical planform of the channel with accuracy. Completion of detailed sediment surveys is recommended to support the development of future dam removal plans. Detailed surveys can be performed in open water using side-scan sonar to identify remnant areas of excavation and historical channel morphology.

We trust this memo meets your requirements. Should you have any other questions or concerns, please contact the undersigned.

Respectfully submitted,



Paul Villard Ph.D., P.Geo., CAN-CISEC, EP, CERP
Director, Principal Geomorphologist

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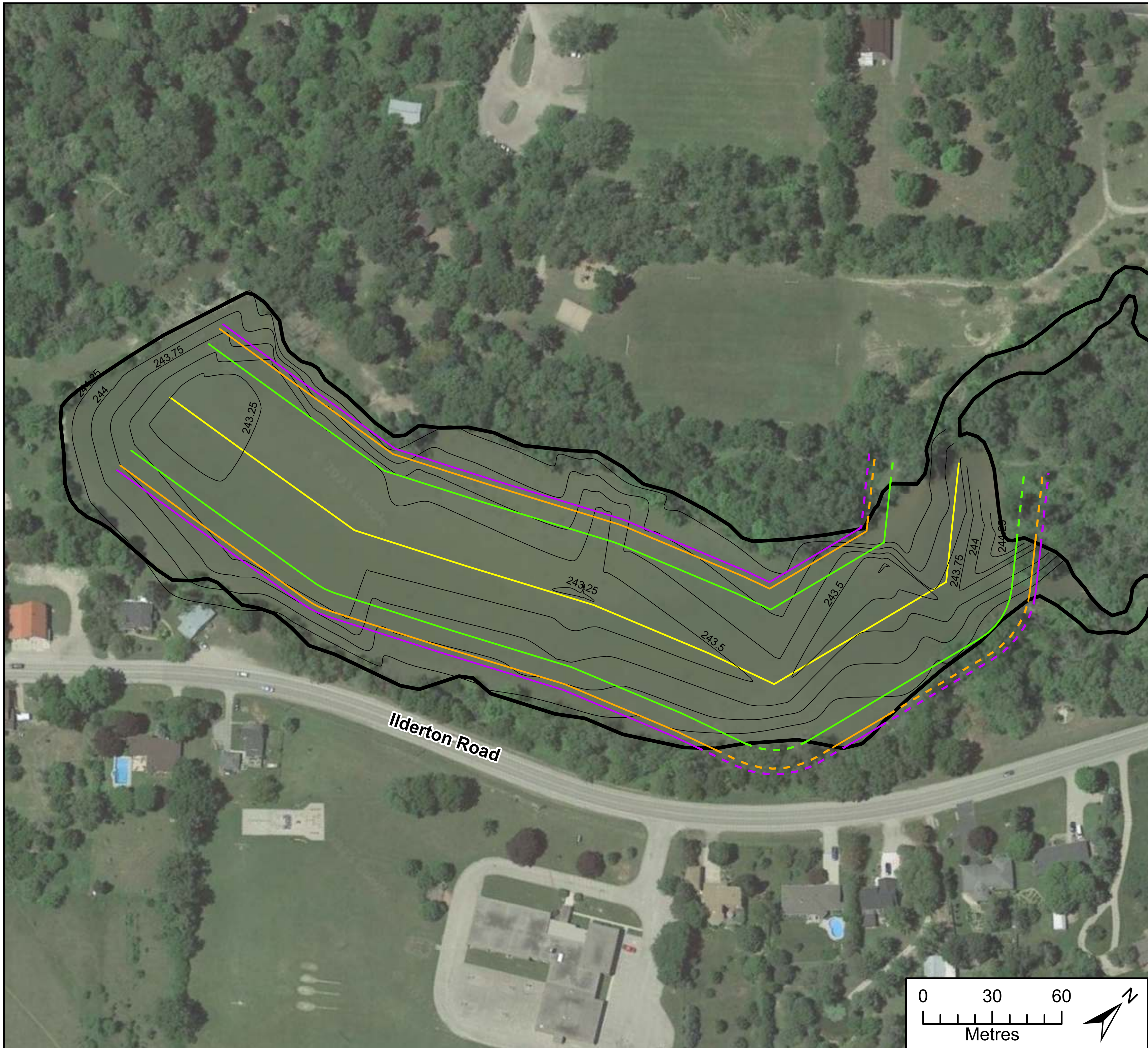
Appendix A
Erosion Hazard Map



GEO | MORPHIX™

Preliminary MBW

Based on Current Thalweg

Coldstream Reservoir

Strathroy, Ontario

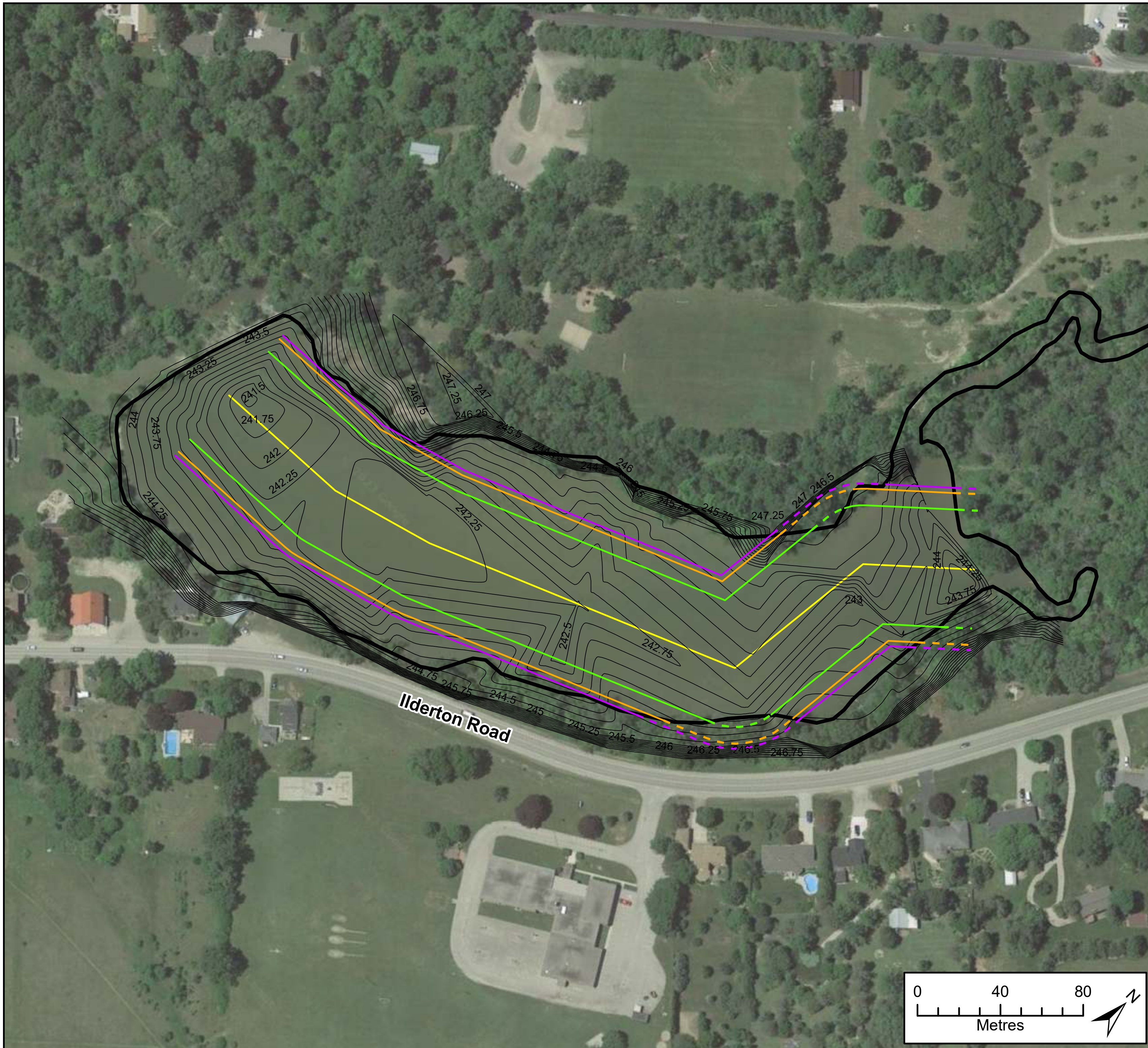
Legend

- Approximate Reservoir Boundary
- Sediment Bed Contours
- Approximate Current Central Tendancy (derived from thalweg of sediment) including removal of more recently deposited sediments
- TRCA (73 m)
- Modified Williams Width (20% Factor of Safety) (57 m)
- Ward Width (20% Factor of Safety) (78 m)
- Williams (outside of top of bank)
- TRCA (outside of top of bank)
- Ward (outside of top of bank)

Corresponding dashed lines represent outside of approximate top of bank

We have reviewed the cross-sections, and the boundary of the reservoir generally appear to correspond with the top of bank

Imagery: Google Earth, 2018. MBW: GEO Morphix Ltd., 2022. Approximate Reservoir Boundary: GSS Engineering, 2022. Print Date: January 2023. PN22087. Drawn By: M.O., P.V.



GEO MORPHIX™

Preliminary MBW

Based on Historical Thalweg

Coldstream Reservoir

Strathroy, Ontario

Legend

- Approximate Reservoir Boundary
- Hard Bottom Contours
- Approximate Historical Central Tendancy
- TRCA (73 m)
- Modified Williams Width (20% Factor of Safety) (57 m)
- Ward Width (20% Factor of Safety) (78 m)
- Williams (outside of top of bank)
- TRCA (outside of top of bank)
- Ward (outside of top of bank)

Corresponding dashed lines represent outside of approximate top of bank

We have reviewed the cross-sections, and the boundary of the reservoir generally appear to correspond with the top of bank

Imagery: Google Earth, 2018. MBW: GEO Morphix Ltd., 2022. Approximate Reservoir Boundary: GSS Engineering, 2022. Print Date: January 2023. PN22087. Drawn By: M.O., P.V.

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Preliminary MBW

Based on Current Thalweg

Head Street Reservoir

Strathroy, Ontario

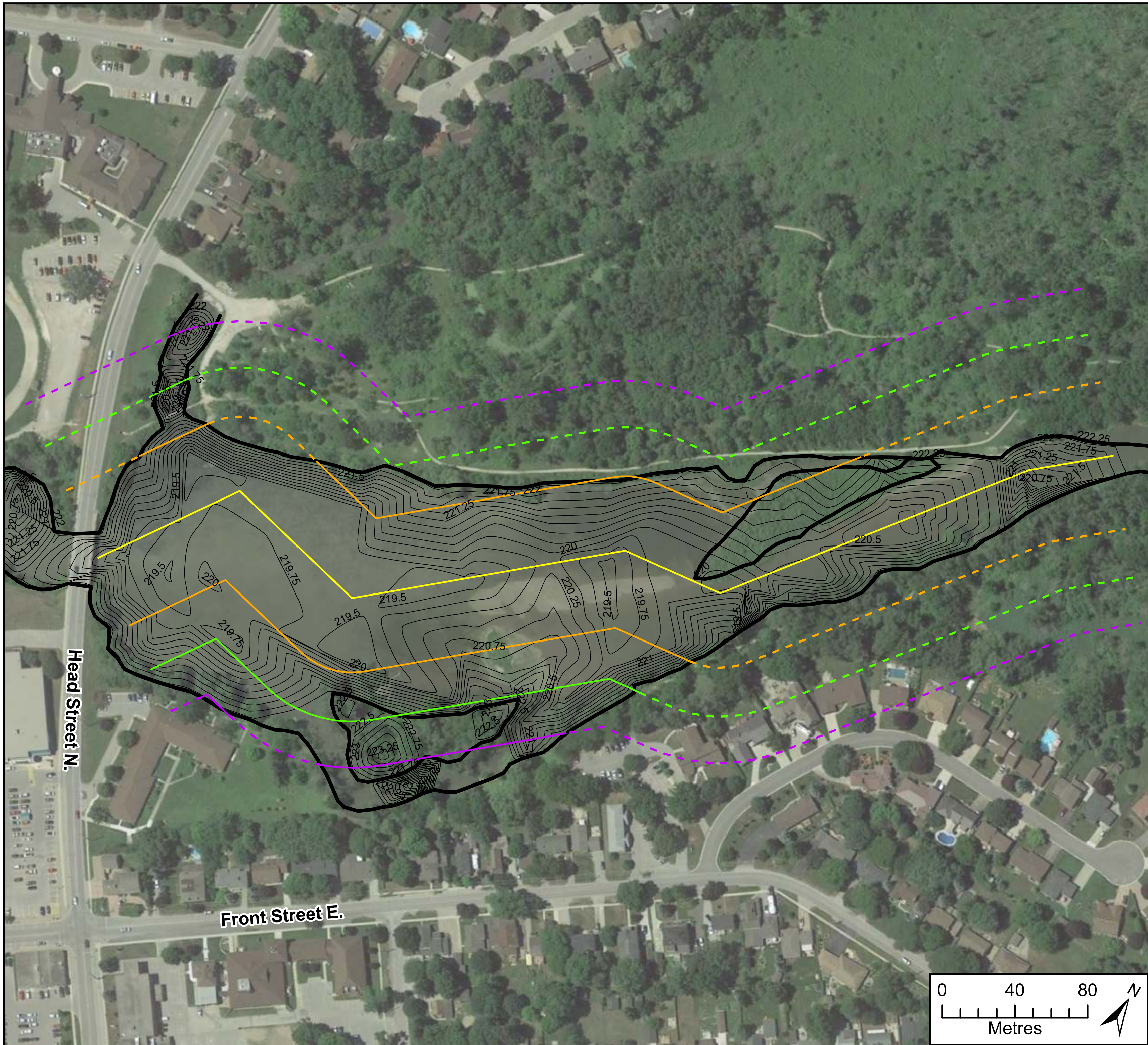
Legend

- Approximate Reservoir Boundary
- Sediment Bed Contours
- Approximate Current Central Tendancy (derived from thalweg of sediment) including removal of more recently deposited sediments
- TRCA (82 m)
- Modified Williams Width (20% Factor of Safety) (136 m)
- Ward Width (20% Factor of Safety) (187 m)
- Williams (outside of top of bank)
- TRCA (outside of top of bank)
- Ward (outside of top of bank)

Corresponding dashed lines represent outside of approximate top of bank

We have reviewed the cross-sections, and the boundary of the reservoir generally appear to correspond with the top of bank

Imagery: Google Earth, 2018. MBW: GEO Morphix Ltd., 2022. Approximate Reservoir Boundary: GSS Engineering, 2022. Print Date: January 2023. PN22087. Drawn By: M.O., P.V.



GEO | MORPHIX™

Preliminary MBW

Based on Historical Thalweg

Head Street Reservoir

Strathroy, Ontario

Legend

- Approximate Reservoir Boundary
- Hard Bottom Contours
- Approximate Historical Central Tendancy
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- Williams (outside of top of bank)
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- Ward (outside of top of bank)

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Imagery: Google Earth, 2018. MBW: GEO Morphix Ltd., 2022. Approximate Reservoir Boundary: GSS Engineering, 2022. Print Date: January 2023. PN22087. Drawn By: M.O., P.V.

APPENDIX C

Contaminant and Particle Size Analysis of Sediment Samples

ST. CLAIR REGION CONS. AUTH.
ATTN: Greg Wilcox
205 MILL POND CRESCENT
STRATHROY ON N7G 3P9

Date Received: 14-APR-22
Report Date: 11-MAY-22 13:32 (MT)
Version: FINAL

Client Phone: 519-245-3710

Certificate of Analysis

Lab Work Order #: L2699441

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Costas Farassoglou
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L2699441-1	L2699441-2	L2699441-3	L2699441-4	L2699441-5
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	14-APR-22	14-APR-22	14-APR-22	14-APR-22	14-APR-22
	Sampled Time					
	Client ID	CS1	CS2	CS3	CS4	CS5
SOIL						
Physical Tests	Grain Size Curve					
	% Moisture (%)	23.1	59.4	53.0	20.1	30.8
	pH (pH units)	7.43	6.74	6.86	7.43	7.04
Particle Size	Gravel (4.75mm - 3in.) (%)					
	Medium Sand (0.425mm - 2.0mm) (%)					
	Coarse Sand (2.0mm - 4.75mm) (%)					
	Fine Sand (0.075mm - 0.425mm) (%)					
	Silt (0.002mm - 0.075mm) (%)					
	Silt (0.005mm - 0.075mm) (%)					
	Clay (<0.002mm) (%)					
	Clay (<0.005mm) (%)					
Cyanides	Cyanide, Free (ug/g)	<0.050	<0.123 DLHM	<0.050	<0.050	<0.050
Metals	Aluminum (Al) (ug/g)	3260	8740	10900 DLM	8150	5290 DLM
	Antimony (Sb) (ug/g)	<0.10	<0.10	<0.20 DLM	0.20	<0.20 DLM
	Arsenic (As) (ug/g)	1.89	2.37	3.02 DLM	4.50	2.81 DLM
	Barium (Ba) (ug/g)	17.1	56.4	75.1 DLM	41.3	33.2 DLM
	Beryllium (Be) (ug/g)	0.16	0.36	0.42 DLM	0.31	0.24 DLM
	Bismuth (Bi) (ug/g)	<0.20	<0.20	<0.40 DLM	<0.20	<0.40 DLM
	Boron (B) (ug/g)	<5.0	7.8	10 DLM	7.2	<10 DLM
	Cadmium (Cd) (ug/g)	0.089	0.255	0.280 DLM	0.166	0.140 DLM
	Calcium (Ca) (ug/g)	200000	114000	174000 DLM	143000	172000 DLM
	Chromium (Cr) (ug/g)	9.68	14.5	18.3 DLM	14.8	11.4 DLM
	Cobalt (Co) (ug/g)	2.43	4.85	5.96 DLM	5.01	3.07 DLM
	Copper (Cu) (ug/g)	4.23	11.5	14.3 DLM	13.4	6.6 DLM
	Iron (Fe) (ug/g)	8330	12200	14600 DLM	14100	9120 DLM
	Lead (Pb) (ug/g)	4.03	6.72	8.1 DLM	13.0	4.2 DLM
	Lithium (Li) (ug/g)	4.3	9.6	10.9 DLM	8.7	6.3 DLM
	Magnesium (Mg) (ug/g)	15200	14200	17700 DLM	20600	19200 DLM
	Manganese (Mn) (ug/g)	266	338	418 DLM	492	313 DLM
	Mercury (Hg) (ug/g)	0.0146	0.0248	0.028 DLM	0.0331	0.011 DLM
	Molybdenum (Mo) (ug/g)	0.27	0.27	0.25 DLM	0.55	<0.20 DLM
	Nickel (Ni) (ug/g)	6.09	11.6	14.4 DLM	11.8	7.8 DLM
	Phosphorus (P) (ug/g)	339	834	850 DLM	587	590 DLM
	Potassium (K) (ug/g)	400	1110	1700 DLM	1040	790 DLM
	Selenium (Se) (ug/g)	<0.20	0.70	0.76 DLM	0.28	<0.40 DLM
	Silver (Ag) (ug/g)	<0.10	<0.10	<0.20 DLM	<0.10	<0.20 DLM

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L2699441-6 SOIL 14-APR-22 CS6	L2699441-7 SOIL 14-APR-22 CS PSA1	L2699441-8 SOIL 14-APR-22 CS PSA 2		
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve		SEE ATTACHED	SEE ATTACHED		
	% Moisture (%)	38.1				
	pH (pH units)	6.84				
Particle Size	Gravel (4.75mm - 3in.) (%)		33.3	<1.0		
	Medium Sand (0.425mm - 2.0mm) (%)		35.8	36.9		
	Coarse Sand (2.0mm - 4.75mm) (%)		21.8	2.7		
	Fine Sand (0.075mm - 0.425mm) (%)		6.6	44.8		
	Silt (0.002mm - 0.075mm) (%)		<1.0	12.1		
	Silt (0.005mm - 0.075mm) (%)		<1.0	11.1		
	Clay (<0.002mm) (%)		1.8	3.3		
	Clay (<0.005mm) (%)		1.8	4.3		
Cyanides	Cyanide, Free (ug/g)	<0.050				
Metals	Aluminum (Al) (ug/g)	DLM 12100				
	Antimony (Sb) (ug/g)	DLM <0.20				
	Arsenic (As) (ug/g)	DLM 3.22				
	Barium (Ba) (ug/g)	DLM 78.3				
	Beryllium (Be) (ug/g)	DLM 0.47				
	Bismuth (Bi) (ug/g)	DLM <0.40				
	Boron (B) (ug/g)	DLM 12				
	Cadmium (Cd) (ug/g)	DLM 0.304				
	Calcium (Ca) (ug/g)	DLM 183000				
	Chromium (Cr) (ug/g)	DLM 19.5				
	Cobalt (Co) (ug/g)	DLM 6.42				
	Copper (Cu) (ug/g)	DLM 15.6				
	Iron (Fe) (ug/g)	DLM 15800				
	Lead (Pb) (ug/g)	DLM 8.8				
	Lithium (Li) (ug/g)	DLM 13.9				
	Magnesium (Mg) (ug/g)	DLM 18700				
	Manganese (Mn) (ug/g)	DLM 495				
	Mercury (Hg) (ug/g)	DLM 0.032				
	Molybdenum (Mo) (ug/g)	DLM 0.29				
	Nickel (Ni) (ug/g)	DLM 15.7				
	Phosphorus (P) (ug/g)	DLM 900				
	Potassium (K) (ug/g)	DLM 1790				
	Selenium (Se) (ug/g)	DLM 0.69				
	Silver (Ag) (ug/g)	DLM <0.20				

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ALS ENVIRONMENTAL ANALYTICAL REPORT

		L2699441-1	L2699441-2	L2699441-3	L2699441-4	L2699441-5
	Sample ID	L2699441-1	L2699441-2	L2699441-3	L2699441-4	L2699441-5
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	14-APR-22	14-APR-22	14-APR-22	14-APR-22	14-APR-22
	Sampled Time					
	Client ID	CS1	CS2	CS3	CS4	CS5
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (ug/g)	159	287	230 DLM	206	190 DLM
	Strontium (Sr) (ug/g)	121	87.3	139 DLM	101	131 DLM
	Sulfur (S) (ug/g)	<1000	1200	<2000 DLM	<1000	<2000 DLM
	Thallium (Tl) (ug/g)	<0.050	0.074	0.10 DLM	0.062	<0.10 DLM
	Tin (Sn) (ug/g)	<2.0	<2.0	<4.0 DLM	8.5	<4.0 DLM
	Titanium (Ti) (ug/g)	120	130	207 DLM	211	208 DLM
	Tungsten (W) (ug/g)	<0.50	<0.50	<1.0 DLM	<0.50	<1.0 DLM
	Uranium (U) (ug/g)	0.754	0.715	0.72 DLM	0.735	0.65 DLM
	Vanadium (V) (ug/g)	13.4	17.6	23.1 DLM	22.2	15.6 DLM
	Zinc (Zn) (ug/g)	21.2	47.2	57.0 DLM	41.3	30.4 DLM
	Zirconium (Zr) (ug/g)	<1.0	1.4	<2.0 DLM	<1.0	<2.0 DLM

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2699441-6	L2699441-7	L2699441-8		
	Description	SOIL	SOIL	SOIL		
	Sampled Date	14-APR-22	14-APR-22	14-APR-22		
	Sampled Time					
	Client ID	CS6	CS PSA1	CS PSA 2		
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (ug/g)	DLM 230				
	Strontium (Sr) (ug/g)	DLM 149				
	Sulfur (S) (ug/g)	DLM <2000				
	Thallium (Tl) (ug/g)	DLM 0.12				
	Tin (Sn) (ug/g)	DLM <4.0				
	Titanium (Ti) (ug/g)	DLM 232				
	Tungsten (W) (ug/g)	DLM <1.0				
	Uranium (U) (ug/g)	DLM 0.72				
	Vanadium (V) (ug/g)	DLM 25.4				
	Zinc (Zn) (ug/g)	DLM 66.1				
	Zirconium (Zr) (ug/g)	DLM <2.0				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.